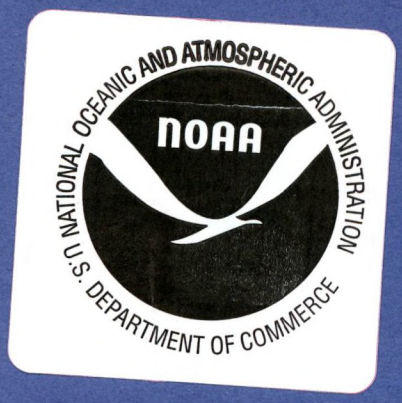
ATDL-84/32
(DE85001798)
Distribution Category UC-11

ENVIRONMENTAL RESEARCH LABORATORIES

Air Resources
Atmospheric Turbulence and Diffusion Laboratory
Oak Ridge, Tennessee

1983 Annual Report

U. S. Department of Commerce
National Oceanic and Atmospheric Administration



DISCLAIMER

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Printed Copy A03
Microfiche A01

Codes are used for pricing all publications. The code is determined by the number of pages in the publication. Information pertaining to the pricing codes can be found in the current issues of the following publications, which are generally available in most libraries: *Energy Research Abstracts (ERA); Government Reports Announcements* and Index *(GRA* and I); *Scientific and Technical Abstract Reports (STAR);* and publication NTIS-PR-360 available from NTIS at the above address.

Printed in the United States of America
USDOE Office of Scientific and Technical Information
Oak Ridge, Tennessee

Foreword

The following is a compilation of abstracts of research contributions from the National Oceanic and Atmospheric Administration Air Resources Atmospheric Turbulence and Diffusion Division for the calendar year 1983. It was prepared by the Technical Information Center, U. S. Department of Energy, Oak Ridge, Tennessee. Copies of individual papers are generally available from the author. The research reported in this document was performed under an agreement between the U. S. Department of Energy and the National Oceanic and Atmospheric Administration.

Bruce B. Hicks, Director
Atmospheric Turbulence and
Diffusion Division, ARL

CONTENTS

CONTENTS (Continued)

Atmospheric Turbulence
and Diffusion Division

Summary of Activities and Plans - FY 1984 - 1985

Plume Transport and Dispersion

Existing techniques for estimating atmospheric dispersion depend largely on the results of the numerous diffusion experiments conducted during the 1950's and early 1960's. However, current theories and recent turbulence experiments are forcing a reconsideration of these results. In particular, most contemporary parameterizations of atmospheric dispersion apply only in steady-state conditions and idealized terrain. Extension to the natural situation in which conditions are continually changing and the surface is not flat and uniform is not a trivial matter. The Atmospheric Turbulence and Diffusion Division (ATDD) has played a leading role in the development of many of the formulations currently popular for use in dispersion models. This role has evolved into a continuing effort to modify the steady-state parameterizations developed over the last several decades, in order to provide the capability to simulate atmospheric transport and dispersion in situations that are typical of real-world applications.

A. PBL Monitoring Program at Oak Ridge

There has been a gradually increasing awareness of the importance of the planetary boundary layer (PBL) in controlling transport and dispersion of pollutants in the lower atmosphere. The PBL is the lower part of the troposphere that responds to the diurnal cycle of heating and cooling at the surface; it is the envelope that contains the daytime mixed layer and the nocturnal surface inversion. As a consequence of an intensive series of meteorological experiments conducted during the last ten years, we now have a sizeable data base regarding the depth of the unstable daytime mixed layer. Several models have been developed, any one of which appears adequate for assessing (or predicting) the afternoon depth of the mixed layer on the basis of external properties such as wind speed, net radiation, and surface characteristics. These relationships have been tested in intensive case studies (e.g., the Wangara study in Australia, and the Minnesota and Sangamon series in North America.) In each case, the surface was selected to be most suitable for answering the physical questions involved; the intent was not to derive results indicative of average conditions but rather to provide answers to specific questions about how the mixed layer can best be parameterized. While experiments of this kind are crucial to the development of rational numerical simulations, they are not representative of the average condition of the atmosphere. For assessment purposes, there are a few critical questions that must be asked about the daytime planetary boundary layer.

(1) What is the mean depth of the mixed layer?
(2) How much does it vary from day to day?
(3) How rapidly does it grow?
(4) How does it vary from location to location?
(5) How well do idealized models of PBL development function in terrain more typical of the real world?

For the night-time case, a similar set of questions arises.

In response to questions of this kind, a two-year program of PBL monitoring has been conducted at Oak Ridge. The experimental plan was to conduct a series of routine examinations of the morning growth of the mixed layer, using tethersondes and sodars in the immediate vicinity of the ATDL. The sounding program was designed to provide enough detail to investigate day-to-day variations as well as the annual cycle. Analysis of the data obtained is now under way.

