DEPARTMENT OF ENERGY OPERATIONAL AND RESEARCH WEATHER PROGRAMS

For almost 60 years, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), have established and supported meteorological operations and atmospheric research at the DOE field offices. The need for meteorological services began in 1944 with the development, fabrication, and testing of atomic weapons and the national security and safety issues associated with them. Meteorological program requirements were subsequently augmented, starting in the late-1960's, by the passage of environmental protection legislation under 40 CFR, which is enforced by the Environmental Protection Agency (EPA), and by several DOE Orders that specify requirements for meteorological services to protect public health and safety and the environment. Quality-assured meteorological data is an important element of a DOE Integrated Safety Management System (ISMS) since it supports the development of Authorization Basis (AB) safety documentation, the consequence assessments of an emergency management system, and the preparation of environmental compliance activities.

The Department of Energy (DOE) continues to address its mission areas of national security, science and technology, energy security, and environmental quality. Atmospheric science research and operations have been an integral part of DOE and its predecessor agencies since the cold war era. It is vital to understand the processes of the atmospheric domain in order to enhance predictive capabilities, particularly to understand how various atmospheric energy-related phenomena interacts with the ocean and terrestrial systems. 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.

DOE coordinates programmatic activities throughout its various offices such as the Office of Science (SC), Defense Programs (DP), Environmental Management (EM), and Energy Efficiency and Renewables (EE). At its core, DOE is a science agency. DOE is the third largest government sponsor of basic research, following the National Institutes of Health and the National Science Foundation. DOE has principal responsibility for basic research in high-energy physics, nuclear physics, and fusion energy sciences. DOE also supports important research in the material science, biology, chemistry, nuclear medicine, global climate change research, and computational science. The Office of Science underpins the applied research and development conducted throughout DOE. The Office of Biological and Environmental Research (BER) has been a member of the Office of the Federal Coordinator for Meteorology (OFCM) since the early eighties, and it is with this tradition that BER participates and supports the various DOE-mission-related activities of the OFCM.

Over the years, there has been some examples of technology transfer from research to operations, such as some of the science associated with DOE's Atmospheric Studies in Complex Terrain (ASCOT) program, contributing to the various modeling routines in the Atmospheric Release Advisory Capability (ARAC) national emergency response service, that is used as an emergency response tool at the DOE field sites and other locations.

Meteorological services at DOE facilities range from cutting-edge basic research to providing daily operational support. Some examples of research and development are investigations of potential global climatic change, radiation and cloud studies, atmospheric chemistry, and studies of atmospheric boundary layer processes. Operational support programs include daily customized weather forecasting services, special project support, on-site meteorological monitoring programs, climatology services, and emergency response program support.

Some DOE sites maintain 24-hour weather watches for severe weather conditions that have the potential to impact site operations, damage property, or threaten lives. DOE-wide lightning safety initiatives, which are becoming integral elements of a ISMS, are supported by DOE operational meteorological programs.

Several DOE field offices and their associated sites and facilities cover large areas (e.g., Idaho National Engineering and Environmental Laboratory (INEEL) nearby Idaho Falls, Idaho; Oak Ridge Reservation in Oak Ridge, Tennessee; Nevada Test Site nearby Las Vegas, Nevada; Hanford nearby Richland, Washington; and Savannah River Site, nearby Aiken, South Carolina). In addition, several DOE sites are situated in areas of complex topography and heterogeneous surface characteristics, creating mesoscale conditions that locally influ-

ence onsite weather and atmospheric transport and diffusion. For these reasons, and to protect public health and safety and environment, onsite meteorological monitoring programs have been, remain, and will always be an essential part of DOE atmospheric science programs.

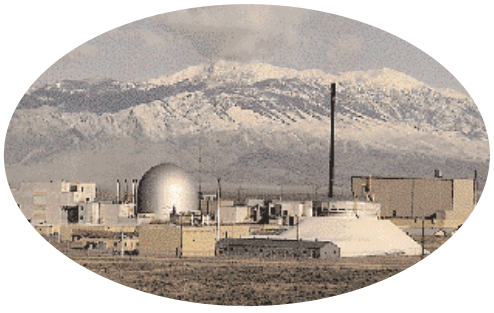
Some DOE sites enhance the spatial resolution of the National Weather Service (NWS) observing network by taking standard surface and upper-air observations. Many of these sites are in remote areas where NWS and community weather observations would otherwise be limited. Weather observations taken at a few DOE field sites are entered into the database via the NWS meteorological data distribution and display system. This distribution and display system interconnects field offices and serves as the distribution system for NWS meteorological products that are centrally produced by the National Centers for Environmental Prediction (NCEP). Some DOE sites employ the National Oceanic and Atmospheric Administration (NOAA) Advanced Weather Information Processing System (AWIPS) [e.g., NOAA Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD), Las Vegas, Nevada].

An accidental release of radioactive, chemical, or even biological toxic material into the atmosphere can have potentially serious health effects, as well as environmental consequences. Meteorological transport and dispersion processes play a key role in determining the fate of radioactive, toxic chemical, or biological agents 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 by accurately measuring and characterizing the important atmospheric processes.

In recognition of this need, DOE has established and supported onsite meteorological monitoring programs since 1944 (i.e., Hanford site). Each meteorological program is primarily directed towards the support of emergency response programs and in the protection of the environment and safety and health of the onsite work force and the public. In addition, research on the modeling of the transport, dispersion, deposition, and resuspension of radioactive, toxic chemical, and biological agent materials is undertaken to refine the models used in these endeavors. Onsite weather forecasting services, each tailored specifically for the special operational and emergency management requirements at each DOE site, provide necessary support to the safety and health programs designed to protect site personnel and the public.

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.

The following narrative highlights meteorological activities at fifteen (15) separate DOE sites:



Argonne National Laboratory (ANL)

Argonne National Laboratory (ANL) is one of DOE's largest research centers. It is also the nation's first national laboratory, chartered in 1946. The University of Chicago manages and operates Argonne for the DOE Chicago Operations Office. Argonne occupies two sites, designated as ANL-East in Illinois and ANL-West in Idaho. The Illinois site is surrounded by forest preserve on 1,500 wooded acres about 25 miles southwest of Chicago's Loop. The site also houses the DOE Chicago Operations Office. Argonne-West occupies about 900 acres about 50 miles west of Idaho Falls in the Snake River Valley. It is the home of most of ANL's major nuclear reactor research facilities.

There are three divisions, Environmental Research (ER), Decision and Information Sciences (DIS) and Environmental Assessment (EAD) at ANL with meteorological research or operational program support. Two cross-divisional groups are involved in these programs at ANL: the Atmospheric Research Section (ARS) and the Atmospheric-Emergency Preparedness (AEP) Group. The ARS is composed of scientist with research activities in both basic and applied science; particular technical strengths are in the areas of air-surface exchange, remote sensing, atmospheric chemistry, and numerical modeling. About half of the ARS support is currently devoted to activities associated with the DOE Atmospheric Radiation Measurement (ARM) Program. The AEP is composed of scientists and engineers in two divisions involved in programs with a greater emphasis on applied science. Particular technical strengths include air pollution meteorology, emergency preparedness and response, and stochastic systems simulations. More than half of the AEP support is associated with DOE's PROTECT Critical Infrastructure Program involving chemical and biological agents.

ARS has operated and maintains a 60 meter (m) meteorological tower and supplies meteorological data for emergency response, facility operations, and regulatory compliance for ANL

operations. Wind and temperature measurements are taken at the 10m and 60m levels. Real-time and historical data are available via the Web (*http://gonzalo.er.anl.gov/ANLMET*).

As part of a larger program for the protection of subway systems from terrorist attacks using chemical agents, AEP is installing sonic anemometers as well as temperature and pressure sensors in the subway tunnels of a large urban subway system. These instruments will assist in the understanding of flows in the tunnels, which are driven by a combination of: (1) the "piston" action of train motion and (2) buoyancy effects and above ground forcing. Measurements from these instruments will be correlated with the above ground measurements to develop and validate predictive and emergency response models for flow and dispersion in subway systems. The AEP group research also focuses on the analysis of routinely measured meteorological data to provide atmospheric boundary layer turbulence information for atmospheric dispersion calculations. Under the Department of the Army Chemical Stockpile Emergency Preparedness Program (CSEPP), ANL provides support to improve the collection efficiency and quality of meteorological data measured at the Army's Demilitarization towers. The data are used the emergency operation centers in support of emergency response exercises and for use in real-time in the event an actual accident. The goal of the CSEPP support is to improve the accuracy and robustness of the data obtained from the meteorological monitoring stations and to develop unified quality control and analyses procedures of the data collected by the towers.

