Comparing measurements with model derived Black Carbon and AAOD based upon AEROCOM, GFED, and Kalman Filter optimized BC emissions: what can we do well and what do we still need to improve?

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Black Carbon (BC) and other absorbing aerosols have a unique impact on the climate system by both scattering and absorbing solar radiation. This leads to a simultaneous cooling effect at the surface and warming effect in the atmosphere, which is different from that of scattering aerosols, such as much of Organic Carbon and Sulfate aerosols, which lead to a cooling at the surface. Because of these reasons, a critical understanding of the emissions, processing, transport, and removal are necessary to increase our understanding of the impacts of aerosols on climate system.

Focusing on absorbing aerosols helps to reduce the complexity of the problem, since only a fraction of aerosols are absorbing, and the primary components can roughly be represented by dust and anthropogenic BC. However, even just BC is tricky to model: it has highly variable emissions in both space and time as urban areas change their characteristics, nations develop, and fires and agricultural clearing are ever changing. Furthermore, once in the atmosphere, the chemical and physical processing often involves interaction with third-party chemical species. Finally, since BC's primary removal mechanism is precipitation, areas that have strong and variable precipitation, such as the Monsoon regions of Asia, are likely to pose a greater modeling challenge.

Recent work, however, has lead to two separate approaches to estimate the impact of absorbing aerosols on a regional to global basis. One has shown that the levels of atmospheric absorption are higher than current bottom-up emissions approaches can achieve by using remotely sensed data, while the other has used surface retrieved and sensed data, in conjunction with a Kalman Filter technique, to show that considerably higher emissions are required to form a match with these measurements. (1,2)

The emissions of BC fall from the latter study fall in the range from about 200% to 300% the emissions currently used by AEROCOM and GFED. (2,3,4) Therefore, to test whether or not this makes an important difference in the modeled fields of BC concentrations and AAOD, it is important to run all three sets of emissions through the same modeling system, using the same meteorology and making sure that all over conditions are the same. This has been done using the MIT-AERO-CAM modeling system, which is based on the CAM3 GCM coupled with a two-moment core-shell aerosol, an interactive radiation model, and a fast urban-scale chemical and physical process model (5,6,7). The previous Kalman Filtering results were obtained using this model, as well as results showing that the BC mixing state, and secondary formation of sulfate both play a large role in the radiative forcing. (2,8)

Finally, the modeled results for the different emissions will not only be compared against existing data used for the optimization, but also different data meant to highlight the time and spatially varying components (9). This allows for a true test of not only the performance under annual or long-term average conditions to be examined, but also how the different emissions deal with the issues of biomass burning, agricultural burning, and the alteration of absorbing aerosols as a function of the environmental temperature, precipitation, and other background pollutants. Furthermore, by using an additional source of data as compared to those used to optimize the emissions, it is expected that the importance of optimizing for the time-varying and mean state changing component can be better quantified.

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