SHARAD Data Analysis with High Resolution Digital Terrain Models

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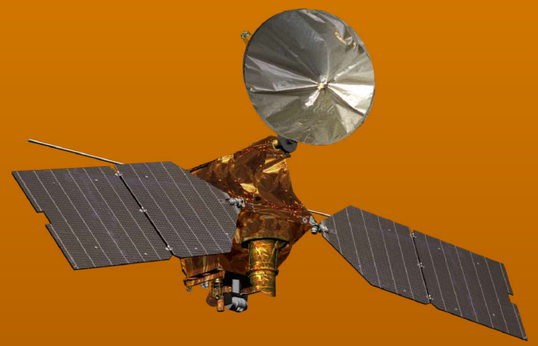
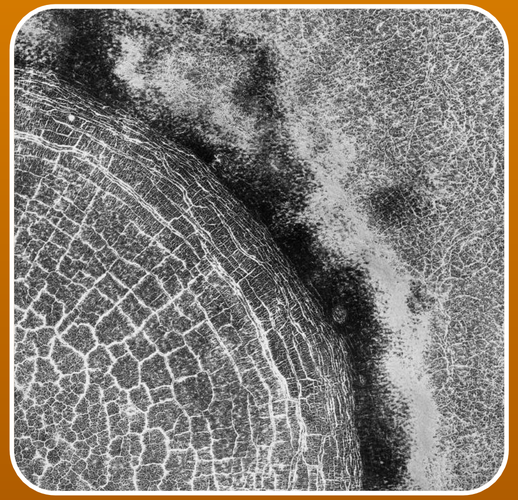
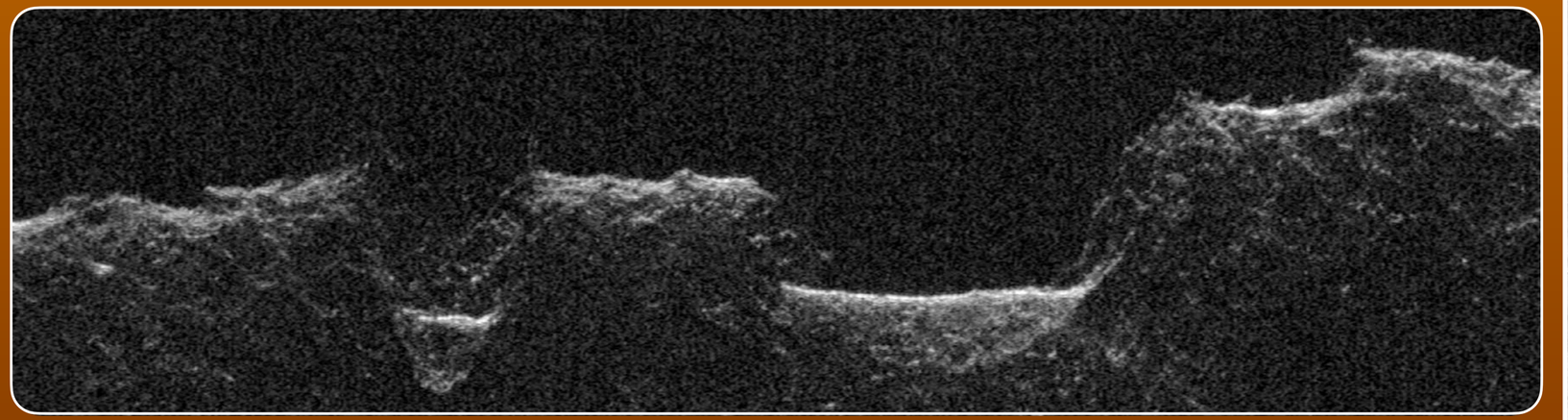


