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Atmospheric Turbulence and Diffusion Laboratory

Oak Ridge, Tennessee

March 1981

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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 years 1979 and 1980. 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.

Steven R. Hanna
Acting Director
Atmospheric Turbulence and
Diffusion Laboratory

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Atmospheric Turbulence
and Diffusion Laboratory

Summary of Activities
and Plans - FY 1980 - 1981

The Atmospheric Turbulence and Diffusion Laboratory (ATDL) in Oak Ridge, Tennessee, is operated for the Department of Energy by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratories. The ATDL is generally concerned with research on the atmospheric consequences of energy production, and the prediction and control of environmental air pollution. Major funding is from DOE's Office of Health and Environmental Research, Pollutant Characterization and Safety Research Division. The ATDL works closely with various divisions of Oak Ridge National Laboratory (ORNL) and with atmospheric sciences units at other national laboratories on environmental projects of mutual concern.

The ATDL research program is organized around the following subject areas: transport and diffusion over complex terrain, atmospheric turbulence and plume diffusion, and forest meteorology and climatological studies. Current research efforts involve experimental and numerical modeling studies of flow over rugged terrain, studies of transport of airborne material in and above a forest canopy, basic studies of atmopsheric diffusion parameters for applications to environmental impact evaluation, plume rise studies, and scientific collaboration with personnel in DOE-funded installations, universities, and government agencies on meteorological studies in our area of expertise.

Transport and Diffusion over Complex Terrain

This research on transport and diffusion over complex terrain represents the ATDL's contribution to the Department of Energy's Atmospheric Studies in Complex Terrain (ASCOT) program. Elements of this contribution include program planning, experimental design, analytical and numerical modeling, data analysis and field studies of the nighttime atmospheric flow in valley environments.

A. Analytical and Numerical Modeling of Drainage Flows.

The driving force for nighttime flows in valley environments is the drainage wind along the valley side-walls. Because of its fundamental role in nighttime flows, the drainage wind was selected for intensive investigation using numerical and analytical modeling techniques. Analytical modeling makes use of basic principals, i.e., fundamental physics, to relate drainage flow windspeed, temperature and thickness to slope angle, cooling at the ground surface and atmospheric stability. Numerical modeling of drainage flows attempts to simulate the detailed temporal and spatial structure of the flow using time-dependent one- and two-dimensional models. These models make use of a physically realistic turbulence parameterization based on the turbulence kinetic energy equation. Very realistic simulations have been performed; however, because these models require a fine computational grid with small time-steps, a long computer running time is required. Efforts are under way to optimize the computer code to achieve faster running times.

B. Field Experiments.

Data collected during the October 1979 drainage flow experiment conducted on a steep ski slope near Los Alamos, New Mexico are being analyzed to determine a threshold bulk Richardson's number below which drainage flows fail to develop. Initial results show that the thickness of the drainage layer verified the predictions of the analytical model.

During the September 1980 Anderson Creek Valley field experiment, ATDL personnel took observations of the nighttime vertical structure of the drainage wind above Putah Creek. Observations were made using pilot balloons, tethersonde, laser anemometer, acoustic sounder and net radiometer. These data are now being reduced.

Observations of nighttime flow continue on a nearly two-dimensional ridge located about 10 mi. from Oak Ridge. Wind observations made at 2 m height above the ground surface at mid-slope and near slope bottom, do not show a drainage wind. Instrumentation has recently been added to gather wind data at these two sites at the 0.5 meter height.

Plans are under way for ATDL's participation in the ASCOT August 1981 field study in the Geysers region of California. ATDL will provide tethersonde observations in support of cooling tower plume rise and diffusion studies.

Atmospheric Turbulence and Plume Diffusion.

Presently practical techniques for atmospheric dispersion estimates (for instance, those recommended by the NRC Safety Guides and the EPA regulations) depend largely on the numerous diffusion experiments conducted during the 1950's and early 1960's. However, current theories and turbulence experiments are forcing a reconsideration of these results for certain cases, especially for strongly convective daytime conditions, and for stable nocturnal conditions.

As a background for diffusion calculations, it is necessary to know the structure of the planetary boundary layer. The latest techniques (second order closure) and physical formulations are being used to calculate the vertical variations of winds, turbulent fluxes, temperature, and cloud physics parameters in the PBL. This model has been used to estimate the diffusion of waste heat from a cooling pond and to estimate flow in the nocturnal boundary layer, for which a new turbulent kinetic energy closure method was developed. Future plans for this model include application to slope flows and to turbulence structure within and above a forest canopy.

A Lagrangian statistical diffusion model permits calculation of diffusion in areas where there are mesoscale variations in mean wind speed and turbulence quantities. In this model the trajectory of each particle adjusts itself to the local mean and turbulent wind field in which it is immersed. Thus it can be applied to diffusion over complex terrain or seashores. An experiment in Boulder, Colorado, was used to provide information on the link between Lagrangian and Eulerian turbulence, so that the model could be operated using Eulerian tower data. The model is used to determine the effects of release height on σ_y and σ_z, the influence of wind shears on diffusion, and to calculate diffusion in complex terrain experiments such as the DOE Geysers experiment.

The St. Louis RAMS data are the best urban meteorological and air pollution data ever collected. Unfortunately very little analysis of these data has been done. ATDL has acquired the hourly data from 1976 and is determining the correlations between meteorological parameters and pollutant concentrations. Statistical relationships for the air pollution data are being studied. Once this analysis is complete, we plan to test the ATDL simple model and a mesoscale puff model with the data. Previous studies with EPA models indicate agreement between predicted and observed concentrations for one-hour averages. Performance standards and methods of evaluating models will be developed.

Forest meteorology and Climatological Studies.

The ATDL deciduous forest meteorology research facility adjacent to ORNL's Walker Branch Watershed has been essentially completed. This facility allows measurements of space and time distribution of a variety of micrometeorological variables within and above the deciduous forest and represents a unique and invaluable national scientific resource.

Instrumentation suitable for measurement of vector wind velocities and turbulence characteristics above the forest were acquired, their calibrators checked in the ATDL wind tunnel, and the sensors installed above the forest at the Walker Branch site.

Preliminary data on component wind velocities and their turbulent fluctuations were collected above the fully-leafed forest. Vertical distributions of woody biomass were observed and this survey was two-thirds completed during FY 1980.

Periodic observations of space and time distributions of wind speeds within the forest were initiated under a variety of synoptic conditions in the various seasons and phenological phases of the deciduous forest. These observations were augmented with a limited study of the spatial and temporal variations in vector wind velocities and in turbulence characteristics within the forest. Comparisons of wind speed and velocity distributions will yield important information about the reality of the universally observed subcanopy wind speed maximum and consequently, about the nature of dispersion processes occurring within deciduous forests.

Collection, as needed, and analysis of forest radiation distribution data continued. Significant models of radiation in vegetation were computer coded and model predictions compared against observed data in preliminary tests of these models.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Lagrangian and Eulerian Time Scale Relations in the Daytime Boundary Layer

Author(s): Steven R. Hanna

Date : January 1980

Published: Accepted for publication in Journal of Applied Meteorology - March 1981 issue.

