First inversion of aerosol emissions from satellite radiances

XIAOGUANG XU[1], JUN WANG[1] AND DAVEN K. HENZE[2]

[1]Univ. of Nebraska-Lincoln, Lincoln, NE 68588, USA (xxu@huskers.unl.edu, jwang7@unl.edu)

[2]Univ. of Colorado-Boulder, Boulder, CO 80309, USA (daven.henze@colorado.edu)

Aerosol optical depth (AOD) retrievals from satellite remote sensing are ideal resources to constrain aerosol emissions through inverting a chemical transport model (CTM). However, direct use of satellite AODs in the inversion can be compromised by the inconsistency in the aerosol single scattering properties between satellite retrieval process and CTM simulation. In this study, we attempt to optimize aerosol emissions using satellite-level radiances, instead of AODs, in combination with the GEOS-Chem adjoint model. Our inversion approach involves two steps. First, AOD values on each 10 km × 10 km pixel are retrieved by fitting the calculated radiances based on GEOS-Chem aerosol composition and optical properties to the satellite (MODIS) cloud-free radiances. Second, species-specific aerosol emissions on each model grid are constrained with the retrieved AODs from the first step through GEOS-Chem adjoint. Since the aerosol single scattering properties used in the AOD retrieval are accorded with those used in the inversion, our approach essentially uses the MODIS radiances to constrain the aerosol emissions.

We illustrate our inversion approach first with an idealized numerical experiment and subsequently demonstrate its feasibility by applying it to optimize emission inventories over China during April 2008. Specifically, we use MODIS radiances to constrain monthly emissions of BC and OC as well as gaseous processors (SO_2, NH_3, and NO_x) from anthropogenic sources at 2° × 2.5° grids. Mineral dust productions from the Gobi and deserts are also optimized at the same spatial resolution but with a daily temporal resolution. Independent observations from both satellite remote sensing and ground-based platforms are used to assess the inversion results through their comparison with relevant GEOS-Chem simulation using prior and posterior emission estimates. The statistical analysis of such comparisons show remarkably better agreements in the posteriori simulation, confirming the improvements in the posterior emission estimates and the effectiveness of the presented inversion approach.