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NOAA Technical Memorandum ERL ARL-88

FISCAL YEAR 1979 SUMMARY REPORT OF NOAA METEOROLOGY LABORATORY SUPPORT TO THE ENVIRONMENTAL PROTECTION AGENCY

Herbert J. Viebrock, Editor

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Richard A. Frank, Administrator

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PREFACE

The work reported herein was funded by the Environmental Protection Agency (EPA) under agreement EPA-79-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, N.C. 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 first generation ozone forecasting technique was developed.

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1. INTRODUCTION

During Fiscal Year 1979, 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 2.2 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. Major field studies were conducted on the long-range transport and transformation of fossil fuel power plant emissions (STATE) and 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. An ozone forecasting technique was developed. The research work is discussed in sections 2.1 and 2.3.

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 1979 is briefly described below.

2.1.1 Regional scale oxidant model

Long range research and development plans in air quality simulation modeling have shifted over the past two years from the urban scale (city specific) models to the regional scale (multistate) models. Recognizing the significance of the transport of ozone and its precursors over long distances in the environment, we initiated a program in FY-77 to develop a regional-scale photochemical air quality simulation model in addition to the ongoing program on urban scale photochemical processes. The regional model is a required tool in assessing the overall environmental strategies for oxidant control. The regional model provides inflow boundary conditions of ozone and its precursors from major upwind emission centers (usually other urban areas) to the urban scale model used in assessing air quality control plans within the urban area. It also allows decision makers to evaluate the impact of oxidant control plans of individual cities from a regional perspective as well as providing the opportunity to assess a regional approach to oxidant control planning.

The regional-scale photochemical model is designed to simulate short-term (1-3 hour averaged) mean concentration of NO, NO_2, O_3, CO, SO_2, SO_4, PAN, and four groups of hydrocarbons over regions roughly 1000 km on a side. In order to take into account earth curvature effects and to interface easily with meteorological observations as well as various other data sets available in one or more of the commonly used map projections, the model uses curvilinear (latitude-longitude) coordinates. The horizontal resolution is 1/4° longitude by 1/6° latitude, approximately 18 x 18 km.

The model consists of four layers. The layer depths are variable in both space and time allowing the model to consider the effects of each of the following physical processes:

(1) dry and wet surface deposition;
(2) buoyant plume rise;
(3) low-level stratification of surface emission at night;
(4) wind shears and turbulence "episodes" associated with the nocturnal jet;
(5) cumulus cloud venting of pollutants, perturbations on photochemical rates, effects on mixed layer depth, and eventually liquid phase chemistry;
(6) mesoscale and large-scale vertical motion induced by terrain and horizontal divergence of the wind;
(7) terrain effects on wind;
(8) mesoscale eddy effects on plume trajectories and horizontal expansion rates;
(9) subgrid scale chemistry effects resulting from point and line source emissions into 18 x 18 km grid cells;
(10) natural sources of hydrocarbons, NO_x, and ozone;
(11) horizontal transport and turbulence diffusion; and
(12) spatial and temporal variations of the synoptic scale inversion base and similar changes in the marine layer depth over large water bodies.

The theoretical formulation and computer coding of the mathematic model was completed in FY-79. This mathematical framework constitutes the backbone of EPA's regional long-range transport modeling research. The model has been cast in a generalized form with modular components describing the various physical and chemical processes occurring on the regional scale. Such a framework allows for refinements, deletions, and additions of phenomenological processes with no retooling of the basic model.

Field programs under the Northeast Regional Oxidant Study (NEROS) have been designed specifically to develop and evaluate the model's treatment of critical phenomenological processes and to evaluate and verify the regional model and its subcomponents, with the objective of using the model to assess the impact of oxidant control plans on regionally transported ozone from one urban center to others.

2.1.2 Mixed layer growth

Mixed layer growth rates over St. Louis after sunrise have been analyzed using data collected by a specially instrumented helicopter during the Regional Air Pollution Study. The growth rate was found to be retarded over the urban center relative to the upwind and downwind fetches. This spatially variable growth rate is explained in large part by advection. The following equations summarize the growth rate statistics from 50 experimental missions:

$$dh/dt = \begin{array}{rl} 27 + 52t & \text{rural} \\ 4 + 40t & \text{upwind suburban} \\ -23 + 56t & \text{urban center} \\ 13 + 40t & \text{6 km downwind} \\ 75 + 22t & > \text{10 km downwind} \end{array}$$

where h is meters and t is hours from sunrise.

Variation in energy budgets engendered by land use patterns can contribute to the urban heat island phenomenon. A comparison of the surface energy budgets for concrete, blacktop, and vegetated soil demonstrated a strong diurnal variation of energy stored in the material (G) which relates to the net radiation (Fn), although the relations differ markedly among the materials. Empirical relationships for G/Fn have been developed from these observations. Surface temperature shows significantly larger amplitudes for the soil in contact with concrete. This is explained by the difference in the conductivity and heat capacity between the surfaces.

2.1.3 Urban turbulence studies

Measurements of the mean and turbulent components of the wind and temperature were obtained in the summer and fall of 1976 on 30-m towers at three urban sites and one rural site in St. Louis, Missouri. This was a special study as part of the Regional Air Pollution Study (RAPS). These data have been extensively analyzed in order to build a framework within which urban turbulence statistics can be parameterized for application in models of airflow and dispersion.

Surface roughness lengths, dimensionless turbulence characteristics, and spectra were derived from these data. Average surface roughness lengths for the three urban sites ranged from 0.7 to 1.7 m and varied by similar magnitude at specific sites as a function of wind direction. Urban roughness lengths estimated from land use features were in agreement with those calculated from the wind statistics. Dimensionless turbulence characteristics and spectra for neutral stratification were in good agreement with Monin-Obukhov similarity theory, which has previously been verified only for homogeneous terrain of small roughness. For stable and unstable conditions, the turbulence structure cannot be adequately described by the similarity relationships. The parameterizations, however, do exhibit considerable order, and it may be that an empirical modification of similarity relationships would be practicable for urban applications.

2.1.4 Urban effects on wind

The extensive data set collected by the 25 stations of the Regional Air Monitoring System (RAMS) in St. Louis has allowed a detailed analysis of some basic urban effects on the mesoscale wind fields.

The urban heat island, a temperature anomaly resulting from fuel combustion and the contrasting radiation budgets of the urban and rural surfaces, has been described by numerous investigators (e.g.,Chandler, 1965). Measurement of temperatures from a surface network is a relatively simple task, and it is not unusual to find that the central urban area is several degrees warmer than the surrounding countryside. Under calm or light wind conditions, it is easily theorized that the urban heat island will generate a centripetal circulation as cool, rural air moves inward and rises over the city in response to thermally-induced pressure gradients. Such flows have been simulated by numerical models.

The existence of the urban heat island and the large urban surface roughness may influence the relation between mean winds recorded simultaneously in the city and the adjacent countryside. It is expected that increased surface roughness will cause a deceleration of flow entering the city. However, in examining winds from a rural and a central urban station in London, Chandler (1965) concluded that there is a critical mesoscale speed of 3-5 m/s below which speeds are relatively higher in the city. Moreover, Chandler found the acceleration to be more intense and frequent at times of strong heat islands. A complementary study by Lee (1977) attempted to establish directional changes associated with accelerated and decelerated flows in London.

The RAMS data used in this study are hourly averaged values of wind speed and direction, temperature, and vertical temperature gradient recorded during all of 1976. The data were separated into wind speed classes of very low speed (VLS, <1.5 m/s), low speed (LS, 1.5-3.5 m/s), and high speed (HS, 3.5-10 m/s). The classes were further classified as low heat island intensity (LHI) and high heat island intensity (HHI). For the VLS and LS winds, the separation by heat island causes a distinct partition by time of day; HHI is essentially a nighttime situation while LHI is a daytime situation.

The analysis focuses on the LS and HS winds since these can be associated with a definite mesoscale flow. Winds from four separate wind direction sectors were considered. A representative rural wind was formed from the data of four stations while an urban wind was formed from the data of five stations in the central city. The winds were compared for many samples with the following results.

1. For wind speeds greater than 3.5 m/s, urban speeds are lower than rural speeds regardless of heat island intensity.

2. For strong heat islands, urban speeds are lower than rural speeds regardless of wind speed.

3. For weak heat islands and winds 1.5-3.5 m/s, urban and rural speeds are about the same, indicating a balance of heat island and roughness effects.

4. For weak heat islands and calm winds (less than 1.5 m/s), urban winds exceed rural winds.

The last two conclusions suggest a critical speed of about 2.5 m/s. This is somewhat lower than values usually cited, but, given that St. Louis is smaller than cities previously used in such studies, it would be surprising in itself. The important point is that the maximum critical speed occurs for daytime, unstable conditions and not nighttime, strong-heat-island conditions.

For an examination of the centripetal wind hypothesis, VLS winds are considered. For such light winds there is no direction associated with the mesoscale flow. Two data classes of several hundred hours each were formed, comprising data collected when the network resultant speed was less than 1.5 m/s. One class is associated with weak heat islands, daytime hours, and convective instability, while the other class is associated with strong heat islands, nighttime hours, and extreme rural stability. Mean centripetal flows are clearly discernable from data of both classes, but the convergence is stronger for the flows associated with the weaker heat islands. This unexpected result is explained in terms of the ease with which sustained vertical motions can be generated over the city by the available forcing under different stability regimes. The detectability of the heat island influence diminishes very rapidly with increasing speed of the large-scale flow.

