Remote Sensing of Particulate Matter Air Quality using Geostationary and low earth orbiting satellite data

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Satellite imagery over the last several decades have provided spectacular views of dust storms, biomass burning smoke, and pollution aerosols near and far downwind of source regions. However, the effect on tropospheric aerosols near the surface is perhaps the most pressing issue, especially PM2.5 which is particulate matter with aerodynamic diameters less than 2.5 µm. In fact, the Global Burden of Disease (GBD) project of the Institute for Health Metrics and Evaluation (IHME) ranks ambient PM2.5 as the 6th-highest risk factor for early death. Also, the World Health Organization assessments indicate that more than 2 million deaths occur each year due to outdoor and indoor air pollution and more than half of this population lives in developing nations. Traditionally, PM$_{2.5}$ is measured from ground-based instruments such as the Tapered Element Oscillating Microbalance (TEOM). Even though some nations have a good network of ground monitors they still cannot provide adequate coverage especially in regions that are not well populated. In most countries, monitoring is probably not a priority and measurements could vary from non-existent to very few monitors although recently there is a proliferation of low-cost sensors. However, it is indeed promising that the number of ground monitors have increased over the last decade and there are nearly 4000 monitors across the globe for which data are publicly available. The research community has long recognized that ground monitors alone are inadequate for providing a global picture of PM$_{2.5}$ especially since a vast of population centers have no ground-monitoring networks. Therefore, other data sets are used to fill the gaps and complement the ground monitors. Satellite data by far offers the best solution for monitoring global air quality at spatial and temporal scales that are not possible by other means. Converting the column AOD to surface PM$_{2.5}$ has been a subject of numerous studies and methods range from simple liner regression to complex statistical methods and machine learning approaches. We will use low earth orbiting and geostationary data sets coupled with meteorological data sets and ancillary information to demonstrate the progress and potential of satellite data for estimating PM2.5.