NOAA Technical Memorandum ERL ARL-203

FISCAL YEAR 1992 SUMMARY REPORT OF NOAA ATMOSPHERIC SCIENCES MODELING DIVISION SUPPORT TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY

Evelyn M. Poole-Kober
Herbert J. Viebrock
(Editors)

Air Resources Laboratory
Silver Spring, Maryland
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Atmospheric Sciences Modeling Division
Research Triangle Park, North Carolina

Air Resources Laboratory
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PREFACE

This document summarizes the Fiscal Year 1992 research and operational efforts and accomplishments of the Atmospheric Sciences Modeling Division (ASMD) working under interagency agreements EPA DW13935371 and DW13935457 between the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA). The summary includes descriptions of research and operational efforts in air pollution meteorology, air pollution control activities, and abatement and compliance programs.

Established in 1955, the Division is part of the Air Resources Laboratory and serves as the vehicle for implementing the agreements with the EPA, which funds the research efforts in air pollution meteorology. The ASMD conducts research activities in-house and through contract and cooperative agreements for the Atmospheric Research and Exposure Assessment Laboratory and other EPA groups. With a staff consisting of NOAA, EPA, and Public Health Service Commissioned Corps personnel, the ASMD provides technical information, observational and forecasting support, and consulting on all meteorological aspects of the air pollution control program to many EPA offices, including the Office of Air Quality Planning and Standards and Regional Offices. The primary groups within the ASMD are the Atmospheric Model Development Branch, Fluid Modeling Branch, Modeling Systems Analysis Branch, Global Climate Research Branch, Human Exposure Modeling Branch, Applied Modeling Research Branch, and Air Policy Support Branch. The staff is listed in Appendix F. Acronyms, publications, and other professional activities are listed in the remaining appendices.

Any inquiry on the research or support activities outlined in this report should be sent to the Director, Atmospheric Sciences Modeling Division (MD-80), Environmental Research Center, Research Triangle Park, NC 27711.

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FISCAL YEAR 1992 SUMMARY REPORT

OF NOAA ATMOSPHERIC SCIENCES MODELING DIVISION SUPPORT

TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY

ABSTRACT. The Atmospheric Sciences Modeling Division, during FY-1992, provided meteorological research and operational support to the U.S. Environmental Protection Agency. Operational activities consisted of the application of dispersion models, the conduct of dispersion studies and model evaluations, and the provision of advice and guidance. The primary research efforts were the development and evaluation of air quality models using numerical and physical techniques supported by field studies, and the initiation of studies under the High Performance Computing and Communications Program. These efforts included evaluation studies of the Regional Acid Deposition Model using aircraft data; tests of the Regional Particulate Model incorporating advanced aerosol chemistry and dynamics modules; study of the sensitivity of the Regional Oxidant Model to biogenic emissions; initiation of the development of the next generation Eulerian grid modeling system; tests of the INPUFF model incorporating complex terrain; construction of a mobile system to measure the dry deposition fluxes of ozone, sulfur, and several nitrogen species; analysis of the STAGMAP diffusion study data; studies of dispersion from area sources using a wind-tunnel; modification of the Hazardous Air Pollutant Exposure Model for daily and seasonal variations of estimated air quality; and development of an air quality model to estimate human exposure to pollutants in residential garages.

1. INTRODUCTION

In fiscal year 1992, the Atmospheric Sciences Modeling Division (ASMD) continued its commitment for providing goal-oriented, high-quality research and development, and operational support to the U.S. Environmental Protection Agency (EPA). Using an interdisciplinary approach emphasizing integration and close cooperation with the EPA and public and private research communities, the Division's primary efforts were studying processes affecting dispersion of atmospheric pollutants, modeling pollutant dispersion on all temporal and spatial scales, and studying the effects of global climate change on regional climate and air quality. The technology and research products developed by the Division are transferred to the public and private national and international user communities. Section 2.1 discusses the Division participation in major international activities, while Sections 2.2 through

2.7 outline the Division research activities in support of the short and long term needs of the EPA and the environmental community. Section 2.8 discusses Division support to the operational programs and to the general air quality model user community.

2. PROGRAM REVIEW

2.1 Office of the Director

The Office of the Director provides direction, supervision, program management, and administrative support in performing the Atmospheric Sciences Modeling Division's mission and in achieving its goals of advancing the state of the atmospheric sciences and enhancing the protection of the environment. The Director's Office also engages in several domestic and international research exchange activities, and provides NOAA meteorologists to an EPA laboratory in Las Vegas, NV, to conduct visibility and remote sensing research.

2.1.1 American Meteorological Society Steering Committee

Beginning in 1979, the Division established a cooperative agreement with the American Meteorological Society (AMS) to improve the scientific basis of air quality modeling. Under this agreement, the AMS maintains a Steering Committee on Scientific Assessment of Air Quality Models to (1) provide scientific reviews of various types of air quality dispersion models; (2) assist in developing a more complete understanding of uncertainty as it affects different aspects of air quality modeling; (3) respond to specific requests regarding scientific aspects of the Division's air quality modeling practices; and (4) plan and conduct scientific workshops in an attempt to advance the state of regulatory dispersion modeling.

2.1.1.1 Air Quality Modeling Uncertainty

To better understand modeling uncertainty, the AMS Steering Committee addressed the role of inherent uncertainty in evaluating dispersion models and published an assessment (Weil *et al.*, 1992). The focus was on elevated point-source models. The assessment concludes that deviations between predicted model ensemble-averages and individual realizations are due to a combination of concentration random variability, model errors, uncertainties in model inputs, and measurement error. A residual analysis is recommended as an effective way of separating the mean model error—the difference between the predicted and observed concentrations—from the natural variability.

2.1.1.2 AMS/EPA Regulatory Model Improvement Committee

The AMS Steering Committee and the EPA formed the AMS/EPA Regulatory Model Improvement Committee (AERMIC) whose charter is to recommend the most appropriate formulations or modeling subsystems to simulate dispersion in flat or rolling terrain, and to indicate how these subsystems can be integrated into a model. Many of the concepts involved in improved parameterization of the planetary boundary layer are already formulated for modeling application. The Committee will oversee the assembly of these concepts into a new or revised modeling system, and the subsequent evaluation of this modeling system using a variety of databases (Weil, 1992).

2.1.2 Interdepartmental Meteorological Committee

The Division Director serves as an Agency representative on the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR). The Committee, composed of representatives from 15 Federal government agencies, was formed in 1964 under Public Law 87-843 to provide the Executive Branch and the Congress with a coordinated, multi-agency plan for government meteorological services and for those research and development programs that directly support and improve these services. The Committee prepared the annual Federal Plan for Meteorological Services and Supporting Research (U.S. Department of Commerce, 1992).

2.1.3 NATO Committee on Challenges of Modern Society

The North Atlantic Treaty Organization (NATO) Committee on Challenges of Modern Society (CCMS) was established in 1969 with the mandate to examine how to improve, in every practical way, the exchange of views and experience among the Allied countries in the task of creating a better environment for their societies. The Committee considers specific problems of the human environment with the deliberate objective of stimulating action by member governments. The Committee's work is carried out on a decentralized basis through pilot studies, discussions on environmental issues, and fellowships.

2.1.3.1 International Technical Meetings

The Division Director serves as the United States representative on the Scientific Committee for International Technical Meetings (ITMs) on Air Pollution Modeling and Its Application, sponsored by NATO/CCMS. A primary activity within the NATO/CCMS Pilot Study on Air Pollution Control Strategies and Impact Modeling is organizing a symposium every eighteen months that deals with various aspects of air pollution dispersion modeling. The meetings are rotated among different NATO members, with every third ITM held in North America and the two intervening ITMs held in European countries.

The 19th NATO/CCMS International Technical Meeting was held in Ierápetra, Crete, Greece, from September 29 to October 4, 1991. The proceedings will be published, as were the proceedings from the 18th

International Technical Meeting held in Vancouver, British Columbia, Canada (van Dop and Steyn, 1991). The Scientific Committee selected Valencia, Spain, as the site for the 20th International Technical Meeting to be held during November/December 1993.

2.1.3.2 Coastal Urban Air Pollution Study

The Division Director serves as the United States representative on the International Oversight Committee for the NATO/CCMS Pilot Study on Urban Pollutant Dispersion near Coastal Areas. This pilot study, sponsored by Greece, originated in a workshop held in Athens during February 1992. The purpose is to understand the causes of high air pollution episodes in coastal urban areas and to devise strategies to mitigate pollution problems caused by vehicular and industrial emissions in these areas. A NATO/CCMS advanced research workshop will be held in 1993 to design a reference experiment in a coastal urban area to collect relevant ambient measurements and emissions for use in evaluation of existing urban dispersion models and for understanding the atmospheric boundary layer at the interface of land and water.

2.1.4 United States/Japan Environmental Agreement

The Division Director serves as the United States Co-Chairman of the Air Pollution Meteorology Panel under the United States/Japan Agreement on Cooperation in the Field of Environment. The purpose of this 1975 agreement is to facilitate, through mutual visits and reciprocal assignments of personnel, the exchange of scientific and regulatory research results pertaining to control of air pollution.

Under this agreement, four Japanese scientists visited the Division in September 1992 to learn about its modeling activities. Other FY-1992 accomplishments include a one-year sabbatical to the Division by a professor from the Tokyo Institute of Polytechnics to conduct joint research into computational fluid dynamics, and a six-week visit by a Division scientist to the National Institute for Environmental Studies in Tsukuba, Japan, to model the transport and formation of oxidants in the greater Tokyo area.

2.1.5 United States/Russia Joint Environmental Committee

The Division Director serves as the United States Co-Chairman of the US/Russia (formerly USSR) Working Group 02.01-10 on Air Pollution Modeling, Instrumentation, and Measurement Methodology, and as Co-Leader of the US/Russia Project 02.01-11 on Air Pollution Modeling and Standard Setting. The purpose of the 1972 agreement forming the US/Russia Joint Committee on Cooperation in the Field of Environmental Protection is to promote, through mutual visits and reciprocal assignments of personnel, the sharing of scientific and regulatory research results related to the control of air pollution. There are four Projects under the Working Group 02.01-10:

Project 02.01-11:	Air Pollution Modeling and Standard Setting
Project 02.01-12:	Instrumentation and Measurement Methodology
Project 02.01-13:	Remote Sensing of Atmospheric Parameters
Project 02.01-14:	Statistical Analysis Methodology and Air Quality Trend Assessment.

Nine NOAA and EPA scientists participated in a US/Russia Symposium in Novgorod, Russia, during October 1990 and presented results of three joint roadway automotive exhaust field studies for intercomparing air pollution methods and characterizing the dispersion of volatile organic compounds from roadways. The studies were conducted in Research Triangle Park, NC (1987), Leningrad, Russia (1988), and Vilnius, Lithuania (1989). The symposium results led to findings for improving air monitoring techniques and produced a comprehensive database for use in developing dispersion models for reactive compounds (Stepanenko, 1992).

During July 1992, a delegation of four NOAA and EPA scientists participated in Working Group and Project meetings at the Voeikov Main Geophysical Observatory, the University of St. Petersburg, and the Hydrometeorological Institute, in St. Petersburg, Russia. Discussions were held regarding joint progress in mass spectroscopy of chemical compounds; complex terrain dispersion modeling; fluid modeling of the effects of terrain irregularities on pollutant dispersion; and remote sensing of atmospheric parameters. A workshop was held on regulatory aspects of air pollution modeling at the Voeikov Main Geophysical Observatory. A protocol was signed outlining future exchanges of scientific information and planning the next Working Group Meeting for the summer of 1993 in the United States.

FY-1992 accomplishments also included a working visit during October and November 1991 by three Russian experts in remote sensing to the NOAA Wave Propagation Laboratory in Boulder, CO; an October 1991 visit by the Division Director to the Voeikov Main Geophysical Observatory in St. Petersburg, Russia, for a meeting of the Working Group 02.01-10 Co-Chairmen; a November 1991 visit to the Division by the Director of the Institute of Atmospheric Physics in Moscow, Russia; and a February 1992 visit to the Division by a Working Group 02.08-10 Russian scientist who is performing the Aral Sea/Owens Lake salt dust modeling comparison.

Other activities included a December 1991 working visit to Research Triangle Park, NC, by two Russian scientists to compare monitoring methods for sulfur dioxide and nitrogen dioxide; a working visit during April and May 1992 by a Russian expert in mass spectroscopy of chemical compounds to the National Institute of Standards and Technology in Gaithersburg, MD; the beginning of a two-year working visit by a Russian expert in remote sensing to the EPA Environmental Monitoring Systems Laboratory in Las Vegas, NV; and the beginning of a two-year National Research Council research associateship by a Russian scientist at the Division's Fluid Modeling Facility in Research Triangle Park, NC.

2.1.6 Eulerian Modeling Bilateral Steering Committee

The Division Director serves as the United States Co-Chairman of the Eulerian Modeling Bilateral Steering Committee (EMBSC). This committee is composed of representatives from the Canadian Atmospheric Environment Service, the Ontario Ministry of the Environment, the Electric Power Research Institute, and the U.S. Environmental Protection Agency. Having coordinated the evaluation of the Canadian Acid Deposition and Oxidant Model (ADOM) and the United States Regional Acid Deposition Model (RADM), the committee is now defining its future mission. One role being considered for the EMBSC is under the new United States/Canada Air Quality Agreement, signed in March 1991. Annex 2 of the agreement calls for the development and refinement of atmospheric models for determining source-receptor relationships, and transboundary transport and deposition of air pollutants.

2.1.7 United States Weather Research Program

The Division Director serves as an Agency representative on the interagency working group for the United States Weather Research Program (USWRP). This new initiative is designed to (1) increase benefits to the Nation from the substantial investment in modernizing the public weather warning and forecast system in the United States; (2) improve local and regional forecasts and warnings; (3) address critical weather-related scientific issues; and (4) coordinate governmental, university, and private-sector efforts. The program is broad in scope, encompassing the full range of atmospheric processes that are part of weather, including dynamics, thermodynamics, synoptics, cloud physics, atmospheric chemistry, electricity, and radiation, as well as their effects on hydrology (U.S. Office of Science and Technology Policy, 1992).

2.1.8 NAS/NRC Board on Atmospheric Sciences and Climate

The Division Director serves as an Agency representative to the Board on Atmospheric Sciences and Climate (BASC) of the National Research Council, National Academy of Sciences. The current activity of the BASC that supports the work of the Division is the formation of a Panel on Atmospheric Aerosols. Specifically, the panel will review existing and new evidence regarding anthropogenic and natural aerosol-producing processes; their sources, characteristics and distribution; their transport and removal; and their quantified effects on atmospheric processes and on the global and regional radiation forcing of the climate system. The panel will advise on the observation, monitoring, and research strategies needed to understand atmospheric processes and aerosol characteristics important in weather and air pollution research. To coordinate the research efforts, Division scientists will serve on the Climate Research Committee and the Panel on Atmospheric Aerosols.

2.1.9 European Monitoring and Evaluation Program

A Division scientist serves as the United States representative to the European Monitoring and Evaluation Program (EMEP) that oversees the cooperative program for monitoring and evaluation of the long-range transmission of air pollutants in Europe. The primary goal of EMEP is to use regional air quality models to produce assessments evaluating the influence of one country's emissions on another country's air concentrations or deposition. The United States and Canadian representatives report on North American activities related to long-range transport. The Division scientist also evaluates European studies of special relevance to the program, providing technical critiques of the EMEP work during formal and informal interactions; and developing and coordinating such programs with EMEP as the modeling studies of the Modeling Synthesizing Center West (MSC-W) at the Norwegian Meteorological Institute in Oslo, Norway.

2.1.10 Clean Air Act Amendments of 1990 Section 812 Assessment Working Group

A Division scientist is a member of the 812 Assessment Working Group with responsibility for developing approaches to assess regional air quality and acidic deposition. The responsibilities of this working group are to produce a retrospective assessment of the benefits and costs of the Clean Air Act (CAA) of 1970 and a prospective assessment of the benefits and costs of the Clean Air Act Amendments (CAAA) of 1990, assuming full implementation. Work in FY-1992 focused on the retrospective assessment, specifically on development of approaches and production of time trends of emissions from 1970 to 1990 for the factual case (implementation of CAA) and the counter-factual case (non-implementation of CAA).

2.1.11 Air Modeling Committee of the Chesapeake Bay Office

A Division scientist is a member of the Air Modeling Committee, a subcommittee of the Chesapeake Bay Modeling Committee and a subcommittee of the Chesapeake Bay Evaluation and Deposition Committee. This subcommittee has responsibility for overseeing the application of the linkage of the Regional Acid Deposition Model (RADM) with water quality models and the interpretation of the findings. This subcommittee also works with other Chesapeake Bay committees to define the top priority air quality scenarios to be simulated by RADM.

2.1.12 Consortium for Advanced Modeling of Regional Air Quality

A Division scientist serves as an Agency representative to the Consortium for Advanced Modeling of Regional Air Quality (CAMRAQ). This consortium is composed of representatives from the Electric Power Research Institute, American Petroleum Institute, Pacific Gas and Electric, California Air Resources Board, Department of Energy, National Oceanic and Atmospheric Administration, Environmental Protection Agency, Department of Defense, Atmospheric Environment Service of Canada, Ontario Ministry of the

Environment, and EUROTRAC (EUROpean experiment on the TRAnsport and transformation of trace atmospheric Constituents). The members of CAMRAQ share a mutual interest in making regional-scale atmospheric models usable tools for air quality and emergency response planning. They also share an interest in bringing the emerging power of high performance computing to regional air quality modeling. The members agreed that forming a consortium to coordinate research and to form a basis for collaboration on projects will enhance the ability of each to achieve their respective goals regarding atmospheric modeling.

2.1.13 National Acid Precipitation Assessment Program

A Division scientist serves as Chairman of the National Acid Precipitation Assessment Program (NAPAP) Subgroup on Processes and Deposition/Air Quality Modeling of the Atmospheric Effects Working Group, following the new mandate and organization of NAPAP under CAAA. This working group will help evaluate the benefits and effectiveness of the acidic deposition control program of CAAA Title IV and will help determine the reduction in emissions that are associated with deposition rates needed to prevent adverse effects. The working group will provide support for future NAPAP assessment activities required by CAAA.

2.1.14 Eulerian Model Evaluation Field Study Program

The Eulerian Model Evaluation Field Study (EMEFS) program is a multiagency program for evaluating regional scale acid deposition models, including the Regional Acid Deposition Model (RADM) and Acid Deposition and Oxidant Model (ADOM). Sponsors of this program include the National Oceanic and Atmospheric Administration, Environmental Protection Agency, Electric Power Research Institute, Canadian Atmospheric Environment Service, and Ontario Ministry of Environment. The Program Management Group (PMG) oversees the project and consists of representatives from each sponsor, including the chairmen from four teams: the Operational Measurements Team, the Diagnostic Measurements Team, the Emissions Inventory Team, and the Model Evaluation Team. The Model Evaluation Team, chaired by a Division scientist, continues to evaluate RADM and ADOM for the United States/Canada Air Quality Agreement and the Eulerian Model Bilateral Steering Committee.

