Using Dynamic Evaluation to Assess CMAQ Model Response Induced by Emissions Changes and Meteorological Variability (2.5)

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In efforts undertaken to demonstrate attainment of the ozone (O_3) standard, regional-scale air quality models are applied with potential emission control strategies in order to estimate pollutant response. A model performance evaluation is also typically performed using model-predicted concentrations with base case emissions to determine its ability to reproduce past observations. However, such an operational evaluation does not establish that a model will respond correctly to emission changes. A dynamic evaluation approach, which evaluates a model's ability to accurately simulate air quality changes related to actual changes in emissions, has been difficult until recently to undertake, yet it is critically relevant to regulatory applications.

A prototype dynamic evaluation effort has been undertaken to assess the Community Multiscale Air Quality (CMAQ) model's predicted O_3 response to substantial real-world NO_X point source emission reductions associated with the EPA's NO_X State Implementation Plan (SIP) Call program implemented from 2003 through May 2004 and to on-road mobile source emissions changes. The emission changes due to the NO_X SIP Call were well characterized from CEMS (Continuous Emissions Monitoring System) hourly measurements, and substantial changes were identified in observed O_3 levels. The selected modeling periods spanned three months (June, July, August), with summer 2002 representing the pre-NO_X SIP Call period. To consider the modeled response to emission changes in light of strong meteorological influences on O_3, two summer periods after the NO_X SIP Call (2004 and 2005) were included that exhibited very different meteorological conditions. Model configurations and inputs included the following: the CMAQ (v4.5) model with the CB4 and SAPRC99 chemical mechanisms, and CMAQ (v4.6) with CB05 chemistry; meteorological fields generated by the Penn State/NCAR Mesoscale Model (MM5 v3.6.3) with 4-D data assimilation (FDDA); and 3-D emissions from the SMOKE (v2.2) processing system. The National Emissions Inventory (NEI) 2001, adjusted to the particular modeling year, was used in simulations with the CB4 and SAPRC99 chemical mechanisms, while the more recent NEI 2002 and NEI 2005 were employed in the CB05 simulations. The MOBILE6 model estimated on-road vehicle emissions with projected VMT and control program information for a reference county only (CB4 and SAPRC99 runs), while the NEIs for 2002 and 2005 contained county-specific control program information. The hourly CEMS point source emissions data were available for each summer period, and the BEIS (v3.13) model generated biogenic emissions estimates.

The results of this first-of-its-kind dynamic evaluation revealed that the model tended to underestimate the maximum 8-h O_3 reductions observed after the NO_X SIP Call was implemented. Statistical results of relative (%) and absolute (ppb) observed and modeled changes for 2004 minus 2002 and 2005 minus 2002 in Gilliland et al. (2008) also indicated that the model predicted changes better at O_3 levels $\geq 95^{th}$ percentile than at the median of the distribution. The CMAQ model with CB05 using updated emission inventories showed incremental improvements in the modeled O_3 response to the NO_X emission reductions. While mobile emission uncertainties may be a factor, results of spatial correlation analysis (e-folding distances) and model comparisons with observations aloft suggest that the contribution of long-range transport of O_3 and precursors was underpredicted, especially when using the CB4 chemical mechanism.