Mesoscale modeling of aerosol transport over Southeast Asia during the dry season: effects of fire and new emissions

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In general, biomass burning is considered to make a significant and continuously increasing contribution to anthropogenic aerosol emissions over the South Asia, Southeast Asia, and East Asia. Observed large-scale aerosol events are frequently related to local biomass burning which have a significant impact on the regional atmosphere, the climate, the ecosystem, and human health. Meanwhile, biomass burning is also a major source of multiple trace gases into the atmosphere and affects the formation of atmospheric chemicals, such as ozone, VOCs, SOA and so on.

Due to the fact that biomass burning has a very strong periodicity (annual or even bi-annual in general), the effects of biomass burning aerosols may be climatologically small, but quite important on a specific regional or seasonal basis. The focus of this work therefore is to quantify the aerosol source and transmission path during a typical biomass burning season. During the dry season (January-April) in northern Southeast Asia, a large amount of aerosols are released into the atmosphere. A large number of studies have proved that these aerosols move eastward under the influence of the Indian Ocean monsoon, but due to thousands of kilometers of cloud cover, there has not been a consistent message in terms of how far downwind these can transport, as detected by satellite. Therefore, we expect the actual transport of aerosol is much higher than predicted by the current generation of models which do not use our newly derived aerosol emissions geospatial products.

This work uses a completely new method to enhance the model’ s ability to reproduce the spatial and temporal distribution of total aerosol emission over Monsoon Asia during the extreme fire burning season in 2016. At the same time, this method is considered reliable by comparing ground stations and satellite data, as the description of aerosol distribution is one of the weaker aspects of atmospheric science. This new approach allows us to more accurately predict aerosol plume emissions heights through a deeper understanding of the physical mechanisms of aerosol motion and formation. In turn, through sensitivity analysis, this paper provides a new perspective to reduce the uncertainty (dynamic mechanisms, multi-data coupling, etc.) of the model's ability to accurately transport aerosols thousands of kilometers downwind.

We find that ground and column observations throughout Southeast and East Asia are most consistent with our model results using the new blended emissions. Next, we conclude that the impact of biomass burning coincides with the highest aerosol loadings of the year in many locations. Third, we find that in regions far downwind, that many measured local peaks occur at the same time that aerosols have been transported downwind from the burning regions. The results show that first, a significant amount of the smoke is lofted into the lower free Troposphere and subsequently transported thousands of kilometers downwind. Second, a significant increase in biomass burning emissions were observed when using a blend of multiple remotely sensed measurements, leading to a new approximation several times the current inventory. Finally, compared with existing inventories, the use of these multiple techniques leads to a better spatial and temporal match with measured peak aerosol events.

Keywords: aerosol transportation, WRF-CHEM, emission inventory

