Martian cold spot regions and associated properties during the 2018 global dust storm using MRO/MCS observations

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The weather and climate on Mars depend heavily on the characteristics of dusts and aerosols. Dust, CO_2, ice, water ice, etc., suspended in the air, play a critical role in the thermal equilibrium, circulation, and transfer of momentum in Mars' atmosphere. Cold spot regions are those radiometrically cold areas where the temperature is less than the CO_2 frost point temperature. These regions have the maximum probability of CO_2 ice formation. On Mars, global dust storms (hereafter, GDS) drastically change the microphysical characteristics of CO_2 ice aerosols, besides their geographical and vertical distributions. With the help of the Derived Data Record (DDR) version 5 obtained from the Mars Climate Sounder (MCS) instrument on board the NASA's Mars Reconnaissance Orbiter (MRO) mission, an attempt is made to investigate the origin of cold spots, their spatial and temporal variation, etc. The work focuses on the cold spot regions' vertical, temporal, and spatial variation during the Martian Year 34 GDS. GDS affected the latitudinal variation of ice cap formation and solar insolation, which in turn impacted the cold spot formation. Cold spot regions were found only at the surface levels at the south pole. Most North Pole cold spots formed on the polar nights, and during the global dust storm season, the cold spot regions in the northern hemisphere started to develop outside the polar ring and at lower altitudes as well. Also, during dust storms, there is a high concentration of dust at higher altitudes, which provides a nucleation site for CO_2 ice, leading to the formation of polar hood clouds.

References:

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2) Cornwall, C., & Titus, T. N. (2009). Spatial and temporal distributions of Martian north polar cold spots before, during, and after the global dust storm of 2001. *Journal of Geophysical Research: Planets*, *114*(E2).

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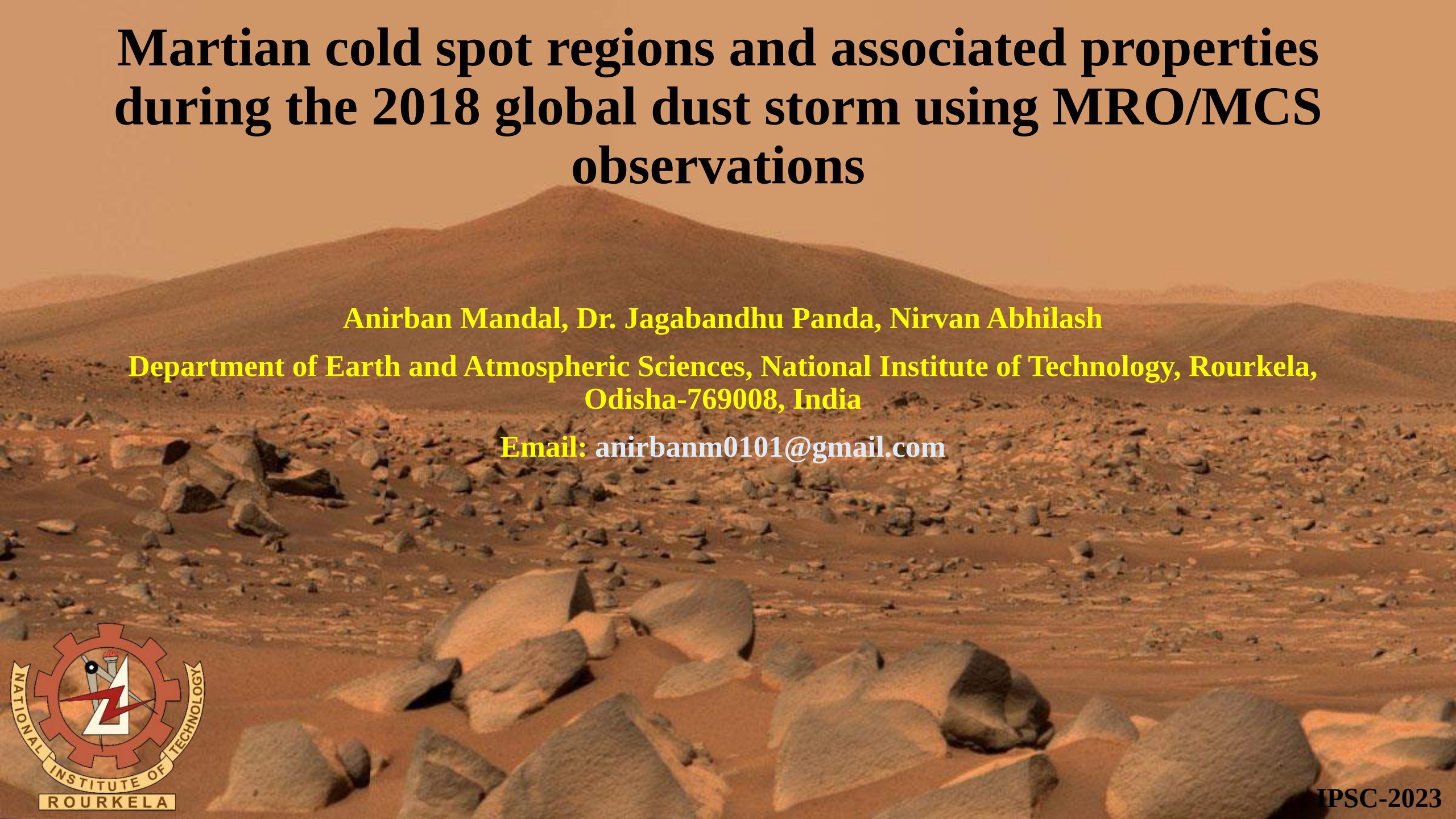

