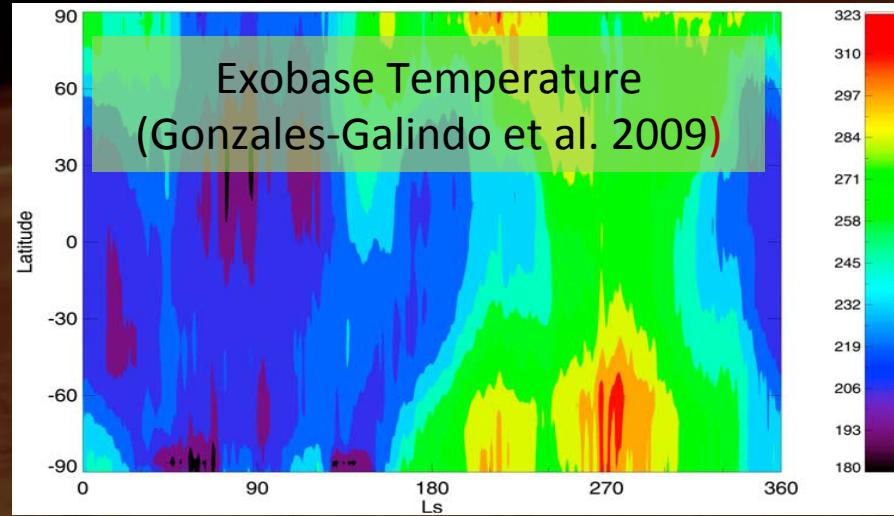


Temporal variability of the Martian hydrogen corona : Observations and Simulations

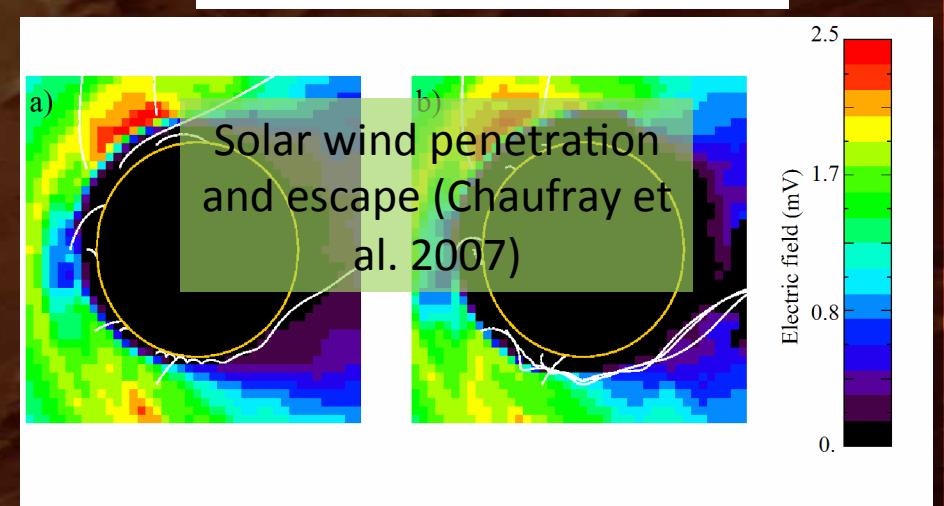
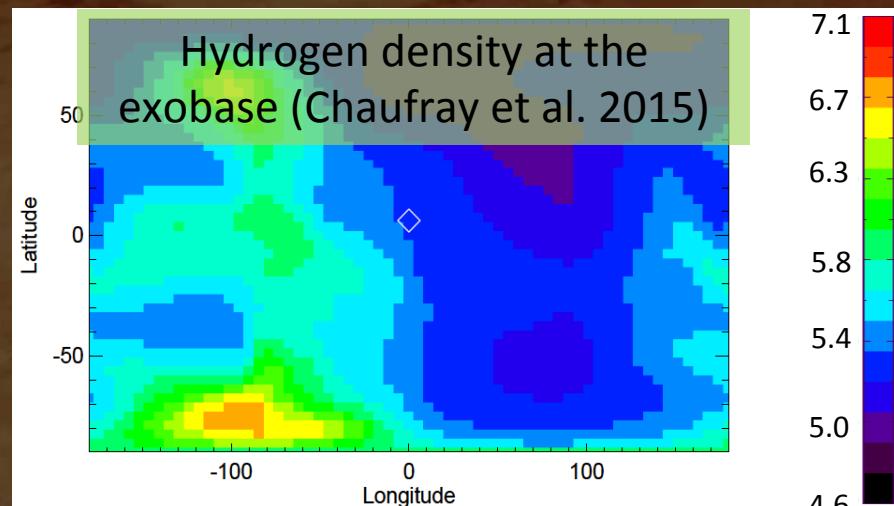
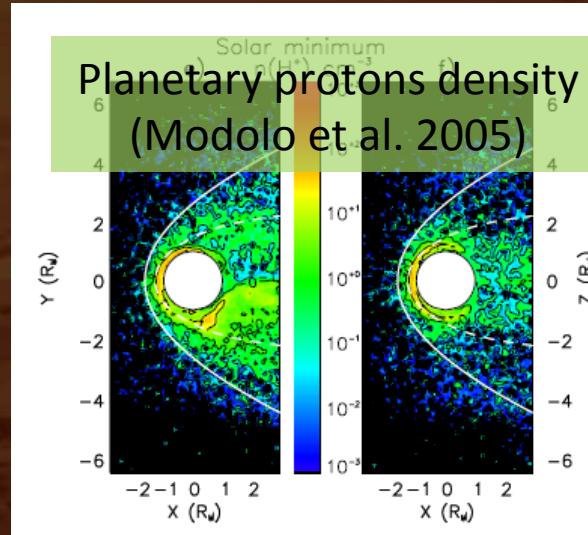
Jean-Yves Chaufray

