

# Preliminary results on Titan atmospheric water vapor from Cassini-CIRS data

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Modeling'

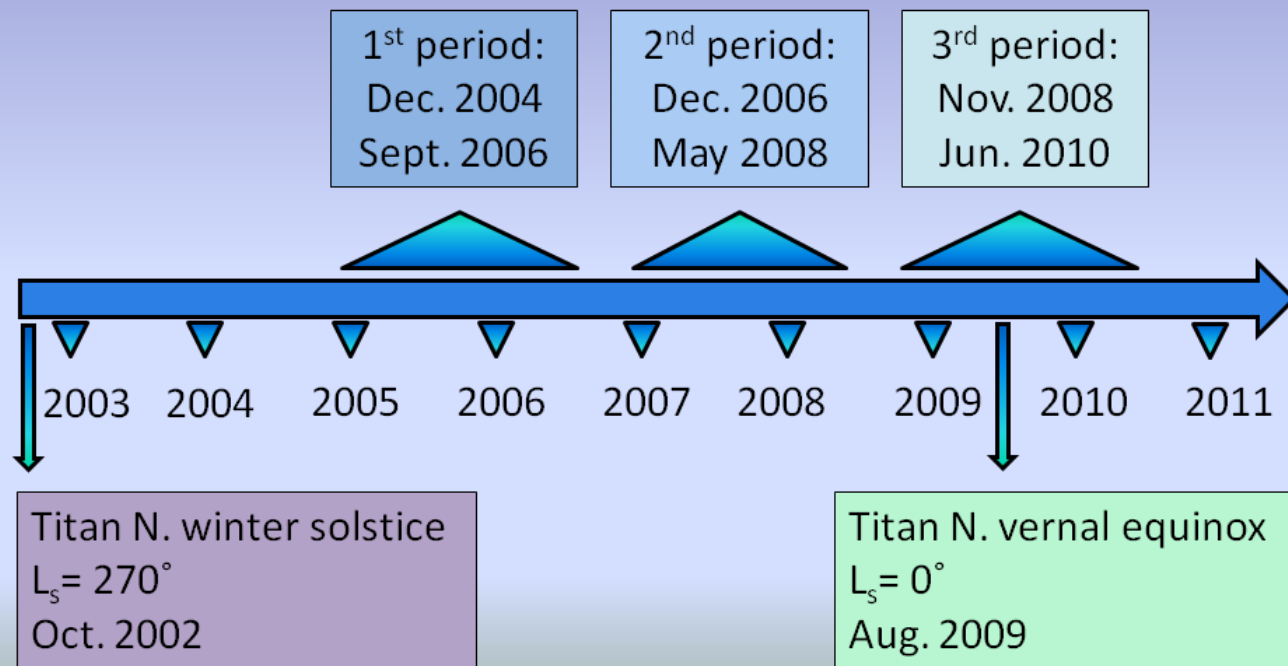
Poipu Koloa, Kauai, Hawaii, April 11-14, 2011

# Data

- Cassini-CIRS (Composite Infrared Spectrometer) Titan data
- Far infrared ( $60 - 600 \text{ cm}^{-1}$ ) (FP1)
- FIRNADCMP high resolution nadir spectra,  $0.25 \text{ cm}^{-1}$
- Average of 20 or 30 degrees of latitude
- Acquisition from max. distance of  $300,000 \text{ km}$  and max. emission angle of  $70^\circ$

