United States
Environmental Protection
Agency

Environmental Sciences
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S3-84-038 Apr 1984

EPA

Project Summary

EPA Complex Terrain Model Development: Description of a Computer Data Base from Small Hill Impaction Study No. 1 Cinder Cone Butte, Idaho

Lawrence E. Truppi and George C. Holzworth

As part of the U.S. Environmental Protection Agency's effort to develop and demonstrate a reliable model of atmospheric dispersion emissions in irregular mountainous terrain, the Complex Terrain Model Development Program was initiated. The first phase, a comprehensive tracer field study, was carried out on Cinder Cone Butte, Idaho, during the autumn of 1980. Eighteen quantitative tracer experiments were conducted, each lasting 8 hr at night or early morning. The main tracer gas was sulfur hexafluoride; a second tracer, Freon 13B1, was used in 10 of the 18 experiments. Averaged meteorological data were recorded from six towers near and on the slopes of the hill. Data consisted of direct and derived measures of temperature, wind, turbulence, solar and net radiation, and nephelometer coefficient of scattering. Hourly values of tracer gas concentrations were detected by a network of approximately 100 samplers located on the slopes of the hill.

This report serves as a user's guide to the data files of meteorological parameters and tracer concentrations to encourage constructive feedback and to promote additional applications and utilizations of various dispersion models. The system used to collect the data, the operational procedures used to run the system, and its performance record are described. Tables of tracer gas release data have been included to assist in any modeling effort. All meteorological and tracer concentration data have been edited and recorded on magnetic tape. These data are now available, upon request, at the National Computer Center, Research Triangle Park, North Carolina, either as tape copies or by interactive computer access.

This Project Summary was developed by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The extensive development of energy resources, especially in the mountainous terrain of the western United States, has generated concern about the resulting impact on air and water quality. Even in relatively simple situations, reliable calculations of atmospheric transport and diffusion are difficult to produce. In complex terrain, mathematical modeling is difficult because the physical processes are more complicated and meteorological measurements are less "representative" than in level terrain settings. The U.S. Environmental Protection Agency (EPA) responded to this problem by the Complex Terrain Model Development (CTMD) Program, a major program to develop and demonstrate reliable models of at-

mospheric dispersion for emissions in mountainous terrain.

An early step in the development of this program was the convening of a workshop on problems in modeling atmospheric dispersion over complex terrain. Following recommendations of the workshop report, EPA's CTMD Program involves a coordinated effort in mathematical model development, field experimentation, and scaled physical modeling. The Program's basic objective is the production of practical models with demonstrated reliability.

Initially, the CTMD Program has focused on stable plume impaction/interaction with elevated terrain. This phenomenon was singled out because of the likelihood of relatively high concentrations and because models that are in use have been challenged extensively. Stable plume interaction has been studied first in relatively simple terrain settings and subsequently in more complex situations.

EPA's prime contractor for carrying out the CTMD program is Environmental Research and Technology, Inc. (ERT). EPA's Fluid Modeling Facility (FMF) and the National Oceanographic and Atmospheric Administration's Wave Propogation Laboratory (WPL) have provided sophisticated measurement capabilities. A comprehensive tracer field study was carried out on Cinder Cone Butte (CCB), near Boise, Idaho, during the autumn of 1980 (Small Hill Impaction Study No. 1, SHIS #1). Based on those data, several models of plume impaction have been tested and some relatively new modeling concepts have been introduced.

This report describes the data collected in the tracer field study on CCB and publicizes their availability. These data offer a wealth of information for model development/testing, which is continuing in the EPA Program.

Procedure

This report describes the setting of CCB, the experimental approach, and the following data archived on magnetic tape in seven sets of data files:

- Tower (six) wind and temperature measurements (unaltered but flagged), solar and net radiation at one location, and nephelometer data;
- Tower wind data refined by applied quality assurance procedures;
- Tracer gas concentrations;
- Winds based on pilot balloon data;
- Winds, temperatures, and moisture measured from tethersondes;
- Winds, temperatures, and moisture measured from balloon-borne minisondes and
- The modelers' archive of derived wind and temperature values at tracer release locations and measured tracer concentrations (tracer values in this file differ from those in data file 3; here averages of co-located samplers, reanalyzed samples, and 10-min samples during a given hour are taken).

