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Correlation of Martian South Polar CO_2 Seasonal Cap Retreat With Low Altitude Clouds: A Control On Annual Accumulation

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Both the north and south polar layered deposits (NPLD and SPLD) comprise the majority of surface ice on Mars and offer a historical record for understanding recent climate. Of importance, the deposits undergo seasonal variability, between winter (when CO_2 ice frost covers the polar regions) and summer (when the CO_2 ice has sublimed). Recent evidence has shown that winds and atmospheric deposition played major roles for forming the spiral troughs that cover the NPLD. Observations of low altitude clouds (or visible expressions of katabatic jumps), radar stratigraphy, and surface morphology, in combination with high resolution mesoscale simulations from the Laboratoire de Météorologie Dynamique, demonstrate that ice is transported across the NPLD by wind to form and modify the troughs [Smith et al., 2013].

We employ the same techniques on the SPLD to find that the processes affecting southern spiral troughs are very similar, although there is an additional seasonal component not detected on the NPLD. Clouds, as mechanisms of deposition, retreat pole-ward during southern spring and summer. The retreat is matched spatially to modeled high speed winds near the CO_2 seasonal ice cap boundary. Our mesoscale simulations reveal that topographic heights of the SPLD primarily drive slope-wind (katabatic) circulations. This existing circulation is reinforced by an additional thermally-direct circulation driven by the retreating CO_2 ice in proximity to nearby exposed low albedo deposits, explaining why enhanced winds (and trough clouds) are mostly found in the vicinity of the CO_2 seasonal ice boundary. In one simulation, at Ls 290°, the ice line is located so that the slope winds produced by the SPLD topography are optimally enhanced (up to 20 ms-1) by thermally directed circulations caused by a nearly 100 K thermal contrast.

This work, in combination with detailed stratigraphic analysis from ground penetrating radar indicates that sites of deposition and retention of ice on the pole coincide with where clouds form. Thus clouds influenced by the retreating CO_2 seasonal cap tell us where annual and long-term accumulation occurs. Regions with many clouds have thicker recent deposits, while those with no clouds have little or no recent accumulation. It is possible, and eventually testable with adequate modeling, that trough morphology is dependent on a seasonal CO_2 ice cap and that the troughs themselves may require a seasonal cap to initiate.