AIR RESOURCES LABORATORY

1993 REPORT

Air Resources Laboratory

U.S. Department of Commerce

National Oceanic and Atmospheric Administration
Environmental Research Laboratories
Air Resources Laboratory
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From the Director

The Air Resources Laboratory (ARL) is a scientific organization with a rich history and a keen eye towards the future. In 1993, we marked our 45th year as leaders in various aspects of atmospheric science related to air quality and climate. But, in response to national needs and in anticipation of the scientific issues that will shape our lives in the coming decades, we are an evolving organization.

In this report, you will read about our recent accomplishments and our vision for the future. Herein we have highlighted our programs to give you a flavor of what we are about and to whet your appetite for more information, which we would be happy to provide.

Much of our effort involves collaborative research and supports other government agencies and programs. So we are particularly sensitive to trends in, and the requirements of, the community with which we interact. Your comments about ARL or this report are always welcome.

BB Hicks

Bruce B. Hicks, Director
Air Resources Laboratory
NOAA/SSMC3, Room 3152
1315 East West Highway
Silver Spring, MD 20910

Telephone	(301) 713 0295, ext. 136
fax	(301) 713 0119
E-mail	hicks@arlrisc.ssmc.noaa.gov
	B.HICKS/OMNET

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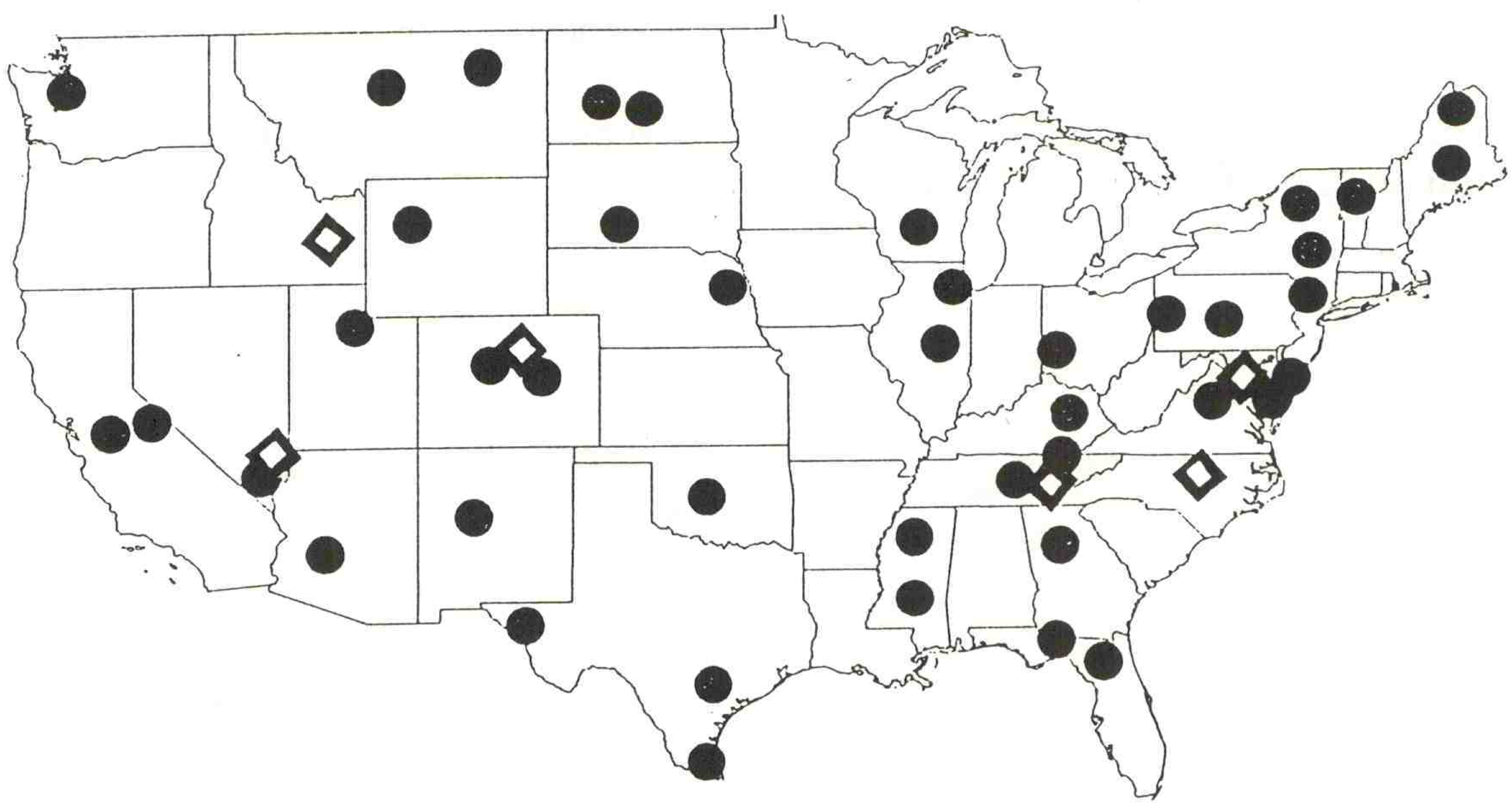
An Overview of ARL

Mission:

Although ARL, probably more than most other NOAA laboratories, works closely with other government agencies, we are first and foremost a NOAA research laboratory. As stated in the NOAA 1995-2005 Strategic Plan, *"NOAA's mission is to promote global environmental stewardship and to describe and predict changes in the Earth's environment."* The ARL contribution to that goal can be summarized in the ARL mission statement:

The Air Resources Laboratory carries out research on processes that relate to air quality and climate, concentrating on the transport, dispersion, transformation and removal of trace gases and aerosols, and the exchange between the atmosphere and biological and non-biological surfaces. The time frame of interest ranges from minutes and hours to that of the global climate. Research in all of these areas involves physical and numerical studies, leading to the development of air quality simulation models. The Laboratory provides scientific advice to elements of NOAA and other Government agencies on environmental problems, emergency assistance, and climate change.

The specific goal of ARL research is to improve and eventually to institutionalize forecasting of air quality, deposition, and related atmospheric environment variables. This is in support of concerns related to effects on human health, ecosystem viability, sustainable development, and international competitiveness.



ARL laboratories (squares) and field monitoring sites (circles) are located throughout the country.

Personnel and Divisions:

The Air Resources Laboratory started as the Special Projects Section of the U.S. Weather Bureau, in 1948. In 1963 (and until 1965), its name was changed to the Meteorological Research Projects Branch of the Weather Bureau. In 1965, the organization (including its field offices) was reconstituted as the Air Resources Laboratories, and most recently (1981) was redefined as a single Air Resources Laboratory with several field divisions. Thus, ARL is not a single, centrally-located laboratory, but a consolidation of spatially distributed laboratories that focus on specific aspects of research related to the overall ARL air quality mission. ARL's approximately 150 federal employees work in laboratories in six states, as follows.

- ***Headquarters Division*** -- Silver Spring, MD
  -- Focus: Transport, wet deposition, and climate change

- ***Atmospheric Sciences Modeling Division*** -- Research Triangle Park, NC
  -- Focus: Integrated modeling

- ***Atmospheric Turbulence and Diffusion Division*** -- Oak Ridge, TN
  -- Focus: Turbulent dispersion and exchange

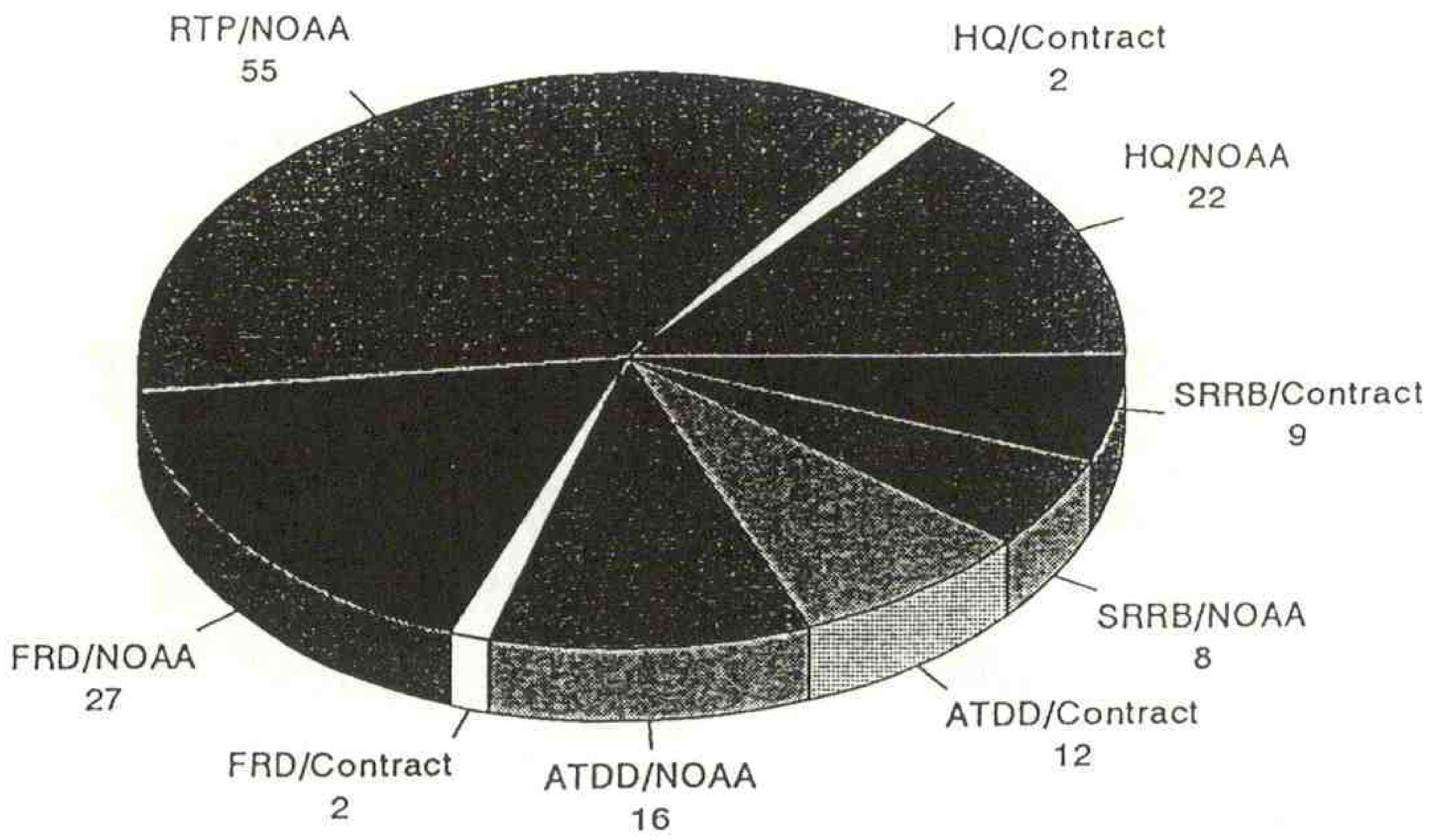
- ***Field Research Division*** -- Idaho Falls, ID
  -- Focus: Air quality transport and model evaluation

- ***Special Operations and Research Division*** -- Las Vegas, NV
  -- Focus: Particle dispersion and deposition, emergency response

