Implementation of far infrared gaseous absorption/ emission in Radiative Transfer Code *MOMO*

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1./ *MOMO*: Matrix-Operator Model[1]

- **Transmission/absorption, scattering** in SW (*200-3650*nm)
- The same + **Emission** in LW (*3.65–100*μm)
- **Remote sensing (inversion of sat data) or simulations** of atmospheric RT, for gaseous atmospheres, aerosols, clouds
- **Radiative budget (forcings, heating rates)**, atmospheric chemistry (actinic fluxes)
- Ocean remote sensing

- **The code is tested in SW (*200-3650*nm)**
- **The code is developed in MI (*3.65–15*μm) and tests will be soon published**
- **The code is currently developed in FI (*15–100*μm)**

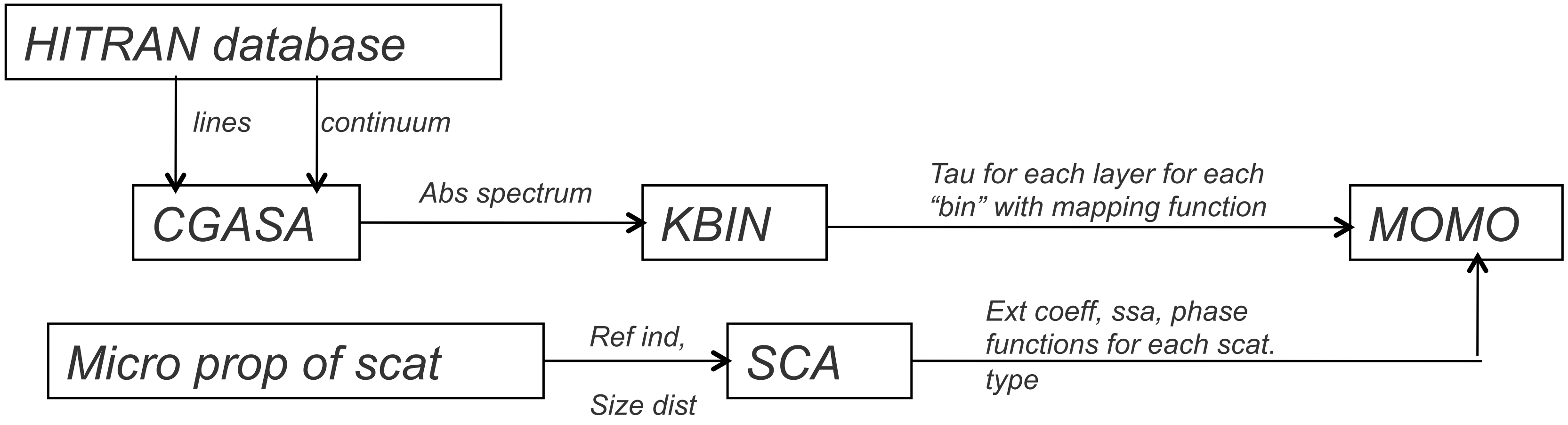
[1] *Fell F. and J. Fischer, JQSRT, 2001*

1./ *MOMO*: Matrix-Operator Model

- Functioning scheme:

INPUT: vertical profile T(z), P(z), c(z)

OUTPUT: Fluxes at each wanted level (spectral radiances or irradiances)



- *CGASA*: Computes gas extinction coeff
- *KBIN*: Makes a k-distribution (reduce comp. time), ideal for sat
- *SCA*: Computes phase functions and macro param of scatterers
- *MOMO*: Solve the radiative transfer equation with all the datas

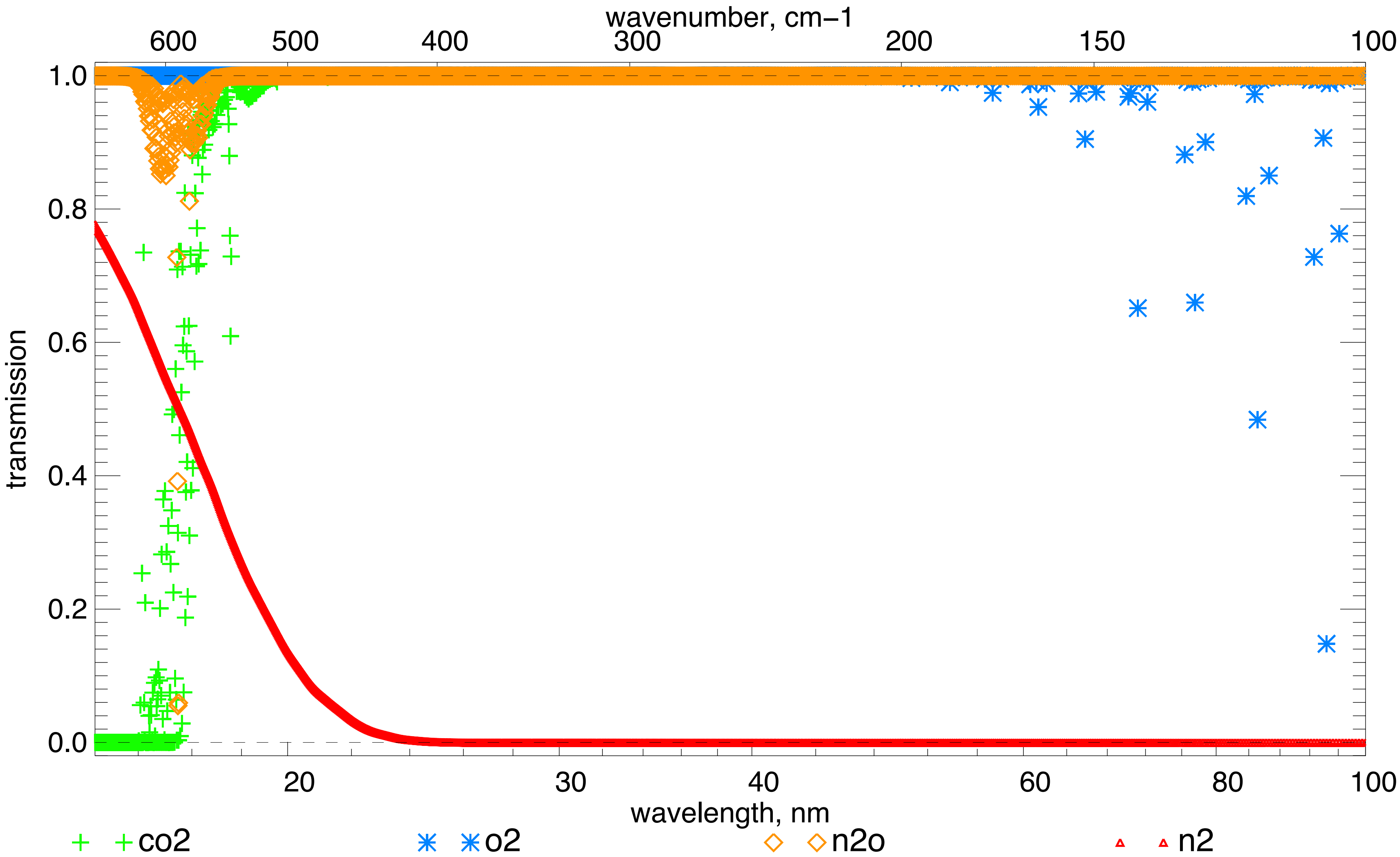
1./ Application of *MOMO* to far Infrared

- Whole atmosphere Transmission spectrums, vertical transmission profiles, TOA upward radiances, Ground downward radiances, Heating rate vertical profile

- Gaseous Species:
  - Mixed Gases (***CO_2***, ***N_2***, ***O_2***, ***N_2O***, *CO*, *CH_4*, *NO*)
  - ***H_2O***
  - ***O_3*** (stratosphere)

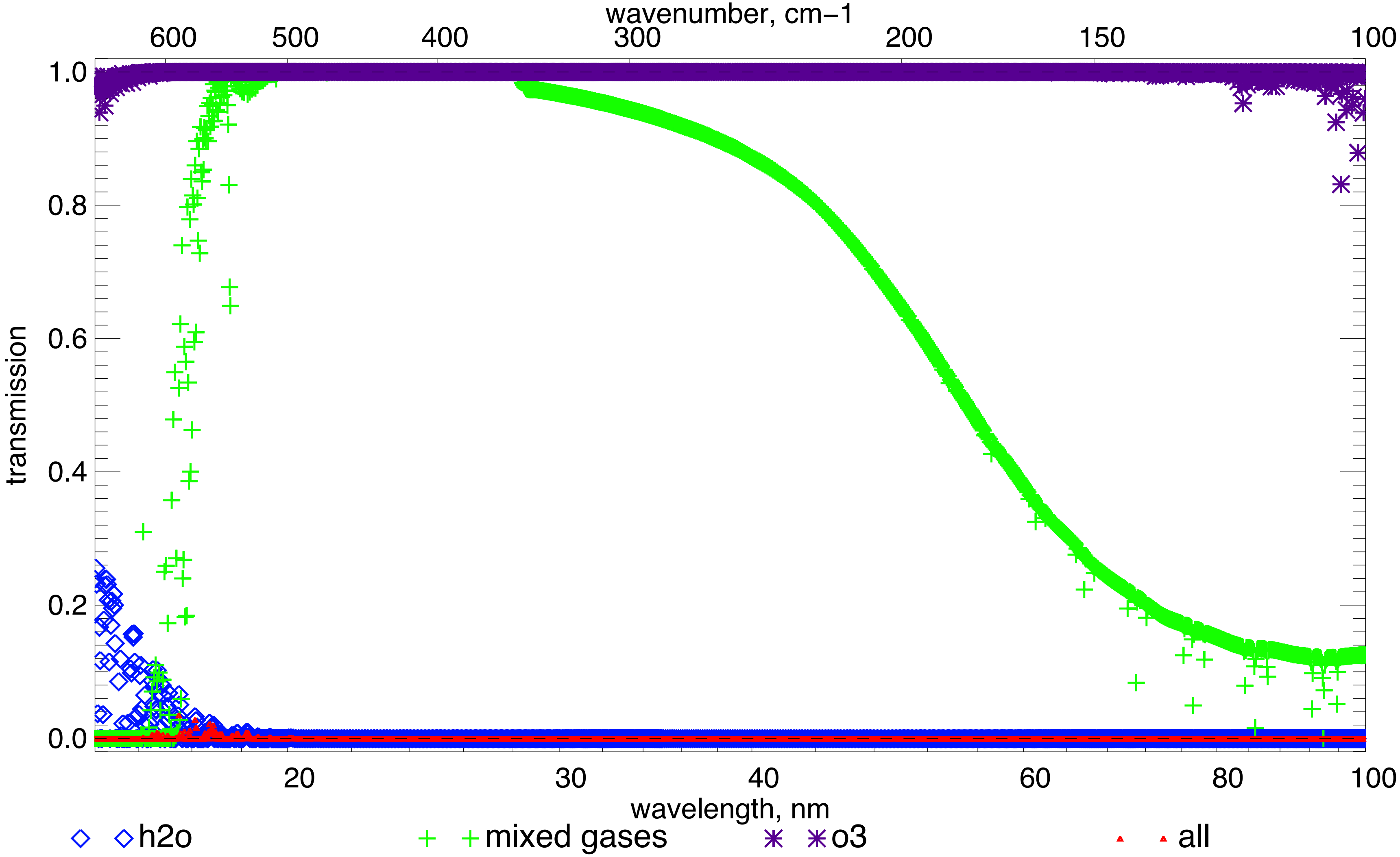
- Parameters : T(z), P(z), gas concentrations: MS Profile, 27 layers.

