

Air dispersion modeling report essay

[Environment](#), [Air](#)



Dispersion modeling can be used for multiple purposes; including to model the path of volcanic ash in the atmosphere after an eruption, to model the plume of pollutants emanating from a coal-burning electricity producing plant, to model the impact that an increase in vehicular traffic will have on ambient air conditions, or for establishing evacuation zones after a release of toxic chemicals. A wide variety of free software is available for public use. To successfully decide which software to use, it is important to understand exactly what needs to be modeled and what output is desired.

Models exist for small local scales and larger planetary scales, for dispersion of primary pollutants (such as KNOX) or for secondary pollutants (such as ozone, which KNOX can convert into), for steady state emissions of particles (from stacks) or for non-steady state puffs (from chemical releases). Model outputs can predict worst case pollutant concentration at a specific time, expected concentrations based on specific atmospheric conditions at a certain point, or create a three-dimensional graphic showing the concentration of a pollutant within space.

For example, the Regional Modeling System for Aerosols and Deposition (REARMS), a program available from the Environmental Protection Agency (EPA) used to model inert and chemically reactive pollutants over regional scales (including processes that contribute to haze), can not be used by emergency response personnel to quickly setup evacuation zones downwind of a hazardous pollutant release. This report focuses on point source dispersion modeling based on the

Gaussian air dispersion equations in order to determine concentrations of pollutants at downwind receptors. The report will discuss the mathematical basis for point source dispersion modeling, the regulatory framework (specifically in Connecticut), and on models that were researched and used in an attempt to model air dispersion from a point-source. MATHEMATICAL BASIS OF AIR DISPERSION MODELING The basic Gaussian equation, according to equation 10. In “ Energy and the Environment” by Fay and Gloom, is: Where QPS is the mass rate of a pollutant in grams/second, H is the effective stack height, y is the horizontal distance, z is the vertical distance, and the sigma represent the standard deviation of the bell shaped pollutant distribution in the horizontal and vertical plane at a specific downwind distance x (Fay & Gloom). The sigma are a function of atmospheric stability.

According to D.

Bruce Turner in the Workbook of Atmospheric Dispersion modeling, there are three basic stability categories; Unstable: net upward heat flux, super adiabatic thermal structure, considerable horizontal and vertical turbulence, typically mid day with clear skies and light wind Neutral: 0 heat flux, near dry adiabatic thermal structure, mid-range turbulence, typically during windy or cloudy days Stable: net downward heat flux, near isothermal or inversion thermal structure, damped out vertical turbulence, typically during nighttime with clear sky and light wind If equations are done by hand, the values of sigma can be determined with charts showing downwind distance x and the atmospheric stability class. Most computer models have this information

embedded within the programming language; users do not need to manually look this up.

There are several assumptions associated with the Gaussian model, including Steady state meteorological conditions (wind speed / direction remains constant) from source to receptor Conservation of mass (no deposition, no chemical reactions in the atmosphere, no components absorbed by vegetation/water bodies) Crosswind and vertical concentration distributions can be well represented by the Gaussian distribution

Continuous, steady state emissions Due to these assumptions, Gaussian dispersion models are limited to a short- term modeling for primary pollutants (pollutants that do not convert to secondary pollutants in the atmosphere) from single point sources. For industries trying to demonstrate compliance with regulatory emission standards from steady state point source emissions, models using Gaussian dispersion models are a good fit.

REGULATORY BACKGROUND The Clean Air Act (CA) is a federal law that regulates air emissions form stationary and mobile sources.

The EPA has delegated the authority to enforce the Clean Air Act regulations to some state and local authorities, including the State of Connecticut.

Regulations found at RASA AAA-1 and (C) require that the owner for any source for which an application for an air permit is submitted demonstrate that the operation will to cause or contribute significantly to a violation of any federal or state air quality standard or prevention of significant deterioration increment. Modeled compliance is demonstrated by adding background levels of pollutants to worst-case scenario modeled levels and

demonstrating compliance with the National Ambient Air Quality Standards (NANAS), Prevention of Significant Deterioration (SD) increments, and the state-specific Connecticut Ambient Air Quality Standards (COCAS) for dioxin.

Facilities which want to construct a new source of air pollution, modify an existing source of air pollution, or need to bring an existing source into compliance with standards are required to demonstrate compliance with these standards using dispersion modeling. Due to the complexity of air dispersion modeling, the State of Connecticut recommends meeting with the Department of Environmental Protection (CT DEEP) prior to starting any modeling project. The CT DEEP Ambient Impact Analysis Guidance document, prepared in July 2009, recommends SCREENS as a screening level air dispersion modeling program and REARMED as the refined modeling program.

If a facility can demonstrate compliance using the worst-case scenarios using the screening models, refined modeling using REARMED is not required.

The CT DEEP provides multiple useful resources for air modeling purposes, such as pre-processed meteorological data for use in REARMED, criteria air pollutant background levels for the most recent three years from six CT DEEP monitored sites, and links to multiple state and EPA guidance documents for successfully completing dispersion modeling analyses. A discussion of the Connecticut recommended models, as well as other models researched during this project, are discussed below.

DISPERSION MODELING PROGRAMS USED

Simultaneous. M The first semi-successful modeling attempt created a three-dimensional visual output of a Gaussian plume. The model,

Gamesmanship's, was created by Harold Been and available from <http://www.>

Metalwork. Com/ matriculated/flagellating/13279-simultaneous . This is a Mutual based model that calculates the dispersion of a continuous point source and outputs a three-dimensional matrix that can be plotted using Mats volume visualization function.

