NOAA Technical Memorandum ERL ARL-139

FISCAL YEAR 1984 SUMMARY REPORT OF NOAA METEOROLOGY DIVISION SUPPORT TO THE ENVIRONMENTAL PROTECTION AGENCY

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

Air Resources Laboratory
Silver Spring, Maryland
July 1985

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Environmental Research Laboratories

NOAA Technical Memorandum ERL ARL-139

FISCAL YEAR 1984 SUMMARY REPORT OF NOAA METEOROLOGY DIVISION SUPPORT TO THE ENVIRONMENTAL PROTECTION AGENCY

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

Meteorology Division
Research Triangle Park, North Carolina

Air Resources Laboratory
Silver Spring, Maryland
July 1985

UNITED STATES
DEPARTMENT OF COMMERCE

Malcolm Baldrige,
Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Environmental Research
Laboratories

Vernon E. Derr,
Director

NOTICE

PREFACE

The work reported herein for FY-1984 was funded by the Environmental Protection Agency (EPA) under agreement EPA DW13930754-01-0 between the EPA and the National Oceanic and Atmospheric Administration (NOAA). The Meteorology Division (MD) serves as the vehicle for implementing the agreement. This relationship was established in 1955 and has continued since that time.

The MD performs and manages a research and operational effort in air pollution meteorology. Research activities define, describe, and study the meteorological factors important to air pollution control activities; operational support activities apply meteorological principles to assist the EPA in the evaluation and implementation of air pollution abatement and compliance programs. Research activities, which are sponsored by the EPA Environmental Sciences Research Laboratory, and other EPA groups, are conducted within the MD and through contract and cooperative agreement. The MD provides technical information, observational and forecasting support, and consultation on all meteorological aspects of the air pollution control program to many offices, including the EPA Office of Air Quality Planning and Standards and Regional Offices.

An inquiry on the research or support activities outlined in this report should be directed to the Director, Meteorology Division, MD-80, Environmental Research Center, Research Triangle Park, N.C., 27711.

CONTENTS

FIGURES

TABLE

ABSTRACT

The Meteorology Division provided research and meteorological support to the Environmental Protection Agency. Basic meteorological support consisted of the application of dispersion models and the conduct of dispersion studies and 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 on urban and regional scales, dispersion in complex terrain, and atmospheric processes related to the acid deposition problem.

Activity highlights included the initial implementation of the first generation Regional Oxidant Model; development of a Photochemical Box Model for use in screening high level O_3 episodes during stagnant conditions in urban areas; description of a model for the diurnal behaviour of the layer of surface-based turbulent mixing and the wind and temperatures averaged over this layer; conduct of a major complex terrain field study at the Tracy Power Plant near Reno, Nevada; and preparation of a scientific assessment document on the status of complex terrain dispersion models.

Work is underway on the development of a regional and mesoscale acid deposition model. A major program to study and to model the transport and transformation of mixed layer pollutants by non-precipitating cumulus convective clouds has been started. An international sulfur deposition model evaluation was started with a large group of European, Canadian, and United States participants.

ABSTRACT

The Meteorology Division provided research and meteorological support to the Environmental Protection Agency. Basic meteorological support consisted of the application of dispersion models and the conduct of dispersion studies and 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 on urban and regional scales, dispersion in complex terrain, and atmospheric processes related to the acid deposition problem.

Activity highlights included the initial implementation of the first generation Regional Oxidant Model; development of a Photochemical Box Model for use in screening high level O_3 episodes during stagnant conditions in urban areas; description of a model for the diurnal behaviour of the layer of surface-based turbulent mixing and the wind and temperatures averaged over this layer; conduct of a major complex terrain field study at the Tracy Power Plant near Reno, Nevada; and preparation of a scientific assessment document on the status of complex terrain dispersion models.

Work is underway on the development of a regional and mesoscale acid deposition model. A major program to study and to model the transport and transformation of mixed layer pollutants by non-precipitating cumulus convective clouds has been started. An international sulfur deposition model evaluation was started with a large group of European, Canadian, and United States participants.

FISCAL YEAR 1984 SUMMARY REPORT OF NOAA METEOROLOGY DIVISION SUPPORT TO THE ENVIRONMENTAL PROTECTION AGENCY

1. INTRODUCTION

During Fiscal Year 1984, the Meteorology Division continued to provide meteorological research and support to the Environmental Protection Agency. Meteorological support was provided by the Air Policy Support Branch and the Environmental Operations Branch to various EPA offices, including the Office of Air Quality Planning and Standards and the Regional offices. This work is discussed in sections 2.5 and 2.6.

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. A major field study was conducted at Tracy Power Plant, near Reno, Nevada, late in the fiscal year. The Fluid Modeling Branch conducted physical modeling experiments on the flow in complex terrain, building downwash, and the effects of automobile wakes. The research work is described in sections 2.1, 2.2, 2.3, and 2.4.

2. PROGRAM REVIEW

2.1 Atmospheric Modeling Branch

The Atmospheric Modeling Branch is responsible for the development, evaluation, and validation of analytical, statistical, 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.

2.1.1 Acid Deposition Studies

2.1.1.1 Acid Deposition Model Development and Evaluation

Meteorology Division personnel continue to monitor an April 1983 agreement the Environmental Protection Agency entered into with the National Center for Atmospheric Research (NCAR) to develop a Regional Acid Deposition Model (RADM) suitable for assessing source receptor relationships and for examining key issues in acid deposition. The RADM will be an advanced, Eulerian computer model simulating the processes and pathways related to acid deposition in the eastern United States and southern Canada. As presently envisioned, the model will cover a domain of 2500x 2500 km with grid cells of about 80x80 km and 15 vertical levels. The approach includes using an established, state-of-the-art meteorological model which simulates transport processes based on fundamental dynamic equations of atmospheric motion. The chemical module may include about 40 species and consist of up to 100 reactions. The strength of the comprehensive Eulerian approach is that it incorporates, in principle, all chemical and physical processes affecting acid deposition on a regional scale, thus leading to a high degree of credibility for the results.

The construction of the RADM is supported by work at three National Laboratories, covering data handling, transport, deposition, and precipitation scavenging. The project officer coordinates all work and is responsible for supplying an emissions inventory for the model. Essential research results of the past few years in atmospheric modeling and chemical mechanisms provide an opportunity to assemble the RADM from existing components, and thus avoid a prolonged and risky development effort. A preliminary, working version of RADM was completed in late calendar year 1984. During FY-1985 the evolving model will be tested on available data sets. However, this version of the model will be in an evolutionary stage. Revised modules will be added to the model during 1986, and the second generation (final) version will be complete in all aspects in early 1987. Full documentation and assessment will be available before the end of 1987.

The Scope of Work was expanded in FY-84 to include the planning, development, and evaluating of an "engineering" assessment model for acid deposition source-receptor relationships. This model is expected to be a simplification of the RADM containing an overall balanced but highly parameterized representation of the physical and chemical details of RADM. The model is expected to be capable of fast-turn-around quantitative evaluation of control options. An engineering model consistent with the first-generation RADM will be completed by December 1985.

The RADM development is proceeding on schedule. The meteorological component, which is based on an existing hydrostatic model, is completed. This model integrates the equations of motion, the continuity equation for dry air, the thermodynamic equation, and the continuity equation for water forward in time to produce the temporal variation of the meteorological variables in three dimensions. A dynamic model processor then converts these primary data to the meteorological data required by the RADM.

The RADM is an episodic model and 12 synoptic periods representing the important acid deposition scenarios on an annual basis have been selected to be processed through the meteorological predictive module. These cases are being used to evaluate the meteorological module and also to be the basis for estimating seasonal and annual average acid deposition. Two additional cases for which extensive precipitation chemistry or air quality data are available are being processed for evaluation of the chemical module and integrated system, i.e., the total model. A preliminary gas-phase chemical module is undergoing testing and evaluation.

2.1.1.2 A Variable Buoyancy Balloon Tracer of Atmospheric Motion

Through an interagency agreement, Sandia National Laboratory is developing a balloon marker system capable of tracing three-dimensional atmospheric motions for periods of time ranging from a few hours up to three days at altitudes between sea level and 500 mb (6 km). Superpressure balloons provide a zero-order approximation to what is desired; however, because the balloons are affected by buoyancy forces that prevent them from responding to the weak, sustained vertical motions associated with meso-and synoptic-scale atmospheric phenomena, they are unsatisfactory.

The desirable balloon system, coupled with a suitable tracking and control system, would provide a tool for studying regional scale source-receptor relationships for acid deposition; Lagrangian climatologies of selected source regions of the United States; accuracy of long range air pollution models; and inherent limits of the predictability of source impacts at long range; relationship between Eulerian meteorological variables provided by weather station data and Lagrangian parameters required for dispersion calculations at arbitrary sites; dispersion in complex terrain; source regions of pollutants responsible for air pollution episodes; and other meteorological and air pollution phenomena. Indoor tests of the prototype balloon and its control and sensor package have been conducted and a field test will be performed in fall 1985.

2.1.1.3 Acid Deposition Modeling Support Activities

The data management function for the National Acid Precipitation Assessment Program Atmospheric Processes work is located at Brookhaven National Laboratory (BNL). This activity maintains an extensive set of precipitation chemistry data bases: APN (Canadian Air and Precipitation Monitoring Network); APIOS (Acid Precipitation in Ontario Study); CANSAP (Canadian Network for Sampling Precipitation); EPRI/SURE (Electric Power Research Institute/Sulfate Regional Experiment); MAP3S (Multi-state Atmospheric Power Production Pollution Study); NADP (National Atmospheric Deposition Program); and UAPSP (Utility Acid Precipitation Study Program). The data from all of these networks are maintained in a common format data base for user requests. This BNL activity also performs such special projects as the preparation of a common data base for the international acid deposition model intercomparison. Finally, the data for the scenarios for the NCAR Regional Acid Deposition Model are being prepared at BNL.

2.1.1.4 Mesoscale Studies for Acid Deposition

The Philadelphia field study showed that a local source effect can be measured in wet acidic deposition. The experiment called for a control area (southern New Jersey) and a target area (southeastern Pennsylvania). When the transport flow was from the control area, over the urban area to the target area, under conditions of wide spread frontal rainfall, there was a clear difference in precipitation chemistry of daytime rainfall. While the largest difference is in nitrate deposition, hydrogen ion and sulfate deposition also were enhanced in the target area rainfall. These results are, however, preliminary and analysis is continuing. This project has a very rigorous quality control and quality assurance procedure with duplicate chemical analyses of some samples by different analytical laboratories. Future work in this project includes additional field studies and extensive numerical modeling efforts.

2.1.1.5 Observational Study of Transport in the Free Troposphere

Anthropogenic pollutants can arrive above a convective mixed layer by penetrative convective cloud activity (venting) or by air mass convergence. These pollutants are then displaced along paths that are not necessarily horizontal, and can subsequently re-enter the mixed layer by either entrainment, subsidence, or in precipitating systems. The development of improved long range transport models will therefore require consideration of the transport and dispersion processes in both the mixed layer and free troposphere.

These processes in the free troposphere are not adequately documented or understood and are generally ignored in current trajectory calculation schemes and source to receptor models. This, of course, is primarily due to the nonavailability of adequate measurement techniques or air parcel tracking technology for this application. For example, tetroons are set to drift along constant density surfaces, however, free tropospheric transport is more likely to occur along isentropic surfaces. The use of chemical traverses requires insitu sampling by aircraft, but logistical requirements make Lagrangian tracking extremely difficult on long range transport scales. To address this problem, a technique to track free tropospheric pollutant transport was recently developed as part of the National Acid Precipitation Assessment Program (NAPAP).

An airborne, two wavelength lidar, the ALPHA-1 system, was modified to track the movement of, and to characterize the dispersion of, a cloud of FDP particles and aerosol distribution, the latter for obtaining concurrent information on atmospheric stratification. Initial field tests of this system were conducted in conjunction with the Cross Appalachian Tracer Experiment (CAPTEX 83) study. On several occasions, an FDP cloud was generated above the mixed layer in Ohio, and subsequently tracked by the ALPHA-1 system across the Applachian mountains. The original circular cloud quickly elongated with travel distance but experienced relatively little lateral or vertical dispersion. Furthermore, the FDP plume-like cloud was observed to become fragmented as it drifted over the Appalachians at altitudes significantly above the mixed layer. The successful demonstration of this new technique to remotely track a tracer cloud provides a new dimension to studies of both transport and dispersion. The relative ease of locating the tracer cloud remotely can provide logistical support for other aircraft conducting in-situ sampling; the diffusive spread of the tracer cloud can be simultaneously characterized in great spatial detail. Additional tests and continued improvements to both the system and to tracking or flight procedures are needed to fully realize the potential of this new technique.

2.1.1.6 Experimental Field Study of Vertical Transport and Chemical Transformation Processes Due to Non-Precipitating Convective Clouds

Under development is an Eulerian Regional Acid Deposition Model (RADM), designed to satisfy the Energy and Security Act of 1980, Title VII requirements to provide a means to test proposed acid deposition mitigation strategies. RADM incorporates all known important processes dealing with emissions, transport and transformation of acidic chemical species and their deposition to the surface of the earth.

Modeling of the vertical exchanges and transformation that occurs as a result of convective clouds, so ubiquitous during the warm season, will be important in the RADM. The many processes associated with these clouds are complicated and knowledge about them is very limited. Therefore, an experimental program was designed to provide a basis for the development of parameteric schemes to treat these processes in the RADM.

The field study is called "VENTEX" for VENTing EXperiment. The VENTEX "core" program is administered as a coordinated program of three basic tasks: 1) exper - imental field studies of vertical transport and chemical transformation due to nonprecipitation cumulus activities, assigned to Pacific Northwest Laboratory, Richland, Washington (PNL); 2) surface based remote and in-situ measurement of flow near clouds; and seasonal correlation between planetary boundary layer and cumulus activity, assigned to Argonne National Laboratory (ANL), Argonne, Illinois; and, 3) parametric methodologies of vertical mass transport due to convective clouds for the Eulerian framework model, assigned to Research Triangle Institute (RTI), Research Triangle Park, North Carolina. Coordination of these project tasks is provided by Division personnel.

A design basis and operations guide for the VENTEX-84 summer field study was prepared. PNL, ANL, and RTI conducted the field study in the general vicinity of Lexington, Kentucky from July 9 to August 17, 1984. The Kentucky Energy Cabinet and the University of Kentucky provided facilities for a base of operations at the Kentucky Energy Center grounds. ANL measured mixed layer heights and cloud parameters using an instrumented tower, doppler sodar, upper air soundings, and special photogrammetry; RTI measured cloud base, top, and width using a laser range finder; and PNL provided upper air soundings and operated two instrumented aircraft, a Cessna and A DC3. The Cessna provided detailed observations of temperature, moisture, Kscat, and ozone from vertical soundings and horizontal transects in both the mixed and cloud layers. Using a newly installed gust probe system, the DC3 measured detailed flow information on the mass flux into and out of the convective clouds as well as appropriate air chemistry data. The results of this program will be a computerized module that computes the gridded mass transport using highly parameterized methods. This module will be designed to be incorporated into the RADM.

2.1.1.7 International Sulfur Deposition Model Evaluation

As an extension of the acidic depostion modeling effort conducted during the U.S./ Canadian Memorandum of Intent on Transboundary Air Pollution, the two nations have organized the International Sulfur Deposition Model Evaluation Program. European, Canadian, and United States regional sulfur deposition modelers have agreed to simulate 1980 ambient concentrations and the dry and wet deposition of SO_2 and SO_4 across eastern North America. These results will be evaluated on seasonal and annual bases. In addition, the modelers will generate 1980 seasonal transfer matrices.

The importance of using standardized sets of model input data is recognized. Meteorological data (1000 and 850-mb wind components, climatological maximum mixing heights, precipitation amounts) and NAPAP Task Group C Version 2.0 SO_2 emissions data were processed for four (4) different grid configurations using identical procedures. After quality assurance tests were conducted on the processed data, an interim report describing the processing procedures and the resulting data sets were distributed to the participants. As a result, abnormalities were identified and corrective measures were executed.

A group of U.S. and Canadian modelers/statisticians have agreed to evaluate and intercompare model results. The evaluation framework comprises two phases. The first phase addresses the computation and interpretation of descriptive statistical analyses, while the second phase focuses on the innovation of model evaluation techniques (e.g., Kriging and pattern recognition).

2.1.1.8 Cross-Appalachian Tracer Experiment (CAPTEX '83)

A regional transport study involving the release and tracking of 16 tetroons was conducted in the Fall of 1983 in support of CAPTEX '83. Each of the tetroons carried a light-weight transponder, which consisted of a Loran-C receiver, a pressure sensor, and a transmitter. With the aid of a Loran-C navigator aircraft, data acquisition/control unit and a computer, the location and the altitude of the tetroon were computed.

During the 7 CAPTEX experiments, 11 tetroons were released from Dayton, Ohio and 5 were released from Sudbury, Ontario. All tetroons and perfluorocarbon tracer gas were released within the same 3-hour period. In some of the experiments, a tetroon was released in the front, in the center, and at the rear of the perfluorocarbon tracer plume.

The tetroon trajectories were documented and included in the CAPTEX '83 data base. The CAPTEX '83 meteorological data base were completed. The aircraft sampling data base will be completed in FY-85.

2.1.1.9 Eastern North American Model of Air Pollution (ENAMAP)

The model code was modified to improve the organization, some of the physical parameterizations (e.g., transport, wet and dry deposition, and vertical diffusion), and some of the model input parameters (e.g., mixing heights). A mass balance calculation was added to verify mass conservation.

The modified version was tested using ambient SO_2 and $SO_4^=$ concentrations and sulfur wet deposition data measured during July 1978. Model input data for 1980 were processed for future model applications.

A sensitivity study was conducted to define the effects of model input parameter changes on the depositions and concentrations. The results were documented and are to be included in the model users guide.

2.1.1.10 Parameterization of Dry Deposition

Dry deposition studies are conducted as an integral part of the program on acid deposition, transport and modeling. In this task, Argonne National Laboratory conducts field experiments and theoretical investigations to develop parameterizations of deposition velocities of acidifying substances in eastern North America. They evaluate uncertainties associated with eddy correlation measurements. Finally they are to develop a module for the Eulerian framework model so that dry deposition can be determined according to chemical species, surface conditions, and meteorological conditions.

