Investigation of Decadal Changes in Aerosol and Asthma

Abstract:

Aerosols, particles of various size and composition suspended throughout our atmosphere, affect both the climate and our health. The amount emitted by both anthropogenic and natural sources changes with time, contributing to the variability of the aerosol. Changes in aerosol composition and size alter the aerosol single scattering albedo (SSA), a measure of how much light is reflected by the aerosol. We observed a decrease in SSA at three locations on the eastern seaboard, and believe sub-micron elemental carbon (EC) may be responsible for this change. In addition to their climatic impact, aerosols can also have adverse health effects. Studies inquiring into the relationship between air pollution and asthma have yielded conflicting results. Differences in size distribution and composition may have more of an effect on asthma than simply the concentration of the aerosol.

Introduction:

Aerosol particles range in size, but the focus of our research is particles ranging from 0.1 microns to ten microns. Most aerosols exist in the troposphere and are washed out of the atmosphere within a week by rain, but some, such as volcanic aerosols, are injected directly into the stratosphere, where their residence time is longer. Aerosols are classified into two groups based on their climatic effects: those that reflect incoming radiation, cooling the atmosphere, and those that absorb it, warming the atmosphere. This can be attributed mostly to their chemical composition. Of particular interest in our research is the extent to which EC affects the aerosol SSA, as EC is highly absorptive.

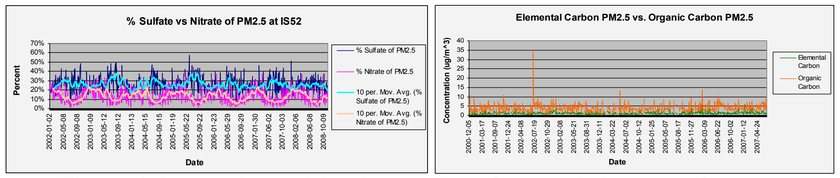

Figure 1 Comparison of the time series of aerosol nitrate, sulfate (right panel, note annual cycle) and carbon (left panel, note effect of one-time events) mass fraction.

Over the last few decades, numerous studies have been conducted to discern a correlation between particulate matter and asthma. One such study was the Six Cities Study, in which mortality rates from air pollution in six U.S. cities were collected. It suggested that fine particulate matter was responsible for asthma related deaths. However, other studies find no correlation between air pollution and asthma. Because of this, more recent studies have looked for a link between the composition of the aerosol and asthma.

Sponsors:
National Aeronautics and Space Administration (NASA)
NASA Goddard Space Flight Center (GSFC)
NASA Goddard Institute for Space Studies (GISS)
NASA New York City Research Initiative (NYCRI)
Columbia University

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Materials:

- EPA data from: http://www.epa.gov/air/index.html
- IMPROVE speciation data from: http://views.cira.colostate.edu/web/
- Asthma ER data for various U.S. cities from: http://www.cdc.gov/
- AERONET data from: http://aeronet.gsfc.nasa.gov

Procedure:

- We correlated changes in aerosol composition and size with changes in the aerosol SSA and aerosol optical thickness (AOT) at CCNY, GSFC, and the Maryland Science Center.
- We compared asthma related ER visits with PM10 and PM2.5 data

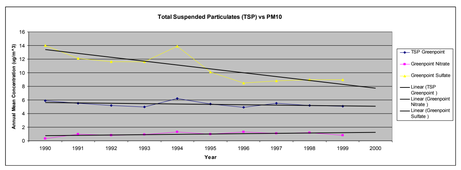

Figure 2. shows that as TSP is decreasing as PM10 is increasing.

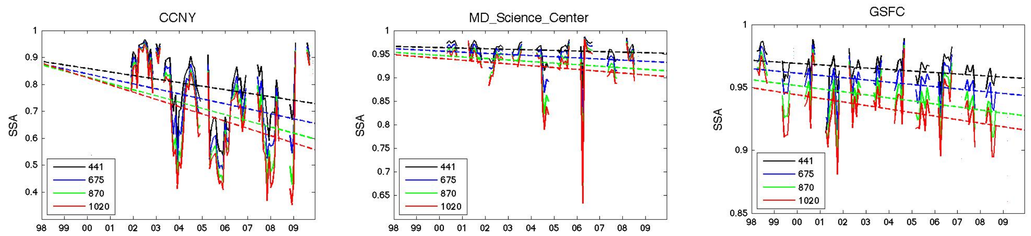

Figure 3. Time series of retrieved aerosol spectral single scattering albedo for CCNY, GSFC, and the Maryland Science Center. Dashed lines are linear trend lines fitted to the data.

