National Aeronautics and Space Administration

FY23 Innovative Spontaneous Concepts Research and Technology Development (ISC)

Demonstrating the use of radar data and stereo-imaging to map seasonal variations of the martian polar deposits over two decades.

Principal Investigator: Gregor Steinbrügge (335); **Co-Investigator:** Yonggyu Gim (334)

Objectives: The objective of this work was to test a novel technique that uses radar sounding data and a priori topographic data to perform geodetically valuable range measurements. Using the Shallow Radar (SHARAD) on the Mars Reconnaissance Orbiter (MRO) in combination with digital terrain models (DTM) derived from MOLA we aimed at proving that we can use individual surface reflectors which are usually considered s clutter as independent range measurements to the surface. This would allow for accuracies better than the inherent range resolution (10 m for SHARAD) and allow impactful new applications.

Background: The seasonal variations of solar flux on Mars polar caps cause a cycle of carbon dioxide exchange between the surface and the atmosphere. MOLA cross-over point observations were previously used to observe thickness variations at the polar caps but are limited to two Earth years, corresponding only to one seasonal cycle on Mars and therefore not allowing to observe further temporal variations and long-term trends. SHARAD observations could extend these observations.

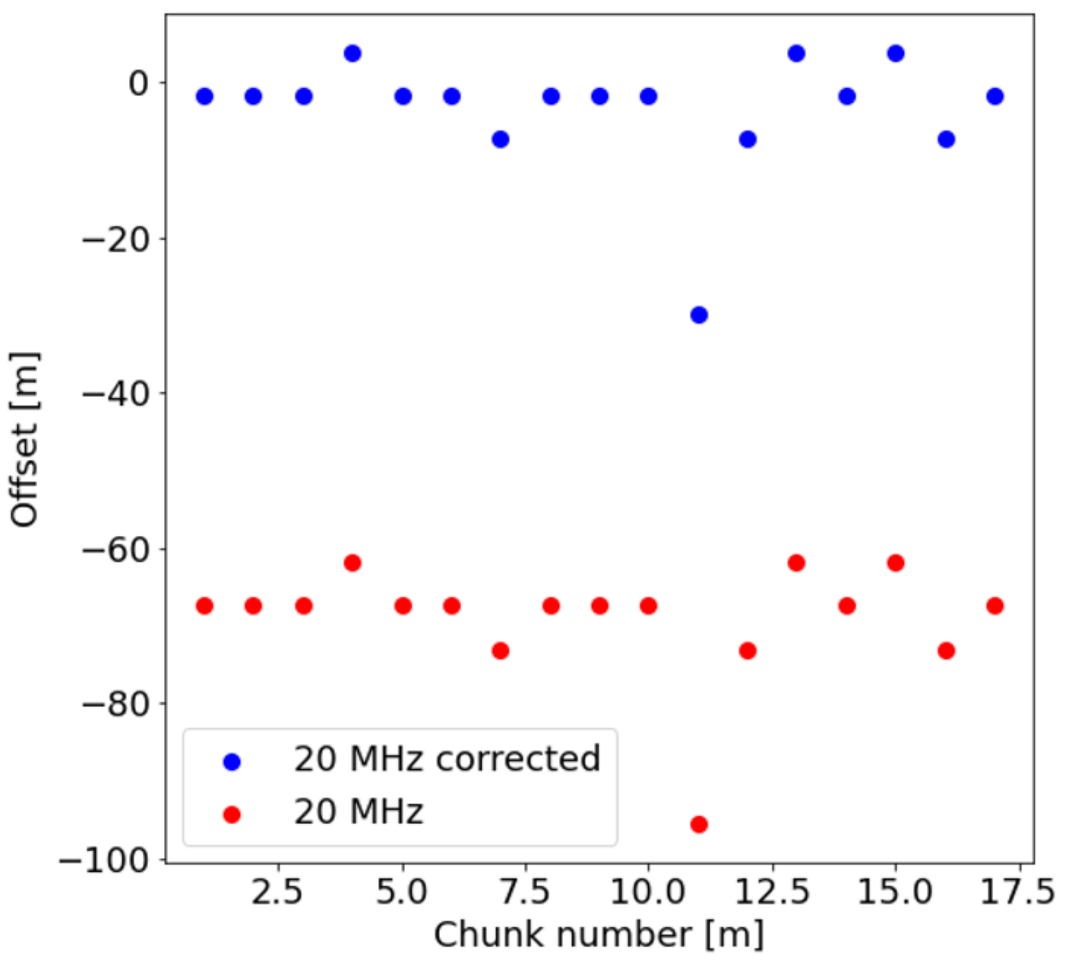

Figure 2. Range differences compared to MOLA with the ionospheric correction using classical auto-focusing (red) compared to our split-band method devised for this project (blue).

