Establishment of a Community Modeling and Analysis Support Mechanism

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ABSTRACT

During the fall of 2001, a Cooperative Research Agreement between the U.S. Environmental Protection Agency and MCNC began a Community Modeling and Analysis System (CMAS) center. The CMAS will foster development, distribution, and use of the Models-3/CMAQ (Community Multiscale Air Quality) air quality modeling system. The CMAS is hosted by MCNC's Environmental Modeling Center in Research Triangle Park, North Carolina. The objectives of the CMAS are to (1) serve as a bridge between members of the Models-3/CMAQ modeling community, (2) encourage the growth of the user community, (3) serve as an information clearinghouse for model applications, emission modeling methods and data, (4) provide education about the models and their uses, (5) maximize the scientific content and performance value of the Models-3/CMAQ system by encouraging the expansion of the contributing developer community and taking advantage of multiple incremental contributions, and (6) provide computer and skill resources to the Models-3/CMAQ modeling community benefitting from economies of scale. Support and development work includes both emission modeling (through the Sparse Matrix Operator Kernel Emission system) and the CMAQ chemistry-transport modeling components. As a community modeling support center, the CMAS is open to all interested participants. The center is organized into five functional parts: (1) Administration, (2) Outreach, (3) Application Support, (4) Software Development, and (5) Modeling Research. The model code accepted and released as a part of Models-3/CMAQ will be open and shared with all. The External Advisory Committee, governing the CMAS policies and priorities, is a technically knowledgeable group including representatives of state and regional agencies, EPA, industry, consultants, academic institutions, and foreign users.

INTRODUCTION

Historically, advances in air quality model technology and data sets could not be easily shared between modelers because of inconsistencies in specific pollutants addressed, scientific approach, variables, and data formats. Over a decade ago, the U.S. Environmental Protection Agency (EPA) recognized that an open source, modular code, unified chemistry ("one-atmosphere"), community supported regional air quality modeling system might enable collaborative development and linking of models for meteorology, air emissions, air quality chemistry and transport, hydrology, and

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environmental and health effects.[1] In response to the need, the EPA developed, and continues to improve, the Models-3 Community Multiscale Air Quality (CMAQ) model system. The Models-3/CMAQ system represented a new paradigm and anticipated the extensibility and power of geographic-based grid modeling.[2,3,4] Documentation for the chemistry and transport portion (CMAQ) of Models-3/CMAQ is maintained at http://www.epa.gov/asmdnerl/models3 . Documentation for the emission modeling part of the system, the Sparse Matrix Operator Kernel Emission (SMOKE) system is available at http://www.emc.mcmc.org.

During the development of Models-3/CMAQ, EPA scientists recognized that support and improvement of the system was too great a commitment of resources for any single organization, and would be more effectively accomplished by a cadre of multiple model users and developers. A workshop held during 1997 explored the methods and opportunities that might be followed to establish a community support system. The proceedings are available at http://www.emc.mcnc.org/CMAS/workshop_draft.html. The workshop participants recommended that collaborative community modeling include (1) representation from all categories of the user community, (2) provision of user support, (3) well-documented, reviewed and tested open code, (4) a mechanism for clear review and testing procedures for model improvements, (5) a means to enhance sharing of ideas and data between Models-3/CMAQ modeling community members, and (6) inclusion of user-requested model applications and research. Existing examples of community models were examined, including two maintained at the University Corporation for Atmospheric Research, specifically the Mesoscale Meteorology Model Version 5 (available at http://box.mmm.ucar.edu/mm5/) and climate model (available at http://www.cgd.ucar.edu/cms/ccm3). EPA issued a competitive Request for Proposals for a cooperative research grant to initiate a cooperative center for a Community Modeling and Analysis System (CMAS). In October 2001, a four-year grant (November 2001-October 2005) was awarded to the Environmental Modeling Center of MCNC in Research Triangle Park, North Carolina. The plan under the grant is that CMAS will become self-sustaining by the end of the grant period through the financial contributions of members and limited services. Modeling software and basic support will be provided at no cost to the users. The EPA will assist the CMAS to the extent possible under the cooperative research grant. EPA will continue to provide improvements to Models-3/CMAQ model software, relevant data sets, and collaboration with EPA scientists facilitated by the grant Project Officer.