IPSC-2023

Outline

- Cold spots on Mars
- Data and Methodology
- Vertical variation of cold spots
- Spatial distribution of cold spots
- Temporal variation of cold spots
- Conclusion

Cold spots on Mars

- Areas with very low surface temperature or atmospheric temperature
- Supports the formation of CO_2 ice
- Important for the understanding of CO_2 dynamics and carbon cycle on Mars

Data and Methodology

- Mars Climate Sounder Derived Data Record Version 5
- Surface temperature or atmospheric temperature less than that of CO_2 frost point temperature at that pressure level
- Martian Year (MY) 34 and MY 33, L_s=180° to 260° timeframe was considered
- 5° L_s bin was considered

Vertical variation of cold spots

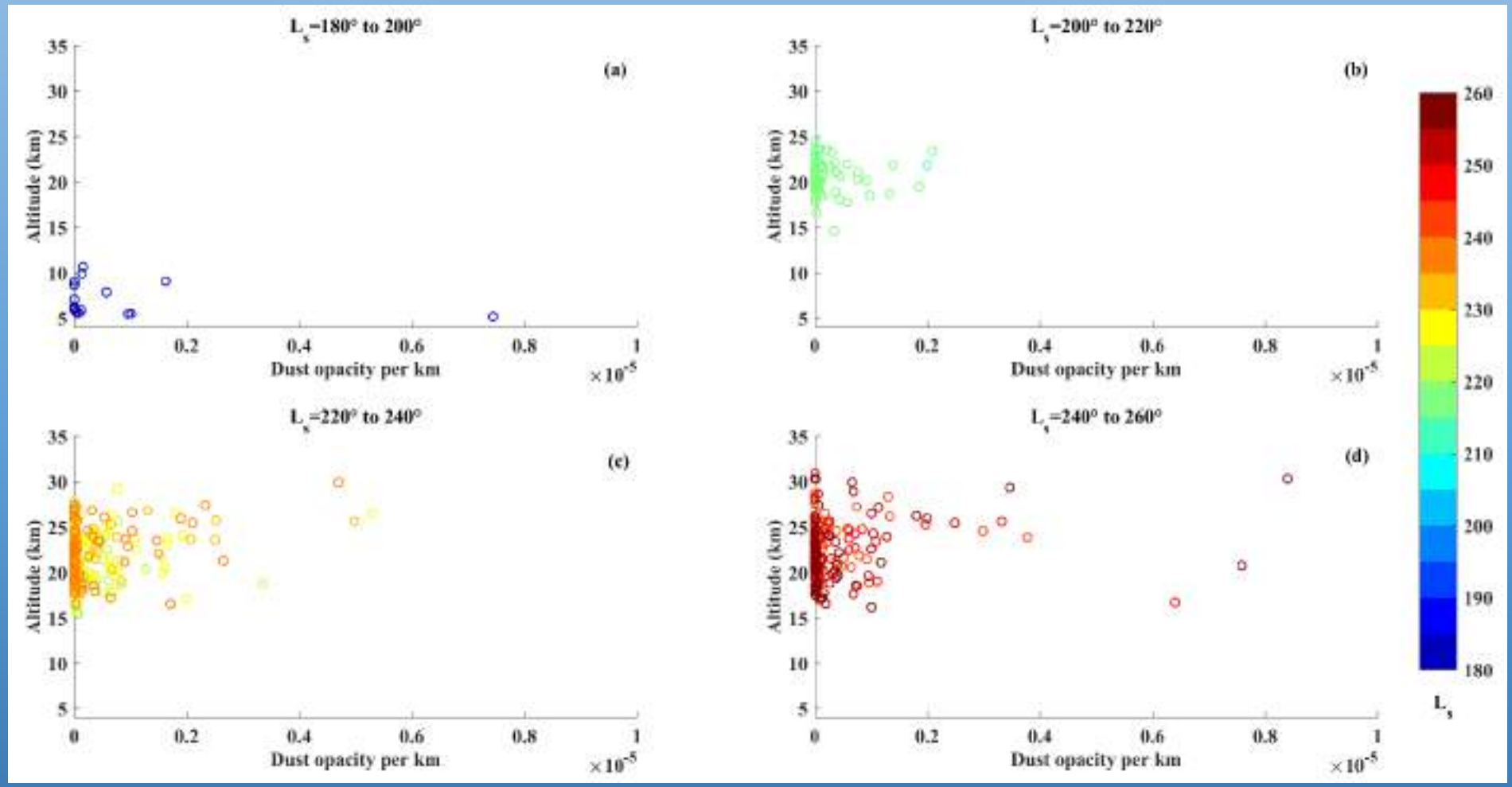

Figure 1: The vertical variation of dust opacity per km for MY33 a) For L_S=180º to 200º, b) For L_S=200º to 220º, c) For L_S=220º to 240º, d) For L_S=240º to 260º.