Atelier magnétopshère Meudon, 05/02/2015

The hydrogen corona : Formation and interactions



Interaction with solar wind



ATMOSPHERE: MGCM

EROSION



EVOLUTION

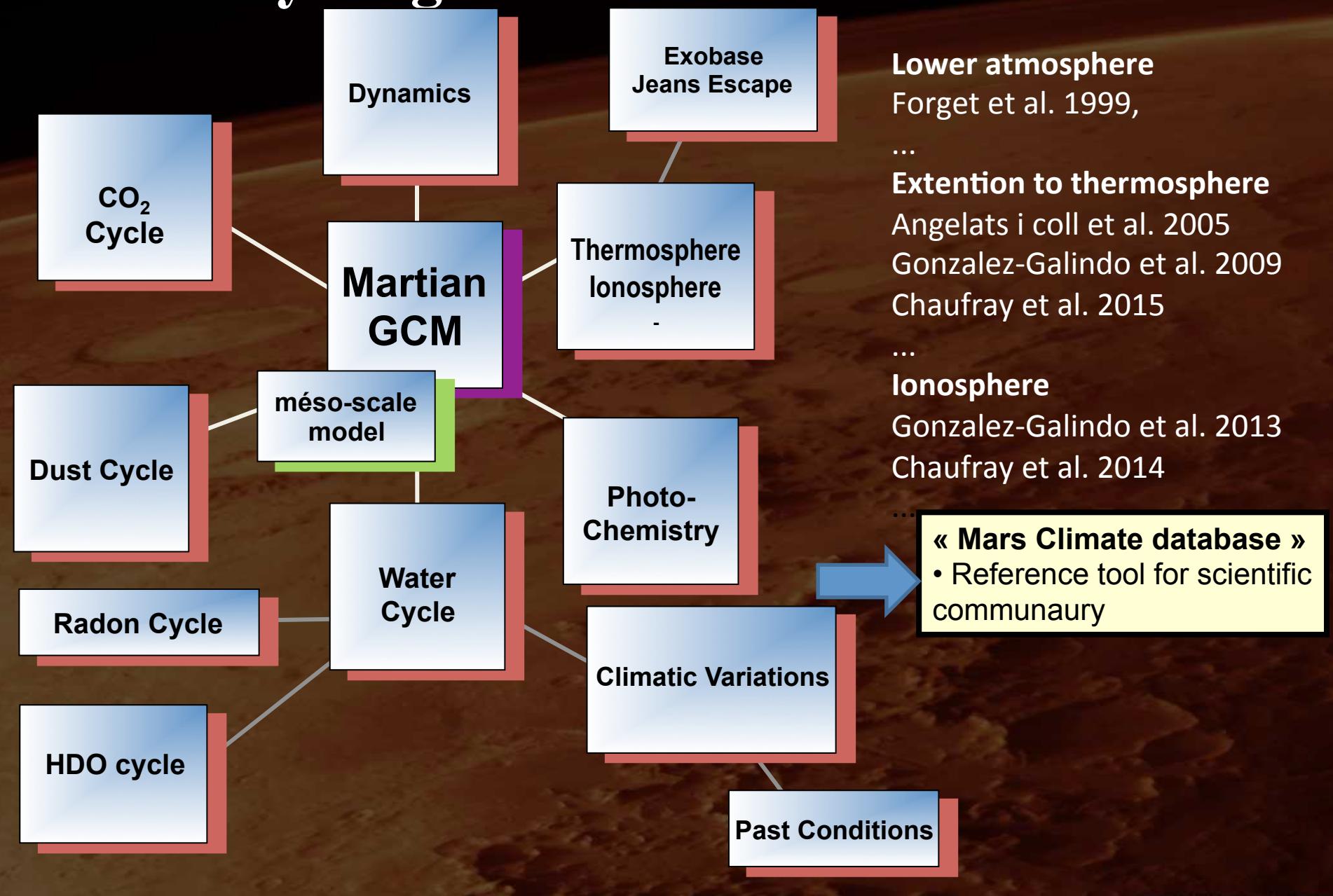
O (cm^{-3})

MAGNETOSPHERE: LatHyS

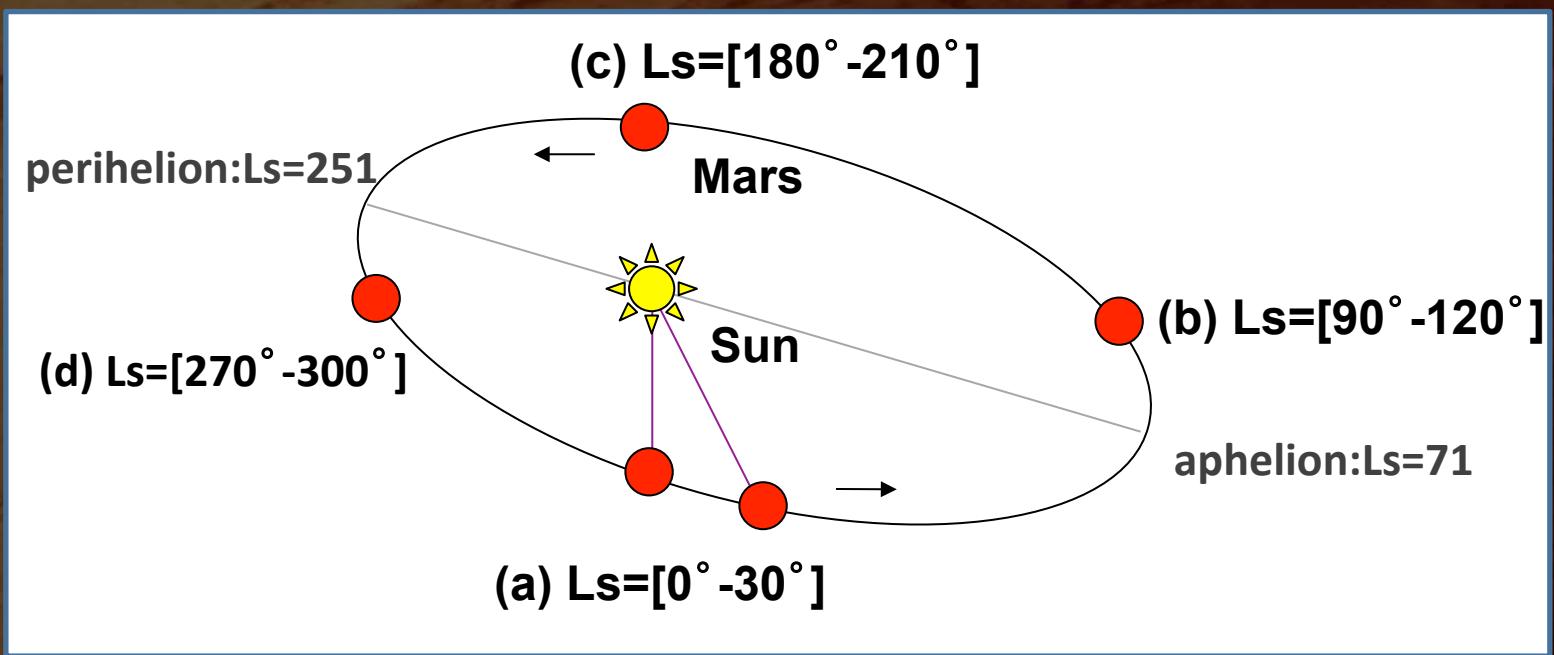
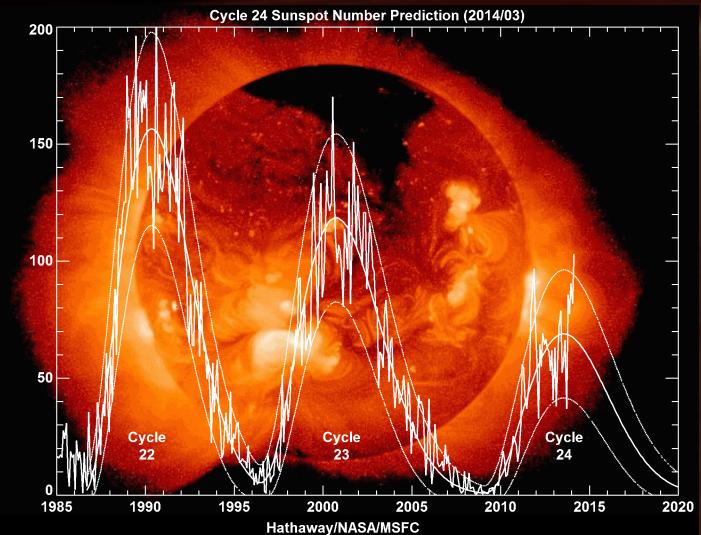
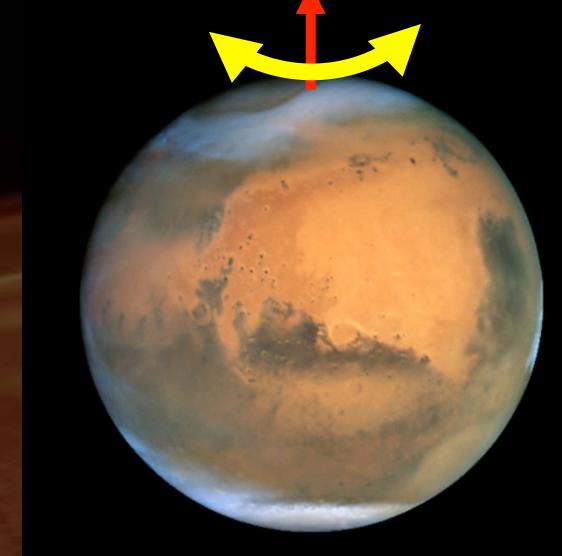
HELIOSARES
2010 – 2014
PI F. Leblanc