Such a module was developed for SO_2 and $SO_4^=$ from field studies for use in the Regional Acid Deposition Model. The product of the dry deposition velocity and the mean concentration yields the surface fluxes. The parameterization scheme is resolved according to 10 land use types: 1) urban land; 2) agricultural land; 3) range land; 4) deciduous forest; 5) coniferous forest; 6) mixed forest including wet lands; 7) water (roughness computed with friction velocity); 8) land outside grid domain; 9) nonforested wetland; and, 10) mixed agricultural and range land. The parameterization provides seasonal variations, while temporal variations are handled through such micrometeorological parameters as friction velocity, stability (Monin-Obukhov length), inversion height, etc. The grid domain covers an area from 67° to 105°W and from 24° to 50°N; each grid is 1/4° longitude and 1/6° latitude. An overall grid value is a composite of individual land use contribution weighted by its proportional areal coverage.

2.1.2 Photochemical Modeling

2.1.2.1 Photochemical Box Model

During the past five years while intensive efforts were underway to evaluate the results from complex photochemical air quality simulation models (Shreffler and Schere, 1982; Schere and Shreffler, 1982, 1984) it has been advantageous to use a relatively simple Photochemical Box Model (PBM) to check and screen the results from the more complex and costly grid and trajectory models. This model was generalized and includes an updated version of the Demerjian chemical kinetic mechanism. A User's Guide (Schere and Demerjian, 1984) was developed and plans were made to include this model in the next version of the UNAMAP model series.

The User's Guide describes the structure and operation of the model and its preprocessors as well as provides the potential user with guidance in setting up input data. The PBM is a simple stationary single-cell model with a variable height lid designed to provide volume-integrated hour averages of O_3 and other photochemical smog pollutants of interest for an urban area for a single day of simulation. The PBM is most appropriate for application in air stagnation conditions with light and variable winds. Horizontal dimensions of the box are typically on the order of 10-50 km; the vertical dimension may vary between 0.1 and 2 km. Chemical reactions are simulated using a 63-step kinetic mechanism that includes diurnal variation of photolytic rate constants. The depth of the mixed layer, or depth of the PBM domain, also follows a diurnal pattern; it can be optionally specified as following a non-linear growth curve. The PBM assumes that emission sources are homogeneously distributed across the surface face of the box volume and that the volume is well mixed at all times. Atmospheric diffusion and wind shear are neglected.

The user must provide the PBM with initial species concentrations, hourly inputs of wind speed, source emission fluxes of CO, NO_x, THC, and hydrocarbon reactivity classes, and boundary species concentrations. Values of measured solar radiation and mixed layer depth may be specified at sub-hourly intervals throughout a simulation.

2.1.2.2 3-D Grid Model Application in Japan

The SAI Urban Airshed Model, a 3-D gridded photochemical air quality modeling system, has been evaluated on the RAPS-St. Louis data base (Shreffler and Schere, 1982; Schere and Shreffler, 1982, 1984). The wind flow fields used in this application were uncomplicated and well behaved. Most of the applications made with the Urban Airshed Model have employed the wind interpolation scheme provided as part of the wind field preprocessor in the modeling system. This scheme works well for non-complex wind flow, such as that for St. Louis, but it cannot handle properly more complex flow.

In 1984 the U.S. National Research Council and the National Institute of Environmental Sciences of Japan began a one-year project to apply the Urban Airshed Model to the Tokyo metropolitan area. The Tokyo area includes mountainous terrain on the west and a land-sea interface to the east and south, providing the elements for a complex wind flow in the area. Alternative wind field algorithms are being studied to provide a credible interpolation for this complex flow. The model will be applied and evaluated on a multi-day episode from July 1981. A comprehensive data base collected during a field study will be used. Some sensitivity analysis will also be performed.

2.1.2.3 Regional Oxidant Model

This program's objective is to develop a Regional Oxidant Model (ROM) that can guide the formulation of regional emissions control strategies for oxidants and precursors. The ROM, in principle, can treat all of the known chemical and physical processes important in oxidant formation and is intended for simulation of pollutant episodes on scales of 2-3 days and 1000 km (Lamb, 1983).

The chemical kinetics mechanism used in the first generation ROM contains 36 reactions and 23 individual reactive species, including 4 organic hydrocarbon reactivity classes. The second generation ROM will contain a more detailed and up-to-date mechanism developed by Systems Applications, Inc. The Carbon-Bond-Extended (CB-X) mechanism as configured for the ROM contains 183 reactions and 72 species, including a condensed mechanism for isoprene, a biogenic organic compound. Efforts are underway to compress this mechanism into one with no more than 50-55 individual species. The CB-X mechanism contains 9 reactive hydrocarbon classes, including isoprene.

The first generation network of processors that supplies the model with meteorological parameters, emissions, species deposition velocities, and other necessary variables was completed, and the model and processor network were applied to a simulation of August 3-5, 1979. Preliminary results of the simulation were presented at the 1984 Air Pollution Control Association meeting in San Francisco.

Work is now underway to develop the second generation processor network which will provide spatial and temporal variations in the meteorological fields that the first generation processors do not supply. A part of the secondgeneration model development effort will consider modifications that would extend the range of applications from its current episode, or multi-day, simulation capability to seasonal averaged, or multi-month simulations. This effort anticipates the possible promulgation of a secondary ozone standard to protect agricultural crops and forests.

Efforts are also underway to develop a plan for evaluating in FY-85 and FY-86 the ROM results from simulations of selected episodes from the NEROS data base. Some non-traditional methods of model evaluation will be attempted in order to verify the predicted probability distributions of concentration from the ROM at given receptor sites. Such traditional techniques as analysis of residuals and scatter plots also will be used.

2.1.3 Boundary Layer Modeling

2.1.3.1. Planetary Boundary Layer Modeling

The Binkowski model (1983) is being extended to allow vertical resolution of the wind, temperature, and moisture profiles. The previous formulation of the diurnally varying layer of surface based mixing is retained along with exchange coefficients which are functions of height and scaling velocities. These exchange coefficients also include modification for non-local effects which occur under convective conditions. Above the layer of surface based mixing, the exchange coefficients are determined by using a method which relies upon a comparison of the local Richardson's number with a local critical Richardson's number. The model is currently being tested and the preliminary results are encouraging.

2.1.3.2 Turbulence Measurements in the Urban Convective Boundary Layer

Vertical dispersion of pollutants emitted into the convective boundary layer (CBL) is highly dependent on the magnitude and structure of turbulence. Turbulent eddies play an important role in transporting and mixing pollutants within the CBL. Advances in understanding dispersion in the CBL have come from laboratory and numerical model results, however, analyses of experimental measurement results are needed for parameterizing turbulence in models and to evaluate model results.

Turbulence measurements of the vertical velocity component were collected by an instrumented research aircraft as part of the Regional Air Pollution Study (RAPS) urban boundary layer field program in St. Louis, Missouri. The objective of this research was to investigate the magnitude and variation of vertical velocity fluctuations characteristics in the afternoon CBL from data obtained over the variable land use features and different roughness elements within this large urban region. Vertical velocity time series for 22.5 km length segments were evaluated to derive statistical information on updrafts and downdrafts at 150 m above the city.

Results revealed that vertical velocity distributions for both urban and nonurban segments displayed positive skewness and negative mode. Statistical results showed that the means and standard deviations of the upward and downward vertical velocities were 20% greater for the urban segments. Results derived from a conditional sampling technique indicated that the mean and extreme updrafts were larger for the urban segments. The fractional amount of time spent in upward motions was consistently less than in downward motions. In addition, comparisons of the width of the largest updraft, CBL height (Zi), and the vertical velocity spectral peak wavelength were performed. Results showed that the largest updraft was about the same magnitude as Zi, however, there was relatively large scatter when individual pairs were compared. The vertical velocity spectral peak wavelength was 1.5 times Zi on average for the urban segments. These experimental results also support numerical model and laboratory results. A conference paper (Godowitch and Ching, 1984) presented some results of this analysis effort.

2.1.3.3 Boundary Layer Diffusion Studies

Analyses were made of SF_6, chaff, power plant, and SO_2 (as a tracer) release into convective boundary layers. Observed lateral diffusion and crosswind-integrated ground concentrations from these various field experiments were compared with results from the laboratory experiments and numerical modeling experiments for similar atmospheric conditions. Surprisingly good comparisons were obtained when all data were made nondimensional using convective scaling. These results were presented at the February 1984 American Meteorological Society (AMS) Specialty Conference on Air Quality Modeling of the Non-homogeneous, Non-stationary Urban Boundary Layer. The paper (Briggs, 1983) also focused on the application of convective scaling theory to surface inhomogeneity effects often found in cities, such as turbulence enhancement over downtown heat islands, and stationary downdrafts caused by cooler surfaces like rivers. A presentation summarizing the application of convective scaling to analytical parameterizations of diffusion in the convective boundary layer was made in January at the 1984 Workshop on Updating Applied Diffusion Models.

2.1.3.4 Boulder Tower Experiment

The field experiment phase of CONDORS (Convective Diffusion Observed with Remote Sensors) was completed in FY-84. The experiment consisted of radar measurements of metallic chaff plumes and lidar measurements of oil fog plumes released simultaneously from the 300-m tower of the Boulder Atmospheric Observatory or at its base. These measurements and concurrent meteorological measurements were made by NOAA's Wave Propagation Laboratory; a single arc of 27 samplers, with releases of SF_6 and freon made proximate to the chaff and oil fog, was provided by NOAA's Field Research Laboratory, Idaho Falls. Further details on the measurements and a description of the goals of the experiment were given in section 2.1.4 of the FY-83 summary report (Viebrock, 1984).

Progress during FY '84 was slow. None of the processed data were delivered on schedule, and about one-third of the data have not been received. The data received were of good quality. Analysis showed that 90% of the freon samples and about 40% of the SF_6 samples were contaminated. A probable cause of the contamination has not been identified, and there is no known means of correcting for it. The purpose of the sampling arc was to serve as "ground truth" for relative concentrations inferred from the 3-diminsional distributions of observed oil fog and chaff densities. This purpose can be served in the case of the chaff plumes, which were released next to the SF_6 sampler measurements for 5 two-hour periods.

All except the least essential meteorological measurements were processed and received and these are virtually complete. Horizontal and vertical distributions of 10-sec wind directions for 8 tower levels were provided for the 13 sampling periods selected for detailed analysis; these will be very useful for comparing with observed lateral and vertical plume distributions and go beyond the usual scope of meteorological measurements. Most of the lidar measurements of oil fog distribution were processed, with improvements in the corrections for attenuation and background haze; these data appear to be of excellent quality and usefulness. Only half of the processed radar data were received. When the chaff plumes were released at the same height as the oil fog plumes, similar behaviors were seen in both observed distributions, which increases our confidence in the results. Furthermore, during most periods the behaviors of these plumes were qualitatively similar to behaviors of elevated and near-surface plumes observed in the laboratory experiments of Willis and Deardorff (1981) and the numerical experiments of Lamb (1979).

2.1.3.5 Modeling Air Quality in the Non-homogeneous, Non-stationary Urban Mixed Layer

An AMS specialty conference on air quality modeling of the non-homogeneous, non-stationary urban boundary layer was held in Baltimore, Maryland on October 31 - November 4, 1983. Its impetus arose from a combination of urban air quality modeling needs and intensive in-house boundary layer research activities.

The conference goals were:

1. Examine and evaluate existing concepts, observations, analyses, and computational methods;

2. Identify and assess existing knowledge that can be usefully applied to meteorological and air-quality diffusion models; and,

3. Identify new observations and understanding that will be needed in order to improve computer simulation of boundary layer flow and diffusion in urban areas.

The sessions were: 1) modeling pollutant transport and diffusion; 2) turbulence and mean structure (fast dynamics) of the urban boundary layer; 3) some observed features of the urban boundary layer; 4) evolution of the mixed layer structure (slow dynamics) of the urban boundary layer; and, 5) dispersion and removal processes in non-homogeneous, non-stationary urban area flows.

A discussion on assessment, conclusions, and recommendations followed. Meteorology Division personnel presented the papers on: 1) urban scale variation of turbulence energy and fluxes; 2) land use variation of turbulence in an urban area; 3) parameterization of subsurface heating for soil and concrete using net radiation; 4) spatial variability in the evolution and structure of the urban boundary layer; and 5) mixed layer dispersion scaling. A collection of papers presented at the conference is in preparation.

2.1.4 Model Development and Evaluation

2.1.4.1 Field Validation of Exposure Assessment Models

A field program and model evaluation study designed to simulate the atmospheric release of gaseous and fine particulate toxic substances was completed by Pacific Northwest Laboratory (PNL) during FY-84. The data available from the field program consists of crosswind integrated concentrations for simultaneous point release of a gaseous and a particulate tracer. The samples were taken on arcs at 100, 200, 800, 1600, and 3200 meters from the source. The ratio of crosswind integrated concentration for the deposition tracer to that for the non-depositing tracer at a height of 1.5 m was used for model comparisons. Two versions of PALDS and two versions of a source depletion model developed at PNL were tested. The source depletion model was modified to account for deposition by a profile correction term. The PAL-DS model accounts for both deposition and sedimentation analytically in its formulation. The PAL-DS model as originally developed does not conserve mass for a general functional form for sigma-z, but by a simple modification this can be remedied. In the model comparisons with field data results, the corrected source depletion model performed slightly better than PALDS, but the modified PAL-DS was nearly as good as the corrected source depletion model. The uncertainties in the diffusion meteorology are such that these results are suggestive rather than conclusive.

2.1.4.2 Pollution Episode Model

The Pollution Episodic Model (PEM) is an urban-scale model which predicts short-term average concentrations of one or two gaseous or particulate pollutants at multiple receptors for up to a maximum of 24 hour scenarios. The concentration algorithms were specifically developed to account for the effects of dry deposition, sedimentation, and a first-order chemical transformation. Hourly values of meteorological parameters are required. The development and evaluation of PEM is being performed by the NOAA Atmospheric Turbulence and Diffusion Division.

An evaluation of PEM with the St. Louis Regional Air Pollution Study data has been completed and the results are contained in Pendergrass and Rao (1984). For this model evaluation effort, the model's predictions were compared with 12 hour average observed concentrations of five pollutant species: SO_2, fine and coarse sulfates, and fine and coarse total mass. A first-order chemical transformation of SO_2 to fine sulfate was considered in addition to the direct emission and dry deposition of all five pollutants. For twenty days, PEM predicted average concentrations of SO_2 and fine and coarse particulate sulfates to within a factor of two. However, the model overpredicted fine and coarse particulate total mass concentrations by a factor of three or four. An overestimation of particulate emission rates is believed to be the principal cause of the higher model predictions. Currently some revisions and options are being incorporated into the model which will be designated PEM-2. An evaluation of PEM-2 with data from the Philadelphia Aerosol Study is planned.

2.1.4.3 Development of MESOPUFF II

An extramural effort to undertake major modifications to the mesoscale puff (MESOPUFF) model was completed. A final report (Scire, et al., 1984a) describes the model revisions and contains the results of a preliminary evaluation of several model algorithms with measurements from the Tennessee Plume Study. Mesopuff II is a Lagrangian puff superposition model that is designed to treat the transport, transformation and wet and dry removal of pollutants from multiple point and/or area sources on a regional scale. The objectives of the modification effort were to make it capable of treating temporal and spatial changes in the relevant atmospheric transport and removal processes. The major additions and important features of Mesopuff II include: the use of hourly National Weather Service (NWS) surface meteorological data and twice daily rawinsonde data, separate wind fields to represent flow within and above the boundary layer, parameterization of vertical dispersion in terms of turbulence variables, parameterization of SO_2 to sulfate and NO_x to NO_3 conversion, resistance modeling of dry deposition, time and space varying wet removal module, and a computationally efficient puff sampling function. In addition, a user's guide for the Mesopuff II modeling package (Scire, et al., 1984b) contains instructions and input/output data for the preprocessor, postprocessor, and model routines.

2.1.5 Cumulus Cloud Venting of Mixed Layer Ozone - An Observational Study

Regional transport models now recognize the importance of the linkage and exchange that occurs between the mixed layer and the free troposphere by penetrating cumulus convective clouds. However, there is as yet insufficient observational evidence to prove that net deposition actually occurs above the mixed layer because of these clouds. A joint experiment conducted with NASA directly addressed this problem. The experiments conducted in July 1981 utilized the airborne UV-DIAL (Ultra-Violet Differential Absorption Lidar) system developed by NASA. This system provides simultaneous range resolved ozone concentration and aerosol backscatter profiles with high spatial resolution. Data were obtained during the afternoon along 130 km east to west and south to north intersecting transects over North Carolina when non-uniformly distributed cumulus clouds were most active. Evening transects were obtained in the downwind region following air mass movement. Space-height analyses for the evening flight show the cloud "debris" to be unambiguously above the top of the mixed layer and appears as patterns of ozone typically in excess of the ambient free tropospheric background. This ozone excess was approximately the value of the concentration difference between the mixed layer and free troposphere determined by DIAL and independent vertical soundings made by another aircraft in the afternoon. The remnant of these convective clouds appeared in layers tilted in the vertical; the ozone and the aerosol features were highly correlated.

2.2 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, near buildings, roadways, and 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 flows.

2.2.1 Complex Terrain Studies

In conjunction with the complex terrain model development project, the Fluid Modeling Branch conducted two separate modeling studies. The first study was a series of tows in the stably stratified salt-water towing tank to test the validity of the assumption of a flat dividing-streamline surface as currently used in several complex terrain models. This assumption allows modelers to simply divide the flow field into two regimes: a horizontal flow in a lower layer and potential flow in an upper layer. One set of tows was made normally (inverted model) with a dividing-streamline height of half the hill height (h), effluent was released at 0.6, 0.7 and 0.8 h, and the resulting hill-surface concentration patterns were measured; a second set of tows was made under identical conditions except that the model was raised out of the water to the point where the water surface was precisely at the dividing-streamline height (i.e., half the hill height), thus forcing a flat dividing-streamline surface (the water surface). Comparison of the two sets of surface concentration patterns suggested that the flat dividing-streamline assumption is quite reasonable. A report on this work was published as an Appendix to the Complex Terrain Model Development Fourth Milestone Report (Snyder and Lawson, 1984).

The second study involved a wind-tunnel experiment of dispersion from a source upwind of a three-dimensional hill of moderate slope. The study was specifically designed to examine the deformations of the plume effected by the hill, and to aid the mathematical modelers in developing and testing their complex terrain models. A report on this work also was published as an Appendix to the Complex Terrain Model Development Fourth Milestone Report (Thompson and Snyder, 1984a).

