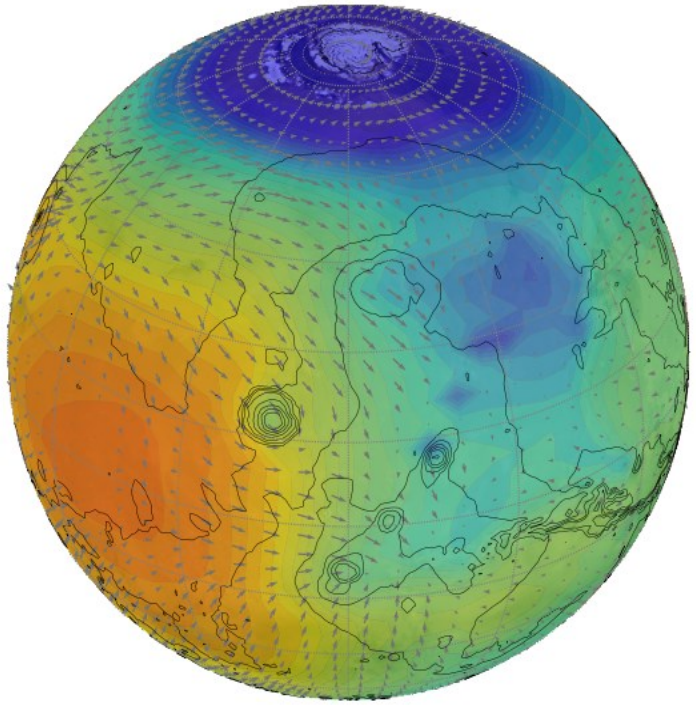
MCD General Description



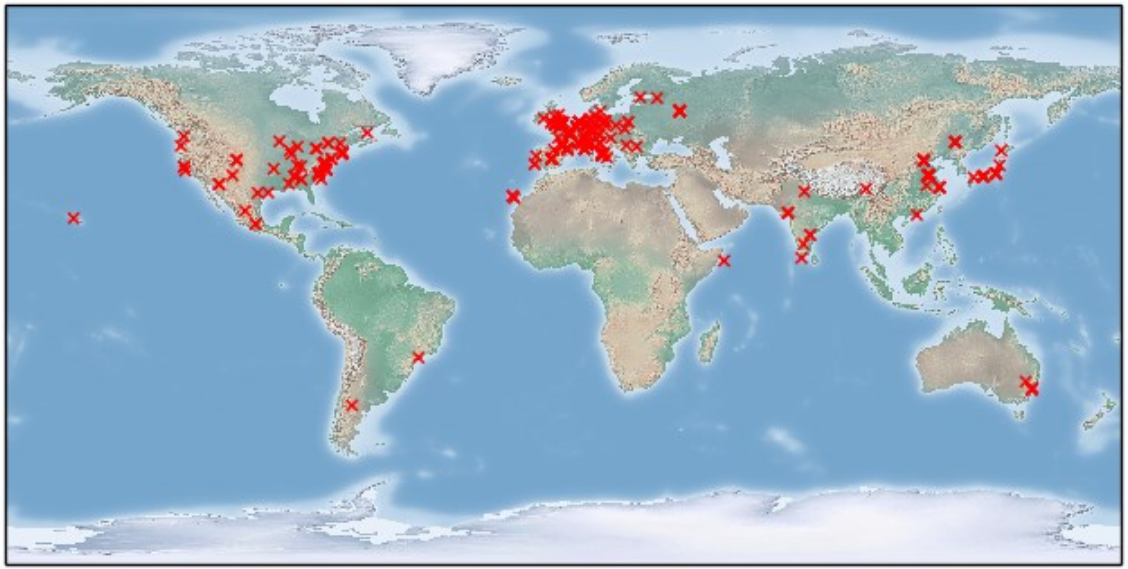
E. Millour, F. Forget and the MCD team

What is the Mars Climate Database ?

- The Mars Climate Database (MCD) is a database **derived from Global Climate Model** (GCM) **simulations**, using the LMD-GCM.
- The MCD is intended to be useful for engineering applications (e.g. Entry Descent & Landing studies) and scientific work which require accurate knowledge of the Martian atmosphere (e.g. Analysis of observations).
- In order to reconstruct the atmospheric state at any point and time, data files storing a mean day (with 12 values per day, i.e. every 2hours) per martian month (30° Ls) are used; the sought climatological values are then obtained by linear interpolations between encompassing month and time of day.

What is the Mars Climate Database ?

- The MCD is freely available, either via light online access (http://www-mars.lmd.jussieu.fr) for moderate needs, or a full version which includes advanced post-processing software (Fortran subroutine call_mcd; examples of C, C++, IDL, MATLAB, SCILAB, python interfaces are provided).
- MCD v4.x and v5.x (v5.2 released in March 2015) have been distributed to more than 250 teams around the world.



MCD contents & main features

- The MCD provides mean values and statistics of main meteorological variables: **pressure**, **atmospheric density**, **temperature**, **winds**.
- Other variables included in the MCD:
  - Surface temperature and pressure
  - Thermal and solar radiative fluxes
  - CO_2 ice cover
  - Dust column opacity and mass mixing ratio
  - Dust effective radius and dust deposition rate
  - [H_2O] vapour and [H_2O] ice columns and mixing ratio
  - Water ice effective radius
  - [CO_2], [CO], [O], [O_2], [O_3] [N_2], [Ar], [H], [H_2], [electrons] mixing ratios
  - Air specific heat capacity, viscosity and reduced gas constant r
  - Convective PBL height, typical updraft and downdraft velocities in PBL
  - Surface heat stress and surface sensible heat flux
  - …

Water cycle model

Chemistry model

Thermosphere model

Ionosphere model

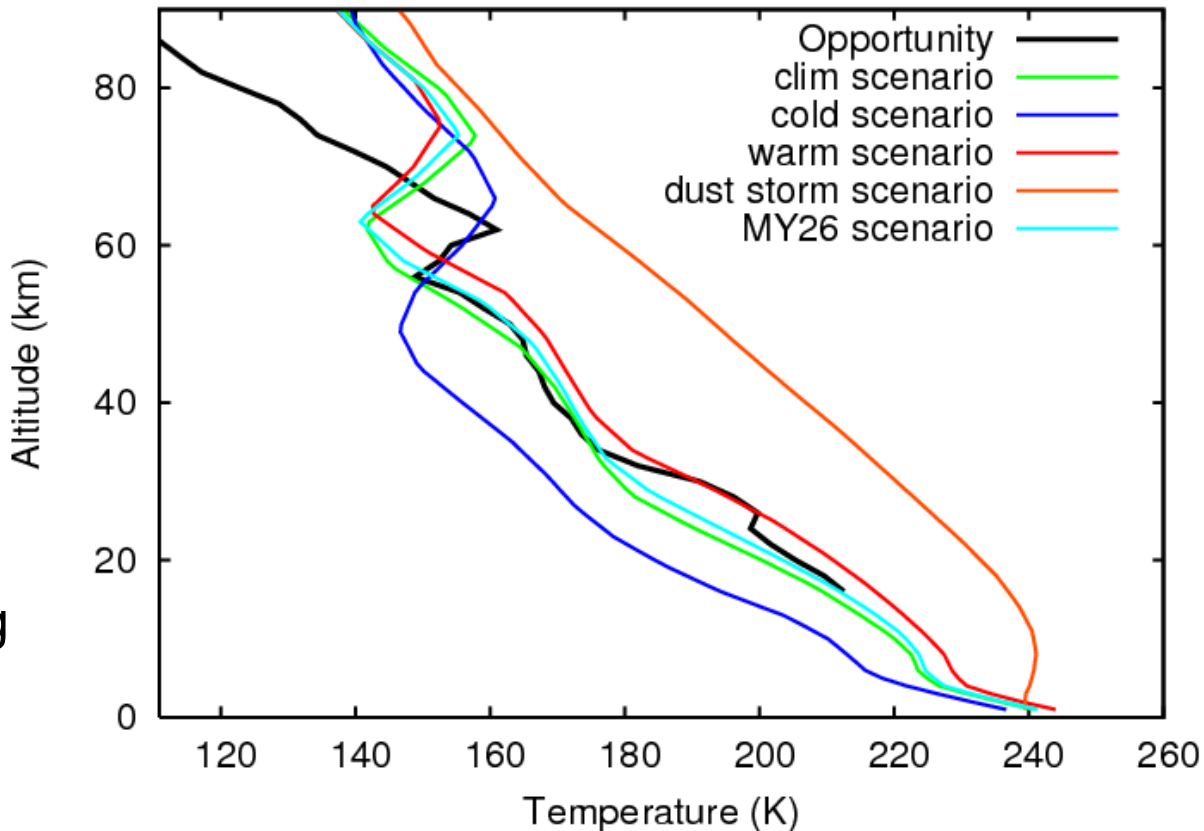
MCD dust scenarios

- The dust load of the Martian atmosphere is highly variable; the MCD includes 4 synthetic dust scenarios to bracket reality.
- New in MCDv5.2: Mars Years 24 to 31 cases

