Retrieval of vertical structure in the Martian atmosphere during 2007 global dust storm by OMEGA/MEx limb observation

*Risei Kogure[1], Arnaud Mahieux[2,3], Hiromu Nakagawa[1], Shohei Aoki[2], Yasumasa Kasaba[1], Nao Yoshida[1]

1. TOHOKU University, 2. Belgian Institute for Space Aeronomy (BIRA-IASB), 3. University of Texas at Austin, USA

Recent studies have revealed an unexpected high abundance of water vapor in the middle atmosphere that supposedly drives the enhancement of the atomic hydrogen escape (Chaffin et al., 2017; Fedorova et al., 2018, 2020, Heavens et al., 2018; Vandaele et al., 2019; Aoki et al., 2019). However, it is unclear how to extract water vapor from the lower atmosphere and place it in the middle atmosphere since water vapor is limited in its vertical propagation by the cold trap of its condensation level. The cold trap leads to water freezing out, confining water in the lower atmosphere. It has been proposed that an inflation of the lower atmosphere due to the sunlight absorbed by the upsurge of dust associated with intensified meridional circulation can transport water vapor effectively into the middle atmosphere (Aoki et al., 2019; Neary et al., 2019). A comprehensive picture of the water transport and the background atmospheric condition in the middle atmosphere is yet to be established. Two-dimensional local distribution of physical parameters can contribute to clarify the transient phenomena, such as rocket dust storm (Spiga et al., 2013).

In this study, we aim to present the 2D vertical structures of water vapor, dust opacity, and CO_2 non-LTE emission in the periods of 2007 global dust storm (Ls = 265-305) using the OMEGA limb observation onboard Mars Express. The indexes of water-vapor, dust opacity are obtained from the wavelength ratio between 2.50 and 2.64 micron (Maltaliati et al., 2011), and the radiance at 2.70 micron (Fouchet et al., DPS, 2004), respectively. CO_2 non-local thermal equilibrium (LTE) emission is detected at 4.3 micron (Piccialli et al., 2016). From the slope of the observed spectrum between 0.5 and 3.0 micron, the effective radius of aerosol particles can be estimated. As the reference, observations during the global dust storm in orbit#4483 (Ls = 268) and orbit#4621 (Ls = 292) is compared with that at clear-sky season in orbit#291 (Ls = 17) and orbit#685 (Ls = 68).

We show a significant increase of water vapor up to ˜60 km altitude during the global dust storm, as reported by recent studies (Vandaele et al., 2019; Aoki et al., 2019; Fedorova et al., 2020). Our result suggests the concentration of water vapor in 40-60 km altitudes. This is totally different from that at orbit#685 at clear-sky season, which shows the confined water vapor up to ˜40 km altitude.

The slopes of observed spectra suggest larger particle size during the global dust storm at orbit#4483 (˜1.0 micron) than that in the clear-sky at orbit#291 (˜0.4 micron). This is comparable with previous studies (Oliva et al., 2018; Clancy et al., 2019). We find that such large aerosols reach into the mesosphere.

We confirmed that the CO_2 non-LTE emission peaks at higher altitudes (100-120 km) during the global dust storm in orbit#4483 (The statistical analysis can be found in Piccialli et al. (2016)). This result basically suggests about 20 km increase of peak altitudes comparing with that in the clear-sky at orbit#291. This can be explained by the heating by absorption of incoming sunlight via suspended dust particles.

We intend to discuss the physical parameters, such as water vapor amount, dust opacity etc by using JACOSPAR (Iwabuchi and Yang, 2011; Iwabuchi et al., 2016), which is a multiple scattering radiative transfer code that uses the backward-propagating Monte Carlo method, and the dependent sampling approach in order to reduce the computation time.

Keywords: Mars, Dust storm, vertical profile, OMEGA