PEER REVIEW OF THE CALMET/CALPUFF MODELING SYSTEM

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SUMMARY

The U.S. Environmental Protection Agency, through their contractor, commissioned a panel of three reviewers to assess whether or not the EPA should recommend use of the CALMET/CALPUFF modeling system for long-range transport assessments in Class I areas, and allow its use in near-field applications. The panel of three reviewers, Dr. K. Jerry Allwine, Dr. Walter F. Dabberdt and Mr. Larry L. Simmons all concluded that the CALMET/CALPUFF modeling system is scientifically sound and represents a significant advancement in regulatory air quality modeling. They recommend its use after revisions to the CALMET and CALPUFF User's Guides. The recommended revisions are to provide more instructions for setting-up and operating the models. After the User's Guides are revised, the models should be operated by an independent reviewer (experienced air quality modeler) to verify that sufficient details are given in the revised User's Guides for setup and operation of the models.

This report gives EPA's charge to peer reviewers, the list of documents available for the review, the primary conclusions and comments resulting from the peer review, and the complete text of review comments from each of the three peer reviewers.

A detailed overview of the mechanics of this peer review process is presented as Appendix E. The qualifications of each of the peer review panel members is presented via copies of their respective resumes in Appendix G.

The KEVRIC Company Inc. provided the administrative management necessary to conduct this peer review. KEVRIC's efforts are outlined in the overview of the process included as Appendix E.

CONTENTS

INTRODUCTION

The CALMET/CALPUFF modeling system can simulate atmospheric dispersion on transport scales of from tens of meters to tens of kilometers (near-field) and from tens of kilometers to hundreds of kilometers (far-field). In the U.S. Environmental Protection Agency's Charge to Peer Reviewers (Appendix D), "EPA is specifically proposing to recommend use of the CALMET/CALPUFF modeling system for long-range transport assessments in Class I areas, and allowing its use in near-field applications." EPA assembled a panel of three reviewers to assess whether or not the CALMET/CALPUFF modeling system should be recommended for use. This report gives the results of that peer review.

The panel of three reviewers, Dr. K. Jerry Allwine, Dr. Walter F. Dabberdt and Mr. Larry L. Simmons were charged by EPA (Appendix D) to evaluate four aspects of the CALMET/CALPUFF modeling system: 1) Model Formulation, 2) Documentation, 3) Performance Evaluation, and 4) User Friendliness of Entire System. The CALMET/CALPUFF modeling system is very complex with numerous model features and options. Nearly one thousand pages of documentation (11 documents) were available for the peer review. Because of the limited resources available to perform this peer review (20 h per reviewer), each reviewer focused on certain portions of the charge. Fortunately, each reviewer focused on complimentary aspects: Allwine primarily focused on Documentation and User Friendliness, Dabberdt primarily focused on Model Formulation and Documentation, and Simmons focused on model operation in near-field applications.

One reviewer (KJA) summarized the results from the three reviews. The significant results of the peer review are given next, with reviewers initials listed with comments attributed to them. All reviewers concur with the significant results listed. Appendices A, B and C give the full text of Allwine's, Dabberdt's and Simmons' peer reviews. EPA's Charge to Peer reviewers is given in Appendix D and the list of documentation considered in the review is given in Appendix F.

PRIMARY RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Model Formulation

1. The CALMET/CALPUFF modeling system represents the state-of-the-practice insofar as dispersion models are concerned. The explicit integration of mesoscale meteorological models such as MM4/5 and CSUMM with a diagnostic, mass-consistent wind model in CALMET is an important and welcome advance in dispersion modeling. The model should serve as a flexible and robust system for a wide range of applications both in the near field and the far field. CALMET provides the ability to simulate a number of important local effects, such as: slope flows, kinematic terrain effects, terrain blocking, and sea breeze circulations.

[WFD]

2. The CALPUFF model represents a very significant advance over MESOPUFF II. CALPUFF explicitly treats virtually all of the important physical processes affecting transport, diffusion, deposition, and transformation. The three most important areas of improvement are: a) the wind field representation provided by CALMET and the explicit integration of mesoscale model outputs, b) the explicit treatment of terrain effects, both in the wind-field model and the dispersion model, and c) a comprehensive treatment of near-field effects, including building effects. [WFD]

3. No aspects of the CALMET and CALPUFF model formulations need to be changed prior to release. If the EPA has not already done so, it is encouraged to retain an independent firm or consultant to perform in-depth tests and checks of the model to ensure that there are not errors in coding. [WFD]

4. The CALMET/CALPUFF modeling system clearly represents the state-of-practice in Lagrangian puff modeling for assessing impacts of the long-range transport of certain air pollutants (represented by first-order chemical transformations). [KJA]

5. The CALMET/CALPUFF modeling system is a significant improvement for long-range transport modeling over MESOPUFF II primarily in: a) the improved treatment of complex wind fields through advanced flow models and the capability of "puff splitting," b) the more general treatment of diffusion using boundary-layer parameterizations, and c) the improved treatment of dry deposition using a "resistance model" formulation. [KJA]

Documentation / User Friendliness

1. The CALMET User's Guide gives sufficient technical detail of the model formulation to understand the scientific foundations of the model. However, the instructions and discussions for operating the CALMET model are unclear and the documentation is not sufficient to guide a typical user in the use of the model and its preprocessors. The CALMET User's Guide is not ready for release without revisions as described in Appendix A. [KJA]

2. The CALPUFF User's Guide gives sufficient technical detail of the model formulation to understand the scientific foundations of the model. However, the instructions and discussions for operating the CALPUFF model are unclear and the documentation is not sufficient to guide a typical user in the use of the model and its preprocessors. The CALPUFF User's Guide is not ready for release without revisions as described Appendix A. [KJA]

3. After revisions to the CALMET and CALPUFF User's Guides are completed, an independent reviewer (experienced air quality modeler not necessarily familiar with CALMET/CALPUFF) should take the User's Guides and the release-ready code (with all preprocessors) and show that the guides and code are complete by setting-up and running

CALMET/CALPUFF for applications of their choice (possibly a near-field and a far-field application). The models should not be released until the document and code pass a minimum "user-friendliness" criteria, that of, "An experienced air quality modeler can efficiently setup and execute the model without external guidance or additional input." The tests by the independent reviewer should not include the use of CSUMM or MM5 results in CALMET. [KJA]

4. The CALMET and CALPUFF User's Guides are well written for technical critique and understanding of the model formulations. The User's Guides organization is similarly appropriate. The presentation of the models and their features are largely very clear and well documented. Some areas requiring clarification are given in Appendix B. [WFD]

5. The CALMET and CALPUFF User's Guides are sufficient to guide a typical user in the use of the models and their preprocessor. However, this reviewer did not attempt to load and execute the model in the course of the review, and there may be implementation issues that require further attention. [WFD]

6. User friendliness concerns do not outweigh general release of the CALMET/CALPUFF modeling system at this time. I envision the release of the modeling system as having two significant benefits to the user community. One, it will provide informed users with a more powerful, flexible, and realistic simulation tool. And two, it may help increase the level of expertise within the user community. (See Appendix B for suggested training program.) [WFD]