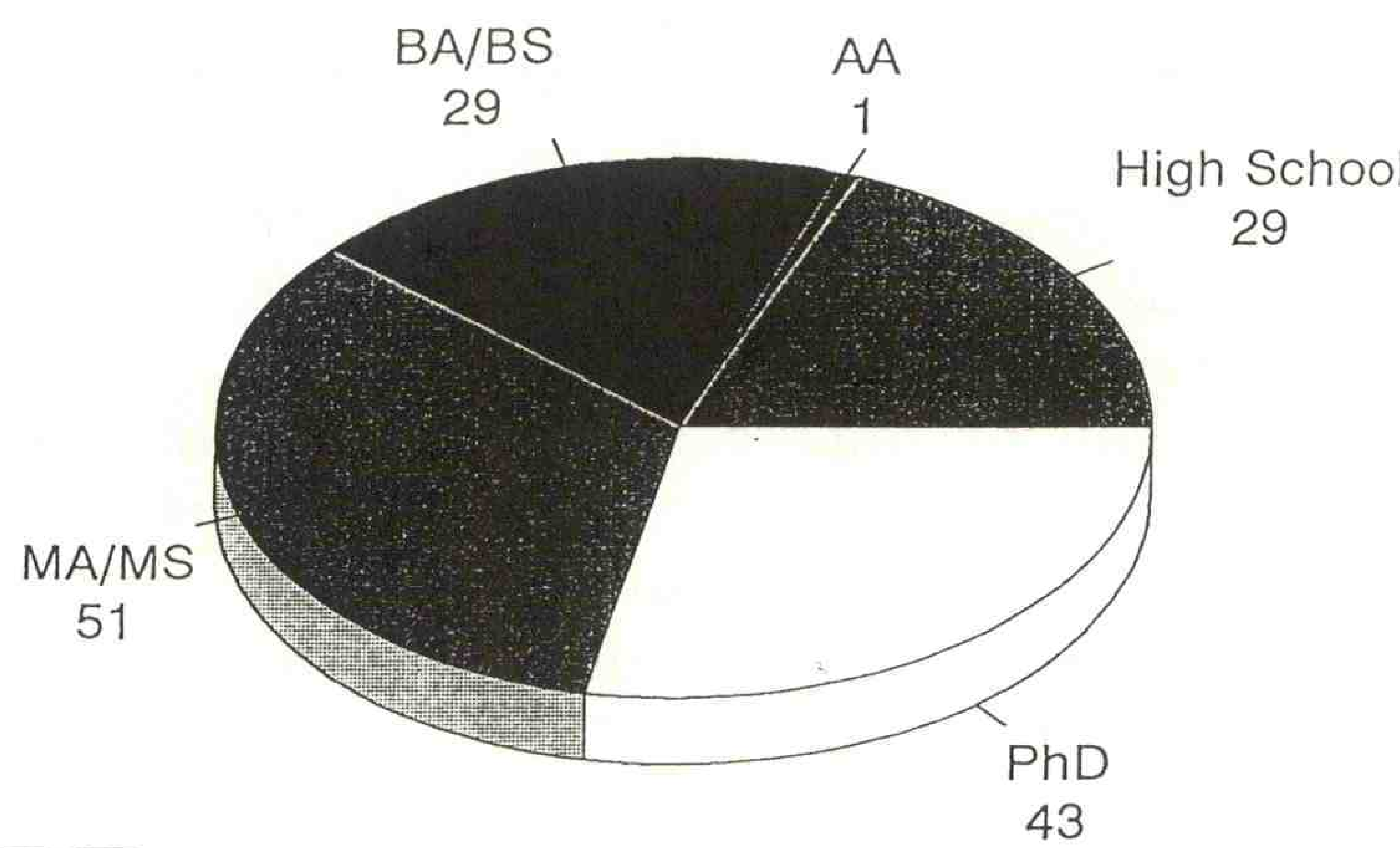
In addition, a ***Surface Radiation Research Branch*** operates in Boulder, Colorado, as a field component of the Headquarters Division.

ARL's greatest resource is its people. At present, scientific and support staff total about 150 NOAA employees and about 70 contract personnel, as summarized in the charts below. Full staff rosters and photographs are included at the end of this report.

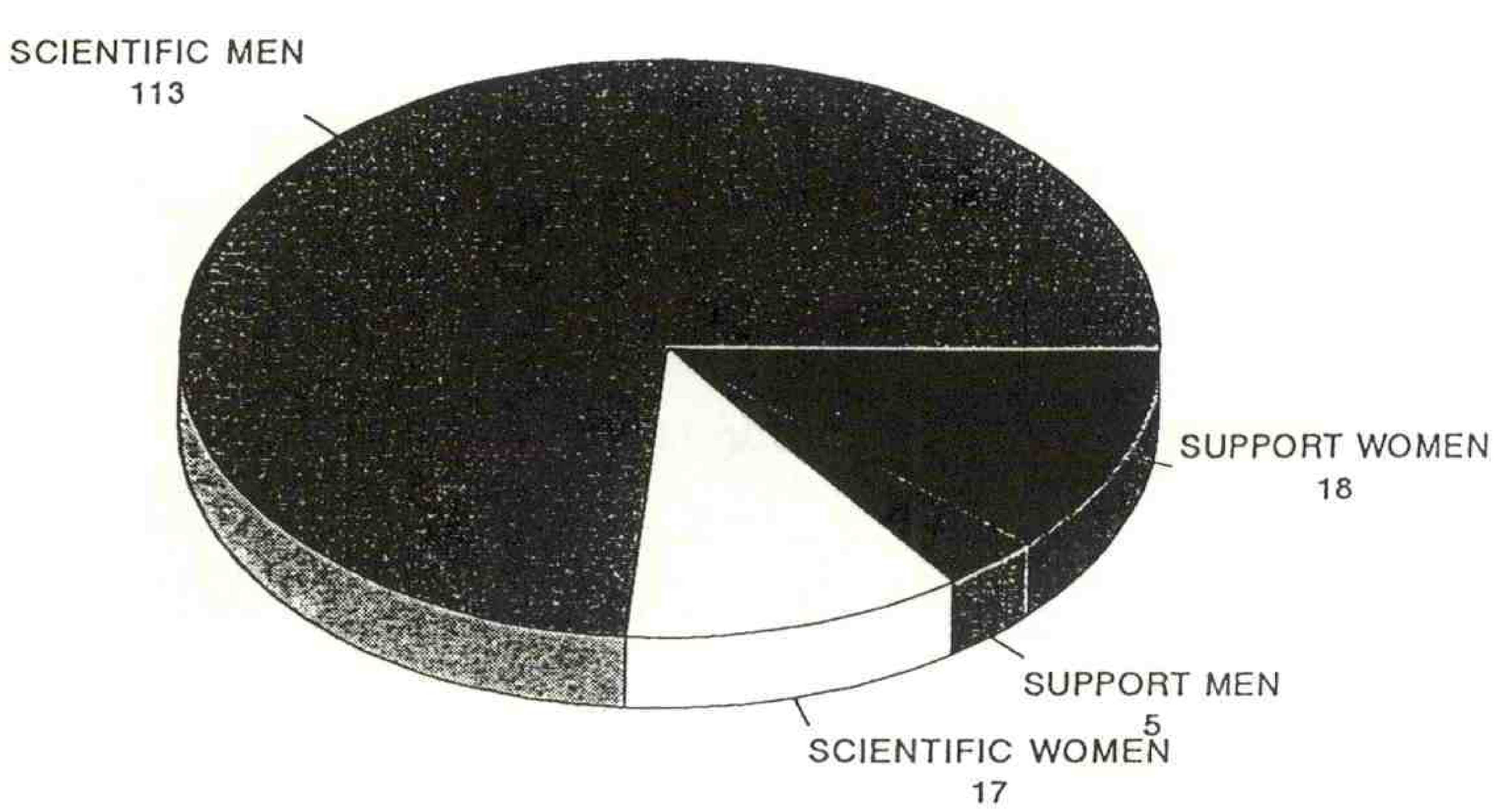
NOAA and contract personnel



Educational Levels



ARL Staff



Research Philosophy:

The research conducted at the various ARL locations is coordinated and organized in three research themes. The accomplishments described in the body of this report are organized according to these themes.

Theme 1. *Air Quality and Dispersion* (air-surface exchange; acid deposition; ozone and oxidants; aerosols and visibility)

Theme 2. *Emergency Preparedness* (nuclear; volcanoes; toxics; dense gases)

Theme 3. *Climate Trends and Variability* (solar radiation, including infrared and ultraviolet; meteorological trends; desertification)

In every case, ***the end product of ARL research is an improved capability to predict air quality***, in some specific guise. This capability will necessarily take the form of a computer model of some kind, driven by meteorological information and emission data, and containing the best available descriptions of all relevant processes. To this end, ***ARL conducts research involving both modeling and measurements, with an emphasis on integration of these activities.*** It is recognized that modern models are invariably data assimilative, and that modern monitoring programs require coupled modeling activities for data interpretation.

The applications of these capabilities range from assessment, typically using climatological or "characteristic" inputs, to short-term prediction, based on the use of meteorological forecast data. The current state of this science is that different applications require different mixes of the processes to be considered, and it is anticipated that future products will retain much of this specialization. In this context, however, there is an over-riding recognition of the need for model products to be as simple as satisfies the demands placed on them, while being adequately complete in their formulation. The models are intended to be parsimonious, data assimilative, and regularly benchmarked against observations made with coupled observing networks. To this end, the organizational components of ARL contribute in the following fashion.

Model Development

- Improving assessment capability for support of regulations and controls -- Research Triangle Park
- Improving the ability to focus on particular locations -- Oak Ridge
- Determining the relationship between concentrations and deposition -- Oak Ridge

- Linking air quality and deposition models with routine forecast products -- Silver Spring

- Extension to radioactivity -- Las Vegas

- Provision of emergency response capability -- Las Vegas, and Silver Spring

- Field testing and evaluation of models -- Idaho Falls

Provision of Data

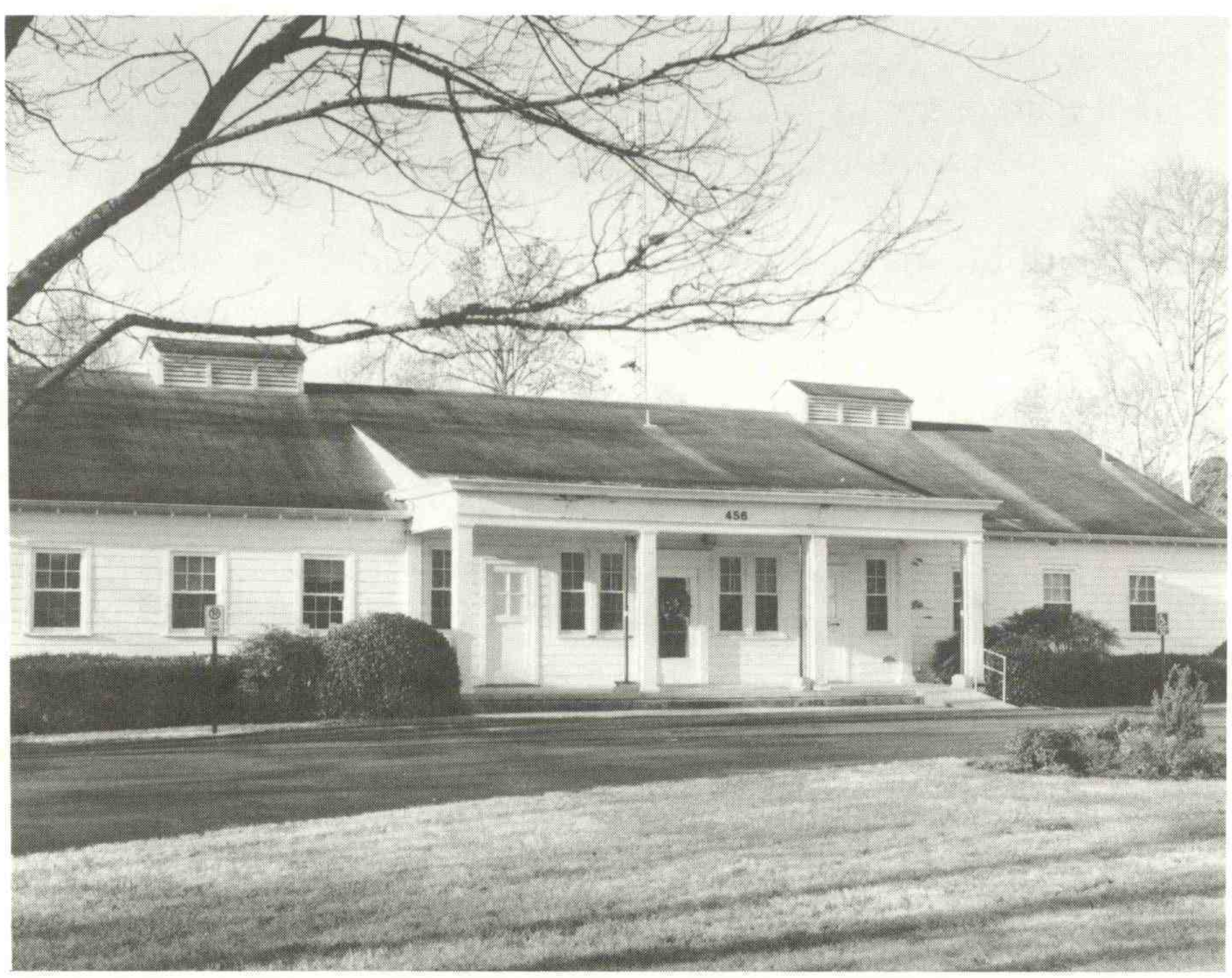
- Ensuring the compatibility of international data sets -- Silver Spring

- Accounting for poor measurement fidelity -- Silver Spring

- Operating integrated networks to couple monitoring observations with model predictions (AIRMoN) -- Silver Spring, Oak Ridge

- Operating networks to characterize data fields required as input for air quality, surface energy balance, and deposition models (solar radiation, etc.) -- Oak Ridge, Boulder, Research Triangle Park

- Providing quality assurance on national radiation data (solar, surface, UV-B) -- Boulder



The ARL Atmospheric Turbulence and Diffusion Division's Oak Ridge, TN, home.

