EVIDENCE OF SEASONAL VARIATION AT THE MARTIAN POLES USING SHARAD DATA. Erica R. Jawin and Bruce A. Campbell, National Air and Space Museum, Center for Earth & Planetary Studies, Smithsonian Institution, Washington, DC USA (jawin@si.edu).

Introduction: The polar layered deposits (PLDs) on Mars contain thick stacks of ice deposits accumulated over the past few million years [e.g., 1]. Seasonal changes at the PLD surface arise through the deposition and removal of seasonal frost during polar night and day, respectively (i.e., polar winter and summer)—at the NPLD, a residual layer of frost persists throughout the year, composed mostly of H₂O ice [2], while at the SPLD a residual cap (SPRC) of mostly CO₂ ice is concentrated in a region ~400 km diameter [3].

To date, no analysis has found robust evidence of seasonal change across the north and south polar regions of Mars using SHARAD [4] data. Much of the uncertainty in such studies comes from the wide range of radar gain with MRO solar panel position. Here we show evidence of surface activity at the martian poles from changes in surface reflectance using the full 16-year database of SHARAD observations and applying a full calibration to the echoes [5]. Through this calibration, radargrams taken at different points during the martian day can be directly compared, thus revealing any seasonal variations across the surface.

Methods: [5] details a SHARAD calibration that includes gain corrections for MRO solar array/high-gain antenna position, ionospheric loss, and altitude. We applied this calibration to all non-rolled SHARAD tracks from 2006 to 2022 and calculated the surface reflectivity at the north and south poles such that surface brightness in day and night tracks could be compared.

From the calibrated SHARAD tracks, we calculated the median surface reflectance in 30 km-radius circular regions which we binned into 0.5-degree maps in our analysis regions. As track coverage increases closer to the polar gaps, in order to ensure adequate track coverage around the entire pole at both day and night, we restricted our analysis to within 5° of both poles and use a minimum of 200 data points per averaging region. We examined the change in surface brightness throughout the martian year, as Ls ranged from 0-360°.

As a calibration site and validation of our technique, we analyzed a nonpolar location that is expected to undergo no day-night surface change. We selected Amazonis Planitia as this calibration site as it is relatively flat, with few large craters, and contained a high density of both day- and night-side SHARAD tracks. We found that the calibrated SHARAD data showed average day-night reflectance variations ~1 dB, and up to 1.5 dB in Amazonis Planitia, which can be credited to subtle differences in the ground coverage between day and night tracks. Therefore, we assume that at polar locations, any day-night variation greater than ~1.5 dB should be due to “real” geologic factors and not SHARAD variability.

Results:

North Pole: We find evidence of radar brightness variability across the NPLD throughout a martian year, in excess of the 1.5 dB threshold identified from our equatorial calibration site. The most distinct seasonal change corresponds to an apparent surface brightening centered ~120°W that has a day-night brightness difference exceeding 2 dB (Fig. 1a-c). This brightening persists from Ls ~80-240°, peaking at Ls 160-180° or north polar late day/late summer, and becomes the brightest location on the NPLD. As the season progresses into north polar night/winter, this bright region darkens and becomes indistinguishable from the surrounding region.

South Pole: Radar brightness variations are also present across the SPLD, with decreased brightness corresponding to the CO₂-bearing SPRC as has been previously identified [5, 6]. Within the SPRC, the surface brightness also changes throughout the season (Fig. 1d-e), with a localized decrease in brightness ~30°W between Ls 60-160° and a minimum at Ls 100-120° or during south polar late day/late summer. This localized minimum disappears during day/summer, with a maximum brightness in the region at Ls 320-340°. The day-night difference exceeds our 1.5 dB threshold across many portions of the SPLD, but there is a broad region of day-night difference >2 dB in the region surrounding 30°W, corresponding to the SPRC.

At both poles, we examined SHARAD coverage maps, temporal coverage, and variations in the gain calibration factors. We found no apparent connections between the day-night brightness variation and any sort of instrument calibration or data coverage bias. We also confirmed that the variations described above repeat over multiple martian years. We therefore conclude that the patterns illustrated in Fig. 1 represent geologic variation at the PLD surfaces on annual timescales.

Interpretations: Both PLDs show locations of day-night surface brightness variations >1.5 dB, which we interpret as evidence of seasonal surface change. Such surface change could be due to the deposition of frost layers (at night/winter), and/or removal of frost by polar day/summer, and the fact that such surface change is visible in SHARAD data implies that surface change must operate over a depth of at least tens of cm on seasonal timescales. The increase in brightness during the north polar day suggests the anomalous area of the
NPLD (exposed during the polar day) is smoother and/or distinct in porosity, composition, or other physical parameters relative to the surrounding NPLD surface, which is then mantled by frost during the polar night. No such distinct properties have yet been mapped in the region around 120°W, for example in geologic mapping of the NPLD by [2], so additional geologic analysis is required and ongoing to explain this observation.

At the SPLD, the largest range in day-night brightness occurs over the SPRC. Several analyses have found evidence of rapid surface change over these CO2-rich deposits, including collapse and scarp retreat during the day/summer. Such topographic variation, combined with seasonal frost deposition and removal, could explain much of the seasonal radar brightness variations we observe.

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Figure 1. SHARAD surface brightness at various points through the season for the (a-c) NPLD and (d-f) SPLD from 85-90° latitude. (a) North polar late day/late summer, Ls = 160-180° shows brightening in a region ~120°W relative to (b) north polar night/winter, Ls = 340-360°. This difference is highlighted in a difference map of surface brightness between Ls = 160-180° and deep night/winter, Ls = 325-25°. (c) South polar day/summer, Ls = 320-340°, compared to (d) South polar night/winter, Ls = 100-120°, shows an area of decreased brightness over the SPRC at night. (e) This difference exceeds 2 dB around 30°W. These variations appear to be due to seasonal variations such as frost deposition and removal at both poles.