CARBON DIOXIDE NON-LTE EMISSIONS IN THE UPPER ATMOSPHERES OF MARS, VENUS AND EARTH FROM VIRTIS OBSERVATIONS

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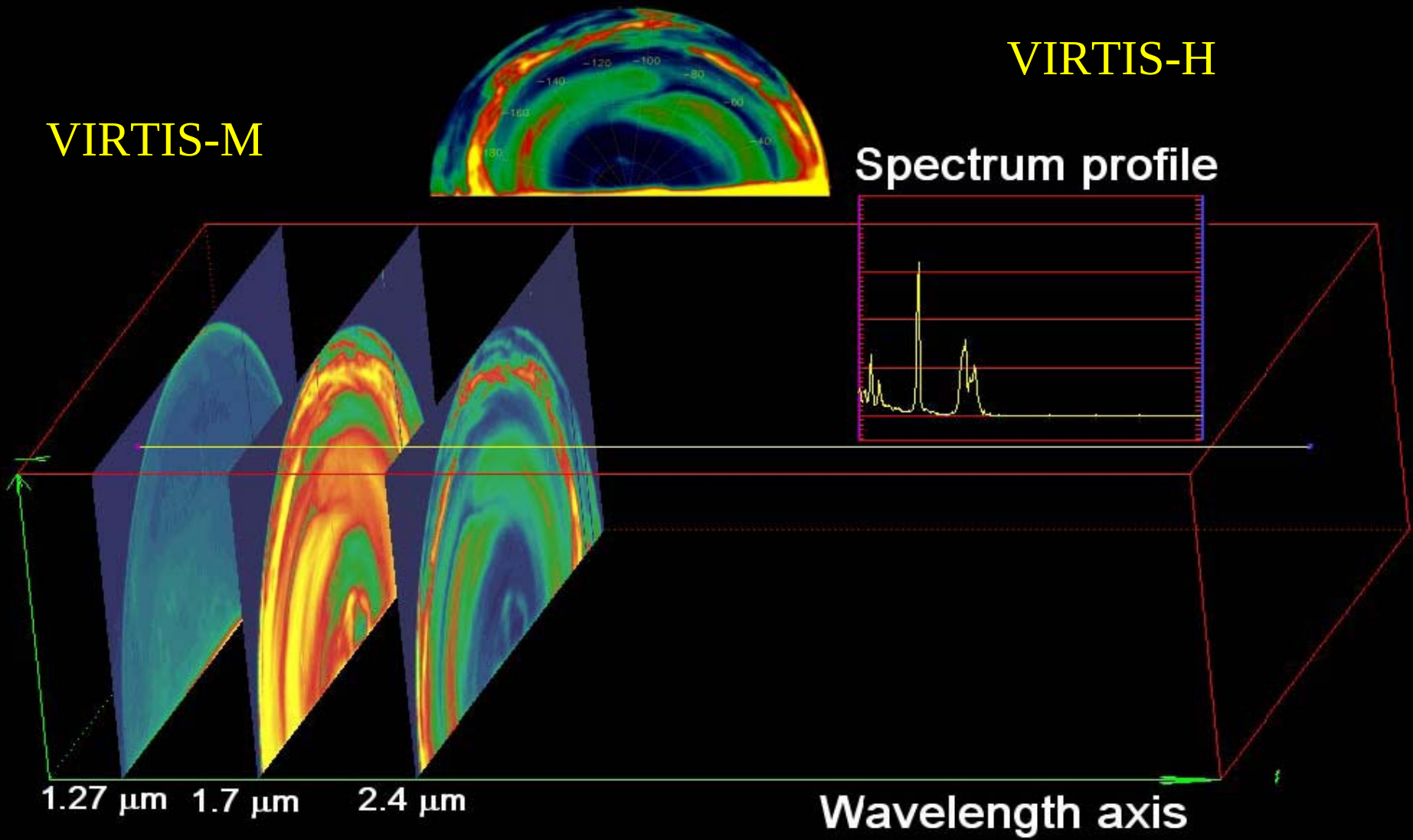
Early observations of CO_2 fluorescence observations in telluric planets

- Venus 1990: NIMS/Galileo Venus (and Earth !) cf Roldan et al, Icarus, 2000
- Mars : PFS and OMEGA/Mars Express (ISO/SWS) /cf Formisano et al, Icarus, 2006, Lopez-Valverde, PSS 2005, Drossart et al, Granada meeting 2006, etc.
- On Earth 4.3 micron CO_2 relatively recent: Many satellite, e.g. ISAMS, ENVISAT/MIPAS

VIRTIS : spectral imaging on Rosetta (PI A. Coradini) and Venus Express (PIs P. Drossart & G. Piccioni)

Scheme of VIRTIS



Credits: ESA/VIRTIS-VenusX

List of observations (VIRTIS-H)

- Earth : Rosetta flyby (ESB1 in 2005 and ESB2 in Nov. 2007) :
- Mars : Rosetta flyby MSB in Feb. 2007
- Venus : Venus Express regular limb observations since Apr. 2006

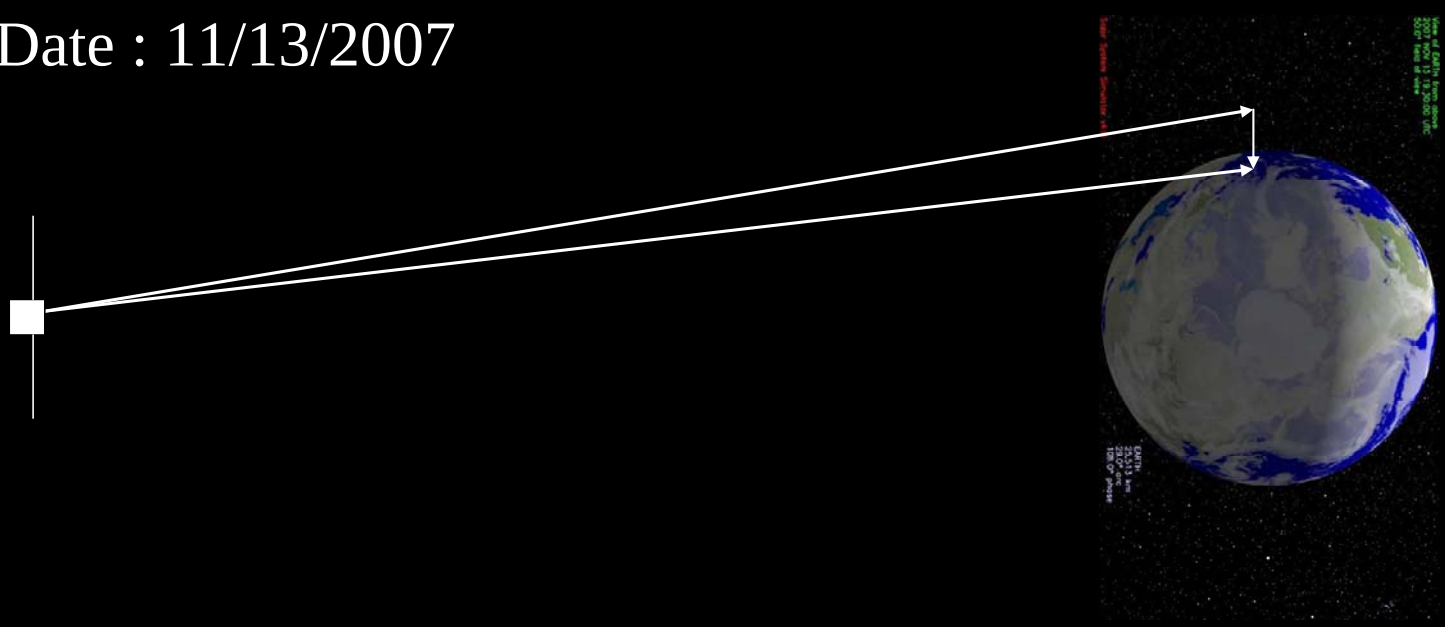
Pointing control (geometry retrieval) still in progress for Rosetta case