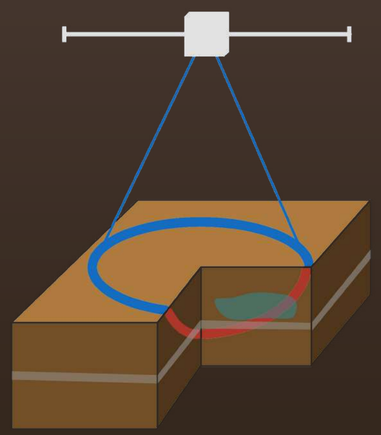


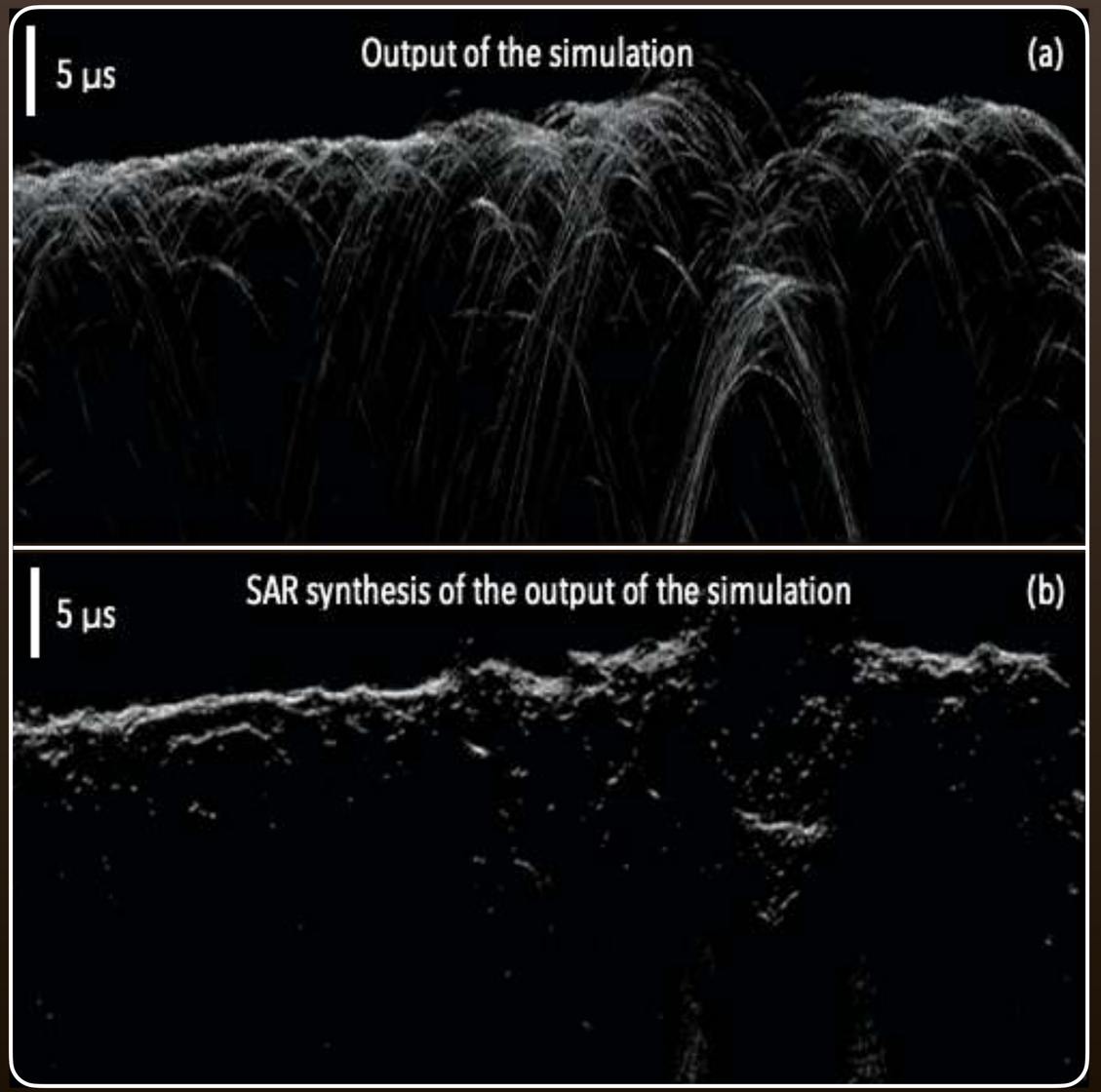


EPSC 2022

Detecting interfaces in the Martian subsurface with SHARAD

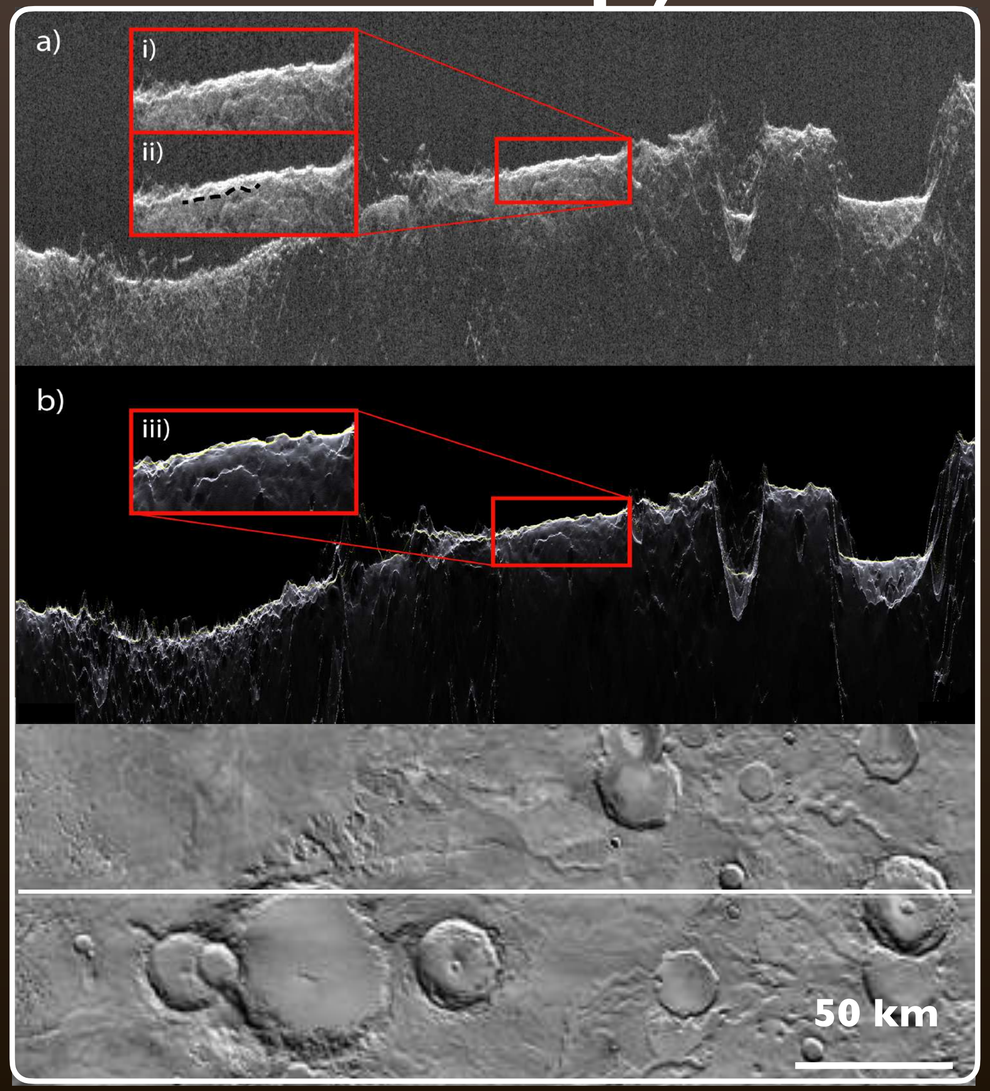
- SHARAD is a Synthetic Aperture Radar (SAR) working at a frequency of 20MHz (15m wavelength in free space).
- Studying the first tens of meters of the shallow martian subsurface using SHARAD data.
- Simulations using Digital Terrain Models (DTMs) are necessary to discriminate off-nadir surface reflections from subsurface ones.
- SPRATS : toolset developed at IPAG which performs coherent simulations as well as SAR synthesis.





