A New Approach to Compute $PM_{2.5}$ for Health Impact Analysis

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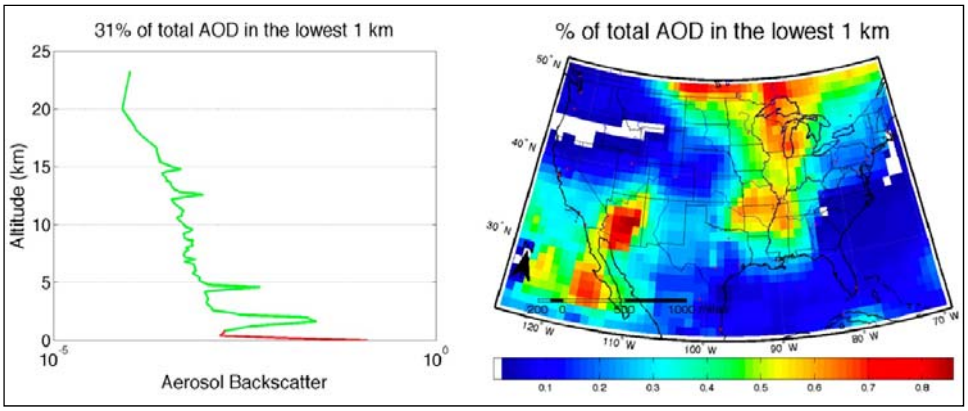
Among air pollutants, particulate matter 2.5 microns in diameter and less ($PM_{2.5}$) is one of the most serious health concerns because these tiny particles can penetrate deeply into the lungs and other body organs, thereby increasing the risk for respiratory illnesses, cardiovascular disease, cancer, and even low birth weight.



CALIPSO data model shows vertical distribution of AOD over Jackson, Mississippi with red line representing the boundary layer which on a particular day represents 31% of total AOD (left) and the significant spatial variations of the % of total AOD in boundary layer across the US (right).

PM2.5 currently is measured primarily by ground monitoring stations located at EPA designated sites, which are very sparse and provide limited geographic coverage. However, there are satellites that make a variety of aerosol observations and provide a daily global picture of atmospheric particulates in the form of aerosol optical depth (AOD). Scientists have attempted to use these AOD data to estimate ground-level $PM_{2.5}$ (GLP) within the Earth's boundary layer, the layer of concern for health that typically extends about 1 km from the surface. However, the multivariate nonlinear relationship between AOD and $PM_{2.5}$ imposes limitations in computing GLP using satellite data. This project proposes to overcome these limitations by computing reliable GLP via a new methodology which has already been tested and validated.

The NIH funded study has two specific aims: (1) develop satellite-derived daily GLP estimates for the contiguous U.S., and (2) examine spatial and temporal associations between GLP exposure and hospital visits for asthma exacerbation in Mississippi. Using our methodology, we will generate daily GLP data for at a resolution of 0.1°x0.1° (~10x10km^2), providing approximately 82,000 data points as opposed to about 300 data points available daily from EPA ground monitoring stations within the contiguous U.S. We will address the nonlinear relationship between $PM_{2.5}$ and AOD which is a function of humidity, temperature, surface pressure, surface wind speed, surface type, boundary layer height, and AOD by accounting for these variables using a machine learning process. The AOD that will be used in this process will be generated by merging AOD data from multiple satellite sensors. Meteorological data will come from NOAA NCEP. Surface type data will be obtained from the satellite-identified vegetation index. Boundary layer height, which is the mixed layer of the atmosphere closest to the ground where people live and work, will come from CALIPSO data which provides vertical profiles of atmospheric aerosol extinction.

Information on GLP levels will allow the scientific community to better understand health impacts from exposure to low, moderate, or high levels of $PM_{2.5}$. Moreover, in places where $PM_{2.5}$ levels are elevated only occasionally, such as Mississippi, the short-term health impact of increases in PM2.5 can be studied more precisely. National GLP data will be made available to other researchers to facilitate future explorations of how PM2.5 exposure impacts a wide range of health conditions, thereby making possible more timely prophylactic treatment, improving healthcare system preparedness, and better informing public health policymaking.