Heterogeneity of SHARAD Reflectivity in the NPLD: Implications for the Climate Record. D. Lalich[1], J. W. Holt[1], and C. Grima[1], [1]University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758 dlalich@utig.ig.utexas.edu

Introduction: The North Polar Layered Deposits (NPLD) are a 2 km thick formation of nearly pure water ice [1] situated in the Planum Boreum region of Mars. Within the NPLD, many sub-parallel internal reflectors are visible in orbital radar sounding data from the Shallow Radar (SHARAD) instrument on the Mars Reconnaissance Orbiter (MRO) [2]. It is theorized that these reflectors contain a global climate record of the late Amazonian period, going back as far as five million years [3]. In general, reflectors are caused by sharp changes in the dielectric properties of a material, but the exact cause of these changes in the NPLD is still under debate. Multiple hypotheses have been proposed to explain these reflectors, with the most common explanations centering on fluctuations in dust content with depth. Linking this fluctuation in dust content to climate parameters would enable the NPLD to be used as a global climate record for the late Amazonian [4].

However, such an exercise depends upon the assumptions that variation of SHARAD reflection power is controlled primarily by dust content and that the influence of local climate conditions is minimal. Under these assumptions, reflection power should be relatively homogeneous across the NPLD for any given reflector. In reality, other factors influence reflection power, such as surface roughness or ionospheric activity, and any global signal carried in reflectors could be obfuscated by local deposition and ablation processes that give rise to heterogeneities in SHARAD reflection coefficients and hence, the measured reflection power.

In an effort to elucidate the contribution of these other processes, we have mapped multiple reflectors across the “saddle region” of the NPLD and will use a combination of these radar observations, surface imagery, and a radar backscattering model to quantify, and ascertain the cause of, variable reflectivity.

Hypotheses: There are a number of processes that could affect SHARAD reflectivity in the NPLD. One possibility is that the composition of the reflecting material changes either spatially or in time. One source of such a change is the seasonal CO_2 cap that forms over the NPLD during the winter, but is absent during the summer [5]. This impacts the surface reflection coefficient, and hence both the surface echo power and the amount of transmitted radar energy. We can test the effect of this change by comparing images and radar data taken during each season.

Another possibility is that certain regions are more or less dust rich than others. Areas with more dust will have higher dielectric constants, and will thus be more reflective. Heterogeneity in dust content could be caused by uneven deposition or ablation, perhaps as a result of prevailing wind or sublimation patterns. Differences large enough to affect radar reflectivity should be visible in imagery.

Surface roughness is another possible source of heterogeneity. It is possible for the same processes that cause variable dust content to also cause variable surface roughness. Changes in roughness at SHARAD wavelengths would not necessarily be visible in imagery, but using the statistical model of [6] we can use the radar data to quantitatively estimate roughness at the relevant scales.

The final source of heterogeneity considered here is the Martian ionosphere. Charged particles in the atmosphere can disrupt the emitted radar pulse on its way to and from the surface [7]. Since the observed

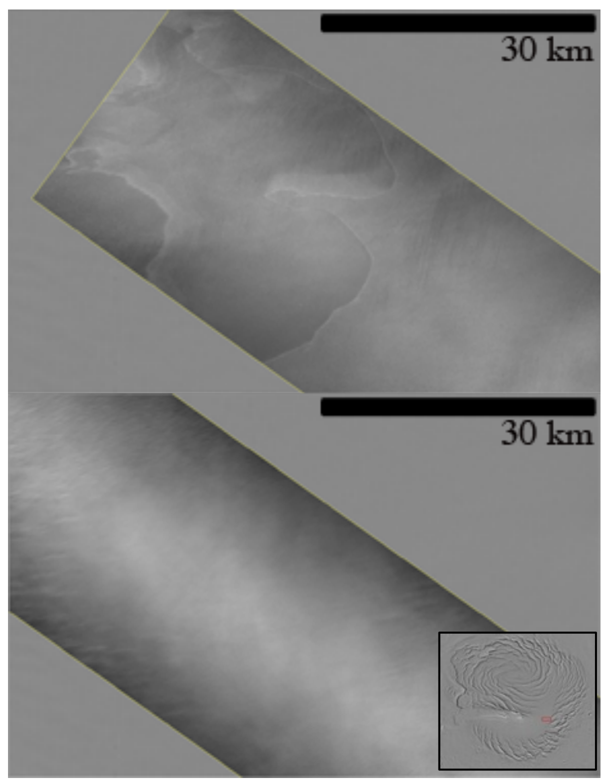

***Figure 1**: (Top) CTX image of NPLD surface taken during northern summer. (Bottom) Same location during early spring. Note the significant albedo differences between seasons and the regional differences in the summer image.*

reflection power is a function of both surface properties and the total power that reaches the surface, ionospheric fluctuations can affect reflection power even if surface properties remain constant. If the ionosphere is the primary driver of reflectivity differences, we should observe the same pattern of heterogeneity propagated from the surface through each subsequent subsurface reflector.

