A Study on Spatial and Temporal Variabilities in the Martian Thermosphere

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Abstract

The primary focus of the present thesis is to investigate and compare the local time, latitudinal, seasonal, and altitudinal variability of heavy (e.g., Ar, CO_2) and light mass species (e.g., He), in the Thermosphere of Mars. The work covered in this thesis starts with a study of the local time variations in heavier species like Ar and CO_2, using measurements from Neutral Gas Ion Mass Spectrometer (NGIMS) aboard the Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft. The results show a persistent local time asymmetry in Ar densities and scale heights (temperatures), wherein the densities during the dusk hours are larger than those in the dawn hours at all altitudes. Ar being a heavy species and small in scale height is mostly affected by the dynamical heating and cooling of the atmosphere. Since the observations used in this study are from two different seasons, to validate these results, we further investigated the dawn-dusk asymmetry by using the measurements from same season. This constitutes the second study in this thesis. This was done using simultaneous measurements from Mars Exosphere Neutral Composition Analyser (MENCA) aboard the Mars Orbiter Mission (MOM) observing dusk side and NGIMS observing the dawn side of Mars. Moreover, these measurements fall during the growth phase of a Planet Encircling Dust Event (PEDE) in June 2018, which helped us to understand the effect of lower atmospheric processes on the steady-state of the upper atmosphere and hence the coupling between the lower and upper atmosphere. The results of the study show that not only do the dawn-dusk asymmetries persist in the same season, but they are enhanced due the radiative heating in the lower atmosphere and by the subsequent expansion of the thermosphere associated with the PEDE–2018.

In the third work, we focus on understanding the spatial and temporal distribution of the lighter species in the Mars thermosphere, using Helium (He) measurements from NGIMS. The accumulation of He in nightside winter polar and the equinoctial southern high latitude regions indicates that the lighter species are primarily controlled by the global circulation at the thermospheric altitudes on Mars. A comparative picture of spatial and temporal variations in different mass species is further presented in the fourth work, where diurnal and latitudinal variations in the mixing ratio of He, N_2, Ar with respect to the dominant species (i.e., CO_2) are studied. In addition, we investigated the response of mixing ratios to the dust storm season of MY 33 and 34 (PEDE-2018). During PEDE-2018, mixing

ratios show strong depletion compared to the dust storm season of MY 33. In addition, the variability in mixing ratios shows an anti-correlation with the trend in CDOD. The depletion factor is found to vary with the varying masses of mixing ratios. While on the day side variability in mixing ratios seems to be controlled by the seasonal variation in homopause altitude, a weak correlation on night side suggests the contribution of different processes. Changes in the atmospheric circulation during dust storm season combined with mass-dependent behavior of thermospheric species are most likely to affect the nightside variability of Mars.