Earth SB2 Rosetta observations

~ Sun Direction

Sun elongation from VIRTIS boresight is 16.2° at 19:30
17.2° at 19:40

Date : 11/13/2007



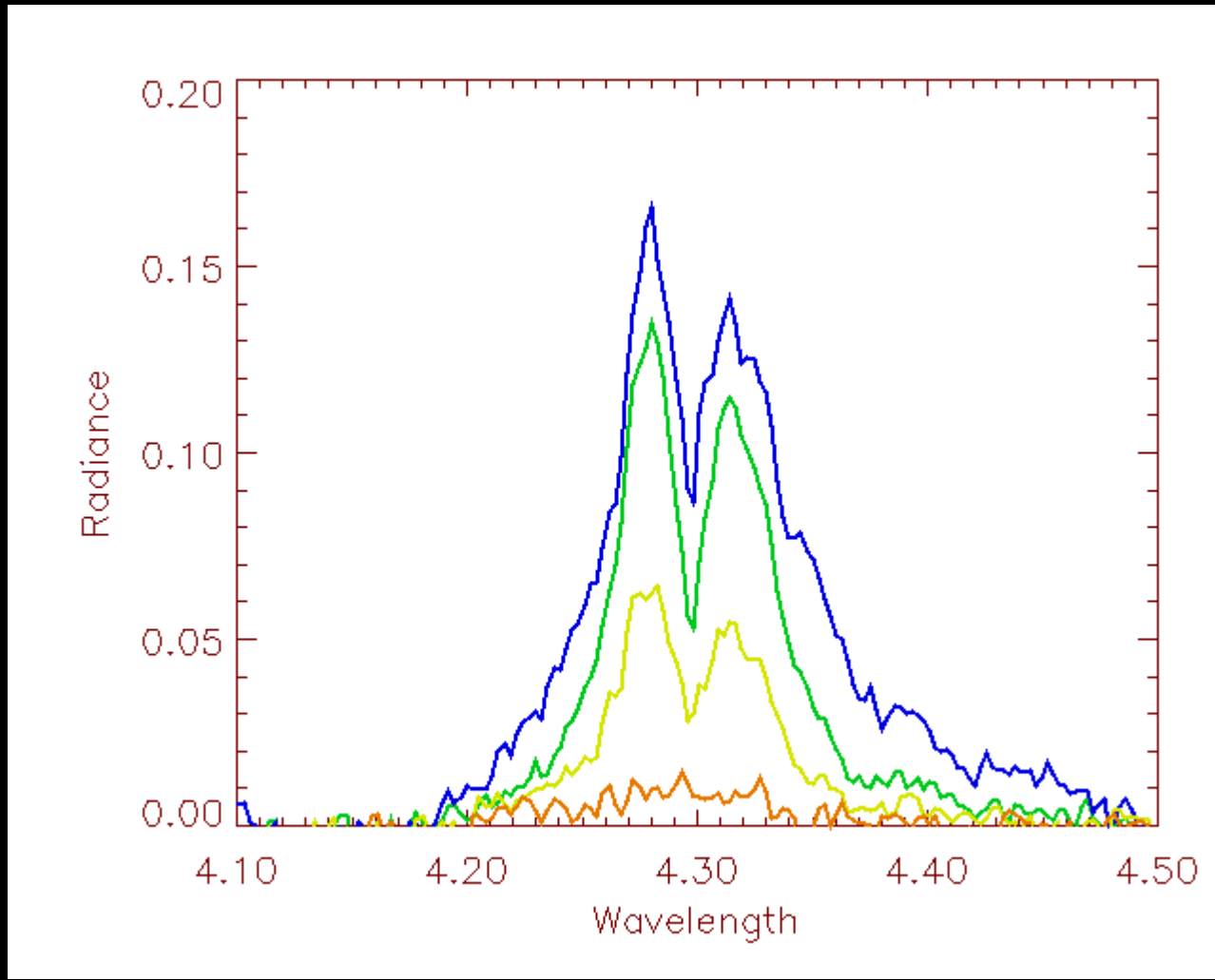
First Slew Start at 19:30 end at 19:40

Earth spectra (limb scan)

Altitudes :

66 km
79 km
89 km
100 km

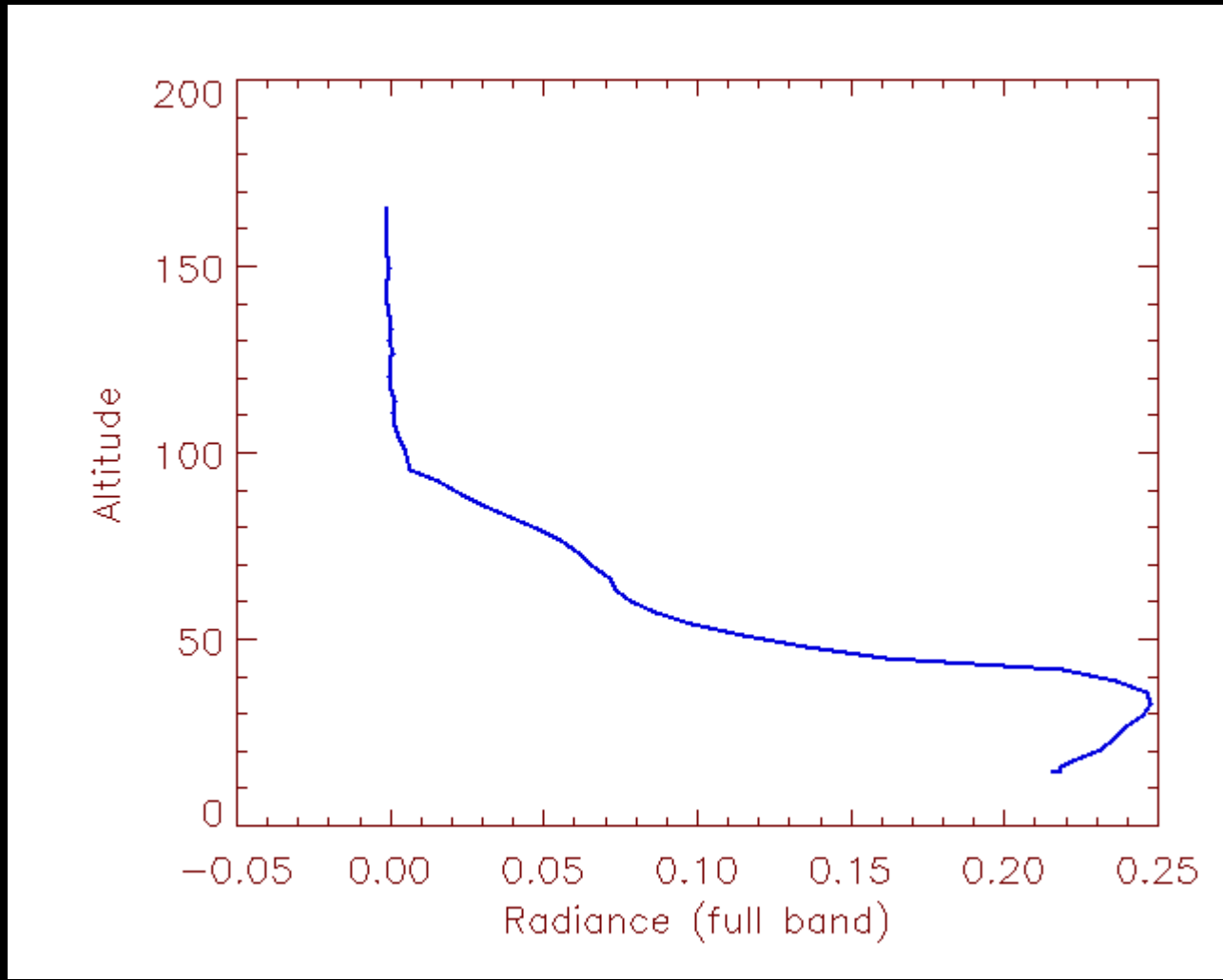
Corresponding to
~10^{-2} to 0.5 10^{-3} mbar



