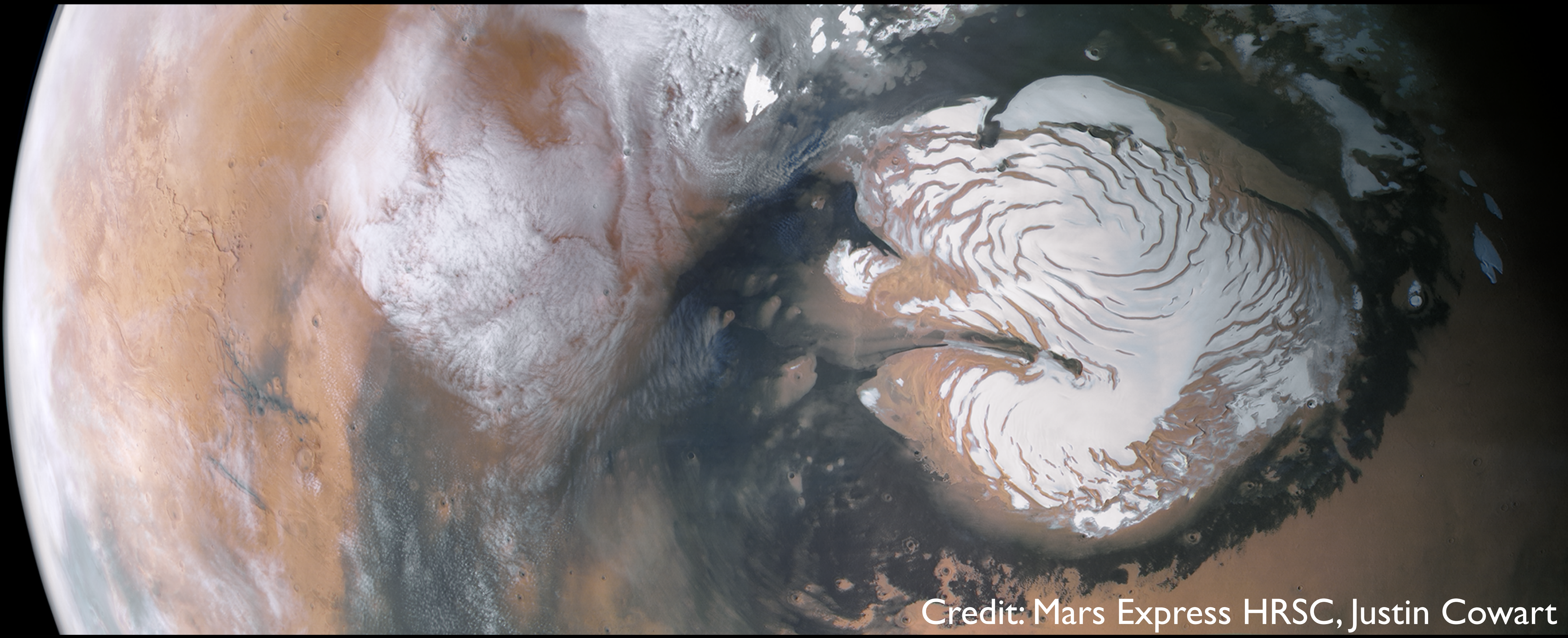
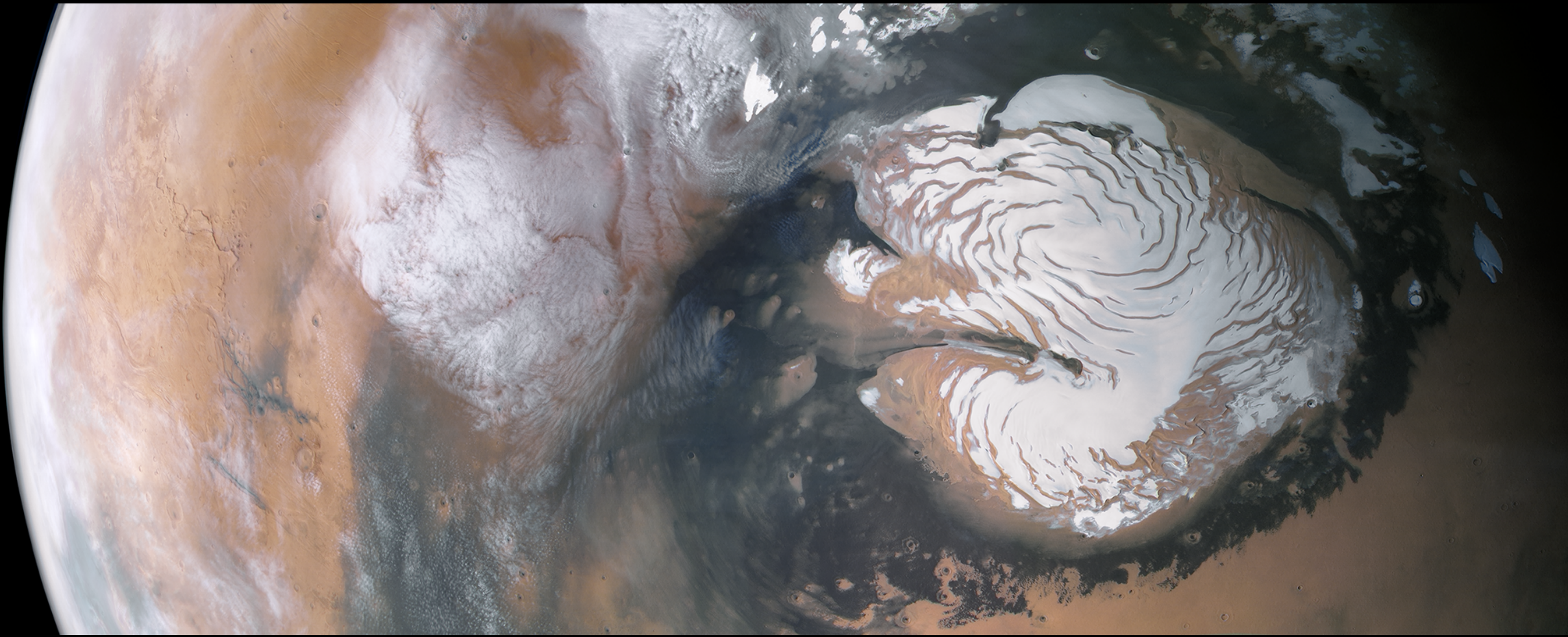
Mars Polar Science: Definition, Activities, and Recommendations



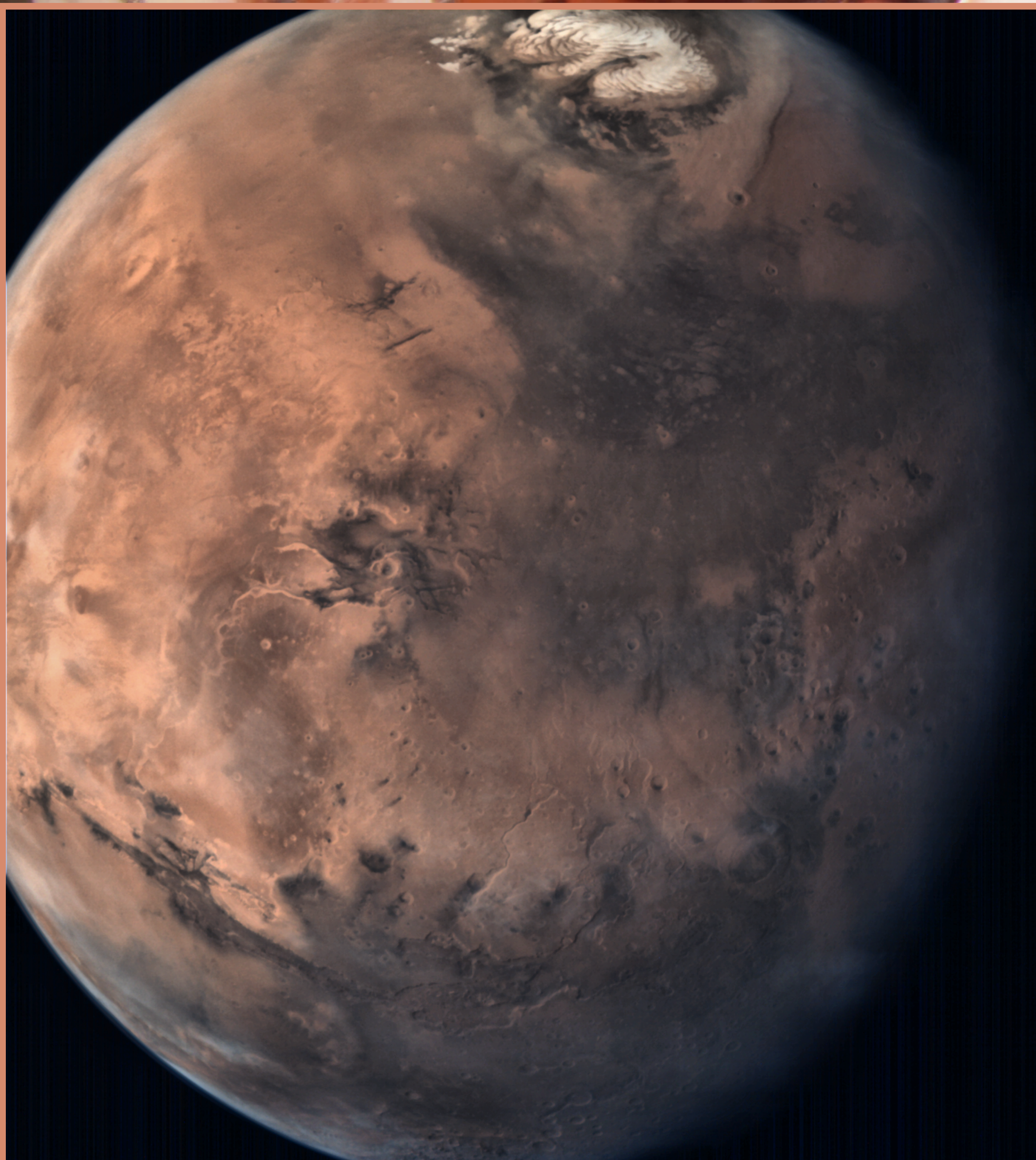
Isaac Smith, PSI

Thank you to the Mars Early Career Travel Grant for supporting my travel.



6th International Conference on Mars Polar Science and Exploration

September 5–9, 2016 • University of Iceland • Reykjavik, Iceland

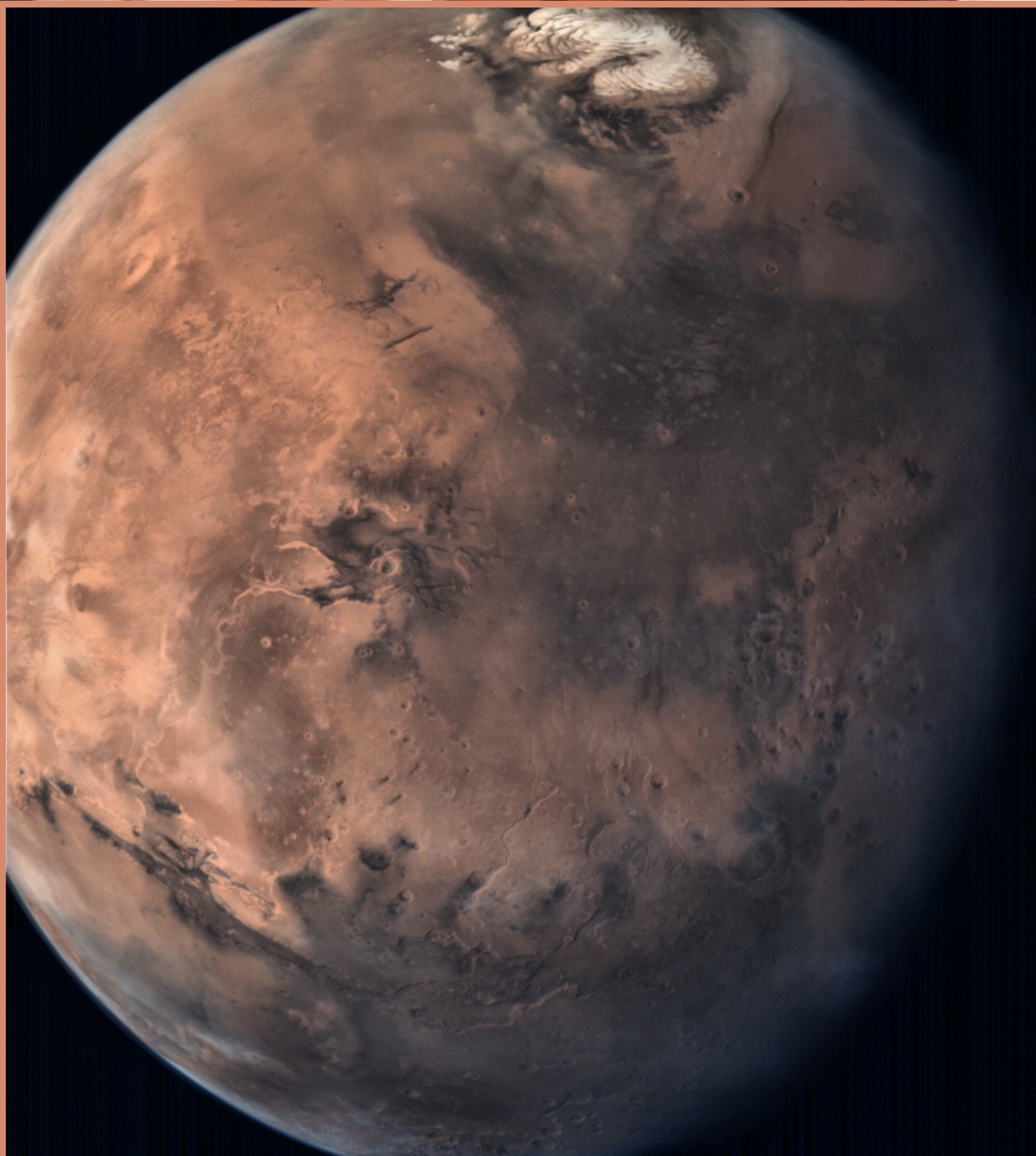


I. B. Smith, Serina Diniega, David W. Beaty, T Thorsteinsson, P. Becerra, A. M. Bramson, S. M. Clifford, C. S. Hvidberg, G. Portyankina, S. Piqueux, A. Spiga, T. N. Titus

Smith, I.B., D. Beaty, T. Thorsteinsson (2017) Meeting Report, 6th International Conference on Mars Polar Science and Exploration, *EOS.*

Smith, I.B., S. Diniega, D. W. Beaty, T. Thorsteinsson,P. Becerra, A. M. Bramson, S. M. Clifford, C. S. Hvidberg,G. Portyankina, S. Piqueux,A. Spiga, T. N. Titus (2018), Introduction to the Special Issue on Mars Polar Science and Exploration: Conference Summary and Five Top Questions, *6th Mars Polar Conference Special Issue, Icarus*

16 Articles published this week



The poles are a record of past climate, and polar processes drive current climate.

The poles influence:
movement of sand in dunes,
dust in the atmosphere,
isotopic ratios,
availability of volatiles,
melting point and stability of liquid water - through time

no priority order, put together by designated synthesis team

Our primary questions (1 of 5)

Polar Atmosphere: What are the dynamical and physical atmospheric processes at various spatial and temporal scales in the polar regions, and how do they contribute to the global cycle of volatiles and dust?

Polar Atmosphere	
	Quantify the interplay of local, regional, and global circulations in the polar regions, including polar vortex, katabatic winds, transient eddies, among others
	Characterize the transport of volatiles and dust aerosols into and out of the polar regions
	Understand and predict the condensation of H_2O and CO_2 ice clouds and their impact on the thermal structure and atmospheric circulation
	Estimate the amount of CO_2 and H_2O frost deposited and lost at the surface via precipitation or sublimation
	Determine dust deposition patterns over the PLD and the specific mechanisms enabling dust lifting

no priority order, put together by designated synthesis team

Our primary questions (2 of 5)

Polar Ices: What do physical characteristics of the Martian PLD reveal about their formation and evolution?

Perennial Polar Ices	
	Determine the energy and mass balance of the polar ice reservoirs, and characterize volatile fluxes (i.e., seasonal deposition and removal, long term accumulation vs. erosion, when and where, at what rates)
	Characterize current/recent perennial ice landforms such as the south polar residual cap and associated features (i.e., distribution, variety, composition, and evolution) and their relationship with seasonal processes
	Quantify the role and efficiency of dust and sand as agents promoting the preservation of buried volatiles
	Determine the vertical and horizontal variations of composition and physical properties of the materials forming the polar layered deposits
	Identify and quantify the differences and similarities between the NPLD and SPLD
	Identify where and hypothesize as to why ice flow model predictions do not match observations

no priority order, put together by designated synthesis team

Our primary questions (3 of 5)

Past Climate: How has the Martian (polar) climate evolved through geologic history, and what record exists of past-states?

Past Climate (Polar) Record	
	Determine and characterize the link between orbital forcing and resultant climate parameters to layer properties at the PLD and non-polar deposits, and then invert to derive polar and global martian history
	Further test the current hypothesis that NPLD formation began at ~4 Ma
	Estimate the climatic conditions that could have formed the SPLD, especially given that current and recent climates are predicted to be unfavorable for accumulation and that the surface age may be greater than 30 Myr
	Determine if the SPLD H_2O ice units (AA_1 and AA_2) were deposited in one or multiple periods of favorable climate
	Characterize the processes and timing that led to the buried CO_2 ice reservoirs at the south pole
	Determine how the SPLD expanse relates to the much larger southern polar deposits in terms of age and climate epochs that are recorded. Specifically, does the Dorsa Argentea Formation (DAF) have origins in an ancient climate and what can DAF presence tell us about that climate?
	Determine the climate forcing that allowed for the development of the south polar residual cap (SPRC), and how it remains in its present-state given that models predict it to be unstable. Also estimate its absolute age

no priority order, put together by designated synthesis team

Our primary questions (4 of 5)

Non-polar ice: What is the history and present state of the mid- and low-latitude volatile reservoirs?

Non-polar Ice	
	Inventory and characterize the non-polar volatile reservoirs at the surface and near-surface
	Determine the accessibility of H_2O ice deposits as a resource for future human exploration, in particular the conditions and lowest latitude under which water-ice reservoirs can be found
	Determine under which conditions the non-polar volatile reservoirs accumulate and persist
	Determine how different chemistries (salts) influence the movement of volatiles and their impact on habitability
	Investigate if liquid water exists or has existed in locations associated with mid- and lower-latitude ice deposits. Could these have provided habitats for, or preserved evidence of, past or present life?

no priority order, put together by designated synthesis team

Our primary questions (5 of 5)

Present day surface activity: What are the roles of volatiles and dust in surface processes actively shaping the present polar regions of Mars?

Present Day Surface Activity	
	Determine the processes by which seasonal CO_2 (alone, or in conjunction with other surface materials) acts as an agent of geomorphic change for: gullies/alcove-aprons, dunes, and araneiform terrain, on various time scales
	Quantify the amount of CO_2 needed for the observed geomorphic processes to occur. Characterize what form (snow or direct deposition), when, and where that CO_2 is deposited/accumulated seasonally
	Determine the present rate of activity and the time needed to produce the existing surface features. Detect changes in environmental conditions as recorded within these landforms
	Observe the distribution of seasonal and diurnal H_2O and CO_2 frost deposited each year, from within the seasonal cap down to the lowest latitudinal-extent
	Characterize inter-annual variability in polar surface processes and determine their relationship to volatile cycles, dust cycles, and weather
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This is the Amazonian!

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This is the Amazonian!

Our goals are frequently linked and inseparable. As examples:

The atmosphere affects the perennial ices, non-polar ice, and present day surface activity.

The climate record is stored within the materials of the perennial and non-polar ices.

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What is Mars Polar Science?

It is important to stress that the adjective *polar* does not have a single definition. In a geological or atmospheric sense, we use polar to refer to **high-latitude processes involving the unique thermal environment of the region, and usually involving volatiles in solid form**. The scope of the conference and of these questions encompasses not just the polar perennial ice caps, but also **seasonal activity related to volatile solid states**, the circumpolar plains, and the atmosphere above these locations. In addition, topics also include **polar-related ice ages** and **atmosphere/ice-related processes that have periodically driven significant quantities of ice to equatorial latitudes**.

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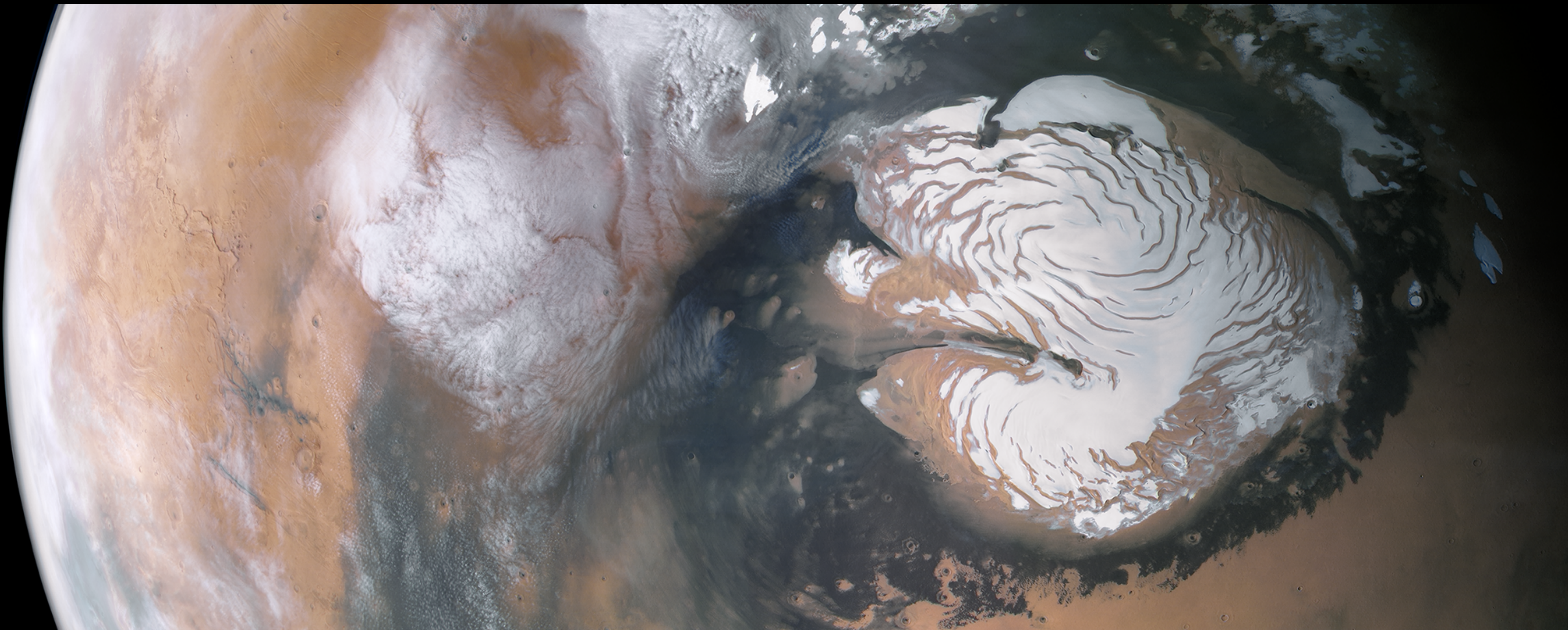

Polar = Polar Layered Deposits

What is Mars Polar Science?