2.1.5 Formation and growth of the nocturnal inversion layer at an urban and rural location

Analyses of helicopter sounding data describing the development of the nocturnal inversion layer were used from 30 summer evening field studies from 1974-76 as part of the EPA's Regional Air Pollution Study (RAPS) in St. Louis, Mo. The strength and top of the radiation inversion were compared for an urban and rural site.

The data were used to test G.I. Taylor's inversion growth model and an empirical second-order polynomial fit. Taylor postulated the growth of the inversion top to be $D = 2(K_H t)^{0.5}$. This relationship appeared to describe accurately the mean growth of the rural inversion top (D) when a thermal eddy conductivity coefficient (K_H) of 0.84 $m^2\ s^{-1}$ was applied. A smaller K_H was found by Anfossi et al. (1974). However, smaller inversion depths were observed in their study. When Taylor's model was applied to individual cases, the relationship predicted initial inversion development but can overestimate the inversion top at sunrise. Conversely, when the model was applied to predicting the inversion top at sunrise, initial inversion layer growth was underestimated in some cases.

A second-order least-square polynomial empirical fit was applied to the data on inversion strength and top as well as inversion base data at the urban site. Results on the rural inversion top data indicated a correlation coefficient of 0.81 and a standard error of estimate of 64.5 m. By normalizing individual data with the inversion top at sunrise, the scatter was reduced and the correlation coefficient improved to 0.90. The remaining scatter is attributed to meteorological variability. Similar results were found for the other inversion parameters.

The rural surface-based inversion formed primarily around sunset. In contrast, an elevated inversion layer was observed to form about 2.5 h after sunset over the urban site in all cases. At sunrise the average inversion tops were 315 m and 325 m above ground at the urban and rural sites, respectively. The inversion strength was greater for the rural data in all cases; average values were 1.6°C and 4.0°C at the urban and rural sites, respectively. The urban inversion layer remained elevated overnight with an average inversion base at 160 m above ground near sunrise.

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

The Regional Air Monitoring System (RAMS) quality assurance and data screening efforts have been completed. First, this effort involved an automated system of screening checks, which included tests for 1) continuity--such as calibration drift, lower detectable limit, gross limits, and relationships among parameters and constant instrument output, and 2) operational status--calibration, out-of-service, missing measurement, and status and sense bits.

Second, in order to identify remaining errors (estimated to be less than 1 percent) that may be due to sensor failure, data acquisition hardware malfunctions, electrical transients, and software errors a graphical review of each RAMS parameter was undertaken. Hourly average data were plotted for the entire study period and manually reviewed by trained personnel. Minute plots were created for any suspect periods of data. Weather data, log books, and any other available data were searched for possible explanations. Finally, a list of unresolved problems and associated plots was forwarded to the contractor for further investigation. All problems at this point have been resolved or at least flagged.

The last stage of this process will be to complete a final archive of the RAMS data, which will incorporate all corrections and flags.

The Upper Air Sounding Network's (UASN) quality assurance and data screening efforts have also been completed. All pibal and radiosonde data collected during RAPS have been automatically checked for consistency within and between stations, completeness, and gross validity. All data have been plotted and manually reviewed. All known errors have been corrected, and a flagging scheme was introduced for downdraft and low angle situations. The final archiving is currently in progress.

In addition, the Regional Air Pollution Study (RAPS) point and area source emission inventory final archives have been completed. Methodologies and retrieval software have been reviewed and updated. Four new industrial plants were added to the point source data base, and annual emissions from four other plants were updated.

There have been several modifications to the area source methodologies and software:

1. The dry cleaning emission factor was modified from .52 lb/person to the national average of 2.37 lb/person.

2. Service station gasoline-handling emission factors have been improved and the volume of gasoline handled has been updated.

3. Highway line source emission factors were updated using the most current version of EPA's Mobile Emissions Model. Corrections for percent hot and cold starts were incorporated by using EPA's Mobile 1. Particulate and sulfur oxide emission factors were derived from AP-42, supplement 9. Average speed values for each road type and each temporal and spatial variation were estimated.

4. Highway area source vehicle-kilometers-traveled (VKT) were spatially reapportioned, emission factors were updated, and a regression equation based on population and land use was used to estimate VKT for grids not reporting VKT.

5. A new category of miscellaneous hydrocarbons has been added, contributing 12,613 tons/yr distributed by population and 41,736 tons/yr distributed by commercial land use.

6. Annual emissions in three other area source categories have been increased: area surface coating from 3,807 tons/yr to 8,991 tons/yr, printing from zero to 8,011 tons/yr, and degreasing from zero to 5,786 tons/yr.

Spatial and temporal apportionment schemes for many of the categories were revised. The final archives have been completed for the point and area source emissions as well as the area source heat emissions.

2.1.7 Soviet-American hill study

Two Soviet scientists spent a period of 5 months at the Fluid Modeling Facility under the auspices of the U.S.S.R.-U.S. Joint Committee on Cooperation in the Field of Environmental Protection. A wind tunnel study of flow and dispersion of pollutants over two-dimensional hills was conducted. Simultaneously, computer programs developed in the U.S.SR. were run to make comparisons with the results of the wind tunnel studies. More than 250 concentration profiles were measured downwind of model stacks of various heights placed at various positions with respect to hills of different slopes. More than 75 profiles were measured with hot-wire anemometry to obtain the mean and turbulent flow fields over the hills. This information was assembled into a data report; a draft scientific report, "Flow and Dispersion of Pollutants Over Two-Dimensional Hills," was prepared. Whereas measured concentration fields were reasonably well predicted by the theory for a hill of small slope, they were not for hills of steeper slope, because the flow separated from the lee sides of the steeper hills.

2.1.8 Guideline for fluid modeling

A draft for public comment of the report "Guideline for Fluid Modeling of Atmospheric Diffusion" was released in June 1979. Fluid modeling can play an important role in describing and predicting the transport and diffusion of pollutants when plumes are affected by obstructions such as hills and buildings. The guideline was prepared for scientists and engineers involved in designing and conducting fluid modeling studies and to air pollution control officials in evaluating the quality and credibility of reports resulting from such studies.

2.1.9 Clinch River - Complex terrain study

A wind tunnel study of dispersion of sulfur dioxide (SO_2) from the Clinch River Power Plant was completed, the data analyzed, and a final report written in FY-79. The Clinch River Power Plant is a 712-megawatt, coal-fired power plant in Carbo, Virginia, about 200 km west of Roanoke. The area surrounding the plant is quite rugged, with closely-spaced hills extending typically 180 m above the river. The plant has two 138-m stacks that are the only significant sources of SO_2 in the area. A 16-month field study performed by Geomet, Inc., under contract 68-02-2260 to EPA, provided a data base for comparison with the wind tunnel results. A 1:1920 scale model of the power plant and surrounding terrain was constructed and installed in the Fluid Modeling Facility Meteorological Wind Tunnel. Two 1-h periods that exhibited neutral atmospheric conditions and a wind direction aligned with the river valley were selected from the field data. Discharge of SO_2 was modeled using a hydrocarbon tracer. The buoyancy and momentum of the effluent were scaled to the field values. Wind velocities, ground level pollutant concentrations, and pollutant concentrations aloft were measured in the model, adjusted to full-scale values, and compared with the field data. The wind field data agreed quite well with the field data. Smoke visualizations of the plumes near the source also showed good agreement. Direct comparisons of the ground level concentrations at the sampling stations downwind of the plant were good for one period but showed some difference for the second period.

2.1.10 Vehicle wake study

In an effort to characterize the turbulence and dispersion behind moving automobiles, a wind tunnel study of vehicle wakes was begun. A wind tunnel with a moving floor was constructed to develop a shear-free boundary flow. Model vehicles (1/8 to 1/32 scale) were fixed in position over the test section floor while the floor moved at the free-stream air speed. This is equivalent to the vehicle moving through a calm atmosphere (or a situation where the vehicle speed is much greater than the ambient wind speed). Measurements of the mean and turbulent velocity components in the wake at downwind distances to 80 times the vehicle height were made with X-configured hot-film anemometers. In addition to scale models of American automobiles, a block-shaped model was also studied. A pure momentum wake was observed behind the block-shaped model, whereas a vortex wake imposed upon a momentum wake was observed for the scale model. The wakes for both model types grew very slowly with downwind distance and exhibited strong shear near the surface.

2.1.11 Widows Creek study

At the request of Dr. Steven Hanna, Atmospheric Turbulence and Diffusion Laboratory, Oak Ridge, Tenn., a wind tunnel study of the flow and dispersion over a 14° ramp was conducted. This ramp was an idealization of the terrain surrounding the Widow's Creek, Ala., Steam Plant of TVA. A preliminary conclusion is that the maximum concentrations on the slope are not substantially larger than would be found under similar circumstances (neutral flow, etc.) in flat terrain. The data will be turned over to Dr. Hanna for further analysis and comparison with field data.

2.1.12 Grid study

Decay of turbulence and dispersion of plumes downstream of a grid were studied in the stratified towing tank in conjunction with personnel under grant 805595 with North Carolina State University. It was evident that the decay of turbulent energy was only mildly affected by the stratification, but that plume growth was severely restricted, even under very weakly stable stratification. A report is in preparation.

