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Characterization of a local dust storm on Mars with REMS/MSL measurements and MARCI/MRO images

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Abstract

A dust storm that developed in sol 852 of the MSL mission close to Gale crater spread above the location of the Curiosity rover during sols 853-855 (December 30, 2014 to January 1, 2015, Ls 263º, MY32). The storm was observed by the MARCI imaging instrument [1] on board the MRO orbit and its effects in the local meteorology were recorded in situ by REMS instrument [2] on board the Curiosity rover. Here we perform a detailed analysis of the REMS data in combination with MARCI images following the evolution of the storm over several sols and comparing the local meteorology with values obtained in the previous and later Martian year at the same Ls.

1. Morphology and evolution of the local storm on sol 852 from MARCI images

We selected images of the MARCI instrument covering the Gale crater on the sols before and after the anomalous pressure detections reported in [3]. The storm, initially at 800 km north of Gale crater, spread over a larger area southward of its initial position reaching the location of Gale crater on the next sol. We measured the surface covered by dust by blinking images on sols 852 and 853, and the area is 482,000 km^2 on sol 852, when the cloud is fully developed, and grows to 678,000 km^2 on sol 853, when the atmospheric dust content seems much lower and the dust covers large areas including Gale crater. We also measured the sizes of the shadows projected from the dust cloud in the ground in a large number of pixels and determined that the highest areas of the storm reached a height with respect to the surface of around 19 ± 2 km.

MARCI images on sols 852 and 853 (Figure 1) show a global displacement of the storm with a minimum average velocity of 8 ms^{-1}. However, considering the UV fluxes measured by the REMS instrument, the dust arrived to Gale crater at least at 07 LTST. This requires a minimum average velocity of 10 ms^{-1} to move dust a distance of 610 km from the dust front in sol 852 at 14:40 LTST to the location of Curiosity on sol 853 at 07:00 LTST.

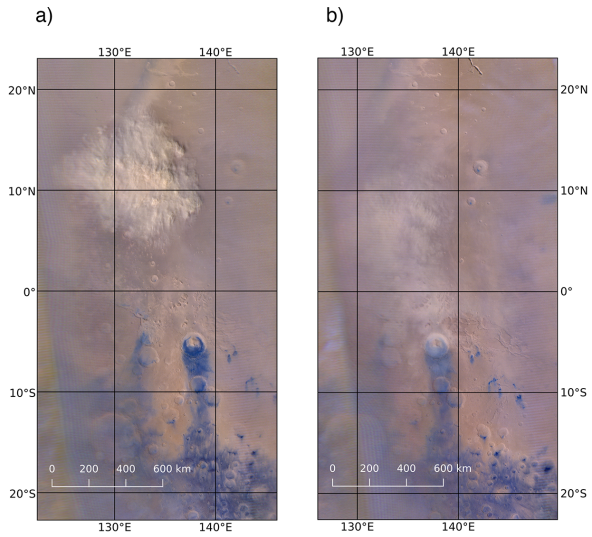

Figure 1: Evolution of the dust storm on sol 852 over Gale crater. a) Image taken by MARCI on sol 852 of the MSL mission (Ls=263º), at ~14:40 LTST for the location of Gale crater. b) Dispersion of the storm on sol 853 reaching Gale crater.

2. REMS measurements

The REMS instrument on board the rover Curiosity measures air pressure, air temperature, ground-temperature, winds, humidity and UV radiation. The meteorological variables from the REMS used in this work are shown in Figures 2 and 3. The atmospheric pressure in Gale reacted to the development of the storm similarly to previous local dust storms observed from in situ data. With the arrival of dust at Gale the amplitude of the daily pressure variation intensified by

~13% with respect to the daily pressure variation at that season. The air temperature close to the surface increased by 14 ± 4 K with the arrival of the dust storm. Previous observations of dust storms have resulted in lower air temperatures in the lower atmosphere and lower thermal amplitudes associated to the fact that solar radiation is expected to be absorbed and diffused by the dust in the upper atmosphere. In the case of the local storm on Gale on sol 853 the evolution of the thermal field suggests that most of the dust on this sol could be located at a small elevation, heating the air near the surface. Ground temperatures near noon decreased slightly with the arrival of dust but cannot be accurately characterized with REMS data. Variations of the relative humidity of the atmosphere were also poorly constrained due to a combination of instrument noise and high inter-daily variability of humidity at the same season on different Martian Years.

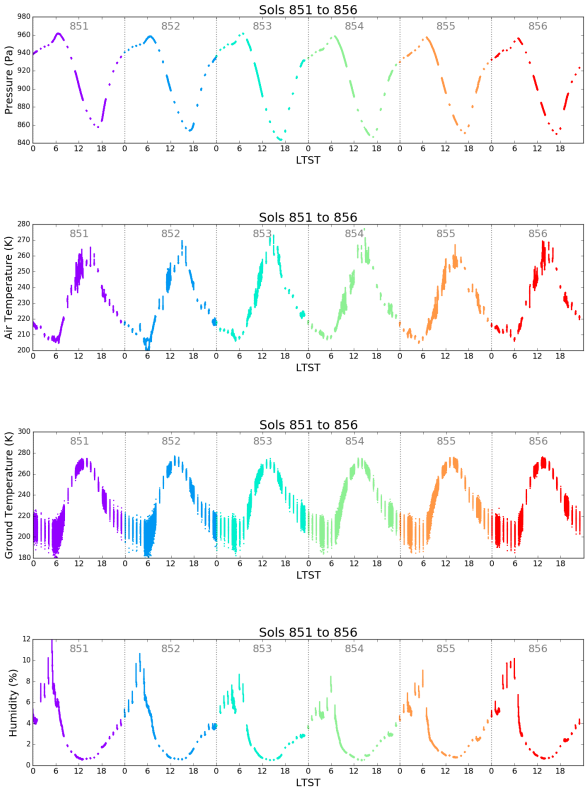

Figure 2: Calibrated REMS data from sols 851 to 856. From top to bottom: Atmospheric pressure, air temperature, ground temperature and humidity.

The atmospheric dust was clearly detectable in the signals recorded by the UV sensors (Figure 2) with decreases of radiation on the order of 30% and a recovery of pre-storm UV fluxes on sol 856.

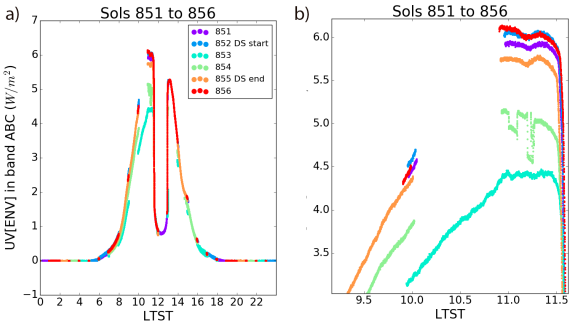

Figure 3: UV fluxes measured with the ABC channel. a) Daily measurements. The central drop of UV flux is caused by shadows partially blocking the detectors. b) Time interval from 9:00 to 11:30 LTST.

3. Conclusions

REMS data show that the storm produced the following effects when the dust arrived to Gale: (1) An increase in the daily amplitude of the atmospheric pressure variation (~15 Pa) mainly through a reduction of the daily minimum pressure (~ 12 Pa) in the late afternoon hours. (2) A decrease of the UV signal (~30 %). (3) An unexpected increase in the temperature of the air close to the surface (~15 K). (4) A slight cooling of the surface near noon (~8 K).

Acknowledgements

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References

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