Using the Aerosol Robotic Network (AERONET) to Observe Trends in Pollutants

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Background

Tiny solid and liquid particles suspended in the atmosphere are called aerosols. Windblown dust, sea salts, volcanic ash, smoke from wildfires, and pollution from factories are all examples of aerosols. Depending upon their size, type, and location, aerosols can either cool the surface, or warm it. They can help clouds to form, or they can inhibit cloud formation. And if inhaled, some aerosols can be harmful to people's health. Aerosol optical depth (AOD), or aerosol optical thickness (AOT) is a quantitative measure of the extinction of solar radiation by aerosol scattering and absorption between the point of observation and the top of the atmosphere.

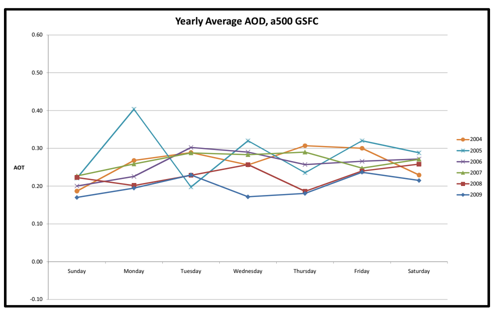
The AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA and LOA-PHOTONS (CNRS). AERONET collaboration provides globally distributed observations of spectral aerosol optical Depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Aerosol optical depth data are computed for three data quality levels: Level 1.0 (unscreened), Level 1.5 (cloud-screened), and Level 2.0 (cloud screened and quality-assured).

Initial Study

I initially thought that if I would be able to observe anthropogenic trends in the data attributable to workweek build up of aerosols and weekend decline as a result of commuter travel emissions. I grouped and averaged the data by the day of the week and could not identify any trends.

I realized that I had to observe the trends or anomalies in the data first, then explain the observations by elucidating the causes.

The initial data, below, graphed by day of week for my location in the mid Atlantic coast shows no identifiable trends.



U.S. East Coast Trends

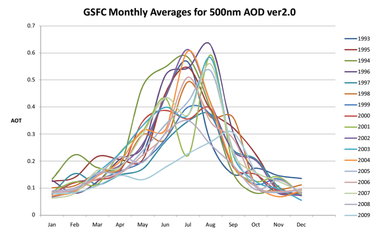
I graphed the monthly average AOT for two locations on the U.S. East Coast. Here there is a well defined trend that in the summer months the AOT rises and in the winter it declines.

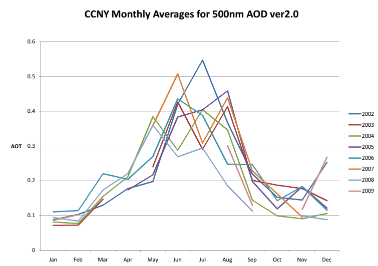
The difference between the seasons that causes the AOT to rise during the summer and fall over the winter is the change in direction of the prevailing winds.

During the summer the region is dominated mainly by Bermuda/Azores high pressure. The clockwise wind flow around these systems brings the moist air from the South, up the Mississippi and across the Midwest picking up aerosols along the way raising the amount of aerosols in the air. Additionally, more hours of sunlight can increase photochemical smog.

The winter months are subject to dry Arctic wind flows that descend from Canada with low aerosol content.

Would this pattern of high turbidity in the summertime and minimum in the winter be replicated elsewhere?

