# A Radiation Course based upon Numerical Methods

May 20, 2015

# Exercise No. 4 – Jacobian and Chapman's rule

1. Run arts on the controlfile “jacobian.arts”. (This time you have to do this only once.)
2. Start Matlab, run “plot\_jacobian.m”. You get a figure with two sub-plots. One is the spectrum of nadir brightness temperature (BT) at the top of the atmosphere, the other is atmospheric zenith opacity. Both are for a spectral range near the 183.31 GHz water vapor line for a midlatitude-summer atmosphere.

* Are there window regions?

1. The atmospheric temperature profile for the calculation was:

**Pressure [hPa] Temp. [K] Altitude [km]**

1013.000000 294.200000 0.000000

902.000000 289.700000 1.000000

802.000000 285.200000 2.000000

710.000000 279.200000 3.000000

628.000000 273.200000 4.000000

554.000000 267.200000 5.000000

487.000000 261.200000 6.000000

426.000000 254.700000 7.000000

372.000000 248.200000 8.000000

324.000000 241.700000 9.000000

281.000000 235.300000 10.000000

243.000000 228.800000 11.000000

209.000000 222.300000 12.000000

179.000000 215.800000 13.000000

153.000000 215.700000 14.000000

130.000000 215.700000 15.000000

111.000000 215.700000 16.000000

95.000000 215.700000 17.000000

81.200000 216.800000 18.000000

69.500000 217.900000 19.000000

59.500000 219.200000 20.000000

* Where does the radiation at the peak of the line (183 GHz) originate?
* Where does the radiation at the wing (150 GHz) originate?

1. Change the variable “freq\_ind” at the beginning of the Matlab script from -1 to a number between 1 and 110. This will select a frequency and mark it with a circle in the BT plot. You get two more plots, the water vapor Jacobian and the opacity between the top of the atmosphere and altitude z, both for the selected frequency.

* Write down the altitude of the Jacobian peak and the altitude where the opacity reaches 1 for some different frequencies.
* Can you think of a reason why the two altitudes are not exactly the same?
* Explain, why the Jacobians are sometimes positive, sometimes negative.