2.1.13 Aspect-ratio hill study

The objective of this study was to gain understanding of the flow structure around two- and three-dimensional hills immersed in a simulated neutral atmospheric boundary layer. More specifically, it was desired to determine (1) how long (compared with its height) a hill must be to be considered two-dimensional rather than three-dimensional, (2) how closely a plume from an upwind source would approach the hill surface as a function of the hill's aspect ratio, and (3) the location and value of the maximum surface concentration. The basic three-dimensional hill shape was a cone. This cone was split longitudinally, and straight sections were inserted between the two halves to increase its aspect ratio. The "infinite" ridge, then, was triangular in shape and extended across the wind tunnel test section. Ethylene was released upstream of the hills as a tracer. Measurements were also made over flat terrain for comparison with those over the various hills. These data have been provided to an EPA contractor for the development of theoretical models and are independently being analyzed in preparation for a scientific report.

2.1.14 Standard design nuclear power plant study

A wind tunnel study was conducted of the dispersion downwind of two standard design nuclear power plants. Observations in the wake of the building complex showed that initial dispersion was greatly enhanced by the buildings and that, for practical purposes, the complex could be treated in theoretical models in much the same way as an individual building having external dimensions the same as the extremel dimensions of the complex. This work is reported as a Ph.D. thesis (Payne, 1979).

2.1.15 Low-hill study

Under a grant to North Carolina State University, a study of the flow and diffusion of pollutants from point and line sources over a two-dimensional hill of rather low slope was conducted. In contrast with previous studies of diffusion over a steep ridge, this low hill had little effect on the diffusion characteristics of the boundary layer except for a slightly enhances spreading of the plume on the downwind slope. This work is reported in an M.S. thesis (Courtney, 1979).

2.1.16 Hot-wire and hot-film data corrections in low-velocity turbulent flows

A study was conducted to determine the yaw response characteristics of hot-film and hot-wire sensors in low speed flows. The study was carried out by mechanically oscillating the sensors in a steady mean flow to simulate turbulent fluctuations with accurately known characteristics. The difference between the measured and expected fluctuating velocities and Reynolds stresses at various mean flow speeds was then used to evaluate correction factors for these quantities in terms of the sensor yaw response.

2.2 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 1979 is briefly described below.

2.2.1 Dispersion from elevated releases

Research is currently underway to characterize dispersion from tall stacks.

Irwin (1979a, 1979c) found that the vertical and lateral dispersion due to atmospheric turbulence, σ_z and σ_y respectively, could be estimated by employing a technique described by Draxler (1976):

$$\sigma_{z,y} = \sigma_{w,v}\ t\ F_{z,y}\ (t/T_i), \tag{1}$$

where $\sigma_{w,v}$ = the total standard deviation of the vertical and lateral wind component fluctuations at the final effective release height, where σ_v is computed over the time period to be associated with the concentration estimate,

t = the downstream travel time,

$F_{z,y}$ = the universal functions describing the rate of growth of σ_z and σ_y,

and T_i = an empirical parameter that is a function of stability and final effective release height. Draxler (1976) has shown ways to relate T_i to the Lagrangian time scale.

Field data, laboratory modeling data, and numerical modeling data were used to determine empirically the functions F_z and F_y. A study of the variation of F_z as a function of $t^* = tw_*/h$ where w_* is the convective velocity scale and h is the depth of the convectively mixed layer, seems to suggest that the universal functions can be characterized as

$$F_z = 1\ /\ [1 + 2t/T_i]^{\frac{1}{2}}, \tag{2}$$

$$F_y = 1\ /\ [1 + (t/T_i)^{\frac{1}{2}}]. \tag{3}$$

The expression given for F_z can be used even during unstable conditions so long as the Gaussian plume model incorporates the multiple reflections at the surface and at h. As $h/L \rightarrow 0$, neutral conditions, T_i for the vertical dispersion becomes $h/\gamma u_*$, where $\hat{h}$ is the convectively mixed layer depth, h, if the Monin-Obukhov scaling length, L, is less than zero and $\hat{h}$ is the planetary layer depth, h', if L >0:

$$\gamma = \begin{cases} 15 & H_e/\hat{h} \geq, 1/10 \\ (15/2)(11-90\ H_e h) & 1/10 > H_e/\hat{h} > 1/30 \\ 60 & H_e/\hat{h} \leq 1/30. \end{cases} \tag{4}$$

where H_e is the final effective release height.

As $-h/L \rightarrow \infty$, convectively unstable conditions, T_i for the vertical dispersion becomes $h/\gamma w_*$. The variation of the scaling time T_i for the lateral dispersion is not as extreme as the variation of T_i for the vertical dispersion. As $-h/L \rightarrow 0$, T_i for the lateral dispersion becomes $h/\beta u_*$, with

$$\beta = \begin{cases} 5/2 & H_e/\hat{h} \geq 1/10 \\ (5/4)(9-70\, H_e/\hat{h}) & 1/10 > H_e/\hat{h} > 1/30 \\ 25/3 & H_e/\hat{h} \leq 1/30. \end{cases} \qquad (5)$$

As $-h/L \to \infty$, T_i for the lateral dispersion tends towards $\hat{h}/\beta w_*$. The variation of the lateral dispersion T_i, as a function of $H_e/\hat{h}$ given in equation (5), is an extension of the analysis performed by Irwin (1979d) which resulted in the characterization given in equation (4) for γ. The characterizations of F_z and F_y are still preliminary. Results thus far suggest that the characterizations of T_i are consistent with those found by Draxler (1976). The resulting estimates of σ_z and σ_y are consistent with numerical and laboratory results for dispersion from tall stacks during convectively unstable conditions. These preliminary results have yet to be cast in a manner to be useful for routine analyses of dispersion. At present, the difficulty with the scheme is that some of the required parameters such as L and u_* cannot be specified except with research quality instrumentation. Some virtues of the scheme are that it explicitly handles release height effects on dispersion, provisions can be made to handle explicitly the effects of buoyant plume rise on dispersion, and provisions can be made to handle the effects on dispersion of the turning of the horizontal wind direction with height. The scheme is applicable to flat terrain and incorporates recent theoretical results of dispersion by using u_* as the scaling velocity during neutral and stable conditions and w_* as the scaling velocity during convectively unstable conditions.

2.2.2 User's guide for RAM

In March 1978 when Version 3 of UNAMAP (a magnetic tape available from National Technical Information Service) became available, the source code for the programs of the RAM system became available. RAM is an efficient Gaussian-plume multiple-source air quality algorithm. The algorithm was designed primarily for use with point and area sources in urban areas and incorporates the urban dispersion parameters of Briggs. Because of demand for methods to consider multiple sources in rural situations, a version with the Pasquill-Gifford parameters representative of rural areas was also made available. The version was labeled RAMR (RAM rural).

The user's guide for RAM, in two volumes presenting the entire system, was completed and printed in November 1978.

2.2.3 Multiple Point Source Algorithm with Terrain Adjustment (MPTER)

Although, since the availability of UNAMAP (Version 3) in March 1978, there has been a model that will estimate impact from multiple sources in rural areas over flat terrain (RAMR), and a model that will estimate impact from a single plant for situations where terrain features are no higher than the elevation of the lowest stack top for the plant (CRSTER), there has not been a readily available model that will consider both multiple sources and adjustments for slight terrain differences. MPTER was assembled to fill this need.

The code was assembled and made provisionally available in January 1979. When the model was applied to regional problems several suggestions were made for improvement; these are being addressed.

2.2.4 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.

The General Motors and the Long Island Expressway (LIE) data were used by the New York State Department of Environmental Conservation to characterize dispersion near highways and to make recommendations for improvement to the HIWAY model. Results from the analysis of the turbulence data are given in Rao et al. (1979). Currently the recommendations for improvement to HIWAY have not been published. However, a summary of the recommended changes is given below.

The vertical dispersion parameter σ_z was determined from the SF_6 concentration from the GM and LIE experiments. The vertical dispersion parameters were computed by solving the Gaussian line source equation for σ_z for each downwind distance, and a plot of σ_z versus downwind distance for both data sets was prepared and compared with the Pasquill-Gifford (PG) curves. There are two interesting observations, both of which suggest that the turbulence near the roadway is dominated by that generated by the vehicles. Most of the computed σ_z's fall between PG stability curves A and C, indicating that the dispersion downwind of the roadway is characteristically unstable even though the atmosphere may be stable. Second, the dispersion downwind of the roadway appears to be only weakly related to the atmospheric stability, as indicated by a large scatter of σ_z between stability classes.

Another recommendation aimed at improving HIWAY estimates was to include an aerodynamic drag factor. This factor would allow the model to make reasonable estimates during low wind speed conditions and account for the initial dilution of the pollutant on the roadway. Analysis of the GM data revealed that the aerodynamic drag factor must be a function of the wind-road orientation angle. This is because the amount of acceleration in the lower layers is most significant under parallel wind-road orientation (see Rao et al., 1979). Hence, an aerodynamic drag factor that is a function of wind-road angle is developed and is incorporated into the HIWAY model. The relation developed is $AU^{0.164} \cos^2 \Theta$, where U is the ambient wind speed (m/s), Θ is the wind-road angle, and A is a constant related to the traffic speed conditions. Data for low traffic speeds are not available at this time. This relation takes its full effect for parallel wind ($\Theta = o$) situations and 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, this allows correction for only low wind speed situations (when ambient wind speeds are less than 2 m/s).