Radiances in $\mu Wm^{-2}sr^{-1}/\mu m$

Earth limb profile

Whole CO_2 band,
Averaged from
4.2 to 4.4 μm



Radiances in $\mu Wm^{-2}sr^{-1}/\mu m$

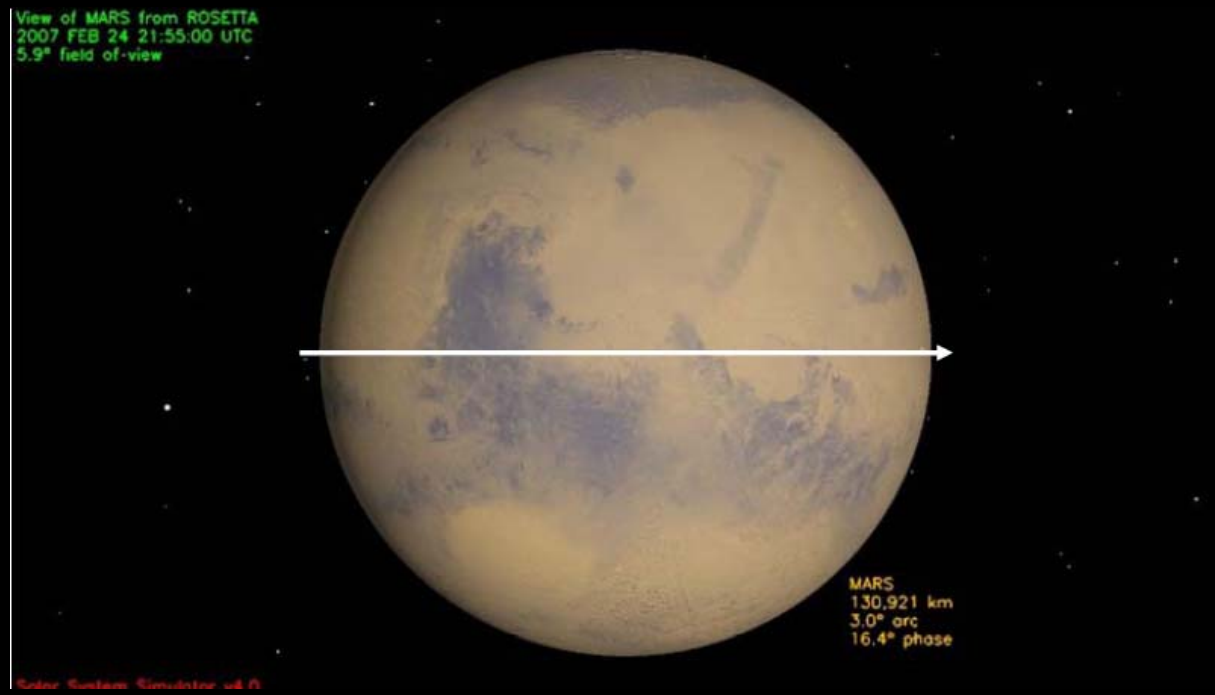
Rosetta Mars flyby

Date : 24/02/2007

Pre-eclipse
VR01 Time= 18:20 1836 60 km at nadir
VR02 Time = 778 Res. 50 km at nadir
VR03 time =22:00 4979 Res. 30 km at nadir

Sequences limb to limb scans VR01/VR02/VR03

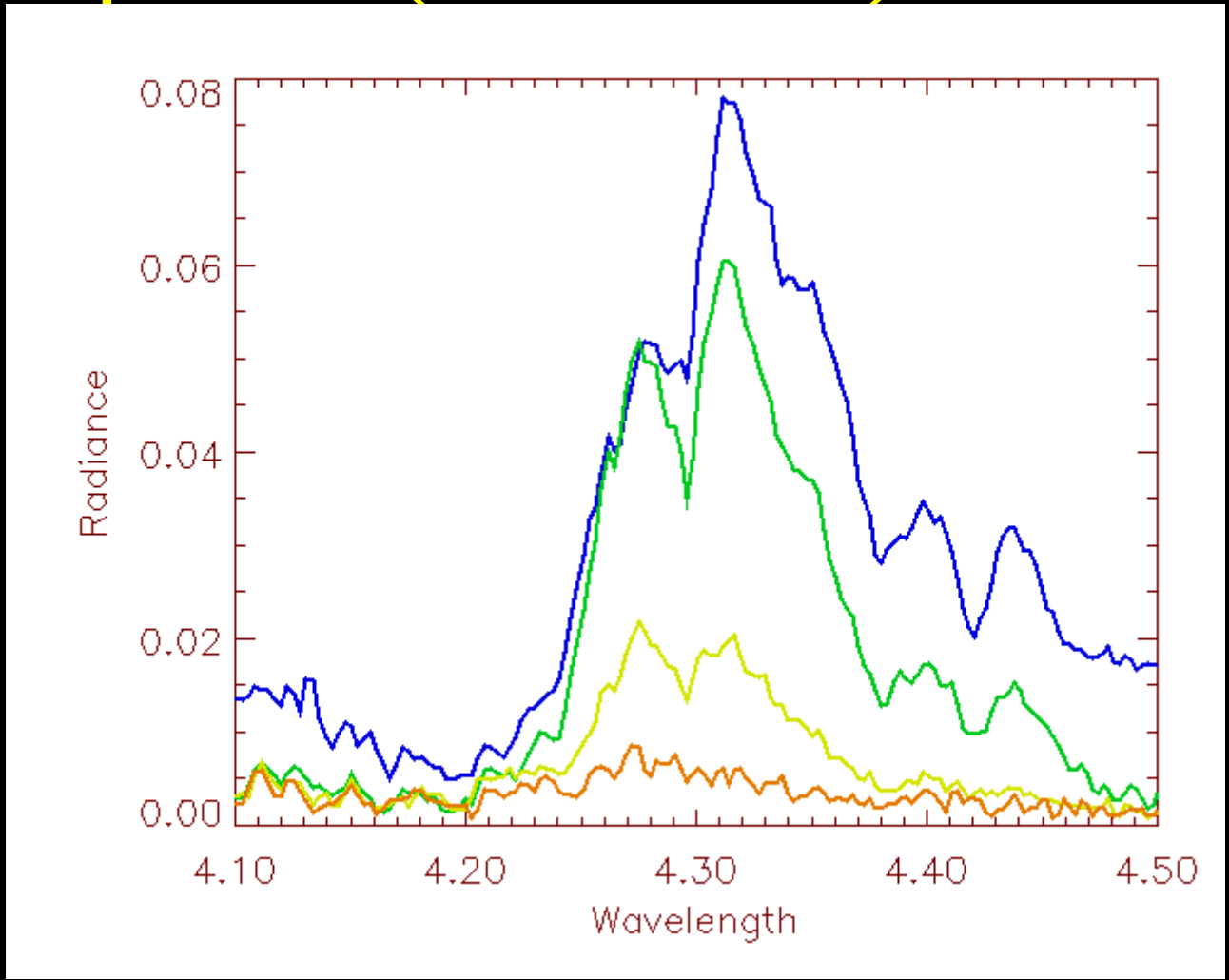
- VR03 = S/C scan; start 24/02/2007 at 21:50 ends at 22:10
- Longitude coverage 5E to 185E
- Latitude coverage: full disk (slit = 1.1 Mars Disk size)
- Spatial resolution 30km at Nadir



