ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 51, 52, 260 and 266

[AH-FRL-4672-7, Docket No. A-88-04]

Requirements for Preparation, Adoption, and Submittal of Implementation Plans

AGENCY: U.S. Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: The "Guideline on Air Quality Models (Revised)" (hereinafter, the "Guideline"), as modified by supplement A (1987), sets forth air quality models and guidance for estimating ambient air concentrations due to sources of air pollutants. The Guideline is presently incorporated by reference into the prevention of significant deterioration (PSD) regulations under the Clean Air Act. On February 13, 1991, EPA issued a Notice of Proposed Rulemaking (NPR) to further clarify and update the Guideline, as well as to augment the Guideline with several new modeling techniques, and to codify the Guideline for all air quality planning purposes. Today EPA takes final action in order to add new models to the Guideline and improve existing models. In addition, this action amends the CFR to incorporate supplement B as codified text, as well as giving regulatory status to long-standing EPA policy regarding the use of air quality models for other regulatory programs. Therefore, EPA is setting out the Guideline, revised by supplements A and B, as appendix W to 40 CFR part 51. Adoption of these new and refined modeling techniques and associated guidance should significantly improve the technical basis for impact assessment of air pollution sources.

EFFECTIVE DATE: This rule is effective August 19, 1993.

FOR FURTHER INFORMATION CONTACT: Joseph A. Tikvart, Chief, Source Receptor Analysis Branch, Office of Air Quality Planning and Standards (MD-14), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711; Telephone (919) 541-5562 or C. Thomas Coulter, (919) 541-0832.

ADDRESSES: Docket Statement: All documents relevant to this rule have been placed in Docket No. A-88-04, located in the Central Docket Section, Room M1500 (First Floor, Waterside Mall), U.S. Environmental Protection Agency, 401 M Street SW., Washington, DC 20460. This docket is available for public inspection and copying from 8:30-12 a.m. and 1:30-3:30 p.m., Monday through Friday. A reasonable fee may be charged for copying.

Document Availability: The new modeling techniques are incorporated as supplement B (1993) to the Guideline. Supplement B may be obtained by downloading a text file from the SCRAM (Support Center for Regulatory Air Models) electronic bulletin board system by dialing in on (919) 541-5742. Supplement B may also be obtained upon written request from the Source Receptor Analysis Branch, U.S. Environmental Protection Agency (MD-14), Research Triangle Park, NC 27711. The "Guideline on Air Quality Models (Revised)" (1986), supplement A (1987), and supplement B (1993) are for sale from the U.S. Department of Commerce, Technical Information Service (NTIS), 5825 Port Royal Road, Springfield, VA 22161. These documents are also available for inspection at each of the ten EPA Regional Offices and at the EPA library at 401 M Street SW, Washington, DC.

SUPPLEMENTARY INFORMATION:

Background [1]

The "Guideline on Air Quality Models" (hereinafter, the "Guideline") was originally published in April 1978. The Guideline promotes consistency in the use of modeling as part of the air management process. By setting forth models, techniques and guidance, the Guideline provides model users with a common basis for estimating pollutant concentrations and impacts, assessing control strategies and specifying emission limits. By rulemaking in June 1978 (43 FR 26380), the Guideline was incorporated by reference into the PSD regulations at 40 CFR 51.166(l) and 52.21(l). The Guideline was subsequently revised in 1986 (51 FR 32176), and later updated with the addition of supplement A (53 FR 392).[2] As a matter of EPA policy, the Guideline has also been applied since its inception to SIP revisions for existing sources of air pollutants and to all new source reviews.

Between 1978 and 1988, in order to support the process of developing and revising the Guideline and in accordance with section 320 of the Clean Air Act, the First, Second, Third and Fourth Conferences on Air Quality Modeling were held. These modeling conferences provided EPA with comments on the Guideline and associated revisions, thereby facilitating introduction of improved modeling techniques into the regulatory process.[3]

On February 13, 1991 (*op. cit.*), EPA proposed additional changes to the Guideline referred to as supplement B. Pursuant to this proposal and Clean Air Act Section 320, the Fifth Conference on Air Quality Modeling was held in March 1991. Its purpose was to solicit public comment on new modeling techniques proposed for inclusion in supplement B, and to guide EPA's consideration of any rulemaking needed to further revise the Guideline. The revisions proposed in supplement B included techniques and guidance for situations where specific procedures had not previously been available, and also improved several previously adopted techniques. As discussed at the modeling conference, proposed changes included:

Complex terrain models (CTDMPLUS and CTSCREEN); Mobile source modeling at signalized intersections; Emissions and dispersion modeling system for airports; Modeling techniques for air pathway analyses;
On-site meteorological program guidance;
General screening techniques;
Method for evaluating models;
Alternate models in appendix B;
Supplementary changes; and
Other topics (including deletion of models no longer used).

For additional information of these issues, please refer to 56 FR 5900-5907, February 13, 1991.

Final Action

Today's action updates the Guideline with changes incorporating supplement B, slightly modified in form since proposal. All significant comments have been considered, and whenever they revealed any new information or suggested any alternative solutions, such were considered in EPA's final action. Also, in keeping with the Office of the Federal Register's current policy on compliance with the Federal Register Act (44 U.S.C. 1502 *et seq.*) and the Administrative Procedures Act (5 U.S.C. 551 *et seq.*), as set forth in 1 CFR part 51, EPA is setting out the Guideline,

[1] In reviewing this preamble, note the distinction between the terms "supplement" and "appendix". Supplements A and B contain the replacement pages to effect Guideline revisions; appendix A to the Guideline is the repository for preferred models, while appendix B is the repository for alternate models justified for use on a case-by-case basis.

[2] On February 21, 1991 the Guideline, as modified by supplement A, was incorporated into the hazardous waste boiler and industrial furnace rules at 40 CFR part 266, subpart H (56 FR 7208). The Guideline was subsequently published as appendix X to part 266 (56 FR 32796); this marked the first time the Guideline had been published for inclusion in the Code of Federal Regulations.

[3] On November 15, 1990, the Clean Air Act Amendments of 1990, Pub. L. 101-549, were enacted. As amended, the Clean Air Act provides continued authority for the air quality modeling conferences and associated revisions to the Guideline.

revised by supplements A and B, as appendix W to 40 CFR part 51. In a complementary action, EPA is hereby removing appendix X to 40 CFR part 266, and changing references to the Guideline in that part to 40 CFR part 51, appendix W. EPA is also updating a reference in § 260.11(a).

As proposed, EPA is adopting CTDMPLUS as a refined technique to be included in appendix A of the Guideline. However, requirements regarding measurement height for collection of meteorological data to run CTDMPLUS are being relaxed from those originally proposed: the maximum height is 100 meters, provided that remote sensing data (e.g., SODAR) up to representative plume height are available on a routine hourly basis. CTSCREEN is being adopted as an acceptable screening technique. The previously used screening model, RTDM, may continue to be used, but the hierarchy in terms of degree of conservatism for complex terrain screening models has been eliminated.

As proposed, a new model, CAL3QHC, is included in the Guideline for estimating carbon monoxide concentrations at signalized intersections. Use of CALINE4 and TEXIN2 may continue in areas where their application has already been established at the time supplement B is promulgated. In response to public comments, the "Guideline for Modeling Carbon Monoxide from Roadway Intersections" has been modified and expanded.

As proposed, EDMS (*E*missions and *D*ispersion *M*odeling *S*ystem) is being included in appendix A of the Guideline for assessing air pollutant concentrations at civilian airports and military bases.

As proposed, DEGADIS (*DEN*se *GA*s *DIS*persion Model) is being included in appendix B of the Guideline. The ISC2 (*I*ndustrial *S*ource *C*omplex) model is not being generally recommended for all air pathway analyses, as originally proposed; it is now being recommended for some specific regulatory programs.

The proposed Solar Radiation/Delta-T (SRDT) method for determining atmospheric stability class is being withdrawn from supplement B (see explanation under "Discussion of Public Comments and Issues").

As proposed, EPA has identified general screening techniques, namely SCREEN and VISCREEN, for preliminary estimates of air quality impact. Minor code changes have been made to SCREEN (renamed "SCREEN2") to ensure reasonable comparability with ISC2 (especially for downwash calculations). To better support VISCREEN, EPA is working with the National Park Service to improve information on background visual ranges and encourage research development of a regional haze model.

As proposed, EPA is including the "Protocol for Determining the Best Performing Model" as the basis for justifying use of an alternative (appendix B) model for a site-specific application.

As proposed, Shoreline Dispersion Model (sea/lake breeze fumigation) and WYNDvalley (valley stagnation) are being included in appendix B of the Guideline. These models, along with MESOPUFF II (long range transport) and PLUVUE II (visibility), which are already in appendix B, are identified as available for application in the unique circumstances to which they apply on a case-by-case basis.

EPA is making several supplementary changes to the Guideline. As proposed, ERTAQ and MPSDM have been deleted from appendix B of the Guideline. EPA has also clarified and updated portions of the Guideline to make it consistent with current regulatory programs that had been established through other Agency activities. As proposed, OCD (*O*ffshore and *C*oastal *D*ispersion Model) in appendix A of the Guideline is being updated. Also as proposed, EKMA and UAM (*U*rban *A*irshed *M*odel), which is also in appendix A, are being updated to include the CB-IV chemical mechanism and guidance.

Finally, supplement B clarifies the appropriate input data for various compliance demonstrations, including that allowable emissions are to be used in PSD NAAQS analyses. Moreover, the Guideline is being codified in the Code of Federal Regulations for projections associated with AQMA analyses (§ 51.46), SIP attainment demonstrations (§ 51.112), analysis of lead concentrations (§ 51.117), regional classification for episode planning (§ 51.150), and preconstruction review of new and modified sources (§ 51.160). As proposed, EPA is not including in the Guideline either a screening technique for point sources of O_3 precursors or recommendations on the use of regional scale models.

Discussion of Public Comments and Issues

All comments presented at the fifth modeling conference and/or submitted to Docket No. A-88-04 are filed in Docket Category IV-D. Also, a verbatim transcript of the conference proceedings is available as Docket Item IV-F-1. EPA has summarized these comments, developed detailed responses, and drawn conclusions on appropriate actions for this Notice of Final Rulemaking in the document "Summary of Public Comments and EPA Responses on the Fifth Conference on Air Quality Modeling: March 1991" (Docket Item V-C-1). In this document, all significant comments have been considered and discussed. Whenever the comments revealed any new information or suggested any alternative solutions, such were considered in EPA's final action.

Major issues raised by the commenters, along with EPA responses, are summarized below. Guidance and editorial changes associated with the resolution of these issues are adopted in the appropriate sections of the Guideline and are promulgated as supplement B (1993) to the "Guideline on Air Quality Models (Revised)" (1986) (Docket Item V-B-1). See the ADDRESSES Section of this Notice (above) for general availability.

Although a more detailed summary of the comments and EPA's responses are contained in the aforementioned response-to-comments document (Docket Item V-C-1), the remainder of this preamble section overviews the primary issues encountered by the Agency during the public comment period. This overview also serves to explain the changes to the Guideline from today's action, and the main technical and policy concerns addressed by the Agency. In our view, all of the changes being made reasonably implement the mandates of the Clean Air Act, and are in fact beneficial to both EPA and the regulated community. While modeling by its nature involves approximation based on scientific methodology, and entails utilization of advanced technology as it evolves, EPA believes these changes respond to recent advances in the area so that the Guideline continues to be comprised of the best and most proven of the available models and analytical techniques, as well as reflect reasonable policy choices.

A. Complex Terrain Models

1. Refined Model: CTDMPLUS (Complex Terrain Model PLus Algorithms for Unstable Situations)

There was general support for the proposal to adopt CTDMPLUS as a refined complex terrain model. However, there was a wide variety of comments on various aspects of the model, e.g., evaluation of CTDMPLUS performance, the need for meteorological data collection using a 150 meter tower, concerns with several of the model's preprocessors, averaging times for pollutant concentration estimates, PC (personal computer) execution time, and the definition of "complex terrain".

EPA does not agree with those comments suggesting that CTDMPLUS has been inadequately evaluated or tested. Indeed, CTDMPLUS is one of the most extensively analyzed and reviewed models ever considered. It is clearly superior in terms of accuracy and utility to other complex terrain models. The Agency does not believe that further evaluation is needed in order to include CTDMPLUS into appendix A of the Guideline.

In so doing, EPA recognizes that data requirements may prove problematical in some circumstances due to the comprehensive nature of the information demanded by the model. Although it would be imprudent to reduce multi-level data requirements for specific parameters as that would significantly compromise the model's accuracy, requirements on measurement location have been relaxed to reflect practical reality. For instance, the maximum height required for tower measurements is 100m, provided that remote sensing data (e.g., SODAR) up to representative plume height are available on a routine hourly basis; this makes the tower height requirement consistent with that already established for RTDM, as a screening technique, in the Guideline. As to those issues related to users learning and applying various preprocessors for CTDMPLUS, they can only be resolved with experience gained through wide application, and EPA encourages consultation with the EPA Regional Offices to discuss appropriate resolution. In addition to seeking assistance from the Regional Offices, users should watch for clarifications to the User's Guide as they are released via SCRAM BBS (Support Center for Regulatory Air Models Bulletin Board System).

For technical and policy reasons, EPA has decided not to make any changes to the handling of averaging times, computer system efficiency, terrain processing modules, or the definition of "complex terrain", although appropriate clarifications have been made to the Guideline to explain limitations and to urge users to confer with the EPA Regional Offices if problems are encountered.

2. Complex Terrain Screening Techniques: CTSCREEN

With regard to CTSCREEN, there was wide support for the proposed adoption of the model as a screening technique. Comments generally related to tabular values for CTSCREEN's operating parameters and the need for adequate technical guidance. Minor typographical errors regarding various model parameters have been corrected. Efforts to ensure the availability of consultation for operating the model will continue through the Regional Offices.

There was also general support for continuing RTDM as an acceptable screening technique, as EPA had proposed. The comments on elimination of a hierarchy in terms of degree of conservatism for complex terrain screening models were somewhat more mixed; the arguments for some structure were ambivalent. However, since all the screening models are conservative, the need for a hierarchy is not clear. Thus, as proposed, the hierarchy of screening models has been eliminated.

3. Intermediate Terrain

There were many comments concerning EPA's proposed clarification of acceptable modeling approaches for receptors in intermediate terrain, i.e., between stack top and plume height. The problems identified by the commenters occur where simplistic complex terrain screening techniques are used. In such circumstances, a more detailed analysis involving comparison of estimates between flat terrain and complex terrain models is necessary.

Given the focus of the comments, it is clear that there is no issue when the newer complex terrain models, i.e., CTSCREEN and CTDMPLUS, are used since these models apply to all terrain above stack height. Recognizing the commenters' concern that the proposed procedure was burdensome, overly complex, lacked formal validation and essentially represented a new technique, EPA is not recommending the approach generally at this time; however, EPA will consider accepting the use of the technique on a case-by-case basis from those who choose to implement the technique.

B. Mobile Source Modeling at Signalized Intersections

1. CAL3QHC

This model is used for estimating carbon monoxide concentrations at signalized intersections. Public comments contend that the Illinois intersection model evaluation study, on which the proposed adoption of CAL3QHC in supplement B was based, was flawed. The comments also contend that the selection of the supplement B intersection model should not be made until further intersection model evaluation is completed, utilizing the more recent New York City data base.

In response to these comments, EPA reevaluated the eight intersection models evaluated with the Illinois data base with the New York City data base. Using the MOBILE4 emissions model, the models were initially evaluated at all six intersection sites in New York City where data were collected. The MOBILE4.1 emissions model, an update to MOBILE4, was then released. The five models performing best using MOBILE4 were then evaluated using MOBILE4.1 at the three intersection sites in New York City with the highest quality data. A statistical scoring scheme was developed to determine the best performing models. The evaluation results showed CAL3QHC, TEXIN2, and CALINE4 to be the best performing models, with none of the three being statistically superior in performance to the others.

EPA points out, however, that TEXIN2 and CALINE4 contain the outdated (mid-1970s) modal emission factors. Since CAL3QHC performed as well as TEXIN2 and CALINE4 and does not contain the obsolete modal emission factors, it is being selected as the recommended intersection model for inclusion in supplement B, as proposed. However, since CALINE4 and TEXIN2 performed as well as CAL3QHC, the use of these models is being allowed for applications where their use has already been established at the time supplement B is promulgated.

2. "Guideline for Modeling CO From Roadway Intersections" (Draft)

Relatively minor public comments were received on receptor placement, ranking criteria for intersections, ambient temperature, persistence factor, hot/cold starts, background levels and wind direction. In response, the "Guideline for Modeling Carbon Monoxide from Roadway Intersections" has been modified, as appropriate, to reflect the commenters' concerns and recommendations.

C. Emissions and Dispersion Modeling System (EDMS)

Since no negative comments were received, EDMS has been identified, as proposed, in the Guideline as a recommended model in appendix A for assessing air pollutant concentrations at civilian airports and military air bases.

D. Modeling Techniques for Air Pathway Analyses

Commenters addressed a variety of topics concerning air toxics. These included applicability of Gaussian models to unconventional or intermittent sources, dense gas models, and model accuracy. In some cases, EPA has planned actions that are responsive to the commenters' concerns. In others, due to limitations of available data bases or alternative modeling techniques on which to base a different approach, the changes to the Guideline have been implemented as originally proposed. As to these and others, commenters were unable to provide specific improvements.

ISC2 is general enough to apply to a broad category of toxic pollutant releases, which is why the model has been included in appendix A. However, supplement B now indicates that ISC2 has been recommended only for some specific regulatory programs; it is not being generally recommended for all air pathway analyses, as originally proposed.

The algorithms in ISC2 for various source types are continuously being reviewed and improvements released as appropriate. Dense gas models in the public domain have been indicated as available for use, but no one model is being required at this time. Per public comment, SLAB and HGSYSTEM will be proposed for addition to appendix B through a supplemental NPR; DENGADIS (DENse GAs DISpersion Model) is being added to appendix B as proposed in the February 1991 NPR.

Evaluating model accuracy is a continuing concern for EPA. However, there is a lack of suitable data bases to take such evaluations beyond their current extent. Nevertheless, where Gaussian models are applied to conventional source types for risk assessment, there is little basis for concern about overestimates of health risks; these models have consistently demonstrated a tendency to underestimate concentrations for longer averaging times.

E. On-Site Meteorological Program Guidance

Since the close of the public comment period, the evaluation supporting the SRDT method was found to have been based on a flawed implementation of the method (software error) and thus the conclusions of that evaluation are suspect. While public comments were generally supportive of the SRDT method, it unfortunately must be withdrawn from supplement B because of this oversight. Pending results of additional evaluations, the SRDT method may be re-proposed in a future supplemental rulemaking to augment the Guideline. However, as proposed, "On-site Meteorological Program Guidance for Regulatory Modeling Applications" (EPA–450/4–87–013) and a Meteorological Processor for Regulatory Models (MPRM)(EPA–600/3–88–043) are cited as the primary source of supplemental guidance and analysis for collection and use of on-site meteorological data (without reference to the SRDT system).

F. General Screening Techniques

1. SCREEN

EPA proposed to identify "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources" with SCREEN as the recommended screening technique in Guideline Section 4.2. A number of changes to SCREEN were suggested by public commenters. As necessary, a number of these changes have been made, through minor code corrections, to ensure reasonable comparability with ISC2. However, based on careful analyses of other suggested changes (e.g., those involving flares and mixing height), EPA has decided to retain SCREEN largely as proposed so as to keep intact the philosophy of SCREEN as a conservative screening technique. As a result of the minor code corrections, this technique has been renamed "SCREEN2".

2. VISCREEN

EPA proposed to identify "Workbook for Plume Visual Impact Screening and Analysis" with VISCREEN as the recommended screening technique for visibility assessments in Guideline section 7.2.4. Numerous detailed comments were provided on VISCREEN and the associated Workbook. However, after careful review, it is apparent that many of the comments were misdirected, sought a level of detail that is inappropriate for a screening analysis, or requested procedures still being researched. As a result, EPA is not changing its proposal on this point. However, to better support the technique, EPA is working with the National Park Service to provide information on background visual ranges and to encourage research development in regional haze modeling techniques.

G. Method for Evaluating Models

EPA proposed to include the "Protocol for Determining the Best Performing Model" ("Protocol") as an adjunct to "Interim Procedures for Evaluating Air Quality Models" (EPA–450/4–84–023) when a party seeks to justify the use of an alternative model for a site-specific application. Most of the comments offered by the public dealt with the degree of flexibility that EPA will permit in developing case-specific model evaluation protocols. This issue is addressed in the Protocol, which indicates that specific test statistics and performance measures described therein may need to be adapted to coincide with the data bases and objectives established for a particular evaluation study. Therefore, EPA has referenced the Protocol in Guideline Sections 3.2 and 10.1, as proposed.

H. Alternate Models in Appendix B

Unlike appendix A of the Guideline, which is a repository of summaries of refined air quality models that are "preferred" for specific applications, appendix B contains summaries of other refined models that may be considered with a case-specific justification. In the February 1991 NPR, EPA solicited comments on the inclusion of four models in appendix B: SDM (Shoreline Dispersion Model), WYNDvalley, MESOPUFF II, and PLUVUE II.

Public comments concerned the lack of an adequate performance evaluation for MESOPUFF II, although data bases for development and assessment of MESOPUFF II or other long range transport models were not identified. In fact, EPA has evaluated the performance of MESOPUFF II and several other long range transport models using available data bases. Although MESOPUFF II was found to be the best performing model, this evaluation resulted in EPA's decision to not propose the model for listing in appendix A of the Guideline. Furthermore, since public comments identifying concerns with the MESOPUFF II estimates of SO_2 conversion and removal presented no additional justification for changes in the model, the policy of case-by-case application of the model using agreed-upon protocols is continuing.

Regarding other models, no comments specifically related to PLUVUE II were received; comments about the proposed inclusion of SDM and WYNDvalley in appendix B of the Guideline were generally favorable. EPA has added SDM and WYNDvalley to appendix B of the Guideline, as proposed; PLUVUE II is already in appendix B. These three models, along with MESOPUFF II and its application protocol, have been identified, as proposed, as models available for application on a case-by-case basis in the following respective parts of the Guideline: Section 8.2.9, 8.2.10, 7.2.4, and 7.2.6. These models are either unique to the specified application or are at least as accurate as other available models. However, due to limitations of data bases for evaluating the models, no further model development or evaluation is feasible at this time. Nor is more detailed guidance appropriate; case-specific consultation with Regional Offices appears to be the most reasonable approach.

I. Supplementary Changes

1. Regional Office Consultation on VOC/NO_x Point Source Modeling

No negative comments were received on this topic, and the Guideline reflects the changes noted in the NPR.

2. Clarification of Modeling Requirements Applicable to PSD (NO_2)

Commenters expressed a desire for modeling techniques more refined than those proposed to handle annual average concentrations of NO_2 as they relate to PSD compliance demonstrations. However, no practical techniques which deal with the explicit use of UAM (*U*rban *A*irshed *M*odel) or with estimating long-term averages were identified. Therefore, since some procedure is needed to treat NO_2 and long-term averages for PSD, the original proposal, though limited, is being maintained for inclusion in the Guideline.

3. PM–10 Issues

No negative comments were received on the proposal to change references to particulate matter so that "PM–10" replaces "TSP" (Guideline Sections 7.2.2 and 11.2.3). Other Guideline changes suggested by commenters which involve references to receptor models are already addressed in the Guideline in a clear and consistent manner; they require no further changes or additions.

4. Clarification on Emissions Data for PSD NAAQS Analyses

Commenters took exception to the use of allowable emissions in modeling analyses for PSD NAAQS. A variety of alternatives was suggested for changing Table 9–2 as proposed, which ranged from the use of actual emissions to use of techniques for statistically approximating emissions variability. EPA maintains however that, once permitted, sources may operate at their legally allowable levels and that these must be considered in the modeling analyses. Appropriate allowances for modifying emissions to represent annual impacts and to account for background sources have been provided for in Guideline Table 9–1 and the proposed Table 9–2, and have long standing in past practice. EPA is authorized by the Clean Air Act to require the use of allowable emissions. Thus, no change to the proposed guidance is being made.

5. Deletion of ERTAQ and MPSDM From Appendix B

No negative comments were received on the proposal to delete these two models from appendix B as requested by the models' developer. These models have been deleted, as proposed.

6. Updates to OCD

No negative comments were received on this topic. This model has been updated to reflect recent improvements prepared by the Minerals Management Service, as proposed.

7. Updates to UAM and EKMA (OZIPP)

No negative comments were received on the proposal to update EKMA (OZIPP) to include the CB–IV chemical mechanism and guidance. Likewise, with respect to UAM, there were no comments on the use of the CB–IV mechanism; therefore, a version of UAM with that chemical mechanism has been specifically recommended in appendix A of the Guideline. Public comments on the "Guideline for Regulatory Application of the Urban Airshed Model" concerning such topics as data base criteria, grid size, boundary conditions, and UAM performance evaluation have been thoroughly addressed through consultation with the work group that helped in its development. A revised guide on the use of UAM in SIP development has been prepared and released; that guidance has been referenced in the Guideline.

8. Codification of the "Guideline on Air Quality Models"

Several commenters opposed EPA's proposal to codify the Guideline in the Code of Federal Regulations for regulatory purposes in certain programs, in addition to PSD permitting. These commenters claimed that codification would unduly limit flexibility of States and sources to use alternative models, data bases, and procedures for these other SIP applications. As stated in its Introduction, the Guideline describes "air quality modeling techniques that should be applied to State Implementation Plan (SIP) revisions for existing sources and to new source reviews * * *", and this has always been EPA policy. Use of the Guideline represents long-standing EPA policy and codification would not, in fact, limit flexibility of States or industry as to models, data bases or attainment demonstrations for SIPs. The Guideline, by its terms, provides the flexibility sought by these commenters, because it allows the use of models other than those set forth in appendix A whenever it is appropriate to do so. EPA believes that the comprehensive use of the Guideline under the other provisions promotes consistency in model usage and is in accordance with the authority granted by Sections 110(a)(2), 165(e), 172, 173, 301(a)(1) and 320 of the 1977 Clean Air Act Amendments (42 U.S.C 7410(a)(2), 7475(e), 7502(a) & (b), 7503, 7601(a)(1) and 7620, respectively). The codification therefore is being implemented as proposed. In order to better facilitate this action, the Guideline, as revised through supplement B, will now be published as appendix W to 40 CFR part 51.[4]

J. Other Topics

1. A Screening Technique for Point Sources of O_3 Precursors

Based on public support, screening techniques for estimating VOC/NO_x point source emission impacts on O_3 have not been included in the Guideline at this time.

2. Usefulness of Regional Scale Models to Regulatory Programs

No public comments on this topic were received. Therefore, as proposed by EPA, recommendations on the use of regional scale models have not been included in the Guideline at this time.

K. Miscellaneous Comments

In addition to the topics described above, substantial comments were received which were not specifically solicited in the February 1991 NPR. These comments pertained to the following: (1) Industrial Source Complex (ISC2) Model; (2) *F*ugitive *D*ust *M*odel (FDM); and (3) general modeling guidance.

1. Industrial Source Complex Model

A wide range of comments were presented on the adequacy of the computational code in general and more specifically on the downwash, area source and deposition algorithms. In response to some of these comments, it should be noted that EPA has completed a program to improve the structure of the code. This enhanced code makes the model much more usable, but does not change the way concentrations are calculated and does not alter the basic downwash, area source and deposition algorithms. In addition, a preprocessor which addresses building orientation in a way consistent with current guidance will be made available, thus relieving some of the computational burden.

Lack of a cavity algorithm in ISC2 to calculate downwash is also of concern to EPA and is a high research priority, but no immediate solution is available.

[4] In a conforming action, EPA is hereby deleting appendix X to 40 CFR 266, subpart H (Hazardous Waste Burned in Boilers and Industrial Furnaces). EPA is also changing reference to the Guideline in part 266 to 40 CFR part 51, appendix W.

Where there is confusion in the Guideline about downwash calculations, clarifications have been made. Other remarks about the downwash calculations reflected confusion on the part of the commenter(s) or a lack of data on which to base a better algorithm. Thus, no further action to change downwash calculations is planned at this time.

EPA shares the commenters' concerns about potential deficiencies in the area source and deposition algorithms and is evaluating these and alternative schemes. If new algorithms are identified for use, they will be proposed for public review and comment before being implemented for regulatory application. Until such a proposal is prepared, the current algorithms in ISC2 should continue to be used, as appropriate.

2. Fugitive Dust Model

There were several strong comments in favor of adopting FDM in appendix A of the Guideline as the recommended model for sources of fugitive dust as it relates to both PM–10 and airborne toxic materials. Nevertheless, there has been insufficient opportunity for public comment on this model. Thus, the model algorithms will be considered in a supplemental NPR.

3. General Modeling Guidance

Highly varied comments and Agency responses on other topics not addressed in the February 1991 NPR are summarized in Section 12 of the "Summary of Public Comments and EPA Responses on the Fifth Conference on Air Quality Modeling: March 1991" (Docket Item V–C–1). The comments deal with a wide range of topics primarily related to management of EPA's modeling guidance. In most cases, the commenters seem to have misunderstood the way in which such guidance is issued and updated by the Agency, or the commenters have made inappropriate recommendations that are not consistent with long-standing EPA policies. As such, with one exception, no action appears appropriate. That exception has to do with determination of PSD impacts in Class I areas; work is underway on this topic and will be subjected to public review and comment when completed.

Administrative Requirements

A. Executive Order 12291

Under Executive Order (E.O.) 12291, EPA is required to judge whether a regulation is "major" and therefore subject to the requirement of a regulatory impact analysis (RIA). The criteria set forth in section 1 of the Order for this determination are: (1) Likelihood to have an annual effect on the economy of $100 million or more; (2) likelihood to cause a major increase in costs or prices for consumers, individual industries, Federal, State, or local governments, or geographic regions; or (3) likelihood to result in significant adverse effects on competition, employment, investment, productivity, innovation, or the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets.

This rule does not change the proposal's conclusions regarding E.O. 12291, specifically that the regulation is not "major" because it would result in none of the adverse effects mentioned above. This rule has been submitted to the Office of Management and Budget (OMB) for review under E.O. 12291, as required, and their written comments and any EPA responses thereto will be available as Docket Item IV–H–1 (see **ADDRESSES**).

B. Paperwork Reduction Act

This final rule does not contain any information collection requirements subject to review by OMB under the Paperwork Reduction Act on 1980, 44 U.S.C. 3501 *et seq.*

C. Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires EPA to consider potential impacts of regulations on small business "entities". Pursuant to the provisions of 5 U.S.C. 605(b), the Administrator hereby certifies that the attached final rule will not have a significant impact on a substantial number of such entities. This rule merely updates existing technical requirements for air quality modeling analyses mandated by various Clean Air Act programs (e.g., prevention of significant deterioration, new source review, SIP revisions) and imposes no new regulatory burdens.

List of Subjects

40 CFR Part 51

Administrative practice and procedure, Air pollution control, Carbon monoxide, Hydrocarbons, Incorporation by reference, Intergovernmental relations, Lead, Nitrogen dioxide, Ozone, Particulate matter, Reporting and recordkeeping requirements, Sulfur oxides.

40 CFR Part 52

Air pollution control, Lead, Nitrogen dioxide, Ozone, Sulfur oxides.

40 CFR Parts 260 and 266

Air pollution control, Hazardous waste.

Dated: June 21, 1993.

Carol M. Browner,

Administrator.

Parts 51, 52, 260 and 266, chapter I, title 40 of the Code of Federal Regulations are amended as follows:

PART 51—REQUIREMENTS FOR PREPARATION, ADOPTION, AND SUBMITTAL OF IMPLEMENTATION PLANS

1. The authority citation for part 51 is revised to read as follows:

Authority: 42 U.S.C. 7410(a)(2), 7475(e), 7502 (a) and (b), 7503, 7601(a)(1) and 7620.

2. Section 51.46 is amended by revising paragraph (b) and removing paragraph (c) to read as follows:

§ 51.46 AQMA analysis: Projection of air quality concentrations.

* * * * *

(b) Unless alternative techniques are approved under § 51.63, such concentrations shall be projected using techniques consistent with the requirements in § 51.112(a).

§ 51.63 [Amended]

3. In § 51.63, paragraph (a) is amended by removing "51.46,".

4. In § 51.112, paragraph (a) is amended by removing the second sentence and adding paragraphs (a)(1) and (a)(2) to read as follows:

§ 51.112 Demonstration of adequacy.

(a) * * *

(1) The adequacy of a control strategy shall be demonstrated by means of applicable air quality models, data bases, and other requirements specified in the appendix W of this part ("Guideline on Air Quality Models (Revised)" (1986), supplement A (1987) and supplement B (1993)). The Guideline and its supplements (EPA Publication No. 450/2–78–027R) are also for sale from the U.S. Department of Commerce, National Technical Information Service, 5825 Port Royal Road, Springfield, VA 22161.

(2) Where an air quality model specified in appendix W of this part ("Guideline on Air Quality Models (Revised)" (1986), supplement A (1987) and supplement B (1993)) is inappropriate, the model may be modified or another model substituted. Such a modification or substitution of a model may be made on a case-by-case basis or, where appropriate, on a generic basis for a specific state program. Written approval of the Administrator

must be obtained for any modification or substitution. In addition, use of a modified or substituted model must be subject to notice and opportunity for public comment under procedures set forth in § 51.102.

* * * * *

§ 51.117 [Amended]

5. In § 51.117, paragraph (c)(1) is amended by adding the phrase ", consistent with requirements contained in § 51.112(a)" immediately after "if desired". Paragraph (c)(2) is amended by adding the phrase ", consistent with requirements contained in § 51.112(a)" immediately after "for demonstration of attainment". Paragraph (c)(3) is amended by adding the phrase ", consistent with requirements contained in § 51.112(a)" immediately after "for the demonstration of attainment".

§ 51.150 [Amended]

6. In § 51.150, paragraph (e) is amended by adding the phrase ", consistent with the requirements contained in § 51.112(a)" immediately after "of this section" in the first sentence, and by removing the second sentence.

7. Section 51.160 is amended by adding paragraphs (f)(1) and (f)(2) to read as follows:

§ 51.160 Legally enforceable procedures.

* * * * *

(f) * * *

(1) All applications of air quality modeling involved in this subpart shall be based on the applicable models, data bases, and other requirements specified in the appendix W of this part ("Guideline on Air Quality Models (Revised)" (1986), supplement A (1987) and supplement B (1993)). The Guideline and its supplements (EPA Publication No. 450/2–78–027R) are also for sale from the U.S. Department of Commerce, National Technical Information Service, 5825 Port Royal Road, Springfield, VA, 22161.

(2) Where an air quality model specified in the appendix W of this part ("Guideline on Air Quality Models (Revised)" (1986), supplement A (1987) and supplement B (1993)) is inappropriate, the model may be modified or another model substituted. Such a modification or substitution of a model may be made on a case-by-case basis or, where appropriate, on a generic basis for a specific state program. Written approval of the Administrator must be obtained for any modification or substitution. In addition, use of a modified or substituted model must be subject to notice and opportunity for public comment under procedures set forth in § 51.102.

8. Section 51.166 is amended by revising paragraphs (l)(1) and (l)(2) to read as follows:

§ 51.166 Prevention of significant deterioration of air quality.

* * * * *

(l) * * *

(1) All applications of air quality modeling involved in this subpart shall be based on the applicable models, data bases, and other requirements specified in the appendix W of this part ("Guideline on Air Quality Models (Revised)" (1986), supplement A (1987) and supplement B (1993)). The Guideline and its supplements (EPA Publication No. 450/2–78–027R) are also for sale from the U.S. Department of Commerce, National Technical Information Service, 5825 Port Royal Road, Springfield, VA, 22161.

(2) Where an air quality model specified in the Appendix W of this part ("Guideline on Air Quality Models (Revised)" (1986), supplement A (1987) and supplement B (1993)) is inappropriate, the model may be modified or another model substituted. Such a modification or substitution of a model may be made on a case-by-case basis or, where appropriate, on a generic basis for a specific state program. Written approval of the Administrator must be obtained for any modification or substitution. In addition, use of a modified or substituted model must be subject to notice and opportunity for public comment under procedures set forth in § 51.102.

* * * * *

9. Part 51 is amended by adding appendix W to read as follows:

Appendix W to Part 51—Guideline on Air Quality Models (Revised)

[EPA Document Number EPA–450/2–78–027R]

Preface

Industry and control agencies have long expressed a need for consistency in the application of air quality models for regulatory purposes. In the 1977 Clean Air Act, Congress mandated such consistency and encouraged the standardization of model applications. The Guideline on Air Quality Models was first published in April 1978 to satisfy these requirements by specifying models and providing guidance for their use. This guideline provides a common basis for estimating the air quality concentrations used in assessing control strategies and developing emission limits.

The continuing development of new air quality models in response to regulatory requirements and the expanded requirements for models to cover even more complex problems have emphasized the need for periodic review and update of guidance on these techniques. Four primary on-going activities provide direct input to revisions of this modeling guideline. The first is a series of annual EPA workshops conducted for the purpose of ensuring consistency and providing clarification in the application of models. The second activity, directed toward the improvement of modeling procedures, is the cooperative agreement that EPA has with the scientific community represented by the American Meteorological Society. This agreement provides scientific assessment of procedures and proposed techniques and sponsors workshops on key technical issues. The third activity is the solicitation and review of new models from the technical and user community. In the March 27, 1980 **Federal Register**, a procedure was outlined for the submittal to EPA of privately developed models. After extensive evaluation and scientific review, these models, as well as those made available by EPA, are considered for recognition in this guideline. The fourth activity is the extensive on-going research efforts by EPA and others in air quality and meteorological modeling.

Based primarily on these four activities, this document embodies revisions to the "Guideline on Air Quality Models." Although the text has been revised from the 1978 guide, the present content and topics are similar. As necessary, new sections and topics are included. EPA does not make changes to the guidance on a predetermined schedule, but rather on an as needed basis. EPA believes that revisions to this guideline should be timely and responsive to user needs and should involve public participation to the greatest possible extent. All future changes to the guidance will be proposed and finalized in the **Federal Register**. Information on the current status of modeling guidance can always be obtained from EPA's Regional Offices.

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1.0 Introduction

This guideline recommends air quality modeling techniques that should be applied to State Implementation Plan (SIP)[1] revisions for existing sources and to new source reviews,[2] including prevention of significant deterioration (PSD).[3] It is intended for use by EPA Regional Offices in judging the adequacy of modeling analyses performed by EPA, State and local agencies and by industry. The guidance is appropriate for use by other Federal agencies and by State agencies with air quality and land management responsibilities. It serves to identify, for all interested parties, those techniques and data bases EPA considers acceptable. The guide is not intended to be a compendium of modeling techniques. Rather, it should serve as a basis by which air quality managers, supported by sound scientific judgment, have a common measure of acceptable technical analysis.

Due to limitations in the spatial and temporal coverage of air quality measurements, monitoring data normally are not sufficient as the sole basis for demonstrating the adequacy of emission limits for existing sources. Also, the impacts of new sources that do not yet exist can only be determined through modeling. Thus, models, while uniquely filling one program need, have become a primary analytical tool in most air quality assessments. Air quality measurements though can be used in a complementary manner to dispersion models, with due regard for the strengths and weaknesses of both analysis techniques. Measurements are particularly useful in assessing the accuracy of model estimates. The use of air quality measurements alone however could be preferable, as detailed in a later section of this document, when models are found to be unacceptable and monitoring data with sufficient spatial and temporal coverage are available.

It would be advantageous to categorize the various regulatory programs and to apply a designated model to each proposed source needing analysis under a given program. However, the diversity of the nation's topography and climate, and variations in source configurations and operating characteristics dictate against a strict modeling "cookbook." There is no one model capable of properly addressing all conceivable situations even within a broad category such as point sources. Meteorological phenomena associated with threats to air quality standards are rarely amenable to a single mathematical treatment; thus, case-by-case analysis and judgment are frequently required. As modeling efforts become more complex, it is increasingly important that they be directed by highly competent individuals with a broad range of experience and knowledge in air quality meteorology. Further, they should be coordinated closely with specialists in emissions characteristics, air monitoring and data processing. The judgment of experienced meteorologists and analysts is essential.

The model that most accurately estimates concentrations in the area of interest is always sought. However, it is clear from the needs expressed by the States and EPA Regional Offices, by many industries and trade associations, and also by the deliberations of Congress, that consistency in the selection and application of models and data bases should also be sought, even in case-by-case analyses. Consistency ensures that air quality control agencies and the general public have a common basis for estimating pollutant concentrations, assessing control strategies and specifying emission limits. Such consistency is not, however, promoted at the expense of model and data base accuracy. This guide provides a consistent basis for selection of the most accurate models and data bases for use in air quality assessments.

Recommendations are made in this guide concerning air quality models, data bases, requirements for concentration estimates, the use of measured data in lieu of model estimates, and model evaluation procedures. Models are identified for some specific applications. The guidance provided here should be followed in all air quality analyses relative to State Implementation Plans and in analyses required by EPA, State and local agency air programs. The EPA may approve the use of another technique that can be demonstrated to be more appropriate than those recommended in this guide. This is discussed at greater length in Section 3.0. In all cases, the model applied to a given situation should be the one that provides the most accurate representation of atmospheric transport, dispersion, and chemical transformations in the area of interest. However, to ensure consistency, deviations from this guide should be carefully documented and fully supported.

From time to time situations arise requiring clarification of the intent of the guidance on a specific topic. Periodic workshops are held with the EPA Regional Meteorologists to ensure consistency in modeling guidance and to promote the use of more accurate air quality models and data bases. The workshops serve to provide further explanations of guideline requirements to the Regional Offices and workshop reports are issued with this clarifying information. In addition, findings from on-going research programs, new model submittals, or results from model evaluations and applications are continuously evaluated. Based on this information changes in the guidance may be indicated.

All changes to this guidance must follow rulemaking requirements since the guideline is codified in Appendix W of part 51. EPA will promulgate proposed and final rules in the **Federal Register** to amend this Appendix. Ample opportunity for public comment will also be provided for each proposed change and public hearings scheduled if requested. Final rule changes will also be made available through the National Technical Information Service (NTIS).

A wide range of topics on modeling and data bases are discussed in the remainder of this guideline. Chapter 2 gives an overview of models and their appropriate use. Chapter 3 provides specific guidance on the use of "preferred" air quality models and on the selection of alternative techniques. Chapters 4 through 7 provide recommendations on modeling techniques for application to simple-terrain stationary source problems, complex terrain problems, and mobile source problems. Specific modeling requirements for selected regulatory issues are also addressed. Chapter 8 discusses issues common to many modeling analyses, including acceptable model components. Chapter 9 makes recommendations for data inputs to models including source, meteorological and background air quality data. Chapter 10 covers the uncertainty in model estimates and how that information can be useful to the regulatory decision-maker. The last chapter summarizes how estimates and measurements of air quality are used in assessing source impact and in evaluating control strategies.

Appendix W to 40 CFR part 51 (the "Guideline on Air Quality Models (Revised)") itself contains three appendices: A, B, and C. Thus, when reference is made to "appendix A" in this document, it refers to the appendix A to appendix W to 40 CFR part 51. Appendices B and C are referenced in the same way.

Appendix A contains summaries of refined air quality models that are "preferred" for specific applications; both EPA models and models developed by others are included. Appendix B contains summaries of other refined models that may be considered with a case-specific justification. Appendix C contains a checklist of requirements for an air quality analysis.

2.0 Overview of Model Use

Before attempting to implement the guidance contained in this document, the reader should be aware of certain general information concerning air quality models and their use. Such information is provided in this section.

2.1 Suitability of Models

The extent to which a specific air quality model is suitable for the evaluation of source impact depends upon several factors. These include: (1) The meteorological and topographic complexities of the area; (2) the level of detail and accuracy needed for the analysis; (3) the technical competence of those undertaking such simulation modeling; (4) the resources available; and (5) the detail and accuracy of the data base, i.e., emissions inventory, meteorological data, and air quality data. Appropriate data should be available before any attempt is made to apply a model. A model that requires detailed, precise, input data should not be used when such data are unavailable. However, assuming the data are adequate, the greater the detail with which a model considers the spatial and temporal variations in emissions and meteorological conditions, the greater the ability to evaluate the source impact and to distinguish the effects of various control strategies.

Air quality models have been applied with the most accuracy or the least degree of uncertainty to simulations of long term averages in areas with relatively simple topography. Areas subject to major topographic influences experience meteorological complexities that are extremely difficult to simulate. Although models are available for such circumstances, they are frequently site specific and resource intensive. In the absence of a model capable of simulating such complexities, only a preliminary approximation may be feasible until such time as better models and data bases become available.