CMAS OBJECTIVES

The purpose of CMAS is to provide technology transfer and support of Models-3/CMAQ for the benefit of the air quality community. Planned activities, which will be phased in over the course of the grant, include the following categories.

Outreach: A Bridge Between Users

A range of communication methods will be used to make CMAS information and products widely available and to enhance communication between members of the community. For example, participation in and the hosting of conferences for users is a key item in transfer of new information and stimulation of ideas and collaboration. The information will be transferred to the community using:

- website and list servers
- conferences, seminars and workshops
- technical working groups
- input from the CMAS External Advisory Committee (EAC)
- printed and electronic materials

- collaboration with professional groups
- technical reports
- newsletters
- site visits

Providing a central point of contact between users will allow the creation and direction of large projects distributed across multiple organizations.

Growth of the User Community

The development of the user community and encouragement of collaborative efforts is the principal initial effort in establishing CMAS. The two main user groups are those interested in regulatory applications and those pursuing the scientific underpinnings of air quality modeling. These include state, federal and regional government entities, regional planning bodies, the private sector (contractors and industry), and universities.

Clearinghouse

Many air quality modeling data sets have value for reuse or for comparison between modelers. The availability of these data is often *ad hoc* and depends on mutual awareness of modelers and their projects. The CMAS will serve as a clearinghouse for model-related data sets, without replicating the archival of relevant data sets held elsewhere. For example, CMAS might archive significant model output data sets or special input files, but not emission inventory data routinely available from the EPA Chief web site.

The CMAS will also act as the clearinghouse for future (after 2002) Models-3/CMAQ releases. Major releases of Models-3/CMAQ should continue on an approximately annual basis. A bug tracking feature, similar to that used for MM5 will be used to help users keep track of model revisions during the interim. Acceptance of new modules into Models-3/CMAQ will be based on science and testing criteria determined by the EAC.

Education

The CMAS will serve as an educational center for the user community by offering training and user support via a help desk, e-mail mailing lists, and web page information. These services will be developed and enhanced through time to reflect user needs. Training will be emphasized, and will include air quality modeling applications, data preparation for modeling, building of interchangeable modeling components, and evaluation of model configurations. Centralizing the development of courses will allow member groups to offer training that is consistent, complete, and up-to-date without having to independently develop and update the material.

Maximize Value of Content by Leveraging Many Partners

The CMAS will follow the priority needs and objectives expressed by the user community in supporting and improving Models-3/CMAQ. Because there are many users who may contribute, CMAS will ensure that the resulting modeling services and products represent the best value added in return for the contributions CMAS community members. Each member of the community will benefit from the compounding of the scientific and financial contributions of the group. This may best be done by focusing pooled resources on those priorities of highest community need, as expressed by the CMAS External Advisory Committee (EAC). Although CMAS model code and documentation will be freely

available to the public, those users becoming contributing members of the CMAS will benefit from the compound result of many members contributing to the cost of model support and development, as well as having a greater claim in the setting of priorities. A membership and financial structure will be established that allows the CMAS to become self-sufficient within four years. Membership structure is still to be determined. One possibility is to have a tiered membership structure. Memberships could include Sponsoring Institutions (agencies able to support the CMAS through grants), CMAS Members (a range of levels of participation and benefits to maintain common services, each with an annual fee), Granting Institutions (agencies support via competitive research grants), Regional Consortia (groups of states or agencies), and Individual Organizations.

Provision of Computer and Science Skills

The CMAS will develop advanced tools to assist users to build models, develop data sets, analyze results, and understand model behavior. The needed tools will be prioritized by the community through the EAC, and developed within the CMAS center and by the community as a whole. CMAS model products, data sets, and model support will be available to the community at no cost. With the consent of the community, the CMAS may provide limited consulting services to users for specific model applications. Often, model applications or data set processing are tasks of sufficient size that some users cannot handle them with in-house resources, yet it is not cost effective to contract out to a for-profit firm. Types of projects that the CMAS could assist in are: input data preparation (emissions, meteorology, and other model inputs), model configuration and application for the evaluation of new science, model configuration and application for state or tribal regulatory purposes or impact assessment, and analyses of modeling studies (operational and diagnostic evaluation through graphical and statistical measures).

