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3D Simulations of the variability of the atmospheric escape at Mars with the EUV solar flux

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Abstract

The exosphere is the collisionless region surrounding a planetary atmosphere. The exosphere of Mars is an important region to characterize the escape processes. It is mainly formed from processes responsible of the atmospheric escape in the underlying atmosphere/ionosphere. The Martian exosphere is mainly composed of atomic hydrogen, molecular hydrogen and atomic oxygen. Atomic and molecular hydrogen escape is dominated by the thermal escape while the oxygen escape is dominated by the O2+ dissociative recombination in the Martian upper ionosphere. Therefore their escape rates are expected to vary strongly with the EUV solar flux which is the main driver of the heating and ionization of the Martian upper atmosphere. In this presentation, we will present simulations obtained from a 3D Martian exospheric model, coupled to the 3D GCM-LMD model for different solar UV conditions representative of current and past conditions.

1. Introduction

Currently, most of the water on Mars is present in different reservoirs at the surface (e.g. ice polar deposits) and in the subsurface. A small amount of water is also present in the Martian atmosphere and its variations are characterized by a strong seasonal cycle [1]. One part of the atmospheric water vapor escapes into the interplanetary medium under atomic H and O form. The hydrogen and oxygen escape is therefore an important clue with regards to the evolution of Mars water. We have used a 3D GCM model coupled to a 3D exospheric model to study the variations of the escape rates with the solar EUV flux.

2.Modelling

2.1 Hydrogen escape

The Jeans escape is derived by integration over the full exobase. The H and H_2 escape along the Martian year with a 1 day time resolution is displayed in Fig. 1 for three different solar activities. The maximal hydrogen escape flux is obtained near Mars perihelion (Ls = 251°) for high solar activity and is equal to 4×10^{26} s^{-1}. This escape rate is three times lower than the H_2 diffusion-limited flux estimated to $1.1\pm0.3\times10^{27}$ s^{-1} at ~ 105 km, for any seasons and solar activity. As shown by the solid lines, the escape rate is well reproduced (at first order) by the simple analytic law $\Phi_{esc} = \Phi_{esc,0}\, e^{\alpha \sin(Ls-\varphi0)}$, with a maximum close to perihelion and a minimum close to aphelion of Mars, showing that exospheric temperatures, and therefore EUV heating is the main driver of the hydrogen Jeans escape at Mars [2]. Escape rates for larger EUV solar flux representative of the past conditions on Mars will be presented.

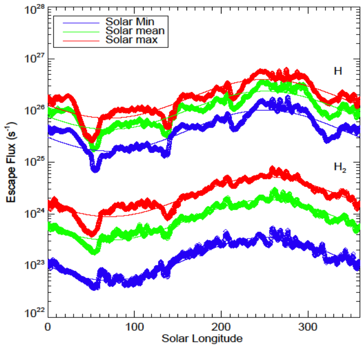

Fig. 1 Atomic and molecular hydrogen escape rates simulated for three different solar activties (F10.7 = 80, 120, 220 respectively). An analytic law $\Phi_{esc} = \Phi_{esc,0}\ e^{\alpha \sin(Ls-\varphi 0)}$ fitting the simulations is also displayed by solid lines

2.2 Oxygen escape

We use our 3D exospheric model [3] to derive the oxygen escape from O2+ dissociative using the 3D GCM results as input. We will present the oxygen escape rates derived from different EUV solar flux.

3. Summary and Conclusion.

The hydrogen and oxygen escape rates have been simulated using the 3D LMD-MGCM coupled to a 3D exospheric model for different solar EUV flux. We will present and discuss the results obtained for larger solar EUV flux representative of possible past conditions on Mars.

References

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