B. Plume Dispersion Analysis

The evaluation of atmospheric diffusion properties from photographic records of plume behavior is a sufficiently difficult task that its application is relatively infrequent. Instead, most studies employ some kind of tracer release and detection, designed to emphasize long-term average characteristics of plumes rather than the short-term variability that is usually visible to the eye. It is precisely such average plume characteristics that standard numerical simulations are intended to reproduce. Recent wind tunnel investigations conducted by ATDL have indicated good agreement between plume dimensions inferred from tracer measurements and values derived from interpreting sequences of plume photographs. This result provides a basis for applying newly available video digitization techniques to the problem. Such methods offer the potential advantage of an automated system for collecting atmospheric dispersion data (provided the plume is visible), and will permit intensive study of vertical diffusion in a manner that is not possible by other means. The technique will permit study of satellite photographs of plumes in regions where tracer experiments are not feasible, and will enable accurate interpretation of archived photographic records of plume experiments. It will provide a mechanism for collecting and analyzing large quantities of dispersion data rather than a few selected case studies as in past experiments. The availability of such data will allow studies of plume variability about mean values, as is required in attempts to estimate errors associated with predictions and for placing bounds on estimated episodic concentrations.

Laboratory and field tests of computerized methods for interpreting plume photographs have been completed, and video recording equipment is on hand. A commercial video digitizer and associated equipment has been purchased and interfaced to a desktop computer. The work to be done under this subprogram will complete the development and testing of the automatic digitizing and analyzing system. Field tests have been conducted, most recently making use of the plume from a large, uncontrolled fire as a source "of opportunity." The developed system will be used in the FY-1984/5 "ASCOT" field programs, as well as in other missions of direct relevance to ATDD and DOE programs.

C. Long-Range Plume Dispersion

The feasibility of using sulfur isotopes in conjunction with deuterated and fluoridated hydrocarbons as tracers in long-range plume experiments is being investigated in collaboration with Oak Ridge National Laboratory and with other DOE facilities. Three isotopes are being considered, each of which occurs naturally: S-34, S-35, and S-36. The radioactive isotope S-35 has excited considerable interest in the past; however, the isotopes S-34 and S-36 appear to be more likely candidates because they are not radioactive.

Complex Topography.

The ATDD subprogram on transport and diffusion over complex topography is a contribution to the Department of Energy's multi-laboratory program of Atmospheric Studies in Complex Terrain (ASCOT). Transport and dispersion of pollutants in areas of complex topography are well recognized as critical areas of uncertainty in our understanding of the lower atmosphere. Proposals for energy development in Colorado, Utah, and Wyoming have brought these issues into sharp focus, since it is now necessary to assess effects of stack emissions in areas where existing dispersion models are gravely deficient. The ASCOT program is addressing this issue through a coordinated multi-laboratory effort involving theoretical, experimental, and modeling studies. Elements of ATDD's contribution to this work include program planning, experimental design, field experimentation, numerical and analytical modeling, physical modeling, and data analysis.

A. Modeling Work.

The trapping of pollutants near the ground during stable nocturnal conditions has long been recognized as a critical air pollution problem. The situation is worse in complex terrain, where cold air drainage down slopes and along valleys can concentrate pollutants in regions of pooling, where dispersion is severely limited. Because of its fundamental role during nighttime conditions, the drainage wind has been selected for intensive investigation using numerical and analytical models of the flow. The relations between the speed, temperature, turbulence characteristics, and thickness of a drainage flow, and causative factors such as slope angle, surface cooling rate, and ambient atmospheric thermal stability are of special interest. The temporal and spatial features of pure katabatic flows are being examined with a time-dependent two-dimensional numerical model using a physically-realistic turbulence parameterization based on the turbulent kinetic energy equations. This model has been tested satisfactorily against field data. A simplified one-dimensional steady-state analytical model of a drainage flow has been developed on the basis of scaled flow quantities, and is being tested against data collected at several sites.

B. Field Studies

ATDD data from the ASCOT study in 1982 in western Colorado were provided to other participants for analysis. ATDD staff also participated in a related (though non-ASCOT) EPA-sponsored study of plume impaction on a ridge; besides providing meteorological data, the ATDD video plume recording and digitization methods were tested under field conditions. A

multi-laboratory study of canyon flow was planned and conducted in western Colorado in September-October 1984, with active ATDD participation in all phases. In particular, ATDD led the newly-formed QA/QC group in developing laboratory and field methods to ensure data accuracy and compatability in the results obtained by different laboratories. A comprehensive summary of all the field measurement programs between 1979 and 1981 was prepared under ATDD leadership for inclusion in a major ASCOT report.

C. Data Analysis

Digital data records from the multi-station PAM network were reduced to graphical form and distributed to other laboratories to facilitate analysis of the Geysers data. ATDD used these data to study the spatial and temporal variability of nocturnal drainage flow. ATDD staff also helped plan and conduct a workshop at LLNL to review and analyze the entire data set for the Geysers region, with the goals of improved understanding of the relevant physical processes, improvements to existing models of these phenomena, and plans for a major field study in western Colorado. Drainage flow data from northern New Mexico were analyzed in a collaborative study with LANL personnel.

