Atmospheric sounding of Mars from ground-based and MEx observations

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Ground-based and MEx observations of Mars

- TEXES Observations (8 μm) , June 2003 -> H_2O_2, H_2O, search for CH_4
- PFS/Mex (3.3 μm): Search for CH_4 variations
- OMEGA/Mex (2-5 μm): CO and H_2O variations over Olympus Mons

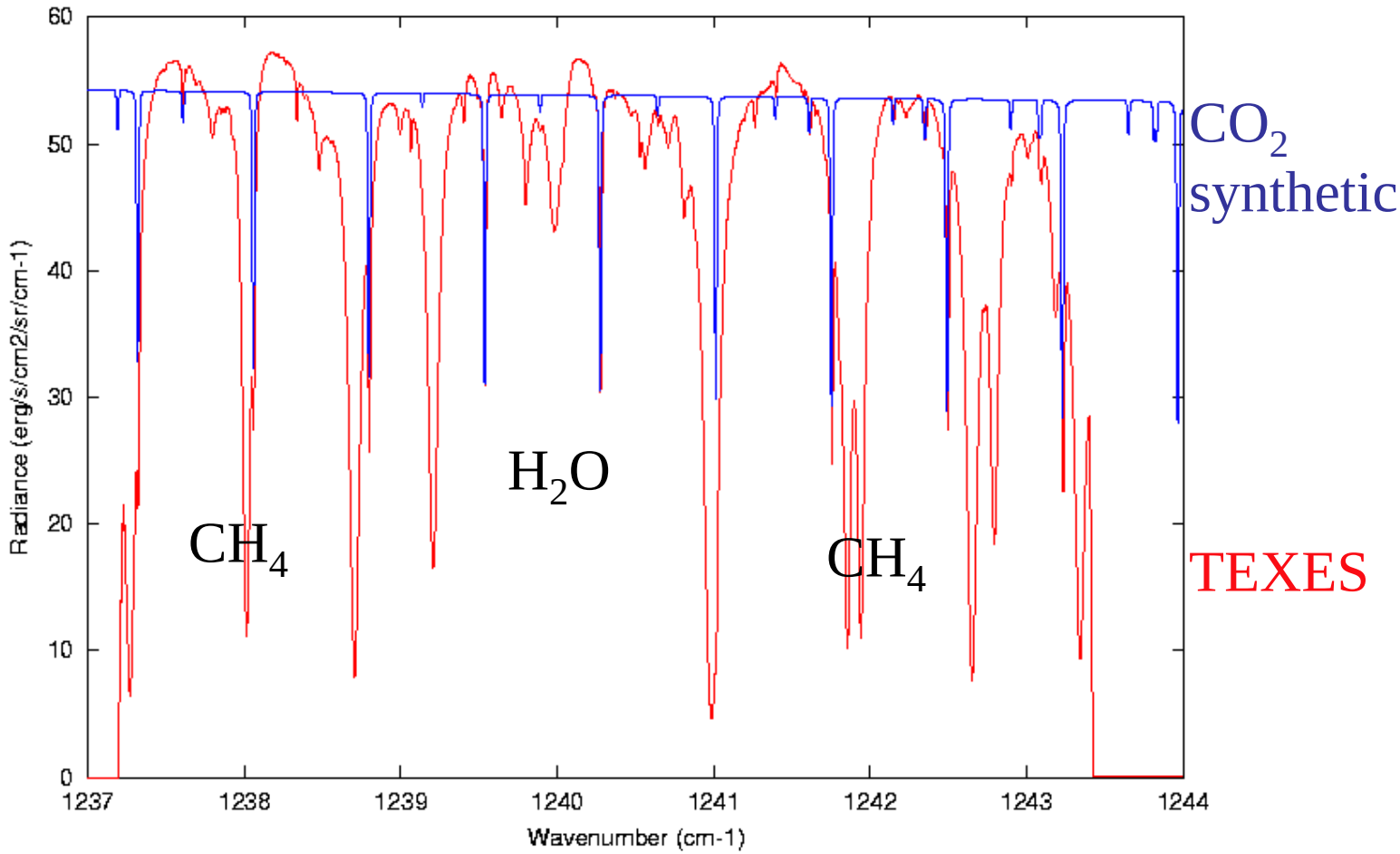
The TEXES data set

- Date: June 19-20, 2003
  (L_s = 206°, H_2O = 10 pr-μm)
- TEXES(Lacy et al.,2002), 3m-IRTF, Mauna Kea
  Spectral range: 1230-1236 cm^{-1},1237-1244 cm^{-1}
  (8.04-8.13 μm) + 995-1005 cm^{-1}(10 μm)
- Spectral resolution: 0.016 cm^{-1} (R = 7.7 10^4)
- Spatial resolution (after convolution):
  1.5x1.5 arcsec
  - > H_2O_2 detection and mapping
    (Encrenaz et al., Icarus 170, 424, 2004)

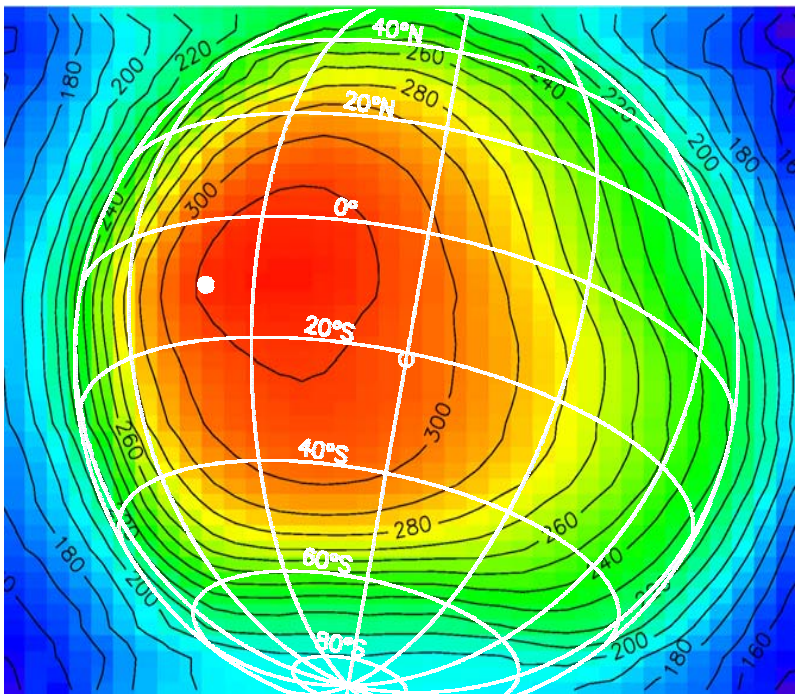
The 1237-1243 cm^{-1} spectrum of Mars (TEXES, IRTF)