Vertical variation of cold spots

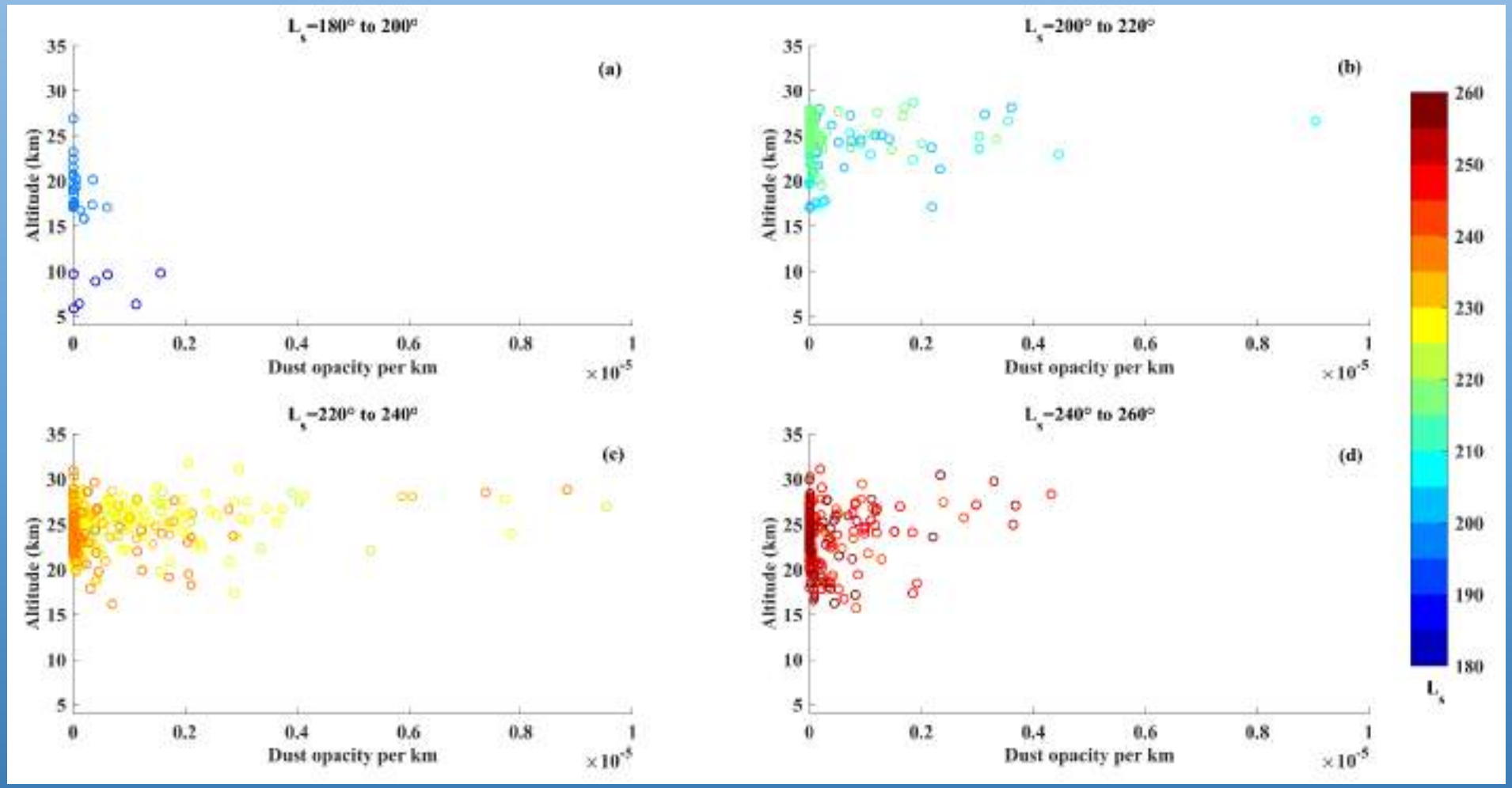

Figure 2: The vertical variation of dust opacity per km for MY34 a) For L_S=180º to 200º, b) For L_S=200º to 220º, c) For L_S=220º to 240º, d) For L_S=240º to 260º.

