Searching for Subsurface Ice in Hellas Planitia, Mars Using Radar

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Space Grant Symposium

April 14th, 2018

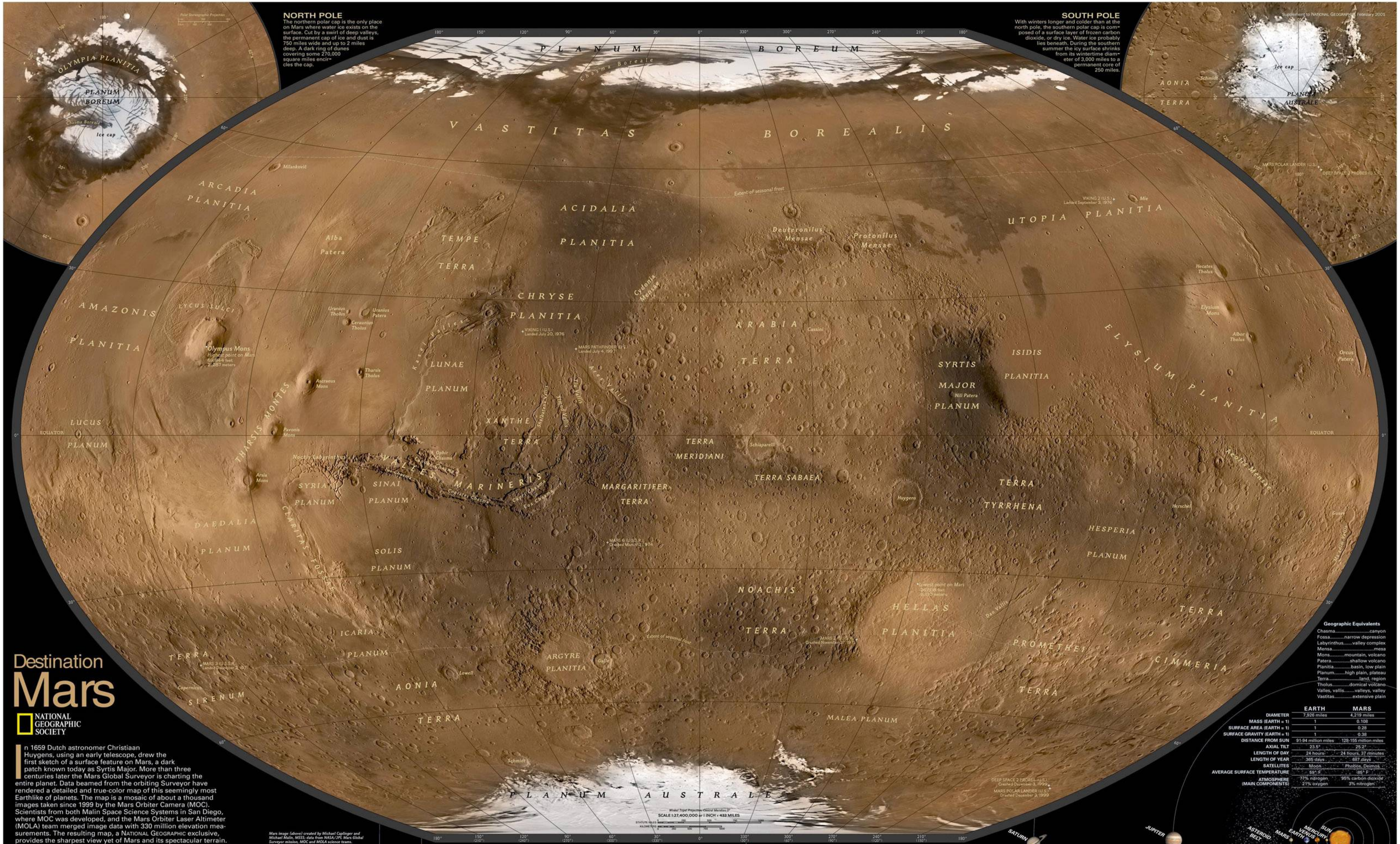
Supplement to NATIONAL GEOGRAPHIC, February 2001

NORTH POLE

The northern polar cap is the only place on Mars where water ice exists on the surface. Cut by a swirl of deep valleys, the permanent cap of ice and dust is 750 miles wide and up to 2 miles deep. A dark ring of dunes covering some 270,000 square miles encircles the cap.

SOUTH POLE

With winters longer and colder than at the north pole, the southern polar cap is composed of a surface layer of frozen carbon dioxide, or dry ice. Water ice probably lies beneath. During the southern summer the icy surface shrinks from its wintertime diameter of 3,000 miles to a permanent core of 250 miles.



Destination Mars

NATIONAL GEOGRAPHIC SOCIETY

In 1659 Dutch astronomer Christiaan Huygens, using an early telescope, drew the first sketch of a surface feature on Mars, a dark patch known today as Syrtis Major. More than three centuries later the Mars Global Surveyor is charting the entire planet. Data beamed from the orbiting Surveyor have rendered a detailed and true-color map of this seemingly most Earthlike of planets. The map is a mosaic of about a thousand images taken since 1999 by the Mars Orbiter Camera (MOC). Scientists from both Malin Space Science Systems in San Diego, where MOC was developed, and the Mars Orbiter Laser Altimeter (MOLA) team merged image data with 330 million elevation measurements. The resulting map, a National Geographic exclusive, provides the sharpest view yet of Mars and its spectacular terrain.

Geographic Equivalents

Chasma.....canyon
Fossa.....narrow depression
Labyrinthus.....valley complex
Mensa.....mesa
Mons.....mountain, volcano
Patera.....shallow volcano
Planitia.....basin, low plain
Planum.....high plain, plateau
Terra.....land, region
Tholus.....domical volcano
Valles, vallis.....valleys, valley
Vastitas.....extensive plain

	EARTH	MARS
DIAMETER	7,926 miles	4,219 miles
MASS (EARTH = 1)	1	0.108
SURFACE AREA (EARTH = 1)	1	0.28
SURFACE GRAVITY (EARTH = 1)	1	0.38
DISTANCE FROM SUN	91-94 million miles	128-155 million miles
AXIAL TILT	23.5°	25.2°
LENGTH OF DAY	24 hours	24 hours, 37 minutes
LENGTH OF YEAR	365 days	687 days
SATELLITES	Moon	Phobos, Deimos
AVERAGE SURFACE TEMPERATURE	59° F	-85° F
ATMOSPHERE (MAIN COMPONENTS)	77% nitrogen 21% oxygen	95% carbon dioxide 3% nitrogen

Longitude numbers increase to the west in accordance with astronomical convention, but some scientists now prefer longitude increasing to the east (eastward longitude shown in parentheses).

Mars image (above) created by Michael Caplinger and Michael Malin, MSSS; data from NASA/JPL Mars Global Surveyor mission, MOC and MOLA science teams. Images of Neptune, Uranus, Saturn, Jupiter, and Mars (right), NASA/JPL/Caltech; Earth image, NASA/GSFC; Mercury image, USGS; sun image, SOHO/ESA/NASA

PLUTO NEPTUNE URANUS SATURN JUPITER ASTEROID BELT MARS EARTH VENUS MERCURY SUN

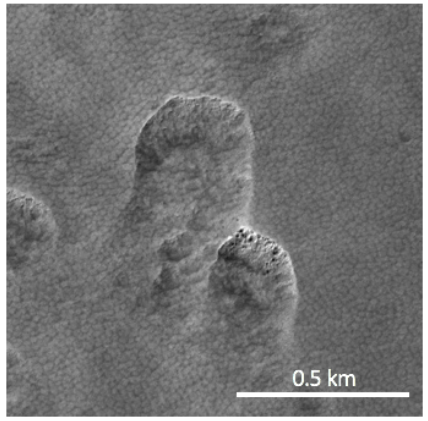
Introduction: Ice on Mars

- Could be a resource for future human exploration
- Gives insight into Mars' climate history
  - Purity
  - Distribution
  - Depth

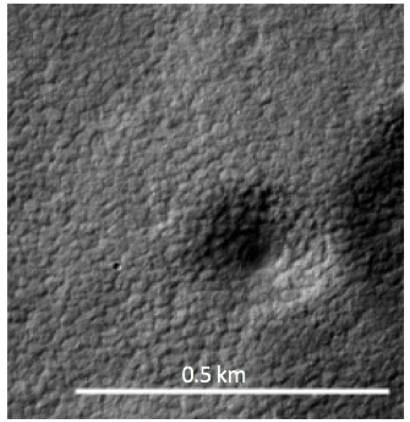
Image credit: NASA/Pat Rawlings

Signs of Subsurface Ice

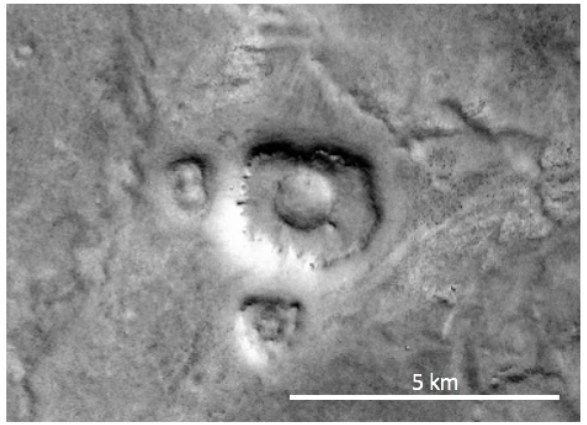
- Scallops and expanded craters: collapse by sublimation of subsurface ice
- Pedestal craters: ice armored by ejecta, lost in surroundings
- Lobate debris apron: debris covered glaciers
- Banded terrain: possible viscous flow of an ice layer