Key support is also provided to Department of Transportation (DOT) in applying an ANL-developed 5-year meteorological database for over 100 locations in the United States to conduct statistical analyses of hazardous materials incidents on a national basis. Recent work for DOT has centered on development of the Table of Initial Isolation and Protective Action Distances for the 2000 Emergency Response Guidebook. Protective Action Distances are given in the Table for over 200 toxic-by-inhalation chemicals and generic compounds for both daytime and nighttime accidents, and represent the safe distance for 90 percent of hazardous materials transportation accidents considering variability in meteorology and spill size. Recent work for DOT has also involved conducting national risk assessments for transportation of certain high volume toxic chemicals like chlorine, ammonia, hydrogen fluoride and sulfur dioxide.

The Atmospheric Boundary Layer Experiments (ABLE) is one of several DOE supported research programs conducted by the ARS. ABLE is located on the lower Walnut Watershed, mostly in Butler County east of the city of Wichita, Kansas. This location is within the existing boundaries of the DOE Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) Clouds and Radiation Test bed (CART) site. The establishment of this facility offers a virtual atmospheric observatory and provides essential research tools for addressing a myriad of unresolved fundamental questions in atmospheric research. The ABLE provides a continuous view of processes in the lower atmosphere over a limited domain within the SGP CART site.

ABLE Doppler Minisodar

General Purpose: The minisodar measures wind profiles from about 10m to 200m above the surface, thus filling in the gap left below the minimum height of the wind profilers. Primary Quantities Measured: The primary quantities measured the the system are the intensity and Doppler shift of backscattered acoustic energy from index of refraction fluctuations (created by temperature and wind fluctuations) embedded in the atmosphere. Description: The minisodar has been developed and fabricated at Argonne National Laboratory (ANL). It consists of a 32 element array of piezoceramic tweeters mounted vertically within a protective enclosure roughly 1.5 m X 1.5m X 1.5m. The acoustic "in phase" transmission is reflected off a plate into a vertically propagating wave. This orientation enables the system to operate in all weather conditions. The minisodars operate by transmitting in two different vertical planes and receiving backscattered energy from refractive index fluctuations moving with the mean wind. By sampling in the vertical direction and two tilted planes, the three components of motion can be determined. The system consists of a single phased array antenna that transmits alternately along three pointing directions: one vertical, one in the north-south vertical plane (to the north) and one in the east-west vertical plane (to the east). The non-vertical beams are tilted about 17 degrees from vertical. Radial components of motion above each pointing direction are determined sequentially, separated by about 1.5 seconds. Thus, the system repeats its sequence about every 5 seconds. The data from each transmit pulse are processed with a FFT centered about each range gate (e.g. every 5m increment in the vertical) to determine the mean Doppler shift. The signal-to-noise ratio is used to determine if each estimate is acceptable. All the acceptable data within an averaging interval (e.g. 15 minutes) are averaged and combined to produce a wind profile if there are enough acceptable data points (25 percent, e.g.) within the interval. The averaged data are output in files with format similar to radar wind profiler (".sod") format for consistency. High resolution radial moments data and spectra can be produced if desired.

The initial focus of the ABLE is measurements of the planetary boundary layer (PBL) where almost all interactions between the atmosphere and humans take place. Many scientific issues may be addressed by use of such a facility, including:

- Natural disaster reduction and public safety;
- Safe and efficient aviation and other transportation;
- Agriculture;
- Water resource management;
- Effective energy production, use and environmental protection;
- Space flight operations;
- Defense; and,
- Related areas of Earth Science.

Instrumentation at the ABLE site includes winds, temperatures, moisture, surface net radiation and soil moisture as the minimum set of atmospheric observations.

The initial set of equipment, which is be available at the ABLE includes:

- Three 915 MHz RWP-RASS (wind speed and direction, virtual temperature profiles);
- Three minisodars (wind and turbulence profiles between heights of 10m and 200m);
- One lidar ceilometer (cloud base height);
- One balloon-borne sounding system (wind, temperature, moisture profiles);
- Five surface flux stations (surface sensible and latent heat, ground heat storage);
- Five soil moisture sampling stations (soil moisture and soil temperature);
- One satellite data receiver-processor;
- One data hub/central location for data collection; and,
- One (extra) instrument pad for visiting scientist instrument accommodation.

Brookhaven National Laboratory (BNL)

The BNL, under the responsibility of the Brookhaven Area Office, has been active in both operational meteorology and atmospheric sciences for the past 50 years. BNL is now managed by Brookhaven Science Associates which is a joint venture by Battelle Memorial Institute Incorporated, The Research Foundation of the State University of New York at Stony Brook, and six other core university partners. Meteorological operations and research cover a wide range of programs encompassing interpretive and theoretical studies. BNL is located near the geographical center of Long Island, New York. Long Island is glacial in origin and, as a result, has sandy soil, mostly gentle undulating contours, and a single water aquifer for the entire island. Elevations vary between 20m and 35m. The BNL site is rectangular and approximately 5,200 acres in area. Winds are predominantly southwesterly, and plume dispersion studies show that it is essential to monitor winds well beyond laboratory borders. The NWS New York City Weather Forecast Office is located at BNL. This office has an umbrella of coverage that includes an estimated population of 1 million. Nearby, in Bohemia, is the NWS Eastern Regional Headquarters that administers a 12-state region.

The mesoscale meteorological measurements necessary for emergency response are the responsibility of the Meteorological Services Group, a support group under the Department of Applied Science, Environmental Biology and Instrumentation Division (EBID).

The Meteorological Services Group maintains two meteorological towers, 10m and 88m, and an instrument shelter. By integrating redundant pairs of standard, approved meteorological sensors throughout the system, an overall data availability of better than 99 percent is achieved. The real-time data are merged into the laboratory emergency response network. A database of 50 years (in digital format since 1960), one of the longest continuous meteorological time series in the United States, is archived and is available. A real-time monitoring network with worldwide web access covers the east-end of Long Island. Coastal weather stations at Smith Point and Orient Point transmit data each minute. Pollution-monitoring data buoys are added during field programs.

The Meteorological Services Group provides a locally tuned forecast twice daily during normal working hours. Weather forecasts and data are available by telephone or the Internet (*www.weather.bnl.gov*). During severe weather events, updates are given every 3 hours and, in the case of a hazardous material or radiological release, a member of the Meteorological Services Group will assist the emergency coordinator with regular forecasts and information on local wind fields and gustiness. Areas of meteorological research include:

- Instrumentation development for field studies of atmospheric constituents, air-sea interaction, and laboratory experiments;
- Gaseous tracer studies of atmospheric transport and dispersion;
- Aerosol formation and behavior;
- Atmospheric pollution studies;
- Modeling of atmospheric chemical reactions;
- Acid rain studies both in the field and in the laboratory;

Figure 3-DOE-1. Battelle operates the Gulfstream-1 as a research facility under contract with the DOE's Atmospheric Chemistry Program.

- Theoretical and observational studies of radiative transfer and fluxes; and,
- Analysis of data and development of parameterizations relevant to global climate change.

The Atmospheric Radiation Measurement (ARM) Program provides the stimulus for a wide range of climate-related studies. The ARM ocean monitoring program is developing instrumentation and a broad ship- and buoy-based observational network in the tropical western Pacific Ocean. The Atmospheric Chemistry Program (ACP) provides the Atmospheric Chemistry Division's concern with aerosol sources, transport, and fate in the global atmosphere and the overall, and little understood, impact of aerosols on global climate dynamics (Figure 3-DOE-1). The ARM External Data Center is the center for collection, archival, and dissemination of all climate-related data sets for the ARM program.

An exciting new effort in radar meteorology focuses on algorithms for cloud detection and cloud mapping using both the WSR-88D radar network and research radar. BNL is a site in the National Aeronautics and Space Administration (NASA) Solar Irradiance Network and continuous short wave absorption measurements are made here. In a related NASA study, oceanic aerosol optical depths are measured and used to validate absorption algorithms in the SeaWiFS ocean color program.