ARL's Role in the Federal Government:

ARL conducts research as needed to answer questions of urgency related to regulatory controls and policy, public safety, and the environment (as it involves atmospheric considerations). ***ARL serves as a provider of scientific information to the administration, the Congress, various state and federal agencies, the public, private industry, and the scientific community.***

In this regard, ARL strives to be a full-service organization, supporting necessary research at selected universities, maintaining a long-term monitoring and analysis infrastructure around which the research is concentrated, and representing NOAA and the national interest in policy debates and scientific discussions on related matters.

A central issue is the relationship of ARL with other laboratories in NOAA, especially among the Environmental Research Laboratories. But equally important is the role that has developed involving other agencies. ***In practice and by intent, ARL is the major point of interaction between NOAA atmospheric research and the related informational and scientific requirements of several other agencies.***

- NOAA is viewed by other agencies as a provider of high-quality and independent advice regarding matters of atmospheric transport, dispersion, air quality, and deposition, and ARL is perceived to be the agent providing access to this advice.

- NOAA values independence from agencies that are more closely influenced by policy and regulatory considerations, and attributes (in part, at least) the high quality of its science to the opportunity to conduct and promote research independently of policy and regulatory processes.

Much of the contribution made by ARL can be viewed as provision of independent atmospheric expertise to assist other agencies in fulfilling their own federal mandates. This provision of scientific information and advice to other agencies can be considered to be a component of NOAA's service function. Financial support for work intended to permit another agency to perform its own function, in its own jurisdictions, with improved credibility and defensibility is normally provided by the other agency concerned. At this time, the major agencies involved are the Environmental Protection Agency and the Department of Energy. ARL is roughly equally supported by NOAA, EPA, and DOE.

- The Environmental Protection Agency provides almost complete support for the ARL team at Research Triangle Park, established specifically to provide meteorological expertise and services to EPA, related to atmospheric dispersion and air quality modeling.

- The Department of Energy provides about 25% of the funding for the ARL team at Oak Ridge, set up to provide a collaborative NOAA/DOE capability to address questions on dispersion, deposition and air quality of relevance to the DOE Oak Ridge Field Office.

- The Department of Energy also provides about 25% of the funding at Idaho Falls, for maintenance and improvement of emergency assistance services to the Idaho National Engineering Laboratory.

- The Department of Energy provides almost all of the funding of the ARL Special Operations and Research Division, in Las Vegas, to support the DOE weapons test program of the Nevada Operations Office.

ARL's Contribution to the NOAA Strategic Plan:

The NOAA Strategic Plan focuses on needs that are related to the performance of NOAA's own mission. The activities of ARL contribute to the goals of the Strategic Plan, but also interject the requirement to consider a higher plane of consideration -- NOAA's role as a source of atmospheric and aquatic environmental guidance to other elements of society and especially to other federal agencies, independent of their own regulatory and control functions. ARL research contributes directly in several NOAA Strategic Plan components, as follows.

<u>Coastal Ecosystems Health</u>

(a) The role of atmospheric deposition as a contributor to coastal ecosystem eutrophication and decay.

ARL is conducting research to develop objective methods for quantifying atmospheric deposition, as it affects coastal ecosystems, with emphasis on nutrients and toxics. Current research is directed specifically to the roles of nitrates and airborne toxic chemicals. ARL is focussing initially on East Coast ecosystems — mainly the Chesapeake Bay and Albermarle/Pamlico Sound. State-of-the-art models are being developed by ARL (Research Triangle Park), and advanced measurement systems as being deployed by ARL (Oak Ridge and Silver Spring). Initial estimates for the Chesapeake Bay indicate that about 30-40% of the nitrogen loading is derived from the atmosphere. ARL chairs the Chesapeake Bay Air Quality Coordination Committee, an officially-endorsed body for consolidating activities among federal and state agencies.

(b) Monitoring of Causative Factors.

ARL is leading a national thrust towards "integrated monitoring," a new multi-disciplinary approach to monitoring to address complex questions. Since monitoring of the actual health of ecosystems only provides indications of damage *after* the damage has occurred, responsible ecosystem monitoring requires attention to those factors that cause the damage to occur, specifically input rates of toxic materials and nutrients. The present objective is to develop cost-effective and proven methodologies for conducting such monitoring.

ARL operates exploratory monitoring stations in coastal areas, where interpretation of atmospheric data is presently difficult and agreement on the results is rare. Techniques are being developed to account for the roles of terrain complexity in the models used to interpolate among monitoring sites and in the simulations used to assess likely inputs in the absence of field data. In particular, techniques to account for moderate terrain complexity have been developed and are now being included in assessment models being developed be ARL for EPA. As yet, there has been no opportunity to test the predictions of these models against field data, however steps to provide a platform suitable for collecting such data have been initiated.

Advance Short-Term Warning and Forecast Services

(a) Air Quality Predictions

A major goal of ARL is to develop the basis on which to extend current prediction services to other environmental variables, necessitated by increasing population and societal pressure. The long-term goals of related research are related to air quality in general (ozone, particulates, etc.) and to UV-B radiation.

In this context, it is apparent that the focus of most atmospheric predictive models is on layers of the atmosphere that move weather systems. For air quality, more attention must be directed to the lower atmosphere (where people live and where pollution is greatest). Relevant models are now available, and are slowly being coupled with weather forecasting models. In the future, data assimilation methods must be extended, to focus on areas where forecasts are specially needed.

(b) Emergency Planning and Response

ARL serves as a center of activity for the provision of specialized meteorological assistance in the event of large releases of hazardous materials into the atmosphere, such as from volcanoes, nuclear accidents, and industrial disasters. In general, NOAA provides basic meteorological support in all such cases, but is also expected to provide related guidance to other agencies and warnings to the public. For this purpose, ARL (as a joint activity with the National Meteorological Center) operates a Regional Specialized Meteorological Centre for the World Meteorological Organization (WMO), to provide emergency response assistance to the nations of North and Central America in the event of a disastrous atmospheric accident. Throughout the entire nuclear era, ARL has provided emergency preparedness and response services to DOE and the Nuclear Regulatory Commission (NRC), relating to nuclear accidents and explosions.

As components of this activity, ARL coordinated much of the multi-agency and multi-national atmospheric research response to the Kuwait oil fires emergency. ARL developed the techniques now in routine use for forecasting the spread of volcanic ash. ARL also developed the methodologies now in place to advise NRC (and several components of DOE) in the event of a nuclear accident. In the distant past, ARL research led to the generation of the now famous "Gaussian plume" dispersion methodology, now routinely used for warning the nearby public in the event of a leak of trace quantities of hazardous gases into the atmosphere.

Seasonal to Interannual Climate Forecasts

(a) Air Quality and Environmental Assessments

As a longer-term extension of ARL's work on air quality prediction, ARL provides objective and independent guidance to policy-makers concerning specific environmental concerns and corresponding regulatory strategies, related to national and global air quality and climate. Specific examples of recent issues include acid rain, tropospheric ozone, visibility, and airborne toxics.

NOAA/ARL provides independent guidance on alternative regulatory and control strategies to the EPA through its Research Triangle Park operation. ARL also conducts extensive field tests of the models developed for such purposes, through its Idaho Falls group.

For more than a decade, NOAA has provided the scientific direction of the National Atmospheric Precipitation Assessment Program, an interagency body to provide necessary cross-agency mechanisms to coordinate research, consolidate knowledge, integrate assessments, and imply national strategies. ARL has been the principal NOAA representative.

In collaboration with scientists from many other agencies, ARL has led scenario-based assessments of toxic chemicals, ozone, and NO_x control options, etc. The importance of this activity is rapidly growing. NOAA is widely viewed as an independent source of expert information on matters of environmental and air quality policy, both nationally and globally. As time progresses, environmental quality is becoming less of a local problem and more of a global concern. Air quality scenario and assessment models will need to broaden their scope from countries to continents.

Predict and Assess Decadal-to-Centennial Change

(a) Detection and Attribution of Change in Air Quality

A major component of ARL research relates to the need to detect the consequences of imposed emission controls in a timely and unequivocal manner, so as to permit remedial adjustments in control strategies. For this reason, ARL has operated a research-grade national monitoring network since about 1985, concentrating on chemicals indicative of industrial and societal emissions — primarily sulfur and nitrogen oxides. Recently the largest-running precipitation chemistry network in the world has been consolidated with this ARL program. Now, we have an ongoing, broad-based network that is specifically designed to reveal changes in the atmospheric environment, with rapidity.

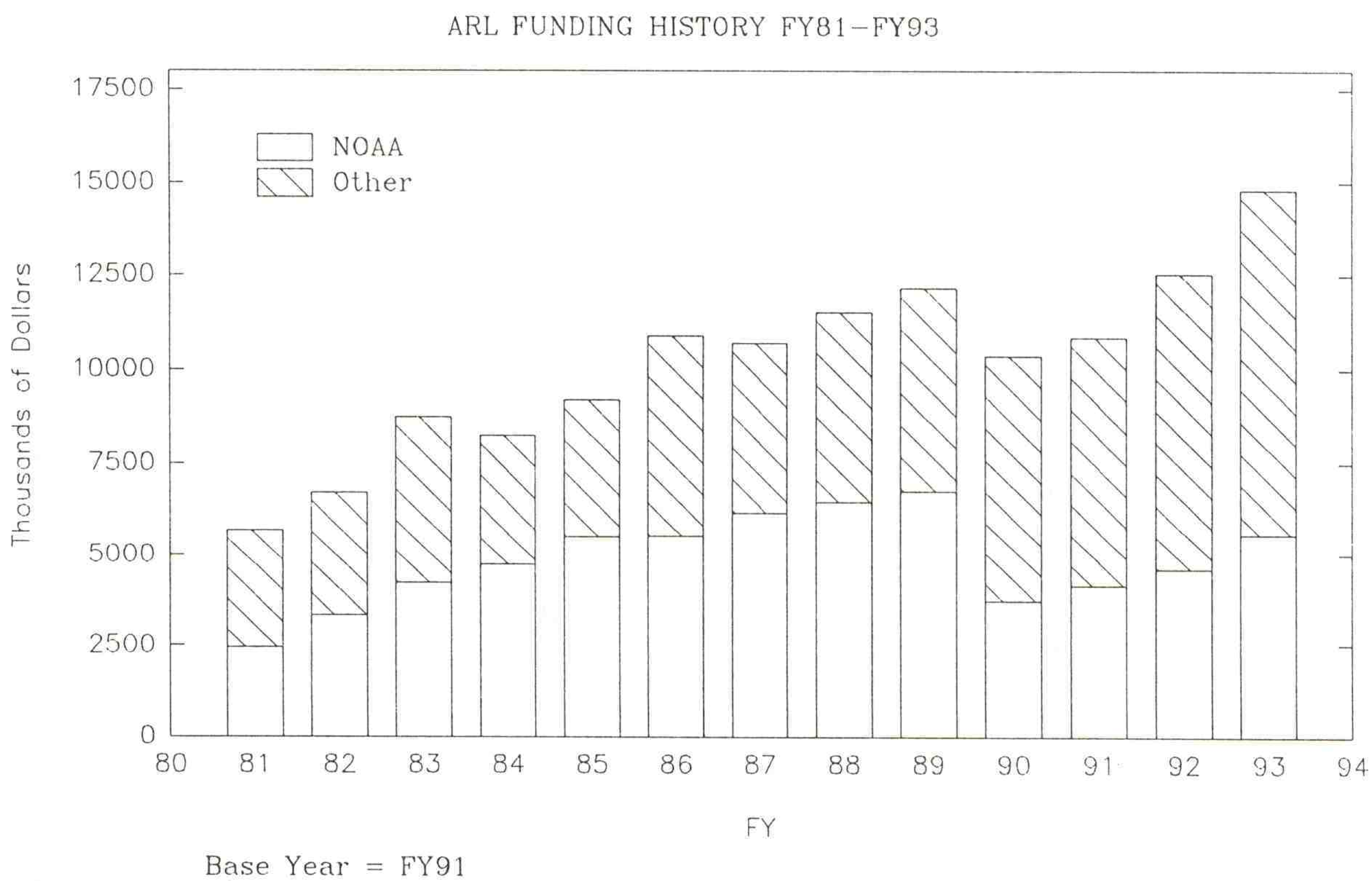
At this time an Atmospheric Integrated Research Monitoring Network (AIRMoN) exists, although in embryonic form. The models that are needed to interpret the data obtained are also on hand, although only as first-generation attempts as yet. The existing AIRMoN program is designed primarily to provide accurate information on the rate of deposition of air chemicals to the surface; present planning is to add a rapid detection component to the AIRMoN program, under funding through the new Health of the Atmosphere program. The intentions are that the AIRMoN will be refined and coupled with real-time analysis and modeling so as to reveal those changes that can be attributed to changes in pollution emissions.

