HIGH RESOLUTION REGIONAL REANALYSIS FROM A GLOBAL MARS GCM AND MESOSCALE MODEL

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Introduction: The Planetary Boundary Layer (PBL) is the atmospheric domain which manifests the interaction between the free atmosphere and the surface of the planet. This region is particularly important as it governs the exchange of mass, heat and momentum between the general circulation of the atmosphere and the surface itself. As expected, the PBL is present on Mars as well as Earth, but with remarkable discrepancies between them. Studies of the Martian PBL showed an exaggeration of Earth's situation (i.e. intense convective conditions pushing plumes and convective vortices to 5-10 km altitude during the day to strongly stably stratified conditions during the night) and gave us more insight in understanding its mechanisms but remains a notably unexplored part of the Martian environment. The reader is referred to chapter "The Martian Planetary Boundary Layer" from Hablerle & Clancy [1] for a comprehensive story about the PBL. Fortunately, we constructed the tools to produce a regional reanalysis from the Mars Climate Sounder (MCS) data using the Oxford Mars GCM (MGCM) [2] & LMD Mars Mesoscale Model (MMM) [3] at Gale Crater to compute the surrounding environment and carry out comparisons with the Rover Environmental Monitoring Station (REMS) onboard the Mars Science Laboratory (MSL) Curiosity rover. The resolution of the system can get to 3 km grid-box length.

Tools and methodologies: We are using the MGCM to produce case studies from different periods of the first Curiosity year (Martian year 31-32) at spectral resolution T170L25. The Data Assimilation procedure "extrapolates" MCS temperatures through the dynamical core of the MGCM to be used accordingly as boundary conditions for the MMM, which in turn downscales the resolution to a minimum of 3 km (5 km was used to compute the bottom maps from Figure 1). This limit is defined by the Physical core of the MMM (when the dynamical core starts constructing the parametrizations). The interface between the two major models is fully automatic and their connectivity is due to the shared Physical core of the MGCM and MMM.

Meteorology of Gale Crater from REMS: As our studies do not exceed 5-sol intervals, the REMS sensors are expected to witness the conflict between the diurnal tide which also drives the regional effects coming from major sites in the vicinity of Gale Crater (anabatic-katabatic winds from Elysium Mons and

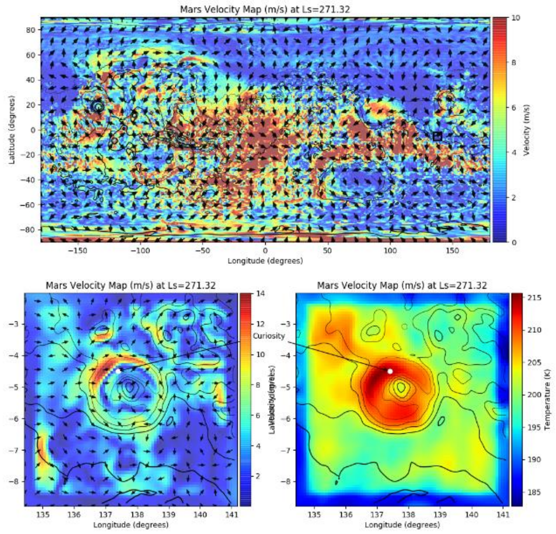

Figure 1. One frame from the horizontal velocity map from the MGCM at T170L25 – bottom pressure level only (top), the horizontal velocity map (bottom left) and the air temperature from the MMM at 5 km grid-box resolution – 5m above the local topography level.

Hellas Basin) and the local topographical effects from Gale Crater itself. Tyler & Barnes [4] show that the local topography merely amplifies the diurnal effects external to the crater, while other models [5][6] suggest a richer environment with gravity waves detaching off the crater rim, but all studies use free running models as opposed to assimilating spacecraft data.

Conclusions: Our interests lie in understanding the PBL using the information from all the scales: Curiosity (microscale) vs MMM (mesoscale) vs MGCM (global scales). The system of models will finally generate the full environment at Gale Crater from Data Assimilation, which will help us understand the Physics that REMS picks up, such as: how much of what REMS observes is influenced by the topography and how much is coming from the general circulation, why is the dust devil activity so low, while the convective vortices are quite rich in time (and present in the rover data), how does the PBL influence the global circulation and is such a set-up (MGCM+MMM) viable for Mars as it is for Earth's atmosphere, is there evidence of dust-lifting mechanisms, is there any presence of gravity waves as the other free running models from the literature predict? Such a set-up is a powerful tool which can assist in researching these topics.

References:

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