Interannual Variability of Dust Storms between Mars Years 24 and 36 and analysis of dust vertical distribution of the MY 34 late-storm

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1. ABSTRACT

Dust storms on Mars cause variations in atmospheric temperatures and dynamics due to direct solar heating and its response. These effects are most intense during the dust storm season (Ls 180º - 360º), when most of the dust transport occurs due to global and regional storms in late boreal winter. Thanks to the measurements taken by the Thermal Emission Spectrometer (TES) onboard the Mars Global Surveyor (MGS) and the Mars Climate Sounder (MCS) onboard the Mars Reconnaissance Orbiter (MRO) it is possible to study the spatial and temporal variability of these storms over the last 12 Martian Years (*Martín-Rubio et al., 2024*). Although each storm must be considered independently, it is possible to observe how the storms occur seasonally following specific recurrence patterns that allow them to be grouped as type A, B and C (*Kass et al., 2016*).

2. METHODS

2.1 TES (MGS) and MCS (MRO) INSTRUMENTS

MGS and MRO satellites both have a near-polar, Sun-synchronous orbit, with measurements centered at 2 A.M./2 P.M. and 3 A.M./3P.M. respectively. In this work we focus on nadir geometry TES observations that provide a vertical resolution of ~3 km extending from the surface to ~40 km for atmospheric temperature profiles. MCS observes the forward limb in the direction of MRO's orbital motion, producing "in-track" measurements. It also takes some "off-track" measurements, looking at different regions or angles relative to the spacecraft's orbital trajectory (Figure 1). Here we use in-track vertical profiles of atmospheric temperature and dust, extending from the surface to an altitude of ~80 km with a resolution of ~5 km.

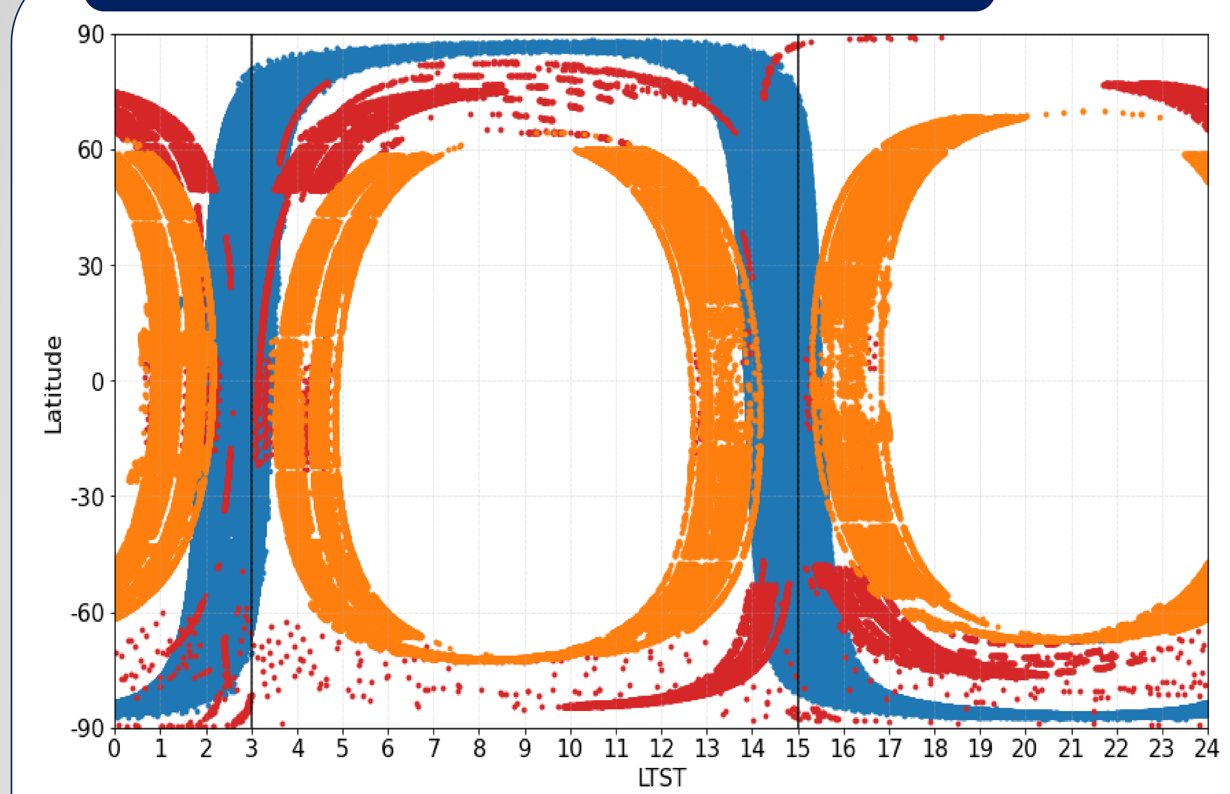


Figure 1. Full-day measurement of the MRO satellite, in-track (blue) and off-track (red and Orange).