All lines identified down to depths of 0.3%

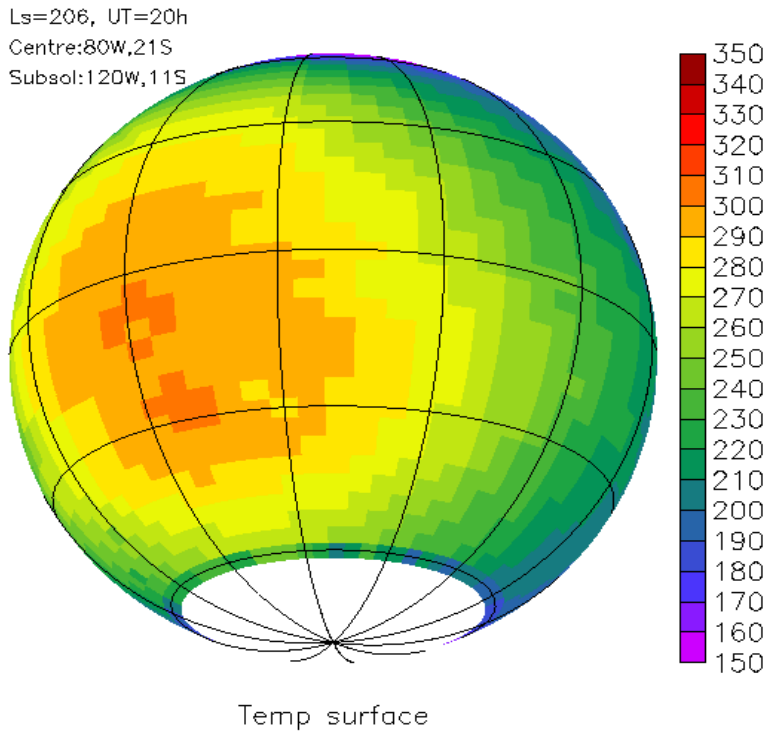
S/N > 1000 in the continuum



The surface temperature of Mars

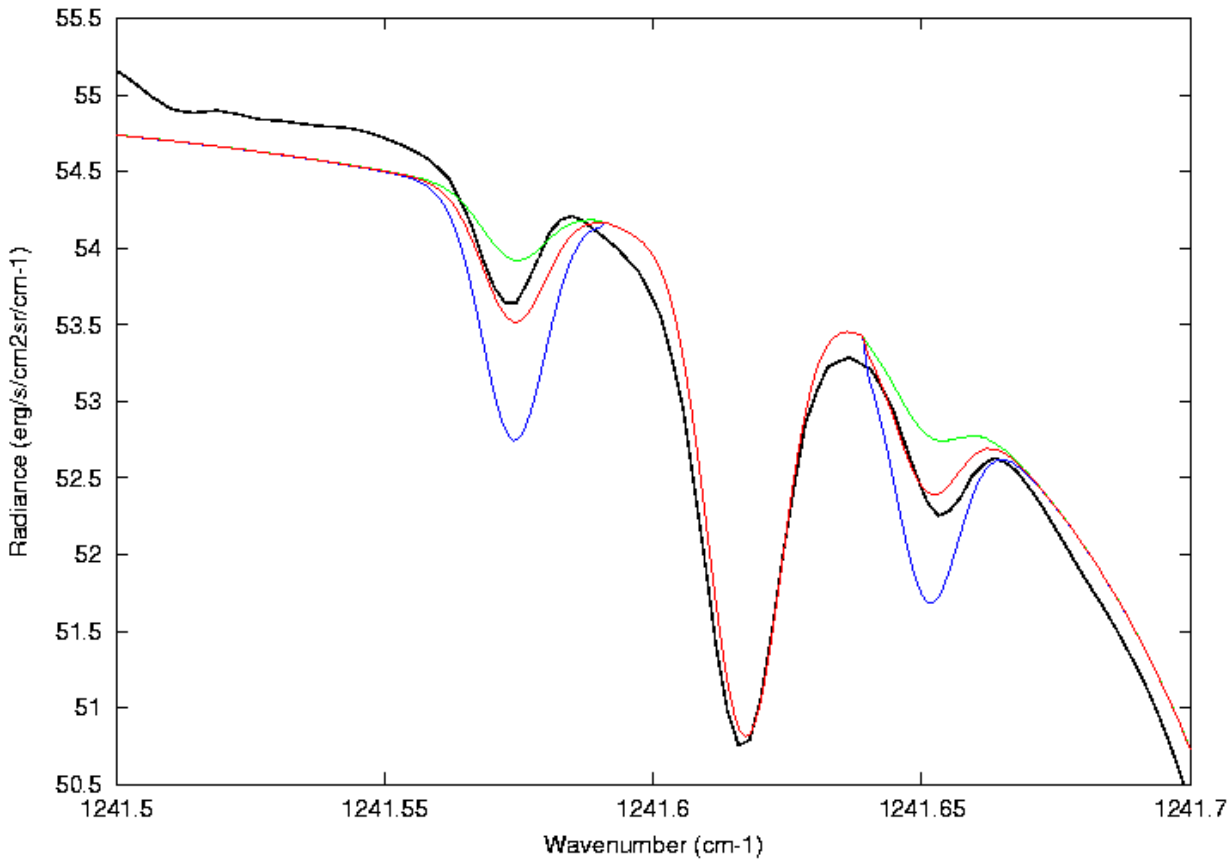


TEXES-Ts



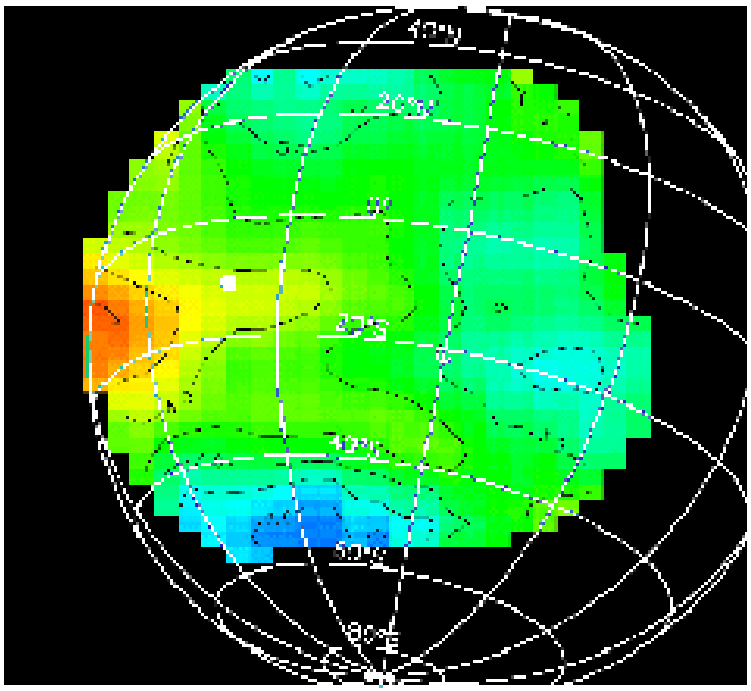
GCM-Ts

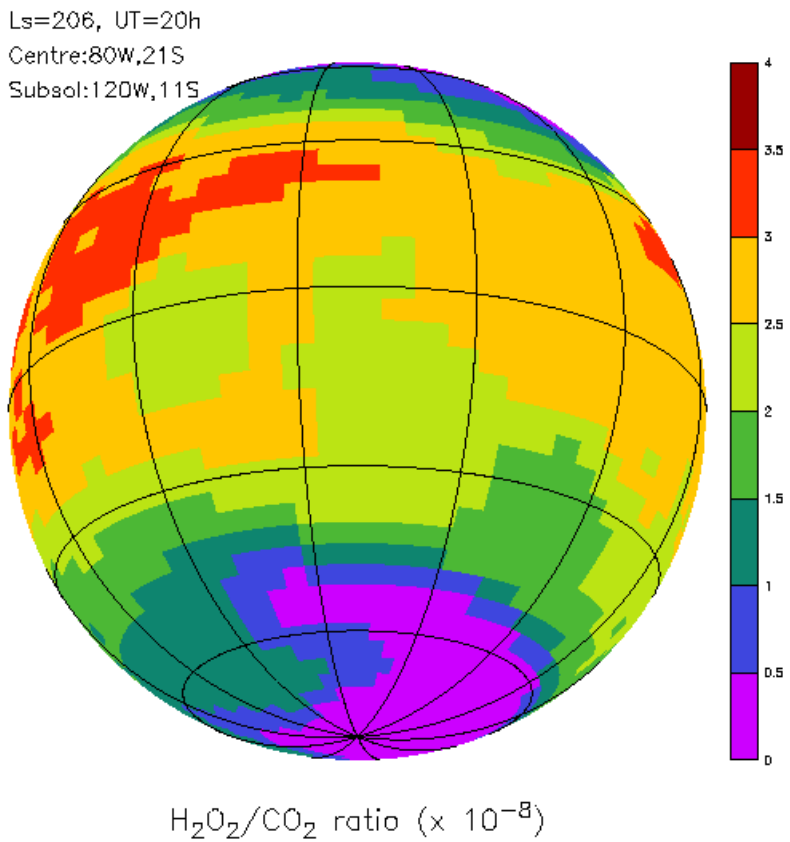
TEXES data vs synthetic models:
H_2O_2 = 20 ppb, 40 ppb, 60 ppb
Best fit: H_2O_2 = 40 ppb



