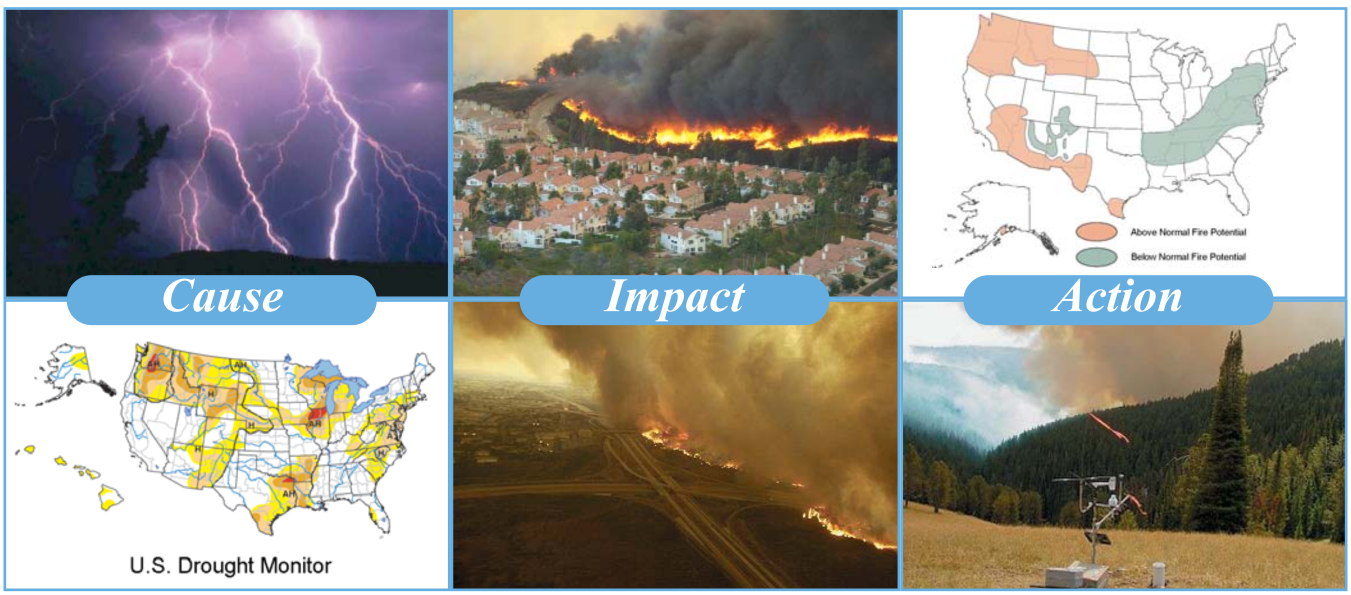
The Federal Plan for Meteorological Services and Supporting Research Fiscal Year 2006

Wildland Fire in the



Urban Environment

OFCM
OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY

FCM-P1-2005
U.S. DEPARTMENT OF COMMERCE/National Oceanic and Atmospheric Administration

Pictures displayed on the cover.
Cause: Lightning strike (Colorado Lightning Resource Page on the National Weather Service Pueblo, Colorado Forecast Office website. http://www.crh.noaa.gov/pub/ltg/ltg_tree_ht_test.JPG; U.S. Drought Monitor, September 20, 2005 Valid 8 a.m. EDT. Author: Douglas Le Comte, CPC/NOAA. Web Site: http://www.drought.unl.edu/dm/monitor.html
Impact: Cedar Fire wildfire about to engulf the Scripps Ranch residential community in Southern California (John Gibbins / The San Diego Union-Tribune); An aerial view of the fire burning in Scripps Ranch near I-15 (John Gibbins / The San Diego Union-Tribune).
Action: Outlook map for national significant fire potential showing either above-average or below-average fire potential during the coming season. (National Seasonal Assessment Workshop Final Report March 28-April 1, 2005. http://www.ispe.arizona.edu/climas/conferences/NASW/west05/NSAWwestproceedings.pdf); "Portable RAWS on the Burnt Ridge Sheep Camp Complex (Interagency Remote Automated Weather Stations (RAWS) Program website. http://www.fs.fed.us/raws/)"

The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 2006

FEDERAL COORDINATOR
FOR
METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

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PREFACE

Since 1965, the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) has developed a Federal Plan that articulates the provision of meteorological services and the support for meteorological and related research by agencies of the Federal government. OFCM's 2006 Federal Plan provides Congress and the Executive Branch with a comprehensive compilation of proposed programs for fiscal year (FY) 2006 and a review of agency programs in FY 2005. The Federal Plan's narratives, timelines, and schedules are current as of August 2005.

The Federal Plan consists of an Executive Summary, three sections, and Appendices. The Executive Summary, which is written as a concise, stand-alone report, provides a high-level view of the Federal resources dedicated to meteorological programs and the achievements of those programs.

This year's feature article (Section 1) examines the threats that wildland fires pose to life and property. Threats to the safety of residents and firefighters are paramount, followed by the direct destruction of property by these often swift-moving blazes. The potential urban environmental impacts of wildland fires include not only increased urban air pollution and health impacts due to smoke particles, but also possible degraded water quality through the release of burned debris into public water sources. These fires also hamper local transportation on the ground and in the air, thereby affecting public safety and commerce. Wildland fire is therefore a hazard whose impacts cut across all five of the priority areas identified during the *2004 User Forum on Urban Meteorology*, jointly sponsored by OFCM and the Department of Homeland Security (DHS) Science and Technology Directorate. These focus areas are severe weather, homeland security (including emergency preparedness and response), air and water quality, and climate-related conditions. This year's feature article summarizes the causes of wildland fires, describes their impacts on urban communities, reviews some activities undertaken by Federal agencies to minimize the impacts, and recommends next steps to address these impacts effectively.

Section 2 of the Federal Plan summarizes the resources requested in the President's FY 2006 Budget, compared with the resources appropriated by Congress for FY 2005. Section 3 contains departmental and agency narratives on programs for providing meteorological services and supporting research and development. It also describes relevant research funded by the National Science Foundation.

Appendix A describes the OFCM's coordination, program, and planning activities. Appendix B addresses the World Meteorological Organization's World Weather Program. Appendix C lists the feature articles published in previous Federal Plans. The acronyms and abbreviations used throughout this year's Federal Plan are defined in Appendix D. The inside front cover lists the current members of the Federal and Interdepartmental Committees for Meteorological Services and Supporting Research, which provide guidance and support for OFCM activities. The inside back cover diagrams the infrastructure through which the OFCM performs its coordinating mission.

Samuel P. Williamson
Federal Coordinator for Meteorological
Services and Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH, FISCAL YEAR 2006

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THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

FISCAL YEAR 2006

EXECUTIVE SUMMARY

For Fiscal Year (FY) 2006, the President's budget requests a total of $3.37 billion for meteorological services and supporting research. Of the requested total, $2.99 billion is designated for operations and $386 million for supporting research. Table ES-1 lists a breakout of the FY 2006 budget proposal.

For FY 2006, 92.8 percent of the total funds requested will go to the Departments of Commerce (DOC), Defense (DOD), and Transportation (DOT). The distribution among these three departments is DOC 57.2 percent, DOD 20.5 percent, and DOT 15.1 percent. The other Federal agencies will share the remaining 7.2 percent.

By comparison, the FY 2006 request represents an increase of 3.1 percent above the $3.27 billion appropriated in FY 2005. Within the three major departments, DOC requests an increase of 5.2 percent; DOD an increase of 0.7 percent, and DOT an increase of 4.4 percent. The DOC increase is attributable to requests for increases by NWS and NESDIS. The overall DOD increase is mainly the result of increases in AF and Navy requested funding. DOT's 4.4 percent increase is largely attributable to an increase in FAA's and FRA's operations requests.

The budget requests for the other departments are as follows:

- Department of Agriculture (USDA) a decrease of 15.8 percent,
- Department of the Interior (DOI) no change,
- Environmental Protection Agency (EPA) no change,
- National Aeronautics and Space Administration (NASA) a decrease of 7.5 percent, and
- the Nuclear Regulatory Commission (NRC) no change.

Figure ES-1 depicts each agency's proportion of the requested FY 2006 Federal budget for meteorological operations and supporting research. Each agency's portion of the requested funding for meteorological operations is shown in Figure ES-2. Of the $2.98 billion requested for meteorological operations, DOC, DOD, and DOT account for slightly over 98.5 percent of the funds. Overall, operational costs increased by 4.7 percent. Figure ES-3 depicts each agency's portion of the proposed Federal supporting research budget. Unlike operations, DOC, DOD, and NASA account for the major share (84.0 percent) of the supporting research budget. Other requests for supporting research funds are: a decrease in NASA (7.6 percent), a decrease in DOT (6.5 percent); an increase in DOD (12.1 percent); a decrease in DOC (16.0 percent); and no change at EPA.

All agencies project a personnel total of 16,365 full-time equivalent (FTE) to be employed in Federal meteorological operations in FY 2006. This figure represents a decrease of 0.5 percent from the 16,444 FTE employed in FY 2005.

Table ES-1. Federal Budget for Meteorological Operations and Supporting Research, FY 2006 (in thousands of dollars)

Agency	Operations	% of TOTAL	Supporting Research	% of TOTAL	TOTAL	% of TOTAL
Agriculture	$15,535	0.5	$28,280	7.3	$43,815	1.3
Commerce	1,839,769	61.6	89,939	23.3	1,929,708	57.2
Defense	619,646	20.7	71,803	18.6	691,449	20.5
Homeland Security	25,020	0.8	0	0.0	25,020	0.7
Interior	2,400	0.1	0	0.0	2,400	0.1
Transportation	483,450	16.2	24,506	6.3	507,956	15.1
EPA	0	0.0	9,000	2.3	9,000	0.3
NASA	2,615	0.1	162,600	42.1	165,215	4.9
NRC	120	0.0	0	0.0	120	0.0
TOTAL	$2,988,555*	100.0	$386,128	100.0**	$3,374,683*	100.0**

* Column total does not equal the same figure in Table 2.1 due to rounding.

** Column total does not exactly equal 100 percent due to rounding for several agencies.

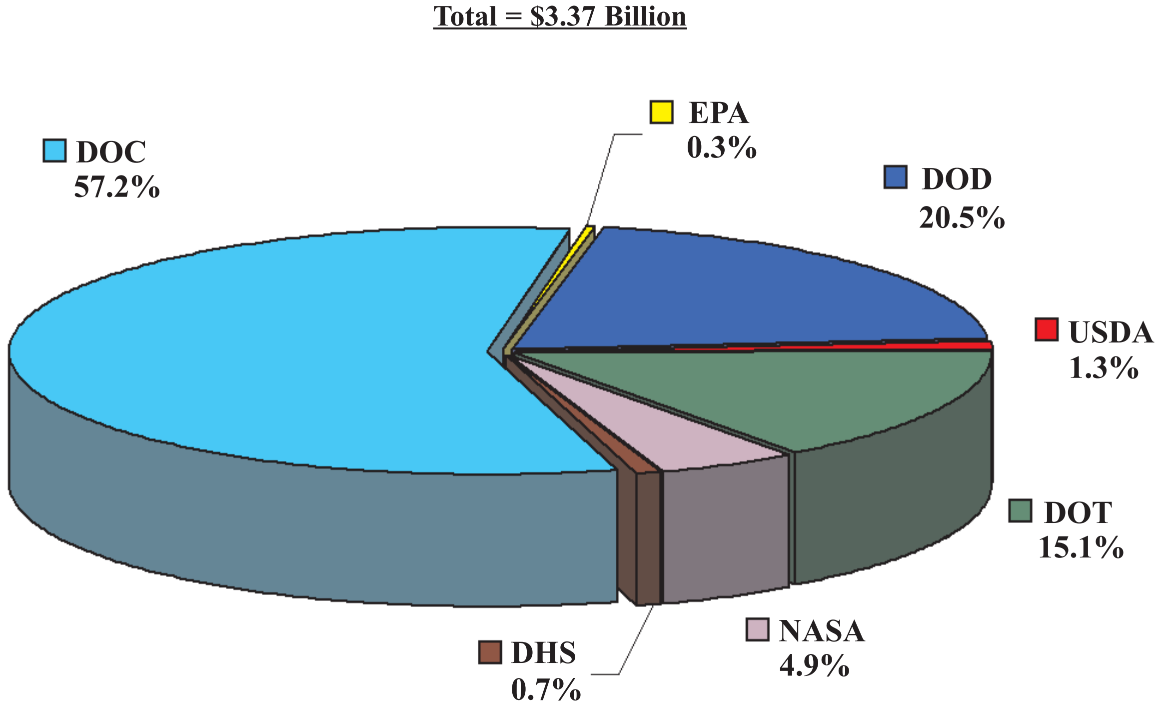

Figure ES-1. Agency Percent of Total Federal Budget for Meteorological Operations and Supporting Research, FY 2006.

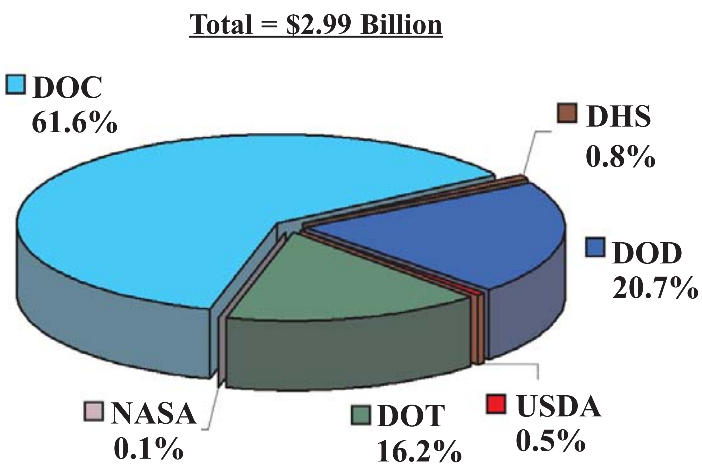

Figure ES-2. Agency Percent of Federal Budget for Meteorological Operations, FY 2006.

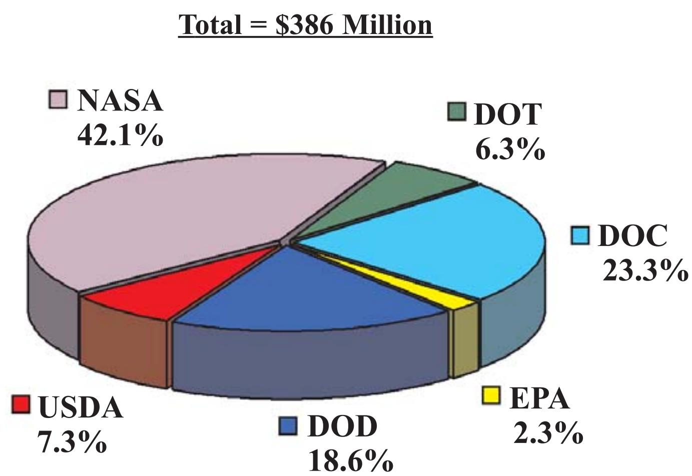

Figure ES-3. Agency Percent of Federal Budget for Supporting Research, FY 2006.

MAJOR PROGRAMS--DOC, DOD, and DOT

NEXT GENERATION WEATHER RADAR (NEXRAD).

The NEXRAD Program which began in FY 1981 was responsible for procurement, installation, and operation of the Weather Surveillance Radar-1988 Doppler (WSR-88D). The first limited production WSR-88D system was installed at Oklahoma City, Oklahoma in May 1990, and commissioned in February 1994. The original program plan called for a total of 161 radars. In response to a National Research Council report, three additional radars were added and raised the total to 164 radar sites.

By agency, as of June 2001, the DOC/National Weather Service had commissioned 123 sites, the DOD (USAF and Army) had commissioned 32 sites (within the states and overseas), and the DOT/FAA had commissioned 12 sites. DOD has three systems at Keesler AFB, Mississippi, for training; DOC/NWS has one each at the National Reconditioning Center, and NWS Training Center in Kansas City, Missouri and at the Radar Operations Center, Oklahoma City, Oklahoma.

AUTOMATED SURFACE OBSERVING SYSTEM (ASOS).

The ASOS program began in 1983, as a joint development effort between the DOC, DOD, and DOT/FAA. Installation of ASOS units started in 1992. A total of 1,002 units have been purchased. The NWS has purchased, accepted, and commissioned 313 sites. The FAA has purchased 570 units, all of which have been accepted and commissioned by the NWS. The Navy has purchased and accepted 72 sites. The Air Force has purchased and accepted 47 sites. Collectively, a total of 1,002 ASOS sites have been commissioned.

AUTOMATED WEATHER INFORMATION SYSTEMS (AWIS).

The DOC, DOD, and DOT require AWIS to facilitate the collection, processing, and interpretation of meteorological data. AWIS are being procured to provide an automated, high-speed, user-friendly man/machine interface to access and process large volumes of sophisticated meteorological data. AWIS supports the timely production of accurate and geographically precise warnings, forecasts, and special tailored products. They also provide the communications capability for expeditious product dissemination.

Major agency systems classified as AWISs are: NOAA's Advanced Weather Interactive Processing System (AWIPS), FAA's Weather and Radar Processor (WARP); Air Force's Joint Environmental Toolkit (JET); and the Navy's Naval Integrated Tactical Environmental Subsystem (NITES).

Advanced Weather Interactive Processing System (AWIPS).

In February 1997, the Secretary of Commerce approved the limited deployment of AWIPS at over 40 sites. On April 9, 1998, the Secretary authorized full-scale production and deployment of AWIPS, through Build 4.2, for the remaining 95 systems. Installation of these 95 systems began in September 1998 and was completed in June 1999. An Operational Test and Evaluation of the commissioning software load (Release 4.2) was successfully conducted from mid-May through June 1999. AWIPS commissioning began in January 2000 and, currently the NWS has commissioned all 139 operational AWIPS systems located at 122 Weather Forecast Offices (WFOs), 13 River Forecast Centers (RFCs), the Spaceflight Meteorology Group (SMG), and 4 National Centers for Environmental Prediction (NCEP).

The NWS successfully completed the final development phase release of AWIPS (Build 5) in early 2003, completed deployment of its first Operational Build (OB1) that summer, completed deployments of Operational Build 2 (OB2) in December 2003, Operational Build 3 (OB3) in August 2004, and Operational Build 4 (OB4) in February 2005. Deployment of Operational Build 5 (OB5) is planned to begin in June 2005. The Operational Builds continue to deliver new functionalities and enhancements in the areas of warning product generation and warning support, hydrological product generation, data and imagery display, communications and infrastructure. Of note within the operational builds of AWIPS is an evolution of the architecture to the Linux open source operating environment which was started in 2001, and will continue through to its planned completion in early 2007.

WARP.

The FAA's WARP will greatly enhance the dissemination of aviation weather information throughout the National Airspace System (NAS). WARP automatically creates unique, regional, WSR-88D-based, mosaic products, and sends these products, along with other time-critical weather information, to controllers through the Display System Replacement and to pilots via the Flight Information System. WARP underwent operational testing and evaluation in early FY 2003 and is operationally fielded at the 21 ARTCCs and the command center. Others systems used for enhancements, testing, and software support bring the total to 25 systems.

JET.

The Joint Environmental Toolkit (JET) will replace several disparate legacy weather systems with a single, integrated means of supporting both garrison and deployed operations, including a "first-in" weather forecasting capability. Combining forecasting, product-tailoring, and mission-impact capabilities in an interactive, network-centric, standards-based package; JET accesses, processes, analyzes, tailors, and integrates terrestrial and space weather information into command and control systems to guide warfighter decision-making. This effort will eliminate Air Force Weather Weapon System (AFWWS) redundancies and inefficiencies, reduce the burden on system administrators, and ultimately extend, consolidate, or replace the following systems: Operational Weather Squadron (OWS) Production System Phase II (OPS II), the New-Tactical Forecast System (N-TFS), the Joint Weather Impacts System (JWIS), and the Army's Integrated Meteorological System (IMETS) weather toolkit.

NITES.

The Navy continued migration towards a modular, interoperable suite of systems to ingest, process, fuse, display, and disseminate METOC information and its impact on tactical operations. The current program consists of four seamless versions known as NITES Versions I-IV. NITES will be fielded through FY 2006. The NITES Version II Object Oriented Redesign (OOR) is the basis for the Joint METOC Segment of the new Global Command and Control System (GCCS) V4.0. Navy is reviewing options to field a follow-on system to NITES that would support naval tactical operations and be interoperable with the other services.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

The NPOESS Program began when Presidential Decision Directive (PDD) NSTC-2 established the Integrated Program Office (IPO) in October 1994. Under the terms of this PDD, the IPO's function is to "...reduce the cost of acquiring and operating polar-orbiting environmental satellite systems, while continuing to satisfy United States DOD and DOC operational requirements for data from these systems." Effectively, the directive combines the current operations and future follow-on activities of the DOD Defense Meteorological Satellite Program (DMSP) with the DOC National Oceanic and Atmospheric Administration (NOAA) Polar-orbiting Operational Environmental Satellite (POES) program. The new follow-on system is called NPOESS, and will be available to launch after the failure of the last operational DMSP or POES satellite, around 2010. Cooperation with foreign governments and international organizations is being nurtured.

NPOESS is an integrated DOC, DOD, and National Aeronautics and Space Administration (NASA) program. Through the IPO, DOC is responsible for operations and overall program management; DOD contracts are used for the acquisition of the satellites, launch vehicles, and associated ground systems; and NASA is responsible for insertion of new and innovative technologies.

The space segment of NPOESS will include space platforms and sensors that will collect and store environmental and other data. This data will be downlinked to a network of receptor sites around the world, which will immediately forward data via fiber optic communications to the Operational Weather Processing Centers (i.e. AFWA, FNMOC, NAVO, and NESDIS). This innovative data distribution scheme is projected to be at least 3 times faster than the required data latency of 90 minutes. The satellite will also provide continuous down-link of data to field terminals used by deployed/remote military units and civilian users to obtain environmental data. The space segment will consist of meteorological, oceanographic, terrestrial, space environmental monitoring, and climatic sensors, in addition to other systems such as surface data collection/location and search and rescue.

The NPOESS constellation will notionally consist of three satellites, which will fly at 833 ± 17 km altitude with an inclination of 98.7 ± 0.05 degrees in three distinct sun-synchronous orbits; early morning, midmorning, and early afternoon. A wide variety of sensors will be carried aboard these platforms to acquire imagery and other meteorological and environmental data.

Each satellite will carry several types of sensors to accomplish its mission: electrical/optical (E/O), microwave (MW), space environmental, and other specialized sensors. The E/O instruments include a Visible/Infrared Imager/Radiometer Suite (VIIRS) to provide imagery in the VIS and IR spectra, a Cross-track Infrared Sounder (CrIS), a passive IR sounder to provide high-resolution vertical profiles of atmospheric properties in conjunction with MW soundings, and an Ozone Mapping and Profiler Suite (OMPS) to measure ozone in the Earth's atmosphere. The microwave instruments include a NASA developed Advanced Technology Microwave Sounder (ATMS) to measure atmospheric temperature and water vapor profiles and a separate Conical Scanning Microwave Imager Sounder (CMIS), consisting of an imager and a supporting sounder, to measure the critical surface and atmospheric phenomena in the MW spectrum under "all weather" conditions. The space environmental sensor suite (SESS) will measure parameters such as electron density profiles, neutral density profiles, and charged particle energies. Other NPOESS instruments include NASA's Total Solar Irradiance Sensor (TSIS) to measure solar energy per unit time per unit area, and the Aerosol Polarimetry Sensor (APS) to retrieve specified aerosol and cloud parameters using multispectral photopolarimetry.

NPOESS will carry other payloads that are similar to existing instruments, such as the French-provided Data Collection System (DCS), which collects and processes measurements from buoys, free-floating balloons, and remote weather stations, for on-board storage and subsequent transmission from the satellite, and the joint Canadian/French Search and Rescue Satellite Aided Tracking (SARSAT) system that uses NOAA satellites in low-Earth and geostationary orbits to detect and locate aviators, mariners, and land-based users in distress. The satellites relay distress signals from emergency beacons to a network of ground stations and ultimately to the United States Mission Control Center (USMCC) in Suitland, Maryland. The USMCC processes the data and alerts the appropriate search and rescue authorities.

Additionally, NPOESS will carry sensors such as the NASA Earth Radiation Budget Sensor and an altimeter. One of the CMIS missions is to use its polarimetric data to measure the ocean surface wind speed and direction, producing data that is comparable to the Advanced Scatterometer (ASCAT) being flown on EUMETSAT's Metop for ocean measurements (i.e. surface stress, surface wind, sea ice coverage).

FY 2003 was a very full year for NPOESS. The most significant activity of the year was the award of the contract to TRW (now Northrup Grumman Space Technology - NGST) at the end of 2002. Northrop is the prime contractor for the entire system, teamed with Raytheon to provide the Ground Segment portion. During FY 2003, the major focus was on completion of the VIIRS, CrIS, OMPS instruments and the command and control and data processing systems, all slated for first use on the joint IPO/NASA NPOESS Preparatory Project (NPP) satellite, slated for launch in the Spring, 2008.

In FY 2000, NASA and NOAA established the Joint Center for Satellite Data Assimilation (JCSDA) to facilitate the use of satellite environmental data by developing new and powerful mathematical techniques to assimilate the data into numerical weather prediction (NWP) models. The NPOESS program arranged for the DoD to participate in this effort, and the IPO is augmenting the JCSDA with funding to ensure NPOESS data is quickly accelerated into weather operations once it begins flowing.

In FY 2003 and early 2004, the NPOESS IPO and NASA completed arrangements with the Kingdom of Norway for installation of satellite C3 antennae on the island of Svalbard and fiber optic communications between the island and the Norwegian mainland. This provides redundant, reliable high volume communications for command and control and data retrieval. The site became operational in January 2004 and began taking data passes from the Navy's Coriolis/Windsat wind measurement satellite.

NPOESS also recently sponsored UCAR's (University Consortium for Atmospheric Research) Cooperative Program for Operational Meteorology, Education and Training (COMET) in branching into high-latitude territory. Since the usefulness of geostationary satellites declines rapidly at latitudes above 60 degrees north and south, NPOESS data are especially important toward the poles. COMET is developing a training series to orient forecasters to the products available from the polar orbiters. COMET is also developing material to help prepare forecasters for the data provided by the NPOESS series satellites.

The IPO is working with the NGST/Raytheon team on a daily basis to ensure ground systems are in place and operating in time for an NPOESS Preparatory Project (NPP) launch in the early 2008 timeframe and that all systems are ready for an expected 2011 NPOESS launch. In addition to DMSP and POES activities at NOAA's Satellite Operations Control Center (SOCC) in Suitland, Maryland, the operational side of the IPO will get busier with the additional responsibilities of WindSat Coriolis, NPP, and NPOESS over the next several years.

More information regarding the NPOESS program can be found at npoess.noaa.gov.

OTHER AGENCY PROGRAMS

For FY 2006, the Department of Agriculture (USDA) requested $43.8 million for meteorological operations and supporting research. Operationally, the USDA supports specialized weather observation networks and also conducts an active supporting research program to ensure an abundance of high-quality agricultural commodities, while minimizing the adverse effects of agriculture on the environment. Under supporting research, USDA focuses on the interactions of weather and climate with plant and animal production and water resources management.

The Department of the Interior's (DOI) FY 2006 request of $2.4 million is primarily to support the Bureau of Land Management's Remote Automatic Weather Station (RAWS) program.

The Environmental Protection Agency (EPA) budget request for FY 2006 is $9.0 million, the same amount as in FY-2005, to provide user-appropriate and scientifically credible air-quality and meteorological programs and models to support regulatory applications.

NASA’s FY 2006 request is for a total of $165.2 million--$2.6 million for operations and $162.6 million for supporting research. These funding levels are composed of the estimated meteorology share of the supporting research and analysis programs as well as Earth Observing System (EOS) and Earth Probe instruments, EOS science, and the EOS Data Information System elements of the NASA Office of Earth Science budget.

The Nuclear Regulatory Commission's (NRC's) request for $120,000 in FY 2006 is for operations. The NRC will dedicate these funds to obtain and analyze meteorological data and information related to siting new nuclear power plants and safe operation of nuclear facilities, to the protection of public health and safety, and protection of the environment.

FEDERAL COORDINATION (See Appendix A for complete details.)

NATURAL DISASTER REDUCTION

Interdepartmental Hurricane Conference

The OFCM annually hosts the Interdepartmental Hurricane Conference (IHC) to provide a forum for the responsible Federal agencies, together with representatives of the user communities such as emergency management, to review the Nation's hurricane forecast and warning program and to make recommendations on how to improve the program. The OFCM hosted the 59th IHC in Jacksonville, Florida, March 7-11, 2005. The theme of the 2005 conference was *The Nation's Tropical Cyclone Program-Priorities for the Next Decade*. The conference attendance was 213; for the sixth consecutive year, attendance has exceeded 200. The 59th IHC was cohosted by the Office of the Oceanographer of the Navy. The keynote address for the conference was given by Dr. James R. Mahoney, Assistant Secretary of Commerce for Oceans and Atmosphere and NOAA Deputy Administrator. At its November 16, 2004, meeting, the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) strongly supported the 58th IHC action item to develop a comprehensive strategy for tropical cyclone research and development to guide interagency efforts over the next decade. In response to that action, the Joint Action Group for Tropical Cyclone Research (JAG/TCR) was formed, and the group conducted a strategic planning session during the 59th IHC to begin developing the framework for a *Strategic Research Plan for Tropical Cyclones*. This effort will build upon the goals and objectives of the OFCM-sponsored *National Plan for Tropical Cyclone Research and Reconnaissance (1997-2002)* and the *U.S. Weather Research Program Hurricane Landfall Implementation Plan*, and articulate the interagency tropical cyclone research priorities for the next decade. The goal is to complete the plan prior to the 60th IHC in March 2006.

Post-Storm Data Acquisition

The OFCM will continue to coordinate, as required, timely post-storm data acquisition surveys in response to Presidentially declared natural disasters and other agency requirements to evaluate, for example, the impact on the coastal ecosystems. These natural disaster reduction efforts contribute to the determination of the intensity and magnitude of storms, and, in many cases, help to determine the extent of damage for use in Presidential disaster declarations. The additional data collected after hurricane landfall is also used in validating modeling efforts with both emergency management models (e.g., FEMA's HAZUS) and hurricane storm-surge models (e.g., NOAA's SLOSH). These models are used in real-time to assist decision makers in evacuation decisions and procedures. Post-storm data are also used to update FEMA Flood Insurance Rate Maps. In FY 2005, post-storm surveys were conducted for Hurricane Dennis; tornado occurrences during March in Houston County in Southeast Alabama, and in Seminole, Miller, and Mitchell Counties in Southwest Georgia; and Hurricane Katrina.

URBAN METEOROLOGY

The OFCM, in partnership with the Department of Homeland Security (DHS) Science and Technology Directorate, conducted a User Forum on Urban Meteorology, September 21-23, 2004, at the Doubletree Hotel and Executive Meeting Center in Rockville, Maryland. The theme of the forum was *Information to Improve Community Responses to Urban Atmospheric Hazards, Weather Events, and Climate*. It focused on the following elements of urban meteorology: severe weather, homeland security, air quality, water quality, and climate. This interagency forum was the direct result of an action item from the October 18, 2002, meeting of the FCMSSR. The forum's proceedings were completed in March 2005. In accordance with direction received at the November 16, 2004, meeting of ICMSSR, the OFCM developed clear guidelines and direction for establishing an interagency working group to address the actions that resulted from the forum.

CLIMATE

During FY 2005, the OFCM made contributions to climate activities in the following two primary areas: in connection with the Urban Meteorology User Forum which was held September 21-23, 2004, and the U.S. Climate Change Science Program (CCSP). The Urban Meteorology User Forum focused on the following elements of urban meteorology: severe weather, homeland security, air quality, water quality, and climate. Results of the forum were briefed at the November 16, 2004, meeting of the ICMSSR and, as a result, OFCM was tasked to develop clear guidelines and direction for establishing an interagency working group to address actions from the forum, and to coordinate and develop an interagency document covering an urban meteorology program, including climate. Dr. James R. Mahoney, Director of the U.S. Climate Change Science Program, briefed the FCMSSR at its December 1, 2004, meeting. Dr. Mahoney noted that many challenges lie ahead for the CCSP program, particularly those related to the budget process and delivering the best possible science to inform decision makers. It was decided that FCMSSR members will continue to stay abreast of the CCSP and will coordinate priorities for atmospheric requirements through OFCM for inclusion in the CCSP.

OPERATIONAL PROCESSING

The OFCM Committee for Operational Processing Centers (COPC) addresses processing and backup capabilities of NOAA's National Centers for Environmental Prediction and Office of Satellite Data Processing and Distribution, the Air Force Weather Agency, and the U.S. Navy's Fleet Numerical Meteorology and Oceanography Center and Naval Oceanographic Office. During FY 2005, the COPC continued to make progress in areas such as model development, observing strategies, database architecture, and backup requirements.

The COPC has begun activities in the area of High Performance Computing and Communications (HPCC). An HPCC model run was conducted on the Weather Research and Forecasting (WRF) Operational Test Bed Distributed Center computers to demonstrate the capability of grid computing and to establish the feasibility of a DOD Joint Operational Test Bed for the WRF modeling framework.

At the March 23-24, 2005, meeting of the COPC, the members endorsed the establishment of a new OFCM-sponsored National Operational Processing Centers (NOPC) Program Council for higher level organizational approval and monetary commitment.

ENVIRONMENTAL SUPPORT TO HOMELAND SECURITY

<u>Atmospheric Transport and Diffusion Research and Development Plan</u>

In September 2004, the OFCM completed work with applicable agencies in developing the report, *Federal Research Needs and Priorities for Atmospheric Transport and Diffusion Modeling*, a FCMSSR action. The report is the result of a process that included consultation with subject-matter experts, including first responders and emergency managers; a careful analysis of research needs and current capabilities to respond to domestic incidents of national significance; a capability gap analysis; and the development of strategies to close the gaps. The report was briefed to the ICMSSR and FCMSSR at their November 16, 2004, and December 1, 2004, meetings, and both committees endorsed the report's recommendations.

On July 19, 2005, the OFCM conducted a special session in conjunction with the 9th Annual George Mason University (GMU) Conference on *Atmospheric Transport and Dispersion Modeling* to begin to address, with the broader private and academic communities, the issue of uncertainty in ATD models-a capstone goal of the *Federal Research Needs and Priorities for Atmospheric Transport and Diffusion Modeling* report. In addition, the OFCM developed an ATD implementation strategy for the report's recommendations for which the OFCM has primary responsibility. The strategy was sent to the FCMSSR and ICMSSR members in August 2005 for their review and comments.

<u>George Mason University Atmospheric Transport and Dispersion Modeling Conference</u>

George Mason University (GMU), Fairfax, Virginia, conducted its 9th Annual Conference on *Atmospheric Transport and Dispersion Modeling*, July 18-20, 2005. The OFCM partnered with GMU to sponsor the event.

On July 19, 2005, the OFCM hosted a session related to the OFCM's ongoing work with the Department of Homeland Security and other members of the Federal meteorological community. The main focus of the ongoing work was to define the concept of operations and the research and development needs required to support the National Incident Management System and emergency responders at Federal, state, and local levels. The OFCM session topic was *Uncertainty in Atmospheric Transport and Diffusion (ATD) Models*. The Federal Coordinator noted that the session objectives were to facilitate a discussion of uncertainties in ATD modeling systems that incorporates academic and private sector inputs, and accounts for uncertainty in meteorological observations and models and in dispersion models; and to help Federal agencies striving to improve their ATD modeling systems to implement the recommendations made by the OFCM JAG for Atmospheric Transport and Diffusion (Research and Development Plan) in their publication *Federal Research and Development Needs and Priorities for Atmospheric Transport and Diffusion Modeling (2004)*. He also stated that the way ahead included: complete the strategy for ATD modeling improvements and present it to the FCMSSR (key elements of the strategy are a core set of ATD modeling systems, recovery of existing ATD data, common framework for model evaluation, and ATD test beds); and through partnership and collaboration within the Federal meteorological community and its customers, the OFCM will continue to identify shortfalls in urban meteorology, and help to organize improvements across all applicable focus areas that will better support users in the urban environment. On August 26, 2005, the OFCM *Implementation Strategy for Federal Atmospheric Transport and Diffusion Modeling and Measurement Improvements* was forwarded to the FCMSSR members.

Homeland Security Environmental Support Plan

The *Homeland Security Environmental Support Plan*, an action from the FCMSSR, will define the mission, roles, and responsibilities of individual Federal agencies as they relate to homeland security and will document each agency's environmental support capabilities and/or requirements. The OFCM worked closely with the Plume Modeling Subset of the Consequence Management, Site Restoration/Clean-up (CMS) Subgroup, which is chaired by the Department of Homeland Security (Emergency Preparedness and Response), to develop an interagency concept of operations for an all-hazards dispersion support framework. The concept of the Interagency Modeling and Atmospheric Assessment Center (IMAAC) was successfully proposed to the Homeland Security Council Deputies and adopted in April 2004.

While the initial goal was to complete the *Homeland Security Environmental Support Plan* by the end of FY 2005, successful completion rests with the completion of the IMAAC concept of operations, which, at this point, is still evolving.

ANNUAL FEDERAL PLAN

In October 2004, the OFCM issued *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2005*. The Federal Plan is congressionally mandated and is a one-of-a-kind document which articulates the meteorological services provided and supporting research conducted by agencies of the Federal government. The Federal Plan helps to reduce overlap and duplication among the agencies. It is a comprehensive publication that documents proposed programs for Fiscal Year (FY) 2005 and reviews agency programs in FY 2004. The plan demonstrates to the Congress and to the Executive Branch how the Federal agencies work together to accomplish their missions in an effective and efficient manner. The special interest article in the FY 2005 Annual Federal Plan, *The Rewards of Managing Weather-Related Risks*, focused on the Federal agencies' meteorological activities related to risk management and assessments, and the socioeconomic impacts of natural hazards.

WEATHER INFORMATION FOR SURFACE TRANSPORTATION

The ICMSSR received an update on weather information for surface transportation (WIST) at its November 16, 2004, meeting. The ICMSSR supported the Working Group for Weather Information for Surface Transportation (WG/WIST) actions to allow all Federal departments and agencies to participate in the development of plans or projects to meet their WIST needs and ensure Federal resources are used efficiently; to develop a multiyear, Federal WIST research program plan to bring together the Federal weather and surface transportation research communities and provide a vision for the public and private sectors to use for planning purposes; and to develop an overarching, multiagency-coordinated WIST implementation program.

The work of the WG/WIST, jointly chaired by NOAA and FHWA, was endorsed in the July 20, 2005, Memorandum of Understanding signed by VADM Conrad C. Lautenbacher, Jr., USN (Ret.) and Ms. Mary E. Peters. Timely and accurate surface transportation information will support improvements in safety and efficiency in transportation operations.

Most recently, on September 23, 2005, OFCM forwarded to ICMSSR members the *Weather Information for Surface Transportation (WIST) Initiative Document-First Steps to Improve the Nation's WIST Capabilities and Services* (September 2005). This Initiative Document represents the initial recommendations of the WG/WIST members on key actions and priorities that should be taken by the responsible agencies in the OFCM Federal coordinating infrastructure to collaborate on and address national surface transportation safety, mobility, and productivity issues.

AVIATION WEATHER

In December 2004, the OFCM issued *Aviation Weather Programs/Projects-2004 Update* which updates the compilation of activities across Federal agencies that began with the *National Aviation Weather Initiatives Final Baseline Tier ¾ Report*, distributed in 2001, and serves as a baseline report for the recently established Joint Planning and Development Office (JPDO) within the Federal Aviation Administration (FAA).

This report updates and extends the analysis of trends in weather-related aviation accidents that first appeared in the *National Aviation Weather Program Mid-Course Assessment*, published in August 2003, and endorsed by the FCMSSR, FAA, and the National Center for Atmospheric Research (NCAR). The effort to deliver improved weather risk reduction products and services must be supported and sustained.

Additional accomplishments which are underway in the area of aviation weather support include follow-up activities from the June 21-24, 2004, *2nd International Conference on Volcanic Ash and Aviation Safety*. These include the development and coordination of interagency volcanic ash operations and implementation plans. The operations plan will identify procedures and agency responsibilities and contacts for responding to a volcanic ash release. The implementation plan will provide the roadmap for further improved science, new technologies for observing volcanic ash (e.g., NASA's efforts), improved detection (USGS), NOAA modeling and forecasting (NAAC forecasts for aircraft avoidance), and education of the international community.

SPACE WEATHER

The overarching goal of the *National Space Weather Program* (NSWP), which is administered by an OFCM program council, is to achieve an active, synergistic, interagency system; providing timely, accurate, and reliable space weather warnings, observations, specifications, and forecasts by 2007. The *NSWP Strategic and Implementation Plans* provide, respectively, broad guidance and a detailed roadmap for the NSWP. It was noted at the November 16, 2004, and December 1, 2004, ICMSSR and FCMSSR meetings, respectively, that the program is nearing the end of the 10-year period, which was addressed in the strategic and implementation plans, and that it was time to perform an interagency assessment to look at the progress toward meeting its goals. It was determined that a comprehensive review of the NSWP was warranted to quantify the progress toward meeting the goals in observations, research, modeling, transition of research to operations, and education and outreach; to determine if actions detailed in the *NSWP Implementation Plan* are on target and moving in the direction detailed by the strategic plan; and to determine whether the strategic goals should be adjusted at this time based on emerging and evolving requirements. A National Space Weather Program Assessment Study Group has been formed and the strategy for completing the assessment completed.

On September 27, 2005, an Interim Assessment Letter Report was sent to the Federal Coordinator and forwarded to FCMSSR members. The report contained early findings and areas where further investigation will take place.

PHASED ARRAY RADAR

The Phased Array Radar Project (PARP) was briefed to ICMSSR at its November 16, 2004, meeting. The ICMSSR supported the JAG's continued work to identify and document the potential needs and benefits that the phased array radar and an adaptive radar sensing strategy would address, and to integrate those identified needs into a multiagency-coordinated research and development (R&D) plan that would focus R&D efforts on meeting each agency's needs. The plan will also prioritize the most pressing R&D needs and provide a roadmap to address those needs within the OFCM coordinating infrastructure. A summary report was distributed to ICMSSR members in early October 2005; and the final multiagency-coordinated R&D plan will be completed by January 2006.

ATMOSPHERIC RESEARCH AND DATA ASSIMILATION/DATA MANAGEMENT

Atmospheric research and data assimilation/data management were challenges and issues discussed at the November 16, 2004, and the December 1, 2004, meetings of ICMSSR and FCMSSR, respectively. It was noted that there was a need to tie future research efforts in science, technology, and transition mechanisms to operational and societal requirements. It was agreed that agencies will support research and development needs and requirements based on agency priorities and will continue to identify issues and concerns that are necessary for the development of capabilities required to realize societal benefits. Agencies will also support and facilitate opportunities for the transition of research into operational applications. Further comments and suggestions will be provided by the agencies to the Federal Coordinator to assist OFCM in the planning and development of a vision and implementation roadmap for the supporting research enterprise of the Federal meteorological community for the next decade.

Also highlighted at the ICMSSR and FCMSSR meetings were data assimilation and data management challenges the community faces, as the size of future data sets increase by orders of magnitude. Advanced modeling and data assimilation techniques are critical to improve the quality of analyses and model results and to maximize the value of the Global Earth Observation System of Systems (GEOSS). Agencies were very supportive of the need for further interagency collaboration efforts in this area. An action item stemming from the FCMSSR meeting was that Federal requirements and capabilities in key areas, like data management and data assimilation, need to be surveyed and further addressed. This interagency work fully supports NOAA's crosscutting priorities.

In response to the above FCMSSR action item, the OFCM undertook a survey of Federal requirements and capabilities in the area of meteorological data assimilation and related data management. On September 15, 2005, the OFCM provided to FCMSSR and ICMSSR members an interim survey/assessment progress report on its efforts; the final report which will examine the gaps in our current data assimilation/data management capability, articulate the challenges that lie ahead in meeting future requirements, and propose a strategy to address these gaps in capability and future challenges, will be completed during January 2006.

COLLABORATION WITH NAS/NRC BOARD ON ATMOSPHERIC SCIENCES AND CLIMATE

The OFCM continued its mutually beneficial interactions with the National Academy of Sciences/National Research Council (NAS/NRC). The NAS/NRC Board on Atmospheric Sciences and Climate (BASC) conducted a planning meeting on June 21, 2005, to discuss *Mesoscale Observation Networks for Meeting Multiple National Needs*. In this planning meeting in which the Federal Coordinator for Meteorology was a participant, a small group of people were asked to brainstorm about a general issue that has been identified as a potential study topic. The Federal Coordinator helped BASC to better define the issue and identify whether an Academy study on the topic would be valuable. The Federal Coordinator noted that the multitude of meteorological impacts on the urban environment alone would warrant the proposed BASC study, and that all five primary focus areas within urban meteorology (severe weather, homeland security, air quality, water quality, and climate) discussed during the *Forum on Urban Meteorology-Meeting Weather Needs in the Urban Community*, conducted by OFCM, September 21-23, 2004, would benefit from improved mesoscale and urban scale observational capabilities. The Federal Coordinator provided a detailed listing of possible study tasks and, also, identified potential sources of observational needs and current capabilities information.

COLLABORATION WITH THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES

CENR Principals

The Federal Coordinator continues to be a participant on the Committee on Environment and Natural Resources (CENR), and continues to assist CENR through review and concurrence of CENR reports and materials.

Subcommittee on Disaster Reduction

The OFCM has been an active participant in the work of the CENR Subcommittee on Disaster Reduction (SDR). Recognizing that disasters can be the result of a technological and/or natural hazard, the subcommittee changed its name from the Subcommittee on Natural Disaster Reduction to the Subcommittee on Disaster Reduction (SDR). Recently, the focus of this group has been to enhance disaster resilience by composing a 10-year agenda for science and technology activities that will produce a dramatic reduction in the loss of life and property from natural and technological disasters. This 10-year agenda identifies a suite of Grand Challenges for disaster reduction. It cuts across all hazards and disaster management stages and identifies priorities for research and investment. Addressing these Grand Challenges will improve the Nation's capacity to prevent and recover from disasters. OFCM is committed to working with SDR to provide a forum for information sharing, development of collaborative opportunities, and interactive dialogue with the U.S. policy community to advance informed strategies for managing risks associated with natural and technological disasters. The Grand Challenges document will contribute to U.S. government planning activities on a number of levels, especially in the area of enhancing the Nation's safety and economic well-being.

AMERICAN METEOROLOGICAL SOCIETY

During FY 2005, the OFCM joined leading environmental science and service corporations in supporting undergraduate scholarships in the atmospheric and related oceanic and hydrologic sciences. The scholarships, awarded for the junior and senior years, are designed to encourage outstanding undergraduates to pursue careers in the fields covered by the awards. The OFCM plans to continue this support.

The OFCM also supports American Meteorological Society (AMS) endeavors by participating in AMS conferences and workshops and other environmental science education and outreach programs. The OFCM staff cochaired the *21st AMS Conference on Weather Analysis and Forecasting* held in Washington, D.C., August 1-5, 2005. In addition, the Federal Coordinator participated in three important AMS-sponsored activities including: the *AMS Corporate Forum* on March 31, 2005, in the Washington, D.C. area, at which he gave a cross-agency and international perspective on GOES-R rebroadcast; *The Future of the U.S. Weather Prediction Enterprise*, July 26-28, 2005, in Boulder, Colorado; and the *Golden Jubilee Symposium*, September 20-21, 2005, in Research Triangle Park, North Carolina, where he served as the session chair for the role of air quality models in decision making.

INTERNATIONAL SUPPORT

The Federal Coordinator provided a comprehensive briefing on the OFCM and interagency coordination of Federal meteorological activities to Dr. Xu Xiaofeng and a delegation of 25 individuals from the Chinese Meteorological Administration, on May 24, 2005.

Then on August 24, 2005, the Federal Coordinator hosted and briefed Dr. Zheng Guoguang, Deputy Administrator of the Chinese Meteorological Administration. Also, news media from Japan attended and conducted interviews at the 59th Interdepart-mental Hurricane Conference in Jacksonville, Florida, March 7-11, 2005.

LIVING WITH WILDLAND FIRE IN THE URBAN ENVIRONMENT

INTRODUCTION

The extraordinary natural, climatic, and geographic diversity of the United States exposes the Nation to a wide range of natural hazards. Additionally, increased population densities and property development in hazard zones have dramatically heightened the Nation's disaster vulnerability. It has been estimated that weather and climate events have up to a $2.2 trillion impact on the U.S. economy annually. Conservative estimates of the comprehensive disaster costs, related to the annual loss of life and property, disruption of commerce, and response and recovery, are at least $20 billion.

The sheer diversity of the hazards and their weather-related determinants pose an additional challenge for urban meteorology. The Office of the Federal Coordinator for Meteorological Services and Supporting Research (commonly known as OFCM), in partnership with the Department of Homeland Security (DHS) Science and Technology Directorate, conducted a User Forum on Urban Meteorology, September 21-23, 2004. During the forum, hazards in five areas of the urban environment were identified: severe weather, homeland security (emergency response to airborne hazards), air and water quality, and climate-related conditions.

Wildland fire is a hazard whose impacts crosscut the aforementioned five hazard areas of the urban environment. As will be discussed later in this paper, severe weather phenomena can cause wildland fire (i.e., thunderstorms) or increase the risk of wildland fire (i.e., strong winds). Wildland fire poses a great threat to life and property and can result in a number of potential urban environmental impacts, including increased urban air pollution and health impacts due to smoke particles, possible degraded water quality through the release of burned debris into public water sources, and hampered local transportation, both on the ground and in the air, thereby affecting public safety and commerce. Climate also plays an important role in the wildland fire hazard (e.g., areas experiencing climate-induced drought conditions may be at increased risk for wildland fires).

The past several decades have seen an increase in population growth in formerly rural areas. For example, many areas in California, Florida, and Texas have seen up to a 30 percent increase in population during the period 2000-2003 (Figure 1-1). This increase has moved more people into an expanding urban environment (i.e., the urban "sprawl" has spread into areas where forests and natural landscapes used to exist). The area where structures and/or other human development meet or intertwine with undeveloped wildland or other forms of vegetative fuels is often referred to as the wildland /urban interface.

Some examples of these wildland fires which have affected the urban environment include the Oakland Hills, California fire in October 1991 (Figure 1-2) with 25 lives lost and 2,900 structures destroyed; the Cerro Grande, New Mexico fire in May 2000 where 235 structures were destroyed and the Los Alamos National Laboratory was damaged; and, more recently, the wildland fires in Southern California which claimed 22 lives, destroyed 3,600 homes, burned nearly 740,000 acres of land, and caused more than $2 billion in property damage. During an average year, nearly 70,000 wildfires burn approximately 4.5 million acres.

The impacts of hazard events such as wildland fires can be mitigated through careful planning and by taking appropriate actions. Communities across the Nation can be better prepared to withstand hazard events through improved research; improved data collection,

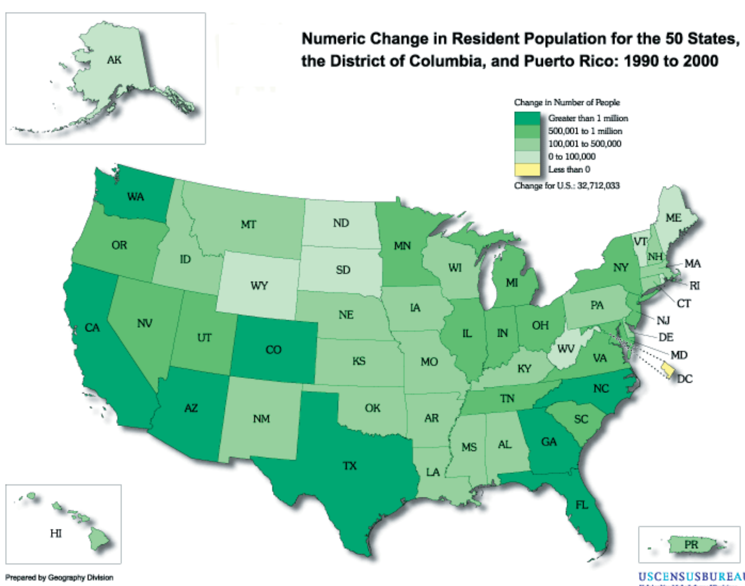

Figure 1-1. Population increases to the coastal/urban areas, 1990-2000. (U.S. Census Bureau)

Article prepared by Ms. Mary Cairns, OFCM staff.

Figure 1-2. A devastating fire occurred in the hills above Oakland and Berkeley, California, on October 20, 1991 (the Oakland Hills fire).

analysis, data assimilation, prediction, and interpretation; improved hazard preparedness and response; and effective public education and warning. It is important to keep in mind that wildland fire is a natural part of the environment for most of the country. While detrimental impacts of fire can be minimized, humans must also learn to live with fire.

This article summarizes the causes of wildland fires, presents a description of the impact wildland fire has on urban communities, reviews some activities undertaken by Federal agencies to minimize the impacts, and provides some recommended next steps to address the spectrum of wildland fire impacts.

Code	USFS	DOI
01	Lightning	Lightning
02	Aircraft	Aircraft
03	Burning vehicle	Vehicle
04	Exhaust-power saw	Exhaust – power saw
05	Exhaust-other	Exhaust – other
06	Logging line	Logging line
07	Brakeshoe	Brakes
08	Cooking fire	Cooking fire
09	Warming fire	Warming fire
10	Smoking	Smoking
11	Trash burning	Trash burning
12	Burning dump	Burning dump
13	Field burning	Field burning
14	Land clearing	Land clearing
15	Slash burning	Slash burning
16	Right-of-way burning	Right-of-way burning
17	Resource management burning	Resource management burning
18	Grudge fire	Grudge fire
19	Pyromania	Recurrent
20	Smoking out bees or game	Smoke out bees/game
21	Insect/snake control	Insect/snake control
22	Job fire	Employment
23	Blasting	Blasting
24	Burning building	Burning building
25	Power line	Power line
26	Fireworks	Fireworks
27	Playing with matches	Ignition devices
28	Repel predatory animals	Repel predators
29	Stove fuel sparks	House/stove flue sparks
30	Other	Other (unknown)
31		Volcanic
32		Other (known)

Table 1.1. Specific causes of wildland fires as defined by USFS and DOI. (Brown et al., 2002)

CAUSES OF WILDLAND FIRES

The causes of wildland fire fall into two distinct categories: human and natural. To understand the impact of wildland fire, one needs to determine the causes to be able to predict high-risk areas for fires, to develop fire-management tools, and to predict the seasonal variations which contribute to fire development.

The public may not be aware of all the possible ways they contribute to the human-generated wildland fires. Human-caused ignitions include those from equipment exhaust, abandoned campfires, cigarettes, and arson. Table 1.1 lists the various sources of wildland fires.

Though ultimately a very small percentage, fires deliberately started for fuels management have resulted in a wildland fire. The Cerro Grande fire in May 2000 is one recent example of a prescribed fire which turned into a wildland fire, enhanced by adverse weather conditions. The fire resulted in over 200 destroyed structures, damage to the Los Alamos National Laboratory, and the evacuation of 18,000 residents. In the period from 1968-2000, 38 of 3,746 prescribed fires went out of control.

Prescribed fire: Any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and National Environmental Policy Act requirements (where applicable) must be met, prior to ignition.

Wildland fires can also be caused by naturally occurring atmospheric phenomena, specifically lightning from thunderstorms. Lightning-initiated wildland fires account for 80 percent of the overall fires in the western United States (Figure 1-3). Climatic events such as El Nino and weather phenomena such as prolonged heat waves can lead to fire-prone areas where fires are easily sustained with dry fuels.

The El Nino weather pattern of 1997-1998 disrupted rainfall patterns, leaving many forests dry. Thousands of deliberately set forest fires, mainly for cultivation, raged out of control in Indonesia, Brazil, and Mexico, burning millions of hectares of rain forest. Thick clouds of smoke blanketed vast areas in Southeast Asia, South America, and Central America, sending tens of thousands of people to hospitals with respiratory illnesses related to the polluted air.

The causes of most wildland fires are known, but not everybody realizes the extent of the impacts wildland fire can have on the urban environment.

POTENTIAL IMPACTS OF WILDLAND FIRES

There are several direct impacts of wildland fires. These impacts include: the loss of life and property; air quality and health problems; affects on transportation, both air and ground; impacts on our forest and rangeland ecosystems, water systems, and wildlife; and impacts on national and local economies.

The greatest impact of wildland fires is the loss of life, both within the firefighting community and the general public. Over the last 100 years, 918 firefighters have lost their lives in wildfires. In 1918, the Moose Lake Fire in Minnesota resulted in a total of 450 lives lost. Second to loss of life is

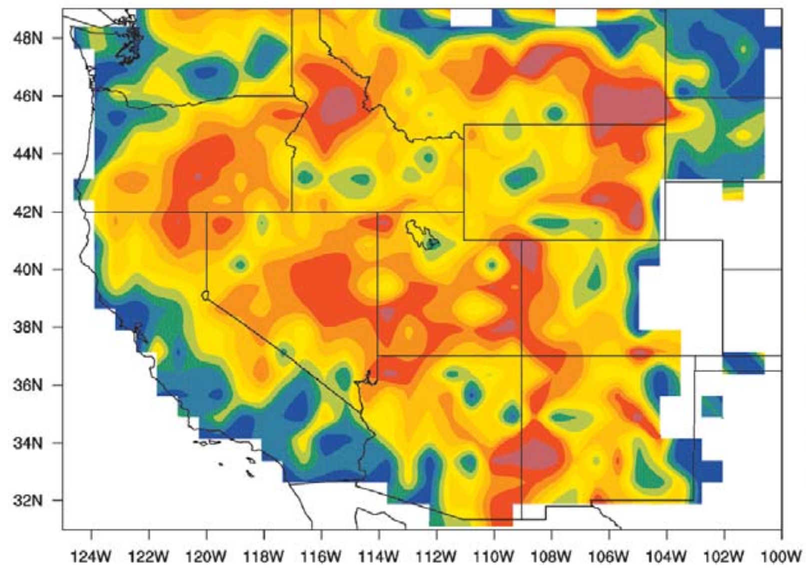

Figure 1-3. Percent of coarse quality controlled western U.S. Federal wildland fires caused by lightning for the period 1970-2000.
(http://www.cefa.dri.edu/Publications/fireoccurrencereport.pdf - Figure 11)

the loss of personal property. In the San Diego County fires, 3,600 homes were destroyed, causing upwards of $2 billion dollars in damage, not to mention the displacement of those families. In 2003, natural catastrophes caused insured losses of $15 billion (USD) across the globe. During that period, two wildland fires resulted in losses of $2.1 billion dollars and 18 victims (dead and missing).

Figure 1-4. Smoke from fires in California, October 2003, as seen from space. At least 22 deaths were blamed on the wildfires. (Image courtesy of NASA)

Smoke from wildland fires in the urban environment can impact air quality and create health issues (Figure 1-4). Smoke can irritate the eyes and respiratory system and worsen chronic heart and lung diseases. The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS), together with the Environmental Protection Agency (EPA) and other local air quality offices, issues air stagnation advisories, instructing the public of the potential health impacts and actions to take, such as avoiding outdoor activity and remaining indoors whenever possible during hazardous situations. One personal example occurred during the 2003 fires in San Diego, California. Cemetery workers were required to stay at home due to the smoke, postponing a family funeral for several days.

Wildland fires can impact both surface and aviation transportation. In 1994, a major interstate through Colorado was closed as the fire burned alongside the hillside next to the pavement. In 2002, the interstate mountain pass between Sacramento, California, and Reno, Nevada, was closed for over a day as the fire "jumped" across the interstate. Air transportation is impacted from smoke plumes or smoke reducing visibilities near major airports. Under these conditions, commercial airlines may be forced to reroute or cancel flights, impacting the Nation's air travel, not to mention the economic impact on the airlines.

One of the more complex issues to understand is the impact wildland fire has on our ecosystems, which includes our forests, rangelands, water systems, and wildlife. Wildland fire can destroy the environment of animals and endangered species (both plant and animal) and eliminate source areas of rich carbon dioxide needed for the balance of our atmosphere. Wildland fire also can directly impact our water supplies. One example is the impact of heavy rains in steep terrain that surrounds a watershed after the steep terrain has been burned by a wildfire. Sediments from burned areas can wash down into rivers that serve as the primary water sources for cities.

Ecosystem: a functional unit consisting of all the living organisms (plants, animals, and microbes) in a given area, and all the non-living physical and chemical factors of their environment, linked together through nutrient cycling and energy flow. An ecosystem can be of any size-a log, pond, field, forest, or the earth's biosphere-but it always functions as a whole unit. Ecosystems are commonly described according to the major type of vegetation, for example, forest ecosystem, old-growth ecosystem, or range ecosystem.

The Buffalo Creek Fire in Colorado in May of 1996 was followed by substantial flooding and erosion 2 months later. The fire burned 12,350 acres. The flooding after the fire killed two people and, in the 3 months following the fire, transported approximately 331,000 m^3 of coarse sediment into the Strontia Springs Reservoir. This reservoir supplies over 75 percent of the drinking water to the city of Denver and experienced a significant degradation in water quality as a result of the input of burned material and sediment. The Denver Water Department, the agency responsible for distributing drinking water from the reservoir, estimates that it spent over $1 million in immediate clean-up efforts after the fire.

Wildland fires also directly impact the economy due to large fire suppression costs. Severe fire seasons due to drought can result in billions of dollars in damages. The Western fire season, spring-summer 2000, resulted in nearly seven million acres burned and an estimated $2 billion in damage costs (including fire suppression). In fiscal year 2005, the U.S. Department of Agriculture Forest Service (USDA-FS) total fire operations budget was slightly over $1 billion; approximately $300 million of this was designated to hazardous fuel reduction. This does not include the costs incurred by the U.S. Department of Interior (DOI) land management agencies, state agencies, and private sector. Typically, prescribed fire costs range from approximately $70 to $150 per acre for treatment. Suppression costs, by comparison, range from $500 to $8000 per acre, depending upon the actions required. Over the last decade, 98 percent of wildland fires are extinguished during initial attack, however, 80 percent of wildland fire costs are driven by the 2 percent of wildland fires which grow into large fires. Preventing wildland fires is obviously extremely important, especially human-caused fires. If a wildland fire begins, early detection and quick initial attack actions are also extremely important.

Wildland fires can also have economic impacts on private businesses and industries. Private businesses may be forced to close down or be destroyed by wildland fire. The timber industry can experience a loss of income from unwanted acreage burned prior to harvest, and large areas of state and federal forests can be lost to recreational uses. One industry beginning to be impacted is the insurance industry. Recently, some companies are not renewing homeowner policies if the home does not have the required defensible space surrounding the house. This has led to increasing insurance rates and new government policies, such as increasing the minimum clearance (defensible space) requirements around homes in susceptible areas.

WHAT CAN WE DO?

Wildland fires have direct impacts on the urban environment. The Federal agencies have begun to respond to the need for mitigating the impacts. The capabilities of current weather/climate services and products to address the wildland fire issue are found across the Federal agencies, state and local governments, industry, and universities. The following are a series of probing questions and brief summaries that the Federal community is tackling in order to address the needs of the urban users to further improve the response to the wildland fire issue:

HOW DO WE IMPROVE OBSERVATIONS AND FORECASTS OF WILDLAND FIRE?

There are several programs within NOAA's NWS, the DOI Bureau of Land Management (DOI-BLM), and the USDA-FS for the data collection, analysis, assimilation, and prediction of wildland fires. There are over 2,200 interagency Remote Automated Weather Stations (RAWS) strategically located throughout the United States. These data are used by NOAA's NWS forecasters to analyze real-time weather conditions, by fire managers to predict fire behavior and monitor fuels, and by resource managers to monitor environmental conditions. The data are also used to monitor air quality and for research studies. Data are collected at the National Interagency Fire Center (NIFC) in Boise, Idaho, via NOAA's Geostationary Operational Environmental Satellite.

NOAA's NWS supports the wildland fire community daily through the provision of forecast products and services. The importance NWS places on these services results from a recognition that decades of fuel accumulation in our Nation's forests, coupled with drought, presents our state and federal fire management partners with larger, more explosive, and more costly wildland fires than any other period in history. NWS also recognizes that the fire management agencies in the United States have begun moving aggressively to deal with these issues through the efficient management of wildland fires and the implementation of prescribed burning programs.

To manage and suppress wildfires, including prescribed fires, fire managers need current and forecast weather and climate services. For instance, if a wildland fire starts due to lightning from thunderstorms, early detection and quick initial attack actions are extremely important to minimize suppression costs and prevent loss of property and lives. Therefore, accurate forecasts of thunderstorm activity and wind direction/speed enhance the fire manager's ability to detect fires, know where to enhance fire surveillance, and respond to the event. The NWS provides continued support to fire managers through their fire weather program which includes the following:

- Daily issuance of our Fire Weather Planning Forecasts, detailing daily forecasts of temperature, wind, humidity, dispersion, and other locally critical parameters.
- Provision of Fire Weather Watches and Red Flag Warnings for critical weather events that impact firefighter safety and preparedness.
- Issuance of Spot Forecasts - site-specific weather for fire managers.

• Incident Meteorologist (IMET) support-a cadre of over 60 specially trained forecasters who work directly with Incident Management Teams.

The DOI-BLM also provides prediction and modeling services. The Predictive Services units reside at the National Interagency Coordination Centers throughout the United States. These units provide decision-support information needed to implement a more proactive approach to anticipating fire activity through the prepositioning and integration of fire weather, fire danger/fuels information, and intelligence resources. In 2000, 20 fire weather meteorologists were hired under the National Fire Plan to team up with intelligence specialists and wildland fire analysts to form Predictive Service units at the National Interagency Coordination Center (NICC) and the Geographic Area Coordination Centers (GACC).

The interagency coordination centers' primary mission is to provide resource support for the functional areas of overhead, crews, aircraft, supplies, and equipment to the field for wildland fire and other emergency operations. They also provide daily, medium-range, and long-range fire-weather, fire-danger, and resource outlooks for use in tactical and strategic planning.

The USDA-FS Fire Consortia for the Advanced Modeling of Meteorology and Smoke (FCAMMS) is a Forest Service research and development initiative that uses high technology for computing, advanced numerical weather prediction models, World Wide Web information delivery, and new sources of information, such as the NASA Terra and Aqua satellites, in a new business partnership framework for advancing fire practice and science. These partnerships include not only federal and state agencies, but also universities (e.g., Washington State University and Jackson State University) and private industry (e.g., Sun Microsystems, Inc.). Many of the real-time model predictions are currently available on-line for use by the fire community.

Lastly, the Joint Center for Satellite Data Assimilation (JCSDA) is working towards the acceleration and improvement of the use of research and operational satellite data in weather and climate prediction models. JCSDA includes NOAA (NWS, National Environmental Satellite Data, and Information Service, and the Office of Oceanic and Atmospheric Research), the National Aeronautics and Space Administration (Goddard Space Flight Center), and the Department of Defense (U.S. Navy and U.S. Air Force). Data assimilation improvements will lead towards a more accurate prediction of weather for the user community.

WHAT ADDITIONAL RESEARCH IS NEEDED TO IMPROVE FORECASTS? WHAT ARE THE GAPS IN OUR CAPABILITY?

The Joint Fire Science Program (JFSP) was established in 1998 to provide scientific information and support for wildland fuel and fire management programs. The program is a partnership of six Federal agencies, consisting of the USDA-FS and the following agencies within the DOI: Bureau of Indian Affairs, BLM, National Park Service, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. All JFSP projects require scientist-manager partnerships along with strong emphasis on transferring research findings to the field.

The National Fire Plan (NFP) was developed in August 2000, following a landmark wildland fire season, with the intent of actively responding to severe wildland fires and their impacts on communities, while ensuring sufficient firefighting capacity for the future. The NFP addresses five key points: firefighting, rehabilitation, hazardous fuels reduction, community assistance, and accountability. As it nears its fifth year, the NFP continues to provide invaluable technical, financial, and resource guidance and support for wildland fire management across the United States. Together, the USDA-FS and the DOI are working to successfully implement the key points outlined in the NFP. The program focus is on short-term, applied research that provides information and tools to specialists and managers, helping them make the best possible decisions and develop sound, scientifically valid plans.

Hazard research is being conducted as a response to fire management needs in the areas of atmospheric and fire-behavior modeling. The USDA-FS established five regional modeling consortia in 2000-2001 to support the NFP. Each FCAMMS supports research and operational needs of the members who include land management agencies participating in the NFP, NOAA NWS, the EPA, appropriate state and tribal agencies, universities, and other research partners. High resolution real-time numerical prediction models, as well as smoke-dispersion and fire-behavior models, are being developed.

Despite current research programs on fire weather and the fire environment, additional research and better coordination of existing research is needed.

WHAT IMPROVEMENTS ARE NEEDED TO ENSURE FIRE MANAGERS AND OTHER USERS OF THE INFORMATION (1) RECEIVE THE REQUIRED INFORMATION/ PRODUCTS/FORECASTS AND (2) MAKE THE RIGHT DECISIONS?

Improvements in the ability to detect and predict wildland fire in and around the urban environment will reduce the impact to the loss of life and property. Key to these improvements is to ensure decision makers and the public receive the required information in a timely manner. The most aggressive public warning program for fires is the NOAA Weather Radio (NWR). The NWR is a nationwide network of radio stations broadcasting continuous weather information direct from a nearby National Weather Service Office. NWR broadcasts NWS warnings, watches, forecasts, and other hazard information 24 hours a day. In addition to the NWR, the communication of warnings to fire managers and the public through partnering agencies, the media outlets (television and radio) and emerging technologies (like cell phones and PDAs) will help create an effective, timely warning system.

One aspect of making the right decision is to receive the required information/ products/forecasts. For instance, having an accurate assessment of the current fire danger is critical information required by decision makers. The USDA-FS National Fire Danger Rating System (NFDRS) "is the keystone of interagency fire danger predictions and provides quantification of risk elements that are critical for daily decisions regarding firefighter resource placement, staffing levels, appropriate suppression responses, and strategic decisions at local, geographical area and national levels." The "Gridded" NFDRS project is a cooperative effort between the Fire Behavior Research Work Unit at the Missoula Fire Sciences Lab and the NOAA NWS Forecast Office in Missoula, Montana. Collaboration continues in efforts to improve this system and its ability to provide fire managers more up-to-date information concerning critical fire-prone areas.

Another example of having the required information/products/forecasts deals with planning actions prior to the fire season. Fire managers who have the responsibility to place limited resources around the country in advance of the fire season or preposition equipment and personnel require forecast information to assist in these decisions. The Climate Ecosystem and Fire Application Program (CEFA) at the Desert Research Institute in Reno, Nevada, along with the National Predictive Services Group, the University of Arizona, and NOAA's Office of Global Programs, conduct yearly workshops for the purpose of creating a "one-voice" seasonal fire outlook (Figure 1-5). The outlooks have begun to provide fire managers with the tools they need for providing quick response to wildland fires.

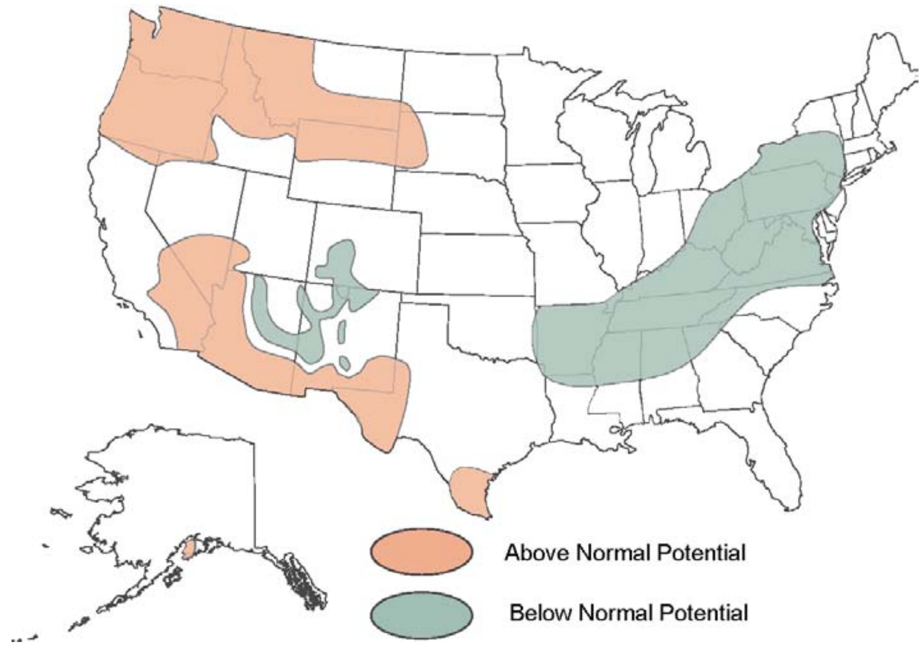

Figure 1-5. The western portion of the map showing the outlook for national significant fire potential was produced during the workshop ending on April 1, 2005. It highlights areas that managers from a variety of geographic areas in the Westconsider to have either above-average or below-average fire potential during the coming season.

After receiving the required information/products/forecasts, a significant factor to ensure the public and users of information make the right decisions is to make certain they have the proper knowledge. To this end, the NIFC Prevention and Education website has an aggressive public awareness program, including public displays, pamphlets, and on-line education materials for a variety of audiences, to include Spanish-speaking personnel. In addition, wildland fire prevention and education teams are available to support any geographic area preceding and during periods of high fire danger or fire activity, with the purpose of assisting the local unit in the prevention of unwanted human-caused wildfires.

Several agencies are also conducting public awareness programs. California has a Fire Safe Council, with over 50 public and private organizations formed to speak with one voice about fire safety. The council has distributed fire prevention education materials to industry leaders and their constituents, evaluated legislation pertaining to fire safety, and empowered grassroots organizations to spearhead the fire safety program. Members include, in addition to state and Federal agencies, the American Red Cross, insurance companies, and realtor organizations. "Firewise" is an education information program for people who live or vacation in fire-prone areas of the United States. Information is supplied and approved by the National Wildfire Coordinating Group, a consortium of wildland fire agencies that includes the USDA-FS, the DOI, the National Association of State Foresters, the U.S. Fire Administration, and the National Fire Protection Association. "Firewise" is sponsored by the National Wildland/Urban Interface Fire Program.

SUMMARY AND THE WAY AHEAD

Clearly there is a need for the Federal agencies to work towards minimizing the impact of wildland fires in the urban environment, both from a public safety and economic standpoint. The efforts of the Federal agencies to address the spectrum of wildland fire impacts will require the following:

• Continued improvement of fire weather observations and forecasts.

• Improved coordination of wildland fire research and the integration of fire weather and fire environment research.

• A comprehensive National wildland fire weather needs assessment to document user needs/requirements for weather information by decision makers in their wildfire and prescribed fire decision-making processes and a framework to meet those needs.

• Increased efforts to provide education and training on new products and services to ensure the information being delivered is understandable and meets the needs of decision makers and the general public.

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SECTION 2

RESOURCE INFORMATION AND AGENCY PROGRAM UPDATES

The tables in this section summarize budgetary information of the Federal government for Fiscal Years 2005 and 2006. The funds shown are those used to provide meteorological services and associated supporting research that has as its immediate objective the improvement of these services. Fiscal data are current as of the end of July 2005 and are subject to later changes. The data for FY 2006 do not have legislative approval and do not constitute a commitment by the United States Government. The budget data are prepared in compliance with Section 304 of Public Law 87-843, in which Congress directed that an annual horizontal budget be prepared for meteorological programs conducted by the Federal agencies.

AGENCY OBLIGATIONS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Table 2.1 contains fiscal information, by agency, for meteorological operations and supporting research. The table shows the funding level for Fiscal Year (FY) 2005 based on Congressional appropriations, the budget request for FY 2006, the percent change, and the individual agencies' percent of the total Federal funding for FY 2005 and FY 2006.

DEPARTMENT OF AGRICULTURE (USDA)

The USDA budget request for FY 2006 is $43.8 million for operations and supporting research, representing a 15.8 percent decrease from FY 2005. A large portion of this decline was due to a reduction in funding for supporting research. USDA has requested a total $28.3 million for research and development programs, an $8.4 million decrease from 2005. The FY 2006 amount requested for meteorological operations is $15.5 million, slightly up from $15.4 million in FY 2005.

Operational activities include specialized weather observing networks such as the snow telemetry (SNOTEL) system operated by the Natural Resources Conservation Service (NRCS) and the remote automated weather stations (RAWS) network managed by the Forest Service. The SNOTEL and RAWS networks provide cooperative data for NOAA's river forecast activities, the irrigation water supply estimates, and Bureau of Land Management operations. The Forest Service is also the world leader in developing emissions factors from fires and modeling its dispersion. The USDA and the Department of Commerce (DOC) jointly operate a global agricultural weather and information center located in Washington, D.C. This Joint Agricultural Weather Facility operationally monitors global weather conditions and assesses the impacts of growing season weather on crop and livestock production prospects. This information keeps crop and livestock producers, farm organizations, agribusinesses, state and national farm policy-makers, government agencies, and foreign buyers of agricultural products apprised of worldwide weather-related developments and their effects on crops and livestock. Furthermore, tracking weather and crop developments in countries that are either major exporters or importers of agricultural commodities keeps the agricultural sector informed on potential competitors. USDA is also actively involved in drought monitoring efforts in concert with the National Drought Mitigation Center.

For supporting research, USDA funds research projects through the Cooperative State Research, Education and Extension Service (CSREES) that study the impact of climate and weather on food and fiber production. The goal of supporting research is to develop and disseminate information and techniques to ensure an abundance of high-quality agricultural commodities and products while minimizing the adverse effects of agriculture on the environment. Furthermore, the Agricultural Research Service (ARS) conducts research on how annual variation in weather adversely effects crop and animal production, hydrologic processes, the availability of water from watersheds, and the environmental and economic sustainability of agricultural enterprises.

DEPARTMENT OF COMMERCE (DOC)

All reported DOC meteorological activities are within the National Oceanic and Atmospheric Administration (NOAA). The NOAA FY 2006 total congressional request of $1.93 billion for meteorological programs represents an increase of 5.2 percent over the FY 2005 appropriated funds. NOAA's FY 2006 operations and supporting research requests for major line office activities are described below:

WEATHER SERVICES

NOAA's National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, it's territories, adjacent waters, and ocean areas for the protection of life and property and the enhancement of the national economy.

TABLE 2.1 METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH COSTS*, BY AGENCY

(Thousands of Dollars)

	Operations			% of FY2006	Supporting Research			% of FY2006	Total			% of FY2005	% of FY2006
AGENCY	FY2005	FY2006	%CHG	TOTAL	FY2005	FY2006	%CHG	TOTAL	FY2005	FY2006	%CHG	TOTAL	TOTAL
Agriculture	15355	15535	1.2	0.5	36702	28280	-22.9	7.3	52057	43815	-15.8	1.6	1.3
Commerce/NOAA(Subtot)	1727721	1839769	6.5	61.6	107038	89939	-16.0	23.3	1834759	1929708	5.2	56.0	57.2
NWS	782981	839263	7.2	28.1	22140	23380	5.6	6.1	805121	862643	7.1	24.6	25.6
NESDIS	907448	963886	6.2	32.3	31039	26214	-15.5	6.8	938487	990100	5.5	28.7	29.3
OAR	0	0	0	0.0	52203	38689	-25.9	10.0	52203	38689	-25.9	1.6	1.1
NOS	23802	23130	-2.8	0.8	500	500	0.0	0.1	24302	23630	-2.8	0.7	0.7
NMAO	13490	13490	0.0	0.5	1156	1156	0.0	0.3	14646	14646	0.0	0.4	0.4
Defense(Subtot)	622256	619646	-0.4	20.7	64080	71803	12.1	18.6	686336	691449	0.7	21.0	20.5
Air Force	293220	309401	5.5	10.4	16752	28675	71.2	7.4	309972	338076	9.1	9.5	10.0
DMSP**	88038	84121	-4.4	2.8	3816	918	-75.9	0.2	91854	85039	-7.4	2.8	2.5
Navy	170191	179809	5.7	6.0	28512	32312	13.3	8.4	198703	212121	6.8	6.1	6.3
Army	70807	46315	-34.6	1.5	15000	9898	-34.0	2.6	85807	56213	-34.5	2.6	1.7
Homeland Security (Subtot)	23890	25020	4.7	0.8	0	0	0.0	0.0	23890	25020	4.7	0.7	0.7
USCG	23890	25020	4.7	0.8	0	0	0.0	0.0	23890	25020	4.7	0.7	0.7
Interior/BLM	2400	2400	0.0	0.1	0	0	0.0	0.0	2400	2400	0.0	0.1	0.1
Transportation(Subtot)	460434	483450	5.0	16.2	26215	24506	-6.5	6.3	486648	507956	4.4	14.9	15.1
FAA	460293	483027	4.9	16.2	22145	21506	-2.9	5.6	482437	504533	4.6	14.7	15.0
FRA	141	423	200.0	0.0	0	0	0.0	0.0	141	423	200.0	0.0	0.0
FHWA	0	0	0.0	0.0	4070	3000	-26.3	0.8	4070	3000	-26.3	0.1	0.1
EPA	0	0	0.0	0.0	9000	9000	0.0	2.3	9000	9000	0.0	0.3	0.3
NASA	2608	2615	0.3	0.1	176000	162600	-7.6	42.1	178608	165215	-7.5	5.5	4.9
NRC	120	120	0.0	0.0	0	0	0.0	0.0	120	120	0.0	0.0	0.0
TOTAL	2854783	2988554	4.7	100.0	419035	386128	4.0	100.0	3273818	3374682	3.1	100.0	100.0
% of FY TOTAL	87.2%	88.6%			12.8%	11.4%			100.0%	100.0%			

*The FY 2005 funding reflects Congressionally appropriated funds; the FY 2006 funding reflects the amount requested in the President's FY 2006 budget submission to Congress.

**DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

NWS data and products form a national information database and infrastructure which can be used by other government agencies, the private sector, the public, and the global community.

The United States is one of the most severe-weather prone countries on Earth. Each year, Americans cope with an average of 10,000 thunderstorms, 2,500 floods, 1,000 tornadoes, as well as 6 deadly hurricanes. Some 90% of all Presidential-declared disasters are weather related, causing approximately 500 deaths per year and $11 billion in damage. According to the American Meteorological Society, weather is directly linked to public safety and about one-third of the U.S. economy (about $3 trillion) is weather sensitive.

More and more sectors of the U.S. economy recognize the impacts of weather, water, and climate on their businesses, and are becoming more sophisticated at using weather, water, and climate information to make better decisions. To meet this growing demand for information and to improve the timeliness and accuracy of warnings for all weather-related hazards, the NWS will continue to enhance observing capabilities, improve data assimilation to use effectively all the relevant data NWS and others collect, improve collaboration with the research community, make NWS information available quickly, efficiently, and in a useful form (e.g., the National Digital Forecast Database) and include information on forecast uncertainty to help customers make fully informed decisions.

With about 4,700 employees in 122 weather forecast offices, 13 river forecast centers, 9 national centers and other support offices around country, NWS provides a national infrastructure to gather and process data worldwide from the land, sea, and air. This infrastructure enables data collection using technologies such as Doppler weather radars, satellites operated by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), data buoys for marine observations, surface observing systems, and instruments for monitoring space weather and air quality. This data feeds sophisticated environmental prediction models running on high-speed supercomputers. Our highly trained and skilled workforce uses powerful workstations to analyze all of these data to issue climate, public, aviation, marine, fire weather, air quality, space weather, river and flood forecasts and warnings around-the-clock. A high-speed communications hub allows for the efficient exchange of these data and products between NWS components, partners and customers. NWS forecasts and warnings are rapidly distributed via a diverse dissemination infrastructure, including NOAA Weather Radio. Finally, customer outreach, education, and feedback are critical elements to effective public response and improvements to NWS services.

The FY 2006 President’s Budget Request supports the funding and program requirements necessary to address established NOAA strategic goals and sets NWS on a path to achieve its vision: Produce and deliver forecasts that can be trusted; use cutting-edge technologies; provide services in a cost-effective manner; strive to eliminate weather-related fatalities; and improve the economic value of weather, water, and climate information.

NOAA requests a total of $744,830,000 and 4,597 FTE to support the continued and enhanced operations of the National Weather Service. The total includes $33,433,000 for Adjustments to Base, $20,946,000 for Program increases, and $13,475,000 for Terminations.

Adjustments To Base:

NOAA requests an increase of $33,433,000 and a decrease of 3 FTE to fund adjustments to base for NWS activities. The increase will fund the estimated FY 2006 Federal pay raise of 2.3 percent and annualize the FY 2005 pay raise of 3.5 percent. The increase will also provide inflationary increases for non-labor activities, including service contracts, utilities, field office lease payments, and rent charges from the General Services Administration.

The above amount includes several transfers:

- $3,200,000 to reflect the transition of the Tropical Atmosphere Ocean (TAO)-Array from NOAA Research to an operational mode in the NWS. This buoy array, located in the Pacific Ocean, provides real-time in-situ data from the tropical Pacific Ocean for monitoring, prediction, and improved understanding of El Niño. Having demonstrated its viability as a research activity, NOAA seeks to transfer the array into operations. NWS is best position to operate and maintain the array.
- $500,000 from Office of Atmospheric Research (OAR) to return funding for the U.S. Weather Research Program to NWS.
- $7,390,000 from Program Support, Facilities Maintenance to fund WFO maintenance in NWS, where it has traditionally been appropriated.
- $20,000 to Office of Marine and Aviation Operations (OMAO) for partial funding of a NOAA Corps Officer position that benefits NWS.
- $37,000 and 3 FTE to the Office of General Counsel within Program Support.

NWS - ORF Program Change HighLights for FY 2006:

NOAA requests a net increase of $20,946,000 and 0 FTE over the FY 2006 base for a total request of $744,830,000 and 4,597 FTE. These changes are summarized at the sub activity level below.

Operations and Research.

A net increase of $18,010,000 and

0 FTE above the base is requested in the Operations and Research subactivity, for a total of $652,287,000 and 4,415 FTE.

• Local Warnings and Forecasts: $14,975,000 and 0 FTE in net increases above the base, for a total of $602,395,000 and 4,116 FTE, are requested under the Local Warnings and Forecasts line item of the Operations and Research subactivity.

•• NOAA requests $5,970,000 and 0 FTE to strengthen the U.S. tsunami warning program. Lessons learned from the 2004 Indian Ocean Tsunami indicate that to mitigate a similar event in the U.S., the following actions are required: 1) quickly confirm potentially destructive tsunamis and reduce false alarms; 2) address local tsunami mitigation and the needs of coastal residents; 3) improve coordination and exchange of information to better utilize existing resources; and 4) sustain support at state and local level for long-term tsunami hazard mitigation. This funding will be used to begin the planned deployment of the 32 deep ocean assessment and reporting of tsunamis (DART) buoys for the Pacific Ocean Basin and the Caribbean/Atlantic Ocean region, next generation DART buoy research and development, and for upgrades and operations and maintenance of sea level monitoring sensors. Funds will also be used to provide for 24/7 operations at the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC), the West Coast/Alaska Tsunami Warning Center (WC/ATWC), upgrade the operations of the NWS International Tsunami Information Center (ITIC), and to expand the U.S. Tsunami Ready Community efforts on the East and West Coasts.

•• NOAA requests $4,000,000 and 0 FTE to begin efforts to develop a nationwide water resources forecasting capability. Through this capability, NOAA will provide America with economically valuable water and soil condition forecasts via: 1) a national digital database incorporating assimilation of all available hydro-meteorological data and observations; and 2) a community hydrologic prediction system (CHPS) necessary to advance water prediction science. This will allow NOAA's research and development enterprise and operational service delivery infrastructure to be integrated and leveraged with other federal water agency activities to form the basis of a national backbone water information system. The initiative provides the water modeling capability to support the U.S. Commission on Ocean Policy mandate for a national water quality monitoring and prediction system. Furthermore, the initiative enables NOAA to deliver a national database of drought analyses and predictions, and generate user friendly Geographical Information System (GIS) products for monitoring drought. The initiative will provide water users - farmers, utilities, land managers, business owners, and decision makers - the ability to assess water availability in real time and make informed decisions to mitigate impacts of extreme water events, (e.g., droughts).

This initiative is expected to provide a return of $12 annually for each $1 invested due to improved decisions associated with irrigation scheduling and water supply management (National Hydrologic Warning Council, May 2002). NOAA's NWS is the only federal entity positioned to lead this activity because of its unique capabilities in data acquisition and processing, existing operational water modeling infrastructure, and robust national service delivery system to provide predictions of water resource variables for forecast periods of hours to months.

•• NOAA Requests $2,072,000 and 0 FTE, for a total of $6,790,000 to accelerate nationwide implementation of ozone air quality (AQ) forecasting capability from FY 2009 to FY 2008 and to deliver an initial particulate matter forecasting capability by FY 2011. Of the increase requested, $1,290,000 is requested in the U.S. Weather Research Program and $782,000 is requested in the Air Quality Forecast program, for a total of $1,290,000 in the U.S. Weather Research Program (USWRP) and $5,500,000 in the Air Quality Forecast program. The effect of poor air quality on the national economy is estimated at $150 billion/year from health effects alone. Accurate air quality forecast guidance, provided in time to take action, can lead to significant savings in these costs. For example, if the public has advance warning of the onset of poor air quality conditions, mitigating actions can be taken, such as not jogging or engaging in other outdoor activity. NWS and OAR are working closely together to develop and deliver these new capabilities. This funding will accelerate benefits to the public. Accelerating deployment of particulates predictions will provide, one year earlier than currently planned, the information needed for people to take protective actions against a significant health risk - a risk that is especially harmful for those with cardiac and respiratory ailments.

•• NOAA Requests and additional $1,115,000 for the U.S. Weather Research Program (above the amount requested to accelerate AQ forecasting - see above) and 0 FTE for a total of $7,457,000 to accelerate improvements in global weather forecasting and accelerate hurricane and other high-impact weather research activities. This increase will restore funding to the USWRP and The Observing-system Research and Predictability Experiment (THORPEX) requested in FY 2005. Key activities directed to hurricane forecasting and research include development, testing, and transition to operations of the hurricane weather research and forecasting (HWRF) community model that promises to significantly improve predictions of the intensity and precipitation of hurricanes at landfall. Other activities include testing and development of promising hurricane research at the Joint Hurricane Testbed, which can be adopted to improve warnings and forecasts by operations centers and numerical assimilation of tropical cyclone data for use in numerical weather prediction models.

•• NOAA requests an increase of $1,100,000 and 0 FTE for a total of $3,500,000 to continue a 10-year plan to improve U.S. aviation safety and economic efficiencies by providing state-of-the-art weather observation and forecast products responsive to aviation user needs. This increase will allow the NWS to procure, install and operate 50 aircraft based water vapor data systems. Water vapor information is critical to depicting weather hazards and reducing forecast errors. This initiative addresses Federal Aviation Administration (FAA) joint safety implementation team (JSIT) recommendations and provides a means for NWS to improve its aviation weather forecast services through three major efforts: 1) increase the number and quality of aviation weather observations; 2) transition successful NOAA, National Aeronautics and Space Administration (NASA) and FAA applied research efforts to operational products; and 3) develop and implement new training programs for forecasters, pilots, and controllers. The aviation program has the FY 2012 goal of a 10% reduction in National Airspace System (NAS) weather-related air traffic delays, which would save $1 billion annually in potential economic losses, while also reducing general aviation weather related fatalities by 25% or 50 lives annually. The Airline Transport Association estimates $10 billion lost to the U.S. economy each year due air-traffic delays.

•• NOAA requests an increase of $298,000 and 0 FTE for a total of $6,098,000 for the Advanced Hydrologic Prediction Service (AHPS). AHPS is NOAA's program to modernize the river forecasting capability and expand it to new waterways. This increase will restore funds requested in FY 2005. With full funding for FY 2006, AHPS will provide enhanced river forecasts, including web accessible displays of probabilistic information, for 308 additional locations throughout the Southeast, South, and West. AHPS priorities are to sustain current hydrological services, deliver more precise forecasts with magnitude and certainty of occurrence information, leverage collaborative research to infuse new science, and provide better water information to benefit the public and the Nation's commerce. Through AHPS, NOAA's NWS will deliver better forecast accuracy; more specific and timely information on fast-rising floods; new types of forecast information; longer forecast horizons; easier to use products; increased, more timely, and consistent access to products and information and expanded outreach.

• Central Forecast Guidance: $3,035,000 and 0 FTE in net increases above the base, for a total of $49,892,000 and 299 FTE, are requested under the Central Forecast Guidance line item of the Operations and Research subactivity.

•• NOAA requests $1,000,000 and 0 FTE to fund focused research, development, and testing of advanced data assimilation algorithms and techniques. Expected improvements include: development of advanced techniques in global and mesoscale atmospheric, ocean and land data assimilation systems; use of new satellite data from the National Polar-orbiting Operational Environmental Satellite System (NPOESS), the NPOESS Preparatory Project and European operational instruments; and increased use of high resolution surface and radar observations for initializing high resolution mesoscale forecasts. Current resources are insufficient to fully utilize current and future observations including radar and satellite date, and inadequate for finer resolution forecast applications. This investment has the potential to provide breakthroughs in storm track prediction performance, as well as increasing the realism of all parts of the systems and improving forecast accuracy across the board. Outcomes include improved winter storm warnings, precipitation forecasts, and lead-times for flash flood and Red Flag warnings.

•• NOAA requests $2,035,000 and 0 FTE to provide for the cyclic replacement of information technology (IT) infrastructure at the National Centers for Environmental Prediction (NCEP) in order to enable the effective use of increasing volumes of model guidance, imagery and observational data and to comply with IT security requirements and related challenges which are projected to increase through the FY06 - FY07 timeframe. By FY06, current resources devoted to NCEP IT cyclic replacement will be insufficient to meet projected data volume demands related to ensemble model systems for weather and climate forecasts and the expanding suite of ocean and coastal model forecasts. The IT cyclic replacement program for operational systems will entail replacement of PCs, workstations, servers, and operating systems to meet data volume demands and ensure against interference from hackers and denial of service attacks.

<u>Systems Operation & Maintenance (O&M)</u>

A net increase of $2,936,000 and 0 FTE above the base is requested in the Systems Operation & Maintenance subactivity, for a total of $92,543,000 and 182 FTE.

• NOAA requests an increase of $2,936,000 and 0 FTE for a total of $43,367,000 for NEXRAD Operations and Maintenance. NEXRAD is the cornerstone of the NWS Modernization and this increase will restore funds requested in FY 2005 for operations and maintenance of the NEXRAD system. Specifically, the requested increase will allow the NWS to implement planned retrofits to WSR-88D communications lines (copper to fiber optic) at 8 sites where deteriorating copper lines make communications unreliable, thus creating a moderate to high risk of communications failure and lost radar data (particularly during severe weather events). Furthermore, NWS will be able to perform planned radar radome and tower maintenance, eliminating the risk of catastrophic radar failure due to lack of structural integrity.

Systems Acquisition

- NOAA requests an increase of $3,530,000 and 0 FTE for a total of $3,530,000 to strengthen the U.S. Tsunami Warning Program. This budget request completes the Administration's 2-year plan to strengthen the U.S. tsunami warning program in light of the December 26, 2004 Indian Ocean Tsunami. Funds will be used to complete the planned acquisition of deep ocean assessment and reporting of tsunamis (DART) buoys for the Pacific Ocean Basin and the Caribbean/Atlantic Ocean region. Expanded monitoring capabilities throughout the entire Pacific and Caribbean basins and significant portions of the mid Atlantic will provide tsunami warning capability for regions bordering half of the world's oceans.

COOP Modernization

- NOAA is requesting an increase of $3,400,000 and 0 FTE with a total FY 2006 funding of $4,277,000 for the Cooperative Observer Network Modernization (COOP), to continue deployment of modernized COOP sites nationwide as NWS implements the "NOAA Environmental Real Time Observation Network" (NERON). NERON will provide the U.S. with a network of accurate, near real-time surface weather data (temperature and precipitation) obtained with state-of-the-art measurement, monitoring, and communication equipment. Quality-controlled, higher-density, real-time surface data will improve temperature forecasting skills, drought monitoring resolution, hydrology planning, and energy optimization for NWS customers. Improved sensors, including wind data, can provide timely data in response to homeland security events or disasters. NERON continues the COOP modernization, begun in FY 2003, and will result in deployment or upgrade of up to 8,000 modernized sites.
- NOAA requests an increase of $5,650,000 and 0 FTE to complete and to sustain NOAA Weather Radio (NWR). Funds will be used to complete NWR broadcast coverage of all areas in the U.S. identified as at high risk of severe weather events, by establishing 17 new broadcasting stations. Additionally, funds will be used to improve network reliability by refurbishing 400 stations established in the 1970s. NOAA is working with the Department of Homeland Security, to make NWR a national all- hazards warning network of 900 broadcasting stations and reaching 97% of the nation's population.
- NOAA requests an increase of $1,497,000 and 0 FTE to establish a Coastal-Global Ocean Observing System (C-GOOS) in the NWS. The C-GOOS Program fulfills the U.S. coastal component of the international GOOS effort and addresses the mandate of the President's Commission on Ocean Policy and the National Oceanographic Partnership Program to bring together government, industry and academia. In FY 2005 Congress provided NOS $8,000,000 to add oceanographic sensors to the existing NWS marine observational backbone. In FY 2006, NOAA's C-GOOS will deploy new buoys, add the capability to enhance future buoys with biological and chemical oceanographic sensors to allow biological and chemical water sampling; provide information on locations of marine endangered or protected species; and monitor coral reef health.
- NOAA requests no change to the $19,285,000 base for Weather and Climate Super-computing. The cyclical upgrade of the NWS weather and climate supercomputing capability is intended to procure the computing and communications equipment needed to receive and to process the increasing wealth of environmental data acquired by modernized observing systems, and to support more sophisticated numerical weather prediction models, and stay current with the available supercomputing technology. Execution of this program promotes public safety and the protection of property by providing the NCEP with the computer systems that are capable of producing more accurate, NWS climate and numerical weather prediction (NWP) guidance products for hurricanes, severe thunderstorms, floods, and winter storms. Additionally, the supercomputing system more accurately forecasts large-scale weather patterns in the medium (3 to 10 days) and extended range (30 days), plus forecasts of major climate events such as El Niño and La Niña. In addition, the computer upgrades will improve the delivery of products to the field and provide system users with enhanced productivity. These products and services will lead to significant economic benefits for users, like the agriculture, construction, and transportation industries.
- NOAA requests no change to the $7,148,000 base for the Weather and Climate Supercomputing Backup. Because of the critical need of the weather and climate output, it is essential that a backup capability be operational, as part of contingency planning.

Automated Surface Observing System

- NOAA requests no change to the $4,675,000 base for the Automated

Surface Observing System (ASOS). This acquisition is a tri-agency program involving NOAA, DOD, and FAA. ASOS provides reliable, 24-hour, continuous surface weather observations. Under the product improvement portion of this acquisition program, NOAA is developing new ASOS sensor capabilities in order to meet changing user requirements and decrease maintenance demands. FY 2006 funding will complete enhanced precipitation identifier sensor deployment of 282 units and acquire and deploy 68 25,000 feet ceilometers.

- NOAA requests no change to the $12,894,000 base for the Advanced Weather Interactive Processing System (AWIPS)/NOAAPort. AWIPS is the cornerstone of the modernized NWS. This system integrates and displays all hydrometeorological data at NWS field offices. AWIPS acquires and processes data from modernized sensors and local sources, provides computational and display functions at operational sites, provides an interactive communications system to interconnect NWS operational sites, and disseminates warnings and forecasts in a rapid, highly reliable manner. This system integrates satellite and radar data more fully and provides to the local field forecaster a capability that significantly improves forecasts and warnings. NOAAPort offers the communications capability to provide internal and external users with open access to much of NOAA's real-time environmental data.

Current AWIPS processing, communications, and storage capacity is inadequate to support current and future system processing demands from the three sources listed above. These preplanned and ongoing NOAA investments in modeling, satellite instruments, and radar improvements (NEXRAD Product Improvement) represent NOAA's commitment to bring forecasters the data and information required to improve forecast accuracy and warning lead times.

System-wide information technology investments are necessary to equip NWS forecast offices with the necessary computer performance and capacity to achieve planned and evolving operational and strategic requirements. Planned improvements in the NWS Tornado Warning Lead Time, Flash Flood Warning Lead Time and Winter Storm Warning Lead Time goals can only be realized through the following actions: improve AWIPS system throughput; add new and improved science; and exploit more accurate and higher resolution data and weather forecast model information. To accomplish this, we must improve AWIPS system's performance and capacity. Current choke points in system performance and capacity have been identified in the following areas: workstation and server performance, network throughput, and software architecture.

Improvements in system throughput can be realized by increasing processing and network capacity. Exploitation of new science requires radar, satellite and model data in addition to processing capacity and the ability to quickly and cost-effectively integrate improved decision assistance tools into the AWIPS software. High-resolution data and model information requires additional communications bandwidth, processing and mass storage capacity. For example, the satellite broadcast network (SBN) does not have the capacity to distribute the entire suite of current Eta-12 data, let alone the higher resolution models and products anticipated in FY 2006 such as WRF-8. Insufficient resolution is a serious limitation in providing timely, accurate forecasts and warnings to the public.

Next Generation Weather Radar

- NOAA requests a decrease $2,360,000 and 0 FTE for a FY 2006 total of $8,460,000 for Next Generation Weather Radar (NEXRAD). The total decrease reflects the completion of contract obligations for open systems radar detection (ORDA) and a ramp-up in dual-polarization development efforts. The FY 2006 plan provides for the deployment of 101 ORDA units and award of the dual polarization development and production contract.
- NOAA requests a decrease of $2,012,000 and 0 FTE for the NWS Telecommunications Gateway (NWSTG) Legacy Replacement with the completion of one-time costs planned for the deployment of the NWSTG Legacy Replacement. The remaining $0.5M is needed to provide a cyclical information technology refresh capability and to avoid future costly NWSTG system upgrades. NWSTG is the communications hub for collecting and distributing weather information to NWS field units and external users. Replacing the NWSTG system with up-to-date technology will reduce current delays in collecting and disseminating data. In FY 2006, NWS will conclude the three-year NWSTG replacement effort at NWS facilities.

Radiosonde Network Replacement

- NOAA requests a decrease of $1,989,000 and 0 FTE for a FY 2006 total of $4,387,000 for Radiosonde Replacement Program to reflect the reduced scope of total radiosonde acquisition. The FY 2006 Budget will modernize 84 out of 102 sites, and will allow a second GPS balloon-borne instrument (radiosonde supplier contract) to be awarded. The NWS radiosonde network provides upper-air-weather observations; the primary source of data required by NWS numerical weather prediction models, which form the basis of all NWS forecasts for day 2 and beyond. Observations of temperature, pressure, humidity, and wind speed/direction are taken twice a day at 102 locations nationwide and in the Caribbean using a radiosonde which transmits the data via radio signal to a ground receiving station usually located at a WFO, where it is processed.

Construction

- NOAA requests an increase of $6,200,000 and 0 FTE for a total of $8,500,000 to finalize the design and implementation of the construction of the NOAA Center for Weather and Climate Prediction (NCWCP). The FY 2006 funding covers the critical long lead procurements for data and communications infrastructure that will be installed in the building during construction and for furnishings, fixtures and equipment that must be procured prior to the completion of construction. Lastly, the funding will be used for project management tasks supporting technical oversight of the design and construction process and the detailed planning necessary to execute the relocation of critical 24x7 operational systems without service interruption. The funding is critical to ensure project continuity for work initiated in FY 2004. Final occupancy of the NCWCP is scheduled for February 2008.

The NWS has had positive results from co-locating its facilities with academic institutions or laboratories in accelerating research into operations and in improving performance. This includes accelerated use of global satellite data through state-of-the-art data assimilation systems; improved model forecasts; decreased time to infuse new science into operations from 7-10 years to 1-3 years.

NCWCP is a new facility to replace the current World Weather Building with a new state-of-the-art facility to meet the operational requirements of NCEP, NESDIS's Office of Research and Applications and Satellite Services Division, and the OAR's Air Resources Laboratory. The Department of Commerce, the State of Maryland, and academic community advisors have all agreed on a shared vision to build a Center of Excellence for Environmental Research, Education, Applications and Operations at a location in suburban Maryland near an academic research institution with the following objectives: meet NOAA operational requirements; create research synergy in weather and climate prediction; accelerate transition of new science and technology into operations; increase interaction between students and professors; and enhance recruitment opportunities.

FY 2004 funding for the NCWCP enabled NOAA to support the General Services Administration to award a build-to-suit lease for the NOAA NCWCP during FY 2004 and includes necessary "above standard" construction costs. The FY 2005 lease award for NCWCP will ensure occupancy of the new facility by 2008 when the current World Weather Building lease expires.

- NOAA requests an increase of $630,000 for a total of $13,630,000 and 0 FTE for the Weather Forecast Office (WFO) Construction, to meet NWS WFO facility requirements. WFO construction, part of the NWS modernization and associated restructuring, began in the 1980s. Required construction elements currently ongoing include the upgrade and modernization of Alaska and Pacific Region Weather Service Offices, Tsunami Warning Centers, and associated employee housing units, upgrades of Heating, Ventilation, and Air Conditioning (HVAC) systems, uninterruptible power supply replacements, and mitigation of all building and fire code violations. This construction effort is essential to bring the NWS into full compliance with federal law and municipal codes. In FY 2006, WFO Construction will focus on continuing to modernize the Alaska and Pacific Region facilities, as well as HVAC upgrades and correcting safety code violations at facilities.
- NOAA requests a decrease of $11,255,000 and 0 FTE for the Suitland Facility, leaving no funding in FY 2006.

ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICES

Proposed funding for FY 2006 includes a decrease in the Polar-Orbiting Satellite Program (POES) of $3.1 million,a net increase in the Geostationary Satellite Program (GOES) of $52.6 million, and an increase in the National Polar-Orbiting Operational Environmental Satellite Systems (NPOESS) of $16.1 million. These changes allow for continuation of procurements to provide the spacecraft and instruments, launch services, and ground systems necessary to assure continuity of environmental satellite coverage. The budget request will maintain a system of polar-orbiting satellites that obtains global data and a system of geostationary satellites that provides near-continuous observations of the Earth's western hemisphere.

Funding for the POES program is decreasing as it approaches the end of its production cycle with two remaining satellites to be launched. The GOES request includes a decrease of $30.4 million for the GOES-N series of satellites, and an increase of $83.0 million for the next generation GOES-R series. The FY 2006 GOES-R funding will begin engineering for several key instruments and continue the imager production begun in FY 2005. Another $16.1 million in funding is included for NOAA's share of the NPOESS program - the converged NOAA and Department of Defense (DOD) polar-orbiting system that will replace the current NOAA series and the DOD Defense Meteorological Satellite Program (DMSP).

A total of $100.3 million is included in the budget request to maintain basic mission satellite services including maintenance and operation of satellite ground facilities; provision of satellite-derived products, including hazards support; and conduct of research to improve the use of satellite data.

Included in the above request is $4.0 million to continue the Ocean Remote Sensing Program, which began in FY 1995. During the next several years, NOAA will acquire data from foreign and other non-NOAA satellites that will provide measurement of ocean currents, surface winds and waves, subsurface temperature and salinity profiles, ice thickness and flows, and other marine factors.

An additional $53.7 million is included in the budget request for the NOAA Data Centers and Information Services subactivity base operating funds.

NOAA OCEAN SERVICE (NOS).

NOS operational oceanographic observing systems are designed to measure both oceanographic and meteorological parameters in order to meet user and partner requirements. As a result, users of the data and information support a broad cross-cut of the marine transportation sector, the climate change research sector, weather and water programs, and ecosystems research community.

Funding provided through the FY 2005 budget will allow the continuation of the second generation of the NOS CO-OPS advanced data quality control program, the Continuous Operational Real-time Monitoring System (CORMS AI), as well as the continued implementation of the Ocean Systems Test and Evaluation Program (OSTEP), which is a development program for bringing new sensor technology into operations. The FY 2005 budget has allowed for sufficient support to operate the National Water Level Observation Network (NWLON) and for continued growth of the Physical Oceanographic Real-Time System (PORTS). Both the NWLON and PORTS programs have subsets of operational water level stations with meteorological sensors installed for various partners and users, including the NWS.

Under the NOAA-Wide Coastal Storms Program (CSP), targeted stations of existing federal and state tide station networks have been funded to be enhanced with new meteorological sensors. Under a NOAA Ocean Service Partnership Proposal first funded in FY 2002, a subset of the NWLON in the Great Lakes was enhanced with new meteorological sensors and with continuous GPS. Previously, special, water level stations were enhanced with meteorological sensors in the Gulf of Mexico with funding from the NWS Southern Region.

In FY 2005, NOS is using some of the IOOS funding to upgrade and enhance the NWLON and continues to work cooperatively with the NWS National Data Buoy Center to establish common collection and quality control procedures and data streams for meteorological and water level data from NOS and NDBC observing systems. NOS operational nowcast/forecast modeling activities are expanding and rely upon NWS Eta model data streams as hydrodynamic model drivers. NOS is cooperating with NWS and OAR in developing a nowcast/forecast capability for the Great Lakes.

OFFICE OF ATMOSPHERIC RESEARCH (OAR).

Requested funding for FY 2006 for Weather and Air Quality research is $38.7 million--a decrease of $13.5 million or more than 25 percent from the FY 2005 enacted level. Increases consist of upward base adjustments of $2.7 million to partially cover inflationary cost increases, plus a critical $1.7 million program increase for Air Quality Assessments. Proposed decreases include $1.5 million from Weather & Air Quality Research Laboratories and Joint Institutes and $1.0 million from Weather and Air Quality Research Programs (Phased-Array Radar) for amounts provided in excess of the FY 2005 request. In addition, terminations totaling $15.0 million are proposed for: Atmospheric Investigation Regional Modeling Analysis and Prediction (AIRMAP) ($4.9 million); New England Air Quality Study ($2.0 million); Targeted Wind Sensing ($2.0 million); Risk Reduction in Water Forecasts at Mississippi State University ($2.0 million); New England Center for the Study of Atmospheric Sciences and Policy ($1.5 million); FY 2005 hurricane research supplemental ($1.0 million); the "STORM" Program at the University of Northern Iowa ($0.6 million); Remote Sensing Research at the Idaho State University/Boise Center Aerospace Laboratory ($0.5 million); East Tennessee Ozone Study ($0.3 million); and the Central California Ozone Study ($0.2 million).

Finally, since NOAA proposed transferring the U.S. Weather Research Program (USWRP) to the National Weather Service (NWS) in FY 2005, the $0.5 million of USWRP funding enacted in FY 2005 in the OAR budget is being proposed for transfer to NWS in the FY 2006 request. Last year's requested transfer to NWS of the Space Environment Center ($5.3 million and 51 FTE) was enacted as requested.

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS).

The FY 2006 DOC/DOD budget request for NPOESS is $644.7 million. FY 2006 funds will be used for the continued development of system architecture, technology development efforts, and critical sensor and algorithm development. NPOESS is planned to be launched in FY 2011. This system will exploit advanced hardware and software technologies to produce a more reliable, longer-lived spacecraft with greater mission capability. In addition to new products, NPOESS will also provide a significant reduction (90 minutes to 30 minutes) in the time required to move from sensed to processed data.

NOAA MARINE AND AVIATION OPERATIONS (NMAO).

NMAO supports meteorological activities by collection of related data from ships and aircraft. The FY 2006 President's Budget does not include any significant increases or decreases from the FY 2005 appropriation for NMAO that are related to meteorological data collection.

DEPARTMENT OF DEFENSE (DOD)

The DOD total budget request for FY 2006, excluding NPOESS funding, is $691.4 million which represents a funding increase of 0.7 percent from FY 2005. Specific highlights for each of the military departments are described below:

U.S. AIR FORCE.

United States Air Force (USAF) resources for meteorological support fall into several categories: general operations, investment and research, Defense Meteorological Satellite Program (DMSP) operations, and DMSP and National Polar-orbiting Operational Environmental Satellite System (NPOESS) supporting research. The total USAF request for FY 2006, including DMSP and NPOESS, is $699.0 million.

General Operations: The operations portion (USAF and DMSP) of the FY 2006 budget request is $393.5 million and funds day-to-day environmental support to the DOD, including the active and reserve components of the Air Force and Army, nine unified commands, and other agencies as directed by the Chief of Staff of the Air Force. Just over 4,400 Active and Reserve Component military and civilian personnel conduct these activities at more than 290 locations worldwide. Approximately 85 percent of personnel specialize in weather; the remainder includes communications, computer, administrative, and logistics specialists.

General Supporting Research: The FY 2006 budget request for supporting research is $28.7 million. The increase in funding over FY 2005 is a result of research and development efforts related to NPOESS. In 2006, Air Force Weather begins data ingest, analysis, and modeling research efforts in preparation for the launch of the NPOESS Preparatory Project (NPP) satellite and the first fully operational NPOESS satellite in 2010. A key systems development effort in FY 2006 is the development of the Joint Environmental Toolkit (JET). JET will provide a single common forecaster interface to the virtual Joint METOC Database (JMDB) for use at all levels of the Air Force Weather support structure. Additionally, it will integrate with joint and coalition command and control and mission planning systems by enabling machine-to-machine exchange of METOC data and information to meet operational planning and execution requirements. Final source selection and contract award is to take place by October 2005.

DMSP Operations: Though funding for DMSP comes from the USAF, this system is a major source of space-borne meteorological data for all the military services and other high-priority DOD programs. DMSP environmental data is also distributed to the National Weather Service (NWS), National Environmental Satellite, Data, and Information Service (NESDIS), the Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC), the Naval Oceanographic Office (NAVOCEANO), and Air Force Weather Agency (AFWA) according to the Shared Processing Program agreement.

The DMSP operations and maintenance portion of the FY 2006 budget request is $84.1 million, the majority of which is for on-orbit satellite operations, long-haul communications, and one dedicated command and control facility. DMSP funds for 120 military and civilian personnel associated with the operation and sustainment of the DMSP command, control, and communications segment.

DMSP and NPOESS Supporting Research: The FY 2006 DOD R&D budget for NPOESS is $305.5 million for the continued development of system architecture, technology, critical sensors, and algorithms. NPOESS, scheduled to be available in 2010, will exploit advanced hardware and software technologies to produce a more reliable, longer-lived spacecraft with greater mission capability.

U.S. NAVY.

The U. S. Navy FY 2006 budget request for meteorological programs is $212.1 million. The request includes $179.8 million for operational programs and $32.3 million for supporting research.

The Naval Oceanography Program (NOP) remains an unique, world-class program. Focusing support in the environmentally complex coastal/littoral regions around the globe, Naval Meteorology and Oceanography (METOC) personnel (Navy and Marine Corps) are required to provide battlespace awareness for the warfighter by assessing the impact of atmospheric and ocean phenomena on sensor and weapon systems. Additionally, and just as important, the Navy and Marine Corps METOC teams provide for safe flight and navigation in support of naval, joint, and combined forces operating throughout the world's oceans. This is done with a cadre of highly trained military and civilian personnel, schooled in both the sciences and warfighting applications. By teaming with, and leveraging the efforts of other agencies and activities, the NOP meets these challenges in a most cost-effective manner, providing a full spectrum of products and services with only a small percent of the Federal weather budget.

The NOP is required to provide comprehensive and integrated weather and ocean support worldwide. The Oceanographer of the Navy sponsors programs in four closely related disciplines - meteorology, oceanography, geospatial information services, and precise time and astrometry. All are used to protect ships, aircraft, fighting forces, and shore establishments from adverse ocean and weather conditions, and to provide a decisive tactical or strategic edge by exploiting the physical environment to optimize the performance and efficiency of platforms, sensors, and weapons.

Owing to the crucial interrelationship of the ocean and the atmosphere, Naval METOC requires various oceanographic products to provide the requisite meteorological services. In addition to aviation and maritime METOC support, Navy and Marine Corps METOC teams provide a variety of unique services on demand, such as electro-optical, electro-magnetic and acoustic propagation models and products, METOC-sensitive tactical decision aids, and global sea ice analyses and forecasts.

Support to naval operations is provided under the direction of the Commander, Naval Meteorology and Oceanography Command (CNMOC) located at the Stennis Space Center, Mississippi and the Marine Corps advocate for METOC, the Deputy Commandant for Aviation, at Headquarters Marine Corps, Washington, DC. Naval METOC support starts with sensing the battlespace physical environment and culminates with weapons arriving on target and personnel operating in the battlespace without being adversely affected by physical environmental phenomena. Operational support for the Navy and Marine Corps includes the day-to-day provision of meteorological and oceanographic (METOC) products and services. As naval operations in the littoral increase, Naval METOC support is directed towards providing on-scene capabilities to personnel that directly furnish environmental data for sensor, weapon system, and personnel planning and employment. These on-scene capabilities are key elements for enabling the warfighters to take advantage of the natural environment as part of battlespace management.

Naval METOC systems acquisition is accomplished through the Program Executive Office for Command, Control, Communications, Computers and Intelligence and Space (C4I and Space) in San Diego, California.

Naval METOC Research and Development (R&D) is cooperatively sponsored by the Oceanographer of the Navy and the Chief of Naval Research. Naval R&D efforts typically have applications to meteorological, oceanographic, and/or tactical systems. Navy's tabulation of budget data includes R&D funding for basic research, applied research, demonstration and validation, and engineering and manufacturing development.

Projects initiated by the Navy and Marine Corps, under sponsorship of the Oceanographer of the Navy, transition from exploratory development to operational naval systems. Such efforts include advances in Naval METOC forecasting capabilities, enhancements to communications and data compression techniques, further development and improvement of models to better predict METOC parameters in littoral regions, and an improved understanding of the impact these parameters have on sensors, weapon systems, and platform performance.

As the Department of the Navy transforms under SEAPOWER 21, increased emphasis will be placed on the naval force's capabilities for operational maneuverability, precision-guided weapons employment, indefinite sustainment and protection of joint forces. The CNMOC Organization is also currently transforming for efficiency and effectiveness to meet the future requirements for SEAPOWER 21. The Naval METOC Community continues to work closely with research developers and operational forces to ensure that naval and joint force commanders will always have the most accurate, timely, and geo-referenced METOC information available for successful operations.

U.S. ARMY.

The U.S. Army estimates a requirement for $46.3 million for operational support and $9.9 million in research and development in FY 2006. The total amount of money budgeted for weather support is estimated because the costs to support U.S. Air Force (USAF) Battlefield Weather forces are normally part of the overall G-3 or G-2 operating budget at the MACOM, Corps, Division, or Brigade level and do not have their own program element or budget line. Operational support is projected to decrease approximately $24.5 million over the FY 2005 expenditures and research is estimated to decrease about $5.1 million from the previous year. Staffing will increase slightly. A supplemental budget of over $24 million for the Meteorological Measuring Set - Profiler (MMS-P) programs in FY 2005 accounts for the significant difference in operational funding levels for the Army from FY 2005 to FY 2006. Increases in staffing are a result of a projected increase in ARYMET units within FORSCOM.

Army monies for meteorology are

spent in four main areas: support to U.S. Army Artillery Met Sections (ARTYMET), support to USAF Battlefield Weather forces at Army locations, research and development related to the Army mission, and the development, production, and maintenance of Army meteorological systems.

U.S. Army Major Commands (MACOMs) with Staff Weather Officers and their associated Battlefield Weather forces provide the same support and services to AFW personnel that they normally provide to Army personnel. This support includes the use of facilities to house weather operations, medical support, access to training facilities, office supplies, utilities and maintenance for weather facilities, vehicles and tactical equipment, and funding for official travel. Eighth U.S. Army, U.S. Army Europe, U.S. Army Pacific, Forces Command, and Training and Doctrine Command all provide this support to Air Force Weather (AFW) personnel assigned at the MACOM level and below.

Major portions of MACOM meteorological budgets go to support Artillery Meteorology Sections, also known as ARTYMET Teams, or Met Sections. Wind data are then passed to the U.S. Army Artillery units for firing computations. Artillery Met Sections range in size from six personnel at a Light Division to twelve personnel at a Heavy Division. Eighth U. S. Army, U.S. Army Europe, U.S. Army Pacific, Forces Command, and the Army National Guard all support Met Sections. Training and Doctrine Command supports twenty-four military and civilian personnel at the U.S. Army Artillery School at Fort Sill, Oklahoma. These personnel train ARTYMET Teams on the use of the AN/TMQ-41 Meteorological Measuring Set. ARTYMET team structures will be changing over the next few years to support the Army's new modularity concept. FORSCOM is already making these changes to its artillery sections, and other MACOMS will follow as their forces transform to the new units of action. No attempt has been made to convert the part time Army National Guard ARTYMET Teams into full time equivalents.

Space and Missile Defense Command (SMDC) supports several meteorological missions. SMDC has funding designated for the operational support at the High Energy Laser Systems Test Facility (HELSTF) for contract services to operate and maintain the instrumentation, equipment, and facilities to support the atmospheric sciences/meteorological mission. HELSTF has also set aside monies for systems acquisition for repair and replacement of meteorological instrumentation and for data services. SMDC also operates contract support services to operate the Ronald Reagan Missile Defense Test Site for operations support and special weather programs.

Headquarters, Department of the Army, Deputy Chief of Staff, G-2 employs two full-time meteorologists for development of meteorological policy; coordination of meteorological support within the Department of the Army and with other Department of Defense and Federal agencies and organizations; Department of the Army Policy concerning weather; environmental services, and oceanographic support to the Army (less those environmental services functions assigned to the Corps of Engineers); and Department of the Army policy concerning peacetime weather support and point weather warnings. This office also sponsors a company grade Army liaison officer at the Air Force Weather Agency (AFWA) in Omaha, Nebraska, to serve in a consulting role to AFWA. The Air Force provides one full time Staff Weather Officer to serve as a liaison between AFW and the Army Staff.

The Training and Doctrine Command (TRADOC) will program the majority of funds for operations support related to logistics (expendables), instructor/support personnel, and meteorological system sustainment at the US Army Field Artillery School (USAFAS). The Meteorological Branch at USAFAS (Ft. Sill, OK) employs 25 instructor and support personnel to conduct training using the AN/TMQ-41 Meteorological Measuring Set (MMS). A significant increase in Operational Support Funding is expected in FY 2006 as USAFAS begins to field the AN/TMQ 52 Meteorological Measuring Set Profiler (MMS-P) as a replacement to the MMS. Within the Operational Support Funding, the increases are pinpointed to Logistics (expendables), Instructor Personnel, and Training Development. TRADOC programmed monies in FY 2005 to fund a TRADOC Systems Manager (TSM) position for the Army's Integrated Meteorological System (IMETS). This position falls under the TRADOC Program Integration Office - All Source Analysis System (TPIO-ASAS) at the US Army Intelligence Center and School (USAICS) at Ft Huachuca, AZ. TPIO-ASAS will fund this position in FY 2006. TRADOC transferred funds to Air Combat Command for maintenance/service of the Automated Surface Observing Sensor (ASOS) system at Fort Rucker, AL. Service costs on this system are estimated to increase slightly in FY 2006.

Forces Command (FORSCOM) will program approximately $14.5 million in FY 2006 for meteorological operations support. This is an increase of nearly $1.7 million from the previous year to support the addition of 6 new ARTYMET sections. The original FY 2005 plan was for 9 additional ARTYMET sections under Army modularity. In FY 2005 only 3 new sections came on line. This plan allows for the other 6 sections to be added in FY 2006. Over 94 percent of the programmed funds will be used in support of FORSCOM ARTYMET operations and the remainder will be spent for supplies, travel and other contracts for AFW forces supporting FORSCOM units.

The Army Materiel Command (AMC) will fund a variety of activities for FY 2006, most of which fall into research and development and systems acquisition. AMC will fund developmental and testing costs associated with the Integrated Meteorological System (IMETS). The IMETS budget for FY 2005 underwent a $11.9 million reduction to fund higher priority needs within the Army. Normal program life cycle issues reduced the Artillery's Profiler budget by $11.8 million in FY 2005. However, the Profiler program received over $24 million in FY 2005 through supplemental funding and was able to purchase an additional 22 systems with this money. Three profiler systems are planned for procurement in FY 2006. Other activities within AMC include Army Research Laboratory, Battlefield Environment Division, which will continue to operate an integrated program of both basic and applied research. The Army Research Office will continue basic research activities and will maintain a relatively stable budget in FY 2006. AMC's Field Assistance in Science and Technology (FAST) Activity will fund deployment of new lightweight meteorological systems to test in support of ARTYMET programs.

As a result of changes in the USARIEM research program for FY 2005, there was a reduction in expenditures on weather-related research. It is anticipated that FY 2006 funding for weather-related research efforts at U.S. Army Research Institute of Environmental Medicine (USARIEM) will decrease significantly relative to the FY 2005 Level due to completion of an SBIR.

DEPARTMENT OF HOMELAND SECURITY (DHS)

On March 1, 2004, the Department of Homeland Security (DHS) assumed primary responsibility for ensuring that emergency response professionals are prepared for any situation in the event of a terrorist attack, natural disaster, or other large-scale emergency. This entails providing a coordinated, comprehensive Federal response to any large-scale crisis and mounting a swift and effective recovery effort. DHS will also prioritize the important issue of citizen preparedness, and educating America's families on how best to prepare their homes for a disaster and tips for citizens on how to respond in a crisis will be given special attention at DHS.

U.S. COAST GUARD (USCG).

All of USCG's funding for meteorological programs is for operations support. For FY 2006, the requested funding level is $25.0 million. (The Coast Guard does not have a specific program and budget for meteorology--all meteorological activities are accomplished as part of general operations.)

