Zonal wind acceleration in the Martian mesosphere during the global dust storm 2018 observed by IR heterodyne spectroscopy

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Recent observations have revealed unexpectedly high abundance of water in the middle atmosphere (1.0 ~ 0.1 Pa), which should affect the atmospheric escape of water to space [Maltagliati et al.,2013]. Heavens et al. [2018] also found that the water vapor abundances in the middle atmosphere are further enhanced during the global dust storm (GDS). However, the detailed picture of the middle atmosphere during the GDS is not yet addressed, even though it is proposed that an intensified meridional circulation may transport water vapor to the middle and upper atmosphere effectively [Shaposhnikov et al., 2019].

On June 2018, the GDS occurred on Mars. The growth phase of the dust storm is June(solar longitude, Ls=196-202°)and the decay phase is August(Ls=220-240°)[Aoki et al.,2019]. It is also suggested that the dust particles were lifted to about 80 km [Fedorova et al.,2020], and equinoctial Hadley circulation reinforced by the GDS transported the water vapor to 100 km [Aoki et al.,2019].

In order to understand the mesospheric response during the dust storm, we have performed the direct measurement of mesospheric zonal winds and temperature from June to September 2018 by ground-based infrared heterodyne spectroscopy. The field of view is 4 arcsec for Martian angular diameter 20 arcsec. The observed CO_2 non-local thermodynamic-equilibrium (non-LTE) emission lines at 10 micron are originated from the mesosphere, peaking at ~ 80 km (~ 0.15 Pa) altitude [Lopez et al., 2011]. The kinetic temperature was derived from doppler width of the emission line and zonal wind velocity was directly derived from line-of-sight doppler shift of the emission line.

The observed kinetic temperature is 140 K from June (Ls=197) to September (Ls=242). Simultaneous observation by MAVEN/IUVS shows a good agreement with this study. On the other hand, zonal wind velocities derived from our observations during the GDS is retrograde 220 m/s from June to September. It is about twice as strong as a few remote sensing measurements of the mesospheric winds during a clear sky [Moreno et al., 2009; Sonnabend et al., 2012]. The uncertainty of retrieved value was roughly estimated to be 49% for kinetic temperature and 46% for zonal wind due to the fitting error, pointing error, and wavelength calibration uncertainty.

We investigate the mechanism to accelerate the zonal wind during the GDS by comparing with simulations by the Martian general circulation model (MGCM) [Medvedev et al.,2013]. MGCM suggested stronger retrograde winds around 0.1 Pa during MY25 GDS than clear sky at the equator, which agrees with this study. We concluded that one of the plausible mechanisms to accelerate the equatorial retrograde winds is intensified meridional advection from the southern hemisphere to the northern hemisphere during the GDS.

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