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FISCAL YEAR 1982 SUMMARY REPORT OF NOAA METEOROLOGY DIVISION SUPPORT TO THE ENVIRONMENTAL PROTECTION AGENCY

Herbert J. Viebrock, Editor

Air Resources Laboratory
Rockville, Maryland
March 1983

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UNITED STATES DEPARTMENT OF COMMERCE

Malcolm Baldrige, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

John V. Byrne, Administrator

Environmental Research Laboratories

George H. Ludwig Director

NOTICE

PREFACE

The work reported herein for FY-1982 was funded by the Environmental Protection Agency (EPA) under agreement EPA-AD-13F24800 between the EPA and the Air Resources Resources Laboratory (ARL), National Oceanic and Atmospheric Administration (NOAA). The Meteorology Division (MD), staffed with both NOAA and EPA personnel, 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, development, 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 grant activities. The MD provides technical information, observational and forecasting support, and consultation on all meteorological aspects of the EPA air pollution control program to many EPA offices, including the EPA Office of Air Quality Planning and Standards and various Regional Offices, as appropriate.

Any inquiry on the research or support activities outlined in this report should be directed to the Director, Meteorology Division, Environmental Protection Agency, Research Triangle Park, NC 27711.

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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 in 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, atmospheric processes in the boundary layer, and the review and assessment of dispersion model parameters.

Activity highlights included conduct of a small hill study at Cinder Cone Butte, Idaho, and preparation for a second study at Hogback Ridge, New Mexico; completion of an initial regional oxidant model; four urban scale photochemical dispersion models were evaluated; the final version of a Lagrangian long-range transport model (ENAMAP-1) was completed and applied to support the U.S./Canadian acid rain memorandum of intent activities; completion of the Fluid Modeling Facility of a Good-Engineering Practice (GEP) stack height demonstration study; and the conduct of a series of experiments in the Fluid Modeling Facility to study the dividing streamline concept and to examine the effects of surface roughness on dispersion from tall stacks.

Version 4 of UNAMAP, fortran source codes for air quality dispersion models, was made available; a handbook for preparing model user's guides was prepared; the exposure of commuters to CO was studied and modeled; work continued on improving the estimates of plume dispersion parameters; operation of a Model Clearinghouse continued; and objective procedures for estimating mixing heights were evaluated.

FISCAL YEAR 1982 SUMMARY REPORT
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1. INTRODUCTION

During Fiscal Year 1982, 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 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 the conduct of 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 models on the urban and regional scales, dispersion in complex terrain, and acid rain related modeling work. Work on the study and modeling of boundary layer processes continued. A major field study was conducted at Cinder Cone Butte, Idaho, early 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, removal of pollutants in and from the atmosphere.

2.1.1 Boulder Tower Experiment

An experimental study, Convective Diffusion Observed with Remote Sensors (CONDORS), was designed within the laboratory and taken to the field for trial runs at the Boulder Atmospheric Observatory, in cooperation with NOAA's Wave Propagation Laboratory. The purpose is to test in the atmosphere, at full scale, some diffusion modeling results from a numerical model and from a laboratory tank that are at odds with standard Gaussian plume models. These results show the height of maximum concentrations from a ground source, averaged over about an hour, lifting off the ground at a modest distance downwind and rising to the upper half of the convective mixing layer. In contrast, maximum concentrations from elevated sources were seen to descend to the ground, thereafter behaving similarly to the ground source plumes. These results apply to convective conditions, typified by partly cloudy to sunny days with low to moderate wind speeds.

The CONDORS field experiment uses two different remote sensors, radar and lidar, to map two different plumes in three dimensions. About 40 gal/hr of oil fog is released so that the lidar can detect it over background aerosols, and a metallic chaff is released that the X-band radar can easily detect. It is hoped that, during the full experiment in FY-1983, both elevated and ground source plumes can be detected independently at the same time, assuring identical meteorological conditions. During the trial runs in September 1982, the oil fog and chaff were released at the same height, in order to make a direct comparison of the two systems. Two elevated and two ground level releases were made. Meteorological measurements included the well instrumented BAO 200 m tower, three or more rawinsondes a day, and radar-detected chaff transport speed. Mixing depth estimates were made using tower and rawinsonde profiles, lidar, radar, and an acoustic sounder.

2.1.2 Regional Photochemical Model

Work is underway to develop a model that can guide the formulation of regional emissions control strategies. In this task the model will be called upon to estimate the impact of sources on concentrations in remote regions, to determine the pollution burden that cities impose on distant neighbors, and eventually to analyze quantitiatively emissions impacts on acid rain, visibility and fine particulates. In all these roles, the utility and credibility of the model will be determined primarily by the extent to which it accounts for all the governing physical and chemical processes. Accordingly, a generalized model is being formulated that in principle can treat all of the chemical and physical processes that are known, or presently thought, to affect the concentrations of air pollutants over several day/1000 kilometer scale domains.

During 1982 a report describing the regional oxidant model was completed (Lamb 1982a). During this same period work was begun on a series of comprehensive tests of the mathematical components that comprise the model. In these tests the model is applied to a series of increasingly complicated problems for each of which the exact solution is known. By comparing the results of the model with the known solutions, we are able to evaluate the accuracy of each facet of the model separately and various facets jointly. The results of these tests will be reported in Part 3 of the regional model report.

Work has continued on the design and construction of the network of preprocessors, or submodels, that provide the input data for the regional model. The network consists of some 10 modules all of which are virtually complete except for three which constitute rather large models in themselves. One of these, which handles terrain effects and the nighttime boundary layer, is currently being tested. A second major processor, which generates the flow fields, is in development; and the third large submodel is still in the formulation stage. The processor network will be described in Part 2 of the regional model report.

During 1982 we began an effort, parallel to the regional model development, whose objective is twofold: to determine the proper way of describing atmospheric motion, including "turbulence" in the model, and to quantify the level of uncertainty inherent in long-range transport model calculations. The latter considers the fact that even if the regional model were perfect and all input data were error-free, differences would still exist between the model's predictions and (error-free) observations due to our inability to quantify the state of the atmosphere at any instant. Understanding the limits of predictability is important not only in the proper use of models in the regulatory process but also in the design of model "validation" experiments and in the formulation of efforts to refine model performance. The basic aspects of this work are described in Lamb (1982b).

2.1.3 Northeast Regional Oxidant Study (NEROS)

The Northeast Regional Oxidant Study (NEROS) was designed to provide the experimental basis for the validation of the NEROS photochemical regional oxidant model. Comprehensive observational programs were conducted during the 1979 and 1980 summer periods. An overview of these efforts was presented by Possiel et al. (1982) and discussed by Vaughn et al. (1982). In addition to preparing model validation data bases, the various processes being modeled were investigated. The modeling features emphasized include studies of urban plume dispersion on regional transport time and distance scales, land use variations in ozone depositions at the surface, the flux of oxidants by cloud venting processes and the chemical transformation rates associated with urban and power plant plumes.

Findings to date show that oxidants in urban plumes do transport on regional scales exceeding twelve hours (Clarke et al., 1982a). Additionally, an interesting case study utilizing a prototype Lagrangian marker parcel of in-house design show the Baltimore urban pollutants to impact Philadelphia and New York City (Clark and Clarke, 1982; Clark et al., 1982b). In another analysis, twelve NEROS tetroon tracks were compared with three current trajectory calculation schemes. The results show the standard deviation of the difference between model predicted and tetroon position data increased with travel time and was 200 km after 21 hours of travel or the best model run. However, individual comparisons varied strongly with different synoptic patterns (Clarke et al., 1982c).

The cloud venting studies do indicate that cloud vertical motions transport significant amounts of pollutants out of the mixed layer (Ching, 1982; Greenhut et al., 1982). Efforts to parameterize this process are underway. A model of cumulus development is being developed for inclusion into the regional model. This computational scheme is based upon a modified Arakawn-Schubert and Johnson technique.

Future plans are to adapt the NEROS model to handle emissions and meteorological processes of the Gulf Coast region. Currently, a field study to determine regional transport of oxidants for the Gulf region is being planned by a workshop, entitled GREATT (Gulf Regional Atmospheric Transport and Transformation) Study.

All data collected in the Baltimore 1980 NEROS study, along with ancillary data, have been collated by experimental day into a comprehensive data base. Computer tapes and documentation are available. Data tapes and reports are also available by individual platform for the Baltimore study. The Columbus and regional NEROS data base will be available by December, 1982.

2.1.4 Models of the Planetary Boundary Layer (PBL)

The Planetary Boundary Layer (PBL) modeling program supports the regional modeling effort by providing a model of PBL process which can be used to set parameterizations in the regional model. The PBL model was described in an extended abstract for the San Antonio Meetings (Binkowski, 1982). Briefly, the current model predicts both the mean layer wind and temperature for the smog based turbulent mixing layer, and the wind and temperature at the top of this layer. A single semi-empirical equation predicts the depth of the layer over an entire diurnal period. A second semi-empirical equation predicts the depth of the nocturnal inversion layer, which is most often deeper than the turbulent mixing layer. A paper describing the model and results is being prepared. The results show that useful estimates of surface friction velocity, heat flux and temperature, as well as the mixing depth and nocturnal inversion depth are given by the model using only a simple estimate of the geostrophic wind, the ground albedo, emissivity, moisture content, and roughness. The wind velocity requires a more careful estimate of the geostrophic wind and terrain shape, but apparently not beyond the capability of available data. Future enhancements will include the addition of active moisture in the PBL and soil layers, and a simple vegetation canopy model for evapotranspiration estimates. The model has been tested only for an arid climate.

2.1.5 Regional Air Pollution Study--Urban Boundary Layer

An integral part of the EPA Regional Air Pollution Study (RAPS) was a comprehensive observational program of the mean and turbulent structure of the urban boundary layer. The experimental period, during 1975 through 1977, consisted of turbulence measurements taken on four towers and aircraft, energy budget studies over grass, concrete, and simulated black top, and helicopter profiles and lidar aerosol measurements of the mixed layer structure and extent. A comprehensive analysis of the temporal, seasonal, and spatial variations of turbulence in the urban surface layer is presented by Clarke, et al., (1982b). They conclude that turbulent fluxes, velocity moments and transport scales are strongly influenced by both the local land use and horizontal advection. Evaluation of the data indicates that similarity theory appropriate to flows over homogeneous surfaces of small roughness is inadequate to describe the urban turbulence. Further, the scaling laws developed for convective time periods based on the height of the mixed layer are inappropriate from the mid to late afternoon period. These results are discussed by Ching, et al. (1982b). Due to the complexity of urban flows, an analysis framework for determining the representativeness of sensible heat flux measurements was developed. The tower and aircraft measurements strongly suggest that sensible heat flux in an urban area depends on the nature of the underlying surface, and the advection due to the horizontal thermal gradient set up the local land use and urban heat island scales, Ching et al., (1982a).

Studies of the formation, evaluation and final dissipation of the nocturnal inversion which utilized the helicopter data are described by Godowitch et al., (1979). An in-depth study of the temporal behavior of the convective mixed layer reveals that growth rates due to turbulent mixing are affected by the strength of the overlying vertical temperature gradient above the nocturnal radiation inversion, the differential height between the top of the nocturnal inversion and the depth of the residual mixed layer, and the strength of the synoptic scale subsidence. These processes, however, may be strongly modified by synoptic scale advection which is not presently considered in mixed layer growth models.

2.1.6 Photochemical Model Evaluation -- Urban Scale

A comprehensive multi-year project to develop and evaluate several urban photochemical air quality simulation models (PAQSM's) for ozone predictions using the RAPS-St. Louis data base has recently been completed. The primary objective of this task was to develop verification statistics from an evaluation of the ozone predictions from four urban scale models using the results obtained from simulations on 20 days selected from the RAPS data base. The days were carefully chosen to represent some of the highest ambient 1-hr ozone concentrations during the RAPS project. Generally these days exhibit stagnation conditions with little cloud cover and were typical of situations conducive to prediction of photochemical smog from local emissions.

The models chosen were a simple box model developed in-house a Lagrangian trajectory model developed by Environmental Research and Technology, Inc., a 2D grid model produced by the Lawrence Livermore Laboratories and a 3D grid model developed by Systems Applications, Inc. The models are similar in that they are all based on numerical solutions of the atmospheric diffusion equation and focus on hour-average data inputs and model derived concentrations. However they differ in the assumptions made toward the simplification of the diffusion equation, the frame of reference of the model and the attainable spatial resolution. The box model is set within the simplest model framework and the 3D grid model is the most complex and data intensive of the model types studied.

All of the models considered in this study require 3 types of data to operate: a meteorological, an air quality, and an emissions data base. During the first portion of this project these data bases were collected and verified concurrently with the development and application of the models to the St. Louis domain.

Initial model evaluation was performed on a 10 day sample from the RAPS data base (Shreffler and Schere, 1982). Results from this phase of the project indicated several minor problems with 3 of the models and a major problem with the 2D grid model, LIRAQ. Results from this model indicated very low levels of chemical reactivity among the ozone precursors leading to miminal ozone levels generated by the model. This was inconsistent with results from the other models studied as well as with monitored data. For this reason and because the mechanics of working with the LIRAQ model were rather awkward, LIRAQ was dropped from the final phase of model testing. Changes were made to the other models to correct the deficiencies discovered from the initial model runs.

In the final testing phase the remaining three models were run on a 20 day sample from the data base (Schere and Shreffler, 1982). Results for prediction of maximum ozone from the Photochemical Box Model (PBM) were generally on the high side. The average O_3 residual showed a 23% overprediction over all test days. However for the 5 stagnation-type days where the maximum observed O_3 occurred within the PBM domain the average overprediction was 8%, considerably better than for the entire sample. Only a slight tendency towards overprediction was indicated for the Lagrangian Photochemical Model (LPM). The biases of the residuals were relatively small, 11% of the average observations at Level-1 and only 2.5% at Level-3. The standard deviations of the residuals were the highest among the three models tested, but nearly halved from the initial tests on the 10 day sample. The large variance in the residuals might be expected since the LPM generates a prediction which likely is the most specific to a particular place and time. Model predictions for maximum O_3 by the 3D Urban Airshed Model (UAM) in a specific sense (at the same time and location as the observed maximum) were consistently low for all evaluations with an average 32% underprediction over the sample. Originally it was thought that spurious numerical diffusion in the advection component of the model was responsible for the low UAM predictions. However the underprediction problem still persisted after the original advection algorithm was replaced with one containing much less inherent numerical diffusion. If the time and location of the model predictions are not constrained to be the same as those for the maximum observed O_3, the average model bias for the 20 days implied a 4% overprediction. This excellent agreement might suggest that the uncertainty in specifying a wind field for a grid model like the UAM could lead to large apparent errors in the model results.

The choice of which particular model to use in a specific application involves not only the accuracy of the model but also the resources required to operate it. The models tested have resource requirements correlated with their level of complexity. In terms of man-months needed to set up a single day simulation and computer time expended (minutes of CPU on a UNIVAC 1100/82) the approximate requirements are:

PBM ----------- 0.15 man-month ----------- 1 minute CPU
LPM ----------- 0.20 man-month ----------- 10 minutes CPU
UAM ----------- 0.50 man-month ----------- 110 minutes CPU

These models are now being made available to EPA's Office of Air Quality Planning and Standards for further statistical and sensitivity testing and ultimately for use in their regulatory decision-making process. Because model development is an evolving area of research it is very likely that subsequent "improved" versions of the models will become available. A performance test with benchmark results now exists for future use in urban air quality model comparisons with any subsequent versions of the models.

2.1.7 Vertical Distribution of Aerosol Scattering Coeffficient During the Growth of the Morning Urban Mixing Layer

Analysis of simultaneous profiles of temperature and aerosol scattering coefficient obtained by an integrating nephelometer were performed to increase our understanding of mixing processes and assist in improving urban air quality dispersion models. These measurements were obtained during 30 summer morning field experiments in St. Louis, MO as part of the Regional Air Pollution Study (RAPS) boundary layer program. Results of the analysis of the growth of the mixing height and nocturnal inversion dissipation have been presented in Godowitch et al., (1979).

