A SHARAD's Eye View of Martian Dunes

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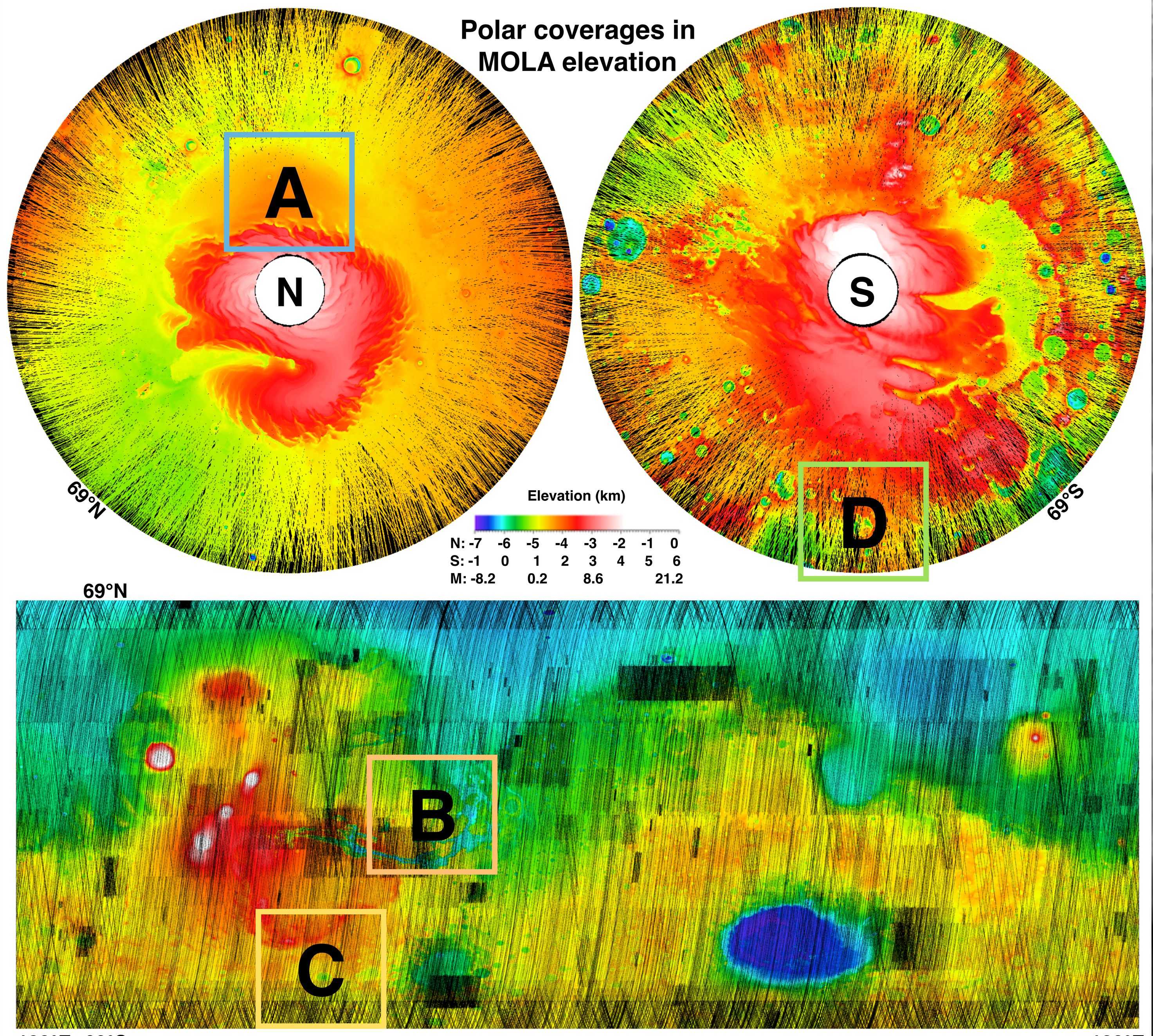
The Mars Reconnaissance Orbiter Shallow Radar transmits pulses at 15–25 MHz from a ~300-km orbit, yielding wavelengths of 15 m in free space, ~8.5 m in water ice, and ~5.5 m in basaltic materials and a lateral resolution of ~3–6 km, reducible along-track to 0.3–1 km with SAR processing [1]. Returns from the nadir surface may be followed by others from subsurface geologic boundaries and off-nadir surface topography. Roughness, such as dune forms at radar-wavelength scales, can induce scattering and reduce the power and coherence of returns.