EXOSPHERE: MEGM

The hydrogen corona : 3D Simulations

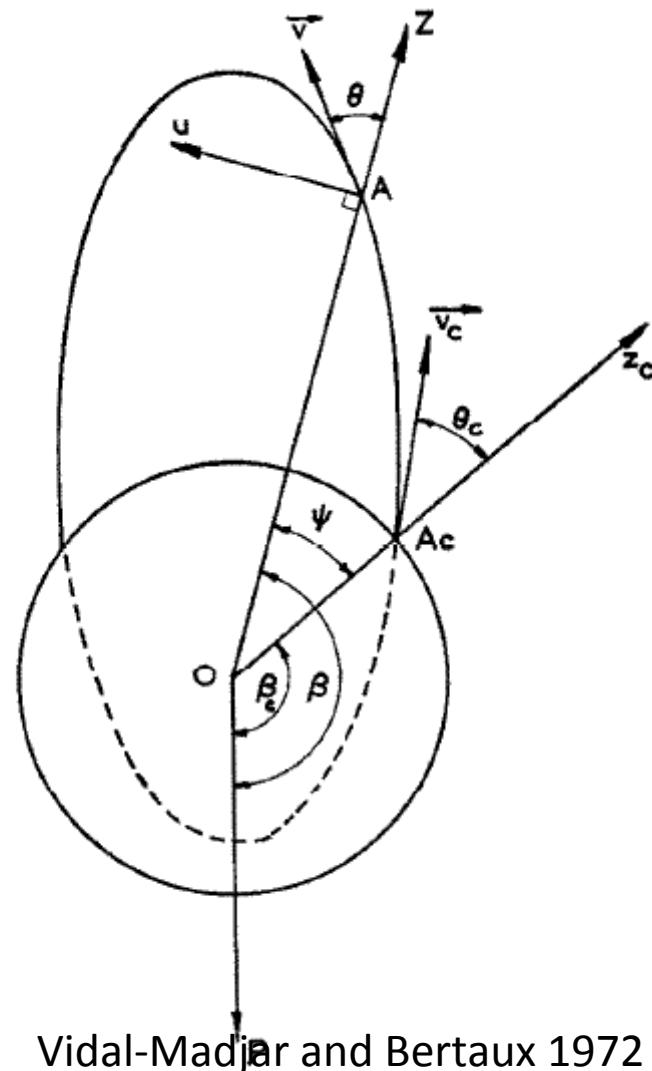


The hydrogen corona : 3D Simulations



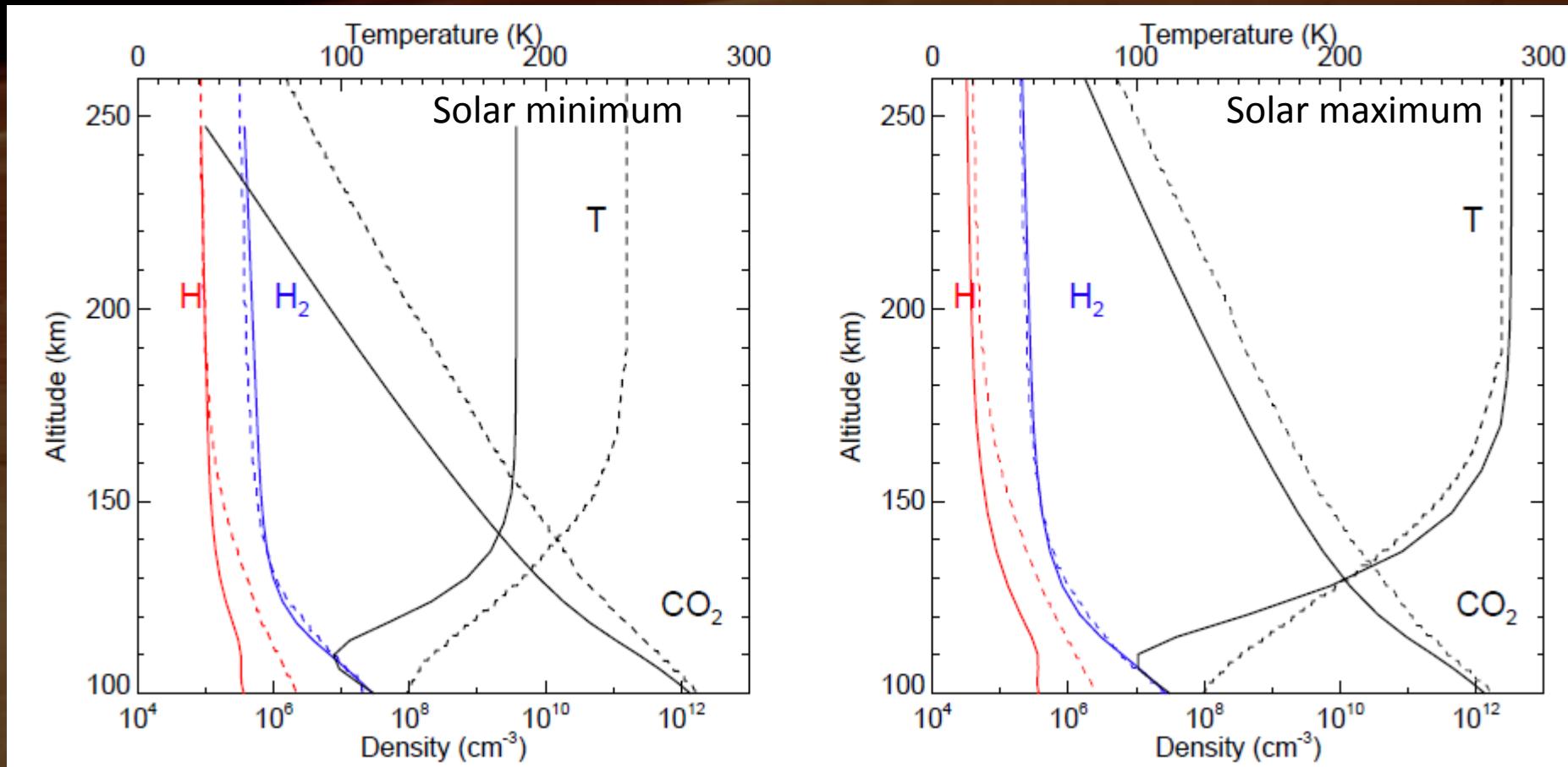
The hydrogen corona : 3D Simulations

- Thermal exospheric density from velocity distribution at the collisional - collisionless boundary (from a critical altitude = ~ 200 km in altitude).
- Non uniform conditions at the exobase
- Balistic and Escape particles
- No balance between upward and downward flux (inconsistent with the top condition used in the GCM)