The Optical Remote Sensing group, within the Department of Advanced Technology, is presently modifying one of its Raman lidar systems for vertical profiling of carbon dioxide. The Raman lidar instrument is a self-calibrating sensor that means that data from a variety of locations in the world can be compared. With the incorporation of a large (1.25m) antenna and advanced filters and detectors, a vertical profile of CO_2 concentration with a precision of 1 part per million (ppm) (Note: atmospheric mean = 370 ppm) and maximum height of 2-3 km can be produced routinely. These profiles will support model development and validation. Importantly, comparison of CO_2 concentrations collected throughout the world and over time will prove invaluable in confirming adherence to the Kyoto protocols.

Hanford

For more than 55 years, meteorological services have been provided to the Richland Operations Office and the Hanford Site. For the last 33 years, this program has been managed by the Battelle Pacific Northwest National Laboratory) (PNNL). Not only has operational support been provided, but also supporting research into atmospheric processes has been a key part of the PNNL support to DOE Richland. The facility covers 560 square miles within the arid and sparsely vegetated Columbia River basin in southeastern Washington.

Global Climate Research Program focuses on the study of basic geophysical processes and on the development of databases that are critical for understanding global and regional climate 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 three climatically distinct sites:

- Southern Great Plains of Oklahoma;
- Tropical Western Pacific just off northern part of Papua, New Guinea; and,
- North slope of Barrow, Alaska.

In addition, carbon dioxide emissions research is aimed at providing a scientific basis for forecasting future emissions of carbon dioxide and other important gases of radiative importance.

The PNNL Meteorological and Climatological Services Project (MSCP) office provides meteorological monitoring and operational support. The monitoring system consists of an array of twenty-six 10m towers, three 60m towers and one 125m tower instrumented with temperature and wind direction and speed sensors. Atmospheric pressure and precipitation data are also collected. 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:

- Extensive data acquisition via a site-wide meteorological monitoring network;
- Weather forecasting services 24-hours/day (Monday through Friday), and 8-hours/day on weekends and holidays;

- Hourly surface observations, and 6-hourly synoptic observations; and,
- Monthly and annual climatological data summaries, plus meteorological input to annual environmental reports.

Idaho National Engineering and Environmental Laboratory (INEEL)

INEEL is managed by the Idaho Operations Office and is on 890 square miles of rolling, arid terrain in southeastern Idaho at the foot of the Lost River and Lemhi mountain ranges. The primary mission of the INEEL for years has been nuclear reactor research with a focus on cleanup and environmental restoration. Meteorological services and supporting research are provided to INEEL via NOAA ARL Field Research Division (FRD). The Division, under administration from various agencies, has provided support to INEEL for over 50 years. Its current mission to DOE/ID is to support emergency response and operations with real-time meteorological data, climatological data, weather predictions, dispersion calculations, and consultation. ARL/FRD maintains other capabilities that are not funded directly by DOE. ARL/FRD designs, arranges, and conducts field studies as needed to evaluate the performance of transport and dispersion models over local, regional, and continental scales, and to obtain high quality databases for model improvement. An airborne geosciences program is also maintained to measure fluxes of carbon dioxide, water vapor, and other atmospheric constituents that affect climate. These interactions provide ARL/FRD staff with additional insights that aid in the understanding of local meteorological phenomena.

ARL/FRD operates a large meteorological monitoring network to characterize the meteorology and climatology of the INEEL site. The network consists of thirty-three meteorological towers that are deployed both on-site and off-site. The overall meteorological measurement program is designed to provide representative data for the INEEL to meet specific operational and potential emergency response situations. The network covers an area of approximately 15,000 square miles. Many of the towers are 15m tall and provide wind speed and direction at 15m and air temperature at 2 and 15m (Figure 3-DOE-2). Fifteen of the 15m towers also provide relative humidity

Figure 3-DOE-2. Meteorological towers record temperature and wind direction and speed at various levels.

at 2m, precipitation, and global solar radiation, eleven provide barometric pressure. The other three towers range from 46 to 76m in height and are instrumented at multiple levels. The sensors at all stations are scanned every second and averaged or totaled over five minutes.

The data are subsequently retrieved into the data display and archive system at the ARL/FRD office through a radio repeater located at an elevation of 8,930 ft MSL. Continuous wind and temperature profiles are obtained from a 915MHz radar wind profiler and Radio Acoustic Sounding System (RASS). A Doppler SODAR supplements the wind profile at lower levels with higher resolution data. Meteorological data are quality-controlled through automated and manual processes.

INEEL meteorological monitoring and emergency response efforts are enhanced with the use of an ARL/FRD meteorological data display and visualization program known as INEELViz. This program has been widely deployed at 50 sites on and around the INEEL for access by federal, state, and Indian tribes via the Internet. Within INEELViz, meteorological data are displayed in real-time and overlaid on maps of the local area that include political and terrain features. In addition, the local MDIFF puff dispersion model can be accessed through the INEELViz front-end and the model output can be displayed as trajectories or concentration isopleths on the INEELViz display screen. The incorporation of RSAC dose conversions permits the user to also view real-time dose estimates from the model output. These features have become very useful enhancements to the INEEL emergency response capability.

Partnerships forged with DOE-ID, the State of Idaho INEEL Oversight Program, and the Shoshone-Bannock Indian Tribes have resulted in additional methods of meteorological data dissemination. Meteorological and background nuclear radiation data from four public access sites on and surrounding the INEEL are displayed at nearby kiosks in real-time. Additional information on nuclear radiation and meteorological tutorials are presented at the kiosks. The data are also available on the Internet at *http://oversite.inel.gov*. ARL/FRD maintains its own web site at *www.noaa.inel.gov*.

Lawrence Livermore National Laboratory (LLNL)

LLNL is located in a valley in California's Coast Range Mountains about 25 miles east of Oakland. LLNL

covers approximately 2 square miles and is operated by the University of California for the DOE Oakland Operations Office. Two groups are involved in the atmospheric sciences at LLNL: the Environmental Protection Department (EPD) and the Atmospheric Sciences Division (ASD).

EPD operates a 40m tower and supplies meteorological data for facility operations, regulatory compliance, and emergency response. Real-time and historical data are available at *http://www-metdat.llnl.gov/*.

Within the LLNL Earth and Environmental Sciences Directorate, ASD conducts research on climate and weather processes on local to global scales on the following issues:

- Understanding the transport, diffusion, deposition, transformation, and atmospheric effects of accidental releases or pollutants;
- Developing and testing models for improved representation of atmospheric processes on building, urban, regional, and global scales;
- Understanding the uptake and removal of carbon dioxide emitted through fossil fuel combustion by the biosphere and oceans so that the effects of future emissions may be accurately predicted;
- Understanding the role of pollutants from fossil fuel emissions in determining greenhouse gas and aerosol concentrations and climate forcing;
- Understanding and predicting the extent to which stratospheric ozone may decrease as a result of anthropogenic emissions;
- Understanding and quantifying the natural variability of the climate system; and,
- Understanding and quantifying interactions between the biosphere and climate. Some of these efforts stem from the need to be able to predict the regional to global environment and its changing nature over the next few decades, so that policy makers will have the information needed for the formulation of national energy policy.

LLNL ASD scientists contribute to two long-term DOE research programs--ARM and the Chemical Biological Non-proliferation Program (CBNP) as well as lead two other programs--Program for Climate Model Diagnosis and Intercomparison (PCMDI) and National Atmospheric Release Advisory Center (NARAC). PCMDI develops and distributes software tools to facilitate model diagnosis and inter-comparison, 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 (*http://www-pcmdi.llnl.gov/*).

Since 1979, LLNL has provided emergency response services via the NARAC program. NARAC is a centralized federal resource responsible to DOE, the Department of Defense (DOD), and other federal agencies under the auspices of the Federal Radiological Emergency Response Plan (FRERP). The NARAC 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. NARAC supports all elements of the DOE Emergency Preparedness and Response Program, NEST, ARG, FRMAC, and the Radiological Assistance Program (RAP).

NARAC consists of 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. ARAC has an entirely new emergency response system with state-of-the-art, high-resolution, terrain-following, variable-gridded diagnostic meteorological and dispersion models including new user interfaces and extensive graphical displays. In addition, the system includes relocatable prognostic model that provides high-resolution 2-3 day forecasts in the region of interest.

NARAC provides a 24-hour on-call response, using redundant computer systems with uninterruptible power. NARAC provides on-site and off-site emergency response services to about 40 DOE and DOD facilities around the United States via a Site Workstation System linked to Livermore. 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. ARAC has responded to over 80 real-world events and conducted thousands of exercises with supported sites and agencies.

