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FISCAL YEAR 1987 SUMMARY REPORT OF NOAA METEOROLOGY DIVISION SUPPORT TO THE ENVIRONMENTAL PROTECTION AGENCY

Herbert J. Viebrock
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PREFACE

This document presents for Fiscal Year 1987 a summary of the research and operational efforts and accomplishments of the Meteorology Division (MD) working under interagency agreement EPA DW13932678-01 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 Meteorology Division is part of the Air Resources Laboratory and serves as the vehicle for implementing the agreement with the EPA, which funds the research efforts in air pollution meteorology. The MD conducts research activities in-house and through contract and cooperative agreements for the Atmospheric Sciences Research Laboratory (ASRL) and other EPA groups. With a staff consisting of NOAA, EPA, and Public Health Service Commissioned Corps (PHS) personnel, the MD 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 (OAQPS) and Regional Offices. The primary groups within the MD are Atmospheric Modeling Branch, Fluid Modeling Branch, Data Management Branch, Terrain Effects Branch, Environmental Operations Branch, and Air Policy Support Branch. The staff is listed in Appendix D. Publications and other professional activities are listed in Appendixes A, B-1, and B-2, and C.

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

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ABSTRACT

The Meteorology Division provided meteorological research and operational support to the U.S. Environmental Protection Agency. Basic meteorological operational support consisted of the application of dispersion models, and the conduct of dispersion studies and model evaluations. The primary research effort was the development and evaluation of air quality simulation models using numerical and physical techniques supported by field studies. Modeling emphasis was on the dispersion of photochemical oxidants and particulate matter on urban and regional scales, dispersion in complex terrain, and the transport, transformation, and deposition of acidic materials.

Highlights during FY-1987 included completion of the Complex Terrain Dispersion Model (CTDM), establishment of an electronic bulletin board for use under the User's Network for Applied Modeling of Air Pollution (UNAMAP), application of the Regional Oxidant Model (ROM) to assess the impact of proposed NOx control strategies on ozone concentrations in the northeastern United States, completion of a sulfur-only version of the Regional Acid Deposition Model (RADM), and initiation of a major field study to evaluate the RADM and other regional dispersion models.

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1. INTRODUCTION

During Fiscal Year 1987, the Meteorology Division (MD) continued to provide meteorological research and support to the U.S. Environmental Protection Agency (EPA). The primary effort of the Division was to conduct research in the basic processes affecting the dispersion of atmospheric pollutants and to model the dispersion on all temporal and spatial scales. The major modeling emphasis was on oxidant dispersion on the urban and regional scales, particulate dispersion on the regional scale, dispersion in complex terrain, and acid precipitation related processes. Work on the study and modeling of boundary layer processes continued. Physical modeling experiments were conducted in the Fluid Modeling Facility on the flow in complex terrain, building downwash, and the effects of building wakes. Participation continued in the Integrated Air Cancer Program and on the use of dispersion models on the North Slope of Alaska. The research effort is described in Sections 2.1, 2.2, 2.3, 2.4, and 2.5. Section 2.1 also discusses the Division's participation in several major international activities.

Meteorological support was provided to various EPA offices, including the Office of Air Quality Planning and standards (OAQPS) and the Regional offices. This work is discussed in Section 2.6 and 2.7.

2. PROGRAM REVIEW

2.1 Office of the Director

The Office of the Director provides direction, supervision, program management, and administrative support in the performance of the Meteorology Division's mission and achievement of the goals to advance the state of the atmospheric sciences and to enhance the protection of the environment.

2.1.1 American Meteorological Society Steering Committee

Beginning in 1979, the Meteorology Division established a cooperative agreement with the American Meteorological Society (AMS) to improve the scientific bases of air quality modeling. The AMS has maintained a Steering Committee of alternating members to: (1) provide scientific review of various types of air quality dispersion models; (2) provide assistance in developing a more complete understanding of uncertainty as it affects various 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 Completed AMS Scientific Workshops

The AMS Steering Committee conducted a workshop during May 1983 in Keystone, Colorado on dispersion in complex terrain. The purpose of the workshop was to encourage atmospheric scientists working in the area of complex terrain dispersion modeling to exchange information on atmospheric processes in mountainous terrain and to make recommendations regarding both the present application of air quality models to complex terrain settings and the research necessary to meet future needs. A workshop summary consisting of a state-of-the-science review concerning the phenomena of importance and physical/mathematical modeling capabilities for dispersion in complex terrain was published (Egan and Schiermeier, 1986).

Under a separate cooperative agreement, the American Meteorological Society conducted a workshop in September 1984 that was funded jointly by the United States and the Canadian provincial and federal governments. The subject of the workshop was Sources and Evaluation of Uncertainty in Long-Range Transport Models. Workshop participants from the United States, Canada, England, Denmark, and Norway joined in the effort to identify and quantify uncertainty in long-range transport model predictions. An AMS report containing the complete documentation of the workshop, including recent developments in model evaluation and sensitivity analysis, and reports of the Eulerian and Lagrangian working groups, was published (Demerjian, 1987).

2.1.1.2 Assessments of Air Quality Modeling Practices

Under the objective of responding to requests regarding the division's air quality modeling practices, the AMS Steering Committee prepared three unpublished assessments on the following topics: (1) Evaluation of Air Quality Models - Past, Present, and Future; (2) Application of Surface Similarity Techniques to Surface Releases of Toxic Pollutants; and (3) On Using Models to Analyze Observations - Applications for Risk Assessment. The recommendations provided in these assessments were incorporated as appropriate into the improvement and application of existing air quality dispersion models by Division scientists.

2.1.2 NATO/CCMS Steering Committee

The Meteorology Division Director serves as one of two United States representatives on the Steering Committee for the North Atlantic Treaty Organization Committee on Challenges to Modern Society (NATO/CCMS) International Technical Meeting (ITM) on Air Pollution Modeling and Its Application. The organization of a symposium every eighteen months dealing with air pollution modeling is one of the main activities within the NATO/CCMS pilot study on Air Pollution Control Strategies and Impact Modeling. The meetings are rotated among different NATO member countries with every third ITM held in North America and the two intervening ITMs held in European countries. The Division Director served as Session Chairman and presented a paper during the 16th NATO/CCMS International Technical Meeting held in Lindau, Federal Republic of Germany in April 1987.

2.1.3 United States/Japan Environmental Agreement

The Meteorology Division Director serves as Chairman of the Air Pollution Meteorology Panel under the United States/Japan Environmental Agreement. The purpose of this 1975 agreement is to facilitate the exchange between the two countries of scientific and regulatory research results pertaining to control of air pollution through mutual visits and reciprocal assignments of personnel.

In FY-1987, no visits were exchanged between the two countries. However, plans were made for a visit to the United States in March 1988 by Japanese Air Pollution Meteorology Panel members in response to the February 1986 trip to Tokyo and Tsukuba Science City by NOAA personnel. Under the agreement, the Division Director was appointed as a Scientific Advisory Member to the 2nd International Conference on Atmospheric Sciences and Applications to Air Quality to be held in Tokyo during October 1988. Division personnel also participated in the visit by Japanese personnel from the Photochemical Air Pollution Panel which was chaired by an EPA scientist.

2.1.4 United States/Soviet Union Joint Environmental Committee

The Meteorology Division Director serves as the United States Co-Project Leader for Air Pollution Modeling and Standard Setting, which is part of the US/USSR Working Group 02.01-10 on Air Pollution Modeling, Instrumentation and Measurement Methodology. The purpose of this 1972 agreement is to promote the sharing of scientific and regulatory research results related to control of air pollution through mutual visits and reciprocal assignments of personnel.

During June 1987, the Division was visited by a delegation of five Soviet scientists headed by the Deputy Director of the Voeikov Main Geophysical Observatory in Leningrad. An overview of Division research activities was presented to the Soviet delegation by Division staff and detailed discussions were held describing mutual progress in the areas of acid deposition and complex terrain dispersion modeling, in the field of fluid modeling, and in the establishment of regulatory standards. A protocol was drafted outlining the next Project-level meeting to be held in Leningrad during May 1988 and future exchanges of scientific information.

2.1.5 Reviews of Meteorology Division Activities

2.1.5.1 Air Resources Laboratory Program Review

The NOAA Environmental Research Laboratories (ERL) conducted a program review of the Air Resources Laboratory (ARL) during March 18-20, 1987. The Meteorology Division Director and three Branch Chiefs participated in the review, presenting overviews of Division technical and organizational activities. Verbal comments indicated that the outside reviewers and NOAA management personnel were favorably impressed with Division accomplishments.

2.1.5.2 Meteorology Division In-House Peer Review

In place of routine reviews of Meteorology Division extramural research programs, a comprehensive peer review was conducted of the Division's in-house research activities. During September 1987, Division scientists made a total of 45 presentations over a three-day period to a panel of six extramural reviewers. Included in the presentations were all research projects that were being conducted by NOAA personnel.

2.1.6 Facility for Advanced Research Model Operation and Analysis

Many source-attribution problems in environmental regulation are so complex due to multi-day transport and interacting nonlinear processes that the only recourse is to design advanced dispersion models to mimic the processes involved. Such models produce realistic simulations of air pollutants moving from multiple source configurations to receptors while undergoing chemical transformations along the way. The results of these model simulations provide information on emission control strategies for use in formulating national environmental policy decisions.

Examples of these advanced dispersion models include the Regional Oxidant Model (ROM) which was used to determine economic benefits from ozone reduction and the effects of secondary standards on rural ozone concentrations, and to assess the impact of alternative control strategies on interurban transport of ozone and precursor pollutants in the northeast United States; the Regional Particulate Model (RPM) which will be instrumental in implementing the PM-10 particulate and anticipated PM-2.5 visibility standards; and the Regional Acid Deposition Model (RADM) as well as the RADM Engineering Model that will be used to evaluate various control scenarios of acid deposition precursor emissions.

The complexities of these models, however, require specially trained personnel to exercise them appropriately and correctly. The models are very computer intensive, involve complex preprocessing of meteorological and emissions data input sets, and require careful treatment of boundary conditions and initialization. Most importantly, the model results must be interpreted by experienced atmospheric scientists in order to improve their credibility in regulatory applications.

Under the current organizational structure, the staff scientists who have been responsible for the development, evaluation, and documentation of these models are being drawn slowly into planning and performing application runs. This migration of activities of a limited number of personnel is causing an erosion of the research program with less time available for the scientists to perform the original research required to continually advance and improve the models. Coincidentally, the "borrowed" staff performing the model applications is not sufficient in numbers to carry out adequately this important technology transfer aspect of the Division's mission.

In an effort to meet both model development and application requirements, plans have been made to establish and operate a Facility for Advanced Research Model Operation and Analysis (Research Modeling Facility) within the Meteorology Division that would provide proper expertise in the applications of advanced dispersion models for the EPA Research, Program and Regional Offices, and other Federal agencies. In this way, both model development and applications could be afforded the stature and resources that each rightfully deserves and requires in supporting the Agency's goals.

2.2 Atmospheric Modeling Branch

The Atmospheric Modeling Branch develops, evaluates and validates analytical and numerical models used to describe the relationships between air pollutant source emissions and resultant air quality, to estimate the distribution of air quality, and to describe and predict the state of the planetary boundary layer. Model scales range from local to global. Studies are conducted to describe the physical processes affecting the transport, diffusion, transformation, and removal of pollutants in and from the atmosphere.

2.2.1 Acid Deposition Studies

2.2.1.1 Development of a Regional Acid Deposition Model (RADM)

A comprehensive Regional Acid Deposition Model (RADM) is being developed as an integral component of the National Acid Precipitation Assessment Program (NAPAP). The project was initiated in 1983 through agreement with the National Center for Atmospheric Research (NCAR). The objective of this program is to develop an Eulerian modeling system capable of describing nonlinear source-receptor relationships and for assessing the effects of changes in emissions of sulfur and other primary pollutants on regional patterns of acid deposition. The modeling system incorporates a mesoscale dynamic meteorological model to drive a 6-level Eulerian transport, transformation and deposition model on an 80km grid covering the entire United States and Southern Canada. The rationale and approach to the modeling effort are contained in two companion NCAR reports (National Center for Atmospheric Research, 1983a and b).

Version I of the RADM (National Center for Atmospheric Research, 1985), containing first generation submodels of gas and aqueous-phase chemistry and initial parameterizations of subgrid-scale cloud processes and dry deposition, was completed in 1985. In FY-1986 the RADM model was subjected to preliminary evaluation studies against Oxidation and Scavenging Characteristics of April Rains (OSCAR) experimental chemistry data (National Center of Atmospheric Research, 1986) and Cross Appalachian Tracer Experiments (CAPTEX) data. It was also subjected to extensive emissions and initial and boundary conditions sensitivity analyses. The chemical component was tested and improved.

During FY-1987, basic technical responsibility for the RADM including the transport, transformation, and deposition components were transferred to the State University of New York at Albany (SUNYA). Work continued at NCAR on the meteorological driver for RADM. Work was initiated on a Version II RADM which will incorporate an advanced chemical module and solver, a modified advection scheme and improved wet and dry deposition modules. Version II of the RADM will be completed in the second quarter of 1988.

A sulfur only engineering model version of the RADM was completed and is fully operational at the Meteorology Division. The engineering model requires chemical fields generated by the full RADM as input and allows the user to vary sulfur emissions to assess the effects of projected sulfur emission control scenarios. The model is also being used to study spatial and temporal scales of nonlinearity.

The MM4, the meteorological driver for RADM, was completed and delivered with documentation. NCAR conducted extensive evaluations and sensitivity studies of the MM4 with the following conclusions: (1) large-scale atmospheric motions have a major, if not dominant, effect on model results and consequently time-varying lateral boundary conditions must be specified, (2) small variations and uncertainty in the initial conditions do not strongly influence model results, (3) relatively simple parameterizations of latent heat processes produce nearly the same simulation skill as the more complex parameterizations, and (4) although there is large variation of model skill from case to case, the climatological skill of the model over many cases is quite good. To improve the overall performance of the MM4, especially on a case by case basis, a program was initiated to assimilate observed surface and radiosonde data at 3 and 12 hour time steps, respectively. Significant progress was made on this four-dimensional data assimilation version of MM4. It will become operational by summer 1988.

