Sounding the upper atmosphere of Venus and Mars with IR molecular spectroscopy

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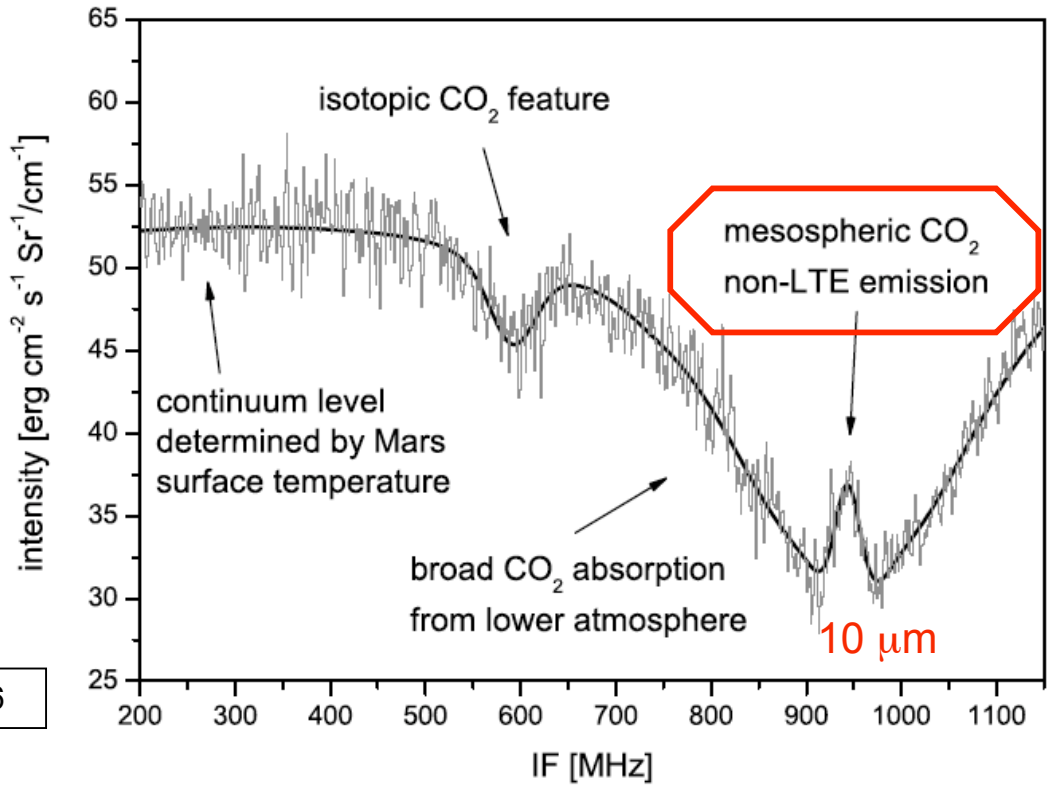
- Motivation: Introduction to tomorrow' seminar on Planetary Atmosphere
- Goals: Most commonly IR emissions observed/studied: *which,why, how*
- Some examples: application of IR molecular spectroscopy in planetary atmosphere studies (included an analysis from my PhD work)
- Summary & Future perspective

"Charla CCD" *12 Jan. 2011*

Seminar tomorrow by M.A. Lopez-Valverde:

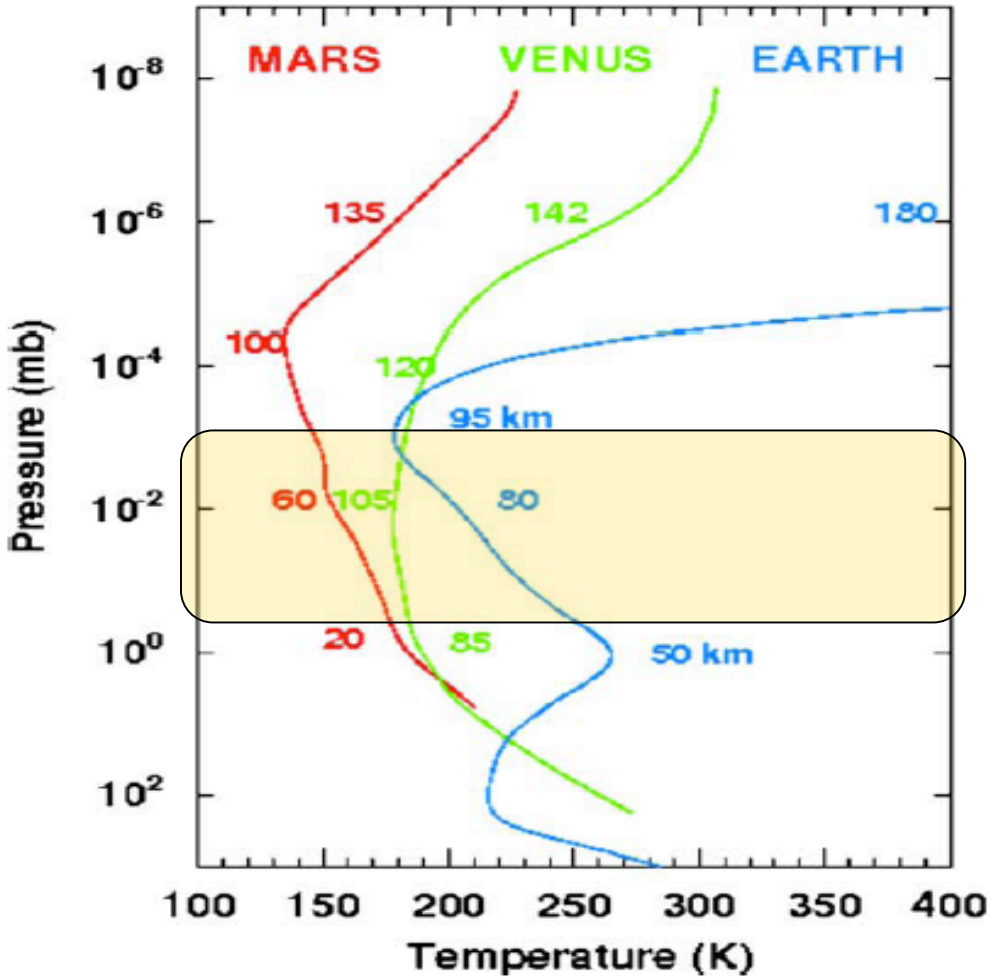
OBSERVATIONS OF MARS ATMOSPHERE FROM THE EARTH



Sonnabend et al. 2006

Winds retrieved from Doppler shifts between CO_2 non-thermal emission from the mesosphere and absorption features form low atmosphere regions.

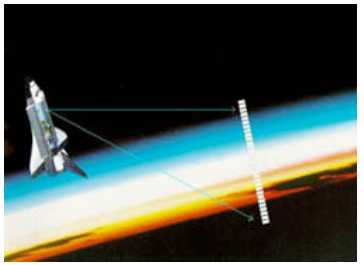
Mesosphere of terrestrial planets



BASIC CHARACTERISTICS

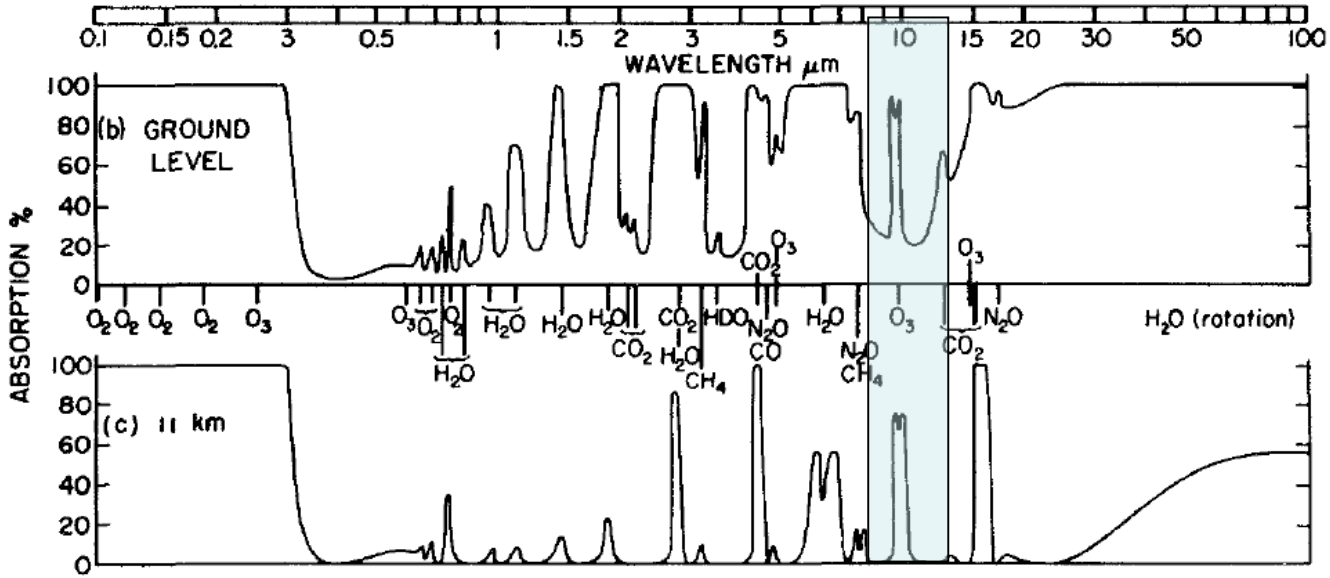
- Temperature decrease
- Low densities
- Radiative transfer in the IR (absorption/emission)
- non-LTE processes