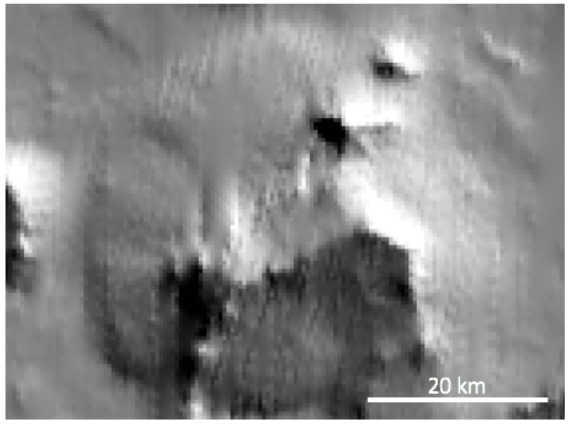
Scalloped depressions



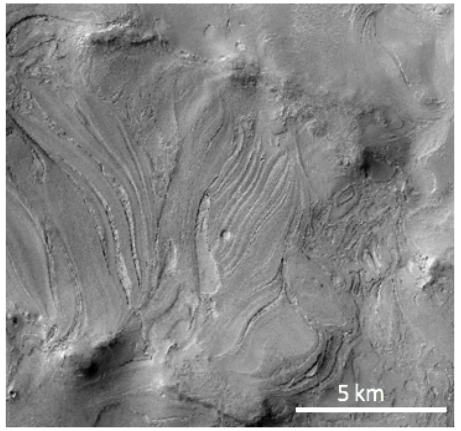
Expanded craters



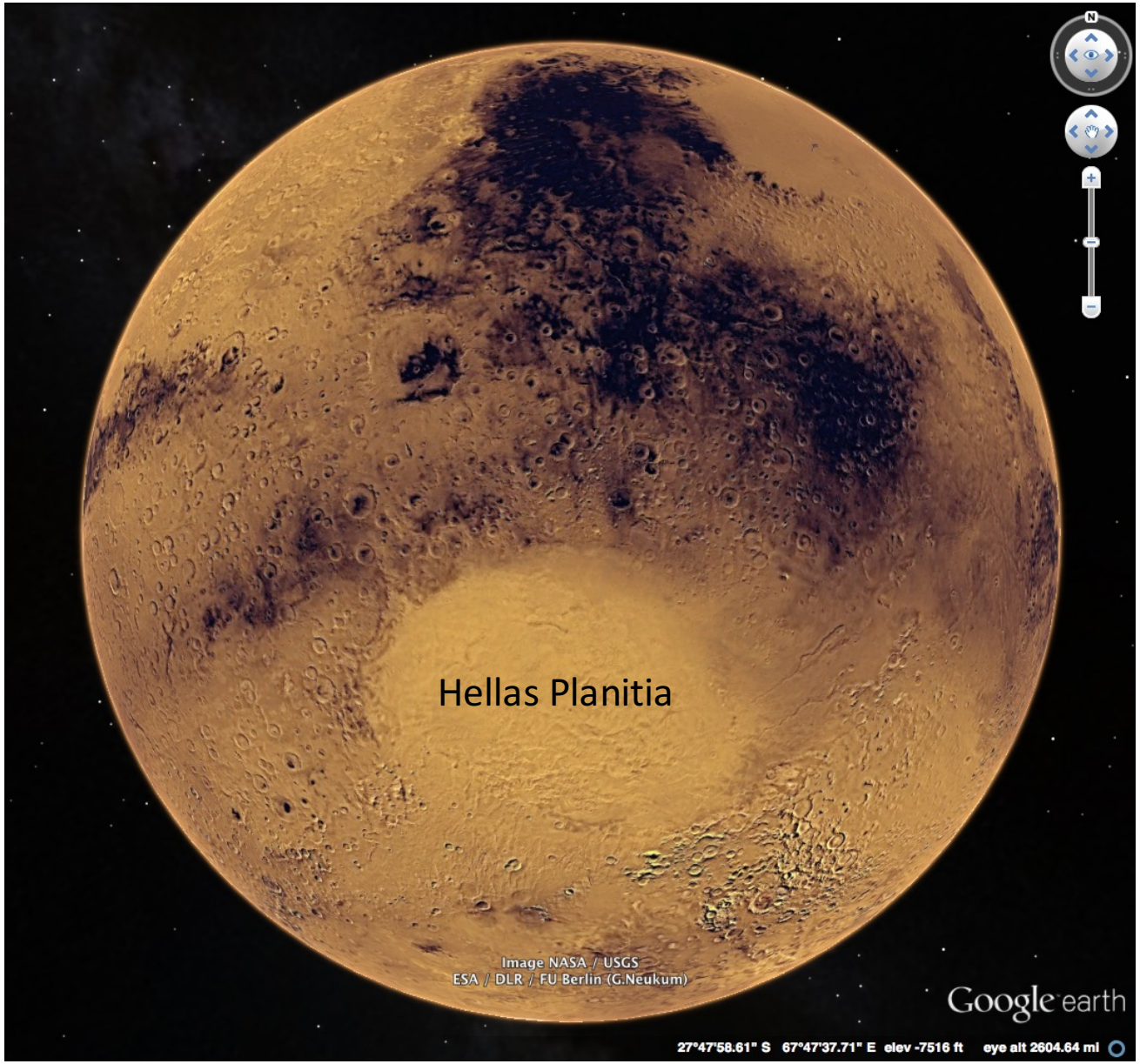
Pedestal craters



Lobate debris apron



Banded terrain



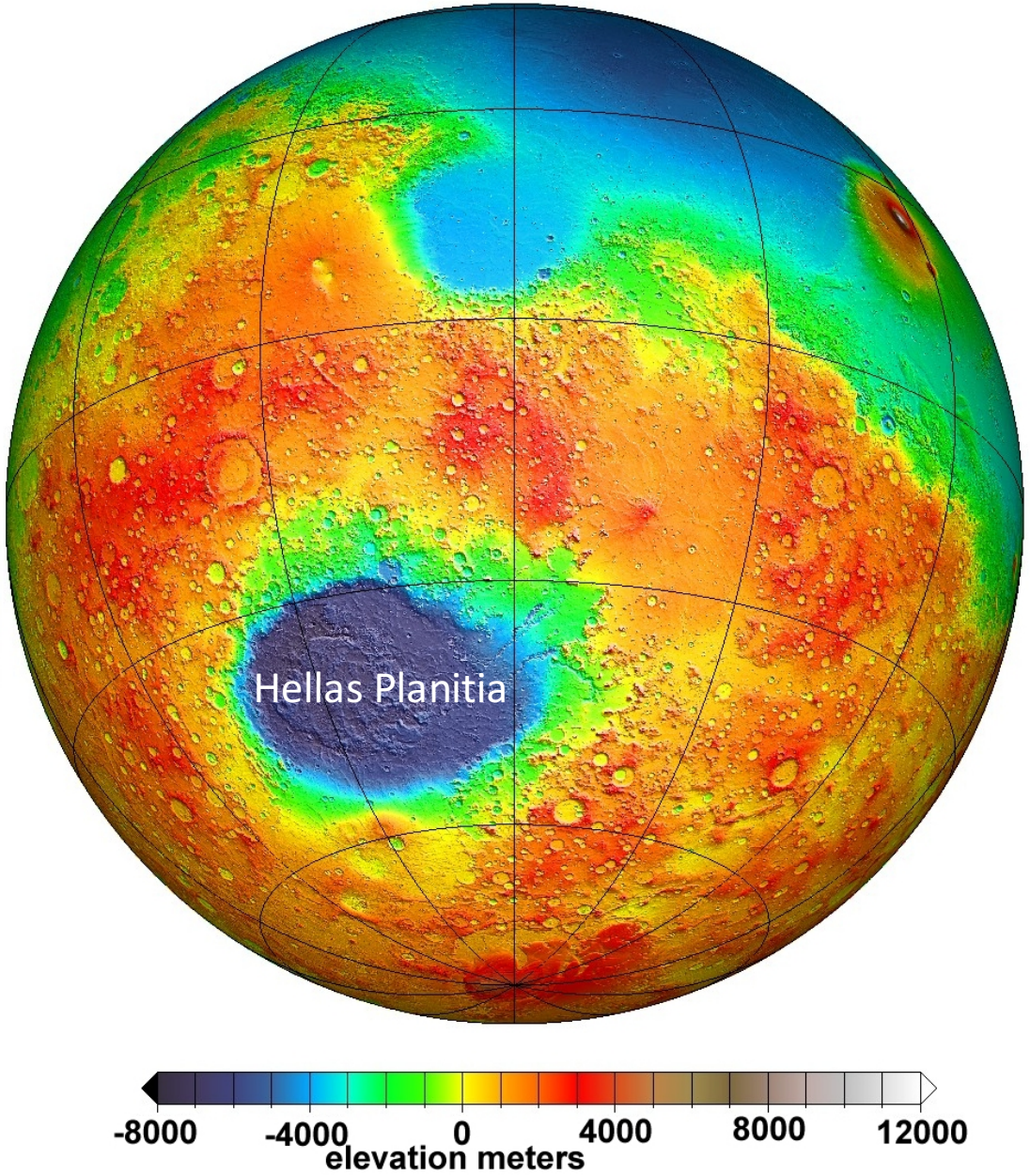


Image credits: NASA

What are the properties of ice in Hellas Planitia?