Vertical variation of cold spots

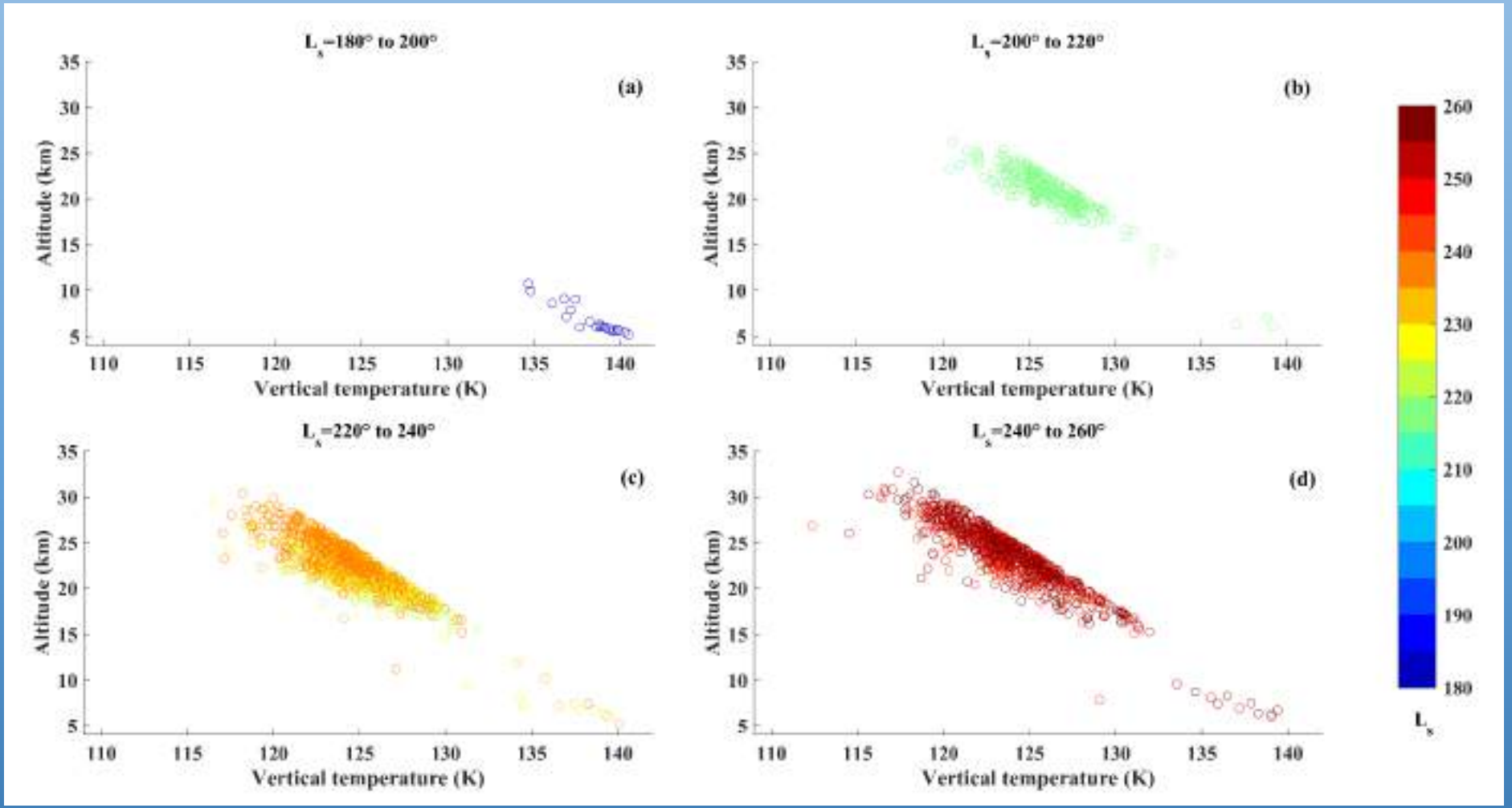

Figure 3: The vertical variation of atmospheric temperature that satisfies the cold spot criterion for MY33 a) For L_S=180º to 200º, b) For L_S=200º to 220º, c) For L_S=220º to 240º, d) For L_S=240º to 260º.

