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Response of the Martian thermosphere to the EUV flux enhancement during solar flare events with a GCM

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The Martian oxygen corona in the exosphere consists of non-thermal oxygen atoms (O∗) produced mainly by the dissociative recombination of O2+ ions produced in the lower thermosphere/ionosphere. The dissociative recombination is the major process of the Martian atmospheric escape in the present solar condition. This means that, in order to calculate the accurate escape flux of O∗, it is needed to understand not only the spatial distribution of O∗ in the exosphere but also the behavior of O2+ in the thermosphere/ionosphere. Many researchers have indicated the dependence of temperature, wind, and composition distributions in the Martian upper atmosphere on long-term variations of the solar EUV flux e.g. solar maximum-to-minimum activities [e.g., Bougher et al., 1991]. Recently, observations by Mars Global Surveyor (MGS) indicated that the Martian lower ionosphere varied significantly in association with enhancement of the solar X-ray and EUV flux range during a solar flare [Mendillo et al., 2006]. It may suggest that the Martian thermosphere also vary largely in association with short-term variations of the solar X-ray and EUV flux. It is also shown time-dependence of terrestrial planet thermospheres on instantaneous variations of the solar EUV flux [Bougher et al., 1999]. This work indicates that time-dependent of each planet thermosphere are different because of difference of main cooling processes. Moreover, it is indicated that temperature of the past Martian thermosphere was much larger, because the solar X-ray and EUV flux of the early sun was more powerful [Valeille et al., 2010]. Solar flares were also more powerful in the early sun, so response of the Martian thermosphere to short-term variations of the solar X-ray and EUV flux may be different from that of the solar X-ray and EUV flux in the present solar condition.

In this sudy, we investigated response of the Martian thermosphere to the short-term variations of the solar X-ray and EUV flux with a Martian Global Circulation Model.

1.This Martian GCM calculates enhancements of the temperature and scale height at the sob-solar point of the exobase by about 42 K and 13 km, respectively, when the solar X-ray and EUV flux (1-20 nm) increases 60 times as much as the usual one for an hour. In this study, variations of the global mean temperature and scale height were 80 K and 27 km, respectively, during a solar cycle. This means that the temperature and scale height of the Martian upper atmosphere would increase by about 50 % during a big solar flare event even in the present condition.

2.This Martian GCM calculates enhancements of the temperature at the sob-solar point of the exobase by about 20 % (42 K) for 2 hours, and it takes 9 hours to decrease to the value of steady state. On the other hand, the Venusian GCM, which was updated by changing the Martian parameter to Venusian parameter, calculates enhancements of the temperature at the same point by about 31 % (63 K) for 1.25 hours, and it takes 3 hours to decrease to the value of steady state. This means that increasing rate of temperature of Venusian thermosphere is larger than that of Martian thermosphere, while time variation of the Venusian thermosphere to the solar X-ray and EUV flux enhancement is shorter than that of Mars, because of deference of main cooling processes.

3.This Martian GCM produces the Martian thermosphere when solar X-ray and EUV/UV flux increases between twice and 20 times. In this state, we simulate the same solar X-ray and EUV flux enhancement of the present sun’s flare. This model calculates enhancements of the temperature at the sub-solar point of the exobase by about 59 % (205 K). This means that effects of solar flares in the early sun on the Martian thermosphere might be larger 3 times than that in the present solar condition.

Keywords: Mars, thermosphere, solar flare, Venus