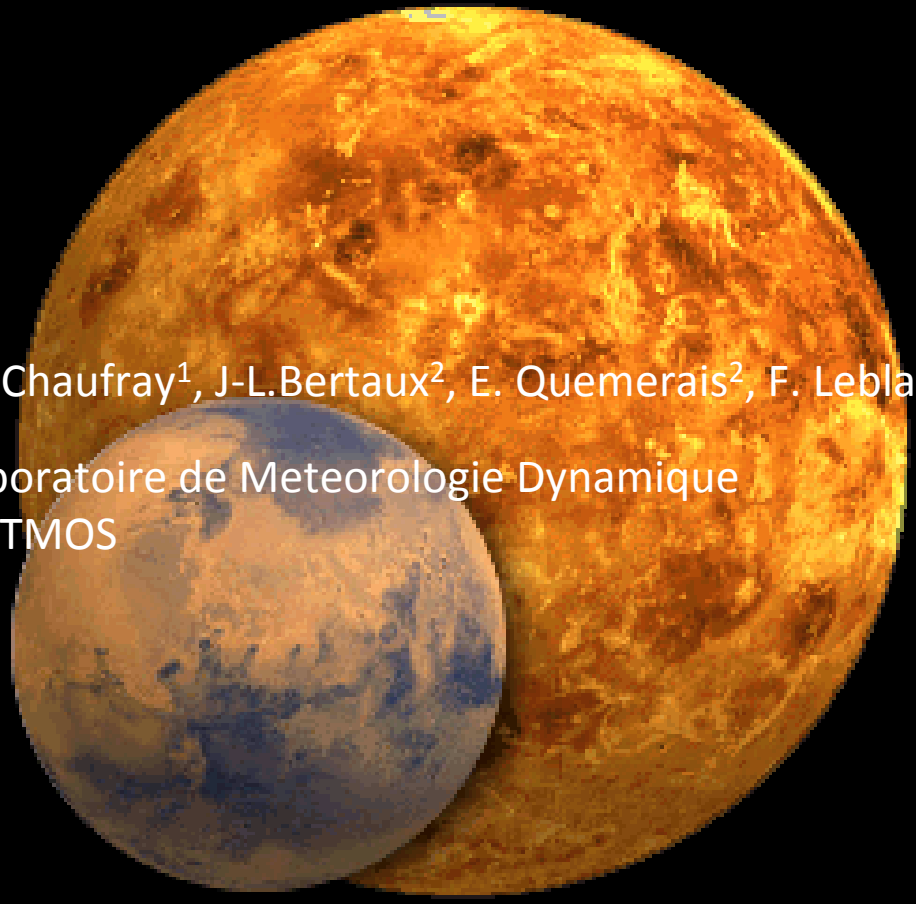
Recent Observations of the Martian and Venusian exospheres



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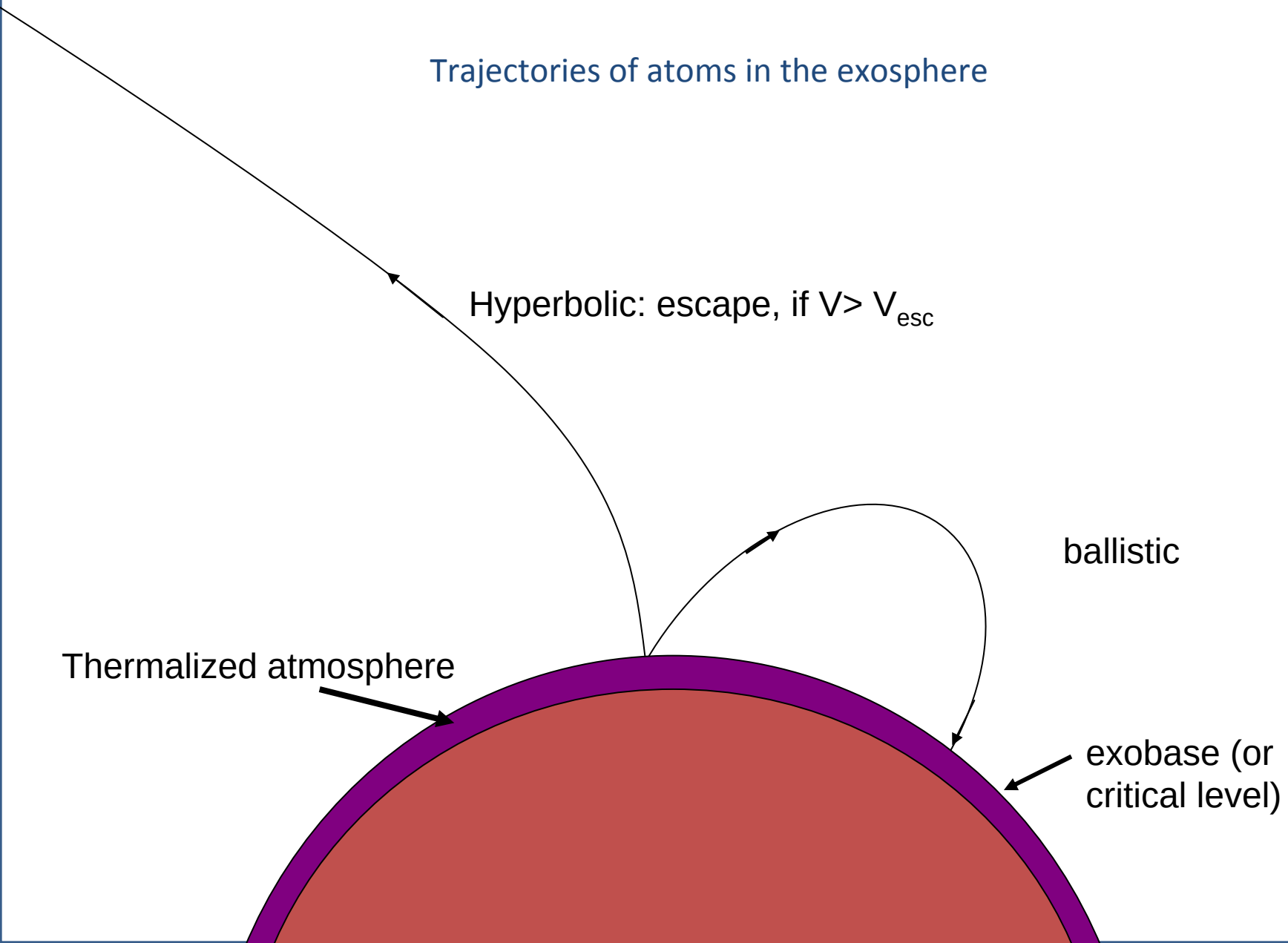
ISSI Meeting ; Bern, December 2009

The exosphere (collisionless)