Mars spectra (limb scan)

Altitudes
73 km
110 km
149 km
188 km

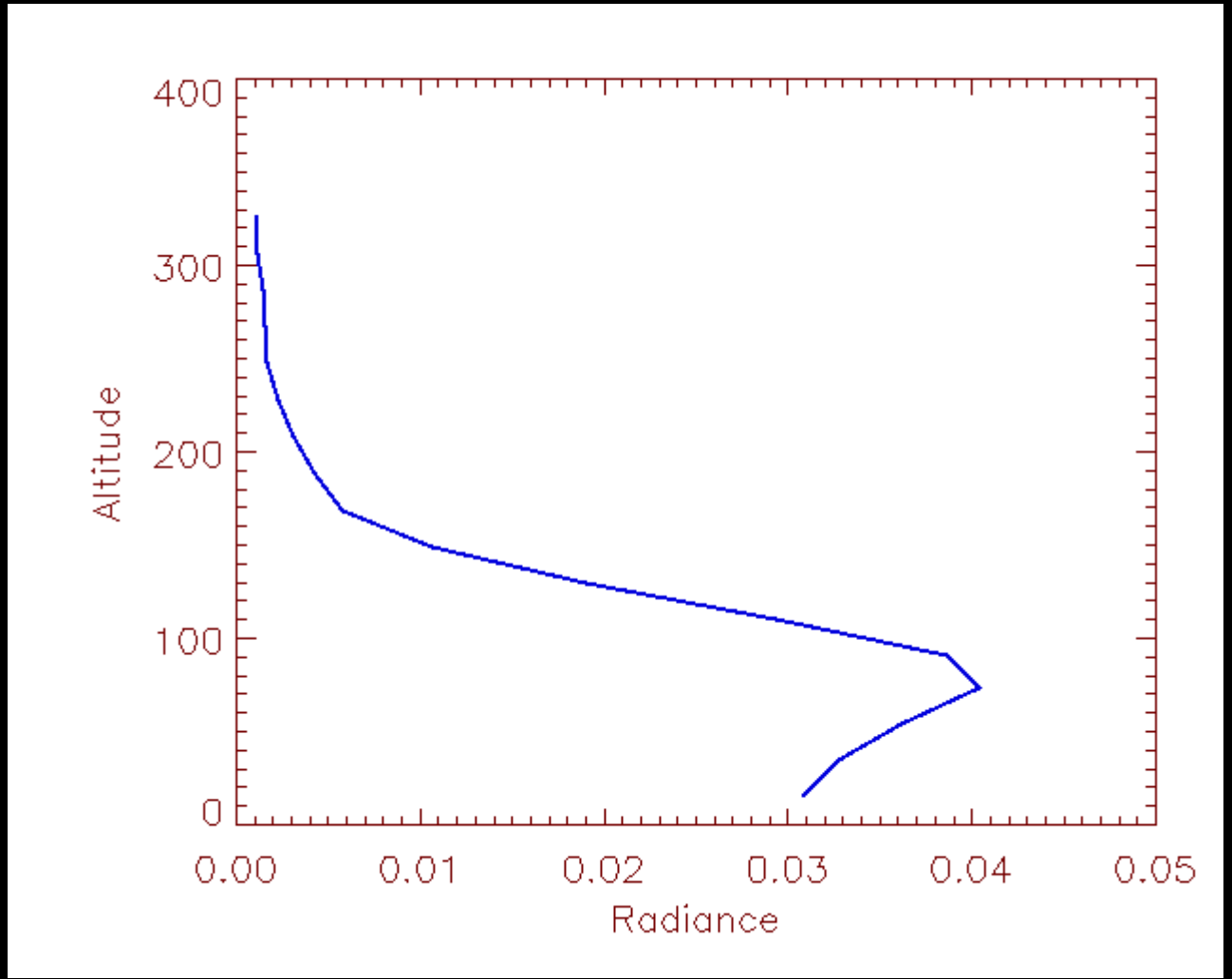
Corresponding to
~10^{-3} to 10^{-9} mbar



Radiances in $\mu W m^{-2} sr^{-1} / \mu m$

Mars limb profile

Total CO_2 band,
Averaged from
4.2 to 4.4 μm



Radiances in $\mu W m^{-2} sr^{-1} / \mu m$

Venus Express observations

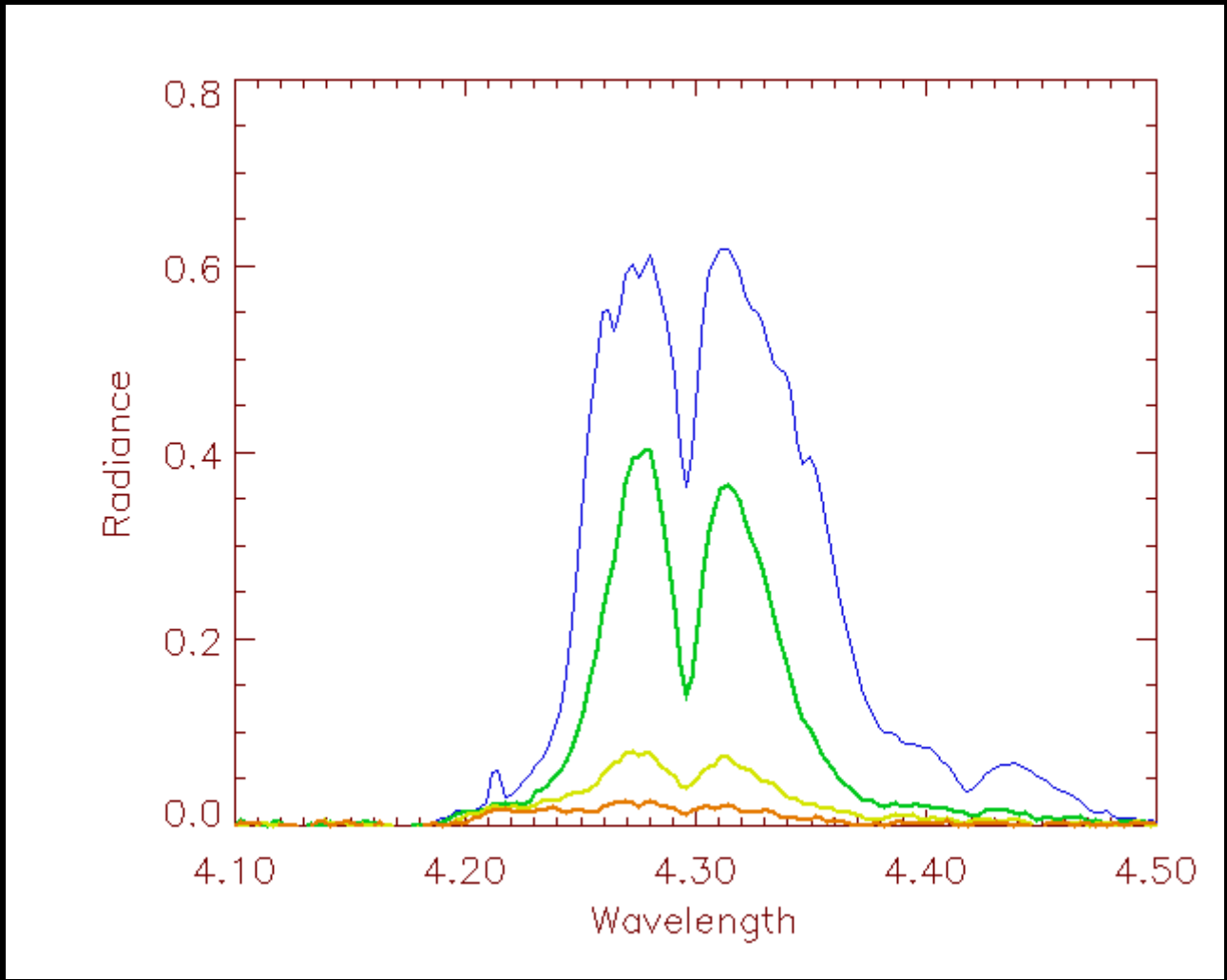
- Limb observations : regular scans of the limb at most latitudes and solar zenith angles
- Example : observations of 2008/10/29

