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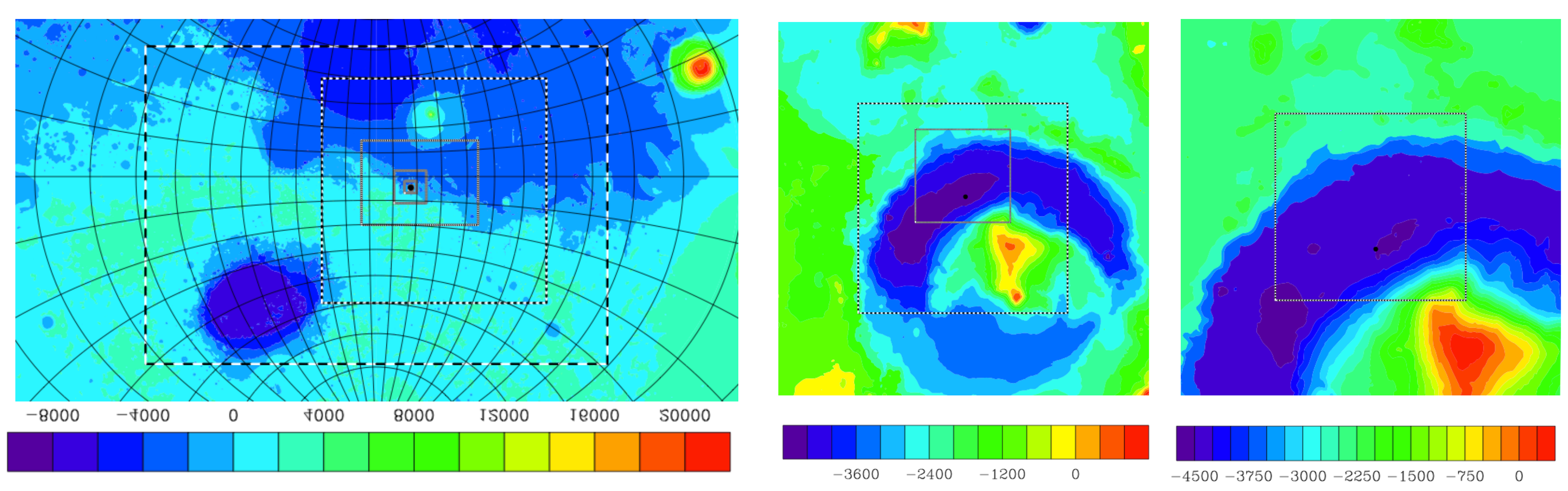
Preliminary Interpretation of the Meteorological Environment Through Mars Science Laboratory Rover Environmental Monitoring Station Observations and Mesoscale Modeling

J. Pla-García[1,2], S. Rafkin[1], F. J. Martín-Torres [3], P. Valentín-Serrano[2], M.-P. Zorzano[2] , J. Gómez-Elvira[2]
and the REMS and MSL Science teams
[1]Southwest Research Institute (SwRI), Boulder CO 80302, USA;
[2]Centro de Astrobiología - INTA-CSIC - Madrid, Spain ; [3]Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Granada, Spain

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 [1-4]. The types of perturbations of pressure, air and ground temperatureS 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 and ground temperatures and wind) to the REMS data available at the location of the Rover for sols 21-25 (when first regular REMS measurements were obtained, Ls 163), sols 51-55 (Ls 180) and sol 215 (Ls 270), in order to provide a baseline of model performance.

MRAMS simulation configuration



Methodology

The simulation is configured with 7 grids (see below). The model is run for 4 sols with 4 grids and then the 3 additional grids are added and run for at least 3 more sols.

Initialization and boundary condition data are taken from a NASA Ames GCM [Haberle et al. 2003] simulation with column dust opacity driven by zonally-averaged TES retrievals. Vertical dust distribution is given by a Conrath-v parameterization that varies with season and latitude