Models are highly specialized tools. Competent and experienced personnel are an essential prerequisite to the successful application of simulation models. The need for specialists is critical when the more sophisticated models are used or the area being investigated has complicated meteorological or topographic features. A model applied improperly, or with inappropriately chosen data, can lead to serious misjudgments regarding the source impact or the effectiveness of a control strategy.

The resource demands generated by use of air quality models vary widely depending on the specific application. The resources required depend on the nature of the model and its complexity, the detail of the data base, the difficulty of the application, and the amount and level of expertise required. The costs of manpower and computational facilities may also be important factors in the selection and use of a model for a specific analysis. However, it should be recognized that under some sets of physical circumstances and accuracy requirements, no present model may be appropriate. Thus, consideration of these factors should not lead to selection of an inappropriate model.

2.2 Classes of Models

The air quality modeling procedures discussed in this guide can be categorized into four generic classes: Gaussian, numerical, statistical or empirical, and physical. Within these classes, especially Gaussian and numerical models, a large number of individual "computational algorithms" may exist, each with its own specific applications. While each of the algorithms may have the same generic basis, e.g., Gaussian, it is accepted practice to refer to them individually as models. For example, the CRSTER model and the RAM model are commonly referred to as individual models. In fact, they are both variations of a basic Gaussian model. In many cases the only real difference between models within the different classes is the degree of detail considered in the input or output data.

Gaussian models are the most widely used techniques for estimating the impact of nonreactive pollutants. Numerical models may be more appropriate than Gaussian models for area source urban applications that involve reactive pollutants, but they require much more extensive input data bases and resources and therefore are not as widely applied. Statistical or empirical techniques are frequently employed in situations where incomplete scientific understanding of the physical and chemical processes or lack of the required data bases make the use of a Gaussian or numerical model impractical. Various specific models in these three generic types are discussed in this guideline.

Physical modeling, the fourth generic type, involves the use of wind tunnel or other fluid modeling facilities. This class of modeling is a complex process requiring a high level of technical expertise, as well as access to the necessary facilities. Nevertheless, physical modeling may be useful for complex flow situations, such as building, terrain or stack down-wash conditions, plume impact on elevated terrain, diffusion in an urban environment, or diffusion in complex terrain. It is particularly applicable to such situations for a source or group of sources in a geographic area limited to a few square kilometers. If physical modeling is available and its applicability demonstrated, it may be the best technique. A discussion of physical modeling is beyond the scope of this guide. The EPA publication "Guideline for Fluid Modeling of Atmospheric Diffusion,"[4] provides information on fluid modeling applications and the limitations of that method.

2.3 Levels of Sophistication of Models

In addition to the various classes of models, there are two levels of sophistication. The first level consists of general, relatively simple estimation techniques that provide conservative estimates of the air quality impact of a specific source, or source category. These are screening techniques or screening models. The purpose of such techniques is to eliminate the need of further more detailed modeling for those sources that clearly will not cause or contribute to ambient concentrations in excess of either the National Ambient Air Quality Standards (NAAQS)[5] or the allowable prevention of significant deterioration (PSD) concentration increments.[3] If a screening technique indicates that the concentration contributed by the source exceeds the PSD increment or the increment remaining to just meet the NAAQS, then the second level of more sophisticated models should be applied.

The second level consists of those analytical techniques that provide more detailed treatment of physical and chemical atmospheric processes, require more detailed and precise input data, and provide more specialized concentration estimates. As a result they provide a more refined and, at least theoretically, a more accurate estimate of source impact and the effectiveness of control strategies. These are referred to as refined models.

The use of screening techniques followed by a more refined analysis is always desirable, however there are situations where the screening techniques are practically and technically the only viable option for estimating source impact. In such cases, an attempt should be made to acquire or improve the necessary data bases and to develop appropriate analytical techniques.

3.0 Recommended Air Quality Models

This section recommends refined modeling techniques that are preferred for use in regulatory air quality programs. The status of models developed by EPA, as well as those submitted to EPA for review and possible inclusion in this guidance, is discussed. The section also addresses the selection of models for individual cases and provides recommendations for situations where the preferred models are not applicable. Two additional sources of modeling guidance, the Model Clearinghouse [6] and periodic Regional Meteorologists' workshops, are also briefly discussed here.

In all regulatory analyses, especially if other than preferred models are selected for use, early discussions among Regional Office staff, State and local control agencies, industry representatives, and where appropriate, the Federal Land Manager, are invaluable and are encouraged. Agreement on the data base to be used, modeling techniques to be applied and the overall technical approach, prior to the actual analyses, helps avoid misunderstandings concerning the final results and may reduce the later need for additional analyses. The use of an air quality checklist, such as presented in appendix C, and the preparation of a written protocol help to keep misunderstandings at a minimum.

It should not be construed that the preferred models identified here are to be permanently used to the exclusion of all others or that they are the only models available for relating emissions to air quality. The model that most accurately estimates concentrations in the area of interest is always sought. However, designation of specific models is needed to promote consistency in model selection and application.

The 1980 solicitation of new or different models from the technical community [7] and the program whereby these models are evaluated, established a means by which new models are identified, reviewed and made available in the guideline. There is a pressing need for the development of models for a wide range of regulatory applications. Refined models that more realistically simulate the physical and chemical process in the atmosphere and that more reliably estimate pollutant concentrations are required. Thus, the solicitation of models is considered to be continuous.

3.1 Preferred Modeling Techniques

3.1.1 Discussion

EPA has developed approximately 10 models suitable for regulatory application. More than 20 additional models were submitted by private developers for possible inclusion in the guideline. These refined models have all been organized into eight categories of use: rural, urban industrial complex, reactive pollutants, mobile sources, complex terrain, visibility, and long range transport. They are undergoing an intensive evaluation by category. The evaluation exercises [8,9,10] include statistical measures of model performance in comparison with measured air quality data as suggested by the American Meteorological Society [11] and, where possible, peer scientific reviews.[12,13,14]

When a single model is found to perform better than others in a given category, it is recommended for application in that category as a preferred model and listed in Appendix A. If no one model is found to clearly perform better through the evaluation exercise, then the preferred model listed in appendix A is selected on the basis of other factors such as past use, public familiarity, cost or resource requirements, and availability. No further evaluation of a preferred model is required if the source follows EPA recommendations specified for the model in this guideline. The models not specifically recommended for use in a particular category are summarized in appendix B. These models should be compared with measured air quality data when they are used for regulatory applications consistent with recommendations in section 3.2.

The solicitation of new refined models which are based on sounder scientific principles and which more reliably estimate pollutant concentrations is considered by EPA to be continuous. Models that are submitted in accordance with the provisions outlined in the Federal Register notice of March 1980 (45 FR 20157) [7] will be evaluated as submitted. These requirements are:

1. The model must be computerized and functioning in a common Fortran language suitable for use on a variety of computer systems.
2. The model must be documented in a user's guide which identifies the mathematics of the model, data requirements and program operating characteristics at a level of detail comparable to that available for currently recommended models, e.g., the Single Source (CRSTER) Model.
3. The model must be accompanied by a complete test data set including input parameters and output results. The test data must be included in the user's guide as well as provided in computer-readable form.
4. The model must be useful to typical users, e.g., State air pollution control agencies, for specific air quality control problems. Such users should be able to operate the computer program(s) from available documentation.
5. The model documentation must include a comparison with air quality data or with other well-established analytical techniques.
6. The developer must be willing to make the model available to users at reasonable cost or make it available for public access through the National Technical Information Service; the model cannot be proprietary.

The evaluation process will include a determination of technical merit, in accordance with the above six items including the practicality of the model for use in ongoing regulatory programs. Each model will also be subjected to a performance evaluation for an appropriate data base and to a peer scientific review. Models for wide use (not just an isolated case!) found to perform better, based on an evaluation for the same data bases used to evaluate models in appendix A, will be proposed for inclusion as preferred models in future guideline revisions.

3.1.2 Recommendations

Appendix A identifies refined models that are preferred for use in regulatory applications. If a model is required for a particular application, the user should select a model from that appendix. These models may be used without a formal demonstration of applicability as long as they are used as indicated in each model summary of appendix A. Further recommendations for the application of these models to specific source problems are found in subsequent sections of this guideline.

If changes are made to a preferred model without affecting the concentration estimates, the preferred status of the model is unchanged. Examples of modifications that do not affect concentrations are those made to enable use of a different computer or those that affect only the format or averaging time of the model results. However, when any changes are made, the Regional Administrator should require a test case example to demonstrate that the concentration estimates are not affected.

A preferred model should be operated with the options listed in appendix A as "Recommendations for Regulatory Use." If other options are exercised, the model is no longer "preferred." Any other modification to a preferred model that would result in a change in the concentration estimates likewise alters its status as a preferred model. Use of the model must then be justified on a case-by-case basis.

3.2 Use of Alternative Models

3.2.1 Discussion Selection of the best techniques for each individual air quality analysis is always encouraged, but the selection should be done in a consistent manner. A simple listing of models in this guide cannot alone achieve that consistency nor can it necessarily provide the best model for all possible situations. An EPA document, "Interim Procedures for Evaluating Air Quality Models",[15,16] has been prepared to assist in developing a consistent approach when justifying the use of other than the preferred modeling techniques recommended in this guide. An alternative to be considered to the performance measures contained in chapter 3 of this document is set forth in another EPA document "Protocol for Determining the Best Performing Model".[17] The procedures in both documents provide a general framework for objective decision-making on the acceptability of an alternative model for a given regulatory application. The documents contain procedures for conducting both the technical evaluation of the model and the field test or performance evaluation.

This section discusses the use of alternate modeling techniques and defines three situations when alternative models may be used.

3.2.2 Recommendations. Determination of acceptability of a model is a Regional Office responsibility. Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the recommendations below. This finding will normally result from a determination that (1) a preferred air quality model is not appropriate for the particular application; or (2) a more appropriate model or analytical procedure is available and is applicable.

An alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use. There are three separate conditions under which such a model will normally be approved for use: (1) If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model; (2) if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the application than a comparable model in appendix A; and (3) if there is no preferred model for the specific application but a refined model is needed to satisfy regulatory requirements. Any one of these three separate conditions may warrant use of an alternative model. Some known alternative models that are applicable for selected situations are contained in appendix B. However, inclusion there does not infer any unique status relative to other alternative models that are being or will be developed in the future.

Equivalency is established by demonstrating that the maximum or highest, second highest concentrations are within 2 percent of the estimates obtained from the preferred model. The option to show equivalency is intended as a simple demonstration of acceptability for an alternative model that is so nearly identical (or contains options that can make it identical) to a preferred model that it can be treated for practical purposes as the preferred model. Two percent was selected as the basis for equivalency since it is a rough approximation of the fraction that PSD Class I increments are of the NAAQS for SO_2, i.e., the difference in concentrations that is judged to be significant. However, notwithstanding this demonstration, use of models that are not equivalent may be used when one of the two other conditions identified below are satisfied.

The procedures and techniques for determining the acceptability of a model for an individual case based on superior performance is contained in the document entitled "Interim Procedures for Evaluating Air Quality Models",[15] and should be followed, as appropriate.[a] Preparation and implementation of an evaluation protocol which is acceptable to both control agencies and regulated industry is an important element in such an evaluation.

When no appendix A model is applicable to the modeling problem, an alternative refined model may be used provided that:

1. The model can be demonstrated to be applicable to the problem on a theoretical basis, and

2. The data bases which are necessary to perform the analysis are available and adequate, and

3a. Performance evaluations of the model in similar circumstances have shown that the model is not biased toward underestimates, or

3b. After consultation with the EPA Regional Office, a second model is selected as a baseline or reference point for performance and the interim procedures[15]/protocol[17] are then used to demonstrate that the proposed model performs better than the reference model.

3.3 *Availability of Supplementary Modeling Guidance*

The Regional Administrator has the authority to select models that are appropriate for use in a given situation. However, there is a need for assistance and guidance in the selection process so that fairness and consistency in modeling decisions is fostered among the various Regional Offices and the States. To satisfy that need, EPA established the Model Clearinghouse and also holds periodic workshops with headquarters, Regional Office and State modeling representatives.

3.3.1 The Model Clearinghouse

3.3.1.1 *Discussion.* The Model Clearinghouse is the single EPA focal point for review of air quality simulation models proposed for use in specific regulatory applications. Details concerning the Clearinghouse and its operation are found in the document, "Model Clearinghouse: Operational Plan."[6] Three primary functions of the Clearinghouse are:

(1) Review of decisions proposed by EPA Regional Offices on the use of modeling techniques and data bases.

(2) Periodic visits to Regional Offices to gather information pertinent to regulatory model usage.

(3) Preparation of an annual report summarizing activities of the Clearinghouse including specific determinations made during the course of the year.

3.3.1.2 *Recommendations.* The Regional Administrator may request assistance from the Model Clearinghouse after an initial evaluation and decision has been reached concerning the application of a model, analytical technique or data base in a particular regulatory action. The Clearinghouse may also consider and evaluate the use of modeling techniques submitted in support of any regulatory action. Additional responsibilities are: (1) Review proposed action for consistency with agency policy; (2) determine technical adequacy; and (3) make recommendations concerning the technique or data base.

3.3.2 Regional Meteorologists Workshops

3.3.2.1 *Discussion.* EPA conducts an annual in-house workshop for the purpose of mutual discussion and problem resolution among Regional Office modeling specialists, EPA research modeling experts, EPA Headquarters modeling and regulatory staff and representatives from State modeling programs. A summary of the issues resolved at previous workshops was issued in 1981 as "Regional Workshops on Air Quality Modeling: A Summary Report."[17] That report clarified procedures not specifically defined in the 1978 guideline and was issued to ensure the consistent interpretation of model requirements from Region to Region. Similar workshops for the purpose of clarifying guideline procedures or providing detailed instructions for the use of those procedures are anticipated in the future.

3.3.2.2 *Recommendations.* The Regional Office should always be consulted for information and guidance concerning modeling methods and interpretations of modeling guidance, and to ensure that the air quality model user has available the latest most up-to-date policy and procedures.

4.0 Simple-Terrain Stationary Source Models

4.1 *Discussion*

Simple terrain, as used here, is considered to be an area where terrain features are all lower in elevation than the top of the stack of the source(s) in question. The models recommended in this section are generally used in the air quality impact analysis of stationary sources for most criteria pollutants. The averaging time of the concentration estimates produced by these models ranges from 1 hour to an annual average.

Model evaluation exercises have been conducted to determine the "best, most appropriate point source model" for use in simple terrain.[8,12] However, no one model has been found to be clearly superior. Thus, based on past use, public familiarity, and availability CRSTER remains the recommended model for rural, simple terrain, single point source applications. Similar determinations were made for the other refined models that are identified in the following sections.

4.2 *Recommendations*

4.2.1 Screening Techniques

Point source screening techniques are an acceptable approach to air quality analyses. One such approach is contained in the EPA document "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources."[18] A computerized version of the screening technique, SCREEN2, is available.[19,20]

All screening procedures should be adjusted to the site and problem at hand.

[a] Another EPA document, "Protocol for Determining the Best Performing Model",[17] contains advanced statistical techniques for determining which model performs better than other competing models. In many cases, this protocol should be considered by users of the "Interim Procedures for Evaluating Air Quality Models" in preference to the material currently in Chapter 3 of that document.

Close attention should be paid to whether the area should be classified urban or rural in accordance with Section 8.2.8. The climatology of the area should be studied to help define the worst-case meteorological conditions. Agreement should be reached between the model user and the reviewing authority on the choice of the screening model for each analysis, and on the input data as well as the ultimate use of the results.

4.2.2 Refined Analytical Techniques

Table 4–1 lists preferred models for selected applications. These preferred models should be used for the sources, land use categories and averaging times indicated in the table. A brief description of each of these models is found in appendix A. Also listed in that appendix are the model input requirements, the standard options that should be selected when running the program and output options.

When modeling for compliance with short term NAAQS and PSD increments is of primary concern, the short term models listed in Table 4-l may also be used to provide long term concentration estimates. When modeling for sources for which long term standards alone are applicable (e.g., lead), then the long term models should be used.

The conversion from long term to short term concentration averages by any transformation technique is not acceptable in regulatory applications.

TABLE 4–1.—PREFERRED MODELS FOR SELECTED APPLICATIONS IN SIMPLE TERRAIN

	Land Use	Model [1]
Short Term (i.e., 1–24 hours):		
Single Source	Rural	CRSTER
	Urban	RAM
Multiple Source.	Rural	MPTER
	Urban	RAM
Complicated Sources [2].	Rural/Urban	ISCST2
Buoyant Industrial Line Sources.	Rural	BLP
Long Term (i.e., monthly, seasonal or annual):		
Single Source	Rural	CRSTER
	Urban	RAM
Multiple Source.	Rural	MPTER
	Urban	CDM 2.0 or RAM [3]
Complicated Sources [2].	Rural/Urban	ISCLT2

TABLE 4–1.—PREFERRED MODELS FOR SELECTED APPLICATIONS IN SIMPLE TERRAIN—Continued

	Land Use	Model [1]
Buoyant Industrial Line Sources.	Rural	BLP

[1] Several of these models contain options which allow them to be interchanged. For Example, ISCST2 can be substituted for CRSTER and equivalent, if not identical, concentration estimates obtained. Similarly, for a point source application, MPTER with urban option can be substituted for RAM. Where a substitution is convenient to the user and equivalent estimates are assured, it may be made. The models as listed here reflect the applications for which they were originally intended.

[2] Complicated sources are those with special problems such as aerodynamic downwash, particle deposition, volume and area sources, etc.

[3] If only a few sources in an urban area are to be modeled, RAM should be used.

5.0 Model Use in Complex Terrain

5.1 Discussion

For the purpose of this guideline, complex terrain is defined as terrain exceeding the height of the stack being modeled. Complex terrain dispersion models are normally applied to stationary sources of pollutants such as SO_2 and particulates.

A major outcome from the EPA Complex Terrain Model Development project has been the publication of a refined dispersion model (CTDM) suitable for regulatory application to plume impaction assessments in complex terrain.[21] Although CTDM as originally produced was only applicable to those hours characterized as neutral or stable, a computer code for all stability conditions, CTDMPLUS,[19] together with a user's guide,[22] and on-site meteorological and terrain data processors,[23,24] is now available. Moreover, CTSCREEN,[19,25] a version of CTDMPLUS that does not require on-site meteorological data inputs, is also available as a screening technique.

The methods discussed in this section should be considered in two categories: (1) Screening techniques, and (2) the refined dispersion model, CTDMPLUS, discussed below and listed in Appendix A.

Continued improvements in ability to accurately model plume dispersion in complex terrain situations can be expected, e.g., from research on lee side effects due to terrain obstacles. New approaches to improve the ability of models to realistically simulate atmospheric physics, e.g., hybrid models which incorporate an accurate wind field analysis, will ultimately provide more appropriate tools for analyses. Such hybrid modeling techniques are also acceptable for regulatory applications after the appropriate demonstration and evaluation.[15]

5.2 Recommendations

Recommendations in this Section apply primarily to those situations where the impaction of plumes on terrain at elevations equal to or greater than the plume centerline during stable atmospheric conditions are determined to be the problem. If a violation of any NAAQS or the controlling increment is indicated by using any of the preferred screening techniques, then a refined complex terrain model may be used. Phenomena such as fumigation, wind direction shear, lee-side effects, building wake- or terrain-induced downwash, deposition, chemical transformation, variable plume trajectories, and long range transport are not addressed by the recommendations in this section.

Where site-specific data are used for either screening or refined complex terrain models, a data base of at least 1 full-year of meteorological data is preferred. If more data are available, they should be used. Meteorological data used in the analysis should be reviewed for both spatial and temporal representativeness.

Placement of receptors requires very careful attention when modeling in complex terrain. Often the highest concentrations are predicted to occur under very stable conditions, when the plume is near, or impinges on, the terrain. The plume under such conditions may be quite narrow in the vertical, so that even relatively small changes in a receptor's location may substantially affect the predicted concentration. Receptors within about a kilometer of the source may be even more sensitive to location. Thus, a dense array of receptors may be required in some cases. In order to avoid excessively large computer runs due to such a large array of receptors, it is often desirable to model the area twice. The first model run would use a moderate number of receptors carefully located over the area of interest. The second model run would use a more dense array of receptors in areas showing potential for high concentrations, as indicated by the results of the first model run.

When CTSCREEN or CTDMPLUS is used, digitized contour data must be first processed by the CTDM Terrain Processor[23] to provide hill shape parameters in a format suitable for direct input to CTDMPLUS. Then the user supplies receptors either through an interactive program that is part of the model or directly, by using a text editor; using both methods to select receptors will generally be necessary to assure that the maximum concentrations are estimated by either model. In cases where a terrain feature may "appear to the plume" as smaller, multiple hills, it may be necessary to model the terrain both as a single feature and as multiple hills to determine design concentrations.

The user is encouraged to confer with the Regional Office if any unresolvable problems are encountered with any screening or refined analytical procedures, e.g., meteorological data, receptor siting, or terrain contour processing issues.

5.2.1 Screening Techniques

Five preferred screening techniques are currently available to aid in the evaluation of concentrations due to plume impaction during stable conditions: (1) for 24-hour impacts, the Valley Screening Technique[19] as outlined in the Valley Model User's Guide;[26] (2) CTSCREEN,[19] as outlined in the CTSCREEN User's Guide;[25] (3) COMPLEX I;[19] (4) SHORTZ/LONGZ;[19,27] and (5) Rough Terrain Dispersion Model (RTDM)[19,90] in its prescribed mode described below. As appropriate, any of these screening techniques may be used consistent with the needs, resources, and available data of the user.

The Valley Model, COMPLEX I, SHORTZ/LONGZ, and RTDM should be used only to estimate concentrations at receptors whose elevations are greater than or equal to plume height. For receptors at or below stack height, a simple terrain model should be used (see Chapter 4). Receptors between stack height and plume height present a unique problem since none of the above models were designed to handle receptors in this narrow regime, the definition of which will vary hourly as meteorological conditions vary. CTSCREEN may be used to estimate concentrations under all stability conditions at all receptors located "on terrain" above stack top, but has limited applicability in multi-source situations. As a result, the estimation of concentrations at receptors between stack height and plume height should be considered on a case-by-case basis after consultation with the EPA Regional Office; the most appropriate technique may be a function of the actual source(s) and terrain configuration unique to that application. One technique that will generally be acceptable, but is not necessarily preferred for any specific application, involves applying both a complex terrain model (except for the Valley Model) and a simple terrain model. The Valley Model should not be used for any intermediate terrain receptor. For each receptor between stack height and plume height, an hour-by-hour comparison of the concentration estimates from both models is made. The higher of the two modeled concentrations should be chosen to represent the impact at that receptor for that hour, and then used to compute the concentration for the appropriate averaging time(s). For the simple terrain models, terrain may have to be "chopped off" at stack height, since these models are frequently limited to receptors no greater than stack height.

5.2.1.1 *Valley Screening Technique.* The Valley Screening Technique may be used to determine 24-hour averages. This technique uses the Valley Model with the following worst-case assumptions for rural areas: (1) P-G stability "F"; (2) wind speed of 2.5 m/s; and (3) 6 hours of occurrence. For urban areas the stability should be changed to "P-G stability E."

When using the Valley Screening Technique to obtain 24-hour average concentrations the following apply: (1) Multiple sources should be treated individually and the concentrations for each wind direction summed; (2) only one wind direction should be used (see User's Guide,[26] page 2–15) even if individual runs are made for each source; (3) for buoyant sources, the BID option may be used, and the option to use the 2.6 stable plume rise factor should be selected; (4) if plume impaction is likely on any elevated terrain closer to the source than the distance from the source to the final plume rise, then the transitional (or gradual) plume rise option for stable conditions should be selected.

The standard polar receptor grid found in the Valley Model User's Guide may not be sufficiently dense for all analyses if only one geographical scale factor is used. The user should choose an additional set of receptors at appropriate downwind distances whose elevations are equal to plume height minus 10 meters. Alternatively, the user may exercise the "Valley equivalent" option in COMPLEX I or SCREEN2 and note the comments above on the placement of receptors in complex terrain models.

When using the "Valley equivalent" option in COMPLEX I, set the wind profile exponents (PL) to 0.0, respectively, for all six stability classes.

5.2.1.2 *CTSCREEN.* CTSCREEN may be used to obtain conservative, yet realistic, worst-case estimates for receptors located on terrain above stack height. CTSCREEN accounts for the three-dimensional nature of plume and terrain interaction and requires detailed terrain data representative of the modeling domain. The model description and user's instructions are contained in the user's guide.[25] The terrain data must be digitized in the same manner as for CTDMPLUS and a terrain processor is available.[23] A discussion of the model's performance characteristics is provided in a technical paper.[91] CTSCREEN is designed to execute a fixed matrix of meteorological values for wind speed (u), standard deviation of horizontal and vertical wind speeds (σ_v, σ_w), vertical potential temperature gradient ($d\theta/dz$), friction velocity (u_*), Monin-Obukhov length (L), mixing height (z_i) as a function of terrain height, and wind directions for both neutral/stable conditions and unstable convective conditions. Table 5–1 contains the matrix of meteorological variables that is used for each CTSCREEN analysis. There are 96 combinations, including exceptions, for each wind direction for the neutral/stable case, and 108 combinations for the unstable case. The specification of wind direction, however, is handled internally, based on the source and terrain geometry. The matrix was developed from examination of the range of meteorological variables associated with maximum monitored concentrations from the data bases used to evaluate the performance of CTDMPLUS. Although CTSCREEN is designed to address a single source scenario, there are a number of options that can be selected on a case-by-case basis to address multi-source situations. However, the Regional Office should be consulted, and concurrence obtained, on the protocol for modeling multiple sources with CTSCREEN to ensure that the worst case is identified and assessed. The maximum concentration output from CTSCREEN represents a worst-case 1-hour concentration. Time-scaling factors of 0.7 for 3-hour, 0.15 for 24-hour and 0.03 for annual concentration averages are applied internally by CTSCREEN to the highest 1-hour concentration calculated by the model.

5.2.1.3 *COMPLEX I.* If the area is rural, COMPLEX I may be used to estimate concentrations for all averaging times. COMPLEX I is a modification of the MPTER model that incorporates the plume impaction algorithm of the Valley Model.[19] It is a multiple-source screening technique that accepts hourly meteorological data as input. The output is the same as the normal MPTER output. When using COMPLEX I the following options should be selected: (1) set terrain adjustment IOPT(1) = 1; (2) set buoyancy induced dispersion IOPT (4) = 1; (3) set IOPT (25) = 1; (4) set the terrain adjustment values to 0.5, 0.5, 0.5 0.5, 0.0, 0.0, (respectively for six stability classes); and (5) set Z MIN = 10.

When using the "Valley equivalent" option (only) in COMPLEX I, set the wind profile exponents (PL) to 0.0, respectively, for all six stability classes. For all other regulatory uses of COMPLEX I, set the wind profile exponents to the values used in the simple terrain models, i.e., 0.07, 0.07, 0.10, 0.15, 0.35, and 0.55, respectively, for rural modeling.

Gradual plume rise should be used to estimate concentrations at nearby elevated receptors, if plume impaction is likely on any elevated terrain closer to the source than the distance from the source to the final plume rise (see Section 8.2.5).

5.2.1.4 *SHORTZ/LONGZ.* If the source is located in an urbanized (Section 8.2.8) complex terrain valley, then the suggested screening technique is SHORTZ for short-term averages or LONGZ for long-term averages. SHORTZ and LONGZ may be used as screening techniques in these complex terrain applications without demonstration and evaluation. Application of these models in other than urbanized valley situations will require the same evaluation and demonstration procedures as are required for all Appendix B models.

Both SHORTZ and LONGZ have a number of options. When using these models as screening techniques for urbanized valley applications, the options listed in Table 5–2 should be selected.

5.2.1.5 *RTDM (Screening Mode).* RTDM with the options specified in Table 5–3 may be used as a screening technique in rural complex terrain situations without demonstration and evaluation.

The RTDM screening technique can provide a more refined concentration estimate if on-site wind speed and direction characteristic of plume dilution and transport are used as input to the model. In complex terrain, these winds can seldom be estimated accurately from the standard surface (10m level) measurements. Therefore, in order to increase confidence in model estimates, EPA recommends that wind data input to RTDM should be based on fixed measurements at stack top height. For stacks greater than 100m, the measurement height may be limited to 100m in height relative to stack base. However, for very tall stacks, see guidance in section 9.3.3.2. This recommendation is broadened to include wind data representative of plume transport height where such data are derived from measurements taken with remote sensing devices such as SODAR. The data from both fixed and remote measurements should meet quality assurance and recovery rate requirements. The user should also be aware that RTDM in the screening mode accepts the input of measured wind speeds at only one height. The default values for the wind speed profile exponents shown in Table 5–3 are used in the model to determine the wind speed at other heights. RTDM uses wind speed at stack top to calculate the plume rise and the critical dividing streamline height, and the wind speed at plume transport level to calculate dilution. RTDM treats wind direction as constant with height.

RTDM makes use of the "critical dividing streamline" concept and thus treats plume interactions with terrain quite differently from other models such as SHORTZ and COMPLEX I. The plume height relative to the critical dividing streamline determines whether the plume impacts the terrain, or is lifted up and over the terrain. The receptor spacing to identify maximum impact concentrations is quite critical depending on the location of the plume in the vertical. Analysis of the expected plume height relative to the height of the critical dividing streamline should be performed for differing meteorological conditions in order to help develop an appropriate array of receptors. Then it is advisable to model the area twice according to the suggestions in section 5.2.

5.2.1.6 *Restrictions.* For screening analyses using the Valley Screening Technique, COMPLEX I or RTDM, a sector greater than 22½° should not be allowed. Full ground reflection should always be used in the Valley Screening Technique and COMPLEX I.

5.2.2 Refined Analytical Techniques

When the results of the screening analysis demonstrate a possible violation of NAAQS or the controlling PSD increments, a more refined analysis may need to be conducted.

The Complex Terrain Dispersion Model PLus Algorithms for Unstable Situations (CTDMPLUS) is a refined air quality model that is preferred for use in all stability conditions for complex terrain applications. CTDMPLUS is a sequential model that requires five input files: (1) General program specifications; (2) a terrain data file; (3) a receptor file; (4) a surface meteorological data file; and (5) a user created meteorological profile data file. Two optional input files consist of hourly emissions parameters and a file containing upper air data from rawinsonde data files, e.g., a National Climatic Data Center TD-6201 file, unless there are no hours categorized as unstable in the record. The model description and user instructions are contained in Volume 1 of the User's Guide.[22] Separate publications[23,24] describe the terrain preprocessor system and the meteorological preprocessor program. In *Part I* of a technical article[92] is a discussion of the model and its preprocessors; the model's performance characteristics are discussed in *Part II* of the same article.[93] The size of the CTDMPLUS executable file on a personal computer is approximately 360K bytes. The model produces hourly average concentrations of stable pollutants, i.e., chemical transformation or decay of species and settling/deposition are not simulated. To obtain concentration averages corresponding to the NAAQS, e.g., 3- or 24-hour, or annual averages, the user must execute a postprocessor program such as CHAVG.[19] CTDMPLUS is applicable to all receptors on terrain elevations above stack top. However, the model contains no algorithms for simulating building downwash or the mixing or recirculation found in cavity zones in the lee of a hill. The path taken by a plume through an array of hills cannot be simulated. CTDMPLUS does not explicitly simulate calm meteorological periods, and for those situations the user should follow the guidance in Section 9.3.4. The user should follow the recommendations in the User's Guide under General Program Specifications for: (1) Selecting mixed layer heights, (2) setting minimum scalar wind speed to 1 m/s, and (3) scaling wind direction with height. Close coordination with the Regional Office is essential to insure a consistent, technically sound application of this model.

The performance of CTDMPLUS is greatly improved by the use of meteorological data from several levels up to plume height. However, due to the vast range of source-plume-hill geometries possible in complex terrain, detailed requirements for meteorological monitoring in support of refined analyses using CTDMPLUS should be determined on a case-by-case basis. The following general guidance should be considered in the development of a meteorological monitoring protocol for regulatory applications of CTDMPLUS and reviewed in detail by the Regional Office before initiating any monitoring. As appropriate, the On-Site Meteorological Program Guidance document[66] should be consulted for specific guidance on siting requirements for meteorological towers, selection and exposure of sensors, etc. As more experience is gained with the model in a variety of circumstances, more specific guidance may be developed.

Site specific meteorological data are critical to dispersion modeling in complex terrain and, consequently, the meteorological requirements are more demanding than for simple terrain. Generally, three different meteorological files (referred to as surface, profile, and rawin files) are needed to run CTDMPLUS in a regulatory mode.

The surface file is created by the meteorological preprocessor (METPRO)[24] based on on-site measurements or estimates of solar and/or net radiation, cloud cover and ceiling, and the mixed layer height. These data are used in METPRO to calculate the various surface layer scaling parameters (roughness length, friction velocity, and Monin-Obukhov length) which are needed to run the model. All of the user inputs required for the surface file are based either on surface observations or on measurements at or below 10m.

The profile data file is prepared by the user with on-site measurements (from at least three levels) of wind speed, wind direction, turbulence, and potential temperature. These measurements should be obtained up to the representative plume height(s) of interest (i.e., the plume height(s) under those conditions important to the determination of the design concentration). The representative plume height(s) of interest should be determined using an appropriate complex terrain screening procedure (e.g., CTSCREEN) and should be documented in the monitoring/modeling protocol. The necessary meteorological measurements should be obtained from an appropriately sited meteorological tower augmented by SODAR if the representative plume height(s) of interest exceed 100m. The meteorological tower need not exceed the lesser of the representative plume height of interest (the highest plume height if there is more than one plume height of interest) or 100m.

Locating towers on nearby terrain to obtain stack height or plume height measurements for use in profiles by CTDMPLUS should be avoided unless it can clearly be demonstrated that such measurements would be representative of conditions affecting the plume.

The rawin file is created by a second meteorological preprocessor (READ62)[24] based on NWS (National Weather Service) upper air data. The rawin file is used in CTDMPLUS to calculate vertical potential temperature gradients for use in estimating plume penetration in unstable conditions. The representativeness of the off-site NWS upper air data should be evaluated on a case-by-case basis.

In the absence of an appropriate refined model, screening results may need to be used to determine air quality impact and/or emission limits.

TABLE 5–1a.—NEUTRAL/STABLE METEOROLOGICAL MATRIX FOR CTSCREEN

Variable	Specific Values				
U (m/s)	1.0	2.0	3.0	4.0	5.0
σ_v (m/s)	0.3	0.75	....	....	....
σ_w (m/s)	0.08	0.15	0.30	0.75	....
$\Delta\Theta/\Delta z$ (K/m)	0.01	0.02	0.035	....	....
WD (Wind direction optimized internally for each meteorological combination)					

Exceptions:
(1) If $U \leq 2$ m/s and $\sigma_v \leq 0.3$ m/s, then include $\sigma_w = 0.04$ m/s.
(2) If $\sigma_w = 0.75$ m/s and $U \geq 3.0$ m/s, then $\Delta\Theta/\Delta z$ is limited to ≤ 0.01 K/m.

(3) If U ≥ 4 m/s, then $\sigma_w \geq 0.15$ m/s.
(4) $\sigma_w \leq \sigma_v$

TABLE 5–1b.—UNSTABLE/CONVECTIVE METEOROLOGICAL MATRIX FOR CTSCREEN

Variable		Specific Values				
U (m/s)		1.0	2.0	3.0	4.0	5.0
u_* (m/s)		0.1	0.3	0.5	....	....
L (m)		−10	−50	−90	....	....
$\Delta\Theta/\Delta z$ (K/m)	0.030 (potential temperature gradient above z_i)					
z_i (m)		0.5h	1.0h	1.5h	....	....

Where h = terrain height.

TABLE 5–2.—PREFERRED OPTIONS FOR THE SHORTZ/LONGZ COMPUTER CODES WHEN USED IN A SCREENING MODE

Option	Selection
I Switch 9	If using NWS data, set = 0. If using site-specific data, check with the Regional Office.
I Switch 17	Set = 1 (urban option).
GAMMA 1	Use default values (0.6 entrainment coefficient).
GAMMA 2	Always default to "stable".
XRY	Set = 0 (50m rectilinear expansion distance).
NS, VS, FRQ (SHORTZ) (particle size, etc.)	Do not use (applicable only in flat terrain.) NUS, VS, FRQ (LONGZ)
ALPHA	Select 0.9.
SIGEPU	(Use Cramer curves (default); if site-specific turbulence data are available, see Regional Office for advice. (dispersion parameters) SIGAPU
P (wind profile)	Select default values given in Table 2–2 of User's Instructions; if site-specific data are available, see Regional Office for advice.

TABLE 5–3.—PREFERRED OPTIONS FOR THE RTDM COMPUTER CODE WHEN USED IN A SCREENING MODE

Parameter	Variable	Value	Remarks
PR001–003	SCALE		Scale factors assuming horizontal distance is in kilometers, vertical distance is in feet, and wind speed is in meters per second.
PR004	ZWIND1	Wind measurement height	See Section 5.2.1.4.
	ZWIND2	Not used	Height of second anemometer.
	IDILUT	1	Dilution wind speed scaled to plume height.
	ZA	0 (default)	Anemometer-terrain height above stack base.
PR005	EXPON	0.09, 0.11, 0.12, 0.14, 0.2, 0.3 (default).	Wind profile exponents.
PR006	ICOEF	3 (default)	Briggs Rural/ASME (1979) dispersion parameters.
PR009	IPPP	0 (default)	Partial plume penetration; not used.
PR010	IBUOY	1 (default)	Buoyancy-enhanced dispersion is used.
	ALPHA	3.162 (default)	Buoyancy-enhanced dispersion coefficient.
PR011	IDMX	1 (default)	Unlimited mixing height for stable conditions.
PR012	ITRANS	1 (default)	Transitional plume rise is used.
PR.013	TERCOR	6*0.5 (default)	Plume patch correction factors.
PR014	RVPTG	0.02, 0.035 (default)	Vertical potential temperature gradient values for stabilities E and F.
PR015	ITIPD	1	Stack-tip downwash is used.
PR020	ISHEAR	0 (default)	Wind shear; not used
PR022	IREFL	1 (default)	Partial surface reflection is used.
PR023	IHORIZ	2 (default)	Sector averaging.
	SECTOR	6*22.5 (default)	Using 22.5° sectors.
PR016 to 019; 021; and 024.	IY, IZ, IRVPTG, IHVPTG; IEPS; IEMIS	0	Hourly values of turbulence, vertical potential temperature gradient, wind speed profile exponents, and stack emissions are not used.

6.0 Models for Ozone, Carbon Monoxide and Nitrogen Dioxide

6.1 Discussion

Models discussed in this section are applicable to pollutants often associated with mobile sources, e.g., ozone (O_3), carbon monoxide (CO) and nitrogen dioxide (NO_2). Where stationary sources of CO and NO_2 are of concern, the reader is referred to sections 4 and 5.

A control agency with jurisdiction over areas with significant ozone problems and which has sufficient resources and data to use a photochemical dispersion model is encouraged to do so. Experience with and evaluations of the Urban Airshed Model show it to be an acceptable, refined approach, and better data bases are becoming available that support the more sophisticated analytical procedures. However, empirical models (e.g., EKMA) fill the gap between more sophisticated photochemical dispersion models and proportional (rollback) modeling techniques and may be the only applicable procedure if the available data bases are insufficient for refined dispersion modeling.

Models for assessing the impact of carbon monoxide emissions are needed for a number of different purposes, e.g., to evaluate the effects of point sources, congested intersections and highways, as well as the cumulative effect on ambient CO concentrations of all sources of CO in an urban area.[94,95]

Nitrogen oxides are reactive and also an important contribution to the photochemical ozone problem. They are usually of most concern in areas of high ozone concentrations. Unless suitable photochemical dispersion models are used, assumptions regarding the conversion of NO to NO_2 are required when modeling. Site-specific conversion factors may be developed. If site-specific conversion factors are not available or photochemical models are not used, NO_2 modeling should be considered only a screening procedure.

6.2 Recommendations

6.2.1 Models for Ozone

The Urban Airshed Model (UAM)[19,28] is recommended for photochemical or reactive pollutant modeling applications involving entire urban areas. To ensure proper execution of this numerical model, users must satisfy the extensive input data requirements for the model as listed in appendix A and the users guide. Users are also referred to the "Guideline for Regulatory Application of the Urban Airshed Model"[29] for additional data requirements and procedures for operating this model.

The empirical model, City-specific EKMA,[19, 30–33] has limited applicability for urban ozone analyses. Model users should consult the appropriate Regional Office on a case-by-case basis concerning acceptability of this modeling technique.

Appendix B contains some additional models that may be applied on a case-by-case basis for photochemical or reactive pollutant modeling. Other photochemical models, including multi-layered trajectory models, that are available may be used if shown to be appropriate. Most photochemical dispersion models require emission data on individual hydrocarbon species and may require three dimensional meteorological information on an hourly basis. Reasonably sophisticated computer facilities are also often required. Because the input data are not universally available and studies to collect such data are very resource intensive, there are only limited evaluations of those models.

For those cases which involve estimating the impact on ozone concentrations due to stationary sources of VOC and NO_x, whether for permitting or other regulatory cases, the model user should consult the appropriate Regional Office on the acceptability of the modeling technique.

Proportional (rollback/forward) modeling is not an acceptable procedure for evaluating ozone control strategies.

6.2.2 Models for Carbon Monoxide

For analyzing CO impacts at roadway intersections, users should follow the procedures in the "Guideline for Modeling Carbon Monoxide from Roadway Intersections".[34] The recommended model for such analyses is CAL3QHC.[35] This model combines CALINE3 (already in Appendix A) with a traffic model to calculate delays and queues that occur at signalized intersections. In areas where the use of either TEXIN2 or CALINE4 has previously been established, its use may continue. The capability exists for these intersection models to be used in either a screening or refined mode. The screening approach is described in reference 34; a refined approach may be considered on a case-by-case basis. The latest version of the MOBILE (mobile source emission factor) model should be used for emissions input to intersection models.

For analyses of highways characterized by uninterrupted traffic flows, CALINE3 is recommended, with emissions input from the latest version of the MOBILE model.

The recommended model for urban areawide CO analyses is RAM or Urban Airshed Model (UAM); see appendix A. Information on SIP development and requirements for using these models can be found in references 34, 96, 97 and 98.

Where point sources of CO are of concern, they should be treated using the screening and refined techniques described in Section 4 or 5 of the Guideline.

6.2.3 Models for Nitrogen Dioxide (Annual Average)

A three-tiered screening approach is recommended to obtain annual average estimates of NO_2 from point sources for New Source Review analysis, including PSD, and for SIP planning purposes:

a. Initial screen: Use an appropriate Gaussian model from appendix A to estimate the maximum annual average concentration and assume a total conversion of NO to NO_2. If the concentration exceeds the NAAQS and/or PSD increments for NO_2, proceed to the 2nd level screen.

b. 2nd level screen: Apply the Ozone Limiting Method[36] to the annual NO_x estimate obtained in (a) above using a representative average annual ozone concentration. If the result is still greater than the NAAQS, and/or PSD increments, the more refined Ozone Limiting Method in the 3rd level screen should be applied.

c. 3rd level screen: Apply the Ozone Limiting Method separately for each hour of the year or multi-year period. Use representative hourly NO_2 background and ozone levels in the calculations.

In urban areas, a proportional model may be used as a preliminary assessment to evaluate control strategies to meet the NAAQS for multiple minor sources, i.e., minor point, area and mobile sources of NO_x; concentrations resulting from major point sources should be estimated separately as discussed above, then added to the impact of the minor sources. An acceptable screening technique for urban complexes is to assume that all NO_x is emitted in the form of NO_2 and to use a model from appendix A for nonreactive pollutants to estimate NO_2 concentrations. A more accurate estimate can be obtained by (1) calculating the annual average concentrations of NO_x with an urban model, and (2) converting these estimates to NO_2 concentrations based on a spatially averaged NO_2/NO_x annual ratio determined from an existing air quality monitoring network.

To demonstrate compliance with NO_2 PSD increments in urban areas, emissions from major and minor sources should be included in the modeling analysis. Point and area source emissions should be modeled as discussed above. If mobile source emissions do not contribute to localized areas of high ambient NO_2 concentrations, they should be modeled as area sources. When modeled as area sources, mobile source emissions should be assumed uniform over the entire highway link and allocated to each area source grid square based on the portion of highway link within each grid square. If localized areas of high concentrations are likely, then mobile sources should be modeled as line sources with the preferred model ISCLT2.

