MARTIAN WATER ICE LATITUDE DEPENDENT MANTLE PREDICTED BY IMPROVED CLIMATE MODEL

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Introduction

Converging geomorphological evidences point to the deposition of a "**Latitude-Dependent Mantle" (LDM)** of water ice on Mars up to ~30° latitude in both hemispheres, of age consistent with the latest obliquity rise to 35°. GCM studies can't explain how ice would accumulate outside the polar regions assuming a permanent reservoir at the north pole like today. We present our simulations at 35° obliquity with the latest improvements of the Mars PCM, with a focus on albedo and thermal inertia.

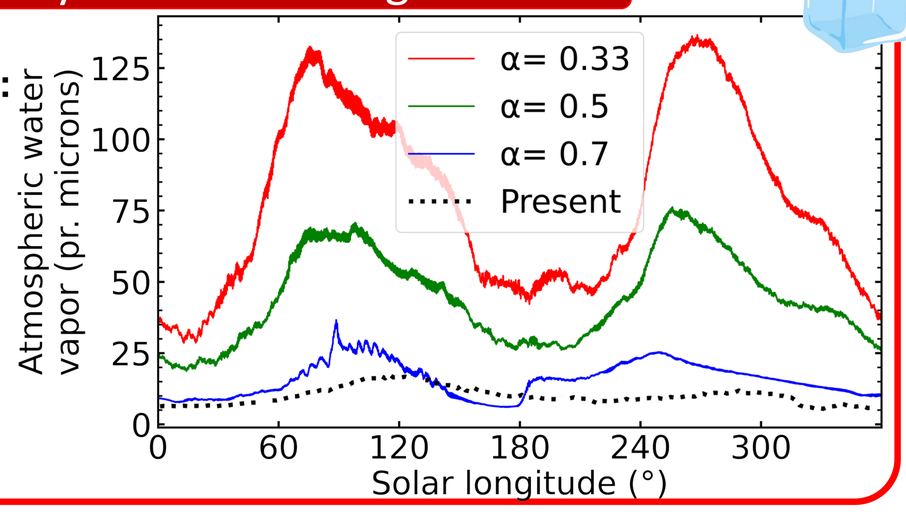
Mars PCM settings

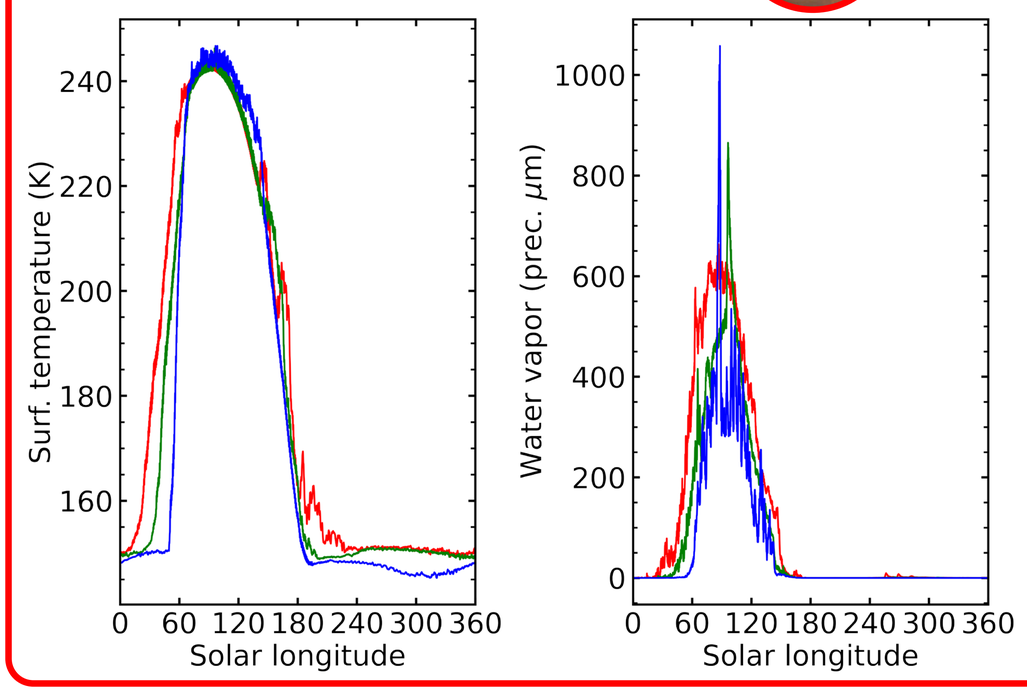
- 0.08 ecc., Lp=270° mild northern summer
- TI feedback with ice accumulation [2]
- **Radiatively active H_2O clouds (RACs) with improved nucleation scheme** [1]
- **Latent heat of ground water ice sublimation /condensation** [1]
- Sentivity of water frost albedo :
  α= 0.33 ; **α = 0.5** ; **α = 0.7**

Atmospheric humidity limited by latent heat of ground ice

Excursion to 35° obliquity increases insolation and sublimation of the NPC:

- Water vapor content is 10 times higher than present [2], or even 100 times higher with RACs [3]
- Latent heat of ground ice reduces the NPC sublimation and limits atmospheric water vapor

