GRID-MAPPING MARS – QUANTIFYING THE GEOGRAPHY OF LANDFORMS

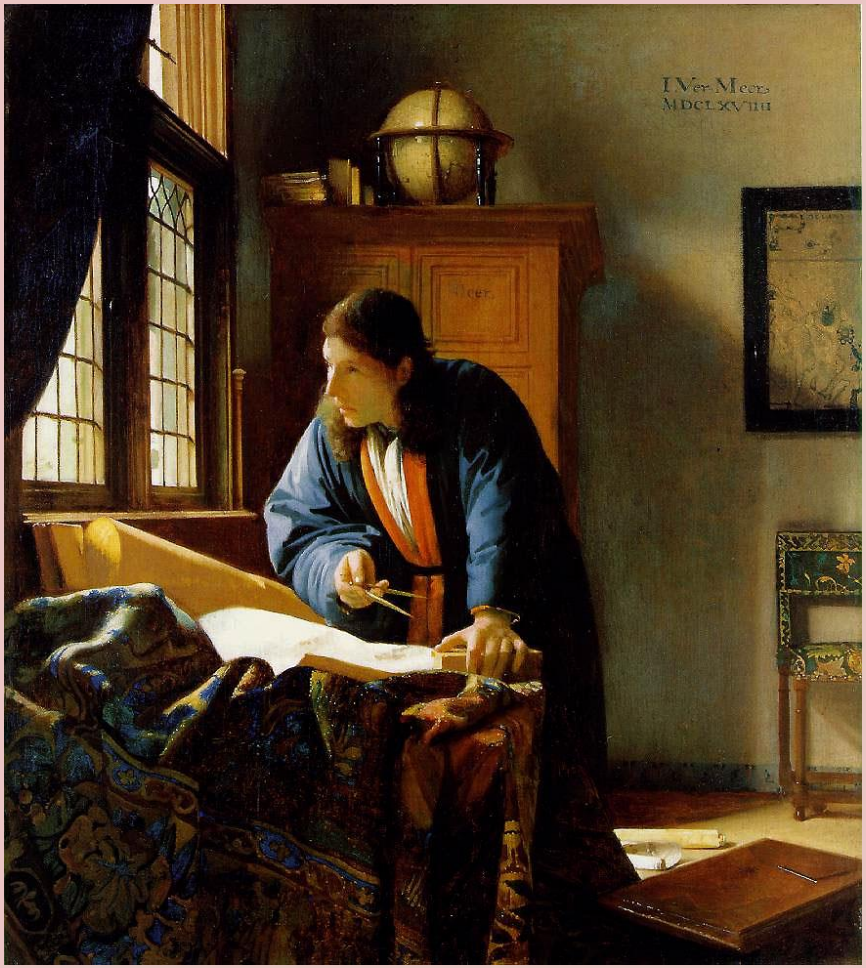
M. VOELKER

INTRODUCTION

GEOGRAPHY

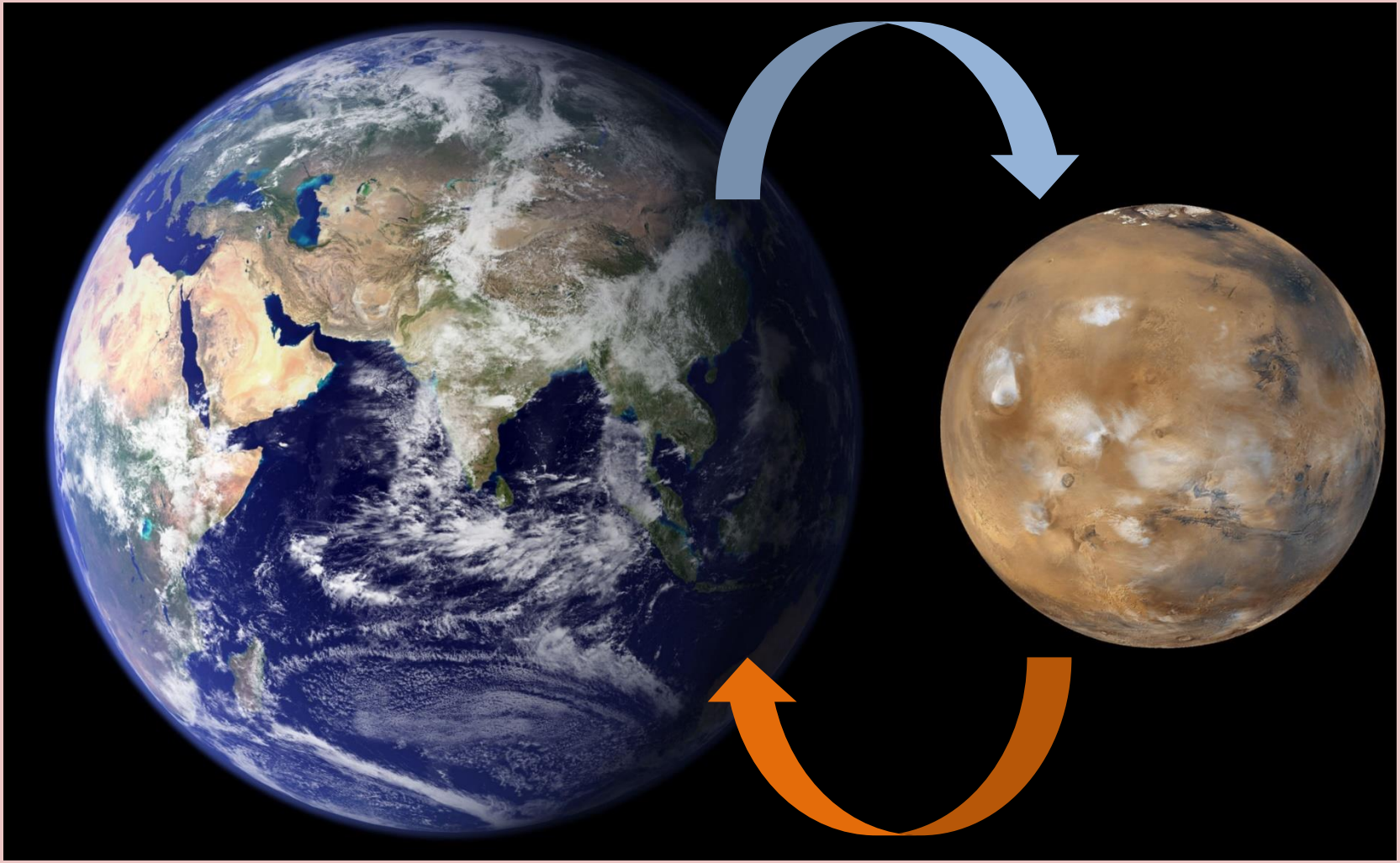
- Analysing the spatial distribution of objects
- Analysing the relationships between geospatial objects
- Interdisciplinary field of science

Here: Geology, Geomorphology, Climatology, Planetary/Space Science, (Human Geography)

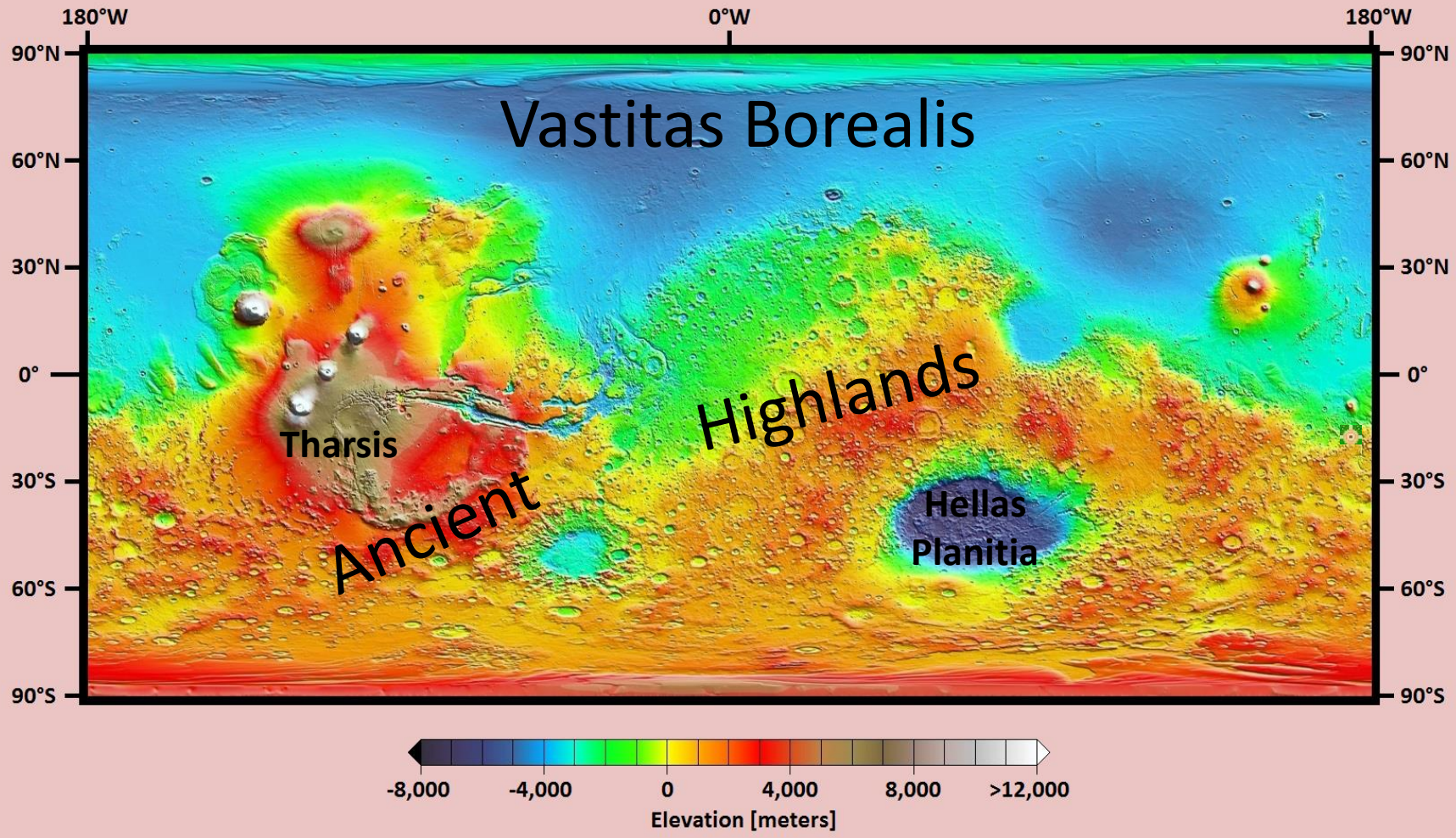


(Jan Vermeer, The Geographer, 1668/69)

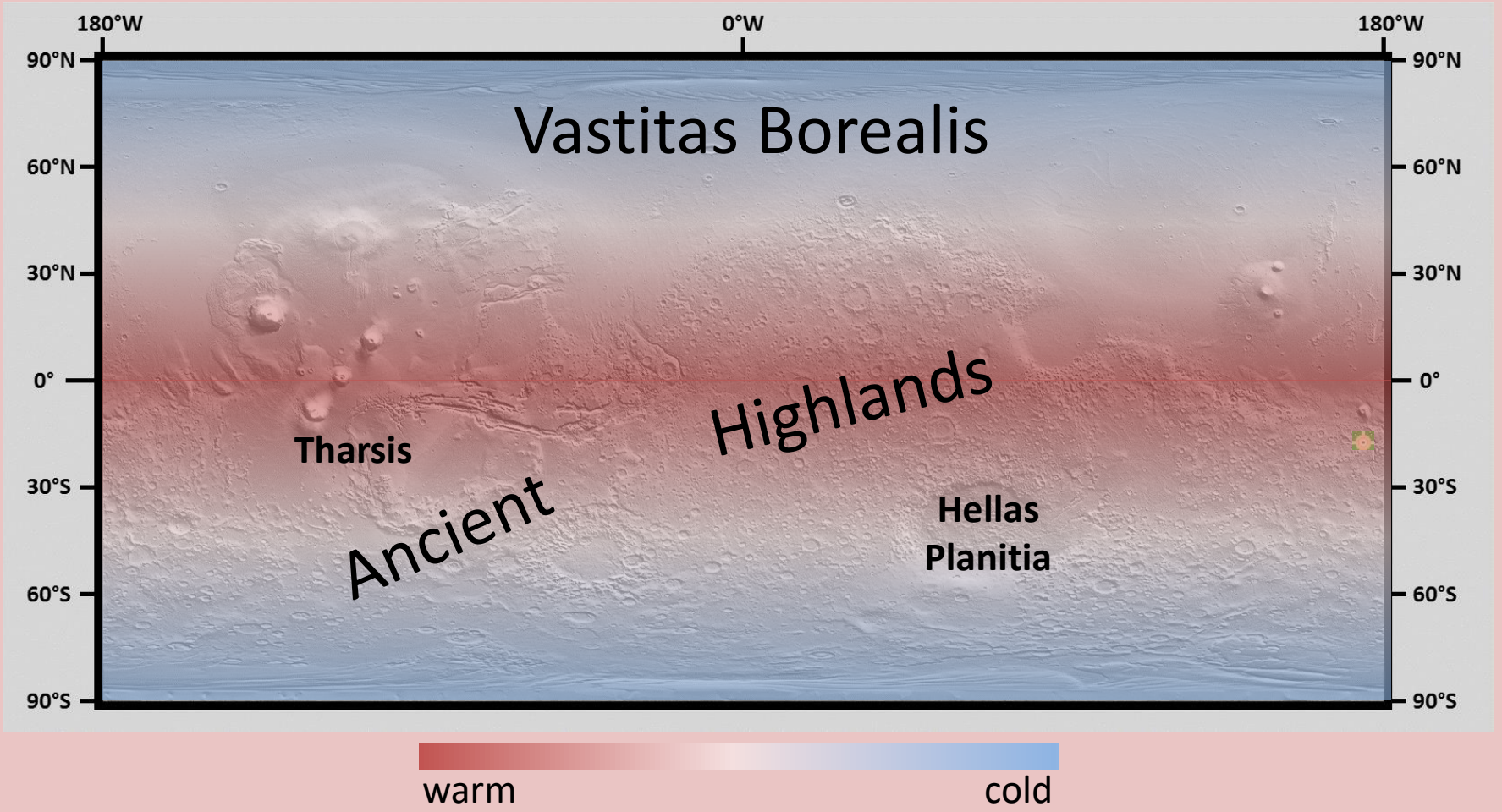
Introduction



INTRODUCTION



INTRODUCTION



INTRODUCTION

READING GEOMORPHOLOGY

Latitude → Temperature → **Evolution** ← Distribution ← **Landforms**

↓

Process

↓

(Aeolian)


