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Seven-Year Climatology of Dust Opacity on Mars

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Abstract

This paper describes the procedure we have used to produce multi-annual dust scenarios for Martian years 24 to 30 from a multi-instrument dataset of total dust opacity observations. This procedure includes gridding the observations on a pre-defined longitude-latitude grid with 1 sol resolution in time, and spatially interpolating the results to obtain complete daily maps of total dust opacity. We used weighted binning as gridding technique, and spatial kriging as method of interpolation. The new dust scenarios are available as NetCDF files, easy to interface to any model including global circulation and mesoscale models for the Martian atmosphere.

1. Introduction

Dust is one of the fundamental components of the Martian atmosphere and one that has a strong impact on the thermal and dynamical structure. Mars general circulation models (GCMs) either use a full modelling of the dust cycle, including physical modelling of the dust lifting, transport, interaction with the water cycle (i.e. scavenging) and sedimentation, or use prescribed dust scenarios to calculate the radiative properties (absorption and scattering of solar and infrared radiation) and the corresponding atmospheric thermal structure. Dust scenarios built using observations of dust opacity can also be adopted to rescale the modelled dust cycle in GCMs. For instance, the LMD-MarsGCM uses dust scenarios for rescaling the dust opacities when producing the Mars Climate Database multi-annual statistics.

So far, dust scenarios have been created using Mars Global Surveyor/Thermal Emission Spectrometer (MGS/TES) observations of total dust opacity for Martian years (MY) 24, 25 and 26, and have been used in the v4 of the MCD. We want to improve these dust scenarios and extend the time coverage to MY 27, 28, 29 and 30, given the current availability

of dust opacity observations for Mars from other instruments and spacecrafts, beyond MGS/TES.

We developed a gridding and interpolating methodology that can work with different observational datasets for all Martian years. The goal has been to create daily maps of total dust opacities from the time when there are available TES observations in MY 24 ($L_s \sim 105^\circ$) until the end of MY 30 (and possibly to extend this series of maps to further Martian years in future). The methodology we used involve weighted binning of a multi-instrument set of total dust opacity observations on a pre-defined grid with 5° resolution both in longitude and latitude and 1 sol resolution in time, and spatial kriging interpolation to fill the missing values. The final result is therefore a series of daily global maps of total dust opacity for seven complete Martian years, which can be easily interfaced with any GCM and used as multi-annual dust scenarios for any study where the inter-annual variability of dust opacity is a key factor.

2. Spacecraft and Instruments

For the purpose of producing the dust scenarios described in the present paper, we have made use of dust opacity observations from the following instruments:

- Mars Global Surveyor / Thermal Emission Spectrometer (TES). See details in [1].
- Mars Odyssey / Thermal Emission Imaging System (THEMIS). See details in [2].
- Mars Exploration Rovers A “Spirit” and B “Opportunity” / Pancam camera. See details in [3].
- Mars Reconnaissance Orbiter / Mars Climate Sounder (MCS). See details in [4].

Data have been collected during about twelve years of spacecraft missions, from 1999 to 2011. Retrieved dust opacities from the different instruments were firstly checked against quality control criteria. Since most GCMs (including the LMD-MGCM) require total dust opacities at an average mean visible wavelength and normalised at a reference pressure level, we transformed the observed infrared opacities

into equivalent visible opacities and we normalised them at the reference pressure level of 610 Pa.

3. Product

Observed or estimated total dust opacities (two-dimensional data) were gridded on a pre-defined time-space grid using the weighted binning methodology (acceptance criteria for the value at each grid point were defined) and, subsequently, incomplete maps were interpolated using the kriging interpolation method. The final result was a set of complete, regular, daily maps of equivalent visible total dust opacities at the reference pressure of 610 Pa from $L_s \sim 105^\circ$ in MY 24 to the end of MY 30. This series of maps was separated in Martian years of 669 sols each and the final product was exported as NetCDF files, ready to be interfaced to the LMD-MarsGCM or other numerical models. Note that MY 24 dust scenario is actually a hybrid scenario built using the first 224 sols of MY 25 to fill the lack of observations in MY24 before $L_s \sim 105^\circ$.

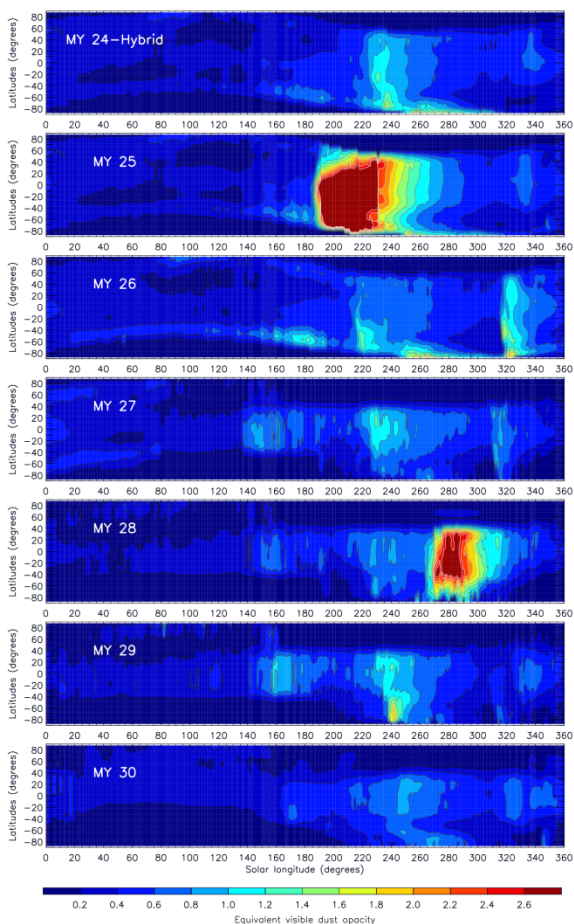


Figure 1: Zonal means of equivalent visible total dust opacity at 610 Pa as a function of latitude and solar longitude for seven Martian years. Data to produce these zonal means are extracted from the NetCDF dust scenario files.

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