THE COHERENT CHARACTER OF THE MARTIAN SURFACE AT 20 MHZ. C. Grima[1], N. E. Putzig[2], B. A. Campbell[3], M. R. Perry[2], K. M. Scanlan[1], [1]Institute for Geophysics, University of Texas at Austin, TX, USA, (cyril.grima@utexas.edu), [2]Planetary Science Institute, Lakewood, CO 80401, USA, [3]Center for Earth and Planetary Studies, Smithsonian Insitution, Washington, DC 20569, USA.

Introduction. Over the last decade the Mars' interior has been actively probed using orbital radar sounders to unveil the planet's subsurface morphology [1, 2]. However, radiometry of the planet's surface return has been underused. The surface echo strength is rich in information regarding the crust's roughness, its composition, and the structure of the upper decameters (the near-surface) [3, 4, 5]. This rich variety of contributions is unlike those provided by other remote sensing technologies that are usually sensitive to a superficial skin altered by weathering. However, untangling the various surface and near-surface contributions from the surface echo strength is usually ambiguous without the support of other observation sources. We report preliminary results from the application of the Radar Statistical Reconnaissance (RSR) technique [4, 6] to the Shallow Radar (SHARAD) data [7]. It provides important guidance for proper selection of backscattering models when studying the surface reflection, and paves the way to further hypothesis discrimination for the regional Martian geology.

Radar Statistical Reconnaissance. RSR assesses the probability distribution of the surface echo amplitude whose shape parameters provide two indicators characterizing the received signal [6]: (i) the coherent energy (P_c) is modulated by the deterministic structure of the ground (e.g., composition, layering) and is rich in information related to the surface dielectric properties; (ii) the incoherent energy (P_n) is modulated by the non-deterministic structure (roughness, near-surface heterogeneity like blocks or voids) and varies with the degree of disorganization and dimension of the elements making up the target at radar scales. The RSR is an improvement over other reflectometry techniques that usually derive dimensionless parameters, without strict quantitative bounds to near-surface properties [5]. We have applied the RSR technique on 0.1°-meshed (∼10 km) grids over several regions. Rolled observations have not been considered to avoid heterogeneous gains across the dataset.

Coherent Content. The coherent content is a unitless value defined as the P_c/P_n ratio [8]. It cancels out any deterministic gain variation effects (e.g., effective permittivity, ionospheric absorption, S/C or instrumental drifts). The coherent content is then a measurement inversely correlated to the occurrence of geometric heterogeneities and their relative dimension. The resulting map is an outline of surface and near-surface scattering structures at around the radar wavelength (Fig. 1). We

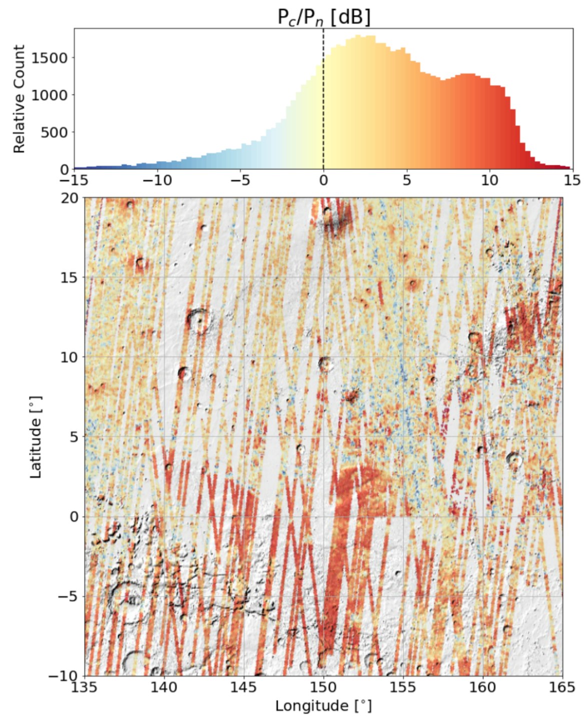

Figure 1: The coherent content (P_c/P_n ratio) distribution (Top) and mapping (Bottom) over the Southern part of Elysium that includes hetergoneous terrains in terms of age, composition and roughness.

observe over the heterogeneous geology covered by our data sets that most terrains have a dominantly coherent surface signal. That includes rough terrains for which we hypothesize that the faster incoherent extinction due to geometric losses is responsible for a dominant coherent energy reaching the antenna. In our data set, a more balanced coherent-incoherent signature is mainly encountered over Hesperian-Amazonian units. The coherent content is also an important source of information when selecting an appropriate backscattering model to study the reflectivity of a specific terrain, e.g., a basic approach based on Fresnel equations might be too simplistic when incoherent energy is dominant. A thorough sensitivity analysis will be carried out that could also partly explain the 25-30 dB range of coherent content detected.