The last recommended change requires modification of the initial vertical dispersion parameter, σ_{z_0}. The σ_z's computed from the tracer data at the nearest roadside receptor were plotted as a function of the wind speed component normal to the roadway. The regression equation is $\sigma_{z_0} = 3.57 - 0.53\ u$, where u is the cross-road wind speed. σ_{z_0} is largest when the wind is parallel with the road and there is no cross-wind component, and it has its smallest effect with winds perpendicular to the roadway.

2.2.5 Commuter exposure

Over the last several years, roadway studies have indicated that commuters have the highest exposure to roadway-associated pollutants. Early attempts to model exposure considered estimates of the probability distribution of 1-h average exposure to automobile-generated sulfuric acid for morning peak period travelers in the Los Angeles area. Since that time there has been an increased interest in developing and improving techniques for estimating the overall frequency distribution of human exposure to air pollution. The difficulty in modeling exposure in a deterministic fashion can be appreciated when one realizes that the problem involves a mobile receptor (the commuter) moving through a field of emissions that vary in time and space. In 1977, EPA asked SRI International, Inc., to investigate factors relating to commuter exposure of roadway pollutants. As a result of that study, a methodology has been designed to compute commuter exposure statistics through simulation of the traffic, vehicular emissions, and atmospheric dispersion of roadway-related air pollutants. The modeling design of a roadway commuter exposure model, currently under development, is highlighted.

The model has been designed to consist of two parts: am emissions preprocessor and the main model. Separation of the emission modeling from the main commuter exposure model will allow modification of the emission treatments of the commuter exposure model package, as emission updates are issued, without change to the main model. The emissions preprocessor will use the Federal Test Procedure (FTP) emissions methodology to compute emission factors for freeways, expressways, and arterials outside the central business district (CBD). A model emissions program will be used to compute emission factors within the CBD.

The main program of the commuter exposure model computes traffic flow, emissions, dispersion, and commuter exposure statistics. Freeways, arterials and CBD streets are the three types of traffic considered. Hourly volumes and speeds are computed for each traffic segment. Subroutines calculate queue lengths, delay times, and driving times in the different modes on each segment. Depending upon the nature of the traffic on each segment, emissions are computed using the appropriate emission factor from the emissions preprocessor. There are three types of dispersion algorithms used in the commuter exposure model. Concentrations from freeways and arterials will be computed using a line source model. A special algorithm will be used for estimating concentrations within street canyons. Finally, background concentrations from the urban area will be computed using a simple box model. The concentration estimates from all the segments will be used to compute commuter exposure statistics. The user will have the option of printing out short-term statistics, which include exposures on each pathway, averages and standard deviations of exposure, percentage of commuters in each of several exposure classes, and probability of experiencing exposure levels in each of several exposure classes. The annual model computes statistics like those mentioned above but appropriate for annual averages.

2.2.6 Application of averaging-time model

An averaging-time model that expresses air pollutant concentration as a function of averaging time and frequency was developed and published in 1969. Its derivation and applications were detailed in 1971. At the request of the EPA Office of Air Quality Planning and Standards (OAQPS), the model was used this year to relate ambient data to proposed new standards for CO, O_3, and NO_2.

OAQPS issued a new standard for O_3 in February 1979. This new standard uses a new type of frequency parameter: the expected number of exceedances of the standard, averaged over three years, shall not exceed once per year. Old computer programs were revised and new programs were written to analyze ambient air quality data to determine the concentration reduction needed at a site to achieve the new O_3 standard. These calculations were made for every ozone site in the National Aerometric Data Bank, and the results and a description of the analyses were prepared by Larsen et al. (1979b).

2.2.7 Application of effects models

A plant injury model that calculates the expected percent age of leaf injury for plants exposed to a given pollutant concentration for a given exposure duration was developed. Computer programs were extensively revised. All available ozone plant injury data were passed through them to calculate the expected percent age of leaf injury of each available plant species as a function of various proposed O_3 standards. The resulting output tables served as background information in the setting of the new O_3 standard.

An animal injury model that expresses percent age of mortality in mice as a function of NO_2 concentration and exposure duration (from 6 min to 1 yr) was developed by Larsen et al. (1979a). The model was used to calculate expected mice mortalities from both ambient concentrations and proposed new NO_2 standards.

2.2.8 Consistency in dispersion modeling

The meteorological laboratory has been jointly reviewing with the Office of Air Quality Planning and Standards the various submodels currently used in Gaussian-plume air quality models. Submodels performing the same basic function, such as characterization of plume rise and characterization of the variation of horizontal wind speed with height, but yet yielding different results have been identified. Some of the variances in the output from the submodels is technically justifiable. For example, it is quite appropriate to characterize the increase in the wind speed with height differently over rural areas than over urban areas. However, some of the variance is not necessary and leads to confusion as to which technical approach is considered the most appropriate for use within the submodel. Hence, efforts are underway to eliminate, where it is technically justifiable, conflicts within the various submodels used in the air quality models.

2.2.9 Guidance on the use of urban versus rural air quality modeling

The dispersion over cities is enhanced compared with that over open country because of urban heating and increases in surface roughness. Thus, in cities, both the mechanical and thermal turbulence are increased, which in turn enhances dispersion. Using the preliminary findings from the Metropolitan Meteorological Experiment (METROMEX) conducted in the St. Louis area from 1971 to 1976, a rule was developed to delineate when to use urban versus rural air quality modeling techniques. The rule delineates the horizontal extent within which dispersion from sources may best be characterized using urban modeling techniques, using information concerning average upward heat flux per unit area and surface roughness length, or land use, or population density.

2.3 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 air quality; and conducts research in air pollution climatology. The Branch Program for Fiscal Year 1979 is briefly described below.

2.3.1 Effects of valley/mountain and sea/land breezes on transport and diffusion

A grant-funded study by the University of Virginia, which is due for completion at the end of FY-80, is concerned with the effects on dispersion of topographically induced air flow. The approach utilizes a numerical model that was originally developed by Pielke (1974) to simulate sea-breezes along the Florida coast. The model has been modified and run for idealized shoreline and valley situations, reproducing the diurnally varying three-dimensional wind fields rather nicely (McNider and Pielke, 1979). The particle trajectories appear quite reasonable, showing enhanced vertical motion in convergence zones and indicating recirculation regimes; they also show complex variations in space and time.

The most recent work has focused on testing the model against experimental data, including incorporation of improved exchange coefficients for the boundary layer and a new scheme for simulating diurnal variations in boundary layer structure. An additional problem that is being attacked is that of the disparity between grid-spacing of the mesoscale mode (~ 5 km) and the scale required to derive dispersion parameters for point sources of pollution; an approach using a statistical particle dispersion scheme is being tried.

Practical applications of these modeling efforts are being stressed so that the model might prove suitable for routine applications in complex terrain situations.

2.3.2 Analyses of St. Louis Regional Air Pollution Study (RAPS) data

The extensive meteorological and air quality data collected during the RAPS were used in two significant studies. The first study (Karl, 1979) explored the applicability of Model Output Statistics (MOS), which are produced operationally by the National Meteorological Center, to forecast ozone concentrations in St. Louis. A least-squares, stepwise multiple-regression program was used to select those independent MOS parameters that best served as predictors in the 24- and 48-hour forecast equations. Thirty-five MOS parameters, including winds, temperature, vertical velocity, height, and moisture at various pressure-surfaces, were considered. Hourly concentrations of O_3 were available for 25 stations in the vicinity of metropolitan St. Louis. The periods that were studied were April through October, the "ozone season," of 1975 and 1976. The daily highest 1-h O_3 concentration at each group of stations, inner city, transitional, and outer, was determined, and data for every third day were set aside for verification. The meteorological variables that were found to be important in predicting maximum 1-h O_3 concentrations were low wind speed, high temperature, ridge aloft, absence of precipitation, high pressure at surface, sinking motion in the boundary layer, and an easterly component in winds above the surface. Forecast concentrations were tested against "seasonality" and persistence concentrations. The results indicate that 24- and 48-hour forecasts of maximum O_3 concentrations are significantly better than chance, persistence, and seasonality. Similar results were obtained when the same general technique was developed to forecast probabilities that daily maximum O_3 concentrations would not exceed the primary standard of 80 ppb (subsequently increased to 100 ppb). The forecasts appear sufficiently successful to warrant consideration of development of the equations for other large metropolitan areas where O_3 is a problem.

The second study (Karl, 1980) of the RAPS data was concerned with the spatial variability of O_3 and other pollutants in metropolitan St. Louis. On days when the region's highest 1-h O_3 concentration exceeded 100 ppb, the highest concentrations in the vicinity of intense precursor emission areas were less frequently within 80-100 percent of the maximum than at more distant stations. The analysis indicated that eight stations, all outside intense emission areas, could have been used in place of the 25 RAPS stations to detect, within 80 percent, the daily network maximum 1-h O_3 concentration. On the other hand, the mean of daily maximum 1-h concentrations of NO, NO_2, CO, and total hydrocarbons all occurred at monitoring sites located within intense emission areas. The scavenging of O_3 by NO was indicated by lower than normal 1-h average O_3 concentrations downwind of intense emission areas for hours before 1000 CDT. But after 1000 CDT, the O_3 concentrations in the urban plume downwind of the city averaged higher than normal.