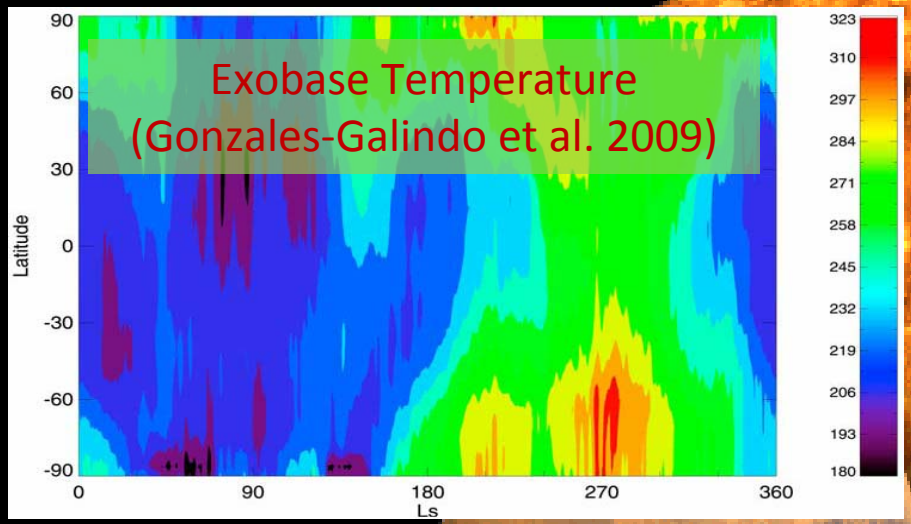
Trajectories of atoms in the exosphere

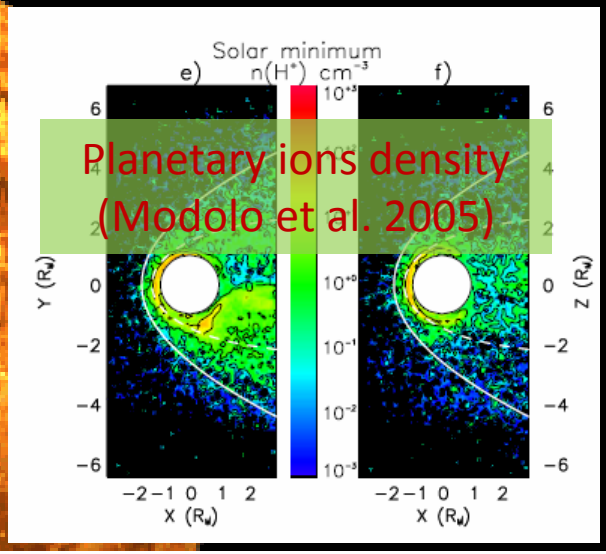


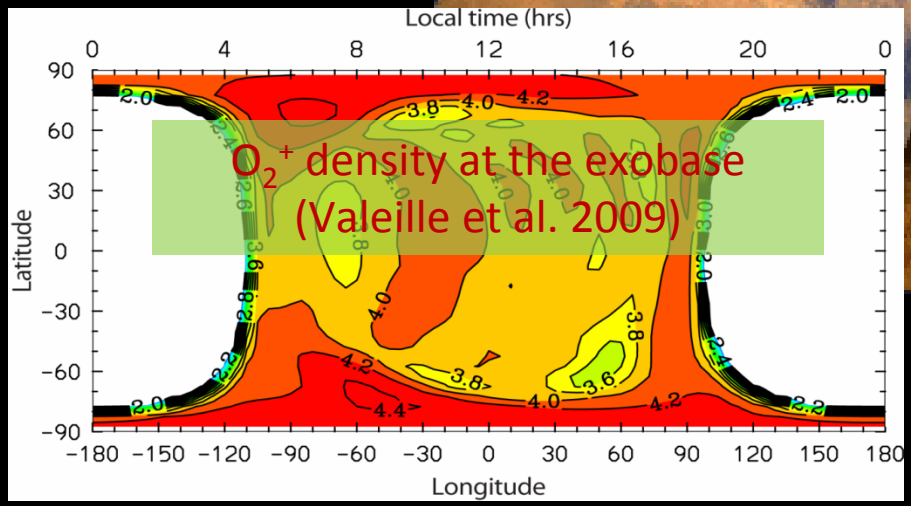
Mars/Venus Exosphere Motivation

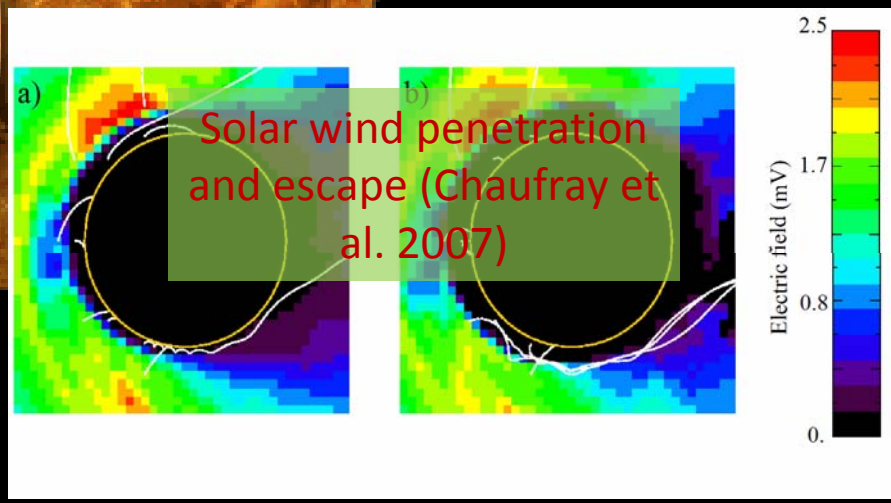
Formation from processes in the thermosphere

Interaction with solar wind



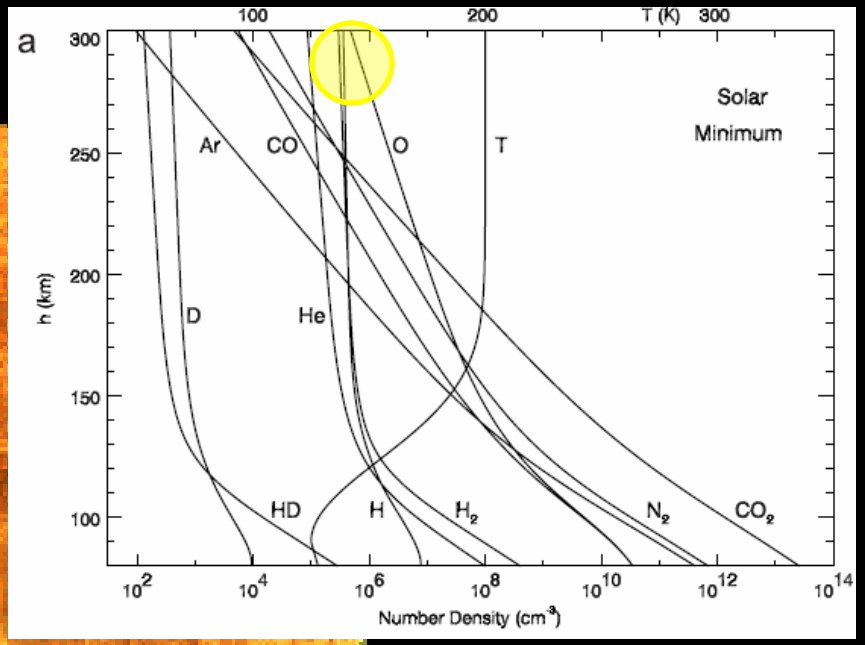






Mars/Venus Exosphere Composition

Martian upper atmosphere composition (Krasnopolsky 2002)



Martian Exosphere

- **H** (Mariner 6-7-9 ; MeX ; Rosetta ; HST)

(Anderson 1971 ; Galli et al. 2007 ; Chaufray et al. 2008)

