

MARS CLIMATE SOUNDER OBSERVATIONS OF THE 2018 GLOBAL DUST EVENT AND COMPARISONS TO PREVIOUS EVENTS. D. M. Kass¹, J. T. Schofield², A. Kleinböhl¹, D. J. McCleese³, N. G. Heavens⁴, J. H. Shirley¹, ¹Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, ²Retired, Pasadena, California, USA, ³Synoptic Science, Pasadena, California, USA, ⁴Department of Atmospheric and Planetary Sciences, Hampton University, Hampton, Virginia, USA. (David.M.Kass@jpl.nasa.gov)

Introduction: The largest of dust storms on Mars are the Global Dust Events (GDE) that affect essentially every aspect of the atmosphere [1]. A GDE occurred in 2018, five Mars Years after the previous one in 2007. The Mars Climate Sounder (MCS) observed the 2018 GDE throughout its lifecycle, from the first signature on June 2, 2018 through to the end around October 15, 2018. This provides an outstanding record of a GDE to help understand and describe them. Previous GDE with good global observations occurred in 2007 and 2001 (observed by TES).

Over its lifetime, a GDE evolves through three phases: Growth, Mature and Decay. During the growth phase, the atmosphere actively lifts dust off the surface and then lofts it high into the atmosphere. The mature phase of the event is when the atmosphere is the most perturbed from its background state. During the decay phase, the dust sediments out of the atmosphere as conditions slowly return to seasonally normal state [1]. Division into simple phases is helpful for studying the storm; however each phase is inherently complex with multiple “sub-phases” or types of activity. Various regions of Mars are also often undergoing quite different activities at any one time.

horizon) of Mars [2]. MCS provides an altitude resolution of ~ 5 km (half a scale height) at the Mars limb. MCS observations normally cover from the surface to ~ 80 km. Some were extended to ~ 100 km during the GDE due to dust and water ice aerosols being found at very high altitudes.

The radiance profiles, combined with on-planet views, are inverted to retrieve geophysical quantities [3-5]. These include temperature, dust, and water ice profiles. The MCS dataset used in this work was optimized for the 2018 GDE by maximizing the ability to retrieve temperature and dust profiles under dusty conditions [6]. The dust profiles are extrapolated to the surface to yield dust opacity column amounts.

Overview of the 2018 Global Dust Event: The first unambiguous signature in the MCS observations is on June 2, 2018 (Ls 186.2°). It showed a strong signature in the dust and in the atmospheric temperatures within five days on June 7, 2018 (Ls 188.7°) (Fig. 1) when zonal mean daytime temperatures at 50 Pa exceeded the 200 K threshold defining a large-scale regional dust event [7]. Within another 2° of Ls, the entire latitude region from 45° S to 45° N had temperatures above 200 K.

The complexity of the initial growth, and the activation of multiple major dust raising centers, is captured in the zonal mean dust column opacity evolution. Both the dust and temperatures increase during the early growth phase. However, there are noticeable differences between the location of the dust and the temperature response during this time period due to the variations in insolation, dynamical heating/cooling, and the very non-uniform dust distribution (especially the vertical distribution).

The 2018 event did not become planet encircling for about another week and a half (on June 17, 2018, Ls 194.9°) and it reached its mature phase on June 23 (Ls 197.9°). There is a significant evolution of the temperature structure as the event transitions from strong growth to the mature phase and then to decay (Fig 1). The event transitioned to the decaying phase around July 18 (Ls 213.3°).

Similarities of GDE: The 2018 GDE is an equinoctial global event and the starting season is in family with three other GDE that started early in the dusty season. The 2018 GDE is best compared to the 2001

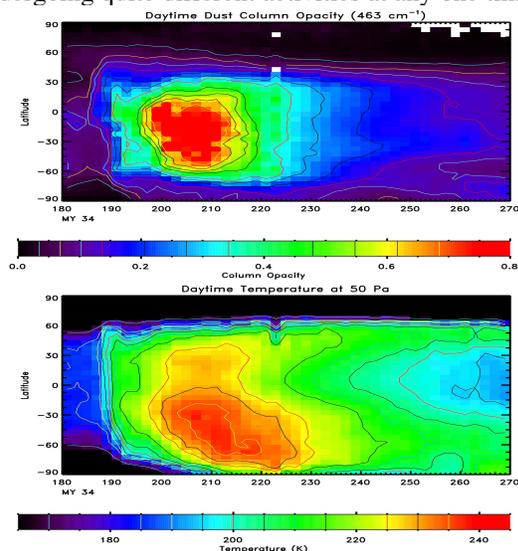


Figure 1: Daytime zonal mean dust column opacity (top) and 50 Pa (~ 25 km) temperatures (bottom) during the 2018 GDE from MCS observations.

