Exercise 4: Atmospheric Brightness Temperature Spectra

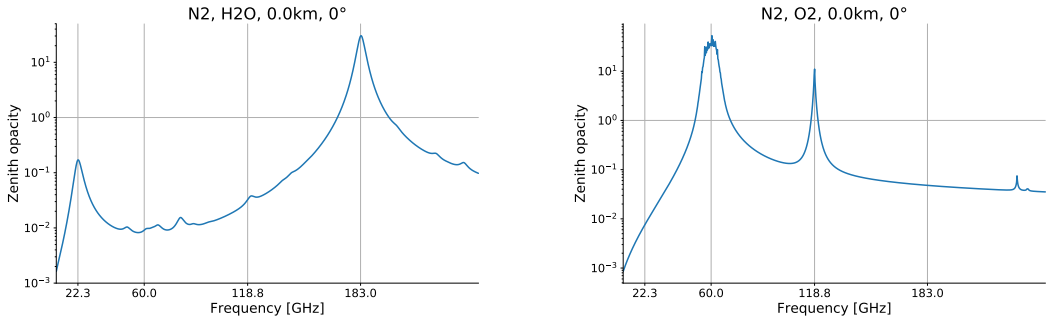
Sample Solution

Effective: 06.02.2019

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 over a wet land surface. You can use the attributive plotting script `plot_bt.py` to visualize the results.

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.)



(a) H_2O and N_2 (b) O_2 and N_2

Figure 1: Zenith opacity separately for O_2 and H_2O molecules.

- We speak of window regions where the zenith opacity is below 1. Where are they?

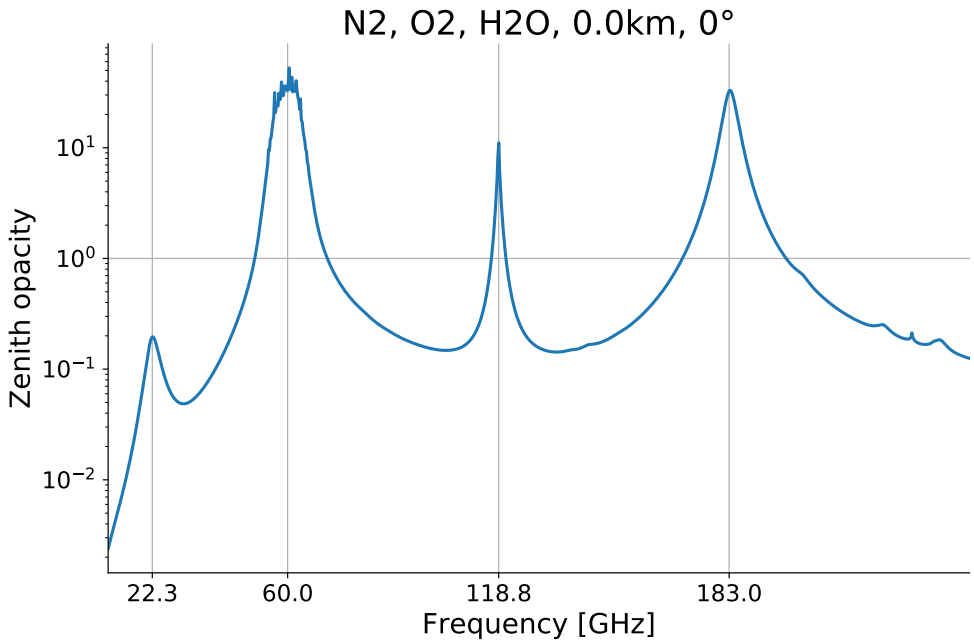


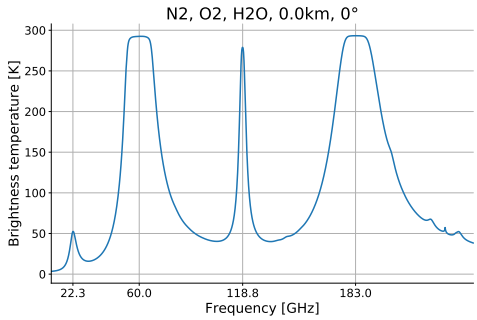
Figure 2: Zenith opacity.

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:

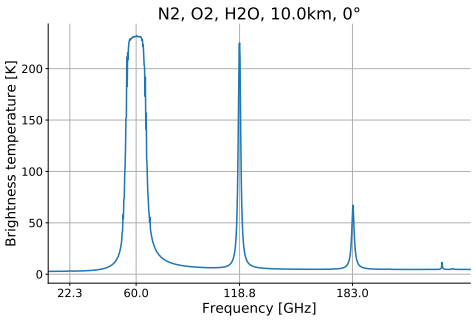
- A ground-based sensor looking in the zenith direction.
- A sensor on an airplane (z = 10 km) looking in the zenith direction.

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?



(a) Ground based.



(b) 10 km height.

Figure 3: Brightness temperature for a sensor positioned at the ground and at 10 km height.

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

Questions

- Explain the brightness temperature simulated in the window regions.
- Why does the line at 22 GHz look different from the others?
- Explain the "funny" shape close to the center of the O_2 line at 120 GHz (you may have to perform an ARTS simulation focused around that frequency).

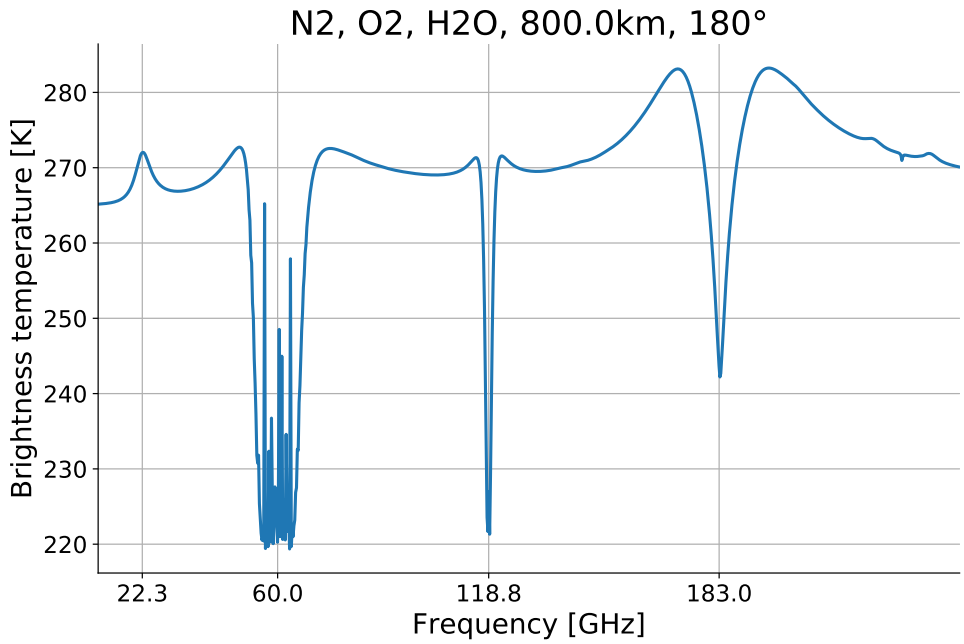


Figure 4: Brightness temperature seen from a sensor looking down.