Spatial distribution of cold spots

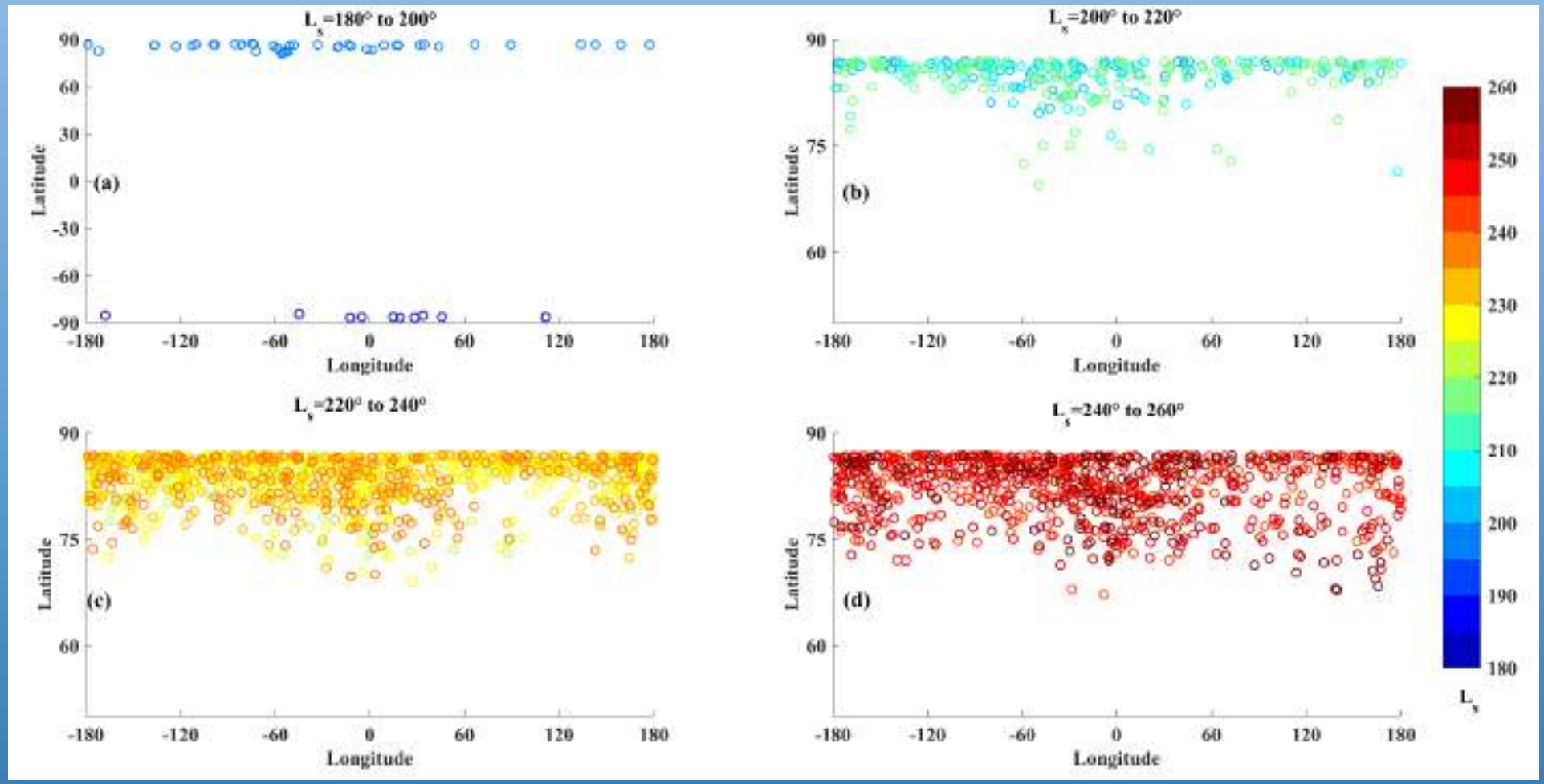

Figure 4: The spatial variation of cold spots for MY34 a) For L_S=180º to 200º, b) For L_S=200º to 220º, c) For L_S=220º to 240º, d) For L_S=240º to 260º.

