APPENDIX D

# WEATHER PROGRAMS OF OTHER AGENCIES

## DEPARTMENT OF AGRICULTURE

Weather is the most important factor influencing the Nation's variability in crop yields and related production. The Nation's food and fiber products are a critical resource impacting our domestic and international economic position and have taken on new dimensions in foreign affairs and national security. The recent expansion in export markets has reduced stocks and benefitted our farm sectors as global consumption of total grains has exceeded production in 3 of the last 4 years. The U.S. Department of Agriculture (USDA) conducts supporting research that focuses on understanding the interactions of weather and climate with plants, animals, forests, and forest ecological systems, and assists the Department of Commerce in determining farmers' needs for weather information and in disseminating that information to them.

The World Agricultural Outlook Board (WAOB), in cooperation with National Weather Service's (NWS) Climate Prediction Center, monitors the daily weather patterns around the world. WAOB agricultural meteorologists convert the weather data into information to assess crop development and yield potential of all major commodity crops for the major producing areas of the world. Special weekly briefings are provided to the Secretary of Agriculture and to the economic and commodity analysts of USDA. The Senate and House Agricultural Committees also request periodic briefings on crop- related drought effects as in 1988 and 1989.

Historically, the Forest Service (FS) has collected meteorological data to assist in the control of forest fires and in the management of smoke from prescribed burning. Other activities also need weather data to ensure sound management decisions. Therefore, a national weather program was established to coordinate all FS meteorological activities and to meet the increasing need for diverse weather information. The major objectives of the program are to: (1) improve quality control of weather data, (2) improve the design and operation of data collection from networks, (3) increase data recovery from the weather stations, and (4) upgrade station maintenance. Meteorological data collected from manual weather stations and Remote Automated Weather Stations (RAWS) support research of weather effects on forestry management, forest fires, smoke management, visibility protection in wilderness areas, and atmospheric deposition. A weather information management system and a library to archive all FS weather data are being developed in cooperation with regional climate centers. The FS monitoring network will provide essential data for use in Global Change Research Program (GCRP) work.

The FS currently operates more than 900 RAWS and manual stations, many in the western United States. Air temperature, relative humidity, soil moisture, wind direction and speed, and precipitation are transmitted via NOAA's Geostationary Operational Environmental Satellite (GOES) telemetry. These data are received via a direct-readout ground site in Boise, Idaho, in cooperation with the Bureau of Land Management. The main use of the data is in the calculation of the fire danger rating for the FS and cooperating agencies. These data are also used by other resource managers; such as, road engineers, wildlife biologists, and hydrologists who monitor precipitation; silviculturalists (who are attempting to maximize tree- planting opportunities); and ecologists, soil specialists, and fisheries biologists (who monitor the effects of runoff). The main secondary user of RAWS data is the NWS for fire weather forecasting and flood warnings.

The Natural Resources Conservation Service (NRCS) operates a network of 1,400 manual snow courses and over 550 automated data collection sites in conjunction with the project (SNOTEL) for the western United States and Alaska. The primary objective of the project is to forecast water supplies and streamflow for the coming spring run-off season. These measurements are made in cooperation with other federal, state, and local agencies, power companies, irrigation companies, and the provincial government of British Columbia.

Water-supply forecasts help irrigators make the most effective use of available streamflow for achieving their agricultural production goals. Farmers who

collectively irrigate more than 10 million acres of land in the western U.S. benefit from water supply forecasts. Other federal agencies and private organizations also use water supply forecast information to help them carry out their missions. These forecasts also help the federal government in administering international water treaties.

Beginning in FY 1987, NRCS initiated an upgrade to the SNOTEL data collection system at a total cost of $5 million. This effort continues and includes upgrading 510 data collection sites in the existing SNOTEL system with new state-of-the-art equipment and adding about 40 additional sites. The data-collection site upgrade will include replacement of snow pillows, transducers, damaged precipitation gauges, antennas, towers, solar panels, battery temperature sensors, and deteriorated shelter houses.

Supporting Research

The mission of the USDA supporting research program is to develop and disseminate information and techniques to ensure high quality commodities and products while minimizing any adverse effects of agriculture on the environment. As part of the USDA reorganization, the new Undersecretary for Research, Education, and Economics was created. This includes the merger of the Cooperative State Research Service and the Extension Service, and the transfer of the Economic Research Service and the National Agricultural Statistics Service (NASS).

The research efforts of the Agricultural Research Service (ARS) relate directly to the effects of climate on agricultural production and the natural resource base. They are directed toward developing technologies and systems for (1) managing precipitation and solar energy for optimum crop production, (2) improving our understanding of water-plant-atmosphere interactions, (3) optimizing the use of energy, water, and agricultural chemicals, (4) reducing plant and livestock losses from pests and environmental stress, (5) developing improved techniques for irrigation and drainage, and (6) minimizing the adverse effects of climate and weather, including atmospheric contaminants, on the environment.

The Cooperative State Research, Education, and Extensive Service (CSREES) coordinates research programs in the state agricultural experiment stations, the 1890 Land Grant Distributions, and cooperating forestry schools. These institutions conduct a wide variety of research applicable to agriculture and forestry. Meteorological research in these institutions is practically all climatological. A proportion of each state's program is consolidated into broad regional research projects. Animals and plants are subjected to many climatic stresses and, therefore, are the focus of this research. Research on the changes in levels of ultraviolet (UV) radiation as part of the GCRP was significantly expanded through the CSREES competitive grants program in FY 1994. The work is coordinated with EPA's UV radiation program and will support assessment efforts to develop related national policy on the environment.

Investigations by NASS support domestic crop estimating programs for all major commodities. Promising studies are underway to develop models relating weather parameters and associated variables to corn ear weight and wheat head weight. Previous efforts to develop models for short-term forecasting have had only limited success. Research will continue in this area with the expectation that the relationships between weather variables and crop yield will improve as better plant process models become available.

A NASS program explores the use of satellite and weather data for assessing crop conditions is continuing. A preliminary investigation using polar-orbiting meteorological satellite data showed a good relationship between crop conditions and reflectance data as determined by the agreement between measured and forecast final corn and soybean yields. The crop conditions assessment procedures, based on meteorological satellite data, are being automated and near real-time applications are being explored.

FS research includes efforts to: (1) understand and control forest fire initiation by lightning, (2) improve the translation of mid-range forecast elements to describe forestry conditions, (3) incorporate drought information into management decision-making, and (4) better describe how regional climatic variability affects the use of daily weather information by foresters. The FS long-term monitoring network will provide critical data for use in the GCRP work.

## DEPARTMENT OF THE INTERIOR

The Department of the Interior's (DOI) atmospheric science activities are primarily research and historically had been reported through the National Science Foundation-sponsored Subcommittee for Atmospheric Research; however, budgetary information for the Bureau of Land Management's operational wildfire data collection system is reported in this Federal Plan. The narrative below describes the full range of DOI's meteorological activities.

Bureau of Land Management (BLM)

BLM is one of five Federal Land Management agencies which have centralized wildfire weather operations in the National Interagency Fire Center (NIFC) at Boise, Idaho. BLM's Initial Attack Management System (IAMS) was designed 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 is moving toward a "file server" environment for the IAMS capabilities. Many of the capabilities that were centrally located in the IAMS have been moved to more remote sites. The system will still provide rapid evaluation, assessment, and decision making assistance for the BLM's wildfire responsibilities.

The principal IAMS inputs remain the same with Remote Automatic Weather Station (RAWS) and Automatic Lightning Detection System (ALDS) information being the primary real time data sets. Additional information on vegetation, slope, elevation, aspect, and terrain data are also used. These are coupled with advanced fire modeling capabilities to facilitate the BLM's fire and resource management objectives.

The BLM's RAWS Program primarily collects meteorological data for fire weather forecasting. In past years, the network also provided considerable support to non-fire entities and was operated year around. However, with increased pressure on operational dollars, the BLM Office of Fire and Aviation Management has decided to "downsize" the network. Current plans are to reduce the fire network by about one fourth in the western states. With continued funding pressures, the requirement to replace aging equipment, and the considerable costs associated with maintaining such a large network, BLM's strategy is to reduce the total number of RAWS, move to a single station classification (all stations configured the same), operate only during the traditional western fire season (RAWS no longer maintained in winter months), and to use any savings in operating funds to replace aging equipment and upgrade the remaining network. The BLM's Resource Management and Oregon O&C (West-Side) RAWS networks will continue to operate and to be supported as in the past. These networks are much smaller and have specific program requirements that differ from fire management.

