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NOAA Technical Memorandum ERL ARL-27

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Environmental Research Laboratories

Fiscal Year 1970 Summary Report of Division of Meteorology Support to the Air Pollution Control Office Environmental Protection Agency

Air Resources
Laboratory
RALEIGH,
N. CAROLINA
February 1971

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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FISCAL YEAR 1970 SUMMARY REPORT OF DIVISION OF METEOROLOGY SUPPORT TO THE AIR POLLUTION CONTROL OFFICE ENVIRONMENTAL PROTECTION AGENCY

Air Resources Laboratory
Division of Meteorology (APCO)
Raleigh, North Carolina
February 1971

PREFACE

Effective communication between individuals or groups is a difficult activity. This is especially true of communications about new problems and new research, since much must be left unsaid and many questions be left unanswered. Nevertheless, periodic summaries of work performed consitute a valuable information source as well as a management "how goes it" tool.

The work reported herein was funded by the Air Pollution Control Office (APCO) (formerly known as the National Air Pollution Control Administration) and was done under agreement between the APCO and the Air Resources Laboratories, National Oceanic and Atmospheric Administration (NOAA)(formerly Environmental Sciences Services Administration), dated February 3, 1970. Although contracted studies are funded directly by the APCO, the NOAA personnel assigned to the Division of Meteorology have the responsibility for monitoring contracts.

Any inquiry on the research being performed should be directed to Mr. R. A. McCormick, Director, Division of Meteorology (APCO), 3820 Merton Drive, Raleigh, North Carolina 27609.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

FISCAL YEAR 1970 SUMMARY REPORT OF DIVISION OF METEOROLOGY SUPPORT TO THE AIR POLLUTION CONTROL OFFICE ENVIRONMENTAL PROTECTION AGENCY

The following brief summaries of meteorological research and other activities present the current status of a variety of projects the Division of Meteorology (DM) is conducting for the Air Pollution Control Office (APCO).

Uniterms: Abatement, absorption, aerosol, air pollution, air quality, albedo, anticyclones, balloon, boundary layer, carbon dioxide, carbon monoxide, chemistry, cooling towers, diffusion, emissions, environment, experiments, fallout, Gaussian, heat island, lasers, Mauna Loa, mesometeorology, meteorology, model, monitoring, North Carolina, oxidants, particulates, plume-rise, prediction, radar, radiation, radiometer, radiosonde, research project, satellite, solar, solar radiation, stacks, sulfur compounds, sulfur dioxide, surveys, tetroon, turbidity, urban, vorticity, washout, wind shear, wind tunnels.

1. HIGHLIGHTS

In October 1969, the Division of Meteorology (DM), Air Pollution Control Office (APCO), sponsored a three day symposium on multiple source diffusion models in conjunction with the North Carolina Air Pollution Consortium comprising Duke University, North Carolina State University, University of North Carolina, Office of Manpower Development of APCO, and the Research Triangle Institute. Approximately 100 people attended the symposium.

Diffusion models have been developed to assess the concentration distribution of carbon monoxide in any urban area, and for simulating dispersion conditions in the Chicago area.

During the year, 18 episodes of high air pollution were forecast by National Meteorological Center (NMC) meteorologists. Ten of these episodes lasted a total of 28 days in the Eastern United States and eight lasted a total of 40 days in the Western United States. Local statements of high air pollution were issued on 38 days during Fiscal Year 1970 by Environmental Meteorological Support Units (EMSU). Almost all local statements coincided with national advisories. A stagnation index was successfully used to designate caution areas for high air pollution potential.

An analysis of constant volume balloon (tetroon) trajectories over Columbus, Ohio, in March 1969, demonstrated that the city induces an average anticyclonic wind turning of about 10 degrees at heights of 100 to 200 meters at night. The anticyclonic turning was found to increase with height and to be greater in inversion conditions than in lapse conditions.

A meteorological and engineering evaluation of the Four Corners Power Plant was conducted at the request of the Department of Health and Social Sciences of New Mexico. The findings demonstrated the need for strict control of stack emissions in areas of low population density where clean air is especially valued for health, retirement, recreation, and forest preservation.

The continuing investigation carried out in western Pennsylvania of the transport and disperison of plumes from tall stacks, constituting the Large Power Plant Effluent Study (LAPPES), has provided additional information on plume rise, downwind plume dispersion, and associated ground-level sulfur dioxide concentrations in the vicinity of coal burning power generation facilities.

Six stations were added to the atmospheric turbidity global network during Fiscal Year 1970. Most of the new stations are located in remote areas free from local sources of air pollution. Additional foreign stations are expected to be added to the network during the coming year.

2. MODEL DEVELOPMENT

2.1 Modeling Symposium at the University of North Carolina

The continuing interest in the various aspects of atmospheric diffusion was evident in a three-day symposium conducted at the University of North Carolina at Chapel Hill in October 1969. Approximately one hundred people attended the symposium sponsored by the DM, APCO. The DM sponsored this symposium in conjunction with the North Carolina Air Pollution Consortium comprising Duke University, North Carolina State University, University of North Carolina, Office of Manpower Development of the APCO, and the Research Triangle Institute. Proceedings will be published in the near future and should provide a useful indication of the current state of the art. The proceedings will consitute a readily available permanent record of current modeling technology.

An "integrated puff" model provides a more realistic physical simulation of the processes of smoke plume dispersion than previously available according to the symposium presentation by J.J. Roberts,

E. J. Croke, and A. S. Kennedy of the Argonne National Laboratory. Their paper described the development and preliminary validation testing of a multiple source, computerized atmospheric dispersion model designed for operational use. It will be used in air resource management against data from a three-year, computerized inventory of sulfur dioxide air quality data recorded by receptors of the Chicago, Illinois, telemetered system.

Mr. Kenneth L. Calder (NOAA) of the DM presented "Some Aspects of Current Urban Pollution Models" which examined the basic structure of many current urban pollution models from the viewpoint of underlying assumptions and physical basis. Due to the complexity of most computer models, Mr. Calder recommends conducting a sensitivity analysis to identify the input parameters which most critically affect the concentration predictions.

Dr. Shin'ichi Sakuraba of the Meteorological Research Institute, Tokyo, presented "The Elevation of Tracer Cloud over an Urban Area." This analysis of tracer-dispersion data from Japan demonstrated that tracer cloud height increases in general with downwind distances from the source. It further showed that a greater rise of tracer cloud is evident as the terrain becomes more complicated; rise is minimum over flat terrain.

Dr. Glen R. Hilst of The Travelers Research Corporation analyzed the advent of computer-oriented simulation models of the physical and chemical system which produce varying levels of air quality in his presentation on "The Sensitivities of Air Quality Prediction to Input Errors and Uncertainities." Dr. Warren B. Johnson, Dr. F. L. Ludwig, and Mr. Albert E. Moon of the Stanford Research Institute reported on their study of the "Development of a Practical, Multipurpose, Urban Diffusion Model for Carbon Monoxide." Dr. Heinz G. Fortak of the Free University of Berlin presented a study on the "Numerical Simulation of the Temporal and Spacial Distributions of Urban Air Pollution Concentrations."

2.2 Carbon Monoxide Diffusion Model Study

The Coordinating Research Council (CRC) sponsored by the American Petroleum Institute, the Automobile Manufacturers Association, and the Air Pollution Control Office (APCO), supports a multimillion dollar research program on vehicle emissions related to atmospheric pollution. As part of the CRC organizational structure, the Air Pollution Research Advisory Committee (APRAC) develops basic information on the nature and effects of vehicle air pollution not only needed by industry to further reduce emissions through the development of improved equipment and petroleum products but also needed by the Government in establishing air quality standards and emission control requirements.

One project of APRAC is the development of mathematical models and methodologies which will predict the spread of automotive generated air pollutants throughout a city and which can be extended to predict how the contamination from such a city will spread throughout neighboring geographical regions. The Division of Meteorology (APCO) shares in the direction and helps to support financially this modeling project, under contract to Stanford Research Institute (SRI).

The SRI has been directed to develop the means to predict the distribution of carbon monoxide, CO, as an inert pollutant, in several cities and to initially validate the prediction methods with existing data; later validation will be attempted in tests to be conducted in two cities. Ultimately, the aim of the project is the development of a model that can be applied to <u>all</u> automotive air pollutants, including those subject to chemical and physical transformations. The progress in the development of two types of diffusion models for CO has been reported by Johnson, et. al. (1970).

A "synoptic" model, which calculates hour-to-hour concentrations for verification studies and possible operational use, is based on a modification of Clarke's (1964) receptor-oriented model. The final version of the model for the DM provides for the handling of extraurban as well as intraurban sources; furthermore, a "street submodel" was developed to convert intraurban background to street-level concentrations.

A climatological model was developed to calculate arithmetic mean concentrations and frequencies of extreme concentrations for planning use. The climatological model uses a joint probability density function for all combinations of specified classes of the input parameters as derived from a large body of hourly meteorological data. Based on statistical relationships by Larsen (1969), the model output can be used to calculate the magnitude of high-percentile and maximum concentrations for any averaging time.

To facilitate modeling development for DM, SRI used modern computer techniques for applying objective contour analysis and graphical display. A computer analysis and display technique is exemplified in figure 2-1 which shows objective isolines describing the CO concentration distribution over Washington, D. C., on the basis of a grid of point values calculated by the diffusion model. The objective analysis is superimposed upon the primary traffic network for Washington, D. C. The analysis shown in figure 2-1 was based upon calculated CO concentrations over a 25 x 25 grid of 625 points. For comparison, a manual analysis and contouring of the identical data is shown in figure 2-2.

Objective techniques for converting traffic data to a time- and

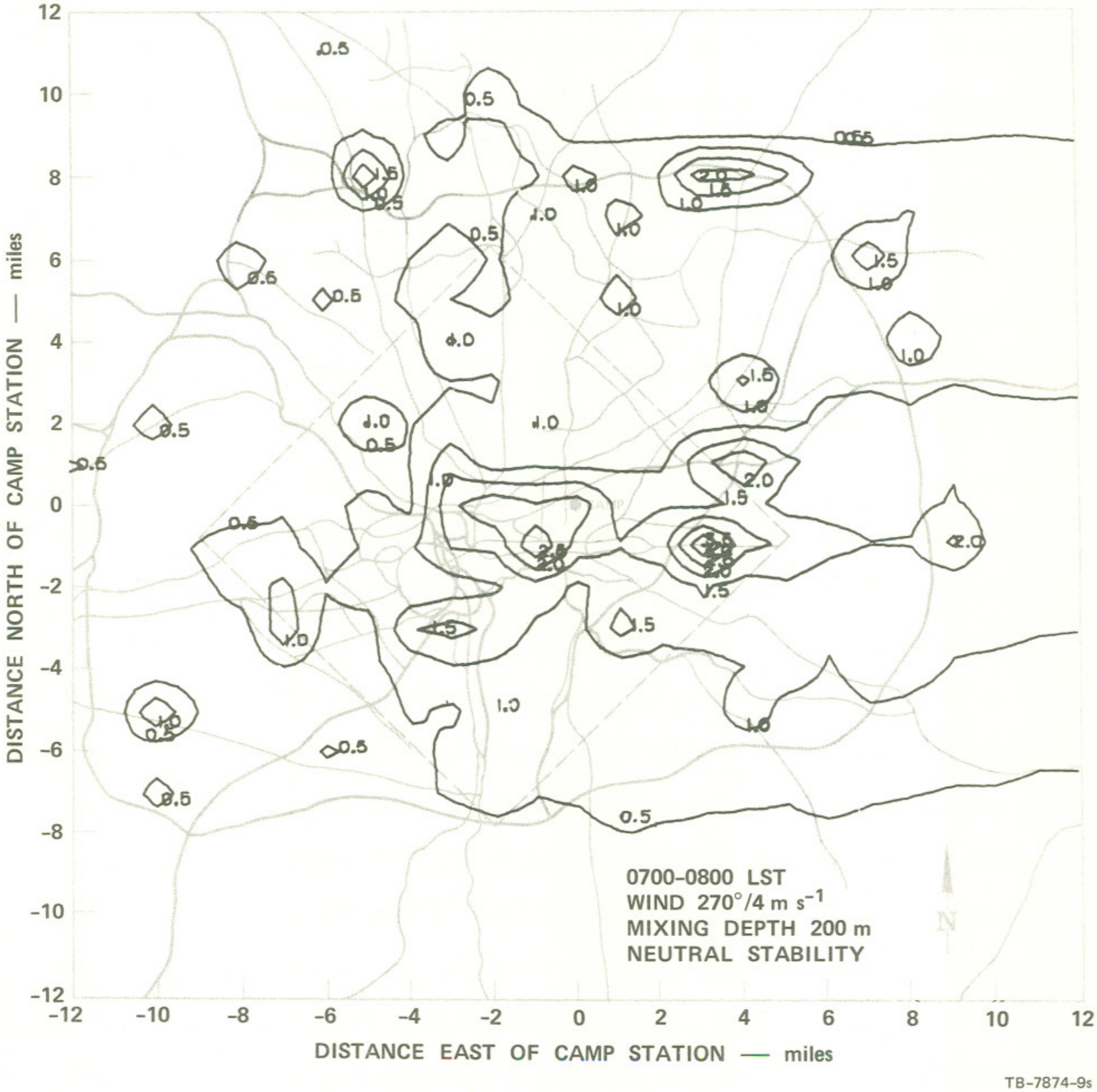


Figure 2-1. Computer calculated intraurban background carbon monoxide concentration (parts per million) distribution over Washington, D. C. area--Computer-generated contour analysis and graphic display (after Johnson, et.al., 1970).

sample, appears to be quite satisfactory. The ratio of standard devia-

for all hourly SO predictions is 0.93. For six-hour

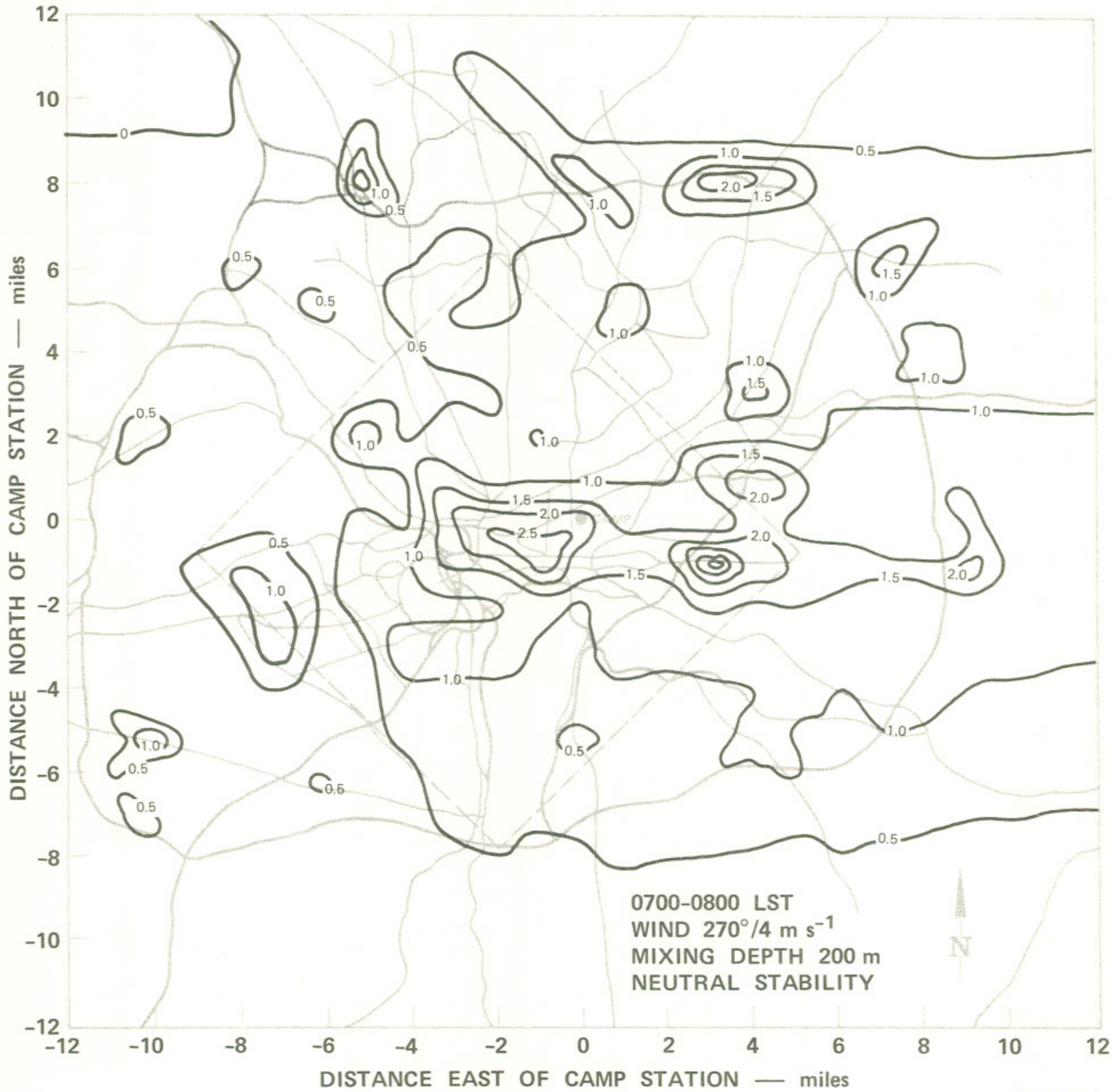


Figure 2-2. Manual calculated intraurban background carbon monoxide concentration (parts per million) distribution over Washington, D. C. area--Hand-contoured analysis and graphic display (after Johnson, et al., 1970)

space-dependent CO emission inventory have been developed by SRI, as well as methods for estimating the meteorology (appropriate to the urban area) from routinely available (airport) weather data. The accuracy of these methods will limit the prediction accuracy of the diffusion models.