# Observations periods

## CIRS observations of Titan

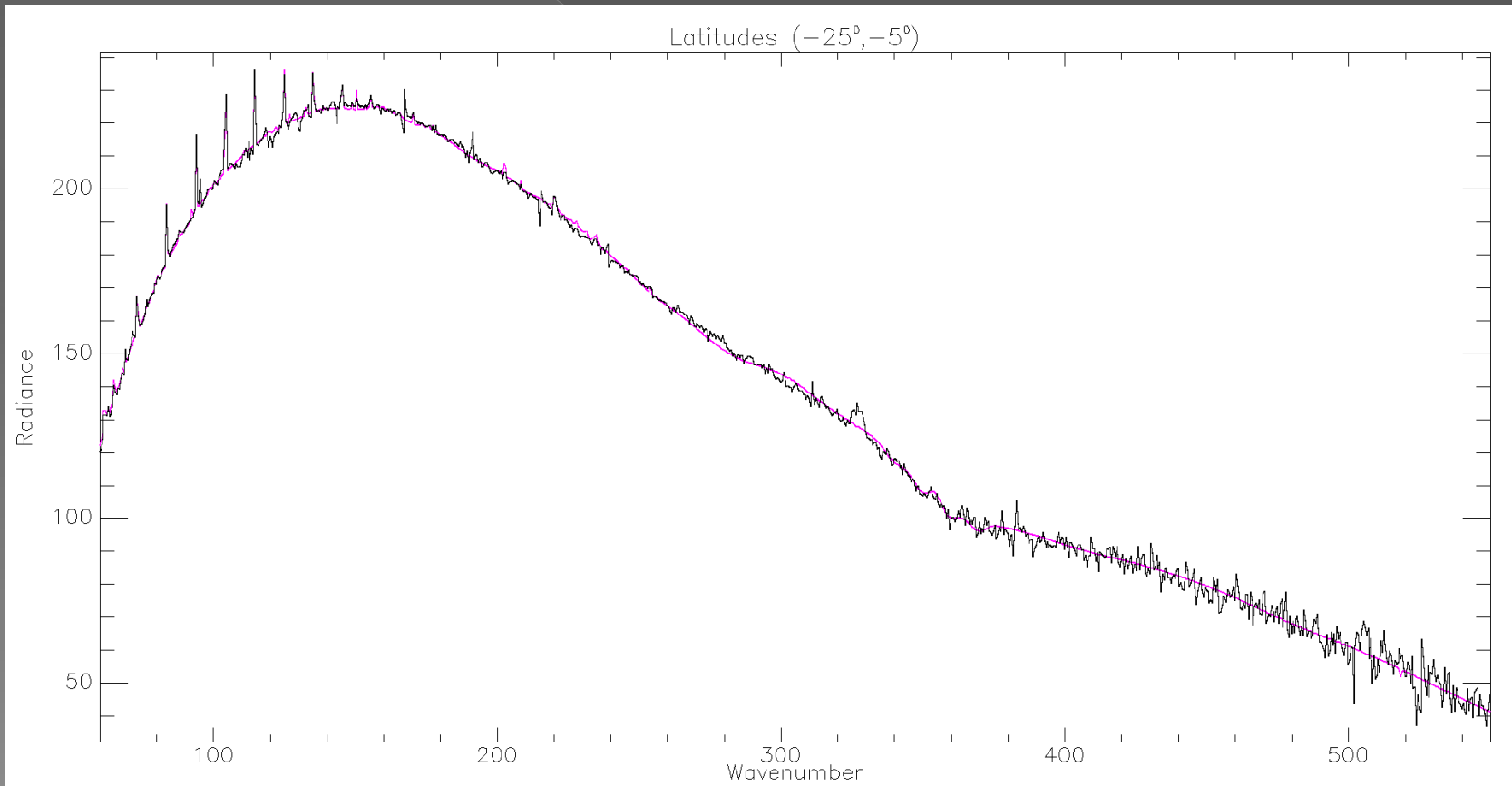


# Method

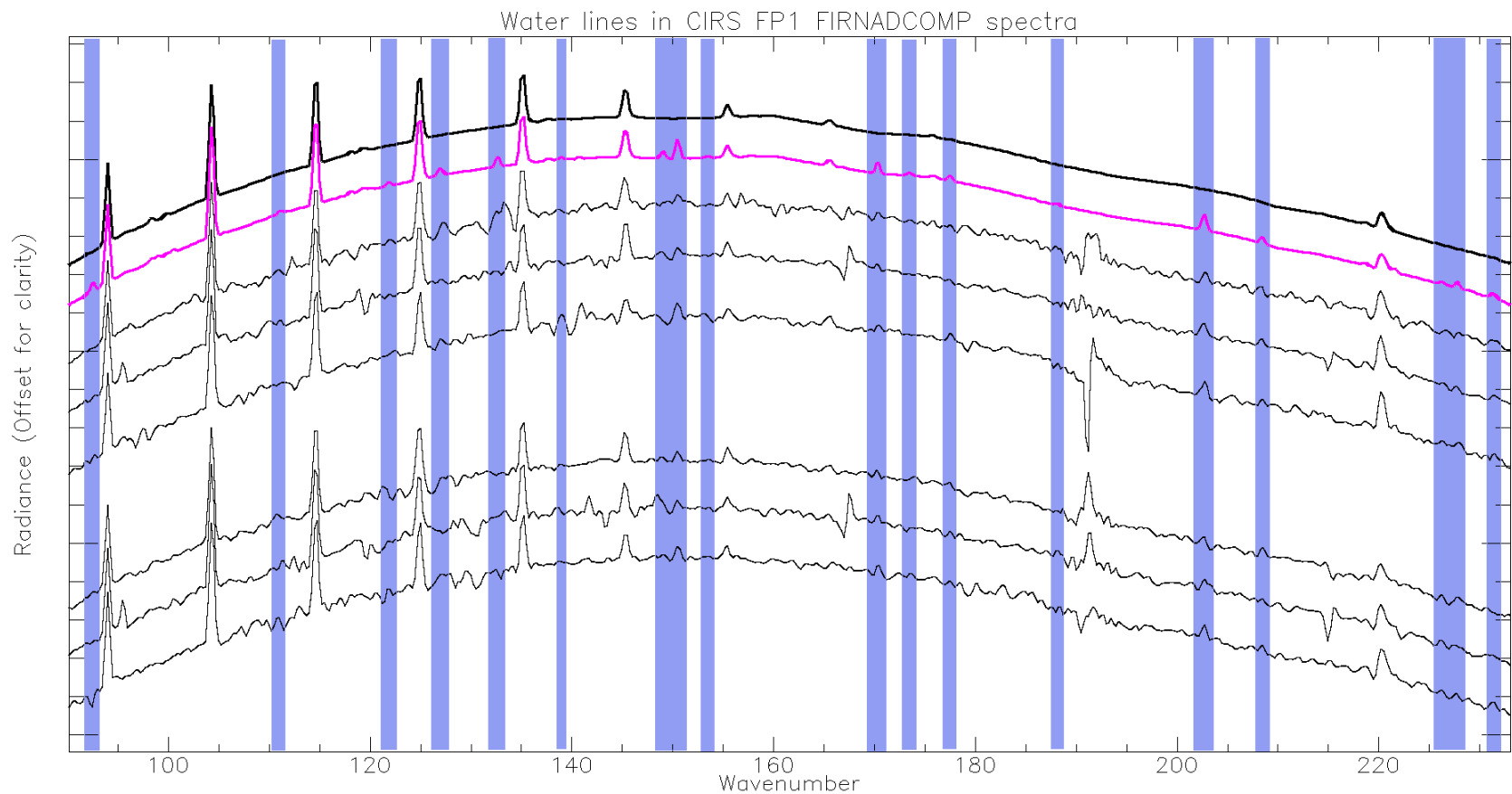
- ◉ Spectrum at 60-600  $\text{cm}^{-1}$ :
  - continuum due to:
    - thermal emission of the planet
    - collision induced absorption (CIA) of  $\text{N}_2$ ,  $\text{CH}_4$ ,  $\text{H}_2$
    - haze, slowly increasing with  $\omega_n$
  - lines of  $\text{CH}_4$ ,  $\text{CO}$ ,  $\text{H}_2\text{O}$ ,  $\text{CO}_2$ ,  $\text{HCN}$ ,  $\text{C}_2\text{H}_2$ ,  $\text{C}_4\text{H}_2$ ,  $\text{C}_3\text{H}_4$ ,  $\text{C}_2\text{N}_2$ ,  $\text{HC}_3\text{N}$ ,  $\text{CH}_3\text{CN}$
- ◉ Retrieval of water vapor:
  - correlated-k for computation of synthetic spectra
  - retrieval code (NEMESIS, developed in Oxford, Irwin et al., 2008) based on the method of optimal estimation (Rodgers, 1976, 2000)

