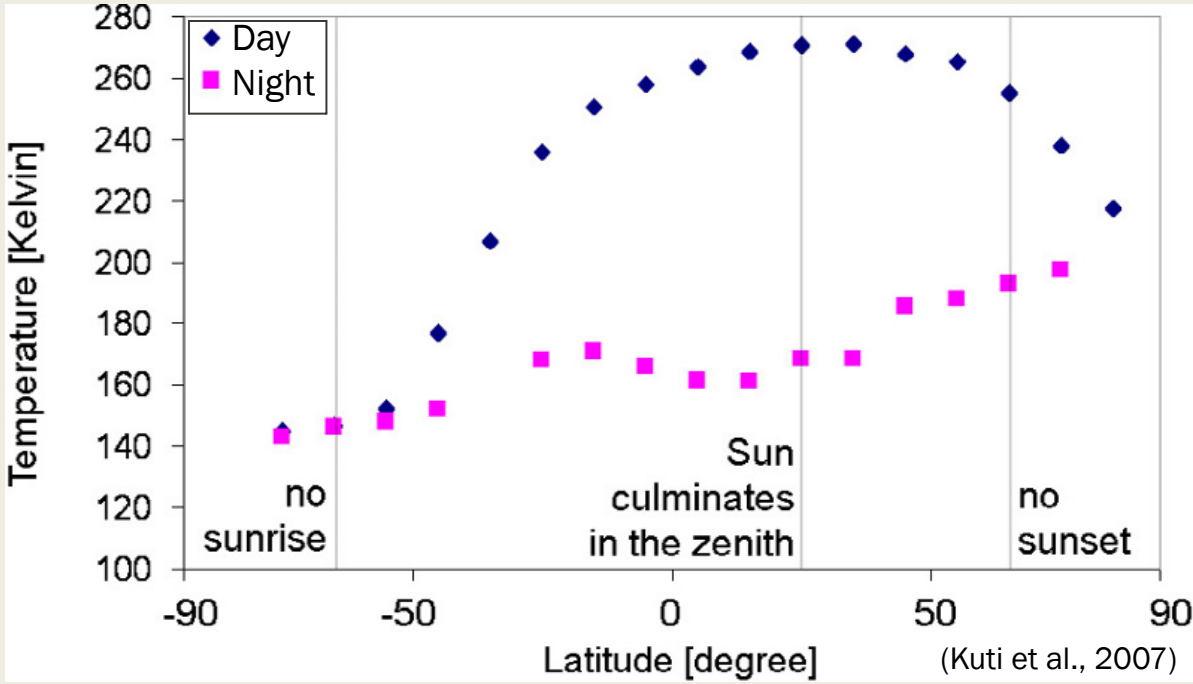
MODELLING LIQUID WATER-TRAPPING MICRO-ENVIRONMENTS ON THE MARTIAN SURFACE

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Environmental conditions

- The surface of Mars is dry and cold: significant fluctuations
  - *Maximum: 271–274 K*
  - *Minimum: ~140 K*
  - *Total daily fluctuation: up to 134 K*

Example: at the summer solstice
(Ls = 90–95°)
region: 300°–330°E
in the band between 90° N and 90° S



(Kuti et al., 2007)

- **On the surface of Mars:**
  the key role of hygroscopic salt crystals
  as an aqueous salty solution (deliquescence)
- **Objective:**
  To investigate how such a crystal could provide moisture in daytime for a hypothetical organism while offering protection against extreme environmental conditions

Why is it important to analyse hygroscopic salts?

- Hygroscopic property
  - *Absorbs atmospheric water vapor*
  - *Can form microscopic, saturated brine (salty solution)*
  - → *Liquid water can form on the surface on a small scale*
- UV protection at a depth of 2–3 mm (UVA, UVB, UVC)
- Light transmittance → photosynthesis is possible

(Marschall et al. 2012, Schuerger 2015, McKay et al. 2003 , Gómez-Silva et al. 2019, Slank et al. 2024)

Salt crystals as potential habitats

1. At night, salt crystals cools and begin to contract
   → due to thermal stress: cracks appear and open
2. The interior of the crystal can establish contact with the atmosphere
3. Temperature drop: relative humidity increases
   → condensation, deliquescence: microscopic liquid film / water film
4. At dawn, it begins to close up
   → the moist surface
   can become enclosed

Relative volume change (150–300 K):