In situations where there are sufficient hydrocarbons available to significantly enhance the rate of NO to NO_2 conversion, the assumptions implicit in the Ozone Limiting Procedure may not be appropriate More refined techniques should be considered on a case-by-case basis and agreement with the reviewing authority should be obtained. Such techniques should consider individual quantities of NO and NO_2 emissions, atmospheric transport and dispersion, and atmospheric transformation of NO to NO_2. Where it is available site-specific data on the conversion of NO to NO_2 may be used. Photochemical dispersion models, if used for other pollutants in the area, may also be applied to the NO_x problem.

7.0 Other Model Requirements

7.1 Discussion

This section covers those cases where specific techniques have been developed for special regulatory programs. Most of the programs have, or will have when fully developed, separate guidance documents that cover the program and a discussion of the tools that are needed. The following paragraphs reference those guidance documents, when they are available. No attempt has been made to provide a comprehensive discussion of each topic since the reference documents were designed to do that. This section will undergo periodic revision as new programs are added and new techniques are developed.

Other Federal agencies have also developed specific modeling approaches for their own regulatory or other requirements. An example of this is the three-volume manual issued by the U.S. Department of Housing and Urban Development, "Air Quality Considerations in Residential Planning."[37] Although such regulatory requirements and manuals may have come about because of EPA rules or standards, the implementation of such regulations and the use of the modeling techniques is under the jurisdiction of the agency issuing the manual or directive.

The need to estimate impacts at distances greater than 50km (the nominal distance to which EPA considers most Gaussian models applicable) is an important one especially when considering the effects from secondary pollutants. Unfortunately, models submitted to EPA have not as yet undergone sufficient field evaluation to be recommended for general use. Existing data bases from field studies at mesoscale and long range transport distances are limited in detail. This limitation is a result of the expense to perform the field studies required to verify and improve mesoscale and long range transport models. Particularly important and sparse are meteorological data adequate for generating three dimensional wind fields. Application of models to complicated terrain compounds the difficulty. EPA has completed limited evaluation of several long range transport (LRT) models against two sets of field data. The evaluation results are discussed in the document, "Evaluation of Short-Term Long-Range Transport Models."[99,100] For the time being, long range and mesoscale transport models must be evaluated for regulatory use on a case-by-case basis.

There are several regulatory programs for which air pathway analysis procedures and modeling techniques have been developed. For continuous emission releases, ISC2 forms the basis of many analytical techniques. EPA is continuing to evaluate the performance of a number of proprietary and public domain models for intermittent and non-stack emission releases. Until EPA completes its evaluation, it is premature to recommend specific models for air pathway analyses of intermittent and non-stack releases in this guideline.

Regional scale models are used by EPA to develop and evaluate national policy and assist State and local control agencies. Two such models are the Regional Oxidant Model (ROM)[101,102,103] and the Regional Acid Deposition Model (RADM).[104] Due to the level of resources required to apply these models, it is not envisioned that regional scale models will be used directly in most model applications.

7.2 Recommendations

7.2.1 Fugitive Dust/Fugitive Emissions

Fugitive dust usually refers to the dust put into the atmosphere by the wind blowing over plowed fields, dirt roads or desert or sandy areas with little or no vegetation. Reentrained dust is that which is put into the air by reason of vehicles driving over dirt roads (or dirty roads) and dusty areas. Such sources can be characterized as line, area or volume sources. Emission rates may be based on site-specific data or values from the general literature.

Fugitive emissions are usually defined as emissions that come from an industrial source complex. They include the emissions resulting from the industrial process that are not captured and vented through a stack but may be released from various locations within the complex. Where such fugitive emissions can be properly specified, the ISC model, with consideration of gravitational settling and dry deposition, is the recommended model. In some unique cases a model developed specifically for the situation may be needed.

Due to the difficult nature of characterizing and modeling fugitive dust and fugitive emissions, it is recommended that the proposed procedure be cleared by the appropriate Regional Office for each specific situation before the modeling exercise is begun.

7.2.2 Particulate Matter

The new particulate matter NAAQS, promulgated on July 1, 1987 (52 FR 24634), includes only particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM–10). EPA has also proposed regulations for PSD increments measured as PM–10 in a notice published on October 5, 1989 (54 FR 41218).

Screening techniques like those identified in section 4 are also applicable to PM–10 and to large particles. It is recommended that subjectively determined values for "half-life" or pollutant decay not be used as a surrogate for particle removal. Conservative assumptions which do not allow removal or transformation are suggested for screening. Proportional models (rollback/forward) may not be applied for screening analysis, unless such techniques are used in conjunction with receptor modeling.

Refined models such as those in Section 4 are recommended for PM–10 and large particles. However, where possible, particle size, gas-to-particle formation, and their effect on ambient concentrations may be considered. For urban-wide refined analyses CDM 2.0 or RAM should be used. CRSTER and MPTER are recommended for point sources of small particles. For source-specific analyses of complicated sources, the ISC2 model is preferred. No model recommended for general use at this time accounts for secondary particulate formation or other transformations in a manner suitable for SIP control strategy demonstrations. Where possible, the use of receptor models[38,39,105,106,107] in conjunction with dispersion models is encouraged to more precisely characterize the emissions inventory and to validate source specific impacts calculated by the dispersion model. A SIP development guideline,[108] model reconciliation guidance,[106] and an example model application[109] are available to assist in PM–10 analyses and control strategy development.

Under certain conditions, recommended dispersion models are not available or applicable. In such circumstances, the modeling approach should be approved by the appropriate Regional Office on a case-by-case basis. For example, where there is no recommended air quality model and area sources are a predominant component of PM–10, an attainment demonstration may be based on rollback of the apportionment derived from two reconciled receptor models, if the strategy provides a conservative demonstration of attainment. At this time, analyses involving model calculations for distances beyond 50km and under stagnation conditions should also be justified on a case-by-case basis (see Sections 7.2.6 and 8.2.10).

As an aid to assessing the impact on ambient air quality of particulate matter generated from prescribed burning activities, reference 110 is available.

7.2.3 Lead

The air quality analyses required for lead implementation plans are given in §§ 51.83, 51.84 and 51.85 of 40 CFR part 51. Sections 51.83 and 51.85 require the use of a modified rollback model as a minimum to demonstrate attainment of the lead air quality standard but the use of a dispersion model is the preferred approach. Section 51.83 requires the analysis of an entire urban area if the measured lead concentration in the urbanized area exceeds a quarterly (three month) average of 4.0 $\mu g/m^3$. Section 51.84 requires the use of a dispersion model to demonstrate attainment of the lead air quality standard around specified lead point sources. For other areas reporting a violation of the lead standard, § 51.85 requires an analysis of the area in the vicinity of the monitor reporting the violation. The NAAQS for lead is a quarterly (three month) average, thus requiring the use of modeling techniques that can provide long-term concentration estimates.

The SIP should contain an air quality analysis to determine the maximum quarterly lead concentration resulting from major lead point sources, such as smelters, gasoline additive plants, etc. For these applications the ISC model is preferred, since the model can account for deposition of particles and the impact of fugitive emissions. If the source is located in complicated terrain or is subject to unusual climatic conditions, a case-specific review by the appropriate Regional Office may be required.

In modeling the effect of traditional line sources (such as a specific roadway or highway) on lead air quality, dispersion models applied for other pollutants can be used. Dispersion models such as CALINE3 and APRAC–3 have been widely used for modeling carbon monoxide emissions from highways. However, where deposition is of concern, the line source treatment in ISC may be used. Also, where there is a point source in the middle of a substantial road network, the lead concentrations that result from the road network should be treated as background (see Section 9.2); the point source and any nearby major roadways should be modeled separately using the ISC model.

To model an entire major urban area or to model areas without significant sources of lead emissions, as a minimum a proportional (rollback) model may be used for air quality analysis. The rollback philosophy assumes that measured pollutant concentrations are proportional to emissions. However, urban or other dispersion models are encouraged in these circumstances where the use of such models is feasible.

For further information concerning the use of models in the development of lead implementation plans, the documents "Supplementary Guidelines for Lead Implementation Plans,"[40] and "Updated Information on Approval and Promulgation of Lead Implementation Plans,"[41] should be consulted.

7.2.4 Visibility

The visibility regulations as promulgated in December 1980[b] require consideration of

[b] 40 CFR 51.300–307.

the effect of new sources on the visibility values of Federal Class I areas. The state of scientific knowledge concerning identifying, monitoring, modeling, and controlling visibility impairment is contained in an EPA report "Protecting Visibility: An EPA Report to Congress".[42] In 1985, EPA promulgated Federal Implementation Plans (FIPs) for states without approved visibility provisions in their SIPs. A monitoring plan was established as part of the FIPs.[c]

Guidance and a screening model, VISCREEN, is contained in the EPA document "Workbook for Plume Visual Impact Screening and Analysis (Revised)."[43] VISCREEN can be used to calculate the potential impact of a plume of specified emissions for specific transport and dispersion conditions. If a more comprehensive analysis is required, any refined model should be selected in consultation with the EPA Regional Office and the appropriate Federal Land Manager who is responsible for determining whether there is an adverse effect by a plume on a Class I area.

PLUVUE II, listed in Appendix B, may be applied on a case-by-case basis when refined plume visibility evaluations are needed. Plume visibility models have been evaluated against several data sets.[44,45]

7.2.5 Good Engineering Practice Stack Height

The use of stack height credit in excess of Good Engineering Practice (GEP) stack height or credit resulting from any other dispersion technique is prohibited in the development of emission limitations by 40 CFR 51.118 and 40 CFR 51.164. The definitions of GEP stack height and dispersion technique are contained in 40 CFR 51.100. Methods and procedures for making the appropriate stack height calculations, determining stack height credits and an example of applying those techniques are found in references 46, 47, 48, and 49.

If stacks for new or existing major sources are found to be less than the height defined by EPA's refined formula for determining GEP height,[d] then air quality impacts associated with cavity or wake effects due to the nearby building structures should be determined. Detailed downwash screening procedures[18] for both the cavity and wake regions should be followed. If more refined concentration estimates are required, the Industrial Source Complex (ISC2) model contains algorithms for building wake calculations and should be used. Fluid modeling can provide a great deal of additional information for evaluating and describing the cavity and wake effects.

7.2.6 Long Range Transport (LRT) (i.e., beyond 50km)

Section 165(e) of the Clean Air Act requires that suspected significant impacts on PSD Class I areas be determined. However, 50km is the useful distance to which most Gaussian models are considered accurate for setting emission limits. Since in many cases PSD analyses may show that Class I areas may be threatened at distances greater than 50km from new sources, some procedure is needed to (1) determine if a significant impact will occur, and (2) identify the model to be used in setting an emission limit if the Class I increments are threatened (models for this purpose should be approved for use on a case-by-case basis as required in section 3.2). This procedure and the models selected for use should be determined in consultation with the EPA Regional Office and the appropriate Federal Land Manager (FLM). While the ultimate decision on whether a Class I area is adversely affected is the responsibility of the permitting authority, the FLM has an affirmative responsibility to protect air quality related values that may be affected.

If LRT is determined to be important, then estimates utilizing an appropriate refined model for receptors at distances greater than 50 km should be obtained. MESOPUFF II, listed in appendix B, may be applied on a case-by-case basis when LRT estimates are needed. Additional information on applying this model is contained in the EPA document "A Modeling Protocol For Applying MESOPUFF II to Long Range Transport Problems".[111]

7.2.7 Modeling Guidance for Other Governmental Programs

When using the models recommended or discussed in this guideline in support of programmatic requirements not specifically covered by EPA regulations, the model user should consult the appropriate Federal or State agency to ensure the proper application and use of that model. For modeling associated with PSD permit applications that involve a Class I area, the appropriate Federal Land Manager should be consulted on all modeling questions.

The Offshore and Coastal Dispersion (OCD) model[112] was developed by the Minerals Management Service and is recommended for estimating air quality impact from offshore sources on onshore flat terrain areas. The OCD model is not recommended for use in air quality impact assessments for onshore sources. Sources located on or just inland of a shoreline where fumigation is expected should be treated in accordance with section 8.2.9.

The Emissions and Dispersion Modeling System (EDMS)[113] was developed by the Federal Aviation Administration and the United States Air Force and is recommended for air quality assessment of primary pollutant impacts at airports or air bases. Regulatory application of EDMS is intended for estimating the cumulative effect of changes in aircraft operations, point source, and mobile source emissions on pollutant concentrations. It is not intended for PSD, SIP, or other regulatory air quality analyses of point or mobile sources at or peripheral to airport property that are independent of changes in aircraft operations. If changes in other than aircraft operations are associated with analyses, a model recommended in chapter 4, 5, or 6 should be used.

7.2.8 Air Pathway Analyses (Air Toxics and Hazardous Waste)

Modeling is becoming an increasingly important tool for regulatory control agencies to assess the air quality impact of releases of toxics and hazardous waste materials. Appropriate screening techniques[114,115] for calculating ambient concentrations due to various well-defined neutrally buoyant toxic/hazardous pollutant releases are available.

Several regulatory programs within EPA have developed modeling techniques and guidance for conducting air pathway analyses as noted in references 116–129. ISC2 forms the basis of the modeling procedures for air pathway analyses of many of these regulatory programs and, where identified, is appropriate for obtaining refined ambient concentration estimates of neutrally buoyant continuous air toxic releases from traditional sources. Appendix A to this Guideline contains additional models appropriate for obtaining refined estimates of continuous air toxic releases from traditional sources. Appendix B contains models that may be used on a case-by-case basis for obtaining refined estimates of denser-than-air intermittent gaseous releases, e.g., DEGADIS;[130] guidance for the use of such models is also available.[131]

Many air toxics models require input of chemical properties and/or chemical engineering variables in order to appropriately characterize the source emissions prior to dispersion in the atmosphere; reference 132 is one source of helpful data. In addition, EPA has numerous programs to determine emission factors and other estimates of air toxic emissions. The Regional Office should be consulted for guidance on appropriate emission estimating procedures and any uncertainties that may be associated with them.

8.0 General Modeling Considerations

8.1 Discussion

This section contains recommendations concerning a number of different issues not explicitly covered in other sections of this guide. The topics covered here are not specific to any one program or modeling area but are common to nearly all modeling analyses.

8.2 Recommendations

8.2.1 Design Concentrations

8.2.1.1 *Design Concentrations for Criteria Pollutants with Deterministic Standards.* An air quality analysis for SO_2, CO, Pb, and NO_2 is required to determine if the source will (1) cause a violation of the NAAQS, or (2) cause or contribute to air quality deterioration greater than the specified allowable PSD increment. For the former, background concentration (see Section 9.2) should be added to the estimated impact of the source to determine the design concentration. For the latter, the design concentration includes impact from all increment consuming sources.

If the air quality analyses are conducted using the period of meteorological input data recommended in section 9.3.1.2 (e.g., 5 years of NWS data or 1 year of site-specific data), then the design concentration based on the highest, second-highest short term concentration or long term average, whichever is controlling, should be used to determine emission limitations to assess

[c] 40 CFR 51.300–307.

[d] The EPA refined formula height is defined as H + 1.5L (see Reference 46).

compliance with the NAAQS and to determine PSD increments.

When sufficient and representative data exist for less than a 5-year period from a nearby NWS site, or when on-site data have been collected for less than a full continuous year, or when it has been determined that the on-site data may not be temporally representative, then the highest concentration estimate should be considered the design value. This is because the length of the data record may be too short to assure that the conditions producing worst-case estimates have been adequately sampled. The highest value is then a surrogate for the concentration that is not to be exceeded more than once per year (the wording of the deterministic standards). Also, the highest concentration should be used whenever selected worst-case conditions are input to a screening technique. This specifically applies to the use of techniques such as outlined in "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised".[18] Specific guidance for CO may be found in the "Guideline for Modeling Carbon Monoxide from Roadway Intersections".[34]

If the controlling concentration is an annual average value and multiple years of data (on-site or NWS) are used, then the design value is the highest of the annual averages calculated for the individual years. If the controlling concentration is a quarterly average and multiple years are used, then the highest individual quarterly average should be considered the design value.

As long a period of record as possible should be used in making estimates to determine design values and PSD increments. If more than 1 year of site-specific data is available, it should be used.

8.2.1.2 *Design Concentrations for Criteria Pollutants with Expected Exceedance Standards.* Specific instructions for the determination of design concentrations for criteria pollutants with expected exceedance standards, ozone and PM-10, are contained in special guidance documents for the preparation of SIPs for those pollutants.[86 108] For all SIP revisions the user should check with the Regional Office to obtain the most recent guidance documents and policy memoranda concerning the pollutant in question.

8.2.2 Critical Receptor Sites

Receptor sites for refined modeling should be utilized in sufficient detail to estimate the highest concentrations and possible violations of a NAAQS or a PSD increment. In designing a receptor network, the emphasis should be placed on receptor resolution and location, not total number of receptors. The selection of receptor sites should be a case-bycase determination taking into consideration the topography, the climatology, monitor sites, and the results of the initial screening procedure. For large sources (those equivalent to a 500 MW power plant) and where violations of the NAAQS or PSD increment are likely, 360 receptors for a polar coordinate grid system and 400 receptors for a rectangular grid system, where the distance from the source to the farthest receptor is 10km, are usually adequate to identify areas of high concentration. Additional receptors may be needed in the high concentration location if greater resolution is indicated by terrain or source factors.

8.2.3 Dispersion Coefficients

Gaussian models used in most applications should employ dispersion coefficients consistent with those contained in the preferred models in Appendix A. Factors such as averaging time, urban/rural surroundings, and type of source (point vs. line) may dictate the selection of specific coefficients. Generally, coefficients used in appendix A models are identical to, or at least based on, Pasquill-Gifford coefficients[50] in rural areas and McElroy-Pooler[51] coefficients in urban areas.

Research is continuing toward the development of methods to determine dispersion coefficients directly from measured or observed variables.[52 53] No method to date has proved to be widely applicable. Thus, direct measurement, as well as other dispersion coefficients related to distance and stability, may be used in Gaussian modeling only if a demonstration can be made that such parameters are more applicable and accurate for the given situation than are algorithms contained in the preferred models.

Buoyancy-induced dispersion (BID), as identified by Pasquill,[54] is included in the preferred models and should be used where buoyant sources, e.g., those involving fuel combustion, are involved.

8.2.4 Stability Categories

The Pasquill approach to classifying stability is generally required in all preferred models (Appendix A). The Pasquill method, as modified by Turner,[55] was developed for use with commonly observed meteorological data from the National Weather Service and is based on cloud cover, insolation and wind speed.

Procedures to determine Pasquill stability categories from other than NWS data are found in subsection 9.3. Any other method to determine Pasquill stability categories must be justified on a case-by-case basis.

For a given model application where stability categories are the basis for selecting dispersion coefficients, both σ_y and σ_z should be determined from the same stability category. "Split sigmas" in that instance are not recommended.

Sector averaging, which eliminates the σ_y term, is generally acceptable only to determine long term averages, such as seasonal or annual, and when the meteorological input data are statistically summarized as in the STAR summaries. Sector averaging is, however, commonly acceptable in complex terrain screening methods.

8.2.5 Plume Rise

The plume rise methods of Briggs[56 57] are incorporated in the preferred models and are recommended for use in all modeling applications. No provisions in these models are made for fumigation or multistack plume rise enhancement or the handling of such special plumes as flares; these problems should be considered on a case-by-case basis.

Since there is insufficient information to identify and quantify dispersion during the transitional plume rise period, gradual plume rise is not generally recommended for use. There are two exceptions where the use of gradual plume rise is appropriate: (1) In complex terrain screening procedures to determine close-in impacts; (2) when calculating the effects of building wakes. The building wake algorithm in the ISC2 model incorporates and automatically (i.e., internally) exercises the gradual plume rise calculations. If the building wake is calculated to affect the plume for any hour, gradual plume rise is also used in downwind dispersion calculations to the distance of final plume rise, after which final plume rise is used.

Stack tip downwash generally occurs with poorly constructed stacks and when the ratio of the stack exit velocity to wind speed is small. An algorithm developed by Briggs (Hanna, et al.)[57] is the recommended technique for this situation and is found in the point source preferred models.

Where aerodynamic downwash occurs due to the adverse influence of nearby structures, the algorithms included in the ISC2 model[58] should be used.

8.2.6 Chemical Transformation

The chemical transformation of SO_2 emitted from point sources or single industrial plants in rural areas is generally assumed to be relatively unimportant to the estimation of maximum concentrations when travel time is limited to a few hours. However, in urban areas, where synergistic effects among pollutants are of considerable consequence, chemical transformation rates may be of concern. In urban area applications, a half-life of 4 hours[55] may be applied to the analysis of SO_2 emissions. Calculations of transformation coefficients from site-specific studies can be used to define a "half-life" to be used in a Gaussian model with any travel time, or in any application, if appropriate documentation is provided. Such conversion factors for pollutant half-life should not be used with screening analyses.

Complete conversion of NO to NO_2 should be assumed for all travel time when simple screening techniques are used to model point source emissions of nitrogen oxides. If a Gaussian model is used, and data are available on seasonal variations in maximum ozone concentrations, the Ozone Limiting Method[36] is recommended. In refined analyses, case-by case conversion rates based on technical studies appropriate to the site in question may be used. The use of more sophisticated modeling techniques should be justified for individual cases.

Use of models incorporating complex chemical mechanisms should be considered only on a case-by-case basis with proper demonstration of applicability. These are generally regional models not designed for the evaluation of individual sources but used primarily for region-wide evaluations. Visibility models also incorporate chemical transformation mechanisms which are an integral part of the visibility model itself and should be used in visibility assessments.

8.2.7 Gravitational Settling and Deposition

An "infinite half-life" should be used fo1 estimates of total suspended particulate concentrations when Gaussian models containing only exponential decay terms for treating settling and deposition are used.

Gravitational settling and deposition may be directly included in a model if either is a significant factor. At least one preferred model (ISC) contains settling and deposition algorithms and is recommended for use when particulate matter sources can be quantified and settling and deposition are problems.

8.2.8 Urban/Rural Classification

The selection of either rural or urban dispersion coefficients in a specific application should follow one of the procedures suggested by Irwin [59] and briefly described below. These include a land use classification procedure or a population based procedure to determine whether the character of an area is primarily urban or rural.

Land Use Procedure: (1) Classify the land use within the total area, A_o, circumscribed by a 3km radius circle about the source using the meteorological land use typing scheme proposed by Auer [60]; (2) if land use types I1, I2, C1, R2, and R3 account for 50 percent or more of A_o, use urban dispersion coefficients; otherwise, use appropriate rural dispersion coefficients.

Population Density Procedure: (1) Compute the average population density, $\bar{p}$ per square kilometer with A_o as defined above; (2) If $\bar{p}$ is greater than 750 people/km^2, use urban dispersion coefficients; otherwise use appropriate rural dispersion coefficients.

Of the two methods the land use procedure is considered more definitive. Population density should be used with caution and should not be applied to highly industrialized areas where the population density may be low and thus a rural classification would be indicated, but the area is sufficiently built-up so that the urban land use criteria would be satisfied. In this case, the classification should already be "urban" and urban dispersion parameters should be used.

Sources located in an area defined as urban should be modeled using urban dispersion parameters. Sources located in areas defined as rural should be modeled using the rural dispersion parameters. For analyses of whole urban complexes, the entire area should be modeled as an urban region if most of the sources are located in areas classified as urban.

8.2.9 Fumigation

Fumigation occurs when a plume (or multiple plumes) is emitted into a stable layer of air and that layer is subsequently mixed to the ground either through convective transfer of heat from the surface or because of advection to less stable surroundings. Fumigation may cause excessively high concentrations but is usually rather short-lived at a given receptor. There are no recommended refined techniques to model this phenomenon. There are, however, screening procedures (see "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources" [18]) that may be used to approximate the concentrations. Considerable care should be exercised in using the results obtained from the screening techniques.

Fumigation is also an important phenomenon on and near the shoreline of bodies of water. This can affect both individual plumes and area-wide emissions. When fumigation conditions are expected to occur from a source or sources with tall stacks located on or just inland of a shoreline, this should be addressed in the air quality modeling analysis. The Shoreline Dispersion Model (SDM) listed in Appendix B may be applied on a case-by-case basis when air quality estimates under shoreline fumigation conditions are needed.[133] Information on the results of EPA's evaluation of this model together with other coastal fumigation models may be found in reference 134. Selection of the appropriate model for applications where shoreline fumigation is of concern should be determined in consultation with the Regional Office.

8.2.10 Stagnation

Stagnation conditions are characterized by calm or very low wind speeds, and variable wind directions. These stagnant meteorological conditions may persist for several hours to several days. During stagnation conditions, the dispersion of air pollutants, especially those from low-level emissions sources, tends to be minimized, potentially leading to relatively high ground-level concentrations.

When stagnation periods such as these are found to occur, they should be addressed in the air quality modeling analysis. WYNDvalley, listed in appendix B, may be applied on a case-by-case basis for stagnation periods of 24 hours or longer in valley-type situations. Caution should be exercised when applying the model to elevated point sources. Users should consult with the appropriate Regional Office prior to regulatory application of WYNDvalley.

8.2.11 Calibration of Models

Calibration of long term multi-source models has been a widely used procedure even though the limitations imposed by statistical theory on the reliability of the calibration process for long term estimates are well known.[61] In some cases, where a more accurate model is not available, calibration may be the best alternative for improving the accuracy of the estimated concentrations needed for control strategy evaluations.

Calibration of short term models is not common practice and is subject to much greater error and misunderstanding. There have been attempts by some to compare short term estimates and measurements on an event-by-event basis and then to calibrate a model with results of that comparison. This approach is severely limited by uncertainties in both source and meteorological data and therefore it is difficult to precisely estimate the concentration at an exact location for a specific increment of time. Such uncertainties make calibration of short term models of questionable benefit. Therefore, short term model calibration is unacceptable.

9.0 Model Input Data

Data bases and related procedures for estimating input parameters are an integral part of the modeling procedure. The most appropriate data available should always be selected for use in modeling analyses. Concentrations can vary widely depending on the source data or meteorological data used. Input data are a major source of inconsistencies in any modeling analysis. This section attempts to minimize the uncertainty associated with data base selection and use by identifying requirements for data used in modeling. A checklist of input data requirements for modeling analyses is included as appendix C. More specific data requirements and the format required for the individual models are described in detail in the users' guide for each model.

9.1 Source Data

9.1.1 Discussion

Sources of pollutants can be classified as point, line and area/volume sources. Point sources are defined in terms of size and may vary between regulatory programs. The line sources most frequently considered are roadways and streets along which there are well-defined movements of motor vehicles, but they may be lines of roof vents or stacks such as in aluminum refineries. Area and volume sources are often collections of a multitude of minor sources with individually small emissions that are impractical to consider as separate point or line sources. Large area sources are typically treated as a grid network of square areas, with pollutant emissions distributed uniformly within each grid square.

Emission factors are compiled in an EPA publication commonly known as AP–42;[62] an indication of the quality and amount of data on which many of the factors are based is also provided. Other information concerning emissions is available in EPA publications relating to specific source categories. The Regional Office should be consulted to determine appropriate source definitions and for guidance concerning the determination of emissions from and techniques for modeling the various source types.

9.1.2 Recommendations

For point source applications the load or operating condition that causes maximum ground-level concentrations should be established. As a minimum, the source should be modeled using the design capacity (100 percent load). If a source operates at greater than design capacity for periods that could result in violations of the standards or PSD increments, this load [e] should be modeled. Where the source operates at substantially less than design capacity, and the changes in the stack parameters associated with the operating conditions could lead to higher ground level concentrations, loads such as 50 percent and 75 percent of capacity should also be modeled. A range of operating conditions

[e] Malfunctions which may result in excess emissions are not considered to be a normal operating condition. They generally should not be considered in determining allowable emissions. However, if the excess emissions are the result of poor maintenance, careless operation, or other preventable conditions, it may be necessary to consider them in determining source impact.

should be considered in screening analyses; the load causing the highest concentration, in addition to the design load, should be included in refined modeling. The following example for a power plant is typical of the kind of data on source characteristics and operating conditions that may be needed. Generally, input data requirements for air quality models necessitate the use of metric units; where English units are common for engineering usage, a conversion to metric is required.

a. Plant layout. The connection scheme between boilers and stacks, and the distance and direction between stacks, building parameters (length, width, height, location and orientation relative to stacks) for plant structures which house boilers, control equipment, and surrounding buildings within a distance of approximately five stack heights.

b. Stack parameters. For all stacks, the stack height and inside diameter (meters), and the temperature (K) and volume flow rate (actual cubic meters per second) or exit gas velocity (meters per second) for operation at 100 percent, 75 percent and 50 percent load.

c. Boiler size. For all boilers, the associated megawatts, 10^6 BTU/hr, and pounds of steam per hour, and the design and/or actual fuel consumption rate for 100 percent load for coal (tons/hour), oil (barrels/hour), and natural gas (thousand cubic feet/hour).

d. Boiler parameters. For all boilers, the percent excess air used, the boiler type (e.g., wet bottom, cyclone, etc.), and the type of firing (e.g., pulverized coal, front firing, etc.).

e. Operating conditions. For all boilers, the type, amount and pollutant contents of fuel, the total hours of boiler operation and the boiler capacity factor during the year, and the percent load for peak conditions.

f. Pollution control equipment parameters. For each boiler served and each pollutant affected, the type of emission control equipment, the year of its installation, its design efficiency and mass emission rate, the data of the last test and the tested efficiency, the number of hours of operation during the latest year, and the best engineering estimate of its projected efficiency if used in conjunction with coal combustion; data for any anticipated modifications or additions.

g. Data for new boilers or stacks. For all new boilers and stacks under construction and for all planned modifications to existing boilers or stacks, the scheduled date of completion, and the data or best estimates available for items (a) through (f) above following completion of construction or modification.

In stationary point source applications for compliance with short term ambient standards, SIP control strategies should be tested using the emission input shown on Table 9–1. When using a refined model, sources should be modeled sequentially with these loads for every hour of the year. To evaluate SIPs for compliance with quarterly and annual standards, emission input data shown in Table 9–1 should again be used. Emissions from area sources should generally be based on annual average conditions. The source input information in each model user's guide should be carefully consulted and the checklist in Appendix C should also be consulted for other possible emission data that could be helpful. PSD NAAQS compliance demonstrations should follow the emission input data shown in Table 9–2. For purposes of emissions trading, new source review and demonstrations, refer to current EPA policy and guidance to establish input data.

Line source modeling of streets and highways requires data on the width of the roadway and the median strip, the types and amounts of pollutant emissions, the number of lanes, the emissions from each lane and the height of emissions. The location of the ends of the straight roadway segments should be specified by appropriate grid coordinates. Detailed information and data requirements for modeling mobile sources of pollution are provided in the user's manuals for each of the models applicable to mobile sources.

The impact of growth on emissions should be considered in all modeling analyses covering existing sources. Increases in emissions due to planned expansion or planned fuel switches should be identified. Increases in emissions at individual sources that may be associated with a general industrial/commercial/residential expansion in multi-source urban areas should also be treated. For new sources the impact of growth on emissions should generally be considered for the period prior to the start-up date for the source. Such changes in emissions should treat increased area source emissions, changes in existing point source emissions which were not subject to preconstruction review, and emissions due to sources with permits to construct that have not yet started operation.

TABLE 9–1.—MODEL EMISSION INPUT DATA FOR POINT SOURCES [1]

Averaging time	Emission limit (#/MMBtu)[2] ×	Operating level (MMBtu/hr)[2] ×	Operating factor (e.g., hr/yr, hr/day)
Stationary Point Source(s) Subject to SIP Emission Limit(s) Evaluation for Compliance with Ambient Standards (Including Areawide Demonstrations)			
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.	Actual or design capacity (whichever is greater), or federally enforceable permit condition.	Actual operating factor averaged over most recent 2 years.[3]
Short term	Maximum allowable emission limit or federally enforceable permit limit.	Actual or design capacity (whichever is greater), or federally enforceable permit condition[4].	Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]
Nearby Background Source(s)—Same input requirements as for stationary point source(s) above.			
Other Background Source(s)—If modeled (see Section 9.2.3), input data requirements are defined below.			
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.	Annual level when actually operating, averaged over the most recent 2 years[3].	Actual operating factor averaged over the most recent 2 years.[3]
Short term	Maximum allowable emission limit or federally enforceable permit limit.	Annual level when actually operating, averaged over the most recent 2 years[3].	Continuous operation, i.e., all hours of each time period under consideration (for all hours of the meteorological data base).[5]

[1] The model input data requirements shown on this table apply to stationary source control strategies for STATE IMPLEMENTATION PLANS. For purposes of emissions trading, new source review, or prevention of significant deterioration, other model input criteria may apply. Refer to the policy and guidance for these programs to establish the input data.

[2] Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.

[3] Unless it is determined that this period is not representative.

[4] Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.

[5] If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8 a.m. to 4 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.)

TABLE 9–2.—POINT SOURCE MODEL INPUT DATA (EMISSIONS) FOR PSD NAAQS COMPLIANCE DEMONSTRATIONS

Averaging time	Emission limit (#/MMBtu) [1]	×	Operating level (MMBtu) [1]	×	Operating factor (e.g., hr/yr, hr/day)
			Proposed Major New or Modified Source		
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition.		Continuous operation (i.e., 8760 hours).[2]
Short term (≤ 24 hours).	Maximum allowable emission limit or federally enforceable permit limit.		Design capacity or federally enforceable permit condition [3].		Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]
			Nearby Background Source(s) [4]		
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition.		Actual operating factor averaged over the most recent 2 years.[5,7]
Short term (≤ 24 hours).	Maximum allowable emission limit or federally enforceable permit limit.		Actual or design capacity (whichever is greater), or federally enforceable permit condition [3].		Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]
			Other Background Source(s) [6]		
Annual & quarterly	Maximum allowable emission limit or federally enforceable permit limit.		Annual level when actually operating, averaged over the most recent 2 years [5].		Actual operating factor averaged over the most recent 2 years.[5,7]
Short term (≤ 24 hours).	Maximum allowable emission limit or federally enforceable permit limit.		Annual level when actually operating, averaged over the most recent 2 years [5].		Continuous operation (i.e., all hours of each time period under consideration) (for all hours of the meteorological data base).[2]

[1] Terminology applicable to fuel burning sources; analogous terminology (e.g., #/throughput) may be used for other types of sources.
[2] If operation does not occur for all hours of the time period of consideration (e.g., 3 or 24 hours) and the source operation is constrained by a federally enforceable permit condition, an appropriate adjustment to the modeled emission rate may be made (e.g., if operation is only 8:00 a.m. to 4:00 p.m. each day, only these hours will be modeled with emissions from the source. Modeled emissions should not be averaged across non-operating time periods.
[3] Operating levels such as 50 percent and 75 percent of capacity should also be modeled to determine the load causing the highest concentration.
[4] Includes existing facility to which modification is proposed if the emissions from the existing facility will not be affected by the modification. Otherwise use the same parameters as for major modification.
[5] Unless it is determined that this period is not representative.
[6] Generally, the ambient impacts from non-nearby background sources can be represented by air quality data unless adequate data do not exist.
[7] For those permitted sources not yet in operation or that have not established an appropriate factor, continuous operation (i.e., 8760 hours) should be used.

9.2 Background Concentrations

9.2.1 Discussion

Background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts. Background air quality includes pollutant concentrations due to: (1) Natural sources; (2) nearby sources other than the one(s) currently under consideration; and (3) unidentified sources.

Typically, air quality data should be used to establish background concentrations in the vicinity of the source(s) under consideration. The monitoring network used for background determinations should conform to the same quality assurance and other requirements as those networks established for PSD purposes.[63] An appropriate data validation procedure should be applied to the data prior to use.

If the source is not isolated, it may be necessary to use a multi-source model to establish the impact of nearby sources. Background concentrations should be determined for each critical (concentration) averaging time.

9.2.2 Recommendations (Isolated Single Source)

Two options are available to determine the background concentration near isolated sources.

Option One: Use air quality data collected in the vicinity of the source to determine the background concentration for the averaging times of concern.[f] Determine the mean background concentration at each monitor by excluding values when the source in question is impacting the monitor. The mean annual background is the average of the annual concentrations so determined at each monitor. For shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified. Concentrations for meteorological conditions of concern, at monitors not impacted by the source in question, should be averaged for each separate averaging time to determine the average background value. Monitoring sites inside a 90° sector downwind of the source may be used to determine the area of impact. One hour concentrations may be added and averaged to determine longer averaging periods.

Option Two: If there are no monitors located in the vicinity of the source, a "regional site" may be used to determine background. A "regional site" is one that is located away from the area of interest but is impacted by similar natural and distant man-made sources.

[f] For purposes of PSD, the location of monitors as well as data quality assurance procedures must satisfy requirements listed in the PSD Monitoring Guidelines.[63]

9.2.3 Recommendations (Multi-Source Areas)

In multi-source areas two components of background should be determined.

Nearby Sources: All sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration for emission limit(s) should be explicitly modeled. For evaluation for compliance with the short term and annual ambient standards, the nearby sources should be modeled using the emission input data shown in Table 9–1 or 9–2. The number of such sources is expected to be small except in unusual situations. The nearby source inventory should be determined in consultation with the reviewing authority. It is envisioned that the nearby sources and the sources under consideration will be evaluated together using an appropriate Appendix A model.

The impact of the nearby sources should be examined at locations where interactions between the plume of the point source under consideration and those of nearby sources (plus natural background) can occur. Significant locations include: (1) The area of maximum impact of the point source; (2) the area of maximum impact of nearby sources; and (3) the area where all sources combine to cause maximum impact. These locations may be identified through trial and error analyses.

Other Sources: That portion of the background attributable to all other sources (e.g., natural sources, minor sources and distant major sources) should be determined by the procedures found in section 9.2.2 or by application of a model using Table 9–1 or 9–2.

9.3 Meteorological Input Data

The meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern. The representativeness of the data is dependent on: (1) The proximity of the meteorological monitoring site to the area under consideration; (2) the complexity of the terrain; (3) the exposure of the meteorological monitoring site; and (4) the period of time during which data are collected. The spatial representativeness of the data can be adversely affected by large distances between the source and receptors of interest and the complex topographic characteristics of the area. Temporal representativeness is a function of the year-to-year variations in weather conditions.

Model input data are normally obtained either from the National Weather Service or as part of an on-site measurement program. Local universities, FAA, military stations, industry and pollution control agencies may also be sources of such data. Some recommendations for the use of each type of data are included in this subsection.

9.3.1 Length of Record of Meteorological Data

9.3.1.1 *Discussion.* The model user should acquire enough meteorological data to ensure that worst-case meteorological conditions are adequately represented in the model results. The trend toward statistically based standards suggests a need for all meteorological conditions to be adequately represented in the data set selected for model input. The number of years of record needed to obtain a stable distribution of conditions depends on the variable being measured and has been estimated by Landsberg and Jacobs[64] for various parameters. Although that study indicates in excess of 10 years may be required to achieve stability in the frequency distributions of some meteorological variables, such long periods are not reasonable for model input data. This is due in part to the fact that hourly data in model input format are frequently not available for such periods and that hourly calculations of concentration for long periods are prohibitively expensive. A recent study[65] compared various periods from a 17-year data set to determine the minimum number of years of data needed to approximate the concentrations modeled with a 17-year period of meteorological data from one station. This study indicated that the variability of model estimates due to the meteorological data input was adequately reduced if a 5-year period of record of meteorological input was used.

9.3.1.2 *Recommendations.* Five years of representative meteorological data should be used when estimating concentrations with an air quality model. Consecutive years from the most recent, readily available 5-year period are preferred. The meteorological data may be data collected either onsite or at the nearest National Weather Service (NWS) station. If the source is large, e.g., a 500 MW power plant, the use of 5 years of NWS meteorological data or at least 1 year of site-specific data is required.

If one year or more, up to five years, of sitespecific data is available, these data are preferred for use in air quality analyses. Such data should have been subjected to quality assurance procedures as described in Section 9.3.3.2.

For permitted sources whose emission limitations are based on a specific year of meteorological data that year should be added to any longer period being used (e.g., 5 years of NWS data) when modeling the facility at a later time.

9.3.2 National Weather Service Data

9.3.2.1 *Discussion.* The National Weather Service (NWS) meteorological data are routinely available and familiar to most model users. Although the NWS does not provide direct measurements of all the needed dispersion model input variables, methods have been developed and successfully used to translate the basic NWS data to the needed model input. Direct measurements of model input parameters have been made for limited model studies and those methods and techniques are becoming more widely applied; however, most model applications still rely heavily on the NWS data.

There are two standard formats of the NWS data for use in air quality models. The short term models use the standard hourly weather observations available from the National Climatic Data Center (NCDC). These observations are then "preprocessed" before they can be used in the models. "STAR" summaries are available from NCDC for long term model use. These are joint frequency distributions of wind speed, direction and P–G stability category. They are used as direct input to models such as the long term version of ISC.[58]

9.3.2.2 *Recommendations.* The preferred short term models listed in appendix A all accept as input the NWS meteorological data preprocessed into model compatible form. Long-term (monthly seasonal or annual) preferred models use NWS "STAR" summaries. Summarized concentration estimates from the short term models may also be used to develop long-term averages; however, concentration estimates based on the two separate input data sets may not necessarily agree.

Although most NWS measurements are made at a standard height of 10 meters, the actual anemometer height should be used as input to the preferred model.

National Weather Service wind directions are reported to the nearest 10 degrees. A specific set of randomly generated numbers has been developed for use with the preferred EPA models and should be used to ensure a lack of bias in wind direction assignments within the models.

Data from universities, FAA, military stations, industry and pollution control agencies may be used if such data are equivalent in accuracy and detail to the NWS data.

9.3.3 Site-Specific Data

9.3.3.1 *Discussion.* Spatial or geographical representativeness is best achieved by collection of all of the needed model input data at the actual site of the source(s). Site-specific measured data are therefore preferred as model input, provided appropriate instrumentation and quality assurance procedures are followed and that the data collected are representative (free from undue local or "micro" influences) and compatible with the input requirements of the model to be used. However, direct measurements of all the needed model input parameters may not be possible. This section discusses suggestions for the collection and use of on-site data. Since the methods outlined in this section are still being tested, comparison of the model parameters derived using these site-specific data should be compared at least on a spot-check basis, with parameters derived from more conventional observations.

9.3.3.2 *Recommendations—Site-specific Data Collection.* The document "On-Site Meteorological Program Guidance for Regulatory Modeling Applications"[66] provides recommendations on the collection and use of on-site meteorological data. Recommendations on characteristics, siting, and exposure of meteorological instruments and on data recording, processing, completeness requirements, reporting, and archiving are also included. This publication should be used as a supplement to the limited guidance on these subjects now found in the "Ambient Monitoring Guidelines for Prevention of Significant Deterioration"[63] and the "Quality Assurance Handbook for Air Pollution Measurement

Systems"[67] contains such information for meteorological measurements. As a minimum, site-specific measurements of ambient air temperature, transport wind speed and direction, and the parameters to determine Pasquill-Gifford stability categories should be available in meteorological data sets to be used in modeling. Care should be taken to ensure that monitors are located to represent the area of concern and that they are not influenced by very localized effects. Site-specific data for model applications should cover as long a period of measurement as is possible to ensure adequate representation of "worst-case" meteorology. The Regional Office will determine the appropriateness of the measurement locations.

All site-specific data should be reduced to hourly averages. Table 9–3 lists the wind related parameters and the averaging time requirements.

Temperature Measurements. Temperature measurements should be made at standard shelter height (2m) in accordance with the guidance in reference 66.

Wind Measurements. Wind speed and direction should be measured at or near plume height for use in estimating transport and dilution. To approximate this, if a source has a stack below 100m, select the stack top height as the transport wind measurement height. For sources with stacks extending above 100m, a 100m tower is suggested unless the stack top is significantly above 100 meters (200m or more). In cases with stacks 200m or above, the Regional Office should determine the appropriate measurement height on a case-by-case basis. Remote sensing may be a feasible alternative. The dilution wind speed used in determining plume rise and also used in the Gaussian dispersion equation is, by convention, defined as the wind speed at stack top.

Multiple level (typically three or more) measurements of wind temperature and turbulence (wind fluctuation statistics) are required for refined modeling applications in complex terrain. Such measurements should be obtained up to the representative plume height(s) of interest (i.e., the plume height(s) under those conditions important to the determination of the design concentration). The representative plume height(s) of interest should be determined using an appropriate complex terrain screening procedure (e.g., CTSCREEN) and should be documented in the monitoring/modeling protocol. The necessary meteorological measurements should be obtained from an appropriately sited meteorological tower augmented by SODAR if the representative plume height(s) of interest exceed 100m. The meteorological tower need not exceed the lesser of the representative plume height of interest (the highest plume height if there is more than one plume height of interest) or 100m.

