MODELING RADAR SCATTERING FROM ICY LUNAR REGOLITHS. T.W. Thompson[1], E. A. Ustinov[1] and E.Heggy[1], Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA, Phone: 818-354-3881, Fax: 818-393-5285, Thomas.W.Thompson@jpl.nasa.gov

Scientific context: The data from two orbital synthetic aperture radars—the Chandrayaan Mini-RF, at 13-cm wavelength (S-band) and the Lunar Reconnaissance Orbiter Mini-RF at 4 cm and 13 cm (X-band)—can provide evidence of presence of ice deposits in the polar shadowed areas. The performance and scientific return from those two experiments require that we understand the radar backscattering characteristics of the icy lunar regoliths sufficiently to assess the possibility of frozen volatiles in the surface and shallow subsurface (defined here as 10 times the wavelength). If ices in the permanently shadowed areas of the lunar poles have the radar characteristics similar to 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, the ice occupying small patches within a larger radar pixel and/or the high CPRs resulting from blocky crater ejecta.

Specular-Diffuse Scattering Models: Our first model for scattering from a lunar surface assumes a mixing model consisting of diffuse and specular components (Figure 1 [1,2]). The specular component results from the surface and sub-surface layers that are smooth to a tenth of a radar wavelength for large (10 wavelengths or more) areas 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, with backscatter being proportional to the cosine of the incidence angle. As diffuse scattering contributes only to the same-sense circular (SC) echoes, it is important to address the SC enhancement as well as CPRs.

Rocky areas associated with young craters 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 SC enhancements are larger than about 2–4; the CPRs are indistinguishable for smaller (SC) enhancements.

Modeling backscatter for ice filling pores in regolith: Our second model addresses CPR changes for the situation where lunar ices fill the pores of the regolith with varying amounts and hence modify the real and imaginary parts of the dielectric constant of the lunar soils. In this case, only the specular backscatter from the surface and the diffuse backscattering from subsurface rocks will change with increased abundances of water ice in the regolith. Assumed dielectric constants are based on measurements of a mixture of lunar-analog basalt from a lava field in Craters of the Moon National Monument (Idaho, USA) and water ice [3]. These dielectric constants result in only small changes in CPRs (lower right-hand panel of Figure 2).

Results: Our modeling [4] indicates that it is important to address the SC enhancement as well as CPR. We note the following:

- If SC enhancement is greater than 10 with a reasonable CPR (greater than unity), then it is indicative of ices similar to those observed on Mercury, Mars, and the Galilean satellites.
- If the SC enhancement is between 2-4 and 10, then our specular–diffuse scattering model can be used to separate ice from rocky areas associated with young craters.

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 and CPRs will be greater than unity.
- 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] Evans and Hagfors (1964) *Icarus*, 150–161. [2] Moore H. J. and Thompson T.W. (1991) *Proc LPSC Conf*, 457–472. [3] Heggy E. et al. (2007) *LPS XXXVIII,* Abstract #1756. [4] Thompson et al. (2011) *JGR*.

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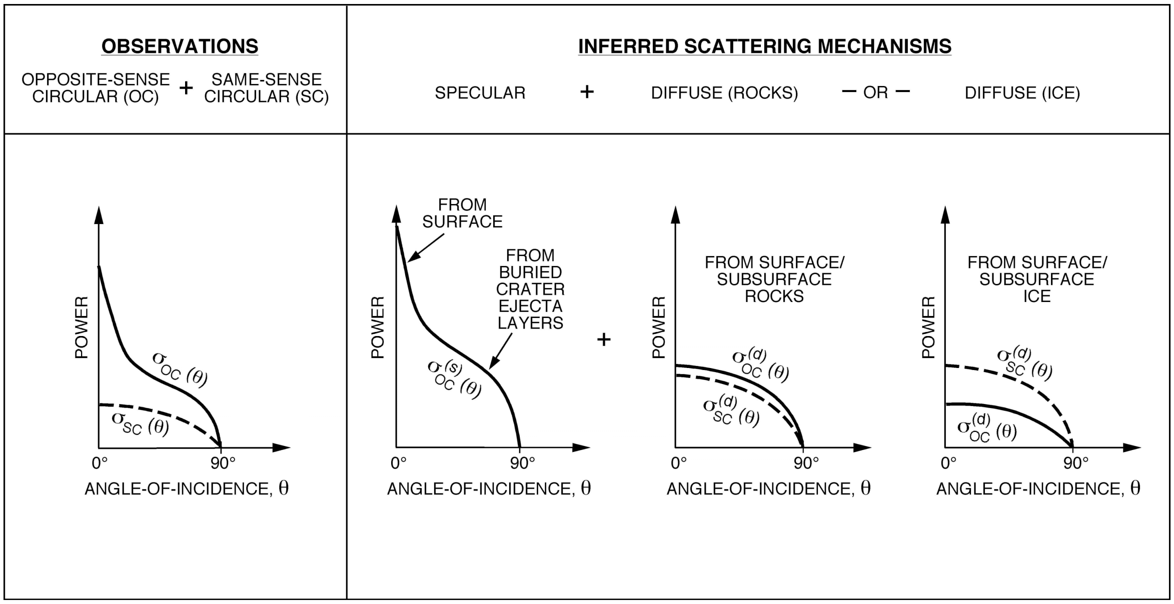