- **Climatology**: "Best guess" scenario for a typical Mars year
- **Cold**: very clear sky
- **Warm**: dusty atmosphere
- **Dust Storm**: severe global dust storm

- Opportunity landed during a local dust storm in MY26

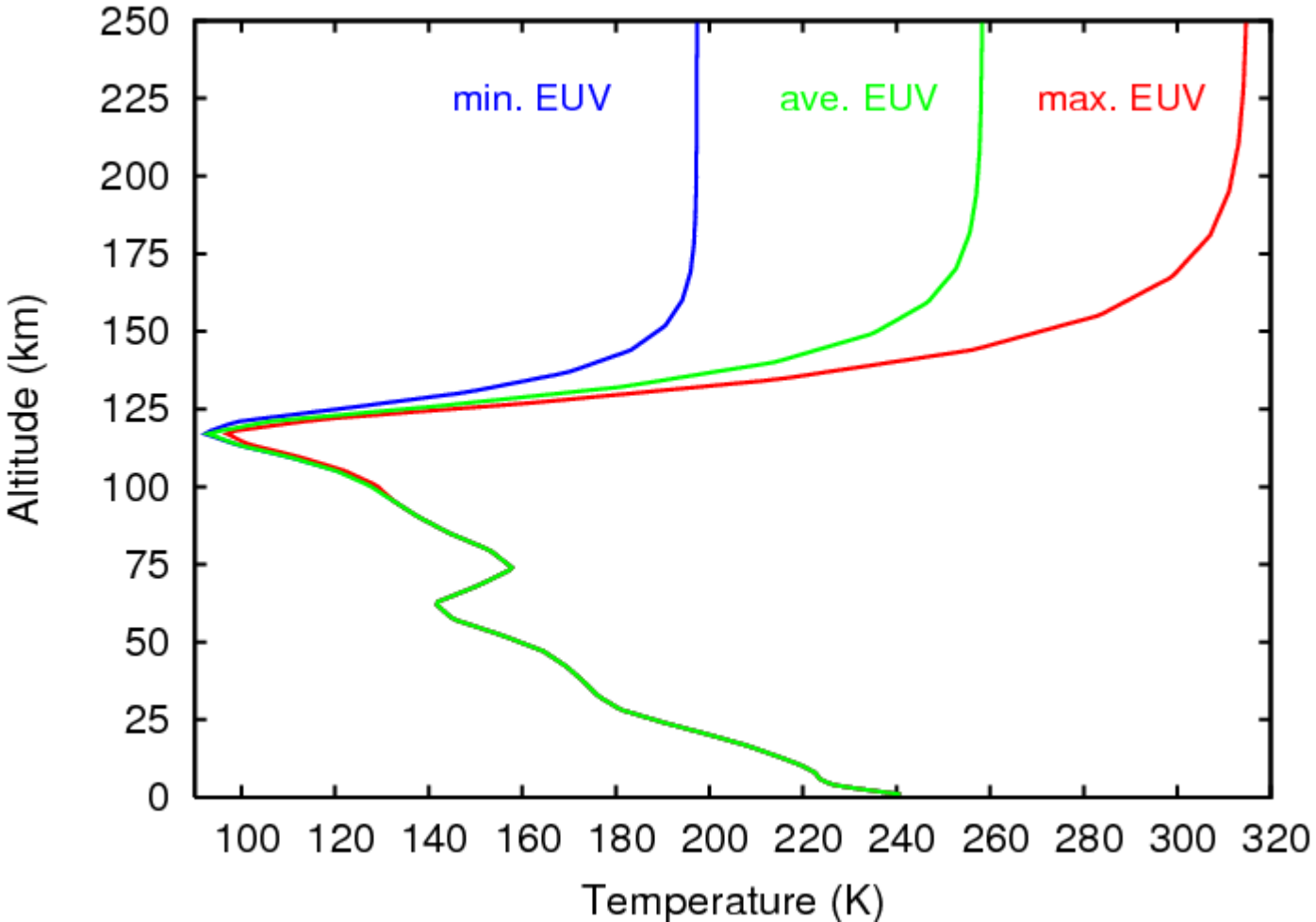
Opportunity entry profile
(retrieved by P. Withers)



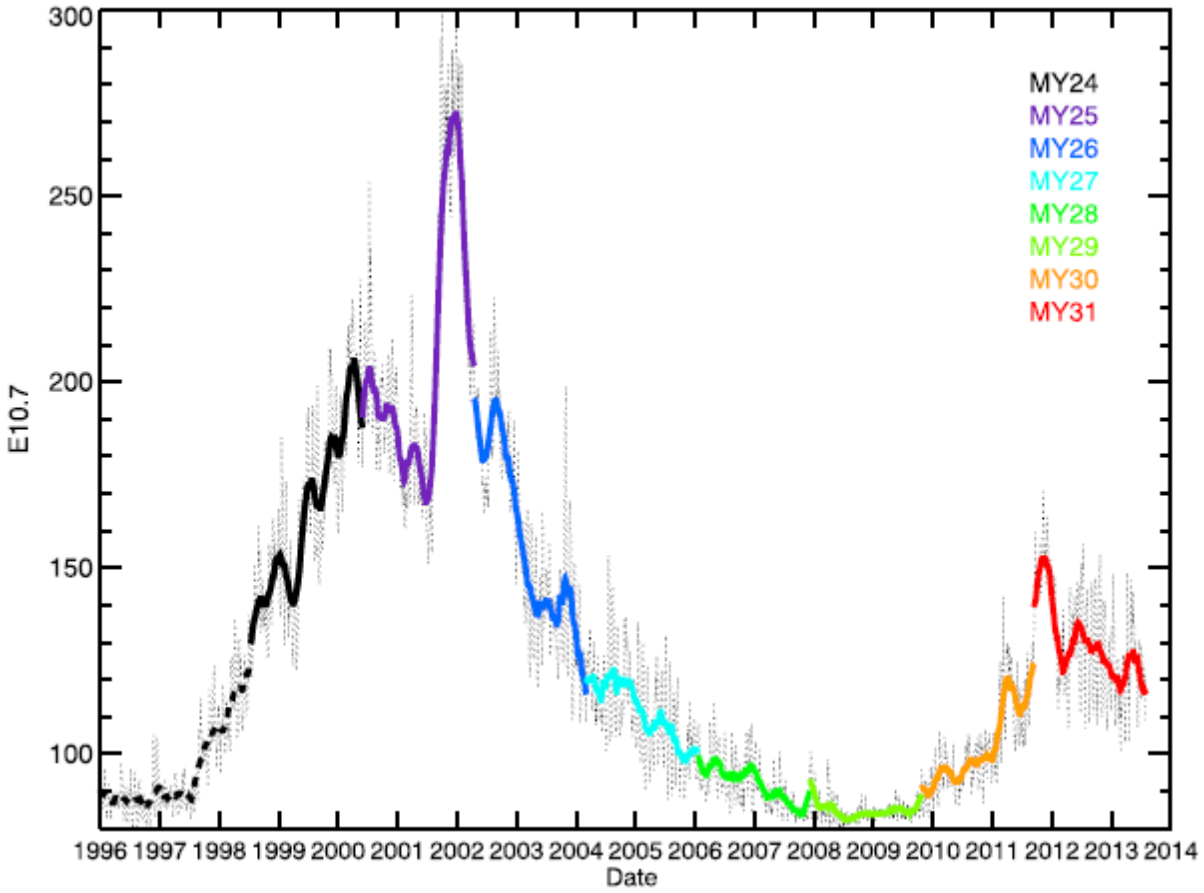
MCD Extreme UV scenarios

- The MCD dust scenarios are topped by 3 EUV scenarios to account for the Sun's 11 year cycle. Important above ~110km
- New in MCDv5.2: Mars Years 24 to 31 cases (realistic EUV input)

- **min**: at Solar Cycle minimum
- ave: average Solar Cycle
- **max**: at Solar Cycle maximum



