R009-17
B 会場 ：9/27　AM1 （9:00-10:30）
9:45〜10:00

#坂田　遼弥 [1],Sun　Wenyi[2],Ma　Yingjuan[2], 関　華奈子 [3],Russell　Christopher T.[2], 寺田　直樹 [1], 堺　正太朗 [1,4], 品川　裕之 [5]
([1] 東北大・理・地球物理学専攻,([2] カリフォルニア大学ロサンゼルス校,([3] 東大理・地球惑星科学専攻,([4] 東北大・理・惑星プラズマ・大気研究センター,([5] 情報通信研究機構

Comparison study of two global multispecies MHD models of Mars

#Ryoya Sakata[1],Wenyi Sun[2],Yingjuan Ma[2],Kanako Seki[3],Christopher T. Russell[2],Naoki Terada[1],Shotaro Sakai[1,4],Hiroyuki Shinagawa[5]
([1]Department of Geophysics, Graduate School of Science, Tohoku University,([2]University of California, Los Angeles, CA, USA,([3]Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo,([4]Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University,([5]National Institute of Information and Communications Technology

Atmospheric escape to space has played a key role in atmospheric evolution and climate change on Mars. As direct and global interactions occur between the solar wind and the upper atmosphere due to lack of a global intrinsic magnetic field, the global configuration of the plasma environment around Mars is required for understanding of atmospheric escape. The spacecraft observations in recent decades have revealed the plasma dynamics significantly, but the global picture cannot be fully captured by only in-situ observations due to temporal and spatial limitations. The global simulation is another important tool to study the solar-wind Mars interactions. Various plasma phenomena have been investigated based on numerical simulations. However, there are still discrepancies not only between simulations and observations, but also among different simulation models. In a comparative study of several numerical models for Mars, the simulation results showed large differences in plasma distributions and ion escape rates, although the models used the same upstream inputs and the neutral atmosphere (Brain et al., 2010). The differences can arise from various factors. The extent to which physical processes are taken into account is a model-dependent issue. Simulations can also be affected by model assumptions (e.g., magnetohydrodynamics, MHD, or hybrid) and numerical implementations (e.g., numerical scheme and grid system).

The purpose of this study is to understand how numerical simulation can be affected by considered physical processes and numerical implementations. We compared two global multispecies MHD models: the "Sun model" based on the BATS-R-US (Sun et al., 2023) and the "Sakata model" based on a newly developed multifluid model (Sakata et al., in prep). Both models consider five ion species (planetary H^+, O^+, $O_2{}^+$, $CO_2{}^+$, and solar wind H^+). We used the typical upstream conditions and neutral atmosphere on present Mars and adopted the same chemical reactions, collision frequencies, and inner boundary conditions. Crustal magnetic fields were not included. In addition to the comparison, we also surveyed the effects of two physical processes: electric resistivity and photoelectron heating. Two types of simulation were performed for the effects of resistivity: simulations with resistivity and those without resistivity. For photoelectron heating, we assumed three heating rates: 0.3 eV, 1 eV, and 5 eV per photoelectron. The baseline case includes the resistivity and assumed 1 eV photoelectron heating.

In the baseline case, the simulation results show good agreement between the two models. The 1D profiles along the subsolar line are nearly identical, including the shock location, the magnetic pileup, and the ionospheric composition, indicating the consistency of the two models. However, there are some discrepancies in the trans-terminator and nightside dynamics. The escape rates of planetary ions are also in good agreement. Both resistivity and photoelectron heating affect the ionosphere. The inclusion of resistivity changes the magnetic configuration in the ionosphere via magnetic diffusion. Photoelectron heating is an important energy source and increases the plasma temperature. These effects change the escape rates of molecular ions largely. We will report the detailed analysis on the differences between the two models' results and the effects of resistivity and photoelectron heating.

References

Brain, D., Barabash, S., Boesswetter, A., Bougher, S., Brecht, S., Chanteur, G., et al. (2010). A comparison of global models for the solar wind interaction with Mars. Icarus, 206(1), 139 – 151. https://doi.org/10.1016/j.icarus.2009.06.030

Sun, W., Ma, Y., Russell, C. T., Luhmann, J., Nagy, A., & Brain, D. (2023). 5-Species MHD study of Martian proton loss and source. Journal of Geophysical Research: Space Physics, 128, e2023JA031301. https://doi.org/10.1029/2023JA031301