United States Environmental Protection Agency

epa.gov/research

# Community Multiscale Air Quality (CMAQ) Modeling System

Innovative Science for a Sustainable Future

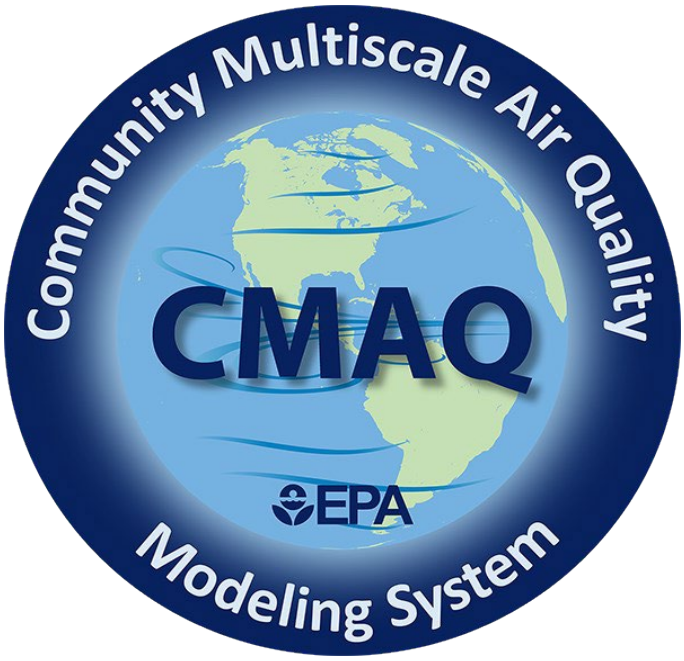
## What is CMAQ?

The Community Multiscale Air Quality (CMAQ) Modeling System is EPA's premier modeling system for studying air pollution from global to local scales. For over a quarter century, EPA and states have used CMAQ—a powerful computational tool for translating fundamental atmospheric science principles to policy scenarios—to support air quality management. CMAQ is continually updated to incorporate new knowledge on the state-of-the science and use high performance computing power to characterize air quality more accurately and efficiently and to 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 the most prevalent 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 has also been used to quantify potential impacts of climate change on air quality and human health.

CMAQ—when coupled with a meteorology model such as the Weather Research and Forecasting (WRF) model—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 describe pollution more holistically across environmental media.

CMAQ can be configured to simulate meteorology and atmospheric chemistry in a sequential fashion (i.e., one model at a time), or it can be "coupled," where CMAQ is embedded in the meteorology model. In the latter case, the impacts of atmospheric chemistry can be reflected actively in the clouds and radiation simulated by the meteorology model. There are options to connect CMAQ to regional and global meteorology models for coupled simulations.




CMAQ is a sophisticated numerical modeling system that runs on multi-processor Linux computing systems. CMAQ requires tens of gigabytes to tens of terabytes of disk space to accommodate input and output files. CMAQ can also be operated in a cloud computing environment.

## What's new in CMAQ?

CMAQ version 5.5 includes the following new features:

- Inclusion of Community Regional Atmospheric Chemistry Multiphase Mechanism (CRACMM) version 2.0 – CRACMM aims to incorporate and leverage knowledge from the broad atmospheric science community to improve predictions of oxidants, hazardous air pollutants, and particulate matter. CRACMM version 2.0 includes updated formaldehyde chemistry impacting ozone and secondary organic aerosol formation.

*(Continued on page 2)*

- New support for running pre-configured global CMAQ simulations coupled with meteorology from the Model for Prediction Across Scales – Atmosphere (MPAS-A).
- Expanded capabilities of the Integrated Source Apportionment Method (ISAM) to quantify source contributions to total secondary organic aerosol (SOA) and individual species.
- Updates to ISAM source attribution estimates, mainly impacting coarse particles and secondary organic aerosols formed through cloud processes.
- Updates to the Decoupled Direct Method (DDM) to improve second order ozone sensitivities.
- Updated chemistry to properly capture photolysis effects from sub-grid clouds.
- Revised algorithms for modeling dry deposition (M3DRY and STAGE updates).
- Improved accuracy and error checking for BDSNP soil NO in the MEGAN biogenic emissions algorithm.
- MCIP (meteorology pre-preprocessor) updates to grid origin definition for fine scale Lambert Conformal Grids (i.e., < 4km).
- Updates to Sulfur Tracking Model (STM) to properly attribute sulfate from gas phase chemistry.
- Updates to the Explicit and Lumped Model Output (ELMO) module to fix erroneous output for several PM aggregates including PMF_OC, PMF_NCOM, TNO3.
- New shp2cmaq python tool to convert GIS shapefiles into gridded netCDF mask files that can be used for defining regions and region families with DESID and using geographic source regions when running CMAQ-ISAM.
- Simplified workflows for easier CMAQ installation.

## Community Engagement

The CMAQ community has hundreds 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. CMAS hosts an 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 and documentation on GitHub: github.com/USEPA/CMAQ

FAQ for upgrading to CMAQv5.5: github.com/USEPA/CMAQ/wiki/CMAQv5.5-Series-FAQ

Two-day test data for CMAQ version 5.5: www.epa.gov/cmaq/test-cases

About CRACMM: www.epa.gov/cmaq/cracmm

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

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

CMAS User Forum: forum.cmascenter.org

*September 2024*