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Study of topographic effects on the main Martian ionospheric peak with the Mars Express MARSIS instrument

B. Sánchez – Cano (1,2), O. Witasse (3), M. Herraiz (1,2), S. M. Radicella (4) and G. Rodríguez – Caderot (5).

(1) Departamento de Física de la Tierra, Astronomía y Astrofísica I, Facultad de Ciencias Físicas, Universidad Complutense de Madrid (UCM), Madrid, Spain (beasanch@fis.ucm.es). (2) Instituto de Geociencias (UCM-CSIC), Madrid, Spain. (3) Research and Scientific Support Department of ESA, ESTEC, Noordwijk, The Netherlands. (4) Telecommunications /ICT for Development Laboratory of Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy. (5) Sección departamental de Astronomía y Geodesia, Facultad de Ciencias Matemáticas, Universidad Complutense de Madrid (UCM), Madrid, Spain.

Abstract

Active Ionospheric Sounding data (AIS) of MARSIS instrument on board Mars Express mission have been used to analyze the effect of the irregular Martian topography on the electron density and altitude of the main ionospheric peak.

1. Introduction

Several parameters such as heliocentric distance, solar activity, or zenith angle must be considered of necessity when the Martian ionosphere is analyzed. However, there are many other factors that have an influence on the ionosphere. One of them is the topography of Mars which is abrupt enough to generate a significant impact on the surrounding plasma.

The most important characteristic of the Mars topography is certainly the dichotomy, a sharp contrast that splits up the planet by the equator, leaving the southern hemisphere about 5 km higher than the northern one. The contrast between both hemispheres is stronger if we consider the presence of volcanic provinces and some deep basins that occupy a large region of the surface in the southern hemisphere. Example of these main topographic accidents, respectively are the volcanic province Tharsis, which includes the highest volcanoes in the solar system, about 21 km in altitude, and Hellas basin, about -5 km (where zero elevation is defined as the equipotential surface whose average value at the equator is equal to the mean radius [1]). As it will be discussed in this paper, this rough topography affects the electron density of the main peak of the Martian ionosphere and its variation in altitude.

2. Methodology

The peak characteristics (altitude and electron density) of the measurements taken by the MARSIS instrument are calculated with respect to the reference surface, that is, the Mars ellipsoid. So it means that no reference to the actual surface elevation is being used in general [2]. It means that a variation in the ionosphere due to this parameter is real and must be considered when the ionosphere is studied and modeled.

The coupling between the topography and the ionosphere has been studied under different conditions (topographic accidents, MARSIS orbits…). Since the only ionospheric parameter which varies along one orbit is the solar zenith angle, to avoid misleading results, every AIS ionogram has been normalized to the same solar zenith angle (χ=0º) using the equations of the NeMars empirical model [3]. The topographic information for the Mars Express orbits comes from MOLA [1].

In a first approximation and taking into account the reference system of the instrument, if the atmosphere were circular, no differences in the altitude measures between both hemispheres would be expected. However, it has been observed that the altitude of the main peak in the ionosphere of Mars in the regions in the south of the dichotomy is higher

than in the north of the dichotomy as if would follow the shape of the planet. The same trend can be seen in most prominent topographic features studied in this work.

This result is consistent with a previous work [4], where using radio-occultation data from Mariner 9 and Mars Global Surveyor spacecraft, similar effects were observed.

3. Summary and Conclusions

The present study describes the variation of the peak characteristics (altitude and electron density) of the main dayside layer of Mars ionosphere with the planetary topography using Mars Express MARSIS data. After applying a correction with the solar zenith angle, the main ionospheric peak is well correlated with different surface features, which is important to be considered when this atmospheric layer is modelling.

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The MARSIS data have been retrieved from the ESA science archive.

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