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General circulation and dynamics of Martian middle atmosphere

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For the Martian atmosphere, there are much less observational data of middle atmosphere (60-130 km altitude) in comparison with the lower (0-60 km altitude) and upper (higher than ˜130 km altitude) atmosphere. But recent studies using the limited observational data and numerical simulations show the importance of middle atmosphere sciences for the climate change and atmospheric escape of Mars.

Atmospheric dust and water on Mars are transported by the meridional circulation. Studies using Mars General Circulation Models (MGCMs) show the seasonal changes of the meridional circulation due to the distance from the Sun and the effects of topography. Especially in southern summer when it is close to the perihelion, the atmospheric temperature becomes globally higher than in northern summer, which is thought to allow the water vapor to go higher and enhance the meridional transport of water from south to north. Moreover, planet-encircling dust storms sometimes occur in southern summer, which is thought to strongly enhance the meridional circulation due to the strong radiative heating by dust in southern hemisphere. But we have never done the mapping of the temperature and wind fields of the middle atmosphere to prove these hypotheses.

The stellar occultations by SPICAM onboard Mars Express have detected several vertical profiles of temperature in the middle atmosphere. In most of the observed profiles the temperature around the height of ˜100 km goes below the CO_2 condensation level, which indicates the existence of CO_2 ice clouds in the height of 60-100 km. Actually cameras onboard Mars Express and Mars Odyssey have observed the CO_2 ice clouds, and the clouds have also been used to detect the wind velocity of middle atmosphere by the cloud tracking method. Note that the wind velocity of middle atmosphere has also been detected from the Doppler shifts on the molecular lines observed from ground-based sub-millimeter telescopes. But the observed temperature and wind fields of Martian middle atmosphere are not well reproduced by current MGCMs, which, for example, the simulated temperature of mesopause (80-100 km altitude) overestimates in 10-30 K and the simulated easterly wind velocity in low latitude of northern summer is less than half of the observations. These discrepancies are probably because of the lack of the effects of gravity waves from lower atmosphere, underestimations of the atomic oxygen concentration which controls the CO_2 infrared cooling, and so on. Moreover, there are studies which indicate the effects of dynamics and material transport in lower atmosphere on the structures of ionosphere. Investigations of the middle atmosphere are important to understand the atmospheric science connected from the surface to ionosphere.

We are proposing the observational plans of Martian middle atmosphere with the MELOS Meteorological Orbiter, which include the mapping of temperature fields, wind fields and compositions from a sub-millimeter sounder and the tracking of CO_2 ice clouds from cameras. In this presentation we introduce the preceding studies of Martian middle atmosphere, and discuss the significances of the mission plans.

Keywords: Mars, Planetary atmosphere, Atmospheric dynamics, Sub-millimeter observation, Space exploration, MELOS