National Aeronautics and Space Administration

P51C-02 PRESSURE DEFICIT IN GALE CRATER AND A LARGER NORTHERN POLAR CAP AFTER THE GLOBAL DUST STORM OF MARS YEAR 34

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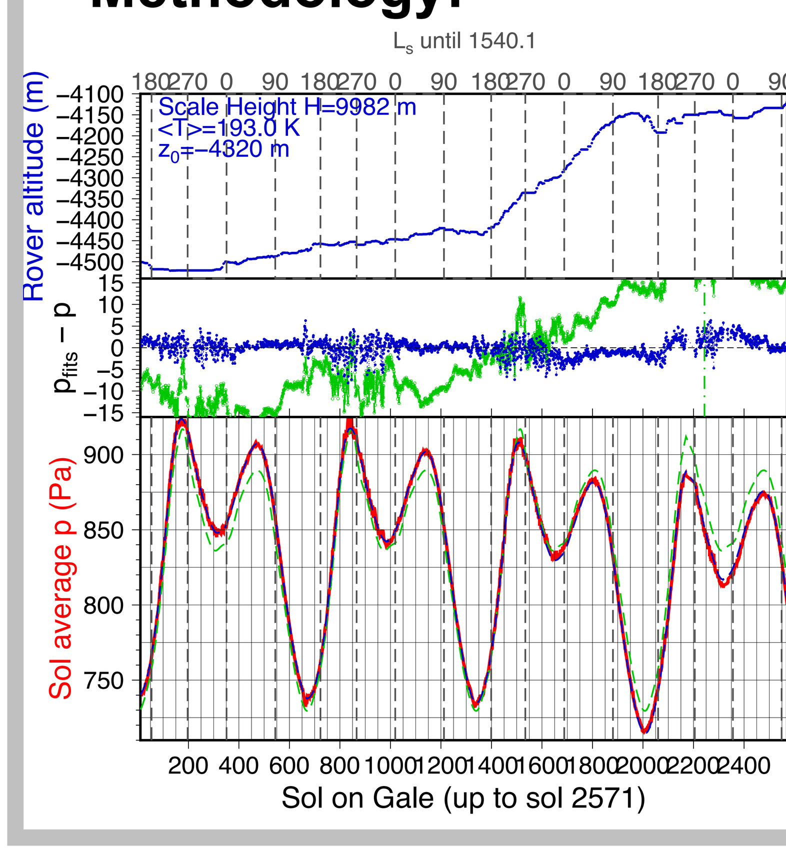
Introduction:

- The atmosphere has been thinning out with height during Curiosity's climb up Gale crater, and the barometer on its Rover Environmental Monitoring Station (REMS) [1] has characterized the rate at which the surface pressure has decreased with altitude.
- The rate of surface pressure drop changed after the global dust storm of MY34 and lasted over the following Northern Hemispheric winter.
- It recovered the rate from before the storm after the sublimation of the NH Polar cap.
- The change in rate can be explained by a lighter atmosphere.
- 3 potential causes for the lighter atmosphere are explored using Mars Climate Sounder observations: (1) changes in extent of the NH polar cap; (2) changes in Hadley cell orientation; (3) changes in atmospheric oscillations.

Result: Only a change in the horizontal extent of the NH polar cap seems to be consistent with the duration of the deficit in atmospheric pressure.

