Water Supersaturation Modeling for Early Mars Climate during Noachian

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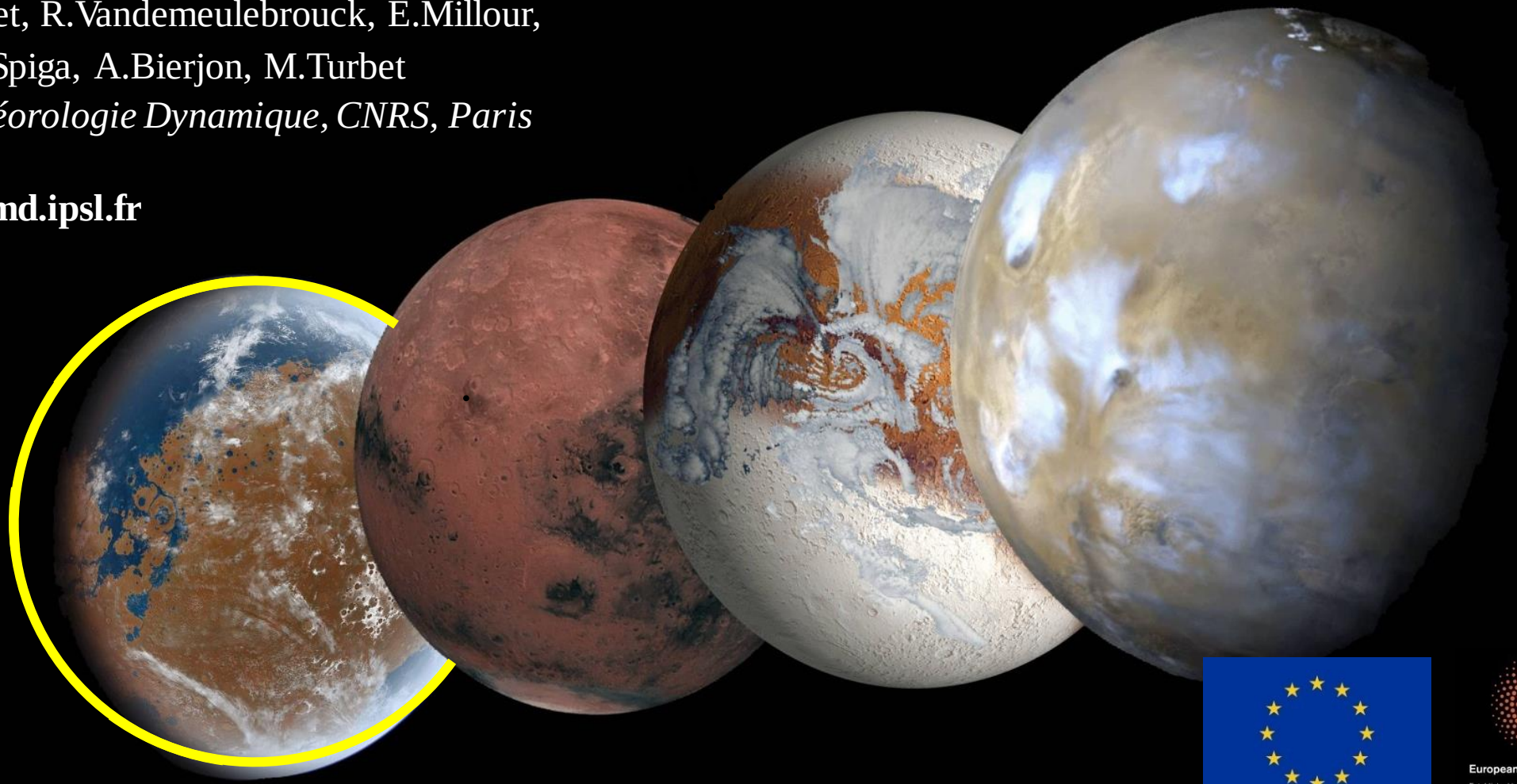

