**CONVECTIVE VORTICES IN GALE CRATER.** H. Kahanpää[1], M. de la Torre Juarez[2], J. Moores[3], N. Rennó[4], S. Navarro[5], R. Haberle[6], M-P. Zorzano[5], J. Martín Torres[5], J. Verdasca[2], A. Lepinette[5], J. A. Rodriguez[5], J. Gomez-Elvira[5], the REMS Team and the MSL team. [1]Finnish Meteorological Institute, P.O. BOX 503, FI-00101, Helsinki, Finland (henrik.kahanpaa@fmi.fi), [2]Jet Propulsion Laboratory, California Institute of Technology, CA 91109, Pasadena, California, USA, [3]York University/Earth and Space Science and Engineering, 4700 Keele Street, North York, Ontario, Canada, [4]University of Michigan, MI 48109, Ann Arbor, Michigan, USA, [5]Centro de Astrobiologia (INTA-CSIC), Madrid, Spain, [6]NASA/Ames Research Center, CA 94035, Moffett Field, California, USA.

**Introduction:** 43 sudden drops in atmospheric pressure, probably caused by dust devils or dustless convective vortices, have been detected by the REMS instrument [1] onboard Mars Science Laboratory (MSL) during MSL sols 1 to 100. The Full-Width at Half Maximum duration of these events is less than 30 s, typically ~7s. Coincident increases in air temperature and variations in wind direction and speed are associated with most of these events. One probable dust devil has also been detected by the Navigation Cameras.

**Background:** Similar sudden pressure drops have been detected by the meteorological instruments onboard the Mars Pathfinder and Phoenix landers. They have been interpreted as being caused by convective vortices such as dust devils [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. However, before the MSL measurements it was not clear if small scale convective vortices occurred in Gale crater. Models predict the suppression of the boundary layer depth on Gale during the day [5]. This tends to suppress vortex activity because it decreases their thermodynamic efficiency [3]. This is consistent with the lack of evidence for dust devils and their tracks on HiRISE images of Gale Crater [6].

**Method:** We use an algorithm capable of detecting deviations from running average values, similar to that used previously to search for significant pressure drops on the Mars Pathfinder [4] and on the Phoenix data [7], to search for sudden pressure drops in the REMS pressure data. Non-significant and false events such as those caused by data gaps were removed by hand.

Variations in temperature (air and ground), wind and UV radiation occurring concurrently with the pressure events are determined by checking the data collected by all REMS sensors around the time that each pressure event occurs.

Movies for monitoring the motions of dust and ice in the atmosphere have been imaged using the Navigation Cameras [8]. Dust devils were sought from these movies [9].

**Results:** 43 pressure events were identified. In most cases the air temperature increases and/or the wind direction and speed changes at the same time with the pressure event. Also dips in UV radiation, possibly caused by dust lifted by vortices and obscuring sunlight, have been detected [10]. One of these UV obscuration events coincided exactly with a pressure event indicating that a dust-lifting vortex probably passed over MSL. One likely dust devil was detected in the atmospheric monitoring movies [9].

All events detected occurred during the daytime, between 9:30 and 15:16 Local Mean Solar Time (LMST). The event intensity peaks around 11 LMST. The maximum intensity of events with magnitude > 0.5 Pa is circa 0.4 events / sol hour. The corresponding pressure event intensities detected by Pathfinder and Phoenix were circa 0.6 and 0.4 events / sol hour, respectively [4, 7].

The magnitude of the pressure drops varies from 0.3 to 2.5 Pa. The distribution of pressure drop magnitudes is similar to that detected by Pathfinder and Phoenix, as can be seen from the following table and graph.

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

**Table 1**. Magnitude statistics of pressure drops with magnitude > 0.5 Pa. Pathfinder data taken from [7] and Phoenix data from [4].

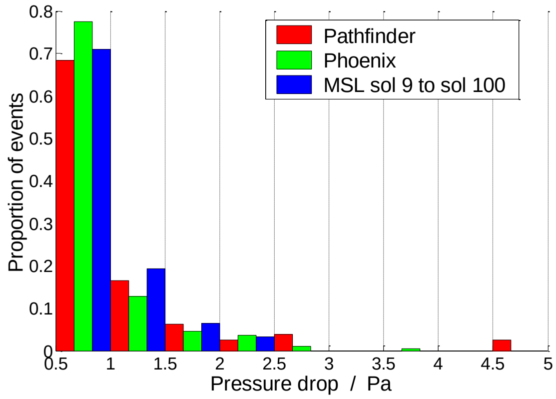


**Fig 1**. Magnitude distribution of pressure drops with magnitude > 0.5 Pa. Pathfinder data taken from [7] and Phoenix data from [4].

**Conclusions:** Several clear small scale convective vortices have been detected. Thus we conclude that at least dustless convective vortices do occur in Gale crater. However not all pressure events detected might been caused by convective vortices.

The pressure drops associated with vortices can be converted to a dust devil density by assuming a dust devil diameter. Orbital observations suggest 6 m as a reasonable value [11] which would imply 195 dust devils per $km^2$ between 1100 and 1200 LMST. During this period, the atmospheric monitoring movies have surveyed 1.14 $km^2$ of the crater floor, but have only observed a single likely detection of a dust devil [9]. This suggests that most vortices are dustless, a conclusion which does not change even for large dust devils (diameter > 100 m). This could also explain the missing observations of dust devils and their tracks by orbiters such as MRO.

Alternatively, if the pressure disturbance is larger in diameter than is the optical core the optical and pressure data can also be reconciled. A 42 m diameter pressure disturbance with a 6 m optical core is just the right size to predict one optical detection over the surveyed area. Larger vortices are also more consistent with the duration of the pressure dips if the dust devils move with the prevailing winds.

The fact that a coincident UV obscuration was observed in only one of the pressure events supports the conclusion that most vortices were not strong enough to lift dust or alternatively that the area where dust if lifted is small compared to the area where the pressure drop is observable. 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.

During MSL sols 1 to 100 the intensity of pressure events was almost the same than what was detected by Pathfinder and Phoenix. The intensities detected by the different missions are not completely comparable as the measurements were not performed exactly at the same time of the Martian year and the vortex activity is expected to change with season. However the vortex intensity is surprisingly high taking into account that the daytime boundary layer depth is suppressed in Gale Crater [3].

The magnitudes of the pressure drops detected by MSL are similar to those detected by the earlier missions. This is surprising since according to modeling the vortices in Gale Crater should be weaker. [3]. However the maximum pressure drop detected by MSL is clearly smaller than those detected by Pathfinder and Phoenix. The number of vortices detected by MSL until sol 100 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.

**References:** [1] Gómez-Elvira J. et al. (2012), *Space Sci. Rev.*, 170(1-4), 583-640. [2] Schofield, J. T., et al. (1997), *Science*, 278, 1752-1758. [3] Renno, N. O., et al. (2000), *J. Geophys. Res.*, 105, 1859-1865. [4] Ellehoj M. et al. (2010), *J. Geophys. Res.*, 115(E00E16). [5] D. Tyler Jr. and J. R. Barnes (2005) *Mars* 1, 1-13. [6] Calef F., presentation in MSL AWG meeting Sep. 17 2012. [7] Murphy, J. R. and S. Nelli (2002), *Geophys. Res. Lett.*, 29(23), 2103. [8] R. Francis et al. (2013) LPSC XLIV. [9] J. Moores et al. (2013) LPSC XLIV. [10] Zorzano M-P., *EGU 2013*, abstract. [11] Cantor B., personal communication.