10 km

INTRODUCTION

READING GEOMORPHOLOGY

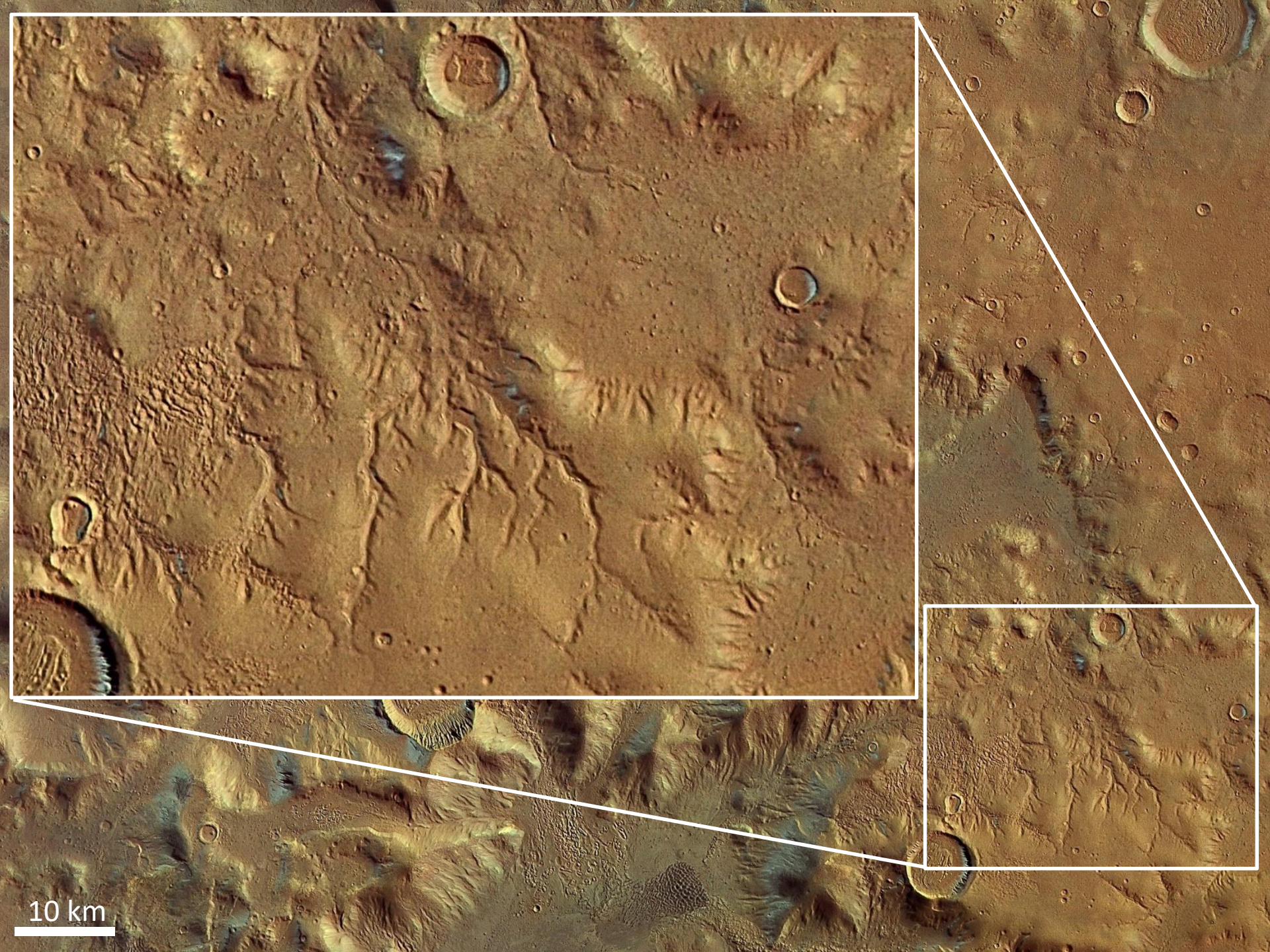
Latitude → Temperature → **Evolution** ← Distribution ← **Landforms**

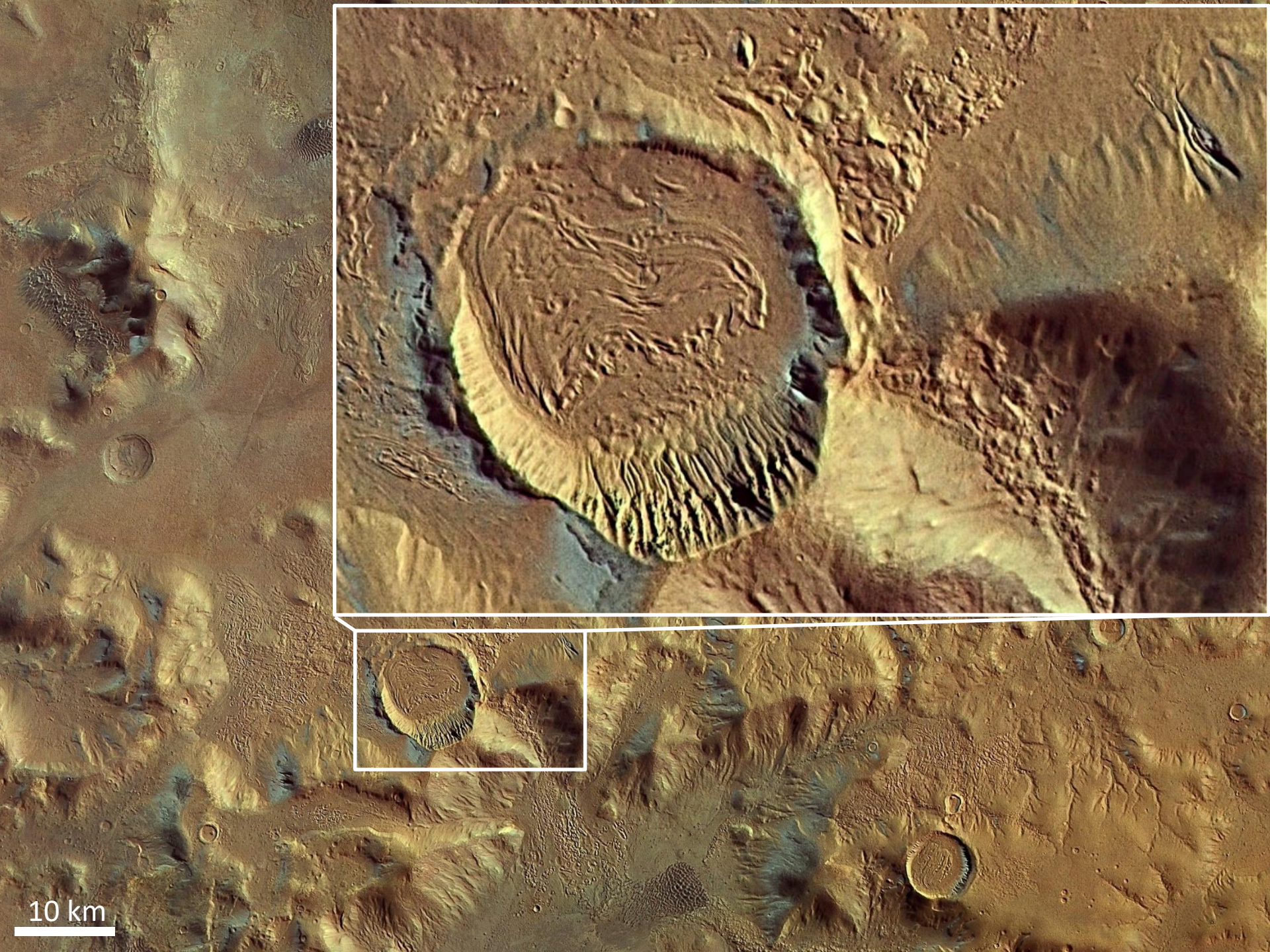
↓

Process

↓ ↘

Aeolian – **Fluvial**


10 km


10 km

INTRODUCTION

READING GEOMORPHOLOGY

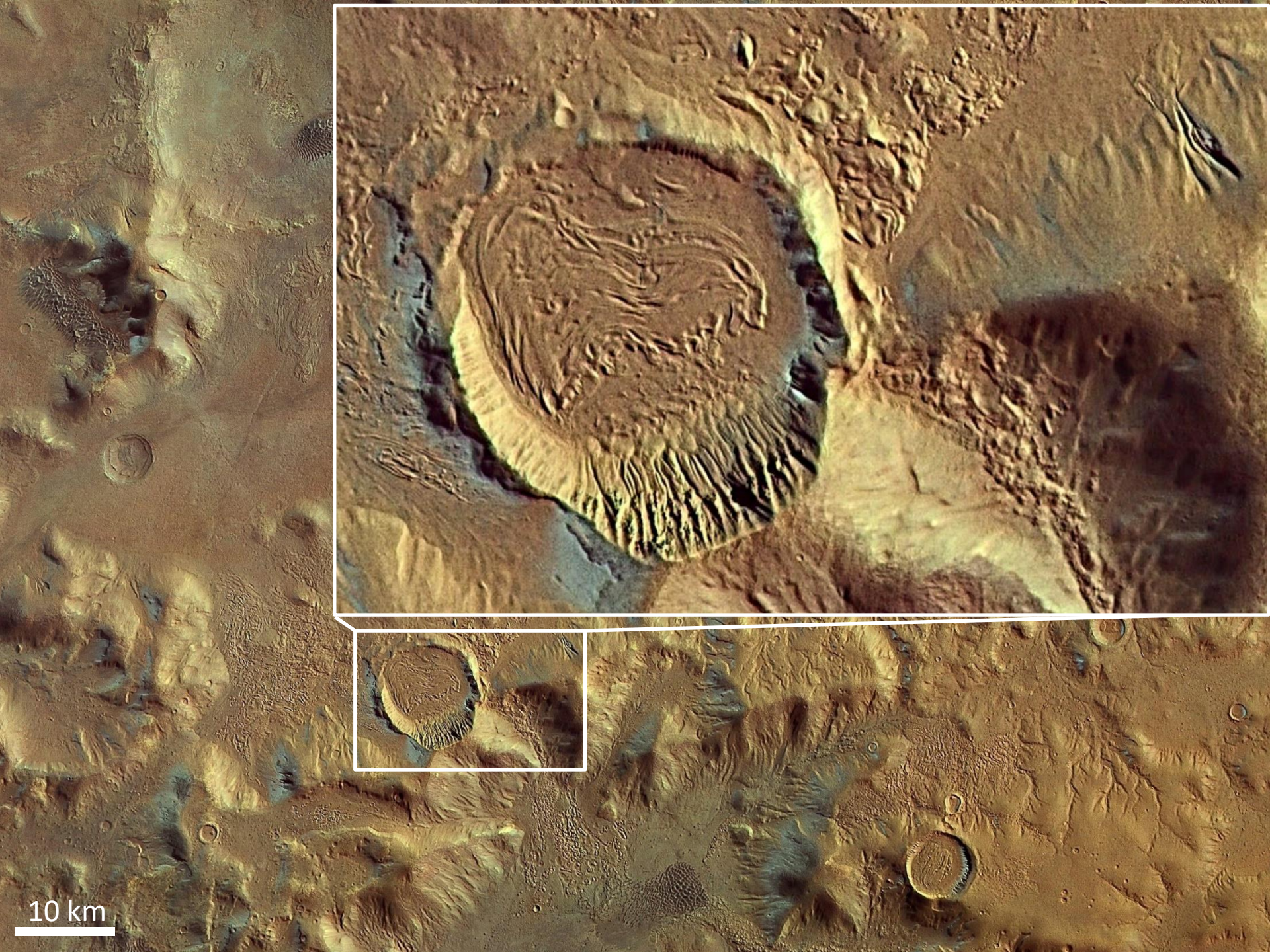
Latitude → Temperature → **Evolution** ← Distribution ← **Landforms**