Although it can be a useful tool to visualize a three- dimensional plume, the author states on his website that the program was developed for a homework assignment, that the software was based on outdated documentation, that he had not tested many of the options embedded in his software for accuracy, and that the EPA has other preferred models available on-line that can be downloaded for free. In addition, the program did not make units clear (such as Celsius, Kelvin, or Fahrenheit for temperature), which could potentially lead to inaccurate calculations.

Due to the potential for errors, this attempt was considered “ semi-successful” and additional air dispersion models researched. L 1023 One failed attempt at air dispersion modeling involved the program L 1023; the failure may be due to the fact that the program was originally written in he sass's and is not compatible with current technology. The program L 1023 was made available with the book “ Workbook of Atmospheric Dispersion Estimates” by D. Bruce Turner.

The book was originally published in 1970 and was an invaluable reference to EPA in creating portions of the Clean Air Act.

The book is cited in multiple EPA reference guides, and has been made available by EPA for public use through the National Service Center for Environmental Publications (<http://Nevis.EPA.Gob>); a website that makes EPA documents available for free download. The program was originally revived on a “floppy diskette” and contained 26 examples for use in obtaining a basic understanding of dispersion modeling using a variety of inputs and combination of parameter values. Although the book no longer comes with “floppy diskette”, the program is available for download from the CAR Press website (<http://w.Vi>

Creepers.Mom/product/ISBN/9781566700238). However, the program does not work. After asking what initial action the user wants to take, the program will only allow the answer to be typed within the middle of the question. Since no answer is provided in the space the program is expecting an answer, the program will either continue to ask the same question or completely shut itself down. A screenshot of where the program gets stuck is below; the white circle indicates where the program allows you to type a response.

The program was installed on two separate computers; on both computer desktops, on both of the local C: drives, and on one network drive with the same result each time.

The CAR Press website states that the program is an all windows version using an SO platform that was updated on September 14, 2006; however the unzipped program files indicates the last update was in 1994. The instructions for uploading the program refer to use of the floppy diskette; some of the steps outlined for successful upload are no longer applicable

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with current computer technology. It is unclear if there is a bug in the program, if the program was not uploaded properly due to the outdated instructions, or if the program (written in the 1980's) is incompatible with current computer technology. Therefore, additional models were investigated for use in point source dispersion modeling.

REARMED/RESEARCHERS The REARMED system is the model preferred by EPA and CT DEEP in estimating pollutant concentrations for regulatory uses. It is available for download from the EPA Support Center for Regulatory Atmospheric Modeling (SCRAM) website. The REARMED system is extremely complex; it involves several preprocessors including REAMER for meteorological data, REMAP for terrain that incorporates USGS digital elevation data, RESURFACE for surface characteristics, and PRIME for incorporating the effects of multi-building facilities. Since the program cannot currently calculate design values for lead, the program also has a post-processing tool, LEADER'S, which can be used to calculate design values from the REARMED output.

The users guide and users guide addendum's for each of these modeling programs are hundreds of pages each; and each individual program requires that the user understand the inputs/outputs for successful implementation of REARMED.

Due to the complexity of REARMED, the EPA recommends that screening models are used prior to REARMED. If a user can demonstrate compliance using the worst-case screening scenario, the complex REARMED model does not need to be used. The RESEARCHERS model is the screening version of

REARMED. To operate RESEARCHERS, a user needs to have the latest REARMED executable download as well as the REMAP terrain preprocessor and PRIME executable. The model will produce worst-case 1-hour average concentrations from a single source without the need for hourly meteorological data input.

It is intended to produce concentration estimates that are CEQ or greater than REARMED, but the 'conservative' aspect of the program will vary on a case-by-case basis. The EPA provides several test cases for operating the RESEARCHERS model, including test cases for area sources, circle sources, flare sources, point sources, point sources with a cap, horizontal point sources, and volume resources. The point source test case is extremely easy to operate; however the intent of the test case appears to be assisting new users with operating models within a DOS window. The test case does not demonstrate how the preprocessors (such as REMAP) are incorporated into the program. Therefore, although familiarity with operating RESEARCHERS was developed, a full understanding of how the program should be used was not gained.

Therefore, the SCREENS modeling program (recommended by the state of CT as a screening program) was used researched for use as a screening level model.

SCREENS The SCREENS model was successfully run; examples of a successful run for particulate matter from a wood burning stove are attached in Appendix A. This model is recommended for screening level assessments by the CT DEEP in the Ambient Impact Analysis Guidelines published in July

2009 and is available for download on the EPA SCRAM website. The program can be used to estimate ambient impacts from point, area, volume, and flares to a distance of 50 kilometers. For point sources, the program requires the following inputs: Emission rate (g/s) Stack height (m) Stack inside diameter (m) Gas exit velocity (m/s)

Gas temperature (K) Ambient temperature (K) Receptor height (ground level or flagpole, in m) urban/rural terrain Worst-case building dimensions (if building downward is applicable). The receptor needs to be selected at both horizontal and vertical distances from the source being analyzed.

The model may need to be run multiple times for receptors in different directions from the original point source. In addition, if the model shows that concentrations are still increasing at the specified receptor area, the receptor area needs to be increased until a decrease in pollutant emissions are observed. The SCREENS model is an interactive model, with self-explanatory prompts.

The program has the ability incorporate building downward effects, estimate concentrations in the cavity recirculation zone, estimate concentrations due to shoreline fumigation, analyze dispersion over both flat and complex terrain, and determine plume rise from flare releases. Worst-case meteorological conditions are built in to the program; the user does not need to look up worst case scenarios for different downwind distances.

The effective stack height is automatically calculated by the program as well. The SCREENS model is specifically for one point-source, it can not model the

maximum concentration that can result from multiple sources. The model can also estimate maximum 1-hour concentrations; it cannot model longer period averages. Models specifically for longer averaging periods are recommended for 24-hour or seasonal/ annual averaging periods.