Exploring the Potential of Satellite Data for Air Quality Applications

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Introduction
Particulate matter or aerosols, reduce visibility, affect human health, and also cause several ecological effects. As defined by Environment Protection Agency (EPA), the dry mass content of particular matter with aerodynamic diameter less than 2.5µm (PM2.5) in the atmosphere is an important parameter for the evaluation of air quality. However, the large spatio-temporal variations of particular matter make it a challenge to judge the air quality and issue prompt health alert from the current ground-based measurement network, especially when the aerosol events come from sources outside the U.S. The launch of EOS TERRA and Aqua satellites provides an unprecedented opportunity to monitor air pollution over the globe. The intent of this study is to explore the potential of satellite aerosol datasets for air quality applications.

Hypothesis
Aerosols with diameters around 1-2µm are efficient in scattering the visible light. During MODIS passing time (locally, 10:30AM for Terra and 2:30PM for Aqua) in cloud-free conditions, the atmospheric boundary layer is well mixed. Hence, the MODIS visible reflectance and its column aerosol optical thickness (AOT) retrievals can be used as indicators of the PM2.5 mass at the surface.

Methodology
Compare MODIS AOT with the ground-based PM2.5 hourly measurements. For each comparison, MODIS AOT time is centered around the PM2.5 observation time period.

Data and Study Area
1) MODIS AOT from TERRA and AQUA, 2002.
2) PM2.5 measured from Tapered-Element Oscillating Microbalance (TEOM) in Alabama and Texas. 3) Sunphotometer data in Stennis, MS. 4) EPA PM2.5 analysis and extinction analysis from IMPROVE measurements.

Quantitative Inter-comparison between PM2.5 and MODIS AOT

Figure 1: (a) Study area with locations (filled circle) of the seven PM2.5 sites in Jefferson County (shaded area), AL. The triangles show major power plant locations. The upper left inset shows all counties in AL and the upper panel shows the monthly PM2.5 concentration (µm-3) as a function of month in 2002. (b) Monthly variation of PM2.5 and MODIS and Sunphotometer (SP) AOT, inset shows the standard deviation of PM2.5 and AOT centered in the mean value (red filled circle) in each bin. The red line in the box shows the median value in each bin.

(1) PM2.5 mass vs. MODIS AOT in Jefferson County, AL. The comparison shows MODIS AOT has a good positive correlation with PM2.5, which can be used to identify air quality category (e.g., good, moderate, unhealthy, etc) with high accuracy (>95%).

Conclusion
Using one year of the MODIS AOT from the TERRA/AQUA satellites colocated with hourly particular matter mass measured at about 40 ground stations over Alabama and Texas, we show that
• The MODIS AOT has a good positive correlation with PM2.5 mass (linear coefficient around 0.7).
• Through statistical analysis, the MODIS product can be used to discern air quality categories such as MODIS AOT centered in the mean value (red filled circle) in each bin.

• However, we would like to outline several factors that could affect the relationship between PM2.5 and satellite-derived AOT. These factors include vertical distribution, optical and hygroscopic properties of aerosols. Aerosol extinction profile from ground-based lidars or from satellite measurements such as CALIPSO are highly important for further enhancing the use of satellite data for air quality studies.

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