Temporal variation of cold spots

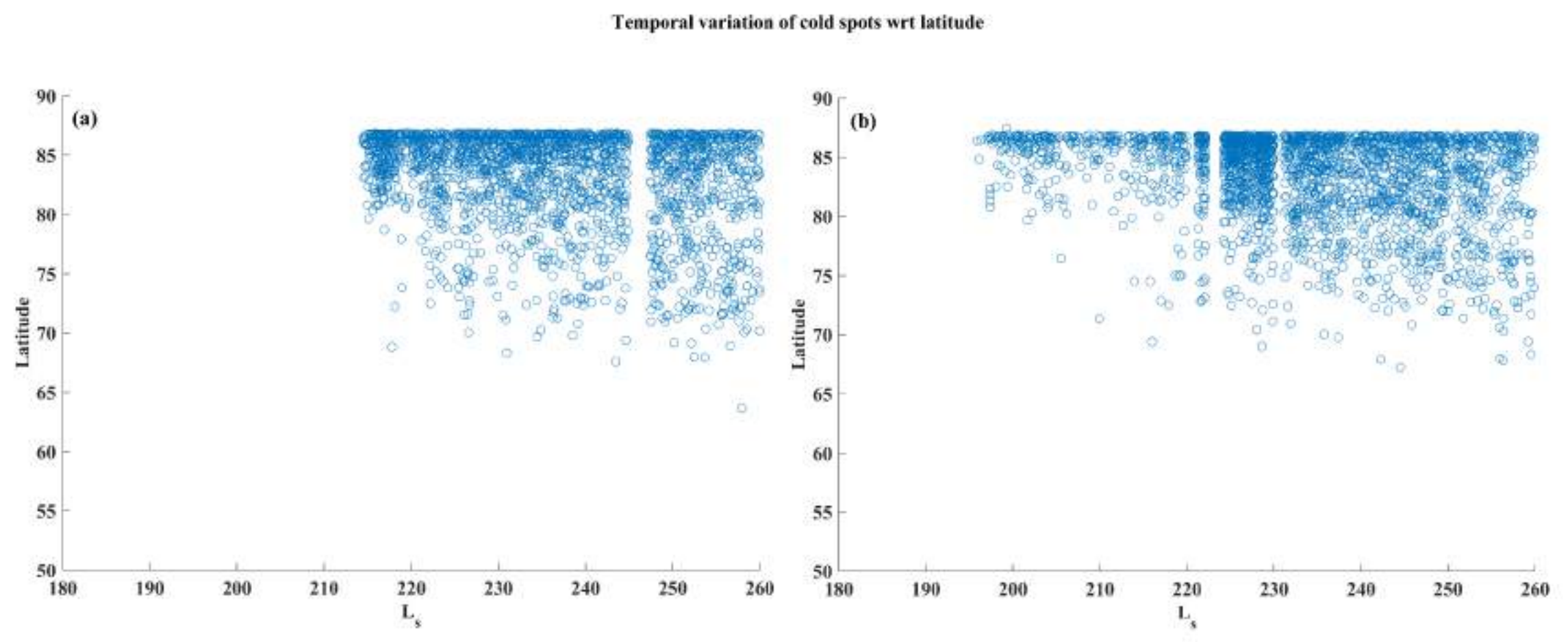

Figure 5: The temporal variation of cold spots w.r.t Latitude averaged over all longitude (For surface temperature) a) For MY33 b) For MY34.