Assessment outputs from RADM are required on seasonal and annual bases. Methods to aggregate episodic realizations of RADM predictions to seasonal and annual periods are being studied. Through two workshops, a clustering approach using transport patterns, precipitation patterns, and wet deposition observations, in that order, has evolved and is being pursued at the University of Michigan. An initial clustering approach will be specified by summer 1988.

2.2.1.2 Development of a Non-Precipitating Cumulus Cloud Transport Module for the RADM (CUVENT).

CUVENT (Cumulus Venting) is a computer module developed to compute the vertical mass flux of pollutants between the mixed layer and the cloud layer by an ensemble of non-precipitating convective cumulus clouds. The module was developed by Research Triangle Institute for integration into the Regional Acid Deposition Model (RADM). CUVENT is based on a cloud transport model by Ritter and Stedman (1985) and a unique closure scheme developed primarily from the VENTEX field measurement program, but also incorporates other data from the scientific literature. The model computes, for each RADM grid, the mass flux at cloud base and the liquid water distribution of an ensemble of cumulus clouds made up of a discrete set of cloud classes that are defined by cloud depth and sky coverage.The predictions are unique to any given vertical distribution of moist static energy, and sensitive to such parameters as heat flux, lifting condensation level (LCL), height of mixed layer, and thickness of the entrainment and LCL zones. The outputs are defined for a single "processor" cloud whose overall dynamics and thermodynamics are identical to the cumulus cloud ensemble. Cloud parameters in the processor cloud are defined as the weighted mean of their respective parameters over all cloud classes. The weights are the cloud amounts that are associated with each cloud class.

A Table "LOOK-UP" version of CUVENT, CUVENTIIA, was developed which significantly reduces the computer execution time. The tables were developed from CUVENT for five characteristic atmospheric categories and ten cloud amounts based on vertical distribution of temperature and moisture. In an operational mode, the host code provides the input meteorology for each grid in the modeled domain. CUVENTIIA applies a threshold criterion to determine the characteristic category and compares it with the LOOK-UP tables to obtain the requisite mass flux value. This program was completed in FY-1987.

2.2.1.3 Development of an Acid Deposition Dry Deposition Module

Modifications to the first generation dry deposition module (Sheih et al., 1986) were performed in order to include specific surface resistances for more chemical species carried in the Regional Acid Deposition Model (RADM) and to account for surface wetness due to either dewfall or rain. The work was conducted through an interagency agreement with the Argonne National Laboratory through the U.S. Department of Energy. The methodology for the bulk surface resistances is based on knowledge of Henry's law constants and reactivity of a chemical species relative to corresponding information for sulfur dioxide and ozone. Tables of surface resistances as a function of solar irradiation, season, and land use were determined for sulfur dioxide, ozone, nitrogen dioxide, hydrogen peroxide, acetaldehyde, formaldehyde, methyl hydroperoxide, peroxyacetic acid, formic acid, ammonia, peroxyacetyl nitrate, and nitrous acid. The methods to compute aerodynamic and boundary layer resistances remain unchanged. The methodology to treat the various pathways influencing the surface resistances, impact of surface wetness on surface resistances, and the revised dry deposition module code are to be documented in early FY-1988.

2.2.1.4 Regional Acid Deposition Model Evaluation

A major program to evaluate regional-scale models, primarily the Regional Acid Deposition Model (RADM), is being implemented. A model evaluation protocol is evolving based on planned surface monitoring and special aircraft measurements to be obtained within the ACID-MODES field program (see Section 2.2.1.5). During FY-1986, a primary surface monitoring network design was approved and an overall sampling plan developed. The plan calls for a surface network to measure selected ambient and precipitation chemistry species over the north-eastern United States and southeastern Canada, a sub-grid scale variability network, a special network to enhance definition of gradients in sensitive receptor regions, and special chemical sites and aircraft monitoring.

Planning workshops were conducted in December 1986 and August 1987 to further the design of the aircraft measurement program. The role of the aircraft sampling in the overall evaluation program is the diagnostic evaluation of the models' ability to simulate the chemical and precipitation processes important in acid deposition. Specifically the program will examine the capability of regional models to simulate the relevant vertical transport and exchange processes, aid in evaluating the models' capability to represent nonlinear processes, and determine if the models can track the chemical histories of radically different synoptic events. Specific flight plans have not evolved, however, one significant recommendation was to use a jet aircraft from the Federal Republic of Germany in the sampling program.

An emission sensitivity analysis was implemented to aid the design of emission data collection from major point sources during the ACID-MODES field program. The purpose is to reduce uncertainty in the daily emission estimates which will be entered into the RADM model for the evaluation. A significant finding was that three-quarters of the variability in hourly emissions of major utility plants is due to load dispatching of the boilers, that is, the controlled turning on and off of utility boilers for a day at a time. A statistical model of the emission variability will be used to develop random realizations of variable emission estimates for use in the RADM Engineering Model to study the responsiveness of the output deposition fields to variability in the emissions input.

Other accomplishments this year included the development of rationale and design of the variability and gradient networks and the special chemical sites. The model evaluation procotol for both operational and diagnostic evaluation has evolved with the network design and will be completed in FY-1988.

2.2.1.5 Acid Model Operational and Diagnostic Evaluation Study (ACID-MODES)

A major field measurement program is being conducted to obtain a data base to evaluate regional scale acid deposition models. Environmental Research and Technology (ERT) was selected to perform the field measurements program which is called the ACID-MODES (ACID Model Operational Diagnostic Evaluation Study). A surface sampling network of 67 sites distributed over a geographic area covering the northern two-thirds of the eastern United States will be established with sampling to span two years from June 1988. The ACID-MODES measurement program is coordinated with the following surface monitoring programs: a) Operational Evaluation Network (OEN) sponsored by the Electric Power Research Institute (EPRI), b) APIOS network sponsored by Ontario Ministry of Environment (OME), and c) CapMON network of the Atmospheric Environment Service of Canada (AES). Collectively, these four networks will provide measurements from more than 100 monitoring stations. The data from the combined network will be used in an operational evaluation of RADM and other regional scale acid deposition models.

The ACID-MODES program will collect and analyse 24 -hr integrated measurements of SO_2, NO_2, HNO_3, NH_3 and particulate (less than 10 micron diameter) sulfate, nitrate and ammonium collected on substrates. Precipitation samples collected on a daily basis will be analysed for H+ (as pH), conductivity, SO_4=, NO_3, NH_4+, Cl-, K+, Ca^{2+}, and Mg^{2+}. Thirty-five of these sites, the so-called NE-35, will be either collocated with or within 5 kilometers of National Dry Deposition Network (NDDN) sites that are in the ACID-MODES sampling domain. The remaining SUP (supplementary) sites will be situated to provide greater spatial density of stations in order to resolve the spatial gradients of deposition in sensitive watershed areas. Continuous measurements of 0_3 will be made at most of the SUP sites to augment those made at the NDDN sites. Additionally, measurements of gaseous HOOH, fine particulates, and SIV are planned for about 20 of the 67 sites in the sampling domain.

Aircraft measurements are planned for up to four sampling periods of about one month each. These aircraft will provide information on the vertical distribution of acidic and precursor pollutants. This data will be used in a diagnostic mode to test model(s) scientific credibility.

2.2.1.6 Mesoscale Studies for Acid Deposition

The objectives of the mesoscale acid deposition program are to determine the effect of emissions from a large urban-industrial area on the wet deposition downwind from the source, to determine the importance of local primary sulfur emissions, and to examine the chemical transport and deposition processes on a finer scale than is done in the regional acid deposition modeling program. Major field studies were conducted in the Philadelphia area, including southern New Jersey and southeastern Pennsylvania (Patrinos and Binkowski, 1986), and the Washington, DC area, including portions of Maryland and Virginia. The major conclusion of these studies is that the urban-industrial emissions had an important effect upon the deposition of nitrate and ammonium ions downwind of the cities. A significant but smaller effect was observed also for sulfate ions.

The mesoscale acid deposition model, MesoSTEM, was used to study the May 1985 Philadelphia storm. These results show that the contribution of primary sulfate is small, wet deposition is more important than dry deposition and that the sulfate production by aqueous phase reactions are much more important than gas phase reactions. For this particular case, the trajectories show that the sampling sites in southeastern Pennsylvania were not in the target area for the Philadelphia emissions, thus confirming the tentative conclusions drawn from the field study data. A model sensitivity analysis suggests that the production of gaseous nitric acid and sulfate was oxidant limited for this particular storm (Carmichael, 1987).

2.2.1.7 ANATEX Model Evaluation Study (AMES)

One method for evaluating the transport and diffusion algorithms of air pollutant models involves the comparison of calculated and measured air concentrations of tracer gas. The measured air concentrations from seven tracer gas releases during the 1983 Cross Appalachian Tracer Experiment (Ferber et al., 1986) provided one of the first evaluation data bases for long-range transport models. The Across North America Tracer Experiment (ANATEX) of 5 January through 30 March 1987 provided much more data from a surface network of 77 sites stretching 3000 km from central North America to the Atlantic Ocean (Draxler et al., 1987). During this study two distinctive perflurocarbon tracers were released at the surface at 2 1/2 -day intervals from Glasgow, Montana and St. Cloud, Minnesota. At 5-day intervals a third distinctive tracer was released at the surface from the St. Cloud site.

The ANATEX Model Evaluation Study (AMES) was initiated in FY-1987 as a joint effort involving the EPA, NOAA, and the Air Force Technical Applications Center to assess the performance of the transport and diffusion algorithms of several operational long-range models using the ANATEX data base. Performances are to be assessed for each of several types of meteorological scenarios. Performance measures are being considered to compare the calculated and observed location, horizontal dimensions and concentrations of tracer "Footprints", defined as the two-dimensional surface manifestations of the tracer puff (Environmental Protection Agency, 1987a). A Monte Carlo technique was proposed to estimate the uncertainty of the location and dimensions of the observed tracer footprints. The evaluation protocol will be developed in FY-1988, and the evaluation completed in early FY-1989.

2.2.1.8 Support to NAPAP

A major activity in support of the National Acid Precipitation Assessment Program (NAPAP) during FY-1987 was to provide the Aquatics Effects Research Program best estimates of dry deposition of total sulfur, based on the fields produced by air quality models, to approximately 1600 eastern watersheds. To produce the dry deposition estimates, average sulfur dry deposition fields from a representative Lagrangian model, RELMAP, and from RADM I were adjusted to match annual data at twelve sites spanning the northeastern United States and Canada. At fourteen sites across southern Ontario the observed annual wet deposition of sulfur was first added to the fitted model estimates (RELMAP and RADM I) of annual dry deposition and second added to the observed dry deposition (inferred from ambient concentration measurements and dry deposition theory), then a ratio of dry-to-total was calculated for each. The model three ratios of dry-to-total sulfur deposition were pair-wise compared to observed data. The relative spatial gradients of dry deposition across southern Ontario produced by the RELMAP are superior to the relative gradients produced by RELMAP linear chemistry model. The emission gradient across

Ontario is similar to the one across Pennsylvania and New York up to the Adirondacks; consequently the ratios are assumed valid for the sensitive receptor regions in the northeastern United States. The results of this program met a key need of the Aquatic Effects Research Program.

Assistance to the NAPAP program was also provided through a siting study to provide guidance on locating five new National Dry Deposition Network sites in the Southeast. A key element of the study was a 2-week simulation of the Regional Oxidant Model for the southeastern United States. The model provided critical information on pollutant field and gradients across space to augment the very sparse spatial coverage of the present networks.

2.2.1.9 RELMAP Acid Deposition Applications and Model Improvements

In response to the need of aquatics effects research, the Regional Lagrangian Model for Air Pollution (RELMAP) was applied to define the annual pattern of sulfur dry deposition across the eastern United States. A modeling approach was preferred since the spatial pattern could not be determined from the available dry deposition data with an acceptable level of uncertainty. This pattern was superimposed with the pattern of sulfur wet deposition, obtained from a spatial analysis of observed amounts, to define the annual pattern of total sulfur deposition. Finally, the sulfur dry and wet deposition patterns were intercompared to determine the relative contributions of each to the total sulfur deposition.

These patterns indicated that 1) the maximum total sulfur deposition, in excess of 80 kg sulfate/ha/yr, occurred across southwestern Pennsylvania and northern West Virginia, 2) the magnitudes of the dry and wet components were approximately equal south of a line from southern New England to southern Indiana, and 3) the relative contribution of wet deposition was greatest, in excess of 70%, across Maine and the upper Midwest.

Another RELMAP application produced seasonal and annual source-receptor matrices for sulfur dry and wet deposition amounts. These matrices were provided to policy analysts to determine the potential effectiveness of various Congressional emission reduction proposals.

The RELMAP algorithms for calculating wet and dry deposition were modified to better represent the actual processes across grid cells. The wet deposition calculation approach was modified to first calculate the amount of wet deposition for each group of a frequency distribution of precipitation rates and then to compute a frequency-weighted mean deposition amount. Second, rather than using a dry deposition velocity based on the predominant land-use category for each grid cell, the model now first calculates the dry deposition on the basis of the land-use-weighted mean. Third, the dry deposition velocities were replaced by the recently revised velocities. Finally, area source emissions were injected into the shallow surface layer at night as opposed to a layer aloft. As a consequence of these modifications, the annual spatial patterns derived from 1980 RELMAP predictions of sulfur dry deposition resembled, to a much greater extent, the annual observed patterns.

2.2.2 Photochemical Modeling

2.2.2.1 Regional Oxidant Model (ROM)

The development of the Regional Oxidant Model (ROM) began in the late 1970's as part of the Northeast Corridor Regional Modeling Project (NECRMP). The NECRMP was initiated because ozone and its precursor species generated by the major urban areas of the Northeast affect air quality over very broad areas such that it is impossible for States to develop viable emissions control plans without taking into account the influx of ozone and precursor species from outside sources. ROM was developed to provide a scientifically credible basis for simulating the regional transport and collective fate of emissions from all sources in the Northeast, and to serve thereby as a basis for developing regional emission control policies for attaining the primary ozone standard in the most cost effective way. The first generation version of the model, ROM1 became operational in 1985 and was used in a number of preliminary studies (Lamb, 1986). The second generation model, ROM2, became operational during FY-1987, and includes more sophisticated treatment of meteorological processes as well as the recently developed Carbon Bond IV chemical kinetic mechanism, which includes explicit treatment of biogenic hydrocarbon emissions. A full scale evaluation of the model using the 1980 NEROS data base commenced during FY-1987.

