NOAA Technical Memorandum ERL ARL-107

DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

FISCAL YEAR 1980 SUMMARY REPORT OF NOAA METEOROLOGY LABORATORY SUPPORT TO THE ENVIRONMENTAL PROTECTION AGENCY

Herbert J. Viebrock, Editor

Air Resources Laboratories
Silver Spring, Maryland
June 1981

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Secretary

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PREFACE

The work reported herein was funded by the Environmental Protection Agency (EPA) under agreement EAP-80-D-X0348 between the EPA and the Air Resources Laboratories (ARL), National Oceanic and Atmospheric Administration (NOAA). The Meteorology Laboratory (ML), 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 EPA research, development, and operational effort in air pollution meteorology is primarily performed and managed by the ML. 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 Environmental Sciences Research Laboratory, EPA, and other EPA groups, are conducted within the ML and through contract and grant activities. The ML provides technical information, observational and forecasting support, and consultation on all meteorological aspects of the EPA air pollution control program to all the EPA offices, including the EPA Office of Air Quality Planning and Standards and the Regional Offices, as appropriate.

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

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ABSTRACT

The Meteorology Laboratory provided research and operational meteorological support to the Environmental Protection Agency. Basic operational 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. Work on the description and modeling of the planetary boundary layer continued. Major emphasis was on modeling photochemical oxidant dispersion and dispersion in complex terrain. In addition, climatic studies were conducted, including the analyses of the relationships between pollutant concentrations and meteorological parameters.

A flow visualization field study of small hill impaction was conducted at Cinder Cone Butte, Idaho as part of the study of dispersion in complex terrain. This was complemented by towing tank studies in the Fluid Modeling Facility. The second Northeast Regional Oxidant Study field program was conducted during July-August 1980 to investigate physical and chemical processes important to long-range transport of oxidants and oxidant precursors. Four photochemical air quality models were evaluated using data for ten carefully selected high ozone days from the Regional Air Pollution Study in St. Louis. The European Model for Air Pollution (EURMAP), which predicts SO_2 and SO_4 concentrations and deposition rates as well as interregional sulfur transport, was adapted for use over eastern North America (ENAMAP).

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OF NOAA METEOROLOGY LABORATORY SUPPORT

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1. INTRODUCTION

During Fiscal Year 1980, the Meteorology Laboratory continued to provide research and operational support to the Environmental Protection Agency. Operational support provided to the Office of Air, Noise and Radiation, the Environmental Protection Agency Regional Offices, and other Environmental Protection Agency components included review of environmental impact statements, implementation plans, and grant and contract proposals; the application of dispersion models; and the conduct of dispersion studies and evaluations. This work is discussed in sections 2.3 and 2.4.

Research support was in the areas of model development and application and climatic analysis. The primary effort was in the development and evaluation of air quality simulation models, with major emphasis on photochemical oxidant dispersion models and dispersion in complex terrain. Work on the description and modeling of the planetary boundary layer continued, using the Regional Air Pollution Study (RAPS) and Sulfur Transport and Transformation in the Environment (STATE) program data bases. A major field study was conducted on the regional dispersion of ozone and its precursors (Northeast Regional Oxidant Study). The Fluid Modeling Facility conducted experiments on the flow over hills and ridges and in complex terrain. Climatic studies included analyses of the relationships between pollutant concentrations, such as sulfates and ozone, and meteorological parameters. The research work is discussed in sections 2.1 and 2.2.

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. Both theoretical and experimental studies are conducted to describe the physical processes affecting the transport, diffusion, transformation, and removal of pollutants in and from the atmosphere. Experimental studies are conducted both in the field and in physical modeling facilities.

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 smaller tunnel is 11 m in overall length, with a test section 3 m long, 1 m wide, and 1 m high. It has an airflow speed range of 0.3 to 21 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. The water channel has a speed range of 0.1 to 1 m/s and the towing carriage a range of 1 to 50 cm/s.

The Atmospheric Modeling Branch program for Fiscal Year 1980 is briefly described below.

2.1.1 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 quantitatively 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. Among these processes are:

1. Horizontal transport;
2. Photochemistry, including the very slow reactions;
3. Nighttime chemistry of the products and precursors of photochemical reactions;
4. Nighttime wind shear, stability stratification, and turbulence "episodes" associated with the nocturnal jet;
5. Cumulus cloud effects - venting pollutants from the mixed layer, perturbing photochemical reaction rates in their shadows, providing sites for liquid phase reactions, influencing changes in the mixed layer depth, perturbing horizontal flow;
6. Mesoscale vertical motion induced by terrain and horizontal divergence of the large scale flow;
7. Mesoscale eddy effects on urban plume trajectories and growth rates;
8. Terrain effects, on horizontal flows, removal, diffusion;
9. Subgrid scale chemistry processes--resulting from emissions from sources smaller than the model's grid can resolve;
10. Natural sources of hydrocarbons, NO_x and stratospheric ozone;
11. Wet and dry removal processes, e.g., washout and deposition.

Of the eleven processes listed above, only the first and last have been treated in any detail in the regional scale models of air pollution developed to date. A review of these models reveals that virtually all of the Eulerian type models are in essence simply expanded urban scale models. They account for the physical processes that are active during daylight hours and within 10 km or so of a source, but they neglect both the processes that are important beyond this distance and those that are active at night.

2.1.2 Northeast Regional Oxidant Study

The second phase of the Northeast Regional Oxidant Study (NEROS) field program was conducted during July-August 1980 at Columbus, Ohio and Baltimore, Maryland. The program was designed to obtain data for validation of a regional scale photochemical model currently under development. The program also sought to obtain additional insight on the physical and chemical processes important in long-range transport of oxidant and its precursors from urban areas into synoptic-scale air masses. The field study was broken into two parts: 1) urban plume characterization on a regional scale, accomplished in the Baltimore area; 2) regional scale polluted air mass characterization accomplished primarily in the Columbus area. The program involved use of ground sites, mobile vans fixed-wing aircraft, and helicopters. Measurements included O_3, NO, NO_x, SO_2, and hydrocarbons upwind and downwind of source areas. Aircraft carried LIDAR, probes for measuring turbulence, temperature and dewpoint, O_3, NO_x, hydrocarbon, and long path monitors for particulates. Ground systems included SODAR, LIDAR, and tethersondes for vertical profiles of O_3, temperature, and wind. Tetroons were released to track air mass trajectories.

The design and implementation of NEROS was accomplished within the Laboratory, as well as in coordination with the overlapping Persistent Elevated Plume Episode program.

2.1.3 Northeast regional oxidant model status

The Northeast regional oxidant model has been designed in a generalized form with modular components describing the various physical and chemical processes occuring on a regional scale. The core of the model is composed of numerical algorithms for solving a coupled set of partial differential equations. All variables required for solution of these equations are calculated by a series of preprocessors which are external to the model itself but essential to its operation. A systematic approach for the development, documentation and implementation of these preprocessors has been designed. Detailed descriptions of function, the inputs, outputs and methods of solution for each of the preprocessors has been incorporated into a computerized system of working documentation. Most model input preprocessors have been developed. The preprocessors are currently in the final stages of testing. An automated system for preprocessor execution has been designed and is currently being implemented and tested. Various raw data sets required as inputs to the model preprocessors have been extracted from data collected during the NEROS experiments in the summer of 1979. These data sets have been thoroughly reviewed for possible error or inconsistencies.

In addition to the preprocessor development, the following model development related tasks were undertaken. First, benchmark testing of Systems Applications Incorporated (SAI) regional scale photochemical model were completed on the following computer systems: 1) UNIVAC 1100/44 (required application of multibanking techniques), 2) IBM 370/168, 3) Digital Equipment Corporation VAX 11/780, and 4) CRAY-1. However, technical problems with SAI's model led to in-house development of a regional scale photochemical model using different schemes for solution of the differential equations. An initial version of the model has been completed and simplified test cases have been executed with positive results. Additional complexities are currently being incorporated into the model.