NaCl: 1.64%

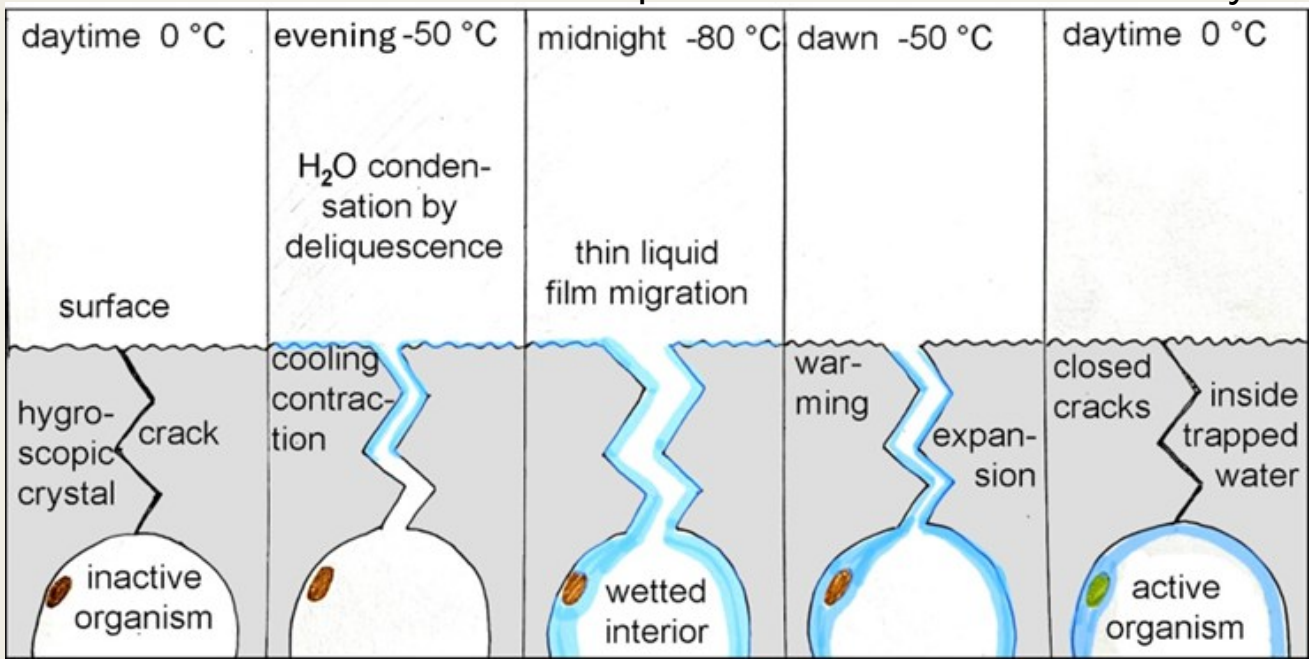
$CaCl_2$ (depending on concentration):