Shallow subsurface reflector identification (first tens of meters deep)

- Southern Martian midlatitudes are rough and highly craterized, resulting in a large amount of clutter, which complexifies the radar data analysis.
- In Terra Cimmeria, Adeli et al. found a reflector that is not present on the simulation, but that cannot be clearly interpreted as subsurface.
- We projected the echo on a DTM and noticed that it followed a plateau.
- We chose this area for our case study to see the impact of DTM resolution and acquirement methods.

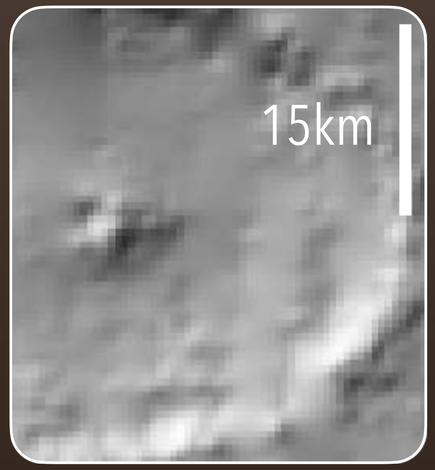


SHARAD profile n°5128501, simulation and ground track. Taken from Adeli et al (2019).

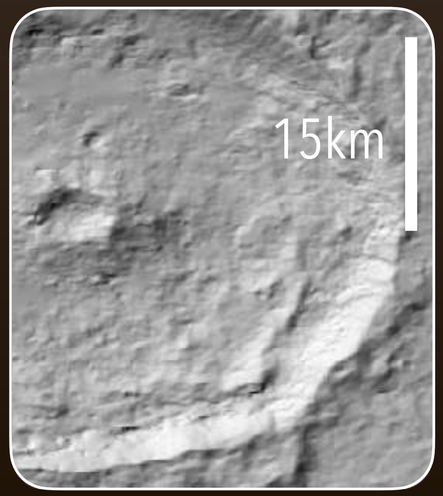
Echo projection and CTX image mapped on top

