Satellite Cloud Assimilation and its Impact on Air Quality Simulations

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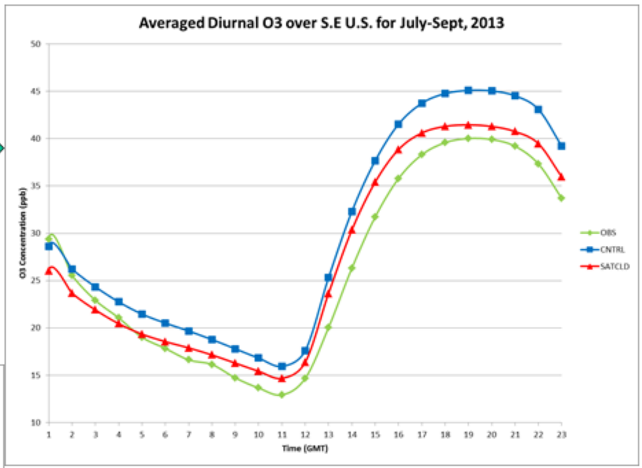
Clouds have a significant role in tropospheric chemistry as they modulate photolysis rates, affect biogenic hydrocarbon emissions, impact boundary-layer development, lead to deep vertical mixing of pollutants and precursors, and induce aqueous phase chemistry. Numerical meteorological models have difficulty in creating clouds in the right place and time compared to observed clouds. This is especially the case when synoptic-scale forcing is weak, as often is the case during air pollution episodes. Consequently, poor representation of clouds affects the photochemical model's ability in reproducing the tropospheric chemical state. One way to improve model cloud simulation is data assimilation. Since satellites provide the best observational platform for defining the formation and location of clouds, satellite observations can be of great value in retrospective simulations.

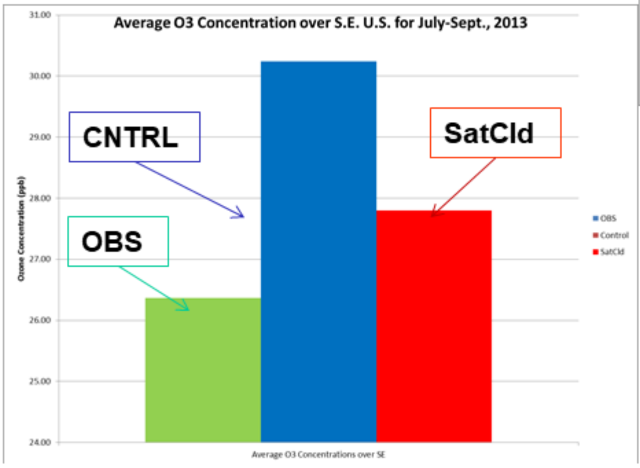
In this study, a new technique is used to assimilate derived cloud fields from the Geostationary Operational Environmental Satellite (GOES) in the Weather Research and Forecasting (WRF) model. The improved meteorological fields, including simulated clouds, are subsequently used for emissions estimates and to drive the Community Multiscale Air Quality (CMAQ) photochemical model. Based on GOES observations, the assimilation technique dynamically supports cloud formation/dissipation within WRF. The technique uses observations to identify model cloud errors, estimates a target vertical velocity and moisture needed to create/remove clouds, and adjusts the flow field accordingly. The technique was tested in air quality simulation over the period of August-September 2013 (NASA's Discover-AQ field campaign). The cloud assimilation on the average improved model cloud simulation by 15% over this period. The cloud correction not only improved the spatial and temporal distribution of clouds, but it also improved boundary layer temperature, humidity, and wind speed. These improvements in meteorological fields substantially improved the air quality simulations by altering the biogenic VOC emissions and by correcting the photolysis rates. Cloud correction reduced isoprene and monoterpene emissions over the southeastern U.S. by 10-20% and improved ozone predictions. Ozone bias over the southeastern United States was reduced by 63%. Preliminary results from this activity will be presented.

Keywords: Air Quality, Satellite Cloud Assimilation, WRF/CMAQ, Biogenic VOC Emission, Ozone Chemistry, Numerical Modeling

Impact of Cloud assimilation on Ozone Concentration

Significant daytime improvement for O3 over S.E. U.S. during summer of 2013.





63% reduction in bias for ozone over S.E. U.S.