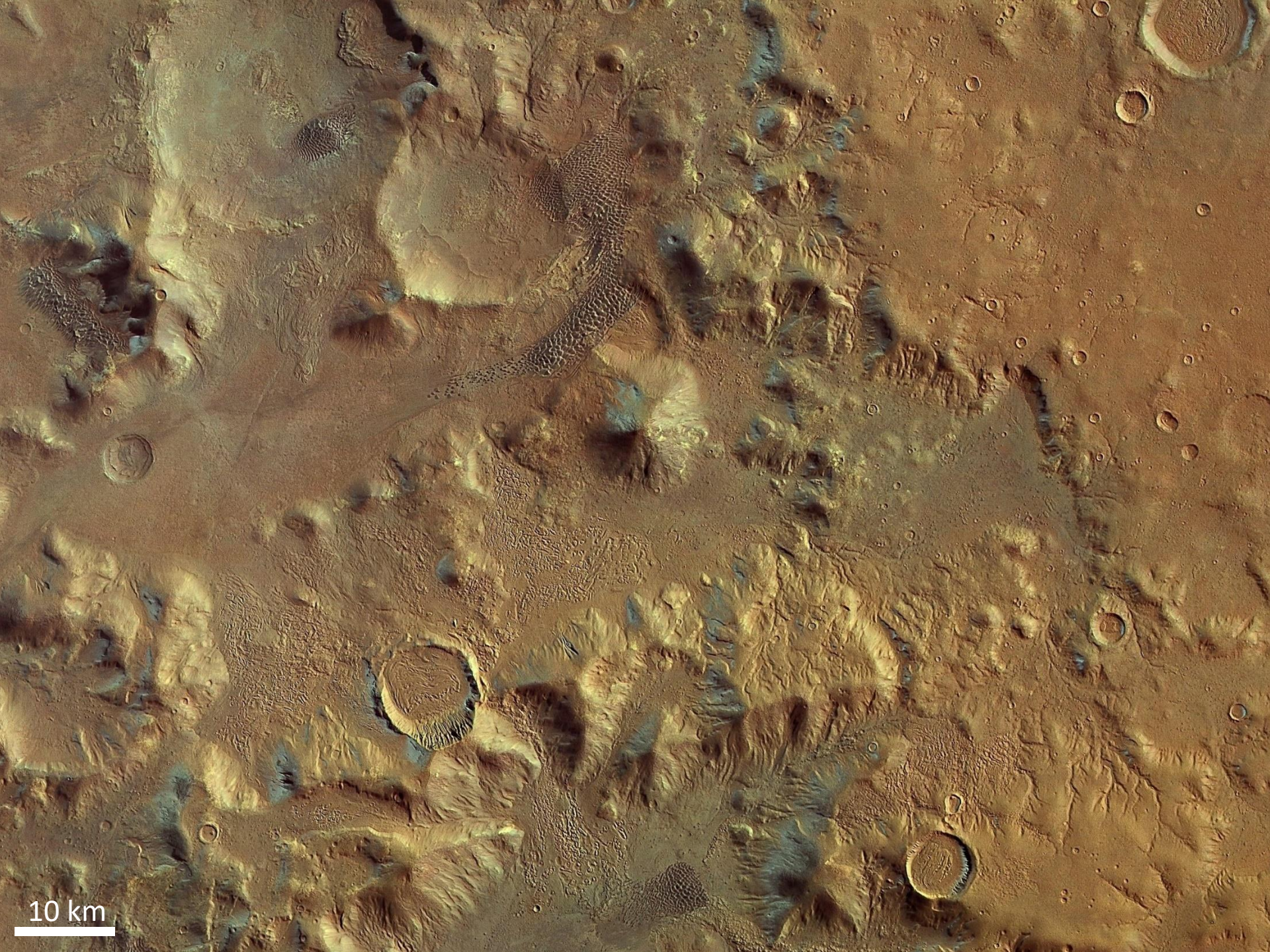
↓

Process

↙ ↓ ↘

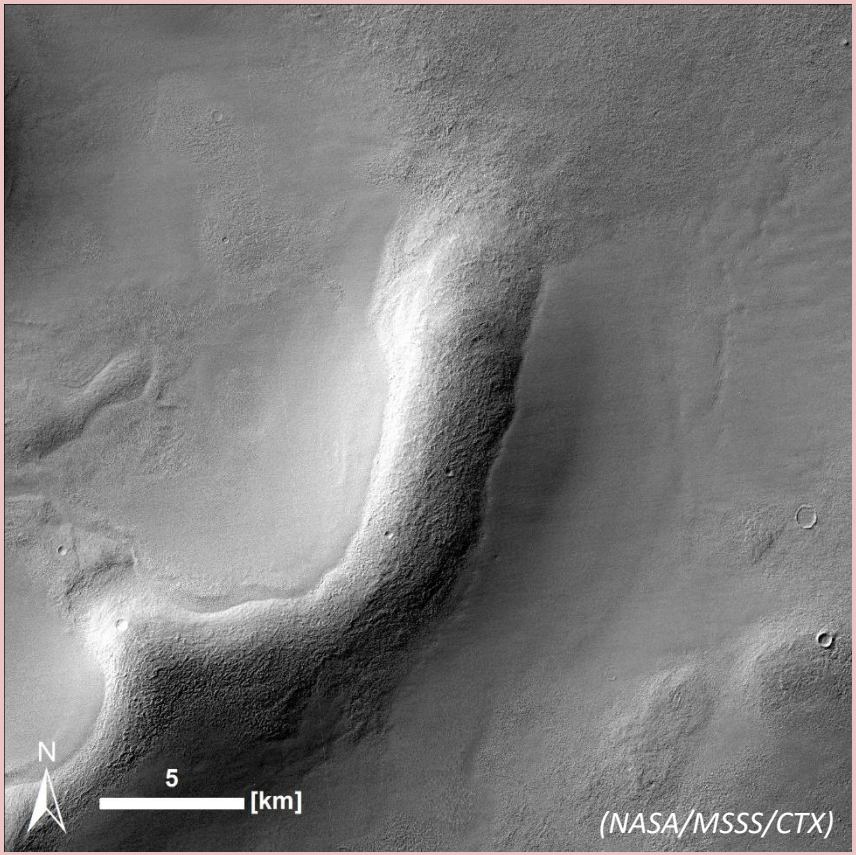
Glacial – (Aeolian) – Fluvial


10 km

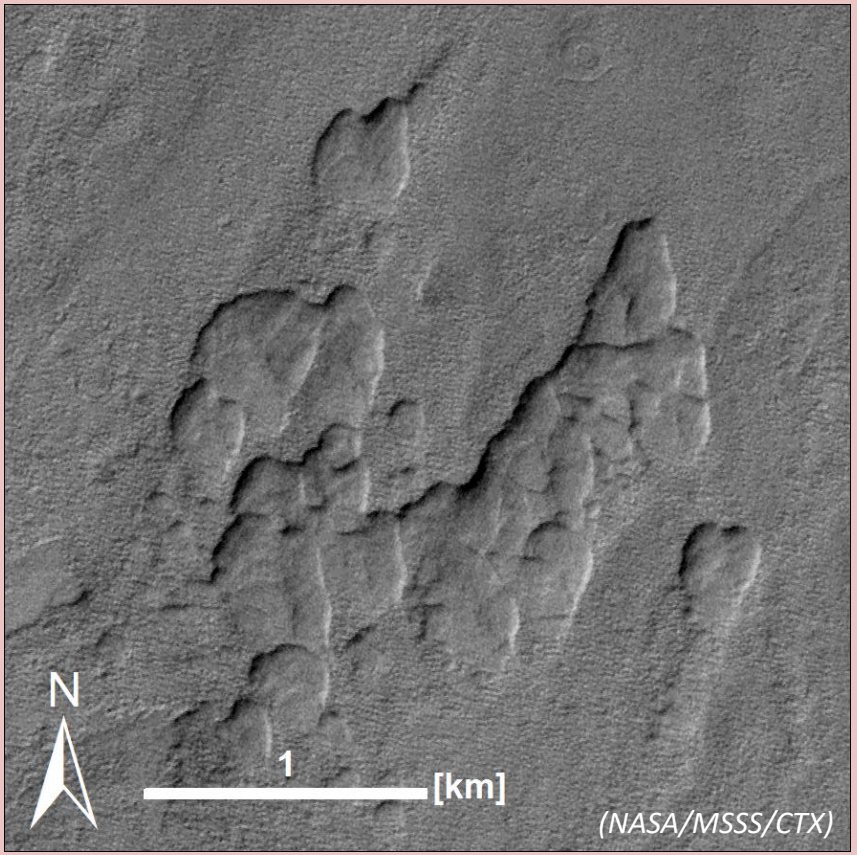

10 km

INTRODUCTION

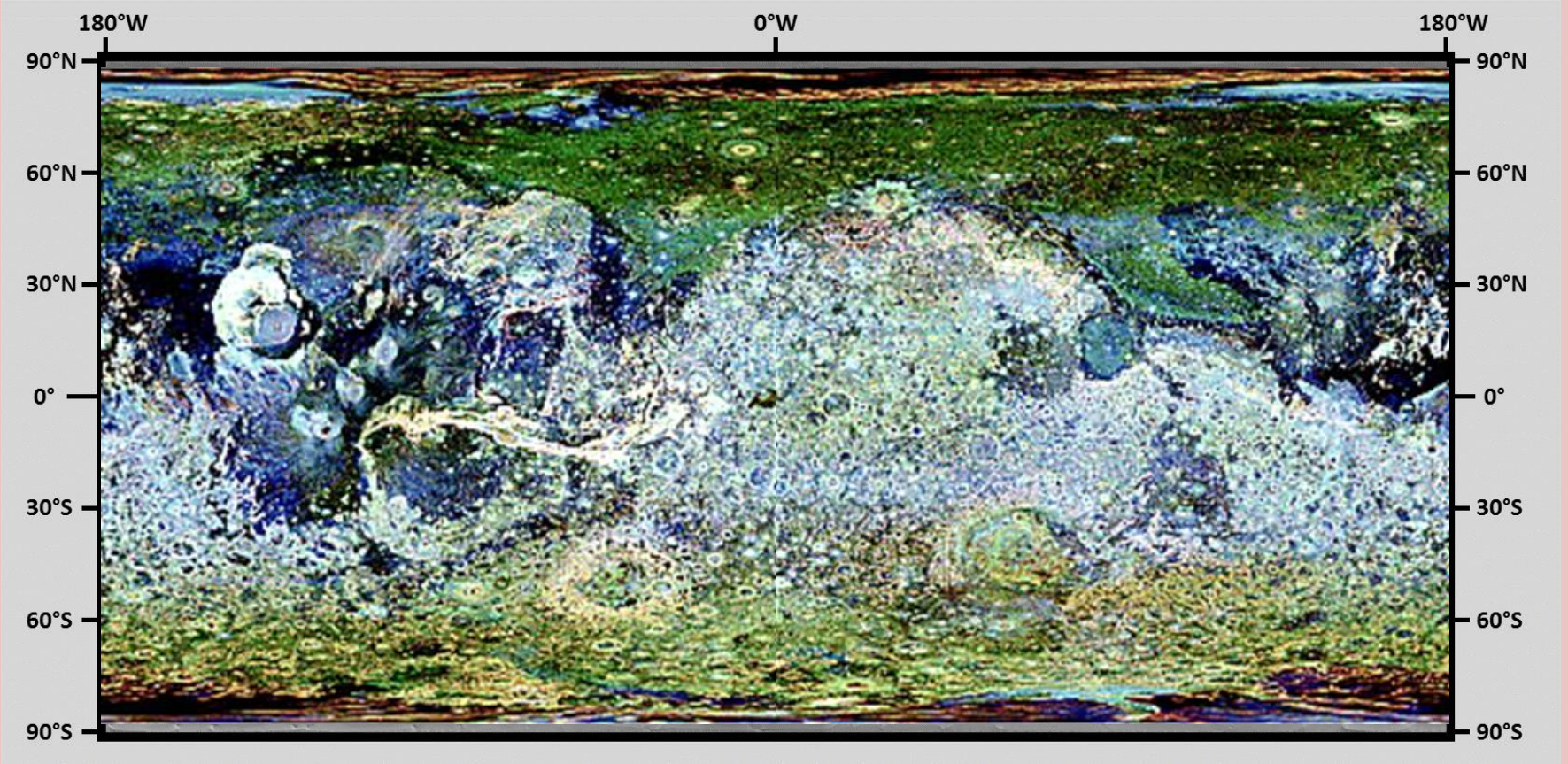
LATITUDE-DEPENDENT MANTLE – LDM (Deposition)



SCALLOPED TERRAIN (Erosion)

