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Community Multiscale Air Quality (CMAQ) Modeling System

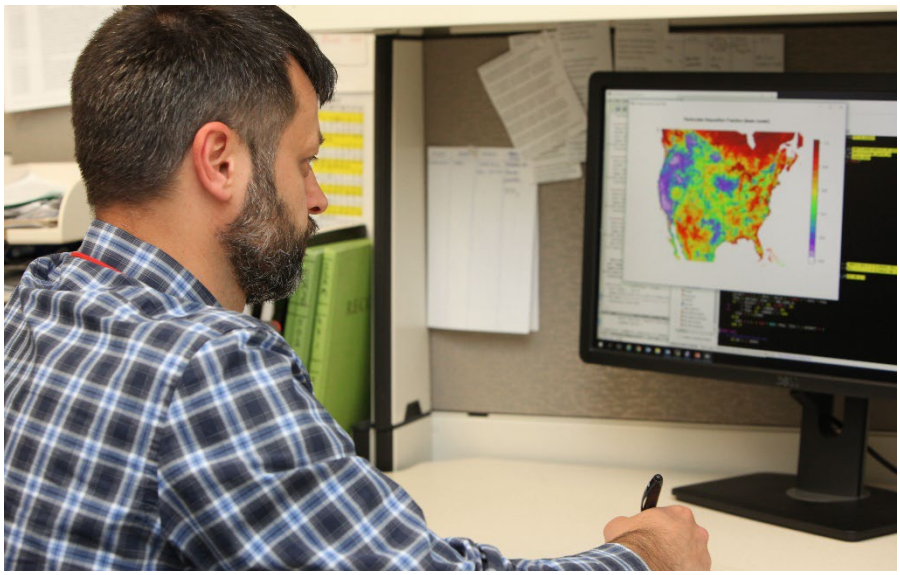
A tool to support air quality management and inform policy to protect public health

What is CMAQ?

The Community Multiscale Air Quality (CMAQ) Modeling System is EPA's premier modeling system for studying air pollution from local to hemispheric scales. For more than two decades, EPA and states have used CMAQ—a powerful computational tool translating fundamental atmospheric science principles to policy scenarios—in support of air quality management. CMAQ is continually updated to incorporate knowledge on the state-of-the science and harness high performance computing power to more effectively and efficiently characterize air quality and protect human health and the environment.

States use CMAQ to develop and assess implementation actions needed to attain National Ambient Air Quality Standards (NAAQS) defined under the Clean Air Act. CMAQ simulates air pollutants of concern—including ozone, particulate matter (PM), and a variety of air toxics—to optimize air quality management. Deposition values from CMAQ are used to assess ecosystem impacts such as eutrophication and acidification from air pollutants. In addition, the National Weather Service uses CMAQ to produce twice-daily forecast guidance for ozone air quality across the U.S.

CMAQ unites the modeling of meteorology, emissions, and chemistry to simulate the fate of air pollutants under varying atmospheric conditions. Other kinds of models—including crop management and hydrology models—can be linked with the CMAQ simulations, as needed, to more holistically simulate pollution across environmental media.



What's new in CMAQ?

In August 2019, EPA released a major update to CMAQ. CMAQ version 5.3 includes the following new features:

- **A more detailed representation of the characteristics of PM:** CMAQ 5.3 improves modeling of PM composition, size distributions, and optical properties. It also enhances the simulation of human-influenced secondary organic aerosols by considering newer laboratory and observational data.
- **Expanded chemistry for ozone and PM formation from global-to-local scales:** CMAQ 5.3 updates the science behind the interactions of chemicals in the air and clouds. These advances reflect the state of the science and are more inclusive of chemical processes not just within the U.S., but under different climatic conditions across the globe.
- **More complex land and atmosphere interactions to support both air quality and ecosystems applications:** CMAQ 5.3 includes two new options for simulating the exchange of pollutants between the land and the atmosphere, improving linkages of CMAQ for ecological applications.
- **Increased emphasis on pollutants originating outside the U.S.:** While air quality has improved through EPA regulations under the Clean Air Act, understanding the fate of air pollutants originating in other countries remains critical for addressing air quality in the U.S. CMAQ 5.3 better captures the influences of reactive chemical species originating from the oceans, and it increases the emphasis on more accurate characterization of pollutants transported through the air from distant sources.

- **Increased scientific consistency between meteorology and chemistry models:** As the state of the science in the meteorology model evolves, changes are introduced into CMAQ to represent the atmospheric processes as consistently as possible between these models. The meteorology model used by CMAQ was updated by adding scientific complexity, incorporating new data sources, and changing the representation of the atmosphere above the troposphere—that is, above where most of the weather occurs. This change is important because intermittent infusions of high concentrations of ozone into the lower atmosphere occur through physical processes at the top of this layer -- the tropopause.
- **Greater flexibility to support increasingly diverse uses of CMAQ:** Some of the software in the CMAQ modeling system has been restructured so that both users and developers can more readily extend CMAQ to meet their needs. For example, a new emissions interface allows for substantial flexibility in the way emissions are mapped, scaled, and checked for quality and can greatly simplify the task of assessing air quality improvements resulting from emission changes.
- **Improved efficiency for CMAQ-ISAM for isolating source contributions to air quality:** The science algorithms used by the Integrated Source Apportionment Method (CMAQ-ISAM) to track contributions from different emission sources to ozone and PM have been updated. Code improvements have led to substantially faster run times to support its practical applications.
- **Fully revised documentation to better reflect CMAQ's current structure and capabilities:** A new comprehensive user's guide provides instructions on setting up and running the model, including guidance on what model options are recommended for different types of modeling applications.

CMAQ Support Tools

New versions of software tools needed for preparing input datasets and evaluating output were released concurrent with CMAQ 5.3:

- **Meteorology-Chemistry Interface Processor (MCIPv5.0):** Prepares atmospheric fields from the meteorology model for use in CMAQ.
- **Fertilizer Emission Scenario Tool for CMAQ (FEST-Cv1.4):** Generates fertilizer application input for CMAQ bi-directional ammonia modeling.
- **Atmospheric Model Evaluation Tool (AMETv1.4):** Used to analyze air quality and meteorology models.
- **Visual Environment for Rich Data Interpretation (VERDIv2.0):** Visualizes gridded output from MCIP and CMAQ.

Community Engagement

The CMAQ community has thousands of users in more than 50 countries. These users include scientists and air quality managers across government, academia, and the private sector. Their input has contributed to developing a more robust model.

To support the CMAQ user community, EPA contracts with the University of North Carolina at Chapel Hill to host the Community Modeling and Analysis System (CMAS) Center, which provides user training and support for the CMAQ modeling system. In 2018, EPA worked with CMAS to launch a new online user forum to connect users with model developers and the international user community to collaborate on using CMAQ and to share feedback for science and feature improvements.

For more information, visit:

EPA's CMAQ website:
www.epa.gov/cmaq

CMAQ source code on GitHub:
https://github.com/USEPA/CMAQ

CMAQ Support Tools:
https://www.epa.gov/cmaq/cmaq-resourcesutilities-model-users

CMAS Center at UNC-Chapel Hill:
www.cmascenter.org

CMAS User Forum
https://forum.cmascenter.org

NOAA/NWS Air Quality Forecasts using CMAQ
https://airquality.weather.gov

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