2.1.15 RADM Application Studies

Efforts during FY-1992 concentrated on planning for RADM applications related to mandates in the 1990 Clean Air Act Amendments (CAAA) involving sulfur and nitrogen deposition and visibility. Studies called for in CAAA are (1) the feasibility of deposition standards; (2) the impact on deposition of trading NO_x emission reductions for SO_2 allocations; and (3) the effects on sulfur deposition reductions that result from trading of SO_2 emission allocations (the SO_2 reductions assigned to each source). A new RADM Engineering Model for calculating light extinction, visual range, and

DeciView, a parameter related to perception due to sulfate in the air, was developed to support the assessment applications.

Several other application studies are being planned. The EPA Region III Office and the Chesapeake Bay Office need nitrogen deposition and source attribution information related to nitrogen deposition to the Chesapeake Bay coastal estuary. The United States/Canada Air Quality Agreement also needs information on the effect of each nation's emission reductions on the sulfur deposition across each other's critical effects regions and a determination of how the responsibility for deposition in eastern North America is evolving. Specific applications of RADM2.1/6 and RADM/EM, provided for the NAPAP 1990 Integrated Assessment, were used in the first biannual report for the United States/Canada Air Quality Agreement (U.S. Environmental Protection Agency, 1992).

2.1.16 Visibility Research and Technical Support

Among the major tasks for the FY-1992 visibility program were the management of several large visibility monitoring and modeling studies; visibility-related technical assistance to the EPA Office of Air Quality Planning and Standards; and interagency coordination on visibility research.

2.1.16.1 Measurement Of Haze And Visual Effects

A congressionally mandated project to estimate the frequency and magnitude of perceptible impacts of the Mohave Power Plant and other influential emission sources in the southwestern United States on visibility at such Class I visibility-protected areas as the Grand Canyon National Park resulted in developing a plan for Project MOHAVE (Measurement Of Haze And Visual Effects) (U.S. Environmental Protection Agency, 1991).

Project MOHAVE was completed during FY-1992 and involved year-long continuous monitoring with two month-long intensive study periods (winter and summer). During the intensive study periods, unique perfluorocarbon tracers were continually released at the Mohave Power Plant and several other major pollution source locations, and monitored at each of 31 visibility and air quality monitoring sites. Using radar wind profilers, upper air monitoring at two locations in the study area increased to four and six locations during the winter and summer intensives, respectively. A regional meteorological deterministic model is being run for each day of the study, with resolution telescoped to 12 km during the year and additional resolution to 0.8 km during intensives. Attribution of the haze levels at the receptor sites will be estimated by reconciliation of results from several independent interpretive analysis methods including deterministic air quality modeling, receptor modeling using artificial and endemic tracers, and spacial pattern (eigenvector) analysis. Data interpretation and reporting activities are anticipated to continue into FY-1994.

2.1.16.2 Interagency Monitoring of PROtected Visual Environments

The Interagency Monitoring of PROtected Visual Environments (IMPROVE) program was designed in 1985 and initiated at twenty locations in 1987. The objective of the program is to monitor visibility in Class I visibility protected areas (156 national parks and wilderness areas nationwide). Each monitoring site includes optical, particle, and scene monitoring. Most of the instrumentation used was specially designed to be operated in remote area locations by non-technical field support personnel. Five Federal agencies (Environmental Protection Agency, National Park Service, Bureau of Land Management, Fish and Wildlife Service, and Forest Service) and three member organizations of state air pollution control agencies (WESTAR, NESCAUM, and STAPPA) oversee operation of the program through a steering committee chaired by a NOAA meteorologist. Several agencies have adopted the instrumentation and protocols developed for IMPROVE for use in their own programs, bringing the number of IMPROVE "look-a-like" sites to more than 40 in this country and nearly 60 worldwide.

During FY-1992, eight new IMPROVE sites were added to the program in the eastern United States. In addition, the interagency Clean Air Status and Trends NETwork (CASTNET), mandated by CAAA, adopted the IMPROVE approach for visibility monitoring to be employed at 30 sites that are planned to start in FY-1993.

2.1.16.3 Technical Support and Interagency Coordination

The EPA Office of Air Quality Planning and Standards required technical support to aid in its participation on the Grand Canyon Visibility Transport Commission. The Commission was mandated by CAAA and is composed of the Governors of seven western states and representatives of several Federal agencies. The Commission is charged with evaluating regional haze impairment at the Grand Canyon National Park and recommending to the EPA by November 1995 any additional regulatory measures that may be needed.

To ensure cost-efficient use of Federal resources for visibility research, a long-term effort was started more than ten years ago to coordinate Federal programs and cooperate with private research activities where appropriate. During FY-1992, this program was responsible for the planning of and partial funding for a Regional Haze Workshop in Phoenix, AZ, during December 1991. The objective was to develop a blueprint for timely scientific input to the Grand Canyon Visibility Transport Commission for use in addressing regional haze in the southwestern United States. The workshop participants included 80 scientists, policy and regulatory analysts, and air quality planners and decision-makers from environmental organizations, industry, and all levels of government. A workshop transactions document was prepared and presented to the Grand Canyon Visibility Transport Commission (Evans and Coffin, 1992).

The Department of Energy (DOE) initiated a long-term program to assess changes in nationwide visibility due to implementation of the National Energy Policy. The DOE sponsored a Visibility Assessment Workshop to aid in the design of their assessment process (Lansford and Laulainen, 1992) and to ensure the credibility and acceptance of these assessment efforts. The DOE assessment program will use the same perception-based visibility index that was designed for the EPA and was presented at the 1992 Conference on Visibility and Fine Particles in Austria.

2.1.17 Remote Sensing Technology Development and Evaluation

2.1.17.1 REmote Monitoring Of Vehicle Exhaust

A device for monitoring tailpipe emissions of vehicles passing through an infrared light beam directed across the roadway was developed by scientists at the University of Denver under the REmote Monitoring Of Vehicle Exhaust (REMOVE) program. Evaluation and development of this technology started in 1988. In FY-1992, the instrument was used to assess the effects of oxygenated fuels on carbon monoxide emissions in Las Vegas, NV. The results of the study were documented in a report that is being published and a journal article that is being prepared. An empirical model was developed using a Las Vegas remote sensing data set to relate vehicle fleet-averaged emissions, as measured by the remote sensor, to repair and malfunction rates. A journal article describing this model will be published.

2.1.17.2 UltraViolet DIfferential Absorption Lidar

Development of the UltraViolet DIfferential Absorption Lidar (UV-DIAL) is supported by the EPA, NOAA, and NASA. The goal is to build a compact active remote sensing system for the measurement of tropospheric ozone along with information about tropospheric aerosol properties (Moosmuller *et al.*, 1992). During testing and evaluation of the system, several ground-based tests and one airborne field test were conducted. These tests indicate that ozone measurements made with this system are accurate to within 5-parts-per-billion-volume (ppbv) of in situ measurements over a range of 2-3 km. Aerosol distributions can also be determined from the data that are provided by this system. Improvements to enhance the system's capabilities to measure sulphur dioxide are ongoing. Future field tests are planned to demonstrate the effectiveness of this system.

2.2 Atmospheric Model Development Branch

The Atmospheric Model Development Branch develops, evaluates, and validates analytical and numerical models that describe the transport, dispersion, transformation, and removal of atmospheric pollutants on local, urban, and regional scales. These are comprehensive air quality modeling systems that incorporate physical and chemical processes, using state-of-science formulations.

2.2.1 Acid Deposition Studies

2.2.1.1 Regional Acid Deposition Model

The Regional Acid Deposition Model (RADM) is a comprehensive Eulerian grid modeling system with a three-dimensional transport, gas and aqueous phase chemistry, and wet and dry removal processes; with a configured domain of 15 vertical levels; and with a 35 x 38 horizontal grid with 80-km resolution. Meteorological data are provided by the Mesoscale Meteorological Model Version 4 (MM4) (Anthes *et al.*, 1987) with Four Dimensional Data Assimilation (FDDA) (Stauffer and Seaman, 1990). The RADM system also includes several special processors, collectively known as the RADM Engineering Models (RADM/EM). The general features of regional scale deposition models are discussed by Binkowski *et al.* (1990). A detailed description of the RADM system is in the NAPAP State of Science and Technology Report No. 4 (Chang *et al.*, 1990).

During FY-1992, a high resolution version of RADM, HRADM, was developed to facilitate a RADM-ROM comparison study. With one universal code, windowed or nested runs with several different resolutions (80km, 40km, 26.7km, and 20km) can be accomplished. In the high-resolution version, windowed and nested, there will be a choice of constant or dynamic boundary conditions. It will include routines for computing integrated reaction rates and mass budgets permitting several diagnostic runs on the windowed domain without having to re-run the full scale HRADM. Several preprocessors, which implement new interpolation routines necessary to generate high resolution meteorological data for HRADM runs, and postprocessors were developed to accommodate the increased functionality.

2.2.1.2 RADM Engineering Models

The RADM Engineering Model (RADM/EM) was developed as a tool to probe the behavior of sulfates in the atmosphere. Its first use was to examine the response of sulfate deposition (wet and dry) to sulfur control strategies. Subsequent improvements led to the development of the Tagged Species Engineering Model (TSEM) (McHenry *et al.*, 1992) and the Sulfate Tracking Model (STM). These two versions of the RADM/EM allowed the apportionment of deposition to particular sulfur source regions (TSEM) or particular sulfate source mechanisms (STM). During FY-1992, the TSEM was expanded from 6 to 15 vertical layers to examine the role vertical resolution plays in sulfate source apportionment.

An expanded version, the Comprehensive Sulfate Tracking Model (COMSTM), was introduced. This version allows the tracking of sulfate from every possible gas- or aqueous-phase chemical-reaction pathway included in the model. A post-processor was developed for TSEM, which allows for an examination of the response of visual range to sulfur control strategies. The extinction coefficients used are empirical functions of sulfate mass and relative humidity.

2.2.1.3 RADM Meteorological Driver

The mesoscale meteorological driver consisting of the Penn State/NCAR Mesoscale Model-Generation 4 (MM4) (Anthes *et al.*, 1987) using Four-Dimensional Data-Assimilation (FDDA) techniques (Stauffer and Seaman, 1990; Stauffer *et al.*, 1991) was operated on a Cray Y-MP computing system at the North Carolina Supercomputing Center (NCSC) in support of various RADM and ROM studies. Modifications were made to the FDDA software that allows production of graphical guidance on workstations. A file management protocol was developed to handle and maintain the data produced.

Through cooperative research with the Pennsylvania State University, the number of vertical layers in a test version of the meteorological driver was increased from 15 to 25, the horizontal grid spacing was reduced from 80 to 54 kilometers, and a 3 to 1 grid nesting capability was developed to bring the minimum horizontal grid resolution down to 18 kilometers. To obtain these refinements in resolution while conserving physical consistency and accuracy, a new cumulus parameterization scheme was employed (Kain and Fritsch, 1990). Also, improvements were made to the surface moisture flux parameterization and the internal long-wave radiation model. Work was begun to modify this improved version of the meteorological driver for operation on a commercially-available computing workstation employing a Reduced Instruction Set Computing (RISC) architecture and a UNIX-compatible operating system similar to that now used on the Cray Y-MP at NCSC. Preliminary studies suggest that the workstation implementation could achieve CPU rates of about one-sixth of that now obtained on a Cray Y-MP processor, and that operator actions required to complete the entire simulation process would be significantly streamlined.

A model development effort was initiated to improve surface flux and PBL parameterizations in MM4/MM5. A one-dimensional test program was developed that consists of a simple surface energy and moisture parameterization, including explicit representation of soil moisture (Noilhan and Planton, 1989) and the latest PBL scheme developed for RADM (Pleim and Chang, 1992). This 1-D prototype simulates fluxes of heat, moisture, and momentum from the surface and throughout the PBL. It was applied to a 2-day period of the Wangara field study and to several days from the First ISLSCP Field Experiment (FIFE) 1987 and FIFE-1989. These experiments show the model's ability to accurately simulate ground temperature, surface fluxes, and boundary layer development.

2.2.1.4 RADM Aggregation Methodology

A method of aggregating deposition fields from thirty 3-day episodic RADM simulations to produce seasonal and annual averages of acid deposition (Samson *et al.*, 1990) was tested for its ability to reproduce annual frequency distributions of ambient concentrations of sulfate and sulfur dioxide. The 1989-1990 Acid-MODES data were used in the test. The eastern United States was partitioned into three regions by cluster analysis of ambient sulfate concentrations: a northeast transport region; a western high-source region; and a southeast low-source region. The RADM aggregation method generally showed improvement in reproducing the regional concentration frequency distributions, for both sulfate and sulfur dioxide, over a random selection of 30 episodes. The analysis of these data is continuing. The results are expected to impact the selection of cases for assessing the emission change effects on visibility using the Regional Particulate Model.

2.2.1.5 Acid Models Operational and Diagnostic Evaluation Study

The databases for the Acid Models Operational and Diagnostic Evaluation Study (Acid-MODES) (Ching and Bowne, 1991) were prepared. Significant efforts were made to achieve the requisite quality of the Acid-MODES field study database to meet the model evaluation requirements as described in Dennis *et al.* (1990). A quality assurance synthesis report is being prepared to document the inter- and intranetwork precision of the five contributing networks to the overall study. These measurements, ending in May 1990, were obtained over a period of two years for evaluating regional acid deposition models. A description of Acid-MODES and the other networks is found in Hansen *et al.* (1989). The contributing networks include the Electric Power Research Institute (EPRI) Operational Evaluation Network (OEN); the Ontario Ministry of the Environment (OME) Acid Precipitation In Ontario Study (APIOS); the Atmospheric Environment Service of Canada (AES) Canadian Air and Precipitation Monitoring Network (CAPMoN); and the Florida Electric Power Coordinating Group (FCG). Measurements at each of these sites included twenty-four-hour integrated aerometric samples that were analyzed for gaseous SO_2, HNO_3, NH_3, particulate sulfate, nitrate, and ammonium. Precipitation samples collected on a daily basis were analyzed for conductivity, pH, sulfate, nitrate, ammonium, Cl^-, Na^+, Ca^{2+}, and Mg^{2+}. Collocated sampling at the Penn State Scotia Range, PA, and at Egbert, Ontario, provided the requisite inter- and intranetwork information on precision and accuracy.

Analysis and modeling studies continued using the aircraft measurements made during the summer 1988 and spring 1990 Acid-MODES intensive field studies. RADM was run at 80 km and 27 km grid resolutions for the August 1988 ZIPPER and CURTAIN flights to study ozone photochemistry. Although the higher resolution model simulation compared better with the measurements particularly in the high-emission upper Ohio Valley region, it was found that there was still a significant discrepancy between measured and modeled peak ozone concentrations. The measured data showed ozone production associated with power plant plumes quite close to the source (3-6 km). Since the grid model is not able to resolve the interactions between dispersion and photochemistry in large point source plumes, the model simulations in these areas are quite unrealistic. Examination of modeled ozone photochemical production rates in the upper Ohio Valley region showed a very sporadic response in both space and time. These findings suggest the need to develop subgrid photochemical plume model parameterization for inclusion in the RADM framework.

2.2.1.6 RADM Evaluation Studies

The Eulerian Modeling Evaluation Field Study (EMEFS) program continued the RADM evaluation efforts following the 1990 completion of the 10-year NAPAP program. EMEFS (Hansen *et al.*, 1989; Dennis *et al.*, 1990) engaged the standing 10-member international External Review Panel to conduct a peer review of the Phase 1 evaluation results for RADM and ADOM. Model evaluation comparisons and interpretation for the 33-day period from August 25 to September 27, 1988, and the 18-day period from July 19 to August 6, 1988, were presented. Of particular interest was the testing of new model versions, RADM2.6 and ADOM2Bg, that incorporate major corrections to account for the large underprediction of sulfate in the NAPAP evaluation.

Tests of RADM2.6 predictions with the new nonprecipitating cloud module aggregated to annual averages showed that the improved representation of the nonprecipitating cloud processes reduced the bias in the annual average SO_4^{2-} concentration from a factor of 0.6 with RADM2.1 to approximately a factor of 0.9 with RADM2.6. Predictions from RADM2.6 were compared to measurements for the July and August period and the August and September period. In addition to RADM2.6, two alternative hypotheses were tested using the same data to examine the ability of each to explain synoptic, seasonal, and spatial contrasts observed in the measurements. Overall, RADM2.6 performed best, but for some tests the performance of RADM2.6 and one or other of the alternative hypotheses were not significantly different. Thus, a wide variety of tests are required to provide enough discriminating power to distinguish between alternative hypotheses.

Studies were conducted to understand model bias incurred as a result of the limited grid resolution (horizontal and vertical). Large differences between RADM results and measured surface SO_2 and O_3 concentrations were observed, particularly during the nocturnal periods. The ozone bias contained a large diurnal component when model results were compared to the hourly data from the National Dry Deposition Network (NDDN). It was concluded that much of the bias was caused by the coarse vertical resolution of RADM, especially the six-layer version. By applying a similarity profile of the planetary boundary layer proposed by Byun (1991), a considerable portion of the high bias of model results was explainable. The study result will be published.

2.2.1.7 RADM Application Studies

Specific applications of RADM2.1/6 and RADM/EM provided final modeling results for the NAPAP 1990 Integrated Assessment. In FY-1992, planning for RADM applications related to mandates in CAAA was emphasized. Studies called for in CAAA with high priority are the effects on sulfur deposition reductions resulting from SO_2 emission allocation trading; the deposition impact of NO_X emission reduction trading for SO_2 allocations; and the feasibility of deposition standards. Application studies are planned for target loading maps of sulfur deposition for the North American negotiations with the Europeans; for nitrogen deposition and source attribution information on nitrogen deposition to the Chesapeake Bay coastal estuary; and for joint United States/Canadian studies of the effect of each nation's emission reductions on the sulfur deposition on critical effect regions and a determination of the responsibility for deposition in eastern North America. Also, assessments of visibility changes as a result of emissions change scenarios are under study.

2.2.2 Dry Deposition Studies

2.2.2.1 Inferential Model for Dry Deposition

The Big Leaf inferential dry deposition model (Meyers *et al.*, 1991; Hicks *et al.*, 1991) was adapted for batch calculation of dry deposition fluxes for the 50-site National Dry Deposition Network (NDDN). For this application the model was modified to 1) calculate dry deposition individually for any number of vegetation species and area weight these to obtain an average site value; 2) adjust meteorological and turbulence parameters, and consequently dry deposition fluxes, as a function of the surface roughness assigned to the individual vegetation species; and 3) include water and barren surfaces.

An analysis program is directed to understanding the uncertainty of the inferential model as applied in the NDDN program. The weekly concentration sampling protocol used in the NDDN shows sulfur dioxide and nitric acid fluxes being biased low by 10% to 20% on an annual basis at some sites; fluxes for nitric acid and particles may be biased low in complex environments; nitric acid and particle deposition is extremely sensitive to wind and turbulence parameters; and the inferential model is relatively insensitive to temperature, relative humidity, and solar radiation. Several preliminary studies conducted at collocated sites and of modeling methods show that 1) the precision of the NDDN network as determined from collocated NDDN sites is very good, generally within 5% to 10%; 2) internetwork precision as determined by collocated CORE (NOAA) and NDDN sites is not as good and requires further study; and 3) the NDDN inferential model and the Canadian dry deposition climatological model do not provide consistent results.

