Tropical and orographic clouds and their association with dust aerosols

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Abstract:

Dust and water ice have an intricate relationship, where dust particles may impact the water ice both dynamically and microphysically [1, 3, 6]. The dynamical relationship between dust and water ice is emphasized in several studies, which is not valid for the dust-cloud microphysical interaction, and most of the previous studies assumed homogenous nucleation [2, 5]. The microphysical interaction between dust and water ice enables water vapor saturation at comparatively lower altitudes with larger particle sizes, primarily within -10–30°N latitudes during the aphelion period. Therefore, we have analyzed the evolution of the tropical cloud belt (TCB) within northern spring and summer (solar longitude (L_S) ~45–135°) using the observations from Mars Climate Sounder onboard Mars Reconnaissance Orbiter [4]. A northward evolution of the cloud belt is observed starting from L_S ~76°, which is the peak phase of the TCB. This variation does not show any noticeable match with the air temperature. However, a possible influence from the upper-tropospheric (~18–35 km altitude) dustiness is observed, which significantly correlates with the TCB's northward evolution. The mechanism observed is supported by the amplitude of migrating semidiurnal tide (SMD) as a proxy of dust forcing and the estimated upper tropospheric dust-driven energy from the density-scaled opacity (Figure 1). Both of these variables and the column water ice opacity showed an apparent northward movement of their maximum values within the three phases of the TCB.

Furthermore, the orographic clouds being a part of TCB shows a strong association with the high-altitude dustiness. However, this association is only observed in the case of haze clouds during the second half of the year (L_S ~225–315°), and it seems more prominent for the Arsia Mons orographic clouds compared to Olympus Mons. MarsWRF model simulations suggested a dynamical influence of dust-laden vertical transport during the perihelion season, which is insignificant over Olympus Mons and the nearby region.

References:

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Figure:

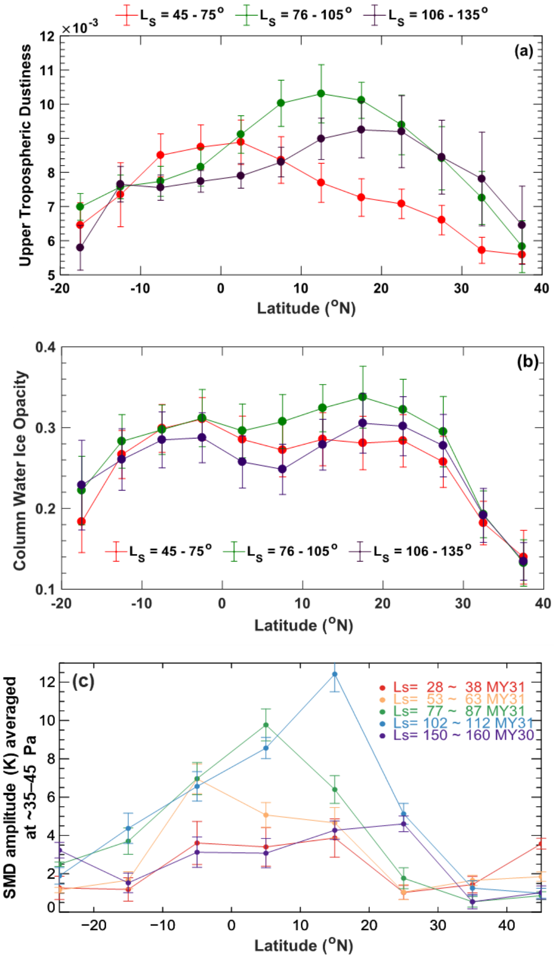

Figure 1. Latitudinal variation of the (a) zonal mean upper tropospheric dust driven energy input (m^2) at 10–40 km altitude, (b) column water ice opacity averaged for MY 29 – 33, and (c) amplitude of migrating semidiurnal tide (K).