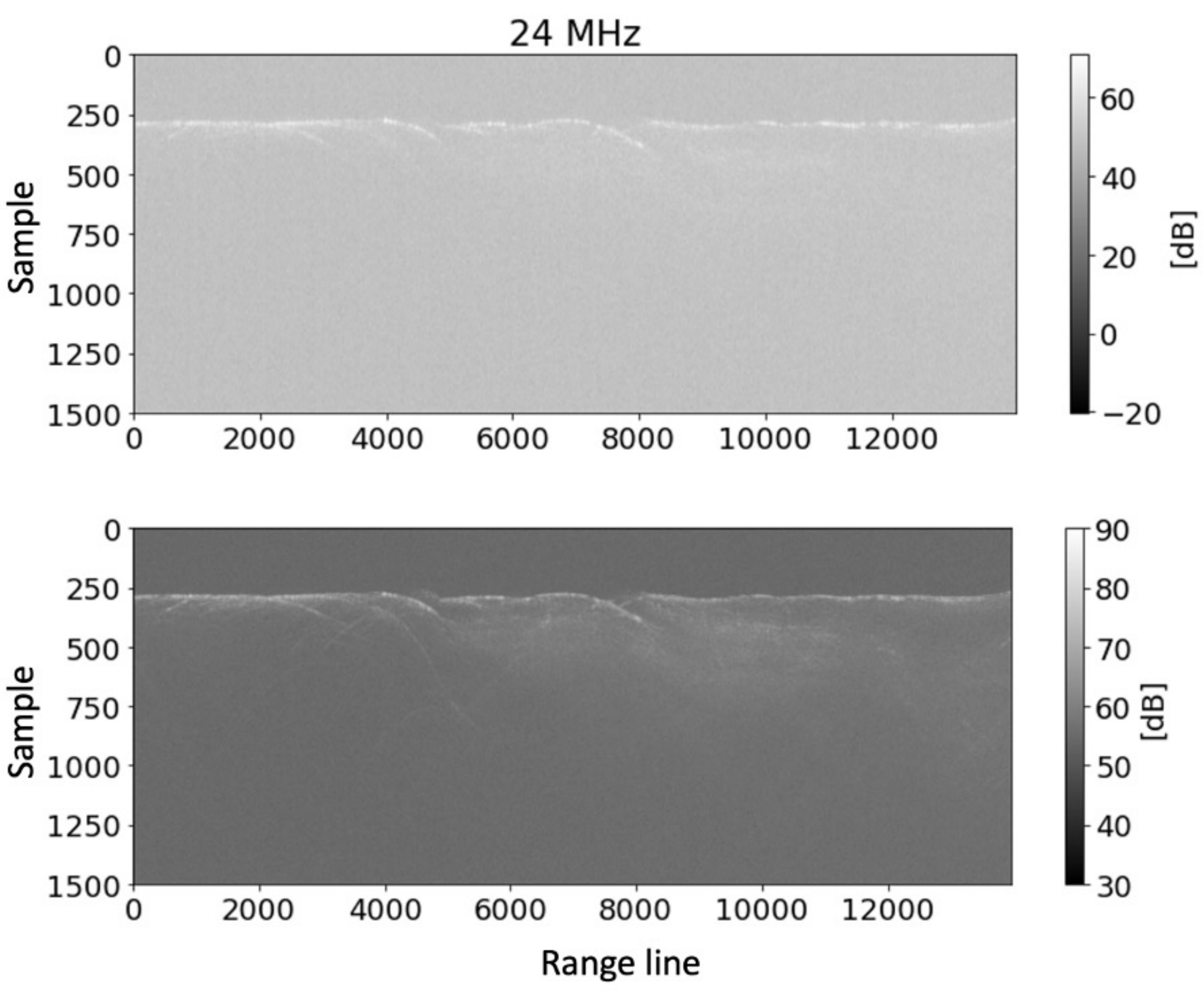

Figure 3. Example of the 24 MHz channel after EMI cleaning and histogram equalization.