CMAS ORGANIZATION

The CMAS is counseled by the EAC, a technically knowledgeable group that guides CMAS in meeting the needs of the community. The EAC acts on behalf of the Models-3/CMAQ modeling community to define needs and priorities, advise on changing requirements, set research and development priorities, review progress of activities, and make recommendations for the advancement of Models-3/CMAQ science and software. The EAC membership consists of three representatives of state air quality agencies, two representatives of industry, two representatives of academic research institutions, three members of the Models-3/CMAQ air quality consulting community, two members of regional air quality planning bodies, one Canadian member, one representative of the balance of the international user community, one ex officio representative of EPA regional offices, and one ex officio representative each from three other involved EPA offices (Table 1). EPA will participate with other EAC members as a partner in the CMAS. New and updated Models-3/CMAQ-related products from EPA will be provided to CMAS, as well as technical information and coordination on modeling products under development by EPA. The EAC members will serve staggered two-year terms with some memberships ending every six months. Monthly conference calls are planned, along with an annual meeting and working sessions held in conjunction with other conferences and meetings. The EAC is creating its operating bylaws, defining review and test procedures for the incorporation of new or revised model code into CMAQ, and establishing operating priorities for all CMAS objectives and functions.

Table 1. External Advisory Committee members to date.

Community Represented	Representative	Affiliation
EPA (OAQPS)	Mr. Mark Evangelista	Emissions, Monitoring and Analysis Division

Community Represented	Representative	Affiliation
EPA (ORD)	Mr. Kenneth Schere	Atmospheric Modeling Division
EPA (OEI)	Dr. Darrell Winner	Office of Environmental Analysis and Access
EPA (Regions)	Mr. Alan Cimorelli	EPA Region 3
State Agency	Mr. Peter Breitenbach	Texas Natural Resource Conservation Commission
State Agency	Dr. Kaduwela Ajith	California Air Resources Board
State Agency	Ms. Sheila Holman	North Carolina Dept. of Health, Environment, and Natural Resources
Industry	Dr. David Chock	Ford Motor Company
Industry	Dr. Alan Hansen	Electric Power Research Institute
University	Dr. Harvey Jeffries	University of North Carolina
University	Dr. Daewon Byun	University of Houston
Consultants	Mr. Ralph Morris	Environ, Inc.
Consultants	Dr. Christian Seigneur	AER Consultants, Inc.
Regional Planning Organization	Mr. Mike Koerber	Lake Michigan Air Directors Consortium
Regional Planning Organization	Dr. John Vimont	Western Regional Air Partnership
International	Dr. Richard Derwent	United Kingdom
Canada	Dr. Weimin Jiang	National Research Council of Canada
Expert Users	Dr. Neil Wheeler	Sonoma Technology

The functions of CMAS are grouped into five general areas, with appropriate links to the EAC and air quality modeling community as a whole. The functions include CMAS administration, outreach, modeling research, development and model applications (Figure 1). The core CMAS staff is organized around these functions, and now consists of a portion of the time of five people, with the balance of the MCNC Environmental Division staff available on an as-needed basis. The CMAS Director is Mr. Robert Imhoff, who also serves the co-Outreach Coordinator with Dr. Adel Hanna. The Research Coordinator is Dr. Rohit Mathur, the Software Development Coordinator is Ms. Alison Eyth, and the Applications Support Coordinator is Mr. Zachariah Adelman. The duties of each position are summarized below.