Future work will consist of field experiments by SRI in San Jose, California, and St. Louis, Missouri, to refine and validate the developed models. San Jose was selected as an experimental city for its excellent computerized traffic-monitoring network. Particular attention will be given to determining the effects of nearby sources (traffic) on CO concentrations near streets adjacent to closely spaced buildings, and to examine the variations in these effects caused by meteorological factors.

2.3 Urban Dispersion Model

During Fiscal Year 1970, the DM with the Atomic Energy Commission (AEC) jointly sponsored studies by the Argonne National Laboratory and the Chicago Department of Air Pollution Control in the development and testing of an urban dispersion model. Following the New York University work of Davidson, as presented at the University of North Carolina Modeling Symposium, an "integrated puff" model was devised and tested using Chicago Telemetered Air Monitoring (TAM) network data. The multiple-source computerized atmospheric dispersion model was formulated and programmed for the IBM 360-75 computer system. The model has been tested against hourly average SO_2 data from five Chicago air quality monitoring stations. This statistical sample of approximately 2300 data points is available. The performance of the model, tested against this sample, appears to be quite satisfactory. The ratio of standard deviation to mean values for all hourly SO_2 predictions is 0.93. For six-hour average predictions, this ratio is 0.64 and for 24-hour average predictions it drops to 0.43. Over 66% of the 24-hour average SO_2 predictions are within $\pm$ 0.05 ppm of observed values and approximately 90% are within $\pm$ 0.1 ppm of actual dosages.

Hourly time series plots of observed and actual SO_2 concentrations indicate that the model is sufficiently accurate to test selective hypotheses about the model itself and to evaluate urban air resource management strategies.

"An Urban Atmospheric Dispersion Model", presented by the Argonne investigators as a preliminary paper in October 1969, will be published in the Proceedings of the Symposium on Multiple Source-Urban Dispersion Models. The final report will discuss the results of further validation tests and report the conclusions of the comprehensive three-year study.

2.4 Urban Air Pollution Prediction Model

Most multiple source urban air pollution models are based on the Gaussian plume representation for the concentration field from a single source. Such models are used for predicting both short-term and long-term characteristics of urban pollution distribution. A contract was placed with Geomet, Inc., Rockville, Maryland, in June 1970 for the critical evaluation of the predictive accuracy of these models. In addition, the sensitivities of model predictions to errors and uncertainties in the input parameters and variables will be determined. The ultimate aim of this study is to define the limitations of this class of air pollution models.

An urgent need exists for a second generation of urban pollution models of a less empirical nature more closely related to the known physical structure of the urban boundary layer and the physio-chemical properties of major pollutants. A contract was issued to the Center for the Environment and Man, Hartford, Connecticut, in May 1970 to demonstrate the feasibility of a mathematical-physical urban pollution prediction model capable of simulating urban-rural meteorological differences with simultaneous inclusion of pollutant concentration as a dependent variable of the model. The study will adapt available numerical boundary layer models to provide a system of simultaneous (coupled) partial differential equations capable of simulating not only the evolution of the purely meteorological fields in the boundary layer but also that of pollutant concentration.

An improved understanding of the time and space variability of air quality on time scales of two hours and longer on a minimum space scale of 5,000 feet for urban, suburban, and rural locations is mandatory for improved understanding of air quality distributions and their simulation by models. To help accomplish this, a contract was awarded to The Research Center of New England, Hartford, Connecticut, in June 1970. The observations to be used in this study are SO_2 and particulate concentration data obtained during the verification phase of a regional air quality model for Connecticut.

2.5 Wind and Water Tunnel Models

A comprehensive review of the literature on wind and water tunnel modeling of atmospheric dispersion is being conducted to evaluate the usefulness of such a modeling facility for the APCO. The areas covered by the study include the wind and thermal fields around buildings and building complexes, the effects of topography on pollutant dispersion, the dispersion of pollutants from power plants and within urban complexes, and plume rise under various classes of stability.

A review (Snyder, 1970) of several recent papers has shown that, in general, it is not feasible to model areas larger than about five kilometers in the horizontal using current techniques unless the flow is dominated by topographic controls. The coupling of cross-wind shear with turbulent diffusion dominates ordinary turbulent diffusion beyond this distance. With conventional wind tunnels, it is not possible to create a cross-wind shear; therefore, it is impracticable to model atmospheric dispersion in large metropolitan areas. Smaller scale studies, however, do appear to hold promise. Various methods of generation of cross-wind shear in wind tunnels are being considered.

3. AIR POLLUTION FORECASTING AND CLIMATOLOGY

3.1 Air Pollution Potential Forecasting

During the past year, 18 episodes of high air pollution potential were forecast by National Meteorological Center (NMC) meteorologists. There were ten episodes lasting a total of 28 days in the Eastern United States and eight episodes lasting a total of 40 days in the Western United States.

NOAA's Environmental Meteorological Support Units issued local statements of high air pollution potential on a total of 38 days. These included 12 days for Chicago, 10 days for Washington, D. C., 3 days for New York City, 9 days for Philadelphia, and 4 days for St. Louis. Almost all local statements coincided with a national advisory of high air pollution potential.

A stagnation index developed by the DM based on observed and forecast precipitation and humidity, 500 mb vorticity, and wind speed and temperature change 5000 feet above the surface, has been successful in delineating the most probable areas (caution areas) for high air pollution potential. Presently, forecasts of stagnation index for periods up to 48 hours are subjectively evaluated from the output of a CDC 6600 computer. The index will soon be depicted and analyzed on a facsimile chart available on the Weather Bureau's FOFAX service. The 4-panel facsimile chart will contain the observed 1200Z index and forecasts out to 36 hours at 12-hour intervals. An example of the facsimile chart is shown in figure 3-1. The upper left panel (fig. 3-1-a)contains the analysis of observed stagnation areas, mixing depths, and average transport wind speeds for the morning period. Figure 3-1-b contains a 12-hour forecast of stagnation areas, mixing depths, and transport wind speeds valid at 0000Z the following day. Figure 3-1-c contains a 24-hour forecast of the stagnation index valid at 1200Z the following morning. Figure 3-1-d contains the 36-hour stagnation forecast and the 36-hour composite stagnation area. Normally, a large composite stagnation area is a necessary, but not sufficient, reason for issuance of a high air pollution potential advisory.

The FOFAX circuit is available at most Weather Bureau field stations. Consequently, the stagnation index facsimile chart can also be used as guidance by field stations for the issuance of local statements of high air pollution potential.

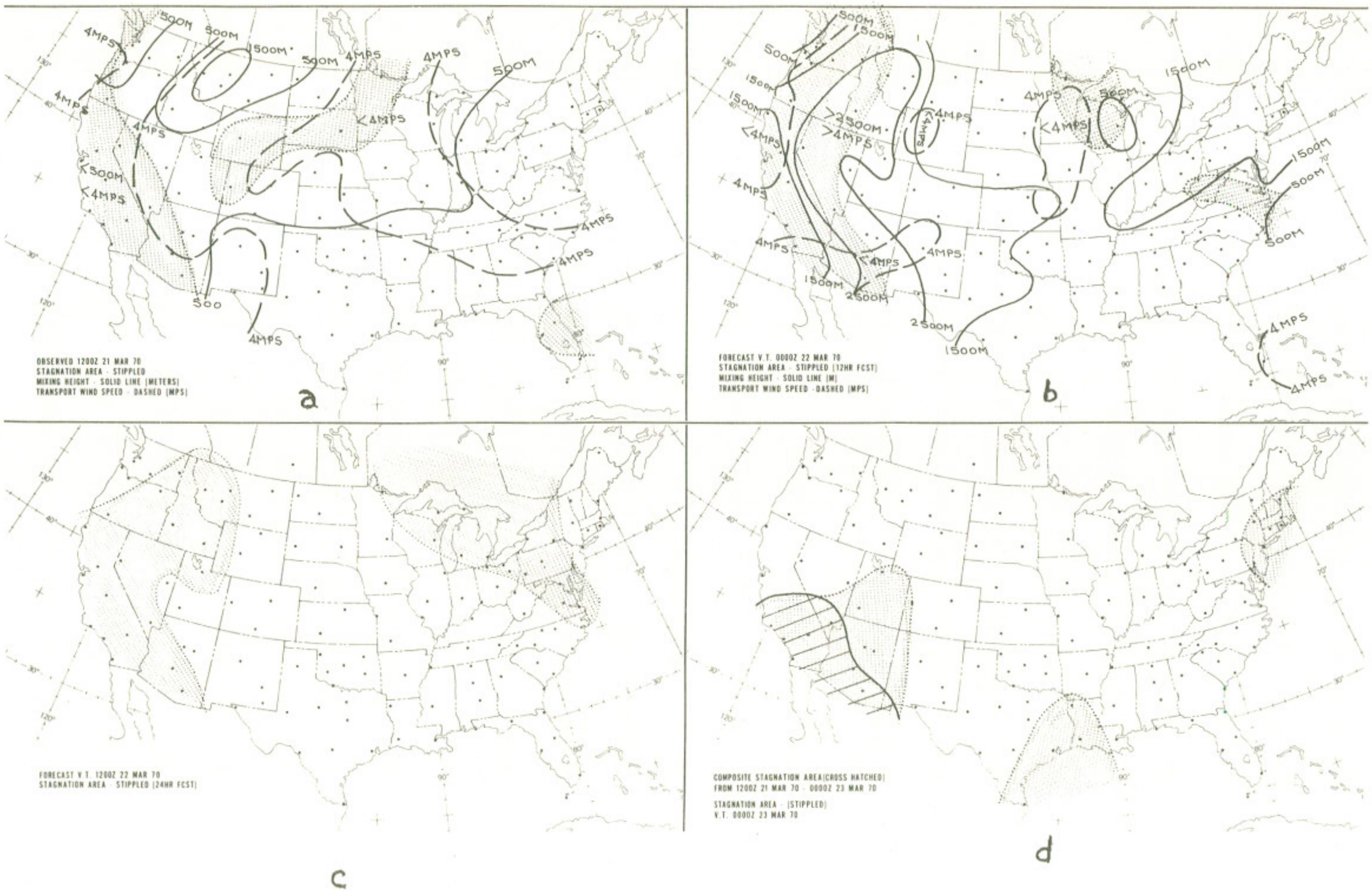


Figure 3-1. Sample facsimile transmission.

3.2 Climatology Study of 48 Contiguous States

A first draft of this study, intended for APCO publication, is near completion. The study was described in our previous Fiscal Year Summary Report. Figures for the 48 contiguous states will include the following seasonal and annual isoline analyses:

Mean urban morning mixing height

Mean afternoon mixing height

Mean wind speed through morning mixing height

Mean wind speed through afternoon mixing height

Theoretical normalized concentrations averaged over city (averaged over city sizes of 10 kilometers to 100 kilometers)

Theoretical normalized concentrations in this study are based upon an urban dispersion model of Miller and Holzworth (1967) in which the independent variables are mixing height, wind speed, and city size (along-wind distance across the city). Fifty charts are enumerated. Theoretical normalized concentrations for city sizes between 10 and 100 kilometers may be interpolated linearly for all practical purposes. Figure 3-2 shows isopleths of median annual morning $\bar{\chi}/\bar{Q}$ values for 10- and 100-km cities. Highest $\bar{\chi}/\bar{Q}$ values are centered over Oregon where for 10-km cities a value of almost 40 sec m^{-1} is indicated. When such small cities in that area grow to 100 km, theoretical concentrations are expected to increase by a factor of about eight, to more than 300 sec m^{-1}. East of the Rockies, the median annual morning $\bar{\chi}/\bar{Q}$ values for 10-km cities vary only between 9 and 13 sec m^{-1}; for 100-km cities the values are generally three to five times greater, except along much of the Atlantic and Gulf Coasts where the factor is approximately two. Assuming the current size of New York City is 50 km,

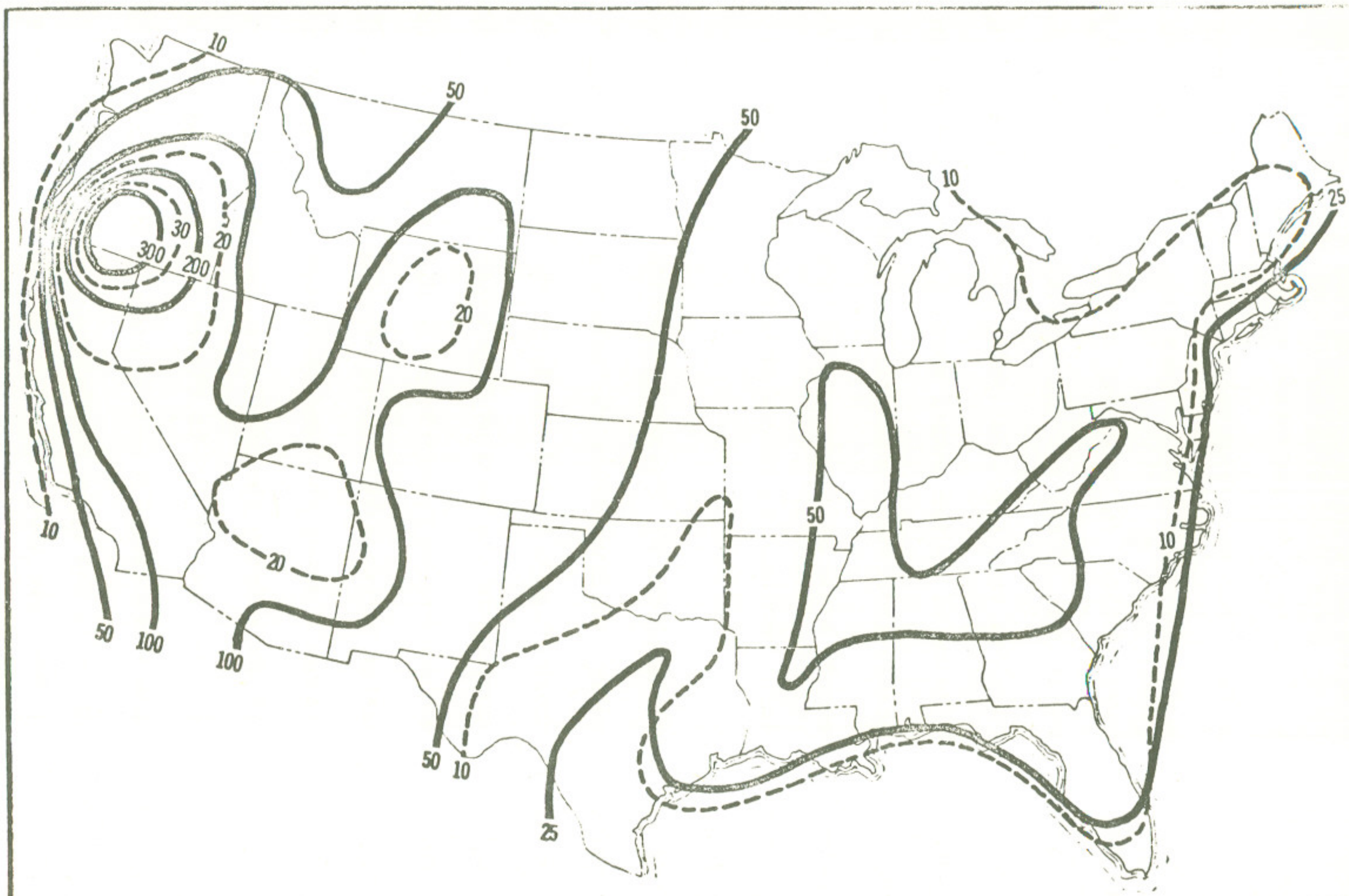


Figure 3-2. Isopleths of median annual morning $\overline{X}/\overline{Q}$ values (sec/m; see text) for 10-km (broken) and 100-km (solid) city sizes.

the interpolated $\bar{X}/\bar{Q}$ value is 13 sec m^{-1}. When that city doubles in size, the median annual morning concentration will increase to only 19 sec m^{-1}, which is less than the 10-km value over parts of Arizona, Wyoming, Oregon, Nevada, and California. Along the southern California Coast the median annual morning $\bar{X}/\bar{Q}$ value for a 50-km city (about 10 km too small for Los Angeles) is 36 sec m^{-1} and is almost three times the corresponding value for New York City, but only one-fifth the value in southern Oregon. In terms of median annual morning values the meteorological potential clearly indicates substantially higher theoretical concentrations in several areas of the west than in the east, for both large and small cities. Morning $\bar{X}/\bar{Q}$ values are generally highest in summer and autumn.

