Radiative transfer in the environment. Weitzmann, fall 2008.

Problem set III:

0. Provide the answer to the Mie-lab homework.

1. Contrast the optical properties of three aerosols (or for the same aerosols properties based on three sources) that you find in the literature and the WWW.
   For each provide as many physical and optical properties as you can find and other details as listed below:
   1. describe and plot the particle size distribution
   2. particle shape
   3. index of refraction (as function of wavelength if applicable)
   4. The absorption, scattering and attenuation spectrum (e.g. as function of wavelength) associated with this aerosols (if relevant, normalized per mass).
   5. The phase function (or volume scattering function).
   6. How the optical properties were derived.

   Discuss what may be the causes for variability in optical properties of the different aerosols (or between sources for the same aerosols). Prepare one power point slide summarizing your findings.

Resources (that I was able to find. I am sure there are more):

a. http://www.lrz-muenchen.de/~uh234an/www/radaer/opac.html - data on an ftp site you can download. Description on site and in a published paper you can download as well.

b. http://www.arm.gov/measurements/measurement.php?id=aerosoptical – you will need to register, which takes 2min.

2. Build a 2-stream radiative transfer model as follows:

   Input irradiance from sky: E_d

A layer between sky and ground with transmission T_1 and reflectance R_1 and absorbance A_1 (their sum is 1, as they represent probabilities of being transmitted, reflected and absorbed).

Light reaching the Earth: T_1E_d
Light reflecting back to sky: $E_u=R_1E_d$
Light absorbed: A_1E_d

Assume the ground absorbs all the radiation hitting it. Add one more layer and calculate the properties of this new atmosphere (R_2, T_2, & A_2) as function of the properties of the one layer atmosphere. Note that light can bounce between layers, so it may be useful to first calculate the light field (E_d & E_u) in the middle between the layers.

Keep doubling the number of layers and find expressions for R_N, T_N, & A_N as function of (R_1, T_1, & A_1) where N is even.

Plot R_N and T_N for N=1,2,4…1024 (log the x-axis) for A_1=0, 0.01, 0.05 and R1=0.001, 0.1 and 0.9 (total on 9 curves for each graph).

This problem was first published by Stokes in the Proceedings of the Royal Society and appears in volume IV of his Mathematical and Physical Papers. If you are having difficulties feel free to consult others for the solution!