More information on the NARAC program can be located on the Internet (*http://www-ep.es.llnl.gov/www-ep/atm/ARAC/arac.html*) and an educational presentation of some past NARAC responses is located at *http://air.llnl.gov/*.

Los Alamos National Laboratory (LANL)

LANL is operated by the University of California under the responsibility of the Albuquerque Operations Office, and is spread across 43 square miles (112 km^2) of the Pajarito Plateau at the foot of the Jemez Mountains that extend up to around 900m above the plateau. LANL is about 30 miles northwest of Santa Fe in north central New Mexico. The Pajarito Plateau slopes to the east-southeast, dropping 400m across the Laboratory, with canyons and mesas running along the slope of the plateau. The broad Rio

Grande Valley lies to the east of the laboratory. Los Alamos has a semi-arid, temperate, mountain climate.

The operational meteorological program at Los Alamos operates a network of six towers (ranging in height from 23m to 92m), a mono-static Doppler SODAR, and three supplemental precipitation stations. Data from four instrumented meteorological towers that are located on the Pajarito plateau drives a diagnostic wind field for the program's plume modeling capability. A fifth tower is located in Los Alamos Canyon to give information on the larger canyons in the area, and a sixth tower is located on top of Pajarito Mountain to measure ambient conditions. The SODAR gives information on winds up to the level of the Pajarito Mountain tower.

More than 100 instruments, consisting of over 20 different types of sensors, are used to collect data throughout the network. Variables measured by the program can be grouped into the categories of wind, SODAR-derived wind, atmospheric state, precipitation-related, radiative fluxes, eddy heat fluxes, subsurface measurements, and fuel moisture. Data collected by the network are checked for quality before its archival, and raw data and real-time displays of graphs and tables are made available via the Internet.

The LANL Air Quality Group provides regulatory and environmental surveillance leadership and services to meet LANL air quality obligations and public assurance needs. The group develops and implements programs to ensure and address institutional compliance with State and Federal laws related to air quality regulations, DOE orders for emergency management, air quality surveillance, dose assessment activities, and community concerns related to air quality issues. The group takes a proactive approach to managing air emissions by providing continuous air monitoring and measurement of external penetrating radiation on-site and off-site. The group also coordinates LANL activities to ensure full compliance with air emission regulations, providing monitoring and modeling for emergency response, and assisting operating groups in developing and implementing new methods and systems to reduce emissions to as low as reasonably achievable. The monitoring capabilities of the Air Quality Group are supplemented by the field team of the Atmospheric and Climate Sciences Group, that operates various sensor systems including a unique Raman lidar system to obtain images of atmospheric water vapor distributions.

Research within the LANL Atmospheric and Climate Sciences Group supports DOE missions in both the defense and civilian sectors, such as work in the propagation of very-low-frequency sound ("infra-sound") waves. Modeling studies contributed to understanding of propagation and, in particular, sources of infrasound. Just as it is possible to infer earthquake epicenters from seismic wave observations, infrasound sources can be inferred from atmospheric observations. This work is an important component of monitoring compliance with the proposed Comprehensive Test Ban Treaty (CTBT). The CTBT work involves a number of organizations within DOE and DOD community, including interactions with other DOE laboratories within the CTBT Research and Development program.

Operational issues involve close work with the Air Force Technical Applications Center (AFTAC) at Patrick AFB, Florida, the DOD organization that handles monitoring systems. In addition, several active international collaborations with other infrasound researchers are ongoing.

The Meteorology Team within the Atmospheric and Climate Sciences Group at Los Alamos National Laboratory conducts analysis and modeling on microscale to mesoscale atmospheric flows and phenomena. In support of the DOE Chemical and Biological Non-proliferation Program, a model for High Resolution and Strong Gradient (HIGRAD) applications is being used to study the effects of radiative heating and shading around groups of buildings. The objective of this study is to determine how these processes may influence the transport of agents within the urban environment. On larger scales, the team is examining the influence of flow merger and urban roughness on the vertical transport and mixing of pollutants with the Regional Atmospheric Modeling System (RAMS) for several western United States valleys and basins. This project is in support of the DOE Environmental Meteorology Program and for the Environmental Protection Agency (EPA). As part of the LANL initiative in Coupled Environmental Modeling, researchers within the Meteorology Team are developing a physics-based fire behavior model (FIRETEC) and coupling this model to the HIGRAD atmospheric dynamics code to examine the details of the interaction between local winds and the intense heat generated by wildfires. Also as part of this initiative, a land surface model is being coupled that includes hydrologic processes (i.e., SPLASH) to the RAMS mesoscale model for multi-seasonal simulations of the water resources of the upper Rio Grande Basin.

Meteorology Team members are also working on the LANL Urban Security project, which is linking physical and urban growth models to address the needs of cities. In this framework, we are using the RAMS model to provide meteorological fields for use by air chemistry, urban runoff, and other models. The Meteorology Team within the Atmospheric and Climate Sciences Group conducts analysis and modeling on microscale to mesoscale.

On global scales, research within the

LANL meteorological community involves the study of climate change and variability. A major project is the development of a global coupled ocean-atmosphere model sponsored by the DOE Climate Change Prediction Program. The global model being developed consists of a Los Alamos global ocean Global Climate Models (GCMs) Parallel Ocean Program (POP), the Los Alamos sea-ice model (CICE), the NCAR Community Climate Model (CCM3), and a "flux coupler" to link the media consistently. The two GCM's and the CICE model exchange heat, momentum, and water mass across the air-sea boundary. A ten-year synchronized simulation revealed the synoptic weather events, seasonal cycles and inter-annual variations.

Observations related to understanding global climate are the focus of the Tropical Western Pacific (TWP) Program Office LANL, an element of the DOE ARM Program. The TWP Program Office is responsible for the development and operation of the TWP CART locale, a large expanse of tropical ocean and maritime continent lying roughly between 10° S and 10° N latitude and from 135° E to 150° W longitude. The maritime continent area is largely in the southwest and the open ocean area in the northeast of the locale. The local climate is characterized by warm sea surface temperatures, deep and frequent atmospheric convection, high rain rates, strong coupling between the atmosphere and ocean, and substantial variability associated with El Niño Southern Oscillation (ENSO) phenomenon.

Scientific questions that need to be addressed in the TWP can be grouped under three main headings:

- Radiation budget and cloud forcing;
- Water and energy budgets; and,
- Ocean-atmosphere interactions.

The program supports a variety of operations at LANL. The primary client of the program is the Emergency Management Group, for which the program provides a plume modeling capability. Other clients use the program's data for such activities as operations and planning, hazard and accident analyses, environmental studies, support for experiments, compliance, and documentation.

Nevada Test Site (NTS)

The NTS is managed and operated by the DOE Nevada Operations Office (DOE/NV). The NTS has been the Nations' underground nuclear weapons testing facility and is now used to support sub-critical experiments and other national defense missions of the United States. The NTS occupies 1,350 square miles of south central Nevada and is approximately 75 miles northwest of Las Vegas, Nevada. The topography of the NTS is complex with a system of dry lakebeds and mountains. Elevations range from nearly 2,700 feet (ft) above mean sea level (MSL) to 7,600 ft MSL. The climate is arid.

Meteorological services are provided to DOE/NV by components of the Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA). The DOC has had a presence on the NTS for more than 45 years through various Interagency Agreements. During this time, NOAA personnel have built a solid technical reputation in meteorological operations and emergency response. Presently, NOAA support is provided by the Air Resources Laboratory/Special Operations and Research Division (ARL/SORD), recognized for its expertise in the transport, dispersion, and deposition of radioactive and toxic materials. SORD has developed a rapid emergency response capability for the unlikely occurrence of an accidental release of radioactive or hazardous material into the atmosphere.

Both basic and applied research is carried out on problems of mutual interest to DOE and to NOAA. Emphasis is on the maintenance of meteorological support to national defense projects and to the stewardship of nuclear weapons. These capabilities focus on those facets of meteorology having a direct bearing on the transport, dispersion, deposition (i.e., fallout), and resuspension of radioactive and/or toxic materials. Other research includes documentation and study of extreme precipitation events, desert thunderstorms, cloud-to-ground lightning, and environmental issues related to air quality and visibility.