Methods: Radar

- Allows us to probe the subsurface
  - Radar reflects off the interface between materials with different dielectric constants
  - Dielectric constant relates to the speed at which electromagnetic waves move through a material
- SHAllow RADar (SHARAD) on the Mars Reconnaissance Orbiter
  - Looked at radargrams for 368 tracks covering Hellas Planitia

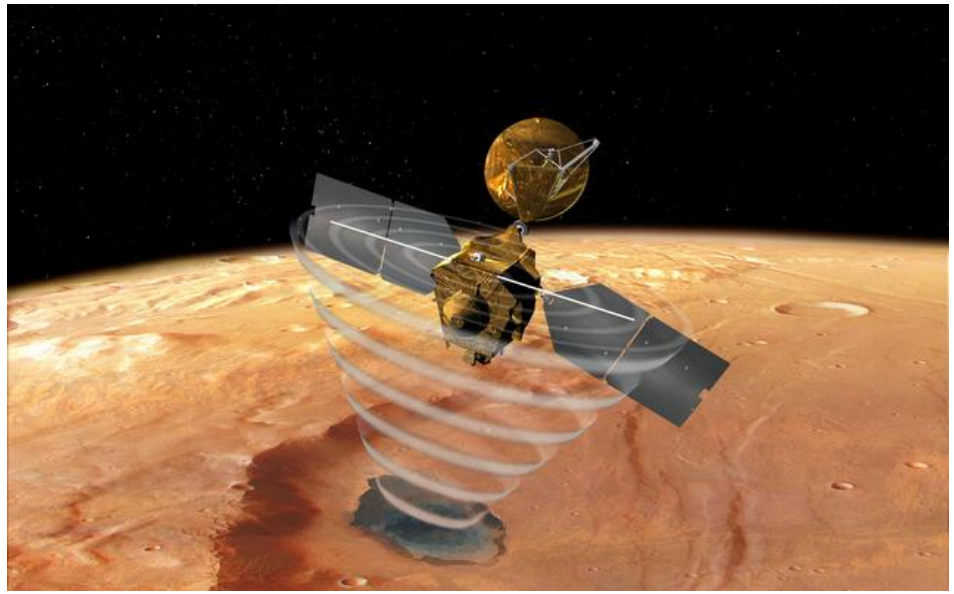
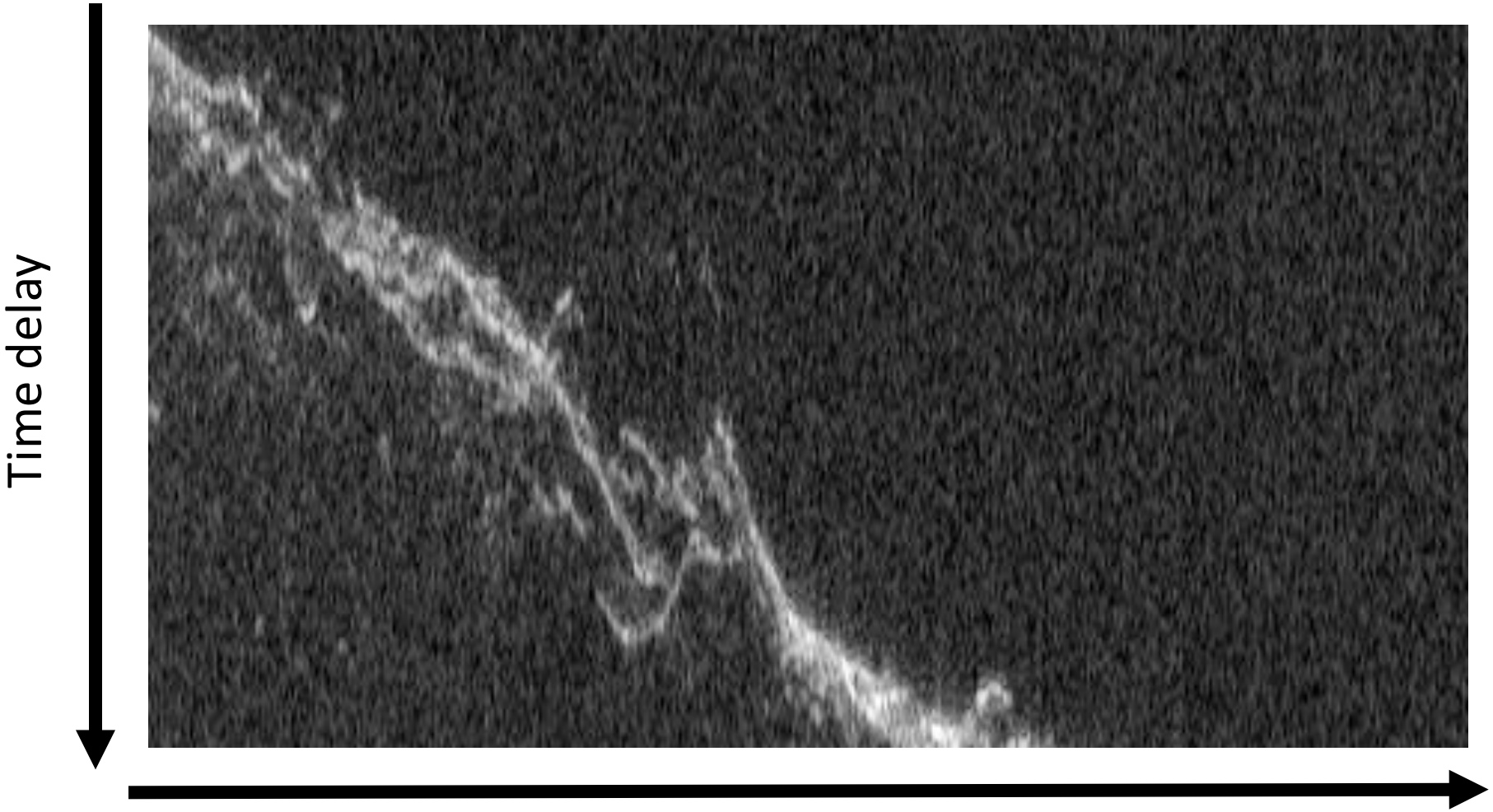


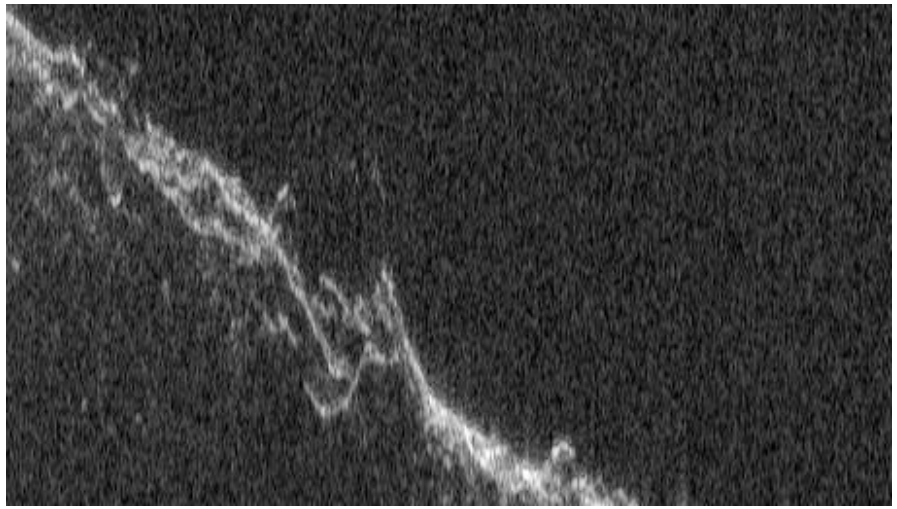
Image credit: NASA/JPL

Radargram

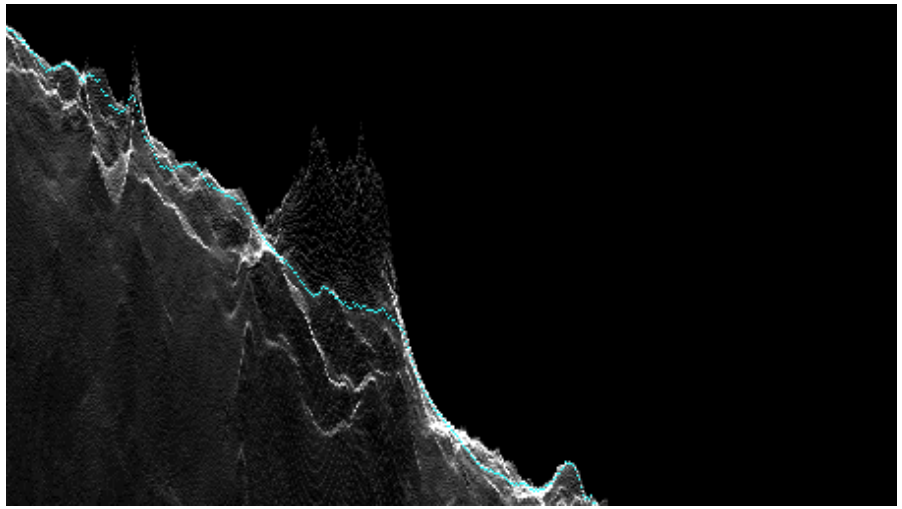


Methods: Clutter

- Reflections from off-nadir surface topography
- Can appear at delay times similar to subsurface reflectors
- To avoid: compare to simulations of what the radar would see based solely on surface topography