In response to a request from the EPA Office of Air Quality Planning and Standards, another wind tunnel study was conducted on revisions to the good-engineering practice (GEP) stack height regulations (Lawson, 1984). Terrain amplification factors were measured for a large matrix of source positions (locations and heights) both upstream and downstream of each of two idealized model hills, an axisymmetric hill and a two-dimensional ridge. The results showed that a "window" of 40% excess concentration extended to 1.8 hill heights (h) in the vertical, 14 h upstream and 10 h downstream for the three-dimensional hill, and 2.2 h in the vertical, 8 h upstream, and 15 h downstream for the two-dimensional ridge. Maximum terrain amplification factors were found on the downstream sides of the hills, with values of 6.8 and 5.6 for the 2-D and 3-D hills, respectively.

The results of recent wind-tunnel and towing-tank studies on aerodynamics and plume dispersion in complex terrain were summarized in two review articles: the first for the Symposium on Tibetan Plateau and Mountain Meteorology (Snyder, 1984a) and the second for the Annual Review of Fluid Mechanics (Snyder, 1984b). These studies were designed to obtain basic physical understanding of flow structure and diffusion, to provide guidance in locating sources, and to provide "rules of thumb" for estimating surface concentrations when a source is located in complex terrain. Terrain amplification factors were compiled for a large variety of hill shapes, slopes, aspect ratios, and source positions from the neutral wind tunnel studies. From the stratified towing-tank studies, the dividing-streamline concept was shown to be a highly useful indicator in determining whether a plume would impact on a hill surface or surmount the top. Limitations of the towing tank for simulating strongly stratified flows over two-dimensional hills also were pointed out.

Stable atmospheric flow over a ridge and a valley was simulated in the salt-water-stratified towing tank. Flow visualization experiments were conducted using dye streamers and models with sinusoidal cross-sections to provide qualitative data on the structure of the flow field over the ridges and within valleys as well as quantitative data on the height of the dividing streamline. These data agree with existing theories based upon the potential energy barrier associated with flow over a ridge. A published report as well as a paper for presentation were prepared (Lee, et al., 1984a, 1984b).

Additional experiments were conducted to test the feasibility of towingtank simulations of strongly stable atmospheric flows over very long (two-dimensional) ridges. Revisions to the paper to be published in the Journal of Fluid Mechanics showed that steady-state conditions are not established in a finite length towing tank and, hence, cast doubt upon the validity of previous laboratory studies (Snyder, et al., 1984). Further results were presented at a workshop in Oxford, England (Thompson and Snyder, 1984b).

A paper on towing-tank and wind-tunnel measurements of concentration distributions on the surface of a hill when a plume impinges from an upwind source was prepared by Snyder and Hunt (1984). The stability was varied between very stable and neutral. The results were compared with the potential flow models developed in an earlier paper by Hunt, Puttock, and Snyder (1979). The comparison showed that the basic physics of the earlier models was correct.

2.2.2 Characterization of Dispersion in Automobile Wakes

Tracer gas experiments were conducted in a specially constructed wind tunnel, with a moving-belt floor, in order to ascertain turbulence length scales and eddy diffusion coefficients that describe diffusion in the wakes of model vehicles (Eskridge, et al., 1984). This information was used to upgrade the ROADWAY model (Eskridge, et al., 1979). Comparisons of the current ROADWAY model with the initial version showed an improvement in model performance. Statistical analyses of the current ROADWAY model and two other highway models, HIWAY-2 and CALINE3, showed that all three models simulated the GM Sulfate experimental data quite well.

The ROADWAY model and Long Island Expressway CO data were used to assess the effects of vehicle speed on air quality near highways (Petersen, et al., 1984). ROADWAY, the only highway model capable of assessing such effects, predicted that the effects on the concentration fields due to traffic-generated turbulence for different vehicle speeds could be significient, but that these effects were generally small when compared with changes in emission rates for different vehicle speeds. Although ROADWAY predicted the greatest traffic speed effect on concentrations during stable conditions, it also predicted significant effects during unstable conditions. The amount of and uncertainties in the field data were inadequate to ascertain any traffic-speed effects on concentrations.

2.2.3 Wind Tunnel Studies

Under a cooperative agreement with the North Carolina State University, a wind tunnel study was conducted to examine the flow structure and dispersion in the wakes of axisymmetric hills. Two conical hill shapes with slopes of 17° and 26° were used. Pollutant sources were placed on the tops and at the downwind bases of these hills. The results of this research were presented in a student's Master's thesis (Gadiyaram, 1984). The presence of the hills caused significant changes in ground-level concentrations. A 40 to 50% reduction in maximum ground-level concentrations was observed when the source was placed on the hill top, but marked increases were observed when the source was moved to the downwind base of the hill. The results clearly illustrated that the slope of a three-dimensional hill is a very important parameter; it determines the location of flow separation on the sides, the size of the cavity behind it, and the characteristics of the wake flow and dispersion.

Also under the cooperative agreement, the first phase of a wind tunnel study was conducted to examine the effectiveness of screens (windbreaks) in reducing wind speeds near storage piles. This provides an intermediate step in constructing a mathematical model to predict the effectiveness of the screens in reducing fugitive-dust emissions. A variety of screen types, placements, shapes and sizes were tested and a paper was presented for one shape of storage pile (an idealized conical shape) (Billman, 1984). The surface-averaged wind speed reduction and a windbreak effectiveness factor based on the relationship between the cube of the wind speed and particle uptake were given for each windbreak. In general, the results showed that the more material (i.e., the larger the size or the lower the porosity), the more effective was the screen. However, effectiveness factors nearly as large as those for the largest windbreaks tested were exhibited by much smaller windbreaks.

Previous work under this cooperative agreement on dispersion in a neutral boundary layer over a step change in surface roughness was published (Pendergrass and Arya, 1984a, 1984b).

2.2.4 Quality Assurance Plan

A Quality Assurance Plan was prepared for the Fluid Modeling Facility, specifying the standard operating procedures for the wind tunnels, water channel/towing tank, and associated equipment and instrumentation. These procedures are to be followed in order to insure that (a) proper techniques are applied in the acquisition of data, (b) traceability of data is maintained, and (c) quality assurance techniques can be applied in assessing the accuracy, reliability, and representativeness of acquired data.

2.3 Data Management Branch

The Data Management Branch is responsible for the coordination of 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.

2.3.1 Regional Oxidant Model Development

The first generation Regional Oxidant Model was finalized and a 60 hour simulation performed using an August 3-5, 1979 scenario. Preliminary analyses of resulting model concentrations are very favorable. Standard procedures were developed for review of data sets produced from each of the 20 processor programs, which prepare inputs to the model core. The structure of these data files was implemented to minimize the effect of changing processor requirements. The file designs also include mechanisms for tracing the origin and history of the data. Organized software and data set libraries using preset file naming conventions provide a means of automating processor and model executions. This automation allows research to proceed in more than one area at a time.

A paper was presented describing the implementation of the ROM and benefits derived by using the Jackson Structured Programming method. Integration of quality control in software design and the formal software certification process also were discussed.

Standard procedures for review of meteorological data have been documented and incorporated into a system for verification and archiving of data collected during the Northeast Regional Oxidant Studies. Verification of the 1979 data was complete and processing of the 1980 data will be completed in FY-85.

2.3.2 Biogenic Emission Inventory Enhancements

The software system which provides gridded biogenic hydrocarbon emission estimates for input to the Regional Oxidant Model (ROM) was upgraded to calculate biomass of tree species as a function of tree diameter. The other source types

- agricultural crops, grasses, leaf litter, water and wetlands use the classical approach where biomass is calculated by the product of a specie biomass factor times the area coverage of that specie. This classical calculation requires knowledge of the spread and distribution of different vegetation species. The EPA National Land Use and Land Cover Inventory, the U.S. Forest Service Inventory of Trees, and the 1978 Census of Agriculture compiled as part of the Oak Ridge National Laboratory's Geo-ecology Data Base provide the raw data necessary for adequate spatial resolution.

The system was modified to include adjustment of emission factors for temperature and light intensity. The base emission factors were reported as rates occurring at 30°C and were adjusted based on equations developed by Tingey (1981) for slash pine (monoterpene) and live oak (isoprene). The monoterpene adjustment was based only on temperature whereas the more complex isoprene adjustment is based on a temperature relation for each of four light intensities with linear interpolation between the curves for intermediate intensities.

2.3.3 ENAMAP Model Support

The ENAMAP-2 model was completely re-written to correct known defects and add several features. The new model has three layers during the day and adds a fourth layer, surface to 50 m, at night. Mixing height can be input as 1) a single default value, 2) seasonal minimum and maximum values for each grid, and 3) gridded values that vary continuously for each time period. The default or seasonally gridded mixing height was allowed to vary diurnally according to a prescribed fixed pattern. Total wet and dry deposition associated with a puff were distributed to individual grid areas covered by the puff based on each grid's individual precipitation and deposition rates. The new model allows for sourcereceptor calculations, snapshots at fixed intervals, choice of either SO_x chemistry, and continuous monitoring of sulfur budget and CPU-time usage. Skewness of the 70 km grid system was corrected. Revision to a latitude-longitude grid system will be completed in FY-85.

A series of data processors were developed to prepare raw data for input into the revised model. These processors perform such functions as interpolation of winds and preparation of precipitation and emissions data.

2.3.4 Support of the National Crop Loss Assessment Network (NCLAN)

During FY-84 the regional structure of midday ozone was studied on a few selected days. Addition of co-monitored NO_x as a surrogate for depleted ozone demonstrated a regional structure of a relatively constant background rising to ridges aligned with the wind flow over the areas with high population density. The kriging variogram structure is limited to about 50 kilometers, similar in geostatistics to occasional enriched ore bodies embedded in a slightly varying background level. A method was proposed for evaluating the influence of local NO emissions on O_3 titration at a monitoring site by comparison of midday values. Determination of the influence of meteorological factors, especially clouds and rain, has not yet been evaluated; however, well mixed sunny days should have early afternoon values that are reasonably uniform across large distances except for local enhancements of titration. A proposed new methodology, not yet evaluated, would consist of a few index stations used to estimate large area hourly ozone levels, to be averaged or otherwise manipulated for exposure estimates. This approach should estimate rural ozone reasonably well, but under/overestimate in emission areas.

2.3.5 Support of In-House Research

The Air Resources Laboratory's Branching Atmospheric Trajectory (BAT) model was implemented to provide a three-layer model that reflects plume spread from vertical wind shears at day/night transitions which could not be done by the single layer Atmospheric Transport and Dispersion (ATAD) model formerly used.

A meterological processor which provides the user a choice of methods for computing the nine basic variables required for dispersion modeling was implemented. Supporting software includes: 1) a preprocessor system to prepare the National Weather Service radiosonde, surface observation, and ten meter tower data; and, 2) a postprocessor to convert the output of the system for direct input to the TUPOS dispersion model.

2.4 Terrain Effects Branch

The Terrain Effects Branch conducts research studies into 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.

2.4.1 Dispersion Model Development for Sources in Complex Terrain

The complex terrain model development program is designed to produce atmospheric dispersion models that are useful in regulatory applications for large pollutant sources located in complex terrain, that have a demonstrated higher degree of reliability than existing models and are reasonable to apply in terms of required computer input parameters (Holzworth, 1980; Schiermeier, et al., 1983). As the first priority, the modeling effort was designed to focus on the one-hour average, ground-level concentrations that result from stable plume impaction on elevated terrain obstacles. To this end, small hill impaction studies were designed to use mobile sources emitting oil fog and tracer plumes to impact on isolated terrain features, features small enough to permit sampling over much of their surfaces.

The Small Hill Impaction Study #1 was conducted on the 100-meter tall Cinder Cone Butte near Boise, Idaho, during October and November 1980. Data from this study were used by Environmental Research & Technology, Inc. (ERT) to evaluate existing dispersion models (Valley, Complex I, Complex II, and Complex Potential Flow Model) and to aid in the development of new models for defining stable plume impaction in complex terrain.

The Small Hill Impaction Study #2 was performed on the 100-meter tall Hogback Ridge near Farmington, New Mexico, during October 1982. This study was designed to expand the applicability of the complex terrain dispersion models developed for Cinder Cone Butte to the case of a two-dimensional-ridge with attendant blocked and drainage flows. Both field studies consisted of quantitative measurements of stable plume impaction and associated flow structures using tracer releases, flow visualization techniques, and meteorological documentation. Other participants in the two field studies included the NOAA Wave Propagation Laboratory (WPL), the NOAA Air Resources Laboratory Field Research Division (ARLFRD), and the NOAA Atmospheric Turbulence and Diffusion Division (ATDD).

Analyses of the Cinder Cone Butte and Hogback Ridge data bases suggest that the concept of a critical dividing streamline height is appropriate for stable flows toward elevated terrain obstacles. Tracer gas released below the dividing streamline dispersed in a highly variable blocked flow and produced relatively large ground-level concentrations on the windward faces of the butte and the ridge. Tracer gas emitted above the dividing streamline dispersed in flows that traveled over the obstacles and produced peak groundlevel concentrations near the crests and on the lee sides. These conclusions are leading toward a complex terrain modeling system with two major flow components, differentiated by the height of the critical dividing streamline. Currently, testing continues on the newly-developed Complex Terrain Dispersion Model (CTDM) which incorporates components for flow above and below the dividing steamline (Strimaitis, et al., 1984).

A Full Scale Plume Study was conducted at the Tracy Power Plant near Reno, Nevada, during August 1984. A preliminary feasibility study was conducted at the same location during November 1983 to ascertain the likelihood of experiencing stable plume impaction on elevated topographic features surrounding the power plant. The Full Scale Plume Study was designed to provide credibility to the modeling results obtained thus far by examining and providing for the transferability of the results from Cinder Cone Butte and Hogback Ridge to an existing power plant. The Electric Power Research Institute (EPRI) joined in both the preliminary 1983 study and the full scale 1984 study.

An inhouse report was completed entitled "Scientific Assessment Document on Status of Complex Terrain Dispersion Models for EPA Regulatory Applications" (Schiermeier, 1984). The document serves as a policy statement of the EPA Office of Research and Development regarding the applicability of existing complex terrain models for regulatory use and contains a summary of the current status and needs for additional research. Results of an independent evaluation of eight complex terrain dispersion models were interpreted in terms of the models' abilities to accurately simulate ground-level concentrations resulting from plume impingement on elevated terrain obstacles.

2.4.2 Green River Ambient Model Assessment

Because of the proposed development of the Green River Oil Shale Formation encompassing the areas of southwestern Wyoming, northeastern Utah, and northwestern Colorado, the EPA Region VIII office in Denver needed site-specific air quality diffusion models. Accordingly, the Green River Ambient Model Assessment (GRAMA) project was initiated in 1980 to provide models for evaluating permit applications in the oil shale development area. The models are being developed by the U.S. Department of Energy (DOE) Pacific Northwest Laboratory through an interagency agreement.

The main objective of this project is to develop improved air quality models for analyzing the impacts within the complex terrain around the region of the Green River Oil Shale Formation. The effort consists of several components, depending on whether emissions are constrained within valley circulations or whether they are carried by convective processes into the prevailing synoptic flow. The components include local, mesoscale, and regional flow models as well as local and mesoscale air quality models.

During FY-84, a progress report (Alwine and Whiteman, 1984) was completed on further refinements to, and a technical description of, MELSAR, a mesoscale Lagrangian puff model for predicting pollutant concentrations within a 450-km by 500-km domain. A fully documented computer code and user's guide for MELSAR and VALMET, a valley scale air quality model will be completed in FY-85.

A report (Whiteman, et al., 1984) also was completed on meteorological and tracer data collected during a three-week period in July/August 1982 in the Brush Creek Valley of northwestern Colorado. The experiments were conducted by the DOE Pacific Northwest Laboratory as part of the GRAMA project and in cooperation with the DOE ASCOT (Atmospheric Studies in Complex Terrain) program during the same period. The objective of the field experiments was to obtain data to evaluate the VALMET model. In the field study, SF_6 (sulfur hexafluoride) was released from a height of 100 meters, beginning before sunrise and continuing until the nocturnal downvalley winds reversed several hours after sunrise. Initial analyses find the VALMET model to have promise in predicting air pollution concentrations in a deep valley. Further work is needed to complete a full analysis of the data and to evaluate and improve the VALMET model using these data.

The GRAMA program participated in the DOE ASCOT tracer study in the Brush Creek Valley during September/October 1984. Sequential 15-min, 30-min, and 60-min tracer samples collected at more than 90 sites will provide additional data for evaluation of the GRAMA air quality models. Concentration measurements during nighttime through noon are of primary interest. A number of ridgetop tracer samplers will provide data on valley ventilation into the mesoscale wind fields. The 1984 field study in combination with the 1982 study provides a good data base for evaluating VALMET.

2.4.3 Complex Terrain Data Base Documentation

A computer data base of meteorological and tracer observations from the Small Hill Impaction Study #2 is being compiled and placed on magnetic tape at the EPA National Computer Center at Research Triangle Park, North Carolina. This 1982 study was performed at Hogback Ridge near Farmington, New Mexico, and the data documentation process is similar to that performed for the 1980 field study at Cinder Cone Butte near Boise, Idaho. Documentation of the Hogback Ridge data base will be contained in a handbook describing the data tape files of meteorological measurements and tracer concentrations to encourage further analyses of the data and to promote additional applications and testing of various dispersion models. This second complex terrain data base will be made available in the form of tape copies or by interactive computer access.

As part of the Green River Ambient Model Assessment program, a joint field study with DOE ASCOT of nighttime drainage flow was conducted in Brush Creek, Colorado, during 1982. Tracer concentrations and meteorological measurements from rawinsonde, tethersonde, and aircraft observations were collected and compiled into a data base of magnetic tape files. These data are now available through the Meteorology Division either as tape copies or by interactive computer access.

2.4.4 Climatological Summaries of Complex Terrain Radiosonde Data

Climatological summaries in the form of vertical profiles of wind and temperature were produced from six years of twice-daily radiosonde observations recorded at ten National Weather Service stations located in the Rocky Mountains and in the Great Basin region of the western United States (Truppi, 1984). Seasonal and diurnal patterns were presented showing terrain influences at each radiosonde station characteristic of early morning and late afternoon conditions. Although climatological patterns were related to the particular valley-ridge topography, terrain influences can be estimated or extrapolated to nearby regions where data may be required for atmospheric dispersion modeling applications.

