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Different contributions for a Mars Ionosphere empirical model based on Mars Express MARSIS data.

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Abstract

An empirical model for the so-called M1 layer in the Mars ionosphere was obtained using more than 450 topside ionograms to analyze the behavior of the M1 peak under different solar zenith angle, solar flux and seasonal conditions based on data from the MARSIS ionospheric sounder on board Mars Express. It also introduces the contribution of the surface magnetic anomalies to the formation of the M1 ionospheric peak in these regions.

The results have been compared with electron density profiles from radio occultation data of the NASA mission Mars Global Surveyor (MGS) and electron density profiles from ionospheric sounding data of Mars Express which are independent from those used to obtain the empirical model.

1. Introduction

The ionosphere of Mars has been an important subject of research over the last 40 years within the framework of our current knowledge of the physics and chemistry of planetary atmospheres and ionospheres. One of the most useful information available of the Mars ionosphere come from radio occultation profiles, which have provided an overview of the structure and composition of the Mars ionosphere. This technique, very commonly used in the case of the Earth's ionosphere [2], has been complemented in 2003 with the European mission Mars Express [1], which includes a low frequency radar, called MARSIS [3]. This instrument can operate as an ionospheric sounder and permits to obtain ionograms to analyze the electron density in the part of the ionosphere situated above the maximum electron density of the ionosphere of Mars (topside) with very global coverage.

The first step in this line of study was to check the validity of the Chapman-layer model and it was possible to conclude than the behavior of Mars ionosphere is very similar to an α-Chapman layer [4]. The second step was to obtain an empirical model combining the Chapman-layer representation with the results obtained from MARSIS data for different latitude, longitude, solar zenith angle and solar flux conditions in regions with no presence of surface magnetic anomalies [5]. The third step introduces the contribution of the seasonal variations and the influence of the surface magnetic anomalies to the M1 ionospheric peak formation and will be described in the next section.

2. Methodology

In the present study, more than 450 topside ionograms have been used to analyze the behavior of the M1 peak under different conditions and with special interest in the seasonal variation and the contribution of the surface magnetic anomalies to the formation of the M1 ionospheric peak in the regions with this kind of anomalies. Therefore, the main parameters to take into account in the model are the solar zenith angle (SZA), solar flux index (F 10.7 cm) and solar longitude (Ls).

The data have been downloaded from the ESA planetary science archive and correspond to both hemispheres for the periods: July-October 2005, January-August 2006, September 2006 - February 2007 and July-December 2007.

The results have been compared with electron density profiles from radio occultation data of the NASA mission Mars Global Surveyor (MGS) of the time period 1998-2005 and topside electron density derived from ionospheric soundings MARSIS data

not included in the data base used to obtain the empirically model described in this study.

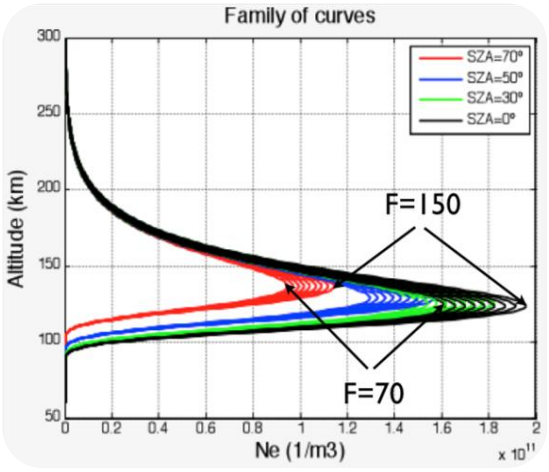

Figure 1: Representation of the electron density with the altitude using the empirical model for the ionosphere of Mars with different conditions of solar flux and solar zenith angle

These comparisons indicate that the empirical model seems to reproduce the observations in an accurate way and realistically represents experimental data over an altitude range 120-180 km. Possible improvements of the model are discussed.

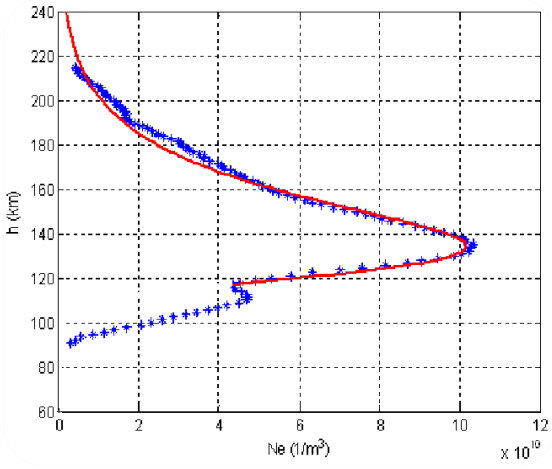

Figure 2: Comparison between experimental data from radio occultation (blue) with the empirical model based on MARSIS data obtained in this study (red).

3. Summary and Conclusions

The present study describes the peak electron density characteristics (Nm and hm) of the M1 layer of Mars ionosphere obtained from MARSIS data. The M1 peak depends essentially on the solar zenith angle, solar flux and solar longitude. The study also analyse ionograms obtained over the regions with surface magnetic anomalies.

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The data have been retrieved from the ESA and NASA science archives.

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