The Mars Climate Database (MCD version 5.2)

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May 14th 2015, Kobe

The Mars Climate Database

a brief history of the MCD project

- 1995: **ESA** (European Space Agency) and **CNES** (French Space Agency) identify the need for a better comprehension of the Martian environment for future missions to Mars.
- 1995: The LMD and AOPP (Oxford University) groups (later joined by the IAA, Spain, group) team up, and funded by ESA and CNES , improve their GCMs to provide outputs (the MCD) to the space agencies and the scientific community.
- 2001: MCDv3.0 (and then MCDv3.1) is released (the first to be really **distributed**, with a large number of users).
- 2005 : MCDv4.0 and MCDv4.1 released.
- 2006 : MCDv4.2 released.
- 2008 : MCDv4.3 released.
- 2012: MCDv5.0 released.
- 2014: MCDv5.1 released.
- 2015: MCDv5.2 released.

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).
- 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 200 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 contents & main features

- The MCD enables to reconstruct realistic conditions using:

  - day-to-day variability of main variables

  - adding random small scale perturbations as vertical gravity waves (of user specified wavelength)

  - adding random large scale perturbations (extracted from EOFs of individual GCM runs)

- The MCD provides a high resolution mode based on 32 pix./deg. MOLA topography (where GCM resolution is 5.625° x 3.75°) combined to Viking Lander 1 pressure records, which yields:

  - high resolution surface pressure

  - reconstructed high resolution atmospheric temperature, using an empirical scheme validated using high resolution GCM runs.

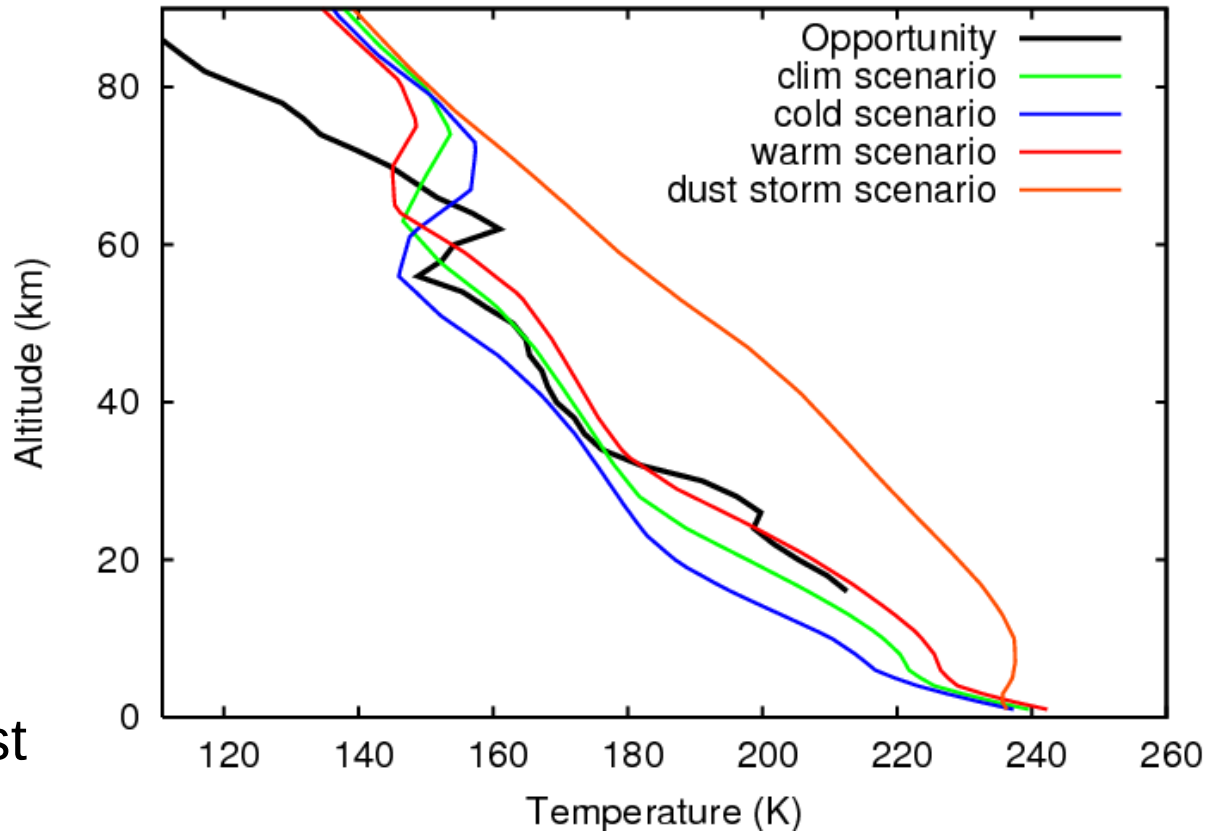
MCD contents & main features

- The dust load of the Martian atmosphere is highly variable; the MCD includes 4 dust scenarios to bracket reality,
- Topped by 3 EUV scenarios to account for the Sun's 11 year cycle.

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

• Note that Opportunity landed during a local dust storm

Opportunity entry profile
(retrieved by P. Withers)