The Coast Guard's activities include the collection and dissemination of meteorological and iceberg warning information for the benefit of the marine community. The Coast Guard also collects coastal and marine observations from its shore stations and cutters, and transmits these observations daily to the Navy's Fleet Numerical Meteorology and Oceanography Center and NOAA's National Weather Service. These observations are used by both the Navy and NOAA in generating weather forecasts.

The Coast Guard also disseminates a variety of weather forecast products and warnings to the marine community via radio transmissions. Coast Guard shore stations often serve as sites for NWS automated coastal weather stations, and the National Data Buoy Center provides logistics support in deploying and maintaining NOAA offshore weather buoys.

The International Ice Patrol conducts iceberg surveillance operations and provides warnings to mariners on the presence of icebergs in the North Atlantic shipping lanes. Coast Guard efforts in meteorological operations and services have not changed significantly during recent years.

DEPARTMENT OF THE INTERIOR (DOI)

The total DOI/BLM weather funding request for FY 2006 is $2.4 million. This amount is for meteorological operations and the support of the Bureau of Land Management (BLM) Remote Automatic Weather Station (RAWS) program. An additional $1.1 million is recovered each year through reimbursable accounts with participating agencies. Normal operations and maintenance of the RAWS program is approximately $900,000 yearly. (This includes travel, transportation, utilities, services, supplies, equipment and other non-labor costs.)

Support of the RAWS program by the BLM will continue in FY 2006, as part of the Wildland Fire Agencies' participation in Fire Weather activities and the National Fire Danger Rating System (NFDRS). In addition to upgrading and maintaining fixed-site RAWS, the BLM will address increasing demand for the use of mobile units for both fire and non-fire applications. Continued efforts will be made to achieve an optimum balance of fixed and mobile RAWS resources and support. Cooperation between DOI agencies and the USDA Forest Service regarding combined meteorological requirements for the National Wildland Fire support functions is ongoing. Interagency RAWS activity is coordinated at a working group level with representation by all participants, and will continue to implement NFDRS standards to ensure the protection of both life and property from wildland fires.

DEPARTMENT OF TRANSPORTATION (DOT)

The DOT total budget request for

FY 2006 is $508.0 million which represents a funding increase of 4.4 percent from FY 2005. The meteorological programs for the Federal Aviation Administration and the Federal Highway Administration, for FY 2006, are described below.

FEDERAL AVIATION ADMINISTRATION (FAA).

For 2006, FAA has requested a total $504.5 million for the Aviation Weather Programs including acquisition of new systems, operations and support, and supporting research. The actual funding for aviation weather in FY 2005 was $482.4 million. The $22.1 million increase in FY 2006 constitutes a 4.5 percent increase in total funding. The changes are comprised of a) increases in acquisitions of $7.1 million (+8.4 percent) to $91.1 million, as new systems are required to enhance support of field operations and the aviation industry; b) increases in operations and support of $14.6 million (+3.9 percent) to $386.1 million, reflecting salary increases throughout the agency and in associated logistics; and c) a decrease for aviation weather research of $0.6 million to a total of $21.5 million.

The funding changes reflect major initiatives in the aviation weather programs to bring much automation to the collection of weather observations from remote sensors, to the dissemination of weather products, graphics and decision making information available for use by the air traffic facilities, pilots, the aviation industry and general aviation users. Specific programs that will see a change in funding greater than $2 million are listed below:

Programs	Changes ($ Millions)
Systems Acquisition:	
• Operation and Supportability Information System (OASIS)	6.2
Operations Support:	
• Equipment Maintenance	2.8
• Flight Service Stations (FSS)	3.3

The AWRP will continue research to understand the geophysical phenomenon in the atmosphere and around airports that present hazardous conditions for aircraft operations. Among these are in-flight icing, turbulence, visibility, ceiling, convective activity, tornadoes, etc. Additional work will be done to improve models, develop better graphics for decision making information, and understand the impacts of space weather.

FEDERAL HIGHWAY ADMINISTRATION (FHWA).

The total FHWA request for surface transportation weather programs in FY 2006 is $3.0 million, all of which will be used for supporting research and special programs.

In 1999, the FHWA began documenting road weather data requirements, which have served as the basis for the majority of work in this area. This work includes addressing the technical aspects of the road transportation system (including environmental data collection, processing, and dissemination) as well as the institutional challenges associated with system implementation.

These institutional challenges encompassed coordination within state and local Departments of Transportation (DOTs) as well as across the transportation and meteorological communities. With regard to technical areas of interest, data collection efforts will include increased coverage of atmospheric and road condition observations, as well as incorporation of road weather data (e.g., pavement and subsurface observations) into broader meteorological observation networks. Better processing includes the application of higher resolution weather models and the development of road condition prediction models (e.g., heat balance models) that are needed to develop the appropriate road weather information.

A new DOT initiative entitled *Clarus* - the Nationwide Surface Transportation Weather Observing System - will develop and demonstrate a regional road weather observing network and, ultimately, nationwide data sharing capabilities. *Clarus* will allow agencies to share quality controlled environmental data, ultimately improving forecasts and value-added weather information products, as well as supporting anytime, anywhere road weather information for all road and transit users.

A multi-year effort has been undertaken by the FHWA in cooperation with six national laboratories to prototype and field test advanced decision support tools for winter maintenance managers. The Maintenance Decision Support System (MDSS) prototype is a decision support tool that integrates relevant road weather forecasts, coded rules of practice for winter maintenance operations, and maintenance resource data to provide managers with customized road treatment recommendations. The first functional MDSS prototype was demonstrated in Iowa in early 2003 and during winter 2003-2004. During winter 2004-2005, the MDSS prototype was successfully deployed in a third demonstration in Colorado. The current focus of the MDSS project is deployment assistance to assure successful technology transfer to the private sector, who can incorporate MDSS modules into their product lines.

The FHWA is researching how Traffic Management Centers (TMCs) around the country integrate road weather information into their operations. The FHWA is documenting the types of road weather information received by TMCs, the means of information delivery, how information needs change as the severity of a weather event increases, and how that information impacts traffic management decisions. The FHWA is also conducting empirical studies to quantify the impacts of various weather events on arterial and freeway traffic as well as investigating several other aspects of traffic management with respect to adverse weather, including traffic signal timing, traffic simulation modeling, and freeway operations. These efforts will help FHWA advance the state-of-the-practice in weather-responsive traffic management.

The efforts described above, as well as future activities captured in the Road Weather Management Program plan will be examined within the context of two key reports published in early 2004 and described below.

In 2002, the FHWA asked the National Research Council (NRC) Board of Atmospheric Sciences & Climate to examine what needs to be done from the research, development, and technology transfer perspectives to improve the production and delivery of weather-related information for the nation's roadways. In March 2004, the NRC released a report, *Where the Weather Meets the Road: A Research Agenda for Improving Road Weather Services*, that recommended the creation of a focused, national road weather research program led by FHWA that brings together the transportation and meteorological communities, identifies research priorities, and implements new scientific and technological advances. NRC recommendations included making better use of existing road weather information and technologies to increase capabilities for transportation research, establishing a nationwide real-time road weather observing system, developing observing capabilities to assess the accuracy of road weather forecasts, improving environmental sensor technologies, and developing new means to effectively communicate road weather information to a wide range of users.

To strengthen relationships between the meteorological and surface transportation communities, the FHWA Road Weather Management Program also co-sponsored the American Meteorological Society (AMS) Policy Forum on Weather and Highways in November 2003, to discuss provision of weather information to improve highway operations, development of strategies to effectively respond to weather information, and policy issues related to effective application of weather services to the management of the nation's highway system. The forum brought together nearly 100 representatives from public, private, and academic sectors at federal, state, and local levels. The report resulting from the forum, *Weather and Highways: Report of a Policy Forum*, included several recommendations including long-term congressional funding to develop a national road weather research, development, and applications program; close coordination of federal and state DOTs to improve the safety and efficiency of highways during adverse weather; and establishing a national road weather data collection, processing, and dissemination system.

Based upon recommendations in the AMS and NRC reports, the FHWA has partnered with the National Oceanic and Atmospheric Administration (NOAA) to achieve shared goals for a safer and more efficient surface transportation system. By working together the agencies can take advantage of the other's investments and expertise as well as promote improved surface transportation weather training, products, and services. A near-term goal of the new partnership is the introduction of new products, services and training to improve the application of weather information to surface transportation operations. Significant investments beyond current budget levels will be needed to address all of the recommendations in the two reports.

FEDERAL RAILROAD ADMINISTRATION (FRA).

In 2006, the FRA requested a significant increase in Nationwide Differential Global Positioning System (NDGPS) funding to accelerate construction of additional NDGPS sites. Thus, FRA plans to transfer approximately $424,500 to NOAA's Forecast Systems Laboratory in 2006.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

All of the EPA's funding of meteorological and air quality programs is for supporting research. The anticipated funding level in FY 2006 for directed meteorological research is $9.0 million, which is the same funding level as in FY-2005.

Currently, increased attention is being paid to the effects of airborne toxins and fine particulate matter on human health, on the effect of climate change on air quality, and the impact on ecosystems. In addition, to promote excellence in environmental science and engineering, EPA established a national fellowship program and substantially increased its support for investigator-initiated research grants. The funding for grants (with reliance on quality science and peer review) and for graduate fellowships (to support the education and careers of future scientists) will provide for a more balanced, long-term capital investment in improved environmental research and development.

The funding for the grants program will remain about the same in FY 2006 as in FY 2005. This program will fund research in areas including ecological assessment, air quality, environmental fate and treatment of toxins and hazardous wastes, effects of global climate change on air quality, and exploratory research. The portion of these grants that will be awarded for meteorological research during FY 2006 cannot be foreseen, but it is probable that the grant awards will increase the base amount of $9.0 million listed above for directed meteorological research.

In collaboration with NOAA, EPA is continuing its development and evaluation of air quality models for air pollutants on all temporal and spatial scales as mandated by the Clean Air Act as amended in 1990. Research will focus on urban, mesoscale, regional, and multimedia models, which will be used to develop air pollution control strategies, human and ecosystem exposure assessments, and air quality forecasting. There will be increased emphasis placed on meteorological research into regional and urban formation and transport of air contaminants in support of the revisions to the National Ambient Air Quality Standards and homeland security. Increased efficiency of computation and interpretation of results are being made possible by means of supercomputing and scientific visualization techniques.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

For FY 2006, NASA requests a total of $165.2 million. The majority of this funding ($162.6 million) is for supporting research.

The meteorology supporting research programs lie within the Earth-Sun System Division of NASA's Science Mission Directorate (SMD). Due to recent organizational changes, the task of extracting meteorology related funds in the SMD budget has become a complicated undertaking. The line items in the Earth-Sun System budget that support Earth Science are Earth Systematic Missions, Earth System Science Pathfinder, Earth-Sun System Multi-Mission Operations, Earth-Sun Research, Applied Sciences, Education and Outreach and Earth-Sun Technology. Estimation of the meteorology share of this budget was a two step process. The Earth Science part of the budget was estimated in the first step and the meteorology share was estimated, in the second step, to be one eighth of this sum.

NUCLEAR REGULATORY COMMISSION (NRC)

The NRC planned expenditure of $120,000 in FY 2006, is for meteorological operations to continue technical assistance for the analysis of atmospheric dispersion for routine and postulated accidental releases from nuclear facilities, and the review of proposed sites for possible construction of new nuclear power plants.

The meteorological support program in the NRC is focused primarily on analyzing and utilizing meteorological data in atmospheric transport and dispersion models. These models provide insight on plume pathways in the near- and far-fields for building wake and dispersion characteristics to perform dose calculations on postulated releases to the environment. Meteorological information is used as input to the probabilistic safety assessment, the assessment of the radiological impacts of routine releases from normal operations, the assessment of other (non-radiological) hazards that may impact safe operation of the facility, and the assessment of design or operational changes proposed for the facility.

Additionally, after a hiatus of some 25 years, the nuclear power industry has expressed an interest in seeking site approvals for new nuclear power plants. Three early site permit applications have been received and are currently under review. These reviews will also consider regional climatology and local meteorology. In addition to its internal review activities, the NRC may seek assistance from other Federal agencies to support its safety reviews.

AGENCY FUNDING BY BUDGET CATEGORY

Table 2.2 depicts how the agencies plan to obligate their funds for meteorological operations broken down by "budget category." The two major categories are "Operations Support" and "Systems Acquisition." To a large degree, these categories correspond to non-hardware costs (Operations Support) and hardware costs (Systems Acquisition). For agency convenience in identifying small components that do not fit into these two major categories, a third category is added called "Special Programs." Programs that provide support to several government agencies such as the Air Force's DMSP are listed on a separate line.

In FY 2006, Operational Costs requested are $2.98 billion with a total of $1.85 billion (62.2 percent) for Operations Support, $1.09 billion (36.8 percent) for Systems Acquisition, and $31.4 million (1.1 percent) for Special Programs.

Table 2.3 describes how the agencies plan to obligate their funds for meteorological supporting research according to budget categories. The agencies' supporting research budgets are subdivided along similar lines--Research and Development (non-hardware), Systems Development (hardware), and Special Programs (for those items that do not easily fit into the two major categories).

For FY 2006, agencies will obligate a total of $386 million in Supporting Research funds in the following manner: $297.6 million (77.1 percent) to research and development and $88.5 million (22.9 percent) to Systems Development.

AGENCY FUNDING BY SERVICE CATEGORY

Table 2.4 summarizes how the agencies plan to obligate operational funds for basic and specialized meteorological services; Table 2.5 is a similar breakout for supporting research funds.

Table 2.4 reveals the distribution of FY 2006 operational funds: basic meteorology services receiving 57.8 percent; aviation 20.1 percent; marine 5.3 percent; agriculture/forestry 0.6 percent; general military services 15.9 percent; and other specialized services accounting for 0.4 percent. Table 2.5 shows the distribution of supporting research funds among the services with basic meteorology receiving 25.0 percent, aviation 6.0 percent, marine 8.5 percent, agriculture and forestry 7.3 percent, general military 7.9 percent, and the remaining 45.2 percent dedicated to other meteorological services.

The definitions of specialized and basic services are described below:

<u>Basic Services</u>.

Basic services provide products that meet the common needs of all users and include the products needed by the general public in their everyday activities and for the protection of lives and property. "Basic" services include the programs and activities that do not fall under one of the specialized services.

<u>Specialized Meteorological Services</u>.

<u>Aviation Services</u>. Those services and facilities established to meet the requirements of general, commercial, and military aviation.

<u>Marine Services</u>. Those services and facilities established to meet the requirements of the DOC, DOD, and DOT on the high seas, on coastal and inland waters, and for boating activities in coastal and inland waters. The civil programs which are directly related to services solely for marine uses and military programs supporting fleet, amphibious, and sea-borne units (including carrier-based aviation and fleet missile systems) are included.

<u>Agriculture and Forestry Services</u>. Those services and facilities established to meet the requirements of the agricultural industries and Federal, state, and local agencies charged with the protection and maintenance of the nation's forests.

<u>General Military Services</u>. Those services and facilities established to meet the requirements of military user commands and their component elements. Programs and services which are part of basic, aviation, marine, or other specialized services are not included.

<u>Other Specialized Services</u>. Those services and facilities established to meet meteorological requirements that cannot be classified under one of the preceding categories; such as, space operations, urban air pollution, global climate change, and water management.

PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS

Table 2.6 depicts agency staff resources in meteorological operations. The total agency staff resources requested for FY 2006 is 16,365. This total represents a decrease of 0.5 percent from FY 2005.

TABLE 2.2 AGENCY OPERATIONAL COSTS, BY BUDGET CATEGORY

(Thousands of Dollars)

	Operations Support		Systems Acquisition		Special Programs		Total			% of FY2006
AGENCY	FY2005	FY2006	FY2005	FY2006	FY2005	FY2006	FY2005	FY2006	%CHG	TOTAL
Agriculture	15355	15535	0	0	0	0	15355	15535	1.2	0.5
Commerce/NOAA(Subtot)	915037	933032	795361	882207	17323	24530	1727721	1839769	6.5	61.6
NWS	703926	744830	63973	72303	15082	22130	782981	839263	7.2	28.1
NESDIS	174975	152738	731388	809904	1085	1244	907448	963886	6.2	32.3
OAR	0	0	0	0	0	0	0	0	0	0.0
NOS	23802	23130	0	0	0	0	23802	23130	-2.8	0.8
NMAO	12334	12334	0	0	1156	1156	13490	13490	0.0	0.5
Defense(Subtot)	468600	492384	152768	126096	888	1166	622256	619646	-0.4	20.7
Air Force	250250	260324	42970	49077	0	0	293220	309401	5.5	10.4
DMSP*	14571	16946	73467	67175	0	0	88038	84121	-4.4	2.8
Navy	168999	178580	1192	1229	0	0	170191	179809	5.7	6.0
Army	34780	36534	35139	8615	888	1166	70807	46315	-34.6	1.5
Homeland Security (Subtot)	23890	25020	0	0	0	0	23890	25020	4.7	0.8
USCG	23890	25020	0	0	0	0	23890	25020	4.7	0.8
Interior/BLM	2400	2400	0	0	0	0	2400	2400	0.0	0.1
Transportation(Subtot)	371780	386620	84019	91107	4635	5723	460434	483450	5.0	16.2
FAA	371639	386197	84019	91107	4635	5723	460293	483027	4.9	16.2
FRA	141	423	0	0	0	0	141	423	200.0	0.0
FHWA	0	0	0	0	0	0	0	0	0.0	0.0
EPA	0	0	0	0	0	0	0	0	0.0	0.0
NASA	2348	2435	260	180	0	0	2608	2615	0.3	0.1
NRC	120	120	0	0	0	0	120	120	0.0	0.0
TOTAL	1799530	1857546	1032408	1099590	22846	31419	2854783	2988554	4.7	100.0
% of FY TOTAL	63.0%	62.2%	36.2%	36.8%	0.8%	1.1%	100.0%	100.0%		

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

TABLE 2.3 AGENCY SUPPORTING RESEARCH COSTS, BY BUDGET CATEGORY

(Thousands of Dollars)

	Research & Development		Systems Development		Special Programs		Total			% of FY2006
AGENCY	FY2005	FY2006	FY2005	FY2006	FY2005	FY2006	FY2005	FY2006	%CHG	TOTAL
Agriculture	36702	28280	0	0	0	0	36702	28280	-22.9	7.3
Commerce/NOAA(Subtot)	88958	71683	18080	18256	0	0	107038	89939	-16.0	23.3
NWS	6430	7494	15710	15886	0	0	22140	23380	5.6	6.1
NESDIS	31039	26214	0	0	0	0	31039	26214	-15.5	6.8
OAR	50333	36819	1870	1870	0	0	52203	38689	-25.9	10.0
NOS	0	0	500	500	0	0	500	500	0.0	0.1
NMAO	1156	1156	0	0	0	0	1156	1156	0.0	0.3
Defense(Subtot)	48557	57147	15094	14656	429	0	64080	71803	12.1	18.6
Air Force	5474	14937	11278	13738	0	0	16752	28675	71.2	7.4
DMSP*	0	0	3816	918	0	0	3816	918	-75.9	0.2
Navy	28512	32312	0	0	0	0	28512	32312	13.3	8.4
Army	14571	9898	0	0	429	0	15000	9898	-34.0	2.6
Homeland Security (Subtot)	0	0	0	0	0	0	0	0	0.0	0.0
USCG	0	0	0	0	0	0	0	0	0.0	0.0
Interior/BLM	0	0	0	0	0	0	0	0	0.0	0.0
Transportation(Subtot)	26215	24506	0	0	0	0	26215	24506	-6.5	6.3
FAA	22145	21506	0	0	0	0	22145	21506	-2.9	5.6
FRA	0	0	0	0	0	0	0	0	0.0	0.0
FHWA	4070	3000	0	0	0	0	4070	3000	-26.3	0.8
EPA	9000	9000	0	0	0	0	9000	9000	0.0	2.3
NASA	109700	107000	66300	55600	0	0	176000	162600	-7.6	42.1
NRC	0	0	0	0	0	0	0	0	0.0	0.0
TOTAL	319132	297616	99474	88512	429	0	419035	386128	-7.9	100.0
% of FY TOTAL	76.2%	77.1%	23.7%	22.9%	0.1%	0.0%	100.0%	100.0%		

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

TABLE 2.4 AGENCY OPERATIONAL COSTS, BY SERVICE

(Thousands of Dollars)

AGENCY	Basic Meteorology FY2005	Basic Meteorology FY2006	Aviation FY2005	Aviation FY2006	Marine FY2005	Marine FY2006	Agriculture & Forestry FY2005	Agriculture & Forestry FY2006	General Military FY2005	General Military FY2006	Other FY2005	Other FY2006	Total FY2005	Total FY2006
Agriculture	0	0	0	0	0	0	15355	15535	0	0	0	0	15355	15535
Commerce/NOAA(Subtot)	1590891	1695671	63700	63700	73130	80398	0	0	0	0	0	0	1727721	1839769
NWS	669953	718295	63700	63700	49328	57268	0	0	0	0	0	0	782981	839263
NESDIS	907448	963886	0	0	0	0	0	0	0	0	0	0	907448	963886
OAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOS	0	0	0	0	23802	23130	0	0	0	0	0	0	23802	23130
NMAO	13490	13490	0	0	0	0	0	0	0	0	0	0	13490	13490
Defense(Subtot)	28932	30568	51501	53983	49355	52145	0	0	483957	473961	8511	8989	622256	619646
Air Force	0	0	0	0	0	0	0	0	293220	309401	0	0	293220	309401
DMSP*	0	0	0	0	0	0	0	0	88038	84121	0	0	88038	84121
Navy	28932	30568	51057	53943	49355	52145	0	0	32336	34164	8511	8989	170191	179809
Army	0	0	444	40	0	0	0	0	70363	46275	0	0	70807	46315
Homeland Security (Subtot)	0	0	0	0	23890	25020	0	0	0	0	0	0	23890	25020
USCG	0	0	0	0	23890	25020	0	0	0	0	0	0	23890	25020
Interior/BLM	0	0	0	0	0	0	2400	2400	0	0	0	0	2400	2400
Transportation(Subtot)	0	0	460293	483027	0	0	0	0	0	0	141	423	460434	483450
FAA	0	0	460293	483027	0	0	0	0	0	0	0	0	460293	483027
FRA	0	0	0	0	0	0	0	0	0	0	141	423	141	423
FHWA	0	0	0	0	0	0	0	0	0	0		0	0	0
EPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NASA	0	0	0	0	0	0	0	0	0	0	2608	2615	2608	2615
NRC	120	120	0	0	0	0	0	0	0	0	0	0	120	120
TOTAL	1619943	1726359	575494	600710	146375	157563	17755	17935	483957	473961	11260	12027	2854783	2988554
% of FY TOTAL	56.7%	57.8%	20.2%	20.1%	5.1%	5.3%	0.6%	0.6%	17.0%	15.9%	0.4%	0.4%	100.0%	100.0%

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

TABLE 2.5 AGENCY SUPPORTING RESEARCH COSTS, BY SERVICE

(Thousands of Dollars)

AGENCY	Basic Meteorology FY2005	Basic Meteorology FY2006	Aviation FY2005	Aviation FY2006	Marine FY2005	Marine FY2006	Agriculture & Forestry FY2005	Agriculture & Forestry FY2006	General Military FY2005	General Military FY2006	Other FY2005	Other FY2006	Total FY2005	Total FY2006
Agriculture	0	0	0	0	0	0	36702	28280	0	0	0	0	36702	28280
Commerce/NOAA(Subtot)	104913	87814	1625	1625	500	500	0	0	0	0	0	0	107038	89939
NWS	22140	23380	0	0	0	0	0	0	0	0	0	0	22140	23380
NESDIS	31039	26214	0	0	0	0	0	0	0	0	0	0	31039	26214
OAR	50578	37064	1625	1625	0	0	0	0	0	0	0	0	52203	38689
NOS	0	0	0	0	500	500	0	0	0	0	0	0	500	500
NMAO	1156	1156	0	0	0	0	0	0	0	0	0	0	1156	1156
Defense(Subtot)	13519	8798	0	0	28512	32312	0	0	22049	30693	0	0	64080	71803
Air Force	0	0	0	0	0	0	0	0	16752	28675	0	0	16752	28675
DMSP*	0	0	0	0	0	0	0	0	3816	918	0	0	3816	918
Navy	0	0	0	0	28512	32312	0	0	0	0	0	0	28512	32312
Army	13519	8798	0	0	0	0	0	0	1481	1100	0	0	15000	9898
Homeland Security (Subtot)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USCG	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interior/BLM	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation(Subtot)	0	0	22145	21506	0	0	0	0	0	0	4070	3000	26214.6	24506
FAA	0	0	22145	21506	0	0	0	0	0	0	0	0	22144.6	21506
FRA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FHWA	0	0	0	0	0	0	0	0	0	0	4070	3000	4070	3000
EPA	0	0	0	0	0	0	0	0	0	0	9000	9000	9000	9000
NASA	0	0	0	0	0	0	0	0	0	0	176000	162600	176000	162600
NRC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	118432	96612	23770	23131	29012	32812	36702	28280	22049	30693	189070	174600	419034.6	386128
% of FY TOTAL	28.3%	25.0%	5.7%	6.0%	6.9%	8.5%	8.8%	7.3%	5.3%	7.9%	45.1%	45.2%	100.0%	100.0%

*DMSP is the Defense Meteorological Satellite Program that supports all DOD Components and other government agencies. It is primarily funded and managed by the Air Force.

TABLE 2.6 PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS
(Units are Full Time Equivalent Staff Years)*

AGENCY	FY 2005	FY 2006	% CHANGE	% of FY 2006 TOTAL
Agriculture	236	234	-0.8	1.4
Commerce/NOAA (Subtotal)	5,717	5,714	-0.1	34.9
NWS	4,654	4,651	-0.1	28.4
NESDIS	870	870	0.0	5.3
OAR	32	32	0.0	0.2
NOS	107	107	0.0	0.7
NMAO	54	54	0.0	0.3
Defense	6,691	6,571	-1.8	40.2
Air Force (Subtotal)	4,714	4,714	0.0	28.8
Air Force Weather	4,594	4,594	0.0	28.1
DMSP	120	120	0.0	0.7
Navy	1,665	1,522	-8.6	9.3
Army	312	335	7.4	2.0
Homeland Security (Subtotal)	108	108	0.0	0.7
USCG	108	108	0.0	0.7
Interior/BLM (Subtotal)	28	28	0.0	0.2
Interior	26	26	0.0	0.2
Reimbursed**	2	2	0.0	0.0
Transportation (Subtotal)	3,662	3,708	1.3	22.7
FAA	3,659	3,705	1.3	22.6
FHWA	3	3	0.0	0.0
EPA	0	0	0.0	0.0
NASA	0	0	0.0	0.0
NRC	2	2	0.0	0.0
TOTAL	16,444	16,365	-0.5	100.0

* Numbers of personnel are rounded to nearest whole number.
** "Reimbursed" are personnel funded by other agencies.

INTERAGENCY FUND TRANSFERS

Table 2.7 summarizes the reimbursement of funds from one agency to another during FY 2005. Agencies routinely enter into reimbursable agreements when they determine that one agency can provide the service more efficiently and effectively than the other. While specific amounts may vary from year-to-year, the pattern shown is essentially stable and reflects a significant level of interagency cooperation.

Department of Commerce. NESDIS will transfer a total of $291.0 million to NASA for procurement and launches of polar-orbiting ($86.2 million) and geostationary ($204.8 million) satellites.

Department of Defense. The Air Force will reimburse DOC a total of $4.64 million for operations [e.g., OFCM support ($170,000), Lightning Data ($638,000), NCEP operations ($14,000), WSR-88D support ($2,531,000), COMET training development ($200,000), geomagnetic data ($215,000), and IPO support ($162,000)]. In addition, the Air Force will reimburse NASA $213,000 for a variety of data and USGS $300,000 for the purchase of a magnetometer. The Navy will reimburse DOC $209,000 for basic climatological analysis and forecasting, and interagency coordination. The Army reimbursements to DOC/NOAA include $569,000 from COE to NWS for maintaining precipitation reporting stations The U.S. Geological Survey will also be reimbursed $500,000 by the Army's COE for operations and maintenance of hydrologic and precipitation reporting stations.

Department of Transportation. The FAA will reimburse NOAA $32.2 million for FY 2006. Included in those funds are development of enhancements and operational support associated with the WSR-88D, ASOS maintenance, the Center Weather Service Units at all Air Route Traffic Control Centers, the World Area Forecast System, meteorology instructors at the FAA, studies, and OFCM support. The FAA will also reimburse the DOD a total of $3.3M for supporting research.

The FRA transferred $141,500 to NOAA's Forecast Systems Laboratory in 2005 to fund the purchase of weather sensing equipment which was installed at the Nationwide Differential Global Positioning System sites constructed in 2005. In 2006, FRA requested a significant increase in NDGPS funding to accelerate construction. Thus, FRA plans to transfer approximately $424,500 to Forecast Systems Laboratory in 2006.

National Aeronautics and Space Administration (NASA). The Air Force will be reimbursed a total of $1.599 million--$1.444 million for observations, forecasts, and operations/maintenance of weather infrastructure and replacement of upper air systems at Trans-Atlantic Abort Landing Sites and $155 million for operation and maintenance of weather towers at Edwards AFB, CA. The UCAR will receive $20,000 for data analysis to improve lightning launch commit criteria. The National Data Buoy Center will receive reimbursements of $133,000 for the operation of two data buoys.

Environmental Protection Agency (EPA). NOAA's Air Resources Laboratory (ARL) will receive $6.7 million for development, evaluation, and application of air quality dispersion models; and for provision of meteorological expertise and guidance for EPA policy development activities.

Nuclear Regulatory Commission (NRC). The NRC enjoys a unique relationship with the DOE as a result of the Energy Reorganization Act of 1974. The act realigned the Atomic Energy Commission into a regulatory organization-NRC and a research and promotional organization-ERDA (which was subsequently absorbed into DOE). As a result, the NRC has access to the DOE national laboratories for technical assistance activities. This assistance, while not a reimbursable agreement, results in the transfer of funds from NRC for specific technical assistance by DOE laboratories. In FY 2005, the NRC expects to task DOE laboratories and the National Oceanic and Atmospheric Administration's National Climatic Data Center at a funding level of $120,000.

FACILITIES/LOCATIONS FOR TAKING METEOROLOGICAL OBSERVATIONS

Table 2.8 indicates the number of facilities/locations or platforms at which the Federal agencies carry out (or supervise) the taking of various types of meteorological observations.

TABLE 2.7 INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Agency Funds Transferred from:	Agency Funds Transferred to:	FY 2004 Funds ($K) Estimated or Planned: Operations	Supporting Research
Commerce/NOAA	NASA (Polar satellite acquisition)	86,200	
	NASA (Geo satellite acquisition)	204,800	
Defense/Air Force	OSDP	53	
	DOC/NOAA/NWS/NCEP	14	
	DOC/NOAA/NWS/OS6		200
	DOC/NOAA/NWS	638	
	DOC/NOAA/OFCM	170	
	DOC/NOAA/NPOESS/IPO	136	
	DOC/NOAA/NWS/SEC	215	
	DOC/NOAA/NESDIS/IPO	26	
	DOC/NOAA/NWS		727
	DOC/NOAA/NWS	1804	
	DOC/NOAA/NWS		138
	DOC/NOAA/NWS	517	
	DOI/USGS	300	
	NASA		190
	NASA	23	
	NSF		140
Defense/Navy	DOC/NOAA/NCDC	44	
	DOC/NOAA/OFCM	165	
Defense/Army	DOC/NOAA/NWS	569	
	DOI/USGS	500	
	DOD/USAF/ACC	60	
Transportation/FAA	DOC/NOAA	24,865	7,310
	DOD/USAF		2,800
	DOD/USN		540
Transportation/FRA	DOC/NOAA	141	
NASA	DOD/USAF/45th SW	1,444	
	DOD/USAF/Edwards AFB	155	
	DOC/NOAA/NDBC	133	
	UCAR		20
EPA	DOC/NOAA/OAR		6,700
NRC	DOE/PNNL	120	

TABLE 2.8 FACILITIES/LOCATIONS FOR TAKING METEOROLOGICAL OBSERVATIONS

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 2004)
Surface, land	
Commerce (all types)	841
Air Force (U.S. & Overseas)	162
Navy (U.S. & Overseas)	72
Marine Corps (U.S. & Overseas)	13
Army (U.S. & Overseas)	45
Transportation (Flight Service Stn)	8
Transportation (Lim Aviation Wx Rptg Stn)	114
Transportation (Contract Wx Obsg Stn)	189
Transportation (Auto Wx Obsg Stn)	198
Transportation (Road Wx Obsg Stn)	2,149
Transportation (Auto Sfc Obsg Sys, fielded)	569
Homeland Security (USCG Coastal)	50
Interior	470
Agriculture	1567
NASA (all types)	46
Surface, marine	
Commerce (SEAS-equipped ships)	140
Commerce (Coastal-Marine Autom Network)	65
Commerce (NOAA/NOS/PORTS)	6
Commerce (Buoys--moored)	64
Commerce (Buoys--drifting)	21
Commerce (Buoys--large navigation)	10
Commerce (Water-level gauges)	*175
*Number of which have meteorology sensors	59
Navy (Ships with met personnel)	29
Navy (Ships without met personnel	288
Homeland Security (USCG Cutters)	232
NASA	2
Upper air, balloon	
Commerce (U.S.)	86
Commerce (Foreign, Cooperative)	22
Air Force, Fixed (U.S. & Overseas)	12
Air Force, Mobile	15
Army, Fixed (U.S. & Overseas)	18
Army, Mobile (U.S. and Overseas)	87
Navy, Fixed (U.S. & Overseas)	11
Navy, Mobile(U.S. & Overseas)	47
Navy, Ships	29
Marine Corps, Mobile	10
NASA (U.S.)	1
Atmospheric Profilers	
Army	9
NASA	1

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 2004)
Upper air, rocket	
Army (U.S. & Overseas)	1
Doppler weather radar (WSR-88D) sites	
Commerce (NWS)	123
Air Force (U.S. & Overseas)	26
Army (U.S. & Overseas)	3
Transportation (Off CONUS	12
Doppler weather radar (Not WSR-88D) sites	
Air Force (Transportable)	9
Army	2
Navy (Fixed)	9
Marine Corps (Mobile)	10
Off-site WSR-88D Processors (PUPs)	
Commerce (NWS)	63
Air Force	59 (+38 OPUPs)
Navy (U.S. and Overseas)	24
Marine Corps (U.S. & Overseas)	9
Army	1
Transportation	25
NASA	1
Airport Terminal Doppler weather radars	
Transportation (Commissioned)	45
Army (not airfield--Test Range/USAREUR)	2
Conventional radar (non-Doppler) sites	
Commerce (NWS)	31
Commerce (at FAA sites)	27
Air Force, Mobile Units	23
Marine Corps, Mobile units	15
Army (U.S. and Overseas)	4
Transportation (FAA (WSP))	34
Weather reconnaissance (No. of aircraft)	
Commerce (NAMO)	3
Air Force Reserve Command (AFRC)	10
Geostationary meteorological satellites (No. operating)	
Commerce (planned config of 2)	2
Polar meteorological satellites (No. operating)	
Commerce (2 primary, 4 standby)	6
Air Force (2 primary, 3 standby)	5
Navy (WINDSAT AND GFO)	2

DEPARTMENT OF COMMERCE WEATHER PROGRAMS
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration (NOAA) is the principal meteorological agency of the Federal government. By law, NOAA is responsible for reporting the weather of the United States, providing weather and flood warnings and forecasts to the general public, developing and furnishing applied weather services, and recording the climate of the United States. This mission is carried out within NOAA by the National Weather Service (NWS); the National Environmental Satellite, Data, and Information Service (NESDIS); the Office of Oceanic and Atmospheric Research (OAR); the National Ocean Service (NOS); and the NOAA Marine and Aviation Operations (NMAO).

NATIONAL WEATHER SERVICE

NOAA's National Weather Service (NWS) has the principal responsibility for planning and operating the basic climate, hydrologic, and weather services and certain specific applied services. The NWS provides climate, water, and weather warnings and forecasts for the U.S., it's territories, adjacent waters, and ocean areas to help protect life and property and enhance the national economy. NWS data and products form a national information data base and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community. In support of this mission, NWS:

• Issues warnings and forecasts of weather, flood, Great Lakes, coastal and ocean conditions.

• Observes and reports the weather and the river and ocean conditions of the U.S. and it's possessions.

• Develops and operates national meteorological, hydrological, climate, space weather and oceanic service systems.

• Performs applied meteorological, hydrological, space environmental and climate research.

• Assists in developing community awareness and educational materials and programs concerning weather-related natural disasters.

• Participates in international hydrometeorological and space weather activities, including the exchange, coding and monitoring of data and forecasts, and also including the installation and repair of hydrometeorological equipment and systems overseas under the Voluntary Cooperation Program.

The basic enabling legislation and authority for weather services are summarized as follows:

• Organic Act of 1890 created the United States Weather Bureau in the Department of Agriculture.

• Enabling Act of 1919 allowed the United States Weather Bureau to enter into cooperative agreements for providing agriculture weather services.

• Flood Control Act of 1938 authorized the establishment, operation, and maintenance of the Hydroclimatic Network by the Weather Bureau for Flood Control; on July 1, 1940, the Weather Bureau was transferred from the Department of Agriculture to the Department of Commerce.

• Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for providing weather observations and services to aviation.

• Reorganization Plan 2 of 1965 placed the "National Weather Service" in the newly created Environmental Science Services Administration (ESSA).

• Reorganization Plan 4 of 1970 made the NWS a part of the newly created National Oceanic and Atmospheric Administration (NOAA).

• International Convention for the Safety of Life at Sea (SOLAS) agreement to which the U.S. is signatory. This sets international policy for safer shipping and cleaner seas. The U.S implements the convention through Executive Order 12234 of Sept. 3, 1980 -- Enforcement of the Convention for SOLAS. Among the obligations of the agreement is to provide meteorological warnings and forecasts to ships at sea using charts and radio messages.

SERVICES

NWS provides climate, water, weather and space weather prediction services; including watches, warnings, advisories, and forecasts 24 hours a day, seven days a week. These services are provided through a national network of 122 Weather Forecast Offices (WFOs), 13 River Forecast Centers (RFCs), and the nine centers of the National Centers for Environmental Prediction (NCEP).

These offices collect data, prepare local warnings and forecasts, and disseminate information to the public both nationally and internationally through NOAA Weather Radio, satellite-based telecommunication systems, radiofacsimile, the media and the internet. Forecast and warning services prepared at WFOs are derived in part from prediction guidance prepared by the 13 RFCs and the nine NCEP centers. These centers are the Hydrometeorological Prediction Center, Storm Prediction Center, Aviation Weather Center, Environmental Modeling Center, Tropical Prediction Center, Climate Prediction Center, Space Environment Center, Ocean Prediction Center, and NCEP Central Operations.

Continually improving the accuracy, timeliness, and accessibility to prediction services is largely a result of research and development both within the NWS and externally from universities and private corporations.

PUBLIC WEATHER SERVICES.

NOAA's NWS Public Weather Service Program provides forecast, warning, and response services to the public, private meteorological firms, broadcast meteorologists, and NWS partners who are responsible for public safety. These partners include Federal, state, and local emergency managers and planners. NWS forecasters use their expertise to routinely modify a local digital database and issue forecasts for every location in the Nation for sky cover, maximum and minimum temperature, wind speed and direction, precipitation, and hazardous weather information at least two times per day.

The digital forecast information is delivered in a variety of formats (e.g., gridded binary format (GRIB2) via anonymous file transfer protocol, eXtensible Markup Language (XML), text, tabular, graphics) to meet customer and partner needs. NWS forecasters issue short-duration watches and warnings for severe weather, such as tornadoes and severe thunderstorms, as well as long-duration watches, warnings, and advisories for hazardous winter weather conditions, high wind events, dense fog, and temperature extremes. NWS forecasters support several health related programs such as Air Quality, Heat Health, and the Ultraviolet (UV) Index. Ground based ozone concentration forecasts are now being produced for the northeast U.S. and a nationwide development effort is underway. An experimental Heat Health Watch Warning System (HHWWS) has been developed for select cities to provide advance notice of excessive heat events. Also, a climatological approach to providing UV alerts for the entire nation is under development.

The NWS Public Weather Service Branch serves as the primary focal point for collaboration with Federal transportation agencies on weather issues related to surface transportation; with federal and private entities on the Ultra-Violet index program, and with the World Meteorological Organization on the provision of public weather services to the international community. Additionally, NWS forecasters provide meteorological support both on-site and from WFOs for terrorist acts and other homeland security concerns, as well as accidental releases/spills of hazardous chemical, biological, or radioactive materials.

In 2005, the NWS began creating, and making readily available, operational forecasts in digital formats. This information is stored in the National Digital Forecast Database NDFD). Output from NDFD is available in the form of web graphics available over the Internet, in GRIB2 format (GRIB2) via anonymous file transfer protocol, or in XML via an experimental web service. NDFD data can also be converted to a file format that can be used with Geographical Information System (GIS) software. NDFD includes various sensible weather elements such as temperature, probability of precipitation, weather and sky cover; and also includes derived elements such as relative humidity and apparent temperature (i.e., wind chill and heat index). For more detailed information on NDFD, please see http://www.nws.noaa.gov/ndfd/.

AVIATION WEATHER SERVICES.

The NWS provides a broad range of services in support of the aviation community. The WFOs prepare Terminal Aerodrome Forecasts (TAFs) four times a day, with amendments as needed, for more than 590 public-use airports in the U.S. and it's territories in the Caribbean and Pacific. These offices also produce about 241 individual route-oriented forecasts three times a day for the 48 contiguous states and over the Pacific Ocean.

NCEP's Aviation Weather Center (AWC) and the Alaska Region's Alaska Aviation Weather Unit (AAWU), and WFO Honolulu, HI prepare area forecasts three or four times daily describing general aviation weather conditions over the lower 48 states, the Gulf of Mexico, Caribbean, Alaska, Hawaii and coastal waters respectively. These three specialized offices also issue in-flight advisories and warnings of hazardous weather conditions associated with thunderstorms, icing, turbulence, and strong, low level winds. The AWC also prepares forecasts of significant aviation weather over the continental U.S. four times a day for flight levels from the surface to 25,000 feet.

NWS Center Weather Service Units located in each of the 21 FAA Air Route Traffic Control Centers provide direct meteorological support to enroute centers, Terminal Radar Approach Controls, airport towers, and Automated Flight Service Stations.

The NWS provides a service to international aviation as one of the International Civil Aviation Organization's (ICAO's) two World Area Forecast Centers. NCEP's Environmental Modeling Center supplies global gridded model data of temperature, winds, and humidity twice a day for flight levels from 5,000 to 45,000 feet. The AWC prepares forecasts four times a day of globally significant thunderstorms, tropical cyclones, severe squall lines, moderate or severe turbulence and icing, and cumulonimbus cloud associated with the above, from 25,000 to 63,000 feet. The forecast charts also

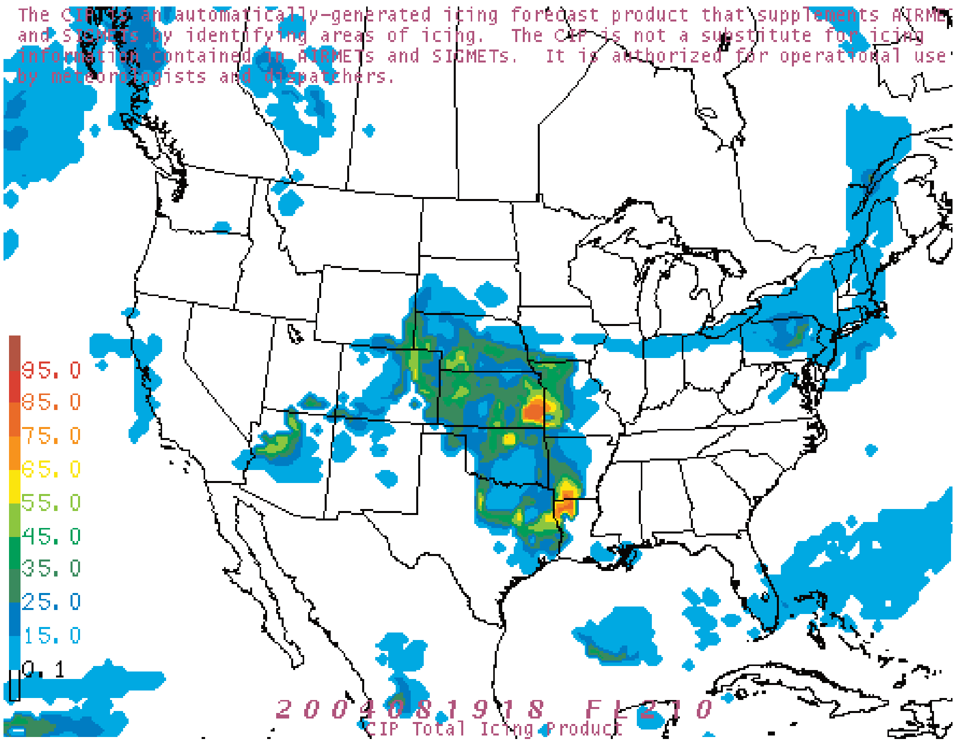


Figure 3-DOC-1. Current Icing Potential (CIP) Product. The FAA's Aviation Weather Research Program and the NWS developed this graphical icing product, updated every 3 hours, and available for user selected altitudes across the contiguous U.S.

include information on volcanoes, radiological releases, jet streams and tropopause heights. This information is transmitted by the International Satellite Communications System with coverage in the Americas, Caribbean, western portions of Europe, the Pacific, and eastern Asia.

Within the framework of the international airways volcano watch, the NWS and NCEP share management responsibility for operating the Volcanic Ash Advisory Centers (VACC) in the state of Washington and Anchorage, Alaska.

The NWS, working closely with the FAA's Aviation Weather Research Program, developed new experimental and operational forecast products designed to improve aviation hazard forecasts from zero to six hours into the future (Figure 3-DOC-1).

New icing and turbulence products for meteorologists and end users became operational in FY 2004. Improved software tools to increase the number of terminal airports covered by a forecast are also under development.

MARINE WEATHER SERVICES.

The NWS Marine Weather Program is the lead for the nation's marine and coastal weather services. Programs include warnings, forecasts, and advisories for coastal waters, offshore, high seas, and near-shore and open waters of the Great Lakes. It leads programs for tropical cyclone, coastal flood, severe convective coastal weather, and coastal hazards such as high surf, rip currents, and tsunamis. NWS forecasters at 46 coastal and marine WFOs, in collaboration with NCEP's Ocean Prediction Center and Tropical Prediction Center, provide a range of weather services focused on the expanding and weather-sensitive U.S. coastal population and those responsible for its safety.

The program develops plans, policy and procedures for the delivery of marine and coastal weather products and services from the coastal WFOs, the Ocean Prediction Center, the Tropical Prediction Center, and the Central Pacific Hurricane Center. It ensures marine and coastal forecast training needs are met. The program works with the NWS's Office of Science and Technology to prioritize tropical, marine and coastal science and technology development and approve new or improved product designs, and with the Office of Operational Systems to ensure the collection of marine and coastal observations and the delivery of marine and coastal products to users. The program creates internal and external partnerships, collects and validates marine and coastal service and mission needs, solicits feedback on products and services and validates whether these needs are met.

The program works with:

- NOAA's NESDIS, the U.S. Navy and the U.S. Coast Guard (USCG) to provide ice warning and advisory services through the joint National Ice Center;
- the Navy, the USCG, the U.S. Maritime Administration, and the Corps of Engineers to safely operate the nation's Marine Transportation System;
- the Department of Defense, Federal Emergency Management Agency, and Corps of Engineers to provide tropical cyclone services;
- the USCG, Navy, Air Force, and private entities to disseminate weather to mariners;
- NOAA's National Ocean Service (NOS) on the PORTS and TIDES programs; and
- the World Meteorological Organization to provide services to the international community.

It also works in cooperation with NOAA's Office of Response and Restoration, the Department of Defense, and Department of Homeland Security for forecasting services for hazardous material spills, marine area search, rescue, and recovery operations, and security needs.

FIRE/ALL HAZARD WEATHER SERVICES.

NOAA's NWS offices provide routine pre-suppression and wildfire weather support to Federal and state land management agencies. NWS forecasters provide routine fire weather forecasts, forecast support for the National Fire Danger Rating System, and site specific forecasts during the local fire season over roughly three-quarters of the Nation.

The NWS deploys a national cadre of specially-trained Incident Meteorologists (IMETs) to large wildfires and coordination centers for on-site weather support. IMETs use weather instrumentation, telecommunications, and display equipment to aid in on-site forecast preparation and briefings.

In the early morning, NOAA's National Centers for Environmental Prediction's Storm Prediction Center issues one and two-day fire weather outlooks that highlight areas with critical and extremely critical fire potential based on the state of the fuels (trees, brush, grasses), and critical weather parameters. Areas where significant lightning activity accompanied by less than 0.1 inch of precipitation (dry lightning) is forecast are also highlighted. Additionally, NWS forecasters provide forecasts in response to hazardous material incidents or Incidents of National Significance (such as the Columbia Recovery effort)

TSUNAMI WARNINGS.

Tsunami watches, warnings, and information bulletins for the Pacific Ocean and Hawaii are prepared by the Richard H. Hagemeyer Pacific Tsunami Warning Center in Ewa Beach, Hawaii, and for west coast of the continental U.S. and Alaska by the West Coast/Alaska Tsunami Warning Center in Palmer, Alaska. NWS collects and analyzes observational data from an international network of seismological observatories, sea-level observing stations, and deep-ocean tsunami detection buoys which operate on a cooperative basis. The centers use these data to prepare and disseminate watches, warnings, and information bulletins to international customers, WFOs, federal and state disaster agencies, military organizations, private broadcast media, and other agencies involved with warning the public.

CLIMATE SERVICES (CS).

Climate prediction products and other services relate to the period of week two out to one year, including seasonal forecasts and hazard assessments. The NWS's Climate Prediction Center produces a suite of products covering these periods. The climate services program provides the strategic vision for climate services at NWS, oversees the program including the expanded regional and local climate services programs, and serves as steward of the climate observing system. It maintains strong ties with other countries; across NOAA lines, specifically through the NOAA Climate Office; with Federal agencies; the university community; and the private sector and encourages collaborative arrangements among the Regional Climate Centers (managed by NOAA/NESDIS), the State Climatologists, and NWS WFOs and regional headquarters to tailor climate forecasts for local users.

HYDROLOGIC SERVICES.

The 122 WFOs, 13 River Forecast Centers (RFCs), and NCEP's Hydrometeorological Prediction Center (HPC) work as a team to provide hydrologic forecast and warning services which minimize loss of life and property damage from flooding and to meet the water service needs of our Nation. RFC hydrologists use a modeling system called the NWS River Forecast System (NWSRFS) to produce forecast time series of discharges or river stages at approximately 4,000 locations along the nation's rivers. HPC provides the quantitative precipitation forecasts serving as the primary forecast input for NWSRFS. RFCs also provide long-term water supply forecasts used by water managers in the western U.S., where decisions about water allocation and use are particularly critical now, with much of the West still feeling the effects of a long-term drought.

WFOs work cooperatively with the RFCs to monitor the major river systems around the clock. Using RFC guidance, advanced Doppler radar (NEXRAD) and telemetered rain gauge observations, WFOs continuously monitor the threat of flash flooding and urban flooding to provide timely flood watches and warnings to protect life and property.

Partnerships with a variety of Federal, state and local agencies are critical to NOAA's NWS Hydrologic Services Program. For example, the NWS works very closely with the United States Geological Service (USGS), the United States Army Corps of Engineers, the Natural Resources Conservation Service (NRCS), the Bureau of Reclamation, and the Bureau of Land Management on a variety of water related issues including stream gauging, support of flood fighting activities, river and water supply forecasting, and water management. River stage observations and stage-discharge relationships provided by the USGS are critical to warning and forecast operations for the Nation's rivers. The NRCS furnishes snow measurements that are combined with advanced snow modeling and analysis provided by NOAA's National Operational Hydrologic Remote Sensing Center to support joint NWS-NRCS water supply forecasting in the western U.S.

The NWS is implementing the Advanced Hydrologic Prediction Service (AHPS) to provide hydrologic forecasts with lead times ranging from days to months. AHPS builds on the existing NWS infrastructure, including AWIPS, NEXRAD, and NWSRFS.

AHPS also provides Ensemble Streamflow Prediction, a feature that allows the NWS to quantify forecast uncertainty. This lets decision makers apply risk-based analyses as they respond to flooding, and as they try to balance competing demands on water supply, especially during periods of drought.

Flash floods, typically caused by intense, small-scale convection, are the leading cause of flood fatalities. Another AHPS capability, known as Flash Flood Monitoring and Prediction (FFMP), combines high-resolution radar rainfall observations with Geographic Information System (GIS) technology to provide more accurate and much more precise flash flood forecasts. The added precision provided by FFMP greatly reduces the false alarm rate of flash flood forecasts, making them more credible and leading to better public response, which will ultimately save lives.

AHPS services are provided as a suite of Web-based products (weather.gov/water), that feature user-friendly menus and maps which allow users to zoom in to areas of interest. Clicking on an area of interest on the national map (Figure 3-DOC-2) brings the user to a map of the NWS WFO serving that area which provides more detailed information on river conditions.

AHPS also opens opportunities to improve NOAA's analysis and forecast capabilities related to coastal water conditions, through joint efforts with other components of NOAA (e.g., National Ocean Service, Office of Oceanic and Atmospheric Research).

OBSERVATIONS.

Observations form the basis for forecasts and the monitoring and evaluation of the environment. Differing applications and requirements are associated with each of these functions. Forecast applications associated with watch and warning functions must be served immediately, while real-time availability is not a significant factor for climate monitoring. The range of differing applications will dictate how future instrument deployments will be conducted. This poses a constant challenge to the optimization of resources placed into in situ and remotely sensed observation platforms.

The fundamental application of observations is to deliver better products and improve services. This demands the link between improved services and observing systems be well defined. We need to determine the gaps in observations to meet varied requirements, emphasizing the importance of metadata and sensor calibration continuity. Coordinated efforts within the Federal community throughout all aspects of observations development, dissemination and use are needed for efficiently utilizing of resources.

The NWS approach for improving observations consists of several efforts:

• Make better use of data from observing systems that currently exist;

• Extend the system life of current observing systems to postpone technical obsolescence;

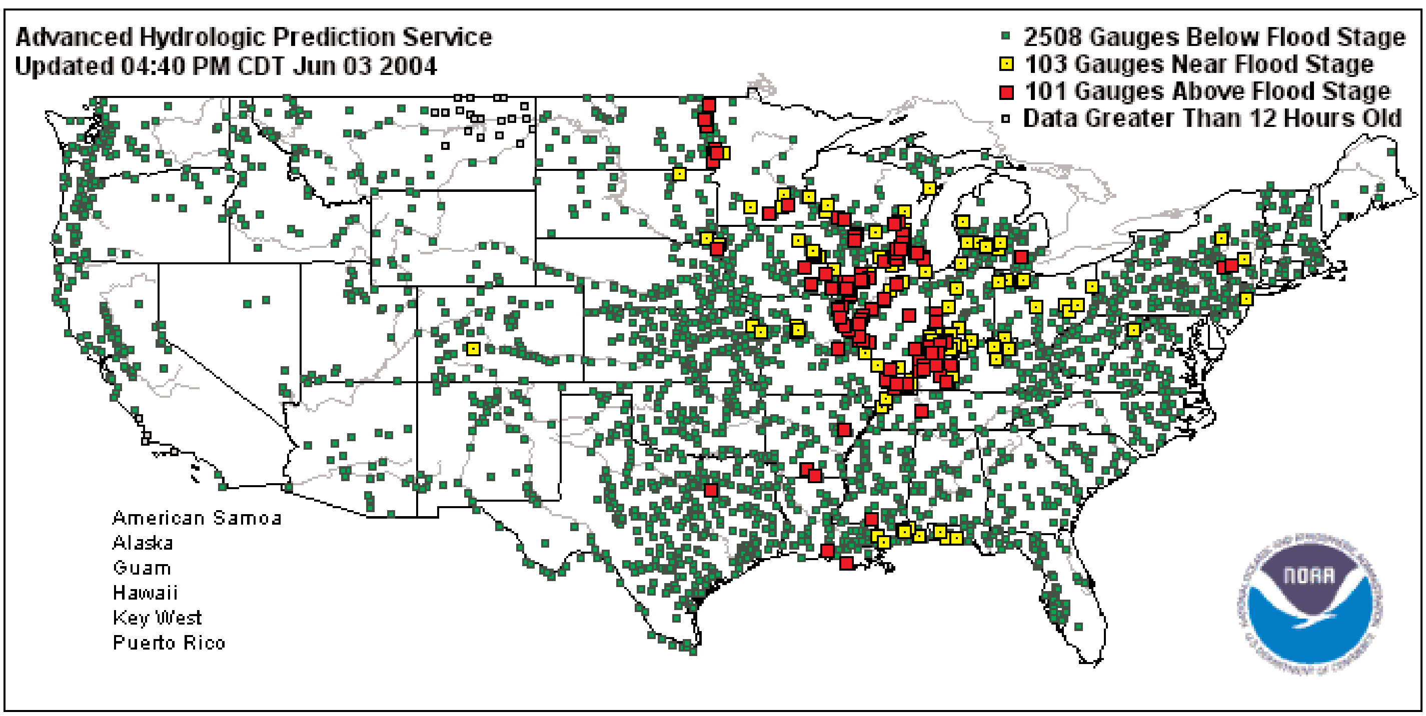


Figure 3-DOC-2. Map showing status of river conditions throughout the Nation. This map is included on the primary AHPS Web page and it provides access to more detailed local information on river conditions, including observations and forecasts at specific locations along rivers, as well as expected impacts that could result from flooding.

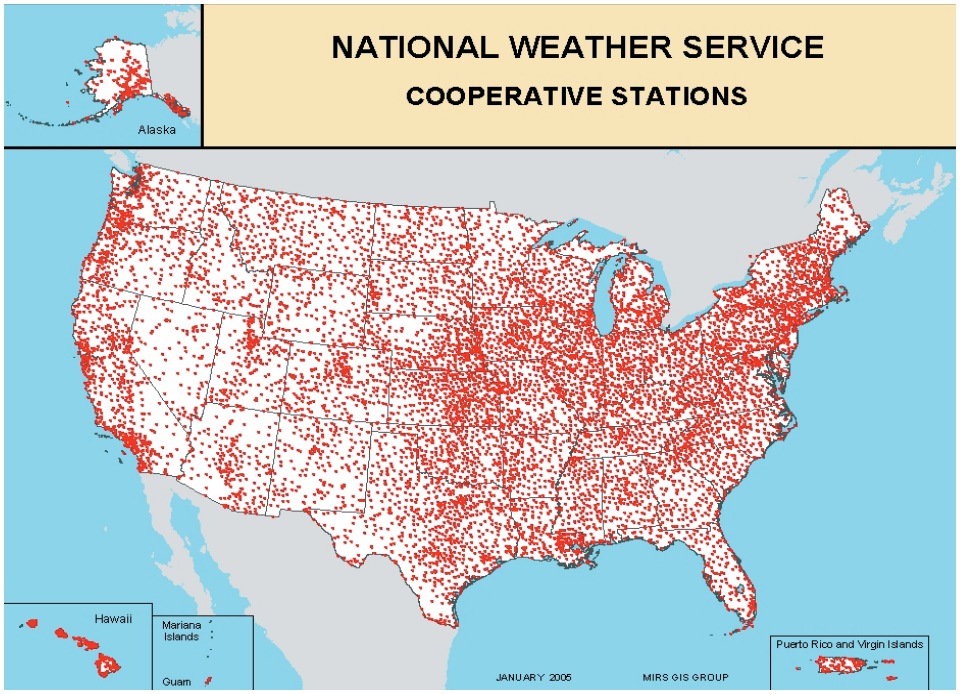


Figure 3-DOC-3. Map showing locations of Cooperative Weather Observer Network (COOP). Interactive web site can be found at *http://www.nws.noaa.gov/om/coop/wfo-rfcmap.htm*

• Replace obsolete observing systems;

• Implement new observing technologies and communication systems that better meet the data needs of our customers; and

• Strengthen the link between user requirements and technology research and development.

The NWS manages programs that produce observations in support of a wide range of customers, such as the aviation, climate monitoring and research communities. As part of its responsibility, the NWS inspects all surface weather observing stations and certifies equipment and observers. NWS Headquarters establishes policy for observations and standards and coordinates with other Government agencies and international organizations.

NOAA's Cooperative Weather Observer Network (COOP) is the Nation's largest and oldest weather network (Figure 3-DOC-3). Modernization of the COOP under NOAA's Environmental Real-Time Observation Network (NERON) is consistent with the President's Climate Change Research Initiative, providing a richer source of data to improve weather, water and climate forecasting and to contribute to climate change research. The COOP is the primary source for monitoring U.S. climate variability over weekly to interannual time frames. These data are also the primary basis for assessments of century-scale climate change. The modernized network will add to NOAA's vision of an-end-to-end monitoring program that "takes the temperature" of the earth's systems.

NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION (NCEP).

NCEP delivers analyses, guidance, forecasts and warnings for weather, ocean, climate, water, land surface and space weather to the Nation and world. NCEP provides science-based products and services through collaboration with partners and users to protect life and property, enhance the Nation's economy and support the Nation's growing need for environmental information. Each service center depends on the observational infrastructure, the data assimilation systems, the numeric modeling function, and the application of model output statistics to produce value added forecast guidance products for NWS field offices and other users.

NCEP is organized into seven science-based, service-oriented centers that generate environmental prediction products and two central support centers that develop and operate numerical models -- the basis for NWS predictions.

<u>Storm Prediction Center</u>.

The Storm Prediction Center (SPC) focuses on hazardous weather events, such as severe thunderstorms, tornadoes, extreme winter weather, and excessive precipitation with emphasis on the first few hours of the forecast period. All Tornado and Severe Thunderstorm Watches issued anywhere in the contiguous U.S. come from the SPC. Also, the SPC prepares Mesoscale Discussions which are technical discussions of developing mesoscale features and their impact on hazardous weather. For longer time periods, the SPC produces the Convective Outlook which are one, two and three-day forecasts of the probability and intensity of both non-severe and severe thunderstorms (including tornadoes). The SPC also issues one and two-day National outlooks for areas with critical and extremely critical fire potential out to two days.

<u>Hydrometeorological Prediction Center</u>.

The Hydrometeorological Prediction Center (HPC) provides forecast, guidance, and analysis products and services (1) to support the daily public forecasting activities of the NWS and its customers, and (2) to provide tailored support to other government agencies in emergency and special situations. As part of this mission, HPC prepares Quantitative Precipitation Forecasts (QPF) used by the RFCs to develop local river and flood forecasts and by WFOs to develop local rainfall, snow and ice forecasts. The HPC provides special QPFs and coordinates with other Federal agencies, such as the Federal Emergency Management Agency (FEMA), during major flood events. The HPC also provides an array of analyses and forecasts out to seven days of frontal systems, pressure patterns, temperature, and precipitation for use by WFOs and the private weather community. Additionally, HPC serves as the backup to the National Hurricane Center.

Aviation Weather Center.

The NCEP experts for aviation meteorology are concentrated at the Aviation Weather Center (AWC). The AWC provides weather warnings, advisories and forecasts to the aviation community under an international agreement through the International Civil Aviation Organization. The AWC provides wind, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and en route aircraft operations for the U.S., the Gulf of Mexico, the Caribbean Sea, the Atlantic and Pacific routes in the Northern Hemisphere and some routes in the Southern Hemisphere.

Environmental Modeling Center.

The Environmental Modeling Center (EMC) improves NCEP's numerical climate, water, and weather predictions through data assimilation and computer modeling. To provide mesoscale predictions (thunderstorms, hurricanes, tornadoes, blizzards, etc.), ocean predictions and global weather and climate predictions, EMC develops, adapts, improves, and monitors data assimilation systems and global, regional and mesoscale models of the atmosphere, land surface, ocean, and atmosphere/ocean/land systems.

The EMC uses advanced modeling methods developed internally and cooperatively with universities, the international scientific community, NESDIS, NOAA laboratories, and other government agencies. As an example, EMC is a partner in the NASA/NOAA Joint Center for Satellite Data Assimilation (JCSDA) designed to accelerate the use of research and operational satellite data in NCEP operational models. The EMC integrates research and technology through collaborative model development projects. These interactions serve as an efficient and effective interface between NCEP and the scientific community that develop ideas, numerical models, and forecast techniques to implement model improvements and improve NWS products.

The EMC conducts applied research and technology transfers and publishes research results in various media for dissemination to the world meteorological, oceanographic, and climate community. EMC also participates in ongoing interactive research programs such as the United States Weather Research Program (USWRP) Hurricane at Landfall project and the community Weather Research and Forecast (WRF) model. Furthermore, EMC is participating in the Winter Storm Reconnaissance Program in the Pacific through targeted observations aimed at improving forecasts across the country. EMC efforts with collaborative development have resulted in improvements to mesoscale and global models, as well as advancements in hurricane track forecasts, climate forecasts and air quality forecasts.

Climate Prediction Center.

The Climate Prediction Center (CPC) provides operational monitoring and prediction of global and regional climate variability, with emphasis on applied research and partnerships, to improve understanding of the global climate system, weather and climate links, extremes and trends. CPC develops and maintains data bases for determining current and historical climate anomalies and trends, and provides analyses and assessments of their origins and linkages to the global climate system. CPC products and services cover time scales ranging from next week (days 6-10) to seasons and out to a year in advance, and cover land, ocean, and atmosphere extending into the stratosphere. CPC's products include probabilistic long range outlooks for temperature and precipitation, the multi-agency U.S. Drought Monitor, a drought outlook, and El Niño Southern Oscillation (ENSO) discussions and outlooks, among many others. WFOs, as well as the public, private industry, and the national and international research community use CPC products and climate services.

Space Environment Center.

The Space Environment Center (SEC) provides national and international forecasts, alerts, and warnings of extraordinary conditions in the space environment, solar radio noise, solar energetic particles, solar X-ray radiation, geomagnetic activity, and conditions of stratospheric warming. The SEC observes, assesses, and predicts activity in the space environment to promote public safety and to mitigate economic loss that could result from disruption of satellite operations, communications and navigation systems, and electric power distribution grids.

The SEC issues to the public, its U.S. Air Force partners, and vendors of value-added services specific predictions of the space weather activity level for the next three days and more general predictions up to several weeks in advance, as well as weekly summaries of observed solar terrestrial conditions. SEC serves as the international World Warning Agency for the International Space Environment Service (ISES). It exchanges international data (solar wind, X-ray, sunspot, corona, magnetic, and ionospheric measurements-in real-time) and, from these data, provides and meets additional specific needs of other government agencies. SEC distributes (receives) data to (from) other countries and issues a consensus set of daily forecasts for international use.

<u>Ocean Prediction Center</u>.

The Ocean Prediction Center (OPC) provides atmospheric and oceanographic warning, forecast, and analysis products and services for the North Atlantic and North Pacific (north of 30 degrees - see Figure 3-DOC-4) as part of the NWS mission of protecting life and property and enhancing economic opportunity. As part of this responsibility, OPC handles U.S. international meteorological obligations to marine interests under the International Convention for Safety of Life at Sea (SOLAS). The OPC provides weather and sea state warnings and forecasts for the offshore waters of the U.S. and the high seas of the Northern Hemisphere north of 30 degrees for planning and operational purposes. OPC warnings and products go directly to ships and are vital for the protection of life and property at sea, and enhancement of the economy. The OPC also coordinates forecasts with and provides forecast guidance to WFOs with coastal responsibilities. The OPC, the Tropical Prediction Center (TPC), HPC, and WFO Honolulu, HI collaborate daily to produce unified and seamless surface weather analyses covering from 30 degrees South to the North Pole, and from East Asia across the Pacific and Atlantic to Western Europe and Africa.

<u>Tropical Prediction Center/National Hurricane Center</u>.

The NCEP experts in the area of tropical meteorology are concentrated in the Tropical Prediction Center (TPC)/National Hurricane Center (NHC). TPC/NHC services include public and marine advisories, watches, and warnings for tropical cyclones in the North Atlantic and eastern North Pacific hurricane basins including the portions of the coastline threatened by such storms. In addition, TPC forecasters provide marine analyses and forecast products for the same areas of responsibility, south of 30 degrees north latitude and a portion of the southeast Pacific. TPC warnings and products go directly to ships and are vital for the protection of life and property at sea, and enhancement of the economy. The TPC/NHC provides guidance, coordination, and tropical weather expertise to WFO forecasters, the media, and private industry.

<u>NCEP Central Operations</u>.

The NCEP Central Operations (NCO) is responsible for NCEP operations, including access to real time data, and its quality control and use in numerical weather prediction systems, as well as the workstations used by NCEP forecasters to access model output and other data necessary for producing guidance products.

The NCO provides management, procurement, development, installation, maintenance, and operation of all computing and communications related services that link individual NCEP activities together. The NCO is the focal point for establishing and executing policies, standards, procedures, and documentation for computing and communications within the entire NCEP organization. The NCO maintains and manages the supercomputer and runs the computer applications that generate all NCEP model products. The NCO leads the technical transition between the research and development of numerical weather and climate prediction models and their operational use on the NCEP computer systems.

In addition, NCO provides 24-hour information services and operational support for NCEP computing systems, including the network which ties together internal NCEP communications, NWS high performance computer systems, forecaster workstations, personal computers and a user service that support all NCEP centers. Since an upgrade to NCEP's main computer systems and facilities in 1999, and throughout subsequent upgrades, NCO has delivered NCEP model forecasts and products to its users with a high degree of reliability and timeliness.

<u>Other NWS Offices with National Responsibilities</u>.

In addition to the NCEP centers, there are two other offices that provide National products. They are the Alaska Aviation Weather Unit and the WFO Honolulu/Central Pacific Hurricane Center.

• Alaska Aviation Weather Unit. The Alaska Aviation Unit (AAWU)

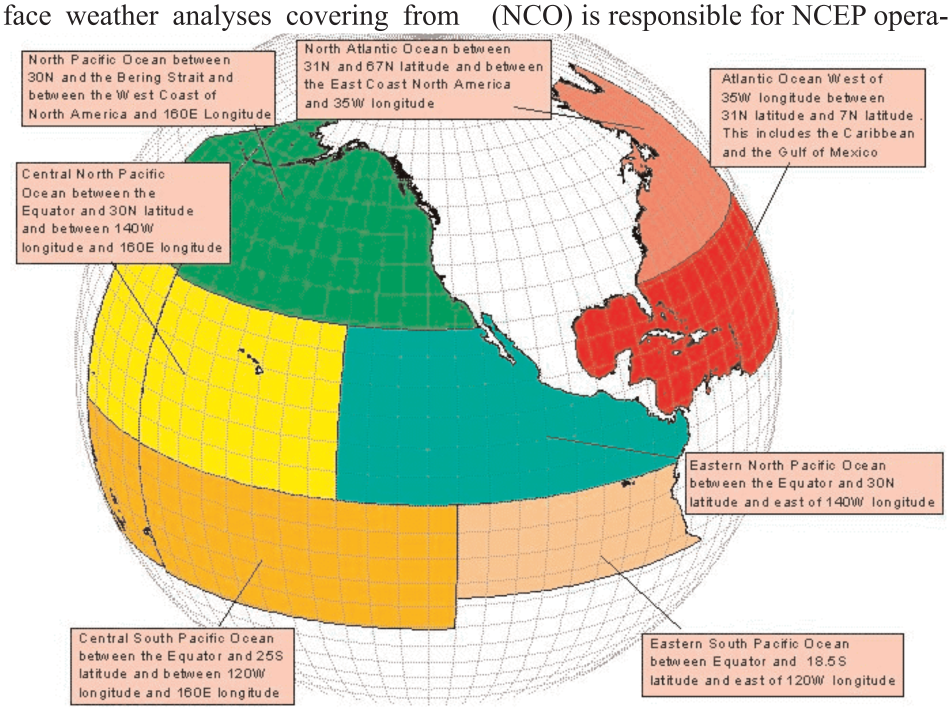
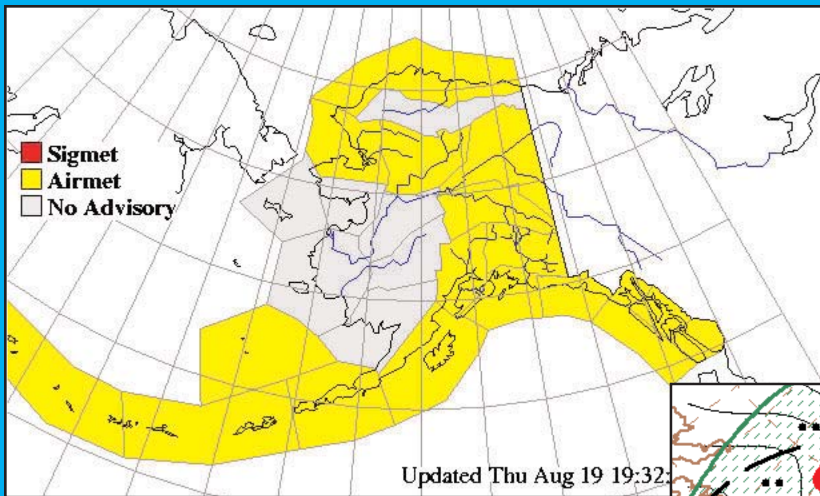


Figure 3-DOC-4. United States High Seas Forecast Areas of Responsibility.

Alaska Aviation Weather Unit



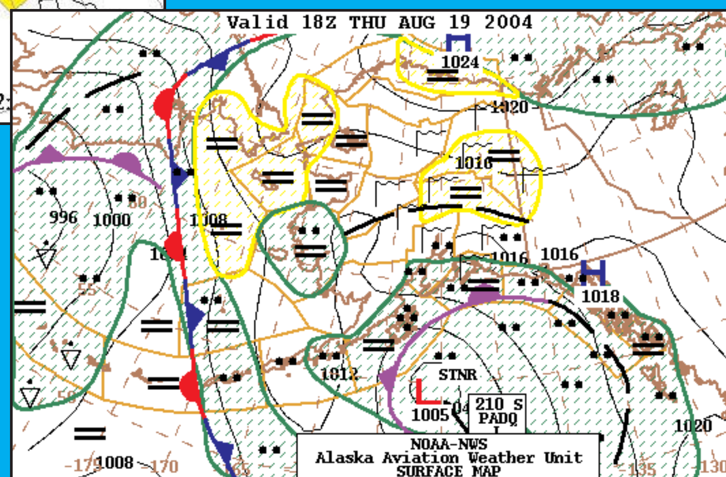


Figure 3-DOC-5. Two products available from the Alaska Aviation Weather Center are an Aviation Weather Clickable map (top, left) and Forecast Surface map (lower, right).

provides wind, temperature, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and enroute aircraft operations for Alaska and surrounding areas (Figure 3-DOC-5).

• WFO Honolulu/Central Pacific Hurricane Center. WFO Honolulu/Central Pacific Hurricane Center (CPHC) provides products in aviation, marine, and tropical cyclone areas. In aviation, WFO Honolulu provides wind, temperature, and flight hazards (e.g., icing, turbulence) forecasts for flight planning and enroute aircraft operations for the central north Pacific from 140 degrees W to 160 degrees E longitude and in the Oakland Flight Information Region south of 30 degrees N latitude through ICAO international agreement. The office handles international meteorological obligations to marine interests under the International Convention for Safety of Life at Sea (SOLAS). WFO Honolulu provides weather and sea state warnings and forecasts for the high seas of the central north and south Pacific south of 30 degrees N latitude. CPHC issues tropical cyclone advisories, forecasts, watches, and warnings for the central north Pacific including Hawaii.

SUPPORTING RESEARCH

The NWS conducts applied research, building upon the more basic research conducted by NOAA laboratories and the academic community. Applied meteorological and hydrological research is integral to providing more timely and accurate weather, water, and climate services to the public.

METEOROLOGICAL RESEARCH.

The NWS conducts meteorological research to develop, test, evaluate, and improve numerical models and analysis/forecast techniques for weather and climate prediction including:

• Techniques for predicting mesoscale phenomena (e.g., heavy precipitation, tornadoes, and severe thunderstorms).

• Models to improve hurricane tracking, hurricane probability estimates, and tropical analyses.

• Storm surge models to assist in developing hurricane evacuation plans for additional coastal basins.

• Techniques to improve prediction of seasonal to interannual climate variability and their impacts on weather variability.

HYDROLOGIC RESEARCH.

The NWS develops, implements and operationally supports improved hydrologic, hydraulic and hydrometeorological models and manages hydrologic data and enhanced quality control procedure to support national flood and water resources forecasting. Research encompasses the following areas:

• Improvements to the Ensemble Streamflow Prediction (ESP) system and its complementary models in the NWS River Forecasting System. Research, development and implementation of improved ESP procedures which improve forecast accuracy and quantify uncertainty at all time scales.

• Specialized flood and flash flood forecasting procedures using linked hydrologic, hydraulic and meteorological models. Major research areas include developing distributed hydrologic models that use high resolution precipitation data from the NWS radar network, improvement of cold region processes in watershed models, and assimilation of data to improve initial conditions. Highly specialized hydraulic models for routing river flows will also provide information for generating maps of inundated areas.

• Development of improved multi-sensor precipitation estimates for input estimates for input into operational hydrologic and atmospheric models. Radar, rain gauge and satellite rainfall estimates are merged to produce optimum rainfall analyses.

• Development of verification methods to assess the added-value of new science and technology to the customer.

SPACE WEATHER RESEARCH.

Research and development at SEC emphasizes understanding of the fundamental physical processes governing the regime from the solar surface, through the interplanetary medium, into the magnetospheric-ionospheric regions, and ending in Earth's upper atmosphere. These processes are manifest in the climatology and disturbances of Earth's magnetic field, the ionosphere, the charged particle populations at satellite orbits, and the atmospheric density at high altitudes (including low-Earth orbit). This applied research is focused on areas where advanced applications can be devised and prototyped to improve the specification and forecast of conditions in the space environment by developing and implementing models and indices, as well as by obtaining and processing new observations.

• Developing of the first dynamic, global ionospheric model to use ensemble Kalman filter techniques to assimilate data every 15 minutes. Disparate data from widely dispersed sources will enable the model output to be useful to radio-communicators and Global Positioning System (GPS) and Loran users.

• Developing of models to characterize and predict geomagnetic storm intensity development, spatially and temporally.

SUPPORT FOR COLLABORATIVE RESEARCH WITH THE ACADEMIC COMMUNITY AND OTHER PARTNERS.

The Collaborative Science, Technology, and Applied Research (CSTAR) program was established to bring NWS-supported collaborative activities with the academic community into a structured program and to create a cost-effective transition from basic and applied research to operations and services. The CSTAR Program issues requests for proposals through which colleges and universities compete for 1-3 years of research funding. CSTAR supports shorter-term research activities with colleges and universities through the NWS/Cooperative Program for Operational Meteorology, Education, and Training (COMET) Outreach Program. The NWS also funds specific applied research grants and cooperative agreements directly in support of hydrology and meteorology research needs.

TRAINING.

NOAA's NWS provides training to its work force to enhance the professional and scientific development of its staff in support of NOAA's NWS mission and strategic goals. Training deficiencies and requirements are identified and addressed via the National Strategic Training and Education Plan (NSTEP) process, described in NWS Instruction 20-102 and available at http://www.nws.noaa.gov/directives/020/pd02001002a.pdf.

Training is provided through a variety of in-residence courses and distance learning techniques. Hands-on, in-residence training can be acquired at any of the three NOAA's NWS professional training facilities. The NWS Training Center (NWSTC) in Kansas City, Missouri, provides technical, meteorological and hydrologic, and management/leadership training. The Warning Decision Training Branch (WDTB) in Norman, Oklahoma, conducts situational awareness and remote sensing training with modules that integrate data for improving the warning decision process.

Finally, the Cooperative Program for Operational Meteorology, Education and Training (COMET) in Boulder, Colorado, offers advanced meteorological and hydrometeorological education to ensure that NWS employees have access to the latest software, hardware to improve forecasting techniques. All three facilities also offer distance learning, Internet modules, teletraining, webcasts and CD-ROM based training. NWS employees have direct access to scientific and managerial training materials through the DOC/NOAA Learning Management System (LMS).

The NWSTC, is also working to expand its leadership training and development skills through NOAA's NWS Leadership Academy. The goal of the Leadership Academy is to enable NWS and NOAA employees to become world-class leaders. The Academy is built on a sequential and progressive design to help develop employee professional skills and capabilities to improve employee performance. From entry into the agency to senior career status, employees can take advantage of courses and processes that are part of a powerful management and leadership learning environment. Finally, NWS is working to develop an organized curriculum to supply the necessary knowledge, skills, and abilities for all positions.

The National Environmental Satellite, Data, and Information Service (NESDIS), part of the National Oceanic and Atmospheric Administration (NOAA), manages the U.S. civil operational environmental satellite systems, as well as the three NOAA National Data Centers (NNDCs) that develop global, national, and regional databases that support meteorology, oceanography, geophysics, and the space environment. From these sources, NESDIS develops and distributes environmental data and information products and services critical to the protection of life and property, the national economy, energy development and distribution, global food supplies, and development and management of environmental resources.

NESDIS was established as a NOAA line office on December 1, 1982. The merger of the former National Environmental Satellite Service (NESS) and the Environmental Data and Information Service (EDIS) formed NESDIS.

NESDIS procures, launches and operates two types of satellites to provide worldwide environmental data and information products and services to Federal agencies, state and local governments, and private users. These are the Polar Operational Environmental Satellite (POES) and Geostationary Operational Environ-mental Satellites (GOES).

Currently NESDIS is operating six polar orbiters. NOAA-17 and NOAA-18 are classified as the primary "operational" satellites and are part of the new series of polar orbiters, with improved sensors, that began with the launch of NOAA-15 in May 1998, followed by NOAA-16 on September 21, 2000, NOAA-17 on June 24, 2002, and finally, the newest, NOAA-18 on May 20, 2005. The NOAA-12, NOAA-14 and NOAA-15 satellites continue to transmit data as stand-by satellites. NOAA-16 will soon also join the ranks as a stand-by, with the successful check-out of NOAA 18. NOAA-17 serves as the primary morning satellite and NOAA-18 the primary afternoon satellite. The POES satellites are constantly circling the Earth in an almost

north-south orbit, passing close to both poles. The orbits are circular, with an altitude between 830 (morning orbit) and 870 (afternoon orbit) km, and are sun synchronous. One satellite crosses the equator at 10:00 a.m. local time, the other at 2:00 p.m. local time. The circular orbit permits uniform data acquisition by the satellite and efficient control of the satellite by the NOAA Command and Data Acquisition (CDA) stations located near Fairbanks, Alaska, and Wallops Island, Virginia. Operating as a pair, these satellites ensure that data for any region of the Earth are no more than six hours old. Each satellite orbits the Earth 14 times per day, collecting global data for atmospheric and surface measurements in support of short-term weather forecasting and longer-term global climate change research. NOAA also manages the command, control, and communications function of the Department of Defense's (DOD's) Defense Meteorological Satellite Program (DMSP) constellations.

An agreement with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) gives EUMETSAT responsibility for the morning segment of the polar environmental mission (circa 9:30 a.m. LST), with U.S.-provided payload instruments and sensors, beginning in 2006. Thus, upon inception of this operational arrangement, NOAA will operate the afternoon mission while EUMETSAT will support the morning mission. Under this joint mission, upgraded instruments will be flown that will result in improvements for the user community. For example, the High Resolution Infrared Sounder (HIRS) instrument will be upgraded resulting in improved atmospheric sounding information. The Advanced Very High Resolution Radiometer (AVHRR) global one-kilometer data will be available enhancing the usefulness of this data for fire detection, CoastWatch, and any other applications that require higher resolution. It also provides the opportunity to use new sensor data from EUMETSAT instruments, in preparation for future NPOESS support.

On October 3, 1994, NOAA, DOD, and the National Aeronautics and Space Administration (NASA) combined the nation's military and civilian environmental satellite programs to create an Integrated Program Office (IPO) to develop, manage, acquire, and operate the national polar-orbiting meteorological satellite system, subsequently designated the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The IPO is organizationally located within NOAA and is headed by a System Program Director responsible to the NPOESS Executive Committee. This committee, which consists of the Under Secretary of Commerce for Oceans and Atmosphere, the Under Secretary of the Air Force, and the NASA Deputy Administrator, serves as a board of directors to ensure that overall program plans also meet the individual needs of the three participating agencies.

The IPO concept provides each of the participating agencies with lead responsibility for one of three primary functional areas. NOAA has overall responsibility for the converged system and is responsible to the IPO for satellite operations. NOAA is also the primary interface with the international and civil user communities. DOD is responsible to support the IPO for major systems acquisitions including launch support. NASA has a primary responsibility for facilitating the development and incorporation of new cost-effective technologies into the converged system. Although each agency provides certain key personnel in their lead role, each functional division is staffed by tri-agency work teams to maintain the integrated approach. The first operational satellite and ground system will be delivered by the shared system performance prime contractor, Northrop Grumman, and is expected to be available late in this decade depending on when the current U. S. polar satellite assets are exhausted.

NPOESS will provide standard meteorological, oceanographic, environmental, climatic, space environmental remote sensing information, as well as continue providing surface data collection and search and rescue capability. The IPO, in consultation with NOAA and DMSP program offices, is also studying additional potential cost effective approaches to maximize user satisfaction during the transition to NPOESS while guaranteeing continued non-interrupted data services.

The first NPOESS launch is planned for 2009. However, the NPOESS system is a launch-on-demand system. Based on this strategy, the first NPOESS satellite, referred to as C1, should be available in 2008 to support any potential on-orbit or launch failure of existing U.S. polar satellites. However, based on the latest revisions, the new launch date for C1 is November 2009 (See Table 3.1).

NESDIS is also responsible for operating two Geostationary Operational Environmental Satellites (GOES), referred to as GOES East and GOES West. Each satellite views nearly one third of the Earth's surface. The GOES-12 (East) satellite is positioned at 75 degrees W longitude and the equator and monitors North and South America and most of the Atlantic Ocean. The GOES-10 (West) satellite is positioned at 135 degrees W longitude at the equator and monitors North America and the Pacific Ocean basin. The two operate together to provide the kind of continuous monitoring necessary for effective and extensive data analyses. GOES East and West circle the Earth in a geosynchronous orbit, which means they orbit the equatorial plane of the Earth at a speed matching the Earth's rotation. This allows them to hover continuously over one position on the Earth's surface.

The geosynchronous plane is about 35,800 km (22,300 miles) above the Earth, high enough to allow the satellites a full-disc view of the Earth. Because they stay above a fixed spot on the surface, they provide a constant vigil for the atmospheric "triggers" of severe weather conditions such as tornadoes, flash floods, hailstorms, and hurricanes. When these conditions develop, the GOES satellites are able to monitor storm development and track their movements.

Additionally, as part of a NOAA bilateral agreement with Japan, GOES-9 has been provided to the Japanese Meteorological Agency to replace a Japanese geostationary satellite. This will ensure Pacific geostationary satellite coverage for Japan, the U.S. and our allies until the operational readiness of the Japanese Multifunctional Transport Satellite (MTSAT-1R) launched in 2005 is determined. MTSAT-1R will replace GOES-9 as the primary geostationary environmental satellite in the west Pacific region. Finally, GOES-11 is being stored in orbit as a replacement for GOES-12 or GOES-10 in the event of failure of either of these systems.

ENVIRONMENTAL SATELLITE SERVICES

OFFICE OF SATELLITE OPERATIONS.

The Office of Satellite Operations (OSO) directs the operation of NOAA's environmental satellites and the acquisition of remotely sensed environmental data. It manages the Satellite Operations Control Center (SOCC) and Command and Data Acquisition (CDA) stations, which command and control, track, and acquire data from these environmental satellites.

OSO took over the command, control, and communications function of the DOD's DMSP constellation in 1998. The mission of DMSP is to provide meteorological and special sensor data to users in support of worldwide DOD missions. DMSP is now operated from the SOCC at Suitland, Maryland. The SOCC is the primary center for normal operations, mission planning, engineering, launch and early orbit support, and anomaly resolution. A new ground system was developed for DMSP called Integrated Polar Acquisition and Control Subsystem.

OFFICE OF SATELLITE DATA PROCESSING AND DISTRIBUTION.

The Office of Satellite Data Processing and Distribution (OSDPD) directs the operations of NESDIS central ground data processing facilities. It processes and distributes data from NOAA and non-NOAA environmental satellites and generates automated and interpretive products for various government agencies, private industry and educational institutions. Key customers include the NWS, DOD, FAA, NASA, worldwide Meteorological Watch Offices, EPA and state environmental protection agencies, foreign meteorological agencies, U.S. airlines, universities and private sector companies.

OSDPD exploits data from NOAA polar and geostationary environmental satellites, foreign (European, Japanese, and Indian) operational satellites as well as domestic and foreign research satellites. The latter includes NASA's Tropical Rainfall Measuring Mission (TRMM), QuikSCAT, Earth Observing System satellites (including Aqua, Terra, and Aura missions), Japan's ADEOS-II, and the DOD's WindSAT mission.

OSDPD products are used in real time in the production of forecasts and warnings of severe environmental events such as tornados, thunderstorms, flash floods and hurricanes. Some OSDPD products, such as calibrated radiances from polar orbiting sounders, vertical temperature and moisture profiles, cloud tracked wind speed and direction, and snow cover, are routinely integrated into numerical weather prediction models on a global scale. These products often provide key model input parameters where routine in-situ measurements are not available.

OSDPD satellite products are generated and distributed to a diverse user community for a broad range of environmental applications. The operational satellite data distribution networks provide user access to real-time or near real-time environmental data and information. Quality assurance procedures are used to systematically evaluate and characterize the satellite products and services. This applies to both the fully automated products such as remapped GOES channel imagery and geophysical parameters (e.g., vertical wind profiles, bulk moisture and atmospheric stability indices, etc) and POES-derived parameters (e.g., channel brightness temperatures, precipitation estimates, vegetation indices, sea-surface temperature, temperature and moisture profiles, etc), as well as to the value-added interpretive or analyzed products used to support disaster mitigation and warning services for various Federal agencies and the international community.

The latter category includes products such as tropical storm position and intensity, fire locations and associated smoke areal extent, quantitative precipitation estimates for flash flood warnings, and volcanic ash plume extent and height. OSDPD works closely with its partners in the customer-supplier chain to ensure the most effective and timely implementation of its satellite data products and services. Working with NESDIS research organizations such as The Office of Research and Application (ORA) on the supplier side, and with government (primarily NWS), educational and other organizations on the customer side, new and enhanced product generation algorithms are tested, evaluated, and implemented when deemed sufficiently validated and operationally useful. In partnership with other agencies and internal NESDIS organizations, new technologies are investigated and periodically deployed to satisfy emerging user requirements.

OSDPD distributes these environmental satellite products to the NWS Advanced Weather Interactive Processing System (AWIPS), National Centers for Environmental Prediction (NCEP) and Weather Forecast Offices (WFOs), and other Federal, state, and private sector organizations through dedicated satellite processing and server configurations, or through the NOAAPORT satellite point-to-multipoint broadcast facility. The satellite data and products transmitted via NOAAPORT include remapped imagery, satellite precipitation estimates, high-density wind direction and speed projections at various atmospheric levels, GOES satellite imagery, and volcanic ash advisory messages. Over one hundred universities receive satellite data and products supplied via NOAAPORT. NOAAPORT also delivers GOES and POES products in near real-time to the AWIPS. AWIPS is the NWS display and analysis workstation used in NWS national centers and field sites to integrate and display satellite data, model output, in-situ observations, and radar and wind profiles used in the production of hydrometeorological analyses and forecasts.

In addition, OSDPD serves as NCEP's backup for NOAA GOES data via the Man Computer Interactive Data Access System (McIDAS) and as a primary source to NCEP of NOAA POES and non-NOAA geostationary satellite data. OSDPD also uses various web sites to disseminate satellite data and products. For example, one site (http://www.ssd. noaa.gov) provides information and products on a multitude of OSDPD operational product areas including: worldwide tropical cyclone analyses, volcanic ash analyses, heavy precipitation analyses, snow/ice cover, and smoke and fire analyses. High quality imagery and derived products are extremely popular during hurricane season. Another OSDPD web site (http:// www.osei. noaa.gov) provides satellite imagery of significant environmental events such as oil spills, icebergs, hurricanes, and fires. Satellite data in digital scientific format are also available from ftp://gp16.ssd.nesdis. noaa.gov/ and several data sets are made available in Geographic Information System (GIS) format through http://www.gis.ssd.nesdis.noaa.gov/. A variety of geophysical products derived from both NOAA and non-NOAA polar orbiting platforms can be found at http://www.osdpd.noaa.gov/PSB/PSB.html.

NESDIS continues to support the Cospas-Sarsat Program through provision of satellites, ground stations, and alert data distribution services. In 2004, Cospas-Sarsat contributed to the rescue of 1,465 people worldwide and 260 people in the U.S. The Cospas-Sarsat program consists of Russia, the U.S., India, France, and Canada providing the space segment and 31 other countries providing ground systems to relay distress alerts and participate in the management of the program. NESDIS operates and maintains the U.S. SARSAT Mission Control Center and twelve Local User Terminals as ground stations.

The Local User Terminals receive 121.5/243/406 MHz emergency beacon signals directly from the satellites and process the information to provide the location of distress transmissions. Cospas-Sarsat will terminate satellite processing of 121.5/243 MHz signals beginning February 1, 2009. This decision was made in response to guidance from the International Civil Aviation Organization and the International Maritime Organization. These two specialized agencies of the United Nations are respectively responsible for international aviation and maritime search and rescue standards. The use of new emergency beacons that can use the Global Positioning System (GPS) to provide an accurate position continues to increase. NESDIS, working with its partners in the U.S. Air Force, U.S. Coast Guard and NASA, is developing plans to augment the Cospas-Sarsat System with search and rescue instruments on future Global Positioning System (GPS) Block III satellites.

NATIONAL ICE CENTER.

The U.S. National Ice Center (NIC), under sponsorship of the U.S. Navy, NOAA, and the U.S. Coast Guard (USCG), is tasked with providing the highest quality operational global, regional, and tactical scale sea ice analyses and forecasts, tailored to meet the requirements of U.S. national interests. NIC ice products are produced in a digital workstation environment using data from polar orbiting satellites, ship/shore station reports, drifting buoys, meteorological guidance products, ice model predictions, and government partners including foreign ice services. The primary remotely sensed data sources used for global and regional-scale ice mapping are visible and infrared imagery from the POES Advanced Very High Resolution Radiometer (1.1 km spatial resolution) and the DMSP Operational Linescan System (0.55 km spatial resolution). In areas of extensive cloud cover, the NIC uses Special Sensor Microwave Imager (SSM/I) sensor data (19 and 37 GHz channels) processed using the CAL/VAL and NASA Team ice concentration algorithms. These algorithms produce 25 km griddled mosaic ice maps that are instrumental in the production of NIC weekly composite Arctic/Antarctic ice maps. Higher resolution ice analysis products, used to ensure the safety of navigation and protect life and property at sea, are dependent upon availability and use of Synthetic Aperture Radar (SAR) data from the Canadian RADARSAT-1. RADARSAT's ScanSAR wide mode produces a 500 km wide swath with 100 m spatial resolution. Images are processed at four different ground stations and transferred to the NIC via dedicated communication lines or via the Internet within six hours of acquisition. The NIC science team, which assists in the transition of pertinent scientific research to operations, is working on the transition of real-time passive and active microwave sea ice products to the NIC operations floor, conducting an evaluation of current sea ice algorithms, and the use of satellite and in-situ data for initializing and evaluating the Polar Ice Prediction System (PIPS).

Routine NIC ice guidance products include regional-scale ice maps, annotated satellite imagery, short and long-term ice forecasts, and legacy ice information and ice climatology. Specialized support services include specific regional support, ship route recommendations, pre-sail ship briefings, aerial ice reconnaissance, and ship rider support. Specific sea ice features analyzed include ice edge position, ice concentration, ice thickness, form or floe size, ice motion, areas of compression and heavy surface deformation, and the location/orientation of open water or thin ice-covered leads. Ice products are disseminated via the Internet (www.natice.noaa.gov) as simple electronic charts in Joint Photographic Experts Group (JPEG format), GeoTiff and other GIS-compatible coverages in the World Meteorological Organization (WMO) digital standard for Sea Ice in GRIDDED (SIGRID-3) format. Date and time of data acquisition as well as the percentage of each data type used in all ice analyses are documented in a metadata narrative.

Another NIC responsibility is oversight of the U.S. Interagency Arctic Buoy Program (USIABP). The USIABP was established in 1992, to provide the management structure and coordination necessary to maintain a baseline network of drifting buoys. Buoys within the array provide sufficient spatial resolution to define surface ,synoptic scale atmospheric pressure, air temperature, and sea-ice drift fields. Data are used in real-time for operational weather and ice forecasting and for research in the Global Climate Change Program. The USIABP is a collaborative program that draws operating funds and services from the collective contributions of government agencies and/or programs. These organizations include: the Naval Oceanographic Office, Office of Naval Research (ONR), NASA, National Science Foundation (NSF), and NOAA's NESDIS, OAR, and the Office of Global Programs (OGP).

OFFICE OF RESEARCH AND APPLICATIONS.

The Office of Research and Applications (ORA) provides guidance and direction for NESDIS research and applications activities. It coordinates the efforts of the Climate Research and Applications Division, Atmospheric Research and Applications Division, and Oceanic Research and Applications Division. These divisions conduct studies on the use of satellite data to monitor environmental characteristics and change and develop algorithms to produce satellite products for applications to operational weather and ocean analyses and prediction. Further, ORA participates in the development of new spacecraft and sensors for future systems. It also carries out a vigorous program to calibrate and validate satellite data to ensure its quality for near-real-time and long-term studies. Additionally, ORA through division participation, actively educates others on technology transfer programs through scientific presentations, technical reports, Internet-based tutorials, and training workshops at domestic and international sites.

Joint Center for Satellite Data Assimilation

THE JOINT CENTER FOR SATELLITE DATA ASSIMILATION (JCSDA).

The JCSDA was created by a Memorandum of Agreement between NOAA and NASA, with affiliated partnerships with the U.S. Navy and U.S. Air Force. This cooperative agreement will allow NOAA, NASA, and DOD to work together to take advantage of their combined science and technology resources in order to accelerate the use of existing and new satellite data. The JCSDA will provide a focal point for joint research and development of common models and infrastructure among its partners. As a result of its collaborative nature, the JCSDA will allow NOAA to improve numerical weather and climate prediction through the optimal use of data from existing satellites and to prepare for the incoming flood of new data from advanced satellite instruments, such as NPOESS, that will be launched during the next five to six years. The JCSDA is tasked with developing new and powerful techniques to assimilate data into numerical weather prediction (NWP) and numerical climate prediction models. JCSDA activities directly support the missions of NASA, NOAA, and as DOD as well as those of other organizations who share or rely on NOAA's environmental assessment, prediction, and stewardship mission. In addition, through its partnership and coordination with DOD and other agencies, the JCSDA will enhance the Nation's ability to respond to increase data reporting and data sharing needs brought on by the renewed emphasis on homeland defense and national security concerns.

The initial projects within the JCSDA will focus on fully exploiting uses of current satellite data. As a part of efforts to facilitate the transition from research into operations, early projects will focus on maturing the process of transitioning these data into operations and developing tools to support future assimilation projects. Six initial scientific priorities have been identified:

• Develop a community-based radiative transfer model (CRTM) to be used by the JCSDA partners in their data assimilation systems. In the next few years, the accuracy and capability of the JCSDA CRTM will be significantly improved by including additional physical processes (e.g., atmospheric scattering) and better numerical techniques and better surface emissivity models to allow more satellite data which is affected by surface to be properly assimilated.

• Develop the data thinning and configuration technology and methodology that will allow faster and efficient delivery of advanced satellite data to major NWP centers in the U.S. and other international partners.

• Advance the techniques to assimilate satellite data in cloudy and precipitation regions by improving radiative transfer models and NWP cloud prediction scheme, thereby significantly increasing the fraction of satellite data being ingested into the assimilation systems.

• Improve the use of satellite land products (e.g., green vegetation fraction, snow cover, snow pack parameters, surface albedo, land, and sea surface temperature) in NWP models.

• Improve the use of satellite data in ocean data assimilation by providing assimilated ocean data sets to the community for research purposes and providing access to and support of an operational ocean data assimilation system.

• Assimilate satellite derived aerosol, ozone and trace gas products to improve forecasts of visibility and health index with the state-of-the-art air quality forecast model including chemical and biological process.

In addition, the JCSDA has a long-term strategic goal of improving the transfer of data assimilation research into operations by fostering common data assimilation code components, including techniques for specifying observation errors, background error co-variances, and data selection and reduction.

The JCSDA approach is already generating measurable accomplishments. Recent accomplishments include:

1. Improved radiative transfer techniques:
   - Microwave land emissivity model implemented in NCEP operational global data assimilation system (GDAS).
   - Community fast radiative transfer model implemented operationally in the GDAS.
   - More AMSU-A data are used over land, snow and sea ice conditions
2. Improved uses of current satellite data:
   - More AMSU-A data are used over land.
   - Increased use of HIRS, AMSU-A data in stratosphere.
   - SSM/I, TRMM precipitation products.
   - AMSU cloud liquid water.
   - GOES-10 IR radiances.
   - QuikSCAT winds.
3. More satellite data being used in NCEP operational models:
   - SSM/I, TRMM precipitation products.
   - AMSU cloud liquid water.
   - GOES-10 IR radiances.
   - QuikSCAT winds.
   - MODIS winds.

POLAR SATELLITE PROGRAM.

The primary mission of the Polar-orbiting Operational Environmental Satellite (POES) System is to provide daily global observations of weather patterns and environmental measurements of the Earth's atmosphere, its surface and cloud cover, and the proton and electron flux at satellite altitude. Since the beginning of the POES program, environmental data and products acquired by its satellites have been provided to users around the globe. These satellites increase the accuracy of weather forecasting by providing quantitative data required for improved numerical weather forecast models. Currently, the two primary operational spacecraft are NOAA-17 and NOAA-18.

NOAA polar satellites carry instruments to provide atmospheric temperature and moisture profiles. In addition to taking thermal images of the earth's surface and atmosphere, the NOAA polar-orbiting satellites carry sounder instruments to provide vertical profiles of atmospheric temperature and moisture. They also provide multi-channel images and carry a data collection and platform location system, and a Search and Rescue Satellite-Aided Tracking (SARSAT) subsystem. The SARSAT subsystem is used to detect and locate distress alerts from maritime, aviation, and land-based users of emergency beacons operating at 121.5 or 243 or 406 MHz.

POES satellites carry four primary instrument systems: the Advanced Very High Resolution Radiometer (AVHRR); and the TIROS Operational Vertical Sounder (TOVS); the Space Environment Monitor (SEM); and the Solar Backscatter Ultra-Violet Instrument (SBUV/2). The AVHRR provides data for real-time transmission to both Automatic Picture Transmission (APT) and High Resolution Picture Transmission (HRPT) users and for storage on the spacecraft tape recorders for later playback. The AVHRR/3 series of instruments, which began with NOAA-15, measures in six spectral channels (0.63, 0.86, 1.6, 3.75, 10.8 and 12 μm) with a nominal spatial resolution of 1.1 km and global resolution of roughly 4 km. Though the AVHRR/3 measures 6 channels, only 5 are transmitted in the data stream at any one time; the 1.6 and 3.75 m channels are time shared. The AVHRR/3 provides stored and direct-readout radiometer data for day and night cloud cover, sea surface temperatures, vegetation indices, fire detection, and snow and ice mapping. TOVS is comprised of the High-resolution Infrared Radiometer Sounder (HIRS) and the Advanced Microwave Sounding Unit (AMSU).

The HIRS/3 is a discrete-stepping, line scan instrument designed to measure scene radiance in 20 spectral bands to permit the calculation of the vertical temperature profile from Earth's surface to about 40 km. Multi-spectral data from one visible channel (0.69μm), seven shortwave channels (3.7 to 4.6μm), and twelve long wave channels (6.5 to 15μm) are obtained from a single telescope and rotating filter wheel containing twenty individual filters. An elliptical scan mirror provides cross-track scanning of 56 increments of 1.8μm. The mirror steps rapidly (<35 msec), then holds at each position while the 20 filter segments are sampled. This action takes place each 100 msec. The instantaneous field of vision (FOV) for each channel is approximately 1.4μm in the visible and shortwave IR, and 1.3μm in the long wave IR band that, from an altitude of 833 km, encompasses an area of 20.3 km and 18.9 km in diameter, respectively, at nadir on the Earth.

Each AMSU-A instrument is composed of two separate units:

(a) AMSU-A2 with two channels at 23.8 and 31.4GHz and (b) AMSU-A1 with twelve channels in the range of 50.3 to 57.3GHz and one channel at 89.0GHz. The AMSU-B has five channels with frequencies centered on 89, 150, 183±1, 183±3, and 183±7Ghz, respectively. AMSU-B, provided by the United Kingdom Meteorological Office, produces soundings of humidity from the surface to 200 millibars (mb). AMSU-A has a nominal FOV of 3.3 degrees (48 km on surface at nadir) and AMSU-B a field of view of 1.1 degrees (16 km on surface at nadir). AMSU-A (AMSU-B) samples 30 degrees (90 degrees) Earth views, covering ±48.95 degrees from the subsatellite point. In addition, the specialized 89GHz channel, with the capability to "see" through high and mid-level clouds to low level precipitation producing clouds, is used to determine the position and structure of tropical cyclones on a global scale. The AMSU-A1 uses two antenna systems, providing observations in the twelve oxygen band channels (3-14) for retrieving the atmospheric temperature profile from the Earth's surface to about 42 km, or from 1000 to 2 mb. The remaining three channels (1 and 2 from A2 and 15 from A1) aid the retrieval of temperature soundings by correction of surface emissivity, atmospheric liquid water, and total precipitable water. These window channels also provide information on precipitation, sea ice, and snow coverage.

The SEM measures solar proton flux, alpha particle and electron flux density, and energy spectrum and total particulate energy distribution at spacecraft altitudes. The two sensors included within this instrument are the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED), in addition to a common data processing unit. This instrument augments the measurements made by NOAA's geostationary satellites.

The NOAA-16, NOAA-17, and NOAA-18 POES carry the SBUV/2. The SBUV/2 instrument is a non-scanning (fixed nadir viewing) spectrometer designed to measure scene radiance and solar spectral irradiance from 160 nanometers to 400 nanometers. Data obtained from the instrument are used to compute the amount and vertical distribution of ozone in the Earth's atmosphere on the sunlit side of the Earth. Ozone evaluation, calibration, and validation activities took place for the new Solar Backscatter Ultraviolet Instrument (SBUV/2) with the launch and successful checkout of NOAA-17 & 18. A new ozone profile retrieval algorithm (Version 8) is under development at NASA. As soon as it becomes available, NOAA will begin to incorporate it in its SBUV/2 processing systems.

Monitoring of global ozone will continue with the SBUV/2 instruments on NOAA-14, NOAA-16, NOAA-17, NOAA-18, and with the TOVS instruments on NOAA-14, NOAA-15, NOAA-16, NOAA-17, and NOAA-18. Experimental ozone products at high temporal resolution are also being produced from the GOES-8 sounder channels. Monitoring is limited to North America. Preliminary results show the GOES total ozone values are comparable to amounts from the Total Ozone Mapping Spectrometer and ground-based measurements.

The ground system required to receive large volumes of digital data from NOAA satellites consists of two major subsystems: the Polar Acquisition and Control Subsystem (PACS) and the Central Environmental Satellite Computer System (CEMSCS). The PACS includes the Wallops, Virginia, and Fairbanks, Alaska, Command and Data Acquisition (CDA) stations and the SOCC at Suitland, Maryland. All the CEMSCS components are in the NOAA facility at Suitland. PACS is used to command and control the spacecraft, monitor its health via housekeeping telemetry, and retrieve and transmit the spacecraft environmental data to the CEMSCS processing and data handling facility. The delivery of NOAA system data from the CDA to Suitland is accomplished by using the General Electric American Communications, Inc. commercial satellite communications network. This system, which includes Earth stations at Suitland, Wallops, and Fairbanks, delivers the data to SOCC. These data are immediately passed to the CEMSCS for processing. The CEMSCS ingests the raw satellite data and pre-processes and stores them along with appended auxiliary information, such as Earth location, calibration, and quality control parameters. The data processed by the CEMSCS are used for environmental products and operational weather predictions that are disseminated to users throughout the world.

The Argos Data Collection (and location) Service (DCS) operates on the NOAA Polar-orbiting Operational Environmental Satellite (POES) constellation and was established through a Memorandum of Understanding (MOU) with France in 1974. NOAA for the U.S. and the Centre Nationale d'Etudes Spatiales (CNES) for France are the lead agencies for this international cooperative agreement. CNES provides for the development and delivery of the Argos DCS instrument. NOAA provides spacecraft integration/launch services, downloads stored mission data via NOAA Command Data Acquisition facilities and provides pre-processed data delivery. Data post-processing and delivery to customers is the responsibility of CNES, which through a subsidiary maintains distribution centers located in Toulouse, France and Largo, Maryland.

The Argos DCS is a space-based, data telemetry system that provides a global means to locate and collect environmental data from fixed and moving, low-power transmitters; i.e., polar ice flows, ocean buoys, birds, mammals, etc in near-real time (15 minutes - 3 hours). The Argos DCS transmits data for operational and research related environmental applications, e.g. meteorology, oceanography and protection of the environment, with the majority of users being government/non-profit agencies and researchers. Argos DCS customers are engaged in over 1000 programs operating approximately 15,000 data collection platforms in 72 counties.

The Argos DCS program continues to develop international partnerships and will incorporate Argos instruments on other international satellite platforms, such as the European Organization for Exploration of Meteorological Satellites (EUMETSAT) METOP satellite series (2005-2010). An instrument upgrade, called the Argos Advanced Data Collection System (A-DCS), incorporates a downlink message capability is scheduled to fly on the NOAA-N' satellite and the National Polar-orbiting Operational Environmental Satellite System (NPOESS) constellation (2009-2018). This new capability, is in response to customer requirements, and will provide the opportunity for new and novel uses of the Argos DCS

GEOSTATIONARY SATELLITE PROGRAM.

Two operational geostationary satellites, GOES-12 (75 degrees W) and GOES-10 (135 degrees W), provide coverage of virtually the entire western hemisphere for operational environmental sensing of the Earth. Additionally, GOES-9 is now located over the western Pacific. The GOES-9 imager replaced the GMS-5 of the Japanese Meteorological Agency as of April 1, 2003, which will be replaced by the Japanese MTSAT-1R in 2005.. The sounder is operating in an experimental mode. The projected launch schedule and associated instruments for geostationary satellites are shown in Table 3.1. It should be noted that current plans as of mid 2005 call for GOES-N to be placed in storage once launched in CY 2005, with GOES-11 (currently in storage) to replace GOES-10 in the west and GOES-12 to remain in the east.

The GOES satellites host an imager capable of detecting atmospheric, sea surface, and land properties in five spectral bands including the 3.9µm and 12.0µm wavelengths. However, beginning with GOES-12, the 12.0µm channel is replaced with a 13.3µm channel, with the goal of achieving more accurate cloud height assignments for mid- and upper-level atmospheric satellite wind-velocity estimates. Unfortunately, this trade-off notably impacts the sea-surface temperature retrievals by eliminating the capability for daytime split-window retrievals, increasing the rms error by about 0.5 degrees C. Also, the spatial resolution of the water vapor channel is improved to 4 km from 8 km.

GOES satellites transmit all five spectral bands simultaneously, providing the user community with continuous views of atmospheric measurements in various wavelengths, each with its own atmospheric, land, and ocean application. GOES spacecraft were designed for flexible scanning of the Earth; a variety of scans or sector coverage can be scheduled.

For example, the full-earth disk is normally scanned once every 3 hours and requires about 30 minutes to complete the entire scan. Depending on requirements to monitor environmental hazards on the Earth's surface or in the atmosphere, 30-minute periods in between the full-disk scans may be scheduled as a mixture of 15-minute intervals (routine operations) or 7½-minute interval (severe storm operations) rapid scans over the contiguous U.S. To further support mesoscale and microscale analyses, 1000 km by 1000 km areas can also be scanned at 1-minute intervals, to capture rapidly developing and dynamic environmental phenomena..

The five channels and respective resolutions are as follows:

- Channel 1 (Visible, .55 m to .75 m) 1 km
- Channel 2 (Infrared, 3.8 m to 4.0 m) 4 km
- Channel 3 (Water Vapor, 6.5 m to 7.0 m) 8 km (4 km starting with GOES M)
- Channel 4 (Infrared, 10.2 m to 11.2 m) 4 km
- Channel 5 (Infrared, 11.5 m to 12.5 m) 4 km

The GOES sounder instruments, consisting of 19 spectral channels, are used for measurements of atmospheric temperature and moisture profiles, surface and cloud top temperatures, and ozone distribution. Products derived from the sounder include precipitable water and a lifted index (a measurement of atmospheric stability). Comparable to the imager, the sounder is capable of providing various scan coverages, such as full Earth imagery, sectored imagery, and local imagery. In routine operations, GOES-12 and GOES 10 provide hourly sounding coverage.

The GOES Space Environment Monitor (SEM) collects data for warnings of solar activity. This block of instruments is more extensive than on POES. The GOES SEM instruments include X-ray monitors that detect solar flares, energetic particle sensors, and three component vector magnetometers to measure changes in the ambient magnetic field. Real-time SEM data are used to support operational NOAA and DOD space environment forecasts and alerts. Data from GOES SEM sensors are archived by the National Geophysical Data Center and provided to retrospective users on line via Internet and on a variety of computer media. GOES-12 has the Solar X-Ray Instrument that provides near-real time x-ray images of the sun.

TABLE 3.1 PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM

Satellite Designator	Planned Launch Date*
NOAA-N	CY 2005
METOP-2	CY 2010
NPP	CY2008
NOAA-N’	CY 2007
NPOESS-C1	CY 2009
METOP-1	CY 2006
NPOESS-C2	CY 2011
NPOESS-C3	CY 2013
METOP-3	CY 2015
NPOESS-C4	CY 2016**
NPOESS-C5	CY 2018**
NPOESS-C6	CY 2019**

GEOSTATIONARY SYSTEM

Satellite Designator	Planned Launch Date*
GOES N	CY 2005
GOES O	CY 2007
GOES P	CY 2008
GOES Q	Cancelled
GOES R	CY 2012
GOES S	CY 2014
MTSAT-1R	CY 2005

*Launch date depends on performance of prior spacecraft and is subject to change.
** Dates are approximate. NPOESS is a launch on demand system.

NOAA Instruments for NOAA Polar-Orbiter and METOP Series

AVHRR - Advanced Very High Resolution Radiometer
SEM - Space Environment Monitor
SBUV - Solar Backscatter Ultraviolet Instrument (NOAA PM mission only)
HIRS - High Resolution Infrared Sounder
DCS ARGOS - Data Collection System
AMSU-A - Advanced Microwave Sounding Unit-A
AMSU-B - Advanced Microwave Sounding Unit-B
SARP - Search and Rescue Processor
SARR - Search and Rescue Repeater
MHS - Microwave Humidity Sounder (NOAA-N/N' and METOP)

Instruments for NPOESS Series

VIIRS - Visible/Infrared Imager/Radiometer Suite
CMIS - Conical Microwave Imager/Sounder
CrIS - Cross-track Infrared Sounder
ATMS - Advanced Technology Microwave Sounder
OMPS - Ozone Mapper/Profiler Suite
SES - Space Environment Suite
A/DCS - Advanced Data Collection System
SARSAT - Search and Rescue Satellite-Aided Tracking System
ERBS - Earth Radiation Budget Sensor
TSIS - Total Solar Irradiance Sensor
ALT - Altimeter (Dual Frequency radar altimeter)

Instruments for GOES-R+ Series

Advanced baseline Imager (ABI)
Hyperspectral Environmental Suite (HES)
Solar Instrument Suite (SEI)
Space Environment In-Situ Suite (SEISS)
Geostationary Lightning Mapper (GLM)

EUMETSAT Unique Instruments for METOP Series Satellites

ASCAT - Advanced Scatterometer
GOME - Global Ozone Monitoring Experiment
GRAS - GPS Receiver for Atmospheric Sounding
IASI - Infrared Atmospheric Sounding Interferometer

GOES also carries a Data Collection System (DCS), which is used to collect and relay environmental data observed by a variety of remotely located platforms, such as river and tide gauges, seismometers, buoys, ships, and automatic weather stations. In support of NOAA missions, GOES DCS data are used in weather forecasts and warnings, reservoir control, and flood monitoring. While the GOES DCS is a critical element for national and international meteorological and hydrological programs, the NWS NEXRAD program relies on the DCS data as a vital input for calibration and validation. Tsunami watches and warnings for the Pacific Ocean are prepared using the Data Collection Platform data transmitted via GOES DCS. The GOES DCS program touches all aspects of our lives in supporting water quality, air pollution, and global environmental monitoring.

The GOES Search and Rescue Satellite Aided Tracking (SARSAT) System is capable of providing an immediate distress alert, unlike the POES satellite SARSAT transponders which must come within line of site of a Local User Terminal, in order to relay the distress beacon back to the U.S. SARSAT Mission Control Center (USMCC). Newer state of the art Cospas Sarsat distress beacons, utilizing the Global Positioning System (GPS), now have the capability to provide location information in the distress message relayed by GOES to the USMCC.

NESDIS continues to improve user access to its operational satellite products and services using new communications technologies, including the Internet. One important on line access system, managed and operated by OSD is the Comprehensive Large-Array Data Stewardship System (CLASS). The CLASS (www.CLASS.noaa.gov) provides satellite data access, display, and electronic transfer. Available data types include AVHRR, ATOVS, DMSP (special sensor), and RADARSAT (authorized subscription users). While developed as an independent system, the CLASS serves as NOAA's initial interoperable interface to NASA's Earth Observing System Data and Information System (EOSDIS). After the phase out of the GOES TAP system in 1998, many users now rely on GOES sectorized images, mapped to standard AWIPS grids, available in near real time at www.goes.noaa.gov.

Near real time images and interpretive analyses of tropical storms and hurricanes worldwide, ash from volcanic eruptions within the western hemisphere, heavy precipitation in the U.S. which cause flash flooding or blizzards, wild fires and smoke within the U.S., and northern hemisphere snow boundaries are located at www.ssd.noaa.gov. Specially enhanced and annotated imagery and image loops of environmental events, such as flooding, hurricanes and other severe storms, volcanic eruptions, fires, and dust storms are available from www.osei.noaa.gov. This web site was set up for use by the news media and general public, and to provide once or twice per day satellite views of an environmental event for Federal, state, and international governments and agencies. Also supporting the media, scientific organizations, and federal and state agencies is a specially designed web site featuring visualizations of satellite data, found at www.nnvl.noaa.gov/.

INTERNATIONAL AND INTERAGENCY SUPPORT FOR DISASTER MANAGEMENT

International Charter.

NOAA, on behalf of the U.S., is a signatory to the International Charter for Space and Major Disasters, and serves in the capacity of Emergency on-Call Officer (ECO) on a rotational basis with other representatives of international space agencies. NOAA is also represented on the Executive Secretariat of the International Charter and periodically serves as the lead agency providing secretariat services, policy leadership, and Charter activities coordination.

The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized users. Each member agency (six space agencies representing Europe, France, Canada, India, Argentina and the U.S.) has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property. An authorized user can call a single number to request the mobilization of the space and associated ground resources of the six space agencies to obtain data and information on a disaster occurrence.

World Summit on Sustainable Development (WSSD) Follow-up.

NOAA plays a key leadership role in the Committee on Earth Observation Satellites (CEOS) World Summit on Sustainable Development (WSSD) Follow-up Program's module addressing Disaster Management and Conflicts. To address the priorities outlined at the WSSD and the specific references to satellite applications, NOAA and other CEOS members are putting together a program plan to increase awareness in the applications and utilization of Earth observation data in developing countries for disaster management and conflicts, as well as to assist in the establishment of infrastructure and communications in support of disaster management and conflicts. The module on Disaster Management will be initiated this year.

U.S. Interagency Collaboration.

NOAA is a member (and chair) of the U.S. Subcommittee on Disaster Reduction (SDR), which provides a unique Federal forum for information sharing; development of collaborative opportunities; formulation of science- and technology-based guidance for policy makers; and dialogue with the U.S. policy community to advance informed strategies for managing disaster risks. This year the SDR, through the U.S. President's National Science and Technology Council, released an interim report entitled *Reducing Disaster Vulnerability Through Science and Technology*, which identified critical opportunities to reduce future loss of life and property as a result of disasters. The report identifies several important themes relevant to disaster reduction and speaks to resources, opportunities, and gaps in science and technology needed to support disaster management.

<u>IGOS Geohazards Theme</u>.

As Co-Chair of the Integrated Global Observing Strategy (IGOS) in 2003, NOAA played a key role in facilitating the formal adoption and recent publication of the *IGOS Geohazards Report*. This report looks at global geohazards observation requirements and outlines an integrated implementation mechanism and action plan for filling the observation gaps over the coming decade. It also examines the impacts of geohazards on society, discusses the roles of implementation by stakeholders, addresses data management issues, and analyses the critical gaps in capacity building and infrastructure. More information is available at http://ioc.unesco. org/igospartners/Geohazards.htm.

<u>CEOS Disaster Management Support Group (DMSG) Legacy</u>.

NOAA led the DMSG effort within CEOS with an objective to support natural and technological disaster management on a worldwide basis by fostering improved utilization of existing and planned Earth observation satellite data. Particular emphasis was placed on working closely with space agencies, international and regional organizations, and commercial organizations on the implementation of these recommendations. Hazards addressed include drought, earthquake, fire, flooding, landslides, oil spill, sea ice, and volcanic hazards. The final report of the DMSG, published in 2002, can be accessed at http://www.ceos.org/pages/DMSG/index.html /.

SUPPORTING RESEARCH PROGRAMS

ATMOSPHERIC WINDS.

Recent advances in numerical weather prediction (NWP) models, both at NOAA's NCEP/EMC and other major International NWP Centers, require higher quality satellite-derived winds, particularly over the traditionally data void oceanic regions of the globe. The NESDIS GOES East and West wind processing suites are totally automated and use a series of geostationary satellite images to derive wind estimates. The automated winds algorithm uses an objective pattern matching technique to estimate velocity, and satellite water vapor and infrared brightness temperature data to assign heights to these derived wind estimates. The automated quality control of image registration is also an important component of the NESDIS GOES East and West winds processing suite.

Approximately 20,000 cloud-drift and water vapor motion wind vectors are derived from both satellites for each cycle and distributed to EMC and to the Global Telecommunications System (GTS). EMC uses these operational NESDIS wind products in their global and regional data assimilation/numerical forecast systems. NESDIS recently completed the effort to reformat the winds in WMO-sanctioned BUFR format. Current work involves the investigation of a slow bias seen in water vapor winds.

The newest satellite wind products include the low-level high-density visible satellite winds. During the daylight hours, visible channel data can be used to track cloud motions. The GOES visible imagery offers high horizontal resolution (1 km) and frequent image sampling (15-30 minutes nominally; higher in special rapid scan modes). The visible channel can depict lower tropospheric cumuliform tracers in areas not covered by opaque cirrus. In terms of tropical cyclones, visible winds can depict the low-level flow in the outer storm vortex region, which is an important area in assessing storm motion. The GOES satellites have an atmospheric sounder that includes two water vapor channels centered at 7.0µm and 7.3µm. These sounder channels can be employed as surrogate imagers to track water vapor features radiating from the lower layers of the troposphere. The weighting function of the 7.0µm channel peaks around 450mb and the weighting function of the 7.3µm channel peaks around 550mb. Water vapor winds generated from these two channels will compliment the imager-based cloud-drift and water vapor winds, resulting in an improved three-dimensional depiction of the wind field. The implementation of these new algorithms and the visible wind products into the operational environment at NESDIS began in 1999. These wind products can be viewed at orbit-net.nesdis.noaa.gov/goes and cimss.ssec.wisc.edu/tropic/real-time. Digital sounding and winds files are available through a GOES computer server within OSDPD.

ATMOSPHERIC MOISTURE AND STABILITY PRODUCTS.

Research continues to improve the atmospheric moisture and stability products from the GOES-12 and GOES-10 sounder instruments. Precipitable water for three layers of the atmosphere: surface to 900 hPa; 900-700 hPa; and 700-300 hPa are computed from the soundings. Total precipitable water (TPW) for the entire atmospheric column, from the earth's surface to the "top" of the atmosphere, is also computed. These precipitable water products are particularly valuable for the short-term forecasting of precipitation, locating those environments favorable for heavy precipitation and flash floods, thunderstorms, and fog. Hourly updates of this information provide useful information for the EMC regional data assimilation systems and for weather forecasters in the field. EMC currently uses the GOES precipitable water retrievals as input to Eta Data Assimilation System (EDAS), which provides the initialization for the Eta forecast model. NESDIS is currently aiding EMC with running global and regional model impact analyses to improve and optimize the use of the GOES derived products in numerical weather prediction schemes. As of July 8, 2003, the hourly cloud-top information from the GOES sounder data are being assimilated into the operational National Centers for Environmental Prediction (NCEP) Eta Data Assimilation System (EDAS). The regional Eta model joins the Rapid Update Cycle (RUC) model as two operational models assimilating GOES sounder cloud information to help improve the initial moisture and cloud field. At present, a blended GOES, SSM/I, and model-derived product is being evaluated. In addition, a precipitable water product has been developed from the POES AMSU sensor and is presently operational. In the near future, the blended product will include the AMSU-derived precipitable water. In addition to the moisture products, numerous atmospheric stability indices can be computed from measurements made by the GOES sounder instrument. Two stability indices, the lifted index (LI) and CAPE index, are computed on a routine basis. Since these indices are produced hourly, sequential images of these derived quantities clearly show the diurnal and dynamic changes associated with weather events.