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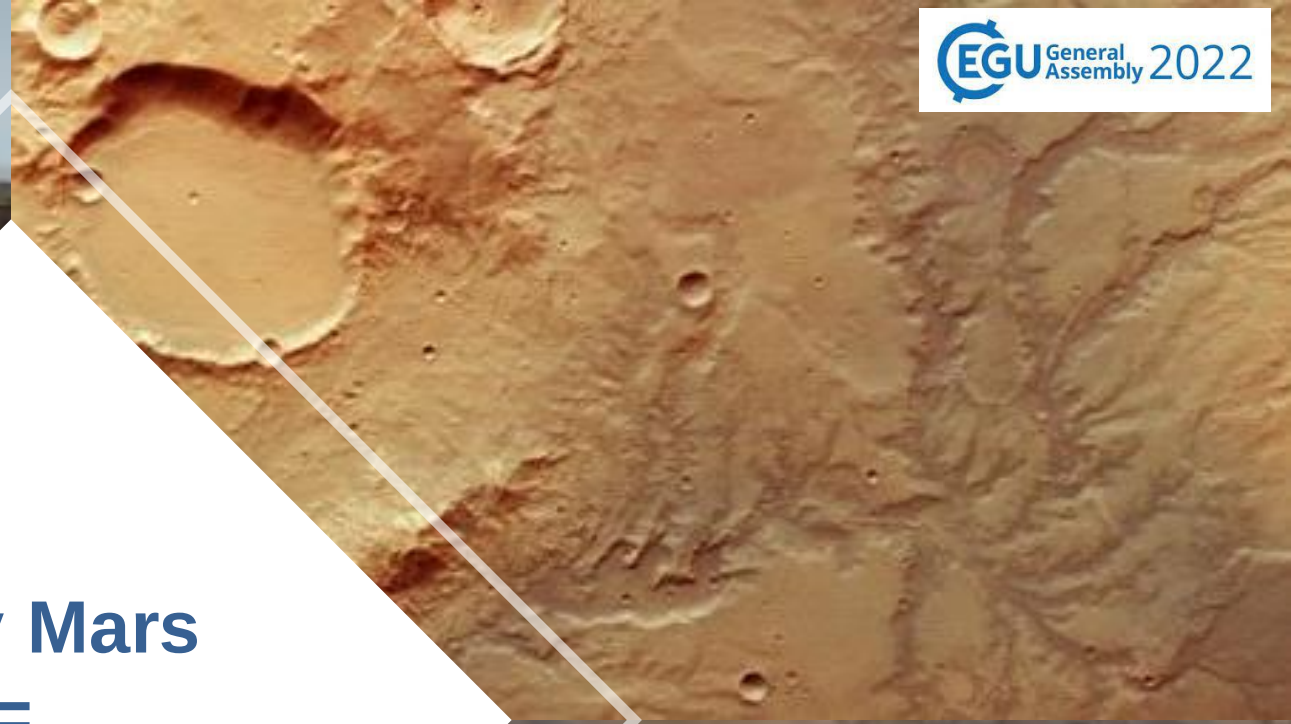
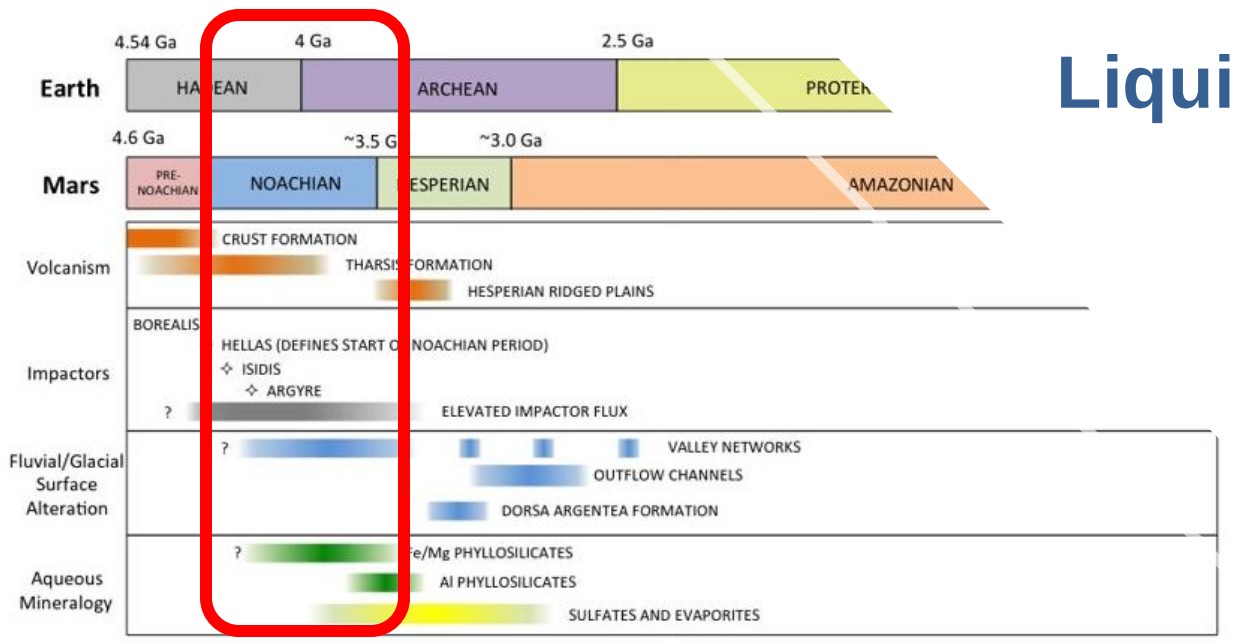