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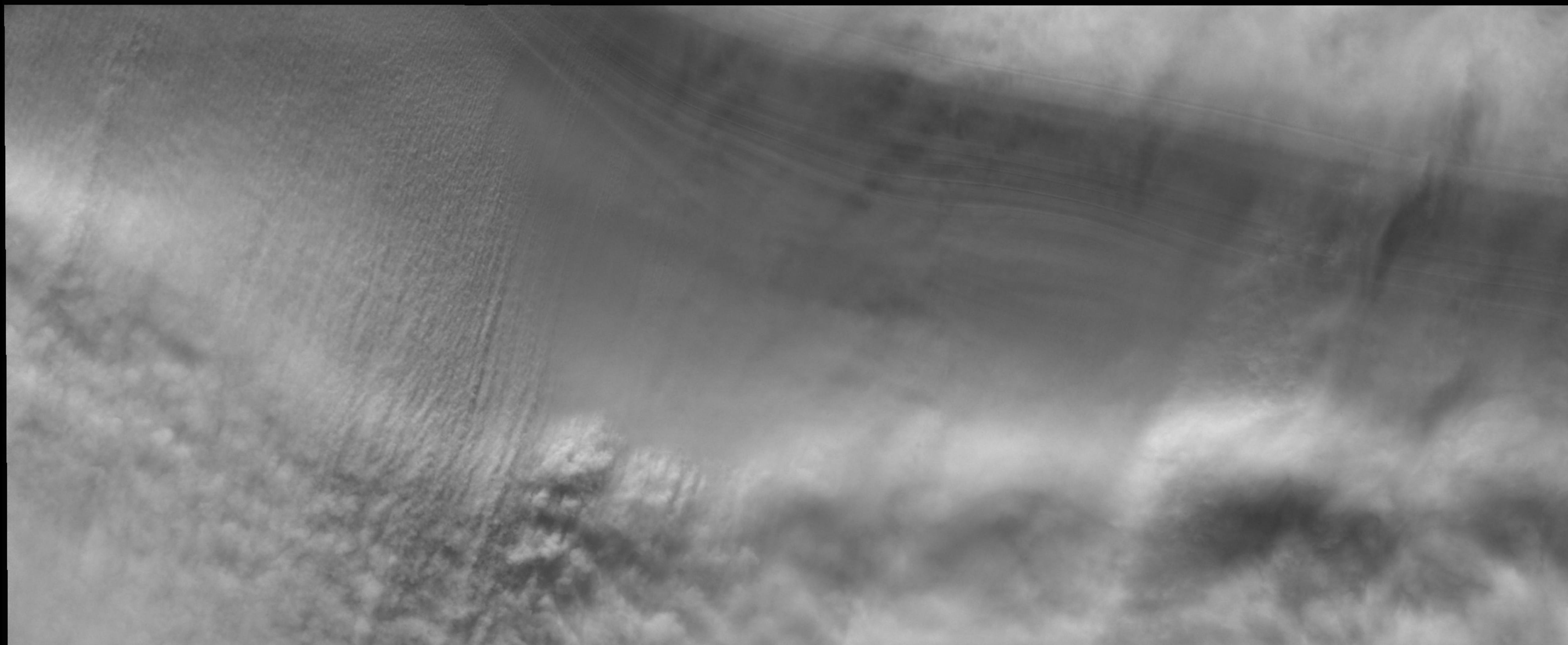
If you care about D/H ratio through time, then you're a polar scientist

What is Mars Polar Science?



Polar = Polar Layered Deposits
Atmosphere interactions with ice

If you care about the lower atmosphere, then you're a polar scientist

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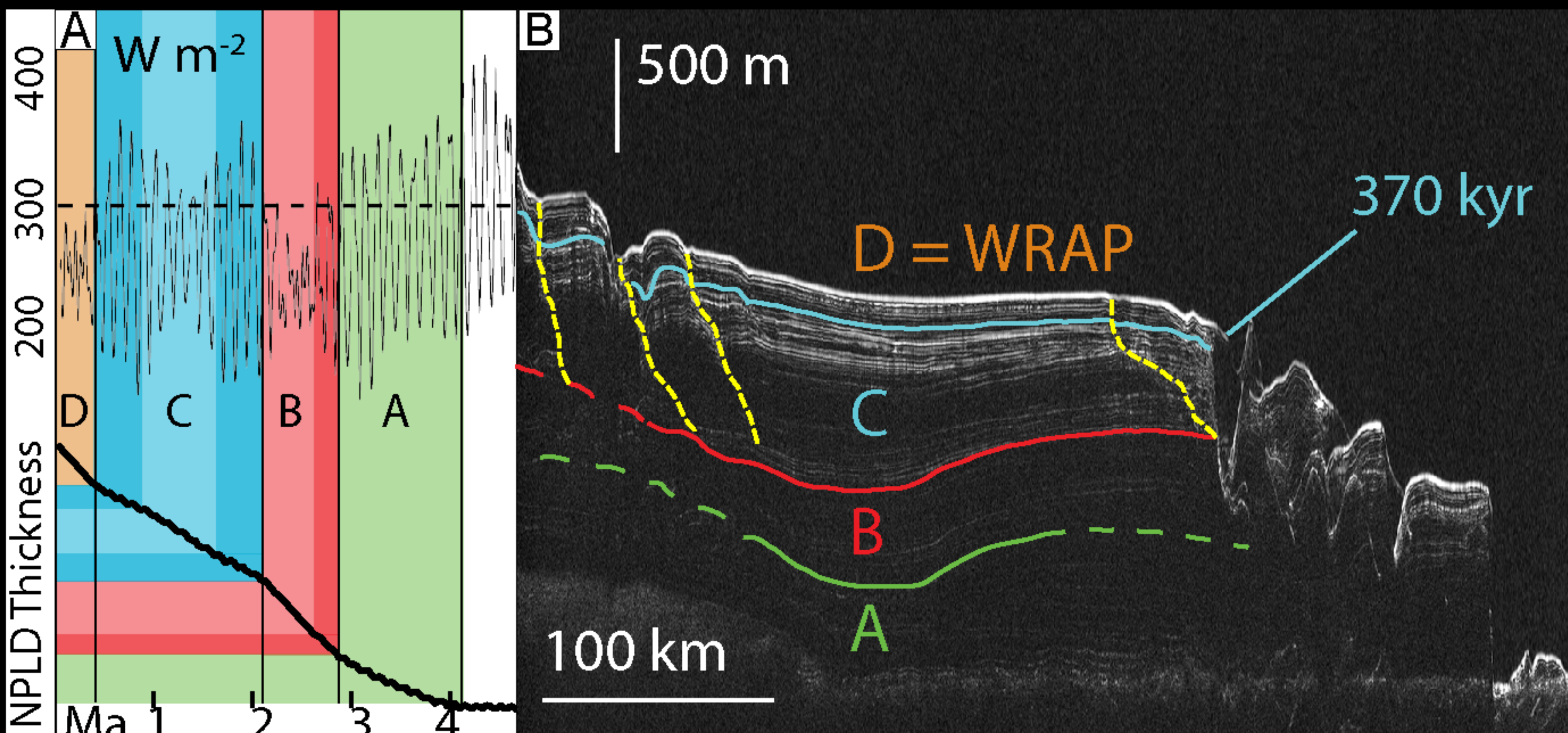

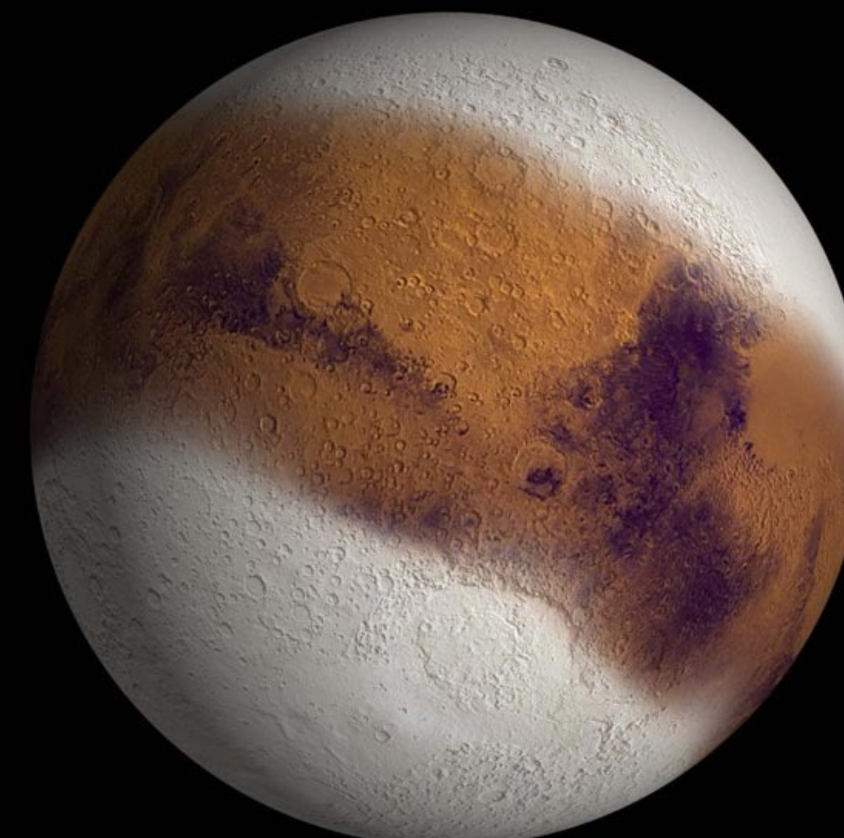

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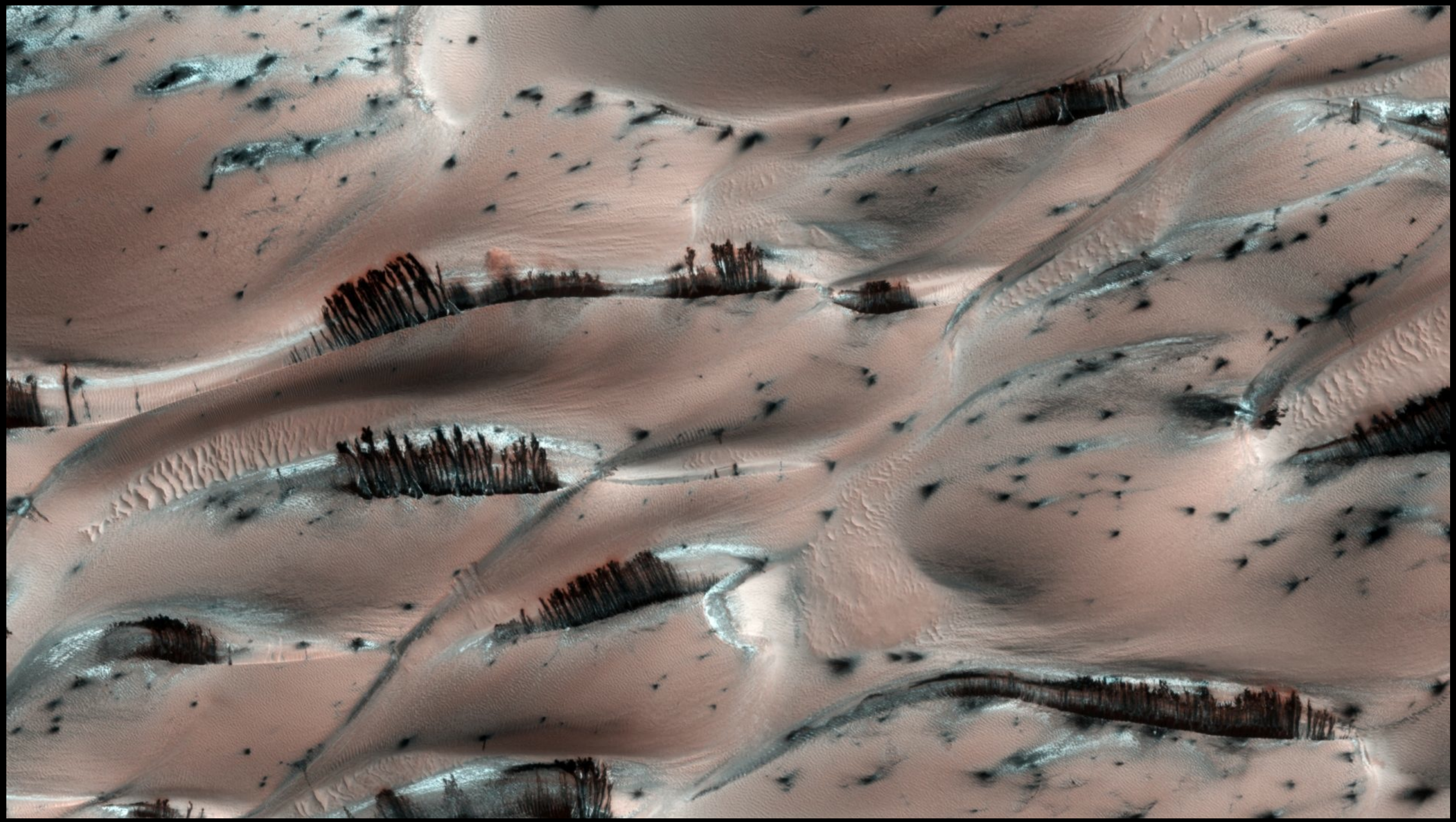
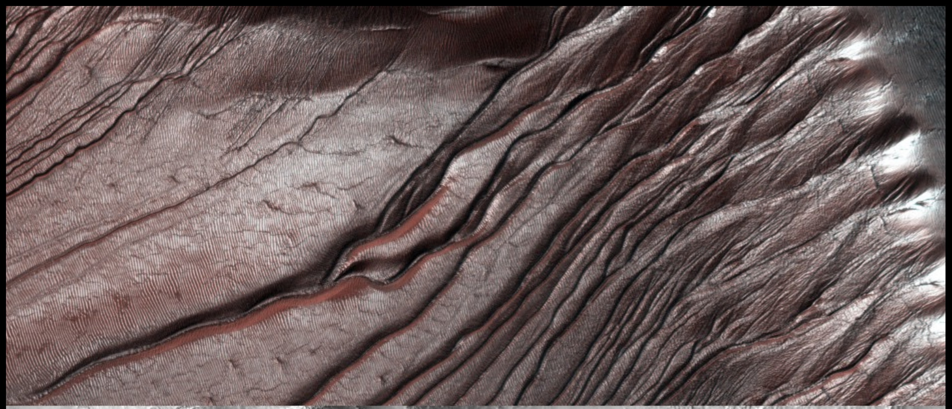
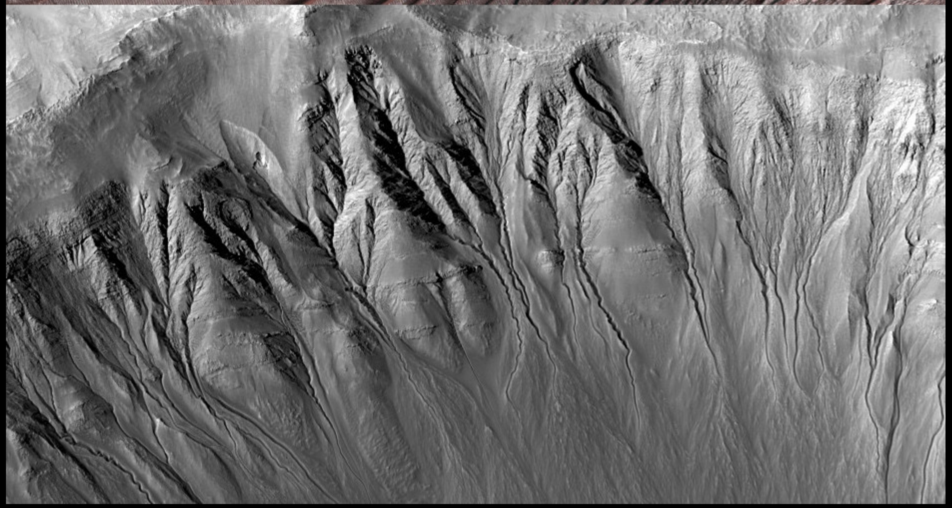
If you care about climate history, then you're a polar scientist

What is Mars Polar Science?

spiders







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If you care about surface processes, then you're a polar scientist

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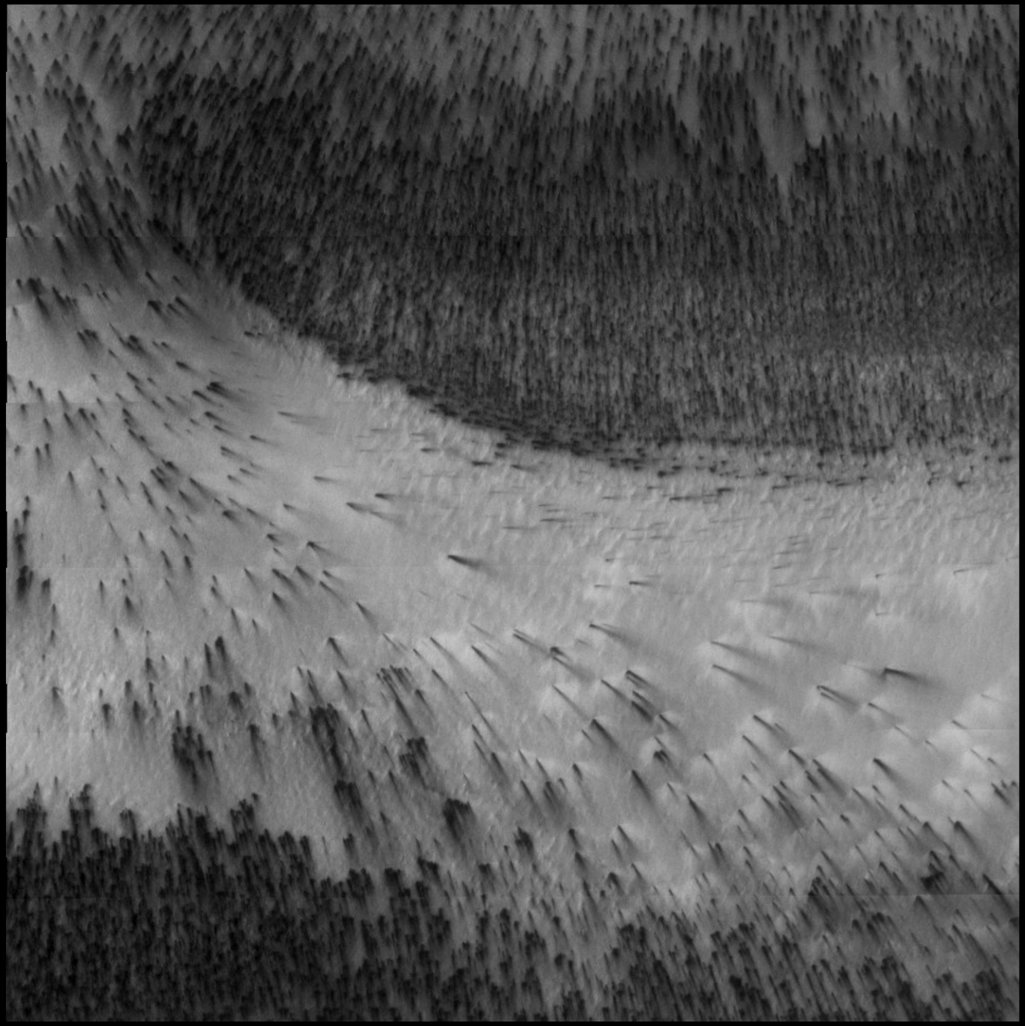

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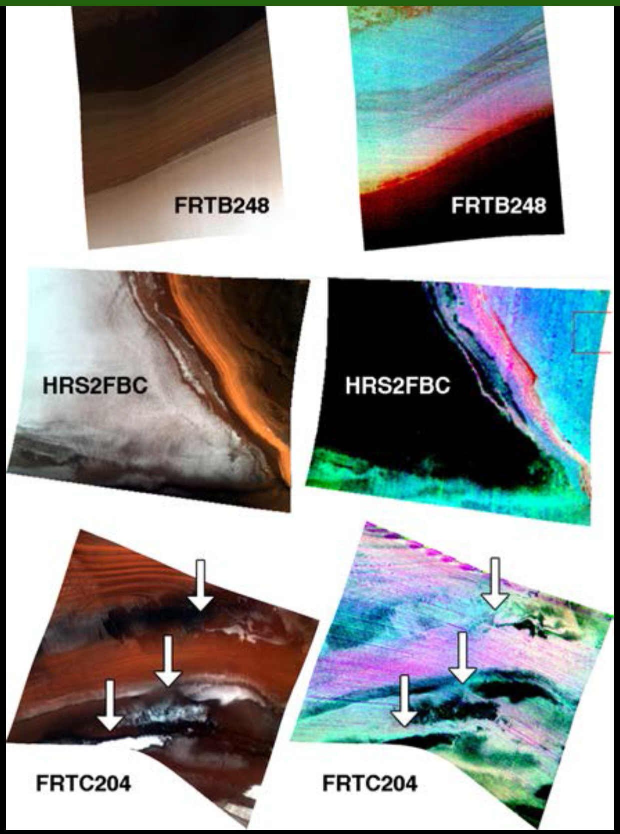
If you care about chemical weathering in ice, you're a polar scientist



Pyroxine in NPLD

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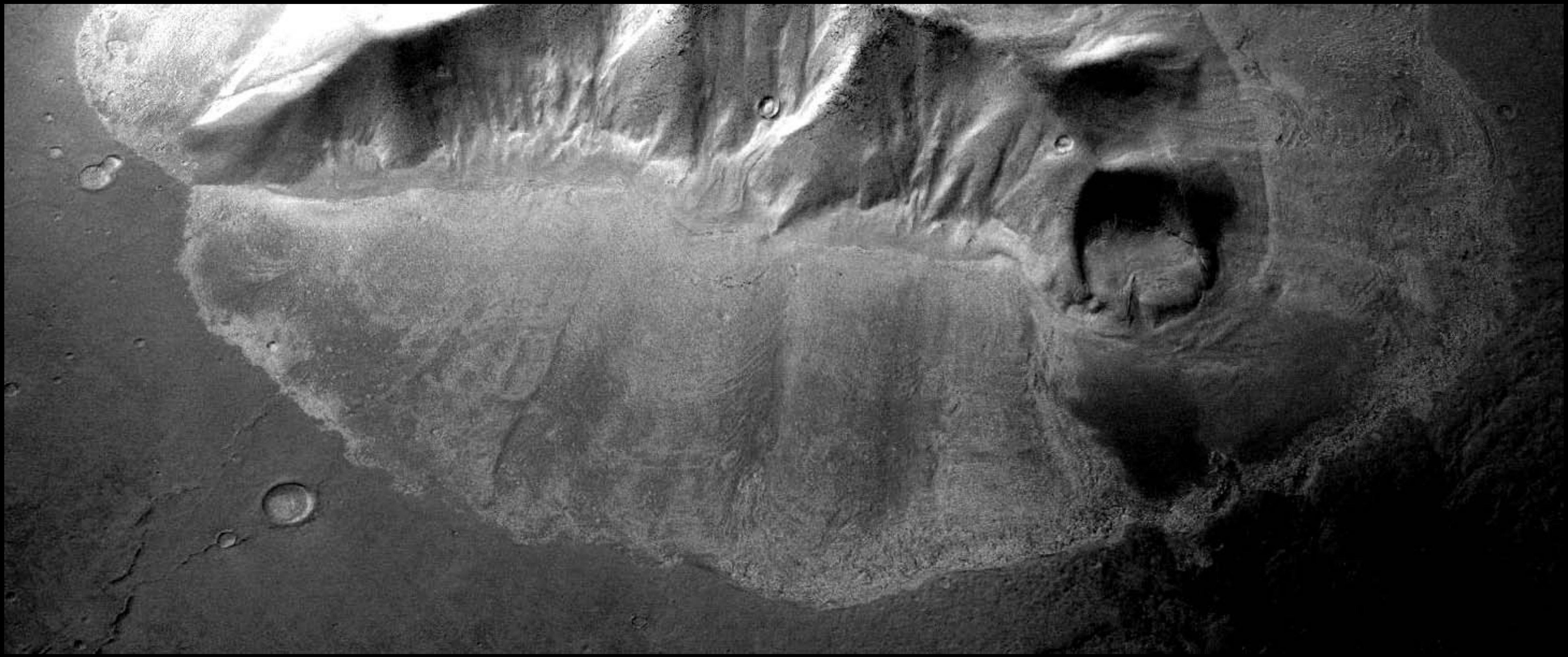

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Mid-Latitude, excess ice

If you care about mid-latitude ice for human exploration, then you're a polar scientist

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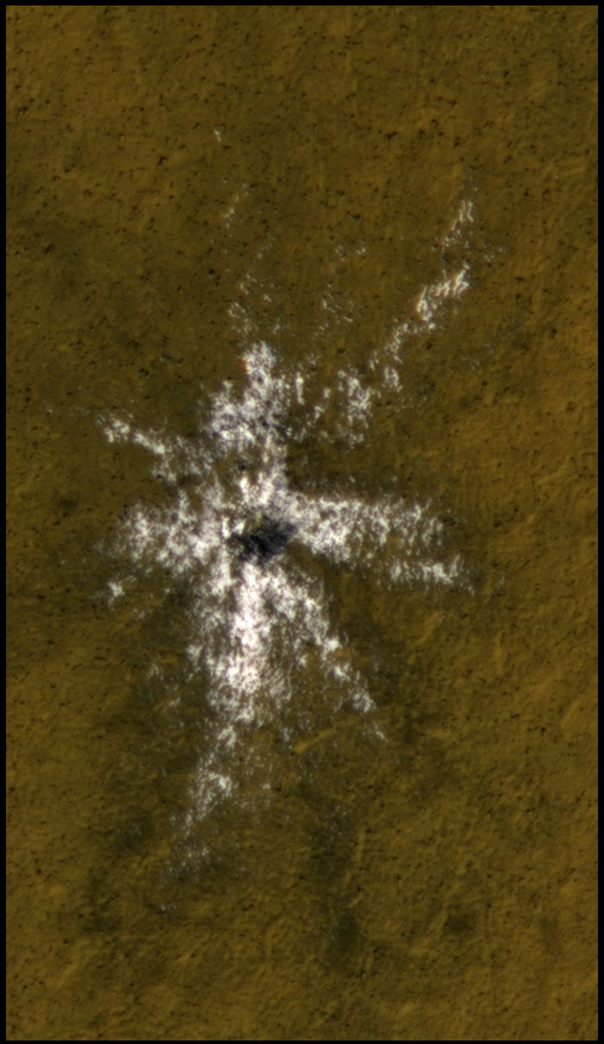