SHARAD Coverage

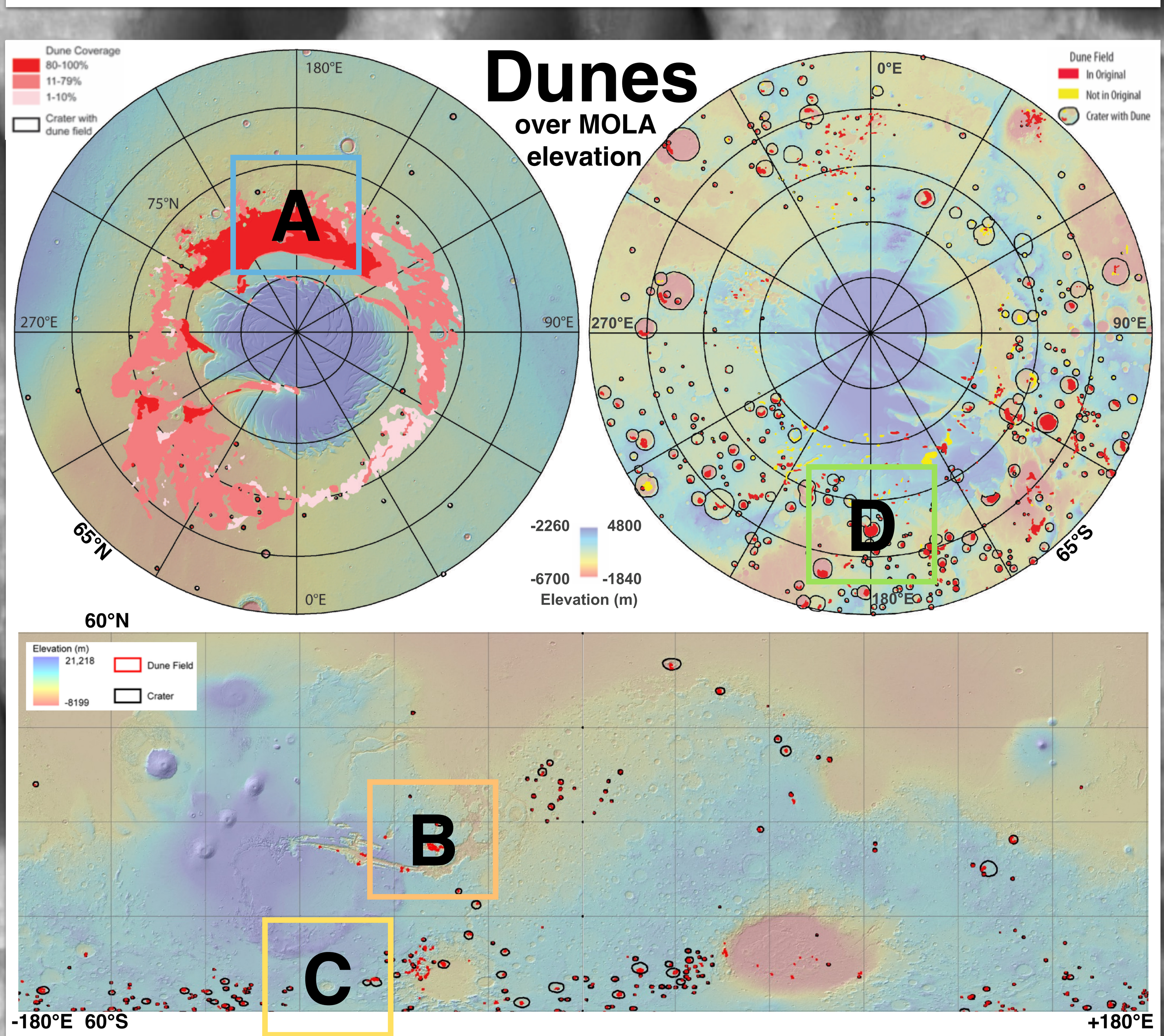
January 2017



Mid-latitude coverage over MOLA elevation

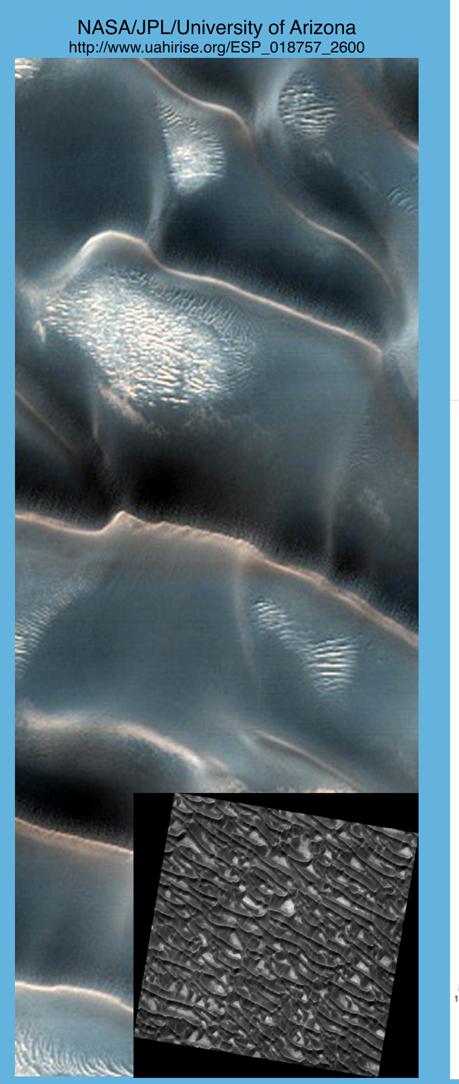