(b) Quality Assurance of Global Data

ARL leads a multi-national effort to ensure that air quality data sets collected by national monitoring networks can be brought together in an objective and seamless manner. A WMO Quality Assurance/Science Activity Center for the Americas is presently being inaugurated, to serve North, Central, and South America. The center will work directly with member nations, and with site operators, to ensure the highest possible integrity of monitored data. A three-agency consortium has been established to provide the necessary support — DOE, EPA and NOAA. A firm funding commitment has been received from EPA and DOE.

ARL Funding History

ARL receives funding from NOAA and other federal agencies. In FY93, about one-third of the total budget was provided by NOAA. Funding for ARL activities has shown a general upward trend over the past decade or so. Most of the increase has been due to increases in resources from other agencies. The dip in funding in FY90 was related to the separation of the Geophysical Monitoring for Climatic Change program to create a separate Climate Monitoring and Diagnostics Laboratory.



Recent Organizational Highlights

In keeping with government-wide efforts to streamline programs and provide higher quality and more cost-effective service to the nation, the Air Resources Laboratory has recently re-aligned its research capabilities, facilities and personnel to strengthen operations in areas where we are widely seen to have special skills and to refocus efforts towards scientific issues of national and international importance. Major changes involved restructuring the ARL presence in Boulder and establishing an integrated surface radiation program there; centralizing surface dust activities in Research Triangle Park, and aircraft activities in Oak Ridge; and welcoming back into the ARL family the NOAA Nuclear Support Office in Las Vegas, Nevada.

Establishment of Surface Radiation Research Branch

A new Surface Radiation Research Branch, in Boulder, under the direction of John DeLuisi, will focus on (a) the scientific direction of new continental U.S. surface radiation program, and (b) calibration of instrumentation for the rapidly evolving ultraviolet-B (UV-B) networks of several US agencies. A more detailed description of the ARL Integrated Surface Irradiance Study (ISIS) is found later.

Return of the NOAA Nuclear Support Office to ARL

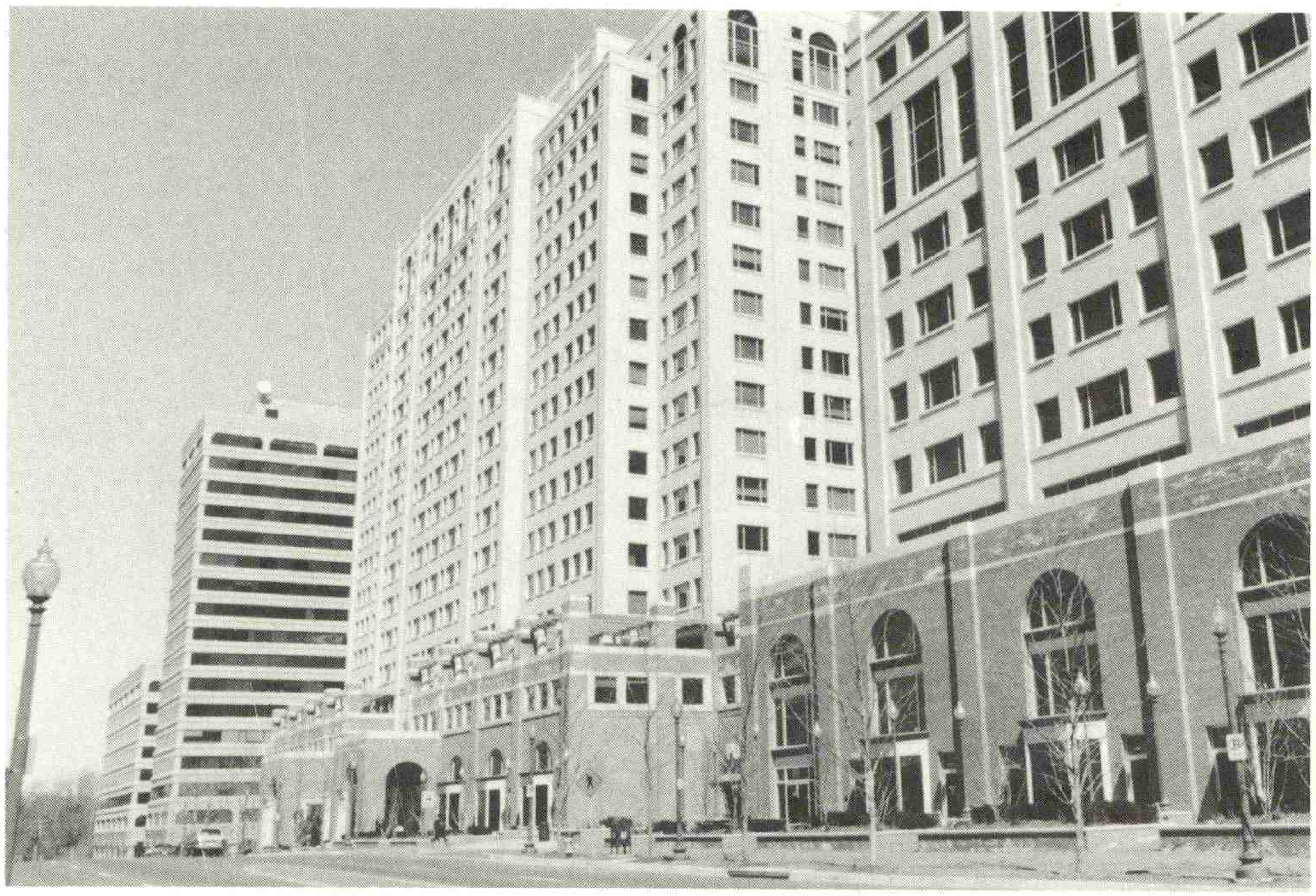
Negotiations with the National Weather Service concluded with an agreement that the NOAA Nuclear Support Office in Las Vegas rejoin ARL in early 1994. The office, to be called ARL Special Operations and Research Division, provides meteorological support for the Nevada nuclear test site, and had been part of ARL from its inception in 1968 until 1976. Because of concern about the resuspension of nuclear material into the atmosphere with the cleanup of the nation's nuclear sites, the work of this group will be focused on understanding problems associated with resuspension and turbulent diffusion and transport. This merger means that most of the NOAA nuclear emergency preparedness responsibilities and capabilities are now consolidated within ARL.

Consolidation of Aircraft Activities at Oak Ridge

To improve ARL and NOAA's aircraft capabilities, we are re-aligning our research platforms to best use available resources. ARL had been operating two aircraft for several years, one in Boulder (a Beechcraft King Air, for aerosol chemistry and cloud physics research) and the other in Oak Ridge (a privately-owned Rutan Long-EZ, for eddy flux measurements). The two activities have been merged in Oak Ridge, with the selection of a de Havilland Twin Otter of the NOAA aircraft fleet as an optimal platform for both air chemistry and eddy flux research. The Twin Otter carries more payload, making it a better workhorse for air chemistry studies, and flies slower, making it better for flux and profile measurements.

Relocation of ARL Headquarters in Silver Spring

In early May, ARL Headquarters moved from Building 2 of the NOAA Silver Spring Metropolitan Center to the third floor of Building 3, at 1315 East West Highway, Silver Spring, Maryland. The new quarters are larger and include a chemistry laboratory, a modeling facility, a computer laboratory, a small library, and meeting rooms. With the arrival of the NOAA Central Library to the same building, our research facilities in Silver Spring are considerably expanded and more convenient.



ARL's Headquarters Division is now located in the NOAA Silver Spring Metro Center Building 3.

High performance Computer Research Network at RTP

The ASMD continues to play an important role in the nation's efforts in high performance computing. As part of the Federal High Performance Computing and Communications (HPCC) Program, the EPA has established a 100 megabit/second Fiber Distributed Data Interface network in Research Triangle Park. This network will interconnect a variety of high performance graphics files and computer servers, including a 1000-processor massively parallel machine.

As a demonstration of the power of the new computational facility, a version of the Regional Oxidant Model (ROM) was successfully ported to the EPA's DECmpp massively parallel computer with 4096 parallel processing elements. Benchmark results demonstrate excellent speed-up compared to VAX computers and even slightly better performance compared to a DEC high-end Alpha workstation.

Upgrade of Idaho National Engineering Laboratory Emergency Support System

This year, the Field Research Division completed an upgraded emergency support system for DOE's Idaho National Engineering Laboratory. This represents the culmination of an effort that began in 1991. The upgrade package involves (1) acquisition of meteorological data from a network of stations in the field; (2) data storage in multiple archive locations; (3) local and remote data access via PC workstations for use during emergencies, exercises, and normal operations; (4) extensive QA/QC procedures; (5) location of up to six workstations at sites designated by the DOE with maintenance provided by FRD; (6) setup and training for these and other workstations; (7) visualization, modeling, and scenario software modules located at FRD offices and at remote locations connected via Internet or modem. These upgrades will enhance operations and emergency response at INEL and improve the quality of ARL's meteorological support system there.

The Fluid Modeling Facility at the ARL Atmospheric Sciences Modeling Division in Research Triangle Park, NC.

Recent Accomplishments - Highlights of ARL Research

This section highlights of some of ARL's recent work, presented according to the thematic structure of the laboratory.

Program Highlights: Theme 1. Air Quality and Dispersion

ARL provides meteorological expertise to NOAA and to other agencies related to all air quality issues, including acid deposition, toxics, ozone and oxidants, sulfur oxides, particulate matter, and radioactivity. In many instances, the products derived from physical and numerical studies take the form of improved models. ***A general goal is to develop new, or improved, numerical models to apply to the solution of air quality problems, both in uniform and in non-ideal, non-homogeneous, and non-stationary conditions.***

- For NOAA

  -- attribution of pollution (and deposition) to specific causes

  -- refining regional budgets of natural and man-made trace substances

  -- prediction of the effects of changes in emissions

  -- changing atmospheric composition.

- For EPA

  -- development and evaluation of numerical models for assessment and regulation of pollutant emissions and effects

  -- prediction of effects of alternative control strategies

  -- prediction of ambient air quality and pollutant deposition for use in effects studies, including effects on watersheds, forests, and human health

  -- understanding and assessment of the effects of changes in global climate on regional air quality.

- For DOE

  -- development of models for use in siting and designing power plants (and other enterprises), especially in complex terrain

  -- attribution of observed (or suspected) environmental effects to specific causes.

Acid Deposition - AIRMoN and DDIM Networks

For many years, ARL has operated separate networks addressing wet and dry deposition, the former being part of operations at Silver Spring, the latter Oak Ridge. These separate networks have historically been referred to as the Multistate Power Production Pollution Study (MAP3S) and the Dry Deposition Inferential Monitoring (DDIM) network. The common feature of these two networks has been their focus on accurately defining deposition at key locations with fine time resolution.