3.75%–6.9%

$CaSO_4 \cdot 2H_2O$: 0.865%

$MgSO_4$: 0.57%

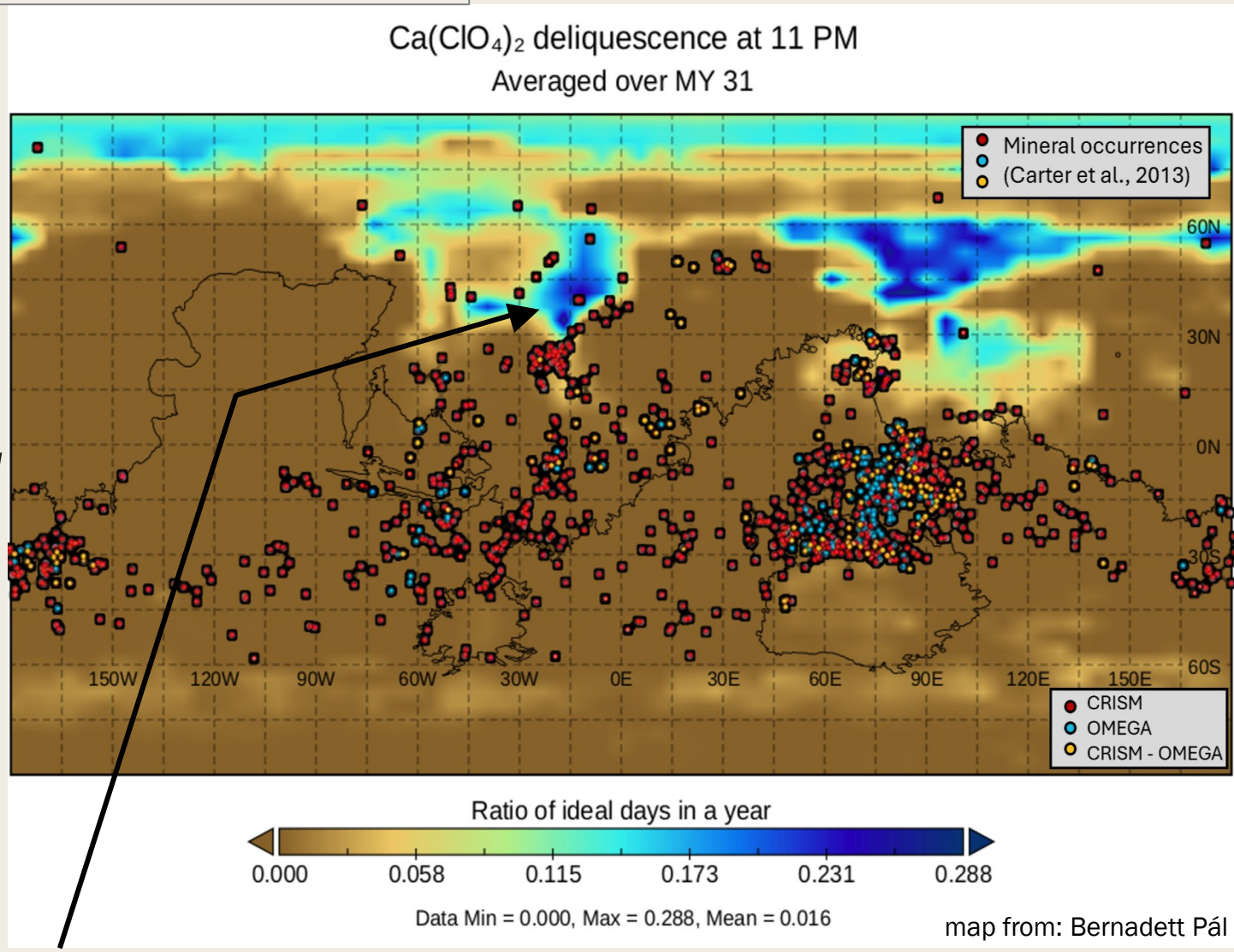
Steps of the theoretical diurnal cycle



Results

Deliquescence Relative Humidity:
The RH threshold at which a solid salt absorbs water vapor and forms a brine.

- **Relative humidity:**
  increases at night
  → can reach the required DRH
- **Salts:** $Ca(ClO_4)_2$ and $CaCl_2$
  → lower DRH, easily form liquid
  model simulation executed
- **Favorable regions:**
  Acidalia, Utopia, Isidis, Hellas margin

