R009-26
Zoom meeting D ：11/2 AM1 (9:00-10:30)
9:45～10:00

TGO/NOMAD からリトリーバルした火星中間圏・下部熱圏の CO/CO2 分布の変動

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Variation of CO/CO2 profiles in the Marian mesosphere and lower thermosphere retrieved from TGO/NOMAD

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CO is produced by the photodissociation of CO_2 and recycled to CO_2 by the catalytic cycle involving HOx in the Martian atmosphere [e.g., McElroy & Donahue, 1972]. In the mesosphere and lower thermosphere (MLT) region of Mars, the number density of CO is determined by the photodissociation, eddy diffusion, and atmospheric circulation. The increase in the CO mixing ratio in the MLT region and further enhancement in the polar region due to the transport of CO-enriched air via meridional circulation are predicted in 3D models [Daerden et al., 2018; Holmes et al., 2019]. On the other hand, the decrease in the CO mixing ratio in the MLT region during a global dust storm is discovered by the Atmospheric Chemistry Suite (ACS) aboard Trace Gas Orbiter (TGO), which suggests that the increase in the hygropause altitude due to the global dust storm leads to the increase in the vertical range over which OH becomes available to convert into CO_2 [Olsen et al., 2021]. Additionally, a substantial variation in the homopause altitude has been found by recent studies [Slipski et al., 2018; Jakosky et al., 2017; Yoshida et al., 2020], which suggests that the order of magnitude changes in the eddy diffusion coefficient at the homopause altitude [Slipski et al., 2018]. It implies variations in the profile of CO mixing ratio in the MLT region. However, the effects of change in the eddy diffusion coefficient on the profile of CO mixing ratio have not been investigated.

To clarify the contributions of photochemistry, eddy diffusion, and atmospheric circulation to the CO/CO_2 profiles in the MLT region, we use the Nadir and Occultation for MArs Discovery (NOMAD) instrument aboard TGO. NOMAD solar occultation is designed as the combination of the Acousto Optical Turnable Filter and echelle grating [Neefs et al., 2015; Thomas et al., 2016]. NOMAD solar occultation operates in the wavelength range of 2.2 - 4.3 μm (2320 to 4350 cm^{-1}) with a high spectral resolution ($\lambda/d\lambda$ = 20000) [Vandaele et al., 2018]. It provides us CO and CO_2 spectra below 100 km and 180 km altitudes, respectively.

In this study, we applied the equivalent width technique [Chamberlain and Hunten, 1987; Krasnopolsky, 1986] to derive a new set of CO and CO_2 column densities with the observed atmospheric transmittance spectra by NOMAD solar occultation. The absorption lines at 4285.0, 4288.2, and 4291.5 cm^{-1} for CO (2-0) band and 3358.7, 3364.9, and 3366.4 cm^{-1} for CO_2 (21102-00001) band are carefully selected for retrievals to avoid the contamination of absorption lines from the nearby diffraction orders [cf. Liuzzi et al., 2019]. It is noted that the line strengths of the selected CO_2 have high sensitivity to the background temperature. We assumed the vertical profiles of temperature simulated in the GEM-Mars model [Neary et al., 2018; Daerden et al., 2019]. We retrieve the CO and CO_2 slant column densities between 60 and ˜100 km altitudes because those slant opacities are saturated below 60 km altitude. The CO and CO_2 spectra observed from April 2018 to September 2020, corresponding to from MY 34 L_s ˜150 to MY 35 L_s ˜280, are investigated.

We found that the retrieved CO/CO_2 ratio between 60 and ˜100 km increases with altitude. The decrease in the CO/CO_2 ratio over the whole altitude range during the global dust storm corresponds to the previous observations [Olsen et al., 2021]. In addition, we found that the CO/CO_2 profiles vary with season and latitude. The slope of CO/CO_2 profiles is about two times larger in L_s = 240 - 270 (southern summer season) than in L_s = 120 - 150 (southern winter season). For interpretation, a 1D photochemical model is compared with newly obtained CO/CO_2 profiles, especially in order to discuss the contributions from the variations in eddy diffusion coefficient and photochemistry in the MLT region of Mars. When we assume a constant eddy diffusion profile of 10^7 cm^2s^{-1}, the CO/CO_2 profile in L_s = 120 - 150 is reproduced. Furthermore, the CO/CO_2 profile in L_s = 240 - 270 is reproduced when we assume a higher eddy diffusion profile by one order of magnitude. The ranges of eddy diffusion coefficient support the recent study by Slipski et al. (2018).