2.4.5 Stack Height Remand Task Force

A Branch representative participated as a member of the Stack Height Remand Task Force upon request from the EPA Office of Air Quality Planning and Standards (OAQPS). The task force is addressing issues and items of the EPA regulations on good-engineering-practice (GEP) stack heights from a case which was remanded by the U.S. First Circuit Court of Appeals. The representative has provided technical review and information to OAQPS and has attended task force workgroup meetings. The final EPA response was delayed pending an appeal to the U.S. Supreme Court. Based on the Supreme Court's decision in August 1984 not to review the lower court order, the EPA must now formulate final regulations early in 1985.

2.4.6 National Acid Precipitation Assessment Program

The national effort aimed at seeking solutions to the acidic deposition problem is centered in the interagency National Acid Precipitation Assessment Program (NAPAP). The Meteorology Division performs research under the NAPAP Atmospheric Processes Task Group C. A Terrain Effects Branch representative serves as the Project Manager for this effort with the Project C effort divided into the following sub-projects.

A. Acid Deposition Model Develoment and Evaluation
B. Precipitation Scavenging Studies and Modeling
C. Precipitation Precursors and Chemical Transformations
D. Dry Deposition Modeling of Acidic Matter
E. Horizontal and Vertical Transport Processes
F. Comprehensive Field Studies and Support Efforts

Four of these sub-projects are administered by three Sub-Project Managers within the Meteorology Division while responsibility for the remaining two (Precipitation Scavenging and Precipitation Precursors) resides with an EPA unit. The three Sub-Project Managers are assisted by four other personnel who are responsible for particular aspects of the subprojects. Altogether, eight Meteorology Division personnel are directly involved in the research effort for Project C: Atmospheric Processes. The report on Comprehensive Field Studies and Support Efforts is described in section 2.4.7.

The Manager of Project C has no direct responsibilities for administering extramural tasks, but instead serves as coordinator of the various subproject efforts. Planning, reporting, and peer review meetings in which the Project C Manager must participate are held frequently because of the close attention focused on the acid deposition program by the agencies involved.

As a NOAA assignment, the Meteorology Division Director serves as Chairman of the NAPAP Atmospheric Processes Task Group C. In this role, the Chairman established the interagency research plans and budgets for FY-86 in concert with the NAPAP Task Force and the nine remaining Task Groups. Also, the Chairman was responsible for monitoring the ongoing FY-84 research activities performed by NOAA, EPA, DOE, and TVA and for updating the FY-85 interagency research plans.

2.4.7 Comprehensive Field Studies and Support Efforts

Rather than relying completely on physico-chemical models for obtaining relationships between pollutant sources and acidic deposition, it is desirable to obtain such relationships by alternate means. During the year, a contract was awarded for a comprehensive field study plan to relate pollutant sources to acidic deposition. A draft study plan (McNaughton and Bowne, 1984) is being revised to incorporate components of additional work underway on analysis of uncertainties of inputs to the components of the design, as well as being combined with a related plan developed under the sponsorship of the Electric Power Research Institute. Rather than recommending one massive study, the combined plan will lay out a phased approach with limited objectives for each phase.

2.4.8 PEPE/NEROS Field Study

In July and August 1980, a major field study was carried out with the principal objective to characterize Persistent Elevated Pollution Episodes (PEPE's) from development through translocation and/or dissipation. This study was performed in conjunction with the Northeast Regional Oxidant Study (NEROS). The conduct of the study, with field headquarters in Columbus, Ohio, was described by Vaughan, et al. (1982). During the past year, descriptive case study analyses were made for selected urban plume experiments and for selected regional pollution episodes. The final report summarized the activities carried out by the numerous participants in the study including quality assurance work, illustrated the case study analyses, and provided information on sources of data resulting from the study (Vaughan, 1984a).

2.4.9 Cold Weather Plume Study

As a cooperative project with the Electric Power Research Institute, a two-week study was conducted of dispersion and pollutant transformations of the plume from a power plant in central Illinois during February 1981. Exchange of reduced and validated data was completed and a final report on the study submitted (Vaughan, 1984b). In addition to listing operational activities, this report summarized pollutant data for each flight segment, together with supporting meteorological data.

2.4.10 Archiving Field Study Data

To ensure the availability of data collected during past field studies, a two-tiered project is underway to collect and archive data from four studies: the Midwest Sulfur Transformation and Transport (MISTT) study conducted in the St. Louis area in 1975-76 in conjunction with the Regional Air Pollution Study (RAPS); the Tennessee Plume study conducted in Central Tennessee and Kentucky in 1978: the PEPE/NEROS study; and the Cold Weather Plume Study.

At the primary level, data from these studies have been collected and, as appropriate, formatted for storage on magnetic tapes. This work was performed under a cooperative agreement with the principal investigator serving as the Data Manager for all four studies. The first of the reports from this effort describing the MISTT data will be maintained by the Division, with work in progress to reformat small portions of the data obtained from the above source, and to provide as full documentation as possible concerning the measurement data to be archived.

2.4.11 Plume Dispersion in the Wake of Surface Obstacles

An inhouse building wake effects research project to evaluate the overall effects on plume dispersion downwind of building wakes has begun. The project will collect data in the meteorological wind tunnel, review available field data, and evaluate methods for estimating dispersion downwind of isolated buildings. Also, the applicability of fluid modeling studies to potential applications will be addressed.

A two-month study of concentration and velocity profiles downwind of an isolated block building was conducted in the meteorological wind tunnel. Velocity and concentration measurements from a surface release will be used to delineate the effect of building scale, building orientation, wind speed, and boundary layer characteristics on their non-dimensional distributions. Additional data collections and analyses will continue during FY-85.

Methodologies for analyzing video-taped images of smoke visualized plumes are being developed as a practical method of describing the short-time scale phenomena of building wake effects on plume dispersion. A sample video tape of a plume in the wake of a block building was recorded in the meteorological wind tunnel and is being used to assess the capabilities of image digitization equipment at North Carolina State University.

2.4.12 American Meteorological Society Workshop

A workshop was conducted during January 1984 by the American Meteorological Society under the sponsorship of the EPA updating applied diffusion models. It was designed to bridge the gap that exists between present modeling practice and current diffusion science as understood in terms of contemporary planetary boundary layer structure. A report on the workshop recommendations is being prepared.

2.4.13 NATO/CCMS Participation

The Meteorology Division Director serves as a member of Panel 2 of the NATO Committee on Challenges of Modern Society (CCMS). Panel 2 was designed to focus on current international developments in air quality modeling under the auspices of the NATO/CCMS Pilot Study on Air Pollution Control Strategies and Impact Modeling. Members of Panel 2 shared information about a large number of air pollution transport models and performed detailed comparisons of the effectiveness of a selected number of them. The Panel's work in this area has influenced regional European cooperation and has served as an impetus for efforts in transboundary air pollution abatement by the European Economic Community (EEC) and by the Organization for Economic Cooperation and Development (OECD).

2.5 Environmental Operations Branch

The Environmental Operations Branch improves, adapts, and evaluates new and existing air quality disperison models, makes them available for use, and consults with users on their proper application. The research work of the branch consists of two major projects: (1) UNAMAP (Users' Network for Applied Modeling of Air Pollution) which makes models available to users; and (2) the improvement of plume modeling techniques.

2.5.1 Rural Model Review

A pilot study, requested by the AMS Steering Committee for the cooperative agreement on Scientific Assessment of Air Quality Modeling, was completed in which potentially useful model evaluation methods were investigated (Irwin and Smith, 1984). The approach taken is essentially clinical as opposed to analytical. Attention was given to the details of the topography and meteorology, and to the limitations of the data base. Using data from one of the Green Flow field experiments it was shown that the correlation of observed and predicted concentrations in time and space is extremely sensitive to the specification of the wind direction. Errors in the wind direction of as little as 2 to 4 degrees can reduce the correlation from almost 1.0 to as low as 0.06 or less. To circumvent these difficulties, a system that was used widely to interpret much of the tracer data obtained during the 1940s and 1950s was employed, namely, one that attempted to reconstruct the centerline concentration profiles as a function of distance downwind for each stability category. The results using this approach revealed stratification in performance among the rural point-source models, stratification that was difficult to discern using more traditional methods of evaluation. A summary of the analysis of the centerline concentration values, taken from an overall standpoint, show a distinct gradation in the performance. The bias to overestimate concentration values for the near receptors during unstable conditions and to underestimate values for the near receptors during stable conditions are clearly shown. The results presented suggest that there are significant differences among the models in terms of performance for this particular data set. Whether these differences will prove to be consistent at other sites cannot be determined easily, but there is adequate reason to believe that an extension of such analysis to data from a fairly large number of suitable networks might be revealing.

2.5.2 Meteorological Processor

The construction of a meteorological processor for use in dispersion modeling is underway. A FORTRAN coded program is being fabricated and plans are to complete and document the code by the summer of 1985.

The development plans for the processor call for work in three areas: consultation with experts on techniques to be employed, fabrication and testing of algorithms into a workable meteorological processor, and performance evaluation of the processor with field data. Work in all three areas has occurred during this year. In June 1984, a second meeting was held with the international workgroup: scientists participating from Denmark, The Netherlands, Norway, and the United States. A report is currently being drafted summarizing the techniques suggested by the workgroup for inclusion in the meteorological processor. Using on-site contract personnel, the computer program's systems design was drafted and significant progress was made towards encoding the algorithms. To properly evaluate the processor requires definition of the profiles of wind, temperature, and turbulence over the lower portions of the boundary layer. Such data are rare. We are assessing the possible use of 5-year data set of 300 m meteorological tower data acquired from the Meteorological Group of the Savannah River Laboratory, near Augusta, Georgia. Initial results suggest these data could be employed for initial evaluation of the meteorological processor.

2.5.3 Evaluation of Alternative Guassian Plume Dispersion Modeling Techniques in Estimating Short-Term Sulfur Dioxide Concentrations

A routinely applied atmospheric dispersion model was modified to evaluate alternative modeling techniques that allow for more detailed source data, onsite meteorologial data, and several dispersion methodologies (Pierce, 1984). These techniques were evaluated using hourly measured SO_2 concentrations at fixed receptors around coal-fired power plants near Paradise, Kentucky, during 1976, and near Johnsonville, Tennessee, during 1977. A significant finding of the evaluation was that the more sophisticated models did not appreciably outperform the routinely applied models. The models using airport meteorological data performed as well as the models using on-site wind data. With the Pasquill-Gifford and Briggs dispersion schemes, small differences in model performance were observed. More substantial differences occurred with models using on-site turbulence measurements. The model using Pasquill's recommendations tended to overpredict peak concentrations. The models based on Draxler's and Cramer's approaches using on-site turbulence yielded mixed results, perhaps in part because the lateral standard deviation of wind direction available was the 1-h average of 5-min values (rather than a 1-h value), thus eliminating the longer period fluctuations that are important in estimating 1-h concentrations in addition to the shorter period fluctuations. Additional research is recommended to improve the application of on-site turbulence measurements and to provide more accurate estimates of plume trajectories for input to atmospheric dispersion models.

2.5.4 Air Quality and Effects Modeling

A plant injury mathematical model, previously developed to model acute and chronic leaf injury data, was developed further by Larsen and Heck (1984) to model National Crop Loss Assessment Network (NCLAN) data. Percent crop yield reduction was estimated as a function of a new parameter, the effective mean O_3 concentration:

$$m_e = [(\sum c_h{}^{-1/v})/n]^{-v}$$

where c_h is the hourly average ambient O_3 concentration for each daytime hour (9:00 A.M. - 4:00 P.M.) of data available at an air sampling site for summer (June 1 - August 31), n is the total number of such available hours, and v is an exposure time-concentration parameter (-0.376).

As one example, crop yield reduction for soybeans was estimated as

$$z = 0.478 \ln (t m_e{}^{2.66}) - 0.42$$

where z is the Gaussian transform of percent crop reduction, t is the hours of exposure (525 h is used; 7 h/day for 75 days), and ln indicates that the natural logarithm is taken of the quantity within parentheses. Crop yield reductions for seven plant species (Figure 1 shows reductions for four species) were estimated

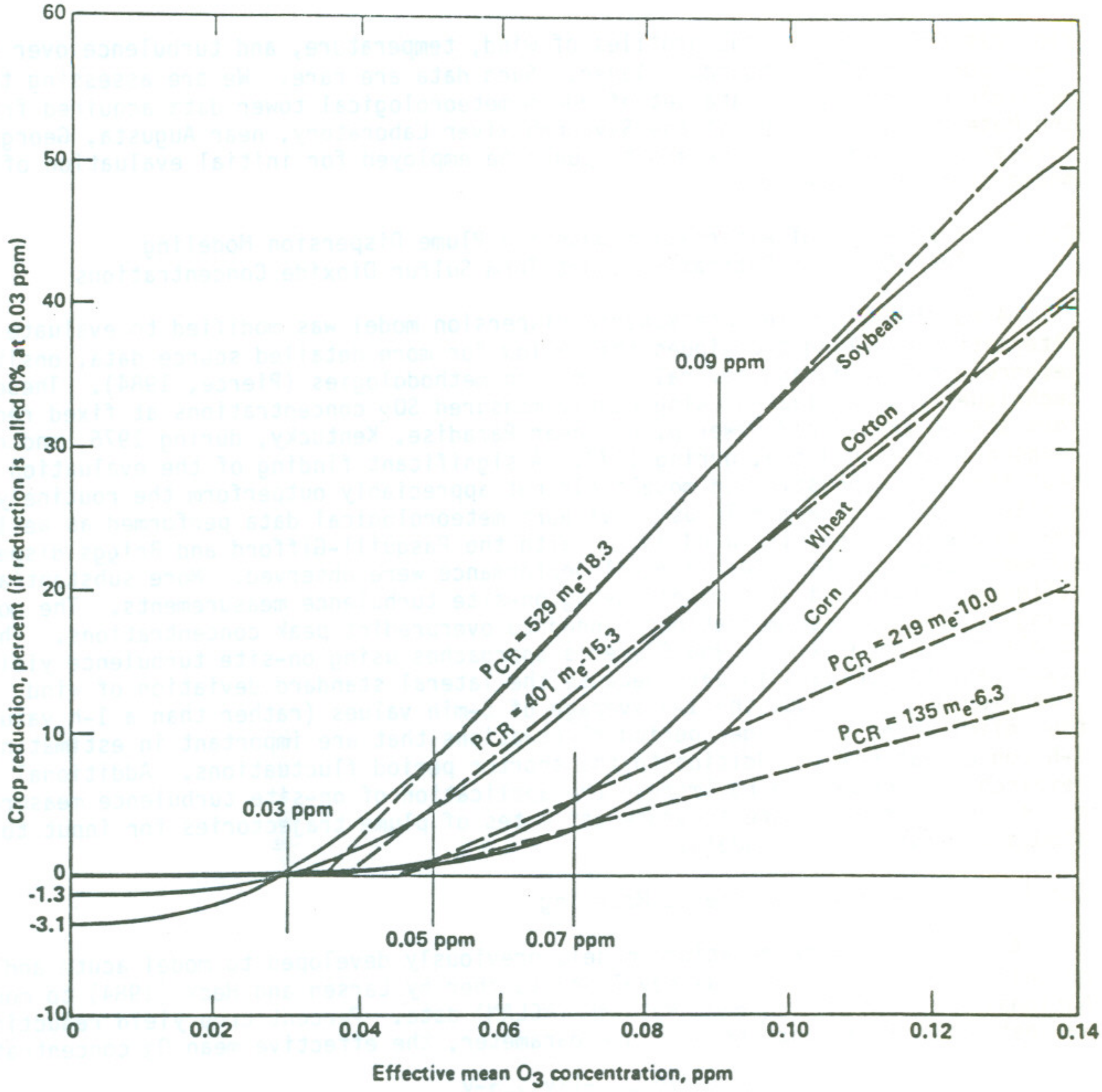

Figure 1. Percent crop reduction estimated for crops exposed to various effective mean O_3 concentrations for 75 days (for 7 h/day, totaling 525 h).

with similar equations for each of the 1824 site-years of 1981-1983 hourly O_3 concentration data available in the National Aerometric Data Bank (NADB). County-average effective mean O_3 concentrations were indicated by shading a U.S. map (Figure 2). Figures 1 and 2 can be used to estimate crop reductions for a given county. Ambient O_3 concentrations reduced the total U.S. crop yield an estimated 5% for years 1981-1983.

2.5.5 Evaluation of the Performance of RAM with the Regional Air Pollution Study Data Base

Atmospheric dispersion models are widely used to assess the impact of emission sources on air quality for varying conditions of topography, meteorology, and source configurations, and for the development of air pollution control strategies. The object of this study (Rao, et al., 1984) was to assess the behavior of RAM (Turner and Novak, 1978) by employing various statistical techniques. Measurements of SO_2 at 13 locations in the St. Louis area collected as a part of the Regional Air Pollution Study (RAPS) were used to assess the simulation capability of RAM. Analysis was performed to determine whether RAM could be calibrated to improve its performance within the urban area. Further, detailed analyses were performed to identify (a) the weaknesses in the current formulation of RAM, and (b) possible improvements to the model.

The RAM air quality simulation model's performance was examined using the RAPS' Level-7 data base. Time series analyses were performed to test the adequacy of RAM in simulating the dynamics of pollutants in the atmosphere. Power spectrum and auto-correlation analyses showed that the predicted concentrations do not have the same temporal characteristics as the observations during the winter season. Both paired and unpaired analyses were included to critically examine the model performance. The paired comparison indicate a better agreement between predicted and observed data at the rural sites than at the urban sites. When the data were segregated according to wind speed and atmospheric stability class, it was found that there was very little agreement between predicted and measured concentrations under extreme stability (either very unstable or very stable) and low wind speed (less than 2 m/sec) conditions.

In order to see how the model predictions compared with the corresponding measured concentrations, time-averaged plots for concentrations were developed. Figure 3 shows the time-averaged concentrations and the mean deviation between measured and predicted concentrations as a function of time after sunrise at various monitoring locations. It is observed that the model underestimated the concentrations during the first 8 hours after sunrise, followed by an overestimation after sunset. It is significant that when the area source emissions are decreasing, an opposite trend between model predictions and observations exists during the first 8 to 10 hours after sunrise. The maximum mixing depth and highest wind speed occurred 7 hours after sunrise at which time the predicted concentrations at the urban sites reached minimum values. Therefore, the results suggested that the predicted ground level concentrations at the urban sites were responding primarily to the area source emissions which reached a mimimum value 7 hours after sunrise and to the meteorological variables which also indicated a maximum dilution (ventilation) at that time. The results suggested that a better characterization of the emission sources together with a fumigation algorithm incorporated into the model might produce a predicted concentration field that would be in phase with the measured concentration field within the urban area.

