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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Foreword

The following is a compilation of abstracts of research contributions from the National Oceanic and Atmospheric Administration Air Resources Atmospheric Turbulence and Diffusion Laboratory for the calendar year 1981. 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.

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Atmospheric Turbulence
and Diffusion Laboratory

Summary of Activities
and Plans - FY 1981 - 1982

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 rates 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 Laboratory (ATDL) 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 program of PBL monitoring has commenced at Oak Ridge. The experimental plan is 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 program will provide a record with enough detail to investigate day-to-day variations as well as the annual cycle. A minimum period of operation of two years is planned, with the expectation that statistical analysis of the data obtained during the first year might well show that a longer period of observation will be required.

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.

Initial tests of methods for interpreting plume photographs have been completed, and video recording equipment is already on hand. A commercial video digitizer and associated equipment has been purchased and interfaced to a desk-top computer. The work to be done under this subprogram will complete the development and testing of the automatic digitizing and analyzing system; bench tests will be carried out, and a series of field studies will be initiated.

Complex Topography.

The ATDL 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 omissions in our understanding of the lower atmosphere. Plans to develop fossil fuel deposits 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 in which 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 ATDL's contribution to this work include program planning, experimental design, numerical modeling, physical modeling, data analysis, and field experimentation.

A. Modeling of Drainage Flows.

The driving force for nighttime flows in valley environments is the cold air drainage wind down slopes and along the valley sidewalls. Because of its fundamental role in nighttime conditions, the drainage wind has been selected for intensive investigation using numerical modeling techniques. Of special interest are the relationships between the speed, temperature, and thickness of the drainage flow, and causative factors such as slope angle, surface cooling rate, and atmospheric thermal stability. The temporal and spatial features of drainage flows are being investigated using time-dependent one- and two-dimensional models which utilize physically-realistic turbulence parameterizations based on the turbulence kinetic energy equations. Comparisons with field observations have been satisfactory, and simulations have been performed which corroborate effects previously associated with slope angles and surface roughness, as well as forest canopy structure (see below: Atmosphere/Canopy Interaction).

Field observations are of limited utility in testing the detailed parameterizations required for models of the kind being developed in this program. Equipment suitable for generating suitable information for testing model parameterizations under controlled conditions is already on hand at this laboratory. Feasibility studies will be initiated, to evaluate the utility of this apparatus and to determine the extent of modifications that might be required to simulate two-dimensional drainage flow over a roughened, cooled surface. If these preliminary tests prove successful, a series of laboratory studies will commence. Profiles of velocity, temperature, and turbulence kinetic energy will be measured at various downslope distances for a range of slope angles.

B. Field Studies.

The ATDL participated in the ASCOT August 1981 field study of cooling tower plume rise and diffusion in the Geysers region of Northern California. A modified tethersonde profiling system was employed, this providing real-time graphical output of wind, temperature, and humidity profiles using an HP-85 microcomputer.

Plans are under way for a preliminary field study of nighttime flows in the oil shale development area in north-western Colorado during the summer of 1982. This ASCOT effort will be a multi-laboratory explorative study involving personnel from the Los Alamos National Laboratory (LANL) and the NOAA Wave Propagation Laboratory (WPL). Major emphasis will be given to documenting large-scale gravity-driven flows and meso-micro-scale interactions.

A drainage flow study over simpler terrain is being planned for June, 1982. This field experiment will also involve LANL, and will be performed as part of an experiment in southwestern Colorado being conducted by the U.S. Forest Service. The focus of this experiment will be on the evolution and stucture of drainage flows and the interaction with ambient winds; the data will be used to test one- and two-dimensional slope flow models.

The ASCOT data from the September 1980 field program are being analyzed in considerable detail. In particular, data obtained by the NCAR Portable Automated Mesonet (PAM) system are being studied to ascertain the utility and information content of activity, trajectories of constant-level tetroons are being analyzed to determine lagrangian velocity fields in the Geysers area, and to compare these with tracer data and numerical model predictions of atmospheric transport.

Atmosphere/Canopy Interaction (Forest Meteorology).

A variety of contemporary concerns involve surface-air exchanges 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 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 assessments of pollution transport and deposition in areas 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 non-forested terrain.

The ATDL forest meteorology research project continues 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, listed below.

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 and architecture, variations in meteorological and climatological conditions, wide fluctuations in biological factors such as surface roughness. Ongoing work at the ATDL/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 of major interest, since this is a factor which determines the accuracy of flux/gradient relations commonly employed in numerical simulations.