7. Assessing the appropriateness of input selections to CALMET would be greatly improved if the user can graphically view the three-dimensional time-varying wind fields. A utility program for easily visualizing the wind fields would be very useful. [LLS]

8. The CALMET and CALPUFF graphical user interfaces (GUIs) are generally easy to use and simple to understand. The help feature is especially useful. Some changes/clarifications to the GUIs are recommended in Appendix A. [KJA]

Performance Evaluation

1. At this stage, the extent of evaluation of CALPUFF performance is probably superior to that of many other models. This extent of evaluation is probably sufficient to allow judgement to be made regarding model performance because CALPUFF incorporates a basic formalism that is well understood and numerous algorithms, each of which has been reasonably well characterized individually. It is the composite that has seen modest but meaningful performance evaluation. Further, the mesoscale and diagnostic wind field modeling approaches used in CALMET have undergone a history of more than 20 years of test and evaluation in the meteorological and wind power communities. [WFD]

2. Enough evaluation work has been done to recommend use of the CALPUFF model as proposed. The EPA is encouraged to seek an independent assessment of the performance of the model against field experimental data, and against other, less comprehensive - but well characterized - models. Much of this has already been done as reflected in the interim draft report of the IWAQM from the Sixth Modeling Conference and the draft EPA report comparing CALPUFF with ISC3. However, a summary study that seeks to integrate the findings from the many individual CALPUFF evaluations done to date would be a valuable addition to what has been an impressive body of work. [WFD]

Additional Comments

1. The application of CALMET using CSUMM or MM5 data should be evaluated on a case-by-case basis rather than allowing this feature to be generally used. The gridded fields from CSUMM and MM5 need to be verified before use in CALMET. A defensible verification procedure should be made available. [KJA]

2. After release of the CALMET/CALPUFF modeling system for general use, the EPA should undertake sensitivity studies of the models in order to provide guidance to users on specifying model options. [KJA]

3. A valuable, future addition would be the ability to use nested grids both in the diagnostic wind field model and in the diffusion model (CALPUFF). This approach could facilitate the treatment of local terrain variations and might avoid some of the complexities of the numerical schemes in CALPUFF which are designed to deal with terrain-induced flow effects on the subgrid scale. [WFD]

4. A future area for improvement in the CALMET/CALPUFF modeling lies in its quantification of uncertainty (as reflected in the model inputs, in the model physics, and through the stochastic nature of the atmosphere). Significant advances are being realized in weather and climate forecasting through the use of ensemble simulations which enable the user to consider the range of likely end states and the associated range of uncertainty. [WFD]

5. Need a “Regulatory Default” Model Protocol (model parameter settings) defined for the CALMET/CALPUFF modeling system so users trained in the world of the Meteorological Processor for Regulatory Models (MPRM) and the Industrial Source Complex (ISC) model will have a smoother transition into using the CALMET/CALPUFF modeling system. [LLS]

6. CALMET and CALPUFF Model Protocols developed during various regulatory applications of the CALMET/CALPUFF modeling system would be useful references for subsequent applications of the models. (Appendix C gives example protocols.) [LLS]

7. User’s should exercise caution when preparing the geophysical data (e.g., terrain elevations and land use categories) for use in CALMET/CALPUFF. The user should verify

that the gridded land use categories overlay the gridded terrain elevations correctly. (Appendix C gives an example of a misalignment of topographic information.) [LLS]

8. The CALMET model assumes that upper-air data is in the National Climatic Data Center's TD6201 format, where wind speed is given to the nearest integer. However, CALMET has an option to read TD6201-type data to the nearest tenth for wind speed. This CALMET option should be invoked when using vertical profiles of wind data from low-threshold sensors (e.g., sodars, towers). [LLS]

APPENDIX A

ALLWINE PEER REVIEW

Peer Review of CALMET/CALPUFF

K. Jerry Allwine
August 1998

INTRODUCTION AND APPROACH

The CALMET/CALPUFF modeling system can simulate atmospheric dispersion on transport scales of from tens of meters to tens of kilometers (near-field) and from tens of kilometers to hundreds of kilometers (far-field). In their Charge to Peer Reviewers, "EPA is specifically proposing to recommend use of the CALMET/CALPUFF modeling system for long-range transport assessments in Class I areas, and allowing its use in near-field applications." This peer review is to assess whether or not the CALMET/CALPUFF modeling system should be recommended for use by EPA.

The peer review was to focus on four aspects of the CALMET/CALPUFF modeling system: 1) Model Formulation, 2) Documentation, 3) Performance Evaluation, and 4) User Friendliness of Entire System. The CALMET/CALPUFF modeling system is very complex with numerous model features and options. Nearly one thousand pages of documentation (11 documents) were available for the peer review. Because of the limited resources available to perform this peer review (20 h), I focused most of my effort (~50 h) on reviewing the CALMET and CALPUFF User's Guides (roughly 750 pages), interacting in a limited fashion with the CALMET and CALPUFF graphical-user-interfaces (GUIs), and documenting the results of my review.

Next are summarized the significant results of my peer review. More detailed results and comments from my peer review are given in the last section.

SIGNIFICANT RESULTS

1. The CALMET/CALPUFF modeling system represents the state-of-science in Lagrangian puff modeling for assessing impacts of the long-range transport of certain air pollutants (first-order chemical transformations).

2. The CALMET/CALPUFF modeling system is a significant improvement in long-range transport modeling over MESOPUFF II primarily in: a) the improved treatment of complex wind fields through advanced flow models and the capability of "puff splitting," b) the more general treatment of diffusion using boundary-layer parameterizations, and c) the improved treatment of dry deposition using a "resistance model" formulation.

3. The CALMET User's Guide gives sufficient technical detail of the model formulation to understand the scientific foundations of the model. However, the instructions and discussions for operating the CALMET model are unclear and the documentation is not sufficient to guide a typical user in the use of the model and its preprocessors. The CALMET User's Guide is

not ready for release without revisions as described in the next section.

4. The CALPUFF User's Guide gives sufficient technical detail of the model formulation to understand the scientific foundations of the model. However, the instructions and discussions for operating the CALPUFF model are unclear and the documentation is not sufficient to guide a typical user in the use of the model and its preprocessors. The CALPUFF User's Guide is not ready for release without revisions as described in the next section.

5. After revisions to the CALMET and CALPUFF User's Guides are completed, an independent reviewer (experienced air quality modeler not necessarily familiar with CALMET/CALPUFF) should take the User's Guides and the code (ready for release with all preprocessors) and show that the guides and code are complete by setting-up and running CALMET/CALPUFF for applications of their choice (possibly a near-field and a far-field application). The models should not be released until the document and code pass a minimum "user-friendliness" criteria, that of, "An experienced air quality modeler can efficiently setup and execute the model without external guidance or additional input." The tests by the independent reviewer should not include the use of CSUMM or MM5 results in CALMET.