In 1990, the Clean Air Act Amendments introduced a new requirement for monitoring networks to study and rapidly report the changes accruing from reductions in emissions. To meet this demand, a new Atmospheric Integrated Research Monitoring Network (AIRMoN) was created by combining the pre-existing MAP3S and DDIM operations within a single organizational structure, so providing a foundation for the expanded operation required to meet the demands of the Clean Air Act Amendments. At this time, AIRMoN is operating at a low level, in anticipation of growth under the new NOAA "Health of the Atmosphere" program.

Forecasts of Rainfall pH

ARL has recently developed a model to forecasts of daily rainfall pH for precipitation chemistry stations in the eastern U.S. The model, called the Hybrid Simple Particle Lagrangian Integrated Trajectory model with Atmospheric Chemistry Including Deposition, or HYSPLIT-ACID, incorporates a non-linear sulfur and nitrogen chemistry module into the Lagrangian HYSPLIT model to produce air concentrations and depositions of major sulfur and nitrogen species. The sulfur chemistry portion of the model has been tested extensively against observations, while the nitrogen chemistry is still being evaluated.

The model is run over the U.S. using Nested Grid Model meteorological data for transport and deposition and 1985 NAPAP emissions data for sources of sulfur and nitrogen. Daily runs produce a 12-hour forecast of precipitation pH. This model is the only known model running operationally in the U.S. to produce forecasts of precipitation pH. Forecasts will be compared with measurements from AIRMoN and possibly the Canadian Air and Precipitation Monitoring Network.

Air Quality Model Training Materials

Many of the models developed by ARL are used by air quality regulatory officials at various levels of government. To assist in the proper use and interpretation of the models, ARL/ASMD prepared personal computer training tutorials for professionals responsible for conducting State and Federal regulatory air quality assessments. The tutorial package contained two video tapes (one describing the Air Quality Modeling Guideline and the other describing the Model Clearinghouse) and tutorials for seven modeling products. This effort was initiated by the Standing Air Simulation Work Group, composed of Federal (EPA), State, and local air pollution regulatory officials.

The North Atlantic Regional Experiment

The North Atlantic Regional Experiment (NARE) is a study of the chemical characteristics of emissions from the North American continent, following in the footsteps of the WATOX study led by ARL during the 1980s. The summer 1993 experiment focused on the transport, transformation, and deposition of ozone and ozone precursors advected from eastern North America to the North Atlantic Ocean. ARL archived meteorological data and provided dispersion model calculations to participating scientists. For the first time, ARL provided an automated back trajectory analysis program, available via electronic mail, for the NARE data period.

ARL also participated in the aircraft experimental component of NARE. The ARL measurement focus was primarily on photochemically active trace gases (O_3, CO, $NO/NO_x/NO_y$, peroxides, VOC grab samples) and aerosols aboard Battelle's G-1 aircraft. The conditions encountered ranged across the entire spectrum, from extremely clean continental background air in northwesterly flow, to heavily polluted air from the Northeastern U.S. Downward mixing of air from the stratosphere or upper troposphere was also noted, occasionally to below 2 km altitude. Preliminary results indicate reasonable agreement between forecast trajectories calculated by HYSPLIT and urban plume locations as determined from the G-1 flights.

Great Waters Research

ARL is involved in determining the atmospheric contribution to the pollution of coastal waters in two important watersheds - the Great Lakes and the Chesapeake Bay.

Great Lakes ARL/ASMD scientists have used the Regional Lagrangian Model of Air Pollution (RELMAP) to estimate the annual deposition of lead, chromium and cadmium to Lake Superior for the International Joint Commission's International Air Quality Advisory Board. The results suggest that long-range transport is more significant than expected. For example, 33% and 75% of the annual atmospheric deposition of lead and cadmium, respectively, can be traced to sources in the mid-Mississippi River Valley, nearly 1000 km from the lake. Even Montreal area sources contribute 7% of the annual deposition of chromium. This would suggest that emission control strategies must include distant as well as local sources.

Under the Atmospheric Nutrient Input to Coastal Areas (ANICA) program, ARL operates an instrumented buoy to provide data for dry deposition velocity calculations. The data are being used to estimate atmospheric nitrogen inputs to the Chesapeake Bay. This observational program is being supported by modeling efforts: ARL scientists tested the Colorado State University Regional Atmospheric Modeling System (RAMS) model over the Chesapeake Bay region to provide mesoscale meteorological fields required to estimate deposition. ARL scientists from Headquarters and ASMD also provide scientific and programmatic leadership in Chesapeake Bay Air Group and the Chesapeake Bay Evaluation and Deposition Committee.

Program Highlights: Theme 2. Emergency Preparedness

ARL provides meteorological support to several agencies, (a) to help predict the dispersion of material from accidental releases into the air, (b) to develop appropriate response strategies, and (c) to provide meteorological assistance in the event of accidents. Work concentrates on dispersion from releases of nuclear materials, industrial accidents, and volcanic eruptions. In this context, NOAA-ARL is viewed by other agencies as a source of high-quality and independent technical expertise.

ARL is one of the world leaders in trajectory modeling, in all of its aspects:

- The prediction of the path to be followed by pollutants released from some source.
- The assessment of concentration fields that might influence population, ecosystems, and the environment in general.
- The identification of specific sources that contribute to air quality problems.

These special capabilities have caused ARL to become a recognized and sought-after authority in the event of accidents (or unusual natural phenomena) that inject potentially hazardous materials into the atmosphere. ***Routine, operational emergency response is not a major thrust of ARL. Our role is to improve the capability by which response can be provided by those agencies charged with this responsibility.*** Hence, ARL concentrates on guiding and advising other agencies who have appropriate responsibilities and jurisdictions. ARL becomes involved in actual response activities when our capabilities are required in order for NOAA to meet its mission or as required to assist other agencies to meet their own missions.

Volcano Response

This year, the ARL-developed Volcanic Ash Forecast Transport and Dispersion (VAFTAD) model was run operationally by the NOAA/NWS/NMC. The Mayon volcano (Philippines) erupted on February 2, 1993 with an estimated ash cloud height of 6 to 7 km. Because the eruption was not (strictly) covered by the Volcano Hazards Memorandum of Understanding under which most of NOAA's response activity is coordinated with other agencies, VAFTAD was not invoked by NMC. ARL, however, opted to assist the Air Force Global Weather Center in running VAFTAD, since the military was very interested in ash forecasts in the area. This situation prompted a clarification of emergency response responsibilities.

NMC successfully ran the VAFTAD model for the two eruptions (4 and 6 km) of Mt. Klyuchevskoy, in Kamchatka. For the future, VAFTAD output will be transmitted over DIFAX during Volcano Hazards Alerts. This paves the way for disseminating other ARL emergency response products.

Nuclear Regulatory Commission Exercises

ARL maintains an emergency response capability, in part, to support the work of the Nuclear Regulatory Commission. In 1993 ARL/Headquarters Division participated in two NRC exercises.

The ARL emergency response team took part in an evening exercise for the Susquehanna, PA, nuclear power plant in February 1993. Meteorological tower data for the plant were available for the first time in such an exercise. The team ran the ARL HYSPLIT and RAMS models to simulate transport from the site. The results were used by NRC managers to evaluate the potential hazard to New York state and Canada.

In June a similar exercise was held for the Ft. Calhoun, NE, nuclear power plant. This exercise involved the Federal Radiological Monitoring and Assessment Center, which is responsible for off-site monitoring of nuclear material. The NMC operational forecasts were originally marred by noise produced by the complex terrain of the Rocky Mountains near the western boundary. Predictions were improved by reducing the time step, increasing the vertical resolution and moving the domain slightly.

Further experiments were performed with RAMS over the Susquehanna nuclear power plant for a case of strong cyclogenesis. Observations showed the impact of the terrain on the wind flow in spite of the strong synoptic gradients. RAMS winds agreed better with observations when fine resolution topography was incorporated. This research emphasizes the importance of topography on local flow even when the synoptic conditions are strong, which confirms the need for fine-scale mesoscale modeling, such as RAMS provides, for emergency response predictions.

DOE Spills Test Facility - Dense Gas Field Studies

ARL/ASMD scientists participated in planning and carrying out experiments in July at the DOE Liquified Gaseous Fuels Spill Test Facility in Nevada. The experiment focused on the mechanics and measurement techniques for releases of a "generic" dense gas, CO_2. Four releases were made, all with good data capture. This experiment is preliminary to larger experiments designed to provide information presently lacking about dense gas diffusion, including behavior in low speed, stable conditions. The most orderly progression of stability states, as determined by Richardson number, was determined to occur near sundown nearly every clear day, the most favorable time for "very stable" releases.

Program Highlights: Theme 3. Climate Trends and Variability

ARL conducts research on trends and variability of the global atmosphere, with a focus on tropospheric and lower stratospheric temperatures, ozone, and tropospheric water vapor. The efforts are directed at detecting trends, but also at defining the variability within which future trends will have to be detected.

Observational data are analyzed for effects of El Niños, quasi-biennial oscillations, volcanoes, and other regular and irregular global scale phenomena. Many of these analyses are used as "ground truth" by those developing satellite measurement techniques. In recent years, ARL has specialized in developing techniques to separate effects of changes in instruments and observing practices from changes in climate; comparing temperature and humidity records from radiosonde measurements with remotely sensed data; comparing model-based description of present climate with observations; and comparing temperature and ozone variations with those estimated from satellite observations.

ARL is also investigating the impacts of global climate changes, as modeled in general circulation models, on regional climates and the effects on forests of these changes.

- For NOAA

  -- development of techniques for separating effects of past changes in instruments and observing practices from changes in climate

  -- comparison of temperature and humidity records from radiosonde measurements with remotely sensed data.

  -- comparison of model-based description of present climate with observations

- For NASA

  -- comparison of temperature and ozone variations with those estimated from satellite observations