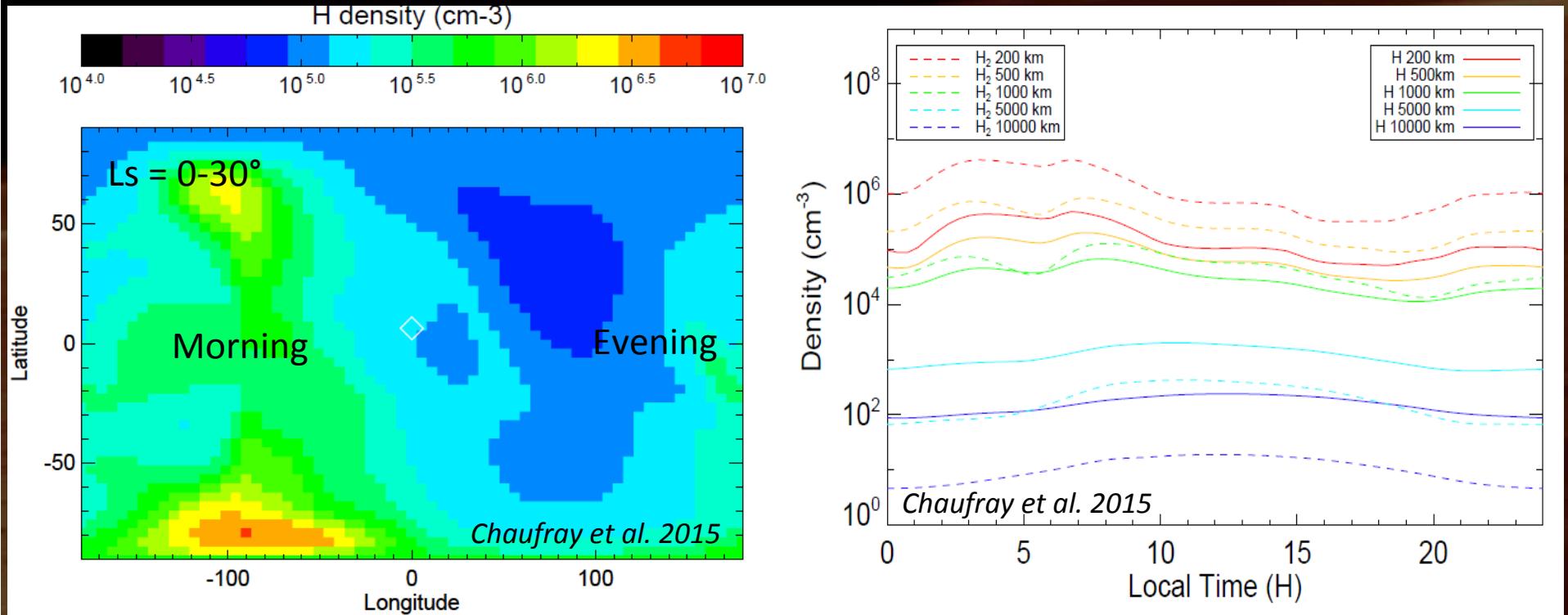
Vidal-Madjar and Bertaux 1972

Thermospheric hydrogen: comparison with 1D photochemical model



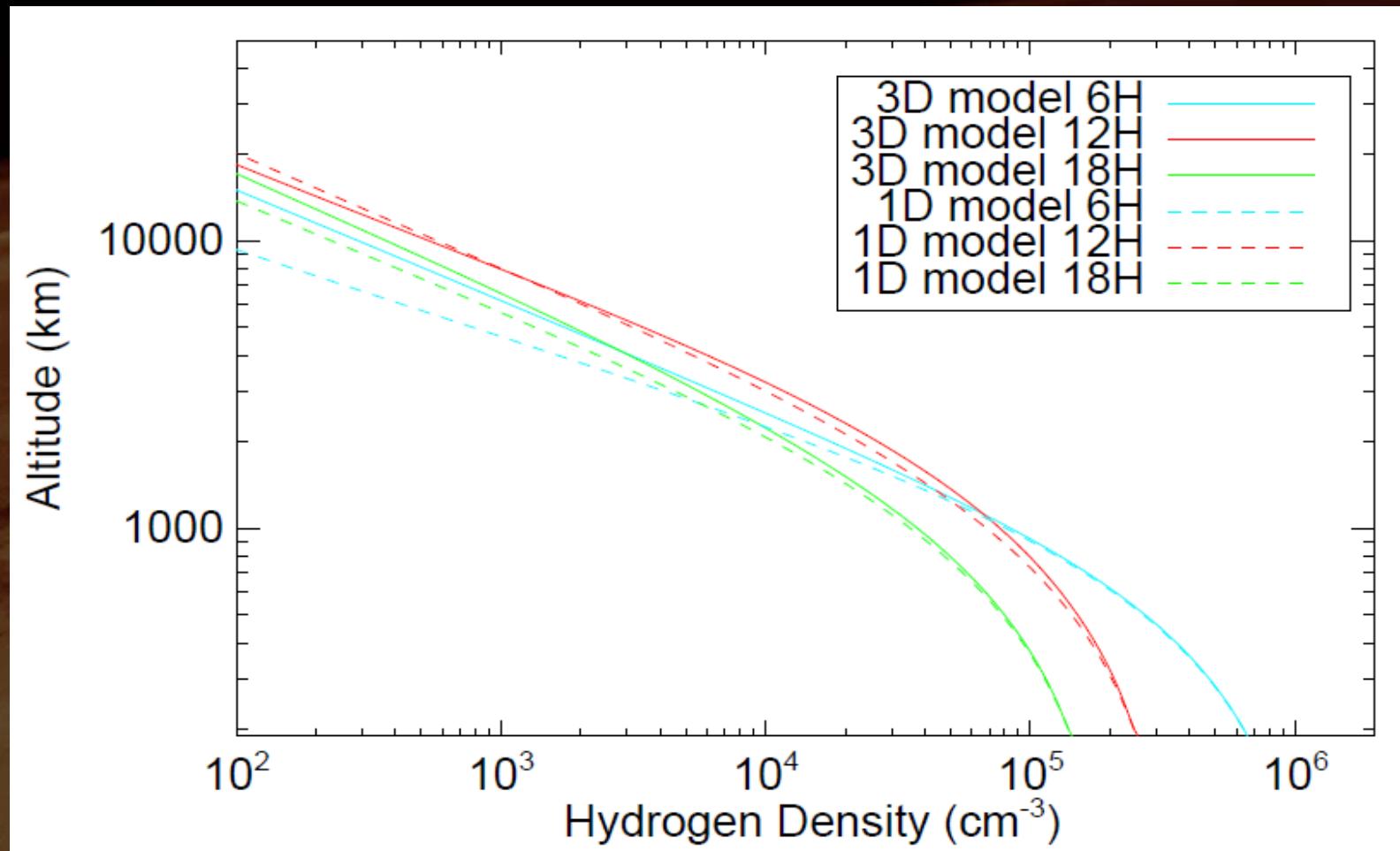
Comparison with 1D photochemical of Krasnopolksy 2010 (SZA = 60°)

