Advanced radiation and remote sensing

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Exercise No. 8 – Scattering

1. Run the Jupyter notebook script `scattering.ipynb`. This will simulate the radiation field at a frequency of 229 GHz for an atmosphere with an ice cloud as well for clear-sky. Since this is a one-dimensional simulation (vertical dimension only), the calculated radiation fields have two dimensions: altitude (pressure) and zenith angle. The Jupyter notebook will plot the two radiation fields in the atmosphere at a zenith angle of 180°. Here, the zenith angle describes the viewing direction. This means that you are looking at the upward directed radiation. The unit is brightness temperature.
   (a) Describe the difference between cloudy and clear-sky radiation.
   (b) Guess where the ice cloud is located in the atmosphere based on the two radiation fields?
   (c) Explain the difference between cloudy and clear-sky radiation.
2. Change the zenith angle (`zenith_angle`) from 180° to 0° and rerun the Python script.
   (a) Describe and explain the difference.
   (b) Why is the brightness temperature at the top of the atmosphere so low?
3. Now you will look at the radiation fields as a function of zenith angle (viewing direction) at a fixed pressure level. In the Python script, change the variable `pressure_level` from `None` to a pressure level in [Pa], which is within the ice cloud and rerun the script.
   (a) Explain the shape of the radiation field without the cloud.
   (b) How does the radiation field with the cloud differ?
4. Make the same calculation as in task 3 but with a less or a more dense ice cloud. To do that, you have to call the function `scattering()` within your script with the argument `ice_water_path` set to your desired value in $\left[\mathrm{kg\,m^{-2}}\right]$. The ice water path is the vertically integrated mass content of ice. In task 3, the function `scattering()` used a default value of $2\,\mathrm{kg\,m^{-2}}$.