B. Canopy Energy Budgets.

Ongoing work is addressing the heat balance of the Walker Branch forest canopy. The thermal behavior of a canopy is essentially determined by its transparency to incoming solar (and infrared) radiation and by the ease with which air parcels can penetrate deep into the canopy. Deep penetration by insolation into a leafless canopy will result in the generation of "hot spots" near the forest floor, resulting in a tendency to sub-canopy thermal instability. On the other hand, radiation will not penetrate so deeply through a leafy canopy, and a tendency to sub-canopy thermal stability is to be expected. In either case, a forest canopy provides a more intimate thermal coupling with the air than does pasture, for example, and foliage-to-air temperature differences are correspondingly smaller.

C. 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. Micro-scale pressure variations, sometimes associated with clearings in the canopy, are also accredited 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 depositing 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 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 contraints.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : An Analysis of Wangara Micrometeorology: Surface Stress, Sensible Heat, Evaporation, and Dewfall

Author(s): B. B. Hicks

Date : June 1981

Published: NOAA Technical Memorandum ERL ARL-104, 36 pp.

Abstract

Eddy fluxes and gradients reported for the Wangara experiment and earlier investigations of flux-gradient relations are used to derive values of the sensible heat flux and friction velocity appropriate to the general area of the Wangara experiment rather than to the considerably smoother central site. Friction velocities appear to be considerably greater than those developed in previous studies of the Wangara data set. Sensible heat fluxes are similar during daytime, but differ greatly from other estimates for night. Dewfall evaluations indicate a total of about 9 mm during the experiment; condensation occurred at rates that sometimes approached but rarely exceeded the theoretical maximum rate of about 0.07 mm/hr. Maximum dewfall occurred under clear skies (less than 40% cloud cover), and in moderate winds.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Review: Atmospheric Deposition and Plant Assimilation of Gases and Particles

Author(s) : R. P. Hosker, Jr. and Steven E. Lindberg

Date : May 1981

Published : Atmospheric Environment Vol. 16, No. 5, pp. 889-910, 1982

Abstract

Abstract—This review and workshop summary examines the interactions of airborne materials with environmental surfaces, particularly vegetative canopies. Key objectives were to: (1) review and describe physical and chemical characteristics of pollutants in the air surrounding various receptors; (2) determine if existing concepts and information describe adequately the transfer of material from the atmosphere to the receptors; (3) assess existing capability for predicting the consequences of interactions between atmospheric substances and vegetation and (4) determine information needs regarding environmental conditions and mechanisms regulating deposition and uptake of airborne substances by vegetation. Although the workshop findings have been updated using the recent literature, nearly all of the original conclusions remain valid and pertinent.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : A Review of Deterministic Urban Air Quality Models for Inert Gases

Author(s) : R. W. Simpson and S. R. Hanna

Date : September 1981

Published : NOAA Technical Memorandum ERL ARL-106, 86 pp.

Abstract

The purpose of this review is to critically examine deterministic air quality models for inert gases in urban areas. Photochemical models and statistical models are not considered, as the term "deterministic" is taken here to refer to models based on physical laws.

There are many reviews which cover the broad spectrum of air quality models, including those by Eschenroeder (1975), Johnson et al. (1976), Hanna (1978a), Drake, et al., (1979), and Turner (1979). By ignoring photochemical and statistical models this review concentrates on a study of the usefulness of the various approximations representing the dispersion of airborne pollutants. The adequacy of a model can only be measured by how well it simulates reality. Yet there is still some confusion on the criteria to be used to evaluate model performance, as evidenced by the work of Eschenroeder (1975), Shaeffer (1979), and Hayes (1979). As pointed out by Hayes (1979) in particular, measures of model performance depend on the use to which the model is to be put. In this review we shall simply point out what the models predict and briefly summarize the usefulness of such predictions at the end. More complete examinations of this problem can be found in the three papers previously cited.

The major area of study in this review centers on how well the various theories of atmospheric dispersion predict pollutant levels and so this is basically a study of the effectiveness of the different treatments of turbulent diffusion. Because we shall only consider models for urban areas, our conclusions have no relevance on how well the different approaches perform for single source cases. Deposition submodels are of course important but these shall only be briefly reviewed. In considering urban models we shall also briefly consider how point, line, and area sources are treated, but only to the extent that the assumptions implicit in incorporating such models are made clear.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Annual Report for 1979 and 1980

Author(s) : Atmospheric Turbulence and Diffusion Laboratory

Date : March 1981

Published : National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161, 61 pp.

Abstract

Bound volume containing abstracts for all ATDL papers, reports, etc., published during 1979 and 1980.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Handbook on Atmospheric Diffusion Models

Author(s) : Steven R. Hanna

Date : March 1981

Published : A Review of Atmospheric Diffusion Models for Regulatory Applications, Technical Note No. 177, WMO No. 581, 37 pp.

