EPSC Abstracts
Vol. 7 EPSC2012-900 2012
European Planetary Science Congress 2012

Evaluation of the radiation scheme in GEM-Mars V4 using MCS temperature profiles

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Abstract

The GEM-Mars model has been updated with a new dynamical core and modifications to various physical parameterisations. The dynamical core is now based on GEM version 4.2.0 with staggered Charney-Phillips vertical levels and an entirely re-formulated set of equations using log of pressure. Another modification to the model is the inclusion of the NASA-Ames radiation code, adapted from the one-dimensional standalone version (http://spacescience.arc.nasa.gov/mars-climate-modeling-group/models.html). The original radiation scheme from GEM-Mars version 3 is kept as an option for comparison.

The model performance will be investigated at a variety of horizontal and temporal scales. Temperature profiles from the Mars Climate Sounder (MCS) (McCleese et al., 2007) will be used to evaluate the impact of the new dynamical core and vertical levels, and to compare heating/cooling rates from the two radiation schemes.

1. Introduction to GEM-Mars V4

GEM-Mars is a three-dimensional global model (GCM) for the Martian atmosphere. The dynamical core is based on the latest version of the GEM (Global Environmental Multiscale) operational weather forecast model for Canada (Côté et al., 1998). A previous version of the model was adapted for Mars (Moudden and McConnell, 2005; Akingunola, 2008) but advancements in the dynamical core and vertical discretization have prompted a major overhaul of the model.

2. NASA-Ames Radiative Transfer Code

The NASA-Ames radiative transfer (RT) code is provided as a one-dimensional model which calculates fluxes in the atmosphere at layer boundaries and at the surface. The 1D model was adapted to run in the GEM-Mars 3D GCM where the fluxes are used to compute heating rates in the visible and infrared (IR) spectral regions.

In both the visible and IR range, the RT code uses the two-stream approximation (quadrature in the visible and hemispheric mean in the IR). The calculations include correlated-k gas opacities for CO_2 and H_2O as well as aerosol optical properties for dust and water ice clouds. The radiative transfer equation is solved in the atmospheric column for 17 Gauss points in 12 spectral intervals (7 visible, 5 IR).

3. Comparison with MCS temperature profiles

The GEM-Mars model was run for 1 year with the NASA-Ames RT code at a horizontal resolution of 4x4 degrees and 74 vertical levels up to a height of approximately 80 km. All other physical parameterisations were turned off, i.e. the planetary boundary layer (PBL) and surface schemes, water cycle, etc. Temperatures and dust extinction profiles from this model run are compared with MCS profiles downloaded from the NASA Planetary Data System. The retrieval algorithm is described in Kleinbohl et al., 2009; 2011. Figure 1 shows a comparison of GEM-Mars V3 and V4 temperatures with MCS temperatures and one location (near the Phoenix lander site, 68N, 125W) and at one time (L_s=122, local time 4am). The red and blue profiles are from two GEM-Mars V3 model runs with the same total dust opacities but different profiles. The green profile is from GEM-Mars V4 and the black profile is from MCS. As expected, there are differences in the PBL and in the region around 20 km where the dust profile plays a large role. To illustrate this, Figure 2 shows the dust extinction profiles from MCS and GEM-Mars V4. Overall, these initial tests of the new version of the model shows promise.

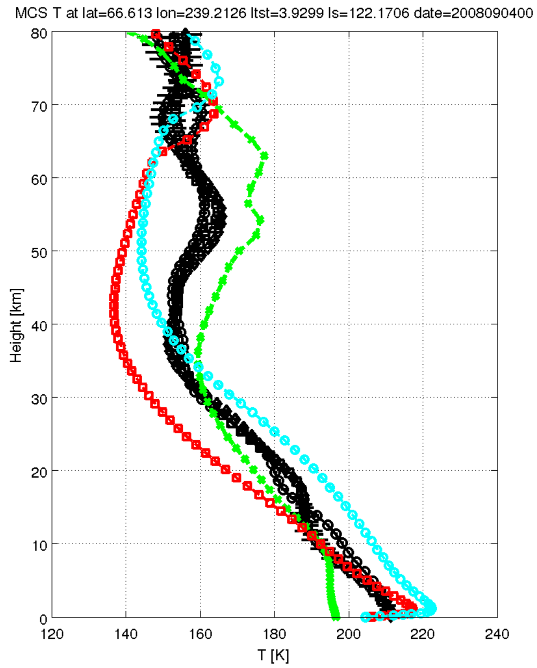

Figure 1: Temperature profiles from MCS (black), GEM-Mars V4 (green) and GEM-Mars V3 (red and blue, same dust opacities, different profiles).

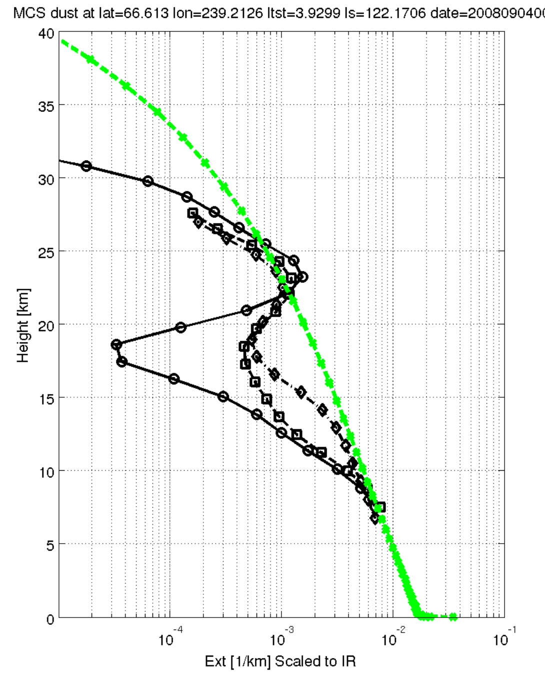

Figure 2: Dust extinction from MCS (black) and GEM-Mars V4 (green) near the Phoenix lander site.

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