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Combining Inverse Modelling and Remotely Sensed Data to Deduct Fire-Induced Emissions of BC and OC

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A significant portion of global Black Carbon (BC) and Organic Carbon (OC) aerosols are emitted into the atmosphere due to fires. Because of the nature of fires being highly variable, these emissions are heterogeneously distributed over space in time. However, due to both the large amount of BC and OC emitted, and the properties of these aerosols, the impact that these fires have on the radiation balance and ultimately the climate system is unique. Furthermore, once emitted into the atmosphere, a critical understanding of their processing, transport, and removal of these aerosols are necessary to increase our understanding of their loadings, properties, and ultimately their impacts on climate system, through both scattering and absorption of solar radiation. Additionally, because of their overlapping sources, both the component associated with fire as well as other anthropogenic sources need to be studied and considered within the same framework.

Recently completed work has used a Kalman Filter based on a coupled climate/radiation/aerosol/urbanization model, and data consisting of BC concentrations and remotely sensed AAODs. This work has produced the first global average estimate and uncertainty of annual BC emissions. This result produced an optimized range for BC emissions ranging from 200% to 300% the emissions currently used by the IPCC, AEROCOM, and Bond et al. However, an important point in these results is directly related to the study of fires: the emissions, concentrations, and AAODs in an annual average sense are significantly underestimated in only a few geographic regions, two of which are impacted by large-scale fire sources.

Therefore, it is clear that emissions from fires are a possibly important component in understanding this underestimation. To better address this, recent work has taken into account the impact of fires on this annual average contribution, as well as its time varying component. By using a decadal time series of satellite AOD measurements, and a new analysis technique, the impact of fires has been both identified and constrained over one of these two critical areas: Southeast Asia. In fact, the unique temporally and spatially varying properties correspond one-to-one with the known large-scale fire events in Southeast Asia over the past decade.

These new constraints have then been combined to form a new set of a-priori emissions for both BC and OC, varying in space and time. Running these new results through the same modelling system allows for a comparison against known datasets, both those used to produce the initial inversion, as well as others not involved with the inversion. These results will be presented, and demonstrate that annual average, inter-seasonal, and inter-annual variations can be captured with this new technique. However, using other commonly used fire-based a-priori emissions sets, specifically based on GFED and MODIS fire radiative power, as well as annual average emissions datasets, and cannot properly capture these variations.

It is hoped that such quantification can lead to further improvement of the emissions from and impacts of large scale human induced fires on the atmosphere and ultimately on the climate system.