Sounding the upper atmosphere…

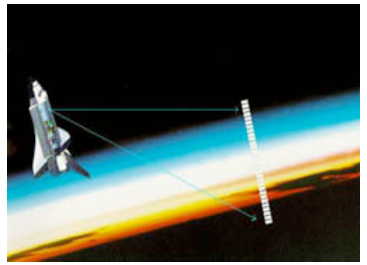


- Ground-base vs. Satellite observations

PROS: -higher spectral resolution - smaller FOV
- long-term coverage - localized limb emission
CONS: - telluric contamination - short-term coverage
- large FOV - limited spectral resolution

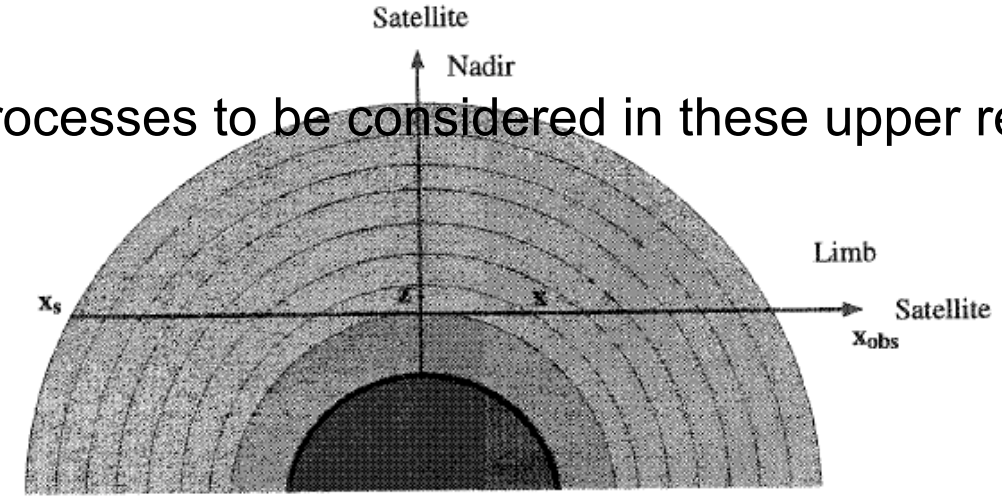


Sounding the upper atmosphere...



- Ground-base vs. Satellite observations
- Limb vs. Nadir observations

PROS: - stronger emission
- better vertical resolution
- thinner weighting function (WF)
- observations geographically localized
- higher spatial resolution



- Non-LTE processes to be considered in these upper regions!!

Which non-LTE IR emissions?

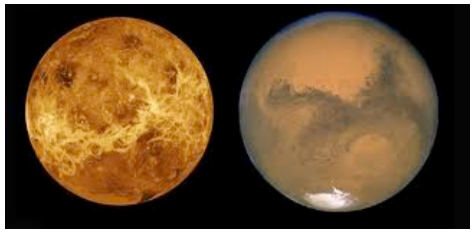
Most commonly studied non-LTE IR emission in the upper atmosphere of Mars and Venus :

- Strong CO_2 daytime emission (4.3 μm, 2.7 μm,10 μm).
- CO daytime emission (4.7 μm, 2.3 μm)
- H_2O vapour around 2.6 μm
- O_2 emission at 1.27 um (airglow)

Those emissions are localized in a determined region in the upper atmosphere

How useful are those non-LTE emissions?