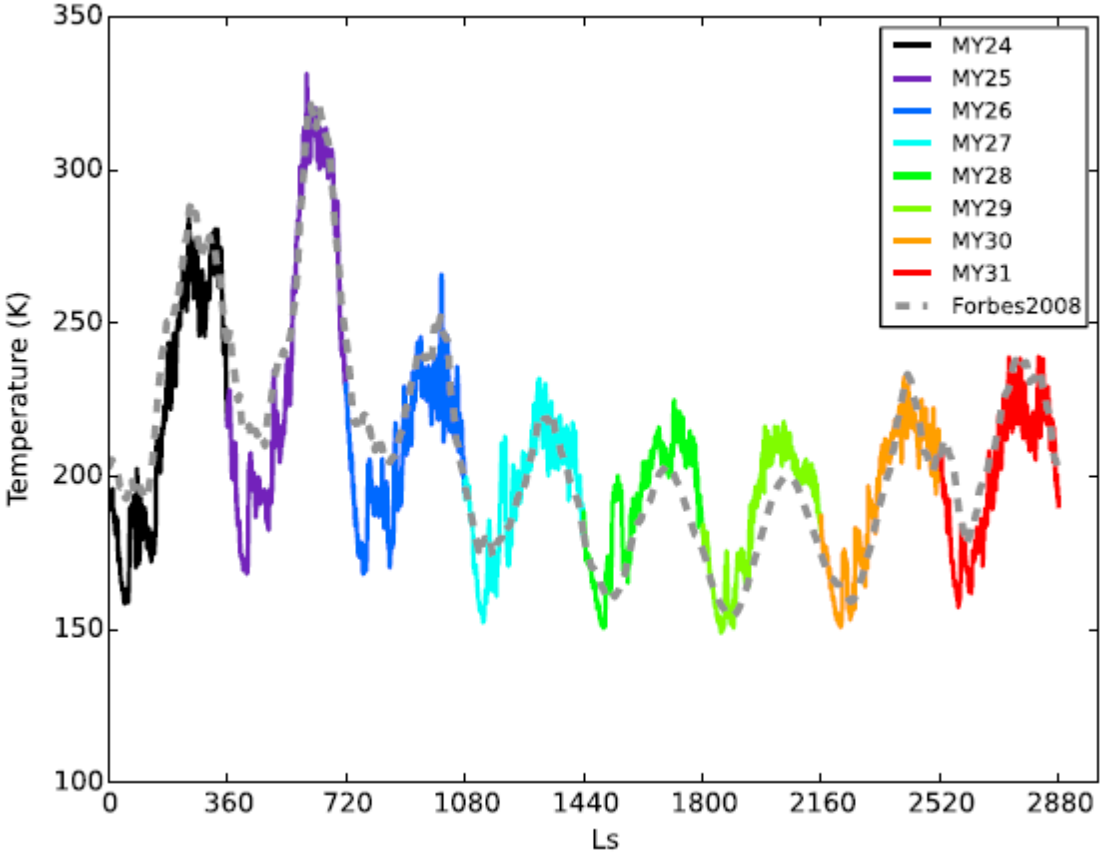
MCD Extreme UV scenarios



Gonzalez-Galindo et al. 2015

- Solar activity cycle (via associated E10.7 proxy index) and running mean (81 Earth days) over Mars Years 24-31

MCD Extreme UV scenarios



Gonzalez-Galindo et al. 2015

- Zonal mean temperature (at exobase, 10^{-6} Pa and latitude 50°S) from GCM simulations, compared to values derived by Forbes et al. 2008

Mars Climate Database v5.2: The Web Interface

One-click presets

LANDING SITE & DATE

Land now at equator!
Curiosity | Phoenix
Opportunity | Spirit
Pathfinder
Viking 1 | Viking 2

TIME OF DAY Morning
Afternoon | Evening | Night

ALTITUDE Near surface
Boundary layer | Troposphere
Mesosphere | Thermosphere

INTEREST Atmosphere
Winds | Weather
Water cycle | Chemistry
Landing engineering
Glaciology | Surface meteorology
Radiative balance

PLOT REQUEST Daily cycle
Vertical profile | Altitude/time plot
Global map | Sphere

Main settings (reset)

(•) **MARS date** Solar longitude [157.5] degrees
Local Time [0.] Martian hour
write a value (or) a range 'val1 val2' (or) 'all'

( ) **EARTH date** YY / MM / DD @ hh:mm:ss UTC
[2016] / [5] / [24] @ [9] : [35] : [47]

CUSTOMIZE COORDINATES ON MARS
write a value (or) a range 'val1 val2' (or) 'all'

- Latitude [all] degree North
- Longitude [all] degree East
- Altitude [10.] [m above surface]

CUSTOMIZE VARIABLE(S) TO BE DISPLAYED

Variable 1 [Temperature (K)]
Variable 2 [(None)]
Variable 3 [(None)]
Variable 4 [(None)]

SUBMIT

Advanced settings and information

If longitude is a free dimension, local time value is
(•) at longitude 0 ( ) fixed for the whole planet

Earth Julian Date [2457532.8]
Mars MY [33] - MM [6] / 12 - sol [332] / 669
EARTH DATE >>> MARS DATE

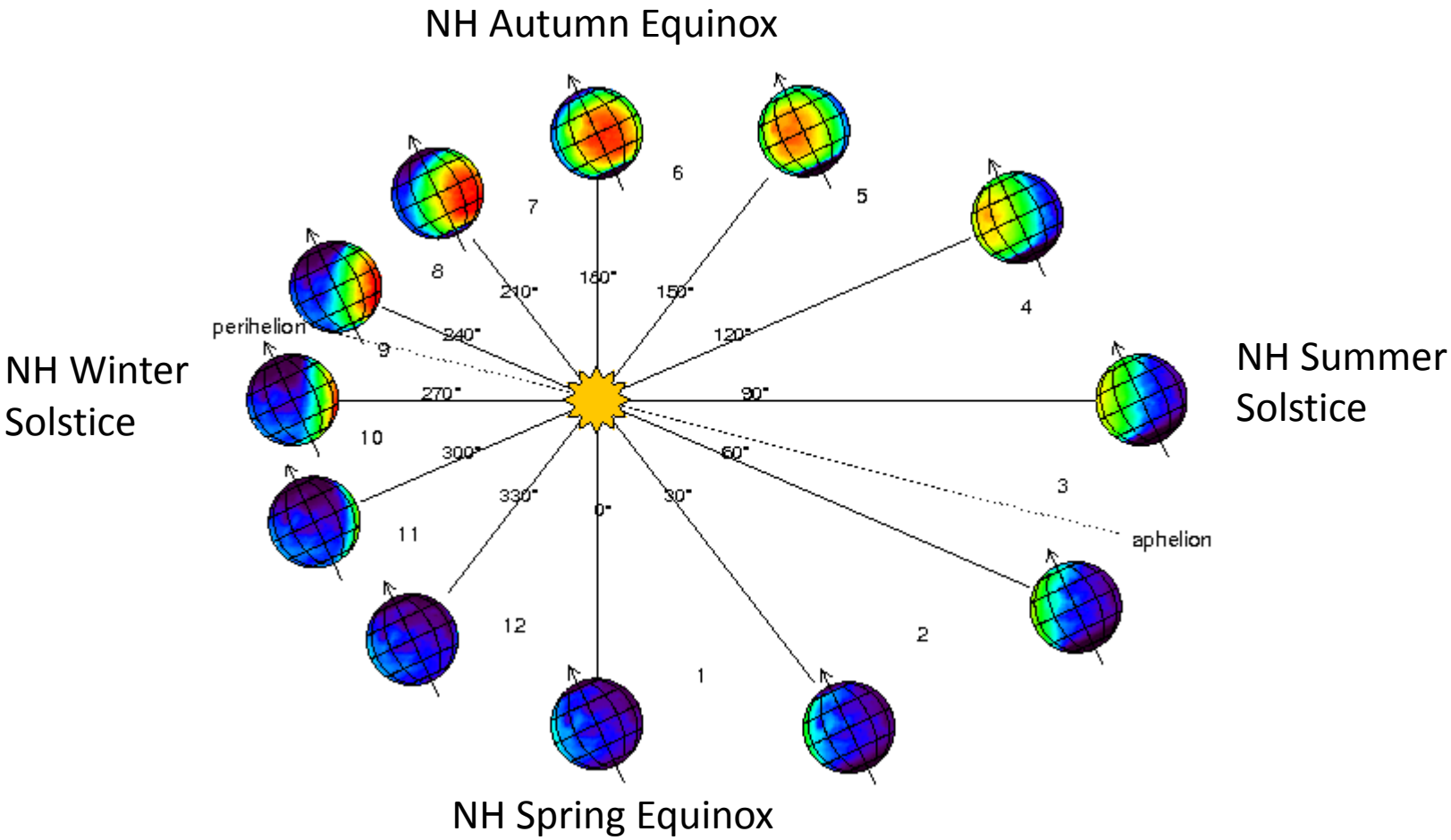
- Dust/EUV scenario [climatology ave solar]
- Use high-resolution topography ( ) off (•) on
- Zonal averaging (only lat/alt plot) (•) off ( ) on
- Figure format (•) PNG ( ) PNG hi-res ( ) EPS

- [1D] Log(values) (•) off ( ) on
- [2D] Colormap [blue green yellow red]
- [2D] Values range [ ] to [ ]
- [2D map] [flat] lat [ ] lon [ ]
- [2D map] Transparency (%) [ ]
- [2D map] Wind vectors (•) off ( ) on
- [2D map] Point at lat [ ] lon [ ]

Open source python interface by A. Spiga (LMD).
Javascript time conversion by E. Millour (link).