The BLM began contracting with a private vendor via the National Weather Service for ALDS data effective April 1, 1997. Data is received at the NIFC in Boise, Idaho, and retransmitted via the existing ALDS/IAMS telecommunications network. The BLM is looking at moving into a file server arrangement in 1998 to further reduce recurring costs associated with telecommunications. Current plans are to continue the operation of the Alaska ALDS as an independent government-owned and operated system.

The BLM's Remote Sensing Support Group at NIFC provides a full range of specialized management, maintenance, data, and support services for the BLM and numerous other Government agencies. This interagency staffed and funded facility performs work under long-term interagency agreements with those agencies within the government having similar equipment and requirements. Staffing levels within this Group are being adjusted to meet the overall interagency requirements.

In addition to the meteorological monitoring BLM conducts primarily to support fire management activities, the BLM also conducts site-specific climate monitoring at over 200 locations on the Public Lands in the eleven western states and Alaska. The operation of these sites ranges from seasonal to annual measurements of precipitation. temperature, soil moisture and other meteorological parameters necessary to assess local climatic influences. These data are primarily used for natural resources management and planning at the local level.

In 1991, the BLM Global Change Research Program established five monitoring sites in BLM wilderness and wilderness study areas to establish baseline conditions for assessment of long term ecosystem trends. A total of 20 sites are planned to be established over the initial 5-year period. A standardized monitoring platform will be operated at these sites to include measurements of climate and atmospheric chemistry.

National Park Service (NPS)

The Park Service monitors air quality and visibility in several national parks and monuments. Gaseous pollutants data are collected on continuous and integrated (24-hour) bases. Surface meteorological data are collected and analyzed for hourly averages. Precipitation chemistry is determined on week-long integrated rainfall samples. Twenty-four average particle concentrations (mass, elemental analyses, some chemical constituent analyses) are measured twice weekly. Atmospheric light extinction is measured continuously and satellite-telemetered to a central location for analyses.

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.

U.S. Geological Survey (USGS or Survey)

The Survey's Water Resources Division (WRD) collects streamflow, precipitation, and other climatological data for a number of projects concerning rainfall/runoff, water quality and hydrologic processes. Currently, the Geological Survey collects hydrometeorological data from approximately 4500 remote Data Collection Platforms. 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 the Geological Survey under a 1992 contract. The Survey currently operates 12 LRGS' which provide near-real-time data to the Survey's computerized National Water Information System.

USGS/WRD is also helping the National Weather Service calibrate the NEXRAD weather radar for precipitation analysis. WRD is operating 36 rainfall collection sites data in the Susquehanna River Basin which provide hourly updates of precipitation. This pilot program will continue through the end of calendar year 1997 with the objective of identifying procedures for data collection and exchange, and developing a model local agreement that can be used by other NWS/USGS Offices in an operational program.

The Survey's Geologic Division, through the National Geomagnetic Information Center (NGIC) in Golden, Colorado, collects data on temporal variations of the Earth's magnetic field from a global network of over 70 geomagnetic observatories. These observatories (which include 13 operated directly by USGS/NGIC) all belong to the INTERMAGNET program. Under INTERMAGNET, data from a global network of geomagnetic observatories are transmitted in near-real-time via satellites and computer links (E-mail) to collection and dissemination points called Geomagnetic Information Nodes (GIN's). Five GIN's are now located in Europe, North America, and Asia.

Magnetic field data are key inputs to the National Space Environment Forecast and Warning Program, which is coordinated by the OFCM, and to the new inter-agency National Space Weather Program. These data are used for nowcasting, forecasting, and modeling of "space weather" -- particularly the effects of geomagnetic disturbances. These effects range from: satellite computer upsets and early re-entry, to disruption of radio communications, to degradation of navigation systems (such as GPS), and to outages of power distribution grids. The roles and responsibilities of agencies participating in the National Space Environment and Warning Program are detailed in the "National Plan for Space Environment Services and Supporting Research, 1993-1997" (FCM P10-1993) which was prepared by the OFCM Committee for Space Environment Forecasting.

The Survey is continuing a joint research program with NASA and USDA to map snowpack water equivalent using satellite passive microwave techniques. The satellite observations are being compared to snowpack water equivalent data from a variety of sources: the Department of Agriculture's Natural Resources Conservation Service automatic Snow Telemetry (SNOTEL) sites; grain size and water equivalent data collected by Survey field teams; and measurements and model estimates by the NOAA National Operational Hydrological Remote Sensing Center (NOHRSC). The object of the program is to

develop algorithms for making near real-time assessments of snowpack water equivalent and extent from space to be used operationally by water resource management agencies in the western United States.

As part of its glaciology program, the Survey maintains a benchmark program on three benchmark glaciers representative of different climatic 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. Analysis of this 36 year long record is providing a greater understanding of the climate variability and its effects on water resources of the western United States.

The Survey participates in the Committee on Volcanic Ash of the OFCM. This committee is preparing the OFCM National Plan for Volcanic Ash. This committee is preparing the National Plan for Volcanic Ash and Aviation Safety. Through its Volcanic Hazards Program, the Survey is responsible for monitoring volcanoes in the United States. Of the approximately 56 historically active volcanoes in the United States, 44 are in Alaska. Until the past decade the Alaskan volcanoes have been largely unstudied. Despite the low population density of much of the State, Alaska's volcanoes underlie the heavily traveled air routes of the North Pacific region.

The OFCM Committee on Volcanic Ash has supported expansion of Survey monitoring activities in the remote Aleutian chain of explosive volcanoes. During FY 1996, Survey and the Alaskan Volcano Observatory (AVO) expanded its network of real-time seismic monitoring stations to 4 additional volcanoes in the Eastern Aleutian Islands and the Western Alaskan Peninsula regions of Alaska. This brings to 10 the number of volcanoes under continuous, real-time surveillance by the AVO. Data and information from the AVO monitoring activities are integrated directly into the regional operational activities of the FAA, DOD, and NWS to provide warnings for pilots and aircraft operators in the Alaskan region.

The Survey also carries out research in past climate change, regional hydrology, the carbon cycle, coastal erosion, volcanic activity, and glaciology. As part of its glaciology program, the Survey continues to measure the winter snow accumulation, summer ice ablation, and net balance on three glaciers representative of different climatic zones of the western United States, one in Washington, and two in Alaska. The analysis of this 35 year long record is providing a greater understanding of the climate variability in the western United States. The Survey 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.

Bureau of Reclamation

Reclamation activities requiring the collection and use of meteorological data include water scheduling, flood hydrology, irrigation project management, and reservoir operations, as well as projects related to hydroelectric energy resources. One example of this is the Agricultural Water Resources Decision Support (AWARDS) system which integrates high-resolution NEXRAD radar rainfall estimates, surface environmental data, crop models, and quantitative precipitation forecasts, with watershed reservoir-canal systems and irrigation district water distribution systems. AWARDS provides operational support for: (1) early warnings to reduce hydrologic risk for loss of property and lives, (2) improved efficiency in canal and reservoir operations, and (3) improved efficiency in irrigation scheduling for water conservation and water quality.

Reclamation is developing a Snow Accumulation Algorithm (SAA) for the national NEXRAD WSR-88D radar network. This development is a cooperative effort with primary support from the WSR-88D Operational Support Facility in Norman, Oklahoma. The prototype SAA was successfully field tested in real-time during the 1996-97 winter at Cleveland and Minneapolis National Weather Service Forecast Offices. The SAA is being improved with data sets from all climatic regions in the Nation which have frequent snowfall. Reclamation's NEXRAD research team, in partnership with National Weather Service's River Forecast Centers (NWSRFC), is also developing calibrated NEXRAD precipitation analyses and runoff models for watersheds above facilities, such as Olympic Dam, where early warning systems are needed.

Multi-agency work on projecting potential effects of climate change and climate variability on western water resources and Bureau operations is continuing under collaborative work with the Global Water and Energy Cycles Experiment (GEWEX) Continental-scale International Project (GCIP) with NOAA's Office of

Global Programs, and the National Centers for Environmental Prediction (NCEP). The NWSRFCs provide detailed streamflow forecasts for Reclamation's operations. Of note is technology transfer effort in the Central Valley Operations Office in Sacramento, where a direct workstation link to the NWS River Forecast System and other hydrometeorological forecast products will provide Reclamation's water managers access to detailed products of immediate value to water management operations.

A Technology Advancement study in collaboration with NCEP and the National Center for Atmospheric Research (NCAR) are examining the utility of mesoscale models for simulation and prediction of extreme precipitation events. These modeling efforts are taking current technologies and applying them to very heavy precipitation events to determine maximum precipitation and better understand limits of extreme precipitation in watersheds above Reclamation facilities for safety of dams studies and early warning applications.