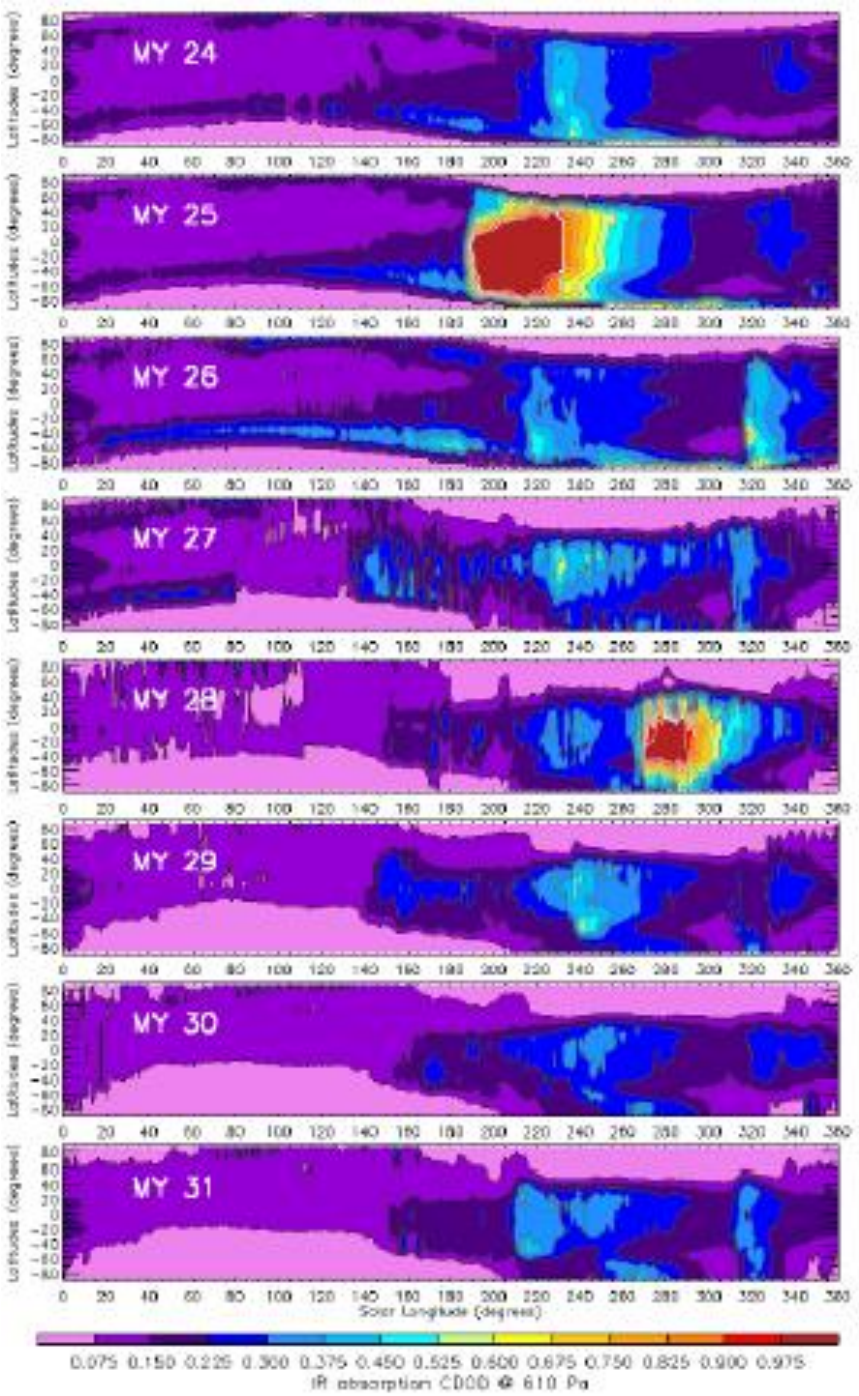


MCD v5.2 dust scenarios

- We have access to dust scenarios for last 8 Mars years (Montabone et al., 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**.

- Moreover, specific simulations for each of the MY years are also provided in MCDv5.2 (New!)



MCD v5.2 dust scenarios

• The **cold scenario**: Very low amount of airborne dust and neglect radiative effect of water ice clouds. 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%.

• 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%.

• The **dust storm scenario** (over Ls=180-360): 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).

Validation of the MCD climatology

- Ongoing work (concerning v5.2)
- Available measurements are the best way to evaluate and validate the MCD, e.g.:

  - **Surface temperatures**, **atmospheric temperatures** and **water vapour** can be compared to **TES** values.

  - **Atmospheric temperatures** and **water ice** can be compared to **MCS** values.

  - **Atmospheric temperatures** can be compared to **MGS** and **Mars Express Radio Occultations**.

  - **Surface pressures** can be compared to **Viking Lander**, **Pathfinder, Phoenix** and **MSL** measurements.