2.3.3 Climatology

Climatological summaries (Holzworth and Fisher, 1979) of dispersion parameters were prepared, based on twice-daily rawinsonde observations at 76 National Weather Service stations including Alaska, Hawaii, and Puerto Rico. The summaries, which are based mainly on analysis of the lower 3 km of each sounding, are presented on national maps. Data are presented on the percentages of all inversions (surface-based and elevated inversions separately), inversion thicknesses, and the heights of elevated inversion bases. Also included are the percentages of high relative humidity in inversions and in adjacent layers, along with percentages for surface-based, elevated, and no-inversion soundings. Lapse rates (including superadiabatic) are also characterized within and below inversions and in specified layers for soundings with no inversion.

Some general conclusions are these: (1) inversions in the lower 3 km are practically always present in the soundings at most locations; (2) inversions are almost always thicker than 100 m and do exceed 1000 m; (3) inversions less than 500 m thick tend to be more intense (large $\Delta T/\Delta Z$) than thicker inversions; (4) wind speeds with surface-based inversions are typically slower at the surface than at 300 m and the most common surface speed class is 2.6-5.0 m/s.

2.3.4 Analysis of Clinch River, Virginia, Power Plant aerometric data

A contract with Geomet, Inc., concerned with dispersion from power plant stack plumes in complex terrain, begun October 31, 1975, was completed late in 1979. Phase II of the contract was satisfied by submission of (1) a report (Koch et al., 1979a) documenting a 16-month aerometric survey focused on the

Clinch River Power Plant, and (2) a magnetic tape of the edited data (Koch et al., 1979b). Phase III, the final phase, was satisfied by a report (Pickering et al., 1979) on analyses of the aerometric data.

The Clinch River Power Plant is located in the southern Appalachian Mountains, about 40 km north of Bristol, Tenn. It is a coal-fired, base-load plant with a generating capacity of 712 MW, although typically its output varied from a daytime peak of 650 MW to a nighttime low around 400 MW. During the survey, June 1, 1976, to September 30, 1977, the plant burned coal with a sulfur content of about 1 percent. The effluent from three boilers was emitted through two 138-m stacks, one with a diameter of 4.76 m and the other 3.81 m.

The plant elevation is 461 m, which puts the stack tops at almost 600 m. The eight monitoring station elevations ranged from 451 m at Castle to 792 m at Hockey. All stations measured winds and SO_2 concentrations continuously, and some also measured temperature and NO_x concentrations and collected airborne particulate materials for sulfate analysis. A stack monitor for SO_2 and NO was located in the duct works of the smaller stack. Monitoring signals from the eight fixed stations and the stack were telemetered to a central computer for processing, display, and storage. A van was routinely deployed during daylight to monitor SO_2, NO_x, and O_3 in the expected area of plume touchdown. A helicopter flew traverses through the plume during two 10-day periods, also measuring SO_2, NO_x, and O_3. Vertical profiles of wind and temperature were obtained semi-routinely at the plant from double-theodolite pibals with attached T-sondes. Although the measurement period extended over 16 months, the last 12 months of data are more reliable because of the inevitable difficulties getting stations established and de-bugged.

Ambient SO_2 concentrations at the fixed monitoring stations never exceeded the National Standards, probably in part because of the low sulfur content of the coal burned. The table summarizes the SO_2 concentrations at the eight stations.

Table 1.--SO_2 concentrations (ppb), October 15, 1976-September 30, 1977

Station	Distance From Power Plant (km)	Type of Terrain	Average Concentration (ppb)	Concentrations $\geq$ 10 ppb (Percent)
Tower	3.4	Plateau	12	25
Munsey	4.2	Valley Side	4	11
Hockey	5.7	Ridge	6	15
Johnson	5.8	Ridge	8	16
Lambert	7.6	Valley Side	3	8
Castle	8.3	Valley	6	16
Nash	10.8	Plateau	2	6
Kent	29.9	Ridge	1	4

The highest average concentration occurred at Tower, the closest station to the plant, and Tower also had the highest frequency of concentrations of 10 ppb or more. The lowest concentrations occurred at Kent, the most distant station. An analysis of the SO_2 concentrations by wind direction showed that the plant had a major impact on all stations, but there were also indications of slightly higher concentrations wit winds from a very small source about 3.5 km north-northeast of the plant. Also, concentrations tended to be higher at all stations with general airflow from the southwest.

An analysis of the 10 highest hourly average SO_2 concentrations revealed that all stations except Hockey had at least one day with at least two of their 10 highest concentrations occurring over consecutive hours, which indicates that such persistence of high concentrations is not exceptional, at least at Clinch River. This analysis also showed a high frequency of the 10 highest hourly concentrations occurring during hours ending at 0913 EST at four valley stations, which phenomenon is hypothesized to be associated with fumigating plumes. On the other hand, the two ridge-top stations experience a comparatively high frequency of high concentrations during nighttime, suggesting that stable plumes from the plant passed near the ridge tops. These ideas are borne out by the diurnal variation in concentration frequencies at the Castle and Johnson stations, which are typical of other valley and ridge stations, respectively.

The mobile van was highly successful as a platform for sampling the power plant plume, being radio-directed in accordance with the observed winds. A total of 866 h of valid SO_2 sampling was accomplished in the van with an overall average concentration of 32.7 ppb. Half of the van-based measurements of SO_2 were 20 ppb or greater, compared with 16.5 percent for the Tower station where the concentrations among the fixed stations were highest. When the van operated within 0.5 km of the plant, the concentrations typically were relatively high, perhaps from plume downwash in association with airflow over nearby ridges. About three-fourths of the sampling in the van was done at 3-10 km from the plant; practically all sampling was during the daytime.

The structure of the power plant plume was analyzed from SO_2 concentrations measured in a helicopter flying horizontally across the plume at successively different elevations and in successively opposite directions. Although the data were corrected for instrument response and air transit time in the sampling tubes, many adjacent-elevation traverses that comprised a cross-section showed successively alternating shifts in the location of peak concentrations. It was speculated that such shifts were caused by meander of the transporting wind during successive traverses. This is supported somewhat by the range of 2-min wind directions recorded on a 30-m tower at the Hockey station (considered to be often near plume elevation). The range of 2-min wind directions generally exceeded the direction range of peak SO_2 concentrations in individual traverses of each complete cross-section.

From the SO_2 cross-sections and pilot-balloon winds, the SO_2 mass flux was calculated and compared with power plant emissions for corresponding hours. The majority of mass flux calculations were considerably less than corresponding emission rates. Apparently, this was partly because the full vertical extent of the plume was not being sampled. For six cross-sections that were composed of an abundance of traverses, there was fair agreement; plant SO_2 emissions ranged from 800 to 1400 g/s, and all calculated flux errors ranged from 4 to 38 percent of the emission rates; half were within 16 percent.

Twenty-four helicopter cross-sections were also used to calculate a "measured" Gaussian diffusion parameter, σ_y, by a method described by Whaley (1974) (data were adequate for only a few σ_z calculations). These values were compared with corresponding Pasquill-Gifford values (Turner, 1970) and σ_y values calculated as recommended by Pasquill (1976) and described by Irwin (1979a). Pasquill's recommendation uses standard deviations of wind direction fluctuations σ_A (radians) in the equation

$$\sigma_y = \sigma_A X f(X)$$

where X is downwind distance in meters and

$$f(X) = (1 + 0.0308X^{0.4548})^{-1} \text{ for } X \leq 10 \text{ km};$$

$$f(X) = 0.333(10{,}000/X)^{\frac{1}{2}} \text{ for } X \geq 10 \text{ km}.$$

When σ_A is used in Pasquill's equation, 11 of 18 cases showed Pasquill σ_y values less than measured and seven cases showed Pasquill σ_y values more than measured. For the 18 cases, the ratios of measured σ_y to Pasquill σ_y had a mean value of 1.16. When 24 cases of Pasquill-Gifford σ_y values were compared to measured values, in 18 cases Pasquill-Turner underestimated the values. The mean of the ratio of measured σ_y to Pasquill-Turner σ_y was 1.47, indicating an enhancement of flat terrain σ_y values when applied over complex terrain. In general, this enhancement amounted to about one-half the class being less stable over complex terrain than indicated by the Pasquill-Gifford (flat terrain) stability classes.

A principal objective of the Clinch River aerometric study was to assemble a typical set of data with which to test the reliability of dispersion models and modeling concepts. However, certain input variables are required in order to routinely calculate hourly average concentrations. Effective stack height was calculated from vertical profiles of temperature and wind speed (Holzworth, 1978), which were derived for the Clinch River Power Plant from temperatures and winds measured continuously at the fixed monitoring stations, from semi-routine pibal and T-sonde measurements at the plant, and from 12-hourly rawinsonde data at nearby National Weather Service stations. Effective stack height was also calculated in the conventional manner (i.e., using stability classes) of the PTMTP model (Turner and Busse, 1973). Comparisons with plume centerline heights based on helicopter traverses gave a mean absolute error of 143 m for variable temperature and wind profile method and 321 m for the PTMTP model subroutine. Consequently, the former method was used in model applications.