3. RESULTS

3.1 TEMPERATURE RESPONSE

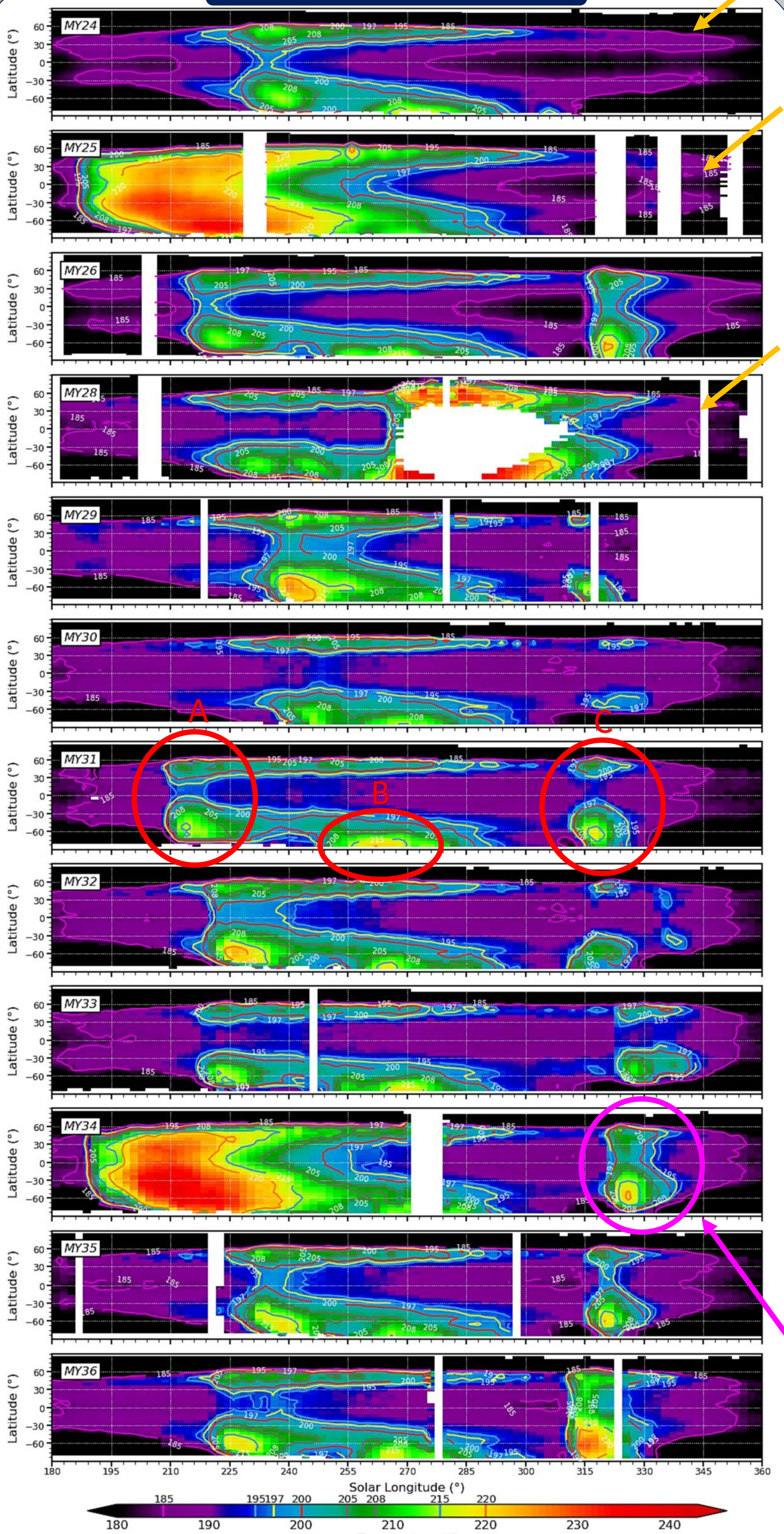
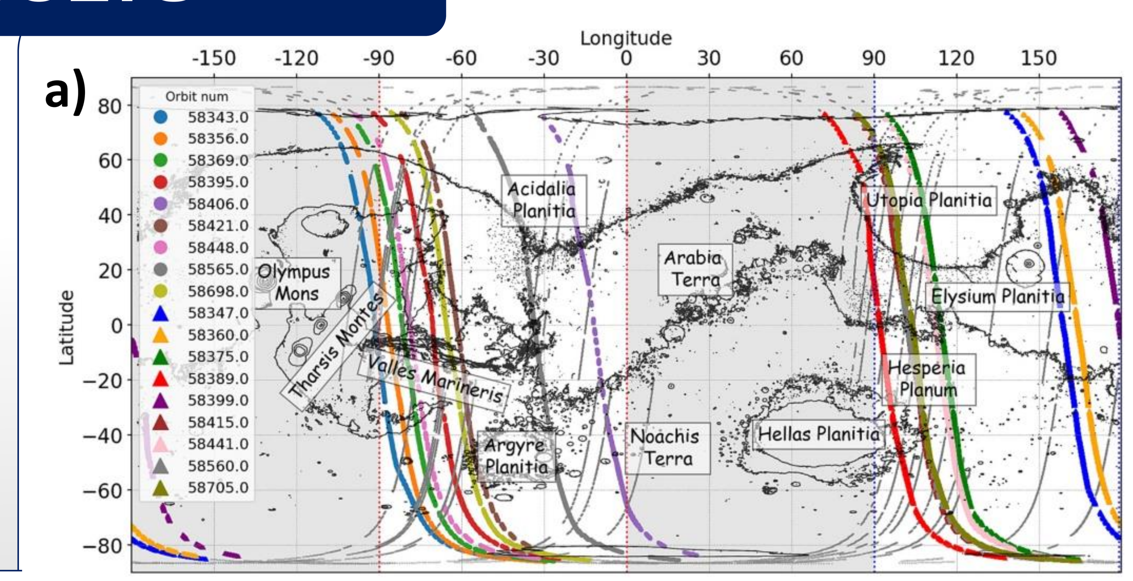