Early Mars
=
Liquid Water



Wordsworth et al. 2016

Which Climates can host lakes and create valley networks ??

Early Mars Climate Modeling: A Warm and Wet Early Mars ?

Only **CO_2/H_2O** ?

Wordsworth et al. 2013, Forget et al. 2013

\+ **GHG gases** (CH_4, SO_2,...) ?

Or **Extreme Events** : Impacts, volcanism ?

Wordsworth et al. 2016

H_2 ?

Ramirez et al. 2014, Turbet et Forget 2021, ...

Greenhouse effect of **Clouds**?

Kite et al. 2021

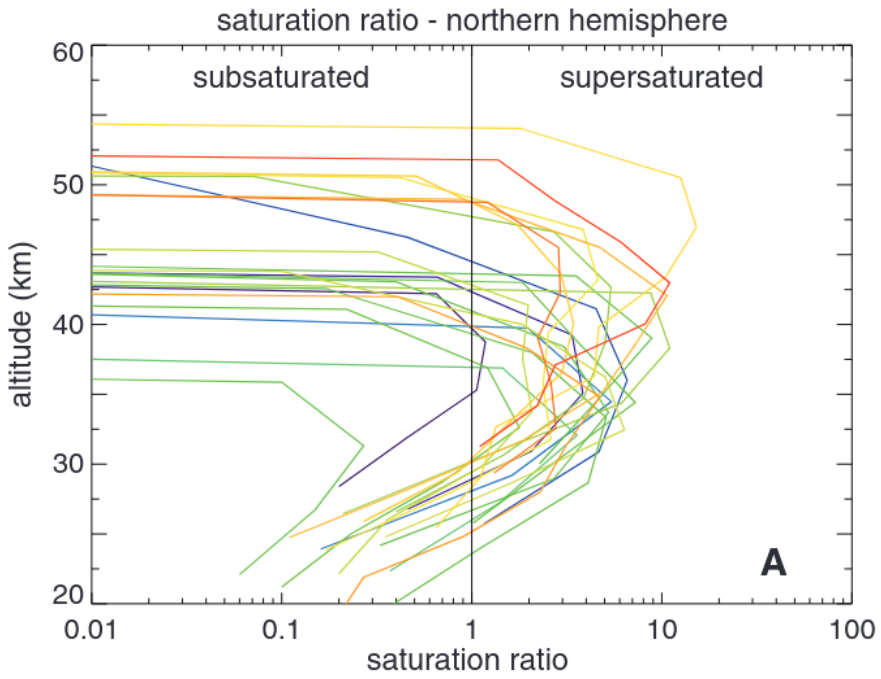
H_2O_2 supersaturation ?

Ito et al 2020

...