1./ Application of *MOMO* to far Infrared



3 Zones: *10-15* microns (N_2O+CO_2), *20-35* microns (N_2) and *35-100* (N_2+O_2))

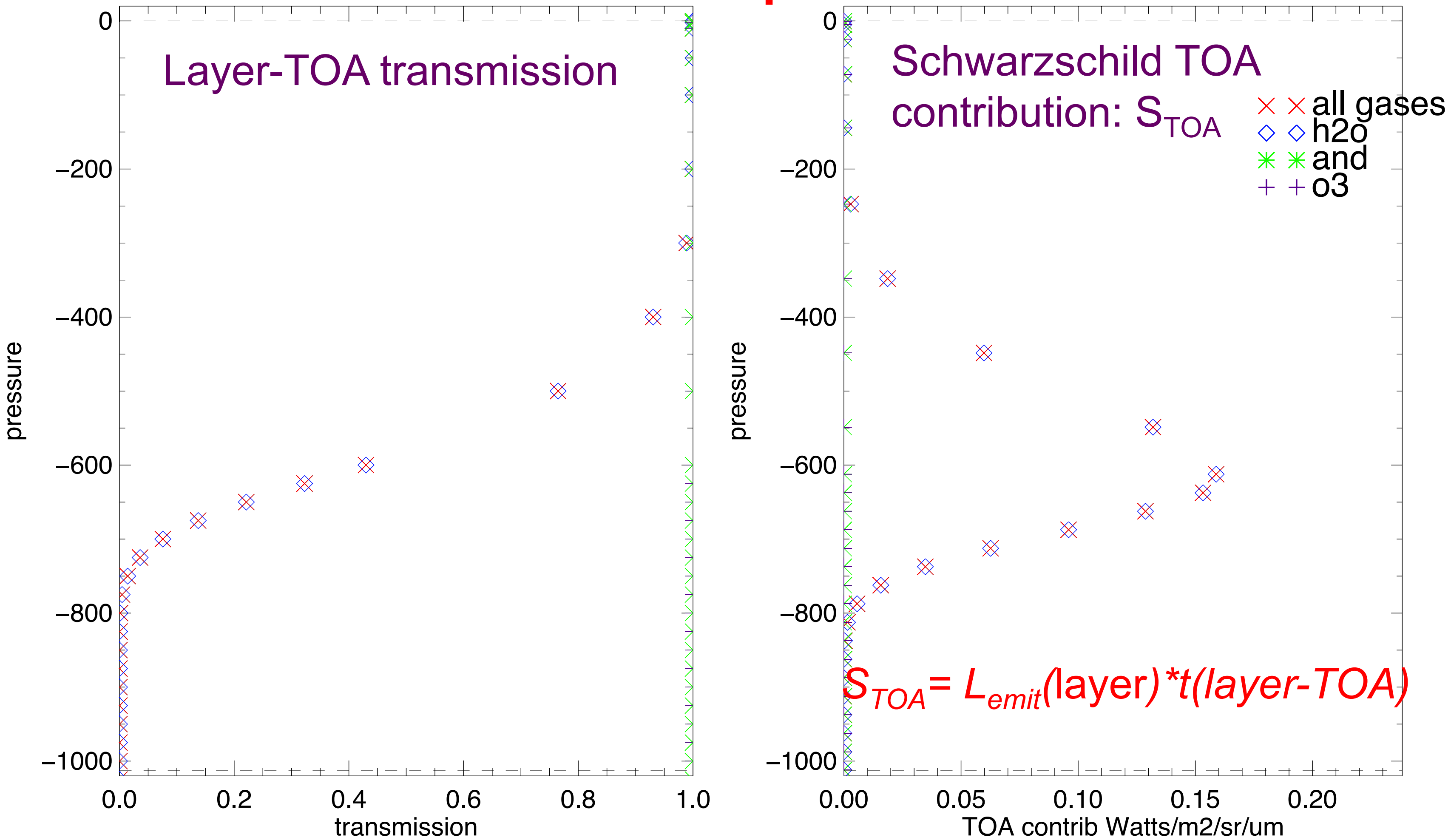
1./ Application of *MOMO* to far Infrared



