Assignment 5: Line by Line Radiative Transfer

Due February 25

1. In this Lab, we will be running a LBLRTM code and interpreting the model results. The LBLRTM was developed in the ATMOSPHERIC AND ENVIRONMENTAL RESEARCH INC. A nice interface for the LBLRTM radiative transfer model is set up at http://irina.eas.gatech.edu/LAB_Source/lbl_mc.asp

(a) Run LBLRTM using the "7 Molecules" option to calculate and plot the transmission function from 0 km to 13 km for the Tropics, Arctic Summer, and Midlatitude Summer Atmospheres from 0 to 2000 cm\(^{-1}\) with a spectral averaging of 10 cm\(^{-1}\).

(b) Briefly explain the major differences between the transmission functions calculated for these standard atmospheres.

(c) Identify on your plots the main IR absorbing band of O\(_3\). Estimate and compare the minimum values of the transmission in this O\(_3\) band for these standard atmospheres. Explain your results.

(d) Using the diffusivity approximation, estimate the absorption optical depth of the ozone absorption band within i) 0 - 13 km.

(e) What is the average absorption of the atmosphere in the so-called “water vapor absorption window”?

(f) Plot the radiance plot for the tropics, Arctic Summer and Midlatitude Summer at a resolution of 1 cm\(^{-3}\). Does this plot represent upwelling or downwelling radiance? Explain why and the major differences between the curves for each atmosphere. Sketch the shape of the curves if you were to look at the radiance from the other direction.

2. Go to the web site http://irina.eas.gatech.edu/LAB_Source/strat.asp

(a) For the spectral resolution of 1 cm\(^{-1}\), calculate and compare transmission of the 0-13 km atmospheric layer and 13-50 km atmospheric layer. Explain the differences.

(b) Based on a), predict how the transmission of the 0-50 km atmospheric layer should look (i.e., similar to 0-13 km or 13-50 km?). Run the model to check it out. Was your guess right? Why or why not?

(c) By increasing the spectral resolution, will you expect to see more fine spectral features in 0-13 km transmission or in 13-50 km transmission? With reference to the line shapes of atmospheric gas spectra, explain why and then run LBLRTM to verify your predictions.

3. The mechanisms controlling the water vapor continuum are contentious but can be divided into two possibilities: foreign-broadening due to air-water vapor collisions; and self-broadening due to H\(_2\)O-H\(_2\)O collisions.

Go to the web site http://irina.eas.gatech.edu/LAB_Source/h2o_mc.asp

(a) For the Tropical Atmosphere, calculate and plot the transmission spectrum with the continuum absorption turned on and with the continuum turned off. Compare the transmission in the clearest parts of the window. How would this difference change in a dry atmosphere?

(b) Calculate the transmission of the Tropical Atmosphere without self-broadening continuum and without foreign-broadening continuum. What is the relative importance of the self-broadening and foreign-broadening continuum in the 8-12 um region?