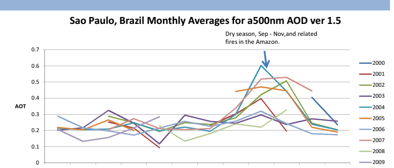


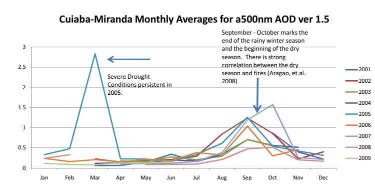


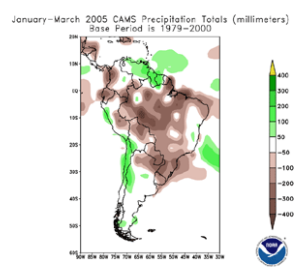
South American Trends

South of the equator in South America the trends are different. Here we look at Sao Paulo, Brazil, which is located on the Atlantic coast in Southeast Brazil, and Cuiaba-Miranda, in central South America just South of the Amazon Basin. The AOT rises in their spring and remains fairly steady for the rest of the year. September - October marks the end of the rainy winter season and the beginning of the dry season. It is common agricultural practice to burn the savanna and farm lands during this dry season. There is also a strong correlation between the dry season and fires further West (Aragao, et.al. 2008). The prevailing winds come from the West, pick up the aerosols from the fires and transports them to the East.

This might explain the spike in 2005 at Cuiaba-Miranda. While it wasn't the spring dry season, there was a severe drought throughout Brazil as shown by the NOAA CAMS precipitation totals. The drought predisposed the area to higher risk of fires, and those fires in the grazing lands and forest areas caused the AOT to spike in 2005. Note that the coastal area of San Paulo was not affected.

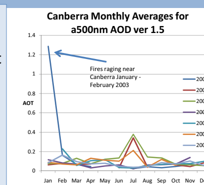






Australia Anomalies

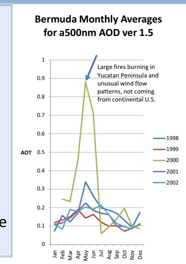
Canberra, located 93 miles inland and between the major cities of Sydney and Melbourne in Southeast Australia has hot summers and cool winters. The AOT levels in Canberra, Australia stay very low for the year. However, there was a very large (1200%) increase in 2003. From accessing MODIS data on fires, I found that the city of Canberra was surrounded by numerous fires in mid-January 2003.



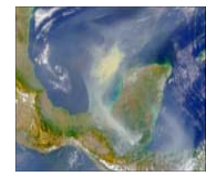
MODIS data used to map fires Jan 14 – 17, 2003

Bermuda Anomalies

Bermuda, 640 miles off the coast of North Carolina, has relatively clean air. Prevailing winds tend to blow any pollution North and East away from the island. The summertime does show a slight rise, due to the humid, polluted summer air coming from the East Coast. The large spike in 2000 was caused by large fires burning in the Yucatan peninsula and unusual wind patterns that conveyed the smoke and ash residue to the North and East.

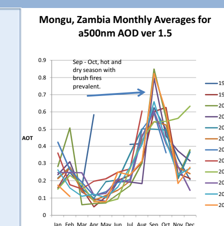


Yucatan peninsula April 24, 2000 courtesy Sea-viewing Wide Field-of-View Sensor (SeaWiFS)

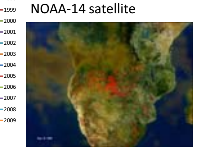


African Trends

Mongu is located in West Central Zambia on the southern tip of Africa. There is a very seasonal rise of the AOD that corresponds to the hot and dry season. During this time the air is contaminated with aerosols and the land is rife with human triggered brush fires. The satellite photo shows fires in red and the brown smoke.



Brush fires Sep 25, 2000 by Advanced Very High Resolution Radiometer (AVHRR) instrument on NOAA-14 satellite



Conclusion

I started out looking for anthropogenic evidence that commuters might be responsible for creating higher aerosol levels and found, with the data supplied by AERONET (Brent N. Holben, PI) that there wasn't a correlation. The averages of the days throughout the years was stable. Was I missing something? The answer was that I needed to organize the data first then describe the trends. When I looked at more seasonal (monthly averages) data, I found distinct peaks and valleys that are possibly a result of changing weather patterns. Seasonal biomass burning contributes greatly to aerosol levels south of the equator while humid air and possibly longer hours of sunlight do the same for the Mid Atlantic. What is the commuter's part then? This would be part of the background aerosol load, while spikes and seasonal trends could be influenced by long-range transport.