In this analysis effort, a least squares linear regression was applied to the aerosol scattering coefficient data in 3 layers: mixing layer, inversion layer, and region above the inversion top. Results indicated that aerosols were not uniformly distributed, as relative large values were observed in the mixing layer compared to the inversion layer where 'cleaner air' was found. The largest negative aerosol gradient was most often found at the mixing height. Results also showed that the linear regression described the vertical aerosol structure in the mixing layer quite well. A negative aerosol gradient existed within the mixing layer during this time period which indicated that aerosols were not well mixed. The average aerosol scattering coefficient in the mixing layer decreased as the mixing height increased and the transport downward of lower values aloft occurred. Aerosols became uniformly distributed when the nocturnal inversion was completely dissipated about 4 hours after sunrise. Additional results have been reported by Godowitch (1982).

2.1.8 Relative Humidity Dependence of the Nephelometer Scattering Coefficient

The operational mode used to study the dependence of the nephelometer scattering coefficient on the relative humidity was to take simultaneous measurements of the scattering coefficient with two nephelometers. One nephelometer was operated at the ambient relative humidity while the other nephelometer was operated at a relative humidity less than about 40 percent. In essence, the relative humidity dependence is given by the difference of the two simultaneous nephelometer measurements.

In one study (Griffing, 1982), the relative humidity dependence of the scattering coefficient was analyzed for four different meteorological situations: (1) the passage of a low pressure system with thunderstorms; (2) the passage of a cold, dry front; (3) a breakdown of the nocturnal temperature inversion; and (4) influx of wood smoke aerosols. For the first case, it was concluded that the aerosol number concentration of hygroscopic aerosol particles was smaller after the passage of the low pressure system. For the second case, despite the fact that the cold front was no longer depicted on the weather maps, the frontal passage was quite prominent in the nephelometer measurements, solar radiation measurements and the relative humidity. For the third case, the breakdown of the nocturnal temperature inversion produced turbulent mixing which increased the relative humidity. As a result, there was a prominent spiked increase of the scattering coefficient. For the fourth case, it was concluded that the relative humidity did not affect the scattering coefficient which results from wood smoke.

Typically, during a high pressure weather system, the scattering coefficient was observed to begin increasing during the early evening after the relative humidity exceeded about 50 percent. During the night, the trend of the scattering coefficient was similar to the trend of the relative humidity. For a period of about 2 to 3 hours after sunrise, the scattering coefficient increased to a relatively large maximum and subsequently decreased. After these variations, the scattering coefficient was relatively constant for the remainder of the day. At first sight, the temporal variation of the scattering coefficient after sunrise was related in a simple fashion to the temporal variation of the relative humidity resulting from the evaporation of dew by solar radiation. However, a careful analysis indicated that the dependence was quite complex. The only plausible explanation was that moisture evaporation from or condensation onto the aerosol particles was retarded with respect to the ambient relative humidity.

2.1.9 Eastern North American Model of Air Pollution (ENAMAP)

The final version of the Lagrangian long-range transport model has been completed. This version is capable of simulating the fate of sulfur and nitrogen compounds across central and eastern North America on a monthly basis. Both analyzed fields and table of source/receptor relationships of monthly average ambient concentrations and wet/dry depositions of SO_2, $SO_4^=$, NO, NO_2, NO_3, HNO_3, and PAN are generated by the model.

The model parameterizations consider the following:

1) three layers within the planetary boundary layer
2) diurnally fluctuating vertical mixing rates
3) seasonally adjusted mixing heights
4) non-divergent wind flow
5) homogeneous and inhomogeneous SO_2 transformation rates dependent on latitude and season
6) dry deposition rates dependent on land-use, atmospheric stability and pollutant species
7) wet deposition rates dependent on pollutant species and an exponential precipitation rate expression

Field and tables of source/receptor relationships of the seven pollutant species have been generated by the model for the months of January and August 1977. Preliminary assessment of model results indicated that this version of the model overpredicted SO_2 and $SO_4^=$ concentrations in the middle Atlantic states, while underpredicting those in the Midwestern states. The causes of the discrepancies are to be investigated. No extensive data base exists for the remaining pollutant species, so no further model performance assessment can be accomplished.

Details concerning the model and the model applications are presented by Endlich, et al., (1982), Bhumralkar, et al., (1982), and Mayerhofer, et al., (1982).

In support of the Regional Modeling Subgroup of Work group 2 under the U.S./Canadian Memorandum of Intent, the ENAMAP-1 model was applied to central and eastern North America using standardized January and July 1978 meteorological and SO_2 emissions data. The model-calculated monthly average ambient $SO_4^=$ concentrations and wet sulfur depositions were compared to available measurements. The model performance was statistically assessed in accordance with subgroup guidelines, which were based on those of the American Meteorological Society's 1980 Workshop on Dispersion Model Performance.

In addition, the model estimated source/receptor relationships for the year of 1978. These estimates were compared to those of the other four U.S. and three Canadian long-range transport models using rank correlations. Both the Work Group 2 Final Report and the Regional Modeling Subgroup Final Report contain discussions of the model attributes and application results of the ENAMAP-1 model and the other seven models.

2.2 Fluid Modeling Branch

The Fluid Modeling Branch conducts physical modeling studies of the air flow and pollutant dispersion in complex terrain, near buildings, and near roadways. The Branch operates a Fluid Modeling Facility consisting of large and small wind tunnels, and a large water channel/towing tank. The large 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. The water channel/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.

2.2.1 Characterization of Automobile Wakes

The description of the turbulent wake of a block-shaped automobile as determined by measurements in a moving-floor wind tunnel (Eskridge and Thompson, 1982a, 1982b) was incorporated into an existing numerical model. Comparisons of the results of the numerical model with field data from a General Motors field experiment showed substantial improvement in the model's predictive capability. Inert species and reactive species highway models based on vehicle wake and surface-layer similarity theory have been made available to all users. These models will be used in conjunction with Gaussian highway models. Experimental work continues on the measurement of the structure of the wakes of streamlined vehicles and dispersion in these wakes.

2.2.2 Evaluation of Crop Isolation Chambers

In a cooperative study with the U.S. Department of Agriculture, the Meteorological Wind Tunnel was used to examine the flow field in and around models of open-top plan-growth chambers used to assess the effects of pollutant gases on plant growth. Specifically, the performance of five types of baffles designed to reduce the ingress of ambient air into the chamber through the open top were tested and evaluated, and the effects of surrounding chambers on the concentration field within the chamber were examined. A conical "hat" with an open area 50% that of the basic chamber was found to yield the most uniform pollutant distribution with the chamber. This work is reported in a paper by Davis, et al. (1982).

2.2.3 Instrument Studies

Hardware and software were developed for an experimental investigation of the response of a variety of types of wind anemometers. Calibrations as well as preliminary yaw and pitch response measurements were completed. This work is being done in response to a request from the EPA Environmental Monitoring Systems Laboratory.

2.2.4 Building Downwash Studies

Papers were prepared from a wind tunnel study on dispersion from two types of standard-design nuclear power plants. Dispersion functions were determined to describe the effluent plume spread in the wake of each plant for different wind directions and different numbers of stacks for each plant. The work is reported by Payne, et al. (1982a, 1982b).

A paper was prepared from a wind tunnel study of the downwash of plumes from short stacks adjacent to rectangular-shaped buildings. The influence of the highly turbulent region found in the lee of the building on the plumes emitted from the stacks was examined through smoke visualization and tracer-gas concentration mappings. The work is reported by Huber and Snyder (1982).

A Good-Engineering-Practice (GEP) Stack Height Demonstration Study was conducted following the EPA guidelines to determine the GEP stack height for a power plant. This study and report (Lawson and Snyder, 1982) will serve as examples to be followed by fluid modeling organizations in the conduct of GEP stack-height determinations to meet the requirements of EPA regulations promulgated in January 1982.

2.2.5 Complex Terrain Studies

Branch personnel participated in a preliminary one-week flow-visualization study at The Hogback Ridge near Farmington, NM, the site of Small Hill Impaction Study #2, to be conducted in the fall by Environmental Research and Technology (ERT). Other participants included ERT, the NOAA Wave Propagation Laboratory and the Los Alamos National Laboratory. The objectives were to obtain a general understanding of the nighttime stable flow over the ridge, to determine a site for a 150 m meteorological tower, to make observations of smoke releases to aid in designing the sampler arrangement, and to determine suitable tracer-release locations and heights for the fall experiments.

Three one-hour periods, representative of stable, neutral and transitional atmospheric conditions, were selected from the results of Small Hill Impaction Study #1 conducted by ERT at Cinder Cone Butte (CCB) for modeling in the wind tunnel and towing tank. The objective was to simulate the meteorological conditions and compare tracer concentration patterns measured in the laboratory with those from the field experiments. In the towing tank, surface concentration patterns on CCB were found to be extremely sensitive to wind direction and, because of the absence of low-frequency fluctuations in wind speed and direction in the towing tank, the concentration distributions were exceedingly narrow; maximum concentrations were 5 to 10 times larger than those observed in the field. An attempt was made to simulate the wind fluctuations by superposing concentration patterns from a series of tows at 18 discrete wind speeds and directions. This attempt was reasonably successful in that 80% of the model concentrations were within a factor of 2.5 of the field values. This portion of work was reported as an appendix (Snyder and Lawson, 1981) to the ERT First Milestone Report (Lavery, et al., 1982). The data from the neutral and transitional simulations are presently being analyzed.

Simulation of the stable case described above was continued in the stratified wind tunnel of the National Institute for Environmental Studies of the Japan Environment Agency (Snyder and Ogawa, 1982). Specifically, this work was designed to investigate the effects of shear (not attainable in the towing tank) on the flow structure and diffusion patterns over CCB. These data are presently being analyzed.

An overview of laboratory (primarily wind tunnel) studies on flow and diffusion in complex terrain was presented by Thompson and Snyder (1981). This paper was an attempt to put the results of a series of experiments in perspective. Ratios of maximum concentrations on a hill surface to the maximum in the absence of the hill were estimated. This ratio may be regarded as a terrain correction factor, and is a function of hill aspect ratio (two- versus three-dimensional), hill slope, atmospheric stability, etc. For upwind sources, terrain correction factors were shown to be typically 1 to 2 for neutral flow over two-dimensional hills and 2 to 4 for three-dimensional hills. Terrain correction factors as large as 10 to 15 were found for low sources placed downwind of two-dimensional hills of moderate to large slope. For strongly stable flow over three-dimensional hills, it was found more useful to compare maximum surface concentrations with those at the centerline of the plume in the absence of the hill. These concentrations have been shown to be essentially equal and are, of course, much larger than would be observed from a plume diffusing normally onto a surface. Further work on sources placed within the separated flow fields downwind of moderately steep hills of varying crosswind aspect ratio showed somewhat smaller terrain correction factors for three- than two-dimensional hills (Castro and Snyder, 1982).

An overview of fluid modeling studies on the structure of strongly stratified flow over hills, specifically, to test the applicability of Sheppard's integral formula for the dividing-streamline height, was prepared by Snyder et al. (1982a, 1982b) for inclusion in the ERT Second Milestone Report (Strimaitis, et al., 1982). This work showed that the dividing-streamline concept was valid when interpreted as a necessary but not sufficient condition for wide ranges of hill shapes, density profile shapes and wind angles, and in strong shear flows as well. Further, studies on strongly stratified flow over two-dimensional hills showed that steady-state conditions are not established in finite length towing tanks; these measurements cast doubt upon the validity of previous laboratory studies on long ridges cut by small gaps. This work also provided guidance to the field-study planners preparing for the fall experiments at the Hogback Ridge.

A series of towing tank and wind tunnel tests was conducted on a model of The Hogback Ridge, again to give guidance to ERT planners of the fall experiment.

2.2.6 North Carolina State University Studies (NCSU)

Through a cooperative agreement with the Department of Marine, Earth and Atmospheric Sciences, NCSU, a number of studies were conducted. A master's thesis (Pendergrass, 1982a, 1982b) examined the effects of a step change in surface roughness (smooth to rough) on dispersion from point sources located near the change. This work showed that dispersion from tall stacks is not governed by the local roughness in the vicinity of the stack, but rather by the roughness far upstream. In practical terms, these results suggest that for a 300 m stack, the roughness length of the surface as far as 50 km upwind is more important than the local roughness in determining the location and value of the maximum ground-level concentration.

A paper was prepared from work dealing with the effects of stable stratification on turbulent diffusion and the decay of grid turbulence (Britter, et al., 1982). This paper showed that horizontal dispersion is largely unaffected by the stratification, but that vertical plume growth reaches predictable asymptotic limits, even though the turbulence does not cease. This is explained by the observation that the vertical velocity fluctuations take on a wave-like character, but are not rotational (i.e., not dispersive). These laboratory results largely agree with recent theoretical models and have strong implications for predicting diffusion in the nighttime stable boundary layer.

Another paper was prepared from an experimental study on stratified flow over trianglular-shaped ridges of various aspect ratios (Castro, Snyder and Marsh, 1982). This study demonstrated that wave amplitudes can be maximized by "tuning" the body shape to the lee-wave field, that in certain circumstances steady wave breaking can occur or multiple recirculation regions can exist on the surface downstream of the body, that spanwise vortex shedding is possible at low Froude numbers, and that the effect of spanwise aspect ratio on the dividing-streamline height is negligible.

A study compared the results of a numerical model with towing tank observations of the flow of an elevated inversion over a three-dimensional hill (Lamb and Britter, 1982). This model was extended to include rotational effects (Lamb and Janowitz, 1982). A further study included measurements in shear layers separating from surface-mounted bluff bodies (Castro, 1981).

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. It provides data management and programming services; this is done primarily through ADP service contracts monitored by the Branch.

2.3.1 Biogenic Hydrocarbon Emissions

The objective of the Biogenic Hydrocarbon Emissions project is to determine the contribution of biogenic hydrocarbon emissions to the formation of ambient ozone. First, a reliable biogenic hydrocarbon emission inventory must be generated. Second, the chemistry module of the regional oxidant model must be modified to treat the biogenic species. Finally, the biogenic and anthropogenic emissions will be used by the regional scale model to predict ambient ozone levels.

The design of the biogenic emissions data handling system has been completed. The system is designed to perform the following functions:

1) generate hourly gridded emissions compatible with the regional model, a) for a variable number of emission species, b) from a variable number of vegetation species, surface water and leaf litter, and c) for any latitude-longitude based grid system;

2) apply temporal variations on a seasonal and/or diurnal basis to emission factors and potential biomass factors;

3) apply temporal variations to emission factors based on meteorological parameters (i.e., temperature, radiation, etc.);

4) allow incorporation of submodels for calculation of parameters such as leaf temperature and light intensity;

5) provide spatial resolution initially dependent on Las Vegas National Land Use and Land Cover Inventory;

6) accommodate more detailed spatial resolution if resources are available for extraction of data from maps;

7) provide method of tuning emission estimate within individual factor ranges to adjust for large variations of factors reported in literature;

8) support information to produce quality assessment of resulting emission estimates; and

9) provide summary reports of emissions.

Preliminary emission and biomass factors have been received from the EPA Corvallis Environmental Research Center. Other sources of biomass data are being reviewed. The USDA Forest Service has provided forest specie data for all states in the modeling regions. Detailed species data is reported on a forest region basis, where there are typically 4-5 regions per state. Data includes total commercial forest land, water area, breakdown of the number of trees of each species by diameter class, etc. Oak Ridge National Laboratory (ORNL) has provided predominant agricultural crops at the county level.

2.3.2 Completion of the Regional Air Pollution Study (RAPS) Data Base Archive

Final update and verification were completed for the Regional Air Monitoring System (RAMS) minute and hourly data and the Upper Air Sounding Network (UASN) pibal and radiosonde data. Magnetic tapes and documentation for all RAPS data sets scheduled for shipment to the National Technical Information Service (NTIS) for public distribution have been prepared. A general purpose binary data translator was developed to provide the most condensed form of data compatible with either IBM 32-bit or CDC 60-bit word formats.