Atmosphere/Canopy Interaction (Forest Meteorology)

A variety of contemporary concerns involve surface-air exchange of mass, heat, and momentum. Among such concerns we can list the transport and deposition of airborne pollutants, especially acid pollutants and radionuclides, and the biosphere's role in the global carbon dioxide balance. Of particular interest in studies of atmospheric turbulence and diffusion is the largely unstudied role of complex canopy structure and physiology in controlling the transport and dispersion of contaminants above and through forests. A forest canopy can be visualized as a very rough surface that tends to retard the wind and generate large turbulent motions, in comparison to the smoother surfaces that have been better studied. By virtue of their areal extent, vertical dimension, and aerodynamic roughness, forest canopies are known to play important roles in the transport, dispersion, deposition, and ultimate fate and effects of mass and energy contained in the atmosphere. Our lack of knowledge of the physical, chemical, and biological mechanisms involved in forest canopy-atmosphere interactions imposes considerable uncertainty on all assessment of pollution transport and deposition in regions containing forests. A particularly interesting example has arisen in the case of the ASCOT field experiments considered above; drainage flow in the Geysers region of northern California has been found to be substantially different from expectations based on experience over nonforested terrain.

The ATDD forest meteorology research project continued to conduct basic scientific studies of the interaction between a deciduous forest canopy and the atmosphere. The program is focusing on three basic areas of canopy-atmosphere interaction as listed below: surface boundary conditions, canopy energy budgets, and above- and in-canopy turbulence and diffusion.

A. Surface Boundary Conditions

Numerical models require specification of surface boundary conditions in a simple yet adequate manner. The method employed must reflect the effects of seasonal changes in canopy structure, variations in meteorological and climatological conditions, and wide fluctuations in biological factors such as stomatal resistance. Ongoing work at the ATDD/ORNL field research site at the Oak Ridge Walker Branch Watershed monitors relevant climatological variables and provides fundamental information on temporal and spatial variations in canopy architecture. The distribution of sources and sinks of various atmospheric quantities is a major interest, since this is a factor which determines the accuracy of flux/gradient relations commonly employed in numerical simulations. Studies designed to quantify spatial and temporal variations in source and sink strength distributions are being designed.

B. Canopy Energy Budgets

Ongoing work is addressing the heat balance of the Walker Branch forest canopy. The thermal behavior of a canopy is determined by its "transparency" to incoming solar and thermal radiation and to turbulent eddies and by the latent heat transfer effected by transpiration of the vegetation making up the canopy. With a leafless forest canopy, insolation and turbulent flow penetrate throughout the canopy and transpiration is essentially nonexistent, creating conditions where the forest floor tends to be warmer than the air above. Consequently, the leafless subcanopy volume tends toward thermal instability. With a foliated forest canopy, on the other hand, canopy density is much greater with the result that neither insolation nor turbulent flow penetrates the forest as deeply. In this situation, elevated temperatures develop at some level in the overstory canopy, the height being dependent upon the time of day (i.e., solar elevation) and the particular architecture of the canopy under consideration. The magnitude of this temperature differential is controlled by convective transfers of sensible heat effected by turbulent flow and by the latent heat transfer of transpiration.

The point is that the thermal behavior of a forest canopy is complex and involves canopy radiation transfer, turbulent exchange of sensible heat, and turbulent exchange of latent heat, the magnitude of which is largely controlled by biological factors. Thus, to understand the manner in which canopy thermal structure affects turbulent transport, dispersion, and deposition of airborne materials within and above a forest canopy, we must fully understand how canopy structure and physiology interacts with incident radiation fields and atmospheric turbulence to create the observed thermal structures of forest canopies. Studies are being conducted and further studies are being planned to further our understanding of these canopy energy exchange phenomena.

C. Above and In-Canopy Turbulence and Diffusion.

The penetration of wind gusts through forest canopies is postulated to be a controlling factor of sub-canopy dispersion of pollutants. Microscale pressure variations, sometimes associated with clearings in the canopy, are also credited with a strong role. At this time, there is no consensus as

to which of these (or other) mechanisms dominates under any specific set of conditions. The matter is of practical importance, since the location of receptors of deposited airborne pollutants, as well as the overall canopy dispersion, will be determined by transport within the canopy. Work at the Walker Branch field site will investigate sub-canopy wind and turbulence and will evaluate the roles of gust penetration and pressure-field variations as causative factors. This work will be closely coupled with studies of pollutant transport across the atmosphere-canopy interface.

Research conducted by this project is closely coordinated with DOE-supported work conducted by the Environmental Sciences Division, ORNL, so as to maximize the effectiveness of the efforts by both organizations. In addition, the forest meteorology research project provides meteorological data to the ORNL research activities whenever possible, within present funding and manpower constraints.

