Advanced radiation and remote sensing

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Exercise No. 4 – Atmospheric Brightness Temperature Spectra

1. Use the ARTS control file rtcalc.arts and Matlab plotting script plot_bt.m to calculate and display the spectrum of atmospheric zenith opacity in the microwave spectral range for a midlatitude-summer atmosphere. There are four spectral lines in the plot.

   Questions:
   - To which species do these lines belong?
     (You can find this out by playing 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. Calculate and display the atmospheric brightness temperature spectrum 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:
   - 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 O2 line at 120 GHz.