Name: ____________________________________

ATOC/ASEN 5560 Mie Code Lab

The purpose of this lab is to learn about the behavior of Mie scattering from particle distributions.T The following files (in mielab.zip) are needed:

`miegamma.f`	Fortran source for Mie code
`waterindex.f`	Fortran source for index of refraction code
`plotmie.pro`	IDL phase function plotting file
`readphase.pro`	IDL procedure to read phase function file

1. Look at the Mie code. Write down the name of the subroutine that performs each of the four steps of "How a Mie code works" in the class notes. Find how many times the lines inside the inner loop are executed for steps 1, 2, and 3. How will these depend on size parameter?

2. The Mie code inputs gamma distribution size parameters and outputs a "scattering" file with the extinction, single scattering albedo, and Legendre series phase function and a "phase function" file with the phase function versus scattering angle. Several hundred integration steps are needed over the size distribution. As a rule of thumb, for cloud distributions the maximum radius in the integration should be about four times the effective radius. The index of refraction of water and ice are output by the `waterindex` program.

   Compute Mie scattering optical properties for liquid cloud droplets with number concentration of 100 cm^{-3}, effective radius of 10 μm, and effective variance of 0.1 ($\alpha = 7$ for a gamma distribution) at wavelengths of 0.87 μm, 1.64 μm, 2.13 μm, 11.0 μm. Also calculate the scattering properties for a cloud with $N = 100\ \mathrm{cm}^{-3}$ and $r_{eff} = 5\ \mu\mathrm{m}$ at 1.64 μm. Finally, compute the Mie scattering optical properties for a mineral aerosol layer index of refraction $m = 1.56 - 0.01i$ and size distribution $N = 200\ \mathrm{cm}^{-3}$, $r_{eff} = 0.7\ \mu\mathrm{m}$, $\alpha = 1$ at 0.65 μm.

Make a table of the extinction (km^{-1}), single scattering albedo, asymmetry parameter, and number of phase function Legendre terms for the 6 cases.

3. Compare the Mie extinction with the simple formula assuming geometric optics for the extinction in terms of the liquid water content and effective radius. Compare the single scattering albedo with the weakly absorbing geometric optics formula:

$$1 - \omega \approx -\frac{8\pi m_i}{3\lambda_{in}} r_{eff} \ ,$$

where $\lambda_{in} = \lambda / m_r$ is the wavelength inside the particle.

Explain why the simple formulas work in some cases and not in others.

4. Graph the phase function (P_{11}) for the six cases. Use two plots of three each.

   Make a table of the effective size parameter x_{eff}, the peak phase function $P(0)$, and the approximate scattering angle at half the phase function peak $\Theta_{1/2}$. Is the actual functional relation between these three quantities as expected?

Explain why the asymmetry parameter is highest for the $\lambda = 11$ μm cloud case even though the size parameter is lower than for the shorter wavelength cloud cases.

5. Write down the 4×4 Stokes phase matrix for the $\lambda = 0.87$ μm cloud case for a scattering angle of $125°$. If unpolarized light is incident on these cloud droplets, what is the resulting Stokes vector, normalized by the scattered intensity? What is the degree of linear polarization of the scattered light?