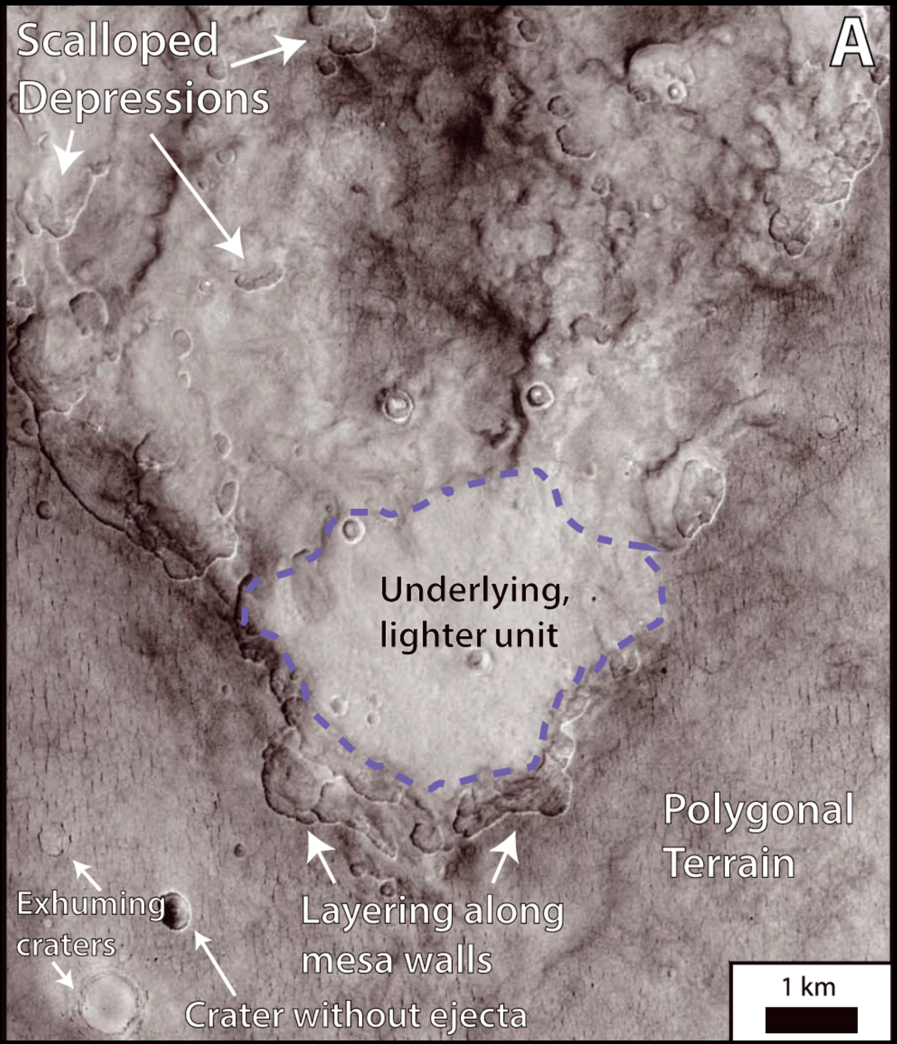

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If you care about mid-latitude ice for biology, then you're a polar scientist

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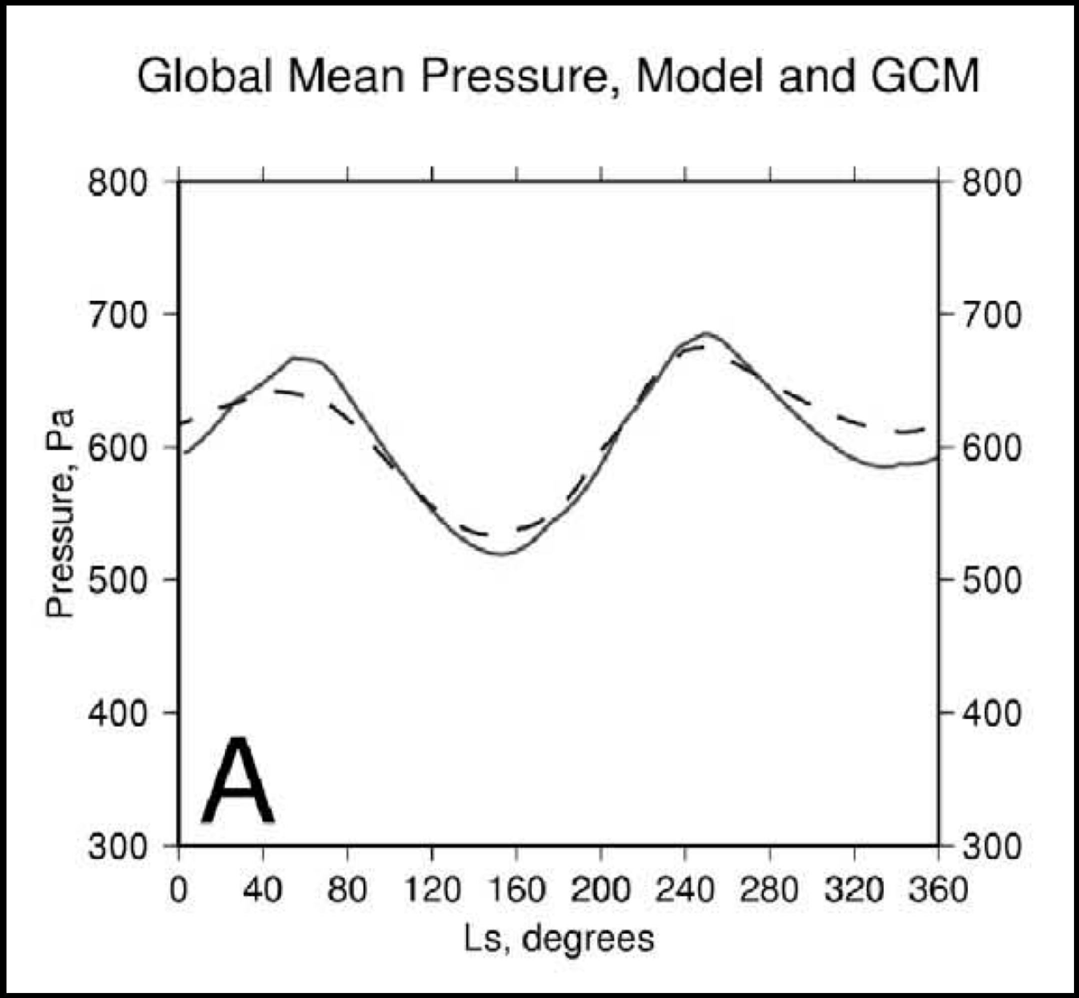

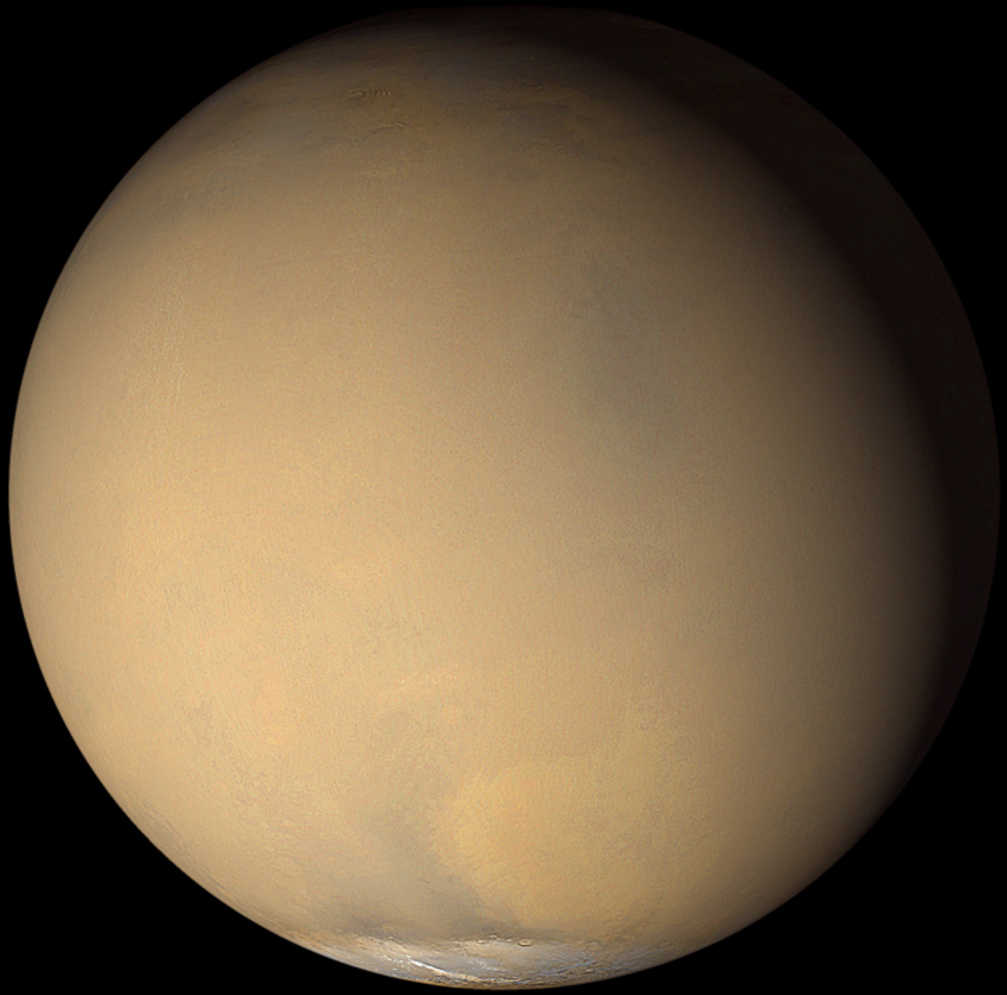

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Surface pressure - dust storms, dune/ripple activity

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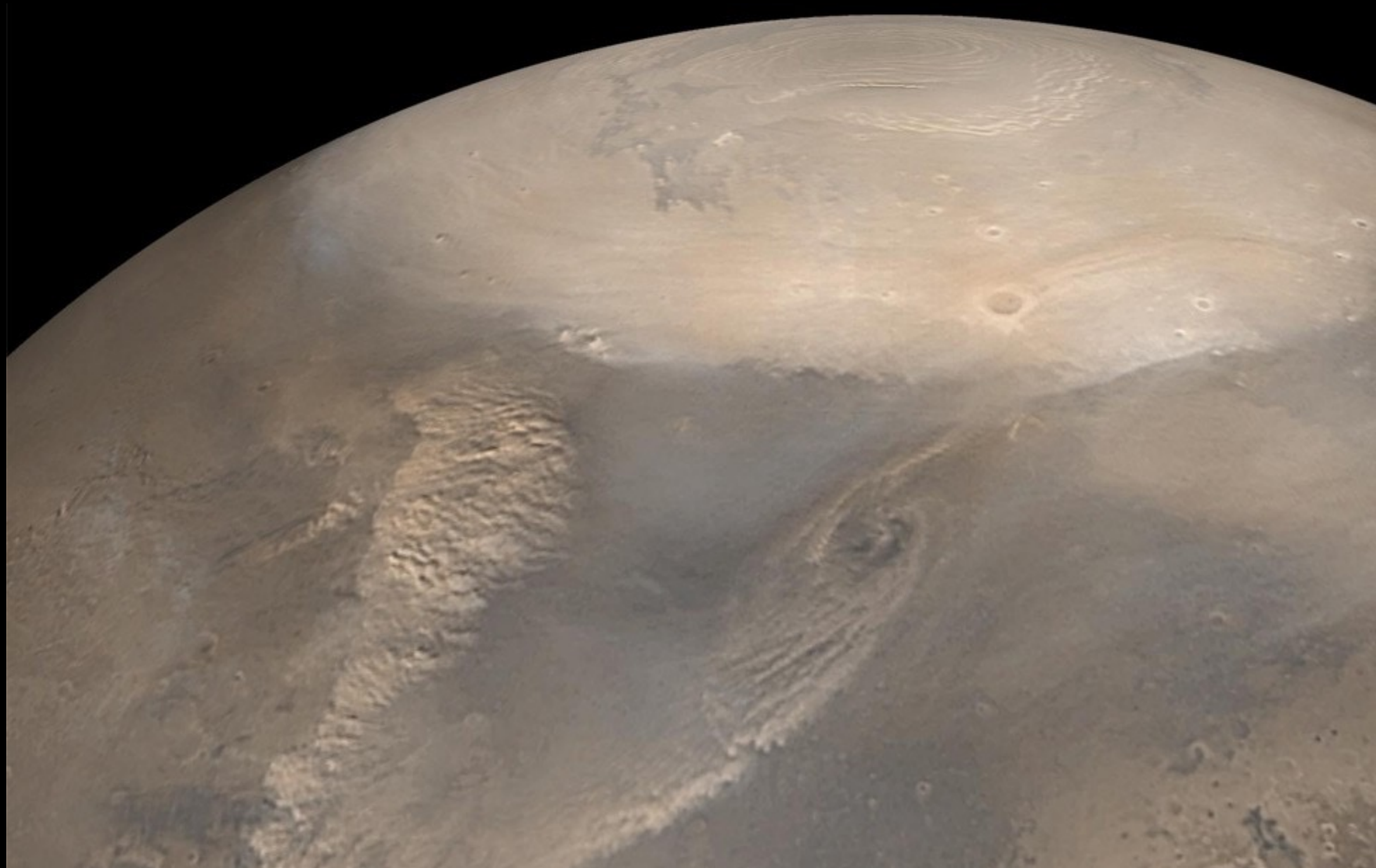

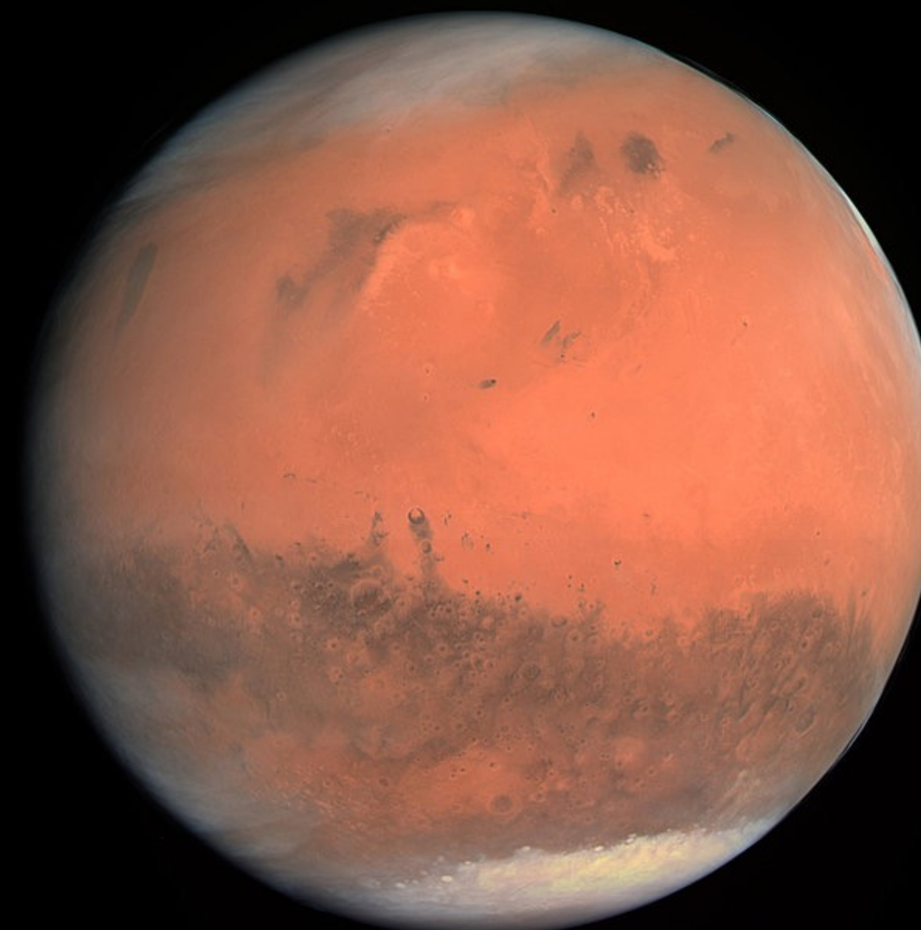

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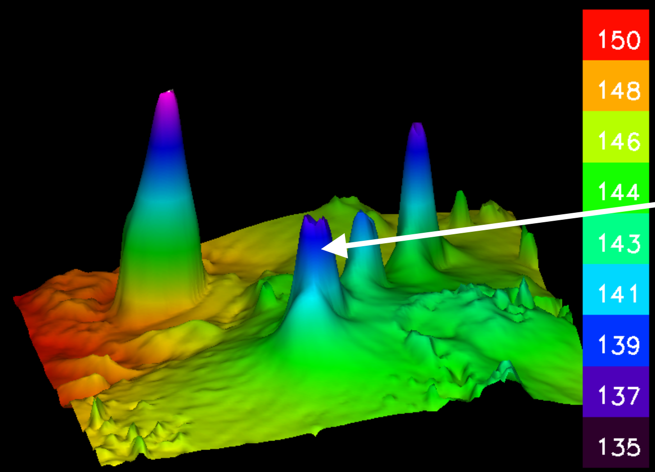
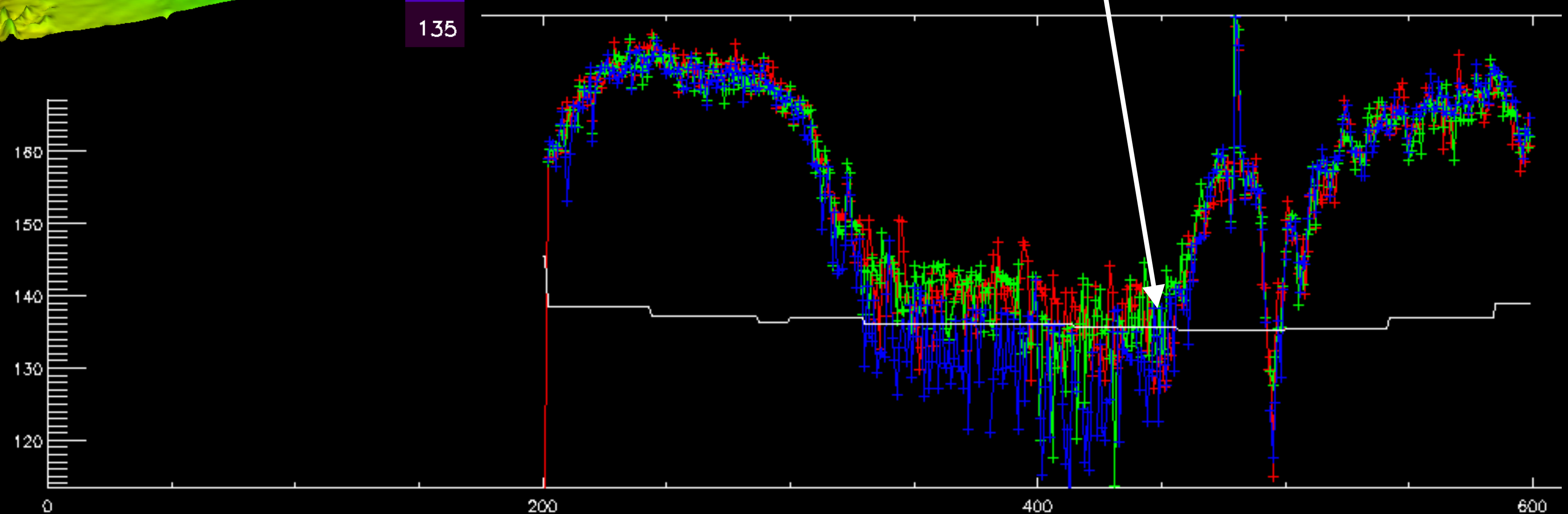


CO_2 frost point



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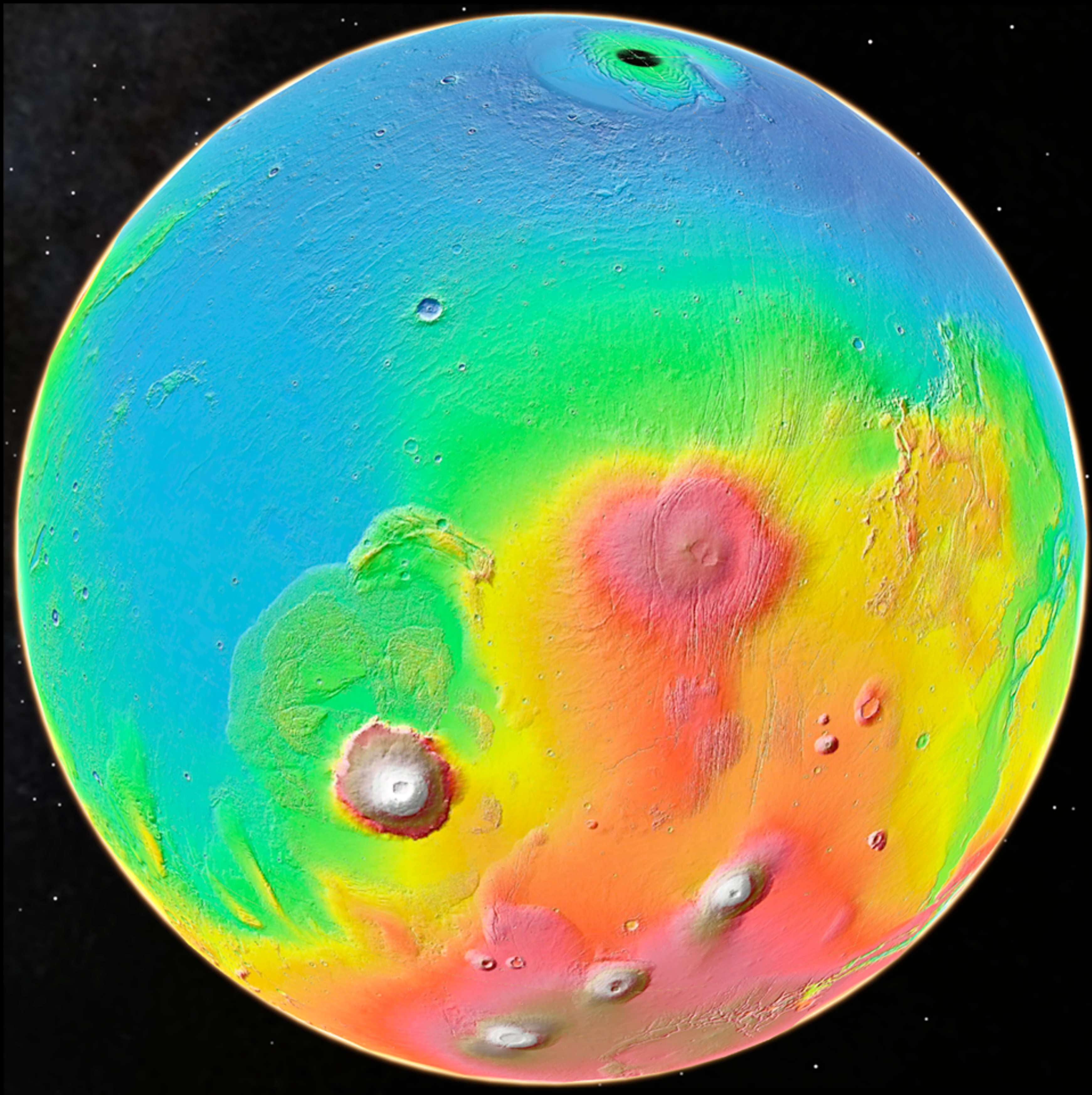