Numerous application studies were performed at the request of the EPA Office of Air Quality Planning and Standards (OAQPS) and the Congressional Office of Technology Assessment. These studies generally focused on the effects that reducing the emission of ozone precursor species (NOx and hydrocarbons) would have on the ozone air quality on regional modeling scales (up to 1000 km).

The major application study performed during FY-1987 involved ROM2 simulations of three individual two-week episodes in the northeast United States and two emission control scenarios for each of the base case episodes. The base anthropogenic emissions were taken from the NAPAP 5.3 inventory for 1980 (Toothman et al., 1984) and the biogenic emissions inventory was developed by Meteorology Division staff (Novak and Reagan, 1986). Each of the two control strategies was created from the base inventory by modifying the hydrocarbon emissions. In the first case the 1980 inventory was projected to a baseline 1987 inventory, taking into account growth, with reductions for existing emissions control programs. In the second, an additional across-the-board 22% reduction in hydrocarbons was used to reflect projections to 1995. The model results indicated that the emission controls reduce peak ozone concentrations most in the areas where the concentrations are highest. Another important attribute of these strategies is that, in general, they lower ozone levels everywhere in all three episodes. The additional controls imposed by strategy 2 lower peak predicted ozone values only slightly from those achieved by control strategy 1, and have almost no effect on concentrations below about the 98-th percentile level.

In other ROM development efforts a utility post-processor is being developed to determine the relative effects of transport, vertical flux, and chemical production on predicted ozone concentrations. This will help in understanding the composite picture of spatially and temporally distributed ozone that is produced from the model by looking at the fractional impacts of the most significant processes in the system. An "inert-species" version of the model is also under development where the chemical species have been replaced with a finite number of inert tracer species that are emitted by different major source areas. The predictions from this version of the model will map out areas of influence, in trajectory fashion, of the emissions from these major source areas.

2.2.2.2 Regional Oxidant Model Chemical Mechanism Development

The initial version of the Carbon Bond IV (CBM-IV) chemical kinetic mechanism was integrated into the production version of ROM2 during FY-1987. This mechanism contains 70 reactions and 28 reactive chemical species, including eight reactive hydrocarbon classes, one of which is an explicit treatment of isoprene, a biogenic organic compound. Simulations performed with the ROM2 thus far have used this mechanistic representation of the chemistry. In the latter part of FY-1987, a draft version of an updated CBM-IV was received from the developers of the mechanism (Systems Applications, Inc.). The revised mechanism contains more refined chemical pathways for the aromatics species, explicit representations for formaldehyde and methanol, and updated rate constants and temperature dependencies for the rates. The revised mechanism contains 82 reactions and 33 species. Initial testing showed this chemistry to be slightly more reactive than its predecessor. It will be integrated into the production version of the ROM2 after further box-model testing.

2.2.2.3 Evaluation of the Regional Oxidant Model

The evaluation of the second generation Regional Oxidant Model (ROM2) using the 1980 Northeast Regional Oxidant Study (NEROS) data base was begun during FY-1987. The purpose of the project is to quantify the performance of the ROM2 in predicting ozone concentrations over regional scales and within major urban source plumes on the regional scale. The model is being run for the period of July 21, 1980 through August 31, 1980 during which time there were several major ozone episodes in the eastern United States. While ozone is the focus of the evaluation effort, the performance of the model for NOx and hydrocarbons will be studied as well.

Methods of aggregating surface monitoring stations for use in preparing statistics of observed and predicted concentrations were studied. The aggregating method based on the frequencies of observed ozone concentrations was chosen. Six groups of monitoring stations were formed based on a cluster analysis of their observed ozone concentrations during the ozone season of 1980. Comparisons of observed and predicted concentrations for each group of receptors will be performed, including use of cumulative frequency distributions of all hourly concentrations and analysis of daily maximum and daily daylight average (0900h-1600h) ozone concentrations.

Comparisons of observed and predicted concentrations for one particular location and time in the modeling domain will not be made, in keeping with the "quasi-deterministic" method of model use. In this method, model results are used only in aggregated, or averaged form because of the uncertainties inherent in the flow field determination.

The Kriging technique will be used to compare the spatial patterns of observed and predicted ozone for selected plumes from major source areas. Analysis of the aircraft data taken during NEROS will help determine the background boundary layer burden of pollutants as well as help determine the downwind extent of major urban source plumes. Comparisons of NOx data from the regular surface monitoring network and hydrocarbon data from the special NEROS surface and aircraft monitors will be made in a diagnostic fashion.

2.2.2.4 Mass Balance Validation of Urban NOx and VOC Emission Estimates

NOx and VOC emissions from urban and industrial complexes comprise a significant fraction of the total emissions of such pollutants nationwide. However, uncertainties in the area source emissions are believed to be large. For example, the VOC emission data may be underestimated by as much as 3 or more for some cities; the VOC/NOx ratios from emission inventories are smaller than ambient concentration ratios from measurements by 5 or more. This situation creates an environment for large associated modeling uncertainty.

The mass balance approach is a means to estimate the magnitude of source strength of the emissions from an urban area. The aggregated emission is determined from measured excess crosswind and vertically integrated pollutant concentration over background in the urban plume just downwind of the emission area. The accuracy of the derived emission will be limited by the sum of observational and modeling uncertainties since the mass balance approach utilizes model calculations to adjust for pollutant transformation and deposition losses from within the emission area upwind of the sampling plane. A research program to examine the feasibility of such an approach was initiated under a cooperative agreement with Washington University.

2.2.2.5 Development of Custom Computing Equipment to Accelerate Regional Scale Model Simulations

The change in the focus of model applications that has occurred in the last ten years from two-day urban scale simulations to seasonal or longer regional scale modeling has magnified the size of models by a much larger factor than the increase in computer capacity during the same period. This disparity between the growth rate of model size and computer power motivated a study to determine the feasibility of building a custom digital hardware device that could be attached to a minicomputer to accelerate the execution of the ROM and other large computer models for applications work. The study showed that 100-fold increase in speed is feasible using an accelerator based on a loosely coupled processor architecture. The study also showed that the vector machine architecture, which is the basis of most of the modern high speed mainframe machines, is not well suited to the ROM, because the "stiffness" of the differential equations that form the modeling basis has large temporal and spatial variability, induced mainly by the highly segregated nature of air pollutant sources on the regional scale. A report will be prepared in FY-1988.

A cooperative agreement was begun in late FY-1987 with the Research Triangle Institute to design a prototype (10-fold speed increase) hardware accelerator and supporting software for use with the ROM model on a VAX or microVAX computer. The hardware will be composed of 22 loosely coupled microprocessors, working in a parallel processing environment. The specific architecture decided upon for the prototype will use the mainframe or host machine to calculate the horizontal transport portion of the model while the microprocessors will solve the chemical and vertical flux portions. The chemical calculations can account for nearly 90% of computational time. Allocating these calculations to the system of parallel processors should therefore afford the most efficient use of the microprocessor environment.

2.2.3 Particulate Matter Modeling

2.2.3.1 Eulerian Regional Particulate Model (RPM)

The objective of this program is to develop, enhance and evaluate an Eulerian Regional Particulate Model (RPM) which focuses on particle size ranges of 0 to 2.5 μm and 2.5 to 10 μm to assist in addressing potential air regulatory issues relating to particulate matter, visibility degradation, and acid aerosols. To obtain this objective, a comprehensive aerosol chemistry and dynamics module (Hudischewskyj et al., 1987) is being incorporated into the Regional Oxidant Model (ROM) (Section 2.2.2.1) along with a convective cloud algorithm being developed internally.

During FY-1987, the aerosol chemistry and dynamics module was received and modified to interface with the ROM. A simple photochemical box model has been modified to provide a test bed for debugging to the aerosol module and for interfacing it with the convective cloud processor. An initial cloud processor was completed and is undergoing performance testing. Following the precedent set with the Regional Oxidant Model, the cloud module will use observed information on the horizontal and vertical extent of cloud cover from the USAF 3D-MEPH cloud archive as well as conventional surface and upper air observations. The cloud module assumes that clouds within a 40 km grid cell can be represented by a simple steady-state process which has an adiabatic updraft mixing with air from the cloud top to yield liquid cloud profiles within the cloud volume. The model generates vertical profiles of cloud water, rain, cloud ice, and graupel (frozen rain) as well as the relative amounts of cloud base and cloud top air. These profiles will be used in the aqueous-phase chemical routine.

Plans have been completed to implement 0 to 2.5 μm particulate matter measurements in the ACID-MODES field study. The measurements will be made at 32 sites over an 8 month period and used, along with other ambient measurements at these sites, to evaluate the RPM and other regional-scale particulate matter models.

2.2.3.2 Evaluation and Testing of the MESOPUFF II Model System

The MESOPUFF II regional Lagrangian puff model was evaluated using meteorological data and tracer concentration measurements from the Cross Appalachian Tracer Experiment (CAPTEX) field program to assess its ability to predict tracer concentrations out to 1000 km. Athough modeled concentrations were within a factor of two of observed values for four of six case studies, the model overpredicted mean and peak concentrations whether paired in time and/or location, especially on the first sampling arc at 300 km downwind. The overpredictions are believed due to the inability of simple parameterizations to simulate the complex dispersion processes occurring during the transition of the boundary layer from unstable to stable conditions, especially when associated with large wind shear through the boundary layer.

MESOPUFF II performed better in predicting the location and timing of the tracer plume at the 300 km sampling arc using mixed layer average wind fields than when either surface or 850 mb wind were used. Additionally, model concentrations were closer to observed values at this arc when the uniform vertical mixing option was applied instead of a vertical Gaussian dispersion coefficient. The results of the model evaluation are to be documented in a report in early FY-1988.

2.2.3.3 RELMAP Modeling of Particulate Matter

A module was added to the Regional Lagrangian Model of Air Pollution (RELMAP) to calculate across eastern North American air concentrations and deposition amounts of two major components of fine particles (i.e., sulfate and primary fine particles) and the anthropogenic component of coarse particles (Eder et al., 1986). The nitrate component of fine particle mass (usually less than the sulfate component) and the nonanthropogenic component of the coarse particle mass (much larger than its anthropogenic counterpart) are not yet considered in the model.

To better understand the roles of the modelled processes a sensitivity analysis was undertaken. Results indicated that the air concentration of fine particles was much more sensitive to the parameterizaton of wet deposition than these for transformation of sulfur dioxide to sulfate and dry deposition (Eder, 1987). Similarly, the air concentration of particles was most sensitive to wet deposition, but dry deposition of coarse particles played a more important role.

In addition to the sensitivity analysis, model calculations for the summer of 1980 were compared to the air concentrations of fine and coarse particles measured during the same period at 14 rural sites of the Inhalable Particulate Network. As expected the model calculations were lower than those measured, by factors of 3 and 5 for fine and coarse particles, respectively. Deficiencies in the particulate matter emissions inventory and the dearth of appropriate particle measurements precluded a more rigorous evaluation. A more thorough evaluation of the model will be performed using the NAPAP 1985 emission and particulate matter data from the ACID-MODES field study.

2.2.4 Boundary Layer Studies

2.2.4.1 Boundary Layer Diffusion Research

Mathematical models accounting for the highly non-Gaussian behavior of observed vertical diffusion in convective boundary layers were developed and tested. It was shown that the descent of the maximum in the vertical concentration profile from elevated sources and the resulting concentration impacts at the surface can be adequately modeled by a relatively simple approach: straight line diffusion with direct reflection from the surface or the lid of the mixing layer, responding initially to an idealized probability distribution function (pdf) of vertical velocity in the turbulence at the height of release. Turbulence field data were used to show considerable natural variation in 1-hr averages of these pdf's. Data from the CONDORS convective diffusion experiment showed that the measured vertical profiles fit the model when averaged over several runs, but individual 30 to 40 min averaging periods showed variable behavior with 50 percent variation in the (dimensionless) surface concentrations. This was consistent with observed variations in the pdf of vertical velocity. A book chapter was prepared that explains and reviews the uses of various theoretical frameworks in analysis of diffusion field experiments. It elaborated especially on surface layer similarity, convective scaling, and statistical theory based techniques. The first of two journal articles on the CONDORS convective diffusion experiment was prepared and submitted for publication. This article gives a detailed description of the experiment and a summary of the preliminary findings already published. The second article, in preparation for FY-1988, will present measured plume contours for each of the 16 averaging periods and a comprehensive analysis of these diffusion patterns in terms of variations in the meteorological variables, using convective scaling as a primary analysis tool.

2.2.4.2 Wide Area Ozone Dry Deposition Study

Analyses of vertical fluxes of ozone and related turbulence parameters was performed from measurements collected from specially-designed aircraft sampling flights during the NorthEast Regional Oxidant Study (NEROS) field program. Objectives of the aircraft flight program were to investigate the daytime and spatial variations of ozone fluxes and deposition over real-world land cover areas. Flight legs were performed at various levels within the convective boundary layer over agricultural cropland and forested ridges surrounding Lancaster, Pennsylvania and above agricultural fields and forested areas in central Ohio. Results for the Lancaster area in Godowitch and Ching (1986) revealed a mean ozone flux of -0.39 ppb m/s during the midday period which corresponded to a mean deposition velocity of 0.90 cm/s at 110 m above the agricultural fields. Results for the agricultural areas in Ohio showed similar ensemble mean values. Analyses of the central Ohio flights also consisted of subdividing the long flight paths of up to 70 km in length into approximately 18 km length segments in order to assess the possible spatial variations due to the land use variations and urban plume effects. The results revealed that vertical flux divergence was generally strong as the largest negative ozone fluxes existed in the lowest level flight legs and values decreased rapidly with height in the convective boundary layer. Due to the strong height dependency, ozone fluxes from segments within low level flight legs were adjusted to a common altitude to eliminate the variability from terrain or aircraft height changes along the flight path. Results revealed no detectable variation in deposition velocity perpendicular to the Columbus urban plume. Additionally, no perceptable differences were found in the ozone fluxes among segments exhibiting varying amounts of agricultural and forested land. Some results of this analysis for the Ohio flights will be published in FY-1988.