Currently, Reclamation's HYDROMET system collects data from approximately 400 hydrometeorological data collection platforms (DCPs) which transmit data in the "real-time" through the GOES to the Bureau'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 Bureau, Federal and state offices. Funding for Reclamation's Global Change Response Program ended in the mid-1990s. Reclamation's weather modification research program has not been funded since 1989 except for reimbursable work.

Minerals Management Service

The Minerals Management Service's Environmental Studies Program gathers offshore environmental data in support of mineral leasing responsibilities. Currently, the Service supports five data buoys which transmit via NOAA satellites from offshore. Wind data are used in the Service's Oil Spill Risk Analysis Model to predict effects of potential spills.

MMS also is collecting meteorological and air quality data within the Breton National Wildlife Refuge, off Louisiana. The data are collected for the purpose of assessing air quality impacts from pollutant sources on the OCS. In FY 1998 MMS will start collecting data to study the atmospheric boundary layer over the Gulf of Mexico using two radar profilers placed on offshore platforms. One will be located near shore near the Louisiana/Texas border; the other in deeper waters about 100-150 km offshore. Also, hourly observations will be transmitted to the National Weather Service on a real-time basis to enhance their forecasting capabilities. MMS plans to collect three years of data.

Bureau of Indian Affairs

The Bureau of Indian Affairs collects atmospheric data to evaluate potentially irrigable Indian Trust lands in the Southwest. The Bureau also shares fire weather data with other Federal agencies while participating in fire weather forecasting at the National Interagency Fire Center.

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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 Cape Canaveral Air Station of Kennedy Space Center (KSC) and Johnson Space Center to support the Space Shuttle program. The focus is on detecting and forecasting the mesoscale weather events which strongly impact Shuttle ground processing, launches, and landing operations.

### Operations

The goal of the operations program is to provide the specialized meteorological data needed by operational forecasters at Cape Canaveral Air Station and Johnson Space Center to support the Space Shuttle program. The focus is on detecting and forecasting the mesoscale weather events which strongly impact Shuttle ground processing, launch, and landing operations. Forecasts and observations for NASA/Kennedy Space Center (KSC) are provided by Air Force meteorologists and contractors. KSC cost shares with the Air Force the expense of operating and maintaining (O&M) the Eastern Range's extensive meteorological network--KSC contributes 40 percent. KSC funds O&M of the Doppler Radar Wind Profiler (DRWP) and the Lightning Detection and Ranging (LDAR) systems.

This operations program requires exploitation of the latest technology. The Applied Meteorology Unit (AMU), collocated with the Air Force's Range Weather Operations, provides a facility to evaluate and, if warranted, transition new meteorological technology into operations. For instance, the AMU strives to develop techniques and systems to help predict and avoid the impacts of KSC's frequent mesoscale summer thunderstorms which endanger the ground processing, launch, and landing operations of the American Space Program--Space Shuttle, DOD, and commercial. Special attention has been given to evaluating mesoscale numerical models. The AMU functions under a joint NASA, Air Force, and national Weather Service Memorandum of Agreement. A major FY 1996-1997 initiative under contract is to replace the meteorological data display/analysis/distribution system, which is obsolete. The Air Force plans to pay most of the costs.

### Supporting Research

The supporting research activities are sponsored by the NASA's Office of Mission to Planet Earth (MTPE). The mission objective of the MTPE Enterprise is to understand the total Earth system and the effects of natural and human-induced changes on the global environment. MTPE is playing a crucial role in the new interdisciplinary field of research called Earth system science. This new field was born as a consequence of the recognition that the Earth's land surface, oceans, atmosphere, ice sheets and biota are both dynamic and highly interactive. It is an area of research with immense benefits to the nation, yielding new knowledge and tools for weather forecasting, agriculture, urban and land use planning, and other areas of economic and environmental importance. In concert with other agencies and global research community, MTPE is providing the scientific foundation needed for the complex policy choices that lie ahead on the road to sustainable development. MTPE has established three broad goals: (1) expand scientific knowledge of the Earth system using NASA's unique capabilities from the vantage points of space, aircraft and in situ platforms; (2) disseminate information about the Earth system; and (3) enable productive use of MTPE science and technology in the public and private sectors.

The pursuit of Earth system science would be impractical without the continuous, global observations provided by satellite-borne instruments. MTPE comprises an integrated slate of spacecraft and in situ measurement capabilities; data and information management systems to acquire, process, archive and distribute global data sets; and research and analysis programs to convert data into new knowledge of the Earth system. Numerous users in academia, industry,

federal, state and local government tap this knowledge to produce products and services essential to achieving sustainable development. MTPE is NASA's contribution to the U.S. Global Change Research Program (USGCRP), an interagency effort to understand the processes and patterns of global change.

The Earth Observing System (EOS), the centerpiece of MTPE, is a program of multiple spacecraft (the AM, PM, Chemistry series, Landsat-7, and others) and interdisciplinary science investigations to provide a 15 year data set of key parameters needed to understand global climate change. The first EOS satellite launches begin in 1998. Preceding EOS are a number of individual satellite and Shuttle-based missions which are helping to reveal basic processes. The Upper Atmosphere Research Satellite (UARS), launched in 1991, collects data on atmospheric chemistry. The Total Ozone Mapping Spectrometer (TOMS) instrument, launched in 1978 and 1991, measures ozone distribution and depletion. Two additional TOMS instruments were launched in 1996, one on the Japanese Advanced Earth Observing System (ADEOS) mission and the other on a dedicated U.S. Earth probe. The French and U.S. collaborated on the Ocean Topography Experiment (TOPEX/Poseidon), launched in 1992, to study ocean topography and circulation. The NASA Scatterometer (NSCAT), also launched on the Japanese ADEOS in 1996, maps ocean winds. In 1997, the Tropical Rainfall Measuring Mission (TRMM) will measure tropical precipitation. Complementing EOS will be a series of small, rapid development Earth System Science Pathfinder (ESSP) missions to study emerging science questions and make innovative measurements in parallel with the 15 year mission of EOS. The first ESSP mission should be ready for launch in 2000.

Data from MTPE missions, both current and future, are captured, processed into useful data products, and broadly distributed by the EOS Data and Information System (EOSDIS). EOSDIS will ensure that data from these diverse missions will remain available in active archives for use by current and future scientists. Since these data are useful beyond the Earth system science research community, EOSDIS will be accessible by environmental decision-makers, resource managers, commercial firms, social scientists and the general academic community, educators, state and local government--anyone who wants the information. Following the recommendation of the National Research Council, MTPE is exploring the creation of a federation of Earth science information partners in academia, industry and government to broaden the participation in the creation and distribution of EOSDIS information products.

The intellectual capital for these missions, and the key to generating new knowledge from them, is vested in an active program of research and analysis. MTPE's research and analysis program funds over 1,700 researchers from nearly every U.S. state. There are also scientists from seventeen other nations, funded by their own countries but, collaborating with U.S. researchers. These researchers develop Earth system models from MTPE data, conduct laboratory experiments, run aircraft campaigns, develop new instruments, and thus expand the frontier of our understanding of our home planet. MTPE-funded scientists are recognized as world leaders in their fields, as exemplified by the awarding of the 1995 Nobel Prize in chemistry to two who identified the threat of cholorflorocarbons to upper atmospheric ozone. The research and analysis program is also the basis for generation of application pilot programs which enable universities, commercial firms, and state and local governments to turn scientific understanding into economically valuable products and services.

In 1996, the first MTPE Science Research Plan was published. The plan lays out a strategy for study in five Earth system science areas of maturing scientific understanding and significant societal importance: land-cover and land use change; seasonal-to-interannual climate variability and prediction; natural hazards research and applications; long-term climate natural variability and change research; and atmospheric ozone research. The plan also outlines some twenty related areas of research which round out the MTPE contribution to Earth system science.

The challenges of Earth system science, sustainable development, and protection of people, property and the environment from natural disasters, require collaborative efforts among a broad range of national and international players. As mentioned above, the USGCRP coordinates research among thirteen U.S. government agencies. MTPE has extensive collaborations with the National Oceanic and Atmospheric Administration (NOAA) on seasonal-to-interannual climate prediction. MTPE is the responsible agent in NASA for managing the development of NOAA's operational environmental satellites. NOAA, NASA, and the Department of

Defense (DOD) are collaborating on a convergence of the civilian and military weather systems. MTPE collaborates with the U.S. Geological Survey (USGS) on a range of land surface, solid Earth and hydrology research. NASA, NOAA and USGS collaborate in the Landsat-7 program, and NASA, DOD and USGS are working together on a third flight of the shuttle radar laboratory modified to yield digital terrain data on most of the Earth's surface. MTPE participates in the World Climate Research Program, the International Geosphere/Biosphere Program, and the ozone assessments of the World Meteorological Organization. Most of MTPE's satellite missions have international participation, ranging from simple data sharing agreements to joint missions involving provision of instruments, spacecraft, and launch vehicles.