The total transmission is quasi *0*! We have to look the transmission profile

1./ Vertical profile of transmission

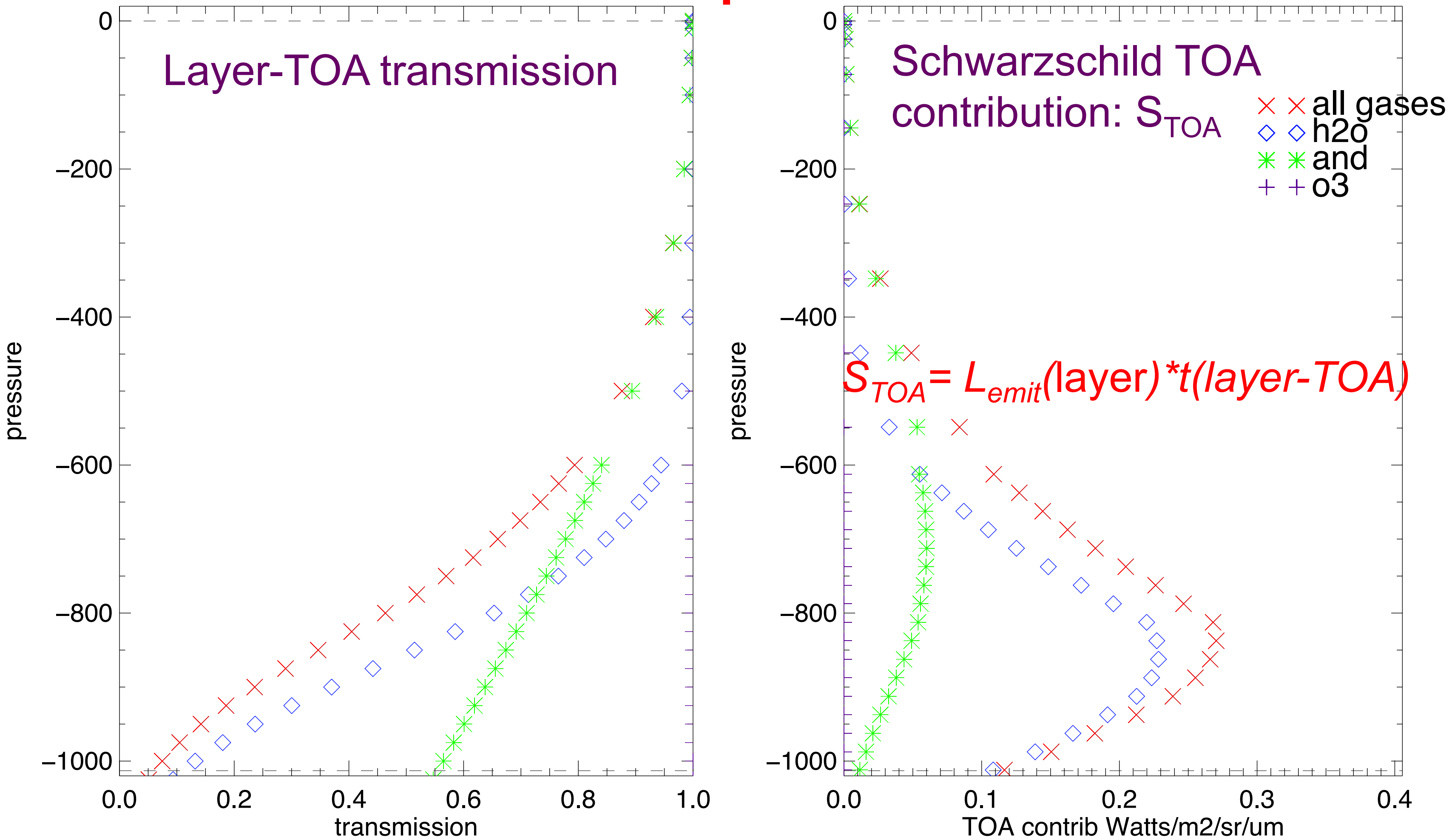
27.3 µm



For λ=*27.3*µm: TOA remote sensing sounds the middle/top of troposphere

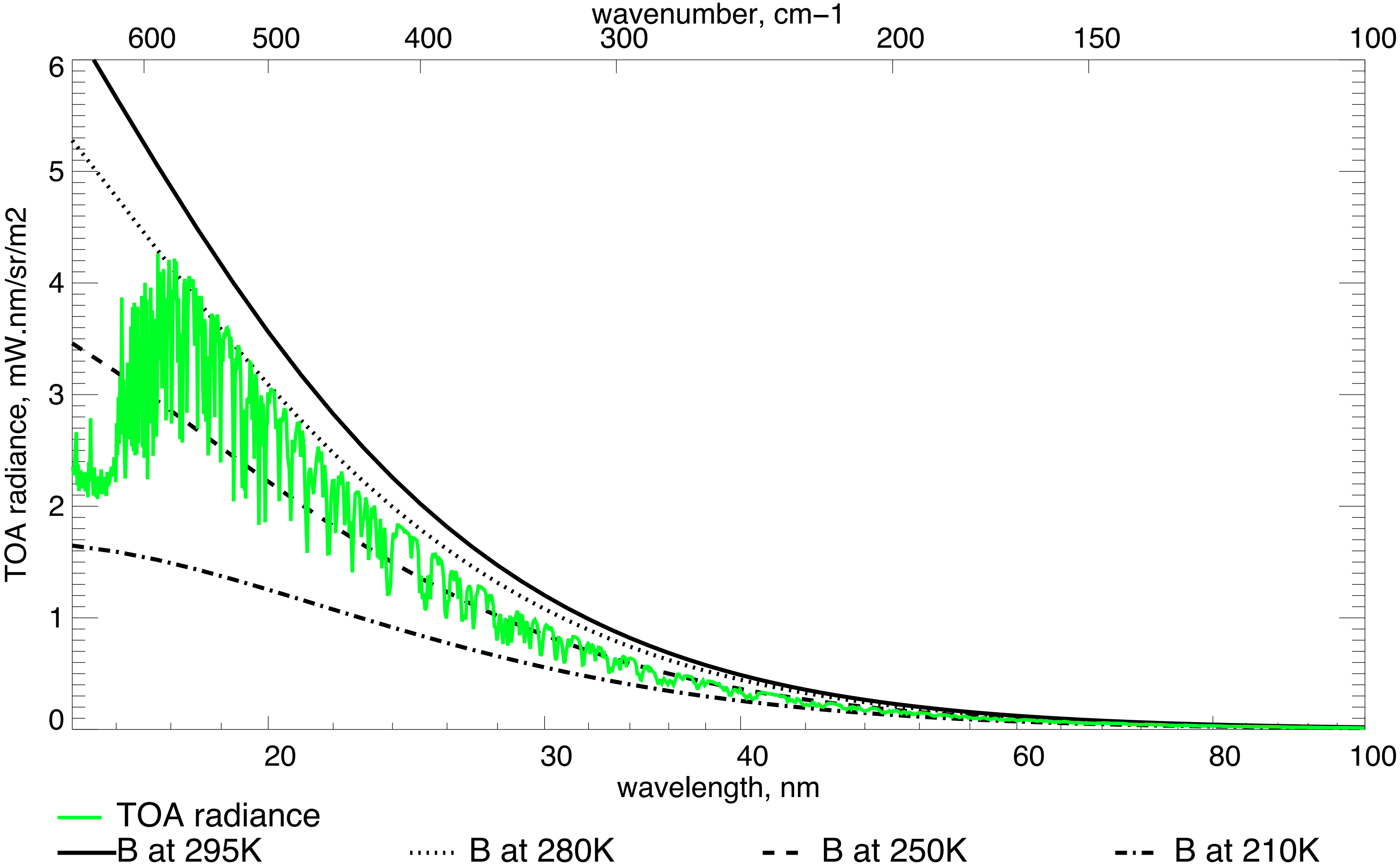
1./ Vertical profile of transmission

18 µm



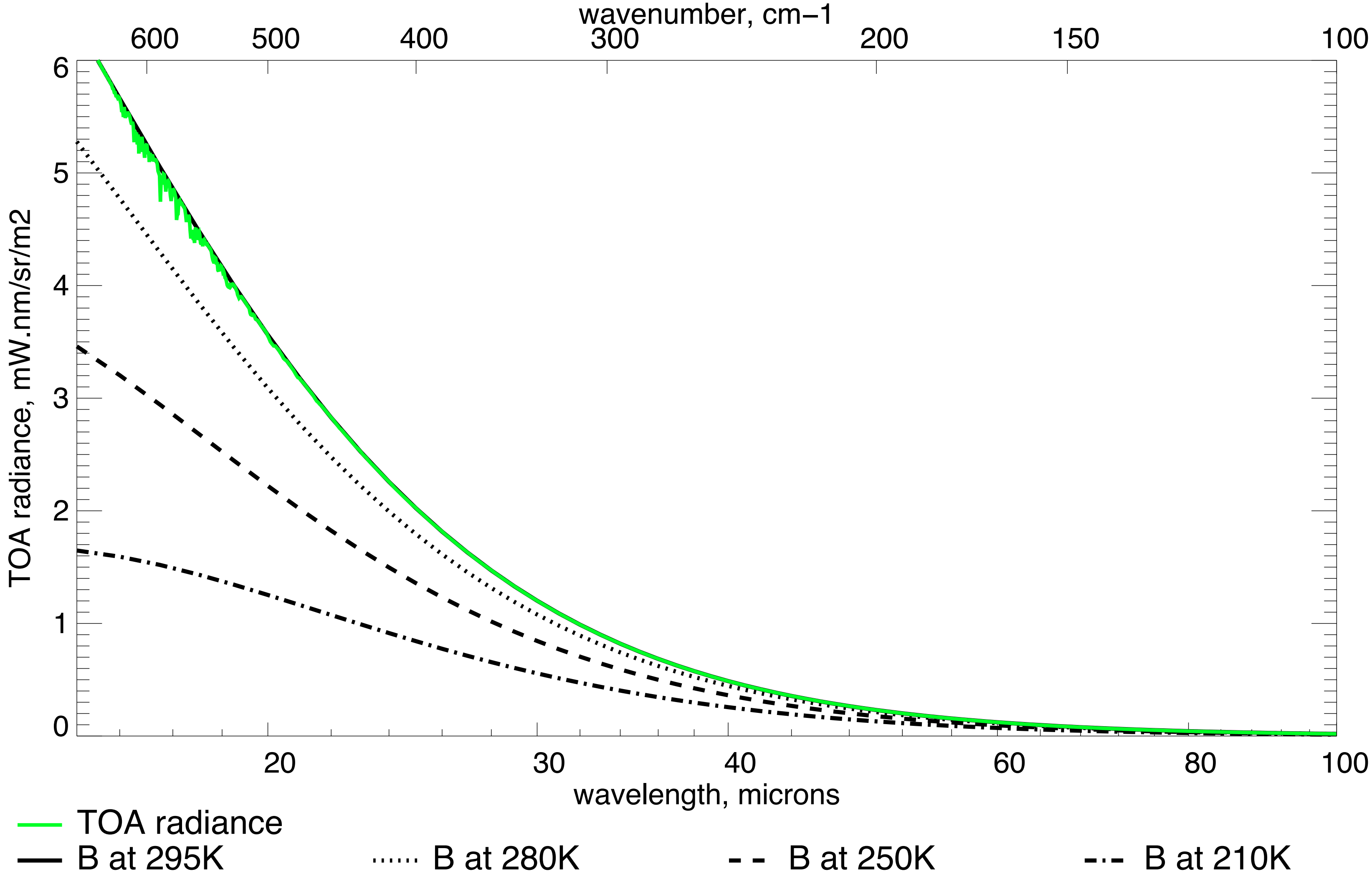
For λ=28µm: TOA remote sensing sounds upper the boundary layer limit

1./ Upward TOA Spectral Radiance



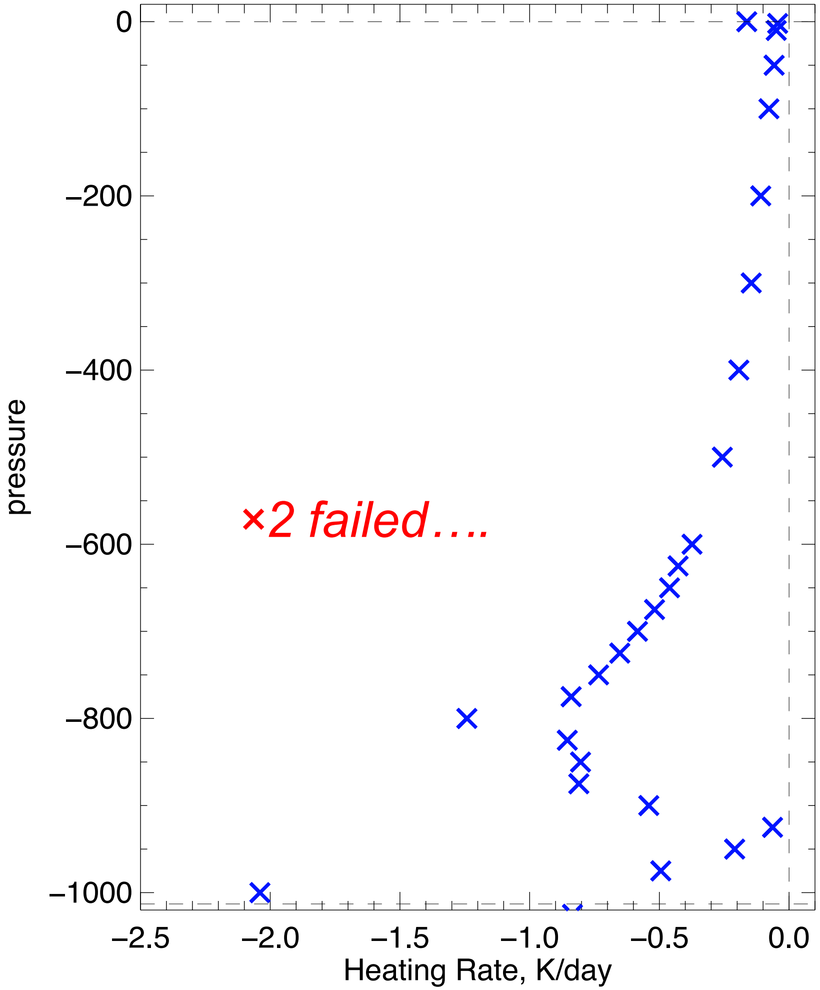
We can see which part of the spectrum sounds which height of the atmosphere

1./ Downward Ground Spectral Radiance



Ground radiance measurements sounds the narrowest layers.

1./ Far-Infrared Heating-Rates

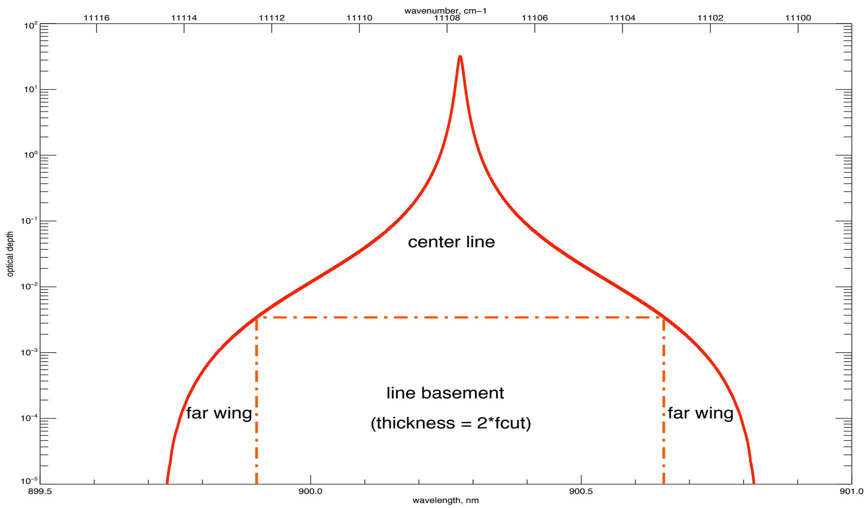


$$HR = \frac{\delta T}{\delta t} = -\frac{g}{C_p}\frac{\delta F}{\delta P}$$

Far-IR Heating-Rates is *15%* of the Middle-IR Heating-Rates

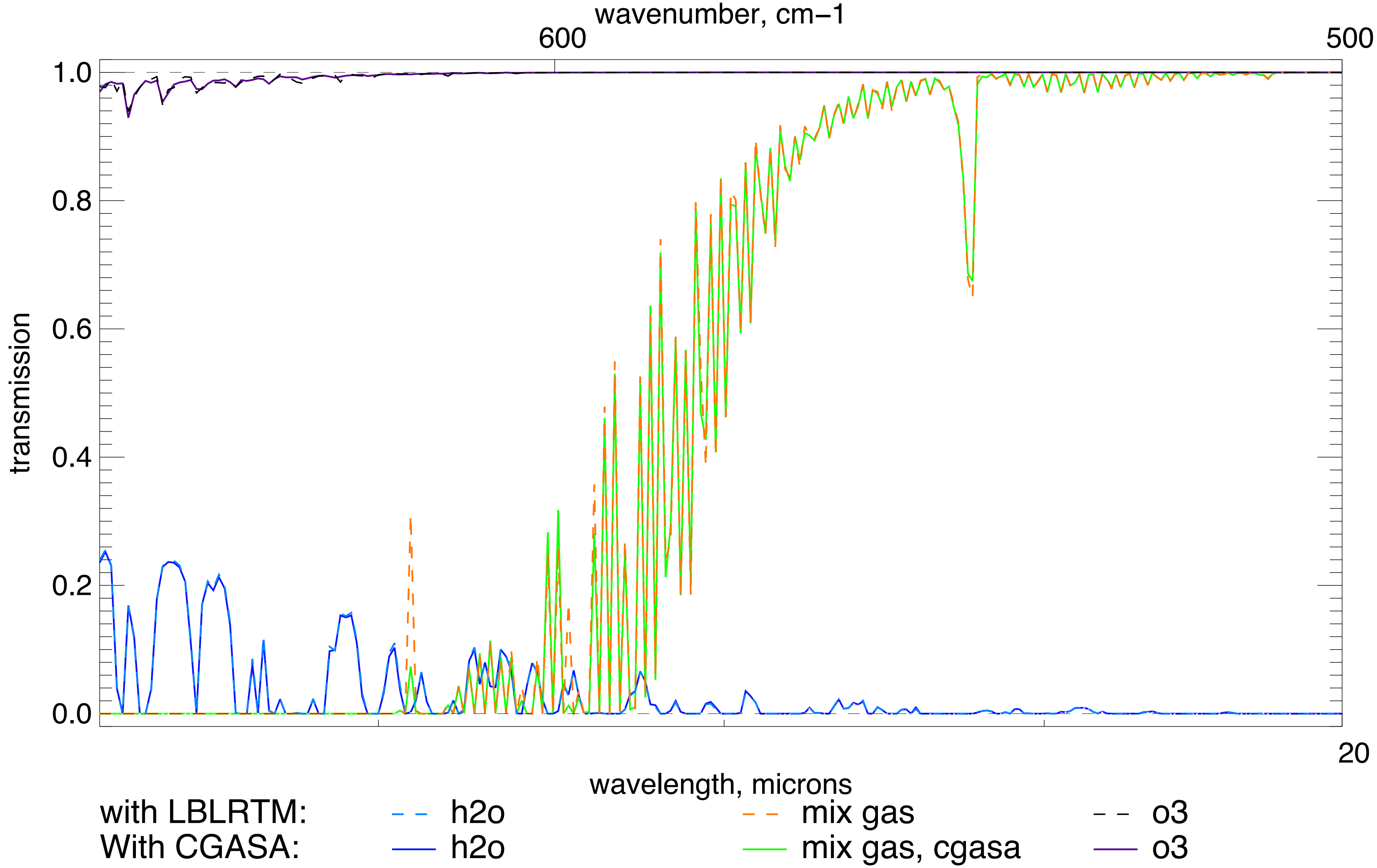
2./ *CGASA*: Modeling the gas absorption

