Homework Assignment #3

Due: April 4

Problem 1 (50 points)

Optical modeling using Mie theory.

Instruction: To perform Mie calculations, go to

http://irina.eas.gatech.edu/Lab_Source/sphere5235.aspx

1) Compute and plot the extinction Qe, scattering Qs, and absorption Qa efficiencies as a function of size parameter. Consider size parameter in a range from 0.2 to 20. Consider three types of aerosol: non-absorbing (m = 1.5), absorbing (m =1.5-i0.01), and strong-absorbing (m=1.5-i0.5) aerosols. Identify and briefly discuss the main differences between Qe, Qs and Qa of these aerosol types.
2) Compute, plot and analyze the extinction Qe and absorption Qa efficiencies as a function of particle radius for the three aerosol types. Consider wavelengths 300 nm, 550 nm and 1000 nm.
3) Compute, plot and analyze the spectral behavior of the extinction Q_e and absorption Q_a efficiencies for three aerosol types. Consider the wavelength range from 300 nm to 1 μm, and particle radius of 0.1, 1 and 10 μm.
4) Consider a 1 km-thick atmospheric layer containing the external mixture of non-absorbing and absorbing aerosols. Show how the effective optical depth and single scattering albedo depends on the fraction of absorbing aerosol. To simplify the problem, assume that all particles have the same radius of 0.1 μm (called mono-disperse aerosols). Take total particle number concentration N= 100 #/cm^3.

Problem 2 (30 points)

Molecular scattering affects the propagation of electromagnetic radiation in the atmosphere in UV and visible wavelengths, resulting in blue color of the sky and sky polarization.

1) Calculate and plot (in polar coordinates) the degree of linear polarization of radiation scattered by air molecules for the case of unpolarized incident light. Briefly describe the polarization pattern as a function of scattering angle.

2) Plot and compare behavior of the Rayleigh scattering phase function and Henyey-Greenstein phase function as a function of scattering angle between 0^0 and 180^0. Consider several values of asymmetry parameter, g, as well as asymptotics for low and high g.

Problem 3 (20 Points)

Determine the effective optical depth, single scattering albedo and asymmetry parameter of an atmospheric layer containing water vapor and aerosol at a certain wavelength. At this wavelength mass absorption coefficient of water vapor is $k_{a,\lambda} = 0.03\ m^2/kg$ and aerosol volume extinction coefficient is $\beta_{e,\lambda} = 0.03\ km^{-1}$, aerosol single scattering albedo is ω_o=0.9 and aerosol asymmetry parameter is g=0.75. The water vapor density is $\rho_v = 10\ g/m^3$.