Abstract

Atmospheric diffusion models that are widely used for regulatory purposes are reviewed. While the Gaussian plume model is most often used in western countries, the gradient-transport (K) model is most often used in eastern countries. The most important parameters predicted by the models are the magnitude and location of maximum ground-level concentrations. The models are compared theoretically and empirically, using observations, and the conclusion is drawn that maximum concentrations predicted by the two models can differ by an order of magnitude, with the sign of the difference depending on the specific application. On average, however, the models agree fairly well. The largest scientific difference is in the plume-rise formulas, whereby the U.S.A. model predicts plume rises for typical industrial stacks that are twice as high as those predicted by the U.S.S.R. model.

Recent developments in model applications to complex terrain, long-range transport and area sources are also reviewed. There is currently much interest in developing measures and standards for model performance. A few "research-grade" models are discussed in order to illustrate the types of model that can be expected to appear in regulatory procedures in the future. These models are not at present in widespread use, either because they have not been adequately tested or because they require excessive computer time.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Natural Variability of Observed Hourly SO_2 and CO Concentrations in St. Louis

Author(s): Steven R. Hanna

Date : April 1981

Published: Atmospheric Environment Vol. 16, No. 6, pp. 1435-1440, 1982

Abstract—Observed hourly pollutant concentrations are stochastic or turbulent variables. For constant given mean wind speed, wind direction, stability and source emissions, observed hourly concentration can be expected to vary from hour to hour. In this study the variable C/Q is used, where C is hourly concentration of CO or SO_2 observed in the St. Louis RAPS network (there are 25 monitoring stations), and Q is the total hourly emissions observed in the region. Wind speed, wind direction, and stability are broken down into 10, 18 and 7 classes, respectively. Calculations of the standard deviation of $\ln(C/Q)$ for joint meteorological classes using hourly data from 1976 indicate that there is a factor of two natural variability in hourly concentrations, independent of the meteorological parameters that are used. There is about 40% more variability in SO_2 concentrations than in CO concentrations, probably due to the dominance of point sources for SO_2 and area sources for CO. A perfect air quality model of the Gaussian type, predicting ensemble average hourly concentrations, cannot hope to produce results that are better than this natural variability.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Destructive Techniques for Assessment of Plant and Canopy Structure

Author(s): Boyd A. Hutchison

Date : April 1981

Published: Presented at the Workshop on Plant Canopy Structure, April 27-30, 1981, Oak Ridge, Tennessee

Abstract

Destructive techniques for assessments of plant canopy structure are reviewed and their relative accuracies are compared. The actual canopy structure assessment method almost invariably involves a variation of the stratified clip method introduced by Monsi and Saeki in 1953 in their studies of herbaceous plant stands. Sampling procedures range from 100% forests to complete harvest of sample plots or transects in herbaceous vegetation and to individual trees or portions thereof in the case of forest. It is concluded that existing sampling procedures are adequate for single-aged, monocultural stands and are probably satisfactory for comparison of structure in monocultures at different ages and on sites of varying quality. The adequacy of these techniques remains to be demonstrated for uneven-aged, mixed-species vegetative stands.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : A Deposition Model for Large Drops or Particles

Author(s): Steven R. Hanna

Date : June 1981

Published: In-house publication

Abstract

A simple deposition model is presented for plumes consisting of drops or particles with diameters ranging from about 10μm to about 1000μm. In this model the plume is divided up into downwind distance increments Δx. The fraction of the mass of drops or particles with a certain diameter that break away from the plume in each increment Δx is assumed to equal $v_d(\Delta x/u)/2R$, where v_d is the fall velocity of the drops or particles, u is the wind speed, and R is the plume radius. This ratio equals the distance the drops fall while they are in the increment Δx divided by the diameter of the plume.

The model is applied to predict deposition of wind blown particles around a uranium tailings pile in New Mexico and deposition of drift drops from a cooling tower in Maryland. The predicted spatial pattern of deposition in New Mexico agrees well with observations and with the predictions of another more complicated model. The magnitude of predicted drift deposition in Maryland is a factor of three high, but the predicted mass median drop diameters are within 40% of the observations.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Applications in Air Pollution Modeling

Author(s): Steven R. Hanna

Date : September 1981

Published: Pending publication in the Proceedings of a Short Course on Turbulence and Air Pollution Modeling, held 21-25 September 1981 in the Hague, The Netherlands

