Air Dispersion Models: Tools to Assess Impacts from Pollution Sources

James A. Westbrook

Complicated processes occurring in nature can be described using mathematical models. When a pollution source emits a chemical into the atmosphere at an initial concentration (mass per unit volume of air), the chemical does not remain at that initial concentration. Atmospheric processes act to disperse the emissions downwind into less concentrated form. Simply stated, air dispersion models are computer tools that use mathematical equations to describe the dispersion process. By knowing the initial chemical release characteristics, one can use a dispersion model to predict chemical air concentrations at selected downwind receptor locations.

Dispersion models play an important role in United States air quality regulatory policy, as implemented by the U.S. Environmental Protection Agency (EPA), and state and local agencies. The Clean Air Act, 42 U.S.C. §§ 7401 *et seq.*, and regulations promulgated thereunder have established standards to protect public health or environmental assets from potentially harmful air pollution impacts. These standards are air concentration-based or health risk-based. Pollution sources can use dispersion models to show that emission impacts will remain below applicable regulatory standards. Clearly, dispersion model development and application has been largely driven by air quality regulations.

Regulatory model applications balance political/regulatory goals with dispersion science. As discussed below, conservative regulatory-approved models merely approximate real-world conditions and do so with a large degree of inaccuracy and uncertainty. Regulatory agencies, however, wish to promote consistency and fairness within the regulatory review process. Thus, dispersion modeling results can be "wrong," as long as everyone consistently uses the same modeling tools and methods to get similar wrong results. This is why years of testing and review may pass before a new, technically "better" dispersion model receives official regulatory status from EPA. EPA wants to ensure that regulatory model output errs on the side of being health protective (overstating actual impacts) and that the models can be consistently applied in regulatory programs.

Air Dispersion Modeling Applications in Regulatory Compliance Programs

Air dispersion modeling has come far since initial model development in the early twentieth century. At that time, air emissions from industrial and mobile sources were substantially unregulated and the dispersion process was not well understood. By the 1950s, scientists were examining the dispersion process to predict atomic bomb fallout. In the 1960s and 1970s, two pioneer scientists, F. Pasquill and F.A. Gifford, developed basic dispersion curves that could be employed in modeling. Another scientist, G.A. Briggs developed equations to describe emissions plume behavior. Computer resources were limited; dispersion modeling calculations would often be completed manually or using relatively crude computer code. In contrast, today's powerful personal computers can perform modeling runs in minutes that took early computers days to complete.

Recognizing the need to protect public health, Congress in 1963 passed the Clean Air Act. In that original legislation and in major amendments in 1970, 1976 and 1990, National Ambient Air Quality Standards (NAAQS) for criteria pollutants were established and NAAQS protection programs implemented. Criteria pollutants include: ozone and the precursors to ozone formation (volatile organic compounds and nitrogen oxides), particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, and several others. To regulate pollution sources and ensure compliance with NAAQS, EPA needed a reliable method to predict air pollution impacts. The impact of emissions on criteria air pollutant concentrations could be obtained directly using ambient air monitoring equipment, or predicted using dispersion models. Dispersion modeling has several advantages over monitoring. Monitoring cannot be used to assess impacts from sources that do not exist. The dispersion modeler has planning flexibility, in that, multiple "what-if" scenarios can be completed. Maximum pollution impacts for various averaging times under worst-case meteorological conditions can be predicted. Modeling can be much more cost effective than monitoring, requiring fewer resources (e.g., time, money) to complete a study. Thus, dispersion modeling has become a preferred tool for ensuring regulatory compliance under the Clean Air Act.

Dispersion models have several regulatory applica-

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tions. Models are frequently used to assess criteria pollutant impacts prior to obtaining permits for new or modified emissions sources. The National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321 *et seq.*, requires analysis of air quality impacts from federally regulated construction, industrial, and mobile source emissions. Dispersion models can be used for this purpose. For Risk Management Plans under Clean Air Act § 112(r), 42 U.S.C. § 7412(r), dispersion models can be used to simulate worst–case impacts from potential accidental chemical releases.

