12.815
Multiple Scattering Exercise (Discrete Ordinates)

References:

1. "Light Scattering in Planetary Atmosphere", J.E.Hansen and L.D,.Travis, Space Science Review 16, 527-610.
2. "An Introduction to Atmospheric Radiation", K.Liou

Discrete Ordinates

Discussion

For this exercise you will examine the effects of changing the single scattering albedo, a, and the asymmetry parameter, g, on the radiative fluxes through a plane-parallel layer of scatterers using a two-stream approximation. Recall that the discrete ordinates method replaces the integral in the radiative transfer equation by a summation, where the dummy variable in the summation represents the direction of the radiation streams. For the two-stream approximation, the summation is truncated after the first term and the radiative transfer equation is solved for the upward and downward intensities.

To run the code on a PAOC workstation (e.g., cirrus) copy the file /disk7/ddlucas/Disort.tar over to your directory. Untarring the file (*tar xf Disort.tar*) creates 8 files in a directory called Disort. The file descriptions are: (1) Compile_Run describes the process of compiling and running the source code for the exercise. (2) DISORT.doc is the documentation for the discrete ordinates code. (3) DISORTsp.f is the main subroutine which the user calls. (4) ErrPack_DISORT.f is the error-handling routine. (5) R1MACH.f and D1MACH.f define the machine constants. (6) LINPAK.fis a linear algebra package. (7) disotest.f is the sample driver for the discrete ordinates exercise.

Only minor modifications to the driver are required for the exercise. The important driver inputs are: (1) PMOM (1, 1) is the asymmetry parameter. (2) DTAU (1) is the optical depth of the layer 1 (denoted b in the output). (3) UTAU (2) is the optical depth at which quantities are output. (4) SSALB (1) is the single scattering albedo for the scatterers in layer 1. The important outputs are: The Downward Diffuse flux (the flux of photons in the downward direction which have been scattered at least once) and the Upward Diffuse flux (the corresponding quantity in the upward direction).

Exercise

a.) Using the discrete ordinates program, show how the single scattering albedo, a, and the asymmetry parameter, g, affect the reflection and transmission of sunlight for a stratified cloud deck. Calculate the fluxes above and below the slab for the sun in the zenith, for $\tau = 10$ and for a black surface below the cloud. Calculate the direct solar flux as a separate item. Calculate for at least the following values of parameters: a = 0.999, g = (1, 0) and a = 0.95, g = 0. Find qualitative reasons for your results.

b.) Also investigate the results for a = 0.5, g = 0 and $\tau = 0.1$ in order to synthesize a thin cirrus cloud and provide a qualitative analysis of your results.