Calendar and dates

- The MCD input date can be an Earth date or Mars Date (solar longitude Ls between 0 and 360°)
- Mars Year 1 begins April 11th 1955 . We are currently Mars Year 33.



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2016 / 5 / 24 @ 9 : 35 : 47

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Available vertical coordinates

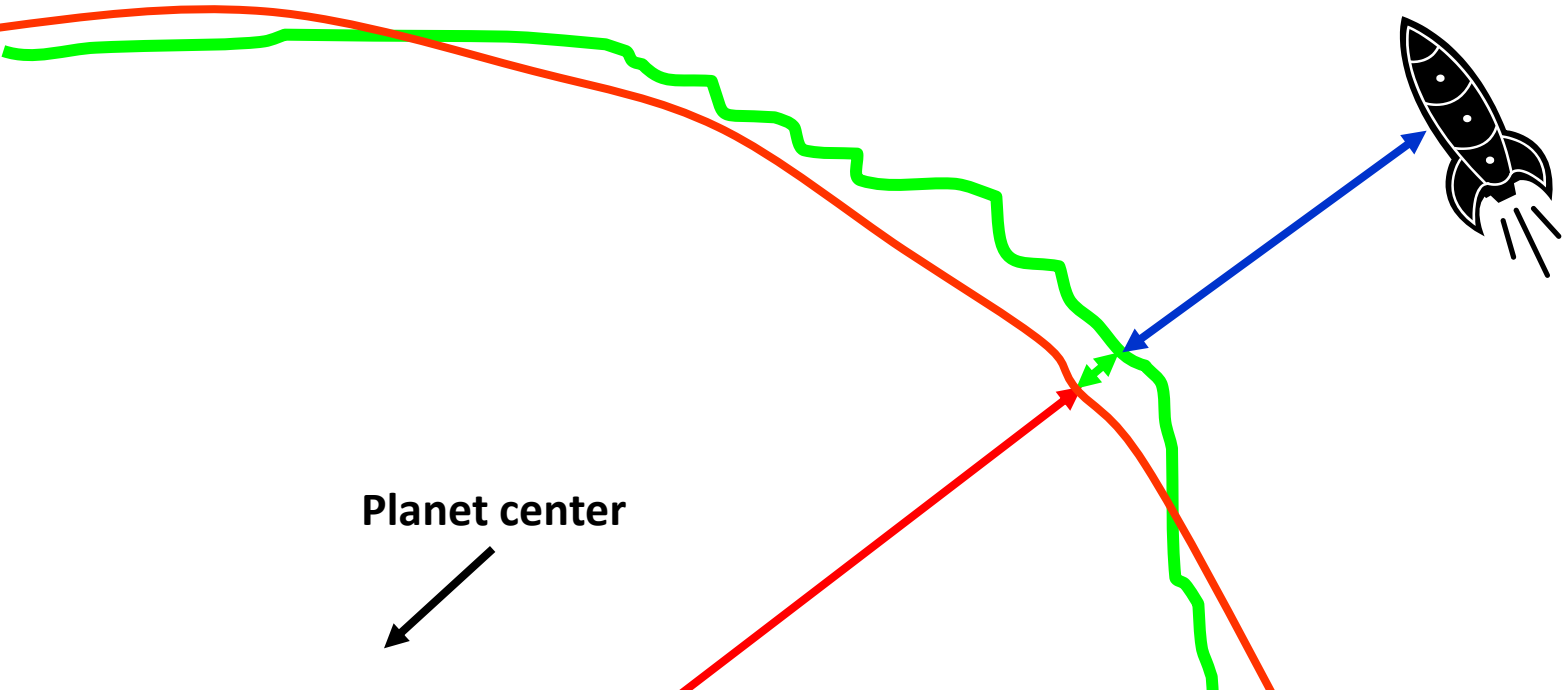
- **Pressure** (Pa)
- **Altitude** (m): above surface/areoid/planet center

Distance to center of Mars =

(**Altitude above surface**)

+ (**MOLA surface topography wrt areoid**)

+ (radius of areoid)



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Mars Climate Database (c) LMD/OU/IAA/ESA/CNES.
Open source python interface by A. Spiga (LMD).
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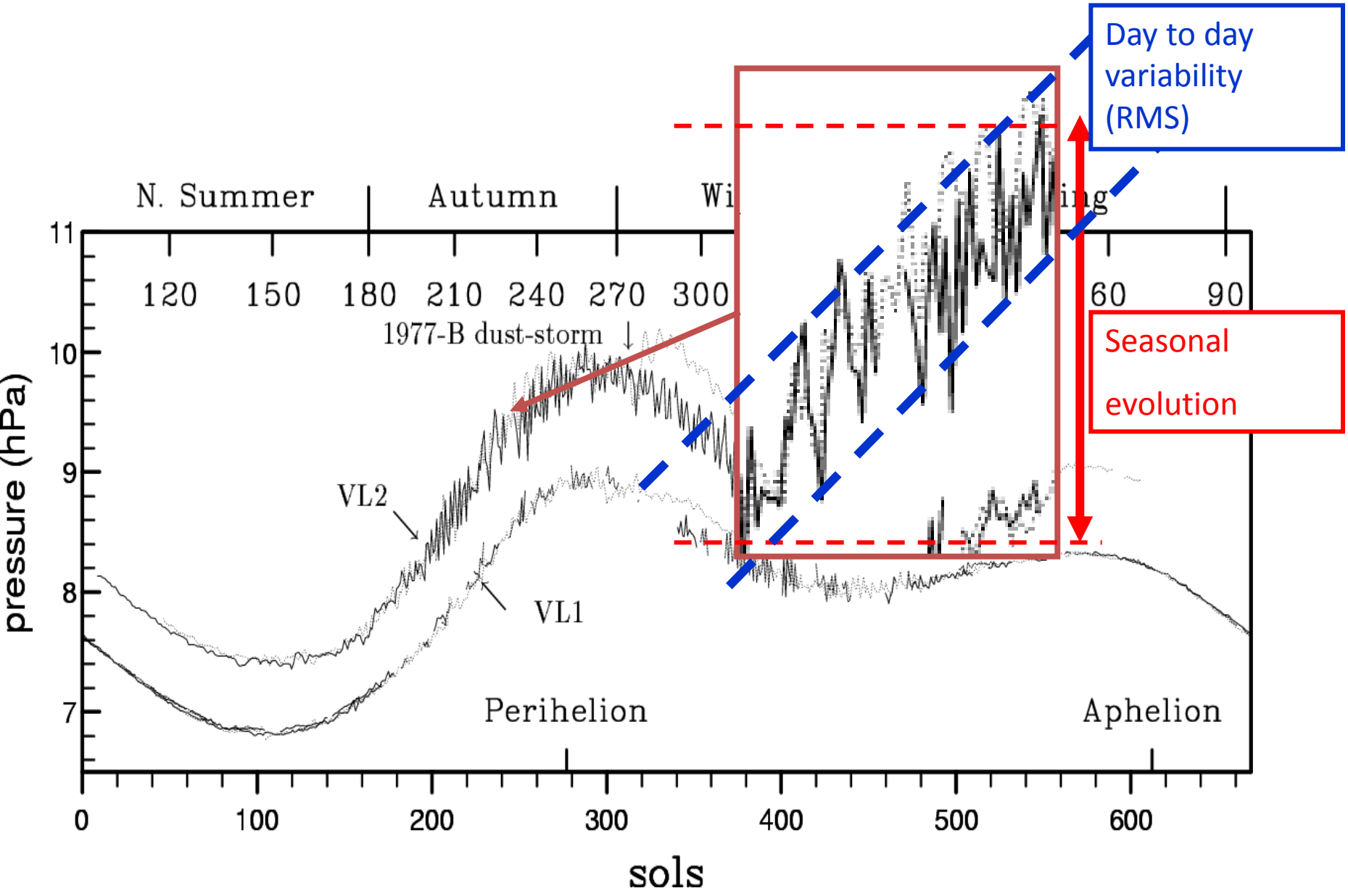
Diurnal and seasonal evolutions and day to day variability