2.1.4 Model evaluation

Evaluation of four photochemical, urban-scale models was undertaken during FY-80 using data from the Regional Air Pollution Study (RAPS) in St. Louis. The models were the Photochemical Box Model (PBM), the Lagrangian Photochemical Model (LPM), Livermore Regional Air Quality Model (LIRAQ), and the Urban Airshed Model (UAM). Before beginning the final evaluation runs, the models were subjected to a number of tests and modifications, and the RAPS emissions inventory was finalized. Modifications to the PBM included incorporation of vertically averaged photolytic rate constants, revision of rate constants based on current literature, and a comparison of results using three different chemical mechanisms. Modification of the LPM included revision of the emissions processor to allow variable parcel size with multiple emissions tracks. Tests and modifications of UAM included revision of rate constants, incorporation of a diffusive-top, vertical averaging of photolytic rate constants, revision of the initial conditions profiles, and an analysis of the influence of various wind field processing schemes.

The models were executed on 10 days of RAPS data; these days were chosen because of high ozone values recorded by the monitoring systems. Predicted and observed ozone, nitric oxides, and carbon monoxide were compared by examining time series and calculating the mean residual, its standard deviation, and the mean absolute residual. The results on the PBM, LPM, and UAM are encouraging but, in some cases, point to deficiences in the models which may require further modifications. Results from the LIRAQ indicate serious problems with the emissions and chemistry modules, and results are not interpretable at this time. Lawrence Livermore Laboratory, builder of LIRAQ, is investigating the apparent errors. Following any additional revisions of the models, further RAPS days will be used for evaluating the models.

2.1.5 Finalization of the Regional Air Pollution Study (RAPS) data base archive

The system design has been completed for implementation of the final

Regional Air Monitoring System (RAMS) data validation. Basically, the current version 6.4 minute data will undergo various updates and flagging in accordance with the recommendations of various validation studies. The updated minute data will be reaveraged internally to form an updated version 7.0 RAM hourly archive. A first draft summary of recognized data problems and the suggested methods of solution has been prepared for final technical review.

Various RAPS data sets such as HI-vol and LBL Dichotomous samples data have been reformatted and condensed into a form suitable for shipment to the National Technical Information Service (NTIS). Efforts are continuing on the final validation and preparation of all appropriate RAPS data sets (i.e., RAMS hour archives, emissions and upper air data, Las Vegas helicopter data, etc.) for eventual submission to NTIS for public distribution.

2.1.6 Characterization of automobile wakes

A theoretical and experimental study of turbulent wakes of automobiles is underway to produce a parameterization that can be used in present and future dispersion models for automobile exhaust. A specially-constructed wind tunnel with a moving floor was used to obtain a uniform approach flow. A stationary vehicle on this moving floor simulates a moving vehicle on a highway under near-calm conditions and provides a convenient platform for otherwise very difficult Eulerian measurements. A vehicle wake may be considered as a vortex wake superimposed on a momentum wake. The first phase of the study characterized the momentum wake. A block-shaped model vehicle was found to produce a pure momentum wake and was used for extensive measurements of velocity deficit and turbulent kinetic energy components. These measurements were compared with three variations of a theory for this type of momentum wake. Length and velocity scales were found that collapsed the vertical and lateral profiles of velocity deficit. The complete results are fully described in Eskridge and Thompson (1980). This work is continuing for the more complicated case of combined vortex and momentum wakes.

2.1.7 Evaluation of crop isolation chambers

A cooperative study with the U.S. Department of Agriculture was performed at the Fluid Modeling Facility to evaluate open-topped plant growth chambers. These exposure chambers are used to isolate crops in the field and serve as control chambers by regulating the pollutants in the air that is supplied to them. Scale models of various chamber designs were studied in the meteorological wind tunnel to determine how the wind affects pollutant distributions within the chambers. This work was reported by Davis and Rogers (1980).

2.1.8 Development of techniques for pulsed-wire anemometers

Measurement of mean velocity profiles and turbulence characteristics in the FMF wind tunnels are an important ingredient in evaluating simulated atmospheric boundary layers for use in modeling pollutant dispersion. The traditional technique of hot-wire anemometry fails to provide accurate measurements of these parameters where wind speeds are low and/or where turbulence intensities are high. A recent development which overcomes some of these difficulties is the pulsed-wire anemometer (PWA). The PWA is based on the principle of directly measuring the flow speed in areas where the flow reverses direction. Application of the PWA is not as straight-forward as the hot-wire owing to the fact that it is a relatively new instrument, hence its operational limitations and capabilities had to be determined. The approach used for evaluation consisted of development and testing of an electronic interface and software for automatically acquiring data from the PWA, comparison of measured velocities and turbulence intensities with data obtained by other investigators, and comparison of wind tunnel measurements with identical measurements taken with the hot-wire anemometer. Some alteration of the PWA circuitry was required to obtain reliable operation. Measurements in the wake of a flat plate showed very good agreement with those obtained by other investigators and demonstrated the PWA's ability to measure highly turbulent flows. Comparison of PWA measurements with hot-wire measurements in a simulated boundary layer showed excellent agreement and pointed out the areas where hot-wire data should be questioned. This PWA technique was then used to delineate the size and shape of the separated flow regions and highly turbulent wakes downwind of various hills in the wind tunnel.

2.1.9 Standard-design nuclear power plants

A wind tunnel study was conducted of 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. A graphical technique was developed to relate lateral dispersion to the projected areas of the building complexes. This work is described in a Ph.D. dissertation by Payne (1979).

2.1.10 North Carolina State University studies

Cooperative studies have been conducted through a grant with the Department of Geosciences, North Carolina State University. One study involved the analysis of the recovery of wakes downwind of two-dimensional hills of varying aspect ratio. It was found that the maximum mean velocity deficit decays as $Ax^{-3/2}$ for all hill shapes, but that the constant of proportionality is strongly dependent upon the slope of the hill. This work will be documented in a Master's thesis. Another study concentrated on flow and dispersion from sources placed within the recirculating cavity regions downwind of three-dimensional hills of various crosswind aspect ratios. Cavity shapes and sizes were investigated with the aid of a pulsed-wire anemometer. Excessive concentrations were observed "upwind" of the source when the source was placed inside the recirculating cavity region. Very large concentrations were also observed when the source was placed on the reattachment streamline because, in this instance, the contaminant is advected directly to the surface. A data report was assembled by Castro and Snyder (1980) and the results will be analyzed and published in the near future. Another study involved numerical calculations of flow over hills under elevated inversion conditions. Comparisons with towing tank studies showed promising results (Lamb and Britter, 1980).

2.1.11 Triangular ridge study

Towing tank studies were conducted on stably stratified flow perpendicular to triangular ridges of various length-to-height ratios. Froude numbers were varied from 0.1 to 1.6 and ∞, and hill aspect ratios were 1,2,4,8 and ∞. Flow patterns were visualized using dyes of various colors. Surface streamlines and upwind separation lines were illustrated by deploying line sources of dye on the model surface. Centerplane streamline patterns using vertical rakes showed dividing streamline heights, speed-up over the crest and lee wave patterns. Point dye released on the surface in the lee of the hill showed the location of reattachment points and rotors. Elevated dye released in the wake of the hills showed vortex-shedding under certain conditions. A motion picture film documents these phenomena and a report is in progress.

2.1.12 Isolated hill field experiment

A preliminary one-week flow-visualization study was conducted at Cinder Cone Butte, Idaho, a 100 m high, isolated hill in the flat and broad Snake River Basin. Limited meteorological observations were made to aid in the interpretation of the flow-visualization results. The site was judged to be well-suited for the first phase of a contract to be awarded for extensive studies to gain understanding of the physical mechanisms governing flow and diffusion of pollutants in complex terrain, in particular, plume impingement under stable flow conditions. Katabatic winds were found to occur under light wind, clear sky conditions shortly after sunset. Separation was found to occur on the lee slope of the hill under neutral conditions if the slope angle exceeded approximately 25°. In an internal report (Snyder, et al., 1980), recommendations were made concerning instrumentation and procedures to be used in future studies.

