THE METEOROLOGY OF GALE CRATER DETERMINED FROM MSL REMS DATA AND MESOSCALE MODELING. S. Rafkin[1], J. Pla-Garcia[2,3], C. Newman[4], V. Hamilton[1], J. Martin-Torres[3], M. Paz-Zorzano[2], H. Kahanpää[5], E. Sebastian[2], [1]Department of Space Studies, Southwest Research Institute, Boulder CO, [2]Centro de Astrobiologia, Madrid, Spain, [3]Instituto Andaluz de Ciencias de la Tierra, Granada, Spain, [4]Ashima Research, Pasadena, CA, [5]Finnish Meteorological Institute, Helsinki, Finland.

Introduction: Gale Crater, in which the Mars Science Laboratory (MSL) landed in August 2012, is the most topographically complex area visited to date on Mars. The meteorology within the crater may also be one of the most dynamically complex meteorological environments, because topography is thought to strongly drive the near-surface atmospheric circulations. The Rover Environmental Monitoring Station (REMS) has provided some clues on the nature of the local meteorology. As with all single station measurements, the meteorological interpretation is typically hindered by a lack of spatial context in which to place the observations. Numerical modeling results, when properly validated against observations, can provide interpretive context. Simulations with the Mars Regional Atmospheric Modeling System indicate thermal and wind thermal signatures associated with slope flows, katabatic winds, and nocturnal mixing events that are consistent with the rover environment monitored by REMS. Of particular note is evidence for two distinct air masses—one in the bottom of the crater and one on the plateau—that have minimal interaction with one another. If there are indeed two distinct air masses, there are strong implications for dust and water vapor cycling within Gale Crater.

Model Validation and Comparison with Data: Pressure and ground temperature are the most robust measurements made by REMS [1]. Comparison of these data to model simulations from the Regional Atmospheric Modeling System (MRAMS) [2] are shown in Figure 1 for selected seasons. Unfortunately, the REMS wind sensor was damaged on landing, making the retrieval of wind speed and direction significantly more challenging. Wind retrievals are still a work in progress, but model predicted wind velocities will be presented in comparison to the most current available wind information. Likewise for air temperature. Additional comparisons of the data to simulations from the MarsWRF GCM run with a high resolution mesoscale nest over Gale will also be presented [3].

The favorable comparison of the model data to the available observations provides a reasonable level of confidence that the model can be used to explore the broader circulations beyond the scope of the single station REMS experiment.

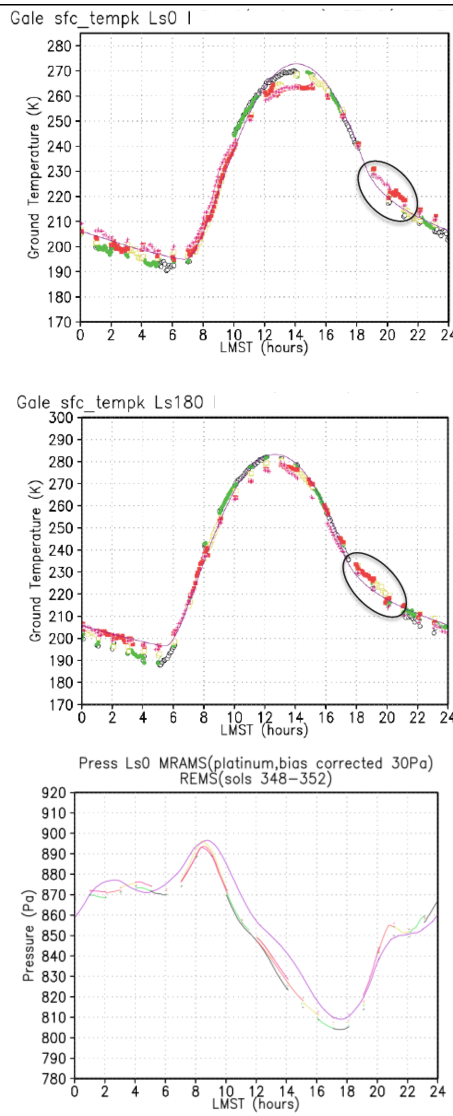

Figure 1. Example comparison of Ground temperature and pressure data to the MRAMS model simulation. The circled areas in ground temperature reveal downslope winds driven by mountain gravity wave activity, strong shear at the nocturnal inversion interface, or some combination of both. Dots in upper ground temperature plots indicate observations while black line is model. Magenta line in lower panel is modeled pressure, other colors are obsevation. Model pressure has been shifted to account for a bias in the global CO_2 abundance.