Abstract

Lagrangian (neutral balloon) and Eulerian (tower and aircraft) turbulence observations were made in the daytime mixed layer near Boulder, Colorado. Average sampling time was about 25 minutes. Average Lagrangian time scale is about 70 seconds and average ratio of Lagrangian to Eulerian time scales ($\beta = T_L/T_E$) is about 1.7. The ratio β is inversely proportional to turbulence intensity, i. These data support the formula $\beta = .7/i$. Lagrangian time scale for the vertical component of turbulence at heights above about 100 m is given by the formula $T_L = .17\, z_i/\sigma_w$, where z_i is mixing depth. This formula is valid for the horizontal components of turbulence at all heights in the mixed layer. Lagrangian spectra in the inertial subrange are best represented by the formula $F_v(n) = 0.2\, \epsilon n^{-2}$.

ATDL Contribution File No. 80/1

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Atmospheric Turbulence and Diffusion Estimates Derived From Observations of a Smoke Plume

Author(s): Carmen J. Nappo

Date : January 1980

Published: Accepted for publication in Atmospheric Environment - Vol. 14.

Abstract

Plan view and elevation photographs of a smoke plume are used to estimate horizontal and vertical dispersion rates. Dispersion rates measured from individual photographs agree with Batchelor's theoretical analysis of relative diffusion. Dispersion rates measured from a composite of plume photographs agree with Taylor's theoretical analysis of single-particle diffusion. These dispersion rates are then used to calculate Eulerian turbulence parameters which are compared with observations made on a 60 m tower near the smoke-plume source. In addition, the Lagrangian turbulence time scale, and the horizontal eddy diffusivity are estimated. The comparisons of estimated with observed parameters are good, suggesting that the smoke-plume technique for estimating atmospheric dispersion is realistic.

ATDL Contribution File No. 80/2

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : A Nonstationary Nocturnal Drainage Flow Model

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

Date : March 1980

Published: Proceedings of 2nd Joint Conference on Applications of Air Pollution Meteorology and 2nd Conference on Industrial Meteorology, March 24-28, 1980, New Orleans, LA., pp. 499-504.

Abstract

The evolution of an idealized nocturnal drainage flow over a large homogeneous uniformly-sloping surface is investigated by a nonstationary model using a variable eddy diffusivity profile determined from considerations of the surface energy budget, ambient atmospheric conditions, surface characteristics and the flow structure. The model formulations and numerical simulations of the evolution of mean wind and temperature profiles in the drainage layer are presented. The effects of important physical parameters, such as the slope, ambient atmospheric stability, surface heat flux (or cooling rate) and aerodynamic roughness, on the drainage flow development are investigated. The assumptions, limitations, and applications of the model are discussed.

ATDL Contribution File No. 80/3

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Drainage Wind Observations Using Neutral-Lift Balloons

Author(s): C. J. Nappo, S. R. Hanna, and H. F. Snodgrass

Date : March 1980

Published: Proceedings of 2nd Joint Conference on Applications of Air Pollution Meteorology and 2nd Conference on Industrial Meteorology, March 24-28, 1980, New Orleans, LA., pp. 495-498

Abstract

Neutral-lift pilot balloons, released at a rate of about two per hour between 6:00 p.m. and 6:00 a.m. and tracked with double theodolite technique, were used to observe the structure of nocturnal drainage winds in the Anderson Creek Valley near the Geysers geothermal region. Observations made during five nights show a persistent drainage flow ~80 m thick lying above the creek. Wind speeds in the drainage flow ranged from 1 m/s to 5 m/s with a mean speed of ~3 m/s. A second drainage flow was observed above the creek drainage flow. Complex valley circulations such as rotors, return flows, and helical flows were also observed.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Complex Terrain Influence on σ_θ and σ_y at TVA's Widows Creek Steam Plant

Author(s): Steven R. Hanna

Date : March 1980

Published: Proceedings of the 2nd Joint Conference on Applications of Air Pollution Meteorology and 2nd Conference on Industrial Meteorology, March 24-28, 1980, New Orleans, La., pp. 567-570.

Abstract

The Widows Creek Steam Plant of the Tennessee Valley Authority (TVA) is located along the Tennessee River in northern Alabama in the Appalachian Mountains. High quality meteorological observations are routinely made from two towers and SO_2 concentrations are measured at about 20 stations. Using these data, the relationships between σ_θ and σ_y in complex terrain were investigated. It was found that observed σ_θ at the valley tower is 60% enhanced for cross valley wind directions. This increase is caused by mesoscale eddies shed by the complex terrain. Pasquill's formula, $\sigma_y = \sigma_\theta \times f(x)$, yields fair agreement with observed σ_y on a monitoring arc 3.5 km from the steam plant. It is necessary to account for initial plume size, σ_{yo}, in making the estimate of σ_y.

ATDL Contribution File No. 80/5

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Adminsitration
1980

Title : Dispersion in the Vicinity of Buildings

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

Date : March 1980

Published: Proceedings of 2nd Joint Conference on Applications of Air Pollution Meteorology and 2nd Conference on Industrial Meteorology, March 24-28, 1980, New Orleans, La., pp. 92-107.

Abstract

This paper very briefly reviews current understanding of flow patterns near simple block-like buildings. Procedures for stack height selection and for estimating effluent dispersion near and downwind of such simple structures are summarized. The discussion emphasizes the case of a source on or close to a building, although upwind and downwind source locations are briefly considered.

ATDL Contribution File No. 80/6

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Experimental Methods and Preliminary Analyses of Drainage Flow Observations During the First ASCOT Field Study.

Author(s): R. P. Hosker, K. S. Rao, and G. A. Briggs

Date : March 1980

Published: Proceedings of 2nd Joint Conference on Applications of Air Pollution Meteorology and 2nd Conference on Industrial Meteorology, March 24-28, New Orleans, La., pp. 488-498

Also in: A Collection of Papers Based on Drainage Wind Studies in the Geysers Area of Northern California; Part I, M. H. Dickerson, editor, Lawrence Livermore National Laboratory UCID-18884, ASCOT 80-7 (in press).

Abstract

Wind and temperature data obtained with two instrumented masts and two wiresondes during the first ASCOT field study, July, 1979 are described and analyzed. Instrument characteristics are given. Features of the nocturnal cold air drainage along Anderson Creek are presented in some detail. Interpretations of the results are given in terms of the local topography and the possible development of a cold air "pool" at the confluence of several surrounding drainage areas.

ATDL Contribution File No. 80/7

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Practical Application of Air Pollutant Deposition Models -- Current Status, Data Requirements, and Research Needs

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

Date : April 1980

Published: To appear in: Proc. of Internat. Conf. on Air Pollutants and Their Effects on the Terrestrial Ecosystem, Banff, Alberta, Canada, May 10-17, 1980. (S. V. Krupa & A. H. Legge, editors, John Wiley & Sons, New York).

ABSTRACT

Methods presently available for simulating transport, diffusion, and wet and dry removal of atmospheric pollutants are surveyed. Current transport and dispersion models are briefly described. Techniques for estimating wet and dry delivery of effluent to the landscape are summarized. Methods for calculating the required removal parameters are given, along with references to available experimental data. Particular transport models and removal schemes are recommended according to the size of the region under study. Data requirements and model weaknesses are described, and topics for additional research are suggested.

ATDL Contribution File No. 80/8

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Sub-Grid Scale Plume Dispersion in Coarse Resolution Mesoscale Models

Author(s): Richard T. McNider, Steven R. Hanna, and Roger A. Pielke

Date : April 1980

Published: Proceedings of 2nd Conference on Applications of Air Pollution Meteorology & 2nd Conference on Industrial Meteorology, March 24-28, 1980, New Orleans, La., pp. 424-429.