For routine tower and surface measurements, the wind speed should be measured using an anemometer, and the wind direction measured using a horizontal vane. Specifications for wind measuring instruments and systems are contained in the "On-Site Meteorological Program Guidance for Regulatory Modeling Applications".[66]

Stability Categories. The Pasquill-Gifford (P–G) stability categories, as originally defined, couple near-surface measurements of wind speed with subjectively determined insolation assessments based on hourly cloud cover and ceiling observations. The wind speed measurements are made at or near 10m. The insolation rate is typically assessed using observations of cloud cover and ceiling based on criteria outlined by Turner.[50] In the absence of site specific observations of cloud cover and ceiling, alternative procedures using wind fluctuation statistics (i.e., the σ_A and σ_E methods)[66] and Turner's method with off-site cloud cover and ceiling and on-site 10m wind speed are recommended.

The two methods of stability classification which use wind fluctuation statistics, the σ_A and σ_E methods, are described in detail in EPA's "On-Site Meteorological Program Guidance for Regulatory Modeling Applications"[66] (note applicable tables in chapter 6). In the case of the σ_A method it should be noted that wind meander may occasionally bias the determination of σ_A and thus lead to an erroneous determination of the P–G stability category. To minimize wind direction meander contributions, σ_A may be determined for each of four 15-minute periods in an hour. However, 360 samples are needed during each 15-minute period. If the σ_A method is being used for stability determinations in these situations, take the square root of one-quarter of the sum of the square of the four 15 minute σ_A's, as illustrated in the footnote to Table 9–3. While this approach is an acceptable alternative for determining stability, as qualified above, σ_A's calculated in this manner are not likely to be suitable for input to models under development that are designed to accept on-site hourly σ's based on 60-minute periods. For additional information on stability classification using wind fluctuation statistics, see references 68–72.

In summary, when on-site data are being used, P–G stability categories should be estimated based on:

(1) Turner's method[55] using site-specific data which include cloud cover, ceiling height and surface (~10m) wind speeds;

(2) σ_E from site-specific measurements in accordance with guidance;[66]

(3) σ_A from site-specific measurements in accordance with guidance;[66]

(4) Turner's method[55] using site-specific wind speed with cloud cover and ceiling height from a nearby NWS site.

Meteorological Data Processors. The following meteorological preprocessors are recommended by EPA: RAMMET, PCRAMMET, STAR, PCSTAR, MPRM,[135] and METPRO.[24] RAMMET is the recommended meteorological preprocessor for use in applications employing hourly NWS data. The RAMMET format is the standard data input format used in sequential Gaussian models recommended by EPA. PCRAMMET is the PC equivalent of the mainframe version (RAMMET). STAR is the recommended preprocessor for use in applications employing joint frequency distributions (wind direction and wind speed by stability class) based on NWS data. PCSTAR is the PC equivalent of the mainframe version (STAR). MPRM is the recommended preprocessor for use in applications employing on-site meteorological data. MPRM is a general purpose meteorological data preprocessor which supports regulatory models requiring RAMMET formatted data and STAR formatted data. In addition to on-site data, MPRM provides equivalent processing of NWS data. METPRO is the required meteorological data preprocessor for use with CTDMPLUS. All of the above mentioned data preprocessors are available for downloading from the SCRAM BBS.[19]

TABLE 9–3.—AVERAGING TIMES FOR SITE-SPECIFIC WIND AND TURBULENCE MEASUREMENTS

Parameter	Averaging time
Surface wind speed (for use in stability determinations).	1-hr
Transport direction	1-hr.
Dilution wind speed	1-hr.
Turbulence measurements (σ_E and σ_A) for use in stability determinations.	1-hr.[1]

[1] To minimize meander effects in σ_A when wind conditions are light and/or variable, determine the hourly average σ value from four sequential 15-minute σ's according to the following formula:

$$\sigma_{1-hr} = \sqrt{\frac{\sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2 + \sigma_{15}^2}{4}}$$

9.3.4 Treatment of Calms

9.3.4.1 *Discussion.* Treatment of calm or light and variable wind poses a special problem in model applications since Gaussian models assume that concentration is inversely proportional to wind speed. Furthermore, concentrations become unrealistically large when wind speeds less than 1 m/s are input to the model. A procedure has been developed for use with NWS data to prevent the occurrence of overly conservative concentration estimates during periods of calms. This procedure acknowledges that a Gaussian plume model does not apply during calm conditions and that our knowledge of plume behavior and wind patterns during these conditions does not, at present, permit the development of a better technique. Therefore, the procedure disregards hours which are identified as calm. The hour is treated as missing and a convention for handling missing hours is recommended.

Preprocessed meteorological data input to most appendix A EPA models substitute a 1.00 m/s wind speed and the previous direction for the calm hour. The new treatment of calms in those models attempts to identify the original calm cases by checking for a 1.00 m/s wind speed coincident with a wind direction equal to the previous hour's wind direction. Such cases are then treated in a prescribed manner when estimating short term concentrations.

9.3.4.2 *Recommendations.* Hourly concentrations calculated with Gaussian models using calms should not be considered valid; the wind and concentration estimates for these hours should be disregarded and considered to be missing. Critical concentrations for 3-, 8-, and 24-hour averages should be calculated by dividing the sum of the hourly concentration for the period by the number of valid or nonmissing hours. If the total number of valid hours is less than 18 for 24-hour averages, less than 6 for 8-hour averages or less than 3 for 3-hour averages, the total concentration should be divided by 18 for the 24-hour average, 6 for the 8-hour average and 3 for the 3-hour average. For annual averages, the sum of all valid hourly concentrations is divided by the number of non-calm hours during the year. A post-processor computer program, CALMPRO[73] has been prepared following these instructions and has been hardwired in the following models: RAM, ISC, MPTER and CRSTER.

The recommendations above apply to the use of calms for short term averages and do not apply to the determination of long term averages using "STAR" data summaries. Calms should continue to be included in the preparation of "STAR" summaries. A treatment for calms and very light winds is built into the software that produces the "STAR" summaries.

Stagnant conditions, including extended periods of calms, often produce high concentrations over wide areas for relatively long averaging periods. The standard short term Gaussian models are often not applicable to such situations. When stagnation conditions are of concern, other modeling techniques should be considered on a case-by-case basis. (See also section 8.2.10)

When used in Gaussian models, measured on-site wind speeds of less than 1 m/s but higher than the response threshold of the instrument should be input as 1m/s; the corresponding wind direction should also be input. Observations below the response threshold of the instrument are also set to 1 m/s but the wind direction from the previous hour is used. If the wind speed or direction can not be determined, that hour should be treated as missing and short term averages should then be calculated as above.

10.0 Accuracy and Uncertainty of Models

10.1 Discussion

Increasing reliance has been placed on concentration estimates from models as the primary basis for regulatory decisions concerning source permits and emission control requirements. In many situations, such as review of a proposed source, no practical alternative exists. Therefore, there is an obvious need to know how accurate models really are and how any uncertainty in the estimates affects regulatory decisions. EPA recognizes the need for incorporating such information and has sponsored workshops[11,74] on model accuracy, the possible ways to quantify accuracy, and on considerations in the incorporation of model accuracy and uncertainty in the regulatory process. The Second (EPA) Conference on Air Quality Modeling, August 1982,[75] was devoted to that subject.

10.1.1 Overview of Model Uncertainty

Dispersion models generally attempt to estimate concentrations at specific sites that really represent an ensemble average of numerous repetitions of the same event. The event is characterized by measured or "known" conditions that are input to the models, e.g., wind speed, mixed layer height, surface heat flux, emission characteristics, etc. However, in addition to the known conditions, there are unmeasured or unknown variations in the conditions of this event, e.g., unresolved details of the atmospheric flow such as the turbulent velocity field. These unknown conditions, may vary among repetitions of the event. As a result, deviations in observed concentrations from their ensemble average, and from the concentrations estimated by the model, are likely to occur even though the known conditions are fixed. Even with a perfect model that predicts the correct ensemble average, there are likely to be deviations from the observed concentrations in individual repetitions of the event, due to variations in the unknown conditions. The statistics of these concentration residuals are termed "inherent" uncertainty. Available evidence suggests that this source of uncertainty alone may be responsible for a typical range of variation in concentrations of as much as #50 percent.[76]

Moreover, there is "reducible" uncertainty[77] associated with the model and its input conditions; neither models nor data bases are perfect. Reducible uncertainties are caused by: (1) Uncertainties in the input values of the known conditions—emission characteristics and meteorological data; (2) errors in the measured concentrations which are used to compute the concentration residuals; and (3) inadequate model physics and formulation. The "reducible" uncertainties can be minimized through better (more accurate and more representative) measurements and better model physics.

To use the terminology correctly, reference to model accuracy should be limited to that portion of reducible uncertainty which deals with the physics and the formulation of the model. The accuracy of the model is normally determined by an evaluation procedure which involves the comparison of model concentration estimates with measured air quality data.[78] The statement of accuracy is based on statistical tests or performance measures such as bias, noise, correlation, etc.[11] However, information that allows a distinction between contributions of the various elements of inherent and reducible uncertainty is only now beginning to emerge. As a result most discussions of the accuracy of models make no quantitative distinction between (1) limitations of the model versus (2) limitations of the data base and of knowledge concerning atmospheric variability. The reader should be aware that statements on model accuracy and uncertainty may imply the need for improvements in model performance that even the "perfect" model could not satisfy.

10.1.2 Studies of Model Accuracy

A number of studies[79,80] have been conducted to examine model accuracy, particularly with respect to the reliability of short-term concentrations required for ambient standard and increment evaluations. The results of these studies are not surprising. Basically, they confirm what leading atmospheric scientists have said for some time: (1) Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and (2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ± 10 to 40 percent are found to be typical,[81] i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site, are poorly correlated with actually observed concentrations and are much less reliable.

As noted above, poor correlations between paired concentrations at fixed stations may be due to "reducible" uncertainties in knowledge of the precise plume location and to unquantified inherent uncertainties. For example, Pasquill[82] estimates that, apart from data input errors, maximum ground-level concentrations at a given hour for a point source in flat terrain could be in error by 50 percent due to these uncertainties. Uncertainty of five to 10 degrees in the measured wind direction, which transports the plume, can result in concentration errors of 20 to 70 percent for a particular time and location, depending on stability and station location. Such uncertainties do not indicate that an estimated concentration does not occur, only that the precise time and locations are in doubt.

10.1.3 Use of Uncertainty in Decision-Making

The accuracy of model estimates varies with the model used, the type of application, and site-specific characteristics. Thus, it is desirable to quantify the accuracy or uncertainty associated with concentration estimates used in decision-making. Communications between modelers and decision-makers must be fostered and further developed. Communications concerning concentration estimates currently exist in most cases, but the communications dealing with the accuracy of models and its meaning to the decision-maker are limited by the lack of a technical basis for quantifying and directly including uncertainty in decisions. Procedures for quantifying and interpreting uncertainty in the practical application of such concepts are only beginning to evolve, much study is still required.[74,75,77]

In all applications of models an effort is encouraged to identify the reliability of the model estimates for that particular area and to determine the magnitude and sources of error associated with the use of the model. The analyst is responsible for recognizing and quantifying limitations in the accuracy, precision and sensitivity of the procedure. Information that might be useful to the decision-maker in recognizing the seriousness of potential air quality violations includes such model accuracy estimates as accuracy of peak predictions, bias, noise, correlation, frequency distribution, spatial extent of high concentration, etc. Both space/time pairing of estimates and measurements and unpaired comparisons are recommended. Emphasis should be on the highest concentrations and the averaging times of the standards or increments of concern. Where possible, confidence intervals about the statistical values should be provided. However, while such information can be provided by the modeler to the decision-maker, it is unclear how this information should be used to make an air pollution control decision. Given a range of possible outcomes, it is easiest and tends to ensure consistency if the decision-maker confines his judgment to use of the "best estimate" provided by the modeler (i.e., the design concentration estimated by a model recommended in this guideline or an alternate model of known accuracy). This is an indication of the practical limitations imposed by current abilities of the technical community.

To improve the basis for decision-making, EPA has developed and is continuing to study procedures for determining the accuracy of models, quantifying the uncertainty, and expressing confidence levels in decisions that are made concerning emissions controls.[83,84] However, work in this area involves "breaking new ground" with slow and sporadic progress likely. As a result, it may be necessary to continue using the "best estimate" until sufficient technical progress has been made to meaningfully implement such concepts dealing with uncertainty.

10.1.4 Evaluation of Models

A number of actions are being taken to ensure that the best model is used correctly for each regulatory application and that a model is not arbitrarily imposed. First, this guideline clearly recommends the most appropriate model be used in each case. Preferred models, based on a number of factors, are identified for many uses. General guidance on using alternatives to the preferred models is also provided. Second, all the models in eight categories (i.e., rural, urban, industrial complex, reactive pollutants, mobile source, complex terrain, visibility and long range transport) that are candidates for inclusion in this guideline are being subjected to a systematic performance evaluation and a peer scientific review.[85] The same data bases are being used to evaluate all models within each of eight categories. Statistical performance measures, including measures of difference (or residuals) such as bias, variance of difference and gross variability of the difference, and measures of correlation such as time, space, and time and space combined as recommended by the AMS Woods Hole Workshop,[11] are being followed. The results of the scientific review are being incorporated in this guideline and will be the basis for future revision.[12, 13] Third, more specific information has been provided for justifying the site specific use of alternative models in the documents "Interim Procedures for Evaluating Air Quality Models",[15] and the "Protocol for Determining the Best Performing Model".[17] Together these documents provide methods that allow a judgment to be made as to what models are most appropriate for a specific application. For the present, performance and the theoretical evaluation of models are being used as an indirect means to quantify one element of uncertainty in air pollution regulatory decisions.

In addition to performance evaluation of models, sensitivity analyses are encouraged since they can provide additional information on the effect of inaccuracies in the data bases and on the uncertainty in model estimates. Sensitivity analyses can aid in determining the effect of inaccuracies of variations or uncertainties in the data bases on the range of likely concentrations. Such information may be used to determine source impact and to evaluate control strategies. Where possible, information from such sensitivity analyses should be made available to the decision-maker with an appropriate interpretation of the effect on the critical concentrations.

10.2 Recommendations

No specific guidance on the consideration of model uncertainty in decision-making is being given at this time. There is incomplete technical information on measures of model uncertainty that are most relevant to the decision-maker. It is not clear how a decisionmaker could use such information, particularly given limitations of the Clean Air Act. As procedures for considering uncertainty develop and become implementable, this guidance will be changed and expanded. For the present, continued use of the "best estimate" is acceptable and is consistent with CAA requirements.

11.0 Regulatory Application of Models

11.1 Discussion

Procedures with respect to the review and analysis of air quality modeling and data analyses in support of SIP revisions, PSD permitting or other regulatory requirements need a certain amount of standardization to ensure consistency in the depth and comprehensiveness of both the review and the analysis itself. This section recommends procedures that permit some degree of standardization while at the same time allowing the flexibility needed to assure the technically best analysis for each regulatory application.

Dispersion model estimates, especially with the support of measured air quality data, are the preferred basis for air quality demonstrations. Nevertheless, there are instances where the performance of recommended dispersion modeling techniques, by comparison with observed air quality data, may be shown to be less than acceptable. Also, there may be no recommended modeling procedure suitable for the situation. In these instances, emission limitations may be established solely on the basis of observed air quality data as would be applied to a modeling analysis. The same care should be given to the analyses of the air quality data as would be applied to a modeling analysis.

The current NAAQS for SO_2 and CO are both stated in terms of a concentration not to be exceeded more than once a year. There is only an annual standard for NO_2 and a quarterly standard for Pb. The PM–10 and ozone standards permit the exceedance of a concentration on an average of not more than once a year; the convention is to average over a 3-year period.[5, 86, 103] This represents a change from a deterministic to a more statistical form of the standard and permits some consideration to be given to unusual circumstances. The NAAQS are subjected to extensive review and possible revision every 5 years.

This section discusses general requirements for concentration estimates and identifies the relationship to emission limits. The following recommendations apply to: (1) Revisions of State Implementation Plans; (2) the review of new sources and the prevention of significant deterioration (PSD); and (3) analyses of the emissions trades ("bubbles").

11.2 Recommendations

11.2.1 Analysis Requirements

Every effort should be made by the Regional Office to meet with all parties involved in either a SIP revision or a PSD permit application prior to the start of any work on such a project. During this meeting, a protocol should be established between the preparing and reviewing parties to define the procedures to be followed, the data to be collected, the model to be used, and the analysis of the source and concentration data. An example of requirements for such an effort is contained in the Air Quality Analysis Checklist included here as Appendix C. This checklist suggests the level of detail required to assess the air quality resulting from the proposed action. Special cases may require additional data collection or analysis and this should be determined and agreed upon at this preapplication meeting. The protocol should be written and agreed upon by the parties concerned, although a formal legal document is not intended. Changes in such a protocol are often required as the data collection and analysis progresses. However, the protocol establishes a common understanding of the requirements.

An air quality analysis should begin with a screening model to determine the potential of the proposed source or control strategy to violate the PSD increment or NAAQS. It is recommended that the screening techniques found in "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources"[18] be used for point source analyses. Screening procedures for area source analysis are discussed in "Applying Atmospheric Simulation Models to Air Quality Maintenance Areas".[87] For mobile source impact assessments the

"Guideline for Modeling Carbon Monoxide from Roadway Intersections"[34] is available.

If the concentration estimates from screening techniques indicate that the PSD increment or NAAQS may be approached or exceeded, then a more refined modeling analysis is appropriate and the model user should select a model according to recommendations in sections 4–8. In some instances, no refined technique may be specified in this guide for the situation. The model user is then encouraged to submit a model developed specifically for the case at hand. If that is not possible, a screening technique may supply the needed results.

Regional Offices should require permit applicants to incorporate the pollutant contributions of all sources into their analysis. Where necessary this may include emissions associated with growth in the area of impact of the new or modified source's impact. PSD air quality assessments should consider the amount of the allowable air quality increment that has already been granted to any other sources. Therefore, the most recent source applicant should model the existing or permitted sources in addition to the one currently under consideration. This would permit the use of newly acquired data or improved modeling techniques if such have become available since the last source was permitted. When remodeling, the worst case used in the previous modeling analysis should be one set of conditions modeled in the new analysis. All sources should be modeled for each set of meteorological conditions selected and for all receptor sites used in the previous applications as well as new sites specific to the new source.

11.2.2 Use of Measured Data in Lieu of Model Estimates

Modeling is the preferred method for determining emission limitations for both new and existing sources. When a preferred model is available, model results alone (including background) are sufficient. Monitoring will normally not be accepted as the sole basis for emission limitation determination in flat terrain areas. In some instances when the modeling technique available is only a screening technique, the addition of air quality data to the analysis may lend credence to model results.

There are circumstances where there is no applicable model, and measured data may need to be used. Examples of such situations are: (1) Complex terrain locations; (2) land/water interface areas; and (3) urban locations with a large fraction of particulate emissions from nontraditional sources. However, only in the case of an existing source should monitoring data alone be a basis for emission limits. In addition, the following items should be considered prior to the acceptance of the measured data:

a. Does a monitoring network exist for the pollutants and averaging times of concern;

b. Has the monitoring network been designed to locate points of maximum concentration;

c. Do the monitoring network and the data reduction and storage procedures meet EPA monitoring and quality assurance requirements;

d. Do the data set and the analysis allow impact of the most important individual sources to be identified if more than one source or emission point is involved;

e. Is at least one full year of valid ambient data available; and

f. Can it be demonstrated through the comparison of monitored data with model results that available models are not applicable?

The number of monitors required is a function of the problem being considered. The source configuration, terrain configuration, and meteorological variations all have an impact on number and placement of monitors. Decisions can only be made on a case-by-case basis. The Interim Procedures for Evaluating Air Quality Models[15] should be used in establishing criteria for demonstrating that a model is not applicable.

Sources should obtain approval from the Regional Office or reviewing authority for the monitoring network prior to the start of monitoring. A monitoring protocol agreed to by all concerned parties is highly desirable. The design of the network, the number, type and location of the monitors, the sampling period, averaging time as well as the need for meteorological monitoring or the use of mobile sampling or plume tracking techniques, should all be specified in the protocol and agreed upon prior to start-up of the network.

11.2.3 Emission Limits

11.2.3.1 *Design Concentrations.* Emission limits should be based on concentration estimates for the averaging time that results in the most stringent control requirements. The concentration used in specifying emission limits is called the design value or design concentration and is a sum of the concentration contributed by the source and the background concentration.

To determine the averaging time for the design value, the most restrictive National Ambient Air Quality Standard (NAAQS) should be identified by calculating, for each averaging time, the ratio of the applicable NAAQS (S) minus background (B) to the predicted concentration (P) (i.e., (S–B)/P). The averaging time with the lowest ratio identifies the most restrictive standard. If the annual average is the most restrictive, the highest estimated annual average concentration from one or a number of years of data is the design value. When short term standards are most restrictive, it may be necessary to consider a broader range of concentrations than the highest value. For example, for pollutants such as SO_2, the highest, second-highest concentration is the design value. For pollutants with statistically based NAAQS, the design value is found by determining the more restrictive of: (1) The short-term concentration that is not expected to be exceeded more than once per year over the period specified in the standard, or (2) the long-term concentration that is not expected to exceed the long-term NAAQS. Determination of design values for PM–10 is presented in more detail in the "PM–10 SIP Development Guideline".[103]

When the highest, second-highest concentration is used in assessing potential violations of a short term NAAQS, criteria that are identified in "Guideline for Interpretation of Air Quality Standards"[88] should be followed. This guideline specifies that a violation of a short term standard occurs at a site when the standard is exceeded a second time. Thus, emission limits that protect standards for averaging times of 24 hours or less are appropriately based on the highest, second-highest estimated concentration plus a background concentration which can reasonably be assumed to occur with the concentration.

11.2.3.2 *NAAQS Analyses for New or Modified Sources.* For new or modified sources predicted to have a significant ambient impact[63] and to be located in areas designated attainment or unclassifiable for the SO_2, Pb, NO_2, or CO NAAQS, the demonstration as to whether the source will cause or contribute to an air quality violation should be based on: (1) The highest estimated annual average concentration determined from annual averages of individual years; or (2) the highest, second-highest estimated concentration for averaging times of 24-hours or less; and (3) the significance of the spatial and temporal contribution to any modeled violation. For Pb, the highest estimated concentration based on an individual calendar quarter averaging period should be used. Background concentrations should be added to the estimated impact of the source. The most restrictive standard should be used in all cases to assess the threat of an air quality violation. For new or modified sources predicted to have a significant ambient impact[63] in areas designated attainment or unclassifiable for the PM–10 NAAQS, the demonstration of whether or not the source will cause or contribute to an air quality violation should be based on sufficient data to show whether: (1) The projected 24-hour average concentrations will exceed the 24-hour NAAQS more than once per year, on average; (2) the expected (i.e., average) annual mean concentration will exceed the annual NAAQS; and (3) the source contributes significantly, in a temporal and spatial sense, to any modeled violation.

11.2.3.3 *PSD Air Quality Increments and Impacts.* The allowable PSD increments for criteria pollutants are established by regulation and cited in 40 CFR 51.166. These maximum allowable increases in pollutant concentrations may be exceeded once per year at each site, except for the annual increment that may not be exceeded. The highest, second-highest increase in estimated concentrations for the short term averages as determined by a model should be less than or equal to the permitted increment. The modeled annual averages should not exceed the increment.

Screening techniques defined in sections 4 and 5 can sometimes be used to estimate short term incremental concentrations for the first new source that triggers the baseline in a given area. However, when multiple increment-consuming sources are involved in the calculation, the use of a refined model with at least 1 year of on-site or 5 years of off-site NWS data is normally required. In such cases, sequential modeling must demonstrate that the allowable increments are not exceeded temporally and spatially, i.e., for all receptors for each time period throughout the year(s) (time period means the appropriate PSD averaging time, e.g., 3-hour, 24-hour, etc.).

The PSD regulations require an estimation of the SO_2, particulate matter, and NO_2 impact on any Class I area. Normally, Gaussian models should not be applied at distances greater than can be accommodated by the steady state assumptions inherent in such models. The maximum distance for refined Gaussian model application for regulatory purposes is generally considered to be 50km. Beyond the 50km range, screening techniques may be used to determine if more refined modeling is needed. If refined models are needed, long range transport models should be considered in accordance with section 7.2.6. As previously noted in sections 3 and 7, the need to involve the Federal Land Manager in decisions on potential air quality impacts, particularly in relation to PSD Class I areas, cannot be overemphasized.

11.2.3.4 *Emissions Trading Policy (Bubbles).* EPA's final Emissions Trading Policy, commonly referred to as the "bubble policy," was published in the **Federal Register** in 1986.[89] Principles contained in the policy should be used to evaluate ambient impacts of emission trading activities.

Emission increases and decreases within the bubble should result in ambient air quality equivalence. Two levels of analysis are defined for establishing this equivalence. In a Level I analysis the source configuration and setting must meet certain limitations (defined in the policy) that ensure ambient equivalence; no modeling is required. In a Level II analysis a modeling demonstration of ambient equivalence is required but only the sources involved in the emissions trade are modeled. The resulting ambient estimates of net increases/decreases are compared to a set of significance levels to determine if the bubble can be approved. A Level II analysis requires the use of a refined model and the most recent readily available full year of representative meteorological data. Sequential modeling must demonstrate that the significance levels are met temporally and spatially, i.e., for all receptors for each time period throughout the year (time period means the appropriate NAAQS averaging time, e.g., 3-hour, 24-hour, etc.).

For those bubbles that cannot meet the Level I or Level II requirements, the Emissions Trading Policy allows for a Level III analysis. A Level III analysis, from a modeling standpoint, is generally equivalent to the requirements for a standard SIP revision where all sources (and background) are considered and the estimates are compared to the NAAQS as in section 11.2.3.2.

The Emissions Trading Policy allows States to adopt generic regulations for processing bubbles. The modeling procedures recommended in this guideline apply to such generic regulations. However, an added requirement is that the modeling procedures contained in any generic regulation must be replicable such that there is no doubt as to how each individual bubble will be modeled. In general this means that the models, the data bases and the procedures for applying the model must be defined in the regulation. The consequences of the replicability requirement are that bubbles for sources located in complex terrain and certain industrial sources where judgments must be made on source characterization cannot be handled generically.

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[1] The documents listed here are major sources of supplemental information on the theory and application of mathematical air quality models.

14.0 Glossary of Terms

Air quality: Ambient pollutant concentrations and their temporal and spatial distribution.

Algorithm: A specific mathematical calculation procedure. A model may contain several algorithms.

Background: Ambient pollutant concentrations due to (1) natural sources, (2) nearby sources other than the one(s) currently under consideration; and (3) unidentified sources.

Calibrate: An objective adjustment using measured air quality data (e.g., an adjustment based on least-squares linear regression).

Calm: For purposes of air quality modeling, calm is used to define the situation when the wind is indeterminate with regard to speed or direction.

Complex Terrain: Terrain exceeding the height of the stack being modeled.

Computer Code: A set of statements that comprise a computer program.

Evaluate: To appraise the performance and accuracy of a model based on a comparison of concentration estimates with observed air quality data.

Fluid Modeling: Modeling conducted in a wind tunnel or water channel to quantitatively evaluate the influence of buildings and/or terrain on pollutant concentrations.

Fugitive Dust: Dust discharged to the atmosphere in an unconfined flow stream such as that from unpaved roads, storage piles and heavy construction operations.

Model: A quantitative or mathematical representation or simulation which attempts to describe the characteristics or relationships of physical events.

Preferred Model: A refined model that is recommended for a specific type of regulatory application.

Receptor: A location at which ambient air quality is measured or estimated.

Receptor Models: Procedures that examine an ambient monitor sample of particulate matter and the conditions of its collection to infer the types or relative mix of sources impacting on it during collection.

Refined Model: An analytical technique that provides a detailed treatment of physical and chemical atmospheric processes and requires detailed and precise input data. Specialized estimates are calculated that are useful for evaluating source impact relative to air quality standards and allowable increments. The estimates are more accurate than those obtained from conservative screening techniques.

Rollback: A simple model that assumes that if emissions from each source affecting a given receptor are decreased by the same percentage, ambient air quality concentrations decrease proportionately.

Screening Technique: A relatively simple analysis technique to determine if a given source is likely to pose a threat to air quality. Concentration estimates from screening techniques are conservative.

Simple Terrain: An area where terrain features are all lower in elevation than the top of the stack of the source.

Appendix A to Appendix W of Part 51—Summaries of Preferred Air Quality Models

Table of Contents

A.0 Introduction and Availability

This appendix summarizes key features of refined air quality models preferred for specific regulatory applications. For each model, information is provided on availability, approximate cost in 1990, regulatory use, data input, output format and options, simulation of atmospheric physics, and accuracy. These models may be used without a formal demonstration of applicability provided they satisfy the recommendations for regulatory use; not all options in the models are necessarily recommended for regulatory use.

Many of these models have been subjected to a performance evaluation using comparisons with observed air quality data. A summary of such comparisons for models contained in this appendix is included in "A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Models," EPA–450/4–83–001. Where possible, several of the models contained herein have been subjected to evaluation exercises, including (1) statistical performance tests recommended by the American Meteorological Society and (2) peer scientific reviews. The models in this appendix have been selected on the basis of the results of the model evaluations, experience with previous use, familiarity of the model to various air quality programs, and the costs and resource requirements for use.

The Availability statement for models in this Appendix that refers to the User's Network for Applied Modeling of Air Pollution (UNAMAP) should be ignored since UNAMAP is no longer operational. However, all models and user's documentation in this appendix are available from: Computer Products, National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487–4650.

In addition, model codes and selected, abridged user's guides are available from the Support Center for Regulatory Air Models Bulletin Board System [19] (SCRAM BBS), telephone (919) 541–5742. The SCRAM BBS is an electronic bulletin board system designed to be user friendly and accessible from anywhere in the country. Model users with personal computers are encouraged to use the SCRAM BBS to download current model codes and text files.

A.1 Buoyant Line and Point Source Dispersion Model (BLP)

Reference

Schulman, Lloyd L., and Joseph S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide. Document P–7304B. Environmental Research and Technology, Inc., Concord, MA. (NTIS No. PB 81–164642)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487–4650.

Abstract:

BLP is a Gaussian plume dispersion model designed to handle unique modeling problems associated with aluminum reduction plants, and other industrial sources where plume rise and downwash effects from stationary line sources are important.

a. *Recommendations for Regulatory Use*

The BLP model is appropriate for the following applications:

Aluminum reduction plants which contain buoyant, elevated line sources;

Rural areas;

Transport distances less than 50 kilometers;

Simple terrain; and

One hour to one year averaging times.

The following options should be selected for regulatory applications:

Rural (IRU=1) mixing height option;

Default (no selection) for plume rise wind shear (LSHEAR), transitional point source plume rise (LTRANS), vertical potential temperature gradient (DTHTA), vertical wind speed power law profile exponents (PEXP), maximum variation in number of stability classes per hour (IDELS), pollutant decay (DECFAC), the constant in Briggs' stable plume rise equation (CONST2), constant in Briggs' neutral plume rise equation (CONST3), convergence criterion for the line source calculations (CRIT), and maximum iterations allowed for line source calculations (MAXIT); and

Terrain option (TERAN) set equal to 0.0, 0.0, 0.0, 0.0, 0.0, 0.0.

For other applications, BLP can be used if it can be demonstrated to give the same estimates as a recommended model for the same application, and will subsequently be executed in that mode.

BLP can be used on a case-by-case basis with specific options not available in a recommended model if it can be demonstrated, using the criteria in section 3.2, that the model is more appropriate for a specific application.

b. *Input Requirements*

Source data: Point sources require stack location, elevation of stack base, physical stack height, stack inside diameter, stack gas exit velocity, stack gas exit temperature, and pollutant emission rate. Line sources require coordinates of the end points of the line, release height, emission rate, average line source width, average building width, average spacing between buildings, and average line source buoyancy parameter.

Meteorological data: Hourly surface weather data from punched cards or from the preprocessor program RAMMET which provides hourly stability class, wind direction, wind speed, temperature, and mixing height.

Receptor data: Locations and elevations of receptors, or location and size of receptor grid or request automatically generated receptor grid.

c. *Output*

Printed output (from a separate post-processor program) includes:

Total concentration or, optionally, source contribution analysis; monthly and annual frequency distributions for 1-, 3-, and 24-hour average concentrations; tables of 1-, 3-, and 24-hour average concentrations at each receptor; table of the annual (or length of run) average concentrations at each receptor;

Five highest 1-, 3-, and 24-hour average concentrations at each receptor; and

Fifty highest 1-, 3-, and 24-hour concentrations over the receptor field.

d. *Type of Model*

BLP is a gaussian plume model.

e. *Pollutant Types*

BLP may be used to model primary pollutants. This model does not treat settling and deposition.

f. *Source-Receptor Relationship*

BLP treats up to 50 point sources, 10 parallel line sources, and 100 receptors arbitrarily located.

User-input topographic elevation is applied for each stack and each receptor.

g. *Plume Behavior*

BLP uses plume rise formulas of Schulman and Scire (1980).

Vertical potential temperature gradients of 0.02 Kelvin per meter for E stability and 0.035 Kelvin per meter are used for stable plume rise calculations. An option for user input values is included.

Transitional rise is used for line sources.

Option to suppress the use of transitional plume rise for point sources is included.

The building downwash algorithm of Schulman and Scire (1980) is used.

h. *Horizontal Winds*

Constant, uniform (steady-state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

Wind speeds profile exponents of 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 are used for stability classes A through F, respectively. An option for userdefined values and an option to suppress the use of the wind speed profile feature are included.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients are from Turner (1969), with no adjustment made for variations in surface roughness or averaging time.

Six stability classes are used.

k. *Vertical Dispersion*

Rural dispersion coefficients are from Turner (1969), with no adjustment made for variations in surface roughness.

Six stability classes are used.

Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform mixing is assumed beyond that point.

Perfect reflection at the ground is assumed.

l. *Chemical Transformation*

Chemical transformations are treated using linear decay. Decay rate is input by the user.

m. *Physical Removal*

Physical removal is not explicitly treated.

n. *Evaluation Studies*

Schulman, L.L., and J.S. Scire, 1980. Buoyant Line and Point Source (BLP) Dispersion Model User's Guide, P-7304B. Environmental Research and Technology, Inc., Concord, MA.

Scire, J.S., and L.L. Schulman, 1981. Evaluation of the BLP and ISC Models with SF_6 Tracer Data and SO_2 Measurements at Aluminum Reduction Plants. APCA Specialty Conference on Dispersion Modeling for Complex Sources, St. Louis, MO.

A.2 CALINE3

Reference

Benson, Paul E., 1979. CALINE3—A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets. Interim Report, Report Number FHWA/CA/TL-79/23. Federal Highway Administration, Washington, DC. (NTIS No. PB 80-220841)

Availability

The CALINE3 model computer tape is available from NTIS as PB 80-220833. The model is also available from the California Department of Transportation (manual free of charge and approximately $50 for the computer tape). Requests should be directed to: Mr. Marlin Beckwith, Chief, Office of Computer Systems, California Department of Transportation, 1120 N. Street, Sacramento, CA 95814.

Abstract

CALINE3 can be used to estimate the concentrations of nonreactive pollutants from highway traffic. This steady-state Gaussian model can be applied to determine air pollution concentrations at receptor locations downwind of "at-grade," "fill," "bridge," and "cut section" highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation, and receptor location. The model has adjustments for averaging time and surface roughness, and can handle up to 20 links and 20 receptors. It also contains an algorithm for deposition and settling velocity so that particulate concentrations can be predicted.

a. *Recommendations for Regulatory Use*

CALINE-3 is appropriate for the following applications:

Highway (line) sources;

Urban or rural areas;

Simple terrain;

Transport distances less than 50 kilometers; and

One-hour to 24-hour averaging times.

b. *Input Requirements*

Source data: Up to 20 highway links classed as "at-grade," "fill," "bridge," or "depressed"; coordinates of link end points; traffic volume; emission factor; source height; and mixing zone width.

Meteorological data: Wind speed, wind angle (measured in degrees clockwise from the Y axis), stability class, mixing height, ambient (background to the highway) concentration of pollutant.

Receptor data: Coordinates and height above ground for each receptor. c.

Output

Printed output includes:

Concentration at each receptor for the specified meteorological condition.

d. *Type of Model*

CALINE-3 is a Gaussian plume model.

e. *Pollutant Types*

CALINE-3 may be used to model primary pollutants.

f. *Source-Receptor Relationship*

Up to 20 highway links are treated.

CALINE-3 applies user input location and emission rate for each link. User-input receptor locations are applied.

g. *Plume Behavior*

Plume rise is not treated.

h. *Horizontal Winds*

User-input hourly wind speed and direction are applied.

Constant, uniform (steady-state) wind is assumed for an hour.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Six stability classes are used.

Rural dispersion coefficients from Turner (1969) are used, with adjustment for roughness length and averaging time.

Initial traffic-induced dispersion is handled implicitly by plume size parameters.

k. *Vertical Dispersion*

Six stability classes are used.

Empirical dispersion coefficients from Benson (1979) are used including an adjustment for roughness length.

Initial traffic-induced dispersion is handled implicitly by plume size parameters.

Adjustment for averaging time is included.

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Optional deposition calculations are included.

n. *Evaluation Studies*

Bemis, G. R. et al., 1977. Air Pollution and Roadway Location, Design, and Operation—Project Overview. FHWA-CA-TL-7080-77-25, Federal Highway Administration, Washington, DC.

Cadle, S. H. et al., 1976. Results of the General Motors Sulfate Dispersion Experiment, GMR-2107. General Motors Research Laboratories, Warren, MI.

Dabberdt, W. F., 1975. Studies of Air Quality on and Near Highways, Project 2761. Stanford Research Institute, Menlo Park, CA.

A.3 Climatological Dispersion Model (CDM 2.0)

References

Irwin, J. S., T. Chico, and J. Catalano, 1985. CDM 2.0-Climatological Dispersion Model—User's Guide. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 86-136546)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487-4650.

Abstract

CDM is a climatological steady-state Gaussian plume model for determining long-term (seasonal or annual) arithmetic average pollutant concentrations at any ground-level receptor in an urban area.

a. *Recommendations for Regulatory Use*

CDM is appropriate for the following applications:

Point and area sources;

Urban areas;

Flat terrain;

Transport distances less than 50 kilometers;

Long term averages over one month to one year or longer.

The following option should be selected for regulatory applications:

Set the regulatory "default option" (NDEF=l) which automatically selects stack tip downwash, final plume rise, buoyancy-induced dispersion (BID), and the appropriate wind profile exponents.

Enter "O" for pollutant half-life for all pollutants except for SO_2 in an urban setting. This entry results in no decay (infinite half-life) being calculated. For SO_2 in an urban setting, the pollutant half-life (in hours) should be set to 4.0.

b. *Input Requirements*

Source data: Location, average emissions rates and heights of emissions for point and area sources. Point source data requirements also include stack gas temperature, stack gas exit velocity, and stack inside diameter for plume rise calculations for point sources.

Meteorological data: Stability wind rose (STAR deck day/night version), average mixing height and wind speed in each stability category, and average air temperature.

Receptor data: Cartesian coordinates of each receptor.

c. *Output*

Printed output includes:

Average concentrations for the period of the stability wind rose data (arithmetic mean only) at each receptor, and

Optional point and area concentration rose for each receptor.

d. *Type of Model*

CDM is a climatological Gaussian plume model.

e. *Pollutant Types*

CDM may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

CDM applies user-specified locations for all point sources and receptors.

Area sources are input as multiples of a user-defined unit area source grid size.

User specified release heights are applied for individual point sources and the area source grid.

Actual separation between each source-receptor pair is used.

The user may select a single height at or above ground level that applies to all receptors.

No terrain differences between source and receptor are treated.

g. *Plume Behavior*

CDM uses Briggs (1969, 1971, 1975) plume rise equations. Optionally a plume rise-wind speed product may be input for each point source.

Stack tip downwash equation from Briggs (1974) is preferred for regulatory use. The Bjorklund and Bowers (1982) equation is also included.

No plume rise is calculated for area sources.

Does not treat fumigation or building downwash.

h. *Horizontal Winds*

Wind data are input as a stability wind rose (joint frequency distribution of 16 wind directions, 6 wind classes, and 5 stability classes).

Wind speed profile exponents for the urban case (EPA, 1980) are used, assuming the anemometer height is at 10.0 meters.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Pollutants are assumed evenly distributed across a 22.5 or 10.0 degree sector.

k. *Vertical Dispersion*

There are seven vertical dispersion parameter schemes, but the following is recommended for regulatory applications:

- Briggs-urban (Gifford, 1976).

Mixing height has no effect until dispersion coefficient equals 0.8 times the mixing height; uniform vertical mixing is assumed beyond that point.

Buoyancy-induced disperion (Pasquill, 1976) is included as an option. Perfect reflection is assumed at the ground.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Physical removal is not explicitly treated.

n. *Evaluation Studies*

Irwin, J. S., and T. M. Brown, 1985. A Sensitivity Analysis of the Treatment of Area Sources by the Climatological Dispersion Model. *Journal of Air Pollution Control Association*, 35: 359–364.

Londergan, R., D. Minott, D. Wachter and R. Fizz, 1983. Evaluation of Urban Air Quality Simulation Models, EPA Publication No. EPA-450/4-83-020. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Busse, A. D. and J. R. Zimmerman, 1973. User's Guide for the Climatological Dispersion Model—Appendix E. EPA Publication No. EPA/R4-73-024. Office of Research and Development, Research Triangle Park, NC.

Zimmerman, J. R., 1971. Some Preliminary Results of Modeling from the Air Pollution Study of Ankara, Turkey, Proceedings of the Second Meeting of the Expert Panel on Air Pollution Modeling, NATO Committee on the Challenges of Modern Society, Paris, France.

Zimmerman, J. R., 1972. The NATO/CCMS Air Pollution Study of St. Louis, Missouri. Presented at the Third Meeting of the Expert Panel on Air Pollution Modeling, NATO Committee on the Challenges of Modern Society, Paris, France.

A.4 Gaussian-Plume Multiple Source Air Quality Algorithm (RAM)

Reference

Turner, D. B., and J. H. Novak, 1978. User's Guide for RAM. Publication No. EPA-600/8-78-016, Vol. a and b. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS Nos. PB 294791 and PB 294792)

Catalano, J. A., D. B. Turner, and H. Novak. 1987. User's Guide for RAM— Second Edition. U.S. Environmental Protection Agency, Research Triangle Park, NC. (Distributed as part of UNAMAP, Version 6), Documentation)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487-4650.

Abstract

RAM is a steady-state Gaussian plume model for estimating concentrations of relatively stable pollutants, for averaging times from an hour to a day, from point and area sources in a rural or urban setting. Level terrain is assumed. Calculations are performed for each hour.

a. *Recommendations for Regulatory Use*

RAM is appropriate for the following applications:

Point and area sources;

Urban areas;

Flat terrain;

Transport distances less than 50 kilometers; and

One hour to one year averaging times.

The following options should be selected for regulatory applications:

Set the regulatory "default option" to automatically select stack tip downwash, final plume rise, buoyancy-induced dispersion (BID), the new treatment for calms, the appropriate wind profile exponents, and the appropriate value for pollutant half-life.

b. *Input Requirements*

Source data: Point sources require location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter and stack gas temperature. Area sources require location, size, emission rate, and height of emissions.

Meteorological data: Hourly surface weather data from the preprocessor program RAMMET which provides hourly stability class, wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is also required.

Receptor data: Coordinates of each receptor. Options for automatic placement of receptors near expected concentration maxima, and a gridded receptor array are included.

c. *Output*

Printed output optionally includes:

One to 24-hour and annual average concentrations at each receptor,

Limited individual source contribution list, and

Highest through fifth highest concentrations at each receptor for period, with the highest and high, second-high values flagged.

d. *Type of Model*

RAM is a Gaussian plume model.

e. *Pollutant Types*

RAM may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

RAM applies user-specified locations for all point sources and receptors.

Area sources are input as multiples of a user-defined unit area source grid size.

User specified stack heights are applied for individual point sources.

Up to 3 effective release heights may be specified for the area sources. Area source release heights are assumed to be appropriate for a 5 meter per second wind and to be inversely proportional to wind speed.

Actual separation between each source-receptor pair is used.

All receptors are assumed to be at the same height at or above ground level.

No terrain differences between source and receptor are accounted for.

g. *Plume Behavior*

RAM uses Briggs (1969, 1971, 1975) plume rise equations for final rise.

Stack tip downwash equation from Briggs (1974) is used.

A user supplied fraction of the area source height is treated as the physical height. The remainder is assumed to be plume rise for a 5 meter per second wind speed, and to be inversely proportional to wind speed.

Fumigation and building downwash are not treated.

h. *Horizontal Winds*

Constant, uniform (steady state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

Separate wind speed profile exponents (EPA, 1980) for urban cases are used.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

k. *Vertical Dispersion*

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform vertical mixing is assumed beyond that point.