2.1.13 Laboratory support for complex terrain field study

A series of towing tank experiments was conducted to provide input to the design of the field experiment to be conducted at Cinder Cone Butte (CCB), Idaho by Environmental Research and Technology (ERT), Inc., beginning in September, 1980. These studies included three phases:

I. A 1:1536 scale model study of CCB to determine whether the hill had significant influences on the flow field at the location of the 150 m meteorological tower under the prevailing wind directions, under various stability regimes, and at what elevations.

II. A 1:640 scale model study to determine source and sampler placement strategies as functions of stability regime and wind direction.

III. Experiments with typical anticipated approach flow density profiles to verify an implicit integral formula that predicts the dividing streamline height for any specified approach-flow density profile.

The basic conclusion from phase I was that the site chosen for the meteorological tower was adequate, but a second 20 m tower was recommended to provide a back-up in the event of unexpected wind directions and to provide positive field confirmation of perturbations induced by the hill. Source and sampler placement strategies were established through interaction with ERT during the phase II studies. The phase III studies demonstrated the validity of the integral formula for predicting the height of the dividing streamline. The recommendation was to use this formula as an operational, real-time decision-making tool for source placement in the field study.

2.2 Terrain Effects Branch

The Terrain Effects Branch conducts research studies on the effects of complex irregular terrain on air quality dispersion, on both an intramural and extramural basis; establishes the relationships among air quality, meteorological parameters, and physical processes affecting the air quality; and conducts research in air pollution climatology.

2.2.1 Dispersion model development for sources in complex terrain

During this fiscal year, the Terrain Effects Branch (TEB) was delegated responsibility for a major program dealing with the development of improved models of atmospheric dispersion for sources located in complex terrain. Based on opinions expressed by participants at an EPA-sponsored Complex Terrain Workshop in FY-79, a Request for Proposal was issued in December 1979 with a deadline of February 10, 1980 for proposal submission. During this period, TEB personnel made visitations to several candidate sites for the first Small Hill Impaction Study to be performed under the proposed contract. The 100-meter tall Cinder Cone Butte near Boise, Idaho, was chosen because of its symmetry and relative isolation from other elevated terrain features, as well as ready availability of electrical service.

After proposal evaluation, the complex terrain contract was awarded to Environmental Research & Technology (ERT) on June 6, 1980. ERT headed a composite team which included Western Scientific Services and North American Weather Consultants as major subcontractors and Computer Genetics Corporation and TRC-Environmental Consultants as minor subcontractors. The contract was structured with a basic slope of work accompanied by three options. The fundamental contract is an eighteen-month effort to perform Small Hill Impaction Study #1 on Cinder Cone Butte and to conduct related dispersion model evaluation and development. Option 1 allows for an additional twelve months to perform Small Hill Impaction Study #2 on Cinder Cone Butte or on another appropriate elevated terrain feature and to continue the model development effort. Option 2 extends the contract thirty months for the performance of a Full Scale Plume Study at an existing electrical generating station located in complex terrain and for the analysis and use of these data in the dispersion models under development. The third option provides for a symposium at which results from the complex terrain field studies and model development activity, together with relevant work in related areas, are presented to the scientific community. Any or all of the options may be exercised in any order, dependent on results to date.

The program is designed to produce atmospheric dispersion models that are useful in regulatory applications for large sources 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 (Holzworth, 1980). As the first priority, the Contractor will model the one-hour average, ground level concentrations that result from stable plume impaction on elevated terrain obstacles. To this end, the small hill impaction studies were designed to use mobile cranes emitting oil fog and tracer plumes to impact on an isolated terrain feature, i.e., a hill small enough to permit sampling over much of the surface.

The first phase of Small Hill Impaction Study #1 was a flow visualization study conducted in September 1980. The purpose of this phase was to gain a qualitative understanding of the physical mechanisms involved in the flow over the butte in order to facilitate the placement of sensors and the conduct of experiments in the second phase, consisting of quantitative tracer measurements in FY-81. Of the ten flow visualization experiments, two were performed during late evenings and eight during early mornings. These experiments proved the design of the Small Hill Impaction Study to be viable, especially the flexibility provided by mobile cranes to enable plume release regardless of wind direction. The Phase I results also showed that many of the features observed in towing tank simulations appear to be applicable in the field.

The ERL Wave Propagation Laboratory (WPL), Boulder, Colorado will participage in Phase II of the Small Hill Impaction Study #1. During FY-80, WPL personnel performed software development to enable on-site processing of lidar measurements of plume particulates. Tests of the modified lidar were conducted during September 1980 in the Geysers geothermal area of California. Additional modifications to increase lidar pulse repetition and processing rates are currently underway.

2.2.2 Green River ambient model assessment

Due to 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 a specific need for the development of site-specific ambient diffusion models. Accordingly, the Green River ambient model assessment program was initiated. The program is being conducted by the Battelle Memorial Institute, Pacific Northwest Laboratories (PNL), through an interagency agreement with the Department of Energy. The main objective of this program 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.

Because a considerable amount of meteorological and air quality data are routinely being collected by existing petroleum industry monitoring sites, the interagency agreement sponsors only limited field measurements to supplement and merge with this industry-sponsored effort. During the period of July 31 to August 16, 1980, PNL performed initial ground-based field experiments in and around Tract C-a in Colorado while airborne measurements were taken over a 400 km area containing the oil shale regions of Utah, Colorado, and Wyoming. These data are being incorporated with measurements taken by other participating agencies and will be used in the development and evaluation of regional scale, mesoscale, local scale, air quality, and climatological models.

2.2.3 Analyses 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. During FY-80, this in-house effort was begun with results currently available for only the mixing heights (Schiermeier and Pooler, 1980); analyses of the transport winds and ventilation factors are continuing.

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.

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 continues to increase during the night, both the urban and rural mixing heights remain relatively constant between midnight and sunrise. Seasonal excursions between morning minimum and afternoon maximum mixing heights are twice as great during summer as during winter. Comparison of urban versus rural mixing heights reveals slightly higher nocturnal values at the urban site, a difference which effectively disappears 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 quadrant while most non-zero morning mixing heights occurred with surface winds from the northern quadrant.

2.2.4 Analysis of widespread haze episodes in the eastern United States

The objective of a two-year grant to the University of California, Los Angeles is to develop a clearer understanding of the manner in which various synoptic scale weather features interact with large pollutant emissions to produce episodes of widespread haze in the eastern United States. Such extensive haze episodes in the eastern United States during the last thirty years have been objectively defined by Patterson, et al. (1979). Detailed three dimensional analyses of a number of conspicuous cases have been completed. Described here is a case study of an episode that occurred in the summer of 1957. Earlier analysis of a similar case in 1959 has been reported by Edinger (1980).

The materials used to make the three dimensional analysis included: the three hourly surface map analyses by the National Weather Service and the twelve hourly rawinsonde observations over the eastern United States. Using these data, three dimensional plumes were constructed for assumed continuous emissions from nine urban-industrial sources in the eastern United States: Boston, New York, Philadelphia, Pittsburgh, Detroit, Cincinnati, Chicago, Evansville, and St. Louis. Air columns at each of these locations extending from ground level to the top of the mixed layer were carried forward in time using the wind fields at the surface, 950, 900, 850, 800, 750, and 700 mb levels. Vertical mixing of the plumes throughout the depth of the mixed layer was imposed during the daytime hours. At night, only the transport and deformation provided by the three dimensional wind field were considered.

The results are portrayed as the perimeters (horizontal envelopes) of the plumes at ground level. Separate perimeters were constructed for 1-day old, 2-day old and 3-day old emissions. It is the superposition of these three envelopes to form a single extensive plume that constitutes the consolidated plume. When all the envelopes for the 1957 case studies completed to date are compared with the observed distribution of haze, the following statistics emerge:

(a) 89% of the weather stations reporting haze lie within the perimeter of the consolidated plume (this includes emissions for all three preceding days from all the sources).

