EPSC Abstracts
Vol. 10, EPSC2015-316, 2015
European Planetary Science Congress 2015

MHD Model Results of Solar Wind Plasma Interaction with Mars and Comparison with MAVEN Observations during Quiet Solar Wind Conditions

Y. J. Ma (1), C. T. Russell (1), A. F. Nagy (2), G. Toth (2), J. S. Halekas (3), J. E. P. Connerney (4), J. R. Espley (4), and P. R. Mahaffy (4), Mehdi Benna (4), James McFadden (5)
(1) Department of Earth and Space Sciences, UCLA, Los Angeles, CA, USA, (2) Department of Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI, USA, (3) Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA, (4) NASA Goddard Space Flight Center, Greenbelt, MD, USA (5) Space Sciences Laboratory, University of California, Berkeley, California, USA (yingjuan@ucla.edu)

Abstract

The Mars Atmosphere and Volatile Evolution mission (MAVEN), launched on November 18, 2013, is now in its primary science phase, orbiting Mars with a 4.5 hour period. In this presentation, we show detailed comparisons between the MHD model results and the relevant plasma observations from MAVEN during quiet solar wind conditions. Through comparison with relevant observation along MAVEN orbits, we find that in general, the time-dependent multi-species MHD model reproduces very well the plasma interaction process around Mars.

1. Introduction

The crustal remanent field on Mars rotates constantly with the planet, varying the magnetic field configuration interacting with the solar wind. It has been found that ion loss rates slowly vary with the sub-solar longitude, anti-correlating with the intensity of the dayside crustal field source, with some time delay, using a time-dependent multispecies MHD model [1]. In this study, we compare our model results with relevant MAVEN plasma observations along the spacecraft orbit during relative quiet solar wind conditions. During the selected time period, MAVEN orbits pass through all different plasma boundaries and regions. Such a comparison is essential in providing a baseline for the general performance of the model.

2. Methodology:

The time-dependent multi-species single-fluid MHD model [1] includes four continuity equations to track the mass densities of the proton and three major ions in Martian ionosphere: O_2^+, O^+ and CO_2^+. All ion species share the same velocity and temperature. The Mars-solar wind interaction is self-consistently calculated in the model by including the effects of the crustal magnetic field, ion-neutral collisions, and major chemical reactions.
We simulate one entire day of plasma interaction using solar wind conditions based on averaged SWIA (Solar Wind Ion Analyzer) observations in the solar wind on Dec 10, 2014 when the solar wind condition is relative steady. The rotation of the crustal field is included in the time-dependent simulation, and Mars rotation axis is set to match the real conditions.

3. Results

Figure 1 shows a three-dimensional view of one MAVEN orbit on Dec 10, from 16 UT to 20 UT. The color on the sphere corresponds to the crustal field magnitude at Dec. 10, 18 UT and the color on the orbit shows the altitude. MAVEN passed by the center of the plasma wake near 18 UT, 20 min before it flew by periapsis. Figure 2 shows trajectory information of MAVEN (latitude, SZA, altitude) and comparison of the density, velocity and magnetic field with relevant plasma observations along MAVEN orbits for Dec 10, 2014. During each orbit, MAVEN spent roughly half of the time in the solar wind. The good agreement of the plasma density, velocity and magnetic field demonstrates that the MHD model used here can reproduce the plasma interaction process around Mars very well.

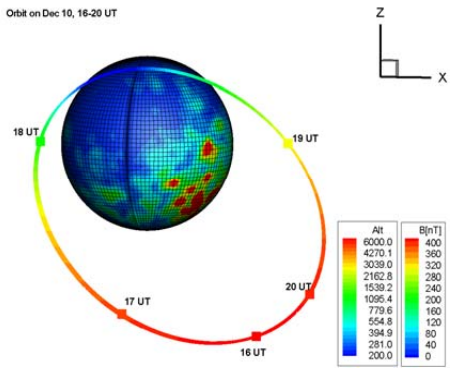

Figure 1: 3D view of MAVEN Trajectory from 16UT to 20UT on Dec 10, 2014.

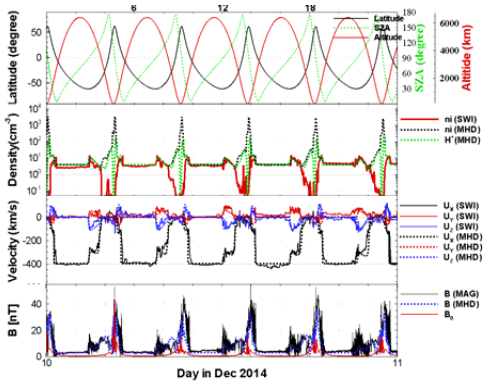

Figure 2: Trajectory information of MAVEN and comparison of the density, velocity and magnetic field with relevant plasma observations along MAVEN orbits for Dec 10, 2014. The solid lines are observations; the dashed lines are from model results.

4. Summary and Conclusions

Through comparison with relevant MAVEN plasma observations, we find that in general, the time-dependent multi-species MHD model reproduces quite well the plasma interaction process around Mars. The bow shock location and plasma conditions inside the magnetosheath region from the model results agree well with SWIA data. The density profiles predicted by the model agree well with both NGIMS and STATIC measurements. We also find that there are some discrepancies between the MHD and the observed magnetic field in the magnetic pile up region. To improve the fit, the model needs to update the neutral density profiles based on MAVEN observations, and photo-ionization rates from the modeled EUV spectrum.

References

[1] Ma, Y., X. Fang, C. T. Russell, A. F. Nagy, G. Toth, J. G. Luhmann, D. A. Brain, and C. Dong: Effects of crustal field rotation on the solar wind plasma interaction with Mars, Geophys. Res. Lett., 41, 6563–6569, doi:10.1002/2014GL060785, 2014