2.3.3 Support of the National Crop Less Assessment Network (NCLAN)

Work was continued on the development of estimates of crop exposure to ozone. The most recent census of agriculture occurred in 1978 so that year was chosen for evaluation purposes. Various weighted interpolation schemes were examined and a method named "kriging," which was largely developed at the Paris School of Mines, was selected for gridding of the data by interpolation. Most of the ozone monitoring is urban oriented, which makes rural estimation difficult. Monitoring stations tend to be clustered around the middle of large metropolitan areas with large areas of the country devoid of any data. The major accomplishment was the development of an extensive data base on ozone. Rough estimates of the crop exposures were attempted for the Office of Technology Assessment. These provided an invaluable assessment of the capability of the procedure and some of its limitations. Kriging incorporates a weighting scheme called a variogram which is essentially a variance to distance relationship. The method provides estimates of the interpolation error which may be used for confidence limits on the data.

An adaptation of the ENAMAP model to ozone was attempted. Estimates were made for the central and eastern U.S. exposure in terms of a monthly average exposure. There was no clear relation between the predicted levels and those observed at stations in this area. Limitations in the accuracy of the emissions data may restrict the success of this approach in future studies. Application of this adaptation of the ENAMAP model to episodic conditions were also attempted with no clear relation established between them.

Future work calls for a review of the literature on surface approximations, development of site selection criteria for rural assessment, and application of the methodology to the data from the period 1978-1982. Combination of these estimates with crop loss models from other NCLAN participants will hopefully provide a clearer understanding of the impact of ozone on agriculture.

2.3.4 Northeast Regional Oxidant Study (NEROS) Data Archive Development

A comprehensive data management system has been designed to provide a systematic approach to data registration, verification and processing. The major emphasis is on traceability and reproducibility of verification techniques and final data sets. This system will encompass all NEROS related raw data sets thru a number of standardized data file formats. Verification, update and access procedures require use of these controlled standard data files.

The continuous graphics development efforts have focused on data verification techniques and analyses of regional oxidant model concentration output files. Significant progress has been made on enhancement of contour and overlay routines, development of wind field, trajectory and aircraft data plots. A Structure Chart Automated Display System (SCADS) was developed to provide a cost and time efficient method of completing program and data structure charts.

2.4 TERRAIN EFFECTS BRANCH

The Terrain Effects Branch conducts research studies on the effects of complex irregular terrain and manmade surface features on air quality 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 air pollution climatology.

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 that are reasonable to apply in terms of required computer input parameters. 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 cranes 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. Participants in this study included the EPA contractor, Environmental Research & Technology (ERT), and the NOAA Wave Propagation Laboratory. Detailed meteorological and tracer gas measurements from the Small Hill Impaction Study #1 were used by ERT to evaluate existing dispersion models (Valley, COMPLEX I, COMPLEX II, and PFM) and to aid in the development of two new models (Neutral and Impingement) for defining stable plume impaction in complex terrain. Results of this FY-81 model evaluation and development were contained in the first complex terrain milestone report (Lavery et al., 1982).

During this fiscal year, ERT continued utilizing the Small Hill Impaction Study #1 data base by performing case study analyses of various plume interactions with Cinder Cone Butte. Results of these analyses were used to further refine the new Neutral and Impingement models into the Lift and Wrap models, respectively. This most recent model development effort is described in the second complex terrain milestone report (Strimaitis et al., 1982). The second milestone report included an explanation of the modeling concepts and physical principles that form the basis for complex terrain model development, and an overview of the findings and conclusions reached thus far in the model development effort.

The second milestone report also contained input from the scaled physical modeling of plume dispersion over Cinder Cone Butte performed by the Fluid Modeling Branch, while the NOAA Wave Propagation Laboratory provided analyses of lidar cross sections of the particulate plume at Cinder Cone Butte prior to impaction.

In anticipation of the Small Hill Impaction Study #2 to be conducted during October 1982, ERT identified several potential ridge sites. The intent is to progress to the next higher level of modeling difficulty, i.e., from the isolated Cinder Cone Butte which allowed flow to bypass it, to a two-dimensional ridge which introduces the concept of blocked flow into the modeling effort. After the approval of the Hogback Ridge near Farmington, New Mexico, for the Small Hill Impaction Study #2, ERT and the NOAA Wave Propagation Laboratory conducted preliminary flow visualization experiments at the site during June 1982. Tracer gas and meteorological measurements for the Small Hill Impaction Study #2 will be performed by the NOAA Air Resources Laboratories Field Research Office of Idaho Falls.

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 has the need for development of 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 project is being conducted by the Battelle Memorial Institute, Pacific Northwest Laboratories (PNL), through an interagency agreement between EPA and the Department of Energy (DOE). The main objective of this project is to develop improved air quality models for analyzing the impacts of the oil shale industry with respect to PSD increments over Class I and Class II areas.

The effort consist 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. Long-term effects will be treated by a sixth component, a climatological model.

During this fiscal year, the combined local flow and air quality model was developed to simulate pollutant transport and diffusion in nocturnal, steady-state, down-valley flows. Concentrations are calculated using a modified Gaussian plume algorithm. The total pollutant mass in the valley cross section is conserved except for allowed escape out the top of the valley. The computer coding has been completed and the model is presently being tested by EPA Region VIII personnel.

Progress has also been made on the mesoscale flow and air quality models. Pollutant parcels are advected in a three-dimensional, mass-conserving, terrain-following wind field. The time histories of the parcel locations are computed for use in a Lagrangian puff dispersion model. The mesoscale flow and puff trajectory modules have been computer coded and are currently useable. Work continues on the testing and refinement of these modules and on the development of additional modules for air pollutant diffusion.

During August 1980, PNL performed ground-based field measurements in the Piceance Creek Basin of Colorado while airborne measurements were taken over a 400-km area containing the oil shale regions of Utah, Colorado, and Wyoming. The results of these experiments were published this fiscal year (Whiteman et al., 1982). During July and August 1982, PNL conducted additional tracer and meteorological measurements during nocturnal drainage flows in Brush Creek Valley, Colorado. The latter field study was performed in conjunction with the ASCOT experiments being sponsored by the DOE.

2.4.3 United States/Canadian Acid Rain Program

The Atmospheric Sciences and Analysis Work Group 2 was one of five work groups established under the Memorandum of Intent on Transboundary Air Pollution, signed by the governments of Canada and the United States on August 5, 1980. The objectives of the work groups were to synthesize available knowledge about the causes and effects of transboundary air pollution, with initial emphasis on acid deposition, for use by the governments of the two countries in negotiating a bilateral air quality agreement. Meteorology Laboratory staff served in several capacities within the Work Group 2 activities, including: Vice Co-Chairman of Work Group 2; Co-Chairman of the Regional Modeling Subgroup; and contributing authors to the Phase III reports on Regional Modeling, Atmospheric Sciences Review and the Final Work Group 2 report.

Eight linear regional-scale models developed by Canadian and United States scientists were applied by the Regional Modeling Subgroup using standardized 1978 emissions and precipitation input data sets. Model results were evaluated with currently-available January, July, and annual 1978 observational data sets. Concentrations and depositions of sulfur compounds as well as source-receptor relationships (transfer matrices) were calculated by the eight long-range transport models using simplified formulations. These were state-of-the-art linear models in which scavenging and chemical transformation processes were treated linearly as a first approximation.

The results of the evaluation of the eight long-range transport models are described in the Regional Modeling Subgroup Final Report (Schiermeier and Misra, 1982). For the 1978 data set, most of the models appeared to perform relatively better in predicting the deposition of sulfur in precipitation than in predicting sulfate concentrations in ground-level air. Based on available 1978 wet deposition measurements, the models were able to reproduce the correct order of magnitude of the large time and space-scale features of measured wet sulfur deposition patterns. In the construction of unit transfer matrices, the models examined by the Regional Modeling Subgroup predicted generally similar relative impacts on ecologically sensitive receptor regions in terms of ranked order of importance, although variations existed among models in the absolute magnitudes of the transfer matrix elements.

2.4.4 Analysis of Regional Air Pollution Study (RAPS) Data

During the RAPS field data acquisition program in St. Louis, a total of 5700 radiosonde soundings were obtained from both urban and rural sites, thus providing a unique opportunity to perform comprehensive analyses of diurnal, seasonal, and spatial variations in mixing heights, transport winds, and ventilation factors. Surface-based mixing heights, mixed layers aloft, and maximum mixing heights were manually determined from detailed plots of radiosonde thermodynamic parameters. Analyses were then performed to determine diurnal and seasonal trends while least-square regression statistics were used to define the urban/rural differences in mixing heights. Atmospheric dispersion as affected by morning mixing heights was evaluated as a function of surface wind direction. During this fiscal year, a paper describing the results of this analysis was completed and cleared for submission to a peer-reviewed journal for publication.

By comparing seasonal averages of two years of radiosonde data, some generalizations of urban/rural mixing height variations can be made. Although the degree of nocturnal stability continued to increase during the night, both the urban and rural mixing heights remained relatively constant between midnight and sunrise. Seasonal excursions between morning minimum and afternoon maximum mixing heights were twice as great during summer as during winter. Comparisons of urban versus rural mixing heights revealed slightly higher nocturnal values at the urban site, a difference which effectively disappeared after the morning transition to instability. The largest percentage of zero morning mixing heights at both sites was related to surface wind directions from the southern sector (warm air advection) while most non-zero morning mixing heights occurred with surface winds from the northern sector (cold air advection).

2.4.5 Plume Dispersion in the Wake of Surface Obstacles

In a wind tunnel study, the influence of the highly turbulent region found in the lee of a model building on plumes emitted from short stacks was examined through smoke visualization and tracer gas concentration mappings. A thick, simulated atmospheric boundary layer was used to provide background dispersion. A rectangular-shaped building with its length equal to twice its height and width was oriented with the long side perpendicular to the approaching wind. The stack was placed midway along the lee side of the building. In all phases of the study, each smoke or tracer release from the stack was repeated with the building removed. This allowed for a simple demonstration of the building wake effects.

The results of this study were accepted for publication (Huber and Snyder, 1982), and are summarized here. A simple mathematical model was developed that provided good estimates of concentrations in the building wake. The building influence was found to be reduced with increases in the effective source height. Application of the "2.5 times rule," i.e., an effective source height at 2.5 times the height of the building, resulted in maximum ground-level concentration in the wake being approximately 20 percent higher than found in the absence of the building. A stack 1.5 times the height of the building resulted in maximum ground-level concentrations in the wake being 250 percent higher, a far more significant effect.

2.5 ENVIRONMENTAL OPERATIONS BRANCH

The Environmental Operations Branch improves, adapts and evaluates new and existing air quality dispersion models, makes them available for use, and consults with users on their proper application. The branch also provides meteorological support to the Environmental Monitoring Systems Laboratory and to four EPA Regional Offices.

The research work of the branch consists of two major projects: 1) UNAMAP (User's Network for Applied Modeling of Air Pollution) which makes models available to users, and 2) the improvement of plume modeling techniques. The tasks related to UNAMAP and three tasks related to improvement of plume models are briefly discussed.

2.5.1 UNAMAP Change

Fortran source codes for air quality dispersion models are made available to users in two ways both referred to by the acronym UNAMAP (User's Network for Applied Modeling of Air Pollution):

1) on magnetic tape available from Computer Products, National Technical Information Service, U.S. Department of Commerce, and

2) to EPA users as executable code on EPA's computer located at Research Triangle Park, NC.

Version 4 of UNAMAP became available in March 1980 and Version 5 is scheduled for delivery to NTIS in December 1982. Change 1 to UNAMAP (Version 4) (Turner, et al, 1981) was completed in December 1981 and issued to users. Line by line changes are indicated for seven models and some information received from a user related to conversion of programs for use on IBM systems is shared.

Near the end of the fiscal year, work was begun on readying models and test data for additions to UNAMAP in Version 5.

2.5.2 User's Guides

In order to most effectively utilize in-house resources a contract is being utilized for the preparation of user's guides. Three documents were completed during the fiscal year, a handbook (Petersen, et al, 1982) for preparing user's guides for air quality models and two users guides, one for the screening model PTPLU, a single source Gaussian dispersion algorithm, (Pierce, et al., 1982) and one for a post CHAVG, a program for hourly average concentrations, (Catalano, et al., 1982).

2.5.3 Model Evaluation

The article, "Extreme value statistics related to performance of a standard air quality simulation model using data at seven power plant sites, "(Turner and Irwin, 1982) which reports on additional analyses on data available from EPA Technical reports on model evaluation, was published. This paper gives somewhat greater insight into single source model evaluation over that available when data from only one site is used.

2.5.4 Commuter Exposure

Over the last several years SRI International has investigated factors relating to commuter exposure and has proposed a methodology for modeling exposures to commuters. The User's Guide to the SRI Commuter Exposure Model (Simmon and Patterson, 1982a) and the Description of the Model Methodology and Code (Simmon and Patterson, 1982b) have been received. The exposure model is a deterministic model incorporating the emissions, traffic, and dispersion into the exposure estimates. Concentrations are estimated along specific commuter routes and a time integrated exposure is determined for each commuter route. The model is primarily designed to estimate exposures along major commuter routes and cannot assess the exposure of all commuters. By its very nature the model is designed to estimate the exposure of commuters at high risk since the exposure estimates are made during the morning and evening rush periods. The model can operate in either of two modes. A short term exposure estimate, that is, the exposure for a specific commuter route, or a long term annual exposure can be computed. The model consists of an emissions preprocessor and the main exposure model. The User's Guide and documentation on Model Methodology have been submitted to NTIS.

2.5.5 Carbon Monoxide Exposures of Los Angeles Area Commuters

Carbon monoxide exposures to commuters were simulated in a 5-day measurement study in Los Angeles County. Exposures were determined by measuring CO in three vehicles as they traveled typical commuter routes. The data collected in this study include measurements of vehicle speed and CO measurements in the interior and exterior of three vehicles during the morning and evening peak traffic periods. In addition, hourly averaged CO measurements were taken from eight South Coastal Air Quality Management District fixed site monitoring stations and six California Department of Transportation vans in the proximity of the commuter routes. These data were used to investigate the relationship of CO exposures to meteorological parameters at fixed site monitors, and to traffic conditions. The results of this study were published (Petersen and Allen, 1982). The average ratio of interior CO concentrations to exterior CO concentrations was 0.92. Concentrations inside and outside the vehicles remained about the same even when the vehicles were driven with vents closed and windows up. The average ratio of the hour average CO concentrations in the vehicles to fixed site measurements was 3.9. However, this ratio decreases with increasing ambient CO levels. Although CO levels in the vehicles frequently exceeded 40 ppm and sometimes exceeded 60 ppm, the hour average CO concentrations did not exceed 35 ppm. Slow moving congested traffic is associated with higher CO levels in the vehicles rather than a high volume of traffic moving at a steady speed.

2.5.6 Estimating Concentrations Downwind from an Instantaneous Puff Release

In April of this year an EPA technical report (Petersen, 1982) was published which provides an approach to estimating concentrations downwind of an instantaneous puff release. Dispersion of the puff is described by the Gaussian puff equation, using the dispersion parameters presented in Meteorology and Atomic Energy. The primary purpose of this work is to provide estimates of the instantaneous peak concentration or average concentration through the use of simple equations and nomograms. Example problems are provided in the document to demonstrate the use of the equations and nomograms. A computerized version of the Gaussian puff model is also provided.

2.5.7 A Gaussian Integrated Puff Model - INPUFF

A Gaussian integrated puff model is currently under development. INPUFF is a flexible single source model with a wide range of applications; including simulation of plume trajectories for complex wind fields where straight line plume calculations are not applicable. Limitations are imposed on the use of the algorithm by the assumptions of non-reactive pollutants with a single stability class as representative of the area being modeled. INPUFF provides a useful short-term (minutes/hours) algorithm for point source applications where Gaussian plume models do not apply for air pollution impact and assessments.

