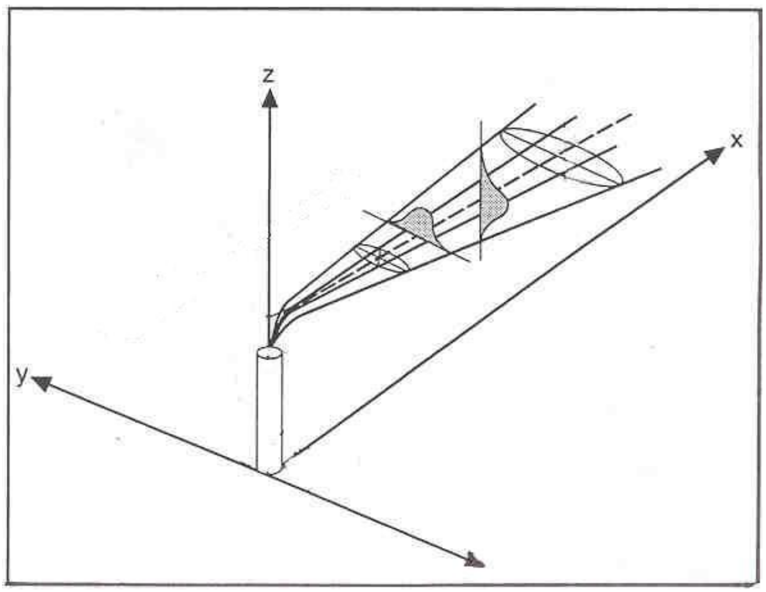
AIR QUALITY DISPERSION MODELING
FACT SHEET

Introduction

Air quality dispersion modeling is a tool that is used to relate the release of air pollutants to the corresponding pollutant concentrations in the ambient atmosphere. Models are useful to study the consequences of new sources of air pollution or changing the amount of pollutants released into the air from existing emission sources. Pre-construction permitting under the Clean Air Act often requires the use of models to estimate the air quality impact from proposed new and modified sources. Other applications involve assessing present air quality, defining cost-effective emissions reduction strategies and analyzing the effects of potential and actual accidental releases of air toxics.

What is air dispersion modeling?



A dispersion model is a set of mathematical equations that simulates the release and dispersion of air pollutants in the atmosphere. These models are typically computer based and are routinely used by scientists and engineers to assess ambient air concentrations. They incorporate the effects of physical and chemical processes through mathematical expressions derived from fundamental scientific principles.

Historically, the most frequently used dispersion models have been based on the Gaussian (or normal) distribution where the air contaminant concentration profile through the plume has the shape of the normal bell curve in both the vertical and lateral direction. New models use non-Gaussian vertical distributions. The concentration is the greatest at the plume centerline and decreases with distance away from the centerline. The rate at which the plume spreads as it travels downwind is a function of atmospheric turbulence. Gaussian models have long been the "workhorse" for dispersion calculations and are routinely used to support the permitting of air pollutant emission sources. The results of Gaussian models generally agree with experimental data and have undergone extensive validation.

As with any model, the accuracy of the model results is dependent upon the quality of the input data.

Air quality models are applied at different levels of sophistication. A first cut or screening level involves the application of relatively simple techniques that provide estimates likely to overstate actual values. Screening models generally use preset, worst-case meteorological conditions and allow for the inclusion of simplifying assumptions that do not require the level of detail that would be involved in a more rigorous analysis. The purpose of conducting a screening level analysis is to eliminate the need for any further analysis for those sources that do not have the potential to cause an air quality concern. Also, a screening analysis can help identify operating scenarios that may produce maximum impacts or locate areas of maximum pollutant concentrations. If the screening analysis cannot dismiss the potential for an air quality impact of concern, a more rigorous or refined analysis is conducted. A refined analysis consists of analytical techniques that provide more detailed treatment of atmospheric processes. Refined analyses require more detailed input data and results in better estimates of pollutant concentrations. In practice, an air quality modeling analysis often involves the use of screening techniques followed, if necessary, by a more refined analysis.

What kind of information do air dispersion models require?

Air dispersion models require input data in three main categories: meteorological conditions, source/emission parameters, and land use/terrain information. Specific requirements vary by source type and the model to be used. Some of the basic models input data include:

- Meteorological data is used by the model to help simulate plume transport and dispersion. Data quantifying the wind direction and speed, ambient temperature, mixing height and atmospheric stability are used as input to the model. Meteorological data recorded hourly by nearby representative National Weather Service stations are often used as input to refined models. Use of actual meteorological data recorded at representative locations can be used to predict both short and long-term concentrations. Screening models often utilize combinations of stability classes and wind speeds to identify the worst-case meteorological conditions, i.e., the combination of wind speed and stability that results in maximum predicted ground level concentrations. Screening models typically estimate hourly pollutant concentrations that can be scaled to longer averaging times using empirically derived ratios.