# Fit of FP1 nadir spectrum

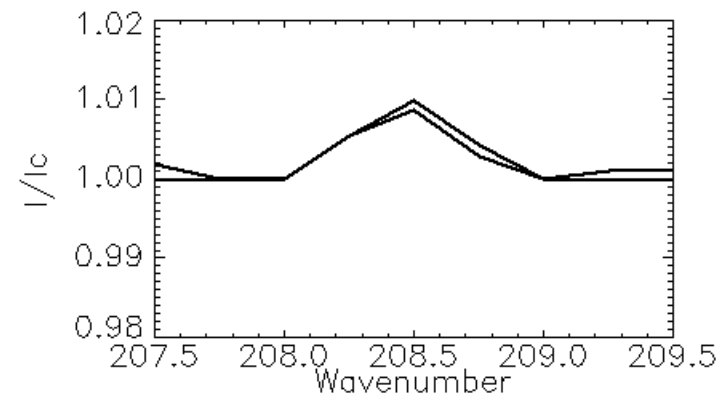
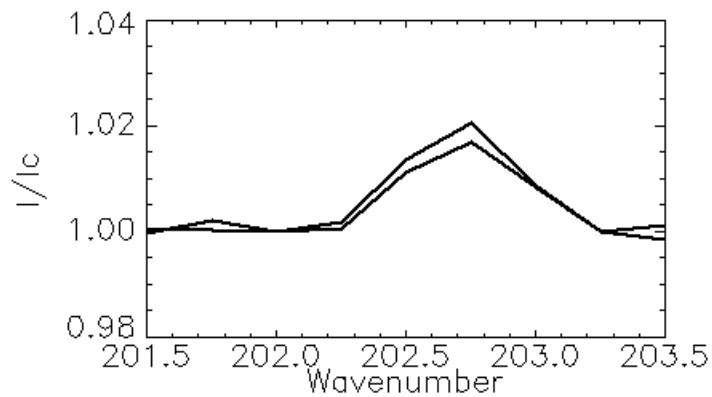
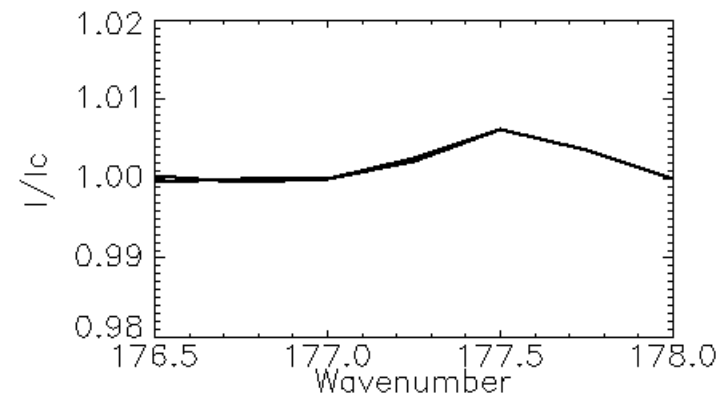
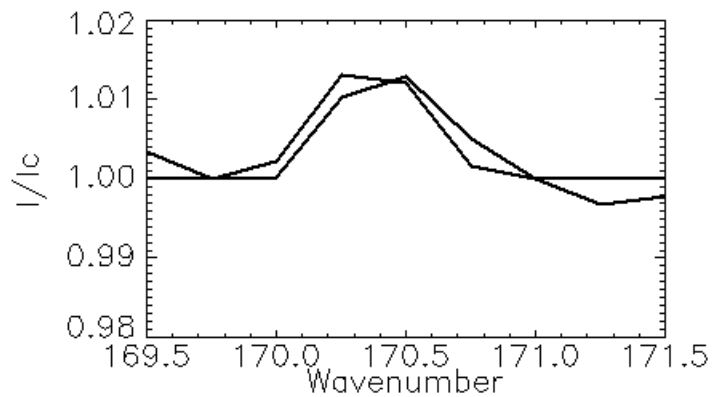
- Constant water mixing ratio profile
- CIA:  $\text{CH}_4$ - $\text{N}_2$  150% of the Borysow, 1991, "nominal" ones, to fit the continuum
- Temperature profile from HASI for the troposphere and CIRS for the stratosphere



