Title

Improving short-term air quality ($PM_{2.5}$) predictions over the U.S. using chemical data assimilation

Authors

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Abstract

Decision-makers across the United States use air quality predictions from the National Air Quality Forecasting Capability (NAQFC) at the National Oceanic and Atmospheric Administration (NOAA) as one of the key tools to protect the public from adverse air pollution-related health effects by dispensing timely information about air pollution episodes. This project aims to enhance the decision-making process by improving the accuracy of NAQFC short-term predictions of ground-level particulate matter of less than 2.5 μm in diameter ($PM_{2.5}$) by exploiting National Aeronautics and Space Administration (NASA) Earth Science Data with chemical data assimilation. The NAQFC uses the Community Multiscale Air Quality (CMAQ) model as the air quality prediction model. We developed a new capability in the community Gridpoint Statistical Interpolation (GSI) system to assimilate Terra/Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth (AOD) retrievals in CMAQ in order to improve the initialization of $PM_{2.5}$ in CMAQ. In contrast to previous studies that only consider errors due to transport, our computation of the background error covariance matrix incorporates uncertainties in anthropogenic emissions. To understand the impact of this approach, three experiments (one background and two assimilation) are performed over the contiguous United States (CONUS) from 15 July to 14 August 2014. The background CMAQ experiment significantly underestimates both the MODIS AOD and surface $PM_{2.5}$ levels. MODIS AOD assimilation pushes both the CMAQ AOD and surface $PM_{2.5}$ distributions towards the observed distributions but CMAQ still underestimates the observations. Averaged over the CONUS, the two assimilation experiments with and without including the anthropogenic emission uncertainties improve the correlation coefficient between the model and independent observations of $PM_{2.5}$ by ~67% and ~48%, respectively, and reduces the mean bias by ~38% and ~10%, respectively. The assimilation improves the model performance everywhere over the CONUS, except for New York and Wisconsin, where CMAQ overestimates the observed $PM_{2.5}$ during nighttime after assimilation, most likely because of an overcorrection of aerosol mass concentrations by the AOD assimilation.