Dry Deposition Monitoring Research

The need for dry deposition data similar to the wet deposition numbers generated by monitoring programs such as the National Atmospheric Deposition Program is well recognized. In the absence of any generally-accepted method for evaluating dry deposition of trace gases and aerosols directly, an inferential technique using concentration data is the only available option. However, the concentration data alone are not adequate for evaluating dry deposition, since site-specific, time-evolving, and species dependent deposition velocities must be taken into account. Suitable deposition velocities might be determined from measurements of wind speed, stability, etc. made in conjunction with the concentration measurements, provided adequate formulations for the deposition velocity are available.

The proposed dry deposition component of the National Trends Network will include both air concentration monitoring and meteorological measurements on a routine basis. A supporting network of research stations is proposed. This "core" network is already in place, in a preliminary form. Stations have been set up at Argonne, Illinois; State College, Pennsylvania; and Oak Ridge, Tennessee. Support for this multilaboratory program has been derived from USGS, EPA and NOAA; however, the bulk of the research support has been from DOE. The present program constitutes the DOE support for work in Tennessee and Pennsylvania. The Illinois work is funded under a separate but closely related work package.

This work combines participants from the NOAA Atmospheric Turbulence and Diffusion Division (Oak Ridge, Tennessee), Argonne National Laboratory, and Pennsylvania State University in a cooperative effort to initiate routine monitoring of dry deposition fluxes of gaseous and particulate air pollutants. Three sites have been selected for intensive effort under this program. Other potential sites have been identified and will be considered further, once the results of initial phases of this program become available. The monitoring network will evaluate dry deposition fluxes for use by ecologists concerned with environmental impact, by regulators concerned about control strategies, and by modelers involved in studies of long-range transport and deposition. Many other institutions collaborate in these studies, including Oak Ridge National Laboratory, the University of Michigan, colorado College, and Denver University.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Eddy Correlation Calculations Done in Real-Time

Author(s): R. T. McMillen

Date : January 1983

Published: Conference Preprints, Fire and Forest Meteorology, April 15, 1983, Ft. Collins, Colorado, pp. 111-114

Abstract

Turbulent wind data were collected above an oak-hickory forest canopy located in irregular terrain in East Tennessee. The data were processed in two distinct ways and the results compared. The first technique involved a three-dimensional coordinate rotation, followed by the accepted method of calculating turbulent fluxes at more ideal sites. The second technique involves real-time mean removal with digital recursive filters, and real-time calculation of the turbulent fluxes. Stability of the solution is examined as a function of the mean removal filter time constant and the accumulation period of the solution.

ATDL Contribution File No. 83/1

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : On the Variation of PBL Dispersion Properties With Height in Unstable Conditions

Author(s): B. B. Hicks

Date : June 1983

Published: NUREG/CR-3773 and to be published as a NOAA Technical Memorandum

Abstract

Recent developments in surface boundary layer and planetary boundary layer meteorology are combined to evaluate the height dependency of the dispersion parameters σ_z and σ_y of the familiar Gaussian plume relationships. Recommendations are based on analyses of surface boundary layer data, such as are collected at industrial sites under existing NRC guidelines.

ATDL Contribution File No. 83/2

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Overview and Suggestions for Future Research on Dry Deposition

Author(s): B. B. Hicks and J. A. Garland

Date : January 1983

Published: Conference Proceedings Fourth International Conference on Precipitation Scavenging, Dry Deposition and Resuspension, November 29-December 3, 1982, Santa Monica, California Vol. 2, pp 1429-1433

Abstract

An examination of available data and models indicates that earlier uncertainties and disagreements about dry deposition are rapidly being reconciled. In general, sulfur dioxide is deposited more rapidly than submicron aerosol sulfate, although sulfur dioxide is deposited less rapidly than had been thought and sulfate particles are deposited more quickly. Surface roughness appears to influence particulate sulfur deposition velocities more than gaseous, so that for very rough surfaces (e.g., forests) it is found that sulfate deposition velocities sometimes approach values appropriate for sulfur dioxide.

ATDL Contribution File No. 83/3

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Status of Research to Develop Acidic Dry Deposition Monitoring Capability

Author(s): B. B. Hicks, Marvin L. Wesely, Rosa G. dePena and Dennis R. Thomson

Date : August 1983

Published: Presented at the 76th Annual Meeting and Exhibition of the Air Pollution Control Association, June 19-24, 1983, Atlanta, Georgia

Abstract

In response to the recognized need for dry deposition data to complement wet deposition results being obtained under the auspices of the National Acid Precipitation Assessment Program, efforts are underway to develop methods for routine monitoring of dry deposition. Since there is no method suitable for direct measurement of dry deposition rates of gaseous and submicron particulate pollutants to natural surfaces, the emphasis is currently on methods for evaluating deposition fluxes from air concentration data and supporting meteorological (and biological) information. Micrometeorological methods for directly measuring dry deposition fluxes in intensive case studies are also being developed. These case studies are intended to provide the basis for procedures used to evaluate dry deposition from the simpler data obtained routinely. Such micrometeorological methods are less applicable in the case of supermicron particles, for which some development of surrogate surface devices seems necessary.

