UPDATED MODEL OF RADAR BACKSCATTER FOR ROUGH LUNAR CRATERS. Thomas W. Thompson and Eugene A. Ustinov, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA: Thomas.W.Thompson@jpl.nasa.gov, phone: 818-354-3881, fax: 818-393-5285

Context - Specular-Diffuse Scattering Models for Lunar Radar Backscatter: We re-examined our radar scattering model for young, rough craters [1] based on unpublished data from the 1980's [2]. Our model for scattering from the lunar surface is a mixing model consisting of varying amounts of diffuse and specular components as shown in Figure 1. The specular component, which consists of only opposite-sense circular (OC) echoes, results from the mirror-like surface and sub-surface layers that are smooth to a tenth of a radar wavelength for large (≥10 wavelengths) areas oriented perpendicular to the radar's line-of-sight. The diffuse component, which has both OC and same sense (SC) circular echoes, is associated with either surface roughness (wavelength-sized rocks) or ice, and is assumed to be uniformly bright, with backscatter being proportional to the cosine of the incidence angle. Only diffuse scattering contributes to the SC echoes.

In the previous version of our model [1], we assumed that diffuse scattering from rocky areas associated with young, rough craters (Erastothenian and Copernican aged) has circular polarization ratios (CPRs) of unity; ices are assumed to have CPRs of 2 (like those observed on Mercury, Mars, and the icy Galilean satellites). A new examination of unpublished 1980's data [2] indicates this diffuse scattering from young, rough craters is better represented by uniformly bright scattering where the OC component is twice that of the SC component as was originally hypothesized by Thompson [3].

Modeling Results: The veracity of our revised model is examined for 61 craters with radar backscatter enhancements in the Arecibo 70-cm images [2] by plotting predicted vs. observed OC enhancements $\gamma = \sigma_{OC}(\theta) / \sigma_{OC-avg}(\theta)$ where θ is the angle of incidence. The predicted OC enhancement for rough, young craters as represented in our 2011 *JGR* paper scattering model [1] is:

$$\gamma(\theta) = \frac{(\alpha/2) + \beta(\theta)}{1 + \beta(\theta)} \qquad (1)$$

Our review of the unpublished 1980's data [2] indicates this predicted OC enhancement is better represented by a second representation (as it was originally hypothesized [3]) where:

$$\gamma(\theta) = \frac{\alpha + \beta(\theta)}{1 + \beta(\theta)} \qquad (2)$$

Here the observed SC enhancement is $\alpha = \sigma_{SC}(\theta) / \sigma_{SC-avg}(\theta)$ and $\beta(\theta)$ is a measure of the relative amounts of echo power in the average specular and diffuse components based on the average lunar radar cross-sections at 68-cm given by Hagfors [4]. In particular,

$$\beta(\theta) = \frac{\sigma_{OC-avg}(\theta)}{\sigma^{(d)}_{OC-avg}(\theta)} - 1 \qquad (3)$$

where $\sigma_{OC-avg}(\theta)$ is the average total OC radar cross section for the average lunar surface; the term $\sigma^{(d)}_{OC-avg}(\theta)$ is the average diffuse scattering; with both being proportional to $\cos(\theta)$.

The key component in these formulations is the readily assessable SC enhancement, α, a consequence of the SC echoes arising only from diffuse scattering. Also, lunar backscatter power is interchangeable with the lunar radar cross-sections, σ, in these formulations.

Summary: Results for 61 craters that have radar backscatter enhancements in the Arecibo 70-cm images are given in Figure 2 as a scatterplot of predicted vs. observed OC enhancements. Note that the second representation given by Equation 2 and labeled "*The Moon* 1974" provides a better fit between the predicted and observed OC enhancements than our original model given by Equation 1 and labeled "*JGR* Paper 2011".