Figure 2. Daytime zonal mean temperature at 50 Pa during the dusty perihelion season for MY 24 to MY 36. MY 24–26 and MY 28–36 are obtained from TES and MCS profiles, respectively. Red circles define storms type A, B and C; yellow arrows the lack of type C storm in temperature response and in pink the MY34 type C storm.

First, we use temperatures around 50 Pa (~25 km) during the dusty season (L_s = 180° - 360°) to perform a time evolution analysis by creating a grid (Figure 2). The maximum values of type A are during L_s = 210° - 240° (210 K to 225 K), of type B during L_s = 250° - 300° (210 K to 220 K) and of type C during L_s = 315° - 350° (197 K to 230 K). We observed that type C storms did not appear in the thermal response figure in years MY 24, 25 and 28 but all of them had late-season a storm (yellow arrows).



Second, we obtain the dust profiles of the C-type storm of the year MY34 for the orbits passing through [-90° to 0°] and [90° to 180°] to analyse the vertical and horizontal displacement of the dust (Figure 3ab). A different vertical distribution of dust has been observed between the two regions: in the western zone the value 0.001 km^{-1} dust extinction exceeds 35 km at all latitudes reaching 45 km, with a greater uplift being observed in the south. The 0.001 km^{-1} dust in the trajectories of the eastern zone reaches altitudes of 35 km, but the east, it is the lower value of 0.0001 km^{-1} that reaches 60 km, creating dust lifts especially in the southern hemisphere.