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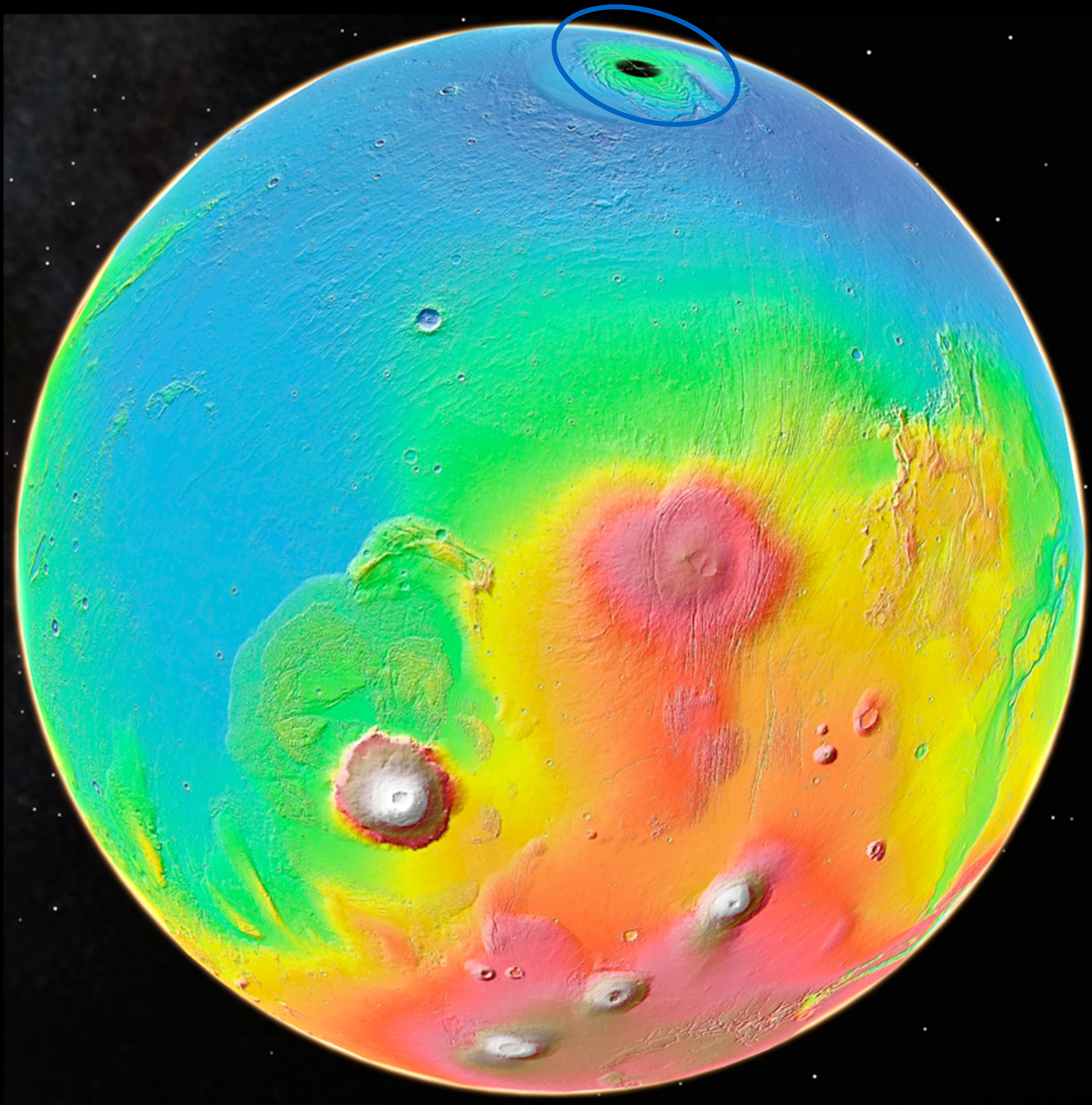

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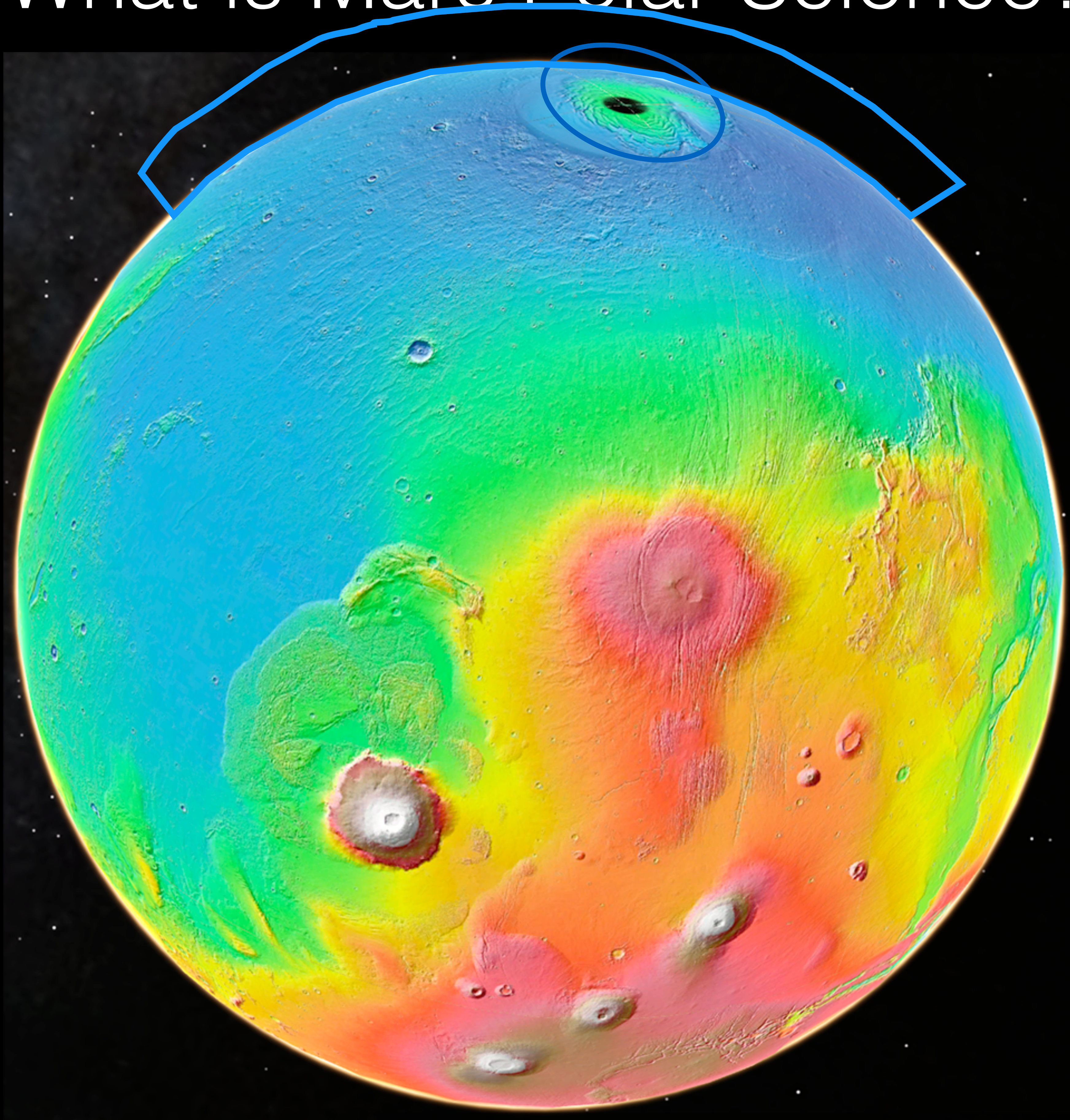

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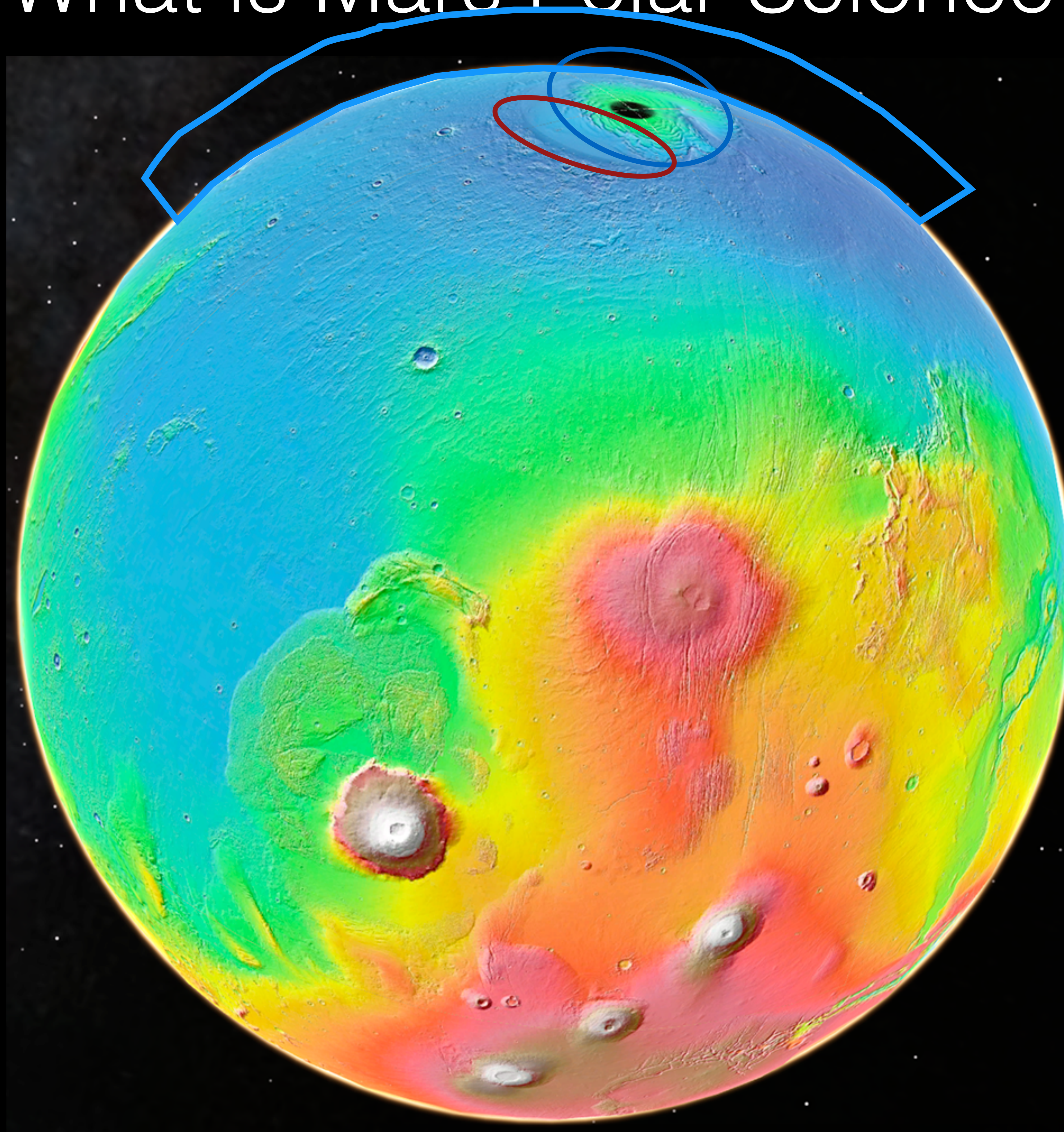

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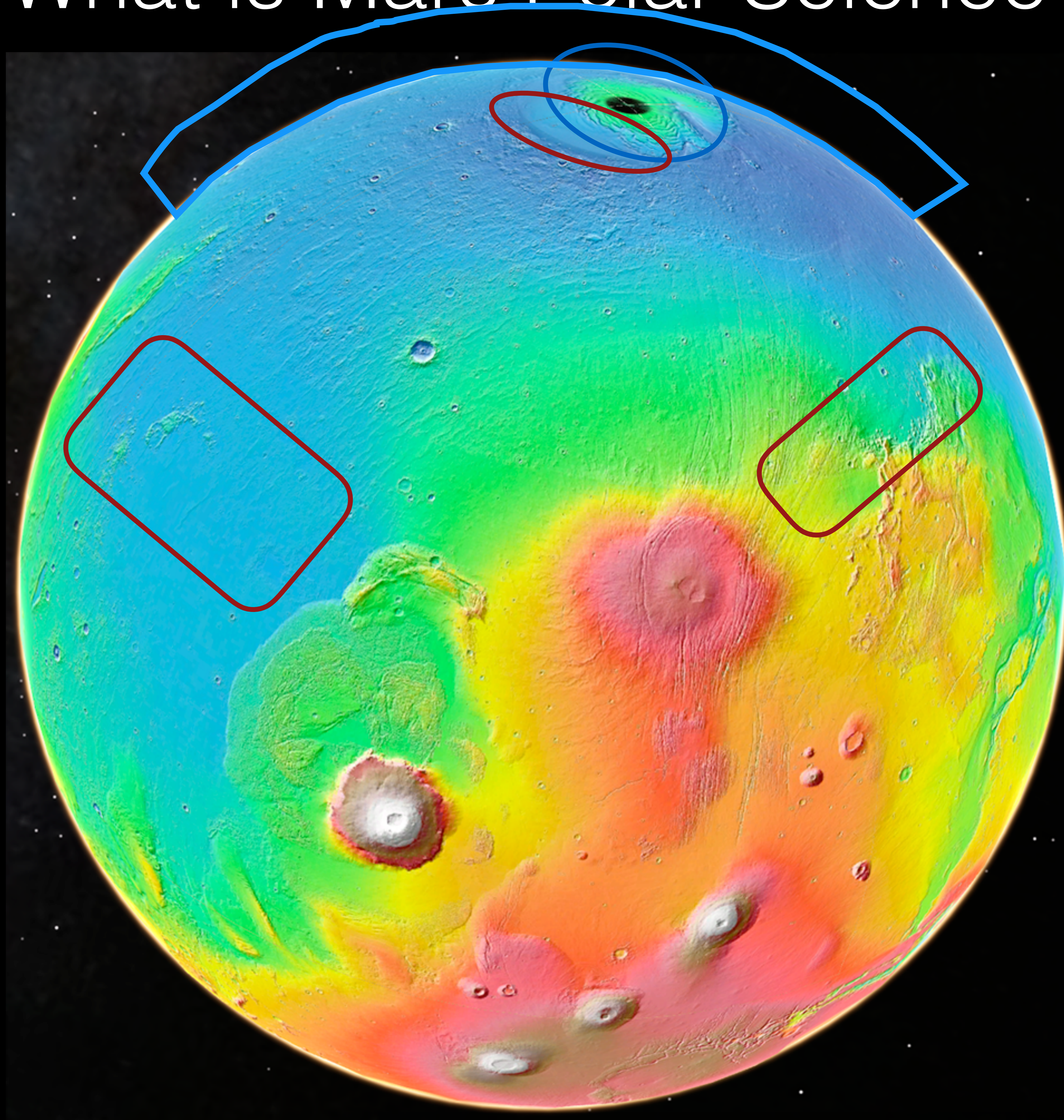

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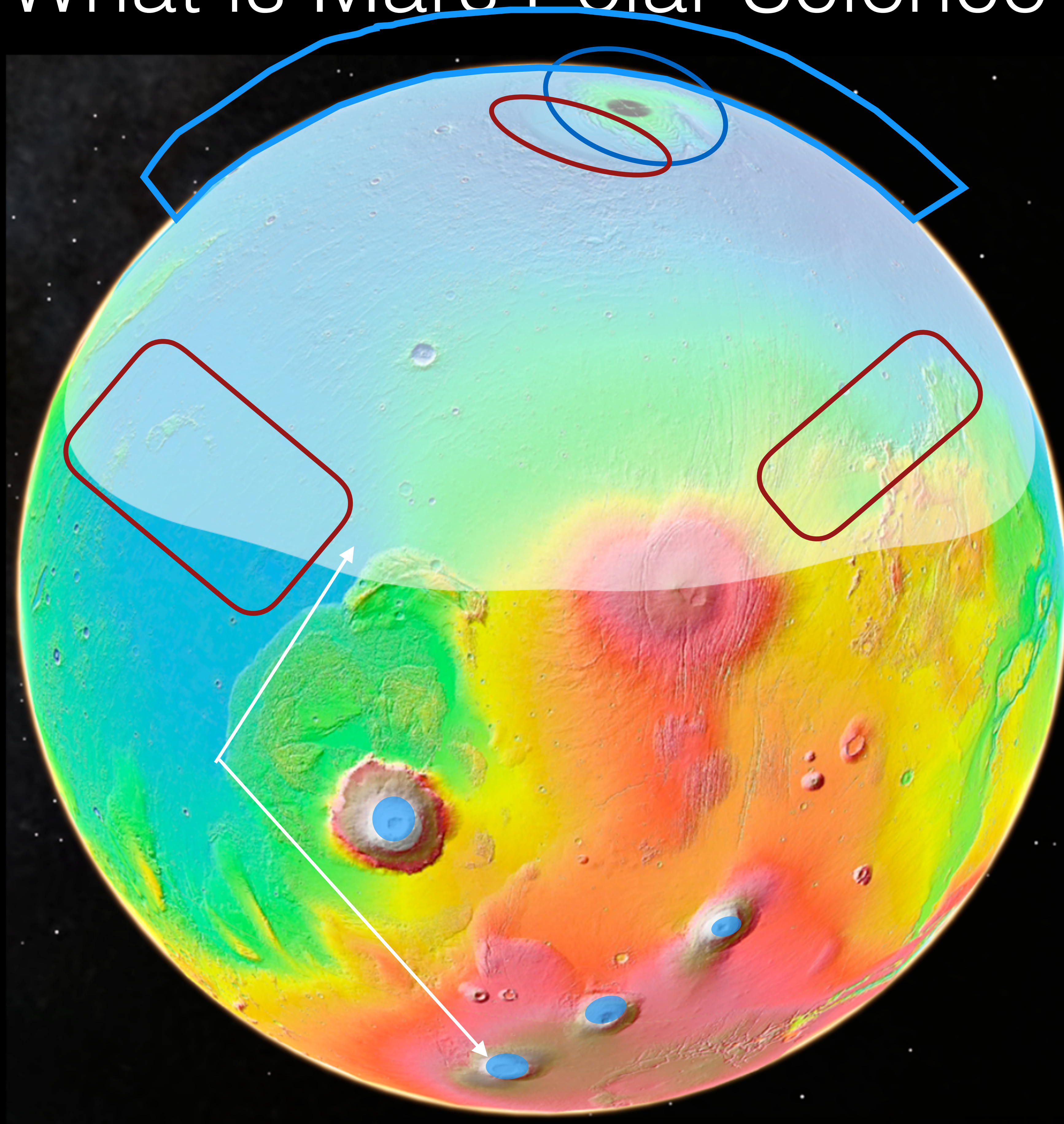
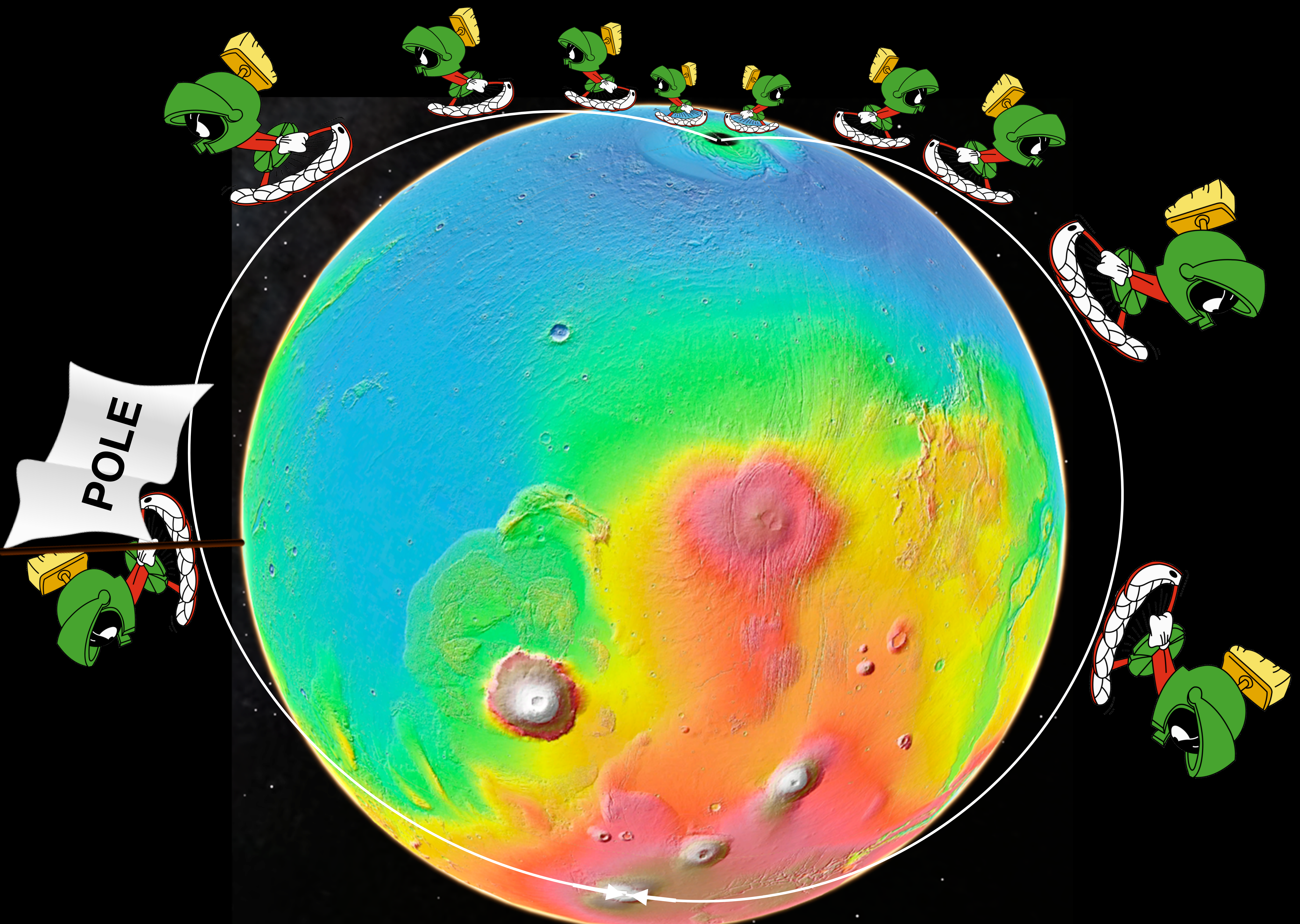
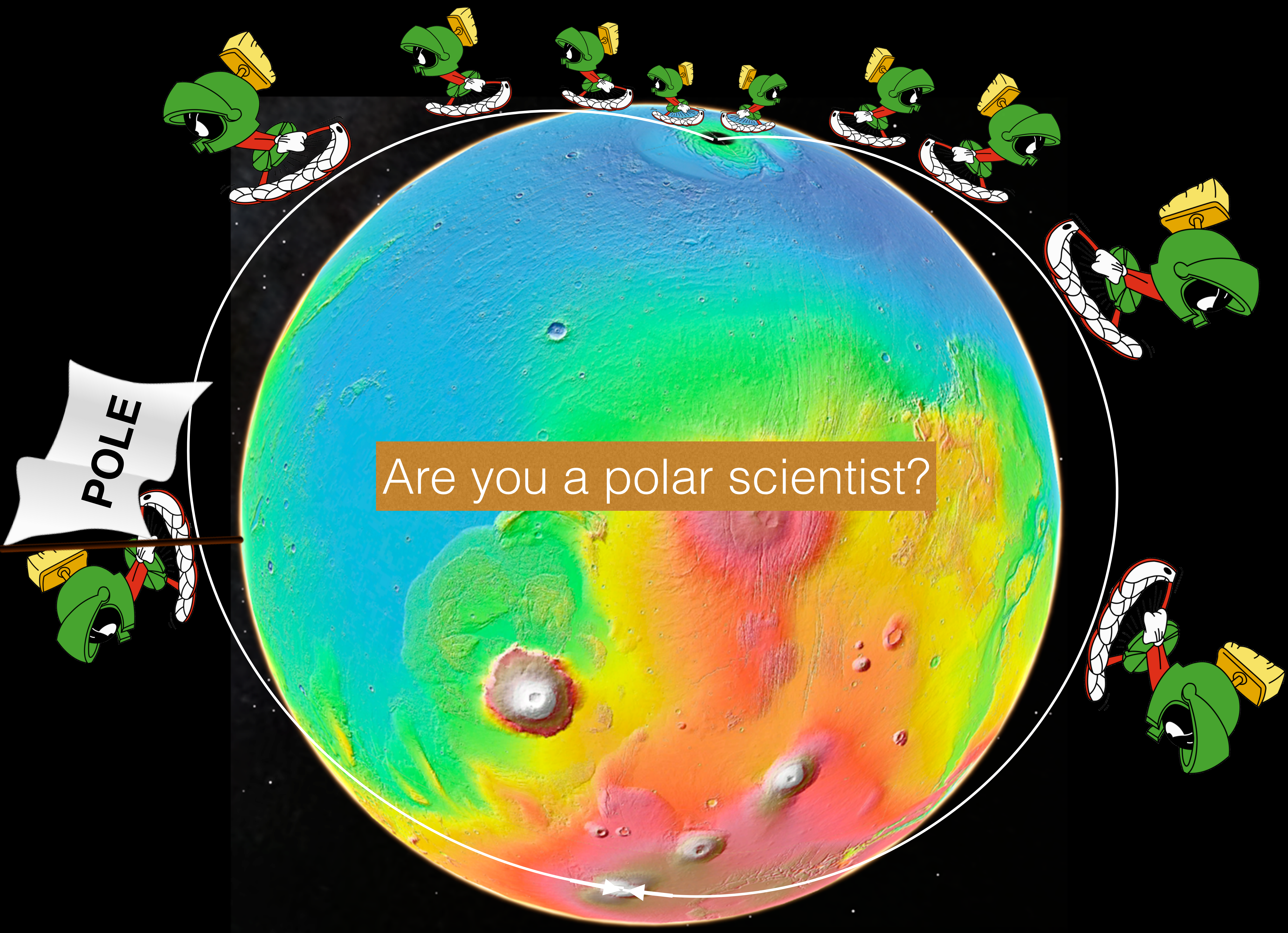
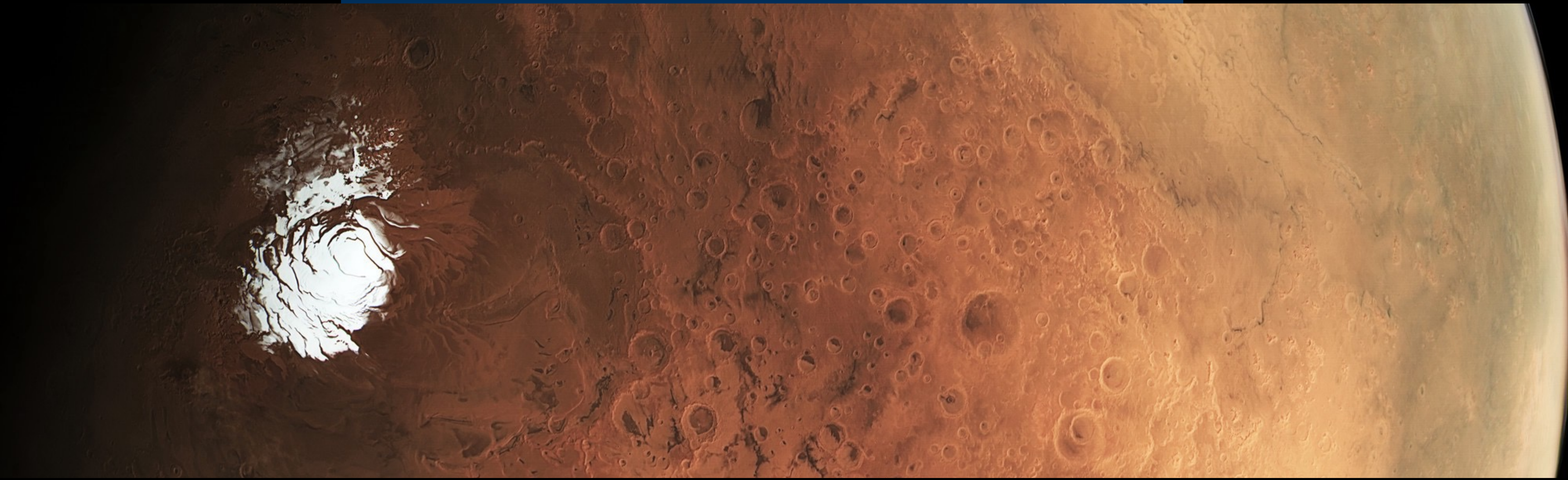


