Interpreting the OMI ultraviolet Aerosol Index to understand absorption by organic carbon aerosols and implications for atmospheric oxidation

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Summary
We develop a simulation of the ultraviolet Aerosol Index (AI) using the Vector Linearized Discrete Ordinate Radiative Transfer model (VLIDORT) coupled with GEOS-Chem aerosol fields. The simulation is used to interpret AI observations from the Ozone Monitoring Instrument (OMI). There is good agreement between simulated and observed values in regions where mineral dust dominates the AI, but a large negative bias exists in biomass burning regions. The addition of absorbing brown carbon (BrC) to the model decreases the overall mean bias between simulated and OMI AI values over major biomass burning regions from -0.52 to +0.004. The inclusion of BrC in the model decreases tropospheric OH concentrations by up to 20% over major biomass burning regions, reducing the overestimate of OH concentrations compared to observations.

Introduction
Biomass burning aerosols consist mainly of black and organic carbon. Traditionally, black carbon is assumed to be the sole absorbing carbonaceous aerosol species in models. Several recent studies have found evidence of absorption by a subset of organic carbon known as “brown carbon” (BrC), which is thought to contribute significantly to the overall absorption by biomass burning aerosol. We introduce BrC to GEOS-Chem and examine its effect on aerosol absorption in biomass burning regions.

Aerosol Index (AI)
- The AI is a method of detecting absorbing aerosols from satellite measurements, and is a product of the Ozone Monitoring Instrument (OMI) [Torres et al., 2007, 2013].
- The AI is calculated by comparing the spectral radiance of the sun to Rayleigh scattering at two wavelengths (354 and 388 nm) in the near-UV region.

Simulation
We follow the method of Buchard et al., (2014) for simulating the AI using the vector radiative transfer model VLIDORT (Spurr 2006).

Comparing Base Case Simulation to OMI AI
- The base case simulation of the AI, including scattering organic carbon as currently used in GEOS-Chem, is compared to corresponding OMI observations.
- The simulation captures major absorption features compared to OMI over desert regions, however it fails to capture absorption by biomass burning aerosols.
- The correlation between the simulated and OMI AI is low in all major biomass burning regions with large mean biases.

Comparing Simulation Including BrC to OMI AI
- BrC is introduced to the simulation by constraining the imaginary part of the refractive index for primary organic carbon (POC) between 300 and 500 nm using the spectral dependence of absorption recommended in the literature and the OMI AI.
- All other properties of BrC are assumed to be the same as the scattering POC currently used in GEOS-Chem.

Effect of BrC Absorption on OH Concentrations
- The figure below shows the percent changes in OH concentrations in the lower troposphere due to the addition of absorbing brown carbon to the GEOS-Chem simulation.
- The tendency of models to overestimate OH concentrations [Mao et al., 2013] is reduced.

OH concentrations decrease by up to 20% over the major biomass burning regions.

References