ARL/SORD provides full meteorological support to all DOE/NV operations on and off the NTS. Meteorology plays a key role in environmental, safety, and health responsibilities of DOE/NV. The SORD staff is responsible for conducting a modern program in support of nuclear and non-nuclear projects authorized by DOE/NV. Furthermore, the mission of SORD involves technical support to the emergency preparedness and response activities of DOE/NV. SORD operates a comprehensive meteorological monitoring program for the NTS, and provides meteorological and climatology services required to support the DOE/NV and contractor programs at the NTS and elsewhere, as necessary. Personnel at SORD also consult with senior scientists and engineers at the DOE National Laboratories, National Aeronautical and Space Administration (NASA), private contractors, Desert Research Institute (DRI), United States Geological Services (USGS), United States Forest Services (USFS), and other NOAA laboratories.

The SORD meteorological monitoring network consists of twenty-nine (29) 10m towers and two 30m towers. Wind direction and speed is measured at the 10m level on all the towers and temperature and relative humidity is sampled at the 2m level. Data from these towers are transmitted via microwave radio to a central processor

that checks the data, creates data files, and archives the data every 15 minutes. The data files are accessed by microcomputer to create graphics products for operational use and for immediate display at 15-minute intervals.

SORD also operates two 915MHz vertical profilers on the NTS--one located in the middle of Yucca Flat and one at the Hazardous Materials Spill Center (HMSC) in Frenchman Flat near Mercury, Nevada. In addition, a NOAA full surface radiation (SURFRAD) budget station is operated and maintained at the Desert Rock Meteorological Observatory (DRA) located in the southern part of the NTS. Upper-air soundings are taken twice daily, at 00 and 12 Universal Time Coordinated (UTC) from the DRA facility. SORD also operates mobile upper-air sounding systems and mobile pilot balloon (PIBAL) equipment to support special projects requiring winds aloft data in real-time.

Large-scale meteorological data and National Center for Environmental Prediction (NCEP) weather forecast products are received via AWIPS, or from University Center for Atmospheric Research (UCAR) and ARL-Silver Spring. Weather products are supplied to DOE contractors, the National Laboratories (e.g., SNL, LANL, and LLNL), the NWS, and Nellis AFB include real-time cloud-to-ground lightning flash graphical products and local forecast products. SORD has also implemented the Regional Atmospheric Modeling System (RAMS) that can predict boundary layer air flow over complex terrain. RAMS accesses the NCEP predictive model outputs and is run at the University of Nevada at Las Vegas Supercomputer Center on a daily basis.

SORD provides meteorological monitoring support and project-specific weather forecast services to the Nuclear Emergency Search Team (NEST), the Federal Radiological Monitoring and Assessment Center (FRMAC), and the Accident Response Group (ARG) activities. Monitoring support includes surface and upper-air data collection and analysis. Weather forecast service entails maintaining a constant weather watch for conditions that might impact NEST/FRMAC/ARG operations and personnel, issuing site-specific mesoscale wind, stability, and weather forecasts, aviation weather support, and providing consultation to the On-Scene Commander and to National Laboratories personnel. SORD maintains a web site (*www.sord.nv.doe.gov*) that includes graphical products that display current meteorological conditions on the NTS, including data from SORD vertical profilers and climatological data.

Oak Ridge Reservation (ORR)

The ORR is home to four DOE sites: Oak Ridge National Laboratory (ORNL), the Y-12 Plant, the East Tennessee Technology Park (ETTP, formerly K-25 Site), and the Oak Ridge Institute for Science and Education (ORISE). Managed by the Oak Ridge Operations Office (ORO), the ORR encompasses nearly 100 square miles of hilly and heavily vegetated terrain in eastern Tennessee.

Meteorological network systems, which support day-to-day operations, are managed and operated at the three main sites by the University of Tennessee/Battelle, BWXT Y-12 and Bechtel Jacobs Company. These network systems provide data that support environmental management (permitting, facility siting and environmental impact assessment), facility safety (safety analyses), emergency management (hazards and consequence assessment), operations (work planning) and substantial research.

The meteorological data acquisition program at ETTP has two main towers. K-1209 is 60m high while K-1208 is 30m in height. In addition, two 10m supplemental towers are still operating. Lastly, a NEXRAD radar system, and The Weather Channel are available to each of the control rooms and emergency response facilities.

The Y-12 Plant has two meteorological towers (i.e., 100m and 60m) located at the east and west ends of the site, respectively, and a Remtech Sodar reporting vertical profile data from 50-500m. ETTP and Y-12 Plant meteorological data is fed into the ORR Emergency Operations Center (EOC) and at emergency control centers for hazard assessment, consequence assessment, and protective action recommendations.

The data acquisition program at the ORNL consists of three (two 30m and one 100m) meteorological towers. Meteorological data is fed to an ORNL central computer system for analysis and dissemination.

The NOAA Air Resources Laboratory/Atmospheric Turbulence and Diffusion Division (ARL/ATDD) is located in Oak Ridge near the ORR. The primary mission of ATDD is atmospheric research. Substantial research programs at ATDD are undertaken with the assistance of staff from ORISE/Oak Ridge Associated Universities (ORAU) and scientists from other national laboratories and organizations in the United States and abroad. ARL/ATDD also works closely with the ORAU to enhance educational opportunities in atmospheric science.

ARL/ATDD research attention is focused on the physics of the lower atmosphere, with special emphasis on the processes contributing to atmospheric transport, dispersion, and air-surface exchange, and on the development and improvement of predictive capabilities using the results of this research. Many other projects are underway such as surface energy balance and CO_2 exchange studies and long-term studies of CO_2 exchange aimed at process-level understanding. Operationally, ARL/ATDD personnel provide meteorological consultation and supplemental data for air quality

analyses, environmental reports, and hazard and consequence assessments. Local climatology data are routinely collected and distributed. Under NOAA funding, ARL/ATDD operates a regional network of 15 towers ranging from the Cumberland Mountains (middle Tennessee) to the Smoky Mountains on Tennessee's eastern border. Wind, temperature, and precipitation data are recovered every 15 minutes by telemetry and made available to users.

ARL/ATDD incorporates NWS forecast products into the high-resolution, regional, meteorological model (i.e., RAMS) to produce twice-daily 12-hour, 24-hour, and 36-hour predictions of surface winds for eastern Tennessee, and transport trajectory predictions for the ORR.

Pantex Plant

The Pantex Plant covers 15,977 acres and is located 27 kilometers (km) (17 miles) northeast of Amarillo, Texas, in Carson County. The Plant was a World War II munitions factory and was converted to a nuclear weapons assembly facility in 1951. Today, it is the nation's only assembly/disassembly facility supporting the nuclear weapons arsenal. Pantex Plant is a government-owned, contractor-operated facility. DOE oversees operation of Pantex Plant through the Amarillo Area Office, which reports to the Albuquerque Operations Office. Mason and Hanger Corporation has been the operating contractor since 1956. On February 1, 2001, BWXT Pantex has assumed the Pantex contract.

The Plant is composed of several functional areas, commonly referred to as numbered zones. These include a weapons assembly/disassembly area, a weapons staging area, an area for development of experimental explosives, a drinking water treatment facility, a sanitary wastewater treatment facility, and vehicle maintenance and administrative areas. Other functional areas include a utility area for steam and compressed air, an explosive test-firing facility, a burning ground for thermally treating explosive materials, and landfills. Overall, there are more than 700 buildings at the Pantex Plant.

The Environmental Protection/ Restoration Department (EP/RD) of the Environment, Safety and Health Directorate is tasked with the quality assurance program for the meteorological data captured by the one on-site two-level tower located in the northeast corner of the Plant site. The data from this tower (10m and 60m) are collected and used by the DOE NARAC site workstation, located in the Plant EOC. These data are collected and archived as 15-minute averages plus maximum and minimum values for each 15-minute period. They are primarily used for input to the NARAC emergency response models that could be used for off-normal events involving radionuclides. Annual dispersion model calculations of offsite radiation doses from on site sources, required by 40 CFR 61, Subpart H, *National Emission Standards for Hazardous Air Pollutants* (NESHAP), are accomplished by the EP/RD. EP/RD uses the EPA-approved CAP88-PC model and the Pantex meteorological tower data processed into the STAR format. This department also maintains the Pantex Plant climatology database.