Upcoming activities over the next two years in the MTPE program include, in the Earth probes program, launch of the Tropical Rainfall Measuring Mission (TRMM) in late 1997. The Lewis and Clark land imaging spacecraft, developed in partnership with commercial firms, will be launched in 1997. The MTPE mission operations program will begin operations and data processing of the TRMM as well as activities for currently orbiting satellites, including TOPEX/Poseidon, UARS, NSCAT and TOMS. The experiments of opportunity program will be focused on Shuttle Imaging Radar-C (SIR-C) and launch the Measurement of Air Pollution from Satellites (Maps) on MIR, a cooperative commercial venture. Within the EOS, a preliminary design review will be held for PM-1 in 1997. Instruments for AM-1 and Landsat-7 will be delivered in 1997. The EOSDIS will release Version 1 in 1997 and prepare for the release of Version 2.

The EOSAM-1 will be launched in June 1998. This mission will provide key measurements that will significantly contribute to our understanding of the total Earth system. The AM-1 instrument complement will obtain information about the physical and radiative properties of clouds, air-land and air-sea exchanges of energy, carbon, and water, measurements of trace gases, and volcanology.

Landsat-7 will be launched no later than December 1998. Landsat-7 will carry a single instrument, the enhanced thematic mapper plus, which will make high spatial resolution measurements of land surface and surrounding coastal regions. This mission will provide data continuity with previous Landsat measurements. Landsat data is used for global change research, regional environmental change studies, national security and other civil and commercial purposes.

The Earth probes program is the component of MTPE that addresses unique, specific, highly-focused mission requirements in Earth science research. The program was designed to have the flexibility to take advantage of unique opportunities presented by international cooperative efforts or technical innovation, and to complement the Earth Observing System by providing the ability to investigate processes that require special orbits or have unique requirements. The currently approved Earth probes are the Total Ozone Mapping Spectrometer (TOMS), NASA Scatterometer (NSCAT), Tropical Rainfall Measuring Mission (TRMM), Lewis & Clark, and Earth System Science Pathfinders (ESSP).

Because winds are a critical factor in determining regional weather patterns and global climate, NSCAT has been developed to measure near-surface wind speeds and directions over the global oceans every two days, under all weather and cloud conditions. The NSCAT data will be useful for both oceanography and meteorology, and will permit the first global study of the influence of winds on ocean circulation, providing data on the effects of the oceans on the atmosphere and improved marine forecasting on winds and waves. The lead center for this program is JPL, and the main contractor for the instrument development is the Harris Corporation.

The NSCAT was launched in August 1996. When NSCAT was first initiated in October 1984, it was planned for launch aboard the Navy Remote Sensing Satellite (N-ROSS). After final cancellation of N-ROSS in March 1988, NSCAT was selected in August 1989, for flight on the Japanese Advanced Earth Observing System (ADEOS). Since a majority of the instrument design had been completed during the period that NSCAT was to fly on N-ROSS, the last few years of the program centered on making design changes to the instrument so that it could be accommodated on the ADEOS spacecraft and completing the instrument. The launch of the Japanese ADEOS spacecraft was slipped from February 1996 when the Japanese experienced anomalies with the spacecraft during integration and test. The ADEOS spacecraft was launched on a NASDA H-II rocket from Tanegashima, Japan on August 17, 1996.

The scientific objectives of the TOMS program are to measure the long-term changes in total ozone and to

verify the chemical models of the stratosphere used to predict future trends. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument (flight model 1) on Nimbus-7 and continued with the TOMS instrument (flight model 2) on the Russian Meteor-3, launched in 1991. As with the earlier developments, GSFC has the responsibility for flight project development, and post-launch mission operations and data analysis. Prime contractors are Orbital Sciences Corporation (OSC) for the TOMS instruments and Pegasus launch services, and TRW for the TOMS-EP spacecraft. The TOMS program consists of a set of instruments (flight models 3, 4, and 5, designated FM-3, FM-4, and FM-5) and one spacecraft. Launch of the EP spacecraft by a Pegasus XL launch vehicle occurred on July 2, 1996. The FM-4 launched on the Japanese ADEOS satellite on August 17, 1996. The FM-5 was completed in 1995 and is planned for a cooperative mission with Russia in 2000.

The latent heat released during precipitation is a significant factor in the large-scale computer models used to predict weather and climate change, yet two-thirds of the global rainfall occurs over the tropics where rain measurements are scarce. The TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. In addition, TRMM will provide precise estimates of the vertical distribution of latent heat in the atmosphere. The TRMM data will be used to understand the ocean-atmosphere coupling, especially in the development of El Niño events, which form in the tropics but effects of which are felt globally, causing floods in some areas, yet droughts in others. GSFC has the responsibility for flight project development, and post-launch mission operations and data analysis. The contractors for the instruments are Hughes Santa Barbara Research Center for the Visible and Infrared Scanner (VIRS), and Hughes Space and Communications for the TRMM Microwave Imager (TMI). The TRMM Phase A study was completed in July 1988, and Phase B completed in February 1991. Award of major contracts began in May 1992. The TRMM launch is planned for November 1997.

The Japanese space agency (NASDA) is an active partner with three Earth probes, providing the ADEOS spacecraft and H-II launch vehicle for the TOMS (FM-4) and NSCAT, and the Precipitation Radar instrument and H-II launch vehicle for TRMM.

The Earth System Science Pathfinder (ESSP) is a science-driven program intended to identify and develop short development time, small satellite missions to accomplish scientific objectives in response to national and international research priorities not addressed by current programs. ESSP will provide periodic "windows of opportunity" to accommodate new scientific priorities and infuse new scientific participation into the MTPE program. By launching ESSP missions on a regular basis, NASA will provide a mechanism by which pressing questions in Earth system science may be addressed in a timely fashion, permitting a continual improvement in our understanding of the Earth system and the processes that affect it.

The programmatic guidelines for the first ESSP AO were specific. The first two ESSP missions will be focused on high-priority Earth system science research, limited to a total mission life cycle cost from NASA of $60 million and $90 million respectively. They will be managed by the principal investigator as a single point of contact accountable for total mission implementation and success, developed in less than 36 months from development authority to proceed, and compatible with EOSDIS standards, including the immediate release of mission data to the scientific community.

The Lewis and Clark missions will demonstrate different land imaging capabilities and other measurements of scientific interest to MTPE. The Lewis mission is a medium resolution Hyperspectral instrument. The Clark mission is a high resolution multi-spectral imager. Both spacecraft will be launched in FY 1997. The "Clark" spacecraft is being built by CTA Incorporated of Rockville, Maryland. The "Lewis" spacecraft is being built by TRW and managed out of their Rodentia Beach, California, office. NASA is managing both projects from NASA Headquarters. Lewis will carry 25 new technologies and Clark will carry 36, including composite structures, advanced avionics and high-efficiency power systems. Lewis will also have three advanced sensors to meet the needs of the commercial remote sensing and Earth science communities: a 384-band Hyperspectral imager; a Linear Etalon Array to scan the Earth and its horizons; and an instrument to measure the Ultra-Violet UV cosmic background. Clark will have a high-resolution imager capable of 15-meter multi-spectral and 3-meter panchromatic measurements; an instrument to measure pollution in the troposphere; and an x-ray spectrometer to capture bursts from solar flares.

The "LightSAR" program is consistent with direction included in House Report 104-812 which

stipulates that NASA's FY 1998 budget request should include additional funding to accomplish this program. The "LightSAR" program is currently one of the missions competing for possible funding under NASA's Earth Systems Science Pathfinder (ESSP) program and may also compete in the upcoming MTPE Data Purchase solicitation.

This program offers a unique capability to undertake short duration flights of instruments on the Space Shuttle and other platforms. The MTPE program has used the capability of Shuttle/Spacelab development in the important areas of design, early test and checkout of remote sensing instruments for free flying missions, and short term atmospheric and environmental data gathering for scientific analysis. Instrument development activities have supported a wide range of instrumentation, tailored for Space Shuttle and airborne missions.

The goal of applied research and data analysis is to advance our understanding of the global climate environment, the vulnerability of the environment to human and natural forces of change, and the provision of numerical models and other tools necessary for understanding global climate change.