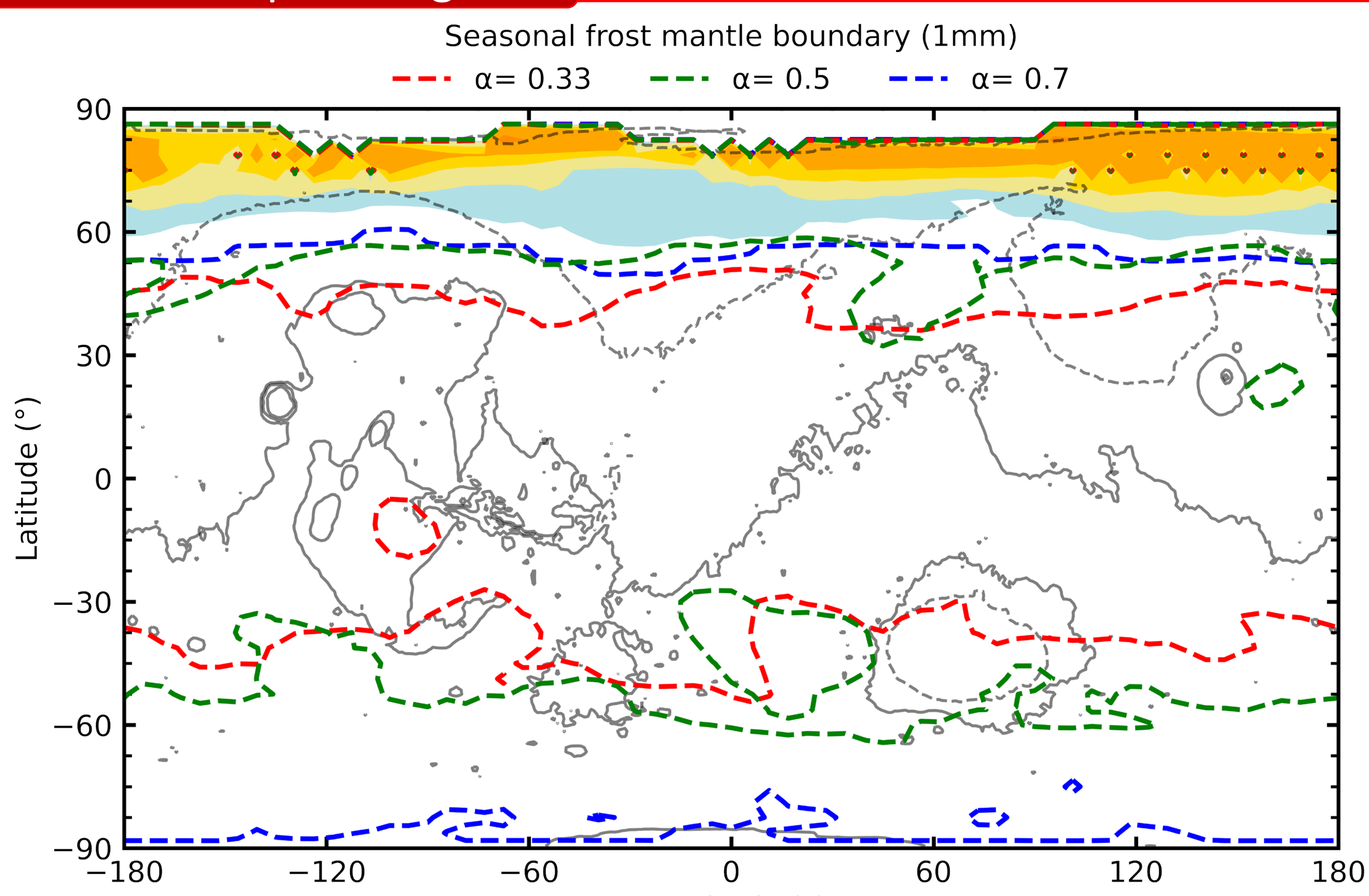




- NPC is ~20K warmer than present-day Mars
- Increased albedo of frost affects the CO2 cycle and acts as a cold trap
- Sublimation is maximal when **α = 0.7** because of complex retroactions with RACs

The Northern Polar Cap (NPC)

Frost deposition outside the polar regions



α= 0.33 :
- No ice accumulation outside the NPC
→ Latent heat cooling isn't sufficient to prevent summertime sublimation

α= 0.5 :
- Ice accumulates outside the NPC at high latitudes in both hemispheres (not shown)

α= 0.7 :
- Multi-annual frost deposition down to ~60° latitude North
- Thermal inertia feedback enhances ice accumulation

Thermal inertia (TI) :
- Set to 800 $J.m^{-2}.K^{-1}.s^{-1/2}$ in the PCM (lower limit for ice)
- TI feedback alone doesn't allow ice accumulation outside the Northern Polar Cap

Main results :
- First GCM simulations to compute RACs and latent heat of ground ice at 35° obliquity : « only » ten times more humid than present
- Using the NPC as an initial ice reservoir, ice can accumulate outside the polar region if summer sublimation is dampened, by higher frost albedo (e.g. due to snowfall) or increased thermal inertia (pore filling or consolidated subsurface ice)

Future developments

- CO_2 albedo parametrization
- Improved H_2O albedo parametrization : snowfall
- Different orbital forcing
- Sensitivity to the dust cycle
- Planetary Evolution Model (PEM) : evolution of subsurface ice table and thermal inertia
- PEM : Microclimate of slopes within PCM cells

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I would be glad to work with you !

References:
[1] **Naar** et al., (2021) 10.5194/epsc2021-559
[2] Madeleine, JB., et al. (2009), 10.1016/j.icarus.2009.04.037
[3] Madeleine, JB., et al. (2014), 10.1002/2014GL059861