Another required input for routine model applications is the Pasquill stability class. This was determined from a bulk Richardson number, based on routine temperature gradient and wind measurements at the Tower Station.

Finally, mixing heights were determined from the contrived vertical profiles of temperature that have already been mentioned.

Fourteen different Gaussian type models were used to calculate hourly average SO_2 concentrations for comparison with observed concentrations at each of the eight monitoring stations from mid-October 1976 through September 1977. The most model-to-measurement comparisons were at Munsey, 4410 h, and the least at Castle, 2392 h, which was washed away in a flood. The models that were evaluated ranged from the basic, flat-terrain PTMTP model (Turner and Busse, 1973), both with and without various adjustments for changes in terrain elevation from that at the plant, to those with adjustments for standard σ_y and σ_z values and with power-law extrapolations of measured wind speed to plume elevation.

A cumulative frequency distribution was prepared of SO_2 concentrations measured and calculated by three different models for each of two stations, which are considered fairly typical. The CRSTER model, which is essentially the PTMTP model with the CRSTER plume height adjustment (Environmental Protection Agency, 1977), which decreases plume height by the full elevation difference between plant base and sampling station for all stabilities, overpredicts concentrations, especially the higher ones.

The PASQUILL model is the flat-terrain PTMTP model, except that (1) plume height (H) is decreased for stable conditions only by a factor (F) of the elevation difference (Z), where $F = 0.6$ for $Z \leq H$ and $F = 0.6H \div Z$ for $Z \geq H$ (Koch, 1978), (2) standard values of σ_y are adjusted for complex terrain by a factor of 3.0 for neutral and stable conditions and a factor of 2.0 for slight instability (Koch, 1978), and (3) the measured transport wind speed is extrapolated by power law to the plume elevation. It shows a rather good comparison with measured concentrations, especially for the higher concentrations at the Kent station.

The SSTM model is the same as the PASQUILL model, except σ_y values are determined as a function of the standard deviation of wind directions (σ_A) and downwind distance (X) as recommended by Pasquill (1976) and as described in an earlier paragraph. The SSTM model does not do as well as the PASQUILL model for extremely high concentrations but it does a little better for moderately high values.

From correlations and root mean square errors, the PASQUILL and SSTM models produced the best overall comparisons. However, the results for the basic flat terrain model without plume height adjustments were surprisingly good.

2.3.5 Complex terrain workshop

During FY-79 it was established that beginning in FY-80 the EPA would have responsibility for a major program dealing with the development of improved models of atmospheric dispersion for sources located in complex terrain. In order to obtain opinions from a broad spectrum of experts on how best to proceed, North American Weather Consultants was hired to conduct a workshop. The primary goal of the workshop was to develop recommendations for the design of a practical, results-oriented program.

The workshop was held in Raleigh, N.C., July 16-20, 1979, with attendance by 47 working experts and an additional 12 persons, including invited speakers and governmental observers. The work was organized into five panels: Model Development and Analysis, Model Evaluation and Application, Experimental Design, Measurement Techniques, and Data Management and Quality Assurance. Because of the magnitude of the problem, "strawmen" scenarios were provided to focus on important and tractable aspects of the overall task.

In general, there was good agreement to study first the problem of stable plume impingement on elevated terrain; the early effort should be oriented towards improving Gaussian models, but later effort should aim towards incorporating complex flow fields and K theory into the models. Also there was good agreement on the wisdom of emphasizing model development throughout and on the need for comprehensive data from field experiments as well as from scaled physical (fluid) modeling upon which to base the model development. But there were divergent views on the scales at which field experiments should be designed. Panels concerned with modeling favored tracer studies on a small (~ 100 m high) isolated hill because of the more tractable logistics involved, providing a better data capture, and because they felt the results could reasonably be scaled up to larger terrain obstacles. The panel concerned with experimental design preferred considerably larger hills because they believed that important meteorological conditions would be more realistic on a larger scale. The group charged with measurement techniques preferred larger hills because the required small scale of tracer and meteorological measurements can be achieved more readily than on 100-m hills. At the full-scale of plumes from large sources there was again overall agreement on the need for corroborating field data. Because the overall project is to be driven by model development it was decided to conduct experiments first on a hill about 100 m high as recommended by the modelers. But additional field studies on larger hills and a full-scale power plant plume will be studied subsequently as necessary. It is planned that these model developments and field study efforts will be accomplished mainly by a competitive contract.

Complete details on the workshop are available in a proceedings published by the EPA (Hovind et al., 1979).

2.3.6 Long-range transport and transformation of SO_2 and sulfate

The grant-supported modeling work by Colorado State University that was described in our 1977 Annual Report has continued, with some refinements incorporated into the model and some initial applications made for the Ohio River basin (Henmi and Reiter, 1979). A major refinement in the model is the ability to keep track of pollutants in three layers: (1) the relatively deep daytime convectively mixed layer, (2) the relatively shallow nighttime ground-based stable layer, and (3) the nighttime remnants of the afternoon mixed layer that extend down to the top of the nocturnal inversion. Other significant additions to the model include the transformation of SO_2 to sulfate by daytime and nighttime rate constants (with sufficient data the transformation has been accomplished as a function of relative humidity), deposition of SO_2 and sulfate in precipitation as a function of precipitation rate, and dry deposition by means of an estimated deposition velocity.

The model was applied to calculate 24-h average air concentration and deposition amounts of SO_2 and sulfate over the Ohio River Basin for May 11, 1974, a day with comparatively abundant measurements. SO_2 emissions were included for all sources with emission rates greater than $\sim 10^5$ tons yr^{-1}, which accounts for about 90 percent of all SO_2 emissions in the basin. The model outputs of surface SO_2 and sulfate concentrations show that the higher concentrations occur in the vicinity of higher emission rates and that the sulfate pattern is smoother than that for SO_2, partly because of the time required for transformation to sulfate and partly because of subjective interpolation of SO_2 concentrations for source locations and strengths. Correlations of deviations from the averages of observed and calculated concentrations were 0.635 for SO_2 (based on 73 measurements of non-urban concentrations) and 0.487 for sulfate (based on 41 measurements), both highly significant. According to the model, on May 11, 1974, 30 percent of the emitted sulfur was removed by precipitation and 53 percent by dry deposition, with 17 percent remaining.

Regional residence times of SO_2 and sulfate over the eastern United States were re-calculated using a more refined model than that employed earlier (Henmi et al., 1978). In the latest model the residence times are dependent upon the mixing-layer height, transformation as a function of relative humidity, precipitation depletion as a function of precipitation intensity and frequency, and a specified rate of dry deposition. The residence time of SO_2 over the eastern United States in the cold season (November-April) ranges from 15 to 30 h and in the warm season (May-October) ranges from 15 to 40 h, while for sulfate the ranges are about an order of magnitude greater, 150-450 h in the cold season and 200-500 h in the warm season. A sensitivity analysis of the independent variables indicates that the residence time is very sensitive to values of input variables. Therefore, the results should be regarded as approximate until greater confidence can be placed in the values of input variables and in the model itself.

The work by Colorado State University described here is continuing. In addition to further refinements in the model, including precipitation acidity, a major effort is being made to optimize the computer program to reduce the running time. Also, a more rigorous verification of the model will be pursued and applications will be made using projected future emissions.

2.3.7 Interrelationships of air quality, emissions, and meteorological conditions

There were relatively high ozone and sulfate concentrations over the eastern United States on July 6 to 10, 1974. A detailed analysis of these data and the associated meteorological condition showed the following: (1) the high concentrations occurred in a very warm, slow-moving high-pressure area; (2) the ozone concentrations were high from July 6 to 10, and midway through the period the sulfate concentrations became high and by July 10 spread over a 1,000,000 km^2 area; and (3) the areas of high ozone concentrations generally did not correspond to the areas of restricted visibility while there was generally good spatial agreement between the areas with high sulfate concentrations and areas of restricted visibility. The complete analysis of the conditions during this episode is found in DeMarrais (1979a).

In DeMarrais (1979b) a brief survey of milestones in the history of air pollution meteorology is presented. In the appendix there is a chronological listing of several hundred original works and events.

In analyses of total suspended particulate (TSP), sulfates (SO_4), and respirable suspended particulate (RSP) data of July 1, 1974, to June 30, 1976, for four stations in the New York City area, the following were determined: (1) SO_4 concentrations, even though they showed large differences in average concentrations and in the distribution of concentrations among stations, varied on an area-wide basis; (2) RSP concentrations among the four sites, even though two of them were only 10 km apart, varied independently; (3) the variations in TSP concentrations among the four sites were more consistent than those shown in RSP concentrations and less consistent than those shown in SO_4 concentration; and (4) at the individual sites, on an annual basis, TSP and SO_4 were fair surrogates of one another, but TSP and RSP, and RSP and SO_4 were not good substitutes for one another. The complete analysis is in DeMarrais and Coventry (1979).

In a short report based on sulfate data for New York City, it is noted that haze as reported by the National Weather Service is a good indicator that sulfate concentrations are relatively high. This report has been submitted for publication.

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

Under an EPA grant, Washington State University used a statistical map classification process and developed a comprehensive set of synoptic map types for each season using 1973-76 data. The study area was centered on St. Louis and employed data for 21 stations within a 500 mile radius of St. Louis. There were 12 types for winter, 13 types each for spring and summer, and 14 types for autumn.