- *CGASA*:
  - Takes line parameters of *HITRAN2008*
  - Takes continuum parameters of recent models (*CKD, MT-CKD*)
- For the wanted spectral intervals, looks all the lines in the neighborhood and compute the optical depth
- Cut the far wings and the basement, put a form factor: F_{fac}
- Is tested with *LBLRTM* in UV, Vis and MI (*0.2-15*μm)



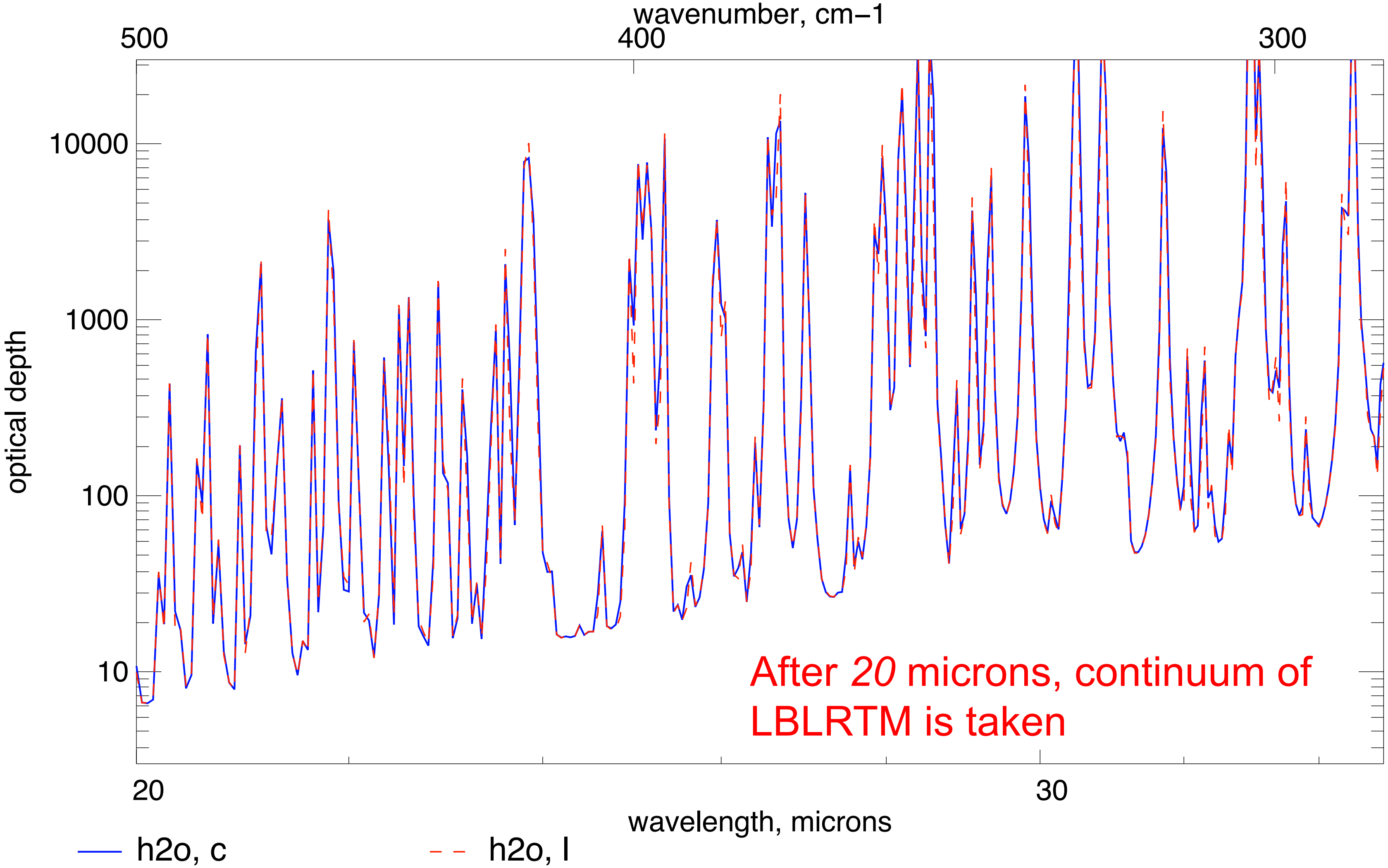
$$F_{\mathrm{fac}} = 1 - \frac{\nu_{\mathrm{lim}}^2}{\nu_{\mathrm{lim}}^2 - \Delta\nu^2}$$

3./ *CGASA* vs *LBL-RTM*: gas transmission



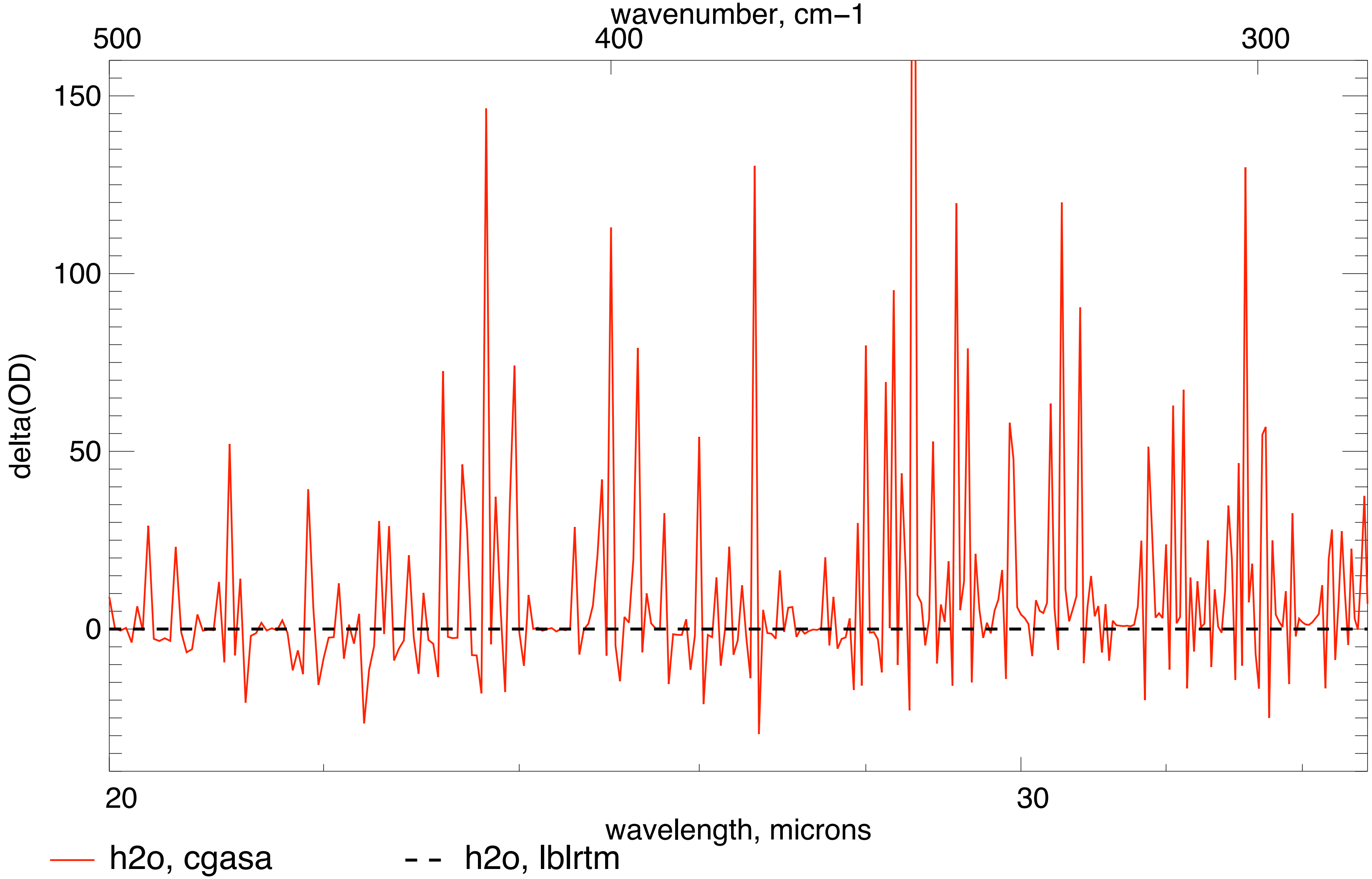
Zoom on the Optical Depth for *15-20*µm. Differences on the peaks only