Figure 3-3 shows isopleths of $\bar{X}/\bar{Q}$ values exceeded on 10 percent of all mornings annually. In some areas the values are much greater than on the median chart (fig. 3-2) and the isopleth patterns are much more intense. For example, in the area of high upper decile concentrations extending from the northern Appalachians to Mississippi the values for 10- and 100-km cities increase by factors of around 7 and 15, respectively, over median values. About the same increases occur over Minnesota. In the western half of the country the increases are mostly by factors of 2-3 for 10-km cities and 3-4 for 100-km cities, except along the Pacific Coast where the increases are around 4 and 8, respectively. In contrast to the median chart (fig. 3-2), the upper decile chart shows that high $\bar{X}/\bar{Q}$ values in the east and west are about equal; values are almost as high over the upper Plains. It is interesting that the upper decile theoretical concentration for New York City (S = 50 km) is 65 sec m^{-1}, whereas a few hundred miles to the southwest over West Virginia the corresponding value

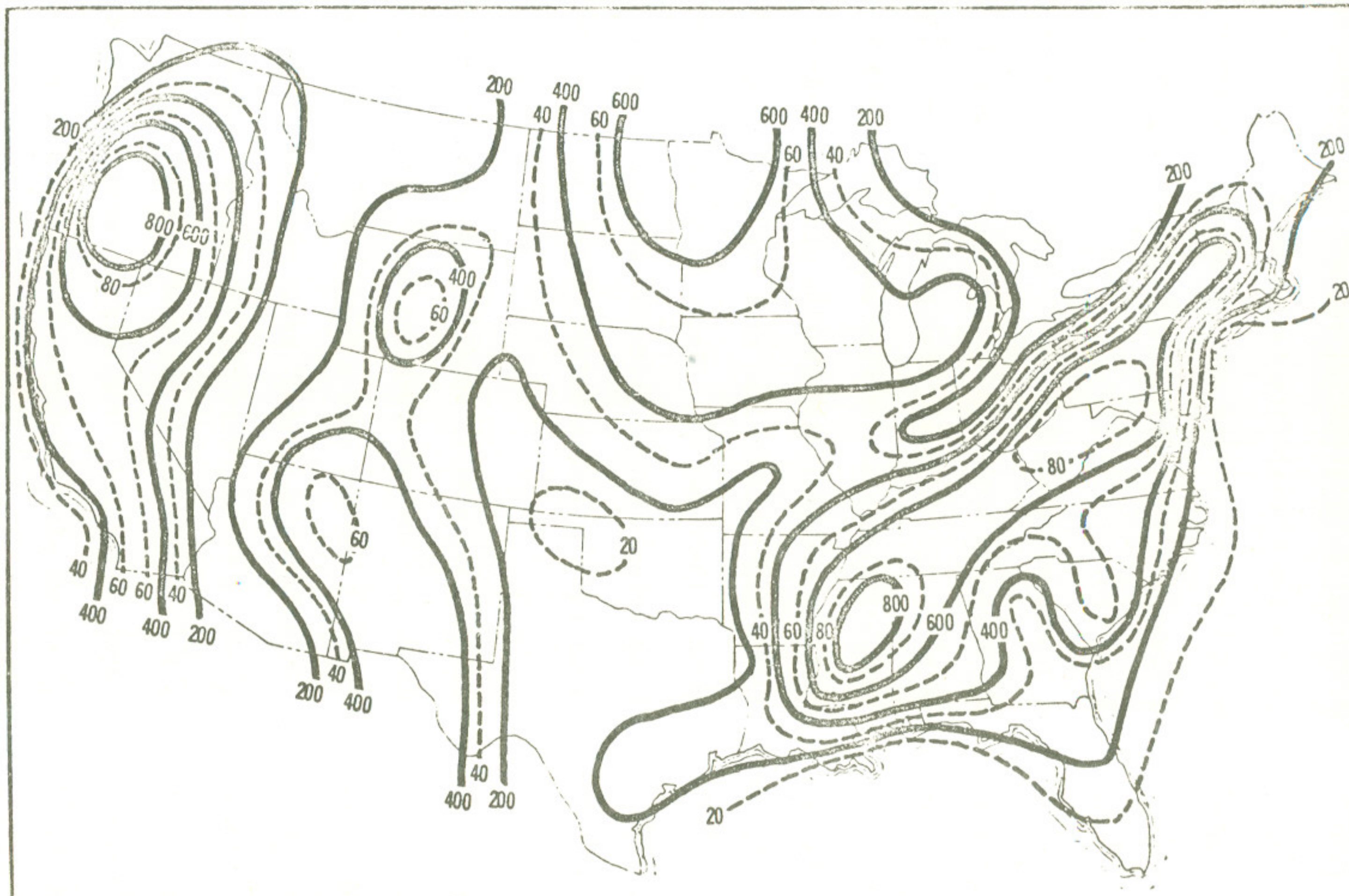


Figure 3-3. Isopleths of $\overline{X}/\overline{Q}$ values (sec/m; see text) exceeded on 10 percent of mornings annually for 10-km (broken) and 100-km (solid) city sizes.

is 375 sec m^{-1} and at Chicago it is about 220 sec m^{-1}. At Los Angeles the upper decile $\bar{X}/\bar{Q}$ value for a 50-km city is 210 sec m^{-1} and in southern Oregon it is more than 400 sec m^{-1}. Over much of Texas and Oklahoma as well as other smaller areas the upper decile $\bar{X}/\bar{Q}$ values are less than 200 sec m^{-1} for 100-km cities.

Figure 3-4 shows isopleths of median annual afternoon $\bar{X}/\bar{Q}$ values for 100-km cities. No isopleths are shown for 10-km cities because all values are 9 or 10 sec m^{-1}. This happens because the afternoon mixing heights are so high that pollutants are carried beyond the downwind edge of the city before a uniform vertical distribution within the mixing layer is achieved. To a large extent this is also true for 100-km cities whose range of $\bar{X}/\bar{Q}$ values is only 13-26 sec m^{-1}. Thus, in terms of median annual afternoon $\bar{X}/\bar{Q}$ values, the meteorological potential for urban air pollution varies only slightly over the contiguous United States, even for 100-km cities.

Figure 3-5 depicts the isopleths of upper decile annual afternoon theoretical concentrations for 10- and 100-km cities. For 10-km cities most values are 10-15 sec m^{-1} and are only a few sec m^{-1} greater than median values; 15 sec m^{-1} is exceeded only in small areas centered in Wyoming and Oregon. Similarly for 100-km cities, most $\bar{X}/\bar{Q}$ values are between 20 and 50 sec m^{-1}, but 50 sec m^{-1} is exceeded in the west around peak values of 106 and 150 sec m^{-1}. Most of the relatively high afternoon concentrations occur in winter when afternoon mixing heights are usually lowest. It is only in the two aforementioned western areas where relatively high afternoon concentrations (fig. 3-5) are approximately coincident with areas of relatively high morning concentrations (figs. 3-2 and 3-3). Such a situation is clearly

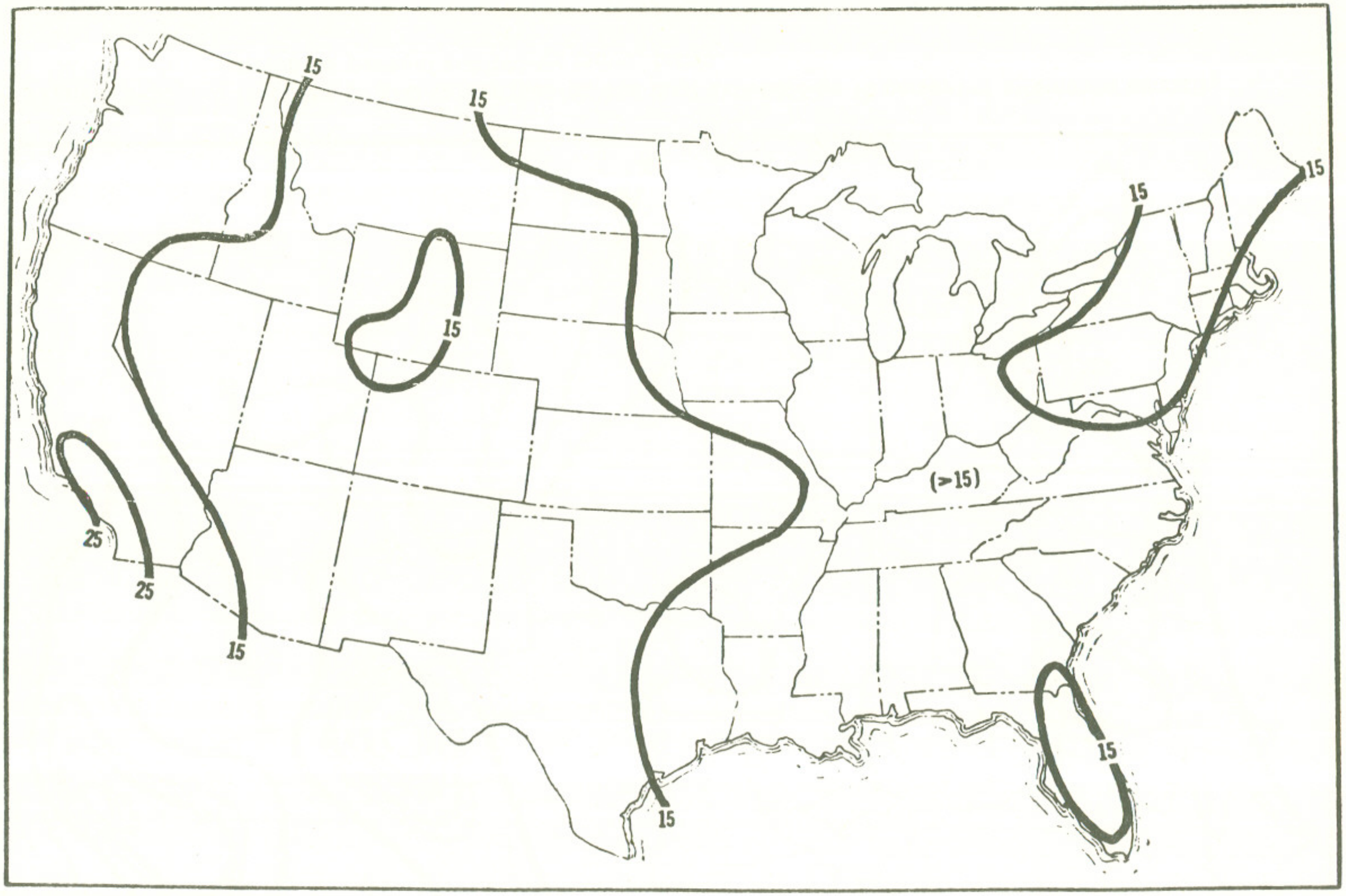


Figure 3-4. Isopleths of median annual afternoon $\overline{X}/\overline{Q}$ values (sec/m; see text) for 100-km (solid) city sizes. For 10-km cities all values are 9 or 10 sec/m.

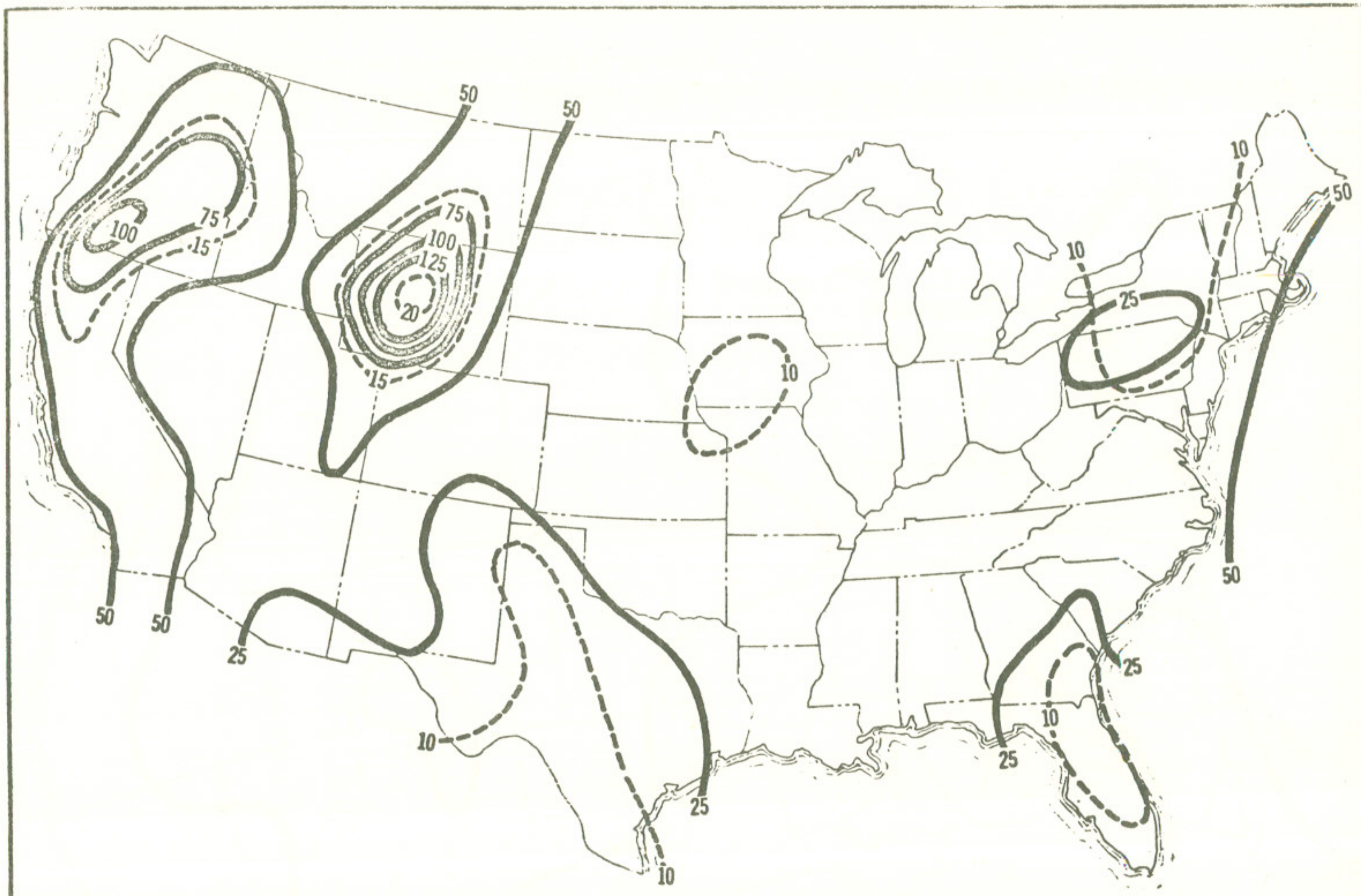


Figure 3-5. Isopleths of $\overline{X}/\overline{Q}$ values (sec/m; see text) exceeded on 10 percent of afternoons annually for 10-km (broken) and 100-km (solid) cities.

undesirable. Fortunately, large cities do not exist in Wyoming and Oregon where the relatively high morning and afternoon concentrations are highest.

3.3 Meteorological Support to the Emergency Operation Control Center (EOCC)

During the past year, the DM provided operational support to APCO's Emergency Operation Control Center (EOCC). The EOCC was established within the Division of Abatement to enable the APCO to meet its responsibility under Section 108 (k), Air Quality Act of 1967, to take steps to prevent imminent and substantial endangerment to the health and welfare of persons from air pollution.

National advisories from NOAA's National Meteorological Center and local statements of high air pollution potential are interpreted for the EOCC by the DM forecaster. Special briefings on weather conditions and extended time forecasts for possible high air pollution potential areas are provided on request or when conditions warrant.

The EOCC routinely supplies to the DM forecaster (on a real-time basis) the average daily and maximum hourly concentrations of carbon monoxide, sulfur dioxide, oxides, and hydrocarbons for the six Continuous Air Monitoring Program (CAMP) stations. During high air pollution potential episodes air quality data are also received from other cities within the advisory area. The air quality data are used to monitor the day-to-day accumulation of pollution within the advisory area and to aid in evaluating the criteria for high air pollution potential.

4. INSTRUMENTATION DEVELOPMENT

4.1 Radiometric Thermasonde

In recent years, advances in instrumentation for measuring meteorological parameters relevant to air quality management have emphasized remote sensing techniques. A knowledge of the vertical profiles of wind and temperature within the planetary boundary layer is fundamental for describing the transport and dispersion of pollutants emitted into the lower atmosphere, usually near the surface.

Recognizing the limitations of conventional sounding techniques, particularly for gathering the required data in urban areas, the APCO began support of the development of remote sensing techniques by contracting with Sperry Rand Corporation in 1966 to develop radiometric techniques for measuring temperature profiles. Three years of research have yielded an operational prototype MARK I millimeter radiometer operating at a frequency of 54.5 gHz, named the Radiometric Thermasonde (Mount, 1970).

After accepting the MARK I in February 1969, the DM initiated a testing program during which the MARK I was operated, subjected to the full range of environmental conditions at five locations in the continental U. S. Shipping via commercial carrier between the test sites provided some rather severe mechanical shocks resulting in minor damage only once, which did not disable the MARK I. During the test period, the MARK I required no maintenance other than infrequent cleaning of air filters and replacement of several pilot lamps. Periodic checks of local oscillator frequency and overall radiometer sensitivity demonstrated the very good stability of the MARK I, and, at the end of the test period, the instrument had not deteriorated significantly in any respect.

The MARK I is being modified to increase its sensitivity, and the damage sustained in shipping has been repaired. Modifications should be complete by mid-September 1970 at which time the MARK I will be returned to field operation.

During testing of the MARK I, more than 100 radiometric soundings of the lower atmosphere were made in conjunction with simultaneous vertical temperature profile measurements by direct means (radiosonde and/or instrumented helicopter). An example of comparative soundings is shown in figure 4-1. The radiometric data were analyzed using semi-empirical techniques developed by Sperry Rand and then compared to the corresponding directly measured profiles. These comparisons indicate that available data reduction techniques are useful in describing all types of vertical temperature profiles within the first 1500 meters above the ground. However, the perfection of a technique to depict elevated inversions requires further research.

Alternate radiometric data processing techniques have been investigated. One technique proposed by NOAA's Wave Propagation Laboratory (WPL) was tested on real data with promising results. Other techniques are being investigated by the Sperry Rand Corporation and the DM scientists.

During FY 1971, efforts will continue in the perfection of radiometric data reduction techniques. The MARK I will be operated at St. Louis, Missouri, for further performance testing.

