MODELING RADAR SCATTERING FROM ICY LUNAR REGOLITHS. T.W. Thompson[1], E. A. Ustinov[1] and E.Heggy[2,3]; [1] Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, 91109, CA, USA, Ph: 818-354-3881, Fax: 818-393-5285, Thomas.W.Thompson@jpl.nasa.gov; [2]Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston 77058, TX, USA. [3]Institut de Physique du Globe de Paris, Paris, 75252, France.

Scinetific context: Two orbital synthetic aperture radars will be imaging the lunar surface in the upcoming years searching for potential evidence of presence of ice deposits in the polar shadowed areas: (1) the Chandrayaan Mini-RF operating at S-Band frequency (13cm wavelength) and (2) the Lunar Reconnaissance Orbiter Mini-RF operating at S-Band and X-Band frequencies (near 3-cm wavelengths). The performance and scientific return from those two experiments depend strongly on our degree of understanding of the radar backscattering characteristics of the icy lunar regoliths in order to access the potential presence of volatiles in the surface and shallow subsurface (identified rougthly here in as 10 times the wavelength). If ices in the permanently shadowed areas of the lunar poles have similar physical characteristics like the ices on Mercury, Mars and the Galilean satellites, then these ices will have a substantial radar enhancement characterized by a Circular Polarization Ratio (CPR) greater than unity. Here we examine the possibilities that this distinct CPR signature may be diminished by factors such as a thin regolith covering the ice and/or the ice occupying small patches within a larger radar pixel and/or the high CPRs are result from blocky crater ejecta.

Quasi-Specular-Diffuse scattering models: Our first model for scattering from lunar surface assumes a mixing model consisting of diffuse and quasi-specular components as shown in Figure 1 [1,2]. The quasi-specular component results from the surface and subsurface layers that are oriented perpendicular to the radar's line-of-sight. The diffuse component, which is associated with either wavelength-sized rocks or ice, is assumed to be uniformly bright, where backscatter is proportional to the cosine of the incidence angle. Rocks are assumed to have CPRs of unity. Ices are assumed to have CPRs of 2 like those observed on Mercury, Mars and Galilean Satellites. This first model as shown in Figure 2 indicates that the radar CPR signatures for ice and rocks are separable if the depolarized (SC, same sense circular) enhancements are larger than about 2-4 and are indistinguishable for smaller depolarized (SC) enhancements.

Modeling backscatter for ice-filled pores in the regolith: Our second model addresses CPR changes for the situation where lunar ices fill the pores of the regolith with varying amounts and hence modulates the real and imaginary parts dielectric constant of the lunar soils at the S and X frequency bands. Here only the quasi-specular backscatter from the surface and the diffuse backscattering from sub-surface rocks will change with increased abundances of water ice in the regolith. The lower right-hand panel of Figure 2 shows changes in CPRs modeled on our two-components mixing model with quasi-specular and diffuse components based on dielectric measurements of mixture of lunar analog basalt from craters of the Moon lava field (Idaho, USA) and water ice. The measurements were carried at the Lunar and Planetary Institute Electromagnetic characterization laboratory [3] at a temperature of 180 K and with dust grain size of 50 μm. Dust contamination in the ice-matrix ranged from 0 to 100% of the sample mass. Both the real and imaginary parts of the dielectric constant showed a nearly linear increase as function of the dust portion in the ice. When integrating the preliminary results of the laboratory measurements we observed that only small changes in CPRs occur.

Preliminary results: Assuming the validity of current geological and geoelectrical model for the permanently shadowed areas, we can note the following:

- If Depolarized Enhancement (SC) >10 and reasonable CPR, then it could be potentially indicative of buried ice.
- If 10 > Depolarized Enhancement (SC) >2-4, then our quasi-specular-diffuse scattering model can be used to separate ice from rocks.

Furthermore,

- If a thin (a few radar wavelengths, a meter or less at S- and X-band wavelengths) regolith covers a Mercury-Mars type ice, then there will be detectable differences in CPRs.
- If on the other hand, ice fills the pore spaces in the regolith, and only modulates the dielectric constant of the regolith then there will be no detectable differences in CPRs.

References: [1] Thompson, T. W., Atlas of lunar radar maps at 70-cm wavelength, *The Moon*, v.10, pp51–85, 1974. [2] Moore, H. J. and T. W. Thompson, *Proceedings for Lunar and Planetary Science*, Lunar and Planetary Institute, Houston, Texas, 21, 457–472, 1991. [3] Heggy E. et al. , *Proceedings for Lunar and Planetary Science*, Lunar and Planetary Institute, Houston, Texas,, abs. 1756, 2007.

