Single-Model Case Study: Air Quality Modeling for PM$_{2.5}$ NAAQS Regulatory Impact Analysis

James Kelly[1], Robin Dennis[2], and Norm Possiel[1]
U.S. Environmental Protection Agency, Research Triangle Park, NC
[1]Office of Air Quality Planning & Standards
[2]Office of Research and Development

Air quality (AQ) models simulate concentrations ozone, particulate matter (PM$_{2.5}$), toxics, acid deposition, and visibility on a 3-dimensional fixed grid. Using inputs for emissions, meteorology, and initial and boundary conditions, AQ models simulate the transport and fate of pollutant and precursor emissions by linking emissions to pollutant concentrations according to mechanistic parameterizations of the key chemical and physical atmospheric processes. This capability makes AQ models valuable planning tools and widely used in a range of regulatory applications. The purpose of this presentation is to describe the technical approaches commonly used in regulatory AQ studies by describing the modeling for the recent PM$_{2.5}$ National Ambient Air Quality Standards (NAAQS) Regulatory Impact Analysis (RIA). Considerations in applying a single AQ model in regulatory studies are then discussed along with potential considerations in using multiple models.

The primary goals of AQ modeling for the RIA are to project representative current-year AQ data to a future year and to estimate the emissions reductions that would be required to meet the existing and revised standard levels in the future. An example of AQ data projected to the year 2020 at monitors in the continental US is shown in Figure 1. Key aspects of the projection methodology include the use of observations to characterize current-year AQ and the application of AQ models only to estimate the relative change in AQ values associated with a change in emissions. The application of AQ models to predict relative changes in AQ values, rather than absolute values, is believed to dampen the impact of possible model biases on projections.

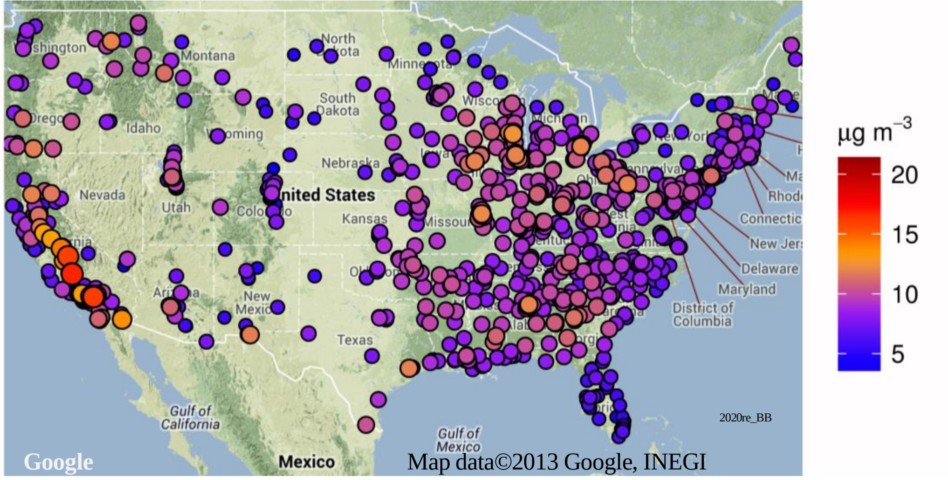

Figure 1. Example of annual AQ values projected to the year 2020 for the PM$_{2.5}$ NAAQS RIA. For details, see http://www.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf

The two AQ models commonly used in regulatory studies in the U.S. are the Community Multiscale Air Quality (CMAQ, http://www.cmaq-model.org/) model and the Comprehensive Air Quality Model with extensions (CAMx, http://www.camx.com/). These are open-source models that have a large degree of similarity in their modular representations of key processes with state-of-the-science parameterizations. The modular nature of these models enables them to host multiple representations of many processes (e.g., gas-phase chemistry, turbulent convection, etc.) in a single model and facilitates the involvement of a large community user group in contributing developments and evaluating model predictions against observations. Through this community and the peer-reviewed literature, along with input from scientific advisory committees, the state-of-the-science in AQ modeling is established. Thus, while a given regulatory study may include results from a single AQ model, the configuration of that model is based on a broad consideration of multiple process parameterizations by a large community of atmospheric modelers and scientists. The considerable effort this community devotes to model evaluation and testing is central to the success of the model development and application process and is required to characterize the continually evolving and improving nature of the modeling systems.

The application of multiple AQ models (or multiple configurations of a single AQ model) could be considered in regulatory AQ studies. Such studies would need to develop approaches for selecting a manageable number of model configurations from the numerous parameterization options available in AQ models as well as the meteorological models, global models and emissions models that provide the input data. Obstacles to such studies would include difficulty in rationalizing the use of poorly-performing or outdated model configurations in an effort to introduce multiple model predictions into the study—e.g., combining results based on new and old scientific understanding is undesirable. Also, the similarity among the state-of-the-science parameterizations of key processes would limit the scope of model diversity in the multiple-model study and could produce a misleading estimate of the diversity of possible outcomes. Finally, the combination of long simulation times for AQ models and the need for multiple simulations in a given regulatory application would present challenges for meeting regulatory deadlines in multiple-model studies. Current computational resources and air decision analysis timelines would almost preclude the use of multiple models in typical applications.