Abstract

The paper is the text of a lecture in a short course on atmospheric turbulence and pollution modeling. It lists the meteorological variables needed to develop diffusion theories, and discusses the relation between Eulerian and Lagrangian systems for their measurement. Several statistical mdoels of diffusion are considered in some detail, including Taylor's theory, the so-called Monte Carlo approach, and Langevin's model. The turbulent energy and Lagrangian time scales of the unstable, stable, and neutral atmosphere are described, and applied in the Monte Carlo model. Recent improvements to the Gaussian plume model are reviewed, especially techniques for including wind speed and plume rise, estimation of dispersion parameters using on-site measurements of wind fluctuations, determination of the correct stability class, and recommended revisions to the familiar "P-G" curves. Gradient-transfer ("K-theory") models and their analytical and numerical solutions are briefly discussed. The similarity method for estimating plume concentration is also summarized. Finally, the special topics of skewness in the vertical velocity distribution, the natural variability of pollutant concentrations, and the representativeness of wind speed observations are considered from the viewpoint of dispersion modeling.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Methods for Estimating Wake Flow and Effluent Dispersion Near Simple Block-Like Buildings

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

Date : May 1981

Published: NOAA Technical Memorandum ERL ARL 108, 138 pp

Abstract

This report is intended as an interim guide for those who routinely face air quality problems associated with near-building exhaust stack placement and height, and the resulting concentration patterns. The report consolidates available data and methods for estimating wake flow and effluent dispersion near isolated block-like structures. The near-building and wake flows are described, and quantitative estimates for frontal eddy size, height and extent of roof and wake cavities, and far wake behavior are provided. Concentration calculation methods for upwind, near-building, and downwind pollutant sources are given. For an upwind source, it is possible to estimate the required stack height, and to place upper limits on the likely near-building concentration. The influences of near-building source location and characteristics relative to the building geometry and orientation are considered. Methods to estimate effective stack height, upper limits for concentration due to flush roof vents, and the effect of changes in rooftop stack height are summarized. Current wake and wake cavity models are presented. Numerous graphs of important expressions have been prepared to facilitate computations and quick estimates of flow patterns and concentration levels for specific simple building. Detailed recommendations for additional work are given.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Observations of Katabatic Flow on a Simple Slope

Author(s): William E. Clements and Carmen J. Nappo

Date : July 1981

Published: Submitted to Journal of Applied Meteorology

Abstract

Observations of a katabatic flow on a simple slope were made for a few hours during a five-day field study that was otherwise characterized by high and gusty winds blowing across the face of the slope. A simple slope in the Jemez Mountains of north-central New Mexico was instrumented with meteorological surface stations and 10 m masts. Data collected during the katabatic flow event indicate a depth ranging from greater than 10 m at the bottom of the slope to near zero at the top. At the bottom of the slope, the wind speed varied from 2.5 m/s at 1.5 m above ground to 0.5 m/s at a height of 10 m. Turbulence intensities dropped by a factor of five from the onset of the katabatic flow at the time of maximum stability. Our data agree well with a simple model of slope flow.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Use of Vegetation to Ameliorate Building Microclimates: An Assessment of Energy Conservation Potentials

Author(s): Boyd A. Hutchison, Fred G. Taylor, Robert L. Wendt, The Ciritical Review Panel

Date : April 1982

Published: ORNL/CON-87, April 1982, Environmental Sciences Division Publication No. 1913, 90 pp

Abstract

An assessment of the space-conditioning energy conservation potentials of landscapes designed to ameliorate building microclimates is made. The physical bases for vegetative modifications of climate are discussed, and results of past study of the effects of vegetation on space-conditioning energy consumption in buildings are reviewed. The state-of-the-art of energy-conserving landscape designs is assessed and recommendations for further research are presented.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Comments on "Interpretation of Flux-Profile Observations at ITCE (1976)" by R. J. Francey and J. R. Garratt

Author(s) : B. B. Hicks

Date : November 1981

Published : Journal of Applied Meteorology, Vol. 21, No. 8, pp 1205-1206

The adequacy of the uniform upwind fetch is of special interest in the case of the ITCE (1976) micrometeorological study, because of the accidental fire that destroyed the natural grass cover in the vicinity of the main site. The search for fetch effects by Francey and Garratt (1981) failed to identify any strong evidence either that the limited fetch was indeed sufficient or that data obtained beneath 16 m height were adversely affected in any consistent manner. Francey and Garratt acknowledge that some effects must be expected, but argue that these are likely to impose random errors upon the conclusions to be drawn rather than a consistent bias. However an analysis of flux divergences using heat fluxes measured at 8.5 and 5.5 m height indicated a variation with wind direction that is similar to the charge of fetch. It is concluded, therefore, that the 8 m level was somewhat influenced by the distant upwind surface. In this, we should not be surprised, since the application of a fetch/height ratio of 200 would provide a first-order estimate of the depth of the full-adjusted surface boundary layer of between 4 and 8 m, in most circumstances of the ITCE study.