The map types were then compared relative to total suspended particulates (TSP) matter and carbon monoxide (CO) data for St. Louis (1975 and 1976 RAPS data). Results indicated that synoptic scale weather phenomena affect both TSP and CO concentrations. However, the set of maps associated with high TSP concentrations was not the same set as that associated with high CO concentrations.

2.4 Air Policy Support Branch

The function of the Air Policy Support Branch is to support activities of the Office of Air Quality Planning and Standards, EPA. General areas of responsibility include (1) the development of air pollution control tactics through the application of mathematical-meteorological diffusion models, (2) technical support and assistance in simulation model techniques to other EPA elements, (3) preparation of 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. 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 during the period from October 1, 1978, through September 30, 1979.

2.4.1 Philadelphia Oxidant Data Enhancement Study

EPA is conducting a program to assess the utility of various photochemical models for use by the states in designing ozone control strategies. Philadelphia, PA. was selected as one of several urban areas to be included in the modeling program. The Philadelphia Oxidant Data Enhancement Study was designed to provide the data base of ambient pollutant and meteorological measurements needed for input to the photochemical models and for verification of the models' performance.

The study included a ground level network of 10 sites operated by state and local air pollution control agencies and five sites operated by Aerovironment, Inc., under contract to EPA. The network extended from $\sim$ 70 km southwest through $\sim$ 70 km northeast of Philadelphia. Extensive air quality and meteorological measurements were made during the period July 9 through September 18, 1979.

An instrumented helicopter operated by EPA-EMSL, Las Vegas, was used as a platform for measuring ozone and oxides of nitrogen aloft within the boundary layer. Grab samples for subsequent species analyses were obtained during the monitoring flights. Upper-air wind and temperature measurements were obtained by rawinsonde soundings from a site 10 km north of downtown by Beukers Lab under contract to EPA. Pibal soundings for wind measurements were provided at two locations by EMSL-Las Vegas.

During FY-80, the measurements obtained from the monitoring program will be compiled by AeroVironment into a composite data base for use in model application and verification exercises. The data will also be analyzed by

AeroVironment to support EPA's modeling program. Analyses will include computation of synoptic and mesoscale trajectories and an interpretation and explanation of observed ozone concentrations in terms of precursor concentrations and meteorological conditions.

2.4.2 Study of the nature of ozone, oxides of nitrogen, and non-methane hydrocarbons in Tulsa, Oklahoma

During the summer of 1977, Research Triangle Institute (RTI) under contract to EPA began a photochemical air pollutant and meteorological monitoring and data analysis program for Tulsa, Oklahoma, and vicinity. Information derived from this study is being used to expand knowledge of ozone formation and transport in various U.S. cities. The ambient monitoring portion of the study was conducted from July through September 1977, and the analysis and interpretation of the data were accomplished by RTI during FY-79 (Environmental Protection Agency, 1979 d,e,f). The study data base will also be used by EPA during FY-80 for application and verification of several photochemical models.

In brief, the program monitored ozone and oxides of nitrogen from one site south of Tulsa (predominately downwind) out to 50 km from the center of the city. Total hydrocarbons and methane measurements (for obtaining continuous non-methane hydrocarbon data) were made at the city sites; and 3-h (0600-0900 CDT) integrated grab samples for analysis of hydrocarbon species were obtained upwind and within the city. Measurements of wind speed and direction were made at sites within the study area. Measurements of ozone and oxides of nitrogen aloft within the boundary layer were obtained from an instrumented aircraft operated by RTI.

The principal findings of the data analysis and interpretation effort indicate that a well-defined plume of elevated ozone concentrations was present downwind of Tulsa at ground level and aloft on days with strong solar radiation and wind speeds of ∿ 4-7 mps. Ozone measurements at 760 m AGL during the afternoon show relatively little lateral spread of the plume downwind to 64 km (the furthest distance the plume was tracked). Daily maximum surface ozone levels were most frequently observed at a site 35 km north of Tulsa, and ozone aloft most often peaked at ∿ 50 km downwind. Ozone concentrations exceeding the NAAQS (0.12 ppm 1-h average) were observed on seven days during the 3-month monitoring program. Ozone measurements upwind and aloft outside of the urban plume indicated that ozone concentrations between 0.06 and 0.08 ppm were generally transported across the study area. Additional details were presented at the APCA 1979 annual meeting (Possiel et al., 1979).

2.4.3 Hot spot guidelines and indirect source guidelines for CO impact assessment

Two carbon monoxide screening methodologies were completed for modeling emission contributions of mobile sources to local CO ambient air quality levels. The Indirect Source Guidelines (Environmental Protection Agency, 1979a) are designed for detailed hand calculations, and the Hot Spot Guidelines (HSG), (Midinski, 1978a,b) are provided for quick screening calculations. Both techniques use recent emission-factor estimating techniques, queuing theory for automobiles on roadways, and state-of-the-art dispersion models to generate tables and nomographs for use in the worksheets included for each method. The guidelines were printed serially during the last five months of 1978.

The HSG are further supported by the publication of more detailed computer dispersion and emission model techniques. The Intersection Midblock Model (Benesh, 1978a) performs calculations on an intersection-by-intersection basis. The modified-ISMAP (Benesh, 1978b) is designed for calculating air quality estimates for a small network of streets. Both the screening methodologies and the models are consistent in terms of CO emission factors and base year calculations.

The HSG were presented at several workshops (Schewe, 1978) throughout the country to local, state, and regional air planners. Several agencies at present are actively using these screening methods.

2.4.4 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 has been estimated this fiscal year: acrylonitrile production, copper smelters, potash processing, electric arc furnaces, benzene storage, ammonium sulphate production, coke over quenching towers and leaks, and small industrial boilers. As part of this responsibility, dispersion analyses conducted by consultants to EPA were also reviewed to provide quality assurance. Review criteria include consideration of such factors as building downwash, terrain impacts, and fugitive emissions (including deposition) commensurate with the level of detail in the plant specifications and the subsequent use of the estimates.

The many applications of dispersion models to industrial sources created the need for a model that could handle the above-mentioned factors for many and variable source types. In response to this need, the Industrial Source Complex (ISC) Model was developed for release to the modeling community (Bowers et al., 1979a,b) and is in press. The ISC Model incorporates many useful options into both a long-term (annual) and short-term model. Details were presented by Bowers et al. (1979c), at the APCA 1979 annual meeting.

2.4.5 Nationwide ozone modeling policy for State Implementation Plan (SIP) submissions

A NOAA meteorologist participated in the development of the EPA ozone modeling policy for those cities that will need to develop an Implementation Plan for attainment of the ozone National Ambient Air Quality Standard by 1987. Technical guidance on the application of photochemical dispersion models to eight large cities with severe ozone problems was written to accompany the policy guidance.

2.4.6 Northeast Corridor Regional Modeling Project (NECRMP)

During FY-79 a NOAA meteorologist participated in the initial phases of an effort to apply combined regional/urban photochemical models to the ozone problem in the Northeastern United States. 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 ozone NAAQS in the near downwind area of these cities. The modeling efforts are to be synchronized with applications of a regional photochemical model, currently under development in the Meteorology Laboratory, that will address the intercity transport problems in the Northeast.

During FY-79 a NOAA meteorologist participated in three major work areas associated with initiation of the project: (1) Development and initiation of the data base collection effort. This work involved working with state air pollution control agencies and metropolitan planning organizations in the Northeast to help them plan their specific responsibilities and tasks to acquire the necessary data to run the models. (2) Development and initial participation in an EPA task force to manage the project. The NOAA meteorologist is the Technical Coordinator on the Task Force and is broadly responsible for overseeing all operational aspects of the project including data acquisition, model validation, and model application. He is also to lead technical individuals in the combined application of the regional/urban scale models. (3) Development of project plans, scopes of work, and protocols. In FY-79 he has been assisting the project manager in developing project plans and protocols. Work is just beginning on the scope of work for contract development of a modeling protocol.

2.4.7 Air quality simulation model performance measures and standards

To assist the air quality analyst in evaluating the appropriateness of a dispersion model for a given application, preliminary performance measures and standards have been developed. Systems Applications, Inc., prepared two reports that EPA has published. The first, "Performance Measures and Standards for Air Quality Simulation Models" (Hayes, 1979), develops a conceptual framework for objectively evaluating model performance. The author provides considerable background material on the elements of the performance evaluation problems, including (1) the type of issues to be addressed by the model, (2) the classes of models to be used, (3) the applications for which the models are suited, and (4) the categories of performance measures that are available.

Five attributes of a "well-behaved" model are defined. These include accuracy of the peak prediction, absence of systematic bias, lack of gross error, temporal correlation, and spatial alignment. The relative importance of each attribute is shown to depend on the issue being addressed and the pollutant being considered. Acceptable model behavior is determined by calculating several mathematical performance "measures" (which address the attributes described above) and comparing their values with specific standards.

The second report, "Procedures for Evaluating the Performance of Air Quality Simulation Models" (Hillyer et al., 1979), provides a general procedural framework for evaluating models. This publication covers problem specification and model selection, the evaluation plan, identifying the requirements of the study, and finally performing the evaluation.

