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High resolution MM5 for Mars with airborne dust effects: preliminary results

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Abstract

Suspended dust is always present in the atmosphere of Mars and greatly influences the climate of the planet.
However, up to now, most of the atmospheric models for the Martian atmosphere did not take into account its effect.
In this work we update the Mars-MM5 model ([1], [2]) using a lifting and a deposition model for the dust, so that, depending on the wind speeds the amount of airborne dust changes.
Very preliminary results are encouraging, demonstrating that for atmospheric opacities not too large (around 0.2) the overall effect is a cooling of the lower atmospheric layers.

1. Introduction

The mesoscale model for the atmosphere of Mars here presented is mainly based on that by [2], but in the present work the contribute of the atmospheric dust opacity has been taken into account.

2. Model description

The studied domain is equatorial, with an elevation variability reaching 7 km and the simulation started on 1st June 2004 (LS = 40°) at 00:00 Local Time (Fig. 1).
The model has been initialized by means of a lower resolution version of the Mars-MM5 (i.e. 300 km), that has been previously initialized with the Mars Climate Database (MCD – [3]).
The atmospheric dust has not been considered for the low resolution MM5 and its opacity has been added to the model only when the high resolution run started. The opacities values have been retrieved by the MCD at the starting time of the run.

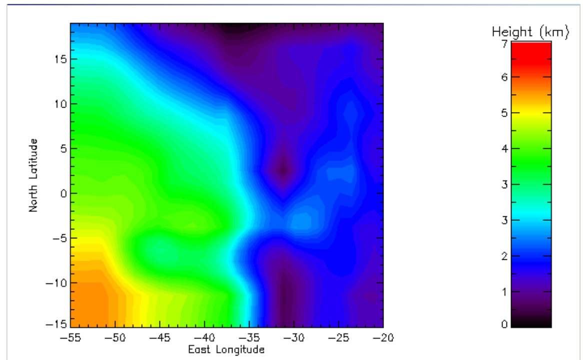

Figure 1: The topography of the domain under study. It has to be noticed that the elevation is respect to the minimum of the domain and not to the mean planetary radius.

2.1 Dust parameterization

After the atmospheric dust opacity has been inserted in the model with the values from the MCD, in order to make it changes with time two different methods can be followed: 1) use the values tabulated by the MCD and 2) find a relation between lifting and deposition of dust related to the wind stress.
In this work the second approach has been preferred, so that the Mars-MM5 depends on the MCD opacities only for the initialization. The relation used for the dust lifting is that described by [4]:

$$F_W\,(\mathrm{kg\ m^{-2}\ s^{-1}}) = (2.3 \times 10^{-3})(\tau^2)(\tau-\tau^*)/\tau^* \qquad (1)$$

Where τ is the wind stress at the surface and τ^* the threshold stress required for lifting, that in this work has been fixed to 10 mN m^{-2}.
In order to convert the atmospheric dust mass to opacity we hypothesized that a unit optical depth corresponds to a density of 6.55 x 10^{-4} g cm^{-2}.
Finally the vertical profile of the dust described by [5] has been used.
In first approximation the dust deposition rate may be considered constant and not dependent on the winds, with a value of 0.003 τ sol^{-1}.

3. Results

By comparing the Mars-MM5 models with and without dust it is evident that the main effect of the dust is a general cooling of the lower atmospheric layers.

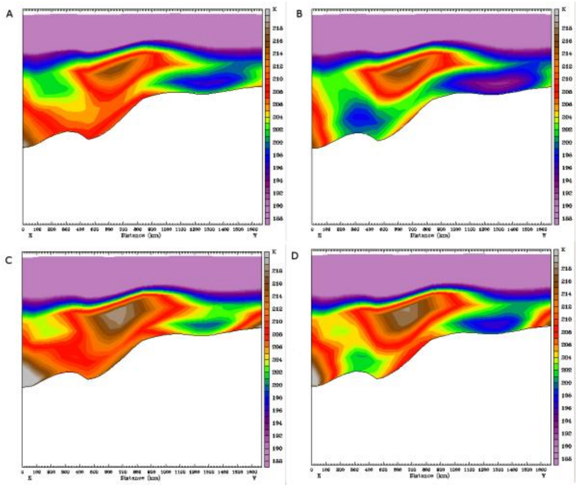

Figure 2: Comparison between Mars-MM5 temperature fields without (A-C) and with (B-D) dust effects. The vertical intersect is located at 0°N and between 45° and 30° W. Figures A and B are for 14:00 LT, whereas figures C and D are for 20:00 LT.

In particular we compared the two models at 14:00 and 20:00 LT (Fig. 2). In the transect shown the main temperature differences are present in the deep valley, where temperature differences of up to 6-8 K can be reached.

On the contrary for $z > 10$ km no main differences can be noted.

4. Conclusions and future works

The preliminary results outlined here seem to be encouraging. However a more accurate work has to be made. In particular different lifting model can be used and compared each other.

Finally, in order to robustly validate the model, a comparison with observational data will be performed

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