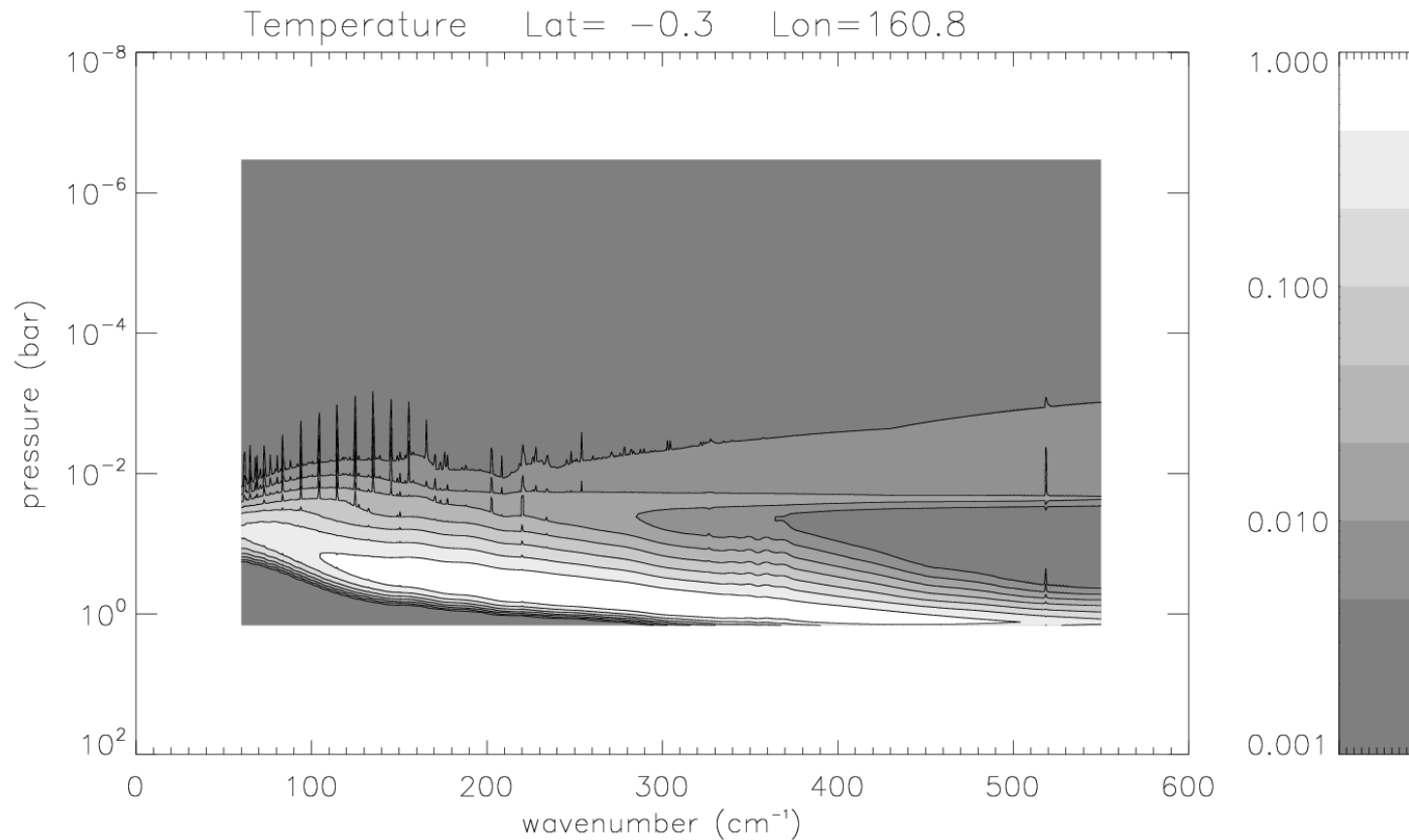
# Water lines



# Water lines fit

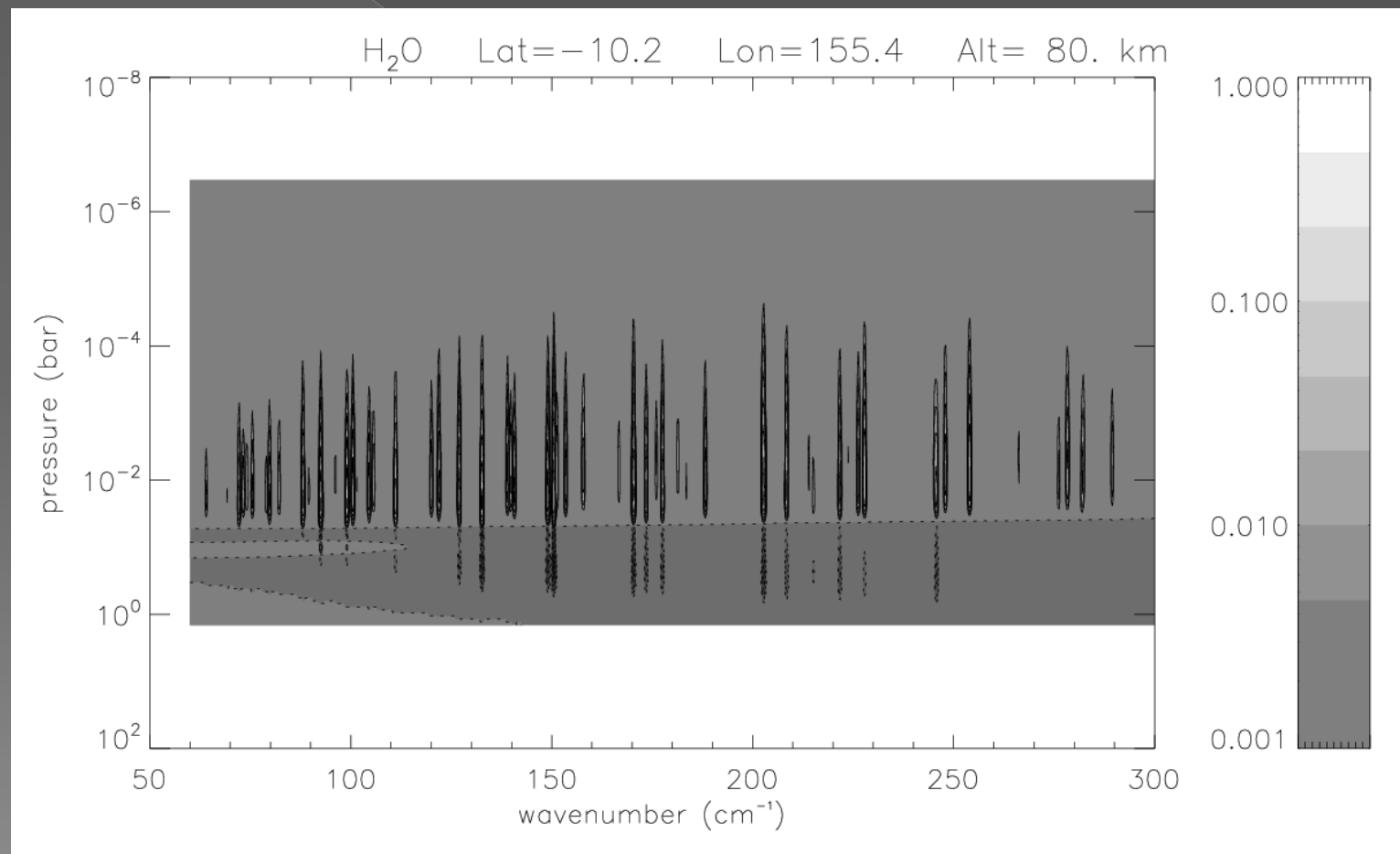


# Sensitivity of the radiance to the Temperature profile

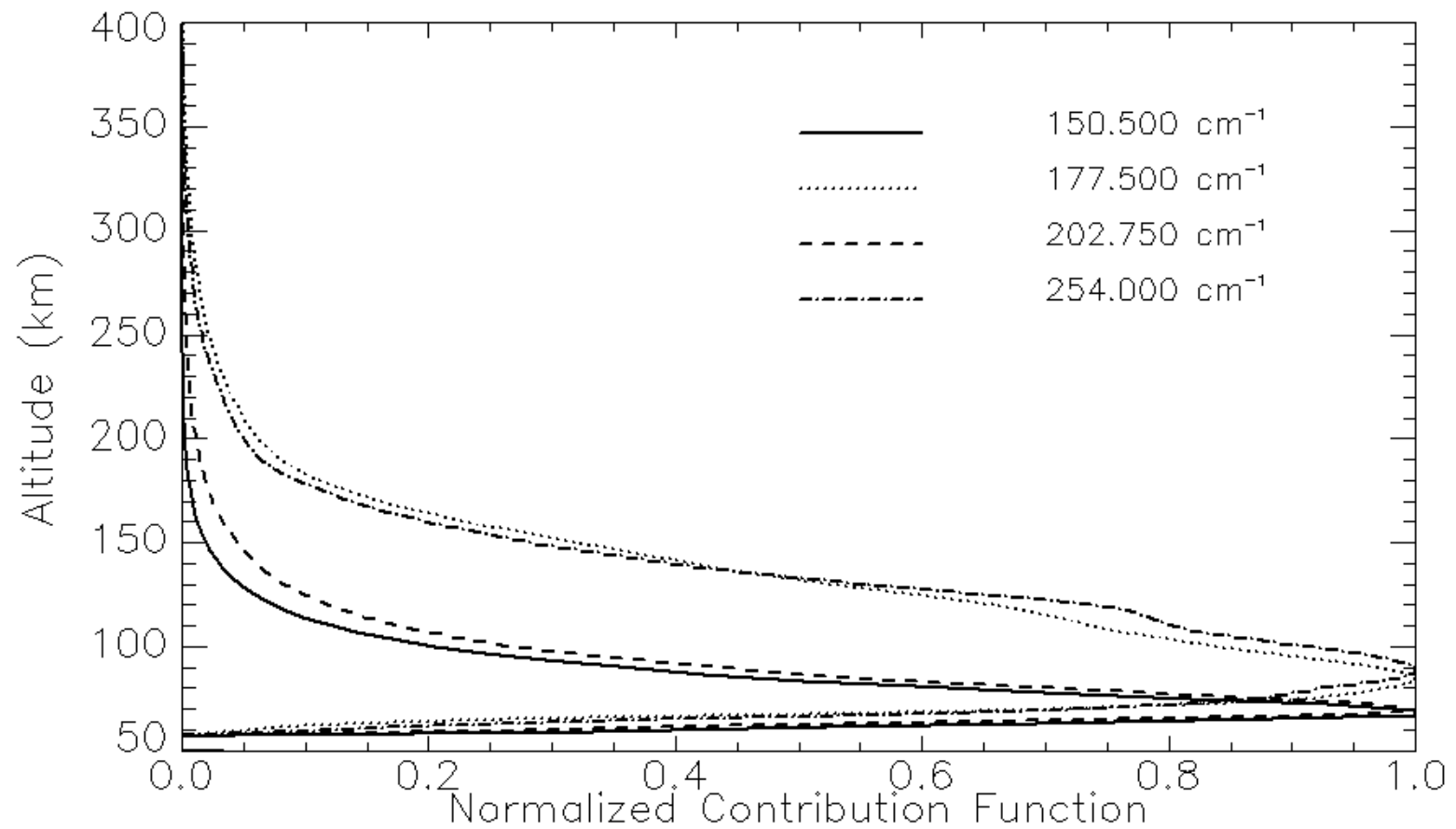


# Sensitivity of the radiance to the water mr

- For a constant water profile the maximum sensitivity is in the stratosphere around 100 km



# Contribution function



# Preliminary results

- 1S, 1365 sp (  $0.14 \pm 0.12$  ) ppb
- 2S, 1160 sp (  $0.13 \pm 0.11$  ) ppb
- 3S, 1629 sp (  $0.13 \pm 0.11$  ) ppb
- 1N, 2929 sp (  $0.16 \pm 0.13$  ) ppb
- 2N, 2481 sp (  $0.13 \pm 0.11$  ) ppb
- 3N, 806 sp (  $0.14 \pm 0.12$  ) ppb
- 19, 2825 sp (  $0.14 \pm 0.12$  ) ppb
- 15a (  $0.10 \pm 0.12$  ) ppb
- 15b (  $0.14 \pm 0.14$  ) ppb
- 15c (  $0.14 \pm 0.14$  ) ppb
- 16 (  $0.15 \pm 0.14$  ) ppb