H_2O_2 mapping on Mars

Encrenaz et al. Icarus 170,424, 2004





TEXES

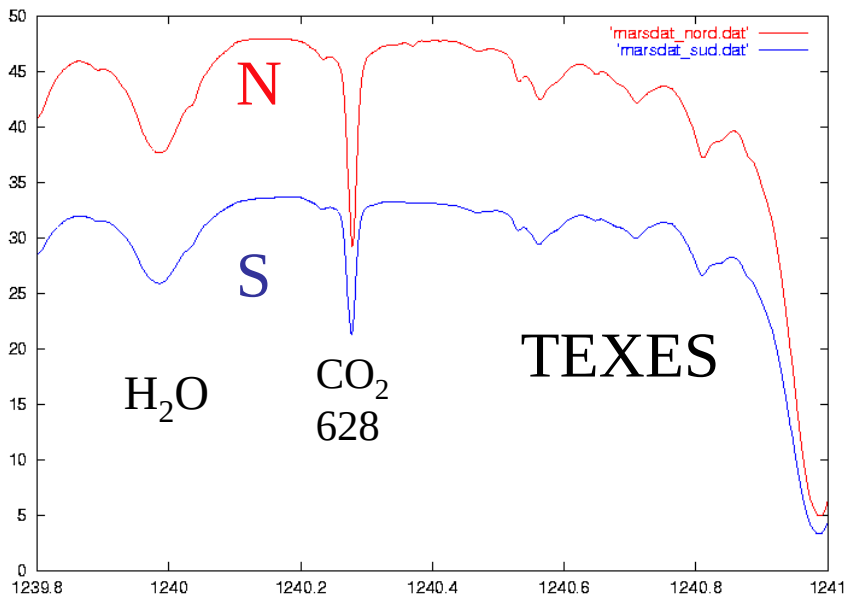
$Q(H_2O_2)_{max} = 4\ 10^{-8}$

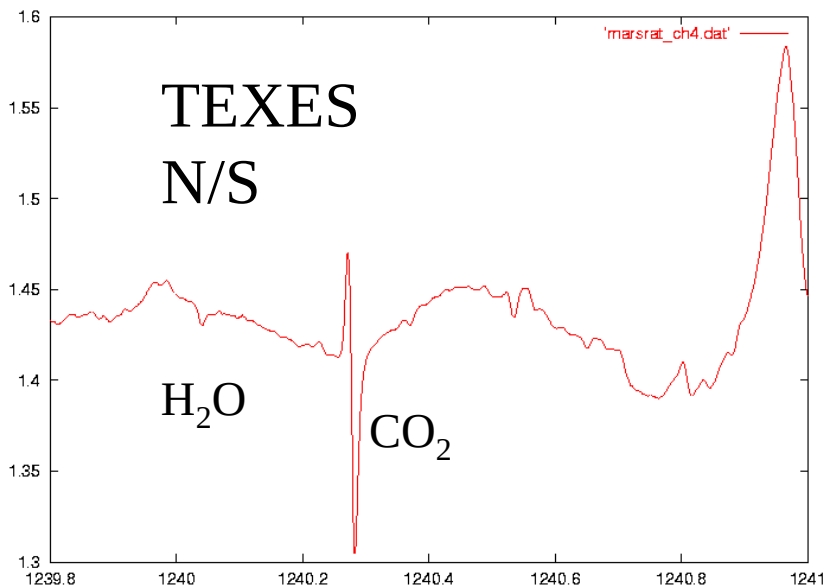
GCM

$Q(H_2O_2)_{max} = 4\ 10^{-8}$

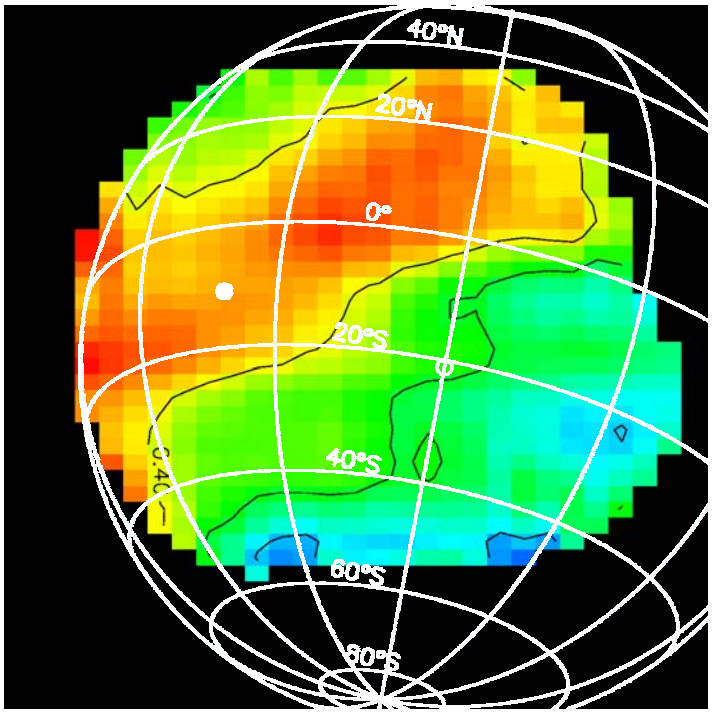
H_2O mapping

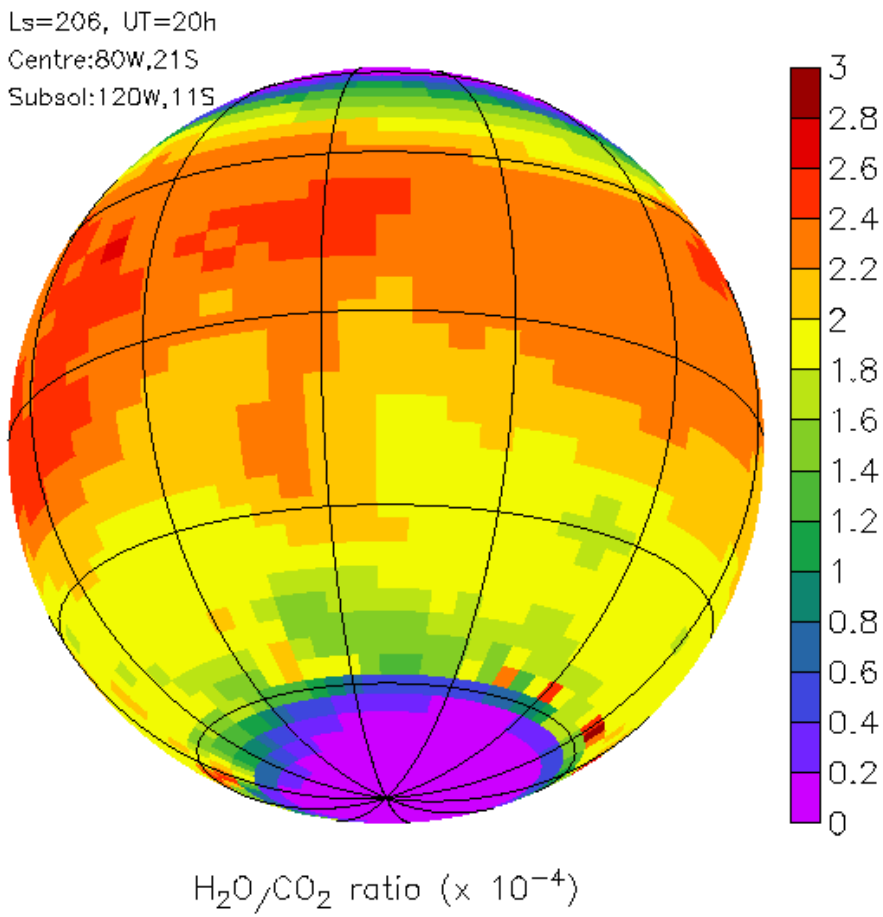
- 1 HDO line usable at 1240.0 cm-1, depth = 1.5%
- Remains in absorption in the N/S ratio -> martian line
- Comparison with CO_2 @ 1241.6 cm-1 -> H_2O mapping