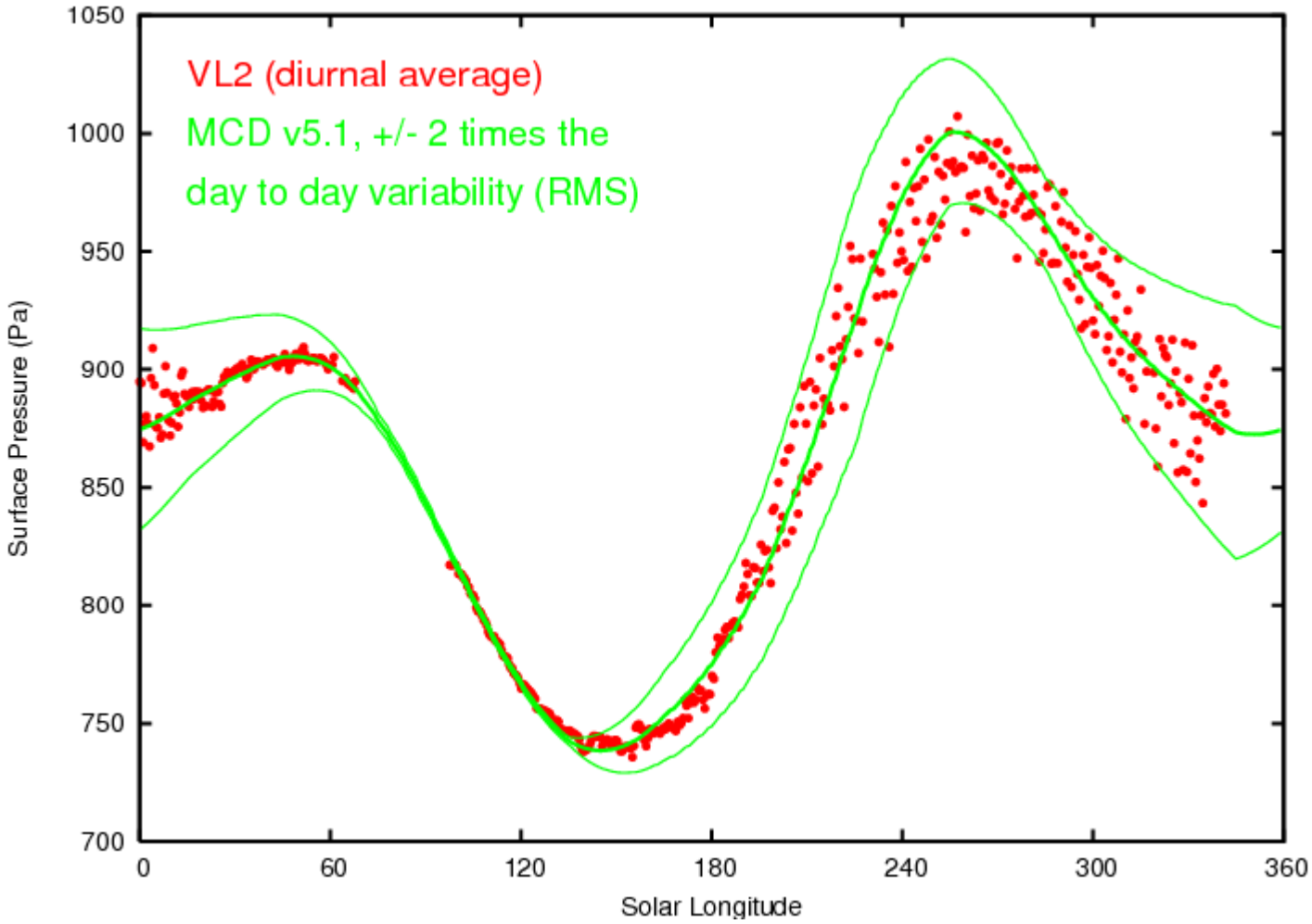
  - **…**

Surface Pressure

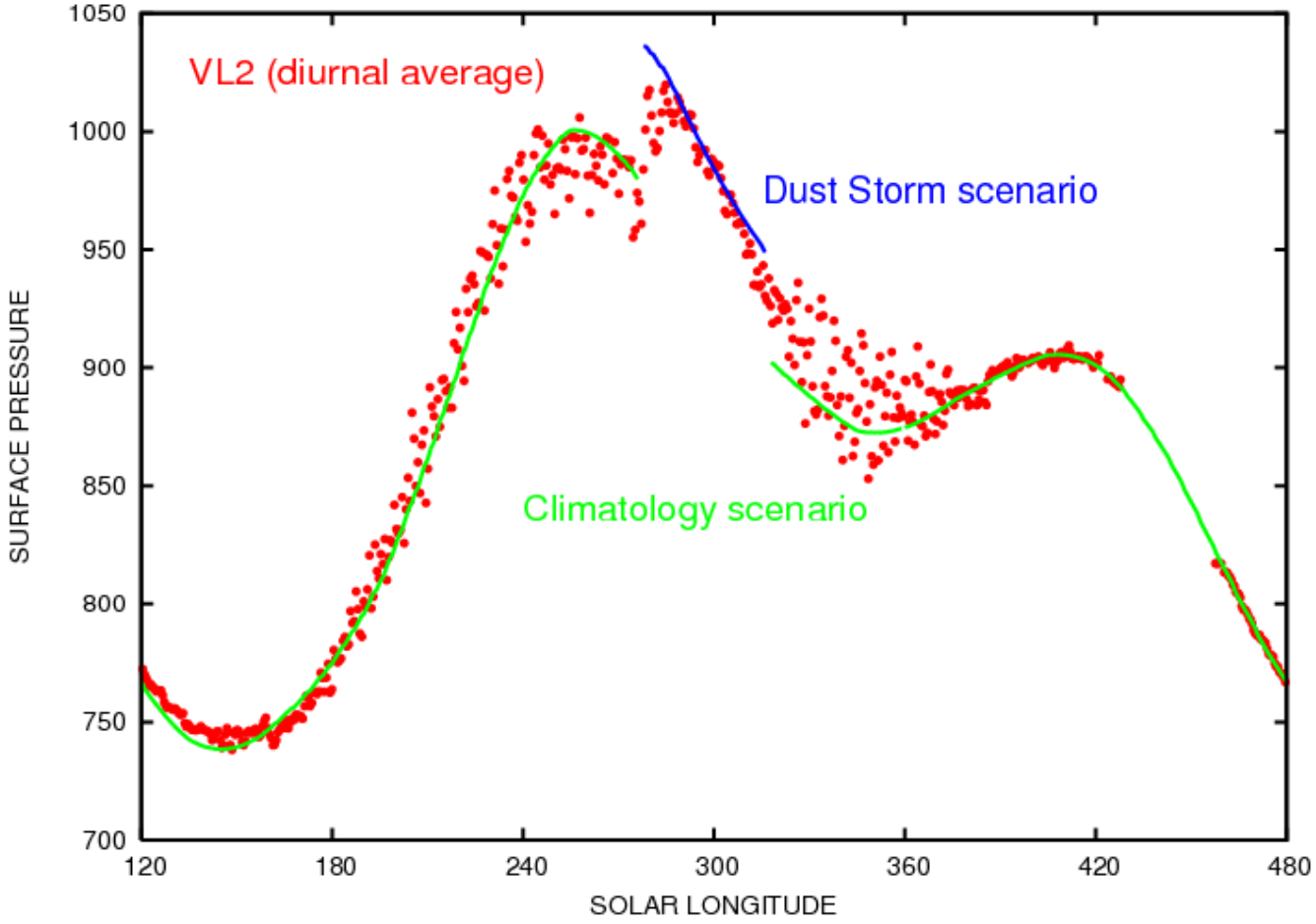
Viking Landers

Mars Years 12-13

Surface pressure at VL2 site and its day to day variability



MCDv5.2 validation – VL2 pressure
Impact of dust scenario



- Change in global behavior due to dust storm is well captured by MCD scenarios.