3.2 VERTICAL PROFILES OF MY34 TYPE C STORM

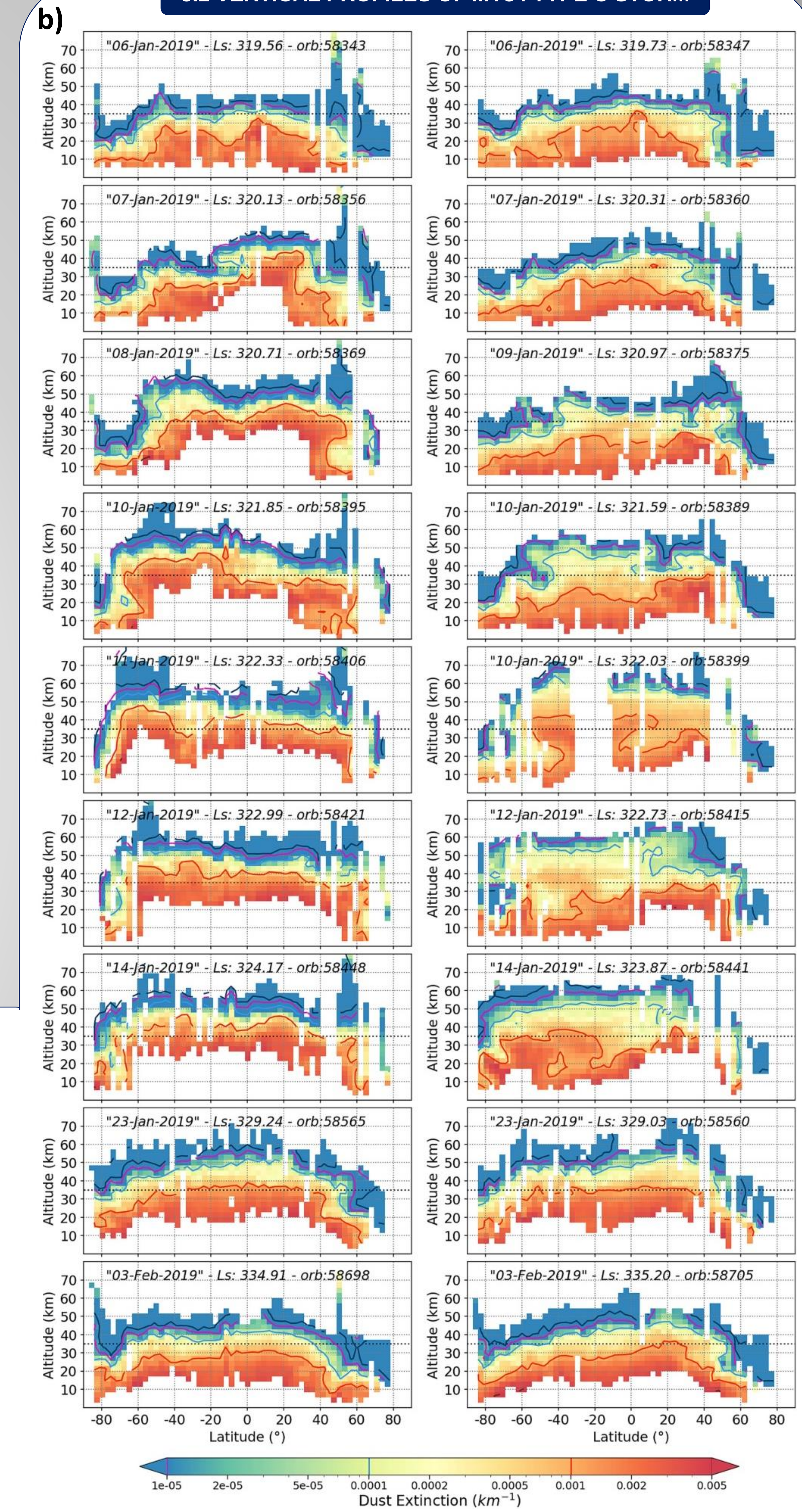


Figure 3. a) Orbits passing through the study area [−90°-0°] and [90°-180°] longitude during the MY 34 type C storm. **b)** Daytime vertical dust distribution as height versus latitude for the selected orbits for zone 1 (left column) and zone 2 (right).

4. CONCLUSIONS

The same storm patterns seem to be repeated every year and can be grouped into type A, B and C storms. In some years (MY28, 34) global dust storms (GDS) occur. Although pattern A,B,C is repeated, type C storms show variability in intensity and duration/timing. Finally, the vertical profiles of MY 24 type C show evidence of the different nature of dust transport between the two selected regions of mars, with dust reaching heights of 60 km.

REFERENCES

1.C. Martín Rubio, et al. Icarus. (2024), 412, 115982.
2.D. M. Kass, et al. Geophysical Rearch Lett. (2016)

Acknowledgements

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