2.2.4.3 Boundary Layer Experimental Measurements Data Base

The objective of this program is to document and archive boundary layer experimental data sets from past field programs. Turbulence measurements collected on two towers and by a research aircraft during the Tennessee Plume Study were subjected to various quality assurance tests and archived on separate data files. A report describing the turbulence parameters and fluxes, quality assurance tests, data format, and selected statistical results will be published in FY-1988.

A data base was constructed of vertical profiles of temperature, dewpoint, sulfur dioxide, and aerosol backscatter coefficient measurements obtained during four summer, three winter, and one fall intensive study periods of the Regional Air Pollution Study (RAPS) urban boundary layer field program in St. Louis, Missouri. The data base contains 2652 individual profiles obtained from helicopter spirals above selected sites in the urban area during experiments focusing on the post-sunset period and the morning transition period after sunrise. A separate data file of inversion parameters including the nocturnal inversion base and top heights, and inversion strength for each profile was also created. A report to be completed in FY-1988 will document the instrumentation, data processing and quality tests, and selected statistical results. Godowitch et at. (1987) contains specific results on the time and space-varying urban boundary layer depth during the morning transition period from the summer experiments.

2.2.5 Technical Support

2.2.5.1 Regional Oxidant Modeling for Northeast Transport (ROMNET)

Preliminary designs were developed for a major three-year program involving the use of the Regional Oxidant Model (ROM) to estimate future-year boundary conditions for urban models. The purpose of the program is to provide State and local agencies in the northeast United States information to estimate inflow boundary conditions when using urban air quality models in future-year emission scenario testing. The ROM will be exercised in this program as the broad regional model which would determine the inflow patterns for most of the Northeastern metropolitan areas. A secondary purpose of the program is to evaluate the effects of combined regional and urban strategies on regional ozone concentrations in the Northeast. The development of a protocol for the anticipated FY-1988 through FY-1990 program was begun during this fiscal year.

2.2.5.2 Southern California Air Quality Study (SCAQS)

The Air Resources Board of the State of California is sponsoring the Southern California Air Quality Study (SCAQS) project to develop a comprehensive and properly archived air quality and meteorological data base for the South Coast Air Basin of California, including the Los Angeles Metropolitan area. The data base will be used to test, evaluate, and improve elements of air quality simulation models for oxidants, NO_2, PM-10, fine particles, visibility, toxic substances, and acidic species. The first field study period occurred during FY-1987, from mid-June through early August. A second study period is scheduled for the fall of 1987. The Model Working Group, a technical advisory group for the SCAQS, included a representative from the Meteorology Division. The group's discussions during this fiscal year focused on needed improvements and modifications to existing air quality models to make them compatible with application to the SCAQS data base. A set of suggestions was prepared and sent to the Management Advisory Group of the SCAQS for consideration.

2.2.5.3 National Acid Precipitation Assessment Program

A physical scientist of the Division serves as chairman of the National Acid Precipitation Assessment Program (NAPAP) Task Group III on Atmospheric Transport and Modeling. During FY-1987, a major technical review of the RADM model development program took place. NAPAP established a ten-member scientific panel to conduct this review. The panel was asked to evaluate the extent to which the program objectives were met and make recommendations on how best to achieve the objectives of a defensible, efficient model. Several key findings were: 1) the development of the Regional Acid Deposition Modeling system over the past four years was an impressive achievement, 2) the plans presented for the second version of RADM appear to assure that the RADM system will be at the forefront of the scientific capabilities while still providing a model that can be used within available computer resources, 3) a comprehensive model evaluation program is needed and it should interact strongly with the model development, and 4) the second version of RADM (RADM II) should be used for the purpose of the NAPAP assessments rather than a simplified engineering model. The panel recommendations are being implemented into the NAPAP.

2.3 Fluid Modeling Branch

The Fluid Modeling Branch conducts physical modeling studies of air flow and pollutant dispersion in such complex flow situations as in complex terrain; and near buildings, near roadways, and near storage piles. The Branch operates the Fluid Modeling Facility consisting of large and small wind tunnels and a large water channel/towing tank. The meteorological 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 simulation of 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 high. It has a speed range of 0.1 to 1 m/s and the towing carriage a range of 1 to 50 cm/s. It is generally used for simulation of strongly stable flow.

2.3.1 Complex Terrain Studies

A project report was prepared describing the contributions of the Fluid Modeling Facility (FMF) to the Complex Terrain Model Development Program (CTMDP) over the past eight years. The primary emphasis of the CTMDP was on plume impaction on nearby hills during nighttime stable conditions. The FMF interacted closely with the model developers participating in the CTMDP and provided support in various ways through the conduct of a wide range of laboratory studies. Work at the FMF prior to the inception of the program provided the basic framework for the Complex Terrain Dispersion Model -- the dividing- streamline concept -- and the focal point around which the field program was designed. At the beginning of the program, the FMF provided direct support as an aid to planning the details and strategies of the field experiments and testing the limits of applicability of the dividing-streamline concept. Later work included exercises of "filling in the gaps" in the field data, furthering the understanding of the physical mechanisms important to plume impaction in complex terrain and in stably stratified flows in general, testing various modeling assumptions, providing data for "calibration" of various modeling parameters, and testing the ability of the laboratory models to simulate full-scale conditions. Finally, several supplemental studies were conducted, broadening and expanding upon the specific requests of the model developers. The report (Snyder, 1987) provides considerable detail and a comprehensive list of over 65 publications generated from the work conducted at the FMF on complex-terrain research. Highlights of this work were also presented by Thompson (1987).

Results of several prior-year studies were written up and accepted for journal publication. One was a series of experiments conducted in a cooperative venture with Los Alamos National Laboratory to investigate the question of when a stable crosswind will sweep clean the valley between two ridges and when the flow in the valley will decouple from the winds aloft and thus stagnate in the valley. This work (Lee et al., 1987), done in the stratified towing tank, suggests that the characteristics of the flow between the ridges may be described using criteria for boundary-layer separation from the lee side of a single ridge, and that the downstream ridge induces separation from the lee side or the upstream ridge only when it is steep-sided. As an offshoot of this work, the conditions conductive to the onset of severe downslope winds on the lee sides of mountains were investigated (Rottman and Smith, 1987). The results showed that elevated rotors associated with breaking waves and severe downslope winds exist when the Froude number based on ridge height was in the range $0.2 \leq Fr \leq 0.6$ for a steep-sloped ridge (40°) and $0.2 \leq Fr \leq 1.1$ for a low-sloped ridge (13°).

Another series of experiments was conducted to examine the unsteadiness of stably stratified flow over hills in the towing tank. A strain-gage force balance was used to measure the drag on a variety of hills (shapes and sizes) -- this provided a direct and overall assessment of the unsteadiness of the flow fields. Analysis of these data should help to assess the similarities between laboratory experiments and full-scale flow fields.

In a prior year, a study of the nature of dispersion from point sources downwind of three-dimensional hills of various crosswind aspect ratios (spanwise breath/height) was conducted (Snyder and Britter, 1987). In FY-1987, this study was extended to the case when the approaching wind was not normal to the spanwise axis of the hill. Surface concentration patterns resulting from sources placed at various heights were examined, with attention limited to cases which led to the greatest concentration for the normal wind direction ($\theta = 0$). Sufficient data were obtained to determine the terrain amplification factor (i.e., the ratio of the maximum ground-level concentration in the presence of the hill to that in its absence) for various wind directions, hills, and source heights, and also to find how the ground level concentration at the position of its maximum for $\theta = 0$ varied with wind directions. The latter allows one to use wind-tunnel data to estimate the effects of long-time-scale wind meander, assuming that wind-tunnel averages are equivalent to full-scale averages of, say, 15 minutes. It was demonstrated that in some circumstances the amplification factor (A) for a particular source position actually increased with small changes in wind direction. In general, however, there was a monotonic decrease in A as θ deviated from zero, which was most rapid for hills of small aspect ratio. In the case of wide hills, the amplification factor was sometimes reduced below unity for large values of θ.

2.3.2 Miscellaneous Studies

Surface and centerplane flow patterns in the wakes of model buildings were observed using a new surface flow visualization technique developed by Langston and Boyle (1982). Dots of ink were spotted at grid points on a mylar sheet and allowed to dry. Oil-of-wintergreen was then lightly sprayed onto the surface. The oil dissolved the ink, and the wind caused the ink-oil film to flow, vividly portraying the surface flow patterns. This technique appears to have several advantages over older techniques. Centerplane flow patterns were observed by placing the mylar sheet on the centerplane of the building and mounting this apparatus on the sidewall of the wind tunnel (to avoid detrimental gravitational effects on the flow pattern). Comparison of one set of results with extremely time consuming pulsed-wire anemometer measurements of Davies et al. (1980) showed similar qualitative features, but slightly different quantitative features -- the splitter plate on the centerplane did not allow the alternate vortex-shedding as would normally be observed. The surface flow patterns supported the postulate of Mason and Morton (1987) that surface-mounted obstacles that divide the flow laterally (e.g., tall-narrow buildings) produced central downwash in their wakes, whereas obstacles that lift the flow (e.g., squat buildings) produced central upwash; these findings have obvious consequences in designing stacks near buildings.

Under a cooperative arrangement with the Los Alamos National Laboratory, a video-image analysis system was developed to investigate diffusion of smoke in the wakes of model buildings in the wind tunnel. Under appropriate conditions, the video image intensity can be related to the vertically integrated smoke concentration. The relationship was established through tests conducted on a 20 cm cubical building with a source located at ground level on the lee edge of the building. Lateral profiles of vertically integrated concentration were measured using standard techniques -- flame ionization detectors and a hydrocarbon source. These measurements were compared with time-averaged light intensity from the video system (with a smoke source) to establish the relationship. Results thus far are highly promising. The advantages of the video analysis technique are: (1) ease of analysis, (2) mapping of the entire concentration field at one time, and (3) measurement of concentration fluctuations, albeit vertically integrated. Disadvantages include: (1) difficulty in quantifying the source, (2) difficulty in obtaining uniformity in illumination, and (3) do not represent point measurements, although the possibility of using sheet lighting to obtain point measurements remains to be explored.

Two separate studies were undertaken to further explore the behavior of dense gases. In a prior study (Britter and Snyder, 1986), CO_2 as the dense gas was released on flat terrain, and the characteristics of the dense-gas plume were measured extensively. One of the current projects was conducted to supplement the data collected by Britter and Snyder to examine the effects of a heavier gas. For this purpose, SF_6 (sulfur hexafluoride) was used as the effluent. It has a specific gravity of 5.11 compared with air; by contrast, CO_2 has a specified gravity of 1.5. The results clearly showed the much stronger effects of the negative buoyancy, much wider lateral plume widths and much thinner vertical dimensions. Interestingly in comparing the vertical concentration distributions for the three sources (tracer in air, CO_2 and SF_6), it was found that the distributions could be fitted by exponentials of the form $C\backslash C_{mx} = exp[-Az^n]$. For the neutrally buoyant plume, $n = 1.5$ ($n = 2$ for a Gaussian distribution) and for the CO_2 plume, $n = 1$. The SF_6 profiles exhibited self-similarity over the entire range of downwind distance, but could not be fitted with a single value of n. These data displayed an n-value of 1.9 close to the surface and approximately 0.6 in the outer portions of the plume (i.e., beyond the point where C/C_{mx} 0.1). The physical significance of this profile shape is not understood. These results will be used in the development and evaluation of a mathematical model.

The second dense-gas study involved the release of CO_2 on sloping terrain in a wind tunnel where the approaching wind direction was up the slope. The purpose was to investigate what wind speed was required to overcome the gravitational tendency of the dense gas to travel down the slope. The terrain model consisted of a ramp of constant slope followed by an elevated plateau. CO_2 releases were made at the mid-slope elevation. Several ramp slopes were investigated and plume characteristics were measured at each of several wind speeds both above the threshold wind speed.

2.4 Data Management Branch

The Data Management Branch coordinates all ADP activities within the Meteorology Division, including the design, procurement, and implementation of data base management, computer systems analysis, and ADP studies. The Branch provides data management and programming services that are done primarily through ADP service contracts.

2.4.1 Regional Oxidant Model Applications

The second generation Regional Oxidant Model (ROM) was executed for three selected episodes to study the impact of Treatment, Storage and Disposal Facility (TSDF) hydrocarbon emissions on maximum hourly ozone August 21 - 30, 1980 in the northeastern United States and August 19 - September 1, 1980 in the southeastern United States. A base case with TSDF emissions and one control strategy with 100% reduction of TSDF emissions were executed for each episode. The TSDF emissions in the northeast United States had little effect on the diurnal pattern or maximum hourly ozone. However, peak hourly ozone concentrations in the southeast United States were influenced by TSDF emissions mainly in over water regions (where atmospheric stability is greater) and only near the relatively large TSDF source regions of Houston and southern Louisiana. A maximum difference of 158 ppb occurred over the Gulf of Mexico.

ROM was executed also in the southeastern United States for August 18 - September 1, 1980 to assist locating monitoring sites as part of the National Acid Precipitation Assessment Program.

2.4.2 Biogenic Hydrocarbon Emission Sensitivity Studies

ROM executions were performed to assess the impact of biogenic hydrocarbon emissions on ozone formation. Model results indicate a 20 ppb to 40 ppb contribution downwind of major NOx plumes northeast of Pittsburgh and in the Appalachians. Contributions of biogenic hydrocarbon in other areas of the Northeast were minimal thus suggesting that biogenic hydrocarbon does not have a major role in non-attainment of the ozone National Ambient Air Quality Standard in urban areas. Model predictions including biogenic hydrocarbon emissions were in agreement with observations in this geographical area.

The biogenic hydrocarbon emissions used in this study were estimated by the Biogenic Emission Software System (BESS). This software and associated data set have been updated to encompass the southeastern United States and to handle emission variations in the spring and fall. Further modifications are underway to include a canopy model in the methodology for incorporating temperature effects on emissions. The general agreement of observed and predicted ozone concentrations lend support to the accuracy of the biogenic hydrocarbon emission estimates and to the treatment of their chemistry in Carbon Bond IV. Using the recommended National Acid

Precipitation Assessment Program methodology for emission uncertainty estimation, an error band of 109% has been calculated for the total biogenic emissions in a ROM grid square.