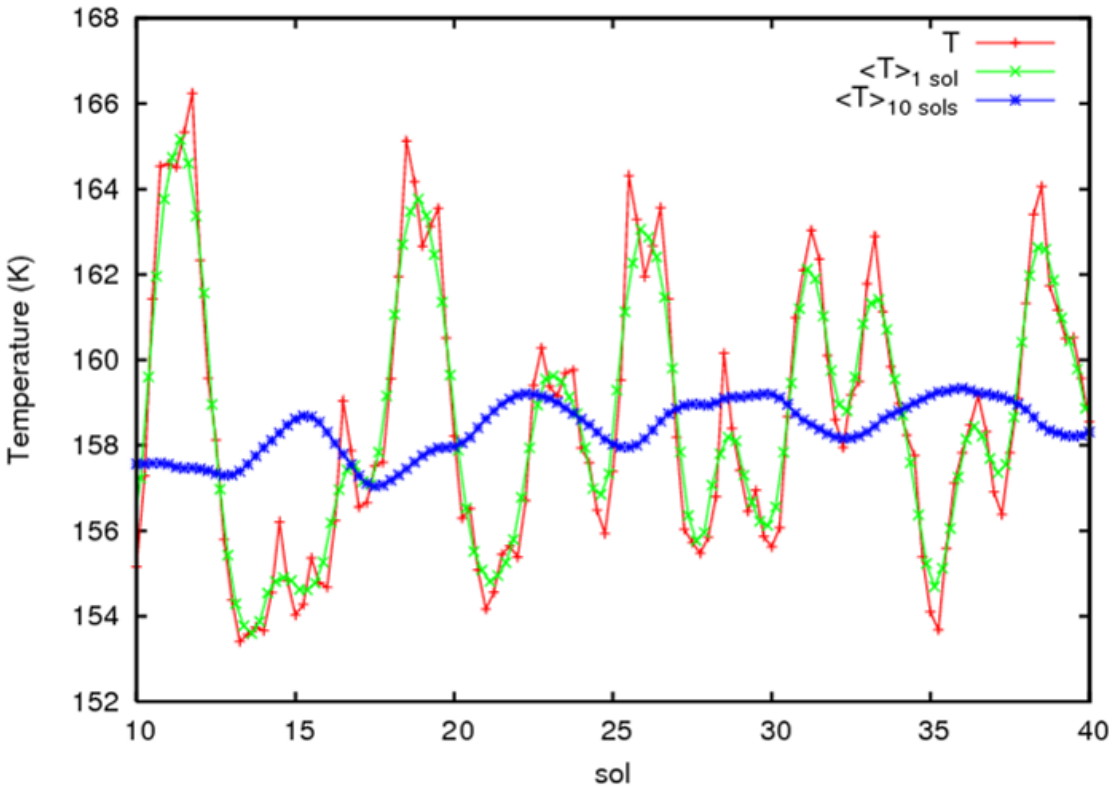


Diurnal mean surface pressure recorded by Viking landers

Day to day RMS of atmospheric variables

- Variables in the MCD are stored along the GCM vertical levels which are (essentially) pressure levels. On these levels, the day to day variability is evaluated as:

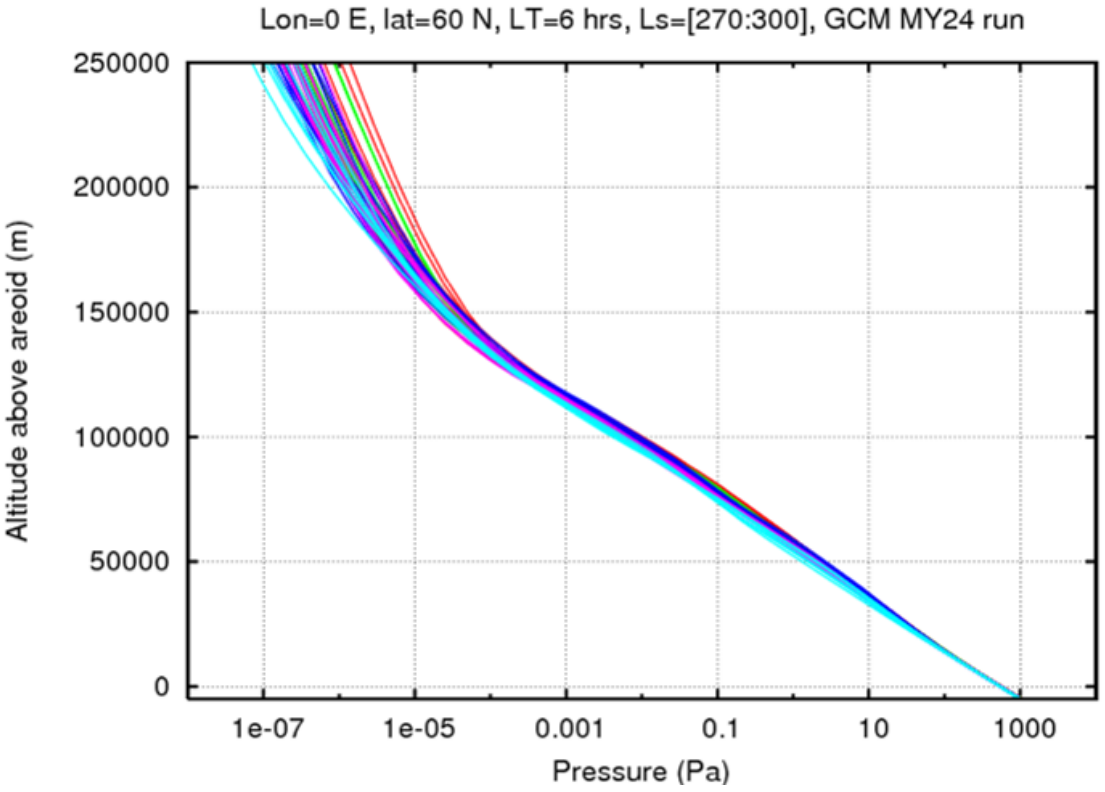
$$RMS(X) = \sqrt{\frac{1}{N}\sum_{1}^{N}\left(< X >_{1\ \mathrm{sol}} - < X >_{10\ \mathrm{sols}}\right)^2}$$



- Such RMS, because evaluated at fixed pressure is relative to that given pressure.

Day to day RMS of atmospheric variables

- The altitude of a given pressure levels varies (and can be computed by integrating the hydrostatic equation).



- The RMS of variables at fixed altitude **is not** the RMS evaluated at fixed pressure.
- The altitude-wise RMS has to be computed on a fixed altitude grid.

- The MCD provides both pressure-wise and altitude-wise RMS of atmospheric variables (temperature, density, winds,..)