The NDDN Big Leaf model is operational and weekly, seasonal, and annual dry deposition data for ozone, sulfur dioxide, sulfate, nitric acid, and nitrate were archived for 1990 and 1991. A brief description of the program was published (Clarke *et al.*, 1992). A technical report describing the program, presenting dry deposition data for 1990 and 1991, and providing an assessment of NDDN model uncertainty will be published.

2.2.2.2 Direct Dry Deposition Measurement Program

A transportable dry deposition measurement system was built to evaluate the accuracy of the inferential model on a site-specific basis and is undergoing evaluation tests. The system can determine meteorological and ozone fluxes by the eddy correlation method, and measurement of nitric acid and possibly sulfur dioxide fluxes by a gradient approach. Eddy correlation sulfur dioxide flux measurement capability will be added. The system will be deployed to 12-15 selected NDDN sites during FY-1993 and FY-1994.

2.2.3 Cloud Processes Studies

Under a Cooperative Agreement with the University of North Dakota, two field studies designed to investigate transport in convective clouds and cloud-pollutant interactions were planned. The first study took place in

August 1990 and used chemical and thermodynamic tracers to investigate mass flux and entrainment processes in nonprecipitating cumulus clouds. Measurements were made using a Citation jet, specially equipped with a unique navigational pointer system capable of tracking air parcels in real time. This system was tested by tagging air parcels below active cumulus cells with the release of SF_6 and then measuring concentrations at various levels within the cloud. Findings of this study show that relatively undiluted updraft air can usually be found throughout an active cumulus cell. Most of the in-cloud air, however, gets progressively diluted with time and altitude through cloud top and side entrainment.

The second field study took place in late May through mid-June 1992. The study used the air parcel tracking system, tested in the first field study, to investigate the interaction of aerosols and cloud microphysics as air flows through a stationary stratiform cloud system. Although the targeted cloud bank along the eastern shore of Lake Michigan formed only once during the experiment, the Citation was able to fly several legs upwind, through, and downwind of the clouds to obtain the anticipated data. Other flights provided opportunities to measure power plant plumes before and during interaction with clouds to see how anthropogenic aerosols affected the cloud droplet size distributions where the plume entered the cloud. On days with strong cumulus development, flights were made below and through convective cells at many altitudes using the navigational pointer system to track individual air parcels to further investigate mass flux and entrainment in convective systems. On days with mostly clear skies, the Citation flew low straight level legs at several heights within the PBL over the lake and the land to make measurements of turbulent fluxes of ozone, SO_2, NO_x, and aerosols.

2.2.4 Photochemical Modeling

2.2.4.1 Regional Oxidant Model

The Regional Oxidant Model (ROM) was developed to provide a scientifically credible basis for simulating the regional transport and collective fate of emissions from all sources over regional scale (1000 km) areas of the United States; and thereby, to serve as a basis for developing regional emission control policies for attaining the primary ozone standard in the most cost-effective way. The focus of the ROM program during FY-1992 was the development and testing of the next operational version, ROM2.2, and its application to the eastern United States. Advances and efficiencies in the computational structure have allowed ROM to be applied on a CRAY super-computer; thus, making possible an expanded computational domain covering the entire eastern United States.

Also, the ROM research focused on the evaluation of the ROM2.2 system; sensitivity of simulated ozone concentrations to the uncertainty in natural source emission estimates; the response of the eastern United States photochemical system to emission reductions of VOC and NO_x emissions; the generation of regional wind fields; and advanced computational techniques. Additionally, progress was made on a program to upgrade the Urban Airshed Model (UAM) system.

2.2.4.2 Development and Testing of ROM2.2

In preparation for additional model application projects that include CAAA mandates, work continued on a new set of enhancements to the second generation ROM system. The updated system, ROM2.2, includes several major changes to the meteorological processes. First, the well-mixed boundary layer is allowed to develop to a fully extended state over a 3- to 4-h period beginning at sunrise. Previously, a fully-mixed boundary layer became established shortly after sunrise. Second, the wind flow in the first model layer during nighttime inversion periods is calculated using ROM's standard diagnostic wind field interpolation scheme (P11). The prognostic meteorological model formerly used to predict the wind flows in the inversion layer was shown to consistently introduce bias in the wind fields, and its use was discontinued. The diagnostic interpolation technique used in P11 was modified to allow calculation of wind fields within the expanded ROM domain in the eastern United States (superdomain). Third, the turbulence representation over urban areas and the vertical cumulus cloud flux parameterizations were modified.

Other changes incorporated into ROM2.2 include the ability to initialize the ROM simulations at midnight (instead of noon); an upgrade to the Biogenic Emissions Inventory System (BEIS) with a new solar radiation algorithm; revision of rate constants for the PAN production and destruction reactions; and integration of the β-matrix calculations into the core model in anticipation of CRAY supercomputer ROM applications. New tracer species were added to the model to track the influence of initial and boundary conditions separately throughout a model simulation. Because of the increased size of the superdomain over previous ROM domains of application, concentrations of all species at all boundaries are assumed to exist at clean tropospheric levels. The first simulations with ROM2.2 for the eastern United States began in FY-1992.

Work was also initiated to complete the development of ROM's layer 0, a shallow diagnostic surface layer of 10-30 m deep. The estimates of trace species concentrations in this layer will account for the heterogeneity in emission distribution within a layer 0 grid cell.

2.2.4.3 Sensitivity of ROM to Biogenic Hydrocarbons

A research project for assessing the effects of biogenic hydrocarbon emissions on the formation of regional scale ozone was completed in FY-1992. This study examined the sensitivity of regional ozone (O_3) modeling in the northeastern United States to uncertainties in biogenic emission estimates (Roselle, 1992; Roselle *et al.*, 1992). Results from several ROM simulations for July 2-17, 1988, were analyzed by comparing episode maximum, daily maximum, and hourly concentrations of selected pollutants. Biogenic emissions of hydrocarbons were increased and then decreased by a factor of 3 to represent the range of uncertainty in these emissions. As a result of the simulations of hydrocarbon concentrations the predicted O_3 changed significantly, depending upon the availability of NO_x. Two emission control strategies were also examined in the study; one strategy included reductions in anthropogenic hydrocarbon emissions, while the other reduced both anthropogenic hydrocarbon and NO_x emissions. Simulations showed that control of hydrocarbon emissions was more beneficial to the New York City Metropolitan Area, while the combination of NO_x and hydrocarbon controls was more beneficial to the other areas of the northeastern United States. The effectiveness of each control strategy varied across the range of uncertainty in biogenic emissions. The effectiveness of the hydrocarbon controls increased as the level of biogenic emissions decreased, whereas the effectiveness of the combined strategy of NO_x and hydrocarbon controls increased as the level of biogenic emissions increased. These results demonstrate that uncertainties in biogenic emissions could lead to significant errors in O_3 predictions and possibly to a choice of a less effective control strategy.

2.2.4.4 ROM Emission—Matrix Reduction Scenarios

A study was initiated in FY-1992 to compare various combinations of anthropogenic NO_x and VOC emission reductions through a series of model simulations (Roselle *et al.*, 1992). Twelve of the 25 simulations planned for this study were completed. Simulations were performed with ROM for a 9-day period in July 1988. Each simulation reduced anthropogenic NO_x and VOC emissions across-the-board by different amounts. Maximum O_3 concentrations for the period were compared between the simulations. Comparison of the simulations suggests that 1) NO_x controls may be more effective than VOC controls in reducing peak O_3 over most of the eastern United States; 2) VOC controls are most effective in urban areas having large sources of emissions; 3) NO_x controls may increase O_3 near large point sources; and 4) the benefit gained from increasing the amount of VOC controls may lessen as the amount of NO_x control is increased.

2.2.4.5 Evaluation of ROM2.2

An evaluation project to assess the transport and dispersion components of the ROM2.2 system involved simulations of the Cross Appalachian Tracer EXperiment (CAPTEX) episodes. Model runs were performed using a version of ROM with chemistry switched off to simulate the movement and spread of a single, chemically-inert tracer plume over northeastern North America from release sites at Dayton, Ohio, and Sudbury, Ontario. An interesting aspect of this effort was to examine the impact on the modeled plume trajectory from different spatial and temporal resolutions of the observed wind profile data used to generate wind fields for the 3-layers of ROM. Initial graphical analyses revealed that the overlap of modeled and observed plumes varied among the episodes and was influenced by the amount of vertical wind shear. Trajectory analyses indicated that the modeled plume pattern corresponded closely to the trajectory derived from layer 2 winds. Further analyses of the observed and modeled concentrations and plume patterns will be made.

An operational model evaluation of ROM2.2 for ozone was also conducted as part of the July 1988 emissions reduction study described above. The model was seen to reproduce the major urban plumes on the regional scale in the eastern United States quite well. There was, however, a systematic underprediction of rural ozone concentrations, especially in the interior regions of the Appalachians and southeastern United States during this intense ozone episode.

A model intercomparison was also begun between ROM and RADM using the July 20–August 6, 1988, data for the eastern United States. Preliminary results suggest that the models appear to be developing very similar ozone fields across the region, especially when one compares the results of the 20-km ROM and the 20-km high-resolution RADM. Significant differences do appear, however, in the oxidized nitrogen species, where RADM has produced relatively more PAN regionally, and ROM has produced much more HNO_3. Model intercomparisons will continue through FY-1993, and also include comparisons with the Aeronomy Laboratory NOAA Oxidant Model (NOM).

2.2.4.6 Development of Wind Fields for ROM

Research on the generation of wind fields for use with ROM continued, with several different methods being explored. During the testing of ROM2.2 on the expanded eastern United States model domain, the existing diagnostic interpolation technique using Fourier analysis of wind observations performed worse than it did with ROM's smaller domain. An alternate method using Barnes' (1973) interpolation techniques followed by a divergence-minimization step performed much better on the ROM superdomain. ROM2.2 wind fields will be generated for eastern United States applications using this technique.

Work also continued on adapting the meteorological outputs from the NCAR/Penn State Mesoscale Meteorological Model (MM4) (Anthes *et al.*, 1987) to the ROM meteorological processing system. In the first phase of the work, hourly profiles of data for each vertical column of MM4 grid cells are provided to the ROM system as quasi-observational data. During FY-1992, differences in the ROM wind fields generated by the MM4 data and by NWS observational data were examined for a 3-day simulation, along with the subsequent differences in ROM simulation results. While the general flow patterns were very similar in both the MM4 and the diagnostically-obtained analyses, the MM4 boundary-layer parameters, especially surface temperatures, heat fluxes, and boundary-layer depths were significantly lower than the comparable estimates from the diagnostic analysis. Because of this, ROM results were also significantly different depending upon which meteorological driver was used. Also, work was initiated on adapting meteorological output from the 80-km CAL-RAMS (CALifornia Regional Atmospheric Modeling System) prognostic model being used for the Lake Michigan Ozone Study modeling project. These data are assimilated by the ROM processor system in much the same way as the MM4 outputs are. Initial results using these data appear quite good; the CAL-RAMS model estimates of wind fields and other parameters are similar to observations. There appears to be less vertical wind shear in the CAL-RAMS data than in the standard ROM processor diagnostic analysis. Further studies with both the CAL-RAMS data and the MM4 model as ROM meteorological drivers will be made.

Work continued on exploring the generation of probabilistic wind fields for use in ROM simulations. In this technique, ensembles of possible wind fields are created that conform to the physical laws of momentum and energy conservation and that agree with measurements at observation times and locations. The differences between the wind fields represent the stochastic nature of the atmosphere and the uncertainties generated from the sparseness of the data and the inherent errors in the measurements. A journal article describing this work will be published.

2.2.4.7 Investigation of Numerical Solvers for Chemical Kinetics

As part of the regional oxidant program's support of the next generation Eulerian model development effort (Models-3), two different numerical solvers for chemical kinetics were tested as candidates for the Models-3 chemical module. A quasi-steady state solution using two passes (predictor-corrector) and a single-pass Crank-Nicholson type solution were investigated using the RADM chemical mechanism in a stand-alone mode. The solvers appeared to be of comparable accuracy when tested against each other and against a highly-accurate Gear predictor-corrector scheme. Further testing is planned, including tests with emissions forcing, and relaxation of error tolerances and minimum time-step constraints.

2.2.4.8 Development of an Improved Urban Airshed Modeling System

Research continued in an effort to upgrade the scientific approaches and the computational algorithms of the Urban Airshed Model (UAM), the photochemical grid model recommended for urban ozone regulatory applications. Work proceeded from algorithm development into testing of meteorological models that were designed to replace the existing outdated UAM processors. The two-pronged meteorological modeling strategy is composed of diagnostic and dynamic approaches, and the UAM code has also undergone considerable restructuring to accommodate data files generated by the meteorological models.

An efficient, diagnostic meteorological model program (UAMMET) was designed to generate multiple input data files required by UAM. The algorithms incorporated into UAMMET rely on routine, hourly surface and twice-daily upper air meteorological observations, land use, and geophysical data. The components of UAMMET contain updated technical approaches applicable in an operational processor and include a diagnostic wind module; surface energy budget module for generating micrometeorological parameters; a practical urban boundary-layer height model for deriving spatially variable nocturnal urban mixing heights; an updated dry deposition module for computing hourly gridded pollutant deposition velocities; an improved algorithm for determining multiple photolytic rates needed by the Carbon Bond IV chemical mechanism in UAM; and the vertical eddy coefficient method removed from the UAM code. The technical approaches and test plans for the diagnostic meteorological model are described in Godowitch *et al.* (1992).

An existing dynamic, hydrostatic meteorological model (SAIMM) was equipped with a four-dimensional data-assimilation (FDDA) technique in order to include observed winds and temperatures in the numerical simulation. The SAIMM/FDDA model was also applied to two urban domains exhibiting complex flow patterns; namely, the Los Angeles basin and the Chicago-Lake Michigan area. Simulations were conducted to test the model's ability to generate realistic wind and temperature fields in these urban environments through a series of data reduction simulations using observed experimental data. Results revealed that as the amount of data assimilated decreased, errors in the simulated winds and temperatures increased. However, results from the simulation that included only routine data provided a better representation of the flow field than a no-FDDA prognostic simulation (Douglas, 1992). An interface processor was also developed to generate compatible wind, temperature, and mixing height input files for UAM. Testing and refinement of the SAIMM/FDDA model is planned. During FY-1993, both meteorological models will be applied to the Southern California Air Quality Study (SCAQS) and Lake Michigan Ozone Study (LMOS) domains and results intercompared as part of a rigorous evaluation effort of the updated UAM system.

2.2.5 Aerosol Modeling Program

The program objective is to develop and evaluate state-of-science atmospheric modeling systems that incorporate the physical and chemical processes important for predicting ambient concentrations and deposition of aerosols, including emissions, transport, chemistry, and removal on urban and regional scales. The modeling tools are used to assist in promulgating air quality standards for fine particles, visibility, and acid aerosols.

2.2.5.1 Regional Particulate Model

The Regional Particulate Model (RPM) is an expansion of the Regional Acid Deposition Model (RADM). The added capabilities include aerosol chemistry and size distributions. Two size ranges are considered (Whitby, 1991): the size range associated with source emissions and particle production processes, designated the nuclei mode, and the size range associated with longer term residence in the atmosphere, designated the accumulation mode. Efforts during FY-1992 concentrated on the behavior of sulfate aerosol particles to relative humidity and ammonia concentrations and to a hypothetical uniform 50% reduction in sulfur emissions. Another study showed the size distributions were strong functions of position relative to major upwind source areas. The total aerosol volume associated with the nuclei mode was less than that associated with the accumulation mode, and the total aerosol volume near large sources was larger for the nuclei mode because of the larger number of particles. The result is consistent with near-source values reported by Whitby (1991). Aqueous production of sulfate would strongly increase the total volume of the accumulation mode particles. Details of the RPM will be reported in a journal article.

Evaluation of this model will be undertaken using data collected during the Acid-MODES field measurement program. From July 1988 to June 1990, a network of 35 cyclonic-separator samplers were operated with a size cut approximating 2.5 μm. At each sampling site, collocated with an Acid-MODES site, 24-hour air concentrations of fine particle, sulfur, calcium, magnesium, chlorine, and other elements were obtained from approximately 12,000 filters via gravimetric or XRF analyses. The protocols and results of initial analyses are summarized by Bennett and Stockburger (1991).

2.2.5.2 Modeling Air Quality Related Values for Federal Land Managers

Air quality modeling tools were developed that can be used by federal land managers to monitor and model visibility and disposition in Class I visibility protected areas. One candidate is the Regional Particulate Model (RPM). A major component of RPM and other interim air quality models is the development of improved meteorological drivers. Efforts are focused on optimizing the use of the MM4 with FDDA to derive high resolution wind fields for the air quality models. A project to produce and provide a year of high time and space resolution meteorological data for use in air quality dispersion models using the MM4-FDDA system was initiated. Upper air meteorological data will be taken at hourly intervals and for grid resolution of 80 km for the contiguous continental United States and will supercede the data from routine, twice daily upper air soundings from the National Weather Service (NWS) stations spaced several hundred kilometers apart. Delivery of this database is anticipated by the end of FY-1993. This effort is being conducted by the Interagency Working Group on Air Quality Modeling (IWAQM) through a Memorandum of Understanding between the National Parks Service, National Forest Service, National Fish and Wildlife Service, and Environmental Protection Agency.

2.2.6 Toxic Deposition to the Great Waters

Title III of the Clean Air Act Amendments of 1990 requires an assessment of the annual atmospheric deposition of toxic substances to the "Great Waters" that consist of the Great Lakes, the Chesapeake Bay, Lake Champlain, and coastal waters (U.S. Congress, 1990). This includes identification of the sources and assessment of their relative contributions.

2.2.6.1 Airborne Toxic Deposition and Modeling Studies

Interim efforts to calculate annual atmospheric loadings to the Great Waters, comprised of the Great Lakes, Chesapeake Bay, Lake Champlain, and Atlantic, Pacific, and Gulf of Mexico coastal waters, are based on 1) preliminary estimates of United States/Canadian toxic emissions (Engineering Science, Inc., 1990), and 2) knowledge of the atmospheric processes and process rates. The objective of this long-term research program is the development of a comprehensive toxics deposition model.

In a cooperative effort with the EPA Office of Air Quality Planning and Standards, and Regions III and V, the REgional Lagrangian Model of Air Pollutants (RELMAP) (Eder *et al.*, 1986) was adapted to simulate the atmospheric deposition of toxic substances to the Chesapeake Bay and Great Lakes (Clark *et al.*, 1992; Clark, 1992). For this first effort, these substances are assumed to be chemically inert and deposited at rates based on published physical attributes (i.e., Henry's Law coefficients, liquid-phase vapor pressures, and phase partitioning ratios, etc.) and empirical data (e.g., precipitation chemistry analyses). In addition to quantifying the atmospheric deposition of 22 toxic substances, the model will rank relative contributions from individual source cells with dimensions ranging from approximately 40 km to 220 km. Preliminary results indicate that the transport scales of toxic pollutants deposited to Lake Michigan vary significantly and are dependent on physical and chemical characteristics as well as continental emission patterns. For example, nearly 75% of the benzo(a)pyrene deposited annually to Lake Michigan is emitted from sources in the adjacent Chicago-Gary area, while approximately 85% of the cadmium deposited is emitted from sources in the St. Louis and southeastern Missouri areas, 400 km from the lake.