2.4.3 Improvement of the Regional Lagrangian Model of Air Pollution (RELMAP)

The wet deposition parameterizations for SO2 and SO4 in RELMAP were modified to include the latest research findings. These modifications result in averaged increases of about 20% for wet deposition of SO4 and average decreases of about 50% for wet deposition of SO2. Dry deposition parameterizations were updated, and higher resolution land use data sets are now being used for input to the dry deposition equations. For the purposes of estimating dry deposition quantities, each RELMAP grid cell is now defined with multiple fractioned land types rather than with the predominate land use type only. This modification produced dry deposition results which showed significantly higher correlation between the values for particular RELMAP grid cells and the observed values at sites located in those grid cells.

Discrete hourly precipitation measurements are now used to incorporate subgrid effects of precipitation on the deposition within each grid cell. This modification results in an average decrease in wet deposition quantities of about 40 percent, with the greatest differences occurring for grid cells with 10 or more precipitation measurement sites.

The RELMAP code and associated data processors have been converted to run in a VAX environment. The RELMAP code has recently undergone a major revision in order to use the latest enhancements to the FORTRAN programming language and to allow more efficient processing in the "source-receptor" mode of operation. It is estimated that present applications of RELMAP in "source-receptor" mode are executing in less than one-third the CPU time that was required for previous versions. This improvement in efficiency has allowed most RELMAP applications to be performed on a MicroVAX.

Output file contents and formats were modified to interface with newly developed graphical analysis software packages, allowing all model results to be immediately displayed and reviewed as soon as the model executions are complete. These graphical analyses are produced on laser-jet printers and are of publication quality.

2.4.4 Branching Atmospheric Trajectory Model (BAT)

The BAT model was converted to the VAX cluster. The model can run both forward and backward trajectories. A routine is also available that will plot the trajectory points with a geographic background.

The data consists of meteorological wind and temperature observations collected on a daily basis from several recording stations in North America. Recordings were made at four different times throughout the day. Data for years 1980 through 1986 are available. There are two tapes for each year, one with forward readings and one with reverse readings. This data is used for tracking particulates from various source locations to various receptor locations.

2.4.5 Modification of the Advanced Statistical Trajectory Regional Air Pollution (ASTRAP) Model

The modification of ASTRAP has progressed to the point where the final report is being written. Several more options were added to make the model more flexible. The model may be run in several modes, either alone or in combination. This includes a test mode with a single default source or with one or more sources from an actual emission set; with or without the time steps being compressed to 12 steps; and with any assortment of virtual sources the user wishes.

A major change in ASTRAP was the replacement of the National Meteorological Center (NMC) precipitation input data sets, which were excessively wet, with precipitation data sets from the RELMAP program. This has reduced the total precipitation entering the model by approximately 75%. An adjustment in the model was also made to include reports of any measured precipitation value. This restored most of the wet deposition lost by using the more realistic data sets, but resulted in model predictions of only 75 to 80% of the ASTRAP wet deposition. Experiments are presently underway to determine what effect, if any, the elimination of the time-compression aspects of ASTRAP will have on the wet deposition results.

To date, the best correlation factors between the revised model and actual data is:

Spring	-	0.62
Summer	-	0.66
Autumn	-	0.39
Winter	-	0.21
Annual	-	0.59

This compares to the ASTRAP results from the International Sulfur Deposition Model Evaluations after Kriging of:

Spring	-	0.66
Summer	-	0.72
Autumn	-	0.42
Winter	-	0.50
Annual	-	0.67

The revised model can simulate annual point source-receptor relationships for the entire combination of all sources against all receptors for an entire year in about three hours of CPU time. The same procedure on the RELMAP model must be measured in CPU weeks.

2.4.6 Division ADP Support

Major upgrades of the in-house ADP capabilities were implemented. These include the procurement of a local area network, fiber optic link to the National Computer Center mainframes and minicomputers, an on-site Microvax II, several personal computers, terminals, plotters, and laser printers all of which provide for greater computer access and a more productive work environment. Graphics hardcopy output devices have been replaced with queued laser printers.

The Regional Acid Deposition Engineering Model (RADM/EM) and the National Center for Atmospheric Research (NCAR) graphics package were installed and are fully operational on the VAX cluster. RADM/EM was executed to support the study of superposition of sources and linearity of deposition predictions. The NCAR graphics package was modified to provide laser printer graphics.

A PC based digitizing capability was developed in support of the complex terrain program.

2.5 Terrain Effects Branch

The Terrain Effects Branch studies the effects of complex irregular terrain and man-made surface features on ambient pollutant dispersion, on both an intramural and extramural basis; establishes mathematical relationships among air quality, meteorological parameters, and physical processes affecting the air quality; and conducts research in the areas of air pollution climatology and acidic deposition.

2.5.1 Complex Terrain Modeling

2.5.1.1 Complex Terrain Dispersion Model Development for Sources in Complex Terrain

The Complex Terrain Dispersion Model, as described in the FY-1985 annual report (Viebrock and Poole-Kober, 1987) was completed in November, 1987. Comparison of model predictions from CTDM and those of other models with most available data sets shows that the CTDM is an improvement over presently available plume impaction models. CTDM is unique in that it was designed to be run on a personal computer with user-interactive input, control, and graphics. The model and a series of user manuals will be made available to the regulatory and scientific community for use in evaluating the impact of point sources on air pollution concentrations in complex terrain.

2.5.1.2 Complex Terrain Data Base Documentation

Three computer data bases of meteorological and tracer gas observations from the CTDM tracer field studies at Cinder Cone Butte, Idaho; Hogback Ridge, New Mexico; and the Tracy Power Plant, Nevada were converted to a new data base applicable to the Statistical Analysis System (SAS) of computer software. SAS software was used to organize data from all three CTMD studies into a series of SAS data sets to form a new combined data base. The new data base is adaptable to SAS software programs where graphics and statistical analysis procedures can be utilized to full advantage. Documentation of the SAS data base is contained in a report, which describes the SAS data sets of meteorological and tracer gas observations. The data base is available as tape copies or by interactive computer access.

2.5.1.3 Complex Terrain Modeling in Unstable Conditions

In response to the needs of the regulatory community for complex terrain algorithms to model transport and diffusion in unstable/convective boundary layers, an in-house research effort was begun to integrate the Complex Terrain Dispersion Model (CTDM) with a combination of the most successful technology in existing models and the most advanced research results on convective boundary layers. Compatibility with the CTDM formulations and data input requirements is a paramount consideration in the direction of the new convective algorithm's development.

A review of the literature on convective boundary layers and of the documentation on currently available models was performed. After discussions with authors of some of the most recent literature, several promising areas of model development were discovered. These areas are the inclusion of convective scaling concepts into the algorithms for plume rise, plume penetration into the elevated stable layer, and the vertical and horizontal diffusion parameters; the extension, where possible, of the flow deformation algorithms in CTDM into conditions involving a well-mixed daytime boundary layer; and an improved specification of the adjustment of the mixing depth by the terrain. Specifically, the convective scaling ideas developed by Deardorff's (1972) numerical simulations and laboratory experiments (Deardorff and Willis, 1974, 1975; Willis and Deardroff, 1974, 1976) and further extended by these authors and others (Weil, 1985, Briggs, 1985) will be the basis for updating the model dispersion parameters and the algorithms for plume rise and penetration.

A fluid modeling study planned for FY-1988 was designed to examine the deformation by terrain of the top of the well-mixed daytime boundary layer capped by a stable layer. Also the study will examine the deformation by terrain of streamlines both within the simulated well-mixed layer and at and above the base of the elevated stable layer. The results of this study will guide the development of improved terrain adjustment parameters.

2.5.1.4 Supplemental Evaluations of the Complex Terrain Dispersion Model

A case study evaluation of the Complex Terrain Dispersion Model was undertaken to compare model estimates against towing tank experiments on a model Cinder Cone Butte terrain feature. The towing tank at the Fluid Modeling Facility simulates the stably stratified conditions which are frequently observed during field experiments at the actual Cinder Cone Butte site. Qualitatively, the concentration distributions from CTDM and the fluid modeling study compare reasonably well with the exception of a few cases where the plume is below the critical dividing streamline height and CTDM does not adequately simulate the magnitude of plume impingement. CTDM does particularly well in estimating the maximum ground-level concentrations when the plume is directed toward the center of the hill regardless of the height of the plume in relation to the critical height. The quantitative agreement was not as good for the particular case of off-center winds and a plume trapped below the critical height.

This cursory evaluation of CTDM will be used in the design of sensitivity studies to be performed in fiscal year 1988 to further improve our understanding of the applicability and limitations of the CTDM.

2.5.2 Climate Change

A new research program on global climate change has started with the goals of studying the emissions of trace gases into the atmosphere and the impact of climate change on the environment. The Meteorology Division is planning research activities that will supply information needed in support of those goals. This will include the impact of climate change on future air quality, the impact of urban emissions on regional and global atmospheric composition, the production of future regional climate and air quality scenarios for environmental effects research using analogue and modeling results, the development of climate descriptors relevent to ecological effects, and the development of new methods for the detection of regional and hemispheric trends in climate. A workshop was held on statistical problems in trend detection, and others planned on regional model sensitivity to climate change and production of climate change scenarios. Research began on large scale atmospheric chemical models, the statistics of gridding, and the evaluation of present climate variability in the United States. Plans call for preparing scenario methods and production by the end of the year.

2.5.3 Wake Effects Studies

2.5.3.1 Video Analysis of Plumes

Research is being conducted to develop and apply video image analysis techniques to study smoke plumes in the wake of wind-tunnel model buildings. A research paper was prepared (Huber, 1987b) in which video image analyses are shown to be especially useful in studying the temporal-spatial plume distributions in ways that are not obtainable from traditional point-tracer measurements.

Spectral analysis was found to identify dominant shedding in the wake of buildings. Further research will continue to refine these techniques. Additional methods for analyzing video images are being evaluated through a cooperative research agreement with North Carolina State University. These methods are primarily related to motion detection and picture texture.

2.5.3.2 Wake Effects

A research project to evaluate the effects of building wakes on plume dispersion is continuing. Data from previous field wind-tunnel modeling studies are being analyzed. No new wind-tunnel studies were conducted during FY-1987, but a large data base of digitized video pictures, velocity measurements, and tracer concentrations was assembled. This data will be analyzed during FY-1988 and additional fluid model studies planned. A paper (Huber, 1986) on the effects of building orientation was presented.

2.5.3.3 Model Evaluation

Model evaluation research is being conducted to identify model evaluation criteria and to develop improved plume disperion models. A research paper on the inherent limitations of a Gaussian plume model for predicting plume concentrations in the wake of buildings (Huber, 1987a) was revised. Potential model improvements will be evaluated in FY-1988.

2.5.4 Dispersion Modeling in the Arctic

Under a cooperative agreement with Washington State University a study of dispersion modeling in the Arctic is underway. A review of existing data bases showed that none were adequate to evaluate models in the Arctic winter. As a result, a major field study was planned and executed. A short pilot study was conducted in the fall of 1986, and the full scale experiment planned for November, 1987.

2.5.5 Western Mesoscale Acid Rain Model

The Rocky Mountain Acid Deposition Model Assessment project is designed to review and select available mesoscale meteorological and acid deposition models for incorporation into a Rocky Mountain mesoscale acid deposition modeling system. This project is being conducted through a contract with Systems Applications, Inc. A report on the review of existing mesoscale models for use in complex terrain was completed (Morris and Kessler, 1987). A two-day workshop with the Western Acid Deposition Task Force was conducted in May 1987 to review the planned project model. The coding of the initial version of the Acid Rain Mountain Mesoscale Model (ARM3) was begun. The Lagrangian model will handle dispersion, chemical conversion, dry deposition and wet deposition processes over a mesoscale complex terrain area. The computer code for the project model accompanied by a draft user's guide will be sent to all interested western state and federal agencies in early FY-1988 for testing and evaluation.

2.5.6 United States and People's Republic of China Joint Research - 1987

In 1984 the United States and the People's Republic of China conducted a long-range tracer experiment in the Beijing area. SF_6 was released from the Meteorological Tower in Beijing after the passage of strong cold fronts. Samplers were set out in arcs approximately 40 km, 70 km and 150 km from the tower. The Chinese provided a helicopter to obtain vertical profiles of concentration.

The planned data exchange with the Chinese occurred in the fall of 1986. The meteorological and tracer data are being analyzed.

2.5.7 Integrated Air Cancer Program

2.5.7.1 Integrated Air Cancer Program Field Study

A long-term research program was initiated to investigate the toxicity of airborne pollutants. The first phase of this research program is a study of the chemical composition and mutagenicity of woodsmoke. A study is underway of the transport and diffusion of woodsmoke in urban areas, to determine the relative effect of nearby sources on the chemical samples taken at a single site and to determine how woodsmoke diffuses. The first field study was conducted in Boise, Idaho, in the winter of 1986-1987, using a 30-m tower instrumented with two sonic anemometers, two bivane anemometers, and a delta T system. During the month of December, six tracer experiments were conducted using four different tracer gases. The tracer gases were released from houses varying from 100 m to 800 m from the primary site where the tower was located. The tracer data were analyzed to determine the impact on the chemical samplers of near versus far away sources. Preliminary analysis of the meteorological data indicates that dispersion on the tracer gases is due primarily to wave-like motion rather than turbulence.

2.5.7.2 Data Analysis Techniques for Turbulence Data

As part of the Integrated Air Cancer Program wind and stability measurements were taken on a 30-m tower in residential Boise. The Boise meteorological data were taken primarily in stable drainage flows. Spectra and autocorrelations of the data do not follow the expected pattern that are found in daytime measurements.

2.5.8 Model Evaluation Field Study Planning

To provide measurement data for evaluation of large regional models of atmospheric transport and transformation processes associated with deposition of acidic species resulting from emissions of precursor species, an agreement was reached to jointly conduct a monitoring study of surface deposition and of above-surface measurements to aid in model diagnostics. Participants in the study, in addition to the EPA, are the Electric Power Research Institute; the Atmospheric Environment Service, Canada; and the Ontario Ministry of Environment.

Procurement actions to obtain a contractor to perform the EPA-sponsored portion of the study were undertaken, with release of a Request for Proposals in March 1987. Following requests for clarification and negotiations, a contract was awarded to Environmental Research and Technology,Inc. at the end of September. The contract calls for a limited-scale pilot study to be performed in March 1988, with full-scale operation of about 70 monitoring sites to begin in June 1988. An option of the contract allows for four intensive measurement periods, during which a number of aircraft would be deployed to measure patterns of species within and above the boundary layer. Another option allows the contractor to collect detailed operational monitoring data from the largest sources of sulfur and nitrogen oxides in the eastern half of the country.