Perfect reflection is assumed at the ground.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Physical removal is not explicitly treated.

n. *Evaluation Studies*

Ellis, H., P. Lou, and G. Dalzell, 1980. Comparison Study of Measured and Predicted Concentrations with the RAM Model at Two Power Plants Along Lake Erie, Second Joint Conference on Applications of Air Pollution Meteorology, New Orleans, LA.

Environmental Research and Technology, 1980. SO_2 Monitoring and RAM (Urban) Model Comparison Study in Summit County, Ohio. Document P–3618–152, Environmental Research & Technology, Inc., Concord, MA.

Guldberg, P. H., and C. W. Kern, 1978. A Comparison Validation of the RAM and PTMTP Models for Short-Term Concentrations in Two Urban Areas. *Journal of Air Pollution Control Association*, 28: 907–910.

Hodanbosi, R. R., and L. K. Peters, 1981. Evaluation of RAM Model for Cleveland, Ohio. *Journal of Air Pollution Control Association*, 31: 253–255.

Kennedy, K. H., R. D. Siegel, and M. P. Steinberg, 1981. Case-Specific Evaluation of the RAM Atmospheric Dispersion Model in an Urban Area, 74th Annual Meeting of the American Institute of Chemical Engineers, New Orleans, LA.

Kummier, R. H., B. Cho, G. Roginski, R. Sinha and A. Greenburg, 1979. A Comparative Validation of the RAM and Modified SAI Models for Short-Term SO_2 Concentrations in Detroit. *Journal of Air Pollution Control Association*, 29: 720–723.

Londergan, R. J., N. E. Bowne, D. R. Murray, H. Borenstein, and J. Mangano, 1980. An Evaluation of Short-Term Air Quality Models Using Tracer Study Data, Report No. 4333, American Petroleum Institute, Washington, D.C.

Morgenstern, P., M. J. Geraghty, and A. McKnight, 1979. A Comparative Study of the RAM (Urban) and RAMR (Rural) Models for Short-term SO_2 Concentrations in Metropolitan Indianapolis. 72nd Annual Meeting of the Air Pollution Control Association, Cincinnati, OH.

Ruff, R. E., 1980. Evaluation of the RAM Using the RAPS Data Base, Contract 68–02–2770, SRI International, Menlo Park, CA.

Londergan, R., D. Minott, D. Wackter, and R. Fizz, 1983. Evaluation of Urban Air Quality Simulation Models. EPA Publication No. EPA–450/4–83–020. U.S. Environmental Protection Agency, Research Triangle Park, NC.

A.5 Industrial Source Complex Model (ISC2)

Reference

Environmental Protection Agency, 1992. User's Guide for the Industrial Source Complex (ISC2) Dispersion Models, Volumes 1, 2, and 3. EPA Publication Nos. EPA–450/4–92–008a–c. Environmental Protection Agency, Research Triangle Park, NC. (NTIS Nos. PB 92–232461, PB 92–232453, and PB 92–232479, respectively)

Availability

The model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page A–1).

Abstract

The ISC2 model is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial source complex. This model can account for the following: Settling and dry deposition of particles; downwash; area, line and volume sources; plume rise as a function of downwind distance; separation of point sources; and limited terrain adjustment. It operates in both long-term and short-term modes.

a. *Recommendations for Regulatory Use*

ISC2 is appropriate for the following applications:

- Industrial source complexes;
- Rural or urban areas;
- Flat or rolling terrain;
- Transport distances less than 50 kilometers;
- 1-hour to annual averaging times; and
- Continuous toxic air emissions.

The following options should be selected for regulatory applications:

For short term or long term modeling, set the regulatory "default option"; i.e., use the keyword *DFAULT*, which automatically selects stack tip downwash, final plume rise, buoyancy induced dispersion (BID), the vertical potential temperature gradient, a treatment for calms, the appropriate wind profile exponents, the appropriate value for pollutant half-life, and a revised building wake effects algorithm; set the "rural option" (use the keyword *RURAL*) or "urban option" (use the keyword *URBAN*); and set the "concentration option" (use the keyword *CONC*).

b. *Input Requirements*

Source data: Location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, and stack gas temperature. Optional inputs include source elevation, building dimensions, particle size distribution with corresponding settling velocities, and surface reflection coefficients.

Meteorological data: ISCST2 requires hourly surface weather data from the preprocessor program RAMMET, which provides hourly stability class, wind direction, wind speed, temperature, and mixing height. For ISCLT2, input includes stability wind rose (STAR deck), average afternoon mixing height, average morning mixing height, and average air temperature.

Receptor data: coordinates and optional ground elevation for each receptor.

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 a(n) "N"-day period for any desired source combinations, and tables of the maximum 50 concentration or deposition values calculated for any desired source combinations for each specified time period.

d. *Type of Model*

ISC2 is a Gaussian plume model.

e. *Pollutant Types*

ISC2 may be used to model primary pollutants and continuous releases of toxic and hazardous waste pollutants. Settling and deposition are treated.

f. *Source-Receptor Relationships*

ISC2 applies user-specified locations for point, line, area and volume sources, and user-specified receptor locations or receptor rings.

User input topographic evaluation for each receptor is used. Elevations above stack top are reduced to the stack top elevation, i.e., "terrain chopping".

User input height above ground level may be used when necessary to simulate impact at elevated or "flag pole" receptors, e.g., on buildings.

Actual separation between each source-receptor pair is used.

g. *Plume Behavior*

ISC2 uses Briggs (1969, 1971, 1975) plume rise equations for final rise.

Stack tip downwash equation from Briggs (1974) is used.

Revised building wake effects algorithm is used. For stacks higher than building height plus one-half the lesser of the building height or building width, the building wake algorithm of Huber and Snyder (1976) is used. For lower stacks, the building wake algorithm of Schulman and Scire (Schulman and Hanna, 1986) is used, but stack tip downwash and BID are not used.

For rolling terrain (terrain not above stack height), plume centerline is horizontal at height of final rise above source.

Fumigation is not treated.

h. *Horizontal Winds*

Constant, uniform (steady-state) wind is assumed for each hour.

Straight line plume transport is assumed to all downwind distances.

Separate wind speed profile exponents (EPA, 1980) for both rural and urban cases are used.

An optional treatment for calm winds is included for short term modeling.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness or averaging time.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

k. *Vertical Dispersion*

Rural dispersion coefficients from Turner (1969) are used, with no adjustments for surface roughness.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform vertical mixing is assumed beyond that point.

Perfect reflection is assumed at the ground.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Time constant is input by the user.

m. *Physical Removal*

Settling and dry deposition of particulates are treated.

n. *Evaluation Studies*

Bowers, J. F., and A. J. Anderson, 1981. An Evaluation Study for the Industrial Source Complex (ISC) Dispersion Model, EPA Publication No. EPA-450/4-81-002. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Bowers, J. F., A. J. Anderson, and W. R. Hargraves, 1982. Tests of the Industrial Source Complex (ISC) Dispersion Model at the Armco Middletown, Ohio Steel Mill, EPA Publication No. EPA-450/4-82-006. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Scire, J. S., and L. L. Schulman, 1981. Evaluation of the BLP and ISC Models with SF_6 Tracer Data and SO_2 Measurements at Aluminum Reduction Plants. Air Pollution Control Association Specialty Conference on Dispersion Modeling for Complex Sources, St. Louis, MO.

Schulman, L. L., and S. R. Hanna, 1986. Evaluation of Downwash Modification to the Industrial Source Complex Model. Journal of the Air Pollution Control Association, 36: 258-264.

A.6 Multiple Point Gaussian Dispersion Algorithm With Terrain Adjustment (MPTER)

Reference

Pierce, Thomas D. and D. Bruce Turner, 1980. User's Guide for MPTER. EPA Publication No. EPA-600/8-80-016. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 80-197361)

Chico, T. and J. A. Catalano, 1986. Addendum to the User's Guide for MPTER. U.S. Environmental Protection Agency. Research Triangle Park, NC 27711. (Distributed as part of UNAMAP. Version 6, Documentation)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487-4650.

Abstract

MPTER is a Multiple Point Source Algorithm. This algorithm is useful for estimating air quality concentrations of relatively non-reactive pollutants. Hourly estimates are made using the Gaussian steady state model.

a. *Recommendations for Regulatory Use*

MPTER is appropriate for the following applications:

Point sources;

Rural or urban areas;

Flat or rolling terrain (no terrain above stack height);

Transport distances less than 50 kilometers; and

One hour to one year averaging times.

The following options should be selected for regulatory applications:

Set the regulatory "default option" (IOPT(25)=1) to automatically select stack tip downwash, final plume rise, buoyancy-induced dispersion (BID), the new treatment for calms, and the appropriate wind profile exponents, and the appropriate value for pollutant half-life.

b. *Input Requirements*

Source data: Location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, stack gas temperature, and optional ground level elevation.

Meteorological data: hourly surface weather data from the preprocessor program RAMMET which provides hourly stability class, wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is also required.

Receptor data: coordinates and optional ground elevation for each receptor.

c. *Output*

Printed output includes:

One to 24-hour and annual average concentrations at each receptor;

Highest through fifth highest concentrations at each receptor for period, with the highest and high, second-high values flagged; and

Limited source contribution table.

d. *Type of Model*

MPTER is a Gaussian plume model.

e. *Pollutant Types*

MPTER may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

MPTER applies user-specified locations of point sources and receptors.

User input stack height and source characteristics for each source are used.

User input topographic elevation for each receptor is used.

g. *Plume Behavior*

MPTER uses Briggs (1969, 1971, 1975) plume rise equations for final rise. Stack tip downwash equation from Briggs (1974) is used.

For rolling terrain (terrain not above stack height), plume centerline is horizontal at height of final rise above the source.

Fumigation and building downwash are not treated.

h. *Horizontal Winds*

Constant, uniform (steady-state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

Separate wind speed profile exponents (EPA, 1980) for both rural and urban cases are used.

i. *Vertical Wind Speed*

Vertical speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients from Turner (1969) are used with no adjustments made for variations in surface roughness or averaging times.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used. Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

k. *Vertical Dispersion*

Rural dispersion coefficients from Turner (1969) are used, with no adjustments made for variations in surface roughness.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used.

Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform vertical mixing is assumed beyond that point.

Perfect reflection is assumed at the ground.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Physical removal is not explicitly treated.

n. *Evaluation Studies*

No specific studies for MPTER because regulatory editions of CRSTER and MPTER are equivalent. Studies for CRSTER are relevant to MPTER as well (See page A–32).

A.7 Single Source (CRSTER) Model

Reference

Environmental Protection Agency, 1977. User's Manual for Single Source (CRSTER) Model. EPA Publication No. EPA–450/277–013. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 271360)

Catalano, J.A., 1986. Single Source (CRSTER) Model. Addendum to the User's Manual. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. (Distributed as part of UNAMAP, Version 6, Documentation)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487–4650.

Abstract

CRSTER is a steady state, Gaussian dispersion model designed to calculate concentrations from point sources at a single location in either a rural or urban setting. Highest and high-second high concentrations are calculated at each receptor for 1-hour, 3-hour, 24-hour, and annual averaging time.

a. *Recommendations for Regulatory Use*

CRSTER is appropriate for the following applications:

Single point sources;

Rural or urban areas;

Transport distances less than 50 kilometers; and

Flat or rolling terrain (no terrain above stack height).

The following options should be selected for regulatory applications:

Set the regulatory "default option" which automatically selects stack tip downwash, final plume rise, buoyancy-induced dispersion (BID), the new treatment for calms, and the appropriate wind profile exponents, and the appropriate value for pollutant half-life.

b. *Input Requirements*

Source data: Emission rate, physical stack height, stack gas exit velocity, stack inside diameter, and stack gas temperature.

Meteorological data: Hourly surface weather data from the preprocessor program RAMMET. Preprocessor output includes hourly stability class wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is also required.

Receptor data: Require distance of each of the five receptor rings.

c. *Output*

Printed output includes:

Highest and second highest concentrations for the year at each receptor for averaging times of 1-, 3-, and 24 hours, plus a user-selected averaging time which may be 2, 4, 6, 8, or 12 hours;

Annual arithmetic average at each receptor;

For each day, the highest 1-hour and 24-hour concentrations over the receptor field; and

Option for source contributions to concentrations at selected receptors.

d. *Type of Model*

CRSTER is a Gaussian plume model.

e. *Pollutant Types*

CRSTER may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

CRSTER treats up to 19 point sources, no area sources.

All point sources are assumed collocated.

User input stack height is used for each source.

User input topographic elevation is used for each receptor, but must be below top of stack or program will terminate execution.

Receptors are assumed at ground level.

g. *Plume Behavior*

CRSTER uses Briggs (1969, 1971, 1972) plume rise equations for final rise.

Stack tip downwash equation from Briggs (1974) is used.

For rolling terrain (terrain not above stack height), plume centerline is horizontal at height of final rise above the source.

Fumigation and building downwash are not treated.

h. *Horizontal Winds*

Constant, uniform (steady-state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

Separate set of wind speed profile exponents (EPA, 1980) for both rural and urban cases are used.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients from Turner (1969) are used in CRSTER with no adjustments made for variations in surface roughness or averaging times.

Urban dispersion coefficients from Briggs (Gifford, 1976) are used. Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

k. *Vertical Dispersion*

Rural dispersion coefficients from Turner (1969) are used with no adjustments made for surface roughness.

Urban dispersion coefficients from Briggs (Gifford, 1975) are used. Buoyancy-induced dispersion (Pasquill, 1976) is included.

Six stability classes are used.

Mixing height is accounted for with multiple reflections until the vertical plume standard deviation equals 1.6 times the mixing height; uniform mixing is assumed beyond that point.

Perfect reflection is assumed at the ground.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Physical removal is not explicitly treated.

n. *Evaluation Studies*

Klug, W., 1974. Dispersion from Tall Stacks. Fifth NATO/CCMS International Technical Meeting on Air Pollution Modeling, Denmark.

Londergan, R. J., N. E. Bowne, D. R. Murray, H. Borenstein, and J. Mangano, 1980. An Evaluation of Short-Term Air Quality Models Using Tracer Study Data, Report No. 4333. American Petroleum Institute, Washington, DC.

Mills, M. T., R. Caiazza, D. D. Hergert, and D. A. Lynn, 1981. Evaluation of Point Source Dispersion Models. EPA Publication No. EPA-450/4-81-032. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Mills, M. T., and F. A. Record, 1975. Comprehensive Analysis of Time Concentration Relationships and the Validation of a Single Source Dispersion Model. EPA Publication No. EPA-450/3-75-083. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Mills, M. T., and R. W. Stern, 1975. Model Validation and Time-Concentration Analysis of Three Power Plants. EPA Publication No. EPA-450/376-002. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Londergan, R., D. Minott, D. Wackter, T. Kincaid, and B. Bonitata, 1983. Evaluation of Rural Air Quality Simulation Models. EPA Publication No. EPA-450/4-83-033. U.S. Environmental Protection Agency, Research Triangle Park, NC.

TRC-Environmental Consultants, Inc., 1983. Overview, Results, and Conclusions for the EPRI Plume Model Validation and Development Project: Plains Site, EPRI EA-3074. Electric Power Research Institute, Palo Alto, CA.

A.8 Urban Airshed Model (UAM)

References

Environmental Protection Agency, 1990. User's Guide for the Urban Airshed Model, Volumes I-VIII. EPA Publication Nos. EPA-450/4-90-007a-c, d(R), e-g; EPA-454/B-93-004, respectively. U.S. Environmental Protection Agency, Research Triangle Park, NC (NTIS Nos. PB 91-131227, PB 91-131235, PB 91-131243, PB 93-122380, PB 91-131268, PB 92-145382, and PB 92-224849, respectively, for Vols. I-VII).

Availability

The model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page A-1).

Abstract

UAM is an urban scale, three dimensional, grid type numerical simulation model. The model incorporates a condensed photochemical kinetics mechanism for urban atmospheres. The UAM is designed for computing ozone (O_3) concentrations under short-term, episodic conditions lasting one or two days resulting from emissions of oxides of nitrogen (NO_X), volatile organic compounds (VOC), and carbon monoxide (CO). The model treats urban VOC emissions as their carbon-bond surrogates.

a. *Recommendations for Regulatory Use*

UAM is appropriate for the following applications: Urban areas having significant ozone attainment problems and one hour averaging times.

UAM has many options but no specific recommendations can be made at this time on all options. The reviewing agency should be consulted on selection of options to be used in regulatory applications.

b. *Input Requirements*

Source data: Gridded, hourly emissions of PAR, OLE, ETH, XYL, TOL, ALD2, FORM, ISOR, ETOTH, MEOH, CO, NO, and NO_2 for low-level sources. For major elevated point sources, hourly emissions, stack height, stack diameter, exit velocity, and exit temperature.

Meteorological data: Hourly, gridded, divergence free, u and v wind components for each vertical level; hourly gridded mixing heights and surface temperatures; hourly exposure class; hourly vertical potential temperature gradient above and below the mixing height; hourly surface atmospheric pressure; hourly water mixing ratio; and gridded surface roughness lengths.

Air quality data: Concentration of all carbon bond 4 species at the beginning of the simulation for each grid cell; and hourly concentrations of each pollutant at each level along the inflow boundaries and top boundary of the modeling region.

Other data requirements are: Hourly mixed layer average, NO_2 photolysis rates; and ozone surface uptake resistance along with associated gridded vegetation (scaling) factors.

c. *Output*

Printed output includes:

- Gridded instantaneous concentration fields at user-specified time intervals for user-specified pollutants and grid levels;
- Gridded time-average concentration fields for user-specified time intervals, pollutants, and grid levels.

d. *Type of Model*

UAM is a three dimensional, numerical, photochemical grid model.

e. *Pollutant Types*

UAM may be used to model ozone (O_3) formation from oxides of nitrogen (NO_x) and volatile organic compound (VOC) emissions.

f. *Source-Receptor Relationship*

Low-level area and point source emissions are specified within each surface grid cell. Emissions from major point sources are placed within cells aloft in accordance with calculated effective plume heights.

Hourly average concentrations of each pollutant are calculated for all grid cells at each vertical level.

g. *Plume Behavior*

Plume rise is calculated for major point sources using relationships recommended by Briggs (1971).

h. *Horizontal Winds*

See Input Requirements.

i. *Vertical Wind Speed*

Calculated at each vertical grid cell interface from the mass continuity relationship using the input gridded horizontal wind field.

j. *Horizontal Dispersion*

Horizontal eddy diffusivity is set to a user specified constant value (nominally 50 m^2/s).

k. *Vertical Dispersion*

Vertical eddy diffusivities for unstable and neutral conditions calculated using relationships of Lamb et al. (1977); for stable conditions, the relationship of Businger and Arya (1974) is employed. Stability class, friction velocity, and Monin-Obukhov length determined using procedure of Liu et al. (1976).

l. *Chemical Transformation*

UAM employs a simplified version of the Carbon-Bond IV Mechanism (CBM-IV) developed by Gery et al. (1988) employing various steady state approximations.

m. *Physical Removal*

Dry deposition of ozone and other pollutant species are calculated. Vegetation (scaling) factors are applied to the reference surface uptake resistance of each species depending on land use type.

n. *Evaluation Studies*

Builtjes, P.J.H., K.D. van der Hurt, and S.D. Reynolds, 1982. Evaluation of the Performance of a Photochemical Dispersion Model in Practical Applications, 13th International Technical Meeting on Air Pollution Modeling and Its Application, Ile des Embiez, France.

Cole, H.S., D.E. Layland, G.K. Moss, and C.F. Newberry, 1983. The St. Louis Ozone Modeling Project. EPA Publication No. EPA-450/4-83-019. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Dennis, R.L., M.W. Downton, and R.S. Keil, 1983. Evaluation of Performance Measures for an Urban Photochemical Model. EPA Publication No. EPA-450/4-83-021. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Haney, J.L. and T.N. Braverman, 1985. Evaluation and Application of the Urban Airshed Model in the Philadelphia Air Quality Control Region. EPA Publication No. EPA-450/4-85-003. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Layland, D.E. and H.S. Cole, 1983. A Review of Recent Applications of the SAI Urban Airshed Model. EPA Publication No. EPA-450/4-84-004. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Layland, D.E., S.D. Reynolds, H. Hogo and W.R. Oliver, 1983. Demonstration of Photochemical Grid Model Usage for Ozone Control Assessment. 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA.

Morris, R.E. et al., 1990. Urban Airshed Model Study of Five Cities. EPA Publication No. EPA-450/4-90-006a-g. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Reynolds, S.D., H. Hogo, W.R. Oliver, L.E. Reid, 1982. Application of the SAI Airshed Model to the Tulsa Metropolitan Area, SAI No. 82004. Systems Applications, Inc., San Rafael, CA.

Schere, K.L. and J.H. Shreffler, 1982. Final Evaluation of Urban-Scale Photochemical Air Quality Simulation Models. EPA Publication No. EPA-600/3-82-094. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Seigneur C., T.W. Tesche, C.E. Reid, P.M. Roth, W.R. Oliver, and J.C. Cassmassi, 1981. The Sensitivity of Complex Photochemical Model Estimates to Detail In Input

Information, Appendix A—A Compilation of Simulation Results. EPA Publication No. EPA-450/4-81-031b. U.S. Environmental Protection Agency, Research Triangle Park, NC.

South Coast Air Quality Management District, 1989. Air Quality Management Plan—Appendix V-R (Urban Airshed Model Performance Evaluation). El Monte, CA.

Stern, R. and B. Scherer, 1982. Simulation of a Photochemical Smog Episode in the Rhine-Ruhr Area with a Three Dimensional Grid Model. 13th International Technical Meeting on Air Pollution Modeling and Its Application, Ile des Embiez, France.

Tesche, T. W., C. Seigneur, L. E. Reid, P. M. Roth, W. R. Oliver, and J. C. Cassmassi, 1981. The Sensitivity of Complex Photochemical Model Estimates to Detail in Input Information. EPA Publication No. EPA-450/4-81-031a. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Tesche, T. W., W. R. Oliver, H. Hogo, P. Saxeena and J. L. Haney, 1983. Volume IV—Assessment of NO_x Emission Control Requirements in the South Coast Air Basin—Appendix A. Performance Evaluation of the Systems Applications Airshed Model for the 26-27 June 1974 O_3 Episode in the South Coast Air Basin, SYSAPP 83/037. Systems Applications, Inc., San Rafael, CA.

Tesche, T. W., W. R. Oliver, H. Hogo, P. Saxeena and J. L. Haney, 1983. Volume IV—Assessment of NO_x Emission Control Requirements in the South Coast Air Basin—Appendix B. Performance Evaluation of the Systems Applications Airshed Model for the 7-8 November 1978 NO_2 Episode in the South Coast Air Basin, SYSAPP 83/038. Systems Applications, Inc., San Rafael, CA.

Tesche, T. W, 1988. Accuracy of Ozone Air Quality Models. Journal of Environmental Engineering, 114(4): 739-752.

A.9 Offshore and Coastal Dispersion Model (OCD)

Reference

DiCristofaro, D. C. and S. R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model, Version 4. Volume I: User's Guide, and Volume II: Appendices. Sigma Research Corporation, Westford, MA. (NTIS Nos. PB 93-144384 and PB 93-144392)

Availability

This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page A-1).

Technical

Contact: Minerals Management Service, Attn: Mr. Dirk Herkoff, Parkway Atrium Building, 381 Elden Street, Herndon, VA 22070-4817, Phone: (703) 787-1735.

Abstract

OCD is a straight-line Gaussian model developed to determine the impact of offshore emissions from point, area or line sources on the air quality of coastal regions. OCD incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shoreline. Hourly meteorological data are needed from both offshore and onshore locations. These include water surface temperature, overwater air temperature, mixing height, and relative humidity.

Some of the key features include platform building downwash, partial plume penetration into elevated inversions, direct use of turbulence intensities for plume dispersion, interaction with the overland internal boundary layer, and continuous shoreline fumigation.

a. *Recommendations for Regulatory Use*

OCD has been recommended for use by the Minerals Management Service for emissions located on the Outer Continental Shelf (50 FR 12248; 28 March 1985). OCD is applicable for overwater sources where onshore receptors are below the lowest source height. Where onshore receptors are above the lowest source height, offshore plume transport and dispersion may be modeled on a case-by-case basis in consultation with the EPA Regional Office.

b. *Input Requirements*

Source data: Point, area or line source location, pollutant emission rate, building height, stack height, stack gas temperature, stack inside diameter, stack gas exit velocity, stack angle from vertical, elevation of stack base above water surface and gridded specification of the land/water surfaces. As an option, emission rate, stack gas exit velocity and temperature can be varied hourly.

Meteorological data (over water): Wind direction, wind speed, mixing height, relative humidity, air temperature, water surface temperature, vertical wind direction shear (optional), vertical temperature gradient (optional), turbulence intensities (optional).

Meteorological data (over land): Wind direction, wind speed, temperature, stability class, mixing height.

Receptor data: Location, height above local ground-level, ground-level elevation above the water surface.

c. *Output*

All input options, specification of sources, receptors and land/water map including locations of sources and receptors.

Summary tables of five highest concentrations at each receptor for each averaging period, and average concentration for entire run period at each receptor.

Optional case study printout with hourly plume and receptor characteristics. Optional table of annual impact assessment from non-permanent activities.

Concentration files written to disk or tape can be used by ANALYSIS postprocessor to produce the highest concentrations for each receptor, the cumulative frequency distributions for each receptor, the tabulation of all concentrations exceeding a given threshold, and the manipulation of hourly concentration files.

d. *Type of Model*

OCD is a Gaussian plume model constructed on the framework of the MPTER model.

e. *Pollutant Types*

OCD may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

Up to 250 point sources, 5 area sources, or 1 line source and 180 receptors may be used.

Receptors and sources are allowed at any location.

The coastal configuration is determined by a grid of up to 3600 rectangles. Each element of the grid is designated as either land or water to identify the coastline.

g. *Plume Behavior*

As in MPTER, the basic plume rise algorithms are based on Briggs' recommendations.

Momentum rise includes consideration of the stack angle from the vertical.

The effect of drilling platforms, ships, or any overwater obstructions near the source are used to decrease plume rise using a revised platform downwash algorithm based on laboratory experiments.

Partial plume penetration of elevated inversions is included using the suggestions of Briggs (1975) and Weil and Brower (1984).

Continuous shoreline fumigation is parameterized using the Turner method where complete vertical mixing through the thermal internal boundary layer (TIBL) occurs as soon as the plume intercepts the TIBL.

h. *Horizontal Winds*

Constant, uniform wind is assumed for each hour.

Overwater wind speed can be estimated from overland wind speed using relationship of Hsu (1981).

Wind speed profiles are estimated using similarity theory (Businger 1973). Surface layer fluxes for these formulas are calculated from bulk aerodynamic methods.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Lateral turbulence intensity is recommended as a direct estimate of horizontal dispersion. If lateral turbulence intensity is not available, it is estimated from boundary layer theory. For wind speeds less than 8 m/s, lateral turbulence intensity is assumed inversely proportional to wind speed.

Horizontal dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement and wind direction shear enhancement.

At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either lateral turbulence intensity or Pasquill-Gifford curves. The change is implemented where the plume intercepts the rising internal boundary layer.

k. *Vertical Dispersion*

Observed vertical turbulence intensity is not recommended as a direct estimate of vertical dispersion. Turbulence intensity should be estimated from boundary layer theory as default in the model. For very stable conditions, vertical dispersion is also a function of lapse rate.

Vertical dispersion may be enhanced because of obstructions near the source. A virtual source technique is used to simulate the initial plume dilution due to downwash.

Formulas recommended by Pasquill (1976) are used to calculate buoyant plume enhancement.

At the water/land interface, the change to overland dispersion rates is modeled using a virtual source. The overland dispersion rates can be calculated from either vertical turbulence intensity or the Pasquill-Gifford coefficients. The change is implemented where the plume intercepts the rising internal boundary layer.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Different rates can be specified by month and by day or night.

m. *Physical Removal*

Physical removal is also treated using exponential decay.

n. *Evaluation Studies*

DiCristofaro, D. C. and S. R. Hanna, 1989. OCD: The Offshore and Coastal Dispersion Model. Volume I: User's Guide. Sigma Research Corporation, Westford, MA.

Hanna, S. R. and D. C. DiCristofaro, 1988. Development and Evaluation of the OCD/API Model. Final Report, API Pub. 4461, American Petroleum Institute, Washington, DC.

Hanna, S. R., L. L. Schulman, R. J. Paine and J. E. Pleim, 1984. The Offshore and Coastal Dispersion (OCD) Model User's Guide, Revised. OCS Study, MMS 84-0069. Environmental Research & Technology, Inc., Concord, MA. (NTIS No. PB 86-159803)

Hanna, S. R., L. L. Schulman, R. J. Paine, J. E. Pleim and M. Baer, 1985. Development and Evaluation of the Offshore and Coastal Dispersion (OCD) Model. Journal of the Air Pollution Control Association, 35: 1039-1047.

A.10 EMISSIONS AND DISPERSION MODELING SYSTEM (EDMS)

Reference

Segal, H. M., 1991. "EDMS—Microcomputer Pollution Model for Civilian Airports and Air Force Bases: User's Guide." FAA Report No. FAA-EE-91-3; USAF Report No. ESL-TR-91-31, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591. (NTIS No. ADA 240528)

Segal, H. M., and Hamilton, P. L., 1988. "A Microcomputer Pollution Model for Civilian Airports and Air Force Bases—Model Description." FAA Report No. FAA-EE-88-4; USAF Report No. ESL-TR-88-53, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591. (NTIS No. ADA 199003)

Segal, H. M., 1988. "A Microcomputer Pollution Model for Civilian Airports and Air Force Bases—Model Application and Background." FAA Report No. FAA-EE-88-5; USAF Report No. ESL-TR-88-55, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591. (NTIS No. ADA 199794)

Availability

EDMS is available for $40 from the address listed below: Federal Aviation Administration, Attn: Mr. Howard Segal, AEE-120, 800 Independence Avenue, SW., Washington, DC 20591, Phone: (202) 267-3494.

Abstract

EDMS is a combined emissions/dispersion model for assessing pollution at civilian airports and military air bases. This model, which was jointly developed by the Federal Aviation Administration (FAA) and the United States Air Force (USAF), produces an emission inventory of all airport sources and calculates concentrations produced by these sources at specified receptors. The system stores emission factors for fixed sources such as fuel storage tanks and incinerators and also for mobile sources such as automobiles or aircraft. EDMS incorporates an emissions model to calculate an emission inventory for each airport source and a dispersion model, the Graphical Input Microcomputer Model (GIMM), (Segal, 1983) to calculate pollutant concentrations produced by these sources at specified receptors. The GIMM, which processes point, area, and line sources, also incorporates a special meteorological preprocessor for processing up to one year of National Climatic Data Center (NCDC) hourly data. The model operates in both a screening and refined mode, accepting up to 170 sources and 10 receptors.

a. *Recommendations for Regulatory Use*

EDMS is appropriate for the following applications:

- Cumulative effect of changes in aircraft operations, point source and mobile source emissions at airports or air bases;
- simple terrain;
- transport distances less than 50 kilometers; and
- 1-hour to annual averaging times.

b. *Input Requirements*

All data are entered through a "runtime" version of the Condor data base which is an integral part of EDMS. Typical entry items are source and receptor coordinates, percent cold starts, vehicles per hour, etc. Some point sources, such as heating plants, require stack height, stack diameter, and effluent temperature inputs.

Wind speed, wind direction, hourly temperature, and Pasquill-Gifford stability category (P-G) are the meteorological inputs. They can be entered manually through the EDMS data entry screens or automatically through the processing of previously loaded NCDC hourly data.

c. *Output*

Printed outputs consist of:

- A monthly and yearly emission inventory report for each source entered; and
- A concentration summing report for up to 8760 hours (one year) of data.

d. *Type of Model*

For its emissions inventory calculations, EDMS uses algorithms consistent with the EPA Compilation of Air Pollutant Emission Factors, AP-42. For its dispersion calculations, EDMS uses the GIMM model which is described in reports FAA-EE-88-4 and FAA-EE-88-5, referenced above. GIMM uses a Gaussian plume algorithm.

e. *Pollutant Types*

EDMS inventories and calculates the dispersion of carbon monoxide, nitrogen oxides, sulphur oxides, hydrocarbons, and suspended particles.

f. *Source-Receptor Relationship*

Up to 170 sources and 10 receptors can be treated simultaneously. Area sources are treated as a series of lines that are positioned perpendicular to the wind.

Line sources (roadways, runways) are modeled as a series of points. Terrain elevation differences between sources and receptors are neglected.

Receptors are assumed to be at ground level.

g. *Plume Behavior*

Plume rise is calculated for all point sources (heating plants, incinerators, etc.) using Briggs plume rise equations (Catalano, 1986; Briggs, 1969; Briggs, 1971; Briggs, 1972).

Building and stack tip downwash effects are not treated.

Roadway dispersion employs a modification to the Gaussian plume algorithms as suggested by Rao and Keenan (1980) to account for close-in vehicle-induced turbulence.

h. *Horizontal Winds*

Steady state winds are assumed for each hour. Winds are assumed to be constant with altitude.

Winds are entered manually by the user or automatically by reading previously loaded NCC annual data files.

i. *Vertical Wind Speed*

Vertical wind speed is assumed to be zero.

j. *Horizontal Dispersion*

Four stability classes are used (P-G classes B through E).

Horizontal dispersion coefficients are computed using a table lookup and linear interpolation scheme. Coefficients are based on Pasquill (1976) as adapted by Petersen (1980).

A modified coefficient table is used to account for traffic-enhanced turbulence near roadways. Coefficients are based upon data included in Rao and Keenan (1980).

k. *Vertical Dispersion*

Four stability classes are used (P-G classes B through E).

Vertical dispersion coefficients are computed using a table lookup and linear interpolation scheme. Coefficients are based on Pasquill (1976) as adapted by Petersen (1980).

A modified coefficient table is used to account for traffic-enhanced turbulence near roadways. Coefficients are based upon data from Rao and Keenan (1980).

l. *Chemical Transformation*

Chemical transformations are not accounted for.

m. *Physical Removal*

Deposition is not treated.

n. *Evaluation Studies*

Segal, H. M. and P. L. Hamilton, 1988. A Microcomputer Pollution Model for Civilian Airports and Air Force Bases—Model Description. FAA Report No. FAA–EE–88–4; USAF Report No. ESL–TR–88–53, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591.

Segal, H. M., 1988. A Microcomputer Pollution Model for Civilian Airports and Air Force Bases—Model Application and Background. FAA Report No. FAA–EE–88–5; USAF Report No. ESL–TR–88–55, Federal Aviation Administration, 800 Independence Avenue, SW., Washington, DC 20591.

A.11 Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS)

Reference

Perry, S. G., D. J. Burns, L. H. Adams, R. J. Paine, M. G. Dennis, M. T. Mills, D. G. Strimaitis, R. J. Yamartino and E. M. Insley, 1989. User's Guide to the Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS). Volume 1: Model Descriptions and User Instructions. EPA Publication No. EPA–600/8–89–041. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89–181424)

Paine, R. J., D. G. Strimaitis, M. G. Dennis, R. J. Yamartino, M. T. Mills and E. M. Insley, 1987. User's Guide to the Complex Terrain Dispersion Model, Volume 1. EPA Publication No. EPA–600/8–87–058a. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 88–162169)

Availability

This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (See page A–1).

Abstract

CTDMPLUS is a refined point source Gaussian air quality model for use in all stability conditions for complex terrain applications. It contains, in its entirety, the technology of CTDM for stable and neutral conditions. However, CTDMPLUS can also simulate daytime, unstable conditions, and has a number of additional capabilities for improved user friendliness. Its use of meteorological data and terrain information is different from other EPA models; considerable detail for both types of input data is required and is supplied by preprocessors specifically designed for CTDMPLUS. CTDMPLUS requires the parameterization of individual hill shapes using the terrain preprocessor and the association of each model receptor with a particular hill.

a. *Recommendation for Regulatory Use*

CTDMPLUS is appropriate for the following applications:

- Elevated point sources;
- Terrain elevations above stack top;
- Rural or urban areas;
- Transport distances less than 50 kilometers; and
- One hour to annual averaging times when used with a post-processor program such as CHAVG.

b. *Input Requirements*

Source data: For each source, user supplies source location, height, stack diameter, stack exit velocity, stack exit temperature, and emission rate; if variable emissions are appropriate, the user supplies hourly values for emission rate, stack exit velocity, and stack exit temperature.

Meteorological data: The user must supply hourly averaged values of wind, temperature and turbulence data for creation of the basic meteorological data file ("PROFILE"). Meteorological preprocessors then create a SURFACE data file (hourly values of mixed layer heights, surface friction velocity, Monin-Obukhov length and surface roughness length) and a RAWINsonde data file (upper air measurements of pressure, temperature, wind direction, and wind speed).

Receptor data: Receptor names (up to 400) and coordinates, and hill number (each receptor must have a hill number assigned).

Terrain data: User inputs digitized contour information to the terrain preprocessor which creates the TERRAIN data file (for up to 25 hills).

c. *Output*

When CTDMPLUS is run, it produces a concentration file, in either binary or text format (user's choice), and a list file containing a verification of model inputs, i.e.,

- Input meteorological data from "SURFACE" and "PROFILE"
- Stack data for each source
- Terrain information
- Receptor information
- Source-receptor location (line printer map).

In addition, if the case-study option is selected, the listing includes:

- Meteorological variables at plume height
- Geometrical relationships between the source and the hill
- Plume characteristics at each receptor, i.e.,

→ distance in along-flow and cross flow direction.

→ effective plume-receptor height difference.

→ effective σ_y & σ_z values, both flat terrain and hill induced (the difference shows the effect of the hill).

→ concentration components due to WRAP, LIFT and FLAT.

If the user selects the TOPN option, a summary table of the top 4 concentrations at each receptor is given. If the ISOR option is selected, a source contribution table for every hour will be printed.

A separate disk file of predicted (1-hour only) concentrations ("CONC") is written if the user chooses this option. Three forms of output are possible:

(1) A binary file of concentrations, one value for each receptor in the hourly sequence as run;

(2) A text file of concentrations, one value for each receptor in the hourly sequence as run; or

(3) A text file as described above, but with a listing of receptor information (names, positions, hill number) at the beginning of the file.

Hourly information provided to these files besides the concentrations themselves includes the year, month, day, and hour information as well as the receptor number with the highest concentration.

d. *Type of Model*

CTDMPLUS is a refined steady-state, point source plume model for use in all stability conditions for complex terrain applications.

e. *Pollutant Types*

CTDMPLUS may be used to model non-reactive, primary pollutants.

f. *Source-Receptor Relationship*

Up to 40 point sources, 400 receptors and 25 hills may be used. Receptors and sources are allowed at any location. Hill slopes are assumed not to exceed 15°, so that the linearized equation of motion for Bouissinesq flow are applicable. Receptors upwind of the impingement point, or those associated with any of the hills in the modeling domain, require separate treatment.

g. *Plume Behavior*

As in CTDM, the basic plume rise algorithms are based on Briggs' (1975) recommendations.

A central feature of CTDMPLUS for neutral/stable conditions is its use of a critical dividing-streamline height (H_c) to separate the flow in the vicinity of a hill into two separate layers. The plume component in the upper layer has sufficient kinetic energy to pass over the top of the hill while streamlines in the lower portion are constrained to flow in a horizontal plane around the hill. Two separate components of CTDMPLUS compute ground-level concentrations resulting from plume material in each of these flows.

The model calculates on an hourly (or appropriate steady averaging period) basis how the plume trajectory (and, in stable/neutral conditions, the shape) is deformed by each hill. Hourly profiles of wind and temperature measurements are used by CTDMPLUS to compute plume rise, plume penetration (a formulation is included to handle penetration into elevated stable layers, based on Briggs (1984)), convective scaling parameters, the value of H_c, and the Froude number above H_c.

h. *Horizontal Winds*

CTDMPLUS does not simulate calm meteorological conditions. Both scalar and vector wind speed observations can be read by the model. If vector wind speed is unavailable, it is calculated from the scalar wind speed. The assignment of wind speed (either vector or scalar) at plume height is done by either:

- Interpolating between observations above and below the plume height, or
- Extrapolating (within the surface layer) from the nearest measurement height to the plume height.

i. *Vertical Wind Speed*

Vertical flow is treated for the plume component above the critical dividing streamline height (H_c); see "Plume Behavior".

j. *Horizontal Dispersion*

Horizontal dispersion for stable/neutral conditions is related to the turbulence velocity scale for lateral fluctuations, σ_v, for which a minimum value of 0.2 m/s is used. Convective scaling formulations are used to estimate horizontal dispersion for unstable conditions.

k. *Vertical Dispersion*

Direct estimates of vertical dispersion for stable/neutral conditions are based on observed vertical turbulence intensity, e.g., σ_w (standard deviation of the vertical velocity fluctuation). In simulating unstable (convective) conditions, CTDMPLUS relies on a skewed, bi-Gaussian probability density function (PDF) description of the vertical velocities to estimate the vertical distribution of pollutant concentration.

l. *Chemical Transformation*

Chemical transformation is not treated by CTDMPLUS.

m. *Physical Removal*

Physical removal is not treated by CTDMPLUS (complete reflection at the ground/hill surface is assumed).

n. *Evaluation Studies*

Burns, D. J., L. H. Adams and S. G. Perry, 1990. Testing and Evaluation of the CTDMPLUS Dispersion Model: Daytime Convective Conditions. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J. O., S. G. Perry and D. J. Burns, 1990. An Analysis of CTDMPLUS Model Predictions with the Lovett Power Plant Data Base. Environmental Protection Agency, Research Triangle Park, NC.

Paumier, J. O., S. G. Perry and D. J. Burns, 1992. CTDMPLUS: A Dispersion Model for Sources near Complex Topography. Part II: Performance Characteristics. Journal of Applied Meteorology, 31(7): 646–660.

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Moore, G. E., T. E. Stoeckenius and D. A. Stewart, 1982. A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Model. EPA Publication No. EPA–450/4–83–001. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Pasquill, F., 1976. Atmospheric Dispersion Parameters in Gaussian Plume Modeling Part II. Possible Requirements for Change in the Turner Workbook Values. EPA Publication No. EPA–600/4–76–030b. U.S. Environmental Protection Agency, Research Triangle Park, NC.

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Gery, M. W., G. Z. Whitten and J. P. Killus, 1988. Development and Testing of CBM–IV for Urban and Regional Modeling. EPA Publication No. EPA–600/3–88–012. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 88–180039)

Petersen, W. B., 1980. User's Guide for HIWAY–2 A Highway Air Pollution Model. EPA Publication No. EPA–600/8–80–018. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS PB 80–227556)

Rao, T. R. and M. T. Keenan, 1980. Suggestions for Improvement of the EPA—HIWAY Model. Journal of the Air Pollution Control Association, 30: 247–256 (and reprinted as appendix C in Petersen, 1980).

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Appendix B to Appendix W of Part 51—Summaries of Alternative Air Quality Models

Table of Contents

B.0 Introduction and Availability

This appendix summarizes key features of refined air quality models that may be considered on a case-by-case basis for individual regulatory applications. For each model, information is provided on availability, approximate cost in 1990, regulatory use, data input, output format and options, simulation of atmospheric physics and accuracy. The models are listed by name in alphabetical order.

There are three separate conditions under which these models will normally be approved for use: First, if a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model (e.g., the maximum or high, second-high concentration is within 2% of the estimate using the comparable preferred model); second, if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the model in Appendix B performs better for the application than a comparable model in Appendix A; and third, if there is no preferred model for the specific application but a refined model is needed to satisfy regulatory requirements. Any one of these three separate conditions may warrant use of these models. See section 3.2, Use of Alternative Models, for additional details.

Many of these models have been subject to a performance evaluation by comparison with observed air quality data. A summary of such comparisons for models contained in this appendix is included in "A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Models", EPA-450/4-83-001. Where possible, several of the models contained herein have been subjected to rigorous evaluation exercises, including (1) statistical performance measures recommended by the American Meteorological Society and (2) peer scientific reviews.

Any availability statement for models in this appendix that refers to the User's Network for Applied Modeling of Air Pollution (UNAMAP) should be ignored since the UNAMAP is no longer operational. However, a source for some of these models and user's documentation is: Computer Products, National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487-4650.

A number of the model codes and selected, abridged user's guides are also available from the Support Center for Regulatory Air Models Bulletin Board System [19] (SCRAM BBS), Telephone (919) 541-5742. The SCRAM BBS is an electronic bulletin board system designed to be user friendly and accessible from anywhere in the country. Model users with personal computers are encouraged to use the SCRAM BBS to download current model codes and text files.

B.1 Air Quality Display Model (AQDM)

Reference

TRW Systems Group, 1969. Air Quality Display Model. Prepared for National Air Pollution Control Administration, DHEW. U.S. Public Health Service, Washington, DC (NTIS No. PB 189194)

Availability

The above User's Guide is available from NTIS at a cost of $16.95. This model is available at no cost in the form of a punched card deck from: Library Services, MD-35, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, Attn: Ann Ingram.

