

The Mars Climate Database, Version 6.1

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The Mars Climate Database, Version 6.1

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Introduction:

The Mars Climate Database (MCD) is a database of meteorological fields derived from General Circulation Model (GCM) numerical simulations of the Martian atmosphere 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.

The GCM that is used to create the MCD data is developed at Laboratoire de Météorologie Dynamique du CNRS (Paris, France) [1] in collaboration with LATMOS (Paris, France), the Open University (UK), the Oxford University (UK) and the Instituto de Astrofisica de Andalucia (Spain) with support from the European Space Agency (ESA) and the Centre National d'Etudes Spatiales (CNES).

The latest version of the MCD, version 5.3 [2], was released in July 2017, and at the time of writing of this abstract we are working on MCDv6.1, which we will release in May 2022. This new version will benefit from all the recent developments and improvements [1,3-5] in the GCM's physics package.

The MCD is freely distributed and 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.

Current applications include entry descent and landing (EDL) studies for future 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, Maven, Trace Gas Orbiter, Hope),...

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.

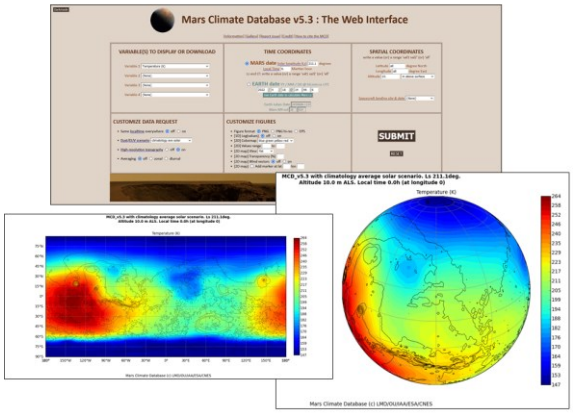


Figure 1: Illustrative example of the online Mars Climate Database web interface and its plotting capabilities.

Overview of MCD 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. 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, 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, These are derived from home-made, instrument-derived (TES, THEMIS, MCS, MERs), dust climatology of the last 12 Martian years [6]. 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.

In practice the MCD provides users with:

- Mean values and statistics of main meteoro-

logical 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, [H20] 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).

Updates and improvements in MCDv6.1:

Compared to MCDv5.3, and aside from the fact that the MCD fields have been computed using the latest version of the LMD GCM, noteworthy improvements and additions in this new version of the MCD include:

- Reference pressure records for the high resolution mode correction now rely on Insight measurements rather than Viking lander 1 ones.
- An implementation of extracting dust opacities from the daily maps used by the GCM rather than providing the climatological (based on the Ls=30° monthly average) value, as illustrated in Figure 2.
- Improved estimations of dust deposition rates using the aforementioned daily variations of atmospheric dust opacity (see Figure 3).
- Computation of the local slope (inclination and orientation) properties.
- Computation of the solar irradiance on local slopes, including in high resolution mode.
- Addition of a slope winds scheme to account for local topographical effects in high resolution mode (see figure 5).

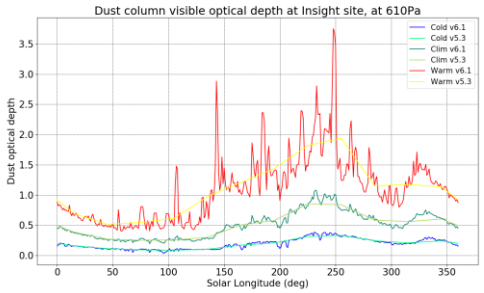


Figure 2: Illustrative example of the dust column visible optical depth over the year at the Insight landing site, for various dust scenarios and using either the (MCDv5.3-style) climatological dust scenario or the "high resolution" (MCDv6.1-style) extraction of day-to-day varying opacities.

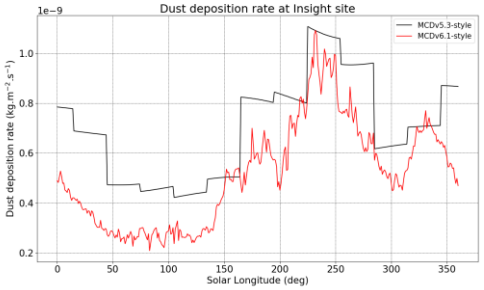


Figure 3: Estimated dust deposition rates on a flat surface at the Insight landing site location, based on the dust opacity extraction method (see figure2). The higher resolution outputs are for the scheme implemented in MCDv6.1

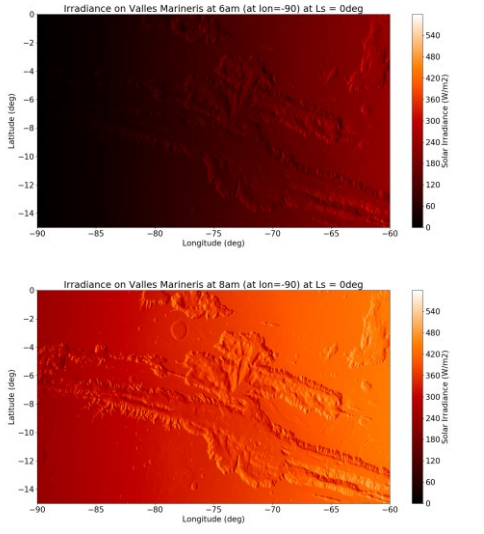


Figure 4: Insolation at 6am (top) and 8 am (bottom) around Valles Marineris, as recomputed with MCDv6.1's high resolution mode. Continued on next page for later times of day.