Abstract

A Lagrangian conditioned particle scheme which is easy to apply in non-uniform mesoscale flow fields was combined with a coarse grid mesoscale model boundary layer to make simple dispersion calculations. Turbulent statistics needed to utilize the conditioned particle scheme were extracted from the simplified exchange coefficient boundary layer and agreed reasonably well with observations. Dispersion statistics from particles released within the model boundary layer also agreed very well with the experiments of Lamb (1978) and Willis and Deardorff (1978).

ATDL Contribution File No. 80/9

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Observations of Nighttime Winds Using Pilot Balloons in Anderson Creek Valley, Geysers, California

Author(s): Carmen J. Nappo and Howell F. Snodgrass

Date : June 1980

Published: Submitted to Journal of Applied Meteorology

Abstract

Nightime winds in Anderson Creek Valley located in the Geysers area of northern California are examined using pilot balloons as air parcel tracers. Observations show a persistent night-to-night pattern of winds above Anderson Creek Canyon and in the valley basin. Before sunset, strong down-slope winds exist; these are believed due to terrain interactions with the late afternoon sea-breeze. The drainage wind within the creek canyon has an average speed of about 3 m/s, grows in thickness at a rate of about 80 m per kilometer of downwind distance and is insensitive to above-valley wind speeds. Balloons in the drainage wind quickly spread throughout the creek canyon. The transition from valley winds to the free, above-valley winds occurs at about 500 m above the valley floor for weak above-valley winds, and about 300 m for strong above-valley winds.

ATDL Contribution File No. 80/10

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Thermal Vegetation Canopy Model Studies

Author(s): J. A. Smith, K. J. Ranson, D. Nguyen, L. Balick, L. E. Link, L. Fritschen, and B. Hutchison

Date : May 1980

Published: Submitted to Remote Sensing of the Environment

Abstract

An iterative type thermal model applicable to forest canopies was tested with data from two diverse forest types. The model framework consists of a system of energy budget equations describing the interactions of short and long-wave radiation within three horizontally infinite canopy layers. A formulation of the energy dynamics within the canopy is used which permits a factorization of canopy geometrical parameters from canopy optical and thermal coefficients as well as environmental driving variables.

Two sets of data characterizing a coniferous (Douglas-fir) and deciduous (oak-hickory) canopy were collected to validate the thermal model. The results show that the model approximates measured mean canopy temperatures to within 2°C for relatively clear weather conditions and deviates by a maximum of 3°C for very hazy or foggy conditions.

ATDL Contribution File No. 80/11

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Diurnal Variation of Horizontal Wind Direction Fluctuations σ_θ in Complex Terrain at Geysers, Cal.

Author(s): Steven R. Hanna

Date : May 1980

Published: Accepted for publication in Boundary Layer Meteorology

Abstract

Horizontal diffusion in the surface layer is dependent on the standard deviation of wind direction fluctuations σ_θ. Diurnal variation of this parameter in complex terrain was studied for the July 1979 Geysers, Cal., experiment using data from a network of 11 short meteorological towers in the 25 km^2 Anderson Creek watershed. Valley side slopes are roughly 20° and maximum terrain difference is about 1 km.

Values of σ_θ for wind directions sampled for one hour at a height of 10 m are about 35° during the daytime. They slowly decrease to about 20° by 8 to 10 p.m. as stability increases but wind speeds are still relatively high. After 10 p.m. the drainage flow sets in at most stations, with speeds of 1 to 2 m/s, and average σ_θ increases to about 30° during the period 11 p.m. to 6 a.m. In general, highest values of σ_θ at night are associated with lowest values of wind speed and greatest static stability. This enhancement of σ_θ by the terrain suggests that horizontal diffusion at night always conforms to that expected during nearly neutral stabilities. That is, Pasquill class D diffusion applies to the horizontal component all night in complex terrain.

ATDL Contribution File No. 80/12

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : What Convective Scaling Does for Diffusion Data

Author(s): Gary A. Briggs

Date : February 1980

Published: Pending publication in Proceedings of Workshop on Diffusion from Tall Stacks in Convective Conditions, Toronto, Canada, May 1979.

Abstract

The purpose of this paper is to illustrate the effectiveness of convective scaling when applied to convective boundary layer turbulence, and to demonstrate its potential for ordering diffusion data. The historical development of convective scaling ideas is reviewed, contrasting the success of the analyses of the Kansas and the Minnesota boundary layer experiments of 1968 and 1973 (convective scaling was applied to the analysis of the latter experiment, but not to the former). Both early and very recent analyses of the famous Prairie Grass diffusion experiment are reviewed, showing how convective scaling resolves questions that were raised in earlier work. Finally, further analyses are carried out on both the Prairie Grass and the Morgantown power plant data sets to compare the effectiveness of several genre of ordering schemes.

ATDL Contribution File No. 80/13

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : User's Guide for ATCOOL Cooling Tower Plume Model

Author(s): Steven R. Hanna

Date : June 1980

Published: NOAA Technical Memorandum ERL ARL-85

Abstract

ATCOOL is a computer program for calculating the variation of cooling tower plume parameters with height and distance downwind. It combines Briggs' plume rise model with Weinstein's cloud physics model. Plume rise, visible plume length, and cloud formation can be calculated. The program listing and a worked example are given.

ATDL Contribution File No. 80/14

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Handbook on Atmospheric Diffusion

Author(s): Steven R. Hanna, Gary A. Briggs, and Rayford P. Hosker, Jr.

Date : July 1980

Published: To be published as a handbook by the Technical Information Center, DOE, Oak Ridge, Tennessee

Abstract

See attached Table of Contents in lieu of abstract.

ATDL Contribution File No. 80/15

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Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Canopy Effects on Predicted Drainage Flow Characteristics and Comparisons with Observations

Author(s): Gary A. Briggs

Date : June 1980

Published: Extended Abstract - Proceedings of Fifth Symposium on Turbulence, Diffusion, and Air Pollution, March 9-13, 1981, Atlanta, Ga., pp. 113-115.

Abstract

A simple model for drainage flow confined by canopy to a height h above a slope of angle β is developed, using a canopy drag characteristics area per unit volume A; A^{-1} can be interpreted as a "line of sight" distance, and Ah as a "canopy density factor." The predictions of this model are compared to those of a previously-developed "open slope" model, in which the flow thickness grows linearly with distance down the slope; the main differences between the models are that the flow speed is more restricted, the flow volume grows much more slowly, and the degree of cooling increases instead of decreases with distance down the slope in the canopy-confined model. In addition, a very simple model that neglects friction and entrainment is suggested for flow traveling down stream beds, converging from the slopes on either side. Some measurements and estimates from measurements of temperature differences, flow speeds, and flow volumes in drainage flows near Anderson Springs, CA are described and compared to the model predictions. The best comparisons are with the canopy-confined model with h = 20m and A^{-1} = 40m, which befits a somewhat sparse canopy, such as occurs in most of the experimental area. The creek bed flow model is partially successful at predicting flow speeds near the creek beds, but appears to need refinement, such as the inclusion of canopy-induced friction.

ATDL Contribution File No. 80/16

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Turbulent Energy and Lagrangian Time Scales in the Planetary Boundary Layer

Author(s): Steven R. Hanna

Date : October 1980

Published: Proceedings of Fifth Symposium on Turbulence, Diffusion and Air Pollution, March 9-13, 1981, Atlanta, Ga., pp. 61-62.