ATDL Contribution File No. 83/4

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Preliminary Estimates of Airborne Pollutant Fluxes to the Camp Branch and Cross Creek Watersheds

Author(s): R. P. Hosker, Jr., K. Shankar Rao, and Bruce B. Hicks

Date : July 1983

Published: To be published as a NOAA Technical Memorandum

Abstract

This report describes a preliminary attempt to model SO_2 concentrations and fluxes to deciduous forest canopies at two research sites operated by the Tennessee Valley Authority, to assess the utility of the present measurement program and data set for modeling purposes, and to recommend improvements necessary to facilitate further analyses.

The Camp Branch and Cross Creek watershed sites characteristics and meteorology are briefly described. A sector-box model with time-dependent mixed-layer depth, first-order chemical conversion of SO_2 to SO_4, and wet and dry en route removal of both chemical species was used to approximate long-range transport from two large coal-fired power plants. SO_2 concentrations at Cross Creek due to a source < 25 km distant were predicted with limited success; individual predictions were accurate within a factor of ten, with a great deal of scatter. For all other source-receptor combinations, individual concentratons were rather poorly predicted, suggesting the influence of factors (complex terrain, smaller but nearby sources, etc.) not incorporated in this early effort. However, predicted SO_2 fluxes based on median concentration values were within about a factor of three of the flux estimates based on observations.

A one-dimensional flux model based on canopy radiation balance and measured vertical gradients (differences) of SO_2 concentration, temperature and moisture is presented. To approximate local fluxes to the watersheds using this model, the vertical profile data must be determined accurately enough that gradients are not masked by the breadth of the data confidence intervals. The SO_2 concentration data from a period of ideal conditions were examined; it was found that the standard deviation of the concentration

at each level exceeded the gradient that would be expected from depositional processes. It was therefore concluded that the existing SO_2 measurement system is not adequate for use with the suggested flux model.

On the basis of these preliminary analyses and on-site equipment inspections, a number of specific improvements in the present measurement and recording techniques are recommended. Possible improvements to the modeling effort are also outlined in some detail.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Turbulence and Dispersion Parameters Derived From Smoke-Plume Photoanalysis

Author(s): Carmen J. Nappo

Date : May 1983

Published: Atmospheric Environment, 18, No. 2, 299-306, 1984

Abstract

Instantaneous and time-averaged photographs of a smoke plume generated in a large wind tunnel are analyzed to obtain downwind estimates of single-particle and two-particle dispersion rates. Single particle, i.e., time-averaged, dispersion rates are measured directly from a methane gas plume released and sampled under wind tunnel conditions identical to the smoke-plume release. The correlation between smoke-plume derived dispersion rates and measured values, is 0.99; the RMS error between these values is 7.6 percent, and the geometric mean of the ratio of measured to derived values is 1.09. Using estimates of single-particle and two-particle dispersion values, the following turbulence parameters are calculated: crosswind velocity variance, σ_2, Lagrangian integral time scale, τ_L, eddy diffusivity, I, eddy dissipation rate, ε, and crosswind turbulence intensity, i. The values of these parameters agree well with values directly measured from the flow field. Details on the use of smoke-plume methods are given, and it is demonstrated that this method is accurate, useful, and cost effective.

ATDL Contribution File No. 83/6

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Solar Radiation Within an Oak-Hickory Forest: An Evaluation of the Extinction Coefficients for Several Radiation Components During Fully-Leafed and Leafless Periods

Author(s): Dennis D. Baldocchi, Detlef R. Matt, Boyd A. Hutchison, and Robert T. McMillen

Date : June 1983

Published: Submitted to Agricultural and Forest Meteorology for publication

Abstract

Global shortwave, photosynthetically active, net and allwave radiation was measured above and at several levels within an oak-hickory forest with instruments mounted on a moving tram system. Profiles of radiation flux densities were quantified using extinction coefficients based on the Beer-Bouguer Law. Data are reported here from periods when the forest was fully-leafed and leafless.

In the fully-leafed forest the solar radiation components are attenuated exponentially in the following manner:

$$PAR > R_n = R_g > allwave,$$

where PAR is photosynthetically active radiation, R_n is net radiation and R_g is shortwave radiation. PAR attenuation is greater than that for the other components because leaves preferentially absorb PAR. The preferential absorption causes the ratio, PAR/R_g, to decrease from 0.49 above the canopy to 0.27 at the forest floor.

Shortwave beam radiation is not attenuated in an exponential manner because leaf angles increase progressively with height in the canopy.

During the leafless phenoseason, the radiation components are attenuated exponentially as follows:

$$R_n > R_g = PAR > allwave.$$

Title: Solar Radiation Within an Oak-Hockory Forest: An Evaluation of the Extinction Coefficients for Several Radiation Components During Fully-Leafed and Leafless Periods (continued)

R_g and PAR are attenuated in a similar manner during this phenological phase because no leaves are present to preferentially absorb PAR. The magnitude of the attenuation coefficients for R_n, R_g and PAR are much greater during winter leafless period because solar elevation angles are low and the canopy consists of dark, opaque, woodbiomass.