- Temperature retrieval in Venus by 10μm ground based observations(*Sonnabend et al. 2010*)
- Winds retrieval on Mars by 10μm ground based observations (*Sonnabend et al. 2006, Lopez-Valverde et al.,in progress*)
- Temperature retrieval on Venus by ground based observations at 4.7μm (*Crovisier et al.2006*),
- Temperature and CO abundances using VIRTIS/Vex limb daytime observations at 4.7 μm (*IAA team, on-going*…)



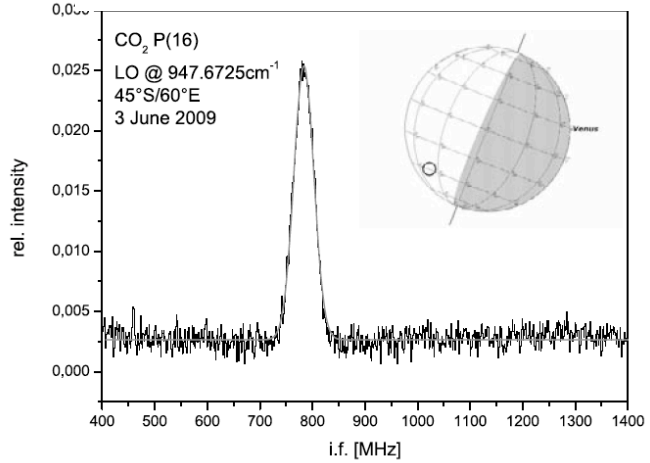
Information about those parameters at these altitudes are sparse for the dayside of Mars and especially for Venus (few data and no GCM)

Let's have a look at some examples…

Some results from recent literature:

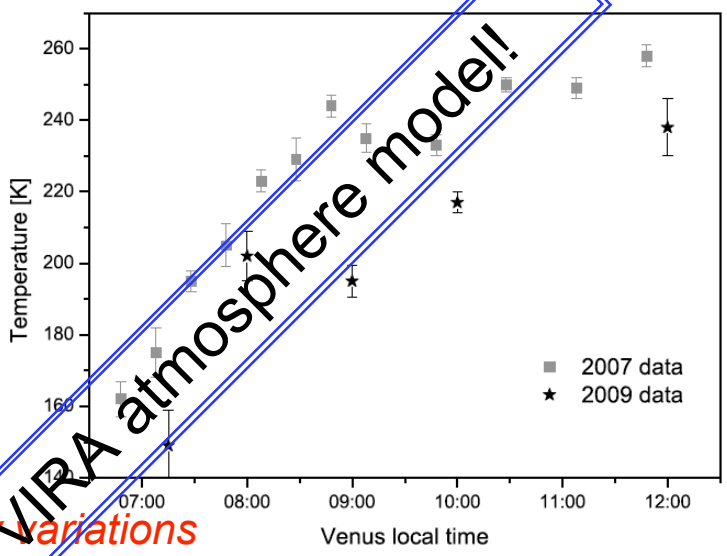
Direct observations of Venus upper mesospheric temperatures from ground based spectroscopy of CO_2

G. Sonnabend,[1] P. Kroetz,[1] M. Sornig,[1] and D. Stupar[1]

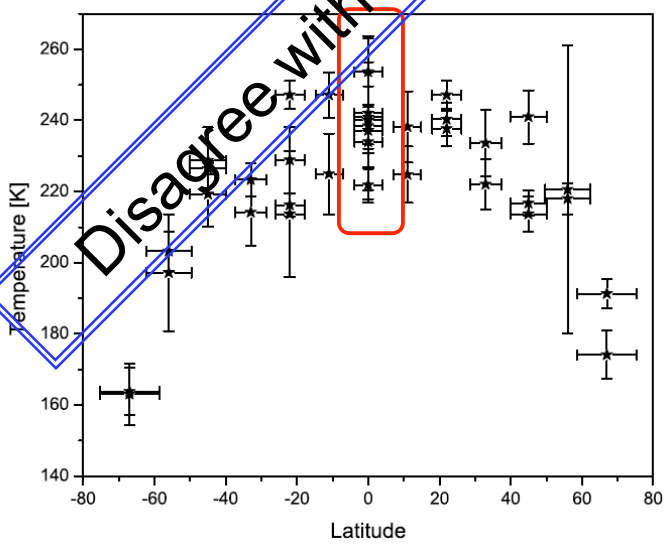


$$\Delta\nu_D = \frac{\nu_0}{c}\sqrt{\frac{8k_B T_{kin}\ln(2)}{m}},$$

Strong dependence with local time and latitude!