2.6 Environmental Operations Branch

The Environmental Operations Branch improves, adapts, and evaluates new and existing air quality dispersion models, makes them available for use, and consults with users on their proper application. The research work of the branch consists of two major areas: model availability and evaluation; and improving characterizations of dispersion meteorology.

2.6.1 Air Quality and Effects Modeling

A previously-developed effective mean ozone concentration parameter (Larsen and Heck, 1984 and 1985) was used to estimate soybean percent crop reduction at each agricultural site in the National Aerometric Data Bank (NADB) during each year 1981-1985. Fourteen ozone concentration parameters were calculated for each of the resulting 320 site-years of data. The three best correlations of these 14 parameters that estimate crop reduction are the effective mean ozone concentration (1 percent of variance unexplained), the arithmetic mean ozone concentration (4 percent unexplained), and the maximum 1-month mean of daily maximum 1-h ozone concentrations (15 percent unexplained). The worst correlation of the 14 is for the parameter used in the present ozone National Ambient Air Quality Standard, the second highest daily maximum 1-h ozone concentration (42 percent unexplained).

The number of site-years at estimated soybean percent crop reduction was plotted versus each of the 14 ozone concentration parameters. A maximum crop reduction line was drawn on each plot. These lines were used to estimate potential ambient standards for each of the 14 ozone parameters that would limit soybean crop reduction at agricultural NADB sites to 5, 10, 15, or 20 percent.

2.6.2 Developments in National Weather Service Meteorological Data Collection Programs as Related to Air Pollution Models

One of the principal inputs to an air pollution model is meteorological data. Recognizing that the National Weather Service was modernizing its meteorological instrumentation and data dissemination systems, a study was conducted in FY-1987 assessing how these changes affect pollution models.

To assess the changes occurring, interviews were conducted with individuals within the National Oceanic and Atmospheric Administration (NOAA) and the EPA. Most of these individuals were from the National Climatic Data Center (NCDC) and The National Weather Service. Based on the findings of these interviews, the following recommendations were formulated.

(1) Recognizing that meteorological processors will need to be modified to handle new NCDC data formats, they should also be upgraded to incorporate our more advanced knowledge of diffusion meteorology. This upgrade could also serve as a catalyst for incorporating more advanced modeling techniques into air pollution models. It should be noted that such efforts have begun with the development of the Meteorological Processor for Diffusion Analysis (MPDA) (Paumier et al., 1986) and the Turbulence Profile Sigmas (TUPOS) model (Turner et al., 1986).

(2) The collection of meteorological data specific to diffusion modeling should be encouraged and the feasibility of collecting some of these data at NWS sites should be investigated. As recommended by an expert panel (Hoffnagle et al., 1981), additional meteorological variables such as horizontal fluctuations of wind direction, harmonic mean wind speeds, low-level temperature gradients, and total solar radiation should be collected for air pollution modeling. The EPA has provided guidance (Environmental Protection Agency, 1987b) for collecting some of these variables at on-site measurement programs. Not all air pollution modeling applicants, however, will have access to an extensive meteorological monitoring program and will have to depend on NWS data. Therefore, there should be active coordination with the Office of the Federal Coordinator regarding NWS meteorological data collection programs. In particular, it is advisable that vigorous participation be maintained in the Working Groups for Automated Surface Observations, Profiler Systems, and Radar Meteorological Observations.

(3) The formatting and handling of meteorological data for regional-scale models should be improved. Regional-scale models require vast amounts of surface, upper-air, and satellite data. Because these models operate sequentially, data must be sorted by hour. Unfortunately, NCDC data are sorted by station and not by hour. Consequently, much effort goes into generating a data set in the appropriate format. Two options which could be investigated include the development of a new NCDC data format and direct access and storage of NWS observations.

(4) The Environmental Operations Branch should maintain active communication with NCDC. In performing this study, it became quite apparent that NCDC is willing to be responsive to the needs of the air pollution modeling community. A users' guide describing meteorological data requirements for the Users Network for Applied Modeling of Air Pollution models would improve communication with NCDC, would provide information on how to order meteorological data from NCDC, and could serve as a valuable reference manual for NCDC meteorologists when dealing with air pollution modeling clients.

2.6.3 RAM

RAM is an air quality model based on the Gaussian-plume simplification of the diffusion equation which assumes time independence in the input meteorology and concentration. When first released (Turner and Novak, 1978 and 1987) the model existed in four versions: 1) urban, short-term; 2) rural, short-term; 3) urban, long-term; and 4) rural, long-term. Later the model was revised to include these four modes in a single model. More recently a default option was added for regulatory applications. Use of this option automatically sets certain parameters to preassigned values for consistency with the "Guideline on Air Quality Models (Revised)" (Environmental Protection Agency, 1986). The model is primarily used to determine 3-hour, 24-hour, and annual impact from point and area sources. The simulation is done using hourly meteorological data for the simulated period.

A second edition of the user's guide (Catalano, Turner and Novak, 1987) was made available to be consistent with the current model.

2.6.4 An Evaluation of a Convective Scaling Parameterization

During limited-mixed convective conditions, high concentrations of air pollutants have been observed at ground-level from buoyant plumes. Routinely-applied Gaussian plume dispersion models have difficulty simulating diffusion for these conditions. However, advances in convective scaling offer some hope for improved model formulations.

A study evaluated the usefulness of a diffusion formula proposed by Briggs (1985). Thirty-nine hours of extensive meteorological, source, and tracer data were analyzed from the Kincaid field study. The evaluation of the Briggs formula showed better model performance than that of a Gaussian plume dispersion model.

Because of the sensitivity of the Briggs formula to values of w* (convective scaling velocity), additional research is recommended to improve estimates of the sensible heat flux. Also, further study of the horizontal diffusion of buoyant plumes in the convective boundary layer is recommended.

2.6.5 An Air Pollution Climatology of an Isolated Point Source

An air pollution climatology (Pierce, 1987), which incorporated convective scaling parameters, is used to investigate the conditions associated with hourly sulfur dioxide concentrations from a coal-fired power plant. One year of data from the Paradise power plant in central Kentucky was analyzed. Variables which were examined included emission rate, plume rise, wind speed, wind direction, stability class, convective scaling velocity, and similarity categories. The results show the meteorological conditions leading to high surface concentrations are the daylight hours having neutral/unstable atmospheric stability, light winds, and effective plume height to mixing height ratios typically greater than 0.85. In more than half of the 30 hours of highest observed concentrations, the atmospheric conditions satisfy the criteria for mixed-layer scaling.

2.6.6 UNAMAP Bulletin Board Service (BBS)

Effort continued on the evaluation and assessment of the User's Network for Applied Modeling of Air Pollution (UNAMAP). The contract final report will contain suggestions for future technology transfer of dispersion modeling through UNAMAP based upon considerable contact with current users. Among the suggested improvements will be the use of a computer based bulletin board for rapid dissemination of information about UNAMAP. In considering the need and relatively low cost of establishing a bulletin board, this recommendation was implemented before completion of the work.

The description of the current version of UNAMAP with comments and/or updates to UNAMAP models is available to download. It is not planned to make all the models available for downloading, because of their size, and time involved in downloading, and this service is already provided by the National Technical Information Service (NTIS). Information on ordering UNAMAP models is given as a part of the UNAMAP description. At present the BBS supports four directories: 1) General UNAMAP information, 2) Model evaluation data archive, 3) Files associated with Change 3 of UNAMAP and 4) Files associated with Change 4 of UNAMAP. To provide better service the BBS will be moved to the fVAX during the next year. The BBS is available 24 hours a day except when it conflicts with programs that need to be used by the PC during the day.

2.6.7 Climatological Version of PAL

Recent interest in long-term exposures to hazardous chemicals from dump sites and industrial complexes stimulated interest in investigating the use of hourly data to estimate long-term concentrations. The versatility of PAL (Point Area Line) model is well suited for estimating concentrations from these complexes. The most straight foward approach to estimating the annual average from hourly data, which PAL needs, is to use all hours of the year.

Since PAL does a trapezoidal integration for line and area sources, this could be computationally very time consuming. A more subtle approach is to select only a sample from the annual concentration estimates. If execution times are relatively short then there may be no reason to use a selection process and introduce additional uncertainty in the annual concentration estimate.

PAL2P (the climatological version of PAL2.0) reads it's meteorological data from a binary file which is the output from METPRO (Meteorological Processor), a specially-designed meteorological pre-processor to produce input data to be used by PAL2P. In the following timing test METPRO produced 8760 simulated hours of meteorology (one year) for the single point source configuration and 100 hours of meteorology for all the other source configurations. The run times necessary for 8760 hours were then extrapolated from the 100 hours. The table below shows the run times for different source configurations for the COMPAQ 286 PC and the fVAX.

Run times on COMPAQ 286

# of Pt. sources	# of Ar. sources	# of Ln. sources	# of Rec.	Tot. Hr. Simulated	Run Time (hr:min:sec)	Proj. Run Time To Cimulate 8760 hr. (hours)
1	–	–	8	8760	0:29:08	same
20	25	17	25	100	4:35:38	402
20	–	–	25	100	0:03:16	5
–	25	–	25	100	2:25:04	212
–	–	17	25	100	2:38:09	231
			Run times on fvax (with other users)			
–	25	–	25	100	0: 20: 04	30
–	–	17	25	100	0:19: 07	28

There were four different source configurations tested in the model runs: (1) single point source, (2) a selection of 20 point sources, 25 area sources and 17 line sources, (3) 20 point sources. (4) 25 area sources, and (5) 17 line sources. Except for the single point source case, 100 hours of meteorology were used in the model runs. The run times for 8760 hours were projected from the run times for the 100 simulations. The number of receptor locations was 25 except for the single point source case. The case with all of the source types represents a moderately large number of sources and would be expected to require long computing times. The point, area, and line sources were then separated into individual runs to determine their separate impact on the total run time. Estimating the annual average concentration from a complex source using the COMPAQ 286 can take over 16 days. Even on the fVAX this run would take over two days. These long run times indicate that selection of meteorological input is a viable alternative, maybe even necessary, rather than using all hours of the year to estimate the annual average concentrations.

As indicated it is expensive to compute long-term concentrations using hourly data. Statistical sampling of the meteorological input data can be utilized to calculate long-term estimates using a subset of the short-term periods. The methods used to select the subset of meteorological data preserves the characteristics of the entire set. Two methods used for selection are Proportionate Stratified Sampling (PSS) and Control Selection Sampling (CSS). Proportionate Stratified Sampling, is a process that selects samples from a sequence of values, making it possible to link other information to each selection. The price paid for the association is that there are no guarantees, other than by selecting many samples, that the overall modes in the meteorological conditions are well characterized in the sample. The CSS uses the joint frequency function to control the selection, and therefore forces the sample to characterize the modes in the data. However, all information regarding sequence is lost and therefore may restrict the occasions when such a scheme is useful. Both the Proportionate Stratified Sampling and Control Selection Sampling techniques were shown to be effective for estimating either seasonal or annual averages from hourly data for an urban area. However, it is not clear if smaller source configurations like industrial complexes are amenable to the approach. This will be addressed in future research.

The conclusion is that the selection schemes are needed when area or line sources are modeled. Their run times were approximately the same and represent nearly 99% of the run time. This suggests a strategy for assessing the environmental air quality impact from a complex source. Concentration estimates from all point sources could be determined from all of the observed hourly data. The impact from line and area sources could be determined from a selection of the hourly data. In this way the effects of the selection scheme on the annual average concentrations are minimized.

2.7 Air Policy Support Branch

The Air Policy Support Branch (APSB) supports activities of the EPA Office of Air Quality Planning and Standards (OAQPS). General responsibilities include: (1) evaluating, modifying and improving atmospheric dispersion and related models to ensure adequacy, appropriateness and consistency with Agency policy and established scientific principles; (2) preparing guidance on applying and evaluating models and simulation techniques that are used to assess, develop or revise national, regional and local air pollution control strategies for attainment/maintenance of ambient air quality standards; and (3) providing meteorological assistance and consultation to support OAQPS's broad responsibilities for development and enforcement of Federal regulations and standards and assistance to the Regional Offices. The meteorologists are typically involved in interdisciplinary team efforts that include engineers, chemists, statisticians, computer specialists and other technical staff.

2.7.1 Modeling Studies

2.7.1.1 Oxidant Modeling of the New York Metropolitan Area (OMNYMAP)

The emissions strategy testing phase of OMNYMAP was completed in FY-1987. Two strategies specified in the 1982 State Implementation Plans for New York, New Jersey, and Connecticut were examined using the Urban Airshed Model (UAM). These included (1) a projection of the 1980 base case emissions to 1988 considering population changes and adopted control techniques; and (2) an additional "extraordinary" control measures. This latter set of controls included such source categories as architectural coatings, auto body refinishing, commercial and consumer solvents, and Reasonable Available Control Technology (RACT) or small sources (< 100 TPY). The resulting average volatile organic compound (VOC) reduction from 1980 was 32 percent for the 1988 projection case which increased to 40 percent with the addition of extraordinary measures. In both strategies NOx emissions were reduced by 14 percent. Initial and boundary concentrations of pollutant species were altered to reflect conditions in the post-control period.

The 1988 projection strategy was modeled with meteorological conditions on two days with high monitored ozone concentrations, July 21 and August 8, 1980. The July 21 case was also used for modeling the effect of "extraordinary" measures. A comparison of the UAM projection case with the 1980 base case ozone predictions indicates a 19 percent decline in peak 1-hour ozone concentrations in the New York urban plume over Connecticut. In addition, the area with base case predictions in excess of the ozone NAAQA (0.12 ppm) decreased by 20 percent to 50 percent depending upon the hour and day simulated. However, there was little additional impact after the imposition of "extraordinary" measures and ozone concentrations above the NAAQA remained across the metropolitan area. The results indicate that additional reductions beyond those achieved from the 1982 SIP measures are necessary to achieve the level of the NAAQS in the New York area (Rao, 1987). The next phase of OMNYMAP will be conducted in FY 1988 and will include the development and testing of procedures for using ROM generated ozone and precursor concentration fields to supply initial and boundary condition inputs to UAM applications.

