A Case Study of Aerosol Data Assimilation with the Community Multi-Scale Air Quality Model over the Contiguous United States using 3D-Var and Optimal Interpolation Methods

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Abstract

This study applies the Gridpoint Statistical Interpolation (GSI) 3D-Var assimilation tool originally developed by the National Centers for Environmental Prediction (NCEP), to improve surface $PM_{2.5}$ predictions over the contiguous United States (CONUS) by assimilating aerosol optical depth (AOD) and surface $PM_{2.5}$ in version 5.1 of the Community Multi-scale Air Quality (CMAQ) modeling system. An optimal interpolation (OI) method implemented earlier (Tang et al., 2015) for the CMAQ modeling system is also tested for the same period (July, 2011) over the same contiguous United States (CONUS). Both GSI and OI methods assimilate surface $PM_{2.5}$ observations at 00, 06, 12, and 18UTC, and MODIS AOD at 18 UTC. The assimilations of observations using both GSI and OI generally help reduce the prediction biases, and improve correlation between model predictions and observations. In the GSI experiments, assimilation of surface $PM_{2.5}$ leads to stronger increments in surface $PM_{2.5}$ compared to its MODIS AOD assimilation at the 550nm wavelength. In contrast, we find a stronger OI impact of the MODIS AOD on surface aerosols at 18 UTC compared to the surface $PM_{2.5}$ OI method. GSI produces smoother result and yields overall better correlation coefficient and root mean squared error (RMSE). It should be noted that the 3D-var and OI methods used here have several big difference besides the data assimilation schemes. For instance, the OI uses the relatively big model uncertainties, which helps yield smaller mean biases, but sometimes causes the RMSE increase. We also examine and discuss the sensitivity of the assimilation experiments results to the AOD forward operators.