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The Mars Climate Database, MCD version 6.1

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General introduction

The Mars Climate Database (MCD) is a database of meteorological fields derived from General Circulation Model (GCM) numerical simulations of the Martian atmosphere using the Mars Planetary Climate Model (PCM) and validated using available observational data. The MCD includes complementary post-processing schemes such as high spatial resolution interpolation of environmental data and means of reconstructing the variability thereof [1].

The latest version of the MCD, version 6.1, was released in December 2022.

The Mars PCM (formerly known as the LMD GCM) that is used to create the MCD data is developed at Laboratoire de Météorologie Dynamique du CNRS (Paris, France) [2] in collaboration with LATMOS (Paris, France), the Open University (UK), the Oxford University (UK) and the Instituto de Astrofísica de Andalucía (Spain) with support from the European Space Agency (ESA) and the Centre National d'Etudes Spatiales (CNES).

The MCD is intended to be useful and used in the framework of engineering applications as well as in the context of scientific studies which require accurate knowledge of the state of the Martian atmosphere. Over the years, various versions of the MCD have been released and handed to more than 400 teams around the world. It is cited in more than 600 peer-reviewed publications (source: NASA ADS).

The MCD is freely available upon request via an online form on the dedicated website: <http://www-mars.lmd.jussieu.fr> which moreover includes a convenient web interface for quick looks.

Overview of the Mars Climate Database contents

The MCD provides mean values and statistics of the main meteorological variables (atmospheric temperature, density, pressure and winds) as well as atmospheric composition (including dust and water vapor and ice content), as the GCM from which the datasets are obtained includes water cycle, chemistry, and ionosphere models[2]. The database extends up to and including the thermosphere (~350km). Since the influence of Extreme Ultra Violet (EUV) input from the sun is significant in the latter, 3 EUV scenarios (solar minimum, average and maximum inputs) account for the impact of the various states of the solar cycle.

As the main driver of the Martian climate is the dust loading of the atmosphere [3-4], the MCD provides climatologies over a series of synthetic dust scenarios: standard year (a.k.a. climatology), cold (i.e: low dust), warm (i.e: dusty atmosphere) and dust storm (see Figure 2 for an illustrative example), These are derived from home-made, instrument-derived (TES, THEMIS, MCS, MERs), dust climatology of the last 12 Martian years [5]. In addition, we also provide additional "add-on" scenarios which focus on individual Martian Years (from MY 24 to MY 35) for users more interested in more specific climatologies than the MCD baseline scenarios.

MCD outputs and validation

The MCD is intended to be useful for both engineering and scientific studies. Known applications include entry descent and landing (EDL) studies for Mars missions, investigations of some specific Martian issues (via coupling of the MCD with homemade codes), analysis of observations (Earth-based as well as with various instruments onboard Mars Express, Mars Reconnaissance Orbiter, Trace Gas Orbiter, Emirates Mars Mission),...

In practice the MCD provides users with:

- Mean values and statistics of main meteorological variables (atmospheric temperature, density, pressure and winds), as well as surface pressure and temperature, CO₂ ice cover, thermal and solar radiative fluxes, dust column opacity and mixing ratio, [H₂O] vapor and ice concentrations, along with concentrations of many species: [CO], [O₂], [O], [N₂], [Ar], [H₂], [O₃], [H] ..., as well as electrons mixing ratios. Column densities of these species are also given.
- Physical processes in the Planetary Boundary Layer (PBL), such as PBL height, minimum and maximum vertical convective winds in the PBL, surface wind stress and sensible heat flux.
- The possibility to reconstruct realistic conditions by combining the provided climatology with additional large scale (derived from Empirical Orthogonal Functions extracted from the GCM runs) and small scale perturbations (gravity waves).
- Dust mass mixing ratio, along with estimated dust effective radius and dust deposition rate on the surface are provided.
- A high resolution mode which combines high resolution (32 pixel/degree) MOLA topography records and Insight pressure records with raw lower resolution GCM results to yield, within the restriction of the procedure, high resolution values of atmospheric variables (pressure, but also temperature and winds via dedicated schemes).

MCD version 6.1 has been validated using many available datasets, and these comparisons are detailed in the validation document [6] distributed with the software.

References

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- [6] Forget F. et al. (2022) Mars Climate Database V6.1 Validation Document