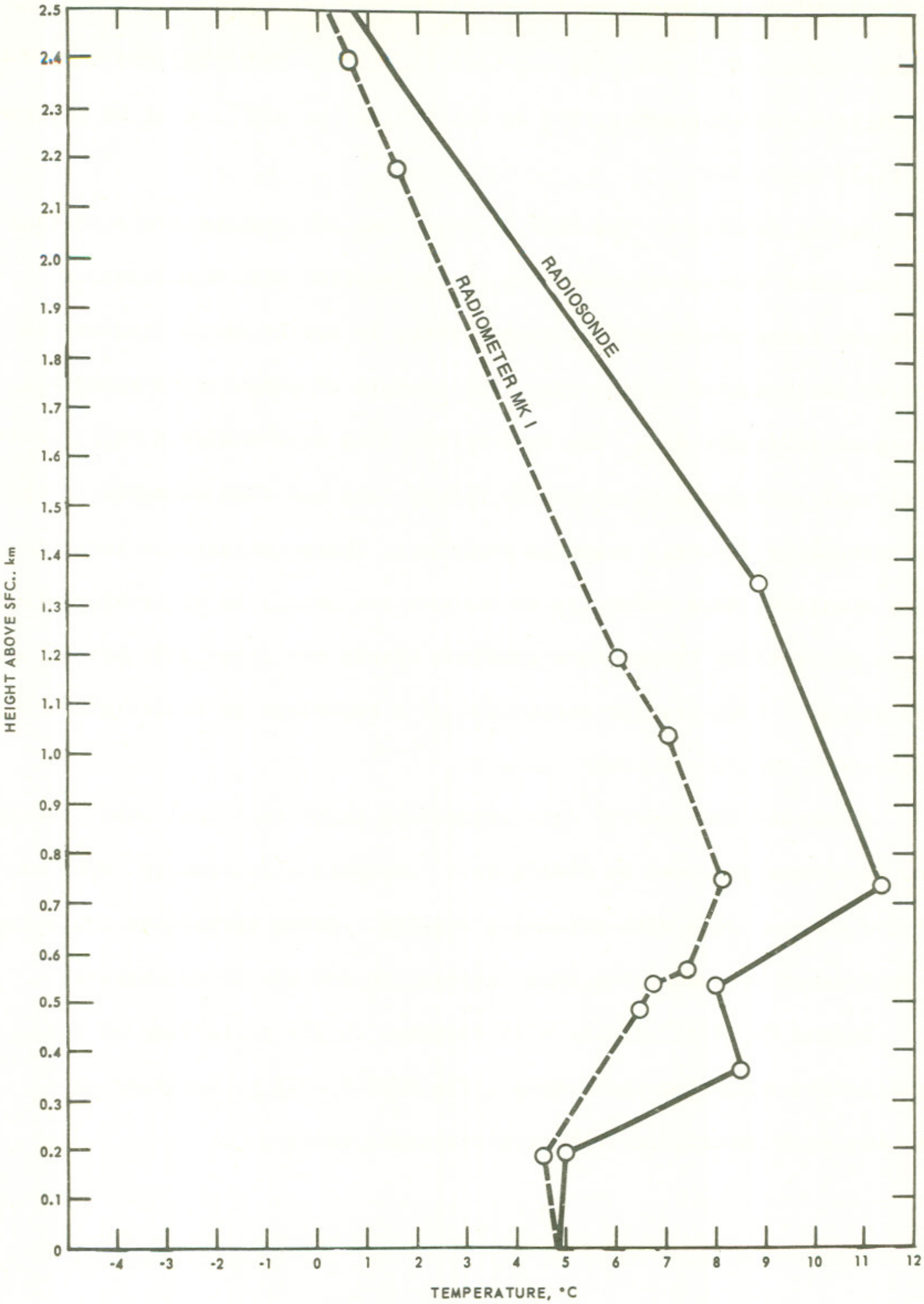


Figure 4-1. Example of vertical temperature profiles taken by thermasonde and radiosonde.

4.2 Acoustic Sounding System

The DM supported the WPL in the development of an acoustic radar system to probe the wind and temperature profile in the planetary boundary layer. The basic technique has been described (Little, 1969, McAllister, et. al., 1969). Preliminary experiments and theoretical investigations confirm the applicability of the acoustic sounding technique, using existing equipment, to indicate the structure of the turbulent eddies in the boundary layer.

An extensive effort by WPL has been directed toward the development of an antenna system to minimize interference from outside noise sources and to avoid adding significantly to the local environmental noise interference. Both theoretical and experimental work is continuing on the solution of this critical problem.

4.3 Laser Probing Technique

Another remote wind sensing technique investigated by WPL and partially supported by the DM is the laser probing technique. The basic concept was outlined by Fisher and Damkevala (1969). It was shown, in experiments conducted by the WPL, using a CW argon laser, that atmospheric aerosol fluctuations illuminated by a laser beam could be detected by a telescope. By using two telescopes to view a common atmospheric cell, the atmospheric fluctuations were correlated. Correlation coefficients near one were obtained. Next, two separated beams were used to illuminate two separated cells. Wind speed was determined using the time delay and cell separation. Later experiments showing considerable promise were made using a pulsed N_2^{++} laser. Work is continuing using the pulsed laser system.

5. FIELD STUDIES

5.1 Large Power Plant Effluent Study (LAPPES)

The Large Power Plant Effluent Study (LAPPES) is now in its third year at the coal-burning generating station complex in western Pennsylvania. The LAPPES project was undertaken to determine the extent and effects of air pollution produced by one of the largest complexes of coal-burning power plants in the United States. Three mine-mouth stations, designed to collectively generate 4880 megawatts of electrical power, are located approximately equidistant along a NW-SE line 39 kilometers long, about 80 kilometers east northeast of Pittsburgh. When fully operational, these stations will emit more than 2000 tons of sulfur dioxide (SO_2) daily into the atmosphere through four 244-meter and two 305-meter stacks.

In an attempt to resolve some of the more pressing questions regarding tall stack dispersion and associated ground-level concentrations, the DM is conducting and sponsoring comprehensive field studies in the western Pennsylvania area. Specifically, three objectives are being pursued:

(1) To develop and validate transport and diffusion models capable of calculating ground-level concentrations of effluents from large power plants with tall stacks.

(2) To measure the magnitude, frequency, and spatial distribution of ground-level pollutant concentrations from large power plants

with tall stacks, singly and in combination, and to compare the observed data with calculated predictions.

(3) To evaluate the effects of sulfur compounds and other effluents from a large power plant complex on vegetation in the region of the installations.

Field studies conducted during the past year to meet these objectives consisted of two month-long series, the seventh and eighth since LAPPES was initiated. Half of the 1969 fall series was conducted on the Keystone Station Site; the remaining half of the fall series and the 1970 spring series monitored effluent from the Homer City stacks. Aerometric sampling of the plume was performed on 33 days during the two scheduled periods. On 24 days plume flights could not be made due to adverse weather conditions, power plant outage, or helicopter malfunction. A total of 145 hours of helicopter time was used during the two series.

Series observations by the DM personnel included extensive SO_2 concentration measurements in the plume aloft and at the earth's surface using a specially instrumented helicopter with a fast response SO_2 detector system. Helicopter measurements of ground-level SO_2 concentrations were complemented with a series of consecutive 30-minute samples made by ten bubblers on the ground beneath the plume. Placement of these portable units was dependent on helicopter location of the plume aloft and usually spanned the expected lateral projection to the ground of the plume aloft, ranging from near the plant to as far out as 26 kilometers.

Both before and after the daily airborne operations, radiosondes were released at the local airport. Although detailed helicopter temperature measurements revealed the stability through the plume's vertical extent, the radiosondes detected such other pertinent features as subsidence inversions aloft. Between these two releases, double-theodolite pilot balloons were taken every 30 minutes at the station being sampled to provide wind data directly affecting plume dispersion.

The agricultural phase of LAPPES, conducted by Division of Economic Effects Research (DEER) personnel, included monitoring of selected trees and plants out to 72 kilometers distance from the power plant complex to determine the rate and extent of sulfur assimilation. This phase is supported by a lead peroxide candle network of 22 sites.

Two field experimental series are planned for fiscal year 1971 to be conducted at the Conemaugh Generating Station.

The large volume of data collected makes it impractical to list all the data in one published volume. Instead, three volumes are currently planned. The first (Schiermeier and Niemeyer, 1970), containing data from the four 1968 series, is now being printed. The second (Schiermeier, 1970), containing data from the three 1967 and 1969 series, has been submitted for publication. The planned final data volume will contain data from the 1970 and 1971 series.

With the compilation and final checking of the data for publication completed, analyses of the data was begun. For each sampling day, time-height charts of the temperature and wind speed have been drawn, from which the stability and wind speed applicable to any given plume observation can be obtained. Vertical distribution of SO_2 within the plume for stable conditions indicates the distribution is often skewed so that the peak crosswind integrated concentration is found above the plume centerline. On some days, there is a reasonable similarity between the distributions measured at the various distances from the plant. More often, there are sufficient differences to suggest that even though the plume outline (top and bottom) may be nearly constant, the distribution of stabilized plume elements within this outline must vary. This variation obscures the contribution of wind direction shear acting on the vertical distribution to the horizontal spreading of the plume. Nevertheless, pilot analyses are underway to quantify the contribution due to shear, as distinct from the spreading due to within-plume turbulence.

A contract was placed with Stanford Research Institute to assemble an improved lidar system, to make further plume measurements in support of the LAPPES study, and to assess the practicality of defining an urban-area aerosol envelope by lidar measurements.

The improved lidar system employs a ruby laser, permitting a higher signal-to-noise ratio than the neodynium laser previously used. A pulse repetition rate of 30 pulses per minute allows faster collection of data, and the new data display system, using a cathode ray tube to give a range-height display of a sequence of lidar shots, furnishes the operator an integrated qualitative picture of a set of shots within a few minutes of collection. The raw data remain stored on video tape for quantitative processing later. The optics of the new system were changed to improve eye safety so that the transmitted beam is slightly divergent. However, the receiver looks at a very narrow field of view retaining the spatial resolution of the previous system.

As part of the LAPPES field series in the spring of 1970, lidar observations of the plume from the Homer City plant were obtained during the final two weeks. About 500 plume cross sections were obtained, with measurements on different days made from just before sunrise until after sunset, so that samples were collected from a bread range of meteorological conditions. Some of the lidar measurements were obtained sufficiently close, temporally and spatially, to the helicopter cross sections to permit a comparison between the aerosol plume detected by the lidar, and the SO_2 plume measured by helicopter.

In the planned processing of the lidar data, analyses will be made of the "instantaneous" plume (actually about a 1-minute composite) in relation to the "mean" plume, deduced from a series of "instantaneous" pictures.

Additional lidar observations are planned for autumn, 1970, to obtain sets of cross sections of the aerosol envelope over an urban area. These cross sections will probably be obtained at a number of points along a downwind traverse across the area. Either Chicago or St. Louis is likely to be chosen for these observations.

5.2 Keystone Power Station Plume Study of Washout (LAPPES)

Conventionally, "washout" is defined by meteorologists as the precipitation scavenging process occurring below the cloud from which precipitation falls; "rainout" is concerned with the incorporation of the pollutant in the condensation process in the cloud. The scavenging processes by natural precipitation are complex and not readily understood, but these mechanisms of transferring airborne pollutants to the ground are pertinent to current air pollution problems. While washout may ameliorate air quality, this scavenging process can create problems at ground level by contaminating natural resources, agricultural crops, and communities.

The mechanism of washout may be pertinent to large pollutant sources, such as power plants, that produce plumes of high effluent (sulfur dioxide (SO_2) in the case of fossil fuel burning facilities) concentration for relatively long distances. Theoretically, precipitation scavenging of such plumes may cause localized hot spots on the ground at relatively long distances from the power plant site. In areas having frequent precipitation the deposition of sulfur acids or salts from power plant plumes may have deleterious effects.

A contract was negotiated with Battelle-Pacific Northwest Laboratories to assess the SO_2 washout of tall stack plumes as a function of precipitation, meteorology, and plume parameters. Three series of field experiments were conducted in the vicinity of the Keystone Power Station in western Pennsylvania in October, 1969, and in January and April, 1970. The experimental method consisted of the subsequent physicochemical analyses of the precipitation and the pollutants. Preliminary analysis of the data reveals some interesting aspects for speculation.

Rather low concentrations of SO_2 (<20μ moles dissolved SO_2/liter rain) were measured in the collected precipitation at distances of about 1 1/4 and 2 1/2 miles from the stack. Desorption of the SO_2 from the droplet, during its relatively long fall in the "clean" air beneath the plume, is suspected as a factor. The desorption effect is illustrated in figure 5-1. If this effect is real, it points out the futility of using a washout coefficient based on an irreversible removal process, to assess SO_2 precipitation scavenging for cases of significant clean-air fall distances. Further consideration of the desorption effect will require a more detailed account of the relationship between SO_2 absorption and solubility in precipitation, particularly as a function of airborne SO_2 concentration and precipitation acidity (pH). The relationship between air and water concentrations of SO_2, relative to its solubility, is indicated in figure 5-2.

5.3 Water Vapor from Cooling Towers

On June 23, 1969, a contract for a "Cooling Tower Study" was initiated with the Illinois Institute of Technology Research Institute. Preliminary results are given here, as the final report from this contract will not be available until mid-FY 71.

The purpose of this study was to describe and evaluate the potential effects of emission of water vapor and heat from cooling towers on local environment, climate, and power plant plumes. In particular, aircraft measurements of temperature and humidity were made to determine the dimensions of the invisible water vapor plume.

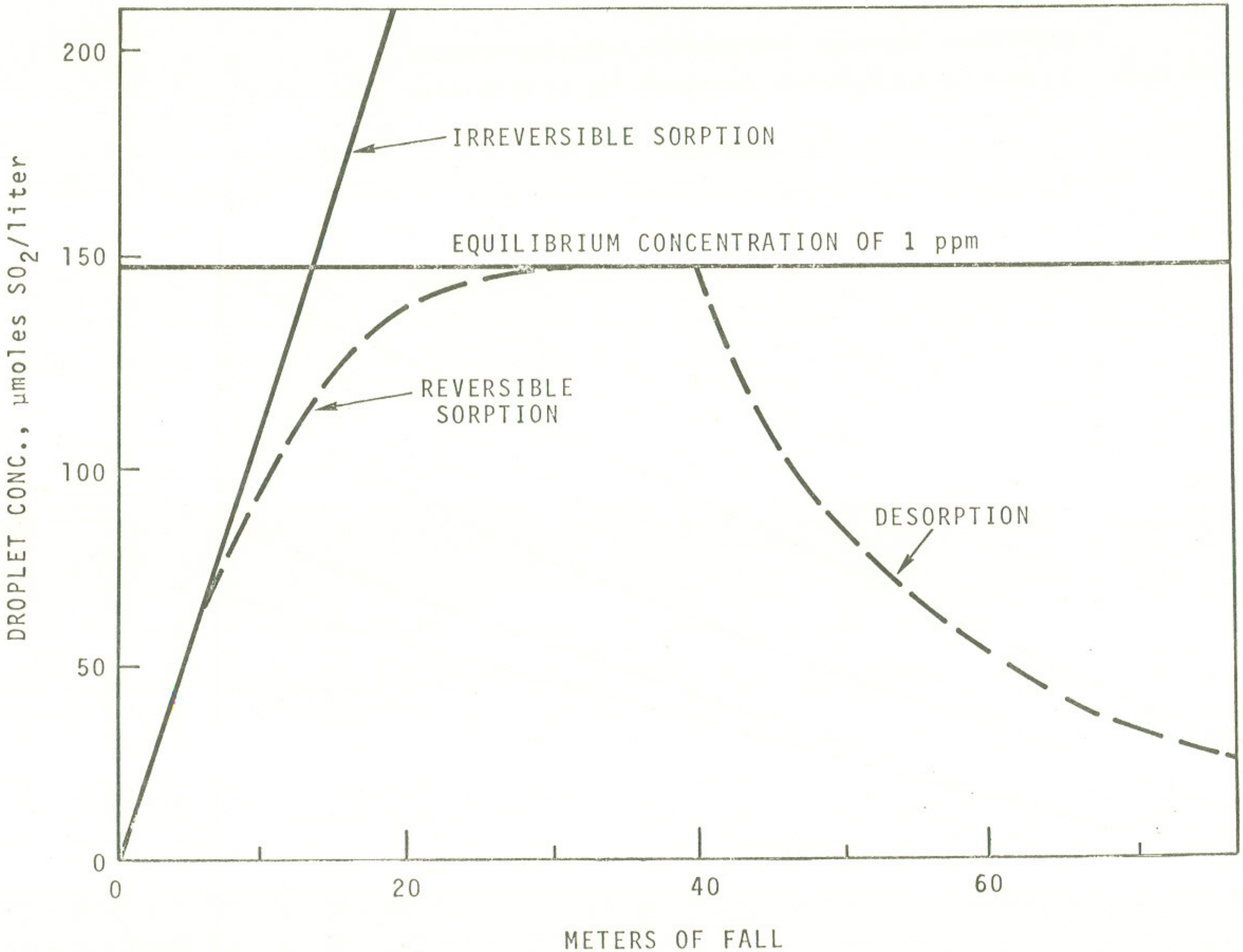


Figure 5-1. Sorption-desorption ratio of SO_2 (courtesy of Battelle-Pacific Northwest Laboratories, Richland, Washington)

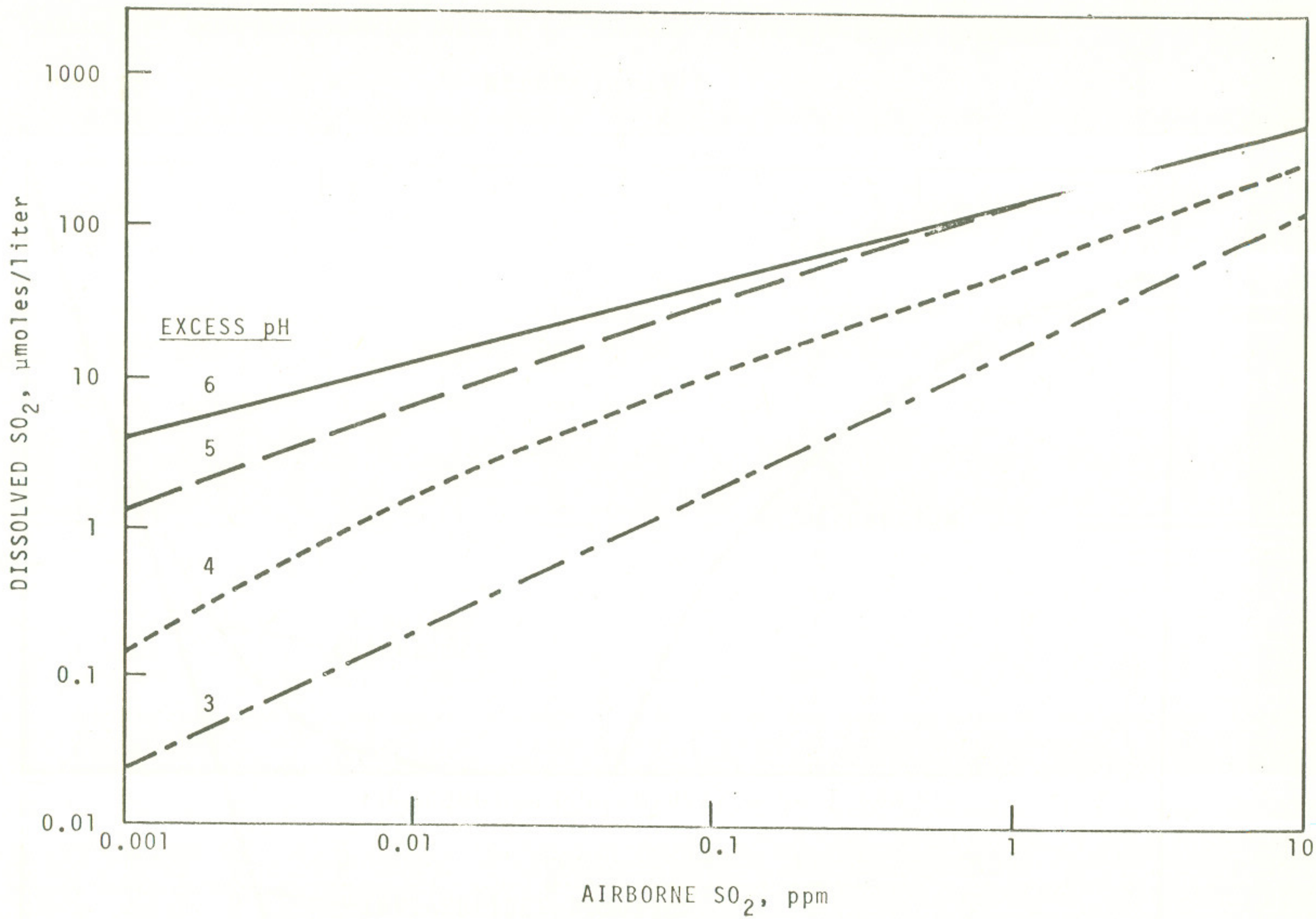


Figure 5-2. Dependence of SO_2 solubility on precipitation acidity. (Courtesy of Battelle-Northwest Laboratories, Richland, Washington)

Data were collected for this contract during ten days in December, 1969. A helicopter was used in measuring air temperature and dew point downwind of the cooling towers. On one occasion, the invisible water vapor plume was detected by differences in dew point six miles downwind. However, differences in air temperature between the invisible plume and ambient air could not be detected at this distance. During several flights, the cooling tower plume subsided about 200 feet after its initial buoyancy had been overcome.