(b) 86% of the haze reports lie within the perimeter of 3-day old emissions.

(c) 76% of the haze reports lie within the perimeter of 2-day old emissions.

(d) 19% of the haze reports lie within the perimeter of 1-day old emissions.

(e) About 1/4 of the area within the perimeter of the consolidated plume is haze free. Typically this hazeless fraction is associated with a deep mixed layer, towering cumulus and thunderstorms.

Not infrequently thunderstorms and showers occur within the haze air volume. The convective activity in this instance is associated with an approaching cold front.

The results to date suggest that under these haze episode conditions: (1) wind shear combined with diurnal fumigation in two days can produce from the nine widely spread urban-industrial sources a continuous volume of hazy air over a major portion of the northeastern United States; (2) most of the reported haze occurs in polluted air 2 or 3 days removed from its source, only a minor fraction of the haze being ascribable to emissions less than one day old; and (3) vigorous cumulus convection and thunderstorms can occur in these hazy air masses.

2.2.5 Impacts of topographic and land/sea circulations on dispersion

Under a grant, the University of Virginia adapted their numerical mesoscale meteorological model to study the effects of mesoscale circulations on atmospheric transport and diffusion. Major achievements during the year included:

An improved representation of the planetary boundary layer when the surface layer is stably stratified has been incorporated into the University of Virginia mesoscale model. Such a parameterization uses a local exchange coefficient formulation, which, along with the profile representation used when a positive surface heat flux exists, has been shown to be as accurate as second order closure techniques, for the case study we have examined in detail. Over sloping terrain (such as in drainage flow simulations), the use of a local exchange coefficient representation such as we use, appears essential if realistic simulations are to be attained. The development of the nocturnal jet over sloping terrain, for example, has been studied effectively (McNider and Pielke, 1980), using this representation of the planetary boundary layer.

A trajectory routine has been included in the University of Virginia mesoscale model permitting simulated parcels, released at arbitrary heights, to be tracked through the model domain. Such a representation should be an accurate representation of reality when area sources larger than the model grid are modeled. Using this procedure, we have illustrated the complex movement patterns associated with the sea- and land-breeze, and with mountain-valley winds. The work (McNider and Pielke, 1979) clearly demonstrates the inadequacy of Gaussian plume models to assess air pollution concentration in such an environment.

In modeling of pollutant concentrations from point sources, use of a dynamic conservation equation in which fluxes are proportional to the gradient of the pollutant is inadequate because of the coarse resolution of mesoscale models. For this case, where the plumes are small compared to the turbulent length scale, a statistical particle dispersion scheme has been developed and is being incorporated into the University of Virginia mesoscale model. The statistical technique (McNider, et al., 1980) should allay some of the concerns associated with the use of grid models to assess pollution concentrations from point sources.

2.2.6 Synoptic meteorology patterns and air quality in the St. Louis area

Work under a grant to Washington State University dealt with synoptic weather typing of surface geostrophic wind patterns and 850-mb pressure patterns across an area of about 500 miles radius centered on St. Louis, MO. The purpose has been to correlate these synoptic weather types with air quality data obtained in 1975-76 during the St. Louis Regional Air Pollution Study program. This research is an extension of an earlier similar grant program that dealt with correlations between surface weather types and RAPS air quality data.

The weather typing scheme used the procedures as developed by Lund (1963). This program is an objective multistation correlation process readily adaptable to computer processing methods and using regular synoptic weather observations. For the identification of weather types based on surface geostrophic wind patterns, correlations were developed using sea level pressure gradients between 17 selected pairs of stations within the study area. The data were divided into seasons, and a total of 36 map types were identified. For the development of synoptic types at the 850 mb level, 0000GMT radiosonde data were used from a total of 18 NWS stations in the test region. The typing process at 850 mb identified a total of 21 map types with three winter season types and six in each of the other seasons.

After the seasonal map types were identified, daily air quality data from the RAPS stations located in the central St. Louis urban area were summarized on the basis of applicable weather types, and statistical tests for significance were carried out on the classified pollutant data. The pollutants considered were ozone, carbon monoxide, total suspended particulates, total sulfate, and total nitrate. When the daily average pollutant concentrations in the central St. Louis area were stratified by map type the 850 mb types provided better or more significant separation of high and low pollutant situations than did the geostrophic types or the previously identified surface pressure pattern types (Robinson, et al., 1980). In general, weather patterns characterized by a high pressure system and southwesterly winds in the St. Louis area were correlated with higher levels of air pollution in the St. Louis urban area. This result, of course, is not unexpected since air pollution events and high pressure systems have long been known to be positively related. The results should, however, provide a basis for classifying synoptic systems objectively for pollutant modeling studies and for other research applications where a more homogeneous set of weather situations would be an advantageous input into a research or operational program.

In the concluding months of the research program, the weather typing and air pollution data will be applied to regional visibility patterns. The research results will then be integrated into a comprehensive technical report.

2.2.7 Further modeling of long-range transport and transformations

Work on this topic has been supported over several years by grants to

Colorado State University. Although the subject is extremely complicated, it has been pursued from a practical approach with highly promising results. Prior work is described in our Fiscal Year 1979 Report (Viebrock, 1980). During the 1980 fiscal year, a considerable effort was devoted to refining the model for calculating 24-hour concentrations of SO_2 and sulfate. In the previous model, the daytime mixing layer height and the nighttime stable layer height were defined from climatological data, and trajectories of the mean wind of the layers were calculated. In contrast, the present version of the model incorporates vertical temperature profiles along a trajectory to determine mixing layer depths over which average transport winds are calculated. The top of the daytime mixing layer is defined as the base of any nonsurface-based temperature inversion. A maximum inversion height is chosen as 3000 m. If no inversion occurs below 3000 m, this height is used for the top of the afternoon mixing layer and winds are averaged over that layer. The top of the nighttime stable layer is defined as the top of the surfaced-based temperature inversion. If no surface-based inversion occurs, 500 m is substituted as the top of the nighttime stable layer. Furthermore, in order to save computing time, interpolation schemes of concentrations for grid points and of precipitation rates observed at meteorological stations into the midpoint of each trajectory segment have been refined. Additional refinements for removal terms due to dry and wet depositions and transformation terms of SO_2 to sulfate were also included. Using the refined model, the geographical distributions of the 24-hour average concentrations of SO_2 and of sulfate over the region between 55°N and 45°N and between 75°W and 95°W were calculated for the dates of January 25 and July 11, 1976. The correlation coefficients between the observed concentrations and the calculated concentrations for January 25 are 0.68 and 0.77 for SO_2 and sulfate, respectively, and for July 11, 0.44 and 0.85, respectively.

Using the available data of precipitation chemistry, studies of the acidity of precipitation have been centered on finding empirical relationships between the acidity and the concentrations of various ions in precipitation samples. Statistically, significant correlations have been obtained between observed pH and the concentrations of $SO_4^=$ and NO_3^- in samples. Therefore, admittedly crudely, it is possible to predict the acidity of precipitation from the model. It is concluded that the results of the model are appropriate as long as the climatological average values were calculated, but would be inadequate for use in studies of short-term average acidity.

A simple, climatological model of SO_2 and sulfate transport, which as input uses wind sounding data, monthly precipitation data, and emissions of SO_2 over the area of interest, has been developed. The model is capable of calculating the transport and deposition amount of sulfur across the national boundary between the US and Canada. Using average wind speeds and directions within the mixing layer, trajectories of air parcels are computed four times a day from each major source for 30 days. It is assumed that SO_2 and sulfate emitted from the source are transported and transformed along the average trajectory determined from 120 trajectories. The long-term average plume from a pollutant source is approximated by a series of puffs. Horizontal dispersion of pollutants from the center of a puff is expressed as the sum of the dispersion due to the meandering of each trajectory and the dispersion due to the vertical shear of wind. The geographical distributions of the monthly average concentrations and deposition amounts of SO_2 and of sulfate were calculated over the region between 35°N and 53°N and between 62°W and 95°W, which encompasses eastern North America. The distributions of acidity in precipitation were calculated also. Further efforts are in progress for the application of the model. Results will be reported in the final report, due early in 1981.