Extinction coefficients for beam radiation were compared with coefficients computed from theoretical models. Agreement between measured and theoretical values is reasonable if light penetration through the upper and lower canopy is considered separately. Deviations from theory are attributed to clumping and gaps in the canopy.

ATDL Contribution File No. 83/7

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Mechanisms of Air Pollutant Deposition to Aquatic Ecosystems

Author(s): Bruce B. Hicks

Date : June 1983

Published: To be published in Conference Proceedings of NATO/CCMS Meeting on Air Pollution Control Strategies and Impact Modelling, June 14-17, 1983, Chapel Hill, North Carolina

Abstract

Deposition directly to exposed water surface contributes only a minor part of the total pollutant input to aquatic ecosystems. A much larger flux normally results from pollutants deposited to the surrounding countryside. In the case of wet deposition, the nature of the underlying surface has little effect on the rate of deposition of material from the atmosphere, although throughfall may be substantially different from above-canopy precipitation. However, dry deposition rates depend strongly on the detailed nature of the surface. For many important trace gases, biological factors are sometimes dominating, whereas for aerosols the aerodynamic roughness of the surface tends to play a major role. Dry deposition directly to lakes and streams is affected by many mechanisms, the relative importance of which can be judged on the basis of laboratory studies and theoretical considerations. The data base referring to natural situations is very limited, and instrumentation suitable for field measurements is still being developed.

ATDL Contribution File No. 83/8

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Network Monitoring of Dry Deposition of Trace Gases and Submicron Particles

Author(s): B. B. Hicks

Date : July 1983

Published: To be published in Conference Proceedings of WMO Technical Conference On Observation and Measurement of Atmospheric Contaminants (TECOMAC), October 17-21, 1983, Vienna, Austria

Abstract

Dry deposition comprises the turbulent exchange of trace gases, the turbulent deposition of submicron aerosols, and the gravitational settling of supermicron particles. In concept, surrogate-surface or collection vessel methods are generally inappropriate for monitoring the turbulent dry deposition fluxes, and methods based on knowledge of turbulent exchange are inappropriate for monitoring gravitational settling. Thus, there can be no single methodology adequate for monitoring all the components of dry deposition in all circumstances. Since the focus of attention under the Natural Acid Precipitation Assessment Program is on trace gases and aerosols, most activity in dry deposition monitoring research is currently addressing the interpretation of air concentration data, using methods based on the interpretation of atmospheric turbulence data, together with supporting biological information.

ATDL Contribution File No. 83/9

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Physical Measurement in ASCOT, Chapter 2

Author(s): R. P. Hosker, Jr.

Date : August 1983

Published: Atmospheric Studies in Complex Terrain Technical Progress Report, FY 1979 through FY 1983, Chapter 2, M. H. Dickerson and P. H. Gudiksen, eds., LLNL Report UCID-19851, ASCOT 84-1, pp 7-81

Abstract

This chapter discussed the field measurements performed in 1979, 1980, and 1981 in the Geysers area of northern California as part of the Department of Energy's "Atmospheric Studies in Complex Terrain" (ASCOT) program. The intent is to acquaint the reader with the rationale of the measurement effort, with the details of the various instruments, materials, and techniques used and the methods of their deployment, and with the data handling procedures for this multi-laboratory effort. Methods of site and vegetation characterization are described. Limitations of direct and remote sensing meteorological measurement systems and of various tracer techniques are discussed. A "systems approach" to overcome some of these limitations is advocated, and recommendations for future work are also included. The hope is that the reader will acquire some feeling for the likely accuracy and representativeness of the data base accumulated during the three intensive study periods, and will be able to benefit from ASCOT's experience when designing similar field programs.

ATDL Contribution File No. 83/10

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : A Study of the Probable Environmental Impact of Fugitive Coal Dust Emissions at the Ravenswood Power Plant, New York

Author(s): K. Shankar Rao and Lynne Satterfield

Date : July 1983

Published: NOAA Technical Memorandum ERL ARL-123, 83 pp.

Abstract

The Ravenswood Power Plant of the Consolidated Edison Company of New York is being converted to use coal as the primary fuel. This report addresses the probable short and long-term air pollution impacts of the fugitive coal dust emissions that are likely to occur during the coal unloading at the facility.

The coal drift consists of particles ranging in size from 0.1 to 200 μm. Assuming a lognormal probability of the particle size distribution, a drift mass spectrum was developed for six particle size ranges considered in the study. A steady state atmospheric advection-diffusion model that accounts for the gravitational settling and dry deposition of the particles was formulated, and an analytical solution, consistent with the basic assumption of the Gaussian plume model, was derived and applied to the present study. The meteorological data used consist of a five year record of hourly surface wind observations. Six wind speed classes and sixteen wind direction classes were considered in the analyses.

This study considers two different coal unloading schedules: coal is unloaded only during daytime (0700-1900 hrs.) in Case I, and around the clock (both day and night) in Case II. The calculated results of ground-level concentrations, atmospheric concentrations and visibilities, hourly surface deposition fluxes, and deposition flux and net deposition rates on monthly and yearly basis were presented for Cases I and II separately.