Various regulatory programs employ air dispersion models to assess human exposure to toxic compounds for health risk assessments. Many states require air permit applicants to show compliance with conservative health-based air toxic concentration thresholds. Some states have public disclosure laws requiring certain facilities to conduct exposure assessments. For example, California has the AB2588 Air Toxic "Hot Spots" program. CAL. HEALTH & SAFETY CODE §§ 44300 *et seq.* Under CERCLA, 42 U.S.C. §§ 9601 *et seq.*, and RCRA, 42 U.S.C. §§ 6901 *et seq.*, programs, persons conducting waste remediation or treatment activities often have to address on-site and off-site impacts from chemicals released into the air. EPA will be required to consider residual health risks following promulgation and implementation of Clean Air Act § 112(d), 42 U.S.C. § 7412(d), Maximum Achievable Control Technology (MACT) requirements for industrial categories. EPA will likely rely upon dispersion models to complete that residual risk assessment.

The federal Prevention of Significant Deterioration (PSD) program provides an important example of dispersion modeling's application to air permitting. Clean Air Act subch. I, pt. C, 42 U.S.C. §§ 7470–7492, 40 C.F.R. pt. 52.21. The PSD program's purpose is to allow industrial growth while maintaining existing air quality in areas that already meet NAAQS. These pollution standards "attainment" areas are classified based upon the additional increment of industrial growth and corresponding air pollution allowed. Class I areas, such as pristine national parks, have special recreational or scenic value, and so deserve the greatest air quality protection. Class II areas are attainment regions within which most industrial facilities are located. Class III areas can be assigned based upon special industrial growth needs. Regardless of an area's class, new or modified "major" sources that will emit significant amounts of specific criteria pollutants are required to apply for a PSD air permit. 40 C.F.R. pt. 52.21(i).

PSD applicants may be required to conduct two separate dispersion modeling analyses: a significance impact analysis and a full impact analysis. By completing the significance modeling analysis, the permit applicant determines if impacts from just the criteria pollutant emissions increases warrant a full modeling impact analysis. For example, for particulate matter with an aerometric diameter less than 10 microns (PM_{10}) a significant impact is a modeled twenty-four-hour average concentration greater than 5 micrograms/cubic meter ($\mu g/m^3$), or an annual average concentration greater than 1 $\mu g/m^3$. 40 C.F.R. pt. 51.165(b)(2).

The full impact analysis consists of a NAAQS analysis and an increment consumption analysis and is required only if modeled impacts of PSD pollutants exceed certain significance thresholds. For the full impact NAAQS analysis, the PSD applicant must show, using a dispersion model, that both facility existing and proposed air emissions will not cause or contribute to a NAAQS exceedance. The analysis focuses on locations within the facility's significant impact area (SIA), where facility emissions, emissions from other nearby facilities, and natural or distant anthropogenic emissions sources (represented by monitoring data) combine to result in maximum predicted air concentrations. 40 C.F.R. pt. 51, app. W. The combined PM_{10} impacts cannot exceed a 50 $\mu g/m^3$ twenty-four-hour average concentration or a 150 $\mu g/m^3$ annual average concentration.

For the PSD increment analysis, the permit applicant must show through dispersion modeling that emissions increases from new or modified sources will not consume more than the available concentration increment. This analysis is performed separately for Class I and Class II areas. For example, the maximum available PSD increment for PM_{10} on a twenty-four-hour basis is 30 $\mu g/m^3$ in Class II areas and 8 $\mu g/m^3$ in Class I areas. 40 C.F.R. pt. 52.21(c). Since other facilities in an area may already consume PSD increment, the maximum amount may not always be available.