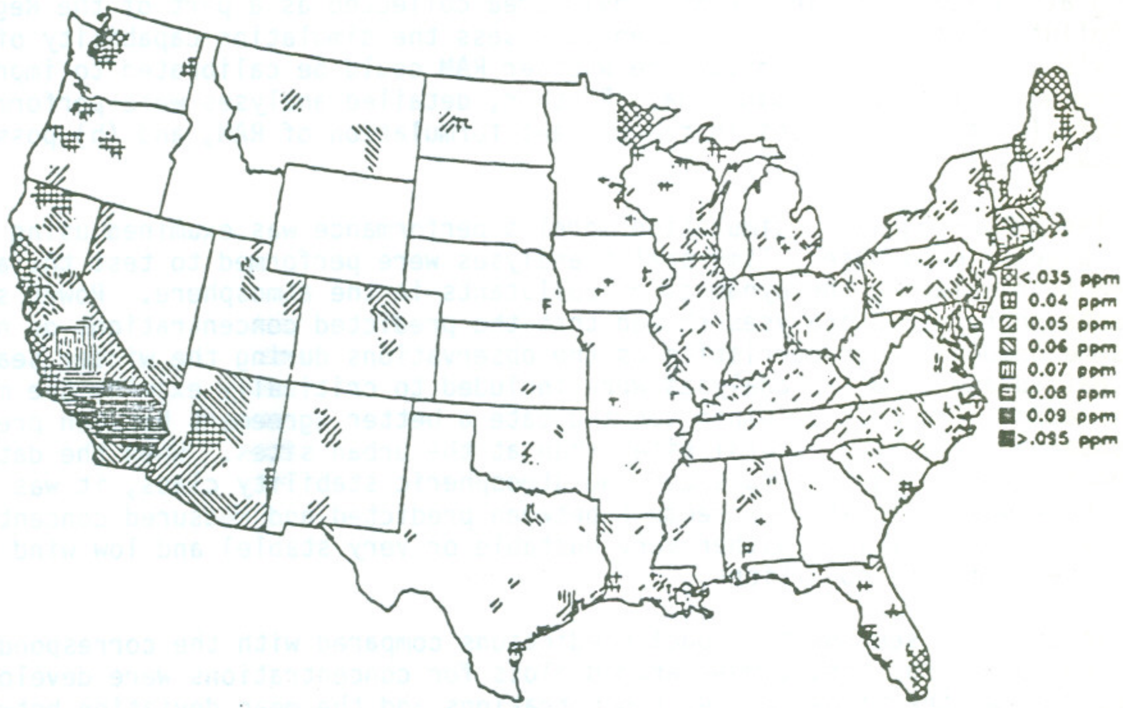

Figure 2. County-average effective mean O_3 concentrations, 1981–1983.

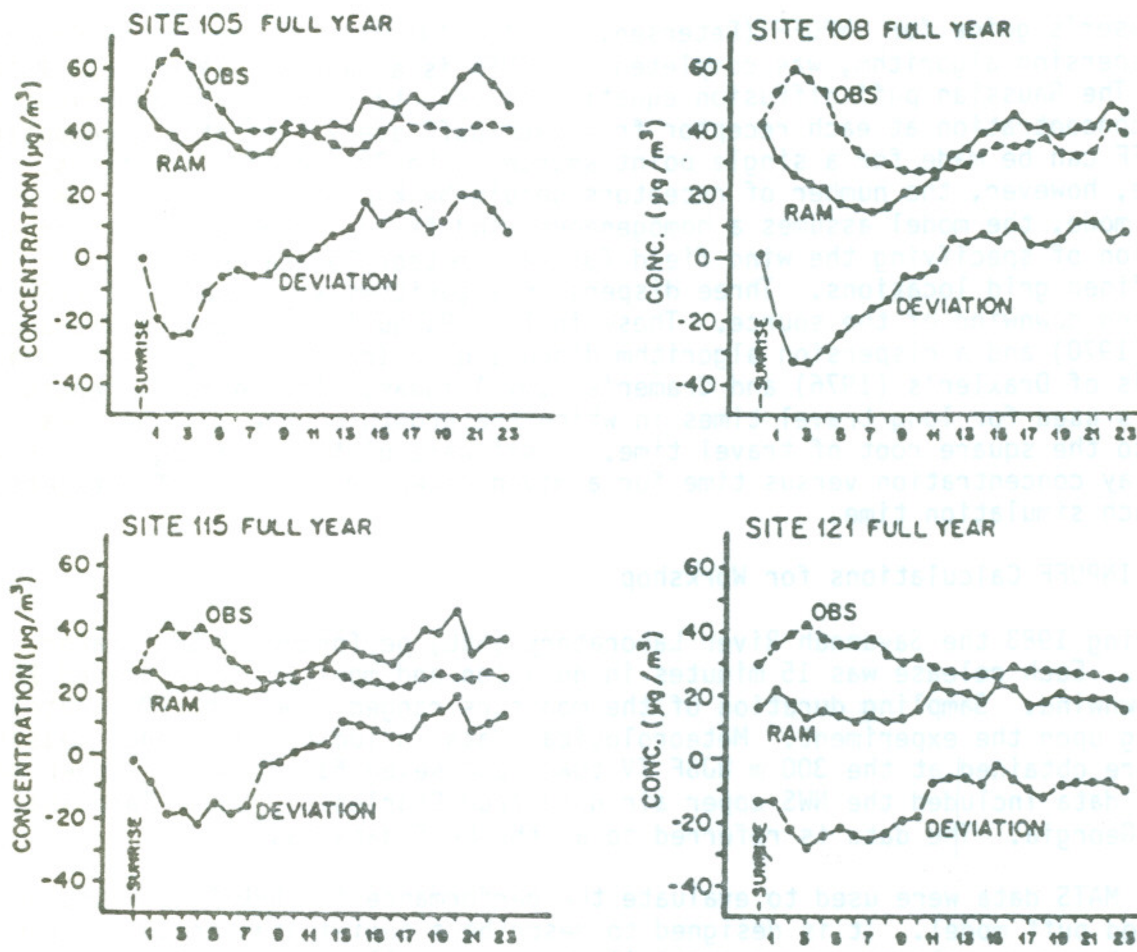

Figure 3. Temporal distribution of time-averaged concentrations at selected monitoring sites. (The horizontal axis is hours after sunrise.)

The measured and predicted daily maximum concentrations are subjected to the "bootstrap" sampling procedure to develop the distribution of the differences between observed and predicted concentrations. These distributions suggested that the errors are random and, therefore, RAM cannot be calibrated to improve model performance within the urban area.

2.5.6 User's Guide for Integrated Puff Model

A user's guide for INPUFF (Petersen, et al., 1984), a single source Gaussian puff dispersion algorithm, was completed. INPUFF is a Gaussian INtegrated PUFF model. The Gaussian puff diffusion equation is used to compute the contribution to the concentration at each receptor from each puff every time step. Computations in INPUFF can be made for a single point source up to 25 receptor locations. In practice, however, the number of receptors should be kept to a minimum. In the default mode, the model assumes a homogeneous wind field. However, the user has the option of specifying the wind field for each meteorological period up to 100 user-defined grid locations. Three dispersion algorithms were used in INPUFF for dispersion downwind of the source. These include Pasquill's scheme as discussed by Turner (1970) and a dispersion algorithm discussed by Irwin (1983), which is a synthesis of Draxler's (1976) and Cramer's (1976) ideas. The third dispersion scheme is used for long travel times in which the growth of the puff becomes proportional to the square root of travel time. A software plotting package was provided to display concentration versus time for a given receptor and the puff trajectories after each simulation time.

2.5.7 INPUFF Calculations for Workshop

During 1983 the Savannah River Laboratory (SRL) performed 14 SF_6 tracer releases. Each release was 15 minutes in duration and monitors were placed 20 - 30 km downwind. Sampling duration of the monitors ranged from 7 to 20 minutes depending upon the experiment. Meteorological data including turbulence measurements were obtained at the 300 m WJBF TV tower and seven 61 m towers. Other meteorological data included the NWS upper air data from Charleston, South Carolina, and Athens, Georgia. The data is referred to as the MATS data base.

The MATS data were used to evaluate the performance of INPUFF, a Gaussian integrated puff model. It is designed to describe a semi-instantaneous or continuous point source release over a spatially and temporally varying wind field. Each of the 14 SF_6 releases were modeled using INPUFF and the results sent to SRL for comparison with other puff models.

2.5.8 Climatological Variability in Modeled Maximum Concentrations

A study compared various periods from a 17-year meteorological data set to determine the minimum number of years' data needed to approximate highest modeled concentration estimates at one station (Burton, et al., 1983). This study indicated that the variability of model estimates due to the meteorological data input was adequately reduced if a 5-year period of record was used. However, for many applications five years of data may not be available or too costly to obtain. Assuming that five years of meteorological data are required to ensure that maximum concentrations have been estimated, and one year of data has been measured at random, then there is an 80% likelihood that, if another 4 years of data were gathered, a higher maximum concentration would be estimated. An environmental issue is the uncertainty in maximum concentration estimates as a function of period of record. Petersen and Irwin (1984) raised the question, "If less than five years of data are collected, how uncertain are we in our estimates of maximum concentrations?"

In this analysis, the high and the high second-high (HSH) concentrations for two typical sources for the 17 years as modeled by the CRSTER air quality model were examined. Resampling techniques were used to assign probabilities of choosing the highest second-high concentration from the 17 year record assuming that one through five years of meteorological data were measured. It was not the intent of the paper to suggest that the exact probabilities estimated from this data base were universal to every city or site location. This was not likely. The important issue was to indicate the short-comings in accepting as little as one year of on-site data and to suggest a method that better ensured that maximum concentrations are properly estimated.

A relatively new statistical technique called "bootstrap" (Efron, 1982) is used to reanalyze the concentrations for the 17 years of CRSTER output. The "bootstrap" method allows one to estimate the distribution of a population parameter, e.g., mean, median, variance, or any percentile, based on a random sample. The method does not require any assumptions regarding the distribution of the underlying population.

In reanalyzing the 17 HSH concentration values a concentration was selected, recorded, and replaced back in the original sample. This process was repeated 500 times. Our "bootstrap" sample now consisted of 500 high second-highs. Employing the procedure described above, HSH concentrations were chosen at random for two years and the highest concentration recorded and both items replaced. This process of selecting multiple years was repeated up to 5 years. The "bootstrap" samples were used to generate Table 1.

The values of the ratios in Table 1 can be used to adjust the HSH based on N years of data for year-to-year variability. If C is the HSH concentration base on N years of model runs, N < 5, and R is a ratio from Table 1, then

$$C_A = C[1+(1-R)],$$

where C_A is the adjusted concentration. Any R could be chosen from the table. Choosing a value of R under the worst case column would provide largest increases to the HSH. The median values would provide a more typical correction.

The corrections for the two sources used in this analysis are similar. For multiple source problems perhaps an average ratio of the small and large source ratios would be appropriate. However, differences in the ratios for different source types need to be verified with other data bases.

Table 1. Ratios Formed from "Bootstrapped" Samples from One through Five Years of Selected High Second-High Concentrations.

	SMALL SOURCE				LARGE SOURCE			
	Worst		Percentile		Worst		Percentile	
N-yrs.	Case	25	50	75	Case	25	50	75
1	0.705	0.798	0.845	0.911	0.679	0.787	0.826	0.897
2	0.705	0.845	0.868	0.995	0.679	0.826	0.897	0.933
3	0.746	0.867	0.964	0.997	0.719	0.831	0.917	0.957
4	0.764	0.868	0.995	0.997	0.788	0.897	0.933	0.957
5	0.802	0.911	0.995	1.000	0.734	0.897	0.933	0.957

2.5.9 Effects of Traffic Speed on the Ambient Pollutant Concentration Near Roadways

Models currently available for assessing air quality downwind of roadways do not incorporate the effects of traffic generated turbulence as a function of vehicle speed. The popularly used models, HIWAY-2 (Petersen, 1980) and CALINE3 (Benson, 1979), were developed from data bases containing predominantly high speed traffic and therefore may have a limited range of traffic speeds over which they are applicable. A numerical model (ROADWAY) developed by Eskridge, et al. (1979), included vehicle wake diffusion dependent upon the turbulent kinetic energy which is proportional to the square of the relative wind speed on the moving vehicle. This model predicted that turbulent mixing and hence pollutant concentrations on and downwind of a roadway are dependent on the vehicle speeds. The vehicle wake turbulence was strongest over the roadway and decreased rapidly from the road. The wake theory predicted that this effect would be most important under stable atmospheric conditions and much less important under neutral and unstable conditions. The Long Island Expressway CO data (Rao, et al., 1979) provided an opportunity to investigate the theoretical predictions of the effect of traffic speed on concentrations downwind of the expressway (Petersen, et al., 1984b).

For the CO data the traffic speed effect on concentrations was not observed for unstable conditions. The effects on the concentration field due to traffic generated turbulence for different vehicle speeds were small when compared to changes in emission rates for different vehicle speeds for unstable and neutral conditions. Uncertainties in the emission rates may have obscured any traffic speed effect present in the data.

No data bases are available to effectively evaluate the ability of ROADWAY to predict the traffic speed effect. In past studies traffic speeds were obtained to estimate the emission rate. These vehicle speeds represented an arithmetic mean vehicle speed. However, in computing the mean vehicle speed for input into ROADWAY, the rms vehicle speed should be computed as this value is more closely associated with the energy production. To effectively test the ROADWAY model one would like to see the GM test track revisited allowing the packs of cars to run at predescribed speeds. Using a tracer and running all the vehicles at predescribed speeds for a variety of atmospheric conditions, the uncertainties which made it difficult to discern the traffic speed effect would be eliminated.

2.5.10 An Evaluation of Wind Measurements by Four Doppler Sodars

During the first three weeks of September 1982 an experiment was conducted at NOAA's Boulder Atmospheric Observatory (BAO) to assess the ability of insitu and remote sensors to measure the mean and turbulent properties of the lower atmosphere. The experiment was conducted in response to the need for comparative data from which scientists could evaluate the accuracy, field precision, and general performance of some of the more commonly used meteorological instruments that measure atmospheric turbulence.

Measurements by four Doppler sodars of wind speed, wind direction, and vertical component of turbulence were compared to similar measurements made on the BAO 300-m instrumented tower (Kaimal, et al, 1984). The sodars were manufactured and were operated during the test by Aerovironment, Inc., Radian, Inc., Remtech et Cie (formerly Bertin), and Xontech Inc. Sodar measurements were compared to measurements made by fast response sonic anemometers at 100, 200, and 300 m. Results of the experiment indicated that all sodars measured wind speed and direction quite accurately and with reasonably high precision. Comparison of the measurements of the vertical component of turbulence indicated that the sodars tended to overestimate the standard deviation of vertical velocity at night and to underestimate it during strongly convective situations. The precision of measurement for the vertical component of turbulence was considerably poorer than that for average wind speed and direction. Comparison also indicated some differences among the various types of sodars. Analysis of the spectra measured by the sodars indicated that measurement inaccuracies may have been due to a combination of sampling volume used by the sodars and aliasing problems.

2.5.11 Indirect Estimation of Convective Boundary Layer Structure for Use in Routine Dispersion Models

Models of atmospheric dispersion designed to predict the transport and diffusion of atmospheric pollutants often require as input meteorological information that is not routinely available. It is possible, however, to estimate the more complex and detailed meteorological parameters required by the models. The purpose of an analysis performed by James Wilczak and Mary Sue Phillips (1984), NOAA, was to draw together various semi-empirical theories of the convective atmospheric boundary layer (ABL). Using these theories, along with readily available measurements, it is possible to demonstrate the accuracy with which the mean and turbulent structure of the convective ABL can be deduced.

The meteorological parameters required for dispersion calculations are the vertical profiles of $\overline{U}$, $\overline{AZ}$, $\overline{\Theta}$, σ_u, σ_v and σ_w u to the height of the capping inversion A_i, as well as the surface heat flux $\overline{w'\Theta'}$ and momentum flux $\overline{u'w'}$. These parameters will need to be known as a function of time, which begins shortly after sunrise until late afternoon. The direct measurements used to predict these parameters consisted of: an early morning temperature sounding obtained from a rawinsonde ascent; the mean surface wind speed and direction measured at one height (nominally 10 m) as well as the turbulent velocities at the same height; two levels of mean temperature near the surface (nominally 2 and 10 m); and an estimate of the local surface roughness.

Twenty-six days of data were used in this analysis. These data were taken in the later summer over two consecutive years at the Boulder Atmospheric Observatory (BAO).

Results showed that most of the detailed meteorological parameters needed for routine dispersion calculations could be estimated from simple, readily available meteorological measurements, with an accuracy of 10 to 30%. Standard deviations for individual realizations were: 50% for surface heat flux, 30% for Z_i (height of the convective boundary layer), up to 0.4^oC for temperature, 30% for wind speed, and 25% for the turbulent velocity components. The most difficult parameter to predict accurately was the wind direction. Ensemble values gave a mean bias of 5^o in the lowest half of the ABL, which increased to approximately 30^o near Z_i, while the standard deviation increased from 10^o at the surface to 60^o near Z_i. We att - ributed these large errors to terrain inhomogeneities.

2.5.12 Proposed Practical Methods for Estimating Plume Rise and Penetration

Nearly all of the air quality simulation models made readily available through the UNAMAP system (EPA, 1983) use plume rise methodology dependent on the wind speed estimated at physical stack top and the surface based Pasquill stability class. For stable situations as indicated by the stability class, one set value of $\delta\Theta/\delta z$ above the stack top is used dependent on that stability class.

Most of the current models also treat plumes in the vicinity of the mixing height in an overly simplistic, all-or-nothing way. (If the plume centerline is above the mixing height, no contribution of the plume to concentration below the mixing height; if the plume centerline is below the mixing height, the entire plume is eddy-reflected downward from the mixing height). Methods have been suggested by Briggs (1975) and others (Weil and Brower, 1982) to consider partial penetration of the plume into the more stable layer above the mixing height.

For situations where such additional meteorological information is available as wind speed and temperature profiles with height it is highly desirable to use this information. The thermal structure is especially important since an inversion layer inhibits plume rise and near adiabatic conditions provides little retardation to the rising plume. The purpose of this investigation was to present methods for plume rise and plume penetration that can make use of profile data.

A paper by Turner (1984) proposes methods for estimating plume rise taking advantage of data on the vertical variation of wind speed and temperature and partial penetration of the plume into the stable layer above the mixing height.