2.5.8 Averaging-Time Models

A single air quality data analysis system is needed for interrelating air pollutant effects, air quality standards, air quality monitoring, dispersion calculations, source-reduction calculations, and emission standards. Two and three-parameter averaging-time mathematical models (expressing air pollutant concentration as a function of averaging time and frequency) have been developed to meet some of the needs of such a single system. Using these models, computer techniques have been developed and used to compare present and potential future National Ambient Air Quality Standards. Ambient air quality data have been analyzed for various air sampling sites to determine and compare percentage concentration reductions needed to achieve various potential ambient standards. At the request of the EPA Office of Air Quality Planning and Standards (OAQPS), regions, and States, these and other techniques have been used to analyze ambient concentration data for CO, NO_2, and SO_2.

Techniques are needed for relating air pollutant concentrations to air pollutant effects so that air quality standards can be set at levels necessary to prevent unwanted effects. For instance, a mathematical model (the Larsen-Heck model) has been developed to express percent leaf injury as a function of air pollutant concentration and exposure duration.

Soybean plants have been exposed experimentally to O_3, SO_2, or both pollutants simultaneously to determine the separate and combined effects of these two pollutants. Analyses of these data have enabled the construction of a new mathematical model to estimate percent leaf injury as a function of measured ambient concentrations of these two pollutants. This is the first time that a two-pollutant plant injury model has been constructed. The results have been presented at a seminar and will soon be submitted for consideration for journal publication.

2.5.9 Improved Plume Dispersion Parameters

As a continuation of previous work on improving the estimates of plume dispersion parameters, the lateral and vertical Gaussian-plume dispersion parameters were estimated and compared with field tracer data collected at 11 sites, Irwin (1982a). The dispersion parameter schemes used in this analysis include Cramer's scheme, suggested for tall stack dispersion estimates; Draxler's scheme, suggested for elevated and surface releases; Pasquill's scheme, suggested for interim use in dispersion estimates; and the Pasquill-Gifford scheme using Turner's technique for assigning stability categories. The schemes suggested by Cramer, Draxler, and Pasquill estimate the dispersion parameters using onsite measurements of the vertical and lateral wind-velocity variances at the effective release height. The performances of these schemes in estimating the dispersion parameters are compared with that of the PasquillGifford scheme, using the Prairie Grass and Karlsruhe data. For these two experiments, the estimates of the dispersion parameters using Draxler's scheme correlate better with the measurements than did estimates using the Pasquill-Gifford scheme. Comparison of the dispersion parameter estimates with the measurements suggests that Draxler's scheme for characterizing the dispersion results in the smallest mean fractional error in the estimated dispersion parameters and the smallest variance of the fractional errors. Centerline values of surface concentration were estimated using the Gaussian plume model and compared with the concentration values determined during five field experiments -- three for near-surface releases and two for elevated releases. Comparison of the concentration estimates with the measurements from the five field experiments suggests that Draxler's scheme for characterizing the dispersion results in the smallest mean fractional error in the concentration estimates and the smallest variance of the fractional errors. Two alternate characterizations of the dispersion, formed by altering Draxler's scheme to be independent of release height, are shown to perform almost as well as Draxler's scheme.

Initial evaluations of some of the currently available schemes for estimating plume dispersion parameters revealed variations in the performance of the schemes from one field experiment to the next, for both the lateral and vertical dispersion parameter comparisons. Therefore, a study was conducted, Irwin (1982b), to investigate whether the variations in averaging time, s; the sampling duration, τ, associated with the turbulence measurements; and the sampling duration, T, associated with the dispersion measurements, accounted for the observed site-to-site variations in the performance of the schemes. The variation in the performance of the lateral dispersion parameter estimates with respect to s suggest that underestimates of the dispersion parameters occur if the averaging time is too long. It was found that for the dispersion parameter schemes tested, s should be 5 seconds or less for the lateral dispersion parameter estimates and perhaps less than 2 seconds for the vertical dispersion parameter estimates. The variations in performance of the dispersion parameter schemes from one experiment to the next were quite large. The percentage error in the lateral dispersion parameter estimates was about ±50 to 60% during stable stratification and about ±20 to 30% for comparisons during unstable stratification. In this analysis, it was not clear whether all or most of these variations could be related to variations in s, τ, and T. The relationships between performance of the dispersion parameter schemes and variations in s, τ, and T may have been obscured by the fact that the data compared was collected at different sites using different experimental designs.

2.5.10 Plume Model to Utilize Turbulence Input

A steady-state Gaussian air pollution simulation model which uses turbulence data (wind fluctuation standard deviations) was formulated using the model MPTER, as a basis, tested and transferred to the UNAMAP project for user guide preparation by contract. Meteorological data including temperature, wind velocity, horizontal fluctuation, and vertical fluctuation are specfied for sufficient levels in the vertical so that linear interpolation between these levels will provide adequately accurate data input.

2.5.11 Comparability of Atmospheric Turbulence Measurements

Advances in modeling of atmospheric transport and diffusion of pollutants, brought about by increased theoretical understanding of turbulence and by better empirical data from field programs, have pointed out the frequently site specific nature of atmospheric turbulence. These advances in understanding suggest that better prediction of atmospheric dispersion may be possible if on-site rather than distant and indirect characterization of turbulence is made. Special workshops of experts on diffusion modeling conducted by EPA and the AMS have noted the need for on-site measurements in their reports. To respond to this need, and in light of the fact that very little comparative data on turbulence measurement is available on which to base an informed opinion, a program to investigate and evaluate the accuracy, field precision, and general performance of some examples of meteorological instruments that are typically used in field programs to measure atmospheric turbulence has been started.

In order to compare and contrast instruments of various types that measure atmospheric turbulence, each of a selected group of these instruments were assembled and operated for a common period of time at the NOAA Boulder Atmospheric Observatory(BAO). The data collected by each instrument system was compared with each other system and to the BAO reference standard in order to examine the similarities and differences in the observations made by each instrument. The operational strengths and weaknesses of each instrument will also be noted.

Two basic types of instrumentation were examined. The first is the traditional, in situ, anemometer and vane type instrument system. The second is the remote sensing dual doppler acoustic sounder. There are other methods for observing atmospheric turbulence, but these are either too new and experimental or too expensive and difficult to operate to be considered operationally available at this time. Of the first group, the several variations that were considered are:

1. 3-axis propeller anemometers (u, v, w)
2. cup anemometer and bi-vane
3. cup anemometer, vertical propeller anemometer, and vane
4. propeller anemometer and bi-vane
5. propeller anemometer, vane, and vertical propeller anemometer

Doppler accoustic sounders measure wind velocity and turbulence at selectable heights. Because of the nature of the return signal, they cannot be operated simultaneously. Four sounder systems from different manufacturers were selected, and installed at the BAO. The sounders were operated sequentially with an operational period of twenty minutes.

The entire experiment was in operation in the field for three weeks in order to get enough data from as wide a variety of conditions as possible. The data collection period was completed on September 21, 1982, and the data analysis phase is beginning. As with the in situ measurements, the data collected by the sounders will be compared with each other and with a reference standard. The end result of the project will be an analysis of the accuracy, precision, and effectiveness of practical methods for on-site turbulence measurements.

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 established scientific principles; (2) preparing guidance on applying and evaluating models and simulation techniques that are used to assess, develop or revise national regional and local air pollution control strategies for attainment/maintenance of ambient air quality standards; (3) organizing and directing aerometric field studies for improving the technical basis of the air quality management approach to air pollution control; and (4) providing meteorological assistance and consultation to support OAQPS's broad responsibilities for development and enforcement of Federal regulations and standards and assistance to Regional Offices.

APSB meteorologists are typically involved in interdisciplinary team efforts which include engineers, chemists, statisticians, computer specialists and other technical staff. Thus, it should be noted that most of the projects discussed in this report required such team efforts and the input of other technical staff.

2.6.1 Northeast Corridor Regional Modeling Project (NECRMP)

The purpose of NECRMP is to use photochemical modeling to support the development of ozone control strategies for the Northeast Corridor that are effective, equitable and credible. One meteorologist is directly involved in the monitoring phase of the ambient air quality and meteorological measurement programs. Data acquired during these programs will be used as a data base for subsequent modeling activities and in various analysis efforts. A report documenting the various urban monitoring studies conducted during 1980 as part of NECRMP was prepared in draft and submitted for clearance. Details on the design of the surface air quality and meteorological monitoring networks, aircraft monitoring flights, upper air meteorological soundings, and attending quality assurance program are provided in the report. The utility of the acquired data base in supporting the planned modeling effort, and the interface between the corridor urban studies and the Northeast Regional Oxidant Study (NEROS) are also addressed. A paper entitled, "Recent EPA Urban and Regional Scale Oxidant Field Programs in the Northeastern U.S." by Possiel et al. (1982) was presented at the Annual Meeting of the Air Pollution Control Association.

In addition, several efforts are underway to analyze and interpret the ambient measurements obtained during NECRMP. The first is being conducted to support the combined application of the NEROS Regional Oxidant Model with urban scale models to the Northeast U.S. The analysis focuses on identifying and characterizing the high ozone episode observed in the Northeast during 1980. Candidate days will be selected for modeling which represent typical pollutant and meteorological regimes during such episodes. The analysis will determine the extent to which the following scenarios occurred:

1. long-range transport of high ozone concentrations into the Northeast Corridor (Washington, D.C. to Boston);
2. along-corridor daytime and overnight transport of high ozone concentrations;
3. flow regimes which inhibit inter-urban transport; and
4. mesoscale flows which affect ozone concentration gradients.

Although this effort will continue through most of FY-83, preliminary analyses indicate the prevalence of complex meteorological conditions, including sea breeze channeling flows, vertical wind speed and direction shear within the boundary and recirculation flows during high ozone episodes which will have to be considered when selecting and applying the models. Results of a portion of this analysis are contained in the paper entitled, "Boundary Layer Transport of NO_x and O_3 from Baltimore, Maryland - A Case Study," (Clark, et al., 1982) presented at the Annual Meeting of the APCA.

The second analysis effort is being conducted by Battelle Columbus Laboratories to answer several technical questions on the spatial and temporal distribution of ozone within the New York and Boston plumes, and in portions of the corridor not impacted by these plumes. Basically, the analysis examines (1) the diurnal increase in ozone within air parcels crossing the urban centers of these cities during the morning peak in precursor emissions, and the history of ozone and precursor concentrations using surface ozone measurements during the mid-morning period of air parcels containing the observed peak ozone concentrations, (2) temporal changes in surface ozone concentrations outside of the urban plumes, (3) the utility of using surface ozone measurements during the mid-morning period inversion rise and dissipation as an indication of ozone concentrations aloft prior to vertical mixing, and (4) the utility of using daytime aircraft measurements within the boundary layer to infer surface ozone concentrations in areas between monitoring sites. A draft report on this effort was submitted by Battelle and is undergoing technical review. The final report is to be completed in early 1983.

2.6.2 Model Clearinghouse

During FY-82 the primary responsibilities of the Model Clearinghouse were to:

1. Respond to Regional Office requests for review of non-guideline models proposed for use on iron/steel facilities, smelters and power plants.
2. Review "special action" State Implementation Plan submittals.

3. Develop and issue an example problem illustrating the use of the "Interim Procedures for Evaluating Air Quality Models."

4. Acquire historical information of the application of models in EPA.

5. Track the usage of models within the regulatory community.

6. Issue periodic information (newsletter) on models and data base usage.

The first activity in FY-82 was to prepare and distribute to the Regional Offices in October a Clearinghouse report, which served as a "newsletter," informing users of the Clearinghouse of the issues and responses which occurred in FY-81. This included a summary of the six major responses by the Clearinghouse to Regional Offices as well as a listing of other issues the Clearinghouse addressed.

The requests for assistance included 12 requiring a written response and 24 resolved orally. Twelve issues, all involving the use of non-guideline models or choices between guideline models, were considered controversial and required a considerable amount of attention. In addition, there were numerous telephone inquiries to the Clearinghouse regarding procedures, technical considerations and policies which were readily resolved or referred elsewhere.

Model Clearinghouse visits to all ten EPA Regions occurred in FY-82. The purpose of these meetings was to gather information on the historical usage of models by Regional Offices and to identify current/upcoming modeling problems which may come to the attention of the Clearinghouse. A secondary purpose was to communicate information to the Regions on the current and future operation of the Clearinghouse.

As a result of these very useful meetings, the Clearinghouse was able to document precedents that have been established for the use of certain models and data base considerations and the circumstances associated with the precedents. In addition a number of broader modeling issues were identified where the Regions have adopted specific, sometimes conflicting, policies in areas where national guidance is lacking or is flexible. At the Regional Office Workshop of August 24-26, 1982, a number of these issues were flagged as needing a nationwide consistent policy and various Regional Offices agreed to take the lead in arriving at a consensus policy.

2.6.3 Example Problem for Evaluating Air Quality Model Performance

In July 1981, the Model Clearinghouse transmitted to the Regional Offices a report entitled, "Interim Procedures for Evaluating Air Quality Models." These procedures are intended to assist in deciding whether a proposed model, not specifically recommended in the Guideline on Air Quality Models, is acceptable on a case-by-case basis for a specific regulatory application. Because many of the techniques described in the interim procedures were new, a need was identified to develop an example problem that would illustrate the use of the procedures.

During FY-82 such an example problem was developed under contract by TRC Environmental Consultants. The contract report was transmitted to the Regional Offices this past July and will be included in an appendix to the interim procedures when they are revised in FY-83. Although the example substantially abbreviates many of the tasks recommended in the interim procedures for a real model comparison problem, it does illustrate the task with which the Regional Offices are most unfamiliar, i.e., the development and execution of the performance evaluation protocol.

The source used in the example was the Clifty Creek generating station, a large, isolated coal-fired power plant in southern Indiana. The protocol established the procedures whereby the relative performance of two models, MPTER and AQ40 (a hypothetical model), in estimating the concentrations corresponding to the National Ambient Air Quality Standard (NAAQS) and the Potential Significant Deterioration (PSD) increments could be calculated. The procedure involved the calculation of certain performance statistics recommended by the American Meteorological Society and the execution of a "scoring scheme" where the relative superiority of each model would be established by comparing confidence limits for each performance measure. To arrive at a final evaluation, each performance measure was "weighted" according to its relevance to the problem.

The results of executing the protocol, although academic, indicated that AQ40 was superior to MPTER in estimating concentrations corresponding to the NAAQS. However, MPTER was the better model to estimate the PSD increments.

As a corollary to this activity, a paper by Wilson, et al. (1982) entitled "Suggested Procedures for Evaluating Air Quality Models," was presented at the AMS Third Joint Conference on Applications of Air Pollution Meteorology. The paper included a decision flow diagram for incorporating the results of comparing a "proposed model" and a formulation and performance into the decision as to the overall acceptability of the proposed model.

2.6.4 Regional Meteorologists Workshop

A workshop for information exchange with the Regional Meteorologists was held in the EPA Regional Office in Denver, Colorado. The workshop was restricted to the attendance of the Regional Meteorologists and persononel active in modeling. There were 30 attendees.

The purpose was primarily to brief the meteorologists on the guideline activities and the Model Clearinghouse activities and in turn to receive information from the Regional Offices on what guidance or information is needed in order to carry out their modeling responsibilities. A discussion of model evaluation activities, resolution of certain model algorithm issues, the results of Model Clearinghouse visits to the Regional Offices, activities of the probability modeling task team and a tentative schedule for issuance of a revised guideline were discussed.

Status reports of different research activities were covered by representatives from the Meteorology Laboratory as well as EPA headquarters representatives. The Regional Meteorologists provided status reports of PSD modeling activities and capabilities in the State agencies within their jurisdictions. A portion of the time was devoted to discussions of modeling issues that have been unresolved for some time. A decision was made to appoint one meteorologist per issue as a leader in an effort to resolve these. Written resolutions are anticipated on a schedule that will permit inclusion in the guideline next spring. Also included was an exercise to discuss a scenario with respect to State modeling guidelines. This resulted in a concensus statement by the Regional Meteorologists. This statement, expressing their opinion concerning the delegation of modeling responsibilities to the States, was submitted to EPA for consideration by the Air Programs Branch Chiefs at their fall meeting. The meteorologists were surveyed following this workshop to assess the usefulness of such meeting workshops. Nine out of ten of the Regional Meteorologists felt that such meetings should take place at least once a year and another meeting has been proposed for next spring.