Meteorological tower data is also used by the Risk Management Department for plume dispersion modeling applied to the Plutonium Dispersal Consequence Analysis for the Basis for Interim Operations (BIO) validation and upgrade reports, other operations directives, and other safety analyses. Routine preventive maintenance on the meteorological instruments as well as calibration and certification are done semi-annually by the United States Bureau of Land Management (BLM). The BLM maintenance depot at Boise, Idaho performs similar work for the United States Forest Service's own meteorological towers instruments. This work is done under a contract administered by the Pantex Emergency Management Department. Emergency repairs and replacement of sensors are also handled by the BLM Idaho depot. Temperature and wind sensors are replaced semi-annually with calibrated and certified sensors. The barometer is replaced annually. During the semi-annual preventive maintenance visits all of the other meteorological instruments are replaced by the BLM technician with rebuilt/refurbished, calibrated equipment, from the Idaho depot. The maintenance check also includes the telephone line, modem, and backup power supply.

As a result of a FY 2000 project meteorological tower data is now displayed on the Pantex Plant Intranet for use by Plant personnel. During FY2001, the potential for replacing the existing wind sensor on the meteorological tower with a 3-dimensional wind sensor will be evaluated. In addition, replacing/upgrading the NARAC computer and software located at the base of the tower that feeds data into the NARAC Site System in the EOC will also be considered.

There are no current or projected supporting meteorological research activities planned at the Pantex Plant.

Rocky Flats Environmental Technology Site (RFETS)

The RFETS is managed by the Rocky Flats Operations Office and is located approximately 16 miles northwest of downtown Denver, Colorado. One of the smaller DOE sites, the facility occupies a 10 square mile area along the foothills of the Rocky Mountain Front Range.

A 61m meteorological tower at the west-end of the site continuously monitors meteorological conditions at surface, 10, 25, and 60m above ground level. The data are analyzed, quality assured, and assembled into data sets for use in atmospheric modeling, cli-

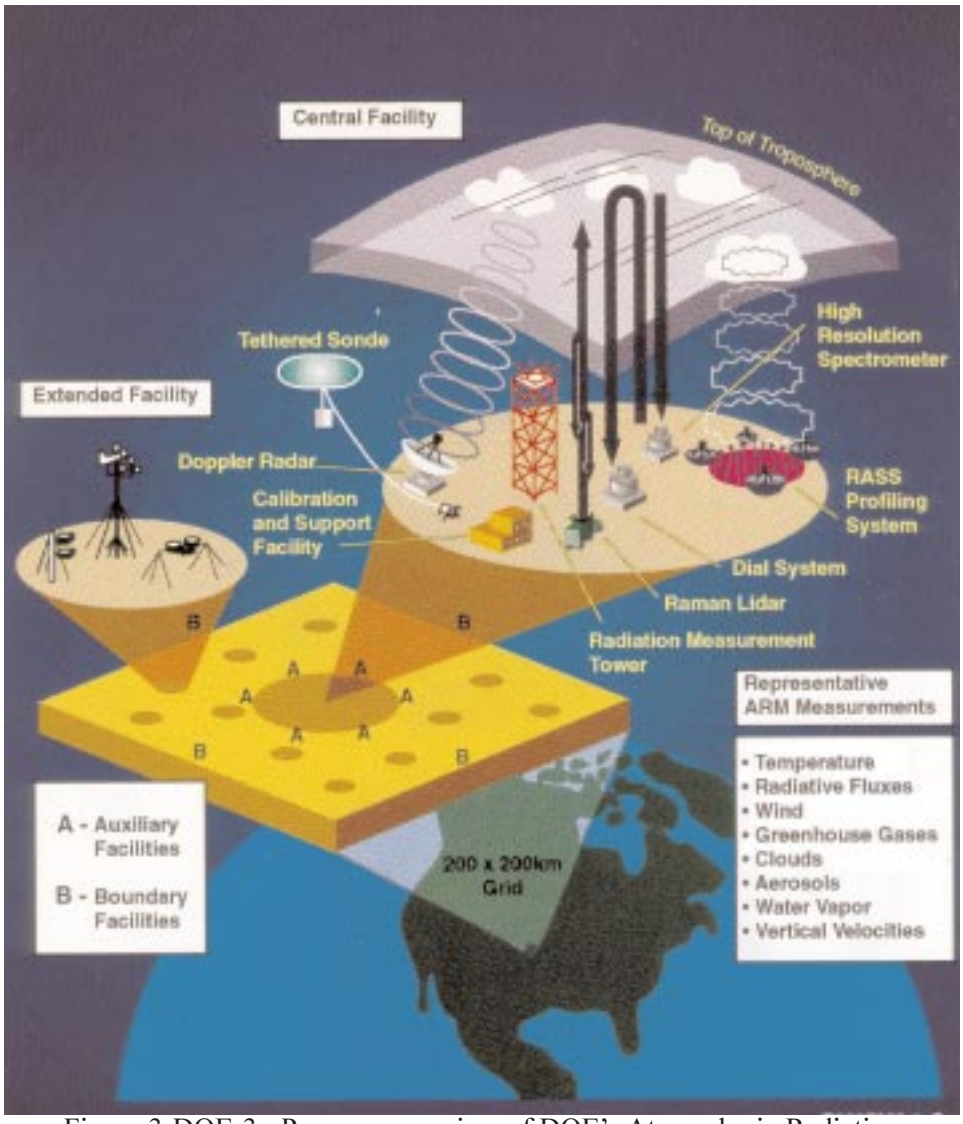


Figure 3-DOE-3. Program overview of DOE's Atmospheric Radiation Measurement (ARM) Program.

matology, and other analyses at the site. Data from the 61 and 10m towers are also transmitted back to the main site every 15 minutes by telemetry for use in emergency response modeling. The Regional Atmospheric Response Center (RARC) conducts meteorological activities associated with emergency preparedness and response at the site. An upper air remote sensing Sound Detection and Ranging/Radio Acoustic Sounding System (SODAR/RASS) continuously monitors winds, temperatures, and atmospheric stability above RFETS.

Through a cooperative agreement with the Colorado Department of Public Health and Environment, meteorological data are transmitted to the site from five surface meteorological stations by telemetry that form a ring around the site perimeter. Another cooperative agreement with NOAA provides near real-time data from multiple monitoring sites throughout the Denver metropolitan area. These data are all received, quality assured, and combined into a 3-dimensional observation set for emergency response modeling every 15 minutes, 24 hours per day.

The RARC provides 24-hour consequence assessment support for any unplanned radiological or chemical releases from the site. The Center responds with customized weather forecasts, plume projections, and dose modeling results that lead to event classifications and protective actions for on-site and off-site populations. RARC also conducts specialized consequence assessments in support of emergency preparedness, hazard assessments, and risk assessments for RFETS. Weather forecasts are provided for severe weather events, such as winter storms, windstorms, and severe thunderstorms.

A customized modeling system has been developed and implemented at RFETS to predict the path and impacts from any radiological emergency at the site. Called the Computer-Assisted Protective Action Recommendation System (CAPARS), the new capability addresses the need for fast, accurate plume predictions in a complex atmosphere.

CAPARS provides a variety of plume, weather, hazard, and related products with the accuracy and speed needed for response to an emergency at RFETS. Eleven integrated major subsystems form the overall CAPARS capability.

The State of Colorado has formally accepted the CAPARS modeling system for emergency response and planning applications at RFETS. A specialized planning version of the CAPARS system has been developed, implemented, and applied for emergency planning at the RFETS. Called the TRAC Risk Assessment/Hazards Assessment Model, the capability is designed to support hazards and risk assessments for RFETS and to form the basis for an evaluation of the size and shape of the Emergency Planning Zone (EPZ) surrounding RFETS.

Sandia National Laboratory (SNL)

The DOE Kirtland Area Office manages SNL in Albuquerque, New Mexico, located between the Rio Grande Valley and Manzano Mountains. SNL covers approximately 80 square miles of flat to mountain-

ous arid terrain. Meteorological Programs at SNL include both support and research activities.

Meteorological services and support are provided through the Environmental Operations Center (EOC) in the Laboratory Services Division (LSD). The mission is to provide meteorological support for various operations including:

- Emergency response;
- Environmental surveillance and characterization; and,
- Regulatory compliance.

The monitoring network consists of six 10m and two 60m towers used to measure wind direction and speed, ambient temperature, and relative humidity. There are also three precipitation gauges, two barometric pressure sensors, and one solar radiation pyranometer in the network.

Key research activities are provided through the Energy and Critical Infrastructure Center in the Energy, Information, and Technology Division. SNL/NM scientists are involved in the Atmospheric Radiation Measurement (ARM) program and the Surface Heat Budget of the Arctic Ocean (SHEBA). The ARM project is a combined measurement and modeling program (Figure 3-DOE-3). The goal is to gain a better understanding of clouds and their effect on atmospheric radiation, with the final goal of developing better climate models. The SHEBA program addresses the interaction of the surface energy balance, atmospheric radiation and clouds over the Arctic Ocean.

