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Preliminary Interpretation of the Meteorological Environment Through Mars Science Laboratory Rover Environmental Monitoring Station Observations and Mesoscale Modeling.

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Abstract

In this study the Mars Regional Atmospheric Modeling System (MRAMS) has been applied to the Gale Crater region, the landing site of the Mars Science Laboratory (MSL) Rover Curiosity. The landing site is at one of the lowest elevations in Gale, between the crater rim and the ~4 km high central mound known as Mt. Sharp. As Curiosity heads toward its long term target of Mt. Sharp, the meteorological conditions are expected to change due to the increasing influence of topographically-induced thermal circulations that have been predicted by numerous previous studies [1, 2, 3, 4]. The types of perturbations of pressure, air and ground temperature and wind measured by the Rover Environmental Monitoring Station (REMS) [5] have never been observed at other locations and these data provide a great opportunity to test the models at the most meteorological interesting area measured to date. We provide a comparison of MRAMS predictions (pressure, air temperature, winds and ground temperature) to the REMS data available at the location of the Rover for sol 23 (when first regular REMS measurements were obtained, L_s=163), sol 53 (L_s=180), sol 196 (L_s=270) and sol 670 (L_s=0).

1. Introduction

In an effort to better understand the atmospheric circulations of the Gale Crater, the Mars Regional Atmospheric Modeling System (MRAMS) was applied to the landing site region using nested grids with a spacing of 330 meters on the innermost grid that is centered over the landing site (Figure 1).

Figures 2 and 3 are comparison examples of model predicted pressure and ground temperature compared to the diurnal cycle measured by REMS in sol 53 (L_s=180).

2. Comparisons MRAMS-REMS

Modeled pressure variations at L_s=180 (Figure 2) indicate that the baseline global pressure is reasonably accurate, as is the amplitude of the diurnal pressure cycle. Besides the dominant diurnal and semi-diurnal tide, both the model and observations show higher frequency variations in pressure. The cause of these perturbations is unclear. In the model, there is no noticeable relationship between upslope/downslope flows and the pressure.

The model ground temperatures are noticeably warmer than the observations (Figure 3). Part of this discrepancy is due to the height of the first model atmospheric level that sits 14-m above the ground. In a strong nocturnal inversion, the model will produce a warmer temperature than at a height of ~1.5m where the REMS temperature sensors are located. There is work in progress to extract the 1.5-m temperature extrapolated from the model using Monin-Obukhov surface layer physics.

2.2 Topographic winds at Gale

In the model, a katabatic flow that adiabatically warms as it descends originates on the north rim of the crater (Figure 4). There is a sudden increase in air density around 21.55 LMST at landing site. The air is only a few K colder than the surrounding environment at the point of origin. By the time it reaches the crater floor, it is approximately the same temperature as the surrounding air. There are numerous convergence boundaries and some turbulent mixing that may also keep the temperatures warmer than would be expected by pure radiative equilibrium arguments. Therefore, the unexpectedly warm observed temperatures as well as the noticeably thermal perturbations at night may be caused by mixing from intermittent nocturnal turbulence and by changes in local air mass.

The MRAMS mesoscale model predictions of slope flows for Gale Crater seem to be in general agreement with REMS observations: timing and direction of incoming wind, wind variability during the day and fixation at night to the same orientation, and indications of turbulent mixing of different masses of air with different temperatures.

Wind speeds show a diurnal pattern with the strongest winds at night, regardless of season. The windiest season is northern winter (L_s=270). The daytime is generally the least windy, although wind gusts associated with turbulence, as indicated by the subgrid scale turbulent kinetic energy can be strong (10.3 m/s in L_s=270 and 6.9 m/s in L_s=163). Wind direction is complex and varies with season. This is due to the interaction of the numerous local flows with the seasonally-evolving larger-scale circulations. For example, the surface winds at L_s=163 and L_s=180 look similar, but there are subtle differences in the strength and location of the local circulations.

3. Figures

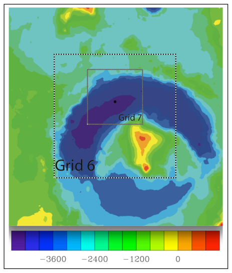

Figure 1: Horizontal Grid Spacing applied to landing site region: 330 meters for Grid 7 and 980 meters for Grid 6. The black dot is the Curiosity location.

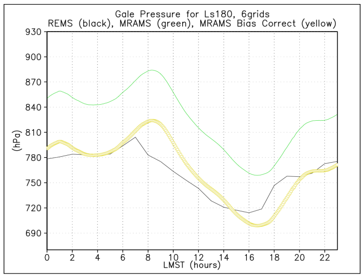

Figure 2: Comparison of MRAMS model predictions to the diurnal pressure cycle measured by REMS in sol 53 (L_s=180).

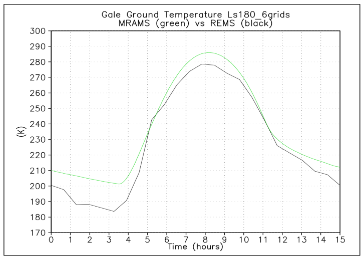

Figure 3: Comparison of MRAMS model predictions to the diurnal temperature cycle measured by REMS in sol 53 (L_s=180).

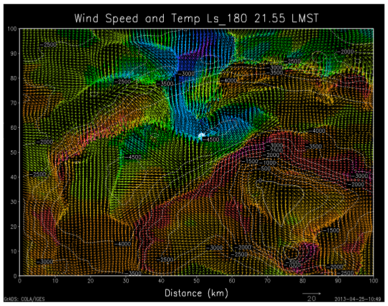

Figure 4: Predictions of diurnal wind speed and temperature cycle for sol 53 (L_s=180). The white dot is the Curiosity location.

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