Water supersaturation occurs on current-day Mars

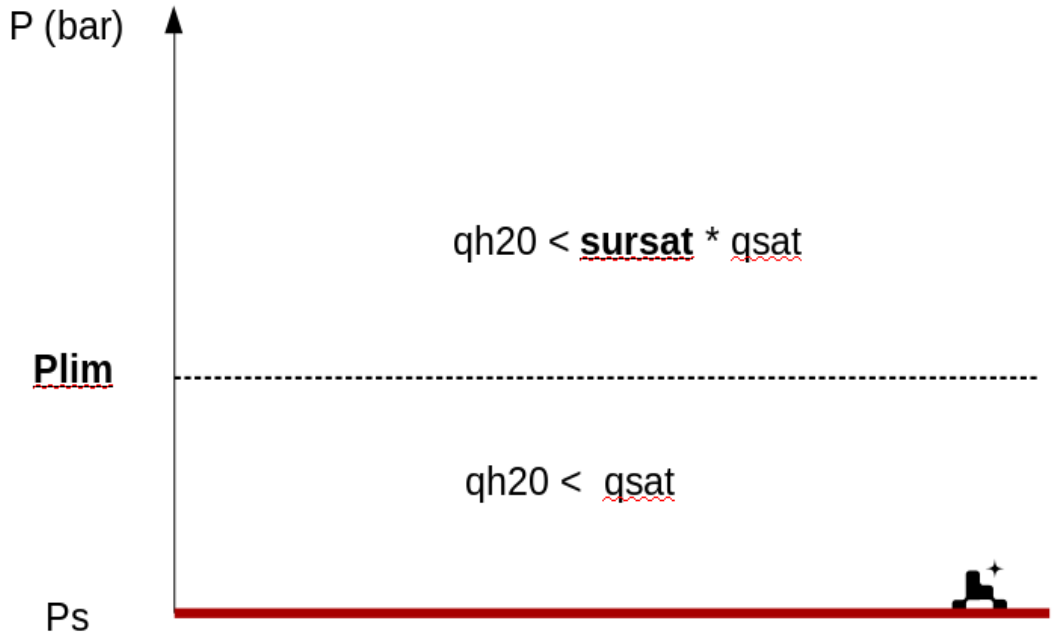
Maltagliati et al. 2011



What about water supersaturation ?

H_2O Supersaturation Modeling

- 3D GCM simulation: Noachian set-up 2bar CO_2/H_2O, Young Sun
- 2 parameters for supersaturation **sursat** and **plim**



- Surface source: Initialized with a global ice layer with low albedo (0.2)
- High Obliquity: 40°

Atmospheric Water Vapor is maximised

Results: Relative Humidity (Zonally and Yearly Averaged)