Topgraphic Thermal Circulations: Model simulations indicate that Gale Crater is dominated by diurnal upslope and downslope circulations. At the lowest point in the crater floor, roughly where MSL landed and has operated, the circulation tends to have a stagnation point where flow diverges toward Mt. Sharp and the crater rim during the day and converges at night.

At night, the stable nocturnal layer in the crater and along the rims tends to set up a situation that favors large amplitude gravity waves (mountain waves) that can produce strong near-surface winds. However, the air in the crater tends to be so stable that these winds do not appear to typically penetrate down to the lowest areas of the crater floor.

In the observations, there is typically an anomolous warming or decrease in the rate of cooling. This is not associated directly with katabatic winds, as these are by definition cold winds. Instead, they likely represent nocturnal mixing events produced by an acceleration of the flow above the nocturnal inversion. Similar, analogous events have been seen on Earth in the Owens River Valley [4]. Although the model does not fully reproduce the observed surface temperature changes, it does show an increase in turbulent kinetic energy at about the same time. Further, parameterizations of turbulence in extremely stable layers are notoriously problematic so it is not unexpected that the model would have difficulty representing the turbulence-driven warming event.

Implications for Water Cycle: None of the mesoscale models were run with an active water cycle. However, the combination of seasonal global circulation patterns and the local thermal circulations suggest that the air mass in the crater should be relatively dry. During the day, upslope divergent flow out of the crater tends to limit the import of water into the crater. At night, air does descend from the surrounding area toward the crater floor, but the extremely stable atmosphere prevents this air from penetrating to the crater floor. Further, the origin of the air is likely to be from a dry source region. For example, during the northern spring and summer when water is coming off the northern polar cap, the origin of the air moving over Gale Crater tends to be from the south. During the northern winter, air entering the crater comes from the north where water is cold trapped at the pole.

References: [1] Gomez-Elvira, J., et al. (2013). [2] Rafkin, S. and T. Michaels (2007), J. Geophys. Res. [3] Richardson, M.I., Toigo, A.D., and Newman, C.E. (2007), J. Geophys. Res. [4] Whiteman, C. D., S. W. Hoch, and G. Poulous, (2009) J. Appl. Met. and Climate.

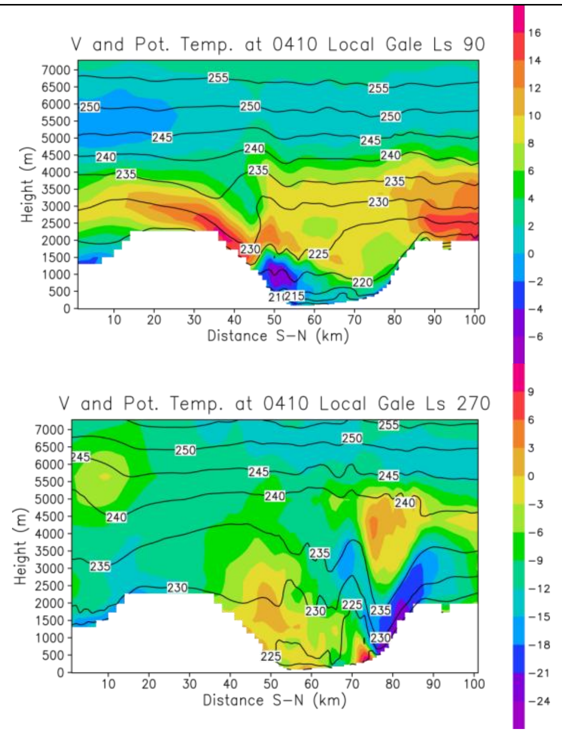

Figure 2. Examples of nighttime mountain wave events simulated in the model that can produce anomolous changes in the ground temperature cooling rate. Winds are shaded, potential temperature contoured.