2.3 Environmental Operations Branch

The Environmental Operations Branch adapts and evaluates new and existing air quality dispersion models for use by the scientific and general community. Models are modified for specific applications and are then made available to the user community through the dissemination of users' guides and computer tapes and through existing computer networks. Close liaison is maintained with the user community to provide guidance in the use of the models and to assess future needs. The branch also provides technical guidance and staff support to various programs engaged in quality assurance, health effects studies, special studies, field projects, and implementation of air pollution laws and regulations. The branch program for Fiscal Year 1980 is briefly described below.

2.3.1 Dispersion near highways

Mathematical dispersion models are currently being used to predict the concentrations of carbon monoxide and particulate species in the vicinity of highways. While there have been a number of models proposed to predict the concentrations for different atmospheric conditions and highway configurations, there have been only a few experimental validation studies. Three recent studies, conducted by SRI, International, the General Motors Corporation (GM), and the New York State Department of Environmental Conservation (NYS), have collected sufficiently detailed pollutant, traffic, and meteorological data to be used for model validation. All three studies were conducted on at-grade roadways in relatively flat terrain. Whereas the SRI and NYS experiments were carried out along major highways with average daily traffic in excess of 100,000 vehicles, the GM study was a controlled experiment on a test track. Of great value in these studies is the inclusion of special tracer gas release experiments.

HIWAY-2 is a result of the recommendations received from the New York State Department of Environmental Conservation. HIWAY-2 is a finite line source model for estimating the impact on air quality from roadways.

Recent studies have demonstrated that the dispersion near the roadway is dominated by the turbulence generated by the moving traffic and that the ambient atmospheric stability plays little role in dispersing the pollutant in the immediate vicinity of the roadway. The dispersion parameters, σ_y and σ_z, indicate the amount the pollutant plume has spread (dispersed) after leaving its source. The vertical dispersion parameter, σ_z, was evaluated from the tracer data collected during the General Motors (GM) Experiment and the Long Island Expressway (LIE) Experiment. The data indicate that the dispersion downwind of the highway is typically between Pasquill stability class A and C, even though the GM data represented a large number of cases when the atmosphere was stable. Also, considerable scatter in σ_z was found between stability classes. For these reasons, the dispersion in HIWAY-2 is specified to be a function of only three stability regimes. For PG stability classes A, B, and C, the unstable curve is used. For stability class D, the neutral curve is used; for stabilities E and F, the stable curve is used. The user specifies the PG stability class (A-F) and the appropriate dispersion curve is chosen by the model.

Sufficiently far downwind the atmospheric dispersion process dominates the dispersion of the plume from the roadway. At 300 meters downwind, the dispersion curves are merged into the PG curves; the unstable curve is merged into the PG class B curve, the neutral curve into the PG class D curve, and the stable curve into the PG class E curve.

Turbulence of the air produced by the motion of automobiles results in a rapid mixing of the pollutants near the highway. This mixing is modeled by assuming that an initial spreading of the pollutant plume occurs over the highway. HIWAY based on a limited data base, used 1.5 meters as the initial vertical dispersion, σ_{z_0}. The value of 1.5 meters is a conservative estimate of the vertical standard deviation of the plume at the downwind edge of the at-grade highway and was considered as a tentative value.

In order to improve the estimate of the initial vertical dispersion, σ_{z_0} was calculated as a function of wind speed from the GM data for the nearest roadside receptor. The initial vertical dispersion parameter is specified as:

$$\sigma_{z_0} = 3.57 - 0.53\ U_c$$

The crossroad wind component is indicated by U_c. HIWAY-2 is programmed such that U_c is computed and used in the equation above to estimate σ_{z_0}, with a minimum value of σ_{z_0} of 1.5 meters.

HIWAY-2 has incorporated in it an aerodynamic drag factor that accounts for the initial dilution of the pollutant on the roadway, and allows the model to make reasonable concentration estimates during low wind speed conditions. Analysis of the GM data revealed that the aerodynamic drag factor must be a function of the wind-road orientation angle, because the amount of acceleration in the lower layers is most significant under parallel wind-road orientation. Hence, an aerodynamic drag factor that is a function of wind-road angle was developed and incorporated into the HIWAY-2 model. The relation developed is:

$$U = C\,u^{0.164} \cos^2 \phi$$

u is the ambient wind speed (m sec^{-1}), ϕ is the wind-road angle, and C is a constant related to the traffic speed. It is observed that C equals 1.85 for moderate to high traffic speed conditions. However, for low traffic speeds, data are not available at this time to evaluate the value of C. This relation takes full effect for parallel wind ($\phi = 0$) situations but has no effect for perpendicular wind cases. If the ambient wind speed is less than the wind speed computed according to the above relation, then only the corrected wind speed will be applied. If the ambient wind speed is greater than the corrected wind speed, no changes to the wind speed are made, thus, allowing correction for only low wind speed situations (ambient wind speeds less than 2 m sec^{-1}).

2.3.2 Commuter exposure model

Over the last several years there has been increasing concern about exposure of commuters to roadway pollutants. Studies during this time indicated pollutants on the roadway to be at sufficiently high levels to be of concern. This concern prompted the Environmental Protection Agency to make estimates of the exposure. The concentration estimates were made using the HIWAY dispersion model. Although the actual exposure estimates in this analysis had large uncertainties, they indicated that there could be significant exposures of the commuter population and that further studies were needed. In 1977 SRI International was asked to investigate factors relating to commuter exposure and to propose a methodology for development of a commuter exposure model. The development of the model incorporating factors including traffic, roadway characteristics, distribution of vehicle types, vehicle operating characteristics, intersection signalization, vehicular emissions, and dispersion is near completion.

It is a deterministic model incorporating the emissions, traffic, and dispersion into the exposure estimates. Concentrations are estimated along a specific commuter route 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 exposures of all commuters. By its very nature, the model is designed to estimate the exposure of commuters to high risk since the exposure estimates are made during the morning and evening traffic 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 average exposure can be computed. The model consists of an emission preprocessor and the main exposure model.

The emissions preprocessor determines the appropriate emission factors to be used in the run and sets up the data to be used by the main model. The preprocessor is separate from the main model so that as updates occur in the emission factors they can easily be added into the preprocessor. The three major functions of the preprocessor are to determine: 1) the federal test procedure (FTP) emission factors for freeways, expressways, arterials, and non-pathway sources, 2) the model emission factors for arterials in the central business district (CBD), and 3) the emission factors used in the area source computations.

The main program has four major functions: 1) traffic flow along each of the commuter routes is computed incorporating factors such as traffic capacity volumes, etc.; 2) the main program computes the emission rates for each link of the commuter route as well as the area sources used in the model; 3) the dispersion algorithms for line sources, area sources, and street canyons are used to compute concentration estimates at point locations along the commuter route; a time-integrated exposure is then computed; and 4) the main model computes short-term or annual exposure statistics.

The output of the commuter exposure model will include short-term and annual statistics. The short-term statistics include: 1) list of exposures on each pathway; 2) the mean and standard deviation of exposure on each pathway; 3) the percentage of commuters in each of several exposure classes; and 4) the probability of experiencing exposure levels in each of several exposure classes. The annual statistics include: 1) the annual average commuter exposure; 2) the annual average exposure on each pathway; 3) the percentage of commuters in each of several exposure classes (for all pathways); and 4) the probability of experiencing levels in each of several exposure classes (for all pathways). In the annual mode there are several optional outputs: 1) the percentage of commuters in each of several exposure classes on any single pathway; 2) the probability of experiencing exposure levels in each of several exposure classes (on any single pathway); 3) pathway exposure associated with different meteorological conditions; and 4) pollution roses.