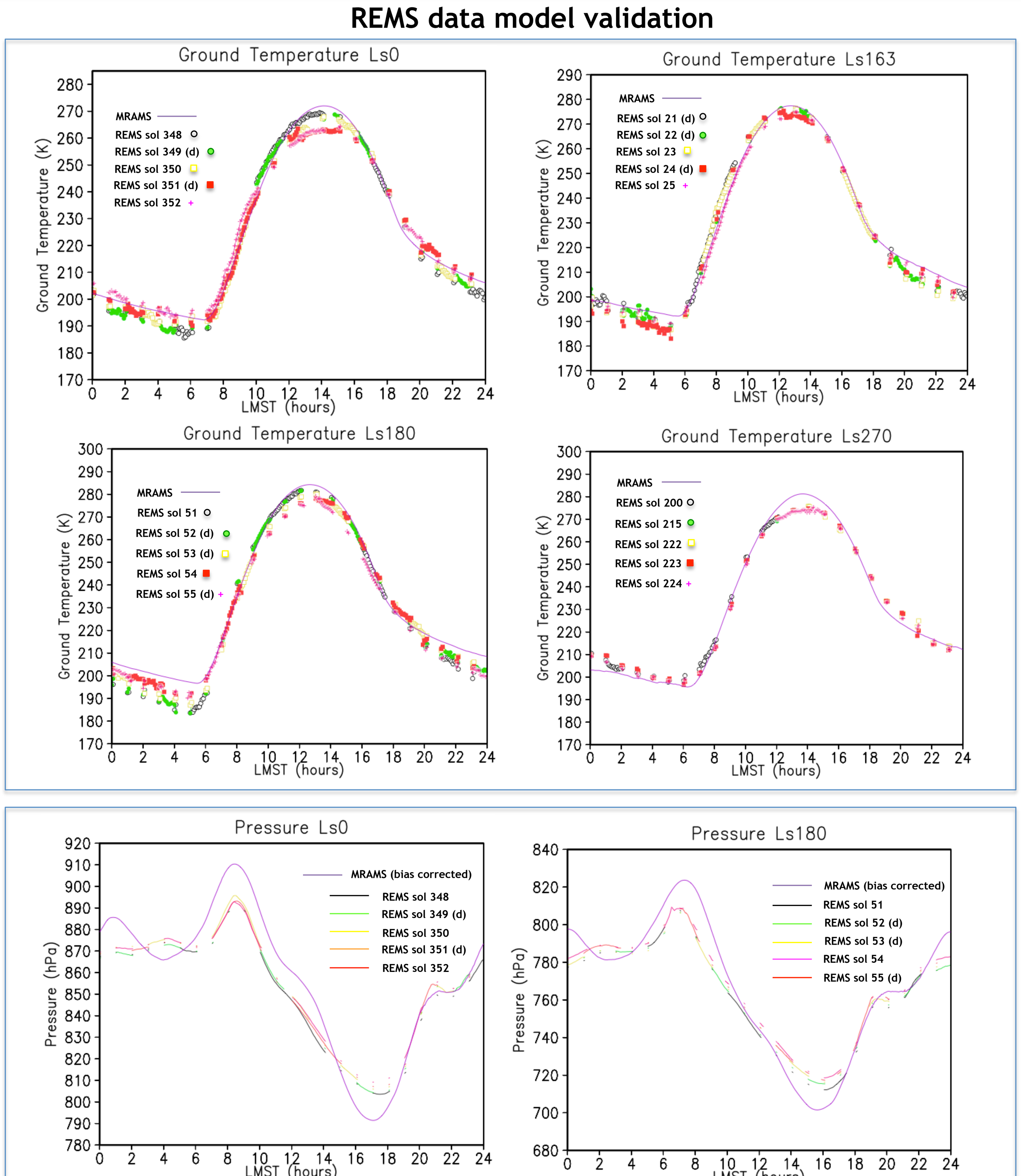
Horizontal Grid Spacing	Physics
Grid 1: 240 km	Subgrid-scale level 2.5 turbulent kinetic nergy parameterization.
Grid 2: 80 km	NASA Ames two-stream, correlated-k radiation.
Grid 3: 26.7 km	Topography shadowing and slope radiation effects.
Grid 4: 8.9 km	Monin-Obukhov surface layer.
Grid 5: 2.96 km	Water microphysics not active.
Grid 6: 0.98 km	CO_2 ice statically placed from GCM.
Grid 7: 0.33 m	Conductive regolith model

Subsurface model
11 soil levels
1mm initial layer depth
1.5m bottom layer depth
Initialized from AMES GCM