Abstract

In order to apply Taylor's statistical diffusion theory or computerized Monte Carlo models to estimate diffusion in the planetary boundary layer (PBL), it is necessary to know the variation with height of the turbulent energy components σ_u^2, σ_v^2, and σ_w^2, and the Lagrangian time scales T_{Lu}, T_{Lv}, and T_{Lw}. In this short note, formulas are recommended for the variation of the turbulent energies and Lagrangian time scales with height for all stability conditions.

ATDL Contribution File No. 80/17

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Cooling Tower Drift Studies at the Paducah, Kentucky Gaseous Diffusion Plant

Author(s): Fred G. Taylor, Steven R. Hanna, and Patricia D. Parr

Date : December 1978

Published: By ORNL as ORNL/TM-6131, Environmental Sciences Division Publication No. 1275

Abstract

The transfer and fate of chromium from cooling tower drift to terrestrial ecosystems were quantified at the Department of Energy's uranium enrichment facility at Paducah, Kentucky. Chromium concentrations in plant materials (fescue grass) decreased with increasing distance from the cooling tower, ranging from 251 $\pm$ 19 ppm at 15 meters to 0.52 $\pm$ 0.07 ppm at 1500 meters. The site of drift contamination, size characteristics and elemental content of drift particles were determined using a scanning electron microscope with energy dispersive x-ray analysis capabilities. Results indicate that elemental content in drift water (mineral residue) may not be equivalent to the content in the recirculating cooling water of the tower. This hypothesis is contrary to basic assumptions in calculating drift emissions. A laboratory study simulating throughfall from 1 to 6 inches of rain suggested that there are more exchange sites associated with litter than live foliage. Leachate from each one inch throughfall simulant removed 3% of the drift mass from litter compared to 7 to 9% from live foliage. Results suggest that differences in retention are related to chemical properties of the drift rather than physical lodging of the particle residue. To determine the potential for movement of drift-derived chromium to surface streams, soil-water samplers (wells) were placed along a distance gradient to Little Bayou Creek. Samples from two depths following rainstorms revealed the absence of vertical or horizontal movement with maximum concentrations of 0.13 ppb at 50 meters from the tower. Preliminary model estimates of drift deposition are compared to deposition measurements. Isopleths of the predicted deposition are useful to identify areas of maximum drift transport in the environs of the gaseous diffusion plant.

ATDL Contribution File No. 80/18

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : A Study of the Sensitivity of Intermediate Scale Transport Models to Various Wind Direction Intervals

Author(s): Walter M. Culkowski

Date : September 1980

Published: Pending publication in the Proceedings of the Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, Gatlinburg, Tennessee, October 1-3, 1980.

Abstract

Extensive data has been made available for the meteorology and releases of Krypton-85 in the area of the Savannah River Laboratory. The following study was performed principally to determine the efficacy of "straight-line" models to the estimation of diffusion parameters at distances of the order of 100 kilometers. Material transported over such intermediate distance scales may be expected to be influenced by numerous wind vectors, sometimes diametrically opposed to one another. This paper concerns itself primarily with the calculation of optimum wind direction intervals for the particular data set. The results are improved considerably if a "power law" with distance is substituted for the mixing depth and arc length.

ATDL Contribution File No. 80/19

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : A Review of Physical Assumptions in Intermediate Range Transport and Diffusion Models

Author(s): Steven R. Hanna

Date : September 1980

Published: Pending publication in Proceedings of Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, Gatlinburg, Tennessee, October 1-3, 1980.

Abstract

Several intermediate range transport and diffusion models are briefly reviewed. The basic physical assumptions in each are summarized and compared, including horizontal and vertical diffusion, specification of wind field interpolation from the wind field to a point, dry and wet deposition, and chemical transformations. Results of model comparisons for inert tracers are presented showing that a good knowledge of the wind field (speed and direction at plume height) is essential for making accurate calculations for both short term episodes and long term averages.

ATDL Contribution File No. 80/20

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : A Note of the Fundamental Accuracy of Air Pollution Models

Author(s): Carmen J. Nappo

Date : September 1980

Published: Pending publication in Proceedings of Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, Gatlinburg, Tennessee, October 1-3, 1980.

Abstract

The measure of accuracy of air pollution models is becoming a subject of increasing concern. These measures are almost always based on a comparison of model predictions with observations; however, because models must necessarily parameterize some physical processes (e.g. turbulence, deposition, or diffusion) and make some limiting assumptions, (e.g. steady-state, isotropic, or homogeneous meteorological conditions), model predictions, in fact, represent averages of ensembles of observations made over those atmospheric conditions which have been assumed and parameterized. The variance of these ensemble averages will increase with the extent of model parameterizations so that the difference between a single element of an ensemble, i.e. an observation, and the ensemble average, i.e. a model prediction, can be quite large. The variances of these ensemble averages of observations define the fundamental accuracy of an air pollution model, i.e. the error bars on the model predictions.

This paper examines the fundamental accuracy of air pollution models by forming ensemble averages of air pollution observations for meteorological conditions assumed and physical parameterizations made by these models. These calculations are made on the urban scale (~25 km) using the St. Louis Regional Air Pollution Study data, and on the regional scale (~100 km) using krypton-85 surface concentrations observations made around the Savannah River Plant. A result of this study is the range of accuracy of various air pollution models for differing meteorological conditions.

ATDL Contribution File No. 80/21

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : The Nocturnal Boundary Layer Over a Sloping Surface

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

Date : October 1980

Published: Proceedings of Fifth Symposium on Turbulence, Diffusion, and Air Pollution, March 9-13, 1981, Atlanta, Ga., pp. 106-108

Abstract

The nocturnal boundary layer over a large homogeneous sloping surface is investigated by a numerical model using a variable eddy diffusivity profile determined from considerations of the turbulent kinetic energy (TKE) equations, surface characteristics, and ambient atmospheric conditions. The model formulations are presented and conditions for the existence of a stationary solution are discussed. For small slope angles ($\beta \sim 0.01$ radians), the Coriolis force is typically of the same order of magnitude as the drainage force. For large slope angles, the Coriolis force is negligible compared to the drainage force. For these two cases, the steady state mean wind and temperature profiles calculated from the model are compared with the stationary analytical solutions based on a constant eddy diffusivity.

ATDL Contribution File No. 80/22

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Effects of Release Height on σ_y and σ_z in Daytime Conditions

Author(s): Steven R. Hanna

Date : October 1980

Published: Pending publication in Proceedings of NATO-CCMS Conference, November 25-28, 1980, Amsterdam, The Netherlands.

Abstract

A statistical diffusion model is used to estimate the variation of σ_y and σ_z with height in daytime conditions. The existing literature is reviewed, showing inconsistencies among the few field data. The statistical Monte Carlo-type model is described in detail and some asymptotic predictions of the theory are outlined. For example, the usefulness of the formulas $\sigma_y = \sigma_\theta x$ and $\sigma_z = \sigma_e x$ are shown, where σ_θ and σ_e are the standard deviations of the horizontal and vertical wind directions.

Results of the model show that σ_y varies little with release height in daytime conditions, but that it can depart significantly from the standard Pasquill-Gifford-Turner (PGT) curves for roughnesses outside their range of derivation. The vertical component σ_z typically increases by a factor of two as heights increase from the surface layer to mid-planetary boundary layer height.

