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Hybrid Simulations of Solar Wind Interactions of Mars

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Abstract

In this paper the results of hybrid simulations of Mars will be presented. These simulations include the crustal magnetic fields and examine their role in the solar wind interaction with Mars. The focus is the ionospheric response to differing situations on the ionosphere as well as the ionospheric loss from Mars. A comparison between solar maximum conditions and solar minimum conditions will be presented. Further, the effect of different crustal magnetic field orientations will also be presented.

1. Introduction

One of the major focus points with regard to understanding the solar wind interaction with Mars is how did Mars lose the water that is now known to have existed on this planet? Over the past decades a variety of research groups have begun to address this issue, via spacecraft missions to the planet and via numerical simulations. This paper will address our efforts on simulating Mars. The approach taken is to use a 3-D kinetic simulation called a hybrid particle code (kinetic ions and fluid electrons) and add more and more physics to these models. References [1], [2], [3] are representative of the evolution of our capabilities. As shown in [3], the code now includes the crustal magnetic fields as well as high resolution ionospheric chemistry. In the paper to be presented the interaction of the solar wind with ionosphere of Mars will be discussed with particular focus on the ionospheric loss rates as a function of solar minimum and solar maximum and the effect that the orientation of the crustal magnetic fields to the oncoming solar wind.

2. Discussion

Several interesting questions have already manifested themselves and can be quickly mention to illustrate the focus of this paper and our research. Figure 1 and 2 show the magnitude of **B** as a function of altitude as well as a function of angle from the subsolar point, $\theta = 0°$ to the midnight point, $\theta = 180°$ and clock angle with the poles being at angles (90°, 90°) N and (90°, 270°)S. Other than the neutral density profile and the EUV flux consistent with solar minimum and solar maximum there are no changes in the simulations. Yet, Fig. 1 and 2 show a considerable difference in the magnetic fields particularly in the subsolar region ($\theta = 0°$). The strong crustal fields on the night side and to the south of the solar wind are not affected but one sees strong interaction with the crustal fields on the day side and at the North Pole. Interestingly, the introduction of the crustal magnetic fields strongly influences the solar min. case but not nearly as strongly at solar max. The presence of more extended ionosphere strongly changes the electrodynamics in Mar's ionosphere, as shown by these two figures.

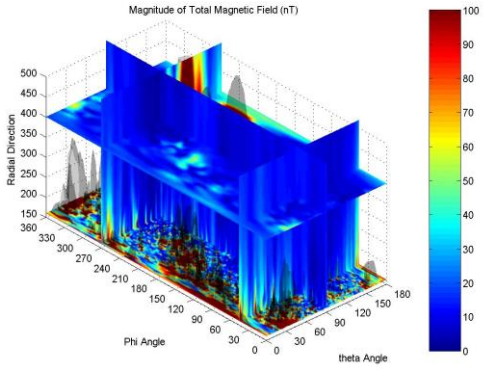

Figure 1: This figure shows the magnitude of B for solar minimum.

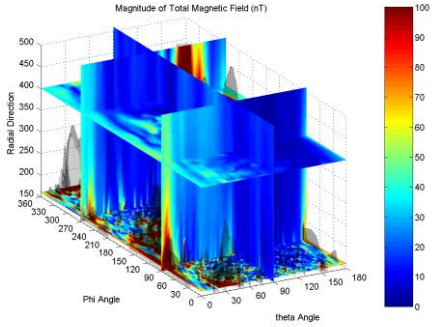

Figure 2: This figure shows the magnitude of B for solar maximum.

3. Summary and Conclusions

In summary we will present further results of our simulations and studies into the solar wind interaction with Mars addressing issues such as alluded to in the discussion section. Further results where the crustal magnetic fields are rotated from the prime meridian, as they are oriented in the previous figures, will be discussed.

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