H_2O on Mars - Ls = 206°





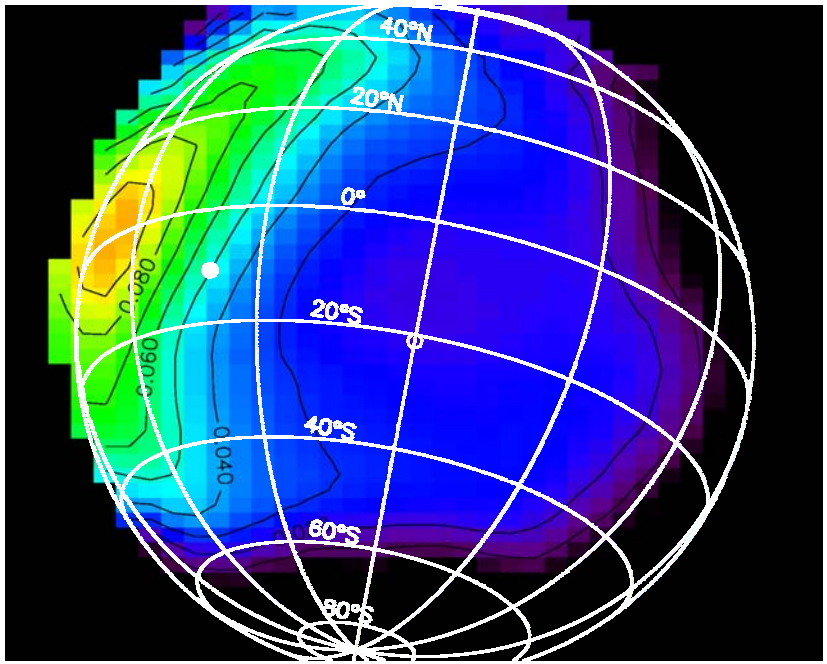
TEXES

$Q(H_2O)_{max}=6\ 10^{-4}$

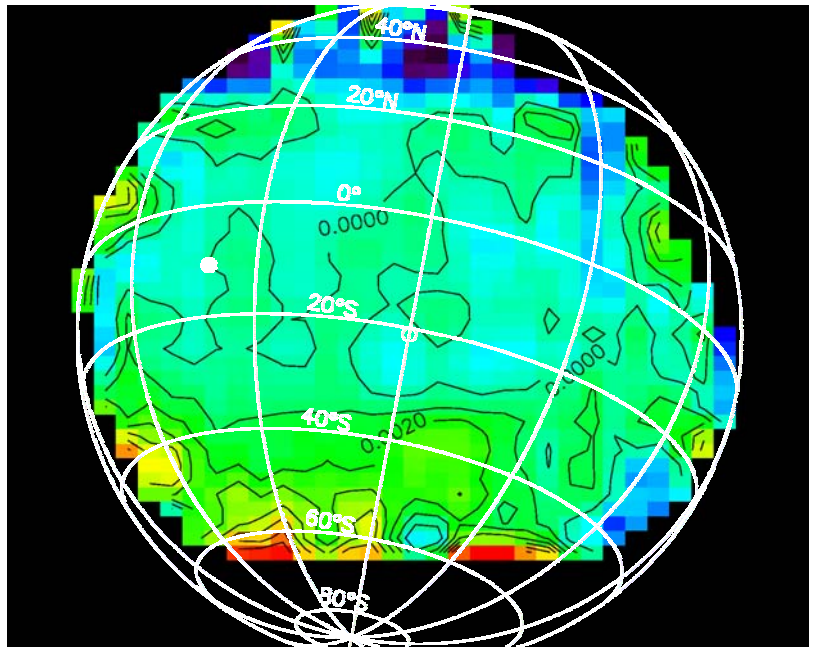
GCM

$Q(H_2O)_{max}=3\ 10^{-4}$

Search for methane variations with TEXES



CO_2



CH_4

Variations of CH_4 line depth are smaller than 0.1%

Summary of TEXES data

-First simultaneous H_2O, H_2O_2, Ts maps, in global agreement with GCM

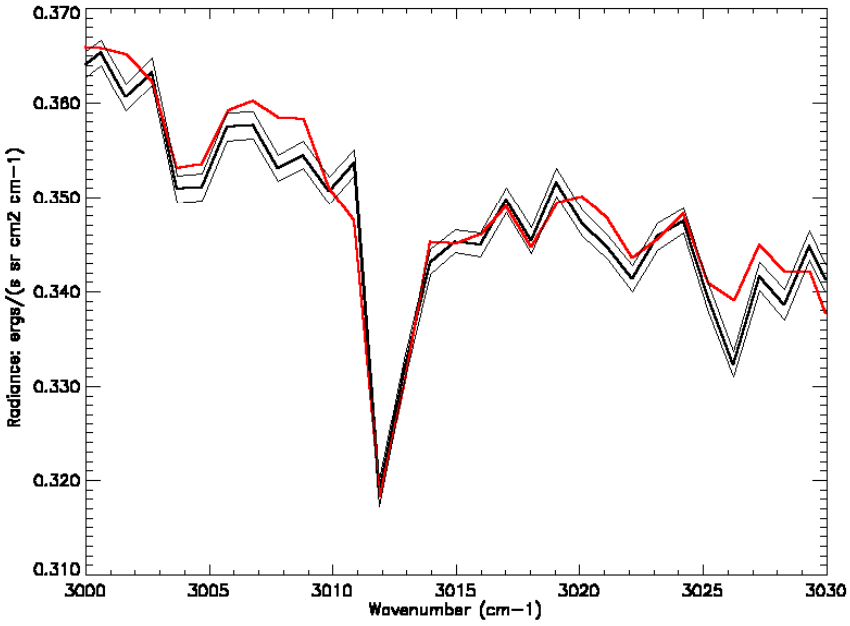
-CH_4 upper limit is consistent with previous measurements (the strong source seen by Mumma north of Hellas is not in the TEXES FOV)

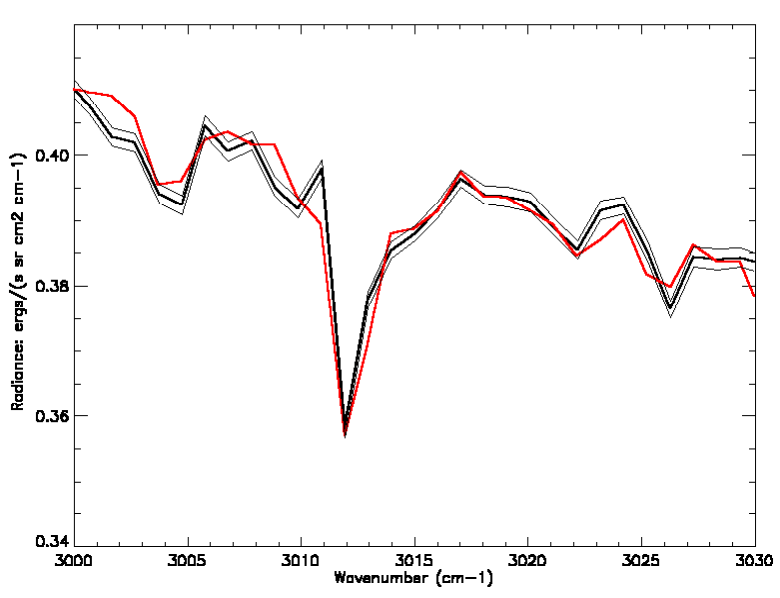
-Next steps: CH_4 mapping at slightly higher frequency (1260-1280 cm^{-1})

Search for CH_4 sources with PFS

- Ground-based measurements by Mumma et al. (DPS 2004): ν_3-R0 and R1 lines (3.3 μm) observed, 2 strong sources, lat = [-10,+10°]
  - long. = 304°W (Hellas), CH_4 up to 250 ppb
  - long. = 58-85°W (Valles Mar.), CH_4 up to 60 ppb
- PFS detection at 3.3 μm (ν_3-Q branch): CH_4: <10 ppb -> 30 ppb (Formisano et al. 2004)
- First detection by Krasnopolsky et al. (2004): GB measurement over the disk, CH_4 = 10 ppb.