So, in addition to providing these data to EMC for use in numerical weather prediction models, the graphical representation of these products allows for the looping of the products in time. This capability aids NWS forecasters in the field, for example, to understand the time evolution of severe storms. Because channel noise has improved with each successive sounder instrument it is anticipated that the GOES sounder moisture and stability products with a horizontal resolution of approximately 50 km, will be generated at a high horizontal resolution of approximately 10 km in the fall of 2003 (Figure 3-DOC-6).

The increased horizontal resolution offers exciting possibilities for enhanced use of these products in mesoscale forecasting. For example, it improves the depiction of gradients in the retrieved products, such as moisture and atmospheric stability, which focuses attention to a local area of interest. These products can be viewed at orbit-net.nesdis.noaa. gov/goes and cimss.ssec.wisc.edu. Digital versions of these products are available from POES and GOES computer servers within OSDPD.

TROPICAL CYCLONE MONITORING.

NESDIS continues to improve upon satellite-based techniques for estimating tropical cyclone positions and intensities, and for describing the internal structure of these storms. Recent sensors, such as AMSU and TRMM, among others, are being incorporated into the NESDIS operational tropical

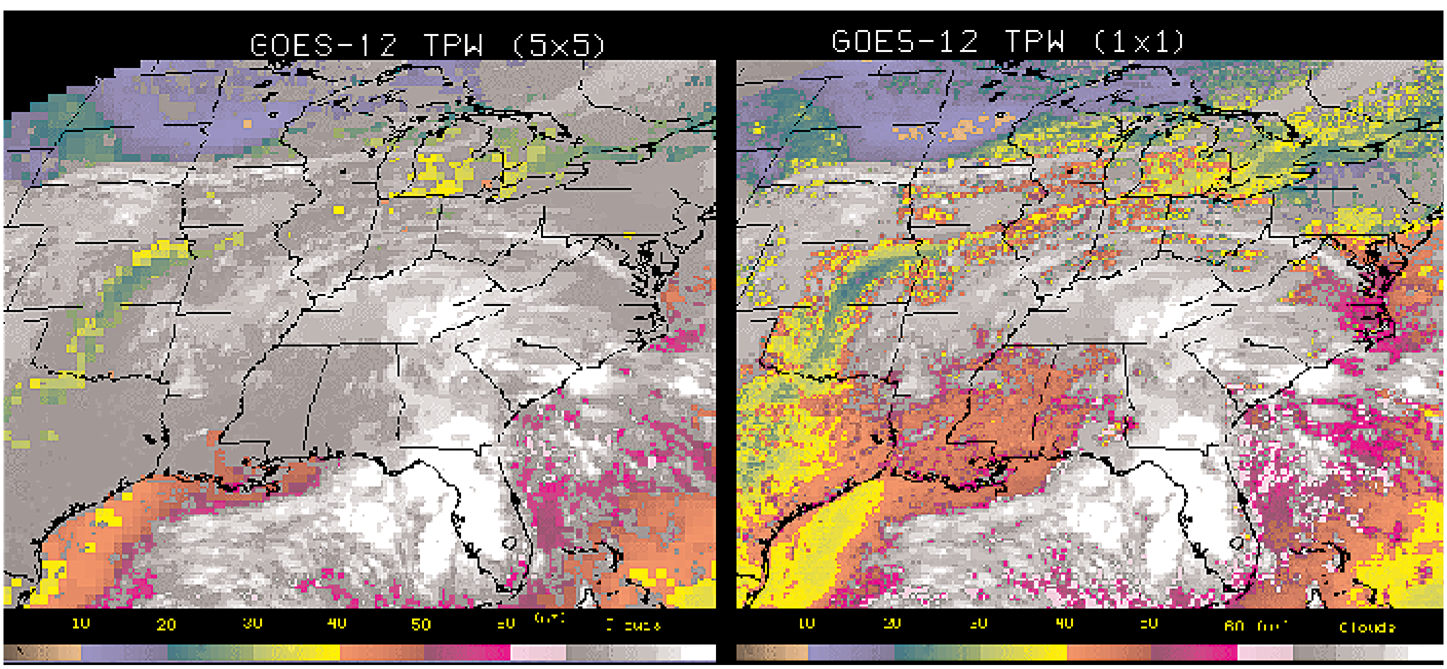


Figure 3-DOC-6. GOES-12 retrieved total preciptable water products at 50 km resolution (left) and 10 km resolution (right)

program, which supports the NWS and DOD hurricane programs. Real-time imagery and NESDIS tropical text messages can be viewed at www.ssd.noaa. gov/SSD/ML/real-time.html. Research is also being performed to improve the forecasts of tropical cyclone formation and intensity change by making better use of satellite observations.

PRECIPITATION ESTIMATES.

The Hydro-Estimator (H-E)--a fully automated adaptation of the semi-manual Interactive Flash Flood Analyzer (IFFA)--produces estimates of instantaneous precipitation rate based on GOES infrared data every 15 minutes. The H-E adjusts its computed rain rates for moisture availability, subcloud evaporation, orographic uplift, and other factors using Eta model fields. The resulting estimates are also the basis for 0-3 hour nowcasts of precipitation via an algorithm for extrapolating cell movement and development called the Hydro-Nowcaster. Other techniques being tested include the GOES Multi-Spectral Rainfall Algorithm (GMSRA), which uses four of the five GOES Imager channels for more precise rain area identification, and a combined GOES and microwave rainfall algorithm (developed at NRL/Monterey) which uses microwave-based rainfall estimates to modify its calibration. Real-time graphics from all three of the above techniques can be accessed at http://orbit-net.nesdis.noaa.gov/arad/ht/ff/index.htm, and real-time validation statistics for these algorithms are available at http://orbit-net.nesdis.noaa.gov /arad/ht/ff/validation/validation.html.

The H-E is now also available to NWS field forecasters via AWIPS. In addition, an improved AMSU-B rain rate algorithm is being implemented, and a new precipitation algorithm has been developed using the AMSR-E is under development. The AMSU-B products are available at http://orbit-net.nesdis.noaa.gov/arad2/MSPPS/index.html, including global long-term estimates for climate monitoring and analysis. Finally, the POES-based microwave algorithms from the microwave sensors are being used to produce automated 24-hour Tropical Rainfall Potential (TRaP) forecasts worldwide (Figure 3-DOC-7). Real-time TraP graphics can be accessed at http://www.ssd. noaa.gov/PS/TROP/trap-img.html.

MICROBURST PRODUCTS.

Several experimental microburst and convective wind gust products are being tested. These products, including the Wind Index (WINDEX) to compute maximum possible convective wind gusts and the Theta-e Deficit (TeD) and Dry Microburst Index (DMI) to compute the potential for wet and dry microbursts, respectively, use sounder data from both GOES-East/West. They are produced hourly and can be viewed at http://www.orbit.nesdis.noaa.gov/smcd/opdb/aviation/mb.html

In addition, a new wet microburst index product, designated as the Wet Microburst Severity Index (WMSI) is being developed and will be implemented in the suite of GOES microburst products. The WMSI assesses the potential severity of wet microbursts by summarizing the physical processes of convective storm development and downburst generation. The WMSI algorithm incorporates such parameters as convective available potential energy (CAPE), to represent the process of updraft formation, and Theta-e Deficit (TeD), to represent down burst development.

LOW CLOUD AND AIRCRAFT ICING PRODUCTS.

Fog and low clouds are a major source of air traffic delays and aircraft accidents. A nighttime, two-channel IR product from GOES has been developed to show regions where low

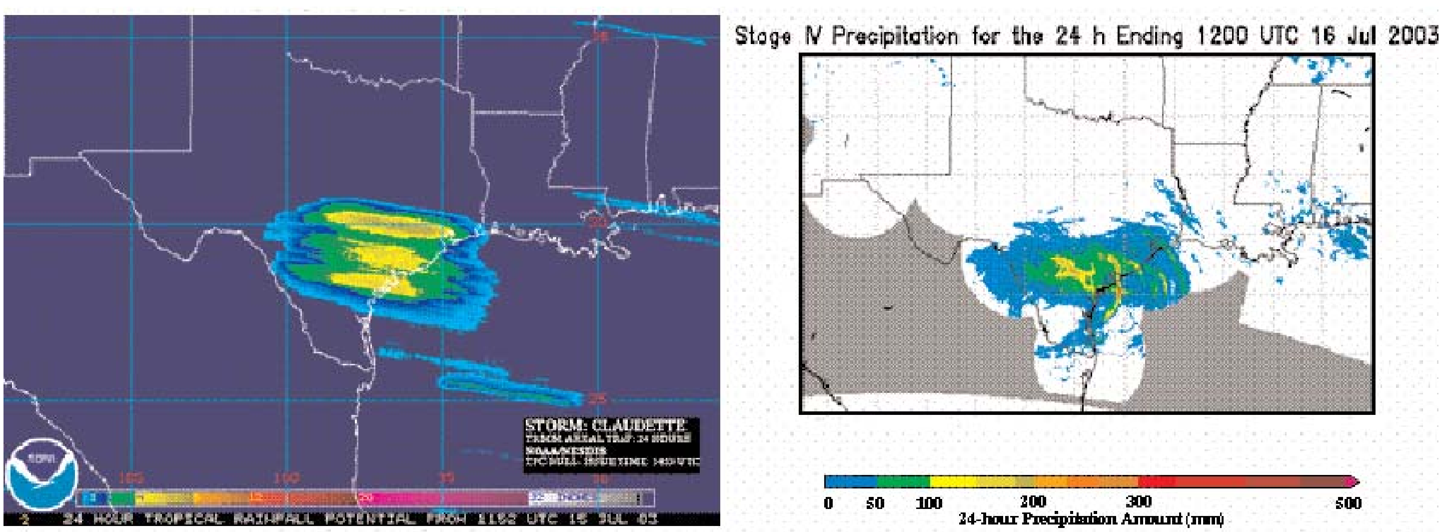


Figure 3-DOC-7. Tropical Rainfall Potential (TRaP) forecast for Hurricane Claudette (left) and corresponding Stage IV radar/rain gauge estimates (right) for the 24 hours ending 1200 UTC 16 July 2003.

ceilings (<1,000 ft) are likely to be found. This product is used to signal deteriorating weather conditions before they are reported by airport weather stations. Fog products for the Continental U.S. and Alaska are available on the Web hourly at: http://orbit-net.nesdis.noaa.gov/arad/fpdt/fog.html .

Areas of "super-cooled" water clouds that can result in hazardous aircraft icing are detectable from GOES by means of an experimental, multispectral product that uses a combination of several IR temperature and visible brightness thresholds. A recent innovation has combined this icing image with the GOES cloud-top height analysis to create an ICing Enhanced Cloud-top Altitude Product (ICECAP) **(**Figure 3-DOC-8)**.** The icing products are provided hourly day and night for the Continental U.S., Alaska, and the East Pacific at http://orbit-net.nesdis.noaa.gov/arad/fpdt/icg.html.

GEOSTATIONARY SEA SURFACE TEMPERATURES.

GOES-12 and GOES-10 are proving capable of producing sea surface temperatures (SST) over most of the Western Hemisphere nearly continuously. The accuracy and spatial resolution achieved with the GOES measurements are close to that achieved from the polar orbiting platforms, and GOES has a unique advantage of high temporal sampling frequency. Unfortunately, the trade-off of replacing the 12.0µm channel with a 13.3µm channel notably impacts the sea-surface temperature (SST) retrievals by eliminating the capability for daytime split-window retrievals, increasing the rms error by about 0.5 degrees C. For the SST determination, the frequent sampling by GOES makes a more complete map of SST possible after clouds have moved on. Additionally, a change in scene temperature over a short period of time may indicate the presence of clouds, thereby enhancing cloud detection.

The abundance of GOES observations helps to maintain a balance between high-quality, cloud-free observations and good geographical coverage of SST estimates. For the first time, GOES is enabling quantification of the diurnal variation of a radiometrically determined SST over large areas and long time periods. This quantification may have important implications in both numerical weather prediction and climate monitoring. NESDIS has been producing the GOES SST hourly product in an experimental configuration since December 1998, from both GOES East and GOES West. A global SST product is produced every three hours; regional SST products are generated every hour. These products were recently implemented operationally and can be accessed as digital files from the GOES computer servers within OSDPD.

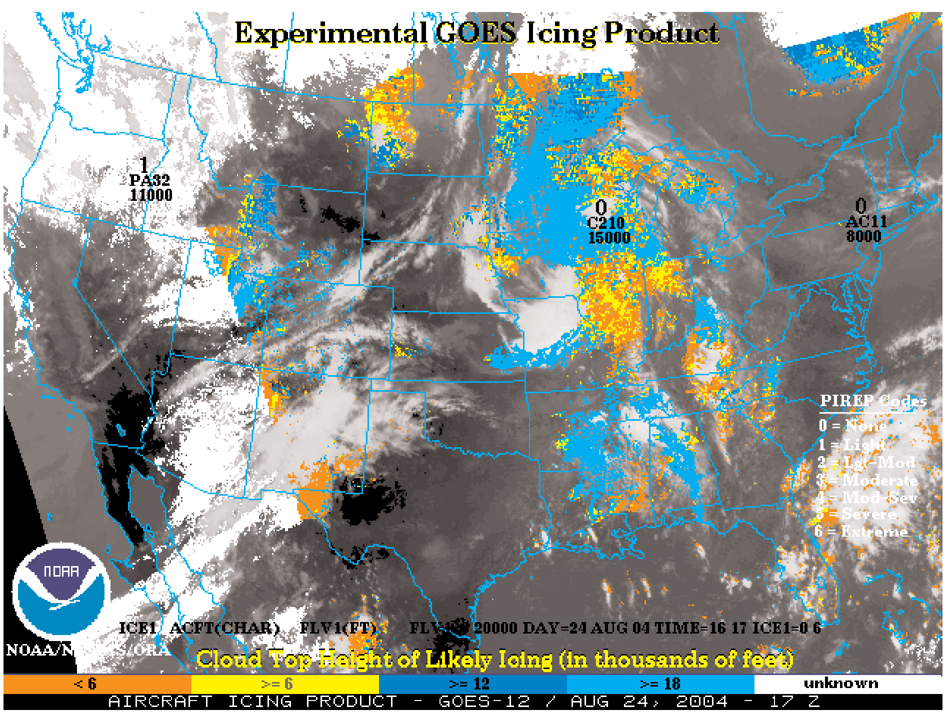


Figure 3-DOC-8. Areas of potential aircraft icing observed by GOES Imager are color-coded according to the estimated maximum cloud top height in 3,000 foot intervals, based on information from the GOES Sounder.

VOLCANIC ASH AND FIRE MONITORING.

A new technique has been developed to mitigate the loss of the 12 m IR band on GOES-12 to help track hazardous volcanic ash clouds. The technique uses IR channels centered at 10.7µm, 13.3µm, and 3.9µm. Several recent eruptions of Soufriere Hills volcano on Montserrat in the eastern Caribbean have shown that this new product is helpful in monitoring ash cloud emissions, even at night. GOES-12 ash product can be viewed for several volcanically active regions at http://www.ssd. noaa.gov /VAAC/ and http://orbit-net.nesdis.noaa.gov/arad/fpdt/volc.html. The analysis of Moderate Resolution Imaging Spectroradiometer (MODIS) data from the NASA Terra and Aqua spacecraft has also yielded valuable information about optimum detection of volcanic ash using several spectral bands. A three-channel combination product based on the 8.6, 11, and 12 m bands has been developed that provides effective discrimination of ash or sulfur dioxide gas with minimal false alarms. This algorithm could be applied to future products from NPOESS and GOES-R, which will have similar spectral bands. Ash cloud advisory statements are provided by NESDIS to the aviation community over southern North America and northern South America, through the Volcanic Ash Advisory Center (VAAC) in Camp Spring, Maryland. GOES infrared and visible images, aerosol and sulfur dioxide products from NASA's Total Ozone Mapping Spectrometer (when applicable), and operational volcanic ash products for the Washington VAAC area of responsibility are found at http://www.ssd.noaa.gov/VAAC/washington.html.

Fire and smoke monitoring algorithms are being developed to automatically detect fires and to monitor their growth and the associated smoke coverage. GOES East spectral channels at 4µm and 11µm have been used to assess trends in South American burning practices over the past 6 years (1995-2000); GOES detected the most fire pixels in the tropical rain forest ecosystem in 1995. The application to clear sky human-initiated burning in South and Central America is now being adapted to monitor cloudy sky lightning and clear sky human-initiated fires in the Canadian provinces and the continental U.S. The continual monitoring from GOES (as often as every 7½ minutes) can assist firefighters to plan evacuation and suppression activities. Studies with Brazil are underway to predict smoke transport and air pollution and health alerts for major cities. An AVHRR fire detection algorithm has been developed for use in monitoring fire and smoke outbreaks around the world. All these new techniques will be used to improve the current operational fire and smoke product (Figure 3-DOC-9) used by the NWS Storm Prediction Center (SPC) in their fire outlook product and other users of fire and smoke detection such as the EPA, Forest Service, state and local agencies. Real time imagery of GOES and POES imagery in support of SPC can be found at: http://www.ssd.noaa.gov/PS/FIRE/.

A GOES Products and Services Catalog is available on line at http://orbit-net.nesdis.noaa.gov/arad/fpdt/goescat_v4/. An up-to-date list and description of operational and experimental products with links to the real-time products are available from this web page. The Polar Products and Services Catalog is under development.

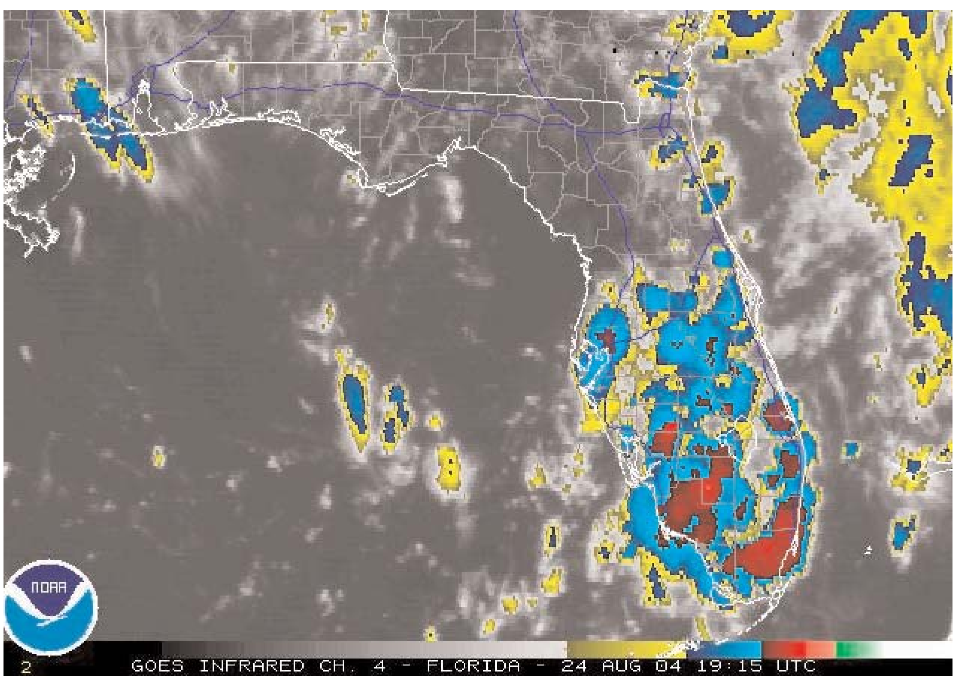


Figure 3-DOC-9. Probable fires appear as sharp white "spots" in the Reflectivity and Infrared images. These images are considered "raw" data, with no analysis of fires and/or smoke. To view official analyses by NOAA meteorologists, see the Hazard Mapping System Fire and Smoke Product.

NPOESS "TEST BED" DATA SETS.

ORA scientists continue to play an important role in the evaluation of proposed contractor sensor design and retrieval methods during the ongoing selection process for NPOESS. ORA scientists have created a variety of "test bed" data sets that are being used in the algorithm evaluation process. This is accomplished through participation in operational algorithm teams with the long-term goals of assuring capability to meet the requirements of all Environmental Data Records. Ozone evaluation, calibration, and validation activities took place for the new Solar Backscatter Ultraviolet Instrument (SBUV/2) with the launch and successful checkout of NOAA-17. A new ozone profile retrieval algorithm has been developed by NASA and is now incorporated into SBUV/2 processing systems. Monitoring of global ozone will continue with the SBUV/2 instruments on NOAA-14, NOAA-16 NOAA-17, and NOAA-18 and with the TOVS instruments on NOAA-14, NOAA-15, NOAA-16, NOAA-17 and NOAA-18. Experimental high temporal ozone products are also being produced from the GOES-12 sounder channels. Monitoring is limited to North America. Preliminary results show the GOES values are comparable to amounts from the Total Ozone Mapping Spectrometer and ground-based measurements.

LAND SURFACE PARAMETERS FOR USE IN WEATHER FORECAST MODELS.

Satellite-derived fields of land surface characteristics are being produced operationally for use in NWP models. These include radiation products delivered in near real-time as forcing variables; surface characteristics, such as fractional green vegetation and albedo, that specify model lower boundary conditions; and validation quantities, such as surface temperature. These products are meant to help the NWP models maintain better soil moisture fields which in turn results in better near surface temperature and humidity forecasts, and better precipitation forecasts. These fields now include POES-based (SSM/I and AMSU) estimates of surface emissivity, snow cover, sea-ice extent and concentration, land surface skin temperature, and soil wetness. Development of snow depth is underway. Plans are in the making to develop the AMSU-A Snow Water Equivalent (SWE) product for operational use. Forward models for surface emissivity at various microwave frequencies have been developed and are being tested in the forecast models. Algorithms to determine clear sky ice surface temperatures have been developed and delivered to Atmospheric Environment Service, Canada for evaluation. New techniques such as automatic edge detection and incorporation of new sensors such as AMSU and NASA's MODIS are in development to improve operational production of daily snow and ice extent products. These products are delivered as digital files to NWP models and to the NWS Climate Prediction Center and other users. Graphical imagery of operational northern hemispheric snow cover can be found on the Internet at www.ssd.noaa.gov/SSD/ML/ realtime.html #SNOW.

CLOUDS FROM AVHRR.

Algorithms are being developed, tested, and validated for determining cloud optical and microphysical properties from imager data such as the AVHRR. These algorithms are in addition to those already developed which estimate amounts and types for each observed cloud layer. The four cloud types are: L - Liquid Water Clouds; M - Mixed Phase Clouds; G - Glaciated Clouds (opaque); and H - High Ice Clouds (semi-transparent). Knowledge of cloud properties is important for both climate-scale and short-medium range forecasts. Accordingly, algorithms and processing systems to estimate cloud properties from imager data are being developed for both applications. Assimilation of cloud properties into NWP models is an objective of NCEP for improving short-medium range forecasts. Other applications of this work include the validation of simulated scenes to be used for the evaluation of new algorithm and instrument designs that is supported by the IPO. In addition, new algorithms are being developed to produce optimal estimates of cloud properties from both imager and sounder data, such as the merge of AVHRR and TOVS data.

AEROSOLS.

Aerosol retrievals from an improved and extended unique PATMOS-BUOY Data set were analyzed to optimize the procedure used in the aerosol correction of sea surface temperature (SST) retrievals. Based on the results, a new aerosol correction algorithm for SST has been developed and delivered to OSDPD for the use with NOAA-16-17 and -18 data. The new correction algorithm uses aerosol optical depth in AVHRR/3 channel 2 (0.83 m), only. The PATMOS-BUOY match up data set was also used for an extensive evaluation of the single-channel 3rd generation algorithm for aerosol retrieval from AVHRR. This aerosol algorithm has now been implemented in the operational aerosol observations (AEROBS) obtained from the AVHRR instrument onboard the NOAA 16 and 17 satellites.

The algorithm uses an improved treatment of atmospheric and surface effects, and provides aerosol optical depth data in three channels at 0.63, 0.83 and 1.6µm. The single-channel 3rd generation algorithm has also been implemented at NASA/LaRC in the Clouds and Earth's Energy System (CERES) SSF processing of aerosol optical depth from the MODIS instruments on the Terra and Aqua satellites. Aerosol data from this algorithm is produced in addition to the primary MODIS multi-channel retrievals. The single-channel retrievals serve as backup for the primary product. They also provide continuity with earlier NOAA/AVHRR aerosol retrievals, and facilitate the quantification of improvements offered by multi-channel retrievals over single-channel ones.

A comparison of the two aerosol products shows an overall good agreement on a global scale. This implies that the simple single-channel algorithm performs well relative to the more sophisticated and comprehensive MODIS multi-channel algorithm. The major differences between the two products appear to be related to the differences in cloud screening and identification of glint regions that lead to differences in sampling. The lessons learned from these and follow up comparisons will be applied to improve the current operational algorithm, and in the risk reduction of aerosol retrieval from VIIRS on the NPOESS satellites. The feasibility of aerosol optical depth retrieval from GOES over most of South and North America has also been demonstrated. A comparison of GOES-retrieved aerosol optical depth with that observed at the AERONET ground stations showed good agreement.

LONG-TERM MONITORING OF NOAA-15 ADVANCED MICROWAVE SOUNDING UNIT-A (AMSU-A) PERFORMANCE.

Since the launch of the NOAA-15 satellite, the AMSU-A level 1B data have been captured from the CEMSCS and stored on optical disks. These data are used for off-line characterization of the instrument radiometric performance on orbit. Over 20 important radiometric parameters are extracted or calculated from the AMSU-A 1B data. NESDIS has already demonstrated that the noise in the observations in all channels is lower (better) than that required by the specifications and, in some channels, it is lower than estimates based on pre-launch test results. NOAA will continue compiling long-term trends of all the parameters to provide a better understanding of the instrument performance. The PC-based software developed for evaluating these data will be improved for better efficiency in processing the data.

CALIBRATION OF THE VISIBLE AND NEAR-INFRARED CHANNELS OF THE AVHRR.

The AVHRR flown on POES is recognized as an invaluable resource for satellite-based studies of the Earth system. The long-term records of geophysical products such as the Normalized Difference Vegetation Index (NDVI), columnar aerosols over the oceans, cloud morphology, and short-wave radiation budget play a central role in climate and global change studies by providing a means to study the environment continuously. It is thus very important to characterize and document the in-orbit performance of the AVHRR flown on the polar orbiters.

Toward this end, a very comprehensive program of post-launch calibration and characterization of the AVHRR has been implemented to ensure the accuracy, continuity, and viability of the various AVHRR-derived geophysical products, with particular attention paid to the visible (Channel 1: 0.58 - 0.68μm), and near-infrared (Channel 2: 0.72 - 1.1μm; Channel 3A: 1.58 - 1.64μm) channels which do not have any onboard calibration devices. The major program elements are: (a) development of an optimal vicarious post-launch calibration technique, utilizing radiometrically stable calibration sites, model simulations of the radiation measured by the sensors, and simultaneous radiation measurements by the AVHRR and by calibrated spectrometers onboard aircraft; (b) enhancement of available vicarious calibration techniques to improve attainable radiometric calibration accuracies beyond ±5 percent; (c) evaluation of the feasibility of using the International Space Station (ISS) as a platform to calibrate satellite sensors, in general, using radiometers on the ISS traceable to the National Institute of Standards and Technology (NIST); (d) establishment of the AVHRR as a traveling calibration standard to monitor the performance of sensors, such as the imager on the GOES, the visible channel of the High-resolution Infrared Radiation Sounder (HIRS), the Moderate-resolution Imaging Spectrometer (MODIS), and various sensors to be flown on ENVISAT; and (e) design of optimal onboard and vicarious calibration techniques for the visible and near-infrared sensors planned under the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The relevance and importance of these activities has been recognized by the national and international user community, as evidenced by the appreciation and endorsement of the Working Group on Calibration and Validation (WGCV) and the Global Observing Systems Space Panel (GOSSP).

To ensure global access to the results of the AVHRR calibration program, and recognizing the importance of the AVHRR-derived products to national and international programs, such as the International Satellite Cloud Climatology Project (ISCCP), the International Geosphere Biosphere Programme (IGBP), the Global Climate, Ocean, and Terrestrial Observing Systems, and to benefit from sensor calibration research elsewhere, active liaison, and collaboration in some instances, has been established with researchers in NASA, NIST, EUMETSAT, China Meteorological Administration, Beijing, China; Rutherford Appleton Laboratory, United Kingdom; National Space Development Agency, Japan; the NOAA/NASA Pathfinder Program; several space agencies and remote sensing laboratories outside the U.S., and academia both in the U.S. and abroad.

CALIBRATION OF GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE INSTRUMENTS.

The GOES ground-system calibration processing was modified to accommodate the changes in spectral locations and field-of-view sizes of the Imager channels that became effective with GOES-12. Additional processing changes are being developed to accommodate the further changes that will be made to the Imager on GOES-N. The most notable of these is a tenfold increase in the time the Imager spends viewing its blackbody for calibrating its infrared channels. The increase is intended to improve calibration precision.

On Nov. 24, 2003, the operational calibration processing in the GOES Imager's infrared channels was modified to deal with artificial depressions in measured brightness temperatures that occurred in the hours near local midnight. These depressions, reaching a maximum of approximately 1K (for a scene at 300K), were most pronounced in the infrared channels at the shortest wavelengths. We believe they were caused by effects of solar heating in the calibration measurements. The processing modification, which invokes a statistical technique to calculate the calibration coefficients near midnight, succeeded in minimizing the artificial brightness-temperature depressions. In addition to calibration, the product processing algorithms for several products will have been modified to accommodate the new channel configuration.

FY 2004 saw considerable progress in the on-orbit calibration of the Imager's visible channel. This channel, lacking an on-board calibration device, can only be calibrated vicariously, i.e., with targets external to the satellite. Here we report results from two such targets. From eight years of observations of a stable Earth target (the Grand Desert in Sonora, Mexico), we estimated that the responsivity of the GOES-8 Imager's visible channel degraded an average of 5.8 percent per year. From routine observations of approximately 60 stars, we estimated visible-channel responsivity degradations of 4.86   0.08 percent for the GOES-8 Imager (from 10/19/95 to 4/1/03) and 5.56   0.18 percent for the GOES-10 Imager (from 1/4/01 to 11/6/03). The difference between the GOES-8 degradation rates from the two methods is a topic of current research.

More information on GOES calibration topics, including the GOES-12 Imager channel changes, the correction for the midnight infrared-channel calibration errors, and the star- and desert-based vicarious calibrations of the visible channel, can be viewed at http://www.oso.noaa.gov/goes/goes-calibration/index.htm

PATHFINDER.

Climate data sets of cloud amount, aerosol optical thickness (AOT) over the oceans, and the Earth's radiation budget for clear and cloudy skies have been retrospectively generated from over 17 years of AVHRR data as part of the NOAA-NASA Pathfinder program. An improved data set spanning the period from July 1981, through the end of 1999, was completed in 2000. This data set is being used to study the relationship between the variation in global mean values of the absorbed solar radiation and variation in aerosol amount caused by major volcanic eruptions. The influence of the aerosol amount on variations in the global surface temperature is also under investigation. The analysis of time series of anomalies of the cloud radiative forcing has been shown to correlate well (spatially and temporally) with El Niño events. A second reprocessing of the entire data set is being proposed, where multiple-layered cloud data will be used. Land surface and ocean products such as the vegetation index and the sea surface temperature will be added.

OCEAN SURFACE WINDS.

Calibration and validation studies are performed by ORA for all new operational ocean surface wind data streams. Product refinement and development activities are currently underway to improve ocean wind vector retrievals in the high wind speed regime, as well as precipitation regimes, where current retrieval algorithms underestimate the wind speeds. There are several satellite-based active and passive microwave sensors planned for launch in the near future from which NOAA would have the opportunity to obtain near real-time data streams. One of these sensors will be the first demonstration of the passive polarimetric technique, which is being relied on in the NPOESS design to meet the nation's ocean surface wind vector requirements.

HIGH-RESOLUTION COASTAL WINDS AND STORM SIGNATURES FROM SYNTHETIC APERTURE RADAR.

ORA scientists are currently developing techniques for deriving high-resolution (1 km or less) winds from synthetic aperture radar (SAR) imagery, and using these derived winds to study ocean surface wind signatures of atmospheric fronts and storms. By sensing variations in ocean surface roughness on the centimeter scale, SAR sensors can image storms, atmospheric waves (such as mountain lee waves), island and mountain wakes and vortex streets, gap flows, atmospheric fronts, and barrier jets. Application demonstrations are currently underway to provide high-resolution winds, imagery, and other SAR-derived products to operational agencies for evaluation. By the year 2007, there will be as many as five wide-swath SAR satellites. If data acquisition and sharing arrangements can be established to obtain access to SAR imagery from these new sources, frequent routine SAR coverage of U.S. coastal areas will be possible. This increased coverage will allow use of SAR-derived marine and atmospheric products for operational purposes.

OCEAN COLOR.

Several programs at ORA are involved in satellite ocean color research. The Marine Optical Buoy (MOBY) Project develops, deploys, and maintains the MOBY off of the coast of Lanai, Hawaii, to measure visible and near-infrared radiation entering and emanating from the ocean. The resulting measurements support the initialization and vicarious calibration of international and national ocean color sensors, such as the Ocean Color and Temperature Sensor, the Sea-Viewing Wide-Field-of-View Sensor, and the recently launched Moderate Resolution Imaging Spectroradiometer.

The Marine Optical Characterization Experiment (MOCE), MOBY's sister project, involves the collection from ship of in-situ measurements of these and other parameters relevant to ocean color in the surrounding region. Data from both sampling platforms furnish time-series of bio-optical measurements that is employed to track sensor drift, define bio-optical relationships, validate satellite-derived products, and develop ocean color algorithms. In addition to MOBY and MOCE, programs exist at ORA to routinely evaluate the accuracy of NESDIS operational ocean color products and to develop algorithms for remotely detecting and predicting the presence of noxious marine biota, such as harmful algal blooms.

CORAL REEF WATCH: NOAA'S EARLY WARNING SYSTEM FOR CORAL REEF HEALTH.

Like the rest of the world, most of the U.S. coral reef systems are threatened due to pollution, over-fishing, and thermal bleaching. This threat includes almost all of Florida and Puerto Rico reefs, nearly half of Hawaii's reefs, and an unknown, but significant, fraction of reefs in the U.S. Pacific Territories. The widely distributed and isolated locations of many coral reefs preclude normal monitoring practices. In 1998, NESDIS established an experimental capability using POES satellites to conduct thermal bleaching surveillance of coral reefs on a world-wide basis. This experiment demonstrated remarkably accurate capabilities for early warning of thermally-induced coral reef bleaching conditions over all global tropical ocean regions, resulting in a series of special International Workshops on Satellite Monitoring of Coral Reefs being convened in June 1999, January 2001, and June 2003. In 2002 NESDIS successfully transitioned two existing experimental satellite reef health monitoring products into viable operational web-based products, in particular the Coral Reef HotSpot, an SST anomalies product, and an accumulated heat stress product. In October 2003, NESDIS declared the experimental coral bleaching monitoring products operational. These operational products include SST anomalies, HotSpots, DHWs and Tropical Indices page, and serve as excellent and useful tool for monitoring the potential coral bleaching events. Operational supports for these coral bleaching products are provided at NESDIS on a 24-hour, seven-day basis.

In addition, the proposed Coral Reef Watch (CRW) program provided support to NOAA's Coral Reef Information Service (CoRIS) promoting U.S. leadership in the emerging global "Virtual Coral Reef Ecosystem Monitoring Laboratory," and continues to provide support solid scientific basis for the development of future monitoring and assessment products and/or capabilities.

COASTWATCH.

NESDIS has responsibility for CoastWatch Program Management. This program managed in conjunction with other NOAA Line Offices, makes satellite data products and in situ data from NOAA environmental buoys available to Federal, state, and local marine scientists and coastal resource managers. Data from the Advanced Very High Resolution Radiometer (AVHRR) on NOAA's polar orbiting spacecraft are collected at Wallops Island, Virginia, and at Fairbanks, Alaska. These data are processed on NOAA computers in Suitland, Maryland, using a set of NOAA-developed multi-channel atmospherically corrected algorithms for determination of SST. Data are then mapped (Mercator Projection) and sectored to predefined coordinates specified for each of the CoastWatch regions. Digital, high-resolution data products (1 km/4 km in a CoastWatch Binary Format) are then passed daily to CoastWatch Regional Nodes in the eastern U.S. (i.e., Southeast, Great Lakes, Northeast, Gulf of Mexico, and Caribbean). For Regional Nodes in the Pacific region, CoastWatch local data acquisition and processing capabilities are in La Jolla, California; Anchorage, Alaska; and Honolulu, Hawaii. The Internet is used as the primary telecommunications pathway for digital data distribution. Once products are delivered to the CoastWatch Regional Nodes they become immediately available for local use. An ever-growing number of Federal, state, and local organizations are establishing a formal relationship with local CoastWatch Regional Nodes for routine timely access to CoastWatch image products. More information about CoastWatch is available on the Internet at coastwatch.noaa.gov/COASTWATCH/. Finally, The CoastWatch AVHRR products have undergone a modernization effort. These products are now in a new format (HDF) and use new processing software which has improved the earth locations of the products. CoastWatch has recently expanded, making available ocean color and ocean surface winds, as well as microwave sea-surface temperature, data and products.

NOAA NATIONAL DATA CENTERS (NNDC)

The NESDIS is responsible for the management of the NOAA National Data Centers (NNDC). The NNDC's consist of three data centers: the National Climatic Data Center (NCDC) located in Asheville, North Carolina, the National Geophysical Data Center (NGDC) located in Boulder, Colorado, and the National Oceanographic Data Center (NODC) located in Silver Spring, Maryland (www.nndc.noaa.gov).

The NOAA National Data Centers were established to be the Nation's primary repository for NOAA data. Since their inception, the role of the data centers has expanded in response to the introduction of new technologies useful to the centers and available to the users. Originally designed to archive only NOAA data, these centers now hold environmental data from a variety of sources, to include other U.S. government agencies, such as DOD and NASA, foreign governments, universities and cooperatives, and numerous commercial research programs.

The three NNDCs are responsible for the Scientific Stewardship of the Nation's environmental data, and developing and operating the associated ingest, monitoring, quality control processing, access, archive, analysis and assessment, creation of climate data records (CDRs), and other product generation systems in support of their national and international commitments and users. The NNDCs archive and provide access to numerous types of data. Each type of data provides a unique perspective for use in climate, oceanographic, space weather, and other geophysical research. It is often the combination of many of these data sets that lead to new discoveries and products that support activities, such as weather forecasting, risk (hazards-public safety and economic) mitigation, weather impact assessments, and climate assessments and predictions.

Data sets are typically divided into the method of collection: Remote (Satellites), Airborne, and In-situ (surface: land and ocean). In-situ includes radar, radiosonde, manual and automated surface observing systems, fixed and drifting buoys, etc. Observational data must be accompanied by comprehensive and complete station history data, referred to as metadata, as well as other ancillary and auxiliary documentation describing the data processing procedures (quality control and assurance) used prior to and after archiving the data.

Climate monitoring, evaluation, and prediction are critical to economic sustainability and environmental stewardship, as well as planning and responding to the quality of life changes that society will encounter in the 21st century and beyond. The challenge facing the NDCCs is not only ingesting and processing very large volumes of new data, but also the convenient and timely access to the data and information. Millions of paper pages and thousands of feet of microfilm/microfiche of recorded instrument measurements and other information dating back hundreds of years are currently under the stewardship of the NNDCs. Over the past 50 plus years, many observations have been stored in digital form. There is now in place a program to convert analog records to digital form. The process will take many years to complete.

The development of a new generation of satellites over the next ten years {NASA's Earth Observing System (EOS), Next Generation Geostationary Operational Environmental Satellite (GOES), and the Joint (DOD/NASA/NOAA National Polar-orbiting Operational Environmental Satellite System (NPOESS)}, the Initial Joint Polar System (IJPS)/MetOp, and the enhancement of the operational Next Generation weather Radars (NEXRAD) {dual polarization} present major data management (stewardship and customer access) challenges to the NNDCs (Figure 3-DOC-10).

To meet these challenges, the NOAA/NESDIS organization has developed the Comprehensive Large Array-data Stewardship System (CLASS) program that will provide a significant portion, but not all, of the funding resources required to improve and maintain the information technology (IT) infrastructure required to support the mandated scientific data stewardship responsibilities for these incredibly large volumes of data.

NATIONAL CLIMATIC DATA CENTER (NCDC)

The National Climatic Data Center (NCDC) is a designated Federal Records Center. It is the officially designated national archive for weather and climate data and information and is the world's largest archive of climate data. The NCDC produces and maintains numerous data sets, products, and assessments, and services many thousands of customers with data and products worldwide. NCDC operates World Data Centers for both meteorology and paleoclimatology. National and global data sets and assessments are produced that support economic and environmental decisions and plans affected by climate variations and change. The NCDC describes the climate of the U.S. through monthly and annual State of the Climate reports. The NCDC is collocated with the U.S. Air Force Combat Climatology Center and the U.S. Navy Fleet Numerical Oceanography and Meteorology Detachment. These three organizations make up the Federal Climate Complex, which together fulfill much of the Nation's climatological requests.

The vision of the NCDC is: To be the most comprehensive and accessible

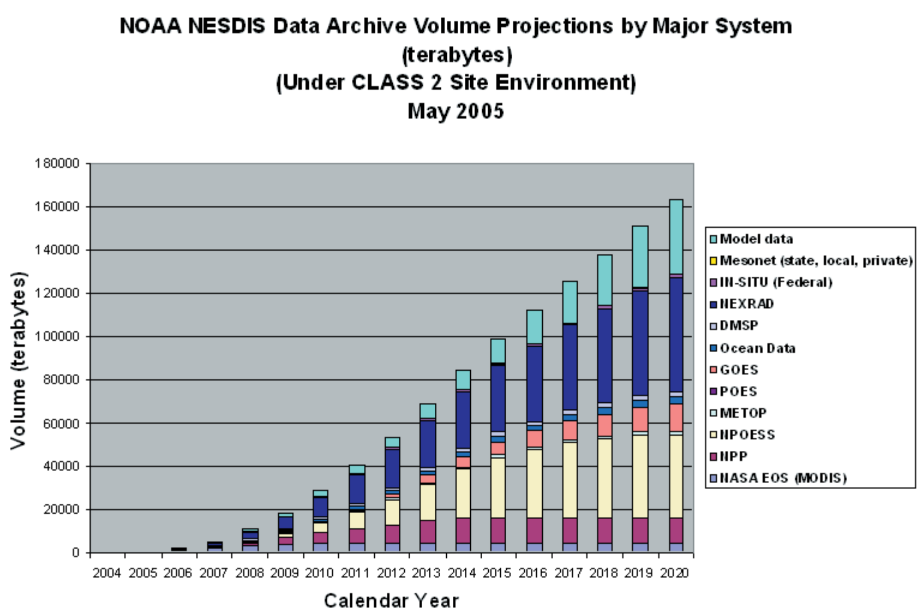


Figure 3-DOC-10. Projected growth of data from major systems that will require processing and storage.

source of quality climate and weather related data and information services and to be an objective authority on climate monitoring.

The mission of the NCDC is: To provide stewardship and access to the Nation's resource of global climate and weather related data and information, and assess and monitor climate variation and change.

The basic functions performed by the NCDC necessary to achieve the mission include: Acquisition (ingest of observations and data) and Quality Assurance Processing, providing Access for new and historical (archived) data, Archiving of data and information (long-term data stewardship), and Assessments (climate monitoring).

The NCDC is the "Nation's Scorekeeper" in terms of addressing severe weather events in their historical perspective. As part of its responsibility for "monitoring and assessing the climate," NCDC tracks and evaluates climate events in the U.S. and globally that have significant economic and societal impacts. Events include drought, hurricanes, tornados, severe storms, flooding, and wildfires. The NCDC is frequently called upon to provide summaries of global and U.S. temperature and precipitation trends, extremes, and comparisons in their historical perspective. Numerous web pages and reports are available dealing with these events and with the "state of the climate" in general. (See http://www.ncdc.noaa.gov/extremes.html and http://www.ncdc.noaa.gov/oa/climate/research/monitoring.html).

The U.S. sustained 62 weather-related disasters during the 1980-2004 period in which overall damages and costs reached or exceeded $1 billion at the time of the event (Figure 3-DOC-11). These disasters do not include any events that had unadjusted damages/losses less than $1 billion dollars, but subsequently may have reached $1 billion after applying the Gross National Product (GNP) inflation/wealth index. Fifty-three of these disasters occurred since 1988 with total unadjusted damages/costs of nearly $260 billion. Seven events occurred in 1998 alone, the most for any year in the summary period, though other years have recorded higher damage totals. (See http://www.ncdc.noaa.gov/oa/reports/billionz.html).

The NCDC developed visualization tools that are used with NEXRAD level II data and NEXRAD level III products. The NCDC NEXRAD Interactive Viewer and Data Exporter load NEXRAD volume scan data and derived products into an OPEN GIS compliant environment. The applications are launched via Java Web Start and run on the client machine while accessing the data remotely from the archive at the NCDC. The NEXRAD Interactive Viewer provides tools for custom data overlays, animations, and basic queries. The export of images and movies is provided in multiple formats. The NEXRAD Data Exporter allows for data export in both vector polygon (Shapefile, GML, Well-Known Text) and raster (GeoTIFF, ESRI Grid, HDF, NetCDF, GrADS) formats. The visualization tools have been used by NASA researchers in studying high atmospheric electronic fields near shuttle launches and by the National Transportation Safety Board in the investigation of aircraft accidents.

<u>Operational Programs</u>:

• Long-term stewardship (archive and access) of the Nation's weather and climate data, as part of the Federal Records Retention System. The NCDC is an approved Agency Records Center and operates under the NARA Federal Records Center guidelines and

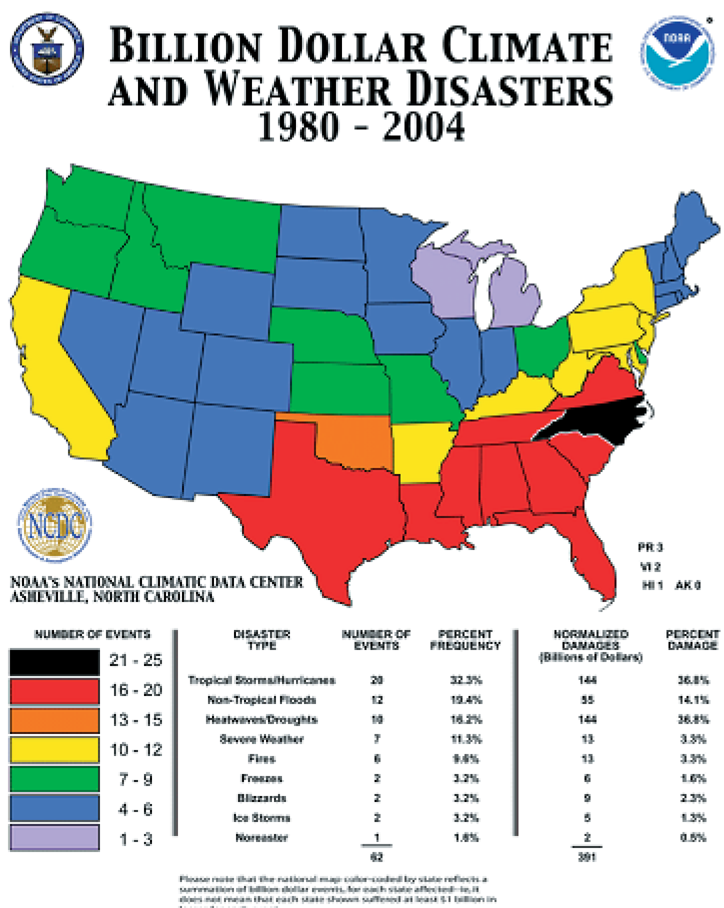


Figure 3-DOC-11. Billion dollar climate and weather disasters (1980-2004) summary.

policies for managing weather and climate data records and information.

• Scientific Data Stewardship functions inherent to the mission of the legislatively designated Nation's Climate Data Center. These include developing and operating the associated ingest, monitoring, quality assessment processing, access, archive, analysis and assessment, creation of climate data records, and other product generation systems in support of national and international commitments.

• National partnerships with Federal agencies (such as the National Aeronautics and Space Administration, Department of Defense, Environmental Protection Agency, Department of Agriculture, Department of Energy, Department of State, National Science Foundation, U.S. Geological Survey, U.S. Global Climate Research Panel), many state agencies, all NOAA Line Offices, Regional Climate Centers, State Climatologists, universities, and many others. These partnerships contribute to the collection, quality assurance processing, and access to regional and national observing networks, to climate monitoring, to the national climate assessments, and to a National Climate Services Program.

• International partnerships with the World Meteorological Organization, International Council of Scientific Unions, World Data Centers, Intergovernmental Panel on Climate Change, UNESCO, and other nations through bilateral and multilateral agreements. Examples are the World Data Center for Meteorology (archiving the data collected by internationally sponsored research programs and actively exchanging climate data with foreign countries to support research and other activities) and the World Data Center for Paleoclimatology (assembling, archiving, and providing access to global paleoclimatic data derived from worldwide tree-rings, stalactites and stalagmites, coral samples, pollen and macro-fossils, lake and bog sediments, marine sediments, ice cores, and other geological and biological sources).

• Maintaining and updating national and global baseline data sets and climate data records that are used for monitoring, evaluation, analyses, and assessments of climate variation and change on global and regional scales. Examples of these data sets include the Global Historical Climatology Network, the U.S. Historical Climatology Network, the Comprehensive Ocean-Atmosphere Data Set, the Comprehensive Aerological Reference Data Set, and the Monthly Climate Data of the World.

• Customer Service. Customers can access data, information, and products through a variety of means, such as real-time and near real-time digital access and retrieval of new and archived historical observations through E-Commerce web enabled capabilities (Internet), as well as through traditional methods, i.e., telephone, e-mail, , facsimile, and traditional post. Digital access, retrieval, and delivery of data on-line and in a robotic storage system via the Internet is the primary and preferred customer service capability. Data and information can also be delivered on magnetic media (tape and disk), hard copy (paper and microfilm), electronic downloads, and staged for FTP transfers. Many of the NCDC assessments, peer reviewed journal articles, published papers, and conference reports are also available on-line.

• Climate Data On-line (CDO) System. The CDO system is NOAA's primary means for distributing and providing access to in situ climate data. CDO includes both recent and historical data, useful for studies of particular weather events and for historical analysis of data for statistical and other research purposes. The general types of data currently included in the system, which continues to be populated, are surface hourly, daily, and monthly data, hourly precipitation data, and 15-minute precipitation data. As data integration efforts continue, the system will be greatly expanded to include numerous additional stations and data types. Also, data summarization and graphing capabilities are being added in 2005. There are two methods to access climate data within CDO:

1) Use the CDO "homepage" - http://cdo.ncdc.noaa.gov - this provides numerous search and retrieval mechanisms, such as by region, country, state, climate division, county, and station; for any required times series.

2) Use the GIS interface - go to http://www.ncdc.noaa.gov and click on "search by map" on the left-hand side bar. The GIS tool-set provides an array of methods to select regions and locations of interest, to overlay various layers of information, etc.

Supporting Research.

The NCDC engages in an active research program to support the operational programs. Examples are:

• Scientific Data Stewardship Program. This program provides an approach to maximizing the performance, quality, and utility of climate observing systems, data, and information so that the scientific integrity and long term utility of climate records for a broad range of users will be ensured. Five fundamental principles provide the framework for this program: (1) ensure Observing System quality during the design phase and real-time monitoring of performance; (2) develop an end-to end Climate Processing System that includes the timely ingest, quality assurance processing, immediate access to new and long-term access to historical records, and the long-term safeguarding of the climate records for future generations; (3) provide basic Information Technology (IT) support; (4) document Earth System Variability through monitoring and evaluation of present, future, and past observations; and (5) enable and facilitate future research through periodic analysis and assessment of new and historical records.

Research activities supporting this program include:

• Digital Access and Retrieval of Data and Information. Significant progress has been made to digitally ingest data in near real-time and make these data available to users within hours, instead of days or weeks, from on-line disk and robotic tape storage systems. Improved access to the Next Generation Internet high-speed communication capabilities have accelerated the amount of data delivered directly from the field to the NCDC at the time or soon after the time of observation. Data are now available from 10 to 400 times faster than ever before. One example of a very successful NWS/NESDIS/NCDC and OAR collaboration is the real-time direct digital ingest and access to NEXRAD (Weather Surveillance Radar-88D) Level II data through NGI connections with about 128 NWS and DOD sites. The NCDC also receives on a near real-time daily basis digital NEXRAD Level III data from a NWS Central Collection facility. New and historical data are now accessible digitally by users from on-line disk and robotic tape storage systems, and a visualization tool is also available.

• Digital Health of the Network Monitoring (Observing System Performance Indicators). The purpose of the network monitoring process is to improve the quality of new observations and the fidelity of the historical archives by providing real-time information on the health and status of NOAA's observing networks (Figure 3-DOC-12). The fully developed system will continually monitor and assess the state of these networks with the intent of providing feedback that could either lead to improvements in the network or changes in analysis techniques to account for problems in the network. Anomalies and systematic performance problems are evaluated and reported to the network manager. The outcome will be improved observing system performance and higher quality data records. In most cases, these data quality issues can be identified and corrected before the data are incorporated into the historical archives and associated databases. The COOP Observing Network and the U.S. Climate Reference Network (USCRN) are regularly monitored and the plan is to add other networks, such as ASOS, Upper Air, etc. The USCRN program has a more rigorous operational daily monitoring system of hourly performance (See www.ncdc.noaa.gov/oa/hofn/global-insitu.html).

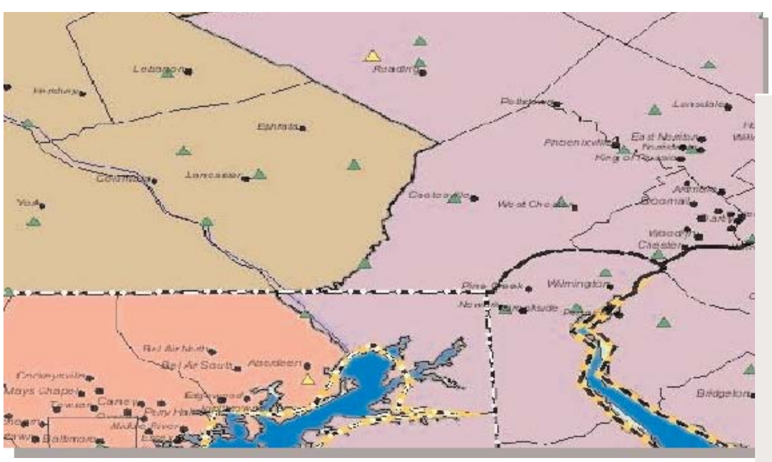
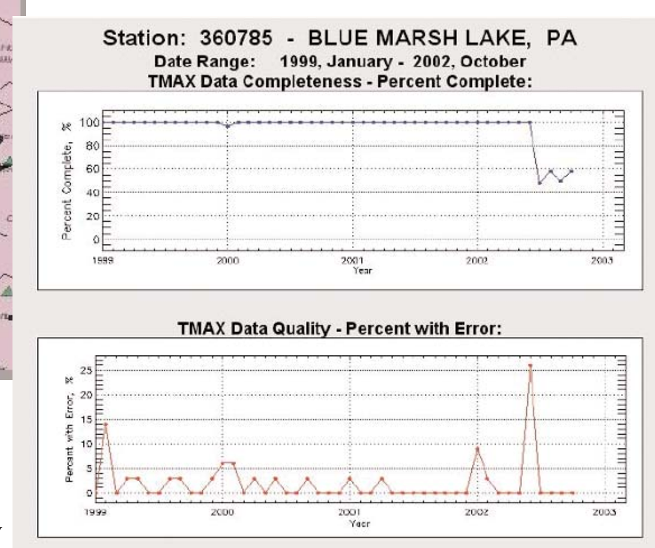


Figure 3-DOC-12. A network monitoring system provides real-time information on the health and status of NOAA's observing networks.



• Assessments and Reports. A series of regular reports are released regarding several key climate issues of concern to the nation. For example, the NCDC releases a monthly and annual State of the Climate for the U.S. and the North American Drought Monitoring Report which is a collaborative effort between Canada, Mexico, and the U.S. (See www.ncdc.noaa.gov/oa/climate/research/monitoring.html). Continuing study of the identification and blending of key parameters from satellite, radar an in-situ observing systems will lead to a new generation of quality climate data records. Understanding and knowledge, as well as new products and services for research and practical economic and environmental uses, will be derived from this progressive approach to maximizing the true value of observations.

• U.S. Climate Reference Network (USCRN). The Ten Climate Monitoring Principles described in the National Research Council Report, Adequacy of Climate Observing Systems (1999), are being used to guide the design, deployment, and life cycle management of the USCRN. The USCRN is the first U.S. observing system built with the primary purpose of providing climate-quality measurements (Figure 3-DOC-13). Data from the fully deployed network of approximately 110 stations will quantify the variance in surface air temperature and precipitation on a national scale. The USCRN climate-quality observations avoid the time-dependent biases typically experienced with other surface observing networks. The USCRN is becoming the Nation's benchmark network, by providing a standard to which satellite, weather radar, and other surface systems (e.g., ASOS, COOP, mesonets, etc.) observations can be validated and verified. In essence, the USCRN is providing the means to enhance the quality and confidence in other observations, as well as contribute to rehabilitating existing historical databases and data sets. This will produce a significant increase in the volume of climate quality data and information that can be used in assessing past climate trends and change, as well as contribute to the present and future climate monitoring, evaluation, and forecast tasks. (See www.ncdc.noaa.gov /crn.html)

• NOAA Operational Model Archive and Distribution System (NOMADS). NOMADS is a collaborative approach to provide access and data analysis capabilities for model and other data (Figure 3-DOC-14). The NCDC, in partnership with the National Centers for Environmental Prediction and the Geophysical Fluid Dynamics Laboratory, initiated this project to address a growing need for remote access to high volume Global Climate Model and Numerical Weather Prediction model data. The NOMADS team has partnered with existing and development activities including CLASS, National Oceanographic Partnership Program's, National Virtual Ocean Data System, the Department of Energy's Earth System Grid, and the Thematic Realtime Environmental Data Distributed Services developed through the National Science Foundation. NOMADS is a pilot project that uses a distributed client-server framework of data servers together with emerging technologies to access data stored in heterogeneous formats at geographically distributed repositories. NOMADS provides, for the first time, long-term stewardship of numerical and climate model runs and provides the regional modeling community with the data necessary to initialize local models. NOMADS also provides the tools necessary to intercompare model and observational data sets from around the world. Currently there are nine working NOMADS systems across the Nation serving data in the distributed framework. (See www.ncdc.noaa.gov /oa/model/model-resources.html)

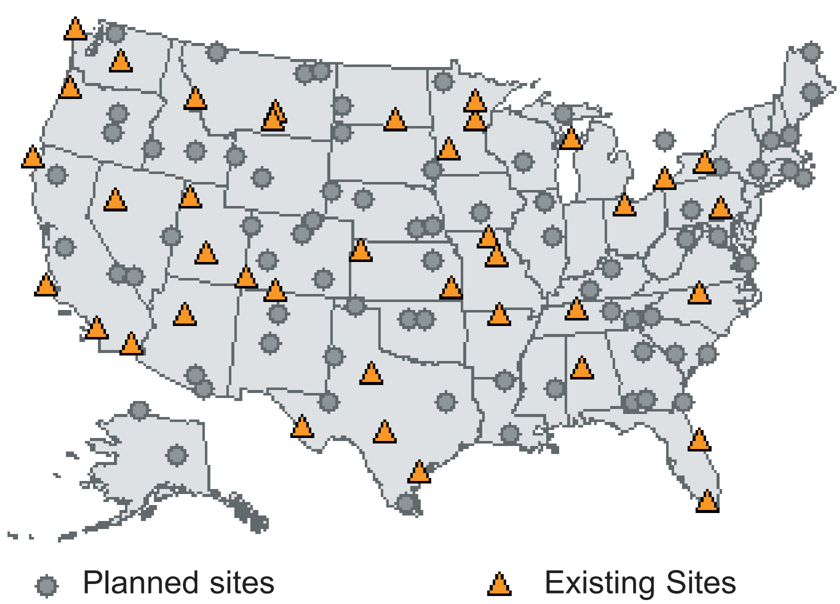


Figure 3-DOC-13. U.S. Climate Reference Network existing and planned sites.

• Climate Database Modernization Program (CDMP). Digital databases of wind speed and direction, precipitation, temperature, and pressure are far more useful than paper and microfilm records. These databases support many disciplines, including economic research, engineering, risk management, and passive (solar, wind) energy enterprises. The CDMP addresses access and utilization issues. The CDMP's goal is to make non-digital (paper/film) historical climate data digitally accessible and retrievable on-line via the Internet. The conversion of paper and microfilm records to digital databases and data sets will provide access to either optically scanned images of records or data manually keyed into digital databases. Many of these records are being merged with the more recent digital databases extending the digitally accessible and retrievable time series to many decades, as well as hundreds of years in some cases. Forty million documents have been imaged and many thousands of observations manually keyed or digitized from the merchant and military ship records, America's military forts, U.S. cities, lighthouses, weather ships, and other sources. However, approximately two thirds of the paper and film-based climate data remain to be digitized. The CDMP provides an unprecedented and unique opportunity to rescue valuable climate data dating back into the 1700s that are in jeopardy of permanent loss due to the deterioration of the paper and microfilm media (See www.ncdc.noaa.gov /oa/climate/cdmp/cdmp.html) .

• NOAA Paleoclimatology Program. Paleoclimatic data is an important segment of documenting and reconstructing annual to century scale records leading to climate records dat-

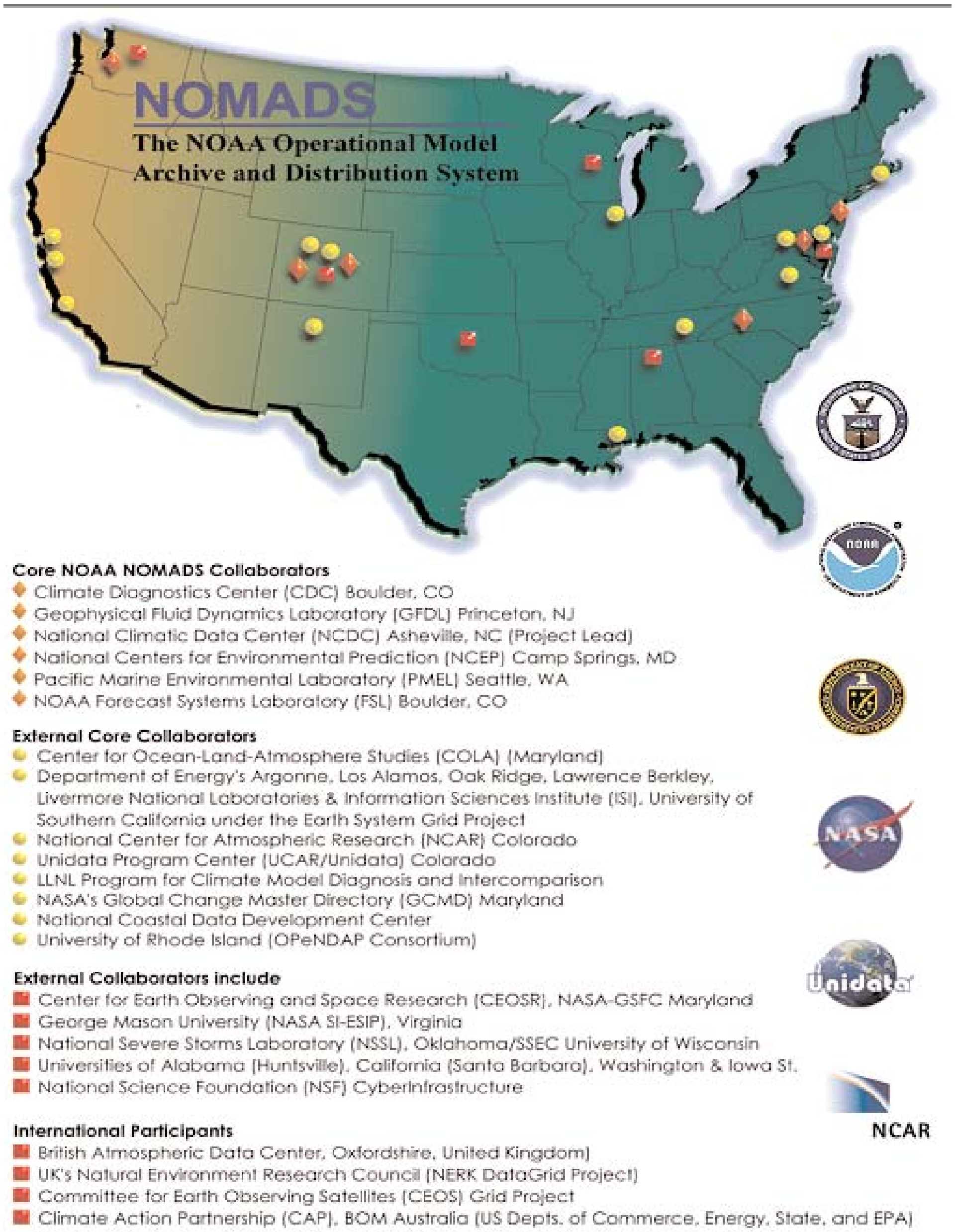


Figure 3-DOC-14. NOMADS is a pilot project and cooperative effort involving six public and private organizations. NOMADS will provide data access and analysis capabilities for model and other data.

ing back tens and hundreds of millennia. The incorporation of this program into the functions and activities of the NCDC enhances the identification and understanding of climate change and variation. The NCDC Paleoclimatology Branch cooperates with many countries in research projects that combine the global paleoclimate database with the instrumental record to extend the climate record back in time for climate model verification and climate change studies. Objectives of the program are to cooperate with researchers in academia, NOAA and other agencies to: conduct original research to describe the global patterns of annual-to-millennial scale climate change, understand the causes of climate change, separate man-induced climate change from natural variability, and validate the models that are used to predict future climates. (See www.ncdc.noaa.gov/paleo/paleo.html)

• Comprehensive Large Array-data Stewardship System (CLASS). CLASS is the NOAA implementation program for an improved architecture for archiving and servicing large-volume data. Advances in technology, including faster network access, web-based interfaces, and emerging discovery and analysis tools, will provide a one-stop capability to access the NOAA large array data sets. The CLASS objective is to establish a web-enabled browse, order, and retrieval delivery system that will enhance and increase the availability and accessibility of satellite, radar, and other data and derived products to customers worldwide. The CLASS integrated storage and web-based access and servicing system design incorporates many of the features and capabilities of the current Satellite Active Archive system built for the POES data stored on a robotic system located in Suitland, MD. The CLASS program has established dual sites, one in Asheville, NC, and another in Suitland, MD. There are plans to move the Suitland site to Boulder, CO, in the second quarter of FY 2006. A third CLASS site is also slated for Fairmont, WV, later in FY 2006.

NOAA Polar-orbiting Environmental Satellite (POES) and Geostationary Orbiting Environmental Satellite (GOES) data are currently available via the CLASS interface. CLASS data and product enhancements will be implemented in phases called campaigns. New major campaigns planned include NEXRAD, National Polar-orbiting Environmental Satellite System Preparatory Program (NPP), National Polar-orbiting Operational Environmental Satellite System, Earth Observing System Long Term Archive, and the European Meteorological Operational Satellite Program (see http://www.class. noaa.gov/nsaa/products/welcome).

• Air Quality Forecasts. NCDC recently began archiving NOAA's Air Quality Forecasts. The Air Quality Forecasts are forecast guidance of one-hour and eight-hour averaged ground-level (surface) ozone concentration. The guidance will be produced twice a day, for hourly intervals through midnight on the following day (48 model hours), seven days a week for the northeastern U.S. initially, and then gradually will include the entire U.S. by 2009.

The NOAA National Weather Service will provide the data. These data provide ground-level ozone forecast guidance for state and local air quality forecasters and help the public limit adverse effects from poor air quality. This forecast guidance would help meet a congressionally directed national air quality forecast capability. These data will have received a high measure of quality control through computer and manual edits (see www.arl.noaa.gov /ready/aq.html).

NATIONAL OCEANOGRAPHIC DATA CENTER.

The National Oceanographic Data Center (NODC) (www.nodc.noaa.gov) manages the world's largest collection of publicly available oceanographic data. NODC holdings include in situ and remotely sensed physical, chemical, and biological oceanographic data from coastal and deep ocean areas. NODC customers reuse this data to answer questions about climate, and ocean and coastal phenomena. Specifically, NODC data archive and access responsibilities support climate research and operational ocean observing system activities as follows:

• NODC performs ocean profile data management for internationally coordinated global ocean observing systems such as the Argo Ocean Profiling Network and the Global Temperature-Salinity Profile Program (GTSPP) in cooperation with applicable JCOMM committees. NODC's objectives are (1) to safeguard versions of the Argo and GTSPP near real-time and retrospective data and information and (2) to provide high quality data to a wide variety of users in a timely and useful manner. The Argo and GTSPP data system present an excellent opportunity to improve ocean and climate forecasting, with consequent benefits for the protection of life and property and effective planning for the effects of seasonal to inter-annual climate variability.

• NODC produces regular updates of the World Ocean Database and World Ocean Atlas. The most recent version, 2001, includes over seven million profiles of scientifically quality controlled ocean temperature, salinity, oxygen, plankton, pigment, and nutrient data. The Atlas presents statistics and objectively analyzed fields for one-degree and five-degree squares generated from World Ocean Database 2001, observed and standard level flagged data. The ocean variables included in the atlas are: in-situ temperature, salinity, dissolved oxygen, apparent oxygen utilization, percent oxygen saturation, dissolved inorganic nutrients (phosphate, nitrate, and silicate), chlorophyll at standard depth levels, and plankton biomass sampled from 0 - 200 m depth. Further information on both products are available at: www.nodc.noaa.gov /OC5/indprod.html.

• The NOAA Marine Environmental Buoy Database (http://www.nodc.noaa.gov /BUOY/buoy.html) is one of the largest and most frequently used data archives maintained by the NODC. This database holds wind, wave, and other marine data collected by the NOAA National Data Buoy Center (NDBC) from moored buoys and C-MAN (Coastal-Marine Automated Network) stations. Parameters reported by both buoys and C-MAN stations include air temperature and pressure, wind speed and direction, wind gust, and sea surface temperature.

• NODC is developing a capability to provide public access to consistently-processed, climate-capable satellite data sets and applying them to various scientific problems. The first products provided in 2003 were Pathfinder reprocessed 9 km and 4 km sea surface temperatures. For further information see www.nodc.noaa.gov/sog/.

NOAA/NODC LIBRARY

NODC houses the NOAA Central Library (www.lib.noaa.gov/) which supports weather and climate research programs by providing a variety of information services, including:

• Access to print and electronic versions of American Meteorological Society journals.

• Access to Meteorological and Geoastrophysical Abstracts (desktop access at the Silver Spring campus).

• Desktop access to Web of Science at several NOAA sites.

• Assistance in obtaining site licenses for 169 National Weather Service field sites for electronic access to Monthly Weather Review and Weather and Forecasting.

• Archival of historic collections of the Weather Bureau.

• Data rescue of hundreds of volumes of meteorological data publications in danger of loss.

NATIONAL GEOPHYSICAL DATA CENTER

National Geophysical Data Center (NGDC) (www.ngdc.noaa.gov) staff archive, assess, and provide access to satellite and ground-based observatory data from national and international programs supporting research in meteorology, climatology, and space weather as well as solar-terrestrial physics, snow and ice, marine geology and geophysics, and solid earth geophysics. The National Snow and Ice Data Center (NSIDC) is an affiliated partner with NGDC. World Data Centers for Solar-Terrestrial Physics, Marine Geology and Geophysics, , Glaciology, and Solid Earth Geophysics under the auspices of the International Council of Scientific Unions are operated by the two national centers. NGDC also hosts the secretariat for the Scientific Committee for Solar-Terrestrial Physics. Research activities focus on satellite remote sensing to assess the long-term changes of the land surface, the space environment, snow cover, and sea ice.

Long-term archive responsibilities for the Nation are provided by NGDC activities. NGDC maintains the Nation's archive for global tsunami and related hazard events. This includes tsunami events, triggers, run-up locations and heights, damage descriptions and photographs. This information is essential for researchers focusing activity on at-risk areas. As part of NOAA's effort to improve tsunami research and warning, NGDC is establishing the long-term archive for ocean bottom pressure and Deep-ocean Assessment and Reporting of Tsunamis (DART) data. NGDC also manages the sole archive of space weather data from GOES, POES and DMSP satellites. NGDC maintains the only archive of raw data records and VNIR imagery collected on DMSP satellites for meteorological, oceanographic and Earth surface studies. The space weather ground-based archives focus on data used in NOAA's space weather forecasts, warnings and alerts. NSIDC manages cryospheric data from both ground-based and satellite instruments. These data stewardship and scientific stewardship activities for satellite and ground-based data include processing, management, analysis and quality assessments.

On line access services to these large databases continue to evolve at NGDC. Data discovery, browsing, and delivery are fairly mature functions. Data directories are managed by relational database management systems available to most search engines. Almost all of the data sets reside in robotic libraries and are accessible online, however some data sets are easier to browse, display and use than others. NGDC recently established Web map-based access to the integrated hazards databases. Users can select events either through the map interface or via a traditional form search and retrieve tsunami event, run-up, earthquake, photographs, and death and damage reports. NGDC has several projects as part of the NESDIS program to digitize and make accessible the most important records in the huge historical archive. Interactive displays of multi-disciplinary data sets and data mining are under development and NGDC has embarked on an environmental scenario generator project to mine information from the archives and to use the mined information to launch a numerical simulation of the atmospheric and space environments.

DMSP program prepares calibrated and geo-referenced records from the raw data records recorded by the scientific instruments on DMSP satellites. Data sets include visible, infrared and microwave imagery, microwave soundings and in situ measurements of the space environment. User services are provided through the Space Physics Interactive Data Resource (spidr.ngdc.noaa.gov/spidr/). Research activities focus on the use of the visible and infrared imagery recorded at night, a unique monitoring capability of DMSP satellites. Starting in 2004, a major effort was undertaken to digitize the nighttime visible imagery to record changes in population and economic vitality over the 30 years of the archive.

GOES, POES and DMSP satellite data of solar activity and the near Earth space environment managed by NGDC provide the long-term monitoring of space weather conditions. These data record the Earth's magnetic field, the electrically charged environment, and solar x-rays from geosynchronous and polar sun-synchronous altitudes. Data from ground-based observatories recording solar activity, ionospheric characteristics and geomagnetic variations complement, enhance and provide ground truth for the satellite measurements. Solar Geophysical Data containing solar and space weather data is published monthly. The space weather program at NGDC archives measurements of total solar and solar spectral irradiance for use in climate studies (http://spidr.ngdc.noaa.gov/ spidr/). Tabular listing of ionospheric parameters and ancient solar images are part of the digitizing and access program.

NATIONAL SNOW AND ICE DATA CENTER.

The National Snow and Ice Data Center (NSIDC) at the University of Colorado, which is affiliated with NGDC, manages several cryospheric-related data archives of interest to meteorology and climatology. These data sets include a collection of historical photographs of glaciers, temperature, pressure and position data from drifting buoys placed on the central Arctic pack ice, and data from the NOAA snow cover and DOD-NOAA sea ice chart digitizing projects. NSIDC provides data management services for a variety of cryospheric research programs sponsored by NASA and NSF. In addition, NSIDC has developed gridded sea ice products (sea ice concentrations and multi-year ice fraction) based on passive microwave data collected by NASA and DMSP satellites. NSIDC is acquiring snow cover, glacier and sea ice records from the former Soviet Union. Online services are available at www.nsidc.colorado.edu (Figure 3-DOC-15).

SUPPORTING RESEARCH.

Natural Hazards Reduction.

Severe tsunami events are relatively rare and frequently the first reaction to a serious event such as the December 26th Indian Ocean tsunami is to clean-

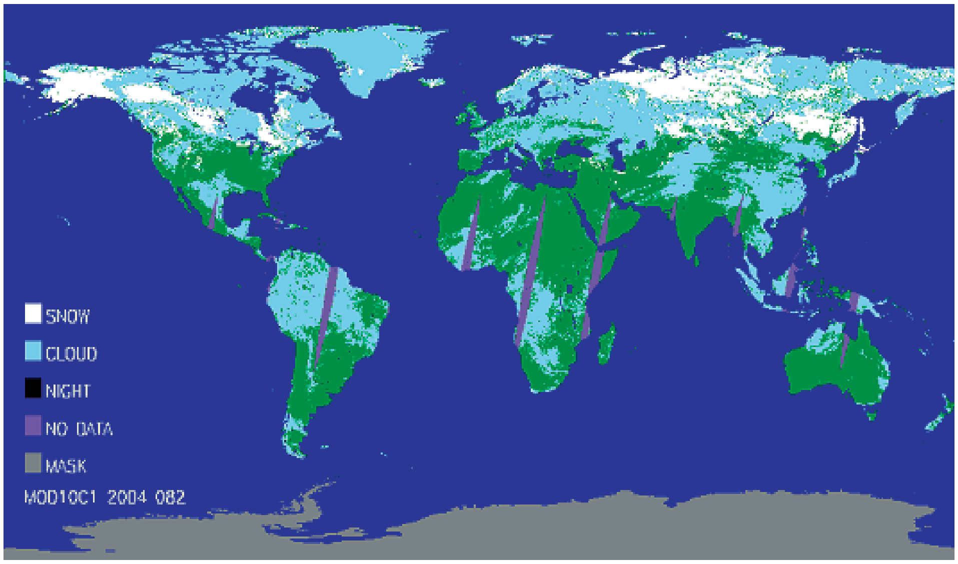


Figure 3-DOC-15. The Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the NASA Earth Observing System of satellites is used to map snow and ice. The figure above is an image from the MODIS/Terra Snow Cover Daily L3 Global 0.05 degree CMG data set (www.nsidc.org).

up the damage. A global database of past tsunami events, run-up heights, death and damage descriptions, and photographs is an essential research tool when identifying at risk areas and likely damage from modeled events. NGDC maintains the nation's global tsunami event database. We are collaborating with Humboldt State University on two projects. The first is to review the completeness and accuracy of the Pacific events reported in the database, extending to include paleotsunami events. The second is to develop a framework for analyzing the socio-economic impact of tsunamis. See http://www.ngdc. noaa gov/seg/hazard/hazards.shtml

Environmental Remote Sensing.

Operational meteorological satellite systems provide a unique opportunity to monitor features on or near the Earth's surface, sometimes on a nightly basis. The DMSP nighttime imagery are used to locate sources of visible and infrared emissions including city lights, lightning, wildfires, flaring gas, and boats. Research projects use the city lights to infer such diverse parameters as population density, economic vitality, and carbon dioxide emissions. More information is available at dmsp.noaa.gov/dmsp.html.

Wildfires Monitored from Space.

DMSP Operational Linescan System imagery offer a unique opportunity to monitor wildfires because each satellite records nighttime visible emissions covering the entire globe each day. Instruments designed to detect clouds also "see" wildfires--many of which burn in very remote areas. NGDC has developed a unique capability to capture the nighttime emissions from both large and small wildfires. The system has been used to assist operationally by the Operational Significant Event Imagery and by firefighters in developing countries. More information is available at dmsp.noaa.gov/ dmsp.html.

Space Weather.

The space weather program is dedicated to the long-term archive and analysis of NOAA's space weather data. This year marks the completion of an 11-year space weather climatology, covering the ionosphere, thermosphere and inner-magnetosphere. The project, which is designed similarly to the NCEP/NCAR re-analysis project, provides the user community with a uniform view of key space

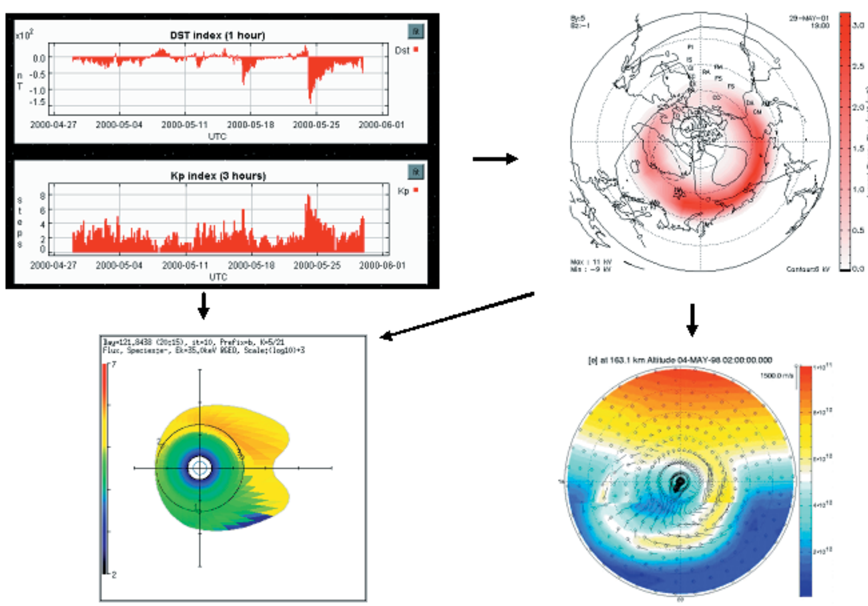


Figure 3-DOC-16. Space Climatology. NGDC researchers use the archive of POES, DMSP, ground-based observatory, and ground-based indices to drive physical models of the near Earth space environment. An assimilation of ionospheric electric fields during the recovery of a major magnetic storm is shown (top right). Physical model outputs for the Earth's magnetosphere (bottom left) and electron density (bottom right) all linked to observational data are shown.

weather domains. In the coming years, analysis of this data will allow for tracking of changes observed in the near-Earth space environment. (Figure 3-DOC-16)

Cryospheric Research at NSIDC.

NSIDC research interests cover a broad spectrum of climate-cryosphere interactions using a variety of observing techniques with special emphasis on arctic regions and satellite-born instruments. Their projects study the long-term record of snow and ice in the arctic, in the sea and in mountainous regions, as well as the hydrology of the southwestern U.S. Algorithms to detect snow, frozen ground and sea ice in passive microwave images recorded on DMSP and NASA satellites have been developed at NSIDC. They have developed models that describe the physical and mechanical properties of snow and ice in glaciers and avalanches. Another area of special interest and study is the interaction between sea ice and the ocean and atmosphere. See www.nsidc.org.

OCEANIC AND ATMOSPHERIC RESEARCH LABORATORIES.

Programs within the Oceanic and Atmospheric Research (OAR) Laboratories support various National Oceanic and Atmospheric (NOAA) meteorological and oceanographic missions. The activities of OAR laboratories are oriented toward providing the scientific and engineering understanding, tools, and techniques that form the basis of improved oceans, weather, water, and climate services.

Special emphasis is placed on improving severe weather, flood, and hurricane warnings and forecasts and on improving the utilization and dissemination of data and information. Severe weather events include flash floods, strong winds, thunderstorms (including tornadoes, lightning, and hail), heavy snowstorms, extreme cold and heat, drought, and geomagnetic storms. The key contributions to improved hurricane forecasts fall under the "Hurricanes at Landfall" (HL) focus of the United States Weather Research Program (USWRP) administered by NOAA's National Weather Service (NWS). They include more accurate prediction of track, intensity, surface winds, rainfall, and human impacts. Improving flood forecasts fall under the component of USWRP labeled "Improving Quantitative Precipitation Forecasting."

In pursuit of improved utilization and dissemination of data, the OAR laboratories conduct both in-house and cooperative research with other NOAA organizations, government agencies, joint institutes, universities, and the private sector. In addition, OAR laboratories conduct research to improve routine weather forecasts and improve the ability to forecast regional air quality and atmospheric deposition.

A significant focus of OAR in the weather and air quality area is the development of operational testbeds under the auspices of the USWRP. These testbeds are the mechanism through which research is transitioned to operations. It is recognized by the USWRP that since NOAA is one of the forecast mission agencies in the program, and the program goals are predominantly operational ones, its most significant role in the USWRP is to provide the infrastructure and capabilities to efficiently and effectively test research products in an operational environment. The testbeds are the Joint Hurricane Testbed, the Mesoscale Numerical Weather Prediction Testbed, and the Joint Center for Satellite Data Assimilation. These testbeds are operated in partnership with other USWRP agencies.

OAR's role is to provide directed research and operational testing, in partnership with the NWS. In addition, the development of the Weather Research and Forecasting (WRF) modeling architecture, also under the auspices of the USWRP, will provide a common modeling structure to be shared by most of the testbeds and between the research and operations communities. Several OAR laboratories are involved in the WRF development in partnership with the NWS and other USWRP agencies.

OBSERVING TECHNOLOGY.

OAR laboratories in Boulder, Colorado, and one in Norman, Oklahoma, are heavily involved with developing new environmental observing system technologies.

The Environmental Technology Laboratory (ETL) in Boulder, Colorado, develops and evaluates new remote-sensing concepts and systems. This development and the associated environmental research directly support the Nation's forecasting and warning services.

The Forecast Systems Laboratory (FSL) in Boulder, Colorado, takes promising new scientific and engineering technologies from the research arena, helps develop them into mature engineering systems, and transfers these technologies to NOAA operations and the private sector.

The National Severe Storms Laboratory (NSSL), located in Norman, Oklahoma, both develops new remote sensing systems and assists in the transfer of these technologies to the NWS.

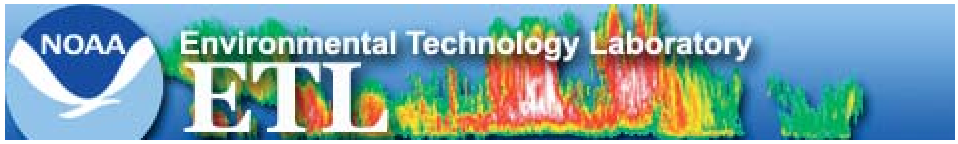
<u>FSL Observing Activities.</u>

FSL is investigating the use of super-pressure balloons in the stratosphere as a platform for monitoring and observing the environment. Among the balloons' capabilities would be atmospheric soundings. The trajectory of the balloons could be controlled to some extent by adjusting their altitude so as to take advantage of the vertical shear. The balloons would carry compact, lightweight sondes whose locations could be tracked as they fell toward the surface. The balloons would comprise a moderately priced global system.

A number of engineering tests have already been performed at altitude by piggybacking on a zero-pressure balloon launched by the Physical Science Laboratory at New Mexico State University and with launches near the Oregon coast. Telemetry was received line-of-sight from a distance of over 200 miles, the storage batteries were charged by solar panels, the proper thermal environment was maintained during the daytime heating cycle, and the instrument package was successfully recovered after descent by parachute.

FSL is also taking a leadership role in implementing the International Earth Observation System includes the development and testing of Remotely Operated Aircraft (ROA, formerly referred to as UAVs) for providing global weather and climate observations. The FSL is one of several NOAA Research laboratories collaborating with NASA in support of this project. The goal of these missions is to evaluate the utilization of ROAs for improved U.S. and global observing. The Altair's integrated sensor package consists of such components as an ocean color sensor and passive microwave sounder developed by the NOAA's ETL, a gas chromatograph and ozone sensor developed by the Climate Modeling and Diagnostics Laboratory, a digital camera system provided by NASA, and an electro optical infrared sensor provided by GA-ASI. High and medium altitude, long-duration ROAs can fly at remote locations in dangerous flying conditions for long periods. This technology provides many scientific benefits such as sustained global high quality all-weather profiles of atmospheric composition (water vapor, aerosol, cloud water and trace gases), and high altitude vertical resolution and profiling. It also offers a rapid response platform for improved high impact weather forecasts at 1-day to 2-week lead times, and better climate change detection, attribution, and prediction in support of policy decisions.

In a related balloon development effort, the Idaho Falls Division of the Air Resources Laboratory (ARL) is refining its constant-level "smart" balloon, intended to serve as a marker of parcels of air moving across the countryside and permitting samples to be made of the changes occurring in its composition. The Idaho Falls group is also active in the development of high wind speed sensors, such as those used on aircraft and for studies of hurricanes. A specialized probe to measure turbulence during hurricanes is now nearing completion, as a joint project with the Oak Ridge Division of ARL. The Oak Ridge group continues to lead in the development of specialized sensors for measuring atmospheric turbulence. Their systems are now widely used for measuring the efficiency of coupling between the air and the surface, and have recently been selected for instrumenting the latest generation of research aircraft, manufactured in Italy.



ETL Observing Activities.

ETL and FSL will continue development of new sensors and innovative techniques for combining observing systems synergistically and economically. Efforts include developing tools and techniques to integrate the data from surface-based and satellite-borne profiling systems for more effective use of these data in forecasts. In support of this effort, ETL has recently added a satellite remote sensing group that uses data from various environmental satellites to study air-sea interaction processes, the global hydrological cycle including water vapor and precipitation, and the Earth's radiation budget.

ETL has demonstrated that tornadoes can be detected well before touchdown by listening for their unique infrasonic signatures. Infrasonic antennas located in the central U.S. have been used to detect and locate numerous tornadoes. Verification of these tornadoes has been provided by Doppler radar and visual sightings. This research effort is continuing and it is proposed that a network of these inexpensive infrasonic systems be deployed at WSR-88D sites to enhance early detection capability.

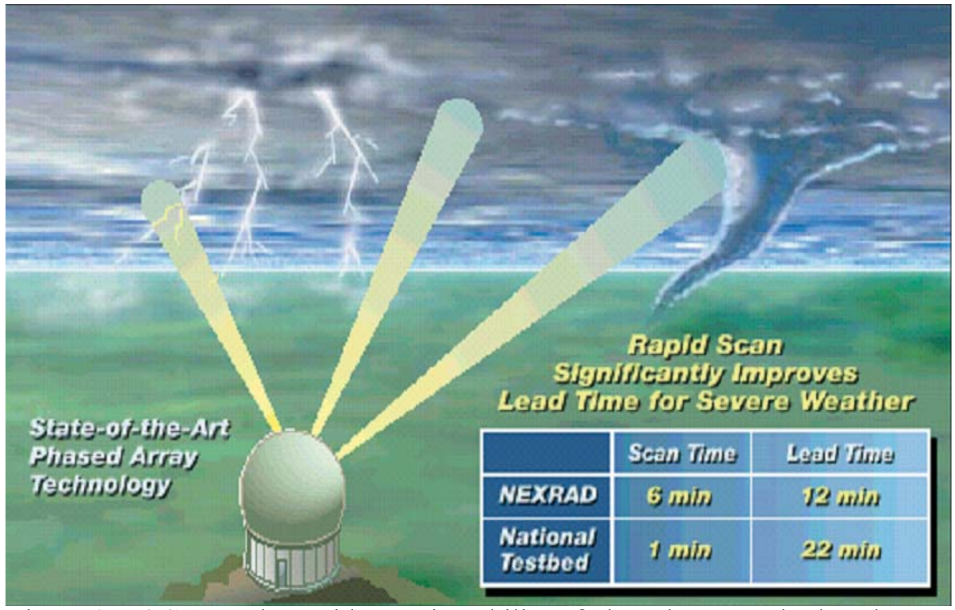
Icing is a weather hazard that occasionally causes aviation disasters, especially in winter. In-flight icing forms on wings and other exposed surfaces as an aircraft flies through clouds that contain super-cooled liquid water droplets. Leveraging earlier work with polarization-sensitive cloud radars, ETL designed a new ground-based cloud radar and radiometer system to monitor clouds in the vicinity of airports and to provide automated warnings of icing conditions aloft. This instrument is the Ground-based Remote Icing Detection System (GRIDS). In addition, FSL continues to perform research and analysis to improve aviation forecasts.

ETL is developing an airborne Polarimetric Scanning Radiometer (PSR) designed to provide higher resolution measurements of sea state quantities, including surface winds. ETL is also investigating the possibility of measuring soil moisture by L-band radiometers.

Starting in 2003, ETL and CMDL have been working together establish a new Arctic Atmospheric Observatory in North East Canada as a part of the SEARCH (Studies of Environmental Arctic Change) Program. The Canadian Observatory is being designed to mirror many of the cloud, aerosol and radiation measurements that are already made in Barrow, Alaska. Since North East Canada and Barrow, Alaska are in markedly different Arctic regimes the long-term measurements from these sites will be complementary in providing information to monitor Arctic atmospheric changes. Long-term data from these sites will be used to improve short-term and long-term forecast models, and improve satellite measurement of meteorological phenomena in the Arctic regions.

ETL is engaging in a comprehensive observation program to improve operational weather forecast and planned climate model treatments of boundary layer forcing processes. This work centers on development and application of observing technologies for surface fluxes and key boundary-layer variables (profiles of temperature, humidity, wind, and cloud properties). Ship-based measurement systems have been developed and are now used routinely on NOAA research vessels to investigate model accuracies in the marine boundary layer. Recently, land-based systems have been developed and deployed. One point of emphasis is linking observed cloud properties (obtained with mm-wavelength cloud radars and microwave radiometers) to cloud effects on surface turbulent and radiative fluxes (this approach is termed cloud forcing). Ship-based and satellite retrievals of cloud and flux properties are being used. ETL is compiling a large data base to allow climatologically-oriented studies of model parameterizations. Future plans include expanding the observational capabilities to add scanning mm-radar capabilities for investigation of precipitation initiation (a critical issue in triggering deep convection in model domains).

The ETL satellite applications group has developed new techniques for monitoring atmospheric properties over the ocean surface including air temperature and specific humidity. Retrievals of these quantities were improved through novel use of satellite atmospheric sounders in combination with passive microwave imaging radiometers. The products are being applied to improved global estimates of the flux of heat between the ocean and atmosphere. ETL is also producing a new satellite-derived sea surface temperature product through the blending of infrared and passive microwave data. The technique takes advantage of the complementary strengths of the two sensor types. The product has significant meteorological applications through its use as an input to numerical weather forecast and climate models.



	Scan Time	Lead Time
NEXRAD	6 min	12 min
National Testbed	1 min	22 min

Figure 3-DOC-17. The rapid scanning ability of phased array radar has the potential to significantly increase the average lead times of tornado warnings.

NSSL Observing Activities.

The NSSL is known for its development of observational capability, both remote and in situ, and in particular for its role in the development of the WSR-88D NEXRAD radar. NSSL is presently working to improve the WSR-88D software algorithms used by the NWS forecasters and is exploring ways to enhance the WSR-88D hardware using dual polarization techniques. Most weather radars, including the WSR-88D NEXRAD radar, transmit radio wave pulses that have a horizontal orientation. Polarimetric radars (also referred to as dual-polarization radars), however, transmit radio wave pulses that have both horizontal and vertical orientations. The horizontal pulses essentially give a measure of the horizontal dimension of cloud (cloud water and cloud ice) and precipitation (snow, ice pellets, hail, rain) particles while the vertical pulses essentially give a measure of the vertical dimension. Since the power returned to the radar is a complicated function of each particle size, shape, and ice density, this additional information results in improved estimates of rain and snow rates, better detection of large hail location in summer storms, and improved identification of rain/snow transition regions in winter storms. The first step in the processing is to prototype a new Radar Data Acquisition (RDA) unit for the WSR-88D capable of processing the additional information to produce the dual polarization information. In March 2002, dual polarized data were collected using the NSSL WSR-88D research radar located on the NSSL Norman, Oklahoma campus. NSSL is assisting the NWS with the next step, the development of a generalized dual-polarization solution for their network of WSR-88D radars.

NSSL researchers are adapting SPY-1 radar technology currently deployed on Navy ships for use in spotting severe weather (Figure 3-DOC-17). Early tests and data collections from the phased array radar system have proved promising, and the technology has the potential to improve the NEXRAD system for all weather radar applications. Using multiple beams and frequencies that are controlled electronically, phased array radar reduces the scan time of severe weather from six minutes for NEXRAD radar to only one minute, producing quicker updates of data and thereby potentially increasing the lead time for tornado warnings well beyond the current average of 11 minutes. Other NSSL developed technology will extend lead times even farther.

HIGH IMPACT WEATHER RESEARCH

The NSSL focuses on research to better understand severe weather systems and their associated hazards, such as tornadoes, hail, high winds, heavy rain and snow, lightning, and ice storms with the goal of helping the NWS improve forecasts and warnings. The parameters of storm development and intensification are identified and studied by incorporating observations from Doppler weather radar, satellites, remote-sensing wind profilers, instrumented aircraft, and lightning-location networks. NSSL's research includes assessment and improvement of numerical models to forecast severe weather systems.

NSSL provides significant technical and scientific support, with a focus on research and development, for the NWS WSR-88D radar program. In 2005, NSSL continued to develop techniques, in cooperation with the NWS, to forecast and warn of weather hazards to aviation and the general public. The Joint Polarization Experiment (JPOLE) was conducted in the spring of 2003, with the overarching goals of testing the engineering design and determine the data quality of the polarimetric KOUN WSR-88D radar, demonstrating the utility and feasibility of the radar to operational users, and collecting data and information that could be used to perform a cost/benefit analysis. Knowledge gained from the Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX) campaigns in the mid- and late-1990's, 1998's Mesoscale Convective System (MCS) Electrification and Polarimetric Radar Study (MeaPRS) and the 2000 Intermountain Precipitation Experiment (IPEX) provided new understanding of severe thunderstorms, storm electrification, winter weather, and tornadoes and led to improved methods to detect, model, and predict these storms (Figure 3-DOC-18).

NSSL works closely with the NWS WSR-88D Radar Operations Center (ROC). NSSL's involvement with the project to re-host the Radar Product Generator to an open systems computation platform (ORPG) was completed in November 2001. The ORPG system will ease the incorporation of new software applications and allow for integration of new hardware technology into the radar system resulting in less time needed for technology transfer. The NWS's ORPG deployment for 170 total radar sites, both operational and non-operational, began August 2001 and ran through 2002. In 2004 and 2005, the ROC and NSSL worked together to extend a prototype research project that provided high-resolution Level II WSR-88D radar data to universities, government users, and private companies to a national level.

Improvement of short-range (1-12 hour) forecasting will be accomplished by the development and evaluation of new local data system technologies and techniques, many of which can be incorporated into operational weather forecasting in the near term. FSL develops and evaluates state-of-the-art workstations for forecast office environments. Specifically, FSL has and will continue to develop capabilities to allow the forecaster to integrate, view, and manipulate observations from current and planned meteorological sensing systems using computer-assisted data display and synthesis techniques. NSSL is collaborating with NWS and FSL to integrate some of NSSL's advanced single and multi-radar display capabilities into AWIPS.

FSL will continue efforts toward effective assimilation of diverse observational data into numerical prediction models. Data from the Aeronautical Radio Incorporated (ARINC) Aircraft Communications, Addressing, and Reporting System (ACARS); WSR-88D Doppler radars; and weather satellites, especially Geostationary Operational Environ-mental Satellite (GOES), are frequent and provide unprecedented resolution, either in the vertical or the horizontal, or both. These data are being more fully exploited in the Local Analysis and Prediction System which provides highly detailed analyses and forecasts over areas hundreds of kilometers on a side, and the Mesoscale Analysis and Prediction System, the basis for operational and frequent short-term forecasts for the lower 48 states. The system has been incorporated into the

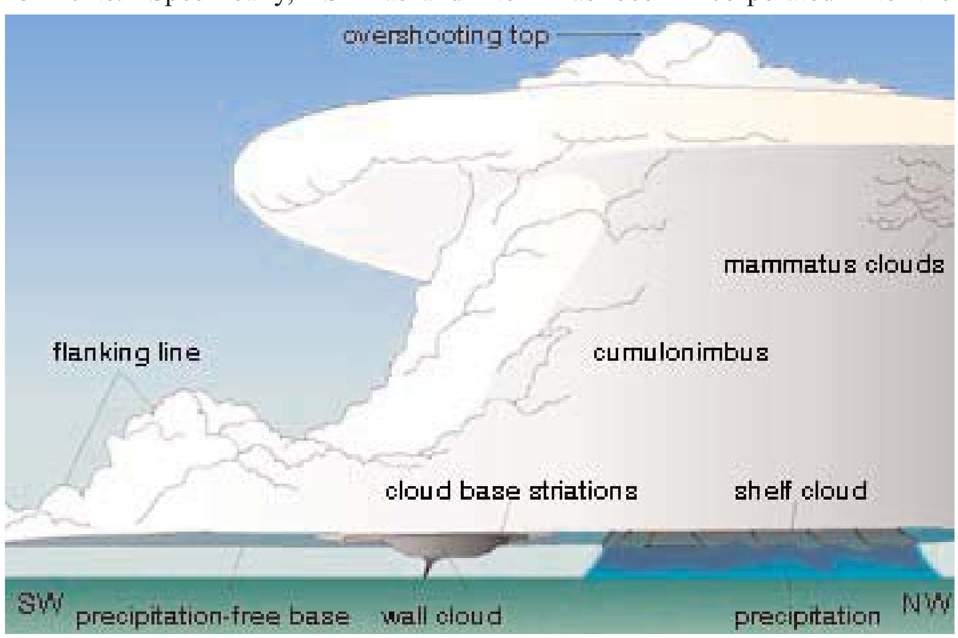


Figure 3-DOC-18. Schematic diagram of a thunderstorm
(Source: NSSL's VORTEX Project web site)

AWIPS system and is being used by a number of other agencies, not only for various regions of the U.S., but for a number of regions throughout the world.

OAR will continue to transfer knowledge of Doppler radar applications, severe weather systems, and heavy rainfall events; much of the transfer is through courses at the NWS training center. Visits and interactions with NWS centers, regional headquarters, and forecast offices continue and NSSL is participating directly in training programs, such as COMET in Boulder, Colorado, and the WSR-88D Operational Support Facility in Norman, Oklahoma.

A multi-year program of coastal meteorology research continues at the Pacific Marine Environmental Laboratory (PMEL). This program also involves ETL and NSSL, the Seattle NWS Forecast Office, the National Center for Atmospheric Research (NCAR), and the University of Washington. Support for the program is also being provided by the Office of Naval Research. This research improves understanding of the effects of prominent terrain on West Coast weather, with the ultimate goal of providing improved forecasts of coastal winds, precipitation, sea state, and storm surges. The emphasis is on the upstream effects of the coastal terrain in the storm environment when the background forcing is strong and the coastal forecasts are most critical. The approach involves special field observations and diagnostic studies using experimental numerical simulations. Field work featuring a NOAA WP-3 research aircraft in the 1990s, for example, has yielded meteorological data for the Pacific Northwest coast with low-level winds of up to 85 knots, in the vicinity of strong fronts and, in one case, an intense, landfalling low pressure system. The case studies from this work provide immediate insights on the influences of the coastal terrain on landfalling storms, and high quality data sets for numerical model initialization and validation. Follow-up field programs in FY 2004 and FY 2005 focused on cloud and precipitation processes using special observations from research aircraft and land-based radars. The results are providing information on how to improve forecasts of storms in the Western U.S. This activity is also coordinated with the NWS Office of Hydrologic Development and NCEP's Climate Prediction center for support to hydrologic resource forecasting to help better forecast floods and droughts.

MESOMETEOROLOGY AND PRECIPITATION FORECASTING AND WARNING RESEARCH

NSSL develops techniques to improve short-term forecasts of significant weather events. Through detailed case studies and regional climatologies, scientists have developed diagnostic tools and aids for operationally forecasting thunderstorms, lightning, flash floods, and large mesoscale convective storms complexes. Experiments such as the Severe Thunderstorm Electrification and Precipitation Study (STEPS) in 2000 were conducted to improve the science behind the technology. STEPS was designed to improve understanding of how severe storms become electrified and to better understand how variations in lightning flash type and flash rate relate to severe storm classification and storm evolution. Other studies underway are focused on the precipitation structure of mesoscale convective systems, the interactions between mesoconvective systems and the larger environment, the use of satellites to infer storm development and rainfall, short-range ensemble forecasting techniques, and winter storm forecasting procedures. Findings from these research activities lead to supporting the forecasting of other high impact weather forecasting events such as heat waves and air quality forecasting.

Figure 3-DOC-19. The OU Doppler-on-Wheels and the NSSL mobile laboratory take measurements of a snowstorm in Idaho during IPEX.

NSSL will continue to investigate various model convective parameterization schemes, along with techniques to improve model initialization through four-dimensional data assimilation in 2002. Also in 2002, NSSL conducted an experiment called the International H2O Project (IHOP). IHOP was a field experiment over the Southern Great Plains (SGP) of the U.S. The chief aim of the 2002 IHOP campaign was improved characterization of the four-dimensional (4-D) distribution of water vapor and its application toward improving the understanding and prediction of convection. The SGP region is an optimal location due to existing experimental and operational facilities, strong variability in moisture, and active convection.

NSSL is working with the NWS Storm Prediction Center (SPC) to improve the nation's ability to forecast severe weather and to enhance severe winter weather guidance products. Data collected during the IPEX campaign held in 2001 should help. The data are being analyzed by NSSL, SPC and University of Utah scientists. The IPEX field and research program was designed to improve the understanding, analysis, and prediction of precipitation and precipitation processes in complex terrain (Figure 3-DOC-19). Data analysis of IPEX continues in 2005.

A crew of NOAA NSSL and National Center for Atmospheric

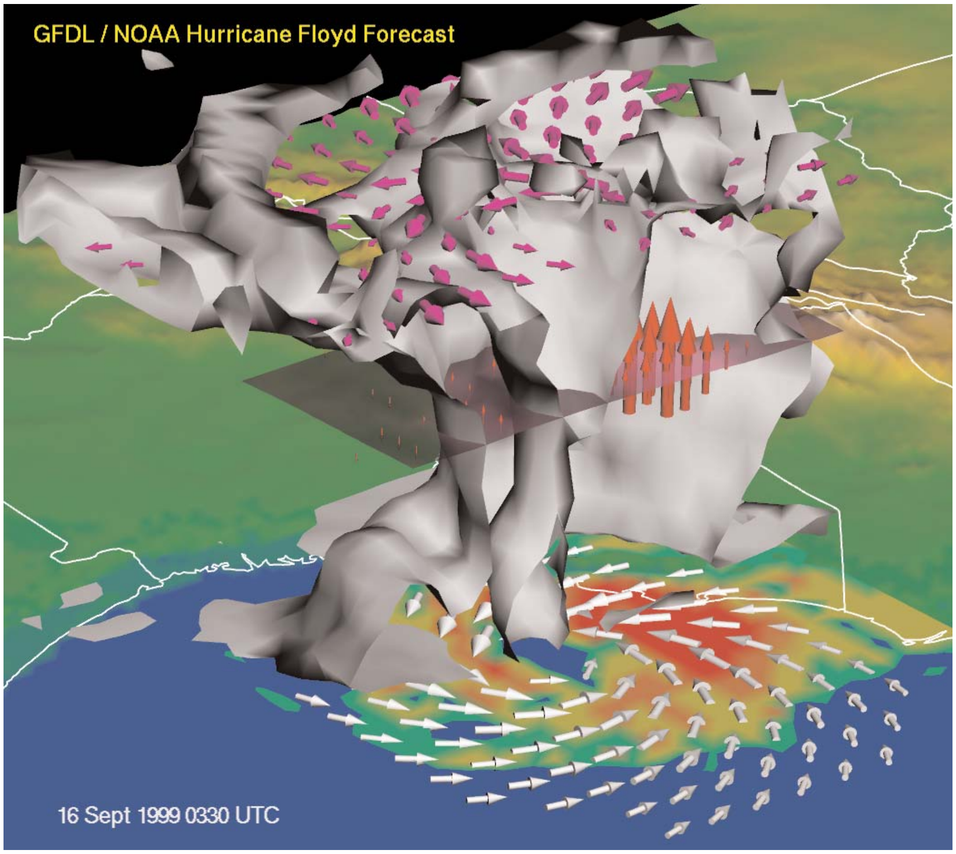


Figure 3-DOC-20. GFDL's 3-D model depiction of Hurricane Floyd

Research (NCAR) scientists and University of Oklahoma and New Mexico Institute of Mining and Technology students and faculty, scrambled to get in position beneath thunderstorms to launch balloons to measure temperature, pressure, humidity, and the electric field profile of storms as part of TELEX, the Thunderstorm Electrification and Lightning Experiment in May and June 2004. The broad objective of TELEX is to learn how lightning and other electrical storm properties are dependent on storm structure, updrafts, and precipitation. This information will point to new ways for the National Weather Service to use lightning observations to improve forecasts and warnings of hazardous weather. TELEX also took advantage of new sensors, the KOUN radar in Norman, a WSR-88D radar modified with polarimetric parameters to provide information about the particle size and water phase of precipitation and the Oklahoma Lightning Mapping Array (LMA). The OK-LMA is a network of ten stations in central Oklahoma that continuously maps the structure of all types of lightning in three-dimensions out to a range of 75 km and in two-dimensions out to a range of 200 km.

Mesoscale Dynamics at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey, develops and utilizes atmospheric models with limited spatial domains to understand mesoscale phenomena and the interaction of these regional scale features with the atmosphere's larger-scale synoptic processes. As part of these research activities, GFDL scientists investigate the practical limits of forecast models to predict the behavior of these mesoscale features through model sensitivity studies. (Figure 3-DOC-20).

The FSL implemented a Rapid Update Cycle (RUC) at NCEP in 1994 with periodic follow up upgrades since. The RUC gave a new analysis of surface and atmospheric conditions every three hours as well as short-range predictions for the next 12 hours. This information is useful to forecasters at local NWS offices around the country and also supports commercial and general aviation.

A higher-resolution, higher-frequency version of the RUC was implemented at NCEP in 2005. The 13 km version of NOAA's Rapid Update Cycle (RUC13) model became operational at 1200 UTC Tuesday 28 June 2005, at the National Centers for Environmental Prediction (NCEP). This is a major milestone for improving the RUC high-frequency short-range forecasts for NOAA and external users, especially for aviation and severe weather forecasting.

The main changes include higher horizontal resolution (from 20 km to 13 km), improved data assimilation especially for moisture/cloud fields, and improved cloud/precipitation physics. Most notable improvements are in surface and cloud/precipitation forecasts, resulting in part from assimilation of new observation types in the RUC13. The model updates every hour, incorporating information from virtually all high frequency data sources: hourly wind profiles; WSR-88D (Doppler radar) velocity azimuth displays; ACARS reports (up to 65,000 per day); cloud-drift winds and estimates of total precipitable water vapor from the GOES satellites; and surface observations. The new RUC also includes explicit forecasts of cloud droplets, ice crystals, raindrops, snowflakes, and graupel (snow pellets). This improves the forecast of precipitation type. The RUC exploits a new, multi-level soil and vegetation model to improve forecasts at and near the earth's surface.

Along with NCAR, NCEP, and the university community, FSL is collaborating on the development of a new mesoscale model, the Weather Research and Forecast (WRF) model. The goal is to have the WRF model become a community model and a tool both for experimental and operational prediction, thus paving the way for quick realization of research advances in forecast dissemination to the public and industry.

The Air Resources Laboratory (ARL) is also involved in the development of new models for operational use by NCEP. The main focus is on mesoscale models and in the development of new capabilities for data assimilation. In particular, the new generation of mesoscale models (such as the WRF model referred to above) will require advanced descriptions of the coupling between the air and the surface, a matter that is being studied intensely in ARL programs involving closely interacting measurement and modeling activities. To this end, ARL maintains the Nation's surface radiation network (SURFRAD), data from which are now routinely employed to test both forecast mesoscale models (such as the Eta model) and satellite outputs. ARL conducts research on the surface energy balance and on the spatial variability of surface fluxes using aircraft. In addition, ARL serves as the provider of the NCEP modeling capability to address situations of atmospheric dispersion, such as of emissions from sources like volcanos, industrial enterprises, and nuclear accidents. In recent work, ARL is developing a new system for forecasting the dispersion of smoke from forest fires, in collaboration with the Association of South East Asian Nations, the U.S. Forest Service, and The Mediterranean Centre for Environmental Studies Foundation.

TROPICAL ATMOSPHERIC RESEARCH

The Tropical Dynamics and Climate Program of the Aeronomy Laboratory (AL) is using precipitation profilers to study the structure, evolution and variability of precipitating cloud systems in the tropics and elsewhere. Precipitation measurements can be made with sufficient vertical resolution to categorize precipitation in deep and shallow convective systems and in stratiform conditions. A recent focus of research with profilers has been to provide ground validation research in support of satellite precipitation measurement missions such as the NASA Tropical Rainfall Measuring Mission (TRMM). These observations have provided important information on the vertical structure and temporal evolution of precipitating cloud systems during TRMM Ground Validation field campaigns. The profiler observations have been made available to the TRMM Science Team and can be viewed on the AL web page (www.al.noaa.gov). The observations made during the field campaigns are the subject of collaborative research with other TRMM researchers with an emphasis on the use of profilers to calibrate scanning radars used for TRMM ground validation research and the use of profilers to retrieve drop-size distributions and related precipitation parameters of interest to the TRMM Science Team. Validation of drop-size distributions used in algorithms is key to improving the retrieval of rainfall estimates from the TRMM satellite data. The profiler-based precipitation research described above also can be used to provide calibration of NEXRAD scanning radars as has recently been demonstrated for Melbourne, Florida. In related activities the Aeronomy Laboratory has teamed with the ETL in hydrometeorological studies in relation to the PACJET campaign on the west coast and also is working with ETL on microphysical process studies utilizing profilers in the North American Monsoon Experiment (NAME).

HURRICANE ANALYSIS AND PREDICTION RESEARCH

The Hurricane Research Division's mission is to advance the understanding and prediction of hurricanes and other tropical weather. HRD's research is based on a combination of models, theories, and observations, with particular emphasis on data obtained with research aircraft. The goals of this research are to:

1. Advance the prediction of tropical cyclone intensity change by improving understanding of the processes that modulate internal storm dynamics and storm interactions with the atmosphere and ocean;
2. Improve the prediction of tropical cyclone tracks by enhancing understanding of the interactions between a tropical cyclone and its environment through an optimal analysis of field observations;
3. Improve the understanding of and ability to predict tropical cyclone frequency and intensity on intraseasonal, interannual, decadal and longer time scales; and
4. Enhance the ability to diagnose and predict the impact of tropical cyclones on life and property through wind, rain, waves, and storm surge.

These goals are accomplished by:

1. Designing and conducting research experiments in the hurricane to collect and provide data for research and applications;
2. Analyzing these data sets and publishing the research in the refereed literature;
3. Developing new technology and applications based on this research to improve NOAA's products; and
4. Providing outreach to the public through the WWW, conferences, presentations, and other means.

Much of HRD's research is based on the in situ and remotely-sensed observations in the inner core of tropical cyclones and their surrounding environment. These observations are primarily collected in our annual field program using the two NOAA turboprop aircraft and jet operated by the NOAA Aircraft Operations Center (AOC). The field program is used to carry out scientific experiments designed to address the goals stated above. Data sets gathered by these experiments, combined with dynamical and statistical models and theoretical development, range from global to microscale, forming the cornerstone of research in HRD. Because of this extensive field experience, HRD scientists are recognized internationally for their knowledge of tropical cyclones as well as their expertise in technological areas such as airborne Doppler radar, dropsondes, cloud microphysics, and air-sea interaction, to name a few. These assets make HRD unique worldwide, and provide NOAA a unique capability.

In 2005, NOAA's HRD begin a multi-year experiment this summer with the NOAA Aircraft Operations Center (AOC) called the Intensity Forecasting Experiment (IFEX). Developed in partnership with NOAA's Environmental Modeling Center (EMC) and National Hurricane Center (NHC), IFEX is intended to improve our understanding and prediction of hurricane intensity change by collecting observations that will aid in the improvement of current operational models and the development of the next-generation operational hurricane model, the Hurricane Weather Research and Forecasting model (HWRF). Observations will be collected in a variety of hurricanes at different stages in their lifecycle, from formation and early organization to peak intensity and subsequent landfall or decay over open waters. There are several unique aspects of IFEX in 2005 that will help improve our understanding and prediction of hurricane intensity change. Some examples are provided below:

Hurricane genesis experiment - Take data to improve our knowledge of the evolution of tropical waves to tropical storms.

SFMR validation - The Stepped-Frequency Microwave Radiometer (SFMR) evaluation of a unique airborne tool that enables the remote measurement of surface wind speeds and rain rates over the water.

Impact of Saharan air on intensity forecast models - Recent research has shown that very dry air originating from the African continent, called the Saharan Air Layer (SAL), may be an important factor in hurricane intensity change.

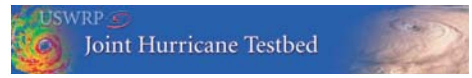
Doppler Radar - Mapping of the center wind field from airborne tail Doppler radar and its transmission to EMC and NHC in real-time.

High-altitude penetrations of the hurricane's center -The high-altitude NOAA G-IV jet will penetrate the inner core of hurricanes. This capability will be vital once a Doppler radar is installed on the G-IV, enabling the three-dimensional mapping of wind fields from nearly top to bottom of hurricanes.

NSF Hurricane Rainband and Intensity Change Experiment (RAINEX) - The main goal of RAINEX is to investigate interactions between a tropical cyclone's inner core and its associated rainbands, and the role this interaction plays in determining intensity change.

HRD coordinates its programs with other NOAA organizations, e.g., NOAA's Aircraft Operations Center (AOC) and the National Center for Environmental Prediction (NCEP), and in particular with the Environmental Modeling Center (EMC) and Tropical Prediction Center/National Hurricane Center (NHC). HRD maintains active research programs with, and receives funding from other governmental agencies, in particular, the Department of the Navy's Office of Naval Research (ONR) and the National Aeronautics and Space Agency (NASA).

In program areas where it is beneficial to NOAA, HRD arranges cooperative programs with scientists at the National Center for Atmospheric Research, and at a number of universities. The highest priority experiment in 2004 is the Coordinated Boundary Layer Air-Sea Transfer (CBLAST) experiment focused on improving numerical model parameterization of the air-sea transfer of energy that fuels the storms. HRD also integrated two recent NASA field experiments and a fifth Convective and Moisture Experiments (CAMEX-5), is being proposed in 2005. HRD is also working with U.S. and international partners on plans for the African Monsoon Multidisciplinary Activity (AMMA) in 2006.



Currently, the HRD research staff consists of 26 full-time employees and 10 employees working under a cooperative joint agreement with the University of Miami (CIMAS).

Under the USWRP and its participating agencies, OAR, NWS, and NESDIS established a Joint Hurricane Testbed (JHT) at the Tropical Prediction Center in Miami, Florida. It is anticipated that the JHT will continue to grow in FY 2005 as more resources become available. This testbed is where the hurricane research will be evaluated for operational use and those research products passing the test will be handed off to operations.

NUMERICAL ANALYSIS AND PREDICTION MODELING

As part of its weather research activities, GFDL conducts long lead-time research to understand the predictability of weather on both large- and small-scales and to translate this understanding into improved numerical weather prediction models. Three groups at GFDL are engaged in weather research activities: Experimental Prediction, Mesoscale Dynamics, and Hurricane Dynamics.

Experimental Prediction at GFDL develops and improves numerical models of the atmosphere-ocean-land system in order to produce useful weather forecasts with lead-times ranging from weeks to seasons and beyond. The group is pursuing several avenues of research to achieve such improvements. First, GFDL scientists are investigating methods of stochastic dynamic prediction in order to extract as much forecast information as possible from numerical weather prediction models, given imperfectly observed initial conditions. In addition, laboratory scientists are developing methods for the assimilation of ocean observations into prediction models in order to improve the forecast of the atmosphere and the ocean.

AIR QUALITY RESEARCH

The principal mission of the ARL is to improve the capability to forecast changes in air quality and atmospheric deposition. Deposition is the factor that links the pollutant characteristics of the air with the terrestrial and aquatic environments. ARL's research focuses on the lower atmosphere, where the atmosphere is in direct contact with other media-- aquatic, terrestrial, and biospheric. The core of ARL research relates to studies of the atmosphere as a component of the total environment. Much of this work is in collaboration with other parts of NOAA (principally NCEP) and with other agencies, such as EPA, DOE, and the DOD.

The ARL Headquarters Division in Silver Spring, Maryland, develops models for air quality prediction, for use in special forecasting (both weather and air quality) programs, and in emergency response. The Atmospheric Sciences Modeling Division, in Research Triangle Park, North Carolina, develops predictive models on local, regional, and global scales for assessing changes in air quality and air pollution exposure as affected by ecosystem management and regulations. This work is primarily to provide technical guidance to the EPA on air pollution control strategies for attainment and maintenance of ambient air quality standards. The Atmospheric Turbulence and Diffusion Division, in Oak Ridge, Tennessee, conducts studies to improve understanding of atmospheric transport, diffusion, and air-surface exchange processes, and to develop new predictive models. The Field Research Division, in Idaho Falls, Idaho, designs and conducts field studies to evaluate the performance of transport and dispersion models, over local, regional, and continental scales, and specializes in the development of high-technology airborne instrumentation (for both aircraft and balloons). The Special Operations and Research Division (SORD), in Las Vegas, Nevada, conducts research on problems of mutual interest to NOAA and DOE that relate to the Nevada Test Site, its atmospheric environment, and its emergency prepared-ness and emergency response activities. SORD also serves as the main NOAA facility working with the Cooperative Institute for Atmospheric Studies and Terrestrial Applications (CIASTA) of the University of Nevada system.

ARL operates two national networks that direct research attention on the needs of the next generation of predictive models. The Atmospheric Integrated Research Monitoring Network (AIRMoN) is a nested-network with sites of varying complexity addressing evolving scientific issues of wet and dry deposition from the atmosphere. A major current item for scientific attention is the atmospheric deposition of nitrogen compounds and its role in promoting eutrophication of ecosystems, primarily coastal. The ARL-run Integrated Surface Irradiance Study (ISIS) serves as the national array of monitoring stations for solar radiation (and ultraviolet-B) with a subset of more advanced stations (the SURFRAD array) where both incoming and outgoing radiation components are monitored. Many of the SURFRAD stations are augmented with instrumentation to measure fluxes of sensible heat, latent heat, momentum, and carbon dioxide. Thus, the SURFRAD program is evolving into one of complete energy balance with supporting data on carbon dioxide exchange. This work forms an intersection with the new flux measurement networks in the U.S. and overseas, referred to as "Ameriflux" and "Fluxnet." All of this work is coupled with ARL research on atmospheric aerosols and with the development of new automatic methods for measuring cloud cover.

Much of ARL's research focus is on expressing air surface exchange processes in numerical models. To this end, ARL scientists have been instrumental in developing methods for describing an air surface exchange appropriate for use with model grid cells of several tens of kilometers on a side. To test the aerial integration capabilities, ARL has instrumented an aircraft of the NOAA fleet (a DeHavilland Twin Otter) to measure all of the eddy fluxes as well as a number of trace gas exchange rates. This instrumented aircraft has been used in several field experiments and has already demonstrated that considerable error can result when local values are inappropriately taken to represent larger areas.

ARL also provides forecast support to NOAA's emergency response systems with emphasis on chemical, nuclear, and volcanic events. For this application, ARL develops and couples advanced dispersion models with the forecast products of the NWS to provide a basis for trajectory and dispersion calculations. The models in question are now widely accepted. The Hazardous Atmospheric Release Model (HARM) is operationally employed at a number of DOE locations. The ARL Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model is now operational in many countries, including China and Australia, as the national dispersion forecasting capability. It also serves the NWS in this role. Registered users can also access HYSPLIT products via the Internet. HYSPLIT is the major product employed in the operations of the Regional Specialized Meteorology Center (RSMC) set up as a joint undertaking of ARL and NCEP under the auspices of the World Meteorological Organization (WMO). The WMO/ RSMC is the source of dispersion products in the event that a pollution plume (in this case, radioactive) crosses international boundaries.

The provision of dispersion forecasts by ARL scientists extends to two specific areas of special relevance - the Nevada Test Site and the Idaho National Engineering and Environment Laboratory. ATL maintains staffs of dedicated dispersion meteorologists at each location, where site-specific models are developed and run using data generated by dedicated regional networks of meteorological sensors.

The Aeronomy Laboratory coordinates an air quality research effort-- the Health of the Atmosphere research. NOAA's Health of the Atmosphere research is focused on the atmospheric science that underlies regional and continental air quality, with the goal of improving our ability to predict and monitor future changes, leading to improved scientific input to decision-making. AL, ARL, CMDL, FSL, PMEL, and ETL participate in the research. The Health of the Atmosphere research goals are:

• Characterize regional ozone episodes - characterize the factors that cause poor air quality in regions of the U.S. where excessive levels of ground-level ozone and fine particle pollution are occurring. In summer 2002, a major field investigation was carried out to characterize air quality in the New England region. Ground-based measurements, ship and aircraft measurements, forecasting, and modeling analyses were applied in the research. Among the processes investigated were the role of nighttime chemistry in the formation of ozone pollution, the role of the sea-breeze/land-breeze circuit in influencing New England's air quality, and the role of the marine boundary layer as a conduit for the movement of pollutants throughout the region.

• Document trends in air quality - help evaluate predicted atmospheric responses to changes in emissions (i.e., the ongoing measurements provided by the AIRMoN and the ozone profiling networks).

• Develop a better understanding of the fundamental science underlying the processes responsible for the formation and distribution of fine particles in the atmosphere to improve the atmospheric predictive capability that links sources of fine particles and their precursors to human exposure and visibility impairment.