Orbit 922

Venus spectra (limb scan)

Altitudes
98 km
107 km
116 km
126 km

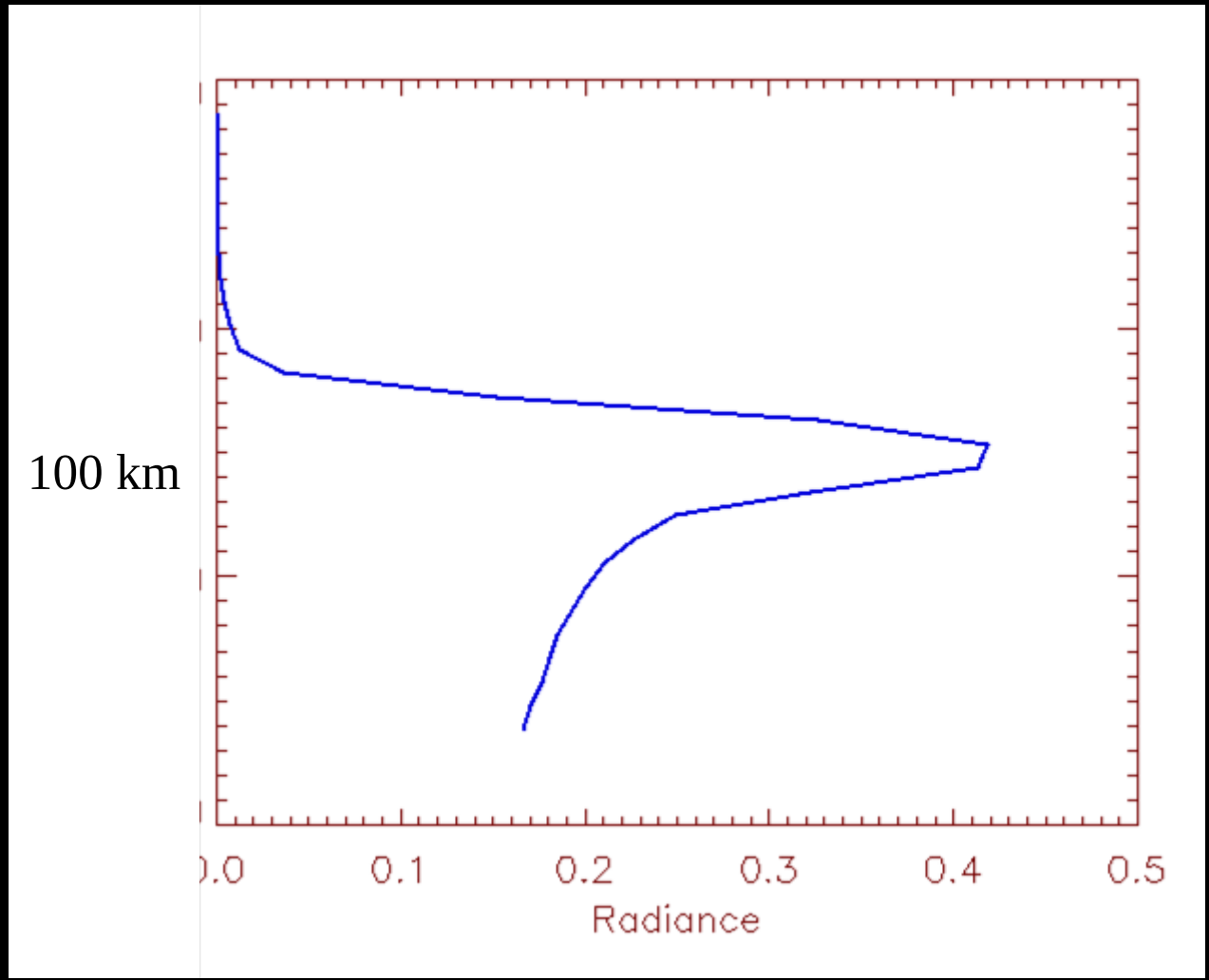
Corresponding to
~10^{-3} to 10^{-9} mbar