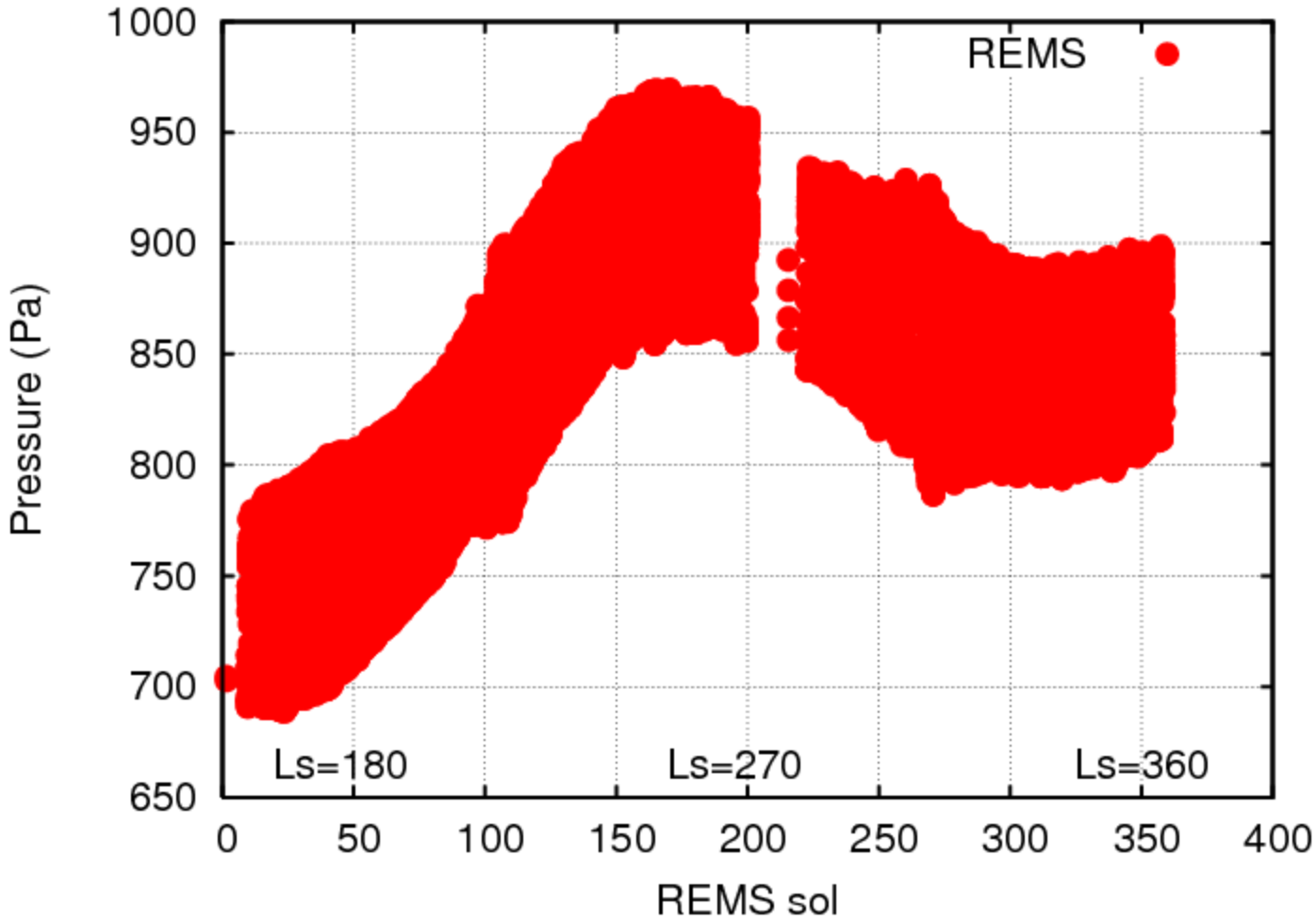
Surface Pressure

REMS onboard Curiosity

Mars Year 31

REMS pressure measurements

- Ongoing measurements for now over a Martian Year (MY31) and continuing



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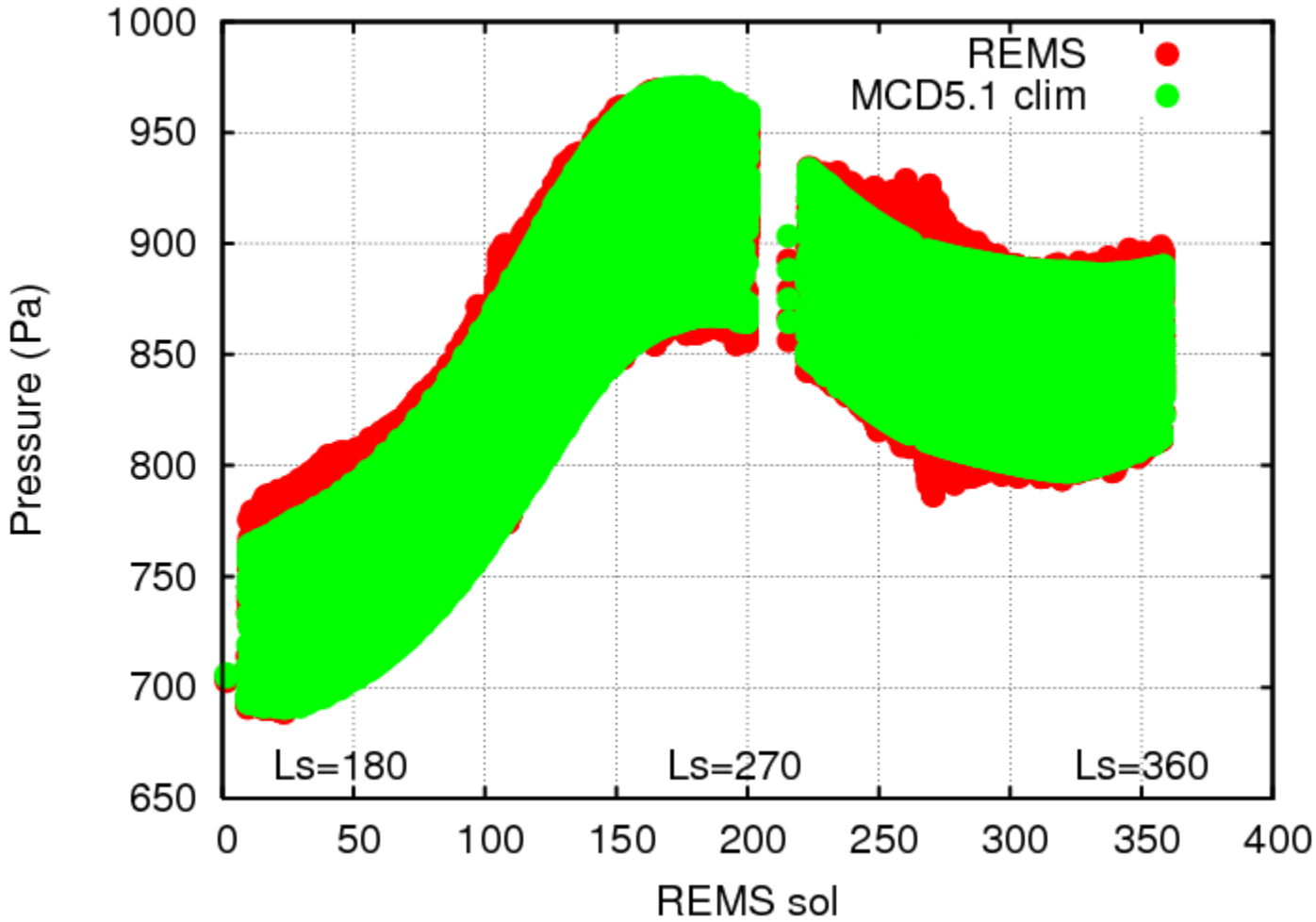