The applied research and data analysis program is divided into two major components: MTPE science and MTPE operations, data retrieval, and storage. The activities that report MTPE science include research and analysis, EOS science, airborne science and applications, commercial remote sensing and Uncrewed Aerial Vehicle (UAV) science program. Operations, data retrieval and storage consists of several independent activities responsible for the operation of currently functioning spacecraft and flight instruments, the purchase and management of scientific data, high performance computing and communications, and the provision of computing infrastructure. Each of the major components of applied research and data analysis has its own set of goals, strategies for achieving goals, performance measures, and accomplishments and plans.

The goal for the MTPE science program is to contribute to the integration of the Earth and environmental sciences into an interdisciplinary scientific understanding of the Earth system and the effects of human-kind on the global environment. Major emphasis is placed on providing early warning and fast response to global environmental changes which pose risks to society. The science program also provides the analysis and integration of critical data and models needed for national and international assessments. An objective of current planning is to achieve the most essential long-term objectives of EOS, and to increase effort on science with near-term payoff, within a sustainable level of funding. The observational program will become resilient, better, and cheaper in the future by (1) taking advantage of the experience being gained in preparation of the first round of EOS flight missions to reduce observing requirements in the future and to simplify the design of instruments for more cost-effective continued operation, (2) finding alternative means to carry out some of the essential measurements at the same level of quality through cooperation with other agencies and nations, and (3) infusing new ideas and technologies into the EOS program through small satellite missions which have lower infrastructure and flight costs.

The Research and Analysis (R&A) science program is essential to the discovery of new concepts and to the design of future missions. The primary mode of research coordination occurs through the USGCRP, the Committee on the Environment and Natural Resources (CENR) Subcommittee on Global Change Research, and the various boards and committees at the National Academy of Sciences.

The strategy of interdisciplinary research is to increase scientific understanding of the global environment and its vulnerability to both human and natural forces of change (e.g. pollution, climate variability, deforestation). Viewing the Earth from space is essential to comprehending the cumulative influence of human activities on its natural resource base. An important priority is to provide accurate assessment of the extent and health of the world's forest, grassland, and agricultural resources. Observations from space are the only source of objective information on the human use of land in a time of rapid land use change. A related priority is to improve understanding and prediction of seasonal-to-interannual climate variation. Reducing uncertainties in climate predictions to a season or a year in advance will dramatically improve agriculture and energy planning. In addition, the natural hazards research priority places emphasis on the use of remote sensing observations for the characterization and mitigation of drought and flood impacts. There is increasing evidence that predictions of extreme weather events can be improved by understanding their links to interannual climate phenomena like El Niño events. Special attention in measuring and modeling the relative forces

like clouds, aerosols and greenhouse gases in long-term climate change, in order to improve our understanding of and prediction of climate on time scales of decades to centuries. A continuing priority is understanding the causes and consequences of changes in atmospheric ozone. Efforts are continuing to make excellent progress on resolving questions related to stratospheric ozone depletion. Emphasis is now being placed on the changing composition of the lower atmosphere, which is sensitive to the unprecedented growth of pollutant emissions in rapidly developing regions throughout the world. Work will continue in the core research programs in MTPE. These programs provide the disciplinary strength that we draw from to solve interdisciplinary priority problems.

EOS interdisciplinary science consists of focused research centered around a specific Earth science data set and interdisciplinary research geared toward a broader probe into Earth science systemic functions. The quality of data utilized is monitored by the scientists at interdisciplinary instrument computing facilities and the research is supplemented by graduate student participation in the EOS science fellowship program.

There are currently over 1,700 scientific activities being funded under the research and analysis program. Approximately 900 are carried out by universities, 100 by national research laboratories, and 700 by the federal government. The distribution of the activities encompasses forty-five of the fifty states.

The airborne science program funds operations of two ER-2's and a DC-8 aircraft. A C-130Q is needed to support selected Earth science investigations. The program also funds operation and support of a core of remote sensing instruments and a facility for analyzing and calibrating data from those instruments. The specifically modified aircraft serve as test beds for newly developed instrumentation and their algorithms prior to spaceflight. The instrumented aircraft provide remote sensing and in situ measurements for many Earth science research and analysis field campaigns, including stratospheric ozone, tropospheric chemistry, and ecological studies throughout the world. The ER-2 aircraft, in particular, are unique in that they are the highest flying subsonic civilian research aircraft and were key in collecting in situ data for our understanding of ozone depletion and stratospheric transport mechanisms.

The Commercial Remote Sensing Program (CRSP), transferred from the Office of Space Access and Technology, will continue to fund cooperative efforts with industrial partners aimed at enabling development of a viable commercial remote sensing industry. The cooperative effort will work to apply space-based data and instrument technology in the development of usable, customer-defined information products. Industry will make significant co-investments, funding the CRSP at about an equal level with NASA.

The Uncrewed Aerial Vehicle (UAV) science program, a new initiative beginning in FY 1997, will augment the MTPE airborne program by making in situ and remote sensing measurements initially focused on the atmosphere; staying over a target for extended periods to measure detailed temporal changes, provide unique views of cloud structures and provide calibration and verification of MTPE's satellite instrumentation. During FY 1997 an AO will be initiated for the selection of three or four scientific investigations carried out using commercially available UAV flight time.

The advanced geostationary studies will investigate the application of the latest technology in developing small compact geostationary satellites that will support both research and operational objectives. For example, one candidate under consideration has the capability to provide the first adequately calibrated observations from geostationary orbit that support climate research. The satellite and instrument would be developed over a four year time period. The first spacecraft would carry an imager and a second spacecraft would carry a sounder. The imager has spectral bands which provide data on cloud albedo, vegetation, cirrus clouds, cloud ice, limited ozone, and both high-level and low-level water vapor along with total water vapor. This would provide stable measurements for MTPE research that have previously been unattainable from geostationary orbit.

In FY 1997, NASA will initiate a data purchase program designed to acquire from commercial sources data sets not otherwise available that are necessary to accomplish broad research goals of Earth system science. The budget authority will be liquidated only as acceptable data is delivered and the proposed contract(s) will be executed with FY 1997 funds only after a broad, agency competition. The purchase will be managed by the Stennis Space Center. A RFP will be issued in FY 1997 to solicit data purchase proposals. It is anticipated that selection of more than one activity will occur. Such innovative methods of procurement were suggested in the Vice President's National Performance Review. Data product generation, data

archival, science analysis, and all other NASA requirements are included in other elements of the MTPE budget.

In FY 1996, continuing into FY 1997 and FY 1998, the following are significant accomplishments in the five priority areas MTPE science is focusing: land cover/land use change, seasonal-to-interannual climate variability, long-term climate system variability, natural hazards, and atmospheric ozone.

Land Cover/Land Use

Major progress was made in characterizing the role of the northern forests as a control on water, heat, and momentum transfers between the surface and the lower atmosphere during the Boreal Ecosystem-Atmosphere Study (BOREAS). Data has since been introduced into experimental weather prediction models significantly improving skill in predicting regional weather.

Seasonal-to-Interannual Climate Variability

Progress continues on forecasting of El Niño events. A study was completed in FY 1996 at GSFC that documented the critical importance of accurate characterization of soil moisture for accurate predictions of global precipitation patterns.

Long-Term Climate System Variability

Global observations by the SAGE and the ERBE provided a unique understanding of the climate effects of the Mount Pinatubo volcanic eruption. The NASA-Goddard Institute for Space Studies (GISS) climate model produced a prediction of effects of Mount Pinatubo aerosols on surface temperature which showed excellent agreement with subsequent observations. Analysis of data obtained on the LIDAR In-Space Technology Experiment (LITE), using the Shuttle, demonstrated the capability of space-based LIDAR to improve significantly global measurements of both natural and anthropogenic aerosols. A national network, the Solar Irradiance Research Network, of aerosol measurements has been initiated at ten secondary schools nationwide.

Natural Hazards

Recent research has demonstrated the utility of SAR for accurate documenting changes in topographic features of the earth's surface. MTPE is implementing with other government agencies a high density global positioning system geodetic array in southern California to measure surface deformation produced by underlying geological faults. Preliminary design research for a "LightSAR" is investigating optimal mission characteristics for supporting the science of SAR interferometry as a method of surface change detection.

Atmospheric Ozone

Analysis of global data from the UARS confirmed that ozone depleting chemicals reaching the stratosphere are primarily of industrial origin. New analysis techniques developed for the TOMS provided the first global data set on surface UV radiation. These results provided the first confirmation of global trends in increasing UV radiation related to ozone depletion. The two TOMS that were launched in FY 1996 (TOMS-EP and TOMS-ADEOS) will provide data for continued ozone and UV trends determination with improved resolution and precision.

