United States
Environmental Protection
Agency

Atmospheric Sciences
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S8-88/003 Feb. 1988

EPA

Project Summary

The Complex Terrain Dispersion Model (CTDM) Preprocessor System: User Guide and Program Description

Michael T. Mills, Elizabeth M. Insley, Robert J. Paine, and Bruce A. Egan

This report describes the theory and operation of a terrain preprocessor computer program which approximates actual terrain features with mathematical functions. The best-fit parameters for these functions are used by the Complex Terrain Dispersion Model (CTDM) in the calculation of lateral and vertical streamline displacement, an important step in the calculation of concentrations at hill receptor locations.

This Project Summary was developed by EPA's Atmospheric 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 Complex Terrain Dispersion Model (CTDM) is a model designed to estimate ground-level concentrations on elevated terrain during periods in which the atmosphere is stably stratified. The model provides concentration estimates for receptors on several isolated hills for multiple averaging periods. The model can accept multiple terrain features; however, the flow is only influenced by one hill at a time.

The central feature of CTDM is its use of a critical dividing-streamline height (H_C) to separate the flow into two discrete layers. This basic concept was suggested by theoretical arguments and was demonstrated through laboratory experiments. The flow below H_C is restricted to lie in a nearly horizontal plane, allowing little motion in the vertical. Consequently, plume material below H_C travels along and around the terrain, rather than up and over the terrain. The flow above H_C is allowed to rise up and over the terrain. Two separate components of CTDM compute ground-level concentrations resulting from material in each of these flows.

An important step in the calculation of concentrations at receptors above H_C is the determination of lateral and vertical streamline displacement. The calculation of these displacements for a hill of arbitrary shape would require the use of an elaborate numerical model and significant computing resources, neither of which can be justified on the basis of increased accuracy of the concentration predictions. The current version of the model is designed to run on a microcomputer.

If one assumes that the portion of the hill above H_C can be fit to a simple mathematical surface, then the lateral and vertical streamline displacements can be estimated from analytical expressions which can be rapidly evaluated. For CTDM to make use of this idealized terrain, the model must have access to hill-fit parameters for a range of H_C values.

Requirements for a CTDM Terrain Preprocessor

CTDM requires much more information about hills than other Gaussian models. CTDM needs a three-dimensional representation of each hill. Therefore, the Terrain Preprocessor produces an analytical description of the hill shape. Although CTDM will accept several distinct hills, the Terrain Preprocessor will processs only one hill at a time. Hence, the Terrain Preprocessor must be run for each hill and the resulting files may be appended *to one large rain file for input to the* CTDM. One constraint of CTDM is that in the calculations, only one isolated hill is considered at a time. A discussion whose purpose is to aid the user in selecting distinct terrain features is included in an appendix to the report.

Summary of Preprocessor Operation

Two programs must be run to generate terrain input parameters to CTDM for a given hill. A third program allows the user to display the contours for the actual and fitted hills. The first program, FITCON, asks the user to define in terms of its name, identification number, maximum elevation and x,y coordinates of the hill center. The user then specifies the name of a master file of digitized contour data and a file to be used for diagnostic output during the fitting process. In the master file, the following data are provided for each contour:

- Contour identification number
- Contour elevation
- Number of digitized plots
- A code indicating whether a contour is input as complete or incomplete
- x, y coordinates of the digitized contour points.

The user chooses one of the following three methods for selection of contours from the master file: (1) all contours selected, (2) contours selected based upon a range of user-specified contour identification numbers, or (3) the specification of a file containing the contour identification numbers for the hill in question. Before a contour is accepted for processing, it must pass a number of tests. Incomplete contours are closed by a reflection of points through the hill center or contour centroid. The program provides special processing for those contours which are to be a series of multiple contours at the same elevation. After qualification and editing, the area and centroid coordinates of each contour are determined by numerical integration. Each contour is then fit to an ellipse by first finding the slope of the line through the centroid in the plane of the contour, which gives the largest second moment for the area within the contour. In the determination of this maximum second moment for a contour to 10° resolution, eighteen lines having equal angular spacing are used. The line associated with the maximum second moment is assumed to define the orientation of the minor axis of the ellipse representing the contour. The lengths of the semi-major and semi-minor axes for this ellipse are calculated from the analytical expressions for the area and second moment of an ellipse.

These fitted ellipse parameters for each contour are input to the second preprocessor program, HCRIT, which determines, for the portion of the hill above a given critical elevation, the best-fit inverse polynomial profiles along the hill major and minor axes. The center coordinates of the fitted hill are calculated as the mean of the ellipse center coordinates for those contours above a given critical elevation. The orientation of the fitted hill is calculated as a vector average of the ellipse orientations, weighted by the ellipse eccentricity. The user can specify the critical elevations to be used by HCRIT in two ways. The first option is to have each contour elevation, with the exception of the uppermost, serve as a critical elevation. Alternatively, the user can specify a number of equally-spaced critical elevations between the lowest and uppermost contour. In the inverse polynomial fit to the hill profile, a critical elevation is treated as an effective hill base. HCRIT provides an input file for CTDM which contains the following information for each critical elevation:

- Ellipse parameters corresponding to the contour at the critical elevation (these parameters are interpolated in the case where a critical elevation does not correspond to a contour elevation)
- Coordinates of the center of the fitted hill
- Orientation of the major axis of the fitted hill with respect to north
- The length scales and exponents for the inverse polynomial fits along the hill's major and minor axes

The third preprocessor program, PLOTCON, uses plot files from FITCON and HCRIT to generate the following screen displays which air in evaluation of the hill-fitting process:

- Map of digitized contours eithe they were input or after they h been qualified and edited
- Map of the digitized contours and their associated fitted ellipses
- For each critical cutoff elevation, a map showing the digitized contours and the contours of the fitted hill at elevations corresponding to the elevations of those digitized contours above the critical elevation

Michael T. Mills, Elizabeth M. Insley, Robert J. Paine, and Bruce A. Egan are with ERT, Inc., Concord, MA 01742.
***Peter Finkelstein** is the EPA Project Officer (see below).*
The complete report, entitled "The Complex Terrain Dispersion Model (CTDM) Preprocessor System: User Guide and Program Description," (Order No. PB 88-162 094/AS; Cost: $19.95, 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 Project Officer can be contacted at:
Atmospheric Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

EPA/600/S8-88/003