ATDL Contribution File No. 80/23

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Plume Diffusion Modeling - An Annual Report to the Nuclear Regulatory Commission

Author(s): S. R. Hanna, G. A. Briggs, F. A. Gifford, and C. J. Nappo

Date : September 30, 1980

Published: In-house publication

Abstract

1. Effects of Release Height on σ_y and σ_z. (S. R. Hanna)

A Monte Carlo diffusion model was developed for use in estimating $\sigma_y(x)$ and $\sigma_z(x)$ as a function of release height, stability, and roughness. First calculations assumed daytime conditions, zero horizontal wind shear, and concentrated on plume travel distances less than 1 km. Forty eight combinations of roughness, stability, and wind speed were used in the model, giving the result that σ_y is only a weak function of release height, but that σ_z increases by a factor of two from the bottom to the middle of the planetary boundary layer (PBL). In future work, neutral and stable conditions, non-zero horizontal wind shears and larger travel distances will be emphasized.

2. What Convective Scaling does for Diffusion Data. (G. A. Briggs)

The concept of convective scaling has come up in the time since several well-known comprehensive diffusion experiments took place (e.g. Prairie Grass, Green Glow, Porton). In convective scaling, the mixing depth, z_i, and the convective velocity, w_*, are important scaling parameters. The Prairie Grass diffusion observations are examined to see whether convective scaling can be used to compare different experiments. For example σ_z/z_i is plotted as a function of $(x/z_i)(w_*/u)$. The parameters z_i and w_* were estimated for all runs. It is found that this approach is very useful in daytime conditions and should be in all future data analyses. This work is essentially complete at this time.

3. Study of the Horizontal Diffusion Length, σ_y. (F. A. Gifford)

The Langevin diffusion equation was applied to estimate σ_y. It is found that use of a Lagrangian time scale of 10^4 seconds yields a theoretical $\sigma_y(t)$ curve that agrees with tropospheric observations of σ_y over several orders of magnitude of σ_y and time. This work is complete with this report.

ATDL Contribution File No. 80/24

4. Representativeness of Meteorological Observations (C. J. Nappo)

In setting up a network of meteorological observation stations, one must always consider the question of number and spacing of the stations, This question relates to the representativeness of observations; i.e., in an urban area is one station sufficient, or is ten a better number? To help answer this question, we are studying the variability of wind speed and direction using data from networks in St. Louis, Savannah River Laboratory, and Idaho Falls. Statistical techniques have been devised and preliminary calculations performed with the St. Louis RAPS data. During the next year, analysis of the remaining data sets will take place.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Atmospheric Removal Processes for Toxic Chemicals

Author(s): Steven R. Hanna

Date : September 1980

Published: In-house publication

Abstract

The literature on atmospheric removal processes for toxic chemicals was reviewed, covering dry and wet deposition and chemical transformation. Not much is known about specific toxic chemicals, but estimates of removal can be made by assuming that measurements of removal rates for other chemicals are roughly valid for toxic chemicals.

ATDL Contribution File No. 80/25

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

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

Author(s): K. S. Rao and L. Satterfield

Date : August 1980

Published: ORNL-EPA Fuel Use Active Program: EIS on Fugitive Emissions, 86 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 exact analytical solution, consistent with the basic assumptions 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 visibilites, 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. 80/26

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Numerical Simulation of the Transport and Dispersion of Pollutants in Slope and Mountain-Valley Flows

Author(s): Steven R. Hanna, Richard T. McNider, & Roger A. Pielke

Date : October 1980

Published: Proceedings of Fifth Symposium on Turbulence, Diffusion, and Air Pollution, March 9-13, 1981, Atlanta, Ga., pp. 220-221.

Abstract

In the present investigation a numerical mesoscale model (the University of Virginia Mesoscale Model, Pielke (1974)) is used to examine the development of slope and mountain flows in two and three-dimensional idealized valleys. Also pollutant dispersion and transport is examined using a Lagrangian conditioned particle model (McNider et al. (1980)).

ATDL Contribution File No. 80/27

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : A Nonstationary Nocturnal Drainage Flow Model

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

Date : July 1980

Published: Pending publication in Boundary-Layer Meteorology

Abstract

The evolution and structure of the steady state of an idealized nocturnal drainage flow over a large uniformly-sloping surface are studied using a nonstationary model with a height-dependent eddy diffusivity profile and a specified surface cooling rate. The predicted mean velocity and temperature profiles are compared with Prandtl's stationary analytical solutions based on the assumption of a constant eddy diffusivity in the drainage layer. The effects of important physical parameters, such as the slope angle, surface cooling, atmospheric stability, and surface roughness, on the steady drainage flow are investigated.

ATDL Contribution File No. 80/28

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1980

Title : Atmospheric Studies in Complex Terrain (ASCOT) Information Survey

Author(s): M. H. Dickerson, Editor

Data : May 1980

Published: UCID-18572, ASCOT 80-3 by Lawrence Livermore National Laboratory, University of California 94550

Abstract

In 1978, under sponsorship of the U. S. Department of Energy (DOE), several laboratories and organizations involved in meteorology research launched the Atmospheric Studies in Complex Terrain (ASCOT) program to investigate atmospheric flow, air concentrations, and dispersion over hilly and mountainous terrain. Participating agencies were Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Los Alamos Scientific Laboratory (LASL), Lawrence Livermore National Laboratory (LLNL), Pacific Northwest Laboratory (PNL), Savannah River Laboratory (SRL), the University of Utah's Department of Meteorology and two facilities of the National Oceanic and Atmospheric Administration: the Air Resources Laboratory (NOAA-ARL) and the Atmospheric Turbulence and Diffusion Laboratory (NOAA-ATDL).

The first task undertaken by participants was to review previous studies on the interaction of the atmospheric boundary layer with underlying terrain. The original intent of this review was to develop a reference document for the ASCOT researchers. Most of the work was completed in about six months and, although the review is not all-inclusive, it has proved to be of great help.

This document is a comprehensive, though not all-inclusive, survey of atmospheric studies in complex terrain. The work is divided into three major sections: (1) physical concepts, (2) modeling, and (3) measurements. Each section contains a brief review and discussion of subtopics accompanied by a liberal number of references. We did not attempt to draw many specific conclusions but, in some cases, noted research areas where further work is indicated. Although the ASCOT program has concentrated on noctural drainage wind studies during the past two years, the reader will find material that spans a broader aspect of atmospheric flow in complex terrain. The ATDL staff worked on the following sections:

1.1 Transport and Diffusion Physics in Valley Environments, pp. 1-2 - 1-67, C. J. Nappo, et al. ATDL Contribution File No. 80/29.

1.2 Plume Rise in a Drainage Flow, pp.1-69 - 1-75, G. Briggs. ATDL Contribution File No. 80/30.

2.1 Using Laboratory Flow Models to Simulate Terrain-Influenced Meteorology, pp 2-1 - 2-35, R. P. Hosker and S. Barr, ATDL Contribution File No. 80/31.

2.2 Numerical Modeling, pp. 2-36 - 2-76, S. Rao, et al. ATDL Contribution File No. 80/32.

2.3 Statistical Modeling, pp. 2-77 - 2-81, S. R. Hanna. ATDL Contribution File No. 80/33.

3.1 Meteorological Measurements Applied to Transport in Complex Terrain, pp 3-1 - 3-28, C. Nappo, R. Hosker, et al. ATDL Contribution File No. 80/34.