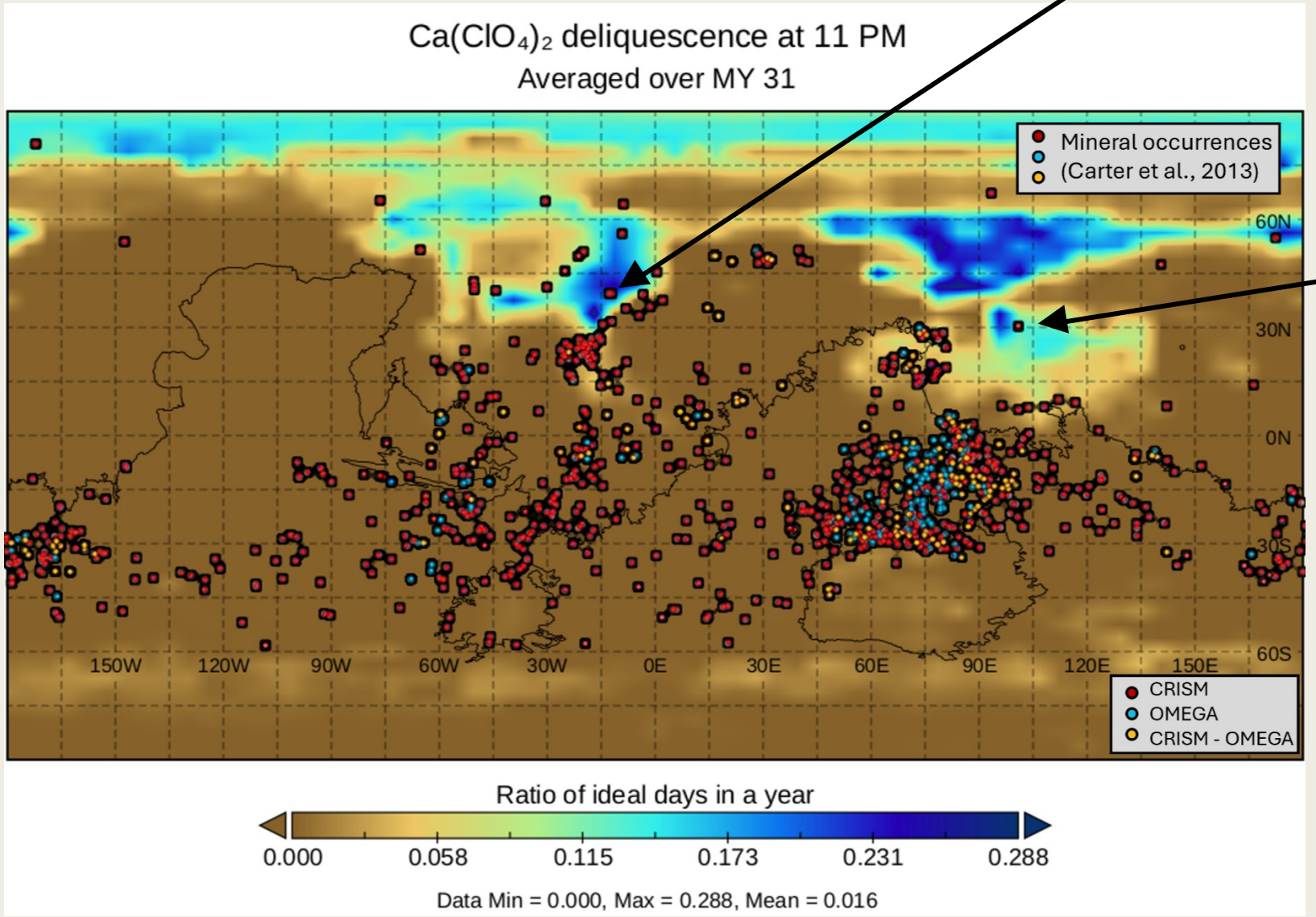


map from: Bernadett Pál

Acidalia Planitia →100–130 favorable sols annually

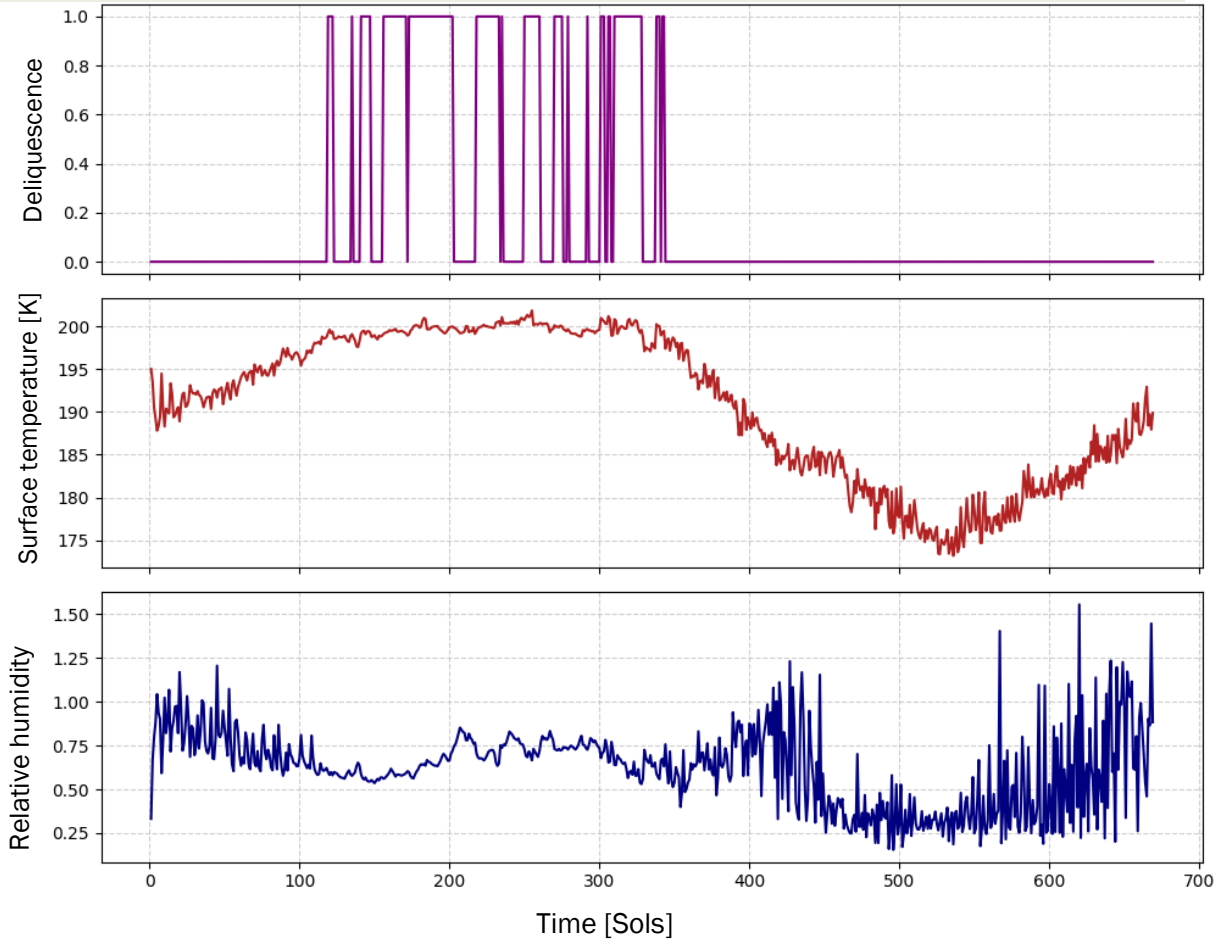
Specific areas

Observed locations:
