THE NEW MARS CLIMATE DATABASE.

F. Forget, E. Millour, S. Lebonnois, L. Montabone, K. Dassas *Laboratoire de Météorologie Dynamique du CNRS, IPSL, Paris, France* (forget@lmd.jussieu.fr) **S. R. Lewis,** *Open University, Milton Keynes, UK* **P. L. Read,** *Atmospheric, Oceanic & Planetary Physics, University of Oxford, UK,* **M. Lopez-Valverde, F. Gonzalez Galindo,** *Instituto de Astrofisica de Andalucia, Granada, Spain,* **F. Montmessin, F. Lefevre** *Service d'Aéronomie, CNRS, France* **M.C. Desjean** *CNES, Toulouse France* **J-P. Huot,** *European Space Research and Technology Centre, European Space Agency, Noordwijk, Netherlands.*

Introduction : What is the Mars Climate Database ?

The Mars Climate Database (MCD) is a database of statistics describing the climate and environment of the Martian atmosphere. It is constructed directly on the basis of output from mulitannual integrations of a Global Climate Model (GCM) developed by Laboratoire de Météorologie Dynamique du CNRS, France [1] in collaboration with the University of Oxford, UK, the Instituto de Astrofisica de Andalucia, Spain, SA, France with support from the European Space Agency (ESA) and Centre National d'Etudes Spatiales (CNES).

The MCD can be used as a tool for mission planning and is applied to prepare for many missions in Europe and the USA. It also provides useful predictions for any scientist or mission design specialists.

Previous versions of the Mars Climate Database has been available to the community for more than 5 years [2]. They have been used by more than 60 teams around the word. Recently, a much improved version has been released, on DVD (version 4.1) and on a new interactive web site.

Why a model-based climate database ? The Martian environment is highly variable. In spite of the new observations available from Mars Global Surveyor and now, Mars Express, it remains difficult to predict what are the climatic conditions on Mars at any time and any locations from the available observational data, especially for climate variables which are not directly observed, like the wind, the water vapor mixing ratio, atmospheric composition, etc...

The Mars GCMs have been extensively validated using available observational data and we believe that they represent the current best knowledge of the state of the Martian atmosphere given the observations and the physical laws which govern the atmospheric environment and surface conditions on the planet. In other words, Models can be used to extrapolate the observations.

What's new in the "new" Mars Climate Database ?

- Extension into the thermosphere up to ~250 km, using a full thermosphere model [3,4] which is an extension of the model below.
- A new reference "dust scenario" based on assimilation of TES observations in 1999-2001 ("Martian Year 24" or "MY24") [5]
- Coupling with a full water cycle model [6], chemistry model [7]. New variable are provided (water, dust, ozone, atmospheric composition)
- Improved access software (includes seasonal interpolation, pressure coordinate, Fortran, IDL , Matlab access tools, etc…)
- New "high resolution" accurate surface pressure predictor .
- Improved web-site (see below)

Which variable can be accessed in the database.

Up to ~250 km:

- *mean variables:*

Temperature, surface pressure, winds (horizontal and Vertical), atmospheric density, atmosphere turbulent kinetic energy, CO2 ice cover, thermal and solar radiative fluxes, dust column opacity, water vapor and ice (column and mixing ratio), [O3], [CO], [O], [O2], [N2] and [CO] volume mixing ratios.

- *Data on day to day variability*:

Full statistics and tools (EOF) to reconstruct variability of temperature, winds, atmospheric density surface temperature, surface pressure, dust opacity

How are the atmospheric variabilities represented

- *The year to year variability and dust content variations* are accounted for with simulation of "years" with different dust content :
  - (1) baseline scenario "MY24"
  - (2-3) "clear" (cold) and "dusty" (warm) scenario to bracket the reality
  - (4) Global dust storm scenario
- *The solar variability*, which affect the atmosphere above 100 km is taken into account by including 3 scenarios to describe the variations of the Extreme UV input solar cycle during the solar cycle ("solar mean", "solar maximum" , "solar minimum")
- *The Seasonal cycle is captured with* the storage of 12 "typical" days (average over 30° of Ls)

around the year. Of course the access software interpolates between these samples, providing results very close to the actual seasonal evolution.

- *The diurnal cycle* is captured with the storage of environmental data 12 times per day (also with interpolation).

- *The Day to day variability:* (e.g. transient waves) can be simulated thanks to the storage of statistics with EOF statistic tools. Variance on various time scale are also provided [2].