The hydrogen corona : Diurnal Simulations



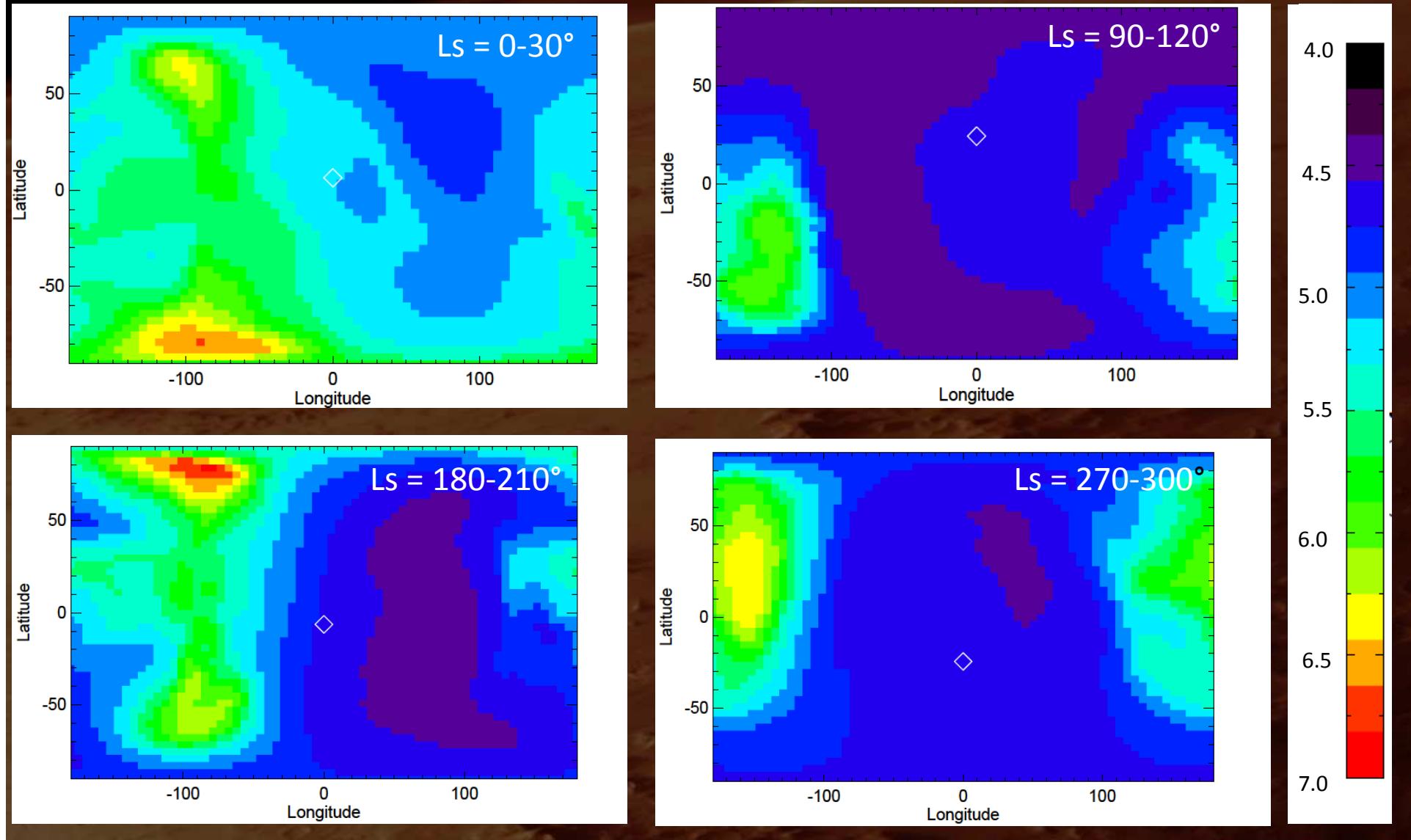
- Hydrogen bulge at the morning side produced by dynamics of the upper atmosphere
- Such a bulge has been detected on Venus (cf my Venus talk)
- Effect on the Lyman-alpha brightness not proportional due to the large optical thickness : Need to be studied with SPICAM/MEX ; IUVS/MAVEN observations

The hydrogen corona : Diurnal

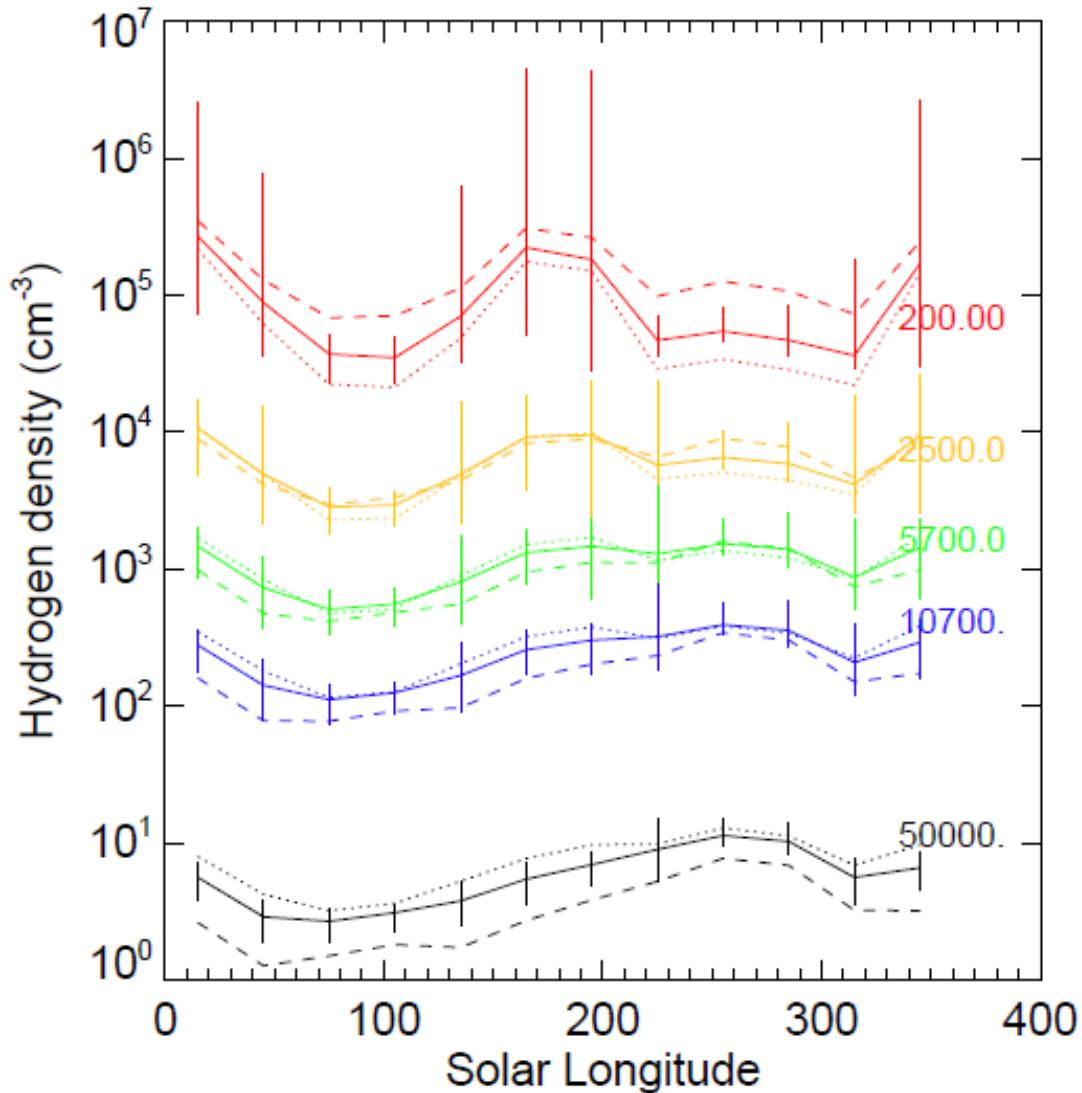


- Below $\sim 1000\text{-}2000$ km exospheric profile defined by local conditions
- Above ~ 5000 km exospheric profile defined by « average » conditions