3./ *CGASA vs LBL-RTM* Optical Depth



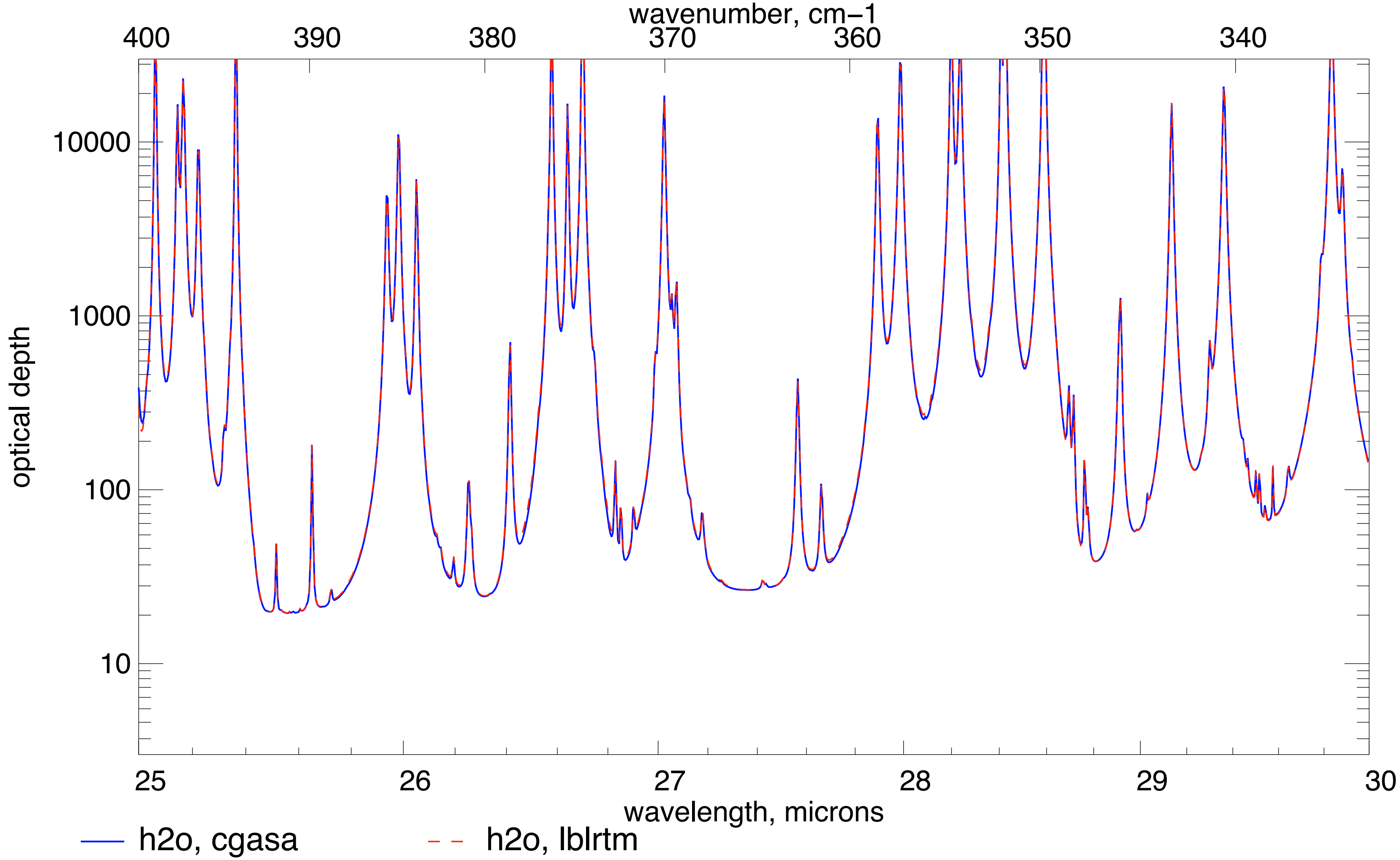
Zoom on the Optical Depth for *20-35*µm. Differences on the peaks only

3./ *CGASA vs LBL-RTM* Optical Depth



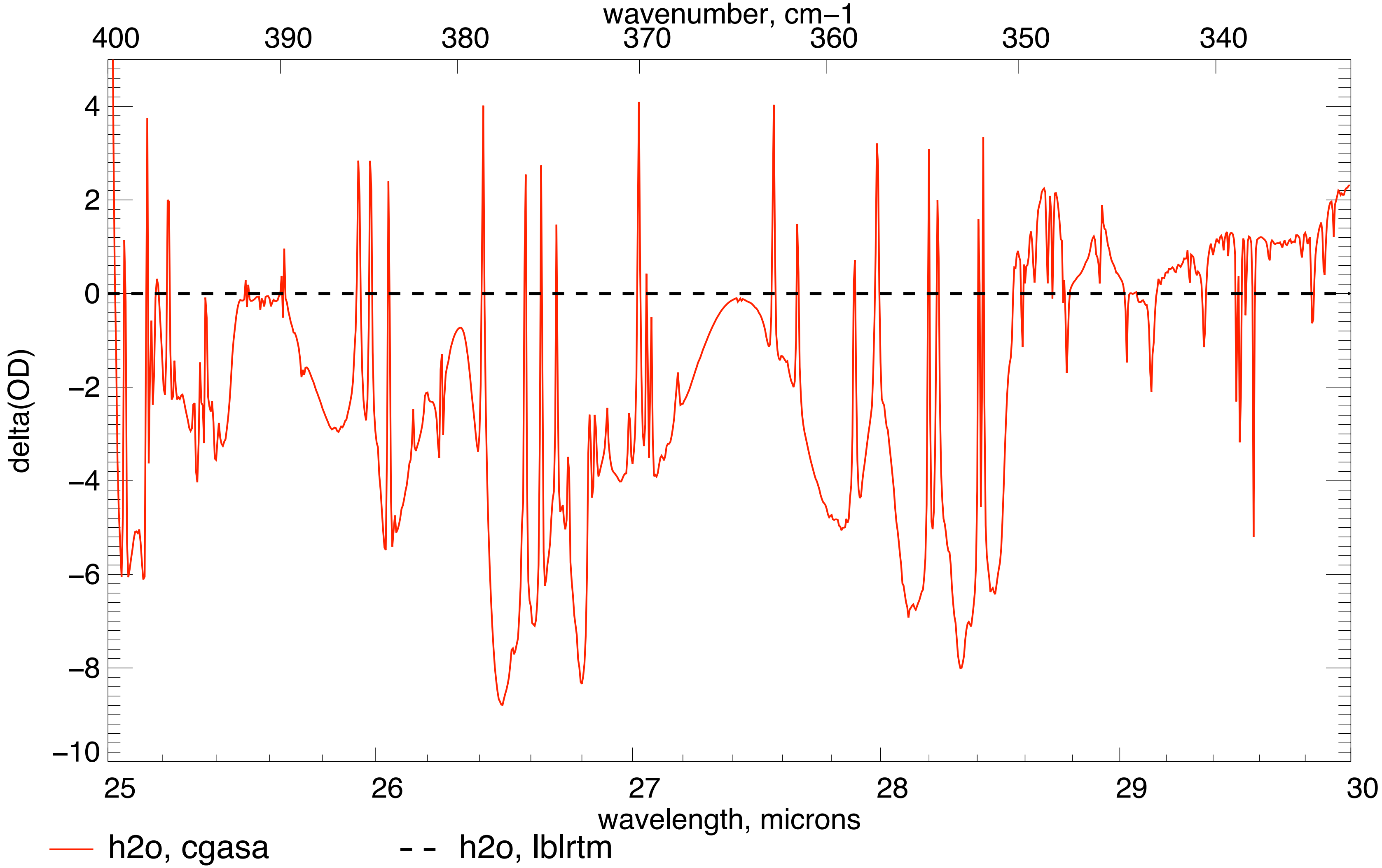
Differences are quite big…. Due to the resolution!

3./ *CGASA vs LBL-RTM* Optical Depth



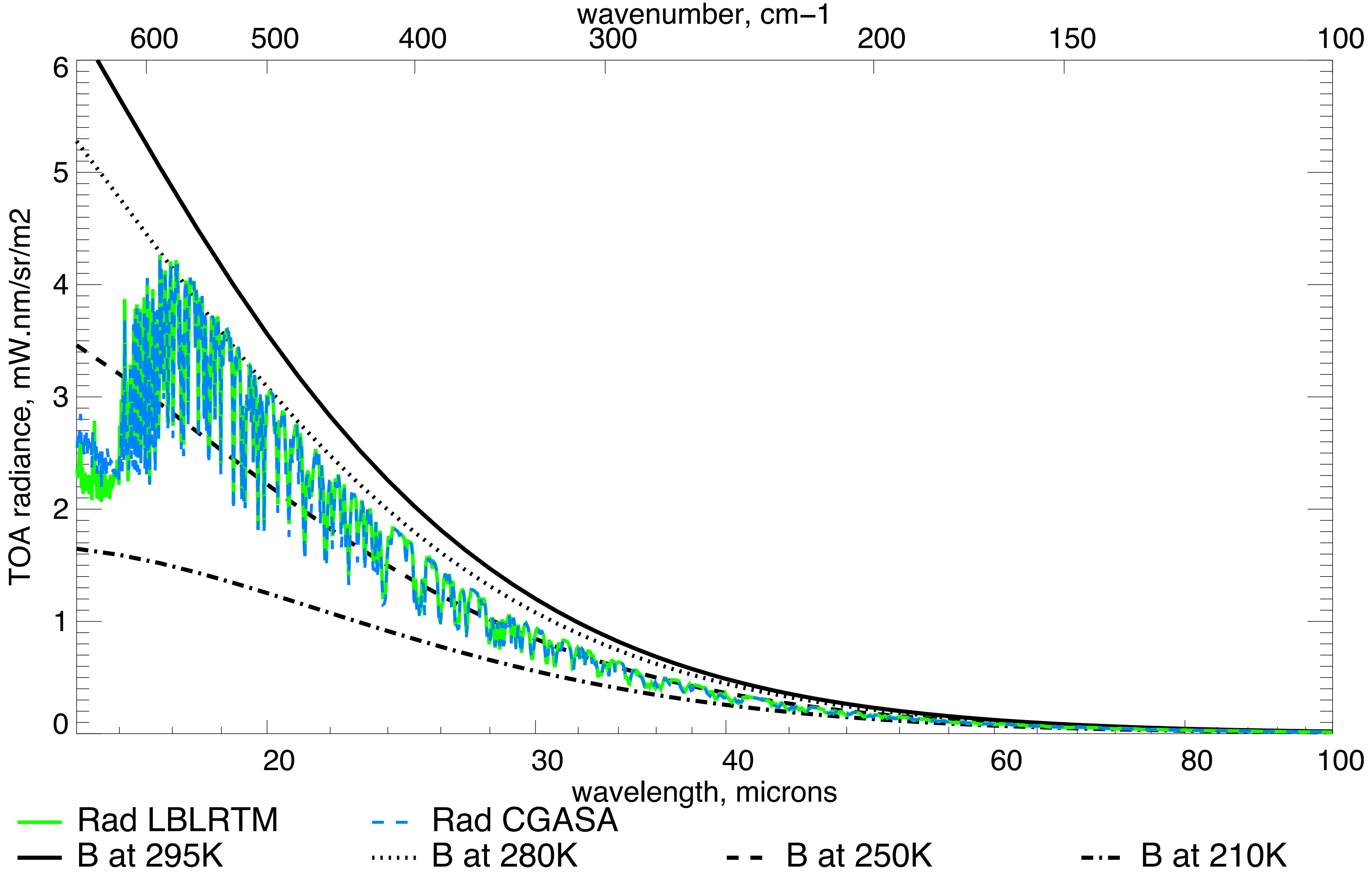
We compute the OD with a higher resolution (*0.1*nm) on the band *25-30*µm