## ENVIRONMENTAL PROTECTION AGENCY

The 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 meteorological programs to support regulatory applications. Applied research and meteorological support is furnished primarily by EPA's National Exposure Research Laboratory in Research Triangle Park, North Carolina, through an interagency agreement with the National Oceanic and Atmospheric Administration (NOAA), which provides approximately 50 research meteorologists to the EPA.

Meteorological support to the EPA Office of Research and Development, the EPA Office of Air and Radiation, the EPA regional offices, and to state and local agencies includes: (1) development and application of air quality dispersion models for pollution control, direct and indirect exposure assessments, and strategy creation; (2) preparation and performance of dispersion studies and air quality model evaluations; and (3) review of meteorological aspects of environmental impact statements, state implementation plans, and variance requests. Meteorological expertise and guidance are also provided for the air quality standard, modeling guideline, and policy development activities of the EPA.

In light of the 1990 Amendments to the Clean Air Act, air quality models and the manner in which they are used are expected to evolve considerably over the next few years. In the area of pollutant deposition, the evaluation of nitrogen and oxidant chemistry, in addition to sulfur chemistry, will clarify the roles of model formulation, cloud processes, radiative transfer, and surface/vertical 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 proposed revisions to the 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 inhalable particulate model development, dispersion models are being enhanced to accurately predict aerosol growth from precursors over regional and local transport distances. To assist in the evaluation of the contribution of various sources to regional air degradation, inert tracer and tagged species numerical models are being 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 the particular source could be isolated.

With respect to oxidant air quality modeling, the roles of biogenic volatile organic compounds, rural nitrogen oxides, and vertical transport will be elucidated. A better understanding will be developed of the fundamental aspects of the ozone nonattainment problem such as differences in urban and rural rates of and/or sources of photochemical production and the interaction through transport of these ozone precursors. Much of this research will be performed under the program entitled North American Research Strategy on Tropospheric Ozone (NARSTO).

Atmospheric research in the areas of climate and climate change includes ozone distribution in the global troposphere, the relationship between that ozone distribution and climate (including temporal and spatial aspects), and regional climate studies addressing the interaction of climate with the biosphere. The climatology program involves both analytical and statistical climatology as well as support for regional-scale climate model development. Climate change issues and their feedbacks with the biosphere are being stressed.

Research in human exposure modeling includes microenvironmental monitoring and modeling, and development of exposure assessment tools. Microenvironmental 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 microenvironmental simulation models for conducting human exposure assessments within enclosed spaces in which specific human activities occur.

In addition to these 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, and regional. Other efforts include construction and application of air pollution climatologies; modeling of agricultural pesticide spray drift and of fugitive particles from surface coal mines; modeling of trace metal deposition to the Great Lakes, nutrient deposition to Chesapeake Bay, and mercury deposition to the Florida Everglades; modeling of accidental releases of toxic compounds forming dense gas clouds and of open burning/open detonation of surplus military munitions; determination and description of pollutant effects on atmospheric parameters; and conversely, determination of meteorological effects on air quality. Measurement data obtained during field programs and from wind tunnel and water channel/towing tank experiments in the EPA Fluid Modeling Facility will be used to continue development and evaluation of these models in the FY 1998-1999 period, along with developing models for pollutant dispersion around natural and manmade obstacles.

EPA participation in the interagency High Performance Computing and Communications (HPCC) Program is enabling increased efficiency in air quality meteorological modeling through research on parallel implementation of the Mesoscale Meteorological Model (MM5), with the subsequent transfer of these achieved efficiencies to the user community. The HPCC Program is also developing a flexible environmental modeling and decision support tool (Models-3) to deal with multiple scales (urban to regional) and multiple pollutants simultaneously, thus facilitating a more comprehensive and cost effective "one atmosphere" approach to related single-stressor and multi-stressor human and ecosystem problems. Models-3 provides a framework to support the constant evolution of environmental models to handle more complex issues such as fine particulates, visibility, toxic pollutants, and multi-media (air and water) environmental assessments in an integrated manner.

The EPA is a participant in the United States Weather Research Program (USWRP), mainly by providing research-in-kind in the area of meteorological simulation modeling on local, meso, and regional spatial scales of pollutants from fossil-fueled power plants, vehicle exhausts, and other emissions sources. The detailed understanding and modeling of the mesoscale circulations that control the atmospheric dispersal of these pollutants will also be applied to coping with accidental releases of toxic or radioactive materials.

The EPA also maintains relations with foreign countries to promote exchange of research meteorologists and research results pertaining to meteorological aspects of air pollution. One of the most active areas of cooperative research is with Russia under the 1972 Nixon-Podgorny Agreement forming the US/USSR Joint Committee on Cooperation in the Field of Environmental Protection and under the 1993 Gore-Chernomyrdin Agreement forming the US/Russia Commission on Economic and Technological Cooperation. Other agreements are in place with Canada, Japan, China, Mexico, and several European countries.

## DEPARTMENT OF STATE

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 global warming. 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.

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 130 countries (including the United States), representing 99 percent of the world's production of ozone depleting substances.

The IPCC, which is jointly sponsored 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 the state of scientific, technical, and economic information regarding climate

change. The IPCC is currently organized in three working groups, examining: (1) the state of the science; (2) impacts and possible response strategies, including mitigation and adaptation; and (3) economics and other cross-cutting issues. The IPCC released its first assessment report in 1990; supplementary reports were released in 1992 and 1994. A full second assessment report from each of the working groups was scheduled for publication in late 1995.

The Framework Convention on Climate Change was negotiated beginning February 1991; the convention was open for signature in Rio de Janeiro at the Earth Summit in June 1992. As of April 1995, it had been ratified by 129 countries, including the United States. The first meeting of the Conference of the Parties to the Convention was held in Berlin in March/April 1995. The convention calls for all countries to develop inventories of their emissions and sinks of greenhouse gases and calls upon developed countries to aim to return these emissions to their 1990 levels by the year 2000. At its first session, the conference decided to begin negotiations on next steps under the convention to elaborate policies and measures and to set quantified limitation and reduction objectives for greenhouse gases.

In addition to its primary role in the fora listed above, DOS is active on the Committee on Environment and Natural Resources (CENR) of the National Science and Technology Council (NSTC). The CENR was established in 1993 to coordinate scientific domestic programs. 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.

## NUCLEAR REGULATORY COMMISSION

The U.S. 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, reviews of facility siting, design, construction and operation are conducted by the Office of Nuclear Reactor Regulation and the Office of Nuclear Material Safety and Safeguards. These reviews include consideration of meteorological factors. The NRC Office for Analysis and Evaluation of Operational Data and the NRC Regional Offices assure that commitments by NRC applicants, permittees and licensees are carried out, and also conduct NRC responses to nuclear facility emergencies. The Office of Nuclear Regulatory Research develops regulations, guides, criteria, and other standards related to the protection of public health and safety and the environment in the licensing and operation of nuclear facilities. This Office also develops and conducts confirmatory research programs in support of activities of the other Offices and in support of rule-making and standards activities.

The primary meteorological area in which the NRC will have an interest during FY 1998 and beyond is improvements in the meteorological capabilities of the NRC and the operators of nuclear facilities to cope with emergencies involving the unplanned releases of radioactive materials. The NRC also maintains an interest in the transport and dispersion of airborne, hazardous non-radioactive materials and their potential effects on the safe operation of nuclear facilities.

## DEPARTMENT OF ENERGY

For nearly 50 years, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission and the Energy Research and Development Administration, have supported meteorological operations and atmospheric research at the DOE field offices. The need for meteorological services began with the development, fabrication, and testing of atomic weapons and the national security and safety issues associated with them. In addition, environmental protection legislation specifies requirements for meteorological services to protect public health and safety and the environment.

The Department of Energy (DOE) addresses many areas relating to energy efficiency use and resources, improved environmental quality and a secure national defense. Atmospheric science research and operations have been an integral part of DOE since the cold war era. Even today's global climate change debates and outcomes are relying on information collected through basic atmospheric science research programs that one day will reduce substantial uncertainties in these areas. It is vital to understand the nature of the atmospheric domain with its various dynamic and chemical aspects of energy-related phenomena.

DOE coordinates programmatic activities throughout its various Offices such as Defense Programs, Energy Research, Environmental Management and Energy Efficiency and Renewables. These Offices are responsible for the management of scientific research programs such as Atmospheric Release Advisory Capability (ARAC), Global Climate Change Research and various clean up activities at former cold war production sites.