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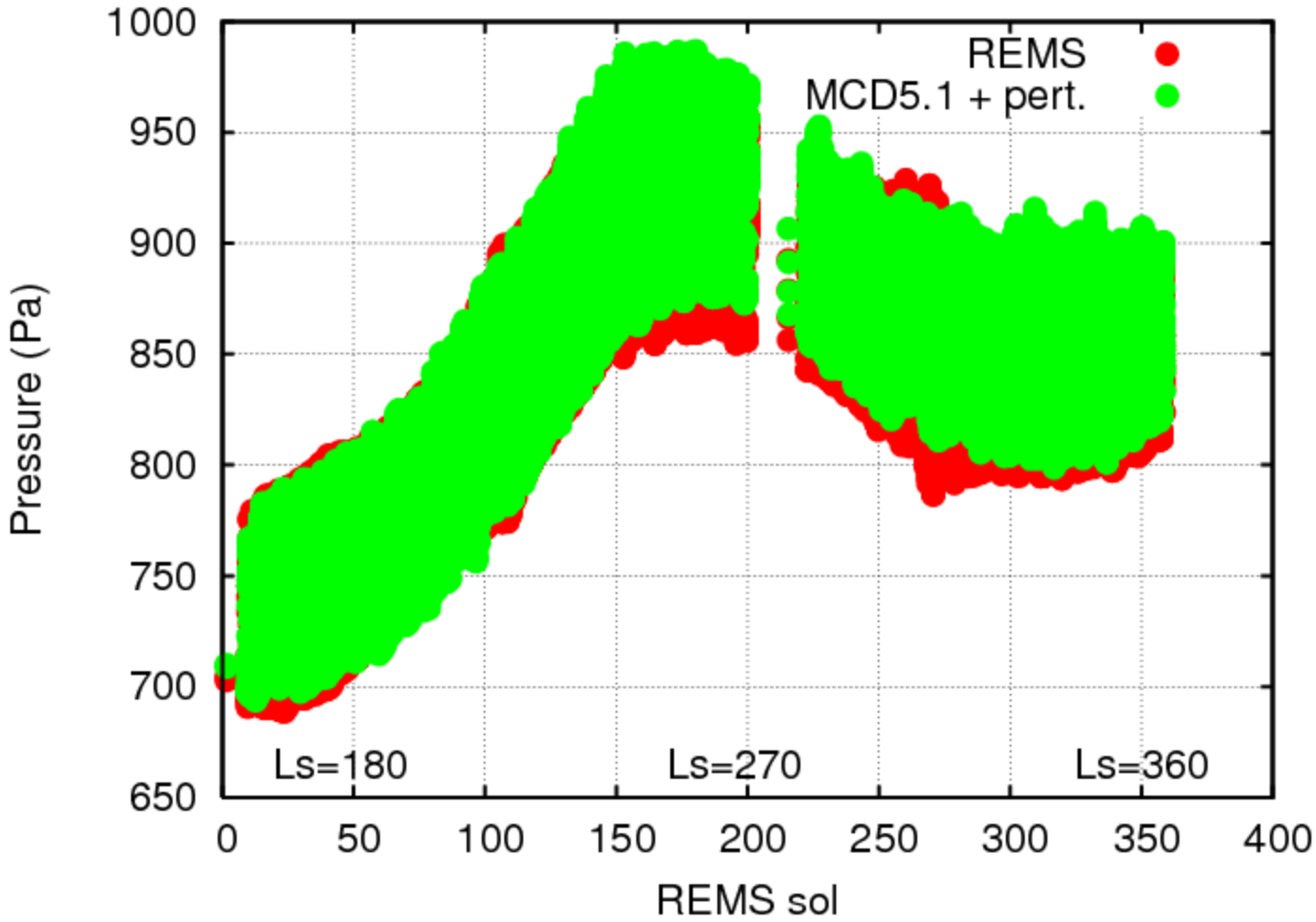


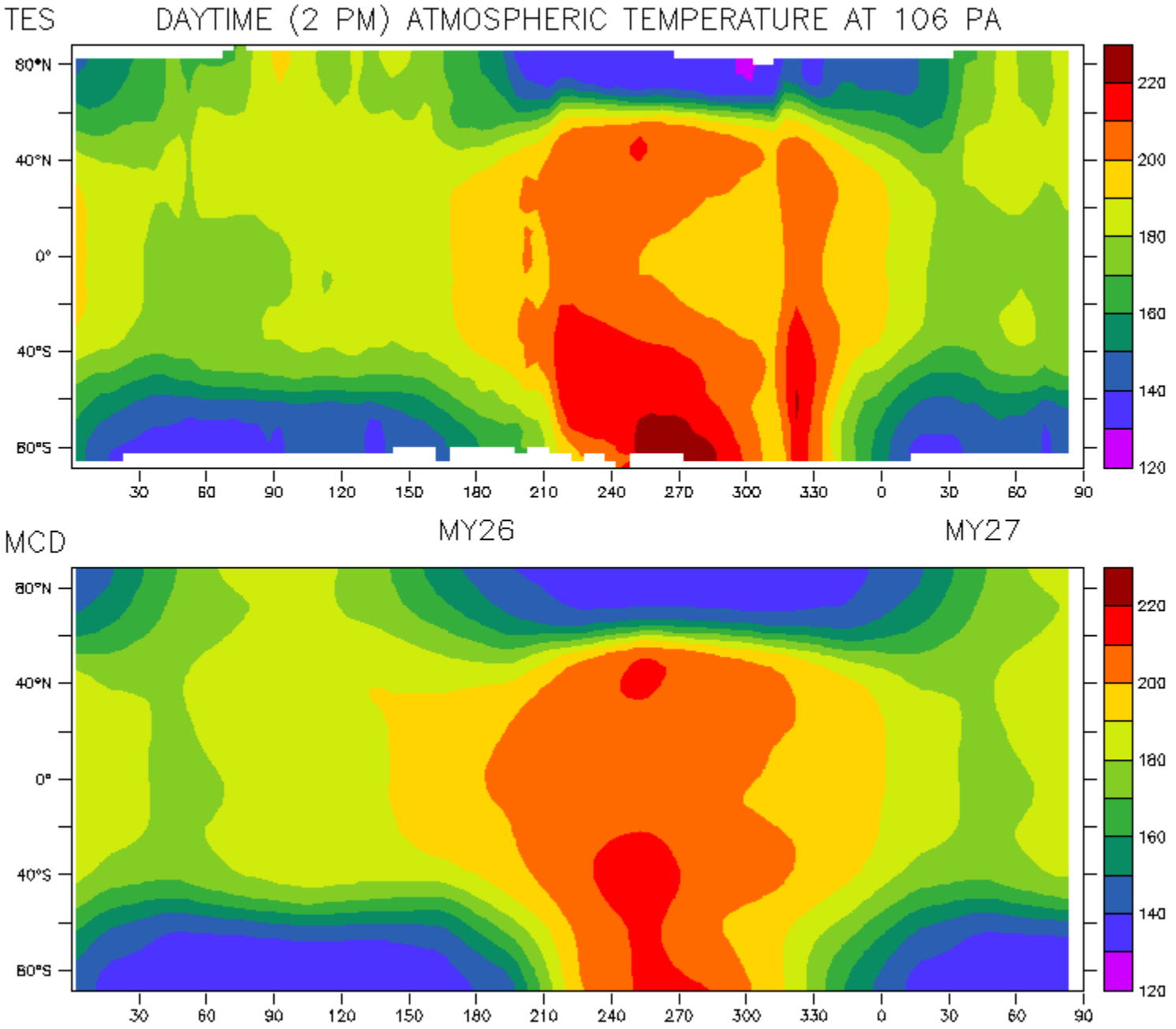
Atmospheric Temperature

TES onboard MGS

Mars Years 24-27

(2am-2pm measurements)