Fig. 1. Components of lunar radar scattering. Observations in opposite-sense circular (OC) and same-sense circular (SC) polarization components lead to inferences of specular and diffuse scattering mechanisms [2].

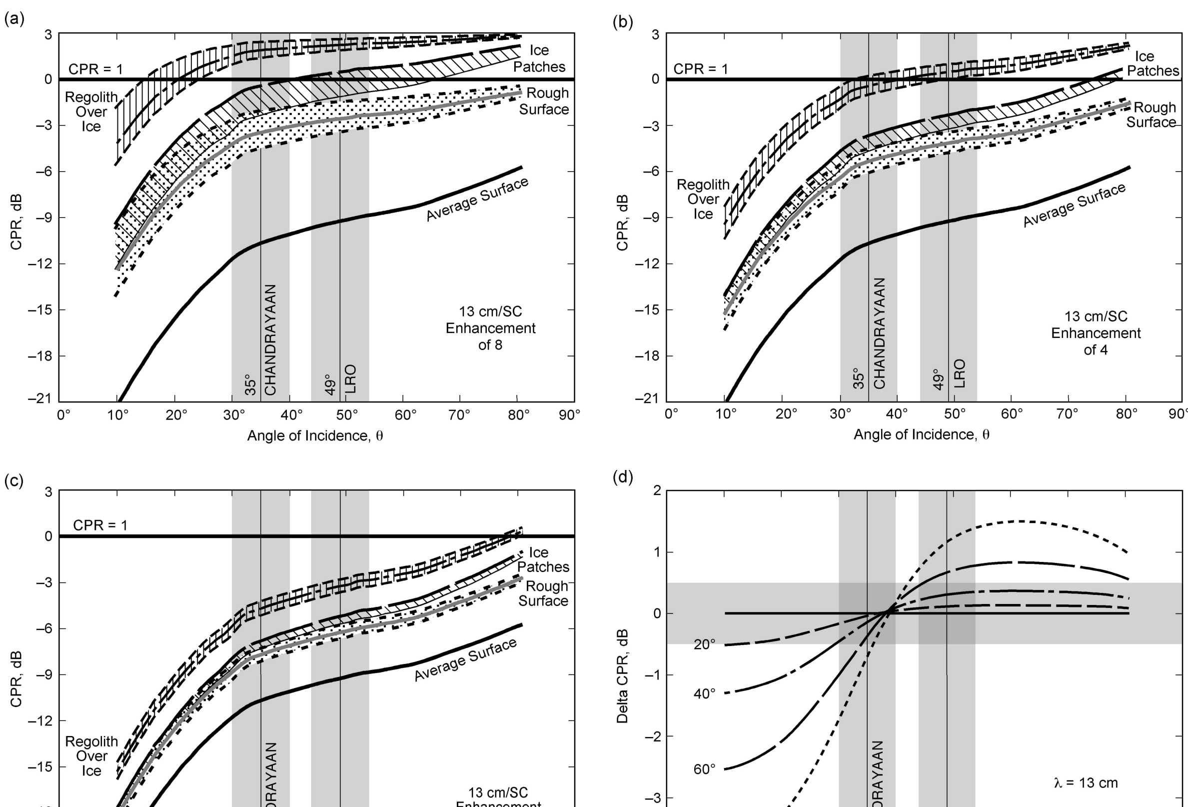

Fig. 2. Modeled lunar radar scattering differences for changes in specular and diffuse scattering from rocks and ice, assuming SC enhancements of 8 (strong), 4 (intermediate), and 2 (weak). Lower-right panel shows modeled CPR differences when ice fills pores in regolith.