DUST LIFTING THROUGH SURFACE ALBEDO CHANGES AT JEZERO CRATER AS OBSERVED FROM MARS2020 MEDA MEASUREMENTS. A. Vicente-Retortillo[1,2], G.M. Martínez[3], R. Hueso[4], C. E. Newman[5], M. T. Lemmon[6], E. Sebastián[1], D. Toledo[7], V. Apéstigue[7], I. Arruego[7], A. Munguira[4], A. Sánchez-Lavega[4], L. Mora-Sotomayor[1], T. Bertrand[8], L. K. Tamppari[9], M. de la Torre Juárez[9], J.-A. Rodríguez-Manfredi[1], [1]Centro de Astrobiología (INTA-CSIC), Madrid, Spain (adevicente@cab.inta-csic.es) , [2]University of Michigan, Ann Arbor, MI, USA, [3]Lunar and Planetary Institute, USRA, Houston, TX, USA, [4]Universidad del País Vasco (UPV/EHU), Bilbao, Spain, [5]Aeolis Research, Chandler, AZ, USA, [6]Space Science Institute, Boulder, CO, USA, [7]Instituto Nacional de Técnica Aeroespacial (INTA), Madrid, Spain, [8]LESIA, Meudon, France, [9]Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA, USA.

Introduction: MEDA, the suite of meteorological sensors onboard the Mars2020 Perseverance rover [1], has been monitoring the environmental conditions at Jezero Crater since February 2021. Simultaneous measurements from the Thermal and Infrared Sensor (TIRS), the Radiation and Dust Sensor (RDS), the Pressure Sensor and the Wind Sensor allows studying dust lifting at the Martian surface by analyzing an unprecedented set of magnitudes, including high frequency measurements (1 – 2 Hz) of surface broadband albedo and temperature, wind speed and direction, and pressure.

Instrument description and methodology: TIRS [2] comprises five channels which measure downward (IR1) and upward (IR4) longwave (6.5 – 30 µm) radiation, atmosphere temperature (IR2), reflected shortwave (0.3 – 3 µm) radiation (IR3), and surface temperature (IR5). Channels IR3, IR4 and IR5 cover an area of about 3 m^2 located at less than 4 meters from the RTG [1]. The RDS has two sets of photodiodes. One of them points towards the zenith and includes a detector (TOP7) with a hemispheric field of view that measures between 190 and 1100 nm [1]. We use the ratio between TIRS IR3 and RDS TOP7 measurements as a proxy for surface albedo (note that the values do not correspond to the actual albedo because TIRS and RDS measure in different spectral bands, but it is valid for our purpose of analyzing rapid changes).

Results:

Surface temperature and albedo changes. We have detected 31 rapid surface temperature changes from TIRS measurements during the first 216 sols of the Mars2020 mission. Approximately half of them occurred within one hour from local noon and all of them were observed between 10 and 16 local true solar time (LTST). All the changes except two are clearly linked to the passage of dusty convective vortices, hereinafter dust devils.

The 31 changes corresponded to decreases in ground temperature values, which could be caused by dust lifting in two ways. One possibility is that the decrease is caused by the passage of lofted dust particles between TIRS and the surface. Another possibility is an actual change in surface temperature caused by transport of particles, either by deposition of particles cooled in the atmosphere or by removal from a location with cooler terrain underneath. In the first case, the surface albedo is expected to remain almost unaltered after the passage of the dust devil; in contrast, in the second case, persistent surface albedo changes are expected.

We have analyzed the ratio between reflected and downwelling shortwave radiation around the 31 changes in ground temperature. Approximately one third of them present small but persistent albedo changes, with two of them being above 1% [3].

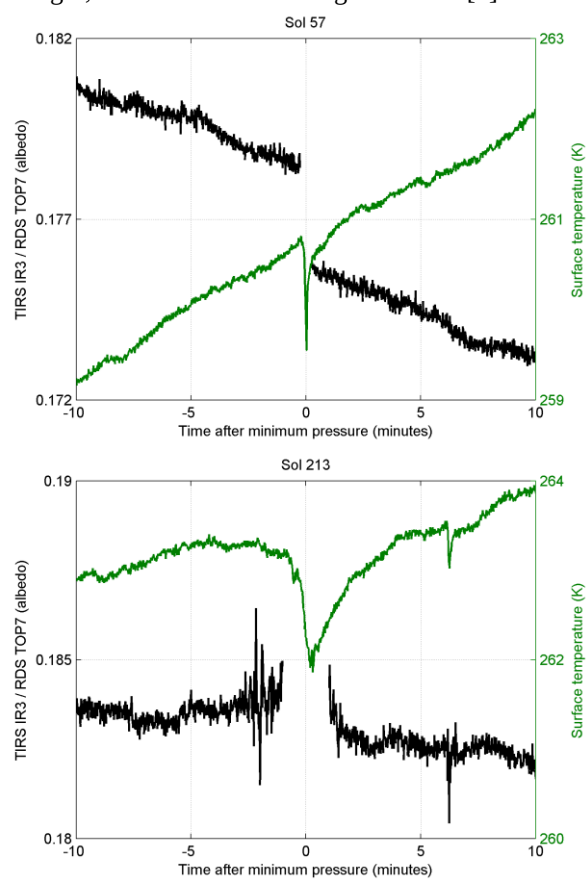

Figure 1. Surface albedo (black) and temperature (green) around the passage of dust devils on sols 57 (top) and 213 (bottom) of the Mars2020 mission.