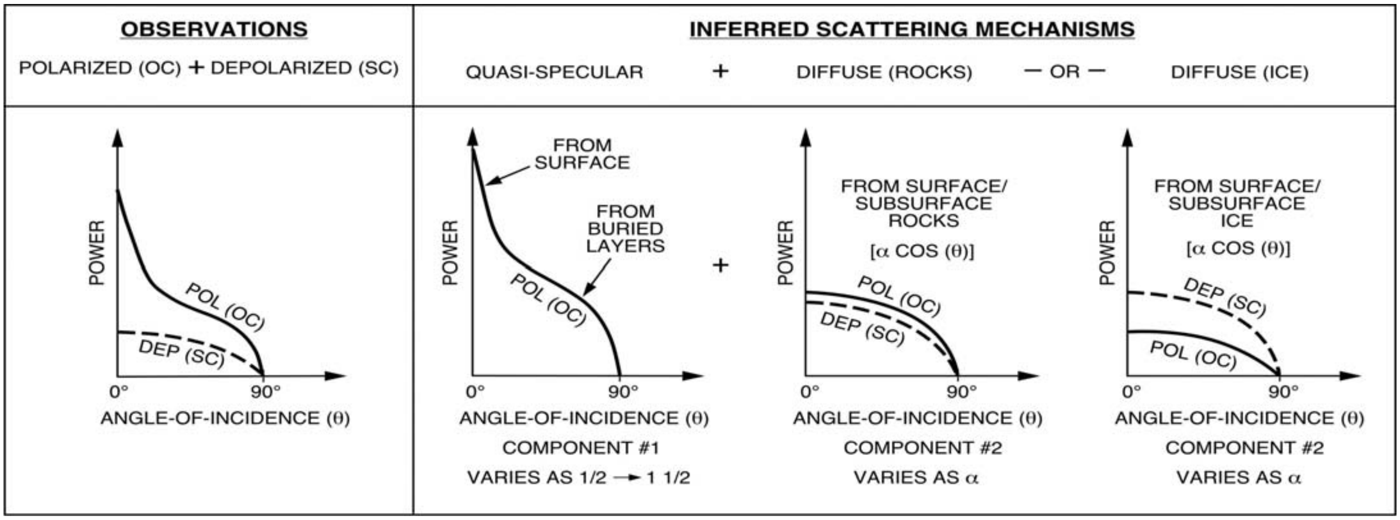

Fig. 1. Lunar radar scattering behavior. Obse vations in polarized (OC, opposite sense circular) and depolarized (SC, same sense circular) components lead to inferences of quasi-specular and diffuse scattering mechanisms [2]. Depolarized (SC, same sense circular) enhancements for rocks and ice are assumed to vary as α (with values of 2, 4, and 8).

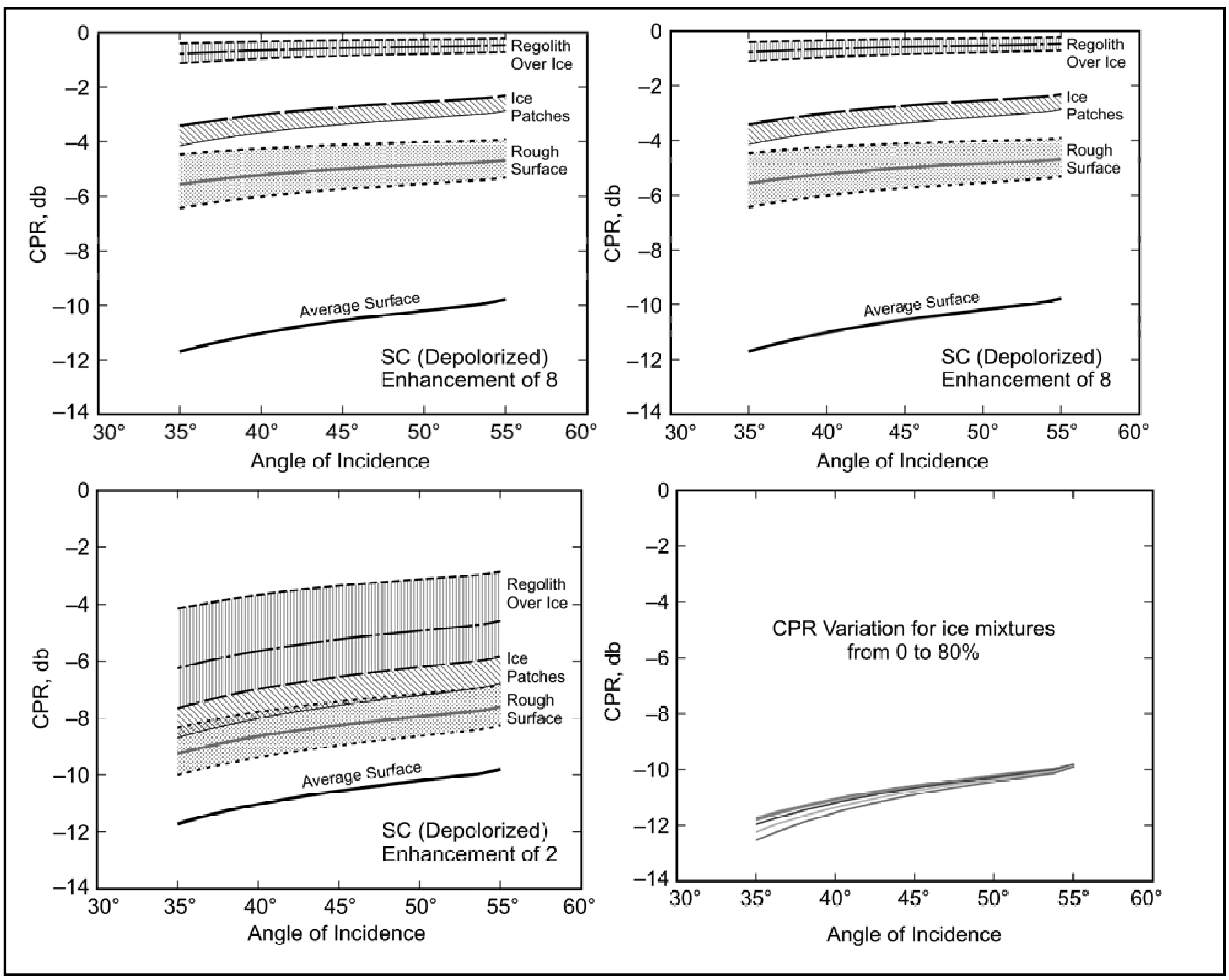

Fig. 2. Lunar Radar Scattering Differences for changes in quasi-specular and diffuse scattering from rocks and ice, assuming SC (depolarized) enhancements of 8, 4, and 2. Lower right panel shows CPR differences when ice fills pores in regolith.