A conservative analysis would therefore omit data obtained above about 8 m from any consideration of flux-gradient relations. The effects on the conclusions drawn by Francey and Garratt cannot be evaluated from the data provided in their tables, but the effects are likely to be small. Inspection of Table 2, for example, suggests that k_m might be increased, but Table 4 indicates otherwise. However, it seems possible that it was fetch inadequacies that resulted in many of the inconsistencies between adjacent height levels, rather than calibration errors as suggested by Francey and Garratt.

References

Francey, R. J. and J. R. Garratt, 1981: Interpretation of Flux-Profiles Observations at ITCE (1976), J. Appl., Meteorology., 20, 603-618.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Analytical Solutions of a Gradient-Transfer Model for Plume Deposition and Sedimentation

Author(s): K. Shankar Rao

Date : September 1981

Published: NOAA Technical Memorandum ERL ARL-109, 75 pp.

Abstract

This report reviews the methods available in the literature for including dry deposition in a Gaussian plume model. A gradient-transfer or K-theory model for the atmospheric transport and ground deposition of gaseous and particulate pollutants emitted from an elevated continuous point source is outlined. This analytical plume model treats gravitational settling and dry deposition in a physically realistic and more straightforward manner than other approaches. For practical application of the model, the eddy diffusivity coefficients in the analytical solutions are expressed in terms of the widely-used Gaussian plume dispersion parameters. The latter can be specified as functions of the downwind distance and the atmospheric stability class within the framework of the standard turbulence-typing schemes.

The analytical plume diffusion-deposition solutions are presented for various stability and mixing conditions. In the limit when settling and deposition velocities are zero, these equations reduce to the well-known Gaussian plume diffusion algorithms presently used in EPA models. Thus the analytical model for estimating deposition described here retains the ease of application associated with Gaussian plume models, and is subject to the same basic assumptions and limitations as the latter.

The deposition model has been applied to particulate pollutants with appreciable settling velocity and to gases which deposit on ground without settling. Calculated results of ground-level concentrations, vertical concentration profiles, surface deposition fluxes, and net deposition and suspension ratios are presented. The atmospheric stability and the magnitude of deposition velocity are shown to have significant effects on these results.

The specification of gravitational settling and deposition velocities in the model is discussed. A field study is proposed to measure one or more of the model parameters, and to provide a good data set for model validation over a 10 km distance from the source. The proposed field experiment is based on a modified Bowen ratio-turbulent variance approach, and it avoids the difficulties associated with the vertical gradient and eddy-correlation methods of surface flux measurements.

This report was submitted in partial fulfillment of Interagency Agreement No. AD-13-F-0177-0 by Atmospheric Turbulence and Diffusion Laboratory. This work, covering the period September 1980 to September 1981, was completed as of September 30, 1981.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : User's Guide for PAL-DS Model: The PAL Model Including Deposition and Sedimentation

Author(s): K. Shankar Rao and H. F. Snodgrass

Date : September 1981

Published: Pending publication as an EPA Report

Abstract

PAL is an acronym for a model which applies a Gaussian plume diffusion algorithm to point, area, and line sources. The model can be used for estimating hourly and short-term average concentrations of non-reactive pollutants at multiple receptors from several sources of each type. PAL is intended to assess the impact on air quality, on scales of tens of meters to several kilometers, of portions of urban areas such as shopping centers, large parking areas, and airports. Level terrain is assumed, and pollutant removal processes are ignored.

This report is a User's Guide to the PAL-DS model that utilizes Gaussian plume-type diffusion-deposition algorithms based on analytical solutions of a gradient-transfer model. The PAL-DS model can treat deposition of both gaseous and suspended particulate pollutants in the plume since gravitational settling and dry deposition of the particles are explicitly accounted for. The analytical diffusion-deposition expressions listed in this report are easy to apply and, in the limit when pollutant settling and deposition velocities are zero, they reduce to the usual Gaussian plume diffusion algorithms in the PAL model.

This report outlines the modifications of the PAL computer program to include deposition. The information is oriented to the model user and the programmer. This report is not a complete User's Guide to the PAL-DS model; it should be used as a supplement to the original User's Guide for PAL.