ATDL Contribution File No. 83/11

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Eddy Fluxes of Nitrogen Oxides to a Deciduous Forest in Complex Terrain

Author(s): B. B. Hicks, D. R. Matt, R. T. McMillen, and J. D. Womack

Date : October 1983

Published: Presented at Meteorology of Acidic Deposition Conference, October 17-18, 1983, Hartford, Connecticut

Abstract

A fast-response NO_x sensor was used to measure eddy fluxes of nitrogen oxides and nitric acid vapor to a deciduous forest canopy in relatively complex terrain, during three days of July, 1982. Preliminary tests were conducted to assure that the covariance methods used in the NO_x flux studies were capable of providing accurate flux determinations. Independent measurements of sensible and latent heat fluxes satisfied the requirements of surface heat energy balance, provided due allowance was made for the effects of storage terms in the canopy. Measurements of Reynolds stress yielded surface friction coefficients near anticipated values, with no evidence of strong effects of either wind direction or atmospheric stability. Measurements of NO_x fluxes and evaluations of corresponding deposition velcoities were probably affected by HNO_3, which was detected by the sensor as if it were NO or NO_2. Subsequent determinations of HNO_3 vapor at the same site indicate that concentrations could be sufficiently large to explain the infrequent appearance of rather high NO_x deposition velocities, sometimes approaching the maximum values permitted by atmospheric turbulent transport processes. These various considerations lead to the conclusion that NO_2 deposition velocities to deciduous forest are likely to be very small at night, and could also be small during daytime.

ATDL Contribution File No. 83/12

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : 1982 Annual Report

Author(s): Atmospheric Turbulence and Diffusion Laboratory

Date : October 1983

Published: Technical Information Center, U.S. Department of Energy, Oak Ridge, Tennessee 37830, 48 pp.

Abstract

Bound volume containing abstracts for all ATDL papers, reports, etc., published during 1982.

ATDL Contribution File No. 83/13

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Dry Deposition of Air Pollutants in an Urban Environment

Author(s): B. B. Hicks and R. P. Hosker, Jr.

Date : October 1983

Published: To be published in Conference Proceeedings of the
AMS Specialty Conference on Air Quality Modeling of the
Nonhomogeneus, Nonstationary Urban Boundary Layer,
October 31-November 4, 1983, Baltimore, Maryland

Abstract

In any given circumstance, dry deposition rates will be proportional to the airborne concentration of the pollutant in question. On this basis alone, we might expect dry deposition fluxes in urban areas to be somewhat greater than in the rural, background locations of interest elsewhere (e.g., in discussions of acid deposition). The exchange of pollutants between the air and receptor surfaces is also likely to be enhanced, because of the large variety of surfaces available and the increased mechanical mixing caused by buildings and other structures; the increased mixing tends to reduce the frequency of occurrence of strong stratification that would otherwise limit dry deposition. Soluble and/or chemically reactive trace gases tend to be deposited to moist surfaces, either via stomatal transfer to the mesophyll tissue of foliage, or to wet soil, stone, or exposed metal after precipitation, fog, or dewfall. Small particles are inefficiently deposited on smooth surfaces, but there is evidence that deposition can be promoted by microscale surface roughness, electrostatic charges, or condensation. Particles larger than about 20 m in diameter deposit largely via gravitational sedimentation and impaction on obstacles. They are found mainly on upward-facing surfaces, or are "filtered" from passing air by obstructions. Monuments, statues, and other structures present special cases of intriguing complexity; it is not yet clear what physical processes dominate.

ATDL Contribution File No. 83/15

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : ASCOT Data Analysis Workshop

Author(s): C. J. Nappo

Date : December 1983

Published: Bulletin, AMS, Vol. 65, No. 7, 712, July 1984

Abstract

As part of the Department of Energy's ongoing Atmospheric Studies in Complex Terrain (ASCOT) program, a workshop was held 7-11 November, 1983, at the Lawrence Livermore National Laboratory, in Livermore, California. The purpose of the workshop was to identify and formulate questions and hypothesis concerning the physics and modeling of transport and diffusion in drainage flows, and ascertain the degree to which existing data collected by ASCOT investigators can provide insight into these questions and hypothesis. A report of the workshop proceedings is scheduled for Spring 1984.

ATDL Contribution File No. 83/16

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : A Photographic Study of a Massive Tire Fire

Author(s): Walter M. Culkowski, Carmen Nappo, Brian Templemen and Jess Wynn

Date : December 1983

Published: Atmospheric Environment, 18, No. 4, 893, 1984

Abstract

In early November 1983 a fire consuming millions of tires near Winchester, Virginia, received wide coverage on national television and most newspapers. This plume was photographed extensively over a six hour period extending from early morning to late evening on video tape and time lapse cinema. Copies of the tapes and films are available on video tape to interested investigators of plume behavior.