The hydrogen corona : Seasonal Simulations

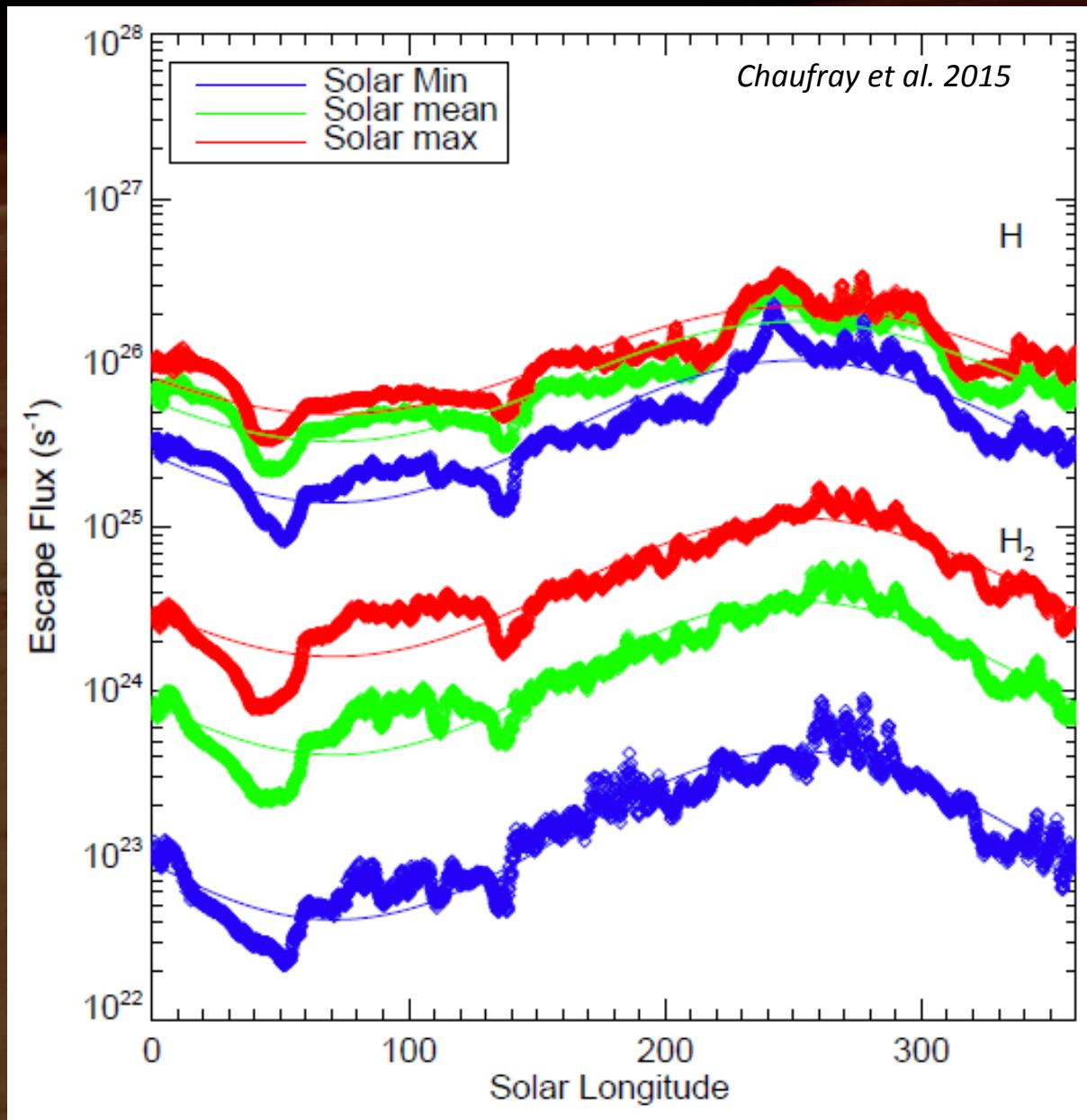


The hydrogen corona : Seasonal and Solar activity variations

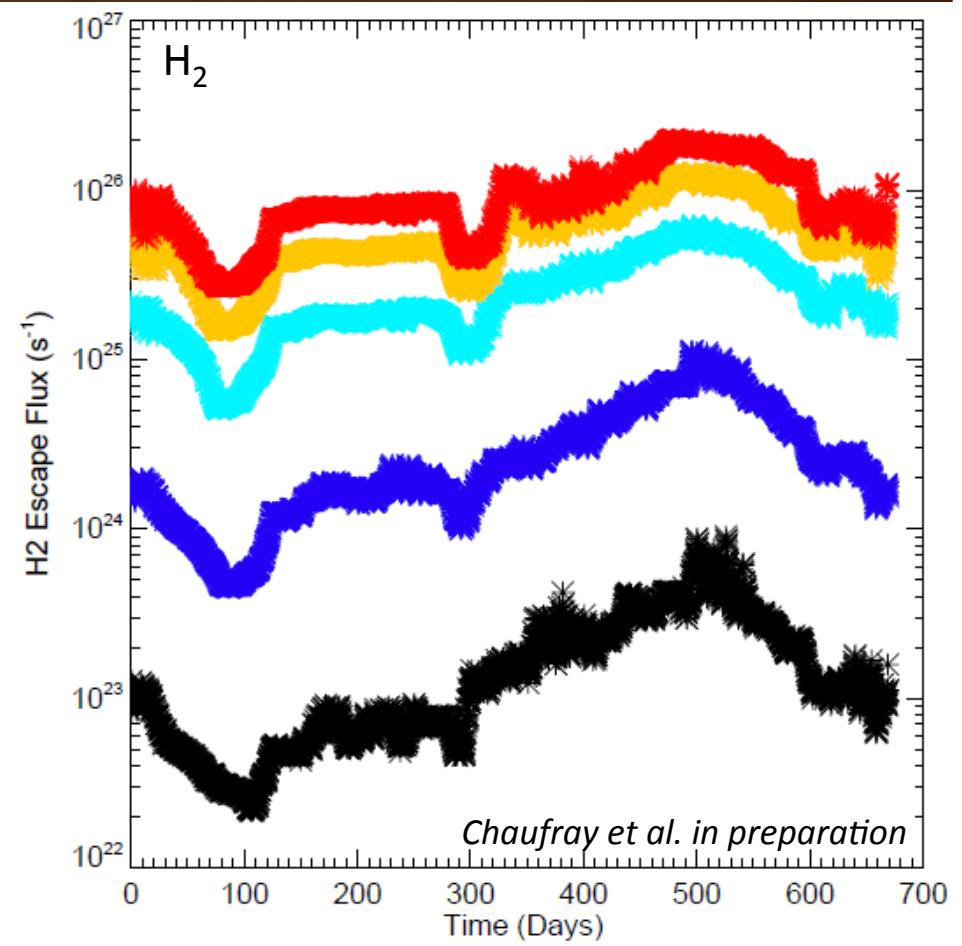
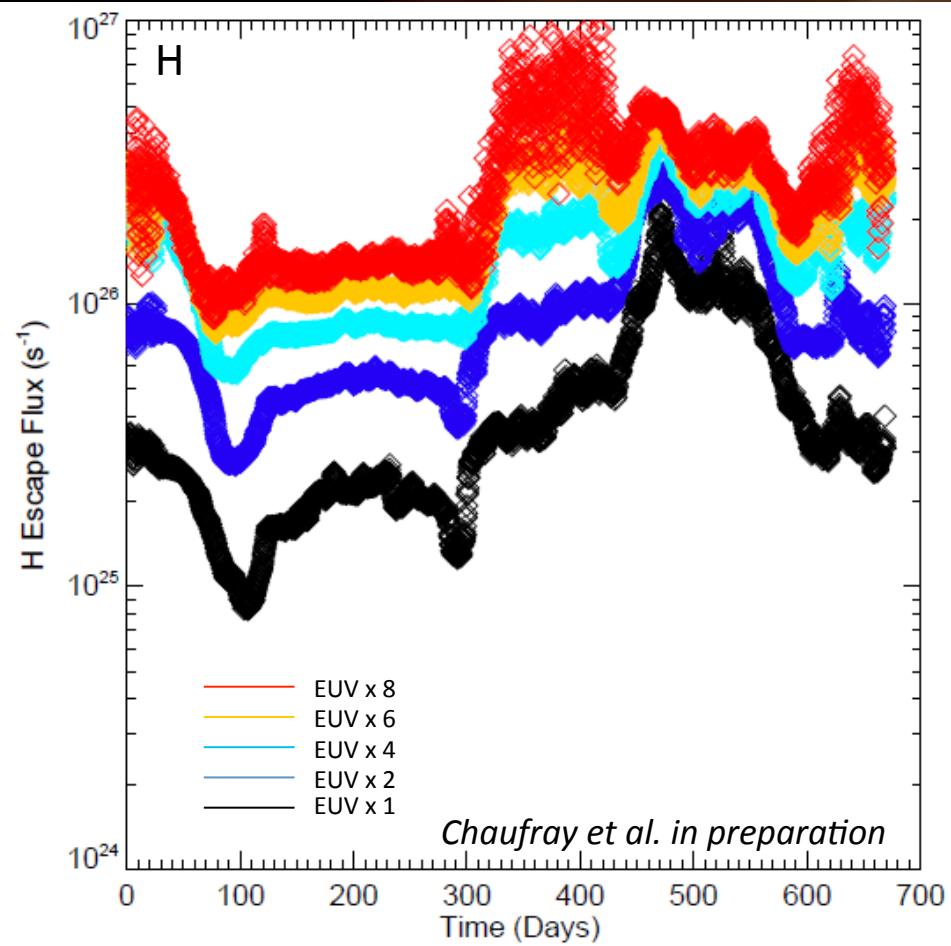