Temporal variation of dust opacity

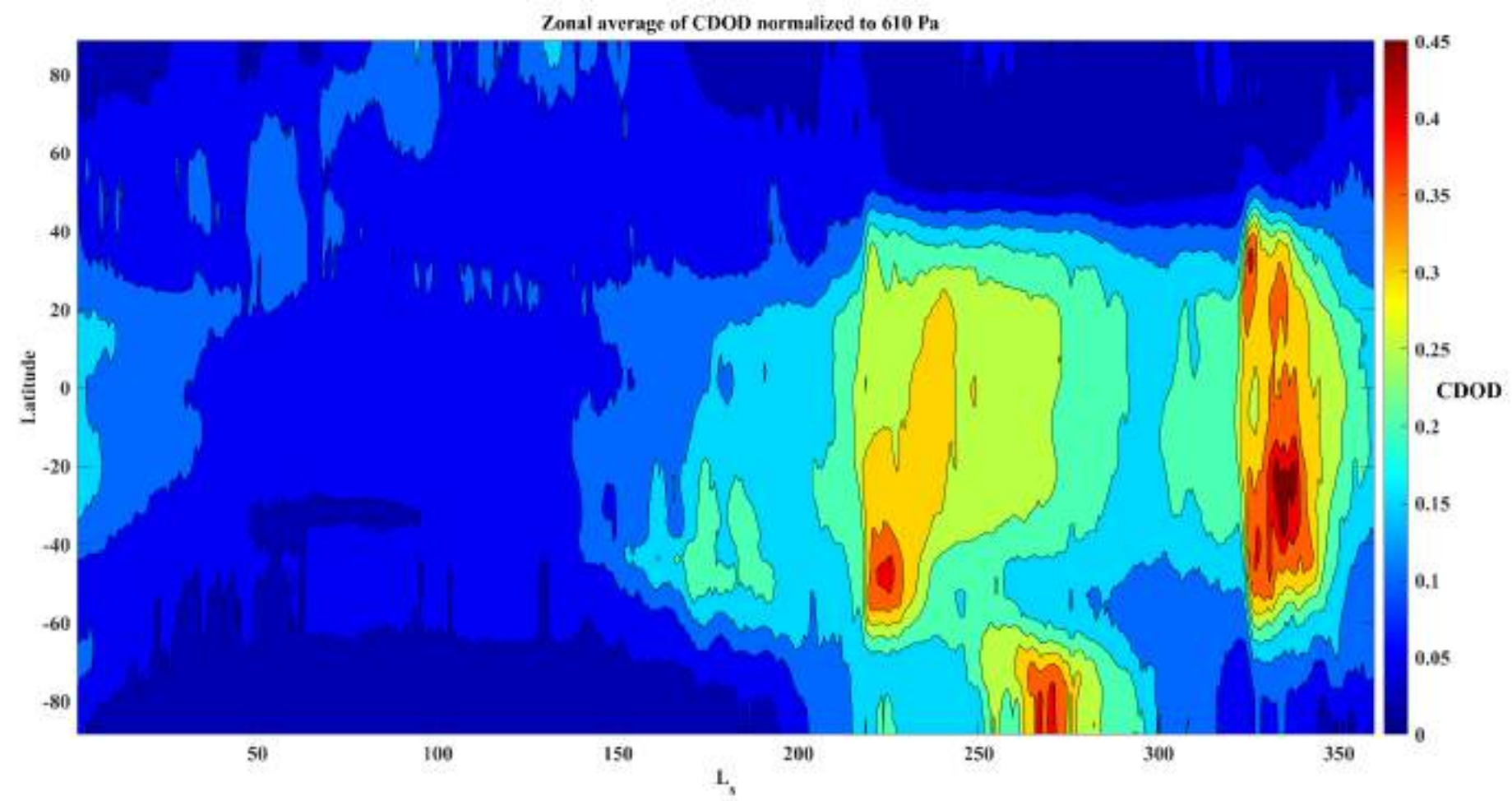

Figure 6: The temporal variation of dust opacity w.r.t Latitude averaged over all longitude for MY33