2.2.6.2 Chesapeake Bay Evaluation and Deposition Committee

The EPA Office of Research and Development and the Air, Radiation and Toxics Division of Region III created the Chesapeake Bay Evaluation and Deposition (CBED) Committee in February 1991 to articulate and satisfy atmospheric research and model needs pertaining to the ecology of the Chesapeake Bay. CBED's major project is to study atmospheric deposition of nitrogen and toxic substances to the Chesapeake Bay. Its efforts are coordinated with the Implementation Committee of the Chesapeake Bay Program Office of Region III.

During FY-1992, CBED initiated a RADM applications project to determine the expected reduction of organic nitrogen deposition to the Bay in the year 2005 as a result of the nitrogen emission reductions required by CAAA. The Committee also recommended and prioritized a list of scientific research and atmospheric modeling projects. One of these is the four-year Baltimore Air Toxics And Nitrogen Deposition Study (BATANDS), which intends to determine the relative contribution of urban emissions to the atmospheric deposition to an adjacent water body. Other projects proposed include the determination of the transport scales of organic nitrogen and toxic pollutants deposited to the Bay and quantification of the organic and inorganic nitrogen deposition.

2.2.7 Technical Support

2.2.7.1 Lake Michigan Ozone Study

During summer 1991, a multi-million dollar field campaign was conducted over the Lake Michigan air basin, including the Chicago Metropolitan Area as part of the Lake Michigan Ozone Study (LMOS). The purpose of the study is to elucidate the causes of high ozone concentrations that form over the lake and downwind areas from Chicago. ROM2.2 simulations are being performed to support portions of the modeling analysis for LMOS. ROM estimated concentrations will be used as boundary conditions for finer scale urban modeling, and a comprehensive model evaluation will be conducted on ROM2.2 using the LMOS field data during FY-1993.

2.2.7.2 Modeling Advisory Committee

The California Air Resources Board (CARB) initiated a Modeling Center within its Technical Support Group in Sacramento. The purpose is to coordinate all regulatory air quality modeling activities within the State and to develop and test tools needed for air quality modeling. A Modeling Advisory Committee (MAC) was established to review and comment on the Center's programs and activities and to provide ongoing expert opinion on a variety of modeling subjects, including model evaluation, model application, and uncertainty in the modeling process. The Committee is composed of members from the scientific community elected by CARB officials for fixed terms of membership. One representative from the Division is serving a 3-year term on MAC.

2.2.7.3 Southern Oxidant Study

FY-1992 was the second year of the multiyear Southern Oxidant Study (SOS), a major field and modeling project concerned with the generation and control of ozone and photochemical processes in the southeastern United States. A consortium of Southeastern universities is coordinating the study. Division personnel are involved in providing technical leadership on aspects of air quality simulation modeling and emission inventory development and project officer assistance on various cooperative agreements. During the summer of 1992, major field intensives were conducted throughout the Southeast using regional scale monitoring networks for ozone, nitrogen, and hydrocarbon chemical species. An intensive field campaign within the Atlanta Metropolitan Area was conducted. A modeling coordination group was formed to guide the air quality modeling for the urban and regional portions of SOS. Several members of the Division are playing key roles in the modeling studies and coordination. Plans started for a centralized data archive for SOS, to be located in Research Triangle Park, NC.

2.2.7.4 Eulerian Model Evaluation Field Study Program

The Eulerian Model Evaluation Field Study (EMEFS) is a multiagency program for obtaining a database and evaluating regional scale acid deposition models, including RADM and ADOM. Contributors to this program include the Acid-MODES study; the Electric Power Research Institute Operational Evaluation Network; the Canadian Atmospheric Environment Service Canadian Air Pollution Monitoring Network; the Ontario Ministry of Environment Acid Precipitation In Ontario Study; and the Florida Coordinating Group Florida Acid Precipitation program. The Program Management Group (PMG), which oversees the project, consists of sponsor representatives and includes four teams: the Operations Measurements Team (OMT); the Diagnostic Measurements Team (DMT); the Emissions Inventory Team (EIT); and the Model Evaluation Team (MET). DMT and MET are chaired by Division scientists.

DMT developed the experimental design and quality assurance plans and conducted the data collection program of aircraft and special enhanced chemistry studies during summer 1988 and spring 1990 intensive field studies. They have archived a high quality diagnostic model evaluation database for both intensive field studies. MET developed the evaluation protocols used in the evaluation of RADM and ADOM for the NAPAP 1990 Integrated Assessment. The PMG activities will continue through calendar year 1993 concluding its formal activities with the report of the next round of RADM and ADOM evaluations to be completed by Spring 1994. The Quality Assurance Synthesis Report is being drafted and will provide the basis for an assessment of the quality of the EMEFS database. A copy of the network and aircraft data for the EMEFS period was distributed to each EMEFS sponsor.

2.2.7.5 Interagency Work Group on Air Quality Models

The Interagency Working Group on Air Quality Modeling (IWAQM) was commissioned through a Memorandum of Understanding between the National Parks Service, National Forest Service, National Fish and Wildlife Service, and Environmental Protection Agency. The major objective is to develop modeling tools that can be used by federal land managers to help with policy on such air quality related values as visibility and deposition in Class I areas. IWAQM is undertaking this effort in three stages. In the first stage, a model based on a modified version of MESOPUFF will be recommended as an interim measure for use by the Federal land managers. In the second and third stages, state-of-science process modules, including meteorological preprocessors, dispersion, and chemistry, will be incorporated into the model. The model and documentation of the interim recommendation was reviewed and a draft version is anticipated during FY-1993. In the second stage, the effort is focused primarily on using MM4-FDDA to derive high resolution wind fields for the air quality models. Eventually, the data will supercede the data used by dispersion models using routine, twice daily upper air soundings from the National Weather Service stations spaced several hundred kilometers apart.

2.2.7.6 Measurement Of Haze And Visual Effects (MOHAVE) Study

The one-year MOHAVE field measurement program began in fall 1991 to provide a database for determining and assessing the relative contributions of the Mohave Power Plant (MPP) to visibility impairment at the Grand Canyon National Park. Detailed meteorological fields are being modeled by Colorado State University in a triple nested mode to provide the transport data for influence functions for the power plant as well as for major potential source regions that may impact the Park. A study of SF_6 tracer released at MPP was conducted in August 1992 and will provide evaluation data for the models.

2.2.7.7 Assistance to Taiwan on the use of RADM

The Division and the State University of New York at Albany provided assistance to Taiwan in the installation of RADM on the Cray X-MP located at the National Taiwan University in Taipei. The work is part of a US/Taiwan cooperative research project sponsored by the National Science Foundation. A demonstration case study using RADM with 20 km grid resolution for Taiwan was successfully performed. A 20 km MM4 simulation made for the TAMEX (Taiwan Area Meteorological EXperiment) provided the meteorological data.

2.2.7.8 Ozone Research Planning and Strategy

An effort was initiated to develop a National Tropospheric Ozone Research Strategy to support Section 185B of CAAA. A work group, comprised of more than 30 eminent scientists from universities and private and public organizations in the United States and Canada, addressed the major science issues relevant to the chemistry, meteorology, and modeling (including its development, evaluation and application) of ozone. When completed, this research strategy will provide the basis for providing the scientific tools to support ozone control policy and regulations. The overall strategy includes research into health and ecological standards, emission inventories, monitoring, alternative fuels, and control technology. It is considered to be a major initiative for a long-term research plan for North America.

2.3 Fluid Modeling Branch

The Fluid Modeling Branch conducts physical modeling studies of fluid flow and pollutant dispersion in complex flow situations, including flow and dispersion in complex terrain, around such obstacles as buildings, and within dense gas plumes. The Branch operates the Fluid Modeling Facility, consisting of large and small wind tunnels, a large water channel/towing tank, and a convection tank. The large wind tunnel has an overall length of 38 m with a test section 18.3 m long, 3.7 m wide, and 2.1 m high. It has an airflow speed range of 0.5 to 10 m/s, and is generally used for simulating transport and dispersion in the neutral atmospheric boundary layer. The towing tank has an overall length of 35 m with a test section 25 m long, 2.4 m wide, and 1.2 m deep. It has a speed range of 0.1 to 1 m/s, and the towing carriage has a range of 1 to 50 cm/s. Generally, the towing tank is used for simulation of strongly stable flow; salt water of variable concentration is used to establish density gradients in the tank, which simulate the nighttime temperature gradient in the atmosphere. A convection tank measuring 1.2 m on each side and containing water to a depth of 0.5 m is used to study the convective boundary layer and flow and dispersion under convective conditions.

2.3.1 Building Downwash in Vicinity of Power Plants

Upon a request from the Electric Power Research Institute (EPRI) to collaborate in their Plume Rise/Downwash Project, the Fluid Modeling Facility agreed to conduct wind-tunnel studies of the behavior of plumes released in the vicinity of typical power plants. The original plans called for modeling two generic, or typical, plants, one being the conventional coal-fired, steam-boiler (SB) plant, and the other, the popular combustion-turbine (CT) plant. The SB plant generally comprises a large building and a nearby stack emitting effluent at approximately 15 m/s and 400° K; the CT plant, on the other hand, generally comprises a small structure with stack emitting effluent directly above it at approximately 25 m/s and 800° K. Because of property boundaries or potential for using the excess heat, the CT plants are frequently constructed in the very near vicinity of SB buildings. Thus, a common problem in the industry is the downwash of CT plumes caused by nearby SB buildings, and this third case was also included in the wind-tunnel modeling studies.

For each power-plant type, five nondimensional parameters were varied:

Stack Height/Building Height	H_s/H_b
Location of Stack	L/H_b
Wind Direction	θ
Effluent Speed/Wind Speed	W/U
Buoyancy (Froude number)	Fr

Also for each power-plant type, the above set of parameters was fixed at values typical of the plant type; this was called the base case. Thereafter, one nondimensional parameter at a time was varied while holding the other parameters at their base-case values. For example, in the SB case, the stack height alone was varied from 0.25 to 2.5 H_b in 9 steps, while keeping all other parameters fixed at the base-case values. Then the stack height was fixed at 1.5 H_b while varying the separation distance alone (7 steps). Next, the stack height and separation distances were fixed while varying the wind direction (5 directions), *etc*. For each set of nondimensional parameters, concentration profiles were measured downwind, both in the presence of a building and in its absence. In this manner, the downwash effects of the power-plant buildings were immediately ascertained.

In a few select cases for each power-plant type, detailed measurements were made of the plume structure, including longitudinal ground-level-concentration profiles, and lateral and vertical concentration profiles at various downwind distances. Several plume cross sections were also measured by taking lateral profiles at numerous elevations at fixed downwind positions. The total number of profiles measured exceeded 300.

A data report was then compiled (Snyder, 1992) which describes the experimental conditions, what data are available, and how they were obtained. The report provides graphical displays of all the data as well as files on floppy disk. Explanations are provided on how the data may be applied in the real world. A preliminary data analysis is also performed, primarily examining the internal consistency and basic trends in the data.

Subsequent to this data report, extensive measurements were made of the flow field around the SB building oriented with its long side perpendicular to the approach wind. Three components of mean wind and turbulence intensity were measured at approximately 2000 points surrounding the building and another data report is in preparation. This data set will be used for evaluating numerical models of flow and diffusion around buildings.

2.3.2 Measurements of Drag on Hills in Stratified Flows

In collaboration with a Professor from the University of Surrey, England, a towing-tank study was conducted to investigate the relationship between various structures observed in stratified flow around obstacles and the aerodynamic drag on the obstacle. The models, idealized hills, were mounted on a frame suspended by wires from the towing carriage and attached by rods to a load cell. This load cell measured the drag on the model hills as they were towed through the stratified towing tank. The flow structure around the obstacles was visualized by releasing dye streamers upstream of the models; the resulting streaklines were photographed with video and 35 mm cameras. Recordings of the load-cell output were compared with the video images to correlate observed changes in drag with changes in flow structure. Four different models were used—two vertical fences and two ridges with cosine cross sections and various lengths. A total of 70 tows was conducted to correlate the drag with the flow structure. Additional tows were performed with elliptical hills to further investigate developing flow structures under certain stratified conditions. These data will be used to augment a database obtained from earlier experiments and to validate a numerical model.

2.3.3 Building Amplification Factors

Wind-tunnel data collected in a previous year were used to derive building amplification factors from measurements of concentrations from point sources near isolated building models in the meteorological wind tunnel. A building amplification factor is defined as the ratio of the maximum concentration observed with the building present to the maximum observed with the same source in the absence of the building. A journal article will be published presenting these factors. The data were compared with other wind-tunnel and field results for similar source/building configurations. Some formulas for estimating concentrations near buildings were also evaluated using these data.

2.3.4 Simulation of the Urban Heat Island

A three-year project on the simulation of an urban heat island using a laboratory convection tank came to fruition this year. The tank used for the measurements was the original tank of Willis and Deardorff (1974), and its dimensions are 120 cm x 124 cm and 45 cm deep. An additional 2.5 cm thick aluminum plate was placed on the floor; a 45-cm-square hole was inserted at its center where heating disks were inserted. Deionized and deaerated water was used to simulate the atmosphere. Metal foil heaters of different sizes were used on the floor of the tank to simulate the heated urban surface area. Initial stable temperature profiles were obtained in the ambient fluid through the use of a resistance-wire heating grid. Application of electrical power to the floor heaters thus set up a circulation pattern that simulates the urban heat-island circulation—temperature and velocity fields induced by a low-aspect-ratio heat island in a calm and stably stratified environment. An extensive and systematic study was conducted with different heating rates of the underlying surface, heat-island sizes, and various ambient temperature gradients.

The convective circulation was found to be turbulent, and the Froude number was found to be the controlling parameter when Reynolds-number independence is obtained. Two analytical models, a bulk-convection model and a hydrostatic model, were developed to predict plume heights, heat-island intensities, and velocity distributions. The experimental results were compared with field observations from several cities, previous numerical simulations, and predictions of the analytical models. Good agreement was found with the proper convective scalings. The experimental results in their nondimensional forms, including thermal plume height, equilibrium height, flow reversal height, heat-island intensity, mean horizontal and vertical velocity distributions, and statistics of temperature and velocity fluctuations, may be applied to any low-aspect-ratio thermal plumes. Partial results were published (Lu *et al.*, 1992), and full details are in preparation.

2.3.5 Numerical Modeling of Flow Around Buildings

A numerical modeling project was instigated using the TEMPEST model (Trent and Eyler, 1989) to simulate flow and diffusion in the vicinity of a simple rectangular-block building. TEMPEST is a turbulent kinetic energy/dissipation (κ-ϵ) model. Initial efforts centered on the flow around a cube and the concentration field resulting from a source on the rooftop. Two papers were prepared, the first investigating the effects of upstream wind shear and turbulence on the flow around the cube (Zhang *et al.*, 1992a) and the second, the effects on the concentration field (Zhang *et al.*, 1992b). The numerical simulations demonstrated that (1) the upwind shear promotes the development of the "horseshoe" vortex at the upwind face of the building, while reducing the size and strength of the recirculating cavity in the lee of the building, (2) turbulence in the approach flow further tends to reduce the size of the lee-side cavity and also influences the flow on the rooftop, and (3) both the value and position of the maximum ground-level concentration are changed dramatically due to the effects of the upstream level of turbulence. Conclusions from comparisons with experimental measurements were that TEMPEST can simulate the main features of the observed flow fields, but much additional work must be done before the model can be applied with confidence.

2.4 Modeling Systems Analysis Branch

The Modeling Systems Analysis Branch supports the Division by providing computer programming and systems analysis needed in the development of mathematical and statistical models. The Branch is the focal point for modeling software design and systems analysis in compliance with stated Agency quality control and assurance requirements. The Branch operates the Facility for Advanced Research Model Operation and Analysis (Research Modeling Facility) to provide expertise in the application and interpretation of advanced dispersion models and to establish definitive scientific standards for model evaluation and policy analysis that are consistent with standards followed in the research and model development efforts.

2.4.1 Regional Oxidant Model Applications

Most applications of ROM were handed over to the EPA Office of Air Quality Planning and Standards. During FY-1992, the branch supported the model becoming fully operational on the CRAY Y-MP that is located at the North Carolina Supercomputing Center (NCSC) in Research Triangle Park, NC. Research concentrated on gathering databases that will be used to evaluate ROM. Field data collected during the Lake Michigan Ozone Study and the Southern Oxidant Study will be used. Computational time available at the NCSC CRAY Y-MP and the EPA CRAY located in Bay City, Michigan, will be used for sensitivity testing.

2.4.2 Biogenic Emissions

The Biogenic Emissions Inventory System (BEIS) (Pierce and Waldruff, 1991), used with ROM and RADM, was incorporated into the Urban Airshed Model. BEIS, designed to compute hourly emissions of VOC and NO_x for counties and model grid cells in the contiguous United States, can be used to prepare State Implementation Plans (SIPs).

Research continued on improving methods for estimating biogenic emissions and in documenting uncertainties associated with biogenic NO_x and VOC emission inventories. It is envisioned that a new version of BEIS will be integrated into the various air quality models during 1993. Through the SOS, the international Global Emissions Inventory Activity (GEIA), and the Joint Emissions Inventory Oversight Group, work continues to synthesize research findings and to incorporate them into an improved version of BEIS.

2.4.3 Southern Oxidant Study (SOS)

The Southern Oxidant Study (SOS) Southern Oxidant Research Program on Emissions and Effects (SORP-EE) supported three areas of research during 1992. The first area of research was the Atlanta Summer 1992 Ozone Field Study to develop a research-grade emissions inventory in cooperation with North Carolina State University, Georgia Institute of Technology, Georgia Department of Natural Resources, and the Atlanta Regional Commission. Special focus is on obtaining detailed estimates of mobile and biogenic VOC emissions. The second area of research was the Baltimore Fort McHenry tunnel study. The objective was to measure VOC concentrations in a controlled tunnel in an effort to rectify suspected underpredictions in the mobile source emissions inventory.

The third and most significant area of research was the Isoprene Flux Experiment undertaken at the NOAA Atmospheric Turbulence and Diffusion Division (ATDD) Walker Branch site in Oak Ridge, TN. The University of Colorado and the University of Wisconsin were given the task of developing an improved understanding of isoprene emission mechanisms. Scientists from the Washington State University, National Center for Atmospheric Research, NOAA ATDD, and EPA worked at the site during July 1992. The objective of the experiment was to collect data that could be used to develop direct and indirect estimates of isoprene fluxes from a hardwood forest. For the first time, a conditional sampler was used near the top of the ATDD micrometeorological tower to gather isoprene samples for inferring isoprene fluxes. The results from the experiment will be used to improve isoprene algorithms in BEIS.

2.4.4 Compilation and Improvement of an Interim Toxic Emissions Inventory

During FY-1992, an interim toxic emission inventory for 28 toxic compounds was compiled for the contiguous United States and Canada, including benzene, 1-3 butadiene, mercury, lead, cadmium, arsenic, and nickel. The inventory was intended to provide an emissions database for modeling transport and deposition of selected toxic emissions to the Great Lakes using RELMAP (Clark, 1992). The inventory and modeling scope was expanded to address transport and deposition for all of the United States, to address the Great Waters Program of Title III, Section 112(m) of CAAA, which includes the deposition of toxic emissions to the Great Lakes, Lake Champlain, Chesapeake Bay, and the coastal waters of the United States.