These procedures were designed to take advantage of methods developed by Briggs to consider the vertical structure of meteorological parameters in estimating plume rise. It was assumed that temperature and wind speed would be available at a number of levels (at least two) above the ground. It was also assumed that the mixing height and the rate of change of potential temperature with height, $\delta\Theta/\delta z$, above the mixing height were available.

2.5.13 Spatial Analysis of Acid Precipitation Data

Kriging, an interpolation procedure that minimizes interpolation error and at the same time gives an accurate estimate of that error, was studied and shown to be an appropriate procedure for the study and analysis of spatial variability in acid precipitation data (Finkelstein, 1984). Variograms, a method of plotting intersta-tion variability as a function of distance, were constructed for H^+, SO_4, NO_3, and NH_4. They were shown to be distance dependent in all cases. Typical isopleth maps of pollutant species in rainfall (Figure 4) were developed, along with their Kriging derived one standard deviation confidence limit. The spatial extent of these confidence limits is considerable, illustrating the difficulty of fine structure analysis of acid precipitation data using existing and older network data. This places certain limits on our ability to detect trends and has implications for model validation. Kriging was shown to be a useful procedure for sampler network design, allowing one to quantitatively predict improvements in spatial analysis by decreasing distance between sampling points.

2.6 Air Policy Support Branch

The function of the Air Policy Support Branch (APSB) is to support activities of the EPA Office of Air Quality Planning and Standards (OAQPS). General APSB responsibilities include: (1) evaluating, modifying and improving atmospheric dispersion and related models to ensure adequacy, appropriateness and consistency with Agency policy and estabilished 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 meteoro-logical assistance and consultation to support OAQPS's broad responsibilities for development and enforcement of Federal regulations and standards and assistance to the Regional Offices. APSB meteorologists are typically involved in interdiscipli-nary team efforts that include engineers, chemists, statisticians, computer specia-lists and other technical staff. Thus, it should be noted that most of the projects discussed required team effort and technical staff support.

2.6.1 Northeast Corridor Ozone Studies

2.6.1.1 Application of the Urban Airshed Photochemical Model to New York

In 1978, a program was instituted designed to evaluate the magnitude and extent of the photochemical oxidant problem in the Northeastern United States, which became known as the Northeast Corridor Regional Modeling Project (NECRMP). This effort re-sulted in several major advancements in the understanding of both urban and regional scale ozone formation, including (1) the development of statewide inventories of volatile organic compounds (VOC); (2) collection of regional and urban scale meteoro-logical data; and, (3) collection of an air quality data base which could be used to evaluate and apply urban and regional scale photochemical models. In reviewing the accomplishments of this effort, the NECRMP Policy Group recommended that an effort be undertaken to model the New York Metropolitan Area including portions of New York, New Jersey, and Connecticut, using a sophisticated modeling technique. Current strategies for the control of photochemical air pollution in the New York Metropolitan area are based upon rather simplistic projection techniques that are unable to consider fully the complexities of the area. In this regard, the Oxidant Modeling for the New York Metropolitan Area Project (OMNYMAP) was initiated via a

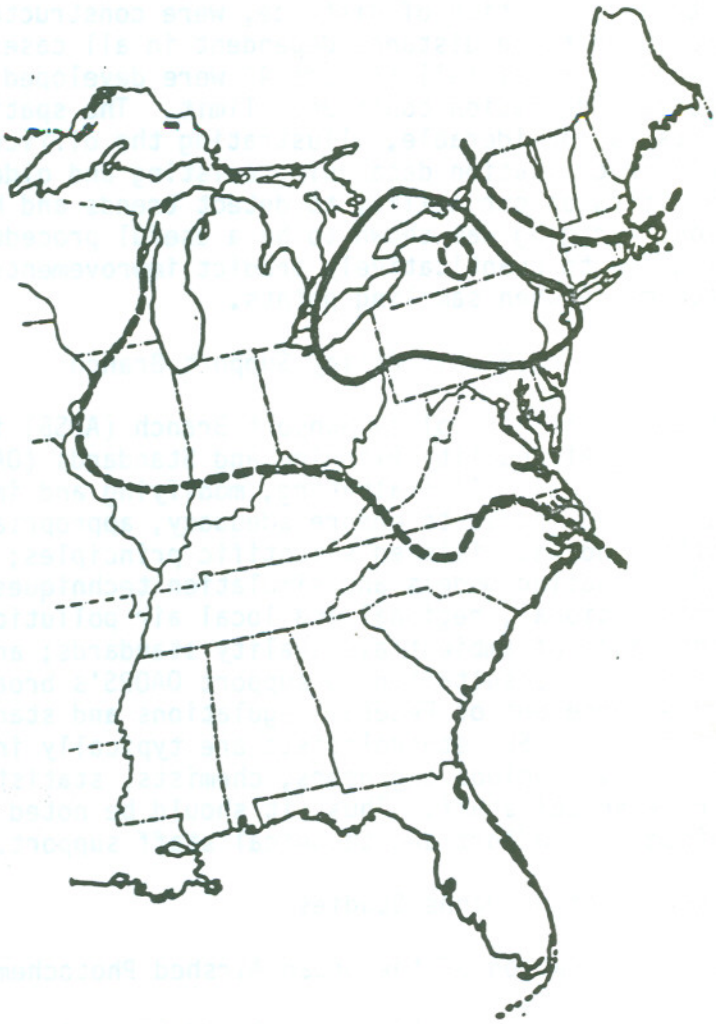

Figure 4. Annual average 4.5 mg L^{-1} isopleth of sulfate (heavy line) with one standard deviation confidence limit on isopleth (dashed line).

Cooperative Agreement with New York State to apply the Urban Airshed Photochemical Model (Airshed) to this area. One main goal of this program is to characterize the extent and magnitude of ozone air quality violations throughout this region. Next, the program will evaluate the effectiveness of currently proposed air quality control strategies to determine whether the standards can be attained by the statutory date, assuming these strategies are fully implemented and effective. Finally, alternative strategies will be tested either to identify additional controls necessary to enable the States to implement an optimal strategy for attainment of the ozone NAAQS.

Support to this effort is being provided by an APSB meteorologist who is a member of the Technical Review Committee, serving in an advisory capacity to provide guidance in the area of emission inventory preparation, and for the development of air pollutant/meteorological input methodologies and a modeling protocol. The OMNYMAP program is scheduled to be completed by August 1986.

2.6.1.2 Analyses of Ozone Concentrations in New York and Boston

A study was completed of ozone and precursor concentrations in the New York City and Boston areas on 20 high ozone days during the 1980 NECRMP field program. This study included analyses to investigate the spatial and temporal characteristics of the New York City and Boston urban ozone plumes, the magnitude of pollutants transported into these cities, and the relationships between surface ozone concentrations and mixed-layer values. The results indicate that peak ozone concentrations occurred 80 km to 100 km downwind from the urban area after 4 to 7 hours of transport. Also, the impact of other corridor cities on pollutant concentrations transported into New York City and Boston was evident. In the New York City area, hydrocarbon and oxides of nitrogen concentrations associated with 24-hour transport from upwind corridor cities were twice the magnitude of concentrations transported from other directions. In the Boston area, the concentration of hydrocarbons aloft during along-corridor transport was triple the magnitude of concentrations when transport was from outside the corridor. The report entitled "Northeast Corridor Regional Modeling Project - Ozone and Precursor Transport in New York City and Boston during the 1980 Field Study" (Possiel, et al., 1984) described the results of these analyses. Information in this report is being used by New York State in the OMNYMAP as a basis for selecting days for the application of the Airshed model.

2.6.2 Interim Procedures for Evaluating Air Quality Models

In 1981 a document entitled "Interim Procedures for Evaluating Air Quality Models" was prepared to provide a general framework for deciding whether a proposed model, not specifically recommended in the "Guideline on Air Quality Models", was acceptable on a case-by-case basis for a specific application. It was recognized that the concepts described in these procedures were relatively new and untested and that after a period of time during which experience is gained and problems are identified, there would be a need to update and revise the procedures.

During the 1981-1984 period considerable experience was gained on the application of the interim procedures through the development of an example problem and through several cases where the procedures were applied to select a model for a specific situation. Based on this experience, an inhouse effort initiated during FY-83 to revise the procedures was completed and published in FY-84.

Major changes in the revised publication include:

1. The document now strongly emphasizes the need to make preliminary concentration estimates with the contending models. These aid in designing the protocol for the performance evaluation and in designing the requisite data base to carry out the evaluation;

2. The document now suggests choosing a limited set of performance measures that focus on the key aspects of the performance evaluation, rather than attempting to include all the general performance evaluation measures identified by the American Meteorological Society;

3. In addition to the use of performance statistics, other criteria are suggested as applicable in some cases to determine the acceptability of a proposed model. These include the consideration of minimum standards of acceptable performance, consideration of the technical merits of the proposed model, and safeguards against underprediction of critical concentrations; and,

4. A detailed example problem which illustrates the use of the Interim Procedures was adapted to the current revised version of the document and included as an appendix.

2.6.3 Arsenic - National Emission Standard for Hazardous Air Pollutants (NESHAPS)

In response to a need for support of the NESHAPS regulatory process, the study, involving dispersion modeling of arsenic emission from sources at the ASARCO Smelter at Tacoma, WA, was completed. The study had four phases:

1. A background study where the appropriate emissions (taking into account the effect of the supplemental control system, meteorology, and air quality data) were identified;

2. A model selection study where candidate models were identified;

3. A model testing study where the candidate model estimates were compared to ambient measurements from certain historical periods; and,

4. A model application phase where the best model, identified from testing, was applied to a base case and several regulatory control cases.

The model selection process identified the ISCLT and the LONGZ models, each with a rural and an urban option, as appropriate candidates for testing. The testing process identified the LONGZ/rural model as the most appropriate technique for estimating long-term concentrations of arsenic in the vicinity of the smelter. However, even this model was not particularly successful in replicating observed concentrations from historical periods. Concentration estimates made via the modeling methodologies were generally higher than monitored values, especially at critical close-in locations. The marginal performance of the LONGZ model was attributed to uncertainties in:

1. The capability of the LONGZ dispersion model to calculate credible average annual and quarterly ground-level concentration produced by smelter arsenic emissions;

2. The accuracy of the arsenic emission inventories and of the source characterization used in the dispersion-model calculations;

3. The accuracy and representativeness of the meteorological data; and,

4. The accuracy and representativeness of the background arsenic concentrations which were added to the model estimates to obtain ambient concentrations.

After completion of the project in February 1984, the LONGZ model was applied to the specified regulatory "control cases." Users of these model estimates were cautioned that the uncertainties in model estimates should be taken into account when interpreting the results.

2.6.4 Regulatory Analysis for the Sulfur Dioxide Standard

A project was initiated to examine several major regulatory issues associated with developing SO_2 emission limits for coal-fired point sources. These issues include the treatment of sulfur variability in coal samples and the use of deterministic and probabilistic approaches for estimating emission limits needed for compliance with the SO_2 National Ambient Air Quality Standards (NAAQS). The results will be used to support programs for implementing the SO_2 NAAQS.

The focus of this project is the application of a Monte Carlo simulation technique known as the Ex-Ex methodology (Hillyer and Burton, 1980) to quantitatively account for sulfur variability in determining emission limits for several example point sources. Included in the analysis are two existing power plants (Eddystone in Philadelphia and Portage des Sioux in St. Louis) and a 1000 MW unscrubbed hypothetical plant run with three climatologies (St. Louis, Philadelphia, and Wichita). The "variable sulfur" emission limits computed for these sources using Ex-Ex will be compared to emission limits generated by assuming the sulfur content in coal samples is constant (current regulatory practice). To provide a comparison of deterministic and probabilistic approaches, emission limits will be computed to comply with the present deterministic form of the NAAQS and with expected exceedance and probability of violation forms. As a result of these computations, a matrix of emission limits will be prepared for the five plant/climatology combinations to assess the relative stringency of these approaches. The matrix elements and a report interpreting the results will be completed during the first quarter of FY-85.

2.6.5 Regional Ozone Impact Analysis

A study was initiated to examine the impact of urban volatile organic compound (VOC) control strategies on rural ozone concentrations. This effort supports a review of the secondary ozone NAAQS, where the major concern is for ozone damage to various plant species. The initial phase of the project is an application of the RTM-III regional photochemical model to a portion of the Midwest. For this analysis, RTM-III will be modified to perform simulations using a 20-km grid spacing across a 600 x 600 km modeling domain. The model will be run for a 4-day regional ozone episode in 1978, and the impact on rural ozone of two generic urban emission control scenarios will be examined. The use of the Regional Oxidant Model (ROM) is being considered as a potential tool for conducting a similar type of modeling analysis for the Northeast United States.

2.6.6 Particulate Matter Impact Due to Surface Coal Mines

During the summer of 1983 a contractor collected field data from four western surface coal mines, specifically recording smoke puff releases on video tape and archiving concurrent meteorological data. During FY-84 a meteorologist was Project Officer on a contract to reduce, quantify, analyze, and interpret these data and survey the literature for mathematical techniques by which particles emitted in surface mine pits could be translated to effective top-of-pit emissions for input to an air quality simulation model. The contractor, TRC Environmental Consultants, Inc., submitted a draft final report in September 1984. TRC identified two techniques for quantifying the amount of particulate matter that may be expected to exit open pit coal mines and be dispersed downwind. Although neither method was acceptable in its present form for regulatory use, either or both methods appeared to be worth additional efforts to improve their performance by strengthening the relationship between physical (geometric) and meteorological variables for different pits. A preliminary application of the two methods indicates that the vast majority of particulate emissions released within mine pits was likely to escape the pits and be transported downwind.

TRC Inc. also defined such quantities for this work as escape velocity, escape fraction, and effective pit width, based on the field data and statistically analyzed relationships between in-pit and out-of-pit meteorological variables flow patterns, and smoke puff behavior. Not surprisingly, no correlation between in-pit and out-of-pit wind direction was found; generally the directions differed by about 60^{o}. A significant positive correlation between in-pit wind speeds was found; generally in-pit speeds are about 25 percent lower.

Since the original smoke puff releases serve as qualitative surrogates for particle emissions from in-pit mining operations, collection of a quantitative data base is recommended. The possibility of conducting field studies will be discussed with the National Coal Association members during FY-85. APSB contract efforts will focus on preparing a computer algorithm for estimating the air quality impact of in-pit emissions and searching for an existing data base on which a performance evaluation might be conducted.

2.6.7 Revising Air Quality Models

A rural version of the MPTER model was prepared by APSB personnel incorporating technical changes proposed in the revised "Guideline on Air Quality Models." This provides the public with a means for testing what the effects might be on model estimates due to the proposed changes. This version of MPTER contained an option accomplishing the following:

1. only final plume rise is used;

2. buoyancy-induced disperison is treated;

3. wind profile power law exponents default to .07, .07, .10, .15, .35, and .55 for stabilities A through F, respectively;

4. terrain adjustment factors are set to zero (i.e., plume is horizontal while terrain varies in height by the full amount);

5. stack tip downwash (Bjorklund and Bowers, 1982) is used when appropriate; and,

6. anemometer height default is 10 m.

A version of CDM containing Briggs' urban disperison coefficients was tested against 1976 annual average SO_2 data from St. Louis. The data and the statistics used were the same as those in the report "Evaluation of Urban Air Quality Simulation Models," (Londergan, et al., 1983). While the modified CDM results compare more favorably with the observed data, the improvement was not statistically significant.

Under a contract, Briggs' urban dispersion coefficients were added to the ISC and PAL models. These models, together with similar urban versions of CRSTER and MPTER, are being thoroughly tested, results documented, and addenda to user's guides written. Following internal review of the results, the revised models should be released in early 1985.

2.6.8 Evaluation of Long Range Transport Model Performance

A program to evaluate eight short-term, long-range transport models -- MESOPUFF, MESOPUFF-II, MESOPLUME, MSPUFF, RTM-II, RADM, MTDDIS, and APPRA-1 -- is now underway via an Interagency Agreement (IAG) with Argonne National Laboratory (ANL). This effort is designed to determine the relative performance of these models for providing guidance on long-range transport model applications to Prevention of Significant Deterioration (PSD) and interstate transport regulatory issues. The first task is the acquisition of model codes and the manipulation of evaluation data sets into formats consistent with these models. The evaluation data sets were obtained from the Savannah River Plant and the Barr-Ferber/Oklahoma tracer studies.

The second task is a five-month effort which includes the application of sample data sets to each model in order to ensure that the data bases are properly applied. In addition, ANL will be selecting statistical and graphical performance measures to be used in the evaluation phase. A pattern interpretation method will be prepared to filter out errors in estimating plume transport in the comparison of observed versus predicted concentrations. In the third task, the model predictions will be generated and compared to observed values using the selected performance measures.

Interim reports are to be provided by ANL at the conclusion of each task. A draft final report describing the data handling procedures, any modifications made to model codes, and an interpretation of model performance in terms of theoretical formulations and assumptions is to be delivered by October 1985.

2.6.9 Evaluation and Sensitivity Analyses of Coastal Fumigation Models

This program consisted of a series of contract studies to conduct statistical analyses and evaluations of coastal fumigation models and their component modules. Products received include a survey of the technical literature on coastal meteorology, a comparative evaluation of several equations for predicting the height of the thermal internal boundary layer (TIBL), and a comparative evaluation of two shoreline fumigation models. The literature survey is a topical annotated bibliography of about 200 entries on coastal meteorology under twelve major topics.

A comparative evaluation of various equations which predict the TIBL height was undertaken. Predictions of TIBL height using these equations was compared to a Brookhaven National Laboratory (BNL) TIBL data base. This data base was obtained from comprehensive field experiments conducted during the 1970's at BNL. A technical paper based on this analysis (Stunder and SethuRaman 1984a) concluded that, "(a) there are several formulations for the TIBL height in use for air quality models, (b) they predict heights that differ by a factor of two or more from actual values, and (c) a better formulation that incorporates knowledge gained from recent observational studies is necessary." Additional evaluation of the TIBL equations was completed and reported by Stunder and SethuRaman (1984b).

The performance of two shoreline fumigation models -- (1) the Lyons and Cole (1973) model as incorporated into the CRSTER air quality model code, and (2) the Misra (1980) shoreline fumigation model -- was being evaluated against field data. The data base selected for the study was a set of observations from a series of studies conducted around the Nanticoke power plant near the shore of Lake Erie during May and June of 1978 and 1979. A report on the results of this performance evaluation is expected in December 1984.

2.6.10 Protocols for Selection of Models for Regulatory Applications

During FY-84, APSB personnel participated in the development and/or review of model performance evaluation protocols for three major power plants. In each case a model was proposed by a company, necessitating a demonstration, using performance statistics in the manner specified in the protocol, that the model performed better/worse than the model recommended by EPA for that situation. Brief summaries of each of these protocols follow.