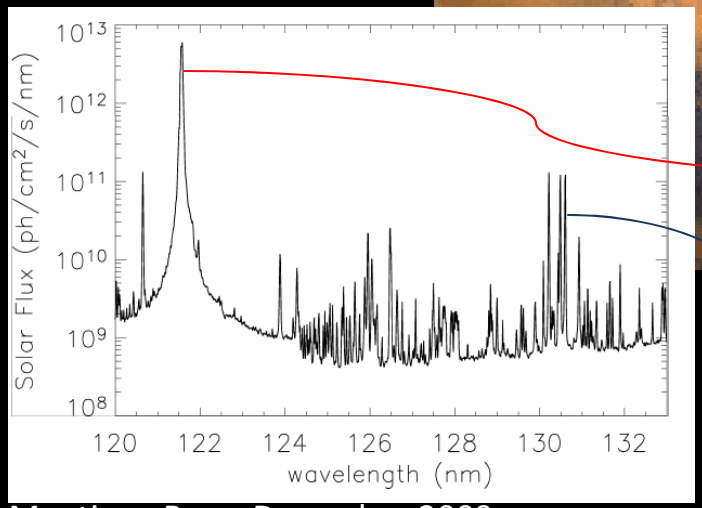
- **O** (Mariner 6-7-9 ; MeX)

(Strickland et al. 1972 ; Stewart et al. 1992 ; Chaufray et al. 2009)

- **H_2** (FUSE)

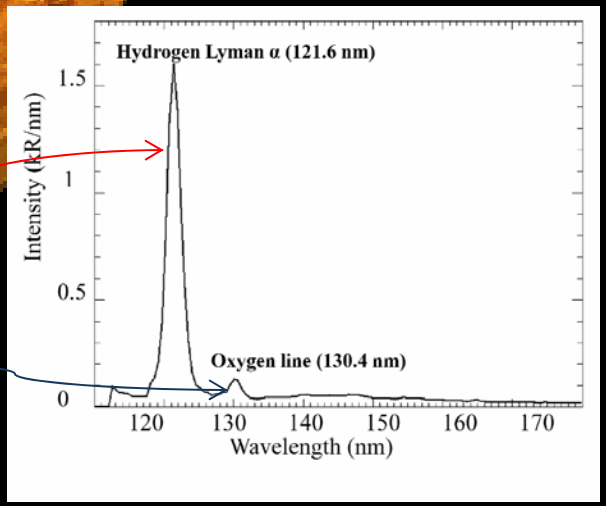
Krasnopolsky and Feldman (2001)

- Other detected species (D, He)