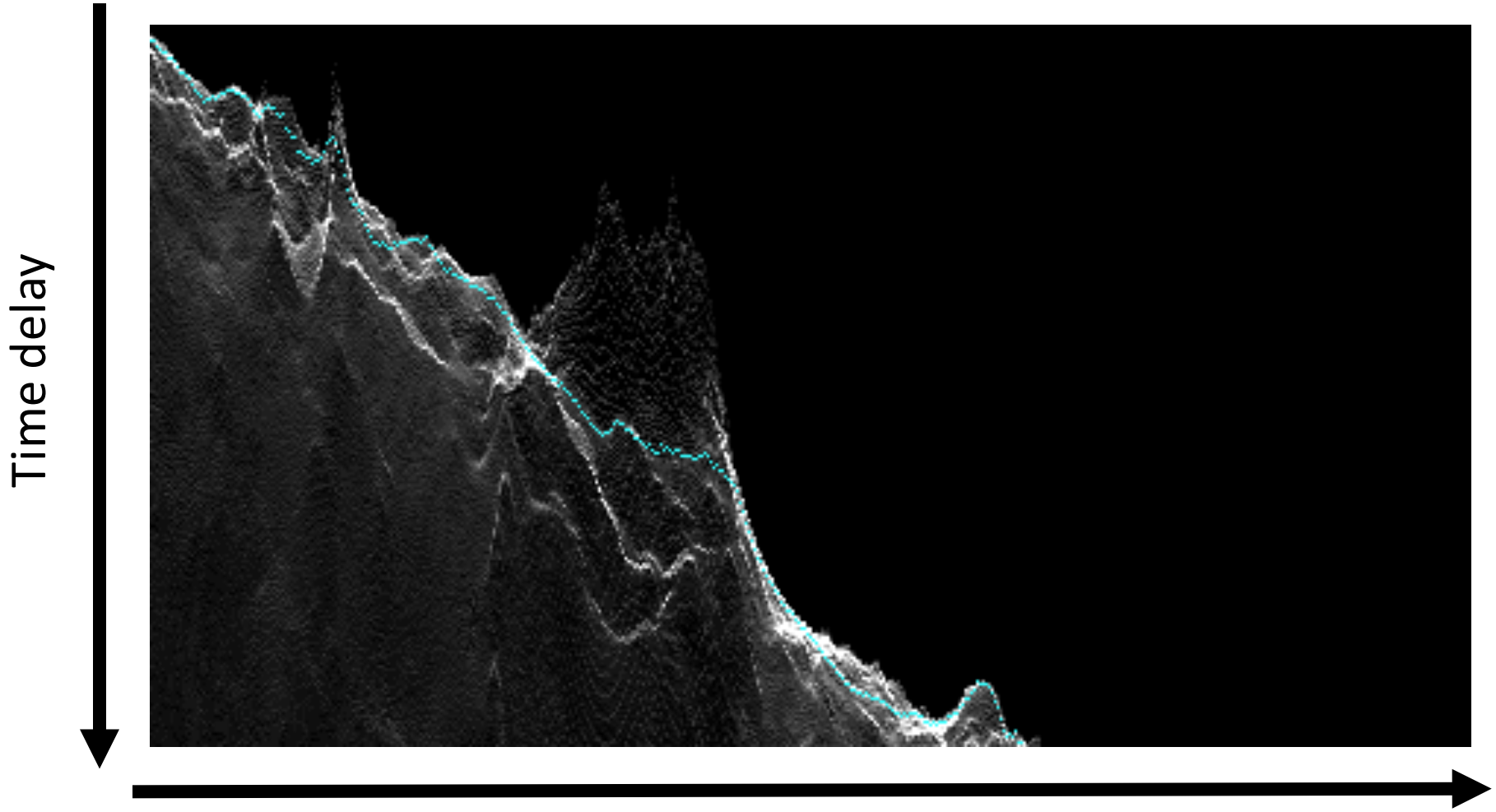


Radargram

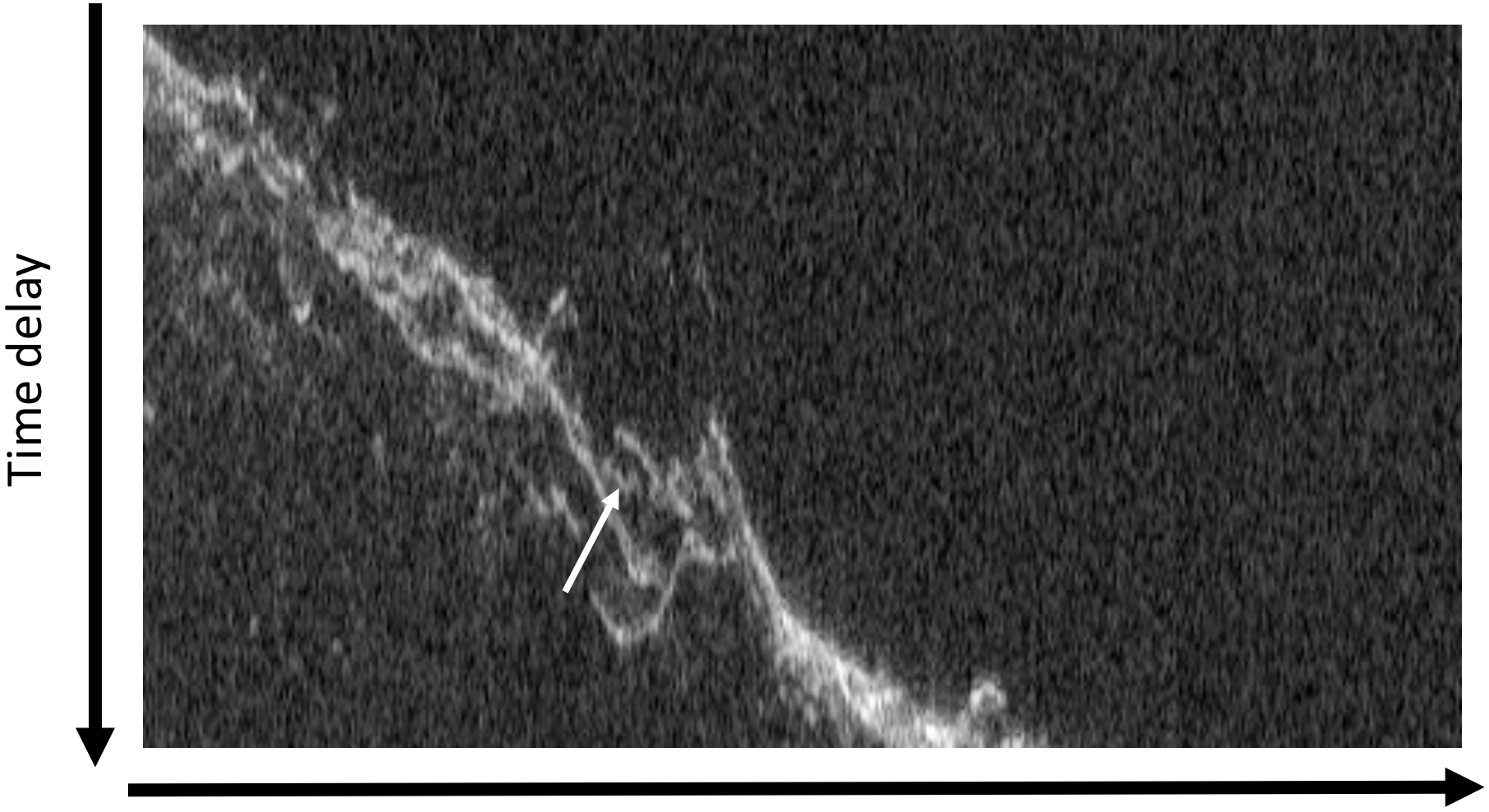


Clutter simulation

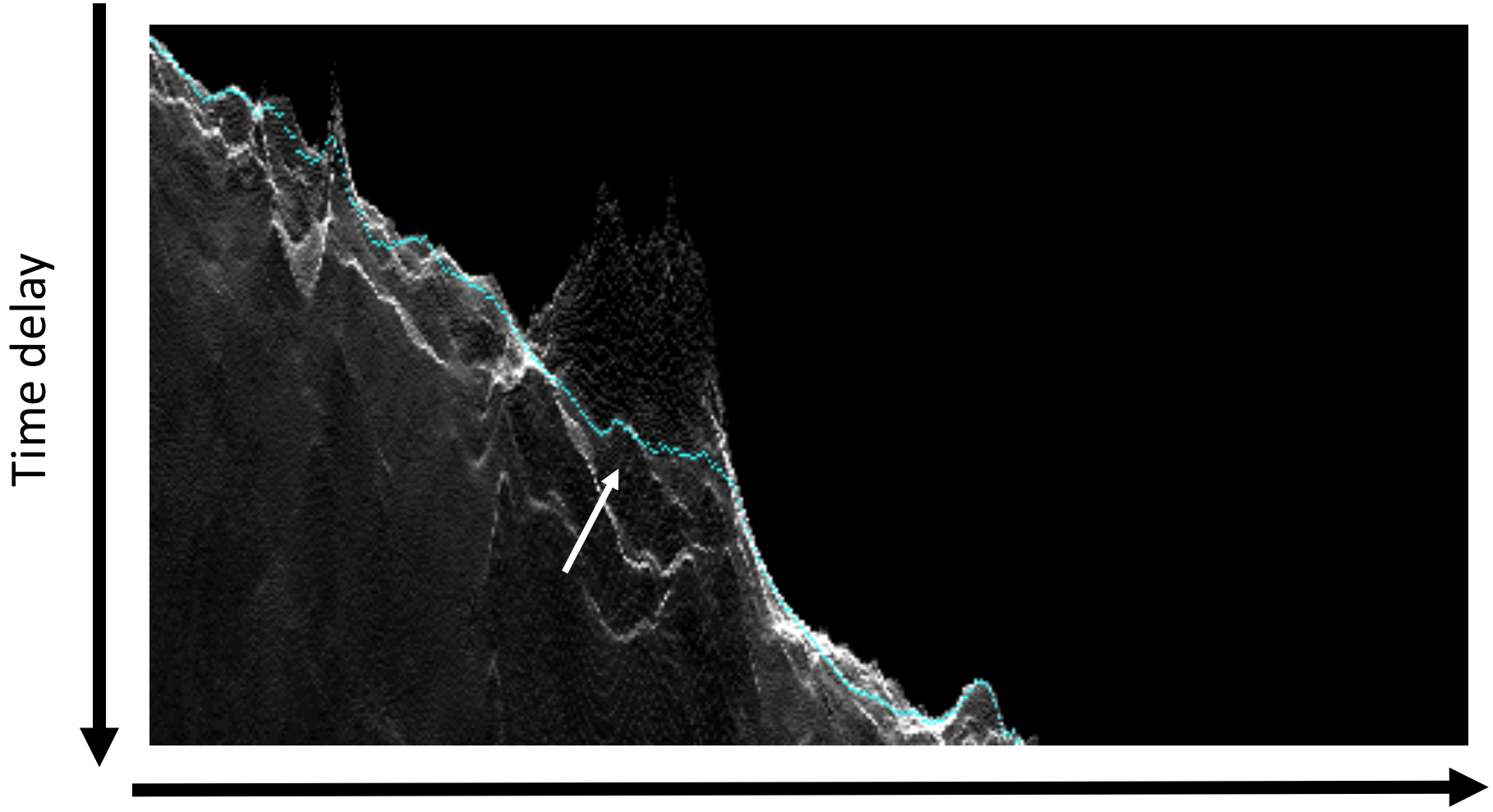
Clutter simulation



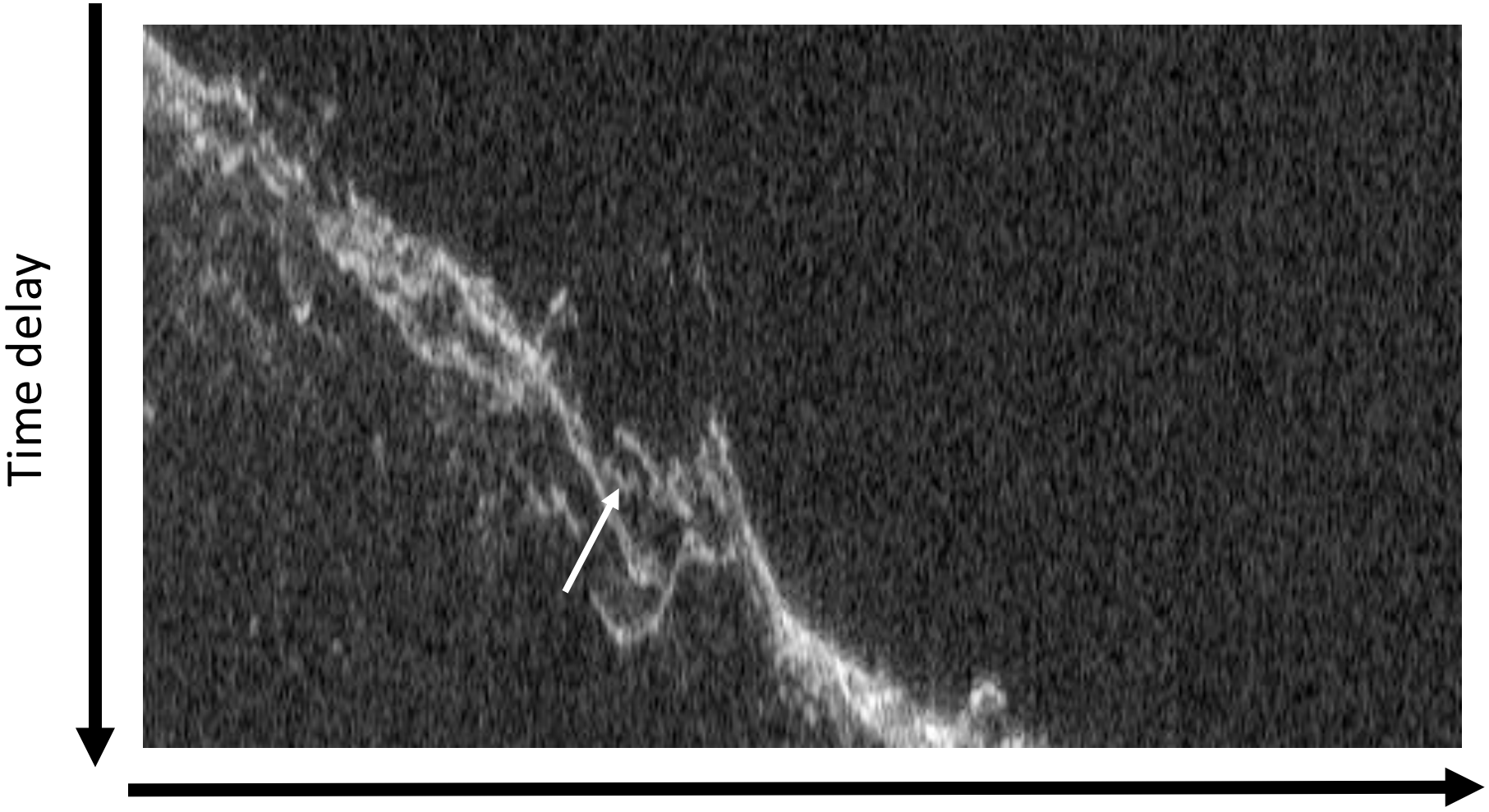
Radargram



Clutter simulation

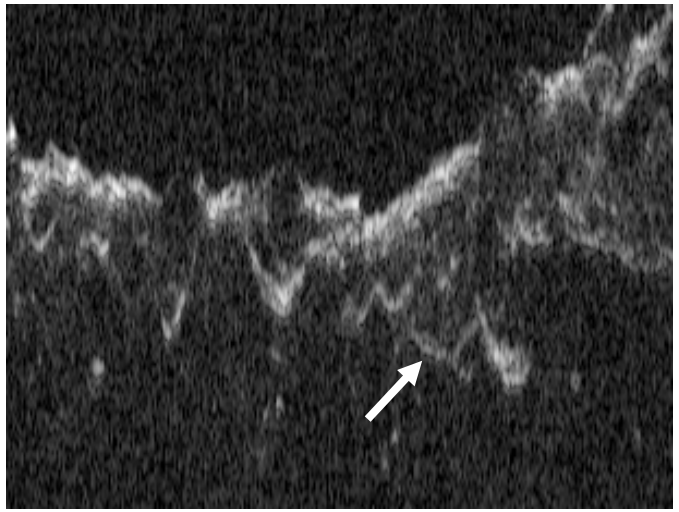


