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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Abstract

In past global dust storms, no long lasting anomalies in the pressure cycle had been observed. The Global Dust Storm of Mars Year 34 (MY34), however, left behind an average surface pressure lower than what was expected based on the values recorded on previous years by the Rover Environmental Monitoring Station (REMS) on Curiosity. The main signal contribution to the daily average surface pressure is the CO2 cycle, which is controlled by the Polar ice sublimation and freezing cycles. We used REMS and Mars Climate Sounder (MCS) data to search for correlations between the REMS anomaly and anomalies in the circulation compared to MCS observations from previous years. The findings include an early start of the retreat season for the Northern Polar cap, followed by the longest period of growth for the Southern Polar (SP) cap ice expansion since Curiosity had landed and then, during the dust storm, the longest retreat season of the Southern Polar cap. We also find a larger Northern Polar Cap extension after the storm, suggestive of a larger deposition of CO2 ice. The changes in length of the SP growth and retreat seasons might be consequence of the response of the zonal mean circulation to the dust storm. Changes in the structure of the zonal mean circulation compared to previous years are found in MCS data and presented. The combination of these anomalies constraint what physical processes may have caused this response in surface pressure after the dust storm.
Introduction:

- The atmosphere has been thinning out with height during Curiosity’s climb-up of 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 abatement 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 Dynamics: (1) changes in atmospheric oscillations, (2) changes in Hadley cell orientation, (3) changes in atmospheric oscillations.

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 areocentric longitude Ls to account for the seasonal cycle, and a power law that models the pressure scale height with height returns a better fit (blue) than ignoring changes with altitude (green).

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.

Results at Gale (and significance):

- For an isothermal atmosphere, surface pressure decays exponentially at a rate characterized by the pressure scale height H20=\(pT(\text{gPa})\).
- Using a smooth version of the observations, H can be calculated as a function of L. The pressure deficit is smaller (green symbols) but still shows a lighter than expected atmosphere.

Large Scale context from MCS:

- Changes in Hadley circulation?

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 65°N.
  - 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.

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

References