In future Health of the Atmosphere research, the OAR Laboratories will integrate their meteorological, chemical, and forecasting expertise to build an assessment and prediction capability for regional air quality that incorporates the influence of multiple-timescale meteorology/climatology. While the ambient levels of pollutants like ozone and fine particles are clearly dependent on pollutant emissions, a large fraction of the variation in those levels is driven by meteorology, both in the short term and longer term. Therefore, the key to assessing both the intended long-term improvements in air quality and the more-episodic variations lies in understanding not only the atmospheric linkages between emissions and concentrations, but also in understanding the coupled chemical and meteorological processes. This "chemical meteorology" research will extend the current program focus on emissions/concentration linkages to include a predictive understanding of the role of synoptic, seasonal/interannual, and longer-term meteorological/climatological changes on the chemistry of the lower atmosphere. Research efforts will also focus on an evaluation and improvement of the tools used to forecast future air quality and the observing systems needed to evaluate their skill.

This approach was used in the summer 2004 New England Air Quality Study, which built on the groundwork laid by the scoping study done as NEAQS 2002. Observations were made from an array of platforms that includes a dozen aircraft, the NOAA research vessel Ronald H. Brown, and several ground sites in New England and Nova Scotia. The research, which is being led by NOAA and the University of New Hampshire and involves several U.S. and international partners, will help provide the solid science to underpin the region's future efforts to improve air quality for its citizens. NEAQS will also help provide the scientific understanding needed for a new air quality forecasting capability that NOAA's Office of Oceanic and Atmospheric Research and National Weather Service are developing in partnership with the Environmental Protection Agency. The forecast guidance was launched in summer 2004 in New England in conjunction with the NEAQS mission.

The Air Quality Research Subcommittee of the Committee on Environment and Natural Resources (CENR) provides interagency collaboration at the U.S. Federal level. NOAA co-leads the AQRS. On the broader international arena, the coordinating body is the North American Research Strategy for Tropospheric Ozone (NARSTO), a tri-lateral public/private partnership focused on ozone and particulate matter research in the U.S., Canada, and Mexico.

ETL uses its suite of remote sensors, including a mobile profiler network, airborne and ground-based ozone Lidars, Doppler Lidar, and supporting turbulence instrumentation to understand and better model the transport, transformation, and fate of primary and secondary pollutants in both rural and urban environments as well as in complex orography. ETL participated in field programs in FY 2002 designed to develop a deeper understanding of climate variability and source pollutants in the New England region (Atmospheric Investigation, Regional Modeling, Analysis and Prediction (AIRMAP) and NEPS, and to investigate the composition of air masses along the Pacific coast of North America as part of the Intercontinental Transport and Chemical Transformation (ITCT) program. ITCT is a coordinated international research program designed to address the question, "How does the transport of chemicals from one continent influence the air quality in other continents, as well as regional and global climate?" ETL will be deploying a number of lidar systems and wind profiler radars in support of these programs.

GLOBAL DRIFTER PROGRAM

AOML manages the deployment of drifting buoys around the world, deploying some 300 new drifters annually and tracking nearly 700. Using research ships, VOS, and United States Navy aircraft, Global Lagrangian Drifters (GLD) are placed in areas of interest. Once verified operational, they are reported to AOML's Data Assembly Center (DAC). Incoming data from the drifter are then placed on the Global Telecommunications System (GTS) for distribution to meteorological services everywhere. The primary goal of this project is to assemble and provide uniform quality control of SST and surface velocity measurements. These measurements are obtained as part of an international program designed to make this data available in an effort to improve climate prediction. Climate prediction models require accurate estimates of SST to initialize their ocean component. Drifting buoys provide essential ground truth SST data for this purpose. The models also require validation by comparison with independent data sets. Surface velocity measurements are used for this validation.

SOUTHERN HEMISPHERE DRIFTING BUOY PROGRAM

In support of Global Climate Observing System (GCOS) requirements, OAR, in cooperation with NWS, the Office of Global Programs (OGP; housed within OAR), AOML, and the Scripps Institution of Oceanography, maintains a network of approximately 100 meteorological drifting buoys in the Southern Hemisphere. The buoys measure atmospheric pressure at sea-level, air temperature, surface sea water temperature, and surface currents. Observations are obtained through the ARGOS data collection and platform location system on-board the NOAA polar-orbiting satellites. The buoys are a subset of the Global Drifter Program.

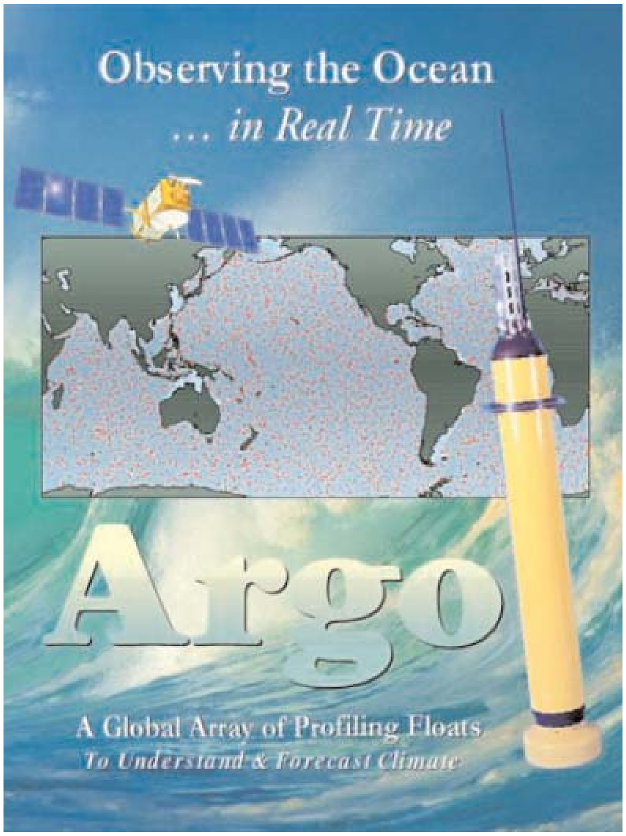
The Tropical Atmosphere Ocean/TRIangle Trans-Ocean buoy Network (TAO/TRITON) array consists of approximately 70 Autonomous Temperature Line Acquisition System (ATLAS) and TRITON moorings in the tropical Pacific Ocean, telemetering oceanographic and meteorological data to shore in real-time via the ARGOS satellite system. Designed to improve detection, understanding, and prediction of El Niño, TAO/TRITON is a major component of the El Niño/Southern Oscillation (ENSO) Observing System, the Global Climate Observing System (GCOS), and the Global Ocean Observing System (GOOS). The array is supported primarily by the United States (NOAA) and Japan (JAMSTEC) with contributions from France (IRD) and Taiwan (NTU). The mooring array is maintained by the TAO Project Office located at PMEL in Seattle, Washington, which has responsibility for project management and logistics. The mooring array operations are being transferred to NWS. These buoys provide climate researchers, weather prediction centers, and scientists around the world with real-time data from the tropical Pacific. El Niño (the warm phase of the ENSO cycle) is associated with a disruption of the ocean-atmosphere system in the tropical Pacific and has important consequences for weather around the globe.

The Pilot Research Moored Array in the Tropical Atlantic (PIRATA) is a project designed as an extension of the TAO array into the Atlantic. The purpose of PIRATA is to study ocean-atmosphere interactions in the tropical Atlantic that are relevant to regional climate variability on seasonal, interannual and longer time scales. It consists of an array of 12 ATLAS moorings similar to those deployed in the Pacific. Planned expansion of the PIRATA array into the hurricane genesis region of the Atlantic will allow for a better understanding of ocean-atmosphere interactions on hurricane development and enhanced predictions of hurricane formation.

ARGO--GLOBAL ARRAY OF PROFILING FLOATS

The ARGO array will deploy a global array of 3,000 profiling floats to better understand and forecast climate. ARGO floats are free-drifting profiling floats that spend most of their life "parked" at 1,000 or 2,000 meters depth, regularly surfacing to make temperature and salinity profile measurements. Observations are made in real-time. As of June 2004, 1250 ARGO floats have been deployed. The Argo array is part of the Global Climate Observing System/Global Ocean Observing System GCOS/ GOOS) and is a major contributor to the WCRP's Climate Variability and Predictability Experiment (CLIVAR) and the Global Ocean Data Assimilation Experiment (GODAE). Along with satellites, ARGO helps initiate the oceanic equivalent of today's operational observing system for the global atmosphere.

Ocean Reference Stations. The Ocean Reference Station network is a planned network of 29 operational ocean moorings that measure high quality air-sea fluxes of heat, moisture, and momentum. These in-situ fluxes will then be used to make regional assessments of flux components from numerical weather prediction models and satellites. The network currently has 2 operational moorings; a partnership with the National Science Foundation's ORION program will greatly enhance the capacity of the network.



The National Ocean Service (NOS) monitors, assesses, and forecasts conditions in the coastal and oceanic environment to maintain a healthy, safe, and economically productive coastal and oceanic environment for present and future generations. NOS is the primary civil agency within the Federal government responsible for the health and safety of our Nation's coastal and oceanic environment. Largely through the Tides and Current Program line, NOS acquires water levels, currents, winds, and other physical oceanographic and meteorological data, and distributes these data and circulation predictions as elements of an integrated NOS program to provide a comprehensive science-based suite of information products required by the marine transportation community to ensure safe and efficient marine transportation, including the transport of oil and other hazardous materials. NOS also provides coastal oceanographic and meteorological products required by the National Weather Service (NWS) to meet its short-term weather and forecasting responsibilities, including tsunami and storm surge warnings. NOS manages several observing systems and programs, however three in particular are heavily linked to the capability of NOAA to meet weather and water needs of the nation.

NATIONAL WATER LEVEL OBSERVATION NETWORK (NWLON)

NOS manages the NWLON, 175 stations located along the coasts of the U.S. and the Great Lakes, from which water level data, as well as other oceanographic and meteorological data, are collected and disseminated. NWLON provides a number of NOAA and other Federal programs with data and supporting information, such as the NOAA Nautical Charting Program, NWS Tsunami Warning System, NWS storm surge warning/forecast activities, and the Climate and Global Change Program. An event triggered or manually triggered NWLON modification is now operational that allows emergency "Tsunami Warning" GOES transmissions to NWS when the water level exceeds a specified high/low limit or when the rate of change between the standard 6-minute water level values exceeds a specified value. A similar event triggered modification is also operated for the NWS storm surge warning program when expected elevations are predicted or observed during coastal storms and hurricanes. This capability for high-rate data has recently been enhanced at many stations by the introduction of 6-minute interval GOES transmissions. Although not all NWLON stations are presently equipped with meteorological sensors, an increasing number of stations are each year. Water level and meteorological data are automatically formatted into bulletin format for inclusion into the NOAA AWIPS pipeline.

PHYSICAL OCEANOGRAPHIC REAL-TIME SYSTEM (PORTS®)

PORTS® is a decision support tool which improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS® measures and disseminates observations and predictions of water levels, currents, salinity, and many meteorological parameters, e.g. winds, barometric pressure, and visibility, needed and requested by the mariner to navigate safely. Highway and railroad bridge mounted "Air Gap" sensors for water level detection are presently being developed and are included in future plans for PORTS®.

The 12 existing PORTS® systems come in a variety of sizes and configurations, each specifically designed to meet local user requirements. PORTS® are partnership programs in which local operating partners fund the installation and operation of the measurement systems. The largest of NOS's existing installations is comprised of over 26 separate instruments. The smallest consists of a single water level gauge and associated oceanographic and meteorological instruments, i.e. winds, barometric pressure, etc. (Figure 3-DOC-21). Regardless of its size, each PORTS® installation provides information that allows shippers and port operators to maximize port throughput while maintaining an adequate margin of safety for the increasingly large vessels visiting United States ports. In addition, prevention of maritime accidents is the most cost effective measure that can be taken to protect fragile coastal ecosystems. One major oil spill, e.g. EXXON VALDEZ, can cost billions of dollars and destroy sensitive marine habitats critical to supporting coastal marine ecosystems. PORTS® provides information to make navigation safer, thus reducing the likelihood of a maritime accident, and also provides the information necessary to mitigate the damages from a spill, should one occur. An extensible PORTS® can be integrated with other marine transportation technologies such as Electronic Chart Display Information Systems (ECDIS) and Vessel Traffic Systems (VTS).

The integration of PORTS® technology and numerical circulation models allows nowcasts and predictions of parameters within the boundaries of the models even at locations where physical measurements are not available. The Chesapeake Bay Oceanographic Forecasting System (CBOFS) is an NOS project that provides forecasts of total water level within the Bay in addition to the astronomical tidal prediction. The New York/New Jersey Harbor nowcast/forecast model came on line in 2003, followed by a Houston/Galveston Bay nowcast/forecast model in 2004. Future operational models will include the St. Johns River, FL and the Great Lakes. Also, ongoing research will enable PORTS® or similar systems to incorporate biological and chemical sensor systems and forecast models as required and integrate the information with circulation measurements to provide information on transports of materials in the ecosystem essential for effective marine resource management and homeland security.

THE NOS CONTINUOUS REAL-TIME MONITORING SYSTEM (CORMS)

CORMS was designed to operate on a 24 hour/7 days a week basis to ensure the accuracy and working status of tide and current observations acquired via the NWLON and PORTS® programs. CORMS improves the overall data quality assurance of real-time measurements, reduces NOAA's potential liability from disseminating inadequate data, and makes the observations more useful for all applications. CORMS ingests real-time data from all field sensors and systems, including the operational nowcast/forecast models, determines data quality, and identifies and communicates the presence of invalid or suspect data to real-time users/customers who rely on the data. CORMS is especially vigilant during storm and tsunami events to ensure the full set of products and services is being disseminated in a timely fashion. An advanced version of this system, CORMS AI, is presently in developmental stages (Figure 3-DOC-22).

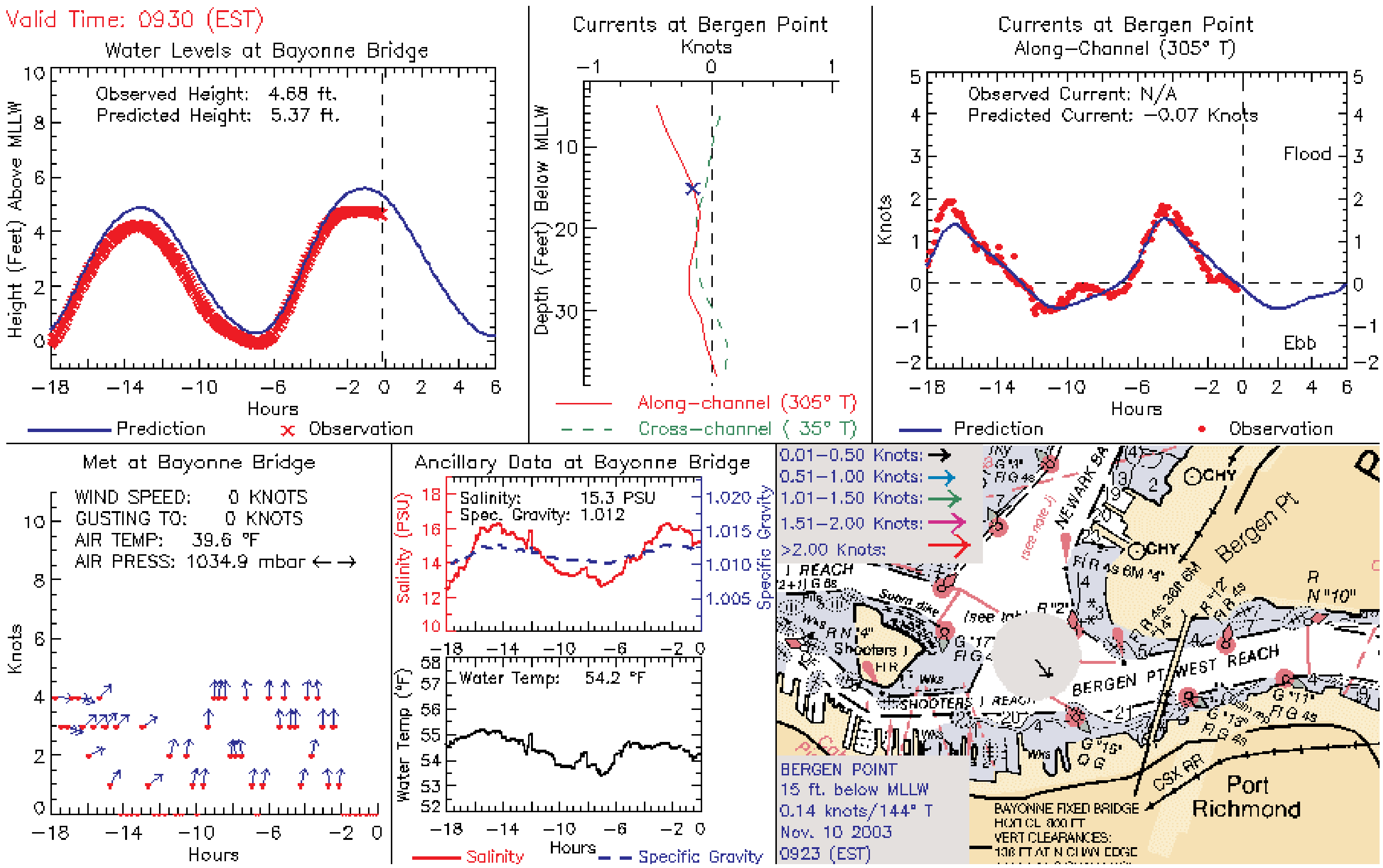


Figure 3-DOC-21. New York/New Jersey PORTS: Bergen Point Composite.

Figure 3-DOC-22. PORTS sites in the New York and New Jersey linked by CORMS.

NOAA Marine and Aviation Operations (NMAO) operates a wide variety of specialized ships and aircraft to support NOAA mission goals. NOAA's ship fleet includes oceanographic and atmospheric research vessels. NOAA's aircraft fleet includes aircraft that collect environmental and geographic data essential to NOAA hurricane and other severe weather and atmospheric research; and aircraft that conduct aerial surveys for hydrologic research for forecasting flooding potential from snow melt.

Figure 3-DOC-24. NOAA Ship KA'IMIMOANA

NOAA SHIPS SUPPORTING METEOROLOGICAL ACTIVITIES

• NOAA Ship RONALD H. BROWN, an oceanographic and atmospheric research platform, is the largest vessel in the NOAA fleet (274 feet). With its instruments and sensors, RONALD H. BROWN (Figure 3-DOC-23) travels worldwide supporting scientific studies to increase our understanding of the world's oceans and climate. An advanced meteorological scientific Doppler radar makes the ship a unique attribute to the research fleet.

Figure 3-DOC-23. NOAA Ship RONALD H. BROWN

• NOAA Ship KA'IMIMOANA (Figure 3-DOC-24) primarily supports the research programs of NOAA's Tropical Atmosphere-Ocean (TAO) Project (real-time data from moored ocean buoys for improved detection, understanding and prediction of El Niño and La Niña). These research programs are designed to improve our understanding of the role of the tropical ocean in the world's climate. The ship deploys, recovers, and services deep sea moorings that measure ocean currents, ocean temperatures, and atmospheric variables, throughout the equatorial Pacific Ocean. In addition to data from these moorings, the ship measures upper ocean currents, surface salinity, carbon dioxide content, and takes upper air atmospheric soundings while underway.

The RONALD H. BROWN and KA'IMIMOANA annually support the Tropical Atmospheric Ocean (TAO) Array by servicing approximately 60 ATLAS and current meter moorings in the central and eastern equatorial Pacific.

In FY 2006, the RONALD H. BROWN will conduct the African Monsoon Multidisciplinary Analysis study to improve understanding of the West African monsoon and its influence both on the regional environment as well as its role in Atlantic tropical cyclone development.

Also in FY 2006, the RONALD H. BROWN will continue work on the NOAA Climate Forcing and Air Quality Programs by conducting a combined Air Quality and Climate Research Study to better characterize marine/continental chemical and meteorological processes to assess their impact on air quality in Texas and radiative forcing of climate. As in previous studies off the New England region, this may include use of NOAA and other aircraft for data collection.

A new initiative this year will be the sharing of weather data obtained by certain NOAA ships with NWS coastal Weather Forecast Offices (WFO). What follows is an excerpt from a February 14, 2005, article in the *NWS Focus* that explains this new partnership further:

NOAA Agencies Join Forces to Test Collaborative Communications Concept

The NOAA Office of Marine and Aviation Operations (NMAO) and the NOAA National Weather Service (NWS) Southern Region are working together to test a new communications project designed to serve the interest of both line offices. In an excellent example of inter-agency cooperation, NMAO and the NWS have devised an information sharing system to benefit NOAA ships and NWS coastal Weather Forecast Offices (WFO). "Our ships are always in need of up-to-date marine forecasts," said Rear Admiral Richard R. Behn, NOAA Director, Marine and Aviation Operations Centers. "In turn, the WFOs are always searching for real time weather data from sea because they don't have buoys everywhere."

NWS Southern Region Marine Services Meteorologist Melinda Bailey says 13 Southern Region WFOs, from Brownsville, Texas to Jacksonville, Fla., will participate in the test project. "Each of the NOAA ships will have a file with a complete list of phone numbers and the names of key personnel in our coastal WFOs. Our specialists can then provide any type of specialized forecast that may be needed." In return, the forecast offices will have access to the NMAO's Ship Tracker software so they will know where the ships are. The forecasters will also have a list of the ship's port, cellular and satellite phone numbers. National Weather Service Southern Region forecast offices participating in the project include Brownsville, Corpus Christi and Houston, Texas; Lake Charles and New Orleans, La.; Mobile, Ala.; San Juan, Puerto Rico; and, Tallahassee, Tampa, Key West, Miami, Melbourne and Jacksonville, Fla.

NOAA's Office Marine and Aviation Operations currently has 18 ships plying the waters of the Pacific and Atlantic Oceans and the Gulf of Mexico. The fleet includes ships that provide hydrographic survey, oceanographic, atmospheric and fisheries research in support of the National Oceanic and Atmospheric Administration mission to predict and understand the Earth's environment and conserve and manage coastal and marine resources.

The test is scheduled to run through the end of year, at which time the results will be evaluated. "If we find the program works well from both the standpoint of the Office of Marine and Aviation Operations and the National Weather Service, we will expand it to include all coastal offices in the United Sates," added Behn.

Another advancement this FY was the development of the NOAA Shipboard Environmental Data Acquisition System (SEAS). SEAS will provide real-time meteorological and oceanographic data to NOAA users from ships at sea through the use of INMARSAT C satellite data transmissions. Along with ships of the NOAA fleet, meteorological observations made onboard merchant vessels of the NOAA voluntary observing ships (VOS) program, are a substantial component of global weather forecasting and climate studies. SEAS equipped vessels are an essential part of the NOAA VOS program and provide as many as 80,000 observations per year. SEAS records weather information in the World Meteorological Organization (WMO) MET transmission format (BBXX) and transmits it in real-time via satellite. All of NOAA's research ships carry SEAS equipment, with the exception of the two small Class 5 vessels (COBB and RUDE). Most of NOAA's ships submit at least one SEAS report a day and some submit up to eight reports a day (one every three hours).

NOAA AIRCRAFT SUPPORTING METEOROLOGICAL ACTIVITIES

NOAA aircraft support a broad range of meteorological activities and projects with its fleet of aircraft based at MacDill Air Force Base in Tampa, Florida. Four of its14 aircraft are dedicated to this purpose throughout the year, providing valuable information to NOAA and the nation.

The NOAA Gulfstream, G-IV(SP) (N49RF), provides scientists with a platform for the investigation of processes in the upper troposphere and lower stratosphere (Figure 3-DOC-25). With a ceiling of 45,000 ft, the G-IV is a critical tool for obtaining the data necessary to improve hurricane track forecasts and for research leading to improvements in hurricane intensity forecasts. The G-IV is also being used for air chemistry studies where a high altitude capability is required. In 2005, hurricane researchers studying the role of Saharan dust on tropical storm development and intensity will also use this aircraft.

Figure 3-DOC-25. NOAA Gulfstream G-IVSP

The NOAA G-IV annually supports Hurricane Synoptic Surveillance missions where the aircraft flies in the environment surrounding the storm at a high altitude releasing GPS dropsondes at pre-selected locations. The data from these vertical atmospheric soundings are transmitted from the aircraft to the NCEP computer site where they are incorporated into the hurricane computer models to improve hurricane track forecasts. The dropsonde (Figure 3-DOC-26) directly measures temperature, pressure, and humidity as it falls through the atmosphere to the surface, and computes wind speed and wind direction using a full-up GPS receiver (which is new in 2005). Recent estimates of the improvement in hurricane track predictions utilizing this aircraft and dropsonde are between 20 and 30 percent, resulting in a savings of $10

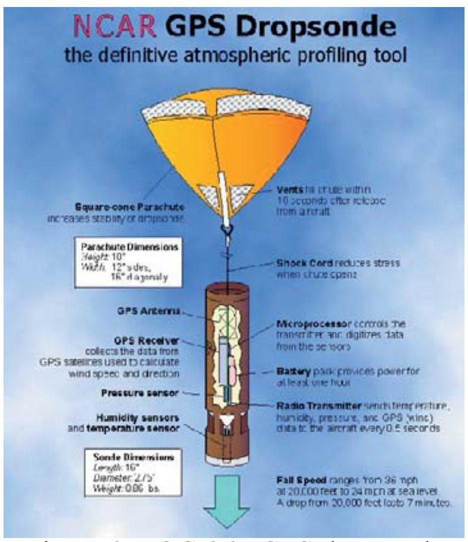


Figure 3-DOC-26. GPS dropsonde

million or more per hurricane in warning and preparedness costs.

The NOAA G-IV also annually supports the Winter Storms Reconnaissance Program in an effort to improve forecasts released 24 to 96 hours before winter storms in the U.S. This aircraft, in conjunction with the Air Force Reserve's WC-130s, utilize the GPS dropsondes to collect data on developing severe winter storms over the Pacific Ocean that will seriously impact the continental U.S. and Alaska. During one month of the two-month season, both aircraft operate in tandem, one from Alaska and the other from Hawaii, to collect data both north and south of the jet stream simultaneously. General improvement in forecast accuracy of up to 20 percent has already been seen, and even higher percentage improvements on individually targeted events have been realized from this program. Typically, during the final month of the program, the NOAA G-IV operates independently from either the base in Alaska or Hawaii as the case may dictate.

A recent additional mission for the G-IV was the support of the THORPEX Regional Campaign (TReC). THORPEX is a global atmospheric research program designed to accelerate improvements in the accuracy of 1 to 14-day weather forecasts for the benefit of society and the economy. TReC was a regional study that took place in the North Atlantic, and the G-IV contributed with a month-long program, operating from bases in Newfoundland and Ireland.

NOAA's Aeronomy Lab, located in Boulder, CO, is presently expanding its air chemistry capabilities on the G-IV beyond just ozone measurements with the addition of a proton transfer reaction mass spectrometer (PTR_MS). The PTR_MS provides in-situ measurements of volatile organic compounds (VOCs) and an instrument to measure carbon monoxide (CO). Beyond just their dedicated research, lab scientists also hope to piggyback on missions during the 2005 hurricane season.

Also during the 2005 hurricane season, scientists from NOAA's Hurricane Research Division will be utilizing the G-IV in an investigation of the Saharan dust layer over the Atlantic. The Saharan Air Layer (SAL) has been investigated fairly extensively during the past several decades, but its role in influencing Atlantic tropical cyclone activity has not been thoroughly examined. This experiment is designed to utilize the G-IV to study the mechanisms by which the SAL's embedded mineral dust, thermodynamic properties, and low-level wind surge affect Atlantic tropical cyclone genesis and intensity change.

NOAA's atmospheric and oceanographic research, as well as its reconnaissance operations, are supported by two WP-3D Lockheed Orion aircraft (N42RF and N43RF) which carry a full array of state-of-the-art environmental research instrumentation (Figure 3-DOC-27). The aircraft research and navigation systems provide detailed spatial and temporal observations of a wide range of atmospheric and oceanic parameters. NOAA's Aircraft Operations Center (AOC) develops and calibrates specialized instruments, integrates user-supplied instrumentation into its automated data recording systems, and processes and


Figure 3-DOC-27. NOAA WP-3 Orion

analyzes data sets collected during various field programs.

The AOC WP-3D aircraft, while executing the complex patterns for hurricane research, also provided storm data to the National Hurricane Center (NHC) in near real-time, transmitting flight level data, GPS dropsonde messages, as well as radar images via its multiple aircraft-satellite data links. With the Stepped Frequency Microwave Radiometers (SFMR) coming online operational during FY 2004, increasing emphasis is being placed on utilizing the NOAA WP-3Ds to map the surface wind fields in and around hurricanes and tropical storms. Real-time surface wind speed maps are critical to providing more accurate forecasts of the locations of hurricane and storm force winds.

The AOC aircraft also augment the Air Force Reserve reconnaissance aircraft during particularly active storm periods when tasking requirements exceed their available resources.

Each year, one of the NOAA WP-3Ds participates in a Hurricane Awareness Tour targeting, alternately, the Gulf and East coast regions of the U.S., those areas that are most vulnerable to land-falling storms. This educational outreach effort is directed at both-middle-grade school children, the age group most likely to see, learn and convey a message home, as well as the general public. These tours are operated in concert with the participation of officials from NHC, the Red Cross, FEMA and other local and state emergency management personnel. This is becoming an increasingly more popular and successful venture as coastal populations grow and the threat of an increasing number of storms place more people in harm's way.

The NOAA WP-3Ds annually support both a summer and winter operation in support of a NESDIS satellite validation program. Operating in regions of high winds and heavy precipitation, one of the WP-3Ds, equipped with microwave scatterometers and radiometers provide underflight validation of NOAA satellite QuickScat and WindSat sensed ocean surface wind vectors. Traditional venues for these operations have been Alaska or Newfoundland in the winter and the Atlantic and Caribbean regions during the summer hurricane season.

Every other year one of the NOAA WP-3Ds participates in an intensive air chemistry program, usually in concert with a number of other Federal agencies and universities. During July 2004, N42RF took part in a multi-platform experiment based from Portsmouth, NH. This New England Air Quality Study (NEAQS) employed a number of aircraft, ground stations, and also the NOAA Ship Ronald H. Brown. The NEAQS project area covered the entire northeastern corridor from Cleveland east and north into Canada. Packed completely with an impressive array of in-situ chemical samplers and three instrument pods mounted beneath the wings of the aircraft, measurements of a wide range of chemical constituents were made at low levels over the urban and rural landmass as well as the marine boundary layer. Additionally, atmospheric profiles were made from the surface to the maximum altitude capability of the aircraft (~25,000 ft). This work will continue in the summer of 2006, during a similar experiment in the Houston area. It should be no surprise that the experiment will be called the Texas Air Quality Study, or TexAQS.

During the winter of 2005, one of the NOAA WP-3Ds completed the Atmospheric Rivers (AR) Project over the Pacific northeast of the Hawaiian Islands. As part of the NOAA weather-climate program, this project focused on documenting the flow of moisture moving in a northeasterly direction toward the U.S. mainland - measurements that are critical to both the global water cycle and to storm prediction.

A study of the pre-cold-frontal low-level jet (LLJ) that precedes land-falling extra-tropical storms approaching the West Coast of the U.S. is scheduled for next winter. This LLJ plays a critical role in the transport of water vapor into the coastal mountains where orographic enhancement of precipitation can generate disastrous floods.

A NOAA AC690A Turbo Commander (N53RF) and a NOAA AC-500 Shrike (N51RF) have been utilized frequently over past years to conduct important snow surveys in the northern and western continental U.S., Alaska, and southern Canada. (N53RF will be retired during FY 2005 and be replaced by a refurbished JetProp Commander - N45RF) (Figure 3-DOC-28). During these survey flights, snow water-equivalent estimates are obtained and sent to the National Operational Hydrologic Remote Sensing Center (NOHRSC) up to three times a day from each aircraft, and after further processing the information is distributed to NWS field offices within five minutes of receipt from each aircraft. These data are used by the NWS to forecast river levels and potential flood events resulting from snowmelt water runoff. Hydroelectric power interests and other water supply managers also use the data to regulate water storage and delivery.

Figure 3-DOC-28. NOAA JetProp Commander - N45RF.

SECTION 3

DEPARTMENT OF DEFENSE WEATHER PROGRAMS

The Department of Defense (DOD) operates a military environmental service system to provide specialized worldwide meteorological, space environmental and oceanographic analysis and prediction services in support of military forces. This system directly supports all phases of military operations, from strategic planning to tactical operations. While the Army and Marine Corps each have a small specialized weather support capability, the Naval Meteorology and Oceanography Command and Air Force Weather are the primary sources of military weather products. The military weather services contribute to the national and international weather observing capability by taking conventional observations on land and at sea where there are no other conventional weather observing capabilities and where the observations are most needed to meet military requirements. In addition, DOD maintains specialized observing capabilities, such as the Defense Meteorological Satellite and Global Weather Intercept Programs, to meet unique military requirements. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.

UNITED STATES AIR FORCE

METEOROLOGICAL AND SPACE ENVIRONMENTAL SERVICES

Air Force Weather (AFW) provides high-quality, mission-tailored terrestrial and space environment observations, forecasts, and services to the United States Air Force (USAF), United States Army (USA), and a variety of United States Government (USG) departments and agencies. See Section 3, United States Army, for details of AFW support to the Army.

AFW ORGANIZATION

AFW is functionally organized under the Director of Weather (AF/XOO-W), Directorate of Operations and Training (AF/XOO), Deputy Chief of Staff for Air and Space Operations (AF/XO), Headquarters Air Force (HAF). The Director of Weather oversees Air Force-wide training, organizing, and equipping of AFW organizations to include the following functions:

• Development of doctrine, policies, requirements, and standards for weather support.

• Evaluation of weather support effectiveness.

• Management of weather officer, enlisted, and civilian career fields.

• Development and implementation of mid- to long-range plans for the organization, equipment, manpower, and technology necessary to meet future Air Force and Army weather requirements.

• Advising Air Staff and subordinate headquarters weather functional managers regarding manpower, career field management, personnel utilization, training, operations policy and procedures, and technology acquisition.

• Advocating and fielding standardized weather equipment.

AFW, a Total Force capability, employs over 4,400 Active and Reserve Component (AC and RC) military and civilian personnel supporting Air Force and Army conventional and special operations forces (SOF) at more than 290 locations worldwide. The majority of AFW personnel are focused on two distinct, yet related functions: characterizing the past, current, and future state of the natural environment and providing responsive weather and weather impact information directly to decision-makers. Environmental characterization is typically accomplished in large, centralized units focused primarily on global and regional scales of weather, whereas support to decision-makers is primarily the realm of personnel embedded in operational units. Normally, these personnel are assigned to weather flights under the operations support squadron of a flying wing, a weather squadron collocated with a supported Army unit, or a weather squadron providing a unique capability such as space launch support.

These weather squadrons may include geographically separated detachments and operating locations.

The centerpiece of global-scale collection and production is the Air Force Weather Agency (AFWA), Offutt AFB, Nebraska, a field operating agency (FOA) reporting directly to the Air Force Director of Weather. AFWA provides timely, accurate, relevant, and consistent terrestrial and space weather products necessary to effectively plan and conduct military operations at all levels of war. AFWA also provides dedicated support to SOF and the National Intelligence Community (NIC). The agency consists of a global processing center collocated with a functional management headquarters, two subordinate centers (the Air Force Combat Climatology Center (AFCCC) and the Air Force Combat Weather Center (AFCWC)), and 11 detachments and operating locations. AFWA also provides backup support to five national weather centers. AFCCC, Asheville, North Carolina, provides centralized climatological database services, produces specialized weather-impact information for DOD and allied nations, and warehouses and distributes atmospheric science-related technical information. From Hurlburt Field, Florida, AFCWC transitions technology to support tactical-level weather operations while developing operational concepts, tactics, techniques, and procedures.

Eight operational weather squadrons (OWS) form the backbone of regionally focused weather operations, providing a variety of weather forecast products and support to units assigned and/or deployed into their area of responsibility (AOR). These AORs are depicted in Figure 3-DOD-1. OWSs produce and disseminate terminal aerodrome forecasts (TAFs), weather watches, warnings, and advisories, planning and execution area forecasts, and other products using the OWS Production System Phase II (OPS II). OWSs also provide theater-scale, tailored environmental information to guide development of mission execution forecasts (MEF) by AC and RC weather personnel embedded in operational units. Moreover, OWSs provide flight weather briefings to aircrews operating within their AOR without home station support or as requested by base or post-level weather forces. When collocated, OWS personnel also support the commanders and staffs of numbered air forces (NAFs) and air and space operations centers (AOCs).

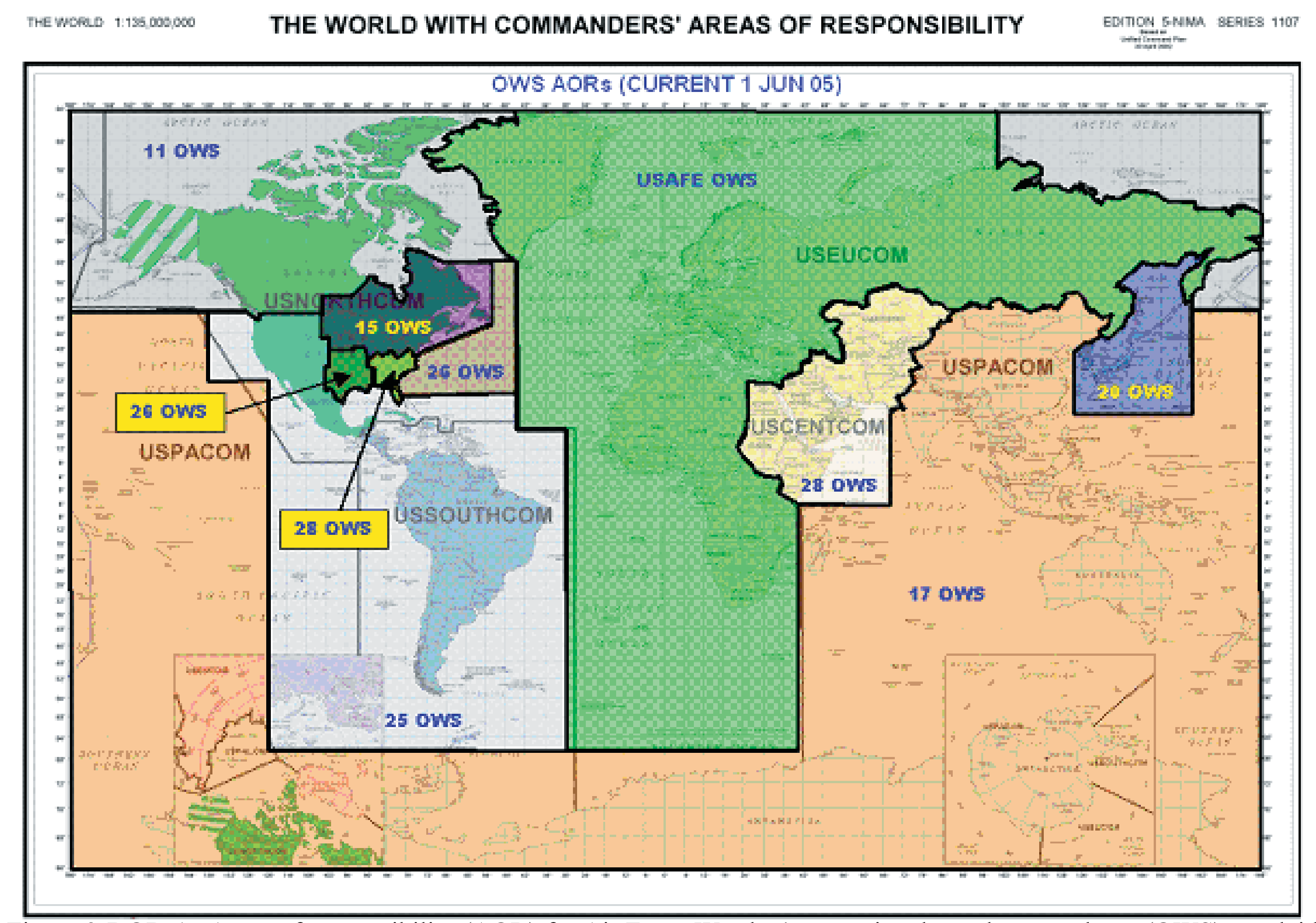


Figure 3-DOD-1. Areas of responsibility (AOR) for Air Force Weather's operational weather squadrons (OWS) overlaid on geographic combatant commander AORs.

At base and post level, weather forces take and disseminate local observations and develop tailored MEFs based on centrally produced guidance. These personnel also act as "eyes forward" for OWSs. Weather personnel deploy with a New Tactical Forecast System (N-TFS), hand-held Kestral observing kits, and the TMQ-53 semi-automated observing system for semi-permanent sites. This equipment, coupled with adequate communications to receive weather data, including satellite imagery, provide the essential capability required for deployed weather forces to meet operational requirements.

The RC is composed of the Air Force Reserve (AFR) and the Air National Guard (ANG), and AFW continues to reengineer these forces to more closely align with AC weather operations. Air Force reservists augment the AC at all levels. To augment OWSs, Air Force Reserve Command recently organized two operational weather flights (OWF), each with just over 20 traditional reserve positions. The OWF traditional reservists perform at least one weekend of drill monthly and 2 weeks of duty each year unless mobilized to the active force. Approximately 50 additional weather personnel serve as AFR individual mobilization augmentees (IMAs) assigned to various active AFW organizations at all echelons, typically in staff or scientific roles. IMAs normally train 1 day each month and for an additional 2 weeks each year.

The ANG traditional program consists of 33 weather flights, ranging in size from 13 to 25 personnel, who meet monthly to train for their wartime mission. These flights provide weather information to Army National Guard and United States Army Reserve units as well as ANG flying units. In addition, the ANG performs peacetime weather operations at locations where the ANG is responsible for airfield support. The Weather Readiness Training Center (WRTC) at Camp Blanding, near Starke, Florida, is also operated by the ANG to provide Army tactical skills training.

CHARACTERIZE THE ENVIRONMENT

To characterize the environment across the globe, AFW continually improves the core processes of collection, analysis, and prediction.

Collection

AFW collects terrestrial and space environmental measurements from ground-, sea-, air-, and space-based sensors across the globe. While openly shared foreign data greatly improves the coverage of measurements across the globe, the Department of Defense retains an assured global weather collection capability. In regions where air, space, and land operations are occurring, environmental data may be insufficient; consequently, AFW maintains a capability to deploy in-theater to establish an environmental data collection network.

AFW personnel take observations essential for effective military operations and for weather analysis and forecasting. Weather personnel at both Air Force and Army locations (garrison and deployed) make observations available to local users and transmit them to military and civil locations throughout the world. United States and foreign rawinsonde reports are primary sources of upper air observations and are supplemented with military and civilian pilot reports. The Army's Forward Area Limited Observing Program (FALOP) and the Army artillery meteorology (ARTYMET) program augment Air Force observations in the tactical environment. Weather data is also received from DOD-operated HF radio receiver sites strategically positioned around the globe to intercept weather broadcasts. These broadcasts originate from nations that do not routinely make data available through World Meteorological Organization (WMO) channels.

The Observing System 21st Century (OS-21) program will provide a much-needed, state-of-the-art life-cycle replacement for Air Force observing equipment. OS-21 includes five different configurations: fixed, deployable, remote, manual, and upper air. The manual configuration is intended for tactical operations and continues the improvements begun under the Manual Observing System and Tactical Meteorological Observing System Modification programs. AFW began fielding the fixed-base automated observing system and will continue to do so through 2006. The remaining configurations will be upgraded or replaced after fielding of fixed-base automated systems nears completion.

Weather radar data is vital to the production of timely severe weather warnings. DOD, the Federal Aviation Administration (FAA), and Department of Commerce (DOC)/National Weather Service (NWS) operate and maintain WSR-88Ds within the Continental United States (CONUS), and the Air Force operates and maintains those that are overseas. The Air Force is transitioning to the network-connected open architecture Open Principal User Processors (OPUPs) at installations with stand-alone legacy PUPs and at all CONUS OWSs, allowing these regional forecasting centers real-time access to WSR-88D radar data at locations for which they have remote forecasting responsibility. Tactical weather radars (TWR) and Ellason weather radars (EWR) provide a deployable weather radar capability for worldwide military contingency operations.

The Air Force Reserve Command's 53d Weather Reconnaissance Squadron (53 WRS), also known as the "Hurricane Hunters," provides another means of collecting vital meteorological data, especially in and around tropical cyclones. Their specially equipped WC-130 aircraft collect temperature, moisture, wind, pressure, and visually observed information at the aircraft location as well as vertical profiles of the atmosphere collected by dropsondes. Hurricane Hunter aircraft penetrate the eyes of tropical cyclones to provide the National Hurricane Center a very accurate center fix location as well as other meteorological parameters, including sea level pressure (Figure 3-DOD-2). In addition to the tropical cyclone reconnaissance, the 53 WRS collects meteorological information to improve wintertime West Coast forecasts and to support scientific field programs when possible.

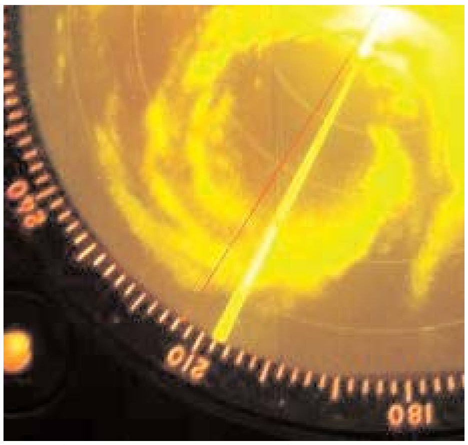


Figure 3-DOD-2. Aircraft radar shows the eye of Hurricane Claudette is 25 nautical miles wide and the wall cloud is weakest in the northeast quadrant (53 WRS website)

The Defense Meteorological Satellite Program (DMSP), which provides cloud, upper air, and space environmental data, is a vital source of global weather data used to support combat operations. On-board sensors provide AFWA and the Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC) with visible, infrared, and microwave imagery, temperature and moisture sounding data, electrically-charged particle fluxes, and other specialized space environment data. The DMSP also supplies direct, real-time readout of regional imagery and mission-sensor data to DOD land-based and shipboard terminals located worldwide (Figure 3-DOD-3).

The present DMSP satellite series (Block 5D-2) uses the Operational Linescan System (OLS) to provide visible and infrared imagery to distinguish between clouds, ground, snow, and water. The DMSP also flies the Special Sensor Microwave Temperature (SSM/T) and water vapor (SSM/T-2) sounders. Processing algorithms convert the sensed data into vertical temperature, moisture, and height profiles of the atmosphere, providing key data for numerical analysis and forecasting. The Special Sensor Microwave Imager (SSM/I) observes rainfall, ocean surface wind speed, cloud and soil moisture, ice conditions, and other environmental data. The Special Sensor for Ions and Electrons (SSIES), Special Sensor Magnetometer (SSM), and the Precipitating Electron and Ion Spectrometer (SSJ), each providing vital inputs to space weather models, measure the space environment on the topside of the ionosphere in situ. The Block 5D-3 spacecraft and sensor suite began service in 2004 with the launch of DMSP Flight 16. These spacecraft add several new capabilities: enhanced microwave imaging and atmospheric temperature/moisture sounding through the Special Sensor Microwave Imager/Sounder (SSMIS); new auroral boundary and electron density measuring capability through the Special Sensor Ultraviolet Spectrographic Imager (SSUSI); and profiles of upper-atmospheric temperature, electron content, and species densities through the Special Sensor Ultraviolet Limb Imager (SSULI).

AFW continues to participate in the refinement of requirements for the National Polar-orbiting Operational Environmental Satellite System (NPOESS). NPOESS will replace the existing DMSP and NOAA polar-orbiting satellite programs beginning in 2010, and is a joint DOD, DOC, and National Aeronautics and Space Administration (NASA) program. A ground terminal system will also provide a direct readout capability for regional/local users similar to that of the DMSP. AFW also expects to gain operational experience as well as benefit from the risk reduction planned with the NPOESS Preparatory Program planned for launch in 2008.

In addition to DMSP polar-orbiting data, AFWA receives stored data from the DOC's Polar-orbiting Operational Environmental Satellite constellation and real-time high-resolution data from the DOC's Geostationary Operational Environmental Satellite (GOES) East and West; the European Union's Meteosat-5, -7, and -8 geostationary satellites; and GOES 9, currently filling the Far East geostationary orbit until AFW transitions to the Japanese Multi-functional Transport Satellite (MTSAT). NESDIS receives test data files from India's INSAT-3A and KALPANA-1 (formerly METSAT-1) geostationary satellites. AFWA plans to accept this data via the Shared Processing Program (SPP) once data geolocation is improved to the appropriate level. AFWA currently receives data from NASA's Tropical Rainfall Measuring Mission (TRMM), Quick Scatterometer (QuikSCAT), and Moderate Resolution Imaging Spectrora-

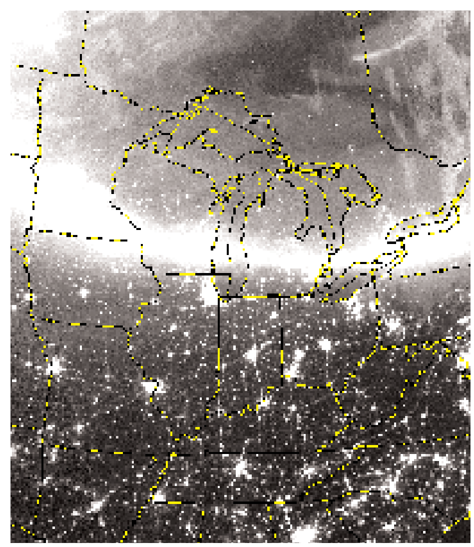


Figure 3-DOD-3. DMSP captures Aurora Borealis, over the midwest; the aurora was pushed toward the equator by a November 4, 2003 geomagnetic storm. (AF Weather website)

diometer (MODIS) via the SPP.

AFW implemented the Joint METSAT Imagery, Software, and Terminals (JMIST) capability to receive real-time visible, infrared, and microwave imagery and other non-imagery weather data from both polar-orbiting and geostationary satellites. JMIST employs network and satellite communications, direct read-out terminals, and client applications to provide ready access and manipulation capabilities for advanced low-orbiting satellite imagery from numerous agencies, to include the US Air Force, US Navy, and NASA.

Space environmental information is obtained through a combination of ground- and space-based systems. For the near-Earth environment, ground-based systems provide highly accurate point source verification and specification, whereas space-based systems enable global coverage and theater-wide situational awareness.

AFWA operates the Solar Electro-optical Observing Network (SEON), a system of ground-based telescopes at Sagamore Hill, Massachusetts; Holloman AFB, New Mexico; Palehua, Hawaii; San Vito, Italy; and Learmonth, Australia (Figure 3-DOD-4). This network provides 24-hour observations of solar phenomena at optical and radio wavelengths.

Figure 3-DOD-4. Solar optical and radio telescopes at Learmonth, Australia.

A worldwide (primarily Northern Hemisphere) network of ground-based ionosondes and other sensors provide ionospheric data. AFW manages 17 automated Digital Ionospheric Sounding Systems (DISS) to measure electron density profiles in the ionosphere. NASA's Jet Propulsion Laboratory (JPL) operates a complementary global network of sensors deriving ionospheric line-of-sight Total Electron Content (TEC) from GPS signals and provides this data to AFWA's Space Weather Branch. In addition, the United States Geological Survey (USGS) operates a network of ground-based magnetometers, primarily in the Northern Hemisphere, which provides the Space Weather Branch with critical measurements of the geomagnetic field and its variances. AFWA receives JPL and USGS data from NOAA's Space Environment Center (SEC), Boulder, Colorado.

From space, the GOES meteorological satellites provide real-time solar X-ray, charged energetic particle, and geomagnetic data through the SEC. The Solar X-Ray Imager (SXI), which became operational January 30, 2003, aboard GOES-12, monitors solar emissions in the extreme ultraviolet (EUV) and X-ray portions of the solar spectrum and provides near real-time display at AFWA and the SEC. DMSP, NOAA, and other DOD geostationary satellites provide charged energetic particle data in low-Earth and geosynchronous orbits. Additionally, AFW leverages space-based data from NASA and other agencies. For example, NASA's Advanced Composition Explorer satellite provides real-time solar wind data critical for forecasting geomagnetic disturbances and their impact to warfighter communications.

Analysis and Prediction

Effective analysis of collected terrestrial and space weather data enables identification of environmental features and conditions that may affect air, space, and land operations and thus require subsequent monitoring. From that analysis, detailed forecasts are developed through a combination of computer models and skilled human intervention.

AFWA's Global Weather Center Division is AFW's main production capability for global space and terrestrial weather analyses and forecasts. Worldwide conventional weather data are relayed to AFWA and combined with civil and military meteorological satellite data to construct a real-time, integrated environmental database. Computer programs further process the data to construct models of the atmosphere and forecast its future behavior. The Satellite Data Handling System (SDHS) facilitates the interaction between forecaster and machine.

The Division's Meteorological Satellite (METSAT) Applications Branch analyzes imagery, develops techniques, inserts technology, and recommends improvements to METSAT products. The branch produces rapid response, tailored METSAT imagery and evaluation for DOD contingency operations and generates automated METSAT imagery products for web-based distribution to DOD users. The branch also tracks and classifies tropical cyclones for the DOD Joint Typhoon Warning Center (JTWC) and the DOC National Hurricane Center; serves as the DOD focal point for volcanic ash plume detection, advisories, and trajectory forecasts; and provides back up for both JTWC satellite operations and the DOC's Washington Volcanic Ash Advisory Center. In addition, the METSAT Applications Branch produces worldwide snow and ice cover analyses to update and refine the snow depth database and generates customized snow depth and dust event analyses for contingency areas.

During Operation IRAQI FREEDOM, branch imagery specialists provided high-resolution analyses of oil fire initiation points for smoke plume dispersion forecast model products. These smoke plumes impacted both air and land operations. Advance notice allowed mission planners to modify operations to maximize mission effectiveness. The branch also develops new capabilities to display and visualize satellite imagery on workstations and infuses state-of-the-art techniques into improved imagery analysis.

The Division's Space Weather Branch employs a suite of state-of-the-art space weather models to specify current solar and global characteristics, extrapolate space weather phenomenon to areas of the globe where observations are not currently available, and to forecast future conditions. These models use available observations and include both climatology-based and physics-based algorithms. More detailed descriptions of both the available observations and current models can be found in Chapter 2 of the *National Space Weather Program Implementation Plan, Second Edition*, available from the Office of the Federal Coordinator for Meteorology.

The Global Theater Weather Analysis and Prediction System (GTWAPS) is the hardware enclave (IBM Scalable Parallel Computing and pSeries® servers) used to run most meteorological models at AFWA. The key software component of GTWAPS is a theater analysis and forecast model, Mesoscale Model version 5 (MM5), which provides fine-scale forecasts (Figure 3-DOD-5).

During Operations ENDURING FREEDOM and IRAQI FREEDOM, AFWA initiated various model window locations and resolutions as mission requirements dictated. The highly responsive nature of the MM5, and the way AFWA employs it, permitted new contingency windows to be operational

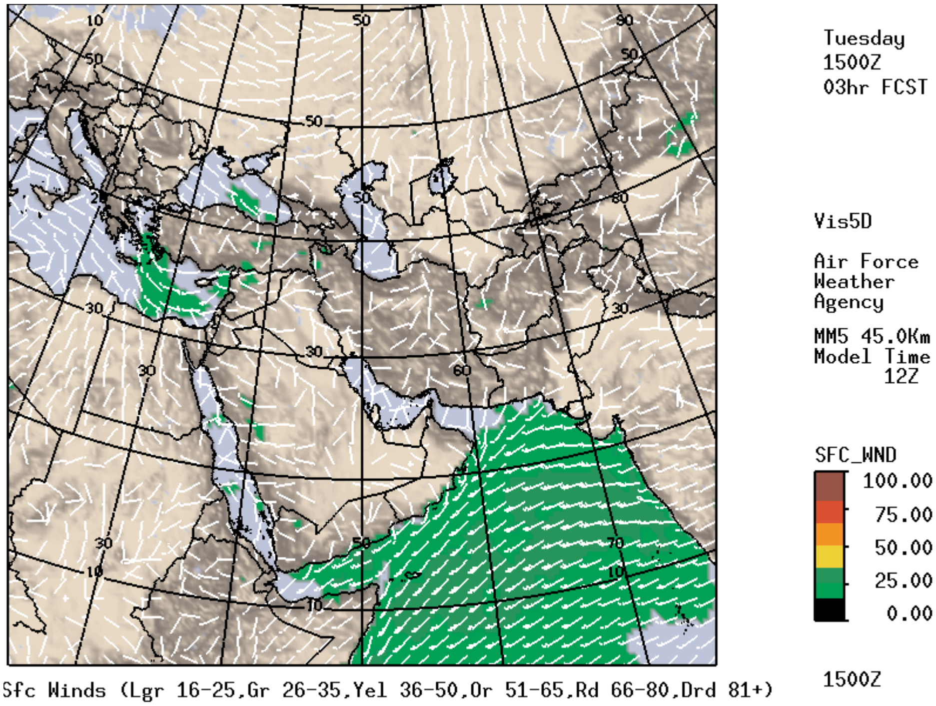


Figure 3-DOD-5. Joint Air Force and Army Weather Information Network (JAAWIN) provide reachback capability for deployed weather forces. This 3-hour forecast of surface winds over Southwest Asia was generated from AFWA's 45-km MM5 (AFWA Website)

within hours. Advancements in cloud modeling have enabled GTWAPS to produce high-resolution products that became a mainstay of weather data during the continuing global war on terrorism. MM5 is routinely provided by AFWA to the NOAA National Centers for Environmental Prediction (NCEP), where it is a backup to their Eta model.

On-going modernization initiatives at AFWA include the Space Weather Analysis and Forecasting System (SWAFS) and the Weather Data Analysis (WDA) program. SWAFS will integrate additional space weather data sources and execute next-generation space weather models for DOD and NIC operations. WDA will continue the modernization of AFWA as a key component of the Air Force Weather Weapon System (AFWWS). The reengineered AFWA will provide standards-compliant hardware and software tools, a central 4-D database, and a classified processing environment to modernize the AFWWS communications and data processing infrastructure. WDA provides a significant increase in the database capability by standing up Joint DOD-approved METOC database segments, promoting interoperability among data sharers. WDA, through the use of the METOC segments and the Joint METOC Broker Language for web services, will improve the interoperability with DOD command and control (C2) and command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) systems by providing a common interface to request the wide range of weather information. In addition, WDA-developed components (to include the Consolidated Dissemination Capability) are reusable within the OWS. This reusability will allow OWS-unique data to become part of the overall AFWWS 4-D database.

The Air Force Combat Climatology Center (AFCCC) is collocated with the National Climatic Data Center to facilitate cooperation and data exchange. AFCCC collects, quality assures, and assesses worldwide surface and upper air observations, satellite-derived soundings, numerical model output such as global gridded surface and upper air model data, a global 3-dimensional cloud analysis (world-wide merged cloud analysis), a global analysis of snow cover, and other specialized environmental data sets. AFCCC exploits these data to generate standard climatic summaries of meteorological phenomena for points around the globe, such as Operational Climatic Data Summaries and Wind Stratified Conditional Climatologies. Modeled climatologies are produced using the Advanced Climate Modeling and Environmental Simulations model. Analysts are available to develop tailored products to meet new requirements. AFCCC employs the Atmospheric Slant Path Analysis Model (ASPAM) to produce vertical profiles for any point on Earth for any time since 1985.

The Air Force Director of Weather is the DOD’s Air and Space Natural Environment Modeling and Simulation Executive Agent (ASNE MSEA). The Director executes this responsibility through the ASNE MSEA office, a division within AFCCC (AFCCC/SM). The executive agent is responsible for ensuring modeling and simulation developers and users have the tools, infrastructure, and databases necessary to represent the air and space natural environment. AFCCC/SM sponsors research and development and fields technology at AFCCC, the designated center providing tailored atmospheric data for modeling and simulation. In cooperation with the National Geophysical Data Center (NGDC) and the Defense Modeling and Simulation Office (DMSO), AFCCC/SM also sponsors ongoing research to develop a similar capability to provide tailored on-demand representations of the space environment.

OWSs are AFW's regional/theater analysis and forecast centers for Air Force and Army operations. OWSs generate a variety of products: hazard charts; drop zone, range, and aerial refueling track forecasts; fine-scale target forecasts; airfield forecasts; and weather warnings, watches, and advisories for Air Force and Army installations within their AOR. OPS II, a component of the Forecasting System 21st Century (FS-21) program to provide necessary computer hardware and software throughout the AFWWS, is the OWS's primary production tool. A hybrid of software, databases, servers, and workstations, OPS II facilitates production and dissemination of weather information to supported forces.

Provide Actionable Environmental Impacts Information to Decision Makers

To provide actionable environmental impacts, AFW continually improves the core processes of tailoring and integration.

Tailoring. Once centralized weather units create a depiction of the past, current, and future state of the natural environment, AFW forces directly supporting decision-makers tailor the information to identify impacts to operations, personnel, weapons and weapons systems, and tactics. These weather forces then help decision makers mitigate these effects through appropriate actions such as routing a flight to a new target, selecting a different weapons load, or adjusting the time of attack.

N-TFS, another component of FS-21, provides garrison and deployed weather forces with the meteorological tools to manipulate and disseminate graphical and alphanumeric products (satellite imagery, graphical forecast products, weather forecasts, advisories, briefings, observations, etc.) to Army and Air Force operational, C2, and support forces worldwide. Additionally, N-TFS ingests data from Air Force and indigenous observing sources, which then are forwarded to OWSs/AFWA for further dissemination and incorporation into centrally produced models.

AFW is currently working toward a single workstation that integrates both the Army's Integrated Meteorological System (IMETS) and the Air Force's N-TFS while providing the necessary interface capability for C2 systems. The Joint Environmental Toolkit (JET) is expected to enhance warfighter awareness of the natural battlespace environment by ensuring accurate, timely, relevant, and consistent terrestrial and space weather and weather impacts information is available and accessible by appropriate personnel and processes. JET will fulfill this role by providing a single common forecaster interface to the virtual Joint METOC Database (JMDB) for use at all levels of the AFWWS support structure. JET integrates with Joint and coalition C4ISR/Mission Planning (MP) systems by enabling machine-to-machine exchange of METOC data and information to meet operational planning and execution requirements. Furthermore, JET enhances the accuracy and utility of terrestrial/space weather and oceanographic information and operational impacts by enabling the forecaster and/or forecast process to incorporate Geographic Information System (GIS) capabilities (to include a standard high-resolution topographic database), forecasting rules of thumb, and operational thresholds into weather and weather impact products. In July 2004, two contractors were selected for a 15-month fly-off. The down select to one contractor is projected for October 2005, with fielding of the first increment to begin in late 2006. Expected delivery of all JET capabilities is FY 2013.

Tactical Decision Aids (TDAs) provide warfighters an automated way to "visualize" environmental impacts on operations. These tools, which continue to be integrated into command and control systems (e.g., mission planning systems), include Target

Acquisition Weapon Software (TAWS) (Figure 3-DOD-6), Infrared Target Scene Simulation (IRTSS), and Tri-Service Integrated Weather Effects Decision Aid (TS-IWEDA). The Air Force Research Laboratory (AFRL), the Navy's Space and Naval Warfare Systems Command, the Navy Research Laboratory (NRL), and the Army Research Laboratory (ARL) are developing these modular programs.

TAWS provides a joint mission-planning tool to combine platform, weapon, target, background, and weather impacts to depict 3-dimensional target acquisition and lock-on range and recognition range versus time. This includes prediction of environmental impacts on night vision goggles and low light-level systems used by air, naval, and ground forces to execute nighttime operations.

IRTSS uses detailed terrain information and multispectral imagery with TAWS weather inputs to generate forecast target scene images for mission rehearsal.

The TS-IWEDA uses environmental data with force, mission, and/or individual weapons rules of engagement or performance parameters to automatically generate mission-impact forecasts for large-scale planning efforts such as Air Tasking Order preparation. TAWS, IRTSS, and TS-IWEDA integrate environmental impacts into the mission execution forecasts for C2 and MP systems throughout the military planning and execution cycle.

The TDA program continues adding weapons systems and targets at the request of users from the Services. Additional decision aids in development or in coordination include the Airborne Laser (ABL) Atmospheric Decision Aid (ADA) to support ABL development and operations and a common radio frequency (RF) system performance prediction capability based on US Navy software.

AFWA's Special Support Operations Branch (SSOB) generates a myriad of products ranging from air refueling forecasts, to detailed mission control forecasts, to weather impacts for SOF operations, and distributes this information via secure media to support worldwide Joint SOF operations. The branch also provides tailored meteorological information for end-to-end planning at US Special Operations Command (USSOCOM), Service component special operations commands, and theater special operations commands. The SSOB is continually involved in global military operations, including Operations ENDURING FREEDOM and IRAQI FREEDOM. Additionally, the SSOB includes the American Forces Network Weather Center, which provides worldwide, broadcast-quality public weather services and planning forecasts through the American Forces Radio and Television Service to over 1,000,000 DOD and Department of State personnel and family members stationed overseas.

AFWA's NIC Weather Branch provides detailed global cloud analyses and forecasts to the intelligence community. The branch provides worldwide mission-tailored planning and execution forecasts for NIC agencies at security levels up to Top Secret/Sensitive Compartmented Information (TS/SCI). The branch also serves as the focal point for AFWA Special Access Program (SAP) requirements; ensures the NIC and other SCI and SAP meteorological requirements are integrated into AFWA programs; monitors and evaluates accuracy and timeliness of centralized weather services to the NIC; and interfaces with the DOD and NIC regarding weather services and the exploitation of weather information.

As the sole source of DOD space environmental information, AFWA partners with NOAA's SEC to meet the nation's military and civilian space weather needs. AFWA's Space Weather Branch provides a suite of automated and manually tailored analyses and forecasts (including advisories and warnings) of space weather phenomena that affect military operations and National Intelligence Com-

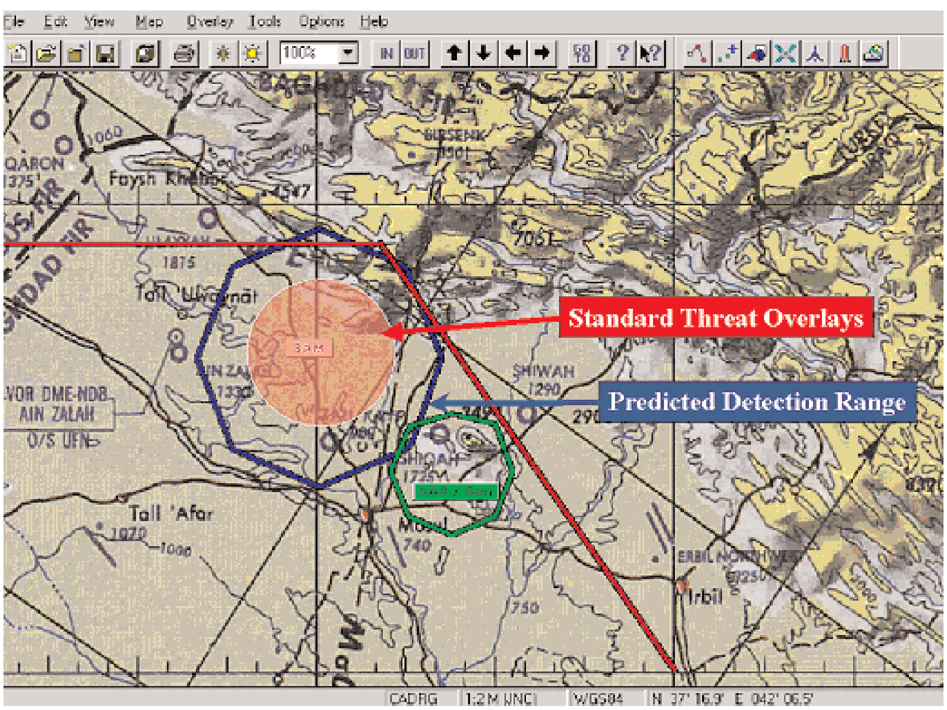


Figure 3-DOD-6. Target Acquisition Weapon Software (TAWS) integrate meteorological conditions and environmental parameters to enhance the mission planning process and increase aircrew situational awareness for mission execution.

munity (NIC) activities. Similarly, signal fades due to space weather effects on UHF satellite communications (SATCOM) links provide valuable planning information to improve command and control capabilities. Further examples of model output informational products include Single-Frequency GPS Receiver Error maps (Figure 3-DOD-7), UHF Satellite Communication Scintillation maps (Figure 3-DOD-8), HF Illumination maps (Figure 3-DOD-9), and Radar Auroral Clutter maps. These products assist warfighters in determining and mitigating space weather impacts to their systems as well as in exploiting enemy space weather susceptibilities for possible asymmetric advantage.

The Air Force provides meteorological and space weather products to the nation's space and missile programs, including a wide range of weather observing services at the Air Force Eastern Range and the Kennedy Space Center (KSC). The Air Force also provides tailored forecasting for NASA's manned and unmanned launches and for commercial launches from KSC.

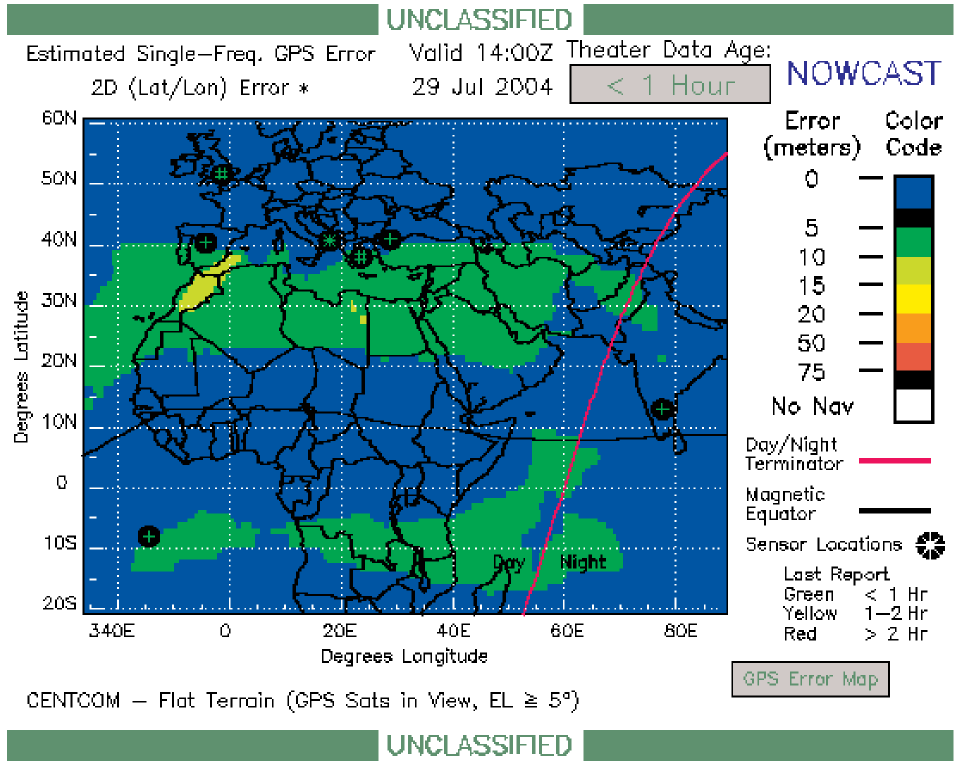


Figure 3-DOD-7. Single-Frequency GPS Receiver Error Map (visualized by HQ AFWA)

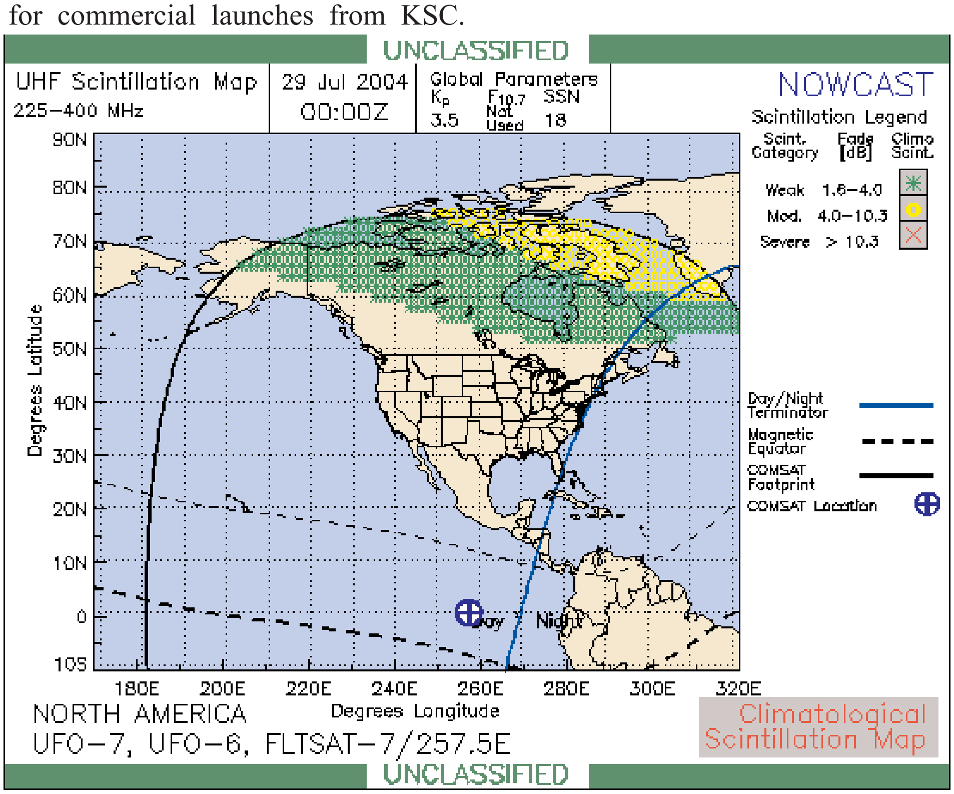


Figure 3-DOD-8. UHF Satellite Communications Scintillation Map (visualization by HQ AFWA)

In addition, the Air Force provides specialized meteorological information for the Air Force Western Range at Vandenberg AFB, California; the Pacific Missile Range, which includes Point Mugu and San Nicholas Island, California, and Barking Sands, Hawaii; White Sands Missile Range, New Mexico; Kwajalein Missile Range, Republic of the Marshall Islands; and other DOD research and test facilities as directed.

The Air Force also provides agrometeorological support to the United States Department of Agriculture's Foreign Agricultural Service and other similar users. The output includes diagnostic soil hydrology and other meteorological information pertinent to crop growth and yield estimation as well as to trafficability and rudimentary flooding estimations.

Integration Tailored environmental information and operational impacts are of little use to decision-makers if the information/impacts are not integrated into the shaping, planning, execution, and sustainment of air, space and land operations. AFW employs a blend of information technology (IT), including automated machine-to-machine interfaces, and personnel

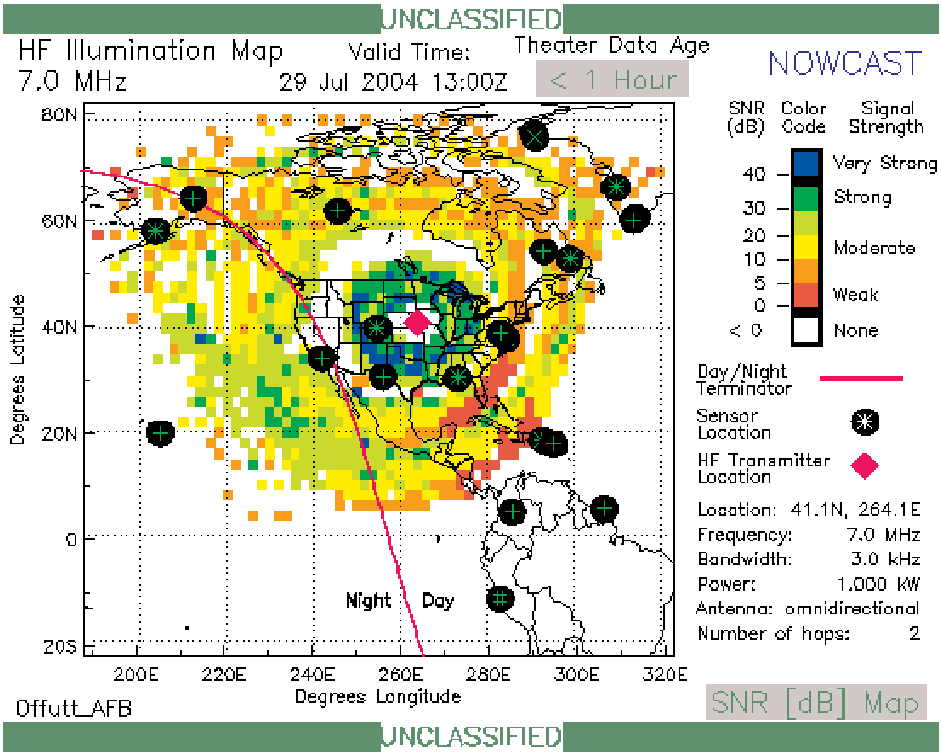


Figure 3-DOD-9. HF Illumination Map (visualized by HQ AFWA).

embedded at the right echelons with decision-makers, to integrate accurate, relevant, and consistent weather and weather impacts information into decision-making processes. Since timeliness is critical to effective integration; AFW operations rely on robust, assured communications for dissemination.

AFWA receives alphanumeric weather data, parses it according to data type, eliminates duplicate reports from different sources, and creates specially tailored bulletins. Some of these bulletins are sent to the large processing centers to provide the input data for global, regional, and fine-scale forecast models. Other bulletins are redistributed to end-users over dedicated circuits, NIPRNET, and satellite broadcast facilities.

High-speed communications between large DOD and civilian processing centers facilitate sharing of data, high-resolution satellite imagery, and output from numerical weather prediction models. Additional circuits provide a subset of these data to OWSs.

Forecaster-developed products and gridded data sets are distributed from AFWA via the Weather Product Management and Distribution System to base/post-level weather forces around the globe using the DOD's Non-Secure Internet Protocol Router Network (NIPRNET) and Secure Internet Protocol Router Network (SIPRNET). Alphanumeric data, including surface, upper-air, space weather, and pilot reports, are also collected and distributed via the Automated Weather Network (AWN), Very Small Aperture Terminal (VSAT) satellite communications system, and the NIPRNET. The AWN, consisting of data collection, message creation, and dissemination software, is a global communications network used for alphanumeric terrestrial and space weather data. The AWN supports DOD as well as federal and foreign meteorological, space, and aviation centers.

AFW operates a website on the NIPRNET known as the Joint Air Force-Army Weather Information Network (JAAWIN). JAAWIN provides worldwide access to numerical model forecasts, satellite imagery, forecaster-in-the-loop (FITL) products, and text bulletins, and includes links to all OWS websites. Additional products are available to classified users via JAAWIN-Secret (JAAWIN-S) and JAAWIN-Sensitive Compartmented Information (JAAWIN-SCI).

Joint Weather Impacts System (JWIS) offers another means of making tailored weather information available to DOD users. JWIS provides a link to weather information from both Air Force and Navy sources for exploitation by command and control systems and applications. AFW successfully demonstrated a JWIS-based machine-to-machine (M2M) weather information transfer to command and control applications during Joint Expeditionary Force Experiment 2004.

Although IT continues to enhance the integration of weather and weather impact information into decision-making processes, well-trained weather professionals are still essential. Designated AFW personnel serve on the staffs of operational Air Force, Army, and Joint force units worldwide. In this capacity, they identify weather-sensitive areas of the operation and provide expert advice to help mitigate weather impacts on personnel, platforms. weapons and weapons systems, and tactics. The ultimate goal is to identify opportunities for an asymmetric advantage over our foes, i.e., when enemy force capabilities are more severely degraded by weather than those of friendly forces.

For Air Force operations, these weather professionals are normally assigned to a flight under an operations support squadron in a flying wing; however, individuals from the weather flight are integrated into flying squadron mission planning and execution processes. In this capacity, they infuse critical weather information at key points in the decision cycle to help aircrews maximize wartime capabilities, enhance flight safety, and optimize training effectiveness. Weather experts are also assigned to weather specialty teams (WST) in air and space operations centers (AOCs). This cross-cutting team integrates all-source actionable environmental information at key decision points of air and space operations planning, execution, and assessment. Armed with this information, decision-makers can balance operational risks against mission need to optimize timing, tactics, target and weapons selection, and other factors affecting air and space operations. Finally, AFW experts are integrated into a variety of other unique mission areas, such as space launch support and research, development, test, and evaluation (RDTE) activities. In each capacity, these specialists enable the supported organization to minimize or alleviate weather impacts to the mission. For instance, to avoid potentially devastating storms, space launch weather personnel may advise decision-makers to adjust launch timing, while RDTE weather personnel may identify potential weather sensitivities to system developers to ensure a safe, effective design.

Likewise, Army weather requirements are incorporated into AFW's overall mission concept. AFW forces are integrated with Army intelligence staffs, and the Army trains and educates Air Force personnel on Army organizations, concepts of operations, and the weather sensitivities. AFW forces are currently habitually aligned with echelons above corps, corps, divisions, separate brigades, aviation brigades, armored cavalry regiments, ranger regiments, and special forces groups (as well as subordinate battalions deployed at forward operating bases). Over the next few years, AFW support to the Army will undergo significant transformation as the Army transitions from a division-centric force based on large standing organizations to a brigade-centric force based on smaller, modular organizations.

RESEARCH INITIATIVES

The overarching objective of the Air Force meteorological and space environmental research and development (R&D) program is to provide capability designers, operational weather personnel, and weather information users with the technology and tools to gain and maintain the advantage over a potential adversary. Documented R&D requirements in the atmospheric sciences are articulated in the AFW Mission Support Plan and in the Mission Area Plans of the Air Force major commands. Space environment R&D is targeted to meet the DOD's space weather requirements as summarized in the National Security Space Architect's Space Weather Architecture Study as well as the National Space Weather Program Implementation Plan, Second Edition. AFW also strives toward improvements through cooperative research and development agreements with for-profit companies. AFW has begun efforts to integrate the Utah State University Global Assimilation of Ionospheric Measurements (GAIM) model. The initial operational capability based on GAIM is planned for 2006.

In meteorological R&D, the Air Force is improving cloud depiction and forecasting (CDF) techniques by doubling the resolution, integrating geosynchronous METSATs into the cloud analysis, using a new cloud interpretation scheme, and blending numerical weather prediction with forecast cloud advection techniques. The Air Force has transitioned key advances in tactical decision aids into operations, permitting improved forecasting of electro-optical system performance and generation of cloud and target scene visualizations for training, system development, and mission rehearsal. In addition to internal efforts, AFW will continue to rely on collaboration and leveraging of efforts with other federal meteorological agencies, research labs, and universities to further improve CDF system performance and meet other research needs.

Mesoscale Modeling for Air Force and Army Operations

Efforts have continued for combining the Land Surface Model (LSM) and MM5 for use by Air Force and Army operations. The LSM analyzes the current state of the land surface to provide information to both DOD and civilian agencies, and through coupling with MM5, will improve forecasting performance in the low levels of the atmosphere. This allows AFW to provide better forecasts for low-level aircraft operations, the dispersion of aerosol contaminants, and the employment of precision-guided munitions. It also allows for assessment of trafficability for ground forces. The advances achieved in the LSM are also being carried over into Weather Research and Forecast (WRF) model development. WRF, the next generation community model expected to replace MM5, is another area of AFWA participation in research. AFWA is closely collaborating with the National Center for Atmospheric Research (NCAR), NOAA's NCEP, NOAA's Forecast Systems Laboratory (FSL), the University of Oklahoma's Center for the Analysis and Prediction of Storms, and others in WRF development. AFWA is preparing to initially implement WRF operationally in 2005 and will continue with sponsorship and funding of development at NCAR and FSL, test and evaluation of real-time runs of the WRF prototype, and will lead the LSM Working Group while participating in others.

Through a joint Air Force-Navy effort, AFWA and FNMOC were awarded a $3 million grant from the DOD High Performance Computing Modernization Office in 2004 to establish an operational test and evaluation center for the WRF modeling framework. Additionally, each organization gained status as a DOD High Performance Computing Distributed Center.

The WRF Operational Test Center (OTC) will greatly enhance DOD's ability to efficiently incorporate state-of-the-science modeling technologies into operations. The end result will be never-before-seen predictive accuracy of fine-scale weather features crucial to DOD operations. A cutting-edge IBM supercomputer suite, split into two identical subsystems, was installed at each weather center. The distributed WRF OTC subsystems will be virtually integrated using high-speed communications networks, allowing operational simulations with real-time weather data from each center. After rigorous test and evaluation, the specialized WRF configurations that perform optimally for DOD and Service-unique mission needs will be implemented at AFWA and FNMOC.

Atmospheric Optical Turbulence

Electro-optical (EO) systems are adversely affected by optical distortions caused by thermal or refractive turbulence. As the sophistication of current and next-generation military systems grows, the requirement for more detailed knowledge of fine-scale (meters or less) atmospheric behavior also grows. The Airborne Laser (ABL) program is one such capability whose performance is highly dependent on the variations of the meteorological conditions that produce optical turbulence. The Air Force program in atmospheric optical turbulence measurements and modeling seeks to address these needs. Researchers used a balloon-borne turbulence sensor mated to a standard radiosonde to obtain measurements, producing data and empirical models that are the basis for ABL system specification. Balloon-borne measurements were made in conjunction with airborne stellar scintillometer measurements to understand the relation between atmospheric structure and path-integrated optical effects. The turbulent scalar spectrum was also sampled using balloon-borne high-bandwidth sensors. As part of an international program, aircraft measurements of temperature and velocity turbulence have been made in different locales worldwide. Horizontal measurements by the aircraft augment the vertical profiling by balloons to assist in the development of the detailed knowledge required to support new EO systems.

United States Weather Research Program (USWRP)

USWRP's mission is to accelerate forecast improvements for high-impact weather phenomena and to facilitate full use of advanced weather information. AFW first entered into discussions with USWRP in 2001 to explore expanded participation in the program. The program currently focuses on land-falling hurricanes, heavy precipitation, and socio-economic impacts. AFW is eager to leverage future efforts in the areas of observing, assimilation strategies for data-sparse regions, and urban forecasting to increase warfighters' abilities to anticipate and exploit the weather. AFW is already committed to the USWRP-affiliated community development of the WRF model and will continue its USWRP involvement during the coming fiscal year.

University Partnering for Operational Support (UPOS)

AFW continued to collaborate through the UPOS program with Johns Hopkins University Applied Physics Laboratory, the University of Alaska at Fairbanks Geophysical Institute, and ARL. UPOS provides a link between university research and the DOD operational community and is currently focused on near-term forecasts of ground, tropospheric, ionospheric, magnetospheric, and solar weather. The goals of UPOS are to provide an alternate path for rapid transition of the best-applied research ideas to the warfighter and to raise awareness of DOD operational needs within the academic community. The partnership delivers prototype operational products to Air Force and Army sponsors. The UPOS Steering Committee, which includes the Air Force Director of Weather, meets semiannually to review progress and approve new projects. UPOS includes warfighter exercise support to demonstrate utility of products through web-based, non-operational access as well as collecting direct user feedback for faster updates of the prototype systems. Some examples of UPOS tropospheric weather work include fine-scale polar numerical weather prediction, operational volcanic plume forecasting, and electromagnetic propagation forecast maps generated from MM5 output. Examples of space science work include high frequency radar and communication propagation to predict the area a transmitter can illuminate, forecasting coronal mass ejections, and improving determination of solar events that will cause militarily significant space weather effects on and near Earth.

Air Force Research Laboratory (AFRL)

In other space weather research, AFRL programs focus on ionospheric impacts to radio frequency systems, space particle specification and forecasts, solar disturbance prediction, and neutral density effects on Low-Earth Orbit (LEO) spacecraft. Working closely with the DMSP System Program Office (SPO) at the Space and Missile Systems Center (SMC) under a Memorandum of Agreement, AFRL supports the development and upgrading of operational space weather sensors, models, and software products to include: space environment sensors on the DMSP spacecraft; state-of-the-art ground-based scintillation detectors; total electron content sensors; DISS; SEON; and the Operationalized Space Environment Network Display suite of web-based products. AFRL also conducts user-supported R&D for NPOESS, the Defense Modeling and Simulation Office (DMSO), the National Reconnaissance Office (NRO), the Ballistic Missile Defense

Office (BMDO), the DOD High Performance Computing Modernization Office, and NASA.

In addition to the AFRL research portfolio, AFW collaborates with others in the space weather community to develop new techniques, models, and systems for transition to operational applications. These include the Community Coordinated Modeling Center (CCMC), the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), and the previously mentioned UPOS.

In conclusion, through a continuous process of review and definition, the Air Force documents its requirements for research aimed ultimately at providing timely, accurate, relevant, and consistent weather information to the warfighter today and in the future. In meteorological R&D, AFW is committed to continued development of the WRF model and collaboration with others to the benefit of the warfighter and the nation. Space weather research will continue with a strong program in 2006 at the AFRL, as well as in leveraged programs such as UPOS, to facilitate the transition of required capabilities to operational use at minimum expense.

METEOROLOGICAL SERVICES

The United States Navy has the unique military requirement to assess meteorological and oceanographic (METOC) impacts on naval, joint, and combined operations. METOC support begins by measuring the battlespace physical environment and culminates with safe, effective weapons systems and sensor employment. Environmental support is global, and historically focuses on areas outside of the contiguous 48 states, but the emphasis is on wherever the Fleet goes and includes force protection within the coastal waters of the U.S. Developing METOC forecasts and determining potential effects on platform, sensor and weapons systems require:

- collection of METOC data through tactical and dedicated sensors (including satellites);
- fusion and analysis of atmospheric and oceanographic data; and
- integration of meteorological and oceanographic information in tactical decision aids and mission planning systems.

The Office of the Oceanographer of the Navy, Chief of Naval Operations (CNO) N7C, is an Echelon I Staff that reports to the Deputy CNO for Warfare Requirements and Programs (N6/N7). The Commander, Naval Meteorology and Oceanography Command, is an Echelon III Command that reports to the Commander, Fleet Forces Command (CFFC). While operational requirements are coordinated through CFFC, it is the Chief of Naval Operations, through the Oceanographer of the Navy, who continues to sponsor operational Navy METOC support services and related research and development (R&D). The Navy METOC organization provides meteorological support services for Navy and joint forces, meteorological products to the uniformed services and other Government agencies, and oceanographic support to all elements of DOD.

The United States Navy is building upon its strengths, thus enabling an asymmetric war fighting advantage over its adversaries. One of these strengths is the Navy's ability to apply Meteorology and Oceanography to its battle problems and challenges in order to leverage the environment for an advantage. The Naval Meteorology and Oceanography Command provides that advantage for the Navy through the application of its scientific disciplines: oceanography, meteorology, geo-spatial information and services and precise time and astrometry.

In 2004, the Naval Meteorology and Oceanography Command aligned internally from a geo-centric to knowledge-centric organization designed to directly and measurably enhance warfighting capabilities.

The Command is aligned along the following warfare and warfare support areas:

- Antisubmarine Warfare (ASW)
- Naval Special Warfare
- Mine Warfare (MIW)
- Intelligence, Surveillance and Reconnaissance (ISR)
- Fleet Operations (Strike Warfare and Expeditionary Warfare)
- Navigation
- Precise Time and Astrometry
- Maritime Operations
- Aviation Operations

In the new Command structure, the Commander, Naval Meteorology and Oceanography Command now directly measures, applies and adjusts resources across the enterprise toward specific warfighting needs. Collection and production are centralized at the Fleet Numerical Meteorology and Oceanography Center (FNMOC) in Monterey, California, and the Naval Oceanographic Office (NAVOCEANO), located at Stennis Space Center, Mississippi. Service delivery is uniformed, minimized, decentralized and located at the Naval Warfighting Command nodes. The Command's personnel are located at its headquarters at Stennis Space Center near Bay St. Louis, Mississippi, and at several field activities located around the world.

Warfare centers, laboratories, and systems commands, through sponsorship by the Chief of Naval Research and the Oceanographer of the Navy, conduct METOC research and development. To ensure that all research and development supported by the Oceanographer is in direct support of the Naval Mission as established by formal Navy Doctrine, the Oceanographer has developed and implemented a comprehensive framework to transition research to operations. The Naval Research Laboratory (NRL) and the Program Executive Office (PEO), C4I and Space (PMW 180) are the primary activities that manage naval METOC research and transition to operations, and are supplemented by various universities, industry partners, and organizations under Navy contract. NRL detachments are collocated with the Fleet Numerical Meteorology and Oceanography Center in Monterey, California and with the Naval Oceanographic Office at Stennis Space Center, Mississippi. The PEO C4I and Space Program Office (PMW-180) is the Navy's program manager for METOC system development and acquisition.

FLEET NUMERICAL METEOROLOGY AND OCEANOGRAPHY CENTER

The U.S. Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC; see https://www.fnmoc.navy.mil/) plays a significant role in the National capability for operational weather and ocean prediction through its operation of sophisticated global and regional meteorological and oceanographic models, extending from the top of the atmosphere to the bottom of the ocean. Through close collabora-

Figure 3-DOD-10. At sea with USS PRINCETON (CG 59) -- Waves crash over the bow of the guided missile cruiser while receiving nearly 100,000 gallons of JP-5 jet fuel from aboard the aircraft carrier USS NIMITZ (CVN 68) during an underway replenishment (UNREP) off the California coast.

tion with the Naval Oceanographic Office (NAVOCEANO), FNMOC is a key component in the Navy's operational weather and ocean prediction program. This program provides information that helps give Naval forces an asymmetric advantage in speed, access and persistence in any combat operation for which they may be called upon. Users of FNMOC's products include all branches of the Department of Defense (DOD), the intelligence community, and other government organizations such as the National Weather Service, private companies, a number of colleges and universities, and the general public.

FNMOC is well known for its long and productive history of implementing, evaluating, operating, maintaining and improving complex Numerical Weather Prediction (NWP) models specifically to meet the requirements of the U.S. Navy. These requirements include the need for a particularly accurate representation of coastal meteorology and the air-sea heat fluxes and wind stresses required to drive the Navy's ocean models. In support of this need, FNMOC acquires and processes over six million observations per day-creating one of the world's most comprehensive real-time databases of meteorological and oceanographic observations-for real-time fusion and assimilation into its models. In addition, FNMOC is designated as the DOD center for global Numerical Weather Prediction. FNMOC uniquely satisfies the military's requirement for an operational global NWP capability based on software certified to DOD information assurance standards and operated in a secure classified environment protected from outside intrusion by DOD certified firewalls. This requirement is driven by the importance of weather and ocean conditions on modern military operations, the need to utilize classified weather observations to guarantee the very best weather and ocean predictions in theaters of conflict, and the imperative to produce and disseminate weather and ocean products to military decision makers without fear of interruption or compromise as a result of cyber terrorists or cyber warfare.

FNMOC employs four primary models, the Navy Operational Global Atmospheric Prediction System (NOGAPS), the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), the Geophysical Fluid Dynamics - Navy (GFDN) model, and the Wave Watch III model (WW3), along with a number of specialized models and related applications. NOGAPS is a hydrostatic, global spectral model that drives nearly all other FNMOC models and applications in some fashion, and forms the basis for the FNMOC global Ensemble Forecast System (EFS). COAMPS is a high-resolution, non-hydrostatic regional model, multiply nested within NOGAPS, which has proven to be particularly valuable for forecasting weather and ocean conditions in highly complex coastal areas. GFDN is a moving-nest tropical cyclone (TC) model, nested within NOGAPS that is used to forecast TC tracks globally. WW3 is a spectral ocean wave model that is employed both globally (driven by NOGAPS) and regionally (driven by COAMPS) in support of a wide variety of naval operations. Other models support and supplement the main models with predictions of ocean thermal structure, ocean currents and other data. All of the models are configured, scheduled and operated under the central control of FNMOC Operations. COAMPS, however, can also be configured, scheduled and operated remotely by users in the field as an on-demand modeling service. This is done over the Web via the FNMOC Centralized Atmospheric Analysis and Prediction System (CAAPS). In general, FNMOC strives to treat the air-ocean environment as a fully integrated system, from the top of the atmosphere to the bottom of the ocean, placing special emphasis on the air-ocean interface.

FNMOC's complex and robust operational prediction capability is designed to deliver, in conjunction with NAVOCEANO, twenty-four hour year round support organized along the following Business Lines:

- Anti-Submarine Warfare
- Naval Special Warfare
- Mine Warfare
- Intelligence, Surveillance and Reconnaissance
- Fleet Operations (including Strike Warfare and Expeditionary Warfare)
- Navigation (including support for Fleet Ballistic Missile Submarines)
- Aviation Safety
- Maritime Safety

For example, some FNMOC products consist of detailed forecasts of wind stresses and heat fluxes to drive very high-resolution ocean models at NAVOCEANO that provide ocean thermal structure and currents in support of anti-submarine and mine warfare operations, or near-shore wind, sea and surf forecasts that directly support Fleet Operations through ship-to-objective maneuver. In many cases, the outputs of the FNMOC models feed directly into applications models, tactical decision aids and other products that provide direct support to various weather-sensitive activities associated with the Business Lines identified above. These include optimum path aircraft routing, optimum track ship routing, issuance of high-winds and high-seas warnings, hurricane/typhoon sortie decisions, covert ingress/egress of Special Operations Forces, ballistic missile targeting, cruise missile launch and targeting, radar performance prediction in support of ship self defense, naval gunfire operations, understanding the threats posed by airborne nuclear/biological/chemical agents, search-and-rescue at sea, and many other activities.

FNMOC also provides a wide-range of meteorological and oceanographic observations and satellite imagery to complement its models and applications products. These include on-demand extracts from its global observational database, a full range of Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I) products, ERS and QuikScat scatterometer wind products, a comprehensive view of tropical cyclones via the FNMOC TC Web Page, and various experimental satellite products fielded for evaluation in conjunction with the Naval Research Lab (e.g., satellite imagery that enhances the visualization of airborne sand and dust). FNMOC also hosts the U.S. Global Ocean Data Assimilation Experiment (GODAE) Monterey Data Server in support of the GODAE. This system serves as a one-stop shop for meteorological and oceanographic data and model products required to support global ocean modeling R&D. It also functions as one of two Argo Global Data Assembly Centers (GDACs), hosting the complete collection of quality-controlled Argo temperature/salinity profiling float data.

Many of FNMOC's products are distributed to users over the Web via the PC-based METCAST system, and subsequently displayed and manipulated on the user's PC with the Joint METOC Viewer (JMV) software. This includes all standard meteorological and oceanographic fields, synoptic observations, and satellite imagery. For those who require only graphical display of model-predicted meteorological or oceanographic fields, FNMOC provides a Web-based capability called MyWxMap (i.e., "My Weather Map"). MyWxMap, requiring only a Web browser for access, allows the user to select and quickly display predicted meteorological and oceanographic fields for any user-defined geographical area.

All of FNMOC's production capabilities are fielded on a collection of computer hardware and software constituting a DOD Major Automated Information System and designated as the Primary Oceanographic Prediction System (POPS). POPS is organized into two subsystems: the Analysis and Modeling Subsystem (AMS) and the Applications, Transactions, and Observations Subsystem (ATOS). AMS is a cluster of SGI and IBM supercomputers on which the major NWP models run. ATOS is a large suite of IBM Linux clusters that ingests, decodes and quality-controls data; does satellite data processing; hosts many of the applications models and products mentioned above; and supports data distribution via a services oriented architecture and Web portal. Note that FNMOC also hosts two DOD High Performance Computing Modernization Program (HPCMP) Distributed Centers, which are integrated closely with POPS.

In addition to its primary role of focused support to the warfighter, FNMOC also plays a key role in the U.S. national program for weather prediction. In this regard, FNMOC's tropical cyclone track predictions, widely recognized as among the best in the world, have proven to be especially valuable, with the National Hurricane Center (NHC) relying on them heavily. FNMOC also provides an important and physically separate backup for some of the models run at the National Weather Service's National Centers for Environmental Prediction (NCEP). In addition, FNMOC serves as the Alternate Joint Typhoon Warning Center (AJTWC), providing the backup for the JTWC located in Pearl Harbor, Hawaii. And finally, the subset of FNMOC products made available to the general public via the Internet is used widely by both commercial and recreational marine interests.

FNMOC benefits greatly from collocation with its supporting R&D activity, the Marine Meteorology Division of the Naval Research Laboratory (NRL/MRY). NRL/MRY is a world-class research organization, with focus on weather-related support for the warfighter. FNMOC and NRL/MRY share space, data, software and computer systems, and together with the nearby Naval Postgraduate School represent one of the largest concentrations of weather-related intellectual capital in the nation. Collocation and close cooperation between research and operations, such as exists between NRL/MRY and FNMOC, is the optimum arrangement for transitioning R&D quickly and cost-effectively into new and improved operational weather prediction capabilities. In addition, both FNMOC and NRL/MRY are working to leverage strategic partnerships and community modeling efforts such as the Weather Research and Forecasting (WRF) and Earth Systems Modeling Framework (ESMF) programs.

NAVAL OCEANOGRAPHIC OFFICE

Since atmospheric conditions are inherently coupled to oceanographic conditions, the Navy's program in meteorology is closely linked with oceanography, which is the focus of the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, Mississippi. NAVOCEANO's primary responsibilities include the collection, processing, and distribution of oceanographic, hydrographic, and other geophysical data and products. NAVOCEANO runs and disseminates products from the world's first operational global ocean model - Naval Research Laboratory (NRL) Layered Ocean Model (NLOM) as well as a number of regional and coastal circulation and wave models. NAVOCEANO also runs the Polar Ice Prediction System (PIPS) ice model.

A key ingredient to ocean model performance is real-time data for assimilation and evaluation. NAVOCEANO is the Navy's primary processing facility for NOAA polar-orbiting satellite data and is nationally recognized for satellite-derived sea-surface temperature and satellite altimeter-derived sea-surface topography and wave height. NAVOCEANO's global sea surface temperature data are critically important to successfully running NOGAPS and COAMPS. Additionally, NAVOCEANO houses a DOD Major Shared Resource Center, enabling transition of the latest research and development models on the most modern scaleable, supercomputing architecture and facilitating transition from R&D to operational use. The NAVOCEANO web site for information is https://www.navo.navy.mil.

NAVAL ICE CENTER

The Naval Ice Center (NAVICECEN), located in Suitland, MD, provides tailored ice forecasts and analyses to DOD. The Navy (through NAVICECEN), NOAA, and the U.S. Coast Guard, jointly operate the National Ice Center (NIC). The NIC provides ice analyses and forecasts for the Arctic and Antarctic regions, coastal U.S. waters, and the Great Lakes to civilian and military activities.

METOC SUPPORT TO THE NAVAL WARFIGHTING AREAS

ANTI-SUBMARINE WARFARE (ASW)

The Naval Meteorology and Oceanography Command provides Anti-Submarine Warfare commanders with critical environmental knowledge that defines the battlespace and helps warfighter planning and operations. The need for this real-time infusion of environmental knowledge is especially important in modern warfighting as ASW is increasingly likely to occur in littoral regions where conditions can change rapidly and dramatically.

Contributions to ASW consist of an unequaled expertise in oceanography and meteorology, a variety of high-tech sensing tools, powerful supercomputers and highly skilled personnel all working together to form a flexible network of warfighter support.

Characterizing the Battlespace. There are several environmental factors that together define the ASW battlespace and help warfighters determine the right platform, weapons, targets, settings, tactics and timing necessary for maximum effectiveness. Naval oceanographers monitor and analyze these variables and provide data directly to decision-makers. These environmental factors include:

- acoustics and ambient noise;
- bathymetry;
- temperature and salinity;
- bottom-mapping;
- tides and currents.

The Naval Meteorology and

Figure 3-DOD-11. Navy pilot discusses current weather conditions displayed on large plasma screens with the forecaster prior to take-off.

Oceanography Command is effectively aligned to provide skills and resources for ASW mission success. Important supporting assets are:

• Skilled Personnel Deployed Worldwide. Military and civilian personnel are deployed worldwide to provide a flexible support team to warfighters. Littoral Warfare Teams combine on-scene and reach back personnel to collect, consolidate and interpret data from a variety of sources and sensors for delivery to decision-makers.

• High-Performance Computing. With the Major Shared Resource Center, advanced models, high bandwidth data transfers and supporting databases information can be processed and delivered quickly to warfighters.

• Advanced Sensing Technology. Gliders, Autonomous Unmanned Vehicles (AUVs), Underwater Unmanned Vehicles (UUVs) and towed sensors define the battlespace for ASW warfighters and aid planning and operations. The unmanned sensors can improve littoral surveying, especially in denied areas, while providing real-time data over extended periods.

• Comprehensive Data Collection. Data that supports warfighting is collected from multiple sources including: Fleet Survey Teams on T-AGS 60 ships and Hydrographic Survey Launches (HSLs), buoys, satellites, remotely operated unmanned sensors and other sources.

• ASW-Specific Training. Naval oceanographers are trained on tactical oceanography as it relates to ASW.

NAVAL SPECIAL WARFARE

The Naval Meteorology and Oceanography Command actively contributes to Naval Special Warfare success by providing a broad array of environmental knowledge, giving warfighters tactical advantages in the forward battlespace. Environmental expertise in the highly-dynamic littoral and riverine environments are especially crucial to Special Forces who are often leading the fight in the global war on terrorism in remote regions of the world.

Naval Special Forces are playing a prominent role in military operations in Afghanistan and Iraq. The environmental information and expertise provided by Naval Oceanography is an integral part of the mission planning and execution process. Near real time intelligence allows NSW forces to use the environment for optimum effectiveness - enabling them to accomplish missions safer and more efficiently while providing critical go/no go recommendations.

<u>Environmental Factors</u>.

Because Naval Special Forces often operate in near-shore, highly-dynamic areas, there are numerous environmental factors that impact mission accomplishment. These include: surf conditions; tides; currents; sea and swell heights; bathymetry; sea temperature; visibility; sediment characteristics; weather conditions; hazardous marine life; and lunar illumination.

<u>Resources and Skills</u>.

Naval Meteorology and Oceanography Command resources and skills that contribute to Naval Special Warfare include:

• Data collection from a variety of sources and sensors, both on-scene and remote.

• Computing power of the Major Shared Resource Center and high-speed transmissions that deliver complex models and data to warfighters real-time.

• Tactical decision aids, satellite imagery with overlays, global and tactical level models and riverine models to improve decision-making of warfighting commanders.

• Global to tactical scale predictions of tide, surf, and current conditions that characterize the battlespace.

• Personnel with scientific expertise and data and imagery analysis skills providing direct support to the NSW Mission Support Center and NSW commanders.

• Reach back cells that work with on scene personnel to refine data, provide expert analysis and deliver products to warfighters.

• AUVs, UUVs, towed sensors and gliders that can collect data in hard to access and denied areas providing intelligence to NSW warfighters over extended periods of time.

• Versatile survey ships, HSLs, aircraft, buoys and other data collection platforms deployable around the world.

MINE WARFARE

Environmental conditions strongly impact mining and mine countermeasures operations. All aspects of mine warfare, from mine laying to mine hunting and mine sweeping operations are significantly affected by environmental conditions, especially in coastal regions where temporal and spatial variability of the environment are the greatest. Knowledge of the littoral battlespace is necessary for successful mission planning of mine warfare sensors and timely execution of tactics to support mining operations. The Naval Meteorology and Oceanography Command provides ongoing support for the Navy's Mine Warfare forces to neutralize threats and to allow for assured access of maritime assets in these strategic regions in interests.

The Naval Oceanographic Office's (NAVOCEANO) bottom mapping and imaging information, oceanographic models, weather forecasts, warfare support teams and mine warfare environmental databases play a vital role in eliminating mine hazards. During Operation Iraqi Freedom environmental data collected from mine countermeasures vessels, survey ships, tactical aircraft, buoys and satellites were critical in developing realistic mine clearance timelines which expedited the clearance of waterways leading to Iraqi ports.

Mine Warfare efforts are a primary focus of the Meteorology and Oceanography Command. Key aspects of this command-wide focus are:

• Oceanographic Expertise. NAVOCEANO scientists are continually developing advanced methods to provide near real-time engagement to the warfighter. NAVOCEANO's scientific expertise, modeling and image analysis tools, on-scene participation and the computing power of the Major Shared Resource Center provide a major contribution to in-theater mine warfare planning and operations.

• Mobile Mine Warfare Teams (MMTs). Specially trained environmental teams from Oceanography community are deployed on vessels in-theater to provide analysis of the meteorological, oceanographic and geologic conditions in the battlespace. They also contribute weather forecasts, interpret bottom-mapping side scan sonar imagery, analyze water properties, bathymetry, tides and currents and provide timely and expert advice to Mine Warfare commanders on the optimization of mine warfare sensors and weapon systems.

Important Oceanographic contributions to Mine Warfare include:

• Mine Warfare Environmental Decision Aids Library (MEDAL). NAVOCEANO's databases are an integral component to the mine warfare tactical decision aid, MEDAL. These databases incorporate in-situ data from the battlespace with existing information to help mine warfare forces effectively plan and conduct operations.

• Weather Forecasts. Oceanography community personnel provide near real-time weather forecasts to assist mine warfare commanders determine mine countermeasure methods to employ and to provide early warning of severe weather that could affect the performance of Naval personnel and assets.

• Bottom Mapping. Oceanography personnel interpret acoustic imagery acquired from tactical units and Underwater Unmanned Vehicles (UUVs) in-theater and/or transmitted to NAVOCEANO where it is assimilated with historic data to provide near real-time description of the seafloor, including seafloor characteristics, water depths, and image mosaics of the seafloor. These data assist mine warfare units determine mine clearance rates and distinguish between mines, other man-made objects and natural features.

• Tides, Currents, Optics and Salinity. Oceanographic experts from the MMTs supply warfighters with accurate tidal, current and salinity data during mine countermeasure operations. This information is crucial in determining deployment windows for UUVs, man/mammal diving operations and for determining sensor performance.

INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE (ISR)

The Naval Meteorology and Oceanography Command collects and disseminates environmental data providing direct support to the Intelligence Community and warfighters, such as special operations forces and expeditionary strike groups.

The command's data collection capabilities are far-reaching - collection platforms, such as ships, buoys, satellites, gliders, UAVs and AUVs can retrieve ISR data worldwide, even in remote and denied areas.

Naval Meteorology and Oceanography Command contributions to the Intelligence, Surveillance and Reconnaissance Community:

• Meso- and micro-scale oceanography and meteorology.

• Long-range forecasting of oceanographic conditions critical to the Intelligence Community.

• Collection and analysis of environmental data that is an important part of Intelligence Preparation of the Battlespace (IPB).

• Target Area METOC (TAM) analysis.

• Better characterization of littoral ocean areas and special operation and expeditionary warfare support through Surf Eagle, which processes intelligence data to produce materials tailored for the warfighter.

• Comprehensive network of sensors for collecting data from all areas of the world - from the oceans to atmosphere. Collection platforms include AUVs, UUVs, towed sensors, gliders, survey ships, launches, buoys and satellites.

• Computing power, models and high-quality imagery for integration and real-time dissemination of ISR to Intelligence Community and warfighter commands.

• Personnel deployed in-theater or remotely to collect, process, analyze and interpret intelligence data in coordination with Intelligence Community.

Figure 3-DOD-12. A Landing Craft Utility (LCU) approaches the well deck of the amphibious assault ship USS TARAWA (LHA 1) while the Chilean Leander-class frigate CS LYNCH (PFG 07) operates in the waters astern of the ship during the Rim of the Pacific (RIMPAC) naval exercise last year.

FLEET OPERATIONS

The Naval Meteorology and Oceanography Command is actively engaged with Fleet forces to provide valuable environmental knowledge to aid warfighter decision-making. Skilled and combat-certified personnel are integrated with the Fleet, where they provide in situ observations, run tactical decision aids and interpret environmental data to provide decision support to fleet commanders.

The onboard personnel work with reachback cells, manned with subject matter experts, to analyze and forecast environmental conditions from launch point to target to determine optimum fleet maneuvers, ingress and egress routes, amphibious landing points and times, flight operations, weapons load outs and target selection.

Major contributions to Fleet Operations, Expeditionary Warfare and Strike Warfare include:

- Collecting, processing, interpreting and delivering environmental data coming from multiple sources.
- Characterizing the battlespace from the atmosphere, to the deep oceans, to the shore.
- Personnel that are warfare-qualified meteorology and oceanography specialists deployed on vessels to support planning and operations.
- Reachback teams that work with onboard personnel to refine data, develop models, conduct forecast analyses and deliver high-quality information to fleet commands.
- Supercomputing capabilities, satellites, and high-bandwidth data transfers that quickly process and deliver information to key decision-makers.
- Battlespace preparation in highly variable littoral regions where factors such as tides, surf, currents and obstructions can have significant affects on fleet objectives.
- Tactical decision aids for optimizing impacts of the environment on specific platforms, sensors and weapons.
- Decision aid libraries, targeting models, radar models and databases.
- Support for Ship to Objective Maneuvers (STOM).

Each Strike Group will retain a highly trained cadre of meteorologists and oceanographers who forecast for the 4.5 acres of US sovereign territory that moves freely in any ocean, at any-time, around the globe; in addition to flight deck weather, they forecast the target area METOC which varies greatly considering the tremendous reach of Naval Aviation along the world's dynamic coastlines.

NAVIGATION

The Naval Oceanography Program is effectively aligned to provide comprehensive oceanographic and navigation knowledge to warfighters. On-scene and reach back personnel, high-tech surveying capabilities, complex models and high-speed data transmissions form a flexible network of near real-time support for navigation. Whether it's assisting mine detection and clearance, ensuring safe passage for submarines and surface ships, or providing special operations forces with advantages in the forward battlespace, Navy Oceanography is engaged to efficiently collect, understand, and apply navigation information to effect advantageous outcomes across strategic, operational, and tactical scales of naval warfare.

Key components of Navy Oceanography's success are:

- Knowledgeable Personnel. Littoral Survey Teams, comprised of military and civilian oceanographers, are deployed globally aboard T-AGS 60 ships and various other platforms to provide quick-response navigation-quality surveys. These teams work in coordination with reach back cells and embedded personnel to deliver environmental information to decision-makers.
- Airborne LIDAR Bathymetry. Using airborne laser bathymetry, Navy Oceanography can provide navigation-quality charts for large areas of coastline. These rapid-response surveys are important for warfighter planning and operations in littoral regions, especially where knowledge is limited or non-existent. The Navy's airborne charting and mapping system combines hydrographic and topographic data with digital imagery to produce more complete characterizations of littoral regions for improved coastal navigation.
- Autonomous Underwater Vehicles (AUVs). The Subsurface Autonomous Mapping System (SAMS) and Seahorse are Navy Oceanography's two programmable, redirectable, free-swimming AUVs. SAMS can conduct physical oceanographic data collection or side-scan sonar bottom-mapping surveys. It has full ocean depth capabilities and can collect 10-12 hours of side-scan data for 40 nautical miles, or up to 16 hours of oceanographic data over 65 nautical miles. The Seahorse AUV is designed to collect high-quality, precision located environmental data from littoral regions. It is capable of pre-programmed independent operations over 72 hours, covering 300 nautical miles.
- Fleet of Multi-purpose Survey Ships. Navy's fleet of 7 survey ships and hydrographic survey launches are deployed around the world to make in situ observations and work with reach back personnel to provide near-real-time support for tactical navigation.
- Navigation and Oceanographic Products. These include: High-resolution bathymetry; navigation-quality charting (for digital or paper products); bathymetric databases; gravity and bathymetry surveys at sea to support SSBN operations; surveys to locate hazards and determine physical bottom conditions; surveys of harbors and approaches.

PRECISE TIME AND ASTROMETRY

The U.S. Navy and Department of Defense require precise time and astrometry for communications, weapons targeting, and precision navigation. The United States Naval Observatory (USNO) is the sole provider to the defense community of this information, which is vital to modern warfare. Key support areas are:

• Time. USNO is the official source of time for the Department of Defense and Navy. It determines, maintains, and disseminates precise time and time interval reference values, ensures uniformity, provides timing data for navigation, precise positioning and C3, and maintains the Master Clock. An active research program to develop even more precise clock systems ensures that USNO will be able to continue to meet the most stringent timing requirements.

• Astrometry. USNO is a world-recognized leader in astrometry. The Astrometry Department determines fundamental positions, motions and distances of celestial objects and ascertains the real-time relative positions of these objects to establish reference frames in the sky. Astrometry is required by the Navy and the Department of Defense for navigation systems, precise positioning, and communications.

• Earth Orientation. USNO provides real-time data about the Earth's orientation and rotation, which are necessary for a variety of high-precision applications, both military and civilian. Earth orientation and rotation parameters impact navigation, precise positioning, astronomy, geodesy, communications, and time-keeping.

Impact on warfighter operations:

• Precise timing and Earth orientation parameters are key enablers for precision strike. Accurate and precise parameters are necessary for the Global Positioning System (GPS), which is used for navigation and weapons systems guidance.

• Precise atomic clocks are used as a time standard for satellites and other communications platforms.

• Precise timing is required for communications in network-centric warfare ensuring interoperability of warfighter support systems, such as tactical data links, Global Information Grid (GIG), FORCEnet synchronization, ISR Battle management, and other C4I systems.

• Astrometry is used as reference for guidance systems and to navigate and orient space-based platforms.

The defense, scientific, commercial, and civilian communities use USNO astronomical catalogs and expertise.

AVIATION OPERATIONS

A key task of the Naval Meteorology and Oceanography Command is to support Naval aviation around the world, with a particular emphasis on mission accomplishment and safety of flight. Meteorologists analyze current environmental conditions and computer models to provide forecasts that enable safe flight operations, provide optimum flight routing, and meet tactical objectives 24 hours a day, 7 days a week. These forecasts are essential to protect lives and property of the Navy and Department of Defense and result in mission accomplishment for the "warfighter." An accurate forecast is often the critical factor in mission success. Routine weather conditions such as cloud cover, dust, and precipitation often have major impacts on the type, effectiveness, and delivery tactics for many of today's sophisticated weapons.

Highly trained meteorologists assigned to globally dispersed activities provide:

• Flight Weather Briefings (DD 175-1).

• Horizontal Weather Depictions (HWD)

• Local area and point weather warnings for Navy airfields.

• Terminal Aerodrome Forecasts (TAF) disseminated every 6 hours.

• In-theater analysis, forecasts, advisories for aircraft.

Several of the state of the art systems used include:

• Optimum Path Aircraft Routing System (OPARS). A computerized flight planning system for determining the most fuel-efficient altitude and flight path that saves millions of dollars a year on fuel costs.

Leading Environmental Analysis and Display System (LEADS) and Navy Integrated Tactical Environmental Subsystem (NITES) Aviation Forecasting Systems. Primary display, analysis, and production systems used by our forecasters.

• Automated Surface Observing System (ASOS) and Remote Automated Weather System (RAWS). Primary airfield environmental observing systems.

• Naval Flight Weather Briefer (NFWB). An automated web-based system used to request, produce and disseminate flight weather briefings.

Figure 3-DOD-13. Navy Mobile Environmental Team (MET) Leader experiences a dust storm at sea aboard the USS GUNSTON HALL (LSD 44).

MARITIME OPERATIONS

The Naval Meteorology and Oceanography Command provides timely and accurate weather and ocean products to ensure safe and efficient ship operations. Key components of Maritime Operations mission are ship routing, forecasts and warnings and support for ice operations.

Significant contributions to maritime safety and efficiency include:

• Optimum Track Ship Routing (OTSR). OTSR is an enroute weather forecasting service to support trans-oceanic transits and coastal operations of Navy and naval support ships. Meteorology and oceanography personnel advise Commanding Officers and Ship Masters at sea, providing weather advisories and storm evasion recommendations to avoid hazardous weather. OTSR services also include sortie recommendations for potentially damaging weather conditions in port. Additionally, OTSR provides climatologic outlooks for preliminary transit and mission planning.

• Delivery of tropical cyclone forecasts, warnings and other products. Established by the U.S. Pacific Command and jointly manned with U.S. Air Force personnel, the Joint Typhoon Warning Center (JTWC) located in Pearl Harbor Hawaii is an internationally recognized tropical cyclone forecasting agency.

• Ship weather forecasts (WEAX).

• Aviation weather forecasts for ship-based helicopters (AVWX).

• High wind and seas warnings, special weather advisories and local area warnings.

• Ice analysis and forecasting by the National Ice Center, a joint operation of the Naval Ice Center, U.S. Coast Guard and NOAA.

• Operational Weather Briefs for other Maritime Operations to include Navy and U.S. Coast Guard Search and Rescue (SAR).

• Joint Operational Area Forecasts (JOAF) for Commanders operating in Littoral regions.

UNITED STATES MARINE CORPS (USMC)

The mission of the Marine Corps METOC Service is to provide meteorological, oceanographic, and space environmental information, products, and services required supporting Marine Corps and other military operations. The Marine Corps METOC support infrastructure is designed to readily deploy and operate in austere expeditionary environments. It is capable of providing sustained, comprehensive, and relevant METOC support to all elements of a Marine Air Ground Task Force (MAGTF), as well as bases and stations of the supporting establishment.

<u>Organization</u>

The Deputy Commandant for Aviation, Headquarters United States Marine Corps (Code ASL-37), is the cognizant office for Marine Corps METOC support and requirements. The Marine Corps METOC organization consists of two operational chains-of-command, one for supporting establishment METOC units and the other for the Fleet Marine Force (FMF).

Supporting establishment METOC units are located worldwide at Marine Corp Air Stations (MCAS) and Facilities (MCAF). These activities are manned and equipped to provide direct aviation METOC support and services to host and tenant units at nine major air stations in the continental United States, one in Hawaii, and two in Japan.

Within the FMF, Marines deploy and employ as scalable, tailorable, combined-arms teams known as Marine Air Ground Task Forces. There are three sizes of MAGTFs. From smallest to largest, they are: Marine Expeditionary Unit (MEU), Marine Expeditionary Brigade (MEB), and Marine Expeditionary Force (MEF). Additionally, Special Purpose MAGTFs (SPMAGTFs) may be formed to support operationally unique situations and/or requirements. All MAGTFs, regardless of size, share four organizational elements that vary in size and composition according to the mission: Command Element (CE), Ground Combat Element (GCE), Aviation Combat Element (ACE), and Combat Service Support Element (CSSE).

FMF METOC activities are organized, trained, and equipped to provide tailored support, products, and services to all combat elements of the MAGTF. METOC support is focused towards impacts on Expeditionary Maneuver Warfare (EMW) operations, particularly Operational Maneuver from the Sea (OMFTS). FMF METOC activities are fully interoperable within joint force operations as part of a service or functional component command. When directed to stand-up as part of a Joint Task Force Headquarters (JTF HQ), they are capable of planning, coordinating, and leading joint METOC operations. Marine METOC forces can rapidly transition from pre-crisis state to full operational capability in a distant theater to provide on-scene support to MAGTF, combined, joint, allied, and coalition operations and other military operations as may be directed.

FMF METOC assets are permanently assigned to Marine Expeditionary Force Headquarters (MEF HQ), Intelligence Battalions, Marine Wing Support Groups (MWSGs), and Marine Wing Support Squadrons (MWSSs). There are three Marine Expeditionary Forces strategically positioned for global response. I MEF, based in southern California and III MEF, forward based in Okinawa, mainland Japan, and Hawaii fall under the control of the Commander, Marine Forces Pacific. II MEF, located at bases in North and South Carolina, falls under the command of the Commander, Marine Forces Atlantic. MEF METOC personnel serve as special staff to the Commanding General (CG)

Figure 3-DOD-14. The transportable Marine Corps Meteorological Mobile Facility Replacement (METMF(R)) houses meteorological support equipment for a Marine Air Ground Task Force (MAGTF) established at an expeditionary airfield.

and are under the direction and cognizance of the G-2 (Intelligence) Division.

The three Intelligence Battalions in the Marine Corps are co-located with respective Marine Expeditionary Force Headquarters. These battalions directly support the MEF G-2 and serve as MAGTF intelligence centers during operations. METOC is a vital part of the intelligence estimate and is an essential element that supports the Marine Corps Rapid Response Planning Process. METOC personnel assigned to these commands provide expertise, products, and services that directly support the Intelligence Preparation of the Battlespace (IPB) process by helping intelligence analysts to effectively evaluate, integrate, and synchronize METOC effects for both enemy and friendly courses of action.

Marine Aircraft Wings (MAWs) conduct the complete range of air operations in support of the MEF, to include anti-air warfare, offensive air support, assault support, aerial reconnaissance, electronic warfare, and control of aircraft and missiles. The MAW serves as the principle headquarters for the ACE. Most of the MAGTF's METOC support assets reside within the MAW, specifically at the MWSG and its subordinate MWSSs. These assets are organized, structured, and capable of supporting a variety of MAGTF and ACE-specific operations as defined by the size, scope, and mission requirements. Dedicated METOC support is available for all MAGTF elements from within the MAW/ACE.

<u>METOC Support Capabilities</u>

Meteorological Mobile Facility-Replacement (MetMF(R)) - The highest level of METOC support to the MAGTF and ACE-specific operations is the deployment of the MetMF(R). The MetMF(R) provides a METOC support capability similar to that found in garrison METOC facilities, is normally deployed as part of MWSS to a Forward Operating Base (FOB), and is the only realistic option for large-scale MAGTF operations. Once established ashore, the MWSS may detach small METOC support teams with portable ancillary equipment to a forward base in support of ACE units that are separated from the main airbase. This redeployment also provides the MetMF(R) with a forward data collection capability that significantly enhances METOC situational awareness and overall support efforts to the entire MAGTF. With appropriate service personnel augmentation, the MetMF(R) is also capable of serving as host for an in-theater Joint METOC Forecasting Unit (JMFU) during joint operations and exercises.

METOC Support Team (MST) - MSTs are task organized and equipped to provide a limited level of METOC support to combat elements other than the ACE (e.g. CE, GCE, and CSSE) and are assigned to support MEU operations. It is capable of rapidly deploying as part of a first-in level of METOC support response to a crisis and can be easily integrated into an Air Contingency MAGTF (ACM). Additionally, the MST can be assigned to augment a JMFU during joint operations.