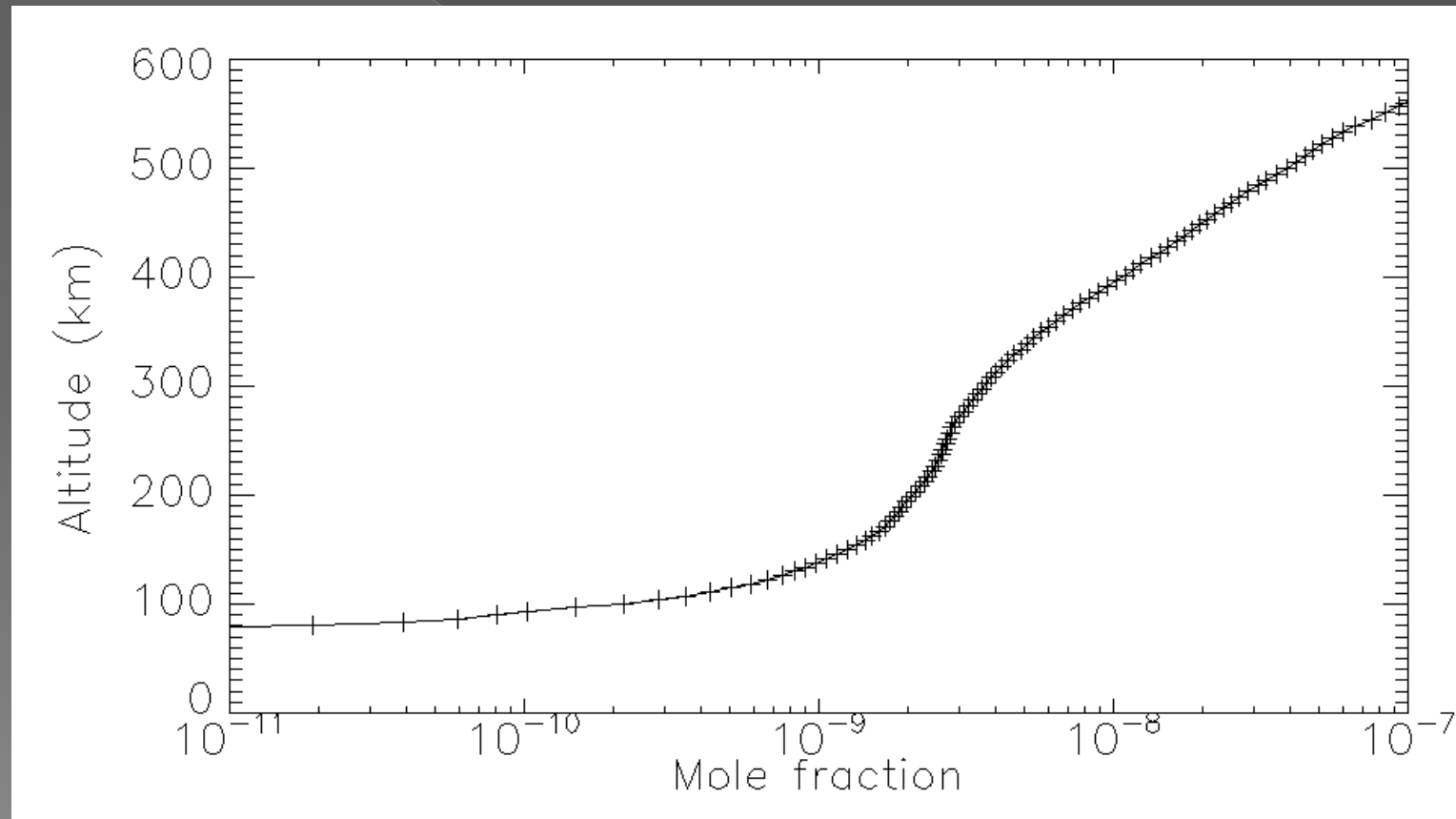
- Water mixing ratio for a constant profile  $\approx 0.14$  ppb
- Changes of the model give differences on the water mr results of less the 0.1 ppb, inside the single retrieval error

# Water column abundance

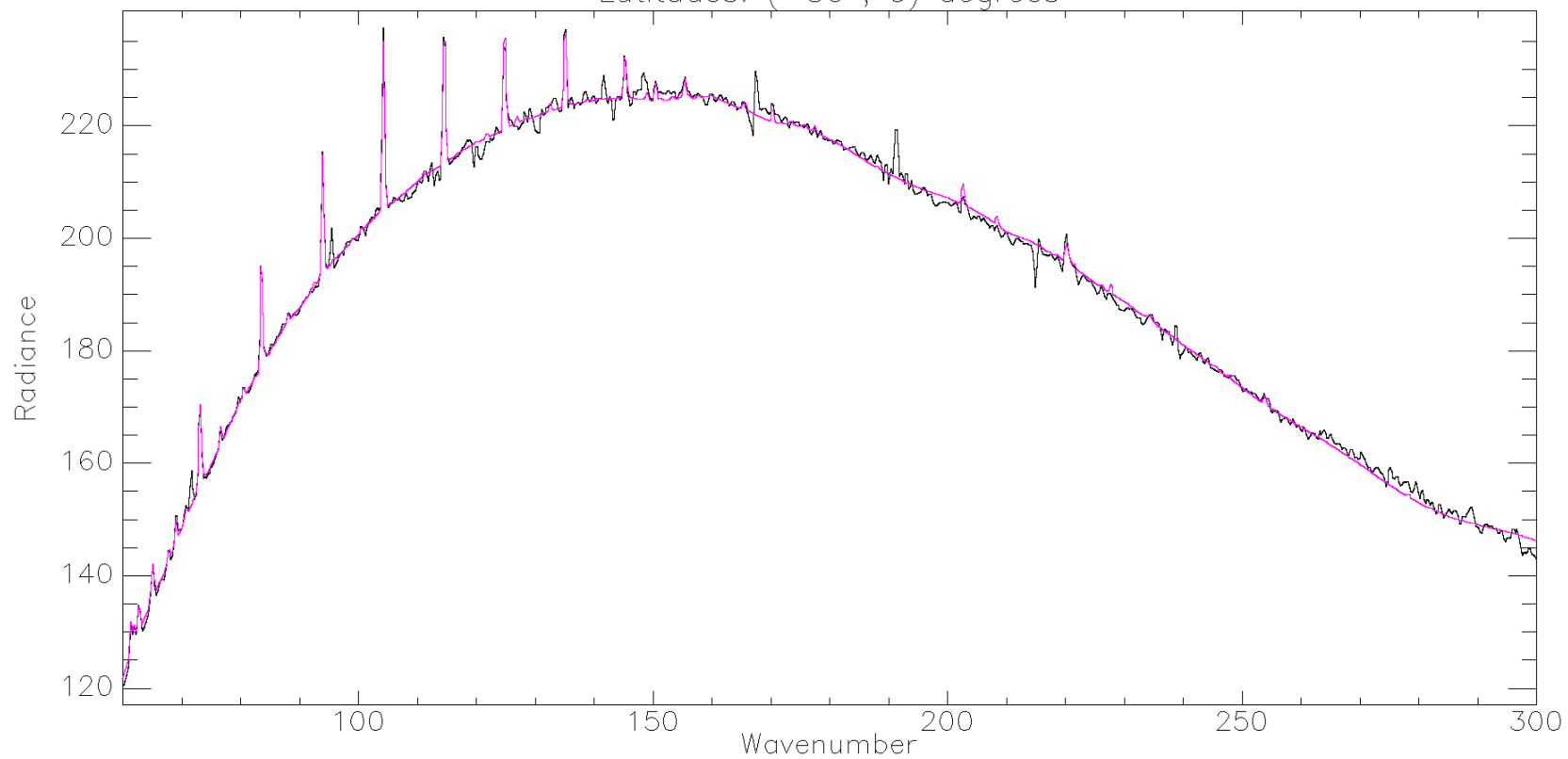
- Assuming a constant water mixing ratio of 0.14 ppb and integrating from a minimum pressure of  $3.37330 \times 10^{-7}$  bar to a maximum pressure of  $0.16112 \times 10^{-1}$  bar (corresponding to the water condense level  $\sim 80$  km) we obtain:
- Column abundance:  $(4.3 \pm 1) \times 10^{14}$  molecules/cm<sup>2</sup>
- Column mass:  $(1.5 \pm 1) \times 10^{-12}$  kg/cm<sup>2</sup>
- Planet mass of gas:  $(1.1 \pm 0.3) \times 10^{+6}$  kg