Simulations with MOLA and HRSC

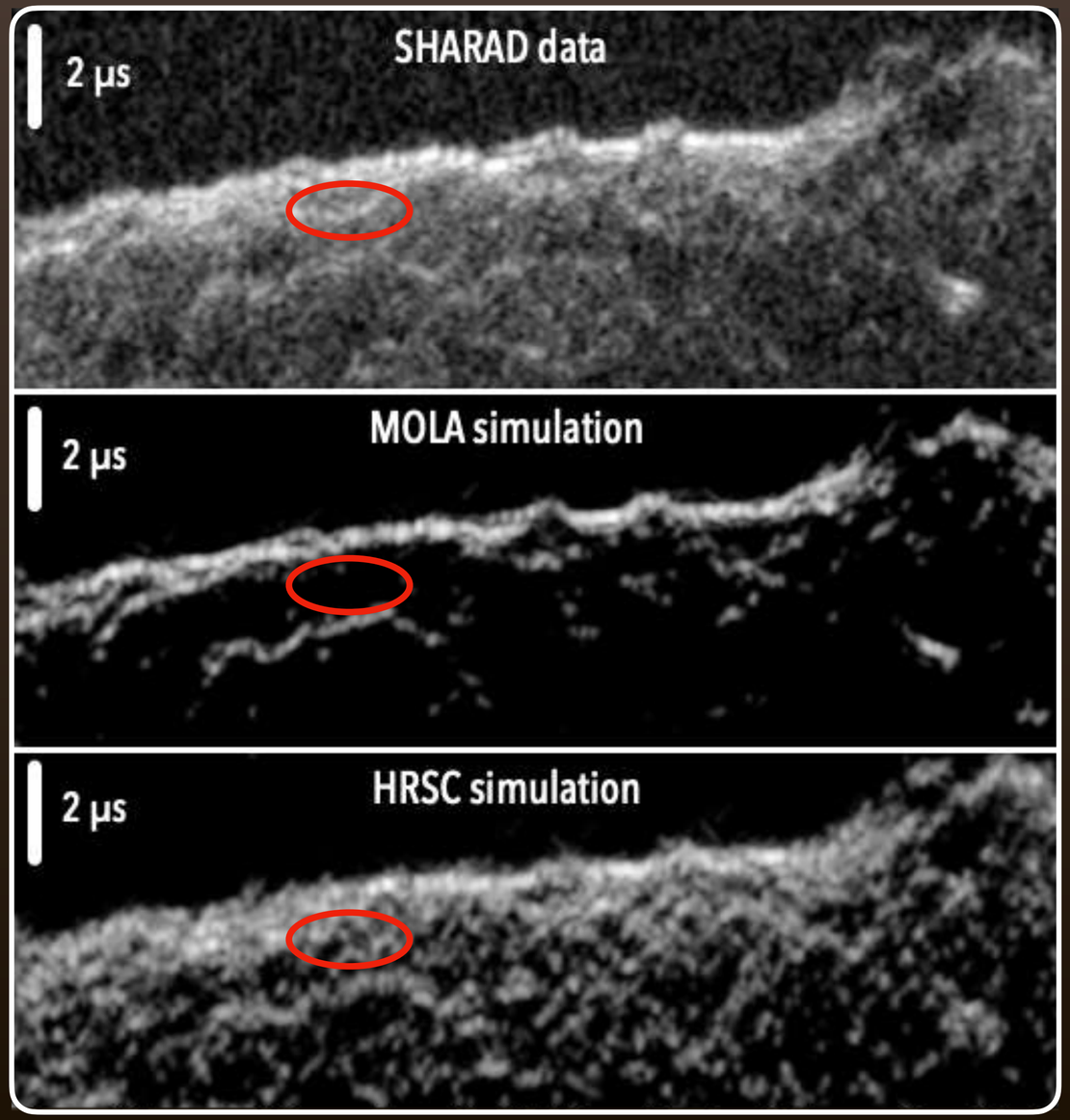
- **MOLA is a laser altimeter** producing a **463m/pix** global topographical map of Mars.
- Brighter reflectors are reproduced on the simulation but smaller details are smoothened.
- **HRSC is a stereo imager** producing **50m/pix** DTMs with photogrammetry and its DTMs cover less than half of the Martian surface.
- Smaller details are visible but the simulation is noisier, due to artifacts on the model at a scale larger than SHARAD wavelength.



