The Diurnal and Seasonal Variation of Dust Aerosol as Observed by EMIRS

Khalid Badri, *Mohammed Bin Rashid Space Centre, Dubai, UAE*, **M. D. Smith**, *NASA Goddard Space Flight Center, Greenbelt, MD, United States,* **C. S. Edwards,** *Northern Arizona University, Department of Physics and Astronomy, Flagstaff, AZ, United States*, **E. Altunaiji,** *Mohammed Bin Rashid Space Centre, Dubai, UAE*, **P. R. Christensen**, *Arizona State University, School of Earth and Space Exploration, Tempe, AZ, United States*, and the **EMIRS Team**.

Introduction:

The Emirates Mars Mission (EMM) successfully began the science phase on 23rd of May 2021 to explore the dynamics of the Martian atmosphere on a global scale (Amiri et al., 2022). The Emirates Mars Infrared Spectrometer (EMIRS) instrument as seen in figure 1, one of three instruments onboard EMM, is an interferometric thermal infrared spectrometer developed by Mohammed Bin Rashid Space Centre (MBRSC) and Arizona State University (ASU) (Edwards et al., 2021). The EMIRS instrument collects spectral data from 6-100+ µm at 5 and 10 cm^{-1} spectral sampling, which is enabled by a Chemical Vapor-Deposited (CVD) diamond beam splitter and digital interferometer control electronics.

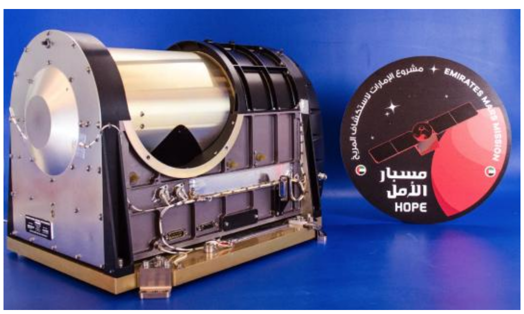

Figure 1: *Emirates Mars Infrared Spectrometer (EMIRS).*

The EMIRS instrument is designed to characterize the geographic, seasonal, and diurnal variability of key characteristics of the red planet such as atmospheric dust and water ice optical depth, water vapor abundance, surface temperature, and atmospheric temperature profiles on sub-seasonal timescales. EMIRS observations provide full local solar time coverage at multiple emission angles providing data on these constituents over the entire Martian disk. EMIRS observations will enhance our understanding of the dust cycle on Mars and how dust influences the current climate and atmospheric dynamics on Mars.

Methodology:

EMIRS data is available at the EMM Science Data Center website in which the global science community can access and download the data set for free and perform their own analysis (https://sdc.emiratesmarsmission.ae). In this paper the variation of dust observed by EMIRS, including the regional dust storm that occurred in January 2022 will be analyzed. Here, we present initial results of the spatial, seasonal and diurnal variation of retrievals of dust optical depth on a global scale. These results also will aid in understanding the relationship between the upper and lower atmosphere, but also enhance the accuracy of models about the Martian planet especially for time-variable phenomena such as the atmospheric behavior due to dust storms (Almatroushi et al., 2021).

Results for the Aphelion-Season Climatology of Dust:.

Figure 2 below shows the seasonal and diurnal variation of dust optical depth and includes retrievals from the EMIRS observations taken between 24 May 2021 (Ls=49°) and 24 February 2022 (Ls=180°). The gap between solar longitude of 100° to 120° is due to solar conjunction, and times when the spacecraft had to enter safe mode. The general dust distribution during this period shows relatively clear conditions with increasing dust as Mars is getting closer to the Northern hemisphere autumn equinox when typically the dust storm period begins at approximately Ls=180°, however it is noticeable that there was a regional dust storm earlier at Ls=153° as seen from the sudden increase in dust optical depth in Figure 2 below.

Additionally, it is notable that the daytime local time variation of dust during this season is relatively small with no significant change diurnally unlike the large changes observed seasonally. In addition, the data presented here is only during the day time, in which there is significant thermal contrast between the dust and the atmosphere in order to accurately retrieve results from the data, however there is work being done on the night time retrievals.

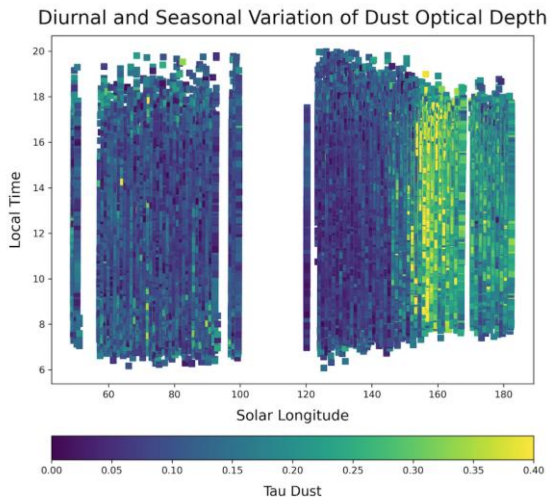

Figure 2: *Variation in Dust Optical Depth with Solar Longitude and Local time*

In Figure 2 it is noticeable that the dust optical depth has decreased a bit after the regional dust storm but still remains higher than it was before the dust storm since the more recent data were taken closer to the beginning of the dust storm season.