Each MWSS within the MAW is structured and organized to provide one MST that consist of one METOC officer, two forecasters, and two observers. When deployed, the MST will normally be assigned to the G/S-2 (Intelligence) division/section of the supported combat element or MEU. The MST deploys with rugged, ancillary environmental collection and data processing equipment. During operations they organically collect METOC products, data, and information from the nearest deployed MetMF(R), Navy METOC OA Division afloat, host nation or other METOC support organizations and agencies to satisfy METOC information requirements.

<u>Specialized METOC Support</u>

The Marine Corps' Chemical Biological Incident Response Force (CBIRF) was established in 1996 as a result of

Figure 3-DOD-15. CH-53 Sea Stallions from Marine Heavy Helicopter Squadron 769 set course for their next destination after receiving fuel from Marine Wing Support Squadron 473 at Forward Operating Base Salerno, Afghanistan.

Presidential Decision Directive (PDD) 39 to manage the consequences of Nuclear, Biological, and Chemical (NBC) materials or weapons used by terrorists. This national level asset is part of the re-activated 4th Marine Expeditionary Brigade - Anti-Terrorism (MEB-AT) located at Indian Head, Maryland. It is comprised of specially trained and equipped Navy, Marine, and civilian personnel who can rapidly be forward deployed and/or respond to a credible threat of a Chemical, Biological, Radiological, Nuclear, or High Yield Explosive (CBRNE) incident in order to assist local, state, or Federal agencies and designated Unified Combatant Commanders in the conduct of consequence management operations. Within the S-2 (Intelligence) section, permanently assigned METOC forecasters provide specialized NBC dispersion forecast products and services that aid mission accomplishment of this organization.

METOC Support Doctrine

Marine Corps Warfighting Publication (MCWP) 3-35.7, MAGTF Meteorological and Oceanographic Support, provides more detailed information about the Marine Corps METOC Service. An electronic copy is available for viewing and downloading from the Marine Corps Combat Development Command (MCCDC), Doctrine Division web site at https://www.doctrine.quantico.usmc.mil/.

ARMY TRANSFORMATION

The United States Army is undergoing a historical transformation from a division-centered Army poised to fight a cold war, to a smaller, brigade based Army ready to engage in any conflict around the globe. Not only is today's threat to our security more complex and more unpredictable than that of the past, but it is one that could also arise anywhere in the world. Speaking to this threat, the 2005 Army Posture Statement addresses four major areas:

- restructure from a division-based to a brigade based force,
- rebalance the active and reserve forces,
- stabilize the force, and
- reengineer the Army's business processes to facilitate the implementation of the first three areas.

Modularity (transforming from a division-centric to a brigade-centric force) is the most visible aspect of Army transformation to the weather community at large. Modular units will be more compact and more deployable than the current division sized units. Implementing a modular force will provide the Army more time to train, provide predictable deployment schedules, and will provide the continuous supply of landpower required by the Combatant Commanders and civil authorities. The force, above the brigade level, will be supported by similarly modular supporting brigades that provide aviation, fires, logistics, and other support.

Transformation to a modular Army dictates changes in both weather support requirements and how weather is provided to units of action. Resized weather teams will rely more on "reach back" capabilities to obtain pertinent meteorological data. The Army and Air Force are working together to determine the optimal weather team sizing, equipment and communications capabilities required to support these new Brigade Combat Teams.

OPERATIONAL EQUIPMENT AND SUPPORT MISSIONS

Although it is transforming to a modular force, the existing weather support structure within the U.S. Army is a mix of Army and USAF personnel and equipment according to Army-Air Force agreement (Army Regulation (AR) 115-10/Air Force Joint Instruction (AFJI) 15-157, Weather Support for the U.S. Army, 30 June 1996). This joint regulation describes the Service responsibilities and those of Major Army Commands (MACOMs) within the Army for providing weather support. The U.S. Army provides direct weather support to two Army missions: upper air observations for Field Artillery fire support, and limited surface weather observations to support Army weapon systems forward of Division tactical operations centers. Air Force (AF) Major Commands (MAJCOMs) provide operational weather services to war fighting MACOMs in combat, contingencies, and peacetime training. U.S. Army Forces Command (FORSCOM), U.S. Army Europe (USAREUR), U.S. Army Pacific (USARPAC), U.S. Army Special Operations Command (USASOC), Eighth U.S. Army (EUSA), and U.S. Army Training and Doctrine Command (TRADOC) have AF Weather personnel providing daily installation and tactical weather support. Army Artillery Meteorological (ARTYMET) Crews provide direct upper air observation support to artillery units in the same MACOMs. During peacetime training and activation, the Air National Guard (ANG) provides AF operational weather support to the U.S. Army Reserve (USAR) and Army National Guard (ARNG), collectively designated the Reserve Component (RC). In addition, during exercises and contingencies, the ANG may augment the active Army Battlefield Weather forces.

The Army also provides the operational weather support to Army Research Development, Test and Evaluation (RDTE) ranges, centers, and other research facilities using the Developmental Test Command's (DTC) Meteorological Teams (MET Teams) and U.S. Army Space and Missile Defense Command (SMDC) contractors. DTC operational support is established under Army Test and Evaluation Command. SMDC provides weather support to the Ronald Reagan Ballistic Missile Defense Test Site at Kwajalein Atoll through a Meteorological Environmental Test Support contractor.

The Army provides the tactical field and communications equipment to USAF weather forces for tactical operations. The Integrated Meteorological System (IMETS) is the U.S. Army's tactical weather communication, intelligence, and information system providing digital weather support to the commanders and staffs of tactical units, from Echelons Above Corps (EAC) to aviation battalions. The Communications and Electronics Command (CECOM) and Army Research Laboratory (ARL) provide fielding and technical support to Program Director (PD), IMETS and to Field Artillery meteorology programs.

ARTYMET Crews are assigned to Artillery units at Division level, to Field Artillery Brigades, and to Separate Brigades with a direct support Artillery Battalion. Army soldiers regularly take tactical upper air observations to support Field Artillery units during tactical training exercises, at permanent Army Artillery Ranges, or during the full range of combat missions. ARTYMET Crews also take limited surface observations at tactical locations on an "as needed" basis to support artillery operational requirements.

ARTYMET Crews in the Active Component (AC) and RC sections currently use the Meteorological Measuring Set (MMS), AN/TMQ-41, to take upper air observations during tactical operations. It is a mobile, upper air sounding system mounted on a High Mobility Multipurpose Wheeled Vehicle (HMMWV). The MMS provides upper air data to the Field Artillery Tactical Data System for use in adjusting artillery fire (Figure 3-DOD-16), to USAF BWTs, and to the Chemical Officer for use in smoke and in Nuclear, Biological and Chemical (NBC) defense operations. The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK develops requirement documents and is the combat and training developer for meteorological equipment used for Field Artillery support.

Figure 3-DOD-16. Accurate wind profiles are essential for the Artillery to engage their targets. Photo courtesy U.S. Army.

Headquarters, Department of the Army, Office of the Deputy Chief of Staff, G-2, is responsible for Army weather support policy. The Office of the Deputy Chief of Staff, G-3, is responsible for validating and prioritizing weather support requirements and programs to meet Army requirements. In addition, an Army Intelligence Officer at the Air Force Weather Agency (AFWA) at Offutt AFB, NE, serves as a consultant to AFWA for Army weather requirements.

ARMY OPERATIONAL SUPPORT PROVIDED BY THE AIR FORCE

Under AR 115-10/AFJI 15-157, the AF provides the Army with the necessary manpower and unique tactical and fixed weather equipment to meet Army tactical and garrison active component (AC) and reserve component (RC) support requirements. Army support manpower requirements are sourced from AF active, reserve, and ANG weather forces. While direct support of the Field Artillery remains an Army responsibility, and is supported by Army ARTYMET teams, AF Battlefield Weather forces provide supplemental information to artillery crews in contingencies for areas beyond direct ARTYMET observation capabilities. The AF assigns AF weather personnel to the war fighting MACOMs at theater, corps, division, armored cavalry regiments, aviation brigades, separate brigades, and Special Forces groups/ranger regiments to provide direct, on site weather support. AF operational weather squadrons (OWSs) and post-level weather organizations provide garrison and tactical weather warning, observing, forecasting, special support, and staff weather officer (SWO) services to Combat, Combat Support, and Combat Service Support units throughout the peacetime/war continuum (Figure 3-DOD-17). Peacetime garrison activities include supporting flying operations at Army Airfields and severe weather watch, warning, and advisory services for aircraft and post resource protection. Per Army-AF agreement, the AF is responsible for installation, operation, and maintenance of standard AF meteorological and observing equipment at Army Airfields. Tactically, the Army is responsible for vehicles, tactical communications, and weather effects criteria. The Army's IMETS is fielded for these purposes and is operated by AFW personnel. The Army also maintains IMETS hardware and software, with the AF maintaining AF software that performs meteorological functions within IMETS. IMETS uses AF meteorological software, but IMETS is hosted on an Army vehicle, uses Army tactical communications and Army weather effects software. IMETS baseline software is hosted on Army Common Hardware and is Defense Information Infrastructure Common Operating Environment (DIICOE) and Joint Technical Architecture - Army (JTA-A) compliant. The Army provides other tactical equipment to AF BWTs through an Army Table of Organizations and Equipment (TOE). The following paragraphs describe weather activities within Army MACOMs.

EIGHTH U.S. ARMY

Eighth United States Army (8th U.S. Army) requires and uses Army resources to conduct two major meteorological services in direct support of Army operations: collecting and disseminating upper air observations for artillery support, and collecting and disseminating limited surface weather observations to support all tactical

Figure 3-DOD-17. Reliable wind forecasts are necessary to ensure safety during airborne operations.(Photo courtesy U.S. Army).

units and operations.

Two ARTYMET crews with the Second Infantry Division use AN/TMQ-41 Meteorological Measuring Sets to collect upper air observations for direct use by field artillery units. ARTYMET crews also collect routine (usually daily) upper air observations for training; these observations are typically fed into the global weather database.

Additionally, under the Forward Area Limited Observing Program (FALOP), Army personnel use tactical weather kits to collect limited weather observations in data sparse, forward areas. Observations are typically collected by intelligence personnel at brigade and battalion tactical operations centers (TOC) during contingencies or exercises and, in turn, are disseminated to and through USAF weather organizations supporting Army air, ground, or special operations.

USAF weather personnel assigned to the 607th Weather Squadron (607 WS) provide fixed and tactical weather support to 8th U.S. Army units. The 607 WS provides garrison and tactical weather observing, advisory, mission forecast, special support, and staff weather officer (SWO) services during contingency, exercise, and armistice operations. 607 WS organizations provide direct, on-site support at eight 8th U.S. Army installations and at deployed locations. Support is focused on air, ground, special operations, and other combat and combat support missions. In late FY 2002, 607 WS transferred armistice theater forecast responsibility to the 20th Operational Weather Squadron (20 OWS) at Yokota Air Force Base in Japan. The 8th U.S. Army Battlefield Weather forces are primarily responsible for providing observations and tailored mission execution forecasts based on 20 OWS overarching forecasts. Lead METOC support during exercises and contingencies remains with the 607 WS detachment supporting USFK/CFC through the Combined METOC Forecast Unit, in close coordination with the 20th OWS. In FY 2006, 607 WS provides 76 trained weather personnel and requires fixed and tactical weather sensing, data processing, and communications equipment. 8th U.S. Army provides USAF weather units needed garrison and tactical communications, tactical vehicles, MTOE and CTA equipment, and operating funds (for expendables, maintenance, etc.) IAW AR 115-10/AFJI 15-157 (June 1996).

UNITED STATES ARMY EUROPE AND SEVENTH ARMY

United States Army Europe (USAREUR) and 7th Army require and use Army resources to provide meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations.

The Air Force's 7th Weather Squadron (7 WS) provides USAREUR/7th Army in-garrison and tactical weather intelligence and support. This includes observing services for in-garrison operations, contingency and exercise operations, SWO services, and specialized support. The United States Air Forces in Europe (USAFE) OWS at Sembach AB, Germany, provides operational-level forecast products for the European Command Area of Responsibility, to include all USAREUR units. Detachment and operating locations located at V Corps and its aviation assets, 1st Infantry Division and its aviation brigade, 1st Armored Division and its aviation brigade, Southern European Task Force, and 7th Army Training Command, as well as 7 WS supporting 7th Army, evaluate and tailor these forecast products to produce mission execution forecasts.

Figure 3-DOD-18. Weather plays an important role in day to day Army operations, such as this bridging operation in South Korea. (Photo courtesy U.S. Army)

The mission of 7 WS and its 11 detachments and operating locations is to provide weather operations support to the Army's garrison and war operations. Additionally, 7 WS conducts weather operations and planning to meet future Army transformation and modularity initiatives. 7 WS will match the deploying weather force structure to the mission that USAREUR is called upon to execute. 7 WS will tailor its assigned weather forces to meet requirements of the new USAREUR structure and utilize "reachback" capabilities to the maximum extent possible to minimize the fielded footprint without compromising weather operations.

Seven IMETS have been fielded within USAREUR (V Corps, two divisions and their aviation brigades, and two separate brigades. The IMETS is geared to interface as a module of the Army Battlespace Control System (ABCS) to inject weather decision products into the common battle picture for Army commanders. IMETS Light was fielded in Oct FY 2005 to Aviation Brigade weather teams, and an upgrade (version 6.4) is expected to be fielded in FY 2006. This version will improve standard data ingest capability and increase the value of weather information available in ABCS.

USAREUR provides supporting USAF weather forces with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operating funds (expendables, maintenance, etc.). Four ARTYMET sections collect upper air observations for direct use by field artillery units. The Forward Areal Limited Observing Program consists of Army personnel taking limited observations at forward areas in the battlespace. USAREUR G2 has funded purchases of handheld weather sensors for use in FALOP training and equipping Army teams to provide limited weather data at Forward Operating Bases and Forward Arming and Refueling Points. These additional "eyes forward" provide critical information that benefits flight safety as well as the theater weather sensing strategy without having to forward deploy more people to austere locations.

U.S. ARMY SPECIAL OPERATIONS COMMAND (USASOC)

Weather support to USASOC allows commanders to improve efficiency, effectiveness and safety of operations for USASOC units. The 10th Combat Weather Squadron (10 CWS) personnel use tactical weather kits to collect limited weather data and provide limited scope meteorological observations from permissive, semi-permissive and uncertain environments in direct support of Army Special Operations Forces (ARSOF). The 10 CWS Combat Weathermen collect weather data at the deployed team level. These observations are passed to operating bases for use by ARSOF commanders and staff, as well as Air Force Special Operations Command (AFSOC) and Air National Guard (ANG) weather personnel. AFSOC personnel providing direct support to USASOC units are assigned to the 10 CWS, OL-A, 320 Special Tactics Squadron (STS), OL-A 321 STS, and OL-A 353 Special Operations Group. ANG personnel providing direct support to USASOC when activated are assigned to the 107th Weather Flight (Michigan ANG), 146th Weather Flight (Pennsylvania ANG) and 181st Weather Flight (Texas ANG). These weather flights provide garrison and tactical support to USASOC units including the United States Army Special Forces Command and the seven subordinate Special Forces Groups (SFG); the 75th Ranger Regiment, the 160th Special Operations Aviation Regiment, the United States Civil Affairs and Psychological Operations Command (USCAPOC); all SFG and regimental subordinate battalions, and two separate aviation companies. Weather support includes: climatology and solar/lunar illumination tables and studies; courses of action and mission impacts analysis; weather watch/warning services; mission execution forecasts; flight weather briefings; drop/landing zone forecasts; training to ARSOF; training of host nation and indigenous forces on conducting limited observation programs; surface, upper-air and tactical radar observations; and Foreign Internal Defense analysis, surveys and training. AFSOC Special Operations Weather Teams (SOWTs) are the DOD's sole source for high-fidelity METOC intelligence data collection from permissive, hostile, or uncertain environments. AFSOC provides staff weather support to USASOC, U.S. Army Special Forces Command (Airborne) and the U.S. Army John F. Kennedy Special Warfare Center and School.

USASOC plans and expends resources for operational and administrative support to Air Force Special Operations Command SOWTs providing meteorological service support to USASOC components. USASOC provides funding for required training beyond standard AF weather training, office and deployable automation systems and connectivity to local networks; dedicated tactical communications systems; operations and maintenance/sustainment to support USASOC requirements; funding for Temporary Duty for USASOC requirements; and some organizational clothing and individual equipment. Additionally, USASOC covers expenditures for tactical equipment items such as NBC equipment; communications; Army developed and procured meteorological equipment, power, vehicles, and life support equipment required to accomplish USASOC weather support missions; and maintenance and supplies for USASOC provided equipment. Seventeen Integrated Meteorological Systems-Light (IMETS-L) have been fielded within USASOC. IMETS-L provides a mobile automated weather data receiving, processing and dissemination system to USAF SOWTs. IMETS-L also provides digital weather support, real-time tailored weather information, forecasts, and weather effects on friendly and hostile weapons systems. USASOC also provides funding for facilities, office space, office furniture, and real property to house supporting special operations weather units, as well as secure storage of required equipment.

UNITED STATES ARMY PACIFIC (USARPAC)

United States Army Pacific (USARPAC) uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating surface weather observations to support tactical units and operations.

USARPAC provides supporting USAF forces with tactical vehicles, MTOE and Common Table of Allowances (CTA) equipment and operations and maintenance funds.

The IMETS and New Tactical Forecast System (NTFS) have been fielded within USARPAC as the primary meteorological equipment for deployed operations. The 25th Infantry Division (Light) (25ID(L)) was given two IMETS-L units ahead of schedule for its year-long deployment to Iraq. The IMETS and NTFS reachback for data via Army provided NIPRNET and SIPRNET conduits.

There are three subordinate commands within USARPAC: United States Army, Hawaii (USARHAW), United States Army, Alaska (USARAK), and United States Army, Japan (USARJ).

The 17th Operational Weather Squadron (17 OWS) provides HQ USARPAC with garrison and tactical weather warnings, forecasts, special support, and SWO services during contingencies and humanitarian operations. Additional Battlefield Weather forces aligned with U.S. Army Japan (USARJ), U.S. Army Hawaii (USARHAW) - including the 25th ID (-) -- and U.S. Army Alaska (USARAK), including 172 SIB, provide direct, on-site support at five USARPAC installations. The weather forces also deploy with their supported Army units, providing tailored battlefield observations and forecasts. AFW reengineering has reduced the requirement for forward deployed weather personnel, instead leveraging IMETS and other recently fielded technology for reachback capability. 17 OWS provides regional weather support, allowing the forward deployed forces to focus on specific area and target forecasts.

The 20th Operational Weather Squadron (20 OWS) at Yokota AB, Japan, provides operational-level forecast products for the USFJ and USFK AORs, to include all USFJ and USFK Air Force and Army units. This includes specific resource protection support (i.e. weather advisories, warnings, and watches), as well as Terminal Aerodrome Forecasts for selected units. The 20 OWS Commander serves as USFJ's Staff Weather Officer (SWO), and also serves as the USARJ SWO. Day-to-day support for Camp Zama, Japan is provided by an Operating Location (OL) under the AF 374th Operations Support Squadron at Yokota AB. The OL on-site at Camp Zama provides observational support and produces mission execution forecasts to support aviation operations.

The 11th Operational Weather Squadron (11 OWS) at Elmendorf AFB, AK, provides operational-level forecast products for the Alaskan Command AOR, to include all USARAK units. The Commander, 11 OWS, serves as the CG, USARAK's Staff Weather Officer. Additionally, 11 OWS is responsible for Terminal Aerodrome Forecasts for Fort Wainwright, along with resource protection weather support (i.e. weather advisories, warnings, and watches) for Forts Wainwright, Greely, and Richardson. The 11 OWS provides flight weather briefing support, as required, to Army, Army Reserve, and Army National

Guard aviation assets in theater. An AF Battlefield Weather personnel (3 ASOS/WE) is collocated with the 172d Infantry Brigade (Separate) (172d Stryker Brigade Combat Team (172 SBCT) at Fort Wainwright and the aviation assets of 4th Battalion, 123d Aviation Regiment. 3 ASOS/WE provides weather support for both tactical and garrison operations, observes the atmosphere and evaluates, then tailors, forecast products to produce Mission Execution Forecasts and staff briefings. After the SBCT conversion, 172 SBCT will include tactical unmanned aerial vehicles (T-UAVs), whose operators will also be receive their weather support from 3 ASOS/WE. The Alaska Army National Guard operates the airfield at Fort Richardson.

U.S. ARMY FORCES COMMAND (FORSCOM)

Weather support to the U.S. Army Forces Command (FORSCOM) is diverse and demanding. FORSCOM, the Army's largest major command, requires and uses Army resources to conduct meteorological services in direct support of Army operations. These services include collecting and disseminating upper air observations for artillery support and collecting and disseminating limited surface weather observations to support all tactical units and operations. FORSCOM consists of more than 750,000 Active Army (AA), U.S. Army Reserve (USAR) and Army National Guard (ARNG) soldiers. These soldiers account for more than 80 percent of the Army's combat power. FORSCOM trains, mobilizes, deploys, and sustains combat ready forces capable of responding rapidly to crises worldwide. The AA component of FORSCOM has nearly 200,000 soldiers. Third U.S. Army is the Army component of U.S. Central Command (USCENTCOM), which is the Joint command responsible for Southwest Asia (SWA), the Persian Gulf, and the Horn of Africa. U.S. Army South (USARSO) serves as the Army component to U.S. Southern Command (USSOUTHCOM). USARSO relocated from Fort Buchanan, Puerto Rico, to Fort Sam Houston, Texas, in CY 2003 and became a FORSCOM major subordinate command October 1st, 2003. FORSCOM also commands three Army Corps: I Corps at Fort Lewis, Washington, III Corps at Fort Hood, Texas, and XVIII Airborne Corps at Fort Bragg, North Carolina. Together they include six divisions, two armored cavalry regiments, five separate brigades and a range of other corps combat, combat support and combat service support units. Two Continental U.S. Armies (CONUSAs), First U.S. Army and Fifth U.S. Army, are responsible for training, mobilization, and deployment support to Reserve Component units in FORSCOM. Another major subordinate command to FORSCOM, the U.S. Army Reserve Command (USARC), commands all U.S. Army Reserve units in the continental United States except those assigned to Special Operations Command. FORSCOM's Army Reserve strength stands at approximately 196,000 soldiers. USARC units are part of the Federal force and make their primary contribution to FORSCOM combat power in combat support and combat service support specialties such as medical, civil affairs, transportation, maintenance and supply.

The ARNG provides FORSCOM a balanced force of 8 National Guard combat divisions, 15 enhanced separate brigades, extensive combat support, and combat service support units. The current FORSCOM ARNG strength is approximately 367,000 soldiers.

The Army is in a period of transformation, over the next several years the Army will transform from its current structure to a structure that has two higher headquarters replacing existing divisions, corps and echelons above corps. This transformation is requiring AF weather to retune its service approach to Army units in terms of manpower and functions.

Weather support to FORSCOM's AA units comes from dedicated AFW forces aligned under three Air Support Operations Groups (ASOGs) within Air Combat Command (ACC): 1 ASOG at Fort Lewis, Washington; 3 ASOG at Fort Hood, Texas; and 18 ASOG at Pope AFB, North Carolina. A weather squadron under each ASOG supports the Corps. Each Army division normally has dedicated AFW forces aligned under an Air Support Operations Squadron (ASOS) or one of the weather squadrons, at their respective installations. Corps and division weather forces are authorized personnel and equipment to support a variety of missions at the various Army echelons. Weather support at each Army echelon is provided according to Army Field Manual 34-81, and Air Force Joint Pamphlet 15-127. Currently, there are nearly 350 AFW authorizations supporting various echelons across FORSCOM. These personnel, enabled by an operational weather squadron, provide garrison and tactical weather warning, observing, mission execution forecast, special support, and SWO services during peacetime, combat, contingency, exercise, or armistice operations.

Air Combat Command (ACC) weather organizations provide direct, on-site support at 11 major Army installations, including the National Training Center at Fort Irwin, California, and the Joint Readiness Training Center at Fort Polk, Louisiana and at deployed locations. Support is focused on air, ground, special operations, and other combat and combat support missions.

FORSCOM provides supporting AFW forces with a Modified Table of Organization and Equipment (MTOE) and operating funds (expendables, maintenance, etc.). ARTYMET requirements in FORSCOM increased from 17 to 20 sections in FY 2005 due to modularity. These 6-person sections, comprised of Army weather personnel, collect upper air observations for direct use by field artillery units. Six more teams are planned to be added in FY 2006 - FY 2007.

The AF's New Tactical Forecast System (N-TFS) is the primary in-garrison and tactical weather equipment for receiving graphics and alphanumeric data. Data is received via the Very Small Aperture Terminal (VSAT), Tactical VSAT (T-VSAT), Non-Secure Internet Protocol Router Network, and Secure Internet Protocol Router Network. Nineteen IMETS and 15 IMETS-Lights, developed by the Army Research Laboratory, have been fielded within FORSCOM. FORSCOM has also fielded commercial Automated Weather Observing Systems at Yakima Training Center Washington, Fort Campbell, Kentucky, and Georgetown Bahamas.

TRAINING AND DOCTRINE COMMAND (TRADOC) PROGRAMS

Headquarters (HQ) TRADOC is responsible for development and management of weather training programs, Army and Joint weather support doctrine (concepts and field manuals), and the establishment of requirement documents for Army tactical weather support. HQ TRADOC is the approval authority for Army-AF weather doctrine, Army weather system requirements, and weather support policy. Key mission areas for the next few years will be to coordinate weather requirements to the Army's Modular Forces; help develop new weather support doctrine, concepts, and tactics, techniques, and procedures; ensure weather, weather effects to operations, and weather support processes/procedures are properly trained across the TRADOC schoolhouses.

The IMETS continues as the state of the art Army weather support system. However, over the next few years its capabilities will be consolidated into the Air Force's Joint Environmental Toolkit (JET) program. The Army will retain research and development efforts related to Army-specific weather support challenges and will be responsible for interfacing JET with Army battle command systems. Initial JET fielding is programmed to begin in FY 2006.

<u>TRADOC Schools and Battle Labs</u>:

• The U.S. Army Intelligence Center and Fort Huachuca (USAIC&FH) is the functional proponent for Army tactical weather support. USAIC&FH represents the Army warfighter by collecting weather support requirements and developing solutions to satisfy those requirements. A key component to providing weather support to the Army is IMETS, fielded by the Army and operated by AFW forces. The USAIC&FH SWO advises the Army Research Lab, USAIC&FH, and AFW on Army weather support issues and helps develop solutions to meet both active and reserve forces' weather requirements. In addition, the USAIC&FH SWO conducts and monitors weather/weather support training to Army Military Intelligence personnel and AFW personnel supporting the Army. The USAIC&FH SWO is assisted by two active duty AFW personnel that support Army concepts, architecture and requirements initiatives; one civilian contractor that manages the Battlefield Weather course; and one Army Government Civilian that serves as the assistant TRADOC Systems Manager for IMETS. This year the USAIC&FH Weather Team drafted the Statement of Requirements (SOR) for Weather Support to the Army's Modular Forces, and they continued to update and expand the weather effects critical threshold value database to be incorporated into the Integrated Weather Effects Decision Aid (IWEDA). The USAIC&FH SWO also updated the IMETS requirements documents as the program went through several acquisition milestones culminating in Joint Requirements Oversight Council (JROC) approval. In FY 2008, the IMETS Program Office will move under the Program Executive Office - Intelligence, Electronic Warfare & Sensors (PEO-IEW&S) as part of the Distributed Common Ground System-Army (DCGS-A) program.

• The USAF SWO at the Army's Combined Arms Center (CAC) is the primary overseer of the Tables of Organization and Equipment (TOE) for BW forces supporting Army operations. The CAC SWO also arranges

Figure 3-DOD-19. The Integrated Meteorological System - Light (IMETS-L). (Photo courtesy U.S. Army.)

for or provides environmental data, concepts of operation, and weather subject matter expertise for programs, projects, and studies conducted by the TRADOC System Manager - Army Battle Command System, the Battle Command Battle Lab-Leavenworth, the Center for Army Lessons Learned, the TRADOC Assistant Deputy Chief of Staff for Intelligence -Threats, the Foreign Military Studies Office, and the TRADOC Analysis Center-Leavenworth. Other key CAC SWO tasks are to develop weather/weather effects scripts and climatology packages to support modeling and simulation efforts of the Battle Command Training Program (BCTP) and the National Simulation Center, and to provide Army weather support instruction at the Command and General Staff College (CGSC).

• The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK is the proponent for upper air meteorological support to the Army. Artillery meteorological crews, Active and Reserve, had used the AN/TMQ-50 to measure surface weather parameters. Tactical reliability issues forced an Army-wide 'STOP-USE' of the AN/TMQ-50 at the end of FY 2003. Artillery meteorological crews currently use manual surface instruments to measure surface weather conditions. The AN/TMQ 55 (TACMET) has been identified to replace the AN/TMQ 50. The AN/TMQ-41 Meteorological Measuring Set (MMS) is utilized to take upper air observations. The MMS provides weather data to the Field Artillery Tactical Data System for ballistic calculations; to USAF BWTs for weather forecasting; and to the Chemical Officer for obscurant deployment, and Nuclear, Biological, Chemical (NBC) defense operations. Active unit's MMSs will be replaced by the AN/TMQ-52 Meteorological Measuring Set Profiler (MMS-P). The MMS-P is scheduled to begin fielding in early FY 2005. The MMS-P is a suite of meteorological sensors and associated software/models which will provide the Field Artillery with current and/or expected weather conditions at a point where the weapon munitions is expected to engage a target (Target Area Met).

Figure 3-DOD-20. Meteorological Measuring Set- Profiler (MMS-P) (Photo courtesy U.S. Army.)

• The Engineer School (USAES), Fort Leonard Wood, MO coordinates weather support requirements for Terrain Analysis and Topographic Engineering. USAES develops methods of measuring and forecasting state of the ground for trafficability assessments using input weather data fields. Their mission also includes identifying, and documenting requirements to interface meteorological and engineer battlefield systems. Due to force cuts, USAES no longer has a full time civilian meteorologist in the Terrain Visualization Center, DCD, but does have an instructor at the Terrain School at Ft Belvoir to teach weather effects on cross-country mobility and engineer missions.

• The U.S. Army Aviation Center (USAAVNC) at Fort Rucker, AL incorporates weather instruction and procedures into rotary-wing training programs in their mission areas. The Center has requirements for weather observations and USAF forecast support at Cairns Army Airfield, Troy Municipal Airport (MAP), Alabama, and Andalusia MAP, Alabama. Additionally, Fort Rucker operates observing and communications equipment to relay weather intelligence and resource protection advisories to numerous Army remote training sites. Two active duty positions are allocated to provide staff support for Army aviation and aviator training weather issues in areas of curriculum, concept development and doctrine. The USAAVNC SWO also supports the U.S. Army Combat Readiness Center (formerly the U.S. Army Safety Center), Air Traffic Services Command, and other Fort Rucker tenants. Operational weather support for aircrews and resource protection are provided by contractors aligned under ACC.

Beginning in FY 2004, ACC civilianized day-to-day operational weather support to aviation operations at Fort Rucker (Cairns Army Airfield, Troy Municipal Airport, and Andalusia Municipal Airport). ACC, under the same contract, manages garrison airfield weather services (observing and/or forecasting) at Fort Belvoir, Fort Benning, Fort Knox, Fort Leonard Wood, Fort Huachuca, and Fort Sill.

ARMY NATIONAL GUARD (ARNG) ARTILLERY

In FY 2005, the Army National Guard (ARNG) downsized its Meteorological (MET) Sections assigned to artillery units at Division level, Field Artillery Brigades (DIVARTY), and in Separate Brigades to two 6-soldier teams in the DIVARTY's, except in the Light DIV where there is one team, equaling fifteen 6-soldier teams with 90 soldiers. In the ARNG "Modular Forces", there is one 6-solder team per Fires Battalion in the Brigade Combat Team (BCT), providing 34 teams with six soldiers each, for 204 soldiers. In the Fires BDE there are 3 MET teams per BDE providing 18 teams with six soldiers each, for a total of 108 soldiers. All together the ARNG has 402 soldiers authorized to Artillery Metrological Teams.

The ARTY MET sections provide upper air observations at least 39 training days each year supporting artillery live fire during Annual Training and monthly Inactive Duty Training. The ARTY MET sections support an average of 20 live fire training days and annually expend in excess of 100 balloons per section. The ARNG's ARTY MET Teams use the Meteorological Measuring Set (MMS), AN/TMQ-41A.

ARMY CORPS OF ENGINEERS CIVIL OPERATIONAL ACTIVITIES

The Corps of Engineers (COE) uses a network of about 10,850 land-based gages. About 55 percent of the sites collect meteorological data, 35 percent a combination of hydrologic and meteorological data, and 10 percent hydrologic or water quality data. The Corps funds or partially funds 58 percent (6350) of all the gages it used. Meteorological gages commonly measure precipitation and temperature as a minimum. Most sites also measure hydrological data. All data are used in the regulation of COE dams and other water projects used for flood control, navigation, hydroelectric power, irrigation, water supply, water quality, and recreation. The COE transfers funds to NOAA/National Weather Service (NWS) to collect and maintain precipitation information from 826 of meteorological sites. Similarly, COE transfers funds to the U.S. Geological Survey to maintain precipitation data collection from 460 sites, while the COE maintains the rest. Seventy-five percent of all Corps sites provide real-time data via satellite, microwaves, meterbursts, landlines, or radio. Data from COE gauging sites are available to other Federal, state and local agencies. The NWS uses 100 percent of all Corps data. Most of the data is also used by other agencies.

UNITED STATES ARMY SPACE AND MISSILE DEFENSE COMMAND (USASMDC)

The High Energy Laser Systems Test Facility (HELSTF), an USASMDC directorate located on White Sands Missile Range, is an Army element of the DOD Major Range and Test Facility Base with the mission of high-energy laser (HEL) test and evaluation for future Army and sister Service HEL weapons. In addition to HEL systems test and evaluation, extensive use has been made of on-site laser systems to perform damage and vulnerability testing on laser-hardened materials, missile and aircraft components, and assorted battlefield equipment. The atmospheric sciences/meteorological mission is to support HEL testing by providing measurements of atmospheric conditions that are extremely important to propagation of any HEL beam thru the atmosphere. Many unique meteorological instruments are maintained to support this critical data collection for HEL testing (Figure 3-DOD-21). The HELSTF meteorological team also supports critical safety analysis of atmospheric dispersion for the very toxic laser fuels used. Efforts for FY 2006 include work required to modernize the atmospheric measurements and data collection/analysis

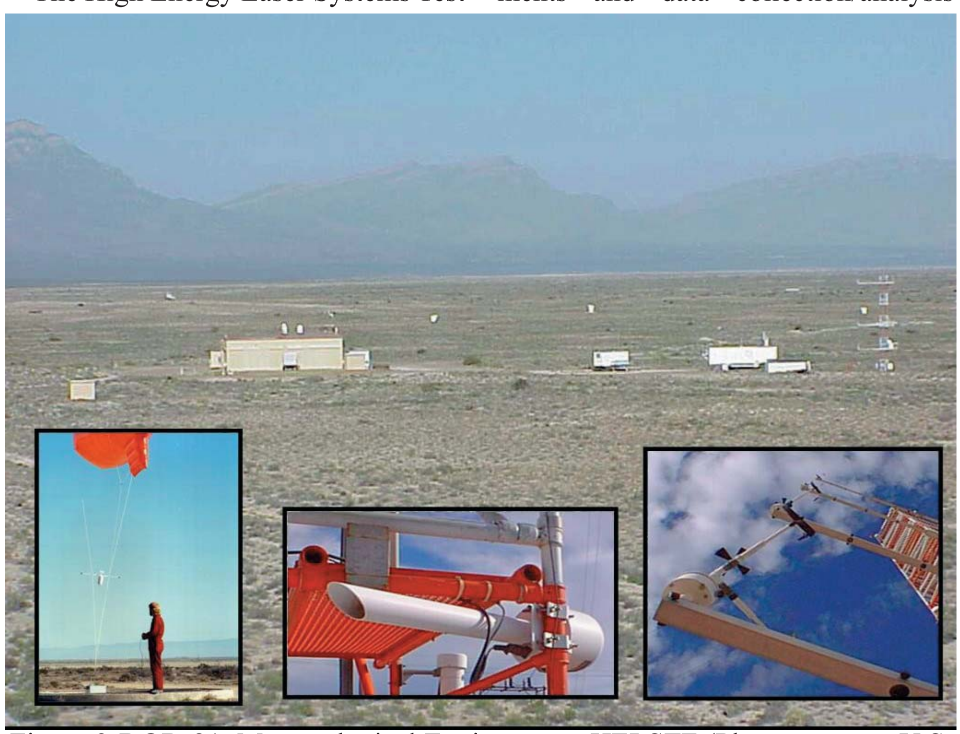


Figure 3-DOD-21. Meteorological Equipment at HELSTF (Photo courtesy U.S. Army.).

capabilities needed to support new laser testing activities.

United States Army Kwajalein Atoll (USAKA) is a subcommand of USASMDC, which provides operational support for the Ronald Reagan Ballistic Missile Defense Test Site (RTS). The RTS meteorological services (Figure 3-DOD-22) support contractor provides meteorological support for range activities including missile operations within the atoll, intra-atoll transportation (marine and aircraft), remote island missile launches including Wake Island, and emergency operations support.

Figure 7. USASMDC is responsible for meteorological support to the Ronald Reagan Ballistic Missile Defense Test Site in the remote Kwajalein Atoll. Photo courtesy U.S. Army.

A full suite of surface and upper air observing equipment is available to support of these operations. Three fixed upper air sounding systems are located on Kwajalein and Roi-Namur. Two portable upper air systems can be deployed to remote locations to provide upper air soundings. Additionally, one dual-polarized -Doppler S-band weather radar and one Doppler C-band weather radar, two DMSP/NOAA satellite receivers (one mobile) both having McIDAS display and management systems, one geostationary satellite receiver, and an intra-atoll mesonet and lightning detection network round out the sensors available to RTS forecasters. RTS, in cooperation with NASA/GSFC, continues to support global climate studies through the Tropical Rainfall Measurements Mission and the follow-on program of Global Precipitation Measurement and a smaller program of monitoring the solar-earth radiation flux for NOAA/ERL.

WEATHER SUPPORT FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDTE)

Under Army-AF agreement, the Army has responsibility for weather support for research, development, test, and evaluation (RDTE) to support Army ground combat missions as specified in AR 115-10/AFJI 15-157. The Corps of Engineers (COE), and the Army Materiel Command (AMC) are the major contributors to weather research. The Medical Research and Development Command does research related to soldiers performance in the range of weather conditions expected to be encountered in all theaters of operations. The Army Test and Evaluation Command (ATEC) is responsible for operational meteorological support to Army RDT&E.

CORPS OF ENGINEERS (COE)

The Corps of Engineers (COE) is responsible for reviewing all emerging Army systems for environmental effects, as stated in Army Regulation 70-1. The Topographic Engineering Center (TEC), and the Cold Regions Research and Engineering Laboratory (CRREL), of COE's Engineer Research and Development Center (ERDC), develop Tactical Decision Aids (TDAs) to interpret the impact of weather on terrain to enhance Army operations. TDAs are transitioned to the Digital Topographic Support System (DTSS).

The ERDC has a vibrant, active program of basic research in ecosystem management. Corps of Engineer owned-lands and DOD installations alike are often critical habitat for many species of flora and fauna, acting as virtual sanctuaries for natural resource preservation within otherwise rapidly developing community surroundings. Maintaining, or even increasing, training is paramount to ensuring the effectiveness of today's soldiers. Striking a balance between fulfillment of soldier training needs and protection of our valued ecosystem is a goal of the ERDC research community.

Under its military mission, the Engineer Research and Development Center's Cold Regions Research and Engineering Laboratory, Hanover, NH provides support to Army weapon systems RDTE with all-season solutions for mitigating adverse environmental effects on Army operations. CRREL conducts basic research in sensor signal interaction with snow, ice, and frozen soil, icing accretion on surfaces and structures, deicing technologies, and cold regions surface-air boundary process. CRREL develops databases and models predicting the state of the terrain supporting tactical decision aids such as mobility analysis and sensor performance. Other programs include weather effects on environmental research for military training lands, winter effects on acoustic sensors, mine detection, helicopter pre-flight deicing and airborne icing avoidance, and estimating snow water equivalence for predicting snow melt runoff and potential for flooding.

As part of the ERDC's Battlespace Terrain Reasoning and Awareness (BTRA) research program, researchers are applying the Battlefield Forecast Model (BFM) and MM5 mesoscale weather forecast models to drive CRREL's state-of-the-ground energy budget model, FASST (Fast All-season Soil STrength model). FASST is a physic-based model that provides ground temperature and moisture profiles, freeze/thaw depths, snow depth, and soil strength index based on the terrain/terrain features and the mesoscale weather information. FASST is an integral component of

BTRA, supporting the production of a number of tactical decision aids. BTRA is available to the military services under the Commercial Joint Mapping Toolkit (CJMTK) umbrella. The FASST soil strength information in BTRA provides the geophysical information required to predict mobility for dynamic terrain conditions. The soil temperature and moisture information from FASST is the linchpin for sensor performance predictions. The Region Specific Probability of detection (RSPd) model in BTRA uses the FASST predicted ground temperatures to predict probability of target detection (Figure 3-DOD-23). Unlike tactical probability of detection models, RSPd does not require target tactical level information. RSPp uses the probability of occurrence of radiometric temperatures in the waveband of interest based on the FASST ground temperature predictions and the classical Johnson approach for a generic target to determine the RSPd metric.

ARMY MATERIEL COMMAND (AMC)

AMC is responsible for the design, development, test, and evaluation of equipment to satisfy requirements for meteorological support equipment. AMC provides climatological and meteorological support to RDTE projects involving electro-optics and obscurants. It is also responsible for determining weather effects critical threshold values and environmental sensitivities of battlefield systems. AMC has several Major Subordinate Commands (MSCs) and elements carrying out weather research and development responsibilities including the Research Development and Engineering Command (RDECOM), which has responsibility for the Army's Research Development and Engineering Centers (RDECs) and the Army Research Laboratory (ARL).

The Army Research Laboratory Battlefield Environment (BE) Division has a robust program in developing very high spatial and time resolution characterizations of the lower atmosphere using both measurements and numerical models. This research is particularly focused on the boundary layer for near-surface Army applications and includes characterizing atmospheric aerosols and predicting the effects of the atmosphere on Army systems, sensors, personnel and operations. This research addresses how to assimilate and fuse battlefield observations to update numerical weather model forecasts and to account for higher resolution effects of complex and urban terrain.

The BE Division within the ARL Computational and Information Sciences Directorate (CISD), consists of three Branches split between Adelphi, Maryland and White Sands Missile Range, New Mexico. The three branches combine basic and applied research programs in the areas of meteorological modeling at high resolution and in complex terrain, atmospheric sensing of aerosols and contaminants using laser scattering, spectral analysis, multi-wavelength imagers, and lidars, atmospheric effects including electromagnetic and acoustic propagation modeling, meteorological measurement technologies, and advanced weather impact decision aids. The Division also provides liaison personnel between Army weather R&D and the coupled programs at the Air Force Weather Agency, Air Force Combat Weather Center and the National Polar Orbiting Environmental Satellite System (NPOESS) Integrated Program Office (IPO). These positions focus on coordinating technology transitioned from the BE Division into Army and Air Force fielded systems.

BE Division and the Army PD-IMETS office are partnering with the Air Force in new programs such as the development of a common Joint Environmental Toolkit (JET). The Army IMETS Army Battle Command System (ABCS) 6.4 software and several AFW system software baselines are to converge and transition into a single baseline JET by the end of FY 2005. The JET baseline combines the AF forecast functions with the Army's weather impact Tactical Decision Aid Army unique C2 links to enhance IMETS capabilities for net-centric Army support. IMETS weather products can be accessed through a web-browser, client server applications, or overlaid on the user's Common Operational Picture (COP) through web services such as publish and subscribe (PASS). IMETS technologies will

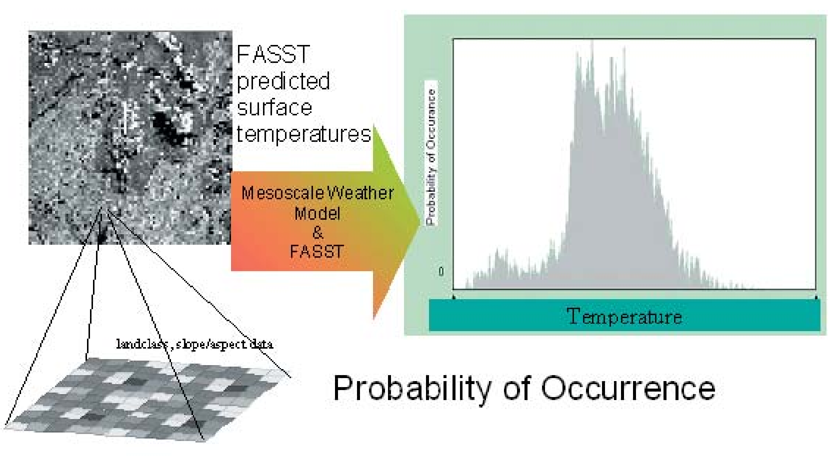


Figure 3-DOD-23. The Region Specific Probability of detection (RSPd) model in BTRA uses the FASST predicted ground temperatures to determine the probability that the temperature of a target of interest is or is not detectable.Photo courtesy U.S. Army.

continue to provide net-centric weather support to Army Battle Command and Future Combat Systems (FCS) as the Distributed Common Ground Station-Army (DCGS-A) Multifunctional Workstation-Weather.

The Meteorological Modeling Branch conducts a research program in the micrometeorological and mesoscale-gamma (small end of mesoscale) processes and structure of the atmospheric boundary layer at scales generally smaller than a few kilometers. This program focuses on the interaction of the land-air interface with wind fields, turbulence, and fluxes. Modeling of aerosol and chemical-biological transport and dispersion in the tactical environment are addressed, including detailed modeling of the boundary layer over complex terrain and within urban domains. A range of numerical weather models is addressed, including non-hydrostatic predictive and diagnostic gridded meteorological models. Diagnostic model output is combined with near real-time observations from lidar, sonic anemometers, and other battlefield sensors to produce rapid refresh analyses for urban domains and complex terrain. Nowcasting and "Weather Running Estimate" products are being developed for the Army Future Force. These are verified against existing numerical weather prediction models and data.

The Atmospheric Effects Branch strives to develop capabilities to measure the battlefield atmosphere in near real-time in a networked environment. They are working on developing methods to manage tactical bandwidth for moving large meteorological data bases, and are producing verified tactical decision aids to assess atmospheric effects and impacts on weapon systems, sensors, and personnel. Weather knowledge management tools are developed for Army C2 and ISR systems including automation of Intelligence Preparation Battlefield (IPB) and integration of various weather effects into ground and aerial vehicle route planning. Controlled field measurements are performed to develop or verify theoretical models for atmospheric and optical turbulence, acoustic propagation, radar propagation, wind flow in small scale urban domains and desert aerosol production. Value added studies are performed to justify Army requirements for higher spatial and temporal meteorological data and model resolution, for the collection of conventional and non-conventional battlefield weather observations, and for the timely dissemination of data.

The Atmospheric Sensing Branch is working to enhance warfighter situational awareness through the utilization of advanced atmospheric instrumentation and novel characterization techniques. They are developing, testing, evaluating, and implementing aerosol classification techniques to enhance identification. They are employing novel polarimetric imaging techniques to analyze effects from surface contaminants for target recognition and identification. This research also includes modeling the effects of forest canopies on acoustic propagation and investigating the use of beamforming techniques for the mitigation of the effects of the atmosphere on sensors, systems, and soldiers.

The Army Research Office, Research Triangle Park, North Carolina, manages the Army's extramural basic research program in the atmospheric sciences. These programs are concerned with understanding the dynamical and physical processes of the atmospheric boundary layer at scales of interest to the Army (millimeters to 10's of kilometers) through measurements, simulations, and theoretical considerations. The basic research program is conducted through the peer-reviewed, individual investigator program and occasional special initiatives. The focus of the research is on the atmospheric processes and effects of the atmospheric boundary layer where the Army operates. Objectives of the research are to develop, from first principles, the physical basis for understanding the boundary layer processes, thereby leading to better understanding of atmospheric effects on soldiers, materials, and weapon systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on airflow, and the development of natural obscurations throughout the diurnal cycle. An essential element of the research is the development of instrumentation to measure the volumetric fields of wind velocity, temperature, and moisture of the boundary layer at turbulence time scales. Special funding areas are also managed. The Defense University Research and Instrumentation Program (DURIP) provides funds for instrumentation needed to support ongoing research activities. The Defense Experimental Program to Stimulate Competitive Research (DEPSCoR) participation is a competition restricted to universities in certain states that compete for additional basic research funds. Also basic research under the Small Business Innovative Research Program (SBIR) is managed for selected topics. A primary focus continues on the analysis and understanding of the stable boundary layer. New initiatives include acoustic tomography of the atmospheric surface layer and measurement and analyses of wind fields in an urban area.

Communications Electronics Command (CECOM), a major subordinate command of AMC, provides support to developing and fielding weather programs through the following organizations: Logistics Readiness Center (LRC), Research, Development and Engineering Center (RDEC), Software Engineering Center (SEC), and Safety office. The CECOM LRC is the level II manager of the Meteorological Measuring Set (MMS) program.

RDEC's Communications-Electronics Research Development Engineering Center (CERDEC), Intelligence and Information Warfare Directorate provides technical management and support to the Program Manager, Intelligence and Effects and Program Manager, Night Vision/Reconnaissance, Surveillance, and Target Acquisition for the IMETS and the MMS-Profiler. A brief description of each of these programs shows CECOM's involvement.

Meteorological Measuring Set (MMS), AN/TMQ-41. The MMS is an upper air meteorological data collection, processing and dissemination system that provides data to the field artillery and target acquisition users. The system is a non-developmental item (NDI). All active Army units and National Guard Bureau are equipped with the MMS.

The Meteorological Measuring Set-Profiler (MMS-P) AN/TMQ-52 System. The Meteorological Measurement Set-Profiler (MMS-P) is a major improvement over the MMS. The AN/TMQ-52 design will support the new generation of artillery weapons. The system will include frequent and update meteorological messages that enhances the meteorological validity over a larger battle space than the current equipment. The MMS-P uses the MM5 mesoscale meteorological model to assimilate data from a variety of sources to provide the best meteorological messages to the user in a timely fashion. The system receives data from ground-based sources, radiosondes, and satellite-based sources, (such as boundary data from communications satellites and, in a future program block improvement, polar orbiting meteorological satellites) through onboard satellite receiving capability. The data affects the operation of the mesoscale meteorological model and for post-processing of the data in order to generate meteorological messages. Finally, an operator interface, in conjunction with the message generation and formatting software, facilitates communication between the MMS-P and all other systems that require interoperability with the MMS-P. Four System Design and Development (SDD) models have been produced. Developmental testing has been successfully completed and Low Rate Initial Production (LRIP) was approved at a MS C decision in FY 2003. The Profiler system has completed Initial Operational Test and Evaluation (IOTE) FY 2005. Full Rate Production (FRP) was approved at a FRP Decision in FY 2005.

The Intelligence and Information Warfare Directorate (I2WD), Communications Electronics Research & Development Engineering Center (CERDEC), Research Development & Engineering (RD&E) Command is providing technical and acquisition support to the Program Manager, Intelligence & Effects and integrating the Integrated Meteorological System (IMETS) into the Distributive Common Ground Station (DCGS) Spiral 4/5 configuration.

The IMETS comes in two basic configurations known as the Vehicle Mounted (AN/TMQ-40B/C/D) and Light (AN/GMQ-36/36A/36B) groups. The IMETS Vehicle Mounted group (Figure 3-DOD-24) has three variants, all with the same function that differ only by vehicle, shelter, and/or generator. The new IMETS-Light (AN/GMQ-36A) will replace the AN/GMQ-36 versions now in production with a CHS-3 cost savings window base computer. The AN/GMQ-36B is a Command Post version that has all the functionality of the AN/GMQ-36A.

Either the IMETS Vehicle Mounted or the IMETS Light configuration can provide the weather component of the Intelligence Electronic Warfare (IEW) sub-element of the Army Battle Command System (ABCS). IMETS has been designated by the DCGS as the Weather Center for DCGS-A weather requirements and is on track to fully support the Future Combat System (FCS) prime. The IMETS provides commanders at all echelons with an automated tactical weather system that receives, processes and disseminates weather observations, forecasts, battlefield visualization, and weather effects decision aids to all Army Tactical Command and Control System (ATCCS) Battlefield Functional Areas (BFAs). IMETS can receive weather information from geostationary satellites (either USA, European, Japanese, or Chinese civilian) depending on the system's location, civilian forecast centers, the Air Force Weather Agency, artillery meteorological sections and remote sensors. IMETS processes and collates forecasts, observations, and climatological data to produce timely and accurate weather products tailored to the specific war-fighters needs. Significant weather and environmental support to war-fighters are the weather applications such as the automated tactical decision aids and contours client. These weather products display the impact of the weather on current or planned operations for both friendly and enemy forces. Weather products can also be overlaid on the Common Operational Picture (COP) or Common Tactical Picture (CTP) accessed by using a browser, and is executed on the users terminal through weather client implementations.

Major test events in FY 2005 include the IMETS Intra-Army Interoperability Certification test, completed during the First Quarter of FY 2005 at the Central Test Support Facility (CTSF) and the ABCS 6.4 Good Enough (GE) Operational Evaluation (OPEVAL) completed in Second Quarter FY 2005. The AN/TMQ-40C Materiel Release is on schedule to occur at the last quarter of FY 2005 and the AN/TMQ-40D for FY 2006. Both of these systems, along with the AN/GMQ-36 are on schedule to field to units. In order to

Figure 3-DOD-24. IMETS Vehicle Mounted Configuration. (Photo courtesy U.S. Army.)

streamline the acquisition process, the IMETS AN/GMQ-36A/B has been given permission to go directly to Materiel Release pending the results of Development Testing and skip Milestone C pending on Development Testing results. FY 2005 efforts will focus on the ABCS 6.4 GE Operational Assessment and fielding and the IMETS-Light (AN/GMQ-36A/B) Materiel Release and fielding decision, along with finishing the fielding efforts for the AN/GMQ-361 to gaining units including the Stryker Brigade. AN/TMQ-40B/C/D systems will also be fielded during FY 2005.

AMC's Field Assistance in Science & Technology (FAST) Activity provides rapid, successful technical solutions for the Warfighter. With Science Advisors (senior AMC scientists and engineers) located at Major Commands throughout the world, AMC-FAST provides support in a wide range of technical areas. Recently FAST has assisted the 82d Airborne Division Artillery (82nd ABN DIVARTY) by providing a lightweight alternative to their previously used meteorological observation equipment.

The 82nd DIVARTY has units dispersed around the globe in support of the Global War on Terrorism. During the initial stages of deployment, these Airborne units typically have no meteorological (MET) measuring capabilities due to the logistics burden of their observation equipment, which includes several large tripod mounted pieces and one generator. Weighing a total of 23,100 pounds, this equipment requires 3 HMMWVs for transport.

AMC-FAST responded to the 82nd DIVARTY's request by providing them with a lightweight system called the Miniature Meteorological Observation Kit (Mini-Met Kit). The 25 pound Mini-Met Kit is stored in a hard-shell case for protection during air drop, vehicular transport or storage. It can also be removed from the case and transported in one soldier's Alice Pack. The contents of this kit allow DIVARTY MET teams to observe current weather at the firing site and to launch and track pilot balloons (PIBALS) in support of artillery fires.

As the XVIII Airborne Corps Field Artillery (FA) has a similar need for accurate, lightweight, man-portable MET equipment, AMC-FAST provided funding for 9 Mini-MET systems total; 4 to be evaluated in the field by the 82d DIVARTY and 5 by the XVIII ABN Corps FA. In their initial evaluation, the 82nd DIVARTY MET compared results obtained using the Mini-MET kit with those obtained from their older MET equipment. Results were reported to be extremely accurate, with less than 3% differences between the two systems for all readings taken. As this new, lightweight weather observation kit is parachute deployable and transportable by just one trooper, the Mini-MET Kit can truly be viewed as a force multiplier.

To use the Mini-Met kits for actual "Call to Fire" during Artillery missions in theater, formal approval must be given by the Army's Artillery School at Ft Sill. To expedite the Schoolhouse's evaluation & approval, XVIII ABN Corps FA has loaned one of their kits to Ft Sill. They are now awaiting formal approval to use the kit during GWOT missions.

It is anticipated that this AMC-FAST project will yield enhanced capabilities for the 82d Airborne DIVARTY and the XVIII Airborne Corps FA by providing them with a robust means to rapidly and accurately acquire the MET data needed to increase early entry artillery accuracy and lethality.

ARMY TEST AND EVALUATION COMMAND (ATEC)

The Developmental Test Command (DTC), a subordinate command of United States Army Test and Evaluation Command (ATEC), is responsible for providing operational meteorological support to eight Army ranges and test sites. Under responsibilities established in AR 115-10/ AFJI 15-157, the DTC meteorological units provide meteorological data collection and analysis, consultation, and weather forecast and warning services to support Army and other DOD research, development, test and evaluation (RDT&E) activities at the eight Army installations. Funding for the Army RDT&E Meteorology Program under Program Element 665702 is sufficient to maintain the basic meteorological support infrastructure at Army RDT&E ranges and sites. However, instrumentation needed to support unique or test-specific requirements generally must be funded by test sponsors. Because the majority of the operational meteorological support workforce at the Army ranges is or soon will be eligible to retire, the Program has implemented an intern program to recruit and train entry-level scientists and technicians to ensure continuity in specialized meteorological support services as senior employees begin to retire.

The Army RDT&E Meteorology Program has entered into a multi-year working relationship with the National Center for Atmospheric Research

(NCAR) to enhance "range scale" (mesoscale to microscale) forecast and analysis capabilities at the Army test ranges. The principal product of this relationship is the Four-Dimensional Weather (4DWX) System, which consists of a central data archival/retrieval system for all range and external meteorological and model data, a high-resolution mesoscale meteorological model (MM5), and a variety of user-configurable displays. The MM5 mesoscale model is used operationally in both predictive and analytic modes to provide detailed information about the past, current, and future structure of the atmosphere over the Army's test ranges. Recent 4DWX enhancements include the implementation of MM5-based real-time four-dimensional data assimilation (RT-FDDA) capabilities at the major Army test ranges and development of Global Meteorology on Demand (GMOD), a globally-relocatable mesoscale modeling system to support Army RDT&E (including DTC Virtual Proving Ground modeling and simulation) at locations other than the Army ranges. In FY 2006, the 4DWX program will begin transition of its operational mesoscale model from MM5 to the next-generation Weather Research and Forecast (WRF) model. Output from mesoscale model forecasts and analyses is used as meteorological input to atmospheric dispersion, noise propagation, ballistic trajectory, and other range applications models to simulate many tests and their associated impacts. The 4DWX system contributes to improved test planning and conduct, selection of more representative locations for test sensors, inclusion of realistic atmospheric effects in virtual testing, and forensic analyses of meteorological effects on test results.

The Chief of the Meteorology Division at Dugway Proving Ground's West Desert Test Center serves as the Program Manager for Meteorological Support to Army RDT&E. Under Program Element 0605384, the Division's Modeling and Assessment Branch also provides the following specialized services: (1) technical assistance to the DTC operational meteorological teams/branches; (2) atmospheric model verification and validation, including algorithm evaluation and the generation of validation data sets; and (3) technical assistance to the DOD CB defense modeling community in the development of new CB hazard assessment models. Division employees also serve on various national and international committees addressing issues related to meteorological measurements, atmospheric dispersion modeling, and CB hazard assessment.

ARMY MEDICAL RESEARCH AND MATERIEL COMMAND

The U.S. Army Research Institute of Environmental Medicine (USARIEM) conducts basic and applied research on the effects of heat, cold, high terrestrial altitude and nutritional status on the health and performance of individual soldiers and combat crews operating Army systems.

Applied research in thermal physiology and biophysical modeling is directed towards improving soldier performance and minimizing health risks in climatic extremes. The sensitivity of the soldier to local weather parameters (primarily ambient temperature, dew point, wind speed, and solar radiation) defines an operational envelope for unimpaired human performance. The overall goals of USARIEM weather-related research programs are to develop methods to effectively monitor and, where possible, extend the operational envelope for both training and operational scenarios.

Weather-related research efforts include the development and validation of automated methods to integrate thermal strain prediction models with real-time weather information resources relevant to dismounted infantry operations. Temporal and spatial scales of interest are meters to kilometers and minutes to several days. USARIEM is working with the Army Research Laboratory Battlefield Environment Division to implement thermal models on Personal Digital Assistant (PDA) devices and the Integrated Weather Effects Decision Aid (IWEDA).

The availability of ground level environmental data at high temporal and spatial resolution continues to pose a significant challenge for predictive model development and validation. A prototype miniature weather station developed under a Small Business Innovative Research (SBIR) project has been refined into a 1 kg battery powered unit which includes a sonic anemometer. An prototype unit was used to collect data during a study of thermal exposure in August, 2005 at the U.S. Army's Ranger Training Brigade (RTB) Ranger School (Ft. Benning, GA). Work continued on the wireless network-capable, expendable, micro-environmental sensing system which has been expanded to consider new sensor applications.

As part of the warfighter physiological status-monitoring (WPSM) program, USARIEM is investigating methodologies needed to integrate real-time local environmental data and warfighter physiological data with predictive model processes. The effective fusion of these two real-time data streams will enable near term environmental strain and performance status predictions for individual warfighters.

The miniature weather station may be used to collect meteorological data to support the prediction of thermal stress on the WPSM system. Research efforts are intended to address capabilities identified in the Operational Requirements Document (ORD) for the Army's Land Warrior program.

DEPARTMENT OF TRANSPORTATION WEATHER PROGRAMS

The Federal Aviation Administration (FAA) has the responsibility to provide national and international leadership in the optimization of aviation weather systems and services. This leadership is manifested through the management of a safe and efficient National Airspace System (NAS) and the encouragement of consensus and cooperation between government agencies, private weather services, research organizations, and user groups involved in aviation weather. The Federal Highway Administration (FHWA) manages programs that provide federal financial and technical assistance to the states, promotes safe commercial motor vehicle operations, and provides access to and within national forests and parks, native American reservations, and other public lands. Safety, efficiency, and mobility in these programs requires the incorporation and use of timely weather and road condition information. The Federal Railroad Administration promotes and regulates railroad safety. It also sponsors research to enhance railroad safety and efficiency, including support for improved collection, dissemination, and application of weather information to reduce hazards to train operations and to railroad employees. The Federal Transit Administration’s mission is to ensure personal mobility and America's economic and community vitality by supporting high quality public transportation through leadership, technical assistance and financial resources.

FEDERAL AVIATION ADMINISTRATION

THE NATIONAL AIRSPACE SYSTEM OF THE FUTURE

In a proactive stroke to broaden the capabilities of the National Airspace System (NAS) for the future, the 108th Congress and President Bush took the first critical step toward transforming the United States air transportation system by passing and signing into law *VISION 100 - Century of Aviation Reauthorization Act (P.L. 108-176).* The Act calls for an integrated, multi-agency plan to transform the nation's air transportation system to meet the needs of the year 2025, while providing substantial near-term benefits. This Next Generation Air Transportation System (NGATS) Initiative will address critical safety and economic needs in civil aviation while fully integrating national defense and homeland security improvements into this future system.

Along with the private sector and academic community, the FAA, NASA, the Departments of Commerce, Defense, Homeland Security, Transportation, and the White House Office of Science and Technology Policy are working together to design and build the NGATS.

The first product of this landmark effort was an Integrated National Plan delivered to Congress in December 2004. This strategic business plan lays out a common vision for the NGATS, establishes benchmarks for success, and establishes a structure through which to design and implement the required changes.

VISION 100 also created the Joint Planning and Development Office (JPDO). Jointly managed by the FAA and NASA and supported by staff from all the agencies involved, the JPDO serves as a focal point for coordinating the research related to air transportation for all of the participating agencies.

Overseeing the work of the JPDO is a Senior Policy Committee chaired by the Secretary of Transportation and that includes senior representatives from the participating departments and agencies and the Director of the Office of Science and Technology Policy. Among its key responsibilities, the Senior Policy Committee provides policy guidance and review; makes legislative recommendations; and identifies and aligns resources that will be necessary to develop and implement the Integrated National Plan. Secretary Norman Mineta chaired the first meeting of the Senior Policy Committee on September 26, 2003.

The JPDO has defined eight strategies that are the first steps towards creating the roadmap for NGATS. While the strategies deal with transforming specific areas of the air transportation system, they make up a larger whole and will integrate the sum of the efforts into building the NGATS system. The transformation strategies are:

1. Develop airport infrastructure to meet future demand.
2. Establish an effective security system without limiting mobility or civil liberties.
3. Establish an agile air traffic system.
4. Establish user-specific situational awareness.
5. Establish a comprehensive proactive safety management approach.
6. Include environmental protection guidelines that allow sustained economic growth.
7. Develop a system-wide capability to reduce weather impacts.
8. Harmonize equipment and operations globally.

For each of the eight Integrated National Plan strategies an integrated product team (IPT) was formed. The

IPTs will be made up of government and private sector experts with extensive aviation experience. The IPTs will be responsible for applying best private and public sector practices to achieve that particular strategy's mission and objectives. The primary responsibility for assembling and leading each IPT belongs to one federal agency.

The IPTs will establish detailed action plans that will break the project down into manageable tasks. Specific IPT activities include:

Managing the planning and orchestrating the execution of all relevant work to complete the assigned strategy;

Conducting analyzes and trade studies to select and validate implementation alternatives;

Analyzing changes currently underway, identifying gaps, and establishing the required Government and/or industry research and development activities to close necessary gaps;

Coordinating with Government and private industry on research and development resources;

Collaborating with industry on research and implementation for the initiative;

Identifying non-technical approaches such as policy, regulation, and operational procedures;

Establishing detailed requirements for individual mission areas;

Conducting advanced concept and technology demonstrations;

Creating a transition plan for implementation of products; and

Creating public/private partnerships that include multi-agency, industry, and Government participation.

The JPDO is responsible for approving the broad strategies of the IPTs as part of the Integrated National Plan and ensuring IPT plans and schedules are consistent with the roadmap and architecture.

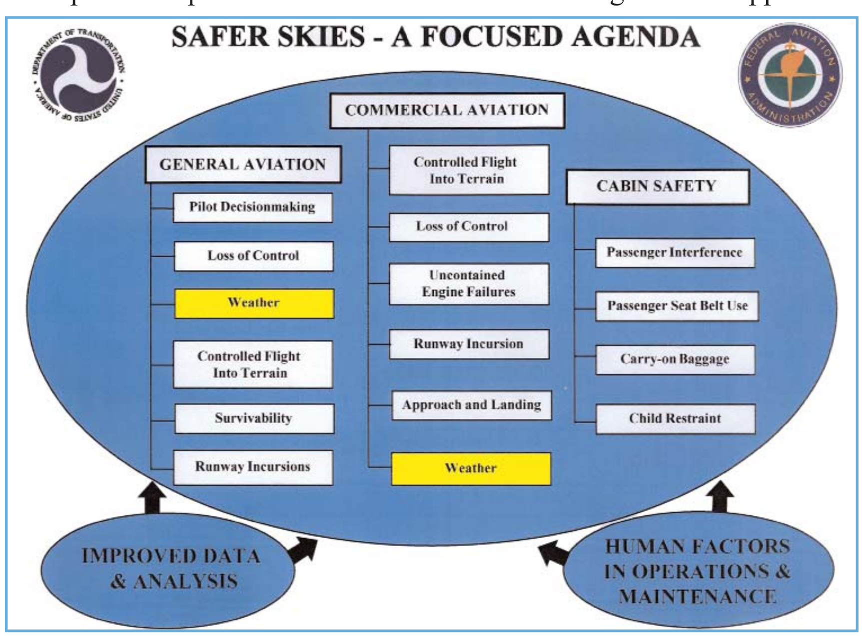
In addition, an NGATS Institute will support the NGATS mission by recruiting, selecting, and assigning private sector experts and technical resources to participate on IPTs and perform technical work for the IPTs and JPDO. These efforts will guarantee the establishment of a collective enterprise among key stakeholders to achieve the transformation, as well as to ensure that we fulfill our critical obligation to create a process that is transparent and fully open to public scrutiny.

AVIATION WEATHER MANAGEMENT

Although the Department of Commerce National Weather Service has the Weather IPT lead within the JPDO, the FAA continues to have the leadership role for the national aviation weather program requirements. As the leader, FAA must conduct continual coordination for identifying needs for aviation weather products and services among the Air Traffic Control organization, the aviation industry components and among service providers. The coordination process leads to opportunities to leverage efforts and resources to form partnerships in finding solutions in response to the needs. The *National Aviation Weather Program Strategic Plan* and the *National Aviation Weather Initiatives* are two documents that formalize the coordination and partnerships.

The FAA focus for aviation weather has been to promote safety first; then improve NAS efficiency to reduce delays and re-routing due to weather. The Administrator has launched *The Safer Skies, A Focused Safety Agenda* which includes a government/industry Commercial Aviation Safety Team (CAST) and Joint Safety Analysis Teams (JSAT) to evaluate accident investigation reports to analyze the series of events leading to the accidents, and get a sense of what and how decisions were made in the course of the flight. Other teams, Joint Safety Implementation Teams (JSIT), using the findings of the JSAT, develop and recommend intervention actions to eliminate or reduce the causes or improve the actions in the decision making process. Training about the decision making process has been identified by these teams as a major part of the solution.

Aviation weather information is complex and highly perishable, is most useful when customers can successfully plan, act, and respond in ways that avoid accidents and delays. FAA will improve the ability of the aviation community to use weather information through a review and upgrade of airmen training and certification programs. FAA will also develop multimedia training tools to support aviation



safety and training initiatives. Funding has been requested to further this effort.

Weather has been made a standard consideration in all aspects of the operation and architecture of the NAS. Aviation weather needs from the field, federal agencies, and industry are entered into the FAA Acquisition Management System (AMS) through which all new programs and changes to the NAS are processed, evaluated, validated, engineered to a requirement, and acquired. The new Air Traffic Organization (ATO) Service components have the responsibility to guide all initiatives through the AMS process and organization, including the Integrated Requirements Team, the Integrated Product Team, and the Decision Boards; to assure the development continues to meet the original need; and to guide the activity should the need evolve. Improvements to the AMS process facilitate non-system or non-hardware (e.g., service improvement or rule changes) solutions receiving the same rigorous evaluation and validation.

The FAA has established an Aviation Weather Technology Transfer (AWTT) Board which addresses the key issues involved in bringing new weather capabilities in to the operational system. At key decision points, the board evaluates the maturity of the capability, its integration into the existing system, its supportability in the field, and the training program to prepare the users.

The FAA relies on other federal agencies for weather services and support, especially NOAA's National Weather Service (NWS) and its Aviation Weather Center. Requirements validated by FAA for domestic and International Civil Aviation Organization (ICAO) users are coordinated annually and supported through the agencies and contractual arrangements. All agencies' efforts in the area of aviation weather services are coordinated for use by everyone, as appropriate. Aviation weather technology includes the ways in which aviation weather information is gathered, assimilated, analyzed, forecast, disseminated, and displayed. The development of this technology also demands that consideration be given to human factors and the application of decision-making tools. FAA will support the use of technology to improve aviation weather information through integration of federal and non-federal resources. Automation, improved product and graphics generation, and dissemination to the cockpit are being developed as early opportunities to achieve these goals.

AVIATION WEATHER ACQUISITION AND SERVICES

One of the primary functions of the FAA ATO organization is the development and management of requirements for the FAA Capital Investment Plan. Recent projects in the Acquisition Management System (AMS) have focused on weather detection and display systems for pilots and air traffic controllers to ensure that aircraft avoid hazardous weather. The following paragraphs describe many of those projects.

The Integrated Terminal Weather System (ITWS) will integrate weather data from sensors in the terminal area to provide and display compatible, consistent, real-time products that require no additional interpretation by controllers or pilots--the primary users (Figure 3-DOT-1). ITWS will use data from automated surface observing systems, Doppler weather radars, and low-level wind-shear alert systems, together with NWS data and products, to forecast aviation impact parameters, such as convection, visibility, icing, and wind shear, including down bursts.

ITWS has been installed at 10 locations, of which 9 are in service. Installations are planned at 11 additional

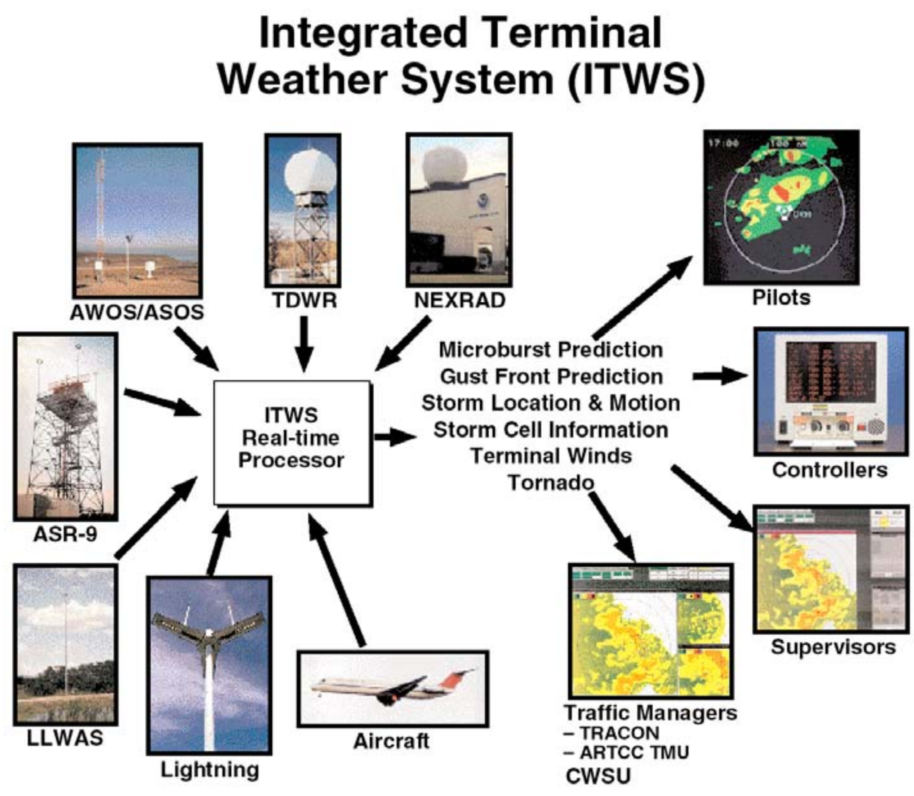
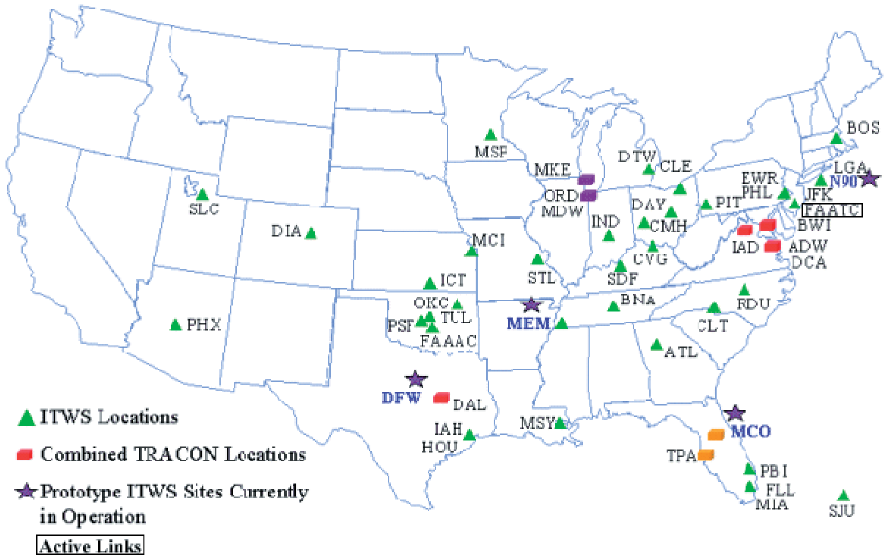


Figure 3-DOT-1. The ITWS integrates data from FAA and NWS sensors and systems to provide a suite of weather informational products.

ITWS Supported Airports



locations by FY 2009. The current long range program has been limited to 22 ITWS, which will cover about 30 high-activity airports that are supported by terminal doppler weather radars.

The Corridor Integrated Weather System (CIWS) is a demonstration program which will take some of the capabilities of the integration software of the ITWS and expand it to cover larger areas beyond the terminals. 'Corridor' in the name implies the area covered will be an elongated zone

Figure 3-DOT-2. Corridor Integrated Weather System (CIWS) Display

which may include a number of terminal areas. The demonstration area extends from Boston southward over New York as far as Washington, and westward over Pittsburgh and Cleveland connecting to Chicago.

The CIWS is expected to integrate information from the WSR-88D and ASR-9 radars and other observing sensors in the corridor to produce weather information products focused on current conditions affecting en route traffic in the corridor (Figure3-DOT-2). It will produce two hour forecasts with trend information and a high-resolution echo tops product. There will be twelve sites, including six in the ARTCCs and one at the Command Center. The comprehensive plan calls for implementation by 2009, however the funding stream has been interrupted in 2006, which may delay implementation to a later year.

The Terminal Doppler Weather Radar (TDWR) program consisted of the development, procurement, and installation of a new terminal weather radar based on Doppler techniques. TDWR units have been located to optimize the detection of microbursts and wind shear at selected airports with high operations and frequent weather impacts. In addition, TDWR has the capability to identify areas of precipitation and the locations of thunderstorms (Figure 3-DOT-3).

Microbursts are weather phenomenon that consist of an intense down draft with strong surface wind outflows. They are particularly dangerous to aircraft that are landing or departing. TDWR scanning strategy is optimized for microburst/wind shear detection. The radars are located near the airport operating areas in a way to best scan the runways as well as the approach and departure corridors. The displays are located in the tower cab and Terminal Radar Approach Control (TRACON).

The FAA has 47 TDWR systems. A software upgrade will integrates TDWR and low level wind shear alert system data has been integrated at 9 high traffic/high weather threat airports.

The Low Level Wind Shear Alert System (LLWAS) provides information on hazardous wind shear events that create unsafe conditions for aircraft landings and departures. A total of 110 airports have LLWAS. The 101 basic systems, LLWAS-2, consists of a wind sensor located at center field and 5 to 32 sensors near the periphery of the airport (Figure 3-DOT-4). A computer processes the sensor information and displays wind shear conditions on a ribbon display to air traffic controllers for relay to pilots. The improvement phase, referred to as LLWAS-Relocation/Sustainment (LLWAS-RS), will include expanding the network of sensors, developing improved algorithms for the expanded network, and installing new information/alert displays. The new information/alert displays will enable controllers to provide pilots with head wind gain or loss estimates for specific runways. These improvements will increase the system's wind shear detection capability and reduce false alarms. Improvements are also expected to reduce maintenance costs. LLWAS-

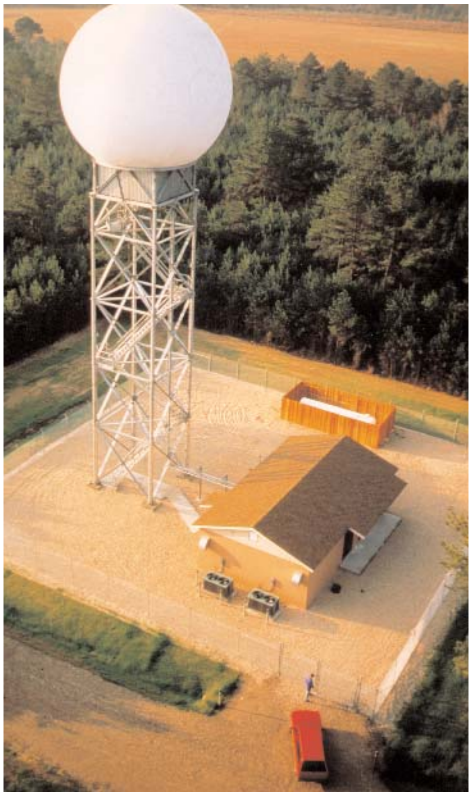


Figure 3-DOT-3. FAA Terminal Doppler Weather Radars provide supplementary wind and precipitation conditions for airport approach and departure.

RS deployment was completed this year.

The Weather Systems Processor (WSP) program provides an additional radar channel for processing weather returns and de-alias returns from the other weather channel in the ASR-9. The displays of convective weather, microbursts, and other wind shear events will provide information for controllers and pilots to help aircraft avoid those hazards. All 34 units are in place and operating. There is also one mobile system in operation.

The Terminal Weather Information for Pilots (TWIP) program provides text message descriptions and character graphic depiction of potentially hazardous weather conditions in the terminal area of airports with installed TDWR systems. TWIP provides pilots with information on regions of moderate to heavy precipitation, gust fronts, and microburst conditions. The TWIP capability is incorporated in the TDWR software application. Text messages or character graphic depiction are received in the cockpit through the Aeronautical Radio Incorporated (ARINC) Communication Addressing and Reporting System (ACARS) data link system. A total of 47 TDWR systems are deployed, installed and commissioned. The TWIP capability is operational at most of the TDWR sites. Activation of TWIP at the remaining sites is dependent on availability of National Airspace Data Interchange Network (NADIN) II connectivity and program funding.

The Flight Information System (FIS) Policy was implemented during FY 2001, through Government-Industry Project Performance Agreements (G-IPPAs) with two industry FIS data link service providers (ARNAV Systems, Inc. and Honeywell International, Inc.). Through the government-industry agreements, the FAA provides access to four VHF channels (136.425-136.500) in the aeronautical spectrum while industry provides the ground infrastructure for data link broadcasts of text and graphic FIS products at no cost to the FAA. Under the agreements, a basic set of text products are provided at no cost to the pilot users while industry may charge subscription fees for other value-added text and graphic products.

The FAA FIS data link program will continue development of necessary standards and guidelines supporting inter-operability and operational use. In addition, the need and feasibility for establishing a national capability for collecting and distributing electronic pilot reports (E-PIREPs) from low-altitude general aviation operations is being evaluated. A concept analysis has been initiated to define the need for transition and evolution of FIS data link services supporting the future NAS architecture including Free Flight operations.

SURFACE WEATHER OBSERVING PROGRAM

Aviation Weather Observations. The FAA has taken responsibility for aviation weather observations at many airports across the country. To provide the appropriate observational service, FAA is using automated systems, human observers, or a mix of the two. It has been necessary to place airports into four categories according to the number of operations per year, any

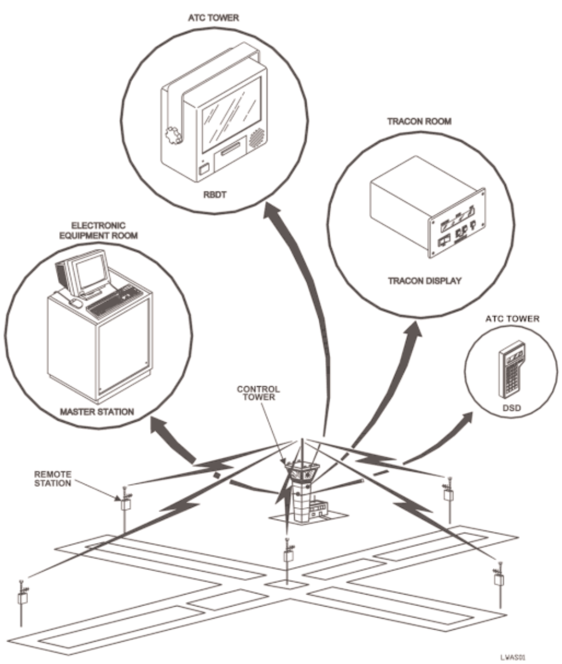


Figure 3-DOT-4. LLWAS equipment on an airfield.

special designation for the airport, and the frequency at which the airport is impacted by weather.

Level D service is provided by a stand-alone Automated Weather Observing System (AWOS) or an Automated Surface Observing System (ASOS). In the future, Level D service may be available at as many as 400 airports.

Level C service includes the ASOS/AWOS plus augmentation by tower personnel. Tower personnel will add to the report observations of thunderstorms, tornadoes, hail, tower visibility, volcanic ash, and virga when the tower is in operation. Level C service includes about 250 airports.

Level B service includes all of the weather parameters in Level C service plus Runway Visual Range (RVR) and the following parameters when observed--freezing drizzle, freezing rain, ice pellets, snow depth, snow increasing rapidly remarks, thunderstorm/lightning location remarks, and remarks for observed significant weather not at the station. Level B service includes about 57 airports.

Level A service includes all of the weather parameters in Level B service plus 10-minute averaged RVR for long-line transmission or additional visibility increments of 1/8, 1/16, and 0 miles. Level A service includes about 78 airports.

Automated surface aviation weather observing systems will provide aviation-critical weather data (e.g., wind velocity, temperature, dew point, altimeter setting, cloud height, visibility, and precipitation type, occurrence, and accumulation) through the use of automated sensors. These systems will process data and allow dissemination of output information to a variety of users, including pilots via computer-generated voice.

The Automated Weather Observing Systems (AWOS) was deployed at over 200 airports to provide the basic aviation weather observation information directly to pilots approaching the airport. The majority of these systems were installed at various non-towered airports to enhance aviation safety and the efficiency of flight operations by providing real-time weather data at airports that previously did not have local weather reporting capability. These systems are built to the standards of quality necessary to ensure the safety of flight operations and are available off-the-shelf as a commercial product. There remain 198 AWOSs.

Automated Surface Observing Systems (ASOS). In a joint program with NOAA's NWS, the FAA has procured, installed, and operates ASOS at the airports where the FAA provides observations and at additional non-towered airports without weather reporting capabilities in accordance with the levels of service listed above. Production is complete and the FAA has 569 systems installed and commissioned.

Aviation Weather Sensor Systems (AWSS), a new program, will have capability similar to ASOS (Figure 3-DOT-5). However, the AWSS is a direct acquisition of the FAA--not from the joint ASOS program. Full production is underway with completion expected in CY 2005

The AWOS/ASOS Data Acquisition System (ADAS) functions primarily as a message concentrator and will collect weather messages from AWOS and ASOS equipment located at controlled and non-controlled airports within each ARTCC's area of responsibility. ADAS will distribute minute-by-minute AWOS/ASOS data to the Weather and Radar Processor (WARP) within the air route traffic control center in which it is installed. ADAS will also distribute AWOS data to the NADIN which will in-turn forward the data to the Weather Message Switching Center Replacement (WMSCR) for further distribution. Field implementation of ADAS is complete.

The Automated Lightning Detection and Reporting System (ALDARS) is a system adjunct to the ADAS. ALDARS collects lightning stroke information from the National Lightning Detection Network (NLDN) and disseminates this data to AWOS/ASOS for the reporting of thunderstorms in METAR or SPECI observations, when appropriate. The use of ALDARS eliminates the need for manual reporting of thunderstorms and increases the number of airports where thunderstorms will be reported. ALDARS is completely operational.

Stand Alone Weather Sensors (SAWS) are back-up systems for some AWOS/ASOS sensors at locations where no other back-up capability is available. SAWS have been demonstrated and full delivery is nearly completed. The full deployment will comprise up to 307 units.

Figure 3-DOT-5. Aviation Weather Sensor Systems an ASOS like supplement for observations.

ASOS Controller Equipment- Information Display System (ACE-IDS) is an electronic cabinet of displays available to the controller at his work station (Figure 3-DOT-6). It provides graphics of information which comes from many sources that originate at many nodes of a LAN which includes, but is not limited to, weather related parameters, observations, and other automated weather products. This system is designed specifically to support operations in high-volume, high-tempo Terminal Radar Approach Control (TRACON) facilities. They are installed at the following TRACONs: Atlanta, Boston, Dallas-Fort Worth,

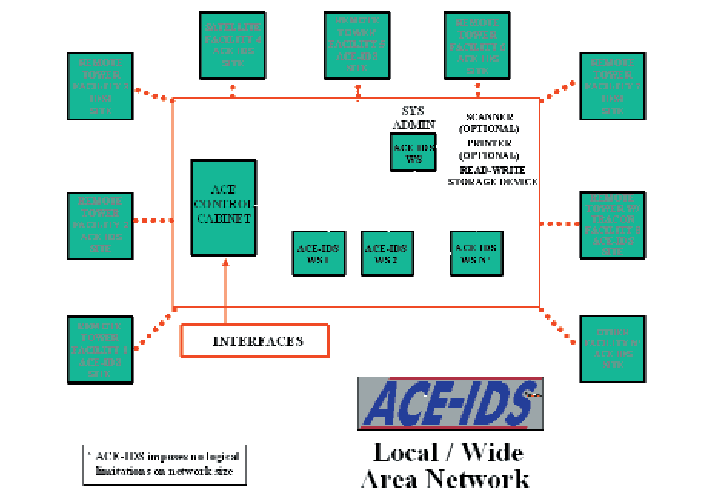


Figure 3-DOT-6. ASOS Controller Equipment- Information Display System (ACE-IDS)

Honolulu, Northern California (San Francisco), Oklahoma City, Potomac (Wash. D.C.), Saint Louis, and Seattle . AWOS for Non-Federal Applications. Under the Airport Improvement Program (AIP), state and other local jurisdictions may justify to the FAA their need to enhance their airport facilities. Upon approval, these improvements may be partially funded by the FAA using resources from the Airway Trust Fund. The local airport authority becomes responsible for the remainder of the funding necessary to complete the procurement, as well as the funding for the regular maintenance. The addition of an AWOS is one of the improvements that qualify for AIP funding assistance. Systems that qualify must meet certain standards which are defined in an FAA Advisory Circular on Non-Federal Automated Weather Observing Systems.

There are more than 275 non-Federal AWOS locations. Some of these are capable of reporting through a geostationary communications satellite. These observations will be entered into the national network for use in support of the NAS and the national weather network.

The New Generation Runway Visual Range (NRVR) program provides for a new generation RVR sub-element of the NAS. The NRVR provides runway visual range information to controllers and users in support of precision landing and take-off operations. The NRVR incorporates state-of-the-art sensor technology and embedded remote maintenance monitoring. The FAA plans to procure and install these NRVR systems at all new qualifying locations. FAA plans also call for the replacement of many existing RVRs in the NAS inventory.

The NRVR provides for near real-time measurement of visibility conditions along a runway (up to three points along the runway can be measured-- touchdown, midpoint, and roll-out) and reports these visibility conditions to air traffic controllers and other users. The system automatically collects and formats data from three sensors: a visibility sensor--forward scatter meters will replace the transmissometers currently in use; a runway light intensity monitor for both runway edges and center-line lights; and an ambient light sensor which controls computer calculations using a day or night algorithm. The data processing unit calculates runway visibility products and distributes the products to controllers and other users.

NRVR visibility sensors will be deployed at 308 airports. Delivery of the NRVR sensors began in November 1998. To date, 230 units have been delivered and 185 have been commissioned. At the current levels of annual funding, the program will be completed by the end of CY 2009.

The FAA is procuring the Operational and Supportability Implementation System (OASIS) to improve weather products, flight information, aeronautical data collection, analysis, and timeliness of dissemination, thereby enhancing the safety and efficiency of the NAS. OASIS will replace the Model-1 Full Capacity Flight Service Automation System, which includes the Aviation Weather Processor. OASIS will also integrate the Interim Graphic Weather Display System functions and include several automated flight service data handling capabilities. This configuration will be an initial deployment capability. Operational testing began in 1999; 16 systems have been deployed from the original plan of 61. Future enhancements leading to the full capability deployment will include: interactive alphanumeric and graphic weather briefings; direct user access terminal (DUAT) service functionality; automated special use airspace; and training support. OASIS will support flight planning, weather briefings, NOTAM service, search and rescue, and pilot access terminal services. Note: This program may be suspended due to an A-76 contract award.

The Next Generation Weather Radar (NEXRAD), known operationally as the Weather Surveillance Radar-1988 Doppler (WSR-88D), is a multi-agency program that defined, developed, and implemented this weather radar. Field implementation began in 1990 and was completed in 1996. There are a total of 161 WSR-88D systems deployed. The FAA sponsored 12 systems in Alaska, Hawaii, and the Caribbean. DOC and DOD WSR-88Ds provide coverage over the continental United States.

The FAA emphasized the development of WSR-88D algorithms that take advantage of the improved detection of precipitation, wind velocity, and hazardous storms. The FAA also stressed that these algorithms provide new or improved aviation-oriented products. These improvements in detection of hazardous weather reduce flight delays and improve flight planning services through aviation weather products related to wind, wind shear, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones and tornadoes. WSR-88D data provided to ATC through the WARP (see description below) will increase aviation safety and fuel efficiency.

In addition, the three funding agencies support the field sites through the WSR-88D Radar Operations Center (ROC) at Norman, Oklahoma. The ROC provides software maintenance, operational troubleshooting, configuration control, and training. Planned product improvements include a shift to an open architecture, new antenna design, dual polarization, and the development of more algorithms associated with specific weather events, such as hurricanes.

The Air Route Surveillance Radar (ARSR-4) provides the ARTCCs with accurate multiple weather levels out to 200 nautical miles. The ARSR-4 is the first enroute radar with the ability to accurately report targets in weather. The ARSR-4 can provide weather information to supplement other sources. The ARSR-4 is a joint FAA/USAF funded project. Forty joint radar sites were installed during the 1992-1995 period.

The Weather and Radar Processor (WARP), has replaced the Meteorologists Weather Processor to provide aviation weather information to the Center Weather Service Units. WARP automatically creates unique, regional, WSR-88D-based, mosaic products, and sends these products, along with other time-critical weather information, to controllers through the Display System Replacement and to pilots via the FIS. WARP greatly enhances the dissemination of aviation weather information throughout the NAS. WARP underwent operational testing and evaluation in early FY 2003 and is operationally fielded at the 21 ARTCCs and the command center. Others systems used for enhancements, testing, and software support bring the total to 25 systems.

The Direct User Access Terminal (DUAT) system has been operational since February 1990. Through DUAT, pilots are able to access weather and NOTAMs and also file their IFR and/or VFR flight plans from their home or office personal computer. This system will eventually be absorbed into OASIS.

AVIATION WEATHER COMMUNICATIONS

It should be noted that FAA communications systems are multi-purpose. Weather data, products, and information constitute a large percentage of the traffic, as do NOTAMS, flight plans, and other aeronautical data.

The National Airspace Data Interchange Network (NADIN II) packet-switched network was implemented to serve as the primary inter-facility data communications resource for a large community of NAS computer subsystems. The network design incorporates packet-switching technology into a highly connected backbone network which provides extremely high data flow capacity and efficiency to the network users. NADIN II consists of operational switching nodes at two network control centers (and nodes) at the National Aviation Weather Processing Facilities at Salt Lake City, Utah, and Atlanta, Georgia. It will interface directly to Weather Message Switching Center Replacement (WMSCR), WARP, ADAS, TMS, and the Consolidated NOTAM System. NADIN II also may be used as the intra-facility communications system between these collocated users during transition to end state.

The Weather Message Switching Center Replacement (WMSCR) replaced the Weather Message Switching Center (WMSC) located at FAA's National Communications Center (NATCOM), Kansas City, Missouri, with state-of-the-art technology. WMSCR performs all current alphanumeric weather data handling functions of the WMSC and the storage and distribution of NOTAMs. WMSCR will rely on NADIN for a majority of its communications support. The system will accommodate graphic data and function as the primary FAA gateway to the NWS's National Centers for Environmental Prediction (NCEP)--the principal source of NWS products for the NAS.

To provide for geographic redundancy, the system has nodes in the NADIN buildings in Atlanta, Georgia, and Salt Lake City, Utah. Each node supports approximately one-half of the United States and will continuously exchange information with the other to ensure that both nodes have identical national databases. In the event of a nodal failure, the surviving node will assume responsibility for dissemination to the entire network.

Currently, specifications for an upgrade or replacement for the WMSCR are being formulated. The needs, when developed, will be entered into the AMS process for validation and acceptance into the NAS architecture.

The Flight Information Service (FIS) is a new communication system to provide weather information to pilots in the cockpit. FIS is a partnership program among the government and private industry with the government providing the base information and the bandwidth while the private companies provide the broadcast and value-added products. New products are screened for technical suitability and value to the pilots. Two companies have demonstrated preliminary products and capability.

The Worldwide Aeronautical Forecast System (WAFS) is a three geosynchronous satellite-based system for collecting and disseminating aviation weather information and products to/from domestic or international aviation offices as well as in-flight aircraft. The information and products are prepared at designated offices in Washington, District of Columbia, and Bracknell, United Kingdom. The United States portion of WAFS is a joint project of the FAA and NWS to meet requirements of the ICAO member states. FAA funds the satellite communications link and the NWS provides the information/product stream.

Two of the three satellites are funded by the United States. The first is located over the western Atlantic with a footprint covering western Africa and Europe, the Atlantic Ocean, South America, and North America (except for the West Coast and Alaska). The second United States-funded satellite is positioned over the Pacific and covers the United States West Coast and Alaska, the Pacific Ocean, and the Pacific rim of Asia. The third satellite, operated by the United Kingdom, is stationed over the western Indian Ocean and covers the remaining areas of Europe, Asia, and Africa. The data available via WAFS include flight winds, observations, forecasts, SIGMETs, AIRMETs, and hazards to aviation including volcanic ash clouds.

The System Wide Information Manager is a new concept developed in conjunction with NGATS to support NAS operations in the 2025 timeframe. For all facets of the NAS operations, all data will be resident on a “data cube” which will be accessible to all users; thus assuring that all users will have the same data. This will assure that collaborative decision making will benefit from the same situational awareness, weather and traffic programs.

AVIATION WEATHER RESEARCH PROGRAM

Working closely with the Integrated Product Team for Weather/Flight Services Systems, ATO sponsors research on specific aviation weather phenomena which are hazardous and/or limiting to aircraft operations. This research is performed through collaborative efforts with the National Science Foundation (NSF), NOAA, NASA, and the Massachusetts Institute of Technology's Lincoln Laboratory. A primary concern is the effective management of limited research, engineering, and development resources and their direct application to known deficiencies and technical enhancements.

Improved Aircraft Icing Forecasts. The purpose of this initiative is to establish a comprehensive multi-year research and development effort to improve aircraft icing forecasts as described in the FAA Aircraft Icing Plan. The objectives of this plan are to develop: (1) an icing severity index, (2) icing guidance models, and (3) a better comprehension of synoptic and mesoscale conditions leading to in-flight icing. The result of this effort will be an improved icing forecasting capability that provides pilots with more timely and accurate forecasts of actual and expected icing areas by location, altitude, duration, and potential severity.

CONVECTIVE WEATHER FORECASTING

The purpose of this research effort is to establish more comprehensive knowledge of the conditions that trigger convection and thunderstorms and, in general, the dynamics of a thunderstorm's life cycle. The program will lead to enhanced capability to predict growth, areal extent, movement, and type of precipitation from thunderstorms. Gaining this forecast capability will allow better use of the airspace and help aircraft avoid areas with hazardous convective conditions (Figure 3-DOT-7.

MODEL DEVELOPMENT AND ENHANCEMENT

This research is aimed at developing or improving models to better characterize the state of the atmosphere and stratosphere in general, with specific emphasis on the flight operation environment specifically, with the aim to provide superior aviation weather products to end users.

AVIATION FORECAST AND QUALITY ASSURANCE

The Product Development Team (PDT) for the Aviation Gridded Forecast System is working on the development of products for dissemination on the Aviation Digital Data System. New algorithms will be developed to present hazardous conditions in the flight operations environment. They will develop a process for automated production of the SIGMETs. There will be capability to assure quality and a real-time verification process.

WEATHER SUPPORT TO DEICING DECISION MAKING (WSDDM)

This system develops products that provide forecasts on the intensity of snow and freezing rain, and how or when these phenomena will change in the short term. This information is needed by airport management to determine when an aircraft will require deicing before take-off. The water content of snow is believed to be an important factor. The output product is designed for non-meteorological aviation users and has been demonstrated at three different airports. Development work has been completed and FAA has made this system available to airport authorities who wish to use it as a decision aid.

CEILING AND VISIBILIT

A development and demonstration is underway in the San Francisco Bay area. The project will have unique sensors and the data will be used in new algorithms to develop improved forecasts. The project will continue over a number of years as progress is evaluated. This project is a joint effort with other Federal agencies and some of the

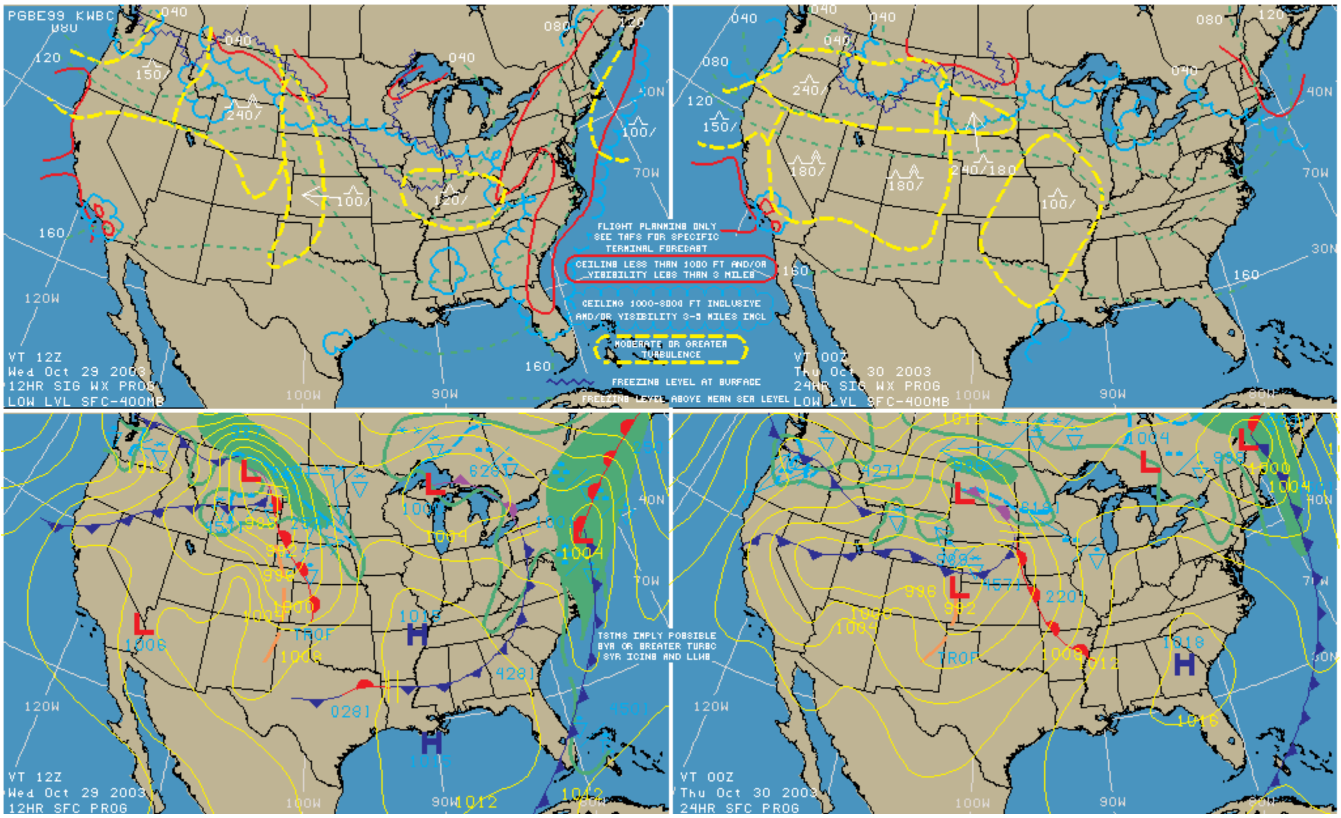


Figure 3-DOT-7. 4-panel Low Level Significant Weather graphics are produced by the Aviation Weather Center and accessible to pilots from their web site. (Source: AWC web site)

effort is performed by academic researchers.

TURBULENC

In addition to the work being performed by the JSAT under the Safer Skies Program, a PDT has a seven-year plan to evaluate wind shear and turbulence around and on the approaches to Juneau, Alaska. Also, they are working with certain airlines to install instruments on aircraft with the capability to measure turbulence as sensed on the aircraft and report this information automatically. The data will be used to verify forecasts and to develop a standard index to report and warn for turbulence.

NEXRAD ENHANCEMENTS

Work is continuing to develop improvements to the existing products and to develop new graphic products. Hardware and software pre-planned product improvements are are being pursued. This is a joint effort between DOT, DOD, and DOC.

Additionally, under the auspices of the OFCM, FAA is investigating the possibilities of developing a multi-use phased array radar to accomplish both weather surveillance and monitor aircraft movement in controlled airspace.

SPACE WEATHER

Space Weather is of concern to the FAA in several areas of operations and regulations. Ionospheric scintillation creates certain errors in the Global Positioning System that affects navigation, especially for instrument approaches to airports. In programs for Wide Area and Local Area Augmentation Systems (WAAS and LAAS) corrections for these effects are being developed. This will be a very important advance to promote the Free Flight management of the National Airspace System. In addition, the effects on the ionosphere have grave impacts on the use of high frequency communications which are essential in air traffic control of flights across the oceans and over the poles of the Earth.

The FAA is embarking on research at the Civil Aeromedical Institute in Oklahoma City, OK, on the radiation effects on fetuses of newly pregnant women when flying at high altitudes and at high latitudes where exposure is increased. The exposure of flight crews to this hazard will be measured to determine if repeated flights in this regime may accumulate deleterious results.

FAA planners for commercial space operations are working on the weather requirements to set criteria for space launch activities. The commercial launch sites in California, Florida and Virginia are co-located with government sites where weather support is available. However, at the new commercial space launch site in Kodiak, Alaska, new criteria must be developed and established for standard procedures.

FEDERAL PROGRAMS IN SUPPORT OF ROAD WEATHER

THE ROAD WEATHER MANAGEMENT PROGRAM

The Federal Highway Administration (FHWA) coordinates a number of activities aimed at improving safety, mobility, productivity, environmental quality and national security on the nation's highways during weather threats. These activities include identification of weather impacts on the roadway environment, traffic flow and operational decisions to build the case for road weather management programs. It also includes research to advance the state of the art concerning road weather management tools, as well as documentation and promotion of the best practices. The FHWA acts through federal aid and national coordination since it does not operate the highway system or environmental observing systems that serve state and local highway operators, private road users, and the traveling public. FHWA activities are conducted as partnerships with other public agencies, private sector vendors, and universities.

Weather cuts across many FHWA and related surface transportation modal activities. Coordination is centered in the Road Weather Management Program within the FHWA's Office of Transportation Operations. Road weather management activities are closely associated with the Intelligent Transportation System (ITS) Program as the framework for advanced road weather information and decision support. Road weather management activities are dependent on, but distinct from, general meteorological activities in two respects. In terms of the geophysical focus, weather must be related to what happens near, on, and under roads as it affects pavements, structures, vehicles, traffic flow and ITS components. In terms of operations, the focus is on the decision making process that uses road weather information as one of many inputs. This has led to a decision-centered approach for defining the program, with road weather information on one side and effective strategies to deal with adverse weather on the other. Program activities are then organized primarily by the ITS subsystems and operational decisions, such as, maintenance management, traffic management and traveler information, and to a lesser extent, emergency management. However, a common information infrastructure, or "infostructure", within ITS includes road weather observations. Environmental observing systems are emerging as contributors to the national weather information system that underlies all general weather products. The FHWA expects that as road weather products advance, there will be a need for greater integration of observation, prediction and science in the total land/air/sea/space environment.

FHWA road weather management activities extend back to the 1970s, but the current coordinating program began in 1997. Over the entire period, the FHWA has achieved both practical successes and developed an expanded vision for the road weather management agenda. There is no question that among the modes in today's operating environment, surface transportation has the most lives, time, and commercial value at risk due to weather threats. The challenge has been to find the right balance across this and other programs. The following sections describe a number of program activities.

THE STRATEGIC HIGHWAY RESEARCH PROGRAM

The United States Congress established the Strategic Highway Research Program (SHRP) under the 1987 Surface Transportation Act. This Act obligated $150 million over five years to improve the performance and durability of our nation's roads. The SHRP program examined a number of different subject areas, but the one most closely related to road weather management was winter maintenance within the highway operations subject area. The research program was active until 1993, producing specifications, testing methods, equipment, and advanced technologies. Following the success of the five-year effort, the FHWA coordinated a national program to work with state and local highway agencies to implement and evaluate the products. This phase, entitled SHRP Implementation, was funded through the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). This Act obligated $108 million over six years, and was administered jointly by the FHWA, the American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB).

The SHRP products encompassed various technology areas. Reports on Anti-icing and Road Weather Information Systems (RWIS), published by 1993, were instrumental in raising awareness of the state of the art among highway operating agencies. Anti-icing techniques, requiring chemical application to pavements before snow fall and ice formation, have had a vital synergy with predictive road weather information, and have in turn led to demand for improved observation and prediction through RWIS.

The SHRP Implementation web site (www4.trb.org/trb/dive.nsf/web/shrp_implementation) contains information on the SHRP Lead States Program, SHRP products under evaluation and implementation, and SHRP in general. An important adjunct to the SHRP anti-icing studies was a follow-up field evaluation of techniques, conducted under the FHWA Test and Evaluation Program. Results appeared in 1998 as *Project No. 28: Anti-Icing Technology*.

After two and half years of study and outreach, the Transportation Research Board Committee for a Future Strategic Highway Research Program (F-SHRP) (www4.trb.org/trb/newshrp.nsf/web/committee?OpenDocument) published *Special Report 260: Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life* (http://trb.org/publications/sr/sr260.pdf). Based upon the strategic direction in this report, the AASHTO Board of Directors passed a resolution in December 2001, supporting F-SHRP and authorizing a National Cooperative Highway Research Program (NCHRP) project to develop detailed research plans. FHWA matched the NCHRP funds and work began on the planning phase of F-SHRP in January 2002. In September 2003, TRB released *Providing a Highway System with Reliable Travel Times* that outlines the Reliability Research Program to address the root causes of unreliable travel times. These causes include adverse weather, traffic incidents, work zones, and special events. By concentrating research resources over the six-year life span of F-SHRP, significant gains can be made in effectively dealing with theses causes of unreliable travel times. Implementation of the F-SHRP plan is dependent upon its level of support within SAFETEA.

THE INTELLIGENT TRANSPORTATION SYSTEMS (ITS) PROGRAM

The synergy of road treatment strategies and RWIS development continues in the FHWA Road Weather Management Program and is strongly allied with the ITS Program. The ISTEA of 1991 established the ITS Program, including its research program that funds most of the FHWA Road Weather Management Program activities. The ITS Program in the United States is overseen by the ITS Joint Program Office (ITS-JPO), which is a cross-modal program hosted in the FHWA.

While ITS initially focused on automated highways and metropolitan areas, a rural focus was initiated in 1996. The rural ITS program identified maintenance and weather as additional ITS focus areas, and recognized the need for total integration of the maintenance, traffic, and emergency management functions across wide areas and between states. Maintenance management continued the SHRP heritage as the main focus of road weather concerns when the Road Weather Management Program was formed, initially as the FHWA "Weather Team", in 1997. However, the long-term agenda continues to integrate road weather across management functions, across modes, and for traveler information. The research activities below are within this overall weather-across-ITS strategy. Intelligent Transportation Systems are also the logical informational interfaces with the national weather information system.

The ITS Joint Program Office has also begun the Vehicle Infrastructure Integration (VII) initiative (www.its.dot.gov/vii/index.htm) to explore the potential of cooperative vehicle highway systems to provide real-time information, and support advanced safety applications. VII could be a significant enabler of weather-related applications, such as vehicle-based sensors that gather environmental data system-wide. This resulting communications network would allow weather, traffic and other information to be transmitted to transportation operators providing a real time view of the conditions on every major road within the transportation network. Such concepts will be explored as the initiative matures. The functional architecture and requirements for VII are under development. Preliminary documents describe some of the weather-related data items that could be directly measured or inferred from vehicle sensor systems including precipitation detection, ambient air temperature, fog or visibility information, and road traction state or mobility.

NATIONAL ITS ARCHITECTURE AND ITS STANDARDS

ITS uses open system principles: a uniformly defined modular structure of information processes with known protocols for exchanging information between modules. The information may be free or for a price, but all ITS applications should be able to get the information needed to support transportation management decisions. The National ITS Architecture is the modular structure and was one of the earliest tasks of the ITS program. Several equipment interfaces are standardized under the category of National Transportation Communications for ITS Protocol (NTCIP) standards, and there are associated data object and message set standards. The ITS program is promoting use of the National ITS Architecture and its communication standards as requirements for federal aid to ITS deployments by highway operating agencies.

Road weather information was not an original focus of the National ITS Architecture, and was defined as flowing from external sources with their own architecture and standards. As road weather gains significance in the ITS, and as the interfaces between road weather and atmospheric weather need to be coordinated, the National ITS Architecture is being adapted. Version 2 of the Environmental Sensor Station (ESS) standard will soon be approved. This NTCIP standard specifies data objects and formats between ESS in the field and central processors for the data (e.g., Road Weather Information System (RWIS) and traffic management systems). The ESS standard will be effective in the integration of different vendors' systems, and create a uniform format for ingest of road weather data into general observing systems.

Another standard that is being considered is the Standard for Traffic Management Center Communications. This standard will be augmented to include message sets for exchange of environmental data between management centers.

Following the rural ITS program definition of weather and maintenance as ITS application areas, the National ITS Architecture has developed the Maintenance and Construction Operations (MCO) user service. User services are the application-oriented requirements clusters for the architecture. Detailing of the architecture with respect to road weather and its maintenance applications, through the MCO user service requirements, was completed in 2002. Among the changes is a definition of a Road Weather Information Service terminator in addition to the existing Weather Service terminator. Together, these represent the division of responsibility for road weather information, provided largely by private vendors and based on ESS observations, and weather generally. The interfaces between the two types of services is then defined as being outside of the ITS. However, the FHWA maintains an interest in specific improvement in environmental information that will enhance road weather prediction, such as higher resolution numerical modeling and better characterization of precipitation at the road surface. The interface from the ESS, which is within the ITS, to both the road weather and general weather services, is also of interest to FHWA.

It is hoped that further detailing of weather applications in traffic and emergency management will lead to further architecture developments in the years ahead. As the interface between the ITS and the evolving national weather information system becomes closer, the National ITS Architecture and standards will provide a technical basis for integration and promotion of open system principles. Version 5.1 of the National ITS Architecture can be found at http://itsarch.iteris.com/itsarch/.

ENVIRONMENTAL OBSERVING SYSTEMS (ESS)

Surveillance is fundamental to the ITS. The state of roadways and traffic is basic to almost all ITS applications. The capabilities to observe traffic, road infrastructure, and the roadway environment are becoming a necessary part of roadway facilities themselves. In 2003, the Road Weather Management Program defined the fundamental data needs of the Weather Response component of this information infrastructure to estimate an aggregate cost for deployment of ESS in 61 metropolitan areas across the nation.

Road weather sensing, through the ESS, is a part of this infrastructure. However, there are many aspects to environmental observation, and some substitutability between methods of observation. The authorizing legislation is focused on metropolitan ITS. Clearly, the need for ESS observations extends further. ESS can be a vital part of homeland security, as well as more prosaic hazardous material spill and environmental management. Many types of fixed, mobile, and remote platforms can observe relevant environmental conditions (i.e., atmospheric, pavement, subsurface, and water level conditions). But all observations ultimately support predictive information for decision support applications. In the case of pavement temperature, the critical predictor for anti-icing strategies, heat balance models relying on high-resolution numerical modeling of insolation and radiation can substitute for ESS observations. However, the use of ESS for localized hazard warning versus general area prediction, and the value of reinitializing heat balance models by ESS data require some level of deployment. Over 2,200 ESS are owned by state transportation agencies in the United States as shown in Figure 3-DOT-6. More than 1,700 of these ESS are field components of RWIS.

Remote ESS are generally fixed, with in situ sensors for the usual atmospheric weather variables as well as pavement and subsurface temperature probes, and pavement chemical concentration or pavement freezing point. In some cases, and potentially over all road mileage, mobile environmental sensors are deployed to observe weather and pavement conditions from vehicles.

An important application of the mobile, and potentially remote, sensing is thermal mapping of road segments. This technique provides snapshots of complete pavement temperature profiles and is used both to select fixed ESS sites and to spatially predict temperatures based on time series predictors at the fixed stations. There are future possibilities for remote sensing of "skin temperature" on roads and adjacent surfaces, by Unmanned Aerial Vehicles and satellites (especially the next generation polar orbiters). This could make a limited deployment of fixed sensors more effective and improve the initialization of heat balance models.

At present, ESS data across the United States are neither integrated nor open. The data are not centrally collected, in standard format, available to all users, nor uniformly used. However, regional and national efforts are paving the way for both openness and integration. Mesoscale environmental monitoring networks (or mesonets) within states and across states, usually under university auspices, are integrating the data across many observing systems. The data are used in some cases to validate weather forecasts and analyses, and in the rare case, for ingest into numerical weather prediction models.

The new FHWA initiative, *Clarus*,

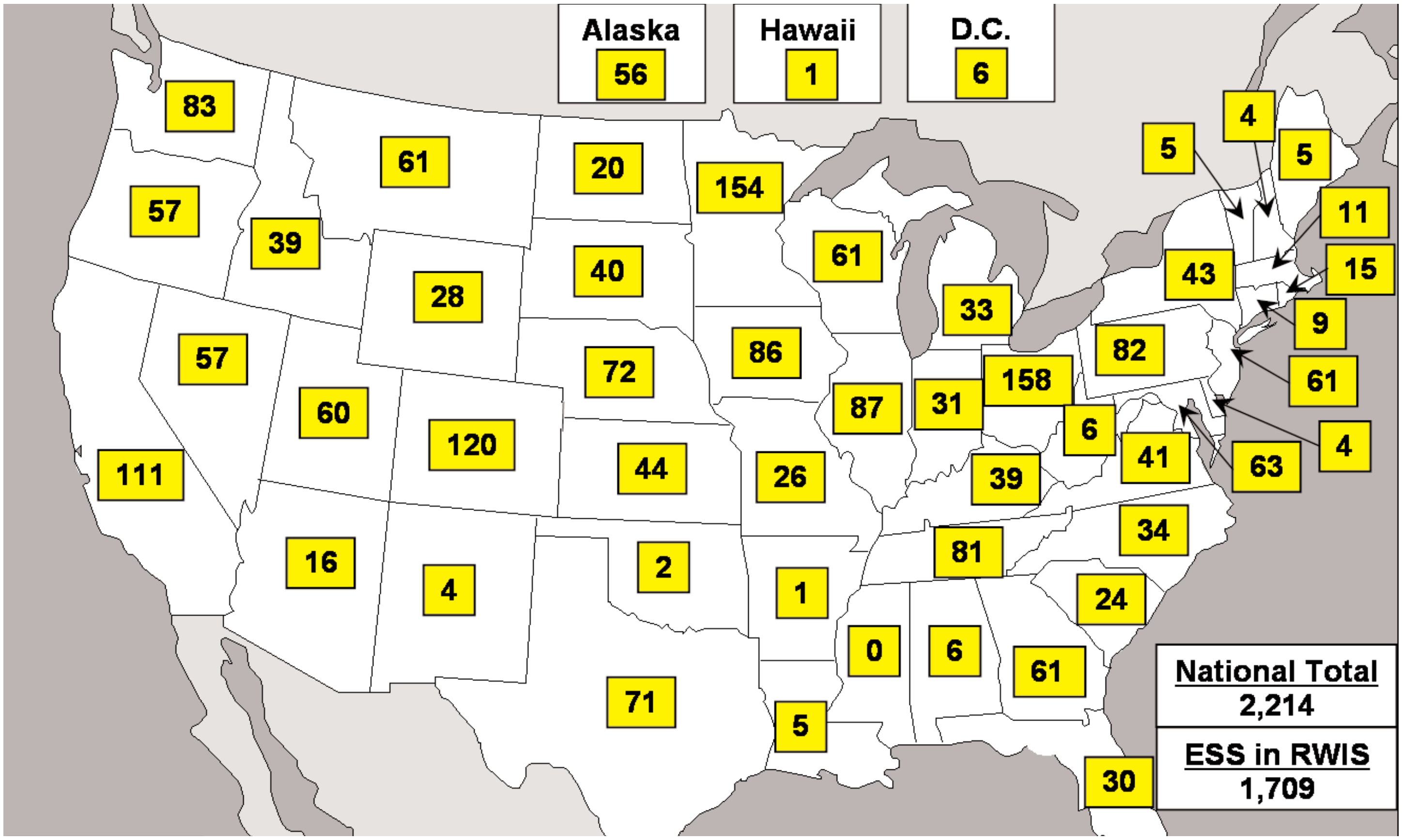


Figure 3-DOT-6. Census of deployed Environment Sensor Station (ESS) units. An ESS is a site measuring atmospheric, pavement and/or water level conditions. Many state transportation agencies deploy ESS as field components of Road Weather Information Systems (RWIS). As shown on the map, there are over 2,214 ESS owned by state transportation agencies. Most of these stations (i.e., 1,709) are part of RWIS and used to support road maintenance activities. The other environmental sensor stations are deployed for various applications including flood monitoring and aviation.

aims to reduce the impact of adverse weather for all road and transit users and operators by designing and demonstrating an integrated road weather observational network, and establishing a partnership to facilitate deployment of a nationwide surface transportation weather observing system. The long-term vision of *Clarus* is that all data from State DOT ESS will be routinely collected, quality-controlled, and translated into an open standard format. Quality assurance algorithms and direct feedback to state DOT points of contact will improve agency awareness of sensor status. Access to robust and calibrated data will be provided through an open Internet data portal. The *Clarus* concept of operations has been completed and the *Clarus* system design is underway. A Proof-of-Concept demonstration is planned in the fall of 2006.

In order to address all these observing issues, the FHWA is participating in multiple OFCM bodies, including the new Weather Information for Surface Transportation (WIST) Working Group, the Phased Array Radar (PAR) Joint Action Group, as well as the Committee on Integrated Observing Systems (CIOS). FHWA is also participating in NOAA's efforts to explore the modernization of the cooperative observer network and development of an Integrated Surface Observing System (ISOS).

The focus of the FHWA remains on the application of ESS observations to road weather management decision-making. From 2001 to 2003, the FHWA sponsored five research projects, under the Cooperative Program for Meteorological Education and Training (COMET) (www.comet.ucar.edu), which became the first to add state DOTs to the traditional partnerships of NWS forecast offices and universities. The COMET projects in Iowa, Nevada, New York, Pennsylvania, and Utah fostered sharing of environmental data and facilitated advanced meteorological modeling to enhance road weather forecasts. Ultimately, these efforts will contribute to the development of decision support tools for winter maintenance managers, traffic managers, and the traveling public. Lessons learned from these projects can help all state DOTs better manage RWIS networks and achieve maximum utility from RWIS data.

In order to enhance observation capabilities and define requirements for road weather observing systems, the Road Weather Management Program worked with the Aurora RWIS Pooled Fund Program and the AASHTO Snow and Ice Cooperative Program to produce the *Road Weather Information System ESS Siting Guidelines* (http://ops.fhwa.dot.gov/publications/ess05/). The guidelines provide a set of recommendations to support uniform siting of ESS that collect road and weather observations for RWIS. These guidelines are intended to help establish uniformity and to improve the usefulness of road weather information derived from ESS observations. The document provides siting criteria that satisfy as many road weather monitoring, detection, and prediction requirements as possible.

DECISION SUPPORT

Under previous efforts within the program, road weather users identified information requirements as the trinity of "relevance, accuracy and timeliness". Those criteria were selected primarily in reaction to synoptic scale forecasts that were: (1) not relevant to climatically localized road hazards; (2) not accurate at such points or at the long time horizons predicted for; and (3) not delivered more than the twice daily nor at frequent prediction times in between.

Improvements in that situation, including National Centers for Environmental Prediction (NCEP) models at mesoscale resolution updated as frequent as hourly, are significant. The related improvements in regional and private numerical prediction are also helpful, but only partially driven by road weather information requirements. This is what motivated the attention away from environmental prediction to the fusion and presentation of existing information, whatever its quality. This was in response to the evident problem that almost all weather-related transportation decisions do not rely on one information source, nor on atmospheric information alone. The gap most in need of attention-between increasingly good and plentiful information, and operational decision-making is the focus of FHWA's decision support research and development.

Decision support is where road weather data tailoring occurs. Each operational decision is specific to a type of road weather management strategy, a particular place and time, and the characteristics of the decision maker (i.e., their expertise, their location, their information processing equipment). Road weather management strategies mitigate weather impacts by advising motorists of prevailing and predicted conditions (e.g., traveler information), controlling traffic flow and roadway capacity (e.g., weather-responsive traffic signal timing, road closure), and/or treating roads to minimize or eliminate weather threats (e.g., anti-icing/deicing). Such strategies are consistent with the FHWA's Office of Transportation Operations vision of creating 21st century highway operations using 21st century technology. In most cases, projects to support decisions about weather threats have also made some contribution to the environmental prediction inputs. The following are several important projects undertaken with FHWA support.

In 1999 and 2000, decision support requirements, first generally and then specifically for winter road maintenance, were studied in the Surface Transportation Weather Decision Support Requirements (STWDSR) project. This project used weather threat scenarios to identify specific decisions made in winter road maintenance, their timing, and the expected confidence of the decisions at various time horizons. General requirements for emergency managers, traffic managers, and road users were also defined. The STWDSR project became an important contributor to the OFCM's WIST needs analysis, the National ITS Architecture modifications, and to the Maintenance Decision Support System (MDSS) prototype project.