The interim toxic emissions inventory is based principally upon speciation of the 1985 NAPAP volatile organic compound (VOC) and particulate matter (PM) point and area source inventories (Benjey, 1992). The emissions are gridded with a geographic information system for use by the RELMAP system.

The interim inventory is being evaluated and expanded to better support the Great Waters Program and the Urban Area Source Toxic Emissions Program of Title III, Section 112(c)(6) of CAAA. The speciation and emission factors used in compiling the present inventory are being updated to reflect the most recent information, and as many as 40 additional toxic pollutant emissions will be compiled. The reference inventory for VOC-based toxic emissions will be changed from the 1985 NAPAP inventory to the 1990 base-year VOC inventory. The 1990 base-year State Implementation Plan (SIP) VOC inventories for non-attainment areas will also be used where available. In addition, the computational procedures used in compiling the inventory are being evaluated for accuracy, and additional quality control steps will be adopted. These steps include cross-checking the multiple data merges necessary to create the inventory and review the use of the applicable source classification codes. Emission inventory estimates will be improved by the increased use of emission factors and activity data rather than speciation factors where data availability allows. These changes will be incorporated into the interim toxic emissions inventory in FY-1993.

Estimation of pesticide emissions from agricultural applications are being addressed separately because conventional emission factors and speciation profiles are not available. Pesticide emissions vary spatially and temporally with use, mode of application, season, soil properties, vegetation cover, and the properties of the pesticide. Volatilization for approximately 110 pesticides was estimated using the method of Jury *et al.* (1983), and emission factors computed for each pesticide, by county for the contiguous United States, using the approach of Johnson *et al.* (1990). The emission factors are applied to a county-level pesticide use database compiled by

Gianessi and Puffer (1991). The resulting emissions are gridded by GIS and modeled by RELMAP. This approach provides rough initial estimates of pesticide emissions for the United States. These toxic emission inventories are not intended for use in assessing health risk, which requires much more detailed individual exposure information and consideration of household and other uses of pesticides.

2.4.5 High Performance Computing and Communications Program

ROM and RADM were optimized for vector and parallel performance on a Cray Y-MP. A draft report discussing performance improvements and documenting procedures was prepared. Several cooperative agreements with university research groups were initiated to evaluate the performance of a variety of atmospheric chemistry and molecular modeling algorithms on massively parallel architectures. A reference chemistry solver was established for benchmark testing. Plans were developed for the implementation of a test-bed research network to support advanced software development activities encompassing distributed computing, visualization, and database management. The network will include massively parallel computers, general workstations and specialized graphic engines, file servers, and a conventional supercomputer.

A modified software life cycle development approach was adapted for use in the development of a third generation air pollution modeling system—Models-3. A draft software requirements specification was prepared along with a document assessing potential risks in the software development project. A pilot project was initiated with the State of North Carolina as part of the technology transfer component of the program. An early prototype air quality assessment system was developed for transfer to the North Carolina Department of Environment, Health, and Natural Resources to obtain feedback on the functionality of user-friendly interfaces to high performance air quality computing applications. A joint research effort was initiated with the EPA Athens Environmental Research Laboratory and the Chesapeake Bay Office to link the Chesapeake Bay Water Quality Model, the 3-D Bay Model, and RADM in a distributed computing environment.

2.5 Global Climate Research Branch

The Global Climate Research Branch performs and directs research to obtain qualitative and quantitative analyses of regional climate and its relationship to air quality for use in evaluating the sensitivities and responses of major environmental systems. The Branch has particular interest in the relationship between tropospheric ozone and meteorology. Data is being evaluated for defining change in air quality and ecosystems.

2.5.1 Global Climate Change Research

The goal of the global climate change research is to understand the physical and chemical elements of climate and the atmosphere, including their properties, feedback mechanisms, and the potential for change under present and future conditions. To support this goal, studies are conducted on the impact of climate change on ecosystems and air quality; the impact of urban emissions on regional and global atmospheric composition; and the development of future climate scenarios for assessing air quality and environmental effects.

Cooperative climate research with the National Center for Atmospheric Research examined the climate from the perspective of extreme events and variability (Katz and Brown, 1992). The importance of climate variability was well developed in the study; supporting a long-held theory that the variability of climate is more important than the average in determining extreme events.

The research emphasized development and application of statistical methods in climate change research, including climate features of significance to impact studies on ecological aspects of the environment. In joint research with the U.S. Forest Service Southern Global Change Program (SGCP), development of climate change scenarios is underway. The SGCP is one of four regionally-managed, national research programs of the U.S. Forest Service Global Change Research Program, including Southeastern and Southern Forest Experiment Stations and 12 states from Texas to Virginia. A survey concerning the interpretation and application of General Circulation Model output for this region and an educational outreach article were developed. Present research focuses on the acquisition and analysis of uniform historical weather data of the temporal and spatial resolution necessary to support site-specific process models as well as regional production assessments. Several research databases are being considered to form the basis of the climate change scenarios. Methods of temporal and spatial interpolation will then be used to achieve a final assessment database.

Sea surface temperature (SST) of the tropical Pacific ocean between January 1989 and December 1990 was modeled using the Modular Oceanic Model developed by the Geophysical Fluid Dynamics Laboratory. The model, forced by the winds and air temperatures from the Comprehensive Ocean Atmosphere Data Set, allowed visual comparisons between the modeled and satellite derived SSTs. Statistical summaries of modeled and satellite derived SSTs were analyzed, and such ocean subsurface dynamics as undercurrent and upwelling, which the satellite could not provide, were visualized using the model output. This work was done cooperatively with the North Carolina Supercomputer Center, Research Triangle Park, NC, and Duke University, Durham, NC.

Traditionally, ozone was characterized as an urban-scale pollutant. However, scientists realized ozone was a regional and even global-scale phenomenon, as high concentrations are routinely observed over vast non-urban areas of most industrialized countries. The advent of satellite derived ozone measurements coincides with this realization. Using data derived from the Total Ozone Mapping Spectrometer, which measures total column ozone concentrations in Dobson Units, and the Stratospheric Aerosol and Gas Experiment, which measures the stratospheric component, scientists are able to estimate the tropospheric (residual) component and under certain meteorological conditions to estimate the boundary-layer component. To determine the appropriateness of such a technique and its feasibility on global scales, an evaluation is being performed using surface data obtained from the Aerometric Information and Retrieval System (AIRS) and residual ozone data from the National Satellite Service Data Center for the 6-year period 1985-1990.

The first phase of this research provided a characterization of the spatial and temporal variability of surface ozone concentrations over the eastern United States (See Section 2.5.3) by using a Rotated Principal Component Analysis (RPCA) applied to data from 77 ozone monitoring stations from the AIRS network for the 6-year period 1985-1990. The analysis allowed segregation of the study domain into subregions whose ozone concentrations exhibit similar intra-subregion variability and dissimilar inter-subregion variability. The similarities and dissimilarities were examined using numerous statistical techniques.

The second phase of the research involved application of an additional RPCA on the residual satellite data for the eastern two-thirds of the United States. The results from this RPCA, applied to the same 6-year period 1985-1990, were compared to the earlier analysis performed on the surface ozone data and determined to what extent the major modes of spatial and temporal surface ozone variability are being captured by the satellite data. However, the widely varying spatial scales between the two data sets prohibit point-by-point comparisons. The surface data obtained from the AIRS network is representative of mesoscales, while the satellite data is representative of macroscales. RPCA reduces this impediment by providing similar spatial scale results, allowing pattern recognition and comparison of ozone concentrations. Temporal variability of these patterns are examined and compared using canonical correlations to compare the intra- and interannual variability of the surface and satellite observations.

2.5.2 Environmental Monitoring and Assessment Program

The Environmental Monitoring and Assessment Program (EMAP) is a long-range effort to monitor status and trends in the major ecological resources of the United States. EMAP recognizes and considers the influence of climate conditions on ecological resources. Although EMAP considers only the recent past, studies of such climate issues as the potential importance of changes in climate means and variability associated with increased levels of greenhouse gases are part of the EMAP objectives.

A report summarized the status of regional climate and forest interactions (Cooter *et al.*, 1991) and a journal article summarizing preliminary research on the development of a regional climate stress indicator is underway. General summaries of historical and recent climatological conditions at regional and larger scales were also produced (Brooks *et al.*, 1992a; Brooks *et al.*, 1992b). Follow-on research focusing on the more detailed analysis of trends present in some of these summaries is underway.

In addition to forest considerations, meteorological stresses to estuaries of Virginia and Louisiana were included in EMAP statistical summaries. The agro-ecosystems EMAP resource group conducted a 1992 pilot study in North Carolina. Data characterizations, atmospheric influences, and remotely sensed vegetation conditions are being investigated for inclusion in future statistical summaries of agro-ecosystems.

2.5.3 The Spatiotemporal Variability of Non-Urban Ozone Contractions over the Eastern United States

The spatial and temporal variability of the maximum 24 hourly O_3 concentrations over non-urban areas of the eastern United States was examined for the period 1985-1990 using principal component analysis (Eder, 1992). Utilization of Kaiser's Varimax orthogonal rotation led to the delineation of six contiguous subregions accounting for 64.02% of the total variance, each of which displayed statistically unique O_3 characteristics. When compared to the entire domain, examination of these characteristics revealed that higher ozone concentrations were observed for the Mid-Atlantic and South Subregions. Concentrations are near the domain average for the Northeast and Southwest Subregions and are lowest in the Great Lakes and Florida Subregions. The percentage of observations exceeding 120 ppb were greatest in the Mid-Atlantic and Southwest Subregions, near the domain average in the Northeast and South Subregions, and lowest in the Great Lakes and Florida Subregions.

Examination of the time series of the principal component scores associated with the Subregions indicates that the Great Lakes, Northeast, South, and Mid-Atlantic Subregions all exhibit a seasonality characterized by higher concentrations during the period from June through August. The Great Lakes and Mid-Atlantic Subregions tend to observe a stronger seasonal cycle, with maximum concentrations occurring during the last week in June and the first week in July, respectively. The strength of this seasonality is weakened for the Northeast and South Subregions and its timing is delayed, until the end of July and the first of August, respectively. The Southwest Subregion experiences a greatly diminished seasonality, with maximum concentrations delayed until the middle of August. The seasonality found in the Florida Subregion is unique in both its strength and timing, as the highest concentrations consistently occur during the months of April and May. The deseasonalized time series, autocorrelations, and spectral density estimates revealed that persistence is much more prevalent in the Florida (autocorrelation significant to a lag of 4 days), South (3 days), and Southwest (3 days) Subregions. Conversely, autocorrelations are only significant to a lag of one day in the Northeast and two days in the Great Lakes and Mid-Atlantic Subregions.

Annually, the highest concentrations generally occurred in 1988 when similar concentration extremes were exhibited across all subregions; however, the Southwest and Florida Subregions recorded equally high concentrations in other years. Trends analyses indicated a slight, though not statistically significant, decrease in mean concentrations for the Mid-Atlantic, Northeast, and Southwest Subregions and a slight increase over the Great Lakes, South, and Florida Subregions.

2.6 Applied Modeling Research Branch

The Applied Modeling Research Branch investigates and develops applied numerical simulation models of sources, transport, fate, and mitigation of air toxic pollutants in the near field. Databases are assembled and used for model development and research on flow characterization and dispersion modeling. Research is coordinated with other agencies and researchers.

2.6.1 Stagnation Diffusion Studies

Field measurements of diffusion in stagnation conditions with wind speeds near 0.5 m/s are being examined to determine the necessary elements for realistic modeling of stagnation diffusion (Briggs, 1992). Data were obtained in 1991 from the STAGMAP (Stagnation Model Analysis Program) experiment conducted in Medford, OR, in a valley-basin complex surrounded by high terrain. Worst cases of high ground concentration from low tracer release heights (7m) were usually extremely stable, with no turbulence above rooftop heights and in some cases transport speeds were only about 0.1 m/s, much slower than 10m height winds; indications are that diffusion in the interbuilding layer must be modeled with building wakes and drag force included. One worst case occurring during midday showed that even a cloud shadow can cause rapid stabilization during stagnation. Background concentrations of tracer released at noon dramatically increased a few hours after sunset, indicating that material carried out of the city by daytime upslope winds returned in the drainage winds caused by cooling of surrounding slopes. Furthermore, daytime mixing depths were suppressed to only 100 to 200m, probably because of over-valley subsidence induced by upslope flows. Upslope flows, drainage flows, and the subsidence or pooling associated with them are important elements to include in a stagnation pollution episode model. A method is being developed for modeling basin circulations using a highly simplified parameterization of complex terrain in terms of the area, total periphery, and mean slope associated with each contour.

As part of the STAGMAP program, several existing air quality models are being technically considered for inclusion in an evaluation exercise using the STAGMAP field measurements. The purpose of this exercise is to establish the utility of existing methods in modeling valley stagnation situations and to define the weaknesses of these models in order to help guide the new model development. Several categories are being considered, including the Lagrangian puff models, Eulerian grid models, Box-type models, and a standard Gaussian plume model for comparison. The evaluations will be performed in FY-1993.

2.6.2 AMS/EPA Regulatory Model Improvement Committee

To expedite the inclusion of state-of-the-art modeling concepts into the EPA regulatory models, the AMS Steering Committee and the EPA formed the AMS/EPA Regulatory Model Improvement Committee (AERMIC). A Division scientist serves on this committee. AERMIC has the charter to formulate and recommend changes in the scientific components of regulatory air models and to participate in the evaluation and implementation of these new methodologies. Initial efforts in FY-1992 focused on major improvements to ISCST2 (U.S. Environmental Protection Agency, 1992b) and its meteorological preprocessor. Improvements are expected in the areas of dispersion, plume rise, complex terrain, and the surface layer parameterizations. The committee designed algorithms for a meteorological preprocessor, which will provide estimates of surface heat flux, surface friction velocity, mixing heights, and the Monin-Obukhov lengths. The meteorological preprocessor, MPRM (Irwin *et al.*, 1988), will be used as the vehicle for the AERMIC algorithms, which will be coded and tested in FY-1993.

2.6.3 Complex Terrain Dispersion Modeling

The Complex Terrain Dispersion Model PLus algorithms for Unstable Situations (CTDMPLUS) and its screening version (CTSCREEN) are proposed as recommended regulatory models for pollutant sources in complex terrain. A full description of the CTDMPLUS system and its performance against a field study database was published in two journal articles (Perry, 1992; Paumier *et al.*, 1992). An effort was initiated to improve the terrain and meteorological preprocessors for the models. In particular, the terrain preprocessor was improved in the way that it fits the input contour data and in the way that it displays the terrain information for the user. The meteorological preprocessor was improved to include an additional method for computing surface heat flux and momentum flux. The existing energy budget method of Holtslag and van Ulden (1983) and Venkatram (1980) was augmented by a near surface profile method suggested by Irwin and Binkowski (1981). In addition, some problems with the calculation of daytime mixing heights during near neutral conditions were resolved. Evaluations of the improved terrain and meteorological preprocessors will be accomplished in FY-1993 and updated user's guides will be produced.

2.6.4 Lagrangian Model for Dispersion in Complex Terrain

As part of the ongoing efforts to develop and improve atmospheric dispersion models for evaluating air pollutant impacts, the Integrated Puff Diffusion Model (INPUFF) (Petersen and Lavdas, 1986) was expanded to improve the capabilities to provide pollutant-impact estimates at locations in or near complex topography. A version of CTDMPLUS (Perry *et al.*, 1989) algorithms that are specifically designed for use with the puff sampling routine were incorporated in INPUFF. These complex terrain algorithms designed for CALPUFF (CALifornia PUFF model) (Scire *et al.*, 1990), provide estimates of concentrations on terrain features that are not represented in gridded terrain information used to drive a wind field model, and that are nearly the same as CTDMPLUS for most situations during steady wind conditions.

The INPUFF model has considerable computation requirements that can hinder its application to long-term releases with frequently varying emissions and meteorology. An improvement to INPUFF, designed to greatly reduce the INPUFF execution time and thus improve its utility, involves the inclusion of a computationally fast integrated puff sampling approach. The puff sampling routine used in INPUFF was adapted from that used in CALPUFF. INPUFF with complex terrain is under evaluation.

2.7 Human Exposure Modeling Branch

The Human Exposure Modeling Branch conducts research to develop and improve human exposure predictive models focusing principally on urban environments where exposures are high. The research includes building wake and cavity models for characterization of gaseous and particulate concentrations from releases within and in the near vicinity of buildings; tracer studies to elucidate air parcel movement within the buildings; and microenvironmental simulation models for human exposure assessments within enclosed spaces in which specific human activities occur. The branch also develops and provides meteorological instrumentation and measurements support to the division field studies programs.

2.7.1 Modeling Human Exposures to Acid Aerosols

An intensive air pollution monitoring and analysis program, a five-year, five-city Metropolitan Aerosol Acidity Characterization Study (MAACS), was started to characterize and model human exposure to acid aerosols and other related pollutants. The first phase of MAACS is the Philadelphia Aerosol Acidity Characterization Study (PAACS). Exposure models will be used to ascertain the extent of human exposures to acid aerosols and provide support for the establishment of an aerosol acidity air quality standard based on human exposure rather than ambient concentrations.

Acid aerosols represent a class of secondary pollutants formed through both heterogeneous and homogeneous phase oxidation of such primary pollutants as sulfur dioxide, nitrogen oxides, and hydrocarbons. Slow reactivity rates, long-distance transport, and meteorological conditions create a wide variety of human exposure patterns. Indoor sources can contribute to exposure as well. Acid aerosols are neutralized by the reaction with gaseous ammonia, but under certain conditions coexist with ammonia.

An exposure experiment for aerosol strong acidity conducted in Uniontown, PA, found that 1) there was little to no spatial variation in outdoor H^+ concentrations within Uniontown; 2) there was significant diurnal variation in outdoor H^+; 3) personal H^+ exposure levels were generally higher than indoor concentrations and lower than outdoor concentrations with the differences being quite pronounced; 4) outdoor concentrations of H^+ were unable to account for interpersonal variability in personal H^+ exposures, and 5) time-weighted microenvironmental models predicted personal exposures for H^+ better than outdoor concentrations alone. The results will be incorporated into the sampling protocol for the Philadelphia study to provide information necessary to enhance the exposure model developed for Uniontown, PA, or develop a new model.

2.7.2 The Hazardous Air Pollutant Exposure Model (HAPEM) for Mobile Sources

The Hazardous Air Pollutant Exposure Model (HAPEM) provides estimates of human exposure to air pollution and characterizes the health risks associated with these exposures (Johnson et.al., 1992). The revised version, HAPEM-MS, was developed to estimate exposure to pollutants emitted by mobile sources. An enhanced version, HAPEM-MS2, includes additional exposure indices, increasing the accuracy of an exposure estimate.

HAPEM-MS2 uses detailed activity diary data from studies conducted in Cincinnati, OH, Denver, CO, and Washington, DC, to develop an activity pattern for distinct population groups, called cohorts. The activity pattern specifies the fraction of time spent by a cohort in over 7000 combinations of home or work location, microenvironment, time of the day or night, and calendar quarter. The ambient pollutant concentration is derived from fixed-site monitoring data specific to the district. The pollutant concentration in each microenvironment is assumed to be a linear function of the ambient concentration within the district. HAPEM-MS2 calculates both the annual average exposure of each cohort to the pollutant and the estimated annual cancer incidence associated with that exposure. Estimates are summed over all cohorts to provide exposure and cancer risk estimates for the entire study area. Additional changes will be considered during FY-1993.