6. The application of CALMET using CSUMM or MM5 data should be evaluated on a case-by-case basis rather than allowing this feature to be generally used. The gridded fields from CSUMM and MM5 need to be verified before use in CALMET. A defensible verification procedure should be made available.

7. The CALMET and CALPUFF graphical user interfaces (GUIs) are generally easy to use and simple to understand. The help feature is especially useful. Some changes are recommended in the next section.

In summary, the scientific foundations of the models are sound and represent the state-of-science for applications models. I recommend that the CALMET/CALPUFF modeling system be recommended for use after revisions to the CALMET and CALPUFF User's Guides as described in the next section, and after an independent air quality modeler has exercised the models with the revised User's Guides and the "release-ready" code. After release of the CALMET/CALPUFF modeling system for general use, the EPA should undertake sensitivity studies of the models in order to provide guidance to users on specifying model options.

DETAILED RESULTS AND COMMENTS

REVIEW OF THE CALMET USER'S GUIDE

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. The CALMET User's Guide gives sufficient technical detail of the model formulation to understand the scientific foundations of the model. However, the instructions and discussions for operating the CALMET model are unclear and the documentation is not sufficient to guide

a typical user in the use of the model and its preprocessors. The CALMET User's Guide is not ready for release without revisions.

2. Sections 1 (Introduction) and 4 (User Instructions) should be revised as discussed below. Sections 2 (Technical Description) and 3 (CALMET Model Structure) are adequate.

3. After revisions are completed, an independent reviewer (experienced air quality modeler not necessarily familiar with CALMET) should take the User's Guide and the code (ready for release with all preprocessors) and show that the guide and code are complete by setting-up and running CALMET for applications of their choice (possibly a near-field and a far-field application). The model should not be released until the document and code pass a minimum "user-friendliness" criteria, that of, "An experienced air quality modeler can efficiently setup and execute the model without external guidance or additional input." The tests by the independent reviewer should not include the use of CSUMM or MM5 results in CALMET.

4. The application of CALMET using CSUMM or MM5 data should be evaluated on a case-by-case basis rather than allowing this feature to be generally used. The gridded fields from CSUMM and MM5 need to be verified before use in CALMET. A defensible verification procedure should be made available.

SPECIFIC CONCLUSIONS AND RECOMMENDATIONS

Section 1. Introduction - This section begins by describing a "Modeling System" that consists of several components. It is not initially clear which components are provided with the CALMET/CALPUFF modeling system. This initial discussion of the "Modeling System" adds an unnecessary level of confusion when trying to understand the basic formulation and features of the already complex CALMET/CALPUFF modeling system. Following are comments/suggestions for improving the Introduction section:

Section 1.2 Comments/Suggestions -

1. Add the following sentence after the first sentence of the first paragraph: "The shaded model components in Figure 1-1 are included in the CALMET/CALPUFF modeling system, whereas the other components are external programs that can be used with CALMET/CALPUFF, but are not required."

2. Change Figure 1-1 by shading the Preprocessors, CALMET, CALPUFF, CALPOST and PRTMET boxes. Change the figure caption to identify the shaded boxes as components of the CALMET/CALPUFF modeling system.

3. Modify Figure 1-2 to show the Geophysical data preprocessor programs (e.g., TERREL, CTGCOMP, CTGPROC, MAKEGEO) and their required input files (e.g., USGS terrain files).

4. Remove the "CSUMM - Prognostic Wind Field Model" box from Figure 1-2 since it is not a model component provided with CALMET.

5. Add a new program box in Figure 1-2 called "CALMM5 Preprocessor" above box titled "MM4/MM5 Data". The CALMM5 preprocessor is provided with CALMET. May want to add a box above this new box called "Gridded Output from MM4/MM5."

6. Shade or hatch all the program boxes in Figure 1-2 to distinguish the computer programs from the computer files. Modify the figure caption to identify shading.

7. Add the word "(Optional)" to the following boxes in Figure 1-2: "MM4/MM5 Data", "MM4 Terrain Weighting Factor File" and "Overwater Data Files."

8. Change the "Prognostic Gridded Wind Field" box in Figure 1-2 to "CSUMM Gridded Wind Field."

9. Add the "OPTHILL" program box to Figure 1-3 (CALPUFF model).

10. Shade or hatch all the program boxes (EPM, OPTHILL and CALPUFF) in Figure 1-3 to distinguish the computer programs from the computer files. Modify the figure caption to identify shading.

11. Shade or hatch all the program boxes (CALPOST and PRTMET) in Figure 1-4 to distinguish the computer programs from the computer files. Modify the figure caption to identify shading.

12. The list of model components after the 1st paragraph in Section 1.2 is incomplete. Descriptions of the following components should be added to make the discussion complete: KSP, EPM, READ56, TERREL, CTGCOMP, CTGPROC, PRLND1, MAKEGEO and CALMM5. The list of model components should be organized under three subheadings:

    • CALMET/CALPUFF Modeling System:
        CALMET, CALPUFF, PRTMET, CALPOST

    • CALMET/CALPUFF Preprocessor Programs:
        METSCAN, READ56, READ62, SMERGE, PXTRACT, PMERGE, CALMM5, TERREL, CTGCOMP, CTGPROC, PRLND1, MAKEGEO, OPTHILL

    • Optional External Programs Interfacing with CALMET/CALPUFF:
        CSUMM, MM4/MM5, CALGRID, KSP, EPM

Section 1.3 Comments/Suggestions -

1. Rename Section 1.3 to "CALMET Features and Options"

2. The statement on "Lambert Conformal Projection" in paragraph 1 is confusing - give some dimension to "large domains," and clarify what you mean by adjusting input winds to a Lambert Conformal projection (and why input winds in a Transverse Mercator projection - UTM grid - are not adjusted). Need brief description of model coordinate system and when to use UTM or Lambert Conformal. Note that UTM grids are given on various topographic maps.

3. In the first paragraph, identify how the initial guess field is typically determined (e.g., interpolation of upper-air observations).

4. Remove CSUMM from Table 1-1 since it is not a module provided with CALMET.

Section 1.4 Comments/Suggestions -

1. Rename Section 1.4 to "Summary of CALMET Data and Computer Requirements"

Add New Section 1.5 -

Add a new Section 1.5 titled "Basic Setup and Operation of CALMET." This new section should give a brief description (details given in Section 4) of the steps and considerations required to run CALMET. The steps should include:

a. Specify Domain and Coordinate System - Define modeling domain depending on application (e.g., near-field, far-field). Brief discussion on choice of domain size, coordinate system, grid resolution.

b. Prepare Geophysical Data - Discuss where can get data and what preprocessing programs to run and how to setup and run preprocessing programs.

c. Prepare Meteorological Data - Discuss where can get data and what preprocessing programs to run and how to setup and run preprocessing programs. Discuss input of optional data (e.g., CSUMM, MM5) and what observations (if any) are required with optional data.

d. Prepare User Control File - Specify run options/conditions using the CALMET GUI. Briefly discuss choice of various options. Discuss "Help" feature of GUI.

e. Run CALMET and Produce Outputs - Discuss the two run options in the GUI. Also discuss how errors are trapped and presented to the user. Describe the outputs and how they are used.

f. Postprocessing Output - Discuss how to setup PRTMET and describe the results.