3.3 Tracer and Diffusion Experiments, pp. 3-40 - 3-57, C. Nappo. ATDL Contribution File No. 80/35.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Spectral Radiation Balances Above an Oak-Hickory Stand During the Spring Leafing Season

Author(s): D. R. Matt, R. T. McMillen, and B. A. Hutchison

Date : January 1979

Published: Proceedings of the Symposium on Forest Meteorology, August 21-24, 1978, Ottawa, Ontario, Canada, pp. 217-219.

Abstract

This paper presents preliminary data on radiation fluxes in three wavebands above a deciduous forest. Data presented were for three days only. The intent of this paper is to acquaint researchers in forest meteorology with our newly completed research site at Walker Branch Watershed.

ATDL Contribution File No. 79/1

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Diffuse Radiation in a Deciduous Forest Varies with Sky Brightness Distributions

Author(s): B. A. Hutchison, D. R. Matt, and R. T. McMillen

Date : January 1979

Published: Proceedings of the Symposium on Forest Meteorology, August 21-24, 1978, Ottawa, Ontario, Canada, pp 213-216.

Abstract

The penetration of diffuse sky radiation via canopy opening into a fully-leafed tulip poplar forest was estimated from canopy structure data obtained from canopy photographs and from sky brightness distribution approximations, using techniques originally developed by Anderson (1964). Small differences were found among mean daily penetration fractions predicted assuming an isotropic sky (UOC), a standard overcast sky (SOC), or an approximation of the weighted daily average predicted using a clear sky brightness distribution. For shorter time periods, penetration of diffuse radiation estimated using the UOC and SOC approximations differed substantially from estimates made using the clear-sky brightness distribution. Most diffuse radiation passes through openings that are within 10 degrees of the solar disk. Hence the directional distribution of diffuse radiation in the forest is strongly controlled by solar position on clear to partly cloudy days. Amounts of diffuse radiation observed in the forest under clear skies agree fairly well with those predicted by the model developed by Reifsnyder et al. (1971). In both cases, penetration increases with increasing solar elevation on clear days. We conclude that the SOC assumption produces acceptable results for time periods of a day or longer, but for shorter times with clear skies the use of the clear sky brightness distribution is necessary for most simulation or prediction modeling.

ATDL Contribution File No. 79/2

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Estimating Ground-Level Concentration Patterns from Isolated Air-Pollution Sources: A Brief Summary

Author(s): Frank A. Gifford

Date : January 1979

Published: Accepted for publication in Environmental Research

Abstract

The current state of the art of modeling the dispersion of air pollutants emitted from isolated sources into the lower atmosphere is briefly described. Thermal and mechanical turbulence in the atmospheric boundary layer are strongly related to solar heating and nocturnal cooling of the ground surface. This results in a marked diurnal variation in the rate of low level pollutants dispersion. The standard mathematical model to describe this phenomenon, the Gaussian plume model, is reviewed and various special problems that arise in applications are discussed, including diffusion parameters, the effect of the averaging period, computational aids to air pollution estimation, removal processes, plume rise, terrain effects, and the attainable accuracy of air quality models.

ATDL Contribution File No. 79/3

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Horizontal Variability of Seasonal Precipitation over the Eastern Tennessee River Valley

Author(s): Carmen J. Nappo and Linda J. Gabbard

Date : February 1979

Published: Monthly Weather Review, Vol. 108, No. 10, October 1980 pp. 1579-1588.

Abstract

Rainfall data from 38 stations over a 32-year period are used to study the horizontal variability of seasonal precipitation over the complex terrain of the eastern Tennessee River Valley region. Subjective analysis of precipitation patterns suggests that horizontal variability is large during summer and small during winter. Objective measures of horizontal variability show that summertime variability is about twice as great as winter and annual variability and that variability is about four times greater across the valley than along the valley during winter and about two times greater during summer. A comparison of seasonal precipitation variability over uniform and complex terrain is made. Horizontal variability is always greater over the eastern Tennessee River Valley region with the greatest difference in summer and the least in winter; also, spatial correlations are always greater over uniform terrain.

ATDL Contribution File No. 79/4

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Modeling the Nocturnal Drainage Flows, Part I

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

Date : December 1979

Published: In-house publication

Abstract

The evolution and structure of the steady state of an idealized nocturnal drainage flow over a large uniformly-sloping surface are studied using a nonstationary model with height-dependent eddy diffusivity profile and a specified cooling rate. The predicted mean velocity and temperature profiles are compared with Prandtl's stationary analytical solutions based on the assumption of a constant eddy diffusivity in the drainage layer. The effects of important physical parameters, such as the slope angle, surface cooling, atmospheric stability, and surface roughness, on the steady drainage flow are investigated. The extension of the model to account for the ambient winds and Coriolis effects is outlined, and its stationary analytical solutions are discussed.

ATDL Contribution File No. 79/5

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Plume Rise and Buoyancy Effects

Author(s): Gary A. Briggs

Date : March 1979

Published: Chapter 8 in Atmospheric Science and Power Production, D. Randerson (ed.), U. S. Dept. of Energy Tech. Info. Center, Oak Ridge, TN (in press).

Abstract

Basic conservation relationships and closure assumptions used in plume rise modeling are reviewed. The existence of a drag force term is questioned, and implications of various closure assumptions are reviewed. A relatively simple model is chosen as a basis for comparing predictions with observations. Comparisons are made for the trajectories of both buoyant plumes and jets, and simple prediction formulas are recommended. For rise limited by stable stratification, prediction techniques are developed for linear stratification, sharp inversions, neutral air overlayed by stable air, and for arbitrary temperature profiles. For rise limited by ambient turbulence, the effects of both large and small eddies and both mechanical and convective turbulence are considered. The prediction for rise in mechanical turbulence is supported both directly and indirectly, but the recommended formula for rise in convective turbulence must be considered tentative until adequate data are available. Finally, plume rise from multiple sources, gas turbines, and moist plumes are considered, as well as stack downwash effects.

ATDL Contribution File No. 79/6

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Forest Meteorology - - Research Needs for an Energy and Resource Limited Future

Editor : Boyd A. Hutchison

Date : February 1979

Published: U.S.DOE Conference Summary [CONF-7808100 (SUMM)]

Abstract

A workshop entitled *Forest Meteorology, Research Needs for an Energy and Resource Limited Future,* was convened 28–30 August 1978 at the University of Ottawa in Ottawa, Ontario. This workshop was held in conjunction with the World Meteorological Organization's International Symposium on Forest Meteorology and was sponsored by the Division of Biomedical and Environmental Research, U.S. Department of Energy.

Forty-two scientists representing Canada and the United States as well as Spain, Sweden, and the United Kingdom participated in the workshop. Current research efforts were discussed and research needs critical to the development of unifying theories in forest meteorology were identified.

The lack of knowledge most seriously limiting the development of unifying theories at this time involves the mechanics of turbulent exchanges. Studies are needed of the mechanisms by which turbulence is created, transported, and destroyed in forest canopies, of the structural characteristics and aeroelastic properties of forests which control the generation and dissipation of turbulence, and of the turbulence structure of the boundary layer above forests.