2.3.3 Carbon monoxide monitoring study for Los Angeles area commuters

A study was performed by SAI to collect CO data in vehicles along typical commuter routes in Los Angeles. During October 1-5, 1979, CO was monitored both inside and outside vehicles traveling typical commuter routes in the Los Angeles county area. Three vehicles were involved during the morning and evening peak traffic periods. Two Interscan continuous CO analyzers were installed in each vehicle to monitor CO levels simultaneously inside and outside the vehicles. The outside sampling probe was located near the fresh air intake while the inside probe was located near the drivers breathing zone.

The monitoring periods and routes were chosen to correspond to representative commuter trips throughout the Los Angeles Basin. Although there are no specific available "typical" commuter routes published, knowledge of the general traffic flows along with other factors such as traffic counts was utilized to select vehicle routes. Each vehicle essentially simulated two commuter travel patterns. It was desired to partition the freeway and arterial driving roughly 80% and 20%, respectively. Furthermore, the routes all used some portion of the "42-mile loop". This loop is instrumented to provide real-time traffic volume and speed data. A further consideration was their proximity to air quality monitoring stations. Since these were placed throughout the area no complications arose in meeting all these requirements.

In order to provide an adequate description of the measurement conditions, a detailed recording of real-time information was made. An unambiquous correspondence among CO levels, vehicle speed and recorded observations were made by assigning an alphabetic code to each notation and simultaneously marking the log and chart papers by "glitch" marks and the progressive code letter.

Traffic count information for city, county and state street and highway systems are available. These data provide peak hour volumes and daily totals for the numerous locations and intersections along each route. All these data were taken during the last year. The 42-mile loop is instrumented for real-time information with hourly volumes and average speed provided. Air quality stations are located throughout the county and all provide hourly CO averages in addition to some yielding the following meteorological information: relative humidity, temperature, wind direction and speed. At some stations, soundings and other measurements are taken: atmospheric pressure and stability, and vertical profiles. These data have been accumulated for later utilization.

Some preliminary observations which may be made based on limited data examination are as follows:

1. Ambient levels throughout the Los Angeles Basin during the week of testing rarely exceeded an hourly average of 15 ppm CO.

2. Commuter exposure during the period consistently averaged greater than 15 ppm over all routes.

3. No significant differences in CO concentrations were found between vehicle interior and exterior for any of the comfort states with the windows opened.

4. For vehicles in the minimum ventilated state, windows up, vents - heater - air conditioner off, the interior concentration does not closely follow the fluctuations of exterior CO levels but rather gradually increases and decreases. Forced ventilation prevents more complete decoupling of interior and exterior environments.

5. Peak CO levels exceeded 100 ppm and commonly exceeded 50 ppm. Traffic congestion conditions were responsible.

A detailed analysis of the data is currently underway.

2.3.4 Dispersion model for Multiple Point Sources With Terrain Adjustment, MPTER

The MPTER model and user's guide was completed in March. MPTER, a multiple point gaussian dispersion algorithm with optional terrain adjustment offers a combination of features so that the model can be used for regulatory applications while still having the flexibility to perform sensitivity analysis and model validation. The User's Guide for MPTER pointed early in 1980 was designated EPA 600/8-80-016. Users outside of the agency can obtain a tape of the MPTER source code from NTIS by asking for PB 80-168156.

2.3.5 Dispersion screening model for point source plumes, PTPLU

Also included on the MPTER tape is the PTPLU model developed early in 1980. PTPLU is an adaptation and improvement of the PTMAX model which is currently being used to screen point sources for the distance of maximum concentrations. PTPLU is a stand alone ASCII FORTRAN program which outputs an analysis of concentration as a function of stability class and wind speed. Unlike PTMAX, PTPLU generates tables both for constant wind speed with height and increasing wind speed with height. PTPLU also allows for optional calculation of buoyancy induced dispersion, stack downwash, and gradual plume rise.

2.3.6 Evaluation of the RAM air quality dispersion model

In November 1978, the Environmental Operations Branch began a study to evaluate the RAM air quality dispersion model using the meteorological and emissions data collected as part of the Regional Air Pollution Study at St. Louis. The model estimates of SO_2 concentration were to be compared with the air quality data collected at the 13 Regional Air Monitoring Sites, about half of which are located within the city limits and the rest are scattered within 50 km of St. Louis. The results to date have verified the results of other evaluation studies that model prediction accuracy, as measured by the mean squared error, improves (the mean squared error decreases) as the averaging time increases. Various other measures of model performance were proposed and tested as part of the research effort. The work is still underway and the final report will be prepared during FY-1981.

2.3.7 On-Site Meteorological Instrumentation Workshop

A workshop entitled "On-Site Meteorological Instrumentation Requirements to Characterize Diffusion from Point Sources" was held in Raleigh, North Carolina, on January 15-17, 1980. The workshop was sponsored by the U.S. Environmental Protection Agency (EPA) and arranged by Environmental Research and Technology, Inc. The purpose of the workshop was to provide EPA with a thorough examination of the meteorological instrumentation and data collection requirements needed to characterize airborne dispersion of air contaminants from point sources, and to recommend, based on an expert consensus, specific measurement techniques and accuracies. Secondary purposes of the Workshop were to (1) make recommendations to the National Weather Service (NWS) about collecting and archiving meteorological data that would best support air quality dispersion modeling objectives and (2) make recommendations on standardization of meteorological data reporting and quality assurance programs.

2.3.8 Averaging-time model

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. As mentioned in previous annual reports, 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 in such a single system. Simplified descriptions of these two models and their uses were incorporated into a World Health Organization book on analyzing and interpreting air monitoring data (Larsen, 1980). The book was written at a level that is hopefully understandable and usable in all nations.

Some new techniques, including computer-generated concentration frequency distribution plots, were developed to calculate air pollutant concentration reductions needed to meet National Ambient Air Quality Standards (NAAQS). The techniques were applied first to the new ozone standard (Larsen, et al, 1980). The maximum concentration reduction needed for each county (with ozone measurements) was indicated by shading on a computer-generated U.S. map. At the request of EPA's Office of Air Quality Planning and Standards (OAQPS), the techniques have also been applied to selected air sampling sites for potential carbon monoxide and nitrogen dioxide standards.

2.3.9 Plant injury model

Techniques are needed for relating air pollutant concentrations to air pollutant effects so that air quality standards can be set at the levels necessary to prevent unwanted effects. As noted in previous annual reports, 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. The model has not been applied to most of the ozone plant injury experimental acute exposure data in the world to determine the model parameters for each available plant species and for groupings of species (species that are grouped together as either sensitive, intermediate, or resistant to injury), and the detailed results have been presented (Heck, et al., 1980). Expected annual maximum 8-hr-average ozone concentrations have been indicated by shading by county on a computer-generated U.S. map so that expected maximum acute plant injury for a species or a grouping of species can be estimated for a particular locale. The Larsen-Heck model results have also been compared with an earlier leaf injury model (Heck-Tingey) for six plant species. The L-H model explained an average of all but 14% of the variance in the leaf injury parameter whereas the H-T model left 3.5 times as much variance, 49%, unexplained. Therefore, the new L-H model fits the plant injury data much better than does the old H-T model.

2.3.10 Health effects support studies

Special daily meteorological summaries were produced for a 7-month study of acute respiratory disease in the Los Angeles Basin for inclusion in statistical analysis of respiratory symptoms and air quality. Hourly meteorological data from Los Angeles International Airport and Long Beach Airport were utilized to represent conditions within nearby study populations, while another population group in Upland, San Bernadino County required utilization of meteorological data observed by FAA at Ontario Airport, requiring special computer processing.