Day-to-day variations

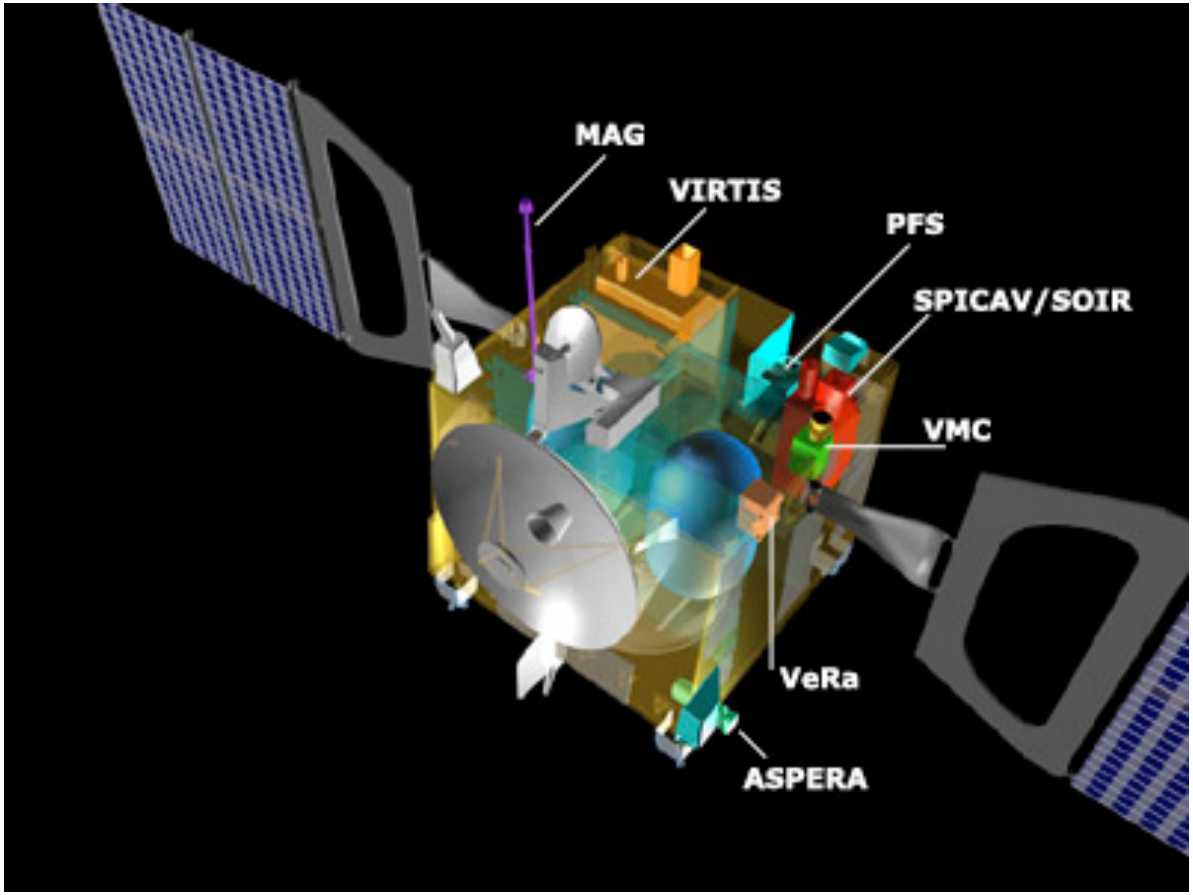


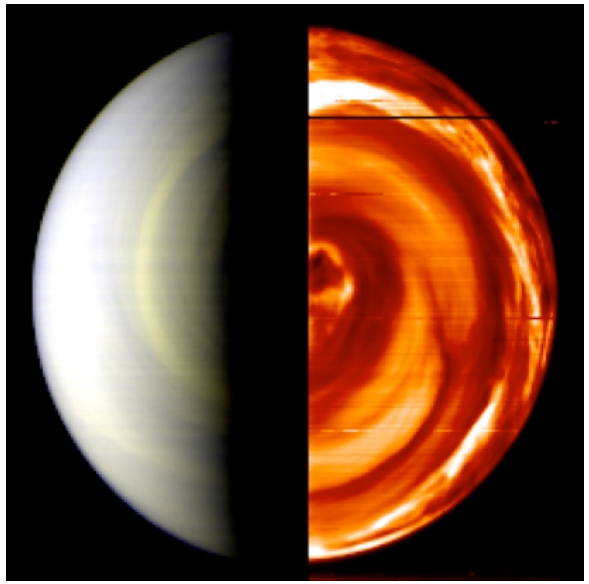
Disagree with VIRA atmosphere model!