In California, companies emitting suspected carcinogens and other toxic compounds may be required to assess compliance with the Safe Drinking Water and Toxic Enforcement Act of 1986, or Proposition 65. Proposition 65 requires that a business provide clear and reasonable warning before knowingly and intentionally exposing any person to a significant level (concentration or dose) of a listed chemical. CAL. HEALTH & SAFETY CODE § 25249.6. In cases where listed chemicals expose off-site persons in the community, dispersion modeling can be used to predict exposure.

Proposition 65 is enforced primarily through citizen lawsuits, not government agency oversight. Businesses can avoid having to give a warning if they complete an exposure assessment supporting a conclusion that the exposure does not give rise to significant risk. 22 CAL. CODE REGS. § 12701(b)(1). The assumptions in the exposure assessment must meet standards of comparable scientific validity. 22 CAL. CODE REGS. 12701(a). Thus, plaintiffs and defendants in Proposition 65 lawsuits frequently battle over the appropriateness of dispersion model input data assumptions. In contrast, exposure assessments performed for new source permitting often follow more prescribed strict standards and guidance. As to compliance, companies emitting Proposition 65-listed chemicals must decide whether to conduct exposure modeling proactively to support a conclusion of no significant risk or meet the warning requirements.

Air Dispersion Modeling Concepts

Technically speaking, air dispersion models accomplish two principal objectives: (1) simulate the downwind dispersion process and (2) simulate an emission plume's movement and behavior. Although different types of models exist to accomplish these objectives, Gaussian models are widely used for regulatory purposes. A Gaussian model disperses emissions in the horizontal and vertical planes using Gaussian (bell-shaped or normalized) pollutant concentration distributions. A plume's shape over time depends largely upon the wind speed and the atmosphere's tendency to become well mixed or unstable. When the atmosphere is unstable, a plume spreads out and disperses more quickly than when the atmosphere is stable.

For different stability conditions, the typical Gaussian model uses standard dispersion parameters (such as Pasquill-Gifford coefficients) that describe concentration deviations about a plume's centerline. Pasquill-Gifford coefficients were developed from research on dispersion over a five- to fifteen-minute averaging period on grassy, relatively flat terrain. RUSSELL E. ERBES, A PRACTICAL GUIDE TO AIR QUALITY COMPLIANCE (2d ed. 1996). Commonly used Gaussian models have a special constraint—plume direction remains constant in any given direction for at least one hour, the minimum averaging time. Incidentally, the one-hour averaging time is much greater than the averaging period used to develop Pasquill-Gifford coefficients, which can lead to model overprediction of air concentrations.

In addition to dispersion parameters, the magnitude of model-predicted ground-level concentrations depends upon the effective plume centerline height. Effective plume height is the source release height plus plume rise due to gas momentum from mechanical air forcing, or from heated gas buoyancy. Figure 1 below depicts a typical Gaussian plume.

Plume movement and behavior are influenced by local meteorology, building downwash and terrain. Meteorology is the most important factor. Meteorological parameters used in dispersion models include wind direction, wind speed, ambient temperature, atmosphere mixing height, and various stability parameters. As mentioned previously, wind speed and stability parameters help determine the modeled shape of a plume. Wind direction dictates the direction of the plume for a given hour. Ambient temperature is used to calculate buoyancy plume rise.

Stack emission sources on buildings can be affected by building downwash, as depicted in Figure 2. Air flowing up and over structures tends to direct these emissions closer to the ground than if the structures did not exist. As a result, ground-level concentrations downwind can increase, hence the term "building downwash." Dispersion models address building downwash by adjusting initial plume spreading and rise for downwash effects. Plume behavior can also be affected by interaction with mountainous or complex terrain. Complex terrain is any terrain located above final emissions plume height during a given hour. Plume impaction on terrain can be a special compliance problem for emission sources located in valleys or near mountains.