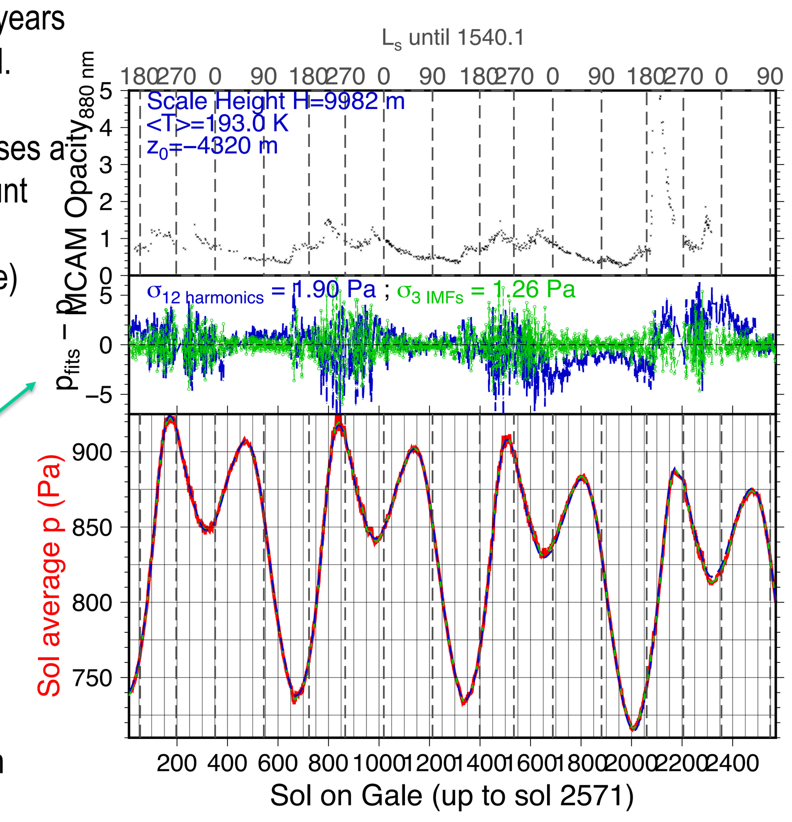
Methodology:



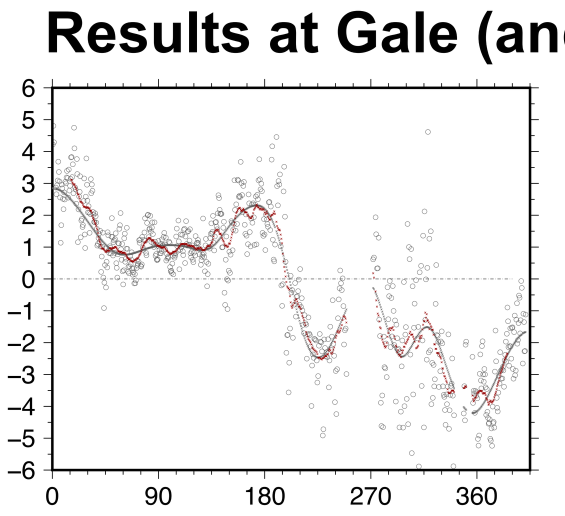
The pressure record collected by REMS during 3 mars years was used to calculate the average pressure for each sol.

A fit to a model of average daily surface pressure that uses a series of harmonics of areocentric longitude Ls to account for the seasonal cycle, and a power law that models the atmospheric thinning with height returns a better fit (blue) than ignoring changes with altitude (green).

An empirical filter, like the Hilbert-Huang (green):
1- has a better result with its first 3 Empirical Modes than the Fourier x exponential (blue).
2- It highlights the times where the observation may be separating from a series of harmonics.



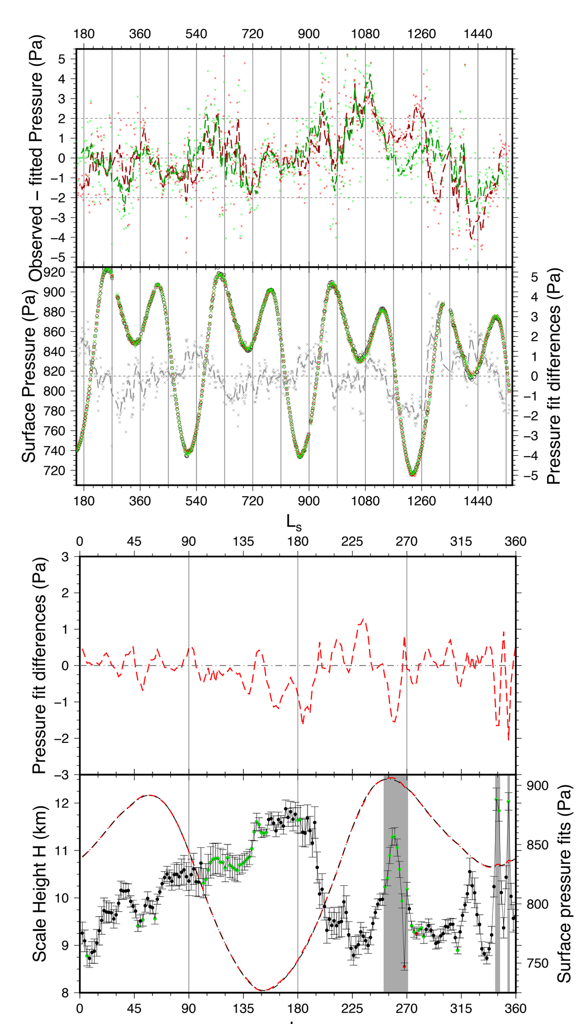
Results at Gale (and significance):