Abstract

AQDM is a climatological steady state Gaussian plume model that estimates annual arithmetic average sulfur dioxide and particulate concentrations at ground level in urban areas. A statistical model based on Larsen (1971) is used to transform the average concentration data from a limited number of receptors into expected geometric mean and maximum concentration values for several different averaging times.

a. *Recommendations for Regulatory Use*

AQDM can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. AQDM must be executed in the equivalent mode.

AQDM can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that AQDM is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Average emissions rates and heights of emissions for point and area sources; stack gas temperature, stack gas exit velocity, and stack inside diameter for plume rise calculations for point sources.

Meteorological data requirements are: Stability wind rose (STAR deck), average afternoon mixing height, average morning mixing height, and average air temperature.

Receptor data requirements are: number and locations of receptors. If the Larsen transform option is to be used to estimate short averaging time concentrations, measured standard geometric deviation of concentrations is required.

c. *Output*

Printed output includes:

One month to one year average concentrations (arithmetic mean only) at each receptor;

Optional arbitrary averaging time by Larsen (1971) procedure (typically 1-24 hr); and

Optional individual point, area source culpability list for each receptor.

d. *Type of Model*

AQDM is a Gaussian plume model.

e. *Pollutant Types*

AQDM may be used to model non-reactive pollutants. Settling and deposition are not treated.

f. *Source Receptor Relationship*

AQDM applies user-specified locations and stack height for each point source.

AQDM uses any location and size for each area source.

Up to 225 receptors may be located on uniform rectangular grid.

Up to 12 user-specified receptor locations are permitted.

Unique release height is used for each point and area source. Receptors are assumed to be at ground level.

No terrain differences between source and receptor are treated.

g. *Plume Behavior*

AQDM uses Briggs (1969) plume rise formulas.

No plume rise is calculated for area sources.

Fumigation and downwash are not treated.

Zero concentration is assumed when plume height is greater than mixing height.

h. *Horizontal Winds*

Wind data are input as stability wind rose (joint frequency distribution) of 16 wind directions, six wind speed classes, and five stability classes.

No variation in wind speed with height is assumed.

Constant, uniform (steady-state) wind is assumed.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Pollutants are assumed evenly distributed across a 22.5 degree sector.

Frequency of occurrence of a meteorological state is interpolated between sector center lines.

Averaging times from 1 month to 1 year or longer are treated.

k. *Vertical Dispersion*

Rural dispersion coefficients from Turner (1969) are used.

Five stability classes are as defined by Turner (1964). Stability classes E and F are combined, and assigned dispersion values equivalent to stability class D.

Neutral stability is split internally into 60% day, 40% night, with the two differing only in the treatment of mixing height.

Mixing height is a function of a single input afternoon mixing height, a single input morning mixing height, modified by the stability class.

l. *Chemical Transformations*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

McNidar, R.R., 1977. Variability Analysis of Long-term Dispersion Models. Joint Conference on Applications of Air Pollution Meteorology, American Meteorology Society, 29 November–2 December, 1977, Salt Lake City, UT.

Turner, D.B., J.R. Zimmerman, and A.D. Busse, 1973. An Evaluation of Some Climatological Dispersion Models. In Appendix E, User's Guide to the Climatological Dispersion Model, EPA Publication No. EPA–R4–73–024, Environmental Protection Agency, Research Triangle Park, NC.

Londergan, R.J., D.H. Minott, D.J. Wachter and R.R. Fizz, 1983. Evaluation of Urban Air Quality Simulation Models. EPA Publication No. EPA–450/4–83–020. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.2 Air Resources Regional Pollution Assessment (ARRPA) Model

Reference

Mueller, S.F., R.J. Valente, T.L. Crawford, A.L. Sparks, and L.L. Gautney, Jr., 1983. Description of the Air Resources Regional Pollution Assessment (ARRPA) Model. TVA/ONR/AQB–83/14. Tennessee Valley Authority, Muscle Shoals, AL.

Availability

The computer code and sample input for this model on magnetic tape and a copy of the User's Guide are available from: Computer Services Development Branch, Office of Natural Resources and Economic Development, Tennessee Valley Authority, OSWHA, Muscle Shoals, AL 35660, Phone: (205) 386–2985.

A hard copy of the model output corresponding with the sample input is also available. The cost of copying model information to a buyer-supplied 2400-ft, high density tape is estimated to be about $100. The User's Guide is free of charge.

Abstract

The ARRPA model is a medium/long-range segmented-plume model. It is designed to compute air concentrations and surface dry mass deposition of sulfur dioxide and sulfate. A unique feature of the model is its use of prognostic meteorological output from the National Weather Service Boundary Layer Model (BLM). Boundary layer conditions are computed by the BLM on a grid with a spatial resolution of 80km, and are archived in intervals of 3 hours. BLM output used by this model includes three dimensional wind field components and potential temperature at 10 height levels from the surface through 2000m above the surface.

a. *Recommendations for Regulatory Use*

Use of the model for transport distances of less than 10km is not recommended. For 10km to beyond 50km, there is no specific recommendation at the present time. The model may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements: Location (latitude and longitude), stack height, stack diameter, stack gas exit velocity, stack gas temperature, SO_2 emission rate, SO_4= emission rate, stack base elevation.

Meteorological data requirements: Hourly wind field components (u,v,w), potential temperature (Θ), Pasquill-Gifford stability class and mixing height. These data are obtained as output from the BLM output preprocessing program called MDPP (Mueller and Valente, 1983). Required input to MDPP is BLM output (in three-hour intervals) of u, v, w, and Θ, surface layer friction velocity (u_*) and surface layer values of the inverse Monin-Obukhov length (L^{-1}).

Receptor data requirements: Gridded receptor array coordinates (x and y) and receptor heights (z) from a receptor preprocessing program called HEIGHT. HEIGHT produces a user-designed array of points which may be skewed up to ±90 degrees relative to the model x axis. The elevation of each receptor is adjusted to give height above smoothed model terrain. Non-gridded receptors can be specified using latitude/longitude coordinates.

c. *Output*

Printed output includes:

Listings of input parameters (except for meteorological data);

Listing of hours processed and flags for missing data periods.

Disk output: Parameters for controlling analysis and printout options in the postprocessing program called ANALYSIS; hourly SO_2 and SO_4= air concentrations and dry deposition amounts at each receptor.

Optional printed output: Two programs are available for displaying model output—DISPLAY and ANALYSIS; DISPLAY prints out hourly gridded concentration and/or deposition fields for user-specified time periods; ANALYSIS prints out (1) the five highest concentrations of SO_2 and/or SO_4= at each receptor for 1-hour, 3-hour (optional) and 24-hour (optional) averaging periods, (2) average SO_2 and/or SO_4 concentrations at each receptor for the entire analysis period and (3) gridded SO_2 and/or SO_4= dry deposition amounts for the day having the greatest dry deposition and for the entire analysis period.

d. *Type of Model*

The ARRPA model is a Gaussian segmented-plume model.

e. *Pollutant Types*

SO_2 and SO_4= are treated.

f. *Source-Receptor Relationship*

One source is treated per model run, though results from several sources may be superimposed.

Either constant or variable emission rates may be used.

Receptors (up to 100) in gridded network may have different elevations. Height of receptors above ground is variable.

g. *Plume Behavior*

Plume rise is computed in a piecewise-continuous manner through discrete model layers (Mueller, et al., 1983).

Plume can be isolated from the ground (lofting).

Plume height varies in time and space.

h. *Horizontal Winds*

Hourly horizontal wind components, specified at 80km intervals across the model grid, are spatially interpolated and vertically averaged through the plume depth to get plume transport vectors. A model option is available that uses the wind vector near the vertical plume center instead of computing a vertically-averaged vector.

i. *Vertical Wind Speed*

The mass-conserving BLM wind field used in this model provides vertical wind components that vary horizontally and vertically, and are used to adjust plume height.

j. *Horizontal Dispersion*

Plume half-width (σ_y) growth goes through four stages:

(1) Growth follows Turner curves for σ_y < 1000m;

(2) A transition in growth behavior from Turner curves to dynamical-statistical (Langevin) theory occurs for 1000m ≤ σ_y < 6000m;

(3) Growth is based on dynamical-statistical theory for σ_y > 6000m; eddy diffusivity computed from Pasquill-Gifford stability class;

(4) Growth approaches that described by Taylor's statistical theory (limit of dynamical-statistical theory for time much larger than the Lagrangian time correlation) for σ_y > 10,000m.

k. *Vertical Dispersion*

Plume half-depth (σ_z) growth is based on combination of Brookhaven curves for elevated plumes and Turner curves for near-ground plumes.

Vertical plume structure is Gaussian, with superimposed reflection terms, until σ_z becomes sufficiently large that a vertically uniform plume assumption is appropriate.

Maximum depth of a plume is 2000m.

l. *Chemical Transformation*

SO_2 oxidation to SO_4= is treated using a first-order chemical reaction rate constant which is parameterized to vary hourly following diurnal and seasonal cycles.

m. *Physical Removal*

Dry deposition is computed using the source depletion equation. Dry deposition velocities vary according to the stability of the surface layer.

n. *Evaluation Studies*

Muller, S. F. and L. W. Reisinger, 1986. Evaluation of the Air Resources Regional Pollution Assessment (ARRPA) Model. (Report in Progress).

B.3 APRAC-3

Reference

Simmon, P. B., R. M. Patterson, F. L. Ludwig, and L. B. Jones, 1981. The APRAC-3/Mobile 1 Emissions and Diffusion Modeling Package. EPA Publication No. EPA-909/9-81-002. U.S. Environmental Protection Agency, Region IX, San Francisco, CA. (NTIS No. PB 82-103763)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487-4650.

Abstract

APRAC-3 is a model which computes hourly average carbon monoxide concentrations for any urban location. The model calculates contributions from dispersion on various scales: extraurban, mainly from sources upwind of the city of interest; intraurban, from freeway, arterial, and feeder street sources; and local, from dispersion within a street canyon. APRAC-3 requires an extensive traffic inventory for the city of interest. APRAC-3, as it exists on UNAMAP (Version 6), has been updated with Mobile 2 emission factors.

a. *Recommendations for Regulatory Use*

APRAC-3 can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. APRAC-3 must be executed in the equivalent mode.

APRAC-3 can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated using the criteria in Section 3.2, that APRAC-3 is more appropriate for the specific application. In this case the model options/mode which are most appropriate for the application should be used.

Although the user's manual for APRAC-3 contains Mobile 1 emission factors, it is recommended that those emission factors be updated with the latest version of Mobile (Mobile Source Emissions Model) for use in regulatory applications.

b. *Input Requirements*

Source data requirements are: Line source (traffic link) end points, road type and daily traffic volume.

Meteorological data requirements are: Hourly wind direction (nearest 10 degrees), hourly wind speed, and hourly cloud cover for stability calculations.

Receptor data requirements are: Coordinates for up to 10 receptors for any single day and up to 8 receptors for the intersection submodel.

c. *Output*

Printed ouput includes:

Hourly calculations at each receptor.

d. *Type of Model*

APRAC-3 is a Gaussian plume model.

e. *Pollutant Types*

APRAC-3 may be used to model primary pollutants.

f. *Source-Receptor Relationship*

Traffic links may have arbitrary length and orientation. Off-link traffic is allocated to two-mile square grids. Link traffic emissions are aggregated into a receptor oriented area source array.

The boundaries of the area sources actually treated are (1) arcs at radial distances from the receptor which increase in geometric progression, (2) the sides of a 22.5° sector oriented upwind for distances greater than 1000m, and (3) the sides of a 45° sector oriented upwind for distances less than 1000m.

A similar area source array is established for each receptor.

Sources are assumed to be at ground level.

Up to 10 receptors are accepted for any single day.

Up to 625 receptors are accepted for a single-hour.

Up to 8 receptors are accepted for the intersection submodel.

Receptors are at ground level.

Receptor locations are arbitrary.

Four internally defined receptor locations on each user-designated street are used in a special street canyon sub-model.

A box model is used to estimate contribution from upwind sources beyond 32km based on wind speed, mixing height, annual fuel consumption.

In street canyon sub-model, contribution from other streets is included in background.

g. *Plume Behavior*

Plume rise is not treated.

Fumigation and downwash are not treated except in street canyon sub-model. In street canyon sub-model, a helical circulation pattern is assumed.

h. *Horizontal Winds*

User input hourly wind speed and direction in tens of degrees are used.

No variation of wind speed or direction with height is assumed.

Constant, uniform (steady-state) wind is assumed within each hour.

The model can interpolate winds at receptors if more than one wind is provided.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero except in street canyon sub-model. Helical circulation assumed by street canyon sub-model.

j. *Horizontal Dispersion*

Sector averaging is used with uniform distribution within sectors. Sector size is 22.5 degrees beyond 1km and 45.0 degrees within 1km.

k. *Vertical Dispersion*

Six stability classes are used. Stability class is determined internally from user-supplied meteorological data modified from Turner (1964).

Dispersion coefficients are adapted from McElroy and Pooler (1968). No adjustments are made for variations in surface roughness.

Downwind distance variation of σ_z is assumed to be ax^b for purposes of doing analytical integration.

In street canyon sub-model, an empirical function of wind speed and street width and direction is used.

Perfect reflection at the surface is assumed.

Mixing height is ignored until concentration equals that calculated using box model. A box model (uniform vertical distribution) is used beyond that distance.

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Ludwig, F. L. and W. F. Dabberdt, 1972. Evaluation of the APRAC-lA Urban Dispersion Model for Carbon Dioxide, SRI Project 8563. Stanford Research Institute, Menlo Park, CA.

B.4 COMPTER

Reference

State of Alabama, 1980. COMPTER Model Users Guide. Alabama Department of Environmental Management, Air Division, Montgomery, AL.

Availability

This model is available to users for tape and reproduction charges. If a tape is sent, the reproduction is free. Send tape and desired format and specifications to: Mr. Richard E. Grusnick, Chief, Air Division, Alabama Department of Environmental Management, 1751 Federal Drive, Montgomery, AL 36109.

Abstract

COMPTER is based on the Gaussian steady-state technique applicable to both urban and rural areas. The model contains the following attributes: (a) Determines maximum 24-hour, 3-hour, 1-hour and variable hour concentrations for both block and running averages; (b) elevated terrain considered with the standard plume-chopping technique or stability dependent plume path trajectory; (c) uses annual hourly meteorological data in the CRSTER preprocessor format; (d) uses Pasquill-Gifford stability curves; (e) allows for stability class substitution in the stable categories. Typical model use is in rural areas with moderate to low terrain features.

a. *Recommendations for Regulatory Use*

COMPTER can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. COMPTER must be executed in the equivalent mode.

COMPTER can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that COMPTER is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Annual or hourly values of emission rate, exit velocity, stack gas temperature, stack height, and stack diameter.

Meteorological data requirements are: Hourly surface weather data from the EPA meteorological preprocessor program. Preprocessor output includes hourly stability class wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is optional.

Receptor data requirements are: Individual receptor coordinates; or a location and distance from the center of five rings of receptors; or a combination of individual receptors and either the rectangular grid or the rings of receptors. Elevations of all receptors may be input.

c. *Output*

Printed output includes:

Highest and second highest concentrations for the year at each receptor for averaging times of 1, 3 and 24-hours, a user-selected averaging time which may be 2–12 hours (variable hourly), and a 50 high table for 1, 3, variable hourly, and 24-hours;

Annual arithmetic average at each receptor; and the highest 1-hour and 24-hour concentrations over the receptor field for each day considered.

Computer readable output includes:

Hourly, 3-hourly, variable hourly, and 24-hourly concentrations for each receptor on magnetic storage device.

d. *Type of Model*

COMPTER is a Gaussian plume model.

e. *Pollutant Types*

COMPTER may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

A maximum 50 sources and 200 receptors are treated.

COMPTER applies user-specified locations of sources and receptors.

User input stack height and source characteristics for each source are applied.

User input topographic elevation for each receptor is applied.

Receptors are assumed to be at ground level.

g. *Plume Behavior*

Briggs' (1969, 1971, 1972) plume rise equations with limited mixing are used.

Plume height is adjustable according to stability with use of plume path coefficient.

h. *Horizontal Winds*

Constant, uniform (steady-state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

Power law wind profile exponents used are 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30, for stability classes A through F, respectively. Anemometer height is assumed to be 10 meters.

i. *Vertical Wind Speed*

Vertical wind speeds are assumed equal to zero.

j. *Horizontal Dispersion*

Dispersion coefficients are from Turner (1969), with no further adjustments made for variations in surface roughness or averaging time.

Optionally, stability class 7 may be treated as Class 6.

Other options for stable class substitution include changing stabilities F and G to E, and reducing E, F, and G to D, E, and F, respectively.

k. *Vertical Dispersion*

Dispersion coefficients are from Turner (1969), with no further adjustments made for variations in surface roughness.

Optionally, by source, buoyancy induced dispersion ($\Delta H^2/10$) is included.

Optionally, stability class 7 may be treated as class 6.

Other options for stable class substitution include changing stabilities F and G to E; and reducing E, F, and G to D, E, and F, respectively.

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Londergan, R., D. Minott, D. Wackter, T. Kincaid and D. Bonitata, 1983. Evaluation of Rural Air Quality Simulation Models. EPA Publication No. EPA–450/4–83–003. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.5 ERT Air Quality Model (ERTAQ)—[Deleted]

B.6 ERT Visibility Model

Reference:

ENSR Consulting and Engineering, 1990. ERT Visibility Model: Version 4; Technical Description and User's Guide. Document M2020–003. ENSR Consulting and Engineering, 35 Nagog Park, Acton, MA 01720.

Availability

The user's guide and model code are available from the National Technical Information Service (see page B–1).

Abstract:

The ERT Visibility Model is a Gaussian dispersion model designed to estimate visibility impairment for arbitrary lines of sight due to isolated point source emissions by simulating gas-to-particle conversion, dry deposition, NO to NO_2 conversion and linear radiative transfer.

a. *Recommendations for Regulatory Use*

There is no specific recommendation at the present time. The ERT Visibility Model may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements are: Stack height, stack temperature, emissions of SO_2, NO_x, TSP, fraction of NO_x as NO_2, fraction of TSP which is carbonaceous, exit velocity, and exit radius.

Meteorological data requirements are: Hourly ambient temperature, mixing depth, wind speed at stack height, stability class, potential temperature gradient, and wind direction.

Receptor data requirements are: Observer coordinates with respect to source, latitude, longitude, time zone, date, time of day, elevation, relative humidity, background visual range, line-of-sight azimuth and elevation angle, inclination angle of the observed object, distance from observer to object, object and surface reflectivity, number and spacing of integral receptor points along line of sight.

Other data requirements are: Ambient concentrations of O_3 and NO_x, deposition velocity of TSP, sulfate, nitrate, SO_2 and NO_x, first-order transformation rate for sulfate and nitrate.

c. *Output*

Printed output includes both summary and detailed results as follows: Summary output: Page 1—site, observer and object parameters; page 2—optical pollutants and associated extinction coefficients; page 3—plume model input parameters; page 4—total calculated visual range reduction, and each pollutant's contribution; page 5—calculated plume contrast, object contrast and object contrast degradation at the 550nm wavelength; page 6—calculated blue/red ratio and ΔE ($U^*V^*W^*$) values for both sky and object discoloration.

Detailed output: Phase functions for each pollutant in four wavelengths (400, 450, 550, 650nm), concentrations for each pollutant along sight path, solar geometry, contrast parameters at all wavelengths, intensities, tristimulus values and chromaticity coordinates for views of the object, sun, background sky and plume.

d. *Type of Model*

ERT Visibility model is a Gaussian plume model for estimating visibility impairment.

e. *Pollutant Types*

Optical activity of sulfate, nitrate (derived from SO_2 and NOx emissions), primary TSP and NO_2 is simulated.

f. *Source Receptor Relationship*

Single source and hour is simulated. Unlimited number of lines-of-sight (receptors) is permitted per model run.

g. *Plume Behavior*

Briggs (1971) plume rise equations for final rise are used.

h. *Horizontal Wind Field*

A single wind speed and direction is specified for each case study. The wind is assumed to be spatially uniform.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients from Turner (1969) are used.

k. *Vertical Dispersion*

Rural dispersion coefficients from Turner (1969) are used. Mixing height is accounted for with multiple reflection handled by summation of series near the source, and Fourier representation farther downwind.

l. *Chemical Transformation*

First order transformations of sulfates and nitrates are used.

m. *Physical Removal*

Dry deposition is treated by the source depletion method.

n. *Evaluation Studies*

Seigneur, C., R. W. Bergstrom, and A. B. Hudischewskyj, 1982. Evaluation of the EPA PLUVUE Model and the ERT Visibility Model Based on the 1979 VISTTA Data Base, EPA Publication No. EPA-450/4-82-008. U.S. Environmental Protection Agency, Research Triangle Park, NC.

White, W. H., C. Seigneur, D. W. Heinold, M. W. Eltgroth, L. W. Richards, P. T. Roberts, P. S. Bhardwaja, W. D. Conner and W. E. Wilson, Jr., 1985. Predicting the Visibility of Chimney Plumes: An Inter-comparison of Four Models with Observations at a Well-Controlled Power Plant. Atmospheric Environment, 19: 515-528.

B.7 HIWAY-2

Reference

Petersen, W.B., 1980. User's Guide for HIWAY-2. EPA Publication No. EPA-600/8-80-018. U.S. Environmental Protection Agency, ESRL, Research Triangle Park, NC. (NTIS No. PB 80-227556)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487-4650.

Abstract

HIWAY-2 can be used to estimate the concentrations of non-reactive pollutants from highway traffic. This steady-state Gaussian model can be applied to determine air pollution concentrations at receptor locations downwind of "at-grade" and "cut section" highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation, and receptor location. The model was developed for situations where horizontal wind flow dominates. The model cannot consider complex terrain or large obstructions to the flow such as buildings or large trees.

a. *Recommendations for Regulatory Use*

HIWAY-2 can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. HIWAY-2 must be executed in the equivalent mode.

HIWAY-2 can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in Section 3.2, that HIWAY-2 is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: A uniform emission rate by lane, roadway end points; height of emission; length, width, and number of lanes; and width of center strip.

Meteorological data requirements are: One set at a time of hourly averages of wind speed, wind direction, and mixing height and the Pasquill-Gifford stability class. Wind speed and direction are preferred to be at 2 meters above ground.

Receptor data requirements are: Coordinates of each receptor.

c. *Output*

Printed output includes:

One hourly average concentration at each specified receptor location.

d. *Type of Model*

HIWAY-2 is a Gaussian plume model.

e. *Pollutant Types*

HIWAY-2 may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

HIWAY-2 applies user-specified end points for a single roadway segment, and user-specified receptor locations.

Plume impact on receptor is calculated by finite difference integration of a point source along each lane of the roadway.

g. *Plume Behavior*

HIWAY-2 does not treat plume rise.

h. *Horizontal Winds*

Constant, uniform (steady-state) wind is assumed for an hour.

Straight line plume transport is assumed to all downwind distances.

An aerodynamic drag factor is applied when winds are parallel to the roadway and speeds are less than 2 m/sec.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

The total horizontal dispersion is that due to ambient turbulence plus the turbulence generated by the vehicles on the roadway.

Beyond 300m downwind total turbulence is considered to be dominated by atmospheric turbulence, with plume dispersion as described by Turner (1969).

Three stability classes are considered: Unstable, neutral and stable.

k. *Vertical Dispersion*

The total horizontal dispersion is that due to ambient turbulence plus the turbulence generated by the vehicles on the roadway.

Beyond 300m downwind total turbulence is considered to be dominated by atmospheric turbulence, with plume dispersion as described by Turner (1969).

Mixing height is accounted for with multiple reflections until the vertical plume size equals 1.6 times the mixing height; uniform vertical mixing is assumed beyond that point.

Three stability classes are considered: Unstable, neutral and stable.

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Rao, S.T., and J.R. Visalli, 1981. On the Comparative Assessment of the Performance of Air Quality Models. *Journal of Air Pollution Control Association*, 31: 851-860.

B.8 Integrated Model for Plumes and Atmospheric Chemistry in Complex Terrain (IMPACT)

Reference

Fabrick, Allan J. and Peter J. Haas, 1980. User Guide to IMPACT: An Integrated Model for Plumes and Atmospheric Chemistry in Complex Terrain. DCN 80-241-403-01. Radian Corporation, 8501 Mo-Pac Blvd., Austin, TX.

Availability

A magnetic tape containing the IMPACT model, a set of test data and a copy of the IMPACT User's Guide are available for a cost of $500 from: Howard Balentine, Senior Meteorologist, Radian Corporation, Post Office Box 9948, Austin, TX 78766.

Abstract

IMPACT is an Eulerian, three-dimensional, finite difference grid model designed to calculate the impact of pollutants, either inert or reactive, in simple or complex terrain, emitted from either point or area sources. It automatically treats single or multiple point or area sources, the effects of vertical temperature stratifications on the wind and diffusion fields, shear flows caused by the atmospheric boundary layer or by terrain effects, and chemical transformations.

a. *Recommendations for Regulatory Use*

IMPACT can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. IMPACT must be executed in the equivalent mode.

IMPACT can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that IMPACT is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

There is no specific recommendation concerning the use of IMPACT for photochemical applications. IMPACT may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements are: For point sources—location (I, J), stack height, exit temperature, volume flow rate or stack diameter and exit velocity, hourly emission rates for all pollutants; for area sources location of corners, and hourly emission rates for each pollutant.

Meteorological data requirements are: Hourly wind speed and direction, surface and elevated, from meteorological stations within and surrounding the modeling area, temperature, pressure, humidity and insolation (the three last variables are optional).

Receptor data requirements are: None since concentrations are output for cells in the computational grid.

Air quality data (optional): One or more vertical concentration profiles for each pollutant.

Other data: 2-D array of terrain heights, 2-D array of surface roughness values (optional).

c. *Output*

Printed output options include:

Surface and elevated horizontal cross sections of pollutant concentrations (instantaneous, or averages over N hours where N=1, 2, 3, . . .);

Horizontal cross sections of diffusivities and wind velocities; and

Arbitrary vertical and horizontal cross sections of pollutant concentrations and diffusivities, and CALCOMP wind field vector plots are generated by the POST post-processor program.

Computer readable output includes:

Concentration, wind field and diffusivity data for each hour.

d. *Type of Model*

IMPACT is an Eulerian finite difference model.

e. *Pollutant Types*

IMPACT may be used to model any inert pollutant.

IMPACT may be used to model SO_2, $SO_4^=$, NO_x, NO_2, O_3, hydrocarbons (depends upon chemistry mechanism selected).

f. *Source-Receptor Relationship*

Up to 20 point sources and 20 area sources may be treated (greater number of sources may be treated by increasing common block storage allocation).

Concentrations are calculated at the center of each cell in the grid.

g. *Plume Behavior*

Briggs (1975) formulation for plume rise is used.

Elevated inversions are considered.

h. *Horizontal Winds*

A three dimensional stability and terrain dependent nondivergent wind field is interpolated from single or multiple wind data measurements using a Poisson technique.

i. *Vertical Wind Speed*

Vertical wind speed is treated at each wind site, user specified or extrapolated from surface data. Interpolated is accomplished as part of the three dimensional wind field interpolation.

j. *Horizontal Dispersion*

A three dimensional diffusivity field is calculated using either the technique of Myrup/Ranzieri or the DEPICT method (see User Guide, Fabrick and Haas, 1980).

k. *Vertical Dispersion*

A three dimensional diffusivity field is calculated using either the technique of Myrup/Ranzieri or the DEPICT method (see User Guide, Fabrick and Haas, 1980).

l. *Chemical Transformation*

Either 3-, 6-, 8- or 15-species mechanisms are currently available (see User Guide). Calculations are also performed for inert pollutants.

m. *Physical Removal*

Physical removal is treated using exponential decay. Half-life is input by the user.

n. *Evaluation Studies*

Fabrick, A. J., R. Sklarew, and J. Wilson, 1977. Point Source Model Evaluation and Development Study. Report prepared for the California Air Resources Board.

Fabrick, A. J., and P. J. Haas, 1980. Analysis of Dispersion Models used for Complex Terrain Simulation. Presented at the Symposium on Intermediate Range Transport Processes and Technology Assessment, Gatlinburg, TN.

Sklarew, R., and V. Mirabella, 1979. Experience in IMPACT Modeling of Complex Terrain Fourth Symposium on Turbulence, Diffusion and Air Pollution, Reno, NV.

Sklarew, R., J. Wilson, A. J. Fabrick and V. Mirabella, 1976. Rough Terrain Modeling. Presented at Geothermal Environmental Seminar '76, Clear Lake, CA.

Sklarew, R., and K. Tran, 1978. The NEWEST Wind Field Model with Applications to Thermally Driven Drainage Wind in Mountainous Terrain. Presented at the AMS Meeting, Lake Tahoe, NV.

Wackter, D., and R. Londergan, 1984. Evaluation of Complex Terrain Air Quality Simulation Models. EPA Publication No. EPA-450/4-84-017. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.9 LONGZ

Reference

Bjorklund, J. R., and J. F. Bowers, 1982. User's Instructions for the SHORTZ and LONGZ Computer Programs, Volumes I and II, EPA Publication No. EPA-903/9-82-004. U.S. Environmental Protection Agency, Region III, Philadelphia, PA.

Availability

The model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, Phone: (703) 487-4650.

Abstract

LONGZ utilizes the steady-state univariate Gaussian plume formulation for both urban and rural areas in flat or complex terrain to calculate long-term (seasonal and/or annual) ground-level ambient air concentrations attributable to emissions from up to 14,000 arbitrarily placed sources (stacks, buildings and area sources). The output consists of the total concentration at each receptor due to emissions from each user-specified source or group of sources, including all sources. An option which considers losses due to deposition (see the description of SHORTZ) is deemed inappropriate by the authors for complex terrain, and is not discussed here.

a. *Recommendations for Regulatory Use*

LONGZ can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. LONGZ must be executed in the equivalent mode.

LONGZ can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that LONGZ is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: For point, building or area sources, location, elevation, total emission rate (optionally classified by gravitational settling velocity) and decay coefficient; for stack sources, stack height, effluent temperature, effluent exit velocity, stack radius (inner), emission rate, and ground elevation (optional);

For building sources, height, length and width, and orientation; for area sources, characteristic vertical dimension, and length, width and orientation.

Meteorological data requirements are: Wind speed and measurement height, wind profile exponents, wind direction standard deviations (turbulent intensities), mixing height, air temperature, vertical potential temperature gradient.

Receptor data requirements are: coordinates, ground elevation.

c. *Output*

Printed output includes:

Total concentration due to emissions from user-specified source groups, including the combined emissions from all sources (with optional allowance for depletion by deposition).

d. *Type of Model*

LONGZ is a climatological Gaussian plume model.

e. *Pollutant Types*

LONGZ may be used to model primary pollutants. Settling and deposition are treated.

f. *Source-Receptor Relationships*

LONGZ applies user specified locations for sources and receptors. Receptors are assumed to be at ground level.

g. *Plume Behavior*

Plume rise equations of Bjorklund and Bowers (1982) are used.

Stack tip downwash (Bjorklund and Bowers, 1982) is included.

All plumes move horizontally and will fully intercept elevated terrain.

Plumes above mixing height are ignored.

Perfect reflection at mixing height is assumed for plumes below the mixing height.

Plume rise is limited when the mean wind at stack height approaches or exceeds stack exit velocity.

Perfect reflection at ground is assumed for pollutants with no settling velocity.

Zero reflection at ground is assumed for pollutants with finite settling velocity.

LONGZ does not simulate fumigation.

Tilted plume is used for pollutants with settling velocity specified.

Buoyancy-induced dispersion is treated (Briggs, 1972).

h. *Horizontal Winds*

Wind field is homogeneous and steady-state.

Wind speed profile exponents are functions of both stability class and wind speed. Default values are specified in Bjorklund and Bowers (1982).

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Pollutants are initially uniformly distributed within each wind direction sector. A smoothing function is then used to remove discontinuities at sector boundaries.

k. *Vertical Dispersion*

Vertical dispersion is derived from input vertical turbulent intensities using adjustments to plume height and rate of plume growth with downwind distance specified in Bjorklund and Bowers (1982).

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Time constant is input by the user.

m. *Physical Removal*

Gravitational settling and dry deposition of particulates are treated.

n. *Evaluation Studies*

Bjorklund, J. R., and J. F. Bowers, 1982. User's Instructions for the SHORTZ and LONGZ Computer Programs. Volume I and II. EPA Publication No. EPA-903/9-82-004. U.S. Environmental Protection Agency, Region III, Philadelphia, PA.

B.10 Maryland Power Plant Siting Program (PPSP) Model

References

Brower, R., 1982. The Maryland Power Plant Siting Program (PPSP) Air Quality Model User's Guide. Ref. No. PPSP-MP-38. Prepared for Maryland Department of Natural Resources, by Environmental Center, Martin Marietta Corporation, Baltimore, MD. (NTIS No. PB 82-238387)

Weil, J.C. and R.P. Brower, 1982. The Maryland PPSP Dispersion Model for Tall Stacks. Ref. No. PPSP-MP-36. Prepared for Maryland Department of Natural Resources, by Environmental Center, Martin Marietta Corporation, Baltimore, MD. (NTIS No. PB 82-219155)

Availability

Two reports referenced above are available from NTIS. The model code and test data are available on MDgnetic tape for a cost of $210 from:

Power Plant Siting Program, Department of Natural Resources, Tawes State Office Building, Annapolis, MD 21401, Attn: Dr. Michael Hirshfield

Abstract

PPSP is a Gaussian dispersion model applicable to tall stacks in either rural or urban areas, but in terrain that is essentially flat (on a scale large compared to the ground roughness elements). The PPSP model follows the same general formulation and computer coding as CRSTER, also a Gaussian model, but it differs in four MDjor ways. The differences are in the scientific formulation of specific ingredients or "sub-models" to the Gaussian model, and are based on recent theoretical improvements as well as supporting experimental data. The differences are: (1) Stability during daytime is based on convective scaling instead of the Turner criteria; (2) Briggs' dispersion curves for elevated sources are used; (3) Briggs plume rise formulas for convective conditions are included; and (4) plume penetration of elevated stable layers is given by Briggs' (1984) model.

a. *Recommendations for Regulatory Use*

PPSP can be used if it can be demonstrated to estiMDte concentrations equivalent to those provided by the preferred model for a given application. PPSP must be executed in the equivalent mode.

PPSP can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that PPSP is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Emission rate (monthly rates optional), physical stack height, stack gas exit velocity, stack inside diameter, stack gas temperature.

Meteorological data requirements are: Hourly surface weather data from the EPA meteorological preprocessor program. Preprocessor output includes hourly stability class, wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is also required. Wind speed profile exponents (one for each stability class) are required if on-site data are input.

Receptor data requirements are: Distance of each of the five receptor rings.

c. *Output*

Printed output includes:

Highest and second highest concentrations for the year at each receptor for averaging times of 1, 3, and 24-hours, plus a user-selected averaging time which MDy be 2, 4, 6, 8, or 12 hours;

Annual arithmetic average at each receptor; and

For each day, the highest 1-hour and 24-hour concentrations over the receptor field.

d. *Type of Model*

PPSP is a Gaussian plume model.

e. *Pollutant Types*

PPSP may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

Up to 19 point sources are treated.

All point sources are assumed at the same location.

Unique stack height and stack exit conditions are applied for each source.

Receptor locations are restricted to 36 azimuths (every 10 degrees) and five user-specified radial distances.

g. *Plume Behavior*

Briggs (1975) final rise formulas for buoyant plumes are used. Momentum rise is not considered.

Transitional or distance-dependent plume rise is not modeled.

Penetration (complete, partial, or zero) of elevated inversions is treated with Briggs (1984) model; ground-level concentrations are dependent on degree of plume penetration.

h. *Horizontal Winds*

Wind speeds are corrected for release height based on power law variation, with different exponents for different stability classes and variable reference height (7 meters is default). Wind speed power law exponents are 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 for stability classes A through F, respectively.

Constant, uniform (steady-state) wind assumed within each hour.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion parameters are Briggs (Gifford, 1975), with stability class defined by u/w^* during daytime, and by the method of Turner (1964) at night.

Urban dispersion is treated by changing all stable cases to stability class D.

Buoyancy-induced dispersion (Pasquill, 1976) is included (using $\Delta H/3.5$).

k. *Vertical Dispersion*

Rural dispersion parameters are Briggs (Gifford, 1975), with stability class defined by u/w^* during daytime, and by the method of Turner (1964).

Urban dispersion is treated by changing all stable cases to stability class D.

Buoyancy-induced dispersion (Pasquill, 1976) is included (using $\Delta H/3.5$).

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Weil, J.C. and R.P. Brower, 1982. The Maryland PPSP dispersion model for tall stacks. Ref. No. PPSP MP-36. Prepared for Maryland Department of Natural Resources. Prepared by Environmental Center, Martin Marietta Corporation, Baltimore, Maryland. (NTIS No. PB 82-219155)

Londergan, R., D. Minott, D. Wackter, T. Kincaid, and D. Bonitata, 1983. Evaluation of Rural Air Quality Simulation Models, Appendix G: Statistical Tables for PPSP EPA Publication No. EPA-450/4-83-003, Environmental Protection Agency, Research Triangle Park, NC.

B.11 Mesoscale Puff Model (MESOPUFF II)

Reference

Scire, J.S., F.W. Lurmann, A. Bass, S.R. Hanna, 1984. User's Guide to the Mesopuff II Model and Related Processor Programs. EPA Publication No. EPA-600/8-84-013. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 84-181775)

A Modeling Protocol for Applying MESOPUFF II to Long Range Transport Problems, 1992. EPA Publication No. EPA-454/R-92-021. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Availability

This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page B-1).

Abstract

MESOPUFF II is a short term, regional scale puff model designed to calculate concentrations of up to 5 pollutant species (SO_2, SO_4, NO_X, HNO_3, NO_3). Transport, puff growth, chemical transformation, and wet and dry deposition are accounted for in the model.

a. *Recommendations for Regulatory Use*

There is no specific recommendation at the present time. The model may be used on a case-by-case basis.

b. *Input Requirements*

Required input data include four types: (1) Input control parameters and selected technical options, (2) hourly surface meteorological data and twice daily upper air measurements, hourly precipitation data are optional, (3) surface land use classification information, (4) source and emissions data.

Data from up to 25 surface National Weather Service stations and up to 10 upper air stations may be considered. Spatially variable fields at hour intervals of winds, mixing height, stability class, and relevant turbulence parameters are derived by MESOPAC II, the meteorological preprocessor program described in the User Guide.

Source and emission data for up to 25 point sources and/or up to 5 area sources can be included. Required information are: location in grid coordinates, stack height, exit velocity and temperature, and emission rates for the pollutant to be modeled.

Receptor data requirements: Up to a 40 X 40 grid may be used and non-gridded receptor locations may be considered.

c. *Output*

Line printer output includes: All input parameters, optionally selected arrays of ground-level concentrations of pollutant species at specified time intervals.

Line printer contour plots output from MESOFILE II post-processor program. Computer readable output of concentration array to disk/tape for each hour.

d. *Type of Model*

MESOPUFF II is a Gaussian puff superposition model.

e. *Pollutant types modeled*

Up to five pollutant species may be modeled simultaneously and include: SO_2, SO_4, NO_x, HNO_3, NO_3.

f. *Source-Receptor Relationship*

Up to 25 point sources and/or up to 5 area sources are permitted.

g. *Plume Behavior*

Briggs (1975) plume rise equations are used, including plume penetration with buoyancy flux computed in the model.

Fumigation of puffs is considered and may produce immediate mixing or multiple reflection calculations at user option.

h. *Horizontal Winds*

Gridded wind fields are computed for 2 layers; boundary layer and above the mixed layer. Upper air rawinsonde data and hourly surface winds are used to obtain spatially variable u,v component fields at hourly intervals. The gridded fields are computed by interpolation between stations in the MESOPAC II preprocessor.

i. *Vertical Wind Speed*

Vertical winds are assumed to be zero.

j. *Horizontal Dispersion*

Incremental puff growth is computed over discrete time steps with horizontal growth parameters determined from power law equations fit to sigma y curves of Turner out to 100km. At distances greater than 100km, puff growth is determined by the rate given by Heffter (1965).

Puff growth is a function of stability class and changes in stability are treated. Optionally, user input plume growth coefficients may be considered.

k. *Vertical Dispersion*

For puffs emitted at an effective stack height which is less than the mixing height, uniform mixing of the pollutant within the mixed layer is performed. For puffs centered above the mixing height, no effect at the ground occurs.

l. *Chemical Transformation*

Hourly chemical rate constants are computed from empirical expressions derived from photochemical model simulations.

m. *Physical Removal*

Dry deposition is treated with a resistance method.

Wet removal may be considered if hourly precipitation data are input.

n. *Evaluation Studies*

Results of tests for some model parameters are discussed in:

Scire, J. S., F. W. Lurmann, A. Bass, S. R. Hanna, 1984. Development of the MESOPUFF II Dispersion Model. EPA Publication No. EPA-600/3-84-057. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.12 Mesoscale Transport Diffusion and Deposition Model for Industrial Sources (MTDDIS)

Reference

Wang, I.T. and T.L. Waldron, 1980. User's Guide for MTDDIS Mesoscale Transport, Diffusion, and Deposition Model for Industrial Sources. EMSC6062.1UR(R2). Combustion Engineering, Newbury Park, CA.

Availability

A magnetic tape copy of the FORTRAN coding and the user's guide are available for a cost of $100 from: Dr. I.T. Wang, Combustion Engineering, Environmental Monitoring and Services, Inc., 2421 West Hillcrest Drive, Newbury Park, CA 19320.

Abstract

MTDDIS is a variable-trajectory Gaussian puff model applicable to long-range transport of point source emissions over level or rolling terrain. It can be used to determine 3-hour maximum and 24-hour average concentrations of relatively nonreactive pollutants from up to 10 separate stacks.

a. *Recommendations for Regulatory Use*

There is no specific recommendation at the present time. The MTDDIS Model may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements are: Emission rate, physical stack height, stack gas exit velocity, stack inside diameter, stack gas temperature, and location.

Meteorological data requirements are: Hourly surface weather data, from up to 10 stations, including cloud ceiling, wind direction, wind speed, temperature, opaque cloud cover and precipitation. For long-range applications, user-analyzed daily mixing heights are recommended. If these are not available, the NWS daily mixing heights will be used by the program. A single upper air sounding station for the region is assumed. For each model run, air trajectories are generated for a 48-hour period, and therefore, the afternoon mixing height of the day before and the mixing heights of the day after are also required by the model as input, in order to generate hourly mixing heights for the modeled period.

Receptor data requirements are: Up to three user-specified rectangular grids.

c. *Output*

Printed output includes:

Tabulations of hourly meteorological parameters include both input surface observations and calculated hourly stability classes and mixing heights for each station;

Printed air trajectories for the two consecutive 24-hour periods for air parcels generated 4 hours apart starting at 0000 LST; and

3-hour maximum and 24-hour average grid concentrations over user-specified rectangular grids are output for the second 24-hour period.

d. *Type of Model*

MTDDIS is a Gaussian puff model.

e. *Pollutant Types*

MTDDIS can be used to model primary pollutants. Dry deposition is treated. Exponential decay can account for some reactions.

f. *Source-Receptor Relationship*

MTDDIS treats up to 10 point sources.

Up to three rectangular receptor grids may be specified by the user.

g. *Plume Behavior*

Briggs (1971, 1972) plume rise formulas are used.

If plume height exceeds mixing height, ground level concentration is assumed zero.

Fumigation and downwash are not treated.

h. *Horizontal Winds*

Wind speeds and wind directions at each station are first corrected for release height. Speed conversions are based on power law variation and direction conversions are based on linear height dependence as recommended by Irwin (1979).

Converted wind speeds and wind directions are then weighted according to the algorithms of Heffter (1980) to calculate the effective transport wind speed and direction.

i. *Vertical Wind Field*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Transport-time-dependent dispersion coefficients from Heffter (1980) are used.

k. *Vertical Dispersion*

Transport-time-dependent dispersion coefficients from Heffter (1980) are used.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Dry deposition is treated. User input deposition velocity is required.

Wet deposition is treated. User input hourly precipitation rate and precipitation layer depth or cloud ceiling height are required.

n. *Evaluation Studies*

None cited.

B.13 Models 3141 and 4141

Reference

Enviroplan, Inc, 1981. User's Manual for Enviroplan's Model 3141 and Model 4141. Enviroplan, Inc., West Orange, NJ.