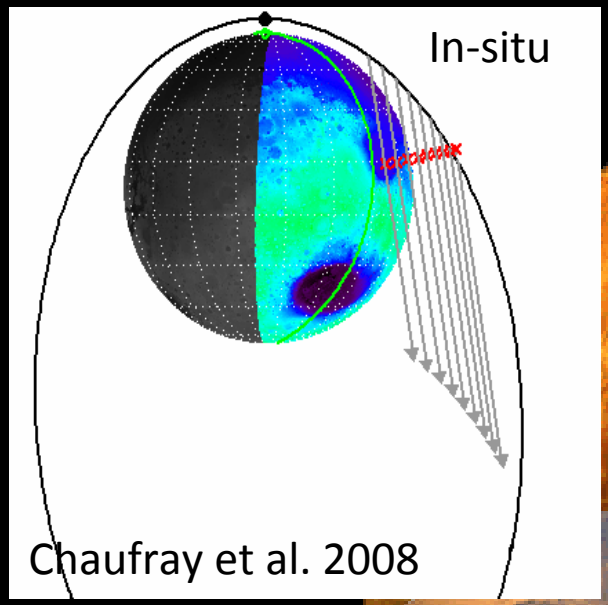


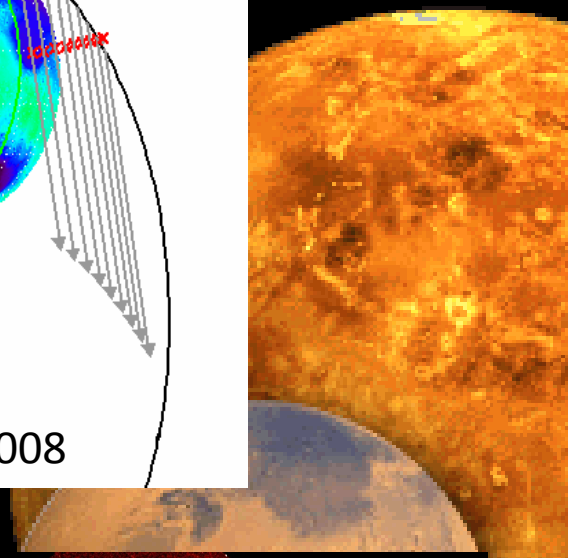
H

O

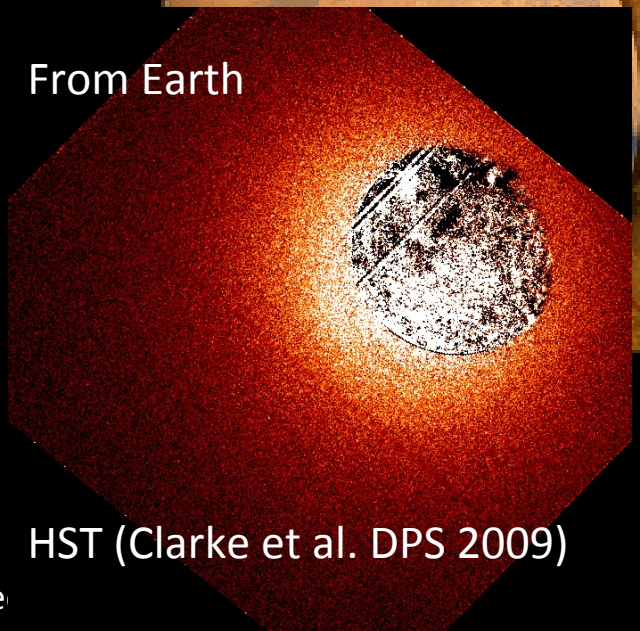


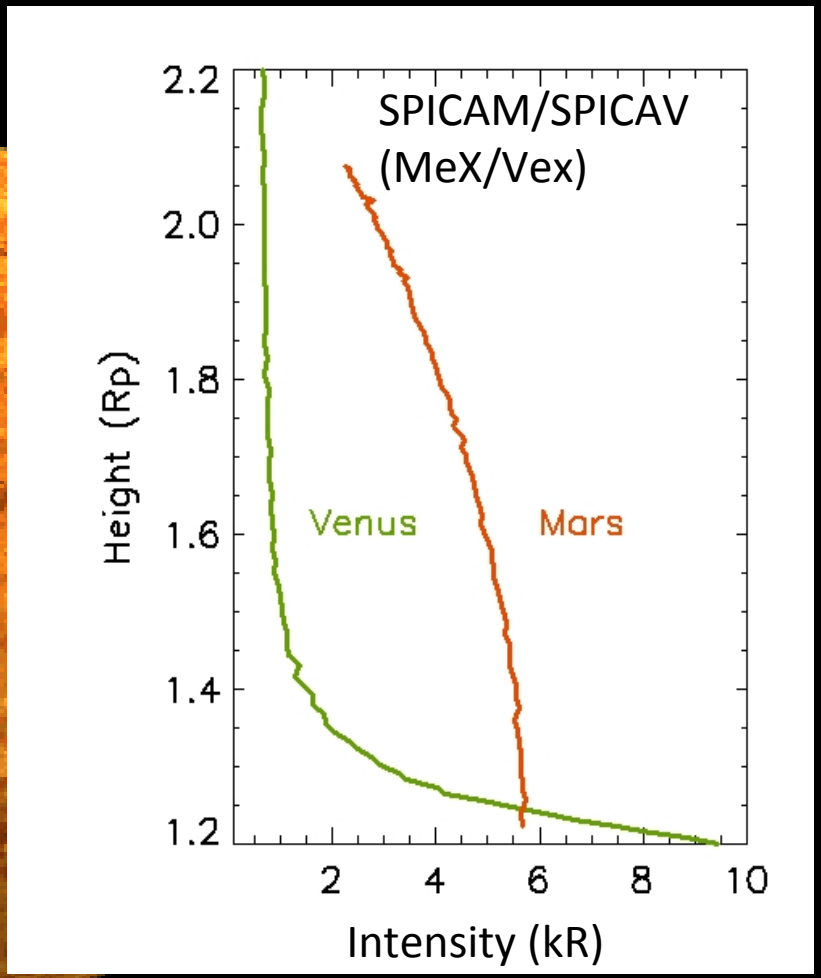
Mars/Venus Exosphere Observations





From Earth





Method 1/2

Forward Comparison between data and models

Cold population (Nc ; Tc)

Theoretical hydrogen profiles

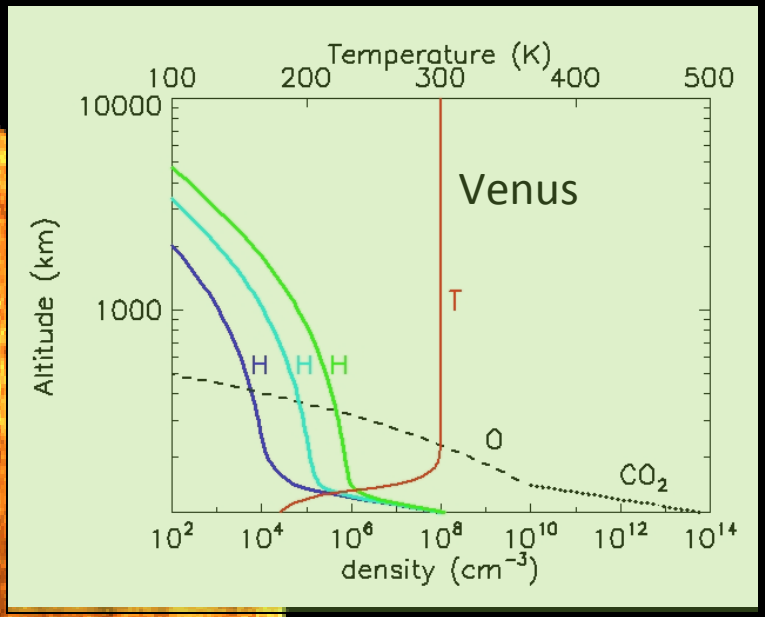
Diffusion equation below the exobase

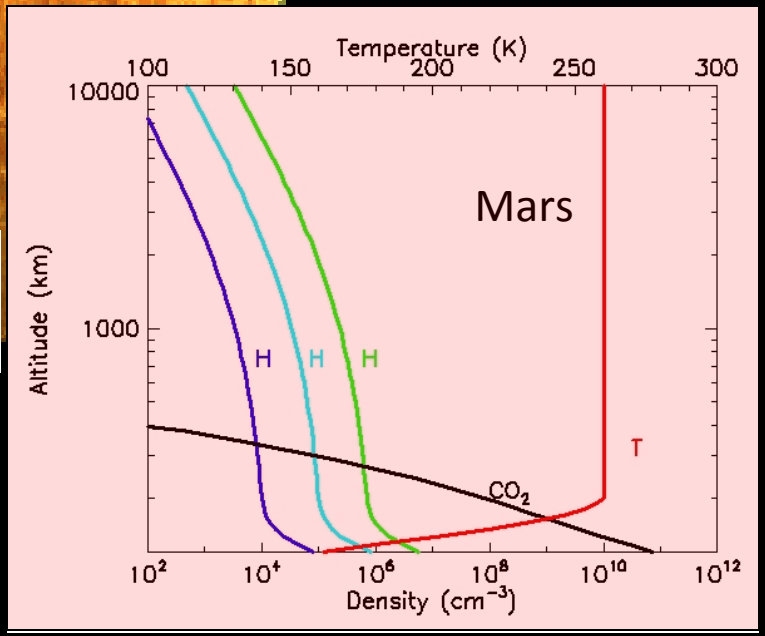
Chamberlain's model above the exobase

Optically thick emission (Multiple scattering)

➔Radiative Transfer Model

$$I_{\lambda,j}(\mathbf{r},\Omega) = \frac{1}{4\pi}\int_0^{\infty} \varepsilon_{\lambda,j}(\mathbf{r}+s\Omega)\exp\left[-\tau_{\lambda,j}(\mathbf{r},\mathbf{r}+s\Omega)\right]ds$$





Method 2/2

Hot population (Delva et al. 2009)

Venus Hot population (Nh ; Th)