Due to the diverse factors that can affect plume behavior, a proliferation of air dispersion models has sprung up. Special models exist to address plume movement in valleys, around mountains, over water, and near shorelines. Other models address short-term impacts for chemicals in different physical states. These models are used to complete dispersion modeling for accidental chemical spills. Separate models that calculate chemical concentrations due to sources emitting into the lee side, or cavity recirculation region, of structures also exist. The list of regulatory-approved models is extensive. 40 C.F.R. pt 51, app. W.

Dispersion models require specific information to run, including emission rates, source release parameters (source location, stack height, stack diameter, and the like), building parameters, receptor location information, terrain height data, meteorological data, and other model-specific options. Source release parameter selection depends upon the source configuration selected. Point sources, volume sources, area sources, and open pits are typical source configurations. Real-

Figure 1

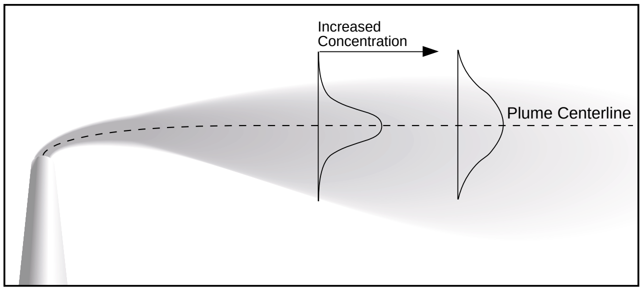
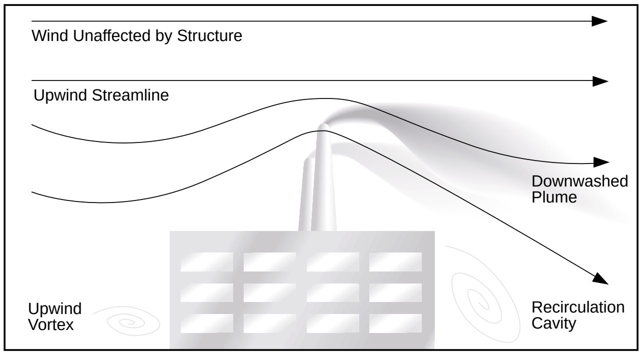


Figure 2



world examples of these source configurations would be emissions released from stacks, a building with open windows, a waste lagoon, and a sand quarry, respectively. Table 1, on page 550, lists key model inputs.

Within the last ten to fifteen years, two Gaussian dispersion models, SCREEN3 and the Industrial Source Complex (ISC3) model have become regulatory "workhorses." These models have been consistently applied in regulatory programs. SCREEN3 is a conservative screening model. EPA recommends using a screening model as an overpredictive first modeling cut. Users can provide site-specific source information with model-provided meteorological parameters to predict maximum one-hour average concentrations in a single direction from a single source. Air concentrations for other averaging periods (e.g., eight hours, twenty-four hours) can be estimated using meteorological persistence factors, as described in EPA's *Screening Procedures for Estimating the Air Quality Impacts of Stationary Sources, Revised.* EPA-454/R-92-019. Limited data input requirements make SCREEN3 relatively easy to use when a modeler's goal is to quickly and simply show that air pollution impacts are not significant. However, a modeler may opt not to use SCREEN3 when conservative model results indicate possible noncompliance with air quality rules.

ISC3 is a "refined" model that can be used if SCREEN3 results indicate air quality impacts greater than regulatory thresholds. Multiple source and receptor networks with site-specific hourly input meteorological data are possible in ISC3. ISC3 generally provides greater modeling flexibility and lower air concentration estimates than SCREEN3. In turn, the more extensive data input requirements of ISC3 mean more effort is required to complete a dispersion modeling study. For a complete description of SCREEN3 and ISC3 model options, the reader is referred to *SCREEN3 Model User's Guide,* EPA-454/B-95-004, and *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models,* EPA 454/B-95-003a.

