Advanced radiation and remote sensing

Lukas Kluft, Manfred Brath, Stefan Bühler

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Exercise No. 7 – Outgoing Longwave Radiation (OLR)

1. Run ARTS on the Python script olr.py. This will calculate the spectrum of outgoing longwave radiation for a midlatitude-summer atmosphere. Our calculation trades accuracy for computational efficiency. For example, we use only water vapor and carbon dioxide as absorbers. We use only 300 frequency grid points and approximately 54,000 spectral lines, whereas for accurate calculations one needs at least 10,000 frequency grid points and 500,000 spectral lines, taking into account absorbing species like ozone and methane. The script plots the spectral irradiance, in SI units, as a function of wavenumber. Planck curves for different temperatures are shown for comparison. We integrate the whole spectrum to quantify the power per square that is emitted by the atmosphere (value in title).

   (a) How would the OLR spectrum look in units of brightness temperature?

   (b) How would the Planck curves look in units of brightness temperature?

   (c) Find the CO_2 absorption band and the regions of H_2O absorption. From which height in the atmosphere does the radiation in the CO_2 band originate?

   (d) Are there window regions?

   (e) What will determine the OLR in the window regions?

   (f) Use the plot to explain the atmospheric greenhouse effect.

2. Investigate how the OLR changes for different atmospheric conditions by modifying the input data. Use the `atmfield.scale(...)` and `atmfield.add(...)` to change the atmosheric data:

   - Add 1 K to the temperature.
   - Increase the CO_2 conentration by a factor of 2.
   - Increase the H_2O conentration by a factor of 1.2.

   (a) Change it, and calculate and plot the spectrum for each change.

   (b) Compare the spectra for humidity and carbon dioxide changes. Where do the changes occur?

   (c) Compare the OLR numbers, which is the more potent greenhouse gas, CO_2 or H_2O?

   (d) What is the effect of the temperature change? Explain.