In the first set of data files, the nephelometer measurements were taken at three locations near the top of CCB. These data (5-min averages of backscatter are listed with Tower B data. A preliminary evaluation of these measurements indicates that they are qualitatively useful for determining when and where plume impact occurs. Although lidar measurements (by WPL) and extensive photography were made of the oil fog plumes, those data are not available for publication at this time. Pertinent scaled physical modeling studies by EPA's FMF are being published as they become available.

Two tracer gases, SF_6 and Freon, were released at different heights from the boom of a mobile crane. The mobility of the release system resulted in a higher number of successful hours per test (normally six or seven hours out of eight) in which significant tracer concentrations were recorded on the hill. The release system upwind of the hill could not be aligned in only one experiment (212) because of variable wind patterns.

The SF_6 and Freon tracer gases were stored in individual compressed gas cylinders kept at ground level. Flexible Tygon tubing, approximately 100 m long, led from the gas cylinders to different release heights on the crane boom. For the first nine experiments (201 to 209), the tracer release tube was attached to the smoke generator platform at the smoke release height but from 0.5 m to 1 m away, horizontally. For the last nine experiments (210 to 218), the tracer release tube was on a separate pulley system independent of the smoke generator platform and about 1 m away, horizontally, from the smoke release. The gas flow was monitored by separate rotameters on the SF_6 and Freon cylinders, and each cylinder's weight loss was monitored by a separate electronic digital scale.

Tracers were sampled by means of approximately 100 individual battery-operated samplers capable of either 10-min of 1-h sequential operation. Each sampler contained 12 individual pumps, each of which intermittently filled a Tedlar bag during the sampling period. Thus, each sampler could take sequential 1-h samples over a 12-h period or sequential 10-min samples over a 2-h period. Normally, 1-1 bags were used for both hourly and 10-min samples. Except for samples taken from reflection masts (described below), all samples were taken at 1 m above ground level. Seventy of the samplers were fixed in location, whereas 10 moveable samplers were placed on either the NW or SE side of the hill, depending on the prevailing wind direction. Of these 80 samplers, typically 60 were used for 1-h average samples and 20 were used for 10-min average samples. Another 20 samplers were used for reflection masts for background ambient air samples and for co-located samplers.

Air samples on a reflection mast were drawn in from 3 m and 6 m (in addition to the normal 1-m height) and also at an uphill site equal in elevation to the 6-m height. The purpose of this sampling strategy was to determine if the tracer gas would "reflect" off the surface as predicted by some dispersion models. Four of these reflection masts were used during Cases 203 to 218. Normally, the 3-m height was sampled on only one of the reflection masts; the other masts were sampled at 6 m and 1 m, in addition to the uphill site.

Results

Meteorological Data Tape Files

Two sets of tower meteorological data files are recorded on one tape. The first set of files, numbers 1 to 323, are edited but uncorrected data.

The second set of files, numbers 324 to 612, are derived from the same wind speed and direction observations as set number one, except that the data have been corrected to account for audited misalignment of wind sets, for consistent errors in instrument calibration, for noncosine response of the wind component propeller sensors, and for the effect of tower wakes on wind speeds.

Wind speed and directions from the Climatronics F460 cup-and-vane anemometers were corrected for erroneous calibration, misalignment to true north, and mean nonlinearity in vane response. Wind speeds and directions derived from the UVW propeller anemometers were corrected for noncosine response, misalignment to true north, and consistent calibration efforts that were greater than the resolution of the measurement provided by the data acquisition system. In addition, corrections were applied to wind speeds derived from both types of wind instruments to account for tower wakes. These corrections resulted in substantially improved correspondence between speed and direction data from the two types of wind sets. Data tape files are located at the National Computer Center, Environmental Research Center, Research Triangle Park, North Carolina on Sperry UNIVAC 1100/83 systems magnetic tape, nine track, odd parity, ASCII-quarter word mode, density 6250 BPI, tape number 004700. UNIVAC users or

users of interactive computer access may assign the tape with the UNIVAC Executive Control Language statement, @ASG,T CTML*CCB,U9S//////Q,004700. Copies of the tape can be produced and translated into formats acceptable to any computer using nine track tape drives.