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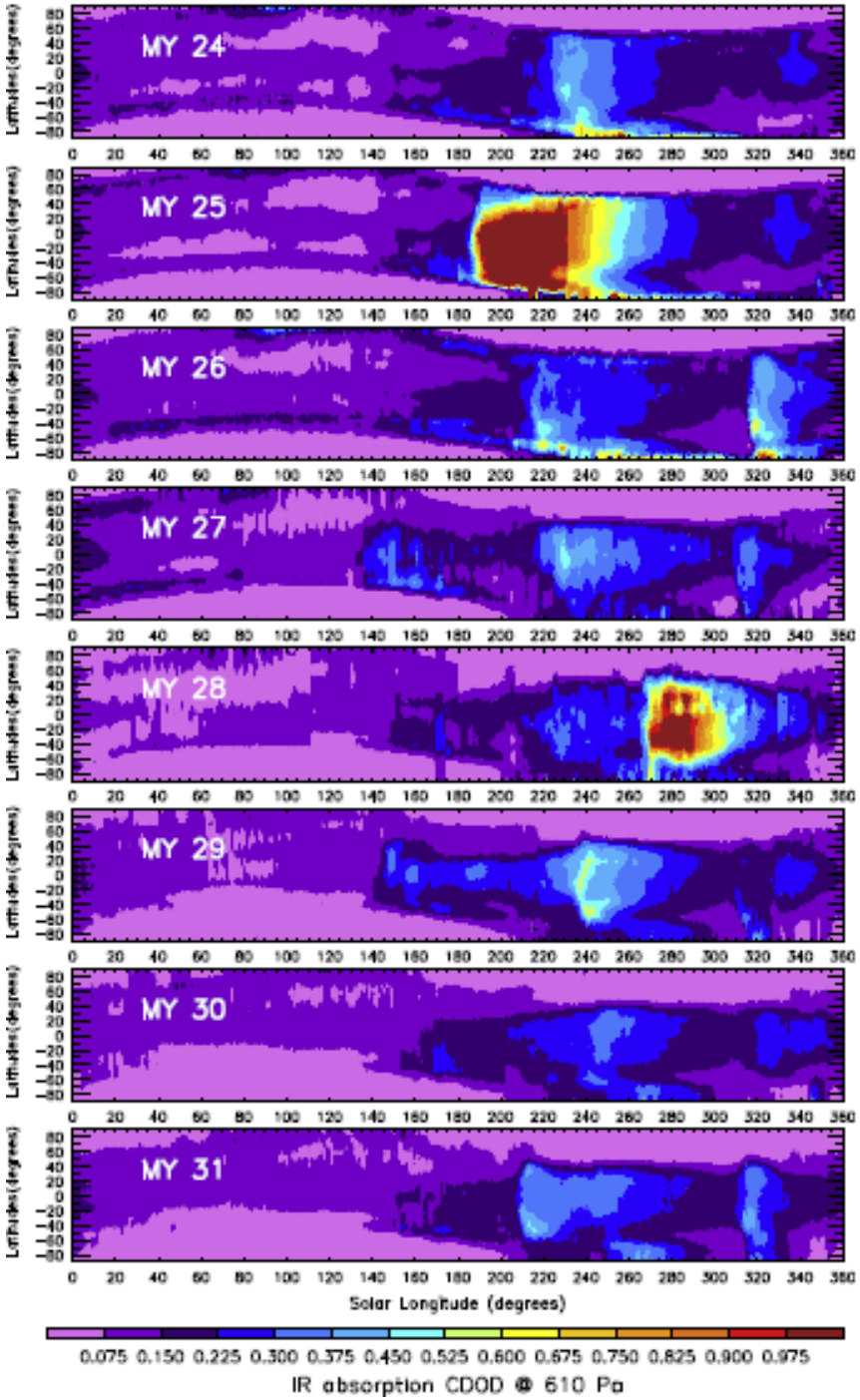
- [2D map] Point at lat lon

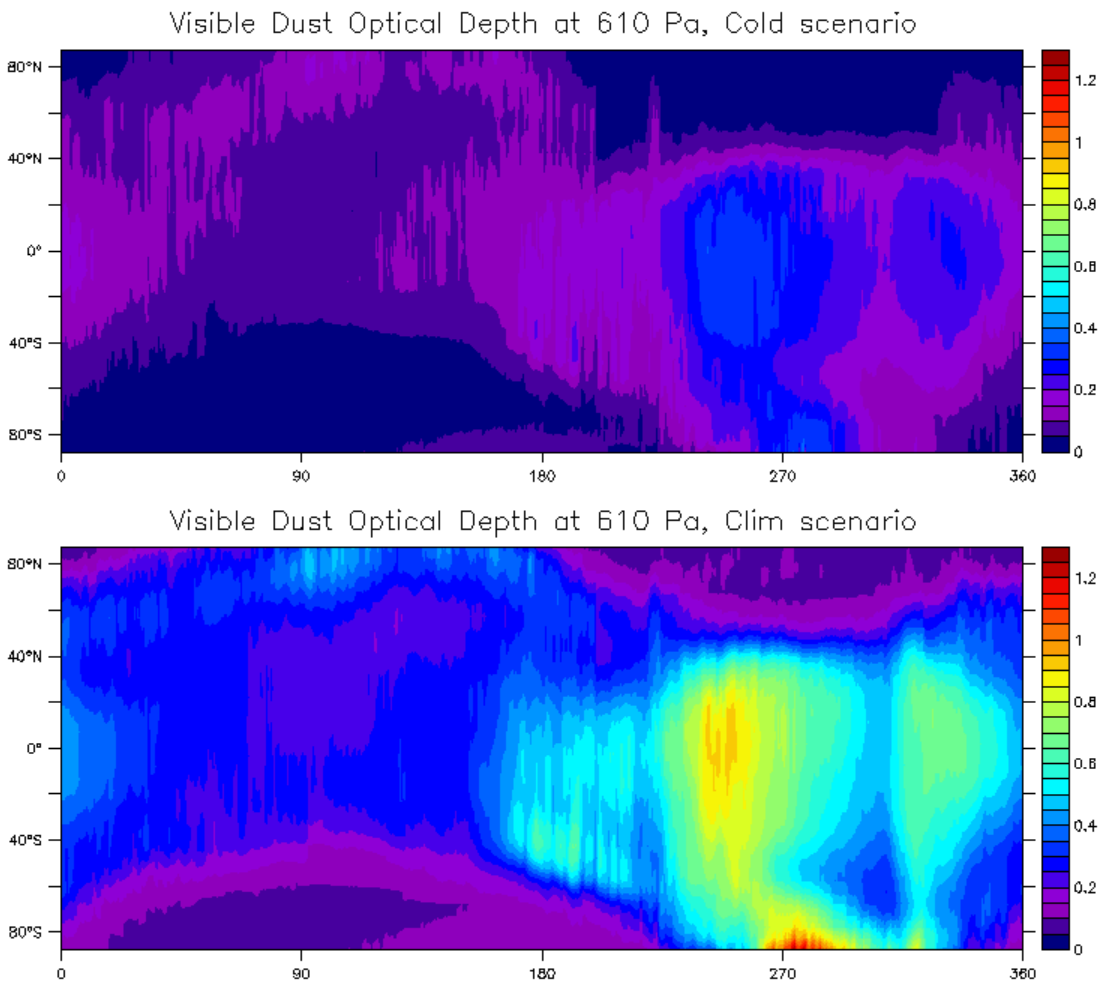
MCD v5.2 dust scenarios

- We have access to dust scenarios for last 8 Mars years (L. Montabone et al. Icarus 2015).
- **Combining** all “non-global dust storm” years (MY 24, 26, 27, 29, 30, 31), we can generate a **mean Mars year dust scenario and climatology**.



