R009-29
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Dependence of ion escape from Mars on ancient solar XUV and solar wind conditions

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Observations of G-type stars indicate that the young Sun emitted stronger X-ray and extreme ultraviolet (XUV) radiation and stronger solar wind than the present Sun (Tu et al., 2005; Wood et al., 2002). Strong solar activity enhance particularly ion escape from a planet and ion escape is one of the candidate processes which have contributed to atmospheric escape and climate change on Mars. However, there is an uncertainty in the stellar XUV flux and the stellar during the early period. To understand and constrain the role of ion escape on ancient Mars, it is needed to investigate how ion escape depends on ancient solar XUV flux and solar wind conditions.
We investigated ion escape from Mars under ancient solar XUV flux and solar wind conditions based on multispecies magnetohydrodynamics (MHD) model of Terada et al. (2009). We assumed two solar XUV conditions: the XUV10 condition where the XUV flux is 10 times higher than the present flux, and the XUV50 condition where the XUV flux is 50 times higher than the present flux. For the solar wind, we also assumed two different conditions. One is the ordinary solar wind conditions where the solar wind density is 70 cm^{-3}, the solar wind velocity is 700 km s^{-1}, and the interplanetary magnetic field (IMF) strength is 6.58 nT, respectively. The other is the strong solar wind conditions where the solar wind density is 700 cm^{-3}, the solar wind velocity is 1400 km s^{-1}, and the IMF strength is 20 nT, respectively. The strong solar wind conditions are an analog of coronal mass ejection (CME) events. We assumed that Mars does not have an intrinsic magnetic field nor crustal magnetic fields. We conducted four simulations with different combination of the XUV conditions (XUV10 or XUV50) and the solar wind conditions (ordinary or strong).
We found that the stronger XUV flux and the stronger solar wind increase the O^+ escape rate. It was three times higher under the XUV50 condition than under the XUV10 condition and 16 times higher under the strong solar wind condition than under the ordinary solar wind condition. The strong XUV flux also increased the escape rates of O_2^+ and CO_2^+. When the XUV flux was weak, i.e. under the XUV10 conditions, however, the strong solar wind increased the O_2^+ escape rate only by a factor of two and decreased the CO_2^+ escape rate. This is because the nightside ionosphere was compressed by a strong return flow in the wake region. The strong return flow might be attributed to the plasma transport into the nightside and the magnetic reconnection in the tail region.

References

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