About 90K difference between south pole and sub-solar point!!

VIRTIS/Venus Express

(launch Nov. 2005 - arrival Abr. 2006)

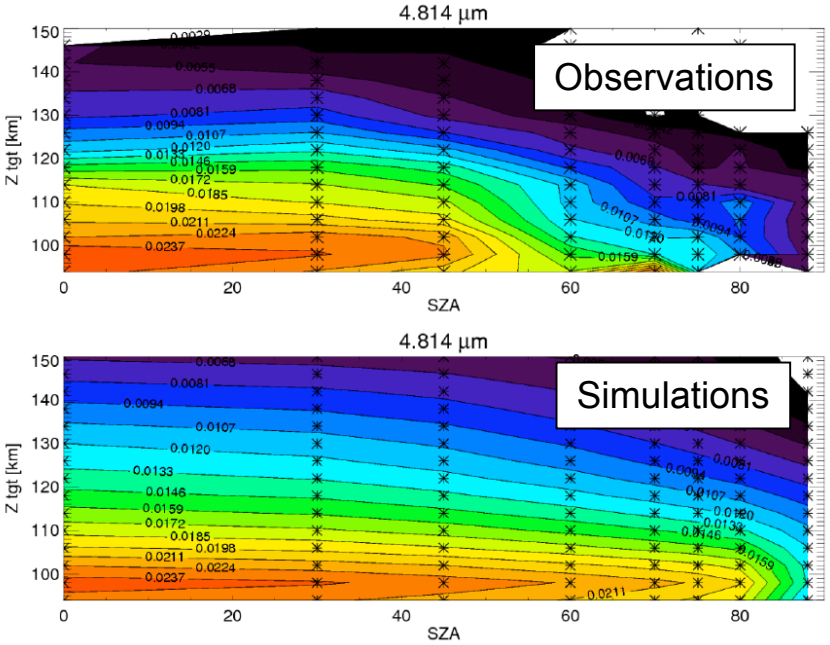




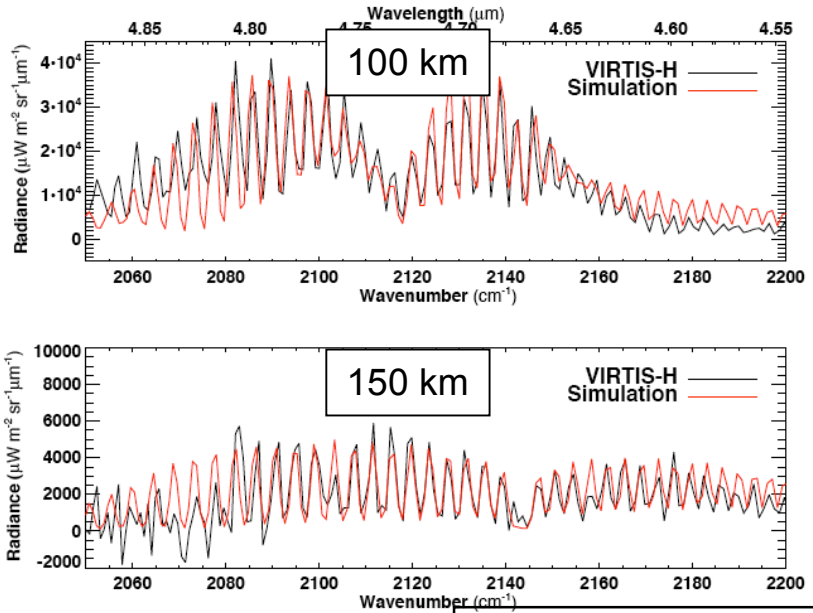
VIRTIS/VenusExpress data analysis (IAA work)