Detailed climatological studies of wind patterns for 14 localities in the United States were produced for a program of site selection for prospective epidemiological studies. Monthly wind roses were produced from available data, sources of pollutants were identified and located, and available air quality data analyzed to estimate population exposure at each perspective site.

Computer software was developed to access a file of daily mortality in the United States, 1973 to 1977. Daily mortality for Pittsburgh and Allegheny County, PA was acquired for the month of August, 1973 to 1977 to investigate daily trends during periods when air stagnation advisories were issued. Six consecutive days of increased mortality were evident in August 1973 and three in August 1976 concurrent with air stagnation advisories. The days in 1976 had reported concentrations of high levels of sulfate particulates, but air temperatures were moderate, discounting a heat wave effect as a source of the increased deaths. A moderate heat wave was concurrent with the stagnation period in August 1973.

2.4 Air Policy Support Branch

The function of the Air Policy Support Branch (APSB) is to support activities of the Office of Air Quality Planning and Standards, EPA.

General areas of responsibility include: (1) providing support to the development of air pollution control strategies through the application of mathematical-meteorological diffusion models, (2) technical support and assistance in simulation model techniques to other EPA elements, (3) preparing guidelines concerning various air pollution control and monitoring systems and (4) organizing and directing aerometric field studies for improving the technical basis of the air quality management approach to air pollution control.

NOAA meteorologists are typically involved in interdisciplinary team efforts which include engineers, chemists, statisticians, computer specialists and other technical staff of the Monitoring and Data Analysis Division. 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. It should also be noted that this report presents the highlights and a short summary of major activities involving NOAA meteorologists during the period from October 1, 1979 through September 30, 1980.

2.4.1 Northeast Corridor Regional Modeling Project (NECRMP)

The purpose of NECRMP is to utilize photochemical modeling to support the development of ozone control strategies for the Northeast Corridor that are effective, equitable and creditable. A photochemical model, previously developed under contract to the Meteorology Laboratory, will be applied to five major cities in the Northeast in order to determine precursor emission reductions necessary to attain the National Ambient Air Quality Standard for ozone downwind of these cities. These urban model applications are to be synchronized with applications of a regional photochemical model currently being refined by the Meteorology Laboratory, which will address the intercity transport problems and the effects of nonurban emissions.

One meteorologist serves as Technical Coordinator on the NECRMP Task Force. In this capacity he: (1) Coordinated the collection of emission inventory and environmental data necessary to operate the models. This involved working with other members of the Task Force, State air pollution control agencies and metropolitan planning organizations to help them plan for their specific data base collection tasks. (2) Planned and developed schedules and budgets for NECRMP. This involved coordinating the activities planned for NECRMP with activities necessary to complete the 1982 State Implementation Plans (SIPs) to ensure that the two projects were complementary to the maximum extent possible and to ensure that enough resources were available to perform the necessary SIP tasks. The budget activities involved careful tracking and adjustments of ongoing tasks to ensure that project funds were expended in an optimum fashion as well as planning for future year budget requirements. (3) Served as project officer on a contract to develop a modeling protocol for NECRMP. The modeling protocol will be a detailed plan which describes how modeling will be used as the basis for selecting and evaluating control strategies.

Another 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. During FY 80, he was responsible for planning and overseeing the upper-air meteorological measurement and aircraft sampling programs in four NECRMP cities (Washington, Baltimore, New York, and Boston). The first program consisted of radiosonde and rawin soundings and the operation of monostatis acoustic radars to obtain temperature, wind and thermal gradient measurements within the layer from ground level to 10,000 ft. MSL. The measurement period began July 18, 1980, and continued through September 12, 1980.

During the sampling program, pollutant and meteorological measurements were made aloft via instrumented aircraft upwind, over and downwind of each urban area on days forecasted to have meteorological conditions conducive to the formation of high ozone concentrations. The APSB meteorologist coordinated with contractors in the field on the selection of flight days and specific flight tracks for operations in Washington, New York and Boston. He coordinated the city-specific meteorological forecasts for these cities and the measurement flights for Baltimore with meteorologists working on the NEROS program. During the five-week study (July 14 through August 15, 1980), monitoring flights were conducted on fourteen days in Washington, D.C.; twenty-two in Baltimore; nineteen in New York; and fifteen in Boston.

This meteorologist was responsible for overseeing the operation of 24 ground level air quality and meteorological monitoring sites in the New York area. This work involved working with State air pollution control agencies in New York, New Jersey and Connecticut and EPA Regions I and II to resolve any impediments to monitoring prior to the start of the field program. He was also responsible for tracking the operational status of these sites in order to resolve any problems and thus ensure a high percent of valid data recovery during the monitoring period (June 1 through September 12, 1980).

2.4.2 Support for proposed visibility regulations

Section 169A of the Clean Air Act requires EPA to promulgate regulations to assure reasonable progress toward the Congressionally declared goal of "the prevention of any future and the remedying of any existing impairment results from manmade air pollution." The proposed regulation does not require the use of modeling techniques; however, two documents released for public comment are intended to aid the States and permitting officials in their decision-making on issues regarding visibility impacts. Original work sponsored by EPA in 1978 has resulted in modified and improved visibility modeling techniques. Screening techniques are at the point where they should now be employed in visibility impairment assessments. These techniques are incorporated in the "Workbook for Estimating Visibility Impairment", released in draft form for public comment in July 1980 (Latimer and Ireson, 1980).

EPA is not alone in the development of plume visibility models, their testing and evaluation. The Agency also released the "User's Manual for the Plume Visibility Model (PLUVUE)" in draft form in July 1980 for public comment (Johnson, et.al., 1980). PLUVUE is considered to be a research model with a number of scientific issues yet to be resolved. The model is designed for use in evaluating visibility impairment from a single plume or small group of sources. Frequent consultation between users and EPA is encouraged to avoid misapplications or unjustified interpretations of results. Testing and evaluation is underway, primarily utilizing data from EPA's VISTTA program.

2.4.3 Air quality impact analyses to support regulations for criteria and hazardous pollutants

Dispersion analyses in support of regulatory actions for criteria and hazardous pollutants from various industrial sources have been performed. These studies used screening and/or detailed dispersion models for specific or prototype plant and stack configurations and receptor locations to estimate annual or short-term pollutant concentrations. Emission impact from the following industries have been estimated this fiscal year: mineral wool, industrial boilers, brick and clay kilns, urea plants, coke ovens, ammonium nitrate plants, asphalt roofing materials, crushed stone operations, sodium carbonate plants and aspects of synfuel industry emissions. Dispersion model estimates were also provided as input to exposure models for selected chemicals including vinylidene chloride, benzene, acrylonitrile and certain emissions from oil refineries. The many applications of dispersion models to industrial source led to the paper by Schewe (1980a) describing a methodology which can be used to proceed through such impact analyses.

Under Section 112 of the Clean Air Act, ORD is required to review regulatory sections involving carcinogens. This includes chemical exposure documents prepared by EPA or its contractors. These reports contain dispersion model estimates prepared by NOAA staff or reviewed by them if done by contractors. In December 1979, EPA held a "Workshop on Exposure of Hazardous Chemicals" to critique the overall methodologies for the three levels of sophistication from screening to very detailed analyses of emissions, atmospheric dispersion, and population exposure. A meteorologist presented a detailed explanation of the modeling procedures used in the three levels of analysis to the assembled consultants. In general, the atmospheric modeling committee reacted favorable to procedures in use but was concerned that error bounds or accuracy of model estimates be adquately understood by the users of the assessment reports. This concern for knowledge of error bounds and accuracy in terms of emissions estimates and population estimates was expressed by each respective committee.

EPA is preparing a document, "Guidance for the Preparation of Exposure Assessments" for which NOAA staff is providing comments. This document is quite broad in scope but does contain a separate section addressing the evaluation of uncertainty mentioned above.