Data: All radar data were acquired using the SHARAD instrument on MRO [7]. SHARAD is an orbital sounding radar using an 85 μs chirped pulse with a 10 MHz bandwidth centered at 20 MHz. It has a theoretical vertical resolution of 8.4 m in water ice, though in practice this is closer to 10.0 m. The along track resolution of 0.3-1 km is achieved with synthetic-aperture data processing techniques [7]. All reflectors were mapped in the commercial seismic software Landmark Decision Space. All imagery is from the Context Camera (CTX), also on MRO.

Preliminary Results: While imagery shows significant differences between summer and winter observations, differenes in the radar data are less clear. Summer coverage of the NPLD is sparse for SHARAD, but the available data indicate little change in reflectivity patterns. This likely means the CO_2 ice cover is simply too thin to make a noticeable difference.

Spatial and temporal variations in surface albedo are visible in imagery which could potentially be linked to differences in radar reflectivity. A detailed comparison may be able to correlate these differences, but data coverage for both imagery and radar will be a limiting factor. SHARAD coverage is sparse in the summer, and due to the residual CO_2 cap, spatial variations in albedo are only visible in summer imagery. This heterogeneity may be a result of variable dust content resulting from local differences in ice and dust deposition and ablation.

Radar data show different patterns in spatial variations of reflectivity between the surface and subsurface layers. This indicates that the ionosphere is likely not the primary control on variation, but it does not preclude the ionosphere from having some effect on reflectivity.

Next Steps: In order to investigate the possibility of changing surface roughness, mapped radar reflectors will be separated into regions based on reflectivity and analyzed using a statistical model [6]. Any differences in surface and subsurface interface roughness could be attributed to local climate processes.

Year-to-year changes in reflectivity will also be investigated. However, due to a lack of repeat SHARAD observations such an analysis may be inconclusive.

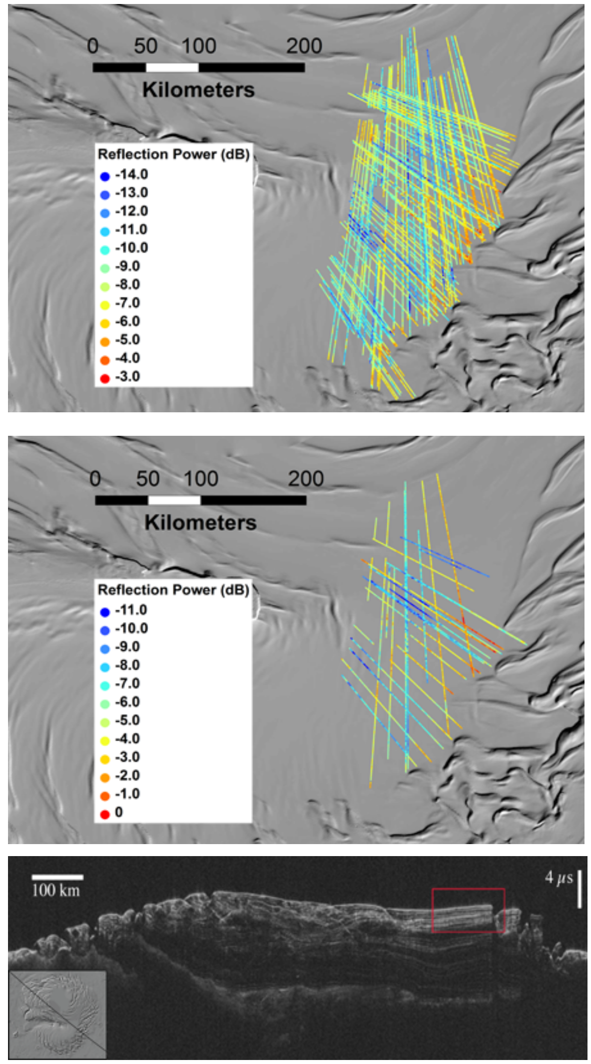

Figure 2*: SHARAD winter (Top) and summer (Middle) surface reflectivity in dB, relative to the maximum. In general, the eastern edge of the saddle region tends to have brighter reflections. (Bottom) SHARAD radar cross-section of the NPLD. Red Box indicates the saddle region.*

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