CHARACTERIZATION OF POLAR REGIONS OF THE MOON USING SAR POLARIMETRY TECHNIQUES

Abstract

Quest for water-ice has been one of the prime objectives for lunar exploration, as it holds key for in-situ resource utilization (ISRU) for sustainable space missions and colonization. Even after a plethora of lunar missions with a range of spectrometers and radars to the Moon, presence of water-ice could not be established. The earlier (prior to 2019) flown SARs had imaged the polar-regions of the Moon using hybrid-polarimetry, with circular-polarization ratio (CPR) as a major measurable parameter and indicator of water-ice. However, this parameter has been found to be equally sensitive to surface roughness, leading to inconclusive results on water-ice determination. To address this ambiguity, ISRO's Chandrayaan-2 Dual-frequency SAR (DFSAR) was designed and flown (in 2019) with full-polarimetry mode, which is a gold-standard in SAR polarimetry.

Using this full-polarimetry mode, DFSAR has imaged the polar regions of the Moon in L-band with 7.5MHz bandwidth. This work focusses on the development of novel processing framework to derive SERD and T-ratio, indicators of roughness and dielectric constant, respectively, to study (and isolate) their contribution to CPR to unambiguously determine the water-ice presence. The thesis presents this work, along with the detailed characterization results generated for 115 impact craters, majorly over the polar regions, processed using about 300 DFSAR datasets. Following are some of the salient outcomes from this study:

- DFSAR system has been evaluated for its specifications, major in-lab characterization results and calibration of its data products for their adequacy in applying them for this study.
- Inter-sensor validation of DFSAR for its polarimetric performance with respect to LRO's MiniRF.
- Full-polarimetry based processing workflow using new parameters of SERD and T-ratio.

- Characterization of the impact craters using the above full-polarimetric techniques.
- Generation of characteristic curves inter-relating CPR, SERD & T-ratio for lunar impact craters.
- Identification of potential water-ice regions; a list of such potential craters has been brought out along with their coordinates.
- High resolution hybrid polarimetry based processing framework to demonstrate the potential of polarimetric SAR data to discriminate features/targets of the scale of single resolution-cell, which otherwise would not have been possible from conventional backscatter data. This is demonstrated over Chandrayaan-3 Vikram landing site.

Keywords: Chandrayaan-2, DFSAR, Polarimetry, CPR, SERD, impact craters, water-ice.