2.4.4 Regional workshop on air quality modeling

In February 1980, the third in a series of regional workshops that began in 1978 was held to bring together Regional Meteorologists, modeling contact persons and engineers responsible for air quality impact reviews with selected ML, DSSE, OGC and OAQPS staffs to continue dialog toward consensus and consistency on modeling issues. This workshop focused on technical questions raised by the Regional Air Branch Chiefs and included sessions on use of modeling/monitoring data, modeling for complex terrain, use of non-guideline models, recommendations on model options, required detail of analysis and additional issues. Reports by the work groups were circulated for reviews and comment by all participants. Several meteorologists participated in and led work sessions as well as assisted in preparing the draft final report (Environmental Protection Agency, 1980a), circulated in July. This report served as an important resource in shaping the proposed revisions to the "Guideline on Air Quality Models", and will be issued in final form shortly.

2.4.5 Proposed revisions to the Guideline on Air Quality Models

NOAA meteorologists have several responsibilities in the updating process for the Guideline on Air Quality Models, which is an important part of EPA's prevention of significant deterioration (PSD) regulations. The public was notified in the Federal Register of March 27, 1980, of EPA's intentions to revise the Guideline and model developers were asked to submit well-documented models that can be considered refined analytical techniques for potential inclusion in the planned revisions. Three public meetings are scheduled for October 1980 and plans to hold the next Conference on Air Quality Modeling in early 1981 were announced. By September 1, 1980, 17 models had been submitted for review and a summary report on Agency proposed actions has been prepared for distribution at the public meetings (Environmental Protection Agency, 1980c). On September 19, 1980, the first draft of the proposed revisions to the Guideline were made available for public review and comment (Environmental Protection Agency, 1980b).

2.4.6 Evaluation and application of model validation techniques

Under a contract jointly funded by the Meteorology Laboratory and the Office of Air Quality Planning and Standards, Teknekron, Inc. staff are evaluating two versions of the EPA Single Source (CRSTER) Model by use of hourly meteorological, air quality, and emissions data collected at four power plants and their monitoring networks. The two versions of the model differ in that one contains the Pasquill-Gifford (P-G) dispersion parameters while the other contains Irwin's proposed dispersion parameters. The monitoring networks are operated by American Electric Power around the Clifty Creek, Tanners Creek, and Muskingum River plants as well as round the Gavin-Kyger-Sporn complex of power plants. The evaluation of the models focused on the 25 highest annual, 24-hour and 3-hour measured and estimated concentrations. In addition, there was also a case-by-case comparison of measured and estimated concentrations for the highest and highest, second-highest measured episodes at all four networks. A number of performance measures were applied including systematic bias, gross error, peak prediction, accuracy scores, and associated confidence limits. Various measures of model skill were also calculated. A draft final contract report is undergoing internal review. In reference to the episode analysis, Mills and Lee (1980) presented findings of the study regarding the critical meteorological conditions for elevated 24-hour and 3-hour SO_2 concentrations around the Clifty Creek plant at the Second Joint Conference on Applications of Air Pollution Meteorology. The distribution of measured 3-hour episodes by peak hour stability class was found to be equally divided between

C and D stability. CRSTER (P-G) calculated 3-hour episodes were equally divided between B and C classes while CRSTER (Irwin) showed a distribution between C and E classes. The distribution of episodes by both CRSTER model versions using peak hour stability class did not appear substantially different.

2.4.7 Model evaluation study based on the ARMCO, Inc. steel plant

A meteorologist is managing a project to evaluate the performance of the Industrial Source Complex (ISC) Model using air quality meteorology and emissions data from the ARMCO, Inc. steel plant in Middletown, Ohio. Data have been gathered over a seven-month period (March-September 1980) from a network of 25 particulate matter samplers operated on a third-day cycle at 13 sites and three samplers on a sixth-day cycle at three sites. An on-site ground level station and a 100m tower provided meteorological data. The company's environmental engineering staff is providing emissions data and other information necessary to characterize plant sources for input to the ISC Model. The ISC Model will be tested in a situation where considerations of fugitive emissions, building wakes, and other complicating factors are crucial to a comprehensive air quality impact assessment. The company began a comprehensive fugitive dust control program midway through the sampling period and an assessment of this program's impact on particulate matter concentrations will be made. The contractor for this evaluation is the H. E. Cramer Co. and a final report is expected in April 1981.

2.4.8 Technical assistance to the EPA Regional Offices

A primary responsibility of NOAA staff is to provide technical assistance and support on air quality simulation modeling applications and dispersion techniques to other EPA elements, especially the Regional Offices. Example requests this year include comments on: power plant modeling analyses for Regions II, III, V, VI, VIII, and IX; models submitted in permit applications to Regions II, IV, IX, and X; the purported effect of long-range SO_2/SO_4 transport on acid rain in Regions I and II; tracer study results and appropriateness of State modeling guidelines for Region VIII.

With this activity in mind, considerable planning has gone into establishing a Clearinghouse for Model Applications. One aspect will be to provide a formal mechanism whereby nonguideline models proposed for use in permit applications or regulatory action can be reviewed at the request of Regional Office by headquarters staff for national consistency and technical soundness before a final decision is made. The Clearinghouse staff would try to review the model and its application and develop a position within a month of receipt of the material. The Regional Office would have to develop its own position and present its analysis with the request. A meteorologist will be the focal point in the Clearinghouse for model reivews. The Clearinghouse will be created in October 1980.

2.4.9 EPA's monitoring and modeling strategy

In order to optimize the application of monitoring and modeling data in air quality management, a joint strategy is required. An ambient air monitoring strategy currently exists but a meteorologist has been working with EPA staff to develop plans for a modeling strategy so that guidance is available on the appropriate mix of monitoring/modeling techniques necessary to provide sufficient information to decision-makers. The current approach to meeting information needs is being surveyed and the adequacy and reliability of these information sources with regard to trade-offs will be studied. The capabilities of both monitors and models needs to be described to indicate their limitations in terms of estimating rare events, e.g., once in 365 days. Other issues of concern in this continuing project include: adequacy of the information base for planning and policy, consistency of program application, analysis/interpretation of data and coordination and management of monitoring and modeling.

2.4.10 Setting emission limits for two power plants in Ohio

NOAA meteorologists were asked to determine emission limits required to attain and maintain the National Ambient Air Quality Standards for SO_2 around the Avon Lake and Eastlake Power Plants of the Cleveland Electric Illuminating (CEI) Company in Ohio. The procedures specified in the "Guideline on Air Quality Models" were followed as closely as possible in determining the emission limits. Analyses using the Single Source (CRSTER) Model were conducted for both plants, with two sets of stack configurations, three operating load conditions, and five years of meteorological data. Annual, 24-hour and 3-hour concentrations were calculated and in all cases the 3-hour highest, second-highest concentration was controlling. Shoreline fumigation is a potential problem for these locations; however, in all cases, fumigation concentration estimates for periods meeting specific criteria were lower than the highest, second-highest CRSTER estimates. The emission limits for the two plants were published in the Federal Register and the report of the modeling results (Environmental Protection Agency, 1980d) has been requested by several interested groups.

2.4.11 Hot Spot Guidelines and Indirect Source Guidelines for CO impact assessment

Interest in the Hot Spot and Indirect Source Guidelines remains high and revisions were made to incorporate new vehicle emission factors. Schewe (1980b) presented an update of the Hot Spot Guideline at the 59th Annual Transportation Research Board Meeting in January 1980 and he conducted a half-day session on each guideline at a joint EPA/State Workshop in Minneapolis, Minnesota in October 1979. However, the requirement for significant meteorological involvement has decreased to the point where NOAA resources are no longer justified. Thus, responsibility for this activity has been shifted to EPA staff.

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5. METEOROLOGY LABORATORY STAFF FISCAL YEAR 1980

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Valentine Descamps, Meteorologist (Boston)
Alan Cimorelli, Meteorologist (Philadelphia)
Lewis Nagler, Meteorologist (Atlanta)
Frank Hall, Meteorologist (Dallas)
Richard Fisher, Meteorologist (Denver)

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