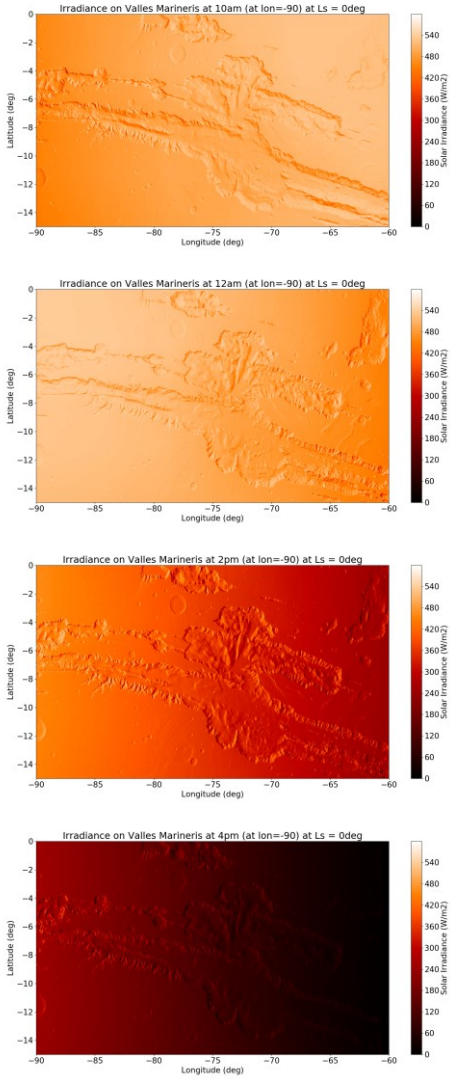


Figure 4 (continued): Insolation at, from top to bottom, 10am, 12am, 2pm and 4pm around Valles Marineris.

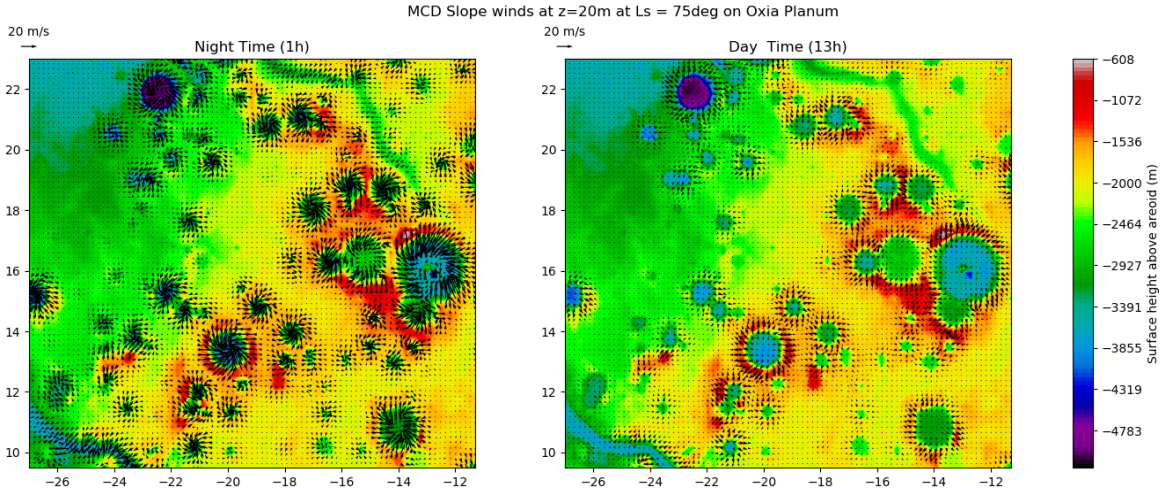


Figure 5: winds at 20m above the surface above Oxia Planum at night (1am) and day (1pm), illustrating the anabatic and katabatic winds produced by the MCDv6.1 slope wind scheme.

References:

[1] Forget et al. (2022), this conference.

[2] Millour et al. (2018), "The Mars Climate Database (version 5.3) », From Mars Express to ExoMars Scienfic Workshop, 22-28 February 2018, ESAC Madrid, Spain.

[3] Bierjon et al. (2022), this conference.

[4] Pierron et al. (2022), this conference.

[5] Liu et al. (2022), this conference.

[6] Montabone et al. (2022), this conference.