# Not constant water profile

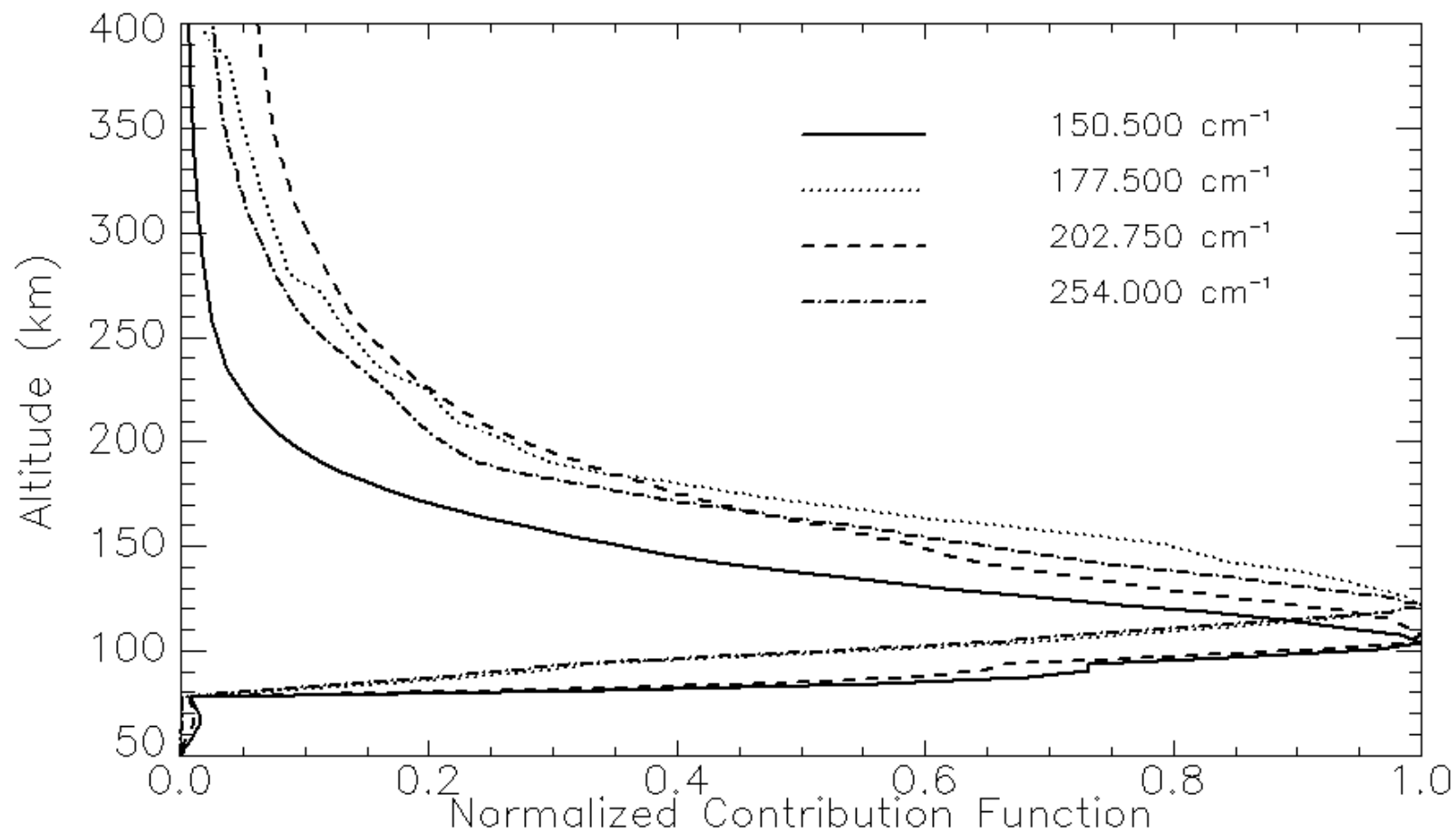
- H<sub>2</sub>O profile from Wilson and Atreya (2004)