In 2005, the Missouri DOT will continue prototype efforts on a Weather Response System to support transportation system operations. The Weather Response System will use products from the NWS, the private sector, state agencies and other sources to create and demonstrate decision support tools tailored for traffic managers.

SUPPORT FOR MAINTENANCE MANAGERS

The Maintenance Decision Support System (MDSS) project is a multi-year effort to prototype and field test decision support components for winter maintenance managers that began in late 1999. The MDSS was designed by a consortium of national laboratories, based on the requirements articulated by maintenance managers, to help the managers improve roadway level of service during winter weather, and to minimize road treatment costs, by optimizing use of labor, materials, and equipment. This data management tool has advanced weather prediction and road condition prediction capabilities, including air and pavement temperatures, precipitation start/stop times, precipitation types and accumulation amounts. These predictions are fused with customized winter road maintenance rules of practice to generate route-specific treatment recommendations (i.e., strategy, timing, and material application rates).

From February to April 2003, the first functional MDSS prototype was demonstrated and evaluated in three Iowa DOT maintenance garages. The main display of the demonstration prototype, shown in Figure 3-DOT-7, includes predicted weather and road conditions, a weather parameter selection menu, a map of roads and weather alerts, as well as forecast animation controls. Lessons learned from the preliminary demonstration were used

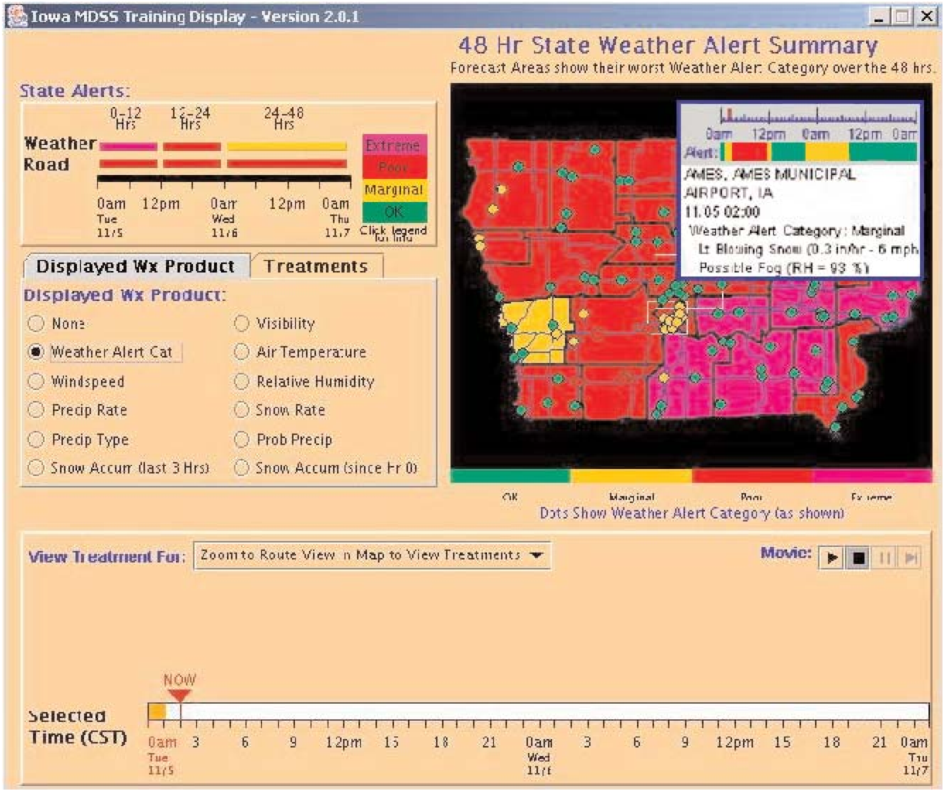


Figure 3-DOT-7 . Schematic of FHWA's Maintenance Decision Support System.

to enhance the prototype prior to a second demonstration from December 2003 to March 2004. Version 2.0 of the MDSS software was released in the fall of 2003. Version 3.0 was made available in November 2004. During winter 2004-2005, the demonstration domain was moved to Colorado to assess prototype capabilities in complex terrain. Lessons learned and recommendations for additional enhancements will be presented at the 7th MDSS Stakeholder Meeting in October 2005.

The focus of this project has changed from prototype development to proactive outreach, deployment assistance, technology transfer, and target enhancements for other surface transportation sectors. In concert with the 6th stakeholder meeting in July 2004, there was a technology transfer workshop for private sector companies that are interested in integrating one or more MDSS prototype modules into their product lines.

Such efforts support the FHWA deployment strategy, which consists of the private sector building end-to-end products based on the core MDSS prototype functionality. These products will be procured by public agencies (e.g., state DOTs), enabling both the private and public sectors to benefit from millions of dollars of high-risk research. One example of technology transfer is the MDSS Pooled Fund Study (PFS) project led by the South Dakota DOT. Other participants include the state DOTs in Colorado, Indiana, Iowa, Minnesota, and North Dakota, as well as Aurora (a pooled fund research program), a private vendor, and the FHWA. The objective of the project is to build, evaluate, and deploy an operational MDSS. The PFS project is refining model components and conducting extensive field tests. Deployment of an operational system is planned in 2006. Additional information on the MDSS projects can be found at www.rap.ucar.edu/projects/ rdwx_mdss.

SUPPORT FOR TRAFFIC MANAGERS

A 2001 survey of 21 traffic management centers found that nearly 90 percent received some general weather information and over 60 percent used customized weather data. In January 2003, the Road Weather Management Program released the *Weather-Responsive Traffic Management Concept of Operations* highlighting the weather-related needs of managers responsible for freeway and arterial route operations. This draft concept of operations addressed road weather data collection, assessment of weather impacts on roadway networks, operational strategies to control traffic and advise motorists during adverse weather, and research needs. It serves as the basis for future work to develop, test, and evaluate these mitigation strategies. The need for a systematic approach to the significant challenge of managing traffic during inclement weather is discussed in the *Research Needs for Weather-Responsive Traffic Management* paper presented at the TRB Annual Meeting in January 2004.

Empirical studies of traffic flow and driver behavior during inclement weather will be completed in 2005. The Road Weather Management Program is working with FHWA's Office of Operations Research and Development to collect empirical traffic, weather, and pavement condition data on both freeway and arterial routes to quantify weather impacts on driver behavior, traffic speeds, traffic volumes, and travel time delay. This research will increase the understanding of how traffic flow and driver behavior change under adverse weather conditions. Once these factors are better understood, the information can be incorporated into traffic simulation models and, ultimately, end user tools.

In 2005, the FHWA expects to disseminate study results to increase awareness of weather impacts among

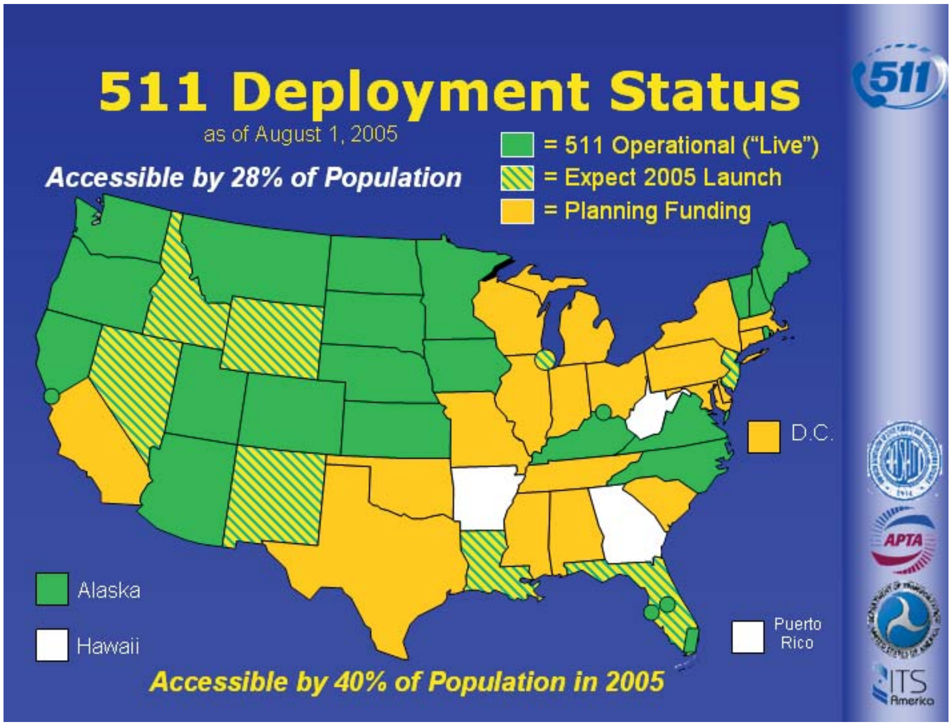


Figure 3-DOT-8 . 511 National Traveler Information Telephone Number Deployment.

operating agencies, to sponsor and encourage others to conduct subsequent studies on weather and traffic modeling, and to promote deployment of weather-responsive traffic management strategies and tools.

511-THE NATIONAL TRAVELER INFORMATION TELEPHONE NUMBER

Just as dialing 911 is the standard way to access emergency aid over the telephone, it was thought that a standardized number for travel information would be beneficial. Accordingly, a broad coalition of ITS interests, with technical support to the FCC docket submission by the FHWA, achieved in 2001, the allocation of a national 511 traveler information telephone number. In 2002, the FHWA sponsored a number of grants to plan for state deployment of 511 services, and guidelines were issued on service content (Figure 3-DOT-8). A survey on traveler information conducted by ITS America indicated that weather and road condition information was highest in demand by travelers. Therefore, road weather information should be a key component of 511 services. The means of delivering information through 511 are still being developed, including ways to serve peak demands for emergency evacuation information, as part of the homeland defense or other threat capability.

In June 2003, the 511 Deployment Coalition released a Deployment Assistance Report, *Weather and Environmental Content on 511 Systems*, to recommend basic content and provide for consistency in 511 systems as they are deployed across the country. Since these systems are in their infancy, gaps exist in defining the types of road weather information travelers desire, appropriate data formats, and the frequency and detail needed for travelers to make safe and effective decisions. The Road Weather Management Program participates in 511 deployment conferences to help establish road weather data requirements and close these gaps. The 511 program also must find ways to complement NOAA Weather Radio broadcasts (and eventually an all-hazards warning system), and use the NWS official watches and warning information.

The 511 capability is just one more way in which ITS is becoming a significant dissemination means for road weather information. As of August 2005, 511 services were operational in 23 states and available to over 28 percent of the population. Additional 511 services are expected to be launched in eleven more states during 2005.

WEATHER IMPACTS ON ROADWAY SAFETY, MOBILITY & PRODUCTIVITY

While the costs of weather to surface transportation are immense, it has been difficult to quantify specific costs or the benefits (as avoidable costs) through better information to support better weather response and mitigation strategies. It is likely that the costs to mobility, in terms of delay due to weather, are the largest component. Initial estimates of the economic impact of weather-related delay on trucks in the 20 major metropolitan areas most affected by adverse weather is on the order of $2 billion per year.

Some delays are due to well-defined closure events. These are due to storms that swamp reasonable treatment activities, but could benefit from more authoritative travel-demand management techniques. This leaves the much more prevalent, and subtle, delays due to more minor threats, like rain, residual snow, or visibility impairments that are difficult to treat in any way. Traffic management strategies to address them must be based on very good observations and dynamic predictions of weather, pavement and traffic conditions. However, it is clear from traffic flow theory that with heavy volumes, as in metropolitan areas at peak times, very small changes in effective capacity (as due to a change in road friction) or very small changes in traffic volume can have large delay effects.

The FHWA is sponsoring closer analysis of delay effects due to weather, work zones and incidents. Paucity of good traffic and road weather data sets has hindered the analysis, but in 2001 and 2002, analyses were conducted for Seattle, Washington and Washington, DC metropolitan areas. These analyses combined surface weather observations with traffic speed data, both empirical and modeled. The results have been consistent in showing about a 12 percent increase in travel time averaged over a wide range of weather events. A second analysis of delay effects in Washington, DC was conducted with archived Doppler radar data for more precise and more dynamic inference of road weather conditions. Analysis results indicated that during peak periods travel time increases by roughly 24 percent when precipitation is present. Better understanding of weather-traffic interactions can, in turn, lead to a stronger attack on delays through traffic management practices, including speed management, access control (e.g., road closure), motorist warning systems, and weather-responsive signal timing.

ROAD WEATHER MANAGEMENT PROGRAM OUTREACH AND TRAINING

The Road Weather Management Program web site (www.fhwa.dot.gov/weather/) was redesigned in January 2004. The site contains information on program objectives and initiatives, weather impacts, benefits of road weather management strategies, technologies to help mitigate weather impacts, training, upcoming events, and other resources such as a listing of over 200 road weather related publications.

Among the most useful resources on the site are the best practices of maintenance managers, traffic managers and emergency managers in response to various weather threats. This resource contains 30 case studies of systems in 21 states that improve roadway operations in adverse weather, as well as an overview of environmental sensor technologies. Each case study has six sections including a general description of the system, system components, operational procedures, resulting transportation outcomes (i.e., improved safety, mobility and/or productivity), implementation issues, as well as contact information and references. Examples of successful road weather management strategies follow.

A maintenance division of the Montana DOT employed mobile anti-icing and de-icing strategies to proactively respond to winter storms. When performance was compared to a maintenance division that used reactive treatment after storms, it was found that average treatment costs (i.e., labor, materials, and equipment costs) for the proactive division were 37 percent lower. Additionally, a higher level of service was achieved on road sections treated by the proactive division resulting in safety and mobility improvements.

On a 19-mile section of Interstate 75 in Tennessee, a fog detection and warning system collects data from two ESS, eight fog detectors, and 44 vehicle speed detectors to predict and detect conditions conducive to fog formation. When established threshold criteria are met, traffic managers may select pre-programmed dynamic message sign (DMS) messages, prerecorded highway advisory radio (HAR) broadcasts, and/or alter speed limits via variable speed limit signs based upon response scenarios proposed by the system. When visibility is less than 240 feet, the worst-case scenario, the Highway Patrol activates eight automatic ramp gates to close the affected interstate section and detour traffic to US Route 11. Between 1973, when the interstate opened, and 1994; there were over 200 crashes, 130 injuries and 18 fatalities on this highway section. Since the fog detection and warning system began operating in 1994, safety has been significantly improved and no fog-related accidents have occurred.

During the Hurricane Floyd evacuation in 1999, traffic and emergency managers with South Carolina DOT and the State Highway Emergency Patrol had not agreed on a lane reversal plan for Interstate 26 prior to hurricane landfall. As a result, there was severe congestion on this route with a maximum per lane volume of roughly 1,400 vehicles per hour. Managers quickly developed a lane reversal plan for reentry operations. Portable DMS and HAR transmitters were deployed to alert travelers of closures and alternate routes, and westbound lanes were reversed. Maximum volumes during reentry exceeded 2,000 vehicles per hour per lane, a 43 percent increase over evacuation volumes. The use of lane reversal and traveler information techniques improved mobility by significantly increasing roadway capacity.

A key outreach activity is the annual Eastern Winter Road Maintenance Symposium & Equipment Expo (or Snow Expo). Over the past ten years, FHWA has partnered with state agen-

Figure 3-DOT-9. Dynamic message signs enable drivers to take precautionary actions based on weather conditions.

cies to host the Snow Expo, which provides a forum for sharing information and technologies used to counter the effects of winter weather. More information on the Snow Expo can be found at www.easternsnowexpo.org.

The FHWA sponsors training programs and conducts outreach to promote Road Weather Management Program products and activities. In 2005, a one-day training course on *Principles and Tools for Road Weather Management* will be offered through the National Highway Institute--Course Number 137030A. The course is aimed at helping those involved in highway maintenance and operations develop techniques and strategies for tackling road weather problems. The course will provide basic knowledge of meteorology and address the technological resources available to support highway personnel in making effective road weather management decisions. Additional details will be listed on National Highway Institute web site (www.nhi.fhwa.dot.gov) when course content and schedules are finalized.

The computer-based Anti-Icing/RWIS Training Program is a comprehensive, interactive training program for winter operations that was jointly developed by AASHTO, with support from FHWA and Aurora. The training program covers an introduction to anti-icing and winter maintenance, winter road maintenance management, winter roadway hazards and principles of overcoming them, weather basics, weather and roadway monitoring for anti-icing decisions, computer access to road weather information, and anti-icing practice in winter maintenance operations.

The Federal Railroad Administration (FRA) supports improving the collection, dissemination, and application of weather data to enhance railroad safety through the Intelligent Weather Systems project, as part of the Intelligent Railroad Systems and Railroad System Safety research programs. These programs address safety issues for freight, commuter, intercity passenger, and high-speed passenger railroads.

Intelligent weather systems for railroad operations consist of networks of local weather sensors and instrumentation - both wayside and on-board locomotives - combined with national, regional, and local forecast data to alert train control centers, train crews, and maintenance crews of actual or potential hazardous weather conditions. Intelligent weather systems will provide advance warning of weather caused hazards such as flooding; track washouts; snow, mud, or rock slides; high winds; fog; high track-buckling risk; or other conditions which require adjustment to train operations or action by maintenance personnel (Figure 3-DOT-10).

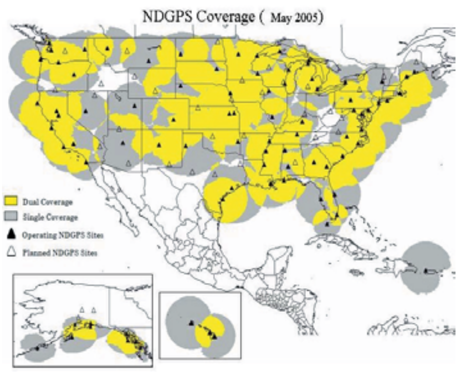
Weather data collected on the railroad could also be forwarded to weather forecasting centers to augment their other data sources. The installation of the digital data link communications network is a prerequisite for this activity.

FRA intends to examine ways that weather data can be collected on railroads and moved to forecasters, and ways that forecasts and current weather information can be moved to railroad control centers and train and maintenance crews to avoid potential accident situations. This is one of the partnership initiatives identified in the National Science and Technology Council's *National Transportation Technology Plan.*

Figure 3-DOT-10. Track washed out by flood waters from Hurricane Alberto.

WEATHER FORECASTING ENHANCED BY NATIONWIDE DIFFERENTIAL GLOBAL POSITIONING SYSTEMS

Nationwide Differential Global Positioning System (NDGPS) is a system of reference stations that monitors GPS and broadcast corrections, which can be used by the GPS receiver to improve the accuracy, integrity and availability of the GPS position.

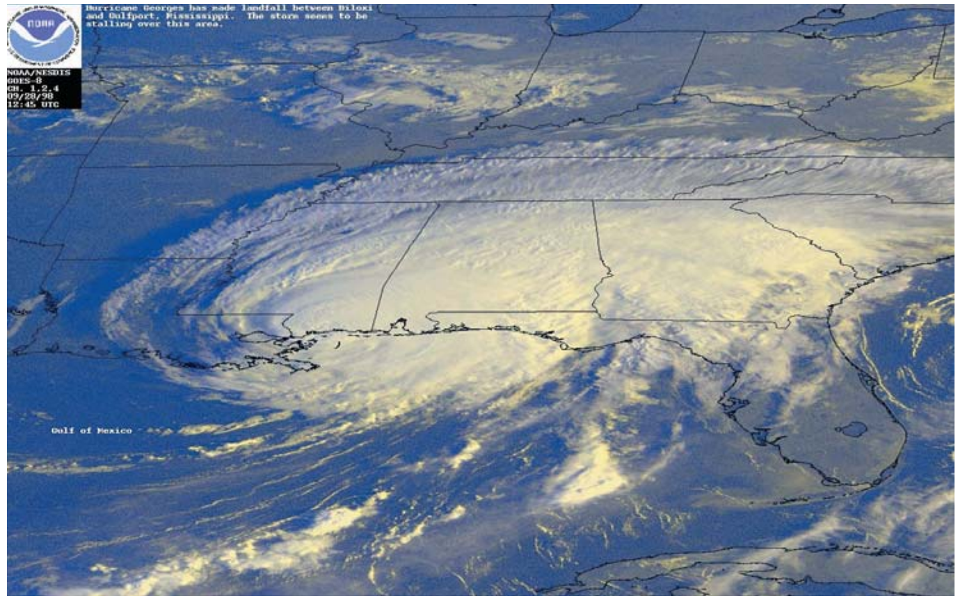


NDGPS is used in a myriad of applications including: maritime navigation, positive train control, precision farming, dredging, graphic information systems and surveying. The Forecast Systems Library (FSL) in the National Oceanic and Atmospheric Administration (NOAA) developed a unique system that very accurately measures the amount of water vapor in the atmosphere by taking advantage of the dual-frequencies, reference station receivers at the NDGPS sites and a suite of weather sensors added to each reference station. The weather sensors, circled in the photo to the right and

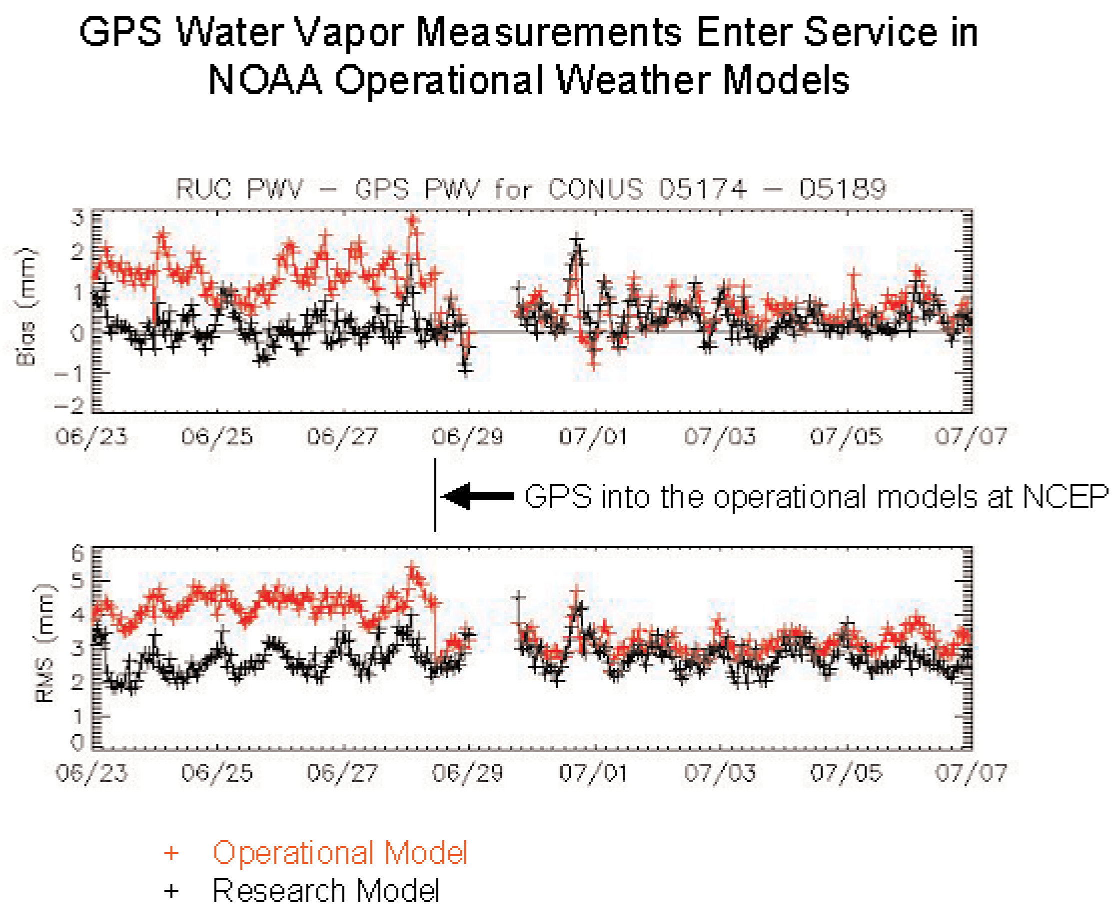
above, measure temperature, relative humidity and barometric pressure. The GPS satellites broadcast on two frequencies, L1 and L2. The FSL uses these two frequencies to correct for the ionospheric delay that is caused by changes in the refractive index associated with the concentration of free electrons in the upper atmosphere. The ionospheric delay is usually about 6-10 times greater than the signal delay caused by the neutral, non-electrically conducting, atmosphere. FSL can than estimate the signal delays caused by the neutral atmosphere by comparing the errors in position between sites that are over 500 km apart by viewing the same satellites for about 30 minutes. Most of the delay in the troposphere (lower atmosphere) is caused by the mass of the atmosphere, or the hydrostatic component, while the induced dipole moment of the water vapor molecules in the atmosphere is responsible for the rest of the delay.

The FSL can accurately estimate the hydrostatic delay by putting a pressure sensor at the NDGPS site and mapping the surface pressure into signal delay using well-known physical relationships. Subtracting the hydrostatic delay from the observed tropospheric delay gives the wet signal delay caused by water vapor in the atmosphere. Then, the wet delay is mapped into the quantity of water vapor responsible for the delay using information about the temperature of the atmosphere and the characteristics of the air at microwave frequencies.

This results in the equivalent height of a column of water that would form if all of the water vapor in the atmosphere were to fall or precipitate. The total precipitable water vapor content is a direct measure of how much raw material is in the atmosphere in the form of rain, snow, hail and clouds. As the water vapor changes state from gas to liquid to solid and back again, it releases or absorbs energy associated with the latent heat bound-up in the molecules. This energy release and absorption is the primary energy responsible for weather. The reason that water vapor is hard to measure is that it only manifests itself when it changes state, and most instruments that can observe water in its gaseous state do not work well under all weather conditions. However, NDGPS works remarkably well in all weather conditions.



Water vapor is the most important component of weather and the least observed. In June 2005, the research and development program to evaluate the use of NDGPS data became an



operational program feeding near-real time data into NOAA's operational models. The addition of this data has greatly improved the model and short-term weather forecasts, especially during periods of active weather such as fronts, hurricanes or tornadoes.

The Federal Railroad Administration will continue to work with NOAA's Forecast Systems Laboratory and the Coast Guard to install weather sensor systems at all of the NDGPS sites as they are built.

NATIONWIDE SURFACE TRANSPORTATION WEATHER OBSERVING AND FORECASTING SYSTEM - *CLARUS*

The weather products available today through both public and private resources are insufficient to meet the demands of transportation operations. Nearly all weather forecasting today is based on observations of the atmosphere. However, the greatest impact of weather events on the safety and mobility of travelers and freight occurs on the surface. Many state DOT's have invested in road weather information systems that provide their agencies with observations on conditions at the surface and just below the surface. Other entities such as agriculture, water districts, electric utilities, and railroads also operate weather observation stations. FRA is developing a partnership with Federal Highways Administration, state DOT's, NOAA and others to establish a nationwide road weather observation network known as *Clarus*.

The goal of the *Clarus* project is to tie this mosaic of private and public observation stations into a cohesive weather forecasting system that is specifically focused on surface conditions.

The Federal Transit Administration's (FTA) mission is to provide leadership, technical assistance and financial resources for safe, technologically advanced public transportation which enhances all citizens' mobility and accessibility, improves America's communities and natural environment, and strengthens the national economy.

FTA's vision for public transportation is clearly making it the transportation mode of choice in America. Public transportation in America can set the standard for "world-class" transportation service, where thriving communities grow with public transportation and access is provided for everyone to fully participate in American life. Through the more than $7 billion annual assistance to the nation's transportation system, FTA maintains the Federal commitment to public transportation.

On a daily basis, transit systems safely and efficiently move millions of people, reducing congestion, facilitating economic development, and connecting people to their jobs and communities. When combined with state and local funding, FTA's assistance promotes sustainable community development, while addressing critical safety and security issues.

Several major initiatives are underway to make the vision a reality, including: designing and delivering an assistance program for the multi-billion dollar-effort to support the lower Manhattan Recovery project; implementing strategies to annually increase transit ridership; and creating a national portfolio of security products and services for transit systems.

Figure 3-DOT-11. A city transit bus attempts to maintain its schedule while safely navigating snow-covered downtown streets.

Figure 3-DOT-12. Minnesota Metro Transit's Hiawatha Light Rail will operate along a 12-mile track from downtown Minneapolis to the southern suburbs of Bloomington.

Buses form the backbone of our nation's transit systems. About 58 percent of all transit users take the bus, and even in many cities with extensive rail systems, more people ride the bus than take the train (Figure 3-DOT-11). One hundred gallons of fuel can be saved each year for every person riding the bus instead of driving. The savings by rail riders are even greater. In this context, FTA assists in providing an energy efficient means of transporting people, thereby, reducing emissions caused by transportation and lessening the Nation's dependence on fossil fuels, including foreign oil (Figure 3-DOT-12).

The United States Department of Transportation has a variety of research development and demonstration programs and initiatives that are targeted at reducing the emissions and improving the efficiency of vehicles including trucks, buses, marine vessels, airport support equipment, and other specialty vehicles. One of FTA's newest initiatives will also look at enhancing research in these and other areas, as a means to support increased annual transit ridership, increased readiness, and more effective program planning and oversight that is responsive to industry needs.

DEPARTMENT OF AGRICULTURE WEATHER PROGRAMS

The Nation's food and fiber products are a critical resource impacting our domestic and international economic situation and are essential for ensuring our national security and shaping foreign policy. Weather is the most important factor influencing the Nation's variability in crop yields and related production. The United States Department of Agriculture (USDA) monitors global weather and agricultural developments through the Joint Agricultural Weather Facility (JAWF). The JAWF provides critical information to decision-makers formulating crop production forecasts, programs that provide natural disaster assistance to U.S. farmers and ranchers, emergency relief programs, and trade policy. USDA operates specialized weather observing networks such as SNOTEL, SCAN, and RAWS that provide vital data and information used to forecast seasonal water supplies in the West, to support national conservation programs, and to monitor the health of the Nation's forests. USDA conducts supporting research that focuses on understanding the interactions of weather and climate with plants, animals, forests, and forest ecological systems.

Numerous agencies within the United States Department of Agriculture (USDA) require a wide range of high quality weather and climatological data to successfully carry out their missions. Some of the diverse applications that require accurate, timely, and comprehensive data include crop monitoring and weather impact assessment, agricultural yield and productivity modeling, natural resource conservation planning, forest fire potential monitoring, irrigation scheduling, water supply information, reinsurance and compliance programs, crop disaster assistance and emergency relief programs, integrated past management, crop yield modeling, and agricultural research studies. The following is a brief description of agency weather activities.

OFFICE OF THE CHIEF ECONOMIST /WORLD AGRICULTURAL OUTLOOK BOARD

The World Agricultural Outlook Board (WAOB), in cooperation with National Weather Service's (NWS) Climate Prediction Center, staffs and supports the Joint Agricultural Weather Facility (JAWF). Created in 1978 as an operational unit, JAWF meteorologists work as a team, monitoring global weather conditions and preparing real-time agricultural assessments (Figure 3-USDA-1). These assessments keep USDA commodity analysts, the Office of the Chief Economist (OCE), and the Secretary of Agriculture and top staff well informed of worldwide weather related developments and their effects on crops and

Figure 3-USDA-1. Joint Agricultural Weather Facility Home page.

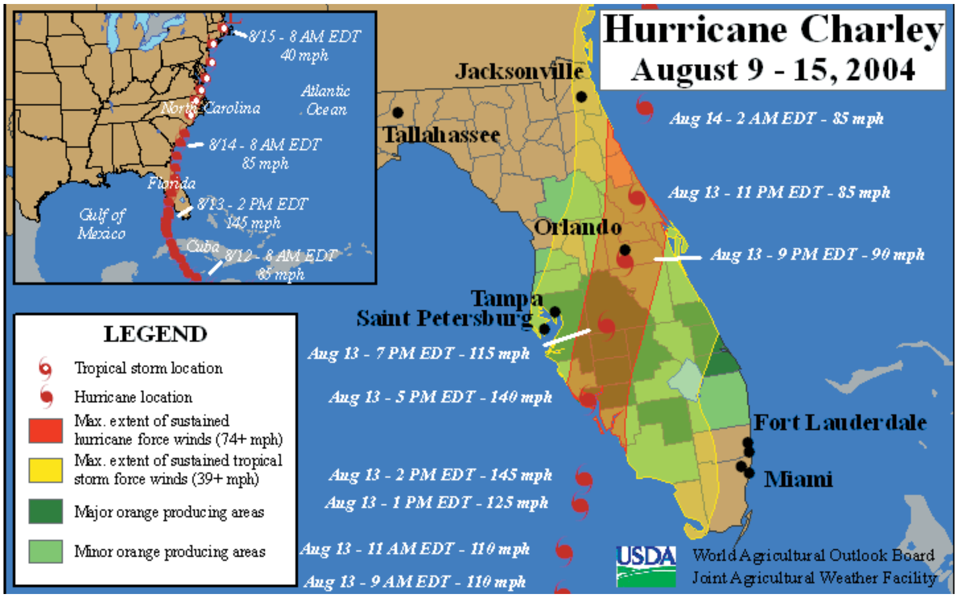


Figure 3-USDA-2. Special agricultural assessment example - Hurricane Charley.

livestock. In addition to providing these routine assessments, WAOB agricultural meteorologists are frequently requested to prepare special assessments when adverse or anomalous weather conditions (i.e., droughts, heat waves, freezes, floods) are observed in major crop producing regions. An example of an assessment made during Hurricane Charley is shown in Figure 3-USDA-2. This special assessment was prepared using sophisticated GIS tools, overlaying the track and sustained wind speeds of the hurricane over Florida orange producing areas. When integrated with economic analyses and information, these routine and special crop-weather assessments provide critical information to decision-makers formulating crop production forecasts and trade policy.

The JAWF serves as the USDA's focal point for weather data received from the World Meteorological Organization's (WMO) Global Weather Observing System. These data are used at JAWF and other USDA agencies for a number of agricultural applications. Another major source of domestic weather and climate data that is used by USDA comes from the NWS's Cooperative Observer (COOP) Network. WAOB agricultural meteorologists merge the weather data with climatological analyses and global agronomic data, to determine the weather's impact on crop development and yield potential. Weekly briefings are provided to USDA commodity analysts and top staff. The Senate and House Agricultural Committees periodically request agricultural weather briefings that focus on the severity and impact of drought, heat waves, and excessive wetness in major crop areas around the Nation.

JAWF's flagship publication is the Weekly Weather and Crop Bulletin (WWCB). First published in 1872 as the Weekly Weather Chronicle, the publication has evolved over the past 132 years into one that provides a vital source of information on weather, climate, and agricultural developments worldwide. The publication is a shining example of how two major departments within the federal government can mutually cooperate, combining meteorology and agriculture to provide a service that benefits the economic well being of the nation (Figure 3-USDA-3). The WWCB highlights weekly meteorological and agricultural developments on a national and international scale, providing written summaries of weather and climate conditions affecting agriculture, as well as detailed maps and tables of agrometeorological information that are appropriate for the season. The WWCB is available in electronic form over the Internet at the following address: http://www.usda.gov/agency/oce/waob/jawf/.

Drought is the leading hazard in economic losses each year in the United States. In the summer of 1999, a monitoring tool known as the Drought Monitor was developed to help assess drought conditions in the United States. The Drought Monitor is a collaborative effort between federal and academic partners, including the University of Nebraska-Lincoln National Drought Mitigation Center, the USDA/OCE/WAOB/JAWF, the NOAA/NWS/CPC, and the NOAA/NESDIS/ National Climatic Data Center. Eight lead authors rotate the responsibility of preparing the Drought Monitor. Produced on a weekly basis, the Drought Monitor is a synthesis of multiple indices, outlooks, and impacts depicted on a map and in narrative form. The official web site for the Drought Monitor can be found

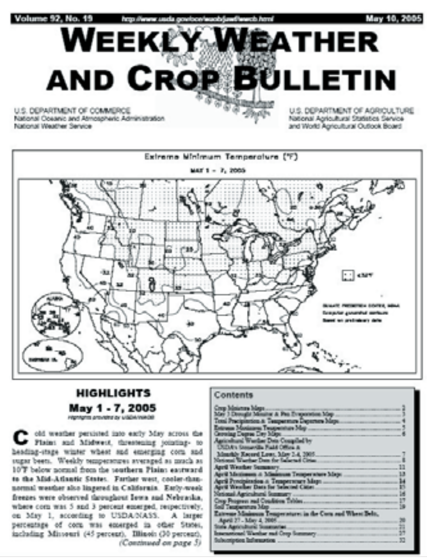


Figure 3-USDA-3. *Weekly Weather and Crop Bulletin* is a joint effort of between the Departments of Agriculture and Commerce.

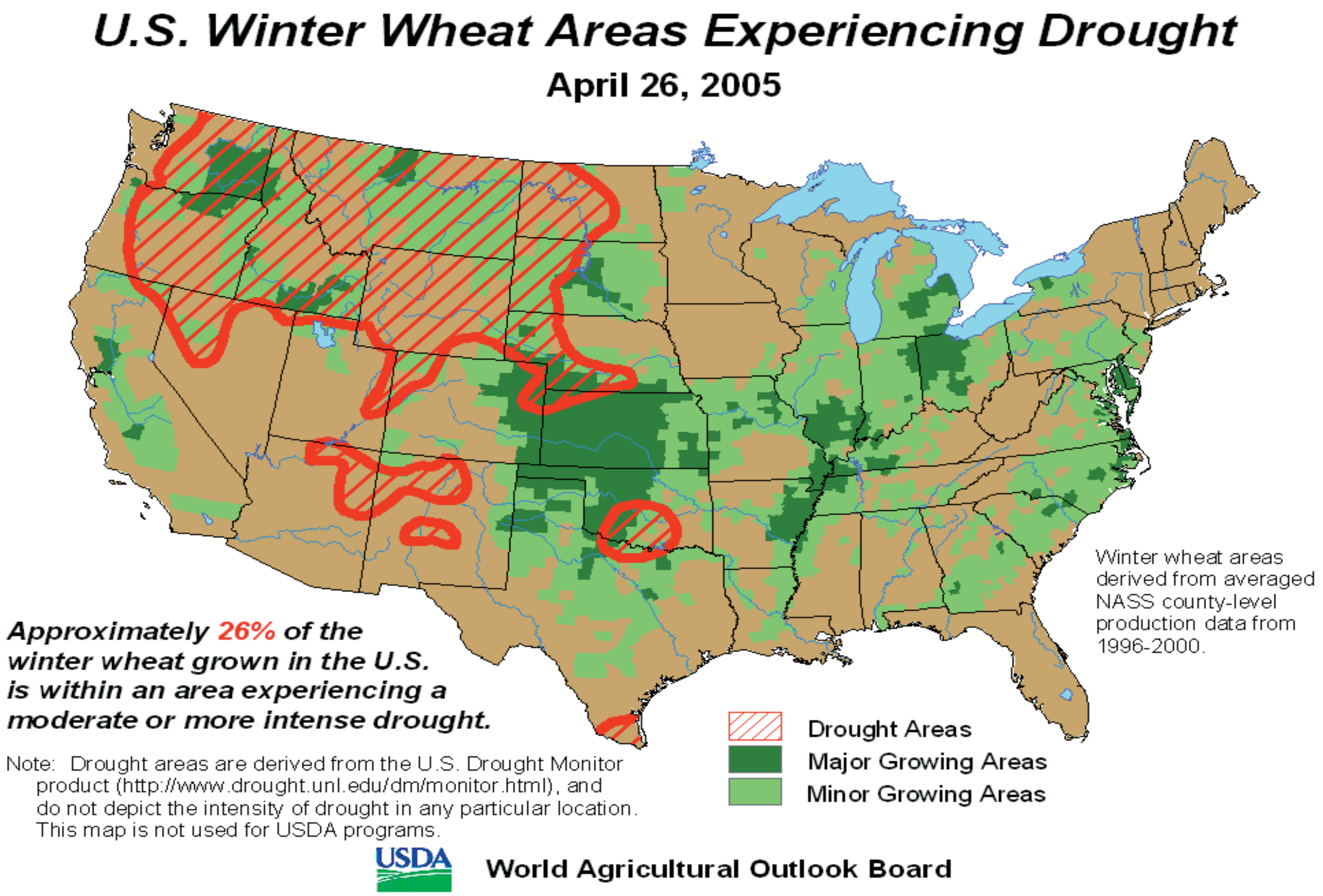


Figure 3-USDA-4. A monthly update of United States winter wheat areas experiencing moderate or more intense drought.

at http://enso.unl.edu/monitor. The Drought Monitor is released each Thursday at 8:30 a.m. Eastern Time. Because the Drought Monitor is prepared in a Geographic Information System, it can be overlaid on agricultural data, to quantify the spatial extent of drought affecting various agricultural commodities (Figure 3-USDA-4).

USDA's Chief Meteorologist is currently serving as the president of World Meteorological Organization's (WMO's) Commission for Agricultural Meteorology. In this position, he leads an effort to enhance the flow of more accurate and timely global agricultural weather information through an ongoing project utilizing internet technology. The World AgroMeteorological Information Service (WAMIS) is a dedicated web server that provides agrometeorological bulletins and advisories issued by WMO Members to the global agricultural community and also provide training modules to aid members in improving their agrometeorological products. The WAMIS web site is: http://www.wamis.net/.

The WAOB/JAWF opened a field office in Stoneville, Mississippi in October 1998. The JAWF Mississippi Field Office is co-located with the Mississippi State University Delta Research Extension Center (DREC). The purpose of the co-located JAWF and DREC Data Center is to collect, quality control, and manage agricultural weather data and to make it available to the entire Mississippi Delta agricultural community, including extension service, researchers, and farmers. In a cooperative effort between USDA, Mississippi State University, Mississippi State University Extension Service, and Meteor Communications Corporation, Inc., a meteor burst communication facility was established on Mississippi Agricultural and Forestry Experiment Station's land in Stoneville. This master communications facility is currently operational, and is being used to collect weather data from numerous meteor burst sites established in the Mississippi Delta region. Currently, there are seven meteor burst sites located in the Delta.

FOREST SERVICE

RESEARCH

Smoke from forest fires and other biomass burning is a national concern as use of prescribed fire in ecosystem management increases. Exposure of fire fighters and citizens to forest fire smoke, changes in visibility and haze, and smoke contributions to regional and local air pollution are of concern. Forest Service Research (FSR) is the world leader in developing emissions factors from fires and modeling its dispersion. FSR has conducted research on impacts of smoke on human health; relationships between on-site meteorology and smoke dispersion; consequences of smoke to visibility in Clean Air Act Class I Areas; and potential of smoke to exacerbate ozone episodes. FSR has provided basic research to support states' air regulatory programs and EPA's development of air quality standards.

Air pollution effects (primarily ozone) remain a serious threat to forest health in some parts of the U.S. FSR is describing long-term effects of air pollution on forests of the Sierra Nevada, Colorado, and southwestern Wyoming. FSR methods for assessing air pollution are also being used in other countries (Czech Republic, Mexico, Bulgaria). Nitrogen and sulfur atmospheric deposition have been studied for many years in eastern forest watersheds, and FSR has demonstrated that increased nitrogen deposition can affect water quality and ecosystem function in western forests. FSR is investigating nitrogen deposition in selected forest ecosystems across the U.S. to improve knowledge of potential nationwide impacts.

NATIONAL FOREST SYSTEM

The weather program works with the USDA Drought Commission. It provides key liaison with the Satellite Telemetry Working Group (STWG) on satellite services and with the National Weather Service, DOI, and the National Wildfire Coordinating Group (NWCG) on the delivery of fire weather forecasting, critical for safety and effectiveness of fire fighting and for flash flood warnings. The weather program oversees the standards for over 600 remote automated weather stations across the country. These stations form the basis for the assessment of fire danger, the pre-positioning of fire fighting resources and the conducting of prescribed fire operations. The costs include contracts for the delivery of this information to agency personnel, fire weather forecasters, and state forestry agencies that use the data in real-time for critical decisions.

WILDLAND FIRE MANAGEMENT

This program uses meteorological data and interpretation skills data for decision-making regarding wildland fire management. The Forest Service State and Private Forestry, Fire and Aviation Management program operates a network of over 600 remote automated weather stations (RAWS) in a national network of 1,500 stations. The network provides real-time information, which is key in the highly utilized weather information management system (WIMS) used by fire agencies across the country.

The agency weather program works with the predictive services unit at the National Interagency Fire Center (NIFC, Boise, ID) in providing technical support and oversight to 10 Geographic Coordination Centers and works closely with the Forest Service Research and Development staff in the oversight of the 5 fire consortia for Advanced Modeling of Meteorology and Smoke locations. This effort, in cooperation with NOAA and EPA, will provide valuable smoke forecasting and air quality information to fire and air quality programs.

NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

SNOW SURVEY AND WATER SUPPLY FORECASTING - MONITORING

Snowmelt provides approximately 80 percent of the streamflow in the West. The NRCS, in partnership with other federal and state agencies, operates the Snow Survey and Water Supply Forecasting Program (SS&WSF) in 11 western states and Alaska. To accurately forecast seasonal water supplies, the program collects critical snow and climate data from high elevation snow packs in the mountainous West. The data collection system includes 922 manual snow courses and over 670 automated SNOTEL (SNOw pack TELemetry) monitoring stations throughout the West. These data, along with information from 575 stream gauges, 310 major reservoirs, and 3,200 climatological observing stations are merged into a hydroclimatic database that is used to produce real-time watershed analyses and water supply forecasts. Monitoring is done in partnership with federal, state, and local agencies, power companies, irrigation districts, and the Provincial Government of British Columbia. This information is the basis for water management decisions under international treaties with Canada and Mexico.

The SNOTEL automated data collection system plays an important role by providing near real-time remote hydrometeorological data required to evaluate snowpacks, potential instream water supplies and drought risk. The SNOTEL network can provide hourly precipitation, temperature, and snowpack depletion information that significantly improves flood stage forecasts and the monitoring of other life threatening snow-related events. SNOTEL information enables emergency management agencies to effectively mitigate drought and flood damages. An added benefit during the late spring and summer is the availability of hourly climate data, which is used to monitor and assess forest and wildfire potential.

Additionally, the SS&WSF Program supports research to improve monitoring technology, data reliability, data quality, water supply forecasting, and water resource modeling.

WATER SUPPLY FORECASTS

Monthly water supply forecasts are produced each year, January through June, in partnership with the National Weather Service (NWS). The purposes of water supply forecasts are to: (1) help irrigators make the most effective use of limited water supplies for agricultural production needs; (2) assist the federal government in administering international water treaties with Canada and Mexico; (3) assist state governments in managing intrastate streams and interstate water compacts; (4) assist municipalities in planning the early management of anticipated water supplies and drought mitigation; (5) operate reservoirs to satisfy multiple use demands including hydropower generation; (6) mitigate flood damages in levied areas and downstream from reservoirs; and (7) support fish and wildlife management activities associated with species protection legislation.

During a typical forecast season, the NRCS SS&WSF Program issues approximately 11,400 seasonal water supply forecasts for 711 locations in 12 Western states. The water supply forecasts are coordinated and peer reviewed by a number of federal agencies and cooperators to ensure highest quality and accuracy. Major cooperators include the Bureau of Reclamation, Corps of Engineers, Bonneville Power Authority, state and local agencies, power utilities, irrigation districts, Tribal Nations, the Provincial Government of British Columbia, the Yukon Territory and Mexico. The primary users of this information include agricultural, municipal, industrial, hydropower, and recreation. Recent Federal legislation related to endangered species protection has placed increased emphasis on timely and accurate forecasts.

The NWCC web site provides snow data, analyses, and forecasts efficiently to approximately 80,000 users. The web site experiences over 2.4 million accesses per month during the snow season.

DROUGHT ASSESSMENT

The SS&WSF Program provides a variety of climate and water supply products that are used to assess Western drought. These include SNOTEL snowpack and precipitation analysis in the mountains, water supply forecasts, and state Surface Water Supply Indexes (SWSI). These products are critical to the weekly production of the interagency Drought Monitor web based report. A cooperative, nationwide network of 64 Soil Climate Analysis Network (SCAN) sites in 38 states monitors soil temperatures and soil moisture to support national drought monitoring, production agriculture, and climate change research.

CLIMATE INFORMATION

NRCS provides climate data and products that directly support agriculture and conservation activities nationwide. Digital maps of monthly and annual precipitation and temperature for the U.S. are available from the NWCC web site. To meet the needs for real-time climate information and analysis, the SS&WSF Program and the NOAA Climate program are sponsoring the Applied Climate Information System (ACIS). ACIS is an Internet-based climate data delivery system that provides the NRCS field offices, USDA, and partners with Internet access to thousands of climate datasets collected by scores of federal, state, and county networks. To support agricultural modeling efforts, the NWCC is also providing serially complete (i.e., no missing data values) temperature and precipitation data for approximately 11,000 climate stations nationwide. NRCS long range planning is supported by the Generation of weather Elements for Multiple (GEM) applications model, which has been used to generate future climate data sets for more than 250 locations nationwide. GEM is being integrated with several NRCS environmental models. Monthly precipitation averages and growing season length information required for wetlands analysis are also available from the NWCC web page at over 6,000 locations in the United States, Guam and Puerto Rico. Finally, wind roses for 237 NWS stations in the United States, plus offices in Guam and Puerto Rico are now available from the NWCC web page. A wind rose gives a very succinct but information-laden view of how wind speed and direction are typically distributed at a particular location. Wind roses are useful planning tools for agricultural and natural resource planning.

AGRICULTURAL RESEARCH SERVICE

Research in this area focuses on how annual variation in weather adversely controls crop and animal production, hydrologic processes, the availability of water from watersheds, and the environmental and economic sustainability of agricultural enterprises. Scientists are developing algorithms and decision support systems for the development of a stochastic storm-generator model and methodology to use contemporary weather radar systems to determine rainfall amounts and the spatial distribution and variability in precipitation associated with individual storms. Additional research is being conducted to integrate seasonal forecasts, other information on extended climate departures from normal and extreme events, corresponding agricultural responses, and associated uncertainties into planning and management decision aids readily useable by producers. The research is conducted in collaboration with the NOAA forecast developers.

COOPERATIVE STATE RESEARCH, EDUCATION AND EXTENSION SERVICE

Cooperative State Research, Education, and Extension Service (CSREES) funding supports research projects that collect and process long-term weather and climatic data and provide immediate and future use as a base of information for the projection and prediction of climatic trends related to environmental impacts of human activities, soils, crops and domestic animals on agroecosystems, forest, and rangelands. Broader areas of study involve atmospheric dynamics, carbon and water cycling, and their role in global change. The impact of changes in UV and ozone level studies also fit into this broad global category.

Historical climatic changes are related to trends visible from present data gathering studies, enabling prediction of future crop production and irrigation needs. CSREES funding supports studies on the impact of climate and weather on food and fiber production. These studies relate to forest plant growth, rangeland productivity, cropping system selection and livestock production practices.

Man's impact on climate systems is also well represented in studies of both micro- and macro-atmospheric change. These involve studies dealing with the atmospheric impact of changes in air quality, water quality and point/nonpoint pollution related to agricultural practices and forest and urban development. Studies on atmospheric impact on nutrient cycling and carbon sequestration are supported with CSREES funds. Research is also being supported that quantifies the impact of climate change on the incidence and severity of plant and animal diseases and pests, invasive species, and biodiversity.

The National Research Initiative (NRI) has funded a wide variety of weather and climate research. Topics have varied from a number of fundamental plant drought tolerance studies to using meteorological data to forecast market performance. Much of the support in this area is also focused on climate change. The NRI has also funded research on how land changes have influenced climate and vice versa.

DEPARTMENT OF ENERGY AND NATIONAL NUCLEAR SECURITY ADMINISTRATION (NNSA) OPERATIONAL AND RESEARCH WEATHER PROGRAMS

For almost 60 years, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), have established and supported meteorological operations and atmospheric research at the DOE field facilities. The need for meteorological services began in 1944 with the development, fabrication, and testing of atomic weapons and their accompanying national security and safety issues. Meteorological program requirements were subsequently augmented, starting in the late-1960's, by the passage of environmental protection legislation under the Clean Air Act, which is enforced by the Environmental Protection Agency (EPA) under 40 CFR enabling regulations, and reinforced by several DOE Orders that specify requirements for meteorological services to protect public health and safety and the environment. Consequently, a meteorological monitoring program has become an even more essential component of each DOE site. Moreover, the acquisition of quality-assured meteorological data and the provision of weather forecasting services is an important element of a DOE Integrated Safety Management System (ISMS). It significantly contributes to the implementation of site-wide personnel safety programs along with site evaluations. These evaluations include, but are not limited to the following: protection of facility workers and the public; development of Authorization Basis (AB) safety documentation; diagnostic and prognostic consequence assessment elements of an emergency management system; preparation of permits to support environmental compliance activities; and, impact analyses of construction and operation of projects and missions requiring National Environmental Protection Act (NEPA) determinations.

OVERVIEW OF DOE AND NNSA OPERATIONAL METEOROLOGICAL PROGRAMS AND SUPPORTING RESEARCH

Recognition of the need for site-specific meteorological services began in 1944, with the development, fabrication, and testing of atomic weapons and their accompanying national security and safety issues. In response to this need, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), and the current National Nuclear Security Administration (NNSA), have established and supported operational meteorological programs and atmospheric research projects at many DOE and NNSA field offices.

Operational meteorological program requirements were subsequently augmented, starting in the late-1960's, by the passage of environmental protection legislation under the Clean Air Act (CAA), enforced by the Environmental Protection Agency (EPA) under 40 Code of Federal Regulations (CFR) enabling regulations, and reinforced by several DOE directives (e.g., DOE O 5400.1) that specify requirements for meteorological services to protect facility worker health and safety, public health and safety, and the environment. Since that time, the CAA has been amended on three occasions, each time including broader requirements, inclusive of stratospheric ozone protection regulations. Consequently, an effectively managed meteorological monitoring program has become an even more essential component of operations at each DOE and NNSA site.

Moreover, the acquisition of quality assured meteorological data, the provision of weather forecasting services, and the development of site-specific climatology from these meteorological programs is an important element of a DOE Integrated Safety Management System (ISMS) that significantly contributes to the implementation of site-wide personnel safety programs and supports multiple evaluations. These evaluations include, but are not limited to the following:

- Protection of facility workers and the public;
- Development of nuclear and chemical safety documentation (e.g., Safety Analysis Reports);
- Diagnostic and prognostic consequence assessment elements of emergency management programs;
- Preparation of air and surface water permits to support environmental compliance activities; and,
- Impact analyses for construction, operation and decommissioning of projects, and missions requiring National Environmental Protection Act (NEPA) determinations.

DOE and NNSA continue to address their fundamental mission areas of national security, science and technology, energy security, and environmental clean up of cold war production sites. Meteorology and atmospheric science contributes to many of these mission elements. Consequently, atmospheric science research programs and weather forecasting operations have been an integral part of DOE, NNSA and its predecessor agencies since World War II. Therefore it is vital to understand the nature of the atmospheric domain and its relationship to terrestrial, ocean, and other environmental domains. Understanding these relationships feeds into the reduction of uncertainties regarding climate change research.

DOE and NNSA administer programmatic activities throughout their various offices, such as the Office of Science (SC), Environmental Safety and Health (ES&H), the National Nuclear Safety Administration (NNSA), and Environmental Management (EM), in which each has some linkages to meteorology and atmospheric science. Some of these program offices are responsible for the management of scientific research programs, such as the National Atmospheric Release Advisory Capability (NARAC), Global Climate Change Research (GCCR), and various environmental cleanup activities at former DOE production sites. Additional activities at DOE and NNSA sites include support to daily operations and national defense programs; all of which require a fundamentally sound well-managed meteorological monitoring program.

Meteorological services at DOE and NNSA facilities range from the conduct of cutting-edge basic research to providing daily support to operational programs and construction projects. Some examples of research and development are investigations of potential global climatic change, radiation transfer mechanisms and cloud studies, lightning and thunderstorm studies, atmospheric chemistry, atmospheric tracer studies, and studies of atmospheric planetary boundary layer processes. Operational support programs include daily-customized weather forecasting services, support to national defense projects and homeland security, onsite meteorological monitoring programs, climatological services, occupational health and safety program support, and emergency management program support.

Some DOE and NNSA sites maintain 24-hour weather watches for severe weather conditions that have the potential to impact site operations, damage property, or threaten lives. DOE-wide and NNSA-wide lightning safety initiatives, which are becoming integral elements of an Integrated Safety Management System (ISMS), are supported by DOE and NNSA operational meteorological programs (e.g., Nevada Test Site (NTS), Hanford, Savannah River Site (SRS), Idaho National Engineering and Environmental Laboratory (INEEL)).

A number of DOE and NNSA field offices and their associated sites and facilities cover large areas (e.g., INEEL, Oak Ridge Reservation (ORR), NTS, Hanford, and SRS). In addition, several DOE and NNSA sites are situated in areas of complex topography and heterogeneous surface characteristics (e.g., land-water interface), creating mesoscale conditions that locally influence onsite weather and more importantly, airflow trajectories associated with atmospheric transport and dispersion. This is why DOE originated a research program addressing Atmospheric Studies in Complex Terrain (ASCOT) during the eighties and early nineties to address emergency response issues in complex terrain environments at the various DOE sites.

For these reasons, and to ensure the protection of public health and safety and the environment, onsite meteorological monitoring programs have been, remain, and will always be an essential part of DOE and NNSA atmospheric science programs. Moreover, partnerships have been forged with other Federal agencies (i.e., Department of Commerce (DOC) via its National Oceanic and Atmospheric Administration (NOAA)). to leverage research resources addressing complementary mission areas.

Some DOE and NNSA sites enhance the spatial resolution of the National Weather Service (NWS) observing network by taking standard surface and upper-air observations. Many of these sites are in remote areas where NWS and community weather observations would otherwise be limited. Weather observations taken at a few DOE and NNSA field sites are entered into the database via the NWS meteorological data distribution and display system. This distribution and display system interconnects field offices and serves as the distribution system for NWS meteorological products that are centrally produced by the National Centers for Environmental Prediction (NCEP). Some DOE and NNSA sites (e.g., NOAA Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD), Las Vegas, NV) employ the NOAA Advanced Weather Information Processing System (AWIPS), as well as vertical profilers and meteorological monitoring networks.

An accidental release of radioactive, chemical, or biological toxic material into the atmosphere can have potentially serious health effects, as well as environmental consequences. Meteorological transport and dispersion processes play a key role in determining the fate of radioactive, chemical, or biological agents released into the atmosphere; including those resulting from malevolent acts. Consequently, a central theme within the DOE and NNSA community has been to protect public health, safety, and the environment on and around DOE and NNSA facilities by accurately measuring and characterizing the important local atmospheric processes necessary to characterize atmospheric transport and dispersion.

In recognition of the aforementioned

needs and requirements, DOE and NNSA have established and continue to support onsite meteorological monitoring programs since the commissioning of an operational meteorological program in 1944 at Hanford. Each meteorological program contributes to the support of emergency management programs and focused towards the protection of the environment and the safety and health of the onsite work force and the public. In addition, research on the modeling of the transport, dispersion, deposition, and resuspension of radioactive, chemical, and biological agent materials is undertaken to refine the transport and dispersion models used in these endeavors. New remote sensing techniques are being developed, such as the "Best" Aircraft Turbulence probe at the ARL Field Research Division (FRD), in Idaho Falls, ID. Onsite weather forecasting services, each tailored specifically for the special operational and emergency management requirements at each DOE and NNSA site, provide necessary support to the safety and health programs designed to protect site personnel, the public, and the environment.

Over the years, operational and research meteorological programs have grown to address and support many environmental, safety, and health issues. Due to the complexity of activities, it was recognized that efforts should be made to coordinate meteorological operations and research among the field offices to enhance cost effectiveness and productivity. To address these considerations, the DOE Meteorological Coordinating Council (DMCC) was formed in 1994, and has been providing support to DOE and NNSA meteorological programs for 10 years. The following narrative highlights meteorological activities at 15 separate DOE and NNSA sites. The activities are subdivided into operational and research components. The DMCC narrative is the last entry signifying the importance of this program in alleviating meteorological and safety coordination across the DOE sites.

ARGONNE NATIONAL LABORATORY (ANL)

Operational

Argonne National Laboratory (ANL) is one of DOE's largest research centers. It is also the nation's first national laboratory, chartered in 1946. ANL is managed and operated by the University of Chicago (UC) for the DOE Chicago Operations Office. Argonne occupies two sites, designated as ANL-East in Illinois and ANL-West in Idaho. The Illinois site is surrounded by forest preserve on 1,500 wooded acres about 25 miles southwest of Chicago's Loop. The site also houses the DOE Chicago Operations Office. Argonne-West occupies about 900 acres about 50 miles west of Idaho Falls in the Snake River Valley. It is the home of most of the ANL major nuclear reactor research facilities.

There are three divisions, Environmental Research (ER), Decision and Information Sciences (DIS) and Environmental Assessment (EAD) at ANL with meteorological research or operational program support. Two cross-divisional groups are involved in these programs at ANL: the Atmospheric Research Section (ARS) and the Atmospheric Emergency Preparedness (AEP) Group. The ARS is composed of scientist with research activities in both basic and applied science; particular technical strengths are in the areas of air-surface exchange, remote sensing, atmospheric chemistry, and numerical modeling. About half of the ARS support is currently devoted to activities associated with the DOE Atmospheric Radiation Measurement (ARM) Program. The AEP is composed of scientists and engineers in two divisions involved in programs with a greater emphasis on applied science. Particular technical strengths include air pollution meteorology, emergency preparedness and response, and stochastic systems simulations. More than half of the AEP support is associated with the DOE Protect Critical Infrastructure Program involving chemical and biological agents.

ARS operates and maintains a 60-meter meteorological tower and supplies meteorological data for emergency response, facility operations, and regulatory compliance for ANL operations. Wind and temperature measurements are taken at the 10-meter and 60-meter levels. Real-time and historical data are available via the Web (http://gonzalo.er.anl.gov/ANLMET).

Research

As part of a larger program for the protection of subway systems from terrorist attacks using chemical agents, AEP Group is installing sonic anemometers as well as temperature and pressure sensors in the subway tunnels of a large urban subway system. These instruments will assist in the understanding of flows in the tunnels, which are driven by a combination of:

- The "piston" action of train motion; and,
- Buoyancy effects and above-ground forcing.

Measurements from these instruments will be correlated with the above ground measurements to develop and validate predictive and emergency response models for flow and dispersion in subway systems.

The AEP group research also focuses on the analysis of routinely measured meteorological data to provide atmospheric boundary layer turbulence information for atmospheric dispersion calculations. Under the Department of the Army Chemical Stockpile Emergency Preparedness Program (CSEPP), ANL provides support to improve the collection efficiency and quality of meteorological data measured at the Army's Demilitarization towers. The data are used the emergency operation centers in support of emergency response exercises and for use in real-time in the event an actual accident. The goal of the CSEPP support is to improve the accuracy and robustness of the data obtained from the meteorological monitoring stations and to develop unified quality control and analyses procedures of the data collected by the towers.

Key support is also provided to Department of Transportation (DOT) in applying an ANL-developed 5-year meteorological database for over 100 locations in the United States to conduct statistical analyses of hazardous materials incidents on a national basis. Recent work for DOT has centered on development of the Table of Initial Isolation and Protective Action Distances for the 2000 Emergency Response Guidebook. Protective Action Distances are given in the Table for over 200 toxic-by-inhalation chemicals and generic compounds for both daytime and nighttime accidents, and represent the safe distance for 90% of hazardous materials transportation accidents considering variability in meteorology and spill size. Recent work for DOT has also involved conducting national risk assessments for transportation of certain high volume toxic chemicals like chlorine, ammonia, hydrogen fluoride and sulfur dioxide.

The Atmospheric Boundary Layer Experiments (ABLE) is one of several DOE supported research programs conducted by the ARS (Figure 3-DOE-1). ABLE is located on the lower Walnut Watershed, mostly in Butler County east of the city of Wichita, KS. This location is within the existing boundaries of the DOE ARM Southern Great Plains (SGP) Clouds and Radiation Test-bed (CART) site. The establishment of this facility offers a virtual atmospheric observatory and provides essential research tools for addressing a myriad of unresolved fundamental questions in atmospheric research. The ABLE provides a continuous view of processes in the lower atmosphere over a limited domain within the SGP CART site.

The initial focus of ABLE is measurement of the planetary boundary layer (PBL) where almost all interactions between the atmosphere and humans take place. Many scientific issues may be addressed by use of such a facility, including:

- Natural disaster reduction and public safety;
- Safe and efficient aviation and other transportation;
- Agriculture;
- Water resource management;
- Effective energy production, use and environmental protection;
- Space flight operations;
- Defense; and,
- Related areas of Earth Science.

Instrumentation at the ABLE site includes winds, temperatures, moisture, surface net radiation and soil moisture as the minimum set of atmospheric observations.

The initial set of equipment, which is available at ABLE includes:

- Three 915 MHz RWP-RASS (wind speed and direction, virtual temperature profiles);
- Three minisodars (wind and turbulence profiles between heights of 10 m and 200 m);
- One lidar ceilometer (cloud base height);
- One balloon-borne sounding sys-

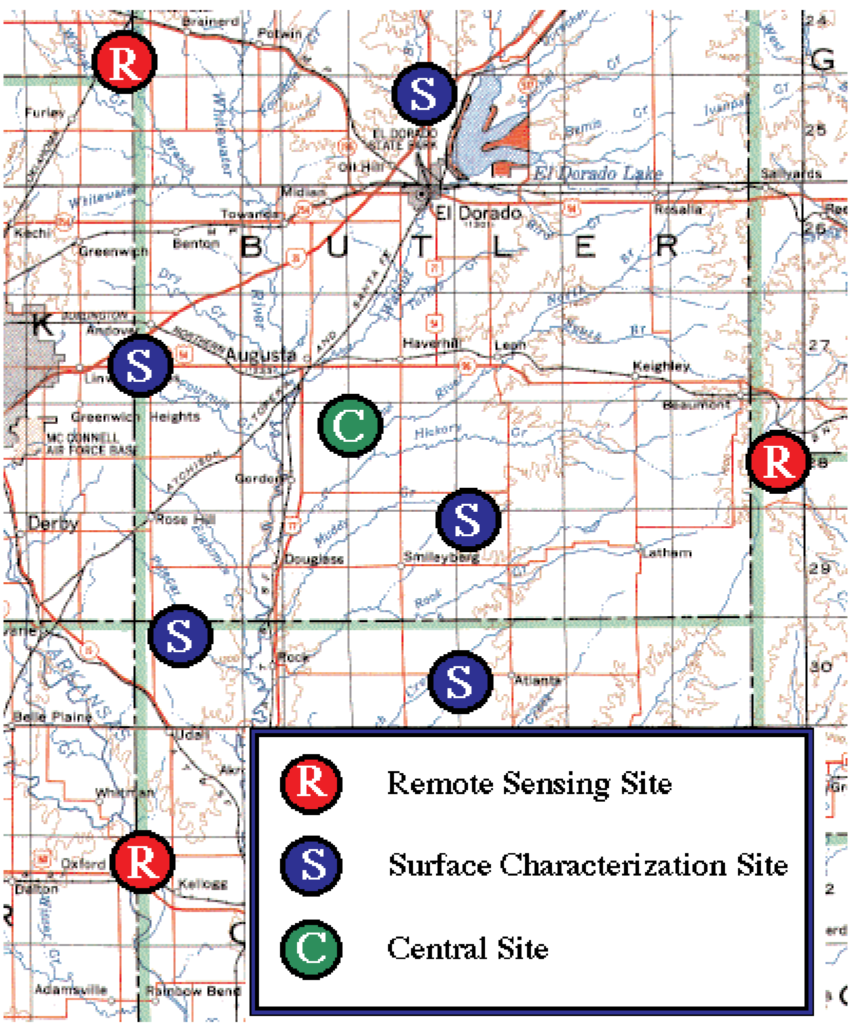


Figure 3-DOE-1. DOE Atmospheric Boundary Layer Experiment (ABLE) site locations in the Midwest.

tem (wind, temperature, moisture profiles);

- Five surface flux stations (surface sensible and latent heat, ground heat storage);
- Five soil moisture sampling stations (soil moisture, soil temperature);
- One satellite data receiver-processor;
- One data hub/central location for data collection; and,
- One (extra) instrument pad for visiting scientist instrument accommodation.

age that includes an estimated population of one million. Nearby, in Bohemia, is the NWS Eastern Regional Headquarters that administers a 12-state region.

The mesoscale meteorological measurements necessary for emergency response are the responsibility of the Meteorological Services Group, a support group under the Department of Applied Science, Environmental Biology and Instrumentation Division (EBID).

BROOKHAVEN NATIONAL LABORATORY (BNL)

Operational

The BNL, under the responsibility of the Brookhaven Area Office, has been active in both operational meteorology and atmospheric sciences for the past 50 years. BNL is now managed by Brookhaven Science Associates, which is a joint venture by Battelle Memorial Institute Incorporated, The Research Foundation of the State University of New York at Stony Brook, and six other core university partners. Meteorological operations and research cover a wide range of programs encompassing interpretive and theoretical studies. BNL is located near the geographical center of Long Island, New York. Long Island is glacial in origin and, as a result, has sandy soil, mostly gentle undulating contours, and a single water aquifer for the entire island. Elevations vary between 20 meters and 35 meters. The BNL site is rectangular and approximately 5,200 acres in area. Winds are predominantly southwesterly, and plume dispersion studies show that it is essential to monitor winds well beyond laboratory borders. The New York City NWS Weather Forecast Office is located at BNL. This office has an umbrella of cover-

The Meteorological Services Group maintains two meteorological towers, 10-meter and 88-meter, and an instrument shelter. By integrating redundant pairs of standard, approved meteorological sensors throughout the system, an overall data availability of better than 99 percent is achieved. The real-time data are merged into the laboratory emergency response network. A database of 50 years (in digital format since 1960), one of the longest continuous meteorological time series in the United States, is archived and is available. A real-time monitoring network with worldwide web access covers the eastern end of Long Island. Coastal weather stations at Smith Point and Orient Point transmit data each minute. Pollution-monitoring data buoys are added during field programs.

The Meteorological Services Group provides a locally tuned forecast twice daily during normal working hours. Weather forecasts and data are available by telephone or the Internet (www.weather.bnl.gov). During severe weather events updates are given every three hours and, in the case of a hazardous material or radiological release, a member of the Meteorological Services Group will assist the emergency coordinator with regular forecasts and information on local wind fields and gustiness.

Research

Areas of meteorological research at BNL include:

- Instrumentation development for field studies of atmospheric constituents, air-sea interaction, and laboratory experiments;
- Gaseous tracer studies of atmospheric transport and dispersion;
- Aerosol formation and behavior;
- Atmospheric pollution studies
- Modeling of atmospheric chemical reactions;
- Acid rain studies both in the field and in the laboratory;
- Theoretical and observational studies of radiation transfer and fluxes; and,
- Analysis of data and development of parameterizations relevant to global climate change.

The ARM Program provides the stimulus for a wide range of climate-related studies. The ARM ocean monitoring program is developing instrumentation and a broad ship- and buoy-based observational network in the tropical western Pacific Ocean. The Atmospheric Chemistry Program (ACP) supports the Atmospheric Chemistry Division's (ACD) concern with aerosol sources, transport, and fate in the global atmosphere and the overall, and the little understood, impact of aerosols on global climate dynamics. The ARM External Data Center is the center for collection, archival, and dissemination of all climate-related data sets for the ARM program.

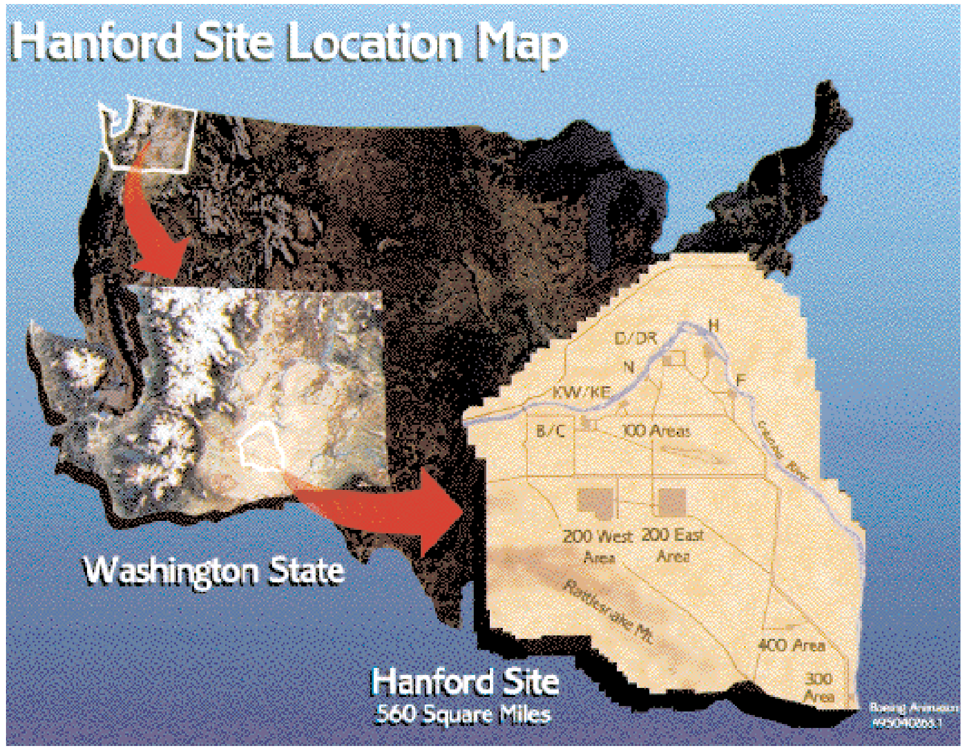
An exciting new effort in radar meteorology focuses on algorithms for cloud detection and cloud mapping using both the WSR-88D radar network and research radar. BNL is a site in the National Aeronautical and Space Administration (NASA) Solar Irradiance Network and continuous short wave absorption measurements are made here. In a related NASA study, oceanic aerosol optical depths are measured and used to validate absorption algorithms in the SeaWiFS ocean color program.

The Optical Remote Sensing (ORS) group within the Department of Advanced Technology (DAT) is presently modifying one of its Raman lidar systems for vertical profiling of carbon dioxide. The Raman lidar instrument is a self-calibrating sensor that means that data from a variety of locations in the world can be compared. With the incorporation of a large (1.25 m) antenna and advanced filters and detectors, a vertical profile of CO2 concentration with a precision of 1 part per million (ppm) (Note: atmospheric mean = 370 ppm) and maximum height of two to three km can be produced routinely. These profiles will support model development and validation. Importantly, comparison of CO2 concentrations collected throughout the world and over time will prove invaluable in confirming adherence to the Kyoto protocols.

HANFORD SITE

Operational

Beginning in 1944, meteorological services have been provided to the Hanford Site. The Hanford Site is an area of 560 square miles within the semi-arid and sparsely vegetated Columbia River basin in southeastern Washington near Richland, Washington. Since 1965, the Pacific Northwest National Laboratory (PNNL) operated for the Department of Energy (DOE) by the Battelle Memorial Institute, has managed the Hanford Site meteorological program. Not only has operational support been provided, but also supporting research into atmospheric processes has been a key part of the PNNL support to DOE. Within PNNL, the Environmental Technology Directorate provides day-to-day operational meteorological and emergency response support to the Hanford site.



Through funding from DOE, the PNNL Meteorological and Climatological Services Project (MCSP) provides meteorological monitoring and operational support to the Hanford Site. The monitoring system consists of an array of 26 10-meter towers, three 60-meter towers and one 125-meter tower instrumented with temperature and wind direction and wind speed sensors (Figure 3-DOE-2). Atmospheric pressure and precipitation data are also collected by this monitoring system. Meteorological data from this network is transmitted via UHF radio to a computer, which decodes the data and plots graphics products for immediate display and use by Hanford Meteorological Station personnel.

Meteorological services include emergency response functions, weather forecasting for onsite operations and special projects, and climatology support. MCSP support to the Hanford site includes: extensive data acquisition via a site-wide meteorological monitoring network; weather forecasting services 24-hours/day during Monday through Friday; weather forecasting services eight-hours/day on weekends and holidays; hourly surface observations, and six-hourly synoptic observations; monthly and annual climatology data summaries; and, meteorological input to annual environmental reports.

PNNL atmospheric sciences staff operate meteorological, atmospheric transport and dispersion and dose assessment, and information display workstations at the Hanford Site's Emergency Operations Center (EOC). Atmospheric sciences staff are involved in facility planning, exercise development, and training activities for Hanford's emergency preparedness program. Assistance is also provided to state and local emergency operations facilities. PNNL staff members have developed MetView software to graphically display Hanford Site and regional meteorological data to support a variety of emergency preparedness and research applications. Staff members have also developed the Air Pollutant Graphical Environmental Monitoring System (APGEMS)-family of software products to improve the ability to rapidly and accurately estimate the atmospheric transport and dispersion and human health and environmental consequences of accidental or unexpected releases on or near the Hanford Site. The flexible user interface and graphical output capabilities of APGEMS allow it to efficiently support a range of users including first responders, experienced hazard assessors, and decision makers.

Research

The Fundamental Sciences Directorate conducts research into meteorological, climatological, and atmospheric chemical processes in support of other major DOE programs such as the Atmospheric Radiation Measurements (ARM) program and the Atmospheric Science Program (ASP).

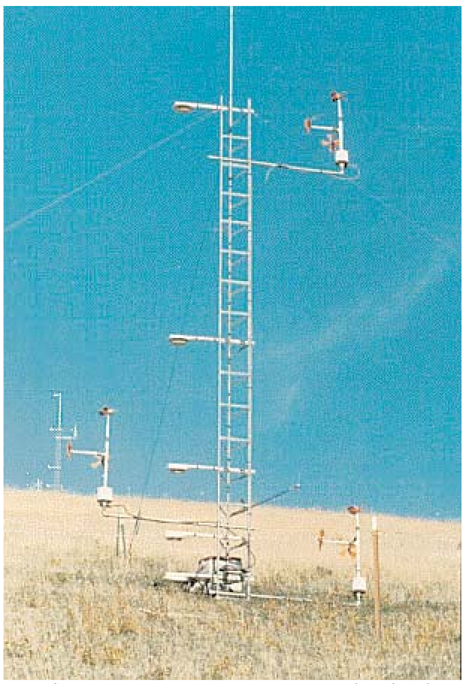


Figure 3-DOE-2. Meteorological towers record temperature and wind direction and speed at various levels.

PNNL plays both management and developmental roles in the ARM program which is focused on the development of cloud and radiation databases and data products that are critical to improved understanding of global and regional climate change and the improvement of climate research and prediction models. In addition to of its roles in ARM, PNNL also conducts research into the processes affecting radiation transfer through the atmosphere and the effects of greenhouse gases, aerosols, and clouds on regional and global climate. The PNNL Atmospheric Remote Sensing Laboratory is a portable system for studying the vertical structure of atmospheric constituents, particularly clouds, which govern radiation transfer through the atmosphere. Capabilities of the Environmental and Molecular Sciences Laboratory (EMSL) are used to conduct molecular level research into aerosol formulation and aging. Carbon dioxide emissions research is aimed at providing a scientific basis for forecasting future emissions of carbon dioxide and other gases of radiative importance.

In support of the ASP, PNNL uses ground-based and airborne measurements systems, numerical and conceptual modeling, and data analysis to conduct research into the vertical transport and mixing processes that govern the distribution in the lower troposphere of trace gases and aerosols released during energy production or use and on chemical processes that govern the transformation and fate of gaseous and particulate pollutants. PNNL manages the DOE Research Aircraft Facility, a Gulfstream 159 twin turboprop aircraft that supports research in atmospheric chemistry, radiation transfer, and aerosol characteristics for DOE.

A hierarchy of atmospheric dispersion models is being developed within DOE's Chemical Biological National Security Program (CBNP) covering transport distances ranging from around individual buildings, through the urban area and beyond the urban area into the surrounding region. These models will allow individuals in intelligence, law enforcement and emergency management to adequately plan against, train for and respond to potential terrorist attacks. PNNL scientists, in collaboration with other government and private scientists, are conducting atmospheric tracer and meteorological field studies for evaluating the models being developed within CBNP. The field studies will provide valuable information to all investigating urban dispersion, urban air quality and atmospheric transport and dispersion in general.

IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY (INEEL)

Operational

INEEL is managed by the Idaho Operations Office and is on 890 square miles of rolling, arid terrain in southeastern Idaho at the foot of the Lost River and Lemhi mountain ranges. The primary mission of the INEEL for years has been nuclear reactor research with a focus on cleanup and environmental restoration. Meteorological services and supporting research are provided to INEEL via NOAA ARL Field Research Division (FRD). The Division, under administration from various agencies, has provided support to INEEL for over 50 years. Its current mission to DOE/ID is to support emergency response and operations with real-time meteorological data, climatology data, weather predictions, dispersion calculations, and consultation. ARL FRD maintains other capabilities that are not funded directly by DOE. ARL FRD designs, arranges, and conducts field studies as needed to evaluate the performance of transport and dispersion models over local, regional, and continental scales, and to obtain high quality databases for model improvement. An airborne geosciences program is also maintained to measure fluxes of carbon dioxide, water vapor, and other atmospheric constituents that affect climate. These interactions provide ARL FRD staff with additional insights that aid in the understanding of local meteorological phenomena.

ARL FRD operates a large meteorological monitoring network to characterize the meteorology and climatology of the INEEL site. The network consists of 33 meteorological towers that are deployed both onsite and offsite. The overall meteorological measurement program is designed to provide representative data for the INEEL to meet specific operational and potential emergency response situations. The network covers an area of approximately 15,000 square miles. Many of the towers are 15-meters tall and provide wind speed and direction at 15-meters and air temperature at 2-meters and 15-meters. Instrumentation on 15 of the 15-meter towers also measure relative humidity at 2-meters, precipitation, and global solar radiation. Barometric pressure is provided on 11 of the towers. The other three towers range from 46-meters to 76-meters in height and are instrumented at multiple levels. The sensors at all stations are scanned every second and averaged or totaled over five minutes.

The data are subsequently retrieved into the data display and archive system at the ARL/FRD office through a radio repeater located at an elevation of 8,930 ft MSL. Continuous wind and temperature profiles are obtained from a 915 MHz radar wind profiler and RASS. A Doppler SODAR supplements the wind profile at lower levels with higher resolution data. Meteorological data are quality-controlled through automated and manual processes.

INEEL meteorological monitoring and emergency response efforts are enhanced with the use of an ARL FRD meteorological data display and visualization program known as INEELViz. This program has been widely deployed at 50 sites on and around the INEEL for access by federal, state, and Indian tribes via the Internet.

Within INEELViz, meteorological data are displayed in real-time and overlaid on maps of the local area that include political and terrain features. In addition, the local MDIFF puff dispersion model can be accessed through the INEELViz front-end and the model output can be displayed as trajectories or concentration isopleths on the INEELViz display screen. The incorporation of RSAC dose conversions permits the user to also view real-time dose estimates from the model output. These features have become very useful enhancements to the INEEL emergency response capability.

<u>Research</u>

Partnerships forged with DOE/ID, the State of Idaho INEEL Oversight Program, and the Shoshone-Bannock Indian Tribes have resulted in additional methods of meteorological data dissemination. Meteorological and background nuclear radiation data from four public access sites on and surrounding the INEEL are displayed at nearby kiosks in real-time. Additional information on nuclear radiation and meteorological tutorials are presented at the kiosks. The data are also available on the Internet at http://oversite.inel.gov. ARL FRD maintains its own web site at www.noaa.inel.gov.

LAWRENCE LIVERMORE NATIONAL LABORATORY (LLNL)

<u>Operational</u>

LLNL is located in a valley in California's Coast Range Mountains about 25 miles east of Oakland. LLNL covers approximately 2 square miles and is operated by the University of California for the DOE Oakland Operations Office. Two groups are involved in the atmospheric sciences at LLNL:

1. Environmental Protection Department (EPD); and,
2. Atmospheric Sciences Division (ASD).

EPD operates a 40m tower and supplies meteorological data for facility operations, regulatory compliance, and emergency response. Real-time and historical data are available at http://www-metdat.llnl.gov/.

The National Atmospheric Release Advisory Center (NARAC) is a centralized emergency response resource supporting federal agencies (http://narac.llnl.gov/). The mission of NARAC is to deliver realistic real-time graphical dose and exposure assessments to emergency decision-makers to assist in the protection of populations at risk for releases of radiological and other hazardous material to the atmosphere (Figure 3-DOE-3). NARAC has developed specific tools to assist elements of the DOE Consequence Management assets, including the Nuclear Emergency Search Team (NEST), Accident Response Group (ARG), Federal Radiological Monitoring and Assessment Center (FRMAC) (http://www.nv.doe.gov/programs/frmac/default.htm), and the Radiological Assistance Program (RAP). Under DOE direction, NARAC supports National Special Security Events, such as the winter 2002 Olympics. NARAC also supports DOE sites and Emergency Operations Centers around the US (http://www.nnsa.doe.gov/).

NARAC's central emergency response system consists of automated continuous worldwide meteorological data acquisition, detailed worldwide terrain and geographic mapping databases, a suite of atmospheric dispersion models and source models to assess explosions, fires, spills, or other types of radiological, chemical, biological releases. The system includes a high-resolution, terrain-following, variable-gridded diagnostic meteorological model (ADAPT) and a prognostic model with parameterizations for urban settings (COAMPS) coupled with a generalized Lagrangian particle dispersion model (LODI).

A staff of NARAC emergency response model experts provides a 24-hour response service. To minimize response time, NARAC has developed and supplied over 40 federal facilities around the US with software that performs meteorological data acquisition, local-scale stand-alone modeling, and reaches back to LLNL for detailed simulations. NARAC mapped products are delivered in 5-10 minutes for a computer-linked site and up to 60 minutes for a non-computer-linked site. Supported sites and organizations can use the client-server-based NARAC iClient tool (for heavy modelers) or NARAC Web (for light modelers) tools to run models and seamlessly distribute products to multiple organizations over the world wide web.

The Regional Modeling and Dispersion Group is investigates regional scale processes affecting dispersion. This group works with the Urban Group to with the goal of developing a seamless set of validated diagnostic and prognostic tools from the building to urban to regional scales. In collaboration with LANL, LLNL developed a prototype prediction capability to assist in multi-agency smoke and fire management of wildfires.

Research

Scientists in the Atmospheric Science Division (ASD) (http://asd.llnl.gov/) at LLNL perform pioneering research on global climate and chemistry and predict the local, urban, regional, and global transport and fate of hazardous and toxic pollutants. Research is focused on major national energy and security policy issues and is based primarily on development and use of advanced computational simulations of the atmosphere, oceans, and biosphere.

ASD conducts research in four areas:

- Atmospheric hazards and consequence assessment;
- Atmospheric transport & fate;
- Carbon cycle and climate model physics; and,
- Climate change & model evaluation.

ASD Major Programs Include:

- Program for Climate Model Diagnosis & Intercomparison (PCMDI);
- Institute for Research on Climate Change & Its Societal Impacts (IRCCSI); and,
- NARAC Programs and the National Atmospheric Release Advisory Center (NARAC).

PCMDI's mission is to develop improved methods and tools for the diagnosis, validation, and intercomparison of global climate models, and to conduct research on a variety of problems in climate modeling and analysis (http://www-pcmdi.llnl.gov/).

The mission of IRCCSI is to improve understanding of climate change and its societal impacts, by facilitating collaborations between the University of California-operated DOE laboratories (i.e., LANL, LLNL, and LBNL) and University of California campuses (http://irccsi.llnl.gov/). In particular, DOE wishes to link the Laboratories' capabilities in high-end climate modeling and climate science with the expertise in regional climate and societal impacts issues resident at the University of California campuses.

The urban Research & Development effort is developing a coupled suite of multi-scale dispersion models to effectively respond to urban releases. LLNL was a co-leader of the Joint Urban 2003 (i.e., JU2003) field study in Oklahoma City, OK, the largest most complex urban tracer experiment performed to date. The Pacific Northwest National Laboratory (PNNL) was the overall leader, while LLNL, LANL, LBNL were co-Principal Investigators. JU2003 was supported by the Department of Homeland Security (DHS), the Defense Threat Reduction Agency (DTRA) and the Department of Defense (DoD). Data from this study is being used to identify key urban physics and to evaluate NARAC's suite of urban models. A new three-year project has begun to develop a next-generation building-

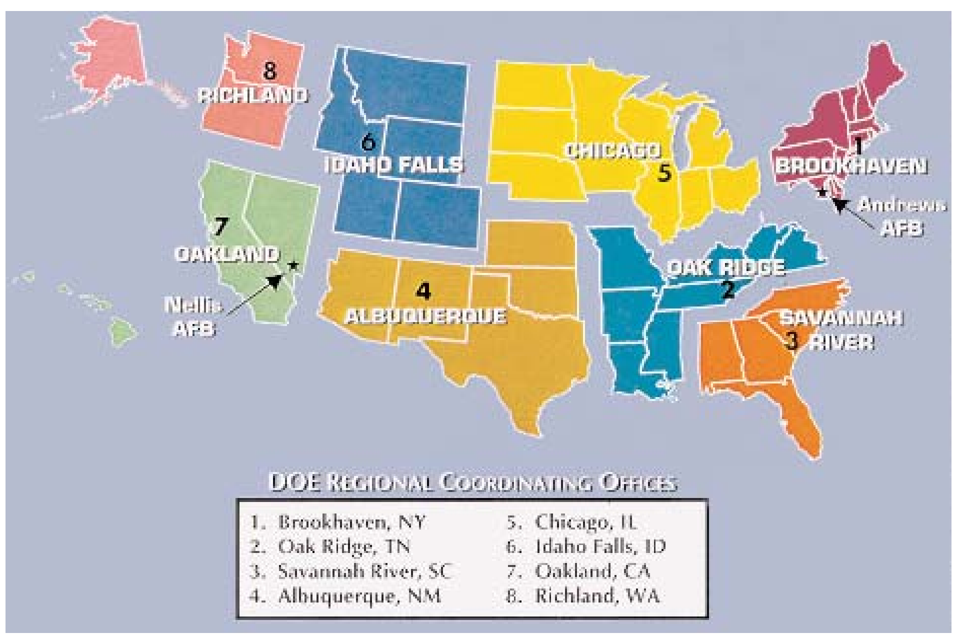
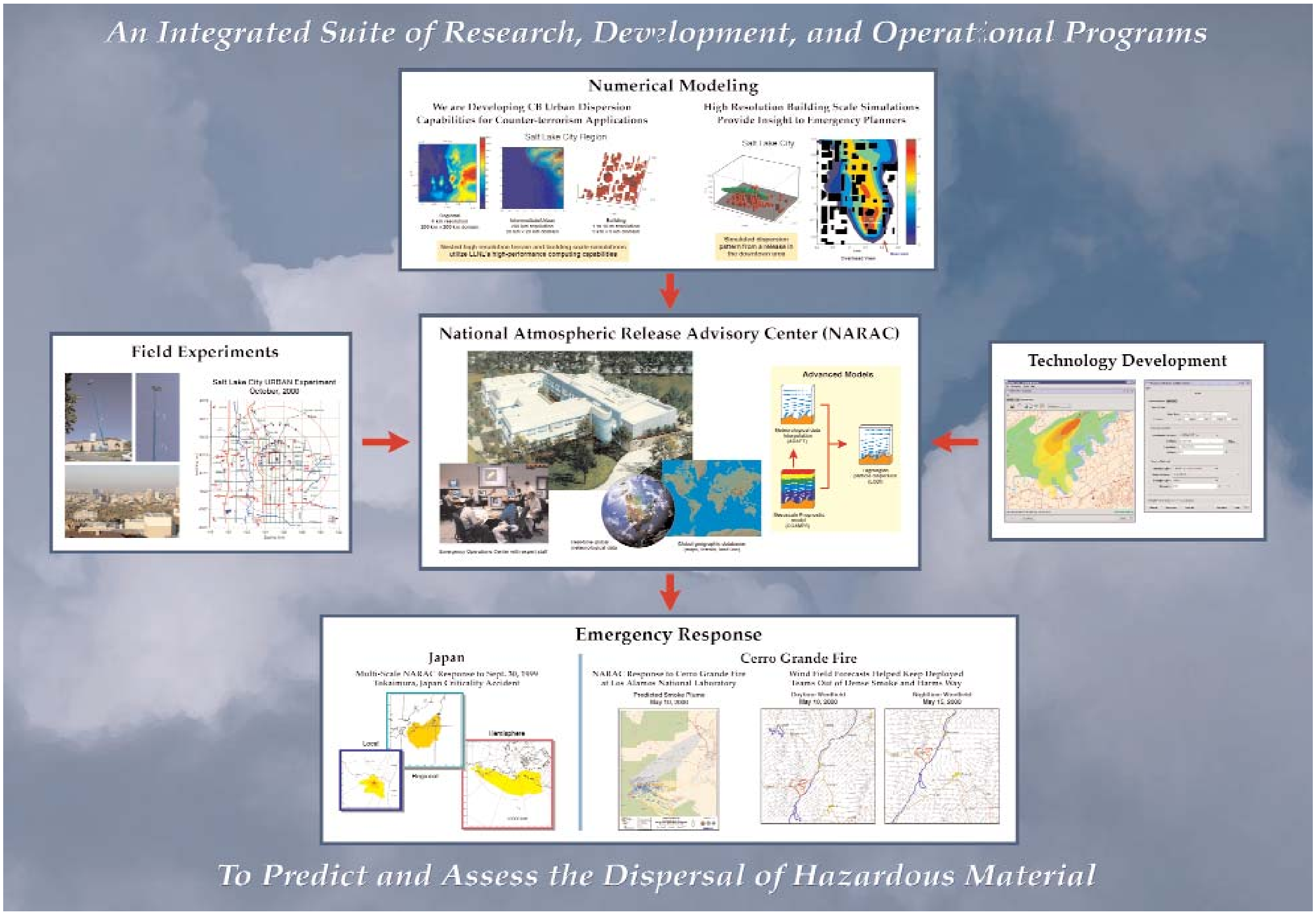


Figure 3-DOE-3. Each of DOE's eight Regional Coordinating Offices maintain a 24-hour response capability for radiological emergencies that may occur in states served by its region.



scale computational fluid dynamics model.

Examples of on-going operational integration projects include:

- Integration of mapping systems for field measurement, modeling results, and dose assessment to support DOE Nuclear Incident Response Team (NIRT) capabilities (SNL, RSL) - DOE;
- Enhancement of source term models for radiological, prompt (i.e., blast, thermal, radiation, explosive effects), and chemical-biological releases (SNL) - DOE and DHS;
- Improved dose-response and toxic load models (Edgewood Chemical and Biological Center, U.S. Army) - DHS;
- Development of building infiltration models to predict indoor exposures (with LBNL) - DHS;
- Incorporation of an empirical urban model (Defense Science and Technology Laboratory, UK) - DHS;
- Meteorological and outdoor dispersion modeling for an operational subway system - DHS; and,
- Standardization and integration with the EPA/NOAA CAMEO/ALOHA toxic chemical databases and atmospheric dispersion models - DHS.

Los Alamos NATIONAL LABORATORY

LOS ALAMOS NATIONAL LABORATORY (LANL)

Operational

LANL is operated by the University of California (UC) under the responsibility of the DOE Albuquerque Operations Office (ALOO), and is spread across 43 square miles of the Pajarito Plateau at the foot of the Jemez Mountains that extend up to around 900 meters above the plateau. LANL is about 30 miles northwest of Santa Fe in north central New Mexico. The Pajarito Plateau slopes to the east-southeast, dropping 400 meters across the Laboratory, with canyons and mesas running along the slope of the plateau. The broad Rio Grande Valley lies to the east of the laboratory. Los Alamos has a semi-arid, temperate, mountain climate.

The operational meteorological program at Los Alamos operates a network of six towers (ranging in height from 23 meters to 92 meters), a monostatic Doppler SODAR, and three supplemental precipitation stations. Data from four instrumented meteorological towers that are located on the Pajarito plateau drives a diagnostic wind field for the program's plume modeling capability. A fifth tower is located in Los Alamos Canyon to give information on the larger canyons in the area, and a sixth tower is located on top of Pajarito Mountain to measure ambient conditions. The SODAR gives information on winds up to the level of the Pajarito Mountain tower.

More than 100 instruments, consisting of over 20 different types of sensors, are used to collect data throughout the network. Variables measured by the program can be grouped into the categories of wind, SODAR-derived wind, atmospheric state, precipitation-related, radiative fluxes, eddy heat fluxes, subsurface measurements, and fuel moisture. Data collected by the network are checked for quality before its archiving, and raw data and real-time displays of graphs and tables are made available via the Internet.

The LANL Air Quality Group (AQG) provides regulatory and environmental surveillance leadership and services to meet LANL air quality obligations and public assurance needs. The group develops and implements programs to ensure and address institutional compliance with State and Federal laws related to air quality regulations, DOE orders for emergency management, air quality surveillance, dose assessment activities, and community concerns related to air quality issues. The group takes a proactive approach to managing air emissions by providing continuous air monitoring and measurement of external penetrating radiation onsite and offsite.

The group also coordinates LANL activities to ensure full compliance with air emission regulations, providing monitoring and modeling for emergency response, and assisting operating groups in developing and implementing new methods and systems to reduce emissions to as low as reasonably achievable. The monitoring capabilities of the AQG are supplemented by the Atmospheric and Climate Sciences Group (ACSG) field team, which operates various sensor systems including a unique Raman lidar system to obtain images of atmospheric water vapor distributions.

<u>Research</u>

Research within the LANL Atmospheric and Climate Sciences Group supports DOE missions in both the defense and civilian sectors, such as work in the propagation of very-low-frequency sound (i.e., infra-sound) waves. Modeling studies contributed to understanding of propagation and, in particular, sources of "infra-sound". Just as it is possible to infer earthquake epicenters from seismic wave observations, "infra-sound" sources can be inferred from atmospheric observations. This work is an important component of monitoring compliance with the proposed Comprehensive Test Ban Treaty (CTBT). The CTBT work involves a number of organizations within DOE and DOD community, including interactions with other DOE laboratories within the CTBT Research and Development program.

Operational issues involve close work with the Air Force Technical Applications Center (AFTAC) at Patrick AFB, Florida, the DOD organization that handles monitoring systems. In addition, several active international collaborations with other infrasound researchers are ongoing.

The Meteorology Team within the ACSG at LANL conducts analysis and modeling on microscale to mesoscale atmospheric flows and phenomena. In support of the DOE CBNP, a model for High Resolution and Strong Gradient (HIGRAD) applications is being used to study the effects of radiative heating and shading around groups of buildings. The objective of this study is to determine how these processes may influence the transport of agents within the urban environment. On larger scales, the team is examining the influence of flow merger and urban roughness on the vertical transport and mixing of pollutants with the Regional Atmospheric Modeling System (RAMS) for several western U.S. valleys and basins. This project is in support of the DOE Environmental Meteorology Program (EMP) and for the EPA. As part of the LANL initiative in Coupled Environmental Modeling, researchers within the Meteorology Team are developing a physics-based fire behavior model, FIRETEC, and coupling this model to the HIGRAD atmospheric dynamics code to examine the details of the interaction between local winds and the intense heat generated by wildfires. Also as part of this initiative, a land surface model is being coupled that includes hydrologic processes (i.e., SPLASH) to the RAMS mesoscale model for multi-seasonal simulations of the water resources of the upper Rio Grande Basin.

Meteorology team members are also working on the LANL Urban Security project, which is linking physical and urban growth models to address the needs of cities. In this framework, we are using the RAMS model to provide meteorological fields for use by air chemistry, urban runoff, and other models. The Meteorology team within the ACSG conducts analysis and modeling on microscale to mesoscale.

On global scales, research within the LANL meteorological community involves the study of climate change and variability. A major project is the development of a global coupled ocean-atmosphere model sponsored by the DOE Climate Change Prediction Program. The global model being developed consists of a Los Alamos global ocean Global Climate Models (GCMs) Parallel Ocean Program (POP), the Los Alamos sea-ice model (CICE), the National Center for Atmospheric Research (NCAR) Community Climate Model (CCM3), and a "flux coupler" to link the media consistently. The two GCM's and the CICE model exchange heat, momentum, and water mass across the air-sea boundary. A ten-year synchronized simulation revealed the synoptic weather events, seasonal cycles and interannual variations.

Observations related to understanding global climate are the focus of the Tropical Western Pacific (TWP) Program Office LANL, an element of the DOE ARM Program. The TWP Program Office is responsible for the development and operation of the TWP CART locale, a large expanse of tropical-ocean and maritime-continent lying roughly between 10 degrees S and 10 degrees N latitude and from 135 degrees E to 150 degrees W longitude. The maritime continent area is largely in the southwest and the open ocean area in the northeast of the locale. The local climate is characterized by warm sea surface temperatures, deep and frequent atmospheric convection, high rain rates, strong coupling between the atmosphere and ocean, and substantial variability associated with El Niño Southern Oscillation (ENSO) phenomenon.

Scientific questions that need to be addressed in the TWP can be grouped under three main headings:

1. Radiation budget and cloud forcing;
2. Water and energy budgets; and,
3. Ocean-atmosphere interactions.

The program supports a variety of operations at LANL. The primary client of the program is the Emergency Management Group, for which the program provides a plume modeling capability. Other clients use the program's data for such activities as operations and planning, hazard and accident analyses, environmental studies, support for experiments, compliance, and documentation.

NEVADA TEST SITE (NTS)

Operational

The NTS is managed and operated by the National Nuclear Security Administration/Nevada Site Office (NNSA/NSO). The NTS has been the Nations' underground nuclear weapons testing facility and is now used to support sub-critical experiments and other national defense missions of the United States. The NTS occupies 1,350 square miles of south central NV and is approximately 75 miles northwest of Las Vegas, NV. The topography of the NTS is complex with a system of dry lakebeds and mountains. Elevations range from nearly 2,700 feet (ft) above mean sea level (MSL) to 7,600 ft MSL. The climate is arid.

Meteorological services are provided to NNSA/NSO by components of NOAA. NOAA has had a presence on the NTS for more than 45 years through the implementation of Interagency Agreements (IA). During this time, NOAA personnel have built a solid technical reputation in meteorological operations and emergency response. Presently, NOAA support is provided by Air Resources Laboratory Special Operations and Research Division (ARL/SORD) recognized for its expertise in the transport, dispersion, and deposition of radioactive and toxic materials (Figure 3-DOE-4). ARL/SORD has developed a rapid emergency response capability for the unlikely occurrence of an accidental release of radioactive or hazardous material into the atmosphere.

ARL/SORD provides full meteorological support to all NNSA/NSO operations on and off the NTS. Meteorology plays a key role in environmental, safety, and health responsibilities of NNSA/NSO. The ARL/SORD staff is responsible for conducting a modern program in support of nuclear and non-nuclear projects authorized by NNSA/NSO. Furthermore, the mission of ARL/SORD involves technical support to the emergency preparedness and response activities of NNSA/NSO. ARL/SORD supports a comprehensive meteorological program on the NTS, and provides meteorological and climatology services required in supporting the NNSA/NSO and contractor programs at the NTS, and elsewhere, as necessary.

Personnel at ARL/SORD also consult with senior scientists and engineers at the DOE National Laboratories, NASA, private contractors, Desert Research Institute (DRI), United States Geological Service (USGS), United States Forest Service (USFS), and other NOAA laboratories.

ARL/SORD operates and maintains a large meteorological monitoring network (MEDA) to characterize the meteorology and climatology of the NTS. This network consists of 29 10-meter towers and two, 30-meter towers. Wind direction and speed is measured at the 10-meter level on all the towers and temperature and relative humidity is sampled at the 2-meter level. Data from these towers are transmitted via microwave radio to a central processor that checks the data, creates data files, and archives the data every 15 minutes. The data files are accessed by microcomputer to create graphics products for operational use and for immediate display at 15-minute intervals. The MEDA system was upgraded in 2004 to include sonic anemometers.

SORD also operates two, 915MHz vertical profilers on the NTS. One tower is located in the middle of Yucca Flat and the other tower is located at the Hazardous Materials Spill Center (HMSC) in Frenchman Flat near Mercury, NV. In addition, a NOAA full surface radiation (SURFRAD) budget station is operated and maintained at the Desert Rock Meteorological Observatory (DRA) located in the southern part of the NTS. Upper-air soundings are taken twice daily, at 00 and 12 Universal Time Coordinated (UTC) from the DRA facility.

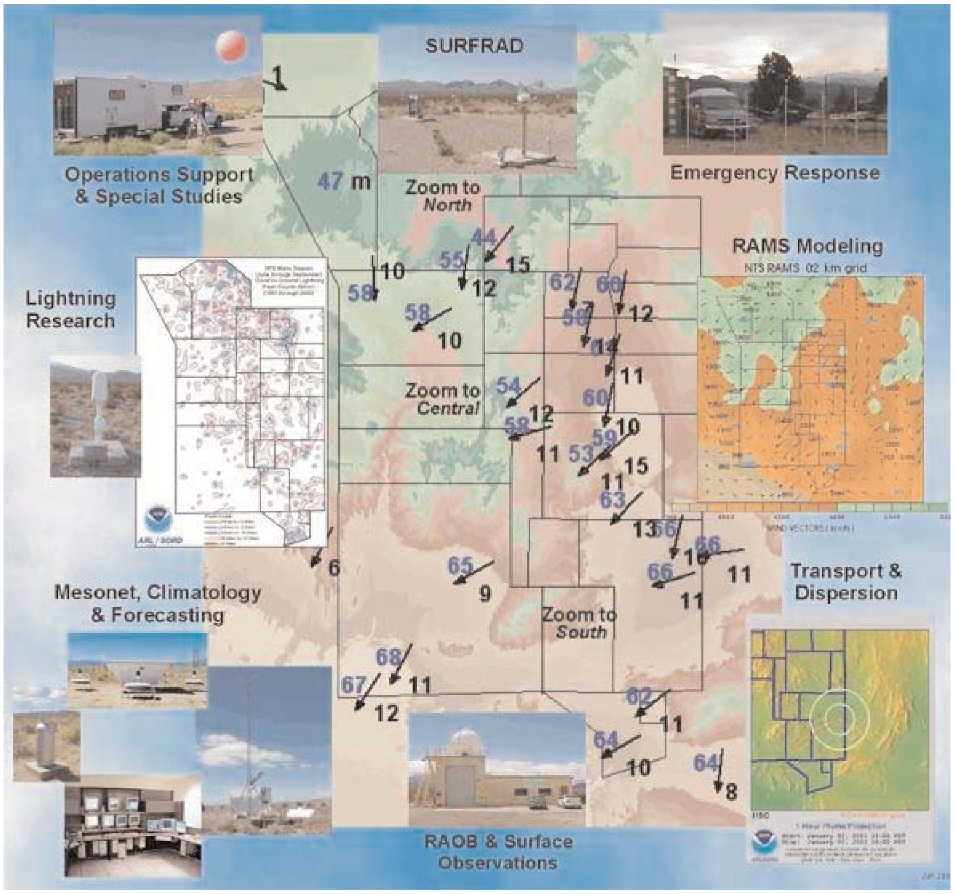


Figure 3-DOE-4. Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD) conducts basic and applied research on problems of mutual interest to National Oceanic and Atmospheric Administration (NOAA) and Department of Energy (DOE), that relate to the Nevada Test Site (NTS), its atmospheric environment, and its emergency preparedness and emergency response activities.

ARL/SORD also operates mobile upper-air sounding systems and mobile pilot balloon (PIBAL) equipment to support special projects requiring winds aloft data in real-time.

Large-scale meteorological data and National Center for Environmental Predictions (NCEP) weather forecast products are received via AWIPS, or from the University Center for Atmospheric Research (UCAR) and ARL-Silver Spring, MD. Weather products supplied to DOE contractors, the National Laboratories (e.g., SNL, LANL, and LLNL), the NWS, and Nellis AFB, include real-time cloud-to-ground lightning flash graphical products and local forecast products. Furthermore, a three-tiered lightning alert and warning procedure has been implemented as part of the NTS Integrated Safety Management program.

ARL/SORD has also implemented the RAMS model for the NTS and Southern Nevada. This model predicts boundary layer airflow and precipitation over complex terrain. The RAMS code accesses the NCEP predictive model outputs and is run twice daily at the University of Nevada at Las Vegas (UNLV) Supercomputer Center on a daily basis. In addition, the NOAA HYSPLIT/HARM dispersion model has been installed on microprocessors in the SORD Meteorological Assessment Center.

ARL/SORD provides meteorological monitoring support and project-specific weather forecast services to NEST, FRMAC and ARG activities. Monitoring support includes surface and upper-air data collection and analysis. Weather forecast service entails maintaining a constant weather watch for conditions that might impact NEST, FRMAC, or ARG operations and personnel, issuing site-specific mesoscale wind, stability, and weather forecasts, aviation weather support, and providing consultation to the On-Scene Commander (OSC) and to National Laboratories personnel. ARL/SORD maintains a web site (www.sord.nv.doe.gov) that includes graphical products that display current meteorological conditions on and around the NTS, including data from ARL/SORD vertical profilers, climatology data, cloud-to-ground lightning information and time-relevant plume transport and dispersion calculations.

<u>Research</u>

Both basic and applied research is carried out on problems of mutual interest to DOE and to NOAA. Emphasis is on the maintenance of meteorological support to national defense projects and to the stewardship of nuclear weapons. These capabilities focus on those facets of meteorology having a direct bearing on the transport, dispersion, deposition (i.e., fallout), and resuspension of radioactive and/or toxic materials. Other research includes documentation and study of extreme precipitation events, desert thunderstorms, cloud-to-ground lightning, and environmental issues related to air quality and visibility. In addition, the SORD program serves as a test bed for advanced NOAA mesoscale prediction models.

A NOAA Climate Reference Station was installed at the Desert Rock Meteorological Observatory in April 2004.

OAK RIDGE RESERVATION (ORR)

<u>Operational</u>

The ORR is home to four DOE/NNSA sites: Oak Ridge National Laboratory (ORNL), the Y-12 National Security Complex, the East Tennessee Technology Park (ETTP, formerly K-25 Site), and the Oak Ridge Institute for Science and Education (ORISE). Managed by the Oak Ridge Operations Office (OROO), the ORR encompasses nearly 100 square miles of hilly and heavily vegetated terrain in eastern Tennessee.

Formerly known as the Oak Ridge Y-12 Plant, and constructed in the early 1940's as part of the Manhattan Project to manufacture nuclear weapons components, the Y-12 National Security Complex (NSC) has now assumed a national security role under NNSA. Y-12 is an 811-acre facility located within the city limits of Oak Ridge, TN, 10 miles from the ORNL and 12 miles from the ETTP, once known as the Oak Ridge Gaseous Diffusion Plant.

Currently operated by BWXT Y-12, the national security programs at Y-12 include manufacturing and reworking nuclear weapon components, dismantling nuclear weapon components returned from the national arsenal, serving as the nation's safe, secure storehouse of special nuclear materials, providing the U.S. Navy with safe, militarily effective nuclear propulsion systems, and reducing the global threat from terrorism and weapons of mass destruction. In early 2004, the Y-12 NSC received, stored and secured a shipment of Libyan nuclear materials.

Meteorological network systems, which support day-to-day operations, are managed and operated at the three main sites by the University of Tennessee (UT)/Battelle, BWXT Y-12 and Bechtel Jacobs Company. These network systems provide data that support environmental management (permitting, facility siting and environmental impact assessment), facility safety (safety analyses), emergency management (hazards and consequence assessment), operations (work planning) and substantial research.

The BWXT Y-12 meteorological program is operations-, environment- and safety- oriented. Y-12 is located in the narrow Bear Creek Valley, and it is bordered by two SW to NE oriented ridges, mostly covered with mature pines and hardwoods. Two meteorological towers have long formed the basis for the meteorological program - a 100-meter tower, instrumented at 10-, 30-and 100-meters, located on the valley floor at the East end of Y-12, and a 60-meter tower, instrumented at 10-, and 60-meters, located on a ridgeline at the West end. In 2003, the data acquisition system was upgraded to an Environmental Systems Corporation (ESC) Windows-based software package, accessing via Ethernet the ESC 8832 data loggers at the towers. This data acquisition package is widely used in air pollution monitoring and in other environmental compliance applications.

Given the complex terrain setting of the Y-12 NSC, a REMTECH PA-2 sodar is used to characterize the winds from 50-meters, extending above the surrounding ridges to a height of 500-meters. Redundant Windows XP polling computers collect 1-hour average sodar data, plus 1-hour, 15-minute, and 1-minute tower data. Displays of the 15-minute data are available in the operations center, in the emergency centers (including the State EOC), and on an internal web page for general use. For real-time emergency response modeling purposes, 15-minute data is also routed to the NARAC meteorological database, and to a specially-formatted file on the Y-12 EOC modeling computers. There, it is accessible by the local chemical model, CHARM®, a commercially available 3-D grid model with an extensive chemical database and source term modeling features. For most other modeling needs, the NARAC iClient model is used at Y-12, where the ridge-valley and generally complex terrain setting has represented a prototype test and demonstration site for 3-D wind field and terrain models.

There is no on-site weather forecasting service at Y-12, but since it is in the city limits of Oak Ridge, representative forecasts are readily available from the local media, the national network services, and the Internet. Local severe weather advisories and warnings are issued by the nearby NWS Office at Morristown, TN, and they are received and disseminated by the Plant Shift Superintendent's (PSS) Office at Y-12. Also available to the PSS is a subscription weather and doppler radar service, as well as lightning detection and prediction equipment. The Y-12 Meteorologist and a Systems (Hardware/Software) Engineer maintain the program, train and assists others, as needed.

The meteorological data acquisition program at ETTP has two main towers. K-1209 is 60 meters high while K-1208 is 30 meters in height. In addition, two 10-meter supplemental towers are still operating. Lastly, a NEXRAD radar system, and The Weather Channel (TWC) are available to each of the control rooms and emergency response facilities.

The data acquisition program at the ORNL consists of three (two 30-meter and one 100-meter) meteorological towers. Meteorological data is fed to an ORNL central computer system for analysis and dissemination.

Research

NOAA Air Resources Laboratory/Atmospheric Turbulence and Diffusion Division (ARL/ATDD) is located in Oak Ridge near the ORR. The primary mission of ATDD is atmospheric research. Substantial research programs at ATDD are undertaken with the assistance of staff from ORISE/Oak Ridge Associated Universities (ORAU) and scientists from other national laboratories and organizations in the United States and abroad. ARL/ATDD also works closely with the ORAU to enhance educational opportunities in atmospheric science.

ARL/ATDD research attention is focused on the physics of the lower atmosphere, with special emphasis on the processes contributing to atmospheric transport, dispersion, and air-surface exchange, and on the development and improvement of predictive capabilities using the results of this research. Many other projects are underway such as surface energy balance and CO2 exchange studies and long-term studies of CO2 exchange aimed at process-level understanding.

Operationally, ARL/ATDD personnel provide meteorological consultation and supplemental data for air quality analyses, environmental reports, and hazard assessments and consequence assessments. Local climatology data are routinely collected and distributed. Under NOAA funding, ARL/ATDD operates a regional network of 15 towers ranging from the Cumberland Mountains (middle Tennessee) to the Smoky Mountains on Tennessee's eastern border. Wind, temperature, and precipitation data are recovered every 15 minutes by telemetry and made available to users.

ARL/ATDD incorporates NWS forecast products into the high-resolution, regional, meteorological model (i.e., RAMS) to produce twice daily 12-hour, 24-hour, and 36-hour predictions of surface winds for eastern Tennessee, and transport trajectory predictions for the ORR.

PANTEX PLANT

Operations

The Pantex Plant covers 15,977 acres and is located 17 miles northeast of Amarillo, TX, in Carson County. The Plant was a World War II munitions factory and was converted to a nuclear weapons assembly facility in 1951. Today, it is the nation's only assembly/disassembly facility supporting the nuclear weapons arsenal. Pantex Plant is a government-owned, contractor-operated facility. DOE oversees operation of Pantex Plant through the Amarillo Area Office (AAO), which reports to the Albuquerque Operations Office. Mason and Hanger Corporation had been the operating contractor since 1956. On February 1, 2001, BWXT Pantex has assumed the Pantex contract.

The Plant is composed of several functional areas, commonly referred to as numbered zones. These include a weapons assembly/disassembly area, a weapons staging area, an area for development of experimental explosives, a drinking water treatment facility, a sanitary wastewater treatment facility, and vehicle maintenance and administrative areas. Other functional areas include a utility area for steam and compressed air, an explosive test-firing facility, a burning ground for thermally treating explosive materials, and landfills. Overall, there are more than 700 buildings at the Pantex Plant.

The Environmental Protection/Restoration Department (EP/RD) of the Environment, Safety and Health Directorate is tasked with the quality assurance program for the meteorological data captured by the one on-site two-level tower located in the northeast corner of the Plant site. The data from this tower (i.e., 10-meters and 60-meters) are collected and used by the DOE NARAC site workstation, located in the Plant EOC. These data are collected and archived as 15-minute averages plus maximum and minimum values for each 15-minute period. They are primarily used for input to the NARAC emergency response models that could be used for off-normal events involving radionuclides. Annual dispersion model calculations of offsite radiation doses from on site sources, required by 40 CFR 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAP), are accomplished by the EP/RD. EP/RD uses the EPA-approved CAP88-PC atmospheric transport and dispersion model and the Pantex meteorological tower data processed into the STAR format. This department also maintains the Pantex Plant climatology database.

Meteorological tower data is also used by the Risk Management Department for plume dispersion modeling applied to the Plutonium Dispersal Consequence Analysis for the Basis for Interim Operations (BIO) validation and upgrade reports, other operations directives, and other safety analyses.

Routine preventive maintenance on the meteorological instruments as well as calibration and certification are done semi-annually by the United States Bureau of Land Management (BLM). The BLM maintenance depot at Boise, Idaho performs similar work for the United States Forest Service's own meteorological towers instruments. This work is done under a contract administered by the Pantex Emergency Management Department. The BLM Idaho depot also handles emergency repairs and replacement of sensors. Temperature and wind sensors are replaced semi-annually with calibrated and certified sensors. The barometer is replaced annually. During the semi-annual preventive mainte-

nance visits all of the other meteorological instruments are replaced by the BLM technician with rebuilt/refurbished, calibrated equipment, from the Idaho depot. The maintenance check also includes the telephone line, modem, and backup power supply.

As a result of a FY 2000 project meteorological tower data is now displayed on the Pantex Plant Intranet for use by Plant personnel. During FY 2001, the potential for replacing the existing wind sensor on the meteorological tower with a three-dimensional wind sensor was evaluated. In addition, replacing/upgrading the NARAC computer and software located at the base of the tower that feeds data into the NARAC Site System in the EOC was also considered.

Research

There are no current or projected supporting meteorological research activities planned at the Pantex Plant.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE (RFETS)

Operational

The RFETS is managed by the Rocky Flats Operations Office (RFOO) and is located approximately 16 miles northwest of downtown Denver, CO. One of the smaller DOE sites, the facility occupies a 10 square mile area along the foothills of the Rocky Mountain Front Range.

A 61-meter meteorological tower at the west-end of the site continuously monitors meteorological conditions at surface, 10-meters, 25-meters, and 60-meters above ground level. The data are analyzed, quality assured, and assembled into data sets for use in atmospheric modeling, climatology, and other analyses at the site. Data from the 61-meter and 10-meter towers are also transmitted back to the main site every 15 minutes by telemetry for use in emergency response modeling. The Regional Atmospheric Response Center (RARC) conducts meteorological activities associated with emergency preparedness and response at the site. An upper air remote sensing Sound Detection and Ranging/Radio Acoustic Sounding System (SODAR/RASS) continuously monitors winds, temperatures, and atmospheric stability above the RFETS site.

Through a cooperative agreement with the Colorado Department of Public Health and Environment (CDPHE), meteorological data are transmitted to the site from five surface meteorological stations by telemetry that form a ring around the site perimeter. Another cooperative agreement with NOAA provides near real-time data from multiple monitoring sites throughout the Denver metropolitan area. These data are all received, quality assured, and combined into a three-dimensional observation set for emergency response modeling every 15 minutes, 24 hours per day.

The RARC provides 24-hour consequence assessment support for any unplanned radiological or chemical releases from the site. The Center responds with customized weather forecasts, plume projections, and dose modeling results that lead to event classifications and protective actions for on-site and off-site populations. RARC also conducts specialized consequence assessments in support of emergency preparedness, hazard assessments, and risk assessments for RFETS. Weather forecasts are provided for severe weather events, such as winter storms, windstorms, and severe thunderstorms.

A customized modeling system has been developed and implemented at RFETS to predict the pathway and impacts from any radiological emergency at the site. Called the Computer-Assisted Protective Action Recommendation System (CAPARS), the new capability addresses the need for fast, accurate plume predictions in a complex atmosphere.

CAPARS provides a variety of plume, weather, hazard, and related products with the accuracy and speed needed for response to an emergency at RFETS. Eleven integrated major subsystems form the overall CAPARS capability.

The State of Colorado has formally accepted the CAPARS modeling system for emergency response and planning applications at RFETS. A specialized planning version of the CAPARS system has been developed, implemented, and applied for emergency planning at the RFETS. Called the TRAC Risk Assessment/Hazards Assessment Model, the capability is designed to support hazards and risk assessments for RFETS and to form the basis for an evaluation of the size and shape of the Emergency Planning Zone (EPZ) surrounding RFETS.

Research

There are no current or projected supporting meteorological research activities planned at RFETS.

SANDIA NATIONAL LABORATORY (SNL)-ALBUQUERQUE

Operational

The DOE Kirtland Area Office (KAO) manages SNL in Albuquerque, NM, located between the Rio Grande Valley and Manzano Mountains. SNL covers approximately 80 square miles of flat to mountainous arid terrain. Meteorological Programs at SNL include both support and research activities.

Meteorological services and support are provided through the EOC in the Laboratory Services Division (LSD). The mission is to provide meteorological support for various operations including:

- Emergency response;
- Environmental surveillance and characterization; and,
- Regulatory compliance.

The monitoring network consists of six 10-meter and two 60-meter towers used to measure wind direction and speed, ambient temperature, and relative humidity. There are also three precipitation gauges, two barometric pressure sensors, and one solar radiation pyranometer in the network.

Research

Key research activities are provided through the Energy and Critical Infrastructure Center in the Energy, Information, and Technology Division. SNL scientists are involved in the ARM program and the Surface Heat Budget of the Arctic Ocean (SHEBA). The ARM project is a combined measurement and modeling program. The goal is to gain a better understanding of clouds and their effect on atmospheric radiation, with the final goal of developing better climate models. The SHEBA program addresses the interaction of the surface energy balance, atmospheric radiation and clouds over the Arctic Ocean.

SAVANNAH RIVER SITE (SRS)

Operational

The SRS is under the responsibility of the Savannah River Operations Office (SR) and operated by the Westinghouse Savannah River Company (WSRC). SRS is located in southwestern South Carolina, along the banks of the Savannah River. The SRS covers an area of approximately 300 square miles and is thickly forested with pine trees. There are also several small streams, a large swamp, and two reservoirs built as cooling ponds for nuclear plant reactors. The topography of SRS is characterized by gently rolling hills with an adjacent flood plain near the Savannah River. The climate at SRS is typical of the southeastern United States with long, hot and humid summers and short mild winters.

The Atmospheric Technologies Group (ATG) of the Savannah River Technology Center (SRTC) has developed and operated a meteorological monitoring and modeling program at the SRS since the early 1970's. This program supports SRS operations in emergency response consequence assessment, weather forecasting, radiological and non-radiological air quality calculations for regulatory compliance, safety analyses, environmental impacts, engineering studies, environmental research and non-proliferation activities.

ATG's meteorological data sources are extensive and quite varied. Onsite meteorological data are obtained from a network of eight 200-foot meteorological observing towers located near the major production sites. The instrumentation on these towers includes sensitive bi-directional vanes (i.e., bivanes), cup anemometers, resistance thermometers and lithium chloride humidity sensors. Another tower is located at the Central Climatology facility, located near the geometric center of the SRS. It includes like instruments near ground level, 60-ft, 120-ft, and 200 ft. Additional meteorological measurements at the Central Climatology facility include precipitation, evaporation, barometric pressure, soil temperature, solar and long wave radiation. Data are collected with dedicated data loggers at each tower site. Each logger is then polled by a remote computer that, in turn, populates a relational database with meteorological data.

A network of twelve manually-read rain gauges is located throughout the SRS. Additional local upper-air data are collected from a balloon-launched airsonde system and a portable tethersonde system. Portable towers are available for use in case studies.

ATG also has access to local radar data, which is then distributed site-wide via the SRS intranet. Regional, national, and international meteorological data are received from a commercial weather data provider via satellite in real time. The data include surface observations, satellite and radar imagery, and predictive model information from the US and abroad.

In addition, ATG has developed the Weather Information and Display (WIND) System as an automated resource for conducting real-time consequence assessments following unplanned releases of hazardous material. The WIND System is a multi-computer platform network that links the real time meteorological observations and forecasts with a suite of atmospheric and aqueous transport and dispersion models. A rolling 24-hour data file is created from data archived in the meteorological database and disseminated to a pc-based workstations that can operate the WIND System's modeling and display software.

In the mid 1990s, a mutual aid agreement with surrounding counties emergency management agencies was created to install and operate four meteorological towers at nearby chemical plants in support of emergency response activities. Data from these towers are incorporated into the SRS meteorological database, integrated into the 24-hour data file, and made available beyond the SRS firewall for use by the off site partner entities using appropriate WIND System software.