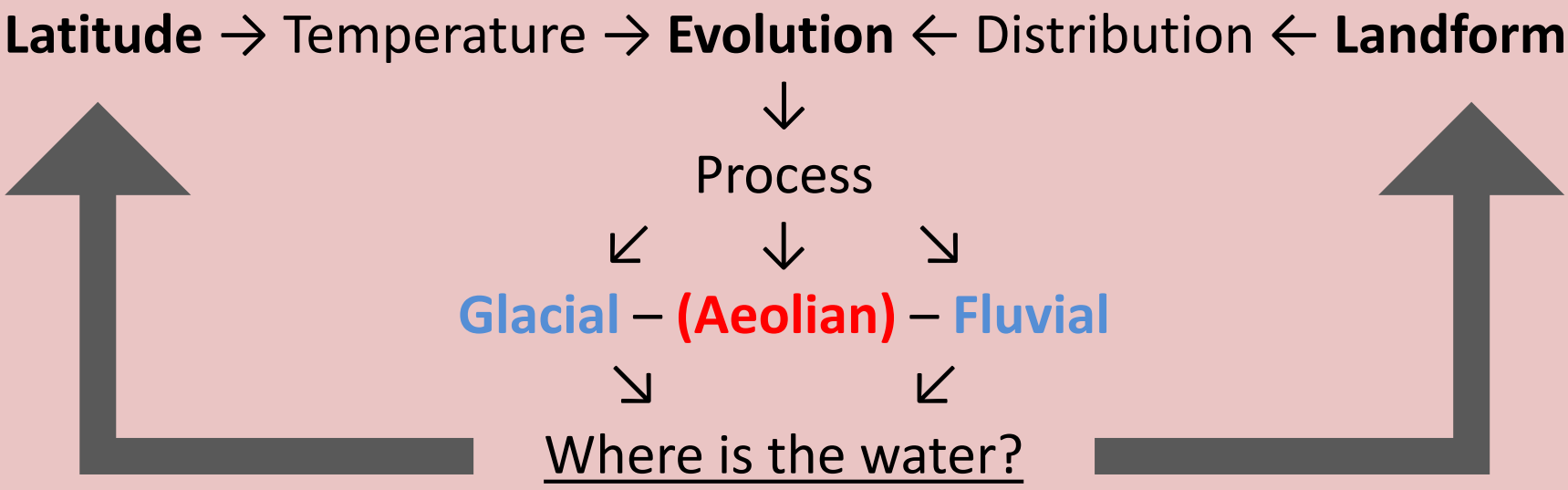


INTRODUCTION



Global distribution of LDM (Kreslavsky and Head, 2002)

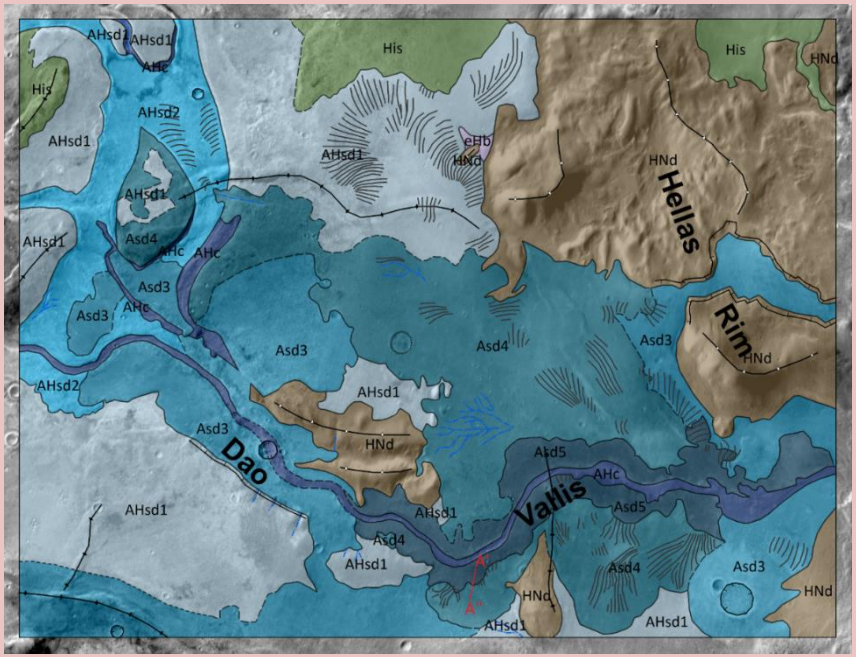
INTRODUCTION



INTRODUCTION

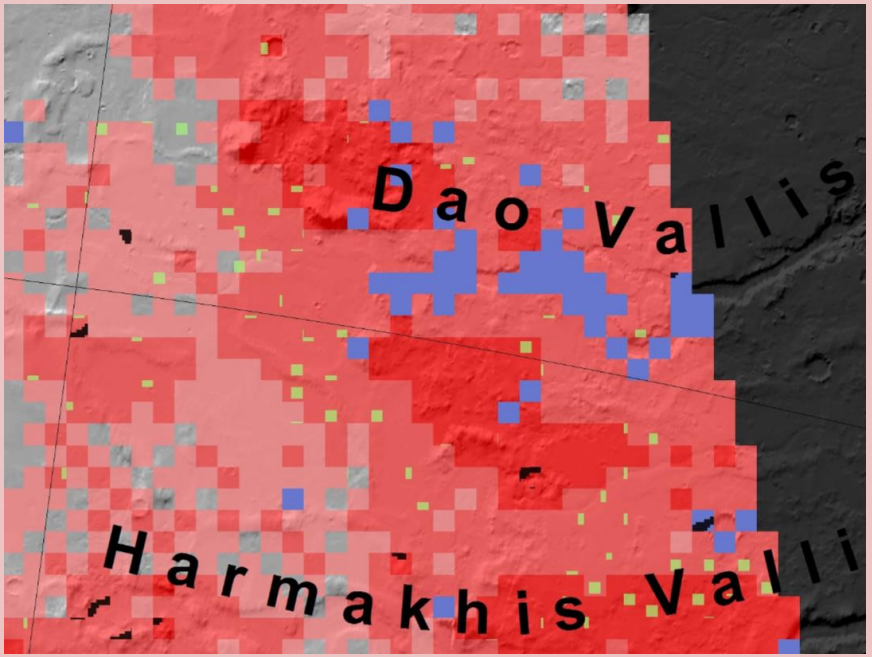
What is the best way to relate both parameters?

Classic geologic mapping



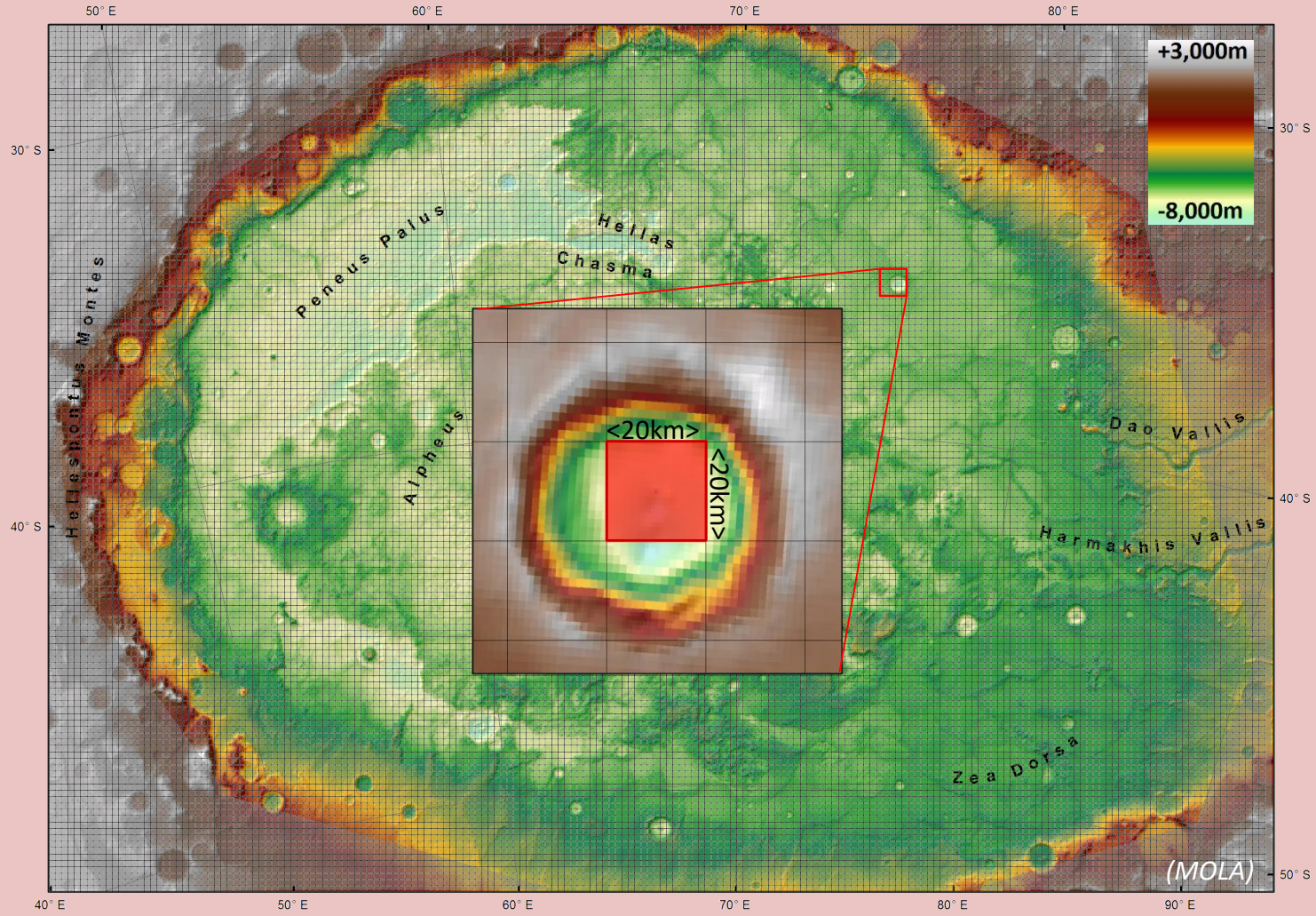
(Voelker et al., 2018)

Grid-mapping



(Voelker et al., 2017)

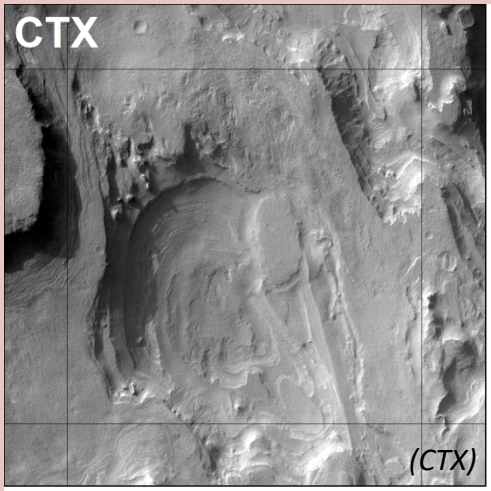
GRID MAPPING

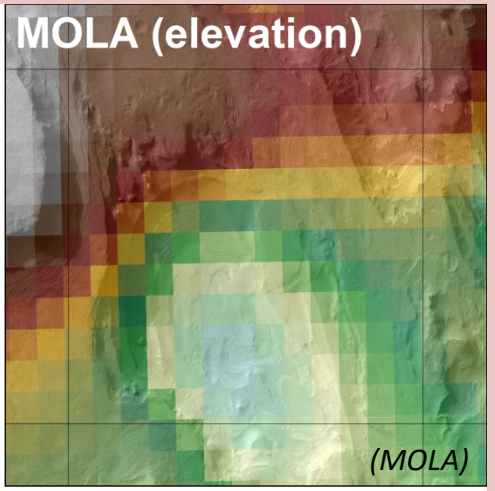


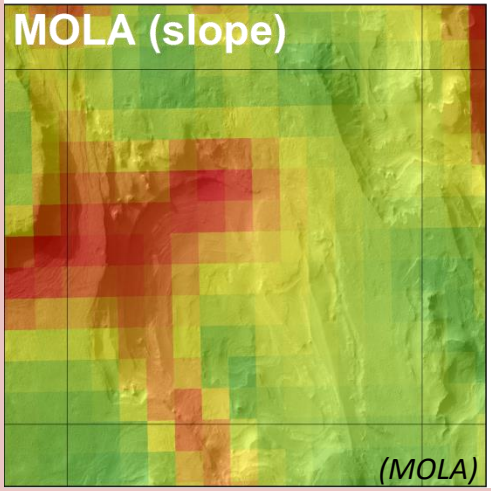
GRID MAPPING

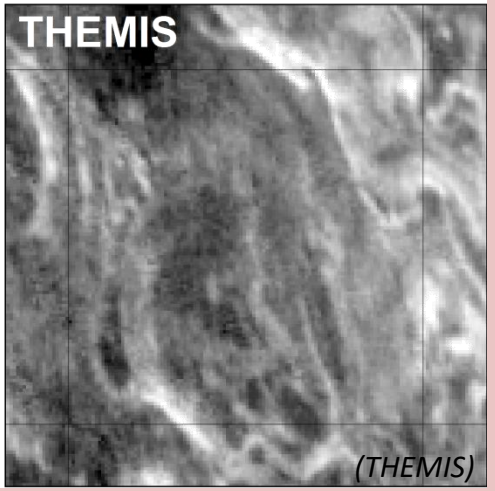
FID	Poly-gons	LTD	Gullies	Dunes
1	2	1	0	0
2	1	2	1	1
3	0	3	2	0
4	0	3	1	0