CMAS Director (Administration)

- Coordination of CMAS activities
- Responsible for achievement of milestones
- Convening of the External Advisory Committee

Outreach Coordinator

- Identification and development of user clientele
- Communication of CMAS value and benefits
- Encouragement of collaborations (identifying collaboration opportunities and funding possibilities

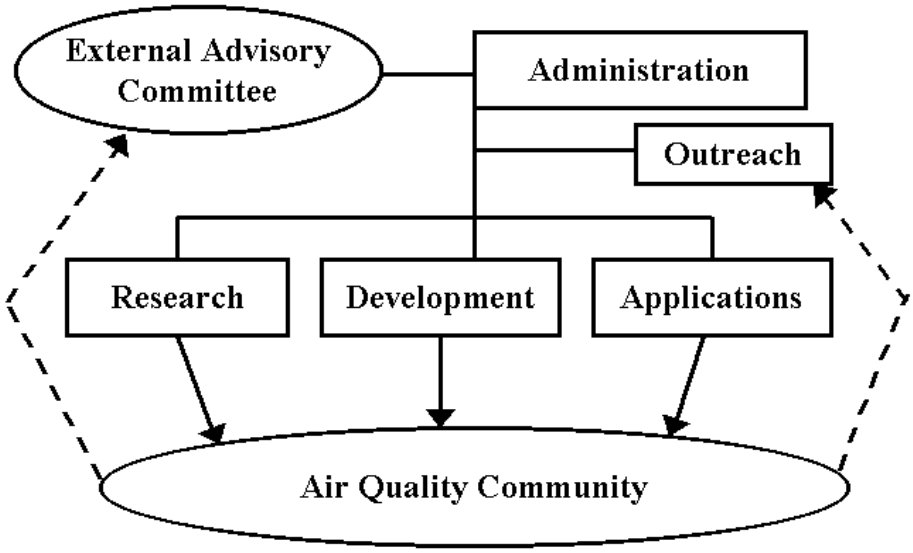
Research Coordinator

- Verification of scientific review of Models-3/CMAQ changes
- Reporting of testing and evaluation
- Coordination of research activities
- Establish dialog with research community to set research agenda
- Research on linkages to other modeling systems

Software Development Coordinator

- Track requests for model changes through code change and testing process
- Document procedures for configuration management, benchmark testing and documentation for the EAC.
- Implement software for tracking and authenticating model versions and options used for each application
- New tool development
- Improvements to the I/O API (data convention in Models-3/CMAQ)
- Parallelization of CMAQ code
- Coupling to other models (ecosystem, etc)

Figure 1. Relationship of CMAS functional areas.