Zonal values of atmospheric temperature (106 Pa)



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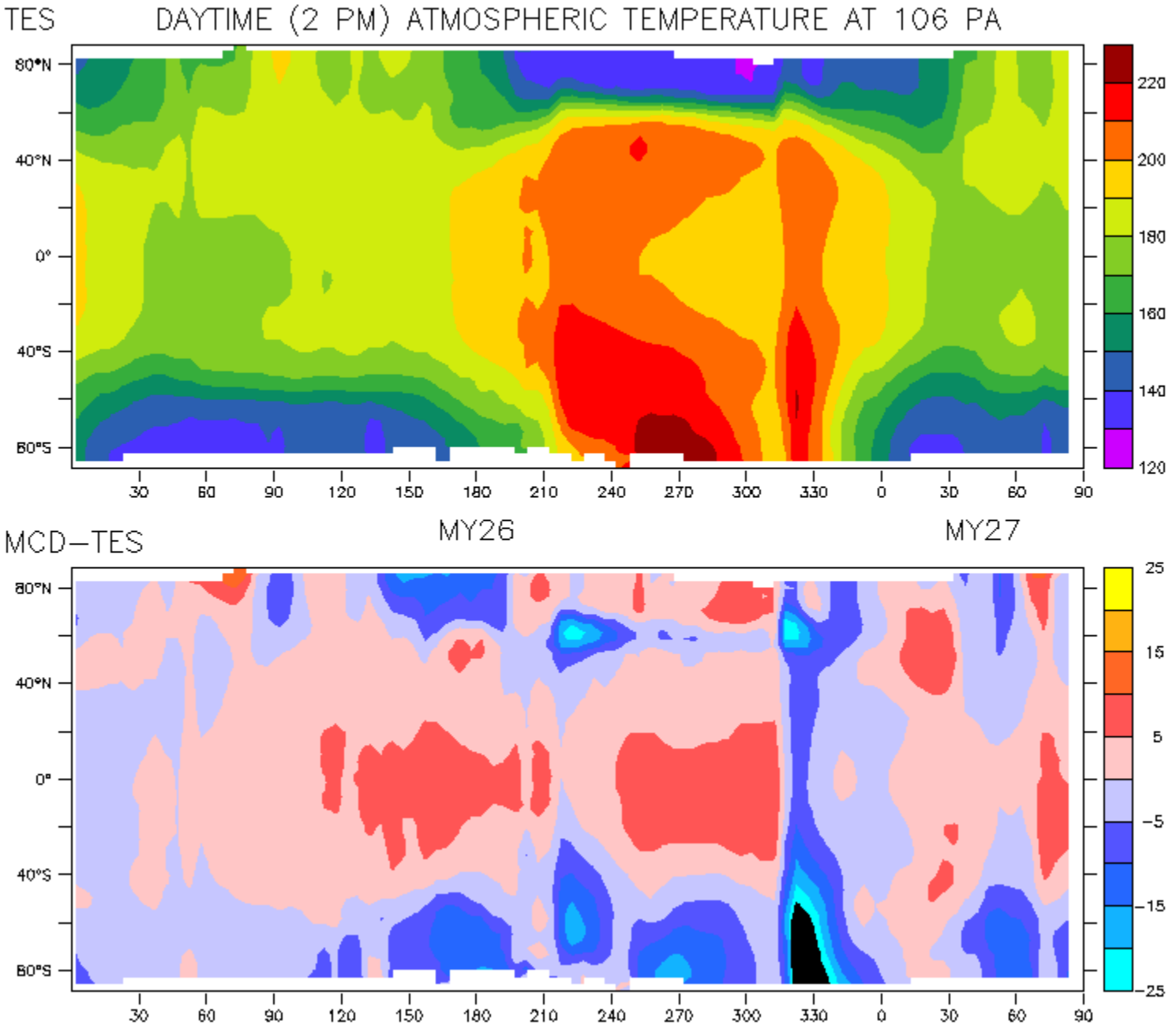
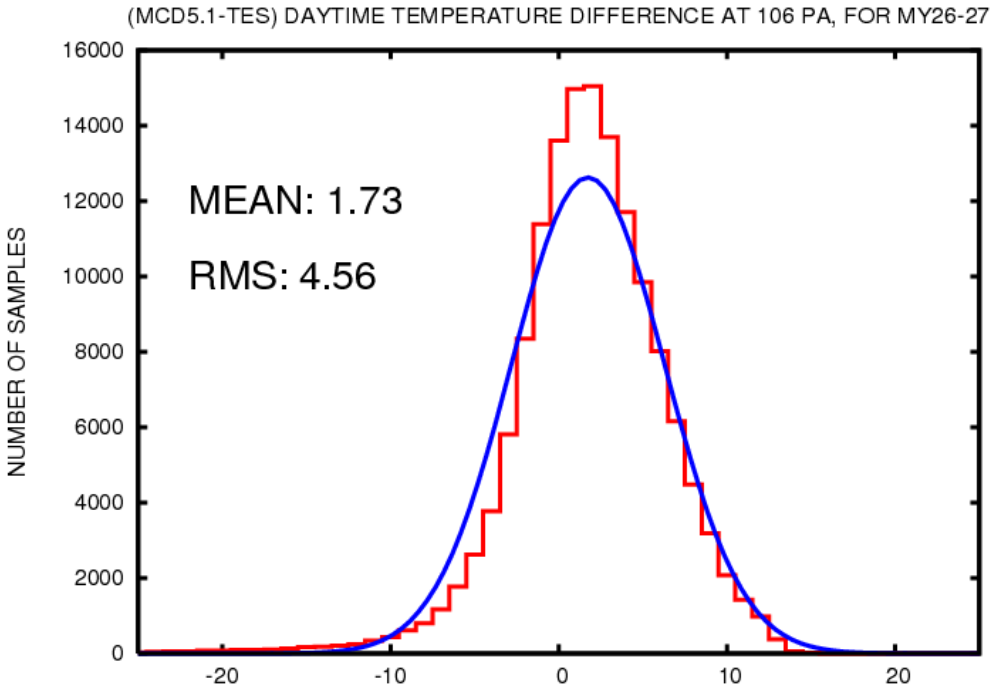
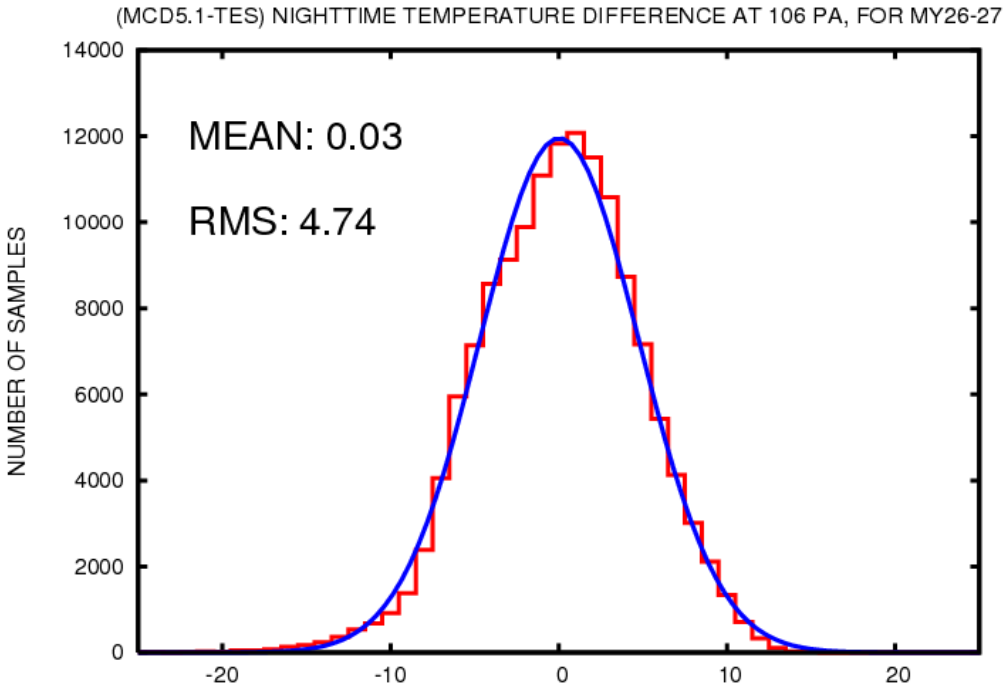




