

Study of the couplings in the Mars' atmosphere with the Mars Express MARSIS total electron content data set

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Abstract

Ten years of Mars Express Total Electron Content (TEC) data from the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) instrument are analysed. We describe the spatial, seasonal, and solar cycle behaviour of the TEC. The TEC temporal profile shows a peak at $L_s=25^{\circ}-75^{\circ}$ which is not related to the solar irradiance variation, but instead coincides with an increase in the thermospheric density, possibly linked to lower atmosphere cycles. With the help of numerical modelling, we compute the contribution of the ion species to the TEC, which allows the study of the coupling between the thermosphere and the ionosphere. We show that the TEC is a useful parameter, routinely measured by Mars Express, to investigate the couplings at work in the Mars' atmosphere.

1. Introduction

The Martian atmosphere is a highly variable system in which the lower and upper parts are strongly coupled. The ionosphere and the thermosphere are closely connected, and influenced by several external and internal forcing mechanisms, such as space weather or gravity waves respectively among many others. In this work, we evaluate how the TEC variations are linked to the seasonal variability of the thermosphere. In addition, we assess the latitudinal response of this atmospheric coupling, its solar activity and solar illumination dependences.

2. Ionosphere-Thermosphere simulation

A numerical simulation of the ionosphere of Mars during a Martian year has been performed in order to

evaluate the role of the neutral atmosphere in the TEC variation observed in the Mars Express MARSIS dataset. We have used the Mars version of the numerical/physical model IRAP plasmasphere-ionosphere model (IPIM). The IPIM model can be run from the Transplanet's Space Weather Prediction Center (<http://transplanet.cdpp.eu>). This model uses as inputs the Mars Climate Database (MCD), built from the Global Circulation Model (GCM) developed at Laboratoire de Meteorologie Dynamique (LMD). The model was run for a fixed solar flux in order to avoid TEC variability due to solar irradiance/solar activity, and to assess the role that the neutral atmosphere has on the ionosphere as a function of season and latitude. Model outputs reproduce the changes in the TEC temporal profile, and seem to confirm the atmospheric coupling. The simulation also allows us to identify the neutral and ionized species that play a role in the thermosphere and ionosphere during each season.

Conclusions

In this work, we show that the TEC observations routinely made by Mars Express-MARSIS can be used to monitor the behaviour of the Martian atmosphere.

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