2.6.5 Task Team on Probabilistic Modeling

A task team including an APSB meteorologist was formed to bring together the required expertise in meteorology, modeling, statistics and control options to investigate and develop probabilistic techniques for use in air quality modeling analyses. A contract effort with Systems Applications, Incorporated (SAI) was initiated to plan and begin to implement the further development of probabilistic techniques, building on the existing expected exceedances (ExEx) model.

In December 1981, SAI prepared an overall plan for the investigation/development of probabilistic techniques. Broadly, the plan calls for: (1) the development of techniques to treat meteorology as a random variable and to incorporate the uncertainty in model estimates in the process of setting emission limits; (2) the testing and refinement of these techniques with several sets of source/meteorological data and (3) the transfer of the techniques to EPA.

Due to funding constraints, only the work on development of an extended ExEx technique to treat meteorology stochastically could be initiated. The contract also includes an investigation of the minimum period of meteorological record needed to be representative of a longer time frame and further development of a plan to treat modeling uncertainty. Seventeen years of preprocessed meteorological data for Philadelphia/Washington was prepared and sent to the contractor along with CRSTER runs for the same period of record. Various subsets of these data will be applied to test sampling techniques for stochastic treatment of meteorology and to investigate the minimum period of record needed for an air quality analysis.

A number of application studies at a hypothetical 1000 MW power plant using ExEx have been performed. This has included the development and testing of a method for screening 1-hour concentration values produced by CRSTER so as to minimize the amount of data required for ExEx and yet retain valid results. Using a cutoff value in CRSTER will minimize the processing time for the 17 years of meteorological data and will greatly reduce computer costs. Further application and sensitivity studies are planned to define technical alternatives in using ExEx and to investigate various policy alternatives in standard-setting and emission regulation.

2.6.6 Industrial Source Complex (ISC) Model Evaluation Study

The ISC Model evaluation study using data from the Armco Steel facility in Middletown, Ohio, was completed. The contractor presented a briefing on the results. The final report, entitled "Tests of the Industrial Source Complex (ISC) Dispersion Model at the ARMCO Middletown, Ohio, Steel Mill," was published (Bowers, et al., 1982).

The primary purpose of the study was to test the performance of the gravitational settling/dry deposition of the Industrial Source Complex (ISC) Dispersion Model using the 1980 particulate air quality measurements, made by Armco and EPA in the vicinity of the Armco Steel Mill at Middletown, Ohio. Statistical comparisons of calculated and observed concentrations were made following the procedures suggested by the AMS. It was found that the ISC Model's gravitational settling/dry deposition option yielded calculated total suspended particulate concentrations in closer agreement with the observed air quality than the corresponding concentrations calculated by the model without using this option. Thus, the results of the study indicated that the ISC Model with this option was an improvement over the modeling techniques currently recommended for particulate sources.

The biases of the observed (minus background) and calculated TSP concentrations show that ISC significantly overestimated the impact of the Armco emissions before dust controls were initiated, while the estimates were much closer to observations for the post-control period. The overestimates were principally determined by monitoring sites adjacent to or inside the plant and the large values before control are primarily influenced by roadway emissions. Because there was significant rainfall and high humidity during the pre-control period, calculated emission rates for roadways and storage piles were likely to be too high. Thus, natural dust controls may be considered to be in effect for a good part of the pre-control period. The variances showed that using the settling/deposition option reduced the noise in the results and the RMS errors showed that this portion improves the model's absolute accuracy. However, the greatest improvement appeared to be associated with the more accurate emission rates for the post-control period. The estimates were in the range of 10 to 20 percent of measured values for the sample days after Armco's dust controls were begun.

2.6.7 Evaluation of Visibility Models

As an output from the EPA contract to develop a visibility model, the staff of SAI published an evaluation of the PLUVUE Model based on work presented at the November 1980 Symposium on Plumes and Visibility. Various components of the plume visibility model were evaluated independently.

It was found that the greatest uncertainties in the model predictions are in the diffusion module, which has the limitations associated with all Gaussian diffusion models. The chemistry module described plume chemistry well in a clean background atmosphere; however, the rate NO-to-NO_2 conversion was slightly overpredicted in the model. Predicted secondary aerosol formation was negligible.

To continue performance evaluation of PLUVUE and obtain comparable information on ERT's visibility model, the AMS performance measures were applied to both models, using the 1979 VISTTA data base. The ERT visibility model underestimated the visual effects of plumes almost to the same degree that PLUVUE overestimated them. SAI submitted a final report entitled "Evaluation of the EPA PLUVUE Model and the ERT Visibility Model Based on the 1979 VISTTA Data Base" Seigneur, et al., 1982). Also, efforts are underway to improve PLUVUE, especially in the areas of aerosol formation and plume chemistry. Additional field data for further evaluation and application of the model to regions other than the desert Southwest U.S. have been gathered.

2.6.8 Particulate Matter Impact Due to Surface Coal Mines

PEDCo Environmental, Inc. and TRC Environmental Consultants submitted a final report entitled "Characterization of PM_{10} and TSP Air Quality Around Western Surface Coal Mines" that (1) provides a summary of monitored PM_{10} and TSP concentrations around western surface coal mines sufficient to assess their relationship to ambient standards and increments; (2) applies new emission factors and the ISC model to estimate PM_{10} and TSP concentrations around several hypothetical surface mines; and (3) assesses the impact of these concentrations on the permitting process. The report is currently undergoing Agency clearance procedures. TSP is total suspended particles and PM_{10} is particulate matter below 10 micrometers.

Based on monitored data available from State agency and contractor files together with data from a National Coal Association survey, a data base was developed. It was found that annual and second-highest 24-hour average TSP and inferred PM_{10} concentrations for 12 mines in several geographic areas exceeded PSD Class II increments; but, due to uncertainties in the data base, the results are considered preliminary.

The modeling analyses used the ISC Model, 1981 EPA emission factors, and BACT (best available control technology) practices and control efficiencies (as defined by EPA Region VIII) applied to annual activity parameters for typical surface mines. Analyses were conducted for Powder River Basin, Green River/Hams Fork Basin and the San Juan River Basin sites. Emissions were distributed by particle size and input to the short-term and long-term versions of ISC to produce 24-hour and annual concentration estimates. Based on the ISC Model results, several preliminary observations were made: (1) the largest mine scenario, 25 million tons/year, shows violations of the annual (and 24-hour) TSP NAAQS; (2) all three hypothetical mines show TSP exceedances of the PSD Class II increment outside the mine boundaries; (3) PM_{10} concentrations consume all the PSD Class II increment at two of the three scenario locations. These observations are tempered by the inherent uncertainties in the input data and validity of the model algorithms to account for specific physical and atmospheric processes.

The need for additional study to better characterize emissions, particle deposition and pit retention, and further evaluation of the ISC Model is recognized and further work is underway. A work plan has been drafted that addresses the pit retention problem through a proposed monitoring program. In addition, a protocol for evaluating the entire predictive process (emissions, monitoring and modeling) will be prepared in FY-83. This will allow a systematic performance evaluation of the ISC Model to be conducted based on an actual surface coal mine.

2.6.9 Guideline on Air Quality Models

Plans to revise the Guideline on Air Quality Models this fiscal year were abandoned after it became evident that a number of projects impacting modeling guidance would not be completed in sufficient time to factor them into a 1982 package. EPA policy concerning the programs that require air quality modeling was also undergoing review and revision and it was determined that a postponement of the guideline to 1983 would not seriously affect any activity.

In lieu of a revised guideline and in order to maintain consistency in modeling activities throughout the Regional Offices a Workshop Summary Report was issued in 1981. This document was reviewed to insure up-to-date guidance and an addendum was issued last July to cover required changes. One major addition in 1982 to this report was in the section on complex terrain modeling. Based on the results of a study of the Environmental Operations Branch, a group of the Regional Meteorologists developed a procedure consisting of a two-tiered screening model approach for use when modeling in complex terrain. This procedure permits the use of Complex I as an additional screen after the initial application of the Valley Model. It is suggested that on-site data be available for input to Complex I. This should be the operational approach until such time as a refined modeling approach for complex terrain is made available to OAQPS from the Meteorology Division.

Following the Second Conference on Air Quality Modleing in August 1981, two papers were written. One paper by Hopper, et al., 1982a entitled "The Development of Modeling Guidance - A Dynamic Process," covered the development and status of EPA modeling guidance and was presented at the AMS Third Joint Conference on Applications of Air Pollution Meteorology. The second paper by Hopper, et al., 1982b entitled "The Role of Air Quality Models in Decision-Making," presented the findings of the May 1981 Airlie House Workshop (a prelude to the Conference) and the recommendations made by the participants (presented at the Conference) on the appropriate means and methods for incorporating modeling uncertainty into the air quality management process. This paper was presented at the annual Air Pollution Control Association meeting.

2.6.10 Modeling in Low Terrain

A study was conducted during FY-82 concerning the possible use of terrain adjustment factors in the CRSTER model for modeling problems where terrain below physical stack height is present in the receptor field. Although the study was prompted by proposals from the State of Iowa to use terrain adjustment factors in a State Implementation Plan revision, it also responds to public comments proposing their general use. A draft report entitled, "Modeling in Terrain Less than Stack Height - Alternatives to Current EPA Modeling Practices," is undergoing internal review.

In the study the literature surveyed indicated that there was some support for the use of terrain adjustment factors, but no supportable methodology to specify the factors. Certain wind tunnel studies and theoretical considerations do suggest that under neutral and some stable conditions, the plume path can be altered (from a straight, level plume) by the presence of terrain but other significant processes such as variations in the dispersion coefficients and transport speed occur simultaneously such that a simple terrain factor is difficult to establish. Most importantly, it is clear from these studies that the behavior of the plume and the effects on concentration estimates are highly case-specific where the geometry of the situation (height of the stack in relationship to the shape and height of the terrain and the distance to terrain) and the stability regime play major roles.

The study also examined the regulatory consequences of postulating certain terrain adjustment factors such as half-height. A number of source-terrain configurations and climatological regimes were considered in this sensitivity study. The MPTER model was used since it contains a terrain adjustment option. It was found that: (1) Concentrations estimated with MPTER are very sensitive to the choice of terrain adjustment factor in relation to the height of terrain, the plume height, the distance to terrain and the stability regime; (2) The choice of terrain adjustment factors can have a significant affect on the estimated second-high short-term concentration and thus, the allowable emission rate; and (3) Estimates under neutral and stable conditions are more sensitive to the choice of factors than are those under unstable-conditions.

To see if certain factors would result in an improvement in estimates, comparisons were made between estimates with MPTER, using a level plume, half-height correction, and half-height correction for C and D stability only, and observed data from a six-station monitoring network in the vicinity of the Clifty Creek power plan in Indiana. The elevation of the monitors range up to about 65 percent of the stack height. The findings of this study were:

1. The MPTER model $C_F = 0.0$ (level plume) tends to slightly overestimate the 1-hour concentrations, reasonably reproduces the 3-hour concentration, slightly underestimates the 24-hour concentration and significantly underestimates the annual mean of the Clifty Creek data.

2. The use of a half-height terrain adjustment factor in MPTER shows an apparent improvement in the 1-hour estimate, when compared to the Clifty Creek data, but worsens the performance for the 24-hour and annual averages.

3. During periods of neutral stability, the MPTER model with C_F = 0.0 (level plume) underpredicts the measured concentrations at Clifty Creek. Under neutral conditions, the use of terrain adjustment factors is supported by potential flow theory; however, their use on the Clifty Creek data base worsens the underprediction.

These results are greatly tempered by an apparent high level of uncertainty in the background contribution at the Clifty Creek monitors. Other factors, such as uncertainties in the values for the dispersion coefficients, emission rates, air quality data, wind profiles and mixing depths as well as complexities of flow not addressed by simple Gaussian dispersion may also contribute to the high level of noise in the performance comparison.

2.6.11 Investigation of Selected Technical Issues in Regulatory Air Quality Modeling

A study was conducted to investigate the effect on estimated concentrations of several proposed technical changes to atmospheric dispersion models and report on the sensitivity of the changes for three hypothetical scenarios and one actual emission-meteorology-air quality data base. The technical changes are: (1) wind profile power law exponents, (2) transitional/gradual plume use, (3) buoyancy-induced dispersion (BID), (4) stack tip downwash and, (5) plume trapping. The objective was to provide information that can be used to judge whether the proposed changes, singly or in combination, should be adopted for regulatory air quality modeling.

The draft report, now undergoing internal review, presents a short background survey for each of the five technical issues, including current EPA regulatory practice, alternative proposals by the Agency, other Federal and State agencies and the public through comments received at meetings and conferences. Additional sections contain the results of the sensitivity study, the results of the Clifty Creek power plant data base and the overall findings of the study.

The sensitivity study was based on a set of modeling scenarios considering three hypothetical but realistic sources with nominal emission rates and stack heights of 65 m, 100 m and 200 m located in Pittsburg, Oklahoma City, and Phoenix. A CRSTER-equivalent version of the MPTER model was used with 1964 meteorological input data. The highest and second-highest concentrations were tabulated for 1-, 3- and 24-hours as well as annual averaging times.

In the sensitivity study when the proposed changes are exercised as a group, there is no well-defined systematic change in the highest concentration estimates. However, concentration estimates for the 65 m stack tend to be higher than the base case for all three meteorological regimes. There is a combination of concentration increases and decreases for 100 m and 200 m stacks, but the decreases are of larger magnitude; the decreases are as much as 39 percent for the 3-hour highest estimate while the greatest increase is 8 percent for the second highest 24-hour estimate. Both extremes are for Oklahoma City with a 200 m stack. The use of BID can reduce concentrations by almost 29 percent or increase concentrations by 13 percent depending on the scenario. The use of changed wind speed profile exponents can result in concentration increases up to 17 percent or decrease by as much as 33 percent, depending on the scenario. The use of stack tip downwash increases concentration estimates a maximum of 8 percent and, as expected, this occurs with the 65 m stack. Concentration estimates using final plume rise may be nearly one half those using transitional/gradual plume rise for moderate and tall stacks.

For the Clifty Creek case, data were analyzed by comparing MPTER model estimates to measured concentrations at six sites during those periods when monitored data were available in 1975. In this case the version of MPTER available on UNAMAP and the version of MPTER that is identical to CRSTER were run. High-5 concentration ratios of estimates to observations and frequency distributions for 1-, 3- and 24-hour averaging times at the six monitor/receptor sites were prepared.

There are seven major findings: (1) In general the incorporation of proposed changes, when included in MPTER/UNAMAP, results in somewhat closer agreement but not marked improvement between model estimates and measured data for 1- and 3-hour estimates. For 24-hour and annual estimates these combinations of changes provide poorer estimates than the MPTER/CRSTER base case. (2) The concentration distribution for MPTER/UNAMAP using BID and CRSTER p's indicates that this combination most often yields the highest estimates of any model run in this study. (3) The concentration distribution for MPTER/UNAMAP using rural p's, and no BID indicates this combination most often yields the lowest estimates of any model run in the study. (4) The concentration distributions for the MPTER/CRSTER base case, MPTER/UNAMAP base case with the different treatment of plume trapping, and MPTER/UNAMAP with BID and rural p's are quite similar. (5) The concentration distributions for MPTER/UNAMAP model runs with and without gradual plume rise and stack tip downwash are essentially identical. This indicates that stack tip downwash is a relatively minor problem at this source and that the monitoring sites are far enough downwind so that a consideration of gradual use and downwash have no more than a minor effect on estimated concentrations. (6) While MPTER/UNAMAP with BID and rural p's appears to perform overall at least as well as any of the other models, the performance does not appear to be an unequivocal improvement over MPTER/CRSTER. (7) The concentration distributions for all model options at individual receptor sites yield a variety of results. For 1- and 3-hour distributions the estimates closely approximate measured concentrations at the 98th percentile and higher, but the estimates are generally significantly lower below this percentile. For 24-hour distributions the measured concentrations tend to a log-normal distribution. While the estimated concentrations tend to follow a similar distribution, they are uniformly lower.

