DUST EROSION AND SEDIMENTATION PATTERNS IN GALE CRATER AS SIMULATED BY THE MARS REGIONAL ATMOSPHERIC MODELING SYSTEM (MRAMS).

A. J. M. Moreau[1], R. M. Haberle[2], and S.C.R. Rafkin[3], M. A. Kahre[2], and J.L. Hollingsworth[2]. [1]Education Associate Program (EAP)-University Space Research Association (anne-flore.j.moreau@nasa.gov), [2]NASA Ames Research Center, [3]Southwest Research Institute.

Introduction: The current NASA mission of the Mars Science Laboratory (MSL) successfully landed the rover Curiosity on the Martian surface on August 6, 2012. The main goal of the mission is to characterize present and past habitability in Gale Crater. Thus, Curiosity carries a Rover Environmental Monitoring System (REMS) that consists of a suite of meteorological instruments that measure the present day environment inside the crater [1]. Such measurements will help us characterize on-going atmospheric aeolian process that are shaping various land forms in the crater such as dune fields, yardangs, and even Mt. Sharp itself.

To better understand present aeolian activity in Gale Crater, we use the Mars Regional Atmospheric Modeling System (MRAMS) to simulate the lifting, transport, and sedimentation of dust in and around the crater. Our ultimate goal is to determine the net dust budget of the crater. Is Gale a net source or sink for atmospheric dust?

To achieve this goal, we begin our studies by focusing on a single season - southern winter - when the local circulation is most vigorous. We use the model to assess where at this season dust is eroded and where it accumulates. Later we plan to conduct simulations for other times of year to build up an annual dust budget for the present day climate system.

Model Description: The Mars Regional Atmospheric Modeling System is a fully non-hydrostatic mesoscale model with a tracer capability for a variety of species. The model is forced by radiative heating due to CO_2 and dust, turbulent mixing of heat, momentum, and tracers, and has a complete soil package for predicting ground temperatures. See [2] for details.

The model has a nesting capability which allows simulations at very high horizontal resolution. In this work we run with 5 grids with grid 5 (the highest resolution grid) at ~3 km resolution.

The model carries both a background and a foreground dust field. The background dust is fixed in time and space and is radiatively active. Foreground dust is lifted, transported and sedimented, and can be either radiatively active or passive. In the present simulations the foreground dust is radiatively passive.

Several options for lifting schemes are available in the model: a constant threshold scheme based on a user-specified stress threshold, and dynamic threshold which is also somewhat tuneable. In this work we use the dynamic threshold scheme.

Initial and boundary conditions are provided by the Mars Global Circulation Model (MGCM) developed at NASA Ames Research Center.

Experiments and Methodology: The simulations were run over 8 days to capture a robust trend in the change in the size of the surface dust reservoir. The foreground dust loading was zero at the beginning of the simulation. Thus, the modeled erosion and accumulation patterns are due to local dust transport. Background dust was initialized using zonally-averaged TES opacities.

Results:

Winds and Surface Stress: Figure 1 shows the maximum surface stress over Gale Crater for the last simulated day. In general the highest wind stresses occur on the crater rims. These are the result of strong nighttime downslope flows. The lowest maximum wind stresses occur at the floor of the crater, particularly in the northern portion where Curiosity is operating. Surface stresses there never exceed 1 mN/m^2. This is a region where modeled winds are generally light and variable throughout the day [3].The model also shows very high stresses near the top of Mount Sharp with maximum surface stresses reaching ~ 35 mN/m^2 on its southwestern flank during the early afternoon. Many yardangs are seen in this region ([4]).

Net Dust Erosion and Accumulation Patterns. Figure 2 shows the net change in the dust reservoirs. To better compare with observed features and modeled patterns, the results have been superimposed on a HiRISE image of Gale taken from [9]

A look at the net dust erosion patterns (Figure 2.a) shows that at this season the wind dynamic tends strongly to erode the crater's rims and Mount Sharp. Good correlations are found between the dark-toned layered yardangs on the western flank of Sharp ([4]) and the erosion feature as modeled by MRAMS. It is noteworthy to mention that the erosion rate over Sharp is spatially variable. The very top of the Mount seems to be shielded from strong eroding winds (erosion rate close to 0), while its western flank experiences an erosion rate of 350 μm/Martian year. Given that Mount

Sharp is ~5.5 km high, such rate implies that Sharp would be eroded away in 15.7 million Martian years.

On the other hand, a look at the net dust sedimentation patterns shows that at this season the basins are preferential areas for dust accumulation. A run initialized with dusty atmosphere and lifting disabled confirms that once settled dust can not be removed from these regions. The sedimentation rate reaches up to 30 μm/Martian year on the northern basin near the rover location. Assuming the basin is ~4000 meters deep, it would take 130 million Martian years to fill it, assuming this accumulation rate is constant. This high sedimentation of dust in the northern basin is the result of the weak winds and low surface stresses mentioned above, and correlates well with the few dust devils observed by MSL [5]. To explain such phenomenon, Renno [6] hypothesizes the role played by the suppressed convective boundary layer, also modeled in Tyler's work [7].

