Title: Modeling Aerosol Formation and Transport in the Pacific Northwest Region with the Community Multi-Scale Air Quality (CMAQ) Modeling System

Authors: Jack Chen, Susan M. O'Neill, and Brian K. Lamb

Department of Civil and Environmental Engineering
Washington State University, Pullman WA

Abstract:

The Community Multi-Scale Air Quality (CMAQ) Model was selected to study aerosol formation and visibility for the Pacific Northwest Region. The model uses RADM2 gas chemistry and the aerosol module to predict ozone and visibility impairment in the area. The model domain encompasses the states of Washington, Oregon and Idaho, and portion of southwestern Canada at 12km resolution and 16 vertical layers. The scenario covered the July 1-15, 1996 period. Anthropogenic emissions were developed for this project by the participating state agencies and processed with SMOKE processor. The biogenic emissions were generated from the GLOBEIS biogenic emission model. Meteorology data was generated using the MM5 Meteorological Model with four-dimensional data assimilation (FDDA) analysis nudging.

CMAQ results were compared with observational data from 12 IMPROVE observation sites. It was found that the CMAQ over-predicted PM2.5 mass concentrations with a normalized bias of 93% and normalized gross error of 98%, but performed well for PM10 with normalized bias of 37%, and normalized gross errors of approximately 50%. For the inorganic aerosol components, the solution tended to over-predict sulfate (SO_4^{2-}) with a normalized bias of 86% and under-predict nitrate (NO_3^-) with a normalized bias of –72%. For combined organic carbon (OC), the solution had a normalized bias of 44% and a gross normalized error of 54%.

Sensitivity analyses on anthropogenic and biogenic emissions were performed for the region. The study focuses on changes in aerosol formation due to changes in anthropogenic and biogenic emissions. The simulations were run with domain-wide, stepwise adjustments of primary aerosol and gas precursor emissions at $\pm$25%, $\pm$50% and $\pm$100%. It was found that organic aerosol formation is linearly related to changes in VOC and most sensitive to changes in biogenic terpene emissions. For percent changes in primary aerosol emissions, there is less change in modeled secondary aerosol formation compared to the effects of percent changes in aerosol gas precursors. For inorganic aerosols, the results vary greatly depending on the local total ammonium to total sulfate molar ratio. When the ratio is much greater than 2 and has high nitrate, the area is sensitive to changes in NH_3 and NOx emissions and less sensitive to changes in SO_2; when the ratio is less than 2 with low nitrates, the area is more sensitive to changes in SO_2 emission and less or negative changes in NOx and NH_3 emissions.