2.6.12 Evaluating Model Performance

This project covers a series of six tasks that will culminate in model evaluation studies for air quality models in each of eight model categories. APSB staff serves as advisers and Project Officers on several of the tasks.

One Task, Evaluation, Selection, and Installation of Data Bases, was assigned under contract for the rural, urban, and complex terrain model categories. An APSB meteorologist served as Project Officer for the complex terrain category, and assisted the EPA Project Officer in selecting data bases for the rural and urban model categories. The data based to be used in the model evaluation studies have been selected for each of the three model categories although acquisition of the complex terrain data bases has been delayed.

Work on another task, Report on Model Accuracy, was performed under contract to Systems Applications, Inc., (SAI) with an APSB Project Officer. SAI proposed a set of aggregate statements of model performance which reflect the performance measures recommended by the AMS. SAI reviewed model evaluation studies for the recommended EPA air quality models and those models which were submitted to EPA for possible inclusion in the Guidelines on Air Quality Models. Where possible, the statistics reported in those studies were recast in a form consistent with the AMS recommendations. The final report, entitled "Measures of Model Performance and the Accuracy for Several Air Quality Models," is undergoing final editorial revisions.

2.6.13 Comparison of Alternative "Plume Sigmas"

An APSB meteorologist completed a draft report on a study comparing the effects of incorporating some alternative plume size (plume sigma) algorithms into the CRSTER-equivalent version of the MPTER air quality model. It was decided at the outset that the algorithms to be tested must:

1. Exist in the current technical literature;

2. Implement, to the extent practicable, the recommendations of the AMS Workshop on Stability Classification Schemes and Sigma Curves;

3. Take into account comments made at various times, including public meetings, conferences, and workshops on the subject; and

4. Have been tested in the context of modeling applications.

Seven algorithms were tested:

1. A modification of a method due to Cramer.

2. A modification of the Pasquill-Gifford approach.

3. A second modification of the Pasquill-Gifford approach.

4. The Brookhaven curves.

5. MPTER with averaging time and plume height related adjustments.

6. The method of Irwin.

7. Briggs rural dispersion curves.

The study contains a sensitivity analysis and a comparison with measured data. The sensitivity analysis consists of a comparison of the concentrations calculated using each of the seven test algorithms and the standard MPTER model. Calculations were made for plants with 65 m, 100 m, and 200 m high stacks, and using meteorology from Pittsburgh, Oklahoma City, and Phoenix. The comparison with measured data was accomplished using data from the Clifty Creek power plan. The results show that no one method is clearly better than another, although the method of Irwin shows particular promise, partly because of its ability to account explicitly for measured horizontal and vertical turbulence, if and when such data may become available. The report is undergoing internal review.

2.6.14 National Air Pollution Background Network (NAPBN)

The NAPBN, which consists of eight remote rural ozone measurement sites established by the EPA Environmental Monitoring Systems Laboratory (EMSL), continued to operate during FY-82. Operations at two of the sites were discontinued at the end of the fiscal year and the remaining sites will be discontinued at the end of 1983. A report entitled "The National Air Pollution Background Network 1976-1980," (Evans, et al., 1982) was published in conjunction with EMSL, describes the network and includes several analyses of data collected during 1979. The results indicate that observed seasonal patterns and mean ozone concentrations support the hypothesis that ozone of stratospheric origin is the prime component of ozone measured at these sites. However, examination of high ozone episodes indicates that long range transport from anthropogenic source areas is the principle mechanism for peak short-term concentrations.

An update of this analysis was initiated in FY-82 to focus on year to year fluctuations and geographic differences in boundary layer background ozone concentrations, as estimated from NAPBN measurements. Initial results indicate that the spring maximum in daytime mean ozone concentrations varies by 15-20 ppb between successive years at specific sites, and the duration of this seasonal ozone increase varies from three to six months. This becomes particularly important when the seasonal increase extends into the summer when photochemical formation of ozone from anthropogenic emissions is greatest. A report discussing the results of this effort will be prepared in 1983.

2.6.15 Evaluation of Objective Procedures for Estimating Mixing Heights

Estimates of mixing height are usually needed as inputs to atmospheric dispersion models and the air quality concentration estimates from such models can be quite sensitive to the values assumed for these inputs. Unfortunately, direct measurement of mixing heights are often unavailable or too costly to obtain for many modeling applications. Consequently, various objective methods applied to standard National Weather Service radiosonde soundings are typically used for estimating mixing heights. An analysis was initiated in 1982 to evaluate seven such objective methods against subjective mixing heights estimated by visual examination of sodar records, aircraft pollutant profiles, and radiosonde soundings. Among the methods included are those developed by Holzworth, and Benkley and Schulman. Thus far, work has concentrated on compiling the data base, which was extracted from the Northeast Corridor Regional Modeling Project (NECRMP) data base, and on developing the first of two sets of subjective mixing heights from radiosonde soundings.

It is anticipated that this project, which will continue through 1983, will culminate in a guideline document for selecting and applying objective methods for mixing height computations.

2.6.16 Review and Recommendations: Non-EPA Models

Four new models were submitted by private developers for possible inclusion on the Guideline on Air Quality Models. All of these models passed the initial screening tests with respect to the adequacy of codes and users manuals. They were then reviewed for technical adequacy and comparability with existing techniques.

Plume 5, a Gaussian model similar to CRSTER but adapted for use with on-site meteorological data was submitted by Pacific Gas and Electric Co. This model can be utilized exactly as CRSTER and this model has been shown to give the same answers as CRSTER for a series of test cases. MTDDIS, submitted by Rockwell International, is a multiple puff Gaussian model. RADM, a random walk diffusion model was submitted by Dames and Moore. RTM, a grid model designed to estimate concentrations at large distances downwind from multiple point sources was submitted by SAI, INC. A recommendation on the regulatory status of these models will be contained in the revised modeling guideline.

2.6.17 Cost Analysis of Regulatory Modeling Analyses

A study of the costs of various kinds of modeling analyses was completed under contract to support the regulatory requirements for a proposed revision to the Guideline on Air Quality Models. This study compares the costs of modeling in support of SIPs and PSD applications within the context of guideline revisions. An attempt was made to analyze the lack of changes in guidance in terms of its effect on the cost of a modeling study. Determining the representative cost of a modeling study is exceedingly difficult since there is no "typical" Model application. The complexity of the situation determines the complexity of the analysis which in turn dictates the input requirements and the tools needed to complete the study. Each study is unique. Therefore, a number of assumptions were made in this cost study and the results should be interpreted only in the context of the assumptions that were made. This report is entitled, "Cost Analysis of Proposed Changes to the Air Quality Modeling Guideline" (Wojcik, et al., 1982).

2.6.18 Technical Consultation

On the average, approximately one third of each APSB meteorologists' time is devoted to responding to telephone requests for technical assistance. At least half of these requests come from outside and frequently address both the technical and policy aspects of modeling for different EPA program requirements. Requests often come from lawyers and managers as well as private consultants and technical experts. Immediate response concerning the application of modeling techniques to programmatic requirements means all meteorologists must keep abreast of the latest technical information and policy changes. For example, one APSB meteorologist is the contact person for questions on meteorological monitoring in the context of ambient monitoring requirements in the PSD regulations. Another meteorologist was heavily involved in responding to requests for answers to various implications of changes to the Clean Air Act. A study was performed to determine the consequences of replacing the 3-hour and 24-hour Class I PSD increments with a 30-day average. In a related study an analysis was performed to determine what relaxation of emission limits would result if 3-hour and 24-hour Class I PSD increment consumption were determined using the sixth-highest concentration estimate instead of the second-highest. OAQPS staff have requested assistance in conducting various modeling/monitoring studies. APSB staff also provide assistance to EPA contract project officers on meteorological aspects of their work plans, sensitivity studies, field programs, analysis of data and technical reviews of reports.

3. REFERENCES

Binkowski, Francis S., 1982: A simple model for the time varying mixing depth and transport flow. Proceedings, AMS/APCA, Third Joint Conference on Applications of Air Pollution Meteorology. January 12-15, San Antonio, Texas.

Bhumralkar, C.M., R. Endlich, K. Nitz, R. Brodzinsky, and P. Mayerhofer, 1982: Lagrangian long range air pollution model for eastern North America. Preprint. 13th International Technical Meeting on Air Pollution Modeling and Its Application, Ile des Embiez, France, September 14-17. 23pp.

Bowers, J.F., A.J. Anderson and W.R. Hargraves, 1982: Tests of the Industrial Source Complex (ISC) Dispersion Model at the Armco, Middletown, Ohio, Steel Mill. EPA-450/4-82-006, Environmental Protection Agency, Research Triangle Park, NC, 468 pp. (NTIS: PB82-257-312).

Britter, R.E., J.C.R. Hunt, G.L. Marsh, and W.H. Snyder, 1982: The Effects of Stable Stratification on Turbulent Diffusion and the Decay of Grid Turbulence, J. Fluid Mech. (to appear).

Castro, I.P., 1981: Measurements in Shear Layers Separating from Surface Mounted Bluff Bodies, J. Wing Engr. and Indus. Aerodyn., v. 7, p. 253-72.

Castro, I.P. and W.H. Snyder, 1982: A Wind Tunnel Study of Dispersion from Sources Downwind of Three-Dimensional Hills, Atmos. Envir., v. 16, no. 8, p. 1869-87.

Castro, I.P., W.H. Snyder, and G.L. Marsh, 1982: Stratified Flow over Three-Dimensional Ridges, submitted to J. Fluid Mech..

Catalano, J. A., and F. V. Hale, 1982: CHAVG - A Program for Computing Averages of Hourly Air Pollutant Concentrations User's Guide. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 56 p.

Ching, J.K.S., 1982: The role of convective clouds in venting ozone from the mixed layer. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21, 1982.

Ching, J.K.S., J.F. Clarke, and J.M. Godowitch, 1982a: Modulation of heat flux by different scales of advection in an urban environment. Submitted for publication to Boundary-Layer Meteor.

Ching, J.K.S., J.F. Clarke, J.S. Irwin, and J.M. Godowitch, 1982b: Relevance of mixed layer scaling for daytime dispersion based on RAPS and other field programs. Atmos. Environ., In press.

Clark, T.L. and J.F. Clarke, 1982: Boundary layer transport of ozone in the Northeast Corridor. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21, 1982, pp. 153-156.

Clark, T.L., J.F. Clarke, and N.C. Possiel, 1982: Boundary Layer Transport of NO_x and O_3 from Baltimore, Maryland - A Case Study. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA., June 20-25, 15 pp.

Clarke, J.F., J.K.S. Ching, R.M. Brown, H. Westberg, and J.H. White, 1982a: Regional transport of ozone. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21, 1982.

Clarke, J.F., J.K.S. Ching, and J.M. Godowitch, 1982b: An Experimental Study of Turbulence in an Urban Environment. EPA-600/3-82-062, Office of Research and Development, Environmental Protection Agency, ESRL/RTP, NC 27711, 151 pp.

Clarke, J.F., T.L. Clark, J.K.S. Ching, P.L. Haagenson, R.B. Husar, and D.E. Patterson, 1982: Assessment of model simulation of long-distance transport. Presented at the Annual meeting of the American Association for the Advancement of Science, Washington, D.C. January 11-15, 1982.

Davis, J.M., A.J. Riordan, and R.E. Lawson, Jr., 1982: A Wind Tunnel Study of the Flow Field within and around Open-Top Chambers used for Air Pollution Studies, (in review).

Endlich, R., C. Bhrumralkar, K. Nitz, B. Cantrell, and T. Clark, 1982: ENAMAP-1A long-term air pollution model: refinement of transformation and deposition mechanisms. Preprint. 75th Annual APCA Meeting, New Orleans, LA. June 20-25. 18 pp.

Eskridge, R.E. and R.S. Thompson, 1982a: Wake of a Block Vehicle in a Shear-Free Boundary Flow - An Experimental and Theoretical Study, Proj. Summary, Envir. Prot. Agcy. Rpt. No. EPA-660/3-82-007, Research Triangle Park, NC 27711.

Eskridge, R.E. and R.S. Thompson, 1982b: Wake of a Block Vehicle in a Shear-Free Boundary Flow: An Experimental and Theoretical Study, Envir. Prot. Agcy. Proj. Rpt. (awaiting printing), Research Triangle Park, NC, 116p.

Evans, G., P. Finkelstein, B. Martin, and N. Possiel, 1982: The National Air Pollution Background Network 1976-1980. EPA-600/4-82-058, U.S. Environmental Protection Agency, Research Triangle Park, NC, 75pp.

Godowitch, J.M., 1982: Diurnal variation in the vertical distribution of aerosol scattering coefficient over St. Louis, MO. Proceedings of the 3rd Joint Conference on Applications of Air Pollution Meteorology. American Meteorological Society, Boston, MA.

Godowitch, J.M., J.K.S. Ching, and J.F. Clarke, 1979: Dissipation of the nocturnal-inversion layer at an urban and rural site in St. Louis, MO. Proceedings of the Fourth Sympsium on Turbulence, Diffusion and Air Pollution. American Meteorological Society, Boston, MA.

Greenhut, G.K., T.P. Repoff, and J.K.S. Ching, 1982: Flux variations and cloud transport of ozone, heat, and momentum in an urban environment. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21, 1982.

Griffing, G.W., 1982: Dependence of nephelometer scattering coefficients on relative humidity: Fronts nocturnal disturbance and wood smoke. EPA-600/3-82-006, NERC, Research Triangle Park, North Carolina 27711, 27 pp.

Hopper, C.J., J.L. Dicke, and J.A. Tikvart, 1982a: The Development of Modeling Guidance: A Dynamic Process. Proceedings of the Third Joint Conference on Applications of Air Pollution Meteorology. American Meteorological Society, Boston, MA.

Hopper, C.J., J.A. Tikvart, and C.S. Burton, 1982b: The Role of Air Quality Models in Regulatory Decision-Making. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.

Huber, A.H. and W.H. Snyder, 1982: Wind tunnel investigation of the effects of a rectangular-shaped building on dispersion of effluents from short adjacent stacks. Accepted for publication, Atmos. Envir.

Irwin, J.S. (1982a): Estimating plume dispersion - a comparison of several sigma schemes. J. Appl. Meteor. (In press).

Irwin, J. S. (1982b): Site-to-site variation in performance of dispersion parameter estimation schemes. Proceedings of the 13th International Technical Meeting on Air Pollution Modeling and its Application, NATO Committee on the Challenges of Modern Society, (In press).

Lamb, R.G., 1982a: A Regional Scale (1000 km) Model of Photochemical Air Pollution. Part I: Model Formulation. EPA Report (in press) 225 pp.

Lamb, R.G., 1982b: Air Pollution Models as Descriptors of Cause-Effect Relationships. Paper presented at the IIASA/WHO Joint Workshop or Ambient Air Pollution-Health Effects and Management, Schloss Laxenburg, Austria 27-30 July 1982. (workshop papers to appear in a special issue of Atmospheric Environment).

Lamb, V.R. and R.E. Britter, 1982: Shallow Water Flow over an Isolated Obstacle. Submitted to J. Fluid Mech.

Lamb, V.R. and G.S. Janowitz, 1982: Shallow Rotating Flow over an Isolated Obstacle, Submitted to J. Fluid Mech.

Lavery, T.F., A. Bass, D.G. Strimaitis, A. Venkatram, B.R. Greene, P.J. Drivas, and B.A. Egan, 1982: EPA complex terrain model development, First milestone report - 1981. EPA-600/3-82-036, Environmental Protection Agency, Research Triangle Park, NC, 327 pp.

Lawson, R.E., Jr. and W.H. Snyder, 1982: Determination of Good Engineering Practice Stack Height: A Demonstration Study for a Power Plant, Environmental Protection Agency (awaiting printing), Research Triangle Park, NC.

Mayerhofer, P, R. Endlich, B. Cantrell, R. Brodzinsky, and C. Bhumralkar, 1982: ENAMAP-1 A long-tern SO_2 and sulfate air pollution model: refinement of transformation and deposition mechanisms. EPA-600/3-82-063, Environmental Protection Agency, Research Triangle Park, NC, 97pp.