Recommended Steps to Complete a Regulatory Dispersion Modeling Study

Assuming a regulatory agency will review the modeling study, the modeler should complete the study in stepwise fashion. Good planning is essential. Prior to proposing a dispersion modeling study to a regulatory agency, the modeler should complete dispersion modeling feasibility studies (what-if scenarios) to assess potential compliance with applicable rules. A regulatory dispersion modeling study should generally follow four basic steps:

1. Understand the Regulatory and Technical Requirements. Review the regulations to select appropriate dispersion modeling tools and to understand how those tools should be applied. Usually, the goal will be to show that air quality impacts will not exceed regulatory thresholds. Thresholds differ for individual chemicals. For example, the sulfur dioxide NAAQS is about 2.4 times higher than the PM_{10} NAAQS over the same averaging period. However, the way the standard is applied (the "design concentration") differs for the two chemicals. As a potential carcinogen, hexavalent chromium is approximately 5,000 times more toxic than benzene through inhalation. CAPCOA 1993. This means that very little hexavalent chromium can cause significant compliance issues.

It is important to know where to obtain good modeling guidance. The first place to look is the *Guideline on Air Quality Models* found at 40 C.F.R. pt. 51, app. W. Meteorological data processing requirements can be found in *On-Site Meteorological Guidance for Regulatory Modeling Applications,* EPA 450/4-87-013. The Clean Air Act PSD regulations provide little guidance on actual steps to complete the significance impact and full impact dispersion modeling studies. PSD applicants can follow the modeling steps provided in the draft, *New Source Review Workshop Manual* (EPA 1990). Texas, Ohio, the South Coast Air Quality Management District, and several other state and local agencies also have separate modeling guidance documents. Specific modeling guidance does not exist for Proposition 65 exposure analyses, but most Proposition 65 analyses follow standard EPA and/or California modeling guidance.

2. Assemble Model Input Data. Required input data must be assembled to complete a modeling study. ISC3 requires emissions data, source release parameters and location information, building parameters (stacks only), meteorological data, receptor location, and terrain height data. If possible, visually review the modeling domain. Source and receptor locations can be obtained from facility plot plans, topographical maps, aerial photographs, or using Global Positioning System receivers. Terrain elevation data are commonly obtained from topographical maps or Digital Elevation Model (DEM) data. To obtain building downwash parameters, structure corner coordinates must be obtained and a special preprocessor called BPIP must be run. Substantial meteorological processing may be necessary, especially if unprocessed on-site meteorological tower data are used. Other model options must be selected, such as rural or urban topography. For risk assessments, special population information must be obtained. Aerial photographs are especially helpful for identifying exposed populations.

It is important to select input parameters such that modeled conditions represent actual conditions as closely as possible. ERBES, A PRACTICAL GUIDE TO AIR QUALITY COMPLIANCE. Understanding the technical workings of the models can help in this process. It is also best to know early on what factors control air quality impacts, and which input data parameters can be changed. This information can be used at Step 4, to mitigate air quality impacts above regulatory thresholds.

3. Develop a Modeling Protocol. Final dispersion modeling should not begin until a modeling protocol is written and approved by the state or local regulatory agency. The protocol can be brief. Spending time up front to get agency approval on the proposed study will save time repeating the study later in response to unexpected comments. The agency will need to review the following: the study purpose, a project/facility description, model selection, list of model input parameters and options, receptor grids and locations, background concentration data (if applicable), and discussion of any other pertinent modeling options and issues. State and local agencies have discretion to approve modeling protocols; however, the agencies usually defer tough model application questions to the EPA Model Clearinghouse.

4. Interpret Model Output. After preliminary modeling has been completed following the approved protocol, model output should be interpreted. It is very easy to make errors entering model input data. Check the output for reasonableness and accuracy. Major headaches will ensue if a modeling study containing data input errors is submitted to the agency.