Radargram

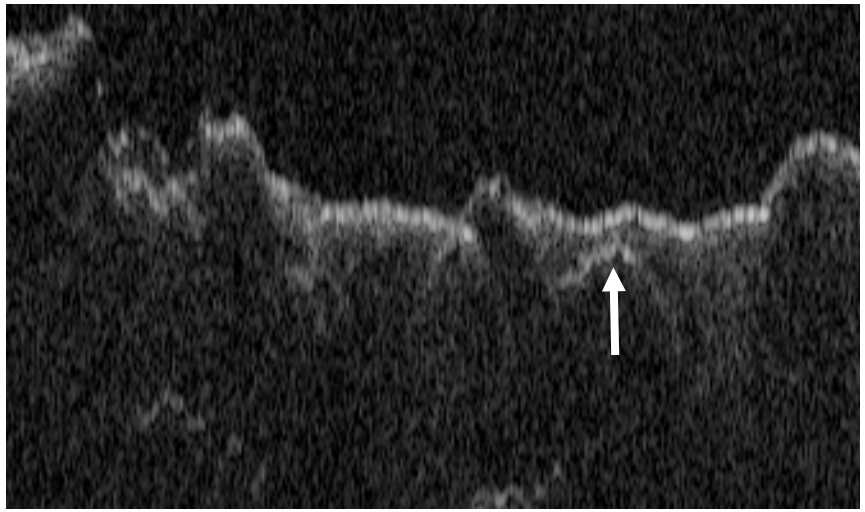


Methods: Confidence Rating

- Lower confidence in those that are absent from the simulations but contiguous with clutter or have some curvature, which is common to clutter
- Higher confidence in those that are not contiguous with clutter or curved



