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Response of the pressure scale heights inside Gale crater to the diurnal changes in atmospheric circulation

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Abstract

This work presents the pressure scale heights inferred from fitting the surface pressure measured by Curiosity's Rover Environmental Monitoring Station to a height dependent model. When the model is an exponential, the resulting pressure scale heights change if the surface pressure is taken at different local solar times of the sol. Those changes reflect changes in the average air temperature in the lowest atmosphere and this air temperature is a response to the combined effects of solar forcing, topographic flows, and the air mass exchange between the inside and outside of Gale crater. The observations are compared to model predictions and the timing for the transitions between different types of atmospheric circulation is inferred from the comparison.

1. Introduction

As the Curiosity rover has been climbing up Gale crater, the barometer on its Rover Environmental Monitoring Station [1] has characterized the rate at which the atmosphere has been thinning out with height [2]. It has led to a decrease in diurnal averages of surface pressure at a rate that depends on thermal properties such as average temperature and temperature gradient of the air layer at those altitudes crossed by the rover. Since the thermal properties of the atmosphere change depending on the combined influence of local circulation and solar forcing, both magnitudes experiment a diurnal cycle of warming or cooling. These changes also relate to the time and strength of the transition from a stable to a convectively unstable lower atmosphere layer, or when orography induces local circulations that can alter temperature profiles inside Gale Crater. This study analyses the times at which the different transitions occur and compares to model predictions for what are the likely processes driving the atmospheric circulation at different times of the sol. "Subsection_heading" in order to have it correctly formatted.

2. Methodology

The pressure record collected by Curiosity's Rover Environmental Monitoring Station (REMS) over three mars years was used to calculate the average daily pressure. Using a fit to a model of surface pressure that uses a series of harmonics of aerocentric longitude L$_s$ to account for the seasonal cycle, and a power law that models the atmospheric thinning with height, the average temperature of the atmospheric layer crossed by the rover and its averaged lapse rate can be calculated.

When the fit is done to the pressure at different Local True Solar Times (LTST) instead of the daily averaged surface pressure, there is a dependence in the resulting pressure scale height, the associated average temperature, and the lapse rate of the atmospheric layer.

3. Results

The resulting diurnal cycle in pressure scale heights marks times at which a transition between different circulation regimes for an average atmosphere inside Gale Crater. The results can be compared to model predictions [3,4] to validate the physical mechanisms obtained by the models, their intensity, and the time at which they occur.

On average, the vertical thermal structure of the hydrostatic atmosphere layer above Gale is found to be stable to convection at ~ −1.6 K/km. When the diurnal changes of surface pressure are considered on an hourly basis, the fit results indicate changes in the vertical structure from stable to unstable. Four periods can be distinguished of cooling and warming:

- Cooling regimes occur at night from 00:00 LTST to 04:30 LTST, during the day from 09:00 LTST to 10:30 LTST, early afternoon from 12:30 LTST to 15:00 LTST, and at the time were topographic flows have been identified on Gale [5], between 20:30 and 21:30 LTST.
- Warming regimes were found after sunrise, from 05:00 LTST to 08:30 LTST, slight warming near noon, from 11:00 LTST to 12:00 LTST, in the late afternoon from 15:30 LTST to 20:00 LTST, and from 22:00 LTST to 23:00 LTST.

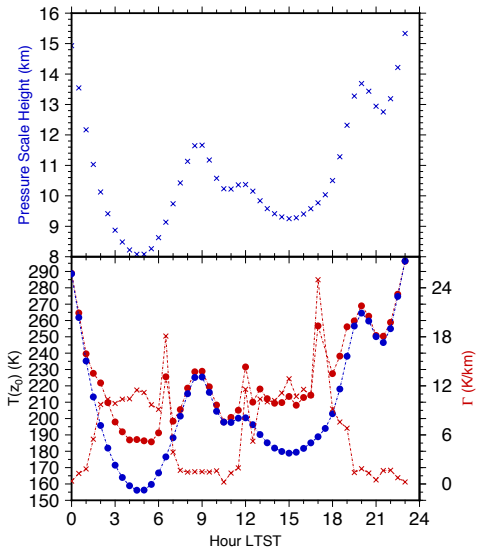

Figure 1 Top: pressure scale height as a function of LTST. Bottom: blue circles for the average temperatures from those pressure scale heights (i.e. isothermal atmosphere) and red circles for the temperature in the center of the layer if a linear positive lapse rate model is used. Red crosses mark the positive lapse rate value.

The change of vertical temperature gradient marking the change of stability inside the crater occur short after sunrise and before sunset.

References

[1] J. Gómez-Elvira, C. Armiens, L. Castañer, *et al. (2012)* REMS: The environmental sensor suite for the Mars Science Laboratory rover. Space Sci. Rev., **170**, pp. 583-640, 10.1007/s11214-012-9921-1.

[2] Pascal, Blaise (1648) *Oeuvres complètes. Périer to Pascal*, 22 September 1648. Paris: Seuil, 1960, **2**:682.

[3] Withers, P (2012), *Space Sci. Rev.*, **170**, 837–860

[4] Tyler, D., Barnes, J.R. (2015) *Geophys. Res. Lett.*, **42** (2015), pp. 7343-7350.

[5] Richardson M.I., and Newman C.E. (2018) *Planetary and Space Science*, 164, pp. 132-157.

[6] Miller, N.M., de la Torre Juárez, M., & Tamppari, L.K. (2018). The effect of Bagnold dunes slopes on the short timescale air temperature fluctuations at Gale crater on Mars. *Geophys. Res. Lett.*, **45** , 11,588–11,594. https://doi.org/10.1029/2018GL080542