This report was submitted in partial fulfillment of Interagency Agreement No. AD-13-F-0177-0 by NOAA's Atmospheric Turbulence and Diffusion Laboratory. This work, covering the period September 1980 to September 1981, was completed as of September 30, 1981.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : User's Guide for MPTER-DS: The MPTER Modeling Including Deposition and Sedimentation

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

Date : September 1981

Published: Pending publication as an EPA Report

Abstract

MPTER is the designation for a multiple point source algorithm with terrain adjustments. The diffusion algorithm is based upon Gaussian plume modeling assumptions. The MPTER model can be used for estimating air pollutant concentrations from multiple sources in rural environments. The model has technical input options for terrain adjustment, stack downwash, gradual plume rise, and buoyancy-induced dispersion, and a great variety of output options. The MPTER model, therefore, may be considered a research tool for exploratory use of various assumptions and parameter values.

This report is a User's Guide to MPTER-DS model which can explicitly account for dry deposition of gaseous and suspended particulate pollutants in the plume. The MPTER-DS model utilizes the Gaussian plume-type diffusion-deposition algorithms based on analytical solutions of a gradient-transfer model. These algorithms are easy to apply and, in the limit when pollutant settling and deposition velocities are zero, they reduce to the usual Gaussian plume diffusion algorithms in the MPTER model.

This report outlines the modifications of the MPTER computer program to include deposition. The information is oriented to the model user and the programmer. This report is not a complete User's Guide to the MPTER-DS model; it should be used as a supplement to the original User's Guide for MPTER.

This report was submitted in partial fulfillment of Interagency Agreement No. AD-13-F-0177-0 by NOAA's Atmospheric Turbulence and Diffusion Laboratory. This work, covering the period September 1980 to September 1981, was completed as of September 30, 1981.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Data Interpretation for Model Development and Validation

Author(s): B. B. Hicks

Date : October 1981

Published: Pending publication in Proceedings of Workshop on the Parameterization of Mixed Layer Diffusion, October 19-23, 1981, Las Cruces, N.M.

Abstract

Experimental errors and natural variability of meteorological variables often combine to confound attempts to deduce details of true, physical behavior. It is possible to express many theoretical results in a manner that almost guarantees the appearance of verification by observations. A simple procedure to detect difficulties in interpretation of data by any analytical technique involving dimensionless properties is to compare the results of the analysis with those of an identical analysis of a randomized data set constructed from the same observations. Experiments involving PBL dispersion quantities are likely to be especially sensitive, since normalization of quantities like σ_v usually involves the convective velocity scale w_*, which in turn is a function of the sensible heat flux and the depth of the mixed layer. It is obvious that any apparent dependence of such normalized quantities on any parameter involving PBL stability should be viewed with great caution, especially the property z_i/L which also involves the depth of the mixed layer and the sensible heat flux.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : A Survey of the Utility of Laboratory Modeling of Atmospheric Boundary Layer Dispersion and Related Phenomena

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

Date : October 1981

Published: Pending publication in Proceedings of Workshop on the Parameterization of Mixed Layer Diffusion, October 19-23, 1981, Las Cruces, N.M.

Abstract

Facilities presently available for laboratory modeling of dispersion-related phenomena include wind tunnels, water channels and tow tanks, electrolytic tanks, and regulated-environment chambers. These devices may be used within certain limits for fundamental studies as well as for practical applications. For example, the behavior of the atmospheric mixing layer under some stability conditions can be examined, the characteristics of the near-body flow and wakes of various obstacles can be determined, or pollutant deposition and uptake by vegetation, soil, and water can be evaluated under controlled conditions. Such information is often crucial to improved physical understanding, theoretical representations, and mathematical models of the phenomena under study. Practical applications may deal with flow and pollutant dispersal near obstacles such as buildings, urban areas, or terrain features, near-source aerodynamic effects such as stack-induced downwash, flows over rough terrain including nocturnal cold air drainage and cross-valley flows, and forest canopy effects, especially near edges, or in notches (fire breaks) and clearing. Such simulations may even be of assistance in planning large field experiments, by suggesting optimum instrument locations, for example. Models of highways and moving vehicles as contaminant sources or receptors are feasible to some extent, as are simulations of buoyant or dense gas dispersion. In some instances, measurement techniques suggested for field use may first be tested in the laboratory, and the aerodynamic influence of various instruments and instrument platforms on the data collected may be assessed. Examples of the above possibilities are presented, together with an extensive bibliography.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : On the Network Monitoring of Dry Deposition

