

## **Simultaneously combining AOD and multiple trace gas measurements to identify decadal changes in urban and biomass burning aerosols**

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This work presents a methodology by which to comprehensively analyze simultaneous tropospheric measurements of AOD and associated trace gasses. It then applies this methodology by focusing over the past 11 years (2006-2016) on one of the most rapidly changing regions of the troposphere: Eastern and Southeastern Asia. The specific work presented incorporates measurements of both aerosol and related gas phase tropospheric measurements across different spectral, spatial, temporal, and passive/active sensors and properties, including: MODIS, MISR, OMI, CALIOP, and others.

This new characterization reveals a trio of new information, including a time-invariant urban signal, slowly-time-varying new-urbanization signal, and a rapidly time-varying biomass burning signal. Additionally, due to the different chemical properties of the various species analyzed, analyzing the different spatial domains of the resulting products allows for further information in terms of the amounts of aerosols produced both through primary emissions as well as secondary processing. The end result is a new characterization, in space, time, and magnitude, of both anthropogenic and biomass burning aerosols.

These results are then used to drive an advanced modeling system including aerosol chemistry, physics, optics, and transport, and employing an aerosol routine based on multi-modal and both externally mixed and core-shell mixing. The resulting characterization in space, time, and quantity is analyzed and compared against AERONET, NOAA, and other ground networks, with the results comparing consistently to or better than present approaches which set up net emissions separately from urban and biomass burning products.

Scientifically, new source regions of emissions are identified, some of which were previously non-urbanized or found to not contain any fire hotspots. This new approach is consistent with the underlying economic and development pathways of expanding urban areas and rapid economic growth throughout Southeast and East Asia. Furthermore, findings are made which are consistent with many individual previous studies, such as the significance of vertical transport and subsequent long-range transport throughout the Northern Hemisphere, and the intra-annual and inter-annual variations in fires due to El-Nino. Such knowledge can allow us to better understand the consequences and impacts of the rapid ongoing changes occurring in these regions.