Exospheric profile

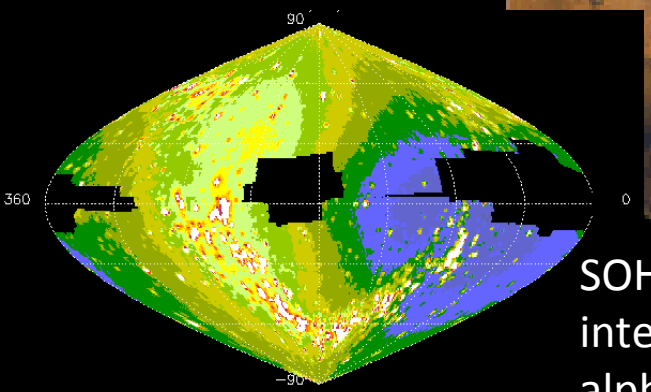
Optically thin assumption

Interplanetary Background

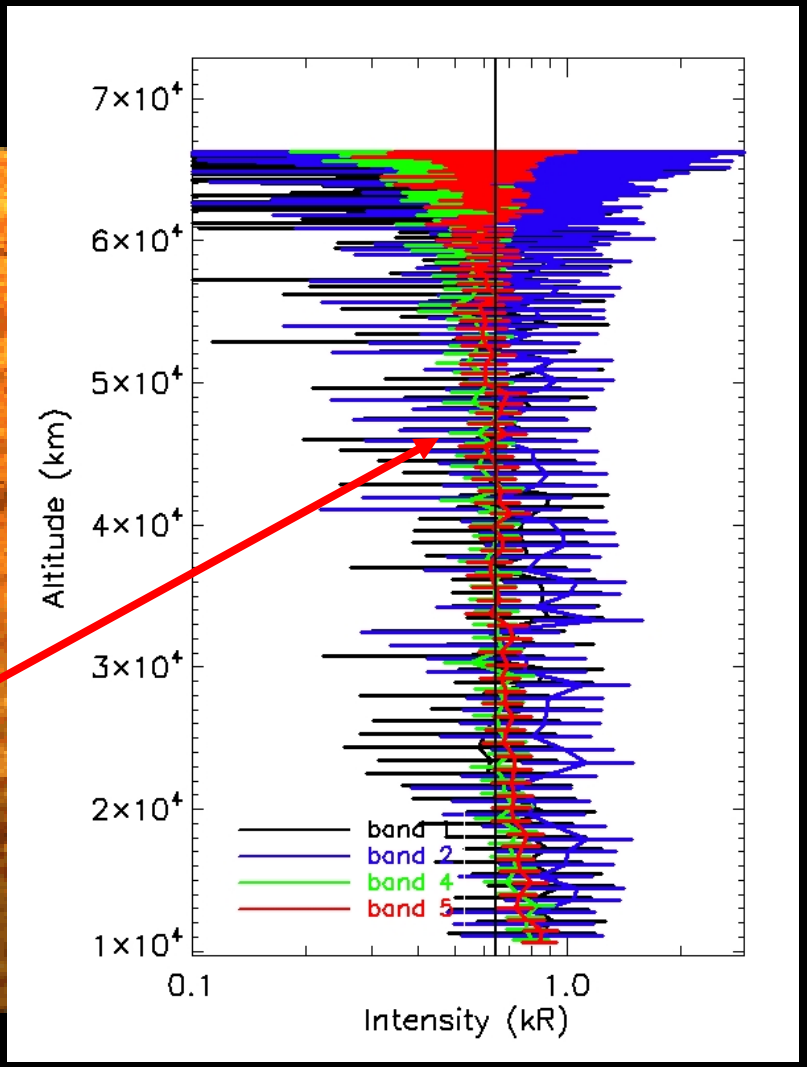
Estimate from SWAN/SOHO maps

Venusian corona extended until 30,000 km

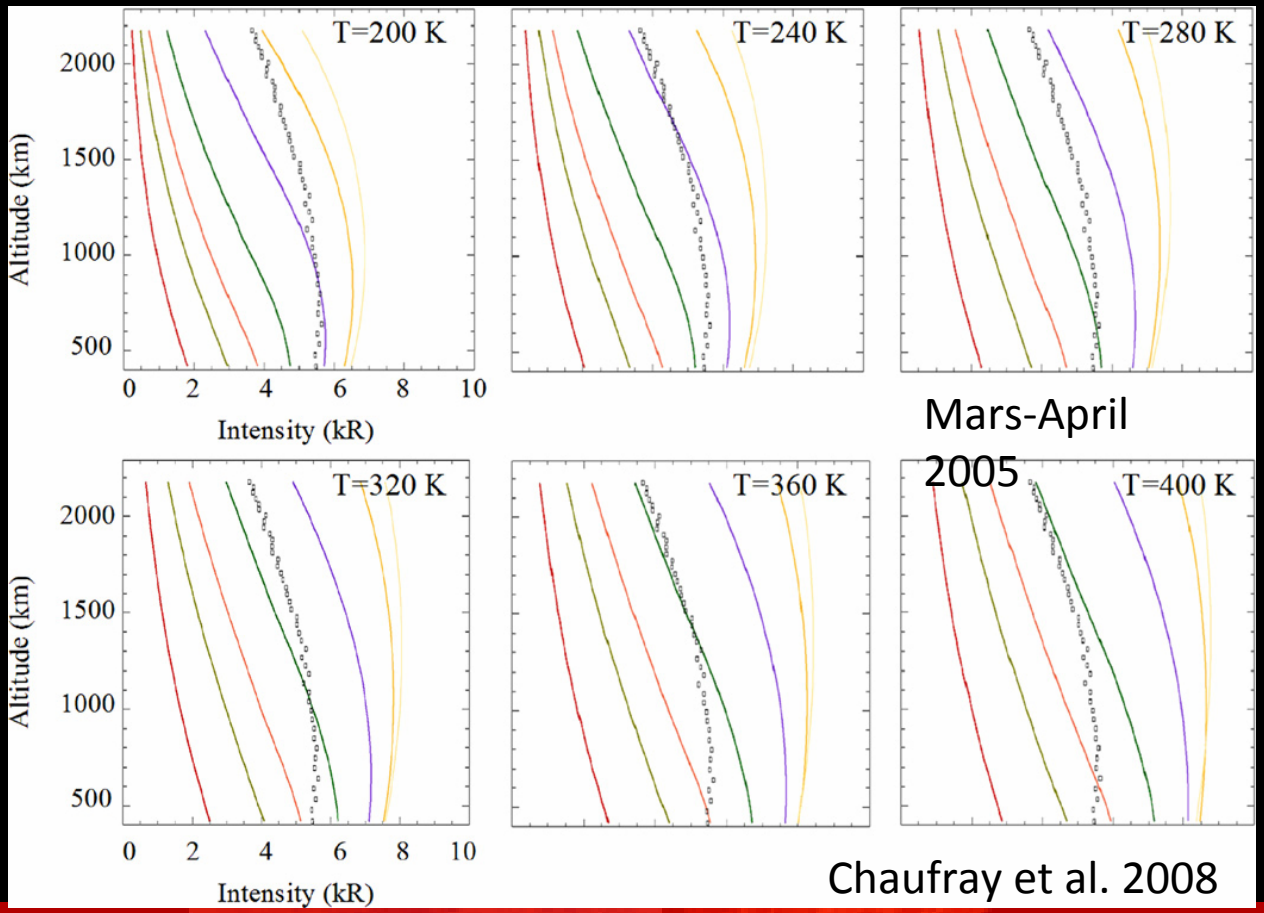
Results very sensitive to IPB



SOHO SWAN map of interplanetary Lyman-alpha skyglow



Mars



Mars-April 2005

Chaufray et al. 2008

<u>1 population models</u>

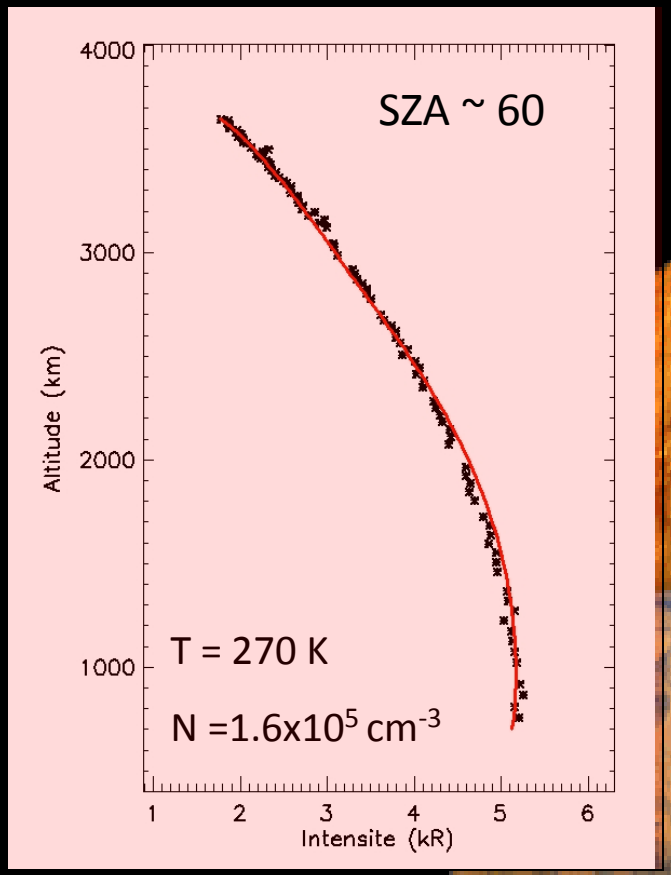
T ~ 200 – 250 K, but not well reproduced at SZA ~ 30° nexo ~ 1-4 x10^5 cm^{-3}