Dunes

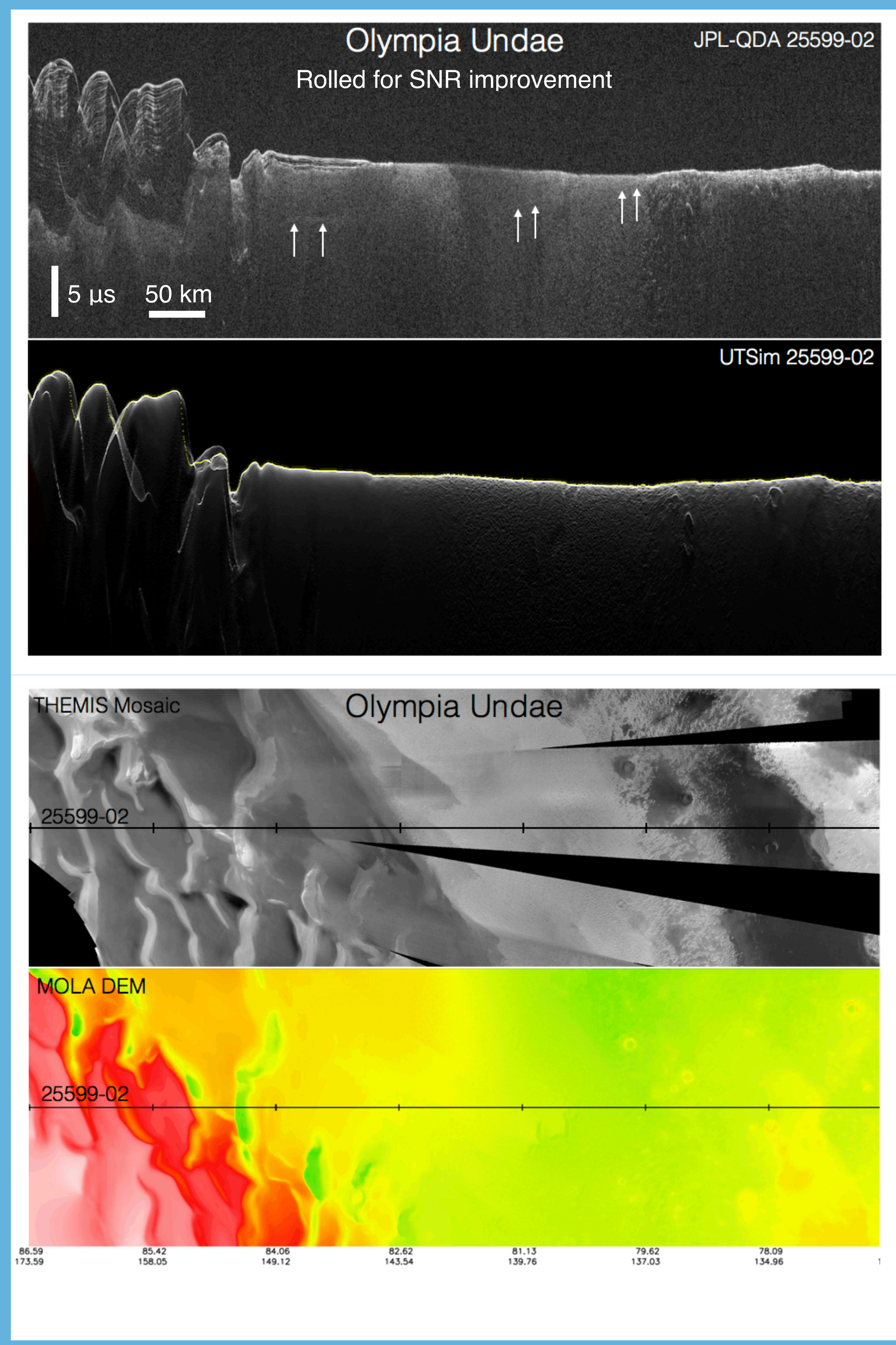
over MOLA elevation



Dune maps by Hayward et al. (2007, 2010, 2012) [10-12]