- ❑ Seasonal variations of H at the exobase ($\sim 200\text{km}$) link to variations of the homopause altitude (Gonzalez-Galindo et al. 2009)
- ❑ Decrease of the hydrogen density with the solar activity due to Jeans escape
- ❑ At higher ($> 5000 \text{ km}$), the exosphere is mainly controlled by the temperature at the exobase
→ Larger density near Mars pericenter

The hydrogen corona : Seasonal Simulations

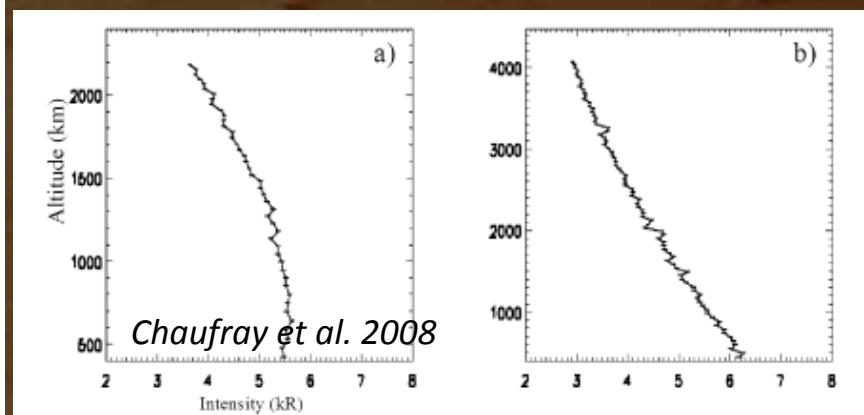
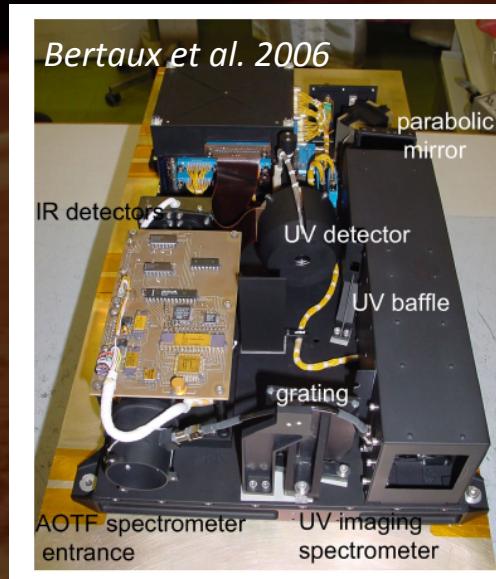


The hydrogen corona : EUV extreme cases (past conditions; solar flare...)

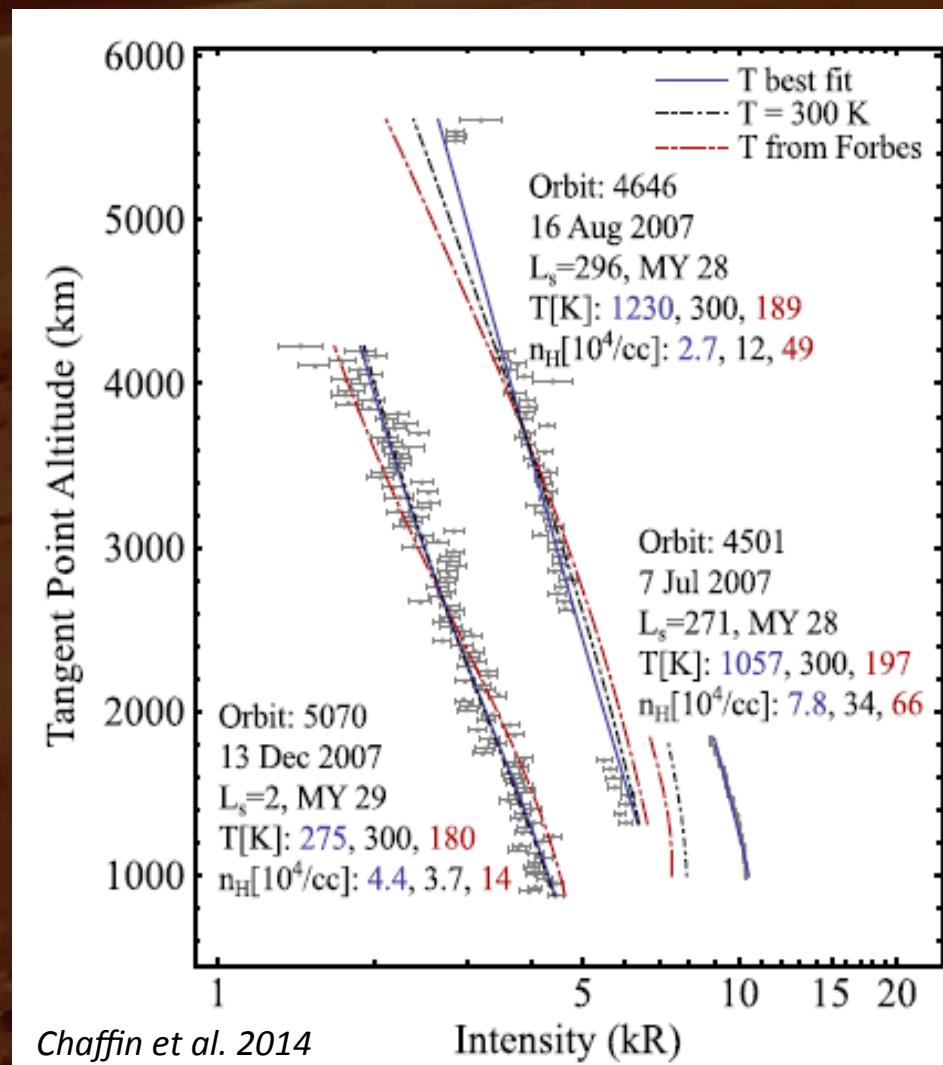


- Large hydrogen escape rate under H₂ form for large solar EUV flux
- Escape rate \sim diffusion limited flux ($\sim 10^{27} \text{ s}^{-1}$)