MOLA



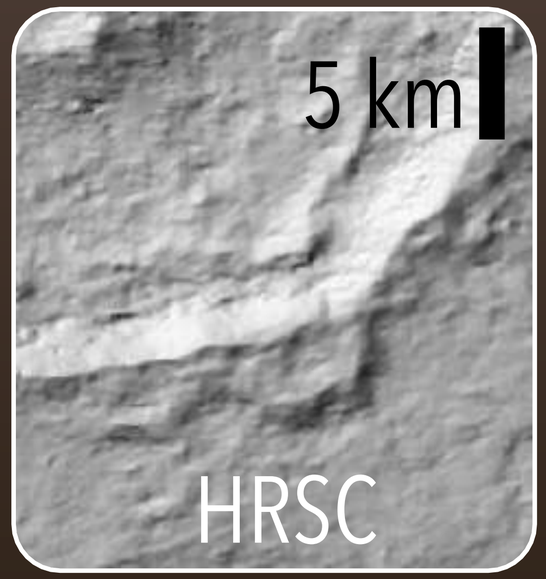
HRSC

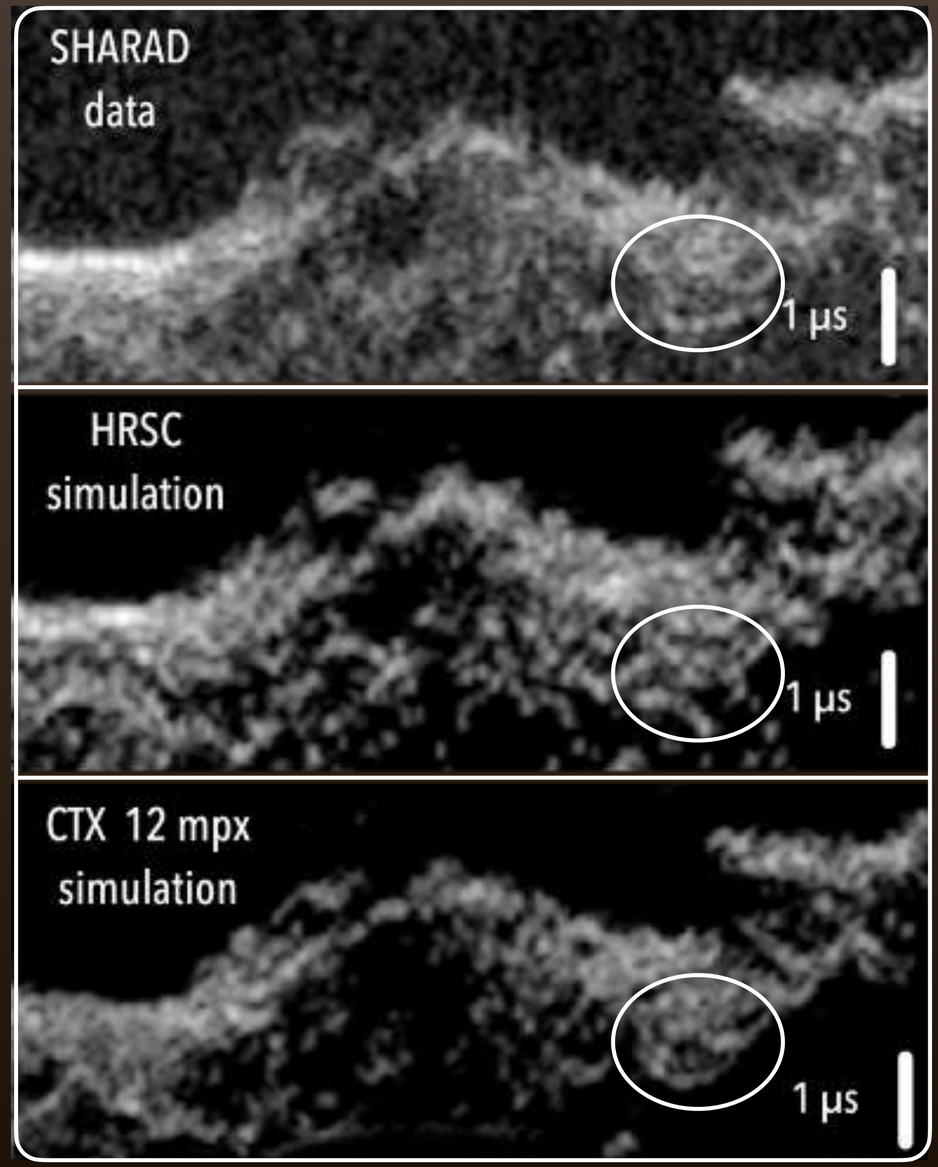


SHARAD profile n°5128501 and simulations using SPRATS

CTX DTMs : great results but poor coverage

- CTX DTMs are made using photogrammetry, but the stereo pair is not acquired simultaneously.
- Two overlapping images must be used to create a surface model, so the coverage in CTX DTMs is far less than the CTX coverage itself.
- No CTX pair available on the area that we are looking at, comparison of the results on an area close to it shows a great improvement on the results.
- The improvement comes from the fact that the artifacts in the CTX model are at a scale of 12m, therefore lower that SHARAD's wavelength.



