ASTR/ATOC 5560   Problem Solving Solutions   Week 2

1. *A CIMEL sunphotometer has a silicon detector that is highly linear in measuring the direct solar flux. When the solar zenith angle is* 60° *the sunphotometer measures a voltage of* $V = 1.673$ *in the 870 nm channel (the spectral bands are determined by interference filters on a filter wheel). When calibrated with the Langley plot method at Mauna Loa Observatory in Hawaii, the voltage extrapolated to the top of the atmosphere is* $V_0 = 2.127$. *The effect of molecular absorption is negligible at this wavelength, but the molecular Rayleigh scattering optical depth is 0.015.*

a) Calculate the aerosol optical depth at this wavelength.

The flux in the direct solar beam is diminished in an atmosphere according to Beer's Law, $F_\lambda = F_{0,\lambda} \exp(-\tau/\mu)$. Since the sunphotometer detector is linear in the flux, Beer's Law also applies to the voltages, and may be solved for optical depth:

$$V = V_0 e^{-\tau/\cos\theta} \quad \tau_\lambda = -\cos\theta \ln(V/V_0)$$

$$\tau_\lambda = -\cos(60)\ln(1.673/2.127) = 0.120$$

To get the aerosol optical depth we need to subtract off the Rayleigh molecular scattering optical depth of 0.015. Thus, the aerosol optical depth is 0.105.

b) Lidar backscattering measurements show that most of the aerosols are in the 1.5 km thick boundary layer. What is the average volume extinction coefficient?

$$\beta = \frac{\tau}{\Delta z} = 0.105/(1.5\,\mathrm{km}) = 0.07\,\mathrm{km}^{-1}$$

c) A typical mass extinction coefficient for sulfate aerosols at this wavelength is $k = 2.5\,\mathrm{m}^2/\mathrm{g}$. *What is an estimate for the aerosol loading (g/m*^{2}*)?*

$$u = \frac{\tau}{k} = 0.10/(2.5\,\mathrm{m}^2/\mathrm{g}) = 0.04\,\mathrm{g/m}^2$$