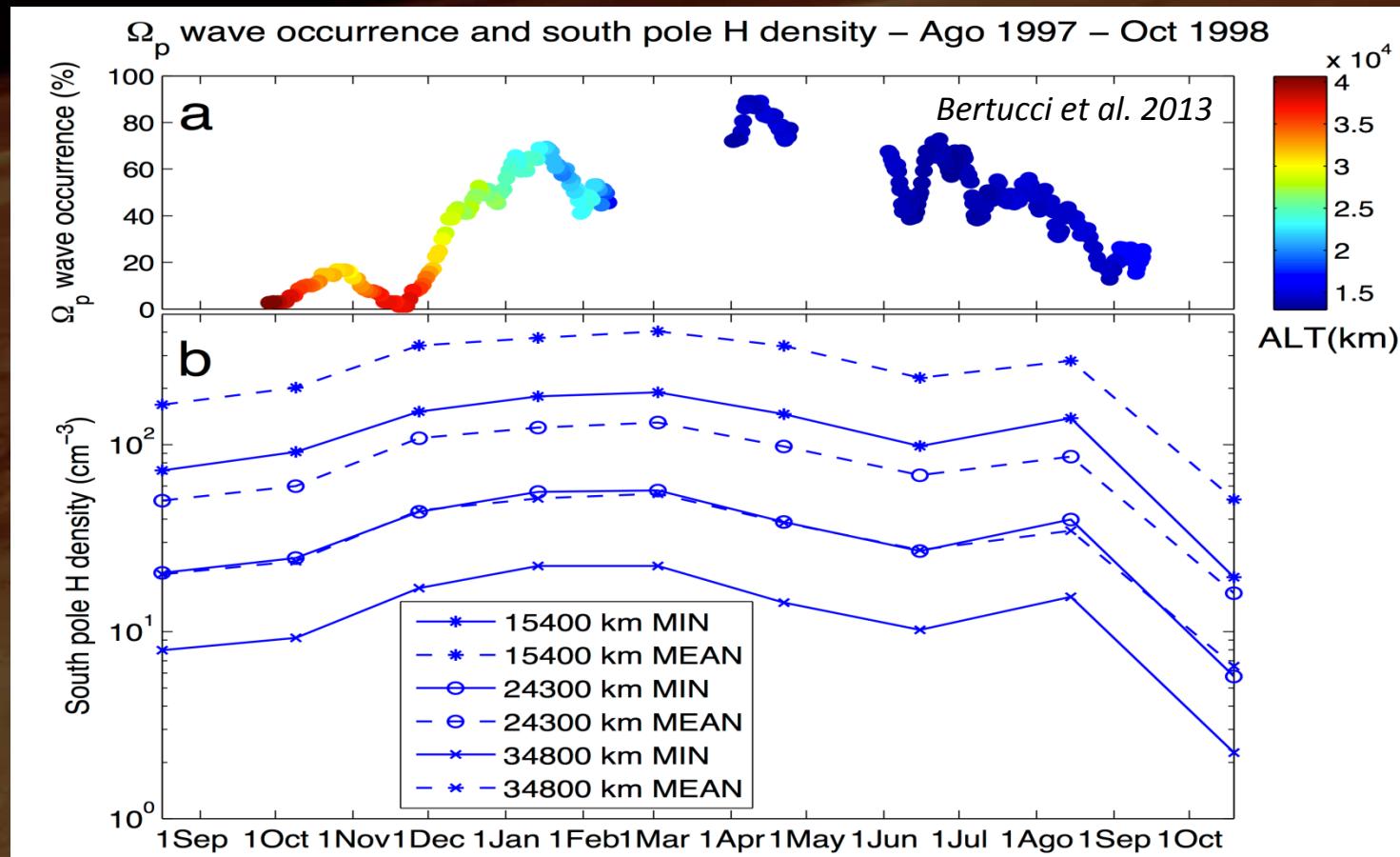
The hydrogen corona : SPICAM/Mars Express observations



Escape rate $\sim 2 \times 10^{26} \text{ s}^{-1}$

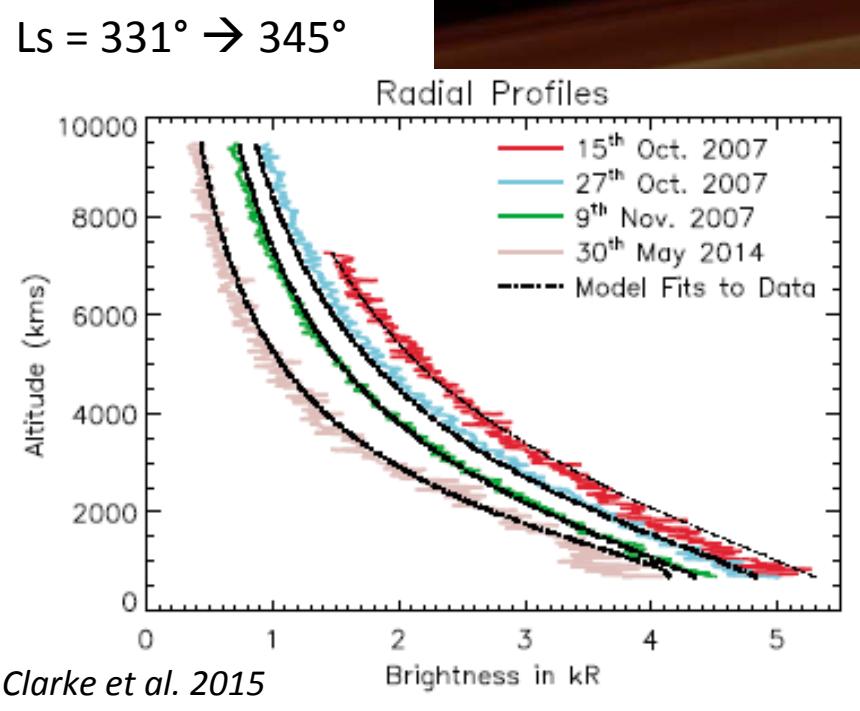


The hydrogen corona : Other evidence of seasonal variations

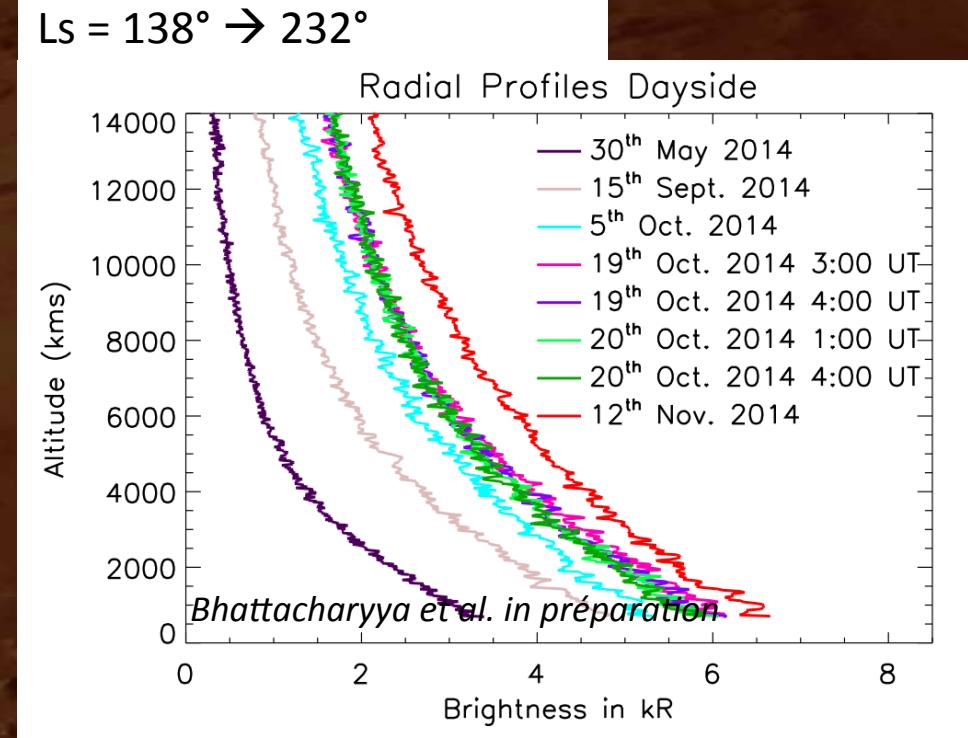


- Magnetopause closer to Mars during $Ls = 0 - 180^\circ$ than $Ls = 180 - 360^\circ$ (Brain et al. 2005)
- X-ray brightness larger during solar max & $Ls = 301^\circ$ (Dennerl et al. 2002 ; 2006 ; Ishikawa et al. 2011)

The hydrogen corona : Other evidence of seasonal variations



HST ACIS observations



Pic of hydrogen density near
 $L_s \sim 230\text{--}330^\circ$? (pericenter :
 251°)

Conclusion

- First 3D time dependent model of thermospheric / exospheric H on Mars (full H cycle included)
- Large temporal variations at different time scale (local time, season, solar cycle)
- Seasonal variations of H corona observed by several independent observations
- Need to compare Model/Observations using 3D radiative transfer model
- Study oxygen escape and O/H escape ratio