Section 2. Technical Description - This section adequately describes the scientific basis of the CALMET model. The foundations of the model are sound and are the "state-of-science" for applications models. I did not have time in this review to check in detail that all the equations are correctly formulated and stated. I'm assuming that with the long development and testing history of this model that the equations are formulated correctly.

Section 3. CALMET Model Structure - This section adequately describes the CALMET model structure.

Section 4. User Instructions - This section needs to be enhanced and extensively reorganized such that a typical user has sufficient instructions and guidance to setup and successfully execute the CALMET model, and to understand and use the outputs from the model. Section 4 should cover the same topics as in the new Section 1.5, only in considerably more detail.

[I consider the revised Section 4 to be very important. This section should lead a user through each step of setting-up and running CALMET including identifying data sources, identifying important model features for typical applications and providing guidance on setting model parameters. The author of this revised Section 4 should start with a new modeling problem (conceptually) and lead the reader through each step and decision he/she needs to accomplish to successfully apply CALMET.]

A possible structure of Section 4 is

- 4.1 Overview - gives a summary of how to setup and run CALMET, gives an overview of what is contained in Section 4, and briefly describes how the user should apply Section 4.

- 4.2 Specify Domain and Coordinate System - gives guidance on how to determine the modeling domain (e.g., near-field or far-field, locations of sources and receptor areas, locations of prominent topographic features that can significantly influence meteorological fields, extent of local circulations); gives guidance on choice of grid size to resolve important topographic influences verses trade-off in computational time; give guidance on which map projection to use, UTM or Lambert Conformal.

- 4.3 Prepare Geophysical Input Data File - gives guidance on where to get data and how to run preprocessor programs to prepare CALMET inputs. This section contains original Sections 4.2 and 4.3.2.

- 4.4 Prepare Meteorological Input Data Files - gives guidance on where to get data, what data to use (should CSUMM or MM5 results be acquired and used) and instructions on how to create CALMET input files. This section contains original Section 4.1 and original Sections 4.3.3 through 4.3.10.

- 4.5 Prepare User Control File - gives guidance on importance of various control

parameters and sensitivity of model results to control parameters (which parameters will most likely not be changed from default values?). Refer to CALMET GUI as easiest approach for preparing CALMET control file and executing CALMET. This section contains original Section 4.3.1.

- 4.6 Run CALMET and Produce Output Files - model can be run from GUI. Describe output files. Describe error trapping in model, where errors are identified to the user, and give actions to be taken by the user in case errors are encountered. This section contains original Section 4.3.11.

- 4.7 Postprocessing of CALMET Results - This section contains original Section 4.4.

SOME COMMENTS ON THE CALMET GUI

1. The CALMET graphical user interface is generally easy to use and simple to understand. The help feature is especially useful. I didn't have time in this review to see that all features of the GUI are working correctly and as expected.

2. The "CALMET Help" screen should include a discussion of the preprocessing that is required before CALMET can be run. This should include as a minimum a brief discussion of specifying the modeling domain and preparing the geophysical and meteorological data files.

3. The "Overview of Modeling System" in the "CALMET Help" screen should be revised to reflect my comments above concerning Section 1 of the CALMET User's Guide. Including CSUMM, MM5 and CALGRID in the list implies that these programs are provided with CALMET/CALPUFF.

4. Some of the technical discussions available under the help feature cannot be printed - the "PRINT" button is not always available in the help window. If possible, it would be useful if all the technical discussions and instructions could be printed from the GUI.

5. Would be useful to describe in the Help utility of what happens when CALMET encounters errors. I found that the error is listed in the LST file with no indication in the execution window that an error occurred during execution.

6. The HELP button on the "Surface Meteorological Stations" input screen is labeled OK.

7. In the "Wind Field Options" screen the "Use Preprocessed Data" option is not described in the help menu. Would be useful if a discussion of this feature can be added.

REVIEW OF THE CALPUFF USER'S GUIDE

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. The CALPUFF User's Guide gives sufficient technical detail of the model formulation to understand the scientific foundations of the model. However, the instructions and discussions for operating the CALPUFF model are unclear and the documentation is not sufficient to guide a typical user in the use of the model and its preprocessors. The CALPUFF User's Guide is not ready for release without revisions.

2. Sections 1 (Introduction) and 4 (User Instructions) should be revised as discussed below. Sections 2 (Technical Description) and 3 (CALPUFF Model Structure) are adequate.

3. After revisions are completed, an independent reviewer (experienced air quality modeler not necessarily familiar with CALPUFF) should take the User's Guide and the code (ready for release with all preprocessors) and show that the guide and code are complete by setting-up and running CALPUFF for applications of their choice (possibly a near-field and a far-field application). The model should not be released until the document and code pass a minimum "user-friendliness" criteria, that of, "An experienced air quality modeler can efficiently setup and execute the model without external guidance or additional input."

SPECIFIC CONCLUSIONS AND RECOMMENDATIONS

Section 1. Introduction - Revise Section 1.2 as described in the above suggested revisions to the CALMET User's Guide, and add a new Section 1.5.

Add New Section 1.5 -

Add a new Section 1.5 titled "Basic Setup and Operation of CALPUFF." This new section should give a brief description (details given in Section 4) of the steps and considerations required to run CALPUFF. The steps should include:

a. Overview - Give a brief overview of setup requirements for typical near-field and far-field (long-range transport) applications of CALPUFF. For example, a typical far-field application of CALPUFF could require a minimum of just two input files, CALMET.DAT and CALPUFF.INP, for sources with constant release rates. The CALMET model would first be run to produce the CALMET.DAT file, and then the CALPUFF GUI could be used to produce the CALPUFF.INP file and run the model. Summarize the number of parameters that need to be specified (different from default) in the INP file for typical near-field and far-field applications of CALPUFF. What model features would typically be invoked for near-field (e.g., building downwash, subgrid scale complex terrain) and for far-field (e.g., puff splitting, deposition) applications. Discuss why CALPUFF was designed to be able to use meteorological files from other models (ISCST3, AUSPLUME, CTDMPLUS). Was this for convenience of comparing with the other models or does this capability extend the technical sophistication of CALPUFF over using the meteorological fields produced by CALMET? This feature of using single station met files in CALPUFF

should not be used in far-field applications.

b. Specify Domain and Coordinate System - Similar discussion as in CALMET. Will want to discuss that any user-defined Cartesian (rectangular) coordinate system can be used. The coordinate system is not limited to just UTM and Lambert Conformal as is implied in the documentation. May want to discuss the computation grid (different from meteorological grid) and how to decide its size. Identify INP file inputs.

c. Prepare Geophysical Data - Discuss what data comes from CALMET. If not using CALMET.DAT file from a run of CALMET, where are the terrain heights, land use, etc. data specified. Discuss the generation of hill data for CTDM. Identify INP file inputs.

d. Prepare Meteorological Data - If using CALMET output refer to CALMET documentation. Discuss preparation of the other meteorological data files that can be used by CALPUFF. Identify INP file inputs.

e. Specify Sources, Species and Emissions Data - Discuss what species list should be used. Discuss how emission data specified (INP file or emission files). May want to identify interaction with EPM. Identify INP file inputs.

f. Specify Chemistry and Deposition Data - Discuss chemistry and deposition data. Where from and where specified. Identify INP file inputs.

g. Specify Receptor Coverage - Discuss choice of receptor coverage. Identify where specified. Identify INP file inputs.

h. Specify Run Conditions - Specify run options/conditions using the CALPUFF GUI. Briefly discuss choice of various options. Discuss "Help" feature of GUI.

i. Run CALPUFF and Produce Outputs - Discuss the two run options in the GUI. Also discuss how errors are trapped and presented to the user. Describe the outputs and how they are used.

j. Postprocessing Output - Discuss how to setup CALPOST and describe the results.

