Advanced radiation and remote sensing

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Exercise No. 4 – Atmospheric Brightness Temperature Spectra

1. Run the ARTS control file `rtcalc.arts` to calculate the spectrum of atmospheric zenith opacity in the microwave spectral range for a midlatitude-summer atmosphere. You can use the attributive plotting scripts (`plot_bt.m` or `plot_bt.py`) to visualize the results.

   Questions:

   Consider the zenith opacity spectrum only to answer the following questions:
   - The spectrum includes four spectral lines. To which species do these lines belong? (Play around with the absorption species selection in the ARTS control file.)
   - We speak of window regions where the zenith opacity is below 1. Where are they?

2. Brightness temperature is a unit for intensity. It is the temperature that a blackbody should have to give the same intensity as measured. Mathematically, the transformation between intensity in SI units and intensity in brightness temperature is done with the Planck formula. The plotting scripts already convert the radiances simulated by ARTS into brightness temperatures. Investigate the brightness temperature spectra for different hypothetical sensors:

   (a) A ground-based sensor looking in the zenith direction.
   (b) A sensor on an airplane ($z = 10$ km) looking in the zenith direction.

   Questions:

   Consider both opacity and brightness temperatures to answer the following questions:
   - In Plot (a), why do the lines near 60 GHz and near 180 GHz appear flat on top?
   - In Plot (b), why is the line at 180 GHz smaller than the line at 120 GHz, although its zenith opacity is higher?
   - Describe the difference between plots (a) and (b). What happens to the lines, what happens to the background? Can you explain what you see?

3. Make the same calculation for a satellite sensor ($z = 800$ km) looking nadir (straight down).

   Questions:
   - Why is the line at 180 GHz "upside-down", but the one at 20 GHz not?
   - Explain the funny shape of the O_2 line at 120 GHz.