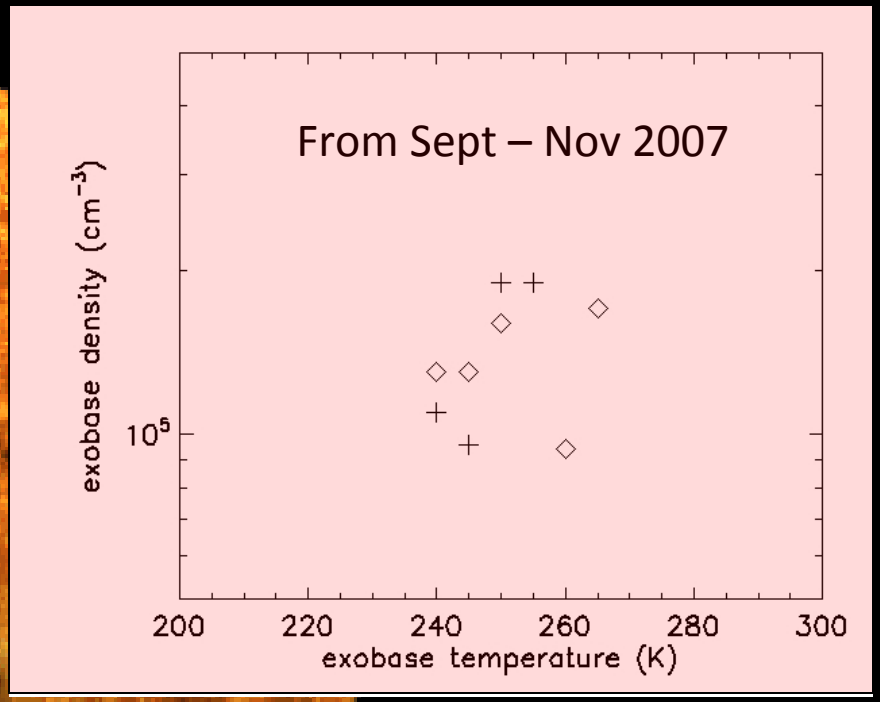
Atmospheric water content escape in ~ 13,000 years (without sources from caps)

<u>2 populations models</u>

hot population ~ 10-20% but origin not understood (need to improve models)

Mars





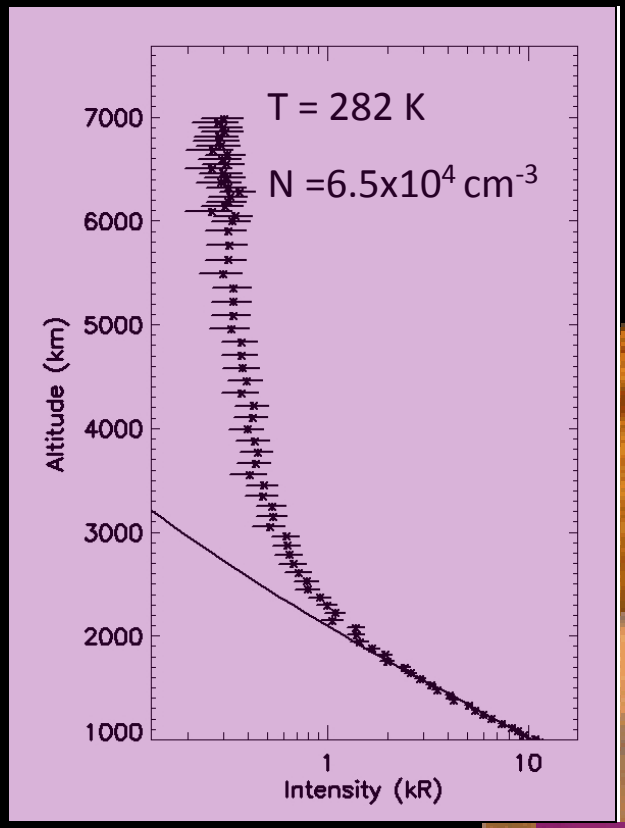
Mars :

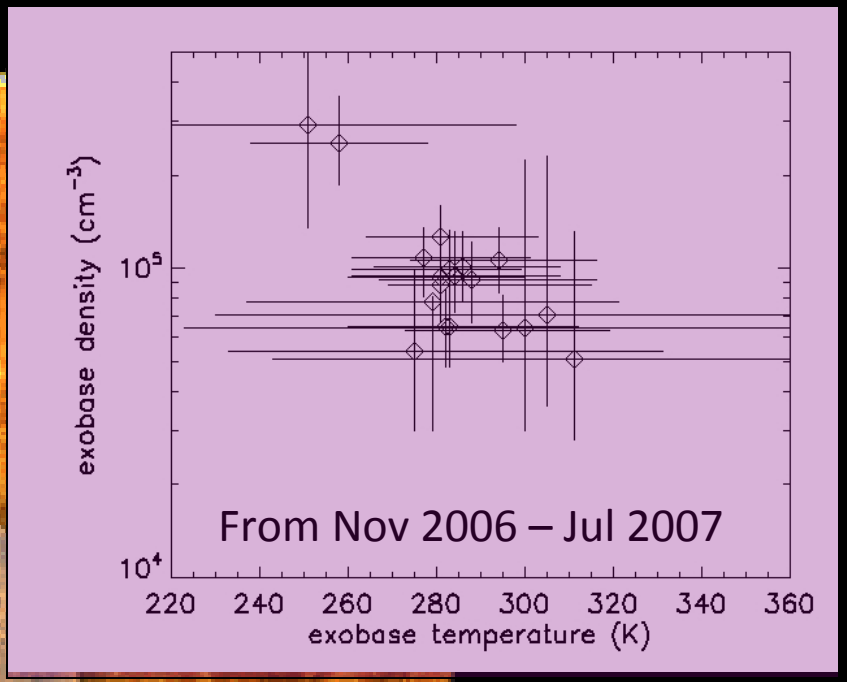
T_{exo} ~ 240 – 280 K (need to use models with two populations Chaufray et al. 2008)

N_{exo} ~ 1 -2 x10^5 cm^{-3}

Results very dependent of the absolute calibration (comparisons with HST ; SOHO)

Venus : Cold population





Chaufray et al. 2010
(paper in preparation)

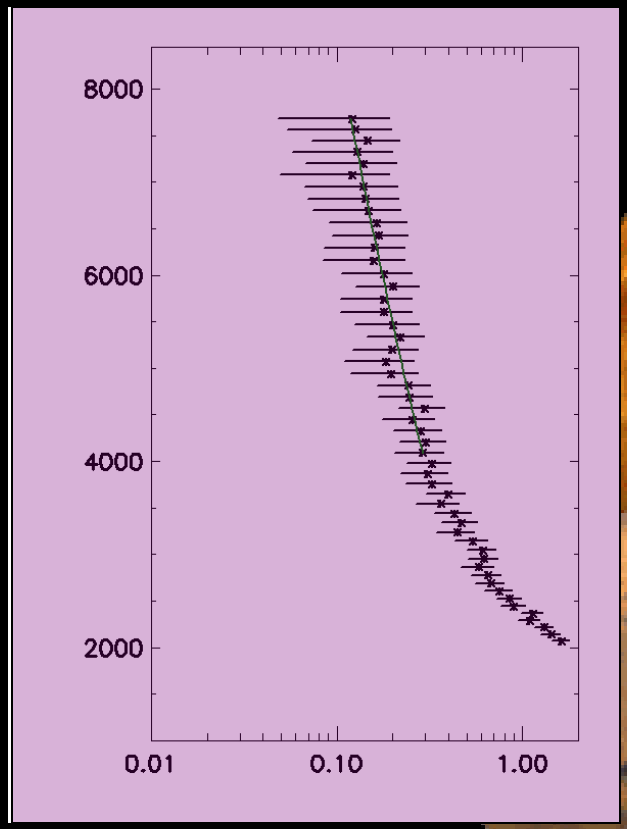
Venus :

