On the Linkage of Global and Regional Models to Assess Climate Change–Air Quality Interactions (4.1)

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Air quality is determined both by emissions of hydrocarbons and oxides of nitrogen and by meteorological conditions, including temperature, wind flow patterns, and the frequency of precipitation and stagnation events. For air quality management applications, regional-scale models are used to assess whether various emission control strategies maintain compliance with the National Ambient Air Quality Standards (NAAQS). These modeling applications typically assume present meteorological conditions, which means that potential changes in climate are not included in the assessment. With emission controls that are implemented over several decades, future climate trends could impact the effectiveness of these controls, which could cause failures to comply with the NAAQS. AMAD initiated the Climate Impact on Regional Air Quality (CIRAQ) project in 2002 to develop a pilot modeling study to incorporate regional-scale climate effects into air quality modeling. It involved collaboration with several academic groups with global-scale modeling expertise, which were supported through the EPA Science To Achieve Results (STAR) grant program. A partnership was also established with the Pacific Northwest National Laboratory (PNNL) to develop regional climate scenarios. Evaluation of the regional climate model (RCM) results identified biases in the RCM's predicted surface temperature under the current climate as compared to "standard" meteorological simulations with data assimilation of meteorological observations. While issues such as temperature biases were identified, precipitation biases were actually lower than in "standard" meteorological predictions, which is notable because precipitation is not included in the data assimilation. Evaluation of the CMAQ air quality predictions showed that meteorological biases were not the dominant influence on O_3 biases; rather, it was the SAPRC chemical mechanism. CMAQ results under the future RCM scenario result in average O_3 increases of approximately 2-5 ppb and 95th percentile (i.e., 4th highest) O_3 increases greater than 10 ppb in some regions. RCM changes in temperature and solar radiation reaching the surface appear to be the largest meteorological factors influencing these modeled increases. Model sensitivity tests show that if the O_3 boundary conditions had not gone down in the global chemistry model under future climate, these O_3 increases would have been even larger. Further, with methane concentrations increased to the levels assumed in the Intergovernmental Panel on Climate Change (IPCC) A1B scenario, the increase in modeled O_3 is larger than the increase caused by higher biogenic emissions of isoprene. Based on the issues raised and predominant sensitivities identified in this pilot study, new efforts are underway to develop a robust series of regional climate simulations with more advanced global climate models (GCMs) and a range of future emission scenarios.

The CIRAQ study contributed directly to the EPA Office of Research and Development report *Assessment of the Impacts of Global Change on Regional U.S. Air Quality*, which was led by the National Center for Environmental Assessment. Additionally, results from CIRAQ were included in the U.S. Climate Change Science Program (CCSP) Synthesis and Assessment Product (SAP) 3.2 *Climate Projections Based on Emissions Scenarios for Long-Lived and Short-Lived Radiatively Active Gases and Aerosols.*