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Abstract

We describe the horizontal distribution of hydrogen density at the exobase of Mars as simulated by coupling a 3D GCM with an exospheric balistic model, taking into account the flight balistic time of the exopheric hydrogen atoms. Such a description is more realistic than the assumptions used in our past study [4]. We simulate 4 Martian rotations at three different seasons. The horizontal variations of the hydrogen density at the exobase are reduced when the exospheric balistic transport is included compared to our previous simulations.

1. Introduction

The Martian hydrogen corona is not spherically symmetric [1, 3]. Such asymmetry results, for example, from the differential heating between the dayside and the nightide leading to local time variations of the exospheric temperature and driving thermospheric winds [6]. Chaufray et al. 2015 [4], simulated the 3D hydrogen corona using the Global Circulation Model of Laboratoire de Météorologie Dynamique (GCM-LMD) to study the possible local time and latitude variations of the hydrogen density. These simulations show the presence of hydrogen bulge in the downwelling regions resulting from the “wind-induced diffusion” [2] that could be responsible of recent helium bulges observed by MAVEN [5]. For light species like atomic hydrogen, the horizontal distribution should be also affected by the balistic motion in the exosphere [7] due to the large horizontal motion during one balistic trajectory (typically 1000 km for a temperature of 200K at the exobase). This effect was not included in Chaufray et alal. 2015 and is investigated in this study.

2. Models

To investigate the effect of the exospheric balistic motion on the hydrogen density at the exobase, we couple the GCM-LMD to an exospheric balistic motion of hydrogen atoms, assuming no loss process and no collisions above the exobase. The upward velocity used as the upper boundary conditions in the molecular diffusion scheme in the GCM-LMD is computed by

$$w_{top} = \frac{\Phi_{bal,up} + \Phi_{esc} - \Phi_{bal,down}}{n},$$

Where n is the local hydrogen density $\Phi_{bal,up}$ and Φ_{esc} are the balistic upward and escape flux depending only on the local conditions, and $\Phi_{bal,down}$ the balistic downward flux computed with the balistic exospheric model by integration over the flux coming from all regions of the exobase.

This assumption differs from our previous simulations [4] where the vertical velocity at the upper boundary was assumed to be the effusion velocity (Φ_{esc}/n). The simulations have been performed at different seasons.

3. Results

The horizontal distribution of the temperature at Ls = 180° is displayed in Fig.1. The horizontal hydrogen density obtained after 4 martian days without and with the exospheric balistic coupling is displayed in Fig. 2 and show that the effect of the exospheric balistic motion is to reduce the simulated nightside bulge of hydrogen at this season and to redistribute the hydrogen towards the dayside as well as to lead to a smoother distribution of the hydrogen density.

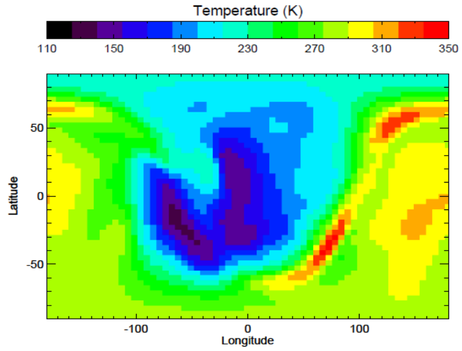

Fig. 1 Temperature at the exobase simulated with the GCM-LMD for solar average conditions at Ls = 270°. The subsolar longitude is 180°.

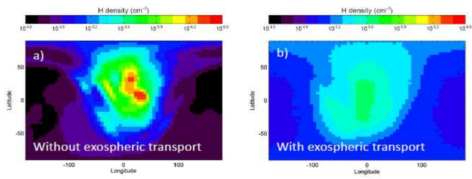

Fig. 2 Horizontal distribution of the hydrogen density at the Martian exobase without (a) and with (b) exospheric balistic coupling.

4. Summary and Conclusions

The effect of the exospheric balistic transport plays an important role in the horizontal distribution of hydrogen at the exobase of Mars. Compared to simulations presented by [4], the main effect of the exospheric balistic transport is to reduce the hydrogen density at the nightside and increase the hydrogen density at the dayside. The hydrogen density is also smoother when this effect is included. In the future, the coupling of this model with a 3D radiative transfer model, will help us to compare with the local time variations of the Lyman-α brightness performed by MAVEN/IUVS [3].

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