Echo Character Pathway. The distribution of all our measurement points in the P_c-P_n space appears to follow a specific track that we refer as the echo character pathway (Fig. 2). P_c and P_n are analytically both equally proportional to the surface effective permittivity

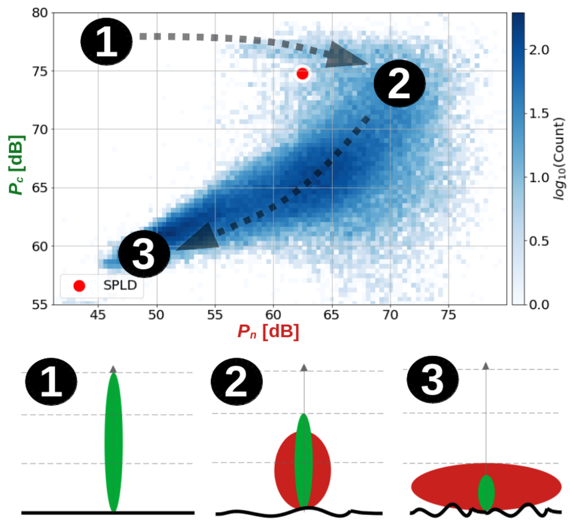

Figure 2: (Top) Distribution of the RSR dataset presented in Fig.1 in a P_c-P_n space. The plot is overlayed by the idealized echo character pathway for a surface of constant permittivity but with increasing roughness. (Bottom) Sketches representing the various stages of the relative P_c and P_n strengths for an increasingly rough surface. SHARAD measures the echo strength at nadir.

so that any relative dynamic in this space is independent of surface composition. We hypothesize this pathway to be driven by surface roughness maturation, signs of advanced geologic alteration. This rational is represented in Fig. 2 by illustrating qualitatively how the P_c and P_n components would relatively respond to increasing roughness. We will verify this hypothesis by mapping the theoretical roughness evolution of the observed pathway would imply with available roughness data. This might provide a tool to assess the roughness of a specific terrain from its position on this echo character pathway.

Absolute Calibration. SHARAD provides only relative radiometric measurements. The absence of an absolute gain calibration value hampers any radiometric study to assess the surface dielectric properties and composition. Such value could be obtained by adjusting the signal strength reflected by a flat area of know dielectric properties (the reference zone). One of the best candidate on Mars is a flat area in the South Polar Layered Deposits (SPLD) [3, 4]. However, a reasonable range of hypothesis for its near-surface structure and composition still leads to, at least, a 4 dB accuracy [4]. Fig. 3 shows the critical impact of this accuracy could have on the geologic interpretation of other Martian terrains. We will constrain the validity of the absolute calibration factor by confining the RSR-derived signal components to several regions where surface/near-surface properties are best known (e.g., former landing sites).

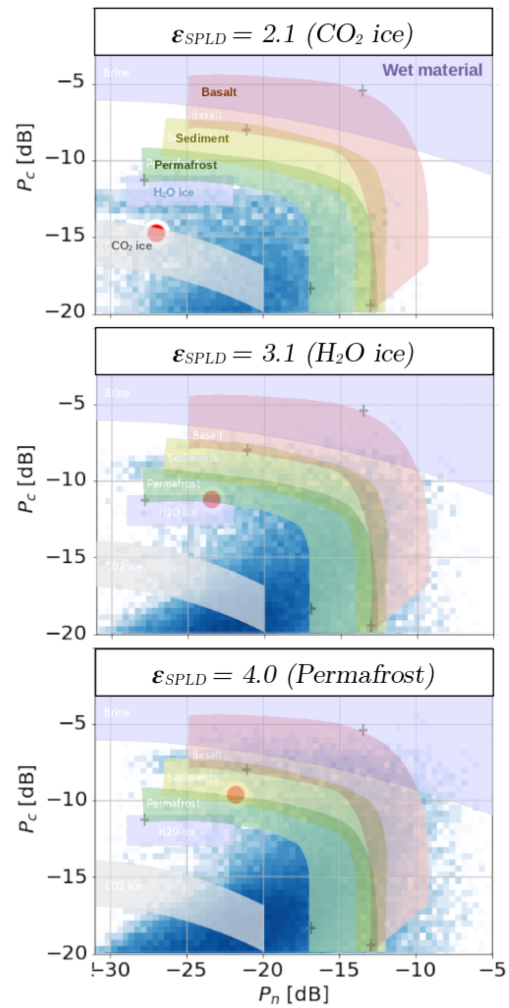

Figure 3: Coherent content distribution for various SPLD permittivities (ε_{SPLD}). It is overlapped with ranges of solutions using the simplified Integral Equation Method for: CO_2 ice (ϵ=1.8-2.2), H_2O ice (2.8-3.1), permafrost (3.1-4.2), sediments (4-7), basalt (6-14), wet material (11-25) and for roughness with RMS height and RMS slope in the range of 0-2 m and 0-1°, respectively, as estimated for Elysium Planitia from [9, 10]. A SPLD near-surface made of CO_2 ice is unlikely since it would not allow any the observed terrains at Elysium to be basaltic.

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