On several occasions, it was observed that the stack plume and cooling tower plumes merged soon after entering the atmosphere. The helicopter crew collected water droplets from the cooling tower plume and measured their pH. Acid plume droplets of pH 4 to 5 were found frequently, and droplets of pH 2 to 3 were also observed. This suggests that SO_2 in the stack plume was rapidly oxidized in the high humidity conditions of the tower plume to form sulfuric acid (H_2SO_4).

5.4 TVA Plume Study

As part of its continuing investigation of the efficiency of stacks to disperse pollution, the DM and the Tennessee Valley Authority (TVA) jointly supported a study of inversion breakup at large power plants in the TVA area. A report summarizing the results was published in March 1970. The work confirms that inversion breakup occurs under appropriate meteorological conditions in the vicinity of the largest TVA plants studied.

Stable plumes were observed and measured as compact flat ribbons with variable lateral and minimum vertical dispersion. Thermally induced mixing subsequently built up through the plume and uniformly stirred the effluent to the ground. Maximum surface concentrations of plume effluent usually persisted for 30 to 45 minutes within a relatively narrow band at distances up to 20 miles from the source, as compared with 1 to 4 miles for the more common coning dispersion model. These surface concentrations of plume effluent depended on (1) plume height, (2) mean wind speed between stack top and plume top, (3) rate of transition from stable to unstable temperature gradient, and (4) distance from the emission source to the area of the initial breakup of that portion of the plume which was emitted immediately prior to the time the vertical mixing first reached stack-top level.

Further analysis of the data indicated that the SO_2 concentration distribution in the plume is Gaussian in the horizontal and uniform in the vertical directions during inversion breakup. As vertical mixing develops through the plume, there is an outward spread of the effluent which is attributed to increased wind direction fluctuation resulting from the stable to unstable temperature gradient transition.

5.5 Fate of SO_2 in Plume Gases

The American Petroleum Institute, the Bituminous Coal Research Inc., the Edison Electric Institute, and the DM jointly sponsored the GCA Corporation, Bedford, Massachusetts, in a comparative study on the fate of SO_2 in plume gases. The two year project terminated in FY 1970. The results of plume and stack measurements for pulverized coal and residual oil-burning power stations showed no statistically conclusive evidence of chemical loss of SO_2 from plumes due to a combination of environmental and sampling problems. However, limited data did indicate that the loss of SO_2 over distances of 0.5 mile to 20.0 miles was small when compared to the probable loss of SO_2 between the stack and 0.5 mile. In seeking a more definitive study, the joint steering committee redesigned the project and awarded a contract for a more comprehensive study of the fate of SO_2 in early plume history.

5.6 Urban Boundary Layer Study

A program to study the structure of the urban boundary layer was conducted in the Columbus, Ohio area during three experimental series (June 1968, September 1968, and March 1969). Meteorological measurements of wind, temperature, and radiation were made during 12 separate nights, normally commencing at sunset and continuing until sunrise.

Wind and temperature measurements were processed to obtain computer plots of wind profiles from each pilot balloon ascent, and cross section plots of the temperature structure from helicopter measurements. Manual analyses of the near-surface temperature and radiation temperature patterns were completed.

Partial analysis of the wind profile data indicated that small effects of the urban area tend to be obscured by the ascent-to-ascent temperature variability; mean profiles for each site and time group (up to six ascents per set) are therefore being computed in the expectation that the urban influence will be more clearly shown. As a first step in studying the urban heat budget, emission data to estimate combustion heating were requested from the Division on Air Quality and Emission Data.

5.7 Urban Trajectory Studies

Constant volume balloons (tetroons) flown across Columbus, Ohio, in March 1969, indicate that at night the city induces an average anticyclonic turning of about ten degrees at heights of 100 to 200 meters. Examples of sequential tetroon trajectories across the city under nearly isothermal conditions are shown in figure 5-3, where the numbers indicate wind direction change in degrees each ten minutes. In general, the anticyclonic turning was found to increase with height, and to be greater in inversion conditions than in lapse conditions. It is hypothesized that the anticyclonic turning is partly the result of the mesoscale high pressure system formed aloft due to warmer temperatures within the city. The abrupt decrease in wind speed and the oscillations set up along flight 21 shows that the downtown area may also act as a barrier to the air flow.

At heights of 100 to 200 meters, the tetroon-measured decrease in wind speed across the city averaged about 20 percent of the upwind speed in lapse conditions but was very small in inversion conditions. In both cases the region of maximum deceleration tilted downwind with height.

The wind speeds and directions form the tetroon observations were compared to winds derived from observed pressure gradients through the use of the geostrophic wind approximation. Hourly pressure values from two different 4-station "grids" were used to calculate winds. Figure 5-4 shows an initial comparison of the observed to the calculated winds and several theoretical solutions to the Ekman profile.

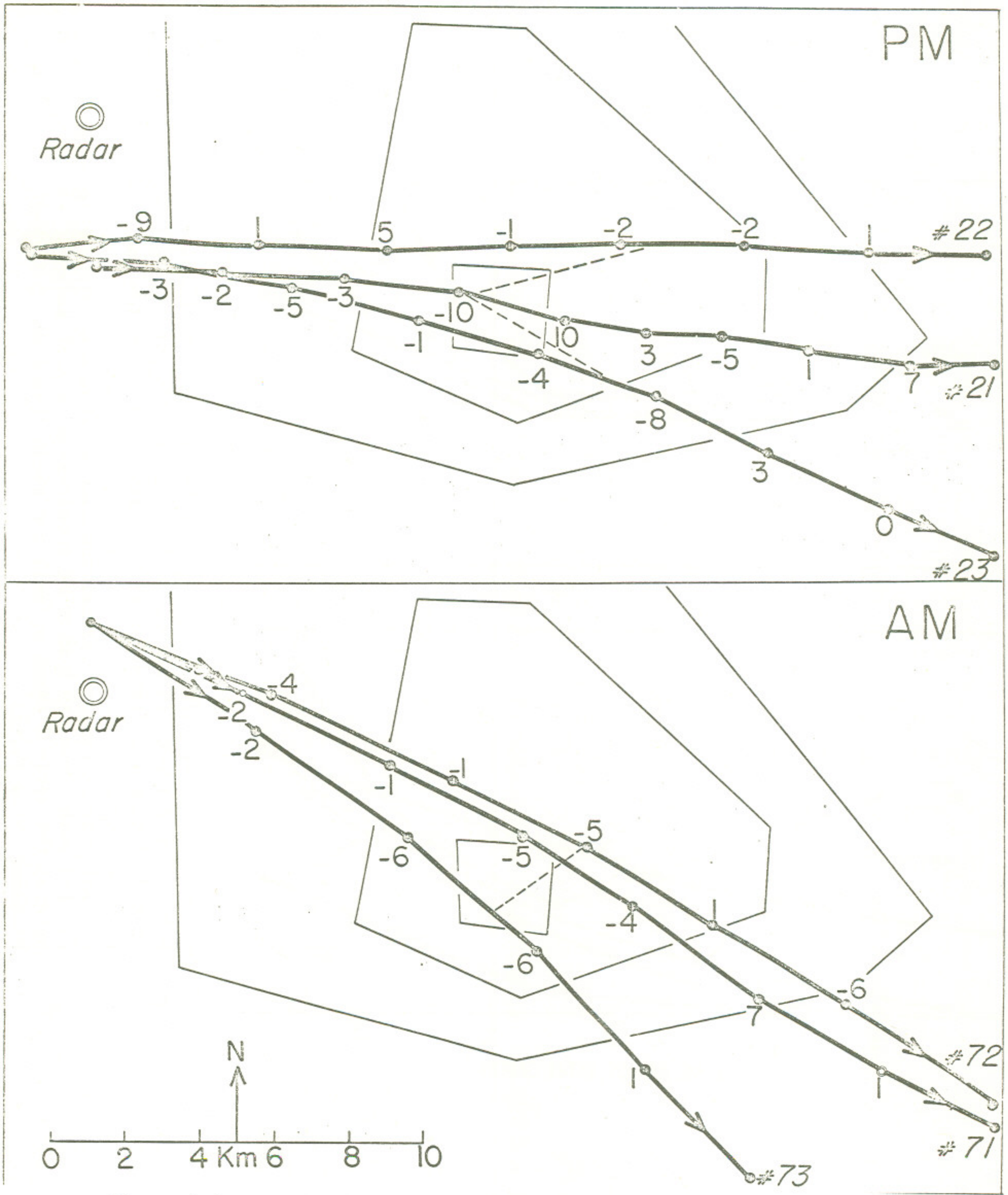


Figure 5-3. Sequential tetroon trajectories across Columbus, Ohio, at a mean height of 150 m before and after midnight. The dots indicate tetroon positions at 10-minute intervals, the numbers the derived wind direction change in degrees per 10 minutes, and the dashed lines connect regions of maximum anticyclonic turning. The small square represents downtown Columbus.

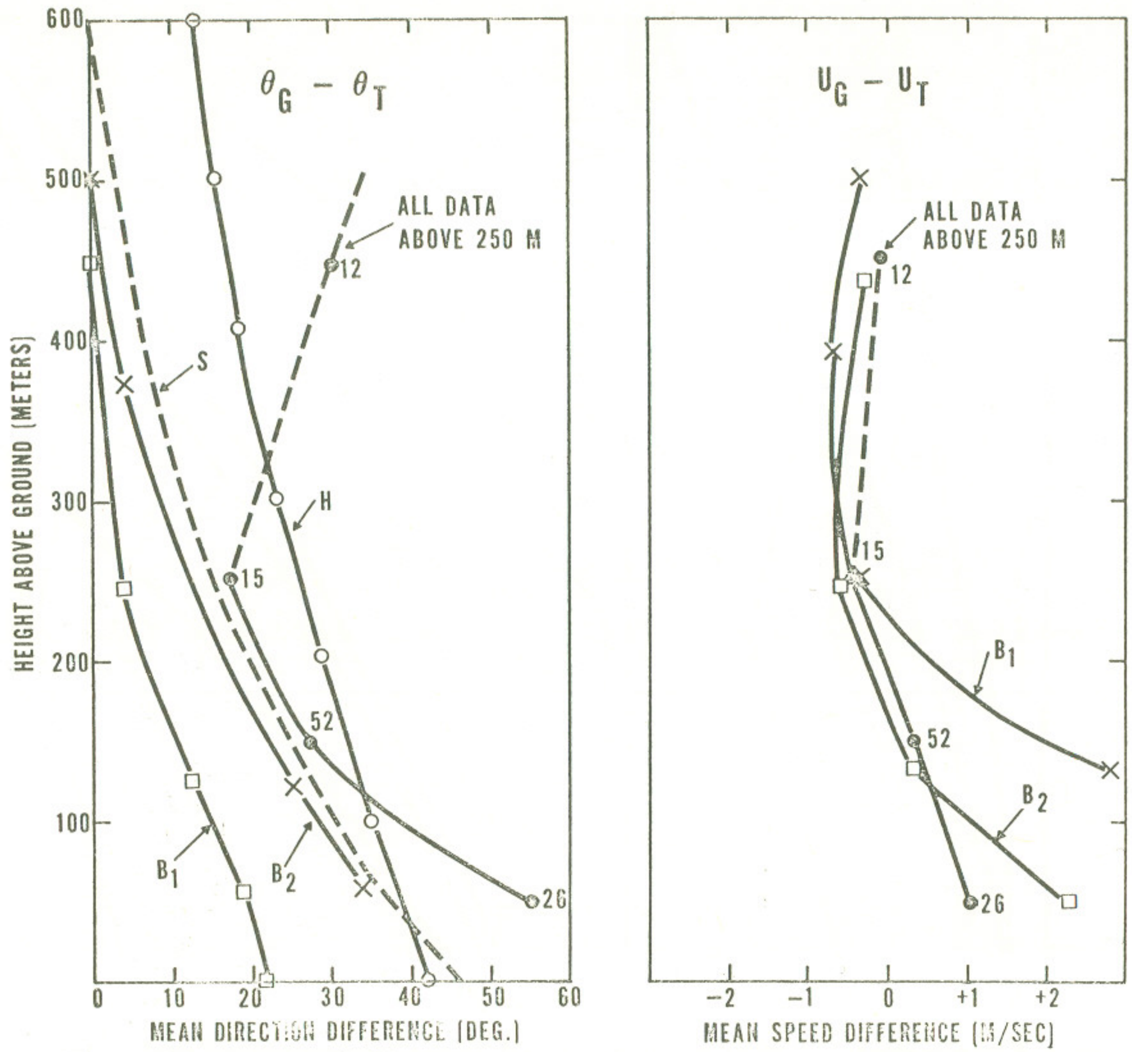


Figure 5-4. Mean differences between calculated geostrophic and tetroon wind direction and speed. Positive values for direction indicate tetroon flow counterclockwise from geostrophic direction and geostrophic speeds higher than tetroon speeds. Numbers adjacent to plotted points are the number of comparisons at each height. Several theoretical Ekman spirals are shown (S-Sutton, B-1, B-2-Bergeron, H-Haurwitz).

5.8 Three Dimensional Trajectories

A major field program to measure the three-dimensional trajectories and associated air quality with tetroons, radar, and an instrumented helicopter was performed in the Los Angeles Basin in September and early October, 1969. Radar emplacement, acquisition of commercial power, radio communications, and helicopter instrumentation were provided by NOAA's Idaho Falls Field Research Office (Air Resources Laboratory) and NOAA's Atmospheric Physics and Chemistry Laboratory. Various municipal agencies in the Los Angeles Basin assisted, especially offices of the City of Glendale and many police departments.

A preliminary presentation of the trajectories and the associated height has been published (ESSA Technical Memorandum ERLTM-ARL 19 June 1970). Figure 5-5 illustrates trajectories from the City of Commerce industrial area. The computer analysis of the data is continuing.

Hourly surface wind data for the Los Angeles Basin has been identified and assembled for the period during which the tetroon flights were conducted. The Los Angeles County Air Pollution Control District has supplied data from 20 stations, and 13 additional sets of observations were available from the Weather Bureau and FAA hourly weather observational network. These data will be used to derive surface trajectories within the area from a mesoscale analysis technique and computer program originally developed for the National Reactor Testing Station at Idaho Falls. Data collected from 40 balloon flights were available for analysis of differences between surface-derived trajectories and air motions measured by balloons.