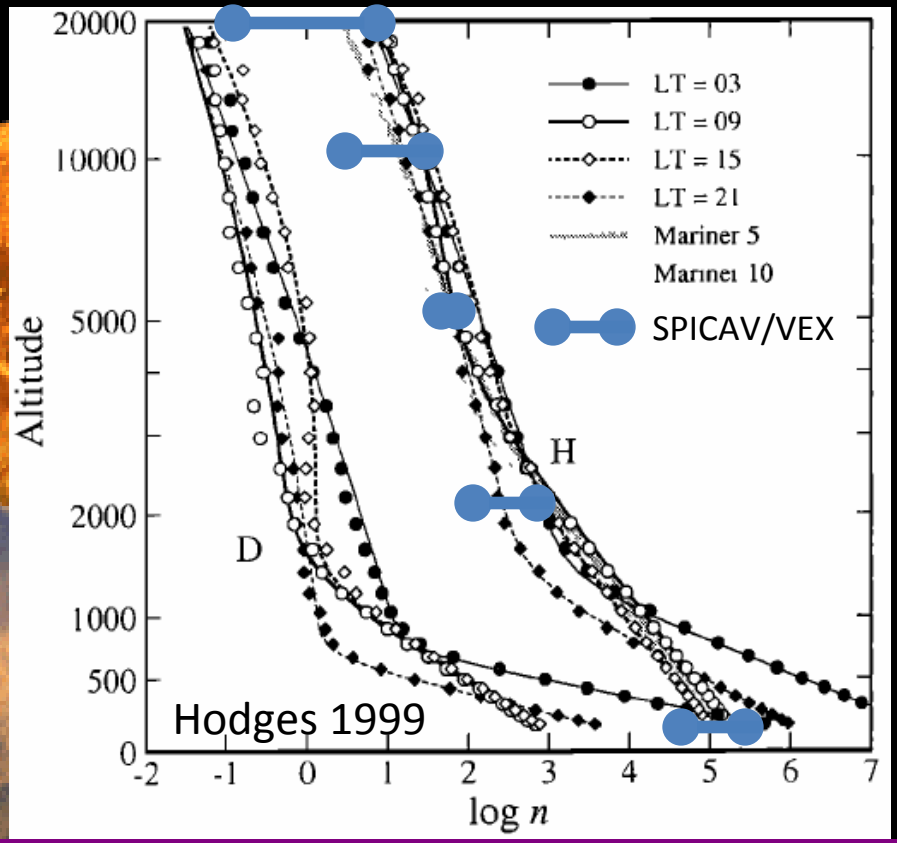
T_{exo} ~ 250 – 320 K

N_{exo} ~ 0.5 -3 x10^5 cm^{-3}

Uncertainty due to absolute calibration T ~ 20 K ; n ~ factor 2

Venus : Hot population





Data from Nov 2006 – Jun 2007 (~ 20 profiles)

Temperature difficult to constrain ; very sensitive to IPB

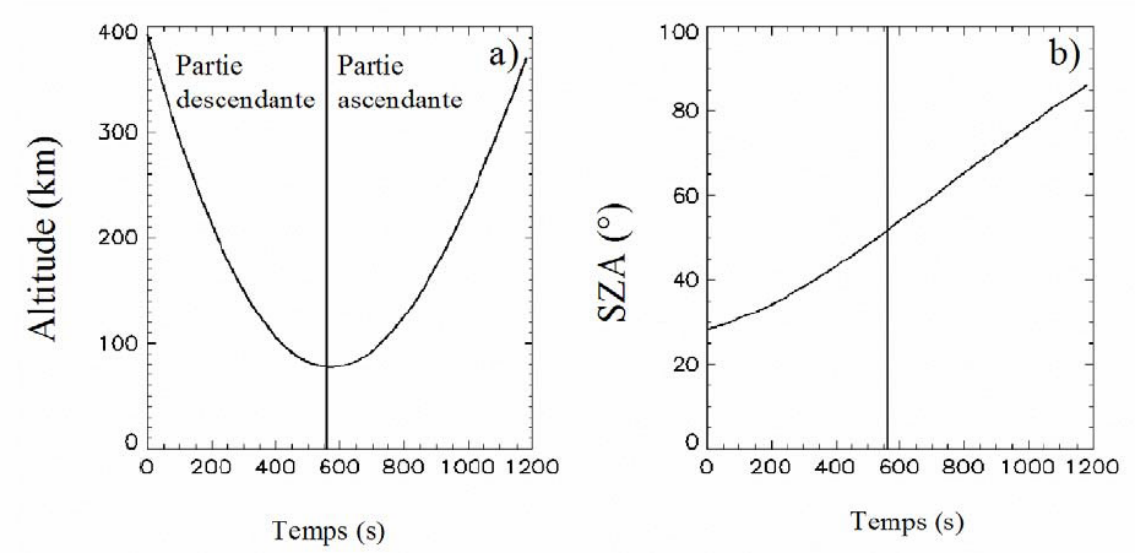
Results in good agreement with model (Hodges 1999)

Chaufray et al. 2010 (paper in preparation)

Mars : Oxygen

Observations from October 2004 – February 2005 (Chaufray et al. 2008)

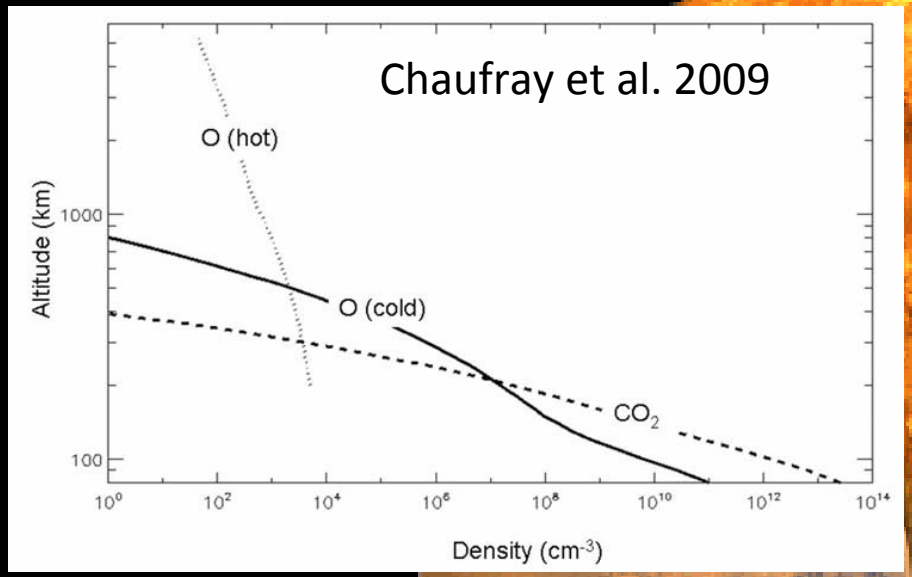
Observations with close geometry observations are gathered to increase the signal to noise ratio

