EPSC Abstracts
Vol. 8, EPSC2013-545, 2013
European Planetary Science Congress 2013

LMD – SwRI Martian Mesoscale Models Intercomparison for ExoMars Landing Site Characterization

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Martian mesoscale models realisticaly simulate Martian meteorology at finer scales (~10km) than Global Climate Models (GCM). This modelling is becoming a central source of insights and diagnostics for future exploration of Mars and is useful to provide best-guesses of atmospheric variations of temperature and wind at mesoscale level. In such context, Model intercomparisons are a fruitful way to evaluate and assess the obtained predictions.

Context: a European Mission to Mars ExoMars is an astrobiology mission to Mars currently under development by ESA, in collaboration with Roscosmos. The program includes two launches with an orbiter (Trace Gas Orbiter, TGO) and a stationary lander (Entry, Descent and Landing Demonstrator Module, EDM) planned for 2016 as well as a rover with its lander planned for 2018. In the context of this mission, the Laboratoire de Météorologie Dynamique (LMD) and South-West Research Institute (SwRI) Martian Mesoscale Models (respectively LMD_MMM [1] and MRAMS [2]) have been compared. The goals were to determine a range of uncertainties and dispersions of their numerical models' predictions, for the entry, descent and landing characterization of the EDM spacecraft in 2016. This intercomparison has therefore been performed at ExoMars landing site, namely in the Terra Meridiani region, for the landing scheduled in northern autumn at Ls = 244°.
This study is the first intercomparison performed in a systematic way between two different Martian mesoscale models, since Kass [3] and Tyler [4] studies in 2002-2003.

Intercomparison strategy This project is driven by a basic rule: both LMD and SwRI have agreed on model configurations, physics package options, and initial conditions, namely dust loading in order to ensure a consistent intercomparison between both models. LMD thus carefully determined in a key preliminary step optimal values of tunable parameters of the radiative transfer scheme so that the two independent models radiative responses match as much as possible in similar settings. Furthermore, the intercomparison has been tested for three typical different atmospheric dust opacity τ, bracketing Mars atmosphere reality:

- $\tau = 0.2$, representative of a clear atmosphere
- $\tau = 1$, representative of a dusty atmosphere
- $\tau = 5$, representative of a very dusty atmosphere

Model configurations Three nested numerical grids have been adopted. In both models, horizontal resolutions for the three nests are the same: 135 km for nest 1 (mother domain), 45 km for nest 2 and 15 km for nest 3. This nest is the highest resolution domain and is a "zoom" on the ExoMars landing site while the upper-level nests provide the regional to large-scale meteorological conditions. Figure 1 shows the configuration of these nests:

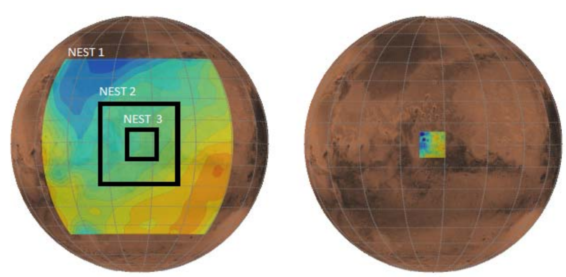

Figure 1: *Topography of simulation domains around ExoMars landing site (-1.82°N, -6.15°W). Left is the nest 1 (mother domain) along with nest 1 and 2 boundaries. Right is only nest 3.*

Simulations were performed in a two-way nesting mode. Topography, thermal inertia, albedo, dust scenario are based on TES measurements in both models.

Results and Analysis Both LMD and SWRI models give qualitatively similar wind and temperature structures. Western boundary currents, slope winds and other wind circulations are observed in both models. Figure 2 and 3 gives an example of obtained results. However, noticeable discrepancies are also observed for the estimated wind and temperature trends, in all three test cases. Indeed, in clear and very dusty atmosphere cases, wind speeds are slightly different.

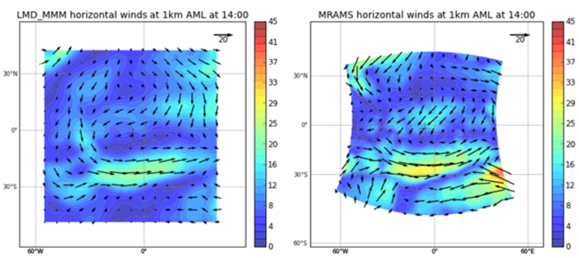

Figure 2: *Horizontal winds obtained from LMD model (left) and MRAMS (right) for a clear atmosphere (τ = 0.2) at 14:00 at 1km altitude in Terra Meridiani Region.*

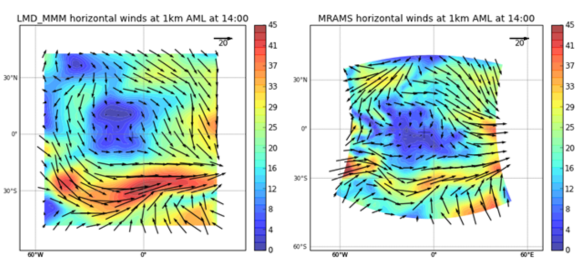

Figure 3: *Horizontal winds obtained from LMD model (left) and MRAMS (right) for a very dusty atmosphere (τ = 5) at 14:00 at 1km altitude above Terra Meridiani Region.*

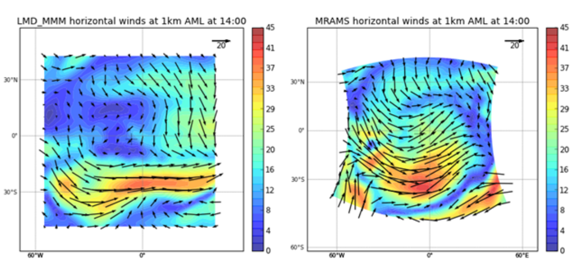

Figure 4: *Horizontal winds obtained from LMD model (left) and MRAMS (right) for a dusty atmosphere (τ = 1) at 14:00 at 1km altitude in Terra Meridiani Region. Strong discrepencies in wind directions and speed are observed.*

The dusty atmosphere case (τ = 1) is more critical and shows interesting discrepancies both in terms of wind directions and amplitudes (up to 70% differences) as illustrated by figure 4.
Different tests have been performed to support the analysis of this intercomparison. First, differences in GCMs results and their sources have been analysed. Then, it has been noticed that using a Planetary Boundary Layer (PBL) with a thermal plume model [5] in LMD_MMM yields more comparable results with MRAMS than without it and without convective adjustment. In fact, the thermal plume PBL gives estimates of wind directions closer to MRAMS results with maximum differences of wind speed of less than 30%. Other findings concern the sensitivities to the chosen date (i.e. regarding day to day variability), to the use of hydrostatic modelling and of a finer topography; these sensitivities are found to be low. Large Eddy Simulation comparisons between LMD and SwRI are also in progress to complete this intercomparison.

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