Section 2. Technical Description - This section adequately describes the scientific basis of the CALPUFF model. The foundations of the model are sound and are the "state-of-science" for applications models. I did not have time in this review to check in detail that all the equations are correctly formulated and stated. I'm assuming that with the long development and testing history of this model that the equations are formulated correctly.

Section 3. CALPUFF Model Structure - This section adequately describes the CALPUFF model structure.

Section 4. User Instructions - This section needs to be enhanced and possibly reorganized such that a typical user has sufficient instructions and guidance to setup and successfully execute the CALPUFF model, and to understand and use the outputs from the model. A possible structure of Section 4 is to add a new Section 4.1 called SETUP AND OPERATION OF CALPUFF with the subsections listed below. This new Section 4.1 should cover the same topics as in the new Section 1.5 (see discussion above), only in considerably more detail. Existing Sections 4.1 through 4.14 would be renumbered 4.2 through 4.15. The new Section 4.1 would refer to the subsequent sections of 4.

[I consider the new Section 4.1 to be very important. This section should lead a user through each step of setting-up and running CALPUFF, including identifying data sources, identifying important model features for typical applications (near-field, far-field), and providing guidance on setting model parameters. The author of this new Section 4.1 should start with a new modeling problem (conceptually) and lead the reader through each step and decision he/she needs to accomplish to successfully apply CALPUFF.]

- 4.1.1 Overview - In addition to that described in the new Section 1.5 above, this subsection should give a summary of how to setup and run CALPUFF, give an overview of what is contained in Section 4, and briefly describe how the user should apply Section 4.

- 4.1.2 Specify Domain and Coordinate System -

- 4.1.3 Prepare Geophysical Data -

- 4.1.4 Prepare Meteorological Data -

- 4.1.5 Specify Sources, Species and Emissions Data -

- 4.1.6 Specify Chemistry and Deposition Data -

- 4.1.7 Specify Receptor Coverage -

- 4.1.8 Specify Run Conditions -

- 4.1.9 Run CALPUFF and Produce Outputs -

- 4.1.10 Postprocessing Output -

SOME COMMENTS ON THE CALPUFF GUI

1. The CALPUFF graphical user interface is generally easy to use and simple to understand. The help feature is especially useful. I didn't have time in this review to see that all features of

the GUI are working correctly and as expected.

2. The "Overview of Modeling System" in the "CALPUFF Help" screen should be revised to reflect my comments above concerning Section 1 of the CALPUFF User's Guide. Including CSUMM, MM5 and CALGRID in the list implies that these programs are provided with CALMET/CALPUFF.

3. The "CALPUFF Help" screen should include a discussion of the preprocessing that is required before CALPUFF can be run. This should include as a minimum a brief discussion of specifying the modeling domain and preparing the geophysical and meteorological data files.

4. Would be useful to describe in the Help utility of what happens when CALPUFF encounters errors.

APPENDIX B

DABBERDT PEER REVIEW

Review of CALMET and CALPUFF Models

This review is a high-level review owing to the extensive documentation and reports provided for the two models and the limited time available to conduct the review. The review focused primarily on the scientific and engineering aspects of the CALMET/CALPUFF modeling system as described in their respective user's manuals. Numerous, varied reports and papers addressing various aspects of model application and performance were also perused, but were not considered in a substantive way in these comments.

In EPA's "Charge to Peer reviewers," it was indicated that the EPA specifically proposes to "recommend use of CALMET/CALPUFF modeling system for long-range transport assessments" **and** "allow its use [for] near-field applications. Accordingly, this review focused both on near- and far-field aspects of the models.

Questions posed by EPA are indicated in *italics* and reviewer comments in normal type face.

1. Model Formulation
    a. *As a non-steady-state Lagrangian plume model, does CALPUFF represent the state-of-the-practice in its handling of mesoscale meteorological phenomena?*

The CALMET/CALPUFF modeling system indeed represents the state-of-the-practice insofar as dispersion models are concerned. The explicit integration of mesoscale meteorological models such as MM4/5 and CSUSUM with a diagnostic, mass-consistent wind model in CALMET is an important and welcome advance in dispersion modeling. The model should serve as a flexible and robust system for a wide range of applications both in the near field and the far field.

CALMET provides the ability to simulate a number of important local effects, such as: slope flows, kinematic terrain effects, terrain blocking, and sea breezes. It also allows the user the ability to isolate localized effects reflected in observations by the use of computational barriers. A valuable, future addition would be the ability to use nested grids both in the diagnostic wind field model and in the diffusion model (CALPUFF). This approach could facilitate the treatment of local terrain variations and might avoid some of the complexities of the numerical schemes in CALPUFF which are designed to deal with terrain-induced flow effects on the subgrid scale.

Other positive attributes of CALMET are:

- Reasonable scheme for estimating vertical velocities
- Appropriate smoothing features
- Ability to consider an unlimited number of surface and upper-air stations (MESOPAC II is limited to 25 surface and 10 upper air stations)

Multiple vertical layers allowed (MESOPAC II is limited to two)

The following are comments and observations that either require further explanation in the documentation or could perhaps form the basis for future CALMET improvements; they are not intended to detract from the positive nature of the recommendations of this review:

Clarify the limitations of the wind turning options available. They do not explicitly consider thermal wind effects leading to backing or enhanced veering. These can only be represented through the "user-defined" scaling factors.

Discussion on the lake/sea breeze option is not clear

Have the authors considered a vorticity conservation option in addition to divergence minimization for the diagnostic wind field model?

Bowen ratio specification does not explicitly consider whether precipitation has occurred recently, thereby modifying the Bowen ratio

Recommend adding an algorithm to specifically incorporate ACARS profiles from landing and departing commercial aircraft

Unclear whether Mahrt's "shooting slope flow parameterization" is a standard feature of CALMET

Update PC performance values to Pentium class PC's

Add discussion concerning the proper use of mesoscale model outputs when 4DDA has been undertaken. Should the observations used in the 4DDA then be excluded from the diagnostic model application, etc.? When might it be more appropriate to explicitly model terrain effects in the mesoscale models, rather than approximate these effects in the DWM?

Unclear whether the 3D temperature fields can be obtained directly from the mesoscale model for use in CALMET.