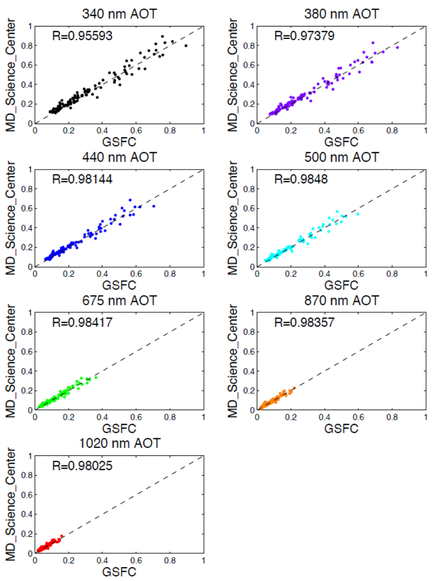

Figure 6. shows the data from GSFC and Maryland Science Center derived from two different instruments. At the GSFC, a CIMEL sun photometer was utilized. The data are consistent.

Results:

In our investigation of temporal changes in aerosol we used a combination of EPA measurements of aerosol mass and mass composition for three sizes: Total Suspended Particulates (TSP) of all sizes; particulate matter less than ten microns in diameter (PM10) and particle matter less than 2.5 microns in diameter (PM2.5), as well as aerosol extinction as measured by the CIMEL sunphotometers as part of the AERONET network. We find, as shown in Figure 2, that the different sized particles have different temporal trends, reflecting time changes in aerosol source/emission strengths. In addition to changes in aerosol size with time, we found that the composition of the aerosol, as measured by aerosol mass speciation, is changing. These changes in aerosol composition suggest that the SSA of the aerosol may also be changing. To investigate this, we examined the SSA data available through the AERONET data set. We find, as shown in Figure 3, that SSA is changing with time. Since SSA is a measure of aerosol scattering, a decreasing trend suggests an increase in aerosol absorption. We examined the aerosol mass speciation data available from the IMPROVE network for PM2.5 and found a weak positive trend in the elemental carbon mass fraction which is consistent with the SSA trend.

No correlation was found between PM10 and PM2.5 levels and asthma in New York or other U.S. cities, but the seasonal variations in asthma show a possible correlation with monthly nitric oxide levels.

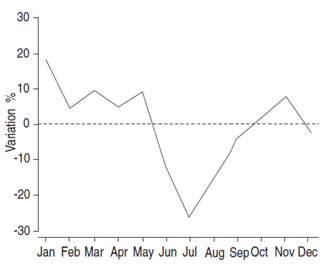

Figure 4. shows seasonal variations in asthma for adults over the age of 24. Peaks occur in the winter and early spring with a trough in the summer. http://www.ersj.org.uk

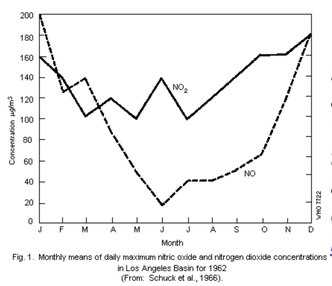

Fig. 1. Monthly means of daily maximum nitric oxide and nitrogen dioxide concentrations in Los Angeles Basin for 1962 (From: Schuck et al., 1966).

Figure 5. shows monthly nitric oxide averages in the Los Angeles basin. These troughs and peaks are similar to the seasonal trends in adult asthma, suggesting a possible correlation. http://www.inchem.org

Discussion:

The IMPROVE and AERONET data suggest changes in aerosol composition consistent with an increase in aerosol absorption but the mass match between the size of the dominant aerosol between measures of aerosol mass (dominated by the larger, micron-sized particles) and atmospheric extinction (dominated by sub-micron particles) suggest that a better, more relevant measure of composition be used to track aerosol changes....two possibilities would be analysis of the newer ultra-fine particle measurements being made at some sites by the EPA and polarimetric measurements of aerosol which permit the retrieval of aerosol refractive index.