3./ *CGASA vs LBL-RTM* Optical Depth



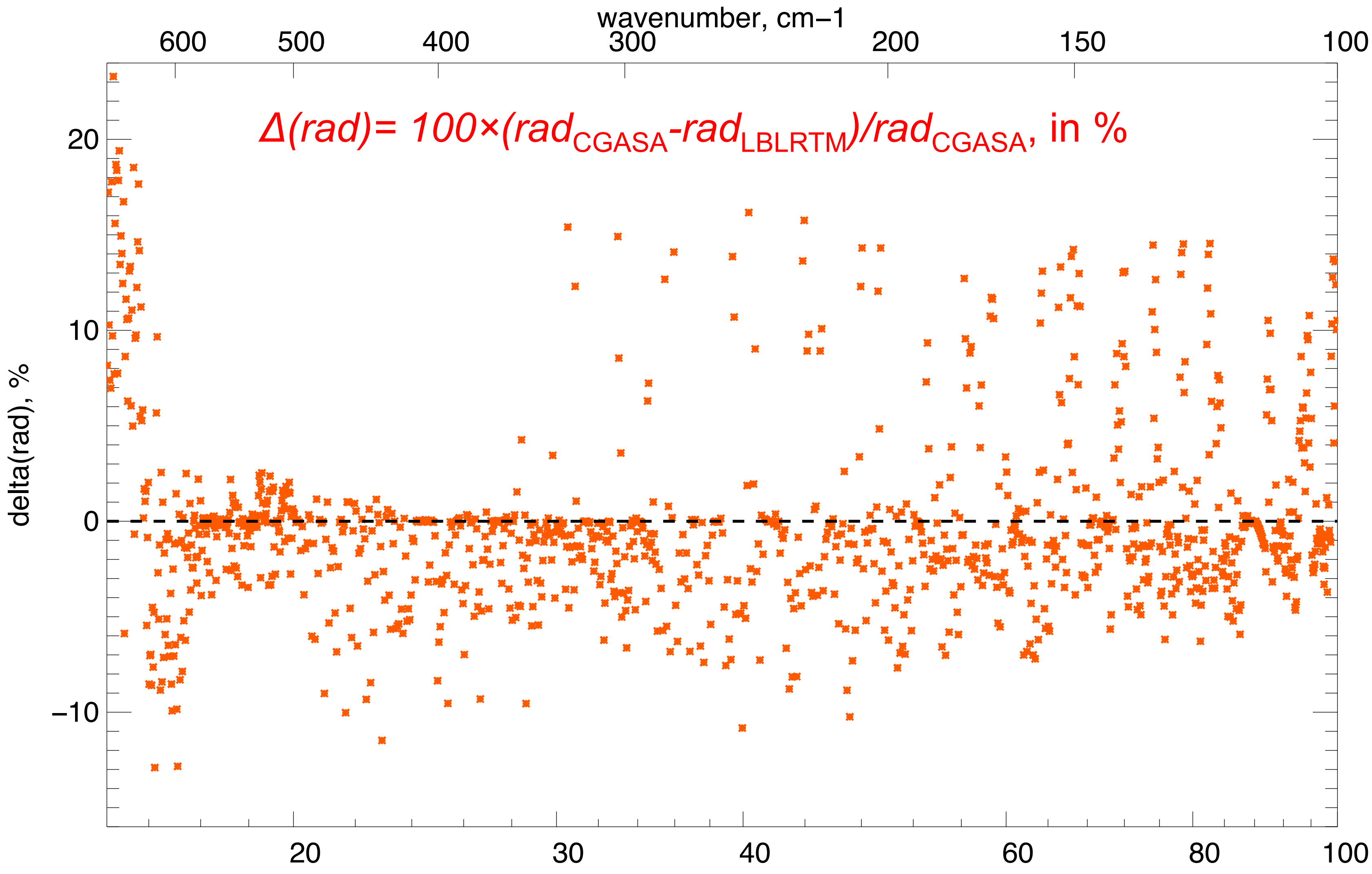
Differences are much smaller: divided by more than *10*.

3./ CGASA vs LBL-RTM, rad(TOA)



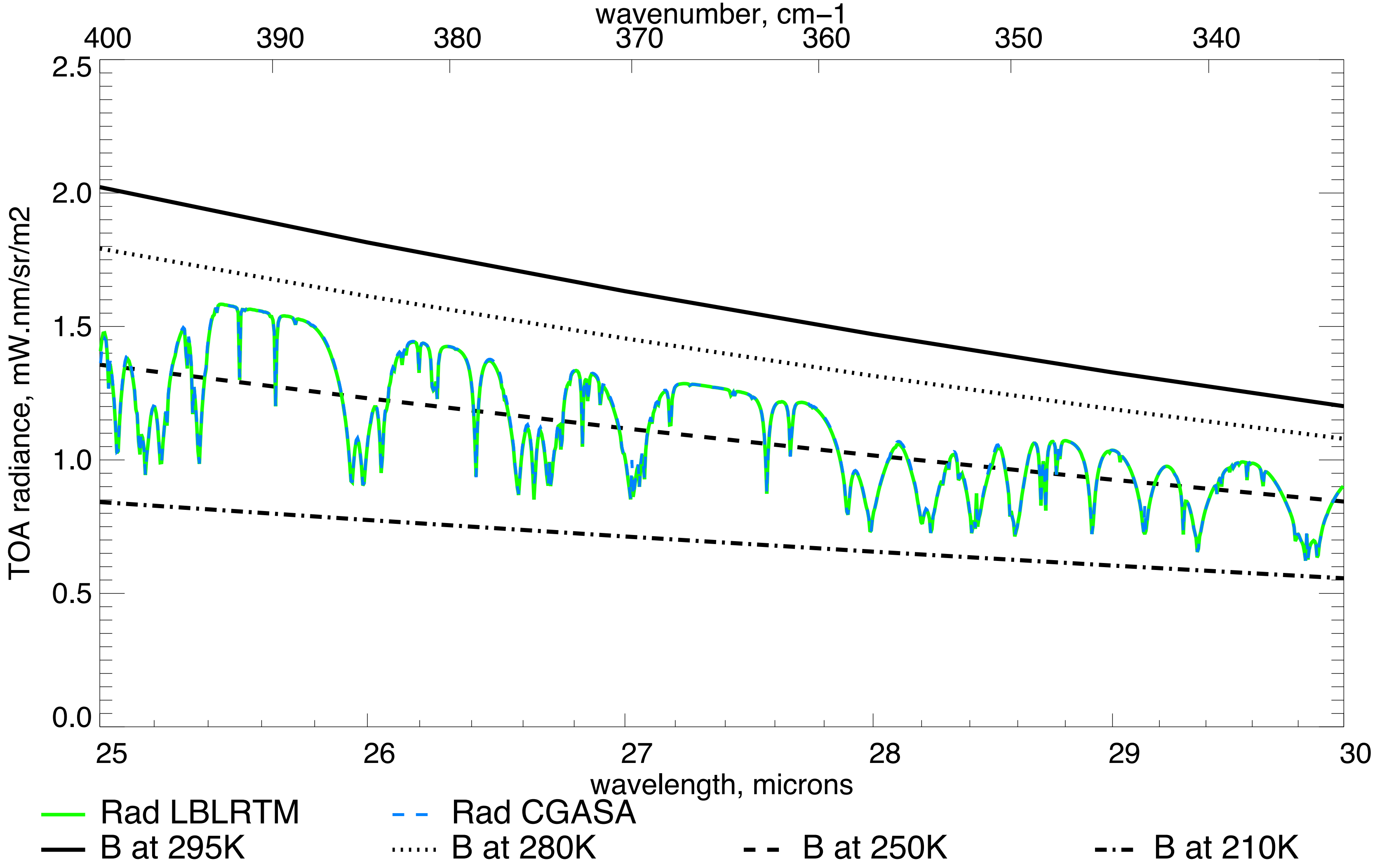
TOA Radiance with crude resolution: There are some differences but not so obvious

3./ CGASA vs LBL-RTM, rad(TOA)



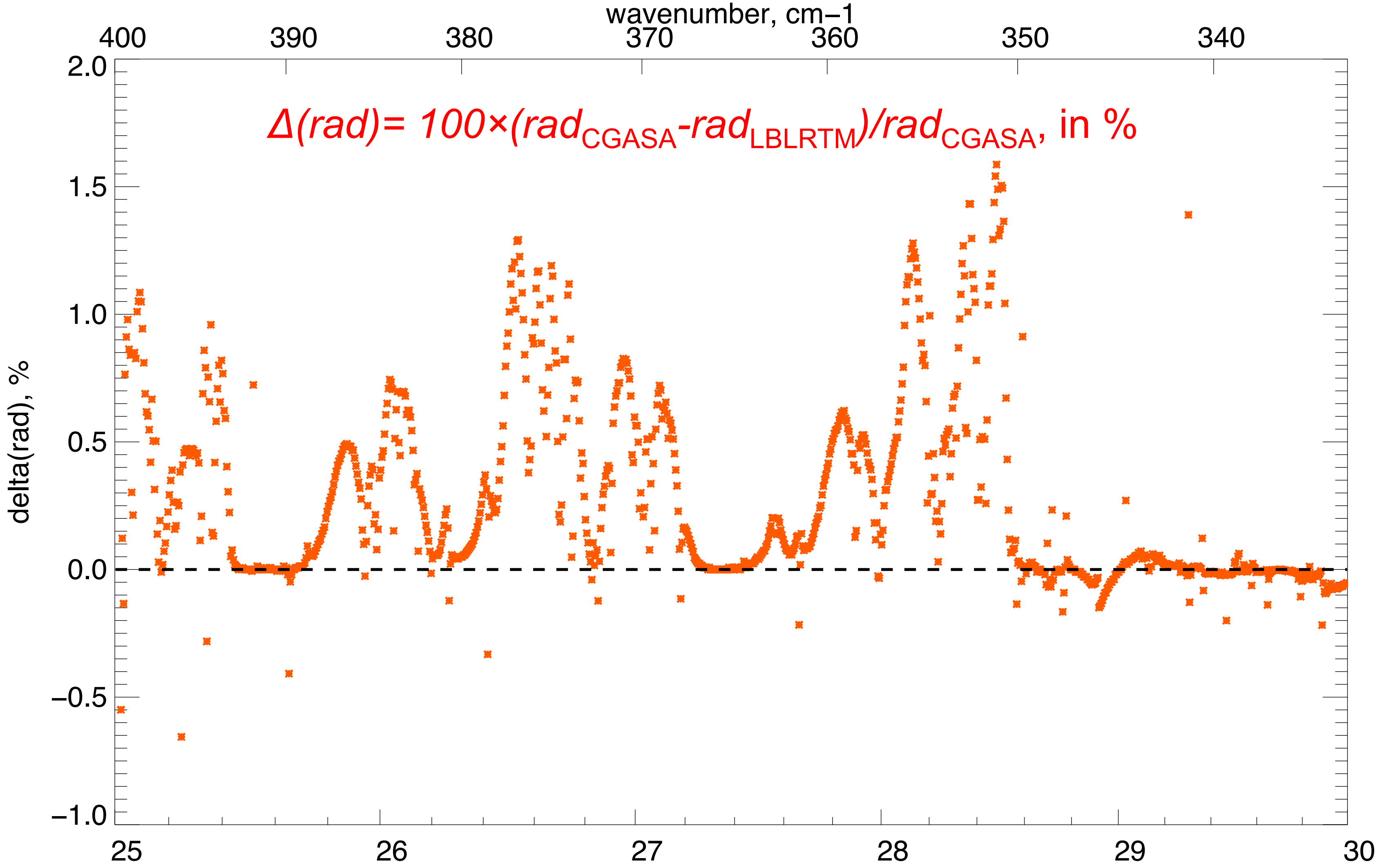
… but many over *5-10%*

3./ CGASA vs LBL-RTM, rad(TOA)



With *0.1*nm resolution, the differences disappear

3./ CGASA vs LBL-RTM, rad(TOA)



