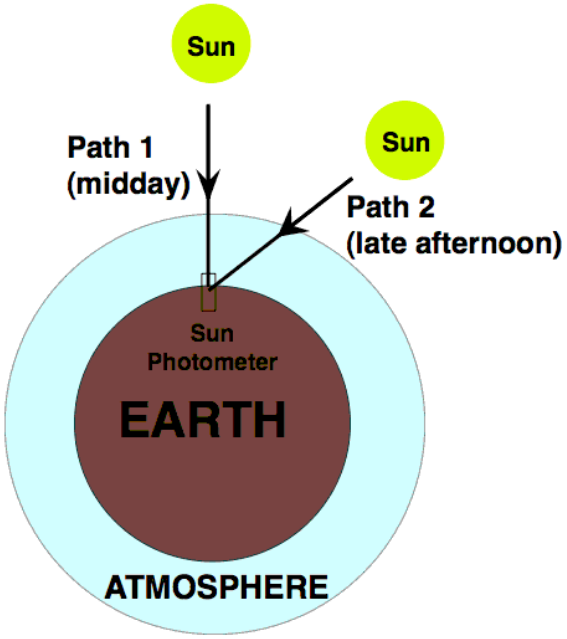

Figure 1. Basic idea for sun photometry. Use the sun as a light source to measure properties of the atmosphere. The path length through the atmosphere changes during the day.

Sun Photometry. Use the sun as a light source to measure the atmospheric column content of ozone, water vapor, aerosol particle pollution, and sometimes cloud optical depth. See Fig. 1.

Solar Zenith Angle θ. When the sun is directly overhead the solar zenith angle is zero degrees. The solar zenith angle is a function of latitude, longitude, and time of day.

Rayleigh Scattering by Molecules. Molecules in the atmosphere (O_2 and N_2) interact with light as dipole scatterers. The scattering amount is much stronger at shorter wavelengths (blue) than at longer wavelengths (red). (Blue sky at noon, red sunsets).

Aerosol Particles Scatter and Absorb Light. Black carbon (soot), mineral dust, sulfates, nitrates, organics, viruses, pollen, etc, scatter and absorb sunlight, reducing the amount at the surface.

Light Absorption by Trace Gases. Ozone (O_3), nitrogen dioxide (NO_2), SO_2, and water vapor (H_20) are a few example of trace gases in the atmosphere that absorb sunlight at certain wavelengths. Sun photometery can be used to measure their concentration.

Procedure

On clear days, use the sun photometer every 1/2 hour to measure the amount of sunlight using your sun photometer. OF COURSE, DON'T LOOK DIRECTLY AT THE SUN! Use the time of day, your latitude and longitude, and determine the solar zenith angle. Make an Excel spreadsheet to plot $(1/\cos(\theta))$ versus $\ln\left(V(\theta)-V_{dark}\right)$. Here $(1/\cos(\theta))$ is the air mass, $V(\theta)$ is the voltage measured at the zenith angle, V_{dark} is the voltage recorded with no light entering the sunphotometer. The air mass typically scales between 1 and 10. This graph is called a Langley plot.

Interpretation

Extrapolate the data to zero air mass. This is the $\ln\left(V(\theta)-V_{dark}\right)$ that you would obtain at the top of the atmosphere, as if the sunphotometer were on a satellite. Calculate the slope of the Langley plot. Compare the value of the slope you get with table of values of the clear sky optical depth from Rayleigh Scattering by molecules in the atmosphere (no aerosols, clouds, or gaseous absorption). Do this for several days, and compare your results. Is it reasonable to conclude that one day is 'cleaner' than another based on sun photometer measurements?

Resources (patarnott@physics.unr.edu)
Sunphotometry.
http://www.patarnott.com/atms360/sunphotometer.htm

GLOBE (Global Learning and Observations to Benefit the Environment).
http://www.globe.gov/

HAZE http://www.concord.org/haze/