

# Exercise 6: Outgoing Longwave Radiation

sample solution

February 3, 2017

1. Run arts on the controlfile *iolr.artsj*. This will calculate the spectrum of outgoing longwave radiation (OLR) for a midlatitude-summer atmosphere. The calculation has been simplified, so that you do not have to wait so long for the results. For example, we use only water vapor and carbon dioxide as absorbers. We use only 1000 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.

2. Use the Matlab program *plot\_olr* to display the results. This time the radiances are shown in SI units, not in brightness temperature. Planck curves for different temperatures are shown for comparison. The number shown is the area under the curve. If this is integrated over direction (one hemisphere) it is the power that the atmosphere loses to space per square meter.

- How would the OLR spectrum look in units of brightness temperature?
- How would the Planck curves look in units of brightness temperature?
- Find the CO<sub>2</sub> absorption band and the regions of H<sub>2</sub>O absorption (ask the teacher to point them out to you). Where in the atmosphere does the radiation in the CO<sub>2</sub> band originate?
- Are there window regions? What will determine the OLR in the window regions?
- Use the plot to explain the atmospheric greenhouse effect to your neighbor.

3. An interesting question is how the OLR changes if the atmospheric composition changes. You can investigate this by modifying the ARTS controlfile. The place to do this is below line 76, where it says “Atmospheric scenario for midlatitude summer”. By adjusting the path “./midlatitude-summer/midlatitude-summer” you can make changes to the atmospheric composition. There are three possibilities:

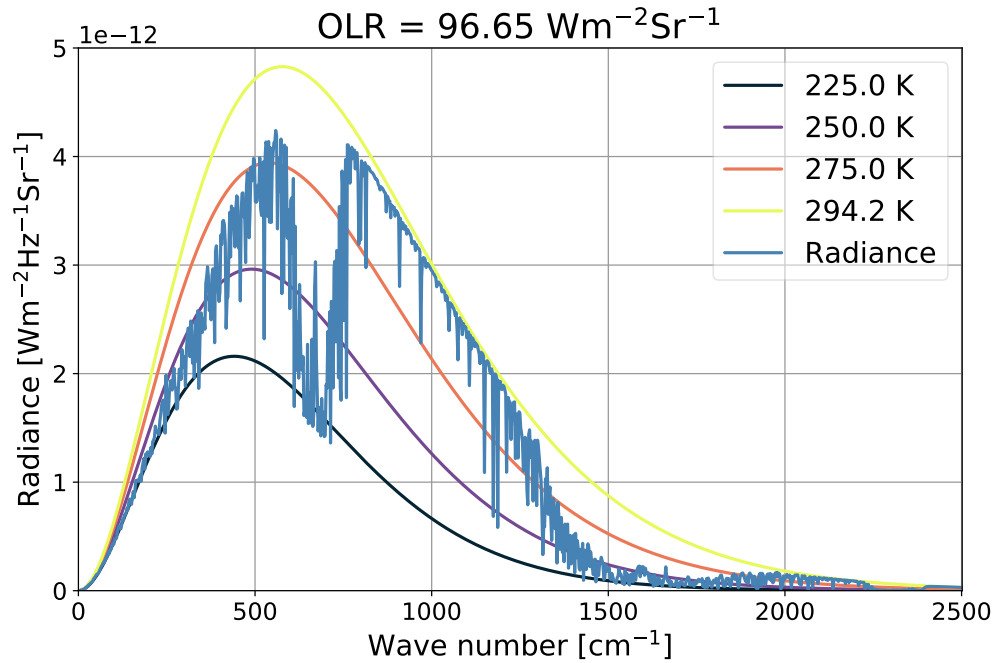


Figure 1: spectrum of outgoing longwave radiation and Planck curves for different temperatures

- Add 1 K to the temperature:  
`“./midlatitude-summer_+T/midlatitude-summer”`
- Multiply the  $CO_2$  concentration by 2:  
`“./midlatitude-summer_+CO2/midlatitude-summer”`
- Multiply the  $H_2O$  concentration by 1.2:  
`“./midlatitude-summer_+H2O/midlatitude-summer”`

Each group should investigate one parameter. Change it, and calculate the spectrum, then make a plot.

- Compare the spectra for humidity and carbon dioxide changes. Where do the changes occur?
- Compare the OLR numbers, which is the more potent greenhouse gas,  $CO_2$  or  $H_2O$ ?
- What is the effect of the temperature change? Explain.

