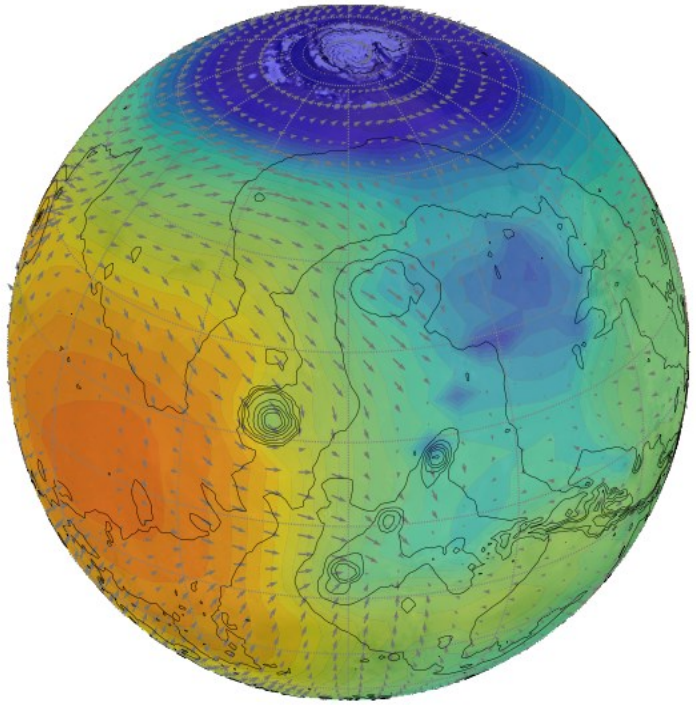
Future improvements

(with the help of users like you !)



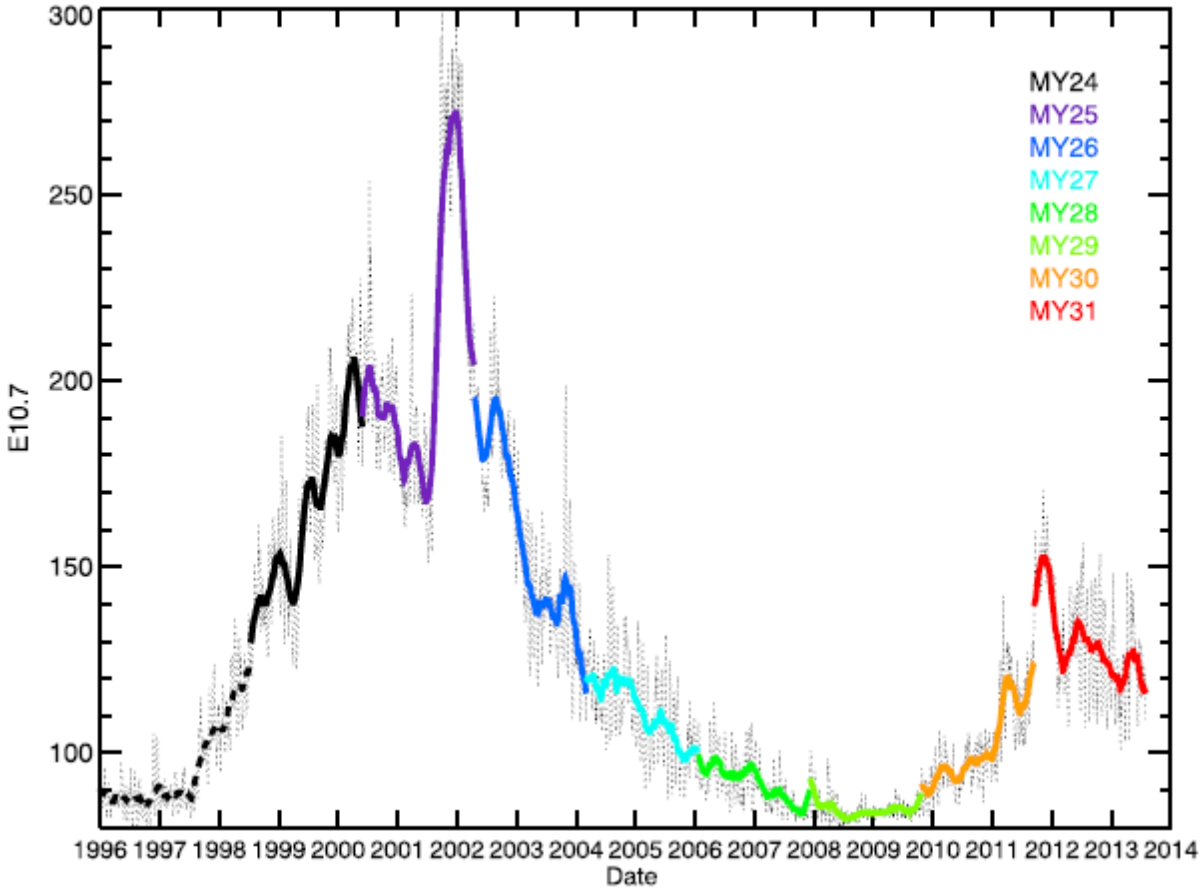
F. Forget, E. Millour, and the MCD team

Improvement of the MCD software and production of an improved MCD version 5.3 (=> end of 2016)

New database files

- **Improved "max", "average" and "min" EUV fluxes for the thermosphere**.
- **Inclusion of Helium in the list of tracers**, a key measurement to compare with MAVEN NGIMS data:
- **Addition of an additional Martian Year scenario, MY32**
- **Better estimation of the ice cloud particle size**

Observed EUV activity

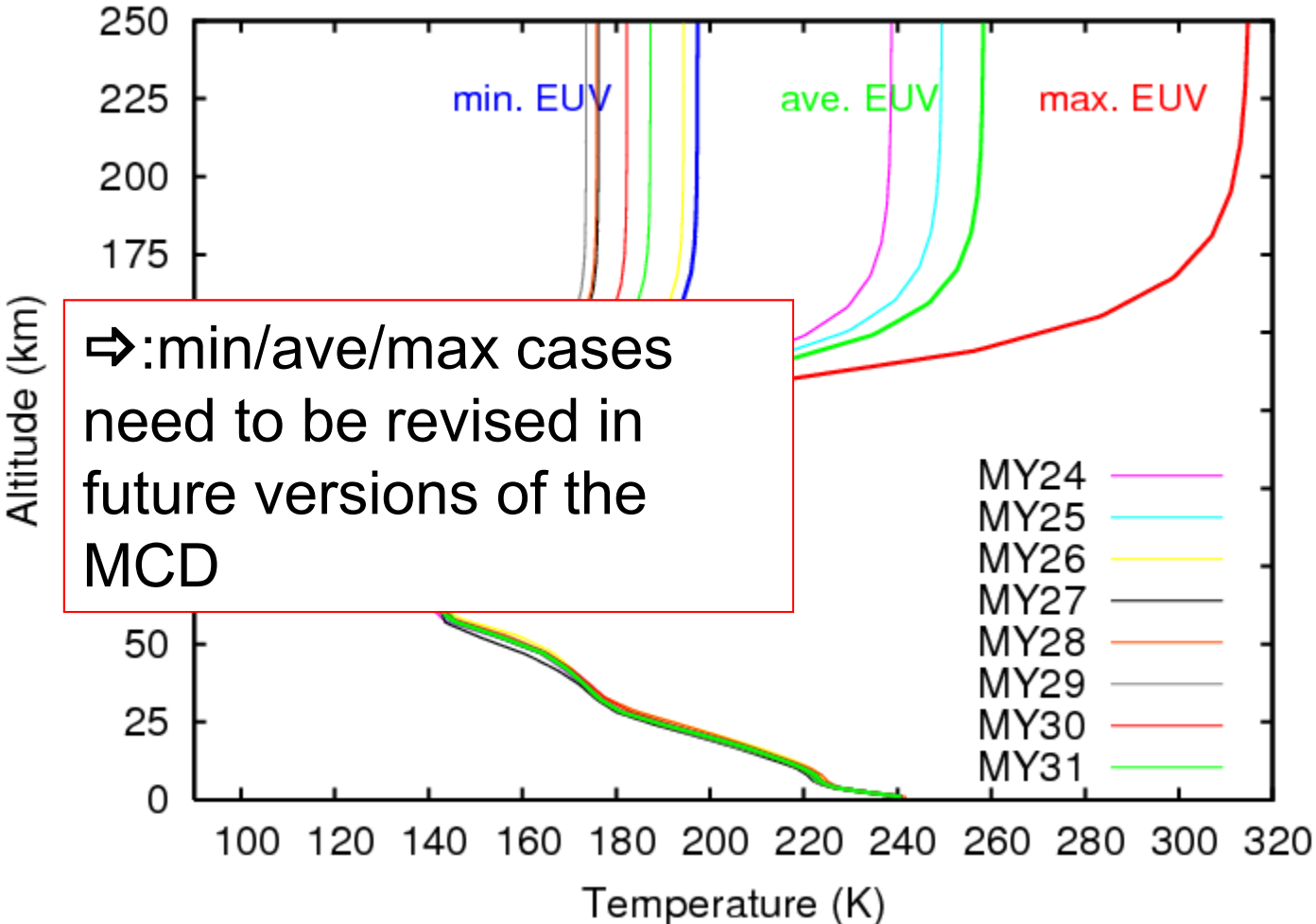


Gonzalez-Galindo et al. 2015

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

MCD Extreme UV scenarios compared to observed EUV scenarios

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



Improvement of the MCD software

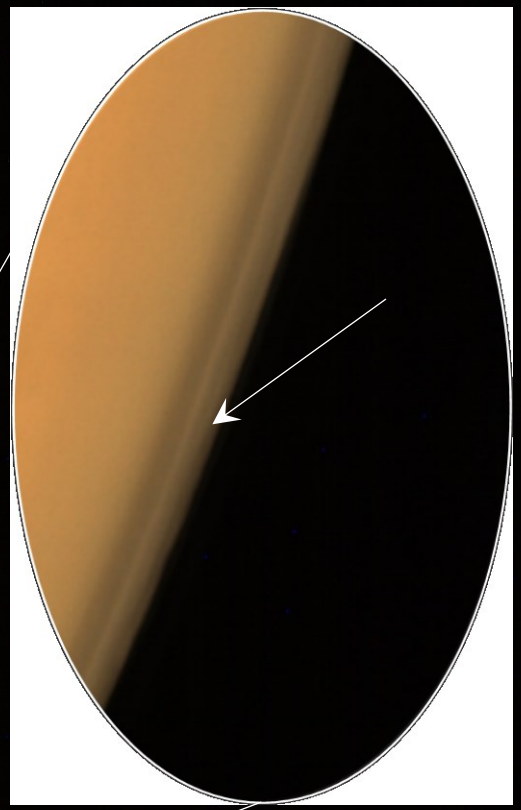
- **Improved extrapolation of species concentration and atmospheric density above the Exobase.**
- **Improved estimation of atmospheric column densities in the high resolution mode:**
- **Improving the MCD interface for non-fortran language and software**
- **Improved use on MS Windows**
- **Other ideas ?**

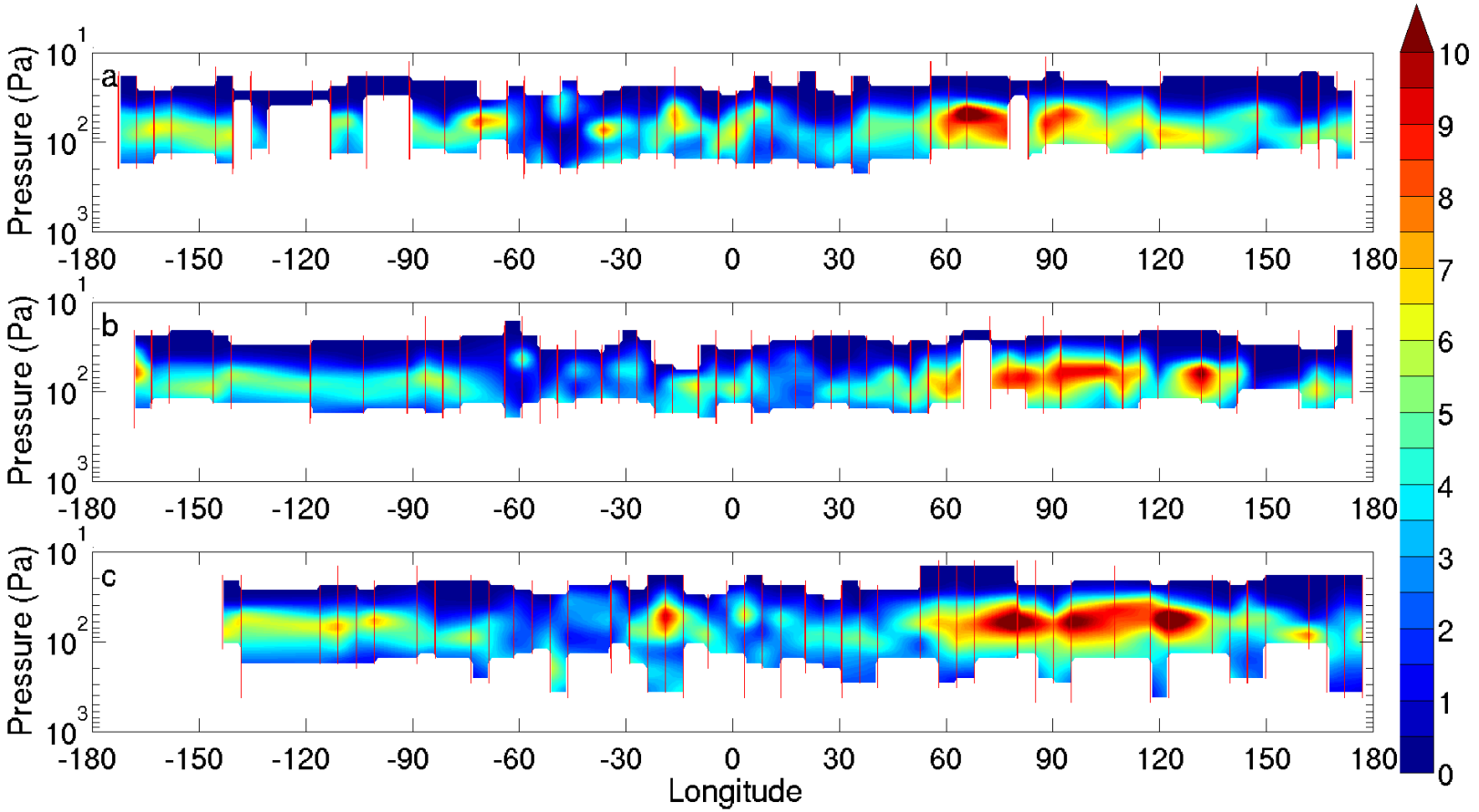
Development of an improved Global Climate Model to generate MCD Version 6.0 (=> end of 2017)

A new GCM v6

- ***Improved Dust cycle: detached layers***

Dust observed by India Mars Orbiter Mangalyaan mission (seen from an altitude of 8449 km)



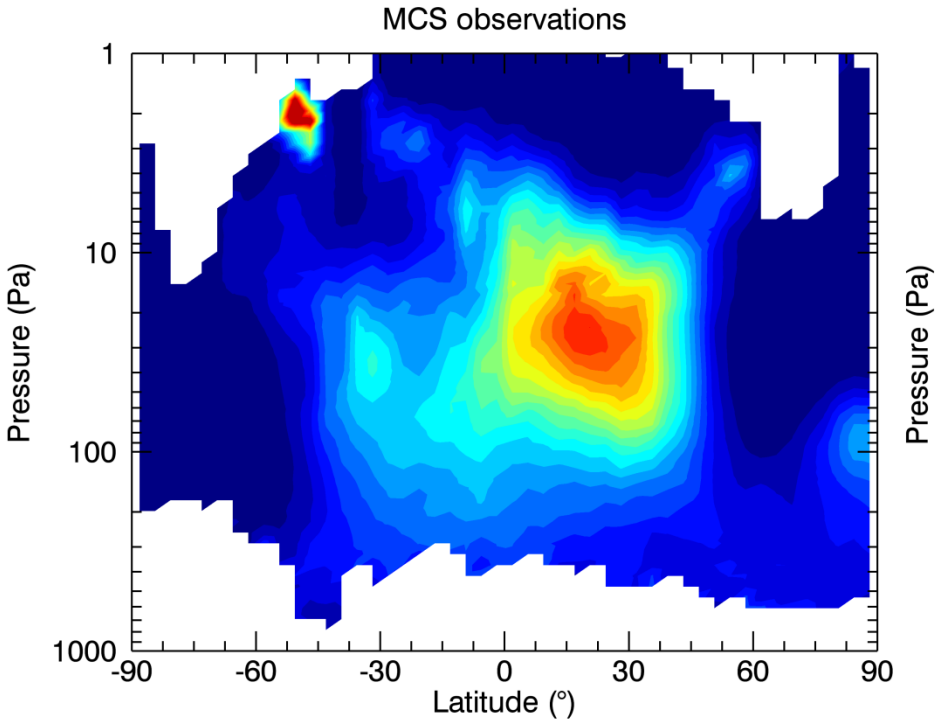


Detached dust layers observed by MCS (Heavens et al. 2010)

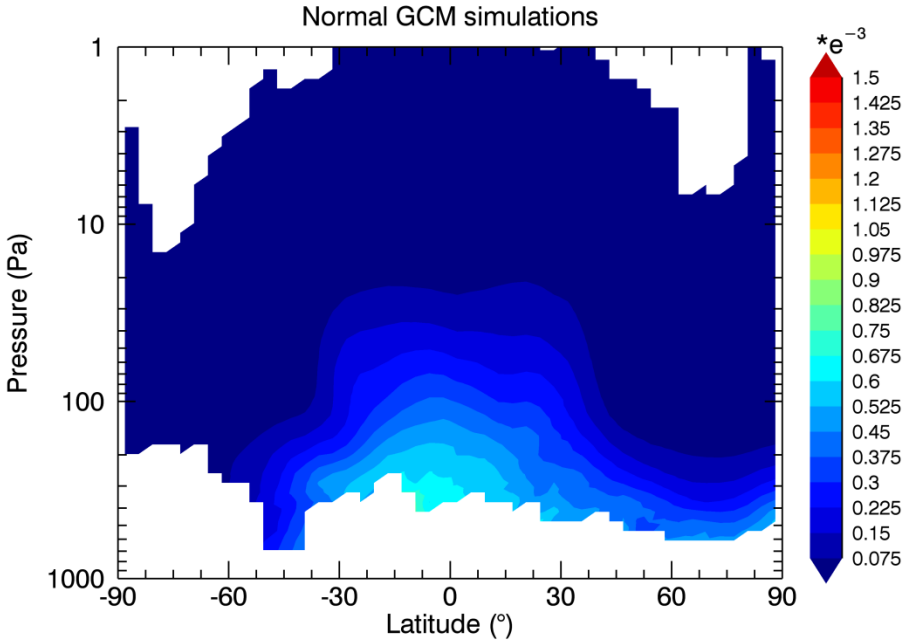
- Dust detached layer quantified by the observation of MCS (*McCleese et al, 2010 ; Heavens et al., 2011a,b,c*), TES(*Guzewich et al, 2013*) and CRISM(*Guzewich et al, 2014*).

Zonally averaged night-time density-scaled dust opacity at MY29 from Ls=145°-150°

MCS observations



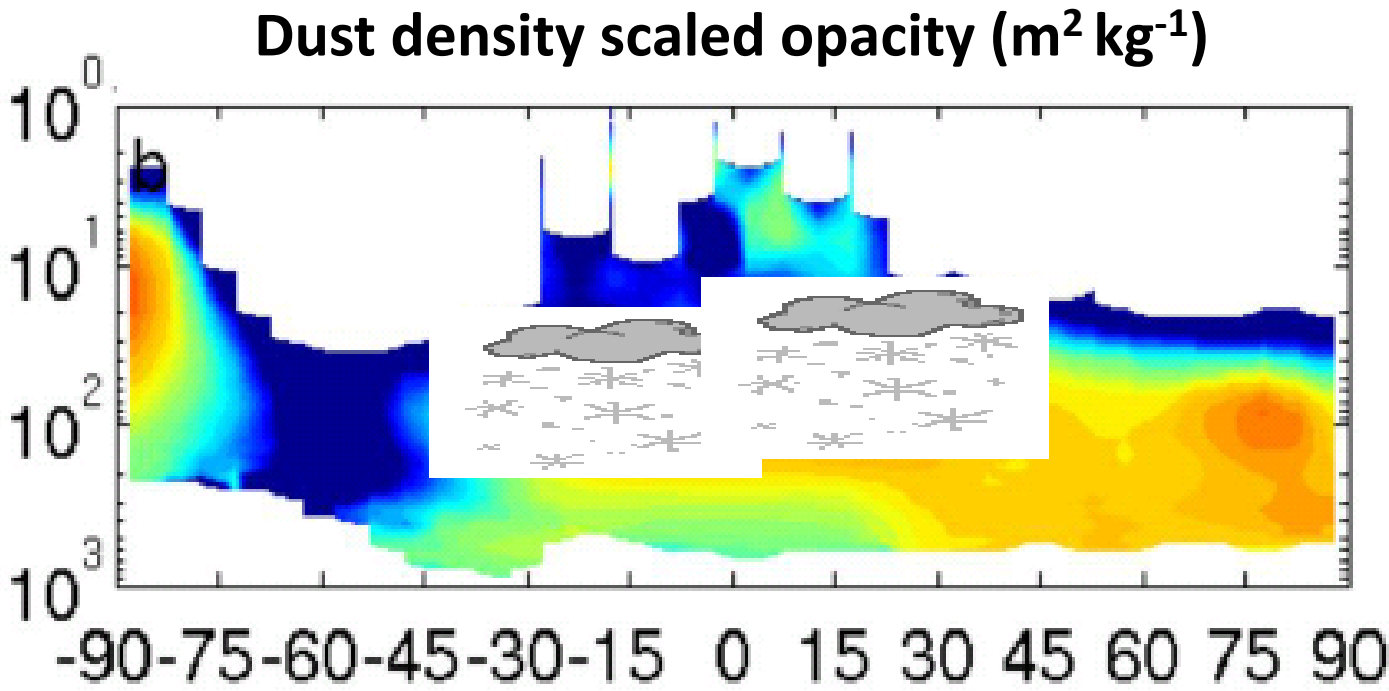
GCM simulations



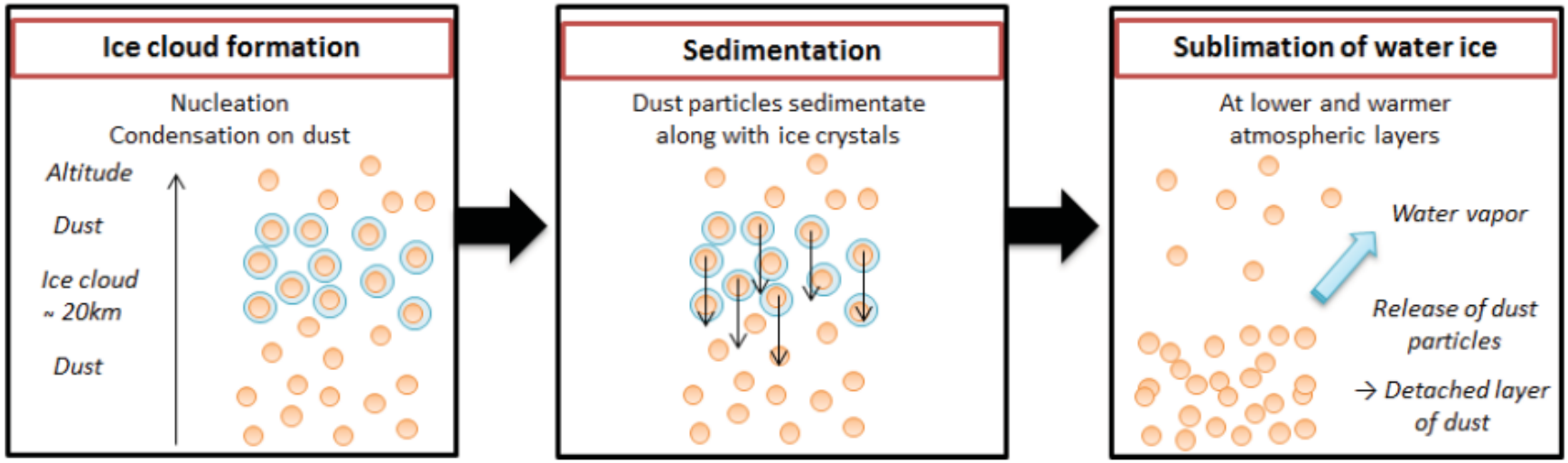
Wang et al. 2015

What is the process forming detached dust layers ?

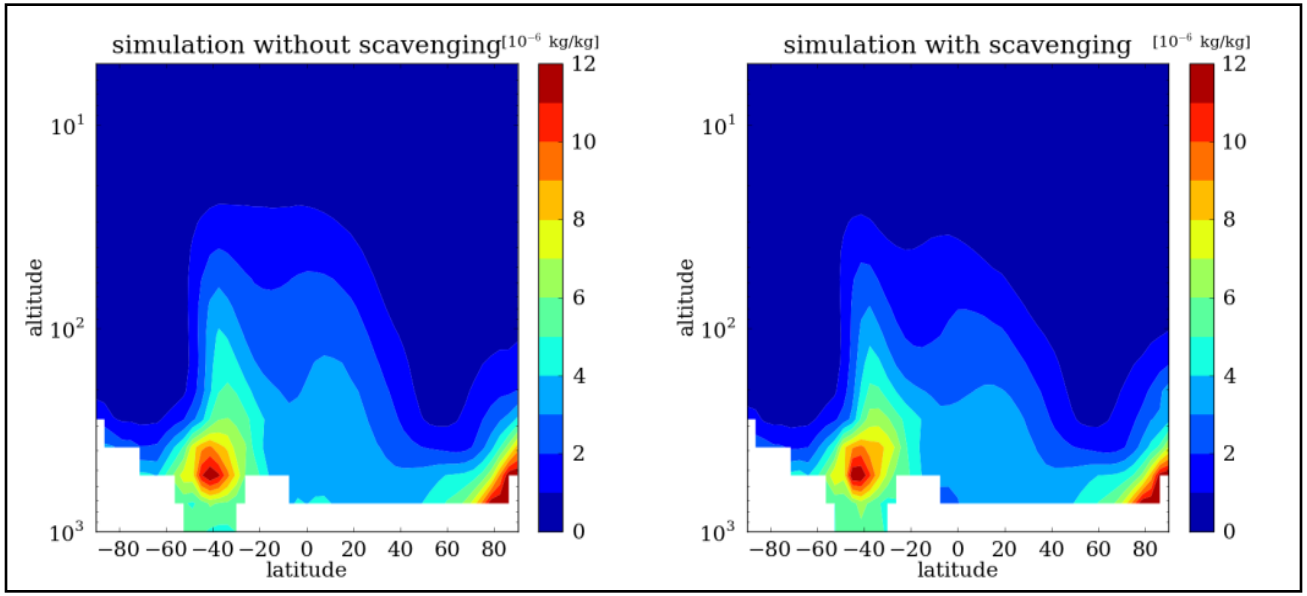
1) Dust enrichment below dust scavenging clouds *(Navarro et al. 2014)*



Scavenging of water ice cloud in LMD GCM

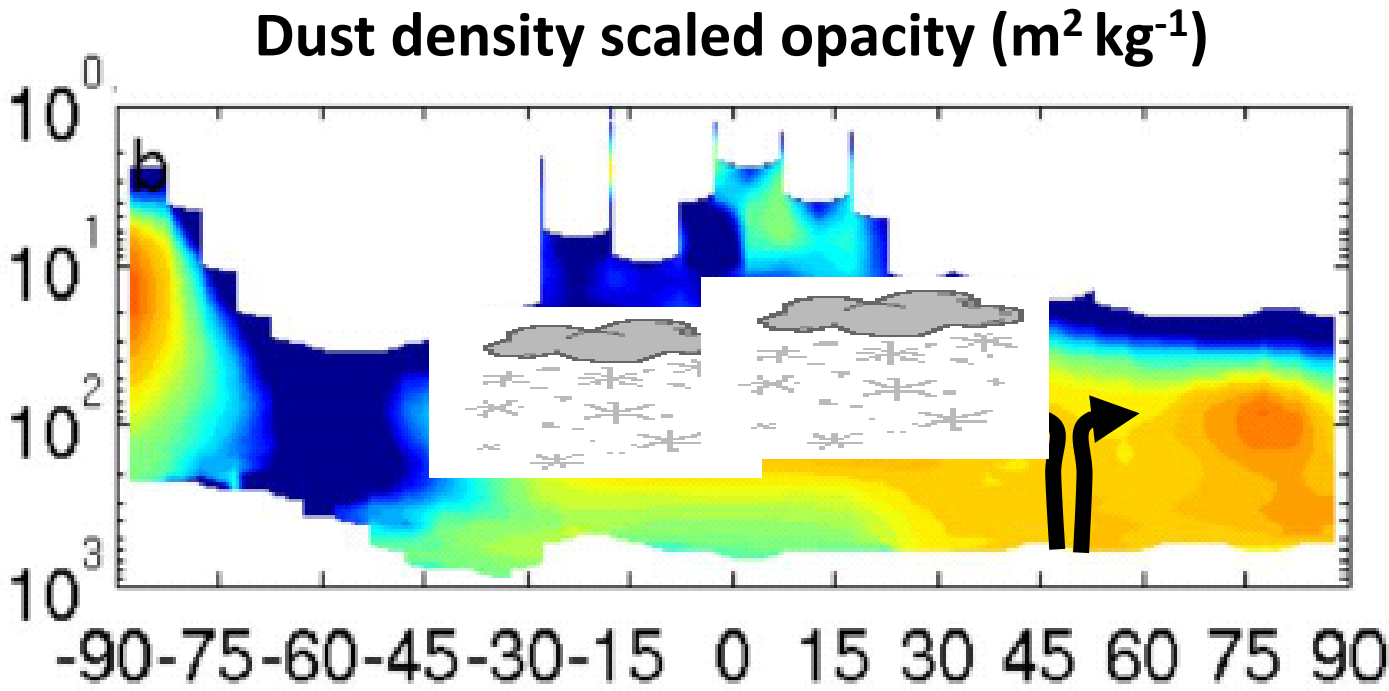


The parameterization in the GCM **does not help the formation of dust detached layers** (*Navarro et al., 2014*)



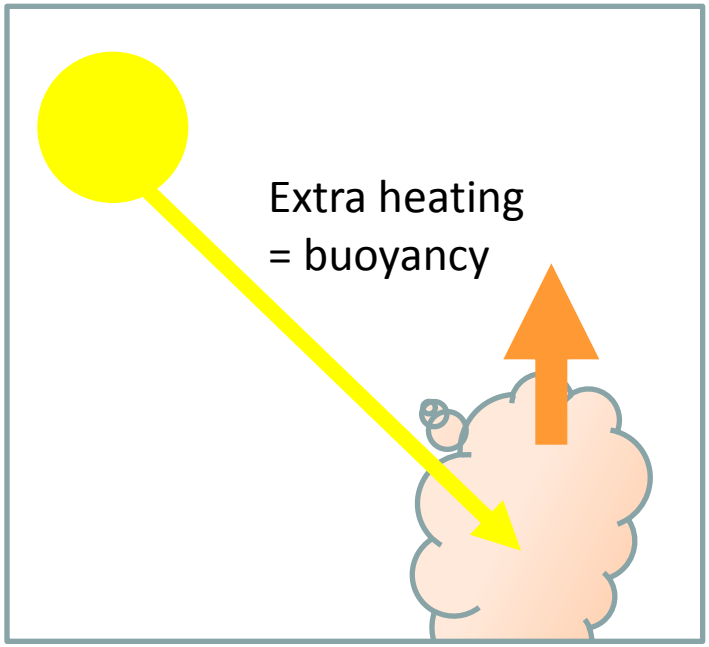
What is the process forming detached dust layers ?

1) Dust enrichment below dust scavenging clouds *(Navarro et al. 2014)*



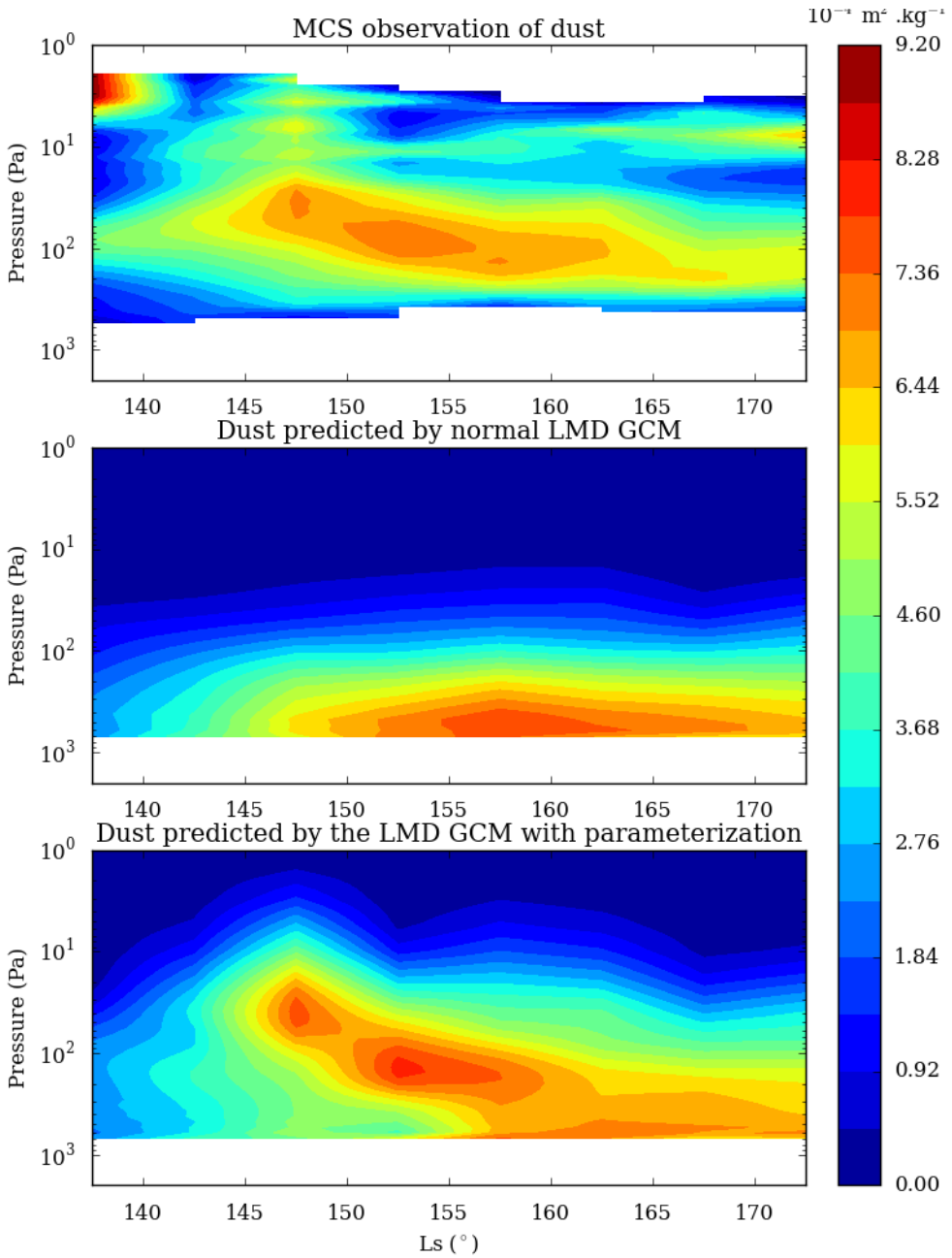
2) Direct transport of dust from the boundary layer to the mid atmosphere by "rocket dust storms" *(Spiga et al. 2013)* & Local topography circulation *(S. Rafkin)*

Parametrization of “sugrid-scale” dust storm & clouds : dust updraft by convection (“Rocket dust storms”)



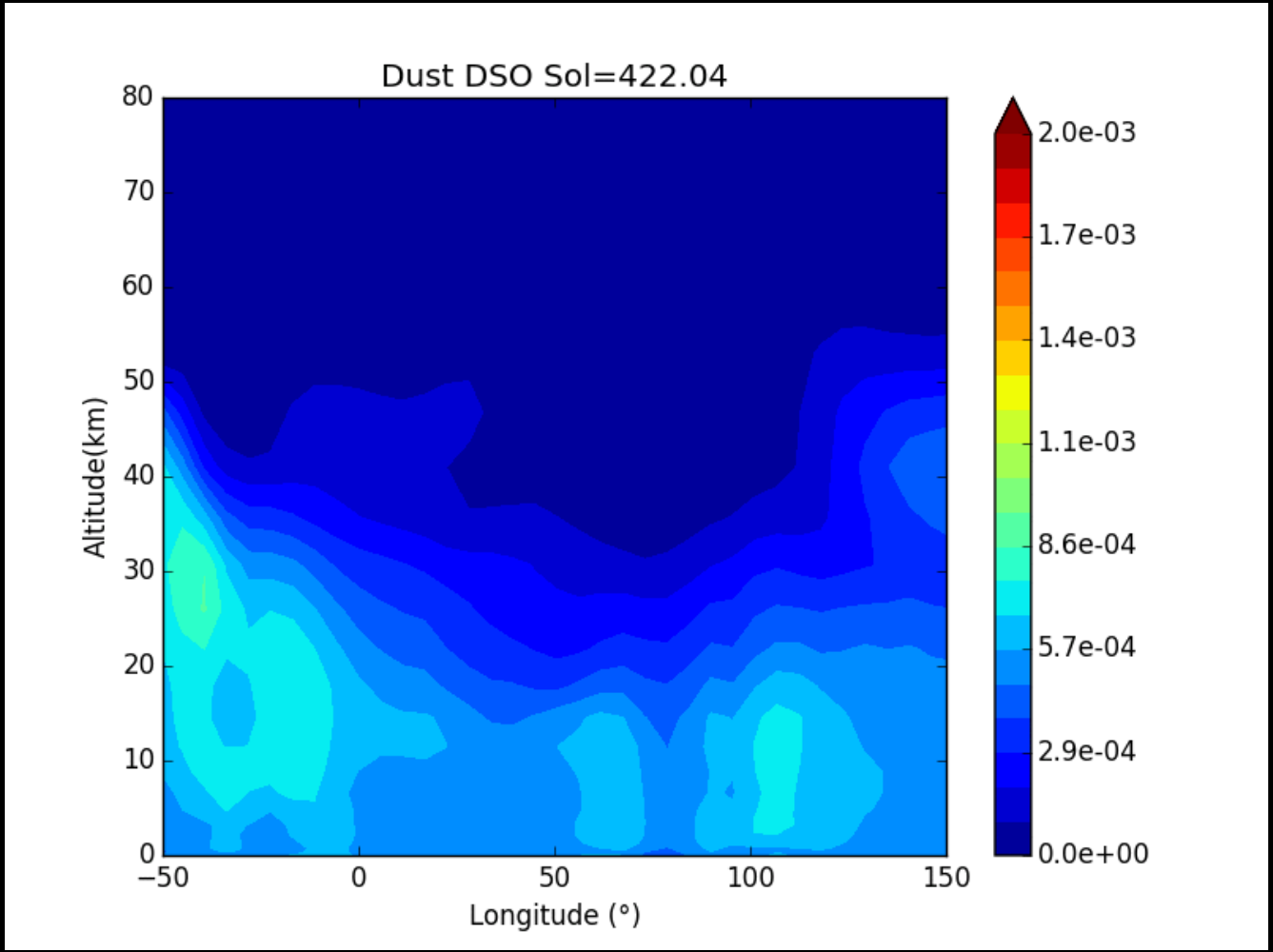
Wang et al. 2015

Zonal mean -10° < lat < 10°

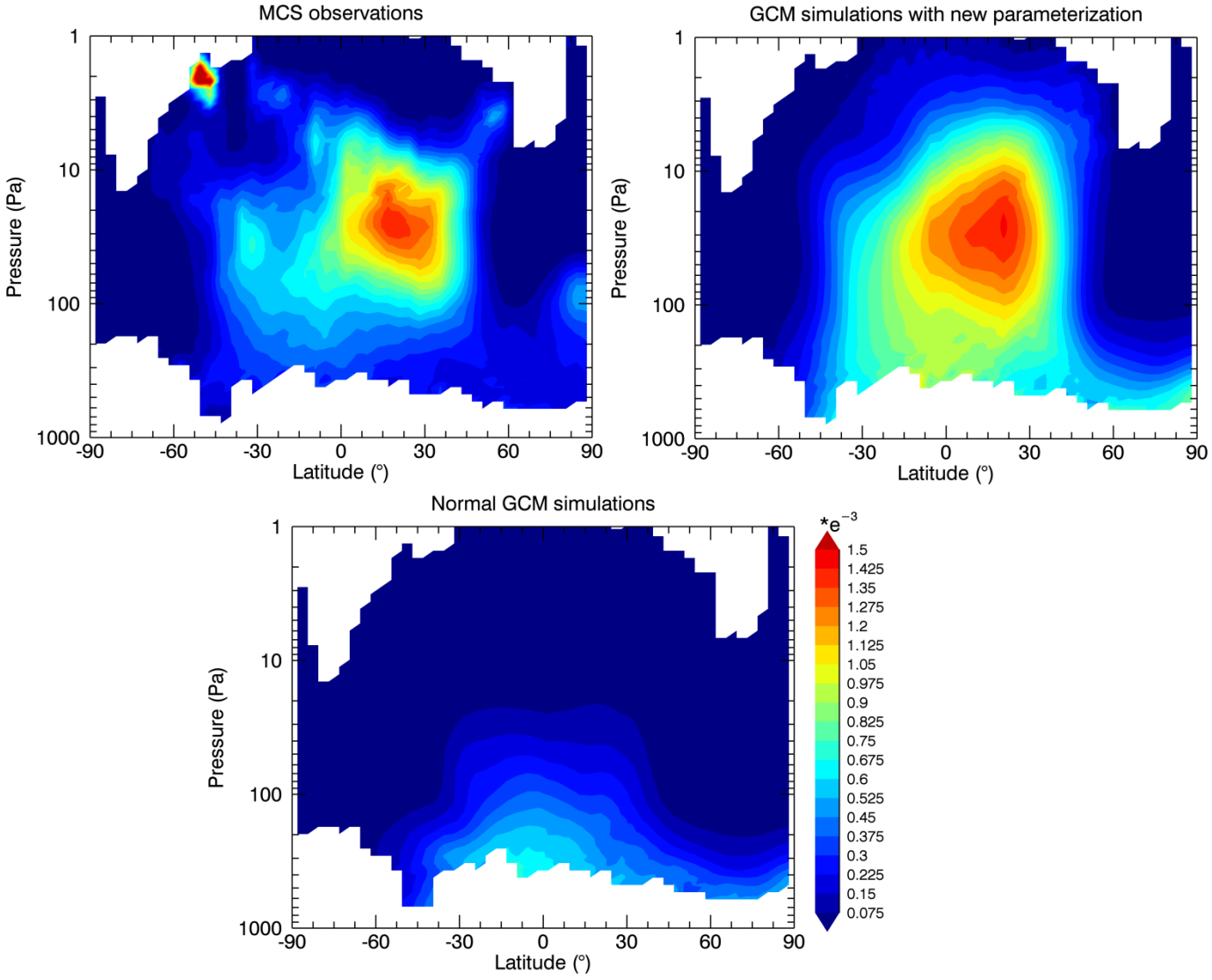


2. Parameterizing rocket dust storm in LMD GCM

2.2 Model results

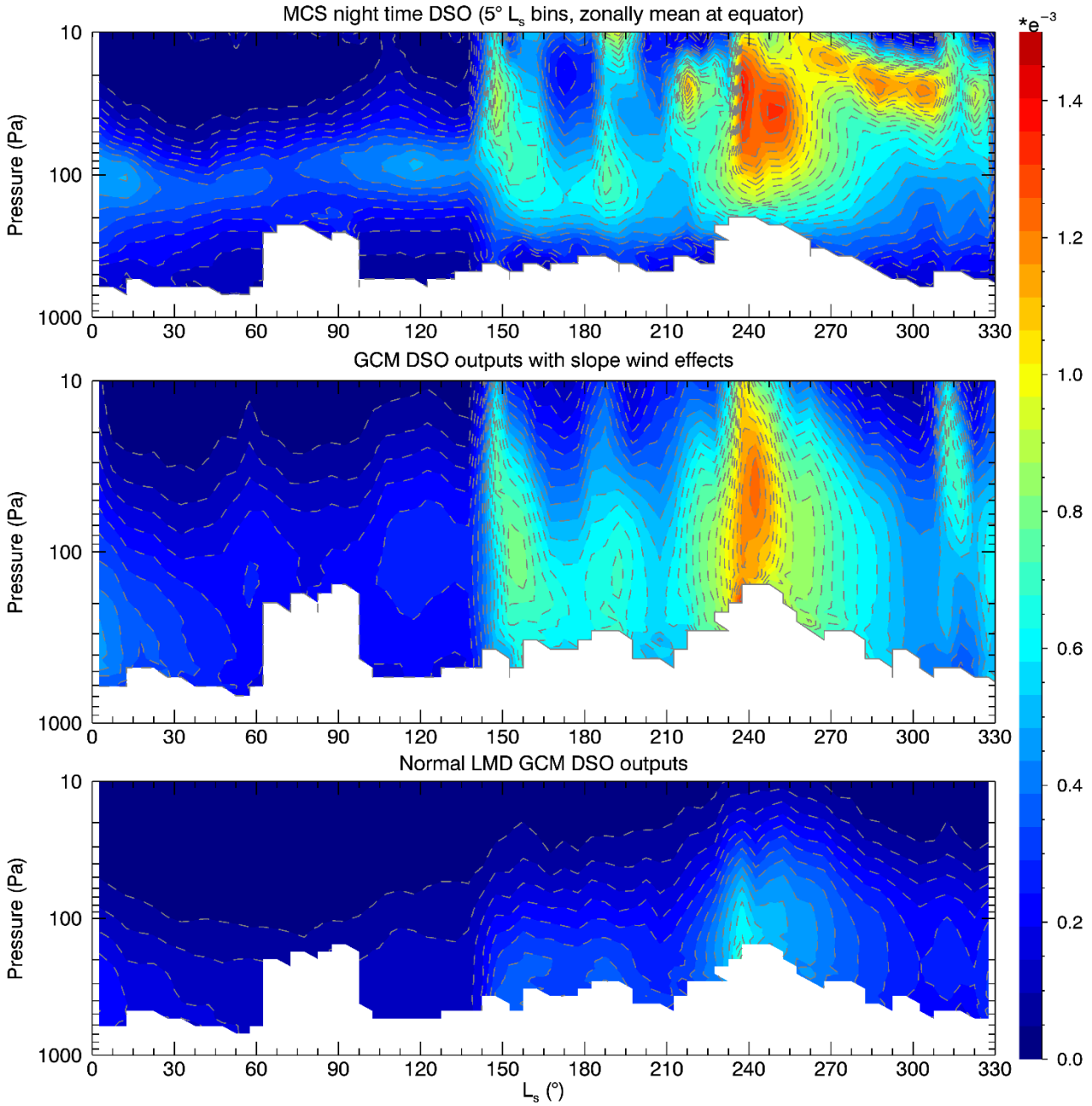


A strong rocket dust storm event happened from sol=422d-427d at equator.



Zonally averaged night-time density-scaled dust opacity at MY29 from Ls=145°-150°

Wang et al. 2015

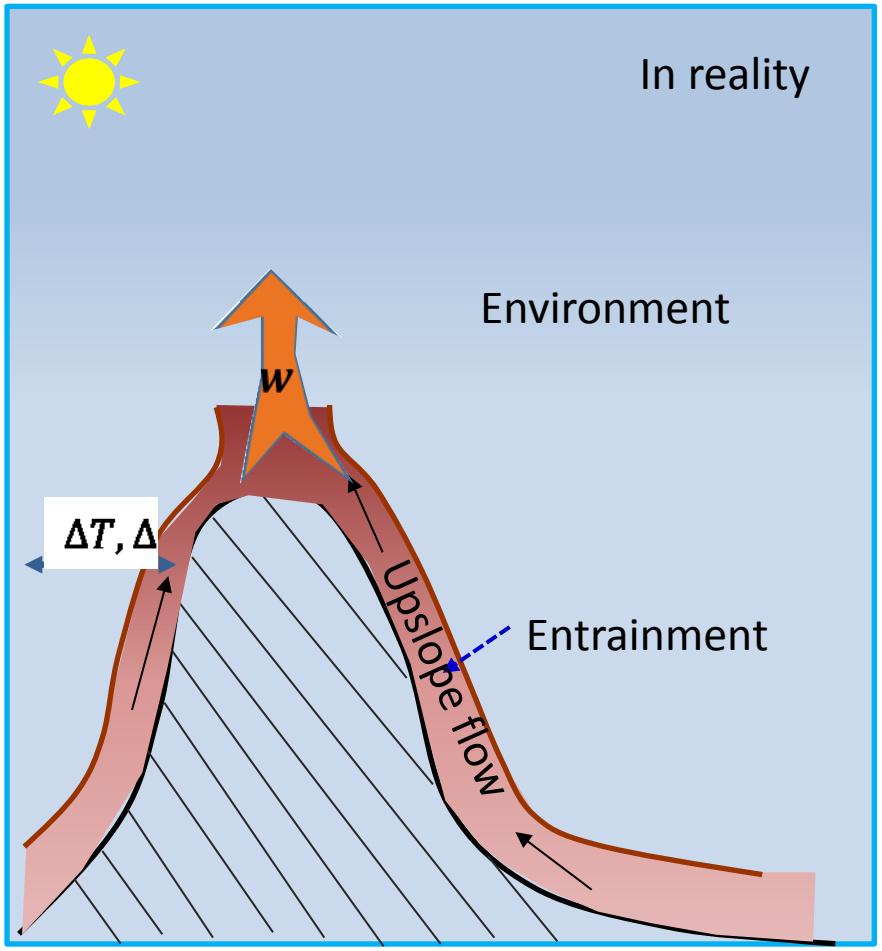


Night-time density-scaled dust opacity at MY29 averaged from Lon=180°E-180°W, Lat=10°N-10°S.

- Good match when dust column optical depth in the dust scenario has a significant increase
- What happened during the clear season?
- Missing observation or missing some atmospheric mechanisms?

Wang et al. 2015

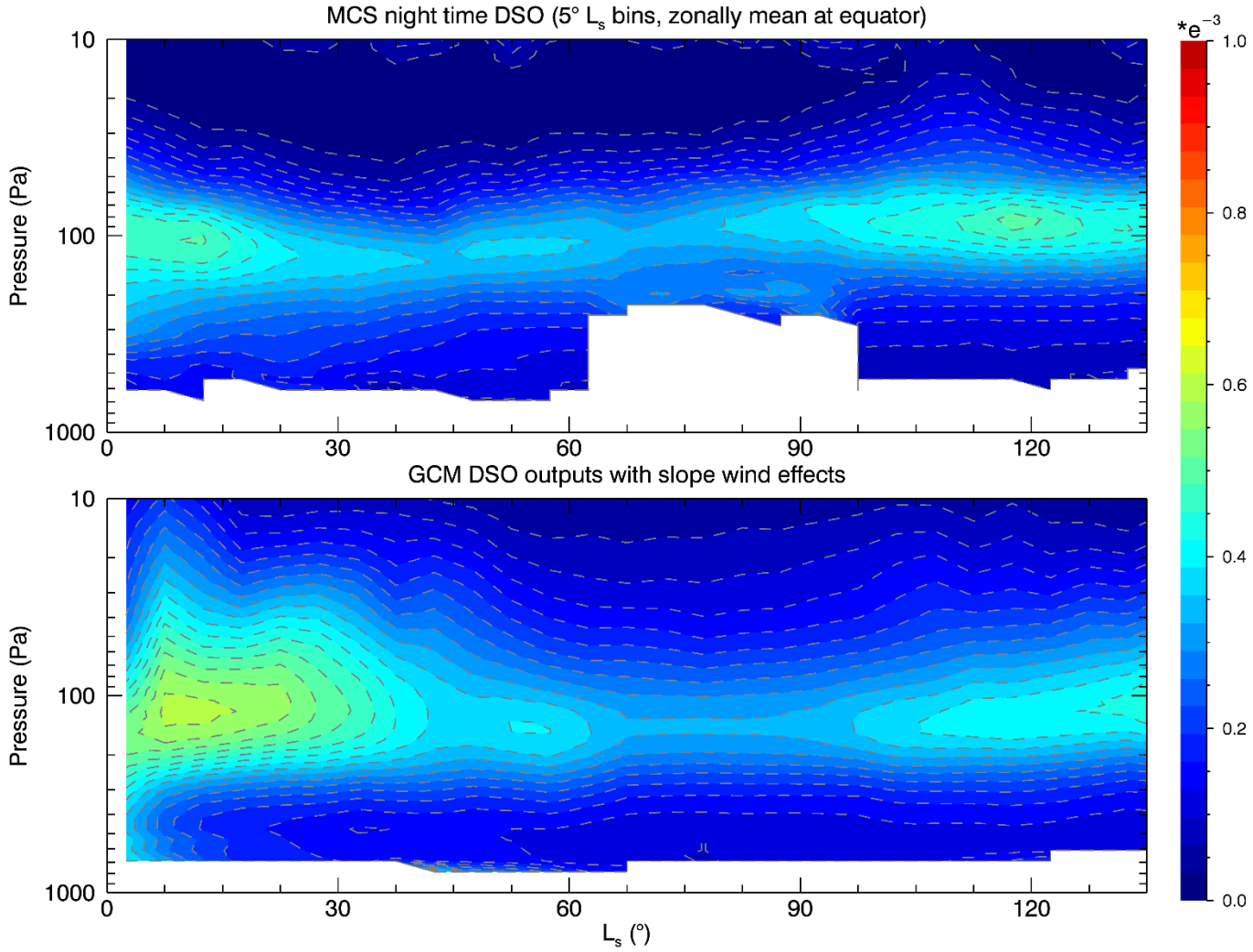
Injection of dust at the top of mountains



Wang et al. 2015

Taking into account slope wind effects

preliminary model results



Night-time density-scaled dust opacity at MY29 clear season (averaged from Lon=180°E-180°W, Lat=10°N-10°S).

A new GCM v6

- ***Improved Dust cycle: detached layers***

A new GCM v6

- ***Improved Dust cycle: detached layers***
- ***Improved water cycle and clouds***
  - **Improving the representation of local cloudiness at sub-grid scale in the GCM**
  - **Including the representation of exchanges of water between the atmosphere and the subsurface**
  - **Improved Modeling of surface seasonal frost.**
  - **Accounting for local transport from the northern polar cap**

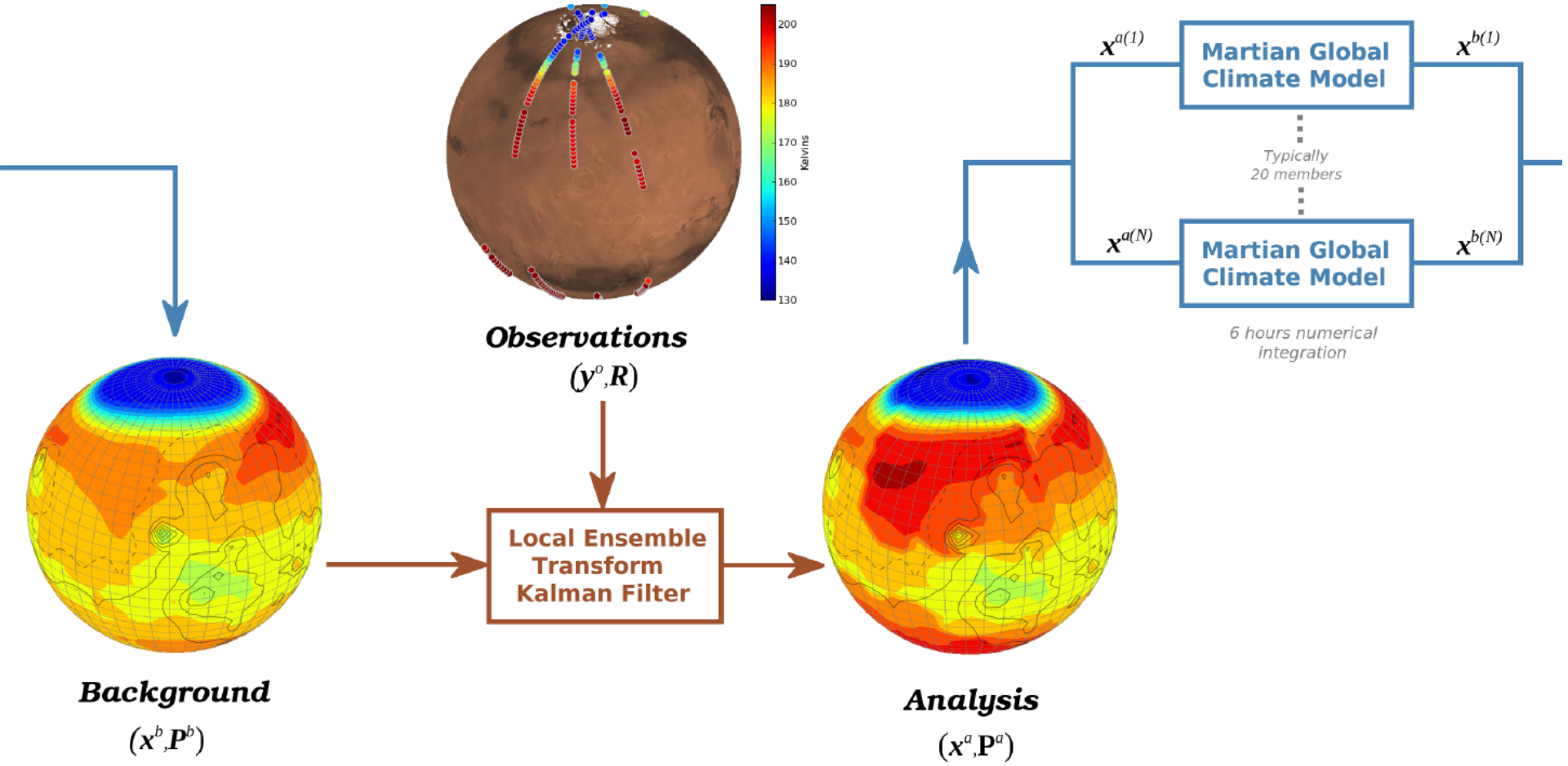
A new GCM v6

- ***Improved CO_2 cycle***
- ***Improved chemical core***
- ***Inclusion of the dynamical effect of non-orographic gravity waves***
- ***Improved surface layer in the atmospheric boundary layer***
- ***Improved Ionosphere in the lower atmosphere (see talk by S. Cardnell today)***
- ***Improved H and H_2 above the homopause***

Long term projects for MCD v7 ?

Meterorological Data assimilation to feed the MCD

(Thomas Navarro, LMD)



The challenge of Data assimilation on Mars

- The flow is not very chaotic BUT the atmospheric temperatures and winds are directly influenced by dust and clouds which are not easy to predict and assimilate

⇨ Assimilation of temperature must be combined with:

- ➢ Assimilation of dust (from dust observations OR from their thermal signature)
- ➢ Assimilation of cloud ice (from ice observations OR from their thermal signature)

⇨ Problem: the Global Climate Model is not yet complete enough to simulate the details of dust and clouds and **their diurnal cycle** (see below)

The future: High resolution and new generation Dynamical Cores

- Very high resolution is possible with **Massively parallel computing**

  ⇨ requires **new generation dynamical cores**

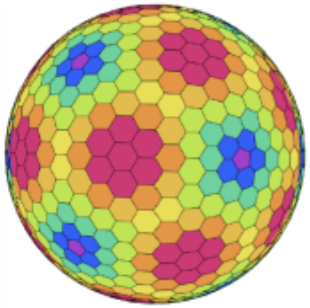
- Quasi-uniform grid rather than lat-lon grid

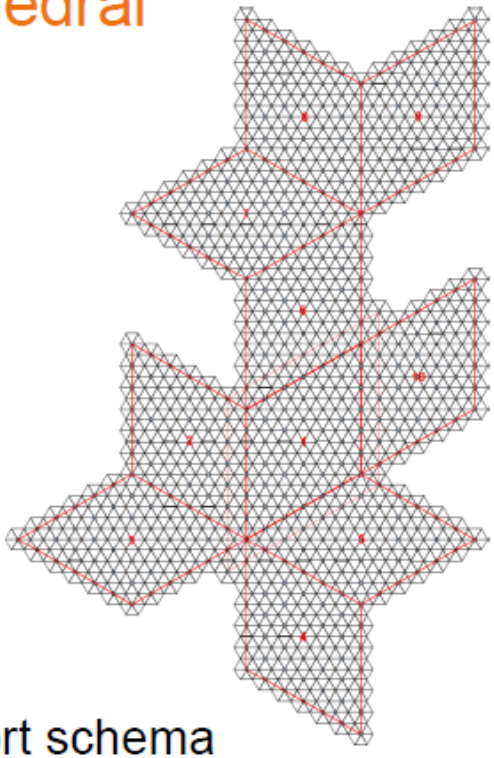
⇨ **High resolution** (mesoscale-like ~50 km): Better representation of topography(circulation, waves, clouds), filamentation of tracers, waves,etc.

⇨ **Super high resolution ?** (~1 km) Could resolve convection, all gravity waves: « cloud resolving models » ?

LMD new Dynamical Core *(Dubos et al. 2015)*

DYNAMICO: new dynamical core, icosahedral



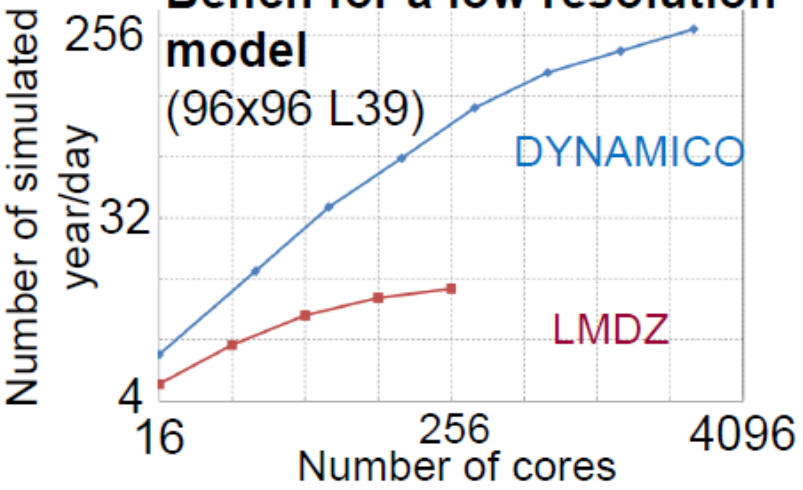


Present:

- New transport schema
- Quasi-uniform mesh
- Energy conserving

Participation to the ICOMEX project
Collaborations with applied mathematic
Collaboration with IIT Delhi (OP Sharma)

Bench for a low resolution model
(96x96 L39)



Bench with different resolutions

degrees	nb cores	year/day
3	320	**100**
1	1 280	**20**
½	11 520	***17***
¼	81 920	***14***

Plans:

- Stretched grid
- Non hydrostatic
- In the IPSL-CM model
- Deep atmospheres (planets)

Thank you