If the checked modeling results are less than regulatory thresholds, the modeling study is completed. If modeling results exceed regulatory thresholds, further dispersion modeling will likely be needed. Relatively high modeled impacts relate directly to model inputs assumed. The most common reasons for high modeled impacts are: high emissions, low release height relative to the ground, low or zero gas exit velocity, unfavor-

Table 1. How Selected Dispersion Model Inputs Influence Impacts

Model Input	**How Used in Model**	**Influence on Modeled Impacts**
Source Configuration		
Point Sources	Point source release parameters required to represent plume behavior	Point source releases have greater plume rise from gas momentum and bouyancy, but lower plume rise from stack tip and building downwash. Plumes from point sources can impinge on terrain.
Fugitive Sources (Volume/Area)	Volume or area source release parameters required to represent plume behavior	Fugitive sources do not have building downwash impacts and plume impingement. Agencies may allow point sources with negligible gas momentum to be modeled as volume sources.
Tilted, Horizontal, or Capped Stacks	Portion or all of vertical gas momentum eliminated, lowering plume rise	Agencies may require lowering gas exit velocity for tilted stacks and eliminating it for horizontal/capped stacks. Turning a stack vertical or removing a rain cap will lower modeled impacts.
Area and Volume Sources—Initial Source Size	Indicates over what volume or area emissions are spread	A larger, justified volume or area source size will result in lowered impacts, unless the source is moved too close to a nearby receptor.
Source Release Parameters		
Emission Rate	Initial chemical mass loading	Reducing the emission rate reduces impacts at a one-to-one ratio.
Stack Height Above Ground	Initial plume rise height above ground	Lower stack heights mean greater impacts; raising stacks is usually the simplest way to reduce impacts.
Stack Gas Flow Rate	Momentum plume rise	If momentum plume rise dominates (often the case), increase flow rate with constant stack diameter (increasing gas momentum) to reduce impacts.
Stack Gas Temperature	Buoyancy plume rise	If buoyancy plume rise dominates, raising gas temperature may lead to lower impacts; usually the effect will be minimal.
Stack Diameter	Plume rise equations	Stack diameter and gas momentum are related, reduce stack diameter with constant flow rate (increasing gas momentum) to reduce impacts (keeping in mind contraints on pressure head).
Receptor Data		
Receptor Location	Downwind distance over which dispersion occurs	Moving a source further from a receptor in similar terrain will reduce modeled impacts.
Receptor Grid Spacing	Grid density for modeled concentration output	Agencies usually specify minimum grid spacing required to locate maximum impacts. The reported maximum impact can be sensitive to the grid resolution and reference point (origin point).
Receptor Terrain Heights	Receptor height moved closer to plume centerline (highest concentrations)	Less conservative screening or refined complex terrain models can be selected that may reduce impacts in terrain.
Meteorological Data		
“Meteorological Data (wind direction, wind speed, temperature, stability parameters, mixing height)	These parameters influence plume behavior, including the region of maximum impacts, and rate of plume dispersion downwind.	Higher modeled impacts usually occur with: (1) stable atmoshpere, light wind speeds, and persistent wind directions, and (2) unstable atmosphere and high winds with building downwash effects.
Urban/Rural Coefficients	Describe appropriate dispersion coefficients for the topography	Where justified, urban coefficients are associated with more atmospheric mixing and tend to reduce modeled impacts.

Note: The effect of changing model inputs will vary on a case-by-case basis. Check with the regulatory agency for guidance on choosing model inputs.

able source configurations, emissions release during stable atmospheric conditions; severe building downwash effects, plume impaction on complex terrain, incorrect target receptor locations; close receptor proximity, and data input errors. Table 1 lists dispersion model input parameters and their potential sensitivity in controlling modeling outcome.