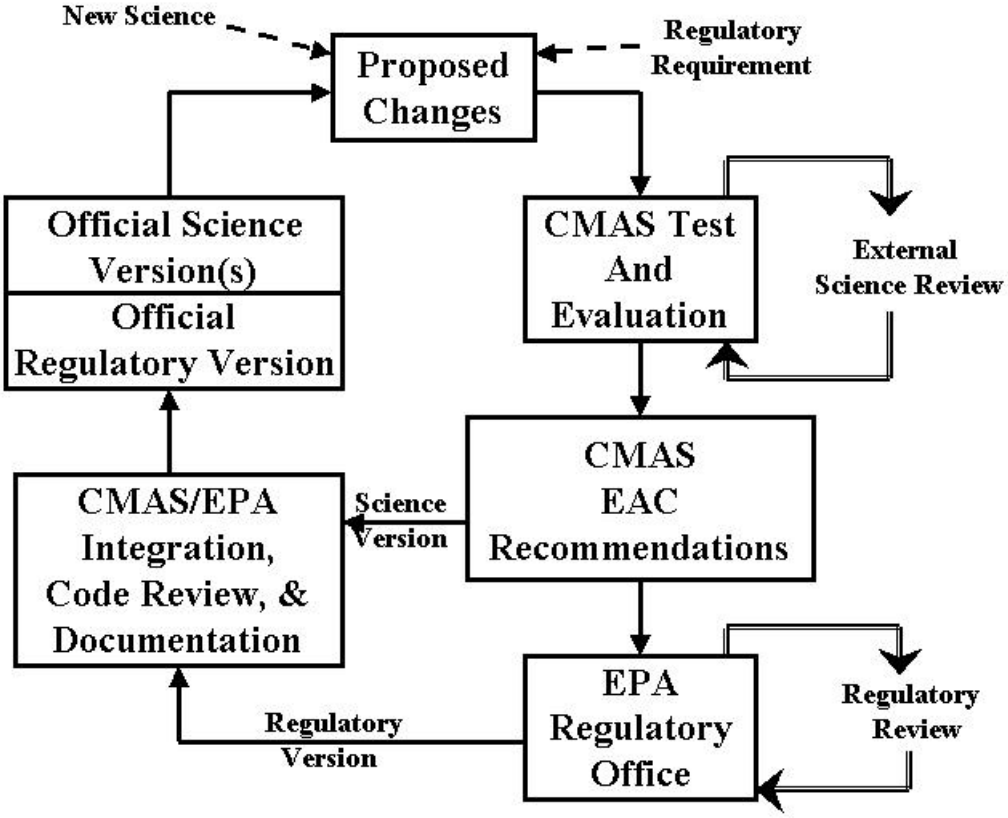
Applications Support Coordinator

- Directs user support
- Help Desk
- Training course development and delivery
- Computing resources
- Shared-data clearinghouse
- Application consulting
- Model testing and integration
- Integration of alternative modules
- Porting and benchmark testing of alternative modeling platforms

RESEARCH AND REGULATORY MODELING

The science underlying Models-3/CMAQ is progressing quickly. Therefore, the software code must be frequently updated to reflect advances in scientific understanding and computational methods. With active air quality modeling community involvement, it is likely that scientists will create variations of different CMAQ modules and features for research purposes. The CMAS would incorporate these innovations on a continuing basis following a definite review and testing procedure. For regulatory modeling, the U.S. EPA Office of Air Quality and Standards shall retain approval authority over model versions, combinations of components, and model setting alternatives acceptable. The general review and approval cycle of model changes is outlined in Figure 2.

Figure 2. General CMAS software change review and approval process.



PLANS FOR INITIATION OF SERVICES

During the first year (2002) of the CMAS, the principal activities include the establishment and creation of the structure and operating procedures of the EAC, planning and implementation of the means for eventual self-sufficiency of the CMAS, definition and implementation of the cost and membership structure, and implementation of model support. A comprehensive model support structure will be a major benefit to the modeling community. Models-3/CMAQ releases during 2002 will continue through EPA, and thereafter by CMAS.

During the second year of operation, the cooperative research grant, CMAS plans to provide releases of Models-3/CMAQ changes, model documentation, user training, and begin a model data clearing house. EPA will provide relevant new development to CMAS during this period. In addition to improvements in the chemical transport model portion of the Models-3/CMAQ system, the emission modeling portion of the system (the Sparse Matrix Operator Kernel Emission or SMOKE), will be maintained and improved. The SMOKE was developed by the MCNC under an EPA cooperative research grant.[5,6] In addition, a new Java® language based modeling framework and interface has been developed by EPA for use with multi-media modeling applications. The framework, called the Multimedia Integrated Modeling System (MIMS), will be applied to Models-3/CMAQ and SMOKE, and will be maintained for air quality modeling purposes by CMAS. Information about MIMS is located on the Internet at http://www.epa.gov/asmdnerl/mims/. Coordinated support of these model software systems will provide users with a "one-stop" help center. Other participants in CMAS will also make software contributions to the Models-3/CMAQ system. To the extent that additional funding is available from sponsors or members of CMAS, these functions may be accelerated or expanded, or research functions begun. The third and fourth years of operation will continue, and hopefully expand, the above functions, depending upon the level of resources available to CMAS.

CONCLUSIONS

The CMAS provides a clear, organized, opportunity for the members of the air quality modeling community to collaborate and leverage the potential of their combined resources in a open, shared modeling system, following the overall priorities of the modeling community. CMAS allows the modeling system results to truly be greater than the sum of the efforts of the individual members of the community. Pooling of resources and science advances will allow for more rapid advances in modeling, more sound, rapid and economical model applications, and for a more knowledgeable community of people using the model and consuming model information.

DISCLAIMER

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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KEY WORDS

air quality modeling
Models-3
CMAS
CMAQ
SMOKE
MIMS
community model