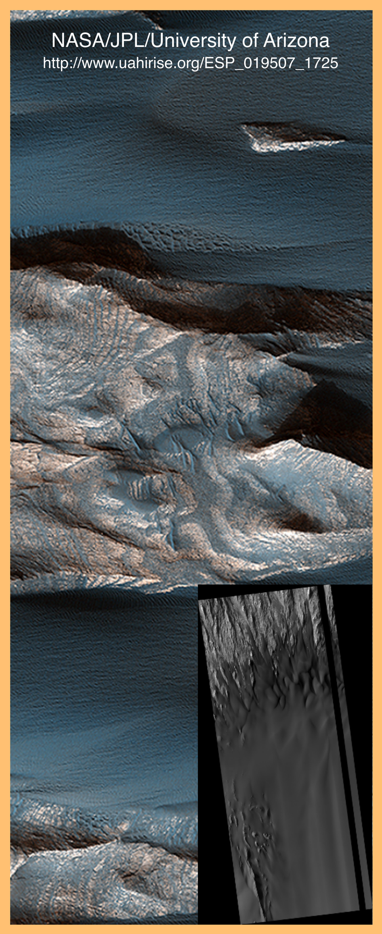
A Olympia Undae dunes

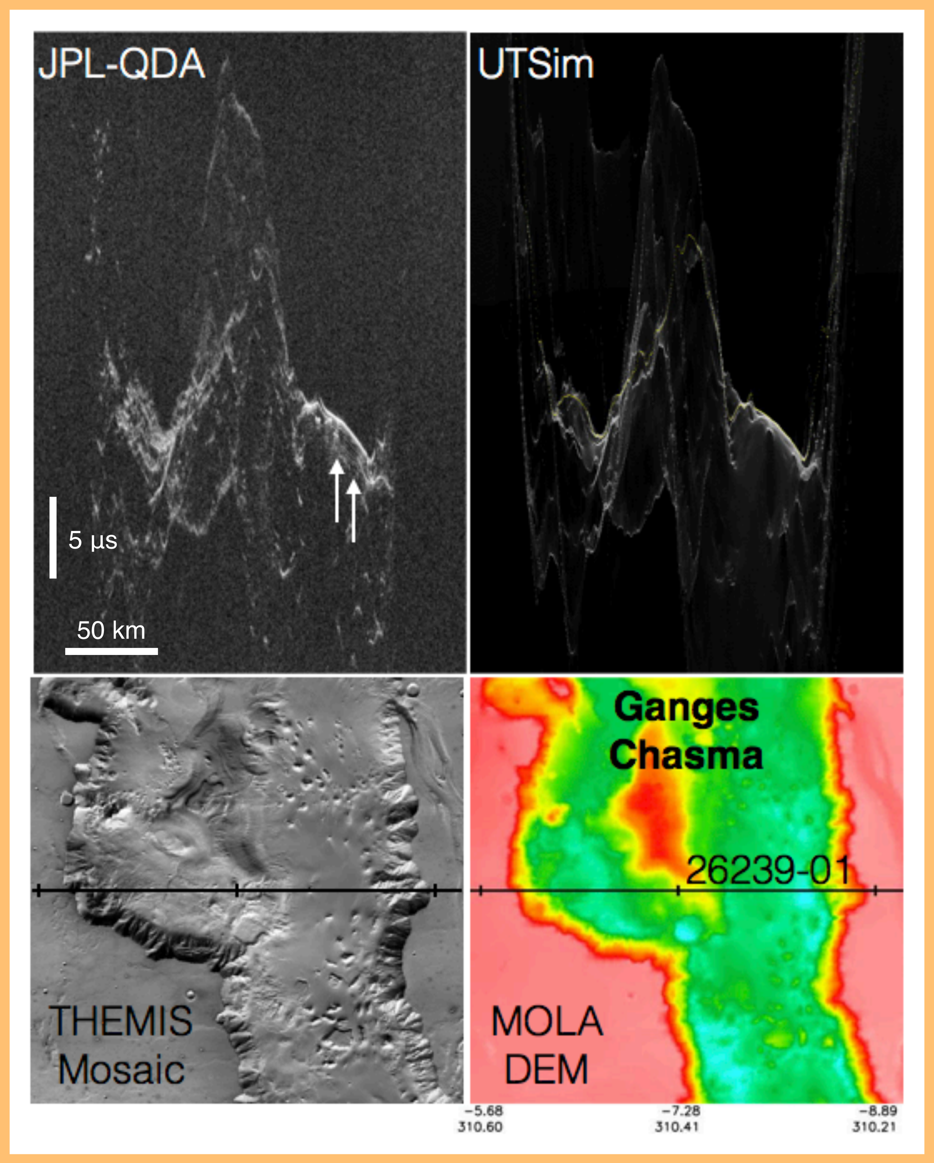




Radar data in Olympia Undae typically have diffuse surface returns and rarely show faint subsurface returns (at arrows on radargram) that likely correspond to the substrate below the sand (Vastitas Borealis deposits). Simulations do not have features corresponding to these deep returns nor to layering seen in the NPLD and Olympia Planum.

