Convective vortices in Gale Crater

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1. Introduction

- Signatures of dust devils and dustless convective vortices were sought in the data measured by the Curiosity rover during MSL sols 1 to 100.
- 43 sudden drops in atmospheric pressure were detected by the Rover Environmental Monitoring Station (REMS) [1].
- One probable dust devil was detected by the Navigation Cameras.

2. Background

- Sudden pressure drops caused by convective vortices such as dust devils have been detected by the Mars Pathfinder and Phoenix landers [2,3,4].
- Martian dust devils and their tracks have also been imaged by Mars Pathfinder, the Mars Exploration Rovers, the Phoenix lander and the HiRISE camera onboard MRO.
- Dust devils and their tracks had however not been detected in HiRISE images of Gale Crater before the landing of MSL [5].

3. Method

- Sudden pressure drops in the REMS pressure data were searched using an algorithm similar to that used previously to search for pressure drops on the Mars Pathfinder [6] and on the Phoenix data [4].
- Non-significant and false events were removed by hand.
- Magnitudes (ΔP) and durations of all recorded pressure drops were determined by fitting a Lorentzian function to each event.
- Variations in temperature (air and ground), wind and UV radiation occurring concurrently with the pressure events were determined by checking the data collected by all REMS sensors around the time that each sudden pressure drop event was detected.
- Movies for monitoring the motions of dust and ice in the atmosphere have been done using the Navigation Cameras [7]. Dust devils were sought from these movies [8].

4. Results

- 43 pressure events were identified.
- In 63% of the events there is a maximum in air temperature simultaneously with the pressure minimum.
- In 92% of the events the wind vector varies rapidly.
- Decreases in UV radiation, probably caused by dust lifted by vortices and obscuring sunlight, have also been detected [9]. One of these UV obscuration events coincided with a pressure event (figure 1).
- One likely dust devil was detected in the atmospheric monitoring movies [8].

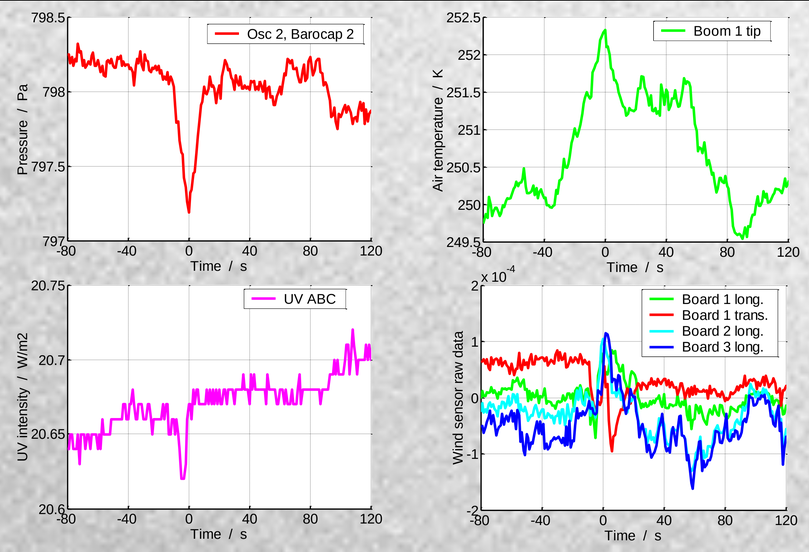

Figure 1. Pressure (up left), air temperature (up right), UV intensity (low left) and boom 2 wind sensor raw data (low right) measured by REMS during a vortex passing on MSL sol 86. The wind sensor data shows that the wind direction changes back and forth during the pressure event.

- The Full-Width at Half Maximum duration of the pressure events is less than 30 s, typically ~7 s.
- The magnitude of the pressure drops (ΔP) varies from 0.3 to 2.5 Pa.
- The distribution of pressure drop magnitudes is shown in figure 2 and table 1. Also the magnitude distributions of the pressure events detected by Pathfinder and Phoenix are shown for comparison.
- In almost all events the pressure curve is smooth with one clear minimum and the Lorentzian function fits well the measured pressure values.
- All events occur daytime, between 9:30 and 15:16 Local Mean Solar Time (LMST).
- The event intensity peaks around 11 LMST. At this time the number of events with magnitude > 0.5 Pa is circa 0.4 events / sol hour.

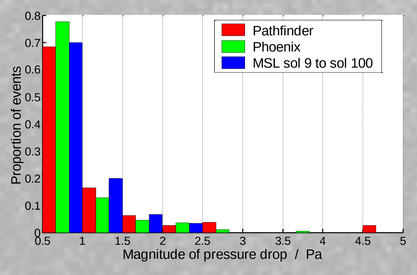

Figure 2. Magnitude distribution of pressure drops with magnitude ΔP > 0.5 Pa. Pathfinder data taken from [6] and Phoenix data from [4].

	Pathfinder	Phoenix	MSL sol 9 to sol 100
Number of events	79	196	31
Mean ΔP	1.01 Pa	0.88 Pa	0.88 Pa
Median ΔP	0.72 Pa	0.74 Pa	0.69 Pa
Max ΔP	4.77 Pa	3.56 Pa	2.47 Pa
Number of events with ΔP > 2.5 Pa	5	3	0

Table 1. Magnitude statistics of pressure drops with magnitude ΔP > 0.5 Pa. Pathfinder data taken from [6] and Phoenix data from [4].

5. Conclusions

Several coincident pressure, temperature and wind variations indicating passing small scale convective vortices have been detected. Thus we conclude that at least dustless convective vortices do occur in Gale crater.

The observed pressure event intensity and magnitude distribution are similar to those detected by Pathfinder and Phoenix [4, 6]. This is surprising taking into account that models predict a suppression of the boundary layer depth on Gale during the day [10]. This tends to inhibit vortex activity because it decreases their thermodynamic efficiency [3]. However the maximum pressure drop detected by MSL is clearly smaller than those detected by the earlier missions (table 1). The number of vortices detected by MSL during the first 100 sols is so small that this could be a statistical coincidence but the lack of pressure events with magnitude higher than 2.5 Pa may also be a consequence of the suppressed daytime boundary layer depth at Gale.

While a surprisingly high number of pressure drops associated with vortices has been detected by REMS the atmospheric monitoring movies have observed only a single likely dust devil [8]. This can be explained by the following:

- Most vortices are not strong enough to lift dust.
- The area where the pressure drop is observable is much larger in diameter than is the optical core where dust is lifted.

In both alternatives the amount of dust lifted to the atmosphere by dust devils is small compared to the number of vortices which must play a role in the overall dust budget of Gale Crater. The fact that a coincident UV obscuration was observed in only one of the pressure events supports this conclusion. This could also explain the missing observations of dust devils and their tracks by orbiters such as MRO.

6. References

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