Nearby SRS, two television stations, WJBF and WAGT, have built a new television tower, where SRTC has installed meteorological instrumentation at the 100 ft, 200 ft, and 1000 ft levels. This local television transmitter tower was instrumented with fast response three-dimensional sonic anemometers and optical water vapor and CO2 sensors at 100-ft, 200-ft, and 1,000 ft. Slow response temperature and humidity sensors were also installed at these levels. The data from this tower will provide vital information for both operational emergency response and for the USFS to conduct control burns. It will also provide valuable data for research in the atmospheric boundary layer.

A joint partnership between Westinghouse Electric Company and a local television station provides local Doppler radar data to SRS and the local community in real-time. This provides valuable site specific radar returns to assist in site operations. The data (e.g., static and time lapse - movie - images) are available through the site internal computer network at employees' desktop computers.

ATG utilizes a regional mesoscale model, RAMS, for providing detailed forecast information. Specifically, forecasts out to 24 hours from RAMS are available as input for the predictive component of WIND System models. Transport calculations blend observed meteorological data with RAMS forecasts to make timely and accurate assessments. The grid resolution used in RAMS varies from 2 km for the inner grid (100 km x 100 km centered on the SRS) and 8 km for the outer grid (250 km x 250 km).

The SRS Atmospheric Technology Center provides access to local, national and international meteorological data to provide comprehensive meteorological support for SRS and WFO customers. On a daily basis, ATG provides weather forecasts in support of site operations. Typical customers include waste handling groups where wind and rain forecasts often determine daily activities. Also, ATG supports the US Forest Service (USFS) prescribed burn program and site heat stress program with detailed observations and forecasts. Custom forecasts are also provided to facility and other senior managers to support protective action decisions for severe weather.

Research

There are no current or projected supporting meteorological research activities planned at SRS.

WASTE ISOLATION PILOT PLANT (WIPP)

Operational

The Waste Isolation Pilot Plant (WIPP) is operated by Westinghouse TRU Solutions for the DOE Carlsbad Area Office (CAO). A cornerstone of the DOE national clean-up strategy, the WIPP is designed to permanently dispose of transuranic (TRU) radioactive waste generated by defense-related activities in the Salado salt formation 2,150 feet beneath the surface. WIPP is located in Eddy County in southeastern New Mexico, 26 miles east of Carlsbad, and occupies 16 square miles of a region know as Los Medanos. Geographically, the region is regarded as a relatively flat, sparsely inhabited plateau with little surface water.

The WIPP Environmental Monitoring Section (EMS) performs meteorological monitoring as part of the Non-radiological Environmental Monitoring Program. The primary meteorological station provides measurement of wind direction and speed, temperature at two-meters, 10-meters, and 50-meters, as well as ground level measurements of barometric pressure, relative humidity, precipitation, and solar radiation. The main function of the station is to generate data for operational support, emergency response and regulatory dispersion modeling applications. Parameters are monitored continuously and the data are stored in the Central Monitoring System, a computerized system including automated parameter checks, real-time displays in the Central Monitoring Room, and data archiving. Meteorological data are compiled and distributed to stakeholders, including the NOAA NWS, on a monthly basis.

WIPP also, under a cooperative agreement with the NWS, maintains a Cooperative Weather Observing Station at the Far Field Station. Data from this station are compiled monthly and the Record of Climatological Observations form is submitted to the Weather Forecast Office in Midland, TX. Under the same cooperative agreement, the Midland office is given access to real-time data from the primary meteorological station.

Research

There are no current or projected supporting meteorological research activities planned at WIPP.

WELDON SPRINGS SITE REMEDIAL ACTION PROJECT (WSSRAP)

Operational

The activities associated with Weldon Springs Site Remedial Action Project (WSSRAP) have been completed. The meteorological monitoring program that had operated at the WSSRAP since 1994 was dismantled in 2003.

Research

There are no current or projected supporting meteorological research activities planned at WSSRAP.

YUCCA MOUNTAIN PROJECT (YMP)

Operational

As part of the DOE Office of Civilian Radioactive Waste Management (OCRWM), the Yucca Mountain Project (YMP) studies may eventually support a recommendation of Yucca Mountain for the nation's first geologic repository for spent nuclear fuel and other high level radioactive waste (Figure 3-DOE-5). The current meteorological program within the YMP focuses on environmental compliance and operational health and safety considerations, for both employees and the general public.

As with a number of DOE sites, the Yucca Mountain area is one of complex topography and heterogeneous surface characteristics, creating mesoscale conditions that locally influence onsite weather. The YMP meteorological program, therefore, includes four full stations for measuring atmospheric dispersion and general meteorological conditions, as well as nine precipitation stations. These stations serve to monitor the significant variations in airflow, rainfall, and temperature caused by the area's complex terrain environment. The meteorological stations are key to the thorough monitoring of these variations that is essential for the YMP ongoing commitment to environmental compliance and to the health and safety of employees and the public.

The YMP meteorological program also provides essential data for the studies necessary to evaluate the site's suitability for a potential repository. Should the site be deemed suitable and a repository licensed, built, and operated, water would be the primary means by which radioactive materials could be transported to the accessible environment. Thus, movement of water from the atmosphere to the surface and on through the mountain is a key concern. The meteorological program provides essential data for the infiltration model of the mountain. Data about precipitation, humidity, evapotranspiration, surface water run-on, solar radiation, air temperatures, and wind patterns all contribute to the overall infiltration model. The model gives special emphasis to the transient, or temporal, versus steady-state rates of water movement through the unsaturated zone of rock at Yucca Mountain. The temporal variation of infiltration may be short term, due to weather fluctuations that drive episodic flow, or much longer term, in periods corresponding to climate change. Data from the meteorological program's ongoing monitoring programs are supplemented by the program's paleoclimatology studies. Together, they provide essential information for the YMP modeling of past, present, and future infiltration rates.

If the potential repository were actually built and operated, continuous meteorological monitoring and analysis would also be essential for the operational facilities on the surface of the mountain, at least until the final closure of the repository. Buildings would be built to withstand the probable maximum flood and wind conditions, and administrative controls would be in place to suspend operations during severe weather conditions. An integral part of the emergency response system would include monitoring the overall environmental situation at the repository site.

In turn, an integral part of the overall environmental monitoring system would be the meteorological monitoring system. This system would collect real-time meteorological information about the site and provide weather forecasting and climatological data. Such data would be essential for management decisions regarding the health and safety conditions for employees and the public.

Research

There are no current or projected supporting meteorological research activities planned at the Yucca Mountain site.

DOE METEOROLOGICAL COORDINATING COUNCIL (DMCC)

Based on a need to facilitate more coordination and cooperation among the meteorological activities at the DOE field offices, the DMCC (i.e., the Council) was established on December 2, 1994. The mission of the Council, now in its eleventh year, is to coordinate meteorological support and research to meet DOE objectives. The objectives of the council are to:

- Promote cost-effective support for all DOE facilities;

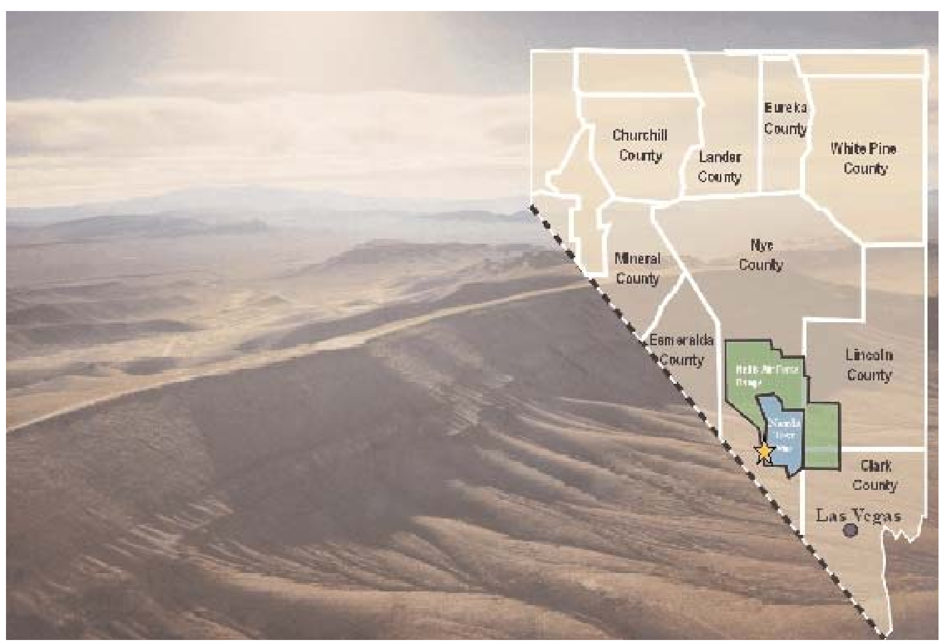


Figure 3-DOE-5. Yucca Mountain (100 miles northwest of Las Vegas, Nevada) is unpopulated land owned by the Federal Government and adjacent to the nation's nuclear weapons test site.

• Plan for future needs, requirements, and missions;

• Advocate awareness of atmospheric science applications and benefits to DOE; and,

• Advocate the use of common methods, procedures, and standards.

Council oversight is provided by a steering committee consisting of DOE and NNSA headquarters and field element representatives. Products of the DMCC include evaluations of meteorological requirements contained in DOE orders and guidance documents, site meteorological program peer reviews, and, as needed, customized technical assistance. Assist Visits have been conducted at NNSA/NSO, WIPP, Pantex, DOE/OR and SNL-Albuquerque. Two follow-up assist visits were also conducted at WIPP. Additional assist visits are in the planning stages and will be conducted over the next several years.

The DMCC web page has been broadened and can be accessed at www.sord.nv.doe.gov. The DMCC can also be accessed through the web page of the Subcommittee for Consequence Assessment and Protective Actions (SCAPA).

DEPARTMENT OF HOMELAND SECURITY WEATHER PROGRAMS

The Department of Homeland Security (DHS) has three primary missions: Prevent terrorist attacks within the United States, reduce America's vulnerability to terrorism, and minimize the damage from potential attacks and natural disasters. The department's first priority is to protect the nation against further terrorist attacks. Component agencies will analyze threats and intelligence, guard our borders and airports, protect our critical infrastructure, and coordinate the response of our nation for future emergencies. Besides providing a better-coordinated defense of the homeland, DHS is also dedicated to protecting the rights of American citizens and enhancing public services, such as natural disaster assistance and citizenship services, by dedicating offices to these important missions. DHS has Five Major Divisions, or "Directorates": Border and Transportation Security (BTS); Emergency Preparedness and Response (EPR); Science and Technology (S & T); Information Analysis and Infrastructure Protection (IAIP); Management. Besides the five Directorates of DHS, several other critical agencies folded into the new department or were created: United States Coast Guard; United States Secret Service; Bureau of Citizenship and Immigration Services; Office of State and Local Government Coordination; Office of Private Sector Liaison; and the Office of Inspector General.

On March 1, 2003, the Department of Homeland Security (DHS) assumed primary responsibility for ensuring that emergency response professionals are prepared for any situation in the event of a terrorist attack, natural disaster, or other large-scale emergency. This entails providing a coordinated, comprehensive federal response to any large-scale crisis and mounting a swift and effective recovery effort. DHS will also prioritize the important issue of citizen preparedness, and educating America's families on how best to prepare their homes for a disaster and tips for citizens on how to respond in a crisis will be given special attention at DHS.

Homeland Security Presidential Directive #5 (HSPD 5), states that "to prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies, the United States Government shall establish a single, comprehensive approach to domestic incident management." It also assigns the Secretary of the Department of Homeland Security the role of principal Federal official for domestic incident management. Based on previous Federal guidelines and legal authorities, a number of Federal agencies have responsibilities, depending on the scenario, and each agency has developed or has access to source-term estimates, dispersion modeling, and consequence assessment capabilities to meet their responsibilities. For a domestic incident, these capabilities would be coordinated by the Secretary of the Department of Homeland Security in cases where a Federal response is required and authorized.

Over the coming year, the goal is to develop an all-hazards dispersion support framework, initially based on atmospheric dispersion modeling and consequence assessment, to support the DHS Secretary in his role as principal Federal official for planning, preparing, and responding to domestic incidents. This framework will provide tailored all-hazards dispersion support to DHS and its Homeland Security Operations Center (HSOC). The primary and most urgent objective is to provide the best available information for atmospheric hazard predictions so that DHS can make appropriate emergency response and consequence management decisions. This effort is based on the work and recommendations of the OFCM-sponsored Joint Action Group on the Selection and Evaluation of Atmospheric Transport and Dispersion Models (JAG/SEATD) report, Atmospheric Modeling of Releases from Weapons of Mass Destruction: Response by Federal Agencies in Support of Homeland Security, August 2002, and the National Research Council's (of the National Academies) Board on Atmospheric Sciences and Climate report, Tracking and Predicting the Atmospheric Dispersion of Hazardous Material Releases: Implications for Homeland Security, 2003.

EMERGENCY PREPAREDNESS AND RESPONSE (EPR)

In March 2003, FEMA joined other federal agencies, programs and offices in becoming the Department of Homeland Security. The new department brings a coordinated approach to national security from emergencies and disasters - both natural and man-made. Today, FEMA is one of four major branches of DHS. About 2,600 full-time employees in the Emergency Preparedness and Response (EPR) Directorate are supplemented by more than 4,000 stand-by disaster reservists.

In carrying out its role, EPR works with all of the agencies to assure that the delivery of meteorology-related information is conducted in keeping with established goals and objectives. As administrator of the National Flood Insurance Program (NFIP), EPR publishes Flood Insurance Rate Maps for all flood-prone communities, which serve as the official demarcation for flood risk. EPR administers the National Hurricane Program and, for regions subject to hurricanes, publishes hurricane evacuation maps based on model simulation results from the National Weather Service's National Hurricane Center.

EPR's priority interests with OFCM are in supporting EPR's pre-disaster initiatives and in promoting standards and procedures which will enhance the ability of the Nation to mitigate and recover from emergencies and disasters. These interests extend to national standards for geographic information systems (GIS) used for delivery of meteorological products and services by other agencies. EPR also actively supports the OFCM-sponsored Working Group for Post-Storm Data Acquisition (WG/PSDA) and the WG/PSDA's efforts to develop a *National Plan for Post-Storm Data Acquisition* to coordinate and support the collection, by the federal agencies, of perishable data after major storms. These data have potential applications in post-disaster mitigation activities, the NFIP flood hazard analysis, the EPR National Hurricane Program hurricane evacuation studies, and other EPR's risk analysis activities, such as the Multi-Hazard Loss Estimation Methodology (HAZUS). The Technical Services Division is the principal contact for hurricane evacuation studies and flood risk analysis as well as the EPR contact point for meteorology-related matters. (*www.fema.gov*) (Figure 3-DHS-1).

UNITED STATES COAST GUARD (USCG)

Since March 2003, the Commandant of the Coast Guard reports directly to the Secretary of Homeland Security. However, the USCG also works closely with the Under Secretary of Border and Transportation Security as well as maintain its existing independent identity as a military service. Upon declaration of war or when the President so directs, the Coast Guard would operate as an element of the Department of Defense, consistent with existing law.

Although no United States Coast Guard (USCG) cutters or shore units are solely dedicated to meteorology, they collectively perform a variety of functions in support of the national meteorology program. USCG ocean-going cutters and coastal stations provide weather observations to the National Weather Service (NWS). Coast Guard communications stations broadcast NWS marine forecasts, weather warnings, and weather facsimile charts and, also, collect weather observations from commercial shipping for the NWS. The Coast Guard also operates the LORAN C radionavigation system and the Maritime Differential GPS (DGPS) Service. The LORAN C system provides Position, Navigation, and Timing (PNT) information to a variety of navigation and non-navigation users throughout the continental United States and Alaska (e.g. radiosondes). The Maritime DGPS Service is an augmentation to the GPS that improves GPS-only accuracy to better than ten meters and provides DGPS coverage to coastal areas of the continental United States, the Great Lakes, Puerto Rico, portions of Alaska and Hawaii, and portions of the Mississippi River Basin.

Coast Guard operates three polar icebreakers - USCGC POLAR STAR, USCGC POLAR SEA, and USCGC HEALY - to serve our Nation’s security, economic, environmental, and scientific interests. These vessels make important marine environmental measurements during dedicated science deployments or in conjunction with other missions.

USCGC HEALY, a new icebreaking research vessel, was delivered to the Coast Guard in November 1999 and conducted successful shakedown tests of the hull, machinery, and scientific equipment during January-August 2000 (Figure 3-DHS-2). The first unrestricted science cruise was conducted in the Eastern Arctic in the

Figure 3-DHS-1. Bay Minette, AL, July 14, 2005. The FEMA mobile Disaster Recovery Center helps applicants with the FEMA recovery process by makeing it easier for applicants to apply for FEMA aid. It contains phone lines and wireless telecommunications. Many areas of southern Alabama were affected by Hurricane Dennis. FEMA Photo/Mark Wolfe.

Figure 3-DHS-2. USCGC HEALEY, the Coast Guard's new icebreaking research vessel, conducting ice trials.

summer of 2001. HEALY, has a length of 420 feet, beam of 82 feet, and displaces over 16,000 tons. Scientific systems and gear include a bottom mapping multi-beam sonar system; a subbottom profiling system; a conductivity-depth-temperature data system; an expendable oceanographic probe system; an Acoustic Doppler Current Profiler; a jumbo coring system; a continuous flow, seawater sampling system; a meteorological measurement system; and a bow tower for clean air experiments. To schedule time on HEALY, see the UNOLS web site, *www.unols.org*. For more information, see the Coast Guard web page for HEALY, *www.uscg.mil/pacarea/healy/*.

USCG conducts the International Ice Patrol (IIP) under the provisions of the International Convention for Safety of Life at Sea (SOLAS). The IIP uses sensor-equipped aircraft to patrol the Grand Banks of Newfoundland to locate and track icebergs which pose a hazard to North Atlantic shipping. Direct observations are supplemented and extrapolated using a numerical iceberg drift and deterioration model. IIP determines the geographic limits of the iceberg hazard and, twice daily, broadcasts iceberg warning bulletins and ice facsimile charts which define the limits of the iceberg threat during the iceberg season (spring and summer). IIP annually archives data on all confirmed and suspected icebergs, and forwards these data to the National Snow and Ice Data Center. These data can be accessed via the IIP web page *www.uscg.mil/lantarea/iip/home.html*. Archived data contains all iceberg sighting data along with the last model-predicted position of each berg.

The Coast Guard participates with the Navy and NOAA in conducting the National Ice Center, a multi-agency operational center that produces analyses and forecasts of Arctic, Antarctic, Great Lakes, and coastal ice conditions.

The Coast Guard also collaborates with NOAA in operating the National Data Buoy Center (NDBC) which deploys and maintains NOAA's automated network of environmental monitoring platforms in the deep ocean and coastal regions. Five Coast Guard personnel fill key technical and logistics support positions within NDBC. Coast Guard cutters support the deployment and retrieval of data buoys, and provide periodic maintenance visits to both buoys and coastal stations, expending approximately 180 cutter days annually. Coast Guard aircraft, small boats, and shore facilities also provide NDBC support.

Meteorological activities are coordinated by the Ice Operations Division of the Office of Aids to Navigation at Coast Guard Headquarters. Field management of Coast Guard meteorological support services is accomplished at the Coast Guard Area and District levels.

DEPARTMENT OF THE INTERIOR WEATHER PROGRAMS

The Interior Department (DOI), is the nation's principal conservation agency, charged with the mission "to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities." The following operational and research programs contribute to the Federal Meteorological Plan.

UNITED STATES GEOLOGICAL SURVEY (USGS)

WATER DATA.

The USGS's Water Resources Discipline (WRD) collects streamflow, precipitation, water quality, ground-water level, and other water resources and climatological data as part of a national network and for a number of projects concerning rainfall runoff, water quality and hydrologic processes. Currently, the USGS collects hydrologic and meteorological data from more than 11,000 surface-water sites, precipitation data from more than 1,100 sites, ground-water level data from more than 23,000 sites, and water quality data from more than 8,900 surface-water, ground-water, and precipitation sites.

Data collected at USGS sites are transmitted from approximately 7,100 remote Data Collection Platforms (DCPs). The data are transmitted to Wallops, Virginia, via GOES and rebroadcast to a domestic communication satellite (DOMSAT). Data are received from the DOMSAT by local readout ground stations (LRGS) procured by USGS. The USGS currently operates 25 LRGS which provide near-real-time data to the USGS's computerized National Water Information System (NWIS). Data from over 1,800 additional sites are transmitted via other telemetry (mostly telephone). Near-real-time streamflow data and ancillary information are provided to National Weather Service River Forecast Centers for about 3400 river forecast points (Figure 3-DOI-1).

The USGS also collects precipitation samples in a number of studies for the determination of atmospheric contribution to the chemical constituent loads to runoff, and for defining the effect of atmospheric deposition on water quality and the aquatic environment.

The USGS serves historical and real-time water resources data on the Internet at its NWIS Web site (http://waterdata.usgs.gov/nwis/).

SNOW AND ICE STUDIES.

The USGS is carrying out a joint research program with NASA, the University of Washington-Seattle's Electrical and Civil Engineering Departments, and the French Space Agency (CNES) to measure snowpack water equivalent or snow depth using satellite passive microwave observations from the Defense Meteorological Satellite Program's (DMSP) Special Sensor Microwave/Imager (SSM/I) sensor. Unlike observations in the visible bands, passive microwave observations are independent of cloud cover and solar illumination and respond to both snow depth and snowpack grain size. The investigation is developing techniques to utilize algorithms that include the effects of grain size metamorphoses and to incorporate these algorithms into hydrologic models. Analysis of the two decade long passive microwave data set for the northern hemisphere snow covered extent has shown that the maximum snow pack has decreased in area and the global snow season is getting shorter, except for northeastern Canada.

The USGS and the BLM have used a

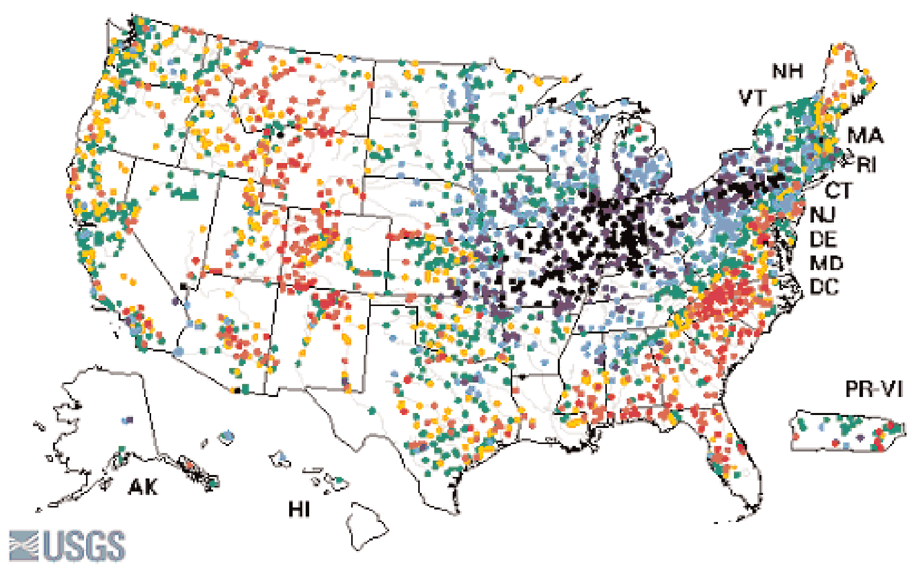


Figure 3-DOI-1. Sample USGS Water Watch map of real-time streamflow compared to historical streamflow for the day of the year. Source: USGS Website: *http://water.usgs.gov/waterwatch/*

combination of Landsat-7 and synthetic aperture radar images of the Bering Glacier, Alaska, which surged in 1993-95, to map the retreat of the glacier terminus as it undergoes large scale disarticulation. Scientists use these data to monitor the level of Berg Lake and the integrity of the ice dam that forms the southern shore of the lake, to assess the potential hazard presented by an outburst flood. In addition, the imagery is being used to plan summer field programs that include hydrographic investigations in expanding Vitus Lake, and both aquatic and terrestrial sampling.

CLIMATOLOGICAL RESEARCH.

USGS also carries out research in climate change, regional hydrology, the carbon cycle, coastal erosion, volcanic activity, and glaciology. As part of its glaciology program, the USGS maintains an observation program on three benchmark glaciers representative of different climactic zones of the western United States, one in Washington, one on the south coast of Alaska and one in the interior of Alaska. At each glacier, the program measures the winter snow accumulation, summer snow and ice ablation, air temperature, and runoff in the glacier basin. Beginning in 1959, this is the longest such record in North America. Analysis of this record is providing a greater understanding of the climate variability and its effects on water resources of the western United States.

The record clearly shows the effects of changing winter precipitation patterns associated with atmospheric conditions in the northeast Pacific Ocean, including El Niño - La Niña events and the Pacific Decadal Oscillation. Analysis of South Cascade mass balance data and NCEP re-analysis data for the northeast Pacific Ocean shows a strong relationship between winter balance and the temperature and on shore moisture flux and between the summer balance and the local temperature, which have been used to examine the effects of future climate scenarios on glacier mass balance.

GEOMAGNETIC DATA.

The Geomagnetism Program (http://geomag.usgs.gov) of the USGS Central Region Geohazards Team provides real-time, ground-based measurements of the Earth's magnetic field, which are an important contribution to the diagnosis of conditions in the near-Earth space environment of the sun, the solar wind, the magnetosphere, the ionosphere, and the thermosphere. During geomagnetic storms, brought about by the complex interaction of the Earth's magnetic field with that of the Sun's, both high- and low-frequency radio communications can be difficult or impossible, global positioning systems (GPS) can be degraded, satellite electronics can be damaged, satellite drag can be increased, and astronauts and high-altitude pilots can be subjected to enhanced levels of radiation.

Ground-based geomagnetic observatory data are complementary to those collected by space-based satellites; indeed, most of the hazardous effects on technological systems brought about by magnetic storms occur at or near the Earth's surface. Therefore, the Geomagnetism Group monitors the surficial magnetic field by operating 14 magnetic observatories in the United States and its Territories. The data from these observatories, plus 15 foreign observatories, are transmitted to the Group's headquarters in Golden, Colorado, where they are processed and analyzed. Data are then transmitted to the Space Environment Center (SEC) of the National Oceanic and Atmospheric Administration (NOAA) and to the U.S. Air Force (USAF) Air Force Weather Agency at Offutt AFB, Nebraska.

USGS observatories are operated in cooperation with Intermagnet, an international consortium overseeing the operation of nearly 80 geomagnetic observatories distributed around the globe. The roles and responsibilities of agencies participating in the National Space Environment and Warning Program are detailed in the *National Space Weather Program Strategic Plan* (FCM-P30-1995).

VOLCANOLOGY AND VOLCANIC ASH PLUMES.

The USGS participates in the Working Group for Volcanic Ash (WG/VA) of the OFCM. This working group is preparing a *National Framework for Volcanic Ash Hazards to Aviation*. Through its Volcanic Hazards Program, the USGS is responsible for monitoring volcanoes in the United States and issuing eruption forecasts and notifications.

When Mount St. Helens, WA, reawakened in September 2004, from an almost 15 year sleep, the eruptions have largely consisted of the extrusion of lava with activity confined to the crater. However, periodic explosions have erupted ash to heights as great as 30,000 feet above sea level. The USGS, NWS, and FAA have worked together to develop procedures and protocols to handle an erupting volcano situated between two major metropolitan centers.

Of the approximately 70 historically active volcanoes in the United States, more than 40 are in Alaska. Until the 1980's, the Alaskan volcanoes had been largely unstudied. Despite Alaska's low population density over much of the state, Alaska's volcanoes underlie the heavily traveled air routes of the North Pacific region. During recent years, the USGS's Alaskan Volcano Observatory (AVO) has expanded its network of real-time seismic monitoring stations to bring 27 of Alaska's volcanoes under continuous real-time surveillance. Data and information from the AVO monitoring activities are integrated directly into the regional operational activities of the FAA, DOD, and NOAA/NWS to provide warnings for pilots and aircraft operators in the Alaskan region. For much of the late spring-early summer 2004, and January-February 2005, Veniaminof volcano on the Alaska Peninsula frequently erupted ash to heights approaching 12,000 feet above sea level. USGS worked with NWS and FAA to establish an appropriate response to Veniaminof's low-level, but frequent activity

Internationally, the OFCM's WG/VA supported expansion of USGS monitoring activities in the remote Pacific Rim of explosive volcanoes. The 100 historically active volcanoes in Alaska, Kamchatka, and the Kuriles are monitored through satellite imagery several times a day. Currently, about 220 aircraft per day - carrying about 20,000 passengers and millions of dollars of cargo value -- fly international Northern Pacific Routes near these historically active volcanoes. About half these flights are United States carriers. AVO, through its working agreement with the Kamchatkan Volcanic Eruptions Response Team (KVERT) in Petropavlovsk-Kamchatsky, Russia, also supplies information about eruptive activity in Kamchatka and the Kuriles to the FAA, the NWS, and numerous domestic and foreign air carriers.

In 2003, the USGS responded to the eruption of Anatahan Volcano in the Northern Marianas, a Trust Territory of the US, which affected aviation flying across the Pacific. A small monitoring system installed in 2003, has enabled USGS scientists to provide notification of significant changes and eruptions to FAA, NOAA, and US Air Force as activity at Anatahan has continued.

The USGS, OFCM, and other US and international sponsors organized the Second International Conference on Volcanic Ash and Aviation Safety on 21-24 June 2004, in Alexandria, VA. The conference was a 4-day assembly of the international aviation, governmental, and scientific community involved with the ash issue. The conference was a forum to exchange technical and operational information, with the goal of identifying ways to improve mitigation of the ash hazard to aviation. The agenda included a combination of plenary sessions, poster presentations, and informal discussions on the topics of eruption monitoring and reporting, ash-cloud detection and forecasting; case histories of encounters and operational solutions, Volcanic Ash Advisory Center operations, the needs of the aviation industry, and education and outreach. More detailed information about the conference is on-line at http://www.ofcm.gov/homepage/text/spc_proj/volcanic_ash/volash2.html

BUREAU OF LAND MANAGEMENT (BLM)

The BLM is one of five Federal Land Management agencies which have centralized wildland fire weather operations at the National Interagency Fire Center (NIFC), in Boise, Idaho. The BLM's Initial Attack Management System (IAMS) was designed in the mid-1980's to provide real-time data access and modeling for the fire management organization. The IAMS required a considerable dedicated telecommunications network for data distribution. In an effort to reduce these inherent telecommunications costs, the BLM has moved into a "web server" environment. Many of the capabilities that were centrally located in the old IAMS have been moved to other web sites.

FIRE WEATHER WEBSITES.

The principal Wildland Fire Management Information System (WFMIS) inputs remain the same with Remote Automatic Weather Station (RAWS) and National Lightning Detection Network (NLDN) information (Figure 3-DOI-2). BLM's new server system is called the BLM Wildland Fire Management Information Site (www.nifc.blm.gov). Additional fire management information is summarized and made available at the Desert Research Institute (wrcc.dri.edu and cefa.dri.edu) and the United States Forest Service Wildland Fire Assessment System (//svinet2.fs.fed.us/land/wfas/). Additionally, the BLM has utilized the Desert Research Institute's capabilities to respond quickly for website support.

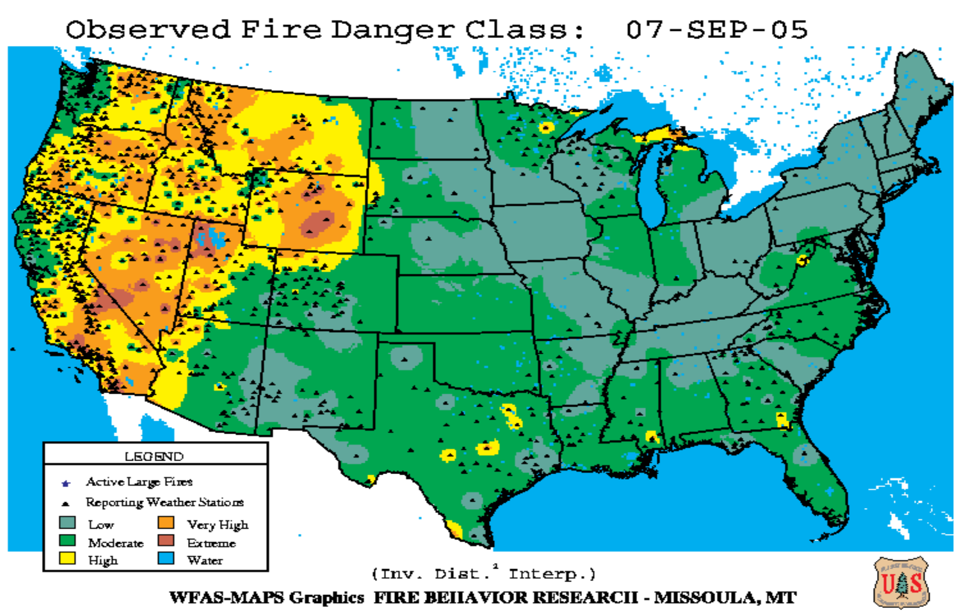


Figure 3-DOI-2. A National Interagency Coordination Center (NICC) graphic of Observed Fire Danger Class for the lower 48 states.

AUTOMATED WEATHER STATIONS.

The BLM's RAWS Program primarily collects meteorological data for fire weather forecasting. However, use of BLM's RAWS data set by other non-fire users has generated sufficient funding to permit year-round operation of the entire network. The BLM's Resource Management and Oregon O&C (West-Side) also operate RAWS networks which are much smaller and have specific program requirements that differ from fire management.

LIGHTNING DETECTION.

In 1997, the BLM began contracting with a private vendor via the National Weather Service for lightning location data. Data are received at the NIFC in Boise, Idaho, and placed on the BLM WFMIS for qualified user access. Current plans are to continue the operation of the Alaska Automatic Lightning Detection System as an independent government-owed and operated system.

FIRE WEATHER SUPPORT.

The BLM's Remote Sensing / Fire Weather Support Unit (RSFWSU) at NIFC provides the full range of program management, equipment dispatch, field and depot maintenance, support and data services for the BLM and numerous other government agencies. This interagency-staffed and funded facility performs work under long term agreements with those agencies within the government having similar equipment and requirements.

CLIMATE MONITORING.

In addition to the meteorological monitoring BLM conducts primarily to support wildland fire management activities, the BLM also conducts site-specific climate monitoring at over 200 manual weather station locations on the public lands in the 11 western states and Alaska. The operation of these sites ranges from seasonal to annual, taking measurements of precipitation, temperature, soil moisture, and other meteorological parameters necessary to assess local climactic influences. These data are primarily used for natural resources management and planning at the local level.

PORTABLE WEATHER STATION.

During the 1999 fire season, the Remote Sensing/Fire Weather Support Unit (RSFWSU) began a 2-year "proof of concept" effort with a portable weather station referred to as the Fire RAWS (FRWS). FRWS are intended for use on or near a fire line and can be rapidly relocated to points desired by Fire Behavior Analysts for real-time weather data. Due to the extreme fire season in both 1999 and 2000, the FRWS was used extensively and was found to be a valuable asset for firefighter safety and fire weather forecasting. Fire managers have also increased the use of FRWS to monitor intentionally-initiated prescribed burns.

Currently, 33 FRWS systems are cached at NIFC for use during the 2005 season. FRWS collect, store, and forward data by interrogated voice radio with new data available every fifteen minutes. Satellite data can be retrieved from the BLM/NIFC website, and hourly satellite data is available to Fire Weather Forecasting Staff for spot forecasts and fire support from all central locations (Geographic Area Coordination Centers, NIFC, etc.).

ALL RISKS SUPPORT.

After the terrorist attack on September 11th, 2001, the RSFWSU was tasked to provide near real-time meteorological data collection at the World Trade Center (Figure 3-DOI-3). This effort was in direct support of the Environmental Protection Agency's task of monitoring air quality in the vicinity of the collapsed towers. The unit also provided remote meteorological support for the Columbia Shuttle accident investigation and recovery effort, and RAWS support has generated interest from the Department of Homeland Security as it assesses its needs for remote and urban environmental monitoring. Using the person-

Figure 3-DOI-3. Remote Sensing/Fire Weather Support Unit providing near-real-time meteorological data collection at the World Trade Center.

nel and resources available at the RSFWSU, the BLM can offer a rapid meteorological support capability that is unique across the federal government.

BUREAU OF INDIAN AFFAIRS (BIA)

The Bureau of Indian Affairs collects atmospheric data to evaluate potentially irrigable Indian Trust lands in the Southwest. The Bureau also collects and shares fire weather data with other Federal agencies while participating in fire management activities for local and interagency use.

Currently, BIA operates the following instrumentation:

- 69 fire weather RAWS stations (permanent stations),
- 5 "manual" weather stations,
- 13 portable RAWS stations used for Prescribed Fire, and
- 10 RAWS deployed on emergency stabilization projects.

MINERALS MANAGEMENT SERVICE (MMS)

The Minerals Management Service (MMS) gathers offshore meteorological data for use in the management of offshore oil and gas resources. The data are used in air quality and oil-spill modeling, model development, and other research projects. Currently, MMS is funding operation of two offshore meteorological buoys in the Gulf of Mexico. Support for one of the buoys will be discontinued in FY 2006. The MMS also utilizes data from other buoys funded by NOAA. The buoys collect air temperature, sea surface temperature, wind direction, wind speed, wave height, and wave spectrum data. Many of the buoys measure relative humidity as well.

MMS operates a profiler at the Louisiana Universities Marine Consortium (LUMCON) facility in Cocodrie, Louisiana (Figure 3-DOI-4). The profiler has been collecting data since October 2004, and will be operating for a three-year period. Data collected at this site may be accessed at http://weather.lumcon. edu/weather-data/doppler. The data collected will be applied to regional models for evaluating impacts from emission sources on ozone, fine particulate matter, and regional haze. The MMS is also planning to install a profiler at the Pensacola Naval Air Station in the Florida Panhandle. The profiler is expected to be installed and operational in the summer of 2005.

Another meteorological data collection effort is ongoing in the Beaufort Sea in Alaska, where six meteorological stations have been collecting data since 2001 (see http://www.resdat. com/mms/). Data collection by these stations will continue in FY 2006. The information will be applied to oil spill modeling and air quality impact evaluations.

MMS has a cooperative agreement with the Coastal Marine Institute (CMI) at Louisiana State University for a study to assess meteorological influences on visibility offshore Louisiana. This study is expected to be completed in FY 2005. In a cooperative agreement with the CMI at the University of Alaska, MMS is supporting a meteorological modeling project for the Cook Inlet and the Shelikof Strait in Alaska. This project is also being concluded in FY 2005.

Figure 3-DOI-4. The MMS Profiler at LUMCON facility in Cocodrie, Louisiana.

The MMS is currently conducting a study entitled *The Breton National Wilderness Increment Analysis*. This study consists of a meteorological and air quality modeling analysis in and around the Breton National Wilderness Area (NWA), which is a Class I area under the Clean Air Act (CAA), and as such is afforded special protections under the Prevention of Significant Deterioration (PSD) provisions of the CAA. The Breton NWA is located on a chain of barrier islands off southeastern Louisiana. The objective of the study is to assess the impacts of Outer Continental Shelf (OCS) oil and gas production activities on the PSD increment consumption. This effort is expected to be completed in FY 2006. Copies of final reports on past meteorological and air quality studies in the Gulf of Mexico may be found at http://www.gomr.mms.gov/homepg/regulate/environ/techsumm/rec_pubs.html.

The MMS is also conducting a study entitled *Development of a Next generation Air Quality Model for OCS Applications*. The model being generated is an enhanced version of the CALPUFF air quality model that is better adapted for over water use. The model will contain improved formulation of the marine boundary layer and over water dispersion. The model will be able to be linked to output from the Pennsylvania State University / National Center for Atmospheric Research mesoscale model (MM5), as well as additional prognostic models such as the Rapid Update Cycle (RUC), Eta, and the Regional Atmospheric Modeling System (RAMS). The model is projected to be completed by the end of FY 2005.

NATIONAL PARK SERVICE (NPS) AND FISH AND WILDLIFE

SERVICE (FWS)

The National Park Service monitors air quality and visibility in a number of national parks and monuments. Gaseous pollutant data are collected on continuous and integrated (24-hour to weekly) bases. Surface meteorological data are collected and analyzed for hourly averages. Precipitation chemistry is determined on week-long integrated rainfall samples. Twenty-four hour, average particle concentrations (mass, elemental analyses, some chemical constituent analyses) are measured every third day. Atmospheric light extinction is measured continuously and relayed to a central location for analyses.

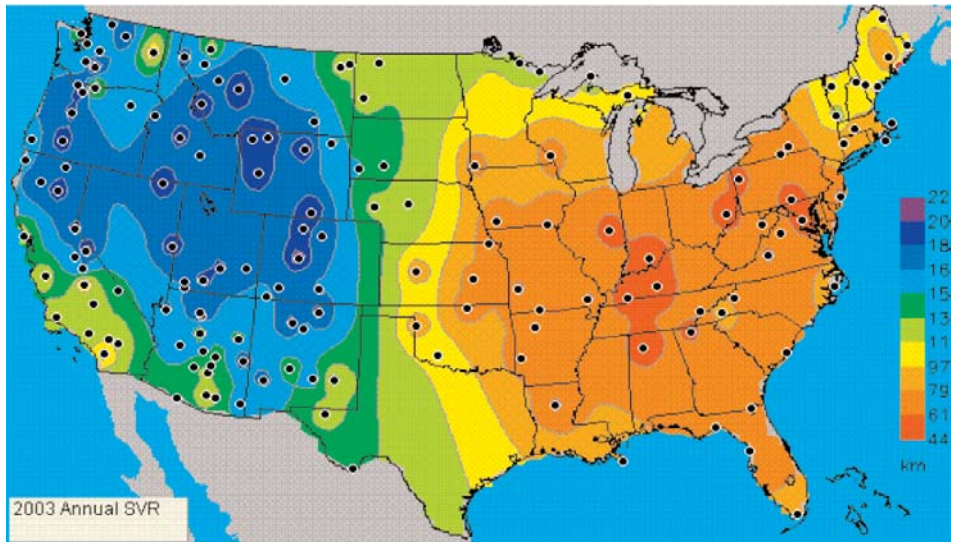


Figure 3-DOI-5. Map of annual average standard visual range (SVR), in kilometers, calculated from IMPROVE particle concentrations. Also shown are the locations of most of the IMPROVE and IMPROVE protocol sites during 2003. http://vista.circa.colostate.edu/views)

MODELING.

The NPS also conducts and contracts research to develop and test air quality models to assess long-range transport, chemical transformation, and deposition of air pollutants. These models are used to estimate source contributions to, and to identify source regions responsible for, observed pollutant loadings.

JOINT MONITORING AND RESEARCH

The Fish and Wildlife Service Air Quality Branch and the NPS Air Resources Division operate under an interagency agreement and are collocated in Lakewood, Colorado. Expertise from both agencies is pooled to address the air quality issues that are the responsibility of the Assistant Secretary of the Interior for Fish and Wildlife and Parks.

The NPS oversees the operation of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network and the IMPROVE Protocol network in cooperation with the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the United States Forest Service (USFS), the FWS, the BLM, and various State organizations. Since 2000, the networks have been expanded to over 170 sites, mostly through funding provided by the EPA in support of their regional haze regulations and through other cooperators. The enhanced network allows a better characterization of visibility and fine particle concentrations throughout rural and remote areas of the country (Figure 3-DOI-5).

BUREAU OF RECLAMATION

The Bureau of Reclamation (Reclamation) activities requiring the collection and use of meteorological data include water supply forecasting, snowpack water equivalent assessment, river system management, reservoir operations, irrigation scheduling, drought status assessment, flood hydrology, and projects related to hydroelectric energy resources. One example of such an ongoing activity is the Watershed and River System Management Program (WaRSMP), which is being developed in partnership with the USGS. Information on WaRSMP is at http://www.usbr.gov/pmts/rivers/rsmgwtrmg.htm.

Other key players in this effort include TVA, the Corps of Engineers, NOAA, NASA, NRCS, the University of Colorado and Colorado State University. This program provides a data-centered framework for science-based water resources decision making. Major components are:

- Hydrologic Database (HDB),
- Modular Modeling System (MMS),
- RiverWare river system modeling framework,
- Stochastic Analysis, Modeling and Simulation (SAMS) system,
- Agricultural WAter Resources Decision Support (AWARDS) and
- Evapotranspiration Toolbox (ET Toolbox) system.

HYDROLOGIC MODELING.

The SAMS hydrologic modeling system is being used in WaRSMP to assist water resource managers in developing likely hydrologic scenarios for water supplies. It allows users to test various water resources management strategies, including extreme drought and high-flow scenarios which haven't been encountered in the historical period of record. Starting in FY 2005, the SAMS capabilities will be implemented on the Colorado River basin.

The RiverWare and HDB data-centered decision support system enables water managers to examine a variety of observed and forecast hydrologic scenarios using hourly, daily, or monthly data within the legal and physical constraints on operations of the river system. This model provides a holistic management tool for watershed and river systems, in order to meet a variety of competing demands for water.

Each new river system requires considerable development work (2-3 years) for RiverWare and HDB implementation. However, such a system can provide for efficient water operations management, and is especially useful during periods of drought and surplus - as demonstrated by the recent *Colorado River Interim Surplus Criteria: Final Environmental Impact Statement.*

Current Reclamation projects under WaRSMP include:

- Planning and developing HDB, MMS and RiverWare systems for the Gunnison, San Juan, Rio Grande, Yakima, and Truckee river systems;
- Development of expanded capabilities to allow HDB to function as the Database of Record which will document management decisions and the data used to make them for Reclamation's Upper and Lower Colorado regions as well as other participating offices;
- SAMS integration and testing for the lower Colorado and Truckee River Basins;
- Implementing AWARDS systems to improve the efficiency of water management and irrigation scheduling for the Tualatin Project, Upper Columbia project areas, and Lower Colorado area;
- Developing the AWARDS/ET Toolbox system in the Middle Rio Grande and providing 24-hour water use estimates for input, via the Corps of Engineers' Hydrologic Engineering Center Decision Support System or a new HDB, to the Rio Grande RiverWare;
- Implementing similar AWARDS/ET Toolbox systems with input to local HDBs and RiverWare systems in the Upper Columbia, Lower Colorado, and possibly the Truckee-Carson areas;
- Integration and testing of emerging Land Surface Modeling Products from NASA's Global Land Data Assimilation Systems for snow mapping, surface energy and water budgets and ET analysis and prediction for water operations management;and
- Testing and development of weather and climate products from the Global Energy and Water Cycle Experiment (GEWEX) for water supply and demand forecasting.

INSTRUMENTATION AND DATA ACQUISITION

NEXRAD estimates of precipitation are used for water supply and water delivery decision-making. Water managers can view the distribution of precipitation over watersheds that supply water to storage facilities, and examine the detailed spatial distributions of precipitation over the irrigated areas along with estimates of soil moisture, and evapotranspiration from crops and riparian vegetation.

The Watershed and River Systems Management Program focuses on integrating multi-disciplinary science into decision support systems that enable water managers to make the best deliveries of water to stakeholders.

Currently, Reclamation's HYDROMET system collects data from approximately 400 hydrometeorological data collection platforms (DCPs) which transmit data in real-time through GOES to Reclamation's DRGS in Boise, Idaho. AGRIMET is another network of 60 DCPs dedicated to analysis of crop water use and water conservation in the Pacific Northwest.

Data collected and products created in Boise are electronically transferred to other BLM, Federal and state offices. Reclamation's primary real-time hydrometeorological information from the NWS, USGS, NASA, and other agencies is displayed on the AWARDS / NEXRAD / ET Toolbox web site: http://www.usbr.gov/pmts/rivers/awards/index.html.

Water supply information from cumulative precipitation estimates from radar is also provided in areas where snow fall is an important source of water. Links directly to USDA Natural Resources Conservation Service and NOAA/National Centers for Environmental Prediction analysis and forecasting web sites are provided to further document the latest information.

TECHNICAL INFORMATION

The National Xeriscape Demonstration Program (NXDP) is nearing an end. The NXDP was initiated by

Reclamation to estimate the benefits of water conserving landscaping. In partnerships with States, field demonstration projects were conducted in Fargo ND, Austin TX, the Colorado Front Range, Phoenix AZ, and southern Nevada. Water savings ranged from 18 to over 50 percent in the demonstration projects, strongly suggesting water planners should consider this water conservation alternative as a supply development option.

SNOWPACK ASSESSMENT.

Snowmelt represents about 80 percent of reservoir storage in Colorado and is largely responsible for spring flooding events in the state. Therefore, it is highly desirable to know snowpack characteristics, such as its snow water equivalent (SWE), its spatial and elevation distribution, and its evolution with time during the water year. With support of the Colorado Water Conservation Board (CWCB), Reclamation has adapted the Snow Data Assimilation System (SNODAS) for enhanced snowpack assessment in the state of Colorado. The SNODAS was developed by the National Operational Hydrologic Remote Sensing Center (NOHRSC), a National Weather Service unit, and data are acquired through the National Snow and Ice Data Center.

SNODAS consists of a spatially distributed snow energy and mass balance model, coupled with an assimilation of all available SWE, snow depth, and snow cover data (from surface, aircraft, radar, satellite). Model outputs are at 1 km resolution and include SWE, snow depth, snowmelt, pack temperature, and sublimation. Comparison with data from Snow Telemetry (SNOTEL) sites and satellite imagery shows faithful representation of SWE and snow cover, respectively. Basin average SWE is substantially reduced over that of SNOTEL because the former is a basin-wide spatial average instead of an arithmetic average of a few high-elevation points. This difference is important hydrologically and holds the promise of coupling snowmelt with a hydrologic model to produce streamflow hydrographs. Such hydrographs would be extremely useful to the decision support systems of water management agencies such as the CWCB and Reclamation, with the ultimate aim of improved forecasting of water supplies and flooding. Colorado SNODAS products have been posted daily at http://www.usbr.gov/pmts/rivers/awards/SNODAS/SNODAS_CO_hist.html, since October

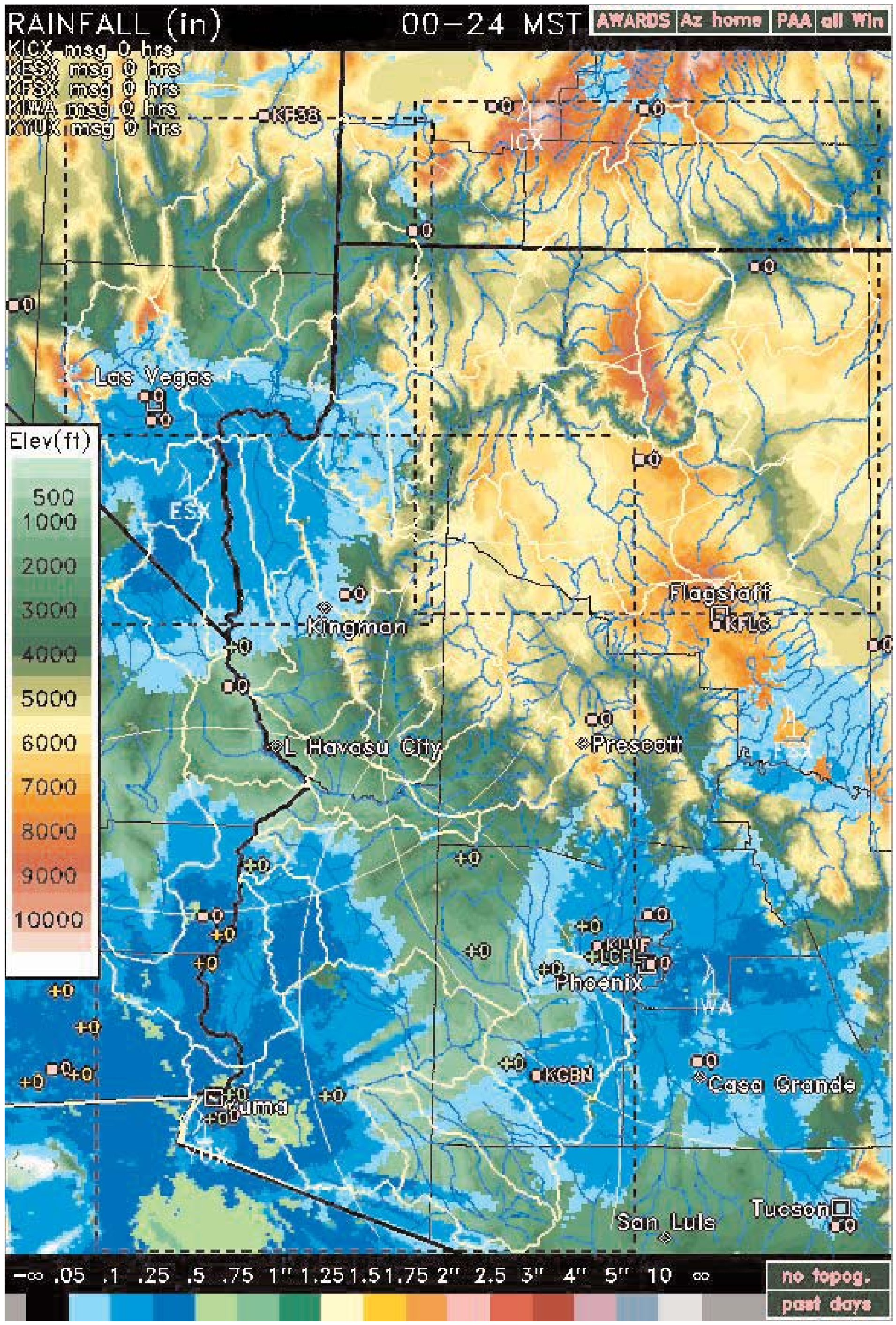


Figure 3-DOI-6. Agricultural Water Resources Decision-Support (AWARDS)/ET Toolbox example for the Lower Colorado River basin. AWARDS merges the precipitation accumulation algorithm (PAA) estimates from five WSR-88D (or NEXRAD) radars into a 2x2km grid.

2003. Future work will consist of verification of SNODAS outputs, improvement of precipitation inputs, and coupling to a hydrologic model. An example of such an online product is given in Figure 3-DOI-6.

DEPARTMENT OF STATE CLIMATE AND ATMOSPHERIC PROGRAMS

The Department of State (DOS) plays an active role in international climate/meteorological policy making as a result of the growing worldwide concern with global environmental issues, including the depletion of the stratospheric ozone layer and climate change. The role of DOS has principally revolved around preparation and negotiation of the United States position in three fora: (1) the Conference of the Parties to the Vienna Convention and its Montreal Protocol on Substances that Deplete the Ozone Layer, (2) the Intergovernmental Panel on Climate Change (IPCC); and (3) negotiation under the United Nations Framework Convention on Climate Change (FCCC). In addition, over the past few years the DOS has played a central and active role in the development and implementation of a number of international science and technology initiatives including the Group on Earth Observations, the Carbon Sequestration Leadership Forum, the International Partnership for the Hydrogen Economy, the Methane-to-Markets Partnership, and Generation IV (a U.S.-led program working on new fission reactor designs that will be safer, more economical and secure).

Stratospheric ozone depletion has been recognized as a critical health and environmental problem for more than a decade. Under DOS leadership, the United States worked to negotiate international agreements to phase out ozone-depleting substances, which should lead to a recovery of the ozone layer in the next century. To date, these treaties have been signed and ratified by more than 170 countries (including the United States). These countries represent 99 percent of the world's production of ozone depleting substances.

The Intergovernmental Panel on Climate Change (IPCC), which was established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), held its first session in 1988. This organization serves as a government forum to assess scientific, technical and socioeconomic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation.. In doing so, the Panel draws on the expertise of thousands of scientists and technical experts. The IPCC is currently organized into three working groups, which examine (1) the state of the science, (2) impacts and adaptation, and (3) mitigation. The IPCC released its first and second assessment reports in 1990 and 1995, respectively, and a third assessment report from each of the working groups was published in 2001. The fourth assessment report, due in 2007, is currently under preparation. In addition to preparing assessment reports, the IPCC also contributes to international negotiations through preparation and review of special reports and development of methodologies requested by the Framework Convention on Climate Change (FCCC).

The FCCC was negotiated beginning in February 1991; the Convention was open for signature in Rio de Janeiro at the Earth Summit in June 1992. As of May 2004, it had been ratified by 189 countries, including the United States. The ultimate objective of the Convention is to stabilize greenhouse gas emissions at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system. It states that such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner. The Convention calls for all countries to develop inventories of their emissions and sinks of greenhouse gases and calls upon developed countries and economies in transition to aim to return these emissions to their 1990 levels by the year 2000.

In December 1997, Parties to the Convention adopted the Kyoto Protocol, which commits developed countries to reducing their collective emissions of greenhouse gases by at least 5 percent by the period 2008-2012. Following Russian ratification in late 2004, the Kyoto Protocol entered into force in February 2005. In early 2001, the United States announced that it would not ratify the Kyoto Protocol. The United States approach to addressing the challenge of climate change harnesses the power of markets and technological innovation. It also holds the promise of a new partnership with the developing world and it recognizes that climate change is a complex, long-term challenge that will require a sustained effort over many generations.

Today the United States is actively engaged in addressing climate change through the Convention, through a wide range of international science and technology initiatives, through multilateral efforts such as the Asia-Pacific Partnership for Clean Development and Climate and bilateral partnerships with 14 countries including Australia, Brazil, Canada, China, India, Italy, Japan, and other countries. Together these initiatives will help improve our global capability to understand and address issues associated with climate change in a manner that supports broader sustainable development goals.

In addition to its primary role in the fora listed above, DOS is active in several relevant interagency processes, including the Committee on Environment and Natural Resources (CENR) of the National Science and Technology Council and the Interagency Working Group on Climate Change Science and Technology (IWGCCST). The CENR was established in 1993 to coordinate scientific domestic programs. Created in 2002, the IWGCCST is a sub-Cabinet level group that reviews all programs that contribute to climate change science and technology. Furthermore, while the emphasis on global environmental issues is a key new component of the department's focus, traditional DOS responsibilities, described in earlier Federal plans, continue. These include, but are not limited to, international aspects of food policy, disaster warnings and assistance, WMO and UNEP activities, and international meteorological programs.

ENVIRONMENTAL PROTECTION AGENCY WEATHER PROGRAMS

Environmental Protection Agency (EPA) is responsible for working with state, local, and other federal government agencies to provide user-appropriate and scientifically-credible air quality and meteorological programs to support regulatory applications. Applied research and meteorological support are furnished primarily by EPA's National Exposure Research Laboratory and EPA's Office of Air Quality Planning and Standards, both located in Research Triangle Park, North Carolina. This activity is provided through interagency agreements with the National Oceanic and Atmospheric Administration (NOAA), which assigns approximately 50 research meteorologists to the EPA.

Meteorological support to EPA's Office of Research and Development, EPA's Office of Air and Radiation, EPA Regional Offices, and to state and local agencies includes: (1) development and application of air quality models for pollution control, direct and indirect exposure assessments, and emission control strategy assessment; (2) preparation and performance of dispersion studies and air quality model evaluations; (3) review of meteorological aspects of environmental impact statements, state implementation plans, and pollution variance requests: (4) air quality forecasting; and (5) emergency response planning in support of homeland security. Meteorological expertise and guidance are also provided for the national air quality standards, modeling guideline, and policy development activities of the EPA.

In light of the 1990 Amendments to the Clean Air Act and the recent national rules, air quality models and the manner in which they are used are expected to continue to grow over the next few years. In the area of pollutant deposition, the evaluation of nitrogen, oxidant, sulfur and aerosol chemistries will help to clarify the roles of model formulation, cloud processes, radiative transfer, and air/surface exchanges in air quality model predictions, leading to a better understanding of model predictions relative to control strategy assessments. Further development and evaluation of existing air quality models will take place to accommodate the inter-pollutant effects resulting from the variety of control programs that are now or may be in place, such as the new National Ambient Air Quality Standards for ozone and particulate pollution. These inter- pollutant effects include trade-offs among controls on ozone, sulfur oxides, nitrogen oxides, and volatile organic compounds, as well as developing predictable methods of forecasting the impacts on various measures of air quality.

With respect to the fine particulate model development, air quality models are being enhanced to accurately predict aerosol growth from precursors over local and regional transport distances. To assist in the evaluation of the contribution of various sources to regional air degradation, inert tracer and tagged species numerical models have been developed. These models will introduce separate calculations for inert or reactive chemical species emitted from a particular source or region. The calculations will proceed to simulate transport and transformation to a receptor point, where the contribution of emission sources can be discerned.

Atmospheric research continues in the area of the effects of climate change on regional air quality. The climate program involves both analytical and statistical climatology as well as support for regional-scale climate model development.

Research in human exposure modeling includes micro-environmental monitoring and modeling, and development of exposure assessment tools. Micro-environmental algorithms are being developed based on field data to predict air quality in buildings, attached garages, and street canyons. These improved algorithms are then incorporated into micro-environmental simulation models for conducting human exposure assessments within enclosed spaces in which specific human activities occur.

In addition to the above major areas, dispersion models for inert, reactive and toxic pollutants are under development and evaluation on all temporal and spatial scales, e.g., indoor, urban, complex terrain, mesoscale, regional, and global. Other efforts include modeling nutrient deposition to Chesapeake Bay and mercury deposition to the Florida Everglades; and determination of meteorological effects on air quality. Atmospheric flow and dispersion experimental data obtained from wind tunnel and convection tank experiments in the EPA Fluid Modeling Facility will be used to continue development and evaluation of these models along with providing researchers with insight into the basic physical processes that affect pollutant dispersion around natural and man-made obstacles. For example, the transport and dispersion of airborne agents in the lower Manhattan, New York area were simulated in the wind tunnel to evaluate Computational Fluid Dynamics modeling systems in an effort to help build confidence in modeling assessment source-receptor rela-

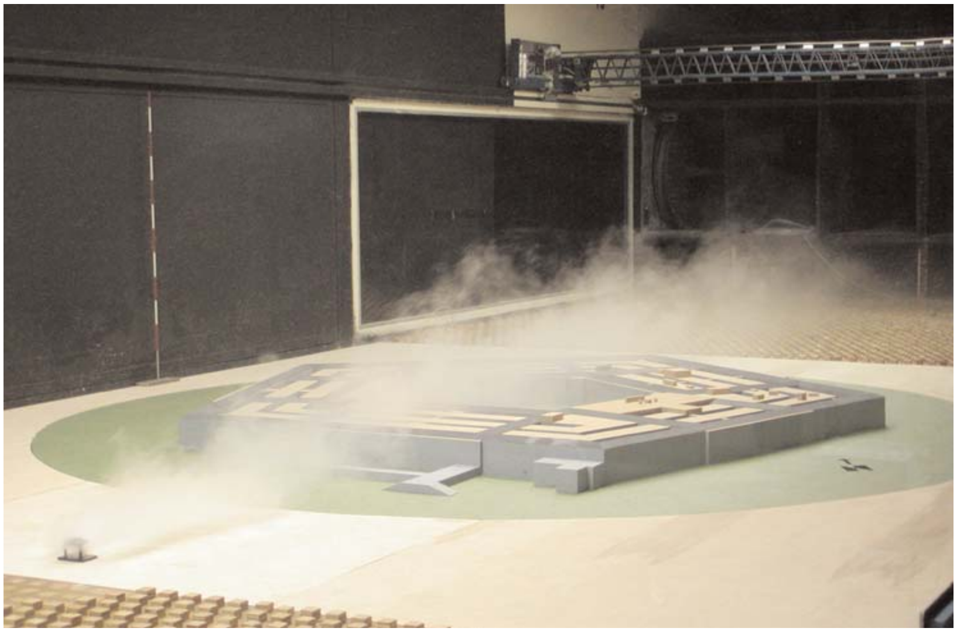


Figure 3-EPA-1. Model of the Pentagon used in the wind tunnel of the Fluid Modeling Facility to study the transport and dispersion of airborne agents.

tionships for horrendous events such as the one that occurred on September 11, 2001 A similar study was conducted for the Pentagon (Figure 3-EPA-1) and will be conducted for the Mid-Manhattan and Washington, DC areas.

Over the past twenty-five years, numerous air quality simulation models have been developed to estimate reductions in ambient air pollutant concentrations resulting from potential emission control strategies. Separate models were developed, for example, for tropospheric ozone and photochemical smog, for acid deposition, and for fine particles. Distinct models also existed for addressing urban scale problems and the larger regional scale problems. It has been recognized, however, that the various pollutant regimes are closely linked chemically, spatially, and temporally in the atmosphere. The principal purpose of the Community Multi-scale Air Quality (CMAQ) modeling project is to develop a "one atmosphere" flexible environmental modeling tool that integrates the major atmospheric pollution regimes in a multi-scale, multi-pollutant modeling system. This system will enable high-level computational access to both scientific and air quality management users for socio-economic applications in community health assessments and ecosystem sustainability studies.

After seven years of development, the Models-3/CMAQ was first released in June 1998, and is being updated annually for use by Federal agencies, States, industry, and academia. The latest version of CMAQ, which includes science enhancements and computational efficiencies, is planned for release in August 2005. It is also intended to serve as a community framework for continual advancement and use of environmental assessment tools. CMAQ, configured for the Windows-NT computer system, is available on tapes from the National Technical Information Service (NTIS). It is accompanied by an Installation and Operations Manual, a User Manual, a Science Document, and a tutorial providing step by step instructions for use of the modeling capabilities. Additional information is available at the Models-3 web site at http://www.epa.gov/asmdnerl/models3/. Figure 3-EPA-2 illustrates the results of CMAQ for ozone and fine particulate matter (PM2.5), sulfates, and visibility for August 8, 2001, for the contiguous United States at 36-km horizontal grid dimension, a period of widespread ambient pollution in the nation.

In FY 2005, EPA is working closely with the National Center for Environmental Prediction of the National Weather Service (NWS) in the continued development, evaluation, and use of a coupled meteorological-chemical transport model (Eta-CMAQ) for predicting ambient air quality over the Continental United States. This capability is built on years of research in air quality, exemplified by the NOAA-led New England Pilot Air Quality Study in 2002 and 2004. In the first phase of the forecasting project, NWS implemented the Eta-CMAQ modeling system, to provide daily forecast guidance for ozone for the northeastern United States starting from September 2004. Within the next few years, the system for ozone will deploy nationwide. Within ten years, the operational forecast capability is projected to be able to forecast particulate matter. State and local air quality management agencies will continue to forecast local air quality, assisted in their efforts by the addition of national forecast guidance for the concentrations of ozone and other air pollutants.

EPA participation in the interagency Information Technology Research and Development (IT R&D) Program is developing a modeling framework that supports integration of diverse models (e.g, atmospheric, land surface, and watershed) as part of EPA's Multimedia Integrated Modeling System (MIMS) project, described at http://www.epa.gov/asmdnerl/mims/. The EPA's IT R&D work also enables increased efficiency in air quality meteorological modeling through research on parallel implementation of the CMAQ modeling system. The evolving MIMS research seeks to improve the environmental management community's ability to evaluate the impact of air quality and watershed

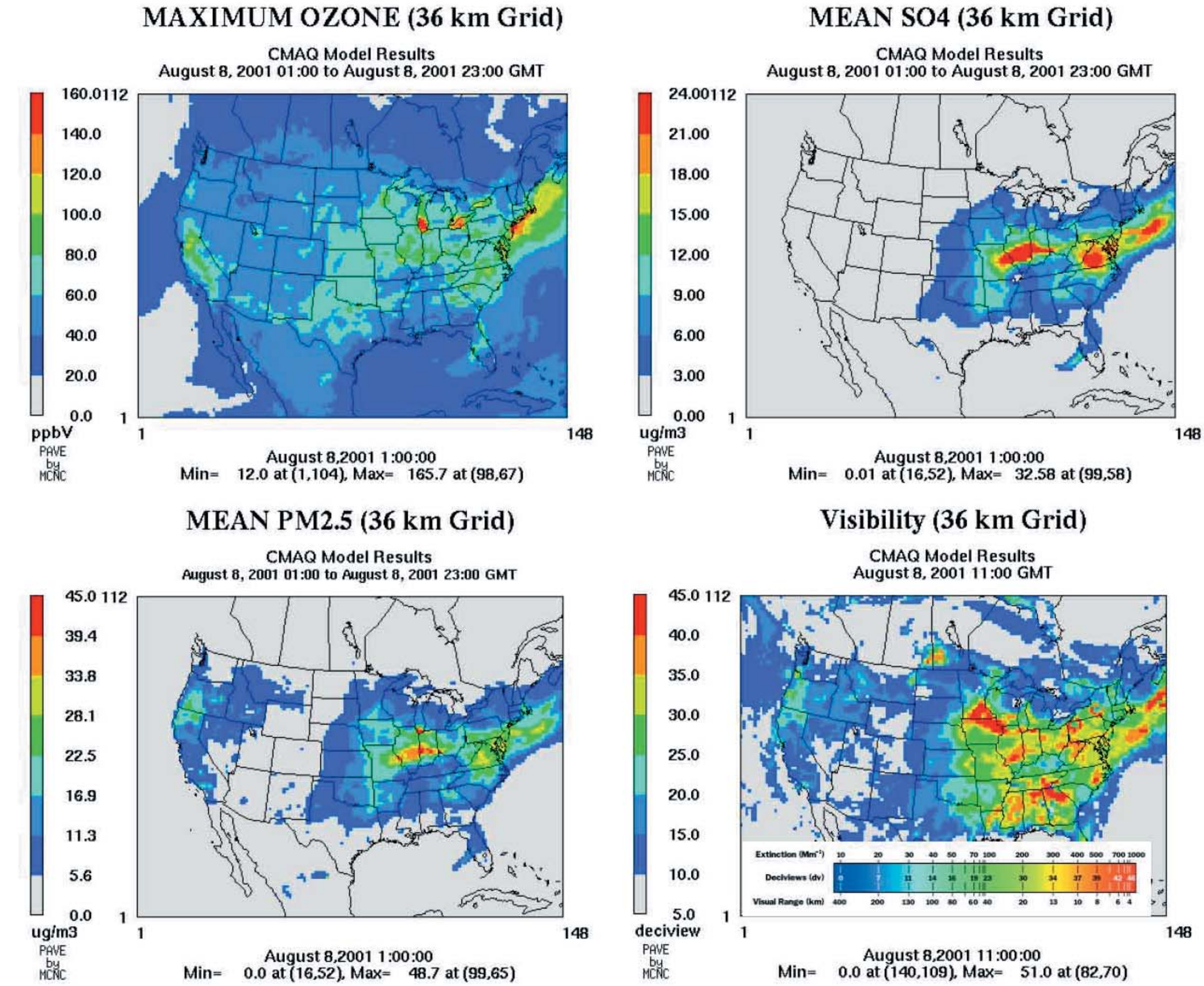


Figure 3-EPA-2. CMAQ simulation results for August 8, 2001, for the contiguous United States at 36-km horizontal grid spacing showing: (upper left) maximum 1-hour average ozone concentrations (ppbV) in each grid cell; (upper right) 24-hour averages of sulfate concentrations (micrograms/m3); (lower left) 24-hour averages of PM2.5 concentrations (micrograms/m3) in each 36-km grid cell; and (lower right) visibility (deciview - see insert) in each grid cell.

management practices, at multiple scales, on stream and estuarine conditions. Toward this goal the primary objectives include (1) developing a prototype multiscale integrated modeling system with predictive meteorological capability for transport and fate of nutrients and chemical stressors; (2) enabling the use of remotely sensed meteorological data; and (3) developing a computer-based problem solving environment with ready access to data, models, and integrated visualization and analysis tools for water and air quality management, local and regional development planning, and exposure-risk assessments. Under the MIMS project, a variety of research areas are being pursued such as the integration of the National Weather Service Next Generation Radar (NEXRAD) Stage IV data into watershed modeling applications; enhanced atmospheric dry deposition models; multi-scale, spatially explicit watershed modeling tools; and model-coupling technology for integrating media specific models. The MIMS development extends the open architecture approach demonstrated in the third generation modeling system, CMAQ, and is the next generation of modeling frameworks under the IT R&D program.

EPA also maintains relations with foreign countries to facilitate exchange of research meteorologists and research results pertaining to meteorological aspects of air pollution. For example, agreements are currently in place with Canada, Japan, Korea, China, and Mexico, and with several European countries under the NATO Committee on the Challenges of Modern Society (CCMS).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WEATHER PROGRAMS

The National Aeronautics and Space Administration (NASA) Headquarters Weather Support Office has continued to improve NASA's weather support capabilities for both manned and unmanned space launch vehicles. It is expected that these improvements will strengthen and enhance the information provided to the ground-based decision makers and astronaut observers to insure that NASA achieves the best operational posture for Space Shuttle launches and landings. The goal of the operations program is to provide the specialized meteorological data needed by operational forecasters at the Kennedy Space Center (KSC) and Johnson Space Center (JSC). NASA also maintains a sophisticated fleet of eighteen Earth-monitoring satellites, measuring a vast number of Earth properties. The focus of Earth Science Research is to integrate satellite observations, numerical model and theoretical studies of various Earth system attributes. These attributes include ocean currents, temperature and biological activity; atmospheric ozone and aerosols; tropical rainfall, lightning; atmospheric temperature and humidity structure; Antarctic and Arctic sea ice; volcanic emissions and gravitational anomalies in the Earth's crust. NASA also performs aviation research to improve safety, develop weather information technologies, and increase aviation system capacity. Advanced operations technologies can increase the number of operations per runway in all weather conditions. The research applies to both commercial and general aviation.

THE NASA VISION:

To improve life here,
To extend life to there,
To find life beyond.

THE NASA MISSION:

To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
...as only NASA can.

SUPPORTING RESEARCH: NASA'S SCIENCE MISSION DIRECTORATE (SMD).

NASA transformed its organization in the summer of 2004, uniting the former Earth and Space Science Enterprises. The Science Mission Directorate will carry out the scientific exploration of the Earth, Moon, Mars and beyond; chart the best route of discovery; and reap the benefits of Earth and space exploration for society. A combined organization is best able to establish an understanding of the Earth, other planets and their evolution, bring the lessons of our study of Earth to the exploration of the Solar System, and to assure the discoveries made here will enhance our work there.

The frontier of Earth system science is to:

(1) explore interactions among the major components of the Earth system - continents, oceans, atmosphere, ice, and life;

(2) distinguish natural from human-induced causes of change; and

(3) understand and predict the consequences of change.

Within the Science Mission Directorate, NASA has established six scientific focus areas for these complex processes. These scientific focus areas are: Atmospheric Composition, Carbon Cycle and Ecosystems, Climate Variability and Change, Earth Surface and Interior, Water and Energy Cycle, and Weather. Roadmaps have been developed to summarize the technology, observations, modeling, field campaigns, basic research, and partnerships needed over the next 25 years to achieve the long-term goals for each of these focus areas.

The availability of fresh water on planet Earth affects billions of people. Floods and drought can be life-threatening. The following questions guide research within the Water and Energy Cycle Focus Area:

• How are global precipitation, evaporation, and the cycling of water changing?

• What are the effects of clouds and surface hydrologic processes on Earth's climate?

• How are variations in local weather, precipitation and water resources related to global climate variation?

• How will water cycle dynamics change in the future?

The Water and Energy Cycle Focus Area studies the distribution, transport, and transformation of water and energy within the Earth system. Since solar energy drives water and energy exchanges, the energy cycle and the water cycle are intimately entwined. Thus, research focuses on the closely linked budgets of energy and moisture. Focus area research is aligned with national and international programs including the Global Energy and Water Cycle Experiment and the water cycle activities of the U.S. Climate Change Science Program.

The approach to these goals rests on a combination of observations, understanding, modeling, prediction, and decision-support systems presented in the Water and Energy Cycle Roadmap. This integrated approach will yield improved overall knowledge of the water cycle and improved predictions of the changing of the water and energy cycles. Future missions on the roadmap will provide key measurements for this focus area including: soil moisture, ocean water storage and flux, global precipitation, groundwater storage, tropospheric water storage, and atmospheric water and energy storage.

Precipitation has only recently been measured from space by the Tropical Rainfall Measuring Mission. The Global Precipitation Measurement (GPM) mission will extend remote sensing of precipitation globally, allowing estimation of this input term in Earth's water budget. Evaporation cannot be measured directly, but can be estimated using models based on estimates of the amount of radiation absorbed by the land, oceans, and atmosphere and validated using selected satellite measurements including ocean salinity from Aquarius and soil moisture from HYDROS. The Water and Energy Cycle Focus Area concentrates on storage as soil moisture, ground water, surface water, and snow.

Weather has enormous influence on human activities. Favorable weather is in many cases critical for agricultural productivity while severe weather can disrupt virtually every enterprise and endanger human life, property, and natural resources. Accurate weather prediction allows preparation for severe events and adaptation to day-to-day variations. Accurate hurricane predictions as well as tornado tracking save lives and property. Agriculture, transportation systems, and numerous other endeavors all rely on weather forecasts for daily decisions and resource allocation.

The direct question, “How can weather forecast duration and reliability be improved?” guides research within NASA's Weather Focus Area.

The Weather Focus Area seeks to apply NASA remote sensing expertise to obtain accurate and globally-distributed measurements of the atmosphere for assimilation into operational weather forecast models thereby improving and extending weather predictions.

Accurate local and regional predictions begin with global simulations. These simulations require the assimilation of satellite measurements of the atmosphere in depth for the entire globe. NASA develops the satellite sensors for sounding the atmosphere's temperature and humidity structure. The latest high-accuracy sensor is the AIRS instrument on board the Aqua satellite. AIRS data are being studied intensely for inclusion into operational processing streams.

Currently, high priority is assigned to the detection and quantification of rainfall rate, generally measured by microwave remote sensing. Surface radars have long been able to estimate rainfall rate, with the assumption of appropriate drop-size distributions and a national network of Doppler radars estimate the locations of wind velocity couplets that signal likely tornado formation. NASA's first weather radar in space, TRMM, enabled global rainfall mapping throughout the seasons increased our understanding of storm-cloud characteristics accompanying various forms and levels of rainfall rates. Extension of satellite weather radar to a global constellation of active and passive sensors can pave the way for future operational missions.

In order to provide a near-real time global view of rainfall, which can be used to monitor regions for the effects of drought and flood, NASA operates the TRMM-based Multi-satellite Precipitation Analysis (MPA). The product is updated every three hours and is publicly available at http://trmm.gsfc.nasa.gov. The MPA is a quasi-global precipitation analysis at fine time and space scales (3-hr, 0.25 degree by 0.25degree latitude-longitude) over the latitude band 50 degree N-S (Figure 3-NASA-1). This analysis

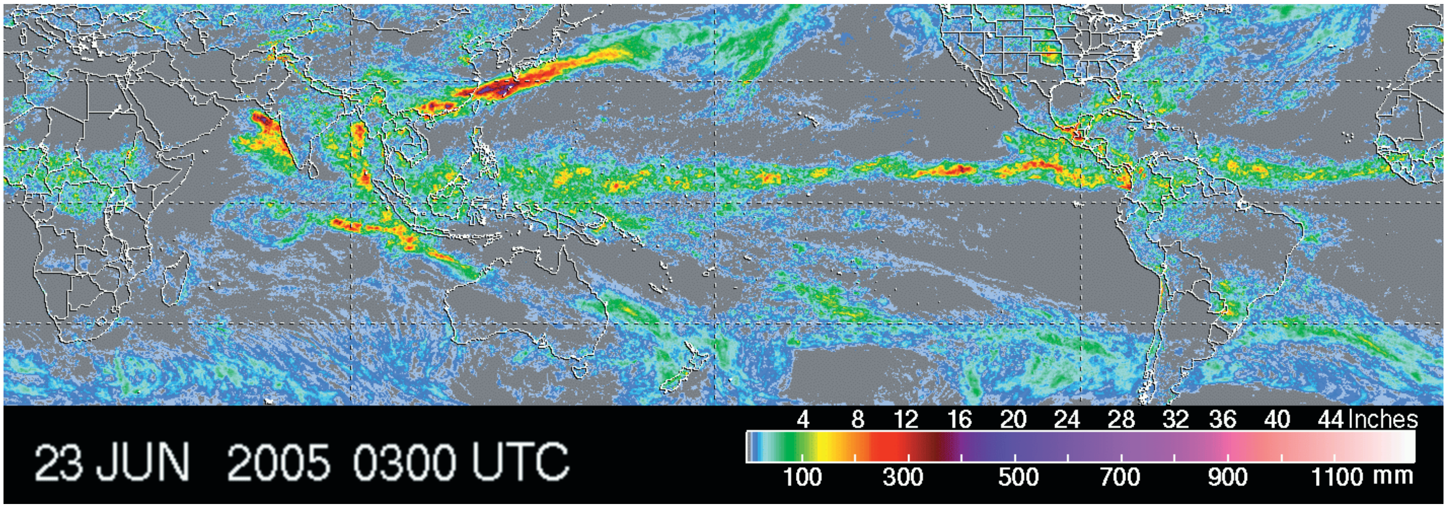


Figure 3-NASA-1. Global view of one week of rainfall accumulation obtained by the TRMM-based Multi-Satellite Precipitation Analysis.

scheme makes use of TRMM's highest quality, but infrequent observations, along with high quality passive microwave-based rain estimates from 3-7 polar-orbiting satellites, and even estimates based on the five geosynchronous IR data covering the tropics. The technique uses as much microwave data as possible, including data from Aqua/AMSR and SSM/I's and AMSU's on operational satellites, and only uses the geo-IR estimates to fill in remaining gaps in the three-hour analysis.

Other NASA weather research is important for the design of new satellite sensors for cloud and rainfall characteristic measurement and focused field programs help researchers to understand the natural variability and structure of the atmosphere, clouds, and storms on finer and finer scales as the numerical models are able to handle the higher-resolution data.

Another key component of the current Weather Focus Area is a set of core efforts to assimilate new NASA satellite data into numerical forecast models and to assess the amount of forecast improvement. Two groups are currently working on this problem, the Joint Center for Satellite Data Assimilation and NASA's Short-term Prediction Research and Transition Center. These centers allow studies of the most effective ways of assimilating new satellite data into global and regional numerical models.

The centerpiece of NASA's Earth Observing System is a sophisticated fleet of eighteen Earth-monitoring satellites, measuring a vast number of Earth properties (Figure 3-NASA-2). The focus of Earth science research is to integrate satellite observations, numerical model and theoretical studies of various Earth system attributes. These attributes include ocean currents, temperature and biological activity; atmospheric ozone and aerosols; tropical rainfall, lightning; atmospheric temperature and humidity structure; Antarctic and Arctic sea ice; volcanic emissions and gravitational anomalies in the Earth's crust. Not all of these measurements are currently being assimilated into numerical forecast models to determine their potential forecast impacts. As basic research concerning scales of variability and physical relationships to other parts of the Earth System is completed, additional EOS data products will be tested for forecast improvement potential.

In addition to precipitation measurement, important new satellite missions to advance weather forecast accuracy include an operational surface moisture monitor, geostationary monitoring of lightning location, strength, and rate, and the global monitoring of vector wind fields through out the depth of the atmosphere. Perhaps the greatest value for a future satellite sensor to would be the implementation of a fleet of Doppler lidar sensors to measure global winds as a function of height.

HIGHLIGHT: NASA SHEDS LIGHT ON HURRICANE BIRTH PROCESS

Severe tropical storms in the form of hurricanes pose a serious hazard to citizens in the eastern United States. In recent years, NASA has made strides in investigating the structure and behavior of tropical cyclones. The new insights into the nature of these deadly storms have come from a multi-pronged approach, fusing Earth Observing System (EOS) datasets with a comprehensive series of aircraft missions called the Convection and Moisture Experiment (CAMEX), and numerical modeling studies. Comprehensive datasets collected from space and in the field have provided many intriguing insights into the processes that govern hurricane growth and evolution. Numerical modeling investigations take the analyses a step further by assimilating diverse observational datasets into a theoretical framework for performing experiments.

The Tropical Cloud Systems and Processes (TCSP) mission is a field research investigation sponsored by the Science Mission Directorate of the National Aeronautics and Space

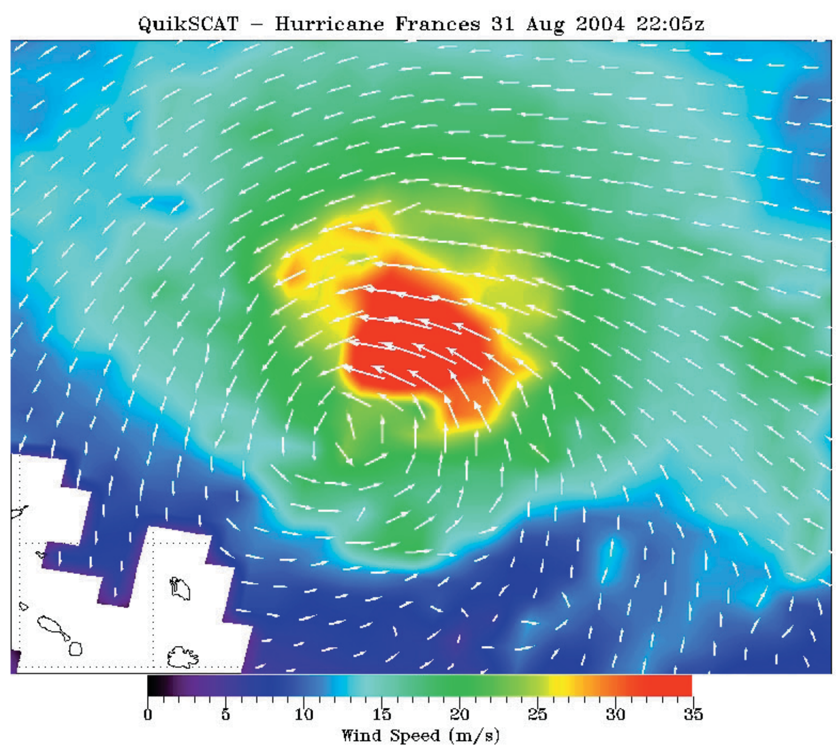


Figure 3-NASA-2. NASA QuickSCAT satellite view of Hurricane Frances (2004) in the Atlantic, showing structure of the low-level wind vortex.

Administration (NASA). The field experiment will run from July 1-28, 2005 and is based out of San Jose, Costa Rica. TCSP builds on the success of previous Convection and Moisture Experiment (CAMEX) missions. The focus of TCSP will be to better understand the complex and myriad processes giving rise to the birth of tropical cyclones over the Eastern Pacific.

TCSP research will address the following topical areas:

1) tropical cyclone structure, genesis, intensity change, moisture fields and rainfall;

2) satellite and aircraft remote sensor data assimilation and validation studies pertaining to development of tropical cyclones; and

3) the role of upper tropospheric/lower stratospheric processes governing tropical cyclone outflow, the response of wave disturbances to deep convection and the evolution of the upper level warm core. Analyses of data sets will address a wide variety of atmospheric space and time scales, ranging from the convective through the synoptic. Investigations will also be conducted to improve upon numerical modeling studies of tropical cyclogenesis, including wave-to-depression transition in the western Caribbean, Gulf of Mexico and Eastern Pacific Oceans (Figure 3-NASA-3).

NASA's ongoing partnership with NOAA's Hurricane Research Division (HRD) during the CAMEX campaigns will continue during TCSP. Two NOAA P-3 aircraft will base out of Costa Rica and fly with the NASA ER-2 high-altitude research aircraft during coordinated missions into developing tropical disturbances. The benefits of scientific collaboration between NASA and NOAA are profound; NOAA aircraft fly in the lower and middle regions of the storm, while NASA aircraft obtain data from the upper region. Together, an entire three dimensional structure of the hurricane can be assessed from the ocean surface all the way into the lower stratosphere.

NASA WEATHER OPERATIONS.

The goal of the NASA weather operations program is to provide specialized meteorological data and techniques needed by Air Force forecasters (45th Weather Squadron (45WS)) at Cape Canaveral Air Force Station (CCAFS), adjacent to Kennedy Space Center (KSC), and by the NWS's Spaceflight Meteorology Group (SMG) at Johnson Space Center (JSC), to support NASA's Space Shuttle and Expendable Launch Vehicle (ELV) programs. Their greatest challenge is to accurately measure and forecast the mesoscale weather events that strongly impact ground processing, launch, and landing operations.

Note: 45WS supports ground processing and launch of Shuttle and ELV's at KSC/CCAFS, and Shuttle Ferry Flight missions. SMG supports Shuttle flight; landing at KSC, Edwards AFB and White Sands Space Harbor; as well as emergency landing sites worldwide.

To successfully support the diverse, unique and complex requirements of their many customers' 24/7 operations, in the mesoscale driven lightning capital of America, requires:

1. A sophisticated weather infrastructure which includes systems normally found only in research field programs rather than operations;

2. A dedicated capability to transition research and technology to support new or poorly satisfied operational requirements;

3. Rigorous training to ensure the weather infrastructure, diverse customer requirements, and dynamic, mesoscale weather are thoroughly understood; and

4. At least 2-3 years on-site experience to adequately master the infrastructure, the weather, and the requirements sufficiently to provide timely, tailored, accurate support to the many weather sensitive daily operations.

SUPPORTING RESEARCH

Applied Meteorology Unit.

The focal point for satisfying requirement three above and assisting with requirements one and two is the Applied Meteorology Unit (AMU). The AMU, co-located with the Air Force's Range Weather Operations at CCAFS, develops, evaluates and, if warranted, transitions new meteorological technology into operations. For instance, the AMU strives to develop techniques and systems to help predict and avoid the impacts of Central Florida's frequent thunderstorms which endanger the ground processing, launch, and landing operations of the American Space Program-Space Shuttle, DOD, and commercial entities. The AMU has focused special attention on evaluating and transitioning mesoscale numerical models, and developing forecast techniques appli-

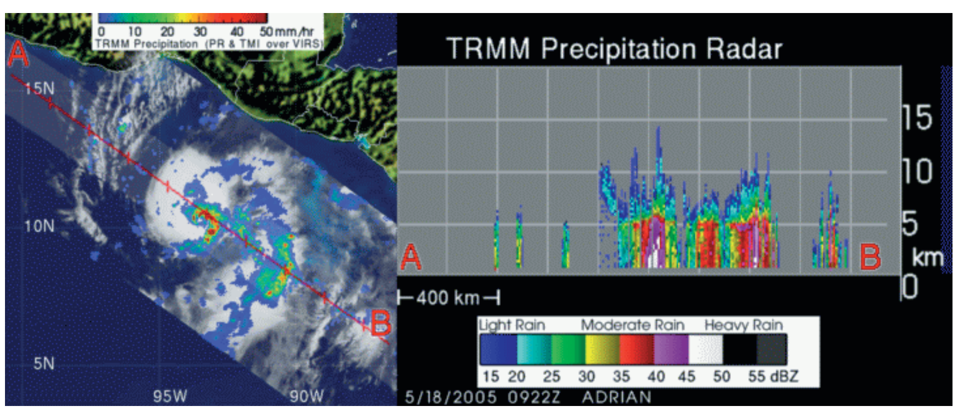


Figure 3-NASA-3. NASA TRMM satellite view of the rain structure in Tropical Storm Adrian (2005) in the eastern Pacific.

cable to Central Florida. The AMU functions under a joint NASA, Air Force, and National Weather Service (NWS) Memorandum of Understanding.

Current AMU tasks and status as of June 05 include:

Task: Objective Lightning Probability Forecast: Phase I

Goal: Develop a set of statistical equations to forecast the probability of lightning occurrence for the day. This will aid forecasters in evaluating flight rules and determining the probability of launch commit criteria violations, as well as preparing forecasts for ground operations.

Discussion: The 45th Weather Squadron (45 WS) forecasters include a probability of thunderstorm occurrence in their daily morning briefings. This information is used by managers for daily planning, especially for lightning sensitive ground operations on Kennedy Space Center/Cape Canaveral Air Force Station (KSC/CCAFS) requiring long lead times or many hours to complete. Much of the current lightning probability forecast is based on a subjective analysis of model and observational data. The forecasters requested development of a lightning probability forecast tool based on statistical analyses of historical warm-season data--a tool to increase the objectivity of daily thunderstorm probability forecasts.

The AMU developed a statistical lightning forecast equations that will provide a lightning occurrence probability for the day by 1100 UTC (0700 L) during the months May - September (warm season). The tool is based on results from several research projects. Tests of the equations show they improve the daily lightning forecast, thus the AMU developed a PC-based tool and GUI from which forecasters can display the daily probabilities. As the GUI was tested, graphs were created that showed the change in probability due to changes in one predictor while holding all other predictors constant. These graphs show the users how sensitive the output probabilities are to changes in one predictor value versus changes in the others.

Three of the data types used to develop the technique were:

Cloud-to-Ground Lightning Surveillance System data,

1200 UTC sounding data from synoptic sites in Florida, and

1000 UTC CCAFS sounding (XMR) data.

The AMU used the CCAFS (XMR) sounding data to calculate the stability parameters normally available to the forecasters through the Meteorological Interactive Data Display System (MIDDS). MIDDS uses the Man-computer Interactive Data Access System (McIDAS) software (Lazzara et al. 1999) for processing and displaying the sounding data. The McIDAS algorithms that process the sounding data used in this task ensured the calculated stability parameter values will be consistent with those available to the forecasters. *Note: The AMU worked with the vendor to correct errors discovered in the COTS algorithms before proceeding with this task.*

Task: Severe Weather Forecast Decision Aid

Goal: Create a new forecast aid to improve the severe weather watches and warnings meant for the protection of KSC) and CCAFS personnel and property.

Discussion: The 45WS morning weather products includes an assessment of the likelihood of local convective severe weather in order to enhance protection of personnel and material assets of the 45th Space Wing, CCAFS, and KSC. Severe weather includes tornadoes, wind gusts 50 kt, and/or hail with a diameter of 0.75 in. Forecasting the occurrence and timing of these phenomena is challenging for 45WS duty forecasters and Launch Weather Officers.

The AMU developed a new severe weather forecast decision aid tuned to the east-central Florida environment to improve the various 45WS severe weather watches and warnings. The decision aid will provide severe weather guidance for the day by 1100 UTC (0700 EDT). The analyses of cumulative distributions of rawinsonde-based stability parameters were used to re-assess the threshold values currently used by 45WS. The AMU recommended adjustments to the threshold values based on the historical severe weather events in east-central Florida and the accompanying stability indices from the morning CCAFS rawinsonde. The AMU archives of severe weather events, stability indices, and synoptic characterizations of atmospheric flow patterns were merged for further analysis.

The display used to evaluate the stability indices was changed from scatter plots to stacked column graphs, providing a different perspective on the relationships between the indices and severe weather. An interactive web-based severe weather forecast tool was developed and delivered to the 45WS for initial evaluation.

With the new graphs, some of the indices show stronger relationships to severe weather occurrence. Specific index thresholds and other criteria were incorporated into the severe weather forecast tool which is now ready for forecaster testing during the upcoming warm season.

Task: Shuttle Ascent Camera Cloud Obstruction Forecast

Goal: Develop a model to forecast the probability at least three Shuttle ascent imaging cameras can view the Shuttle launch vehicle (LV) unobstructed by cloud at any time from launch to Solid Rocket Booster (SRB) separation.

Discussion: Optical imaging of the Shuttle launch vehicle (LV) from ground-based and airborne cameras is susceptible to obstruction by clouds. The Columbia Accident Investigation Board (CAIB) recommended the Shuttle ascent imaging network be upgraded to have the capability of providing at least three useful views of the LV from lift-off to SRB separation. In response, the NASA/KSC Weather Office tasked the AMU to develop a model to forecast the probability cloud will not obstruct the view of at least X imaging cameras at any time from launch to SRB separation. An analysis of the sensitivity of viewing probabilities to upgrades of the camera network was developed in collaboration with the Shuttle Launch Director, the KSC Intercenter Photo Working Group, and the 45WS Shuttle Launch Weather Officer.

A 3-D computer model was randomly seeded with cloud fields and viewing probabilities were computed for selected cloud scenarios. The AMU model was based on computer simulations of:

1. idealized, random cloud coverage scenarios;

2. the optical lines-of-sight from cameras to the LV using the camera network before and after upgrades for Return to Flight (RTF); and

3. a LV ascent trajectory for a launch from Pad 39B to the International Space Station (ISS). Based on the results, launch day criteria and launch decision strategies are being developed and coordinated with senior Shuttle management.

Task:Stable Low Cloud Evaluation

Goal: Examine archived data collected during rapid stable cloud development events resulting in cloud ceilings below 8000 ft at the Shuttle Landing Facility (SLF). Document the atmospheric conditions favoring this type of cloud development to improve the ceiling forecast issued by the SMG for Shuttle landings at KSC.

Milestones: Identified days in the time period 1993 - 2003 that had low-level temperature inversions and cloud ceilings below 8000 ft. Retrieved visible satellite images from those same days for comparison.

Discussion: Approximately 25 days of satellite images were retrieved from the satellite database and loaded onto the AMU weather display systems. These images were analyzed to identify days with rapid low cloud development.

Task: Hail Index

Goal: Evaluate current techniques used by the 45WS to forecast the probability of hail occurrence and size. Hail forecasts are required to protect personnel and material assets at KSC, CCAFS, Patrick Air Force Base and the Melbourne International Airport. The evaluation results will be used by the 45WS to determine if a new technique is needed.

Milestones: The AMU used data from the Cloud-to-Ground Lightning Surveillance System (CGLSS) to evaluate the Neumann-Pfeffer Thunderstorm Index (NPTI) technique, as the hail size forecast generated by the computer code is contingent on a "yes" thunderstorm forecast by the NPTI.

Discussion: On 966 days with lightning activity in the local area as indicated by CGLSS, the NPTI forecast a "yes" on only 511 days. This level of performance suggests that the computer code should be modified to generate a forecast hail size independent of the NPTI forecast.

Task: RSA and Legacy Wind Sensor Evaluation

Goal: Compare wind speed and direction statistics from the legacy and RSA sensors on the Eastern (ER) and Western (WR) Ranges to determine the impact of the sensor changes on wind measurements. The 45WS and 30WS (Vandenberg AFB, CA) need to know of any differences in the measurements between the two systems as they use these winds to issue weather advisories for operations.

Milestones: Analyzed 4 hours of archived RSA and legacy wind data from Tower 300 on the WR on a day with northeast winds at 10 to 20 kts.

Discussion: The average wind speeds and directions were similar for both instruments but the RSA peak speeds were several knots higher than the legacy gusts. A study using synthetic data showed that the algorithm used to calculate the legacy peak speeds likely caused a large percentage of the difference. However, these results have limited utility as the archived gusts are not used to evaluate Launch Commit Criteria (LCC). Efforts are underway to obtain the legacy peak speed data used to evaluate LCC during launch operations. *Note: The KSC Weather Office and the AMU believe the algorithm is faulty*

Task: Volume Averaged Height Integrated Radar Reflectivity (VAHIRR)

Goal: Transition the VAHIRR algorithm into operations. The current lightning launch commit criteria (LLCC) for anvil clouds to avoid triggered lightning are overly conservative and lead to costly launch delays and scrubs. The VAHIRR algorithm was developed as a result of the Airborne Field Mill program to evaluate a new LLCC for anvil clouds. This algorithm will assist forecasters in providing fewer missed launch opportunities with no loss of safety compared with the current LLCC.

Milestones: The VAHIRR algorithm was acquired from the National Center for Atmospheric Research.

Discussion: The VAHIRR algorithm was received and installed on a local computer for development. There were also several discussions with Mr. Tim Crum and Mr. Randy George of the Radar Operations Center in Norman, OK on the process of integrating new algorithms into the WSR-88D operational system.

Task: Mesoscale Model Phenomenological Verification Evaluation

Goal: Find model weather-phenomena verification tools in the literature that could be transitioned into operations. Forecasters use models to aid in forecasting weather phenomena important to launch, landing, and daily ground operations. Methods that verify model performance are needed to help forecasters determine the model skill in predicting certain phenomena.

Milestones: Collected journal articles describing the development and/or use of new phenomenological verification techniques. Created tables containing information about each technique.

Discussion: The tables include the article reference, weather phenomenon being verified, model being verified, model and observational data used, name of the new technique, and the feasibility of transitioning the technique to operations.

Task: ARPS Optimization and Training Extension

Goal: Provide assistance and support for upgrading and improving the operational Advanced Regional Prediction System (ARPS) and ARPS Data Analysis System (ADAS) that is used to make operational forecasts at the National Weather Service in Melbourne, FL (NWS MLB) and SMG forecast offices.

Milestones: Completed the upgrade of the operational ADAS to software version 5.1.2 at the NWS MLB, and created a data-conversion program to process Automated Surface Observing System (ASOS) data.

Discussion: The upgrade and installation of ADAS onto the new Linux workstation at the NWS MLB was completed. A new data-ingest program was written to improve the ADAS analysis quality at off-hour times by incorporating ASOS observations. The AMU also corrected an erroneous specification of soil type over the Bahamas and improved the terrain resolution.

Task: User Control Interface for ADAS Data Ingest

Goal: Develop a GUI to help forecasters at NWS MLB and SMG manage the data sets assimilated into the operational ADAS.

Milestones: Completed installation of GUI at NWS MLB.

Discussion: A fully functional ADAS control GUI was installed at NWS MLB following trouble-shooting of certain map background issues

Task: Anvil Transparency Relationship to Radar Reflectivity

Goal: Determine if the NWS MLB WSR-88D radar can be used to analyze anvil cloud transparency.

Discussion: Anvil cloud transparency is an important element in forecasting triggered lightning launch commit criteria. Opaque anvils can carry an electrical charge. If a vehicle flies through such a charge, it could trigger lightning and be destroyed. The AMU identified 45 days during summer 2003 with thunderstorm anvil cirrus clouds over the KSC Shuttle Landing Facility weather observation site (KTTS), based on a comparative analysis of satellite imagery and the KTTS observations.

The NOAA Radar Operations Center is processing the WSR-88D Layer Reflectivity Maximum products for the 45 case days. These will be used in a comparative analysis with the surface observations of anvil transparency from KTTS.

Task: Range Standardization and Automation (RSA) Support

Goal: Help Eastern Range personnel evaluate proposed designs and implementations of the weather systems upgrade by the RSA and SLRSC contractors. AMU participates in design reviews, acceptance tests and other functions as required.

OTHER KENNEDY SPACE CENTER SUPPORTING RESEARCH

Lightning Launch Commit Criteria (LLCC) [Airborne Field Mill (ABFM)] Program

The KSC Weather Office continued to direct the analysis of data gathering from KSC's major field research program called the Lightning Launch Commit Criteria (LLCC) program. The LLCC program used an aircraft equipped with field mills and cloud physics sensors, in combination with several ground based radars and other sensors, to collect the data necessary to relax the lightning launch constraints while making them even safer. LLCC was cooperatively funded by the Shuttle program, NASA ELVs and the USAF. The team included more than 50 personnel from eleven organizations including other Governmental agencies, NASA Centers, universities and their contractors.

Based on analyses of the extensive data base of in-situ and radar measurements, the team developed revised LLCC for both Attached Anvils and Detached Anvils. Working with colleagues from the National Center for Atmospheric Research (NCAR), Marshall Spaceflight Center (MSFC), the University of Arizona (U AZ), the Hurricane Research Division (NOAA/HRD), National Severe Storms Lab., Aerospace Corp. and others, KSC developed and applied software to perform a variety of analyses on the massive data set. These analyses included correlation and power spectral analyses, and extensive statistical examinations of the radar, cloud physics and electric field data.

KSC facilitated and participated in defining the new LLCC. To help the Lightning Advisory Panel (LAP) determine the threshold electric field aloft that poses a triggered lightning hazard, KSC acquired information from Shuttle and Titan about the length of the ionized plum from their solid rocket motors. From data obtained elsewhere on the likely potential difference required to trigger lightning, the LAP used the plume lengths to convert the triggering threat potential to a corresponding threshold electric field.

In order to automate processing of ABFM data for the determination of the decay of electric fields with distance from cloud edges, KSC developed an automated cloud edge detection algorithm. A paper describing the algorithm and its testing appeared in the May 2004 issue of the Journal of Atmospheric and Oceanic Technology. (Ward, J.G. and F.J. Merceret, 2004: An Automated Cloud-Edge Detection Algorithm Using Cloud Physics and Radar Data, J. Atm. & Ocean. Tech., 21(5), 762-765)

Winds

The KSC Weather Office (KSCWO) requested the Shuttle Program to reexamine its day of launch upper air winds procedures to ensure spatial and temporal variability are being optimally accounted for. The KSCWO presented several briefings on temporal wind persistence as a function of vertical feature size and related instrumentation matters to the Space Shuttle Natural Environments Panel challenging engineers from the Shuttle, Titan and new Expendable Launch Vehicle programs (Atlas V and Delta IV) to reconsider their assumptions and launch day procedures.

OPERATIONS

In addition to Supporting Research, the KSC Weather Office continues to work with the Eastern Range (ER) to improve the KSC and ER weather infrastructures and improve operational processes and facilities.

Visibility Sensors.

In FY2004, KSC began transmitting Visibility and Soil Moisture data to JSC/SMG from five suites of newly installed sensors west of KSC to aid in the forecast of morning fog that could impact Shuttle landings.

Range Standardization and Automation (RSA)

The KSC Weather Office, SMG at JSC, and the AMU continue to actively participate in plans and proposals for projects managed by the RSA program. RSA is a major Air Force program to modernize the Eastern and Western Range infrastructures. Many issues remain with RSA's pending changes. Thus, the Air Force and NASA weather communities continued to expend significant resources to solve potential major RSA deficiencies, since NASA KSC, JSC and MSFC depend heavily on this infrastructure for their weather support. A major success was the RSA contractor's decision to discard their proposed Control and Display (C&D) system, and instead partner with NOAA's Forecast Systems Lab to deliver a COTS AWIPS (Automated Weather Information System). This will provide Range Weather Operations with a very capable system that is cost effective, and compatible with both future AWIPS upgrades and with SMG. However, in FY 2003 and FY 2004 Air Force budget redirection seriously threatened cancellation of the entire RSA weather system which would have seriously degraded long term weather support to the American Space Program. Fortunately, the program is still progressing. Although deliveries of some weather sensors, models, and control and display systems began in FY2000, budget restrictions have delayed full operational capability and acceptance by the Eastern Range to FY 2007 (a decade plus delay from original schedule).

Spacelift Range Systems Contract (SLRS-C)

In addition to the RSA Modernization programs, the new SLRS-C provides Sustaining Engineering for the legacy systems and also the systems RSA is delivering. SLRS-C is currently upgrading or replacing three systems currently owned by NASA Kennedy Space Center:

- 50 MHz Doppler Radar Wind Profiler,
- Shuttle Landing Facility Weather Tower and Sensor system, and
- the Lightning Detection and Ranging (4D total lightning) system. Upon completion of each program, the system will be turned over from NASA/KSC to the Eastern Range. Despite numerous logistical and programmatic hurdles all three programs will likely succeed:
- SLF in FY 2006,
- 4D lightning in FY 2007, and
- 50 MHz profiler in FY 2007.

50 MHz Doppler Radar Wind Profiler (DRWP)

Replacement of many KSC DRWP and its electronic components components began in FY 2004 and finished in FY 2005. Meanwhile, several antenna field issues were corrected,

1. The Air Force funded a project to improve the drainage of the DRWP antenna field that flooded during very heavy rains.
2. During droughts, the very dry antenna ground plane caused erroneous side lobe returns. The Profiler O&M contractor designed and a contractor installed a sprinkler system to wet the antenna field during droughts. The sprinkler system is now installed which solved the side-lobe problem during dry weather.

Shuttle Landing Facility (SLF) Weather Sensors

SLRSC also contracted to replace and modernize all SLF weather instrumentation. SLRS-C chose the AF Weather Agency FMQ-19 as the basic system to ensure adequate logistics support. To meet special NASA requirements, the system has been modified to provide 1 second winds, additional ceilometers off both runway approaches, and a 120 minute (vs 30 minute) UPS backup. After several communication links are complete, the system will become operational and turned over to the AF expected by FY 2006.

Lightning Detection and Ranging (LDAR) System.

Since LDAR was originally developed as a research system in the late 80's, its components are increasingly subject to obsolescence, thus costs and the risk of system failure are increasing. KSC worked with the Range to justify raising the priority of a replacement LDAR in the AF Space Command priority list. The AF and KSC worked with SLRS-C to overcome numerous obstacles: electromagnetic interference; NASA and AF requirements vs. COTS capabilities; site selection for antenna towers; takeover of COTS contractor by Finish international company; etc. Major unresolved KSC issues: transmission of LDAR data to SMG and NWS Melbourne; and an expected requirement to perform environmental impact assessments (EIS) on all seven antenna sites because of the location of two towers in marshlands. The EISs will delay antenna installation until FY 2006; testing until FY 2006, and project completion until FY 2007.

TAL Atmospheric Sounding System (TASS).

The Radio Automatic Theodolite System (RATS) was used to provide SMG with upper level winds, temperatures and humidity at the Shuttle Transatlantic Abort Landing (TAL) sites in Spain, Morocco, and Gambia. RATS became obsolete when the manufacturer announced cessation of sonde production. A replacement system called TASS, a Global Positioning System (GPS) based Sippican W9000, was selected, procured, integrated and tested with the help of the Eastern Range. The initial system is now installed and operational. The Eastern Range owns, operates and maintains the system for NASA. In order to improve TASS' user friendliness, reliability, and accuracy, NASA will funded the ER to upgrade the Operating System from DOS to Windows, and upgrade the sondes in FY 2005.

Sonic Lightning Locator (SOLLO).

The KSC Weather Office funded development of a new lightning detection system capable of locating lightning strikes in 4D with an accuracy of <5 meters (a considerable improvement over the 250-300 meter accuracy of our current lightning location system.). Called SOLLO, it uses a sensor to detect the time of arrival of the electromagnetic pulse from a lightning strike, and then one elevated detector and three surface based detectors to measure the time of arrival of thunder from the lightning, to very accurately calculate the location of the lightning strike. SOLLO also calculates the amperage, rise time, and polarity of the strike. During FY 2004, KSC replaced/upgraded SOLLO components to enhance its capability to operate reliably in the corrosive KSC/ER environment. During the 2004 and 2005 spring/summer lightning season, KSC installed SOLLO systems at the Shuttle Launch Complex and a new technology development and testing facility for further testing.

KSC/CCAFS Weather Observation Site Relocation.

The 24/7 official KSC/CCAFS Weather Observation Site is located in a very aging structure with its view of Shuttle Landing Facility (SLF) runway totally obscured. We convinced architects and managers of a project to build a new SLF air traffic control tower to include two floors for weather observers and equipment. The Range Technical Service Contractor (CSR) provided detailed specifications to ensure the final design met strict observing requirements. The tower project is complete; and move in was completed in FY 2005. The tower enables observers to provide much more accurate weather depictions over SLF, especially during rapidly changing conditions, thus improving aircraft, Space Shuttle and future RLV safety.

Lightning Launch Commit Criteria (LLCC) Revision

During analyses of Airborne Field Mill (ABFM) Program data, the Lightning Advisory Panel (LAP) concluded the radar definition of cloud edge, top and base in the LLCC was not sufficiently conservative. Based on ABFM measurements of electric fields high enough to trigger lightning with radar reflectivities as low as 5 dBZ, the LAP concluded the radar threshold needed to be lowered from10 dBZ to 0 dBZ. The conclusion was reached one week before the launch of first Mars Rover on board a Delta.

A new definition was quickly staffed from the LAP thru 45WS and 45th Space Wing Safety, and the revision recommended at the Delta/Mars Rover Launch Readiness Review two days before launch. Although Launch and Program managers are normally reluctant to accept last minute changes to procedures, we emphasized the revision was a safety issue and they accepted the change exactly as proposed.

Columbia Accident Investigation

The entire NASA and Eastern Range weather communities (KSC, JSC/SMG, MSFC, GSFC, LRC, and 45WS) were deeply involved supporting the Space Shuttle Columbia accident investigation. Weather analyses were crucial to: identifying likely debris impact locations over the western and central United States; characterizing the atmosphere during reentry, beginning in the very data sparse upper Mesosphere; identifying possible anomalous wind shears during launch ascent; analyzing Columbia's exposure to the atmosphere during the 39 days Columbia was on the launch pad; and numerous engineering studies. NOAA/NWS also provided considerable help.

<u>Helios Accident Investigation</u>

NASA's premier solar-powered research aircraft (Helios) crashed just west of Barking Sands, Kauai in late June 2003. The KSC Weather Office participated on the Mishap Board along with Dr. John Brown from NOAA/Forecast Systems Lab. Due to Helios' many unique design and power characteristics, it had many very complex stability and control physics and characteristics.

Initial research revealed little was known about the atmosphere's behavior west of Kauai, specifically the atmosphere's combined response to the wake turbulence from the Trade Wind flow over the island, shear lines from air flowing around Kauai, sea breezes, and the large scale pattern. Thus the Weather Office contracted with NCAR (Dr. Bob Sharman) and the University of Hawaii (Dr. Duane Stevens) to perform high resolution atmospheric numerical model simulations to try to understand the atmosphere Helios encountered. In addition, the University of Hawaii designed and implemented a very low budget, aircraft data gathering program offshore of Barking Sands, Kauai to measure wind and temperature profiles, and turbulence features. We used the aircraft data to understand small-scale features and to validate results from NCAR's high resolution model simulations. The final Helios Mishap Board report was released to the public.

BUDGET

Budget changes from FY 2005 to FY 2006 for core O&M capabilities are mostly due to inflation with two exceptions.

1. The funds transferred to Eastern Range for weather support began to increase in FY 2005 as NASA returned to launching Shuttles after 2 ½ years of analyses and program changes following the Columbia accident.

2. A $200K increase in the FY 2005 budget to O&M the LDAR and DRWP systems. Both are R&D systems developed in the late 1980's which are now used to support operations. Their components are rapidly becoming obsolete and hard/expensive to replace. The AF expects to replace LDAR by FY 2006 and DRWP by late FY 2005, and then assume system ownership from NASA. Meanwhile O&M costs will continue to escalate.

Three significant programs required large budget outlays/commitments:

1. Shuttle Landing Facility (SLF) weather system (replacement),

2. 4D Lightning Detection and Ranging (LDAR) (replacement), and

3. 50 MHz Doppler Radar Wind Profiler (DRWP) (upgrade).

The AF is funding a significant portion of and managing the programs. Estimated costs are: SLF: $1.8M; LDAR: $2.6M; and DRWP $3+M. NASA's contributions are to satisfy unique NASA requirements and to facilitate the modernization and system transition to the AF.

NUCLEAR REGULATORY COMMISSION WEATHER PROGRAMS

The United States Nuclear Regulatory Commission (NRC) licenses and regulates all nuclear facilities subject to the Atomic Energy Act of 1954 as amended. The licensing and operation of these nuclear facilities require the identification of meteorological and climatological conditions that can affect the safe operation of the facility, and that provide input to the assessment of the radiological impacts of any airborne releases from the facility.

Within the NRC, the Office of Nuclear Reactor Regulation and the Office of Nuclear Material Safety and Safeguards conduct reviews of nuclear facility siting, design, construction, and operation. These reviews include consideration of meteorological factors. The two offices also conduct rulemaking to establish regulatory requirements. The NRC Regional Offices assure that licensing conditions are followed by NRC licensees. Together with the NRC Incident Response Operations, they also carry out NRC responses to nuclear facility emergencies.

The Office of Nuclear Regulatory Research (RES) conducts research in various categories to identify potential safety issues, and to prepare the agency to regulate the use of new technology. RES also develops regulatory guidance and participates in the development of criteria and consensus standards related to the protection of the public health and safety and the environment.

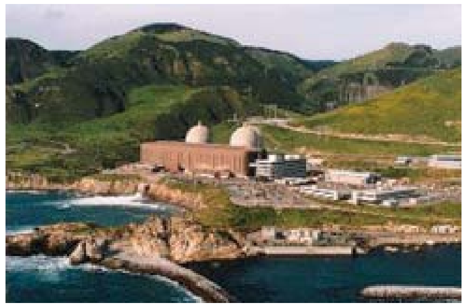


Figure 3-NRC-1. NRC regulates commercial nuclear power plants. The photo shows the operating nuclear plant at Diablo Cayon, CA.

At the present time, the NRC is a user of meteorological information, rather than performing research in this field. Meteorological data will be used to assess radiological impacts of routine airborne releases from facilities and to evaluate the impact of proposed changes in plant design or operation on unplanned releases. Information of this type is also important for developing scenarios of climatological impacts on the isolation of long-lived nuclear wastes. The NRC also maintains an interest in the transport and dispersion of airborne, hazardous, non-radioactive materials, and the effects of extreme meteorological events on the safe operation of nuclear facilities.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent agency of the Federal Government established to promote and advance scientific and engineering progress. The NSF sponsors and funds scientific and engineering research and education projects and supports cooperative research to gain new understanding of the behavior of the Earth's atmosphere and oceans. NSF does not itself conduct research but funds research performed by scientists at universities and other entities. In addition, NSF provides support for the maintenance and operation of the National Center for Atmospheric Research (NCAR) which is devoted to large-scale atmospheric research projects conducted in cooperation with universities and other Federal, state and/or local organizations.

The Division of Atmospheric Sciences manages NSF's basic atmospheric research support. This research focuses on new and fundamental knowledge needed to better understand the atmosphere and related sciences and to manage atmospheric science programs including natural disaster reduction, space weather, global change, and air quality.

NATURAL DISASTER REDUCTION

NSF supports fundamental and applied research to address weather phenomena that are either life threatening or economically disruptive. Focus areas include:

Better understanding and forecasting of hurricane track and intensity;

Better quantitative precipitation forecasting and estimation;

Optimal use of observations in numerical models; and

The societal/economic impacts of improved weather information.

The total research support for FY 2005 was approximately 14 million. In FY 2006, support is expected to remain level.

Space Weather. NSF supports research under the National Space Weather Program (NSWP). The objective of the NSWP is to perform the research and technology transfer needed to improve the specification and forecasts of space weather events that can cause disruption and failure of space borne and ground based technological systems and can endanger human health. Examples of NSF support of space weather include conducting a highly successful competition for space weather research grants and providing support for the Center for Integrated Space Weather Modeling (CISM), a multi-institutional effort led by Boston University and dedicated to providing advance warning of potentially harmful space weather events. The NSF's NSWP support in FY 2005 was about $14 million and is expected to be the same in FY 2006.

GLOBAL CHANGE

Under the United States Global Change Research Program (USGCRP), NSF programs support research and related activities that advance fundamental understanding of dynamic, physical, biological, and socioeconomic systems as well as interactions among those systems. In addition to research on Earth system processes and the consequences of changes in those systems, NSF programs facilitate data acquisition and data management activities necessary for basic research on global change, promote the enhancement of modeling designed to improve representations of Earth system interactions, and develop advanced analytic methods to facilitate fundamental research. NSF also supports fundamental social and economic research on the general processes used by governments and other organizations to identify and evaluate different types of policies for mitigation, adaptation, and other responses to changing global environmental conditions.

The total NSF FY 2005 USGCRP funding was about $185 million. In FY 2006, funding is expected to be level. The Division of Atmospheric Sciences USGCRP funding for FY 2005 was about $44.0 million with FY 2006 funding expected to be level also.

AIR QUALITY

NSF supported fundamental research in the area of air quality helps develop improved understanding of the sources, formation, atmospheric processing and fates of ambient air pollutants. Atmospheric oxidant species (and their precursors), sulfur dioxide, nitrogen oxides, carbon monoxide, fine particles (and their precursors), and acids are important atmospheric constituents that influence air quality, and in turn habitability, human health and climate. Field experiments, laboratory studies, instrument development, new methods of chemical analysis, and improved models of atmospheric chemical reaction mechanisms, transport and depositional phenomena are examples of air quality research supported by NSF. These categories provide scientific and technical input for management and control of atmospheric pollutant gases and particles.

NOTE: NSF budget data is not captured in Tables 2.1-2.5.

APPENDIX A

FEDERAL COORDINATION AND PLANNING

BASIS FOR FEDERAL COORDINATION PROCESS

In 1963, Congress and the Executive Office of the President expressed concern about the adequacy of coordination of Federal meteorological activities. In response, Congress directed in Section 304 of Public Law 87-843--the Appropriations Act for State, Justice, Commerce, and Related Agencies--that the Bureau of the Budget prepare an annual horizontal budget for all meteorological programs in the Federal agencies.

The Bureau of the Budget (now the Office of Management and Budget) issued a report entitled "Survey of Federal Meteorological Activities" (1963). The report described each agency's program in some detail, particularly its operational services, and detailed the relationship between the programs of the various agencies. The report revealed close cooperation but little evidence of systematic coordination. Based on this study, the Bureau of the Budget issued a set of ground rules to be followed in the coordination process. It established a permanent general philosophy for assignment and assessment of agency roles in the field of meteorology and set certain goals to be achieved by the coordination process. The Bureau of the Budget tasked the Department of Commerce (DOC) to establish the coordinating mechanism in concert with the other Federal agencies. It also reaffirmed the concept of having a central agency--the DOC--responsible for providing common meteorological facilities and services and clarified the responsibilities of other agencies for providing meteorological services specific to their own needs.

The implementation of these directives by DOC led to the creation of the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) which operates with policy guidance from the Federal Committee for Meteorological Services and Supporting Research. The principal work in the coordination of meteorological activities and in the preparation and maintenance of Federal plans is accomplished by the OFCM staff with the advice and assistance of the Interdepartmental Committee for Meteorological Services and Supporting Research, and over 30 program councils, committees, working groups, and joint action groups.

MISSION AND STAFFING OF THE OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY (OFCM)

The mission of the OFCM is to ensure the effective use of Federal meteorological resources by leading the systematic coordination of operational weather requirements and services, and supporting research, among the Federal agencies. To discharge its mission, OFCM has meshed its objectives with the objectives of the agencies that provide the services and perform the research.

These objectives include:

- Documenting agency programs and activities in a series of national plans and reports that enable agencies to revise/adjust their individual ongoing programs and provide a means for communicating new ideas and approaches to fulfill requirements.
- Providing structure and programs to promote continuity in the development and coordination of interagency plans and procedures for meteorological services and supporting research activities.
- Preparing analyses, summaries, or evaluations of agency meteorological programs and plans that provide a factual basis for the Executive and Legislative branches to make appropriate decisions related to the allocation of funds.
- Reviewing Federal weather programs and Federal requirements for meteorological services and supporting research. This review may suggest additions or revisions to current or proposed programs, or identify opportunities for improved efficiency, reliability, or cost avoidance through coordinated actions or integrated programs.

DOC currently has ten positions assigned to OFCM. DOC also provides administrative support to OFCM and approximately one-half of OFCM's annual operating budget. The Department of Defense (DOD) currently provides two senior staff officers--one Air Force and one Navy--and contributes approximately one-fourth of the annual operating budget. The Department of Transportation (DOT) Federal Aviation Administration (FAA) provides one professional staff member and also provides approximately one-fourth of the annual operating budget. These three agency representatives are designated Assistant Federal Coordinators for liaison to their respective agencies. In all, 13 meteorologists, oceanographers, physical scientists, and administrative and computer-support personnel are assigned to the OFCM staff.

FEDERAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

The Federal Committee for Meteorological Services and Supporting Research (FCMSSR), established in 1964, provides policy-level agency representation and guidance to the Federal Coordinator to address agency priorities, requirements, and issues related to services, operations, and supporting research, and also resolves agency differences that arise during the coordination of meteorological activities and the preparation of Federal plans. The Under Secretary of Commerce for Oceans and Atmosphere, who is also the Administrator of the National Oceanic and Atmospheric Administration (NOAA), serves as the FCMSSR Chairperson.

The 15 Federal agencies that engage in meteorological activities, or have a need for meteorological services, are represented on FCMSSR. The FCMSSR membership includes: DOC, DOD, DOT, the Departments of Agriculture (USDA), Energy (DOE), Homeland Security (DHS), Interior (DOI), and State (DOS), the Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), National Transportation Safety Board (NTSB), Nuclear Regulatory Commission (NRC), the Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB).

HIGHLIGHTS FOR FISCAL YEAR 2005 AND PLANS FOR FISCAL YEAR 2006

NATURAL DISASTER REDUCTION

INTERDEPARTMENTAL HURRICANE CONFERENCE

The OFCM annually hosts the Interdepartmental Hurricane Conference (IHC) to provide a forum for the responsible Federal agencies, together with representatives of the user communities such as emergency management, to review the Nation's hurricane forecast and warning program and to make recommendations on how to improve the program. The OFCM hosted the 59th IHC in Jacksonville, Florida, March 7-11, 2005. The theme of the 2005 conference was *The Nation's Tropical Cyclone Program-Priorities for the Next Decade*. The conference attendance was 213; for the sixth consecutive year, attendance has exceeded 200. The 59th IHC was cohosted by the Office of the Oceanographer of the Navy. The keynote address for the conference was given by Dr. James R. Mahoney, Assistant Secretary of Commerce for Oceans and Atmosphere and NOAA Deputy Administrator. At its November 16, 2004, meeting, the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) strongly supported the 58th IHC action item to develop a comprehensive strategy for tropical cyclone research and development to guide interagency efforts over the next decade. In response to that action, the Joint Action Group for Tropical Cyclone Research (JAG/TCR) was formed, and the group conducted a strategic planning session during the 59th IHC to begin developing the framework for a *Strategic Research Plan for Tropical Cyclones*. This effort will build upon the goals and objectives of the OFCM-sponsored *National Plan for Tropical Cyclone Research and Reconnaissance (1997-2002)* and the *U.S. Weather Research Program Hurricane Landfall Implementation Plan*, and articulate the interagency tropical cyclone research priorities for the next decade. The goal is to complete the plan prior to the 60th IHC in March 2006. The conference also highlighted the success of the Stepped Frequency Microwave Radiometer (SFMR), which provides critically needed surface-wind and rainfall-rate information in the tropical cyclone environment, supporting National Hurricane Center and emergency management requirements. The SFMR, which is currently flown on NOAA's WP-3D aircraft, is being transitioned from research to operations. In fact, as a result of the 2004 hurricane season which ravaged the state of Florida, the Department of Defense received a $10.5 million Congressional supplement to install the SFMR on the Air Force Reserve Command's WC-130J hurricane hunter aircraft. Initial operational capability is scheduled for August 2006. Financial support for the SFMR development was provided by the OFCM through the Improved Weather Reconnaissance Program. Other actions from the 59th IHC include the development of a comprehensive long-term interagency strategy for airborne reconnaissance observations as a subset of the Global Earth Observation System of Systems (GEOSS); facilitating a meeting of Web site owners from NHC, FEMA, USACE, etc., to discuss improved linkages, formats, and other related issues needed to improve customer use and understanding; and developing a path ahead to implement recommendations from the OFCM-sponsored study *Warning Messages-Exploring Customer Understanding*, which was completed in June 2005, to improve the understanding and use of tropical cyclone forecasts and warnings. In

May 2005, the 43rd edition of the *National Hurricane Operations Plan (NHOP)*, which provides the basis for hurricane reconnaissance for the 2005 season and details Federal agency responsibilities, operations, and procedures; products; aircraft, satellite, radar, and buoy data collection; and marine weather broadcasts, was published based on the inputs and discussions from the 59th IHC. The comprehensive NHOP was critical to ensuring successful weather and reconnaissance operations for the 2005 hurricane season.

