Meteorological pressures at Gale crater from a comparison of REMS/MSL data and MCD/LMD modelling: effects of dust storms

Iñaki Ordonez-Etxeberria[1], Ricardo Hueso[1], Agustín Sánchez-Lavega[1], E. Millour[2], F. Forget[2]

[1]Dpto. de Física Aplicada I, Escuela de Ingeniería de Bilbao, Universidad del País Vasco, [2]Laboratoire de Météorologie Dynamique (LMD)

Introduction: We examine the global record of atmospheric pressure in Gale crater measured in-situ by the Rover Environmental Monitoring Station Instrument (REMS) [1] on the Mars Science Laboratory rover over more than 2 Martian years (1514 sols). In a previous work we analysed the presence of transient pressure events caused by dust devils and surface turbulence [2]. Here we present a global analysis of daily pressure variations comparing REMS pressure data with pressure predictions from the Mars Climate Database (MCD) [3, 4], finding events of few sols of duration. On certain groups of sols the difference between the MCD synthetic data and the measurements becomes large and separates from the global trend in the REMS data. Previous studies of global surface pressures measured by the Viking landers [5, 6] and REMS [7] have assessed the decisive role of atmospheric dust in enhancing the amplitudes of daily pressure tides. In particular [7] compared the amplitudes of the diurnal and semidiurnal tides with the amount of local dust at Gale crater finding a nearly perfect correlation. From a comparison with images from the MARCI instrument we show that regional dust storms induce a characteristic signature in the pressure signal measured by REMS sols before the dust arrives to Gale crater. Our aim in this work is to detect and characterize local meteorological events that last for a few sols and that could be caused by local dust and regional dust storms.

Data: REMS pressure data here analysed extends from August 7, 2012 (the day after landing; Ls = 150.6°, Martian Year MY = 31) to November 9, 2016 (Ls = 258.1°, MY = 33) covering a total of 1514 sols or more than two Martian years. We compare this record with synthetic data from the Mars Climate Database (MCD). MCD [3, 4] is a database of atmospheric parameters computed from the average of several runs of a Global Climate Model (GCM) of the Martian atmosphere. We also use the aerosol optical depth values derived from images acquired by the MastCam instrument on board the MSL rover [7] and the aerosol optical depth measurements observed by REMS UV sensors [8]. We also examine images obtained by the Mars Color Imager (MARCI) instrument [9] on board the Mars Reconnaissance Orbiter (MRO). This instrument provides regular wide-angle color images of the Martian surface and its atmosphere from a sun-synchronous orbit allowing observing dust storms and clouding systems.

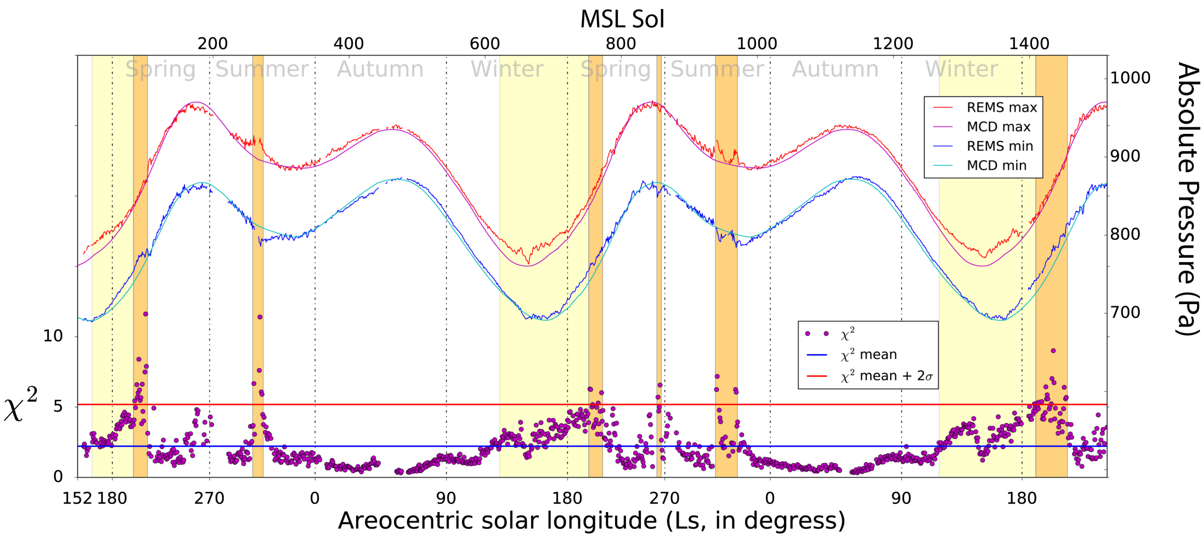

Figure 1: REMS and MCD maximum and minimum pressures (top curves) with the comparison of both data sets using a chi-square comparison that takes into account data for each hour (magenta dots). Groups of sols where anomalous pressures occur are highlighted in orange.

Methodology: We compare REMS and MCD daily pressure data. For each sol we use MCD data calculated for the same aerocentric longitude Ls as the REMS measurements and we compare the daily behaviour discretizing both datasets with 24 points per sol. For each sol a chi-square factor representative of the differences between both time series can be computed. The comparison of REMS and MCD pressure data using this method is shown in Figure 1. Values of chi-square have a mean value of 2.22, and a standard deviation of 1.48. Sols where the chi-square difference between REMS and MCD is greater than the mean value plus 2 standard deviations (5.18) are exceptional and appear in well defined groups of sols. These groups of sols are highlighted in orange in Figure 1 and represent extreme deviations from the MCD values that cannot be explained solely by local orographic effects not fully accounted in the MCD simulations.

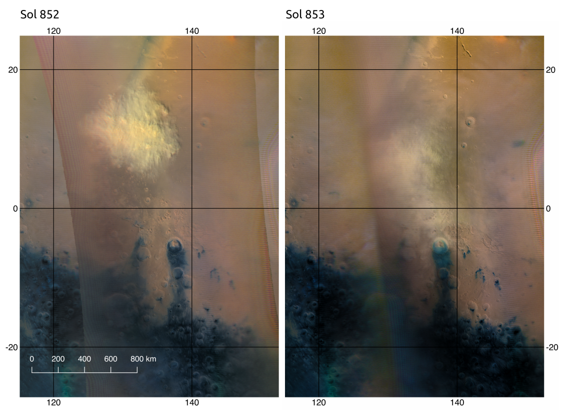

Figure 2: Example of a regional dust storm developing close to Gale crater on sol 852 and injecting large amounts of dust in the crater on sol 853.

Results: The differences in pressure values corresponding to high values of chi-square are well correlated with peaks of dust optical depth measured by MastCam and REMS/UV photodiodes. However in many cases the peaks of dust opacity over Gale crater appear a few sols after the maximum difference between REMS and MCD pressures. Images obtained by the MARCI instrument allow us to identify local and regional dust storms close to or above Gale crater at the time of the MCD-REMS pressure anomalies (see Figure 2). We identify dust storms in different regions of the planet which could trigger of the pressure anomalies with respect to the MCD model.

Conclusions: REMS data is globally well reproduced by the MCD and the GCM simulations under its standard scenario. Groups of sols in which REMS and MCD data show mismatches correspond to local or regional dust storms. It is possible to detect the development of dust storms in locations far away from Gale crater from their signature on the local pressure data. The arrival of the dust from those storms maximizes the pressure differences later on.

References:

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