Meteorological services at DOE facilities range from complex research to daily operational support. Some examples of research are investigations of potential global climatic change, ultraviolet and infrared radiation studies, and studies of atmospheric boundary layer processes. Operational support includes daily weather forecast services, special project support, on-site meteorological monitoring, climatological services, and emergency response assistance. Some sites maintain 24-hour weather watches for severe weather conditions that could impact site operations, damage property, or threaten lives.

Several DOE field offices cover large areas, and some sites contain complex topography and heterogenous surface characteristics, creating locally driven conditions that influence on-site weather. For these reasons and to protect the environment and public health and safety, on-site meteorological monitoring has been and remains an essential part of DOE atmospheric science programs.

Some DOE sites contribute to the national weather observing network by taking standard surface and upper-air observations. Many of these sites are in remote areas where weather observations would be sparse if not for the presence of DOE meteorological monitoring programs. Weather observations taken at several DOE field sites are entered to the national weather database via the NWS Automation of Field Operations and Services (AFOS) system--the NWS' primary meteorological data distribution and display system. AFOS also 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). DOE facilities with AFOS units are connected to the NWS AFOS network through NOAA's Air Resources Laboratory (ARL) that supports the DOE/Nevada Operations Office in Las Vegas, Nevada, which serves as the hub for the NWS/DOE AFOS network.

An accidental release of radioactive or toxic material into the atmosphere can have potentially serious health and environmental consequences. Meteorological processes play a key role in determining the fate of pollutants released into the atmosphere. For example, the processing, fabricating, and underground testing of nuclear weapons all have the potential for industrial accident scenarios. In addition to these activities, the use of nuclear material in the generation of electric power and the storage of nuclear waste from power generation, weapons' complexes, and medical and commercial processes are all potential sources of nuclear material that could be accidentally released into the atmosphere. Consequently, a central theme within the DOE community has been to protect public health, safety, and the environment on and around DOE facilities. Therefore, DOE has required and supported on-site meteorological monitoring, directed the development of emergency response capabilities at DOE facilities, funded research on the modeling of the transport, dispersion,

deposition, and resuspension of radioactive and toxic materials, and advocated on-site weather forecasting services tailored specifically for the special operational and emergency management requirements at each DOE facility. Much of the research and most of the operational support has been provided by the atmospheric research programs at the six major field offices directly involved in national defense programs. Over the years, these programs have grown to address many environmental, safety, and health issues. Due to the complexity of these activities, it was recognized that efforts should be made to coordinate meteorological operations and research among the field offices to enhance cost effectiveness.

Based on a need to facilitate more coordination and cooperation among the meteorological activities at the DOE field offices, the DOE Meteorological Coordinating Council was created in 1994. The mission of the council is to coordinate meteorological support and research to meet DOE objectives. The objectives of the council are to: (1) promote cost-effective support for all DOE facilities; (2) plan for future needs, requirements, and missions; (3) advocate awareness of atmospheric science applications and benefits to DOE; and (4) facilitate the use of common methods, procedures, and standards. The council is composed of senior DOE personnel and managers of DOE meteorological programs. The following narrative highlights the meteorological activities of the DOE sites.

The Idaho National Engineering Laboratory (INEL) 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. Meteorological services and supporting research are provided by ARL's Field Research Division (FRD) with the mission to support emergency response exercises and INEL operations with meteorological data, weather predictions, dispersion calculations, and consultation. 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 the model improvement. They are recognized for their unique field experimentation capabilities, for expertise in conducting tracer studies, and for using direct and remote sensing technologies in support of tracer experiments.

To meet other mission requirements, ARL/FRD operates and manages a large meteorological monitoring network to characterize the meteorology and climatology of the INEL site. The network consists of 30 wind towers that provide wind and temperature data. The overall Meteorological Monitoring Program is designed to provide representative data for the INEL area to meet specific operational and potential emergency response situations. Most towers are 15 meters tall; however, four towers range from 45 to 75 meters in height. All towers are instrumented at multiple levels. Eleven have relative humidity, precipitation, and solar radiation sensors. Continuous wind and temperature profiles are obtained from a 915 MHz Doppler wind profiler and a Radio Acoustic Sounding System (RASS). Wind profiles generally extend to 5,000 feet above ground; temperature profiles extend to 1,500 feet. All meteorological data are quality-controlled and archived for future use. Additional use of this database is made in operational weather forecasts tailored to meet INEL and contractor requirements and to prepare climatological summaries that are distributed to users.

DOE operations at the Nevada Test Site (NTS) are managed by the Nevada Operations Office (NV). NTS is the Nation's underground nuclear weapons testing facility and occupy 1,350 square miles of south central Nevada. The topography of the NTS is complex with a system of dry lake beds and mountains. Elevations range from nearly 2,700 feet above mean sea level (MSL) to 7,600 feet MSL; the climate is arid.

Meteorological services are provided by ARL's Special Operations and Research Division (SORD). Over the last 40 years, ARL/SORD personnel have built a solid technical reputation in meteorological operations in the nuclear weapons testing arena. They are recognized for expertise in the transport, dispersion, and deposition of radioactive materials and for developing a rapid emergency response capability for the unlikely occurrence of an accident resulting from the release of radioactive material into the atmosphere.

Both basic and applied research are 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 (fallout), and resuspension of radioactive and/or toxic materials.

ARL/SORD provides full meteorological support to all DOE/NV operations on and off the NTS. The staff is responsible for conducting a modern program in support of nuclear and non-nuclear projects authorized by NV. Furthermore, ARL/ SORD provides technical support to the NV emergency preparedness and response activities, operates a thorough meteorological monitoring program for the NTS, and provides meteorological and climatological services required in

support of NV and contractor programs at the NTS and elsewhere, as necessary. ARL/SORD personnel also consult with senior scientists and engineers at the DOE National Laboratories, NASA, private contractors, EPA, USGS, USFS, and other NOAA laboratories.

The SORD meteorological monitoring network consists of thirty-one 10-meter towers and two 30-meter towers. Wind direction and speed are 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 microcomputers to create graphics products for operational use and for immediate display at 15 minute intervals.

ARL/SORD is the DOE node for distribution of NWS AFOS products. Other weather products supplied to DOE contractors, the National Laboratories, NWS, and Nellis Air Force Base include real-time cloud-to-ground lightning flash graphical products and local forecast products. ARL/SORD also provides meteorological monitoring support and weather forecast services to Nuclear Emergency Search Team (NEST) and Federal Radiological Monitoring and Assessment Center (FRMAC) 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 operations and personnel, issuing site-specific, mesoscale wind, stability, and weather forecasts, and providing consultation to the on-scene commander and to National Laboratories personnel.

The DOE Oak Ridge Operations Office (OR) is located on nearly 100 square miles of hilly and heavily vegetated terrain in eastern Tennessee and is supported by ARL's Atmospheric Turbulence and Diffusion Division (ATDD). ARL/ATDD's primary mission is atmospheric 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. The program is organized around three ARL-wide themes: air quality, emergency preparedness, and climate variability. The objectives are: (1) to develop better methods for describing atmospheric transport, diffusion, and air-surface exchange in numerical simulations; (2) to extend the applicability of these techniques to non-ideal situations such as non-stationary conditions, complex terrain, and nonhomogeneous vegetation; and (3) to develop and test improved numerical models incorporating these new methods. Most ARL/ATDD programs are air quality-related. They include studies of complex terrain flows, Lagrangian stochastic dispersion modeling, the behavior of the nocturnal boundary layer, and -- of increasing interest to decision makers -- model uncertainties. Surface energy balance and $CO_2$ exchange studies are related to questions of global climate, and therefore cover a wide range of ecosystems ranging from the temperate to the Arctic; long-term studies of $CO_2$ exchange aimed at process-level understanding have been under way at the Walker Branch Watershed forest in Oak Ridge for several years. Special experimental capabilities include portable automated solar-powered systems to directly and continuously measure air-surface exchange of momentum, heat, water vapor, and $CO_2$, along with local surface energy budgets, and a unique approach to measuring such exchanges from low-flying light airplanes to explore spatial variability of the data at low cost. Recent emergency preparedness activities include independent evaluations of atmospheric dispersion models for several agencies, and the design and co-management of large tracer dispersion studies. Activities aimed at climate variability include the daily operation of NOAA's integrated solar irradiance study (ISIS) network that provides long-term data on incoming solar radiation and surface radiation balance at sites across the U.S. Research programs are undertaken with the assistance of personnel of the Energy/Environment Systems Division of Oak Ridge Associated Universities (ORAU), and in close collaboration with scientists from Oak Ridge and other National Laboratories and from other government agencies, universities, and research organizations in the U.S. and abroad.