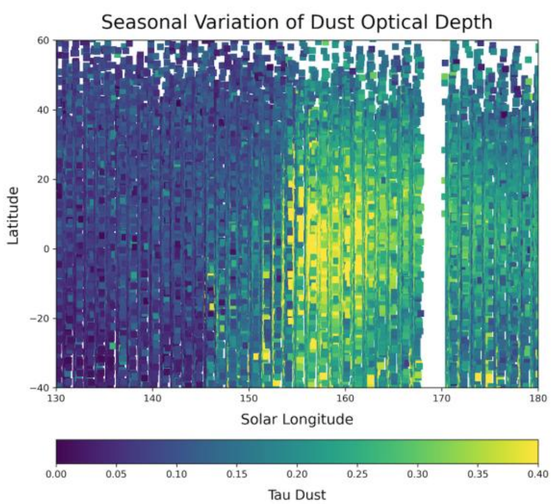

Figure 3: *Latitudinal Variation in Dust Optical Depth with Solar Longitude*

Figure 3 above, which gives the variation of dust as a function of season and latitude, shows more clearly the beginning and the end of the regional dust storm that occurred in January 2022. The sudden increase is clearly portrayed within the figure in dust optical depth at Ls=153°. The main concentration of the storm was within the equatorial regions, with some high optical depths in both the northern and southern regions.

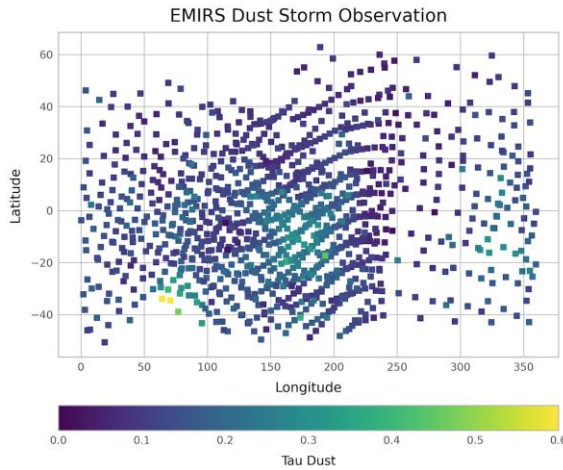

Figure 4: *EMIRS Observation before Regional Dust Storm.*

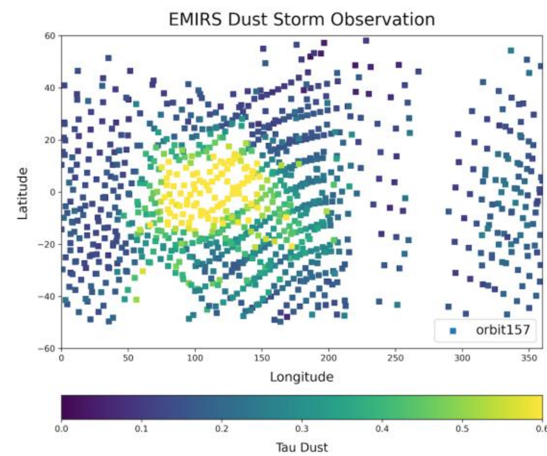

Figure 5: *EMIRS Observation during Regional Dust Storm.*

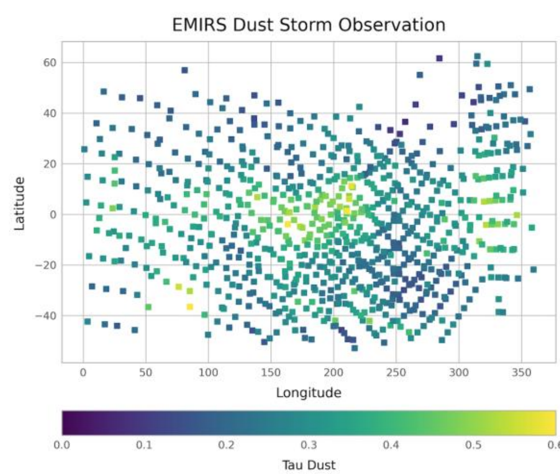

Figure 6: *EMIRS Observation after Regional Dust Storm.*

As seen from the figures above, the high abundance of the column integrated quantities of dust suggests a regional dust storm that began between 90° and 180° longitude. The dust storm was observed to begin in the southern hemisphere and move northward expanding to a regional size in approximately 11 to 12 days. After the active portion of the dust storm ended, dust was transported to all longitudes increasing the dust load over most of the planet. After the dissipation of the dust storm as seen in figures 2 and 3, there remained a general increase in dust optical depth throughout the regions which could indicate that a lot of the dust that was lifted into the atmosphere due to the active dust storm has not yet completely settled out, and since the dust is still in the atmosphere it relates to a higher optical depth. In addition, the recent observations capture the transition between the aphelion season with cooler temperatures and less dust, and the perihelion season with warmer temperatures and more dust lifted into the atmosphere.

Future Work:

We will continue analyzing the seasonal, spatial, and diurnal variations of dust using observations from EMIRS, with particular attention to the evolution of large dust storms. Addition work will be done in order to have a better understanding of the effect that dust storms have on other quantities retrieved by EMIRS (such as atmospheric temperatures, cloud opacity, and water vapor abundance) as well as aiding in exploring one of the main EMM science goals in further understanding the connection between the upper and lower atmosphere.

References:

Amiri, H.E.S., Brain, D., Sharaf, O. et al. The Emirates Mars Mission. Space Sci Rev 218, 4 (2022). https://doi.org/10.1007/s11214-021-00868-x

Almatroushi, H., AlMazmi, H., AlMheiri, N., AlShamsi, M., AlTunaiji, E., Badri, K., ... & Young, R. (2021). Emirates Mars Mission characterization of Mars Atmosphere dynamics and processes. Space Science Reviews, 217(8), 1-31.

Edwards, C.S., Christensen, P.R., Mehall, G.L. et al. The Emirates Mars Mission (EMM) Emirates Mars InfraRed Spectrometer (EMIRS) Instrument. Space Sci Rev 217, 77 (2021). https://doi.org/10.1007/s11214-021-00848-1