A. 12.4°W, 39.3°N
B. 100.6°E, 30.2°N

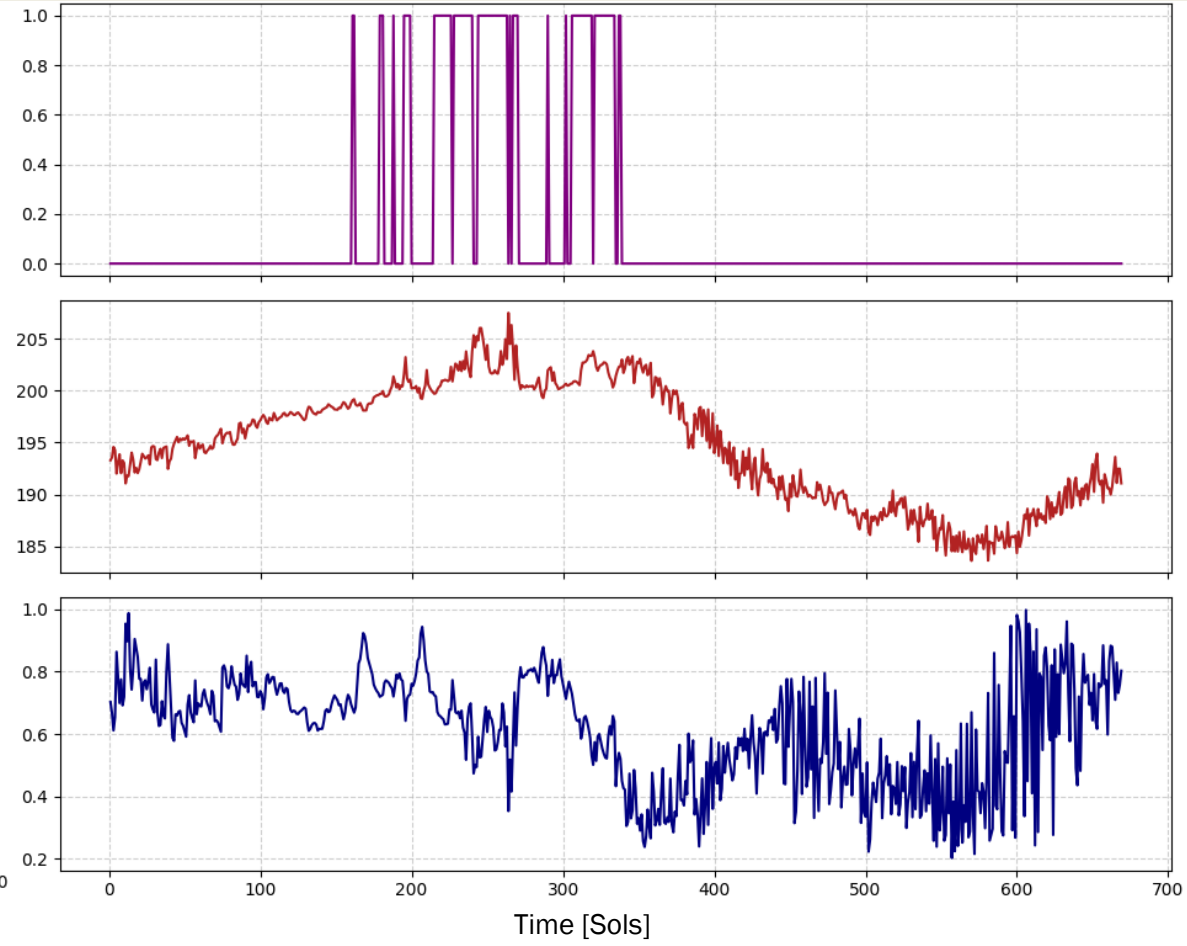


- $Ca(ClO_4)_2$: $T = 199$ K, RH w.r.t. liquid $= 0.51$
- Range between Sol 150–350: late northern spring – mid-northern summer

