Advanced radiation and remote sensing

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Exercise No. 7 – Scattering

1. Run arts on the controlfile `scattering.arts`. This will simulate the radiation field at a frequency of 229 GHz for an atmosphere with an ice cloud. It will also simulate the radiation field at the same frequency for the same atmosphere without the ice cloud. Since this is a one-dimensional simulation (vertical dimension only), the calculated radiation fields have two dimensions: altitude (pressure) and zenith angle.

2. Run the python script `plot_field.py`. It plots the two radiation fields in the atmosphere at a zenith angle of 180° (upward radiation). The unit is brightness temperature.
   - How do the radiation fields differ?
   - Can you guess where the ice cloud is located in the atmosphere based on the two radiation fields?
   - Explain the difference in radiation.

3. In the python script, change the zenith angle from 180° to 0° (downward radiation). For this you have to change the variable `zenith_angle` from -1 to 0. Run the script again.
   - How do the radiation fields differ?
   - Can you explain the difference?
   - Why is the brightness temperature at the top of the atmosphere so low?

4. Now you will look at the radiation fields as a function of zenith angle for a fixed pressure. In the python script, change the variable `p_level` from -1 to 41. This will put you directly in the ice cloud. Run the script. Remember that 0° is downward radiation (equivalent to looking up).
   - Explain the shape of the radiation field without the cloud.
   - How does the radiation field with the cloud differ?
   - How would you expect the radiation field in the cloud to look like if the cloud were much thicker (more scattering)?

5. *[BONUS]* If you want you can check your answer to the last question. You can turn the ice cloud into a thick fog to increase the scattering. To do that, you have to change the number density in the controlfile `scattering.arts`. In line 125 change the factor from 4 to 100. This will ensure that the ice cloud is very thick. Run the controlfile and afterward run the python script.
   - What is the brightness temperature in the cloud now?