2.7.1.2 Regional Ozone Impact Analyses

2.7.1.2.1 Treatment Storage and Disposal Facility (TSDF) Analyses

During FY-1987 two regional oxidant models, ROM and RTM-III, were applied to quantify the impact of ozone percursor emissions from Treatment, Storage, and Disposal Facility (TSDF) sources on short-term peak ozone concentrations. Results from the modeling are being used to estimate the costs and benefits of TSDF source controls on agriculture yields and human health.

The region selected for model simulations includes most of the eastern United States east of 99° longitude and north of 28° latitude. Within this modeling region are such large population centers as the Northeast Corridor, Houston, Chicago, and Atlanta as well as the important agricultural croplands of the Midwest and the timber producing forests of the Southeast. Additionally, most of the nation's largest TSDF emission sources are located in this modeling domain.

Anthropogenic hydrocarbon and NOX emissions data from the 1980 NAPAP Version 5 inventory and biogenic hydrocarbon emission data were processed into grid-average emissions for the 1/6° latitude by 1/4° longitude model grid resolution. The models were applied using these emissions and meteorological data for two high ozone episodes which occurred in 1980. There were approximately 30 days simulated in this study.

Two TSDF emission scenarios were simulated. One scenario assumed no control on TSDF emissions while the other assumed 100 percent TSDF emissions control, i. e., zero emissions. Model results for each scenario were compared to determine the reduction in short-term peak ozone concentrations attributable to 100 percent TSDF control. Model results based on the 1980 ozone episodes show 100 percent control on TSDF emissions in the northeastern United States has little effect on reducing maximum hourly ozone concentrations, given the spatial resolutions of the models. Appreciable reduction of peak hourly ozone concentration did occur over the southeastern United States but was limited mainly to the Gulf of Mexico and near the relatively large TSDF source regions in Houston, Texas and southern Louisiana. Technical reports documenting these results are in preparation for publication in FY-1988.

2.7.1.2.2 Regional Ozone Control Strategies

The program to apply two regional oxidants models, ROM and RTM-III, to assess the impact on ozone concentrations of regional strategies for benefits analyses continued in FY-1987. The RTM-III model was applied in the Midwest and Southeast to determine the utility of this model using a coarse grid size (1/2° lat. x 1/2° long.) which could be run on a PC. The results indicate that the grid resolution is sufficient to adequately replicate maximum concentrations on a regional basis. Attempts to install a version of RTM-III with finer resolution (1/6° lat. x 1/4° long.) on the IBM were unsuccessful and work with this model was terminated. The ROM became available for applications during FY-1987 and was used successfully for examining several emission scenarios in the Northeast. Specifically, ROM was applied using meteorological conditions for three episodes in the Spring and Summer of 1980 for a 1980 base case and two VOC emission control scenarios. The ROM ozone predictions for each scenario were extrapolated using a procedure developed to form a six-month data record for the vegetation growing season (April through September). The gridded predictions were converted to county average concentrations to form input for economic analyses. These analyses are being conducted to estimate the monetary benefits of the two control strategies in terms of both agricultural and human health related effects. The results of these ROM applications will also be used to evalute the effectiveness of VOC controls in reducing ozone concentrations to the level of the NAAQS and in the design of additional strategies for both VOC and NOX controls during FY-1988.

2.7.1.3 Regional Ozone Modeling for Northeast Transport (ROMNET)

A three year effort was initiated in FY-1987 to quantify ozone and precursor transport in the Northeast using the Regional Oxidant Model (ROM). This program, entitled Regional Ozone Modeling for Northeast Transport (ROMNET) is designed to: (1) provide air pollution control agencies in the Northeast with information on ozone and precursor transport between urban areas; (2) assess the impact of regional emissions controls on ozone concentrations and interurban transport; and (3) provide guidance to States for incorporating ozone and precursor transport on future State Implementation Plan (SIP) development activities. ROMNET is a high priority program and includes the participation of several EPA Offices and the State Agencies in the Northeast. In brief, the ROMNET technical tasks include the application of ROM for several meteorological episodes with a 1985 base year emissions inventory and various VOC and NOx control strategies. During FY-1987, a draft of the program protocol was prepared and issued to the participants for review. FY-1988 activities will include (1) the development of inventories and associated data handling systems; (2) the selection of episodes and the preparation of meteorological data bases; and (3) the design of control strategies. Actual ROM simulations are planned for FY-1988 and FY-1990. A meteorologist serves as both the chairman of the ROMNET Strategy Committee and as the Technical Coordinator for the program, while another meteorologist serves as the chairman of the ROMNET Modeling Committee.

2.7.1.4 Evaluation and Sensitivity Analysis of Coastal Fumigation Models

During FY-1987 the final report on the sensitivity analysis of coastal fumigation models was published (Sethu-Raman, 1987). This research effort can be divided into two distinct segments. The first involved determining the proper Thermal Internal Boundary Layer (TIBL) characterization. The TIBL, which usually originates at the land-water interface and grows parabolically inland, is the boundary between stable marine air above and unstable air below. The TIBL parameterizaton is the most sensitive variable in coastal models. The second phase involved evaluating two coastal point source dispersion models, the Lyons and Cole (1973) and the Misra (1980) models. The Misra model was found to be superior. The final report also included methods to characterize the TIBL and the Brunt-Vaisalla frequency using available meteorological data. Completing this step was necessary in order to consider proposing the model for regulatory applications. In the next step the Misra model will be included as a subroutine in the widely used MPTER air quality model so that it can be evaluated in FY-1988 using several data bases.

2.7.2 Model Guidance

2.7.2.1 Guideline on Air Quality Models (Revised)

The Federal Register notice of September 9, 1986 announced EPA's proposal to add four new models to the revised modeling guideline and solicited public comment during the succeeding 90 days. The new models include (1) the Rough Terrain Dispersion Model (RTDM) developed by ERT, Inc. (Paine and Egan, 1987) and proposed for use as a third level screening technique in complex terrain applications; (2) the Offshore Coastal Dispersion (OCD) Model (Hanna et al., 1984); (3) a revision to the Industrial Source Complex (ISC) Model that improves the building downwash algorithm; and (4) the AVACTA II Model (Zannetti et al., 1985) to be listed in Appendix B of the guideline. Following a review of the comments and preparation of a response (Environmental Protection Agency, 1987c) the notice of final promulgation was prepared in which the only significant change from the proposal was to limit the revised downwash algorithm to cases where the stack height to building height ratio is equal to or less than 1.5. This was done primarily because the developer did not provide any evaluation data demonstrating what the effect on concentration estimates would be for ratios greater than about 1.5. Technical evaluation of the proposed technique indicated that for ratios between 1.5 and 2.5 the new algorithm would likely result in lower concentration estimates than those using the current algorithm. This was judged unacceptable since previous studies indicated the current algorithm itself could yield underestimates of monitored concentrations. In addition a study was conducted on a preliminary version of the revised model to determine the sensitivity of estimated high and high-second-high concentrations to the change in the models. The results for the particular stack and building configurations tested show increases from above 170 to 400 percent in concentrations due to the new building downwash algorithm, depending on averaging time, for rural cases. Qualitatively similar, but smaller, increases were found for urban cases.

The final notice was submitted for the EPA management and Office of Management and Budget (OMB) review in late July. Although the OMB had not completed its review by the end of the fiscal year editorial comments were made and no technical concerns were raised. Thus these additions, which will be published as Supplement A to the revised guideline, should officially appear by the end of the calendar year. At the same time Supplement A is issued, RTDM and the revised ISC model will be added to UNAMAP Version 6, submitted to NTIS and distributed without charge to previous purchasers of UNAMAP. The OCD model is currently available from NTIS and AVACTA II is available from the developer.

2.7.2.2 Model Clearinghouse

The FY-1987 activities for the Model Clearinghouse included:

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

2. Reviewing draft and formal Federal Register actions.

3. Documenting Clearinghouse decisions and discussions.

4. Summarizing Clearinghouse activities at various meetings.

5. Issuing an internal summary report of activities for FY-1986.

6. Visiting six Regional Offices for the purpose of coordinating Modeling Clearinghouse issues, activities and future plans.

7. Issuing an internal summary report of FY-1986 -FY-1987 visits to all ten Regional Offices.

During FY-1987 there were a total of 111 modeling referrals to the Model Clearinghouse from the Regional Offices. Nineteen of these referrals required a written response, 80 referrals were resolved orally, and 12 referrals where discussed but a Clearinghouse recommendation was not requested.

During FY-1987 the Clearinghouse conducted or participated in a number of activities categorized as coordination and information exchanges with the Regional Offices. One of the first activities was to prepare and distribute to the Regional Offices in October 1986, a Clearinghouse report that served as a "newsletter", informing Clearinghouse users about the issues and responses which occurred in FY-1986. During FY-1987 the Clearinghouse continued its policy of sending copies of its written responses (along with incoming requests) to all Regional Offices. In this way the Regional Offices were informed of decisions that may affect their modeling activities.

The Model Clearinghouse requires an advance opinion of the Regions on particularly sensitive issues with national implications. During FY-1987 two such cases arose, both involving referral from Region IV. In both cases the proposed Clearinghouse response was discussed in some detail at the 1987 Regional/State Modelers Workshop before the response was finalized.

During FY-1986 personnel from the Clearinghouse began a series of visits to the Regional Offices. During that year Regions I, II, III, and V were visited. The primary objective of the visits was to gather information on the historical usage of models by the Regional Offices in order to identify upcoming modeling problems. A secondary purpose was to communicate information to the Regions on the operation of the Clearinghouse. Each visit consisted of (1) discussions on several announced topics, (2) discussions of specific modeling problems identified by the Regions, and (3) meetings with management personnel where the current and future operation of the Clearinghouse was discussed.

During FY-1987 several events took place to conclude this activity. First, an oral report on the findings and issues identified during the FY-1986 visits was presented to all the Regions at the November 1986 Regional Office Mini-Workshop. Second, the remaining six Regional Offices were visited, completing this activity with the Regions IX/X visits in March 1987. Third, a lengthy summary report of the visits was presented at the annual Regional/State Modelers Workshop in May 1987. Discussion at this workshop focused on broad nationwide modeling and regulatory issues identified from the visits.

2.7.2.3 On-site Meteorological Data Guidance

The On-site Meteorological Data Work Group formed in December 1985 completed the on-site meteorological data guidance document entitled "On-site Meteorological Data Guidance for Regulatory Modeling Applications", (Environmental Protection Agency, 1987b). The document covers siting and exposure, data recording, processing and reporting, quality assurance, and maintenance for the variables of wind speed, wind direction, temperature, temperature difference, dew point, precipitation, pressure, and solar radiation. The document also includes a separate section covering these topics for the use of Doppler SODARs to collect elevated wind speed and wind direction.

The guidance document underwent extensive review by all EPA Regional Offices, as well as selected external review by 25 reviewers representing other Federal agencies, State and local air pollution control agencies, instrument manufacturers, private industry, and consultants.

Work has continued on the development of a PC-compatible on-site meteorological data processor for regulatory models. The Meteorological Processor for Regulatory Models (MPRM) is being developed by the Meteorology Division to produce the same type of output as the existing RAMMET preprocessor provides for National Weather Service data. However, MPRM has the potential to replace RAMMET since it also provides output files for running long-term models (CDM-2.0 and ISCLT) and the RTDM model (in the default mode). The processor provides considerable flexibility to the user in terms of input data formats, and utilizes a modular design that can easily be upgraded to provide input to future regulatory models and incorporate revisions in data processing methods. MPRM is scheduled to be made available in FY-1988.

2.7.2.4 Air Toxics Modeling Guidance

During FY-1987 work began on developing an air toxics modeling guidance document to provide a logical and consistent approach to the selection of appropriate meteorological screening methods and techniques for estimating ambient concentrations from various toxic/hazardous pollutant releases. In this way, State and local air pollution control agencies can use consistent and scientifically adequate methods based on physical state, process release conditions, and dispersion characteristics. For each of these categories, a systematic approach to modeling transport and dispersion characteristics is presented. Extensive technical review is underway and publication is expected in FY-1988.

2.7.3 Additional Support Activities

2.7.3.1 Air Toxics Program

Dispersion modeling is an integral part of health risk assessment analyses that evaluate the ambient exposure of people to various toxic/hazardous chemicals. During FY-1987, dispersion modeling analyses were completed for approximately 30 substances ranging from methylene chloride to acetaldelyde and phosgene. The unique characteristics of some toxic/hazardous chemical sources required development of modified modeling techniques to treat such sources. For example, a screening model was developed to simulate the effects of denser-than-air plumes from jet-type releases.

Technical support was provided during the development and technical review phases of the Ooms/DEGADIS dense gas dispersion model project. This model simulates continuous or intermittent dense gas release from elevated or ground-level sources. In this model, denser-than-air plumes remain elevated and are transported downwind until density differences cause the plumes to reach ground-level. At that touchdown point, the plumes are dispersed horizontally by gravitational effects. The Ooms/DEGADIS model should have wide applications because it more realistically simulates dense toxic/hazardous chemical releases.

National Air Toxics Workshops were conducted in Raleigh, Boston, Kansas City and San Francisco for State and EPA technical and management personnel to share ideas and experiences in developing and improving air toxics programs. At each workshop a meteorologist chaired the session on ambient modeling which consists of a presentation on technical assistance available for modeling air toxics, a review of two State modeling programs by their modelers, and a question and answer period.

2.7.3.2 Regional/State Modelers Workshops

This year two workshops were held. The first was a "mini-workshop" consisting of two half-day sessions in conjunction with the Fifth Joint Conference on Applications of Air Pollution Meteorology. Most of the 30 attendees were modelers from the 10 Regions, the States of Illinois, New York, and Texas. Major topics presented included (1) status of several activities associated with the revised guideline including State authority for implementating the guidance; (2) status of workgroups concerned with volatile organic compound (VOC) modeling, on-site meteorological data and technology transfer related to the CTDM model; (3) a summary of recent and proposed workshops on modeling toxic and hazardous pollutant releases; (4) Model Clearinghouse activities; and (5) several modeling topics of general interest.