CO non-LTE limb emission at 4.7 um

Sza-Altitude radiance maps



Spectral comparison: simulations-data

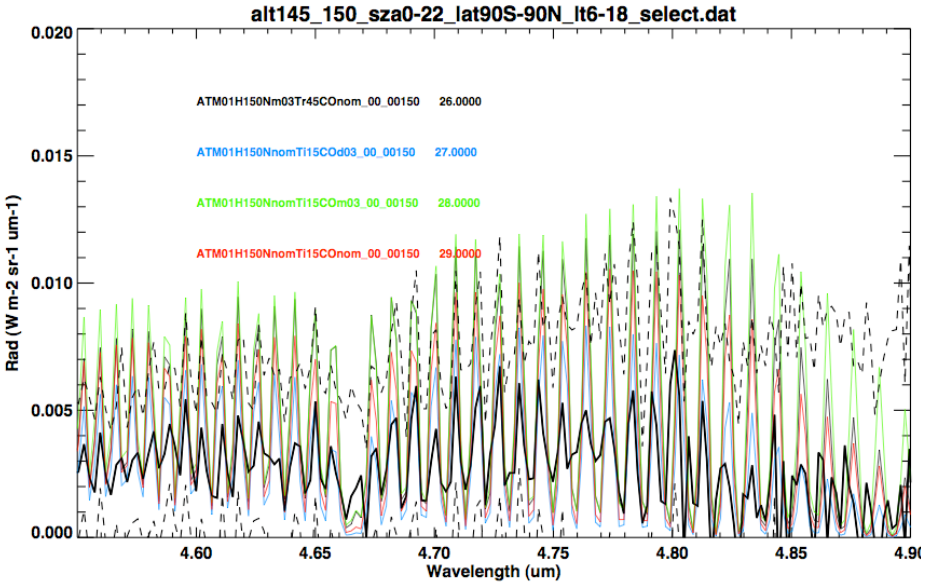


Gilli et al. 2010

Results:

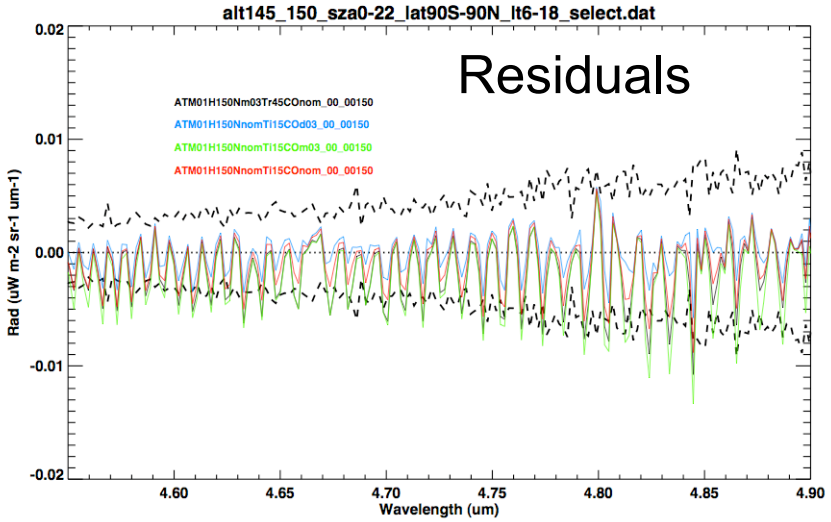
- good agreement model-data (Sza and altitude variation observed)
- Method χ^2 to derive *Temperature* and *CO density* in the Venus upper atmosphere by using those non-LTE emissions **(on-going)**

Preliminary but promising results..



"Good" signal up to <u>150 km</u>!!

FB rotational lines very well identified



Summary

IR molecular spectroscopy is very valuable to sound "inaccessible" region of the terrestrial planets upper atmosphere

WHICH

4.3um, 2.7 um, 4.7um, 1.27 um, 10um: most commonly studied IR emissions to derive atmospheric parameter

HOW

ground base/satellite, Nadir/limb emission

WHY

Energy balance, Temperature, winds and composition retrievals: unknown parameters in the upper atmosphere of Mars and Venus.

- No GCM (global circulation model) for Venus to contrast the observations (work in progress).
- EMGCM for Mars but very sparse data.