Evidence for CH_4 variations over the surface of Mars (PFS)



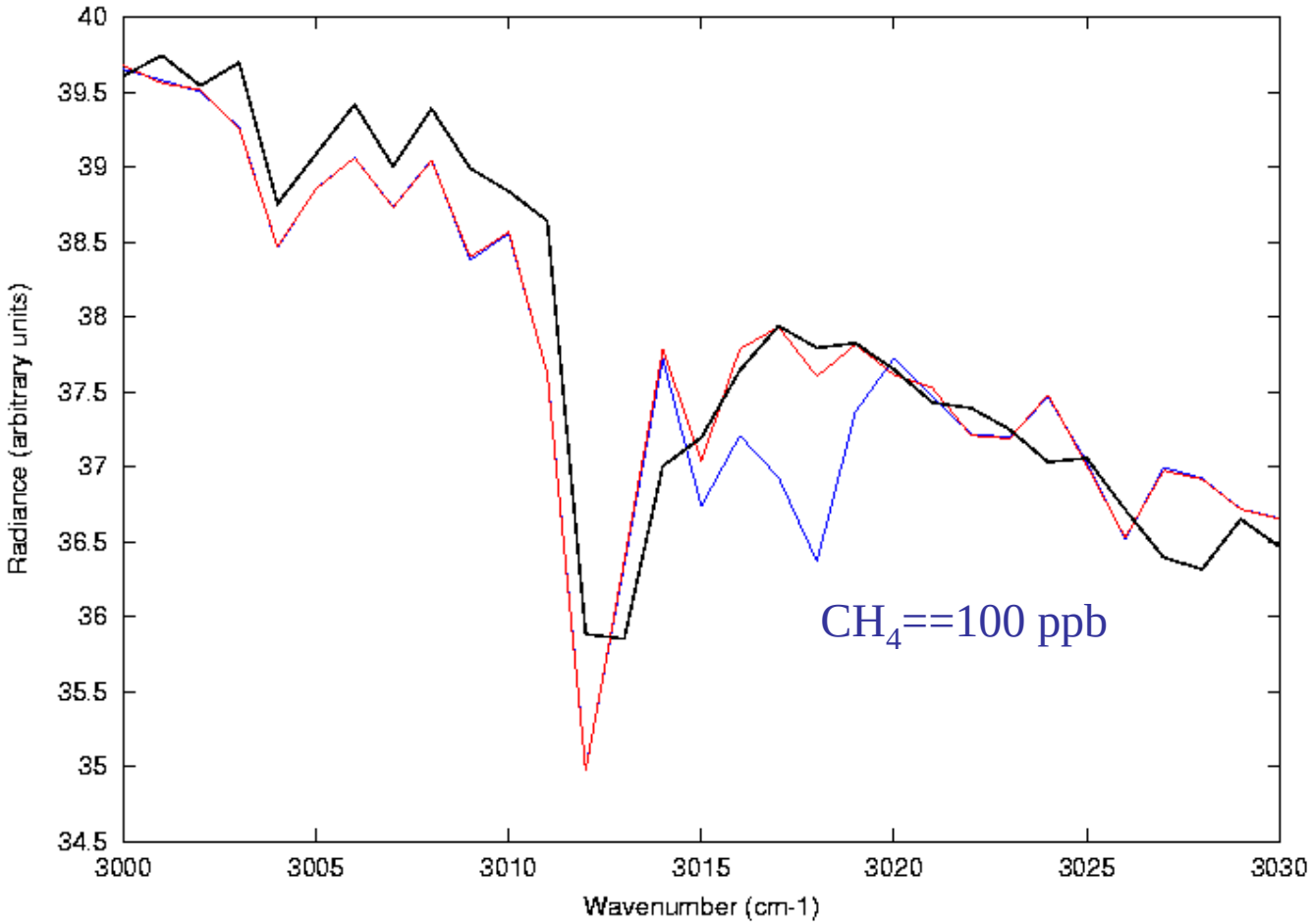


Orbit 145, long.=0°
CH_4 = 35 ppb

Orbit 72, long. =190°W
CH_4 = 0 ppb

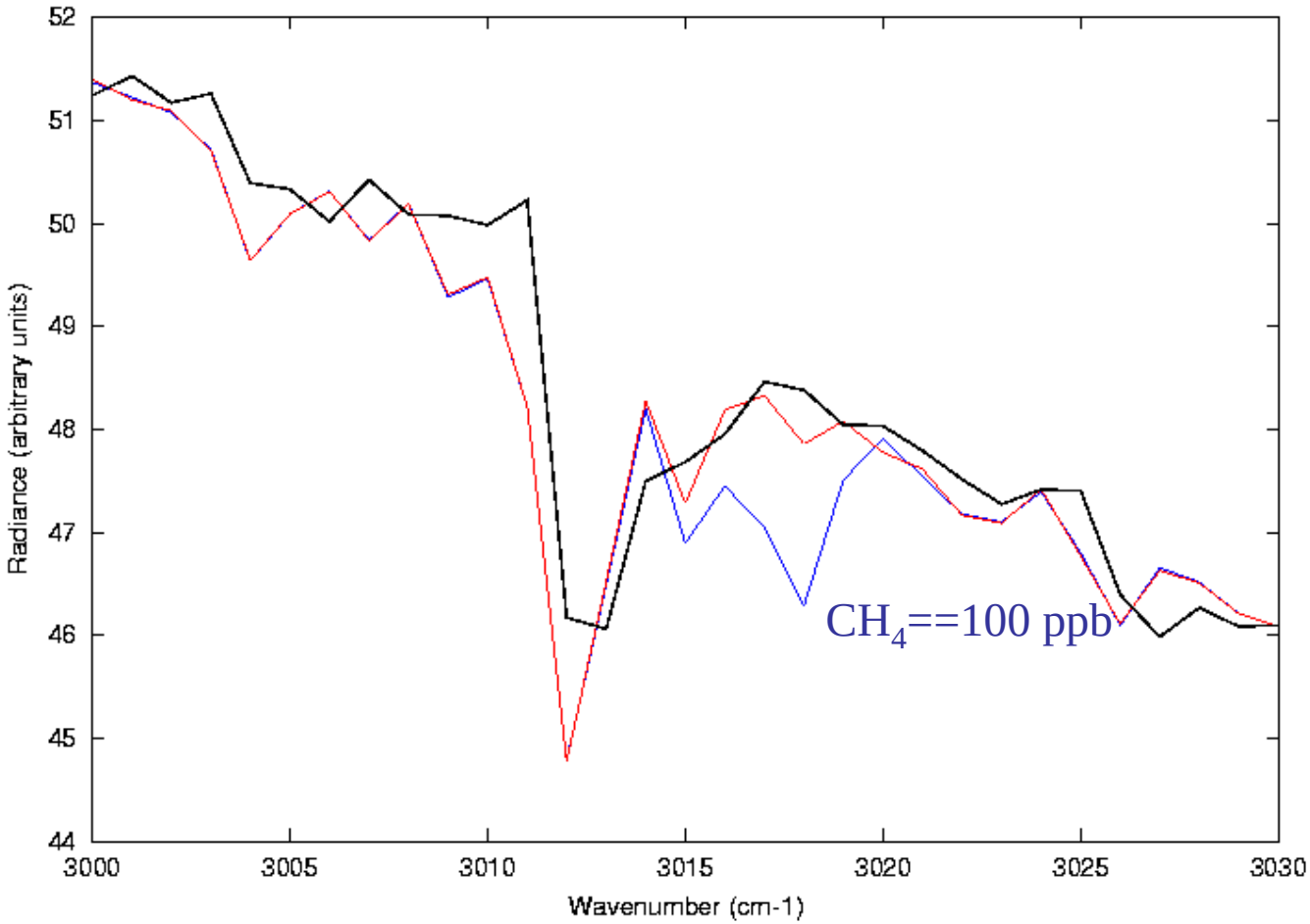
Formisano et al., 2004

Summation over Region 1 (North of Hellas)
lat. =[-10,+10°], long. = [284 - 305°W](11 orbits, 700 spectra)



