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Assessing Zones of Low Radar Reflectivity Across the South Polar Cap of Mars

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The Mars Reconnaissance Orbiter Shallow Radar (SHARAD) revealed near-surface zones of low radar reflectivity (reflection-free zones, RFZs) in many areas of Planum Australe (Phillips et al., 2011, Science 332). The most poleward, RFZ_3, corresponds geographically to a geologic unit AA_3 (Tanaka et al., 2007, 7th Int'l Mars Conf. abs. 3276) that exhibits sublimation features. Geometric considerations demonstrated that RFZ_3 consists of three distinct layers of CO_2 ice, preserved from earlier periods of atmospheric collapse (Bierson et al., 2016, GRL 43). However, the nature of other RFZs at lower latitudes remains undetermined, with none of the SHARAD observations examined to date providing definitive geometric constraints on their composition. While CO_2-ice composition has not been ruled out, these RFZs differ in important ways from RFZ_3. Surface imagery in the vicinity of the outlying RFZs does not generally exhibit sublimation features similar to those seen in AA_3, SHARAD reflectivity exhibits a lower contrast with surrounding materials relative to RFZ_3, and there are no indications of distinct layering within the outlying RFZs as there are in RFZ_3. In addition, climate modeling of atmospheric collapse episodes (Wood et al., 2016, LPSC abs. 3074) suggests that CO_2 accumulation is highly concentrated at the highest latitudes. An alternative explanation for the outlying RFZs is that they consist of nearly pure water ice deposited during times when atmospheric dust was nearly absent. Such conditions may occur coeval with eras of CO_2 accumulation at the higher latitudes. To test these possibilities, we are working to constrain the composition of the outlying RFZs, using the recently produced 3-D SHARAD data volume that encompasses the entire Martian south polar ice cap (Foss et al., 2017, The Leading Edge, 36). Work is ongoing, but we expect that the geometric corrections and improvements to the overall signal-to-noise ratio provided by the 3-D radar imaging processing may now allow us to distinguish between CO_2 and H_2O composition, perhaps by enhancing faint layering that extends below the outlying RFZs. First looks at data in Promethei Lingula show promise for applying this method to the RFZ found there, but a loss of vertical resolution in the 3D volume relative to the 2D single-orbit observations complicates the analysis.

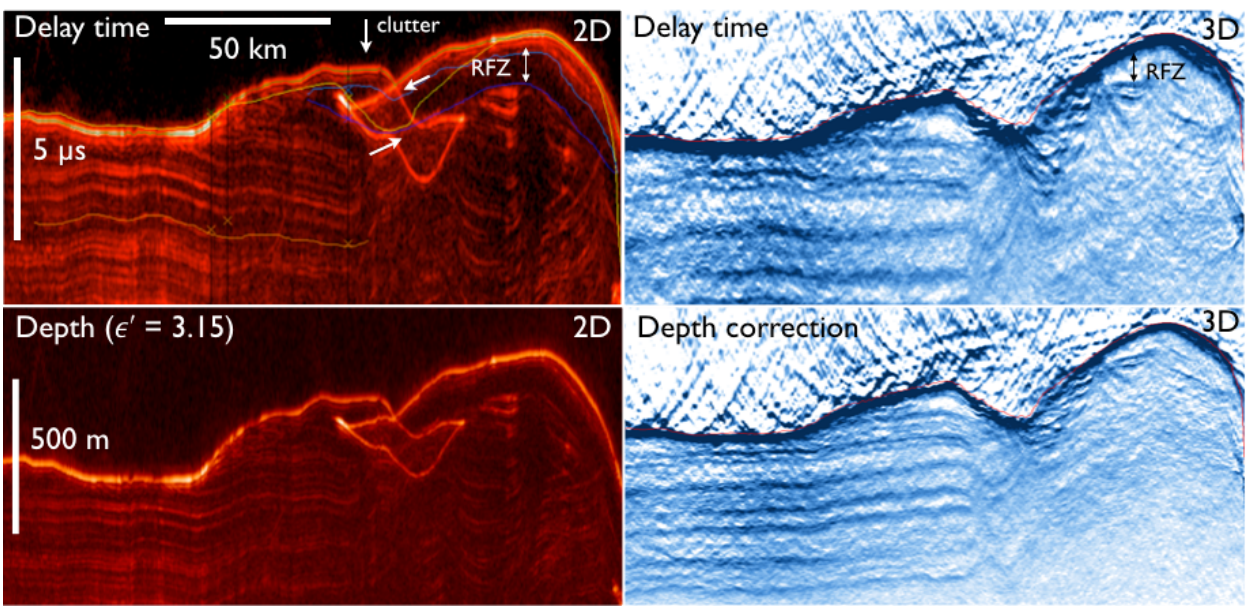

Figure shows radargrams for SHARAD observation 27683-01 (left) crossing the RFZ in Promethei Lingula in delay time (top) and corrected to depth (bottom) assuming pure water ice ($\epsilon' = 3.15$) in the subsurface along with corresponding profiles from the Planum Australe 3-D volume (right). Radargrams show return power (high: red/yellow and blue; low: black and white) that is lowest in the RFZ on the right side of each radargram. Yellow line in upper left panel and red line in right panels represents the MOLA-determined nadir surface.