For an isothermal atmosphere, surface pressure decays exponentially at a rate characterized by the pressure scale height $H(z_0)=RT(z_0)/g$.

If H is considered constant throughout the year, the pressure deficit reached up to 4 Pa (red symbols show a running mean of the differences).
In the time periods Ls~195º-240º (after the global dust storm) and Ls~275º-390º (after the C storm)

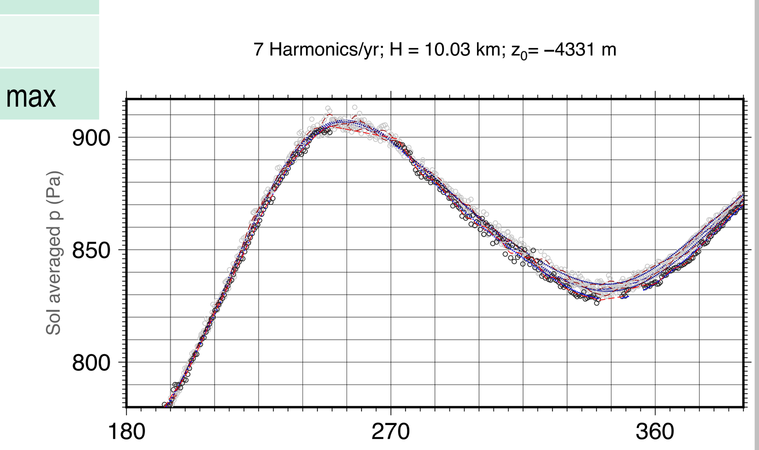
Using a smooth version of the observations, H can be calculated as a function of Ls. The pressure deficit is smaller (green symbols) but still shows a lighter than expected atmosphere.



MY	Aphelion p_{max}	△ Ls	NH Summer p_{min}	△ Ls	Perihelion p_{max}	△ Ls	SH Summer p_{min}
31	N/A		N/A		254.75	88	342.75
32	57.75	94.25	152.0	101.75	253.75	86.5	343.25
33	57.5	94.5	152.0	101.5	253.5	87.25	340.75
34	55.5	96	151.5	104	255.5	87.75	343.25
	SPC growing		SPC max	NPC growing			NPC max

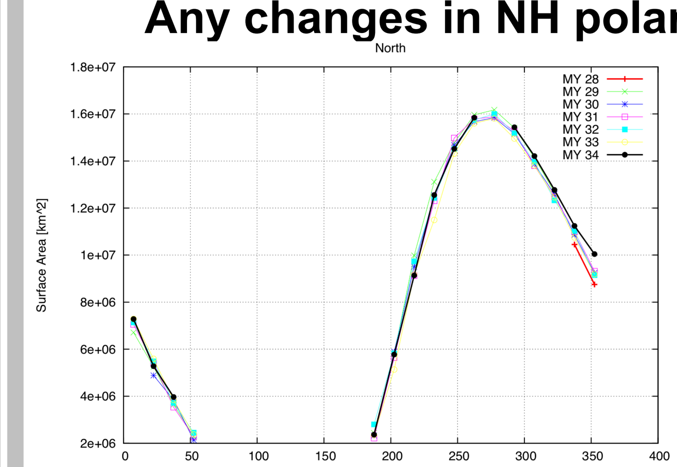
Interannual comparison of the polar seasons durations based on when the pressure minima and maxima where observed.