Categories	
0	Absent
1	Possible
2	Present
3	Dominant
4	No data

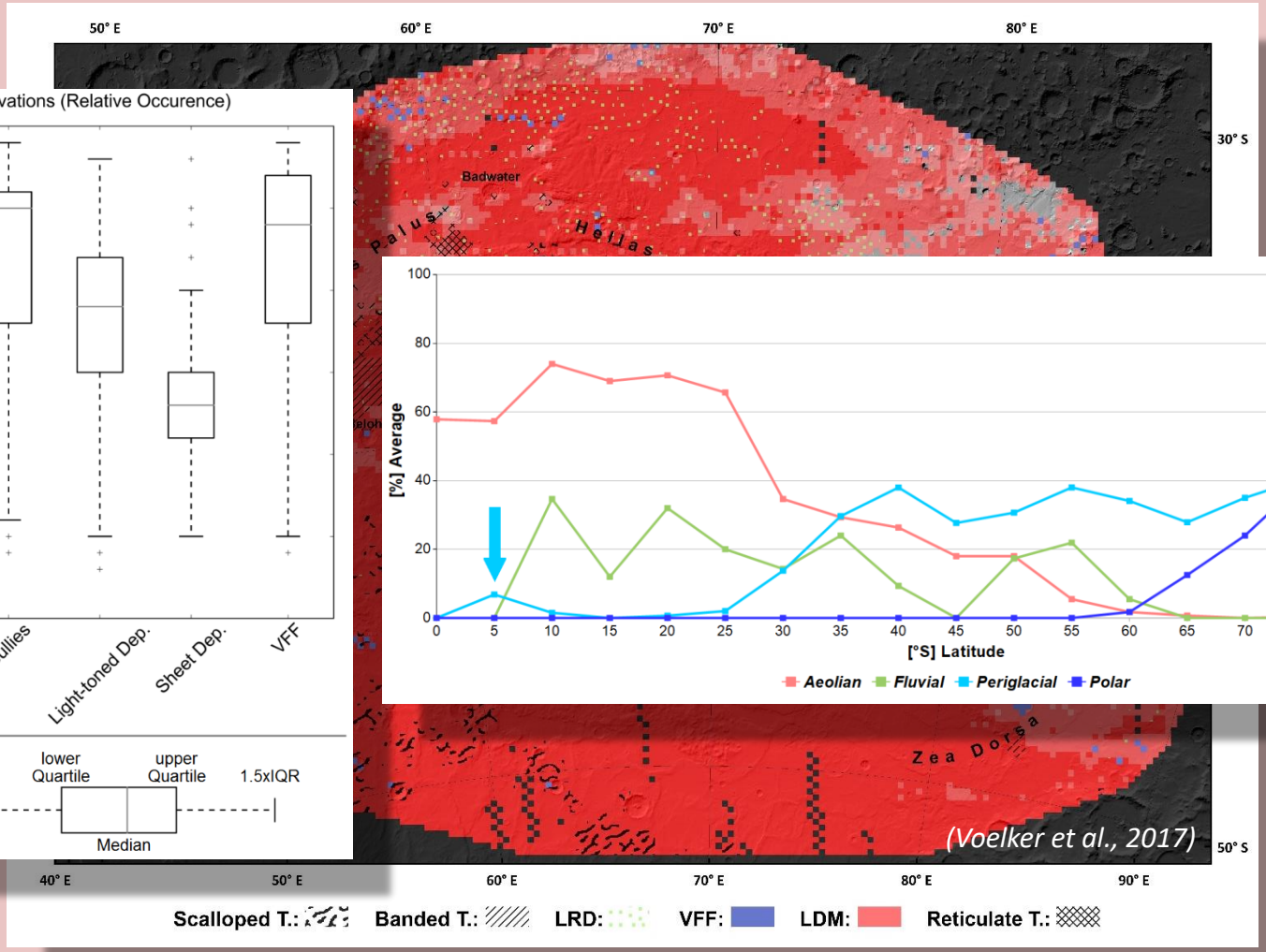








GRID MAPPING



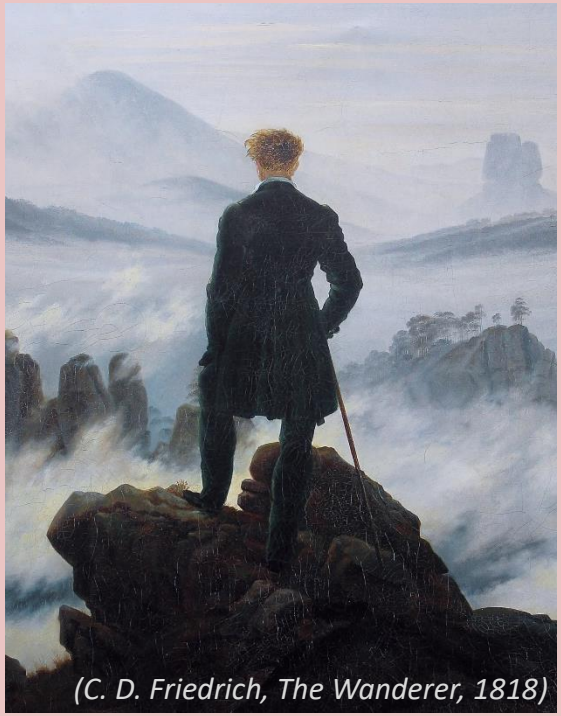
GRID MAPPING – PERSONAL PART!

Why not using machine learning?

- Too diverse selection of landforms; some landforms can be too similar or diffuse
- High variation of image qualities

- Human experience
- Human creativity
- Human intuition
- Getting a human feeling for the study area
- Finding new things serendipitously

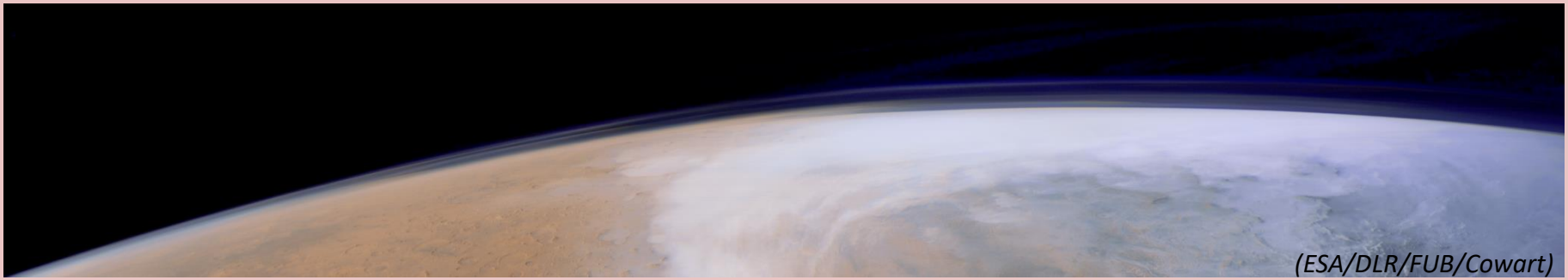
- *BUT: Machine learning can be used complementarily*


(C. D. Friedrich, The Wanderer, 1818)

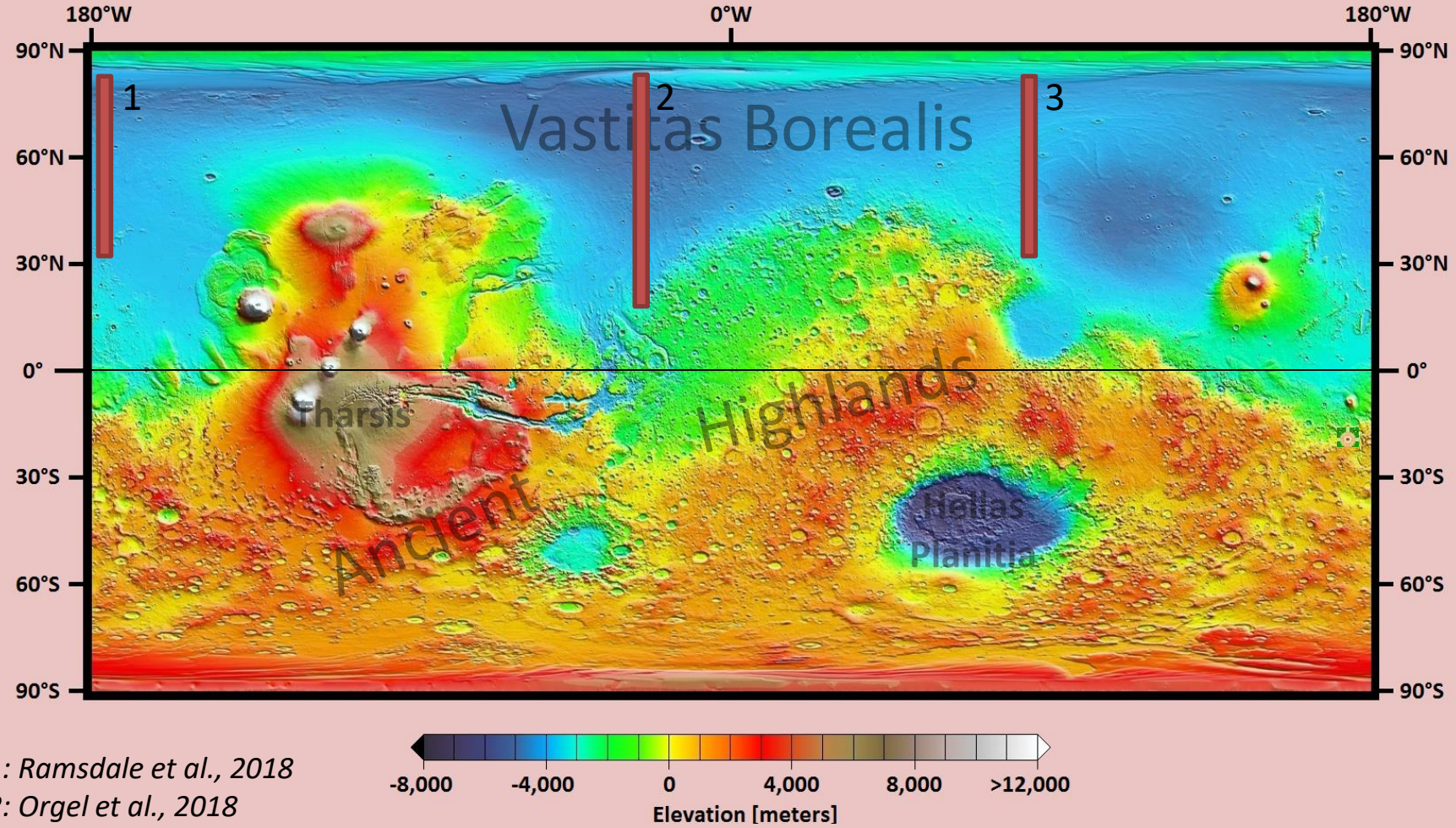
GRID MAPPING

Key questions of this work:

- Can geography reveal information about composition/evolution of landforms?
- What climatic information can we derive from the distribution of landforms?
- Is it possible to distinguish climate zones/environments?
- What is the difference between the northern and southern hemisphere?



GRID MAPPING: NORTHERN LOWLANDS



1: Ramsdale et al., 2018
2: Orgel et al., 2018
3: Séjourné et al., 2018

GRID MAPPING: NORTHERN LOWLANDS

APPROACH

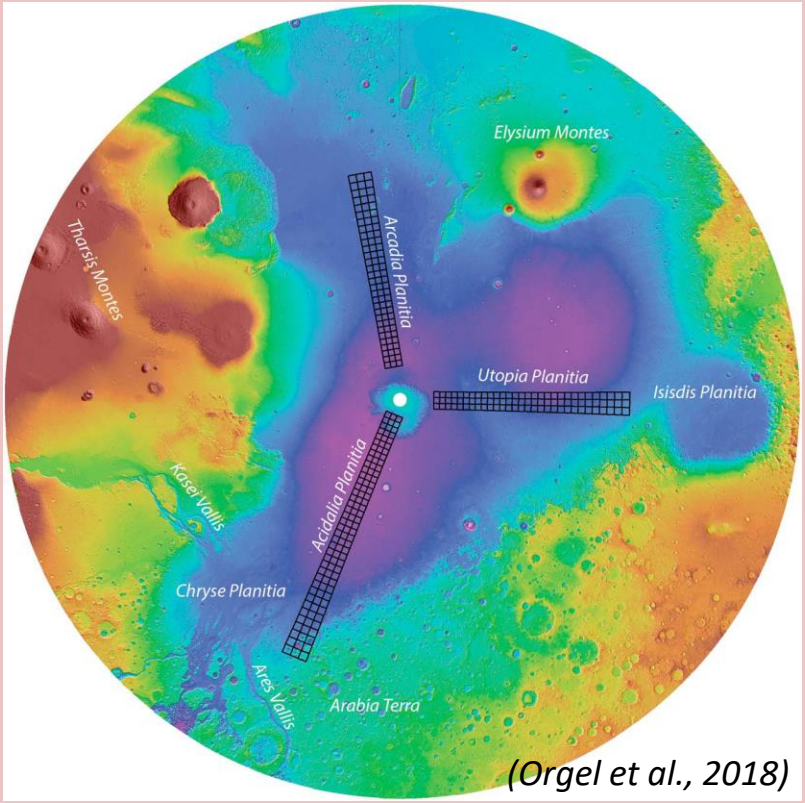
- Grid Mapping acc. to RAMSDALE et al. (2017)
- GIS environment
- Mapping scale 1:10,000 to 1:20,000
- Grid-size 20×20 km
- Focus on periglacial landforms