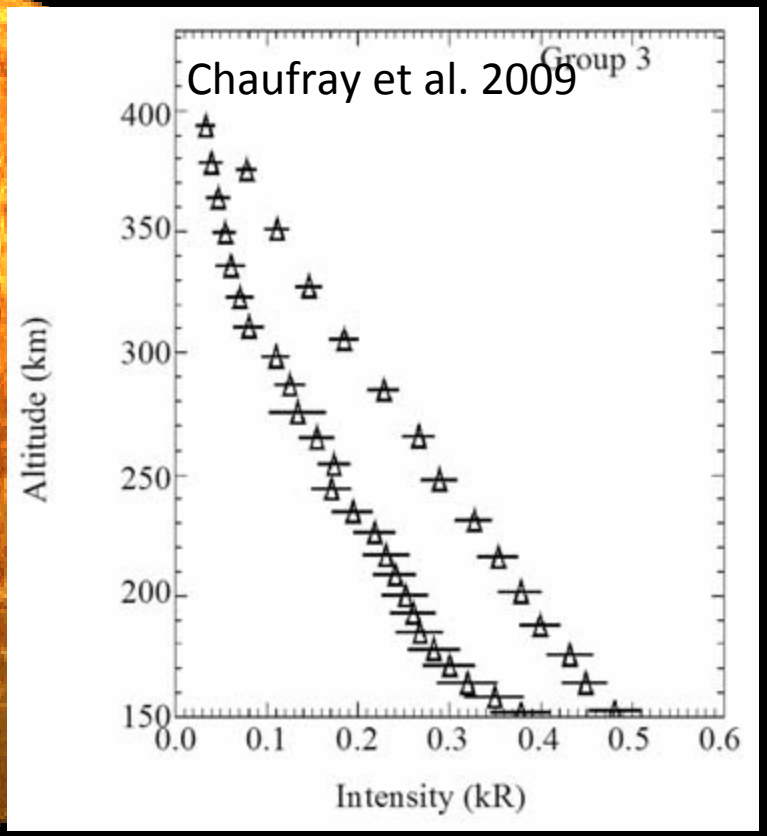


Each group of observations is divided in two parts with different SZA

Sources : Solar resonant scattering (~80%) + photoelectron impact (~20%)

Mars : Oxygen





Temperature fixed to 200 K →

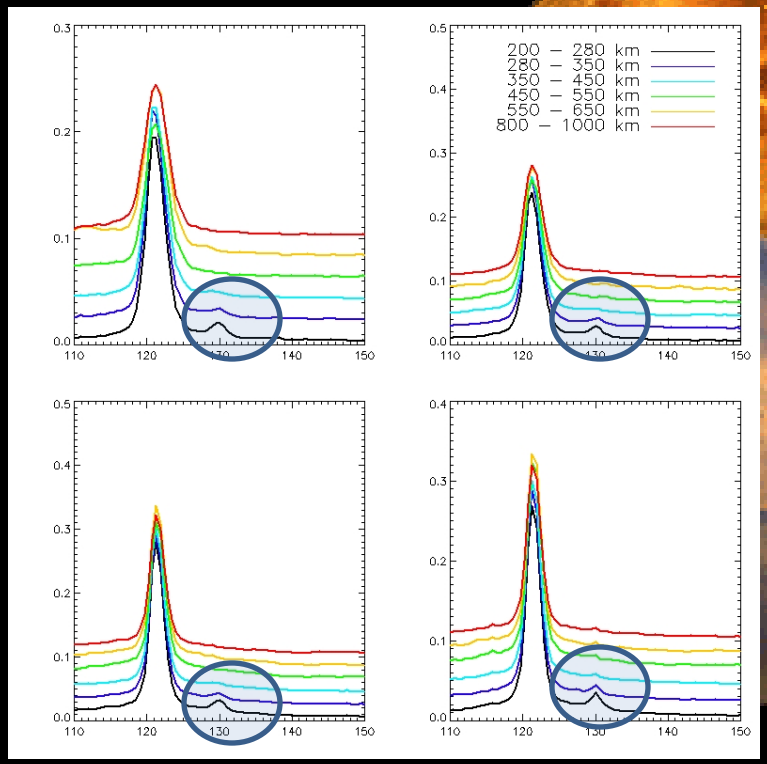
	N (cm^{-3})
O	0.5 - 2 x10^7

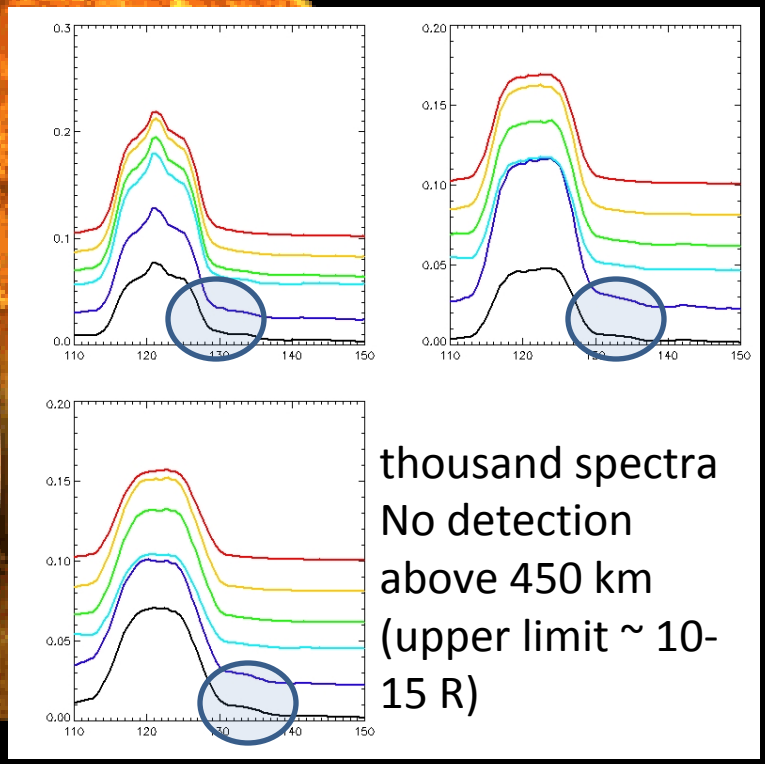
Profiles better repoduced with high temperature (~ 300 K) possibly due to the presence of a hot population

$O_2^+ + e^- \rightarrow O^* + O^*$

Attempt to observe directly the hot oxygen population (preliminary results)

From model : Hot population contribution above 500 km ~ 10 R (Chaufray et al. 2009)





thousand spectra
No detection above 450 km (upper limit ~ 10-15 R)

Conclusion

Differences on Mars/Venus due to general planetary parameters well understood

- larger scale height on Mars than Venus
- larger intensity on Venus than on Mars
- Cold H population produced by diffusion and H_2 dissociation (~ same upper atmosphere)

Origin of hot population on Venus not well known: (ions-neutral reactions in the thermosphere as suggested by Hodges 1999 ?).

Same processes should occur on Mars ➔ Hot population. Is this hot population directly escape or populate the upper atmosphere ?

Need to quantify the different mechanisms by realistic 3D models ; need to study variabilities (spatial ; seasonal)

- chemical sources
- charge exchange (H-ENA from SW protons and planetary protons)