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THEMIS observations of the 2018 Mars planet-encircling dust storm

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Abstract

The THEMIS instrument on-board Mars Odyssey continues to produce high quality visible and thermal-IR images of Mars extending its record of nearly 9 Mars Years of observations. Here we present THEMIS thermal-IR observations taken during the recent planet-encircling dust storm during the summer of 2018 (Mars Year 34). THEMIS observations of the dust storm show the distinct thermal signature of the storm and the spatial and temporal variation of column dust optical depth before, during, and after the storm.

1. Introduction

A large, planet-encircling dust storm was observed on Mars during the summer of 2018 (Mars Year 34) by many different instruments (e.g., [1, 2]). Among those are observations taken by the THEMIS instrument on the Mars Odyssey spacecraft.

THEMIS infrared images are taken in 9 spectral bands with central wavelengths ranging from 7 to 15 µm [3]. The band at 15 µm can be used to retrieve a "T15" temperature representative of a broad layer in the atmosphere centered at about 25 km. The other bands can be used to retrieve surface temperature and column dust and water ice aerosol optical depth [4]. During Mars Year 34 (MY 34), the Odyssey spacecraft was in a Sun-synchronous orbit with local times of about 7:15 AM ("morning") and 7:15 PM ("evening"). THEMIS systematically took images of Mars during the period before, during, and after the dust storm. The evening observations have sufficient thermal contrast between the surface and atmosphere that the column abundance of dust optical depth can be retrieved. Surface and atmospheric temperatures can be retrieved from both morning and evening observations.

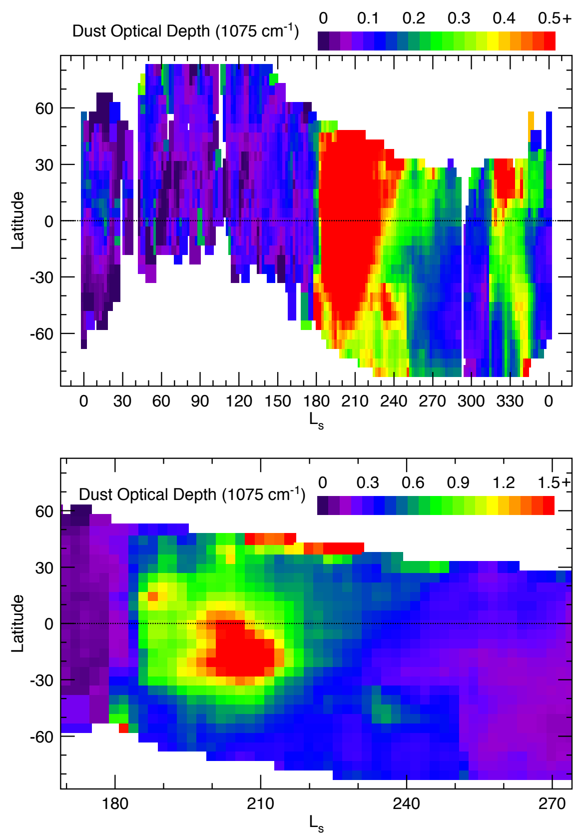

Figure 1: Column-integrated dust optical depth (at 1075 cm^{-1}) retrieved from THEMIS evening observations during MY 34 as a function of Ls and latitude. The bottom panel shows the period around the dust storm in greater detail.

2. Dust Optical Depth

The dust optical depth retrieved from the THEMIS evening observations are shown in Figure 1. The first half of MY 34 (Ls=0°–180°) was typical for that season. At about Ls=185° dust optical depth was observed to rapidly increase, spreading to cover a large portion of the planet over a period of a couple weeks. Dust optical depth reached a globally-integrated maximum at around Ls=205° with peak optical depth (at 1075 cm^{-1}) exceeding three in places. Dust optical depth gradually decreased after Ls=205° as dust settled out of the atmosphere. During this period, retrieved dust optical depth was observed to remain greater at more northerly latitudes. A late-season storm was observed at about Ls=315°. Although retrieved dust optical depth was much lower than in the earlier planet-encircling storm, this late-season storm was still quite strong given the historical record of storms at that season.

3. Thermal Response

The thermal response to the planet-encircling dust storm observed by THEMIS both during the morning and evening local times is shown in Figure 2 as the difference in temperature between MY 34 (which had the big dust storm) and the previous MY (which did not have a planet-encircling dust storm). Evening atmospheric temperatures (~25 km) were observed to be 20–50 K warmer than those observed at the same seasonal date (Ls) the previous Mars Year. Morning atmospheric temperatures show a smaller increase (15–25 K) over the previous Mars Year and with a different latitude dependence. The thermal effect of the strong late-season dust storm at Ls=315° has is very small at these local times. The change in surface temperatures shows a more complex dependence. The morning cooling is caused by diminished solar heating, while small evening warming is caused by downward radiation from the warm dust.

4. Summary and Conclusions

THEMIS observations provide important information about the spatial and temporal variation of temperatures and dust optical depth before, during, and after the planet-encircling dust storm of MY 34. Detailed analysis of these and other observations promises to provide new insights into the processes that drive these poorly-understood storms.

Acknowledgements

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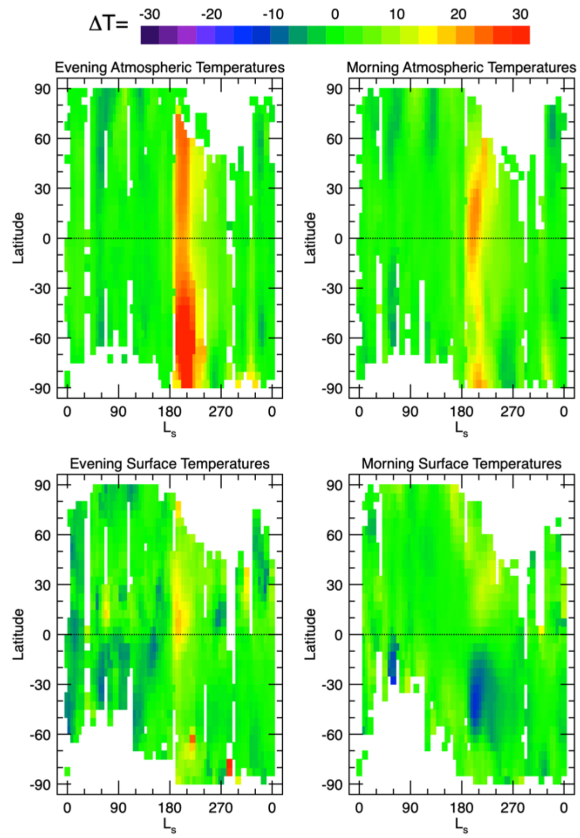

Figure 2: The year-over-year change in temperatures observed by THEMIS. Shown are the MY 34 (dust storm) values minus the MY 33 (no dust storm) values. Atmospheric temperatures are “T15”, representative of an altitude of ~25 km.

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