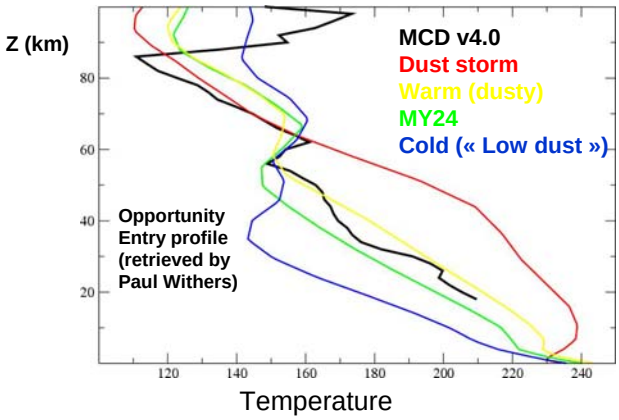

Figure 1 **An example** Opportunity profile (black) retrieved by Paul Withers (The large observed temperature increase may not be real according to P. W.) compared to the prediction The colored lines show the Mean MCD profile for various dust scenario. At this time, Mars Express and TES has shown that the atmosphere was dustier than usual.

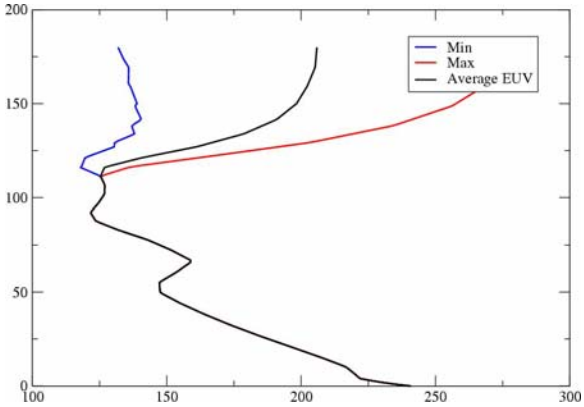

Figure 2. The same mean MCD profile topped with various Solar EUV inputs.

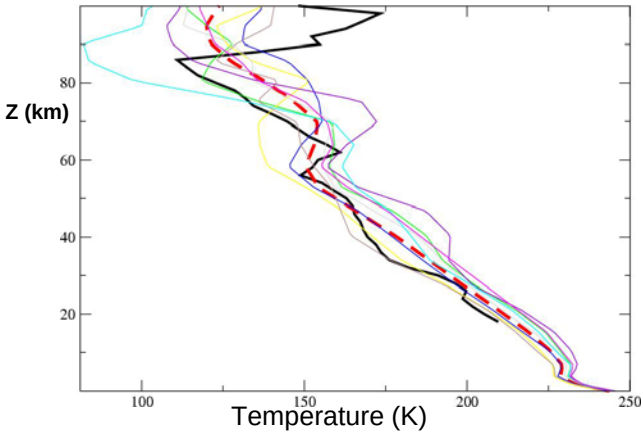

Figure 3. The Opportunity entry profile (black) compared to the mean MCD profile (dashed red line) and possible profiles created by the database when reconstructing the day to day variability present in GCM simulations (colored solid lines).

How to access the database ?

- ***For moderate use****: The World Wide Web site.* **http://www-mars.lmd.jussieu.fr/**

An interactive web site allowing you to compute, download or plot any profile, slice or block or any data interactively : in a variety of graphical and numerical formats. In February 2006, a much improved, brand new version of the web site (Live Access Server v6.2.1) is put online :

- access to all new variables, with all possible scenarios, up to 250km
- new vertical coordinates : 3 choices : exact altitude above areoid, exact pressure level, exact altitude above surface
- allow output comparisons
- averages, min, max, sum, variances
- numerous output formats (gif, ps, text, netcdf, arcview gridded, ferret script, fortran formatted text…)

- ***For intensive or precise work: the DVD-ROM***

The new MCD V4.1 is available for distribution on a DVD-ROM containing the data files (in NetCDF format) and access software including variability models to account for the sub-grid scale and day-to-day variations of the martian atmosphere + high resolution surface pressure prediction.

- The softwares are written in very portable Fortran 77
- Unix and Linux prefered, but can be used on windows
- IDL and Mathlab interface subroutines are now provided
- C interface example

Just contact François Forget (forget@lmd.jussieu.fr) at LMD.

References:

[1] Forget, F., et al. Improved general circulation models of the martian atmosphere from the surface to above 80km J. Geophys. Res., 104, E10, pp 24,155-24,176, 1999.

[2] Lewis, S. R., et al. A climate database for Mars J. Geophys. Res., 104, E10, pp 24,177-24,194, 1999.