The traditional annual workshop was held in San Francisco. There were attendees from the 10 Regional Offices, and the States of California, Florida, Illinois, New York and Oregon. Several persons participated in various sessions by conference call hookup. Workshop focus was on issues regarding RTDM, Clearinghouse, CTDM and VOC Workgroups, modeling PM10 and Toxics, on-site meteorological data guidance and the revision of other guidance documents. Each State and Regional Office presented modeling highlights and issues of concern. There was also a demonstration of the NOAA/Coast Guard hazardous response model and the Coastal Climate Company's automated weather station.

2.7.3.3 Regulatory Work Groups

Providing technical assistance and consultation through memberships on several regulatory work groups and task forces is an important aspect of each meteorologist's duties. As an expert resource on modeling, data bases and interpretation of results, staff members help generate sound technical options and positions on key issues facing policy-makers. Meteorologists serve on: (1) the Work Group to Revise the Modeling Guidelines; (2) the Technology Transfer Work Group; (3) the Visibility SIP Work Group; (4) the On-site Meteorological Data Work Group; (5) the Valley Stagnation Work Group; (6) the Stack Height Remand Task Force; and (7) the NO_2 PSD Increment Work Group. As noted earlier, meteorologists serve as chairmen of the Strategy Committee and the Modeling Committee of the ROMNET Program.

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APPENDIX B-1. PRESENTATIONS

Ching, J.K.S, Briefing to ORD/OADEMQA staff on the ACID-MODES program. Headquarters, Environmental Protection Agency, Washington DC, April 6, 1986.

Clark, T.L. Preliminary results of an evaluation of sulfur deposition models, Poster Session, ORD Innovative Research Highlights 1986, Headquarters, Environmental Protection Agency, Washington, DC, November 3, 1986.

Clarke, J.F., and F.A. Schiermeier. Regional modeling of transboundary pollutant fluxes. Briefing to President's Office of Science Technology Policy, Washington, DC, September 3, 1987.

Collins, D. (visitor). Wind tunnel modeling of dispersion from aluminum smelter in Australia. Seminar at Fluid Modeling Facility, Research Triangle Park, NC, October 3, 1986.

Dennis, R.L. Aggregation, Field Study Program, and RADM Program as they relate to the 1990 Assessment, Environmental Protection Agency, Washington, DC., September 21, 1987.

Dicke, J.L. On-site meteorological program guidance. EPA Standing Air Montoring Work Group, Winter Meeting, Las Vegas, NV, December 10-11, 1986.

Dicke, J.L. Practical applications of models for calculating the impact of design and construction of industrial enterprises. Presentation at the US/USSR Working Group 02.01-10 on Air Pollution Modeling and Standard Setting, Research Triangle Park, NC, June 2, 1987.

Huber, A.H. A look at pollution dispersion in the wake of a building. Seminar presented at North Carolina State University, Raleigh, NC, December 5, 1986.

Huber, A.H., J. Borek, S. Rajola, and A. Ait-Kheddache. Evaluation of building wake effects on plume dispersion. ORD Innovative Research Highlights 1986, Environmental Protection Agency, Washington, DC, October 1986.

Mr. Wizard Studio (producer). Fluid Modeling video-tape presentation on How About. Reports on Science and Technology for Television underwritten by the National Science Foundation and General Motors Research Laboratories, October 1986.

Perry, S.G. The EPA complex terrain dispersion model: An update on its performance and data input requirements. Presentation at US/USSR Working Group 02.01-10 on Air Pollution Modeling and Standard Setting. Research Triangle Park, NC, June 3, 1987.

Pierce, T. E. Estimating ambient air concentrations from a buoyant plume in a convectively-mixed atmosphere. Poster Session, Headquarters, Environmental Protection Agency, Washington, DC, November 3, 1986.

Pierce, T. E. An evaluation of convective scaling parameterization for estimating the diffusion of buoyant plumes. Presentation at 16th NATO/CCMS Internationahl Tecnical Meeting on Air Pollution Modeling and Its Application, Lindau, Federal Republic of Germany, April 6-10, 1987.

Schere, K.L. Predictions of O_3 plumes with the Environmental Protection Agency Regional Oxidant Model. Poster session, ORD Innovative Research Highlights 1986, Headquarters, Environmental Protection Agency, Washington, DC, November 3, 1986.

Schiermeier, F.A. Current status and future plans for EPA complex terrain model development program. Presentation to Electric Power Research Institute Plume Model Validation and Development Advisory Committe, Hartford, CT, October 29, 1986.

Schiermeier, F.A. Predictions of ozone plumes by the Regional Oxidant Model. Poster Session, ORD Innovative Research Highlights 1986, Headquarters, Environmental Protect Agency, Washington, DC, November 3, 1986.

Schiermeier, F.A. Technology transfer of ORD Meteorology Division research products. Presentation at EPA/OAQPS Regional/State Modelers Mini-Workshop, Durham, NC, November 19, 1986.

Schiermeier, F.A. Report on implementation of Working Group 02.01-10 on Air Pollution Modeling, Instrumentation, and Measurement Methodology. Presentation at the Tenth Meeting of US/USSR Joint Committee on the Cooperation in the Field of Environmental Protection, Washington, DC, December 15-16, 1986.

Schiermeier, F.A. Overview of Meteorology Division research programs. Presentation at NOAA/OAR/ERL, Air Resources Laboratory Program Review, Boulder, CO, March 18-20, 1987.

Schiermeier, F.A. Model evaluation requirements for air pollution policy and abatement strategies. Presentation at 16th NATO/CCMS International Technical Meeting on Air Pollution Modeling and Its Applications, Lindau, Federal Republic of Germany, April 6-10, 1987.

Schiermeier, F.A. Overview of Meteorology Division research programs. Presentation at US/USSR Working Group 02.01-10 on Air Pollution Modeling and Standard Setting, Research Triangle Park, NC, June 2, 1987.

Thompson, R.S. Recent work at the EPA Fluid Modeling Facility on diffusion in complex terrain. Presentation at Third Southeastern Conference on Geophysical Fluid Dynamics, Oak Ridge, TN, October 18, 1986.

APPENDIX B-2. WORKSHOPS

This section lists the workshops in which the Meteorology Division participated and the names of the Division participants.

1. Joint EPA/DOE Technical Workshop on the Determination of Atmospheric Dilution for Emergency Preparedness, Research Triangle Park, NC, October 15-17, 1986.

   F.S. Binkowski
   G.A. Briggs
   S.G. Perry
   T.E. Pierce, Jr.
   W.H. Snyder

2. Model Evaluation Field Study Sampling Protocol Workshop, Atmospheric Environmental Service, Toronto, Canada, October 15-17, 1986.

   J.K.S. Ching

3. Advanced Studies Institute on the Chemical and Meteorological Aspects of Atmospheric Source-Receptor Relationships, Oak Ridge, TN, October 20-24, 1986.

   F.S. Binkowski

4. Regional and State Modelers Mini-Workshop, U.S. Environmental Protection Agency, Durham, NC, November 18-19, 1986.

   J.L. Dicke
   R.F. Lee
   F.A. Schiermeier
   J.S. Touma
   D.A. Wilson

5. Workshop on Evaluation and Documentation of Chemical Mechamisms, Environmental Protection Agency, Raleigh, NC, December 1-3, 1986.

   K.L. Schere

6. Diagnostic Acid Deposition Model Evaluation Field Program, Environmental Protection Agency, Research Triangle Park, NC, December 1-3, 1986.

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

7. EPA/APCA/ASME Environmental Information Exchange, Research Triangle Park, NC, December 2-3, 1986.

   N.C. Possiel

8. Tenth Meeting of the US/USSR Joint Committee on Cooperation in the Field of Environmental Protection, Washington, DC, December 15-16, 1986.

   F.A. Schiermeier

9. Motor Vehicle Industry Scientist's Workshop on Ozone Trends and Atmospheric Chemistry, Durham, NC, December 16-17, 1986.

   K.L. Schere

10. Second NAPAP Data Coordination Workshop, Washington, DC, January 15, 1987.

    R.L. Dennis

11. National Air Toxics Workshop, Environmental Protection Agency, Raleigh, NC, March 16-19, 1987.

    J.L. Dicke

12. National Air Toxics Workshop, Environmental Protection Agency, Boston, MA, April 13-17, 1987.

    J.L. Dicke

13. National Air Toxics Workshop, Environmental Protection Agency, Kansas City, MO, April 27-30, 1987.

    J.L. Dicke

14. Regional and State Modelers Workshop, Environmental Protection Agency, San Francisco, CA, May 12-15, 1987.

    R W. Brode
    J.L. Dicke
    J.S. Touma
    D.A. Wilson

15. National Air Toxics Workshop, Environmental Protection Agency, San Francisco, CA, May 18-20, 1987.

    J.L. Dicke

16. Joint US/USSR Working Group 02.01-10 on Air Pollution Modeling, Instrumentation, and Measurement Methodology, Washington, DC; Research Triangle Park, NC; Boulder, CO; and Las Vegas, NV, June 1-8, 1987.

    F.A. Schiermeier

17. Regional Office Annual Workshop, Southern Pines, NC, July 13-16, 1987.

    J.L. Dicke
    N.C. Possiel
    J.S. Touma
    D.A. Wilson

18. RADM Aggregation Workshop, Boston Landing, NY, July 20-21, 1987.

    J.F. Clarke
    R.L. Dennis

19. Acid Model Operational, Diagnostic Evaluation Study (ACID-MODES) Design Study Workshop, U.S. Environmental Protection Agency, Raleigh, NC, August 4-7, 1987.

    J.K.S Ching
    T.L. Clark
    J.F. Clarke
    R.L. Dennis

20. SIMS Workshop- Statistical Issues in Global Climate Change, Stanford University, Stanford, CA, September, 1987.

    P.L. Finkelstein

APPENDIX C. VISITING SCIENTISTS

1. P.G. Baines, Principal Research Scientist
   Division of Atmospheric Research
   Commonwealth Scientific and Industrial Research Organization
   Mordialloc, Victoria, AUSTRALIA

   Spent one month at the Fluid Modeling Facility under a cooperative agreement with North Carolina State University conducting studies of drag on hills in the stratified towing tank and presenting a series of 6 lectures on modeling stratified flow over hills.

2. I.P. Castro, Lecturer
   Department of Mechanical Engineering
   University of Surrey
   Guildford, Surrey, ENGLAND

   Spent 5 days at the Fluid Modeling Facility under a cooperative agreement with North Carolina State University conferring on papers in the process of publication and conducting studies of drag on hills in the stratified towing tank.

3. J.T. Lee, Research Scientist
   Atmospheric Sciences Group
   Los Alamos National Laboratory
   Los Alamos, NM

   Spent 2 one-month periods at the Fluid Modeling Facility conducting wind-tunnel studies of flow and concentration patterns on the lee sides of buildings -- developing analysis routines to relate video image intensities to line-integrated concentrations.

4. J.W. Rottman, Senior Research Associate
   Department of Marine, Earth and Atmospheric Sciences
   North Carolina State University
   Raleigh, NC

   Spent a full year at Fluid Modeling Facility (under a cooperative agreement with North Carolina State University) conducting theoretical and experimental studies on two projects: (1) comparison of numerical and laboratory observations of pollutant transport and dispersion in complex terrain, and (2) conditions leading to severe downslope winds on the lee side of mountains.

5. W. Seiler, Director
   Fraunhofer Institute Fúr Atmospheric Umweltforschung
   Kreuzeckbanknstrass, Federal Republic of Germany

   Spent 5 days assisting in the devlopment of German participation in the ACID-MODES field study.

APPENDIX D. METEOROLOGY DIVISION STAFF - FISCAL YEAR 1987

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

Office of The Director

Francis A. Schiermeier, Meteorologist, Director
Herbert Viebrock, Meteorologist, Assistant to the Director
Marc Pitchford, Meteorologist (Las Vegas, NV)
Evelyn M. Poole-Kober, Technical Information Clerk
Joan Emory, Secretary

Atmospheric Modeling Branch

Dr. John F. Clarke, Meteorologist, Chief
Dr. Francis Binkowski, Meteorologist
Dr. Gary Briggs, Meteorologist
Terry Clark, Meteorologist
Dr. Jason Ching, Meteorologist
Dr. Robin Dennis, Physical Scientist
Brian Eder, Meteorologist
James Godowitch, Meteorologist
Dr. Robert Lamb, Meteorologist
Kenneth Schere, Meteorologist
Alvina Boyd, Secretary

Fluid Modeling Branch

Dr. William H. Snyder, Physical Scientist, Chief
Joseph Aquino, Engineering Aid
Lewis Knight, Electronics Technician
Robert Lawson, Physical Scientist
Joseph Smith, Mechanical Engineering Technican
Ralph Soller, Mechanical Engineering Technican
Roger Thompson, (PHS), Environmental Engineer
Anna Cook, Secretary

Data Management Branch

Joan H. Novak, Computer Systems Analyst, Chief
William Amos (EPA), Computer Programmer
O. Russell Bullock, Computer Systems Analyst (Since June 1987)
Adrian Busse, Computer Specialist
Dale Coventry, Computer Systems Analyst
Alfreida Rankins, Computer Programmer
James Reagan (PHS), Statistician
John Rudisill, Computer Specialist
Barbara Hinton (EPA), Secretary

Terrain Effects Branch

Dr. Peter L. Finkelstein, Meteorologist, Chief
Dr. Robert Eskridge, Meteorologist
Dr. Alan Huber, Meteorologist
Dr. Steven Perry, Meteorologist
Dr. Francis Pooler, Jr., Meteorologist
Lawrence Truppi, Meteorologist
Hazel Hevenor (EPA), Secretary

Environmental Operations Branch

D. Bruce Turner, Meteorologist, Chief
Dr. Clifford B. Baker, Meteorologist
Mark Garrison, Meteorologist (Philadelphia, PA)
John Irwin, Meteorologist
Dr. Ralph Larsen (PHS), Environmental Engineer
Lewis Nagler, Meteorologist (Atlanta, GA)
William Petersen, Meteorologist
Thomas Pierce, Jr., Meteorologist
Everett Quesnell, Meteorological Technician
Sylvia Coltrane, Secretary

Air Policy Support Branch

James L. Dicke, Meteorologist, Chief
Roger Brode, Meteorologist
Dennis Doll, Meteorologist
Russell Lee, Meteorologist
Norman Possiel, Jr., Meteorologist
Jawad Touma, Meteorologist
Dean Wilson, Meteorologist