- For EPA

  -- cooperative work on regional effects of climate change

The Integrated Surface Irradiance Study

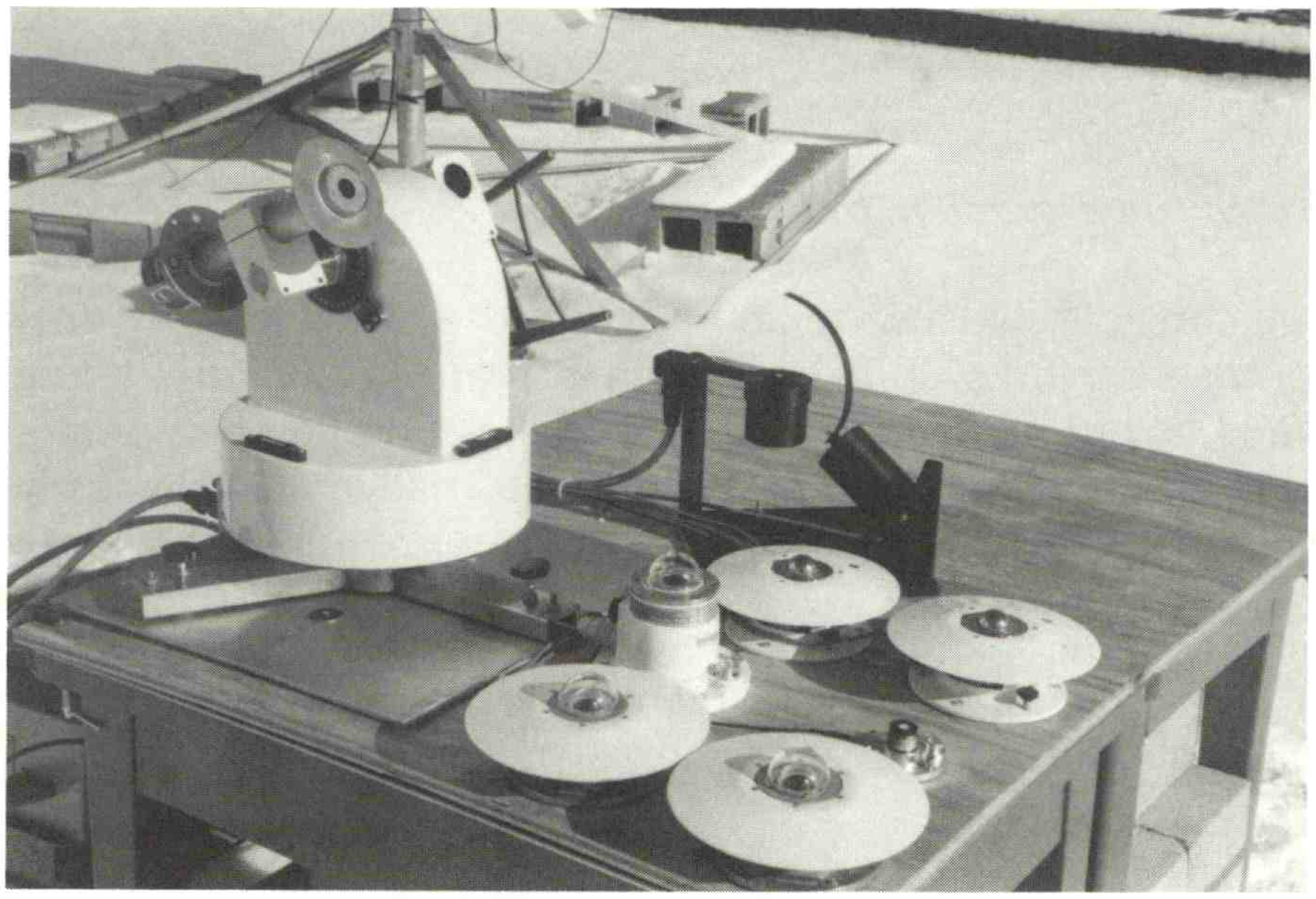
There has been considerable debate about the future of the NOAA solar radiation and UV-B monitoring networks. The problems that are widely perceived are (1) instrumentation has not been regularly calibrated, (2) broken instrumentation has not been replaced and/or repaired, (3) quality control on delivered data has been deficient, and (4) some sites are now less suitable for measurements than when they were set up. The restructuring of the National Weather Service injects another set of difficulties, since some existing sites will be moved, some closed, and some automated. In practice, operation of a high-quality solar radiation station of any kind requires daily inspection of the instruments, so some rationalization is obviously necessary.

Reorganization of NOAA's continental U.S. solar and UV-B radiation monitoring programs has been largely consolidated within the Air Resources Laboratory. The goal is to generate a single, coherent network, with common data recording, transfer, and archiving characteristics, and with as much continuity as possible, addressing needs of the surface irradiance and energy budget communities and with components addressing each of infrared and ultraviolet radiation.

A new calibration program is being constructed. For sensors of radiation in visible wavelengths, calibration will be a joint activity involving NOAA and the National Renewable Energy Laboratory in Golden, Colorado. For UV-B, a new national calibration capability is being constructed in Boulder, Colorado, as a joint NOAA/National Institute of Standards and Technology (NIST) activity and under multi-agency sponsorship. An infrared calibration facility is being planned.

A new SURFRAD program has received support from the Office of Global Programs. This will set up a small number of comparatively sophisticated surface radiation "observatories" across the continental US. These stations will be of the standard expected of Baseline Surface Radiation Network stations of the WMO World Climate Research Programme.

Through its long-standing involvement with the World Meteorological Organization, ARL also remains active in the study and interpretation of atmospheric turbidity. Major reviews of the WMO atmospheric turbidity monitoring program have been completed, and ARL has recently led an international meeting to explore possible plans for the future.



A mock setup of a typical SURFRAD instruments suite, including a normal incident sun photometer, UV-B sensor, multi-filter shadowband radiometer, spectral pyranometer, infrared radiometer and photosynthetically active radiation sensor.

Meteorological Trends

Temperature Trends

ARL analysis of global temperature variations showed 1993 to be a relatively cool year. Based on a 63-station radiosonde network, global tropospheric temperatures in 1993 were 0.1 °C below the 1958-1991 average, only 0.1 °C warmer than the cool temperatures of 1992 occasioned by the Pinatubo eruption. During the winter of 1992-1993 the global tropospheric temperature was almost 0.2°C below the 1958-1991 average, making it the coldest winter globally since 1976. Global temperatures in the low stratosphere were a record 1.3°C below the 1958-1991 average, and in the tropopause layer a record 1.0°C below this average.

Radiosonde Data Inhomogeneities

A study documenting the effects of changes in radiosonde observation on climatological upper-air temperature records has shown that changes in sensors and changes in data treatment induce data discontinuities, some as large as several degrees Celsius. The most serious effects seem to be in the stratosphere, where there is a distinct possibility that we have been overestimating a cooling trend by neglecting data inhomogeneities. Thus temperature trends found in previous studies by ARL and other investigators may need to be revised to accommodate these new results.

US Cloudiness Trends

Changes in cloud cover are thought to be intimately related to other climatic changes. ARL cloudiness monitoring efforts show that, in the United States, cloud cover in 1993 was 3% above the average value of 58%, a value exceeded only in the strong El Niño years of 1957, 1972 and 1982. Based on linear regression, United States cloud cover has increased by 0.7% per decade during 1950-1993. We note that with the continuing implementation of the Automated Surface Observing System, this 44-year record of cloud cover will be terminated.

Water Vapor Climatology

ARL is constructing a global water vapor climatology using world-wide radiosonde data from 1973-93. The result will be mean monthly temperatures and humidity quantities from the surface to 300 mb. Issues such as historical changes in instruments and practices and the quality of the meteorological observations are treated in assembling this data set, which will be used in studies of the variability and trends in atmospheric humidity; for evaluation of climate models; and as "sky-truth" for more modern satellite and lidar-based water vapor measurements. ARL is participating in the Global Energy and Water Experiment's Water Vapor Project as the principal provider of radiosonde-based humidity analyses.

Aerosol Studies

In a cooperative effort between Headquarters Division and ASMD, a simplified version of a dust re-suspension model was coded into a test version of the HYSPLIT model's emission subroutine. Depending upon the land use type, which sets the threshold friction velocity, a dust emission rate is computed for each meteorological grid square, at each meteorological data time at which the model predicted friction velocity exceeds the threshold velocity. The emission module will be further tested and refined with data collected during the Lake Owens Dust Experiment.

TOGA/Coupled Ocean-Atmosphere Response Experiment

Scientists from ARL/ATDD participated in the Tropical Ocean Global Atmosphere (TOGA) Coupled Ocean-Atmosphere Response Experiment in February, 1993. The ARL eddy correlation flux measurement instrumentation was installed on a 40-foot sailing vessel to make energy, momentum, and CO_2 flux measurements, needed to assess the exchanges between the atmosphere and ocean in the tropical western Pacific. The resulting dataset includes 10 days of continuous eddy correlation flux data and is believed to be the first such complete flux data set collected on the open ocean with no significant flow distortion. Two other important data periods cover the earlier very rough, high wind Coral Sea crossing, and a shorter highly convective period on station. These unique data will provide important insights into the processes controlling air-sea exchanges in the tropics, which, in turn, are thought to be important in controlling the global climate.

The sailing vessel Malaita was instrumented with an eddy correlation flux measurement system for determining air-sea interactions during TOGA/COARE.

International Programs

ARL scientists contribute to many international scientific efforts. Here we describe two of recent interest, which highlight ARL's interactions with other emergency response modeling groups around the world.

Regional Special Meteorology Center

ARL has been designated as a Regional Special Meteorology Center (RSMC) by the World Meteorological Organization to provide meteorological transport and dispersion products to requesting countries in their WMO region of responsibility whenever there is potential for transboundary movement of hazardous pollutants. The National Weather Service/NMC is the initial phone contact for RSMC emergencies. Any responses to an emergency after the initial response will still be handled by ARL.

ARL is upgrading its modeling and communications facilities to adapt its products to RSMC requirements. Scientific developments have included the new capability to access NMC data to drive a detailed diagnostic model (the RAMS model from Colorado State University) to yield higher-resolution data. Organizational developments have seen a new emphasis on the need to compare the Washington and Canadian transport and dispersion forecast products of the respective RSMCs. A comparison conducted in 1993 revealed that in general the various model results were in agreement, however there were some differences in how the forecast models predicted the development and structure of a low pressure system upwind of the site of a hypothetical accident. There were further differences resulting from how the source terms were specified. Some of these issues will be addressed at an upcoming "User Requirements Workshop."

European Tracer Experiment

ARL is participating in the fall 1994 European Tracer Experiment (ETEX). The RAMS model was configured for the ETEX grid to provide forecast tracer concentrations. The model was used in an ETEX dry run (tracer experiment without tracer release) in preparation for the actual experiment. Simulations were performed in both a series of 12 hour analyses and 60 hour forecast mode. Frictional effects over the Alps were predicted by RAMS which had a significant impact on the wind fields. These effects were not observed in the NMC fields which are normally used at ARL to drive dispersion models, which demonstrated the importance of capturing mesoscale features and boundary layer processes.

International Activities

Throughout the organization, ARL staff interact with scientists around the world to accomplish our mission. Here we list some of our recent international ventures.

Australia

Through a collaboration with Dr. Jorg Hacker, of Australia's Institute for Atmospheric and Marine Science, ARL/ATDD is now using his software to assist with vector data processing. The software has been tailored for processing airborne flux data, so it is well suited for processing data from the ATDD mobile flux platform.

Bruce Forgan of the Australian Bureau of Meteorology, Australia visited Silver Spring to work on completing a major report for the World Meteorological Organization on measurements of aerosol optical depth. ARL scientists were major contributors to this report, which concluded that the measurements are generally quite poor. As a result, WMO has set up a committee to review the past situation and to advise on how to proceed.

China

A cooperative study between scientists from NOAA the Chinese National Center for Marine Environmental Forecasts of the life cycle of black carbon aerosols in the atmosphere was conducted at Chinese coastal stations and during cruises over the East China Sea and the West Pacific. Black carbon aerosols strongly absorb radiation, which may have profound effects on climate. Surface measurements of black carbon were taken and isobaric air trajectories were used to trace its transport pathways. The black carbon half-life in the marine boundary layer was estimated to be 19 hours, and the tropospheric residence time as five days. A tentative conclusion of this work is that of long-range transport of black to the South Pole is not through the boundary layer, but more likely through the free troposphere.

Czech Republic

ARL/ASMD participated in an EPA delegation to the Czech Republic to review air dispersion and human exposure modeling activities in support of an ongoing cooperative research program with the Czech Hydrometeorological Institute.

ARL also constructed a dry deposition inferential method (DDIM) filterpack-type monitoring system, for deployment in Czechoslovakia. One was placed in the mountains at Rudolice, Czech Republic and another was planned for the Moravian farmlands at Kosetice. These stations will focus primarily on sulfur, with one station being background and one being an affected site. The Rudolice site is in the "Black Triangle" and commonly measures at or above 200 ppb SO_2 in the winter. Rudolice is in an area where approximately 600,000 acres of forestland were destroyed by sulfur deposition, and are now primarily grassland. In conjunction with the DDIM site establishment, Dr. Jaroslav Santroch of the Czech Hydrometeorological Institute spent one week visiting ARL.

Egypt

ARL/FRD staff members collaborated with Egyptian experimental teams in a atmospheric diffusion study in El Dabaa in June. Sampling equipment and tracers were prepared, and ARL scientists acted in an advisory role during the field tests.

Germany

ARL/ATDD participated in the SANA Flux Experiment performed at Melpitz, Germany, 10-24 September, 1993. The experiment, to assess anticipated air quality changes in eastern Germany, was a benchmark test to verify modeled air-to-surface fluxes of SO_2 and $SO_4^=$ against measured fluxes. The experimental participants included several German groups (including the Fraunhofer-Institut in Garmisch-Partenkirchen and the Institute fur Tropospharenforschung e.V.), as well as Basel University (Switzerland).

Hungary

ARL was visited during April by three Hungarian scientists; Dr. Laszlo Horvath and Mr. Laszlo Bozo (Hungarian Meteorological Service), and Dr. Tamas Weidinger (Eotos Lorand University, Budapest). They met with ARL scientists both in Silver Spring and in Oak Ridge to discuss research interests and approaches.