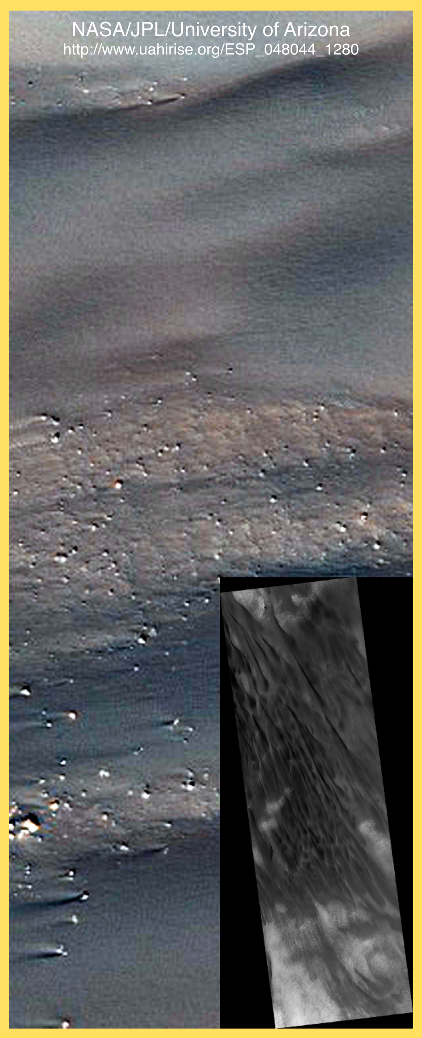
B Ganges Chasma dunes

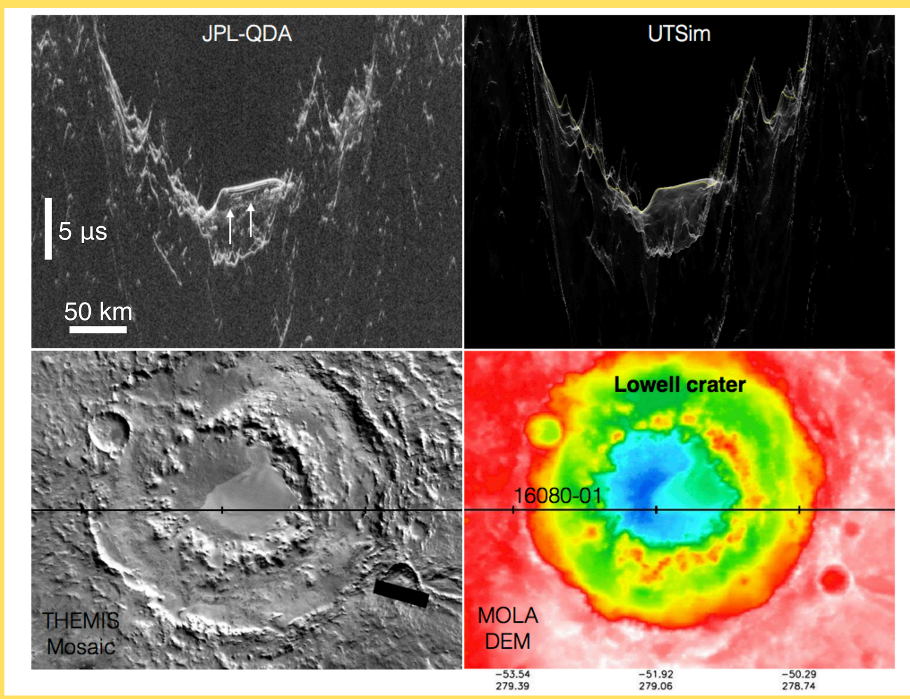




Features on the surface of sand dunes in Ganges Chasma are of a scale well below the SHARAD wavelength, and they produce relatively strong surface returns. A sequence of fainter returns often follows, with a slightly stronger, more coherent return (at arrows on radargram) at a delay of ~2 µs (122 m for sand dielectric of 6) that may represent the base of the sand. Lack of corresponding returns in the clutter simulations supports the interpretation that the late returns are from subsurface interfaces.