Vertical Grid Spacing

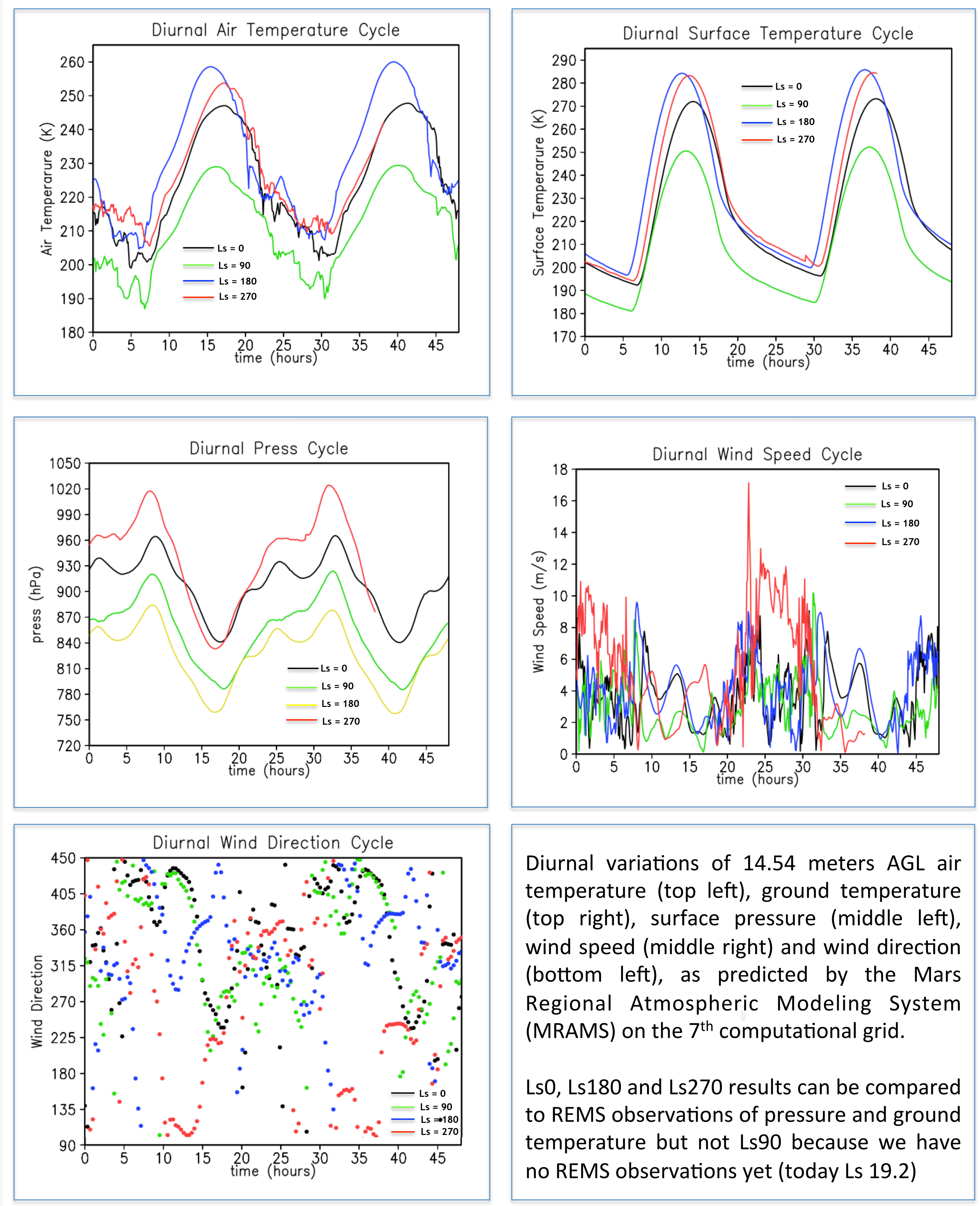
14.54m: First atmospheric layer	2500m: Maximum grid spacing
30m: Initial vertical grid spacing	50: Number of vertical grid points
1.12: Geometric stretch factor	51 km: Model top

