**HOMEWORK ASSIGNMENT 5**

**Due date: Dec.2**

**Problem 1 (40 points)**

Dust aerosols in an atmosphere of the planet X have optical depth of 0.1, single scattering albedo of 0.84, and asymmetry parameter of 0.8 at the 0.6 µm wavelength. At this wavelength the only other radiatively active component is some gas absorption with optical depth 0.02.

a) Calculate the delta scaled total atmospheric optical properties.

b) Calculate the approximate atmosphere albedo assuming a black surface for a sun angle of \( \mu_0 = 0.5 \). *Hint:* use the Eddington approximation for an optically thin layer.

c) Calculate the direct and diffuse solar flux transmission at the surface for \( \mu_0 = 0.5 \).

d) Calculate the surface albedo for which the presence of the atmosphere results in a decrease of the total albedo (atmosphere+surface) compared with the surface alone.

**Problem 2 (30 points)**

Modeling the effects of clouds on solar radiation using a SBDART code

http://arm.mrcsb.com/sbdart/cgi/sbdart-setup.cgi?run-type=layer-flux&run-with-clouds=on

1) Investigate how an increase of cloud optical depth affects the solar direct, diffuse and global fluxes reaching the surface. Consider two cases: low-level water clouds and high-altitude cirrus clouds. Explain your results.

2) Calculate and compare the solar radiative heating rates caused by a cloud located at 3 km with the optical depth of 1 and 10. Explain your results (refer to Petty’s Chapter 13).

**Problem 3 (40 Points)**

CO2 is a key greenhouse gas. Investigate how increasing concentrations of CO2 affect the radiative forcing at the top of the atmosphere (at pressure of about 11-13 mbar) and at the surface. Consider cases of no CO2, present CO2 concentrations and doubled CO2. Perform calculations for two standard model atmospheres: Tropics and Sub-Arctic summer with and without water vapor. Compare and explain your results.

*To run the IR radiative transfer code, link to*

http://irina.eas.gatech.edu/RT_Class/radcode.htm
Problem 4 (30 points)

The following are questions on a radiative transfer code you selected for your class project:

1) What technique is used to account for multiple scattering? Briefly discuss the advantages and drawbacks of this method.

2) Any radiative transfer code must be rigorously tested. Design a number of test runs for testing the performance of your radiative transfer code for (a) clear sky, (b) in the presence of aerosols, and (c) in cloudy conditions. In the latter case, consider both absorbing and non-absorbing clouds.

3) Can your code be used to compute radiation fluxes (or intensity) on Venus? Why or why not.