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Mars-Solar wind interaction: coupling between hybrid and exospheric models

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Abstract

Solar wind interacts efficiently with Mars, it contributes to the erosion of the gazeous envelope and concurs to the atmospheric dynamic. The electromagnetic coupling with the neutral environment takes place with ionization processes which act as a catalyzer. A three-dimensional model has been developped to describe the solar wind and planetary plasma dynamic. Parallelization of the model has been accomplished and enable us to reach a grid resolution of 80 km or less, which are slightly more than plasma scale height in the ionophere. This model has been coupled to a three dimensional exospheric model giving the description of the neutral corona at different seasons. The seasonal effect of the thermosphere-exosphere on the Martian plasma environment is investigated and discussed in this presentation.

1. Introduction

The solar wind interaction with the Martian neutral environment is investigated by means of three dimensional hybrid simulations. In such formalism, ions have a kinetic description while electrons are treated as an inertialess fluid, ensuring the neutrality of the plasma and contributing to currents and pressure terms. This model has been successfully used to describe the near ionized environment of Mars [1, 2, 3]. The main drawback of the hybrid formalism is the coarse spatial resolution that a sequential program with a uniform grid description can afford (about 130-150 km), mainly restricted by computational limitation (memory and CPU). In the frame of the HELIOSARES project (PI F. Leblanc) dedicated to the modeling of Mars environment (neutral and charged species) from the lower atmosphere to the solar wind, a modeling effort of parallelization has been conducted. In parallel, developments concerning a three-dimensional exospheric model have been performed. Such model allows providing a description of the Martian exosphere of CO_2 and O from the exobase level to few Martian radii [4].

2. Methodology

In a similar approach than [5], simulations outputs of the exospheric model have been used as inputs of the hybrid model. A realistic and three dimensional description of the neutral environment is therefore used to constrain the production in the hybrid model.

2.1 The exospheric model

This model provides the description of thermal exospheric components (O, CO, CO_2 and O_2) as well as a description of non-thermal oxygen component. The non-thermal oxygen contribution is estimated by means of a Monte-Carlo approach with a description of the thermosphere determined by the general circulation model LMD-MGCM [6]. The contribution of the thermal part of the exosphere is obtained by using a Chamberlain approach extended to three-dimension and adapted to include planet's rotation. Simulation results of this model are presented in [4].

2.2 The hybrid model

The hybrid model used in this work has been presented in[1], parallelized and completed with a realistic ionsopheric description with the implementation of a simplified chemistry model [7]. An updated version of the model with a crustal field description is presented by [8]. This simulation model provides a description of the electromagnetic environment and the dynamic of 6 ion species (H^+_{sw}, He^{++}, H^+_{pl}, O^+, CO_2^+ and O_2^+). Simulations are performed on a meso-scale calculation server CICLAD (http://ciclad-web.ipsl.jussieu.fr) dedicated to Institut Pierre Simon Laplace modeling effort : The project has access to 5 servers of 32-cores with 4Go memory per CPU. Communications are perfomed with infinite-band cables.

3. Simulations

Simlations are performed at mean solar activity for both exospheric and hybrid models. The description of CO_2 thermal component is used in the hybrid model while the description of the oxygen corona takes into account both thermal and non-thermal components. Four hybrid simulations corresponding to four exospheric simulations are discussed. The four exopsheric simulations have been performed using a description of the thermosphere representative of the four Martian seasons. This coupling allows us to estimate the seasonal effect of thermosphere-exosphere on the Martian plasma dynamic and identify the influence of diurnal asymetry on the plasma environment.

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