Less critical but of considerable importance in view of societal problems of energy and resource limitations is the problem of radiation exchanges in and above forests and of how they relate to forest productivity. Simple techniques must be developed for the determination of the structural features of forests that control radiation exchanges and these structural data must then be used to validate existing radiation exchange models which have largely been developed and tested in agricultural crop canopies. With a better understanding of how forest structure controls radiation penetration and consequently, photosynthetic production, possibilities for genetically engineering highly productive forests for energy, fiber, or saw logs could be better assessed.

It was further noted that the historical absence of responsibility for forest meteorology in either the forestry or weather service bureaucracies of Canada and the U.S. has seriously hampered advancement of scientific knowledge in this field. Most forest meteorology research conducted in the past was made in support of other research efforts; as a result, there has been little continuity in our research efforts. The workshop recommended that serious consideration be given to the establishment of federal agency responsibility for forest meteorology and suggested that an organization along the lines of the Pinchot Institute or the Eisenhower Consortium of the U.S. Forest Service may serve to administer such responsibility.

Finally, the workshop created a task force on forest meteorology that was charged to continue efforts on behalf of this field of science in terms of specific workshop recommendations. Task force members include Lloyd W. Gay, University of Arizona, Tucson; James Harrington, Forest Fire Research Institute, Ottawa, Ontario; Willy Z. Sadeh, Colorado State University, Fort Collins; Roger H. Shaw, Purdue University, West Lafayette, Indiana; Stan Tajchman, West Virginia University, Morgantown; and chairman, Boyd A. Hutchison, Atmospheric Turbulence and Diffusion Laboratory, National Oceanic and Atmospheric Administration, Oak Ridge, Tenn.

ATDL Contribution File No. 79/7

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Power Law Variations of Wind Speed Profiles at Three Sites in the Oak Ridge Area

Author(s): Walter M. Culkowski

Date : June 1979

Published: Preprints of 72nd APCA Annual Meeting held in Cincinnati, Ohio, June 24-28, 1979. Preprint number 79-22.5.

Abstract

Three towers near the Tennessee Valley Authority's Kingston, Tennessee steam plant are in locations having distinct terrain features. The first, the subject of a report at the previous APCA meeting (1), is a 110-meter tower located on the side of a hill overlooking a moderately sized lake; the second, a 45-meter tower, is located on an extensive ridge; the third, a 61-meter temporary tower built to supply site survey data for the Clinch River Breeder Reactor (CRBR) project, was located in a heavily wooded river valley. The comparison of wind speed and diffusion data at these three locations is the subject of this report. The data for the Kingston stations are presented on an annual basis from data gathered from October 1975 through December 1977. The CRBR data is based on data taken from April through December 1976.

ATDL Contribution File No. 79/8

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Smoke as a Quantitative Atmospheric Diffusion Tracer

Author(s): F. A. Gifford

Date : September 1979

Published: Atmos. Environ., Vol. 14, pp. 1119-1121

Abstract

Abstract – Generalizations of the "opacity method" of analyzing visible smoke-plume diffusion are presented. The horizontal dispersion length, σ_y, is derived from the outline of a plume having an arbitrary vertical concentration distribution. The vertical dispersion length, σ_z, is derived for a plume with concentration varying as arbitrary powers of y and z in the exponential terms. Examples of observations of σ_y and σ_z based on Skylab-4, U-2, and ordinary land-based photographs are presented.

ATDL Contribution File No. 79/9

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Flow and Diffusion Near Obstacles

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

Date : March 1979

Published: Chapter 7 in Atmospheric Science & Power Production, D. Randerson (ed.), U. S. Dept. of Energy Tech. Inf. Center, Oak Ridge, TN (in press).

Abstract

This chapter consolidates presently available information on flow and effluent diffusion near obstacles. The flow patterns found near bluff bodies in general, and buildings in particular, are discussed in detail. The responses of near-body flows to velocity gradients, to the presence of a ground plane, to wind incidence angle, to clustering effects, to ambient turbulence level, and to atmospheric stability are examined. Estimation procedures for roof and wake cavity size and the downwind behavior of the turbulent wake are given. Methods for estimating stack heights, downwash, and concentrations near and downwind of buildings are summarized. Cases where the source is upwind, on or close to a structure, or downwind are considered.

ATDL Contribution File No. 79/10

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Recent Studies of Diffusion Parameters for Air Pollution Applications

Author(s): F. A. Gifford

Date : July 1979

Published: In-house publication

Abstract

The turbulence structure of the planetary boundary, or mixed layer, is now well know as a result of the Kansas and Minnesota experiments. This paper summarizes recent studies in which diffusion data are examined from the vantage point of current boundary layer structure information, to improve and extend specification of the crosswind and vertical diffusion lengths, σ_y and σ_z. The vertical diffusion length, σ_z, is found generally to agree well with the early (P-G) σ_z-curves, now in widespread use. An improved parameterization of σ_z in daytime convective conditions is obtained by use of the Deardorff-Willis free-convection similarity scaling. The horizontal diffusion length is best expressed as $\sigma_y = \sigma_\theta \times f(x)$ where σ_θ is the standard deviation of the wind direction, and the universal function f is defined by several studies. Recent detailed guidelines on many particular diffusion parameterization problems, including sampling duration, surface roughness, wind turning, mixing depth, plume buoyancy, and stability categorization are summarized.

ATDL Contribution File No. 79/11

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Phoenix Lagrangian Turbulence Observations Using Pibals and Tetroons

Author(s): Steven R. Hanna

Date : June 1979

Published: Project Phoenix - The September 1978 Field Operation NOAA/ERL Propagation Lab. & NCAR, Dec. 1979, Boulder, CO, Chapt.12, pp 138-149.

Abstract

To complement Eulerian turbulence observations made during Project PHOENIX by WPL remote sensors, instruments on the WPL 300-m tower, and the NCAR aircraft, we have developed a method of tracking balloons by radar that permits Lagrangian turbulence observations. The resulting measurements enable us to compare Lagrangian and Eulerian time scales and determine the shape of the Lagrangian energy spectrum. The ratio of Lagrangian to Eulerian time scales in daytime conditions was measured to be about two. Typical Lagrangian time scales were about 100 seconds for 20 minute sampling times.

ATDL Contribution File No. 79/12

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : SPIF: A Preprocessor for Structured Programming In FORTRAN

Author(s): David B. Elliott and Lee E. Nipper

Date : August 1979

Published: In-house publication

Abstract

FORTRAN, a 22-year old programming language, has some major weaknesses as a higher-level computer language. In this paper some extra control statements are presented which remove a few of FORTRAN's weaknesses. These control statements are similar to those found in other preprocessor. One such preprocessor, SPIF (Structured Programming In FORTRAN), is described in this paper.

Using a preprocessor such as SPIF can yield many benefits. Among these are (1) easier coding, (2) more readable computer code, and (3) enhanced skill in using structured coding techniques.

The SPIF proprocessor has been implemented at the Atmospheric Turbulence and Diffusion Laboratory (ATDL) in Oak Ridge, Tennessee. The portability of this preprocessor and the computer time required in its use are discussed. An example application of SPIF is in the appendix.

ATDL Contribution File No. 79/13

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : A Comparison of Temperature and Wind Speed Functions in the Lowest Thirty-Two Meters During Unstable Conditions

Author(s): Walter M. Culkowski

Date : July 1979

Published: In-house publication

Abstract

The results of fitting wind speed and temperature functions suggested by Benoit (1977) to the Minnesota 1973 data are compared to the functions of the primitive logarithmic and to the logarithmic plus simpler logarithmic and logarithmic plus linear profiles appear sufficiently accurate for many practical purposes, fitting the experimental curves to within a few hundreths of a degree for temperatures and a few centimeters per second for wind speeds.