Availability

A magnetic tape copy of the FORTRAN coding and the user's guide are available for a cost of $1,900 from: Environplan, Inc., 59 Main Street, West Orange, NJ 07052.

Abstract

Models 3141 and 4141 are modifications of CRSTER (UNAMAP VERSION 3) and are applicable to complex terrain particularly where receptor elevation approximately equals or exceeds the stack top elevation. The model utilizes intermediate ground displacement procedures and dispersion enhancements developed from an aerial tracer study and ground level concentrations measured for a power plant located in complex terrain.

a. *Recommendations for Regulatory Use*

3141 or 4141 can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. 3141 or 4141 must be executed in the equivalent mode.

3141 or 4141 can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in Section 3.2, that 3141 or 4141 is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Emission rate, physical stack height, stack gas exit velocity, stack inside diameter, stack gas exit temperature.

Meteorological data requirements are: Hourly surface weather data from the EPA meteorological preprocessor program. Preprocessor output includes hourly stability class, wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is also required. Wind speed profile exponents (one for each stability class) are required if on-site data are input.

Receptor data requirements are: Distance of each of five receptor rings, and receptor elevation.

c. *Output*

Printed output includes:

Highest and second highest concentrations for the year at each receptor for averaging times of 1, 3, and 24 hours, plus a user-selected averaging time which may be 2, 4, 6, 8, or 12 hours.

Annual arithmetic average at each receptor.

For each day, the highest 1-hour and 24-hour concentrations over the receptor field.

d. *Type of Model*

3141 and 4141 are Gaussian plume models.

e. *Pollutant Types*

3141 and 4141 may be used to model non-reactive pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

Up to 19 point sources are treated.

No area sources are treated.

All point sources are assumed to be collocated.

Unique stack height is used for each source.

Receptor locations are restricted to 36 azimuths (every 10 degrees) and 5 user-specified radial distances.

Unique topographic elevation is used for each receptor.

g. *Plume Behavior*

Briggs (1969, 1971, 1972) final plume rise formulas are used.

If plume height exceeds mixing height at a receptor location after terrain adjustment, concentration is assumed equal to zero.

h. *Horizontal Winds*

Wind speeds are corrected for release height based on power law variation exponents from DeMarrais (1959), different exponents for different stability classes, reference height=7 meters. Exponents used are 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 for stability classes A through F, respectively.

Constant, uniform (steady-state) wind is assumed within each hour.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Dispersion coefficients are Pasquill-Gifford coefficients from Turner (1969).

Dispersion is adjusted to 60 minute averaging time by one-fifth power rule (Gifford, 1975).

Buoyancy-induced dispersion (Briggs, 1975) is included.

k. *Vertical Dispersion*

Dispersion coefficients are Pasquill-Gifford coefficients from Turner (1969).

Buoyancy-induced dispersion (Briggs, 1975) is included.

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Ellis, H.M., P.C. Liu, and C. Runyon, 1979. "Comparison of Predicted and Measured Concentrations for 54 Alternative Models of Plume Transport in Complex Terrain, Presented in APCA Annual Conference, Cincinnati, OH.

Ellis, H.M., P.C. Liu, and C. Runyon, 1980. Comparison of Predicted and Measured Concentrations for 58 Alternative Models of Plume Transport in Complex Terrain. *Journal of the Air Pollution Control Association,* 30(6): 670–675.

Londergan, R., D. Minott, D. Wachter, T. Kincaid and D. Bonitata. Evaluation of Rural Air Quality Simulation Models. EPA Publication No. EPA–450/4–83–003, Environmental Protection Agency, Research Triangle Park, NC.

Wackter, D., and R. Londergan, 1984. Evaluation of Complex Terrain Air Quality Simulation Models. EPA Publication No. EPA–450/4–84–017. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.14 MULTIMAX

Reference

Moser, J.H., 1979. MULTIMAX: An Air Dispersion Modeling Program for Multiple Sources, Receptors, and Concentration Averages. Shell Development Company, Westhollow Research Center, P.O. Box 1380, Houston, TX. (NTIS No. PB 80–170178).

Availability

The above report is available from NTIS ($16.95 for paper copy; $5.95 on microfiche). The accession number for the computer tape for MULTIMAX is PB 80–170160, and the cost is $370.00. Requests should be sent to: Computer Products, National Technical Information Service, U.S. Department of Commerce, 5825 Port Royal Road, Springfield, VA 22161, Phone: (703) 487–4650.

Abstract

MULTIMAX is a Gaussian plume model applicable to both urban and rural areas. It can be used to calculate highest and second-highest concentrations, for each of several averaging times due to up to 100 sources arbitrarily located.

a. *Recommendations for Regulatory Use*

MULTIMAX can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. MULTIMAX must be executed in the equivalent mode.

MULTIMAX can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that MULTIMAX is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Emission rate, physical stack height, stack gas exit velocity, stack inside diameter, and stack gas temperature.

Meteorological data requirements are: Hourly surface weather data from the EPA meteorological preprocessor program. Preprocessor output includes hourly stability class, wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is also required. Wind speed profile exponents (one for each stability class) are required if on-site data are input.

Receptor requirements are: Individual receptor points, arcs and circles of receptors, or lines of receptors may be input, with receptor point locations, receptor line end points, and receptor circle center and radius defined in either cartesian or polar coordinates.

c. *Output*

Printed output includes: Highest and second-highest concentrations for the year at each receptor for averaging time of 1, 3, and 24 hours. Annual arithmetic average at each receptor.

Computer readable output includes: Input data and results.

d. *Type of Model*

MULTIMAX is a Gaussian plume model.

e. *Pollutant Types*

MULTIMAX may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

Up to 100 point sources at any location may be input.

Area sources are not treated.

Point sources may be at any location.

Unique stack height is used for each source.

Unique topographic elevation is used for each receptor; must be below top of stack.

Receptors can be defined individually, or along lines or arcs.

g. *Plume Behavior*

MULTIMAX uses Briggs (1969, 1971, 1972) final plume rise formulas.

If plume height exceeds mixing height, concentrations downwind are assumed equal to zero.

h. *Horizontal Winds*

Wind speeds are corrected for release height based on power law variation exponents from DeMarrais (1959), different exponents for different stability classes, reference height=10 meters. The exponents are 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 for stability classes A through F, respectively.

Constant, uniform (steady-state) wind is assumed within each hour.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients from Turner (1969) are used in MULTIMAX with no adjustments made for variations in surface roughness.

Six stability classes are used, with Turner class 7 treated as Class 6. Averaging time adjustment is optional.

k. *Vertical Dispersion*

Rural dispersion coefficients from Turner (1969) are used in MULTIMAX with no adjustments made for variations in surface roughness.

Six stability classes are used, with Turner class 7 treated as Class 6.

Perfect reflection at the ground is assumed.

Mixing height is accounted for with multiple reflections until the vertical plume size equals 1.6 times the mixing height; uniform mixing is assumed beyond that point.

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Londergan, R., D. Minott, D. Wackter, T. Kincaid, and D. Bonitata, 1983. Evaluation of Rural Air Quality Simulation Models. EPA Publication No. EPA-450/4-83-003. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.15 Multiple Point Source Diffusion Model (MPSDM—[Deleted]

B.16 Multi-Source (SCSTER) Model

Reference

Malik, M.H. and B. Baldwin, 1980. Program Documentation for Multi-Source (SCSTER) Model. Program Documentation EN7408SS. Southern Company Services, Inc., Technical Engineering Systems, 64 Perimeter Center East, Atlanta, GA.

Availability

The SCSTER model and user's manual are available at no charge to a limited number of persons through Southern Company Services. A magnetic tape must be provided by those desiring the model. Requests should be directed to: Mr. Bryan Baldwin, Research Program Supervisor, Air Quality Program, Southern Company Services, Post Office Box 2625, Birmingham, AL 35202.

Abstract

SCSTER is a modified version of the EPA CRSTER model. The primary distinctions of SCSTER are its capability to consider multiple sources that are not necessarily collocated, its enhanced receptor specifications, its variable plume height terrain adjustment procedures and plume distortion from directional wind shear.

a. *Recommendations for Regulatory Use*

SCSTER can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. SCSTER must be executed in the equivalent mode.

SCSTER can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that SCSTER is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Emission rate, stack gas exit velocity, stack gas temperature, stack exit diameter, physical stack height, elevation of stack base, and coordinates of stack location. The variable emission data can be monthly or annual averages.

Meteorological data requirements are: Hourly surface weather data from the EPA meteorological preprocessor program. Preprocessor output includes hourly stability class wind direction, wind speed, temperature, and mixing height. Actual anemometer height (a single value) is optional. Wind speed profile exponents (one for each stability class) are optional.

Receptor data requirements are: Cartesian coordinates and elevations of individual receptors; distances of receptor rings, with elevation of each receptor; receptor grid networks, with elevation of each receptor.

Any combination of the three receptor input types may be used to consider up to 600 receptor locations.

c. *Output*

Printed output includes:

Highest and second highest concentrations for the year at each receptor for averaging times of 1-, 3-, and 24-hours, a user-selected averaging time which may be 2–12 hours, and a 50 high table for 1-, 3-, and 24-hours.

Annual arithmetic average at each receptor; and the highest 1-hour and 24-hour concentrations over the receptor field for each day considered.

Optional tables of source contributions of individual point sources at up to 20 receptor locations for each averaging period.

Optional magnetic tape output in either binary or fixed block format includes: All 1-hour concentrations.

Optional card/disk output includes for each receptor: Receptor coordinates; receptor elevation; highest and highest, second-highest, 1-, 3-, and 24-hour concentrations; and annual average concentration.

d. *Type of Model*

SCSTER is a Gaussian plume model.

e. *Pollutant Types*

SCSTER may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

SCSTER can handle up to 60 separate stacks at varying locations and up to 600 receptors, including up to 15 receptor rings.

User input topographic elevation for each receptor is used.

g. *Plume Behavior*

SCSTER uses Briggs (1969, 1971, 1972) final plume rise formulas. Transitional plume rise is optional.

SCSTER contains options to incorporate wind directional shear with a plume distortion method described in Appendix A of the User's Guide.

SCSTER provides four terrain adjustments including the CRSTER full terrain height adjustment and a user-input, stability-dependent plume path coefficient adjustment for receptors above stack height.

h. *Horizontal Winds*

Wind speeds are corrected for release height based on power law exponents from DeMarrais (1959), different exponents for different stability classes; default reference height of 7m. Default exponents are 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 for stability classes A through F, respectively.

Steady-state wind is assumed within a given hour.

Optional consideration of plume distortion due to user-input, stability-dependent wind-direction shear gradients.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients from Turner (1969) are used.

Six stability classes are used.

k. *Vertical Dispersion*

Rural dispersion coefficients from Turner (1969) are used.

Six stability classes are used.

An optional test for plume height above mixing height before terrain adjustment is included.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Physical removal is treated using exponential decay. Half-life is input by the user.

n. *Evaluation Studies*

Londergan, R., D. Minott, D. Wackter, T. Kincaid and D. Bonitata, 1983. Evaluation of Rural Air Quality Simulation Models. EPA Publication No. EPA-450/4-83-003. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.17 Pacific Gas and Electric Plume5 Model

Reference

User's Manual for Pacific Gas and Electric PLUMES Model, 1981. Pacific Gas and Electric Company, San Francisco, CA.

Availability

The User's Manual will be supplied for cost of reproduction. An IBM version of the model can be obtained on a user supplied tape free of charge from: Mr. Robert N. Swanson, Pacific Gas and Electric Company, 245 Market Street, Rm. 451, San Francisco, CA 94106.

Abstract

PLUME5 is a steady-state Gaussian plume model applicable to both rural and urban areas in uneven terrain. Pollutant concentrations at 500 receptors from up to 10 sources with up to 15 stacks each can be calculated using up to 5 meteorological inputs. The model in its "basic" mode is similar to CRSTER and MPTER. Several options are available that allow better simulation of atmospheric conditions and improved model outputs. These options allow plume rise into or through a stable layer and crosswind spread of the plume by wind directional shear with height, initial plume expansion, mean (advective) wind speed, terrain considerations, and chemical transformation of pollutants.

Differences that exist between PLUME5 and CRSTER are in the following areas: Stability class determination, hourly mixing height schemes, hourly stable layer data, randomization of wind direction, extent of data set required for preprocessing meteorological data inputs.

a. *Recommendations for Regulatory Use*

PLUME5 can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. PLUME5 must be executed in the equivalent mode.

PLUME5 can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that PLUME5 is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Cartesian or polar coordinates of each source with stack height, diameter, gas temperature, and exit velocity for each stack.

Meteorological data requirements are: Surface data—hourly meteorological data including wind direction, wind speed, temperature, and either ceiling height and total sky cover or sigma A or Delta T depending on how stability is computed; stable layer data—either NCC data or site specific user supplied data.

Receptor data requirements are: Cartesian or polar coordinates of each receptor.

c. *Output*

Printed output includes:

Highest and second highest concentrations for the year printed out at each receptor for averaging times of 1, 3, and 24-hours, plus a user-selected averaging time which may be 2, 4, 6, 8, or 12 hours.

Annual arithmetic average at each receptor.

For each day, the highest 1-hour and 24-hour concentrations over the receptor field are printed.

Hourly effective stack height and effective stack height distributions.

Vertical profiles of maximum pollutant concentrations above a designated height (Z_o) for the data period processed.

Cumulative number of exceedances of 1 hour and 24-hour specified values for all receptors during the entire meteorological data period. These specified values will normally be National and State Ambient Air Quality Standards.

Computer readable output includes:

Hourly concentrations for each receptor on magnetic tape.

Computer file for input to plotting routine. The file stores the highest 1-hour (or other specified time period) concentration at each receptor for the entire meteorological data period for input into a user supplied plotting routine.

d. *Type of Model*

PLUME5 is a Gaussian plume model.

e. *Pollutant Types*

PLUME5 may be used to model primary pollutants. Chemical transformations of pollutants are treated by exponential decay and/or ozone limiting procedures.

f. *Source-Receptor Relationship*

Can input up to 10 separate sources with up to 15 stacks per source.

Unique stack height for each source. Rectangular or circular receptor locations (up to 500) can be either model generated or user input.

Terrain considerations:

When plume rise, H, is above the stable layer top concentration estimates will only be calculated for receptors at or above the stable layer top. If the receptor is below the stable layer top, then the concentration is zero.

When plume rise falls within the stable layer, concerntration estimates will be only caluclated for receptors located within this region. If the receptor height is above or below the stable top, then the concentration is zero.

When plume rise falls below the stable layer and the receptor height is above the stable layer base, then the concentration is zero. If the receptor height is below the stable layer base, the receptor height is redefined.

g. *Plume Behavior*

PLUME5 uses Briggs (1975) final plume rise formulas.

Expansion of plumes within and above a stable layer is treated.

h. *Horizontal Winds*

User-supplied hourly wind directions are read to nearest 1, 5, 10, and 22.5 degrees. (The 5, 10 and 22.5 degree values are randomly modified to nearest whole degree within the intervals).

PLUME5 employs the extrapolated mean wind speed at stack height when the effective stack height is equal to or less than the height of the inversion base above ground. If the plume rises into a stable layer, a separate algorithm is used.

Constant, uniform (steady state) wind assumed within each hour.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

Six stability classes are defined by either radiation index and wind speed (STAR), wind direction fluctuation, or temperature lapse rate.

Nighttime stability class is based on wind direction fluctuations or temperature lapse rate and may be modified according to the method of Mitchell and Timbre (1979).

Dispersion curves are from Turner (1969).

k. *Vertical Dispersion*

Six stability classes are defined by either radiation index and wind speed (STAR), wind direction fluctuations, or temperature lapse rate.

Nighttime stability class is based on wind direction fluctuations or temperature laspe rate and modified according to the method of Mitchell-Timbre (1979).

Dispersion curves are from Turner (1969).

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay and/or ozone limiting procedures.

m. *Physical Removal*

Physical removal is treated using exponential decay. Half-life is input by the user.

n. *Evaluation Studies*

Londergan, R., D. Minott, D. Wackter, T. Kincaid and B. Bonitata, 1983. Evaluation of Rural Air Quality Simulation Models. EPA Publication No. EPA-450/4-83-003. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Wackter, D., and R. Londergan, 1984. Evaluation of Complex Terrain Air Quality Simulation Models. EPA Publication No. EPA-450/4-84-017. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.18 PLMSTAR Air Quality Simulation Model

Reference

Lurmann, F. W., D. A. Godden, and H. Collins, 1985. User's Guide to the PLMSTAR Air Quality Simulation Model. ERT Document No. M-2206-100, Environmental Research & Technology, Inc., Newbury Park, CA.

Availability

The above report and a computer tape are available from: Computer Products, National Technical Information Service, U.S. Department of Commerce, 5825 Port Royal Road, Springfield, VA 22161. Phone: (703) 487-4650.

Abstract:

PLMSTAR is a mesoscale Lagrangian photochemical model designed to predict atmospheric concentrations of O_3, NO_2, HNO_3, PAN, SO_2, and SO_4= from reactive hydrocarbons, NO_X and SO_X emissions. PLMSTAR is intended to simulate the behavior of pollutants in chemically reactive plumes resulting from major point source emissions. The model's Lagrangian air parcel is subdivided into a 5 layer/9 column domain of computational cells. The approach allows for realistic simulation of the combined effects of atmospheric chemical reactions and pollutant dispersion in the horizontal and vertical directions. Other key features of the model include: the capability for generation of trajectories at any level of a three-dimensional, divergence-free wind field; the capability for calculating and utilizing the time and space varying surface deposition of pollutants; an up-to-date O_3/RHC/NO_X/SO_X chemical mechanism that utilizes eight classes of reactive hydrocarbons; the capability for simultaneously handling both point and area source emissions; and the capability to simulate overwater conditions and land/water transitions.

a. *Recommendation for Regulatory Use*

There is no specific recommendation at the present time. The PLMSTAR Model may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements are: Emission rates, stack parameters, diurnal emission profiles, and RHC, NO_X, and SO_X partitioning profiles.

Meteorological data requirements are: Station location, grid geometry, surface winds, surface roughness, surface temperature, temperature profiles, mixing heights (optional), cloud cover, solar radiation, and winds aloft.

Receptor data requirements are: Receptor locations and topography.

c. *Output*

Printed output includes: Computed concentrations at specified times and receptors along the trajectory.

d. *Type of Model*

PLMSTAR is a Lagrangian photochemical model.

e. *Pollutant Types*

The key chemical species included in the model are O_3, NO, NO_2, HNO_3, PAN, SO_2, SO_4=, CO, and eight classes of reactive hydrocarbons. Twenty additional intermediate species are included in the chemical mechanism.

f. *Source-Receptor Relationships*

Source-receptor relationships for individual sources are calculated using a differencing technique. That is, simulations are made with and without an individual source (or group of collocated sources) in addition to the RHC/NO_X/SO_X emissions from all other sources in the region. The emission processors allow for up to 250 point sources and an unlimited number of area sources (allocated to a grid of 36 x 36 squares) to be included in the simulation.

g. *Plume Behavior*

Plume rise calculations are based on Briggs (1975).

h. *Horizontal Winds*

Gridded hourly multi-level horizontal wind fields are generated using techniques similar to those reported by Goodin et al. (1979). These involve wind data interpolation, divergence minimization, and terrain adjustment. Trajectory path segments are then generated by interpolation from the gridded horizontal wind fields in 15 minute steps at the user selected vertical level. Either source or receptor oriented trajectory may be generated.

i. *Vertical Wind speed*

Vertical speed is produced by WINDMOD, but is not utilized in the trajectory calculation or the pollutant advection algorithm.

j. *Vertical Dispersion*

Vertical eddy diffusivities (Kz) over land are calculated as a function of wind speed, stability, surface roughness, and boundary layer height. Over water, wind speed, air-to-sea temperature difference, humidity, and boundary layer height are the key parameters.

The effects of vertical dispersion on pollutant concentrations are calculated by numerically integrating finite difference approximations to the diffusion equation.

Mixing heights can be internally calculated or externally specified.

k. *Horizontal Dispersion*

Horizontal eddy diffusivities (K_y) are calculated either as a function of K_z and stability class or as a function of σ_y. The effects of horizontal dispersion on pollutant concentrations are calculated by numerically integrating finite difference approximations to the diffusion equation.

l. *Chemical Transformation*

PLMSTAR incorporates a slightly condensed version of the Atkinson et al. (1982) photochemical mechanism for O_3/RHC/NO_x/SO_x/air mixtures. The mechanism contains 62 reactions involving 38 species, including 8 classes of organic precursors. The effects of chemical transformations on pollutant concentrations are computed by numerically integrating the nonlinear kinetic rate equations.

m. *Physical Removal*

Dry deposition of O_3, NO_2, HNO_3, PAN, SO_2, and SO_4= is based on the model of Wesely and Hicks (1977).

n. *Evaluation Studies*

Lurmann, F. W., D. A. Godden and A. C. Lloyd, 1982. The Development and Selected Sensitivity, Tests of the PLMSTAR Reactive Plume Model, Presented at the Third Joint Conference on Applications of Air Pollution Meteorology, San Antonio, TX.

Godden, D. and F. Lurmann, 1983. Development of the PLMSTAR Model and its Application to Ozone Episode Conditions in the South Coast Air Basin, ERT Document No. P-A702-200, Environmental Research & Technology, Inc., Newbury Park, CA.

Blumenthal, D. L., T. B. Smith, D. E. Lehrman, N. L. Alexander, F. Lurman, and D. Godden, 1985. Analysis of Aerometric and Meteorological Data for the Ventura County Region, Ref. #90094-511-FR. Sonoma Technology, Inc., and Environmental Research and Technology, Inc., for the Western Oil and Gas Association, Los Angeles, CA.

B.19 Plume Visibility Model (PLUVUE II)

Reference

Environmental Protection Agency, 1992. User's Manual for the Plume Visibility Model, PLUVUE II (Revised). EPA Publication No. EPA-454/B-92-008. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Availability

This model code is available on the Support Center for Regulatory Air Models Bulletin Board System and also from the National Technical Information Service (see page B-1).

Abstract

The Plume Visibility Model (PLUVUE II) is a computerized model used for estimating visual range reduction and atmospheric discoloration caused by plumes resulting from the emissions of particles, nitrogen oxides and sulfur oxides from a single emission source. PLUVUE II predicts the transport, dispersion, chemical reactions, optical effects and surface deposition of point or area source emissions. Addenda to the User's Manual were prepared in February 1985 to allow execution of PLUVUE II and the test cases on the UNIVAC computer.

a. *Recommendations for Regulatory Use*

The Plume Visibility Model (PLUVUE II) may be used on a case-by-case basis. When applying PLUVUE II to assess the visual impact of a plume, the following precautions should be taken to avoid the possibility of error:

1. Treat the optical effects of NO_2 and particles separately as well as together to avoid cancellation of NO_2 absorption with particle scattering.
2. Examine the visual impact of the plume in 0.1 (or 0), 0.5, and 1.0 times the expected level of particulate matter in the background air.
3. Examine the visual impact of the plume over the full range of obser-ver - plume - sun angles.

b. *Input Requirements*

Source data requirements are: Location and elevation; emission rates of SO_2, NO_x, and particulates; flue gas flow rate, exit velocity, and exit temperature; flue gas oxygen content; properties (including density, mass median and standard geometric deviation of radius) of the emitted aerosols in the accumulation (0.1–1.0 μm) and coarse (1.0–10 μm) size modes; and deposition velocities for SO_2, NO_x, coarse mode aerosol, and accumulations mode aerosol.

Meteorological data requirements are: Stability class, wind direction (for an observer-based run), wind speed, lapse rate, air temperature, relative humidity, and mixing height.

Other data requirements are: Ambient background concentrations of NO_x, NO_2, O_3, and SO_2, background visual range or sulfate and nitrate concentrations.

Receptor (observer) data requirements are: Location, elevation, terrain which will be observed through the plume (for observer based run with white, gray, and black viewing backgrounds).

c. *Output*

Printed output includes: Plume concentrations and visual effects at specified downwind distances for calculated or specified lines of sight.

d. *Type of Model*

PLUVUE is a Gaussian plume model.

e. *Pollutant Types*

PLUVUE II treats NO, NO_2, SO_2, H_2SO_4, HNO_3, O_3, primary and secondary particles to calculate effects on visibility.

f. *Source Receptor Relationship*

PLUVUE treats a single point or area source.

Predicted concentrations and visual effects are obtained at user specified downwind distances.

g. *Plume Behavior*

PLUVUE uses Briggs (1969, 1971, 1972) final plume rise equations.

h. *Horizontal Winds*

User-specified wind speed (and direction for an observer-based run) are assumed constant for the calculation.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

User specified plume widths, or widths computed from either Pasquill-Gifford-Turner curves (Turner, 1969) or TVA curves (Carpenter, et al., 1971) are used in PLUVUE.

k. *Vertical Dispersion*

User specified plume depths, or computer from Pasquill-Gifford-Turner curves (Turner, 1969) or TVA curves (Carpenter, et al., 1971) are used in PLUVUE.

l. *Chemical Transformation*

PLUVUE II treats the chemistry of NO, NO_2, O_3, OH, $O(^1D)$, SO_2, HNO_3, and H_2SO_4, by means of nine reactions. Steady state approximations are used for radicals and for the $NO/NO_2/O_3$ reactions.

m. *Physical Removal*

Dry deposition of gaseous and particulate pollutants is treated using deposition velocities.

n. *Evaluation Studies*

Bergstrom, R. W., C. Seigneur, B. L. Babson, H. Y. Holman and M. A. Wojcik, 1981. Comparison of the Observed and Predicted Visual Effects Caused by Power Plant Plumes. Atmospheric Environment, 15: 2135–2150.

Bergstrom, R. W., Seigneur, C. D. Johnson, and L. W. Richards, 1984. Measurements and Simulations of the Visual Effects of Particulate Plumes. Atmospheric Environment, 18(10): 2231–2244.

Seigneur, C., R. W. Bergstrom, and A. B. Hudischewskyj, 1982. Evaluation of the EPA PLUVUE Model and the ERT Visibility Model Based on the 1979 VISTTA Data Base. EPA Publication No. EPA–450/4–82–008. U.S. Environmental Protection Agency, Research Triangle Park, NC.

White, W. H., C. Seigneur, D. W. Heinold, M. W. Eltgroth, L. W. Richards, P. T. Roberts, P. S. Bhardwaja, W. D. Conner and W. E. Wilson, Jr, 1985. Predicting the Visibility of Chimney Plumes: An Inter-comparison of Four Models with Observations at a Well-Controlled Power Plant. Atmospheric Environment, 19: 515–528.

B.20 Point, Area, Line Source Algorithm (PAL–DS)

Reference

Petersen, W. B, 1978. User's Guide for PAL—A Gaussian-Plume Algorithm for Point, Area, and Line Sources. EPA Publication No. EPA–600/4–78–013. Office of Research and Development, Research Triangle Park, NC. (NTIS No. PB 281306)

Rao, K. S. and H. F. Snodgrass, 1982. PAL–DS Model: The PAL Model Including Deposition and Sedimentation. EPA Publication No. EPA–600/8–82–023. Office of Research and Development, Research Triangle Park, NC. (NTIS No. PB 83–117739)

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Phone: (703) 487–4650.

Abstract

PAL–DS is an acronym for this point, area, and line source algorithm and is a method of estimating short-term dispersion using Gaussian-plume steady-state assumptions. The algorithm can be used for estimating concentrations of non-reactive pollutants at 99 receptors for averaging times of 1 to 24 hours, and for a limited number of point, area, and line sources (99 of each type). This algorithm is not intended for application to entire urban areas but is intended, rather, to assess the impact on air quality, on scales of tens to hundreds of meters, of portions of urban areas such as shopping centers, large parking areas, and airports. Level terrain is assumed. The Gaussian point source equation estimates concentrations from point sources after determining the effective height of emission and the upwind and crosswind distance of the source from the receptor. Numerical integration of the Gaussian point source equation is used to determine concentrations from the four types of line sources. Subroutines are included that estimate concentrations for multiple lane line and curved path sources, special line sources (line sources with endpoints at different heights above ground), and special curved path sources. Integration over the area source, which includes edge effects from the source region, is done by considering finite line sources perpendicular to the wind at intervals upwind from the receptor. The crosswind integration is done analytically; integration upwind is done numerically by successive approximations.

The PAL–DS model utilizes Gaussian plume-type diffusion-deposition algorithms based on analytical solutions of a gradient-transfer model. The PAL–DS model can treat deposition of both gaseous and suspended particulate pollutants in the plume since gravitational settling and dry deposition of the particles are explicitly accounted for. The analytical diffusion-deposition expressions listed in this report in the limit when pollutant settling and deposition velocities are zero, they reduce to the usual Gaussian plume diffusion algorithms in the PAL model.

a. *Recommendations for Regulatory Use*

PAL–DS can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. PAL–DS must be executed in the equivalent mode.

PAL–DS can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that PAL–DS is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data: Point-sources—emission rate, physical stack height, stack gas temperature, stack gas velocity, stack diameter, stack gas volume flow, coordinates of stack, initial σ_y and σ_z; area sources—source strength, size of area source, coordinates of S.W. corner, and height of area source; and line sources—source strength, number of lanes, height of source, coordinates of end points, initial σ_y and σ_z, width of line source, and width of median. Diurnal variations in emissions are permitted. When applicable, the settling velocity and deposition velocity are also permitted.

Meteorological data: Wind profile exponents, anemometer height, wind direction and speed, stability class, mixing height, air temperature, and hourly variations in emission rate.

Receptor data: Receptor coordinates.

c. *Output*

Printed output includes:

Hourly concentration and deposition flux for each source type at each receptor; and

Average concentration for up to 24 hrs for each source type at each receptor.

d. *Type of Model*

PAL–DS is a Gaussian plume model.

e. *Pollutant Types*

PAL–DS may be used to model non-reactive pollutants.

f. *Source-Receptor Relationships*

Up to 99 sources of each of 6 source types: Point, area, and 4 types of line sources.

Source and receptor coordinates are uniquely defined.

Unique stack height for each source.

Coordinates of receptor locations are user defined.

g. *Plume Behavior*

Briggs final plume rise equations are used.

Fumigation and downwash are not treated.

If plume height exceeds mixing height, concentrations are assumed equal to zero.

Surface concentrations are set to zero when the plume centerline exceeds mixing height.

h. *Horizontal Winds*

User-supplied hourly wind data are used.

Constant, uniform (steady-state) wind is assumed within each hour. Wind is assumed to increase with height.

i. *Vertical Wind Speeds*

Assumed equal to zero.

j. *Horizontal Dispersion*

Rural dispersion coefficients from Turner (1969) are used with no adjustments made for surface roughness.

Six stability classes are used.

Dispersion coefficients (Pasquill-Gifford) are assumed based on a 3 cm roughness height.

k. *Vertical Dispersion*

Six stability classes are used.

Rural dispersion coefficients from Turner (1969) are used; no further ajustments are made for variation in surface roughness, transport or averaging time.

Multiple reflection is handled by summation of series until the vertical standard deviation equals 1.6 times mixing height. Uniform vertical mixing is assumed thereafter.

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

PAL–DS can treat deposition of both gaseous and suspended particulates in the plume since gravitational settling and dry deposition of the particles are explicitly accounted for.

n. *Evaluation Studies*

None.

B.21 Random-Walk Advection and Dispersion Model (RADM)

References

Austin, D. I., A. W. Bealer, and W. R. Goodin, 1981. RandomWalk Advection and Dispersion Model (RADM), User's Manual. Dames & Moore, Los Angeles, CA.

Runchal, A. K., W. R. Goodin, A. W. Bealer, D. I. Austin, 1981. Technical Description of the Random-Walk Advection and Dispersion Model (RADM). Dames & Moore, Los Angeles, CA.

Availability

A magnetic tape of the computer code and the user's manual are available for a cost of $440.00 from: Mr. C. James Olsten, Dames & Moore, 445 South Figueroa Street, Suite 3500, Los Angeles, CA 90071–1665.

Abstract

RADM is a Lagrangian dispersion model which uses the randomwalk method to simulate atmospheric dispersion. The technical procedure involves tracking tracer particles having a given mass through advection by the mean wind and diffusion by the random motions of atmospheric turbulence. Turbulent movement is calculated by determining the probability distribution of particle movement for a user-defined time step. A random number between 0 and 1 is then computed to determine the distance of particle movement according to the probability distribution. A large number of particles is used to statistically represent the distribution of pollutant mass. Concentrations are calculated by summing the mass in a volume around the receptor of interest and dividing the total mass by the volume. Concentrations can be calculated for any averaging time. RADM is applicable to point and area sources.

a. *Recommendations for Regulatory Use*

There is no specific recommendation at the present time. The RADM model may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements are: Emission rate, physical stack height, stack gas exit velocity, stack inside diameter, stack gas temperature. Hourly rates may be specified.

Meteorological data requirements are: Gridded wind field including wind speed, wind direction, stability class, temperature and mixing height.

Receptor data requirements are: coordinates, ground elevation, and receptor cell dimensions.

c. *Output*

Printed output includes:

Average concentration by receptor for user-specified averaging time (concentrations are printed for each block of n hours).

Average concentrations for the entire period of the run.

d. *Type of Model*

RADM is a random-walk Lagrangian dispersion model.

e. *Pollutant Types*

RADM may be used to model inert gases and particles, and pollutants with exponential decay or formation rates.

f. *Source-Receptor Relationship*

Multiple point and area sources may be specified at independent locations.

Unique stack characteristics are used for each source.

No restriction is placed on receptor locations.

Perfect reflection at the surface is assumed for the portion not removed by dry deposition.

Particles leaving the gridded area are removed from simulation.

g. *Plume Behavior*

Briggs (1975) final plume rise equations are used.

Inversion penetration by the plume is allowed.

Fumigation may occur as mixing height rises above a plume which has penetrated an inversion.

h. *Horizontal Winds*

Wind speed, wind direction, stability class, temperature and mixing height are supplied on a gridded array.

Any wind field may be used as long as output is in correct format for RADM input.

Wind field is updated at user-specified intervals, which may be less than one hour if data are available.

Vertical wind speed profile is used based on surface roughness and stability using Monin-Obukhov length.

i. *Vertical Wind Speed*

Assumed equal to zero.

j. *Horizontal Dispersion*

Dispersion is based on diffusivity values calculated from surface roughness, stability class and Monin-Obukhov length.

Diffusivity is a function of height.

k. *Vertical Dispersion*

Dispersion is based on diffusivity values calculated from surface roughness, stability class and Monin-Obukhov length.

Diffusivity is a function of height.

l. *Chemical Transformations*

Simple exponential decay or formation is used.

m. *Physical Removal*

Dry deposition is treated.

n. *Evaluation Studies*

Runchal, A. K., A. W. Bealer, and G. S. Segal, 1978. A Completely Lagrangian Random-Walk Model for Atmospheric Dispersion. Proceedings of the Thirteenth International Colloquium on Atmospheric

Pollution, National Institute for Applications of Chemical Research, Paris; pp. 137–142.

Goodin, W. R., A. K. Runchal and G. Y. Lou, 1980. Evaluation and Application of the Random-Walk Advection and Dispersion Model (RADM). Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, DOE/NOAA/ORNL, Gatlinburg, TN.

Goodin, W. R., D. I. Austin and A. K. Runchal, 1980. A Model Verification and Prediction Study of $SO_2/SO_4^=$ Concentrations in the San Francisco Bay Area. Second Joint Conference on Applications of Air Pollution Meteorology, AMS/APCA, New Orleans, LA.

B.22 Reactive Plume Model (RPM–II)

Reference

D. Stewart, M. Yocke, and M–K Liu, 1981. Reactive Plume Model—RPM–II, User's Guide, EPA Publication No. EPA–600/8–81–021. U.S. Environmental Protection Agency, ESRL, Research Triangle Park, NC. (NTIS No. PB 82–230723)

Availability

The above report is available from NTIS ($16.95 for paper copy; $5.95 on microfiche). The accession number for the computer tape for RPM–II is PB83–154898, and the cost is $460.00. Requests should be sent to: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Phone: (703) 487–4650.

Abstract

The Reactive Plume Model, RPM-II, is a computerized model used for estimating short-term concentrations of primary and secondary pollutants resulting from point or area source emissions. The model is capable of simulating the complex interaction of plume dispersion and non-linear photochemistry. Two main features of the model are: (1) The horizontal resolution within the plume, which offers a more realistic treatment of the entrainment process, and (2) its flexibility with regard to choices of chemical kinetic mechanisms.

a. *Recommendations for Regulatory Use*

There is no specific recommendation at the present time. The RPM–II Model may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements are: Emission rates, name, and molecular weight of each species of pollutant emitted; ambient pressure, ambient temperature, stack height, stack diameter, stack exit velocity, stack gas temperature, and location.

Meteorological data requirements are: Wind speeds, plume widths or stability classes, photolytic rate constants, and plume depths or stability classes.

Receptor data requirements are: Downwind distances or travel times at which calculations are to be made.

Initial concentration of all species is required, and the specification of downwind ambient concentrations to be entrained by the plume is optional.

c. *Output*

Short-term concentrations of primary and secondary pollutants at either user specified time increments, or user specified downwind distances.

d. *Type of Model*

Reactive plume model.

e. *Pollutant Types*

Currently, using the Carbon Bond Mechanism (CBM–II), 35 species are simulated (68 reactions), including NO, NO_2, O_3, SO_2, $SO_4^=$, five categories of reactive hydrocarbons, secondary nitrogen compounds, organic aerosols, and radical species.

f. *Source-Receptor Relationships*

Single point source.

Single area or volume source.

Multiple sources can be simulated if they are lined up along the wind trajectory.

Predicted concentrations are obtained at a user specified time increment, or at user specified downwind distances.

g. *Plume Behavior*

Briggs (1971) plume rise equations are used.

h. *Horizontal Winds*

User specifies wind speeds as a function of time.

i. *Vertical Wind Speed*

Not treated.

j. *Horizontal Dispersion*

User specified plume widths, or user may specify stability and widths will be computed using Turner (1969).

k. *Vertical Dispersion*

User specified plume depths, or user may specify stability in which case depths will be calculated using Turner (1969). Note that vertical uniformity in plume concentration is assumed.

l. *Chemical Transformation*

The RPM–II has the flexibility of using any user input chemical kinetic mechanism. Currently it is run using the chemistry of the Carbon Bond Mechanism, CBM–II (Whitten, Killus, and Hogo, 1980). The CBM–II, as incorporated in the RPM–II, contains 35 species and 68 reactions focusing primarily on hydrocarbon-nitrogen oxides-ozone photochemistry.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Stewart, D. A. and M–K Liu, 1981. Development and Application of a Reactive Plume Model. Atmospheric Environment, 15: 2377–2393.

B.23 Regional Transport Model (RTM–II)

Reference

Morris, R. E., D. A. Stewart, and M–K Liu, 1982. Revised User's Guide to the Regional Transport Model—Version II. Publication No. SYSAPP–83/022, Systems Applications Inc., San Rafael, CA.

Availability

The computer code is available on magnetic tape for a cost of $100 (which includes the User's Manual) from: Systems Applications, Inc., 101 Lucas Valley Road, San Raphael, CA 94903.

Abstract

The Regional Transport Model (RTM–II) is a computer based air quality grid model whose primary use is estimating the distribution of air pollution from multiple point sources and area sources at large distances (on the scale of several hundred to a thousand kilometers). RTM–II offers significant advantages over other long-range transport models because it is a quasi-three dimensional hybrid (grid plus Lagrangian puff) approach to the solution of the advectiondiffusion equation. Furthermore, its formulation allows the treatment of spatially and temporally varying wind, mixing depths, diffusivity, and transformation rate fields. It is also capable of treating spatially varying surface depletion processes. While the modeling concept is capable of predicting concentration distributions of many pollutant species (e.g., NO_X, CO, TSP, etc.), the most notable applications of the model to date focus on the long-range transport and transformation of SO_2 and sulfates.

a. *Recommendations for Regulatory Use*

There is no specific recommendation at the present time. The RTM Model may be used on a case-by-case basis.

b. *Input Requirements*

Source data requirements are: Major point source SO_2 and primary sulfate emissions, including stack height, diameter, exit velocity, exit temperature, and hourly emission factors; area source SO_2 and primary $SO_4^=$ emissions in gridded format.

Meteorological data requirements are: Gridded u, v wind fields at user specified update interval (model configured for separate wind fields in each of two layers), derived from twice daily radiosonde data, time variation linear between a maximum convectively driven boundary layer and a minimum mechanically driven boundary layer, spatial interpolation by an inverse distance weighted objective scheme; gridded hourly precipitation fields determined either by averaging precipitation rate of all stations in grid (if high density), or by inverse distance weighted interpolation (if low density).

Other data requirements are: Parameter file, containing region definition, starting time, output and averaging time intervals, region top specifications, and various operational flags; horizontal diffusivity fields calculated from wind fields; land use type file; deposition velocities and roughness length determined internally from tabulated values associated with land use types; initial conditions and boundary conditions for both layers (boundary conditions may be time varying).

c. *Output*

Printed output includes:

Diagnostic information.

Instantaneous SO_2 and sulfate concentration fields for lower and upper layers at pre-specified time intervals.

Average SO_2 and sulfate concentration fields for upper and lower layer, over pre-specified time intervals. Accumulated dry and wet deposition for each species over pre-selected time intervals.

d. *Type of Model*

RTM-II is a hybrid Eulerian grid and Lagrangian puff model.

e. *Pollutant Types*

RTM-II is configured for SO_2 and sulfate only. Primary sulfate emissions may be included.

f. *Source Receptor Relationships*

Area sources and minor point sources are specified at each grid within the modeling domain.

Up to 500 major point sources (modeled with the Gaussian puff submodel) are allowed.

Grid average concentration and deposition totals are provided at each grid within the modeling domain (dry deposition for lower layer grid only). All lower grid average concentration values are assumed to be representative of ground-level receptors.

g. *Plume Behavior*

Plume rise (Briggs, 1971) is calculated for all major point sources regardless of whether they are treated in the Gaussian puff submodel.

h. *Horizontal Winds*

Gridded u, v wind fields are used at a user specified update interval for each layer.

Gaussian puff submodel tracks puff centroids horizontally at user specified time intervals.

i. *Vertical Wind Speed*

Considered implicitly if convergent or divergent winds are provided.

j. *Horizontal Dispersion*

Plume dispersion is based on σ_y differentials derived from a power law fit to Turner (1969) dispersion curves. Variable stabilities within adjacent cells are considered.

Horizontal eddy diffusivities are proportional to the wind field deformation and are calculated from the gridded wind fields as ancilliary input. Maximum and minimum constraints are imposed on the magnitude of the diffusivities.

k. *Vertical Dispersion*

Plume dispersion is based on σ_z differentials derived from a power law fit to Turner (1969) dispersion curves. Variable stabilities within adjacent cells are considered.

Vertical dispersion across the mixed layer-surface layer interface is considered when calculating pollutant deposition.

l. *Chemical Transformation*

Linear SO_2 oxidation is treated. Rate constant is diurnally and latitudinally variable. A minimum oxidation rate constant is specified to account for heterogeneous oxidation during the nighttime.

m. *Physical Removal*

Dry deposition of SO_2 and sulfate is treated. Precipitation scavenging of SO_2 (reversible) and sulfate (irreversible) is treated.

n. *Evaluation Studies*

Stewart, D. A., R. E. Morris, M-K Liu, and D. Henderson, 1983. Evaluation of an Episodic Regional Transport Model for a Multiple Day Episode. *Atmospheric Environment,* 17: 1225–1252.

B.24 SHORTZ

Reference

Bjorklund, J. R., and J. F. Bowers, 1982. User's Instructions for the SHORTZ and LONGZ Computer Programs, Volumes I and II. EPA Publication No. EPA-903/9-82-004a and b. U.S. Environmental Protection Agency, Region III, Philadelphia, PA.

Availability

This model is available as part of UNAMAP (Version 6). The computer code is available on magnetic tape from: Computer Products, National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Phone: (703) 487-4650.

Abstract

SHORTZ utilizes the steady state bivariate Gaussian plume formulation for both urban and rural areas in flat or complex terrain to calculate ground-level ambient air concentrations. It can calculate 1-hour, 2-hour, 3-hour etc. average concentrations due to emissions from stacks, buildings and area sources for up to 300 arbitrarily placed sources. The output consists of total concentration at each receptor due to emissions from each userspecified source or group of sources, including all sources. If the option for gravitational settling is invoked, analysis cannot be accomplished in complex terrain without violating mass continuity.

a. *Recommendations for Regulatory Use*

SHORTZ can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. SHORTZ must be executed in the equivalent mode.

SHORTZ can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that SHORTZ is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: For point, building or area sources, location, elevation, total emission rate (optionally classified by gravitational settling velocity) and decay coefficient; for stack sources, stack height, effluent temperature, effluent exit velocity, stack radius (inner), actual volumetric flow rate, and ground elevation (optional); for building sources, height, length and width, and orientation; for area sources, characteristic vertical dimension, and length, width and orientation.

