Open Burn/Open Detonation Dispersion Model (OBODM)

Reference

Bjorklund, J.R., J.F. Bowers, G.C. Dodd and J.M. White, 1998. Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide, Vols. I and II. DPG Document No. DPG-TR-96-008a and 008b. U.S. Army Dugway Proving Ground, Dugway, UT.

Abstract

OBODM is intended for use in evaluating the potential air quality impacts of the open burning and detonation (OB/OD) of obsolete munitions and solid propellants. OBODM uses cloud/plume rise, dispersion, and deposition algorithms taken from existing models for instantaneous and quasi-continuous sources to predict the downwind transport and dispersion of pollutants released by OB/OD operations. The model can be used to calculate peak concentration, time-mean concentration, dosage (time-integrated concentration), and particulate gravitational deposition for emissions from multiple OB/OD sources for either a single event or up to a year of sequential hourly source and meteorological inputs. OBODM includes a data base of empirical emissions factors for many explosives and propellants. The OBODM program is designed for use on IBM-compatible PCS using the MS-DOS® (Version 2.1 or higher) operating system and will also run under most WINDOWS® environments. OBODM requires 505 kilobytes of conventional memory, a math coprocessor, and a minimum of 3 megabytes of hard disk storage. Volume I of the user's guide contains instructions for installing and running the model and example problems. Volume II discusses the model's mathematical algorithms and default meteorological inputs.

Availability

OBODM and the two-volume user's manual are available on the Dugway Proving Ground website at *www.dugway.army.mil*. Requests for the OBODM source code should be addressed to Meteorology & Obscurants Division, West Desert Test Center, Dugway Proving Ground, Dugway, UT 84022-5000.

a. Recommendations for Regulatory Use

There is no preferred model for application to the open burning and open detonation of obsolete or unsafe munitions and propellants. OBODM is specifically designed to predict the buoyant rise and dispersion of emissions from these instantaneous (open detonation) and short-term quasi-continuous (open burn) releases when a refined model is needed.

b. Input Requirements

OBODM source inputs include the source coordinates and physical dimensions, explosive or propellant type, pollutant species of interest, effective heat content of the explosive/propellant, burn rate for an open burn, total mass of explosive/propellant, and pollutant emissions factor. An OBODM data base provides much of this information for many explosives and propellants. For particulate matter, if the user wishes to consider gravitational settling and deposition, the particle density and particle size distribution (or particle mass-median diameter and geometric standard deviation) are also required. If the user wishes to consider the chemical transformation of a gaseous pollutant, the pollutant half-life must be specified. When OBODM is used with sequential hourly meteorological inputs, hourly source inputs also can be used.

OBODM allows up to 50 individual sources.

OBODM meteorological inputs consist of the mean wind speed and wind direction at 10 meters, standard deviations of the wind azimuth (σ_A) and elevation (σ_E) angles, longitudinal turbulence intensity, wind-profile exponent, mixing depth, vertical potential temperature gradient, relative humidity, vertical wind-direction shear (normally set to 0), and barometric pressure. OBODM uses the 10-meter wind speed and Pasquill stability category or net radiation index (NRI) to assign default values for any input not provided by the user except for the wind speed, wind direction, and ambient air temperature. The model will also calculate the NRI if cloud cover and height data are entered. OBODM can process from 1 to 8784 hours (1 year) of sequential meteorological inputs in a single run. Standard preprocessed meteorological input files for regulatory models such as ISCST3 can be used with OBODM.

OBODM uses a polar or Cartesian coordinate system for regular and discrete receptors. Receptor heights are required in open terrain. When OBODM is used in its complex terrain screening mode, all receptors are assumed to be at ground level and ground elevations are required. OBODM will accept a maximum of 10,000 receptors in a regular grid plus a maximum of 100 discrete receptors.

c. Output

Printed output options include:

- Program control parameters, source data, and receptor data;
- Tables of hourly meteorological data for each specified day;
- "N"-day average concentration or total deposition calculated at each receptor for any desired source combinations;
- Concentration or deposition values calculated for any desired source combinations at all receptors for any specified day or time period within the day;
- Tables of highest and second-highest concentration or deposition values calculated at each receptor for each specified time period during an "N"-day period for any desired source combinations, and tables of the maximum 50 concentration or deposition values calculated for any desired source combination for each specified time period.