India

Mr. Sundaravadhiyar Sivaramakrishnan, of the Indian Institute of Tropical Meteorology, visited ATDD under a World Meteorological Organization fellowship, sponsored by the United Nations Development Program. His research involves ATDD's surface energy exchange models and flux measurement techniques and analysis of chemical flux data from NOAA's 1992 Regional Oxidants in the SouthEast (ROSE) study in western Alabama.

Israel

Dr. Uri Dayan from the Environmental and Risk Assessment Section of Soreq Nuclear Research Center spent a sabbatical year at ARL/ASMD. His research involves using synoptic climatology to improve estimates of ozone concentrations, and evaluating air quality models for improving estimates of human exposure.

Italy

Dr. Dennis Baldocchi (ATDD) was involved in an extended collaboration at the University of Tuscia in Viterbo, Italy. There he developed a mechanistic and environmentally-driven model for computing CO_2, water vapor, and sensible heat exchanges over a temperate forest landscape, and a coupled analytical model for leaf photosynthesis and stomatal conductance. The integrated model was tested (for CO_2, water vapor, and net radiation exchange) against a comprehensive database collected at the Walker Branch Watershed near Oak Ridge.

Japan

Professor Masaaki Ohba (Tokyo Institute of Polytechnics) visited ARL/ASMD for six weeks during the summer to examine a numerical code for simulating flow around buildings and scientific visualization methods based on the Advanced Visual Systems, Inc. system. Model comparisons are being made to the wind tunnel study data on pollutant dispersion around high-rise buildings that were collected during his initial 12 month visit.

Korea

A cooperative effort with the Korea involved continuous surface observations of trace gases at Cheju Island from February 1992 until February 1993. Preliminary data analysis has been finished to determine hourly averaged gas concentrations utilizing the daily automatic calibration data. This work is intended to help quantify the outflow of pollutants from the Korean peninsula.

Mexico

ARL/ASMD participated in EnviroMex '93 conference in Monterrey, Mexico in September and discussed intensive sampling methods in air quality monitoring. The EnviroMex '93 conference was held to promote the National Environmental Technology Trade Initiative, intended to expand the export of U.S. environmental technology. The conference was a forum to communicate to Mexican officials and business people the importance attached to environmental issues by the U.S. government and U.S. citizens, especially with regard to future economic relations between the two countries.

Poland

Dr. R. Kozlowski of the Polish Academy of Sciences and Mr. J. Bednarczyk, a Wieliczka Salt Mine ventilation engineer, visited in September, to collaborate with ARL/ATDD and Caltech staff on analyzing results from the year of microclimate and air pollutant monitoring within the Mine, and in making recommendations on remedial measures for the severe moisture problem within key areas of the Mine. A lecture on the study and its findings was presented at Carnegie-Mellon University. Findings were reviewed with U.S. Bureau of Mines specialists. It appears that a standard air conditioning system of relatively modest size and cost ($100K plus installation) will be adequate to protect the cultural objects preserved within this World Heritage Site. Findings and recommendations were verbally presented to NOAA, to the National Park Service, and to Polish Embassy staff. A public lecture was presented at the Interior Department, followed by a briefing at the State Department.

Russia

Two Russian visitors, Drs. Felix Rovinsky and Vladimir Egorov, from the Institute of Global Climate and Ecology, Moscow, visited the ARL Silver Spring, Oak Ridge, and RTP offices in June. Topics of discussion included: precipitation chemistry standard solutions by U.S. and Russian national laboratories; precipitation chemistry, aerosol, and gas concentrations in Russia over the last several decades; and appropriate levels of effort in the development of air toxics programs. The meeting concluded in Silver Spring with the generation of a joint proposal to begin coordinating an integrated monitoring effort in both countries involving the exchange of relevant samples, the exchange of personnel in site visits, and the examination and field testing of models.

Dr. Winston Luke participated in an April inspection tour of an aviation support facility in the remote Siberian village of Cherskiy (69°N, 162°E) to evaluate its suitability as a transportation and support center for research in the Russian Arctic. The inspection team judged the facility more than adequate to support research activities.

Sweden

Dr. Carmen Nappo spent three months in residence at Uppsala University in Sweden, to continue his research on a model of wave/turbulence interactions. His model on gravity-wave interactions is being merged with Uppsala's mesoscale atmospheric boundary layer model.

Thailand

Alan Huber (ARL/ASMD) participated in a U.S. EPA delegation to Thailand to provide urgent assistance regarding extremely high SO_2 concentrations observed near the Mae Moh Power Station. This visit resulted in a program to assist the Royal Thai Government on pollutant modeling, ambient monitoring, and health effects. Dr. Oranut Paisarnuchapong and Mr. Opas Ujjin, under the U.S. Asian Foundation fellowship program, visited ARL/ASMD for 3 months for training with air dispersion models and meteorological instrumentation. A multi-year human exposure study in the area of the Mae Moh Power Station is anticipated. ASMD is also developing a plume fumigation algorithm and meteorological measurement capabilities needed to model conditions at Mae Moh.

Outreach and Community Service

The Air Resources Laboratory promotes the ideals of equality of opportunity, good neighborliness, and community service in its official activities and the private lives of its staff members. Here we list just a few of the contributions of the laboratory and its employees during 1993. The heavy emphasis on science education is not accidental, as we try to use our collective scientific experience and training to encourage young people's interest in the natural world.

ARL scientists serve as Adjunct Professors at the following universities and colleges:

- Duke University
- Georgia Institute of Technology
- Hebrew University (Jerusalem)
- North Carolina State University
- University of Nevada at Las Vegas
- University of North Carolina
- University of Tennessee at Knoxville

ARL staff members participated in activities at the following schools:

- Beaumont Elementary School
- Creedmore (NC) Elementary School
- Denver Public Schools Executive Internship Program
- Durant Road Elementary School (Raleigh, NC)
- Glenwood School (Chapel Hill, NC)
- Linden Elementary School (Oak Ridge, TN)
- Morrisville (NC) Elementary School
- Piney Branch (MD) Elementary School (Silver Spring, MD)
- Sacred Heart Adult Education Program (Washington, DC)
- Vanderhoof Elementary School (Arvada, CO)
- West Millbrook Middle School (Raleigh, NC)
- Woodland School (Oak Ridge, TN)

ARL staff also worked with these youth and educational programs:

- Anderson County (TN) Ecological Study Center
- Boy Scouts of America
- Duke University Talent Identification Program Statistics weekend program held at Meredith College (Raleigh, NC)
- Environmentors (Washington, DC), a mentoring program in environmental science for high school students
- Jefferson County (CO) Sheriff's Dept.
- Research Triangle Science and Mathematics Partnership
- "Science-by-Mail" Program Tennessee Discovery Center

ARL scientists served as judges at the Southern Appalachian Science Fair (eastern TN), Montgomery County and Baltimore County (MD) Science Fairs, and the American Museum of Science and Energy's Science Olympiad. ARL/ATDD staff also participated in the Second Annual Environmental Fair held in Oak Ridge, attended by approximately 3000 middle school students.

ARL/Headquarters Division staff members participate in the ***National Geographic Kids Network on Acid Rain***. ARL donates pH meters and instructions to elementary schools worldwide. The students collect rain samples and measure their acidity. Results are compared within the student network and with research quality networks run by ARL and others.

ARL Staff Photographs

Headquarters Division

Working from left to right in back row are Monte Poindexter, James Angell, Barbara Stunder, Jeffery McQueen, Roland Draxler, Dian Gaffen, and Richard Artz; in the middle row are Jerome Heffter, Bruce Hicks, Rebecca Ross, Lester Machta, Milton Smith, Albion Taylor, Glenn Rolph, and Winston Luke; seated in front are Richard Valigura, Betty Wells, William Elliott, Maureen McMahon, Sharon WIngfield, and Allison Elgin.

Atmospheric Turbulence and Diffusion Division

Working from left to right in back row are Ed Dumas, Jerry Herwehe, Detlef Matt, and Rick Eckman; in the middle row are Sue Sheffield, Lynne Satterfield, Mark Hall, Bob McMillen, Will Pendergrass, Randy White, Jess Wynn and Kevin Birdwell; and in the front row are Kimberly Hill, S. Sivaramakrishnan, Tim Crawford, Kambhampati S. Rao, Rayford Hosker, Barbara Johnson, Chris Vogel, Jerry Sharp, and Sharon Conger.

Atmospheric Sciences Modeling Division

Staff Includes:

Alvarez, Raul
Atkinson, Dennis G.
Bailey, Desmond T.
Bagley, Pamela V.
Benjey, William G.
Binkowski, Francis S.
Briggs, Gary A.
Bullock, Orren R.
Byun, Daewon W.
Ching, Jason K.
Clark, Terry L.
Clarke, John F.
Cooter, Ellen J.
Coventry, Dale H.
Crescenti, Gennaro
Davis, Kelly M.
Dennis, Robin L.
Edem, Victoria O.
Eder, Brian K.
Finkelstein, Peter L.
Gillette, Dale A.
Godowitch, James
Huber, Alan H.
Irwin, John S.
Knight, Lewis A.
Lawson, Robert
Leduc, Sharon
Lee, Russell F.
Lewis, Lisa
Novak, Joan M.
Petersen, William
Perry, Steven G.
Pierce, Thomas E.
Pitchford, Marc L.
Pleim, Jonathan A.
Poole-Kober, Evelyn
Possiel, Norman C.
Roselle, Shawn J.
Rudisill, John H.
Schere, Kenneth L.
Schiermier, Francis
Schwede, Donna B.
Snyder, William H.
Streicher, John J.
Templeman, Brian D.
Thomas, Pamela, P.
Torian, Alfreida R.
Touma, Jawad S.
Truppi, Lawrence E.
Viebrock, Herbert J.
Walter, Gary L.
Warnick, Barbara A.
Wilson, Dean A.
Young, Jeffery O.
Zelenka, Michael P.

Field Research Division

From left to right: Kirk Clawson, Jim Brunn, Brad Reese, Roger Carter, Joyce Silvester, Jerry Sagendorf, Dianne Hoover, Dave George, C. Ray Dickson, Gene Start, Russ Ackermann, Randy Johnson, Tom Watson, Clarence Nagamoto, Brian Lathem, and Neil Hukari.

Solar Radiation Research Branch

From left to right in back row are Trevor Ley, Scott Sandberg, Tony Vergamini, Young Kim, and John Augustine; in the middle row are Tess Johnson, John DeLuisi, Farn Parungo, and Kathleen Szabo; kneeling in front are Betsy Weatherhead, Jennifer Barnett, and Justine Sanchez.