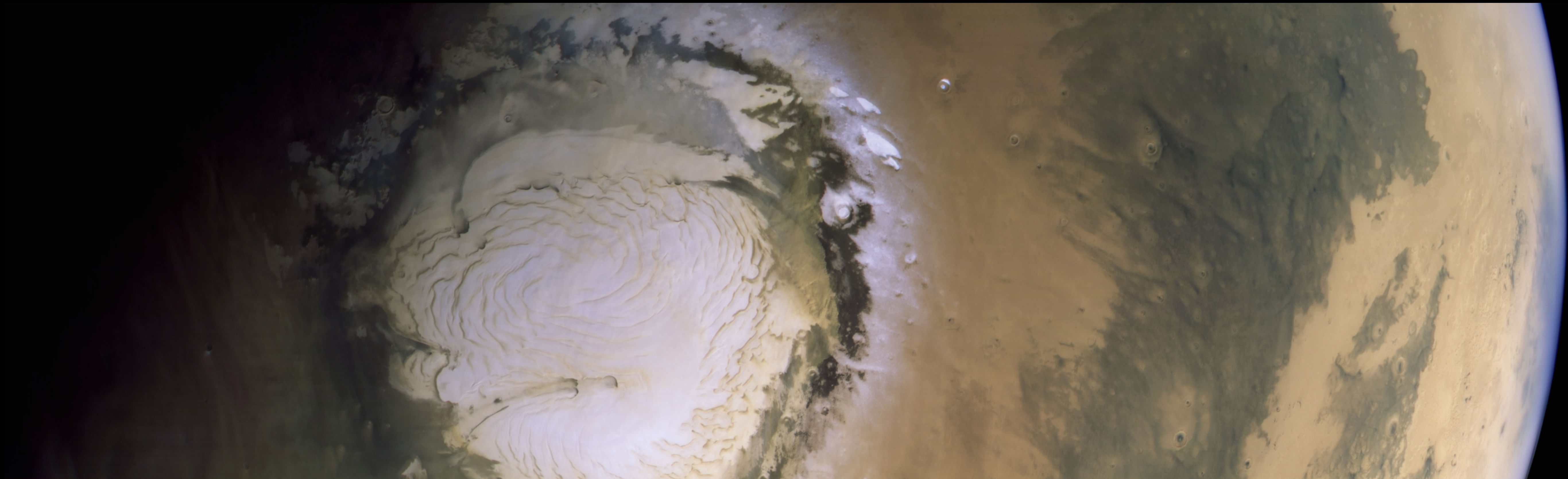

POLE


POLE
Are you a polar scientist?

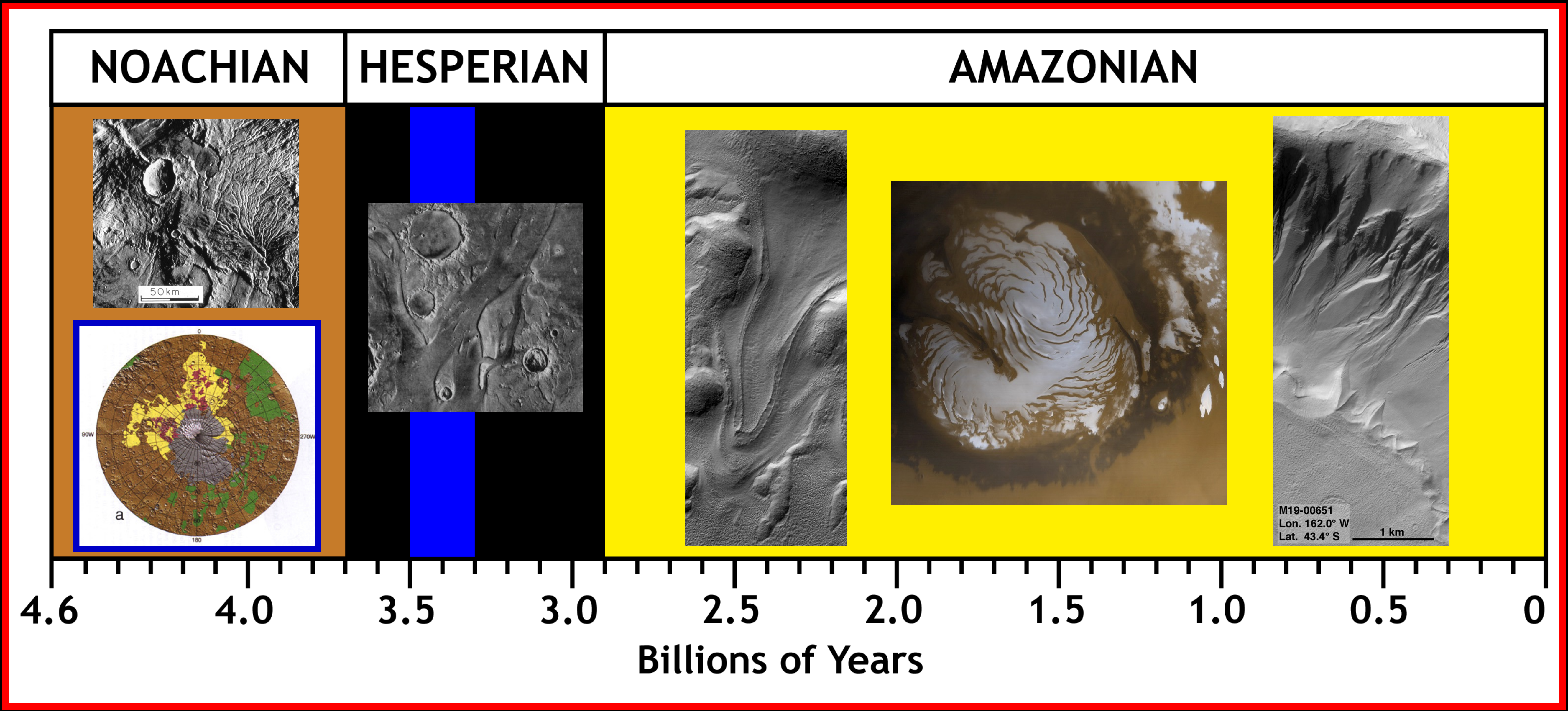
In summary, Mars is currently a polar planet.

Basically, much of the Amazonian



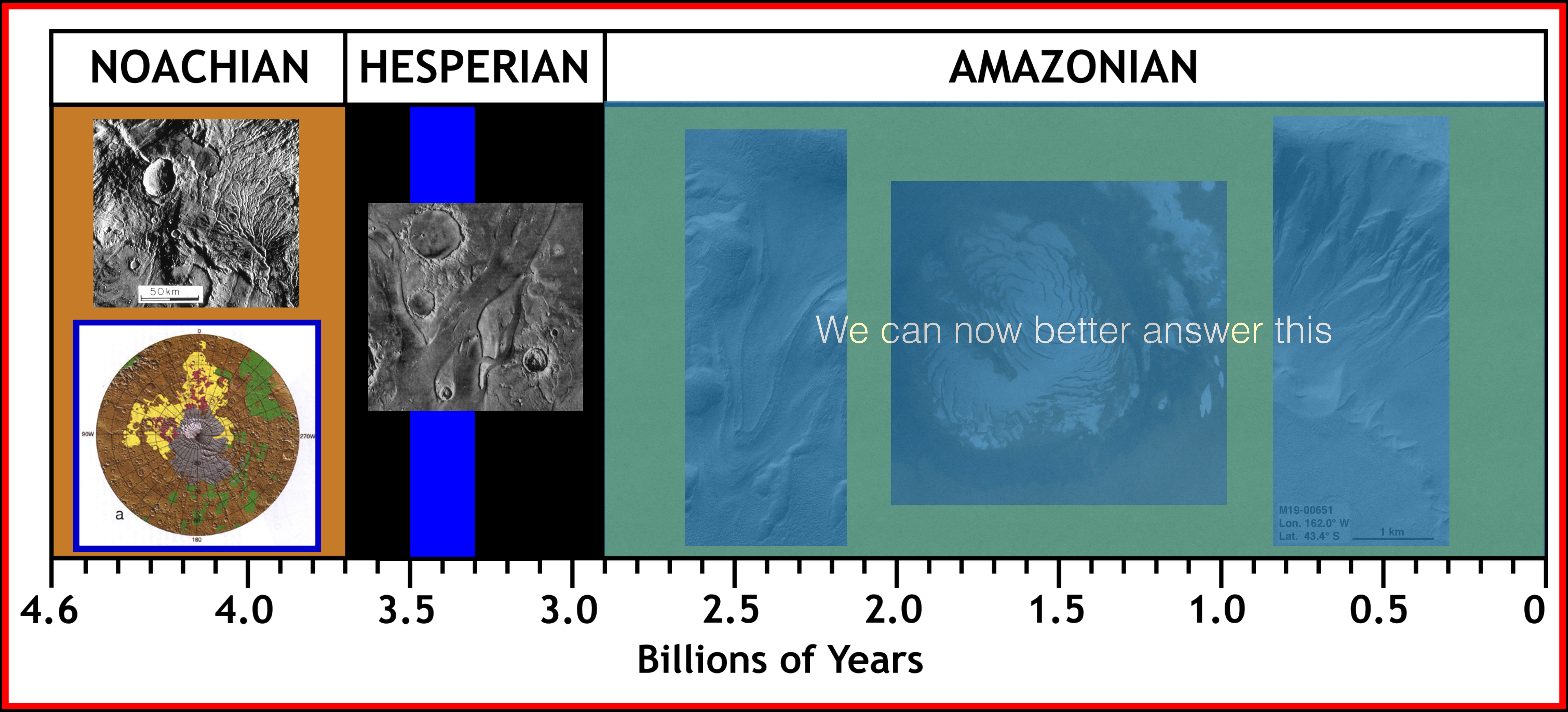


Mars Climate History: A Geological Perspective



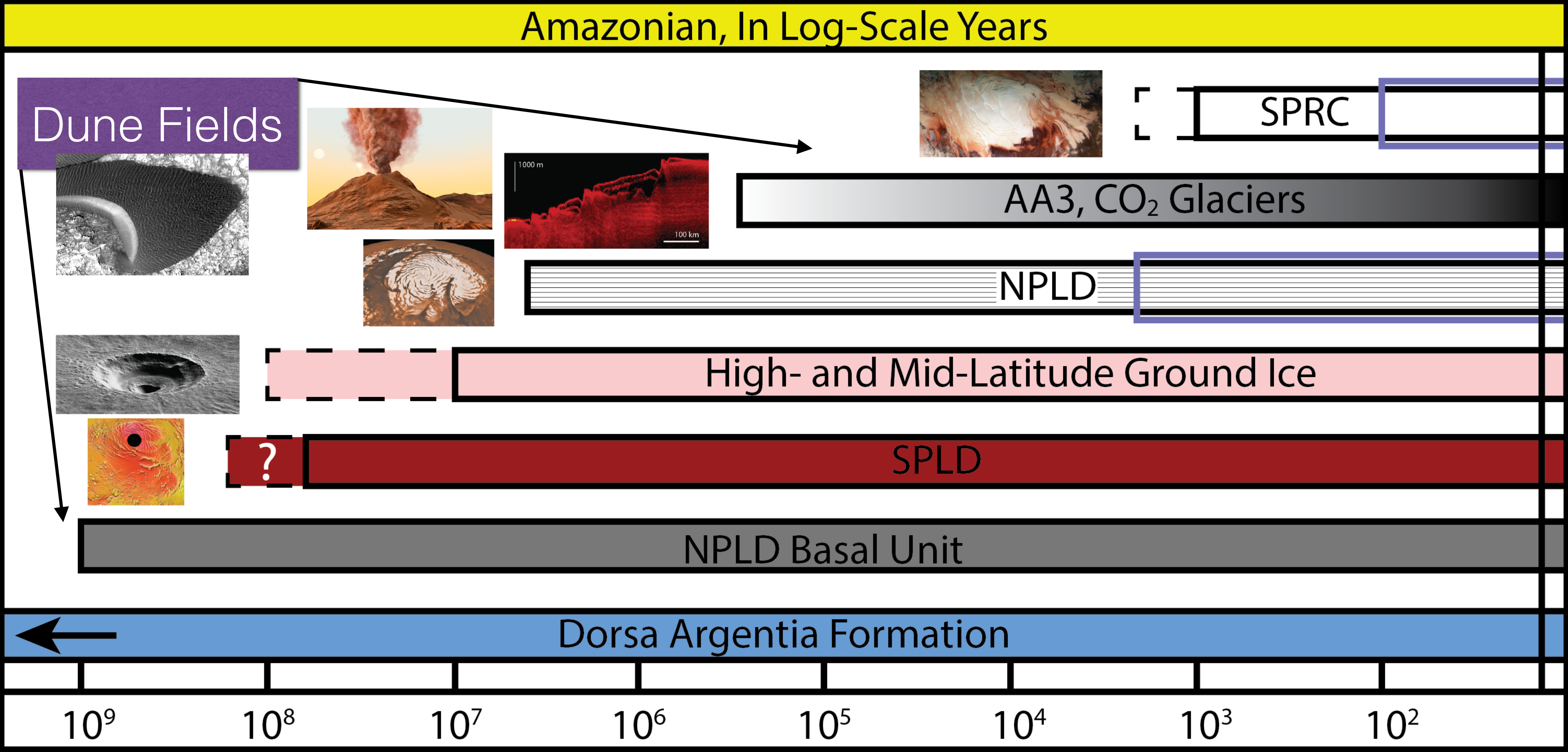
From Head et al, numerous conferences

Mars Climate History: A Geological Perspective

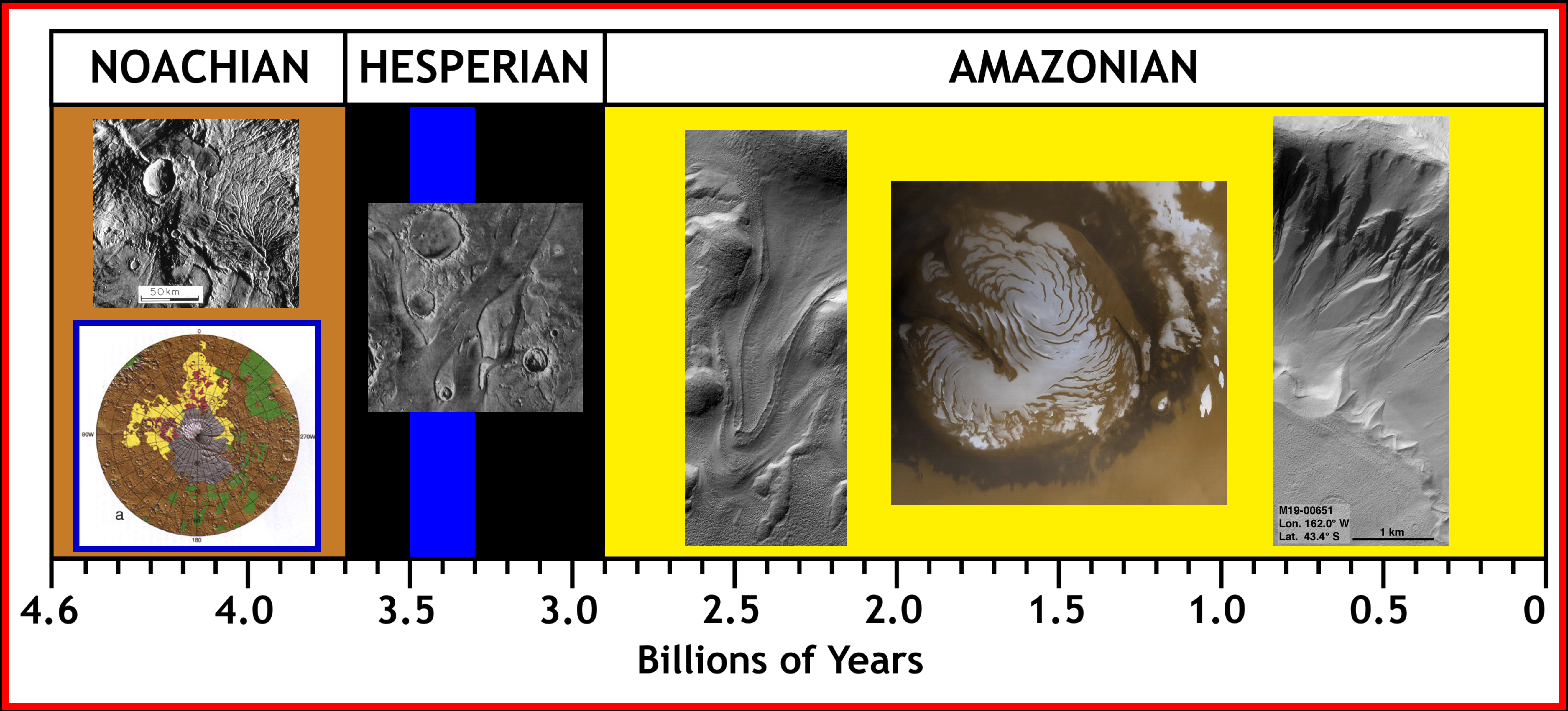


From Head et al, numerous conferences

With known ice deposits, we have climate information at various baselines and resolutions



The Amazonian is nearly 2/3 of Mars history, and underrepresented in the Goals Document



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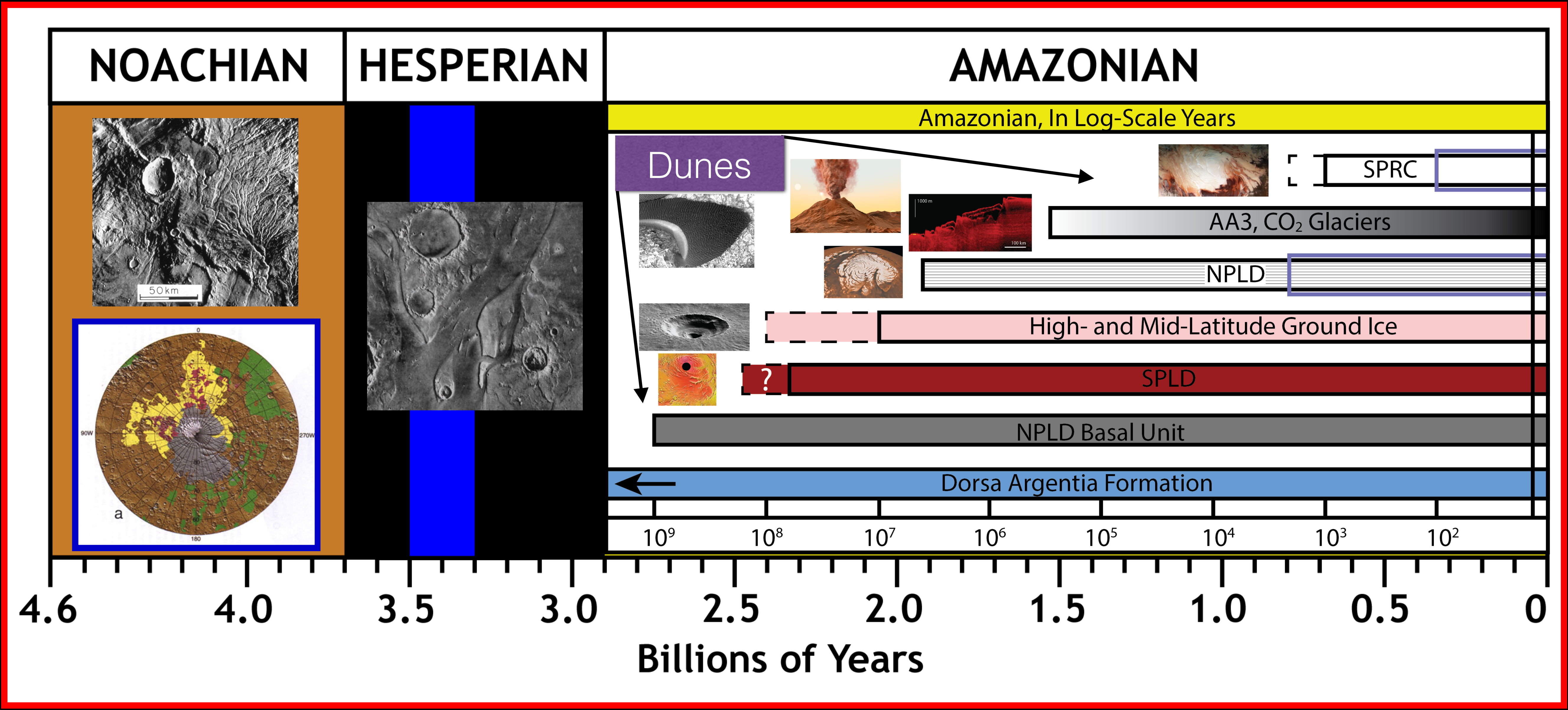


Arguments to Update Goals Document with respect to Polar Science

Goals Document changed formats between 2012 and 2015

2012 had Goal, Objective, Investigation
2015 has Goal, Objective, Sub-objective, Investigation

Because of this, many polar science investigations were bundled with non-polar science, and moved down a level - effectively demoting polar science

Arguments to Update Goals Document with respect to Polar Science

GOAL III: UNDERSTAND THE ORIGIN AND EVOLUTION OF MARS AS A GEOLOGICAL SYSTEM

Objectives	Sub-objectives
A. Document the geologic record preserved in the crust and interpret the processes that have created that record.	**A1:** Identify and characterize past and present geologic environments and processes relevant to the crust.
	A2: Determine the absolute and relative ages of geologic units and events through Martian history.
	A3: Constrain the magnitude, nature, timing and origin of past planet-wide climate change.
B. Determine the structure, composition, and dynamics of the Martian interior and how it has evolved.	**B1:** Identify and evaluate manifestations of crust-mantle interactions.
	B2: Quantitatively constrain the age and processes of accretion, differentiation and thermal evolution of Mars.
C. Determine the manifestations of Mars' evolution as recorded by its moons.	**C1:** Constrain the planetesimal density and type within the Mars neighborhood during Mars formation, as implied by the origin of the Mars moons.
	C2: Determine the material and impactor flux within the Mars neighborhood, throughout Mars' history, as recorded on the Mars moons.

The aeolian community has over 70 members and was definitely underrepresented.