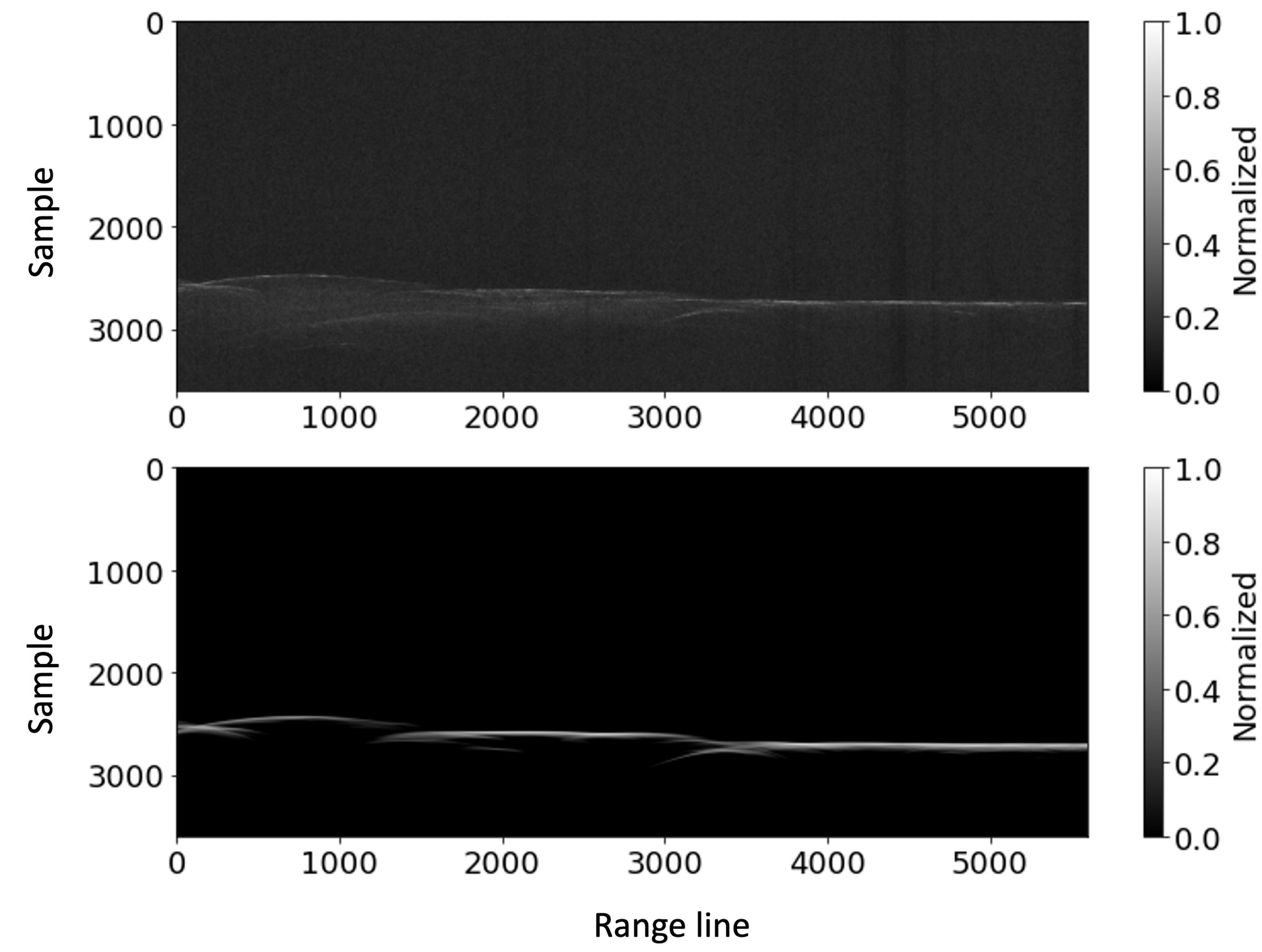

Figure 1. Example of a SHARAD track after pre-processing (top) and the associated cluttergram (bottom). The dynamic range of the cluttergram has been chosen to best mimic the radargram based on the signal-to-noise ratio of the latter.

Approach and Results: We used a study region on the South Polar Layered Deposits. We pulse compressed the EDR (raw) data of SHARAD and computed cluttergrams from MOLA (Figure 1). Afterwards we used the pulse compressed radargrams and the DTM derived cluttergrams to compute a differential range. We subdivided each profile into chunks of 300 range lines and cross-correlated each chunk independently as one range measurement.

Even for nighttime observations the ionosphere is still a significant limitation and can add 10s of meters of offset even for low total electron contents (TEC). The classical auto-focusing technique we initially used for correcting the ionosphere was not accurate enough for our purposes. We therefore devised a new approach in which we split the SHARAD bandwidth and exploit the fact that the ionospheric delay is frequency dependent. Using this technique, we obtained significantly better results (Figure 2).