Payne, A.W., Jr., W.H. Snyder, F. Binkowski, and J.E. Watson, Jr., 1982a: Diffusion in the Vicinity of Standard-Design Nuclear Power Plants; Pt. I: Wind Tunnel Evaluation of Diffusive Characteristics of a Simulated Suburban Neutral Atmospheric Boundary Layer, Health Phys. J. (to appear).

Payne, A.W., JR., W.H. Snyder, F. Binkowski, and J.E. Watson, Jr., 1982b: Diffusion in the Vicinity of Standard-Design Nuclear Power Plants; Pt. II: Wind Tunnel Evaluation of Building-Wake Characteristics, Health Phys. J. (to appear).

Pendergrass, W.R., 1982a: Dispersion Over a Step Change in Surface Roughness, M.S. Thesis, Dept. of Marine, Earth, and Atmos. Sci., NC State Univ., Raleigh, NC, 153p.

Pendergrass, W.R., 1982b: Dispersion Over an Upstanding Step Change in Surface Roughness, 3rd Joint Conference on Applications of Air Pollution Meteorology, Jan. 12-15, San Antonio, Texas, Amer. Meteorological Soc., Boston, MA.

Petersen, W.B., 1982: Estimating Concentrations Downwind from an Instantaneous Puff Release. EPA-600/3-82-078. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 73 p. (NTIS: PB 82-261-959).

Petersen, W.B. and R. Allen, 1982: Carbon monoxide exposures to Los Angeles Area Commuters. J. Air Pollut. Control Association, 32, 826-833.

Petersen, W.B., J.S. Irwin, D.B. Turner, J.A. Catalano, and F.V. Hale, 1982: Handbook for Preparing User's Guides for Air Quality Models. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 53p.

Pierce, T. E., D. B. Turner, J. A. Catalano, and F. V. Hale, 1982: PTPLU - A Single Source Gaussian Dispersion Algorithm. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 98 p.

Possiel, N.C., J.F. Clarke, T.L. Clark, J.K.S. Ching and E.L. Martinez, 1982: Recent EPA Urban and Regional Scale Oxidant Field Programs in the Northeastern U.S. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.

Schere, K.L. and J.H. Shreffler, 1982: Final Evaluation of Urban-Scale Photochemical Air Quality Simulation Models. EPA Report, (in press), 322 pp.

Schiermeier, F.A. and P.K. Misra, 1982: Regional modeling subgroup report. United States/Canada Memorandum of Intent, Report No. 2F-M, 198 pp.

Seigneur, C., A.B. Hudischewskyj, and R.W. Bergstrom, 1982: Evaluation of the EPA PLUVUE Model and the ERT Visibility Model Based on the 1979 VISTA Data Base. EPA-450/4-82-008. Environmental Protection Agency, Research Triangle Park, NC, 70pp.

Shreffler, J.H. and K.L. Schere, 1982: Evaluation of Four Urban-Scale Photochemical Air Quality Simulation Models. EPA-600/382-043, Environmental Protection Agency, Research Triangle Park, NC, 165pp.

Simmon, P.B. and R.M. Patterson, 1982a: Commuter Exposure Model--User's Guide. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 139 p.

Simmon, P.B. and R.M. Patterson, 1982b: Commuter Exposure Model--Description of Model Methodology and Code. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 99p.

Snyder, W.H. and R.E. Lawson, Jr., 1981: Laboratory Simulation of Stable Plume Dispersion over Cinder Cone Butte: Comparison with Field Data, in EPA Complex Terrain Modeling Program, First Milestone Report - 1982, Rpt. No. EPA-600/3-82-036, Envir. Prot. Agcy., Res. Tri. Pk., NC, 250-304p.

Snyder, W.H. and Y. Ogawa, 1982: Simulation of Flow and Diffusion over Cinder Cone Butte in a Stratified Wind Tunnel, Data Report, National Inst. for Envir. Studies, Tsukuba, Japan.

Snyder, W.H., R.S. Thompson, R.E. Eskridge, R.E. Lawson, Jr., I.P. Castro, J.T. Lee, J.C.R. Hunt, and Y. Ogawa, 1982a: The Structure of Strongly Stratified Flow over Hills: Dividing-Streamline Concept (in review).

Snyder, W.H., R.S. Thompson, R.E. Eskridge, R.E. Lawson, Jr., I.P. Castro, J.T. Lee, J.C.R. Hunt, and Y. Ogawa, 1982b: The Structure of Strongly Stratified Flow over Hills: Dividing-Streamline Concept, Appendix
Milestone Rpt. to EPA (awaiting printing).

Strimaitis, D.G., A. Venkatram, B.G. Greene, S. Hanna, S. Heisler, T.F. Lavery, A. Bass, and B.A. Egan, 1982: EPA complex terrain model development, Second milestone report - 1982. Environmental Protection Agency, Research Triangle Park, NC, 402 pp.

Thompson, R.S. and W.H. Snyder, 1981: Air Pollution and Terrain Aerodynamics: A review of fluid modeling studies at the EPA Fluid Modeling Facility, Pres. at ASCE Fall Conv., St. Louis, MO, October.

Turner, D. B. and J. S. Irwin, 1982: Extreme value statistics related to performance of a standard air quality simulation model using data at seven power plant sites. Atmos. Environ., 16, 1907-1914.

Turner, D. B., T. E. Pierce, W. B. Petersen, and A. D. Rankins, 1981: Change 1 to UNAMPA (Version 4). Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 99 p.

Vaughan, W.M., M. Chan, B. Cantrell, and F. Pooler, 1982: A study of persistent elevated pollution episodes in the northeastern United States. Bull. Am. Meteorol. Soc., 63, 258-266.

Whiteman, C.D., N.S. Laulainen, G.A. Sehmel, and J.M. Thorp, 1982: Green River air quality model development, Meteorological data - August 1980 field study in the Piceance Creek Basin oil shale resources area. EPA-600/7-82-047, Environmental Protection Agency, Research Triangle Park, NC, 172 pp.

Wilson, D.A., W.M. Cox and K.P. MacKay, 1982: Suggested Proceedings for Evaluating Air Quality Models. Proceedings of the Third Joint Conference on Applications of Air Pollution Meteorology. American Meteorological Society, Boston, MA.

Wojcik, M., J. Wojcik, P. Bareford, M. Havelock, M. Geraghty and S.E. Haupt, 1982: Cost Analsyis of Proposed Changes to the Air Quality Modeling Guidelines. EPA-450/4-82-014, U.S Environmental Protection Agency, Research Triangle Park, NC, 294pp. (NTIS: 83-112-177).

4. BIBLIOGRAPHY

(The list below includes publications and presentations of Meteorology Laboratory personnel, and publications prepared under grants and contracts monitored by Laboratory personnel.)

Binkowski, F.S., 1982: A simple model for the time varying mixing depth and transport flow. Proceedings, AMS/APCA, Third Joint Conference on Applications of Air Pollution Meteorology. January 12-15, San Antonio, Texas.

Bhumralkar, C.M., R. Endlich, K. Nitz, R. Brodzinsky, and P. Mayerhofer, 1982: Lagrangian long range air pollution model for eastern North America. Preprint, 13th International Technical Meeting on Air Pollution Modeling and Its Application, Ile des Embiez, France, September 14-17. 23pp.

Bowers, J.F., A.J. Anderson and W.R. Hargraves, 1982: Tests of the Industrial Source Complex (ISC) Dispersion Model at the Armco, Middletown, Ohio Steel Mill. EPA-450/4-82-006, Environmental Protection Agency, Research Triangle Park, NC, 468pp.

Briggs, G.A., 1981: Comments on 'Similarity model for maximum ground-level concentration in a freely convective atmospheric boundary layer'. Boundary Layer Meteorology, 21; 531-533.

Briggs, G.A., 1982: Similarity forms for ground-source surface-layer diffusion. Boundary Layer Meteorology, 23, 489-502.

Briggs, G.A., 1982: Simple substitutes for the Obuknov length. Preprint volume of the Third Joint Conference on Applications of Air Pollution Meteorology, American Meteorological Society, Boston, MA, pp. 68-71.

Britter, R.E., J.C.R. Hunt, G.L. Marsh, and W.H. Snyder, 1982: The Effects of Stable Stratification on Turbulent Diffusion and the Decay of Grid Turbulence, J. Fluid Mech. (to appear).

Castro, I.P., 1981: Measurements in Shear Layers Separating from Surface Mounted Bluff Bodies, J. Wind Engr. and Indus. Aerodyn., V. 7, p. 253-72.

Castro, I.P. and W.H. Snyder, 1982: A Wind Tunnel Study of Dispersion from Sources Downwind of Three-Dimensional Hills, Atmos. Envir., V. 16, No. 8, p. 1869-87.

Castro, I.P., W.H. Snyder, and G.L. Marsh, 1982: Stratified Flow over Three-Dimensional Ridges, submitted to J. Fluid Mech.

Catalano, J. A., and F. V. Hale, 1982: CHAVG - A Program for Computing Averages of Hourly Air Pollution Concentrations User's Guide. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 56 p.

Ching, J.K.S., 1982: The role of convective clouds in venting ozone from the mixed layer. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21, 1982.

Ching, J.K.S., J.F. Clarke, and J.M. Godowitch, 1982: Modulation of heat flux by different scales of advection in an urban environment. Submitted for publication to Boundary-Layer Meteor.

Ching, J.K.S., J.F. Clarke, J.S. Irwin, and J.M. Godowitch, 1982: Relevance of mixed layer scaling for daytime dispersion based on RAPS and other field programs. Atmos. Environ. In press.

Clark, T.L. and J.F. Clarke, 1982: Boundary layer transport of NO_x and O_3 from Baltimore, Maryland - a case study. Proceedings of AMS/APCA Conference on Air Pollution Meteorology, San Antonio, TX. January 12-15, pp. 153-156.

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Clark, T.L. and J.F. Clarke, 1982: Boundary layer transport of ozone in the Northeast Corridor. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21, 1982.

Clark, T.L. and T.R. Karl, 1982: Application of prognostic meteorological variables to forecasts of daily maximum one-hour ozone concentrations in the northeastern U.S. J. Appl. Meteor. (in press).

Clark, T.L., J.F. Clarke and N.C. Possiel, 1982: Boundary Layer Transport of NO_x and O_3 from Baltimore, Maryland - A Case Study. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA, pp. 280-283.

Clarke, J.F., J.K.S. Ching, and J.M. Godowitch, 1982: An Experimental Study of Turbulence in an Urban Environment. EPA-600/3-82-062, Office of Research and Development, Environmental Protection Agency, ESRL/RTP, NC 27711, 151 pp.

Clarke, J.F., J.K.S. Ching, R.M. Brown, H. Westberg, and J.H. White, 1982: Regional transport of ozone. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21, 1982.

Clarke, J.F., T.L. Clark, J.K.S. Ching, P.L. Haagenson, R.B. Husar, and D.E. Patterson, 1982: Assessment of model simulation of long-distance transport. Presented at the Annual Meeting of the American Association for the Advancement of Science, Washington, D.C.

Davis, J.M., A.J. Riordan, and R.E. Lawson, Jr., 1982: A Wind Tunnel Study of the Flow Field within and around Open-Top Chambers used for Air Pollution Studies, (in review).

DeMarrais, G.A. and T.L. Clark, 1982: Meteorology and air quality modeling in complex terrain - A literature review. EPA-600/3-82-040, Environmental Protection Agency, Research Triangle Park, NC, 116 pp.

Eberhard, W.L. and G.T. McNice, 1982: Plume dispersion tracked by UV lidar. Eleventh International Laser Radar Conference, NASA Conference Publication No. 2228: 145-148.

Endlich, R., C. Bhrumralkar, K. Nitz, B. Cantrell, T. Clark, 1982: ENAMAP-1A long-term air pollution model: refinement of transformation and deposition mechanisms. Preprint, 75th Annual APCA Meeting, New Orleans, LA. June 20-25. 18p.

Eskridge, R.E. and S.T. Rao, 1982: Measurement and Prediction of Traffic-Induced Turbulence near Roadways, Pres. at 3rd Joint Conf. on Appl. of Air Poll. Meteorol., January 12-15, San Antonio, TX.

Eskridge, R.E. and R.S. Thompson, 1982: Wake of a Block Vehicle in an Shear-Free Boundary Flow: An Experimental and Theoretical Study, Envir. Prot. Agcy., Proj. Rpt. (awaiting printing), Research Triangle Park, NC, 116p.

Eskridge, R.E. and R.S. Thompson, 1982: Wake of a Block Vehicle in a Shear-Free Boundary Flow - An Experimental and Theoretical Study, Proj. Summary, Envir. Prot. Agcy., Report No. EPA-600/3-82-007, Research Triangle Park, NC.

Eskridge, R.E. and R.S. Thompson, 1982: Experimental and Theoretical Study of the Wake of a Block-Shaped Vehicle in a Shear-Free Flow, Atmos. Envir. (to appear).

Evans, G., P. Finkelstein, B. Martin, and N. Possiel, 1982: The National Air Pollution Background Network 1976-1980. EPA-600/4-82-058, U.S. Environmental Protection Agency, Research Triangle Park, NC, 75p.

Finkelstein, P. L. "Spatial Analysis of Acid Rain Data," Symposium presented at Ontario Ministry of the Environment, Toronto, Canada, July 1982.

Finkelstein, P. L., D. A. Mazzarella, T. J. Lockhart, W. J. King, and J. H. White, 1982: Quality Assurance Manual for Meteorological Monitoring, EPA-600/4-82-060. Environmental Monitoring Systems Laboratory, EPA, Research Triangle Park, NC 27711, 103 p.

Finkelstein, P.L. and S.K. Seilkop, 1981: "Interpolation Error and the Spatial Variability of Acid Precipitation," Proceedings of the 7th Conference on Probability and Statistics in Atmospheric Science, pp. 206-212, A.M.S. Boston.

Godowitch, J.M., 1982: Diurnal variation in the vertical distribution of aerosol scattering coefficient over St. Louis, MO. Proceedings of the 3rd Joint Conference on Applications of Air Pollution Meteorology, American Meteorological Society, Boston, MA.

Greenhut, G.K., T.P. Repoff, and J.K.S. ChiNg, 1982: Flux variations and cloud transport of ozone, heat, and momentum in an urban environment. Preprint Volume, Third Joint Conference on Application of Air Pollution Meteorology, San Antonio, TX. January 15-21.

Griffing, G.W., 1982: Dependence of nephelometer scattering coefficient on relative humidity: Fronts, nocturnal disturbance and wood smoke. EPA-600/3-82-006, Research Triangle Park, North Carolina 27711, 27pp.

Hopper, C.J., J.L. Dicke and J.A. Tikvart, 1982: The Development of Modeling Guidance: A Dynamic Process. Proceedings of the Third Joint Conference on Applications of Air Pollution Meteorology, American Meteorological Society, Boston, MA.

Hopper, C.J., J.A. Tikvart and C.S. Burton, 1982: The Role of Air Quality Models in Regulatory Decision-Making. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.

Huber, A.H. and W.H. Snyder, 1982: Wind tunnel investigation of the effects of a rectangular-shaped buidling on dispersion of effluents from short adjacent stacks. Accepted for publication, Atmos. Envir.

Irwin, J. S. (1982): Estimating plume dispersion - a comparison of several sigma schemes. J. Appl. Meteor. (In press).

Irwin, J. S. (1982): Site-to-site variation in performance of dispersion parameter estimation schemes. Proceesings of the 13th International Technical Meeting on Air Pollution Modeling and Its Application, NATO Committee on the Challenges of Modern Society. (In press).

Irwin, J.S. and T.M. Brown, 1982: A Sensitivity Analysis of the Treatment of Area-Sources by the Climatological Dispersion Model. To be published in Journal of Air Pollution Control Association.

Irwin, J. A. and D. B. Turner, 1982: An Analysis of Complex I and Complex II -- Candidate Screening Models. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 57 p.

Lamb, R.G., 1982: A Regional Scale (1000 km) Model of Photochemical Air Pollution. Part I: Model Formulation. EPA Report (in press) 225pp.