Radiances in $\mu Wm^{-2}sr^{-1}/\mu m$

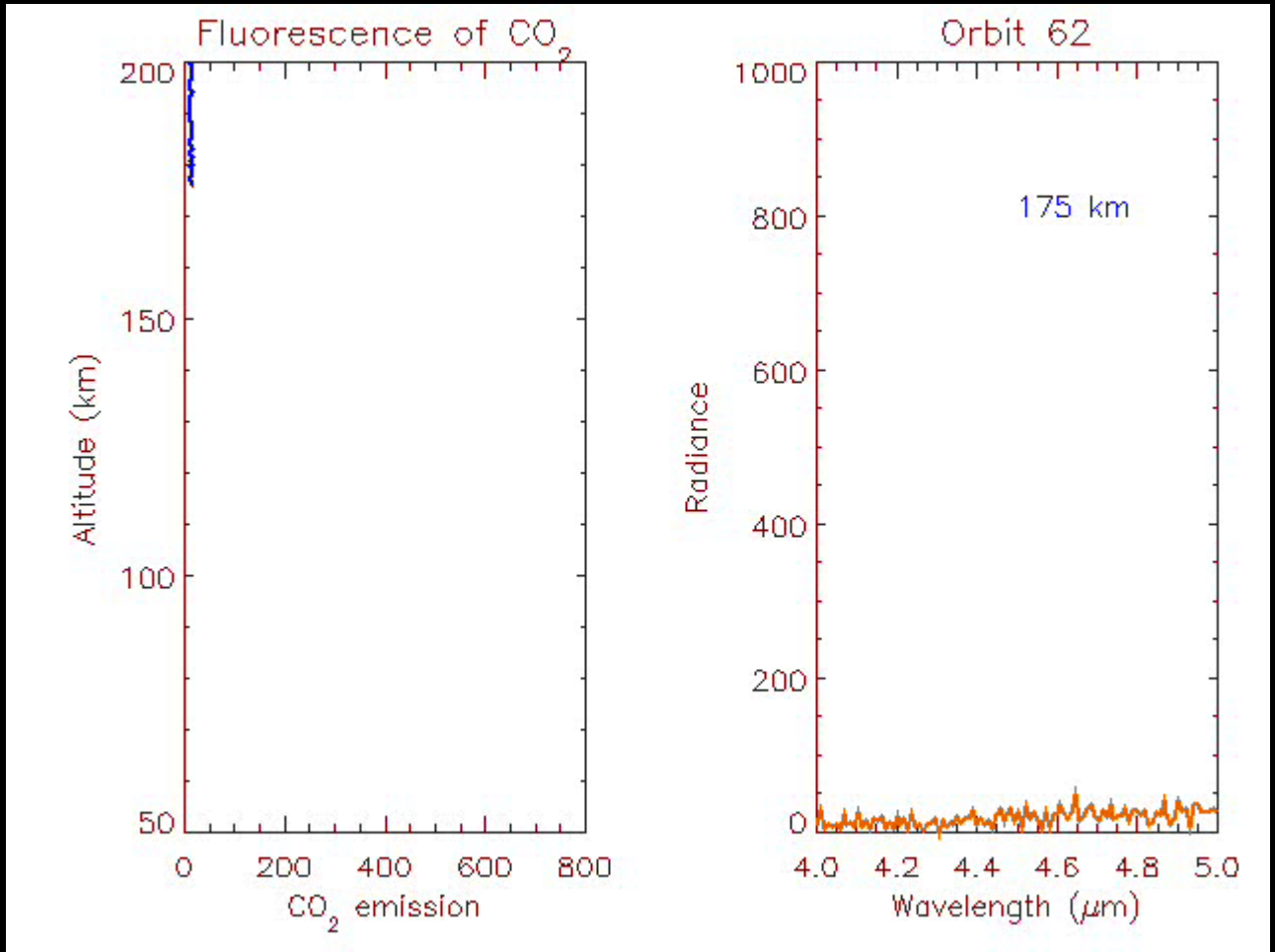
Venus Profile

Total CO_2 band,
Averaged from
4.2 to 4.4 μm

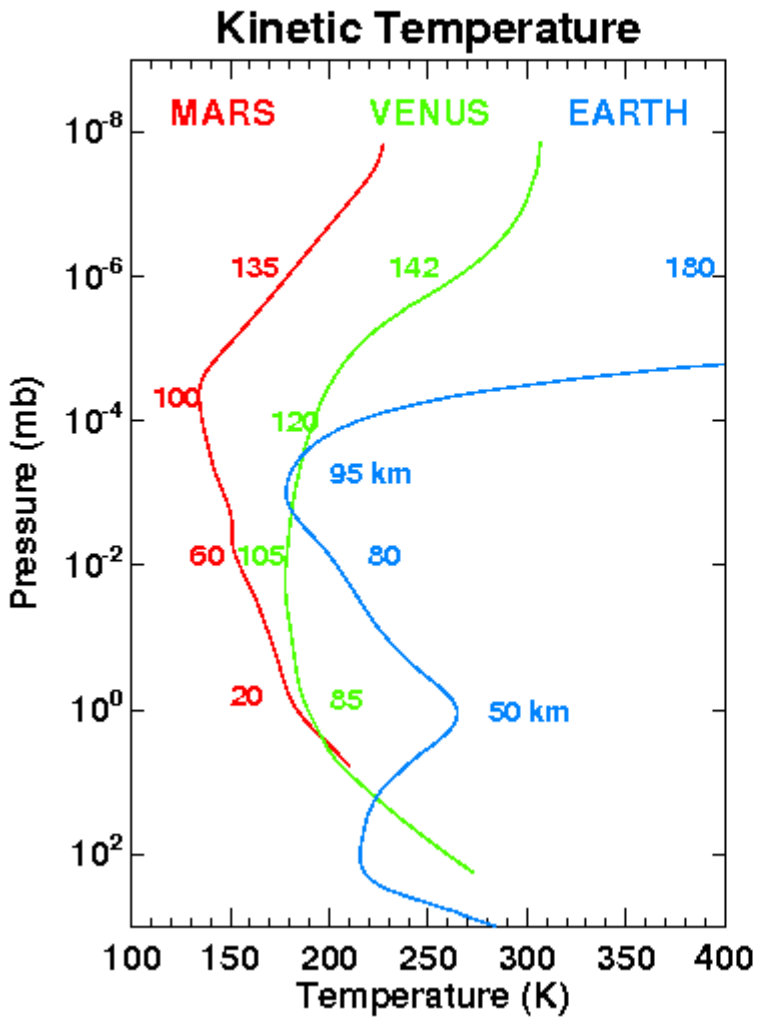


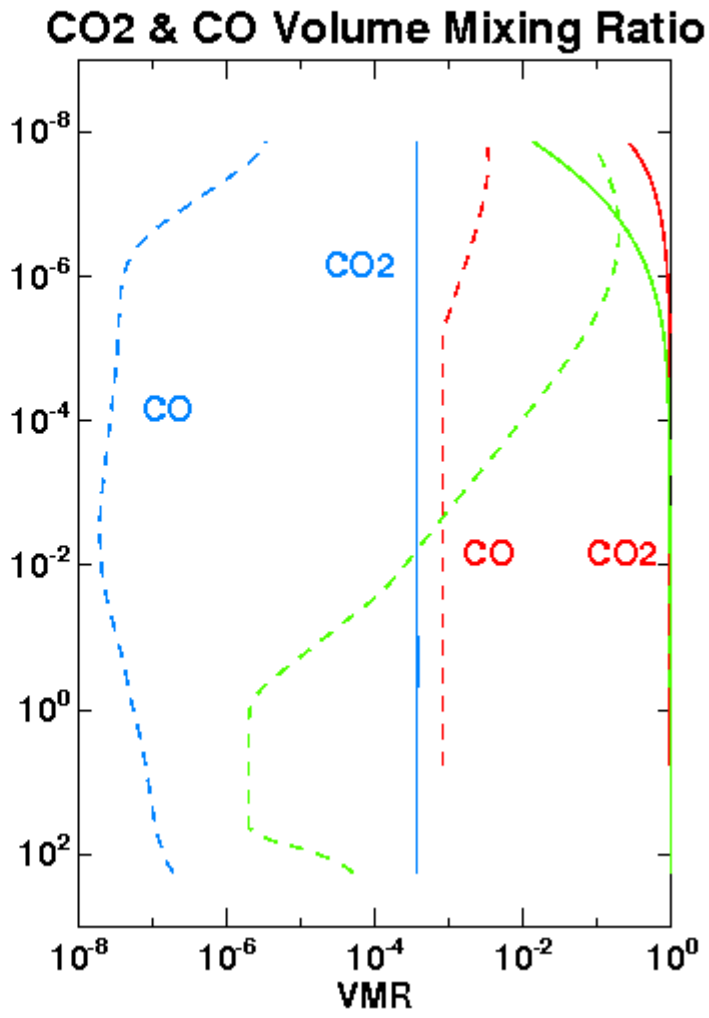
Radiances in $\mu W m^{-2} sr^{-1} / \mu m$

Venus limb scan (orbit 62 / June 2006)



