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Response of the Martian thermosphere and ionosphere to short-term variations of the solar X-ray and EUV flux

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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 the escape flux of O∗ on response of temperature, wind, and composition distributions in the Martian upper atmosphere to long-term variations of the solar EUV flux e.g. solar maximum-to-minimum activities and seasons [Valeille et al., 2009]. 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]. Mendillo et al. [2006] showed that the enhancement of the solar X-ray flux (1.8-5 nm) range caused increase in the production rate of O2+ twice as much as the averaged cases during a big solar flare event at 110 km altitude. Moreover, recent models simulated the increase in the escape flux of O∗ from the Martian atmosphere, when the solar wind dynamic pressure was suddenly increased [Kaneda et al., 2009]. Kaneda et al. [2009] indicated that the escape rate of O∗ correlated negatively with the solar wind dynamic pressure (Psw) under steady state conditions, whereas the escape rate of O∗ correlated positively with Psw for a nonstationary condition because of the difference of variations of the ionopause. Therefore, in order to understand dependence of the Martian exosphere on the variations of the thermosphere/ionosphere and the spatial distribution of the Martian oxygen corona and escape of the Martian atmosphere, it is very important to estimate responses of the thermosphere/ionosphere to short-term variations of the solar X-ray and EUV flux and Psw, which are significantly different from those to the long-term variations.

A general circulation model (GCM) of the Martian thermosphere/ionosphere has been developed from the Venusian thermosphere GCM (VGCM), which has been developed at Tohoku University. This Martian GCM calculates wind, temperature and composition distributions in the Martian upper atmosphere (100-200 km altitude region) solving the conservation equations of momentum and energy and the continuity equation of composition. The distributions calculated by this GCM are in agreement with previous simulations and observations [e.g., Bougher et al., 1990]. In the present study, we investigate the response of neutral and ion densities in the Martian thermosphere and ionosphere to short-term variations of the solar X-ray and EUV flux (0.1-5 nm). This GCM will make it possible to investigate the responses of the Martian exosphere or escape flux to various solar activities, e.g., solar flares by coupling this GCM with an exospheric model [e.g., Kaneda et al., 2009].

Keywords: Mars, Thermosphere, Ionosphere, General Circulation Model, Solar flares