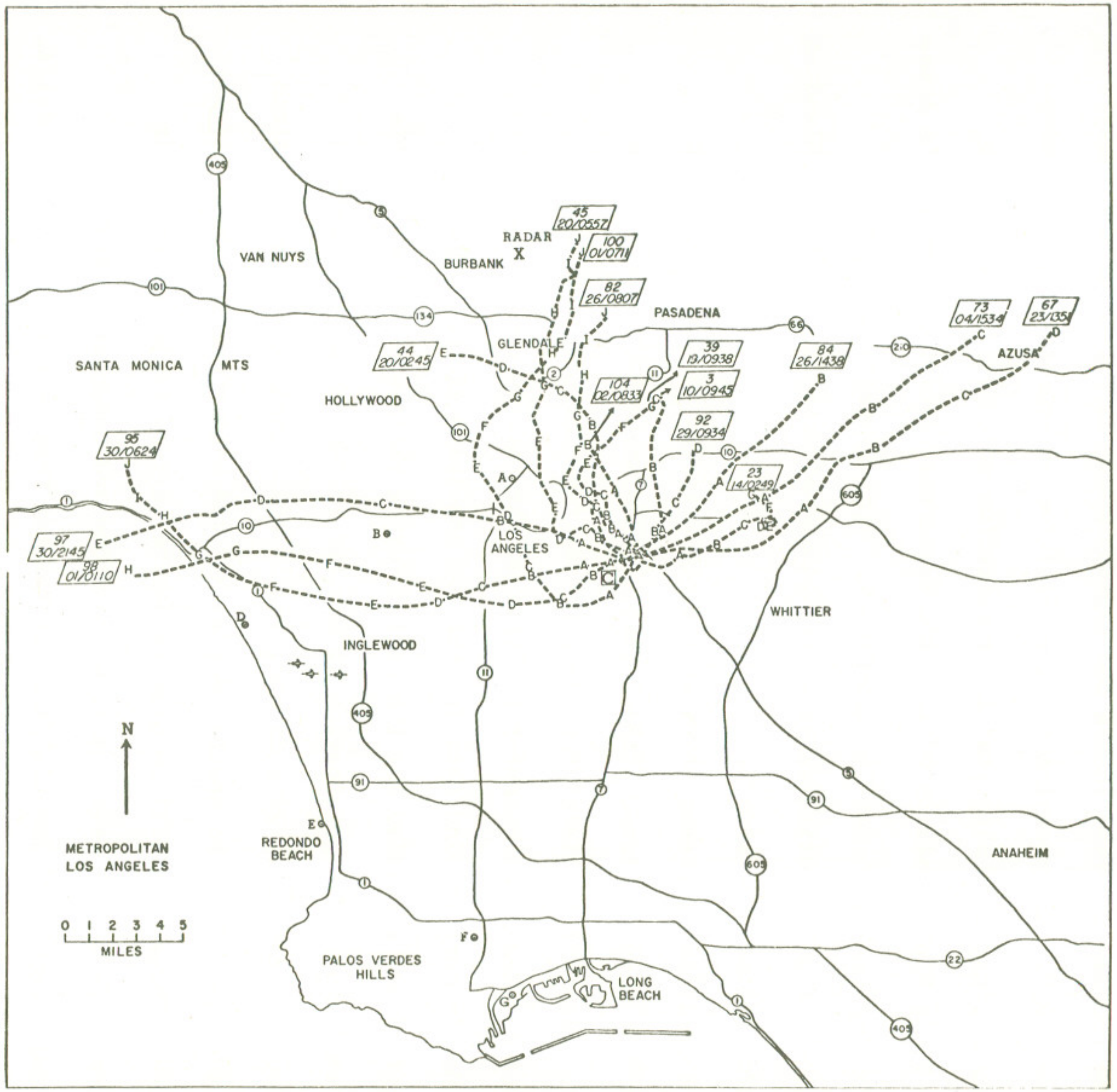
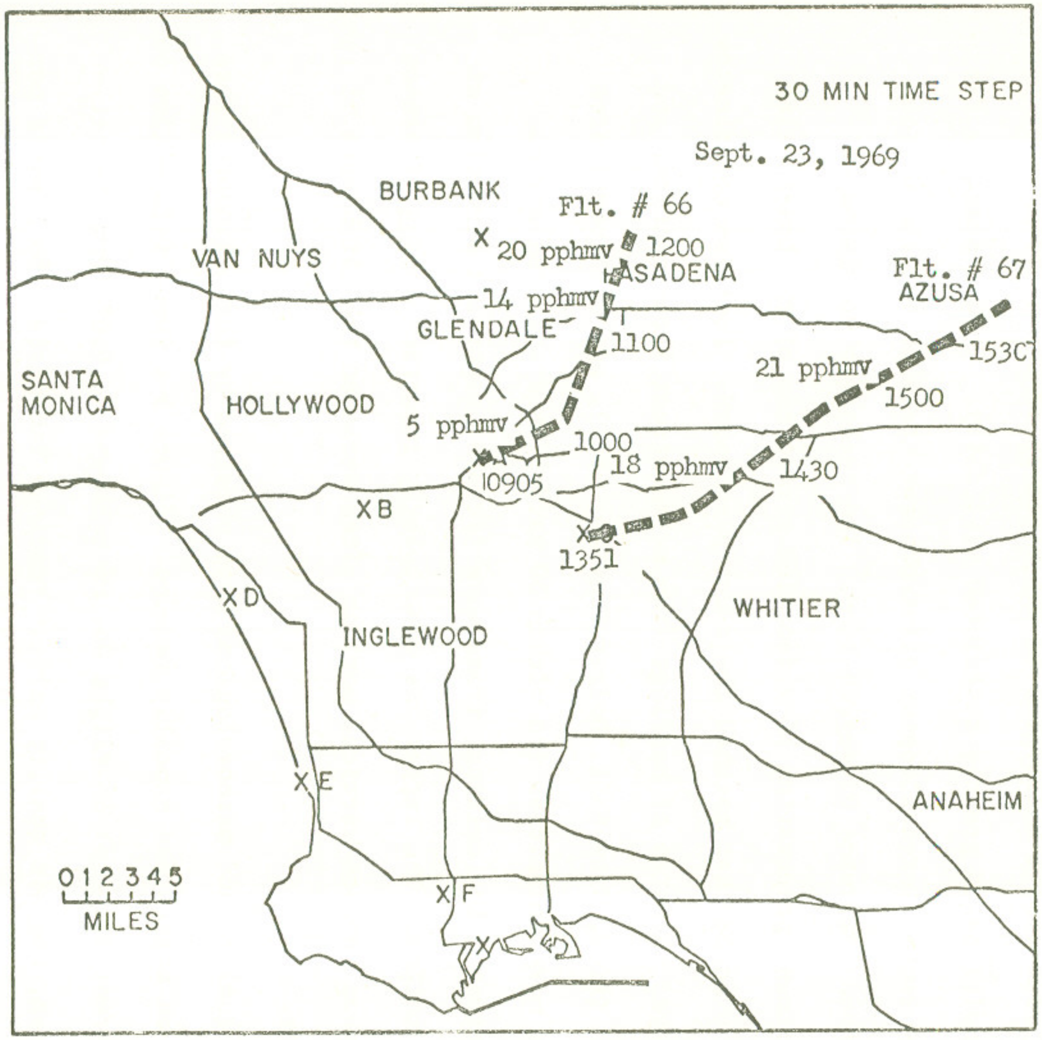


Figure 5-5. Tetroon trajectories from the City of Commerce industrial area of Los Angeles.

One of the objectives of the Los Angeles experiment was to acquire air quality data along the trajectory of an "air parcel" represented (approximately) by the three-dimensional path of the tetroon which required vectoring a helicopter to the vicinity of the tetroon under the usual conditions of greatly restricted visibility. It was possible for the radar controller-helicopter pilot/observer team to see the tetroon in less than 5 minutes of search time. The technique consisted of pre-experiment preparation of a detailed street map of the Los Angeles Basin on a scale that matched the radar plot board. Position coordinates were relayed in terms of bearings from major street inter-sections and landmarks (i.e., City Hall, Dodger Stadium, etc.), and the coordinates were made more definitive (to within 50 yards) by specifying street intersections. The critical items were tetroon height and direction of vertical motion. The latter was particularly important during afternoon flights when tetroon vertical motions often exceeded the climb rate of the helicopter.

Air quality and meteorological data obtained by the helicopter were recorded on charts and manually reduced. Figure 5-6 shows information on two different flights: on flight No. 66 released at 0905 from the city-center area, the air quality oxidant readings increased from 5 parts per hundred million by volume (pphm) during the first hour to 14 pphm at the end of the second hour and finally to 20 pphm at the end of the flight near Pasadena; the following flight, No. 67, from launch site "C" (fig. 5-5), showed similar oxidant readings toward the end of the flight near Azusa. A vertical cross section of the air quality profile is shown in figure 5-7. The oxidant plus the NO readings are based on a chromium trioxide filter that converts $NO \rightarrow NO_2$. The NO_2 is then counted as an



METROPOLITAN LOS ANGELES

Figure 5-6. Tetroon trajectories and simultaneous air quality measurements at flight altitude.

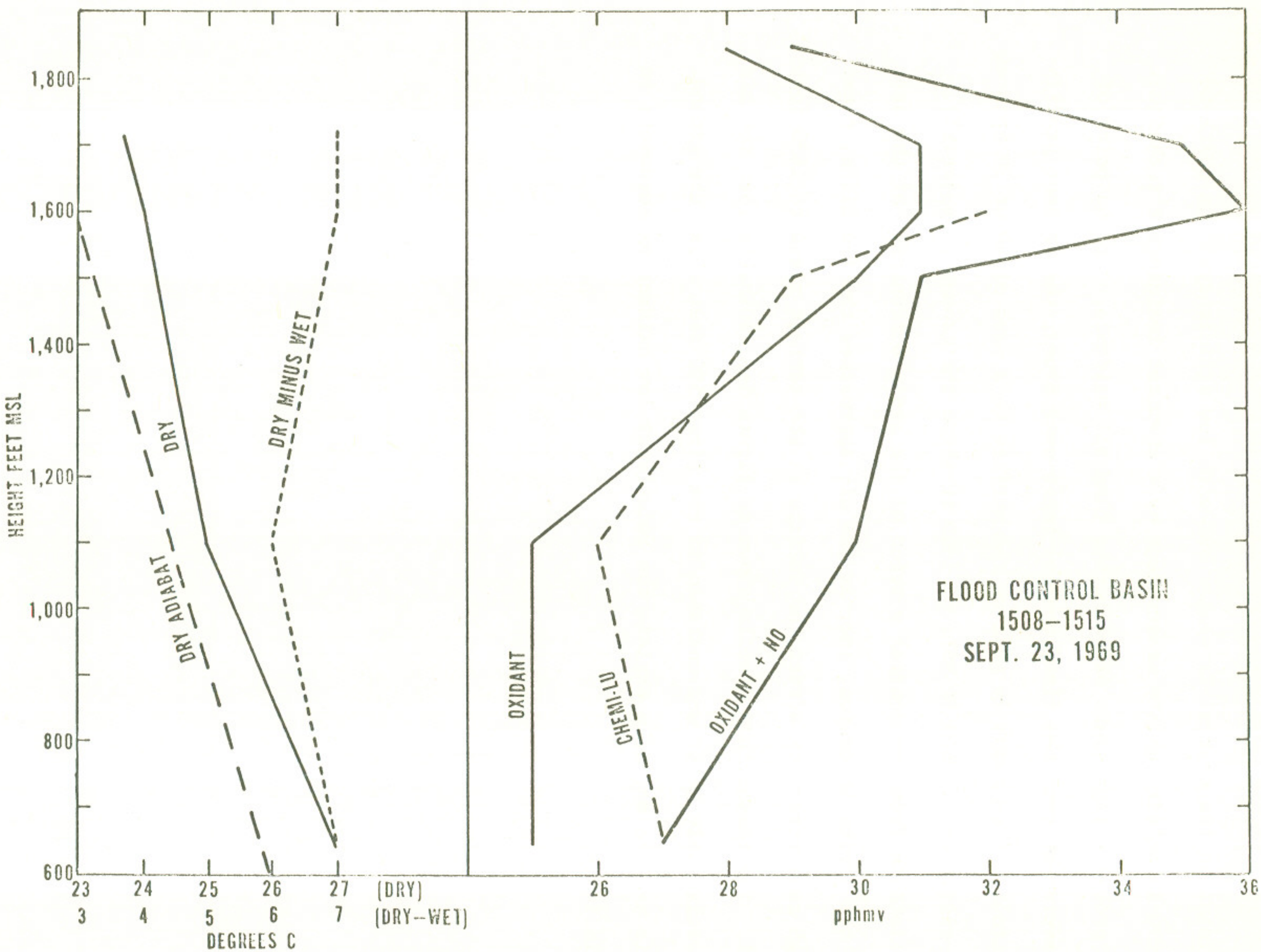


Figure 5-7. Air quality vertical profile over the Flood Control Basin near Azusa on September 23, 1969, between 1508 - 1515 h.

oxidant in the neutral KI sensor but with low efficiency. The CHEMI-LU curve is an air quality measurement by a chemical luminescent technique. It probably represents ozone rather than all oxidants. At the point of measurement over the flood control basin near Azusa, the oxidant profile increased from about 26 pphm at the surface to a peak of about 30 pphm at an elevation of 1600 ft MSL, or 1000 ft above the ground. Apparently, pollutants from the central portion of the basin concentrate at the base of the marine inversion, and, as the air approaches the foothills, these high concentrations affect the surface as the terrain rises to 1600 feet MSL. The temperature profile shown in figure 5-6 indicates that the air is relatively moist and unstable in the first 500 feet above the ground. This profile may help explain the relatively low oxidant measurements in this layer.

5.9 Atmospheric Turbidity Network

A program to measure the atmospheric turbidity coefficient at a network of stations in the U. S. was begun in 1960. A summary of these measurements covering the period 1961 through 1966 has been published (Flowers, McCormick & Kurfis, 1969). During the past year, five new stations were added to the network: Adrigole, Ireland; Bowerchalk, England; Ankara, Turkey; South Pole Station, Antarctica; Los Alamos, New Mexico; Mt. Hopkins, Arizona. With the exceptions of Ankara and Bowerchalk, the new stations are in relatively remote locations and represent the types of places desirable for a world-wide background network.

Turbidity measurements from the South Pole Station, elevation 2800 meters, and Mt. Hopkins, elevation 2377 meters, indicate very low turbidity values, e.g., the December 1969 average values were 0.012 and 0.013, respectively, with only small absolute variations. Except for the six months darkness at the South Pole, these are ideal sites from which to monitor the global variation of turbidity.

In the next year, 20 to 25 additional foreign stations will be added to the network. Stations added in past years at Poona, India; Mauna Loa, Hawaii; and Bet Dagan, Israel; will also be part of the new network, as well as the 20 to 25 stations that are part of the U. S. network. All of these stations will be equipped with a new dual-wavelength sunphotometer developed by the DM this year. Arrangements have been made to manufacture these new instruments which should begin to be commercially available by December 1970. The new sunphotometer will be capable of making accurate solar radiation measurements at both 380 and 500 namometers (nm) wavelength. From these, the turbidity coefficients at the two wavelengths and Ångströms wavelength coefficient can be calculated.

5.10 Radiation Studies

A research project was planned during FY 1970 to measure and contrast the radiation energy budget of an urban area with that of a nearby rural location. This project is intended to investigate how the urban-rural radiation differences are affected by atmospheric pollution and by urban structures. Instruments and data acquisition equipment were ordered late in FY 1970 and measurements will commence during FY 1971.

At each of two sites, one urban and one rural, the following parameters will be measured: upward and downward directed solar radiation in three spectral intervals (< 400nm, 400 to 700 nm, and > 700 nm), upward and downward directed long wave radiation (> 3000 nm), water vapor, and common pollutants which can affect radiative energy transfer, such as CO_2, NO_2, O_3, and particulates. An aircraft will be outfitted to measure some of these parameters to determine their vertical variation. Initial observations will be made at Raleigh, N.C., to check out equipment and standardize the observing procedure.

A system designed to monitor the atmospheric transmission of solar radiation is being tested in Raleigh, N.C. At the end of the test period of 3 to 4 months, the equipment will be installed at NOAA's Mauna Loa Observatory, Hawaii. The primary purpose of the program is to determine whether there are any long period trends in the spectral quality of solar radiation which could be caused by changes in the opacity of the atmosphere. The system was built by Eppley Laboratories as a 13-channel normal incidence pyrheliometer for measurements of the direct solar beam and spectral radiation. The system includes five pyranometers for spectral measurements of the direct plus diffuse radiation on a horizontal surface, and a component which controls the collection of the data and records it on magnetic tape. Five of the normal incidence channels cover spectral intervals identical to those of the pyranometers so that the separate diffuse and direct components will be available. Measurements by this system should permit discrimination between effects due to water vapor variations and those due to changes in the amount of particulates. The wavelength sensitivities of the instruments are presented in Table 5-1.

TABLE 5-1
Instrument wavelength sensitivities.

Pyranometer	Wavelength (Nanometers)	Pyrheliometer Channel	Wavelength (Nanometers)
Quartz	280-4000	1 (UV)	285-380
GG 22	>390	2	390-450
OG 1	>530	3	445-510
RG 8	>695	4	495-555
UV	295-385	5	552-602
		6	600-700
		7	650-1040
		8	1100-1950
		9 (GG 22)	>390
		10 (OG 1)	>530
		11 (RG 8)	>695
		12 (Quartz)	280-4000
		13 (Quartz)	280-4000

5.11 Maritime Aerosol Study

A research contract was awarded the Research Foundation of the State University of New York, Albany, New York, for a comprehensive survey of maritime aerosols. University scientists will be assisted by faculty and graduates of the New York State Maritime College.

The basic investigation will consist of oceanic observations to determine the distribution of aerosol concentrations over the Pacific and Indian Oceans in the Southern Hemisphere. Oceanic observations over the North Atlantic will continue. Maritime College graduate officers will make the aerosol measurements from U. S. merchant ships. A Gardner small particle detector, whose principle of operation is based on a saturated expansion chamber, will be used to monitor the total number of atmospheric particles larger than 0.001μ. This lower size limit can be varied on the Gardner detector up to 0.1μ to give some size discrimination. A sedimentation foil, under development, will supplement the small particle data. The stable "sticky" surface of foil will collect all material settling upon it for many days.

5.12 Mixing Height Determinations by Means of an Instrumented Aircraft

The University of Florida under contract to the APCO conducted mixing height determinations by means of instrumented aircraft and submitted their final report (McCaldin, 1970).

The main objective of the study was to evaluate daytime mixing height estimates determined by the Holzworth technique (1967, 1969), based on regularly scheduled vertical temperature profile measurements (radiosondes), surface temperatures, and the assumption of a dry adiabatic lapse rate in the mixing layer. Evaluations were performed by making vertical soundings with an instrumented aircraft and recording data that would furnish independent measures of the mixing height. Data included a vertical temperature profile, an accelerometer trace which indicated atmospheric turbulence, and a record of particle concentrations. The mixing height was then determined on the basis of each of these parameters. One hundred forty-five atmospheric soundings were made from an instrumented aircraft.