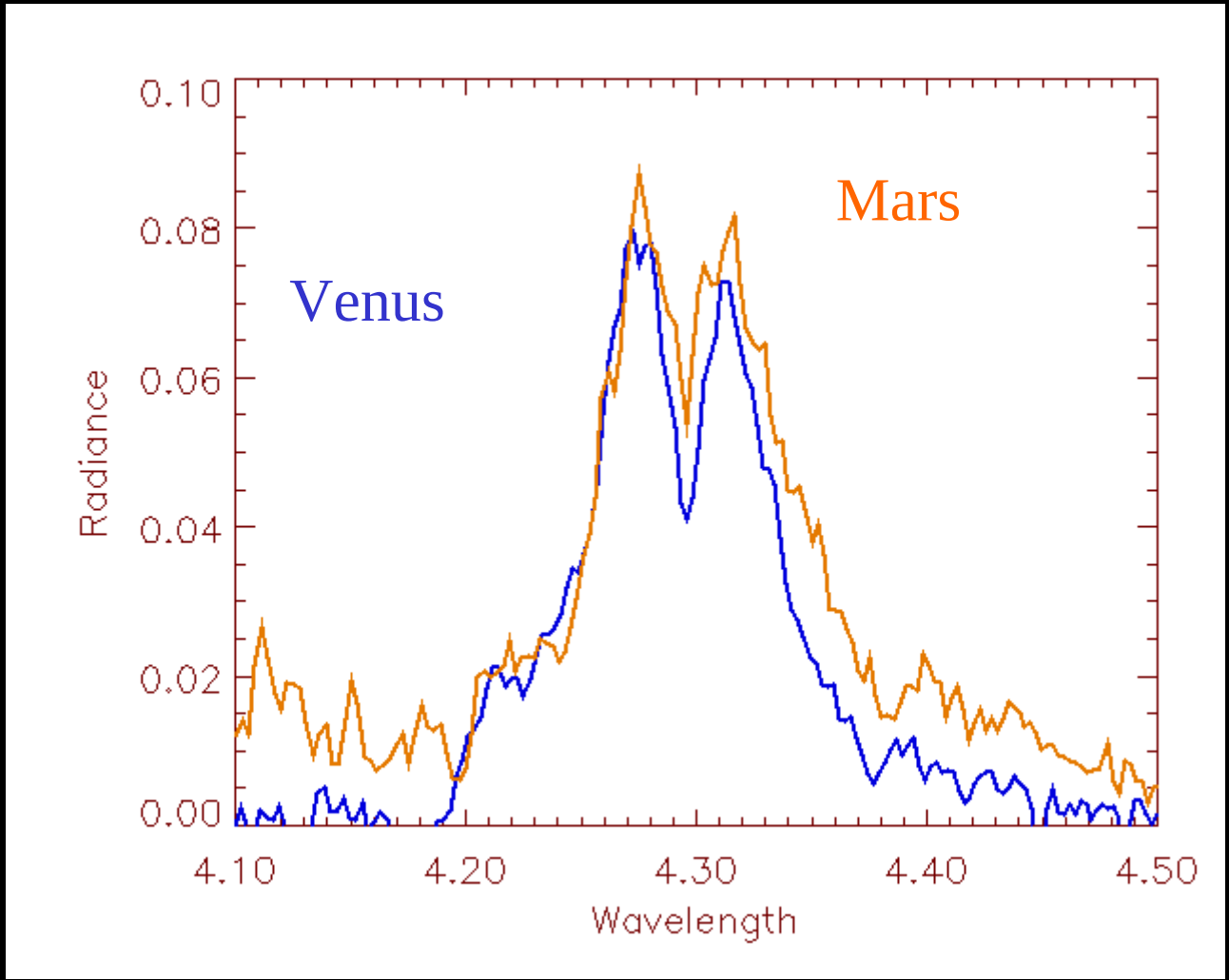
Modelling : see poster by M. Lopez-Valverde





Comparison Venus/Mars

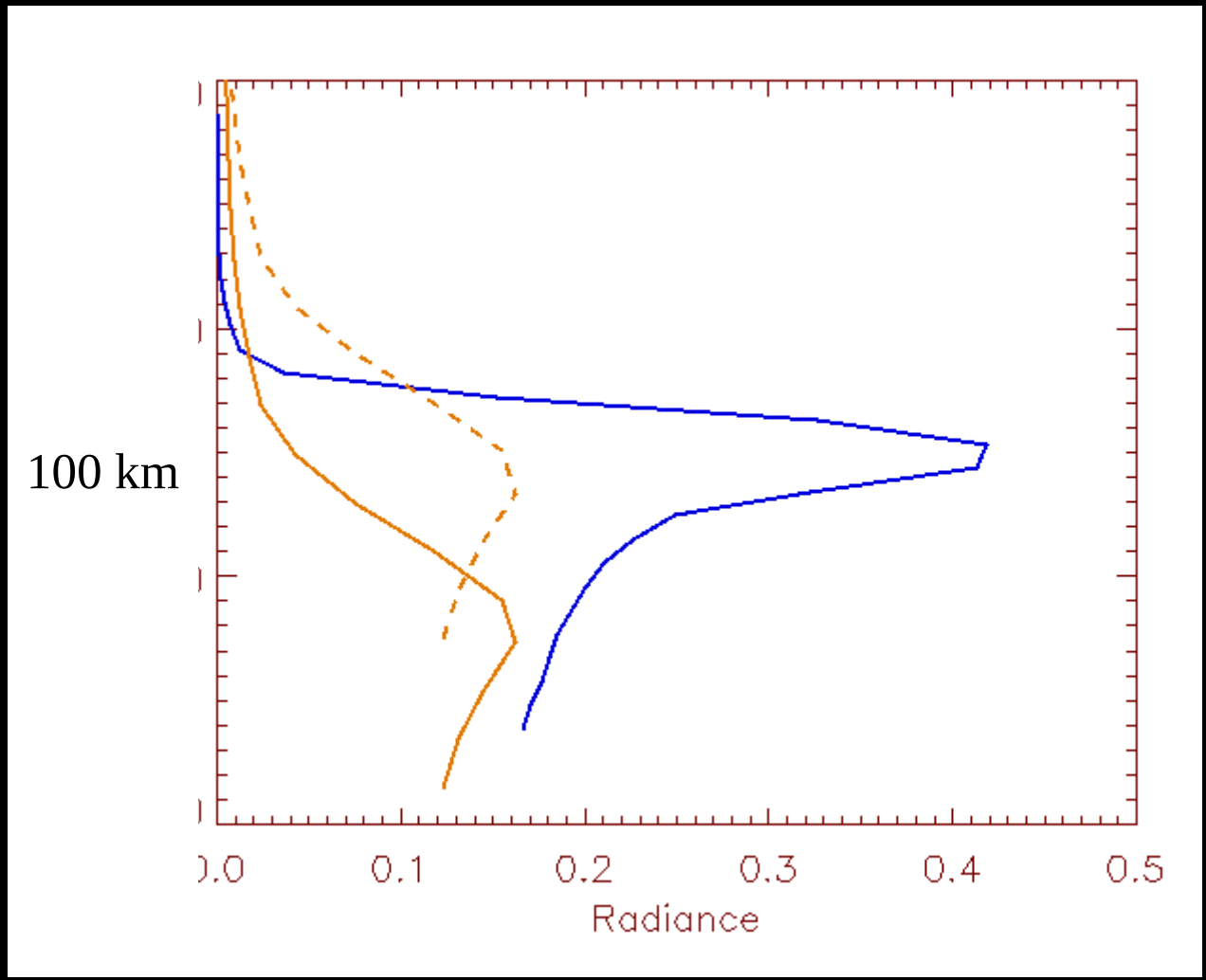
Comparison of spectra at similar pressure
(mars x 4 to take the distance to Sun into account)
Altitudes :
~110 km (Mars)
~120 km (Venus)
Pressure~10^{-5} mbar
(preliminary –SZA corrections to be added)