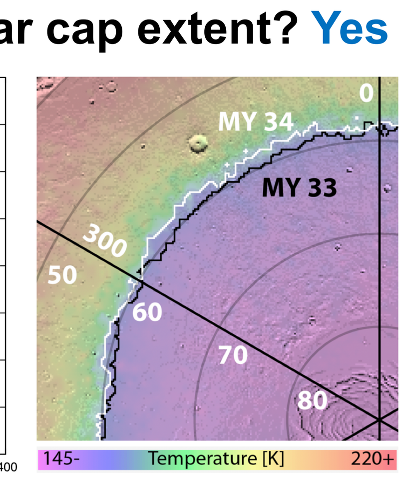
On each column in the table
Blue numbers mark anomalies below the mean – standard deviation
Red numbers mark anomalies above the mean + standard deviation



Large Scale context from MCS:

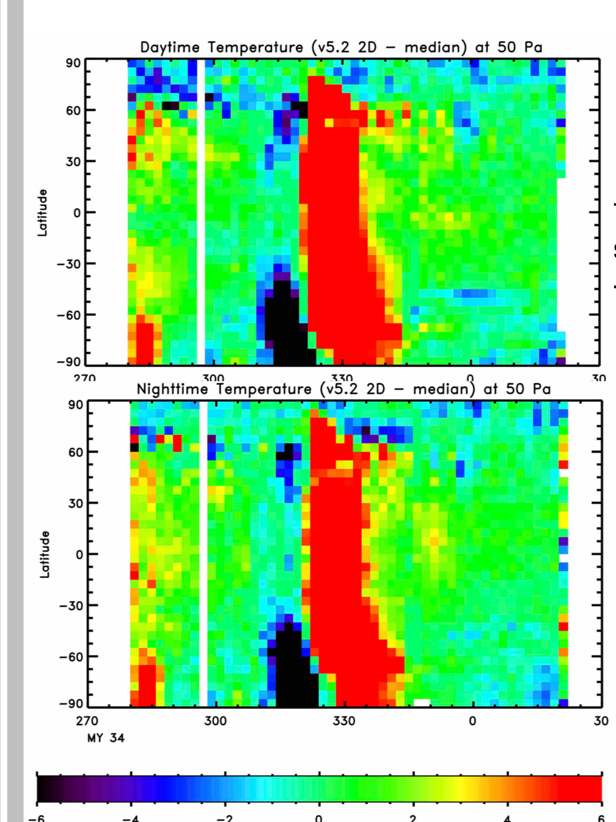
Any changes in NH polar cap extent? Yes





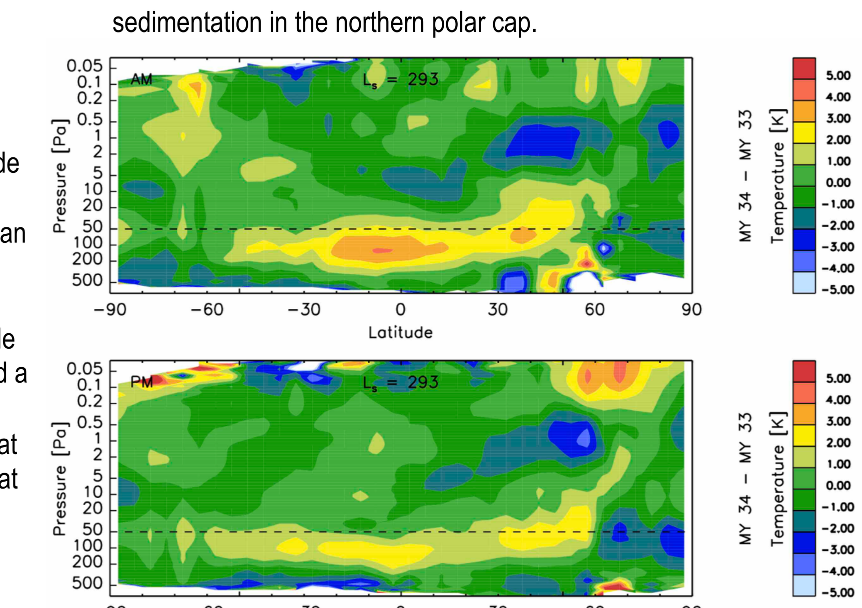
Increased area coverage of the NH polar cap in the season after the Global Dust Storm