1. The Lovett Power Plant, located in the Hudson River Valley of New York, currently generates 495 megawatts of electricity from the burning of 0.37 percent sulfur oil. In April 1984 the EPA Administrator agreed to a request from the utility to convert the plant to low sulfur (0.6-0.7 percent) coal with a new emission limit of 1.0 lbs SO_2/mm Btu. One provision of the agreement was that the company had to develop a protocol for a performance evaluation acceptable to EPA and to execute this protocol once the new stack was erected and the conversion to coal was completed. The company drafted a protocol for the comparative evaluation of New York State NYSDEC model, a modified version of the NYSDEC model (the company's model of choice), and the COMPLEX I model. A series of negotiations took place between the company, the State of New York, and the EPA on the details of the protocol and the proposed monitoring network until an agreement was reached.

According to the protocol, the Company will install an 11-station monitoring network with most monitors located on high terrain 2-4 km north of the plant. The network will include a monitor located on the lee-side of the mountain ridge in order to detect possible high concentrations suggested by fluid modeling of ridges and measurements made on the Hogback Ridge in New Mexico. A 5-station network to collect meteorological data will also be deployed.

The model comparison tests to be used in the performance evaluation consist of regulatory tests (68% of the weight) and scientific tests (32% of the weight). The "regulatory tests" include comparisons between the second-highest observed and predicted concentrations and the 25 highest observed and predicted concentrations.

The "scientific tests" include annual concentrations, a case study analysis to determine the degree that the same meteorological conditions are associated with the highest 25 observed and calculated 1-hour concentrations, statistical comparisons of predicted and observed concentrations for all the nonstable class data, and comparisons of predicted and observed concentrations for only the stable class hours.

The protocol contains a provision to guard against underprediction, whereby calculations of the model with the highest score will be adjusted upward if the highest observed concentrations are significantly underpredicted. Protocol execution will not likely take place until the 1987/1988 time frame.

2. During FY-84, APSB personnel assisted EPA's Region II staff in the development of protocol to be executed in FY-85 for the comparative performance evaluation between an industry model (supported by the Commonwealth of Puerto Rico) and COMPLEX I applied in the Guayanilla Basin on the southern shore of Puerto Rico. Initial performance evaluation will be done using two years of data from a 3-station network. The subsequent evaluation will include approximately six months of data from four additional monitors. Meteorological data from an existing 76 meter tower will be input to the models. Stability will be determined using 10-meter σ_Θ data and methods in Appendix A to the "Regional Workshop on Air Quality Modeling: A Summary Report."

Measures of performance include the ability to predict maximum and second highest 3- and 24-hour concentrations, unpaired in time and location, and the ability to predict maximum and second highest 3- and 24-hour concentrations at each monitor unpaired in time. Performance measures that define model behavior in the upper tail of the distribution are accuracy (using ratios of average predicted to average observed values) for 1-, 3-, and 24-hour averaging periods and precision (using ratios of variances, predicted to observed) for the same averaging periods.

Meteorological case studies consist of quantitative skill scores at each monitor, based on the number of cases in common between predicted and observed concentrations (stratified by stability class), for the upper 5 percent of the 1-hour values.

3. In February 1984, APSB personnel reviewed the draft protocol for the comparative evaluation of COMPLEX I and the LAPPES model for the Warren Power Plant in Pennsylvania. In general the protocol was quite good. However, APSB personnel advised EPA that it is important to protect against the possible application of the proposed model (LAPPES) if it is clear that the model will result in an emission limitation that could cause measured ambient standards violations. To address this underprediction problem it was decided to average the top 10 observed concentrations and the top 10 estimated concentrations, both unpaired in space and time. If the ratio of the average observed to average estimated concentration exceeds 1.0, then the allowable emission rate indicated by the model will be reduced by that ratio.

The data base for the performance evaluation consists of a specially designed seven-station network which will provide one year of air quality measurements against which model predictions can be compared. Meteorological data collection began in late Spring 1984 from three towers; most of the model input data are from a 160 foot tower near the plant. Stability will be determined using 10-meter σ_Θ data and methods in Appendix A to the "Regional Workshops on Air Quality Modeling: A Summary Report." Performance measures include the highest second-highest values, the second-highest values by station for stations with the 3 highest observed and 3 highest predicted second-highest values, maximum value by station, the highest 25 values over all events, the highest 25 values for stability categories, and annual average concentrations.

2.6.11 Miscellaneous Support Activities

Model Clearinghouse Activities continued in FY-84 and included:

1. Responding to Regional Office requests for review of non-guideline models proposed for use;

2. Reviewing State Implementation Plans (SIP);

3. Documenting Clearinghouse decisions and discussions;

4. Summarizing Clearinghouse activities at various meetings; and,

5. Issuing periodic information (newsletter) on models and data base usage.

A total of 119 modeling issues were referred to the clearinghouse for consideration.

Among other Branch activities, the draft revised "Guideline on Air Quality Models" was completed and submitted February 1, 1984, for the EPA Headquarters review and concurrence on publishing the notice of proposed rulemaking. Following incorporation of all comments, the guideline was submitted for Office of Management and Budget (OMB) approval. The public hearing on the proposed revisions will serve as the Third Conference on Air Quality Modeling in February 1985.

The workshop for information exchange with the Regional Meteorologists and modeling contacts was held in Atlanta, GA, March 27-30, 1984. The focus was for each Region to present current policy on a variety of modeling issues and status of selected topics followed by discussion/feedback from the other participants.

APSB meteorologists serve on a number of short-duration task groups, formed to develop or revise existing regulations and programs or to generate options and potential positions on key questions facing policymakers. Current memberships include: (1) the Work Group to Revise the Modeling Guideline; (2) the Visibility SIP Development Work Group; (3) the Visibility Task Force; (4) the Stack Heights Remand Task Force; (5) the Emissions Trading Policy Work Group; (6) the NECRMP Model Work Group (until April 1984); and, (7) the OMNYMAP Technical Review Committee (since August 1984).

3. REFERENCES

Alwine, K. J., and C. D. Whiteman. Green River ambient model assessment program FY-83 progress report - technical description of MELSAR: a mesoscale air quality model for complex terrain. PNL-5048, Battelle Pacific Northwest Laboratory, Richland, WA., 97 pp. (1984)

Benson, P.E. CALINE3 - A versatile dispersion model for predicting air pollutant levels near highways and arterial streets. FHWA/CA/TL-79/23, California Department of Highways, Sacramento, CA., 129 pp. (1979).

Billman, B. J. Windbreak effectiveness for the control of fugitive - dust emissions from storage piles - a wind tunnel study. Proceedings, Fifth Symposium on Transfer and Utility of Particulate Control Technology, Kansas City, MO. August 1984, Electric Power Research Institute, Palo Alto, (1984).

Binkowski, Francis S. A simple model for the diurnal variation of the mixing depth and transport flow. Boundary Layer Meteorology 27:217-36 (1983).

Bjorklund, J. R., and J. F. Bowers. User's instructions for the SHORTZ and LONGZ computer programs, Volumes I and II. EPA-903/9-82-004A and B. U.S. Environmental Protection Agency, Middle Atlantic Region III., Philadelphia, PA., 716 pp. (1982).

Briggs, G. A. Plume rise predictions. Chapter 3 in Lectures on Air Pollution and Environmental Impact Analyses, D. A. Haugen (ed.), American Meteorological Society, Boston, 59-111 (1975).

Burton, C. S., T. E. Stoeckenius, and J. P. Nordin. The temporal representativeness of short-term meteorological data sets: implications for air quality impact assessments. SYSAPP-83/092, Systems Applications, Inc., San Rafael, CA,, 68 pp. (1983).

Cramer, H. E. Improved techniques for modeling the dispersion of tall stack plumes. Proceedings, Seventh International Technical Meeting on Air Pollution Modeling and Its Application. Brussels, September 1976. NATO/CCMS No. 51, (PB 270 799) 731-780 (1976).

Draxler, R. R. Determination of atmospheric diffusion parameters. Atmospheric Environment 10:99-105 (1976).

Efron, B. The Jackknife, the bootstrap and other resampling plans. Pub. No. 38, Society for Industrial and Applied Mathematics, Philadelphia, PA., 92 pp. (1982).

Environmental Protection Agency. User's network for applied modeling of air pollution, UNAMAP (version 5). (Computer programs on magnetic tape for air quality simulation models.) (PB83-244 368) National Technical Information Service, U. S. Department of Commerce, Springfield, VA. (1983).

Environmental Protection Agency. Interim procedures for evaluating air quality models revised. EPA-450/4/84-023, U.S. EPA Office of Air Quality Planning Standards, Research Triangle Park, N.C., 144 pp. (1984).

Eskridge, R. E., F. S. Binkowski, J. C. R. Hunt, T. L. Clark, and K. L. Demerjian. Highway modeling: Part II - Advection and diffusion of SF_6 tracer gas. Journal of Applied Meteorology 18:401-412 (1979).

Eskridge, R. E., W. B. Petersen, S. T. Rao, and G. Sistla. Turbulent diffusion behind vehicles: experiments and verification of roadway models. Proceedings, 77th Annual Meeting of the Air Pollution and Control Association, San Francisco, CA., June 1984, Pittsburgh, (1984).

Finkelstein, P. L. The spatial analysis of acid precipitation data. Journal of Climate and Applied Meteorology 23:52-62 (1984).

Gadiyaram, P. Flow and dispersion over three-dimensional axisymmetric hills: a wind tunnel study. M.S. Thesis, Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, N.C., 126 pp. (1984).

Gillani, N. V. Project MISTT measurements and data base. Unpublished EPA Report, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 81 pp. (1984).

Godowitch, J. M., and J.K.S. Ching. Turbulence parameters impacting dispersion in an urban convective boundary layer. Preprints, Fourth Joint Conference on Applications of Air Pollution Meteorology, October 16-19, 1984, Portland, OR. American Meteorological Society, Boston, (1984).

Hillyer, M. J., and C. S. Burton. The ExEx method: incorporating variability in sulfur dioxide emissions into power plant impact assessment. SAI184EF80-80, SAI, Inc., San Rafael, CA., 87 pp. (1980).

Holzworth, G. C. The EPA program for dispersion model development for sources in complex terrain. Preprints, Second Joint Conference on Applications of Air Pollution Meteorology, March 24-28, 1980, New Orleans, LA. American Meteorological Society, Boston, 465-468 (1980).

Hunt, J. C. R., J. S. Puttock, and W. H. Snyder. Turbulent diffusion from a point source in stratified and neutral flows around a three-dimensional hill: Part I: diffusion equation analysis. Atmospheric Environment 13:1227-39 (1979).

Irwin, J. S. Estimating plume dispersion - A comparison of several sigma schemes. Journal of Climate and Applied Meteorology 22:92-114 (1983).

Irwin, J. S., and M. E. Smith. Potentially useful additions to the rural model performance evaluation. Bulletin American Meteorological Society 65:559-568 (1984).

Kaimal, J. C., J. E. Gaynor, P. L. Finkelstein, M. E. Graves, and T. J. Lockhart. An evaluation of wind measurements by four doppler sodars. EPA Report and Project Summary (in press), Environmental Sciences Research Laboratory, Research Triangle Park, N.C., (1984).

Lamb, R. G. The effect of release height on material dispersion in the convective planetary boundary layer. Preprints, Fourth Symposium on Turbulence, Diffusion and Air Pollution, January 18-19, 1979, Reno, NV. American Meteorological Society, Boston, (1979).

Larsen, R. I., and W. W. Heck. An air quality data analysis system for interrelating effects, standards, and needed source reductions: Part 8 - an effective mean O_3 crop reduction mathematical model. Journal of Air Pollution Control Association, (in press) (1984).

Lawson, R. E., Jr. Effect of terrain-induced downwash on determination of good-enginerring-practice stack height. Internal Report, Envirornmental Research Sciences Laboratory, Research Triangle Park., N.C., 21 pp. (1984).

Lee, J. T., S. Barr, R. E. Lawson, W. H. Snyder, and G. L. Marsh. Towing tank studies of stratified flow over ridges and valleys. LA-UR-84-1314, Los Alamos National Laboratory, Los Alamos, NM, 29 pp. (1984a).

Lee, J. T., S. Barr, R. E. Lawson, W. H. Snyder, and G. L. Marsh. Towing tank studies of stratified flow over ridges and valleys. Preprints, Third Conference on Mountain Meteorology, October 16-19, 1984, Portland, OR. American Meteorology Society, Boston, (1984b).

Londergan, R., D. Minott, D. Wachter, T. Kincaid, and D. Bonitata. Evaluation of rural air quality simulation models. EPA-450/4-83-003, U.S. Office of Air Quality Planning Standards, Research Triangle Park, N.C., 300 pp. (1983).

Lyons, W. A., and H. S. Cole. Fumigation and plume trapping on the shores of Lake Michigan during stable, onshore flow. Journal of Applied Meteorology 12:494-510 (1973).

McNaughton, D. J., and N. E. Bowne. Comprehensive field study plan to relate pollutant sources to acidic deposition. Internal EPA Report, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 122 pp. (1984).

Misra, P. K. Dispersion from tall stacks into a shoreline environment. Atmospheric Environment 14:396-400 (1980).

Pendergrass, W. R., Jr., and S. P. S. Arya. Dispersion in neutral boundary layer over a step change in surface roughness, Part I: mean flow and turbulence structure. Atmospheric Environment 18:1267-79 (1984a).

Pendergrass, W. R., Jr., and S. P. S. Arya. Dispersion in neutral boundary layer over a step change in surface roughness, Part II: concentration profiles and dispersion parameters. Atmospheric Environment 18:1281-1296 (1984b).

Pendergrass, W. R., and K. S. Rao. Evaluation of the pollution episodic model using the RAPS data. EPA-600/3-84-087, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 61 pp. (1984).

Petersen, W. B. User's guide for HIWAY-2: a highway air pollution model. EPA-600/8-80-018, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 69 pp. (1980).

Petersen, W. B., J. A. Catalano, T. Chico, and T. S. Yuen. INPUFF -- A single source Gaussian puff dispersion algorithm user's guide. EPA-600/8-84-027, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 123 pp. (1984).

Petersen, W. B., R. E. Eskridge, S. T. Rao, and V. Pagnotti. Effects of traffic speed on the ambient pollutant concentration near roadways. Proceedings, 77th Annual Meeting of the Air Pollution Control Association, June 24-29, 1984, San Francisco, CA., (1984).

Petersen, W. B., and J. S. Irwin. Climatological variability in maximum concentrations. Atmospheric Environment (in press) (1984).

Pierce, T. E. An evaluation of alternative Gaussian plume dispersion modeling techniques in estimating short term sulfur dioxide concentrations. EPA-600/3-84-079, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 151 pp. (1984).

Possiel, N. C., C. W. Spicer, P. R. Sticksel, G. M. Sverdrup, A. J. Alkezweeny, and W. E. Davis. Northeast corridor regional modeling project - ozone and precursor transport in New York City and Boston during the 1980 field study. EPA 450/4-84-011, U.S. EPA Office of Air Quality Planning Standards, Research Triangle Park, N.C., 65 pp. (1984).

Rao, S. T., M. Keenan, G. Sistla, and P. Samson. Dispersion of pollutants near highways - data analysis and model evaluation. EPA-600/4-79-011, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 158 pp. (1979).

Rao. S. T., G. Sistla, V. Pagnotti, W. B. Petersen, J. S. Irwin, and D. B. Turner. Evaluation of the performance of RAM with the Regional Air Pollution Study data base. (To be submitted) Journal of Climate and Applied Meteorology (1984).

Schere, K. L., and K. L. Demerjian. User's guide for the photochemical box model (PBM). EPA-600/8-84-022a, Environmental Sciences Laboratory, Research Triangle Park, N.C., 118 pp. (1984).

Schere, K. L., and J. H. Shreffler. Final evaluation of urban-scale photochemical air quality simulation models. EPA-600/3-82-094, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 259 pp. (1982).

Schere, K. L., and J. H. Shreffler. Examination of one-hour NO_2 predictions from photochemical air quality models. EPA-600/3-84-046, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 106 pp. (1984).

Schiermeier, F. A. Scientific assessment document on status of complex terrain dispersion models for EPA regulatory applications. EPA-600/3-84-046, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 132 pp. (1984).

Schiermeier, F. A., T. F. Lavery, D. G. Strimaitis, A. Venkatram, B. R. Greene, and B. A. Egan. EPA model development for stable plume impingement on elevated terrain obstacles. Proceedings, 14th International Technical Meeting on Air Pollution Modeling and Its Application, Copenhagen, Denmark, September 1983. NATO/CCMS (In press) (1983).

Scire, J. S., F. W. Lurmann, A. Bass, and S. R. Hanna. Development of the Mesopuff II dispersion model. EPA-600/3-84-057, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 82 pp. (1984).

Scire, J. S., F. W. Lurmann, A. Bass, and S. R. Hanna. User's guide to the Mesopuff II model and related processor programs. EPA-600/58-84-013, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 214 pp. (1984).

Shreffler, J. H., and K. L. Schere. Evaluation of four urban-scale photochemical air quality simulation models. EPA-600/3-82-043, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 179 pp. (1982).

Snyder, W. H. Terrain aerodynamics and plume dispersion: a perspective view gained from fluid modeling studies. Proceedings, Symposium on Tibetan Plateau and Mountain Meteorology, Beijing, People's Republic of China, March (1984a).

Snyder, W. H. Fluid modeling of pollutant transport and diffusion in stably stratified flows over complex terrain. In Annual Review of Fluid Mechanics, (In press, Volume 17) (1984b).

Snyder, W. H., and J. C. R. Hunt. Turbulent diffusion from a point source in stratified and neutral flows around a three-dimensional hill: Part II: laboratory measurements of surface concentrations. Atmospheric Environment 18:1969-2002 (1984).

Snyder, W. H., and R. E. Lawson, Jr. Stable plume dispersion over an isolated hill: releases above the dividing-streamline height. EPA-600/3-84-103, Appendix A, EPA complex terrain model development fourth milestone report - 1984. Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 233-268 (1984).

Snyder, W. H., R. S. Thompson, R. E. Eskridge, R. E. Lawson, I. P. Castro, J. T. Lee, J. C. R. Hunt, and Y. Ogawa. The structure of strongly stratified flow over hills: dividing-streamline concept. Journal of Fluid Mechanics (In press) (1984).