Effect of the terrain. Figure 1 shows surface temperature and albedo during the passage of dust devils on sols 57 (upper panel) and 213 (lower panel). In the first case, the surface albedo shows a clear and persistent variation. These measurements suggest that we could be analyzing the generation of a dust devil track that crosses the region observed by TIRS.

In the second case, the change in ground temperature measurements is not accompanied by a change in surface albedo. This suggests that the change in ground temperature could be caused by lofted particles travelling between TIRS and the surface. In this case, we do not expect significant changes in surface appearance.

Images of the TIRS field of view and thermal inertia values derived from MEDA [4] suggest fine-grained and loosely packed material on sol 57, which could have been transported leading to the clear albedo change shown in Figure 1. In contrast, observations suggest abundant exposed bedrock on sol 213, which could reduce dust availability.

Surface temperature and albedo rapid changes appear to cluster at certain locations. Occasionally there are sols with more than one rapid variation, such as sol 57, which contrast with long periods where these changes are absent. The period between sols 138 and 153 is particularly relevant, since there were convective vortices with an associated pressure drop similar to or above 2.5 Pa that did not cause noticeable changes in surface temperature or albedo. This suggest that dust mobility and availability for lifting at this region was low in comparison with other regions; this is further supported by the high thermal inertia values observed from MEDA measurements.

Wind speeds. Following the previous discussion, determining a wind speed threshold for dust lifting is a challenging task: first, it depends on dust availability and mobility at the surface, which depends on the rover location; and second, wind speeds are not measured at the exact region where observed dust lifting occurs; in this regard, the analysis of dust lifting through surface albedo changes with MEDA minimizes potential uncertainties due to the small distance between the wind sensor booms and the TIRS target.

Despite these difficulties, it is possible to estimate an upper bound for which we observe dust lifting and a subsequent albedo change under favorable conditions. The two most significant albedo changes occurred with peak wind speeds of 15 and 18 m/s.

Figure 2 shows reflected shortwave radiation and wind speed around the passage of the selected dust devils on sols 57 (upper panel) and 213 (lower panel). The strong decreases in shortwave radiation suggest that the convective vortices lifted significant amounts of dust. Although peak wind speeds were higher on sol 213 than on sol 57, the clear albedo change was found on sol 57. At the time of this writing, no albedo changes have been detected for wind speeds below 15 m/s, but it is not possible to discard dust lifting with lower wind speeds; on the other hand, as shown in Figure 2, some peak wind speeds above 20 m/s were not associated with a clear albedo change, supporting the importance of dust availability and mobility at the surface observed by TIRS [3].

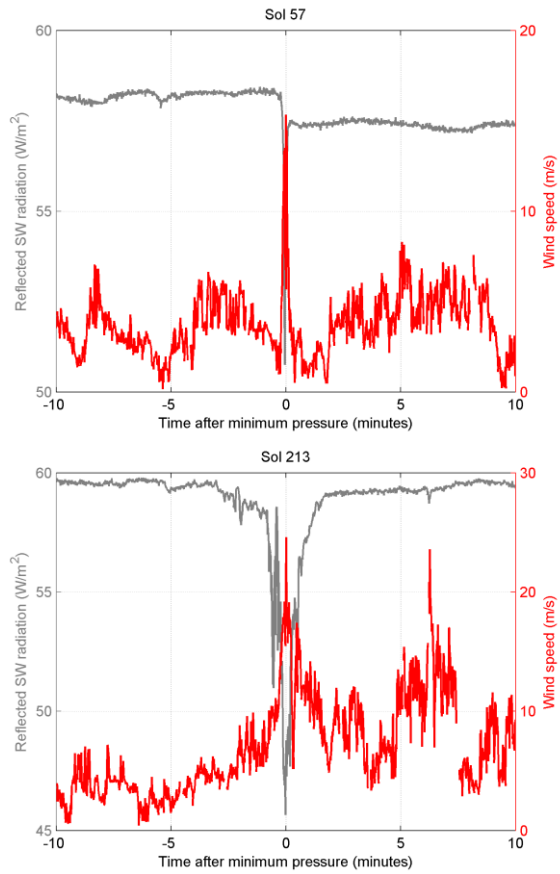

Figure 2. Reflected shortwave radiation (gray) and wind speed (red) around the passage of dust devils on sols 57 (top) and 213 (bottom) of the Mars2020 mission.

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References: [1] Rodriguez-Manfredi, J.A. et al. (2021) *Spa. Sci. Rev.*, *217*, 48. [2] Sebastián, E. et al. (2020) *Measurement*, *164*, 107968. [3] Vicente-Retortillo, A. et al. (2022) *GRL*, in prep. [4] Martínez, G.M. et al (2022) *JGR*, in prep.