Mixing height measures based on each of these parameters were then compared with independently estimated mixing heights based on Holzworth's technique. There was no statistical difference between the Holzworth estimates and aircraft turbulence measures of the mixing height (fig. 5-8). Mixing heights based on aircraft temperature profiles were found to be 7 to 9 percent less than those of the Holzworth and aircraft turbulence techniques. Apparently, this is a result of the criteria used in selecting mixing heights from the aircraft temperature profiles. A poor correlation (r = 0.25) was found between calculated mixing heights and the depth of the mixed layer derived from particulate profile data. This lack of agreement is probably due to the presence of aerosols above the current mixed layer that had been transported there on previous days.

Marked difference in visibility below and above the mixing layer were photographed, and particle concentrations in each atmospheric regime were recorded. Over New Orleans, there were about fifty times more particles in the mixing layer than in the clean air above, as sampled from airfraft traverses.

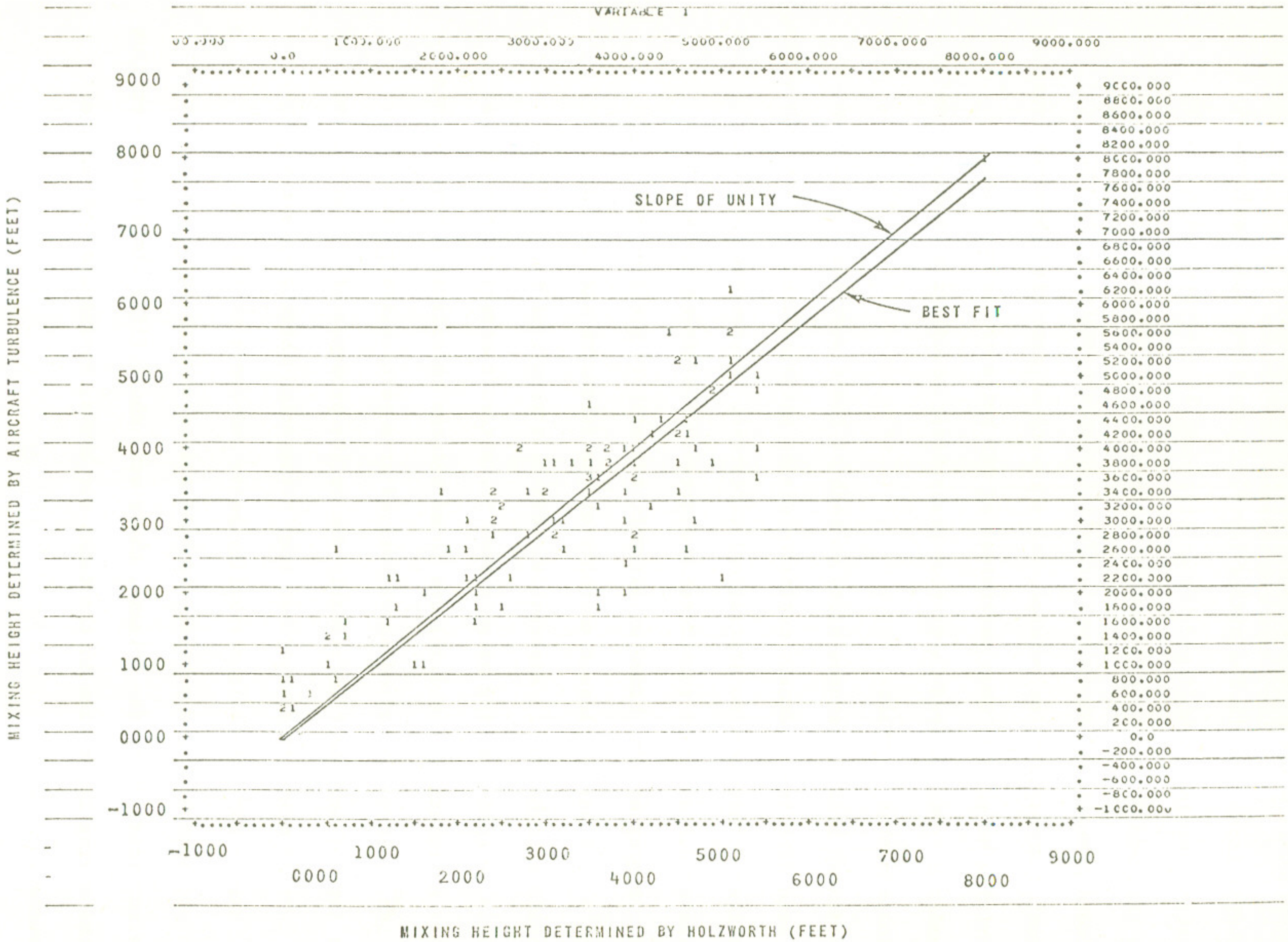


Figure 5-8.

Mixing height regression: Holzworth technique vs. aircraft turbulence.

6. LARGE-SCALE EFFECTS OF AIR POLLUTION

6.1 Long-Term Geophysical and Biological Effects of Air Pollution

A critical review by Dr. G. D. Robinson of the Center for the Environment and Man, Hartford, Connecticut, under contract to the APCO, summarized the present state of knowledge on the long-term geophysical and biological effects of air pollution relative to the APCO's responsibility and needs for research, and monitoring activities. In outline, the primary items of recommended research and monitoring were to:

(1) Ensure continuation of monitoring of carbon dioxide (CO_2) content of the atmosphere.

(2) Ensure continuation of a survey of atmospheric turbidity and particulate loading.

(3) Ensure that an adequate effort is perpetuated on monitoring precipitation chemistry and its biological implications.

(4) Support research on the effect on atmospheric structure and cloudiness of artificially increased water content of the lower stratosphere.

(5) Support research on the theory and numerical modeling of climate and commission a survey of the problem.

An explicit recommendation with respect to the CO_2 measuring program was to establish a station in the South Pacific between 15°S and 30°S, in addition to the continued support and maintenance of NOAA's Mauna Loa's monitoring program.

6.2 Satellite Surveillance

During the year, the APCO contracted with the Space Science and Engineering Center of the University of Wisconsin to study the feasibility of techniques for satellite surveillance of global atmospheric pollution. The measurement of CO, CO_2, and O_3 has been considered and investigations have been performed to determine what useful information can be obtained from monitoring aerosols. The minimum requirement is to determine level of turbidity from satellite data. As the result of these preliminary studies, emphasis will be placed on the feasibility of satellite monitoring of the whole earth albedo and atmospheric turbidity against the ocean surface background.

7. SUPPORT TO OTHER APCO PROGRAMS

7.1 Bureau of Abatement and Control

7.1.1 Division of Abatement Support of Air Quality Control Region (AQCR) Programs

The Clean Air Act, as amended, requires States to develop air quality standards and implementation plans to achieve them. The Division of Abatement, APCO, is charged with evaluating the implementation plans of the various States. Meteorologists supporting the Division of Abatement (DOA) worked closely with the DOA Staff in helping the States to generate rational and acceptable plans to control their pollution.

Meteorologists continued to participate in the initial development of AQCRs by: (1) preparing the meteorological portions of a status report that describes and enumerates the resources available to an AQCR and (2) evaluating the resources and identifying "gap" areas. Broadly, a "gap" area is an aspect of a program where resources are insufficient to develop and evaluate an acceptable plan to achieve regional air quality standards. Status reports were completed for 24 AQCRs (4 others were completed in FY 69). Meteorologists participated in a dozen "gap" area meetings.

An example of meteorological contributions to this stage of development of the AQCR is found in Louisville and Pittsburgh. Additional sampling sites were selected for these AQCRs from which to gather data for developing and evaluating the implementation plans. (See par. 5.3.2, FY 69 Summary Report of Division of Meteorology Support to the APCO.)

Meteorologists participated in three workshops, attended by representatives of most of the 50 States, which presented procedures to the States for selecting the most appropriate sets of emission restrictions to achieve air quality standards. Since a systematic method for relating emissions to air quality is needed, the dispersion model has an important role in the selection prodecure. The workshops provided opportunities to introduce many State and local officials to the application of air pollution models. For example, the meteorologists used a diffusion model (Martin and Tikvart, 1968) to develop an appropriate emission control strategy for a hypothetical AQCR.

Efforts to support activities of the DOA by the use of dispersion models on a broad scale continues. Primarily, the long-term urban model described by Martin and Tikvart (1968) was used to select the most effective set of emission standards for the Detroit-Windsor and Port Huron-Sarnia international areas. At the request of the International Joint Commission, the dispersion model was used to determine the relative impact on each country from the various classes of sources in the United States and Canada. The study provided valuable data on the responsibility of each country for improving the air quality of the Detroit-Windsor and the Port Huron-Sarnia areas.

With crude, but readily available, emission and meteorological data, the DOA meteorologists determined the spatial distribution of pollutants over the urban portions of most of the first 35 AQCR's designated. These analyses were used to judge objectively the adequacy of existing air quality sampling networks and whether all portions of an AQCR are proceeding towards or maintaining an air quality standard.

The long-term dispersion model has been incorporated as a sub-module in a computer system called Implementation Planning Program (IPP). Other sub-modules are an abatement strategy model, a cost effectiveness model, and an information package. The system, developed by TRW, Inc., under contract to the APCO, (a) accepts source, meteorological, air quality and economic data; (b) "calibrates" the dispersion model; (c) estimates the impact of existing pollutant emissions on air quality; (d) determines allowable pollutant emissions for selected emission standards; (e) selects appropriate control devices and determines their cost; and (f) estimates the air quality after controls have been implemented. This system provides information which helps determine the set of emission control alternatives which will allow selected air quality standards to be achieved at the least cost. The control regulations submitted by the States as part of their implementation plans will be evaluated with this system.

The IPP was used to determine the compatibility of air quality standards in a tri-state AQCR. The problem was whether an air quality standard of 80 μg/m^3 annual mean concentration of particulates in State 1 would interfere with the efforts of the two adjoining States to achieve a lower particulate standard of 70 μg/m^3. The southeastern corner of State 1 was relatively free of particulate emissions, except for a few isolated point sources (one was a major power plant). An answer to the question of compatibility was obtained by considering the impact of these sources alone and also in conjunction with all other sources in the AQCR. To evaluate their impact on the AQCR's air quality, the IPP dispersion model was verified and calibrated to realistically estimate air quality.

First, the impact of a specific control strategy was determined. The case selected was the particulate emission control strategy which all three States intended to impose on existing particulate sources. The strategy consisted of the following emission standards and restrictions:

Source Type	Standard or Restriction
Combustion	Ironton Heat Input Standard
Process	San Francisco Bay Area Process Weight Rate Standard
Incineration	Grain loading standard of 0.2 grains per standard cubic foot
Area	Banning of open burning and residential coal burning

The dispersion model estimates (Figure 7-1) indicated that this strategy, when it is implemented, should result in an annual mean concentration of particulates of 69 μg/m^3 or less for all portions of the AQCR, thus achieving the standard of 70 μg/m^3.

Next, the impact of existing emissions of particulates from sources

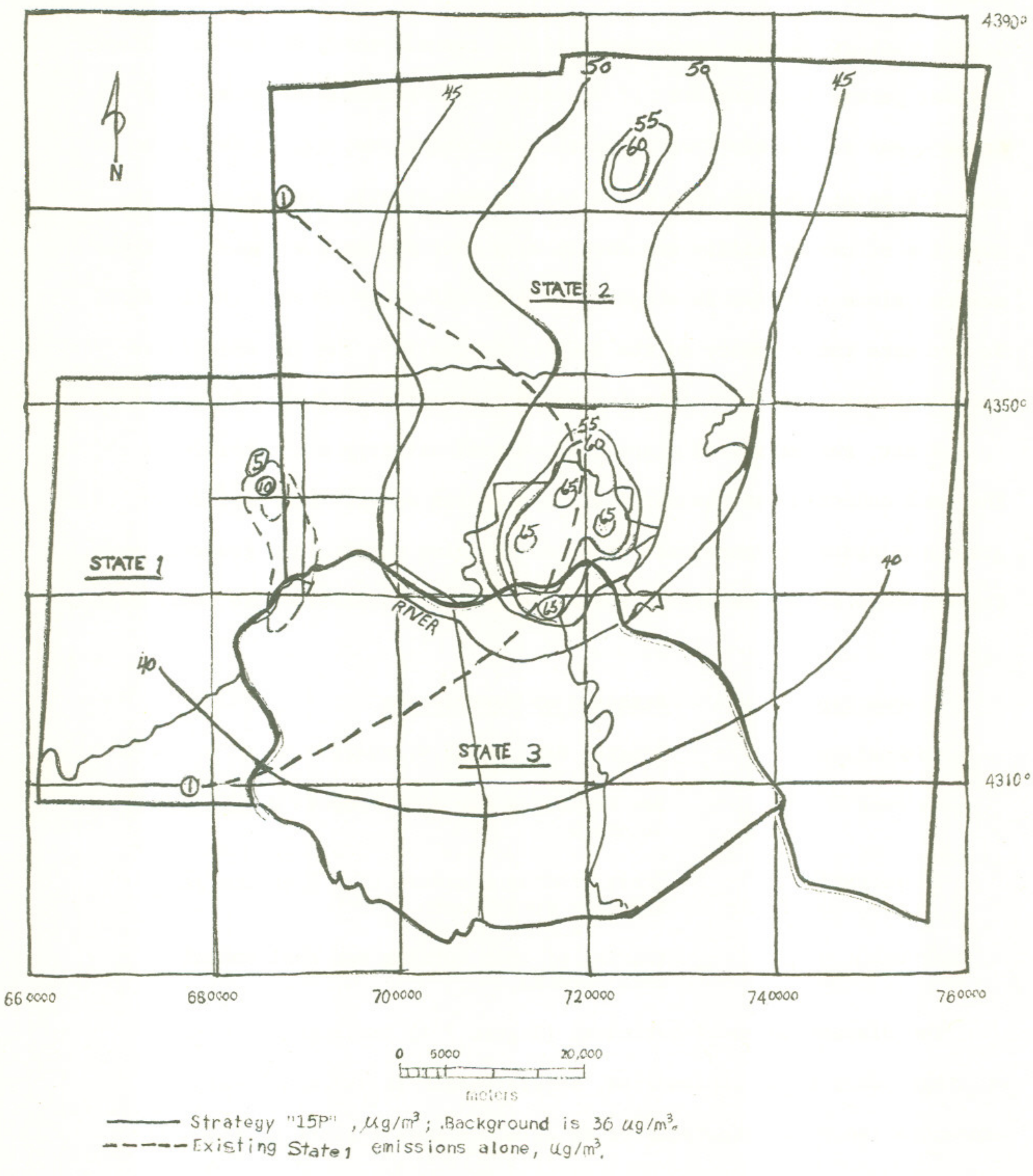


Figure 7-1. Calculated suspended particulate contamination in Tri-State AQCR.

in State 1 alone was determined. The dispersion model estimates indicated that the emissions contributed a maximum of 12 $\mu g/m^3$ to the annual mean concentration of particulates outside of State 1 (Figure 7-1). The contribution in the vicinity of the maximum concentration allowed by the selected strategy was 1 $\mu g/m^3$. Therefore, even if no attempt was made to control emissions in State 1, the standard of 70 $\mu g/m^3$ should still be achieved. It should be noted, however, that this specific control strategy provided for stringent control of State 1 sources and would reduce the impact of existing sources by more than 50 percent.

Emission projections were not available for this analysis. However, preliminary estimates indicated that industrial and urban development in the southeastern portions of State 1 was unlikely to be sufficiently great to seriously jeopardize the efforts of adjoining States to reach their air quality objective of 70 $\mu g/m^3$, provided these States vigorously implemented their control plans.

In summary, an analysis of diffusion model estimates indicated that a particulate standard of 80 $\mu g/m^3$ in State 1 should not interfere with the efforts of adjoining States in the AQCR to reach a particulate air quality level of 70 $\mu g/m^3$. It also indicated that the standard of 80 $\mu g/m^3$ is unnecessarily high for State 1, one of the "cleaner" portions of the AQCR.

7.1.2 Abatement Activities

New Cumberland, West Virginia - Knox County, Ohio

The DOA meteorologists participated in an Abatement Conference concerning air pollution originating from the Toronto Power Plant of the Ohio Edison Company. They also attended the executive sessions to assess the plans of the company to alleviate the problem. They used data acquired by the Division of Health Effects Research, Bureau of Criteria and Standards, for an epidemiological study of the area to show that the company's actions to reduce the impact of the plant's emissions on New Cumberland were insufficient to obtain satisfactory air quality. Finally, they participated in the planning to maintain an air quality surveillance network, and they installed needed wind sensors in the area after the health effects study was terminated.

Parkersburg, West Virginia - Marietta, Ohio

The DOA meteorologists contributed to a technical report on the nature and extent of air pollution in this Ohio River Valley area and participated in an abatement conference. This conference, supplementary to a similar action taken in 1967, was occasioned by legal challenges by the area's largest emission source. Meteorologists calculated the reduction in emissions required to achieve desirable air quality. These calculations were used by the conferees as the basis for recommendations that ultimately were accepted by the Secretary of Health, Education, and Welfare.

Mount Storm, West Virginia

This abatement activity was initiated on complaints of Maryland Christmas-tree growers that sulfur dioxide (SO_2) from the Mount Storm, West Virginia, plant of the Virginia Electric and Power Company was damaging their trees. The area was surveyed during late September, and a short period study was undertaken during the fall of 1969.

The Meteorology Branch, DOA, operated two wind recording stations in the region during November and December; the DOA also conducted two field investigations during that period. In addition to hourly pibals and observations of the weather, the Branch conducted approximately 15 hours of monitoring of temperature and SO_2 by aircraft sampling. In coordination with the aerial work, the Branch also conducted nearly 50 hours of mobile ground monitoring in November and an additional 40 hours in December. Field data and Weather Bureau records were used in an analysis of the transport and diffusion of particulate matter and SO_2.

