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Quantitative Estimation of Lunar Water-Ice through Chandrayaan-2 L&S band SAR

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Various recent studies using earth based radio-telescopes as well as lunar orbiting satellite data have confirmed the presence of water-ice in the lunar Polar Regions. The characteristic scattering from lunar regolith and ice deposits have been extensively studied by Mini-SAR on Chandrayaan-1 and Mini-RF on Lunar Reconnaissance Orbiter (LRO). However, the nature and distribution of water-ice in the permanently shadowed crater interiors are yet to be ascertained unambiguously. L-band (1.25 GHz) and S-band (2.5 GHz) polarimetric SAR onboard ISRO's forthcoming lunar mission, Chandrayaan-2, promises to provide new insights into the characteristics of lunar polar volatiles and quantitative estimation of lunar polar water-ice. The dual-frequency SAR will image the permanently shadowed regions (PSR) of lunar poles at steep to moderate incidence angles (10°-35°), at different polarizations including hybrid circular and full-polarimetric modes in L and S band and will help in resolving ambiguities related to high CPR (Circular Polarization Ratio) anomalies associated with lunar water-ice and rock debris. A quantitative theoretical two-layer scattering model was parameterized and simulated based on integral equation method (IEM) for lunar surface conditions as a function of radar incident angle, regolith thickness, surface and subsurface roughness, abundance of buried rocks and $FeO+TiO_2$ content of lunar regolith [1]. The scattering model corresponding to Chandrayaan-2 L and S band frequencies revealed that buried water-ice, other volatiles and buried rocks mixed in lunar regolith produce distinctly different radar backscatter in HH-polarization as observed at different incident angles. This characteristic was used to develop a Polar-ice detection index (LPDI) $= \left(\sigma^0_{S-HH} - \sigma^0_{L-HH}\right) / \left(\sigma^0_{S-HH} + \sigma^0_{L-HH}\right)$. LPDI was simulated for different concentrations (2% - 6% v/v) of buried ice and rock fragments mixed with lunar regolith and the characteristic curves at different incident angles are shown in Figure 1. It was observed that as the rock concentrations in the regolith increases LPDI difference between water-ice and rock increases. This index will be very useful for identifying, characterizing and quantitatively estimating water-ice in the lunar PSR using Chandrayaan-2 dual-frequency SAR data.

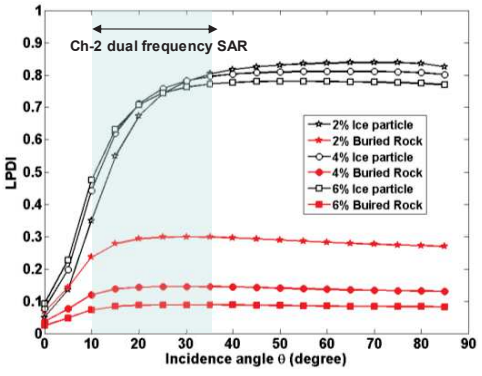

Figure 1. Lunar Polar Ice Index (LPDI) corresponding to different fraction of ice particles and burried rocks embeded in lunar regolith shown as a function of radar incidence angle.

1. W. Fa, M. A. Wieczorek, and E. Heggy, "Modeling polarimetric radar scattering from the lunar surface: Study on the effect of physical properties of the regolith layer," *J. Geophysical. Research,* **116**, 2011, E03005, doi: 10.1029/2010JE003649.