In the Future…

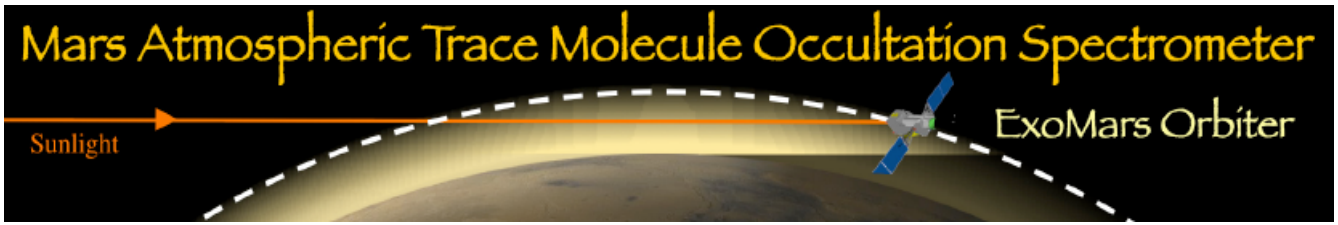
PlanetsNews

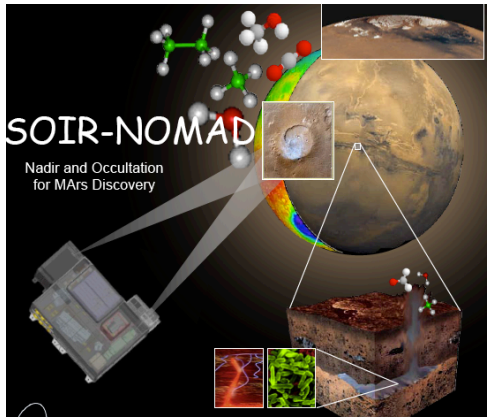
Venus

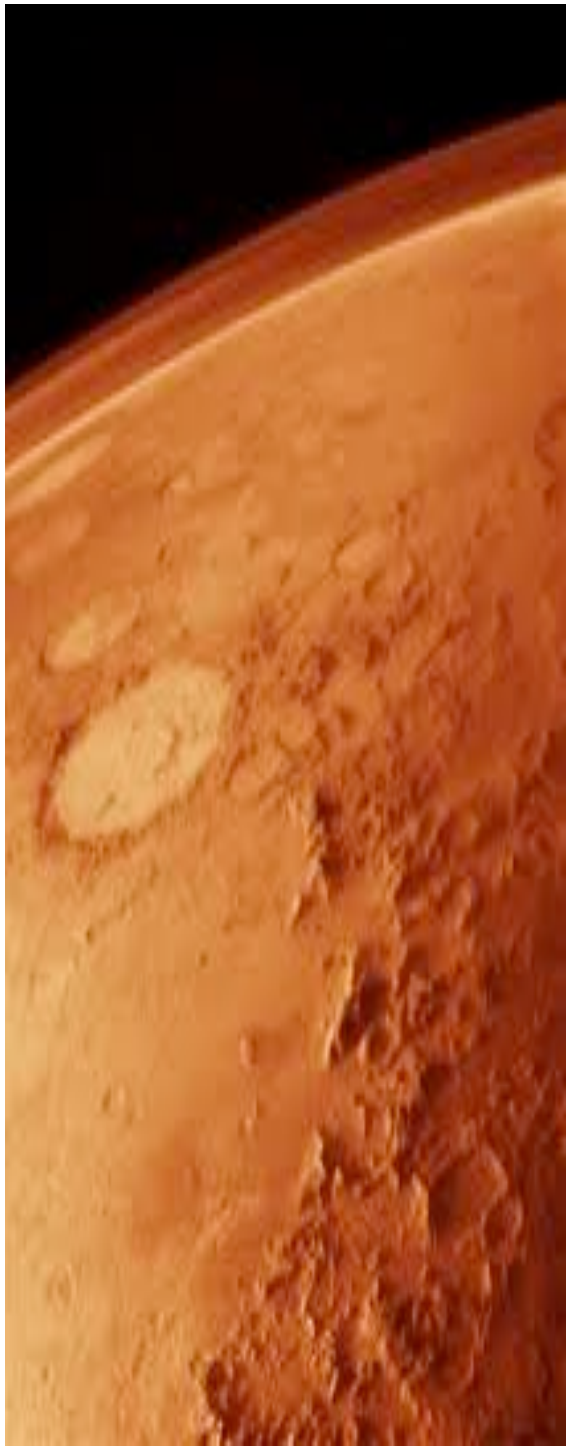
- Akatsuki VCO (Venus Climate Orbiter):
  Dic 2010: it failed the insertion to Venus Orbit!
- in situ exploration??

Mars

- Exomars mission (2016): NOMAD *(IAA Team)*
  MATMOS







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