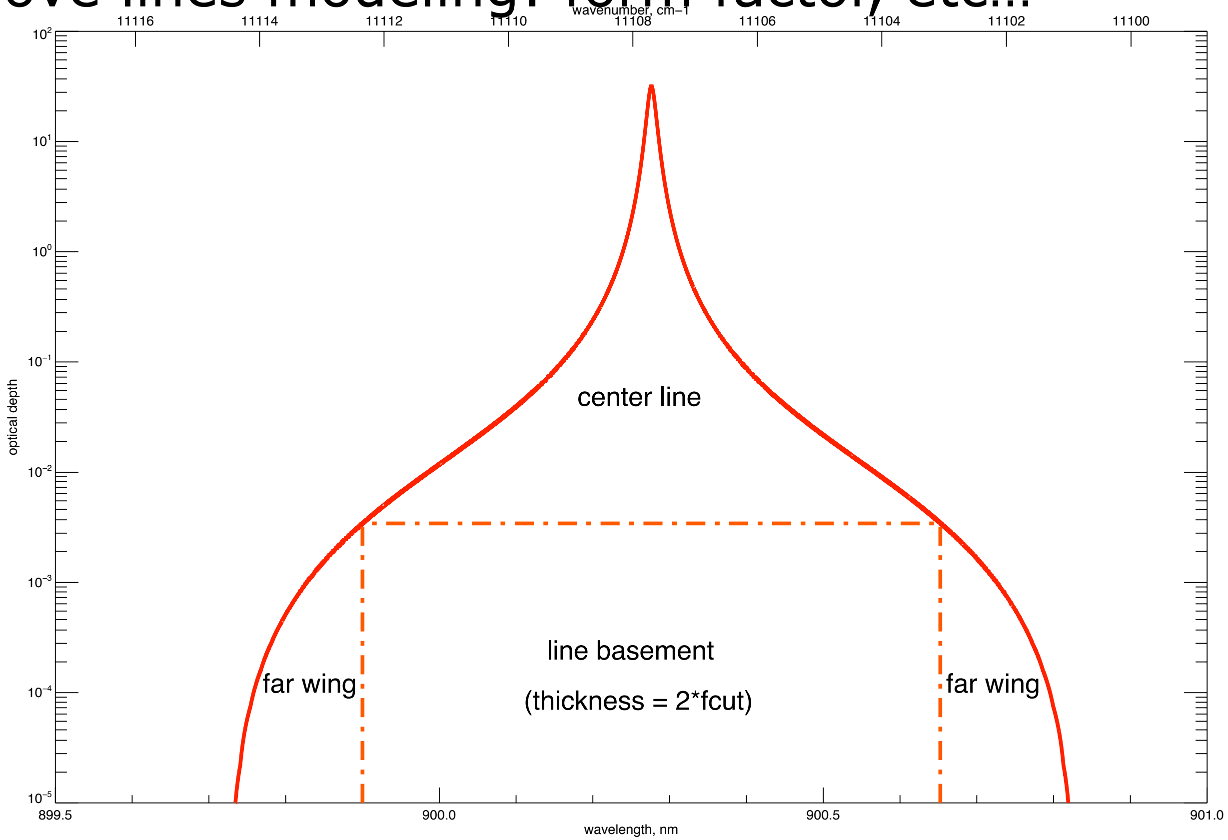
… and most of the points are under *0.2%*, quasi all are under *1%*

3./ *CGASA vs LBL-RTM*: conclusion

- Resolution is a crucial issue (*0.1*nm = good standard)

-> If, then need to economize time => K-distribution

- Input continuum values, efficiency for CO_2 and O_3
- Improve lines modeling: form factor, etc…

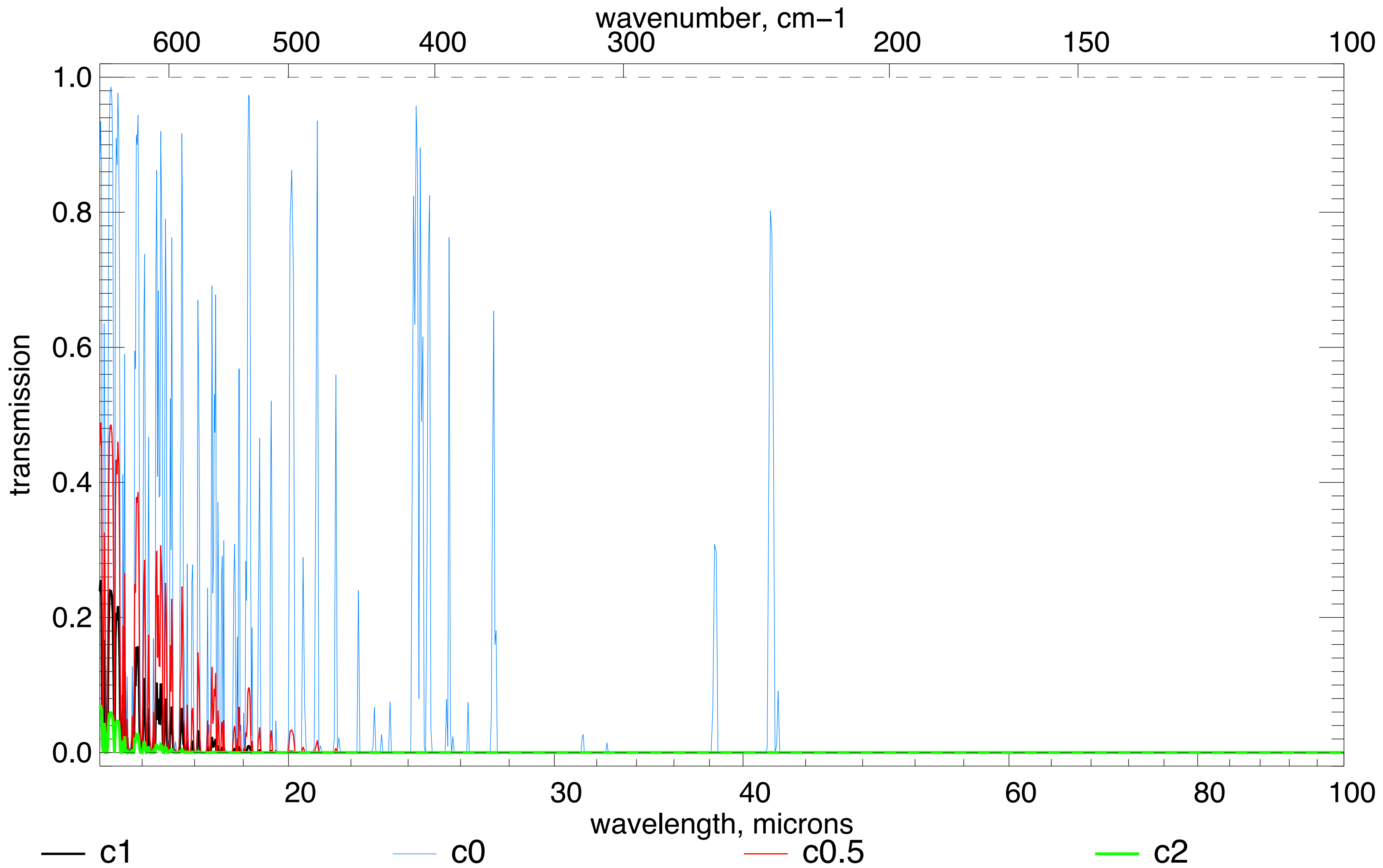


4./ Continuum sensibility

- We take LBL-RTM input data, and look:
  - With normal continuous (*cont=1*)
  - Without continuum (*cont=0*)
  - With half continuum (*cont=0.5*)
  - With double continuum (*cont=2*)

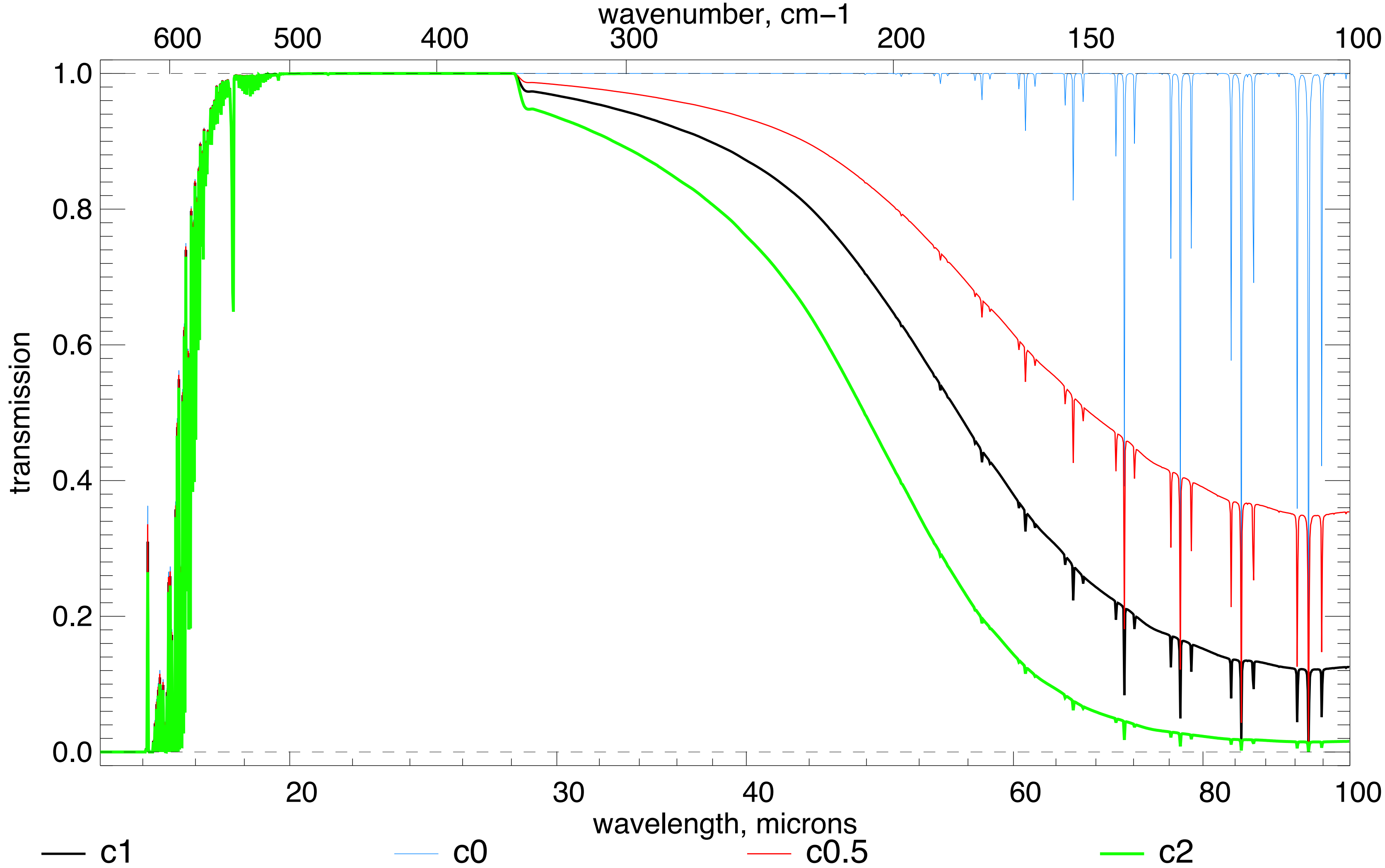
- We look what happens on:
  - Transmission
  - Optical Depth
  - TOA radiance
  - Heating rates