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a) ref sursat=1

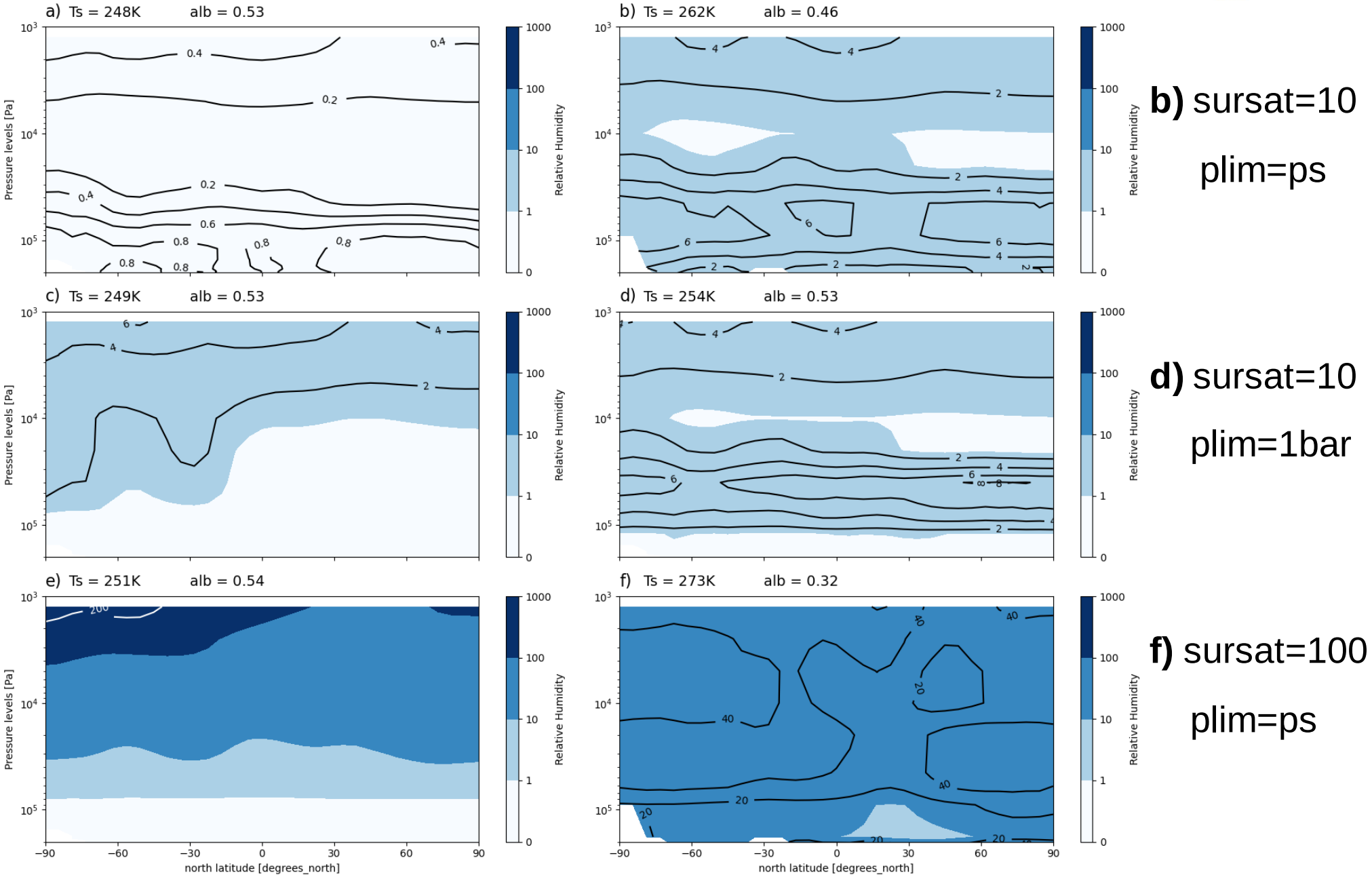
b) sursat=10
plim=ps

c) sursat =10
plim=0.5bar

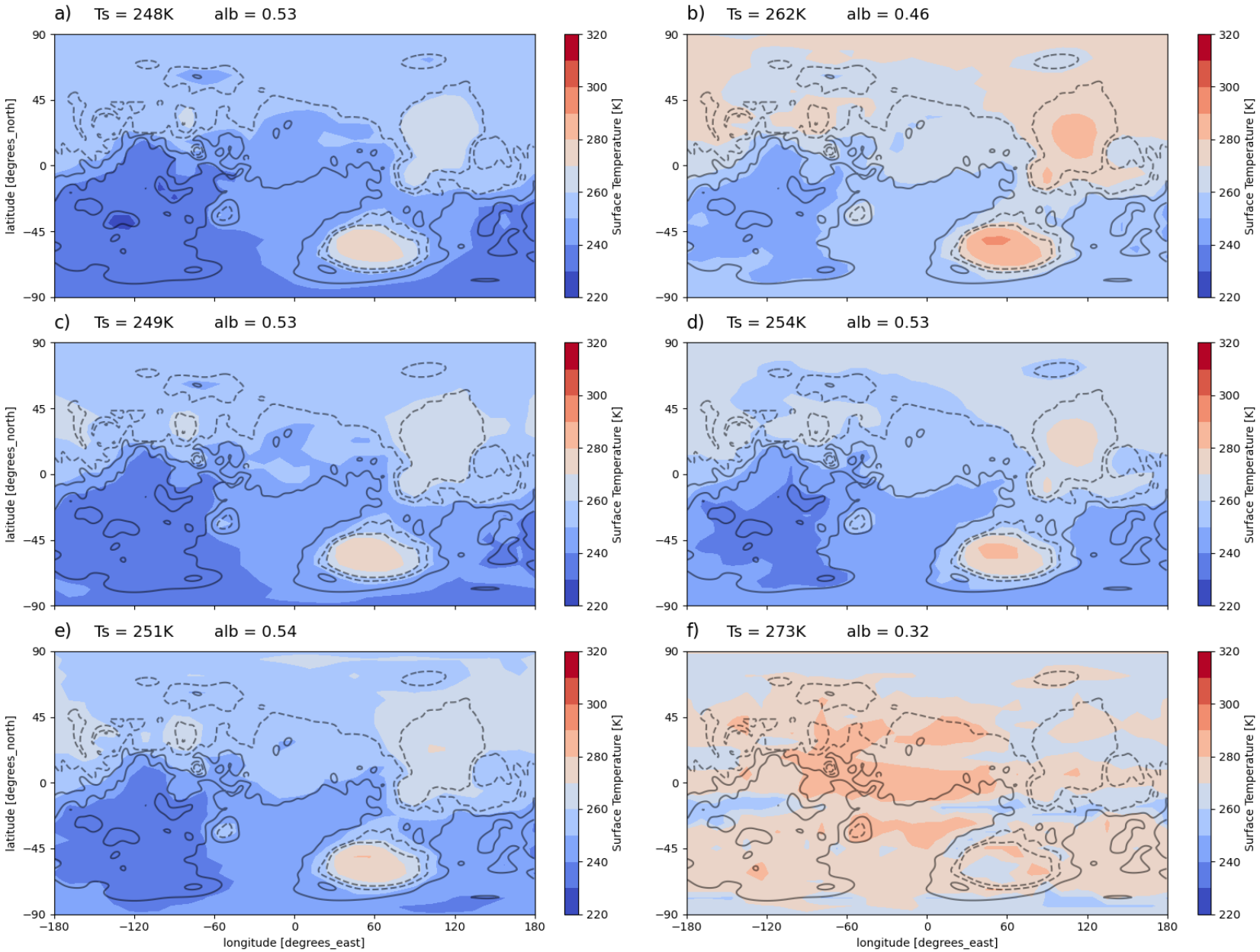
d) sursat=10
plim=1bar

e) sursat=1000
plim=0.5 bar

f) sursat=100
plim=ps



Results: Surface Temperature (Zonally and Yearly Averaged)



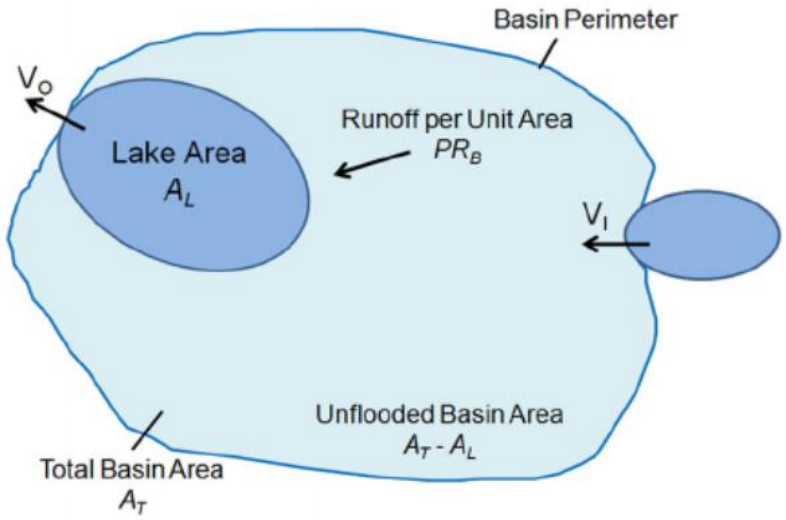
- No warming when supersaturation is allowed only <0.5 bar
- Global Surface Temperature > 0°C for the sursat=100 simulation
- Warming through absorption of IR of water vapor and the raising clouds

Take-Home Messages:

- **We simulated water supersaturation in an Early Mars Climate considering a abundant source of water on the surface**
- **Supersaturation can warm Early Mars only with unrealistic supersaturation ratio**
- **Supersaturation is only efficient when it occurs in the lower layers of the atmosphere**

Future works:

- Simulate an efficient source of water in atmosphere layers (photochemistry ?)
- Mars Through Time: Lake evolution through a surface hydrology model using HR topography
- Methodology: Watershed hierarchy (*Barnes et al. 2020*)



Matsubara et al. 2011