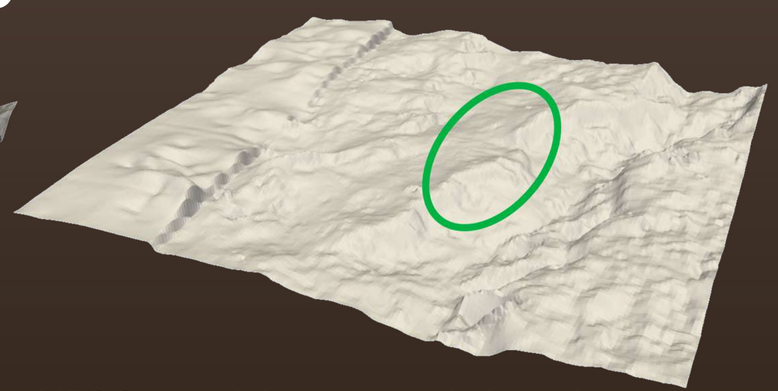


Southern portion of SHARAD profile n°5128501 and simulations using SPRATS

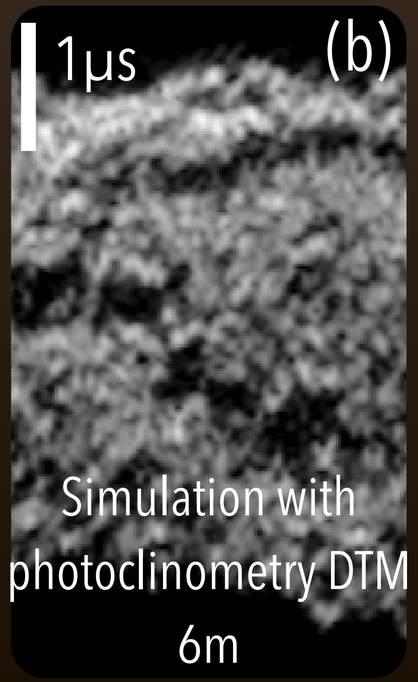
Correction of the HRSC model using photoclinometry

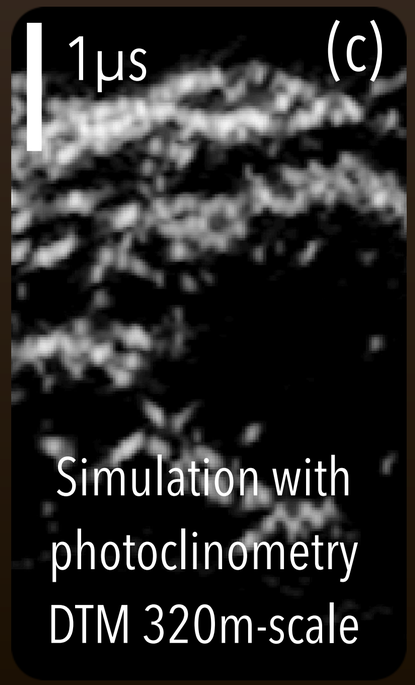
- One of the two CTX images were available on our region of interest. We can use photoclinometry (Douté and Jiang 2020) to correct the HRSC DTM with the 6m/pix CTX image.
- The edge of the plateau (green circle) where the reflector is thought to come from has been straightened by the photoclinometry.
- 6m photoclinometry DTM (b) contains too much small-scale variation.
- Wavelet transform at 320m allows to smoothen these asperities and we retrieve the reflector.

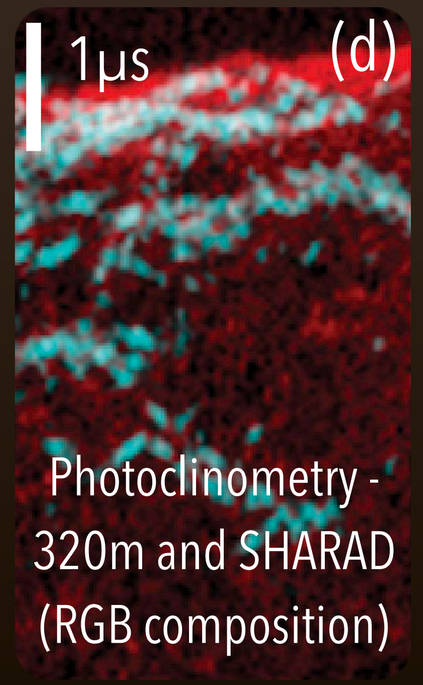
HRSC model and CTX image mapped on top, amplification of the topography by a factor of 20



HRSC model corrected by photoclinometry, Amplification of the topography by a factor of 20







