THE MARS CLIMATE DATABASE (MCD VERSION 5.1). E. Millour[1], F. Forget[1], A. Spiga[1], T. Navarro[1], J.-B. Madeleine[1], L. Montabone[1,2], F. Lefevre[3], J.-Y. Chaufray[3], M.A. Lopez-Valverde[4], F. Gonzalez-Galindo[4], S.R. Lewis[5], P.L. Read[6], M.-C. Desjean[7], J.-P. Huot[8] and the MCD/GCM development team, [1]Laboratoire de Meteorologie Dynamique, IPSL, Paris, France (millour@lmd.jussieu.fr), [2]Space Science Institute, Boulder, USA, [3]Laboratoire Atmospheres, Milieux, Observations Spatiales, IPSL, Paris, France, [4]Instituto de Astrofisica de Andalucia, Granada, Spain, [5]Department of Physics and Astronomy, The Open University, Milton Keynes, UK, [6]Atmospheric, Oceanic & Planetary Physics, University of Oxford, UK, [7]Centre National d'Etudes Spatiales, Toulouse, France, [8]European Space Research and Technology Centre, European Space Agency, Noordwijk, Netherlands.

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 is developed at Laboratoire de Météorologie Dynamique du CNRS (Paris, France) [1-3] in collaboration with 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 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 150 teams around the world. Current applications include entry descent and landing (EDL) studies for future missions (Insight, ExoMars), 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 and Mars Reconnaissance Orbiter),...

Towards MCD version 5.1: At the time of writing, the currently distributed Mars Climate Database is MCDv5.0. We are however currently running GCM simulations which include some updates and improvements which will be beneficial and will issue an MCDv5.1 in May 2014.

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 [4,5], chemistry [6], and ionosphere [7,8] models.

The database extends up to and including the thermosphere [9,10] (~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 **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 8 Martian years [11]. Additional "add-on" scenarios which focus on individual Martian Years (MY 24 to 31) will also be provided for users more interested in specific climatologies than the MCD baseline scenarios designed to bracket reality.

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, [H20] vapour and ice concentrations, along with concentrations of many species: [CO], [O2], [O], [N2], [Ar], [H2], [O3], [H] ..., as well as electrons mixing ratios.
- Dust mass mixing ratio, along with estimated dust effective radius and dust deposition rate on the surface are also provided
- Following the recent improvements on the parametrization of physical processes in the Planetary Boundary Layer (PBL) [12], many related fundamental quantities such as PBL height, minimum and maximum vertical convective winds in the PBL, surface wind stress and sensible heat flux,...are available.
- A high resolution mode which combines high resolution (32 pixel/degree) MOLA to-

pography records and Viking Lander 1 pressure records with raw lower resolution GCM results to yield, within the restriction of the procedure, high resolution values of atmospheric variables.

- 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) schemes.

Validation of the MCD: The MCD is continuously being evaluated and validated via comparisons with available datasets from various instruments, as shown in the following illustrative examples:

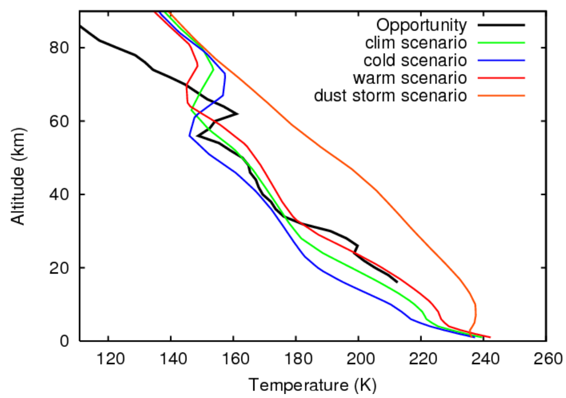

Figure 1: Illustration of the way the MCD dust scenarios bracket reality, in the present case with a comparison to the temperature profile (retrieved by P. Withers) from Opportunity entry, which occurred during a local dust storm.

