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Study of radiative heating rates in the Martian atmosphere under different atmospheric dust loading scenarios

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1. Introduction

Dust plays a main role in the atmosphere of Mars: it has a direct impact on its thermal structure, and by absorbing and scattering the incoming solar radiation, it provides forcing to its dynamics [1]. Martian general circulation models (GCMs) and regional climate models employ two-stream approximation radiation codes to compute the internal radiation fields [2][3][4].

The objective of this work is to provide estimates of internal radiation field and heating rate differences that can be expected from two-stream codes in mesoscale dynamical models due to differences in the scattering phase function for dust aerosols. We discuss the implications in the characterisation of Mars' dust cycle and its effects in its atmosphere and dynamics.

2. Model

The two-stream code evaluated in this work has been implemented in both GCM and mesoscale climate models e.g, [4][5][6], and it is compared with a discrete ordinates method radiation code (DISORT) using multiple streams [7].

The visible and infrared spectral regions are treated separately. The visible and near infrared (0.4 to 4.5 μm) is divided into 7 intervals, while the thermal infrared (4.5 to 1000 μm) is divided into 5 spectral intervals [2][4]. Absorption data for relevant gases are loaded from HITRAN [8] and transformed into correlated-k tables. Local and seasonal atmospheric profiles and the chemical composition are retrieved from LMD Mars Climate Database [3][9].

Dust aerosol particle optical properties are loaded from the MOPSMAP database [10] using wavelength-dependant properties obtained from [11]. Input particle physical properties (size, shape, etc.) and atmospheric dust loading for different scenarios are derived from [12][13], with dust vertical distribution following a Conrath-profile [3].

3. Methodology

Internal radiation fields and heating rates calculated with the two-stream approximation are compared with 4, 8, and 16-stream outputs from DISORT code, using detailed descriptions of dust aerosol particle phase functions [13].

4. Results

The heating rates for 3 cases with low (τ = 0.1), moderate (τ = 0.8), and high (τ = 1.5) atmospheric dust loading were calculated using the different radiation codes. For all these scenarios, the average differences between the 2, 4, and 8-stream codes with respect to the DISORT 16-stream calculations are of about 10%, 1% and 0.1%, respectively; being the performance of the implementation proportional to the number of streams used.

5. Conclusions

We are evaluating the influence of using DISORT multiple streams radiation code in regional dynamical models and its impact on the retrieved internal radiation fields and heating/cooling rates.

This is a work in progress and the latest results for a number of characteristics situations, including the study of local dust storm effects, and the influence of dust particle properties and its vertical distribution will be presented.

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