REMS data model validation



d = rover drive sol

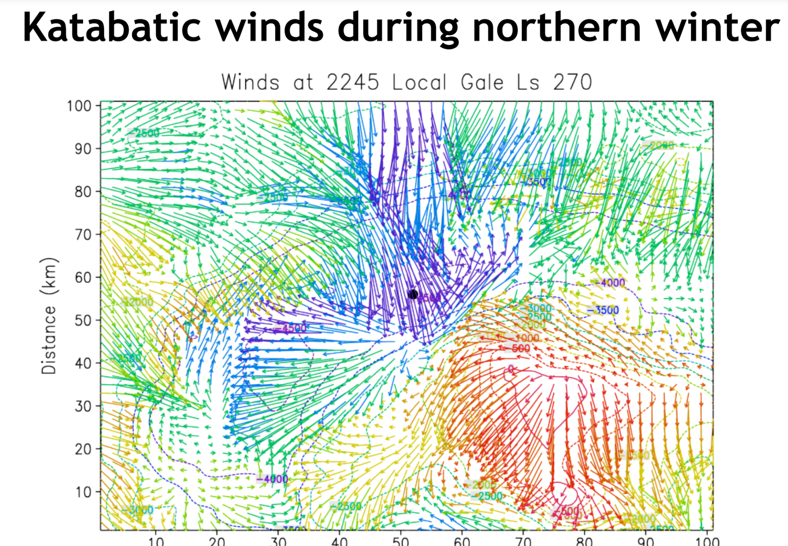
MRAMS predictions



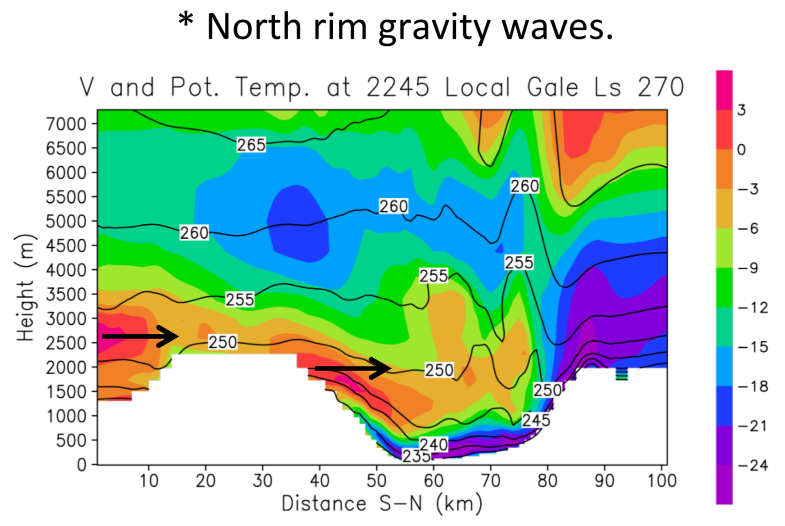
Diurnal variations of 14.54 meters AGL air temperature (top left), ground temperature (top right), surface pressure (middle left), wind speed (middle right) and wind direction (bottom left), as predicted by the Mars Regional Atmospheric Modeling System (MRAMS) on the 7th computational grid.

Ls0, Ls180 and Ls270 results can be compared to REMS observations of pressure and ground temperature but not Ls90 because we have no REMS observations yet (today Ls 19.2)

Katabatic winds during northern winter



* Ls270: the only season where downslope can flush out crater air mass and where northern hemisphere air make it into the crater.
* Warm air from south overrides.
* Massive push of cold air.
* North rim gravity waves.



Conclusions

* Pressure and ground temperature provide the most robust parameters with which to test the model predictions. Daytime ground temperatures are in good agreement with observations, but the temperatures at night are warmer than observed. This may be due to uncertainties in the observations at cold temperatures or errors in the model.

* Both model and observations show high frequency variations in pressure. No causal effect was found between these variations and slope flows

* The model does appear to be doing a reasonable job representing the meteorological conditions. The exception is the total baseline pressure and air temperature. Air temperature is under investigation. The nighttime conditions are also perhaps slightly suspect with the model showing generally warmer ground temperature conditions.

* The windiest season is northern winter (Ls270). Unfortunately for this season we have only a few REMS observations data, due to a problem with rover active computer and solar conjuntion.

[1] Rafkin, S. C. R., and T. I. Michaels (2003), J. Geophys. Res., 108(E12), 8091. [2] Michaels, T. I., and S. C. R. Rafkin (2008), J. Geophys. Res.-Planets, 113. [3] Toigo, A. D., and M. I. Richardson (2003), J. Geophys. Res., 108(E12), 8092. [4] Tyler, D., J. R. Barnes, and E. D. Skyllingstad (2008), J. Geophys. Res.-Planets, 113(E8). [5] Gómez-Elvira, J., et al. (2012), Space Science Reviews, 170(1-4), 583-640
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