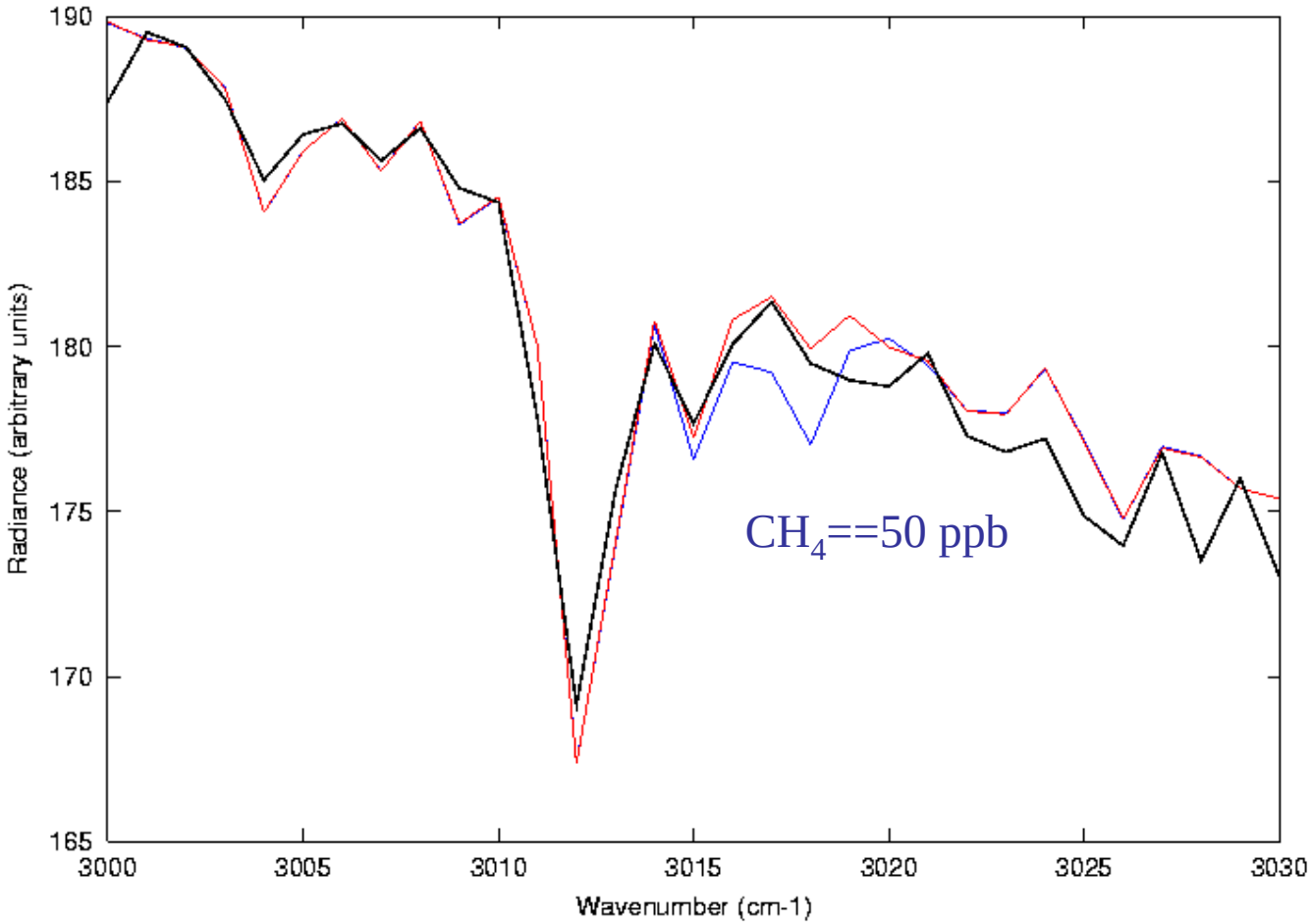
CH_4 < 30 ppb

Summation over Region 2 (Valles Marineris)
lat. =[-10,+10°], long. = [53-74°W](14 orbits, 850 spectra)



CH_4 < 30 ppb

Summation over full orbit (30), January 2004
lat. = 298-305°W, 240 spectra



CH_4 < 60 ppb

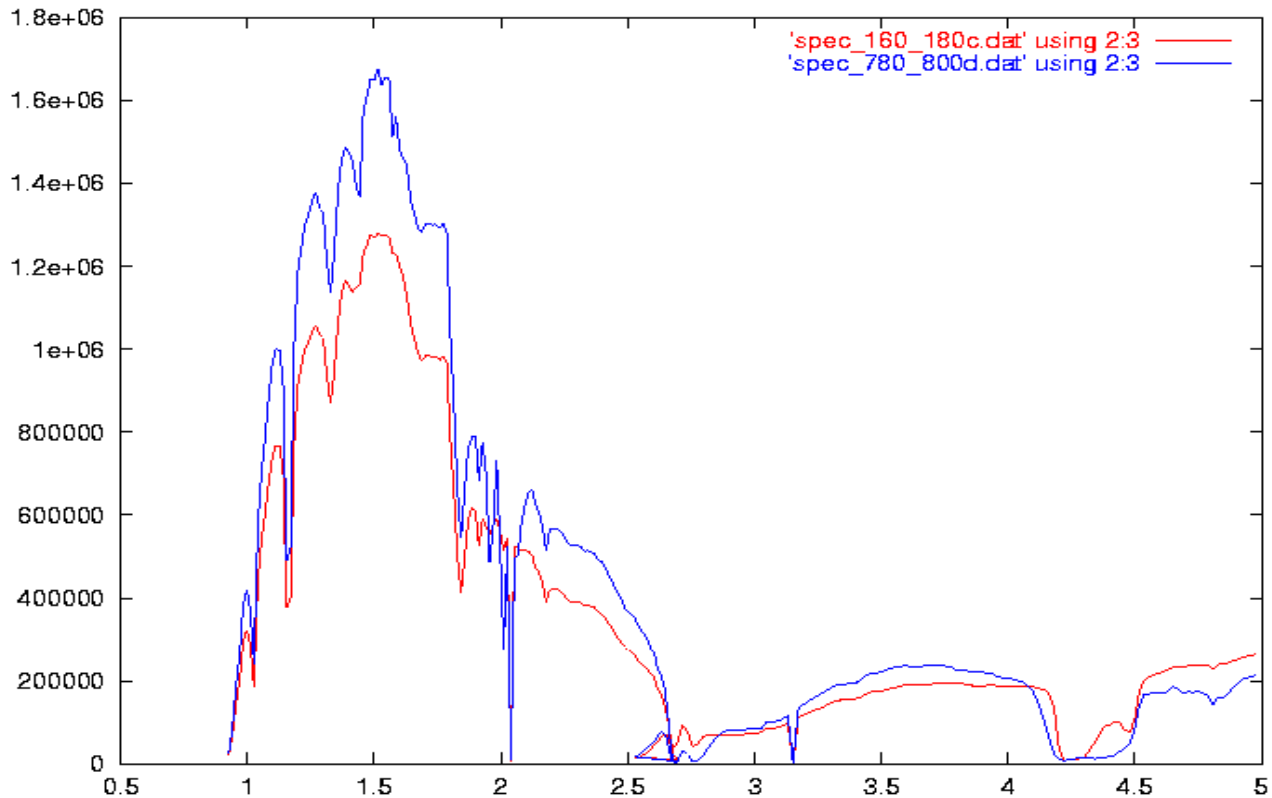
Search for CH_4 sources: conclusions

- No evidence for CH_4 enhancement at selected regions from PFS summations over 6-month period (January-August 2004)
- Possible seasonal variations?
- More integration needed to cover one seasonal cycle