Temporal variation of dust opacity

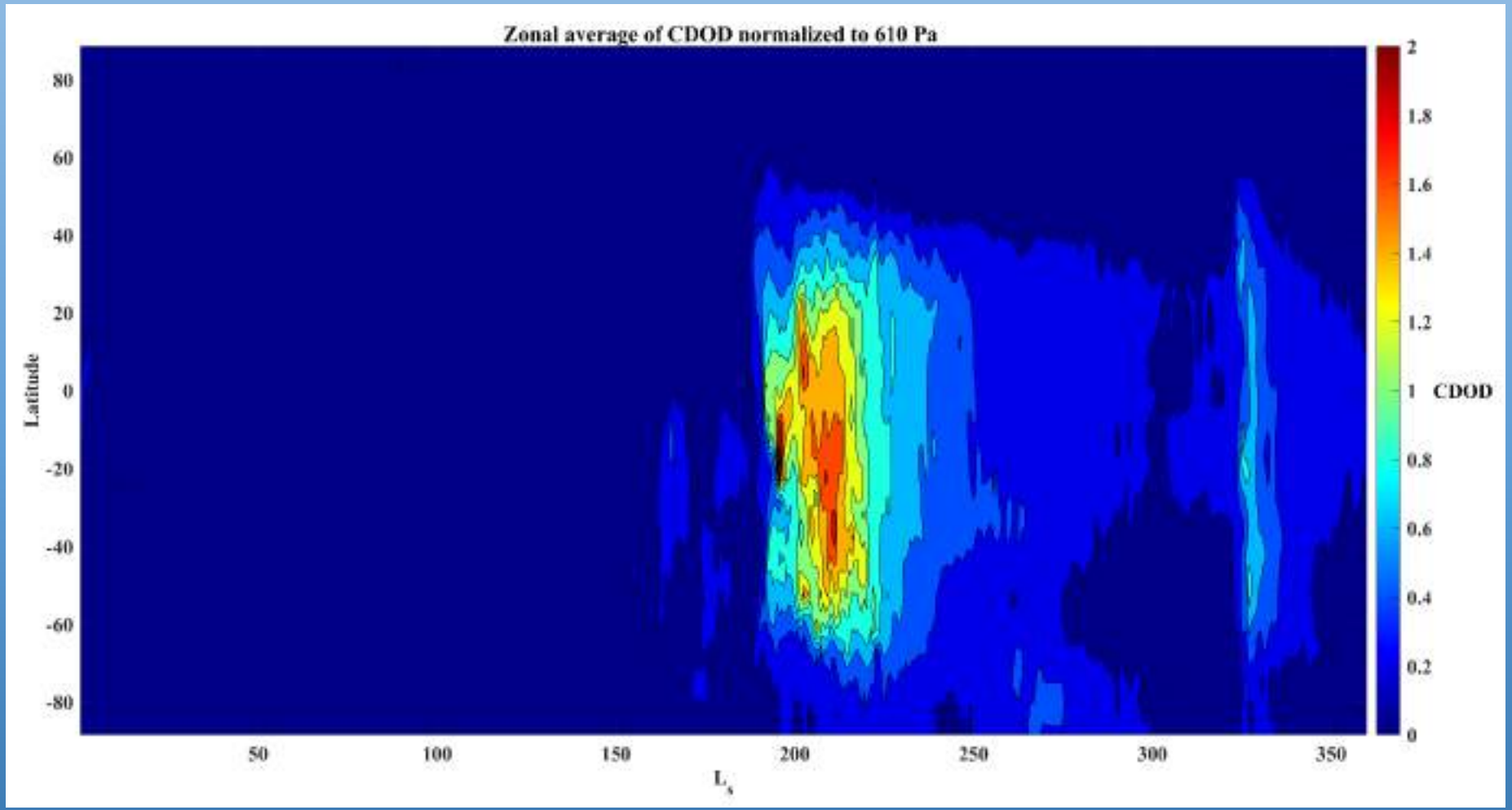

Figure 7: The temporal variation of dust opacity w.r.t Latitude averaged over all longitude for MY34.

Conclusion

- Global dust storm helped create more cold spots
- During the initiation and peak phase of the GDS, the effect of GDS on the formation of cold spots is maximum.
- After L_s=230°, the effect of the polar night is more dominant
- Dust storms, in general, may help in the formation of cold spots
- High concentrations of dust at higher altitudes can provide nucleation site for CO_2 ice, leading to the formation of clouds

Thank You