2.4.8 Effect of Irwin's proposed dispersion scheme on concentration estimates

In this study, NOAA meteorologists investigated the effect of Irwin's proposed revision (as of January 1979) to the Pasquill-Gifford "sigmas" on calculated concentrations using the Single Source (CRSTER) Model. The study was done in two parts. The first was a sensitivity study, a comparison between the concentrations predicted using Irwin's proposed sigmas and those using the Pasquill-Gifford sigmas. The second part was a comparison between the model-predicted concentrations and monitoring data around the Muskingum River Plant. Details were presented in a paper at the AMS Symposium in Reno, Nev. (Lee et al., 1979), and a joint ML/EPA contract, currently in progress, involves a broader investigation.

2.4.9 Effects of sulfur variability in coal

The purpose of this project is to develop and implement realistic procedures to account for the random variations in sulfur content of coal, as well as the variations in efficiency of the control equipment. Currently, several methods are being used to estimate the emission rates to be used in modeling air quality impact of power plants.

A task group has been formed to develop and apply the required procedures. It consists of persons from EPA along with a NOAA meteorologist, and representatives of the regional offices and two contractors. Although the work is still in progress, a tentative modeling procedure has been developed and tested for a limited number of cases.

2.4.10 Technical assistance for the Pan American Health Organization in Brazil and the World Meteorological Organization

At the request of the Pan American Health Organization of the World Health

Organization (WHO), a NOAA meteorologist spent four weeks in Rio de Janeiro, Brazil, as an advisor to the Fundacao Estadiral de Engenharia de Meio Ambient (FEEMA) of the state of Rio de Janeiro. In addition to presenting a 15-h training course (an introduction to transport and dispersion modeling) to FEEMA and industry personnel, he advised the FEEMA meteorologist on the theory of atmospheric diffusion and on the intricacies of model selection and application, including loading and executing dispersion models on the FEEMA computer.

Draft curricula for training personnel in all four World Meteorological Organization (WMO) categories in air pollution meteorology were prepared by a group of specialists, including a NOAA meteorologist, following the WMO Meeting on Education and Training in Meteorological Aspects of Atmospheric Pollution and Related Environmental Problems in 1977. Following review and approval by the WMO Executive Committee, the curricula were published (World Meteorological Organization, 1978).

2.4.11 Technical assistance to the EPA regional offices

One responsibility of the NOAA personnel is to provide technical support and assistance on air quality simulation modeling applications and techniques to various EPA elements, especially the Regional Offices. Typical requests are summarized here.

NOAA personnel provided review, evaluation, and recommendations on two models prepared for Region III by H. E. Cramer Co. Assistance on resolving modeling issues surrounding two power plants in the Cleveland area was given to Region V. NOAA meteorologists responded to Region VII requests regarding appropriate modeling for ASARCO smelter operations. The PSD application for the Colstrip Power Plant in Montana required considerable consultation and assistance between Region VIII and NOAA staff as did the review and comment on the air quality assessment associated with smelter regulations in Region IX. Region X requested assistance in evaluating a new model for PSD use at the Port Valdez, Alaska, refinery; this is an on-going project.

2.4.12 Washington National Airport air quality study and related aviation activities

In cooperation with the FAA, EPA conducted a 6-week monitoring program at Washington National Airport to determine the impact of jet aircraft during queuing and take-off on ambient CO and NO_X. A NOAA meteorologist is participating in the modeling analysis, using the PAL model, one objective of which is to assess the applicability of the model to this situation and other airports in the future. The CO impact analysis implies a 1-ppm CO increase above background due to aircraft operations. Modeled NO_X concentrations are comparable with measured values for a rather limited number of scenarios. This appears to be caused by monitors located within the aircraft turbulence mixing cell that may extend a few hundred meters from the queue area and runway.

EPA requested that NOAA meteorologists determine the CO impact of general aviation activities at the Van Nuys, Calif., airport through a dispersion model study. Results indicated the possibility of violating the 1-h CO NAAQS but the concentration gradient was very steep and major impact was limited to a few hundred meters around the major taxiway and runway. Details were presented at an aviation conference and published in the proceedings (Schewe et al., 1978).

2.4.13 Regional workshops on air quality modeling

Several NOAA meteorologists participated in and led sessions during two workshops held in November and December 1978. The objective was to bring together the regional meteorologists, senior engineers responsible for air quality impact reviews, and the regional air branch chiefs, as well as selected Meteorology Laboratory and EPA staff, to work toward a consensus on several issues. The issues discussed included data bases, simple and complex terrain modeling, mobile source and complex terrain modeling, mobile source modeling, regional modeling procedures for PSD/NSR review, and additional items. Reports by the work groups were circulated for review and comment among all participants. A final report was issued by EPA in September 1979. This should serve the regional offices as a basis for selecting air quality models and data bases in those situations where the "Guideline on Air Quality Models" indicates that (1) selection of alternatives is appropriate, or (2) a case-by-case analysis is necessary.

2.4.14 Lead monitoring guidelines

EPA issued two guidelines to define requirements for meteorological and ambient lead monitoring in the vicinity of point sources. The purpose of monitoring is to determine compliance with the National Ambient Air Quality Standard for lead and to use the data in control strategy demonstrations. NOAA meteorologists drafted portions of the guidelines regarding meteorological data required, exposure of instruments and operating specifications, and quality assurance and data reporting.

The "Guideline for Short-Term Lead Monitoring" (Environmental Protection Agency, 1979c) is designed to assist states that do not have enough ambient lead data to meet Implementation Plan requirements. The second guideline is for longer term use and includes the criteria that should be met in designing a monitoring network around lead point sources (Environmental Protection Agency, 1979b).

2.4.15 Case study analysis of Supplementary Control System reliability

A NOAA meteorologist served as project officer on a contract studying the reliability of a supplementary control system (SCS). With an SCS, SO_2 emissions from a facility are temporarily curtailed when meteorological conditions conducive to high ambient SO_2 concentrations exist or are anticipated. The contract report describes a case study demonstration for the Kincaid Power Plant of SCS reliability analysis techniques that are presented in "Technique for Supplementary Control System Reliability Analysis and Upgrading" (EPA-450/2-76-015). A user manual for the PROBL model is also provided. Although the report is dated August 1978, final changes were necessary and the report was not available until January 1979 (Egan et al., 1978).

2.4.16 Representativeness of meteorological data for air pollution modeling

A NOAA meteorologist served as project officer on a contract to determine the meteorological representativeness of the year 1964 for dispersion modeling compared with 30-year climatological norms and also the 5-yr period 1970 - 1974. The area east of the Mississippi River was studied. Representativeness of critical parameters for modeling, i.e., wind speed, wind direction, stability, temperature, and mixing heights, was analysed for 15 stations at three typical stack heights with the Single Source (CRSTER) Model. Although numerous individual relationships between 1964 and the longer periods are observable, simple conclusions or recommendations covering all situations may not be conclusive. The contractor reports are still being reviewed prior to publication; however, the highlights were presented at the Air Pollution Control Association annual meeting in June 1979 (Magil et al., 1979).

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5. METEOROLOGY LABORATORY STAFF
FISCAL YEAR 1979

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.

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William Keith, Meteorologist (Washington, D.C.)
Frank Johnson, Meteorologist (Las Vegas, Nev.)
Marc Pitchford, Meteorologist (Las Vegas, Nev.)
Dr. Ernest Peterson, Meteorologist (Corvallis, Ore.)

Robert Chalfant, Electronic Technician (Emissions Measurement and Characterization Division)
Juanita Jones, Technical Information Assistant, Librarian (EPA)
Vickie Sanders, Secretary (EPA)
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John Clarke, Meteorologist
Dr. Robert Eskridge, Meteorologist
Dr. George Griffing, Physical Scientist
Dr. Robert Lamb, Meteorologist
Dr. Jack Shreffler, Physical Scientist
Dr. Francis Binkowski, Meteorologist
Terry Clark, Meteorologist
James Godowitch, Meteorologist
Kenneth Schere, Meteorologist
Alfreida Rankins, Meteorologist
Ralph Soller, Meteorological Technician
John Rudisill, Meteorological Technician
James Reagan, Health Services Officer (PHS)
Joseph Steigerwald, Student Meteorologist
Charles Trepte, Student Meteorologist
Mark Shipham, Student Meteorologist
Paul Gunthorpe, Student Physical Scientist
Bess Flowers, Secretary

Data Management Section

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Adrian Busse, Computer Specialist
Dale Coventry, Computer Systems Analyst
Robert Jurgens, Computer Systems Analyst
Earl Amos, Computer Programmer (EPA)
William Council, Student Trainee
Philip Griffin, Student Computer Technician
Sheila Pinkney, Clerk-Typist (EPA)

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Roger Thompson, Environmental Engineer (PHS)
Lewis Knight, Electronic Technician
Joseph Smith, Meteorological Technician
Alton Payne, Student Physical Scientist
William Pendergrass, Student Engineering Technician
Carolyn Coleman, Clerk-Typist (EPA)
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Gerard DeMarrais, Meteorologist
Hazel Hevenor, Secretary (EPA)

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Dr. Ralph Larsen, Environmental Engineer (PHS)
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Everett Quesnell, Meteorological Technician (Environmental Monitoring Systems Laboratory)
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Edward Burt, Meteorologist
Charlotte Hopper, Meteorologist
Dean Wilson, Meteorologist
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