Observations of CO and H_2O over Olympus Mons with OMEGA/MEx

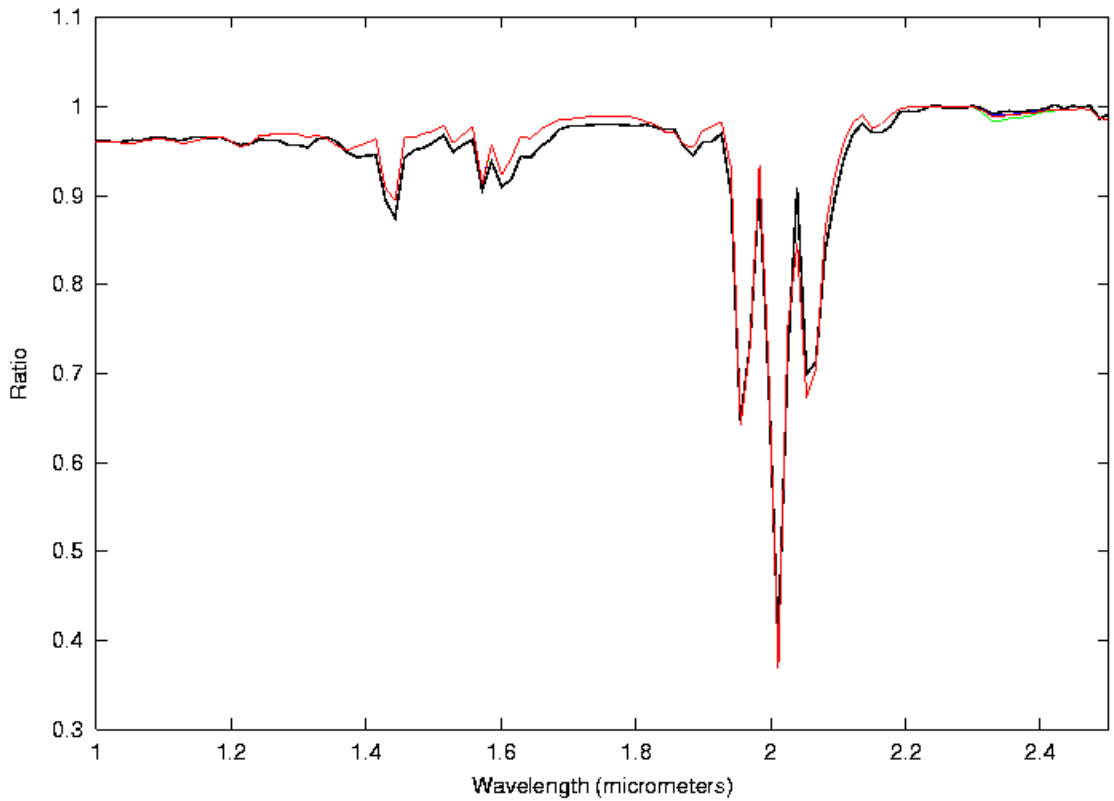
- OMEGA: Spectral range 0.3-5.2 μm, R = 100, S/N > 100 per spectrum, high spatial resolution (<1 km)
- CO signatures:
  - (1-0) band at 4.7 μm (mostly thermal if Ts > 260 K)
  - (2-0) band at 2.35 μm (reflected); observed with ISM/Phobos
- H_2O signature: 2.6 μm, in the wing of a strong CO_2 band
- CO signatures are too weak to be detected on individual spectra -> summation over latitude and longitude (21 x 32 = 672 spectra)

Omega spectra:
foot and summit of Olympus Mons



Ratio Olympus Foot/Olympus summit
Synthetic vs Observed

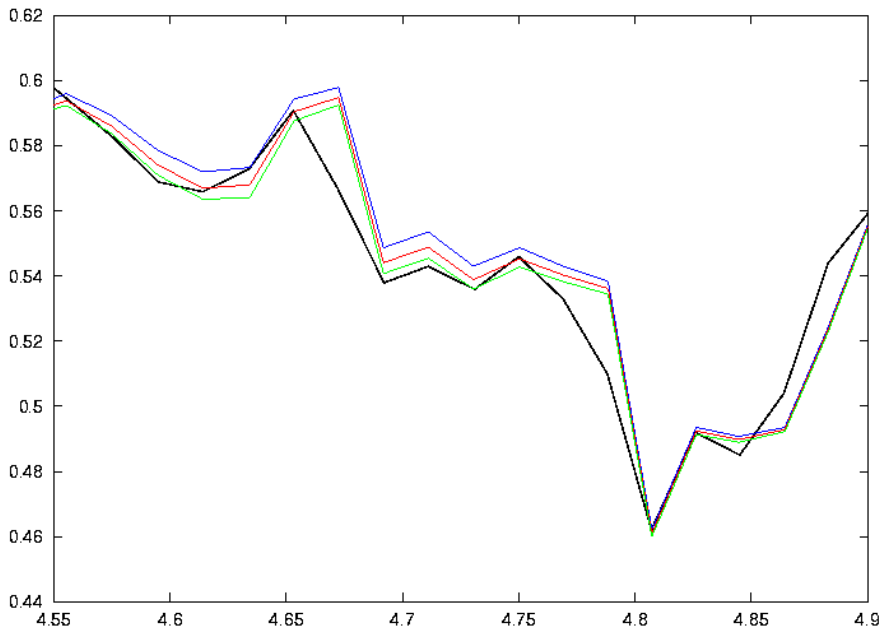
Determination of atmospheric parameters
Olympus Summit: Ps = 1.4 mb; Foot: Ps = 7.5 mb



Comparison of ratios (foot/summit): CO(1-0) band, Omega spectra vs synthetic

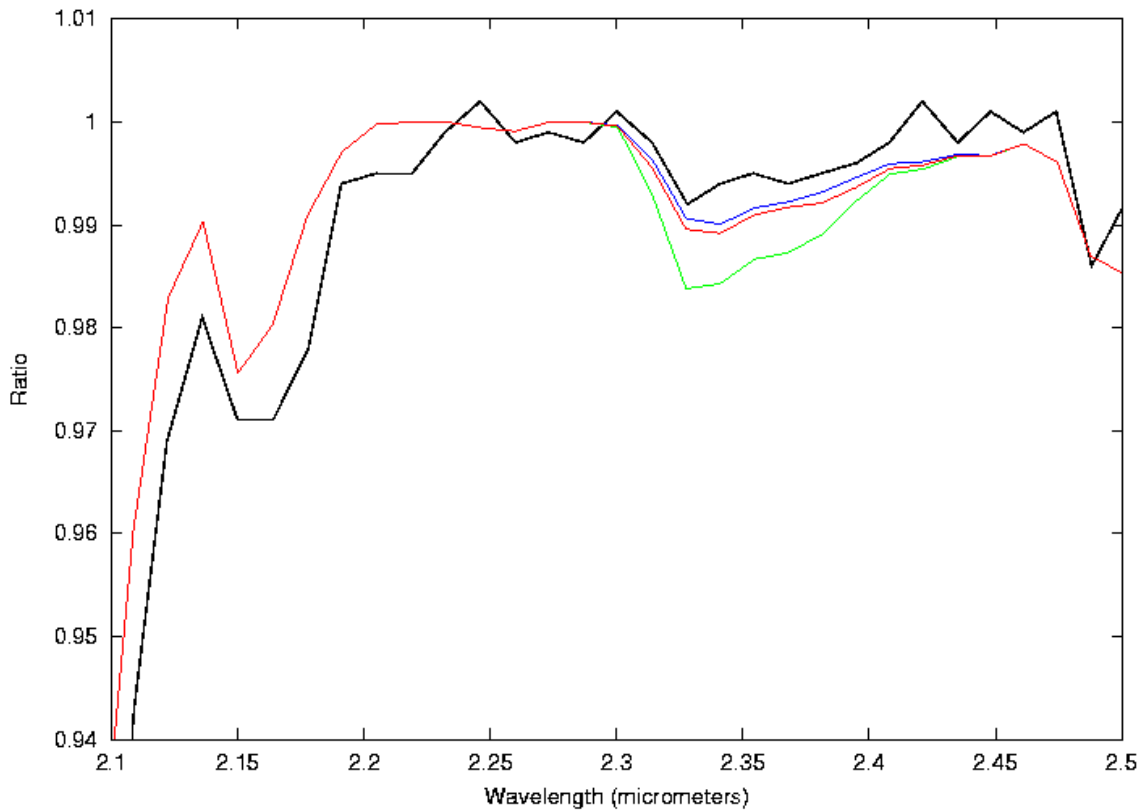
CO_{foot} = 8 10^{-4}, CO_{summit} = 8 10^{-4}, 4 10^{-4}, 2 10^{-4}

- Discrepancies at 4.67 and 4.79 μm
- -> Mineralogic features?