Lamb, R.G., 1982: Air Pollution Models as Descriptors of Cause-Effect Relationships. Paper presented at the IIASA/WHO Joint Workshop or Ambient Air Pollution-Health Effects and Management, Schloss Laxenburg, Austria, 27-30 July 1982. (Workshop papers to appear in a special issue of Atmospheric Environment.)

Lamb, V.R. and G.S. Janowitz, 1982: Shallow Rotating Flow over an Isolated Obstacle, Submitted to J. Fluid Mech.

Lamb, V.R. and R.E. Britter, 1982: Shallow Water Flow over an Isolated Obstacle, Submitted to J. Fluid Mech.

Laulainen, N.S., C.D. Whiteman, W.E. Davis, and J.M. Thorp, 1981: Mixing layer growth and background air quality measurements over the Colorado oil shale area. Preprints, Second Conference on Mountain Meteorology, American Meteorological Society, Boston, MA, 165-172.

Lavery, T.F., A. Bass, B. Greene, R.V. Hatcher, A. Venkatram, and B.A. Egan, 1982: The Cinder Cone Butte dispersion experiment. Extended Abstracts, Third Joint Conference on Applications of Air Pollution Meteorology, American Meteorological Society, Boston, MA, 216-219.

Lavery, T.F., A. Bass, D.G. Strimaitis, A. Venkatram, B.R. Greene, P.J. Drivas, and B.A. Egan, 1982: EPA complex terrain model development, First milestone report - 1981. EPA-600/3-82-036, Environmental Protection Agency, Research Triangle Park, NC, 327 pp.

Lavery, T.F., A. Bass, D.G. Strimaitis, A. Venkatram, B.R. Greene, P.J. Drivas, and B.A. Egan, 1982: EPA complex terrain model development, First milestone report - 1981, Addendum - Microfiche of model evaluation calculations. Environmental Protection Agency, Research Triangle Park, NC, 1143 pp.

Lawson, R.E., Jr. and W.H. Snyder, 1982: Determination of Good Engineering Practice Stack Height: A Demonstration Study for a Power Plant, Environmental Protection Agency (awaiting printing), Research Triangle Park, NC.

Lockhart, T. J. and P. L. Finkelstein, 1981: "Precision of Meteorological Instruments in a Monitoring Application," *Instruments and Observing Methods Report No. 9*, W.M.O., Geneva, pp. 197-203.

Lynch, M., W.L. Eberhard, and G.T. McNice, 1982: Lidar in atmospheric dispersion studies - Some quantitative aspects. Eleventh International Laser Radar Conference, *NASA Conference Publication No. 2228*: 143-144.

Mayerhofer, P., R. Endlich, B. Cantrell, R. Brodzinsky, and C. Bhumralkar, 1982: *ENAMAP-1 A long-term SO_2 and sulfate air pollution model: refinement of transformation and deposition mechanisms.* EPA-600/3-82-063. Environmental Protection Agency, Research Triangle Park, NC, 97pp.

Nappo, C.J., J.Y. Caneill, R.W. Furman, F.A. Gifford, J.C. Kaimal, M.L. Kramer, T.J. Lockhart, M.M. Pendergast, R.A. Pielke, D. Randerson, J.H. Shreffler, and J.C. Wyngaard, 1982: The Workshop on the Representativeness of Meteorological Observations. Bull. Am. Meteorol. Soc., 63, 761-764.

Payne, A.W., Jr., W.H. Snyder, and J.E. Watson, Jr., 1982: *Atmospheric Releases from Standardized Nuclear Power Plants: A Wind Tunnel Study*, Envir. Prot. Agcy. Project Report EPA-600/3-82-035, Research Triangle Park, NC.

Payne, A.W., Jr., W.H. Snyder, F. Binkowski, and J.E. Watson, Jr., 1982: Diffusion in the Vicinity of Standard-Design Nuclear Power Plants; Pt. I: Wind Tunnel Evaluation of Diffusive Characteristics of a Simulated Suburban Neutral Atmospheric Boundary Layer, *Health Phys. J.* (to appear).

Payne, A.W., Jr., W.H. Snyder, F. Binkowski, and J.E. Watson, Jr., 1982: Diffusion in the Vicinity of Standard-Design Nuclear Power Plants; Pt. II: Wind Tunnel Evaluation of Building-Wake Characteristics, *Health Phys. J.* (to appear).

Pendergrass, W.R., 1982: *Dispersion Over a Step Change in Surface Roughness*, M.S. Thesis, Dept. of Marine, Earth, and Atmos. Sci., NC State Univ., Raleigh, NC, 153p.

Pendergrass, W.R., 1982: Dispersion over an Upstanding Step Change in Surface Roughness, *3rd Joint Conference on Applications of Air Pollution Meteorology*, January 12-15, San Antonio, TX, Amer. Meteorol. Soc., Boston, MA.

Petersen, W.B., 1982: *Estimating Concentrations Downwind from an Instantaneous Puff Release.* EPA-600/3-82-078. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 73 p.

Petersen, W.B. and R. Allen, 1982: Carbon monoxide exposures to Los Angeles Area Commuters. J. Air Pollut. Control Association, 32, 826-833.

Petersen, W.B., J.S. Irwin, D.B. Turner, J.A. Catalano, and F.V. Hale, 1982: Handbook for Preparing User's Guides for Air Quality Models. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 53 p.

Pierce, T.E., D.B. Turner, J.A. Catalano, and F.V. Hale, 1982: PTPLU - A Single Source Gaussian Dispersion Algorithm. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 98p.

Possiel, N.C., J.F. Clarke, T.L. Clark, J.K.S. Ching, and E.L. Martinez, 1982: Recent EPA Urban and Regional Scale Oxidant Field Programs in the Northeastern U.S. Proceedings of the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA.

Schere, K.L., 1982: Photochemical model evaluations using data of the Regional Air Pollution Study--box and grid models. Proceedings of Third Joint Conference on Applications of Air Pollution Meteorology, San Antonio, TX. 11-15 January, 1982, AMS, Boston, MA, pp. 33-36.

Schere, K.L. and J.H. Shreffler, 1982: Final Evaluation of Urban-Scale Photochemical Air Quality Simulation Models. EPA Report, (in press), 322pp.

Schiermeier, F.A. and P.K. Misra, 1982: Regional modeling subgroup report. United States/Canada Memorandum of Intent, Report No. 2F-M, 198 pp.

Seigneur, C., A.B. Hudischewskyu and R.W. Bergstrom, 1982: Evaluation of the EPA PLUVUE Model and the ERT Visibility Model Based on the 1979 VISTA Data Base. EPA-450/4-82-008. Environmental Protection Agency, Research Triangle Park, NC, 70pp.

Shreffler, J.H., 1982: Intercomparison of surface and upper air winds in an urban area. Boundary-Layer Meteorol., (IN PRESS, Aug. 1982).

Shreffler, J.H., 1982: Evaluation of the Lagrangian Photochemical Model using data of the Regional Air Pollution Study. AMS/APCA Third Joint Conference on Applications of Air Pollution Meteorology, January 12-16, 1982, San Antonio, TX.

Shreffler, J.H., 1982: Observations and modeling of NO_x in an urban area. Proceedings of the U.S.-Dutch Symposium on NO_x. Maastricht, The Netherlands, May 24-28, 1982.

Shreffler, J.H. and R.B. Evans, 1982: The ozone record of the Regional Air Pollution Study (RAPS), 1975-1976. *Atmos. Environ.*, 16, 1311-1321.

Shreffler, J.H. and K.L. Schere, 1982: *Evaluation of Four Urban-Scale Photochemical Air Quality Simulation Models. EPA-600/3-82-043, Environmental Protection Agency, Research* Triangle Park, NC, 165pp.

Shreffler, J.H. and K.L. Schere, 1982: *Evaluation of Four Urban-Scale Photochemical Air Quality Simulation Models. EPA-600/3-82-043, Environmental Protection Agency, Research* Triangle Park, NC, 165pp.

Simmon, P.B. and R.M. Patterson, 1982: *Commuter Exposure Model--User's Guide.* Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 139p.

Simmon, P.B. and R.M. Patterson, 1982: *Commuter Exposure Model--Description of Model Methodology and Code.* Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 99 p.

Snyder, W.H. and R.E. Lawson, Jr., 1981: Laboratory Simulation of Stable Plume Dispersion over Cinder Cone Butte: Comparison with Field Data, in *EPA Complex Terrain Modeling Program, First Milestone Report - 1982*, EPA-600/3-82-036, Environmental Protection Agency, Research Triangle Park, NC, p. 250-304.

Snyder, W.H. and Y. Ogawa, 1982: *Simulation of Flow and Diffusion over Cinder Cone Butte in a Stratified Wind Tunnel, Data Report*, National Institute for Environmental Studies, Tsukuba, Japan.

Snyder, W.H., R.S. Thompson, R.E. Eskridge, R.E. Lawson, Jr., I.P. Castro, J.T. Lee, J.C.R. Hunt, and Y. Ogawa, 1982: *The Structure of Strongly Stratified Flow over Hills: Dividing-Streamline Concept* (in review).

Snyder, W.H., R.S. Thompson, R.E. Eskridge, R.E. Lawson, Jr., I.P. Castro, J.T. Lee, J.C.R. Hunt, and Y. Ogawa, 1982: The Structure of Strongly Stratified Flow over Hills: Dividing-Streamline Concept, *Appendix to Environmental Research and Technology Second Milestone Report to EPA* (awaiting printing).

Spangler,T.C. and G.H. Taylor, 1981: Flow simulation techniques used in the small hill impaction study. *Preprints, Second Conference on Mountain Meteorology*, American Meteorological Society, Boston, MA, 125-128.

Spangler, T.C. and G.H. Taylor, 1982: Flow simulation techniques used in the small hill impaction study. *Extended Abstracts, Third Joint Conference on Applications of Air Pollution Meteorology*. American Meteorological Society, Boston, MA, 220-223.

Stearns, L.P., E.W. Barrett, and R.F. Pueschel, 1982: Effects of a power plant plume on radiative transfer. *Meteorologische Rundschau*, 35:76-84.

Strimaitis, D.G., A. Venkatram, B.R. Greene, S. Hanna, S. Heisler, T.F. Lavery, A. Bass, and B.A. Egan, 1982: *EPA complex terrain model development, Second milestone report - 1982*. Environmental Protection Agency, Research Triangle Park, NC, 402 pp.

Thompson, R.S. and W.H. Snyder, 1981: Air Pollution and Terrain Aerodynamics: A review of fluid modeling studies at the EPA Fluid Modeling Facility, *Presented at the ASCE Fall Conv.*, St. Louis, MO, October.

Turner, D. B., and J. S. Irwin, 1982: Extreme value statistics related to performance of a standard air quality simulation model using data at seven power plant sites. *Atmos. Environ.*, 16, 1907-1914.

Turner, D.B., J.S. Irwin, and A.D. Busse, 1982: *Comparison of RAM Model Estimates with 1976 St. Louis RAPS Measurements of Sulfur Dioxide*. To be published in Atmos. Environ.

Turner, D. B., T. E. Pierce, W. B. Petersen, and A. D. Rankins, 1981: *Change 1 to UNAMAP (Version 4)*. Environmental Sciences Research Laboratory, EPA, Research Triangle Park, NC 27711, 99 p.

Vaughan, W.M., M. Chan, B. Cantrell, and F. Pooler, 1982: A study of persistent elevated pollution episodes in the northeastern United States. *Bull. Am. Meteorol. Soc.*, 63, 258-266.

Venkatram, A., D. Strimaitis, D. DiChristofaro, J. Pleim, T. Lavery, A. Bass, and B.A. Egan, 1982: The development and evaluation of advanced mathematical models to simulate dispersion in complex terrain. *Extended Abstracts, Third Joint Conference on Applications of Air Pollution Meteorology*. American Meteorological Society, Boston, MA, 167-170.

Vukovich, F. and D. Enlich, 1982: Estimating cloud parameters for NEROS I. EPA-600/3-82-011, Environmental Protection Agency, Research Triangle Park, NC, 29 pp.

Whiteman, C.D., 1981: Temperature inversion buildup in valleys of the Rocky Mountains. *Preprints, Second Conference on Mountain Meteorology*, American Meteorological Society, Boston, MA, 276-282.

Whiteman, C.D., 1982: Breakup of temperature inversions in deep mountain valleys, Part I - Observations. *J. Appl. Met.*, 21: 270-289.

Whiteman, C.D., 1982: Breakup of temperature inversions in deep mountain valleys, Part II - Thermodynamic model. *J. Appl. Met.*, 21:290-302.

Whiteman, C.D., N.S. Laulainen, G.A. Sehmel, and J.M. Thorp, 1982: *Green River air quality model development, Meteorological data - August 1980 field study in the Piceance Creek Basin oil shale resources area.* EPA-600/7-82-047, Environmental Protection Agency, Research Triangle Park, NC, 172 pp.

Wilson, D.A., W.M. Cox and K.P. MacKay, 1982: Suggested Proceedings for Evaluating Air Quality Models. *Proceedings of the Third Joint Conference on Applications of Air Pollution Meteorology.* American Meteorological Society, Boston, MA.

Wojcik, M., J. Wojcik, P. Bareford, M. Havelock, M. Geraghty and S.E. Haupt, 1982: *Cost Analysis of Proposed Changes to the Air Quality Modeling Guidelines.* EPA-450/4-82-014, U.S. Environmental Protection Agency, Research Triangle Park, NC, 294pp.

5. METEOROLOGY LABORATORY'S STAFF FISCAL YEAR 1982

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

Dr. Kenneth L. Demerjian, Physical Scientist, Director
Herbert J. Viebrock, Meteorologist, Assistant to the Director
Dr. Francis Pooler, Jr., Meteorologist (Assigned to EPA Regional Field Studies Office)
Marc Pitchford, Meteorologist (Las Vegas, NV)
Dr. Ernest Peterson, Meteorologist (Corvallis, OR) (until January 1982)
Lawrence E. Niemeyer (T), Meteorologist (until January 1982)
Evelyn Poole -Kober (T)(EPA), Technical Information Clerk
Vickie Deaton (EPA), Secretary (until April 1982)
Mary E. Fitch (EPA), Secretary
Mary Williams (Student), Clerk-Typist

Atmospheric Modeling Branch

Dr. Jack H. Shreffler, Physical Scientist, Chief
Dr. Francis Binkowski, Meteorologist
Dr. Gary Briggs, Meteorologist
Dr. Jason Ching, Meteorologist
Terry Clark, Meteorologist
Dr. John Clarke, Meteorologist
James Godowitch, Meteorologist
Dr. George Griffing, Physical Scientist
Dr. Robert Lamb, Meteorologist
Kenneth Schere, Meteorologist
Orren Bullock (Student), Meteorologist
Mark Shipham (Student), 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 Technical
Judith Haden (Student), Engineering Aid
Carolyn Coleman (T)(EPA), Clerk-Typist (until May 1982)
Michele Richardson (T)(EPA), Clerk-Typist (until September 1982)

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
William Amos (EPA), Computer Programmer
Tony Brown (COOP), Computer Science Trainee
Barbara Hinton (PT)(EPA), Secretary

Terrain Effects Branch

Francis A. Schiermeier, Meteorologist, Chief
Lawrence Truppi, Meteorologist
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)
Everett Quesnell, Meteorological Technician (Assigned to Environmental Monitoring Systems Laboratory)
Thomas Asbury (Student), Meteorologist
Valentine Descamps, Meteorologist (Boston, MA)
Alan Cimorelli, Meteorologist (Philadelphia)
Lewis Nagler, Meteorologist (Atlanta, GA)
Frank Hall, Meteorologist (Dalla, TX) (until May 1982)
Richard Fisher, Meteorologist (Denver, CO)
Joan Emory (EPA, Secretary)

Air Policy Support Branch

James L. Dicke, Meteorologist, Chief
Charlotte Hopper, Meteorologist
Dean Wilson, Meteorologist
Russell Lee, Meteorologist
Norman Possiel, Jr., Meteorologist