2.7.3 Exposure to Alternative Fuels

A special modeling study was completed to assess the potential impact of methyl-cyclopentadienyl manganese tricarbary (MMT) as an additive to vehicle gasoline fuels. As a result of the working group's assessment report, an industry application for including MMT in the United States fuels was not accepted.

The development and preliminary evaluation of an air quality model for estimating human exposures in residential garages was completed. Pollutant concentrations from tailpipe and evaporative emissions are being examined. A field study was conducted in the garage of a residential home to examine the dispersion of automobile emissions. An inert tracer, sulfur hexafluoride, was released inside the garage and monitored throughout the house. Smoke releases were recorded using video cameras for imaging analysis of the dispersion characteristics in and around the garage. Also, pollutant concentrations from gasoline and methenol fuel tanks were measured in a series of experiments where a warm car was parked inside the closed garage. The potential effect of human exposure to hazardous pollutants from alternative fueled automobiles is part of a new major program that will include additional microenvironments.

2.7.4 Atmospheric Transport Component of the MultiMedia Model

The multimedia human exposure model, MMSOILS (MultiMedia SOILS), is a screening tool for the transport and fate of pollutants posing long-term human exposure and health risks. A study was conducted to evaluate the atmospheric transport component to verify specific algorithms, examine simplifying assumptions, and identify strengths and weaknesses of MMSOILS. The study included an intercomparison of MMSOILS with two other models, ISCLT (Industrial Source Complex-Long Term model) and PAL (Point, Area, Line model). The three models were applied to data from two operational hazardous waste facilities to illustrate model comparisons and to provide an approximate assessment of atmospheric dispersion for specific chemical species. Specific issues concerning complex terrain and deposition and settling velocities were also addressed. The results will be published in FY-1993.

2.7.5 Meteorological Instrumentation Upgrade

An effort is underway to upgrade the level of meteorological measurement capability and to improve field monitoring support, involving fast response sensors, sounding systems, open path monitors, basic meteorological platforms, data logging capabilities, radiation sensors, vertical temperature arrays, and calibration and audit equipment. Upgrades will allow greater emphasis on field studies incorporating meteorological monitoring; on efforts dealing with evaluating instrumentation; and on developing quality assurance and quality control for new sensor technology.

Recommendations include further developing and defining specific roles and responsibilities towards the support of meteorological measurement capabilities within the Agency. Standard operating procedures for meteorological monitoring and for internal Quality Control audits are needed.

2.8 Air Policy Support Branch

The Air Policy Support Branch supports activities of the EPA Office of Air Quality Planning and Standards (OAQPS). The Branch's general responsibilities include (1) evaluating, modifying, and improving atmospheric dispersion and related models to ensure adequacy, appropriateness, and consistency with established scientific principles and Agency policy; (2) preparing guidance on applying and evaluating models and simulation techniques that are used to assess, develop, or revise national, regional, state, and local air pollution control strategies for attainment and maintenance of National Ambient Air Quality Standards (NAAQS); and (3) providing meteorological assistance and consultation to support the OAQPS in developing and enforcing Federal regulations and standards and assisting the EPA Regional Offices.

2.8.1 Modeling Studies

The Regional Oxidant Model (ROM) was applied to examine two strategic issues of importance to the Ozone Transport Commission: 1) "What are the estimated impacts on ozone in the Northeast of applying more stringent emission controls in States adjacent to the Transport Region?"; and 2) "What are the estimated impacts on ozone in the Northeast of adopting the California Low Emissions Vehicle Program in the Transport Region?" Six emission scenarios were designed and simulated to address these issues. The results were reported to the Commission members in June 1992 and are being used by the commissioners and governors to formulate regional control policies for attainment of the ozone National Ambient Air Quality Standards (NAAQS) in the Northeast.

ROM was applied in support of the Lake Michigan Ozone Study (LMOS). This work included base case applications for an 8-day episode in July 1991. Two sets of simulations were performed. In one, the meteorological inputs and the meteorologically sensitive emissions (i.e., biogenic and mobile source emissions) were derived from routine National Weather Service meteorological measurements. In the other, the meteorological inputs were obtained from a prognostic meteorological model. The ROM results are being used to provide initial and boundary conditions for the application and evaluation of a newly developed urban scale photochemical model (UAM V) by an LMOS contractor. The results will also be used for an operational evaluation of ROM and a comparison of performance between the two types of meteorological inputs.

Applications of ROM were performed to assess the sensitivity of regional ozone levels to reductions in man-made emissions of the primary precursor species, volatile organic compounds (VOC) and nitrogen oxides (NOx). This work included simulations for a matrix of 12 scenarios with different combinations of emission reductions in VOC and NOx (e.g., 25 percent reduction in VOC emissions and 50 percent reductions in NOx). The analysis is designed to provide decision makers with information to assess the adequacy of existing control requirements and to formulate new policies on controlling either or both of these ozone precursors. Briefings on the implications of the results were given to OAQPS.

A multiyear effort has begun to use ROM to provide ozone and precursor concentration estimates to State air pollution control agencies. These data will be used by States in setting boundary conditions for urban scale modeling to be performed as part of the development of ozone State Implementation Plans (SIPs). This work includes ROM application scenarios and emission projections for future years when areas are to be in ozone NAAQS attainment. ROM simulations provide the only credible means of estimating future changes in regional and inter-urban ozone and the effectiveness of SIP strategies. A protocol describing how ROM will be used in the SIP process was prepared and distributed to State agencies (Possiel *et al.*, 1992). Thus, most of the effort focused on developing base-case regional-emission inventories for simulating base-year conditions. ROM simulations will begin in FY-1993.

ROM was used as part of a screening analysis for the Department of the Interior Minerals Management Service (MMS) to estimate the impacts of off-shore oil and gas-production emissions in the Gulf of Mexico on ozone levels in areas of Texas and Louisiana. Three emission scenarios were simulated using meteorological data for two ozone episodes. In addition to a base-case scenario, there were two bounding scenarios: one with off-shore emissions doubled from the base case and one with off-shore emissions removed. The results will become a key part of an environmental impact assessment required of the MMS.

A mainframe system was developed to produce statistics and graphics for operational evaluations of ROM. The Regional Evaluation Support System (RESS) was designed to calculate and provide analysts with easy access to model performance information to define and compare the performance of ROM against ambient databases. Accuracy, bias, and gross error are among the statistics generated by the system.

A PC system to produce and display time animations of ROM predictions was completed and a user's guide delivered. This system was used to visualize the formation, decay, and transport of ROM-predicted ozone concentrations across the eastern United States. Presentation of these animations was used to understand the complex processes and policy implication of long-range ozone transport. In addition, the ozone animation was shown nationwide by the Cable News Network.

2.8.2 Modeling Guidance

2.8.2.1 Revisions to the Guideline on Air Quality Models

The Fifth Conference on Air Quality Modeling, held March 19-20, 1991, in Washington, DC, served as the public hearing for the proposed revisions, Supplement B, to the Guideline on Air Quality Models (Revised) (U.S. Environmental Protection Agency, 1987). Most comments addressed three issues: (1) instrumentation for and evaluation of the new on-site stability determination scheme, (2) on-site instrumentation and data requirements for the CTDMPLUS model, and (3) concerns about the ISC model, especially the area source algorithm. A summary document covering all the comments and responses was prepared for review by the EPA regulatory work group. Although a few of the proposed revisions are being modified in response to the public comments, virtually all of the proposals are proceeding to final rulemaking. Supplement B is at the Office of Manpower and Budget (OMB) awaiting approval. Following OMB approval, Supplement B will be published and will become part of the Guideline on Air Quality Modeling (Revised).

2.8.2.2 Support Center for Regulatory Air Models

The Support Center for Regulatory Air Models Bulletin Board System (SCRAM BBS), one of several electronic bulletin board systems that comprise the OAQPS Technology Transfer Network (TTN), was created to foster technology transfer among all users of regulatory air quality models. The SCRAM BBS is a mechanism for providing technical support for air modeling activities. Users experiencing problems with regulatory models can leave messages on the BBS or call designated telephone numbers to obtain assistance.

SCRAM BBS publishes *SCRAM NEWS*, which provides articles on new features and models added to the BBS, tips on using models, and discussions of issues related to modeling guidance. Division meteorologists contributed articles and announcements relating to models and to model revisions that are on the SCRAM BBS.

2.8.2.3 Model Clearinghouse

The FY-1992 activities for the Model Clearinghouse included the following:

1. Responding to EPA Regional Office requests to review nonguideline models proposed for use.

2. Reviewing draft and formally submitted *Federal Register* actions.

3. Documenting Clearinghouse decisions and discussions.

4. Summarizing Clearinghouse activities at various meetings.

5. Issuing an internal summary report of FY-1992 activities.

6. Entering FY-1992 records into a computerized database.

7. Providing direct modem access for the Regional Offices to the computerized database.

8. Disseminating Clearinghouse memoranda and reports to the public through a bulletin board system.

There were 143 modeling referrals to the Model Clearinghouse from the Regional Offices during FY-1992. These included 14 regulatory modeling problems, each of which required a written response, 118 referrals, each of which required an oral response, and 11 referrals, each of which only required discussion without Clearinghouse recommendations being requested. Requests for assistance, either written or by telephone, came from the 10 Regional Offices, indicating that there is an awareness of and a desire for Clearinghouse support throughout the Agency.

The Clearinghouse conducted or participated in coordination and information exchange activities with the Regional Offices. In October 1991, a Clearinghouse report was prepared and distributed to the Regional Offices; the report informed Clearinghouse users about issues and responses that occurred during FY-1991.

The Clearinghouse continued its policies of sending copies of written responses and incoming requests to the Regional Offices, to keep them informed of decisions affecting their modeling activities; attaching to each response an updated list of all Clearinghouse memoranda issued during the fiscal year to help the Regional Offices maintain complete records; and, seeking advance opinions from the Regional Offices on particularly sensitive issues with national implications. One sensitive case arose involving the use of the Huber-Snyder directional downwash in the Industrial Source Complex model. The proposed Clearinghouse response was circulated to all Regional Offices for comment before the response was finalized.

The Model ClearingHouse Information Storage and Retrieval System (MCHISRS), a PC software system for storing key information on each

Clearinghouse referral, allows the user to search the MCHISRS database electronically to find records with like characteristics and to consider the consistency aspects of new referrals. There are approximately 1020 referrals in the database. The Regional Offices are able to directly access MCHISRS to make their own national consistency determinations.

Agency memoranda and Clearinghouse reports are available to the public through the SCRAM BBS. The bulletin board includes three types of information: (1) selected historical memoranda on generic and recurring issues generated by the Clearinghouse from FY-1981 through FY-1992; (2) FY-1989 through FY-1992 Clearinghouse memoranda; and (3) FY-1989 through FY-1991 Model Clearinghouse reports.

2.8.2.4 TSCREEN Model

Efforts continued on improving the air dispersion screening model, TSCREEN (U.S. Environmental Protection Agency, 1990), for use in Superfund toxic and hazardous pollutant impact activities and resulted in a revised and re-coded version. TSCREEN, an IBM PC computer program, provides simplified screening methods for determining maximum short-term impact from various well-defined release scenarios that might involve toxic air pollutants, by use of interactive menus and data entry screens. Revisions include an additional scenario (air strippers) for Superfund sites, ability to estimate ambient air quality impact on elevated receptors and complex terrain, and more extensive on-line help. Re-coding includes the development of new interactive menus and data screens. TSCREEN is based on a logical problem solving approach outlined in a workbook of air toxic screening techniques. The extensive help, text editing and graphical display capabilities guide the user throughout the model execution. Model features and uses were summarized in Touma and Stroupe (1992) and Stroupe and Touma (1992).

2.8.2.5 Guidance on Dense Gas Models for Air Toxic Releases

Refined air toxic models are increasingly being used for environmental assessment studies for possible control technologies. A document (U.S. Environmental Protection Agency, 1991b) provides guidance for applying refined dispersion models to atmospheric releases and to demonstrate for the non-expert user the application of dense gas models. Dense gas models are more complex due to the nature of the releases being simulated (e.g., jets, aerosols, supercooled liquids, etc.). Efforts initiated in 1991 continued to identify the predominant release scenarios for hazardous chemicals at industrial facilities. These scenarios will be used for developing methods, technical procedures and guidance for input data, and the proper application of dense gas models. All dense gas models being reviewed are in the public domain and include DEGADIS, SLAB, ADAM, HGSYSTEMS and ALOHA.

2.8.3 Additional Support Activities

2.8.3.1 Regional and State Modelers Workshop

The annual meeting of EPA Regional and State air pollution modelers was held at the offices of EPA Region X in San Francisco, CA, April 20-24, 1992. Most of the workshop was devoted to status reviews of activities at each Region; long-range impact (air quality; visibility and wet and dry deposition at National Parks and other Class I areas); photochemical oxidant modeling in compliance with CAAA; and activities to revise and upgrade the Industrial Source Complex (ISC2) model. Presentations were given on the status of work to provide a numerically accurate area-source algorithm and an improved particle deposition algorithm for use in the ISC2 model. A summary was presented of the status of work to fabricate a plume dispersion model based on boundary-layer parameterizations. There is strong interest regarding changes or modifications of ISC as it is most often the model used in regulatory assessments involving Prevention of Significant Deterioration and New Source Review. The workshop also reviewed issues and concerns raised by the Regional and State modelers.

2.8.3.2 AMS/EPA Regulatory Model Improvement Committee

The AMS Steering Committee and EPA established AERMIC to assist in the introduction of state-of-the-art modeling concepts into regulatory dispersion models. AERMIC formulates and recommends changes in the scientific components of regulatory air models and participates in the evaluation and implementation of these new methodologies. The initial focus is on the Industrial Source Complex (ISC) model because of its wide use in regulatory applications. Improvements are expected in the areas of dispersion, plume rise, complex terrain, and the surface layer parameterizations.

The committee designed algorithms for a meteorological preprocessor to provide estimates of surface heat flux, surface friction velocity, mixing heights, and the Monin-Obukhov lengths. A two-day workshop was conducted March 18-19, 1992, to review the committee activities. Presentations were made by representatives of the Danish National Environmental Research Institute, Roskilde, Denmark, who reviewed the development of the Danish version of the ISC model. Presentations were also given by a representative of EPRI who plans to develop improved characterizations of plume rise and downwash in the vicinity of buildings. The design of the meteorological processor was completed and coding begun. The design of the dispersion model is underway.

2.8.3.3 Interagency Work Group on Air Quality Models

The EPA has not recommended a refined dispersion model for regulatory application to assess the air quality impacts of a source on distant receptors (>50 km), especially in Federal Class I areas. This is also true of models for multiple sources on a regional- or long-range transport scale. Any model proposed for such an application must be approved on a case-by-case basis accompanied by extensive technical and performance justification.

In October 1991, the U.S. Environmental Protection Agency, National Park Service, Fish and Wildlife Service, and Forest Service signed a Memorandum of Agreement to foster cooperation in the development, evaluation, and application of air quality dispersion models for such situations and to mutually assist in rulemaking to adopt acceptable models according to the EPA modeling guideline. The Agreement established an Interagency Work Group comprised of technical staff representing OAQPS, ORD, and Regional Offices. The Work Group selected the National Park Service representative as its chairman. The Work Group met several times (November, December, February, June and September), to develop a work plan with an objective accomplishment schedule, to review status of work; and to draft interim recommendations for modeling long-range transport for Class I impacts.

The work plan (Irwin *et al.*, 1992) recommends a phased approach. The first phase would provide by December 1992 a recommended modeling approach involving the use of the MESOPUFF II Lagrangian puff dispersion model. Even though this model has some known deficiencies, it could be used with reliance on expert judgement while more suitable modeling methods are developed and tested. The second phase would provide by December 1993 a more comprehensive Lagrangian puff modeling system for general use. The third phase, which as yet remains unfunded, would investigate the feasibility of developing a combined modeling system involving a Lagrangian puff-in-grid modeling system with an Eulerian grid modeling system to properly handle near impacts coupled with chemical transformation byproducts resulting from long-range transport.

2.8.3.4 Belarus Environment Mission

At the invitation of the Belarus State Committee of Ecology, an air quality management expert team was organized by the World Bank to review existing laws and practices relating to air quality management in Belarus and the Former Soviet Union (FSU). The team met in Minsk, Belarus, from June 28 to July 12, 1992. One of the findings is that the FSU environmental laws do not effectively enforce compliance or mitigate over zealous enforcement. Another difference is that the FSU system allows a new source to emit up to the point that the FSU 20-minute air pollutant standard is not exceeded. Unlike the United States system that forces more controls on new sources, the FSU system requires placement of controls on existing sources, making room for future development. A report is being drafted summarizing the existing system of air quality management in the FSU, including recommendations for strengthening and improving the existing system to make it more suitable and effective in regulating air quality and adapting to a free market economic system.

2.8.3.5 European Community of Regulatory Assessment Dispersion Models

A Workshop on Objectives for Next Generation of Practical Short-Range Atmospheric Dispersion Models was conducted at Riso, Denmark. There were 114 participants from 22 countries at this 3-day workshop. This was the first of three planned workshops aimed at establishing a common European basis for assessing air pollution impacts within the European Community (EC). It was recommended at the workshop that representatives of the Riso National Laboratory and the Agency form a work group to conduct a prototype model evaluation using the EPA Industrial Source Complex model and the Danish Air Quality Dispersion model, and to provide the results for discussion at the second workshop.

2.8.3.6 Regulatory Work Groups

Meteorologists participate in various regulatory work groups and task forces. As experts on models, databases, and interpretation of model results, they generate sound technical positions and options on key issues facing policymakers. Division meteorologists served on the Work Group to Revise the Modeling Guideline; the Technology Transfer Work Group; the Visibility SIP Work Group; the On-Site Meteorological Data Work Group (Chairman); the Valley Stagnation Work Group; the Stack Height Remand Task Force; the NO_2 PSD Increment Work Group; the Open Burning/Open Detonation Technical Steering Committee; the Prescribed Burning Work Group; the Interagency Work Group on Air Quality Models; the AMS/EPA Regulatory Model Improvement Committee; the Work Group on the Lead SIP Requirements Pursuant to the New Lead NAAQS; the Emission Trading Policy Update Task Force; and the Ozone Transport Commission Modeling Committee.