POST-STORM DATA ACQUISITION

The OFCM will continue to coordinate, as required, timely post-storm data acquisition surveys in response to Presidentially declared natural disasters and other agency requirements to evaluate, for example, the impact on the coastal ecosystems. These natural disaster reduction efforts contribute to the determination of the intensity and magnitude of storms, and, in many cases, help to determine the extent of damage for use in Presidential disaster declarations. The additional data collected after hurricane landfall is also used in validating modeling efforts with both emergency management models (e.g., FEMA's HAZUS) and hurricane storm-surge models (e.g., NOAA's SLOSH). These models are used in real-time to assist decision makers in evacuation decisions and procedures. Post-storm data are also used to update FEMA Flood Insurance Rate Maps. In FY 2005, post-storm surveys were conducted for Hurricane Dennis; tornado occurrences during March in Houston County in Southeast Alabama, and in Seminole, Miller, and Mitchell Counties in Southwest Georgia; and Hurricane Katrina. A senior OFCM staff person is spearheading efforts in the development of a Memorandum of Understanding (MOU) between the Department of Commerce (DOC)/OFCM and the Department of Defense/Office of the Secretary of Defense, to provide USAF Auxiliary-Civil Air Patrol aerial support and reconnaissance for post-storm and natural disaster data assessment. The MOU has been approved by the NOAA General Counsel's Office and is currently being reviewed at the DOC level. It will then be forwarded to the Air Force for their concurrence.

URBAN METEOROLOGY

The OFCM, in partnership with the Department of Homeland Security (DHS) Science and Technology Directorate, conducted a User Forum on Urban Meteorology, September 21-23, 2004, at the Doubletree Hotel and Executive Meeting Center in Rockville, Maryland. The theme of the forum was *Information to Improve Community Responses to Urban Atmospheric Hazards, Weather Events, and Climate*. It focused on the following elements of urban meteorology: severe weather, homeland security, air quality, water quality, and climate. This interagency forum was the direct result of an action item from the October 18, 2002, meeting of the FCMSSR. The forum's proceedings were completed in March 2005. In accordance with direction received at the November 16, 2004, meeting of ICMSSR, the OFCM developed clear guidelines and direction for establishing an interagency working group to address the actions that resulted from the forum. This was submitted to the ICMSSR members on June 29, 2005. The OFCM obtained Committee approval for formation of the Working Group for Urban Meteorology (WG/UM) and has implemented the working group. The goal of WG/UM is "…to define a multi-agency coordinated R&D program to support implementation of tools and systems for cost-effective mitigation of severe weather events and other weather-related hazards in the urban environment. The hazard categories include severe weather events, homeland security (emergency response to airborne hazards), air and water quality hazards, and climate-related conditions."

CLIMATE

During FY 2005, the OFCM made contributions to climate activities in the following two primary areas: in connection with the Urban Meteorology User Forum which was held September 21-23, 2004, and the U.S. Climate Change Science Program (CCSP). The Urban Meteorology User Forum focused on the following elements of urban meteorology: severe weather, homeland security, air quality, water quality, and climate. Results of the forum were briefed at the November 16, 2004, meeting of the ICMSSR and, as a result, OFCM was tasked to develop clear guidelines and direction for establishing an interagency working group to address actions from the forum, and to coordinate and develop an interagency document covering an urban meteorology program, including climate. Dr. James R. Mahoney, Director of the U.S. Climate Change Science Program, briefed the FCMSSR at its December 1, 2004, meeting. Dr. Mahoney noted that many challenges lie ahead for the CCSP program, particularly those related to the budget process and delivering the best possible science to inform decision makers. It was decided that FCMSSR members will continue to stay abreast of the CCSP and will coordinate priorities for atmospheric requirements through OFCM for inclusion in the CCSP. An OFCM Senior Staff Meteorologist serves as a liaison to the CCSP and the Subcommittee on Global Change Research and is continuing to participate in CCSP activities. She attended the March 2, 2005, CCSP meeting and is supporting plans for the November 14-16, 2005, workshop on *Climate Science in Support of Decision Making* to be held in Arlington, Virginia. She also attended the March 9, 2005, CCSP Communications Interagency Working Group (CIWG) meeting which discussed the provision of general information about CCSP to the public. The OFCM staff person attends the monthly meetings of CIWG and also helped design the template for its quarterly fact sheets. The OFCM has also developed and coordinated a climate products and services survey for use by its interagency Committee for Climate Analysis, Monitoring, and Services (CCAMS). A meeting of CCAMS was held May 3, 2005. At this meeting, the Federal Coordinator spoke on the role of CCAMS membership, the relationship of CCAMS to the National Science and Technology Council (NSTC) Committee on Environment and Natural Resources (CENR), how NSTC/CENR links to the CCSP, the relationship between the OFCM and the NSTC/CENR and CCSP, and products and organizations. Another important activity which is carried out in connection with the Federal Coordinator's role as member of the NSTC/CENR is review and concurrence of a number of CENR reports and materials. These include the *Terms of Reference for the Interagency Working Group on Earth Observations* (which has now been formally established as the Group on Earth Observations); a proposal for a new CENR Subcommittee on Science and Technology for Sustainability; CENR *Grand Challenges Report*; appendices, clearance memorandum, concurrence sheet, draft, and final *Strategic Plan for the U.S. Integrated Earth Observation System*; the document *Science and Technology Lessons Learned from the December 26, 2004 Indian Ocean Disaster*; and the plan *Tsunami Risk Reduction for the United States: A Framework for Action.*

Another accomplishment concerns an OFCM request of the CCAMS agencies to complete a survey to identify new climate products that have been developed and implemented since the Board on Atmospheric Sciences and Climate defined "climate services" in 2001 as "the timely production and delivery of useful climate data, information, and knowledge to decision makers." On September 21, 2005, the results of the survey were forwarded to the Director of the U.S. Climate Change Science Program. The Federal Coordinator noted that the climate services activities should be considered an integral part of the CCSP. Further, the OFCM is using its infrastructure to reach out and invite many government, private, and academic individuals to attend the November 14-16, 2005, *Climate Science in Support of Decision Making* workshop; and the OFCM has agreed to provide financial support for an evening poster session of the workshop.

OPERATIONAL PROCESSING

The OFCM Committee for Operational Processing Centers (COPC) addresses processing and backup capabilities of NOAA's National Centers for Environmental Prediction and Office of Satellite Data Processing and Distribution, the Air Force Weather Agency, and the U.S. Navy's Fleet Numerical Meteorology and Oceanography Center and Naval Oceanographic Office. During FY 2005, the COPC continued to make progress in areas such as model development, observing strategies, database architecture, and backup requirements. The COPC has begun activities in the area of High Performance Computing and Communications (HPCC). An HPCC model run was conducted on the Weather Research and Forecasting (WRF) Operational Test Bed Distributed Center computers to demonstrate the capability of grid computing and to establish the feasibility of a DOD Joint Operational Test Bed for the WRF modeling framework. In addition, efforts are underway to continue to improve backup support and capabilities and to coordinate preparation for the implementation of the WRF system, in accordance with the *National Concept of Operations Framework for the Operational Processing Centers*, which is contained in an April 1, 2004, memorandum of agreement signed by the directors of the Operational Processing Centers. At the March 23-24, 2005, meeting of the COPC, the members endorsed the establishment of a new OFCM-sponsored National Operational Processing Centers (NOPC) Program Council for higher level organizational approval and monetary commitment. The COPC will report to the new program council, with the Working Group for Cooperative Support and Backup (WG/CSAB) reporting to the COPC. Three joint action groups (JAG) will report to WG/CSAB; these are the JAG for Operational Community Modeling (JAG/OCM), the JAG for Centralized Communications Management (JAG/CCM), and the JAG for Operational Data Acquisition for Assimilation (JAG/ODAA). Future COPC activities include JAG/OCM reporting on its progress in preparing a *WRF Joint Implementation Plan* and discussion of the charter for NOPC. The COPC will also consider a request from the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Senior Users Advisory Group (SUAG) for the OFCM COPC to provide oversight and foster the synergistic coordination, program development, and implementation of NPOESS data exploitation strategies.

ENVIRONMENTAL SUPPORT TO HOMELAND SECURITY

ATMOSPHERIC TRANSPORT AND DIFFUSION RESEARCH AND DEVELOPMENT PLAN

In September 2004, the OFCM completed work with applicable agencies in developing the report, *Federal Research Needs and Priorities for Atmospheric Transport and Diffusion*

Modeling, a FCMSSR action. The report is the result of a process that included consultation with subject-matter experts, including first responders and emergency managers; a careful analysis of research needs and current capabilities to respond to domestic incidents of national significance; a capability gap analysis; and the development of strategies to close the gaps. The report was briefed to the ICMSSR and FCMSSR at their November 16, 2004, and December 1, 2004, meetings, and both committees endorsed the report's recommendations. As a result, all agencies with a vested interest in atmospheric transport and diffusion modeling are to incorporate applicable recommendations into their planning, programming, and budgeting process. This plan is available for downloading from the Department of Homeland Security (DHS) Lessons Learned Information Sharing Web site, as is the August 2002 OFCM report *Atmospheric Modeling of Releases from Weapons of Mass Destruction-Response by Federal Agencies in Support of Homeland Security*. On July 19, 2005, the OFCM conducted a special session in conjunction with the 9th Annual George Mason University (GMU) Conference on *Atmospheric Transport and Dispersion Modeling* to begin to address, with the broader private and academic communities, the issue of uncertainty in ATD models-a capstone goal of the *Federal Research Needs and Priorities for Atmospheric Transport and Diffusion Modeling* report. In addition, the OFCM developed an ATD implementation strategy for the report's recommendations for which the OFCM has primary responsibility. The strategy was sent to the FCMSSR and ICMSSR members in August 2005 for their review and comments. The implementation strategy has three parts: (1) working with the agencies to identify and improve a baseline set of national ATD modeling capabilities; (2) helping the agencies implement a common framework for model development and evaluation; and (3) recommending criteria for multifunctional joint urban test beds. Currently, the OFCM is moving forward to establish JAGs to address parts 2 and 3 of the strategy. Further, the implementation of the strategy and the work of the JAGs will fall under the purview of the Working Group for Urban Meteorology (WG/UM). As a result of the September 2004 Urban Meteorology Forum, the OFCM will focus future ATD modeling coordination efforts on urban areas and shift responsibility for these efforts from the Working Group for Environmental Support to Homeland Security to the WG/UM.

GEORGE MASON UNIVERSITY ATMOSPHERIC TRANSPORT AND DISPERSION MODELING CONFERENCE

George Mason University (GMU), Fairfax, Virginia, conducted its 9th Annual Conference on *Atmospheric Transport and Dispersion Modeling*, July 18-20, 2005. The OFCM partnered with GMU to sponsor the event. Technical topics of interest for the conference were: new developments in basic theories of boundary layer models and transport and dispersion models; urban-scale meteorological and dispersion experiments and models; computational fluid dynamics (CFD) model theory and applications; field experiments and laboratory experiments concerned with boundary layer studies and turbulence and dispersion studies; mesoscale meteorological modeling for input to transport and dispersion models; the use of remote sensing technology in boundary layer and transport and dispersion studies; model evaluation methods, uncertainty/sensitivity analyses, and risk assessments; improvements in model inputs (e.g., land-use data, 3-D building data) and output visualizations; and methods and criteria for emergency response and decision-making.

On July 19, 2005, the OFCM hosted a session related to the OFCM's ongoing work with the Department of Homeland Security and other members of the Federal meteorological community. The main focus of the ongoing work was to define the concept of operations and the research and development needs required to support the National Incident Management System and emergency responders at Federal, state, and local levels. The OFCM session topic was *Uncertainty in Atmospheric Transport and Diffusion (ATD) Models*. The Federal Coordinator noted that the session objectives were to facilitate a discussion of uncertainties in ATD modeling systems that incorporates academic and private sector inputs, and accounts for uncertainty in meteorological observations and models and in dispersion models; and to help Federal agencies striving to improve their ATD modeling systems to implement the recommendations made by the OFCM JAG for Atmospheric Transport and Diffusion (Research and Development Plan) in their publication *Federal Research and Development Needs and Priorities for Atmospheric Transport and Diffusion Modeling (2004)*. He also stated that the way ahead included: complete the strategy for ATD modeling improvements and present it to the FCMSSR (key elements of the strategy are a core set of ATD modeling systems, recovery of existing ATD data, common framework for model evaluation, and ATD test beds); and through partnership and collaboration within the Federal meteorological community and its customers, the OFCM will continue to identify shortfalls in urban meteorology, and help to organize improvements across all applicable focus areas that will better support users in the urban environment. On August 26, 2005, the OFCM *Implementation Strategy for Federal Atmospheric Transport and Diffusion Modeling and Measurement Improvements* was forwarded to the FCMSSR members.

HOMELAND SECURITY ENVIRONMENTAL SUPPORT PLAN

The *Homeland Security Environmental Support Plan*, an action from the FCMSSR, will define the mission, roles, and responsibilities of individual Federal agencies as they relate to homeland security and will document each agency's environmental support capabilities and/or requirements. The OFCM worked closely with the Plume Modeling Subset of the Consequence Management, Site Restoration/Cleanup (CMS) Subgroup, which is chaired by the Department of Homeland Security (Emergency Preparedness and Response), to develop an interagency concept of operations for an all-hazards dispersion support framework. The concept of the Interagency Modeling and Atmospheric Assessment Center (IMAAC) was successfully proposed to the Homeland Security Council Deputies and adopted in April 2004. The IMAAC began operations in an interim capacity in April 2004. The seven departments and agencies participating in the IMAAC-DOC/NOAA, DOD, DOE, DHS/S&T, EPA, NASA, and NRC-developed an interagency Memorandum of Understanding (MOU). In the MOU, each agency agreed to participate in the Senior Management Council (SMC) and Senior Scientific Advisory Council (SSAC) and to develop an annex detailing agency-specific roles and responsibilities and implementation details. When fully implemented, the IMAAC will support the development and implementation of a set of IMAAC products, capitalizing on the Federal agencies' suite of meteorological and ATD models that DHS can use to respond to incidents of national significance. While the initial goal was to complete the *Homeland Security Environmental Support Plan* by the end of FY 2005, successful completion rests with the completion of the IMAAC concept of operations, which, at this point, is still evolving.

ANNUAL FEDERAL PLAN

In October 2004, the OFCM issued *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2005*. The Federal Plan is congressionally mandated and is a one-of-a-kind document which articulates the meteorological services provided and supporting research conducted by agencies of the Federal government. The Federal Plan helps to reduce overlap and duplication among the agencies. It is a comprehensive publication that documents proposed programs for Fiscal Year (FY) 2005 and reviews agency programs in FY 2004. The plan demonstrates to the Congress and to the Executive Branch how the Federal agencies work together to accomplish their missions in an effective and efficient manner. The special interest article in the FY 2005 Annual Federal Plan, *The Rewards of Managing Weather-Related Risks*, focused on the Federal agencies' meteorological activities related to risk management and assessments, and the socioeconomic impacts of natural hazards. During January 2005, the OFCM issued a call for agency input to *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2006*. The feature article for the FY 2006 Annual Federal Plan focuses on the Federal agencies' meteorological activities related to minimizing the impact of wildland fires on the urban environment; its title is *Living with Wildland Fire in the Urban Environment*.

WEATHER INFORMATION FOR SURFACE TRANSPORTATION

The ICMSSR received an update on weather information for surface transportation (WIST) at its November 16, 2004, meeting. The ICMSSR supported the Working Group for Weather Information for Surface Transportation (WG/WIST) actions to allow all Federal departments and agencies to participate in the development of plans or projects to meet their WIST needs and ensure Federal resources are used efficiently; to develop a multiyear, Federal WIST research program plan to bring together the Federal weather and surface transportation research communities and provide a vision for the public and private sectors to use for planning purposes; and to develop an overarching, multiagency-coordinated WIST implementation program. WG/WIST is actively working on its tasks with interagency meetings on January 27, March 16, April 28, July 11, and September 15, 2005, and making additional progress between meetings. The OFCM's *Weather Information for Surface Transportation-National Needs Assessment Report* (December 2002) is a groundbreaking requirements report which has provided the foundation for both NOAA and DOT surface weather program initiatives. It was also fully endorsed by the FCMSSR, the DOT Under Secretary for Policy, and VADM Conrad C. Lautenbacher, Jr., USN (Ret.), Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator, and Ms. Mary E. Peters, FHWA Administrator during their August 18, 2003, meeting. The work of the WG/WIST, jointly chaired by NOAA and FHWA, was again later endorsed in the July 20, 2005, Memorandum of Understanding signed by VADM Conrad C. Lautenbacher, Jr., USN (Ret.) and Ms. Mary E. Peters. Timely and accurate surface transportation information will support improvements in safety and efficiency in transportation operations.

Most recently, on September 23, 2005, OFCM forwarded to ICMSSR members the *Weather Information for Surface Transportation (WIST) Initiative Document-First Steps to Improve the Nation's WIST Capabilities and Services* (September 2005). This Initiative Document represents the initial recommendations of the WG/WIST members on key actions and priorities that should be taken by the responsible agencies in the OFCM Federal coordinating infrastructure to collaborate on and address national surface transportation safety, mobility, and productivity issues. These proposed actions are focused on tackling the weather condition having the most impact on the surface transportation systems-liquid precipitation-and on other areas where ongoing R&D or other activities can be leveraged to improve weather information for surface transportation capabilities and services. While completing these initiatives is only the first step, this step is significant in that it will demonstrate the benefits gained when the responsible Federal agencies can develop a shared vision, together with the needed resources, to begin to address national surface transportation safety and efficiency issues. This document will be followed at a later date by both a WIST research and development plan and a WIST implementation plan, which will be developed by the OFCM-sponsored WG/WIST. The roadway portion of this activity is in accordance with Section 5308 (Road Weather Research and Development Program) of the *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)*, which was enacted August 10, 2005, and will support agency initiatives in road weather and education and training of road weather information users.

AVIATION WEATHER

In December 2004, the OFCM issued *Aviation Weather Programs/Projects-2004 Update* which updates the compilation of activities across Federal agencies that began with the *National Aviation Weather Initiatives Final Baseline Tier ¾ Report*, distributed in 2001, and serves as a baseline report for the recently established Joint Planning and Development Office (JPDO) within the Federal Aviation Administration (FAA). This document identifies all or most of the federally supported research and development (R&D) efforts relevant to reducing weather-related risks to aviation. Many of these activities include industry, university, and association partners. With this update, we have increased the focus on another objective of our compilation effort: tracking progress toward completing the R&D phase and transferring the results-whether as specific technology products or as improved information products and services-into aviation operations. This report also updates and extends the analysis of trends in weather-related aviation accidents that first appeared in the *National Aviation Weather Program Mid-Course Assessment*, published in August 2003, and endorsed by the FCMSSR, FAA, and the National Center for Atmospheric Research (NCAR). The effort to deliver improved weather risk reduction products and services must be supported and sustained. Particularly essential is education and training for all general aviation pilots on how to deal with the deadliest weather-related hazards. Weather hazards will always be with those who fly; our goal must be to continually reduce the risks from encountering these hazards. Additional accomplishments which are underway in the area of aviation weather support include follow-up activities from the June 21-24, 2004, *2nd International Conference on Volcanic Ash and Aviation Safety*. These include the development and coordination of interagency volcanic ash operations and implementation plans. The operations plan will identify procedures and agency responsibilities and contacts for responding to a volcanic ash release. The implementation plan will provide the roadmap for further improved science, new technologies for observing volcanic ash (e.g., NASA's efforts), improved detection (USGS), NOAA modeling and forecasting (NAAC forecasts for aircraft avoidance), and education of the international community. The OFCM attended the National Business Aviation Association, Inc., and Friends and Partners in Aviation Weather Annual Meeting held in Las Vegas, Nevada, in October 2004, and will continue to implement the *National Aviation Weather Program* during FY 2005. The Federal interagency *Aviation Weather Program* has resulted in a major reduction of weather-related accidents. The program is on track for meeting the established goal to reduce weather-related accidents by 80 percent by 2007.

SPACE WEATHER

The overarching goal of the *National Space Weather Program* (NSWP), which is administered by an OFCM program council, is to achieve an active, synergistic, interagency system; providing timely, accurate, and reliable space weather warnings, observations, specifications, and forecasts by 2007. The *NSWP Strategic and Implementation Plans* provide, respectively, broad guidance and a detailed roadmap for the NSWP. It was noted at the November 16, 2004, and December 1, 2004, ICMSSR and FCMSSR meetings, respectively, that the program is nearing the end of the 10-year period, which was addressed in the strategic and implementation plans, and that it was time to perform an interagency assessment to look at the progress toward meeting its goals. It was determined that a comprehensive review of the NSWP was warranted to quantify the progress toward meeting the goals in observations, research, modeling, transition of research to operations, and education and outreach; to determine if actions detailed in the *NSWP Implementation Plan* are on target and moving in the direction detailed by the strategic plan; and to determine whether the strategic goals should be adjusted at this time based on emerging and evolving requirements. A National Space Weather Program Assessment Study Group has been formed and the strategy for completing the assessment completed. The review methodology was developed by the Committee for Space Weather (CSW) at its January 26, 2005, meeting, including who will do the assessment and how it will be completed. The NSWP Assessment Study Group met for the first time July 7-8, 2005. On September 27, 2005, an Interim Assessment Letter Report was sent to the Federal Coordinator and forwarded to FCMSSR members. The report contained early findings and areas where further investigation will take place. The outcome is important to NOAA and supports the item, "Develop and evaluate space environment forecast models," which is included in Table 13 (Research Milestones for Improving Weather Forecasts and Warnings) of NOAA's 5-year research plan (January 2005). The OFCM also participated in *Space Weather Week* from April 5-8, 2005, in Broomfield, Colorado. *Space Weather Week* was sponsored by NOAA Space Environment Center and partners, and is for users and researchers interested in space weather.

LIGHTNING DATA

The OFCM JAG for Lightning Detection Systems (JAG/LDS) met during FY 2004 to work on the new Lightning Data Contract. In addition, JAG/LDS members served as members of the Technical Evaluation and Business Committees for contract selection. The NOAA National Weather Service (NWS) contract was in effect beginning FY 2005. The new contract is for one base year and four one-year options. Some benefits are: (1) improving warning services by identifying and categorizing severe weather, (2) monitoring interagency resources needed for fire protection and services (e.g. resource allocations for USDA Forest Service and DOI/BLM, and use of NOAA NWS Incident Meteorologists, especially in the Western and Alaska Regions), and (3) enabling improved transportation services by supporting a more efficient use of the National Airspace System, resulting in both cost savings to industry and the public as well as enhanced public safety. This activity supports NOAA's Strategic Plan Mission Goals to *Serve Society's Needs for Weather and Water Information* and *Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation*. JAG/LDS successfully completed its charge by its parent Committee for Environmental Services, Operations and Research Needs (CESORN), and the JAG was disestablished June 15, 2005, at the conclusion of its last meeting. Further actions regarding lightning detection systems will be addressed by CESORN.

PHASED ARRAY RADAR

The Phased Array Radar Project (PARP) was briefed to ICMSSR at its November 16, 2004, meeting. The ICMSSR supported the JAG's continued work to identify and document the potential needs and benefits that the phased array radar and an adaptive radar sensing strategy would address, and to integrate those identified needs into a multiagency-coordinated research and development (R&D) plan that would focus R&D efforts on meeting each agency's needs. JAG/PARP held its first meeting on December 7, 2004, and has continued to aggressively move forward to develop a comprehensive plan to document the operational, research, and technical weather radar needs of the Federal agencies. Working meetings were held May 12-13, June 22-23, and July 27, 2005. The plan will also prioritize the most pressing R&D needs and provide a roadmap to address those needs within the OFCM coordinating infrastructure. A summary report was distributed to ICMSSR members in early October 2005; and the final multiagency-coordinated R&D plan will be completed by January 2006. This activity is supportive of the item, "Continue investigating the utility of phased array radar technologies," which is included in Table 13 (*Research Milestones for Improving Weather Forecasts and Warnings*) of NOAA's 5-year research plan (January 2005).

ATMOSPHERIC RESEARCH AND DATA ASSIMILATION/DATA MANAGEMENT

Atmospheric research and data assimilation/data management were challenges and issues discussed at the November 16, 2004, and the December 1, 2004, meetings of ICMSSR and FCMSSR, respectively. It was noted that there was a need to tie future research efforts in science, technology, and transition mechanisms to operational and societal requirements. Key areas such as urban meteorology, homeland security, mesoscale/microscale processes, aviation weather, weather information for surface transportation, and tropical cyclones were highlighted as needing attention. It was agreed that agencies will support research and development needs and requirements based on agency priorities and will continue to identify issues and concerns that are necessary for the development of capabilities required to realize societal benefits. Agencies will also support and facilitate opportunities for the transition of research into operational applications. Further comments and suggestions will be provided by the agencies to the Federal Coordinator to assist OFCM in the planning and development of a vision and implementation roadmap for the supporting research enterprise of the Federal meteorological community for the next decade.

Also highlighted at the ICMSSR and FCMSSR meetings were data assimilation and data management challenges the community faces, as the size of future data sets increase by orders of magnitude. Advanced modeling and data assimilation techniques are critical to improve the quality of analyses and model results and to maximize the value of the Global Earth Observation System of Systems (GEOSS). Agencies were very supportive of the need for further interagency collaboration efforts in this area. An action item stemming from the FCMSSR meeting was that Federal requirements and capabilities in key areas, like data management and data assimilation, need to be surveyed and further addressed. This interagency work fully supports NOAA's crosscutting priorities. It also supports the item, "Advance data assimilation techniques; satellite, radar, ocean, hydrologic, and land surface assimilation," which is included in Table 13 (*Research Milestones for Improving Weather Forecasts and Warnings*) of NOAA's 5-year research plan (January 2005).

In response to the above FCMSSR action item, the OFCM undertook a survey of Federal requirements and capabilities in the area of meteorological data assimilation and related data management. This effort comprised two component tasks: (1) identification of current operational requirements for data assimilation (e.g., uses of data assimilation in operational prediction and analysis) and of the ongoing and planned R&D, conducted or supported by Federal entities, for new or improved data assimilation capability; and (2) review of relevant crosscutting goals and objectives for atmospheric and meteorological services and supporting research and development (R&D), as a basis for future capability requirements for data assimilation.

On September 15, 2005, the OFCM provided to FCMSSR and ICMSSR members an interim survey/assessment progress report on its efforts; the final report which will examine the gaps in our current data assimilation/data management capability, articulate the challenges that lie ahead in meeting future requirements, and propose a strategy to address these gaps in capability and future challenges, will be completed during January 2006.

COLLABORATION WITH NAS/NRC BOARD ON ATMOSPHERIC SCIENCES AND CLIMATE

The OFCM continued its mutually beneficial interactions with the National Academy of Sciences/National Research Council (NAS/NRC). The NAS/NRC Board on Atmospheric Sciences and Climate (BASC) conducted a planning meeting on June 21, 2005, to discuss *Mesoscale Observation Networks for Meeting Multiple National Needs.* In this planning meeting in which the Federal Coordinator for Meteorology was a participant, a small group of people were asked to brainstorm about a general issue that has been identified as a potential study topic. The Federal Coordinator helped BASC to better define the issue and identify whether an Academy study on the topic would be valuable. The Federal Coordinator noted that the multitude of meteorological impacts on the urban environment alone would warrant the proposed BASC study, and that all five primary focus areas within urban meteorology (severe weather, homeland security, air quality, water quality, and climate) discussed during the *Forum on Urban Meteorology-Meeting Weather Needs in the Urban Community*, conducted by OFCM, September 21-23, 2004, would benefit from improved mesoscale and urban scale observational capabilities. The Federal Coordinator provided a detailed listing of possible study tasks and, also, identified potential sources of observational needs and current capabilities information.

COLLABORATION WITH THE COMMITTEE ON ENVIRONMENT AND NATURAL RESOURCES

CENR PRINCIPALS

The Federal Coordinator continues to be a participant on the Committee on Environment and Natural Resources (CENR), and continues to assist CENR through review and concurrence of CENR reports and materials. These include the *Terms of Reference for the Interagency Working Group on Earth Observations* (which has now been formally established as the Group on Earth Observations); a proposal for a new CENR Subcommittee on Science and Technology for Sustainability; CENR *Grand Challenges Report*; appendices, clearance memorandum, concurrence sheet, draft, and final *Strategic Plan for the U.S. Integrated Earth Observation System*; the document *Science and Technology Lessons Learned from the December 26, 2004 Indian Ocean Disaster*; and the plan *Tsunami Risk Reduction for the United States: A Framework for Action.*

SUBCOMMITTEE ON DISASTER REDUCTION

The OFCM has been an active participant in the work of the CENR Subcommittee on Disaster Reduction (SDR). Recognizing that disasters can be the result of a technological and/or natural hazard, the subcommittee changed its name from the Subcommittee on Natural Disaster Reduction to the Subcommittee on Disaster Reduction (SDR). Recently, the focus of this group has been to enhance disaster resilience by composing a 10-year agenda for science and technology activities that will produce a dramatic reduction in the loss of life and property from natural and technological disasters. This 10-year agenda identifies a suite of Grand Challenges for disaster reduction. It cuts across all hazards and disaster management stages and identifies priorities for research and investment. Addressing these Grand Challenges will improve the Nation's capacity to prevent and recover from disasters. OFCM is committed to working with SDR to provide a forum for information sharing, development of collaborative opportunities, and interactive dialogue with the U.S. policy community to advance informed strategies for managing risks associated with natural and technological disasters. The Grand Challenges document will contribute to U.S. government planning activities on a number of levels, especially in the area of enhancing the Nation's safety and economic well-being.

Immediately following the Indian Ocean tsunami, Dr. Kathie Olsen (Associate Director for Science, Office of Science and Technology Policy, Executive Office of the President) asked the SDR to identify the science and technology lessons learned from the disaster. The OFCM representation on the SDR helped the SDR identify a number of areas for focused Federal attention. Some of the areas identified included (1) targeted risk assessment of at-risk communities, (2) the need for clear warnings reaching everyone at risk, and (3) the need to address both national and regional challenges to reduce the threat of tsunamis and other coastal hazards. As part of the CENR tsunami documents clearance process, the Federal Coordinator emphasized a critical area which required additional emphasis in the document *Science and Technology Lessons Learned from the December 26, 2004 Indian Ocean Disaster* and the plan *Tsunami Risk Reduction for the United States: A Framework for Action*-that is, whether planning for a tsunami, a hurricane, or other hazards, response plans need to account for the entire demographics of the at-risk population-especially the poor, seniors, the disabled, and individuals in poor health-ensuring the at-risk population has a mechanism to obtain safe haven.

In addition, through the OFCM representation on the SDR, the OFCM has helped craft the subcommittee's annual operations plan.

AMERICAN METEOROLOGICAL SOCIETY

During FY 2005, the OFCM joined leading environmental science and service corporations in supporting undergraduate scholarships in the atmospheric and related oceanic and hydrologic sciences. The scholarships, awarded for the junior and senior years, are designed to encourage outstanding undergraduates to pursue careers in the fields covered by the awards. The OFCM plans to continue this support. The OFCM also supports American Meteorological Society (AMS) endeavors by participating in AMS conferences and workshops and other environmental science education and outreach programs. The OFCM staff cochaired the *21st AMS Conference on Weather Analysis and Forecasting* held in Washington, D.C., August 1-5, 2005. The focus for this conference was *Educating and Training the User Community and the Public on Weather Analysis and Forecasting*. In addition, the Federal Coordinator participated in three important AMS-sponsored activities including: the *AMS Corporate Forum* on March 31, 2005, in the Washington, D.C. area, at which he gave a cross-agency and international perspective on GOES-R rebroadcast; *The Future of the U.S. Weather Prediction Enterprise*, July 26-28, 2005, in Boulder, Colorado; and the *Golden Jubilee Symposium*, September 20-21, 2005, in Research Triangle Park, North Carolina, where he served as the session chair for the role of air quality models in decision making.

INTERNATIONAL SUPPORT

The Federal Coordinator provided a comprehensive briefing on the OFCM and interagency coordination of Federal meteorological activities to Dr. Xu Xiaofeng and a delegation of 25 individuals from the Chinese Meteorological Administration, on May 24, 2005. Then on August 24, 2005, the Federal Coordinator hosted and briefed Dr. Zheng Guoguang, Deputy Administrator of the Chinese Meteorological Administration. Also, news media from Japan attended and conducted interviews at the 59th Interdepart-mental Hurricane Conference in Jacksonville, Florida, March 7-11, 2005.

PUBLICATIONS AND OFCM'S WEB SITE.

The following publications were prepared in hardcopy form and/or have been placed on OFCM's Web site (www.ofcm.gov):

- *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2005*

- *Federal Atmospheric Transport and Diffusion Research and Development Plan*

- *Aviation Weather Programs/Projects-2004 Update (Tier ¾ Baseline Update)*

- *Proceedings of the 2nd International Conference on Volcanic Ash and Aviation Safety*

- *Proceedings of the User Forum on Urban Meteorology*

- *National Hurricane Operations Plan*

- *Federal Meteorological Handbook No. 1-Surface Weather Observations and Reports*

The following documents are

planned for publication during FY 2006:

• *The Federal Plan for Meteorological Services and Supporting Research-Fiscal Year 2006*

• *National Hurricane Operations Plan*

• *Homeland Security Environmental Support Plan*

• *Federal Meteorological Handbook No. 3-Rawinsonde and Pibal Observations*

• *Federal Meteorological Handbook No. 11-Doppler Radar Meteorological Observations; Part B-Doppler Radar Theory and Meteorology*

• *Federal Meteorological Handbook No. 11-Doppler Radar Meteorological Observations; Part C-WSR-88D Products and Algorithms*

• *Federal Meteorological Handbook No. 11-Doppler Radar Meteorological Observations; Part D-WSR-88D Unit Description and Operational Analysis*

• *Federal Meteorological Handbook No. 12-United States Meteorological Codes and Coding Practices*

During FY 2005, OFCM continued to make substantial progress on its use of the Internet. In addition to information about the office, OFCM has placed its current publications on its Web site, and keeps the Web site current with information regarding workshops and forums being conducted by the office. OFCM will continue to make information available on the Internet during FY 2006.

Table A.1 Current OFCM Publications

Publication Title	Date	Number
Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 2005	October 2004	FCM-P1-2004
Urban Meteorology: Meeting Weather Needs in the Urban Community	*January 2004*	*FCM-R22-2004*
National Plan for Space Environment Services and Supporting Research: 1993-1997	August 1993	FCM-P10-1993
National Severe Local Storms Operations Plan	May 2001	FCM-P11-2001
National Hurricane Operations Plan *WSR-88D Tropical Cyclone Operations Plan*	May 2005	FCM-P12-2005
National Winter Storms Operations Plan	December 2003	FCM-P13-2003
Federal Plan for Cooperative Support and Backup Among Operational Processing Centers	Nov 2002	FCM-P14-2002
National Plan for Stratospheric Monitoring, 1988-1997	July 1989	FCM-P17-1989
National Aircraft Icing Technology Plan	April 1986	FCM-P20-1986
National Plan to Improve Aircraft Icing Forecasts	July 1986	FCM-P21-1986
Federal Plan for the Coordination of Automated Weather Information System Programs	May 1988	FCM-P23-1988
Federal Plan for Meteorological Information Management	July 1991	FCM-P24-1991
National Plan for Tropical Cyclone Research and Reconnaissance (1997-2002)	January 1997	FCM-P25-1997
National Aviation Weather Program Plan	September 1992	FCM-P27-1992
National Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS) Operations Plan	August 1997	FCM-P28-1997
Federal Plan for Marine Environmental Data, Services, and Supporting Research	June 1996	FCM-P29-1996
The National Space Weather Program: Strategic Plan	August 1995	FCM-P30-1995
The National Space Weather Program: Implementation Plan - 2nd Edition	July 2000	FCM-P31-2000
National Aviation Weather Strategic Plan	April 1997	FCM-P32-1997
National Post-Storm Data Acquisition Plan	March 2003	FCM-P33-2003
National Aviation Weather Initiatives	February 1999	FCM-P34-1999
National Aviation Weather Initiatives, Final Baseline Tier 3 and 4 Report	April 2001	Unnumbered
National Aviation Weather Program/Projects (Tier 3/4 Baseline Update)	December 2003	FCM-R21-2003
Federal Meteorological Handbook No. 1 - Surface Weather Observations and Reports	September 2005	FCM-H1-2005

Table A.1 Current OFCM Publications (cont.)

Publication Title	Date	Number
Federal Meteorological Handbook No. 2 - Surface Synoptic Codes	December 1988	FCM-H2-1988
Surface Synoptic Code Tables (Update)	July 1990	FCM-T1-1990
Federal Meteorological Handbook No. 3 - Rawinsonde and Pibal Observations	May 1997	FCM-H3-1997
Federal Meteorological Handbook No. 10 - Meteorological Rocket Observations	December 1988	FCM-H10-1988
Federal Meteorological Handbook No. 11 - Doppler Radar Meteorological Observations		
Part A - System Concepts, Responsibilities and Procedures	June 2003	FCM-H11A-2003
Part B - Doppler Radar Theory and Meteorology	June 1990	FCM-H11B-1990
Part C - WSR-88D Products and Algorithms	February 1991	FCM-H11C-1991
Part D - WSR-88D Unit Description and Operational Analysis	April 1992	FCM-H11D-1992
Federal Meteorological Handbook No. 12 - United States Meteorological Codes and Coding Practices	*December 1998*	*FCM-H12-1998*
Directory of Atmospheric Transport and Diffusion Consequence Assessment Models	*March 1999*	*FCM-I3-1999*
Federal Directory of Mobile Meteorological Equipment and Capabilities	*December 1995*	*FCM-I5-1995*
A Guide to WMO Code Form FM 94 BUFR	*March 1995*	*FCM-I6-1995*
Tropical Cyclone Studies	December 1988	FCM-R11-1988
Tropical Cyclone Studies Supplement	August 1989	FCM-R11-1988S
Interdepartmental Meteorological Data Exchange System Report, IMDES	*August 1998*	*FCM-R12-1998*
Federal Meteorological Requirements 2000	October 1990	FCM-R13-1990
U.S. Wind Profiler: A Review	*March 1998*	*FCM-R14-1998*
Atmospheric Modeling of Releases from Weapons of Mass Destruction	August 2002	FCM-R17-2002
Weather Information for Surface Transportation--National Needs Assessment Report	*December 2002*	*FCM-R18-2002*
Report on Wind Chill Temperature and Extreme Heat Indices: Evaluation and Improvement Projects	*January 2003*	*FCM-R19-2003*
National Aviation Weather Program Mid-Course Assessment	*August 2003*	*FCN-R20-2003*
Standard Formats for Weather Data Exchange Among Automated Weather Information Systems	November 1994	FCM-S2-1994
Standard Telecommunication Procedures for Weather Data Exchange (under revision)	October 1991	FCM-S3-1991
Federal Standard for Siting Meteorological Sensors at Airports	*August 1994*	*FCM-S4-1994*
Proceedings of the Workshop on Multiscale Atmospheric Dispersion Modeling within the Federal Community	*June 2000*	
Proceedings of the Aviation Weather User Forum--Aviation Weather: Opportunities for Implementation	*July 2000*	

Table A.1 Current OFCM Publications (cont.)

Publication Title	Date	Number
Proceedings for the Symposium on Weather Information for Surface Transportation: Delivering Improved Safety and Efficiency for Tomorrow	*February 2000*	
Proceedings of the Symposium on Weather Information for Surface Transportation -- Preparing for the Future: Improved Weather Information for Decision Makers	*March 2001*	
Proceedings of the Forum on Risk Management and Assessment of Natural Hazards	*July 2001*	
Proceedings of the Workshop on Strategy for Providing Atmospheric Information	*March 2002*	
Aviation Weather Training: A Report on Training for Emerging and Recently Implemented Aviation Weather Programs	*April 2002*	*FCM-R16-2002*
Proceedings of the Workshop on Effective Emergency Response	*May 2002*	
Federal Research and Development Needs and Priorities for Atmospheric Transport and Diffusion Modeling	*September 2004*	*FCM-R23-2004*
Aviation Weather Programs/Projects-2004 Update (Tier ¾ Baseline Update)	*December 2004*	*FCM-R21-2004*
Proceedings of the 2nd International Conference on Volcanic Ash and Aviation Safety	*November 2004*	
Proceedings of the User Forum on Urban Meteorology	*March 2005*	

Italics = publication available online at *www.ofcm.gov"*

APPENDIX B

WORLD WEATHER PROGRAM

The Department of Commerce (DOC) was designated by the President, following Senate Concurrent Resolution 67 (1968), to be the lead agency for coordinating United States participation in the World Weather Watch Program (WWWP). Until 1983, DOC published a separate report on WWWP plans. Beginning with the 1983 edition of the *Federal Plan for Meteorological Services and Supporting Research*, a section on the WWWP has been included, obviating the need for a separate report.

The Global Observing System: Its Impacts and Future

BGEN John J. Kelly, Jr. (USAF, Ret.)
Deputy Under Secretary, NOAA, and U.S. Permanent Representative with the WMO

EXECUTIVE SUMMARY

Weather and its changes have a strong influence on almost every aspect of our daily lives. Weather ultimately determines what crops we grow, how we prepare for our daily activities, if, when and how we can travel, and how we respond to on-going or impending natural disasters. Every day, across the far reaches of the globe, Members of the World Meteorological Organization (WMO) provide vital services to help their constituents cope with weather, climate and water related occurrences. The ability of Members to provide these vital services is in large part due to the information and observations provided by the WMO's World Weather Watch (WWW) that is comprised of the Global Observing System (GOS), Global Telecommunication Systems (GTS) and Global Data Processing and Forecast System (GDPFS).

The GOS is complex by its very nature and requires international cooperation at the highest levels (Figure B-1). The heart of the GOS is a surface-based subsystem that is operated mainly by the Member's National Meteorological and Hydrological Services (NMHS) and a space-based subsystem that is operated by either national or international space agencies[1]. An NMHS-operated Global Telecommunication System facilitates the transfer of GOS observations for a myriad of purposes that range in scale from nowcasting to climate and focus on a number of diverse but cross cutting areas such as tropical storms, disaster mitigation, water resources, airport terminal weather, and agriculture.

Figure B-1. The Global Observing System is complex by its very nature and requires international cooperation at the highest levels.

This article will address the importance of the WWW GOS in "taking the pulse of the planet" by providing for improved monitoring of the Earth's atmosphere, land and water bodies - essential elements to the Global Earth Observation System of Systems (GEOSS). GOS is complemented by another WMO-supported effort, the Global Ocean Observing System (GOOS). GOOS is the framework for a coordinated and sustained international observation of the ocean and provides the primary ocean contribution to GEOSS. Strong cooperation will be required between WMO and United Nations Educational, Scientific and Cultural Organization (UNESCO) Intergovernmental Oceanographic Commission (IOC) through the Joint Commission for Oceanography and Marine Meteorology (JCOMM), and the Intergovernmental IOC-WMO-

[1]The WMO Consultative Meetings on High-Level Policy on Satellite Matters provides a forum at the highest levels for dialogue between WMO and research and operational space agencies.

UNEP (U.N. Environmental Programme Committee) Committee for GOOS.

WWW GOS HISTORY

The WWW provides the basis for NHMS' around the world to coordinate the collection of oceanic and atmospheric observations, communicate this data to each other in near-real time, develop effective tools to use the data for society's benefit, and provide archive repositories for the data.

Since the beginning of the WWW in 1963, the GOS has provided continuous and reliable global observations for use by WMO Members. Early observational requirements of the GOS were focused mainly on synoptic meteorology and directed at the rapid expansion in civil aviation. Yet, the GOS remains dynamic and the requirements imposed upon it have continued to evolve reflecting both innovations in observing systems and societal needs.

NMHS' have borne this through better designed and integrated observation systems, improved data telecommunications, and modern high-end computers to manage data flow and produce the numerically based weather and climate products. These efforts have also led to data exchange and quality control arrangements among the NHMS' to ensure accessible and accurate data regardless of its origin.

Over time, the data richness available from the GOS has provided the global observations needed to produce consistent weather forecasts out to day seven and for predicting hazardous weather events days in advance, predictions which are now used routinely by the aviation, marine, fire weather and other diverse communities. Those improvements have occurred across a diverse number of application areas in turn resulting in increasingly positive impacts on products and services provided by NMHS' world-wide.

The evolution of the GOS was made possible by the advances in technology that have affected almost every aspect of day-to-day life on this planet. With respect to the GOS, technology has driven dramatic improvements in both terrestrial and ocean-based observing systems: atmospheric soundings from more accurate rawinsondes with Global Positioning System-capability, shipboard sonde systems, and instrumented commercial aircraft through the Aircraft Meteorological Data Relay (AMDAR), all improve collection of upper-level wind measurements; automatic weather stations deployed in remote areas operate with improved reliability under extreme conditions; advanced digital Doppler radar systems providing integrated in-situ wind and precipitation measurements; technologically advanced ocean and ice buoys provide measurements of the marine and oceanic ice boundary layer environment; an array of free-drifting floats in every ocean provide information about the global heat balance; and a moored array of buoys in the tropical Pacific Ocean to provide insight on the El Nino - Southern Oscillation phenomenon (Tropical Ocean-Global Atmosphere (TOGA) Tropical Atmosphere-Ocean (TAO) array).

Advances in the space based component have been equally impressive. Instrumentation has developed well beyond the era of uncalibrated vidicon camera systems used on the early United States Television Infrared Observation Satellite (TIROS). They now include passive visible, infrared and microwave imaging systems for inferring atmosphere, cloud, land and sea surface properties; passive infrared and microwave atmospheric sounding systems for the determination of vertical temperature and moisture profile; and active microwave instruments for measuring rainfall, sea level altimetry and sea state.

The early success of the United States' meteorological space ventures to polar and geostationary orbit were followed by the development of similar systems by other nations resulting in a robust operational space based GOS. Today, operational polar orbiting systems are operated by China, the Russian Federation, and the United States and geostationary systems are operated by China, Europe, India, Japan, and the United States, with plans by Europe to enter the polar orbiting satellite arena and plans by the Republic of Korea and the Russian Federation to provide operational services for WMO Members from geostationary orbit.

All operational polar and geostationary systems provide multi-channel digital imagery, while the United States' polar system also provides microwave imaging and sounding data, and both its polar and geostationary systems provide infrared sounding data. Furthermore, today's space-based component of the GOS is composed of a robust operational component that is supplemented by a dynamic research component, with research satellites providing high resolution multi-spectral imagery and hyperspectral sounding data for use by WMO Members as well as enabling derivation of tropical rainfall, ocean surface winds, and altimetry.

GOS EVOLUTION - THE WAY AHEAD

Growth of the GOS is expected to continue at an astounding rate! Major improvements are expected for the accuracy and timeliness from both in situ and remotely sensed data platforms. Furthermore, the volume of data associated with the newer GOS, especially those related to satellite and radar systems, is expected to increase exponentially over the next decade. A key aspect of realizing the benefits of all of this data for analysis and predictions of environmental conditions will be the development and implementation of sophisticated data assimilation systems. The data assimilation step is crucial to maximize the strengths of each observing system while minimizing their weaknesses in order to improve the analysis, initial conditions and subsequent forecasts for weather, water and climate, and especially for extreme events.

At the direction of the World Meteorological Congress, WMO's Commission on Basic Systems (CBS) studied the evolution of the GOS and issued WMO/TD No. 1267: *Implementation Plan for Evolution of Space and Surface-Based Sub-Systems of the GOS*. One main purpose of the plan was to help Members prepare for the massive changes in the GOS that were anticipated over the next two decades. Forty-seven recommendations in the plan provided the framework for the evolution of the GOS.

Twenty recommendations for the space-based sub-system addressed calibration, multi-spectral imaging (tens of channels) and hyper-spectral sounding (thousands of channels), ocean surface wind and altimetry, temporal coverage for low earth orbiting (LEO) satellites, atmospheric wind and aerosol profiles from active sensors, global measurements of precipitation using active radar and passive microwave sensors, and radio occultation sounders.

Twenty-seven recommendations for the ground-based sub-system addressed data coverage, distribution and coding, broader use of ground based and in situ observations, moving toward operational use of targeted observations, optimization of rawinsonde distribution and launches, development of the AMDAR Program and alternative AMDAR systems, atmospheric moisture measurements, improved observations in ocean areas, improved observations over tropical areas and new observing technologies.

The developers of the plan recognized its evolutionary nature and as a result for most of the recommendations provided comments concerning the recommendation, progress if the associated activity was already underway, actions that reflected what was to occur next, and schedules for the realization of the recommendation. On a regular basis CBS is reporting back to Members on the status of the implementation recommended in this plan.

One main purpose of the plan was to help Members prepare for the anticipated massive changes in the GOS. In that document, three issues are brought forward that must be addressed for successful implementation of an evolved GOS. They deal with continuity, utilization and cooperation:

- The future GOS should build upon existing sub-systems, both surface and space based, and capitalize on existing and new observing technologies not presently incorporated or fully exploited; each incremental addition to the GOS will be reflected in better data, products and services from the NMHS';
- The scope of the next decades' changes to the GOS will be so massive that new revolutionary approaches for science, data handling, data access, product development, training, and utilization will be required. There is an urgent need to study comprehensive strategies for anticipating and evaluating changes to the GOS;

The implementation of the new GOS should facilitate the strengthening of cooperation at national, regional, and global levels among Members. The evolution of the GOS in developing countries must address some of the issues that fall into three categories: a) infrastructure; b) training; and, c) equipment and consumables.

The evolution of the GOS will be greatly aided by The Observing System Research and Predictability Experiment (THORPEX), where new technologies and new adaptive observing strategies and data assimilation will be tested and guidelines for their utilization within the GOS for weather forecasts on a one- to fourteen-day timeframe will be developed (Figure B-2). Other studies will deal with the exploitation of the new data and information from the GOS being exploited for nowcasting and seasonal to interannual and longer term climate studies.

Studies such as those envisioned by

Figure B-2. The evolution of the GOS will be greatly aided by The Observing System Research and Predictability Experiment (THORPEX). New technologies and adaptive observing strategies and data assimilation will be tested and guidelines for their utilization within the GOS for weather forecasts on a one- to two-week timeframe will be developed.

THORPEX require a stable baseline observing system against which their results can be measured. In the development of the vision for the GOS by 2015, the space based sub-system was based on well defined plans by the operational and research space agencies. Thus for the space based sub-system we expect as a baseline an improved stable operational analysis and prediction systems complemented by a known dynamic research component focused on key observing issues and related data assimilation advances required to take full advantage of improved observations and associated observing strategies, especially those related to targeted observations.

For the surface based sub-system to become a viable baseline requires some components to either grow or become reinvigorated. Foremost among them are a complete and stable Regional Basic Climate Network (RBCN) embedded within a wholesome Regional Basic Synoptic Network (RBSN) where some components may be operated in a flexible manner, improvements in AMDAR and Troposphere Airborne Meteorological Data Reports (TAMDAR), and increased oceanic coverage to include upper air soundings, drifting buoys, and Argo floats; thus providing a stable baseline against which new observing technologies and strategies could be tested. Argo, drifting buoys and other oceanic observations are also critical elements of GOOS.

Other high priority GOOS observation systems and capabilities that contribute to GOS are: 1) tsunami warning capabilities in the Pacific and Atlantic Oceans, and the Caribbean sea as part of an International Tsunami Warning System (http://www.prh. noaa.gov /itic/); 2) Global Sea Level Observation System (http://www.pol.ac.uk/psmsl /programmes/gloss.info.html); and 3) Global Ocean Data Assimilation Experiment (www.uwgodae. org).

Thus, we can see that the 21st Century will be one filled with opportunity and challenge. The intersection of the technological advances referred to earlier with advances in communications capabilities provides an unprecedented opportunity to capitalize on the phenomenal growth in data and information that will become available during the first 25 years of this century.

Particularly relevant is the evolution of the WMO Information System (WIS) and how it will allow for the provision of data and information, and its use within a wide array of model-based prediction systems to Members on scales appropriate to their needs.

DATA AND MODELS

Numerical Weather Prediction (NWP) relies on measurements of temperature (and/or pressure), winds and moisture. There is no single observing system that can provide all three parameters at the same place and the same time with the required accuracy. Also, there is no single observing system that provides a uniform (in space and time) distribution of these measurements. Both ground based and space based components of the GOS present a major challenge to derive data assimilation and modeling systems which account for the strengths of each observing system while avoiding their weaknesses.

For example, the data assimilation should be able to take into account the poor vertical but good horizontal resolution and spatial distribution of satellite data while also accounting for the good vertical but poor horizontal and temporal resolution of radiosonde data. Likewise, the system should also be able to account for the good temporal resolution but poor spatial distribution of aircraft data. It is through sophisticated assimilation systems and models that a coherent depiction of the earth-atmosphere from the measurements achieved by the GOS will hopefully be derived.

During the next decade, with advanced satellite systems, ground based radar, AMDAR and other in-situ systems there will be over a million times increase in the amount of data that is available. Most of that data will be focused on global NWP through complex data assimilation systems which are an inherent component of the entire prediction system and it is highly unlikely that any NMHS will want all of the data all of the time; but all NMHS' will want some of that data all of the time and portions of that data some of the time. While models appear to be entering an era of targeted observations, for NMHS' there can be no doubt that a targeted information era has begun.

Up to five years ago it was not possible to realistically address this issue; however, today the symbiotic relationship that is developing between technology and communications is making it a reality. Thus data that flows through the WIS will be made up of a stable operational component complemented by a dynamic segment that depends on user needs, model capabilities and advances in data assimilation. Defining how those two components coexist will require development work that addresses societal needs, NMHS capability, WIS components and the symbiotic relationship between technology and communications.

As the requirements on Members for user services is growing, it is not unreasonable to expect Member needs from the GOS to expand. In the past, global NWP requirements for data were based on communications and computer technology that were applicable to the mid to late 20th Century. Today, modern Global Data Processing Centers (GDPCs) are using exceptionally powerful computers with advanced data assimilation models which couple asynoptic data into models with advanced physics.

Both Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs) have clearly shown that continuous assimilation of high resolution data into those models results in improved global forecasts. During the past decade this has changed so that to provide the best forecasts today's modern GDPCs now require all data from upper air observations, not just significant level data, as well as hourly surface data and data from special networks. This need lies beyond the current scope of Resolution 40, but clearly, any Member that is truly interested in accurate global forecasts must respond to that need. An innovative outlook means trust across borders, nation to nation, level of government to level of government, and government to citizen. An innovative outlook means that the user becomes integrated as a part of the system at all levels. To avail ourselves of that opportunity will require Members to work together in global science and operational partnerships.

Distribution of increased amounts and types of data for WMO and related programs is under development in the Future WMO Information System (FWIS; http://www.wmo.ch/web/www/FWIS-Web/homefwis.html). FWIS will build on the current GTS that communicates data among processing centers.

STAFFING AND TRAINING

Some fear that the role of the human will decrease with this revolution in technology. Nothing could be further from the truth. While some activities will be replaced through better uses of technology, the increase in data volume, products and applications areas will place the human at the very heart of maximizing the use of this impressive system. Our ability to monitor and forecast on a global scale will place the human at the very center of how that information is used on a daily basis in a tremendous number of applications areas.

By anticipating the weather of the next week will allow for applications to focus on mitigation of natural disasters through concentrating on regions prone for flooding and then managing the information and data flow into the NMHS that will allow for those phenomena to be addressed in an efficient and timely manner. Thus, training an increasingly diverse user community in how to utilize the system and to access the correct data for a specific application will be of paramount importance.

Furthermore, training in advanced applications of satellite data and its use in nowcasts and numerical prediction systems will take on increasing importance. Satellite data will provide information for a variety of real-time applications that range from nowcasting severe weather and floods to detection and monitoring of: areas of snow melt, wet ground, fires, aerosols, surface temperature for heat stress, and forecast model output fields. With the massive increase in information and data that will become available over the next decade it is necessary for WMO to embrace even more training opportunities, especially as it relates to developing and implementing more sophisticated data assimilation system designs with the future GOS in mind.

STRONG TIES TO GEOSS

The phenomenal growth and increase in capability that are expected to occur within the GOS places it on a natural intersection with GEOSS. Indeed, there is a clear juxtaposition between GOS and GEOSS. In June 2004, the fifty-sixth session of the WMO Executive Council formally declared that several WMO systems including GOS and WIS should be considered as core components for GEOSS. Furthermore, in the long view the GOS, in some ways, cross-cuts each of the GEOSS nine societal benefit areas, some quite substantially:

- Improving weather information, forecasting and warning
- Reducing loss of life and property from natural and human induced disasters
- Improving water resource management through better understanding of the water cycle
- Understanding, assessing, predicting, mitigating and adapting to climate variability and change
- Improving the management and protection of terrestrial, coastal and marine ecosystems
- Understanding environmental factors affecting human health and well being
- Improving management of energy resources
- Supporting sustainable agriculture and combating desertification
- Understanding, monitoring and conserving biodiversity

WMO is a strong contributor to GEOSS, and is home to the Secretariat of the intergovernmental Group on Earth Observations (GEO) at its headquarters in Geneva[2]. WMO is also a strong contributor to GOOS. GOOS is composed of global ocean and coastal ocean components, and has several submodules: the Global Climate Observing System (GCOS), Living Marine Resources Panel, Health of the Oceans, and the Global Terrestrial Observing System. In fact the GCOS program, of which the WMO is a prime sponsor, has been recognized as the formal climate component of the GEOSS; the GCOS Implementation Plan which can be found at http://www.wmo.int/web/gcos/gcoshome.html is part of the overall GEOSS implementation effort.

The space and ground-based components of the WWW are among the core contributors to GEOSS (Figure B-3). Observing and accurately predicting the Earth's environment is critical for the health, safety and prosperity of all nations. As responsibilities of WMO

2 WMO is the physical host of the GEO Secretariat, but the Secretariat operates at the direction of the Group on Earth Observations Plenary.

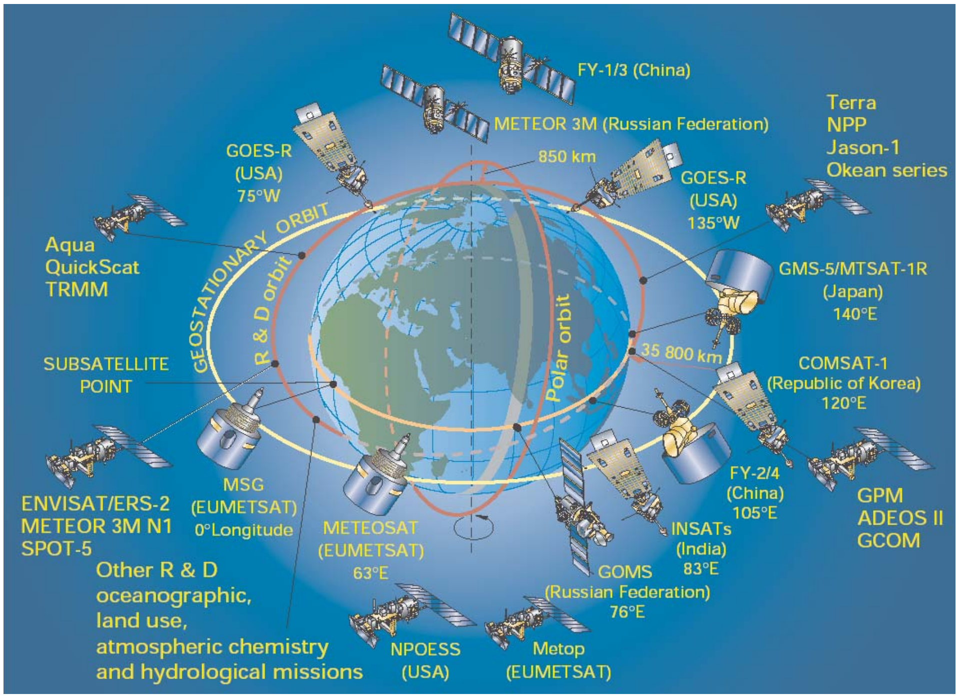


Figure B-3. The space-based component of the GOS.

Members increase to take on broader roles in monitoring and forecasting for the environment, many of the sub-systems that contribute to GEOSS that are not part of the WWW will become important for WMO Members.

Too often we become enthralled with placing an economic value on the need to justify monitoring climate, weather and the Earth's environment as well as our ability to forecast them. As is clearly recognized by the GEOSS 10 Year Implementation Plan: "*Understanding the Earth system - its weather, climate, oceans, land, geography, natural resources, and natural and human-induced hazards - is crucial to enhancing human health, safety and welfare, alleviating human suffering including poverty, protecting the global environment, and achieving sustainable development*."

The reason we want to monitor the "pulse of our planet" is not solely for economic benefit but for human health and well being while learning how to sustain humankind's future on our evolving planet Earth.

THE GOS FUTURE AND NHMS'

There is no question that we are improving in our ability to utilize data from the GOS. The reason clearly lies in more and better observations and our ability to utilize them. Today we have improved high resolution models with better physics that are linked to the improved observations with powerful data assimilation systems. As the GOS evolves continued progress in science, models and data assimilation coupled with awareness of importance of transitions will help guide us toward full utilization. As we move forward, there are some critical questions that will accompany the implementation of the evolving GOS:

• The broad implications of targeted observations need to be addressed, with guidance on targeting needing to be developed only after careful scientific consideration;

• How adaptive observing is implemented within the GOS needs full consideration as observations not deemed necessary at a particular instant in time in one part of the world may provide valuable information elsewhere;

• How Members can best benefit from the tremendous amounts of data that will become available;

• How we fully train Members to utilize data from the GOS so that opportunities are not lost;

• While not all Members will have the ability to cope with the full data sets, all Members will have a responsibility to contribute fully to the evolving GOS, this will likely require refinements to data exchange policy.

Applications areas are expanding dramatically with an unparalleled opportunity for growth. For almost any given applications area opportunities to exploit multiple data sets from a variety of sensors, all with different characteristics, will abound. Data volumes will be tremendous in comparison with today's operational systems - at least six orders of magnitude.

We should expect great improvements to the GOS; including very high spatial and temporal resolution with both space-based and ground-based active and passive sensors. In concert with these new capabilities we must prepare for vast growth in data volume and content which will be available from systems in just the first few decades of this new century. On the horizon lies the promise of improved data for the various services Members provide. Better science will occur by realizing the opportunities afforded by the future GOS through new approaches, international partnerships and science teams.

Planning for tomorrow's GOS must take into account all observing assets, capitalizing on their strengths as a key component of a comprehensive and sustained GEOSS. As we take advantage of the future's promise, marked changes will occur in the ways we approach data handling, science, product development, training and utilization. To prepare for the daunting task of monitoring and understanding the Earth system from these new data, and ensuring their full utilization, we must work together in global science and operational partnerships.

We move forward by building on the successes of today and aggressively planning and developing appropriate mechanisms focused on exploitation as a global community in partnership: the user, national and international science groups, operational agencies, research satellite agencies, and WMO. To do this is a challenge, but it is a challenge that must be met.

We strive for full exploitation, but whose responsibility is it to ensure the future GOS is utilized to maximize benefit in a given applications area: the user, national and international science groups, the operational agencies, the research agencies, WMO? In fact, the responsibility rests with all communities. In this regard, GOS as part of GEOSS will provide a wider spectrum of users and further increase the value of its observations.

APPENDIX C
PREVIOUS FEATURE ARTICLES

Year	Edition	Title	Author
2004	FY 2005	The Rewards of Managing Weather-Related Risks	Mr. Samuel P. Williamson, OFCM
2003	FY 2004	Weather and The Urban Environment: Meeting The Needs of Urban Communities	Ms. Margaret R. McCalla, OFCM
2002	FY 2003	The Need For Weather Information For Surface Transportation: Keeping The Country Safe and On The Move	Ms. Mary M. Cairns, OFCM
2001	FY 2002	Research to Operations: Bridging the Valley of Death	Mr. Robert Dumont, OFCM
2000	FY 2001	The Legacy of Hurricane Floyd--Inland Flooding and a Massive Evacuation	Mr. Robert Dumont, OFCM
1999	FY 2000	Natural Disaster Reduction--Reducing the Impacts of Natural Hazards	OFCM Staff in collaboration with Dr. William Hooke, OAR, and Ms. Keli Tarp, NOAA Public Affairs
1998	FY 1999	Aviation Weather: Taking A Leadership Role	FAA's Aviation Weather Policy Division (ARW-100) Staff
1997	FY 1998	Owning The Weather--An Army Force Multiplier	Mr. Richard J. Szymber, Army
1996	FY 1997	Space Weather - A New Challenge for Meteorologists	Col Jud Stailey, USAF
1995	FY 1996	The Role of Federal Agencies in International Aviation Meteorology	Mr. Blaine K. Tsugawa, OFCM
1994	FY 1995	Data Continuity in the Climatological Record	Dr. Nathaniel B. Guttman, NCDC Mr. Andrew H. Horvitz, NWS Mr. Arthur L. Booth, NOAA-EOSDIS
1993	FY 1994	Training and Professional Development in the Modernized Weather Services	Mr. Eli Jacks, NWS Mr. LeRoy Spayd, NWS
1992	FY 1993	Mesoscale Meteorology	Mr. Floyd F. Hauth, OFCM
1991	FY 1992	Some Recent Developments in Lightning Mapping Systems	Dr. Donald R. MacGorman, NOAA Dr. Frederick R. Mosher, NOAA Ms. Jan S. Lewis, NOAA

Year	Edition	Title	Author
1990	FY 1991	The Next Generation Weather Radar - A System for Locating and Tracking Severe Weather	Mr. E. Don Sarreals, NEXRAD JSPO
1989	FY 1990	Strategic Plan for the Modernization and Associated Restructuring of the National Weather Service	Verbatim reproduction of a plan required by Congress and submitted by DOC and OMB
1988	FY 1989	Supercomputers for Meteorological Services and Supporting Research	(Source or author unknown)

APPENDIX D

ACRONYMS AND ABBREVIATIONS

3D-VAR	Three Dimensional VARiational (DOD)
4DWX	Four Dimensional Weather (DOD)
AA	Active Army
AAO	Amarillo Area Office (DOE)
AASHTO	American Association of State Highway and Transportation Officials (FHWA)
AAU	Alaskan Aviation Unit (NOAA/NCEP)
AB	Authorization Basis
ABCS	Army Battle Command System (DOD)
ABFM	Airborne Field Mill (NASA)
ABL	Airborne Laser (DOD)
ABLE	Atmospheric Boundary Layer Experiment (DOE)
AC	Active Component (DOD)
AC&A	Atmospheric Chemistry and Aerosols (DOE)
ACARS	ARINC Communication Addressing and Reporting System
ACD	Atmospheric Chemistry Division (DOE)
ACE	Aviation Combat Element (DOD)
ACE-IDS	ASOS Controller Equipment - Information Display System (FAA)
ACIS	Applied Climate Information System (USDA)
ACP	Atmospheric Chemistry Program (DOE)
ACSG	Atmospheric and Climate Sciences Group (DOE)
ADA	Atmospheric Decision Aid (DOD)
ADAPT	Atmospheric Data Assimilation and Parameterization Tool (DOE)
ADAS	AWOS/ASOS Data Acquisition System (FAA)
ADEOS	Advanced Earth Observing System (NASA)
AEC	Atomic Energy Commission (DOE)
AEP	Atmospheric Emergency Preparedness (DOE)
AESS	Allied Environmental Support System (DOD)
AF	Air Force
AFB	Air Force Base
AFCCC	Air Force Combat Climatology Center
AFCWC	Air Force Combat Weather Center
AFFSA	Air Force Flight Standards Agency
AFGS	Aviation Forecast Gridded System
AFJI	Air Force Joint Instruction
AFR	Air Force Reserve
AFRL	Air Force Research Laboratory
AFSOC	Air Force Special Operations Command
AFTAC	Air Force Technical Applications Center
AFW	Air Force Weather
AFWA	Air Force Weather Agency
AFWIN	Air Force Weather Information Network
AFWWS	Air Force Weather Weapon System
AF/XOO	Air Force Director of Operations and Training (DOD)
AF/XO	Air and Space Deputy Chief of Staff for Air and Space Operations (DOD)
AF/XOO-W	Air Force Director of Weather
AGFS	Aviation Gridded Forecast System (FAA)
AGRIMET	A conjunction of the words "agricultural" and "meteorology", is a satellite-based network of automated agricultural weather stations operated and maintained by the U.S. Bureau of Reclamation (DOI)
AHPS	Advanced Hydrologic Prediction Services (NOAA/NWS)
AI	Aircraft Icing (NASA)
AIP	Airport Improvement Program (FAA)
AIRMAP	Atmospheric Investigation Regional Modeling, Analysis, and Prediction (NOAA/OAR)

AIRMoN	Atmospheric Integrated Research Monitoring Network (NOAA/OAR)
AIRS	Atmospheric Infrared Sounder (NASA)
AL	Aeronomy Laboratory (NOAA/OAR)
ALDARS	Automated Lightning Detection and Reporting System (FAA)
ALOHA	Areal Locations of Hazardous Atmospheres (a transport and dispersion code)
ALOO	Albuquerque Operations Office
AMC	Army Materiel Command
AMDAR	Aircraft Meteorological Data Relay (WWP)
AMIS	Automated Meteorological Information System (DOD)
AMPS	Automated Meteorological Profiling System (NASA)
AMOS	Automated Meteorological Observing System (DOD)
AMS	Acquisition Management System (FAA)
	American Meteorological Society
AMSR-E	Advanced Microwave Sounding Radiometer
AMSU	Advanced Microwave Sounding Unit
AMU	Applied Meteorology Unit (NASA)
ANG	Air National Guard (DOD)
ANL	Argonne National Laboratory (DOE)
AOC	Aircraft Operations Center (NOAA)
	Air and Space Operations Center (DOD)
AOML	Atlantic Oceanographic and Meteorological Laboratory (NOAA/ERL)
AOR	Area of Responsibility (DOD)
AOT	Aerosol Optical Thickness (NOAA/NESDIS)
APGEMS	Air Pollutant Graphical Environmental Monitoring System
APS	Aerosol Polarimetry Sensor (APS)
APT	Automatic Picture Transmission (NOAA/NESDIS)
AQG	Air Quality Group (DOE)
AR	Army Regulation
ARAC	Atmospheric Release Advisory Capability (DOE)
ARCS	Atmospheric Radiation CART Sites (NOAA/OAR)
ARG	Accident Response Group (DOE)
ARGO	Global Array of Profiling Floats (NOAA/OAR)
ARGOS	French Satellite Data Collection System
ARINC	Aeronautical Radio Incorporated
ARL	Army Research Laboratory
	Air Resources Laboratory (NOAA and DOE)
ARM	Atmospheric Radiation Monitoring (DOE)
ARNG	Army National Guard
ARO	Army Research Office
ARS	Agricultural Research Service (USDA)
	Air Traffic System Requirements Service (FAA)
	Atmospheric Research Section (DOE)
ARSPACE	Army Space Command
ARSR	Air Route Surveillance Radar (FAA)
ARSST	Army Space Support Team
ARTCC	Air Route Traffic Control Center (FAA)
ARTYMET	Artillery Meteorological (DOD)
ARW	Aviation Weather Directorate (FAA)
ASCAT	Advanced Scatterometer
ASD	Atmospheric Sciences Division (DOE)
ASDAR	Aircraft to Satellite Data Relay
ASNE MSEA	Air and Space Natural Environment Modeling and Simulation Executive Agent (DOD)
ASOG	Air Support Operations Group (DOD)
ASOS	Automated Surface Observing System
	Air Support Operations Squadron (DOD)
ASP	Atmospheric Science Program (DOE)
ASR	Airport Surveillance Radar (FAA)

ATC	Air Traffic Control (FAA)
ATCCS	Army Tactical Command and Control System
ATD	Atmospheric Turbulence and Diffusion
ATDD	Atmospheric Turbulence and Diffusion Division (NOAA/ARL)
ATEC	Army Test and Evaluation Command
ATG	Atmospheric Technologies Group (DOE)
ATLAS	Autonomous Temperature Line Acquisition System (NOAA/OAR)
ATMS	Advanced Technology Microwave Sounder
ATO	Air Traffic Organization (FAA)
	Air Tasking Order (DOD)
ATOS	Appalachian Tropospheric Ozone Study (NOAA/AOC)
ATWIS	Advanced Transportation Weather Information System (FHWA)
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
AVO	Alaskan Volcano Observatory (DOI/USGS)
AVP	Advanced Vehicle Technologies Program (FTA)
AWARDS	Agricultural Water Resources Decision Support (DOI/BUREC)
AWC	Aviation Weather Center (NOAA/NCEP)
AWIPS	Advanced Weather Interactive Processing System (NOAA)
AWIS	Automated Weather Information System
AWN	Automated Weather Network (DOD)
AWOS	Automated Weather Observing System (FAA)
AWR	Aviation Weather Research (FAA)
AWSS	Aviation Weather Sensor System (FAA)
AWTT	Aviation Weather Technology Transfer (FAA)
BAMP	Breton Aerometric Monitoring Program (DOI)
BASC	Board on Atmospheric Sciences and Climate
BCTP	Battle Command Training Program (DOD)
BE	Battlefield Environment (DOD)
BER	Biological and Environmental Research (DOE)
BFA	Battlefield Functional Areas (DOD)
BIO	Basis for Interim Operations (DOE)
BLM	Bureau of Land Management (DOI)
BMDO	Ballistic Missile Defense Office (DOD)
BNL	Brookhaven National Laboratory (DOE)
BUFR	Binary Universal Form for the Representation of Meteorological Data
BUREC	Bureau of Reclamation (DOI)
C^2	Command and Control (DOD)
C^4I	Command, Control, Communications, Computers, and Intelligence (DOD)
CAAM	Computer Assisted Artillery Meteorology (DOD)
CAC	Combined Arms Center (DOD)
CAIB	Columbia Accident Investigation Board
CALJET	California Land-falling Jets Experiment (NOAA/OAR)
CAMEO	Computer Aided Management of Emergency Operations
CAMEX	Convective and Moisture Experiment (NASA)
CAO	Carlsbad Area Office
CAP	Civil Air Patrol
CAP88-PC	Clean Air Act Assessment Package-1988 - Personal Computer (DOE)
CAPARS	Computer-Assisted Protective Action Recommendation System (DOE)
CARDS	Comprehensive Aerological Reference Data Set (NOAA/NCDC)
CARS	Condition Acquisition and Reporting System (FHWA)
CART	Clouds and Radiation Testbed (DOE)
CASPER	Computer Aided System For Planning Efficient Routes (FHWA)
CAST	Commercial Aviation Safety Team (FAA)
CAT	Clear Air Turbulence
CAWIS	Committee for Automated Weather Information Systems (OFCM)

CBIRF	Chemical Biological Incident Response Force (DOD)
CBAP	*Catastrophic Backup Action Plan*
CBNP	Chemical Biological Non-Proliferation Program (DOE)
	Chemical Biological National Security Program (DOE)
CBOFS	Chesapeake Bay Oceanographic Forecasting System (NOAA/NOS)
CBRNE	Chemical, Biological, Radiological, Nuclear, or High-Yield Explosive (DOD)
CBS	Commission on Basic Services (WWP)
CCAFS	Cape Canaveral Air Force Station
CCCM	Climate and Carbon Cycle Modeling (DOE)
CCM3	Community Climate Model-3 used at LANL (DOE)
CCMC	Community Coordinated Modeling Center (DOD)
CCMS	Committee on the Challenges of Modern Society (EPA)
CDA	Command and Data Acquisition
CDF	Cloud Depiction and Forecasting (DOD)
CDFS	Cloud Depiction and Forecast System (DOD)
CDPHE	Colorado Department of Public Health and Environment (DOE)
CECOM	Communications and Electronics Command (DOD)
CEMSCS	Central Environmental Satellite Computer System (NOAA/NESDIS)
CENR	Committee on Environment and Natural Resources
CEOS	Committee on Earth Observation Satellites (NOAA/NESDIS)
CERES	Clouds and Earth's Radiant Energy System (NASA)
CFD	Computational Fluid Dynamics
CFIT	Controlled Flight Into Terrain (NASA)
CFR	Code of Federal Regulations (DOE)
CGSC	Command and General Staff College (DOD)
CHAMMP	Computer Hardware Advanced Mathematics and Model Physics (DOE)
CHARM	An Atmospheric Transport and Dispersion Model
CIASTA	Cooperative Institute for Atmospheric Studies and Terrestrial Applications (NOAA/OAR)
CICE	Sea Ice Code at LANL
CIDE	Communications Interfaces and Data Exchange (OFCM)
CIOS	Committee for Integrated Observing Systems (OFCM)
CIRES	Cooperative Institute for Research in Environmental Sciences
CIWS	Corridor Integrated Weather System (FAA)
CLASS	Comprehensive Large Array-Data Stewardship System (NOAA/NESDIS)
CLIVAR-GEWEX	Climate Variability and Predictability - Global Energy and Water Cycle Experiment
CLIVAR-VAMOS	Climate Variability and Predictability - Variability and Predictability of the American Monsoon System
C-MAN	Coastal-Marine Automated Network
CMAQ	Community Multi-scale Air Quality (EPA)
CMDL	Climate Monitoring and Diagnostics Laboratory (NOAA/OAR)
CME	Coronal Mass Ejection
CMFC	Coordinating METOC Forecast Center (DOD)
CMIS	Conical Scanning Microwave Imager Sounder
COADS	Comprehensive Ocean-Atmosphere Data Set (NOAA/NCDC)
COAMPS	Coupled Ocean-Atmosphere Mesoscale Prediction System
COARE	Coupled Ocean-Atmosphere Response Experiment
COE	Corps of Engineers (DOD)
COMET	Cooperative Program for Operational Meteorology, Education and Training
CONUS	Continental United States (DOD)
CONUSA	Continental United States Armies (DOD)
COPC	Committee for Operational Processing Centers (OFCM)
COOP	Cooperative Observer Program (NOAA/NWS)
CORMS	Continuous Real-time Monitoring System (NOAA/NOS)
COSMIC	Constellation Observing System for Meteorology, Ionosphere, and Climate (DOD)
COTS	Commercial Off-the-Shelf
CPC	Climate Prediction Center (NOAA/NCEP)
CPHC	Central Pacific Hurricane Center (NOAA/NCEP)

CRADA	Cooperative Research and Development Agreement
CrIS	Cross-track Infrared Sounder
CRN	Climate Reference Network (NOAA)
CRREL	Cold Regions Research and Engineering Laboratory (DOD)
CS	Climate Services
CSD	Climate Services Division (NOAA/NWS)
CSEPP	Chemical Stockpile Emergency Preparedness Program (DOE)
CSRA	Central Savannah River Area (DOE)
CSREES	Cooperative State Research, Education, and Extension Service (USDA)
CSW	Committee for Space Weather (OFCM)
CTA	Common Table of Allowances (DOD)
CTBT	Comprehensive Test Ban Treaty (DOE)
CWS	Combat Weather Squadron (DOD)
CWSU	Center Weather Service Unit (FAA)
CWT	Combat Weather Team (DOD)
CXD	Combined X-ray Dosimeter (DOE)
CY	Calendar Year
DAC	Data Assembly Center (NOAA/OAR)
DAMPS	Distributed Atmospheric Modeling Prediction System (DOD)
DAT	Department of Advanced Technology (DOE)
DCO	Data Collection Office (NOAA/NWS)
DCP	Data Collection Package
	Data Collection Platform (DOI)
DCS	Data Collection System (NOAA/NESDIS)
DEPSCoR	Experimental Program to Stimulate Competitive Research (DOD)
DGPS	Differential Global Positioning System (USGS)
DHS	Department of Homeland Security
DIS	Decision and Information Sciences (DOE)
DISS	Digital Ionospheric Sounding System (DOD)
DMCC	DOE Meteorological Coordinating Council (DOE)
DMS	Dynamic Message Sign (FHWA)
DMSO	Defense Modeling and Simulation Office (DOD)
DMSP	Defense Meteorological Satellite Program (DOD)
DNT	Dinitrotoluene (DOE)
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOMSAT	Domestic Communications Satellite (DOI)
DOS	Department of State
DOT	Department of Transportation
DRA	Desert Rock Meteorological Observatory at NTS (DOE)
DREC	Delta Research Extension Center (USDA)
DRGS	Direct Readout Ground Stations (DOI)
DRI	Desert Research Institute (DOE)
DRWP	Doppler Radar Wind Profiler (NASA)
DTC	Developmental Test Command (DOD)
DTED	Digital Terrain Elevation Data (DOD)
DTRA	Defense Threat Reduction Agency
DTSS	Digital Topographic Support System (DOD)
DUAT	Direct User Access Terminal (FAA)
DURIP	Defense University Research Instrumentation Program (DOD)
EAC	Echelon Above Corps (DOD)
EAD	Environmental Assessment Division (DOE)
EBID	Environmental Biology and Instrumentation Division (DOE)

ECDIS	Electronic Chart Display Information System (NOAA/NOS)
ECMWF	European Centre for Medium-Range Weather Forecasting
EDAS	Eta Data Assimilation System (NOAA/NESDIS)
EDIS	Environmental Data and Information Service (NOAA)
EERE	Office of Energy Efficiency and Renewable Energy (DOE)
ELV	Expendable Launch Vehicle (NASA)
EM	Office of Environmental Management (DOE)
EMC	Environmental Modeling Center (NOAA/NCEP)
	European Modeling Center (NOAA/NCEP)
EMP	Environmental Meteorology Program (DOE)
EMS	Environmental Monitoring Section (DOE)
ENSO	El Niño-Southern Oscillation
EO	Electro-optical
	Earth Observation (NASA)
EOC	Emergency Operations Center
EOS	Earth Observing System (NASA)
EOSDIS	EOS Data and Information System (NASA)
EPA	Environmental Protection Agency
EPD	Environmental Protection Department (DOE)
EPIC	Equatorial Pacific Investigation of Climate (NOAA/AOC)
EPR	Emergency Preparedness and Response Directorate (FEMA)
E-PIREPS	Electronic Pilot Reports (FAA)
EP/RD	Environmental Protection/Restoration Department (DOE)
EPZ	Emergency Planning Zone (DOE)
ER	Eastern Range (NASA)
	Environmental Research (DOE)
ERBS	Earth Radiation Budget Satellite (NASA)
ERC	Extended Research Checkout
ERDA	Energy Research and Development Administration (DOE)
ERDAS	Eastern Range Dispersion Assessment System (NASA)
ERDC	Engineering Research and Development Center (DOD)
ERL	Environmental Research Laboratories (NOAA)
ESD/IPC	Environmental Satellite Distribution/Interactive Processing Center (NOAA/NESDIS)
ESE	Earth Science Enterprise (NASA)
ESP	Energy Spectrometer for Particles (DOE)
	Ensemble Streamflow Prediction (NWS)
ESS	Environmental Sensor Station (FHWA)
ESSP	Earth System Science Pathfinders (NASA)
ETIS	Evacuation Traffic Information System (FHWA)
ETL	Environmental Technology Laboratory (NOAA/OAR)
ETOS	East Tennessee Ozone Study (NOAA/OAR)
ETTP	East Tennessee Technology Park (DOE)
ET Toolbox	Evapotranspiration Toolbox (DOI)
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EUSA	Eighth U.S. Army
EUV	Extreme Ultraviolet
EWR	Ellason Weather Radar (DOD)
FAA	Federal Aviation Administration
FALOP	Forward Area Limited Observing Program (DOD)
FAS	Foreign Agricultural Service (USDA)
FBA	Fire Behavior Analysts (DOI)
FCC	Federal Communications Commission
FCCC	Framework Convention on Climate Change (DOS)
FCMSSR	Federal Committee for Meteorological Services and Supporting Research (OFCM)
FCS	Future Combat System (DOD)
FDD	First Digitized Division (DOD)

FDIC	Force Development and Integration Center (DOD)
FEM3MP	LLNL finite element model (DOE)
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRETEC	Fire Code at LANL (DOE)
FIRST	FAA Icing Remote Sensor Testbed (NOAA/OAR)
FIS	Flight Information System (FAA)
FITL	Forecaster-in-the-Loop (DOD)
FLENUMMETOCCEN	Fleet Numerical Meteorology and Oceanography Center, Monterey, California
FMF	Fleet Marine Force
FMH	Federal Meteorological Handbook (OFCM)
FNMOC	Fleet Numerical Meteorology and Oceanography Center (DOD)
FOA	Field Operating Agency (DOD)
FORSCOM	U.S. Army Forces Command
FOV	Field of vision
FR	Flight Rules
FRA	Federal Railroad Administration
FRD	Field Research Division (NOAA/ARL)
FRERP	Federal Radiological Emergency Response Plan (DOE)
FRMAC	Federal Radiological Monitoring and Assessment Center (DOE)
FRWS	Fire RAWS (DOI)
FS-21	Forecasting System 21st Century (DOD)
FS	Forest Service (USDA)
FSA	Farm Services Agency (USDA)
FSL	Forecast Systems Laboratory (NOAA/OAR)
FSR	Forest Service Research (USDA)
FTA	Federal Transit Administration
FTE	Full-time Equivalent
FTP	File Transfer Protocol
FU	Forecast Unit
FWS	Fish and Wildlife Service (DOI)
FY	Fiscal year
G-IV	Gulfstream IV (NOAA)
GAA	GOES Active Archive (NOAA/NESDIS)
GAC	Global Area Coverage
GACC	Geographic Areas Coordination Center (DOI)
GACP	Global Aerosol Climatology Project (NASA)
GAIM	Global Assimilation of Ionospheric Measurements (DOD)
GAPP	GEWEX Applications Prediction Program (DOI/BUREC)
GAO	General Accounting Office
GCCR	Global Climate Change Research (DOE)
GCCS	Global Command and Control System (DOD)
GCIP	GEWEX Continental-scale International Project (DOI)
GCM	Global Climate Models (DOE)
GCOS	Global Climate Observing System (WWP)
GCPS	Global Climate Perspectives System
GCRP	Global Change Research Program
GDPC	Global Data Processing Centers (WWP)
GDPFS	Global Data Processing and Forecast System (WWP)
GEM	Generation of weather Elements for Multiple (USDA)
GEOSAR	Geostationary Earth Orbit Search and Rescue (NOAA/NESDIS)
GEOSS	Global Earth Observation Systems of Systems (WWP)
GEWEX	Global Energy and Water-Balance Experiment
GFDL	Geophysical Fluid Dynamics Laboratory (NOAA/ERL)
GHCN	Global Historical Climatology Network
G-IPPA	Government-Industry Project Performance Agreement (FAA)
GIN	Geomagnetic Information Nodes (DOI)

GIS	Geographic Information System
GLD	Global Lagrangian Drifters (NOAA/OAR)
GLONASS	Global Navigation Satellite System (NOAA/NESDIS)
GMS	Geostationary Meteorological Satellite-Japan (WWP)
GMSRA	GOES Multi-Spectral Rainfall Algorithms (NOAA/NESDIS)
GMU	George Mason University
GOES	Geostationary Operational Environmental Satellite (NOAA)
GOOS	Global Ocean Observing System
GOS	Global Observing System (WWP)
GOSSP	Global Observing Systems Space Panel (NOAA/NESDIS)
GPCP	Global Precipitation Climatology Program
GPS	Global Positioning System
GPS/MET	GPS for Meteorology
GRIB	Gridded Binary (FM 92-X Ext.)
GRIDS	Ground-based Remote Icing Detection System (NOAA/OAR)
GSFC	Goddard Space Flight Center (NASA)
GSN	GCOS Surface Network (WWP)
GTS	Global Telecommunications System (WWP)
GTSPP	Global Temperature-Salinity Profile Project
GTWAPS	Global Theater Weather Analysis and Prediction System (DOD)
GUAN	GCOS Upper Air Network (WWP)
HAF	Headquarters Air Force (DOD)
HaL	Hurricanes at Landfall (NOAA/OAR)
HAR	Highway Advisory Radio (FHWA)
HARM	Hazardous Atmospheric Release Model (NOAA/OAR)
HAZMET	Hazardous Material (FHWA)
HCRS	Highway Closure and Restriction System (FHWA)
HDB	Hydrologic DataBase (DOI)
HELSTF	High Energy Laser System Test Facility (DOD)
HF	High Frequency
HFRB	High Frequency Regional Broadcast
HIGRAD	Transport and Dispersion Model at LANL (DOE)
HIRS/3	High Resolution Infrared Radiation Sounder (NOAA/NESDIS)
HMI	Hydrologic Modeling Inventory (DOI)
HMSC	Hazardous Materials Spill Center (DOE)
HMMWV	High Mobility Multi-purpose Wheeled Vehicle (DOD)
HPC	Hydrometeorological Prediction Center (NOAA/NCEP)
HPCC	High Performance Computing and Communications
HRAP	Hydrologic Rainfall Analysis Project (DOI)
HRD	Hurricane Research Division (NOAA/ERL)
HRPT	High Resolution Picture Transmission (NOAA/NESDIS)
HSA	Hydrologic Service Area (NOAA/NWS)
HSM	Heat Stress Monitor (DOD)
HYDROMET	A network of automated hydrologic and meteorologic monitoring stations located throughout the Pacific Northwest (DOI)
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory (NOAA/OAR)
HUD	Head-up display (NASA)
IA	Interagency Agreement
IAMS	Initial Attack Management System (DOI)
IAS	International Airspace System (NOAA/NWS)
IAV	Interim Armored Vehicle (DOD)
IBCT	Interim Brigade Combat Teams (DOD)
ICAO	International Civil Aviation Organization
LCC	Launch Commit Criteria
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research (OFCM)

ICSU	International Council of Scientific Unions
IDCS	International Data Collection System (WWP)
IEW	Intelligence and Electronic Warfare (DOD)
IFFA	Interactive Flash Flood Analyzer (NOAA/NESDIS)
IGBP	International Geosphere Biosphere Programme (WWP)
IHC	Interdepartmental Hurricane Conference (OFCM)
IIP	International Ice Patrol (USCG)
IMA	Individual Mobilization Augmentee (DOD)
IMAAC	Interagency Modeling and Atmospheric Assessment Center
IMDES	Interdepartmental Meteorological Data Exchange System
IMETS	Integrated Meteorological System (DOD)
	Incident Meteorologists (NOAA/NWS)
IMPROVE	Interagency Monitoring of Protected Visual Environments (DOI)
INEEL	Idaho National Engineering and Environmental Laboratory (DOE)
INSAT	India's National Satellite (WWP)
IOC	Intergovernmental Oceanographic Commission (WWP)
IPB	Intelligence Preparation of the Battlespace (DOD)
IPCC	Intergovernmental Panel on Climate Change (WWP/DOS)
IPEX	Intermountain Precipitation Experiment (NOAA/OAR)
IPO	Integrated Program Office
IR	Infrared
IRTSS	Infrared Target Scene Simulation Software (DOD)
ISCCP	International Satellite Cloud Climatology Program (NOAA/NESDIS)
ISES	International Space Environment Service (NOAA/OAR)
ISIS	Integrated Solar Irradiance Study (NOAA/OAR)
ISMS	Integrated Safety Management System (DOE)
ISS	International Space Station
ISTEA	Intermodal Surface Transportation Efficiency Act (FHWA)
IT	Information Technology
ITCT	Intercontinental Transport and Chemical Transformation (NOAA/OAR)
ITCZ	Inter-tropical convergence zone
ITS	Intelligent Transportation System (FHWA)
ITS-JPO	ITS Joint Program Office (FHWA)
IT-RD	Information Technology Research and Development (EPA)
ITWS	Integrated Terminal Weather System (FAA)
IWEDA	Integrated Weather Effects Decision Aid (DOD)
IWGCCST	Interagency Working Group on Climate Change Science and Technology (DOS)
IWRS	Improved Weather Reconnaissance System (OFCM)
IWRPC	Improved Weather Reconnaissance System Program Council (OFCM)
JAAWIN	Joint Air Force-Army Weather Information Network (DOD)
JAG	Joint Action Group
JAG/OCM	Joint Action Group for Operational Community Modeling
JASL	Joint Archive for Sea Level
JAWF	Joint Agricultural Weather Facility (USDA)
JCOMM	Joint Commission for Oceanographic and Marine Meteorology (WWP)
JCS	Joint Chiefs of Staff (DOD)
JCSDA	Joint Center for Satellite Data Assimilation (NOAA/NCEP)
JET	Joint Environmental Toolkit (DOD)
JGOFS	Joint Global Ocean Flux Study
JHT	Joint Hurricane Testbed (NOAA/OAR)
JMDB	Joint METOC Database (DOD)
JMFU	Joint METOC Forecast Unit (DOD)
JMIB	Joint METOC Interoperability Board (DOD)
JMIST	Joint METSAT Imagery, Software, and Terminals (DOD)
JMV	Joint METOC Viewer (DOD)
JPL	Jet Propulsion Laboratory (NASA)

JSAT	Joint Safety Analysis Team (FAA)
JSIT	Joint Safety Implementation Team (FAA)
JSC	Johnson Space Center (NASA)
JSCP	Joint Strategic Capabilities Plan (DOD)
JTWC	Joint Typhoon Warning Center (DOD)
JWIS	Joint Weather Impacts System (DOD)
KAO	Kirtland Area Office
KLC	Kodiak Launch Center (NASA)
KM	Kilometer
KSC	Kennedy Space Center (NASA)
KVERT	Kamchatka Volcanic Eruption Response Team (DOI)
LAAS	Local Area Augmentation System (FAA)
LAC	Local Area Coverage
LAN	Local Area Network
LANL	Los Alamos National Laboratory (DOE)
LAPS	Local Analysis and Prediction System (NOAA/FSL)
LDAR	Lightning Detection and Ranging
LDCM	Landsat Data Continuity Mission (NASA)
LDIS	Local Data Integration System (NASA)
LEO	Low Earth Orbit
LLCC	Lightning Launch Commit Criteria (NASA)
LLNL	Lawrence Livermore National Laboratory (DOE)
LLWAS	Low Level Wind Shear Alert System (FAA)
LLWAS-RS	LLWAS-Relocation/Sustainment (FAA)
LODI	Transport and Dispersion Model at LLNL (DOE)
LRGS	Local Readout Ground Stations (DOI)
LSD	Laboratory Services Division
LSM	Land Surface Model (DOD)
LV	Launch Vehicle
LWS	Living With A Star (NASA)
M2M	Machine-to-Machine
MACOM	Major Army Command
MAGTF	Marine Air Ground Task Force
MAJCOM	Major Command (DOD)
MAW	Marine Aircraft Wing
MB	Millibars
MC	Meteorological Codes
MCAF	Marine Corps Air Facilities
MCAS	Marine Corps Air Station
MCCDC	Marine Corps Combat Development Command (DOD)
MCD	Mesoscale Discussions (NOAA/NWS)
MCO	Maintenance and Construction Operations (FHWA)
MCS	Mesoscale Convective System (NOAA/OAR)
MCSP	Meteorological and Climate Services Project
MCWP	Marine Corps Warfighting Publication (DOD)
MDIFF	Transport and Dispersion Code at INEEL (DOE)
MDCRS	Meteorological Data Communications and Reporting System (WWP)
MDSS	Maintenance Decision Support System (FHWA)
MeaPRS	MCS Electrification and Polarimetric Radar Study (NOAA/OAR)
MEDA	Meteorological Data System
MEF	Mission Execution Forecast (DOD)
MEPED	Medium Energy Proton and Electron Detector (NOAA/NESDIS)
MES	Marine Environmental Services (OFCM)
MET	Mobile Environmental Teams (DOD)

	Meteorological Teams (DOD)
METMF	Meteorological Mobile Facility (DOD)
METOC	Meteorological and Oceanographic (DOD)
METSAT	Meteorological Satellite
MHS	Microwave Humidity Sounder (NOAA/NESDIS)
MHz	Megahertz
MIMS	Multimedia Integrated Modeling System (EPA)
MM5	Mesoscale Meteorological Model-Version 5.0 (DOD)
MME	Mobile Meteorological Equipment (OFCM)
MMS	Meteorological Measuring System (DOD)
	Mineral Management Service (DOI)
	Modular Modeling System (DOI)
MMS-P	Meteorological Measuring System-Profiler (DOD)
MOA	Memorandum of Agreement
MOBY	Marine Optical Buoy (NOAA/NESDIS)
MOCE	Marine Optical Characterization Experiment (NOAA/NESDIS)
MODIS	Moderate Resolution Imaging Spectrometer (NASA)
MOS	Model Output Statistics
MP	Mission Planning (DOD)
MPA	Magnetospheric Plasma Analyzer (DOE)
MPC	Marine Prediction Center (NOAA/NCEP)
MS	Monitoring the Stratosphere (OFCM)
MSFC	Marshall Space Flight Center (NASA)
MSL	Mean Sea Level
MSS	Meteorological Sounding System (NASA)
MST	Meteorological Support Teams (DOD)
MSU	Microwave Sounding Unit (NOAA/NESDIS)
MTN	Main Telecommunications Network (WWP)
MTOE	Modified Table of Organization and Equipment (DOD)
MTPE	Mission to Planet Earth (NASA)
MTSAT	Multi-functional Transport Satellite
MWSS	Marine Wing Support Squadron
MW	Microwave
N511	National 511-Traveler Information Service (FHWA)
NADIN	National Airspace Data Interchange Network (FAA)
NAF	Numbered Air Force
NAME	North American Monsoon Experiment
NAMIS	NATO Automated Meteorological Information System (DOD)
NMAO	NOAA Marine and Aviation Operations
NAP	Non-insured Crop Disaster Assistance Program (USDA)
NAPP	National Aerial Photography Program (USDA)
NAOS	North American Atmospheric Observing System (NOAA)
NARAC	National Atmospheric Release Advisory Center (DOE)
NARSTO	North American Research Strategy for Tropospheric Ozone (EPA)
NAS	National Airspace System (FAA)
	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NASS	National Agricultural Statistics Service (USDA)
NATCOM	National Communications Center (FAA)
NATO	North Atlantic Treaty Organization (DOD, EPA)
NAVICECEN	Naval Ice Center
NAVOCEANO	Naval Oceanographic Office
NAVLANTMETOCCEN	Naval Atlantic Meteorology and Oceanography Center, Norfolk, Virginia
NAVMETOCCOM	Naval Meteorology and Oceanography Command
NAVPACMETOCCEN	Naval Pacific Meteorology and Oceanography Center, Pearl Harbor, Hawaii

NAWPC	National Aviation Weather Program Council (OFCM)
NBC	Nuclear, Biological, and Chemical (DOD)
NC	NOAA Corps
NCA	National Command Authority (DOD)
NCAR	National Center for Atmospheric Research
NCAS	NOAA Center for Atmospheric Sciences
NCDC	National Climatic Data Center (NOAA/NESDIS)
NCEP	National Centers for Environmental Prediction (NOAA/NWS)
NCO	NCEP Central Operations (NOAA/NCEP)
	Non-commissioned officer (DOD)
NDBC	National Data Buoy Center (NOAA/NWS)
NDGPS	Nationwide Differiental Global Positioning System
NDI	Non-developmental item
NDOP	National Digital Orthoquad Program (USDA)
NDRI	Natural Disaster Reduction Initiative (NOAA)
NDVI	Normalized Difference Vegetation Index (NOAA/NESDIS)
NEPA	National Environmental Policy Act
NERON	NOAA's Environmental Real-Time Observation Network
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NESHAP	*National Emission Standards for Hazardous Air Pollutants* (DOE)
NESS	National Environmental Satellite Service (NOAA)
NEST	Nuclear Emergency Search Team (DOE)
NETRAD	Networked Radars
NEXRAD	Next Generation Weather Radar (WSR-88D)
NFIP	National Flood Insurance Program (FEMA)
NFDRS	National Fire Danger Rating System (DOI/BLM)
NGDC	National Geophysical Data Center (NOAA/NESDIS)
NGIC	National Geomagnetic Information Center (DOI)
NGST	Northrup Grumman Space Technology
NHC	National Hurricane Center (NOAA/NCEP)
NHI	National Highway Institute (FHWA)
NHOP	National Hurricane Operations Plan (OFCM)
NIC	National Ice Center (DOT/USCG)
	National Intelligence Community (DOD)
NIFC	National Interagency Fire Center (DOI)
NIPRNET	Non-secure Internet Protocol Router Network (DOD)
NIRT	Nuclear Incident Response Team
NIST	National Institute of Standards and Technology (DOC)
NITES	Navy Integrated Tactical Environmental Subsystem
NLDN	National Lightning Detection Network (FAA)
NMC	National Meteorological Center(s) (WWP)
NMHS	National Meteorological and Hydrological Services (WWP)
NMOC	Naval Meteorology and Oceanography Command
NMP	New Millennium Program (NASA)
NMS	National Military Strategy (DOD)
NMTN	National Meteorological Telecommunications Network (WWP)
NNDC	NOAA National Data Center (NOAA/NESDIS)
NNSA	National Nuclear Security Administration (DOE)
NNSA/NSO	National Nuclear Security Administration/Nevada Site Office (DOE)
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center (NOAA/NESDIS)
NODDS	Navy Oceanographic Data Distribution System
NOGAPS	Navy Operational Global Atmospheric Prediction System
NOS	National Ocean Service (NOAA)
NOTAMS	Notices to Airmen (FAA)
NOWS	NVG Operations Weather Software (DOD)
NPDES	National Pollutant Discharge Elimination System (DOE)

NPN	NOAA Profiler Network (NOAA/OAR)
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Program (NASA)
NPS	National Park Service (DOI)
NRC	Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service (USDA)
NRI	National Research Initiative (USDA)
NRL	Naval Research Laboratory
NRO	National Reconnaissance Office (DOD)
NRVR	New Generation Runway Visual Range (FAA)
NSC	National Security Complex
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center (NOAA)
NSO	Nevada Site Office (DOE)
NSS	National Security Strategy (DOD)
NSSL	National Severe Storms Laboratory (NOAA)
NSTC	National Science and Technology Council
NSTEP	National Strategic Training and Education Plan (NOAA/NWS)
NSWP	National Space Weather Program (OFCM)
NTCIP	National Transportation Communications for ITS Protocol (FHWA)
N-TFS	New Tactical Forecast System (DOD)
NTIS	National Technical Information Service
NTS	Nevada Test Site (DOE)
NTSB	National Transportation Safety Board
NV	Nevada Operations Office (DOE)
NVG	Night vision goggles (DOD)
NWA	National Wilderness Area (DOI)
NWCC	National Water & Climate Center (USDA)
NWCG	National Wildfire Coordinating Group (USDA)
NWIS	National Water Information System (DOI)
NWLON	National Water-Level Observation Network (NOAA/NOS)
NWP	Numerical Weather Prediction
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast Service (NOAA/NWS)
NWSTC	National Weather Service Training Center (NOAA/NWS)
NXDP	National Xeriscape Demonstration Program (DOI)
O&C	Oregon and California Railroad Land Grants (DOI)
OAR	Office of Oceanic and Atmospheric Research (NOAA)
OASIS	Operational and Supportability Implementation System (FAA)
OB	Operational Build
OCAP	Operating Consortium of ASDAR Participants (WWP)
OCE	Office of the Chief Economist (USDA)
OCRWM	Office of Civilian Radioactive Waste Management
OCWWS	Office of Climate, Water, and Weather Services (NOAA/NWS)
OFCM	Office of the Federal Coordinator for Meteorology
OGP	Office of Global Programs (NOAA)
OMB	Office of Management and Budget
OMEGA	Operational Medicine Environmental Grid Application (DOD)
OMPS	Ozone Mapping and Profiler Suite
ONR	Office of Naval Research
OOR	Object Oriented Redesign
OPAREA	Fleet Operational Area (DOD)
OPARS	Optimum Path Aircraft Routing System (DOD)
OPC	Operational Processing Centers
OPS-II	Operational Weather Squadron Production System, Phase II
OPUP	Open Principal User Processor

OR&F	Operations, Research, and Facilities (NOAA/NWS)
ORA	Office of Research and Applications (NOAA/NESDIS)
ORAU	Oak Ridge Associated Universities (DOE)
ORD	Operational Requirements Documents (DOD)
ORISE	Oak Ridge Institute for Science and Education (DOE)
ORPG	Open Systems Radar Product Generator (NOAA/OAR)
ORR	Oak Ridge Reservation (DOE)
ORS	Optical Remote Sensing
ORNL	Oak Ridge National Laboratory (DOE)
OROO	Oak Ridge Operations Office (DOE)
OS	Office of Science, South Carolina
OS-21	Observing System 21st Century (DOD)
OSC	On-Scene Commander (DOE)
OSDPD	Office of Satellite Data Processing and Distribution (NOAA/NESDIS)
OSE	Observing System Experiments (WWP)
OSEI	Operational Significant Event Imagery (NOAA/NESDIS)
OSHA	Occupational Safety and Health Administration
OSO	Office of Satellite Operations (NOAA/NESDIS)
OSSE	Observing System Simulation Experiments (WWP)
OSTEP	Ocean Systems Test and Evaluation Program (NOAA/NOS)
OSTP	Office of Science and Technology Policy
OTC	Operational Test Centers
OTH	Over the horizon (NOAA/OAR)
OTSR	Optimum Track Ship Routing (DOD)
OWF	Operational Weather Flight (DOD)
OWS	Operational Weather Squadron (DOD)
OWSE	Operational World Weather Watch Systems Evaluation (WWP)
PAA	Precipitation Accumulation Algorithm (DOI)
PAC	Procurement, Acquisition, and Construction (NOAA/NWS)
PACS	Polar Acquisition and Control Subsystem (NOAA/NESDIS)
PAR	Phased Array Radar
PATMOS	Pathfinder Atmosphere (NOAA/NESDIS)
PAWRP	Phased Array Weather Radar Project
PBL	Planetary Boundary Layer (DOE)
PC	Program Council (OFCM)
	Personal Computer (DOE)
PCB	Polychlorinated Biphenyl
PCMDI	Program for Climate Model Diagnosis and Intercomparison (DOE)
PD	Program Director (DOD)
PDD	Presidential Decision Directive
PDT	Product Development Team
PECAD	Production Estimates and Crop Assessment Division (USDA)
PIBAL	Pilot Balloon
PIPS	Polar Ice Prediction System (NOAA/NESDIS)
PIRATA	Pilot Research Moored Array in the Tropical Atlantic (NOAA/OAR)
PIREP	Pilot Report
PMC	Project Management Coordinator (DOE)
PMEL	Pacific Marine Environmental Laboratory (NOAA/ERL)
PNNL	Pacific Northwest National Laboratory (DOE)
PNT	Position, Navigation, and Timing (USCG)
POES	Polar-orbiting Operational Environmental Satellite (NOAA)
POP	Parallel Ocean Program (DOE)
POPS	Primary Oceanographic Prediction System (DOD)
PORTS	Physical Oceanographic Real-Time System (NOAA/NOS)
ppm	Part per Million (DOE)
PSDA	Post-Storm Data Acquisition (OFCM)

PSR	Polarimetric Scanning Radiometer (NOAA/OAR)
PSS	Plant Shift Superintendent
PUP	Principal User Processor
QPF	Quantitative Precipitation Forecast (NOAA/NCEP)
QuikSCAT	Quick Scatterometer
R&A	Research and Analysis
R&D	Research and Development
RAFC	Regional Area Forecast Center (WWP)
RAMS	Regional Atmospheric Modeling System (DOE)
RAMSDIS	RAMM Branch Advanced Meteorological Satellite Demonstration and Interpretation System (NOAA/NESDIS)
RAP	Radiological Assistance Program (DOE) Remedial Action Plan (DOE)
RARC	Regional Atmospheric Response Center (DOE)
RASS	Radio Acoustic Sounding System (NOAA/OAR and DOE)
RATS	Radio Automatic Theodolite System (NASA)
RAWS	Remote Automatic Weather Station (USDA/DOI)
RBCN	Regional Basic Climate Network (WWP)
RC	Reserve Component (DOD)
RCC	Regional Climate Center (NOAA/NESDIS)
RCTM	Road Condition and Treatment Module (FHWA)
RDA	Radar Data Acquisition
RDEC	Research Development and Engineering Center (DOD)
RDTE	Research, Development, Test and Evaluation (DOD)
REIP	Reengineered Enterprise Infrastructure Program (DOD)
RF	Radio Frequency
RFETS	Rocky Flats Environmental Technology Site (DOE)
RFOO	Rocky Flats Operations Office (DOE)
RFC	River Forecast Center (NOAA/NWS)
RMTN	Regional Meteorological Telecommunications Network (WWP)
ROC	Radar Operations Center (NOAA/NWS)
RPC	Rapid Prototype Center (NOAA/SEC)
RSA	Range Standardization and Automation (NASA)
RSAC	Transport and Dispersion Code at INEEL (DOE)
RSFWSU	Remote Sensing/Fire Weather Support Unit (DOI)
RSMC	Regional/Specialized Meteorological Centers (WWP)
RSS	Receiving Set Satellite (DOD)
RTH	Regional Telecommunications Hub (WWP)
RUC	Rapid Update Cycle (NOAA/OAR)
RVR	Runway Visual Range (FAA)
RWIS	Road Weather Information System (FHWA)
SAA	Satellite Active Archive Snow Accumulation Algorithm (DOI/BLM)
SAFETEA	Safe, Accountable, Flexible, and Efficient Transportation Equity Act of 2003 (FHWA)
SAMS	Stochastic Analysis, Modeling, and Simulation (DOI)
SAP	Special Access Program
SAR	Synthetic Aperture Radar (NOAA/NESDIS)
SARSAT	Search and Rescue Satellite Aided Tracking
SATCOM	Satellite Communications
SATS	Small Aircraft Transportation System (NASA)
SAWS	Stand Alone Weather Sensor (FAA)
SBIR	Small Business Innovation Research Program
SBUV	Solar Backscatter Ultra-violet Instrument (NOAA/NESDIS)
SCAN	Soil Climate Analysis Network (USDA)

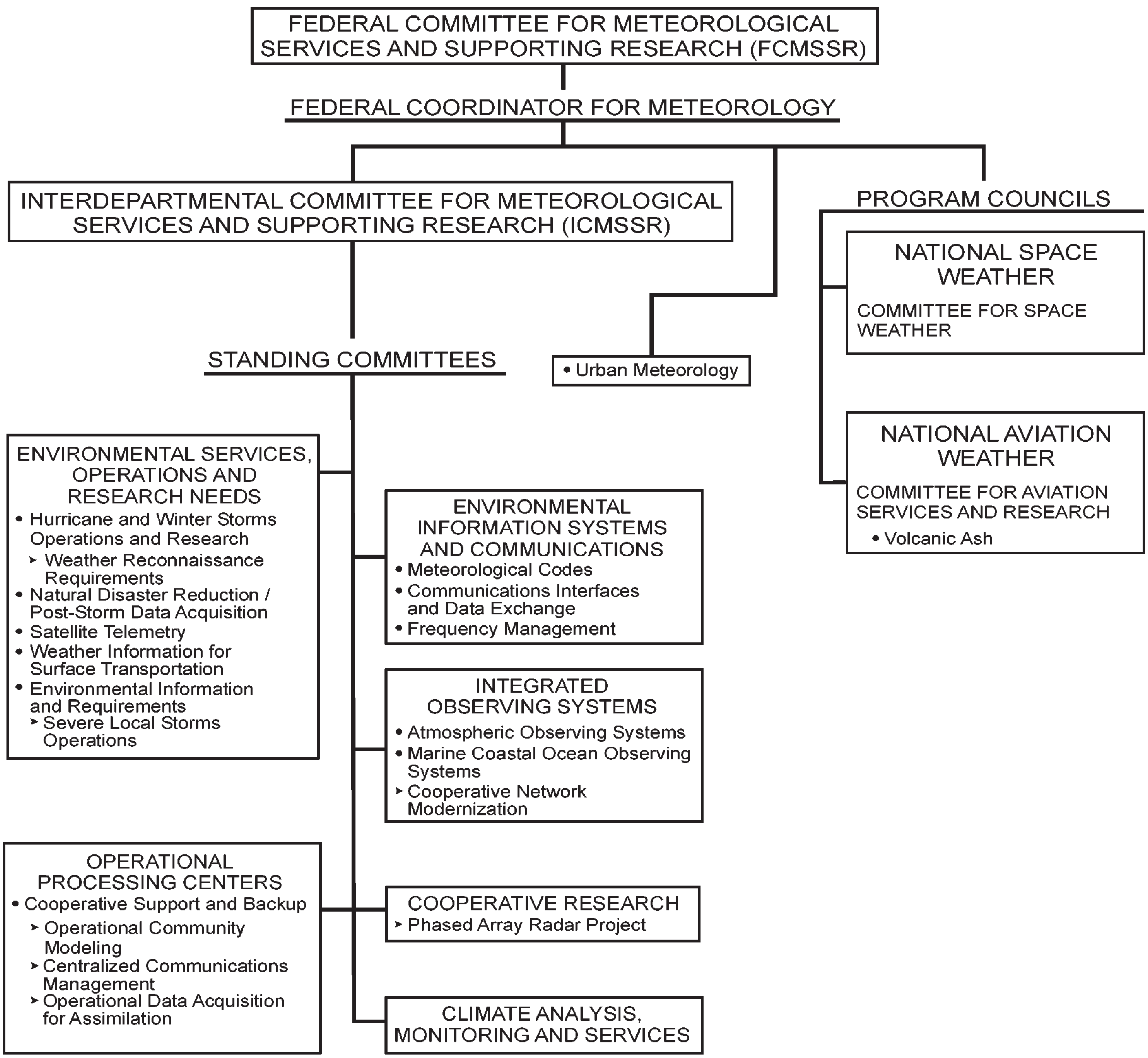
SCAPA	Subcommittee for Consequence Assessment and Protective Actions
SCI	Sensitive Compartmented Information (DOD)
SDHS	Satellite Data Handling System (DOD)
SeaWiFS	Sea-viewing Wide Field Scanner (NASA)
SEC	Space Environment Center (NOAA/NCEP)
	Sun Earth Connection (NASA)
SEM	Space Environment Monitor (NOAA)
SEMSIM	Southeastern Michigan Snow and Ice Management (FHWA)
SEON	Solar Electro-optical Observing Network (DOD)
SESS	Space Environmental Sensor Suite
SFMR	Stepped Frequency Microwave Radiometer
SGP	Southern Great Plains (DOE)
SHEBA	Surface Heat Budget of the Arctic Ocean (DOE)
SHEP	State Highway Emergency Patrol (FHWA)
SHRP	Strategic Highway Research Program (FHWA)
SIGRID	Sea Ice in Gridded Format (NOAA/NESDIS)
SLF	Shuttle Landing Facility
SLRS-C	Spacelift Range System Contract (NASA)
SMC	Space and Missile Systems Center (DOD)
SMDC	Space and Missile Defense Command (DOE)
SMG	Spaceflight Meteorology Group (NASA)
SNDR	Subcommittee on Natural Disaster Reduction
SNL	Sandia National Laboratory (DOE)
SNODEP	SNOw DEPth
SNOTEL	Snow Pack Telemetry (USDA)
SOCC	Satellite Operations Control Center (NOAA/NESDIS)
SODAR	Sound Detection and Ranging (DOE)
SODAR/RASS	Sound Detection and Ranging/Radio Acoustic Sounding System (DOE)
SOF	Special Operations Forces (DOD)
SOLAS	International Convention for Safety of Life at Sea (NOAA/NCEP, DHS/USCG)
SOPA	Synchronous Orbit Plasma Analyzer (DOE)
SORD	Special Operations and Research Division (NOAA/ARL)
SPLASH	Hydrologic Code at LANL (DOE)
SPAWARSYSCOM	Space and Naval Warfare Systems Command
SPC	Storm Prediction Center (NOAA/NCEP)
SPO	System Program Office (DOD)
SPP	Shared Processing Program
SR	Savannah River (DOE)
SRB	Solid Rocket Booster
SRS	Savannah River Site (DOE)
SRTC	Savannah River Technology Center (DOE)
SS&WSF	Snow Survey & Water Supply Forecasting (USDA)
SSIES	Special Sensor for Ions and Electrons (DOD)
SSJ	Special Sensor Precipitating Elecron and Ion Spectrometer (DOD)
SSM	Special Sensor Magnetometer (DOD)
SSM/I	Special Sensor Microwave/Imager (DOC, DOD, DOI)
SSM/T	Special Sensor Microwave/Temperature (DOD)
SSOB	Special Support Operations Branch (DOD)
SST	Sea Surface Temperature
SSU	Stratospheric Sounding Unit (NOAA)
SSUSI	Special Sensor Ultraviolet Spectrographic Imager (DOD)
STAR	Weather Data Format used at Pantex (DOE)
STIWG	Satellite Telemetry Interagency Working Group (OFCM)
STP	Solar-Terrestrial Physics
STS	Special Tactics Squadron (DOD)
STWDSR	Surface Transportation Weather Decision Support Requirements (FHWA)
SURFRAD	Surface Radiation Budget Station at NTS (DOE)

SVS	Synthetic Vision System (NASA)
SWA	Southwest Asia (DOD)
SWAFS	Space Weather Analysis and Forecasting System (DOD)
SWE	Snow Water Equivalent (DOI/BUREC)
SWO	Staff Weather Officer (DOD)
	Space Weather Operations (NOAA/OAR)
SWR	Supplemental Weather Radar (DOD)
SWSI	Surface Water Supply Index (USDA)
SXI	Solar X-Ray Imager (DOD)
T2	Technology transfer
TAF	Terminal Aerodrome Forecast
TAL	Transatlantic Abort Landing (NASA)
TAMDAR	Troposphere Airborne Meteorological Data Reports (WWP)
TAO	Tropical Atmosphere Ocean
TAWS	Target Acquisition Weather Software (DOD)
TCP	Transformation Campaign Plan (DOD)
TDA	Tactical Decision Aid (DOD)
TDWR	Terminal Doppler Weather Radar (FAA)
TEA-21	Transportation Equity Act for the 21st Century (FHWA)
TEC	Topographic Engineering Center (DOD)
	Total Electron Content (DOE)
TED	Total Energy Detector (NOAA/NESDIS)
TEDS	Tactical Environmental Data Server (DOD)
TESS	Tactical Environmental Support System (DOD)
THORPEX	The Observing System Research and Predictability Experiment (WWP)
TIMEX	Thunderstorm Initiation Mobile Experiment (NOAA/OAR)
TIROS	Television Infrared Observation Satellite (NOAA/NESDIS)
TOC	Tactical Operations Center (DOD)
TOE	Table of Organization and Equipment (DOD)
TOGA	Tropical Ocean and Global Atmosphere
TOVS	TIROS-N Operational Vertical Sounder (NOAA/NESDIS)
TNT	Trinitrotoluene (DOE)
TPAWS	Turbulence Prediction and Warning System
TPC	Tropical Prediction Center (NOAA/NCEP)
TPW	Total Precipitable Water (NOAA/NESDIS)
TRACON	Terminal Radar Approach Control (FAA)
TRADOC	Training and Doctrine Command (DOD)
TRB	Transportation Research Board (FHWA)
TRITON	Triangle Trans-Ocean buoy Network (NOAA/OAR)
TRMM	Tropical Rainfall Measuring Mission (NASA)
TRU	Transuric (DOE)
TSIS	Total Solar Irradiance Sensor
TUAN	Tactical Unmanned Aerial Vehicle (DOD)
TWC	The Weather Channel
TWIP	Terminal Weather Information for Pilots (FAA)
TWP	Tropical Western Pacific (DOE)
TWR	Tactical Weather Radar (DOD)
UAV	Unmanned Aerial Vehicle (DOD)
UC	University of Chicago or California
UCAN	Unified Climate Access Network (USDA)
UCAR	University Corporation for Atmospheric Research
UHF	Ultra High Frequency
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization (WWP)

UNLV	University of Nevada at Las Vegas (DOE)
UPOS	University Partnering for Operational Support (DOD)
USA	U.S. Army
USACE	U.S. Army Corps of Engineers
USAES	U.S. Army Engineer School
USAF	U.S. Air Force
USAFE	U.S. Air Forces in Europe
USAFAS	U.S. Army Field Artillery School
USAIC&FH	U.S. Army Intelligence Center and Fort Huachuca
USAR	U.S. Army Reserve
USARAK	U.S. Army Alaska
USARC	U.S. Army Reserve Command
USAREUR	U.S. Army Europe
USARHAW	U.S. Army Hawaii
USARIEM	U.S. Army Research Institute of Environmental Medicine
USARJ	U.S. Army Japan
USARPAC	U.S. Army Pacific
USASMDC	U.S. Army Space and Missile Defense Command
USASOC	U.S. Army Special Operations Command
USCENTCOM	U.S. Central Command
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USGCRP	U.S. Global Change Research Program
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USHCN	U.S. Historical Climatology Network
USIABP	U.S. Interagency Arctic Buoy Program (NOAA/NESDIS)
USMC	U.S. Marine Corps
USMCC	U.S. SARSAT Mission Control Center (NOAA/NESDIS)
USN	U.S. Navy
USSOCOM	U.S. Special Operations Command (DOD)
USWRP	U.S. Weather Research Program
UT	University of Tennessee
UTC	Universal Time Coordinated (Zulu)
UV	Ultra-violet
VA	Volcanic Ash
VAAC	Volcanic Ash Advisory Center (NOAA/NESDIS)
VAS	VISSR Atmospheric Sounder
VCP	Voluntary Cooperation Program (WWP)
VII	Vehicle Infrastructure Integration (FHWA)
VIIRS	Visible/Infrared Imager/Radiometer Suite
VIN	Vegetative Index Number (USDA)
VIRS	Visible and Infrared Scanner (NASA)
VISSR	Visible and Infrared Spin Scan Radiometer
VISTAS	Visibility Improvement State and Tribal Association of the Southeast (DOI)
VORTEX	Verification of the Origins of Rotation in Tornadoes Experiment (NOAA/OAR)
VOS	Voluntary Observing Ship (WWP)
VPR	Vertical Profile of Reflectivity (DOI)
VSAT	Very Small Aperture Terminal (DOD)
VSL	Variable Speed Limit (FHWA)
VTMX	Vertical Transport and Mixing Experiment (DOE)
VTS	Vessel Traffic System (NOAA/NOS)
WAAS	Wide Area Augmentation System (FAA)
WAFC	World Area Forecast Center (WWP)
WAFS	World Area Forecast System (WWP)

WAMIS	World Agrometeorological Information Service (USDA)
WAOB	World Agricultural Outlook Board (USDA)
WARP	Weather and Radar Processor (FAA)
WaRSMP	Watershed and River System Management Program (DOI)
WCT	Wind Chill Temperature (OFCM)
WDA	Weather Data Analysis (DOD)
WEFAX	Weather Facsimile (WWP)
WETM	Weather Team (DOD)
WFAS	Wildland Fire Assessment System (DOI)
WFMIS	Wildland Fire Management Information Site (DOI)
WFO	Weather Forecast Office (NOAA/NWS)
WG	Working Group
WG/VA	Working Group for Volcanic Ash (DOI)
WG/PSDA	Working Group for Post-Storm Data Acquisition (FEMA)
WGCV	Working Group on Calibration and Validation (NOAA/NESDIS)
WINCOM	Weather Information Communications (NASA)
WIMS	Weather Information Management System (USDA)
WINDS	Weather Information and Display System (DOE)
WIPP	Waste Isolation Pilot Plant (DOE)
WIS	WMO Information System(WWP)
WIST	Weather Information for Surface Transportation
WMC	World Meteorological Center(s) (WWP)
WMO	World Meteorological Organization
WMSCR	Weather Message Switching Center-Replacement (FAA)
WOCE	World Ocean Circulation Experiment
WPDN	Wind Profile Demonstration Network (NOAA)
WPSM	Warfighter Physiological Status Monitoring (DOD)
WRD	Water Resources Division (DOI/USGS)
WRF	Weather Research and Forecast (DOC, DOD)
WRS	Weather Reconnaissance Squadron (DOD)
WRTC	Weather Readiness Training Center (DOD)
WSDDM	Weather Support to Deicing Decision Making (FAA)
WSP	Weather Systems Processor (FAA)
WSR-88D	Weather Surveillance Radar-1988 Doppler (NEXRAD)
WSRC	Westinghouse Savannah River Company (DOE)
WSSRAP	Weldon Springs Site Remedial Action Project (DOE)
WST	Weather Specialty Team (DOD)
WWCB	Weekly Weather and Crop Bulletin (USDA)
WWP	World Weather Program
WWW	World Weather Watch (WMO)
	World Wide Web
XOW	Air Force Director of Weather (DOD)
YMP	Yucca Mountain Project (DOE)

FEDERAL METEOROLOGICAL COORDINATING INFRASTRUCTURE



September 2005

LEGEND:
- • Designates a Working Group
- ➤ Designates a Joint Action Group