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Mars mesospheric zonal wind at global dust storm 2018

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The temperature and density profiles observed in the middle to upper atmospheres on Mars show substantial perturbations resulting from superposition of various atmospheric waves, including the gravity waves (GWs). GWs are known to play an important role in determining the general circulation in the middle atmosphere by dynamical stresses caused by GW breaking. Recent MAVEN also revealed that the observed wavelike perturbations in the upper atmosphere likely represent upward propagating GWs of tropospheric origin (Nakagawa et al., under revision). Numerical simulations demonstrated that the filtering effect by background winds plays a major role in the vertical propagation of GWs generated in the lower atmosphere. The processes and dynamics in the middle atmosphere have thus an important role on the regional coupling between lower and upper atmosphere. Yet, very few direct measurements have been performed so far, and the general circulation in the middle atmosphere on Mars relies on General Circulation Models (GCMs). Recent studies have highlighted the efficiency of mass transport from the lower to upper atmospheric reservoir and increase of the atmospheric water loss in the southern summer, which happens to be a dusty season (at a solar longitude, Ls, of 240 degree or later). Answering questions about the atmospheric coupling between lower and upper atmosphere and their links with dust activities in the troposphere is a key to an understanding the mechanisms of the mass transport into the upper atmosphere.

Sonnabend et al. (2002) reported zonal wind measurements at about 80 km altitude around northern spring equinox, by using mid-IR wavelengths heterodyne technique which provides 10-100 times improved spatial resolution over sub-mm or radio observations. They showed highly variable nature of the winds in the range between 180 m/s prograde to -94 m/s retrograde. At present, the source to drive the variability has yet to be fully quantified. Currently, a very strong dust storm has developed on Mars for the first time after the previous one occurred in 2007. This is a rare opportunity to observe drastic changes in the Martian atmosphere under such a strong dust storm. Here we present direct observations of Mars zonal wind velocities around northern fall equinox to northern winter during Mars Year (MY) 34 global dust storm.

Observations were carried out using Mid-Infrared Laser Heterodyne Instrument (MILAHI) at the Tohoku-0.6m dedicated telescope Facility on Haleakala, Hawaii for continuous monitoring. A detailed description of the instrument is given by Nakagawa et al. (2016). On 27 June 2018 (Ls = 200 deg), we observed Mars whose angular diameter to be ˜20.6 arcsec against the diffraction-limited field of view (FOV) of the telescope of ˜4.3 arcsec. The acquisition time for an individual spectrum was ˜5 min. Spectra were co-added to achieve a sufficient signal-to-noise ratio. The instrument beam has been switched during observing run between limb-geometry at the equatorial dayside limb and nadir-geometry at the martian disk center, in order to extract the zonal wind-doppler effect. The retrieved wind velocities was found to be -48〜-56 m/s, which is basically in an agreement with previous study. To assess implications of the observations, we will perform simulations with a high-resolution MGCM which captures life cycles of a significant portion of small-scale GWs including generation, propagation, and dissipation.

This massive dust storm could engulf Mars for months. We will be continuing to monitor the middle atmosphere. The next campaign will be performed during 22 August and 6 September 2018 (Ls = 240 deg), while the dust continues to slowly settle out of the atmosphere. In this paper we will also introduce the coordinated observations by ALMA. Our ToO observations have been successfully performed on 30 June and 16 July 2018.