Name: ________________________________

ATOC/ASTR 5560 Radiative Processes — Lab 8

November 2, 2001

The purpose of this lab is to learn about simple solar radiative transfer approximations, specifically the first order scattering solution and the Eddington two-stream model. Log in to nit and copy the following files to your directory:

`/home/rt/simplert/simplert.pro`	IDL file for the lab
`/home/rt/simplert/readscatfile.pro`	IDL procedure to read miegamma scattering files

1. Code the first order scattering radiative transfer solution in section `FirstOrder` of the IDL file. Use the linear in optical depth form of the first order solution. Calculate the upwelling radiance as a function of zenith angle for a solar flux $S_0 = 1$. Review the IDL code to see how the scattering angle is calculated from the solar and outgoing directions and how the phase function is calculated. Write down the line you coded in IDL:

   Plot the first order solution radiances for the mineral aerosol case in Lab 7. You will need the scattering file from `miegamma.f` for this case. The radiances are plotted versus zenith angle in the solar plane (for convenience the $\phi = 180°$ direction is plotted with negative zenith angles). Use an aerosol optical depth of 0.15 and compute the radiance field for two sun angles: $\theta_0 = 0°$ and $\theta_0 = 60°$.

   What is the layer thickness (km) for this aerosol distribution corresponding to an optical depth of 0.15?

   If the solar flux is unity ($S_0 = 1$), what are the units of radiance?

   In radiative transfer terms, why does the radiance increase for large zenith angles.

Explain the differences between the radiance plots for the two sun angles.

2. The Eddington two-stream solution for flux reflectance (albedo) and transmittance from Meador and Weaver (1980) has been coded in IDL for you. Use section `Eddington` in the IDL file and the special case solutions in the notes to check 1) the albedo and absorptance in the optically thin limit, and 2) the albedo in the conservative scattering limit. Choose your own parameters for a few cases and give the results below (don't bother with delta-Eddington yet).

3. A highly accurate multi-stream radiative transfer model has been run for the $\lambda = 2.13$ μm, $r_{eff} = 10$ μm cloud cases in Lab 7. Below is a table with results for albedo R and absorptance A for different optical depths and sun angles. The results are for a single homogeneous layer atmosphere above a black surface.

τ	ω	g	μ_0	R_{MS}	A_{MS}
1.0	0.97854	0.843	1.0	0.04717	0.02387
10.	0.97854	0.843	1.0	0.29783	0.31510
1.0	0.97854	0.843	0.25	0.32230	0.07568
10.	0.97854	0.843	0.25	0.56047	0.27518

Compare the **Eddington** and the **delta-Eddington** albedo and absorptance with the multi-stream results. List percentage errors.

For what range of parameters do the Eddington and delta-Eddington approximations appear to perform worse.

4. Make plots of the **delta-Eddington** albedo and absorptance versus optical depth using section `PlotEddington`.

   a) Consider the effect of single scattering albedo: use $\omega = 0.9999, 0.999, 0.99$ with $g = 0.85$ and $\mu_0 = 1.0$.

   b) Consider the effect of sun angle: use $\mu_0 = 1.0, 0.866, 0.5$ with $\omega = 0.99$ and $g = 0.85$.

   Describe the behavior of the reflection and absorption in the two optical depth limits ($\tau \to 0$ and $\tau \to \infty$) for the $\mu_0 = 1$ plot.

   Explain the results in terms of multiple scattering and the scattering geometry.