Point A



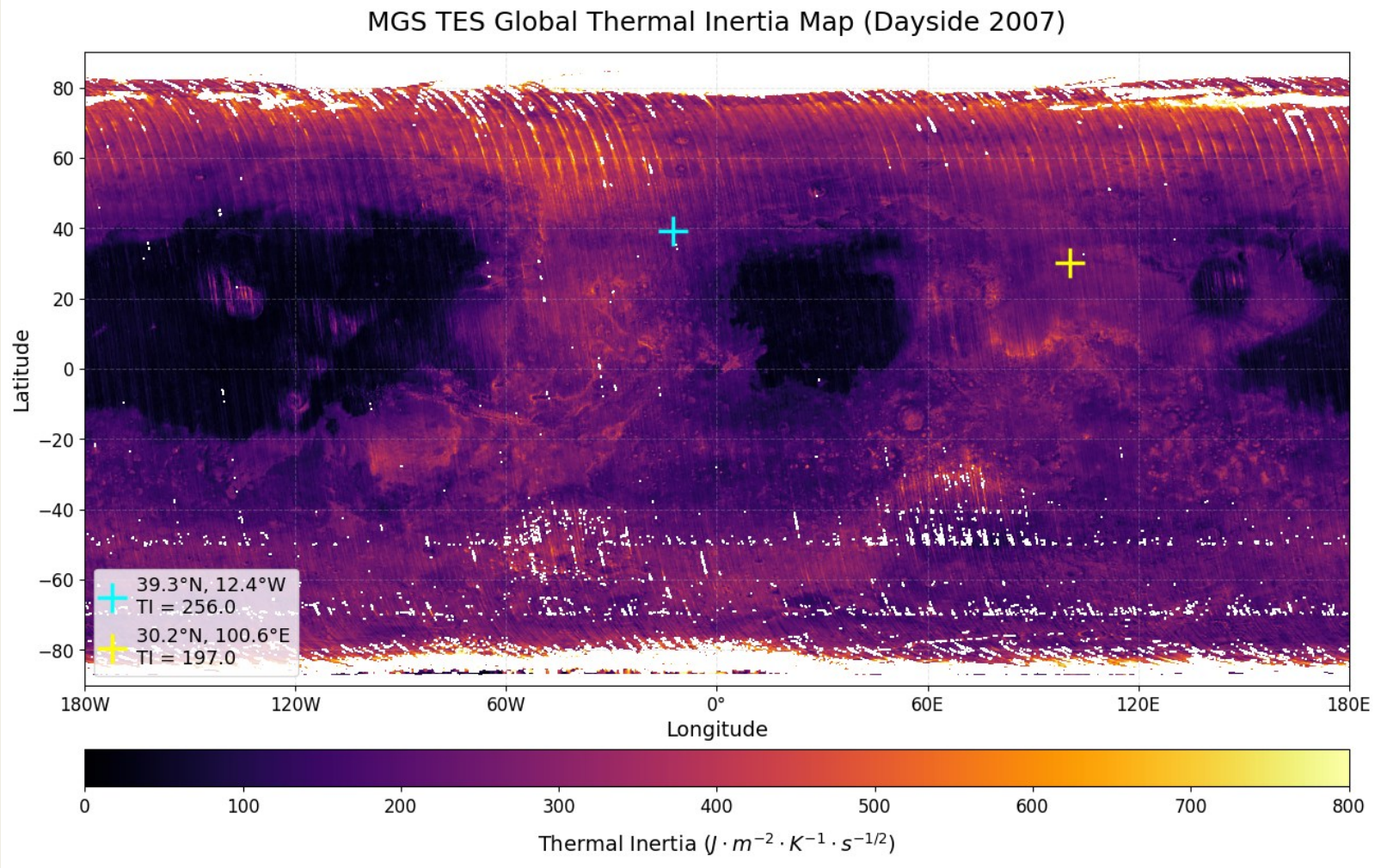
Point B



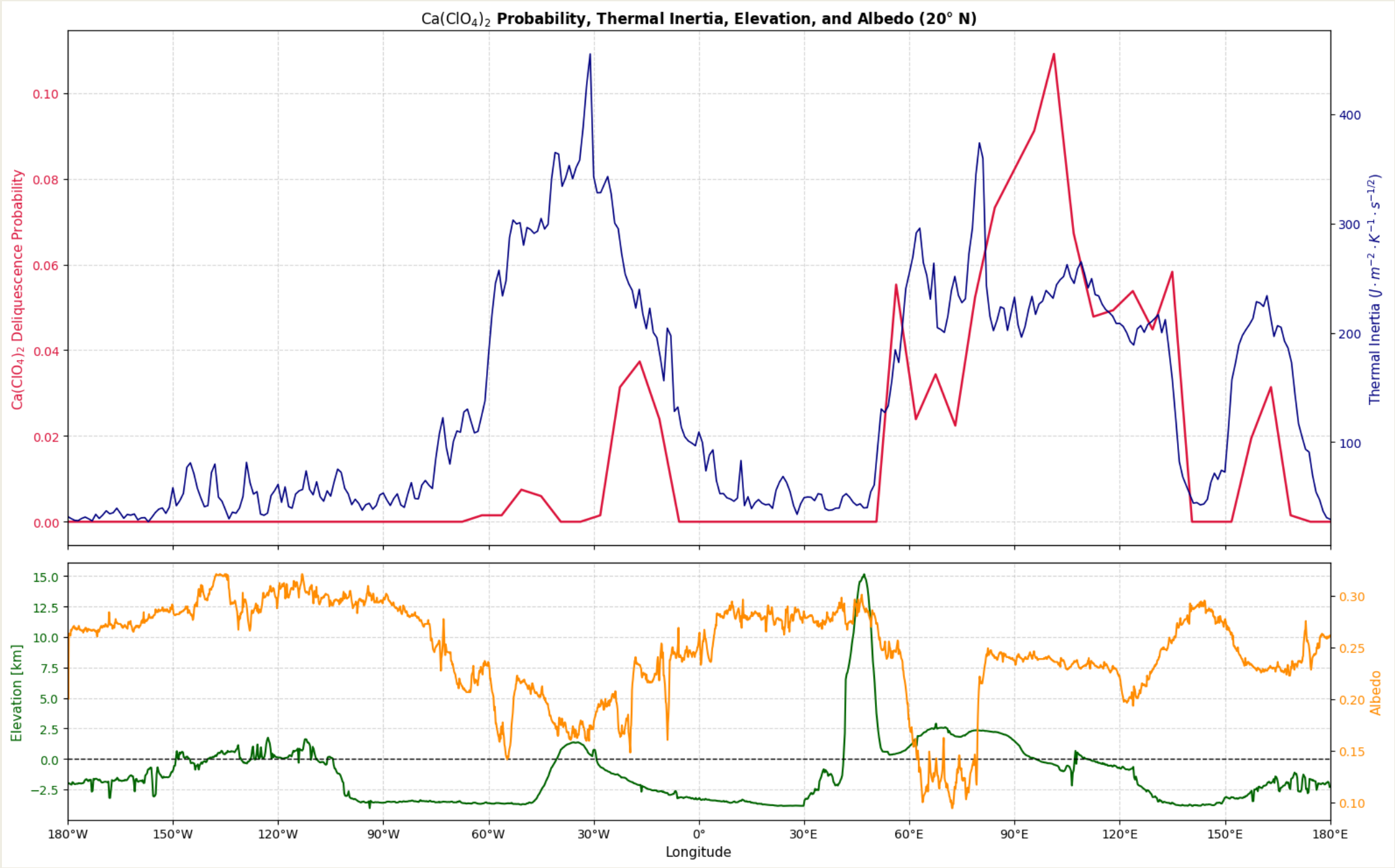
Number of favorable sols: 123

Number of favorable sols: 93

Thermal inertia (TI)



