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Project Summary

A Workshop Report on the Complex Terrain Model Development Project (February 4-6, 1986)

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In early October 1985 an initial version of the Complex Terrain Dispersion Model (CTDM) was delivered to EPA. A final version will be delivered in August 1987. Over the next several months, CTDM will be modified and will undergo extensive evaluation. A major step in the evaluation of CTDM and its evolution toward becoming a regulatory model was a workshop that was conducted in February 1986. The workshop was attended by the model developers, EPA, other regulatory agencies, air quality consultants and university scientists. Each participant was asked to exercise the model to assess its overall effectiveness and validity. Each participant also gave a 1/2-hour presentation of his findings. After the presentations, the participants were partitioned into three workgroups to discuss:

- **CTDM algorithms,**
- **applications and practical considerations of the model, and**
- **evaluation of the model.**

The full report discusses the recommendations of the workshop participants.

This Project Summary was developed for 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 Model Development (CTMD) project is being sponsored by the U.S Environmental Protection Agency (EPA) to develop, evaluate and refine practical models for calculating ground-level air pollutant concentrations in mountainous terrain. The emphasis of the project is to develop models with known accuracy and limitations for simulating 1-hour concentrations during stable conditions. To support the model development activities, four major tracer and flow visualization field experiments have been conducted since September 1980. The resulting data bases and data from towing tank and wind tunnel studies, conducted at the EPA Fluid Modeling Facility, and our understanding of the physical processes have been used to develop the Complex Terrain Dispersion Model (CTDM).

The delivery of the final model will include estimates of the accuracy and precision of the model and an assessment of its overall limitations.

A workshop was conducted in February 1986 as a major step in evaluating CTDM and its evolution toward becoming a regulatory model. The workshop was attended by the model developers, EPA, other regulatory agencies, air quality consultants and university scientists. Each participant was provided a diskette or tape of the CTDM code, a draft User's Guide and the Fifth Milestone Report (DiCristofaro, et al 1986, EPA Document Number EPA/600/

3-85/069) and was asked to exercise the model to assess its overall effectiveness and validity in whichever way they choose. For example, some of the participants evaluated the model using SO_2 and meteorological data collected around electric generating plants, some performed sensitivity studies, and some compared model assumptions to theoretical and numerical model calculations. Each participant gave a 1/2-hour presentation of his findings. After the presentations, the participants were partitioned into three workgroups to discuss:

- CTDM algorithms,
- applications and practical considerations of the model, and
- evaluation of the model.

The full report discusses the recommendations of the workshop participants.

Recommendations

The key recommendations of the three workgroups are:

CTDM Algorithm Workgroup

1. The CTDM-formula for σ_z requires further evaluation; specific topics to be investigated include:
   (a) *the ability of sodar to estimate* the height of the surface boundary layer and to identify elevated layers in which a plume may be trapped;
   (b) spectral analyses of w-data to identify wave contributions to σ_w;
   (c) the validity of theoretical estimates of σ_w in the surface boundary layer;
   (d) the validity of the assumption that $\sigma_w = 0.0$ above the surface boundary layer;
   (e) the model of Pearson et al. (1983); and
   (f) *an evaluation of the algorithm* with the Stable Plume Experiment (SPEX) dataset.
2. $T_{LY} = \infty$ and, therefore, $\sigma_Y = \sigma_v t$.
3. For regulatory applications the Gaussian form of the crosswind distribution should be retained in CTDM, reflecting the general availability of one-hour average meteorological data. Other variants should be used when proper data are available.
4. The LIFT component of CTDM should differentiate among the inner layer, the rapid distortion theory (middle) layer and the outer layer. The model should include an internal boundary layer over elevated terrain.
5. The formulation of the T_z factor along the lines suggested by the Hunt and Mulhearn (1973) theory should be explored further.
6. LIFT should be modified to simulate the strong lateral deflections of streamlines near H_c.
7. Wind shear and stratification should be accounted for in the T-factor formulations.
8. Although no modifications to CTDM are recommended to handle travel time more rigorously, the user should be aware that problems arise when the source to receptor travel time becomes comparable to the averaging time.
9. While it is recognized that the inclusion of slope flow effects in CTDM is not within the current scope of the present phase of CTMD, it is recommended that model users be made aware of their potential influence on GLC, especially when the height scale of the topography exceeds 500m and the winds are less than 5 m/sec.

Applications Workgroup

1. CTDM should be delivered as a *stand-alone model that handles the* stable plume impingement problem. The model should be able to handle blocks of *stable* meteorological conditions so 3-hour and longer average concentrations can be calculated.
2. The workgroup strongly recommends that CTDM be eventually incorporated into a plume model (e.g., the tall stack plume model being developed by EPRI or the new EPA model TUPOS) that handles non-stable conditions. The group does not recommend its incorporation into existing regulatory models.
3. CTDM should be used primarily as a *refined model and not an advanced* screening model. There are existing regulatory models that can be used as screening tools.
4. Because CTDM is a refined model, we recommend that the appropriate meteorological data be collected to provide input data: vertical profiles of wind speed and direction up to plume height, vertical profiles of temperature up to the top of the terrain under consideration, and turbulence statistics (σ_v and σ_w) near plume height.
5. If the plume height is below around 10L (10 times the Monin-Obukhov length), then perhaps low level ($\sim$10m) measurements could b[e] used to characterize the SBL and t[o] estimate CTDM meterological input
6. A CTDM preprocessor should be de[-]veloped that includes objective pro[-]cedures to parameterize terrain i[n] the model.
7. CTDM should include case-study an[d] graphical displays that will help th[e] user clearly understand the mode[l] simulations.
8. The user's guide should explain th[e] essential features of CTDM, includ[-]ing a description of the new feature[s] that distinguish CTDM from cur[-]rently employed Gaussian plum[e] models.

Model Evaluation Workgroup

1. Further work needs to be performed in developing the model before a large model evaluation effort is undertaken.
2. The statistical tests used in the evaluation of CTDM should be consistent with those used by OAQPS. Specifically, subsets of the tests OAQPS has used in prior model evaluations focusing on measures of bias and root-mean square error should be *employed. In this way CTDM per*formance can be compared more readily with other model evaluations.
3. CTDM should be evaluated using data bases beyond those collected in the CTMD program. Confidence in the model will improve if good performance can be demonstrated for a range of terrain and meteorological settings similar to those encountered in regulatory practice. Data bases identified for possible use were Steptoe Butte, Warren Power Plant, Widows Creek Power Station, Bowline Power Station, Mt. Tom Power Station and the Westvaco Luke, Maryland Mill.
4. Model evaluation should continue with the FSPS data base with particular attention to the σ_z formulation. The Freon data base contains information which can be used to examine model calculations vs. ground-level observations. The Freon tracer plume was not affected by buoyant rise and buoyancy induced dispersion.
5. The limits of applicability of CTDM will need to be defined carefully. Some information on this can come from knowledge of theoretical limits (e.g., doesn't handle local drainage

flows); other information can come by efforts of recommendation (3), above.

6. Finally, the workgroup recommended that sensitivity studies be performed to examine the effect of input errors on predicted peak concentrations. Inputs identified for evaluation in decreasing order of importance are: wind direction, vertical diffusion, shape and orientation of hill from source, dividing streamline height, plume rise, potential temperature gradient and horizontal diffusion.

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The complete report entitled "A Workshop Report on the Complex Terrain Model Development Project (February 4-6, 1986)," (Order No. PB 87-100 681/AS: Cost $11.95 subject to change) will be available only from:
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