Are there plans to incorporate other modeled or analyzed fields into CALMET, such as the Univ. Oklahoma mesoscale model, NCEP's Eta model, and NCEP's analyzed fields?

On the dispersion side, CALPUFF also represents significant advances over MESOPUFF II. This is especially the case regarding CALPUFF treatment of near-field building effects and near- and far-field terrain effects on both transport and diffusion. The developers have tried, and I believe succeeded, in building into CALPUFF explicit treatment of virtually all of the important physical processes affecting transport, diffusion, deposition, and transformation. This is not to say that there is not room for improvements in the individual parameterizations, but the present model configuration represents a significant advance over other puff and plume models such as MESOPUFF II and ISC. The report from the IWAQM indicates there may still be limitations in the CALPUFF treatment of the linear chemistry involving SO_2 and other pollutants; I have not considered these issues in this review.

b. *Within the context of regulatory dispersion models in the US, does CALPUFF provide significant advances over MESOPUFF II? If so, what do you think are the most important scientific advancements of CALPUFF?*

As indicated in my response to Issue 1-a., it is my opinion that **CALPUFF indeed represents a very significant advance over MESOPUFF II**. The three most important areas of improvement are:

The wind field representation provided by CALMET and the explicit integration of mesoscale model outputs

The explicit treatment of terrain effects, both in the windfield model and the dispersion model

A comprehensive treatment of near-field effects, including building effects

c. *Are there modules or features of CALPUFF in which an improved formulation or treatment is necessary? If so, please discuss what is needed prior to release of the model for general use.*

It is not my opinion that any aspect of the CALMET/CALPUFF system needs to be changed prior to release. This is not to say that there may not be errors in the code or in the algorithms, but such checking goes far beyond the scope of this review. In fact, if the Agency has not already done so, I would encourage it to retain an independent firm or consultant to perform independent, in-depth tests and checks of the model to ensure that there are not errors in coding and the like. The Agency is also encouraged to seek an independent assessment of the performance of the model against field experimental data, and against other, less comprehensive - but well characterized - models. Much of this has already been done as reflected in the interim draft report of the IWAQM from the Sixth Modeling Conference and the draft EPA report comparing CALPUFF with ISC3. However, a summary study that seeks to integrate the findings from the many individual CALPUFF evaluations done to date would be a valuable addition to what has been an impressive body of work.

Are there areas where the model might be improved? Nesting would represent an important improvement to both CALMET and CALPUFF. In the case of the latter, it might improve the treatment of terrain effects on the transport fields and on dispersion, while perhaps simplifying the model as well. The developers and the Agency might consider pursuing nesting as a means to explicitly consider terrain effects, especially with the rapid advances in PC and workstation processing speeds and RAM.

Another area for improvement of this and other models lies in their quantification of <u>uncertainty</u> (as reflected in the model inputs, in the model physics, and through the stochastic nature of the atmosphere). Significant advances are being realized in weather and climate forecasting through the use of ensemble simulations which enable the user to consider the range of likely end states and the associated range of uncertainty. This expertise may be highly transferable to the problem of dispersion simulation.

2. Documentation

a. *Is the current organization of the CALMET and CALPUFF User's Guides adequate?*

Are the model formulations sufficiently documented for technical critique and understanding?

Both user's guides are well written and provide very adequate documentation. The organization is similarly appropriate. And the availability of user tutorials given by the developers is an added positive factor.

b. *Is the discussion and presentation of the model and its features clear? Please note any sections of the documentation that were unclear or confusing.*

The presentations are largely very clear and well documented (and supported by the liberal use of references). Where certain areas were not clear, they have been identified in Section 1 (e.g. CALMET lake/sea breeze discussion of this review).

c. *Is the documentation sufficient to guide a typical user in the use of the model and its preprocessors?*

Yes. However, this reviewer did not attempt to load and execute the model, and so I am only indicating my opinion based on the documentation I have read. There may be implementation issues that would require further attention. A second issue concerns what constitutes a "typical user?" Given the applications and users with whom I am familiar, I expect that most informed users will find the documentation at least sufficient, if not far superior to many other models.

3. Performance Evaluation

a. *Have sufficient comparisons and sensitivity studies been completed to allow judgement to be made regarding model performance? If more comparisons are needed, are data available or would this entail new field studies?*

A very difficult set of questions to answer. At this stage, the extent of evaluation of CALPUFF performance is probably superior to that of many other models. Is this sufficient? Probably yes, because CALPUFF incorporates a basic formalism that is well understood and numerous algorithms, each of which has been reasonably well characterized individually. It is the composite that has seen modest but meaningful performance evaluation. Further, the mesoscale and DWM modeling approaches used in CALMET have undergone a history of more than 20 years of test and evaluation in the meteorological and wind power communities.

b. *Has enough evaluation work been done to recommend use of the model?*

Yes, the model is recommended for use as proposed. Additionally, I recommend that the Agency pursue additional studies to further characterize its performance, and make further improvements. This issue was addressed earlier in my response to Issue 1-c.

4. User Friendliness of Entire System

a. *Do "user friendliness" concerns outweigh general release of the system at this time?*

No, they do not in this reviewer's opinion. I envision the release of CALMET/CALPUFF as having two significant benefits to the user community. One, it will provide informed users with a more powerful, flexible, and realistic simulation tool. And two, it may help increase the level of expertise within the user community.

b. *If 'yes' to (a.), what specifically needs to be addressed?*

Although I responded 'no,' I suggest that a more formal user orientation and training program be adopted. This could be the EARTH TECH program, or other programs conducted by other firms. In any case, it would be helpful and desirable to have EPA involvement to ensure the quality of such programs. For example, EPA might seek to develop a series of computer-based learning modules to provide tutorials. The University Corporation for Atmospheric Research through its COMET program has a very successful history of providing similar training modules to the weather forecasting community.

APPENDIX C

SIMMONS PEER REVIEW

The combination of CALMET and CALPUFF is under consideration by the U.S. Environmental Protection Agency for "Guideline" status. CALMET creates the wind fields and CALPUFF advects and disperses along the wind vectors created by CALMET. This model combination is a major departure from the past Guideline models that have relied on a single hourly wind vector that applied over the entire modeling domain run in a steady-state mode. The CALMET and CALPUFF approach allows for dynamic wind fields that change spatially and temporally, a characteristic that we all see in the real world.

We must pay a price for this sophistication. There is a steep learning curve for this model. For those of us trained in the "Regulatory Default" world of the Meteorological Processor for Regulatory Models (MPRM) and the Industrial Sources Complex (ISC) model, the CALMET/CALPUFF model can seem very confusing. We need some format that serves as a "Regulatory Default" to help state agency personnel in their review.

Earth Tech, Inc., as authors of the model, have provided software tools to aid in the transition of ISC and CTDMPLUS files to CALPUFF. They have also provided Graphical User Interface (GUI) files to aid in setup of the CALMET and CALPUFF input files and the post-processor CALPOST. Their GUI software has a standard windows interface with Help Files that can assist the user in selecting a variable setting. Earth Tech, Inc. also provides a 2.5 day hands-on training course. I attended the course in Charlottesville, Virginia over May 20 through 22, 1998 and found it very helpful.

