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Project Summary

TUPOS—A Multiple Source Gaussian Dispersion Algorithm Using On-Site Turbulence Data

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TUPOS and its postprocessor, TUPOS-P, form a Gaussian model which resembles MPTER but offers several technical improvements. TUPOS estimates dispersion directly from fluctuation statistics at plume level and calculates plume rise and partial penetration of the plume into stable layers using vertical profiles of wind and temperature. The model user is thus required to furnish meteorological information for several heights above ground in a separate input file.

TUPOS can be used for short-term (hours to days) impact assessment of inert pollutants from single or multiple sources and can be expected to have greatest accuracy for locations within 10 km of the source. Although TUPOS will make computations for receptors having any ground-level elevation, it is not intended as a complex terrain model, but rather as a model for calculations over flat or gently rolling terrain. TUPOS will optionally treat buoyancy-induced dispersion but does not include building down-wash, deposition, or fumigation.

The maximum number of point sources and the maximum number of receptor locations are easily adjusted at the time of program compilation and have no specific limit. The program is initially configured to handle 25 sources and 180 receptors.

Output from TUPOS consists primarily of tape or disk concentration files, which are then analyzed and summarized by the postprocessor, TUPOS-P. An hourly concentration file is automatically created by TUPOS; the user has the option of creating a partial concentration file.

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

TUPOS and its postprocessor, TUPOS-P, form a Gaussian model which resembles MPTER but offers several technical improvements. TUPOS estimates dispersion directly from fluctuation statistics at plume level and calculates plume rise and partial penetration of the plume into stable layers using vertical profiles of wind and temperature. In order to do this adequately, considerable knowledge of the variation of meteorology in the vertical dimension must be known.

Information must be furnished by the user for each simulated hour at several levels for the five variables: ambient air temperature, wind direction, wind speed, standard deviation of wind azimuth, and standard deviation of wind elevation angle. These parameters are interpolated vertically for calculating plume rise, dilution, plume dispersion, and transport. This profile information must be provided in sufficient detail so that linear interpolation between levels is reasonable. One of the levels specified must be that of the mixing height.

Source parameters are physical stack height above ground, stack top inside diameter, stack gas temperature, stack gas exit velocity, and pollutant emission rate. As an option, values for three variables: stack gas temperature, stack gas exit velocity, and emission rate can be entered hourly.

Optional features of the TUPOS computer code include:

- Stack downwash, buoyancy-induced dispersion, and gradual plume rise;
- Terrain adjustment as a function of stability category; and
- An optional program-generated polar coordinate grid, with sector size and azimuth spacing entered as input.

Output from TUPOS consists primarily of tape or disk concentration files which are then analyzed and summarized by the postprocessor, TUPOS-P. An hourly concentration file is automatically created by TUPOS; the user has the option of creating a partial concentration file.

By making the number of sources and receptors easily adjustable at the time of compilation and by removing functions that are largely bookkeeping to the postprocessor, the TUPOS system should be easily adaptable to computer systems with small core storage.

Discussion

TUPOS is a Gaussian plume steady-state model using measured (or inferred) turbulence data (wind fluctuation standard deviations) as part of the meteorological input. It is a useful short-term (hours to days) algorithm to evaluate the effects of multiple point sources in the near field (within 10 km). It is the intent of the authors that TUPOS be applied to sources from which the effluent is dominated by buoyancy or momentum (not heavier than air releases). Only simple terrain adjustments are made; it is not expected that plume impaction be considered. The model includes the following optional computational features in common with MPTER:

- Stack downwash,
- Buoyancy-induced dispersion,
- Gradual plume rise, and
- Terrain adjustment as a function of stability category.

Although TUPOS will make computations for receptors having any ground-level elevation, it is not intended as a complex terrain model, but rather as a model for calculations over flat or gently rolling terrain. TUPOS will optionally treat buoyancy-induced dispersion but does not include building downwash, deposition, or fumigation.

Modeling features unique to TUPOS include:

- Layer-by-layer plume rise and
- Partial plume penetration above the mixing height.

TUPOS retains limitations typical of Gaussian plume models including:

- No consideration of nonlinear pollutant removal or chemical reactions,
- No consideration of spatial variation in meteorology, and
- No consideration of increased horizontal dispersion due to wind direction shear through the vertical extent of plumes.

Also, TUPOS has no provision for calculating the effects from area or line source emissions.

Emission Data

The following information is required for each point source:

- East and north coordinates of the point source (user units),
- Pollutant emission rate (g/s),
- Physical stack height (m),
- Stack gas temperature (K),
- Stack inside diameter (m), and
- Stack gas exit velocity (m/s).

The east-north coordinate system can be provided in any consistent units. Also, the stack ground-level elevation is required if the terrain adjustment option is used.

Receptor Data

The user has the option of designing his or her own receptor grid or instructing TUPOS to generate a polar coordinate receptor grid. In either case, the location (user length units) and, if the terrain adjustment option is used, the ground-level elevation (user height units) are required for input. Additionally, for the user-supplied receptors, the receptor height above ground (m) must be given.

Meteorological Data

Hourly meteorological data are required for specific levels. The user may prepare the data in the format specified, or data prepared by the Meteorological Processor for Dispersion Analyses, (MPDA-1) may be used. The hourly meteorological data needed for the computations are as follows:

- Year,
- Julian day,
- Hour,
- Number of vertical levels,
- Level number corresponding to the mixing height,
- Stability category,
- Height above ground of each level (m),
- Ambient air temperature at each level (K),
- Wind direction at each level (degrees),
- Wind speed at each level (m/s),
- Standard deviation of the azimuth angle (radians) at each level, and
- Standard deviation of the elevation angle (radians) at each level.

There are four stability categories in TUPOS: unstable, day-time neutral, nighttime neutral, and stable designated 1 to 4, respectively. These can be defined using the ratio of Monin-Obukhov length to mixing height. (The stability category is contained in the output from MPDA-1.)

It is assumed that the variation of meteorological parameters with height is provided in sufficient detail such that linear interpolation with height between levels yields reasonable values. Any information required for a height below the height of the lowest level is assigned the value of the lowest level. Similarly, any information required for a height above the height of the highest level is assigned the value of the highest level.

Output primarily consists of tape or disk files, which are then analyzed and summarized by a separate postprocessor, TUPOS-P. An hourly concentration file is automatically created by TUPOS the user has the option of creating a partial concentration file. For convenience a brief summary of the simulation is printed; however, the user is encouraged to exercise the postprocessor TUPOS-P to obtain a detailed listing of the results.

Conclusions and Recommendations

A computer code, TUPOS, is provided to make dispersion calculations. The dispersion parameters are characterized in terms of the wind fluctuation statistics at plume height. Plume rise is calculated layer-by-layer and provisions are included for estimating the amount of material that penetrates above the mixing height. Extensive comparisons of calculated values with field measurements have not been made. The model produces an output file of calculated hourly concentrations that can conveniently be processed with a companion code, TUPOS-P. Evaluation of this model by those having appropriate data sets is encouraged.

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The complete report, entitled "TUPOS—A Multiple Source Gaussian Dispersion Algorithm Using On-Site Turbulence Data," (Order No. PB 86-181 310/AS; Cost: $16.95, subject to change) will be available only from:

National Technical Information Service
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