MCS and the GDE Observations: MCS is a passive 9 channel limb radiometer observing the limb (or

GDE since they started at very similar seasons and both were observed globally by IR temperature profiling remote sounding instruments (TES and MCS).

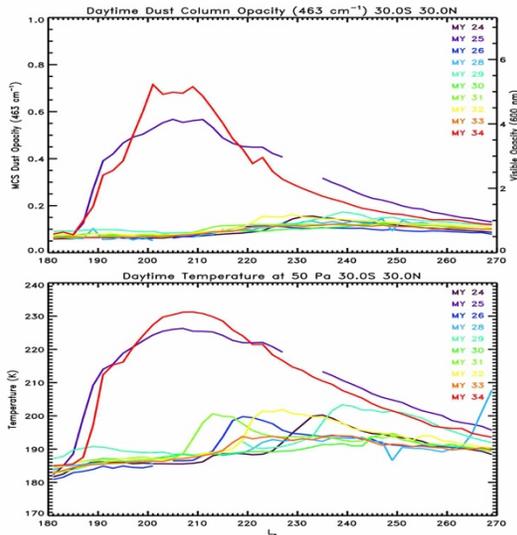


Figure 2: Daytime tropical zonal mean dust column opacity (top) and 50 Pa (~25 km) temperatures (bottom) during MCS and TES years.

The 2018 and 2001 GDE initiated in very different regions and had different dust opacities during the growth phase. However, in their overall and globally averaged behavior, the two storms are very similar (Fig. 2). They share a very fast initial temperature rise over a broad latitudinal band [8]. During a second phase of growth, both storms reach the warmest temperatures in the southern tropics and extra-tropics. These regions evolve southward through the southern mid-latitudes into the southern polar region. During the decay phases, both initially start cooling in the tropics and extra-tropics. Likewise, these latitudes exhibit the most rapid overall cooling.

It is more difficult to compare the 2018 GDE to the 2007 GDE due to observational limitations during the latter [3]. The two events occurred in very different atmospheric conditions, as the 2007 GDE was a solstitial one. It initiated in a dusty atmosphere in the middle of an ongoing south polar regional event. The 2007 GDE shares the very rapid rise in temperature during the initial growth phase with the 2018 GDE. While the tropics were significantly affected, the warmest regions were in the southern mid-latitudes and polar regions throughout. The 2007 GDE had a longer mature phase, but was much shorter overall.

Differences from Regional Dust Storms: Based on the available observations, GDE are clearly distinct from large-scale regional dust events, even the largest of these, in a number of aspects. GDE appear to be a fundamentally different type of event implying

they are not part of a continuum of event sizes. However, there is a limited sample of three globally characterized GDE and ~20 large scale regional events.

The first distinction, used to define the two types, is that a GDE has planet encircling opaque dust. In addition, the dust extends much higher in the atmosphere. The significantly increased amount of airborne dust leads to a number of expected differences.

The clearest distinctions between the large regional events and the GDE are in the temperature observations [7]. The simple distinction is that the absolute peak daytime 50 Pa zonal mean temperature in GDE are > 235 K while those for large-scale regional events are ≤ 225 K. Differences between the two families of events are obvious when focusing on the impact to the tropics (Fig. 2). GDE have a strong signature in this region while large-scale regional events only ever modestly influence it.

Since all GDE share the behavior of rapid zonal mean temperature rise over a broad latitudinal band, it is a potential early discriminator of the ultimate fate of a large event initiating during the seasonal window for the start of GDE (i.e. Ls 185° to 310°). The one non-GDE to cause noticeable tropical warming was the MY 29 A event and it took 7° of Ls [7]. (The rapid rise times of late C events can result in a rapid broad warming, if the equator is affected, however all cases have initiated well after the latest GDE [7]).

Conclusions: Observations of the 2018 GDE provide an excellent view of how such events evolve and interact with the atmosphere. The combination with observations of observations of other dust events, both GDE and regional ones, indicate that GDE share a number of characteristics that appear to distinguish them from even the largest regional dust storms. The recent observations will also enable significant further modeling and analysis to develop a better understanding of global dust events.

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