Savannah River Site (SRS)

The SRS is under the responsibility of the Savannah River Operations Office (SR) and operated by the Westinghouse Savannah River Company. SRS is located in southwestern South Carolina, along the banks of the Savannah River. The SRS covers an area of approximately 300 square miles. It 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. The topography of SRS is characterized by gently rolling forested hills with an adjacent flood plain near the Savannah River. The climate at SRS is typical of the southeastern United States with long, hot and humid summers and short mild winters.

The Atmospheric Technologies Group (ATG) of the Savannah River Technology Center (SRTC) developed the SRS meteorological monitoring and modeling program in the early 1970's. This program supports the SRS operations in the areas of emergency response consequence assessment, radiological and non-radiological air quality calculations for regulatory compliance, safety analyses, environmental impacts, engineering studies, environmental research and nonproliferation activities.

Meteorological activities include daily weather forecasting services in support of operations at SRS, with particular emphasis on severe weather impacts. Local meteorological data are obtained from a network of eight 200-foot meteorological observing towers located near the major production sites. The instrumentation on these towers includes sensitive bi-directional vanes (i.e., bi-vanes), cup anemometers, resistance thermometers and lithium chloride humidity sensors. Additional meteorological instrumentation is located at the Central Climatology Facility located near the geographical center of the site to measure precipitation, evaporation, barometric pressure, soil temperature, solar and long wave radiation. Central Climatology includes a 200-foot tower instrumented at four levels. A network of twelve additional rain gauges (that are read daily) is located within SRS. Additional local upper-air data are collected from three acoustic Doppler radars, an airsonde system, and a tethersonde system. Portable towers are used for case studies (Figure 3-DOT-4).

A collaborative agreement with surrounding counties involves assisting them to install and operate several local meteorological towers at nearby chemical plants. Data from these towers are being integrated into the SRS meteorological archiving and display system the Weather Information and Display System (WINDS).

The WINDS is the primary consequence assessment system for atmospheric and hydrologic releases from SRS operations. A suite of atmospheric models linked to real-time site wide atmospheric monitoring provides transport, dispersion and consequence calculations for emergency response.

The WIND system underwent a complete re-engineering to improve the computer system reliability, performance and serviceability. The re-engineering involved distributing the data processing and utilizing new data acquisition hardware and relational data base software. New workstation clustering for data management and PC/NT user workstations for local

Figure 3-DOE-4. Tethered meteorological Tower (Tethersonde).

model operation and graphical user interfacing for displays were added.

An advanced non-hydrostatic, three-dimensional, prognostic atmospheric model is run twice daily on the SRTC's CRAY computer separate domains: (1) the Central Savannah River Area (CSRA), (2) kilometer grid resolution); and (3) the area encompassing South Carolina and Georgia (20km resolution).

The CSRA model provides forecasts with a minimum of six hours useable forecast fields. The Georgia-South Carolina model run provides forecasts with a minimum of 24 hours useable forecast fields. These forecast fields are integrated into the WIND system consequence assessment models. Additional model runs are conducted on an expanded domain to include the entire southeastern United States on an ad hoc basis when the SRS is threatened by hurricanes.

An aqueous model is also resident on WINDS and linked to real-time stream flow monitors operated by the USGS. This model enables consequence assessments for emergency response to site streams and the Savannah River.

Regional, national, and international meteorological data are received from a commercial weather data provider via satellite in real-time. Weather workstations provide surface and upper observations, analyzed and forecast weather parameter fields from the NWS and the European Modeling Center. These data are input into an advanced, three dimensional, prognostic, atmospheric modeling system for applications locally in the southeastern United States and globally. Satellite and Doppler radar data are also available in near real-time.

Waste Isolation Pilot Plant (WIPP)

The Waste Isolation Pilot Plant (WIPP) is operated by Westinghouse Electric Company's Waste Isolation Division for the DOE Carlsbad Area Office. A cornerstone of the DOE's national clean-up strategy, the WIPP is designed to permanently dispose of transuranic radioactive waste generated by defense-related activities in the Salado salt formation 2,150 ft beneath the surface. WIPP is located in Eddy County in southeastern New Mexico, 26 miles east of Carlsbad, and occupies 16 square miles of a region know as Los Medanos. Geographically, the region is regarded as a relatively flat, sparsely inhabited plateau with little surface water.

The WIPP Environmental Monitoring (EM) Section performs meteorological monitoring as part of the Non-radiological Environmental Monitoring Program. The primary meteorological station provides measurement of wind direction and speed, temperature at 2, 10, and 50m, as well as ground level measurements of barometric pressure, relative humidity, precipitation, and solar radiation. The main function of the station is to generate data for operational support, emergency response and regulatory dispersion modeling applications. Parameters are monitored continuously and the data are stored in the Central Monitoring System, a computerized system including automated parameter checks, real-time displays in the Central Monitoring Room, and data archiving. Meteorological data are compiled and distributed to stakeholders, including the NOAA NWS, on a monthly basis.

In addition to the primary meteorological station, the Far Field Station serves as a secondary meteorological station and measures wind direction and speed at 10m as well as temperature, barometric pressure at ground level. System upgrades are currently being considered for this station.

WIPP also, under a cooperative agreement with the NWS, maintains a Cooperative Weather Observing Station at the Far Field Station. Data from this station are compiled monthly and the Record of Climatological Observations form is submitted to the Weather Forecast Office in Midland, Texas. Under the same cooperative agreement, the Midland office is given access to real-time data from the primary meteorological station.

Weldon Springs Site Remedial Action Project (WSSRAP)

Various facilities at Weldon Springs in St. Charles County, Missouri were no longer needed, and a Remedial Action Plan (RAP) was developed to restore the site to its environmental baseline. This activity is being coordinated under the Weldon Springs Site Remedial Action Plan (WSSRAP), under the management of DOE Oak Ridge Operations Office (ORO), and operated by an integrated Project Management Contractor (PMC) consisting of MK-Ferguson and Jacobs Engineering Group, Inc. WSSRAP, which is approximately 30 miles west of St. Louis, Missouri, is approaching completion.

The mission of the WSSRAP has been to conduct environmental restoration of the following:

- A 166-acre inactive uranium feed materials plant (i.e., chemical plant area);
- A 51-acre raffinate pit area;
- A 9-acre limestone quarry located 4 miles from the main site; and,
- Associated vicinity properties.

Within the scope of remediation is cleanup of both radiological and chemical contaminants resulting from historical operations that included trinitrotoluene (TNT) and dinitrotoluene (DNT) production (i.e., 1941-1945), and uranium processing (i.e., 1956-1966).

Fourteen interim response actions were developed and approved by WSSRAP. Interim response actions are activities that will not change the ultimate disposal method but will mitigate or eliminate conditions that pose immediate or potential threats to worker safety, public health, or the environment. Some of the interim actions taken were removal of exposed friable asbestos, overhead piping, polychlori-

nated biphenyl (PCB) electrical equipment, power poles and wires, demolition of all buildings, isolation and capping of Ash Pond, and capping of other highly contaminated areas.

A meteorological monitoring program has been operated at the WSSRAP since 1994. The program consists of a single monitoring station, located at the eastern edge of the chemical area, more than 400 ft from the nearest building and is considered representative of all areas undergoing remediation. The WSSRAP meteorological station continuously measures and records wind speed and wind direction at 10m above ground level, as well as horizontal wind fluctuation at 10m above ground level, barometric pressure, relative humidity, solar radiation, and precipitation intensity.

The data collected by this station has been used to support numerous project functions at the site, including:

- Meteorological information to support emergency response activities in the event of an unscheduled chemical or radiological release;
- Information for atmospheric dispersion modeling to provide an environmental safety and health contribution to engineering design of site facilities;
- Rainfall, temperature, and wind speed data to support wetland and lake ecological studies and for support of foliar vegetation absorption analysis;
- Precipitation data to support the correlation of aquifer level fluctuations in the quarry and Femme Osage Slough;
- Environmental reporting including the annual Site Environmental Report and the Effluent Information System/On-Site Discharge Information System Report;
- Wind speed data needed for compliance with Occupational Safety and Health Administration (OSHA) construction management activities;
- Precipitation data to support the National Pollutant Discharge Elimination System (NPDES) storm water permit application;
- Temperature and relative humidity data to support environmental safety and health field activities during periods of extreme heat and cold;
- Groundwater studies to evaluate the impact of rainfall on contamination in the underlying aquifer; and,
- Wetland and lake ecological studies for support of foliar vegetation absorption analysis.