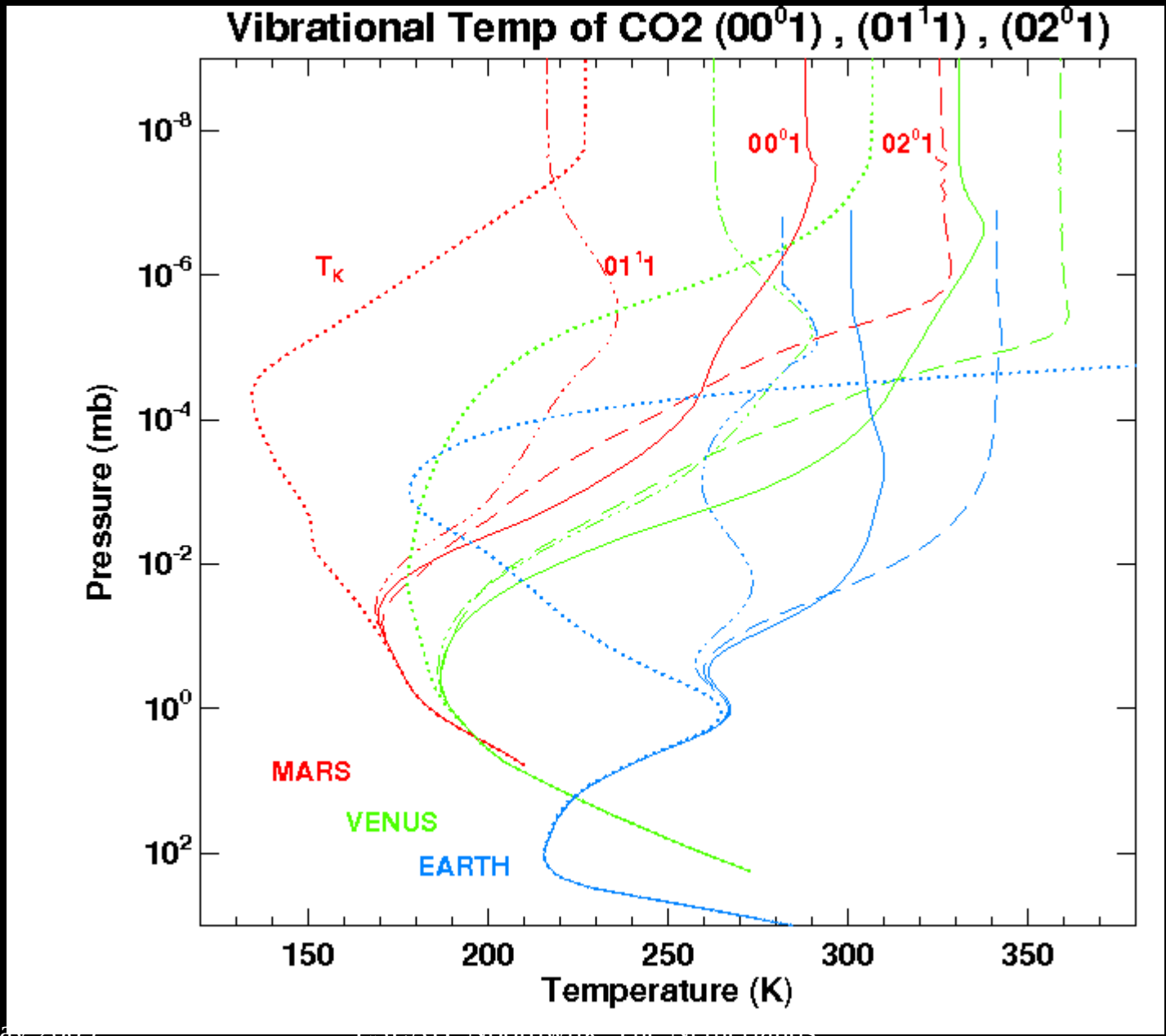
Radiances in $\mu W m^{-2} sr^{-1} / \mu m$

Comparison Venus/Mars

Difference in altitude
⇒ corresponds to the difference in pressure
Difference in shape
=> corresponds to the difference in scale height



Radiances in $\mu Wm^{-2}sr^{-1}/\ \mu m$


Vibrational Temp of CO2 (00^{0}1) , (01^{1}1) , (02^{0}1)
Pressure (mb)
Temperature (K)
10^{-8}
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}
150
200
250
300
350
T_K
01^{1}1
00^{0}1
02^{0}1
MARS
VENUS
EARTH

Conclusions

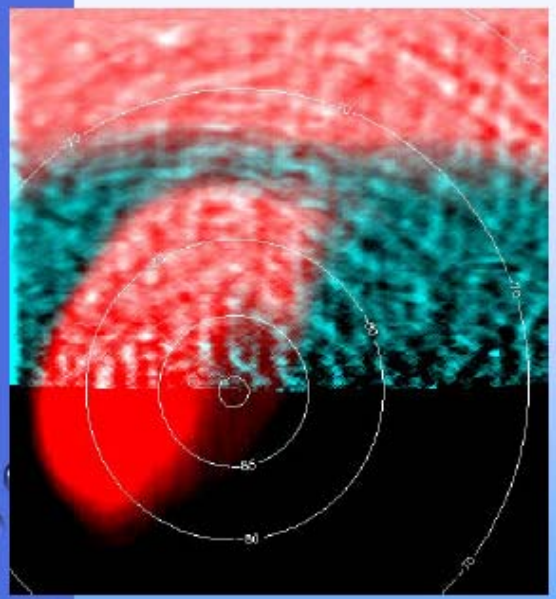
- VIRTIS observations of the three telluric planets offer a unique opportunity of comparison of CO_2 emissions to be combined with Mars Express observations (PFS/OMEGA) and Earth observations (MIPAS/Envisat) to build a large database

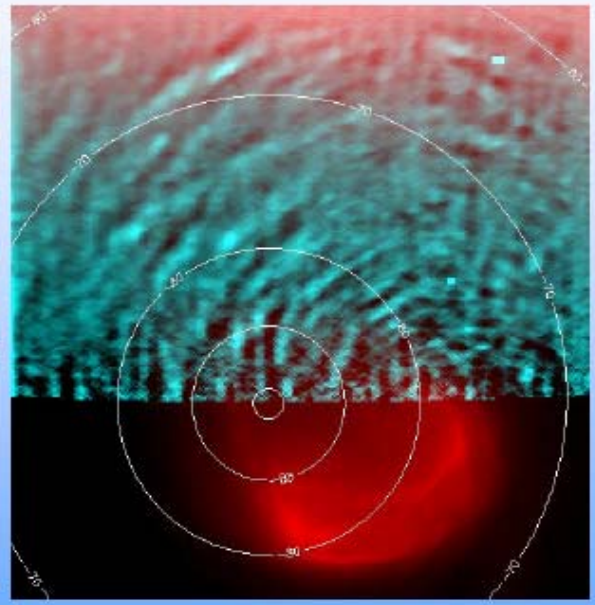
$\Rightarrow$ Improvements in the modelling : towards a better understanding of the upper atmospheric structure (cf Gilli and Lopez-Valverde presentations)

Ref. JGR Planets special issue for Venus

$\Rightarrow$ Towards a future use of CO_2 emissions as a probe of the mesospheric levels (the 'ignorosphere' of planets) : variations of emissions related to dynamics (Garcia et al, JGR 2009)

Gravity waves in CO_2 fluorescence on Venus observed with VIRTIS





Red: 5.05μm

Green and Blue:

Waves at 4.3μm

Garcia et al, JGRE, 2009