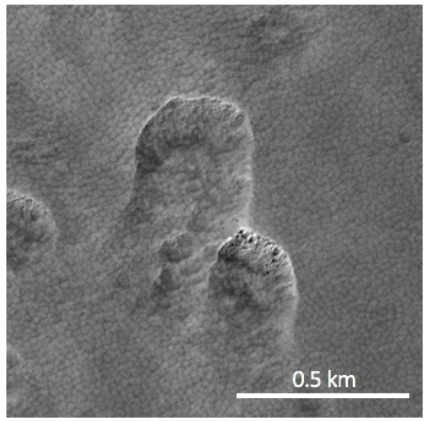
Contiguous with clutter



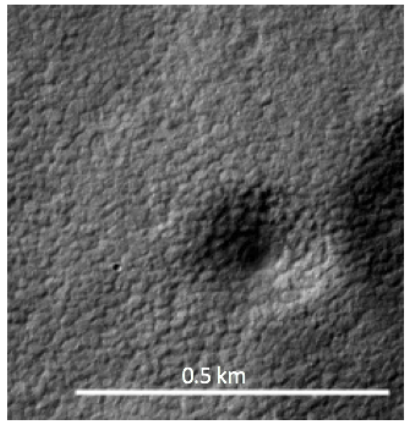
Curved

Methods: relationship to ice features

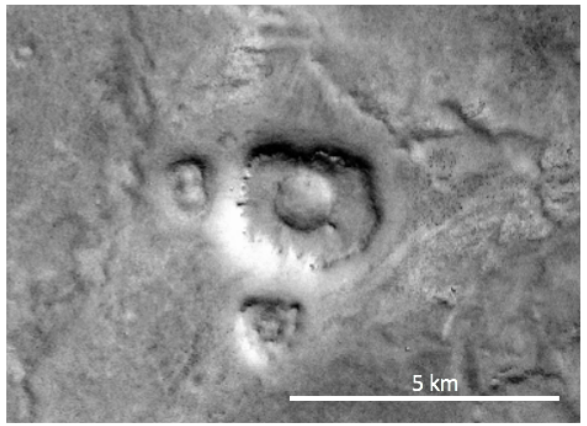
- For reflectors we have higher confidence in, looked at Context Camera (CTX) images of the area to identify features potentially associated with ice