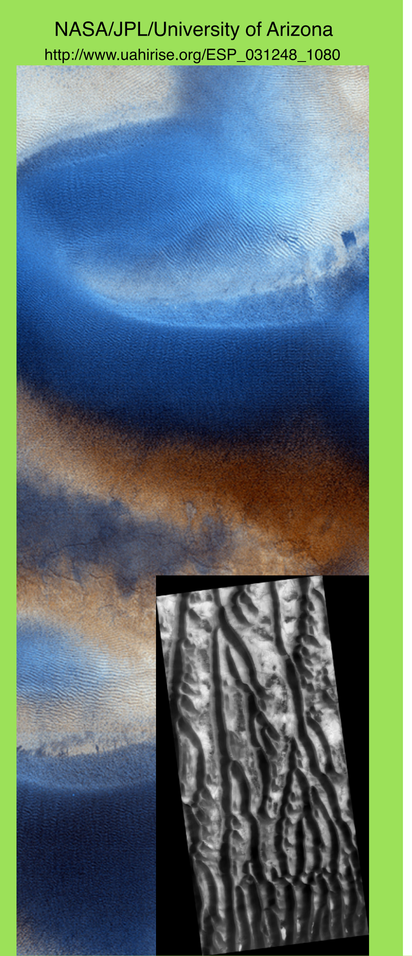
C Lowell crater dunes

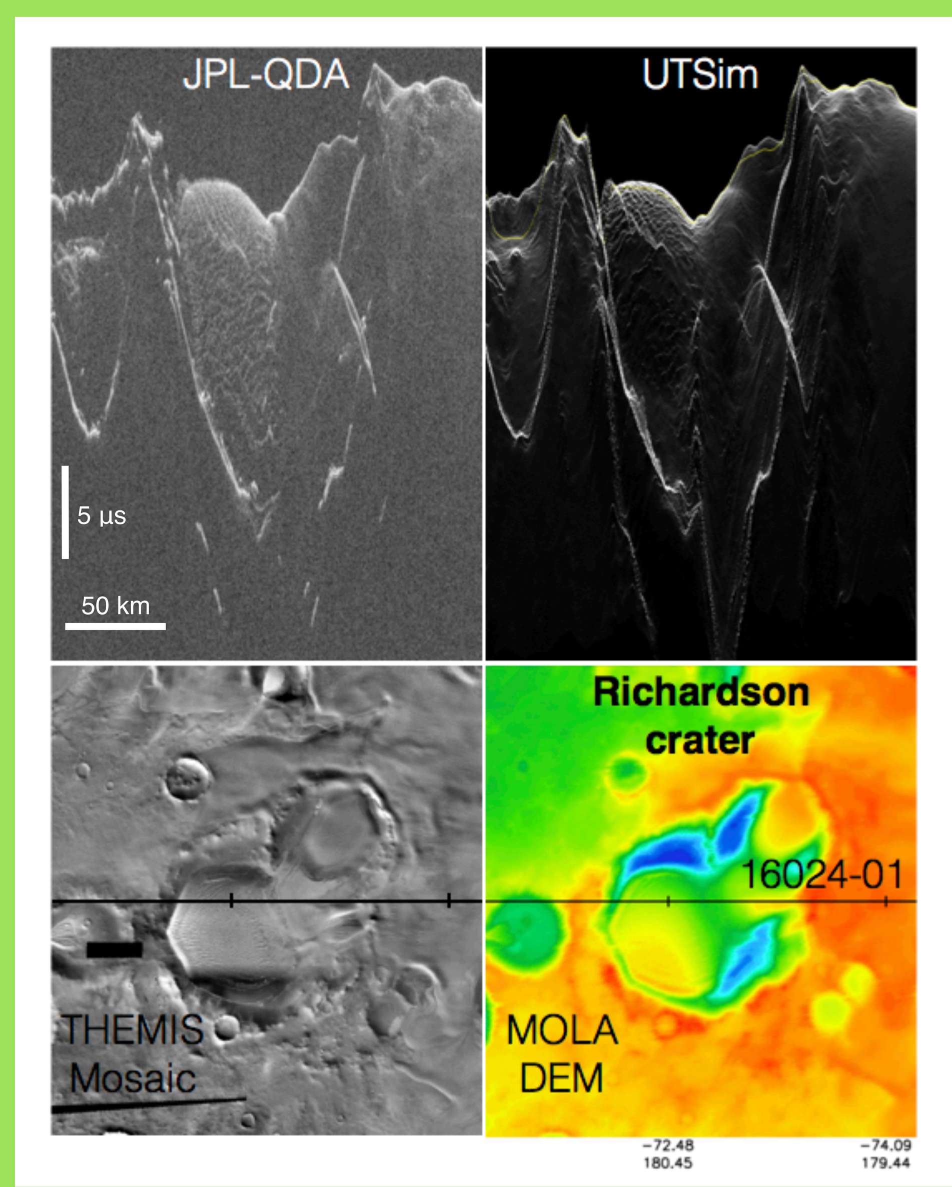




The dune field at crater's center yields a strong surface return followed by a weaker return (at arrows on radargram) at a delay of ~1.4 µs (86 m for a sand dielectric of 6) that may be from either the crater floor or other boundary such as ground ice. Lack of a corresponding return in the clutter simulation supports a subsurface source of the late return.

D Richardson crater dunes





Richardson crater is located on the periphery of the south polar layered deposits (SPLD) and contains mounds of materials that are likely composed largely of water ice. However, extensive dunes on the scale of the SHARAD wavelength occur at the surface and result in diffuse radar returns. Simulations reproduce nearly all the features seen in the radargrams, indicating surface sources and no evidence for subsurface returns. Unlike in the north, many areas of the SPLD are subject to diffuse returns that may be precluding the detection of deeper layering [9].

Conclusions