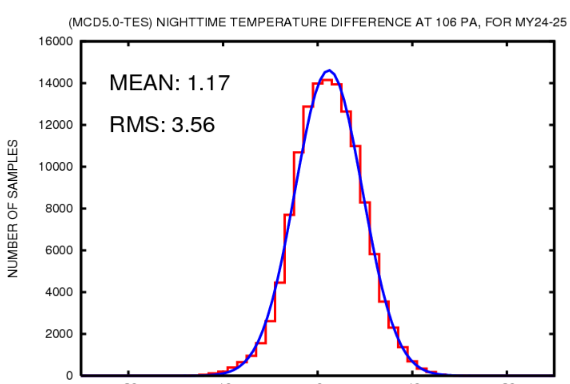

Figure 2: Example of comparisons between MCD predictions of temperatures (at 106 Pa) and nighttime measurements by the Thermal Emission Spectrometer (TES) onboard Mars Global Surveyor (data kindly provided by M.D. Smith). Distributions of binned temperature differences (using bins of 1K) between MCD5 Climatology scenario predictions and TES measurements (at 2am) over Mars Years 24 and 25 (up to Ls=180°, i.e. before the global dust storm) for latitudes ranging from 50°S to 50°N. Displayed MEAN and RMS values are computed from the obtained histograms and the blue curve correspond to normal distributions of same MEAN and RMS.

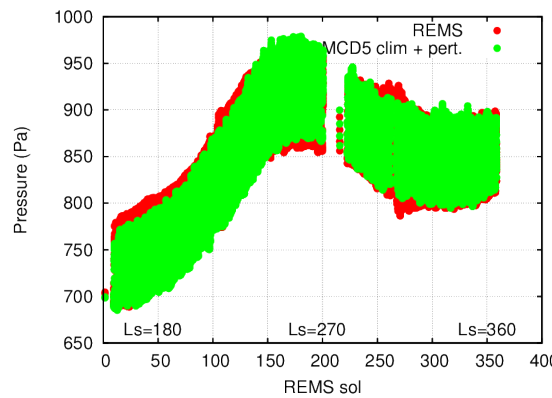

Figure 3: Comparison of the surface pressure, as measured by the REMS instrument onboard Curiosity, over the second half of Mars Year 31, and MCD predictions.

Obtaining the Mars Climate Database: The MCD may be accessed either online (in a somewhat simplified form) via an interactive server available at http://www-mars.lmd.jussieu.fr (useful for moderate needs), or from the full version which includes advanced access and post-processing software (written in Fortran, but examples of Matlab, IDL, C/C++ and Python interfaces are provided), just contact millour@lmd.jussieu.fr and/or forget@lmd.jussieu.fr to obtain a free copy.

References: [1] Forget F., et al. (1999) *JGR*, 104, E10. [2] Lewis S., et al. (1999) *JGR*, 104, E10. [3] Forget F., et al. (2014), *5th Int. Workshop on Mars Atmosphere Modeling and Observations*. [4] Madeleine J.-B., et al. (2012) *GRL*, 39:23202. [5] Navarro T., et al. (2014) submitted to *JGR, Planets*. [6] Lefevre F, et al. (2011), *4th Int. Workshop on Mars Atmosphere Modeling and Observations*. [7] Gonzalez-Galindo F., et al. (2013) *JGR (Planets)*, 118. [8] Chaufray J.-Y., et al. (2014), *5th Int. Workshop on Mars Atmosphere Modeling and Observations.* [9] Gonzalez-Galindo F., et al. (2009) *JGR*, 114. [10] Gonzalez-Galindo F., et al. (2014) , *5th Int. Workshop on Mars Atmosphere Modeling and Observations.* [11] Montabone L., et al. (2014) submitted to *Icarus*. [12] Colaitis A., et al. (2013) *JGR (Planets)*, 118.