Strimaitis, D. G., T. F. Lavery, A. Venkatram, D. C. DiCristofaro, B. R. Greene, and B. A. Egan. EPA-600/3-84-103, EPA complex terrain model development, fourth milestone report - 1984. Environmental Sciences Research Laboratory, Research Triangle Park, N.C., (In press) (1984).

Stunder, M., and S. SethuRaman. A comparative evaluation of the thermal internal boundary layer height equations. Preprints, Third Conference on Meteorology of the Coastal Zone, January 1984, Miami, FL. American Meteorological Society, Boston, (1984a).

Stunder, M., and S. SethuRaman. A comparative evaluation of the coastal internal boundary layer height equations. Boundary-Layer Meteorology (In press) (1984b).

Thompson, R. S., and W. H. Snyder. Dispersion from a source upwind of a three-dimensional hill of moderate slope. Appendix B, EPA complex terrain model development fourth milestone report - 1984. Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 269-286 (1984a).

Thompson, R. S., and W. H. Snyder. Fluid modeling of blocking and upstream influences of stable flow over two-dimensional hills. Proceedings, Workshop on Wind/Water Tunnel Dispersion Modeling, September 1984, Oxford, England, September, 5 pp. (1984b).

Tingey, D. T. The effect of environmental factors on the emission of biogenic hydrocarbons for live oak and slash pine. Atmospheric Biogenic Hydrocarbons 1:53-79 (1981).

Truppi, L. E. Diurnal and seasonal patterns of temperature and wind flow in the planetary boundary layer for ten locations in complex terrain. Preprints, Third Conference on Mountain Meteorology, October 16-19, 1984, Portland, OR. American Meteorological Society, Boston, (1984).

Turner, D. B. Workbook of atmospheric dispersion estimates. U.S. Office of Air Programs Publication No. AP-26 (PB 191 482) U. S. Environmental Protection Agency, Research Triangle Park, N.C., 84 pp. (1970).

Turner, D. B. Proposed pragmatic methods for estimating plume rise and plume penetration through atmospheric layers. Atmospheric Environment Submitted as a preliminary communication. (1984).

Turner, D. B., and J. H. Novak. User's guide for RAM. EPA-600/8-78-016a and b, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 60 pp. (1978).

Vaughan, W. M. Transport of pollutants in plumes and PEPES. EPA Report (in press), Environmental Sciences Research Laboratory, Research Triangle Park, N.C,, 66 pp. (1984a).

Vaughan, W. M. Cold weather plume study. EPA Report (in press), Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 157 pp. (1984b).

Vaughan, W. M., M. Chan, B. Cantrell, and F. Pooler. A study of persistent elevated pollution episodes in the northeast United States. Bulletin of the American Meteorological Society 63, 258-266 (1982).

Viebrock, Herbert J. Fiscal year 1983 summary report of NOAA Meteorology Division support to the Environmental Protection Agency. NOAA TM-ERL-ARL-127, Air Resources Laboratory, Silver Spring, MD, 60 pp. (1984).

Weil, J. C., and R. B. Brower. The Maryland PPSP dispersion model for tall stacks. Environmental Center, Martin-Marietta Corporation Report PPSP-MP-36, Maryland Department of Natural Resources, Baltimore, MD. (1982).

Whiteman, C. D., R. N. Lee, M. M. Orgill, and B. D. Zak. Green river air quality model development: meteorological and tracer data - July/August 1982 field study in Brush Valley, Colorado. EPA-600/3-84-106, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 139 pp. (1984).

Wilczak, J. M., and M. S. Phillips. An indirect estimation of convective boundary layer structure for use in routine dispersion models. EPA-600/3-84-091, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 79 pp. (1984).

Willis, G. E., and J. W. Deardorff. A laboratory study of dispersion from a source in the middle of the convectively mixed layer. Atmospheric Environment 15:109-117 (1981).

4. BIBLIOGRAPHY

Batterman, S. A., J. A. Fay, D. Golomb, and J. Gruhl. Air quality models pertaining to particulate matter. EPA 600/3-84-074, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 73 pp. (1984).

Behunek, J. L., T. H. Vonder Haar, and P. Laybe. Determination of cloud parameters for NEROS II from digital satellite data. EPA-600/3-84-044, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 40 pp. (1984).

Binkowski, F. S. A simple model for the diurnal variation of the mixed depth and transport flow. Boundary-Layer Meteorology 27:217-236 (1983).

Briggs, G. A. Analytical parameterizations of diffusion: the CBL. Presentation at the Workshop on Updating Applied Diffusion Models, January 24-27, 1984, Clearwater, Florida. American Meteorological Society, Boston, 1984.

Briggs, G. A. Diffusion modeling with convective scaling and effects of surface inhomogenuities. Presentation. AMS Specialty Conference on Non-Homogeneous, Non-Stationary Urban Boundary Layer, October 31-November 4, 1983, Baltimore, (1983).

Bullock, O. R. Spatial and temporal interpolation of NEROS radiosonde winds EPA-600/3-84-086, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 84 pp. (1984).

Castro, I. P., W. H. Snyder, and G. L. Marsh. Stratified flow over three-dimensional ridges. Journal of Fluid Mechanics 135:261-282 (1983).

Ching, J. K. S., J. M. Godowitch, and J. F. Clarke. Urban scale variations of turbulent energy fluxes. Presentation. AMS Speciality Conference on Modeling the Non-Homogenous, Non-Stationary Urban Boundary Layer, October 31-November 4, 1983, Baltimore, (1983).

Clark, T. L., and J. F. Clarke. A lagrangian study of the boundry layer transport of pollutants in the northeastern United States. Atmospheric Environment 18:287-297 (1984).

Clark, T. C., and D. H. Coventry. Sulfur deposition modeling in support of the U.S./Canadian memorandum of intent on acid rain. EPA-600/7-83-058, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 123 pp. (1983).

Clarke, J. F. J. K. Ching, and J. M. Godowitch. Land use variation of turbulence in an urban area. Presentation. AMS Specialty Conference on Modeling Non-homogeneous, Non-Stationary Urban Boundary Layers, October 31-November 4, 1983, Baltimore, (1983).

Clarke, J. F., T. C. Clark, J. K. S. Ching, P. L. Haagenson, R. B. Husar, and D. E. Patterson. Assessment of model simulation of long-distance transport. Atmospheric Environment 17:2449-2462 (1983).

Drake, R. L. Green River air quality model development, related studies, general information and bibliography. EPA-600/3-83-103, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 404 pp. (1983).

Eskridge, R. E., and S. T. Rao. Measurement and prediction of traffic-induced turbulence and velocity fields near roadway. Journal of Climate and Applied Meteorology 22:1431-1443 (1983).

Eskridge, R. E., W. B. Petersen, S. T. Rao, and G. Sistla. Turbulent diffusion behind vehicles: experiments and verification of roadway models. Proceedings, 77th Annual meeting of the Air Pollution Control Association, San Francisco, California, June 1984, Pittsburgh, (1984).

Finkelstein, P. L. The spatial analysis of acid precipitation data. Journal of Climate and Applied Meteorology 23:52-62 (1984).

Fox, D. G., D. Randerson, M. E. Smith, F. D. White, and J. C. Wyngaard. Synthesis of the rural model reviews. EPA-600/3-83-108, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 41 pp. (1983).

Godowitch, J. M., J. K. S. Ching, and J. F. Clarke. Presentation. Spatial variability in the evolution and structure of the urban boundary layer. AMS Speciality Conference on Modeling Non-Homogeneous, Non-Stationary Urban Boundary Layers, October 31-November 4, 1983, Baltimore, (1983).

Greenhut, G. K., J. K. S. Ching, and R. Pearson, Jr. Transport of ozone by turbulence and clouds in an urban boundary layer. Journal of Geophysical Research 89:4757-4766 (1984).

Irwin, J. S. Site-to-site variation in performance of dispersion parameter estimation schemes. In Air Pollution Modeling and Its Application III, C. De Wispelaere (ed.), Plenum Publishing Corp., 605-617 (1984).

Irwin, J. S. Preparing meteorological data for use in routine dispersion calculation - workshop summary report. NOAA TM-ERL-ARL-122, 20 pp. (1983).

Irwin, J. S., and M. E. Smith. Potentially useful additions to the rural model performance evaluations. Bulletin of the American Meteorological Society 65:559-568 (1984).

Lamb, R. G. Air pollution models a descriptors of cause-effect relationships. Atmospheric Environment 18:591-606 (1983).

Lamb, R. G., and J. H. Novak. U.S. EPA regional model for regional transport of photochemical oxidants and their precursors. Proceedings of the EPA International Conference on Long Transport Models for Photochemical Oxidants and their Precursors. EPA-600/4-84-006, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., April 1983. OECD, Paris, (1983).

Lamb, R. G. A regional scale (1000km) model of photochemical air pollution. Part 2. Input processor network design. EPA-600/3-84-085. Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 297 pp. (1984).

Lavery, T. F., D. G. Strimaitis, A. Venkatram, and B. R. Greene. EPA complex terrain model development: third milestone report - 1983. EPA-600/3-83-101, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 271 pp. (1983).

Lee, J. T., S. Barr, R. E. Lawson, Jr., W. H. Snyder, and G. L. Marsh. Towing tank studies of stratified flow over ridges and valleys. LA-UR-84-1314, Los Alamos National Laboratory, Los Alamos, NM, 29 pp. (1984).

National Center for Atmospheric Research. Regional acid deposition: Design and management plan for a comprehensive modeling system. EPA-600/3-84-040, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 33 pp. (1984).

National Center for Atmospheric Research. Regional acid deposition: Models and physical processes. EPA-600/3-84-041, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 386 pp. (1984).

Novak, J. H., and J. H. Southerland. Northeast corridor regional modeling project emission inventory. Proceedings of the EPA International Conference on Long Range Transport Models for Photochemical Oxidants and their Precursors. EPA-600/4-84/006, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., April 1983. OECD, Paris, (1983).

Novak, J. H. Implementation of the U.S. EPA regional oxidant modeling system. Proceedings, 77th Annual Meeting of the Air Pollution Control Association, San Francisco, California, June 1984, Pittsburgh, (1984).

Pendergrass, W. R., and K. S. Rao. Evaluation of the pollution episodic model using the RAPS data. EPA-600/3-84-087, Environmental Sciences Research Laboratory Research Triangle Park, N.C., 61 pp. (1984).

Petersen, W. B. Puff model for emergency response. Presentation. 63rd Annual Meeting of the Transportation Board, January 16-20, 1984, Washington, D.C., (1984).

Petersen, W. B., R. E. Eskridge, S. T. Rao, and V. Pagnotti. Effects of traffic speed on the ambient pollutant concentration near roadways. Proceedings, 77th Annual Meeting of the Air Pollution Control Association, San Francisco, California, June 1984, Pittsburgh, (1984).

Pierce, T. E. An evaluation of alternative gaussian plume dispersion modeling techniques in estimating short-term sulfur dioxide concentrations. EPA-600/3-84-079, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 151 pp. (1984).

Pitchford, M., and D. Allison. Lake Tahoe visibility study. Journal of the Air Pollution Control Association 34:213-221 (1984).

Possiel, N. C. Northeast corridor regional modeling project--ozone and precursor transport in New York City and Boston during the 1980 field program. EPA-450/4-84-011, U.S. EPA Office of Air Quality Standards, Research Triangle Park, N.C., 64 pp. (1984).

Rao, K. S. Plume concentration algorithms with deposition, sedimentation, and chemical transformation. EPA-600/3-84-042, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 87 pp. (1984).

Rao, K. S., and M. M. Stevens. Pollution episodic model user's guide. EPA-600/8-84-008, Environmental Sciences Research Laboratory. Research Triangle Park, N.C., 186 pp. (1984).

Rao, S. T., G. Sistla, V. Pagnotti, W. B. Petersen, J. S. Irwin, and D. B. Turner. Examination of the performance of real-time air quality model (RAM) with Regional Air Pollution Study (RAPS) Data Base. Proceedings, 77th Annual Meeting of the Air Pollution Control Association, San Francisco, California, June 1984, Pittsburgh, (1984).

Schere, K. L. An evaluation of several numerical advection schemes. Atmospheric Environment 17:1897-1907 (1983).

Schere, K. L., and K. L. Demerjian. User's guide for the photochemical box model (PBM). EPA-600/8-84-022, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 118 pp. (1984).

Schere, K. L., and N. C. Possiel. U.S. EPA Regional oxidant model - background and overview. Proceedings, 77th Annual Meeting of the Air Pollution Control Association, San Francisco, California, June 1984, Pittsburgh, (1984).

Schere, K. L., and J. H. Shreffler. Examination of one-hour NO_2 predictions from photochemical air quality models. EPA-600/3-84-046, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 106 pp. (1984).

Schiermeier, F. A. Scientific assessment document on status of complex terrain dispersion models for EPA regulatory application. EPA-600/3-84-103, Environmental Sciences Research Laboratory. Research Triangle Park, N.C., 132 pp. (1984).

Schiermeier, F. A., and P. K. Misra. Evaluation of eight linear regional-scale sulfur models by the Regional Modeling Subgroup of the United States/Canadian Memorandum of Intent Work Group 2. Proceedings, International Specialty Conferencce on the Meteorology of Acidic Deposition, Hartford, Connecticut, October 1983, Air Pollution Control Association, Pittsburgh, (1983).

Scire, J. S., F. W. Lurmann, A. Bass, and S. R. Hanna. Development of the MESOPUFF II dispersion model. EPA-600/3-84-057, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 82 pp. (1984).

Shreffler, J. H., K. L. Schere, and K. L. Demerjian. Progress in photochemical air quality simulation modeling. Air Pollution Modeling and Its Applications III, C. DeWispelaere (ed.), Plenum Press, New York, 477-506, (1984).

Sigmon, J. T., K. P. Knoerr, and E. J. Shaughnessy. Microscale pressure fluctuations in a mature decidous forest. Boundary-Layer Meteorology 27:345-358 (1983).

Snyder, W. H. Terrain aerodynamics and plume dispersion: A perspective view gained from fluid modeling studies. Proceedings of the Symposium on Tibetan Plateau and Mountain Meteorology, March 1984, Beijing, People's Republic of China, (1984).

Snyder, W. H., and R. E. Lawson, Jr. Stable plume dispersion over an isolated hill: release above the dividing-streamline height. EPA-600/3-84-103, Appendix A, EPA complex terrain model development fourth milestone report - 1984. Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 233-268 (1984).

Thompson, R. S., and W. H. Snyder. Fluid modeling of blocking and upstream influences of stable flow over two-dimensional hills. Proceedings of the on 2nd workshop wind/water tunnel disperison modeling. September 1984. Oxford, England.

Thompson, R. S., W. H. Snyder, and R. E. Lawson, Jr. Laboratory simulation of neutral plume dispersion over Cinder Cone Butte: Comparison with field data. Appendix B, EPA-600/3-83-101, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 212-251 (1983).

Truppi, L. E. EPA complex terrain model development. Description of a computer data base from small hill impaction study no. 1 Cinder Cone Butte, Idaho. EPA-600/3-84-038, Environmental Sciences Research Laboratory, Research Triangle Park, N.C., 102 pp. (1983).

Viebrock, H. J. Fiscal Year 1983 Summary Report of NOAA Meteorology Division Support to the Environmental Protection Agency. NOAA-TM-ERL-ARL-127 60 pp. (1984).

5. METEOROLOGY DIVISION STAFF FISCAL YEAR 1984

All personnel are assigned to the 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 J. Viebrock, Meteorologist, Assistant to the Director
Dr. Kenneth L. Demerjian, Physical Scientist
Dr. Jack H. Shreffler, Physical Scientist (Assigned to Office of the Director Evironmental Sciences Research Laboratory)

Marc Pitchford, Meteorologist (Las Vegas, NV)
Evelyn Poole-Kober (T) (EPA), Technical Information Clerk
Joan Emory, Secretary

Atmospheric Modeling Branch

Dr. John Clarke, Meteorologist, Acting Chief
Dr. Francis Binkowski, Meteorologist
Dr. Gary Briggs, Meteorologist
Dr. Jason Ching, Meteorologist
Terry Clark, Meteorlogist
Dr. Robin Dennis, Physical Scientist
James Godowitch, Meteorologist
Dr. Robert Lamb, Meteorologist
Kenneth Schere, Meteorologist
Bess Flowers, (PT) (EPA), Secretary

Fluid Modeling Branch

Dr. William H. Snyder, Physical Scientist, Chief
Roger Thompson, (PHS), Environmental Engineer
Dr. Robert Eskridge, Meteorologist
Robert Lawson, Physical Scientist
Robert Chalfant, Electronics Technician
Lewis Knight, Electronics Technician
Joseph Smith, Mechanical Engineering Technician
Ralph Soller, Meteorological Technician
Judith Haden (Student), Engineering Aid
Eileen Ward (Student) (EPA), Clerk-Typist (until March 1984)

Data Management Branch

Joan H. Novak, Computer Systems Analyst, Chief
James Reagan (PHS), Statistician
Adrian Busse, Computer Specialist
Dale Coventry, Computer Systems Analyst
Alfreida Rankins, Computer Programmer
John Rudisill, Meteorological Technician
Brian Eder (T), Computer Programmer
William Amos (EPA), Computer Programmer
Barbara Hinton (PT) (EPA), Secretary

Terrain Effects Branch

Francis A. Schiermeier, Meteorologist, Acting Chief
Dr. Francis Pooler, Jr., Meteorologist
Lawrence Truppi, Meteorologist
Dr. Alan Huber, Meteorologist
George Holzworth (T), Meteorologist
Hazel Hevenor (EPA), Secretary

Environmental Operations Branch

D. Bruce Turner, Meteorologist, Chief
Dr. Ralph Larsen (PHS), Environmental Engineer
William Petersen, Meteorologist
John Irwin, Meteorologist
Dr. Peter Finkelstein, Meteorologist (Assigned to Environmental Monitoring Systems Laboratory)
Thomas Asbury (Student), Meteorologist (until May 1984)
Valentine Descamps, Meteorologist (Boston, MA)
Alan Cimorelli, Meteorologist (Philadelphia, PA)
Lewis Nagler, Meteorologist (Atlanta, GA)
Richard Fisher, Meteorologist (Fort Collins, CO)
Lisa Lewis (PT), Secretary

Air Policy Support Branch

James L. Dicke, Meteorologist, Chief
Charlotte Hopper, Meteorologist (until November 1983)
Dean Wilson, Meteorologist
Russell Lee, Meteorologist
Norman Possiel, Jr., Meteorologist
Jawad Touma, Meteorologist