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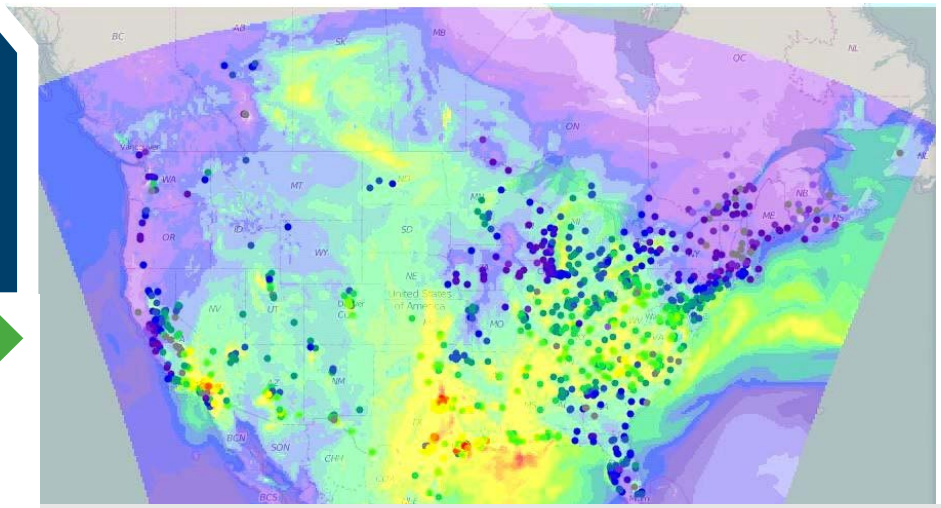
INNOVATIVE RESEARCH FOR A SUSTAINABLE FUTURE

EPA's Community Multiscale Air Quality Modeling System (CMAQ)

Tools for controlling air pollution & studying climate change



A CMAQ map showing averaged ozone concentrations across the United States.

What is CMAQ?

For more than a decade, EPA and states have used EPA's Community Multiscale Air Quality (CMAQ) Modeling System, a powerful computational tool for air quality management. The National Weather Service also uses the model to produce daily U.S. forecasts for ozone air quality.

States use CMAQ to develop and assess implementation actions needed to attain National Ambient Air Quality Standards (NAAQS). The system simultaneously models multiple air pollutants, including ozone, particulate matter, and a variety of air toxics, to help regulators determine the best air quality management scenarios for their communities, states and countries.

CMAQ brings together three kinds of models:

- Meteorological models to represent atmospheric and weather activities.
- Emission models to represent man-made and naturally-occurring contributions to the atmosphere.
- An air chemistry-transport model to predict the atmospheric fate of air pollutants under varying conditions.

In October 2016, EPA released the newest version of the modeling system — CMAQ 5.2 for beta testing. A final version is scheduled for release in June 2017. CMAQ 5.2 includes the following new features:

- **New windblown dust emission model:** This physics based model has been evaluated and shown to be better with observations than previous dust emission components in CMAQ.
- **New pathways to organic aerosol:** New sources of secondary organic aerosols have been added to the model (heterogeneous uptake of glyoxal and methylglyoxal in CB6) and properties of traditional secondary organic aerosol have been updated. The volatility of both secondary and primary organic compounds are now treated consistently with each other. In addition, a new model species has been added to account for the organic aerosol compounds resulting from combustion processes.
- **New gas-phase photochemistry mechanism:** A new way to model gas-phase photochemistry mechanisms has been added to CMAQ 5.2. This allows for a better treatment of rural and remote chemistry, which is particularly important for modeling compliance strategies for a lowered NAAQS standard. CMAQ 5.2 also includes an extension for modeling oceanic halogen chemistry in hemispheric simulations.
- **Instrumented diagnostic capabilities:** Several diagnostic capabilities are included with this model version that allow users to probe source-receptor

relationships. The tools include: 1) Decoupled Direct Method in Three Dimensions (DDM3D) for calculating sensitivity coefficients for user defined parameters; 2) Integrated Source Apportionment Method (ISAM) for tracking contributions from sources and regions; and 3) Sulfur Tracking Model (STM) for tracking sulfate production pathway contributions. The instrumented models are useful tools for a variety of decision support applications.

A Little History

Using data about land use, meteorology, and emissions, CMAQ provides detailed information about the concentrations of air pollutants in a given area for any specified emissions or climate scenario. Since 1998, when the first version was released, CMAQ has been used to evaluate potential air quality policy management decisions. The model provides reliable information for decision makers about the estimated impacts of different air quality policies.

Since its inception, CMAQ has been able to incorporate data from related models that have alternate mathematical processes. This has allowed inclusion of new science in the model to address increasingly complex air pollution issues.

Community Based Development

CMAQ stands out from other air quality models because it incorporates input from a large, world-wide user community. To support the CMAQ user community, EPA and the University of North Carolina at Chapel Hill host the Community Modeling and Analysis System (CMAS) Center, which distributes CMAQ software, hosts user email exchanges, and provides new user training on the CMAQ modeling system.

This growing community, which includes thousands of users in more than 50 countries, has helped assess and improve the model's functionality. Users include scientists, researchers and air quality modelers, as well as governmental air quality managers who apply the modeling system in their environmental management programs. Their input has helped EPA scientists prioritize modeling research to improve CMAQ's capabilities.

CMAQ Model Application

CMAQ has been used to address several major air pollution issues in recent years. New fuel and car standards finalized by EPA in 2014 were developed with input from CMAQ. The new fuel standards require the amount of sulfur in gasoline to be reduced by more than 60 percent starting January 1, 2017. Under the new rule, motor vehicle particulate-matter emissions are to be reduced by 70 percent and nitrogen-oxides emissions by 80 percent. Once fully in place, the standards will help avoid up to 2,000 premature deaths per year and 50,000 cases of respiratory ailments in children.

In developing the rule, CMAQ was used to calculate 8-hour ozone concentrations; daily and annual $PM_{2.5}$ concentrations; annual nitrogen dioxide (NO_2) concentrations; annual and seasonal (summer and winter) air toxics concentrations; visibility levels, and annual nitrogen and sulfur deposition total levels. These factors were calculated for the years 2018 and 2030, with and without the rule. CMAQ results were used in combination with other tools to determine how the new standards would impact various health outcomes.

For more information, visit:

EPA's CMAQ resource page:
http://bit.ly/EPA-CMAQ

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

Download CMAQ:
www.github.com/USEPA/CMAQ

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