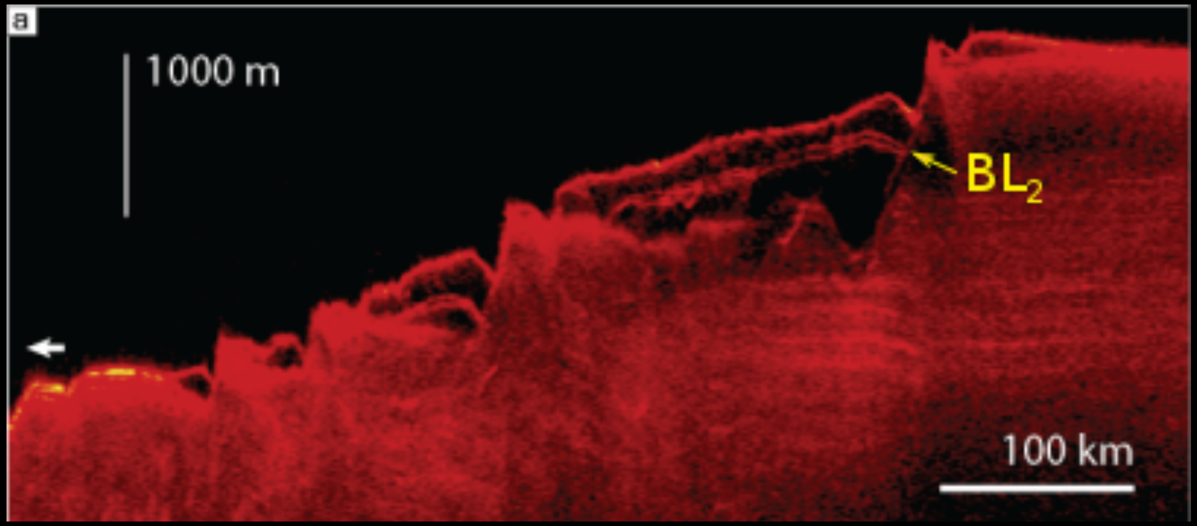
Investigation III.A3.2: Characterize surface-atmosphere interactions as recorded by **aeolian**, glacial/periglacial, fluvial, lacustrine, chemical and mechanical erosion, cratering and other processes.

Arguments to Update Goals Document with respect to Polar Science

2015 Goals Document was missing State of the Art

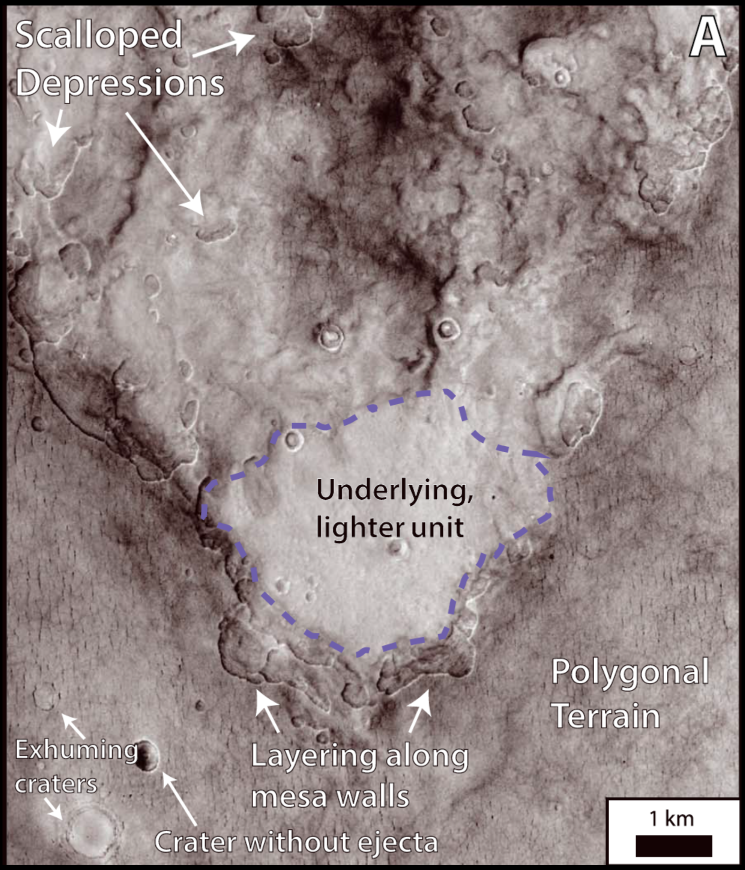
Massive CO_2 ice in SPLD

Phillips et al., 2011
Bierson et al., 2016
Putzig et al., 2017



Mid-latitude Ice discovered in 2015, 2016

Bramson et al., 2015
Stuurman et al., 2016

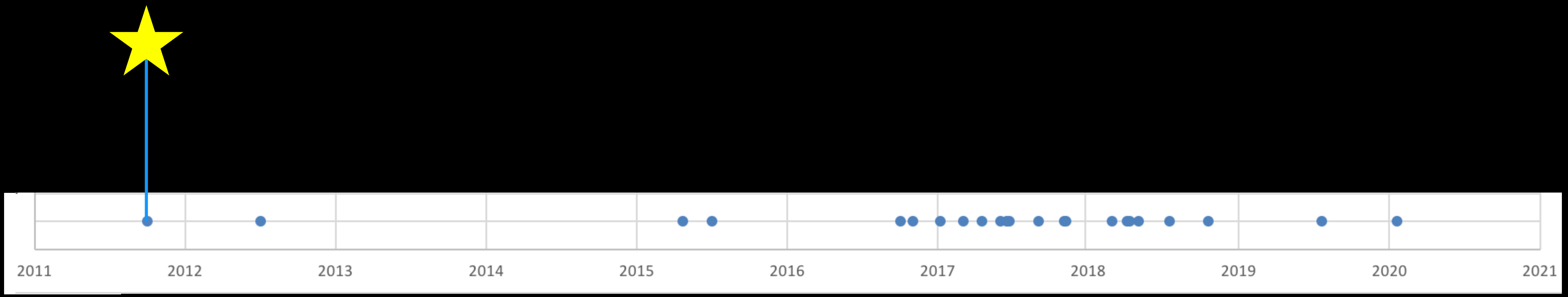


The “Polar Model”

for requesting changes to the goals document

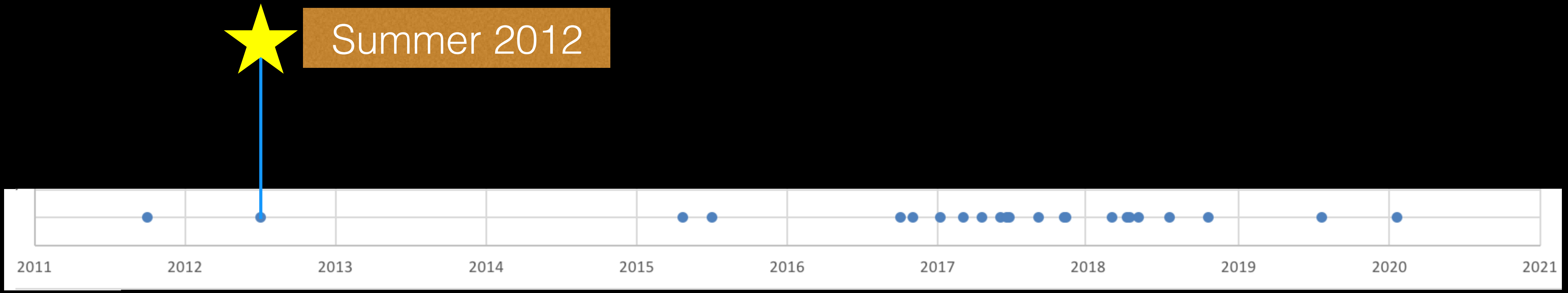
What steps and activities has the polar community undertaken in order to submit our report and have discussions with the goals committee?

- 5th in a series
- Approximately 4 year cadence
- <u>Mars polar science had narrow focus, atmosphere and ice at high latitudes</u>
- Anticipated 2012 Goals Major Revision



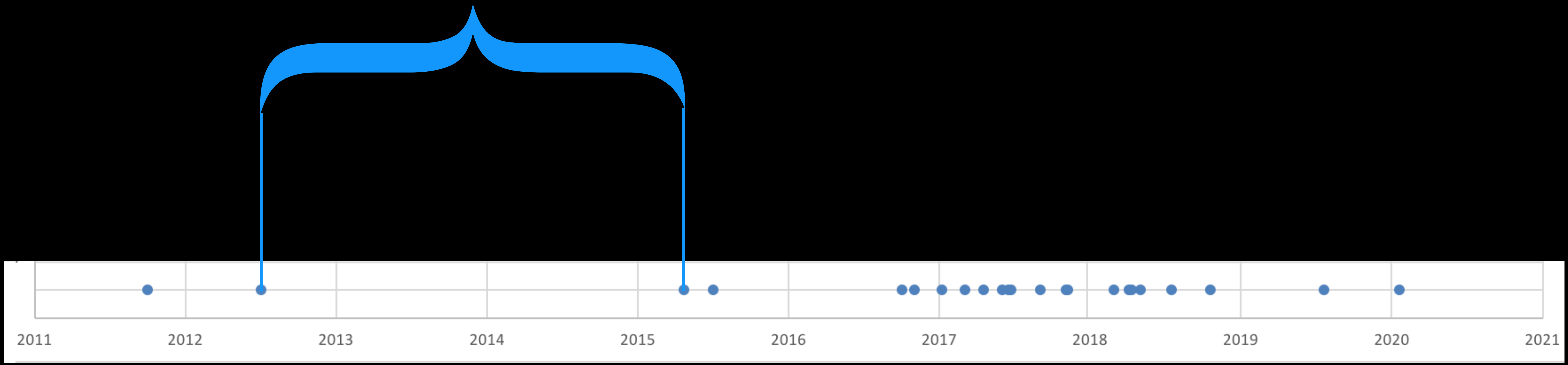
2012 MEPAG Goals Revision

- Few major changes from 2010
- Polar Science represented well for the state of the art

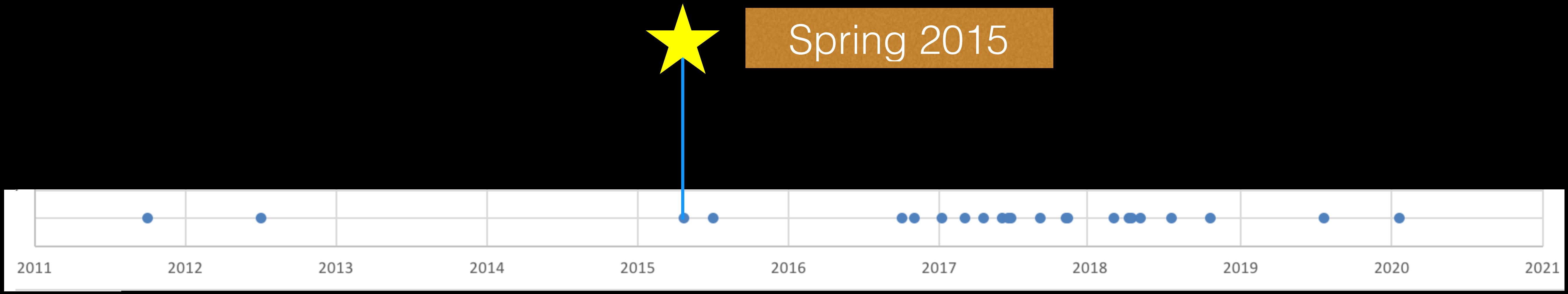


Many Scientific Breakthroughs

Nearly 3 years of continued and new investigations

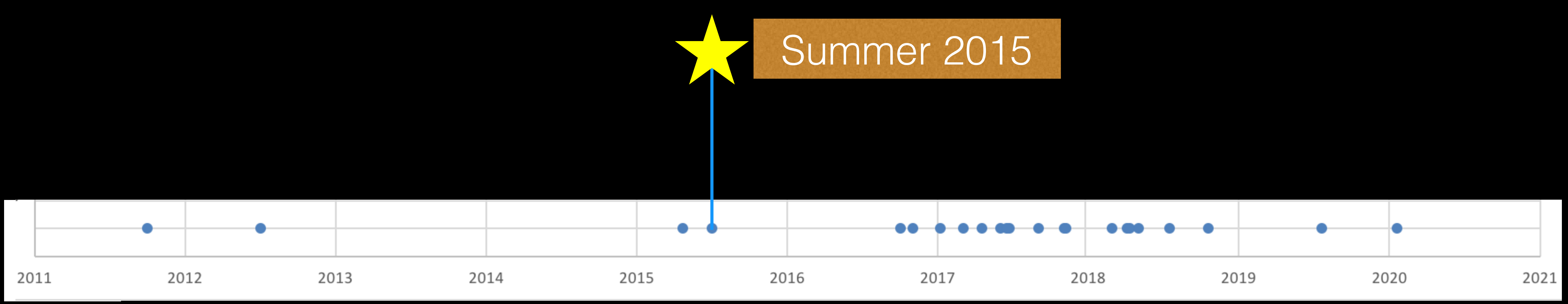


- Discussion of visiting the Bagnold Dune fields with Curiosity
- Reports of updated science, surface monitoring



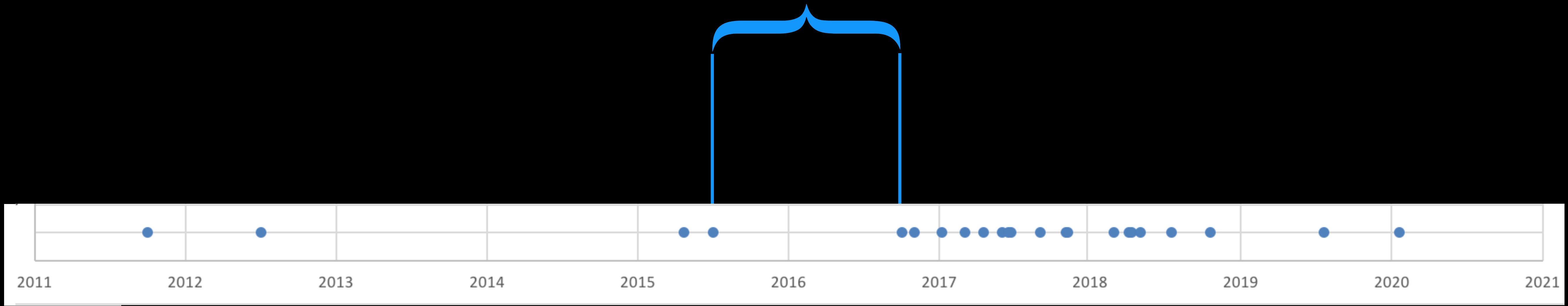
2015 MEPAG Goals Revision

- Major structural change
- Polar Science is partially demoted, and various discoveries r included

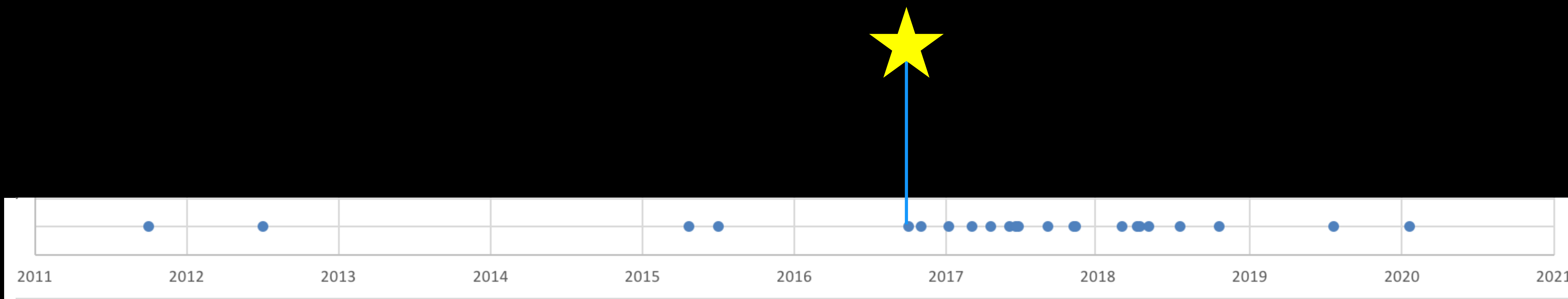


Many Scientific Breakthroughs

Another year of discoveries

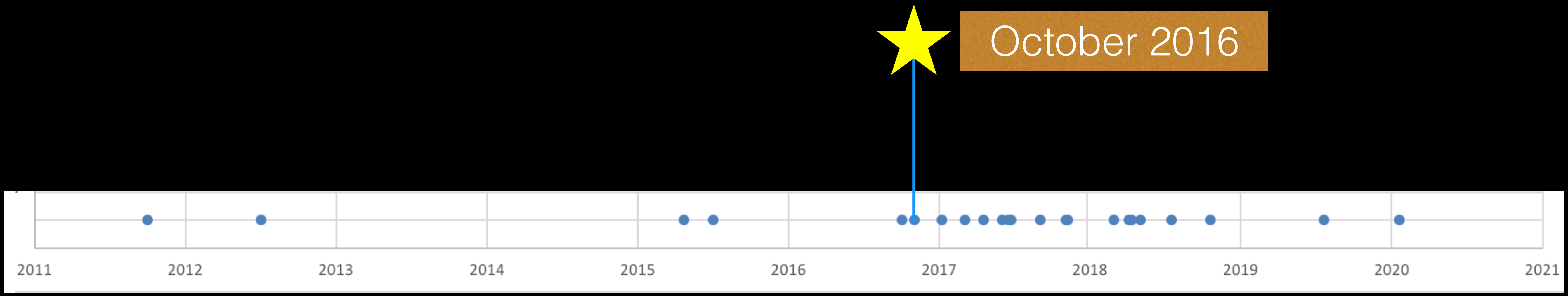


- 102 attendees! 11 countries, 22 students
- Discoveries presented in front of group for first time
- Agreement of the interconnectedness of many other investigations with Mars Polar Science
- Discussion of how 2015 MEPAG goals document under-represents state of the art of Mars Polar Science
- Decision to approach MEPAG



Invitation to present summary of 6th Polar Conference at MEPAG 32 virtual meeting

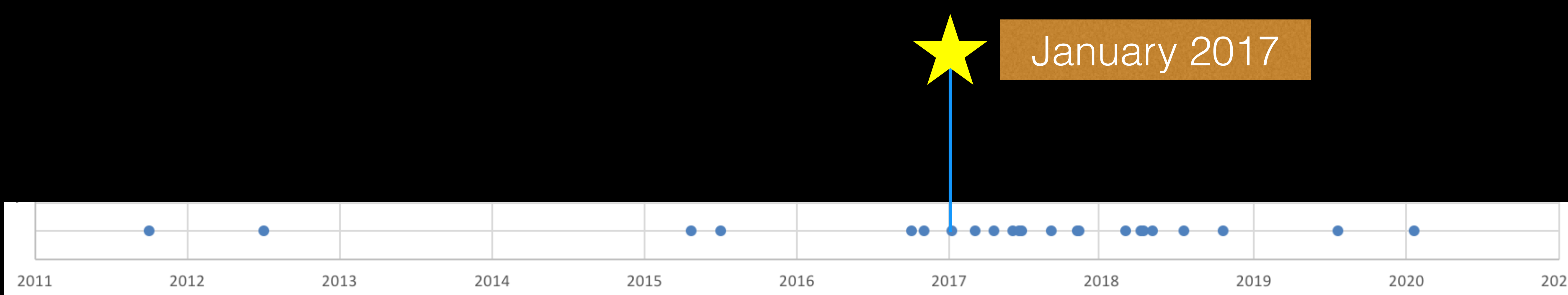
- 4 slides, 10 minutes
- Presented statistics and major questions
- Requested presentation at face-to-face meeting in February



Mars Polar Intrigue Spurs Multidisciplinary Collaboration

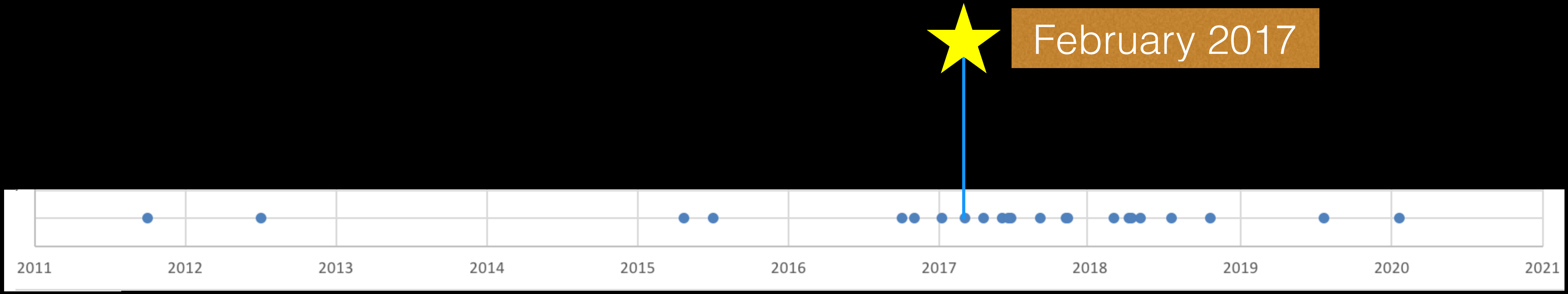
Sixth International Conference on Mars Polar Science and Exploration; Reykjavík, Iceland; 5–9 September 2016

EOS publication highlighting conference and summary



Presentation at MEPAG 33 meeting

- Presented Conference Summary
- Demonstrated the interconnectedness of Polar science with other communities
- Demonstrated the >4 years of discoveries without update to Goals Document



LPSC

March 20–24, 2017
The Woodlands, Texas

#LPSC2017

Lunar and Planetary 48th
Science Conference

SPECIAL SESSION: Mars Volatile Surface-Atmospheric Interactions: Past and Present

13 presentations

Planetary Cryospheres and Polar Processes II: Mars

13 presentations

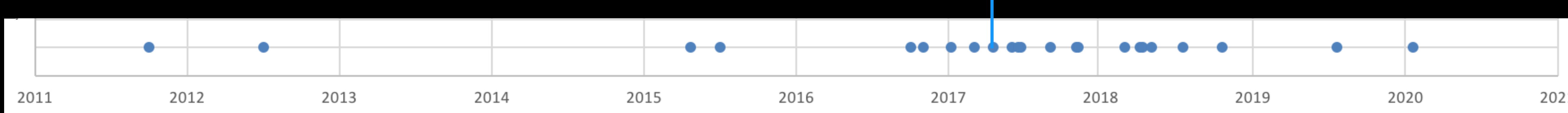
Planetary Cryospheres and Polar Processes III: From Mars to Pluto

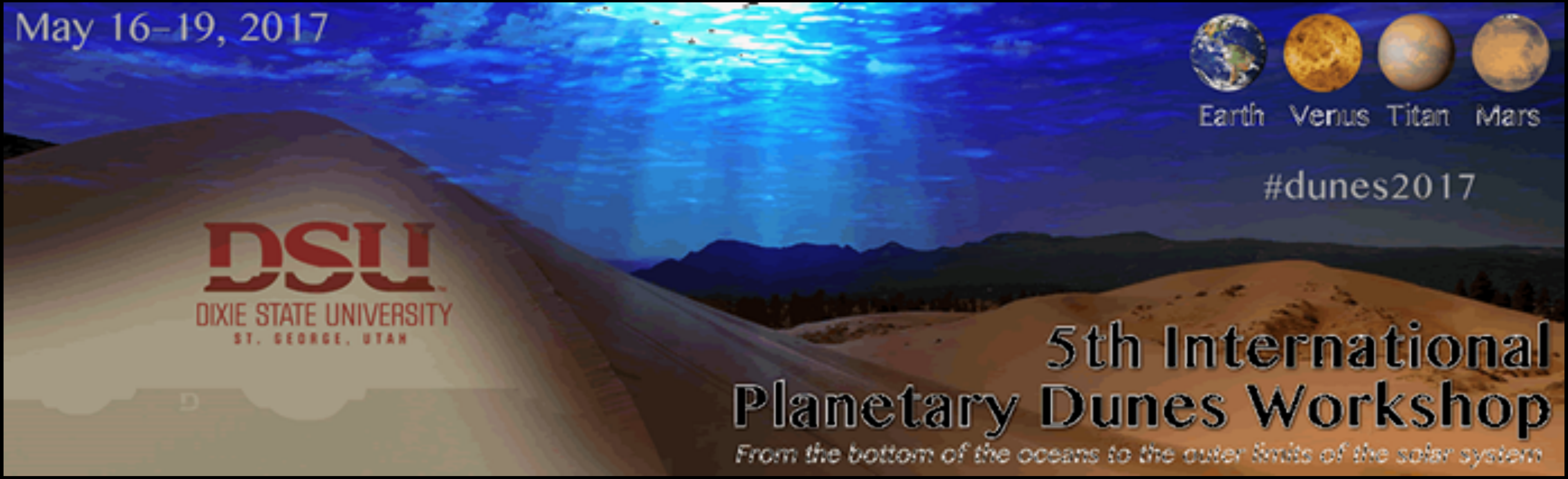
30 presentations

>50 presentations

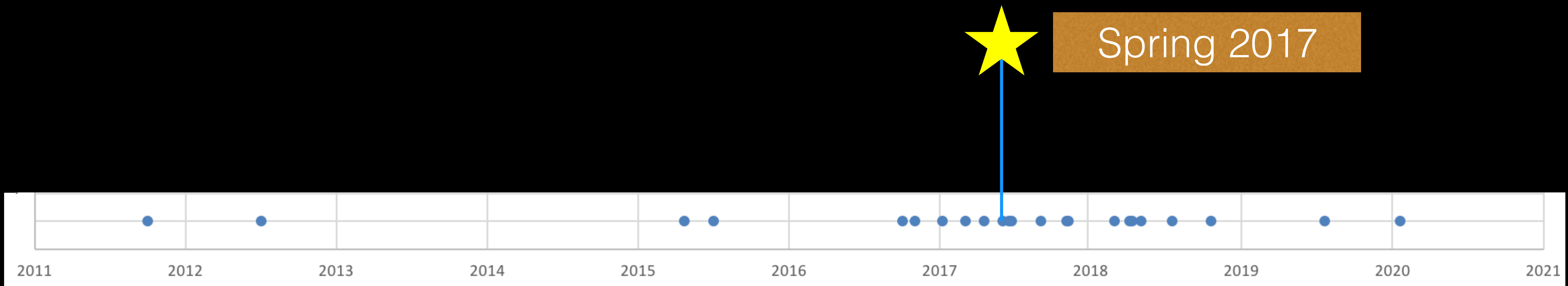
Annual Polar Luncheon

Annual Aeolian Luncheon





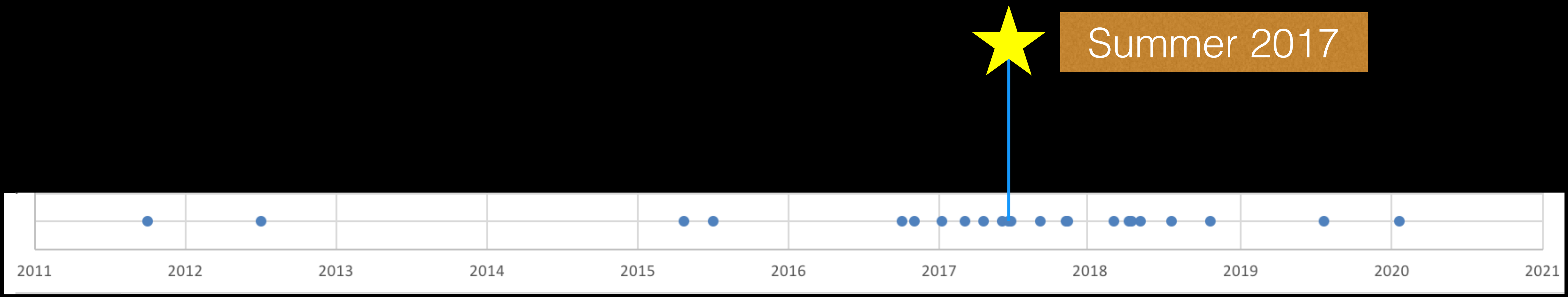
- 65 attendees
- Visited a dune on Mars!
- Reports of updated science, surface monitoring