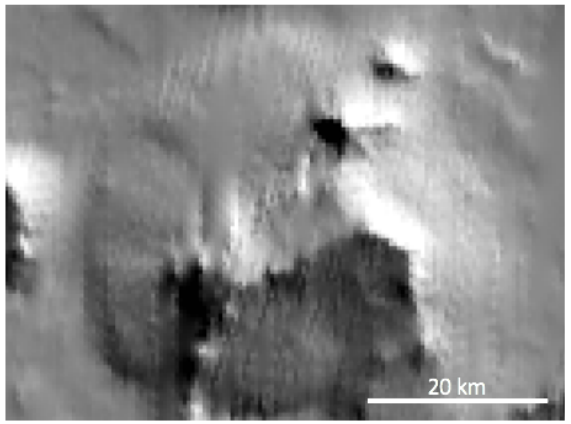
Scalloped depressions



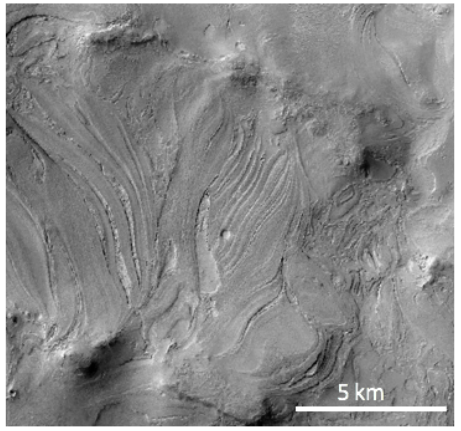
Expanded craters



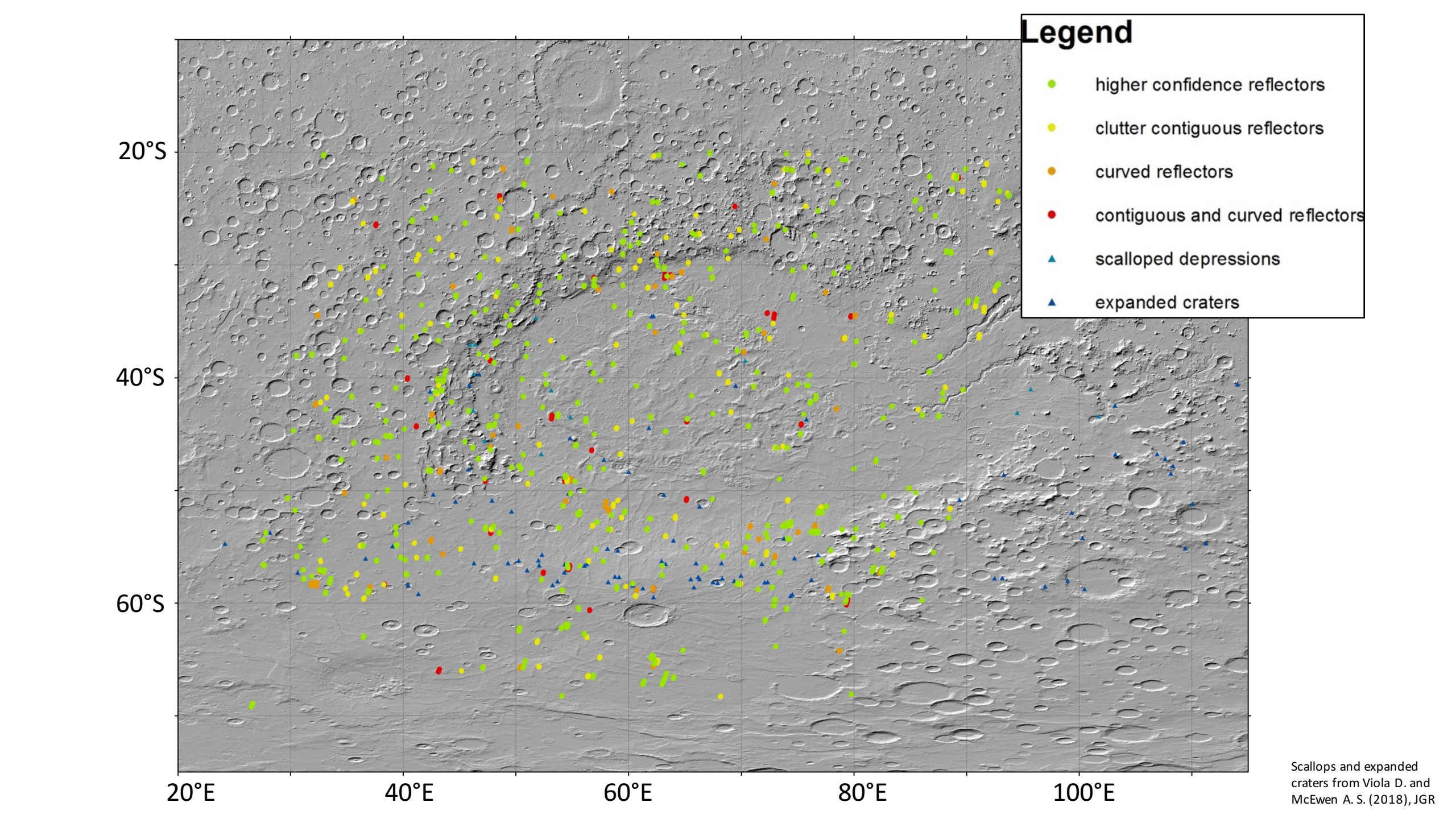
Pedestal craters



Lobate debris apron



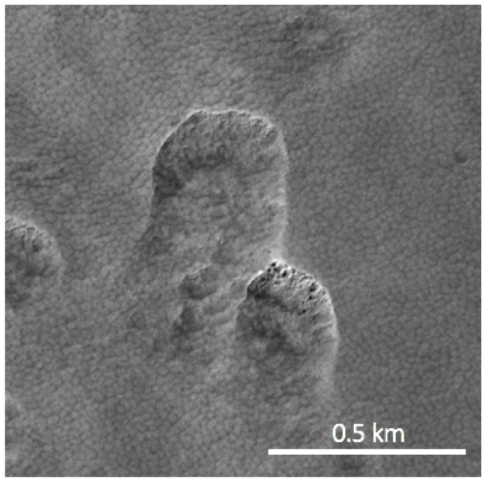
Banded terrain



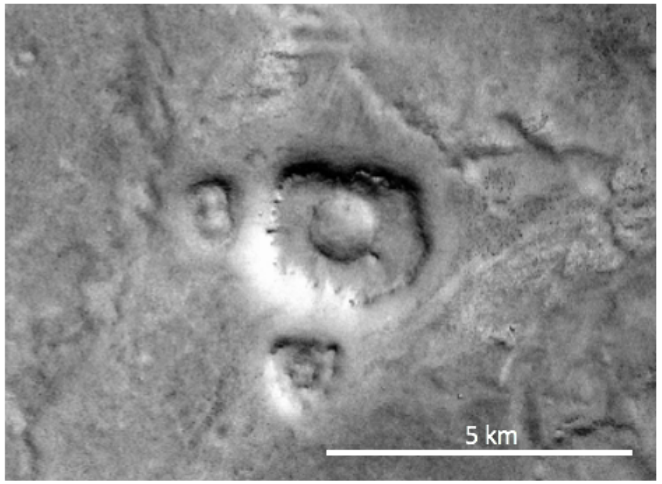
Scallops and expanded craters from Viola D. and McEwen A. S. (2018), JGR