4./ Continuum sensibility: on transmission



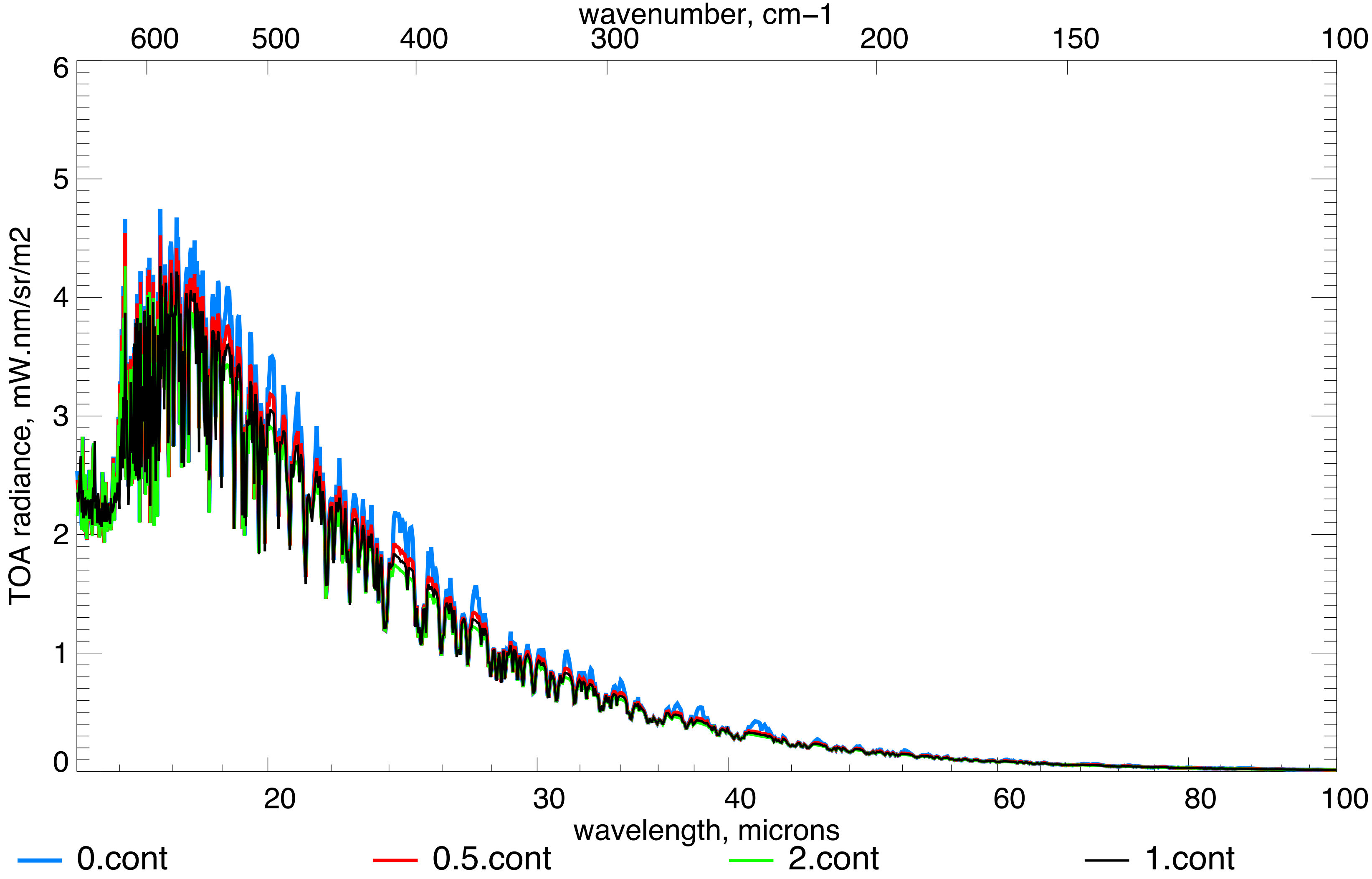
Transmission is of course impacted by the continuum value

4./ Continuum sensibility: on transmission



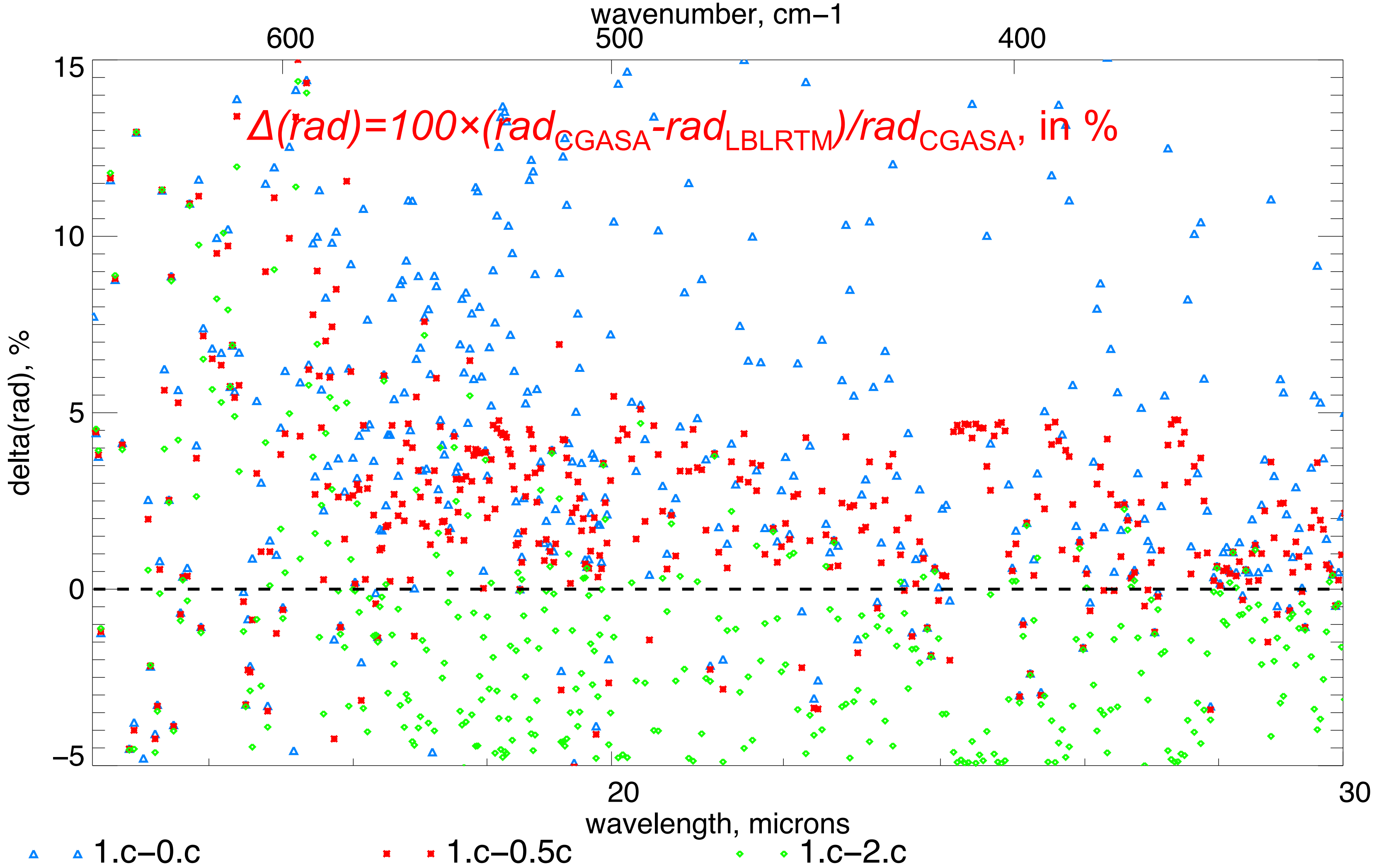
Transmission of mixed gases only is much more significant

4./ Continuum sensibility: on *Rad*(TOA)



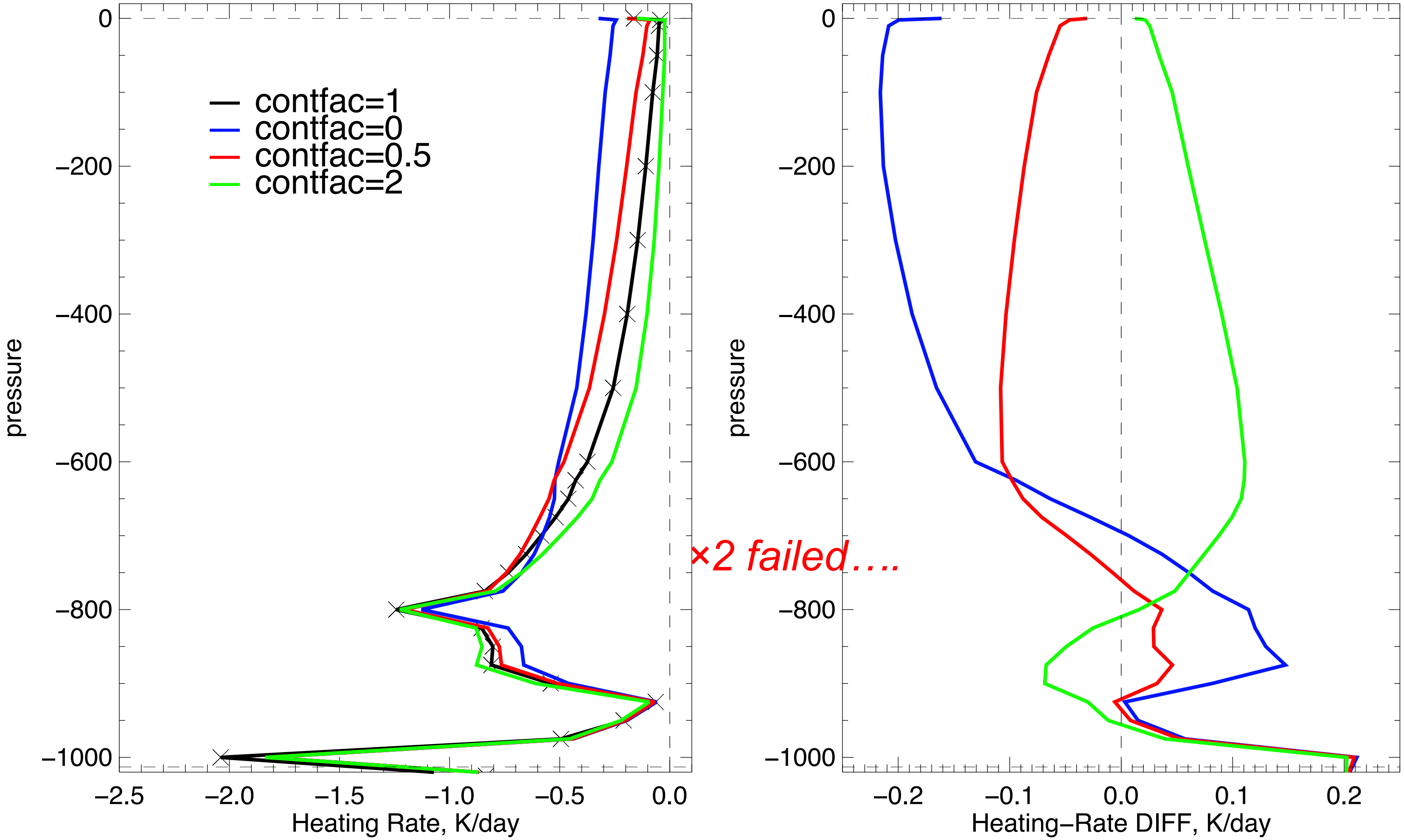
The more continuum we have, the less TOA radiance we have

4./ Continuum sensibility: on *Rad*(TOA)



TOA fluxes: *6%* more without cont, *2.5%* more with half, *2.5%* less with double

4./ Continuum sensibility: on Heating-Rates



More continuum decrease the HR in the boundary layer and increase HR over it

4./CONCLUSION & OUTLOOK

CONCLUSIONS:

- *MOMO* = good tool to simulate the fluxes also in Far-IR: TOA fluxes, heating-rates.
- *MOMO* = good tool for sensitivity study
- *CGASA* (spectroscopic subprogram of *MOMO*) is true, but caution to the resolution, problem of efficiency, theoretical interrogations on line shape factor.

OUTLOOK:

- We need to put our coefficients for continuum over *20*µm
- We need to find a faster method for CO_2 and O_3
- We need to compute the ext coeff with a high resolution and then use the k-distribution method for the fluxes computing

THANK YOU FOR YOUR ATTENTION!