ATDL Contribution File No. 83/17

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : Evaluation of the Pollution Episodic Model Using the RAPS Data

Author(s): Will Pendergrass and K. S. Rao

Date : December 1983

Published: To be published as an EPA report and NOAA Technical Memorandum

Abstract

The Pollution Episodic Model (PEM) is an urban-scale model capable of predicting short-term average ground-level concentrations and deposition fluxes of one or two gaseous or particulate pollutants at multiple receptors. The two pollutants may be nonreactive, or chemically-coupled through a first-order chemical transformation. Up to 300 isolated point sources and 50 distributed area sources may be considered in the calculations. Concentration and deposition flux estimates are made using the mean meteorological data for an hour. Up to a maximum of 24 hourly scenarios of meteorology may be included in an averaging period. PEM is intended for studies of the atmospheric transport, transformation, and deposition of pollutants in urban areas, and to assess the impact of new sources or source modifications on air quality for regulatory purposes and urban planning.

This report describes an evaluation of the PEM using the St. Louis Regional Air Pollution Study (RAPS) data. This evaluation was designed to test the performance of the model by comparing its concentration estimates to the measured air quality data, using appropriate statistical measures. Twenty days, ten summer and ten winter, were selected from the RAPS data base for the PEM evaluation. The model's performance was judged by comparing the calculated 12-hour average concentrations with the corresponding observed values for five pollutant species, namely, SO_2, fine and coarse sulfates, and fine and coarse total mass. A first-order chemical transformation of SO_2 to fine sulfate was considered in the calculations in addition to the direct emission and dry deposition of all five pollutants. The model domain, covering 125 x 125 km with a 50 x 50 receptor grid, included 286 point sources and 36 area sources in the greater St. Louis urban area. Hourly meteorological data and detailed emission inventories for the five pollutants were used as inputs to the model.

Title: Evaluation of the Pollution Episodic Model Using the RAPS Data (continued)

Statistical tests for evaluation of the model performance included standard measures of differences and correlation between observations and calculations paired in space and time. For each pollutant, scatterplots of calculated concentrations and differences versus observed concentrations were presented; a linear regression line was determined and evaluation statistics were tabulated. Additional plots, examining the model performance as a function PEM evaluation days and RAMS station locations, were shown.

The emphasis in this evaluation was on SO_2 and sulfate concentration predictions. For the twenty PEM evaluation days, PEM performed satisfactorily in predicting average concentrations of SO_2, and fine and coarse sulfates to within a factor of two. The model overpredicted the average concentrations of fine and coarse total mass by a factor of three to four over the evaluation period. This was attributed primarily to overestimation of emission rates and incorrect location of area sources, which dominate the fine and coarse total mass emissions. Other possible sources of errors in the calculations were listed and discussed.

The work described in this report was performed by NOAA's Atmospheric Turbulence and Diffusion Division in partial fulfillment of Interagency Agreement No. AD-13-F-1-707-0 with the U.S. Environmental Protection Agency. This work, covering the period October 1982 to December 1983, was completed as of February 29, 1984.

ATDL Contribution File No. 83/18

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Division
National Oceanic and Atmospheric Administration
1983

Title : An Experimental Study of Sulphur and NO_x Deposition to Grassland

Author(s): Bruce B. Hicks

Date : June 1984

Published: To be submitted to Boundary Layer Meteorology for publication

Abstract

A study of eddy fluxes of sulfur and nitrogen compounds to a field of wheat stubble and natural grasses was conducted during September, 1979. The site was in southern Ohio, where sulfur dioxide and sulfate concentrations were typically sufficiently high to ensure that the sensors used operated well above their detection limits. Three independent sulfur sensors were used. Two were modified commercial devices, arranged to measure gaseous sulfur and submicron particulate sulfur separately. The third sulfur sensor was a prototype device offering higher speed of response, and was used to measure total sulfur (excluding supermicron particles). The results of all tests using these sulfur sensors indicated lower deposition velocities for particulate than for gaseous sulfur compounds. Experiments employing a fast-response detector of nitrogen dioxide failed to provide statistically meaningful results. The scatter of the results indicated effects of local site irregularities, probably associated with farming practices and grazing operations in the vicinity of the site. Measurements of sensible heat flux and Reynolds stress supported the supposition that the site was adequate for micrometeorological work, in general.

ATDL Contribution File No. 82/11

Air Resources Atmospheric Turbulence and Diffusion Laboratory.
Annual report. 1973- [v.1
Contributions (no.74-87)- Oak Ridge, Tenn., Environmental Research Laboratories, Air Resources Atmospheric Diffusion Laboratory, 1974-

v. illus. 28 cm. (ATDL-106-)

A compilation of the Laboratory's Contributions for the calendar year. Prepared by the Technical Information Center, U.S. Atomic Energy Commission, Oak Ridge, Tenn. Research reported was performed under an agreement between the U.S. Atomic Energy Commission and

(cont. next card)

Air Resources Atmospheric... Annual report. 1973- [v.1... 1974

(card 2)

NOA75-182027