In [8], Kite suggests that Mount Sharp has entered a late erosional stage. At this season, for this model's settings, the output erosion patterns present good agreement with this theory. However, Kite's hypothesis assumes that all the dust is removed from the crater. The net accumulation modeled by MRAMS suggests this assumption may be too simplistic.

The integration of the overall dust budget over the studied area indicates that at this season Gale is losing dust at a rate of $7.3\text{x}10^6$ m^3/Martian year.

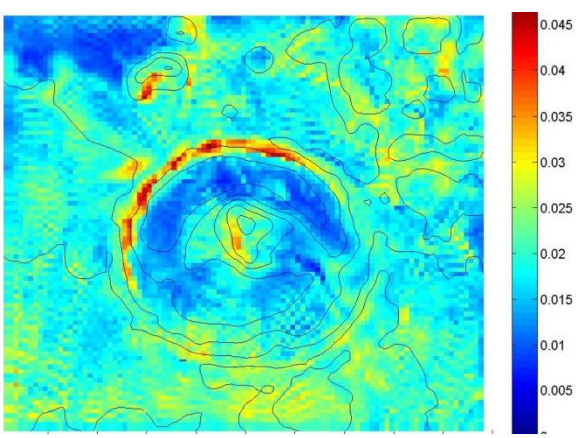

Figure 1 Maximum Surface Stress Pattern over Gale Crater for the last simulated day. Contour plot highlights the topography levels and the shaded colors show the surface stress (N/m^2).

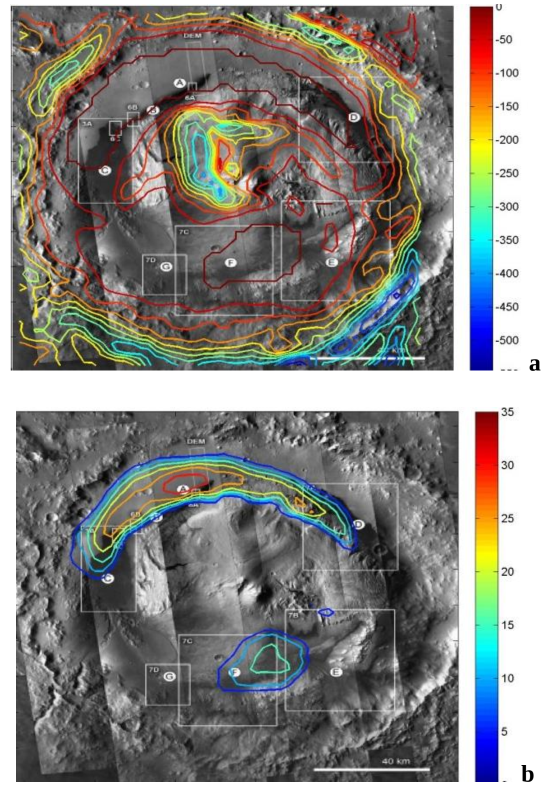

Figure 2 Net dust erosion (a) and accumulation (b) patterns in Gale Crater. Units are given in μm/Martian year. Contours are superimposed on a HiRISE image of Gale taken from [9].

Conclusion and future work: The preliminary results from this work suggest that Gale is primarily in an erosional environment. With the exception of the northern floor of the crater where Curiosity is operating, our similations indicate a net loss of dust. However, these results apply to a single season. Clearly, we need to explore how these patterns change with season. We also need to conduct sensitivity studies of these results to different assumptions about dust lifting. However overall, our results show good correlations with both observations and previous modeling studies. Erosion and sedimentation patterns show that Mount Sharp and Gale's rims experience strong eroding winds able to generate dust lifting. On the other hand, mechanisms in the northern basin seem complex and to prevent dust lifting.

References:[1] Gomez-Elvira. et al. (2014), *JGR, submitted*. [2]Rafkin S. C. R et al. (2001). *Icarus 151, 228-256.* [3] Haberle R. M. et al. (2014) *Mars, In press.* [4] Anderson R. B et al (2010) *Mars 5, 76-128.* [5] Kahanpää H. et al (2013) *LPS XLIV Abstract #3095*. [6] Renno N. O. et al. (1998) *JAS, 55, 3244-3252.* [7] Tyler D. Jr et al (2010) *Mars 8, 58-77.* [8] Kite E. J. (2013) *arXIv:1205.6840 [astro-ph.EP]*. [9] Hobbs S. W. et al. (2010) *Icarus 210, 102-115.*