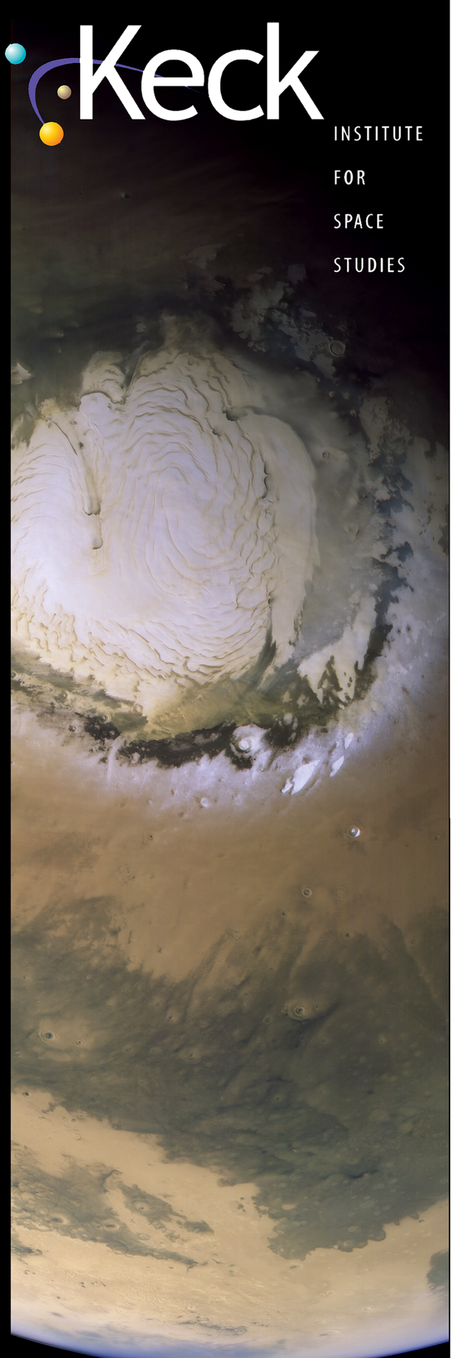
Invitation to Submit Report to MEPAG Goals Committee and Polar Vote

- MEPAG officially requests a report from the Mars Polar community
- Polar community votes on highest priority science based on conference summary that was submitted to special issue
- Send an initial "skeleton" report highlighting anticipated requests

Polar Atmosphere	
	Quantify the interplay of local, regional, and global circulations in the polar regions, including polar vortex, katabatic winds, transient eddies, among others
	Characterize the transport of volatiles and dust aerosols into and out of the polar regions
	Understand and predict the condensation of H_2O and CO_2 ice clouds and their impact on the thermal structure and atmospheric circulation
	Estimate the amount of CO_2 and H_2O frost deposited and lost at the surface via precipitation or sublimation
	Determine dust deposition patterns over the PLD and the specific mechanisms enabling dust lifting
Perennial Polar Ices	
	Determine the energy and mass balance of the polar ice reservoirs, and characterize volatile fluxes (i.e., seasonal deposition and removal, long term accumulation vs. erosion, when and where, at what rates)
	Characterize current/recent perennial ice landforms such as the south polar residual cap and associated features (i.e., distribution, variety, composition, and evolution) and their relationship with seasonal processes
	Quantify the role and efficiency of dust and sand as agents promoting the preservation of buried volatiles
	Determine the vertical and horizontal variations of composition and physical properties of the materials forming the polar layered deposits
	Identify and quantify the differences and similarities between the NPLD and SPLD
	Identify where and hypothesize as to why ice flow model predictions do not match observations
Past climate polar record	
	Determine and characterize the link between orbital forcing and resultant climate parameters to layer properties at the PLD and non-polar deposits, and then invert to derive polar and global martian history
	Further test the current hypothesis that NPLD formation began at ~4 Ma
	Estimate the climatic conditions that could have formed the SPLD, especially given that current and recent climates are predicted to be unfavorable for accumulation and that the surface age may be greater than 30 Myr
	Determine if the SPLD H_2O ice units (AA_1 and AA_2) were deposited in one or multiple periods of favorable climate
	Characterize the processes and timing that led to the buried CO_2 ice reservoirs at the south pole
	Determine how the SPLD expanse relates to the much larger southern polar deposits in terms of age and climate epochs that are recorded. Specifically, does the Dorsa Argentea Formation (DAF) have origins in an ancient climate and what can DAF presence tell us about that climate?
	Determine the climate forcing that allowed for the development of the south polar residual cap (SPRC), and how it remains in its present-state given that models predict it to be unstable. Also estimate its absolute age
Non-polar ice	
	Inventory and characterize the non-polar volatile reservoirs at the surface and near-surface
	Determine the accessibility of H_2O ice deposits as a resource for future human exploration, in particular the conditions and lowest latitude under which water-ice reservoirs can be found
	Determine under which conditions the non-polar volatile reservoirs accumulate and persist
	Determine how different chemistries (salts) influence the movement of volatiles and their impact on habitability
	Investigate if liquid water exists or has existed in locations associated with mid- and lower-latitude ice deposits. Could these have provided habitats for, or preserved evidence of, past or present life?
Present day surface activity	
	Determine the processes by which seasonal CO_2 (alone, or in conjunction with other surface materials) acts as an agent of geomorphic change for: gullies/alcove-aprons, dunes, and araneiform terrain, on various time scales
	Quantify the amount of CO_2 needed for the observed geomorphic processes to occur. Characterize what form (snow or direct deposition), when, and where that CO_2 is deposited/accumulated seasonally
	Determine the present rate of activity and the time needed to produce the existing surface features. Detect changes in environmental conditions as recorded within these landforms
	Observe the distribution of seasonal and diurnal H_2O and CO_2 frost deposited each year, from within the seasonal cap down to the lowest latitudinal-extent
	Characterize inter-annual variability in polar surface processes and determine their relationship to volatile cycles, dust cycles, and weather
	Determine the present-day role and extent of seasonal polar deposits of H_2O within surface changes



Unlocking the Climate Record Stored within Mars' Polar Layered Deposits



The Keck Institute for Space Studies
presents a short course on:

The
Polar Ice Caps
and
Climate of Mars

Tuesday, August 8, 2017
8:15 A.M. Coffee
8:45 A.M. - 12:30 P.M. Short Course

Salvatori Seminar Room
South Mudd Building
California Institute of Technology

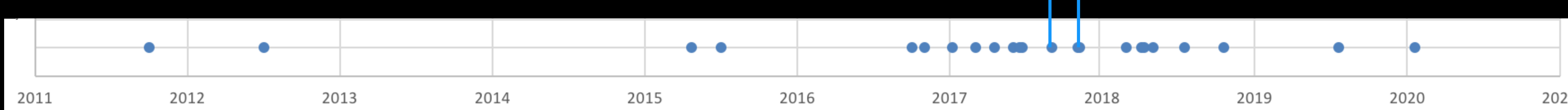
Prof. Shane Byrne - University of Arizona
Overview of Mars' Polar Caps and Present-day Conditions

Dr. Patricio Becerra - Universität Bern
Polar Stratigraphy

Dr. Melinda Kahre - NASA Ames
Amazonian Climate Modeling

Prof. Christine Hvidberg - Univ. of Copenhagen
Terrestrial Ice Sheets in Climate Studies

More than 35 Polar experts and Engineers met in two Workshops to design several mission concepts.



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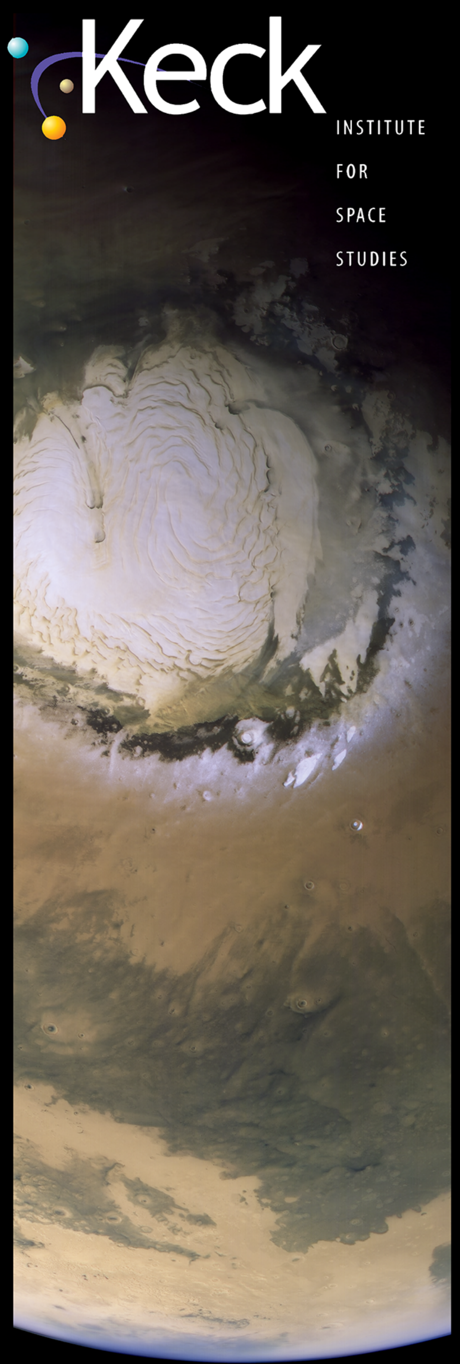
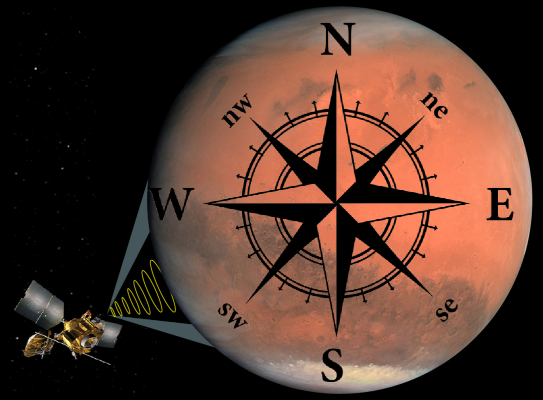
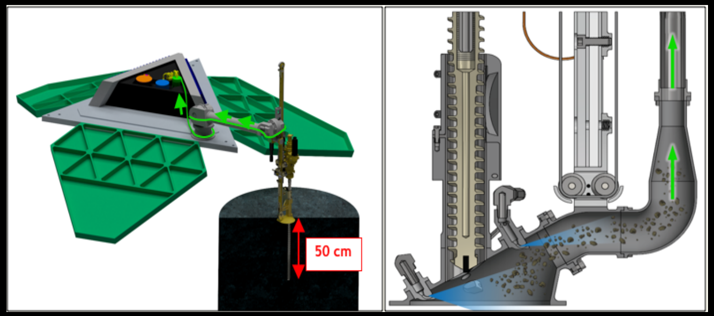


- Enumerated "4 Big Questions"
- 3 mission concepts (posters)

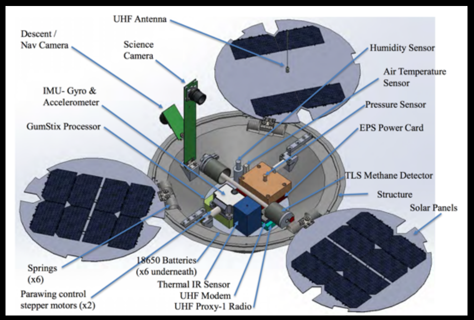
COMPASS: Climate Orbiter for Mars Polar Atmospheric and Subsurface Science - led by I. B. Smith

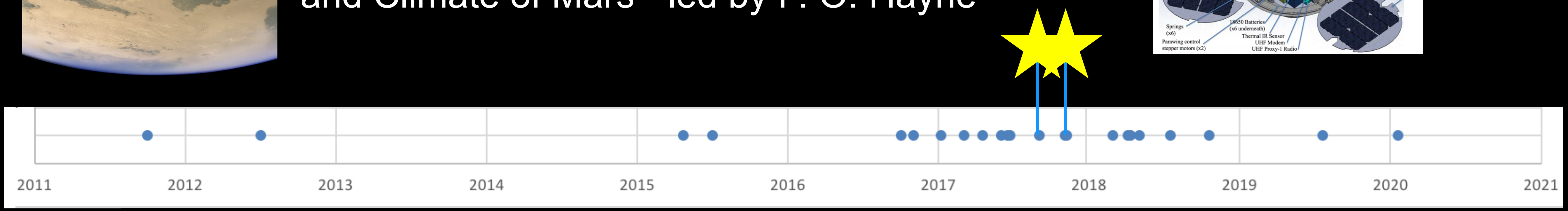


M-PRESS: Mars-Polar Reconnaissance of Environment and Subsurface Stratigraphy - led by S. Byrne



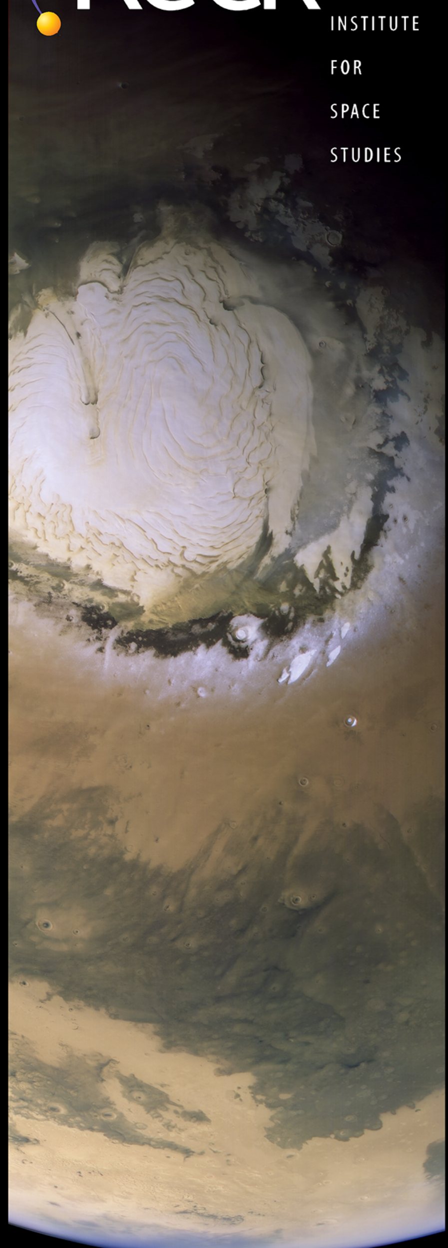
Mars Polar$_{\textbf{DROP}}$**:** Distributed Micro-landers to Investigate the Polar Ice Caps and Climate of Mars - led by P. O. Hayne





Unlocking the Climate Record Stored within Mars' Polar Layered Deposits

Keck INSTITUTE FOR SPACE STUDIES



- Enumerated "4 Big Questions"
- 3 mission concepts (posters)

>15 posters today!

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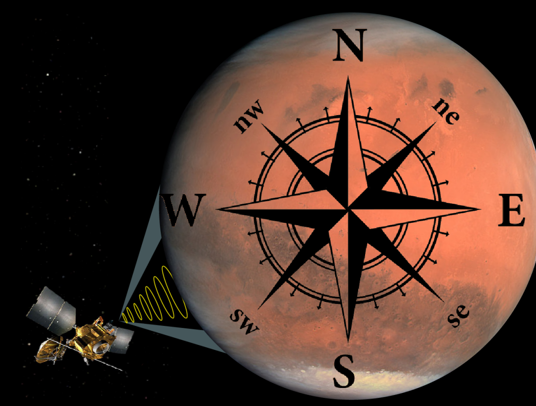

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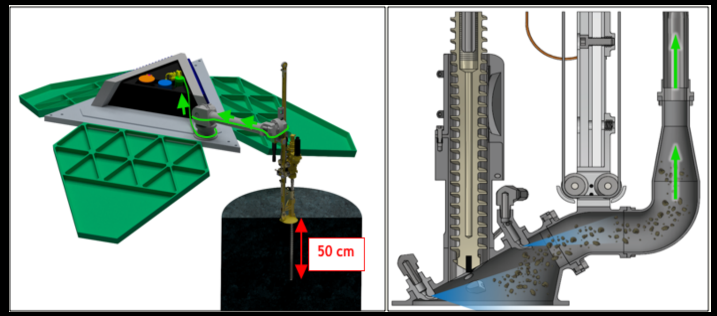
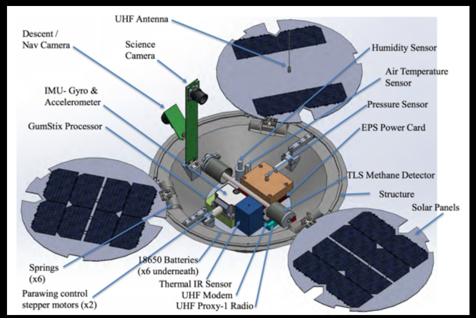
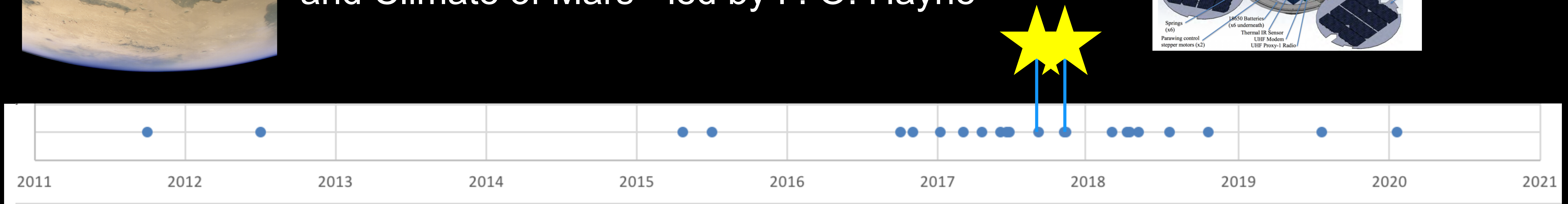


Mars Polar**DROP:** Distributed Micro-landers to Investigate the Polar Ice Caps and Climate of Mars - led by P. O. Hayne





Priority Recommendations Concerning Mars Polar Science for the Mars Exploration Program Analysis Group (MEPAG) Goals Document

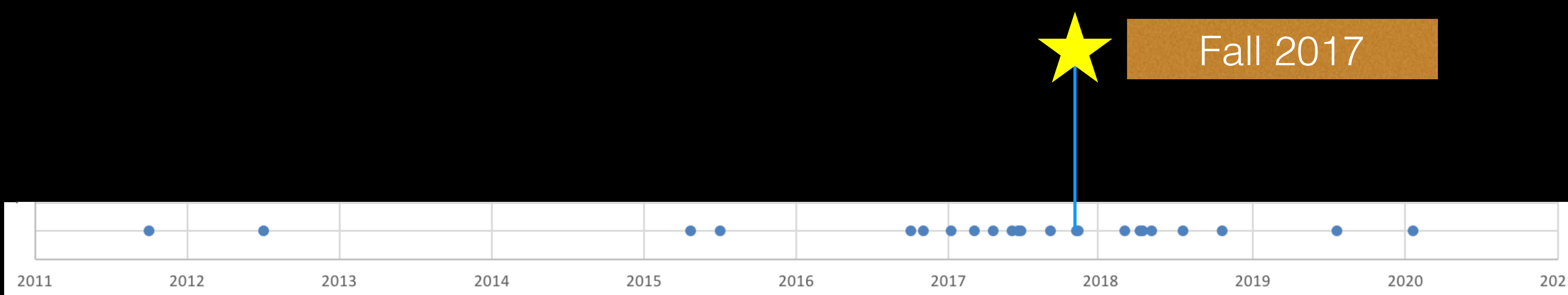
November 1, 2017

Contributing Authors:

Isaac B. Smith
Wendy M. Calvin
Serina Diniega
K. Michael Aye
Tim N. Titus
Candice J. Hansen

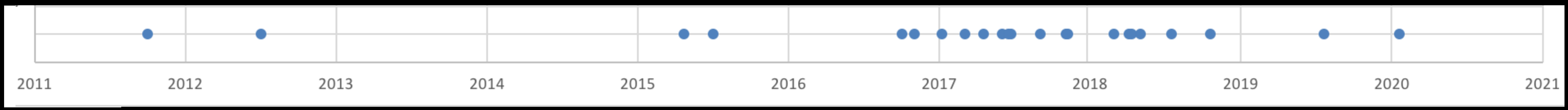
6 authors but
constant interaction with polar community

- Numerous recommendations related to Goals II and III



Mars Polar Telecon

- Run by Tim Titus
- Bi-weekly telecons, every other Monday
- Backbone of Polar Science organization
    - Discuss observation priorities
    - Plan workshops/conferences
    - Advertised for priority vote



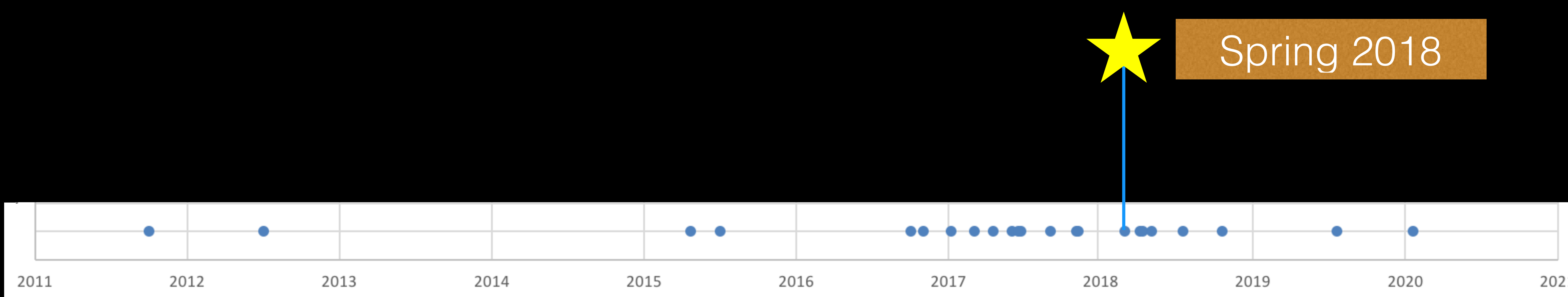
Priority Recommendations Concerning Mars Polar Science for the Mars Exploration Program Analysis Group (MEPAG) Goals Document

First Iteration

Contributing Authors:

Isaac B. Smith
Wendy M. Calvin
Serina Diniega
K. Michael Aye
Tim N. Titus
Candice J. Hansen

- Numerous recommendations related to Goals II and III



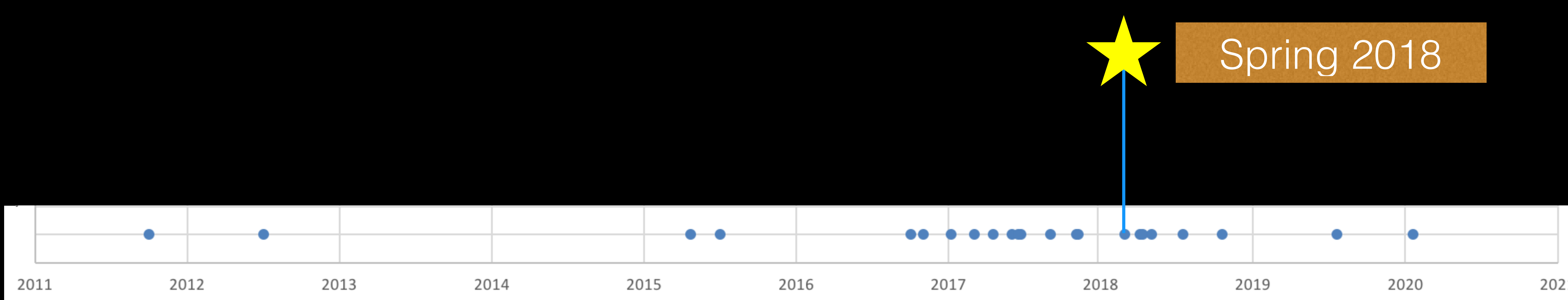
GOAL III: UNDERSTAND THE ORIGIN AND EVOLUTION OF MARS AS A GEOLOGICAL SYSTEM

Objectives	Sub-objectives
A. Document the geologic record preserved in the crust and investigate the processes that have created and modified that record.	**A1.** Identify and characterize past and present geologic environments and processes relevant to the crust.
	A2. Determine the absolute and relative ages of geologic units and events through Martian history.
	A3. Identify and characterize processes that are actively shaping the present-day surface of Mars.
	A4. Constrain the magnitude, nature, timing, and origin of past planet-wide climate change.
B. Determine the structure, composition, and dynamics of the Martian interior and how it has evolved.	**B1.** Identify and evaluate manifestations of crust-mantle interactions.
	B2. Quantitatively constrain the age and processes of accretion, differentiation, and thermal evolution of Mars.
C. Determine the manifestations of Mars' evolution as recorded by its moons.	**C1.** Constrain the planetesimal density and type within the Mars neighborhood during Mars formation, as implied by the origin of the Mars moons.
	C2. Determine the material and impactor flux within the Mars neighborhood, throughout Mars' history, as recorded on the Mars moons.