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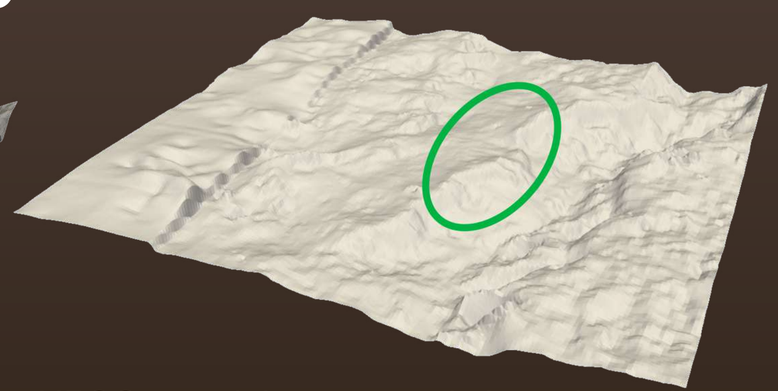

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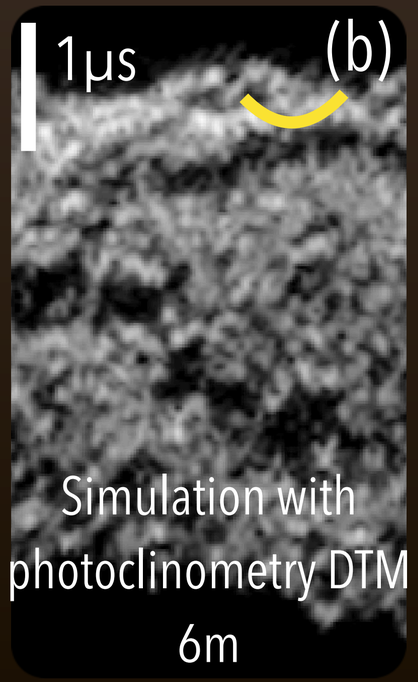

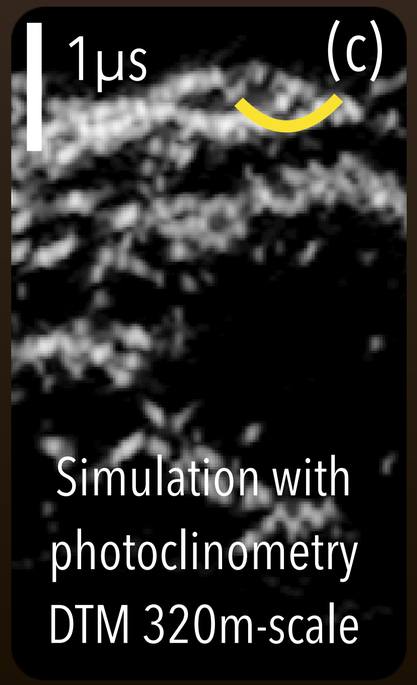

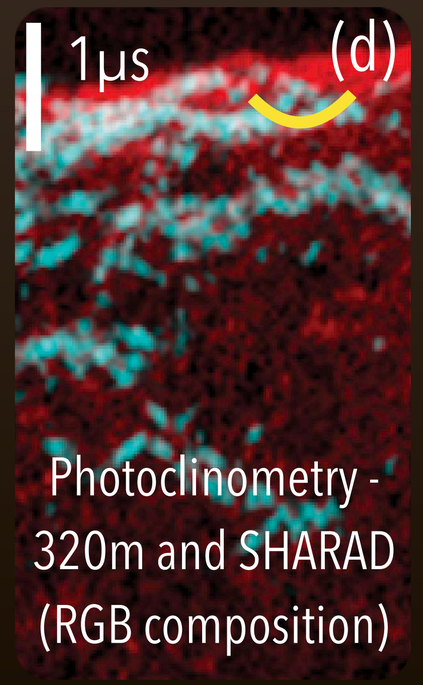

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Conclusions

- Coherent simulations allow for a **complete radar data simulation**, to match the real data as close as possible.
- **Optical models are necessary** to study the first tens of meters of the Martian subsurface in rough areas with SHARAD data, but **stero-photogrammetry introduces artifacts** in the models that can mislead the interpretation.
- Photoclinometry is a way to improve the resolution of optical DTMs and to correct errors.
- **Coherent simulations** provide a way to **assess a DTM quality** based on the comparison with real data : useful for future missions where DTM sources are limited.

Thank you !

Questions ?