Author(s) : Bruce B. Hicks

Date : November 1981

Published : For submission to Atmospheric Environment

Abstract

Continued concern about the effects of "acid deposition" has focussed attention on the lack of data suitable for documenting trends. In the case of dry deposition, the situation is complicated by uncertainty about how to regard results obtained by using collection vessels like those popularized during studies of radioactive fallout. A study of the two-month dry accumulation data obtained at selected sites by the National Atmospheric Deposition Program shows considerable effects due to bird droppings and to soil particles, presumably of local origin. While such effects can be minimized by relatively simple remedial measures, neither can be completely eliminated. It is therefore apparent that there is questionable utility in continuing two-monthly dryfall collections, even when the conceptual difficulties concerning the use of collection vessels are not considered. A program of careful air chemistry and meteorological measurement seems more appropriate, designed to permit the evaluation of dry deposition rates by applying the results of intensive research programs presently under way. This report represents a summary of the deliberations of an NADP subcommittee set up to investigate the question of dry deposition monitoring. Members of the subcommittee were E. B. Cowling, H. Feely, R. Graham, A. J. Johannes, V. C. Kennedy, J. M. Miller, J. M. Prospero, and G. Stensland.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Critical Assessment Document on Acid Deposition
Chapter VII - Dry Deposition

Author(s) : B. B. Hicks

Date : October 1981

Published : Pending publication as an EPA Report

Summary

The rate of transfer of pollutants between the air and exposed surfaces is controlled by a wide range of chemical, physical and biological factors, which vary in their relative importance according to the nature of the surface, the characteristics of the pollutant, and the state of the atmosphere. The complexity of the individual processes involved and the variety of possible interactions among them combine to prohibit easy generalization; nevertheless, a "deposition velocity", by v_d, analogous to a gravitational falling speed, is of considerable use. In practice, knowledge of v_d enables fluxes, F, to be estimated from airborne concentrations, C, as the simple product $v_d \bullet C$.

Particles larger than about 5 m diameter are deposited at a rate that is controlled by Stokes law, although with some enhancement due to inertial impaction of particles transported to near the surface in turbulent eddies. The settling of submicron-sized particles in air is sufficiently slow that turbulent transfer tends to dominate, but the net flux is often limited by the presence of a quasi-laminar layer adjacent to the surface, which presents a considerable barrier to all mass fluxes and especially to quantities with very low molecular diffusivity. The concept of a gravitational settling velocity is inappropriate in the case of gases, but transfer is still often limited by diffusive properties very near the receptor surface.

Pollutant characteristics are often critical. For particles, we must consider size, shape, mass, and wettability; for gases we must be concerned with molecular weight and polarization, solubility, and chemical reactivity. In this context, the acidity of a property that

is being transferred to some receptor surface by dry processes is a quality of special importance that may have strong impact on the efficiency of the deposition process itself. Little is known about the detailed chemical composition of large particle agglomerates, however it is accepted that their residence time is quite short (i.e., they are deposited relatively rapidly) and there are substantial spatial and temporal variations in both their concentrations and their composition.

In order to evaluate deposition rates, several different approaches are possible. Field experiments can be conducted to monitor changes in some system of receptors from which average deposition rates can be deducted. More intensive experiments can measure the deposition of particular pollutants in some circumstances. Neither approach is presently capable of monitoring the long-term, spatial-average dry deposition of airborne contaminants. Instead, it is usually necessary to infer dry deposition fluxes from air concentration data, using a formulation of the deposition velocity that takes into account the spatial and time variations known and important.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Report of the Workshop on the Representativeness of Meteorological Observations

Author(s) : C. J. Nappo, J. Y. Caneill, R. W. Furman, F. A. Gifford J. C. Kaimal, M. L. Kramer, T. J. Lockhart, M. M. Pendergast, R. A. Pielke, D. Randerson, J. H. Shreffler, and J. C. Wyngaard

Date : November 1981

Published : Bulletin of AMS Vol. 63, No. 7, July 1982, pp. 761-764

Abstract

A workshop on the representativeness of meteorological observations was held in June, 1981 in Boulder, Colorado. The purpose of this workshop was to establish definitions, suggest possible ways of making quantitative determinations of representativeness, present examples of applications of representativeness, and make recommendations for future study and development of the subject. Several types of representativeness are discussed, each type being a function of a specific application. Statistical measures which can be used to quantify representativeness are described. It is recognized that representativeness is a relative concept which can only be described in a statistical sense over some interval of space or time.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Diffusion from Low Level Radioactive Waste Facilities

Author(s) : Walter M. Culkowski and Steven R. Hanna

Date : September 1981

Published : Pending publication as NRC Report

Abstract

The appropriateness of meteorological models applied to hazard studies of spent nuclear material was undertaken by the ATDL. The literature of uranium and gypsum tailings piles, buried wastes and the various generic models used to assess their environmental impact was reviewed. Attention was primarily concerned with uranium tailings piles with their large inventory of radioactive material (~1500 curies or more). It was found that the elaborate models often employed for the suspension/resuspension of tailings pile material would not be verified by observational data and proved no more effective in producing "reasonable" results than for simpler algorithms.