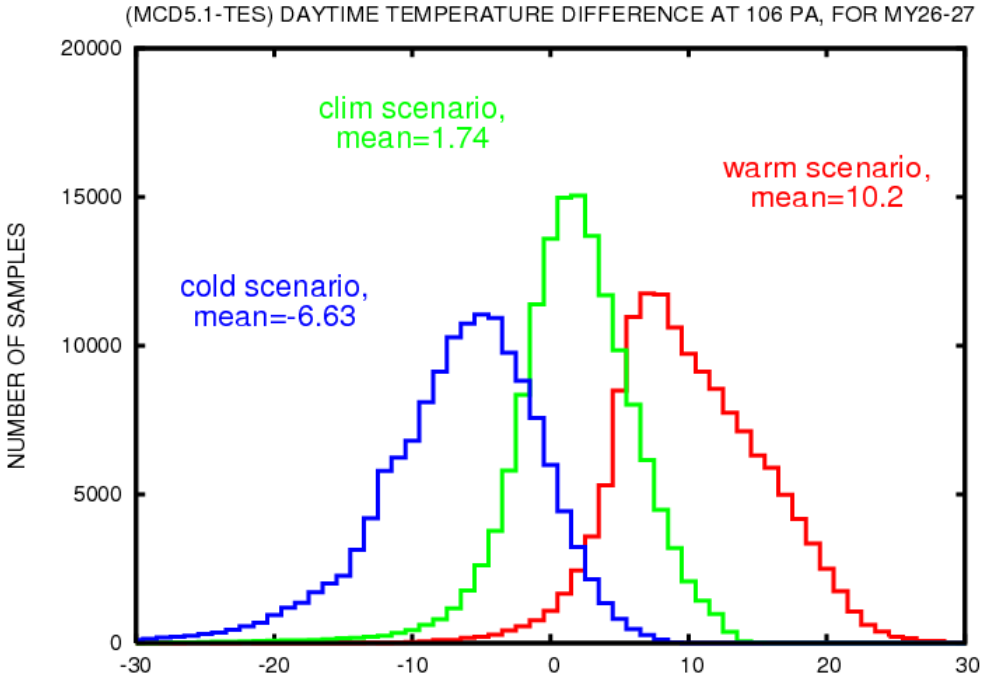


Distributions of atmospheric temperature difference, at 106 Pa, between MCDv5.2(high res.) and TES.

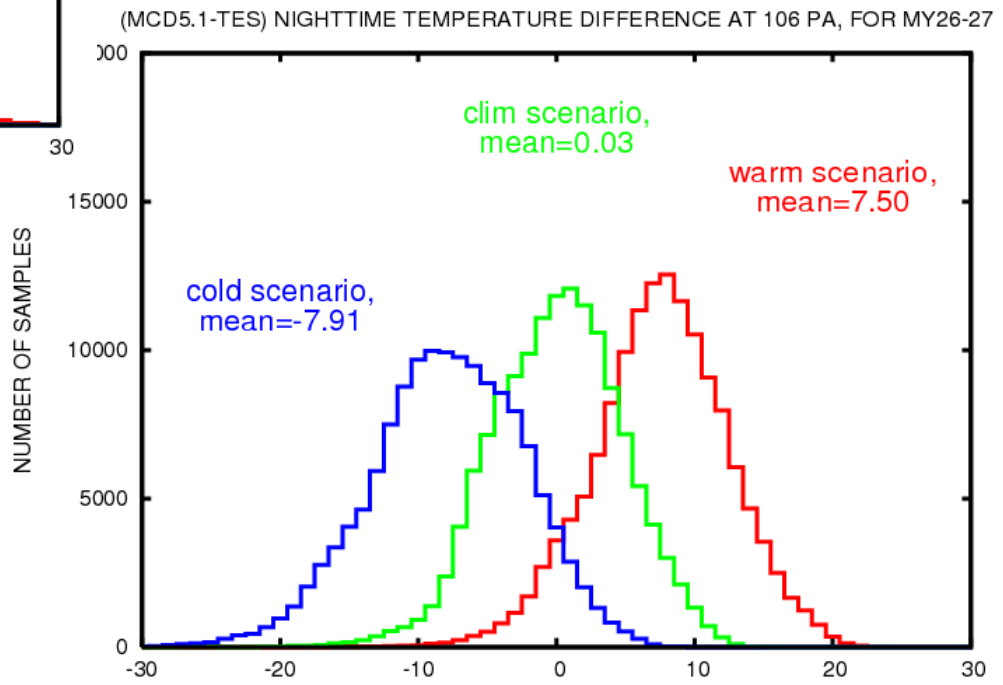
MCD a bit too warm at 2pm.