References: [1] Thompson, T. W., et al. (2011) *JGR*, 116, doi:10.1029/2009JE003368. [2] Thompson T. W. (1987), *Earth, Moon and Planets*, 37, 59–70. [3] Thompson T.W. (1974), *The Moon*, 10, 51–85. [4] Hagfors, T. (1970), *Radio Science*, 5, 189–227,

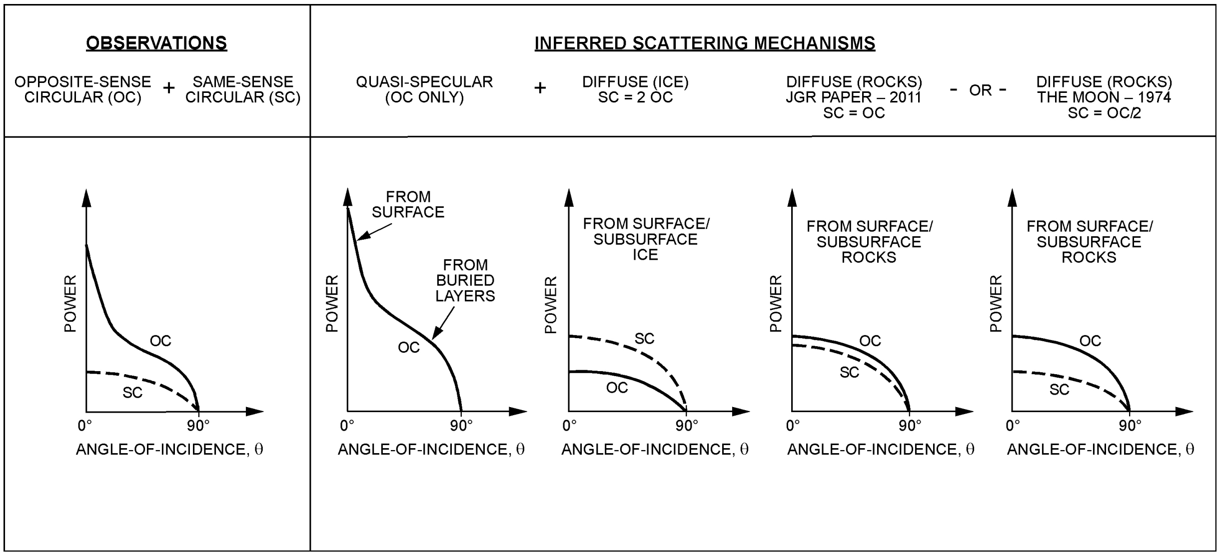

Fig. 1. Lunar radar scattering model components. Observations in opposite-sense circular (OC) and same-sense circular (SC) polarizations lead to inferences of specular and diffuse scattering mechanisms [1]. SC echoes are assumed to be uniformly bright and to vary as a cosine of the angle of incidence with the ratios of SC to OC echo powers of 2:1 for ice and either 1:1 or 1:0.5 for rocks associated with young (Erastothenian and Copernican aged), rough craters.

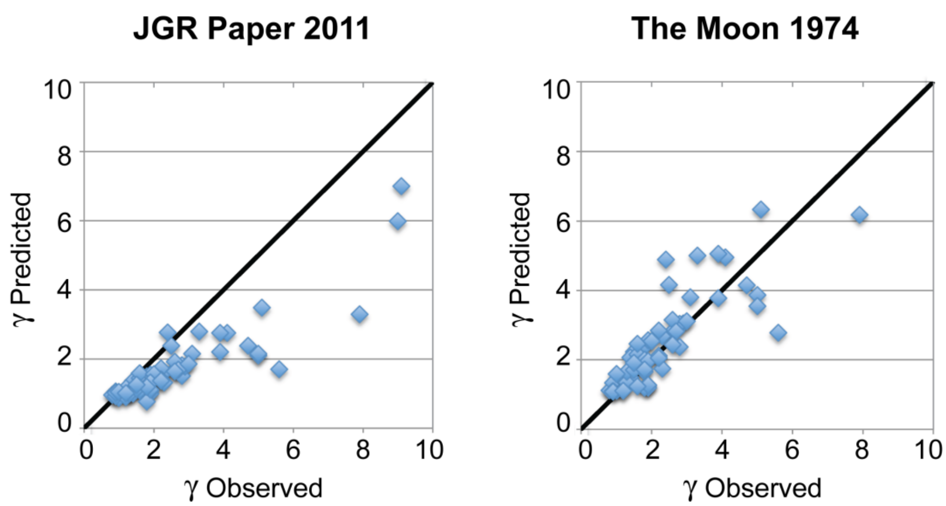

Fig. 2. Scatterplots of predicted vs. observed OC enhancements $\gamma = \sigma_{OC} / \sigma_{OC-avg}$ for 61 craters that have radar backscatter enhancements in the Arecibo 70-cm images [2]. Note that the second representation given by Equation 2 and labeled "*The Moon* 1974" provides a better fit between the predicted and observed OC enhancements than our original model given by Equation 1 and labeled "*JGR* Paper 2011".

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