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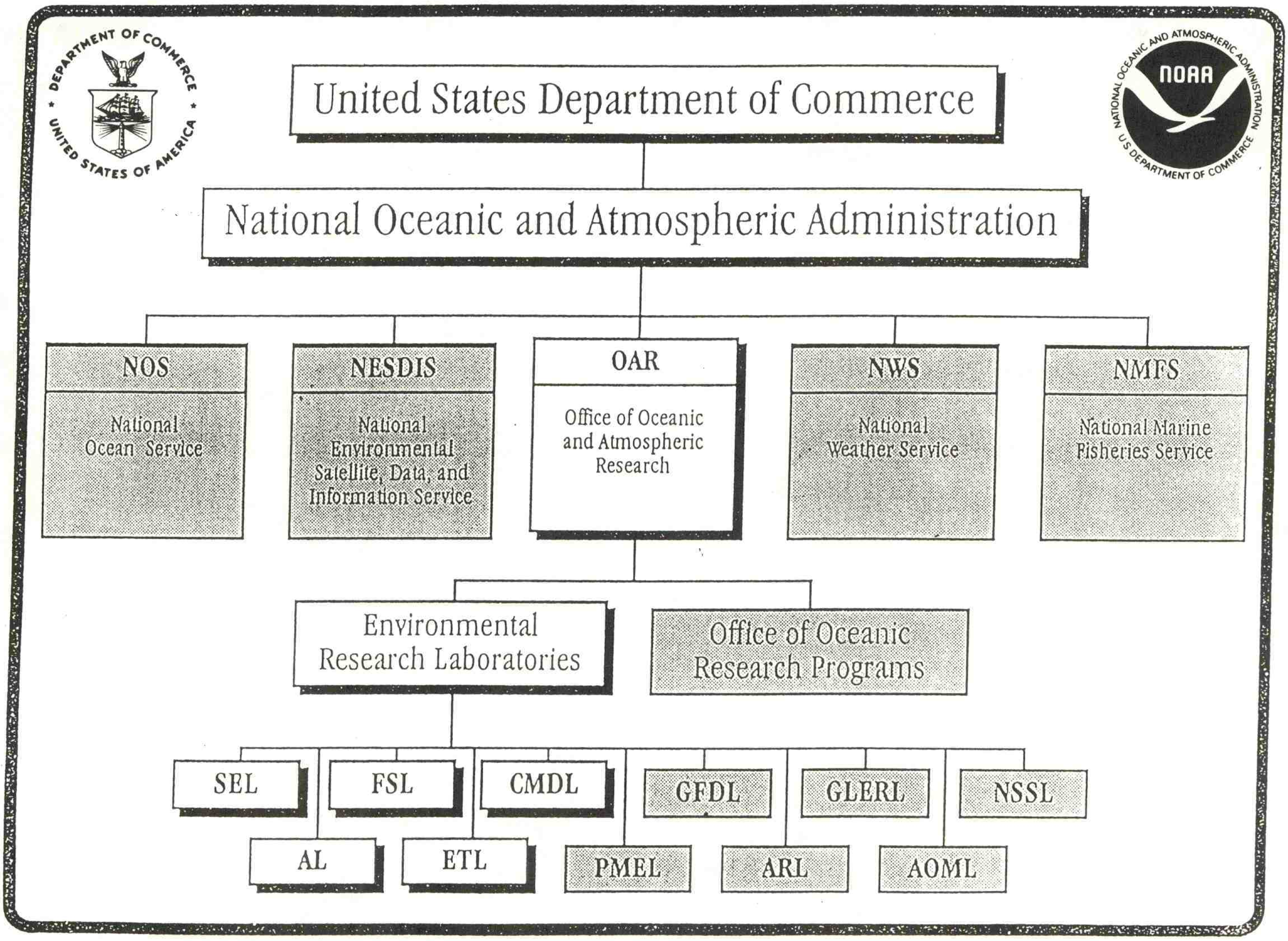
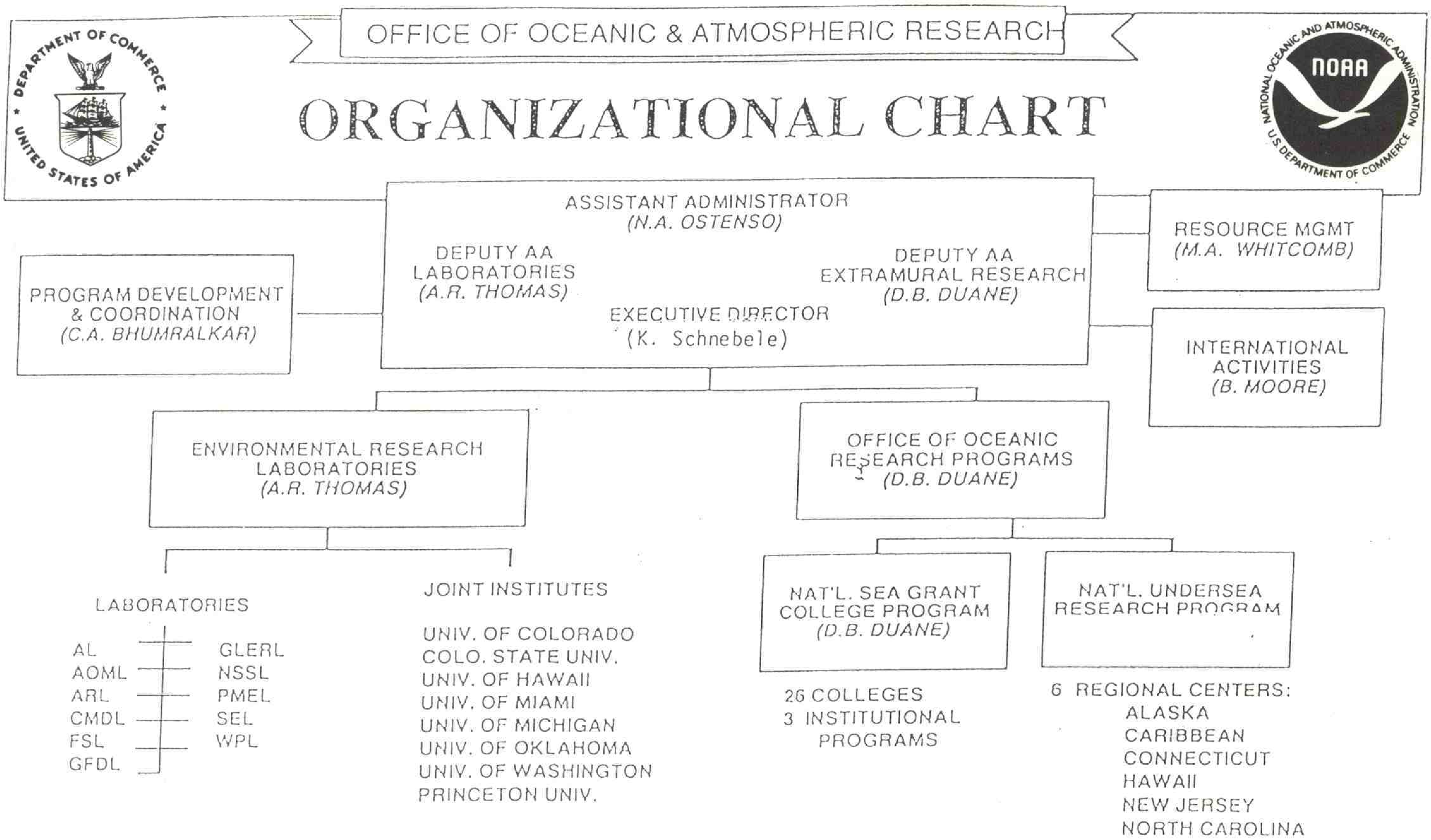
Organizational Charts

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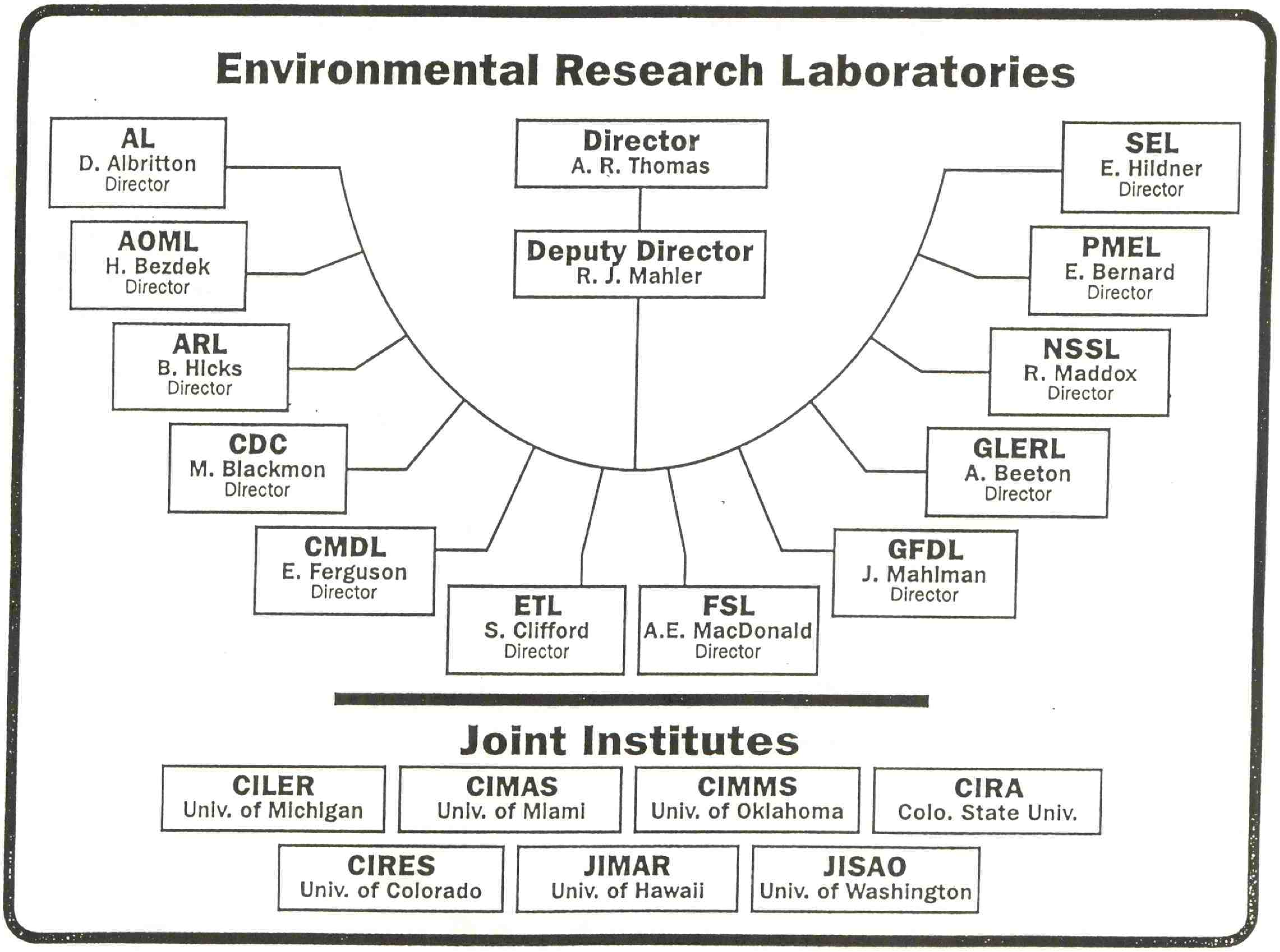
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- Atmospheric Trends and Variability
- · Long-range plume predictions (WMO/IAEA)
- · Operational support to NRC

Surface Radiation Research Branch
Boulder, CO

Chief, John DeLuisi

- Atmospheric Opacity
- UV-B

Atmospheric Turbulence and Diffusion Division
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- Dispersion Studies
- Air/Surface Interactions
- Emergency Preparedness
- · Support to OR and to OR contractors
- · Site specific studies
  - Yucca Mountain
  - Rocky Flats
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- · Complex terrain (ASCOT)

Atmospheric Sciences Modeling Divn.
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- Global Processes Research
- Fluid Modeling
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- Applied Modeling Research
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- Field Operations Branch
- Applied Sciences Branch
- Technical Support Branch
- · Nuclear Meteorology
- · Resuspension
- · Mesoscale Modeling
- · Computer Applications

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List of Acronyms

AIRMoN	Atmospheric Integrated Research Monitoring Network
ANICA	Atmospheric Nutrient Input to Coastal Areas
ARL	Air Resources Laboratory
ASMD	Atmospheric Sciences Modeling Division
ATDD	Atmospheric Turbulence and Diffusion Division
DDIM	Dry Deposition Inferential Monitoring
DOE	Department of Energy
EPA	Environmental Protection Agency
ETEX	European Tracer Experiment
FRD	Field Research Division
HPCC	High Performance Computing and Communications
HYSPLIT-ACID	Hybrid Simple Particle Lagrangian Integrated Trajectory model with Atmospheric Chemistry Including Deposition
ISIS	Integrated Surface Irradiance Study
MAP3S	Multistate Power Production Pollution Study
MRF	Medium Range Forecast
NAPAP	National Acid Precipitation Assessment Program
NMC	National Meteorological Center
NIST	National Institute of Standards and Technology
NARE	North Atlantic Regional Experiment
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NWS	National Weather Service
SURFRAD	Surface Radiation monitoring network
TOGA/COARE	Tropical Ocean Global Atmosphere/Coupled Ocean-Atmosphere Response Experiment
RAMS	Regional Atmospheric Modeling System
RELMAP	Regional Lagrangian Model of Air Pollution
ROM	Regional Oxidant Model
ROSE	Regional Oxidants in the SouthEast
RSMC	Regional Specialized Meteorological Centre
RTP	Research Triangle Park
UV-B	Ultraviolet-B
VAFTAD	Volcanic Ash Forecast Transport and Dispersion
WATOX	Western Atlantic Ocean Experiment
WMO	World Meteorological Organization

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