AT721 Homework 2

Due Wed February 19

1) In this problem you will run BHMIE for a single particle. You will also need the index_water code that calculates the index of refraction of water and ice (available in fortran and IDL). If you have a code that already does this (that you trust), and is applicable to these wavelengths, that is fine as well.

    a. Plot the extinction efficiency, single scattering albedo and asymmetry parameter for a cloud water sphere of radius 8 um for wavelengths ranging from 0.4 microns to 10 um. Are we anywhere close to the Rayleigh regime?

    b. Repeat part (a) in the microwave, frequency range 10 GHz to 200 GHz, for a cloud drop (radius=8 micron), drizzle drop (radius=0.1 mm) and a rain drop (radius=1 mm). For both, also calculate the Rayleigh approximation for each parameter. Where does the Rayleigh approximation roughly hold?

    c. From the (complex) amplitude scattering matrix elements $S_1(\Theta)$ and $S_2(\Theta)$ for the rain drop case at a frequency of 30 GHz, plot the phase function $P_{11}(\Theta)$ and the fractional polarization $P_{12}(\Theta)/P_{11}(\Theta)$. Could we consider raindrops to be strongly polarizing of radiation at this frequency, at least from a single scattering event? What might happen after multiple scattering events?

2) In reality we rarely run a Mie code for a single particle, but rather we typically integrate over a range of particle sizes. In this problem we'll work with a simple exponential (Marshall-Palmer type) distribution of rain drops that we will characterize in the microwave at a frequency of 30 GHz. The size distribution is written

$$N(D) = \frac{N}{D_m}\exp(-D/D_m)$$

where D is the diameter and N is the total # of drops per unit volume; it is easily shown the D_m is the mean diameter of the distribution.

    a. For a mean rain drop diameter of 3 mm, plot the drop size distribution, as well as the volume extinction coefficient per unit diameter versus diameter. Which drop size contributes the most to the extinction?

    b. Calculate the mass extinction coefficient, single scattering albedo, and asymmetry parameter of the distribution, and compare them to what you'd get if you used a single drop with either the 1) mean diameter or the 2) effective diameter. Which diameter is most closely related to the optical properties of the distribution?

Hints:

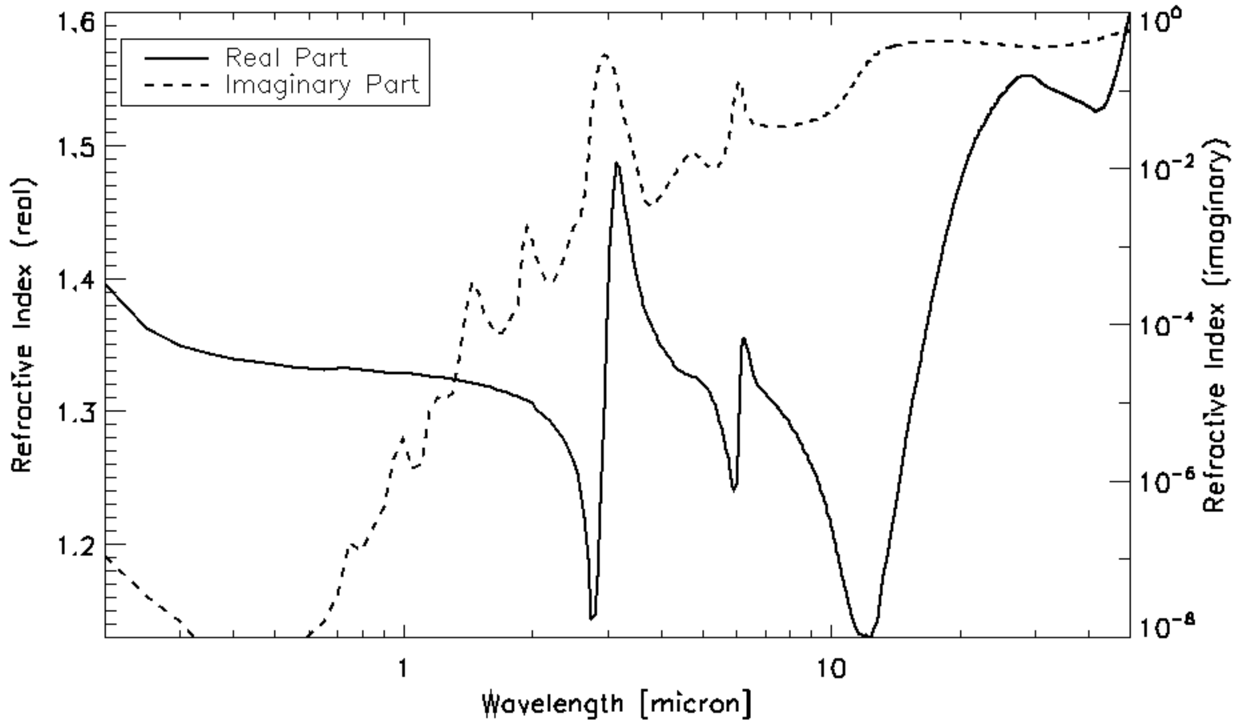
- *In problem 1, it is perfect valid to attempt to use the Rayleigh approximation to calculate a single-scattering albedo (which generally will NOT equal zero).*
- *In problem 2, be sure to integrate far enough out in the size distribution. The quantity of primary interest is D^2 N(D), as this is how the extinction efficiency goes per size bin.*

Codes you will need:

`bhmie` (in fortran or IDL). You may also try to download a matlab or python version if you prefer.
`index_water` (in fortran or IDL)

They are both under **http://reef.atmos.colostate.edu/~odell/at721/resources/codes/**

The index of refraction of water at visible to IR frequencies looks like this:



The index of refraction of water at microwave frequencies looks like this: