

# **Key issue in Mars atmosphere and climate**

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# Objectives of Mars atmosphere studies

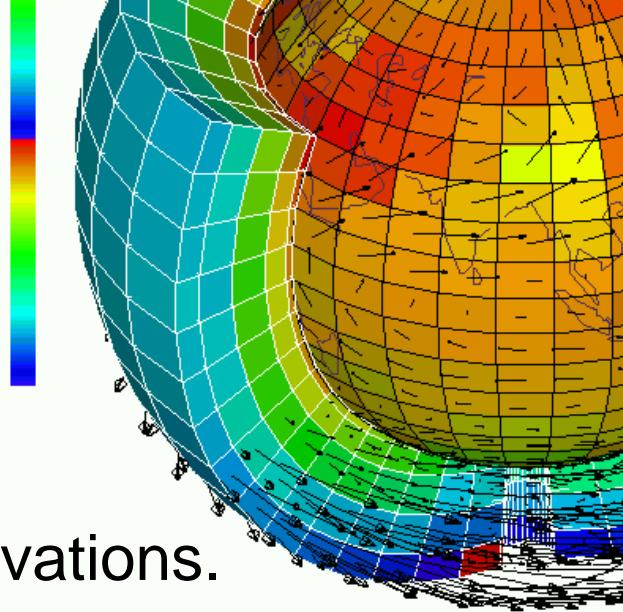
- Of course : understand the present Martian climate system
  - ⇒ Extrapolation to the past : understanding the Mars evolution
- Learn meteorology from another atmosphere: comparative meteorology
- Prepare future missions

## *Mars climate : a complex system*

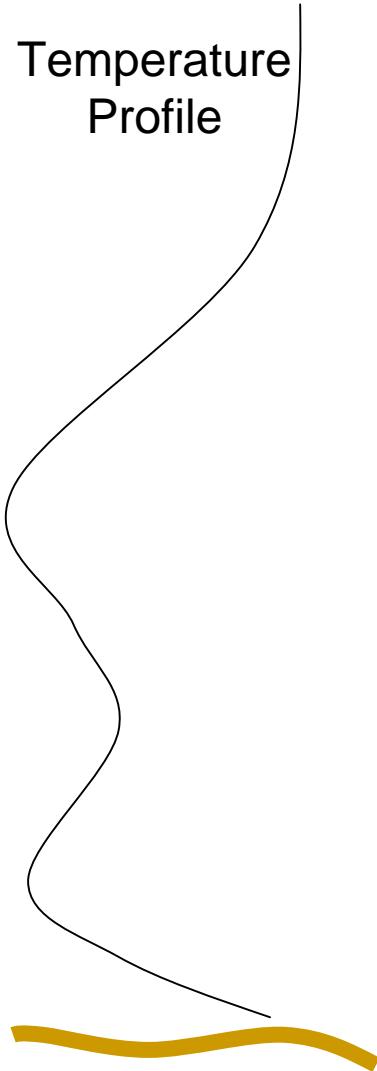
# Like on Earth : Growing role of climate modelling

- To Interpret the observations
- To interpolate and extrapolate the observations.

- ⇒ Global Climate Models (3 main groups :
- NASA Ames GCM (USA)
  - GFDL-Caltech (USA)
  - In Europe : LMD-AOPP-IAA (used to produce the «*European Climate database* »)
- ⇒ More and more important : mesoscale models



# Mars meteorology: Mars thermal structure and circulation



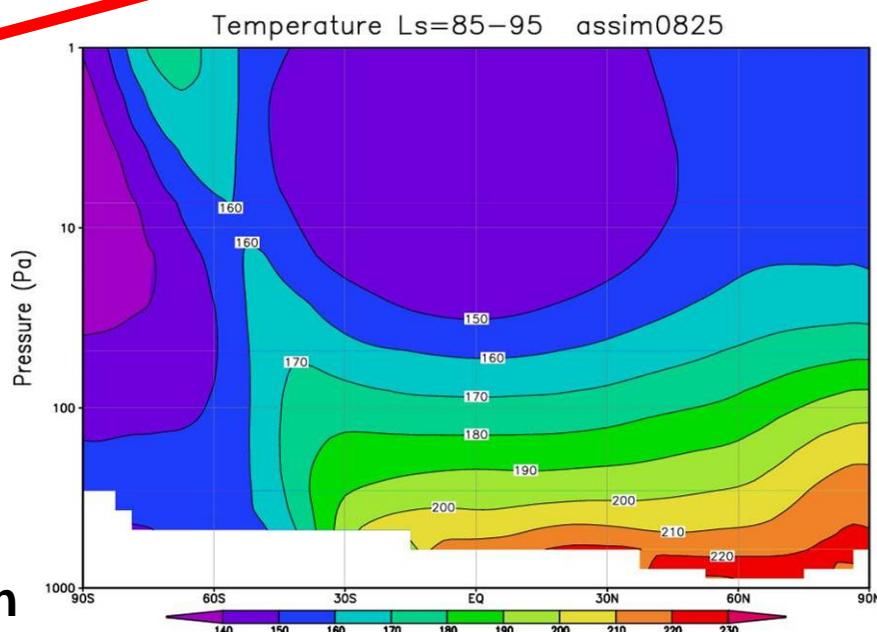
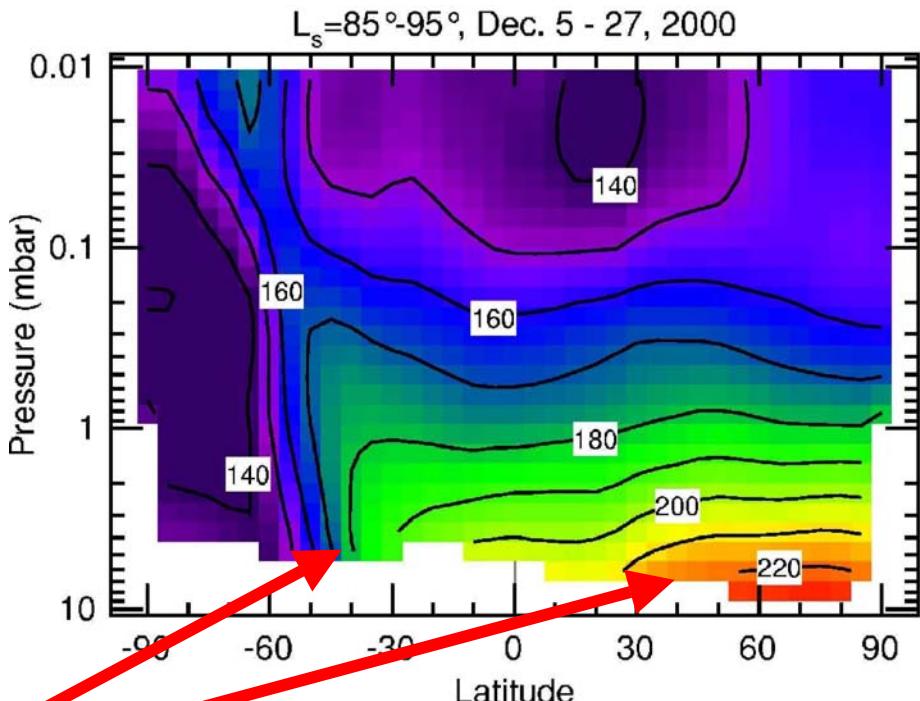
**Lower atmosphere ( $z < 50$  km): :**

- **Global thermal structure:** mostly well understood

# MGS TES temperature (example: $L_s = 90^\circ$ )

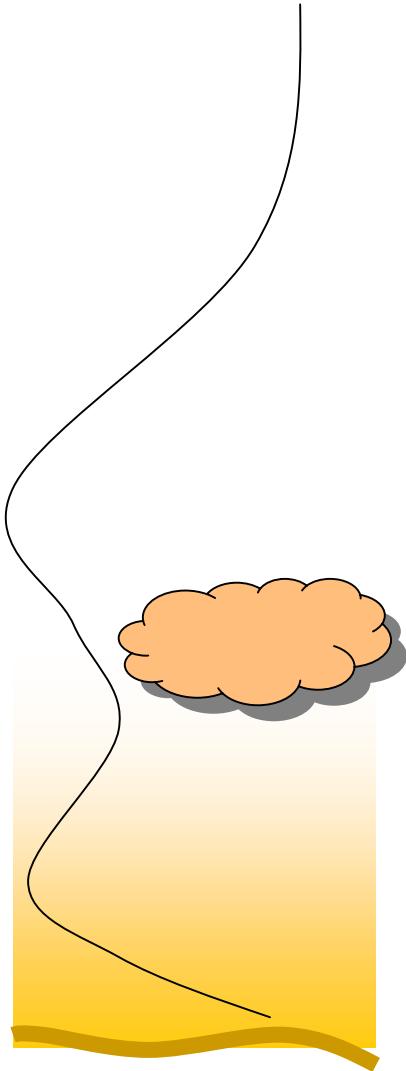
*(Smith et al.)*

- Poor vertical resolution  
Near surface phenomenon ?
- Only 2pm-2am data



**LMD GCM simulation**

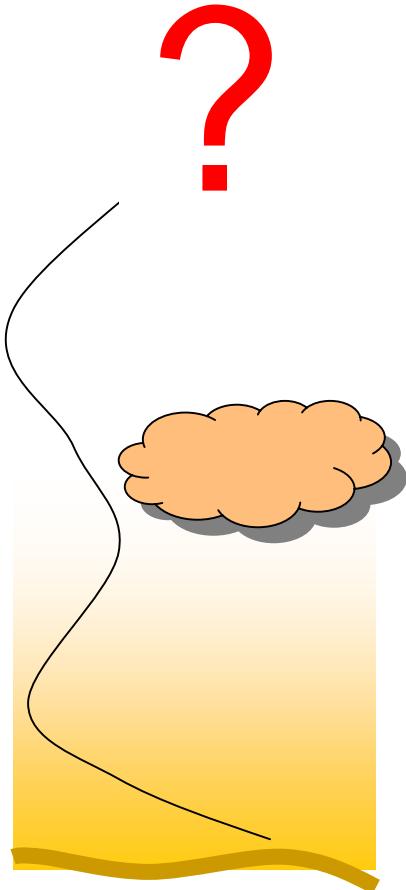
# Mars meteorology: Mars thermal structure and circulation



## Lower atmosphere ( $z < 50$ km):

- Global thermal structure well understood
  - Only If the dust is known : variability, properties not understood
  - Puzzling role of clouds
- We can now study the details of meteorology ([comparative meteorology](#))
- Still not well constrained, but of key importance, : [small scale phenomena](#) (waves, convection, etc...)
- Almost [no data](#) on winds
- Big problem : the polar regions

# Mars thermal structure (and circulation)



**Upper atmosphere ( $z > 50$  km):**  
**« ignorance-sphere »**

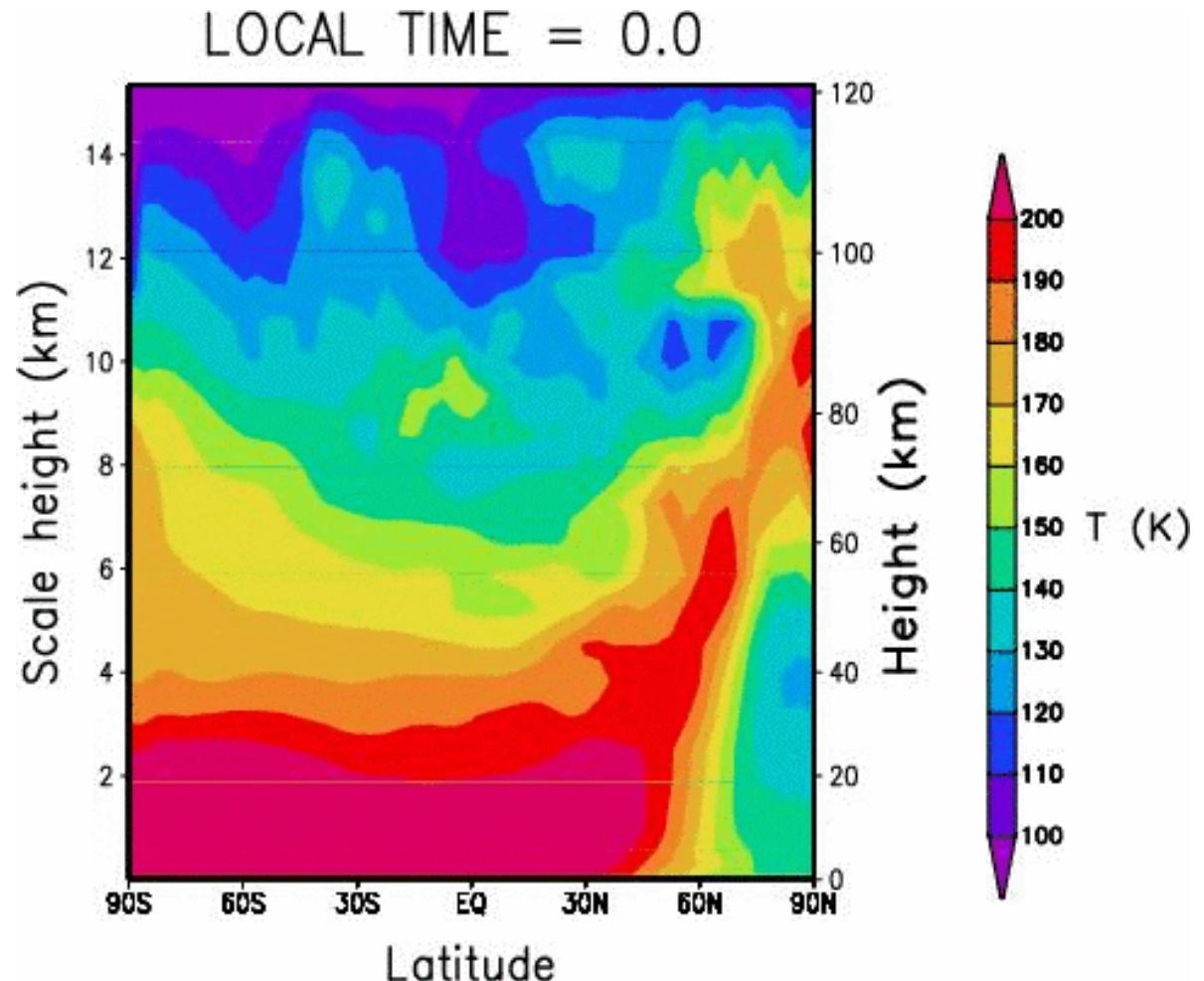
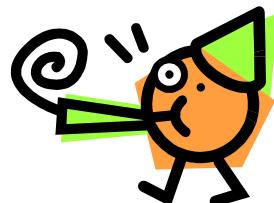
Key issue for :

- comparative meteorology
- Preparation of future missions

# Active and variable atmospheric dynamics

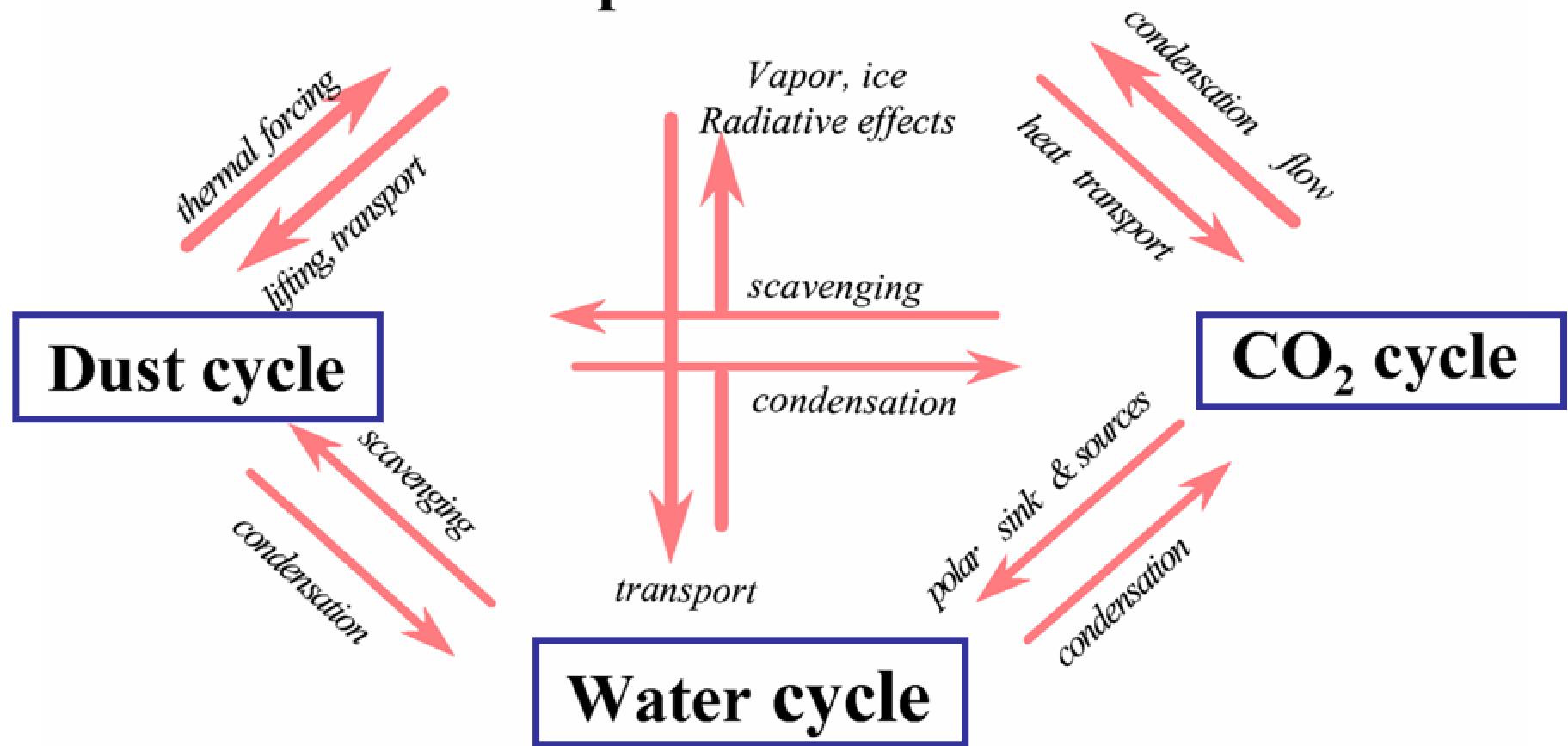
Atmospheric temperature (GCM simulation)  $L_s=270^\circ$

Waves  
(no stratosphere):  
Atmospheric  
Dynamic  
fiesta:

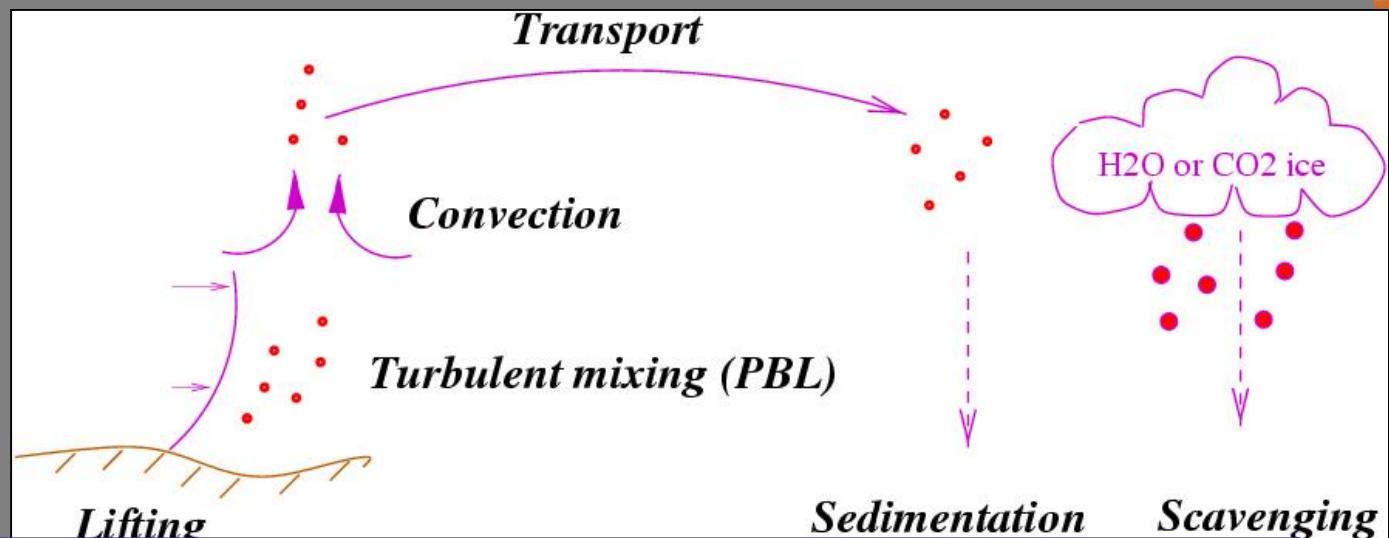


## *Mars climate : a complex system*

### **Atmospheric circulation**

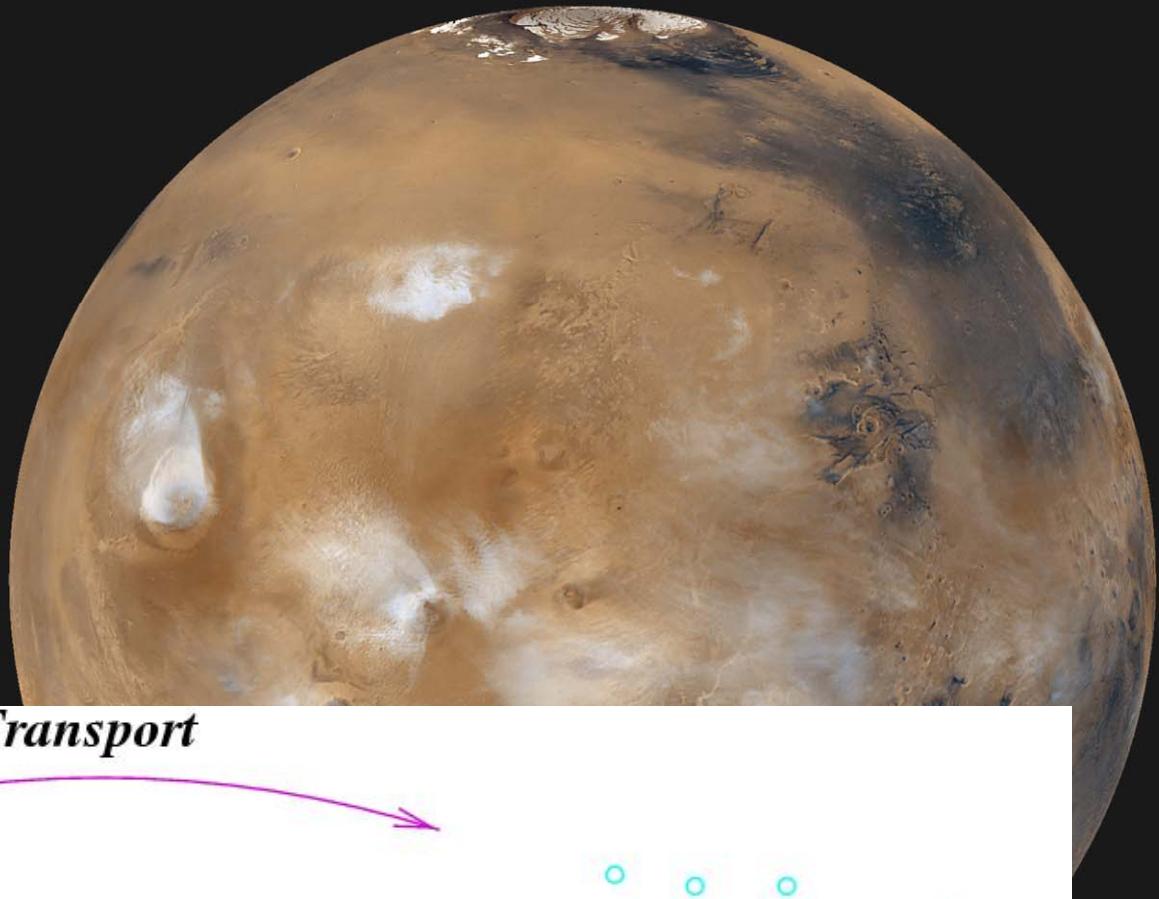


# The dust cycle



- ⇒ THE key variable factor in Mars climate
  - ⇒ Past climate simulations
  - ⇒ Role of aeolian erosion and sedimentation in the past of Mars
- Coupling dust – water ice ? Vertical variations ?
- What are the global dust storms ?
- Lifting : Why global dust storms only in some year ?

# The water cycle



*Transport*

*Convection*

*Boundary layer*

*Sublimation*

*Surf exchange*

*Atm. Condensation*

*Condensation*

## MGS TES dataset :

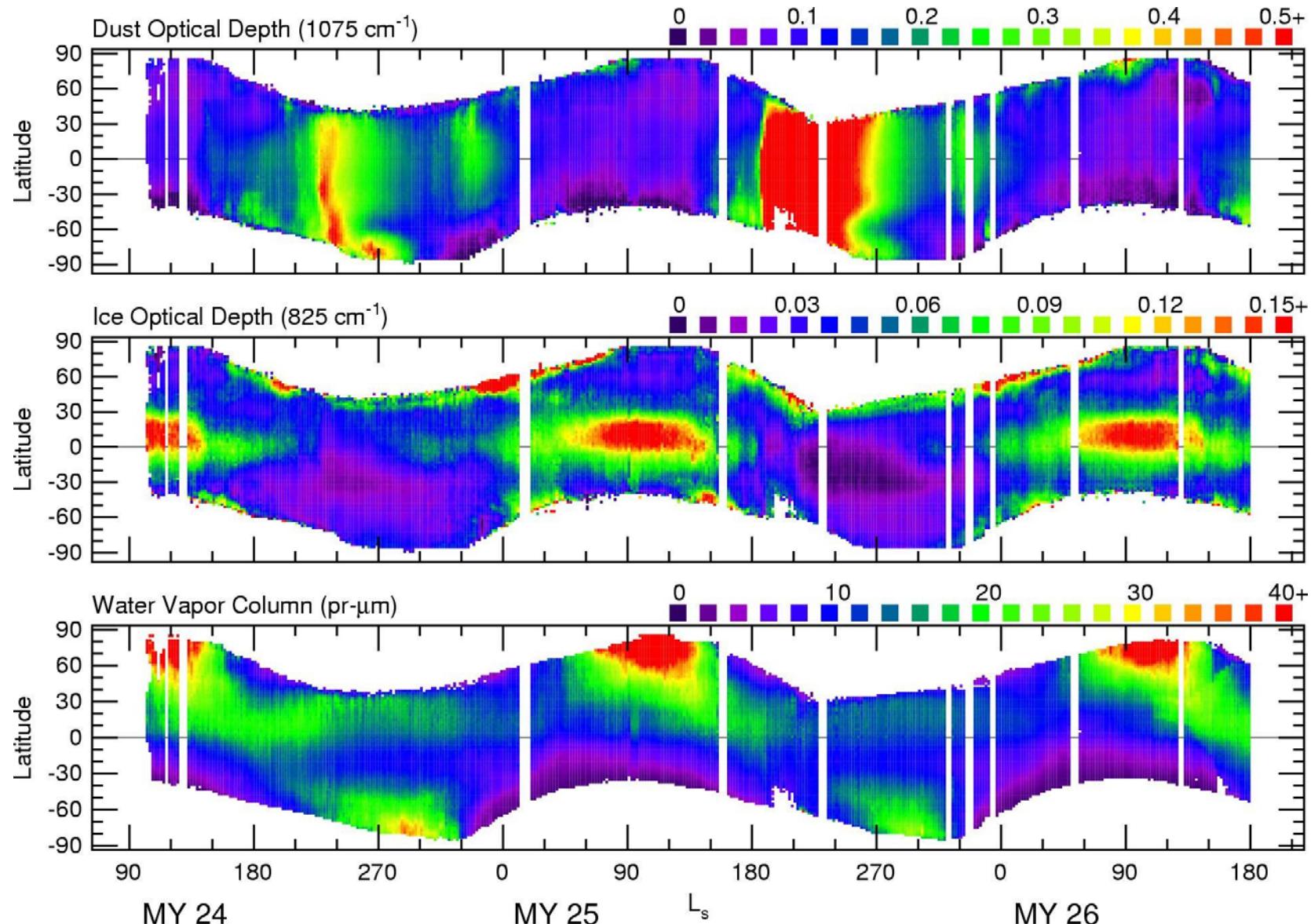
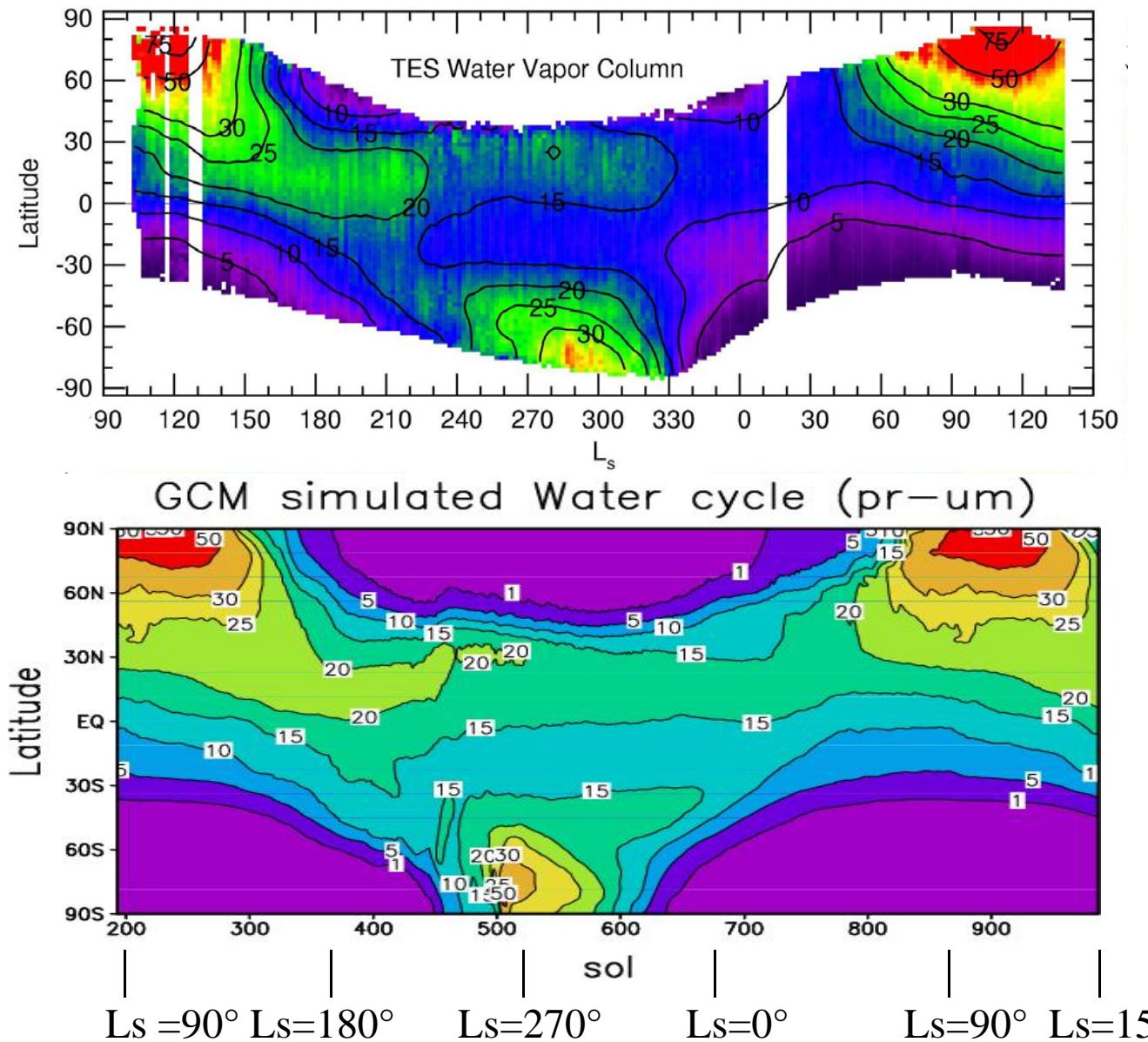


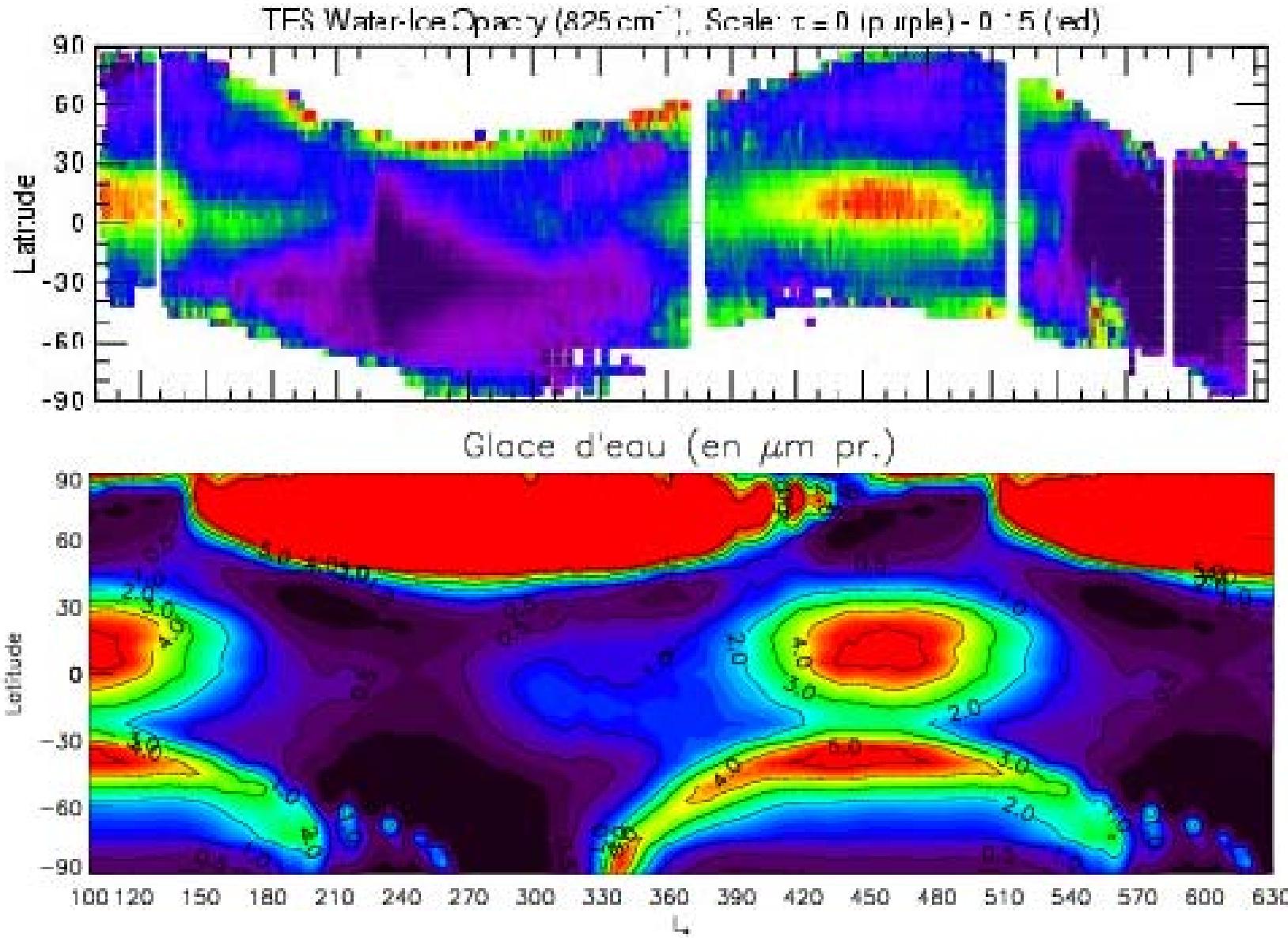
Figure 5. Smith, TES Interannual Variability

# GCM simulation



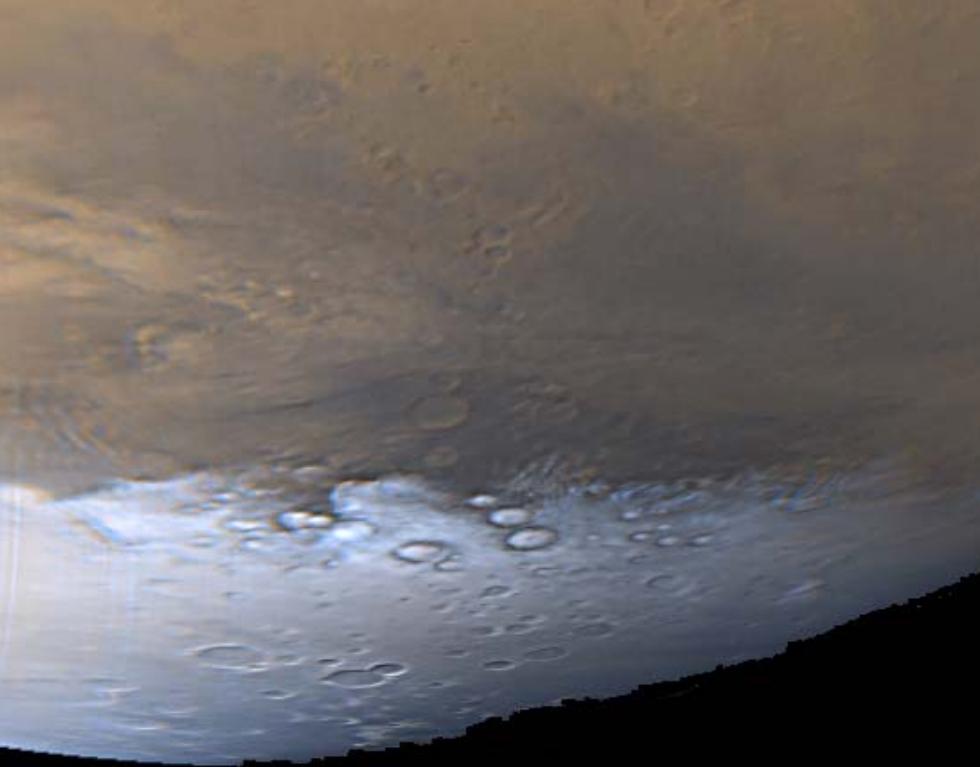
# Simulation of Water ice clouds

Montmessin et al., LMD GCM

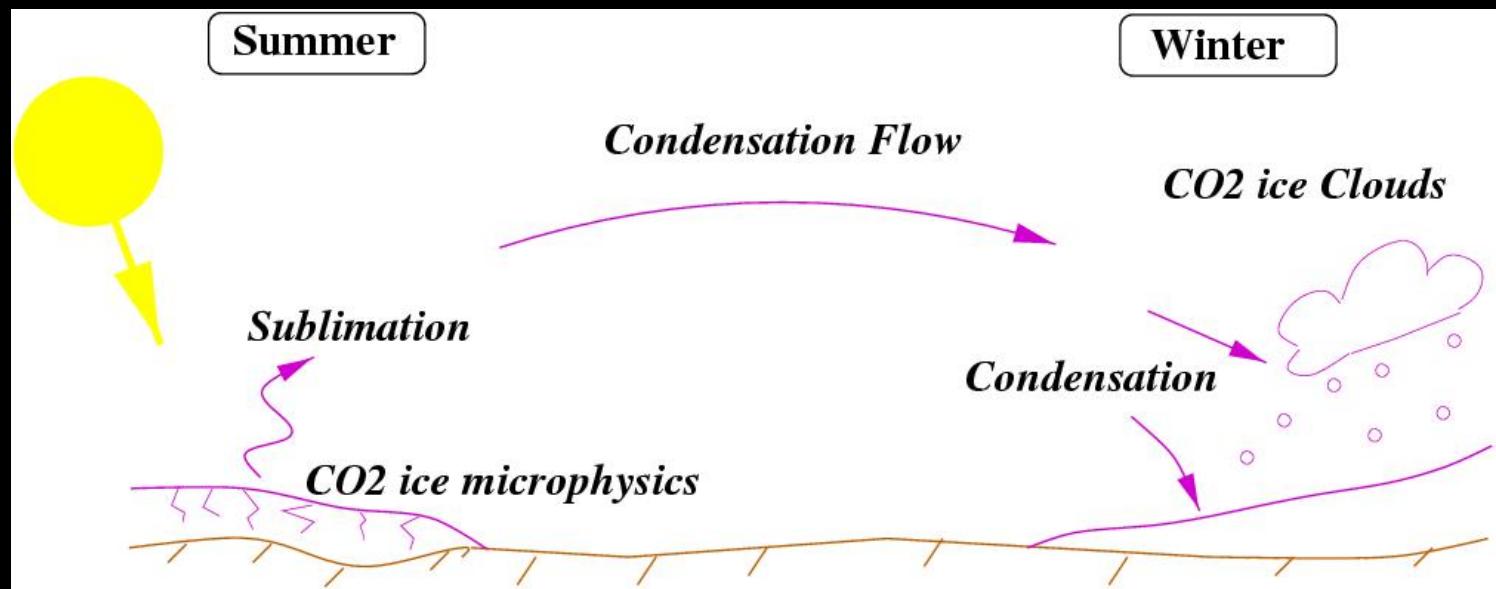


# Water cycle : key issues

- Interranual variability ? Accurate measurements ?
- Vertical variations ?
- Exchange with sub-surface ?
- Impact of clouds (radiative – scavenging)
- Polar processes



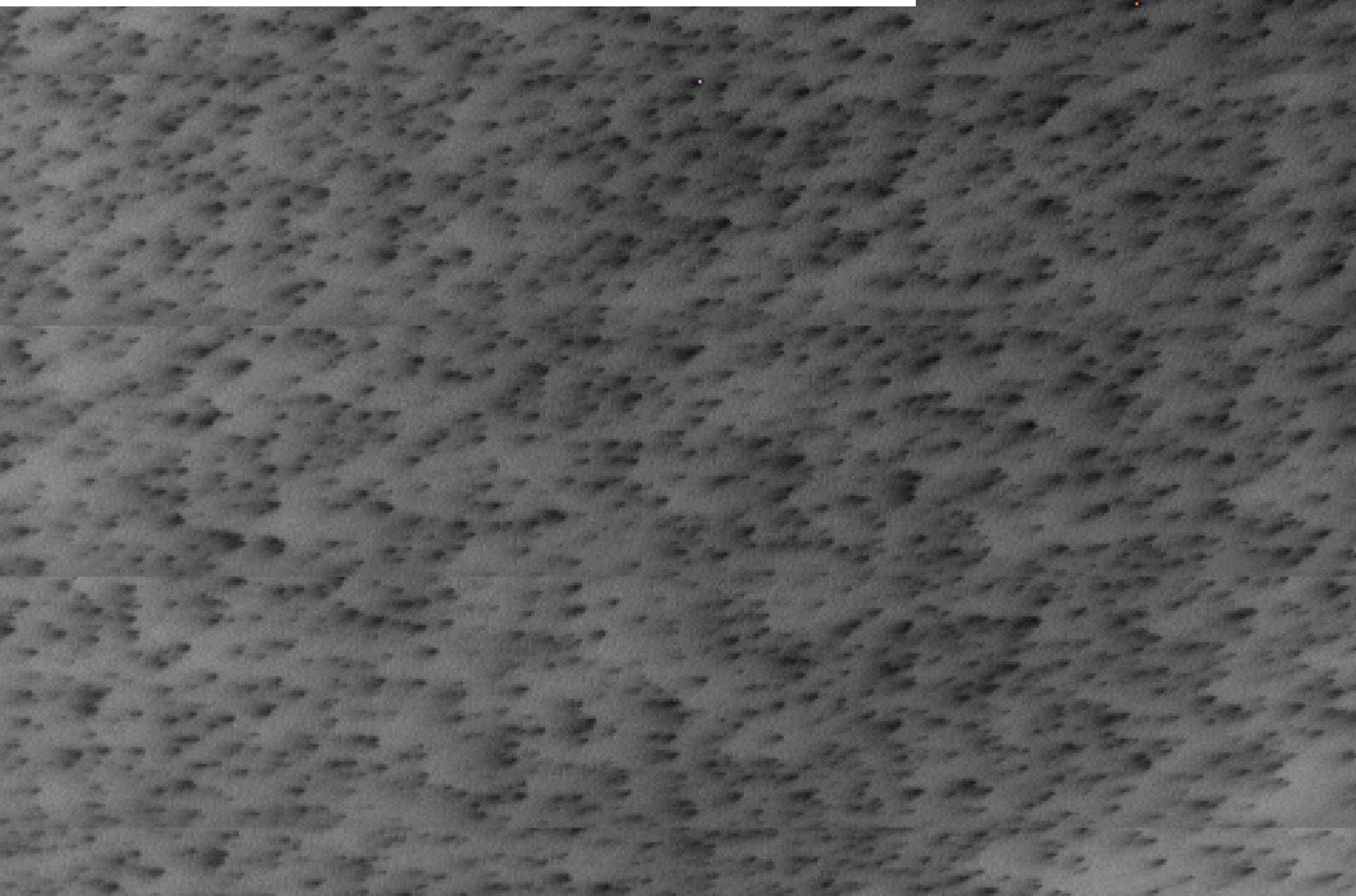
# The CO<sub>2</sub> cycle



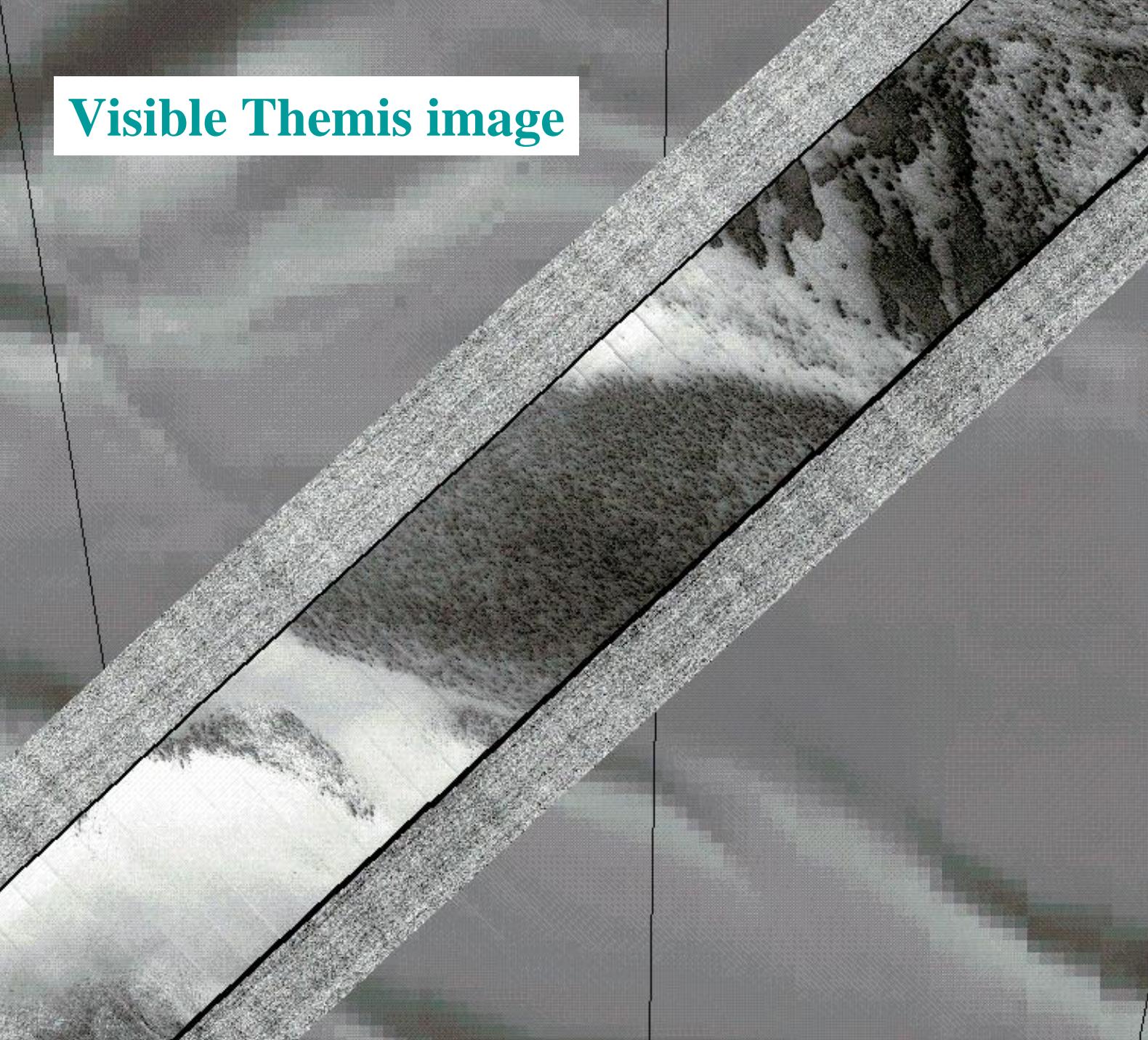
# CO<sub>2</sub> cycle : key issues

- **What is going on in the polar night ?**  
(CO<sub>2</sub> clouds, CO<sub>2</sub> depletion ? Convection ?)
- **What is going on when CO<sub>2</sub> sublime**  
(H. Kieffer : « *it's a zoo* »):
  - « Spider », « geyser », Criptic region, water frost vs CO<sub>2</sub> frost, dust

Subliming CO<sub>2</sub> seen by Themis (Titus et al.)



V06450007



Titus et al.

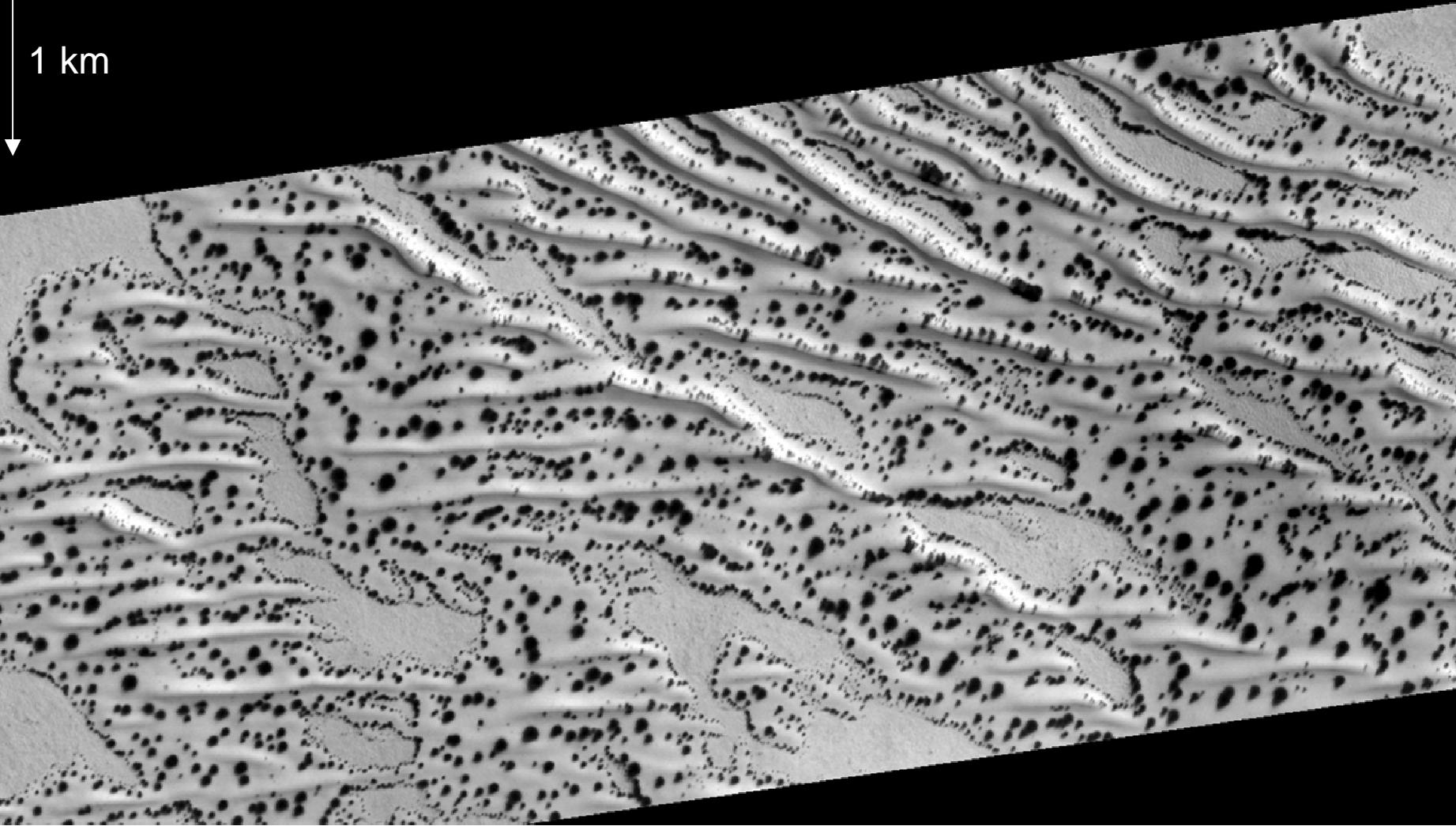
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Thermal IR  
temperature map  
It Is All Dry Ice !

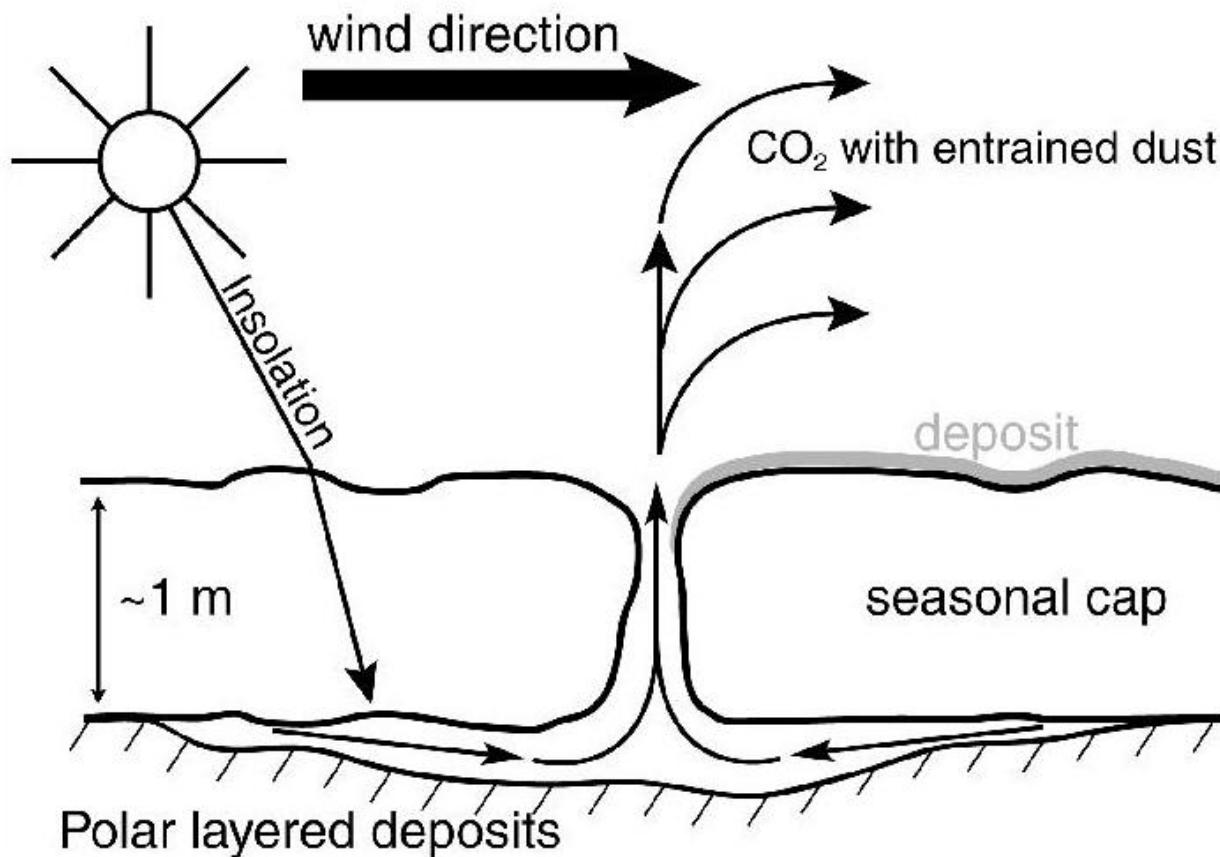
Titus et al.

# Sublimation of CO<sub>2</sub> ice and snow

1 km

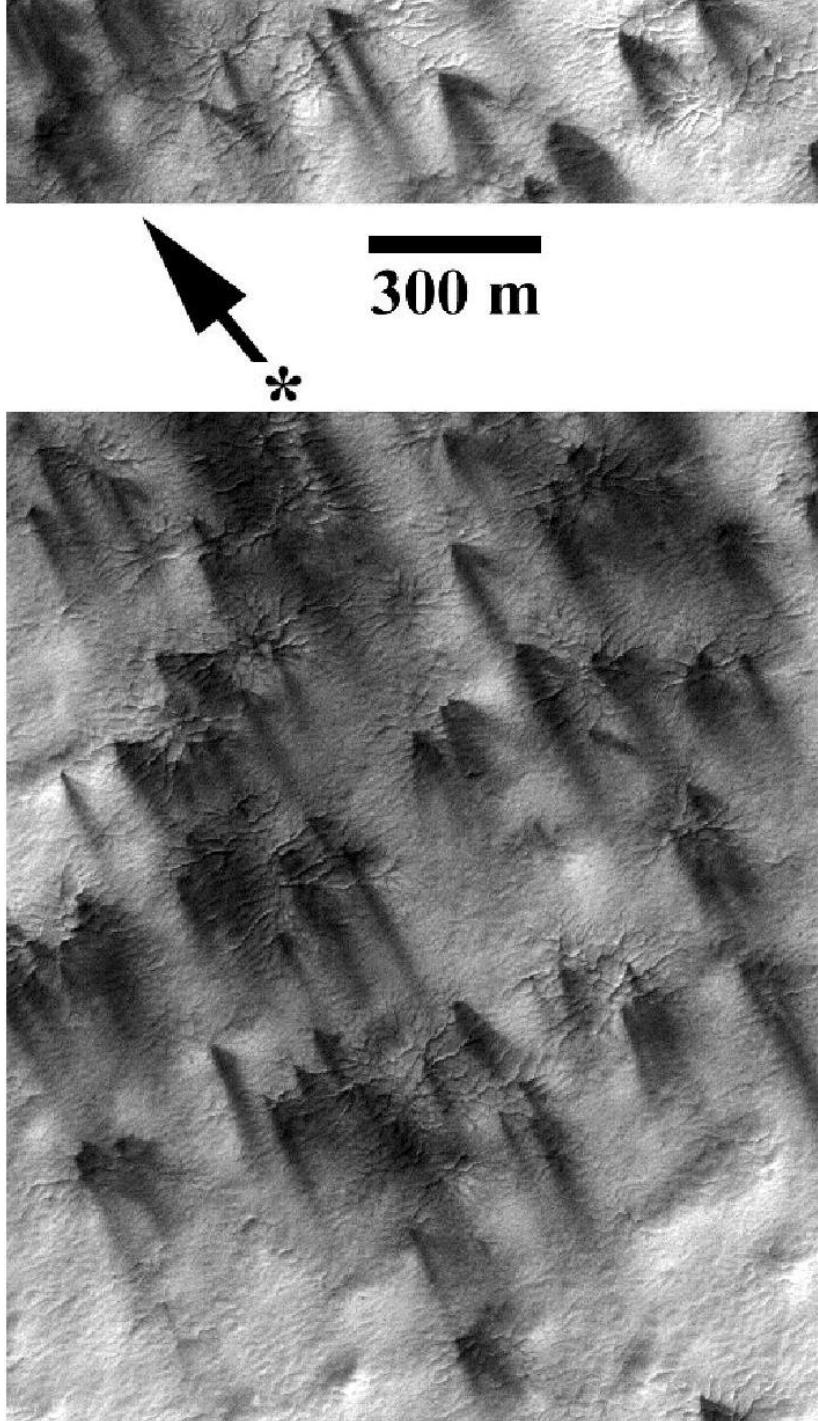


(Piqueux et al. 2003)

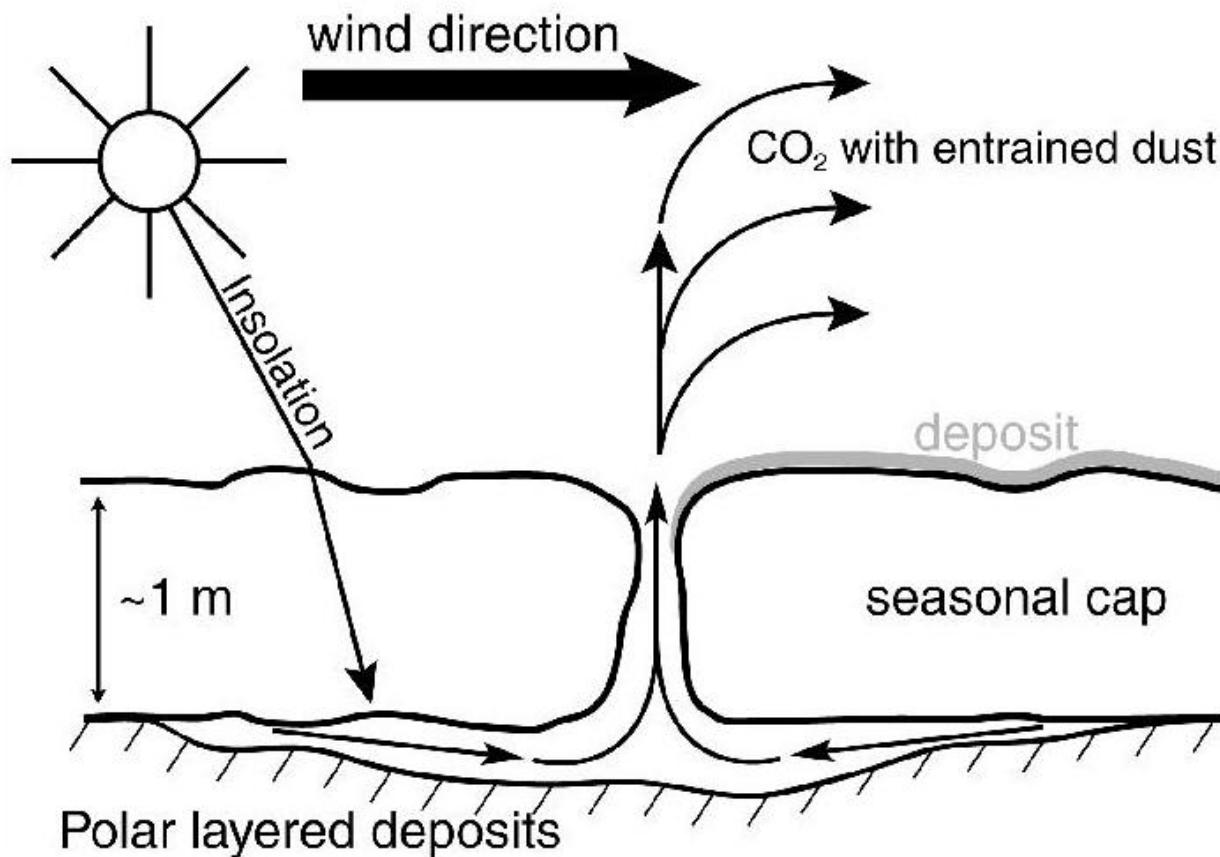


# Formation of “Spider” in the “criptic” region

(Piqueux et al. 2003)

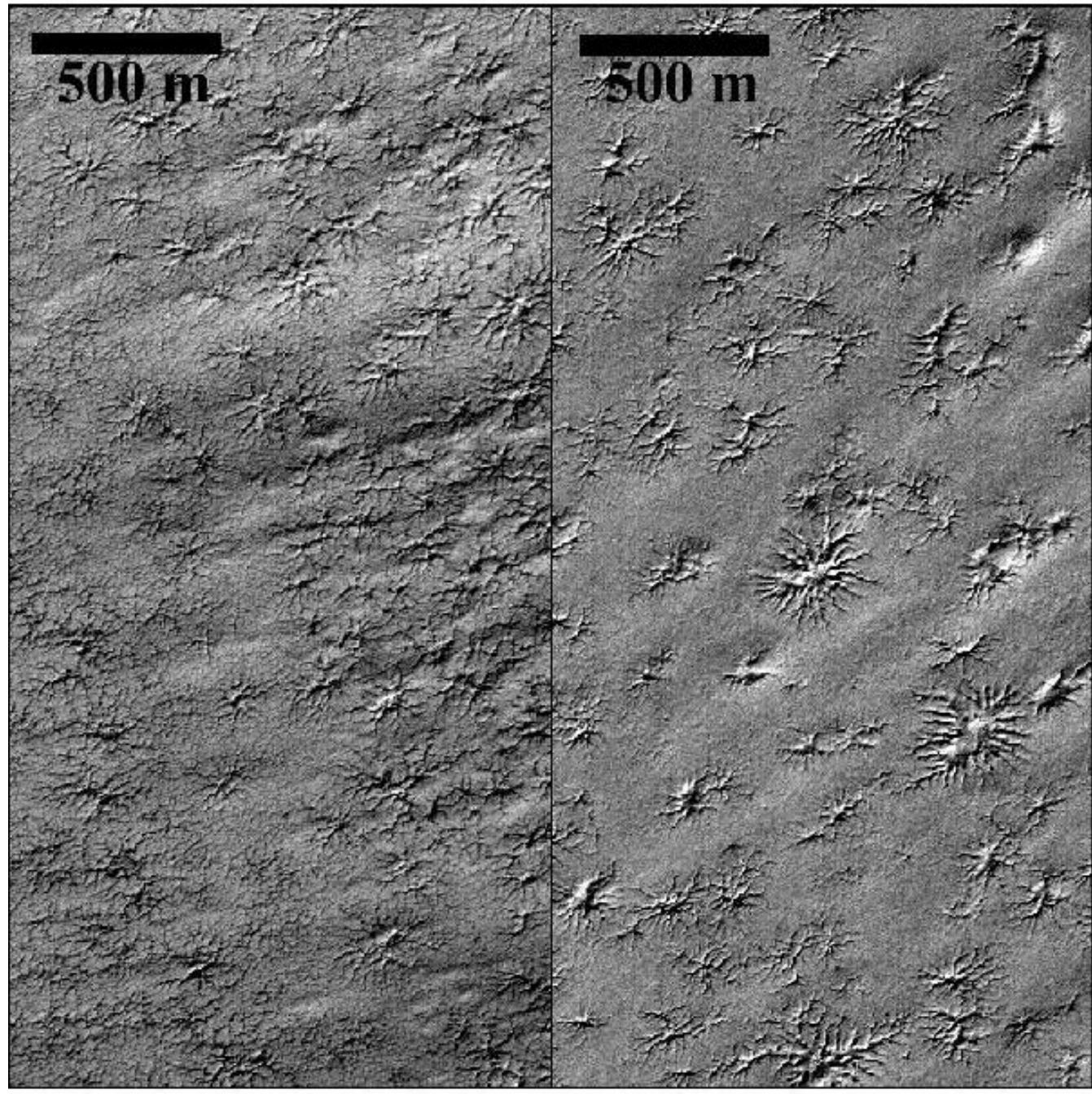


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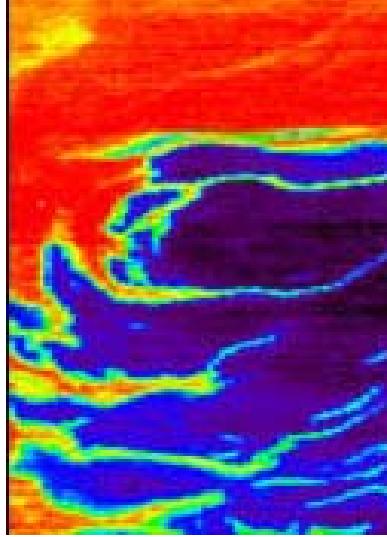
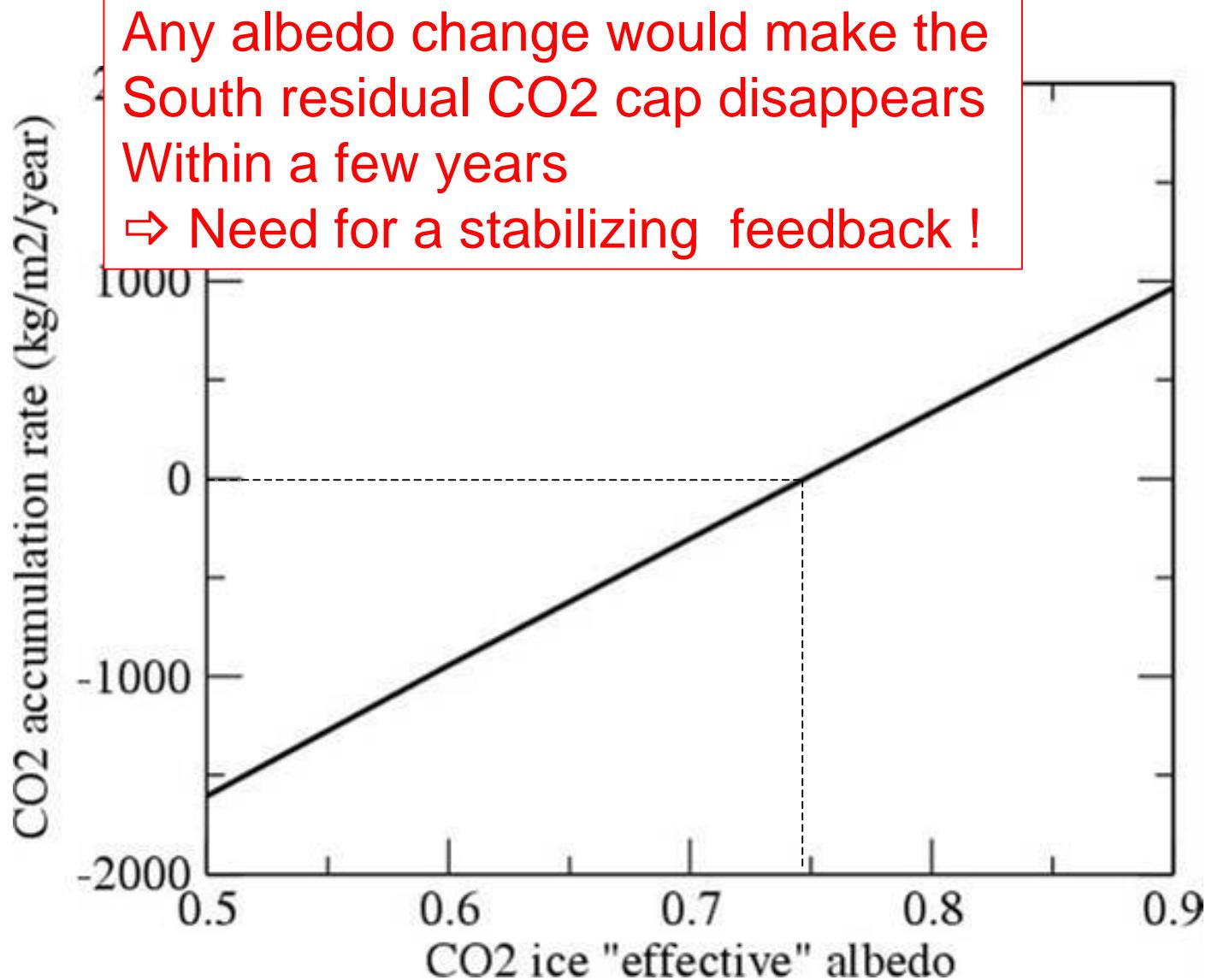
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(Piqueux et al. 2003)



# CO<sub>2</sub> cycle : key issues

- **What is going on in the polar night ?**  
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- **What is going on when CO<sub>2</sub> sublime**  
(H. Kieffer : « *it's a zoo* »):
  - « Spider », « geyser », Criptic region, water frost vs CO<sub>2</sub> frost, dust
  - What is the residual south polar cap ???



"permanent CO<sub>2</sub>  
ice seen by  
Omega

# A rising topic : atmospheric composition and chemistry

- ⇒ Source, sink, transport
- ⇒ Lots of unprecedented data from Mars Express, Odyssey and terrestrial observations:  
O<sub>3</sub>, CO, Ar, H<sub>2</sub>O<sub>2</sub> ? CH<sub>4</sub> ? ... etc.

# Conclusion

Most likely : Mars Express will have

- Given us a lot of answers about Mars
- And raised even more questions !