- Source/emission parameters define how the emissions are released into the atmosphere. For example, for pollutants that are vented from stacks, emission information needed by models include the temperature and velocity of the gases exiting the stack, height and diameter of the stack, and emission rates of the pollutants to be addressed. Models also require dimensions of adjacent building structures if estimating pollutant concentrations due to downwash (entrainment of pollutants into building wakes and cavities).

- Land use information and terrain elevations are also important input parameters in the dispersion modeling analysis. The rate at which a plume disperses and eventually reaches ground level is affected by the degree of urbanization of the surrounding area. Generally, greater plume dispersion is found in urban environments due to enhanced mechanical and thermal turbulence. Land use within the vicinity of the facility is used to determine whether the area should be viewed as urban or rural. Additionally, terrain information is input to the model. This data is used to establish the base elevation of on site structures including buildings and the stack. It is also used to establish the elevation of receptors where pollutant concentrations are to be predicted.

How are air quality models used?

Models are typically used to predict future pollutant concentrations from new sources or sources that are undergoing modification. Regulators will use modeling results to insure predicted ground-level pollutant concentrations meet ambient standards and thresholds established to protect human health and welfare. Modeling can be a useful tool to evaluate the effectiveness of implementing emission control strategies. Modeling is also used to help locate monitors that measure actual air pollution levels in the lower atmosphere. Finally, modeling can be used to analyze actual or potential accidents that release contaminants to the atmosphere.

What pollutants are typically modeled?

Models can be used for evaluating the dispersion of a wide variety of air pollutants. The chemical and physical properties of a pollutant and how the pollutant is actually released into the atmosphere are important considerations when selecting the most appropriate model. For example, hot exhaust gases released from a stack would be buoyant and be subject to plume rise whereas a cold, heavier-than-air pollutant release would behave as a dense gas. Determining the concentration of ozone, the deposition of acid rain or the impairment to visibility requires specialized models due to the way pollutants are transformed once emitted into the atmosphere. Pollutants that are highly toxic and have the potential to be emitted in large quantities in the event of an industrial accident (e.g. tank failure) can be modeled using accidental release models. These are special models designed to predict short-term pollutant concentrations resulting in a sudden release of a large quantity of a toxic chemical. Accidental release models usually form the basis of an emergency response plan and can be used to help identify affected population and establish evacuation routes in the event of an emergency.

Current regulatory models

A versatile screening model called SCREEN3 is often used to make preliminary concentration estimates. For a more refined analysis, the Industrial Source Complex (ISC) model has been the "workhorse" for regulatory applications for the past 20 years. When complex terrain is an issue (i.e., terrain elevations higher than stack top), the Complex Terrain Diffusion Model Plus Algorithms for Unstable Situations (CTDMPLUS) is the prefered model. Additionally, CTSCREEN, a screening version of CTDMPLUS that does not require site-specific meteorological data can also be used. A new model called AERMOD has been proposed by EPA as a preferred model for most regulatory applications and will replace ISC. AERMOD is an enhanced Gaussian plume dispersion model based on an up-to-date characterization of the atmospheric boundary layer. It is applicable in all types of terrain at distances out to 50 km. Another new model, CALPUFF, is the preferred model for assessing long-range transport of pollutants and is used to predict impacts to areas beyond 50 km. Numerous alternative models have also been developed over the years. It is up to the project modelers to select the most appropriate application based on project resources and needs.

Additional sources of information

The United States Environmental Protection Agency (EPA) maintains a Web site called the Support Center for Regulatory Air Models (SCRAM) at www.epa.gov/ttn/scram. This Web site is a source of information on atmospheric dispersion models that support regulatory programs required by the Clean Air Act. Documentation and guidance for these computerized models are a major feature of this website. Another resource is EPA's Guideline on Air Quality Models (40 CFR Part 51 Appendix W). The "Guideline" recommends air quality modeling techniques for regulatory application and is available on EPA's SCRAM Web site. State regulatory agencies provide excellent resources for dispersion modeling. Finally, the A&WMA (www.awma.org) offers short courses in dispersion modeling and its applications.

Air & Waste Management Association
A&WMA Air Quality Dispersion Modeling Fact Sheet

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