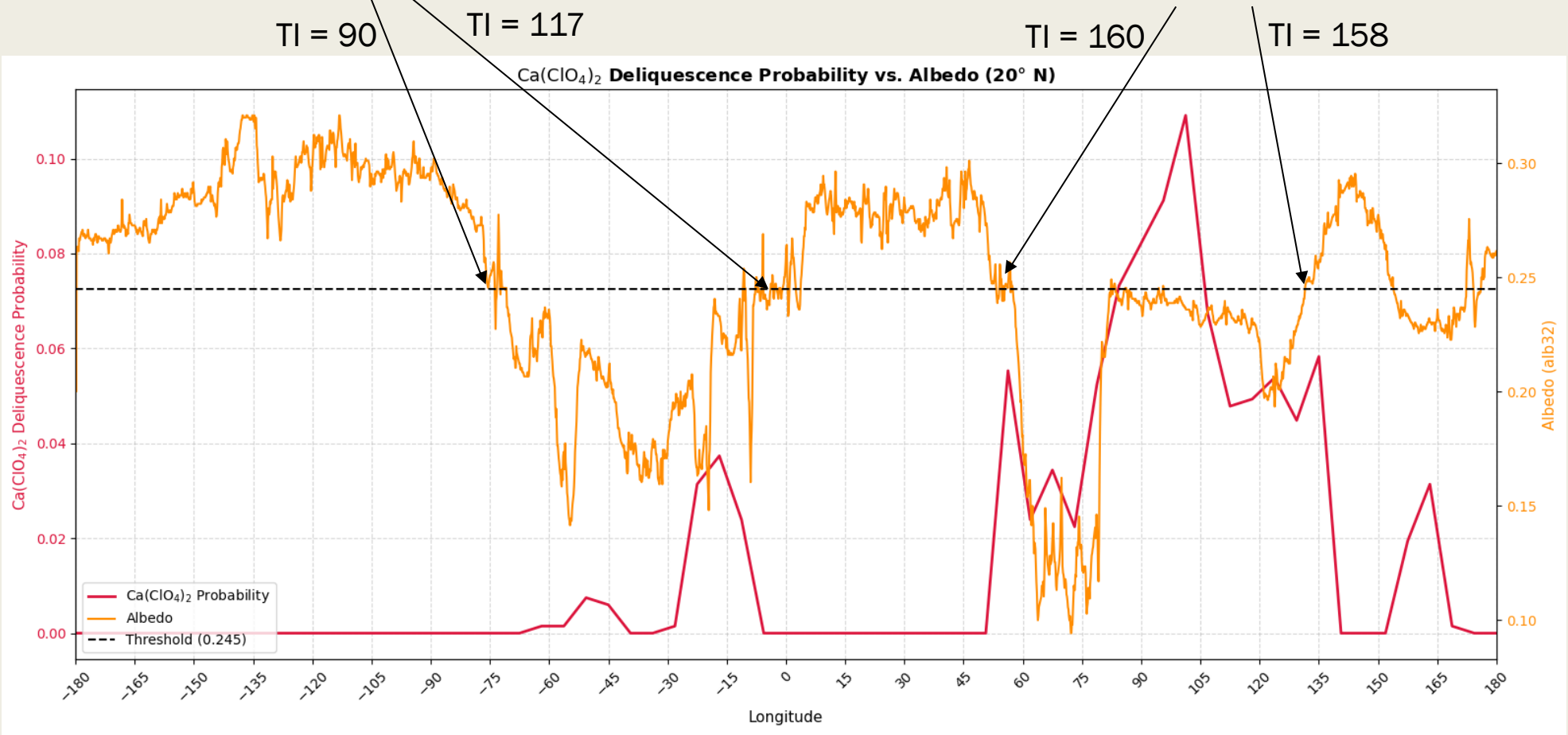
- Describes a material's resistance to temperature changes: $\mathrm{TI} = \sqrt{k\rho C}$
- The higher the value, the slower it warms up and cools down
- Determined by the micro- and macroscopic properties of the top few cm–dm surface layer
  (Piqueux et al., 2024)


Ca(ClO4)2 Probability, Thermal Inertia, Elevation, and Albedo (20° N)
Ca(ClO4)2 Deliquescence Probability
Thermal Inertia (J · m−2 · K−1 · s−1/2)
Elevation [km]
Albedo
Longitude
0.00
0.02
0.04
0.06
0.08
0.10
100
200
300
400
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
0.10
0.15
0.20
0.25
0.30
180°W
150°W
120°W
90°W
60°W
30°W
0°
30°E
60°E
90°E
120°E
150°E
180°E

- Constant Albedo baseline: A = 0.245
- Deliquescence probability increases significantly below the albedo threshold (A $\lesssim$ 0.25)
- <u>Anti-correlation:</u> Lower Albedo (Higher daytime temperatures) → Higher Deliquescence Probability
- <u>At the threshold boundary:</u> Thermal Inertia becomes the deciding factor for deliquescence

Temperature remains below 199 K

Higher surface temperatures



Future plans

- Main objective: understand the physical mechanisms behind brine formation
- Variability in similar areas: Identifying key drivers of deliquescence probability
- Thermal Inertia (TI): Evaluating its role and thermodynamic significance
- Refining parameters in favourable regions:
  - *Temperature fluctuations*
  - *Relative humidity*

Mars Climate Database (MCD)

- 3D Martian climate and weather database
- Based on climate model simulations from the Mars Planetary Climate Model (PCM)
- Objective: providing accurate physical and atmospheric data
- Spatial coverage:
  - *Vertically: extends from the surface to an altitude of 300 km*
  - *Horizontally: divides the planetary surface into a* $5.625° \times 3.75°$ *(longitude ×latitude) degree grid*
- Temporal averaging:
  - *Seasonal (12 months)*
  - *Diurnal cycle (12 time steps)*
  - *Typical days*