- Statistics computed for:
  - Pressure: 106 Pa
  - MY26: 0 < Ls < 360
  - MY27: 0 < Ls < 85
  - -50 < latitude < 50
  - Bins of 1K

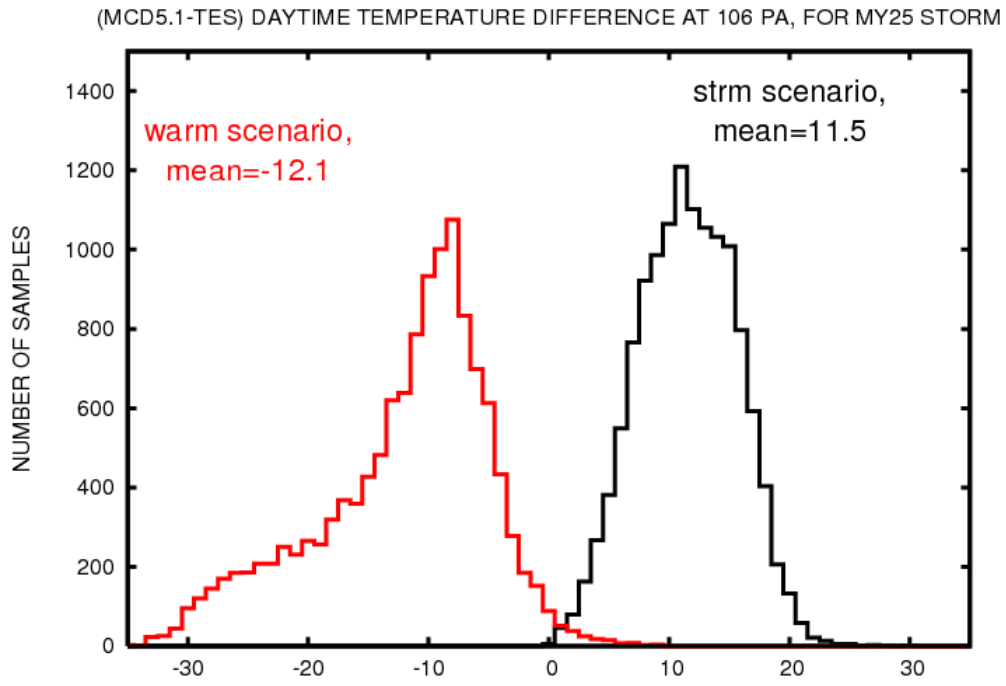
Bracketing TES with MCDv5.2 scenarios



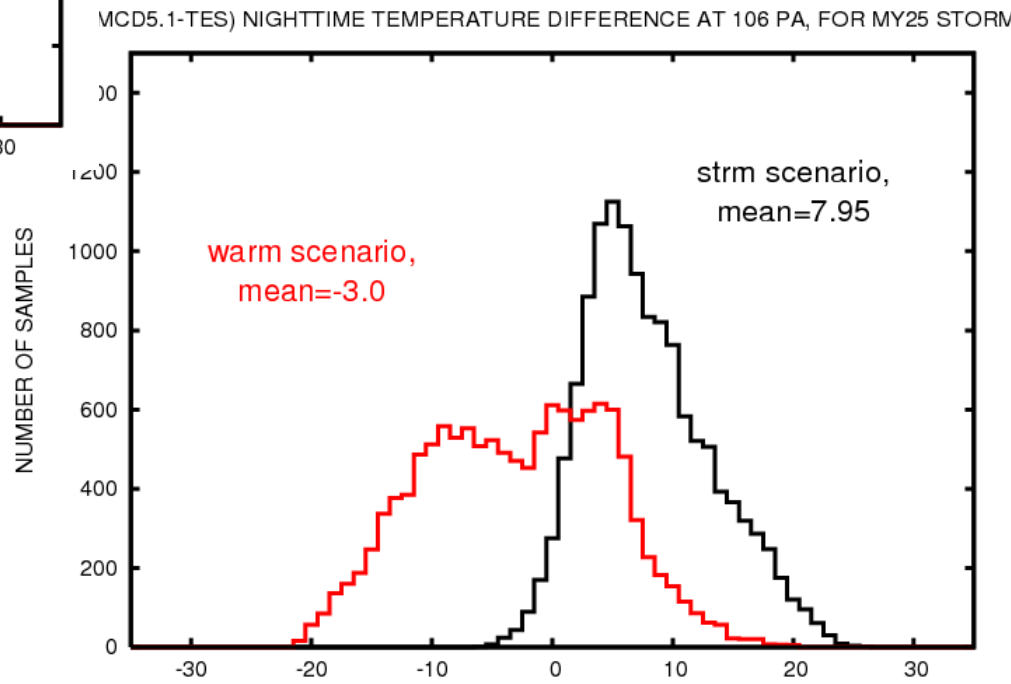
during regular martian years (e.g. MY26-27)



Bracketing TES with MCDv5.2 scenarios



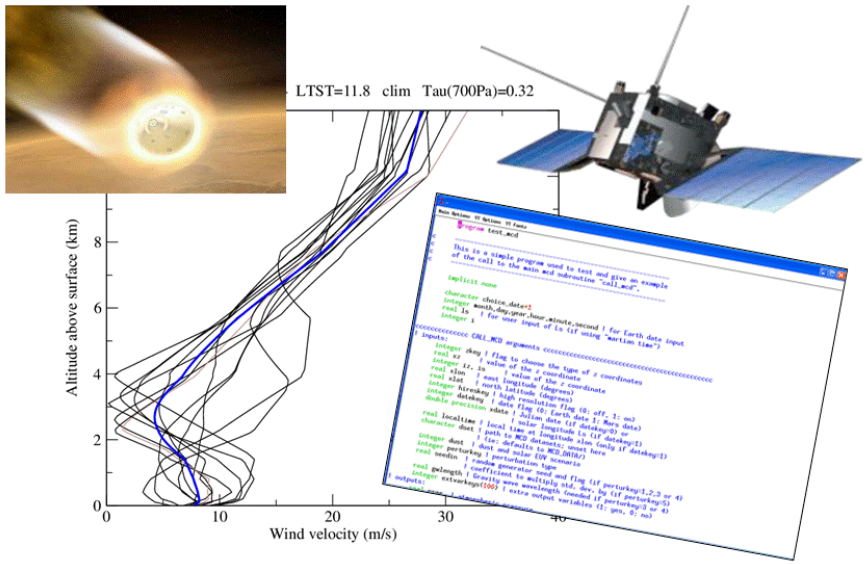
during global Planet encircling storm (MY25)



Using the Mars Climate Database

The full version: contact us!
millour@lmd.jussieu.fr,
forget@lmd.jussieu.fr

- Access software "call_mcd" (Fortran)
- Matlab, C, C++, IDL, Python, and Scilab interfaces



The light "web" version:
http://www-mars.lmd.jussieu.fr

- For quick plots
- Very easy to use, all you need is a web browser.