[3] M. Angelats i Coll, Forget, F., M. A. Lopez Valverde, F. Gonzalez-Galindo The first Mars Thermospheric general circulation model: the Martian atmosphere from the ground to 240 km *Geophys. Res. Lett.*, Geophysical Research Letters, Volume 32, Issue 4, CiteID L04201 (2005).

[4] Extension of a Martian general circulation model to thermospheric altitudes: UV heating and photochemical models González-Galindo, F.; López-Valverde, M. A.; Angelats i Coll, M.; Forget, F. *Journal of Geophysical Research,* 110, Issue E9, CiteID E09008 , (2005)

[5] See Montabone et al., this issue.

[6] Montmessin, F., F. Forget, P. Rannou, M. Cabane and R. M. Haberle The origin and role of water ice clouds in the Martian water cycle as inferred from a General Circulation Model *J. Geophys. Res.* 109, E10, CiteID E10004 (2004).

[7] Lefèvre, S., S. Lebonnois, F. Montmessin and F. Forget Three-dimensional modeling of ozone on Mars *J. Geophys. Res.* 109, E07004, 2004

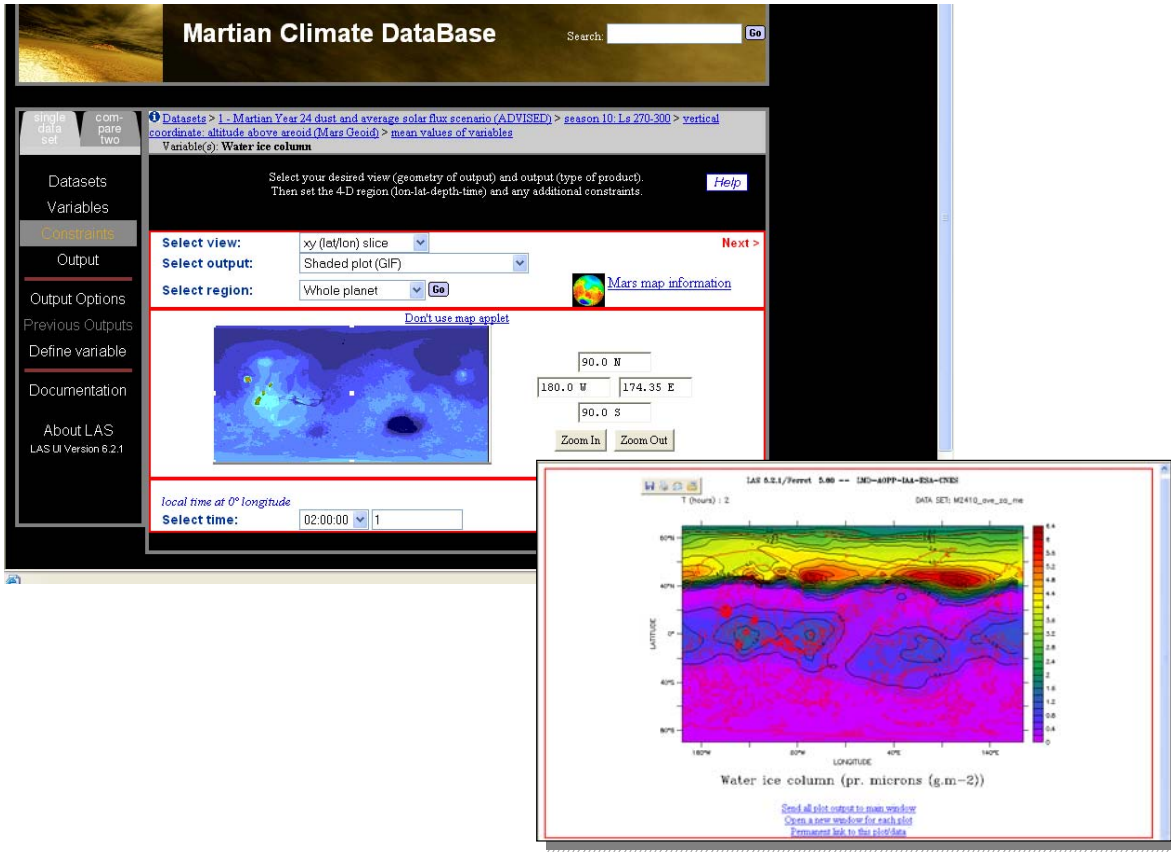

Figure 4 : A snapshot of the new Mars Climate Database website (here, retrieving a map of water vapor column), to be available at: **http://www-mars.lmd.jussieu.fr/**