DATASETS

- CTX, ConTeXt Camera (visual; 6 m/px)
- MOLA, Mars Orbiter Laser Altimeter

STUDY AREAS

Region	Author	Latitudes	Landforms
Arcadia	Ramsdale et al., 2018	30°-80°N	17
Acidalia	Orgel et al. 2018	20°-84°N	13
Utopia	Séjourné et al., 2018	30°-80°N	11



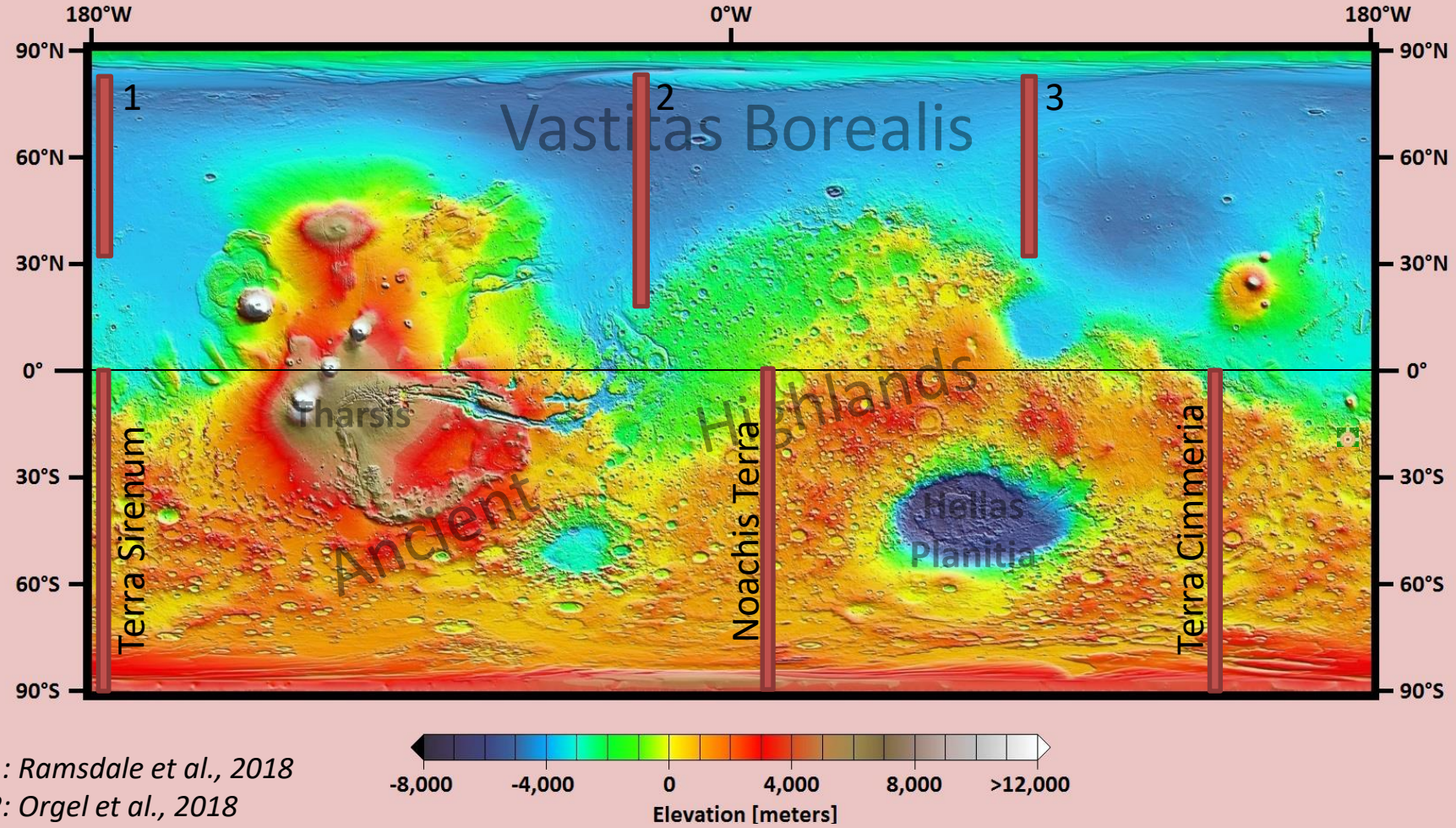
(Orgel et al., 2018)

GRID MAPPING: NORTHERN LOWLANDS

RESULTS

Region	Author	Results
Arcadia	Ramsdale et al., 2018	- Ground ice occurs between 35°-78°N - Volatile-loss from 35°-70°N - Support of airfall hypothesis of LDM
Acidalia	Orgel et al. 2018	- Identification of 4 landform assemblages: 1: Polar cap 2: ice-related landforms 3: water-related landforms 4: irregularly shaped pits
Utopia	Séjourné et al., 2018	- Identification of 3 landform assemblages: 30°-38°N: Polygons, bright mounds, age: 1 Ga 38°-47°N: LDM, Scalloped T., polygons (100m), age: 10 Ma 47°-78°N: LDM, polygons (30m), age: 1.5 Ma

GRID MAPPING: SOUTHERN LOWLANDS



1: Ramsdale et al., 2018
2: Orgel et al., 2018
3: Séjourné et al., 2018

METHODS

APPROACH

- Grid Mapping acc. to RAMSDALE et al. (2017)
- GIS environment
- 27 Landforms: (peri-)glacial, fluvial, aeolian
- Mapping scale 1:20,000
- 2 of 3 study areas have been mapped

DATASETS

- **CTX (visual; 6 m/px)**
- MOLA (elevation, slope, aspect)
- THEMIS (thermal inertia)
- DCI (Dust Cover Index)
- Albedo

LOCATION OF LANDFORMS

PARAMETERS

LARGE-SCALE SYNTHESIS

GOAL

Analysing the distribution of landforms on Mars‘ southern hemisphere by latitude, topography, and surface properties.

METHODS

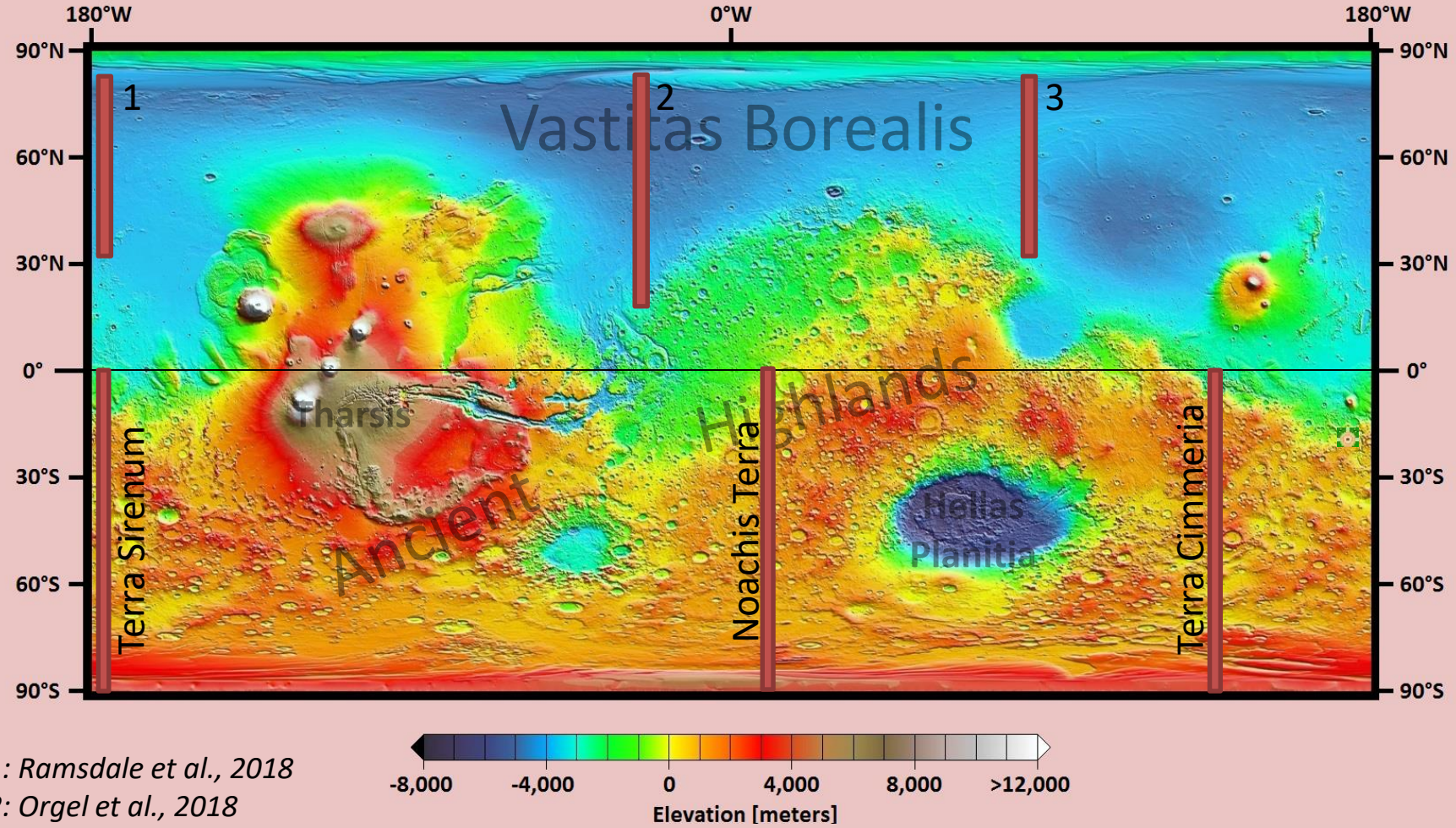
MAPPED LANDFORMS

(Peri-)glacial Landforms	
Latitude-dependent mantle (LDM)	Pedestal craters
Viscous-flow features (VFF)	Palimpsests
Scalloped terrain	Polygons
Gullies	

Fluvial landforms	
Dendritic channels	

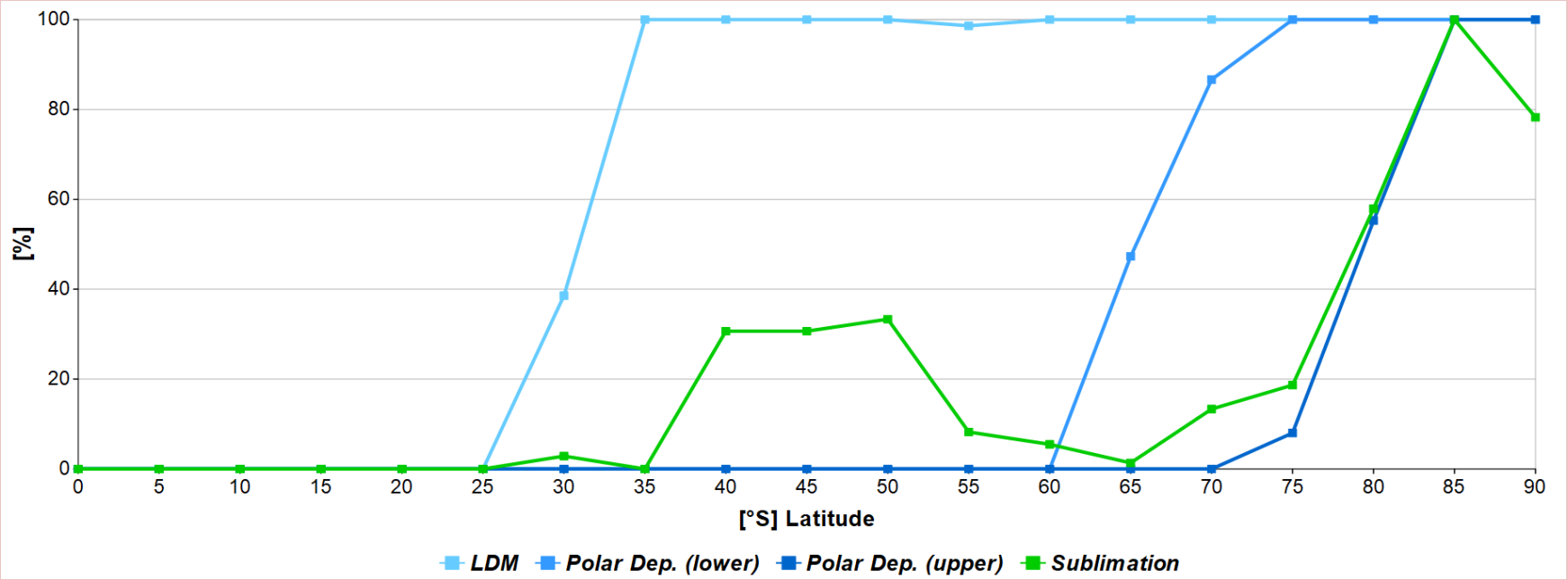
Aeolian Landforms	
Dunes	Transversal Aeolian Ridges (TARs)
Ripples	Dust