Latitudes: (-30 , 0) degrees



# Contribution function



# Results

- 1S, 1365 sp (  $0.20 \pm 0.03$  )  
\*TP
- 2S, 1160 sp (  $0.17 \pm 0.03$  )  
\*TP
- 3S, 1629 sp (  $0.16 \pm 0.03$  )  
\*TP
- 1N, 2929 sp (  $0.20 \pm 0.03$  )  
\*TP
- 2N, 2481 sp (  $0.16 \pm 0.03$  )  
\*TP
- 3N, 806 sp (  $0.16 \pm 0.03$  )  
\*TP

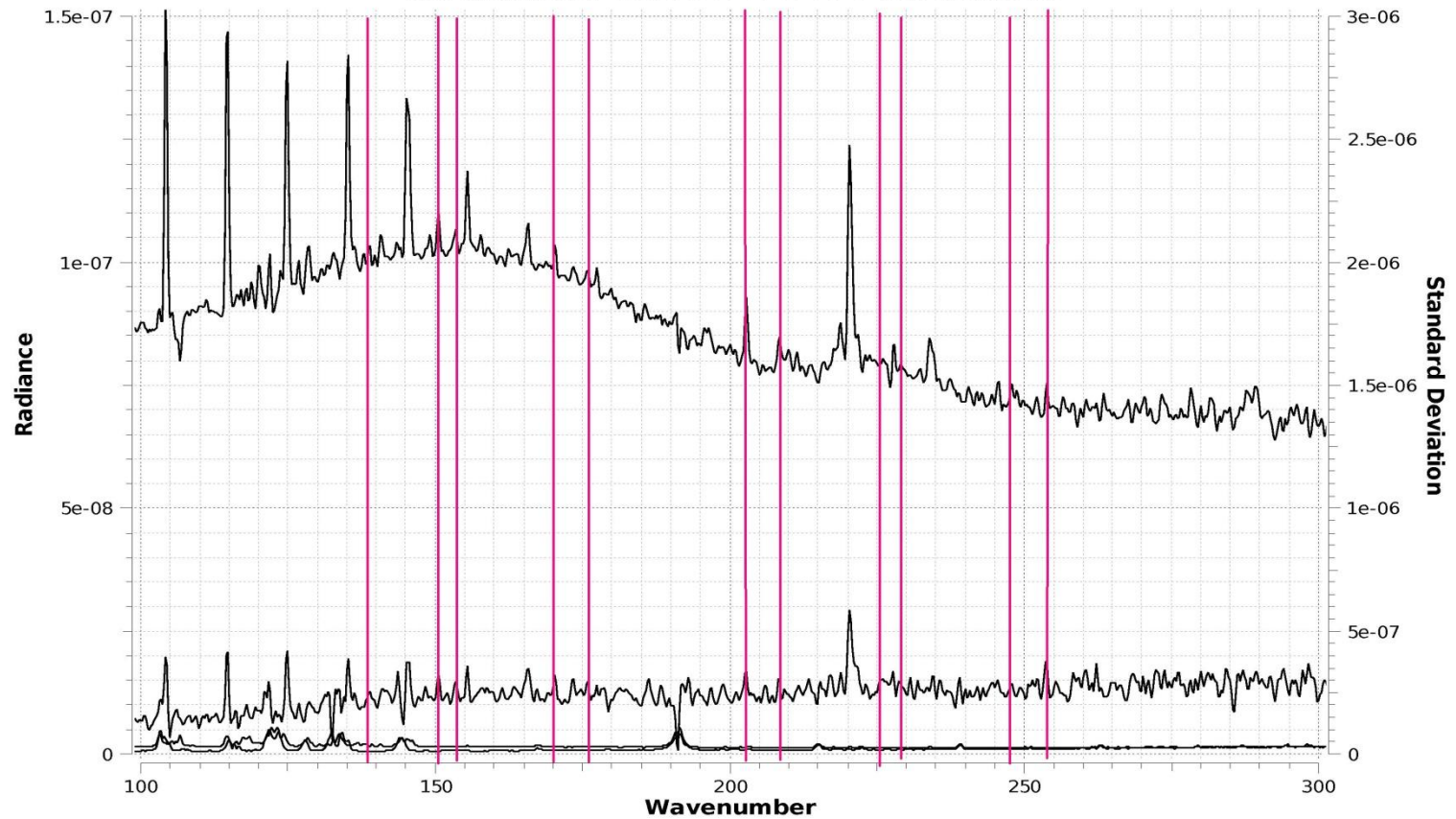
- Scaling factor to the Wilson-Atreya water profile  $\approx 0.14$  ppb

- Changes of the model give differences on the water mr results of less the 0.1 ppb, inside the single retrieval error

- For wilson water profile: Column abundance:  $5.79108e+14$  molecules/cm<sup>2</sup> Column mass:  $1.73241e-11$  kg/cm<sup>2</sup> Planet mass of gas:  $1.63152e+07$  kg

# Detection of water in limb spectra

**CIRS FP1 FIRLMBINT - Latitude -40 40 - Max Distance to Titan 50,000km - Curve A 100 150 km altitude / Curve B 220 270 km altitude**



— avg\_FIRLMBINT\_alt100\_150\_latM40P40.txt\_Ispm[]\_Index\_0\_Version\_0 — avg\_FIRLMBINT\_alt220\_270\_latM40P40.txt\_Ispm[]\_Index\_0\_Version\_0  
— avg\_FIRLMBINT\_alt220\_270\_latM40P40.txt\_Ispm[]\_Index\_1\_Version\_0 — avg\_FIRLMBINT\_alt100\_150\_latM40P40.txt\_Ispm[]\_Index\_1\_Version\_0

Altitude centered at 120 km

Altitude centered at 250 km

# Future work

- ◉ Use the limb data to constrain the water profile at two different altitudes
- ◉ Once new information on the water profile will be available we can reanalyze nadir data with an improved water profile
- ◉ Investigate the water amount for all latitudes



# Contribution function