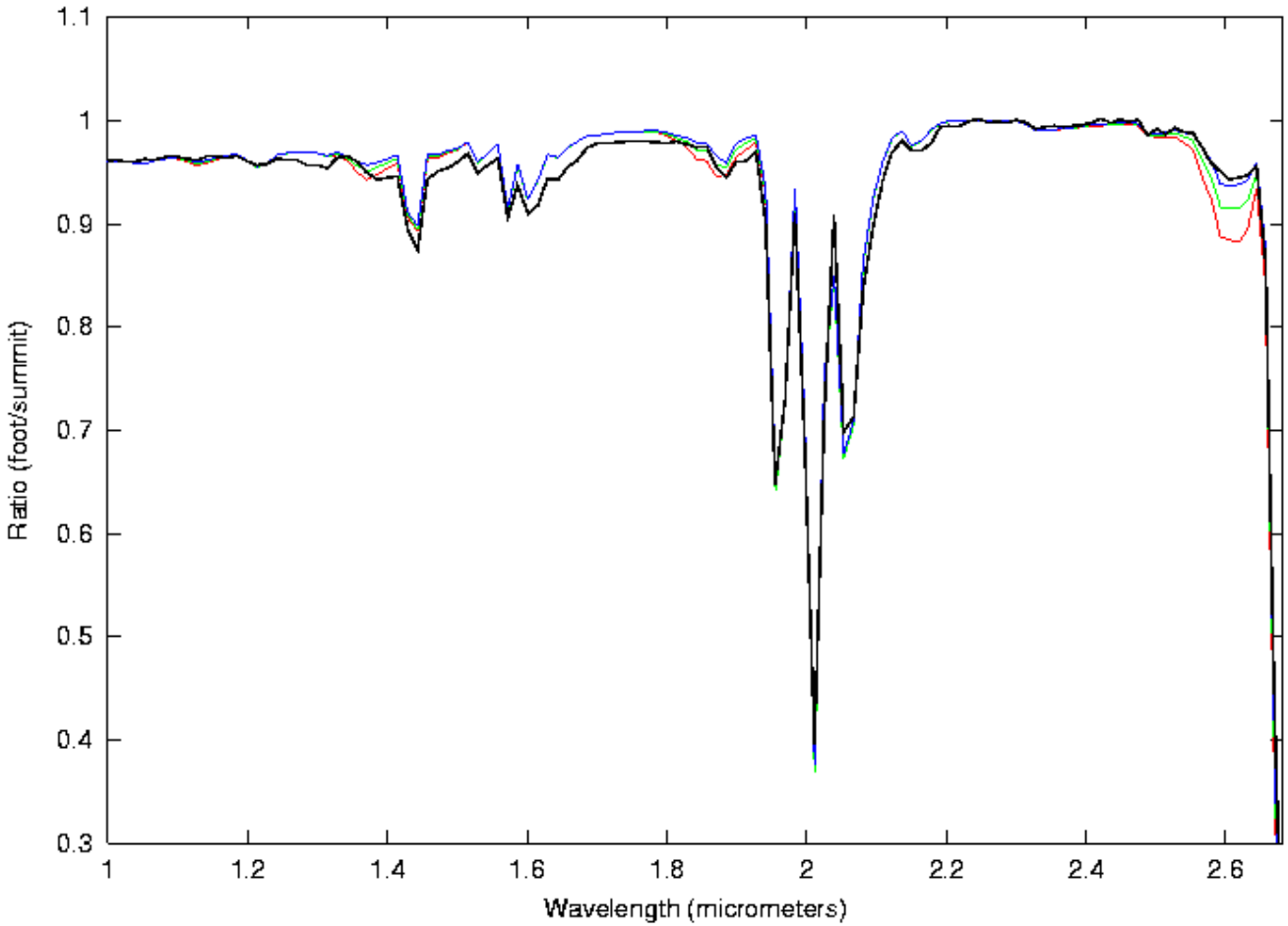


Comparison of ratios (foot/summit): CO(2-0) band, Omega spectra vs synthetic

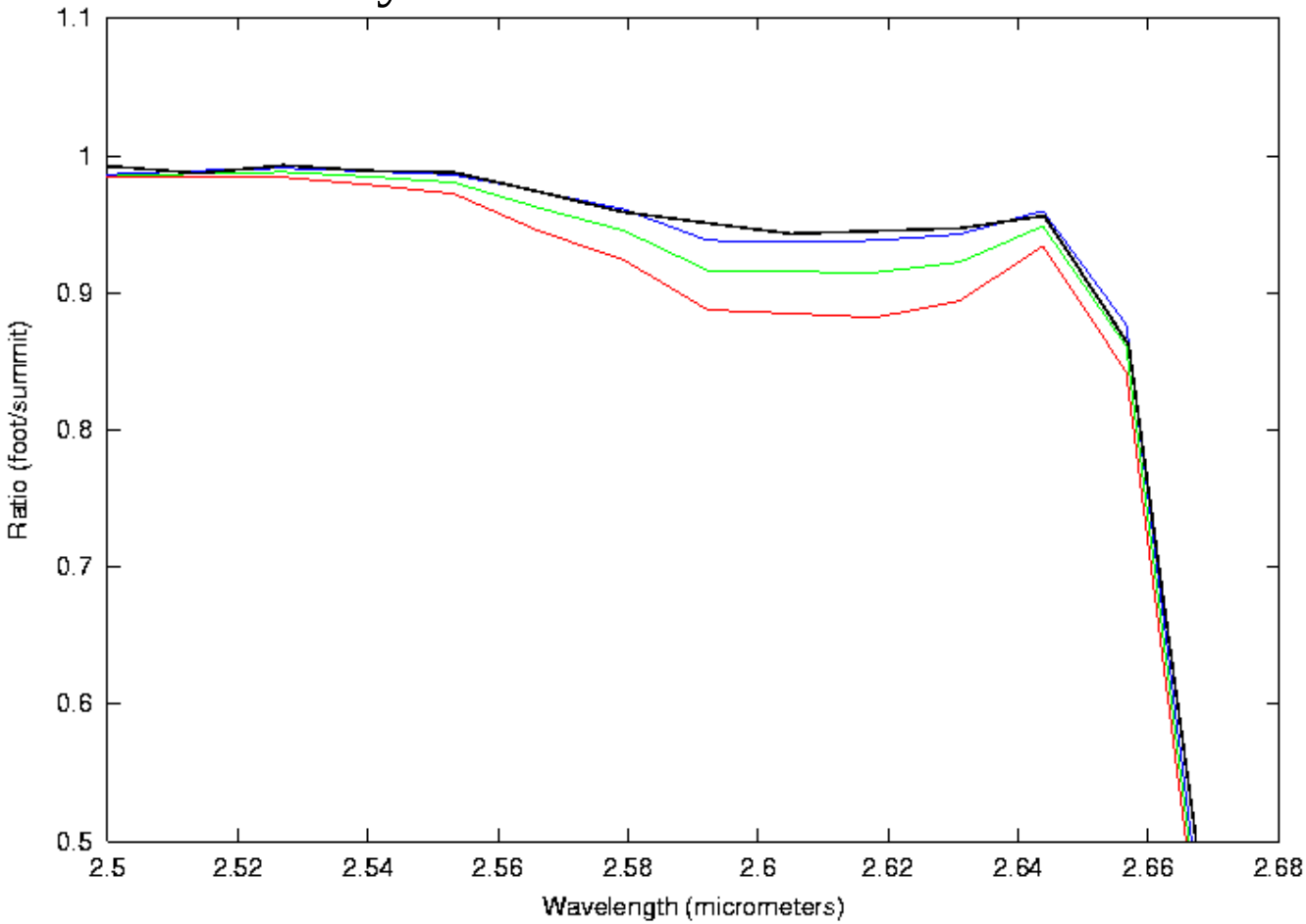
CO_{foot} = 8 10^{-4}, CO_{summit} = 8 10^{-4}, 4 10^{-4}, 0



H_2O signatures in the OMEGA spectra



Comparison of OMEGA data with uniformly-mixed synthetic models



H_2O = 1.5 10^{-4}; H_2O = 6 10^{-4}; H_2O = 3 10^{-4}

Summary of OMEGA data

- OMEGA data, after summation, allow the detection of the 2 CO bands, but mineralogic features are present in both cases. The H_2O band at 2.6 μm is clearly detected.
- OMEGA data are consistent with a uniform CO mixing ratio of $8\ 10^{-4}$, but are not sensitive enough to detect a depletion by a factor 2. A depletion by a factor 4, as suggested by ISM/Phobos, seems to be excluded.
- OMEGA data are consistent with an H_2O mixing ratio of $1.5\ 10^{-4}$ (about 8 pr-μm) in agreement with Viking and TES data for Ls = 337°.