The tentative conclusions were discussed in a meeting with representatives of the power company and the states. Since that time, the company has taken remedial action. Monitoring of the region by the DOA continues with the operation of three wind recording systems to study wind patterns along the North Branch of the Potomac River. Air quality is also being monitored in the valley.

7.1.3 Support to Federal Agencies

The Federal Facilities Branch, DOA, is charged with monitoring a phased and orderly plan to reduce air pollution from Federal installations. Federal agencies are charged by Executive Order 11507, February 5, 1970, to provide leadership in the nationwide effort to protect and enhance the quality of our air and water resources.

The support of the Federal Facilities Branch by the DOA meteorologists involved evaluating plans to control emissions from ammunition plants, from installations that dispose of a variety of munitions, from new defense installations, and from power plants which use fuel from Federal or Indian Lands.

At the request of the National Park Service the DOA, the APCO, the agencies of the State of Montana Park Service, and the U. S. Forestry Service began a study of the effects on the surrounding region of fluorine emitted from Anaconda's Columbia Falls Aluminum Plant. Meteorologists installed three wind recording systems in order to determine the wind patterns over the region between the plant and Glacier National Park, the region of APCO's primary interest. Data from these systems will be used with other information in calculating the concentrations of fluorine entering Glacier National Park and the frequency with which such events occur.

7.1.4 Division of Control Agency Development (DCAD)

Meteorologists assigned to the Division of Control Agency Development (DCAD) provided technical information and consultation on all aspects of air pollution control. Programs, surveys, and demonstration grants were reviewed. Assistance was given in the development of local emission standards and control practices and in delineating of Air Quality Control Regions.

Four Corners Power Plant, New Mexico

At the request of the Department of Health and Social Sciences, State of New Mexico, a meteorological and engineering evaluation has been made of the Four Corners Power Plant near Farmington, New Mexico.

A study was made of the history of the power plant, its operation, the air pollution climatology, the stack emissions, and the possible effects of resulting concentrations of particulates and SO_2. Four generating units are in operation, and the fifth unit is expected to start operation in 1970, resulting in a total plant capacity of over 2000 megawatts.

Specifically, some findings were: (1) regulation of particulate emissions on the basis of a percentage removal efficiency was inadequate because percentage values allow emissions to vary depending on the magnitudes of the initial source strengths; (2) plume behavior evaluation based on available airport observations made near the surface was inadequate; (3) short-period high concentrations of particulates and SO_2 resulted in detectable health and vegetation damage within a few miles of the stacks; (4) visibility was noticeably reduced 100 to 150 miles away.

A 15-minute film with time-lapse sequences showing the behavior of the plume from the Four Corners Plant was shown at the 63rd Annual Meeting of the Air Pollution Control Association, St. Louis, Missouri, June 14 to 19, 1970.

Helena Valley, Montana

Meteorological support has been provided to the Helena Valley, Montana, Area Environmental Pollution Study. The State of Montana and the APCO are cooperating in a study of the types, amounts, sources, distribution, and effects of environmental pollution in the Helena Valley area, with a view to recommending solutions of any air pollution problems that are found. The most important source of air pollution is a lead smelter with a 400-foot stack, which emits SO_2 and particulates. Two baghouses, with short stacks and much lower emission rates, are also sources of SO_2. A summary of the air pollution climatology of the area was prepared and estimates of SO_2 concentrations were made for periods less than one hour, and for the duration of the study (June through November). Annual SO_2 concentrations were also determined. Continuous observations of SO_2 concentrations from four stations and sulfation plate observations from 125 stations were available throughout the study. These measurements showed that under certain meteorological conditions (for example, those that cause downwash) the lower elevation sources such as the baghouses must be controlled, as well as the 400-foot stack, if satisfactory community air quality is to be attained. Findings pertaining to SO_2, and the need for emission control, were reported to the Montana State Board of Health in a public hearing on the subject of emission regulations on May 21, 1970.

A study was made of operations of a smelter in Tacoma, Washington, and of the possible effects of a proposed new stack 1100 feet high. Testimony was given opposing the use of the tall stack in lieu of emission control at a variance application hearing in Tacoma, Washington, March 12, 1970. It was shown that the tall stack would not eliminate the occurence of high levels of ground concentration of pollutants from the smelter caused by looping and fumigation conditions and that a high stack might threaten vegetation on slopes many miles away. The variance, which would have exempted the smelter from fines while the new stack was being constructed, was denied.

Office of Regional Activities

By law, public consultations are required prior to the designation of each Air Quality Control Region (AQCR). The Atmospheric Sciences Branch, DCAD, has the responsibility of providing any meteorological material needed for the reports prepared by the Office of Regional Activities, APCO, in preparation for the consultations. A total of 91 reports have been prepared. Wind data have been supplied for 57 regions, general climatological data sufficient for the application of a simple diffusion model were supplied for 34 regions, and a diffusion climatology was written for three regions (Los Angeles, San Francisco, and Seattle) where the application of a diffusion model was not appropriate.

Palm Beach County, Florida

A DCAD meteorologist visited Palm Beach County, Florida, to provide advice to State authorities about air pollution resulting from the burning of cane fields. Photographs of the burning operations were made from the ground and from an airplane. It appears that meteorological forecasts might assist in reducing the effects of smoke on urban and resort areas by recommending times of optimum weather for burning. A report discussing the various ways meteorology might be applied to alleviate the air pollution problems from field burning is in preparation.

Other Technical Assistance

Miscellaneous technical assistance activities occupied a major part of the time of the DCAD meteorologists. Consultation was provided to control agencies on questions of plume rise and diffusion calculations, sources of climatological data, suitable instrumentation, and data processing and analysis. Several important review functions also were performed and recommendations were provided on the following subjects:

(1) Application of meteorology in specific air pollution control agencies (State of Utah, Chicago, and Philadelphia).

(2) Meteorological contracts under consideration for funding by agencies.

(3) Engineering reports submitted to agencies containing diffusion calculations for various kinds of industrial sources.

(4) Proposed emission regulations.

7.2 Bureau of Criteria and Standards (BCS)

The Bureau of Criteria and Standards (BCS) develops air quality criteria and evaluates State standards (Office of Criteria and Standards), collects and analyzes air quality and emission data (Division of Air Quality and Emission Data), and conducts research on the effects of air pollutants on people, animals, plants, and property (Division of Health Effects Research and Division of Economic Effects Research).

Early in the fiscal year at the request of the BCS Director, a "Plan for Estimating Future Air Quality" was formulated in collaboration with an urban planner from the Division of Air Quality and Emission Data. This plan indicated the necessity of emission data, air quality data, dispersion models for stable pollutants, photochemical dispersion models, validation of these models, and application of the models to projected emissions for estimation of future levels of air quality. The plan also indicated estimates of the manpower, dollars, and time required to accomplish these tasks.

A presentation on "Atmospheric Diffusion Models" was made before the National Academy of Science/National Academy of Engineering Committee Advisory to NOAA on December 9, 1969. A summary of these remarks was later prepared for use by the Committee.

7.2.1 Office of Criteria and Standards

Dispersion computations were made for single and multiple sources to assess property-line concentrations resulting from air pollutant emissions from Federal facilities. To partially fulfill frequent requests of this nature, a computer program was devised to calculate the maximum fumigation concentration from a single source and the distance from the source that this maximum occurs.

On two occasions computations were made of the rate of decrease of air pollutant levels downwind of a large area source. These computations were useful in assessing the compatibility at the border of two States having different air quality standards. Modeling techniques similar to those employed by Miller and Holzworth (1967) were used.

Reviews were made of numerous draft documents: Chapter 6, "Atmospheric Carbon Monoxide Concentrations" in Air Quality Criteria for Carbon Monoxide; Chapter 3, "Atmospheric Photochemical Oxidant Concentrations" in Air Quality Criteria for Photochemical Oxidants; and Comparison of Air Pollution from Aircraft and Automobiles," prepared for the Associate Administrator for Plans of the Federal Aviation Administration by the Center for Transportation Studies at Rutgers University. Reviews were also made of work proceeding under the NAPCA contract: photochemical modeling; the development of a five year program on air pollution aspects of urban and transportation planning.

As an aid in evaluating proposed emission standards for automobiles, it is desirable to determine the contribution of motor vehicle emission to various air quality levels, especially during periods of high air pollution potential. It is also desirable to estimate future (1985 or 1990) air quality levels and the contribution of motor vehicle emission to this air quality; considering urban growth, increased industrialization, and more effective emission controls. Since a validated photochemical diffusion model was not available to make these assessments, a dispersion model for estimating concentration distributions of carbon monoxide (CO), hydrocarbons (HC), and oxides of nitrogen (NO_x) was applied to determine the contribution of different source types to the concentration of each air quality constituent and to indicate the variation of respective pollutant concentrations across the area so that the location and magnitude of maximum concentration could be identified.

It was decided to apply a diffusion model similar to Turner's (1964) Nashville model to Philadelphia, using available annual emission inventory data for that city. The Philadelphia emissions of CO, HC, and NO_x were classified according to source (stationary point, stationary area, and mobile area). Variations in emission rates for a number of components for each type of source were classified by hour of day, day of week, and season. The data were stored on magnetic tape for input to the dispersion model. The basic elements of the dispersion model contained three subprograms which calculated the concentrations at (1) a grid of receptor points from any number of point sources, (2) a grid of receptor points from nearby area sources, and (3) a grid of receptor points from more distant sources.

Validation of the model is difficult since, by the nature of the model, the concentrations from the area sources are representative of areas 2.5 km on a side.

Preliminary analysis indicated that calculated CO concentrations were too low by about a factor of five. This underestimation by the model may have been due to the actual CO measurements being more representative of street-side concentrations than general area concentrations calculated by the model. Calculated HC and NO_x concentrations are nearly the same as those measured. These statements are based on limited data and must be considered preliminary.

7.2.2 Division of Air Quality and Emission Data

Oxidant Concentrations

An investigation of background concentrations of oxidant to indicate the highest expected values which would be due to natural sources revealed hourly values as high as 0.08 ppm at Point Barrow, Alaska, during the months of February through April 1965. Similar hourly concentrations have been measured at the Chicago Continuous Air Monitoring Program (CAMP) stations during the winter.

During the summer, even higher hourly concentrations were measured in air which according to best estimates had been over Lake Michigan for about six hours and over land between the shore and CAMP station for less than ten minutes.

Pollution roses for oxidant were made for Chicago, Washington, D. C., Denver, and Philadelphia. Similar daily patterns were obtained for 1967 and 1968 for Chicago with the highest average (24-hour) oxidant values recorded on days with winds from the NNE through ENE (off Lake Michigan). See Table 7-1.

TABLE 7-1

Mean of average daily oxidant concentrations for each prevailing wind direction for average daily wind speed greater than or equal to ten miles per hour. (Chicago CAMP station)

Direction	1967 Daily Concentration (ppm)	1967 No. of Cases	1968 Daily Concentration (ppm)	1968 No. of Cases
N	0.020	10	0.016	8
NNE	0.027	12	0.021	14
NE	0.033	16	0.030	15
ENE	0.038	13	0.038	7
E	0.034	8	0.025	6
ESE	0.034	2	0.032	1
SE	0.021	10	0.024	5
SSE	0.021	15	0.017	17
S	0.023	47	0.021	57
SSW	0.020	31	0.025	38
SW	0.018	17	0.015	32
WSW	0.008	13	0.011	23
W	0.013	19	0.010	14
WNW	0.011	18	0.008	9
NW	0.017	20	0.007	10
NNW	0.018	10	0.007	7

A possible explanation of high daily average concentration of oxidant in winds with a long trajectory over Lake Michigan would be that ozone which has been brought down from the stratosphere is normally depleted when mixed with Chicago's other air contaminants. Therefore, the least amount of natural ozone would remain in air which had been over a populated area longest while air which arrived from Lake Michigan and had only brief contact with other pollution would, on the average, show higher oxidant content.

From an examination of the oxidant samples from the National Air Sampling Network (a 24-hour sample is taken once every two weeks) it was found that 74 out of 80 stations showed a decrease between 1968 and 1969. In checking for a possible meteorological reason for the decrease it was found that at each of 12 sites (chosen because data were easily available) scattered across the U. S., the average maximum temperatures occurring on the sampling days were lower in 1969 than in 1968. The production of oxidant by photo-chemical reaction with automobile exhaust gases is considered to be related to sunshine intensity and air temperature. To see if these factors were present, scatter diagrams were made for specified temperature ranges relating oxidant concentration and hours of sunshine. At temperatures below 80°, the scatter was random, but above 80° there was indication of an increase in the total 24 hour collection of oxidant. However, it was not conclusive that the lower maximum temperatures were the determining factors in causing lower oxidant in 1969.

Suspended Particulate Concentrations

During Fiscal Year 1970, occasional unusually high concentrations of suspended particulate were noted at Cape Vincent, New York, a station in a non-urban location established primarily to measure background concentrations. An analysis of data revealed that days with high particulate concentrations often are characterized by winds from the direction of Rochester, N.Y., 90 miles away across Lake Ontario, and lake temperatures cooler than air temperatures. This implied that a stable layer was over the lake on those days, inhibiting rapid dispersion of the urban pollution "plume".

7.2.3 Division of Health Effects Research

A two-station meteorological network was installed and operated as part of a five station air quality network in New Cumberland, West Virginia, from November 1969 through June 1970 in support of an asthma study. Two meteorological stations were established in Chattanooga, Tennessee, in March and continued in operation to support a second study in this area of effects of nitrogen dioxide and particulate matter on human health. All data obtained from the above studies were reduced, quality controlled, punched, and programmed to be machine listed in formats designed to facilitate interpretation by APCO investigators. Moisture, wind, and temperature measurements were also made in Cincinnati in support of air sampling and the testing of sampling instruments.

Meteorological data were obtained routinely from the National Weather Records Center, analyzed, and climatological summaries prepared for three cities included in the Health Effects Surveillance Network. Assistance was given to the Aerometric Section in the analysis and reduction of aerosol data. These data were used to determine significant differences in the direct effects of pollutants on the health of different population groups.

Consultation was furnished, and temperature data for Philadelphia and Missouri were obtained from the National Weather Records Center to support a pilot study on mortality. Nationwide mortality data for a ten year period are used. After elimination of the effects of flu epidemics and temperature (positive effect with high temperatures in summer, positive effect with low temperatures in winter), mortality statistics for portions of the study area will be compared for urban areas (higher pollution levels) and rural areas (pollution free areas) to see if significant effects of air pollution on mortality can be detected.

7.2.4 Division of Economics Effects Research

Little meteorological support was requested by the Division of Economics Effects Research during this fiscal year other than the provision of estimates of concentrations of total particulates downwind from areas of agricultural burn.

7.3 Office of Manpower Development--Institute for Air Pollution Training

The Institute for Air Pollution Training is a branch of the Office of Manpower Development, APCO. The DM supports the Institute by providing two meteorologists on a full-time basis; one functions as Chief, Air Quality Management Section, the other as a member of the Field Studies Section. The Institute offers the following three one-week courses in the meteorology of air pollution:

(1) "Meteorological Aspects of Air Pollution" -- designed for scientists having no meteorological training and for meteorological technicians. This course was presented twice to a total of 60 students.

(2) "Diffusion of Air Pollution - Theory and Application" -- meteorologists working in air pollution control and for graduates of the Meteorological Aspects course. This course was also presented twice to a total of 58 students, including 21 NOAA employees.

(3) "Meteorological Instrumentation in Air Pollution" -- for engineers and technical personnel responsible for designing, procuring, and maintaining networks of air pollution measuring instruments having meteorological sensors. This course is still in the pilot development stage and was presented only once to twenty students, of whom one was a NOAA employee.

Blocks of instruction on air pollution meteorology were presented in 17 of the Institute's 74 technical courses and orientations. In addition, seven special seminars and lectures were conducted for various universities and professional organizations.

8. INTERNATIONAL ACTIVITIES

8.1 North Atlantic Treaty Organization (NATO), Committee on the Challenges in Modern Society (CCMS)

In March 1970, Mr. K. L. Calder and Mr. J. Zimmerman attended a meeting in Ankara, Turkey, of the working group on air pollution of the NATO Committee on the Challenges in Modern Society (CCMS). Of primary meteorological concern was the availability of appropriate meteorological input data for a mathematical model of the air pollution situation in Ankara, Turkey.

Following a proposal by the United States, a panel of technical experts was established to consider various aspects of the mathematical modeling of air pollution. Mr. R. A. McCormick and Mr. K. L. Calder met in Paris in May 1970 with the two West German members of the panel to formulate working plans and to develop and agenda for the first meeting of the full panel to be held in Frankfurt, Germany, in October 1970.

8.2 World Meteorological Organization (WMO)

In May 1970, Mr. R. A. McCormick attended the WMO meeting and was elected chairman of the Executive Committee Panel on Meteorological Aspects of Air Pollution. The meeting, in Geneva, Switzerland, dealt primarily with criteria for establishing a global network of baseline and regional air pollution monitoring stations for contaminants of known or suspected influence on weather and climate.

8.3 Organization for Economic Cooperative Development (OECD)

In May, 1970, Mr. R. A. McCormick chaired a special meeting of the Study Group on Mathematical Models for the Prediction of Air Pollution. The special meeting was called by the OECD Secretariat for the Study Group at the request of the Norwegian representative to consider aspects in which it could, and should, assist in the study of the "acid rain" problem over Scandanavia.

8.4 Other

In February 1970, Mr. R. A. McCormick presented an invited paper, "Air Pollution in the Locality of Buildings," at the Royal Society Discussion Meeting on Architectural Aerodynamics in London.

In May 1970, Mr. R. A. McCormick visited with officials and toured facilities of the Ente Nazionale per l'Energia Elettrica (ENEL) in Italy. Discussions were centered mainly on matters related to the meteorological and topographical considerations of thermal power plant siting, and the possibilities for cooperative activities or studies for the resolutions of common problems.

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GPO 833 - 247