Operationally, ARL/ATDD personnel provide meteorological consultation and supplemental data to local OR users for air quality analyses, environmental reports, and emergency preparedness. Local climatological data are routinely collected and distributed. Under NOAA funding, ARL/ATDD operates a regional tower network of 15 sites ranging from the Cumberland mountains to the west of Oak Ridge to the Smoky Mountains on the east; wind, temperature, and precipitation data are recovered every 15 minutes by telemetry and made available to users. ARL/ATDD also works closely with the ORAU to enhance educational opportunities in atmospheric science.

Meteorological services to the DOE Richland Operations Office has been provided by Battelle Pacific

Northwest Laboratories (PNL) for nearly 50 years. Not only has operational support been provided, but also supporting research into atmospheric processes has been a key part of PNL's support to DOE-Richland. The facility covers 560 square miles within the arid and sparsely vegetated Columbia River basin in southeaster Washington. Key DOE research activities at PNL's Environmental Science Research Center include the Global Change Research Program (GCRP), the Atmospheric Radiation Measurement (ARM) program, the Atmospheric Chemistry Program (ACP), the Core Carbon Dioxide Research program, the Computer Hardware Advanced Mathematics and Model Physics (CHAMMP) program and the Mexico City Air Quality Study.

GCRP focuses on the study of basic geophysical processes and development of databases that are critical for understanding global and regional climatic change. The ARM program is designed to characterize empirically the radiative processes in the atmosphere with high spatial, temporal, and spectral resolution and accuracy at four to six climatologically important sites distributed worldwide. The goal of the CHAMMP program is to produce a climate modeling system having 10,000 times the capacity of the current generation of models and computers. In addition, carbon dioxide emissions research is aimed at providing a scientific basis for forecasting future emissions of carbon dioxide and other radiatively important gases.

PNL's Meteorological and Climatological Services Project (MSCP) office provides meteorological monitoring and operational support. The monitoring system consists of an array of twenty-three 10-meter towers and three 60-meter towers instrumented with temperature and wind direction and speed sensors. Data from this network are transmitted via UHF radio to a computer that decodes the data and plots graphics products for immediate display and use by Hanford Meteorological Station personnel. Other meteorological data are received via the NWS/DOE AFOS network. Meteorological services include emergency response functions, weather forecasting for on-site operations and special projects, and climatological support. MSCP support to the Hanford site includes: (1) extensive data acquisition via a site-wide meteorological monitoring network, (2) around-the-clock weather forecasting services, (3) hourly surface observations, 6-hourly synoptic observations, and twice-daily pilot balloon releases, and (4) monthly and annual climatological data summaries, plus meteorological input to annual environmental reports.

Support to the Rocky Flats Office (RFO) is provided by EG&G, Rocky Flats, Inc. This facility is located along the eastern slopes of the Rocky Mountains, approximately 15 miles northwest of Denver, Colorado, and is one of the smaller sites, covering only 10 square miles. Part of the former Rocky Flats nuclear weapons facility has been transformed into the National Wind Technology Center as a research facility to aid industry in developing advanced wind energy systems for the future.

EG&G scientific and technical personnel provide meteorological and climatological services in support of RFO site operations. Weather forecasts are issued twice daily to support on-site operations and other weather-sensitive activities. A constant weather watch is maintained during routine working hours for severe thunderstorms, lightning, winter storms, and strong winds. In addition, EG&G manages and operates a meteorological monitoring program that uses local NOAA/ERL meteorological data. They also conduct dose assessments, run dispersion models, and support an emergency response preparedness program. The Colorado Department of Public Health has formally approved the Rocky Flats emergency response program. On-site meteorological monitoring is provided by wind and temperature data collected from a 60-meter tower. This tower is equipped with standard meteorological sensors at the surface, 10 meters, 25 meters, and 60 meters above the ground. Data are transmitted to the forecast office and to the Emergency Operations Center every 15 minutes. These data are also archived for future use. EG&G plans to have a SODAR/RASS system operationally on-site, and there are plans to access meteorological data from five Colorado Department of Public Health and Environment 10-meter towers near the plant.

The Savannah River Operations Office (SR) is located in extreme southwestern South Carolina, along the banks of the Savannah River. The Savannah River Site (SRS) covers an area of approximately 300 square miles and is managed by the Westinghouse Savannah River Company--the primary producer of tritium for use in nuclear weapons. The climate is typical of the southeastern U.S. with hot, humid summers and mild, wet winters. SRS is heavily vegetated with evergreen trees and contains many streams, a swamp, and a 2,700-acre reservoir built as a cooling pond for the plant reactors.

Support to SR operations is provided by the Westinghouse Savannah River Meteorological Program and includes daily weather forecast services for the SRS.

Meteorological data is obtained from a local network of eight 200-foot towers with sensors at the 200-foot level, a 200-foot tower instrumented at four levels, and a 1,000-foot tower. Additional local upper-air data are collected from three acoustic Doppler radars, a Beukers rawinsonde system, and an airsonde and tethersonde system. Other meteorological data are received via the NWS/DOE AFOS network. Research on atmospheric transport and dispersion is also conducted to provide SRS with the best modeling capability available to support emergency response operations and other programs.

The Lawrence Livermore National Laboratory (LLNL) is operated by the University of California for the DOE Oakland Operations Office. Within the LLNL Environmental Programs Directorate, the Atmospheric Sciences Division (ASD) conducts research on climate and weather processes on regional to global spatial scales. At the regional scale the focus is to develop advanced models for accurately predicting the transport, diffusion, deposition, transformation, and atmospheric effects of accidental releases or pollutants. On the global scale, ASD researches the mechanisms of global environmental and climate change through the development and diagnosis of state-of-the-art models that represent key processes affecting the atmosphere, oceans, and biosphere. Two major programs within ASD include PCMDI and ARAC.

The Program for Climate Model Diagnosis and Intercomparison (PCMDI) develops and distributes software tools to facilitate model diagnosis and intercomparison, documents the features of models that are in use by the world climate community, and archives extensive collections of model output data. The Program also provides quality global observational products for application as model validation data.

The Atmospheric Release Advisory Capability (ARAC) Program is a centralized national resource responsible to the U.S. Department of Energy (DOE), the U.S. Department of Defense (DOD), and other federal agencies under the auspices of the Federal Radiological Emergency Response Plan (FRERP). ARAC's mission 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. ARAC supports all elements of the DOE Emergency Preparedness and Response Program, including the Nuclear Emergency Search Team (NEST), the Accident Response Group (ARG), the Federal Radiological Monitoring and Assessment Center (FRMAC), and the Radiological Assistance Program (RAP).

ARAC maintains and operates the ARAC Emergency Operations Center that consists of redundant computer systems with uninterruptable power, automated continuous worldwide meteorological data acquisition, detailed worldwide terrain and geographic mapping databases, and a suite of three-dimensional, complex terrain, atmospheric dispersion models prepared to assess explosions, fires, vents, spills, or other releases of radiological or hazardous material. The ARAC Center is staffed by meteorologists and computer technicians with 24-hour on-call response. Part of the ARAC Program provides on-site and off-site emergency response services to about 40 DOE and DOD facilities around the U.S. via a dedicated Site Workstation System linked to the ARAC Center at LLNL. Each Site Workstation also collects on-site meteorological data from one or more towers. The response time for the delivery of an initial ARAC assessment is less than 15 minutes for a computer-linked site and 45-90 minutes for a non-computer-linked site.

## FEDERAL EMERGENCY MANAGEMENT AGENCY

The Federal Emergency Management Agency (FEMA) is the central agency within the federal government responsible for emergency preparedness training and exercises, mitigation, response, and recovery. Working closely with state and local governments, FEMA funds emergency programs and offers technical guidance and training. FEMA also coordinates federal disaster relief resources in a catastrophic disaster. These coordinated activities ensure a broad-based program to protect life and property and provide recovery assistance after a disaster. The agency was formed in 1979 by Presidential Executive Order 12127, replacing five former agencies and consolidating the Nation's emergency-related programs, including meteorological emergencies.

In carrying out its role, FEMA 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, FEMA publishes Flood Insurance Rate Maps for all flood-prone communities, which serve as the official demarcation for flood risk. FEMA also publishes hurricane evacuation maps based on model simulation results from NWS's National Hurricane Center for regions subject to hurricanes.

FEMA's priority interests with the Office of the Federal Coordinator for Meteorology (OFCM) are 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. FEMA 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. For meteorologically-related matters, the Hazard Identification and Risk Assessment Division, Mitigation Directorate, is the principal contact point within FEMA. (FEMA Web Site: *www.fema.gov*)