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Variability of the Martian ionosphere during a full Martian year from GCM simulations

F. González-Galindo (1), G. Gilli. (1) , M.A. López-Valverde (1), J.-Y. Chaufray (2) and F. Forget (2)
(1) Instituto de Astrofísica de Andalucía, CSIC, Granada, Spain, (2) Laboratoire de Météorologie Dynamique, IPSL, Paris, France (ggalindo@iaa.es)

Abstract

We present the results of a simulation of the evolution of the Martian photochemical ionosphere during a full Martian year. The simulation has been performed using the LMD-MGCM, in its ground-to-exosphere mode [1, 4, 8], including ionospheric chemistry. We focus on the study of the variability of the simulated ionosphere with season, latitude and solar zenith angle (SZA). Comparisons with available data and previous models are also presented.

1. Introduction

During the last two decades a renovated interest in the Martian ionosphere has grown, fed by the measurements performed by different instruments on board the Mars Global Surveyor and Mars Express missions. These data show an important coupling between the ionosphere and the underlying neutral atmosphere, as well as a significant variability in the electronic profiles [2, 12].

Different models, including 1-D models and a GCM, have been used in the past to simulate this atmospheric layer [2, 6, 9]. However, those simulations were performed only for short periods of time, and up to our knowledge the evolution of the Martian ionosphere during an entire Martian year has not been simulated so far. We present a full Martian year simulation of the ionosphere performed with the LMD-MGCM. We focus on the layers below 180-200 km, where the ionosphere is dominated by photochemical processes (in upper layers the ionospheric structure is controlled mainly by plasma dynamics [11]; see also another presentation by our team in this Conference [3]), and in particular in the variability of the main ionospheric peak.

2. Ionospheric LMD-MGCM

The model used in this study self-consistently studies all the atmospheric layers from the surface up to the thermosphere, so that a complete and coherent coupling of the lower and the upper atmosphere is achieved. For this work, the photochemical model used to describe the upper atmosphere [8] has been extended to take into account Nitrogen and ionospheric chemistry, raising the total number of equations in the model to 93 reactions between 25 chemical species. The photodissociation and photoionization coefficients are calculated rigorously by the model, and secondary ionizations are including following a recent parameterization [10]. The ions are advected by the winds, allowing us to study the day-to-night transport and the population of the nighttime ionosphere.

3. Summary of the main results

The shape of the ionospheric profiles predicted by the model is in good agreement with observations. Also the ionospheric composition, dominated by O_2^+ and with non negligible contributions from NO^+ and O^+ is in agreement with Viking observations.

The altitude and concentration of the main electronic peak at the subsolar point vary during the Martian year, due to the eccentricity of the Martian orbit. The peak concentration and altitude are minimum during the aphelion season and maximum around the perihelion.

The model predicts a variability of the main electronic peak concentration and altitude with solar zenith angle. Comparisons with available data show that this variability is well captured by the model, although it tends to overestimate the altitude of the main electronic peak. This may be linked to the overestimation of the temperatures in the upper mesosphere/lower thermosphere by the LMD-MGCM [5, 8].

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