As of the end of 2000, the site has been essentially remediated and almost all contaminated materials have been permanently disposed in the 45-acre onsite disposal cell. The contaminated material in the cell is covered by at least I foot of clean soil, and the cell cap is due to be placed during 2001. Thus, the meteorological station is no longer necessary to support radiological activities or dispersion modeling. However, it will continue to be operated for at least another year in support of general construction activities and groundwater studies.

Yucca Mountain Project (YMP)

As part of DOE's Office of Civilian Radioactive Waste Management (OCRWM), the Yucca Mountain Project (YMP) studies may eventually support a recommendation of Yucca Mountain for the nation's first geologic repository for spent nuclear fuel and other high level radioactive waste. The current meteorological program within the YMP focuses on environmental compliance and operational health and safety considerations, for both employees and the general public (Figure 3-DOE-5).

As with a number of DOE sites, the Yucca Mountain area is one of complex topography and heterogeneous surface characteristics, creating mesoscale conditions that locally influence onsite weather. The YMP meteorological program, therefore, includes four full stations for measuring atmospheric dispersion and general meteorological conditions, as well as nine precipitation stations. These stations serve to monitor the significant variations in airflow, rainfall, and temperature caused by the area's complex terrain environment. The meteorological stations are key to the thorough monitoring of these variations that is essential for YMP's ongoing commitment to

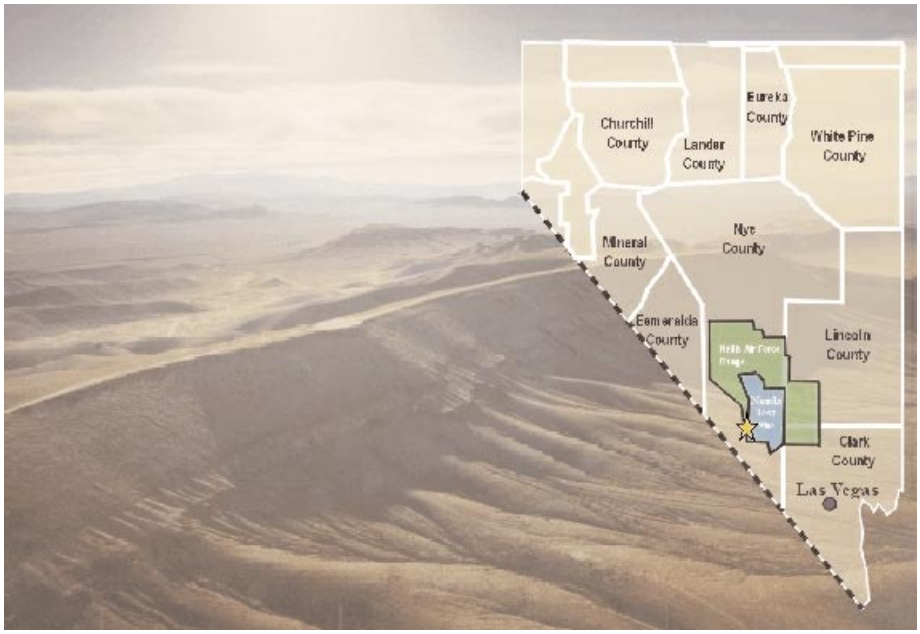


Figure 3-DOE-5. Yucca Mountain (100 miles northwest of Las Vegas, Nevada) is unpopulated land owned by the Federal Government and adjacent to the Nation's nuclear weapons test site.

environmental compliance and to the health and safety of employees and the public.

The YMP meteorological program also provides essential data for the studies necessary to evaluate the site's suitability for a potential repository. Should the site be deemed suitable and a repository licensed, built, and operated, water would be the primary means by which radioactive materials could be transported to the accessible environment. Thus, movement of water from the atmosphere to the surface and on through the mountain is a key concern. The meteorological program provides essential data for the infiltration model of the mountain. Data about precipitation, humidity, evapotranspiration, surface water run-on, solar radiation, air temperatures, and wind patterns all contribute to the overall infiltration model. The model gives special emphasis to the transient, or temporal, versus steady-state rates of water movement through the unsaturated zone of rock at Yucca Mountain. The temporal variation of infiltration may be short term, due to weather fluctuations that drive episodic flow, or much longer term, in periods corresponding to climate change. Data from the meteorological program's ongoing monitoring programs are supplemented by the program's paleoclimatology studies. Together, they provide essential information for the YMP modeling of past, present, and future infiltration rates.

If the potential repository were actually built and operated, continuous meteorological monitoring and analysis would also be essential for the operational facilities on the surface of the mountain, at least until the final closure of the repository. Buildings would be built to withstand the probable maximum flood and wind conditions, and administrative controls would be in place to suspend operations during severe weather conditions. An integral part of the emergency response system would include monitoring the overall environmental situation at the repository site. In turn, an integral part of the overall environmental monitoring system would be the meteorological monitoring system. This system would collect real-time meteorological information about the site and provide weather forecasting and climatological data. Such data would be essential for management decisions regarding the health and safety conditions for employees and the public.

DOE Meteorological Coordinating Council (DMCC)

Based on a need to facilitate more coordination and cooperation among the meteorological activities at the DOE field offices, the DMCC (the Council) was established in December 1994. The mission of the Council is to coordinate meteorological support and research to meet DOE objectives. The objectives of the council are to:

- Promote cost-effective support for all DOE facilities;
- Plan for future needs, requirements, and missions;
- Advocate awareness of atmospheric science applications and benefits to DOE; and,
- Advocate the use of common methods, procedures, and standards.

Council oversight is provided by a steering committee consisting of DOE headquarters and field element representatives. Products of the DMCC include analysis of meteorological requirements embedded in DOE orders and guidance, site meteorological program peer reviews, and, as needed, customized technical assistance. Assist visits have been conducted at DOE/NV, WIPP, Pantex, and DOE/OR. A follow-up assist visit was also conducted at WIPP. Additional assist visits are in the planning stages and will be conducted over the next several years. The DMCC web page has been broadened and can be accessed at *www.sord.nv.doe.gov*.

Space Weather Activities

Los Alamos National Laboratory is involved in a full spectrum of space weather activities. LANL's responsibility begins with the design, fabrication, testing, and integration of space hardware on United States satellite assets. LANL is also responsible for the collection, analysis, and archiving of data from those instruments, and for providing value-added data products, theory, simulation, and expertise to end-users. DOE's National Nuclear Security Administration (NNSA) funds the activities described here in accordance to a Memorandum of Understanding with other United States agencies, such as the DOD. The two primary programs that provide space weather data and make them available to a broad user community are: (1) several series of classified geosynchronous satellites and (2) the Global Positioning System (GPS).

The geosynchronous data set at LANL spans more than 26 years (two complete solar cycles) of energetic particle data and 13 years (1989-present) of complete energy coverage, from nearly zero eV to many MeV. The current generation of LANL/GEO satellite instruments include three particle detectors--(1) the Magnetospheric Plasma Analyzer (MPA), (2) the Synchronous Orbit Plasma Analyzer (SOPA), and (3) the Energetic Spectrometer for Particles (ESP). Using funding from the NSF Space Weather Program and Boeing Corporation, LANL has produced a set of "merged" data from the MPA, SOPA, and ESP detectors and provided those data to NSF, Boeing, and other interested agencies and researchers.

The GPS consists of 24 satellites at 55 degree inclination orbits with a period of 12 hours. GPS is best known for its navigational mission and for the ability to measure ionospheric total electron content (TEC) along the line of site from a ground station to a satellite. The GPS satellites, however, have

an additional space weather capability provided by energetic particle detectors, which measure the energetic particle radiation environment. To date, the GPS energetic particle data have primarily been used in studies of the Earth's relativistic electron belt. A major change is planned for this program as the Burst Detector Dosimeter (BDD) instruments will be replaced by Combined X-Ray Dosimeters (CXD). BDD instruments were flown on 4 of the 24 GPS satellites, providing simultaneous coverage from four spacecraft. CXD instruments will be flown on every GPS IIF spacecraft, eventually providing a constellation of 24 simultaneously operating energetic particle detectors measuring the Earth's radiation belts. When complete, the GPS constellation will represent the largest operational fleet of space weather platforms in existence.