d. Type of Model

OBODM uses a Gaussian puff model for open burns and a square-wave quasi-continuous Gaussian plume model for open burns. The square-wave qausi-continuous source model is an analytic solution to the integral of the Gaussian puff equation with respect to time over the duration of the release. That is, the quasi-continuous source model is the analytic equivalent of representing a quasi-continuous release by an overlapping series of Gaussian puffs.

e. Pollutant Types

OBODM can be used to model primary pollutants. Settling and deposition of particulates are treated.

f. Source-Receptor Relationships

User specified locations are used for sources and receptors. Receptors need not be at ground level except in complex terrain. Receptor heights above ground-level must be the same for receptors in the regular array, but not for the discrete receptors.

g. Plume Behavior

Plume rise for quasi-continuous sources (open burns) is calculated by the Briggs (1971) equations as modified by Dumbauld *et al.* (1973) to account for the horizontal dimensions of large burns. Cloud rise for instantaneous sources (open detonations) is calculated using equations derived by Dumbauld *et al.* (1973) using assumptions analogous to those used to derive the Briggs (1971) equations for continuous sources.

The method of Weil and Brower (1984) is used to account for partial plume or cloud penetration into the stable layer above the surface mixing layer.

A tilted plume is used for particulates with settling velocities.

Partial reflection at the ground surface is assumed for particulates with settling velocities. OBODM computes the reflection coefficient as a function of settling velocity (Bowers *et al.*, 1979).

The SHORTZ/LONGZ complex terrain methodology (Bjorklund and Bowers, 1982) is used in the complex terrain screening mode.

h. Horizontal Winds

Winds are assumed to be horizontally uniform and steady-state. Default wind-profile exponents are based on wind speed and stability or wind speed and net radiation index.

i. Vertical Wind Speed

The vertical wind speed is assumed to be zero.

j. Horizontal Dispersion

OBODM uses semi-empirical Dugway Proving Ground (DPG) dispersion coefficients which directly relate plume and puff growth to atmospheric turbulence and vertical wind shear. The lateral dispersion coefficient, which differs for quasi-continuous and instantaneous sources, is from Cramer *et al.* (1972). The alongwind (longitudinal) dispersion coefficient is from Dumbauld and Bowers (1983). Plume/cloud growth by entrainment during buoyant rise is included (Bjorklund *et al.*, 1998). The horizontal dispersion coefficients depend on the cloud stabilization time for detonations and fast burns and on the concentration averaging time for lengthy burns.

k. Vertical Dispersion

OBODM uses the DPG vertical dispersion coefficient which relates vertical plume/cloud growth to the vertical turbulence intensity and includes the effects of entrainment during buoyant rise (Bjorklund *et al.*, 1998).

l. Chemical Transformation

Chemical transformations are approximated by exponential decay with the decay coefficient specified by the user.

m. Physical Removal

Dry deposition of particulates by gravitational fallout is treated using the methodology from the original ISC model (Bowers *et al.*, 1979).

n. Evaluation Studies

Bowers, J.F., J.E. Rafferty and J.M. White, 1990. Summary of Dugway Proving Ground Experience in Diffusion Development and Verification for MMW Obscurants. In Proceedings of Smoke/Obscurants symposium XIII, Program Manager Smoke/Obscurants, Aberdeen Proving Ground, MD.

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Cramer, H.E., J.R. Bjorklund, R.K. Dumbauld, J.E. Faulkner, F.A. Record, R.N. Swanson, and A.G. Tringle, 1972. Development of Dosage Models and Concepts. Document No. DTC-TR-72-609-1, U.S. Army Dugway Proving Ground, Dugway, UT.

o. Literature Cited

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Bowers, J.F., J.R. Bjorklund, and C.S. Cheney, 1979. Industrial Source Complex (ISC) Dispersion Model User's Guide, Vols. I and II. Report Nos. EPA-450/4-79-030 and 031, U.S. Environmental Protection Agency, Research Triangle Park, NC.

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Dumbauld, R.K. and J.F. Bowers, 1983. Functional Methodologies for Characterizing Wind-Speed and Turbulence Profiles and Turbulent Diffusion Coefficients within and above Vegetative Canopies and Urban Domains. H.E. Cramer Company, Inc. Report No. Tr-83-341-01 prepared for U.S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

Weil, J.C. and R.P. Brower, 1984. An Updated Gaussian Plume Model for Tall Stacks. *Journal of the Air Pollution Control Association*, **34**: 818-827.