Buried wastes present no problem to the "air pathway" at the present time, but studies of tritium seepage through the earth to the atmosphere indicate that a potential problem with gaseous seepage exists.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Overview of Transport, Diffusion, and Deposition

Author(s): B. B. Hicks

Date : December 1981

Published: Extended Abstract to be published in the Proceedings of Workshop on Meteorological Aspects of Emergency Response Plans for Nuclear Power Plants, December 1-3, 1981, Menlo Park, CA.

Abstract

The development of models suitable for emergency response has been a major goal of recent meteorological research. A wide range of models of greatly varying complexity is now available, yet the fundamental transport, diffusion and deposition phenomena that they describe are not yet fully understood. Furthermore, it is often not clear how to decide which model will best apply in a given set of conditions. The transport and diffusion processes of importance have been investigated in field experiments that have tended to fall into either of two broad categories, "holistic" (or "integral") investigations of plume behavior in selected circumstances, or "reductionist" studies of the processes that control various aspects of plume behavior. Recent work has largely succeeded in documenting dispersion characteristics over horizontally-uniform, flat surfaces, with vegetation of limited density and height. The real world represents problems that have not been overlooked, but progress towards their solution has been slow. There are three main problems that need to be addressed: non-stationary conditions, non-simple terrain,and non-simple surface texture. Of these, only the question of "complex terrain" is currently receiving substantial attention, yet the other factors are intimately coupled with it.

In geographical situations of practical interest to the nuclear power industry, the meteorological dispersion and deposition problems are complicated by the nearby presence of water. Rivers provide preferred routes for channeling the flow of airborne material. Shoreline sites impose perhaps the most difficulties of all complex terrain situations, since in this case the land and water surfaces differ in almost all important respects. Stability regimes are completely different, as are

the surface roughnesses and deposition rates of both particulatte and gaseous pollutants. Dynamical features of flow in coastal regions have received a lot of attention, especially with the advent of remote-probing techniques. However the matter of the dry deposition rate of airborne particles to water surfaces remains unresolved. It is fortunate, perhaps that this is not a critical matter in considerations of nuclear emergency response. However, the same cannot be said of wet deposition. A question that might well be asked of all who advocate specific responses to emergencies is "What happens if it rains?"

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : Release Characteristics and Atmospheric Dispersion

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

Date : December 1981

Published: Final report of Workshop on Meteorological Aspects of Emergency Response Plans for Nuclear Power Plants, December 1-3, 1981, Menlo Park, California

Abstract

This "Paper" is really an extended abstract (4 pp) of a presentation for a Nuclear Regulatory Commission-sponsored Workshop on Meteorological Aspects of Emergency Response Plans for Nuclear Power Plants, December 1-3, 1981, in Menlo Park, California, and is included in the final report that workshop.

The work deals with effluents emitted very close to buildings, and addresses the questions of how building geometry and effluent release characteristics affect the flow and concentration patterns, whether concentrations close to the buildings and in the near wake can be predicted or at least bounded, and how rapidly the building influence on far wake concentrations disappears.

The discussion is largely based on an extensive review and summary of available information and computational techniques in Methods for Estimating Wake Flow and Effluent Dispersion Near Simple Block-Like Buildings (R. P. Hosker, Jr., NUREG/CR-2521 and NOAA Tech. Memo ERL-ARL-108, May, 1981). The flow field near a simple building is described, and a simple method for bounding building surface concentrations is outlined. Current models for near and far-wake concentrations are briefly discussed. Specific recommendations for additional field, laboratory, and theoretical work are given.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1981

Title : A Study of Dewfall and Average Momentum Fluxes in an Arid Region: An Analysis of Wangara Data

Author(s) : Bruce B. Hicks

Date : December 1981

Published : For submission to Quarterly Journal of the Royal Meteorological Society

Abstract

Micrometeorological flux-gradient relations are used to deduce average values of sensible heat flux and friction velocity for most hours of the Wangara experiment. Friction velocities appropriate for the general area of the Wangara study are tabulated, rather than for the uncharacteristically smooth central site alone. Heat fluxes are used to derive average evaporation rates, using net radiation and ground heat transfer values. At night, dewfall is found to have been a common occurrence, at rates that averaged about 0.015 mm/hr and sometimes approached (but never exceeded) the value of about 0.07 mm/hr that has been proposed as a natural limit. The average nocturnal dewfall was about 0.22 mm. During the 44 days of the experiment, it appears that about 20 mm of rain fell, augmented by about 9 mm of dewfall. Evaporation amounted to about 26 mm of water.