Recent Simulation of the Martian upper atmosphere from Global Circulation Model and Global Exospheric Model and first comparisons with MAVEN/IUVS observations.

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Introduction:

Understanding the physical processes of the Martian upper atmosphere is crucial to estimate the escape rates of the current Martian atmosphere. To uderstand these processes, our team has developped and coupled several 3D models able to simulate the Martian atmosphere from the surface to the exosphere and its interaction to the solar wind. These models have been used to study Jeans escape of light species (Chaufray et al. 2015a), and non-thermal escape of heavy species, particularly the atomic oxygen escape (Yagi et al. 2012). The MAVEN mission (Jakosky et al. 2015), in orbit around Mars since September 2014, is dedicated to study the escape processes, and has started to observe systematically the species important in the Martian upper atmosphere such as H (Chaffin et al. 2015), O (Chaufray et al. 2015b, Deighan et al. 2015), and He (Mahaffy et al. 2015). In this presentation, I will present some updates of our models, including improvements in the computation of H, H_2 and O density in the thermosphere/exosphere as well as new species (He) and first comparison with the Imaging Ultraviolet Spectrograph (IUVS).

Modeling:

Several improvements were recently included in our models to describe the Martian upper atmosphere. In the GCM-LMD (Forget et al.. 1999, Gonzalez-Galindo et al. .2009), we have recently included He, a species observed systematically for the first time by the Neutral Gas and Ion Mass Spectrometer (NGIMS) aboard MAVEN. This species is chemically inert and therefore a very good tracer of the dynamics in the Martian upper atmosphere. The vertical density profiles of the main species in the Martian thermosphere, including He as simulated with the 3D GCM-LMD model near northern autumn equinox are displayed in Fig. 1.

We also recently update the Exospheric Global Model (EGM) to better describe the non-thermal oxygen component in the Martian upper atmosphere. The universal elastic cross section from Lewkow and Kharchenko (2014) has been implemented to describe the collisions between hot oxygen atoms and the background atmosphere (O, CO_2, and N_2).

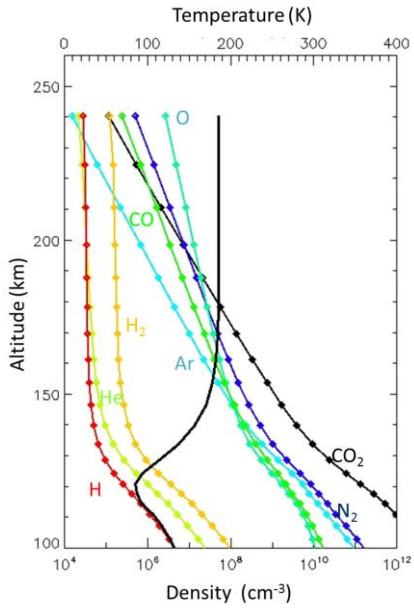

Fig. 1 Typical density profiles of the main species in the Martian thermosphere, including helium, simulated with the GCM-LMD at Ls =180-210°. The temperature profile is also indicated by the thick black solid line.

Comparison with IUVS/MAVEN:

In order to directly compare the results of our simulations to the MAVEN/IUVS observations, we have updated our resonance line radiative transfer model (Chaufray et al. 2015b) by including 3D variations of the oxygen density and temperature simulated by the GCM-LMD and two different populations as simulated by the EGM (one population at thermal equilibrium with the atmosphere and one suprathermal population produced from O_2^+ dissociative recombination). The simulated O 130.4 nm brightness is compared to the MAVEN/IUVS observations (Chaufray et al. 2015b, Deighan et al. 2015). Examples of first comparisons with the MAVEN/IUVS observations obtained during the insertion orbit and during coronal scans on the nominal orbit are displayed in Fig. 2 and 3 showing a reasonable agreement between observations and simulations.

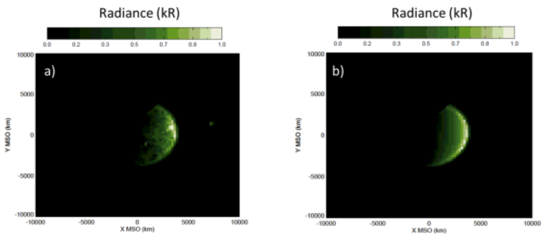

Fig. 2 Comparison between the observed O 130.4 nm emission brightness by IUVS during the Mars insertion orbit of MAVEN (Ls ~ 210°) (2a) and the simulated emission using the oxygen density profiles, extended above the exobase (2b) at the same season. The observed and simulated brightness are projected into X-Y Mars Solar Orbital (MSO) axis. The sun is on the X axis on the right The brightness decrease is mainly due to the decrease of the solar flux with solar zenith angle.

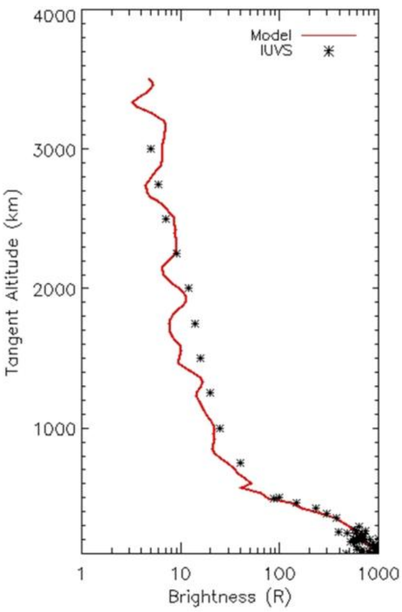

Fig. 3 vertical profile of the O I 130.4 nm brightness observed by IUVS (black stars) during the first months of observations (from the average coronal scans between MAVEN orbits 335-624(Ls = 230-300°) above 500 km (from Deighan et al. 2015) and from one single coronal scan during MAVEN orbit n° 422 below 500 km. The simulated profile (Ls = 270°) including both thermal and non-thermal oxygen populations is represented in red. The simulated profile is noisy due to the noise from the Monte Carlo resonance radiative transfer model used to simulate the brightness.

The first comparisons of the hydrogen corona as simulated with our model and the observations done by IUVS (Chaffin et al. 2015) show an important disagreement which is not understood yet but could come from another source of hydrogen in the Martian upper atmosphere not included in these simulations.

Acknowledgements

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