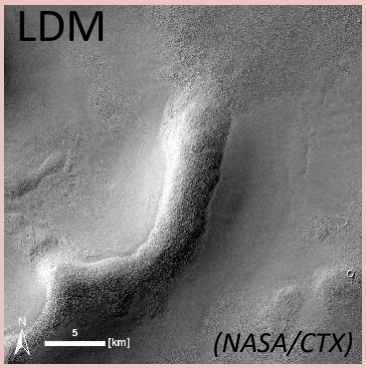
RESULTS – NOACHIS TERRA

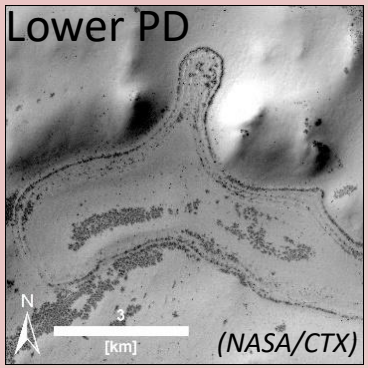


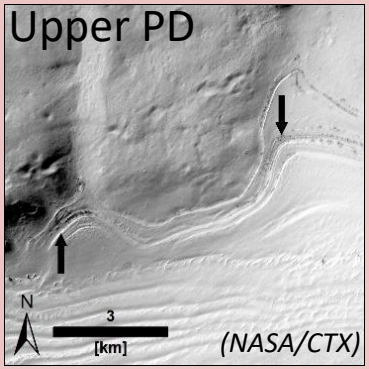
1: Ramsdale et al., 2018
2: Orgel et al., 2018
3: Séjourné et al., 2018

