

Microwave Weighting Functions and Radiances

AOS 640
Prof. Petty

due at end of semester

1. Objectives

- Implement a radiative transfer code for computing emission weighting functions and top-of-the-atmosphere microwave brightness temperatures for an arbitrary temperature/humidity profile and arbitrary microwave frequency.
- Perform numerical experiments designed to give insight into the role of various environmental variables, as well as viewing angle, on the weighting functions and brightness temperatures observed by satellite microwave sounders.

2. Deliverables

a. Writeup See Section 4.

b. Printout of complete model source code. Use small fixed-width font, double columns, if possible, and be sure to comment liberally.

3. Programs

I will provide a Fortran program to interpolate level data (temperature, pressure, humidity) from an operational sounding to finer vertical intervals. The purpose is to ensure that all atmospheric layers in your radiative transfer code can be considered optically thin and/or nearly isothermal.

You will need to write three additional (separate) programs of your own to complete this project:

(a) A program that computes mean properties for each *layer* bounded by the *levels* in the interpolated sounding. The primary properties of interest are the layer mass, layer mean pressure, layer mean temperature, layer mean specific humidity, and layer water vapor burden. I will provide a sample output file for you to verify the correctness of your program.

(b) A program that reads a layer file of the above type and, for a specified microwave frequency ν , surface emissivity ε , and zenith angle θ , outputs two results: (1) the emission weighting function $W(z)$, and (2) the top-of-the-atmosphere microwave brightness temperature T_B . You will need to use the subroutine `GasabsR98` that I provide on the project web page. This routine is in Fortran. Unfortunately, it is probably nontrivial to convert this to another language, so if you prefer to use C, IDL, or MatLab for the remainder of your programs, you will probably need to find out how to call a compiled Fortran

routine from the language of your choice. I can explain how this is done in C; I know it is possible in IDL but am not as familiar with the details; I don't know whether it's possible from MatLab, though it may be.

(c) A generalization of the above program that computes T_B for a user-specified range of frequencies $[\nu_1, \nu_2]$ and interval $\Delta\nu$.

4. Writeup

Once you have your weighting function and brightness temperature calculations working, perform the following experiments and write up the results. Simple line plots of weighting functions and/or brightness temperature spectra should be included where appropriate, but please do not spend inordinate time/effort on *cosmetics*. For example, if you know how to plot one curve in a X - Y plot but would take several hours to figure how to make your software do two curves on the same plot, then feel free to plot them separately and then trace one curve onto the other plot by hand.

All I am really looking for in your writeup is evidence that

- you succeeded in getting your model code to work,
- you performed the indicated experiments, and
- you have gained enough insight into radiative transfer to be able to offer concise and correct interpretations of the results.

I: Using the Greenbay sounding as an input, call your program from a loop in which frequency varies from 1.0 to 200 GHz at 0.1 GHz intervals, for a surface emissivity of 1.0, surface temperature of 300 K, and a nadir angle of 0 degrees. (If you need tips on how to efficiently set up this loop with your existing program, let me know – I don't want people to spend a long time on setting up and running the loop because they didn't anticipate the need for looping when writing the code!).

a) Plot the resulting brightness temperature as a function of frequency, and identify the features that you see.

b) In your results from the above, find two frequencies for which the computed brightness temperature is approximately 250 K (give or take a degree or two). One should fall somewhere in the 50–60 GHz range; the other should be in the 170–180 GHz range. On a single graph, plot the weighting functions for both frequencies. Discuss the physical reasons for the similarities and differences between the two weighting functions, especially in light of the fact that both yield approximately the same T_B for this sounding.

c) For a frequency of 53.0 GHz, plot the weighting function for two nadir angles, 0 degrees and 50 degrees, on the same plot. Explain the difference between the two plots.

d) For a frequency of 53.0 GHz, nadir angle of zero, and surface temperature of 300 K, plot two weighting function curves: one for the case that the surface emissivity is 0.5, the other for the case that it is 1.0. Discuss how the surface emissivity impacts the atmospheric weighting function profile.

II: Repeat the loop over frequency described at the top of the previous part, but for a surface emissivity of 0.5. Compare your computed T_B spectra with your earlier results for an emissivity of 1.0. Over what frequency ranges (to the nearest GHz), is the atmosphere effectively opaque, so that the surface emissivity has no significant bearing on the computed T_B s?

III: Compute the T_B spectra again for the two emissivities (0.5 and 1.0), but this time using a radiosonde profile representing a dry, cold polar atmosphere (use the Fairbanks profile linked to from the AOS 640 web page). How do your spectra change, and why? For what ranges of frequencies is the atmosphere effectively opaque now?

IV: Find out the channel frequencies of the AMSU-A and AMSU-B sensor. Use your program to determine at which altitudes the respective weighting functions peak. For the AMSU-B channels, you will want to repeat this for both the Fairbanks and Greenbay soundings.

If anything is unclear in the above, or if I have forgotten to specify any important variable values, let me know.