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Mars Express characterization of the Martian ionosphere

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Abstract

15 years after its launch, Mars Express has collected a large dataset of ionospheric observations. These include electron density profiles and the total electron content of the ionosphere. Mars Express measurements cover more than one solar cycle and have allowed for an unprecedented characterization of the Martian ionosphere, its temporal and spatial variability, and its couplings with the lower atmosphere and with the space environment.

1. Introduction

Sounding the ionosphere of Mars to characterize the interaction of the atmosphere with the space environment of the planet was one of the primary objectives of Mars Express when the mission was launched. 15 years later, it is a good time to look back and check to what extent this objective was achieved.

2. Mars Express ionospheric measurements

Most of the ionospheric observations performed by Mars Express comes from two instruments, MaRS and MARSIS.

Mars Express Radio Science experiment (MaRS) uses radio occultation observations at two frequencies to obtain vertical profiles of electron densities from the base to the top of the ionosphere [8], being the only current instrument able to measure the whole ionospheric altitude range. To date it has collected about 900 profiles. The distribution of the observations can be seen in Fig. 1

The Mars advanced radar for subsurface and ionospheric sounding (MARSIS) is a synthetic-aperture radar [2]. It can operate in two different modes, both of them providing information about the ionosphere. The Active Ionospheric Sounding (AIS) mode allows obtaining electron density profiles above the main ionospheric peak. More than 40000 of these electron density profiles have been obtained during the Mars Express mission, and their distribution is shown in Fig. 2. The Subsurface Sounding mode provides as a by product the total electron content of the ionosphere [10].

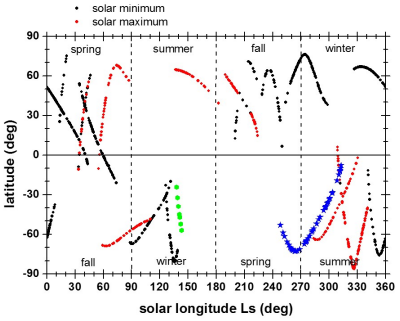

Figure 1: Latitudinal and seasonal distribution of the MaRS electron density profiles

Other Mars Express instruments provide complementary information about the ionosphere. SPICAM measured the CO_2^+ UV doublet, a UV dayglow emission produced by ionization of CO_2 [3]. ASPERA provides information about the interaction of the ionosphere with the solar wind [4].

In addition, Mars Express observations have fostered the development of computational models of the ionosphere, including semiempirical models [6, 11], 1D models [9] and GCMs [1].

All these datasets result in an unprecedented amount of information about the ionosphere of Mars that allow for a much more complete characterization of the region, its variability and its couplings with other regions. The long duration of the mission allows to study

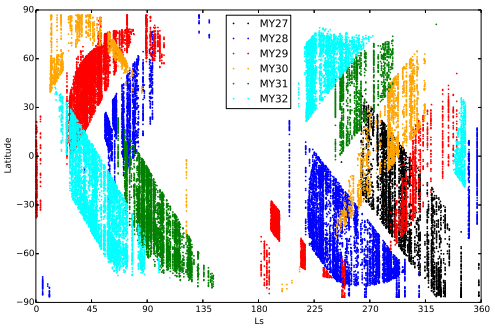

Figure 2: Latitudinal and seasonal distribution of the MARSIS AIS dataset, with different colors representing data obtained at different Mars Years

the solar cycle and interannual variability of the Martian ionosphere. The quality of the obtained data has allowed for some breakthroughs, such as the discovery of an electron density peak in the lower ionosphere never seen before [7] or an unprecedented characterization of the nightside ionosphere [5].

In the talk we will show how Mars Express has advanced our knowledge of the ionosphere describing its most relevant ionospheric discoveries. Complementarity with other missions will also be discussed.

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