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APPENDIX A: ACRONYMS

Acid-MODES	Acid Models Operational and Diagnostic Evaluation Study
ACM	Asymmetrical Convective Model
ADOM	Acid Deposition and Oxidant Model
AERMIC	AMS/EPA Regulatory Model Improvement Committee
AES	Atmospheric Environment Service of Canada
AIRS	Aerometric Information and Retrieval System
AMS	American Meteorological Society
APIOS	Acid Precipitation In Ontario Study
AQRV	Air Quality Related Values
ATTD	Atmospheric Turbulence and Diffusion Division
AUSPEX	Atmospheric Utility Signatures, Predictions and EXperiments
BASC	Board on Atmospheric Sciences and Climate (NAS/NRC)
BATANDS	Baltimore Air Toxics and Nitrogen Deposition Study
BEIS	Biogenic Emissions Inventory System
BOREAS	BOReal Ecosystem-Atmospheric modeling System
CAA	Clean Air Act of 1970
CAAA	Clean Air Act Amendments of 1990
CAL-PUFF	CALifornia PUFF model
CAL-RAMS	CALifornia Regional Atmospheric Modeling System
CAMRAQ	Consortium for Advanced Modeling of Regional Air Quality
CAPMoN	Canadian Air and Precipitation Monitoring Network
CAPTEX	Cross-APpalachian Tracer EXperiment
CARB	California Air Resources Board
CARB/MAC	CARB Modeling Advisory Committee
CASTNET	Clean Air Status and Trends NETwork
CBED	Chesapeake Bay Evaluation and Deposition Committee
CBL	Convective Boundary Layer
COMPLEXI	A complex terrain dispersion model.
COMSTM	COMprehensive Sulfur Tracking Model
CONDORS	CONvective Diffusion Observed with Remote Sensors
CPU	Central Processing Unit
CT	Combustion Turbine power plant
CTDMPLUS	Complex Terrain Dispersion Model PLus algorithms for Unstable Situations
CTSCREEN	A screening version of CTDMPLUS
CURTAIN	Vertical up and down sawtooth aircraft transect pattern.
DOE	Department of Energy
EC	European Community
EMAP	Environmental Monitoring and Assessment Program
EMBSC	Eulerian Modeling Bilateral Steering Committee
EMEFS	Eulerian Model Evaluation Field Study
EMEFS/DMT	EMEFS Diagnostic Measurement Team
EMEFS/EIT	EMEFS Emissions Inventory Team
EMEFS/MET	EMEFS Model Evaluation Team
EMEFS/OMT	EMEFS Operations Measurement Team
EMEFS/PMG	EMEFS Program Management Group

EMEP	European Monitoring and Evaluation Program
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EUROTRAC	EUROpean experiment on the TRAnsport and transformation of trace atmospheric Constituents
FCCSET	Federal Coordinating Council for Science, Engineering, and Technology
FCG	Florida Electric Power Coordinating Group
FDDA	Four Dimensional Data Assimilation
FIFE	First ISLSCP Field Experiment
FSU	Former Soviet Union
GCCP	Global Climate Change Program
GEIA	Global Emissions Inventory Activity
GIS	Geographic Information System
HAPEM	Hazardous Air Pollutant Exposure Model
HAPEM-MS	Hazardous Air Pollutant Exposure Model-Mobile Source
HFID	Fast response flame ionization detector
HPCC	High Performance Computing and Communications Program
HRADM	High resolution RADM
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research
IGAC	International Global Atmospheric Chemistry
IMPROVE	Interagency Monitoring of PROtected Visual Environments
INPUFF	INtegrated PUFF diffusion model
ISC-2	Industrial Source Complex model - Version 2
ISCST	Industrial Source Complex Short-Term model
ITM	International Technical Meeting
IWAQM	Interagency Work Group on Air Quality Models
LAI	Leaf Area Index
LCM	Linear Chemistry Model
LMOS	Lake Michigan Ozone Study
MAACS	Metropolitan Aerosol Acidity Characterization Study
MAD	Modal Aerosol Dynamics model
MARS	Model for an Aerosol Reacting System
MCHISRS	Model ClearingHouse Information Storage and Retrieval System
MESOPUFF	MESOscale Lagrangian PUFF dispersion model
MM4	Mesoscale Meteorological Model - Version 4
MMS	Department of Interior Minerals Management Service
MMSOILS	MultiMedia SOILS
MMT	Methyl-cyclopentadienyl manganese tricarbary
Models-3	Third generation air quality modeling system
MOHAVE	Measurement Of Haze And Visual Effects
MOU	Memorandum Of Understanding
MPP	Mohave Power Plant
MSC-W	Modeling Synthesizing Center - West (Norwegian Meteorological Institute
NAAQS	National Ambient Air Quality Standards
NADP	National Acid Deposition Program
NAPAP	National Acid Precipitation Assessment Program
NASA	National Aeronautics and Space Administration
NATO/CCMS	North Atlantic Treaty Organization Committee on Challenges of Modern Society

NCAR	National Center for Atmospheric Research
NCSC	North Carolina Supercomputing Center
NDDN	National Dry Deposition Network
NDM	Non-Depleting Model
NEM	NAAQS Exposure Model
NESCAUM	NorthEast States for Coordinated Air Use Management
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NOM	NOAA Oxidant Model (Aeronomy Laboratory)
NPS	National Park Service
NRC	National Research Council
NWS	National Weather Service
OAQPS	Office of Air Quality Planning and Standards (EPA)
OEN	Operational Evaluation Network
OMB	Office of Management and Budget
OME	Ontario Ministry of the Environment
ORD	Office of Research and Development (EPA)
OSTP	Office of Science and Technology Policy
OTC	Ozone Transport Commission
PAACS	Philadelphia Aerosol Acidity Characterization Study
PAL	Point Area Line model
PBL	Planetary Boundary Layer
PC	Personal Computer
PEM	Personal Exposure Monitoring
PM	Particulate Matter
PSD	Prevention of Significant Deterioration
RADM	Regional Acid Deposition Model
RADM/EM	RADM Engineering Model
RELMAP	REgional Lagrangian Model for Air Pollution
REMOVE	REmote Monitoring Of Vehicle Exhaust
RESS	Regional Evaluation Support Service
RISC	Reduced Instruction Set Computing
ROM	Regional Oxidant Model
ROMNET	Regional Ozone Modeling for NorthEast Transport
RPCA	Rotated Principal Component Analysis
RPM	Regional Particulate Model
RTDM	Rough Terrain Dispersion Model
SAIMM	Systems Applications International Mesoscale Model
SARMAP	SJVAQS/AUSPEX Regional Modeling Adaptation Project
SB	Steam Boiler power plant
SCAQS	Southern California Air Quality Study
SCION	Southeast Consortium for International Oxidant Networks
SCRAM BBS	Support Center for Regulatory Air quality Models Bulletin Board System
SGCP	Southern Global Change Program (U.S. Forest Service)
SHAPE	Simulation of Human Activity and Pollutant Exposure
SJVAQS	San Joaquin Valley Air Quality Study
SIP	State Implementation Plan
SLMA	Southern Lake Michigan Area
SORP-EE	Southern Oxidant Research Program-Emissions and Effects
SOS	Southern Oxidant Study
SOS/SERON	Southern Oxidants Study/SouthEast Regional Oxidant Network

SOS/T	State Of Science and Technology reports (NAPAP)
STAPPA	State and Territorial Air Pollution Program Administrators
SST	Sea Surface Temperature
STAGMAP	STAGnation Model Analysis Program
STM	Sulfate Tracking Model
TAMEX	Taiwan Area Meteorological EXperiment
TEMPEST	Transient Energy Momentum and Pressure Equations Solutions in Three-dimensions
TRIS	Toxic chemical Release Inventory System
TSCREEN	Air dispersion screening model
TSEM	Tagged Species Engineering Model
TTN	Technology Transfer Network (OAQPS)
UAM	Urban Airshed Model
UAMMET	Urban Airshed Model METeorological module
US/USSR	United States/Union of Soviet Socialist Republics
USWRP	United States Weather Research Program
UV-DIAL	UltraViolet DIfferential Absorption Lidar
VALLEY	A complex terrain dispersion model
VOC	Volatile Organic Compounds
WESTAR	WEstern STates Air Resources council
ZIPPER	Zigzag aircraft transect pattern

APPENDIX B: PUBLICATIONS

Allwine, K.J., B.K. Lamb, and R.E. Eskridge. Wintertime dispersion in a mountainous basin at Roanoke, Virginia: Tracer study. *Journal of Applied Meteorology* 31:1295-1311 (1992).

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APPENDIX C: PRESENTATIONS

Asakura, K., and Y. Ichikawa (Central Research Institute of Electric Power Industry, Tokyo, Japan). Research on atmospheric diffusion at the CRIEPI. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, June 8, 1992.

Bossert, J. (Los Alamos National Laboratory, Los Alamos, NM). Numerical modeling of atmospheric flow in complex terrain. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, December 12, 1991.

Braverman, T.N. The EPA expectations for regional and project-level air quality analysis. Presentation at the 62nd Annual Meeting of the Institute of Transportation Engineers, Washington, DC, August 11, 1992.

Briggs, G.A. Requirements for modeling stagnation pollution episodes in complex terrain. Status Briefing on STAGMAP to the EPA Office of Air Quality Planning and Standards, Durham, NC, November 3, 1992.

Byun, D.W. Interpretation of model-observation biases caused by design artifacts: vertical and horizontal resolutions in RADM. Presentation at the Model Evaluation Team/External Review Panel Meeting, Monterey Bay, CA, March 31, 1992.

Byun, D.W. Influence of the PBL structure on the photochemical ozone prediction: Preliminary study with RADM. Presentation at the Third US/FRG/CEC Workshop on the Photochemical Ozone Problem and Its Control, Lindau, Germany, July 1, 1992.

Castro, I.P. (University of Surrey, Guildford, U.K.). Vortex shedding from rings and things. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, July 30, 1992.

Ching, J.K.S. Status and plans for state-of-science air quality simulation modeling. Presentation at the Fourth National Environmental Information Conference, Philadelphia, PA, December 3, 1991.

Ching, J.K.S., O.R. Bullock, Jr., J.E. Pleim, and K.L. Schere. Proposed meteorological modeling for the next generation air quality modeling. Presentation at the CAMRAQ Meeting, Research Triangle Park, NC, April 15, 1992.

Clark, T.L. Modeling the air transport and fate of toxic pollutants. Presentation at the EPA/EPRI/UARG Risk Assessment Workshop, Durham, NC, April 28, 1992.

Clark, T.L. Atmospheric deposition modeling. Presentation to the Great Lakes Advisory Committee Meeting, Washington, DC, May 18, 1992.

Clark, T.L. Modeling the atmospheric deposition of toxic pollutants to the Great Waters. Presentation at the Air Quality Management Training Workshop, Charlotte, NC, July 17, 1992.

Clark, T.L. The role of atmospheric modeling in estimating toxic pollutant deposition to Lake Michigan. Presentation at the Lake Michigan/Superior Loadings Study Workshop, Research Triangle Park, NC, September 1, 1992.

Dennis, R.L. EPA's third generation modeling system (Models-3): An overview. Presentation at the A&WMA Specialty Conference on Tropospheric Ozone and the Environment, Atlanta, GA, November 4, 1991.

Dennis, R.L. EPA's High Performance Computing and Communication (HPCC) program and the third generation modeling system program. Presentation at the University of Kentucky Computer Science Center, Lexington, KY, November 20, 1991.

Dennis, R.L. Model evaluation: Illustrations from the evaluation of the advanced acidic deposition models. Presentation at the Canadian Institute for Research in Atmospheric Chemistry (CIRAC) and the Ontario Section of the A&WMA Conference on Air Quality Modeling, Toronto, Ontario, Canada, January 27, 1992.

Dennis, R.L. Comparison of RADM evaluation results against the Canadian Twin Otter Data for the first EMEFS intensive. Presentation at the Atmospheric Environment Service Seminar Series, Downsview, Ontario, Canada, January 30, 1992.

Dennis, R.L. An overview of EPA's third generation modeling system (Models-3). Presentation at the EOHSI Symposium on Ozone Air Quality and Health Effects, Rutgers University, Piscataway, NJ, May 27, 1992.

Dennis, R.L. Comparison of RADM predictions of oxides of nitrogen using aircraft measurements. Seminar presented at the Norwegian Meteorological Institute, Oslo, Norway, June 12, 1992.

Dennis, R.L. Evaluation and diagnosis of the Regional Acid Deposition Model's predictions of oxidants and oxides of nitrogen using aircraft measurements. Presentation at the Third US/FRG/CEC Workshop on the Photochemical Ozone Problem and Its Control, Lindau, Germany, June 30-July 3, 1992.

Dennis, R.L. Linking urban and regional models. Presentation at NAPAP Workshop on the Urban Perspective of Acid Rain, Raleigh, NC, September 23, 1992.

Godowitch, J.M. Overview of the Urban Airshed Model and coastal urban experimental studies. Presentation at NATO/CCMS Workshop on Transport and Dispersion in Urban Coastal Areas, Athens, Greece, February 6, 1992.

Godowitch, J.M. Features of urban boundary layer structure from experimental profile measurements. Presentation at the International Conference on Urban Thermal Environment, Tohwa University, Fukuoka, Japan, September 8, 1992.

Hass, H. (University of Cologne, Cologne, Germany). Using the EURAD (European RADM) System: Experiences, Evaluations and Developments. Seminar presented at the Atmospheric Sciences Modeling Division, Research Triangle Park, NC, April 15, 1992.

Lee, R.F. Description of the new ISC2 dispersion model. Video teleconference presentation to the Region IV State and Local Modelers Workshop, Atlanta, GA, November 13, 1991.

Lee, R.F. Demonstration of the new ISC2 dispersion model, and discussion of selected applications. Presentation at the Sixteenth US/Russian Working Group 02.01-10 Meeting on Air Pollution Modeling, Instrumentation and Measurement Methodology, St. Petersburg, Russia, July 13, 1992.

Lu, J. (North Carolina State University, Raleigh, NC). Physical simulation of urban heat island induced circulation under stratified environment—Part I: Mean temperature field. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, November 7, 1991.

Lu, J. (North Carolina State University, Raleigh, NC). Physical simulation of urban heat island induced circulation under stratified environment—Parts II: Velocity field; Part III: Some turbulence characteristics. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, April 24, 1992.

Novak, J.H. EPA's high performance computing and communications program. Presentation to the High Performance Computing and Communications Information Technology Subcommittee of the Federal Coordinating Council for Science, Engineering, & Technology (FCCSET), Washington, D.C. April 7, 1992.

Novak, J.H. Prototype air quality assessment project. Presentation at the North Carolina Department of Environment, Health, and Natural Resources, Raleigh, NC, March 9, 1992.

Perry, S.G. Research activities of the Atmospheric Sciences Modeling Division. Presentation at the Federal, State, and Local Air Pollution Modelers Annual Regional Meteorologists Workshop, San Francisco, CA, April 21, 1992.

Perry, S.G. Applied research in Atmospheric Sciences Modeling Division pertinent to regulatory modeling. Presentation by satellite to the EPA Regional Offices, State and Local Air Pollution Agencies, and Air Pollution Training Institute's Air Pollution Dispersion Models Course, North Carolina State University, Raleigh, NC, May 1, 1992.

Pierce, T.E. EPA's Biogenic Emissions Inventory System. Presentation at the Southern Oxidant Study Workshop on Biogenic Emissions, Raleigh, NC, October 23, 1991.

Pierce, T.E. Emission data needs for regional and urban scale models. Presentation at the Southern Oxidant Study Annual Workshop, Atlanta, GA, November 14, 1991.

Pierce, T.E. Proposal for computing biogenic emissions in the Atlanta domain. Presentation at the Southern Oxidant Study Workshop on the Atlanta Emissions Inventory, Atlanta, GA, January 24, 1992.

Pierce, T.E. Sensitivity of biogenic emissions to uncertainties associated with corn. Briefing to the EPA Office of Air Quality Planning and Standards, Durham, NC, February 5, 1992.

Pierce, T.E. Availability of emissions data for regional models. Presentation at the Southern Oxidant Study Workshop on Regional Modeling, Research Triangle Park, NC, February 27, 1992.

Pierce, T.E. Procedures for estimating biogenic hydrocarbon emissions. Presentation at the International Global Atmospheric Chemistry (IGAC)—Global Emissions Inventory Activity (GEIA) Workshop on Non-Methane Hydrocarbon Emissions, Boulder, CO, April 10, 1992.

Pierce, T.E. Uncertainties in biogenic emission inventories. Presentation at the Third US/FRG/CEC Workshop on the Photochemical Ozone Problem and Its Control, Lindau, Germany, June 30, 1992.

Pitchford, M.L., and W.C. Malm. Development and application of a standard visual index. Presentation at the Conference on Visibility and Fine Particles, Vienna, Austria, September 15, 1992.

Pitchford, M.L., and P.H. McMurry. Relationship between measured water vapor growth and chemistry of atmospheric aerosol for Grand Canyon, Arizona, in winter 1990. Presentation at the Conference on Visibility and Fine Particles, Vienna, Austria, September 16, 1992.

Pleim, J.E., and J.K.S. Ching. Analysis of horizontal and vertical structure of regional scale atmospheric chemistry model simulations compared to aircraft measurements. Presentation at the Spring Meeting of the American Geophysical Union, Montreal, Quebec, Canada, May 15, 1992.

Pleim, J.E., and J.K.S. Ching. Comparison and analysis of aircraft measurements and mesoscale atmospheric chemistry model simulations of tropospheric ozone. Presentation at the 1992 Quadrennial Ozone Symposium, Charlottesville, VA, June 5, 1992.

Poole-Kober, E.M. The mission of the Atmospheric Sciences Modeling Division Library. Invited presentation to a class seminar on special libraries and information management. School of Library and Information Sciences, University of North Carolina at Chapel Hill, Chapel Hill, NC, October 15, 1992.

Poreh, M. (Professor, Israel Institute of Technology, Haifa, Israel). Fluctuations of line-integrated concentrations across plumes diffusing in turbulent flows. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, October 9, 1991.

Porter-Locklear, F. (Pembroke State University, Pembroke, NC). Numerical studies of propagation of singularities in semilinear hyperbolic systems. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, July 20, 1992.

Possiel, N.C. Compiling base case Clean Air Act NO_x emissions: Approach and assumptions. Chesapeake Bay Evaluation and Deposition Committee Meeting, May 21, 1992.

Possiel, N.C. The structure of ROM and its use for regulatory assessments. Presentation at the Environment Canada, Atmospheric Environment Services, Southern Atlantic Region Oxidants Modeling Workshop, Halifax, Nova Scotia, May 15, 1992.

Possiel, N.C. Examples of recent air transport studies. Presentation at the Southern Appalachian Workgroup Meeting, Atlanta, GA, June 11, 1992.

Possiel, N.C. Results of ROM applications to assess the benefits of expanding the transport region. Presentation at the Ozone Transport Commission Meeting, Lake Placid, NY, June 14, 1992.

Possiel, N.C. Results of ROM applications to assess the benefits of adopting a low emissions vehicle program in the Northeast. Presentation at the Ozone Transport Commission Meeting, Lake Placid, NY, June 15, 1992.

Possiel, N.C. Impacts of stringent motor vehicle controls on Northeast United States ozone levels. Presentation at the Third US/FRG/CEC Workshop on Photochemical Ozone Problem and Its Control, Lindau, Germany, June 30, 1992.

Possiel, N.C. ROMNET II—Description and perspectives. Presentation at the Electric Power Research Institute, Photochemical Modeling Workshop, Cambridge, MA, August 19, 1992.

Roselle, S.J. Estimates of ozone response to various combinations of NO_x and VOC emission reductions in the eastern United States. Presentation at the 1992 Quadrennial Ozone Symposium, Charlottesville, VA, June 6, 1992.

Rottman, J.W., and C. Chen. (NASA/Goddard Space Flight Center, Greenbelt, MD). Upstream effects in finite depth stratified shear flows over topography. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, July 13, 1992.

Schere, K.L. The 1992 ROM program support for the southern oxidants study. Presentation at the First Annual Southern Oxidants Study Workshop, Atlanta, GA, November 12, 1991.