Meteorological data requirements are: Wind speed and measurement height, wind profile exponents, wind direction, standard deviations of vertical and horizontal wind directions, (i.e., vertical and lateral turbulent intensities), mixing height, air temperature, and vertical potential temperature gradient.

Receptor data requirements are: coordinates, ground elevation.

c. *Output*

Printed output includes: Total concentration due to emissions from user-specified source groups, including the combined emissions from all sources (with optional allowance for depletion by deposition).

d. *Type of Model*

SHORTZ is a Gaussian plume model.

e. *Pollutant Types*

SHORTZ may be used to model primarv pollutants. Settling and deposition of particulates are treated.

f. *Source-Receptor Relationships*

User specified locations for sources and receptors are used.

Receptors are assumed to be at ground level.

g. *Plume Behavior*

Plume rise equations of Bjorklund and Bowers (1982) are used.

Stack tip downwash (Bjorklund and Bowers, 1982) is included.

All plumes move horizontally and will fully intercept elevated terrain.

Plumes above mixing height are ignored.

Perfect reflection at mixing height is assumed for plumes below the mixing height.

Plume rise is limited when the mean wind at stack height approaches or exceeds stack exit velocity.

Perfect reflection at ground is assumed for pollutants with no settling velocity.

Zero reflection at ground is assumed for pollutants with finite settling velocity.

Tilted plume is used for pollutants with settling velocity specified. Buoyancy-induced dispersion (Briggs, 1972) is included.

h. *Horizontal Winds*

Winds are assumed homogeneous and steady-state.

Wind speed profile exponents are functions of both stability class and wind speed. Default values are specified in Bjorklund and Bowers (1982).

i. *Vertical Wind Speed*

Vertical winds are assumed equal to zero.

j. *Horizontal Dispersion*

Horizontal plume size is derived from input lateral turbulent intensities using adjustments to plume height, and rate of plume growth with downwind distance specified in Bjorklund and Bowers (1982).

k. *Vertical Dispersion*

Vertical plume size is derived from input vertical turbulent intensities using adjustments to plume height and rate of plume growth with downwind distance specified in Bjorklund and Bowers (1982).

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Time constant is input by the user.

m. *Physical Removal*

Settling and deposition of particulates are treated.

n. *Evaluation Studies*

Bjorklund, J. R., and J. F. Bowers, 1982. User's Instructions for the SHORTZ and LONGZ Computer Programs. EPA Publication No. EPA-903/9-82004. EPA Environmental Protection Agency, Region III, Philadelphia, PA.

Wackter, D., and R. Londergan, 1984. Evaluation of Complex Terrain Air Quality Simulation Models. EPA Publication No. EPA-450/4-84-017. U.S. Environmental Protection Agency, Research Triangle Park, NC.

B.25 Simple Line-Source Model (GMLINE)

Reference

Chock, D. P., 1980. User's Guide for the Simple Line-Source Model for Vehicle Exhaust Dispersion Near a Road, Environmental Science Department, General Motors Research Laboratories, Warren, MI.

Availability

Copies of the above reference are available without charge from: Dr. D. P. Chock, Environmental Science Department, General Motors Research Laboratories, General Motors Technical Center, Warren, MI 48090.

The User's Guide contains the short algorithm of the model.

Abstract

GMLINE is a simple steady-state Gaussian plume model which can be used to determine hourly (or half-hourly) averages of exhaust concentrations within 100m from a roadway on a relatively flat terrain. The model allows for plume rise due to the heated exhaust, which can be important when the crossroad wind is very low. It also utilizes a new set of vertical dispersion parameters which reflects the influence of traffic-induced turbulence.

a. *Recommendations for Regulatory Use*

GMLINE can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. GMLINE must be executed in the equivalent mode.

GMLINE can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in Section 3.2, that GMLINE is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Emission rate per unit length per lane, the number of lanes on each road, distances from lane centers to the receptor, source and receptor heights.

Meteorological data requirements are: Buoyancy flux, ambient stability condition, ambient wind and its direction relative to the road.

Receptor data requirements are: Distance and height above ground.

c. *Output*

Printed output includes: Hourly or (half-hourly) concentrations at the receptor due to exhaust emission from a road (or a system of roads by summing the results from repeated model applications).

d. *Type of Model*

GMLINE is a Gaussian plume model.

e. *Pollutant Types*

GMLINE can be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

GMLINE treats arbitrary location of line sources and receptors.

g. *Plume Behavior*

Plume-rise formula adequate for a heated line source is used.

h. *Horizontal Winds*

GMLINE uses user-supplied hourly (or half-hourly) ambient wind speed and direction. The wind measurements are from a height of 5 to 10m.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Dispersion Parameters*

Horizontal dispersion parameter is not used.

k. *Vertical Dispersion*

A vertical dispersion parameter is used which is a function of stability and wind-road angle. Three stability classes are used: unstable, neutral and stable. The parameters take into account the effect of traffic-generated turbulence (Chock, 1980).

l. *Chemical Transformation*

Not treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

Chock, D. P., 1978. A Simple Line-Source Model for Dispersion Near Roadways. *Atmospheric Environment*, 12: 823-829.

Sistla, G., P. Samson, M. Keenan, and S. T. Ras, 1979. A Study of Pollutant Dispersion Near Highways. *Atmospheric Environment*, 13: 669-685.

B.26 Texas Climatological Model (TCM-2)

Reference

Staff of the Texas Air Control Board, 1980. User's Guide to the TEXAS CLIMATOLOGICAL MODEL (TCM). Texas Air Control Board, Permits Section, 6330 Highway 290 East, Austin, TX.

Availability

The TCM-2 model is available from the Texas Air Control Board at the following cost:

User's Manual only—$20.00
User's Manual and Model (Magnetic Tape)—$80.00

Requests should be directed to: Data Processing Division, Texas Air Control Board, 6330 Highway 290 East, Austin, TX 78723.

Abstract

TCM is a climatological steady-state Gaussian plume model for determining long-term (seasonal or annual arithmetic) average pollutant concentrations of non-reactive pollutants.

a. *Recommendations for Regulatory Use*

TCM can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. TCM must be executed in the equivalent mode.

TCM can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that TCM is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Point source coordinates emission rates (by pollutant), stack height, stack diameter, stack gas exit velocity, stack gas temperature; area source coordinates (southwest corner), size, emission rate.

Meteorological data requirements are: Stability wind rose and average temperature.

Receptor data requirements are: Size and spacing of the rectangular receptor grid.

c. *Output*

Printed output includes:

Period average concentrations listed, displayed in map format, or punched on cards at the user's option.

Culpability list option provides the contributions of the five highest contributors at each receptor.

Maximum concentration option provides the maximum concentration for each scenario (run).

d. *Type of Model*

TCM is a Gaussian plume model.

e. *Pollutant Types*

TCM may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

Arbitrary location of point sources and area sources are treated.

Arbitrary location and spacing of rectangular grid of receptors are used. (Area source grid is best defined in terms of the receptor grid, so that the receptors fall in the center of the area source).

Receptors located in simple terrain may be modeled.

g. *Plume Behavior*

Briggs (1975) plume rise equations, including momentum rise, are used for point sources.

Two-thirds power law is used when transitional rise option is selected. Flares are treated.

h. *Horizontal Winds*

Characteristic wind speed is calculated for each direction-stability class combination.

This characteristic speed is the inverse of the average inverse speed for the stability-wind direction combination.

Wind speed is adjusted to stack height by a power law using exponents of 0.10, 0.15, 0.20, 0.25, 0.30, and 0.30 for stabilities A through F, respectively.

i. *Vertical Wind Speed*

Vertical wind speed is assumed to be zero.

j. *Horizontal Dispersion*

Uniform distribution within each 22.5 degree sector is assumed.

k. *Vertical Dispersion*

Dispersion parameters for point sources are fit to Turner (1969); for area sources in the urban mode the fit is to Gifford and Hanna (1970).

Seven stability classes are used.

Pasquill A through F are treated, with daytime "D" and nighttime "D" given separately.

In the urban mode, E and F stability classes are treated as D-night. Perfect reflection at the ground is assumed.

l. *Chemical Transformation*

Chemical transformations are treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Physical removal is treated using exponential decay. Half-life is input by the user.

n. *Evaluation Studies*

Londergan, R. J., D. H. Minott, D. J. Wachter and R. R. Fizz, 1983. Evaluation of Urban Air Quality Simulation Models. EPA Publication No. EPA-450/4-83-020. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Durrenberger, C. S., B. A. Braberg, and K. Zimmermann, 1983. Development of a Protocol to be Used for Dispersion Model Comparison Studies. Presented at the 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA.

B.27 Texas Episodic Model (TEM-8)

Reference

Staff of the Texas Air Control Board, 1979. User's Guide to the TEXAS EPISODIC MODEL. Texas Air Control Board, Permits Section, 6330 Highway 290 East, Austin, TX.

Availibility

The TEM-8 model is available from the Texas Air Control Board at the following costs:

User's Manual only—$20.00

User's Manual and Model (Magnetic Tape)—$80.00

Requests should be directed to: Data Processing Division, Texas Air Control Board, 6330 Highway 290 East, Austin, TX 78723.

Abstract

TEM is a short-term, steady-state Gaussian plume model for determining short-term concentrations of non-reactive pollutants.

a. *Recommendations for Regulatory Use*

TEM can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. TEM must be executed in the equivalent mode.

TEM can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that TEM is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements*

Source data requirements are: Locations, average emission rates and heights of emissions for both point and area sources; stack gas temperature, stack gas exit velocity, and stack inside diameter for point sources for plume rise calculations.

Meteorological data requirements are: Hourly surface weather data from the EPA meteorological preprocessor program. Preprocessor output includes hourly stability class, wind direction, wind speed, temperature, and mixing height. Any combination of hourly meteorological data up to 24 hours may be used, (e.g., 1, 3, 5, 8, 24 hours).

Receptor requirements are: Size, spacing and location of rectangular grid of receptors.

c. *Output*

Printed output includes: concentration list;

Spatial array (concentrations displayed as on a map);

Punched cards of the concentration list;

Culpability list (percent contributions) of the five highest contributors to each receptor;

Maximum concentration; and

Point source list.

d. *Type of Model*

TEM is a Gaussian plume model.

e. *Pollutant Types*

TEM can be used to model non-reactive pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationship*

Arbitrary locations of point sources and area sources are treated.

Arbitrary location and spacing of rectangular grid of receptors is treated. Area source grid is best defined in terms of the receptor grid so that the receptors fall in the centers of the area sources.

Receptors located in simple terrain may be modeled.

g. *Plume Behavior*

Briggs (1975) plume rise equations are used, including momentum rise, for point sources.

Transitional rise is calculated.

Stack-tip downwash may be evaluated.

h. *Horizontal Winds*

Wind speeds are adjusted to release height by power law formula, using exponents of 0.10, 0.15, 0.20, 0.25, 0.30 and 0.35 for stabilities A through F, respectively.

Steady-state wind is assumed.

i. *Vertical Wind Speed*

Vertical wind is assumed equal to zero.

j. *Horizontal Dispersion*

Gaussian plume coefficients are fitted to Turner (1969). The Turner curves are treated as 10-minute averages and the coefficients are adjusted to represent 30-minute or hourly as appropriate.

In the urban mode, stable cases are shifted to neutral nighttime (D-night) conditions and urban mixing heights are used.

k. *Vertical Dispersion*

Dispersion parameters for point sources are fit to Turner (1969); for area sources, in the urban mode, the fit is to Gifford and Hanna (1970).

Total reflection of the plume at the ground is assumed.

In the urban mode, E and F stability classes are treated as D-nighttime.

l. *Chemical Transformation*

Chemical transformation is treated using exponential decay. Half-life is input by the user.

m. *Physical Removal*

Physical removal is treated using exponential decay. Half-life is input by the user.

n. *Evaluation Studies*

Londergan, R., D. Minott, D. Wachter, T. Kincaid and D. Bonitata, 1983. Evaluation of Rural Air Quality Simulation Models. EPA-450/4-83-003, Environmental Protection Agency, Research Triangle Park, NC.

Durrenberger, C. J., B. A. Broberg, and K. Zimmermann, 1983. Development of a Protocol to be Used for Dispersion Model Comparison Studies. Presented at the 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA.

B.28 AVACTA II

Reference

Zannetti, P., G. Carboni and R. Lewis, 1985. AVACTA II User's Guide (Release 3). AeroVironment, Inc., Technical Report AV-OM-85/520.

Availability

A magnetic tape copy of the FORTRAN coding and the user's guide are available at a cost of $2,500 (non-profit organization) or $3,500 (other organizations) from: AeroVironment, Inc., 825 Myrtle Avenue, Monrovia, CA 91016. Phone: (818) 357-9983.

Abstract

The AVACTA II model is a Gaussian model in which atmospheric dispersion phenomena are described by the evolution of plume elements, either segments or puffs. The model can be applied for short time (e.g., one day) simulations in both transport and calm conditions.

The user is given flexibility in defining the computational domain, the three-dimensional meteorological and emission input, the receptor locations, the plume rise formulas, the sigma formulas, etc. Without explicit user's specifications, standard default values are assumed.

AVACTA II provides both concentration fields on the user specified receptor points, and dry/wet deposition patterns throughout the domain. The model is particularly oriented to the simulation of the dynamics and transformation of sulfur species (SO_2 and SO_4=), but can handle virtually any pair of primary-secondary pollutants.

a. *Recommendations for Regulatory Use*

AVACTA II can be used if it can be demonstrated to estimate concentrations equivalent to those provided by the preferred model for a given application. AVACTA II must be executed in the equivalent mode.

AVACTA II can be used on a case-by-case basis in lieu of a preferred model if it can be demonstrated, using the criteria in section 3.2, that AVACTA II is more appropriate for the specific application. In this case the model options/modes which are most appropriate for the application should be used.

b. *Input Requirements* (all time-varying)

A time-varying input is required at each computational step. Only those data which have changed need to be input by the user.

Source data requirements are: Coordinates, emission rates of primary and secondary pollutants, initial plume sigmas (for non-point sources), exit temperature, exit velocity, stack inside diameter.

Meteorological data requirements are: Surface wind measurements, wind profiles (if available), atmospheric stability profiles, mixing heights.

Receptor data requirements are: Receptor coordinates.

Other data requirements: Coordinates of the computational domain, grid cell specification, terrain elevations, user's computational and printing options.

c. *Output*

The model's outpout is provided according to user's printing flags. Hourly, 3-hour and 24-hour concentration averages are computed, together with highest and highest-second-highest concentration values. Both partial and total concentrations are provided.

d. *Type of Model*

AVACTA II is Gaussian segment/puff model.

e. *Pollutant Types*

AVACTA II can handle any couple of primary-secondary pollutants (e.g., SO_2 and SO_4=).

f. *Source Receptor Relationship*

The AVACTA II approach maintains the basic Gaussian formulation, but allows a numerical simulation of both nonstationary and nonhomogeneous meteorological conditions. The emitted pollutant material is divided into a sequence of "elements," either segments or puffs, which are connected together but whose dynamics are a function of the local meteorological conditions. Since the meteorological parameters vary with time and space, each element evolves according to the different meteorological conditions encountered along its trajectory.

AVACTA II calculates the partial contribution of each source in each receptor during each interval. The partial concentration is the sum of the contribution of all existing puffs, plus that of the closest segment.

g. *Plume Behavior*

The user can select the following plume rise formulas:

Briggs (1969, 1971, 1972)
CONCAWE (Briggs, 1975)
Lucas-Moore (Briggs, 1975)
User's function, i.e., a subroutine supplied by the user

With cold plumes, the program uses a special routine for the computation of the jet plume rise. The user can also select several computational options that control plume behavior in complex terrain and its total/partial reflections.

h. *Horizontal Winds*

A 3D mass-consistent wind field is optionally generated.

i. *Vertical Wind Speed*

A 3D mass-consistent wind field is optionally generated.

j. *Horizontal Dispersion*

During each step, the sigmas of each element are increased. The user can select the following sigma functions:

Pasquill-Gifford-Turner (in the functional form specified by Green et al., 1980)
Brookhaven (Gifford, 1975)
Briggs, open country (Gifford, 1975)
Briggs, urban, i.e., McElory-Pooler, (Gifford, 1975)
Irwin (1979)
LO-LOCAT (MacCready et al., 1974)
User-specified function, by points
User-specified function, with a user's subroutine

The virtual distance/age concept is used for incrementing the sigmas at each time step.

k. *Vertical Dispersion*

During each step, the sigmas of each element are increased. The user can select the following sigma functions:

Pasquill-Gifford-Turner (in the functional form specified by Green et al., 1980)
Brookhaven (Gifford, 1975)
Briggs, open country (Gifford, 1975)
Briggs, urban, i.e., McElroy-Pooler, (Gifford, 1975)
LO-LOCAT (MacCready et al., 1974)
User-specified function, with a user's subroutine

The virtual distance/age concept is used for incrementing the sigmas at each time step.

l. *Chemical Transformation*

First order chemical reactions (primary-to-secondary pollutant).

m. *Physical Removal*

First order dry and wet deposition schemes.

n. *Evaluation Studies*

Zannetti P., G. Carboni and A. Ceriani, 1985. AVACTA II Model Simulations of Worst-Case Air Pollution Scenarios in Northern Italy. 15th International Technical Meeting on Air Pollution Modeling and Its Application, St. Louis, Missouri, April 15-19.

B.29 Shoreline Dispersion Model (SDM)

Reference

PEI Associates, 1988. User's Guide to SDM—A Shoreline Dispersion Model. EPA Publication No. EPA-450/4-88-017. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 89-164305)

Availability

The user's guide is available from the National Technical Information Service. The model code is available on the Support Center for Regulatory Air Models Bulletin Board System (see page B-1).

Abstract

SDM is a hybrid multipoint Gaussian dispersion model that calculates source impact for those hours during the year when fumigation events are expected using a special fumigation algorithm and the MPTER regulatory model for the remaining hours (see Appendix A).

a. *Recommendations for Regulatory Use*

SDM may be used on a case-by-case basis for the following applications:

- Tall stationary point sources located at a shoreline of any large body of water;
- Rural or urban areas;
- Flat terrain;
- Transport distances less than 50 km;
- 1-hour to 1-year averaging times.

b. *Input Requirements*

Source data: Location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, stack gas temperature and shoreline coordinates.

Meteorological data: Hourly values of mean wind speed within the Thermal Internal Boundary Layer (TIBL) and at stack height; mean potential temperature over land and over water; over water lapse rate; and surface sensible heat flux. In addition to these meteorological data, SDM access standard NWS surface and upper air meteorological data through the RAMMET preprocessor.

Receptor data: coordinates for each receptor.

c. *Output*

Printed output includes the MPTER model output as well as: special shoreline fumigation applicability report for each day and source; high-five tables on the standard output with "F" designation next to the concentration if that averaging period includes a fumigation event.

d. *Type of Model*

SDM is hybrid Gaussian model.

e. *Pollutant Types*

SDM may be used to model primary pollutants. Settling and deposition are not treated.

f. *Source-Receptor Relationships*

SDM applies user-specified locations of stationary point sources and receptors. User input stack height, shoreline orientation and source characteristics for each source. No topographic elevation is input; flat terrain is assumed.

g. *Plume Behavior*

SDM uses Briggs (1975) plume rise for final rise. SDM does not treat stack tip or building downwash.

h. *Horizontal Winds*

Constant, uniform (steady-state) wind is assumed for an hour. Straight line plume transport is assumed to all downwind distances. Separate wind speed profile exponents (EPA, 1980) for both rural and urban cases are assumed.

i. *Vertical Wind Speed*

Vertical wind speed is assumed equal to zero.

j. *Horizontal Dispersion*

For the fumigation algorithm coefficients based on Misra (1980) and Misra and McMillan (1980) are used for plume transport in stable air above TIBL and based on Lamb (1978) for transport in the unstable air below the TIBL. An effective horizontal dispersion coefficient based on Misra and Onlock (1982) is used. For nonfumigation periods, algorithms contained in the MPTER model are used (see Appendix A).

k. *Vertical Dispersion*

For the fumigation algorithm, coefficients based on Misra (1980) and Misra and McMillan (1980) are used.

l. *Chemical Transformation*

Chemical transformation is not included in the fumigation algorithm.

m. *Physical Removal*

Physical removal is not explicitly treated.

n. *Evaluation Studies*

Environmental Protection Agency, 1987. Analysis and Evaluation of Statistical Coastal Fumigation Models. EPA Publication No. EPA-450/4-87-002. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS PB 87-175519)

B.30 WYNDvalley Model

Reference

Harrison, Halstead, 1992. "A User's Guide to WYNDvalley 3.11, an Eulerian-Grid Air-Quality Dispersion Model with Versatile Boundaries, Sources, and Winds," WYNDsoft Inc., Mercer Island, WA.

Availability

Copies of the user's guide and the executable model computer codes are available at a cost of $295.00 from: WYNDsoft, Incorporated, 6333 77th Avenue SE., Mercer Island, WA 98040. Phone: (206) 232-1819.

Abstract

WYNDvalley 3.11 is a multi-layer (up to five vertical layers) Eulerian grid dispersion model that permits users flexibility in defining borders around the areas to be modeled, the boundary conditions at these borders, the intensities and locations of emissions sources, and the winds and diffusivities that affect the dispersion of atmospheric pollutants. The model's output includes gridded contour plots of pollutant concentrations for the highest brief episodes (during any single time step), the highest and second-highest 24-hour averages, averaged dry and wet deposition fluxes, and a colored "movie" showing evolving dispersal of pollutant concentrations, together with temporal plots of the concentrations at specified receptor sites and statistical inference of the probabilities that standards will be exceeded at those sites. WYNDvalley is implemented on IBM® compatible microcomputers, with interactive data input and color graphics display.

a. *Recommendations for Regulatory Use*

WYNDvalley may be used on a case-by-case basis to estimate concentrations during valley stagnation periods of 24 hours or longer. Recommended inputs are listed below.

Variable Recommended Value

Horizontal cell dimension 250 to 500 meters
Vertical layers 3 to 5
Layer depth 50 to 100 meters
Background (internal to model)
Zero (background should be added externally to model estimates)
Lateral meander velocity default
Diffusivities default
Ventilation parameter (upper default boundary condition)
Dry deposition velocity zero (site-specific)
Washout ratio zero (site-specific)

b. *Input Requirements*

Input data, including model options, modeling domain boundaries, boundary conditions, receptor locations, source locations, and emission rates, may be entered interactively, or through existing template files from a previous run. Meteorological data, including wind speeds, wind directions, rain rates (optionally, for wet deposition calculations), and time of day and year, may be of arbitrary time increment (usually an hour) and are entered into the model through an external meteorological data file. Optionally, users may specify diffusivities and upper boundary conditions for each time increment. Source emission rates may be constant or modulated on a daily, weekly, and/or seasonal basis.

c. *Output*

Output from WYNDvalley includes gridded contour maps of the highest pollutant concentrations at each time step and the highest and second-highest 24-hour average concentrations. Output also includes the deposition patterns for wet, dry, and total fluxes of the pollutants to the surface, integrated over the simulation period. A running "movie" of the concentration patterns is displayed on the screen (with optional printout) as they evolve during the simulation. Output files include tables of daily-averaged pollutant concentrations at every modeled grid cell, and of hourly concentrations at up to eight specified receptors. Statistical analyses are performed on the hourly and daily data to estimate the probabilities that specified levels will be exceeded more than once during an arbitrary number of days with similar weather.

d. *Type of Model*

WYNDvalley is a three dimensional Eulerian grid model.

e. *Pollutant Types*

WYNDvalley may be used to model any inert pollutant.

f. *Source-Receptor Relationships*

Source and receptors may be located anywhere within the user-defined modeling domain. All point and area sources, or portions of an area source, within a given grid cell are summed to define a representative emission rate for that cell. Concentrations are calculated for each and every grid cell in the modeling domain. Up to eight grid cells may be selected as receptors, for which time histories of concentration and deposition fluxes are determined, and probabilities of exceedance are calculated.

g. *Plume Behavior*

Emissions for buoyant point sources are placed by the user in a grid cell which best reflects the expected effective plume height during stagnation conditions. Five vertical layers are available to the user.

h. *Horizontal Winds*

During each time step in the model, the winds are assumed to be uniform throughout the modeling domain. Numerical diffusion is minimized in the advection algorithm. To account for terrain effects on winds and dispersion, an ad hoc algorithm is employed in the model to distribute concentrations near boundaries.

i. *Vertical Wind Speed*

Winds are assumed to be constant with height.

j. *Horizontal Dispersion*

Horizontal eddy diffusion coefficients may be entered explicitly by the user at every time step. Alternatively, a default algorithm may be invoked to estimate these coefficients from the wind velocities and their variances.

k. *Vertical Dispersion*

Vertical eddy diffusion coefficients and a top-of-model boundary condition may be entered explicitly by the user at every time step. Alternatively, a default algorithm may be invoked to estimate these coefficients from the horizontal wind velocities and their variances, and from an empirical time-of-day correction derived from temperature gradient measurements and Monin-Obukhov similarities.

l. *Chemical Transformation*

Chemical transformation is not explicitly treated by WYNDvalley.

m. *Physical Removal*

WYNDvalley optionally simulates both wet and dry deposition. Dry deposition is proportional to concentration in the lowest layer, while wet deposition is proportional to rain rate and concentration in each layer. Appropriate coefficients (deposition velocities and washout ratios) are input by the user.

n. *Evaluation Studies*

Harrison, H., G. Pade, C. Bowman and R. Wilson, 1990. Air Quality During Stagnations: A Comparison of RAM and WYNDvalley with PM-10 Measurements at Five Sites. *Journal of the Air & Waste Management Association*, 40: 47-52.

Yoshida, C., 1990. A Comparison of WYNDvalley Versions 2.12 and 3.0 with PM-10 Measurements in Six Cities in the Pacific Northwest, Lane Regional Air Pollution Authority, Springfield, OR.

Maykut, N. et al., 1990. Evaluation of the Atmospheric Deposition of Toxic Contaminants to Puget Sound, State of Washington, Puget Sound Water Quality Authority, Seattle, WA.

B.31 Dense Gas Dispersion Model (DEGADIS)

Reference

Environmental Protection Agency, 1989. User's Guide for the DEGADIS 2.1—Dense Gas Dispersion Model. EPA Publication No. EPA-450/4-89-019. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711. (NTIS No. PB 90-213893)

Availability

The model code is only available on the Support Center for Regulatory Air Models Bulletin Board System (see page B-1).

Abstract

DEGADIS 2.1 is a mathematical dispersion model that can be used to model the transport of toxic chemical releases into the atmosphere. Its range of applicability includes continuous, instantaneous, finite duration, and time-variant releases; negatively-buoyant and neutrally-buoyant releases; ground-level, low-momentum area releases; ground-level or elevated upwardly-directed stack releases of gases or aerosols. The model simulates only one set of meteorological conditions, and therefore should not be considered applicable over time periods much longer than 1 or 2 hours. The simulations are carried out over flat, level, unobstructed terrain for which the characteristic surface roughness is not a significant fraction of the depth of the dispersion layer. The model does not characterize the density of aerosol-type releases; rather, the user must assess that independently prior to the simulation.

a. *Recommendations for Regulatory Use*

DEGADIS can be used as a refined modeling approach to estimate short-term ambient concentrations (1-hour or less averaging times) and the expected area of exposure to concentrations above specified threshold values for toxic chemical releases. It is especially useful in situations where density effects are suspected to be important and where screening estimates of ambient concentrations are above levels of concern.

b. *Input Requirements*

Data may be input directly from an external input file or via keyboard using an interactive program module. The model is not set up to accept real-time meteorological data or convert units of input values. Chemical property data must be input by the user. Such data for a few selected species are available within the model. Additional data may be added to this data base by the user.

Source data requirements are: Emission rate and release duration; emission chemical and physical properties (molecular weight, density vs. concentration profile in the case of aerosol releases, and contaminant heat capacity in the case of a nonisothermal gas release; stack parameters (i.e., diameter, elevation above ground level, temperature at release point).

Meteorological data requirements are: Wind speed at designated height above ground, ambient temperature and pressure, surface roughness, relative humidity, and ground surface temperature (which in most cases can be adequately approximated by the ambient temperature).

Receptor data requirements are: Averaging time of interest, above-ground height of receptors, and maximum distance between receptors (since the model computes downwind receptor distances to optimize model performance, this parameter is used only for nominal control of the output listing, and is of secondary importance). No indoor concentrations are calculated by the model.

c. *Output*

Printed output includes in tabular form:

- Listing of model input data;
- Plume centerline elevation, mole fraction, concentration, density, and temperature at each downwind distance;
- σ_y and σ_z values at each downwind distance;
- Off-centerline distances to 2 specified concentration values at a specified receptor height at each downwind distance (these values can be used to draw concentration isopleths after model execution);
- Concentration vs. time histories for finite-duration releases (if specified by user).

The output print file is automatically saved and must be sent to the appropriate printer by the user after program execution.

No graphical output is generated by the current version of this program.

d. *Type of Model*

DEGADIS estimates plume rise and dispersion for vertically-upward jet releases using mass and momentum balances with air entrainment based on laboratory and field-scale data. These balances assume Gaussian similarity profiles for velocity, density, and concentration within the jet. Ground-level denser-than-air phenomena is treated using a power law concentration distribution profile in the vertical and a hybrid top hat-Gaussian concentration distribution profile in the horizontal. A power law specification is used for the vertical wind profile. Ground-level cloud slumping phenomena and air entrainment are based on laboratory measurements and field-scale observations.

e. *Pollutant Types*

Neutrally- or negatively-buoyant gases and aerosols. Pollutants are assumed to be non-reactive and non-depositing.

f. *Source-Receptor Relationships*

Only one source can be modeled at a time.

There is no limitation to the number of receptors; the downwind receptor distances are internally-calculated by the model. The DEGADIS calculation is carried out until the plume centerline concentration is 50% below the lowest concentration level specified by the user.

The model contains no modules for source calculations or release characterization.

g. *Plume Behavior*

Jet/plume trajectory is estimated from mass and momentum balance equations. Surrounding terrain is assumed to be flat, and stack tip downwash, building wake effects, and fumigation are not treated.

h. *Horizontal Winds*

Constant logarithmic velocity profile which accounts for stability and surface roughness is used.

The wind speed profile exponent is determined from a least squares fit of the logarithmic profile from ground level to the wind speed reference height. Calm winds can be simulated for ground-level low-momentum releases.

Along-wind dispersion of transient releases is treated using the methods of Colenbrander (1980) and Beals (1971).

i. *Vertical Wind Speed*

Not treated.

j. *Horizontal Dispersion*

When the plume centerline is above ground level, horizontal dispersion coefficients are based upon Turner (1969) and Slade (1968) with adjustments made for averaging time and plume density.

When the plume centerline is at ground level, horizontal dispersion also accounts for entrainment due to gravity currents as parameterized from laboratory experiments.

k. *Vertical Dispersion*

When the plume centerline is above ground level, vertical dispersion coefficients are based upon Turner (1969) and Slade (1968). Perfect ground reflection is applied.

In the ground-level dense-gas regime, vertical dispersion is also based upon results from laboratory experiments in density-stratified fluids.

l. *Chemical Transformation*

Not specifically treated.

m. *Physical Removal*

Not treated.

n. *Evaluation Studies*

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o. *Operating Information*

The model requires either a VAX computer or an IBM®-compatible PC for its execution.

The model currently does not require supporting software. A FORTRAN compiler is required to generate program executables in the VAX computing environment. PC executables are provided within the source code; however, a PC FORTRAN compiler may be used to tailor a PC executable to the user's PC environment.

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Appendix C to Appendix W of Part 51—Example Air Quality Analysis Checklist

C.0 Introduction

This checklist recommends a standardized set of data and a standard basic level of analysis needed for PSD applications and SIP revisions. The checklist implies a level of detail required to assess both PSD increments and the NAAQS. Individual cases may require more or less information and the Regional Meteorologist should be consulted at an early stage in the development of a data base for a modeling analysis.

At pre-application meetings between source owner and reviewing authority, this checklist should prove useful in developing a concensus on the data base, modeling techniques and overall technical approach prior to the actual analyses. Such agreement will help avoid misunderstandings concerning the final results and may reduce the later need for additional analyses.

Example Air Quality Analysis Checklist [1]

1. Source location map(s) showing location with respect to:

- Urban areas.[2]
- PSD Class I areas
- Nonattainment areas [2]
- Topographic features (terrain, lakes, river valleys, etc.)[2]
- Other major existing sources [2]
- Other major sources subject to PSD requirements
- NWS meteorological observations (surface and upper air)
- On-site/local meteorological observations (surface and upper air)
- State/local/on-site air quality monitoring locations.[2]
- Plant layout on a topographic map covering a 1km radius of the source with information sufficient to determine GEP stack heights.

2. Information on urban/rural characteristics:

- Land use within 3km of source classified according to Auer (1978): Correlation of land use and cover with meteorological anomalies. Journal of Applied Meteorology, 17: 636–643.
- Population.

—>total

—>density

- Based on current guidance determination of whether the area should be addressed using urban or rural modeling methodology.

3. Emission inventory and operating/design parameters for major sources within region of significant impact of proposed site (same as required for applicant)

- Actual and allowable annual emission rates (g/s) and operating rates.[3]
- Maximum design load short-term emission rate (g/s).[3]
- Associated emissions/stack characteristics as a function of load for maximum, average, and nominal operating conditions if stack height is less than GEP or located in complex terrain. Screening analyses as footnoted on page 1 or detailed analyses, if necessary, must be employed to determine the constraining load condition (e.g., 50%, 75%, or 100% load) to be relied upon in the short-term modeling analysis.

—Location, Universal Transverse Mercators (UTM's)

—Height of stack (m) and grade level above Mean Sea Level (MSL)

—Stack exit diameter (m)

—Exit velocity (m/s)

—Exit temperature (°K)

- Area source emissions (rates, size of area, height of area source).[3]
- Location and dimensions of buildings (plant layout drawing).

—To determine GEP stack height

—To determine potential building downwash considerations for stack heights less than GEP

- Associated parameters.

—Boiler size (megawatts, pounds/hr. steam, fuel consumption, etc.)

—Boiler parameters (% excess air, boiler type, type of firing, etc.)

—Operating conditions (pollutant content in fuel, hours of operation, capacity factor, % load for winter, summer, etc.)

—Pollutant control equipment parameters (design efficiency, operation record, e.g., can it be bypassed?, etc.)

- Anticipated growth changes.

4. Air quality monitoring data:

- Summary of existing observations for latest five years (including any additional quality assured measured data which can be obtained from any state or local agency or company).[4]
- Comparison with standards.
- Discussion of background due to uninventoried sources and contributions from outside the inventoried area and description of the method used for determination of background (should be consistent with the Guideline on Air Quality Models).

5. Meteorological data:

- Five consecutive years of the most recent representative sequential hourly National Weather Service (NWS) data, or one or more years of hourly sequential on-site data.
- Discussion of meteorological conditions observed (as applied or modified for the site-specific area, i.e., identify possible variations due to difference between the monitoring site and the specific site of the source).
- Discussion of topographic/land use influences.

6. Air quality modeling analyses:

- Model each individual year for which data are available with a recommended model or model demonstrated to be acceptable on a case-by-case basis.

—Urban dispersion coefficients for urban areas

—Rural dispersion coefficients for rural areas

- Evaluate downwash if stack height is less than GEP.
- Define worst case meteorology.
- Determine background and document method.

—Long-term

—Short-term

- Provide topographic map(s) of receptor network with respect to location of all sources.
- Follow current guidance on selection of receptor sites for refined analyses.
- Include receptor terrain heights (if applicable) used in analyses.
- Compare model estimates with measurements considering the upper ends of the frequency distribution.
- Determine extent of significant impact; provide maps.
- Define areas of maximum and highest, second-highest impacts due to applicant source (refer to format suggested in Air Quality Summary Tables).

—>long-term

—>short-term

7. Comparison with acceptable air quality levels:

- NAAQS.
- PSD increments.
- Emission offset impacts if nonattainment.

8. Documentation and guidelines for modeling methodology:

- Follow guidance documents.

—>"Guideline on Air Quality Models, Revised" (EPA–450/2–78–027R)

—>"Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised" (EPA–450/R–92–019), 1992

—>"Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations)" (EPA–450/4–80–023R), 1985

—>"Ambient Monitoring Guidelines for PSD" (EPA–450/4–87–007), 1987

—>"Requirements for Preparation, Adoption and Submittal of Implementation Plans: Approval and Promulgation of Implementation Plans", 40 CFR Parts 40 and 51 (Prevention of Significant Deterioration), 1982

[1] The "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised", October 1992 (EPA–450/R–92–019), should be used as a screening tool to determine whether modeling analyses are required. Screening procedures should be refined by the user to be site/problem specific. (Available from NTIS as document EPA–450/R–92–019. NTIS number to be provided).

[2] Within 50km or distance to which source has a significant impact, whichever is less.

[3] Particulate emissions should be specified as a function of particulate diameter and density ranges.

[4] See footnote 2 of this checklist.

AIR QUALITY SUMMARY—FOR NEW SOURCE ALONE

[Pollutant: ______[1] ______[2] ______[2]]

	Highest	Highest 2nd high	Highest	Highest 2nd high	Annual
Concentration Due to Modeled Source (µg/m³)					
Background Concentration (µg/m³)					
Total Concentration (µg/m³)					
Receptor Distance (km) (or UTM Easting)					
Receptor Direction (°) (or UTM Northing)					
Receptor Elevation (m)					
Wind Speed (m/s)					
Wind Direction (°)					

[1] Use separate sheet for each pollutant (SO_2, TSP, CO, NO_x, HC, Pb, Hg, Asbestos, etc.)
[2] List all appropriate averaging periods (1-hr, 3-hr, 8-hr, 24-hr, 30-day, 90-day, etc.) for which an air quality standard exists.

Mixing Depth (m)
Temperature (°K)
Stability
Day/Month/Year of Occurrence

Surface Air Data From ______
Surface Station Elevation (m) ______
Anemometer Height Above Local Ground Level (m) ______

Upper Air Data From ______
Period of Record Analyzed ______
Model Used ______
Recommended Model ______

AIR QUALITY SUMMARY—FOR ALL NEW SOURCES

[Pollutant: ______[1] ______[2] ______[2]]

	Highest	Highest 2nd High	Highest	Highest 2nd High	Annual
Concentration Due to Modeled Source (µg/m³)					
Background Concentration (µg/m³)					
Total Concentration (µg/m³)					
Receptor Distance (km) (or UTM Easting)					
Receptor Direction (°) (or UTM Northing)					
ptor Elevation (m)					
Wind Speed (m/s)					
Wind Direction (°)					

[1] Use separate sheet for each pollutant (SO_2, TSP, CO, NO_x, HC, Pb, Hg, Asbestos, etc.)
[2] List all appropriate averaging periods (1-hr, 3-hr, 8-hr, 24-hr, 30-day, 90-day, etc.) for which an air quality standard exists.

Mixing Depth (m)
Temperature (°K)
Stability
Day/Month/Year of Occurrence

Surface Air Data From ______
Surface Station Elevation (m) ______
Anemometer Height Above Local Ground Level (m) ______

Upper Air Data From ______
Period of Record Analyzed ______
Model Used ______
Recommended Model

AIR QUALITY SUMMARY—FOR ALL SOURCES

Pollutant: [______[1] ______[2] ______[2]]

	Highest	Highest 2nd high	Highest	Highest 2nd high	Annual
Concentration Due to Modeled Source (µg/m³)					
Background Concentration (µg/m³)					
Total Concentration (µg/m³)					
Receptor Distance (km) (or UTM Easting)					
Receptor Direction (°) (or UTM Northing)					
Receptor Elevation (m)					
Wind Speed (m/s)					
Wind Direction (°)					

[1] Use separate sheet for each pollutant (SO_2, TSP, CO, NO_x, HC, Pb, Hg, Asbestos, etc.)
[2] List all appropriate averaging periods (1-hr, 3-hr, 8-hr, 24-hr, 30-day, 90-day, etc.) for which an air quality standard exists.

Mixing Depth (m)
Temperature (°K)
Stability
Day/Month/Year of Occurrence

Surface Air Data From ______
Surface Station Elevation (m) ______
Anemometer Height Above Local Ground Level (m) ______
Upper Air Data From ______

Period of Record Analyzed ______
Model Used ______
Recommended Model ______

STACK PARAMETERS FOR ANNUAL MODELING

Stack (m) No. length	Serving emission rate for each pollutant (g/s)	Stack exit diameter (m)	Stack exit velocity (m/s)	Stack exit temperture (°K)	Physical stack height (m)	GEP stack ht. (m)	Stack base elevation (m)	Building dimensions	
								Height	Width

STACK PARAMETERS FOR SHORT-TERM MODELING[1]

Stack (m) No. length	Serving emission rate for each pollutant (g/s)	Stack exit diameter (m)	Stack exit velocity (m/s)	Stack exit temperture (°K)	Physical stack height (m)	GEP stack ht. (m)	Stack base elevation (m)	Building dimensions	
								Height	Width

[1] Separate tables for 50%, 75%, 100% of full operating condition (and any other operating conditions as determined by screening or detailed modeling analyses to represent constraining operating conditions) should be provided.

PART 52—APPROVAL AND PROMULGATION OF IMPLEMENTATION PLANS

1. The authority citation for part 52 is revised to read as follows:

Authority: 42 U.S.C. 7401–7642.

§ 52.21 [Amended]

2. In § 52.21, paragraph (l)(1) is revised to read as follows; paragraph (l)(2) is amended by revising "the 'Guideline on Air Quality Models (Revised)' (1986) and Supplementary A (1987)" to read "appendix W of part 51 of this chapter ('Guideline on Air Quality Models (Revised)' (1986), supplement A (1987) and supplement B (1993))".

§ 52.21 Prevention of significant deterioration of air quality.

* * * * *

(l) * * *

(1) All estimates of ambient concentrations required under this paragraph shall be based on the applicable air quality models, data bases, and other requirements specified in appendix W of part 51 of this chapter ("Guideline on Air Quality Models (Revised)" (1986), supplement A (1987) and supplement B (1993)). The Guideline and its supplements (EPA Publication No. 450/2–78–027R) are also for sale from the U.S. Department of Commerce, National Technical Information Service, 5825 Port Royal Road, Springfield, VA, 22161.

* * * * *

PART 260—HAZARDOUS WASTE MANAGEMENT SYSTEM, GENERAL

1. The authority citation for part 260 continues to read as follows:

Authority: 42 U.S.C. 6905, 6912(a), 6921–6927, 6930, 6934, 6935, 6937, 6938, 6939, and 6974.

§ 260.11 [Amended]

2. Section 260.11 is amended by revising the last reference in paragraph (a) to read as follows:

§ 260.11 References.

* * * * *

"Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised", October 1992, EPA Publication No. EPA–450/R–92–019, Environmental Protection Agency, Research Triangle Park, NC.

* * * * *

PART 266—STANDARDS FOR THE MANAGEMENT OF SPECIFIC HAZARDOUS WASTES AND SPECIFIC TYPES OF HAZARDOUS WASTE MANAGEMENT FACILITIES

1. The authority citation for part 266 is revised to read as follows:

Authority: 42 U.S.C. 6905, 6912(a), 6924, and 6934.

Appendix X—[Removed]

2. Part 266 is amended by removing appendix X.

3. Section 266.104 is amended by revising paragraph (e)(3) to read as follows:

§ 266.104 Standards to control organic emissions.

* * * * *

(e) * * *

(3) Conduct dispersion modeling using methods recommended in appendix W of part 51 of this chapter ("Guideline on Air Quality Models (Revised)" (1986) and its supplements), the "Hazardous Waste Combustion Air Quality Screening Procedure", provided in appendix IX of this part, or in Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised (incorporated by reference in § 260.11) to predict the maximum annual average off-site ground level concentration of 2,3,7,8–TCDD equivalents determined under paragraph (e)(2) of this section. The maximum annual average concentration must be used when a person resides on-site; and

* * * * *

4. Section 266.106 is amended by revising paragraph (h) to read as follows:

§ 266.106 Standards to control metals emissions.

* * * * *

(h) *Dispersion Modeling.* Dispersion modeling required under this section shall be conducted according to methods recommended in appendix W of part 51 of this chapter ("Guideline on Air Quality Models (Revised)" (1986) and its supplements), the "Hazardous Waste Combustion Air Quality Screening Procedure", provided in appendix IX of this part, or in Screening Procedures for Estimating the Air

Quality Impact of Stationary Sources, Revised (incorporated by reference in § 260.11) to predict the maximum annual average off-site ground level concentration. However, on-site concentrations must be considered when a person resides on-site.

* * * * *

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