Results: 649 reflectors

- Higher confidence: 413

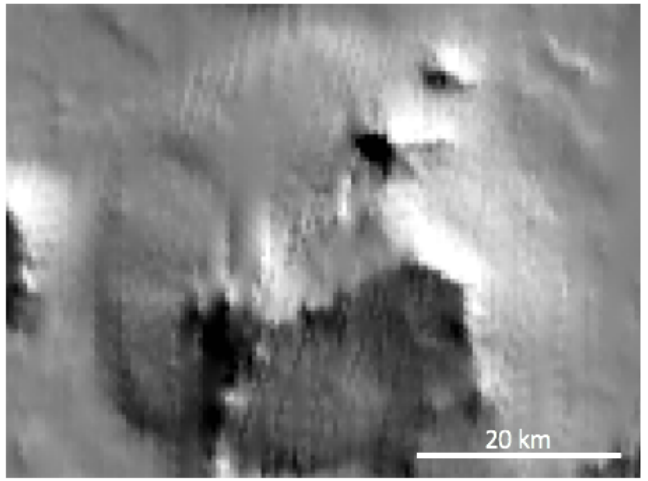


Scalloped depressions: 23

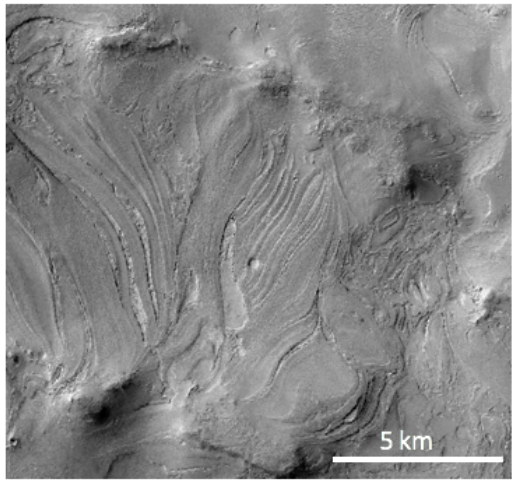


Pedestal craters: 3

Near but not associated with pedestals themselves: 18

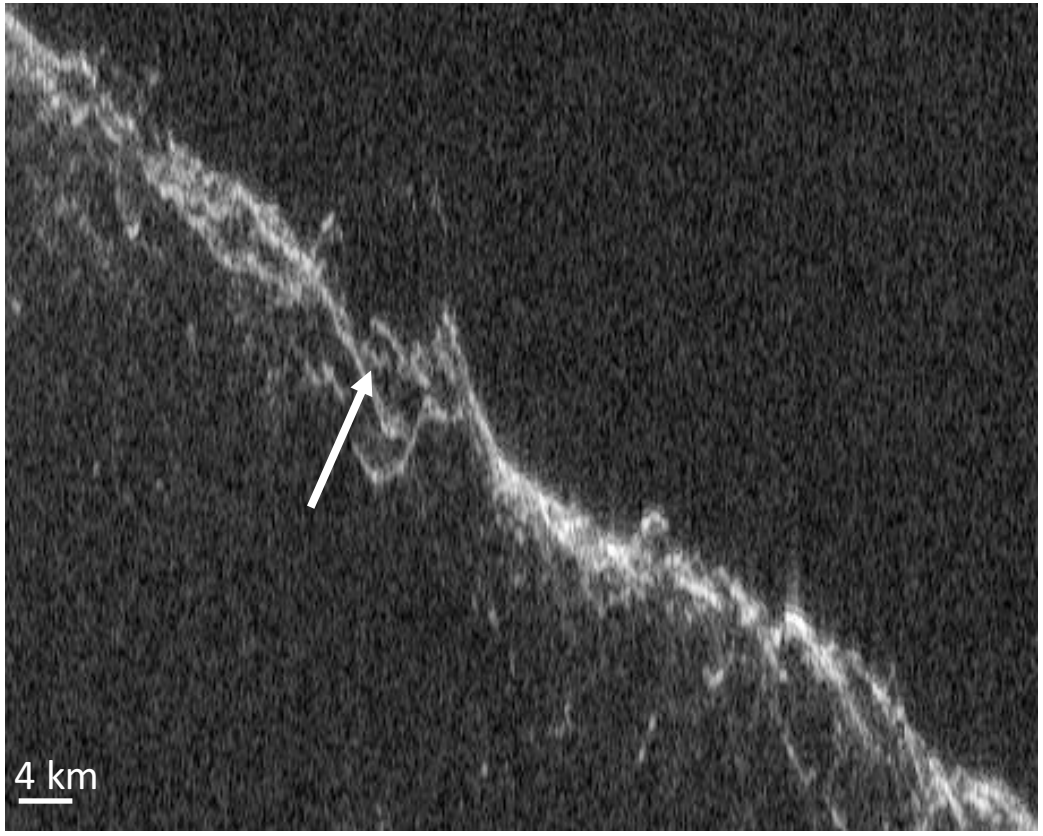


Lobate debris apron: 1

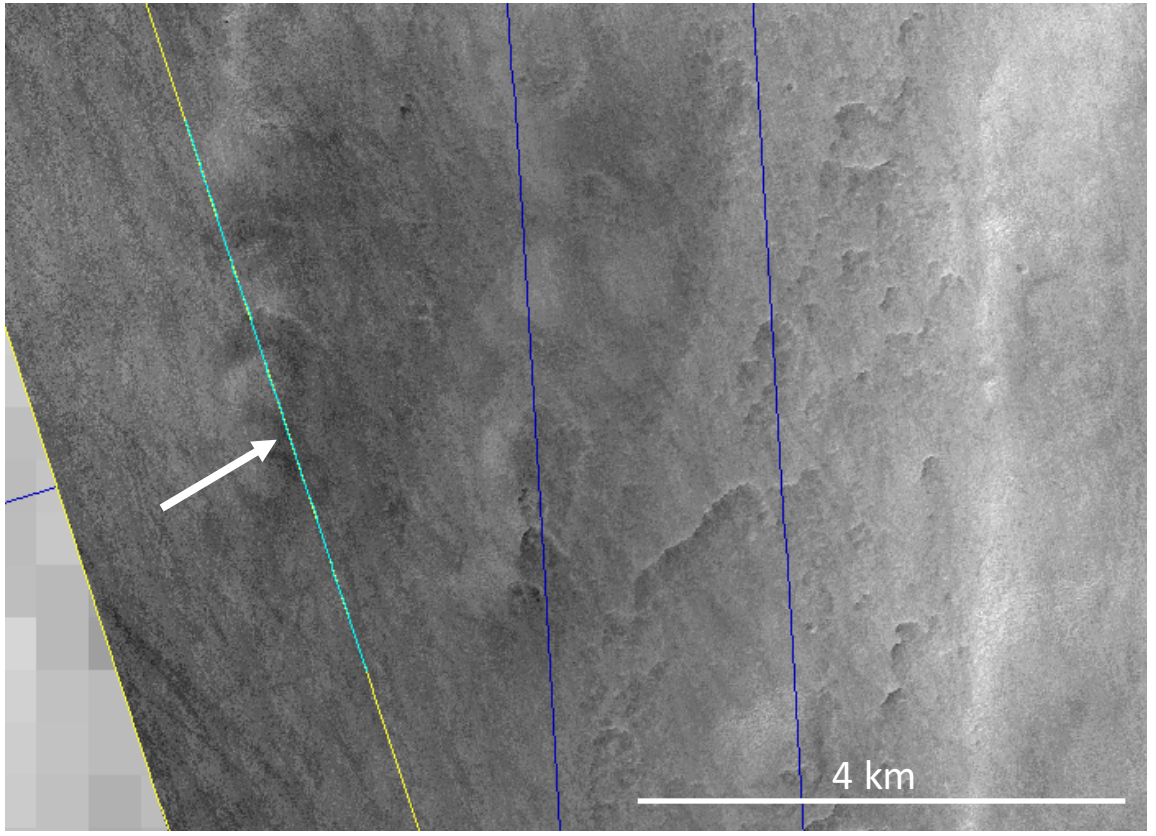


Banded terrain: 5

Scalloped Depressions



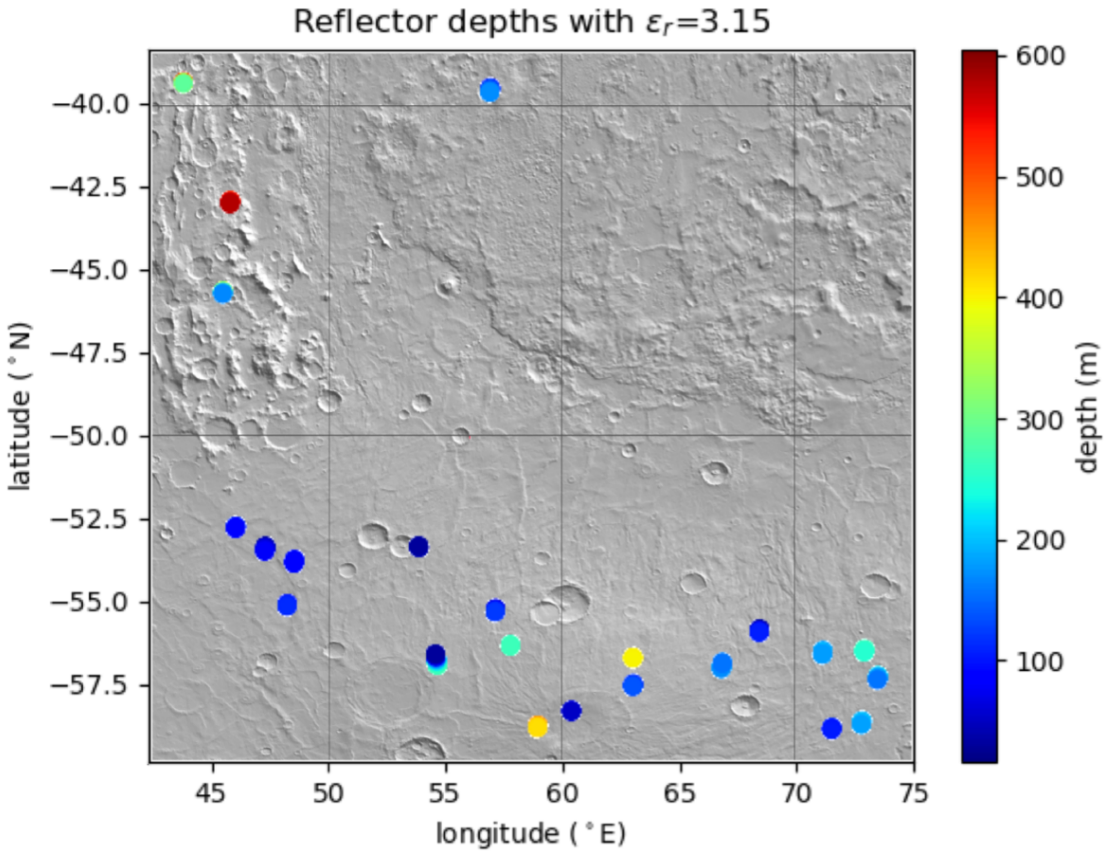
Radargram



Overhead view

Scalloped Depressions

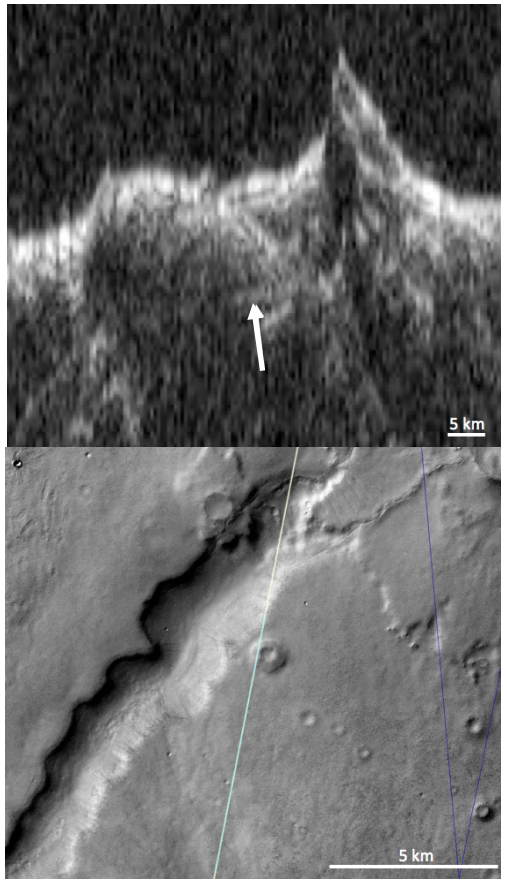
- Calculated depth of the reflectors assuming a dielectric constant of $\varepsilon_r = 3.15$ (pure ice)
- Median depth of reflectors with this dielectric constant: 165 m
- Scallops typically 10-20 m deep



Other features: ice thicknesses

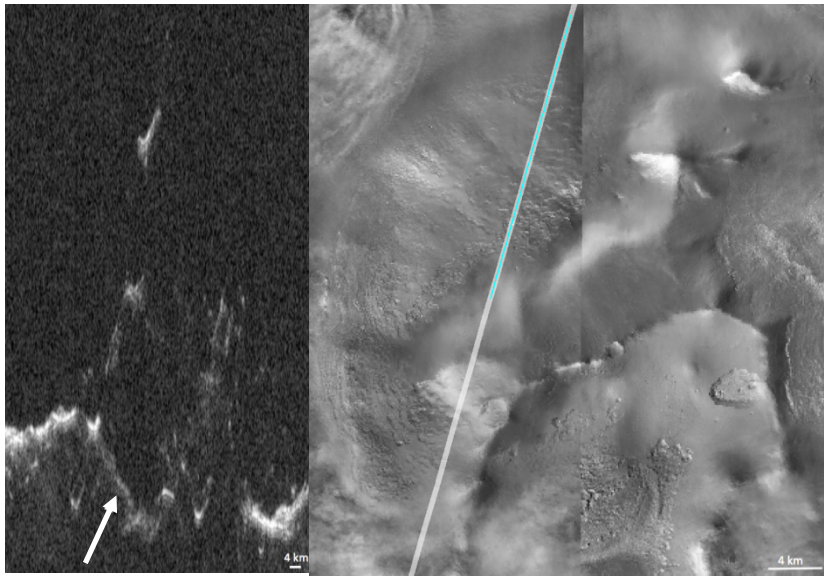
Pedestal craters

- 103 m



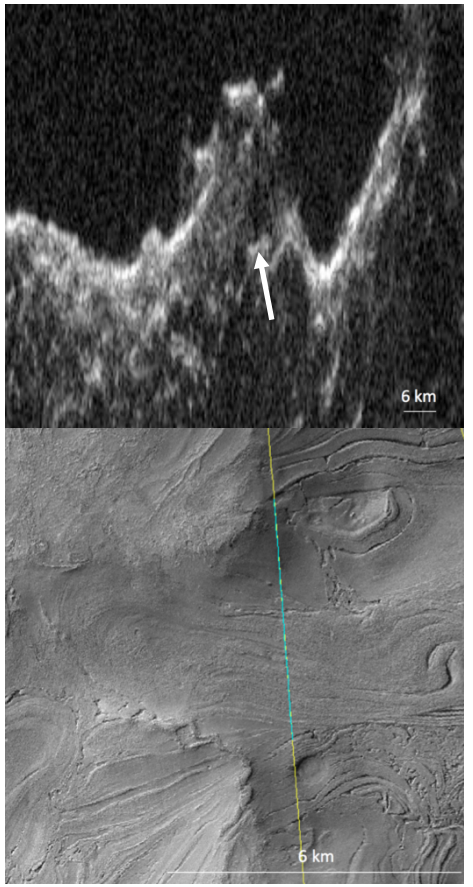
Lobate debris apron

- Up to 1 km



Banded terrain

- 265 m on average



Conclusions

- We found radar reflectors near terrain associated with ice in Hellas Planitia
- These reflectors allow us to constrain the thickness of the ice
  - Reflectors are 100s of meters deep if associated with the bottom of the ice layer
- Future work:
  - Additional analysis of reflectors near scalloped depressions to determine ice purity
  - Additional analysis of reflectors near other features like pedestal craters

Acknowledgements

- Jack Holt and Michael Christoffersen provided the clutter simulations


Thank You

Banded Terrain

- Ice and salt-related processes have been suggested for the origin of this terrain.
- Calculated depth of the reflectors assuming $\varepsilon_r = 3.15$ (pure ice) and $\varepsilon_r = 6$ (salt).
- The median depth with $\varepsilon_r = 3.15$ is 265 m and with 6 is 192 m.