ATDL Contribution File No. 79/14

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Instrument Guidelines for Measurement of Meteorological Characteristics of Long-Term Ecological Research Sites

Author(s): Boyd A. Hutchison

Date : September 1979

Published: Final Report to the National Science Foundation by the Institute of Ecology (Grant DEB 7920243) entitled: Guidance Documents for Long-Term Ecological Research

Abstract

Guidelines for meteorological instrumentation for measurement and characterization of meteorological processes of ecological and biological importance at long-term ecological research sites are developed. The following instrument options are recommended:

1. Shortwave Radiation:

   Eppley Precision Spectral Pyranometer equipped with dual, precision ground and polished Schott WG 7 optical glass domes.

   Eppley Black and White Pyranometer.

2. Air Temperature:

   Analog Devices Two-Terminal IC (integrated circuit) Temperature Transducer Model AD590L.

   Platinum resistance thermometer.

3. Dewpoint:

   Thermoelectric Dew Point Hygrometer (General Eastern Instruments Corporation System No. 1100 MPS or EG&G Cambridge Systems Model 220)

   Thermoelectric Dew Point Hygrometer (General Eastern Instruments Corporation System No. 1100 AP or EG&G Cambridge Systems Model 880A).

   Hair hygrometer.

4. Wind Speed:

   Kurz Instruments Incorporated Model 475 Meteorological Wind Speed Sensor.

   Sensitive cup anemometer (Gill Generator anemometer, R. M. Young Model 12102 or equivalent).

5. Wind Direction:

   Potentiometric sensitive direction vane (Gill microvane, R. M. Young Model 12302 or equivalent).

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6. Precipitation:
   Weighing bucket recording rain gauge (Belfort Instrument Company Model No. 5-780 or equivalent).

   Remote recording weighing bucket rain gauge (Belfort Instrument Company Model No. 5915 or equivalent).

7. Net Allwave Radiation*:
   Funk type net pyrradiometer (Swissteco Type S-1 or equivalent)

   Fritschen net pyrradiometer with heavy-duty domes.

*Optional as determined by site considerations.

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : 1978 Annual Report

Author(s): Atmospheric Turbulence and Diffusion Laboratory, NOAA

Date : December 1979

Published: National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161, 347 pages, $19.00

Abstract

Bound volume containing all ATDL papers, reports, etc., published during 1978.

ATDL Contribution File No. 79/16

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Comments on "Similarity Model for Maximum Ground-Level Concentration in a Freely Convective Atmospheric Boundary Layer"

Author(s): Gary A. Briggs

Date : October 1979

Published: Submitted to Boundary Layer Meteorology

Abstract

Comments on a paper by Bryan R. Kerman published in Boundary Layer Meteorology, vol. 16, pp. 345-408. Mainly critizes paper for inconsistencies in modeling approach and in analysis of data. Submitted to BLM, reply from author forwarded by editor, resubmission delayed pending diplomatic negotations with the author.

ATDL Contribution File No. 79/17

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Studies of Wind & Turbulence Above a Deciduous Forest in Complex Terrain

Author(s): Detlef R. Matt

Date : September 1979

Published: (Withdrawn)

Abstract

ATDL Contribution File No. 79/18 Withdrawn

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Hourly-Averaged Mast Data, Tethered Balloon Temperature Soundings, and Neutral-Density Balloon Trajectories Observed in Nocturnal Drainage Flows During the First ASCOT Field Study on Anderson Creek, CA

Author(s): C. J. Nappo, R. P. Hosker, S. R. Hanna, G. A. Briggs, R. T. McMillen, K. S. Rao, and H. F. Snodgrass

Date : December 1979

Published: In-house publication

Abstract

The data as well as a description of the measurement equipment used during the first ASCOT field study of 15-27 July, 1979 near Anderson Springs, California are presented. The data taken during nighttime drainage wind conditions include hourly-averaged wind speed, direction, and temperature measured on instrumented 10 m masts, temperature soundings obtained with tethered balloons, and double-theodolite trajectory observations of neutrally buoyant pilot balloons.

ATDL Contribution File No. 79/19

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Entrainment Coefficient Versus Ri for Drainage Flows and Compatibility with Turbulence Scaling Assumptions

Author(s): Gary A. Briggs

Date : December 1979

Published: In-house publication

Abstract

This report summarizes an analysis of the slope flow laboratory experiment of Ellison and Turner (J. Fluid Mech., 1959) to determine flow Richardson number, Ri, and flow entrainment coefficient, E, as a function of the slope angle above horizontal, β. Various assumptions for turbulent velocities and length scales are examined theoretically for compatibility with the experimental results, making use of buoyancy, momentum, and energy conservation relationships. It is concluded that the turbulent length scale may be of the order of the flow depth for large β, but must be limited by the turbulent velocity variance and the local stratification for the small β case. This result is consistent with the assumption that the local turbulent length scale is proportional to $z/(\text{constant} + z/L)$, where z is height above the surface and L is the Monin-Obukhov length.

ATDL Contribution File No. 79/20

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : The Logarithmic Integral as a Functional for Estimating Wind and Temperature Profiles in Unstable Cases

Author(s): Walter M. Culkowski

Date : December 1979

Published: In-house publication

Abstract

Temperature and wind profiles from the Prairie Grass and Minnesota experiments were examined for those cases where solar radiation exceeded 0.020 cal/cm^2 sec (Prairie Grass) or the reported Monin-Obulkhov length indicated unstable conditions (Minnesota). The logarithmic integral provided an excellent fit to the data sets yielding an average error of 0.09°C for temperature profiles and 6 cm/sec for wind speed data.

ATDL Contribution File No. 79/21

Publication of the Air Resources
Atmospheric Turbulence and Diffusion Laboratory
National Oceanic and Atmospheric Administration
1979

Title : Analytic Modeling of Drainage Flows

Author(s): Gary A. Briggs

Date : July 1979

Published: In-house publication

Abstract

A simple analytic model is developed for drainage flow down a constant slope with a well-defined crest. From buoyancy and momentum conservation, it is shown that on a constant slope, the flow Richardson number, Ri, tends toward a constant value. Experience with plumes suggests that the entrainment constant, E, also approaches a constant. Together, Ri and E being constant implies linear growth of the drainage depth, dh/dx = constant. All of these predictions are confirmed by the results of Ellison and Turner's laboratory experiments (J. Fluid Mech., 1959). Their experimental results for E and Ri as a function of slope angle are used in this model (which is a simplified form of Ellison and Turner's model) to make specific predictions for flow velocity, U, flow depth, h, and flow cooling compared to the ambient temperature, ΔT. For the case with constant heat flux removed from the drainage layer it is predicted that $U \propto x^{1/3}$ and that $\Delta T \propto x^{-1/3}$. For the case with constant cooling of the layer (ΔT = constant and heat flux limited by ground cooling), we find $U \propto x^{1/2}$ and heat flux $\propto x^{3/2}$; this regime could only hold until the heat flux approaches the net outgoing radiation. An analysis of the surface drag term is made, demonstrating that it is negligible on slopes larger than a few degrees.

ATDL Contribution File No. 79/22