AT622 Project 1
Spring 2015
Due Friday March 27, 2015

This project explores microwave radiances in the earth's atmosphere. You will write a radiative transfer code to calculate microwave brightness temperatures, considering absorption and emission by atmospheric gases (primarily water vapor and oxygen). The absorption coefficients are supplied by a subroutine for microwave frequencies from 1-300 GHz.

A. Using the subroutine "absorb.f" (in Fortran) , "absorb.pro" (in IDL), absorb.py (in Python), or absorb.m and MPM93.m (in Matlab), compute & plot the absorption coefficient as a function of frequency across the spectrum for the [cloud-free] U.S. Standard Atmosphere (in file Std-atmos.txt) for the near-surface layer and a layer high in the atmosphere. Compare your results to the zenith transmittance of the figure below and discuss.

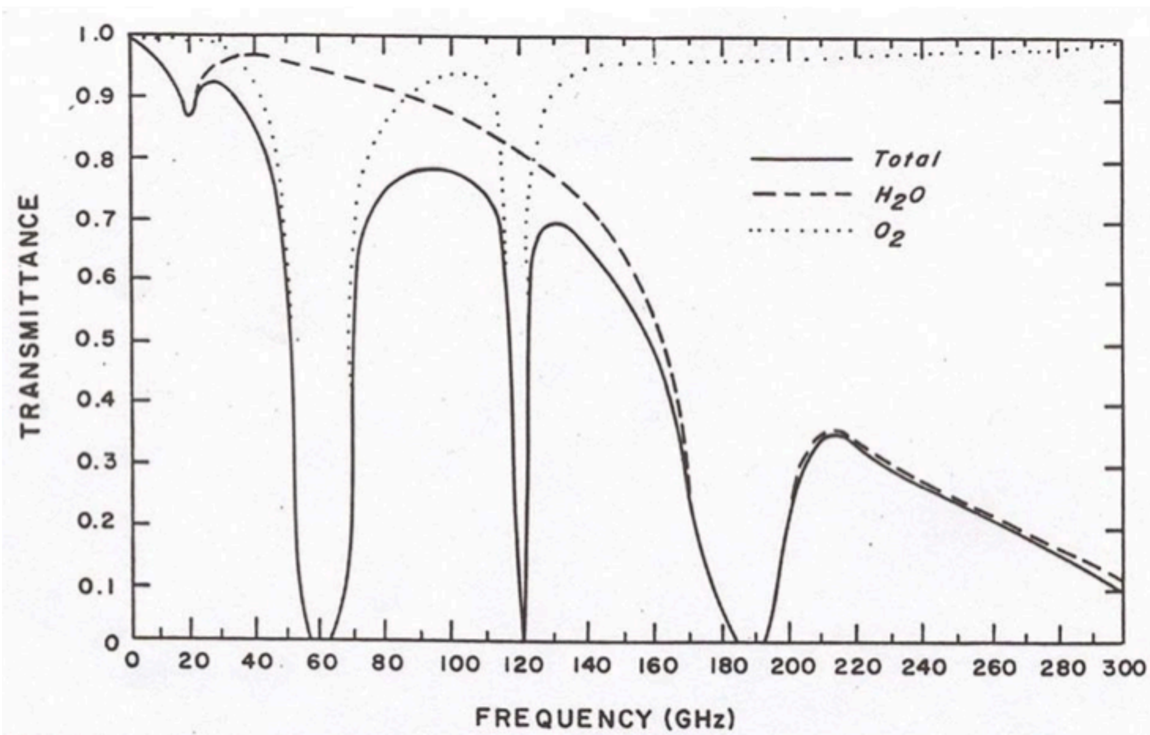

Figure 1: Atmospheric transmission as a function of frequency in the microwave [after Grody, 1976].

B. Derive the relationship between radiance and brightness temperature (TB) at the frequencies being considered. Explain how you can exploit this relationship in part C below.

C. Develop a radiative transfer code to compute upwelling TOA TBs and downwelling surface TBs. Consider absorption, emission, as well as reflection from the surface. Remember cold space is equivalent to a 2.7 K blackbody. Assume the surface emissivity is 0.5 and is specular (that is, angle of reflection equals angle of incidence), a reasonable assumption over the ocean. Write the code so that the surface emissivity, the model atmosphere, the surface temperature, as well as the view angle are all parameters that can be modified by the user. The code should be written individually (no group efforts here). You may write the code in any language you like (Fortran, IDL, Python, and Matlab are reasonable choices).

D. Test that your code is working properly as follows. First, show that it works in the limiting case of an isothermal atmosphere. Be sure to write down the equations for the downwelling surface TB and upwelling TOA TB in this case. Second, record output for the following cases. You should be able to match the numbers provided to 1-2 K. For simplicity, assume the surface temperature equals the temperature of the air directly above the surface. You will note that some of these numbers may depend strongly on the number of layers you use.

Freq [GHz]	View Zenith	TB↓@Surf	TB↑@TOA
30	0°	17.1 K	158.8 K
183 GHz	53°	287.3 K	233.1 K

E. For the 183 GHz case above, with a viewing zenith angle of 53° [this is typical of conically-scanning microwave sensors], plot the downwelling and upwelling weighting functions. Are the TBs you calculated consistent with what you'd expect based on the weighting functions?

F. Now explore the *sensitivity* of TB down at the surface and upwelling at TOA to changes in the atmospheric water vapor. Use your code to compute the change in the TBs (downwelling at surface and upwelling at TOA) to a uniform +5% change in the water vapor profile, for channels measuring at 22 GHz and 183 GHz. Assume a viewing zenith angle 0°. Physically try to explain the sign and relative magnitudes of the changes, based on surface-to-space optical depth and the weighting functions of the different cases.