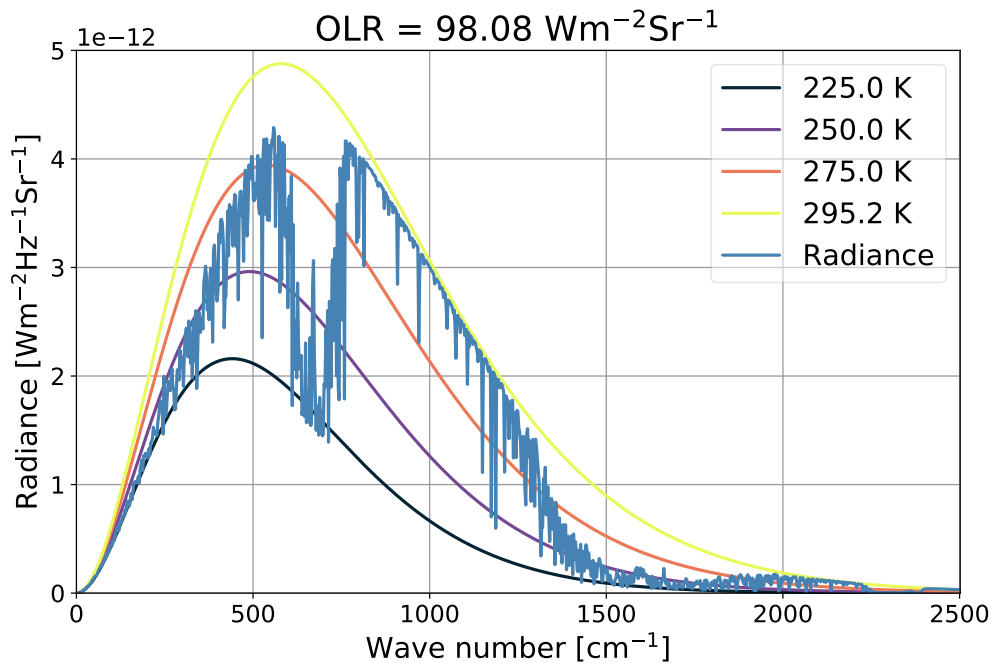


Figure 2: spectrum of outgoing longwave radiation for higher Temperature (+1K)

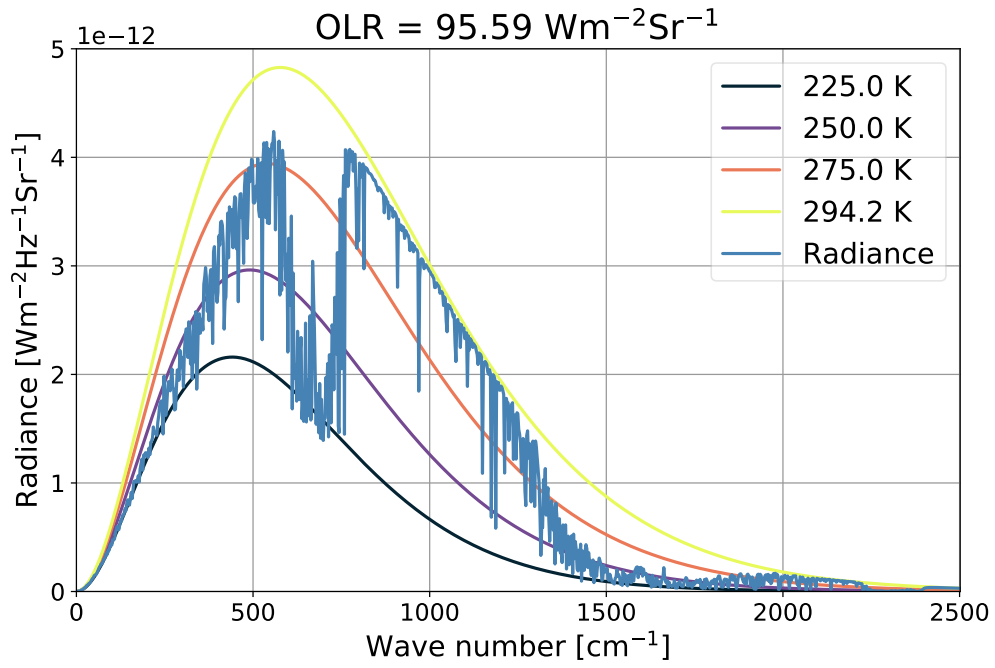


Figure 3: spectrum of outgoing longwave radiation for higher  $CO_2$  concentration

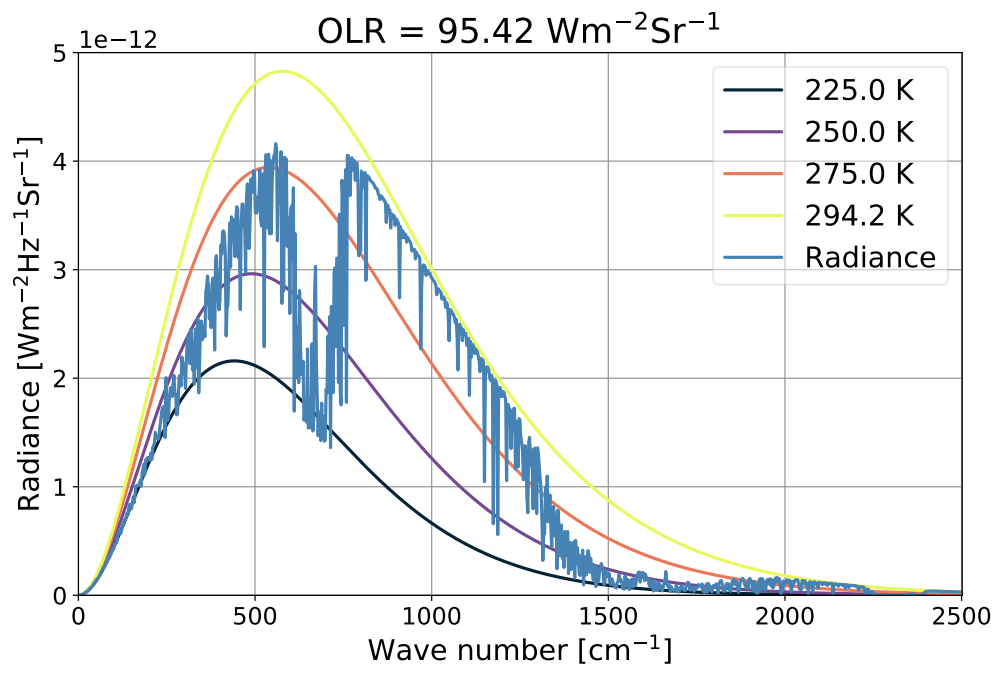


Figure 4: spectrum of outgoing longwave radiation for higher  $H_2O$  concentration