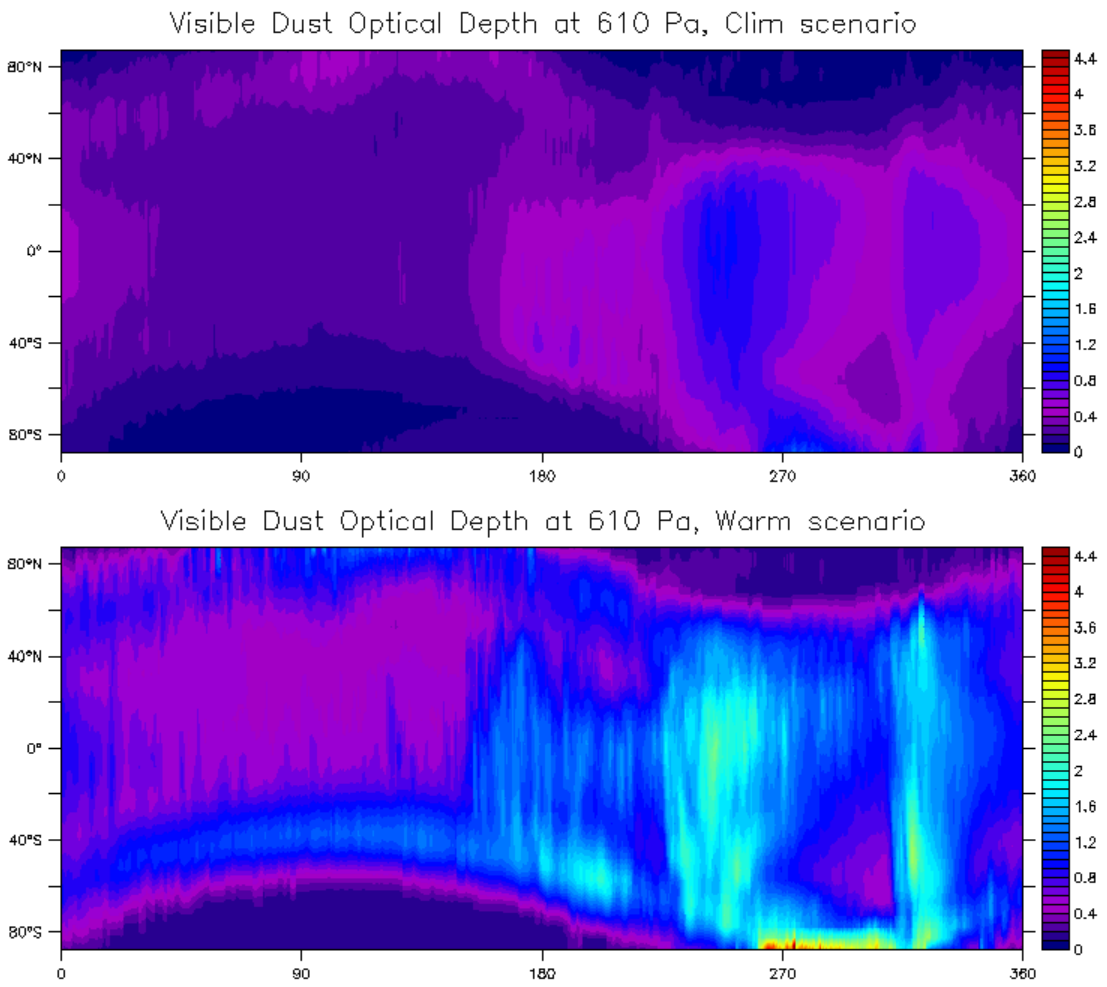
MCD v5.2 dust scenarios

- The **cold scenario**: Very low amount of airborne dust. Dust opacity at a given season and location is taken as the minimum over the 8 Martian years MY24-MY31 dust scenarios, moreover decreased by 50% and neglecting the radiative effects of clouds.



MCD v5.2 dust scenarios

- The **warm scenario**: Very high amount of airborne dust (but not a planet encircling dust storm event). Dust opacity at given season and location is taken as the maximum over the 8 Martian years (excluding the global dust storm periods during MY25 and MY28), moreover increased by 50%.



MCD v5.2 dust scenarios

• The **dust storm scenario**: An extreme case of fixed high opacity (tau=5) combined with "darker dust" properties (ie: using Ockert-Bell dust properties instead of Wolff et al. properties).

• Covers only the "dusty season" (second half of the year; Ls between 180° and 360°).

• Moreover the dust storm simulations are ran starting from "climatology" initial conditions every Martian month (30° of Ls). This enforces realistic CO2 (and associated surface pressure) and H2O cycles while capturing the effect of the onset of an intense planet encircling dust storm.

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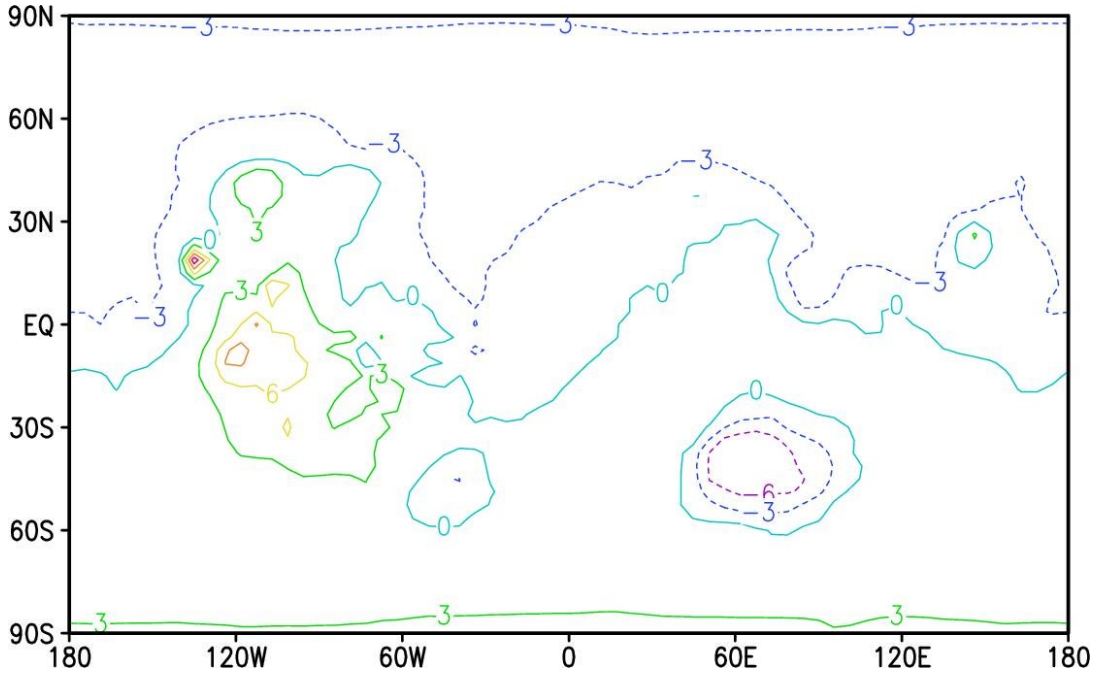
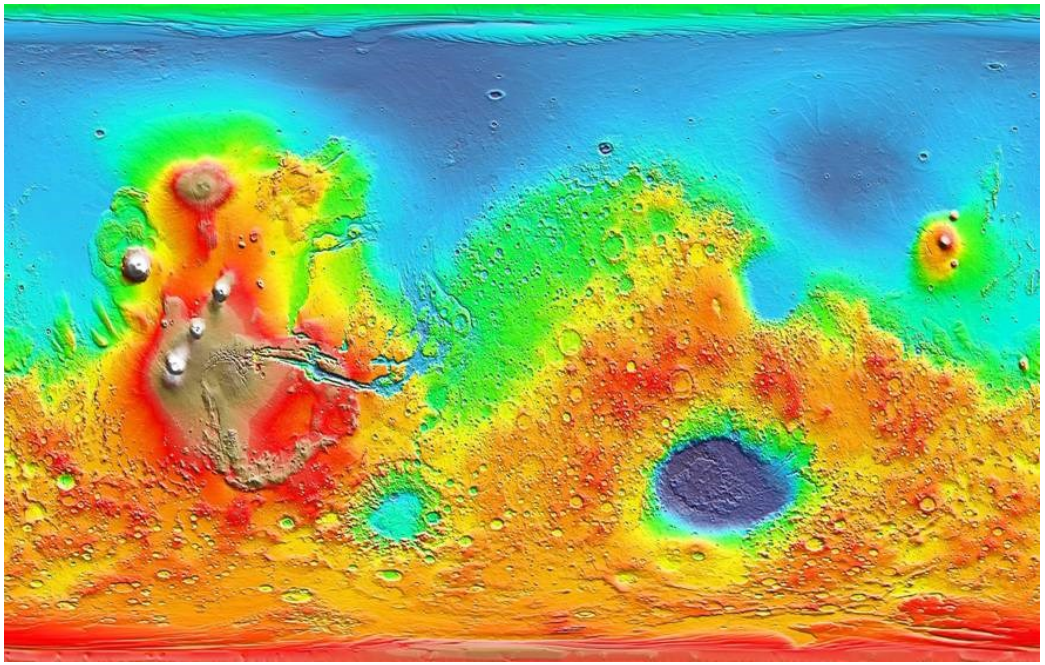
Open source python interface by A. Spiga (LMD).
Javascript time conversion by E. Millour (link).