Changes in Hadley circulation? Yes

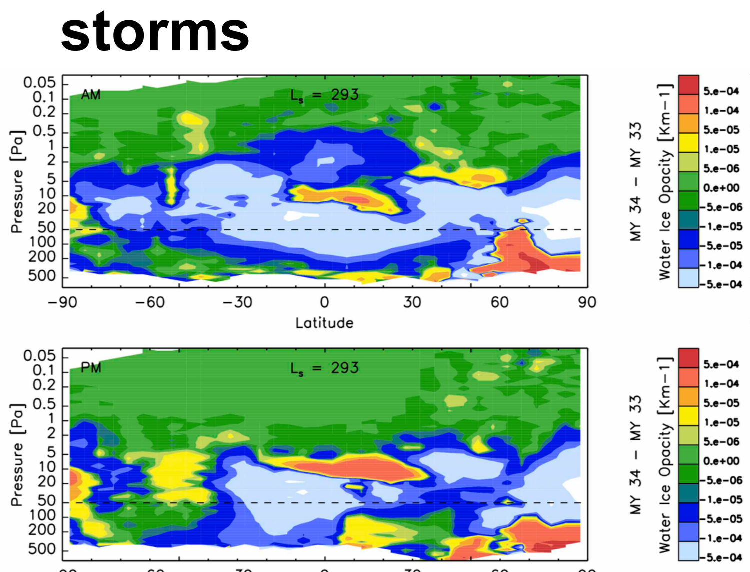


The temperatures at 50 Pa showed
- South of ~55 deg latitude an overall warmer atmosphere in MY34 than MY33 for the same Ls period.
- North of ~65 deg latitude the atmosphere showed a long lasting cooler atmosphere except for at Ls~310-340 especially at night that would have favored ice formation.

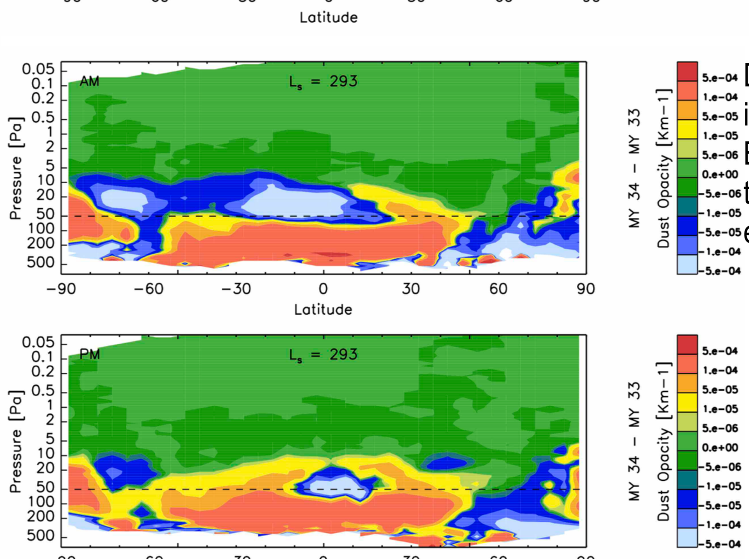
The zonal mean temperatures averaged from Ls 281º to 305º showed an overall colder atmosphere poleward of 60ºN latitude in MY34 than in MY33. This would favor ice formation and sedimentation in the northern polar cap.



