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Dynamical model of the Martian ionosphere and its temporal variations

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Abstract

In the frame of the HELIOSARES project (PI F. Leblanc), we have extended the LMD Martian-GCM (MGCM) including the ion dynamics. A multifluid approach is used to compute the dynamics of the main ion of the Martian ionosphere. The dynamics equation takes into account the effects of ion gradient pressure, polarization electric field and the ion-neutral collisions. The ions dynamics is needed to describe accurately the ions density above 180 km. This region is important to estimate both neutral and ion escape. For example, the hot neutral oxygen atoms escaping from Mars were found to be produced mainly above 180 km [1]. We simulate the dynamics of the Martian ionosphere at equinoxes and solstices for different solar activities. We will show and discuss the results of these simulations.

1. Introduction

Recent observations by several Mars Express instruments show that the dynamics of the ionosphere could play an important role in the structure of the upper ionosphere and the plasma escape processes [2,3]. Supersonic transterminator flows reaching velocity ~ 5 km/s were derived from IMA-ASPERA on Mars Express [3]. Such supersonic flows were also observed on Venus by the Retarding Potential Analyzer (ORPA) on Pioneer Venus Orbiter (PVO) [4]. From ORPA measurements, the ionosphere of Venus was horizontally divided into three regions:

(1) The dayside region with slow velocity and ion density decreasing monotonically with increasing solar zenith angle
(2) The terminator region (80° < SZA < 110°) or transition region with the highest ion velocities.
(3) The nightside region where the flow slows and become chaotic

The dynamics of the Martian ionosphere should be similar to the venusian ionospheric dynamics.
The future NASA mission MAVEN could provide a better picture of the global dynamics of the Martian ionosphere and the extension of a 3D GCM model to describe the Martian ionosphere up to the exobase will be useful to interpret such observations.

2. Model

The LMD-MGCM is a 3D model of the dynamics of the Martian atmosphere including its interaction with the surface and several cycles (CO_2 cycle, water cycle, dust cycle, …) [5]. The Martian atmosphere dynamics, composition and heating is computed from ground to the exobase [6]. The main neutral species of the Martian upper atmosphere are included in the model (CO_2, O, N_2, CO, H_2, H). The ionization sources have been included recently [7] to describe the ionospheric peaks at 120 km. In the new ionospheric dynamical core presented here, the dynamics of the ions is splitted in horizontal and vertical movements. Inertia terms are neglected in the vertical dynamics compared to the strong pressure gradients, ambipolar electric field, gravitation and collisions with neutral. The ions and electron temperatures are imposed constant in time and uniform on isobar surfaces. In the simulations presented here we do not consider ionospheric currents and magnetic fields.

3. Simulations

We perform simulations with and without the ionospheric dynamics to understand and quantify the effect of the dynamics. Our simulations indicate the presence of the two first horizontal regions observed by ORPA-PVO with a peak of horizontal velocity at terminator. Velocity at terminator reaches ~1km at the exobase suggesting that the large velocity found by IMA-ASPERA cannot be explained by pressure gradients alone. Finally, Simulations at different season (Ls = 0°, 90°, 180° and 270°) and for different solar conditions have been performed and will be presented and discussed.

4. Conclusions

We have included a new ionospheric dynamical core in a 3D MGCM model to describe the upper part of the Martian ionosphere. In the future, we will include both ionospheric and crustal magnetic fields. The results of these simulations will be coupled to exospheric and induced magnetospheric model [8, 9] in order to compute the Martian escape rates and its temporal variations.

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References

[1] Chaufray J-Y. et al., JGR 112, E9009, 2007.

[2] Fränz M. et al., Planet. Space Sci., 58, 1442, 2010

[3] Lundin R. et al., Geophys. Res. Lett., 35, L18203, 2008

[4] Miller K.L. and Whitten R.C., Space Sci. Rev., 55, 165, 1991

[5] Forget, F.. et al., JGR, 104, 24,155, 1999

[6] Gonzalez-Galindo F. et al., JGR, 114, E04001, 2009

[7] Gonzalez-Galindo F., et al., 4th MAMO meeting, February 2011, Paris, France, 2011

[8] Yagi M., et al., Icarus, submitted

[9] Hess, S. et al., DPS-EPSC, September 2011, Nantes, France