Topography:

call_mcd, at GCM resolution, uses and provides:
Smoothed topography (MOLA averaged)
3.75°(lat) x 5.625° (lon)

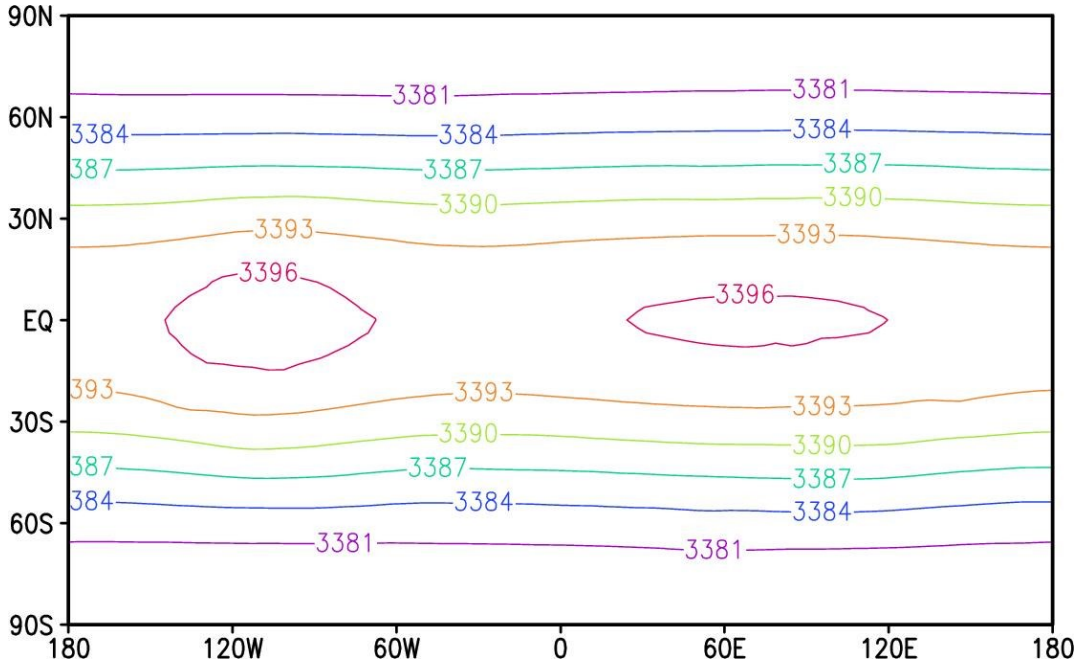


call_mcd, at high resolution, uses and provides: high resolution (1/32deg) MOLA topography: (horizontal resolution better than 2 km)



Areoid (zero datum):

call_mcd, at GCM resolution,
uses and provides:
Smoothed areoid
(from MOLA)
3.75°(lat) x 5.625° (lon)



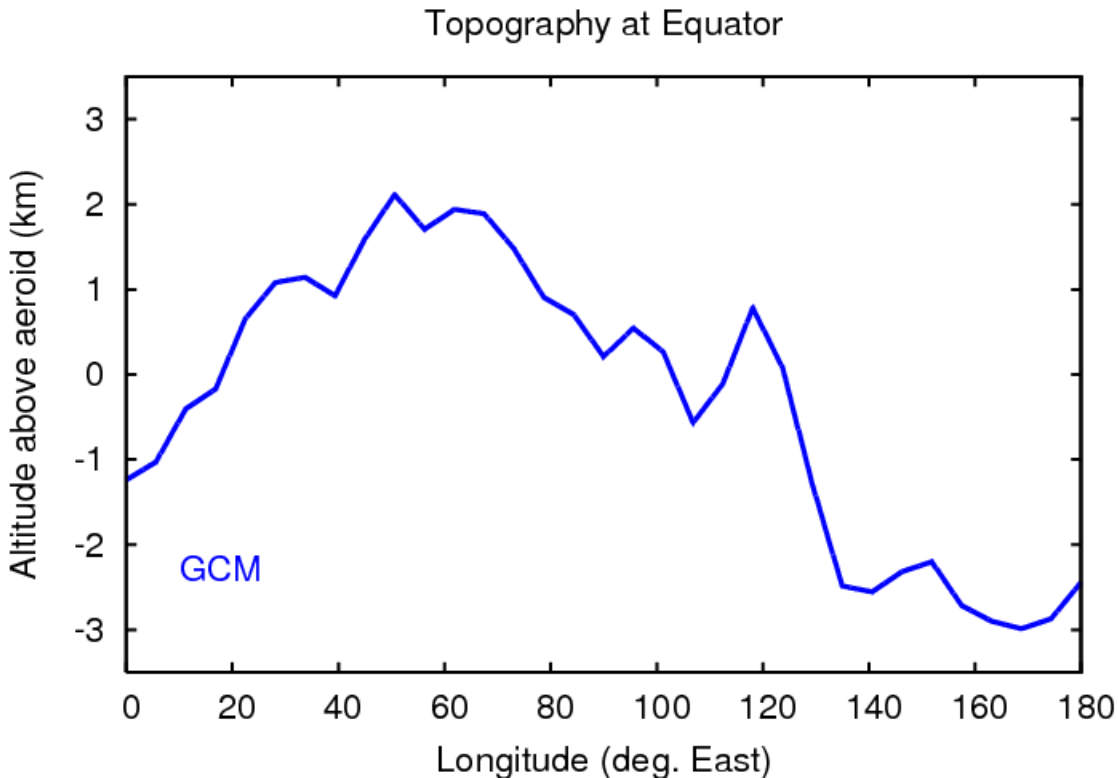
radial distance to planet center (km)
(MOLA team. Smith et al. 2000)

call_mcd, at high resolution,
uses and provides: high resolution MOLA areoid
(using spherical harmonics expansion coefficients)

Spherical harmonics coefficients mgm1025 (and Fortran reconstruction routine) available on MOLA website

MCD high resolution outputs

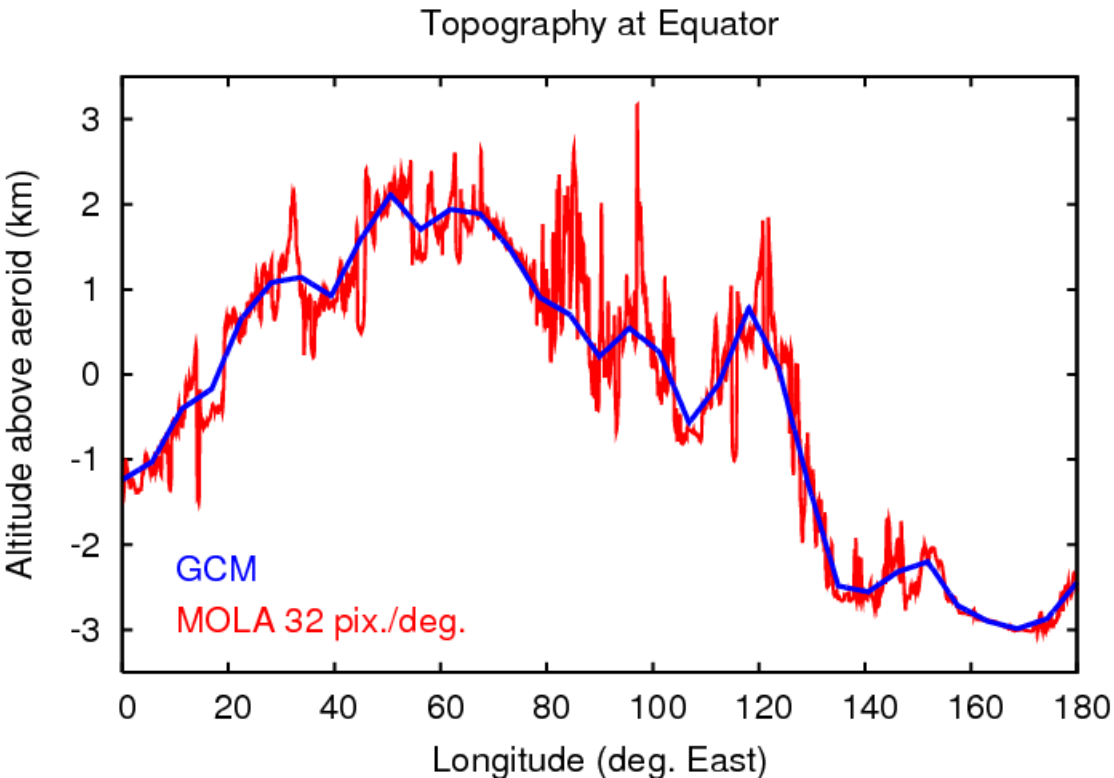
- The GCM from which the MCD is derived is run at 5.625° x 3.75° resolution in longitude x latitude.



MCD high resolution outputs

- The GCM from which the MCD is derived is run at 5.625˚ x 3.75˚ resolution in longitude x latitude.
- The MCD post-processing software includes a high resolution mode based on 32 pix./deg. MOLA topography

High resolution surface pressure is obtained by combining GCM surface pressure, MOLA topography and VL1 pressure records (procedure validated by Spiga et al. 2007)



MCD high resolution outputs

- The high resolution scheme extends to the reconstruction of atmospheric temperature and density (empirical scheme validated using high resolution GCM runs).

Example: temperatures above Valles Marineris