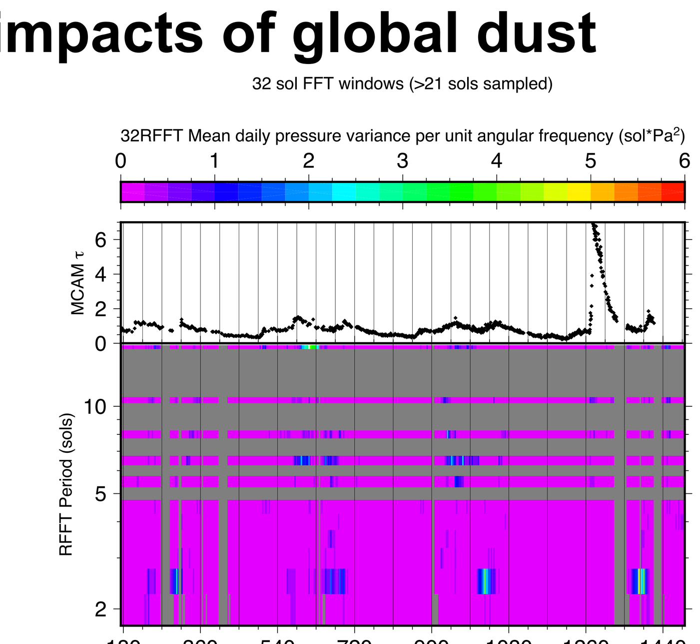
Increasing our understanding of the impacts of global dust storms



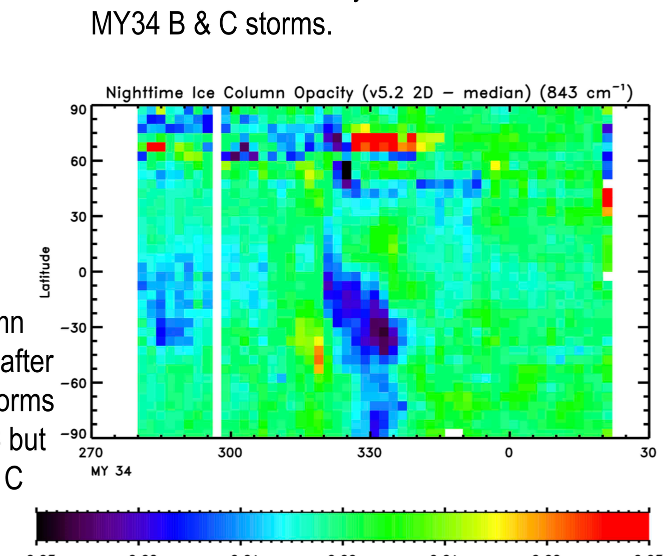
Water Ice column opacity decreased after the MY34 B & C storms compared to MY33 but increased after the C storm at low altitudes over the NP.



Dust column opacity increased after the MY34 B & C storms compared to MY33 at most altitudes except over the NP.



Baroclinic wave activity decreased after the MY34 B & C storms.



Nighttime Ice column opacity decreased after the MY34 B & C storms compared to MY33 but increased after the C storm over the NP.

Summary and conclusions:

Goal: Understand changes associated to global dust storms.

Previous analyses had found no changes in surface pressure after previous dust storms. Within an error bar of 5 Pa. This analysis finds a change in surface pressure of ~2 Pa to 4 Pa

Dynamical effects are not found in the Hadley cell. It seems to have a similar structure in MY33 and MY34 albeit its being colder at latitudes northward of 65N.

Dynamical effects are found in the shorter lived baroclinic waves. The atmosphere is calmer, with less oscillations occurring during and after the global dust storm. This is consistent with previous observations.

The northern polar cap extent increased in MY34 after the global dust storm and, again, after the C storm. It is unclear how this can be a dynamic effect. It is consistent with the colder northern pole after the storms. We cannot exclude a radiative effect from changes in ice albedo or surface thermal emission.

In absence of a clear mechanism explaining the colder polar atmosphere, it is unclear if the colder pole is a consequence of the dust storms or just a coincidence.

References

[1] J. Gómez-Elvira, et al. (2012). REMS: The Environmental Sensor Suite for the Mars Science Laboratory Rover. Space Sci. Rev., 170, 583–640, doi 10.1007/s11214-012-9921-1.

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