Schere, K.L. Regional ozone modeling research at EPA—Current and future directions. Briefing to Director of the EPA Office of Air Quality Planning and Standards, Durham, NC, April 10, 1992.

Schere, K.L. Meteorological modeling for the EPA oxidant research program. Presentation to the CAMRAQ Steering Committee, Research Triangle Park, NC, April 15, 1992.

Schere, K.L. Intercomparison of the USEPA Regional Oxidant Model (ROM) and the Regional Acid Deposition Model (RADM). Presentation at the Third US/FRG/CEC Workshop on the Photochemical Ozone Problem and Its Control, Lindau, Germany, July 2, 1992.

Schere, K.L. Emerging assessment methods. Presentation at the EPRI Ozone Modeling Workshop, Cambridge, MA, August 19, 1992.

Schere, K.L. Modeling science—Policy considerations. Presentation to the EPA Regulations and Guidance Work Group on the 185B Project, Research Triangle Park, NC, September 17, 1992.

Schiermeier, F.A. Implications of the Clean Air Act Amendments of 1990 on Atmospheric Sciences. Presentation at the Meeting of Subcommittee on Atmospheric Research, Committee on Earth and Environmental Sciences, Washington, DC, October 17, 1991.

Schiermeier, F.A. Atmospheric Sciences Modeling Division modeling activities related to coastal urban dispersion. Presentation at the NATO/CCMS Workshop on Air Pollution Transport and Diffusion Over Coastal Urban Areas, Athens, Greece, February 6, 1992.

Schiermeier, F.A. Atmospheric Sciences Modeling Division modeling activities for particulate matter (PM-10) State Implementation Plans. Presentation at the Standing Air Simulation Work Group Meeting, San Francisco, CA, April 24, 1992.

Schiermeier, F.A. Report on implementation of Working Group 02.01-10 on Air Pollution Modeling, Instrumentation, and Measurement Methodology. Presentation at the Fourteenth Meeting of the US/Russia Joint Committee on Cooperation in the Field of Environmental Protection, Washington, DC, May 11, 1992.

Schiermeier, F.A. Opening address and plans for Working Group research activities. Presentation at the Sixteenth US/Russia Working Group 02.01-10 Meeting on Air Pollution Modeling, Instrumentation, and Measurement Methodology, St. Petersburg, Russia, July 13, 1992.

Schiermeier, F.A. Overview of Atmospheric Sciences Modeling Division research programs. Presentation to the Atmospheric Physics Faculty, St. Petersburg University, St. Petersburg, Russia, July 15, 1992.

Schiermeier, F.A. Overview of Atmospheric Sciences Modeling Division research programs. Presentation at the Interim Joint Meeting of the United States/Japan Air Pollution Meteorology Panel, Research Triangle Park, NC, September 24, 1992.

Snyder, W.H. Some observations of the influence of stratification on diffusion in building wakes. Invited presentation at the Fourth IMA Conference on Stably Stratified Flows—Flow and Dispersion over Topography, University of Surrey, Guildford, England (Sponsored by the Institute of Mathematics and its Applications; cosponsored by the Royal Meteorological Society), September 21-23, 1992.

Zhang, Y.Q. (North Carolina State University, Raleigh, NC). Numerical simulation of flow around a building. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, October 10, 1991.

Zhang, Y.Q. (North Carolina State University, Raleigh, NC). Numerical simulation of flow and dispersion around a building. Seminar presented at the Fluid Modeling Facility, Research Triangle Park, NC, July 1, 1992.

Zhang, Y.Q., S.P.S. Arya, A.H. Huber, and W.H. Snyder. Simulating the effects of upstream turbulence on dispersion around a building. Presentation at the Fourth International Summer Colloquium and International Symposium for Young Scientists on Climate, Environment and Geophysical Fluid Dynamics, July 20-29, 1992, Beijing, PRC, Chinese Academy of Sciences.

APPENDIX D: WORKSHOPS

NATO/CCMS International Technical Meeting (ITM) Round-Table Discussion on Harmonization of Atmospheric Dispersion Models, Ierápetra, Greece, October 2, 1991.

J.S. Irwin
F.A. Schiermeier

Lake Michigan Urban Air Toxics Study Workshop, Research Triangle Park, NC, October 16-17, 1991.

T.L. Clark

Southern Oxidant Study Workshop on Biogenic Emissions, Raleigh, NC, October 23, 1991.

T.E. Pierce

Chesapeake Bay Evaluation and Deposition Committee Workshop, Annapolis, MD, October 30-November 1, 1991.

T.L. Clark

The Regional Modeling Code Comparison Workshop, Atmospheric Sciences Research Center, State University of New York at Albany, Albany, NY, November 6-8, 1991.

F.S. Binkowski
D.W. Byun
R.L. Dennis
J.E. Pleim

First Annual Southern Oxidants Study Workshop, Atlanta, GA, November 12-14, 1991.

T.E. Pierce
K.L. Schere

EPA Region IV Training Workshop on CTDMPLUS/CTSCREEN Models, Atlanta, GA, November 14-15, 1991

S.G. Perry

Global Emissions Inventory Activity Planning Workshop, Baltimore, MD, December 1-2, 1991.

W.G. Benjey

Model Evaluation Team Workshop to Prepare for External Review Panel Review of RADM and ADOM Evaluation Results, Buffalo, NY, December 4-6, 1991.

D.W. Byun
J.K.S. Ching
R.L. Dennis

Model Testing Protocol/Chamber Database Workshop, University of North Carolina at Chapel Hill, Chapel Hill, NC, December 9-10, 1991.

K.L. Schere

EPA, Arizona Public Service Company, Desert Research Institute, Salt River Project, and Southern California Edison Company Regional Haze Workshop, Scottsdale, AZ, December 10-12, 1991.

M.L. Pitchford

Workshop on a Research and Monitoring Agenda for Lake Champlain, Burlington, VT, December 17-19, 1991.

T.L. Clark

Southern Oxidants Study/SERON SCION Workshop, Birmingham, AL, January 15, 1992.

K.L. Schere

Southern Oxidant Study Workshop on the Atlanta Emissions Inventory, Atlanta, GA, January 24, 1992.

T.E. Pierce

Workshop on the Approaches to Reducing Uncertainty in Mass Balance Models for Toxics: Lake Ontario Case Study, Buffalo, NY, February 3-5, 1992.

T.L. Clark

Canadian Ministry of the Environment, Regional Meteorologists Training Workshop on CTDMPLUS/CTSCREEN Models, Victoria, B.C., Canada, February 4-5, 1992.

S.G. Perry

Methane Emissions from Natural Gas Industry Advisory Committee Workshop, Durham, NC, February 4-6, 1992.

W.G. Benjey

NATO/CCMS Workshop on Air Pollution Transport and Diffusion Over Coastal Urban Areas, Athens, Greece, February 6-7, 1992.

J.M. Godowitch
F.A. Schiermeier

DOE Visibility Assessment Workshop, Denver, CO, February 11-12, 1992.

M.L. Pitchford

Model Evaluation Team Workshop to Prepare for External Review Panel Review of RADM and ADOM Evaluation Results, Buffalo, NY, February 24, 1992.

R.L. Dennis

Baltimore Air Toxics and Nitrogen Deposition Study (BATANDS) Workshop, Annapolis, MD, February 25, 1992.

T.L. Clark

Southern Oxidant Study Workshop on Regional Modeling, Research Triangle Park, NC, February 27, 1992.

T.E. Pierce

Science Team Meeting and Workshop of the Southern Oxidants Study/ SouthEast Regional Oxidant Network (SOS/SERON), U.S. Environmental Protection Agency, Research Triangle Park, NC, February 27-28, 1992.

K.L. Schere

Aerosol Research Workshop, NOAA Air Resources Laboratory, Boulder, CO, March 3-4, 1992.

F.S. Binkowski
J.K.S. Ching

Implementation of Title I of the 1990 Clean Air Act Amendments Workshop, Research Triangle Park, NC, March 3-5, 1992.

T.N. Braverman

National Academy of Sciences Panel on Intersection Air Quality Modeling, Washington, DC, March 9-10, 1992.

T.N. Braverman

Second Annual Southeast Affiliate of IAMSLIC Libraries Workshop, Skidaway Institute of Oceanography, University of Georgia, Savannah, GA, March 11-13, 1992.

E.M. Poole-Kober

AMS/EPA Regulatory Model Improvement Committee (AERMIC) Workshop, Durham, NC, March 18-19, 1992.

J.S. Irwin
R.F. Lee
S.G. Perry
F.A. Schiermeier
W.H. Snyder

Lake Michigan Mass Balance Workshop, Durham, NC, March 31-April 1, 1992.

T.L. Clark

External Review Panel Review of RADM and ADOM Evaluation Results for Phase 1 of the Eulerian Model Evaluation Field Study Program, Monterey, CA, March 31-April 3, 1992.

F.S. Binkowski
D.W. Byun
J.K.S. Ching
R.L. Dennis
J.A. Pleim

Southern Oxidants Study/SERON SCION Workshop, Research Triangle Park, NC, April 7, 1992.

K.L. Schere

International Global Atmospheric Chemistry (IGAC)—Global Emissions Inventory Activity (GEIA) Workshop on Non-Methane Hydrocarbon Emissions, Boulder, CO, April 10, 1992.

T.E. Pierce

Systems Software and Tools for High Performance Computing Environments Workshop, Pasadena, CA, April 14-16, 1992.

J.O. Young

ERL Data Management Workshop, Boulder, CO, April 16-17, 1992.

J.H. Novak

Regional, State, and Local Modelers Workshop, Grand Canyon, AZ, April 20-24, 1992.

D.T. Bailey
T.N. Braverman
J.L. Dicke
J.S. Irwin
R.F. Lee
J.S. Touma
D.A. Wilson

EPA/EPRI/UARG Risk Assessment Workshop, Durham, NC, April 28, 1992.

T.L. Clark

Building Partnerships for Information Access, EPA/NOAA Librarians Meeting, Bethesda, MD, April 28-30, 1992.

E.M. Poole-Kober

Workshop on Numerical Modeling Techniques, North Carolina Supercomputing Center, Research Triangle Park, NC, May 4, 1992.

K.L. Schere

Chesapeake Bay Evaluation and Deposition Committee Workshop, Research Triangle Park, NC, May 21-22, 1992.

B.G. Benjey
J.K.S. Ching
T.L. Clark
R.L. Dennis
N.C. Possiel

Measurement Of Haze And Visual Effects (MOHAVE) Workshop, Colorado State University, Fort Collins, CO, May 27-28, 1992.

F.S. Binkowski
J.K.S. Ching

Federal Highway Administration (FHWA) Workshop on Traffic Modeling, Research Triangle Park, NC, June 9-10, 1992.

T.N. Braverman

EMEP/MSC-W Modeling Strategy Meeting Workshop, Lysebu, Oslo, Norway, June 10-11, 1992.

R.L. Dennis

NAS/NRC Planning Workshop for Panel on Atmospheric Aerosols, Washington, DC, June 16-17, 1992.

F.A. Schiermeier

Third US/FRG/CEC Workshop on the Photochemical Ozone Problem and Its Control, Lindau, Germany, June 30-July 3, 1992.

R.L. Dennis
T.E. Pierce
N.C. Possiel
K.L. Schere

The Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN, July 5-10, 1992.

F.S. Binkowski
J.E. Pleim

SARMAP Evaluation Review Panel, San Ramon, CA, July 13, 1992.

R.L. Dennis

National Academy of Sciences Panel on Intersection Air Quality Modeling, Irvine, CA, July 13-14, 1992.

T.N. Braverman

US/Russia Air Pollution Modeling Workshop, St. Petersburg, Russia, July 13-16, 1992.

R.F. Lee

Sixteenth US/Russia Working Group 02.01-10 Meeting on Air Pollution Modeling, Instrumentation, and Measurement Methodology, St. Petersburg, Russia, July 13-17, 1992.

F.A. Schiermeier

Air Quality Management Training Workshop, Charlotte, NC, July 13-17, 1992.

T.L. Clark
N.C. Possiel
K.L. Schere

Data Analysis Conference of the Southern California Air Quality Study (SCAQS), UCLA, Los Angeles, CA, July 21-23, 1992.

K. L. Schere

High Performance Computing and Communications (HPCC) Program Interagency Offsite Planning Workshop for System Software, Berkeley Springs, WV, July 22-24, 1992.

R.L. Dennis
J.O. Young

EPRI Ozone Modeling Workshop, Cambridge, MA, August 19-20, 1992.

K.L. Schere

Chesapeake Bay Evaluation and Deposition Committee Workshop, Annapolis, MD, August 20-21, 1992.

T.L. Clark

Lake Michigan/Superior Loading Study Workshop, Research Triangle Park, NC, September 1-2, 1992.

T.L. Clark

EMEP Steering Body Meeting, Geneva, Switzerland, September 1-3, 1992.

R.L. Dennis

Southern Oxidants Study/SERON Science Team Workshop, Research Triangle Park, NC, September 9-10, 1992.

K.L. Schere

Workshop on Photochemical Oxidant Research — Integrating Federal, Public, and Private R&D, US Environmental Protection Agency, Research Triangle Park, NC, September 14-15, 1992.

J.K.S. Ching
K.L. Schere

Chesapeake Bay Evaluation and Deposition Committee Workshop, Annapolis, MD, September 16-17, 1992.

T.L. Clark

NAPAP Workshop on the Urban Perspective of Acid Rain, Raleigh, NC, September 23-24, 1992.

R.L. Dennis
J.K.S. Ching
F.S. Binkowski

APPENDIX E: VISITING SCIENTISTS

1. I.P. Castro
   Department of Mechanical Engineering
   University of Surrey
   Guildford, Surrey, England

Dr. Castro spent six weeks at the Fluid Modeling Facility. He and the staff jointly conducted towing-tank measurements on the structure of stratified flows over hills.

2. Dr. Igor Granberg
   Institute of Atmospheric Physics
   Russian Academy of Sciences
   Moscow, Russia

Dr. Igor Granberg spent January 13-14, 1992, at the Atmospheric Sciences Modeling Division and explained modeling the dispersion of dust produced from drying water bodies. Field studies are being conducted by federal agencies in the United States and Russia on the dust being produced from Owen's Lake in California and the Aral Sea in Russia. Dr. Granberg is exploring possible areas of collaboration in modeling this phenomena.

3. Dr. Heinz Hass
   University of Cologne
   Cologne, Germany

Dr. Heinz Hass spent April 13-17, 1992, in Research Triangle Park, NC, to attend the CAMRAQ meeting. He presented a seminar entitled, "Using the EURAD (European RADM) System: Experiences, Evaluations and Developments," to the Atmospheric Sciences Modeling Division. He discussed with Division scientists working on the RADM system modeling issues and future plans. His visit was very important for the continuation of the close collaboration between ASMD, University of Cologne, and State University of New York at Albany on the development, evaluation, and application of the RADM system.

4. N.S. Volberg
   A. Pavlenko
   Voeikov Main Geophysical Observatory
   St. Petersburg, Russia

Drs. Volberg and Pavlenko spent two weeks at the Atmospheric Sciences Modeling Division and the EPA Atmospheric Research and Exposure Assessment Laboratory to compare passive diffusive samplers with Russian methodology for sulfur dioxide and nitrogen dioxide measurements in ambient air. This work was performed under the US/Russia Working Group 02.01-10, Project 02.01-12 on Instrumentation and Measurement Methodology.

APPENDIX F: ATMOSPHERIC SCIENCES MODELING DIVISION STAFF FY-1992

All personnel are assigned to the U.S. Environmental Protection Agency from the National Oceanic and Atmospheric Administration, except those designated EPA, who are employees of the Environmental Protection Agency, or PHS, who are members of the Public Health Service Commissioned Corps.

Office of the Director

Francis A. Schiermeier, Supv. Meteorologist, Director
Herbert J. Viebrock, Meteorologist, Assistant to the Director
Dr. Raul J. Alvarez, III, Physical Scientist (Las Vegas, NV, Since 10/91)
Dr. Robin L. Dennis, Physical Scientist
Dr. Peter L. Finkelstein, Physical Scientist
Dr. Marc L. Pitchford, Meteorologist (Las Vegas, NV)
Evelyn M. Poole-Kober, Technical Editor
Barbara R. Hinton (EPA), Secretary

Atmospheric Model Development Branch

Dr. Jason K.S. Ching, Supv. Meteorologist, Chief
Dr. Francis S. Binkowski, Meteorologist
O. Russell Bullock, Jr., Meteorologist
Dr. Daewon W. Byun, Physical Scientist (Since 1/92)
Terry L. Clark, Meteorologist
Dr. John F. Clarke, Meteorologist
Gerald L. Gipson, Physical Scientist
James M. Godowitch, Meteorologist
Dr. Jonathan A. Pleim, Physical Scientist
Shawn J. Roselle, Meteorologist
Kenneth L. Schere, Meteorologist
B. Ann Warnick, Secretary

Fluid Modeling Branch

Dr. William H. Snyder, Supv. Physical Scientist, Chief
Aly G. Khalifa, Engineering Technician (Since 3/92)
Lewis A. Knight, Electronics Technician
Robert E. Lawson, Jr., Physical Scientist
Roger S. Thompson (PHS), Environmental Engineer
Anna L. Cook, Secretary

Modeling Systems Analysis Branch

Joan H. Novak, Supv. Computer Specialist, Chief
William E. Amos (EPA), Computer Programmer
Dr. William G. Benjey, Physical Scientist
Dale H. Coventry, Computer Specialist
Thomas E. Pierce, Jr., Meteorologist
John H. Rudisill, III, Computer Specialist
Alfreida R. Torian, Computer Specialist
Gary L. Walter, Computer Scientist (Since 10/92)
Dr. Jeffrey O. Young, Mathematician (Since 11/91)
Pamela P. Thomas, Secretary (Since 12/91)

Global Climate Research Branch

Dr. Sharon K. LeDuc, Supv. Physical Scientist, Chief
Dr. Ellen J. Cooter, Meteorologist
Brian K. Eder, Meteorologist
Lawrence E. Truppi, Meteorologist
Ella L. King (EPA), Secretary

Applied Modeling Research Branch

William B. Petersen, Supv. Physical Scientist, Chief
Dr. Gary A. Briggs, Meteorologist
Lewis H. Nagler, Meteorologist (Atlanta, GA)
Dr. Steven G. Perry, Meteorologist
Lisa M. Lewis, Secretary (Since 7/92)

Human Exposure Modeling Branch

Dr. Alan H. Huber, Supv. Physical Scientist, Chief
Gennaro H. Crescenti, Physical Scientist
Everett L. Quesnell, Meteorological Technician
Brian D. Templeman, Meteorologist
Dr. Michael P. Zelenka, Meteorologist
E. Frances Horvath (EPA), Secretary

Air Policy Support Branch

John S. Irwin, Supv. Meteorologist, Chief
Dennis G. Atkinson, Meteorologist
Dr. Desmond T. Bailey, Meteorologist
Thomas N. Braverman (EPA), Environmental Engineer
C. Thomas Coulter (EPA), Environmental Protection Specialist
James L. Dicke, Meteorologist (Until 6/92)
Russell F. Lee, Meteorologist
Norman C. Possiel, Jr., Meteorologist
Jawad S. Touma, Meteorologist
Allan R. Van Meter, Meteorologist (Since 10/92)
Dean A. Wilson, Meteorologist
Brenda P. Cannady (EPA), Secretary

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