One weakness with implementation of CALMET is in the area of visualization of the wind fields. The utility, PRTMET, can give a snap-shot of a single layer for a single period. While that is helpful, it is not always sufficient in assessing the appropriateness of input selection to CALMET. This problem has been addressed partially by a third party vendor. Enviromodeling Ltd. of Santiago, Chile provides a product called CalDESK that takes the CALMET input and output files and allows for animation of the wind fields. I have used CalDESK for about five months. It was very helpful as part of a study in Abu Dhabi over a domain of 350 by 150 kilometers in seeing the coastal influence and how the emissions from off-shore platforms were impacting the main land. CalDESK contains a feature that allows forward or backward trajectory of a plume from a single source. This feature is helpful in explaining how varying wind fields like cyclonic flow can bring emissions from sources in different directions to impact a specific receptor. Tools like CalDESK must come forward for CALMET/CALPUFF to be effectively utilized. Earth Tech, Inc indicated that they are working on such a tool and it should be available late this year.

Our firm assisted in preparing a Model Protocol to use CALMET/CALPUFF for a sulfur dioxide State Implementation Plan (SIP) project for a section of the Ohio River Valley based in Marshall County, West Virginia. That protocol relied on integrating the data from four 100-meter towers and co-located SODARs extending over a 15 kilometer section of the Ohio River Valley. A consortium of industries in the area pooled their resources to collect the meteorological data and to conduct the study. This group is comprised of the local facilities of CONOCO, Columbian

Chemicals, PPG, Bayer and ORMET and operates under the name Industrial Sources Group (ISG). The Division of Environmental Protection (DEP) in West Virginia is the lead agency.

The DEP established a stakeholders group called the Technical Assessment Group to prepare the technical protocol. Representatives from U.S. EPA in Regions III and V participated with those from Ohio EPA under the leadership of the DEP. NOAA personnel assisted the DEP in review of the SODAR data. Representatives from the local electric utilities, American Electric Power and First Energy Corporation and their consultants participated in the group. Finalization of the Model Protocol occurred in December, 1997. Approval of the protocol occurred in May, 1998. Extensive testing was undertaken in selecting the switch settings for the model.

An important input to CALMET is the GEO.DAT file. This file contains the terrain heights and land use characteristics for the area of the modeling domain. These data are available from Digital Elevation Model (DEM) files and Land Use and Land Classification (LULC) files provided by the U.S. Geological Survey. The CALMET tool CTGPROC.EXE is used to prepare the LULC data. The CALMET tool MAKEGEO.EXE then prepares the GEO.DAT file. However, the user must exercise some judgement in preparing these files. An example is the use of LULC data. Our project utilized the LULC information directly from the U.S. Geological Survey files for a section of the Ohio River centered on the Mitchell Power Station. The result was that the land typing for the river was shifted west in the northern portion of the drawing and east in the southern portion of the drawing. This mis-matching of terrain elevation to land typing would yield inappropriate local slope flows. The user must be cautioned to review the LULC data closely and make appropriate corrections. This is commonly seen with electrical transmission line corridors that have a LULC category of 14 and corresponding CALMET input value of 10. These corridors may be better classified as pasture with significantly different characteristics for purposes of CALMET.

At this time the only way to get vertical profile meteorological data into CALMET is to use the UP.DAT file. Up until recently, that file relied on the TD6201 format. Velocity is limited to integer values in TD6201. Therefore, a threshold velocity of 1 meter per second is assumed in TD6201 and is an artifact of the National Weather Service instrumentation. Today we use wind sensors with threshold values in the area of 0.22 meters per second. The TD6201 format does not reflect this sensitivity in wind speed. The TD6201 formatted data for valley settings would define many hours as calms when in fact wind speeds would exceed 0.22 meters per second. The influence of the TD6201 format was tested in several CALPUFF runs for the Ohio River sites. We modified TD6201 to allow wind speeds with a FORTRAN format of F5.1 for contrast. TD6201 model runs showed unrealistically high impact in the valleys after extended calms. The same model runs with the modified TD6201 data did not show these unrealistically high impacts because the buildup of pollutants did not occur as shown with the original TD6201 formatted data. Earth Tech, Inc. has addressed this issue in CALMET by allowing for a modified TD6201 format. The user can specify comma delimited data of a TD6201 type that allows non-integer wind speeds. I highly recommend this option be used to input on-site meteorological data to CALMET.

I recommend the use of CALMET and CALPUFF.

APPENDIX D

EPA'S CHARGE TO PEER REVIEWERS

Charge to Peer Reviewers

EPA is proposing the use of CALPUFF for regulatory applications. It is therefore prudent that a science peer review be done to assess to modeling systems formulation, documentation, existing performance evaluations, and user friendliness. EPA is specifically proposing to recommend use of the CALMET/CALPUFF modeling system for long range transport assessments in Class I areas, and allowing its use near-field applications.

1. Model formulation

Note that exact calculation of visibility impairment (or any other air quality related value) is the purview of the applicable Federal Land Manager. (i.e., EPA is only offering specific guidance on the basic parameters.)

a. As a non-steady-state Lagrangian plumemodel, does CALPUFF represent the state-of-the-practice in its handling of mesoscale meteorological phenomena?

b. Within the context of regulatory dispersion models in the US, does CALPUFF provide significant scientific advances over MESOPUFF II? If so, what do you think are the most important scientific advancements of CALPUFF?

c. Are there any modules or features of CALPUFF in which an improved formulation or treatment is necessary? If so, please discuss what is needed prior to release of the model for general use.

2. Documentation

a. Is the current organization of the CALMET and CALPUFF User's Guides adequate? Are the model formulations sufficiently documented for technical critique and understanding?

b. Is the discussion and presentation of the model and its features clear? Please note any specific sections of the documentation that were unclear or confusing.

c. Is the documentation sufficient to guide a typical user in the use of the model and its preprocessors.

3. Performance Evaluation

CALPUFF has been evaluated with data from several field studies. Availability of suitable data is limited. EPA is unaware of any evaluation that has assessed CALPUFF's treatment of secondary pollutants. (Note that EPA is recommending that CALPUFF's outputs be used for assessment of secondary pollutants, but is not requiring it.) Given this:

a. Have sufficient comparisons and sensitivity studies been completed to allow judgment to be made regarding model performance? If more comparisons are needed, are data available or would this retail new field studies?

b. Has enough evaluation work been done to recommend use of the model?

4. User Friendliness of Entire System

EPA and IWAQM recognize that operation of the CALMET/CALPUFF system as presently configured is arduous. It is believed, though, that with time and experience and the expenditure of additional resources in the future, the system's ease of use will improve. Nevertheless, it would be useful to know:

a. Do "user friendliness" concerns outweigh general release of the system at this time?

b. If "yes" to (a.), what specifically needs to be addressed?

