Exploring the Potential of Satellite Data for Air Quality Applications

Sundar A. Christopher* and Jun Wang
University of Alabama in Huntsville, Huntsville, Alabama
* [sundar@nsto.uah.edu]

Introduction

Particulate matter or aerosols, reduce visibility, affect human health, and also cause several ecological effects. As defined by Environmental 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 in particulate 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 to 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 (µg/m3) as a function of month in 2002. (b) Relationship between MODIS aerosol optical thickness and PM2.5 mass, (c) Monthly variation of PM2.5 and MODIS and Sunphotometer (SP) AOT, inset shows the diurnal variations (in Central Standard Time, CST) of PM2.5 in different seasons, (d) Air Quality Index (AQI) derived from MODIS data. The box shows the ±1 standard deviation of PM2.5 and AQI centered in the mean value (red filled circles) in each bin. The red line in the box shows the median value in each bin.

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 time analysis, the MODIS AOT product can be used to discern air quality categories such as CALIPSO are highly important for further enhancing the use of satellite data for air quality studies.

• This study implies that assimilation of MODIS AOT has the potential to improve the air quality forecasts.

References:


Acknowledgements

This research was supported by NASA’s Radiation Science Interdisciplinary and ACMAP programs. The MODIS data were obtained through the NASA/GSFC Data Center and the atmospheric data was obtained from NASA-ERL, GSFC. We thank the U.S. Environmental Protection Agency and the U.S. Geological Survey for providing the hourly PM2.5 data. We also thank Dr. McNider for his continuing encouragement. For more information, please visit http://www.nsstc.uah.edu/~sundar/publications.html. The images of IMPROVE extinction and PM mass analysis in U.S. are from http://www.cira.colostate.edu/improve, and http://www.epa.gov/airquality/aqi/index.html.