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Application, Evaluation, and Process Analysis of the US EPA ' s 2002 Multiple-Pollutant Air Quality Modeling Platform

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ABSTRACT

A multiple-pollutant version of CMAQ v4.6 (i.e., CMAQ-MP) has been applied by the US EPA over continental US in 2002 to demonstrate the model ' s capability in reproducing the long-term trends of ambient criteria and hazardous air pollutants (CAPs and HAPs, respectively) in support of regulatory analysis for air quality management. In this study, a comprehensive model performance evaluation for the full year of 2002 is performed for the first time for CMAQ-MP using the surface networks and satellite measurements. CMAQ-MP shows a comparable and improved performance for most CAPs species as compared to an older version of CMAQ that did not treat HAPs and used older versions of national emission inventories. CMAQ-MP generally gives better performance for CAPs than for HAPs. Max 8-h ozone (O_3) mixing ratios are well reproduced in the O_3season. The seasonal-mean performance is fairly good for fine particulate matter ($PM_{2.5}$), sulfate (SO_4^{2-}), and mercury (Hg) wet deposition and worse for other CAPs and HAPs species. The reasons for the model biases may be attributed to uncertainties in emissions for some species (e.g., ammonia (NH_3), elemental carbon (EC), primary organic aerosol (POA), HAPs), gas/aerosol chemistry treatments (e.g., secondary or- ganic aerosol formation, meteorology (e.g., overestimate in summer precipitation), measurements (e.g., NO_3^-), and the use of a coarse grid resolution. CMAQ cannot well reproduce spatial and seasonal variations of column variables except for nitrogen dioxide (NO_2) and the ratio of column mass of HCHO/NO_2. Possible reasons include inaccurate seasonal allocation or underestimation of emissions, inaccurate BCONs at higher altitudes, lack of model treatments such as mineral dust or plume-in-grid process, and limitations and errors in satellite data retrievals. The process analysis results show that in addition to transport, gas chemistry or aerosol/emissions play the most important roles for O_3 or $PM_{2.5}$, respectively. For most HAPs, emissions are important sources and cloud processes are a major sink. Simulated P_{H_2} H_{O_2}/P_{HNO_3} and HCHO/NO_2 indicate VOC-limited chemistry in major urban areas throughout the year and in other non-urban areas in winter, but NO_x-limited chemistry in most areas in summer.

KEYWORDS

Multi-Pollutant; Air Toxics; Model Evaluation; Process Analysis

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