Advanced radiation and remote sensing

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Exercise No. 4 – Atmospheric Brightness Temperature Spectra

1. Run the Python script rtcalc.py to calculate the spectrum of atmospheric zenith opacity in the microwave spectral range for a midlatitude-summer atmosphere over a wet land surface.

   Consider the zenith opacity spectrum 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 Python script.
   - 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. ARTS is capable to perform simulation in units of brightness temperature. Uncomment the code part for the second task. 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 ($z = 10\,\mathrm{km}$) looking in the zenith direction.

   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 before?
   - 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 as in task 2 for a satellite sensor ($z = 800\,\mathrm{km}$) looking nadir (straight down).

   Answer following questions:

   - Explain the brightness temperature simulated in the window regions.
   - Why does the line at 22 GHz look different from the others?
   - Investigate the the O_2 line at 120 GHz. Perform an ARTS simulation focused around that frequency. Why does the shape close to the center of the O_2 line at 120 GHz looks so differently compared to the 183 GHz.