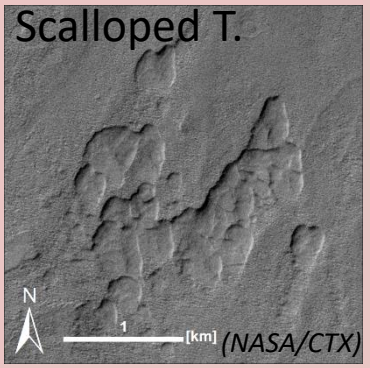
RESULTS – NOACHIS TERRA



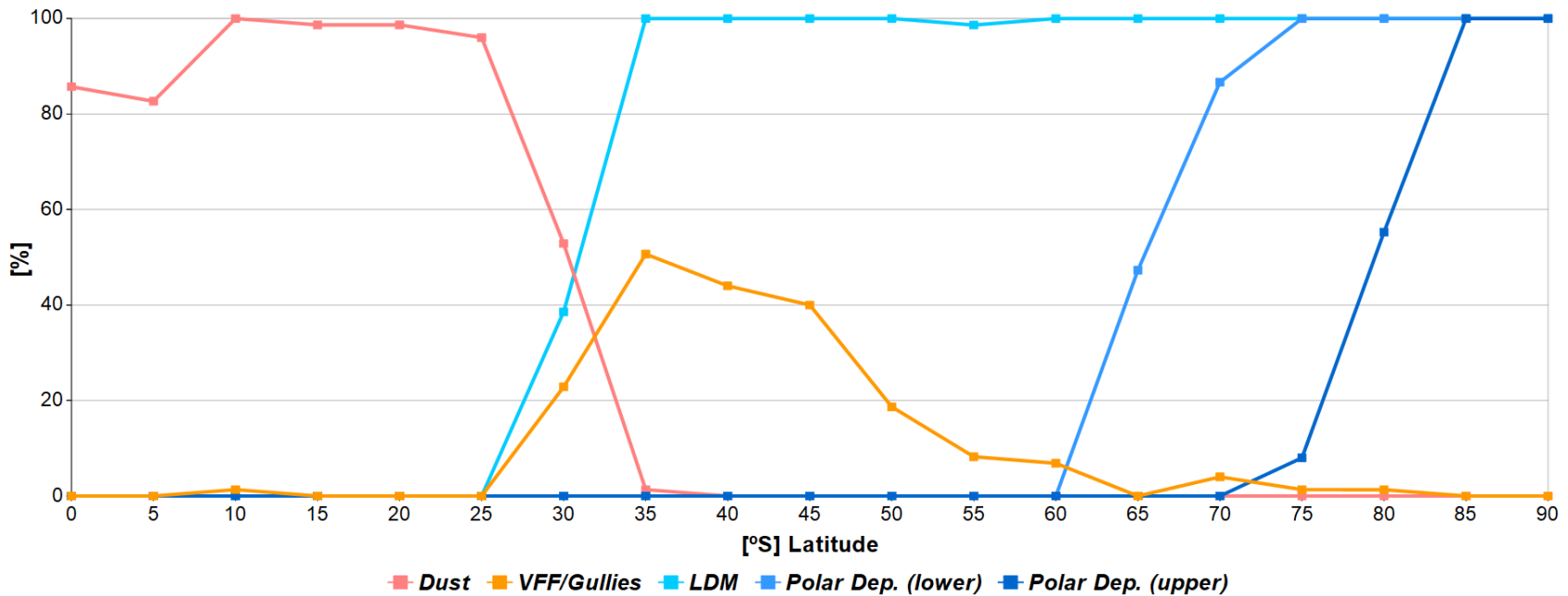


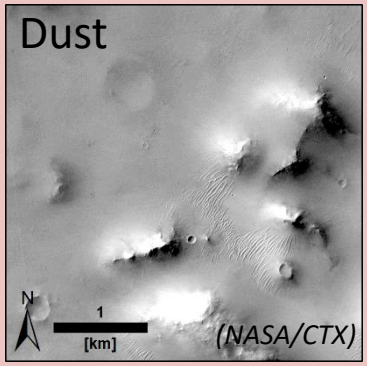


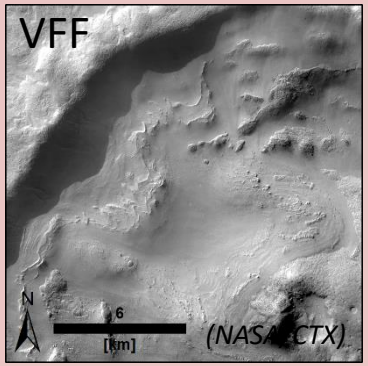


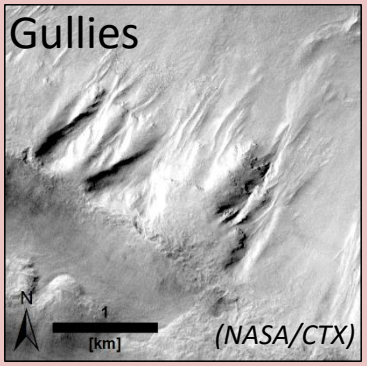


RESULTS – NOACHIS TERRA

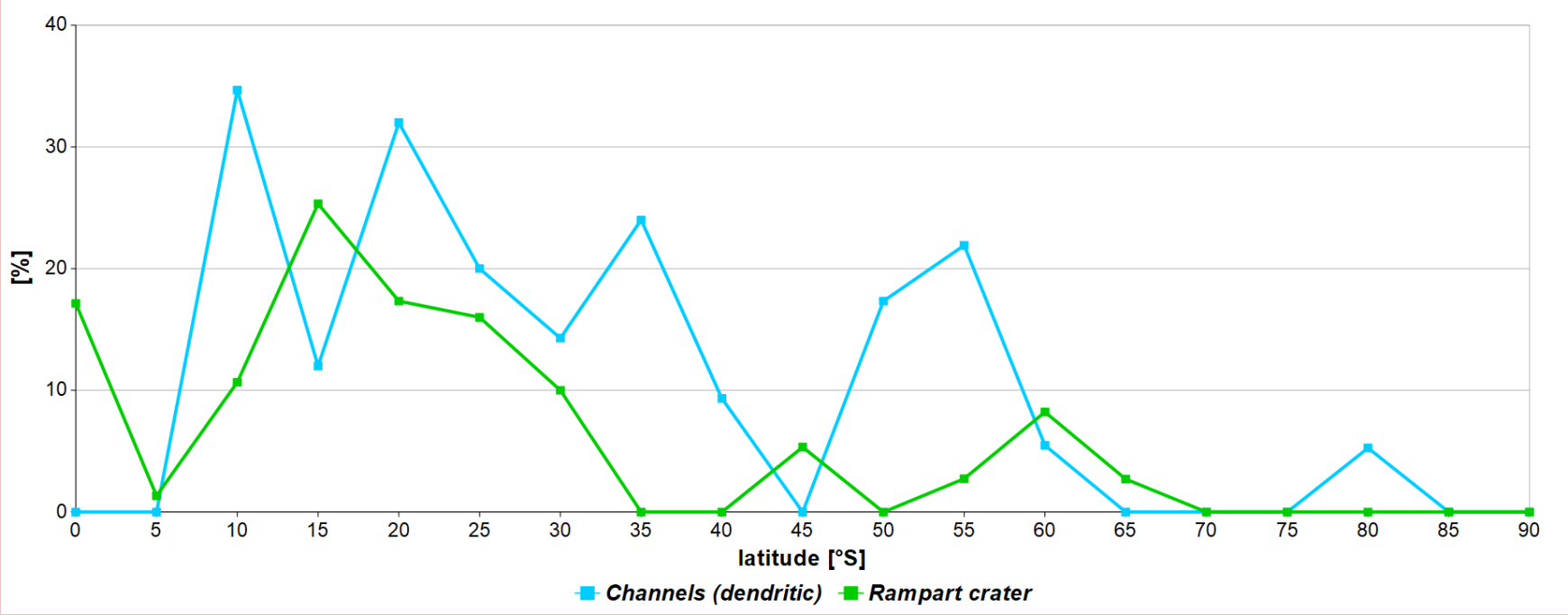


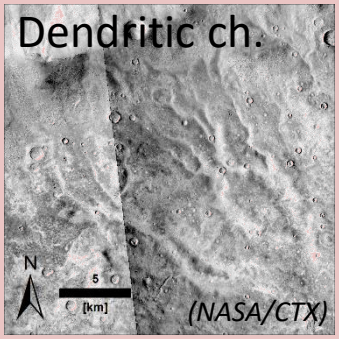


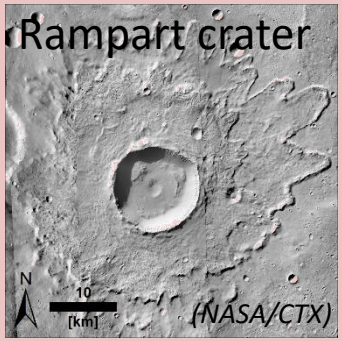




RESULTS – NOACHIS TERRA

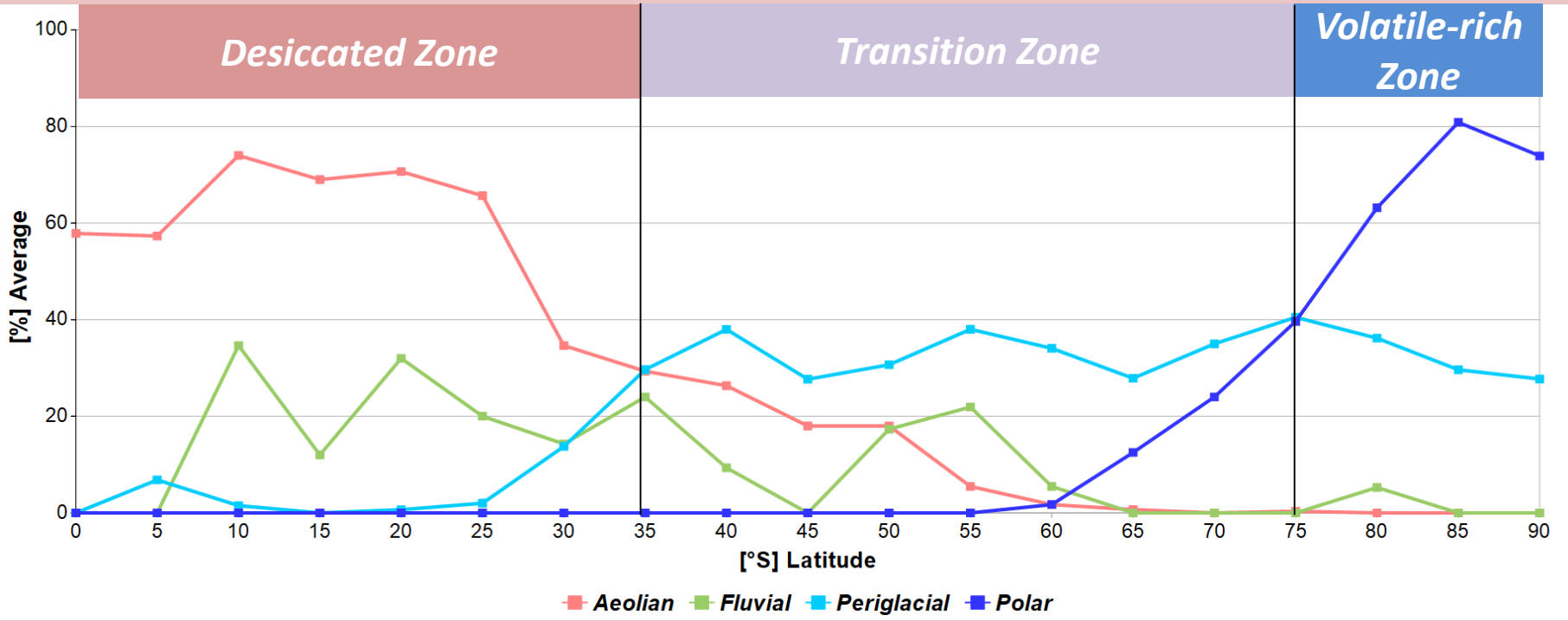






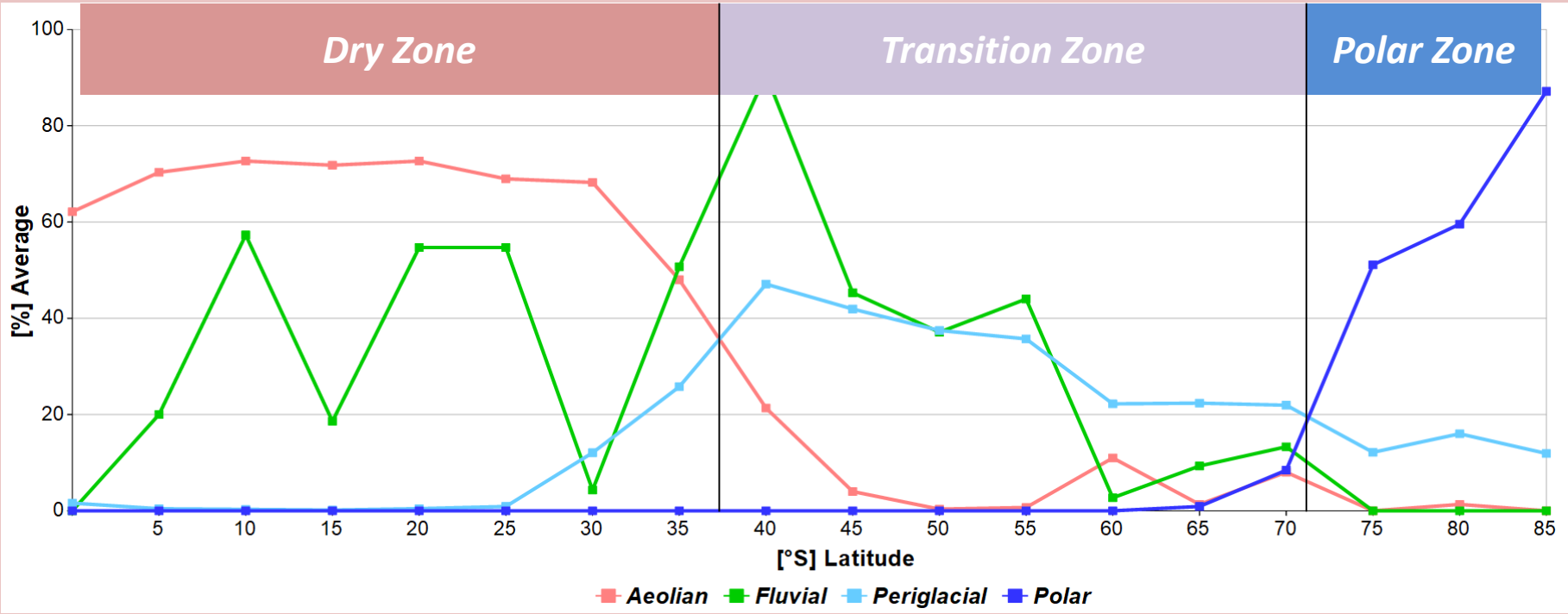
RESULTS – NOACHIS TERRA

ENVIRONMENTAL ZONES



Process	Landforms
Aeolian	*Dunes, transversal aeolian ridges (TAR), ripples, dust*
Fluvial	*Channels (dendritic)*
(Peri)-glacial	*LDM, scalloped terrain, viscous-flow features, polygons, gullies, pedestal craters, palimpsests*
Polar	*Polar deposits (lower, upper), polar pits, dark material*

RESULTS – TERRA CIMMERIA

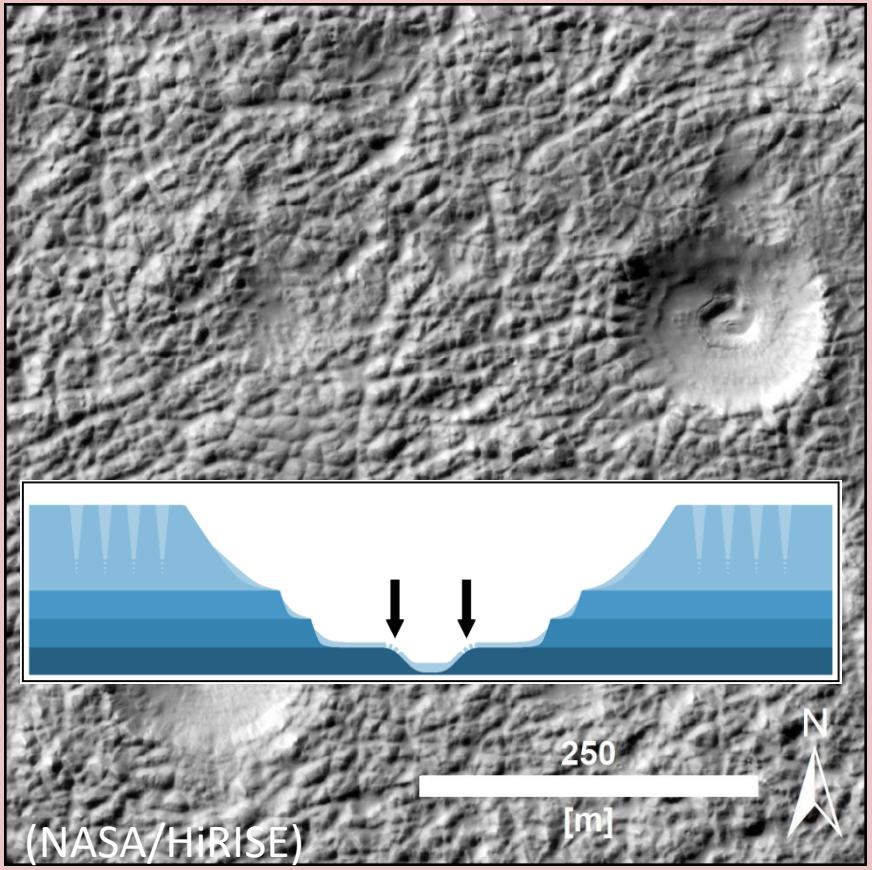


Process	Landforms
Aeolian	*Dunes, transversal aeolian ridges (TAR), ripples, dust*
Fluvial	*Channels (dendritic)*
(Peri)-glacial	*LDM, scalloped terrain, viscous-flow features, polygons, gullies, pedestal craters, palimpsests*
Polar	*Polar deposits (lower, upper), polar pits, dark material*

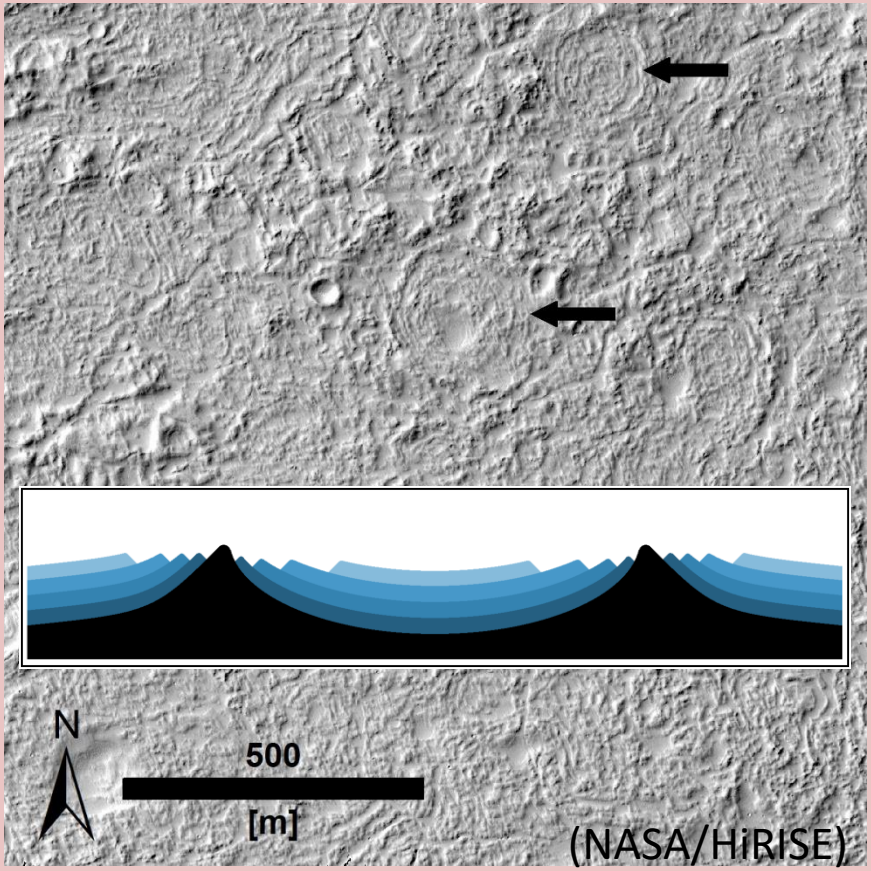
RESULTS – NOACHIS TERRA

SERENDIPITIES

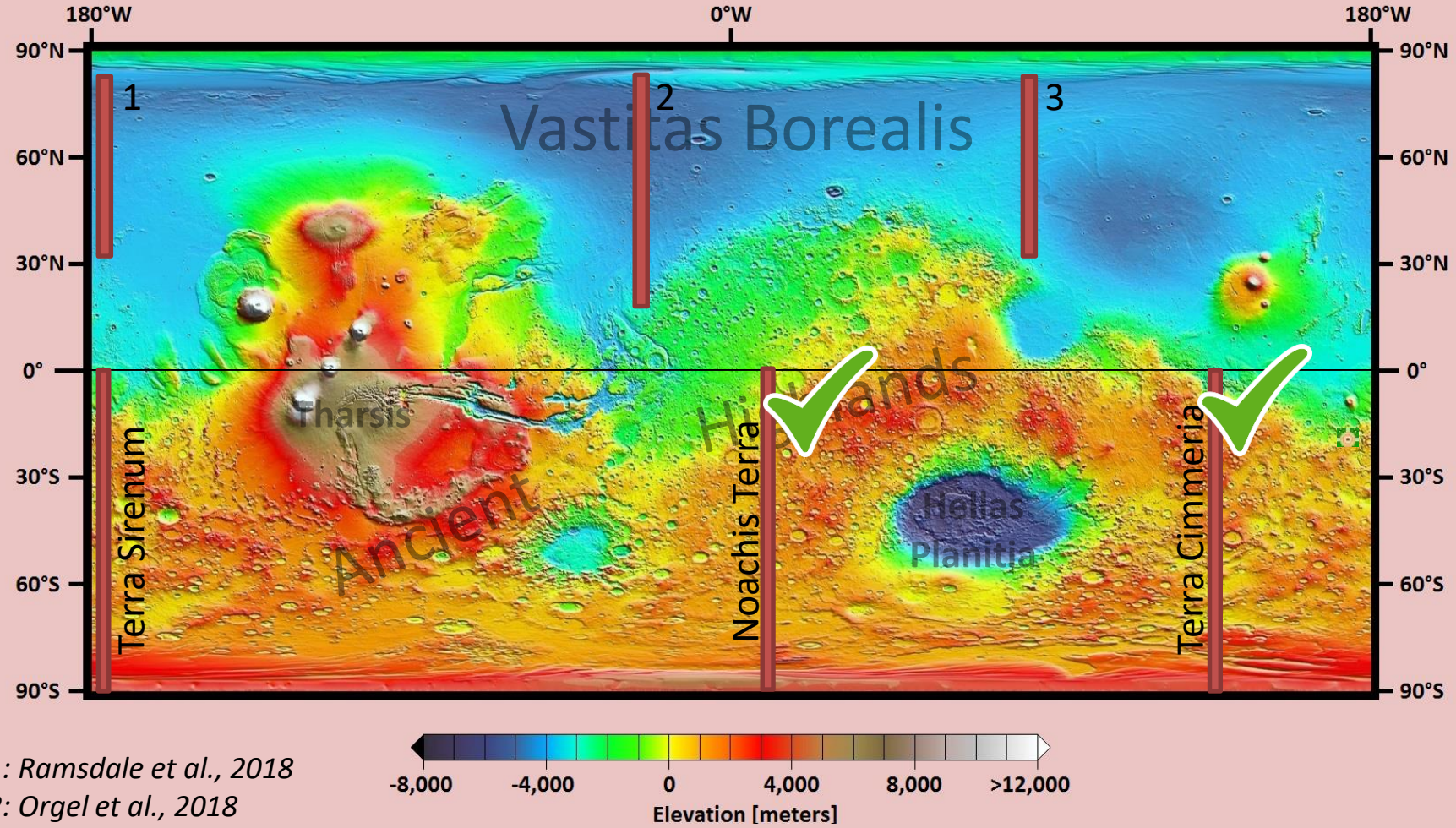
Funnel-like craters



Palimpsests



OUTLOOK



1: Ramsdale et al., 2018
2: Orgel et al., 2018
3: Séjourné et al., 2018

SUMMARY

Key questions of this work:

- **Can geography reveal information about composition/evolution of landforms?**

  → *Yes! The apparent latitude-dependence of landforms suggests a relation to climatic conditions, and hence, the existence or absence of volatiles.*

- **What climatic information can we derive from the distribution of landforms?**

  → *There are environments where water- and ice-related landforms are (1) absent (too warm and dry), (2) under erosion (metastable), and stable (cold and "wet" enough)*

- **Is it possible to distinguish climate zones/environments?**

  → *There are three environments; Desiccated Zone (0°-30°S), Transition Zone (30°-60°S), and a stable Volatile-rich Zone (60°-90°S)*