The high frequencies of SHARAD suffer from an elevated EMI background limiting the capability to match the radargrams to the cluttergrams. To mitigate this issue, we implemented a notch filter (Figure 3). Since we can assess the SNR from the data, the accuracy of the range measurements is to some extent predictable. Using only measurements with a high-quality score we were able to demonstrate that it is indeed possible to use SHARAD observations in combination with MOLA to perform range measurements within the inherent resolution of SHARAD (Figure 4).

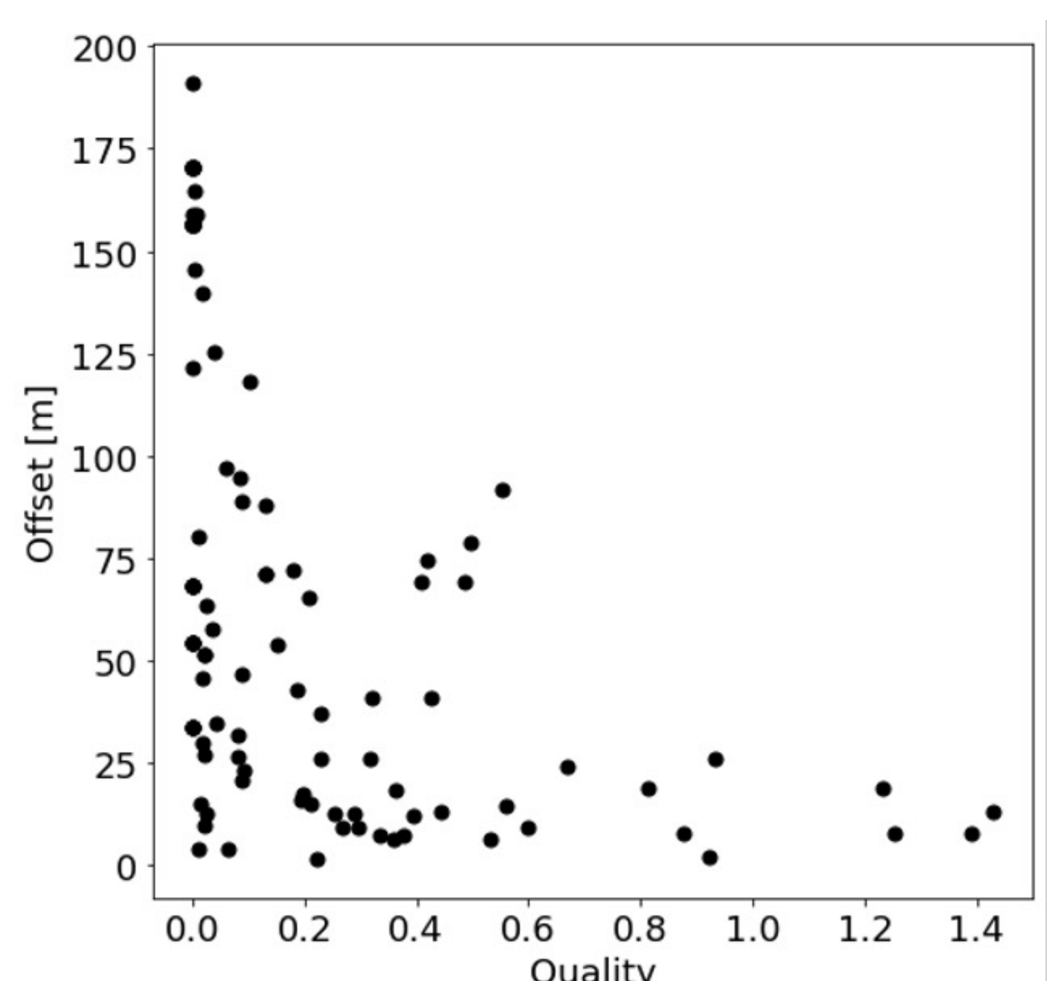

Figure 4. Example of range offsets vs. quality factor (not exploiting the oversampling capability, so limited to 10 m resolution best case).

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Publications:

Steinbruegge, G., Gerekos, C., and Gim, Y. “Demonstrating high resolution altimetry measurements using radar sounding and a priori topography data with SHARAD”, TBD, in prep.

PI/Task Mgr. Contact Information:
Tel: +1 (818) 3937-913
Email: Gregor.B.Steinbruegge@jpl.nasa.gov