APPENDIX E

OVERVIEW OF PEER REVIEW PROCESS

OVERVIEW OF THE PEER REVIEW PROCESS
for the
PEER REVIEW OF CALMET/CALPUFF AIR DISPERSION MODELING SYSTEM

The US Environmental Protection Agency, Office of Air Quality Planning & Standards, Air Quality Modeling Group, in an effort to provide for independent, credible peer reviews of air dispersion models and studies retained a contractor, The KEVRIC Company Inc. of Silver Spring MD/Durham, NC to manage and coordinate the peer review project.

The peer review as handled as a work assignment under a general contract with the KEVRIC Company. Once the work assignment was issued, KEVRIC prepared a detailed work plan for the approval of the Work Assignment Manager (WAM). For the CALMET/CALPUFF project, the official WAM was Warren Peters. The acting WAM was Tom Coulter. Other EPA technical support was provided by John Irwin.

The work plan provided a description of the tasks to be completed, the estimated time frame and estimated manhours/cost requirements. The description below describes the process by which the peer review for CALMET/CALPUFF Air Dispersion Modeling system was conducted.

The information provided to KEVRIC under the Work Assignment Statement of Work included;

- a "Charge to Reviewers", formulated by EPA, that outline the specific direction and technical scope of the task for the peer review team.
- a list of qualified candidates, as known to EPA
- a list of materials to provided to the peer reviewers by KEVRIC/EPA

KEVRIC contacted several persons on the qualified candidate list, described the project to them and requested their participation based on their interest and availability. Three candidates were retained, Dr. Jerry Allwine, Mr. Larry Simmons and Dr. Walt Dabberdt. Dr. Allwine, consented to act as chairperson, in that he would, in addition to providing peer review, compile a report that would summarize all of the peer reviewers comments and opinions into one concise report. This peer review team was approved by the acting WAM.

KEVRIC provided a sub-contract mechanism for the peer reviewers to be compensated for their time. It was estimated that each peer reviewer would spend up to 20 hours on the review and Dr. Allwine would spend an additional 20 hours compiling a report.

KEVRIC then arranged for the review materials to be reproduced and distributed to each reviewer. The materials provided to be reviewed were those provided to KEVRIC by USEPA as

provided under the work assignment. These materials were as follows:

1) Users Guide for the CALMET meteorological Model
2) Users Guide for the CALPUFF Dispersion Model
3) EPA, 1998. Inter-Agency Workgroup on Air Quality Modeling (IWAQM) Phase II Final Report and Summary: Recommendations for Modeling Long Range Transport Impacts. EPA-454/R-98/XXX.
4) An executable copy of the code for the CALMET/CALPUFF models.

Once these materials were distributed, KEVRIC scheduled a teleconference call which involved the team members, V. Hanzel of KEVRIC, and Tom Coulter and John Irwin of EPA. The conference call was conducted to discuss the charge to the reviewers and establish commonality in the peer reviewers efforts and to initiate the peer review. This discussion resulted in another piece of documentation being requested as background information. Subsequently, KEVRIC reproduced and distributed he MESOPUFF II Users manual to the team members. In addition, Dr. Allwine indicated that here were two recent reports that would be of interest to the team members and that he would provide them to the other reviewers.

The peer reviewers were instructed to perform their review according to the "Charge to Reviewers". It was agreed that contact amongst them was permissible and encouraged. The comments for Dr. Dabberdt and Mr. Simmons were to be forwarded to Dr. Allwine via email.

After the reviewers provided comment, a draft report was compiled by Dr. Allwine that provided a summary of the opinions of the team and specific individual comment, as appropriate. This report was distributed via email to all parties for their review.

A second conference call was scheduled by KEVRIC to discuss the draft report and determine if any changes, modifications or clarifications were needed. Dr. Allwine revised the draft report and redistributed the final version to the team members.

The final version of the report was compiled, reproduced and submitted to EPA by KEVRIC. This compilation included addition of other documentation such as resumes of the reviewers, this overview of the process and additional reports reviewed (as provided by Dr. Allwine).

APPENDIX F

LIST OF DOCUMENTS REVIEWED

Robe, F.R. and J.S. Scire. 1998. "Combining Mesoscale Prognostic and Diagnostic Wind Models: A Practical Approach for Air Quality Applications in Complex Terrain." Preprints, Tenth Joint Conference on the Application of Air Pollution Meteorology, Phoenix, Arizona. American Meteorological Society, Boston, MA. January 11-16, 1998.[1]

Scire, J.S. 1997. "A Simple Soil Moisture Model for Air Quality Applications." Presented at the 12th AMS Symposium on Boundary Layers & Turbulence, Vancouver, BC, Canada, July 28 - August 1, 1997. Earth Tech, Inc., Concord, MA.[2]

Scire, J.S. and F.R. Robe 1997. "Fine-Scale Application of the CALMET Meteorological Model to a Complex Terrain Site." Presented at the AWMA's 90th Annual Meeting and Exhibition, Toronto, Ontario, Canada, June 8-13, 1997. Earth Tech, Inc., Concord, MA.

[1] Provided to team members by Dr. Jerry Allwine. Copy attached.
[2] Provided by EPA as part of review.

Scire, J.S., D.G. Strimaitis and R.J. Yamartino. 1998. A User's Guide for the CALPUFF Dispersion Model (Version 5.0) - DRAFT. Earth Tech, Inc., Concord, MA.[2]

Scire, J.S., F.R. Robe, M.E. Fernau and R.J. Yamartino. 1998. A User's Guide for the CALMET Meteorological Model (Version 5.0) - DRAFT. Earth Tech, Inc., Concord, MA.[2]

Stimaitis, D.G., J.S. Scire and J.C. Chang. 1998. "Evaluation of the CALPUFF Dispersion Model with Two Power Plant Data Sets." Preprints, Tenth Joint Conference on the Application of Air Pollution Meteorology, Phoenix, Arizona. American Meteorological Society, Boston, MA. January 11-16, 1998.[2]

U.S. EPA. 1992. A Modeling Protocol for Applying MESOPUFF II to Long Range Transport Problems. EPA-454/R-92-021. U.S. Environmental Protection Agency, Research Triangle Park, NC.[2]

U.S. EPA. 1994. A Revised User's Guide to MESOPUFF II (v 5.1). EPA-454/B-94-025. U.S. Environmental Protection Agency, Research Triangle Park, NC.[2]

U.S. EPA. 1998. A Comparison of CALPUFF with ISC3 - DRAFT. U.S. Environmental Protection Agency, Research Triangle Park, NC.[2]

U.S. EPA. 1998. Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long-Range Transport Impacts - DRAFT. U.S. Environmental Protection Agency, Research Triangle Park, NC.[2]

Wu, Z.X., J.S. Scire and R. O'Neal. 1998. "Comparison of One Year of MM5 and CALMET Meteorological Fields with Observations in the Western United States." Preprints, Eighth PSU/NCAR Mesoscale Model User's Workshop, , Boulder, Colorado. June 15-16, 1998, pp. 131-137.[1]

APPENDIX G

PEER REVIEW PANEL MEMBER'S QUALIFICATIONS

RESUMES