GOAL II: UNDERSTAND THE PROCESSES AND HISTORY OF CLIMATE ON MARS

Objectives	Sub-objectives
A. Characterize the state of the present climate of Mars' atmosphere and surrounding plasma environment, and the underlying processes, under current orbital configuration	A1. Constrain the processes that control the present distributions of dust, water, and carbon dioxide in the lower atmosphere, at daily, seasonal and multi-annual timescales.
	A4->A2. Constrain the Processes by which volatiles and dust exchange between the surface and atmospheric reservoirs.
	A2-> A3. Constrain the processes that control the dynamics and thermal structure of the upper atmosphere and surrounding plasma environment
	A3->A4. Constrain the processes that control the chemical composition of the atmosphere and surrounding plasma environment
B. Characterize the history of Mars' ~~recent~~ Amazonian climate, and the underlying processes, through different orbital configurations	B2-> B1. Determine the climate record that is expressed in geological, glaciological, and mineralogical features of the polar regions.
	B3 -> B2. Determine the record of the climate of the recent past that is expressed in geological and mineralogical features of low- and mid-latitudes.
	B1->B3. Determine how the chemical composition and mass of the atmosphere has changed in the recent past

- Goal III, agreed with committee on table and text.
- Goal II, still discussing changes within the text



Lunar and Planetary Science Conference
The Woodlands, Texas
March 19-23, 2018

49th LPSC

Mars Polar Caps Where Ice Lingers — 9 presentations

Dreams of a Glacial Mars — 13 presentations

Mars Ice and Polar Processes — 23 presentations

Mars Atmosphere — 23 presentations

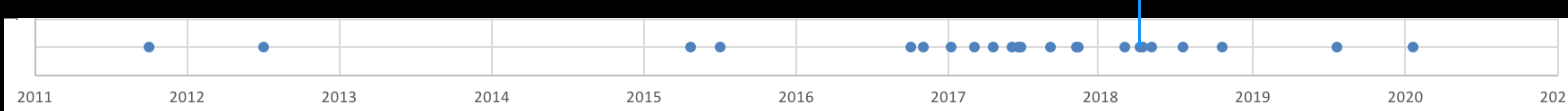
Aeolian Geology — 10 presentations

~90 presentations

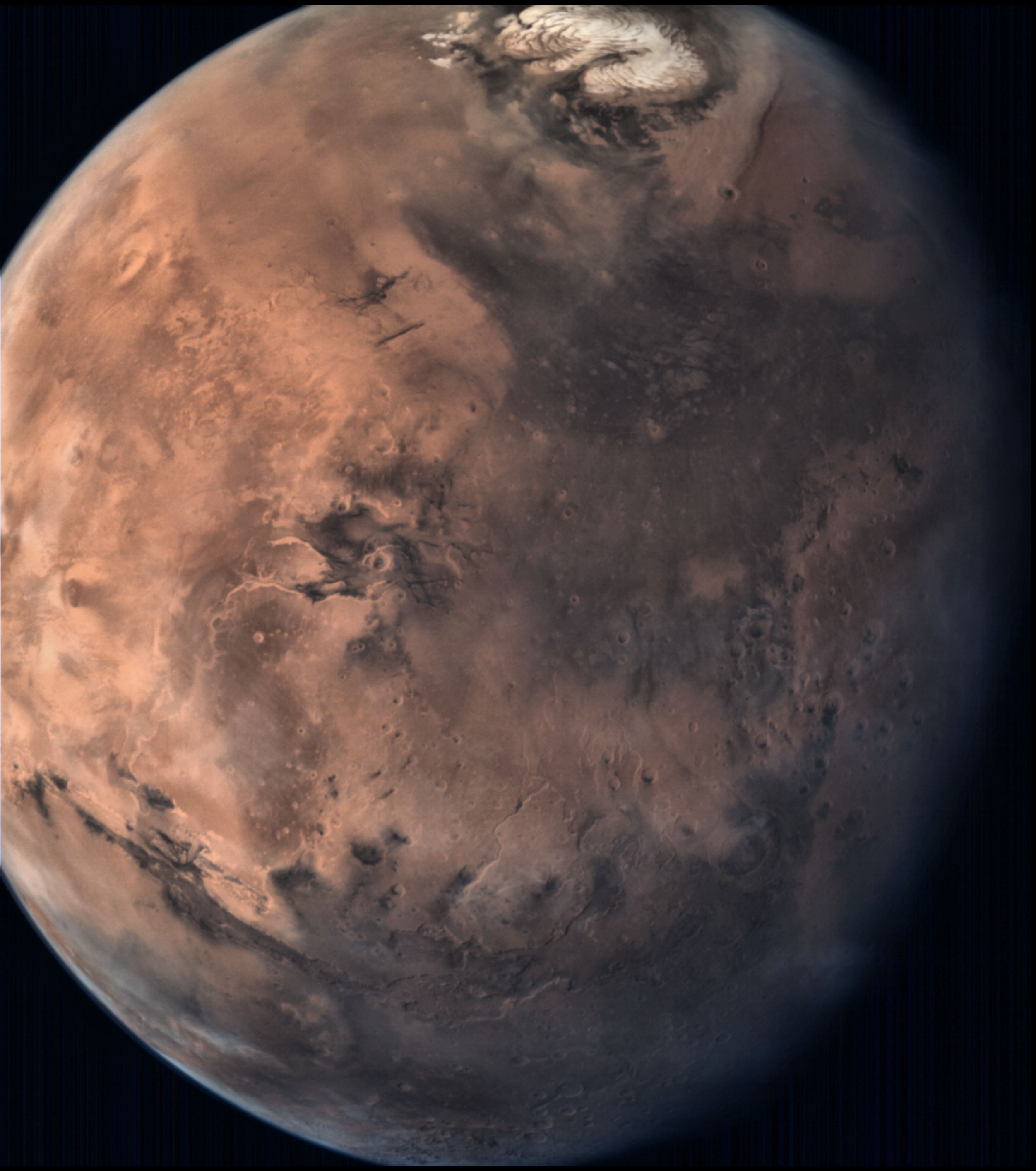
Annual Polar Luncheon

Annual Aeolian Luncheon

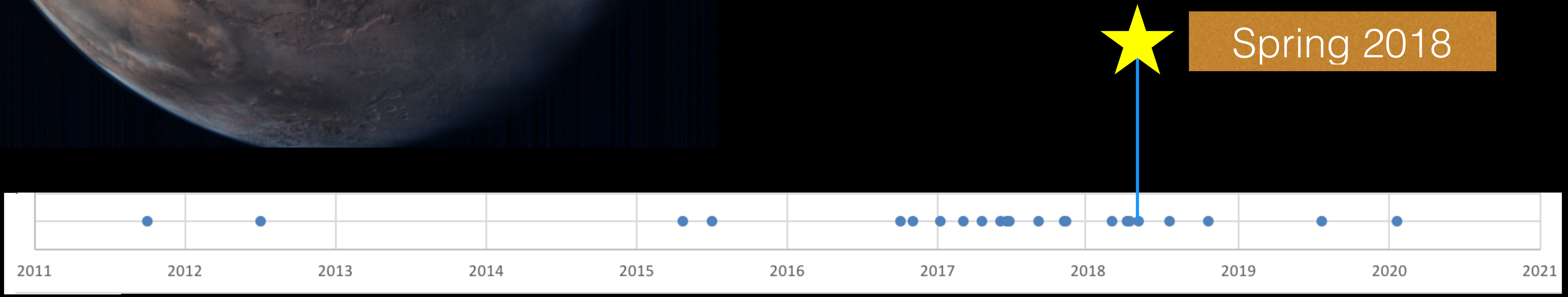
Spring 2018



Special Issue



- 16 peer reviewed articles
- Adrian Brown and Mike Sori guest editors
- Finalized this week

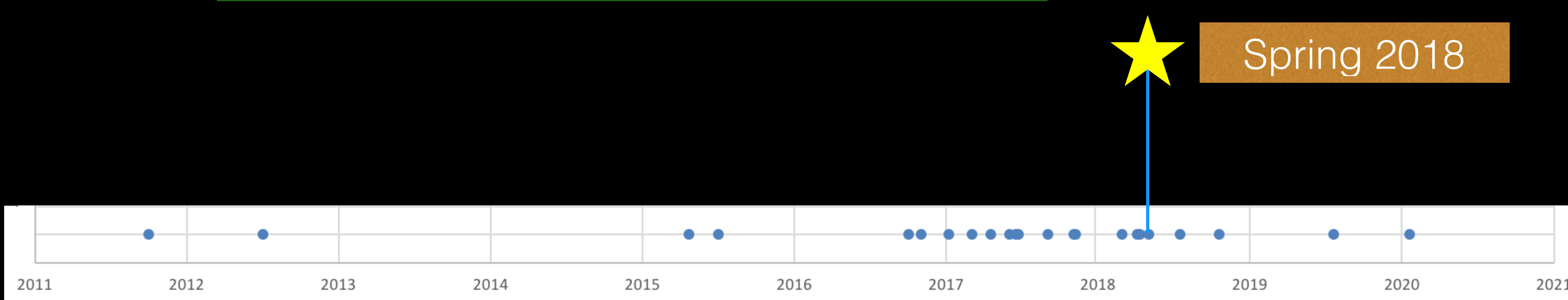


Presentation at MEPAG 36 meeting

- Polar Recommendations
- 3rd presentation for polar science updates

- Next steps:
    - Finalize text for Goal II
    - Send to executive committee for approval
    - Send to wide community for discussion

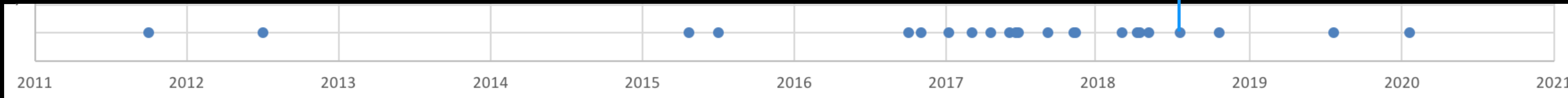
~2 years total to advocate for these changes



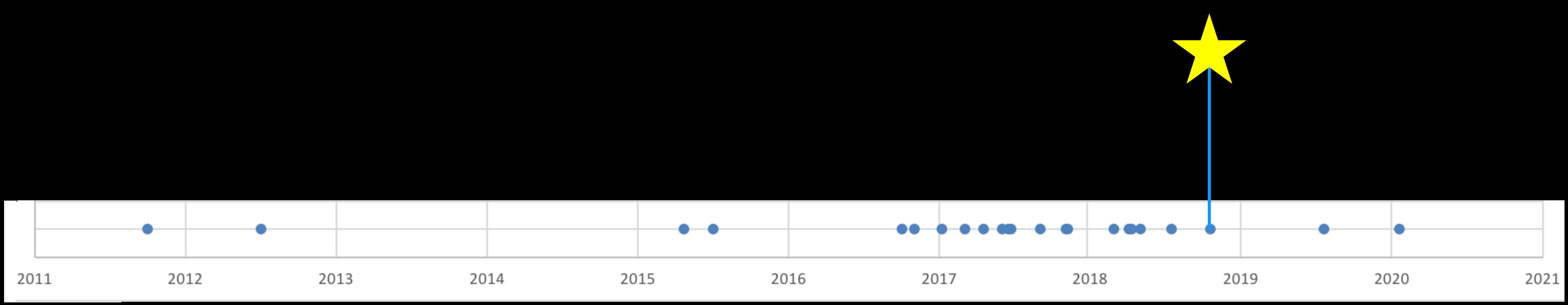
Abstracts due April 11, 40-50 attendees expected

- Volatiles reservoirs
- Volatiles and dust affect past climate
- Mass and energy budget of polar regions
- PLD composition and stratigraphy
- CO_2 affect on geomorphology
- Surface chemistry from volatiles
- Aeolian activity related to volatile abundance on seasonal and orbital time scales

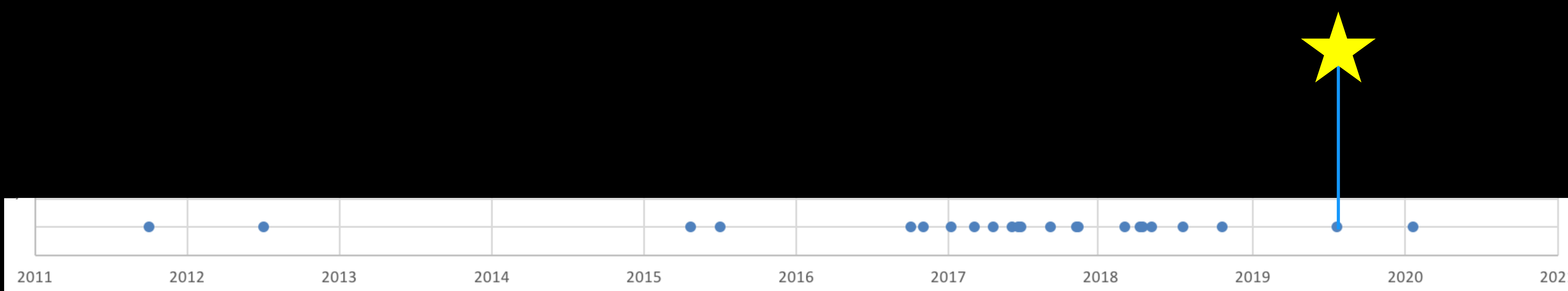
Summer 2018



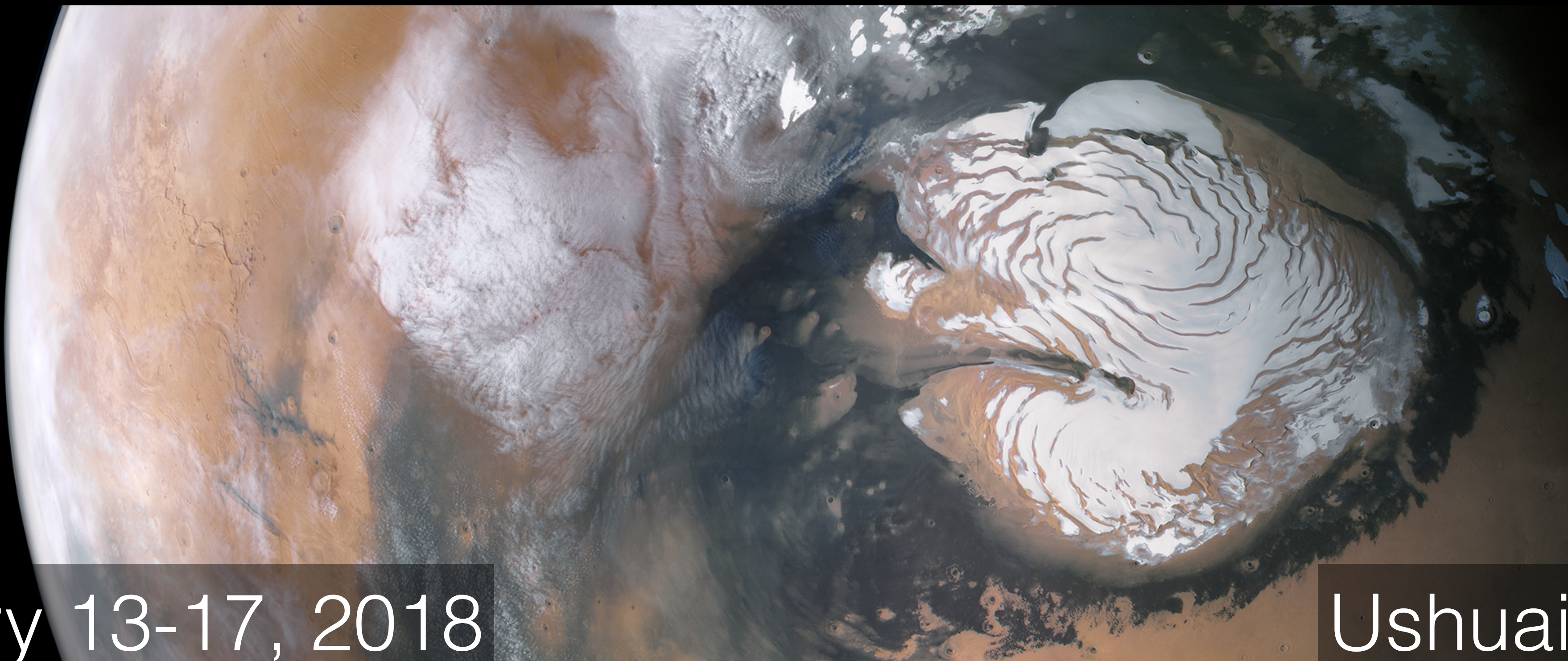
- Entirely separate workshop run by Canadians and Europeans
- Evidence that multiple groups feel this is important right now
- Announcement next week



- Time to showcase Mars Polar Science!
- Full Goals Revision following the conference

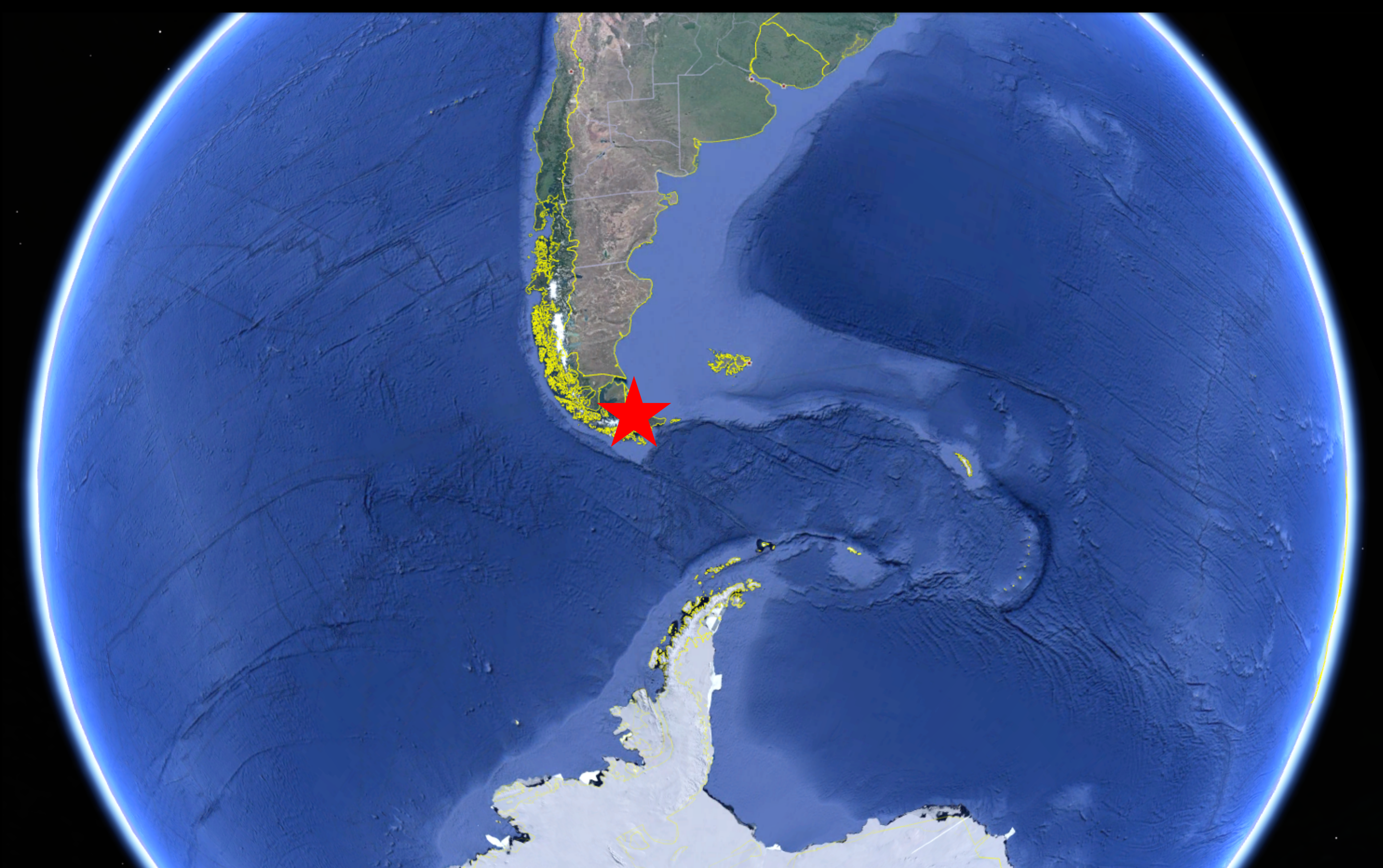


7th International Conference on Mars Polar Science and Exploration

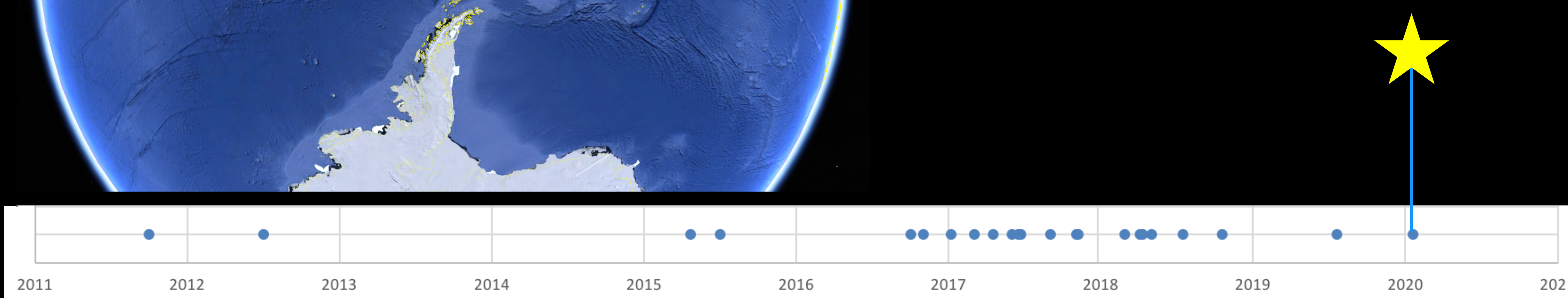


January 13-17, 2018

Ushuaia, Argentina



Abstracts due Fall 2019
100 attendees expected
Several great field trips



A closing thought

With many Mars missions winding down, and engineering being the biggest component of the Mars budget for this decade, support for R&A programs would enable the wider community to better sustain itself without a large contraction.

Current projections imply that R&A programs, already over subscribed, will be used more heavily. Funding rates will drop well below 20%, and many people will have to leave the field.

Getting rates above 30% for this period will retain enough scientists so that we can survive until new missions are flown.