Tracer Gas Concentrations Data Tape Files

Tracer concentrations are stored on 18 tape files, one for each experiment, numbered 613 to 630, following the corrected meteorological tower data on tape number 004700. Each record has observed concentrations of SF_6 and Freon 13B1 detected by one sampler in the network in a sequential 1-hr period or a sequential 10-min period. Included in each tape record are values of quality (flags), gas chromatograph identification, sampler location, sampling start and end times, Tedlar bag identification, analysis date and time, and values of gas chromatography response and attenuation. Tracer gas release data are presented in the text of the document, consisting of emission rates, times of release, and location and heights of release. To supplement the tracer gas concentration data, calibration data observed on the gas chromatograph instruments during all experiments are included on the data tape on eight files, 631 to 638, immediately following the tracer gas tape files. There are eight tape files, one for each gas chromatograph employed in tracer gas analysis. Each record in the files identifies the instrument, the date of calibration, the calibration gas concentration, and the resulting gas chromatograph response.

Pilot Balloon Data Tape Files

North American Weather Consultants operated pilot balloon systems from the upwind of two locations about 1.3 km NW and SE of the CCB center. Wind profiles were derived from double theodlite measurements of trajectories from pilot balloons or minisonde balloons released approximately once an hour. Of 27 data tape files, 9 contain wind profiles for 9 days preceding the days of tracer gas release and 18 contain data from experiments 201 to 218. Files are numbered 639 to 665 following the gas chromatography calibrations data on tape number 004700. Data records contain computed wind speed and direction at 30 sec intervals after release.

Tethersonde and Minisonde Data Tape Files

North American Weather Consultants operated tethersonde and minisonde systems from the same two locations NW 7nd SE of CCB. The tethersonde was operated in an ascent-descent sequence yielding profiles of temperature, pressure, relative humidity, mixing ratio, wind speed, and direction once an hour to a height of at least 200 m above local terrain. Release times were scheduled 30 min after the pilot balloon soundings to obtain wind profiles every half hour. Minisonde flights were conducted when wind speeds were too high to allow tethersonde operation, or when the tethersonde system was not working. The minisonde was operated as a free release balloon sounding to obtain profiles of temperature, wet bulb temperature, and pressure and was sometimes tracked as a pilot balloon for wind profiles.

Of 17 tape files, 10 contain tethersonde data and 7 contain minisonde data. Files are numbered 666 to 675 for tethersonde data and 676 to 682 for minisonde data on tape number 004700, immediately following the pilot balloon data files.

Modelers' Data Base Tape Files

The modelers' data archive contains observed 1-hr average tracer gas concentration data, tracer release information, and meteorological variables and derived parameters estimated at release height for each of the hours when either SF_6 or Freon tracer was released. The method of estimating meteorological data appropriate to the release heights of the tracer gases relies on assumptions and procedures described in the text.

Data are stored at the National Computer Center, Environmental Research Center, Research Triangle Park, North Carolina on the Sperry UNIVAC 1100/83 system's magnetic tape, nine track, odd parity, ASCII-quarter word mode, density 6250 BPI, tape number 002689. UNIVAC users or users of interactive computer access may assign the tape with UNIVAC Executive Control Language statement, @ASG,T CTML*CCBTR, U9S//////Q,002689. Copies of the tape can be produced and translated into formats acceptable to any computer using nine track tape drives.

There are four tape files. File no. 1 contains a chronological listing of SF_6 tracer release data and associated meteorological parameters for the eighteen experiments. File no. 2 contains SF_6 concentrations recorded by the network of samplers during the releases described in file no. 1. Similarily, file no. 3 and file no. 4 document the release and detection of the Freon gas tracer.

Conclusion

This report describes the data collected in the tracer field study at Cinder Cone Butte, Idaho and illustrates the availability of the data to encourage additional applications in utilization and testing various dispersion models. Data are arranged on magnetic tape files so that identification and acquisition is easily accomplished by any user with interactive computer access to the UNIVAC computer at the National Computer Center, Research Triangle Park, North Carolina or with access to any computer capable of reading standard nine-track magnetic tape. The report describes the instruments used to collect the data, the operational procedures used to run the collection system, and the performance record of the system.

*The EPA authors **Lawrence E. Truppi** and **George C. Holzworth** are on assignment from the National Oceanic and Atmospheric Administration, Department of Commerce, to the Environmental Sciences Research Laboratory, Research Triangle Park, NC 27711*

The complete report, entitled "EPA Complex Terrain Model Development: Description of a Computer Data Base from Small Hill Impaction Study No. 1 Cinder Cone Butte, Idaho," (Order No. PB 84-161 439; Cost: $13.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA authors can be contacted at:
Environmental Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

☆ U S GOVERNMENT PRINTING OFFICE, 1984 — 759-015/7639

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

Official Business
Penalty for Private Use $300