By varying input parameters, a dispersion modeler may be able to mitigate high impacts and show compliance. If not, nondispersion modeling strategies, such as applying additional emissions controls, may need to be considered. Controlling emissions is a straightforward way to reduce modeled impacts at a one-to-one ratio but is often the last resort. This is because emission levels relate directly to operational flexibility and because control equipment can be expensive. Thus, a preferred method to mitigate impacts is to propose alternate source release parameters (see Table 1). Elevating sources can be the easiest way to reduce modeled impacts. EPA has set a cutoff for creditable stack height increases to the maximum height above stack base where building downwash occurs (using standard formulas), or 65 meters, whichever is greater. 40 C.F.R. pt. 51.100(ii). This Good Engineering Practice (GEP) limitation keeps sources from raising stacks arbitrarily to dilute emissions.

Regulatory dispersion models are designed to be conservative (i.e., to overpredict air concentrations). Thus, regulatory agencies can be assured that modeling output will err on the side of being health protective. Since regulatory compliance under most state air toxics programs are tied to fixed concentration ceilings, regulations usually require precise model results without regard to model inaccuracy. The standard Gaussian representation of plume behavior and dispersion comes with several assumptions and constraints. Uncertainty exists in each fundamental component of dispersion models in the following areas: plume rise equations; Pasquill-Gifford dispersion coefficients derived under a limited, potentially nonrepresentative set of conditions; Gaussian curves used to represent only vertical and crosswind, not downwind dispersion; and building downwash equations that idealistically represent complex flows around structures. As described in *Error Propagation in Air Dispersion Modeling,* by Milton R. Beychok, www.air-dispersion.com/feature.html, any combination of these and other error sources could lead to modeled concentrations more than a factor of 10 greater than actual conditions.

Future Air Dispersion Modeling Developments

Air dispersion modeling will continue to evolve due to advances in model development, improved computer resources, and changing environmental regulations. Researchers and model developers will continue to search for ways to simulate the dispersion process with more certainty. Greater certainty could, in time, lead USEPA to relax model conservatism.

The next-generation refined dispersion model, AERMOD, will upgrade and replace ISC3. AERMOD development has been led by a group of scientists, the American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC). Starting from existing ISC3 computer code, AERMOD incorporates significant technical improvements over ISC3. The improvements include better dispersion and plume rise simulation within the well-mixed atmosphere near the earth’s surface, and better terrain handling procedures. To take full advantage of the improved features, more detailed meteorological data must be input than was previously required. AERMOD has been undergoing years of regulatory review and testing but should become the new regulatory workhorse by 2000. Computer resources will also continue to improve, keeping in step with model developments.

The Internet has become a powerful tool for disseminating regulatory models and guidance. Information on models can be obtained more quickly than in the past. New graphical user interfaces have already begun and will continue to make input data entry and analysis more user friendly. However, model user friendliness comes with the potential danger that model users will not take the time to understand how model inputs affect model outputs. The old saying rings true in dispersion modeling: “garbage in, garbage out.”

Changes in air quality regulations will also change model application methods. For example, EPA recently promulgated a new PM$_{2.5}$ NAAQS. Now, particulate matter sources must show compliance not only with the PM$_{10}$ NAAQS but also with the lower PM$_{2.5}$ NAAQS values. This may become a major compliance issue for many sources, including combustion sources that emit most particulate matter in the lower size ranges.

How will upcoming changes in modeling tools and regulations affect regulated entities? The answer must be considered on a case-by-case basis. Greater realism could mean either higher- or lower-calculated air quality impacts. Regulatory dispersion models may continue to become more accurate and less conservative. However, regulators should exercise caution to ensure that existing political/regulatory goals can still be met using new modeling tools, to balance clean air and health protection with economic viability. Persons who rely on air dispersion modeling to assess regulatory compliance with strict standards should monitor these developments closely. Environmental managers looking at upcoming major projects that cause air emissions may want to complete feasibility studies updating past modeling studies using new models and modeling guidance. Regardless of what impact future developments will have, air dispersion modeling will doubtless continue to be an important regulatory tool to assess impacts from air pollution sources.