The lateral resolution of SHARAD limits its utility in dune studies to larger fields. SHARAD's wavelength is similar to the scale of many dune forms, further limiting its use to those fields with relatively muted surface features. Such fields of smaller dunes or sand sheets typically allow radar signals to penetrate and reflect from interior or underlying interfaces. These cases yield information about layering within and beneath dunes, providing data relevant to dune formation and evolution and associated climate history.

References

[1] Seu R. et al. (1997) JGR 112, E05S05. [2] Plaut J. J. et al. (2009) GRL 36, L02203. [3] Choudhary P. et al. (2016) IEEE Geosci. Remote Sensing Lett. 13, 1285-1289. [4] Edwards C. S. et al. (2011) JGR 116, E10008. [5] Putzig N. E. et al. (2014) JGR 119, 1936-1949. [6] Phillips et al. (2008) Science 320, 1182-1185. [7] Selvans M. M. et al. (2010) JGR 115, E09003. [8] Smith et al. (2003) NASA PDS MGS-M-MOLA-5-MEGDR-L3-V1.0. [9] Campbell et al. (2015) Lunar Planet. Sci. XLVI, Abstract 2366. [10] Hayward R. K. et al. (2007) USGS Open File Report 2007-1158. [11] Hayward R. K. et al. (2010) USGS Open File Report 2010-1170. [12] Hayward R. K. et al. (2012) USGS Open File Report 2012-1259.

Acknowledgements

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