CREATING MULTISPECTAL MOSAICS OF MARS' SOUTH POLAR RESIDUAL CAP FROM CRISM MAPPING DATA. S. F. A. Cartwright[1], F. P. Seelos[2], R. T. Poffenbarger[2], and W. M. Calvin[1], [1]Department of Geological Sciences & Engineering, University of Nevada—Reno, (scartwright@nevada.unr.edu), [2]Johns Hopkins University Applied Physics Laboratory.

Introduction: The south polar residual cap (SPRC) is a 1–10 m-thick deposit of CO_2 ice overlying a ~4 km-high dome of dusty water ice layers known as the south polar layered deposits (SPLD) [1]. In the upper surface of the SPRC, active erosional processes have riddled the ice with pits and troughs that form a variety of distinctive morphologies seen to evolve on observational timescales of just a few Mars Years [2]. Additionally, water-ice-rich deposits have been observed in small windows through the SPRC, along its margins, and in an extensive outlying deposit [2, 3] (Fig. 1A); these exposures are distinct from the underlying SPLD, but their exact nature and connection to the creation of SPLD climate records remain unclear [4, 5].

Investigating compositional variation among exposures of these different ice deposits is an area of active research and will be a critical step in understanding their formation, the mechanisms that drive their evolution, and their utility in studying climate history. To further this effort, we are using data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [6] to constrain the grain sizes and mixing ratios of dust with H_2O and CO_2 ices across a variety of south polar ice terrains. Previous work [7] identified eight spectral endmembers that may represent distinct mixtures in the interior of the SPRC and along its margins. This work used hyperspectral short-wave infrared (SWIR) observations (438 bands, 18–36 m/pix) of 6 localized sites. To evaluate these endmembers in a broader spectral context and to map their presence more widely, we are now using CRISM mapping observations (72–261 bands, 90–180 m/pix) to produce hyperspectral mosaics of the SPRC and surrounding ice exposures.

Processing Pipeline: The CRISM investigation is currently building a pipeline to generate spectrally optimized SWIR mosaics in 5 × 5º map tiles that cover low- and mid-latitude regions of the planet [8]. Relying on both heritage and novel processing routines, this pipeline 1) applies a series of strip-independent corrections to address observational conditions that obscure surface spectral features (e.g., atmospheric gas absorption, noise from high detector temperatures) and 2) uses a network of radiometrically calibrated observations as tie points to reconcile remaining inter-strip variance and generate a spectrally consistent mosaic tile.

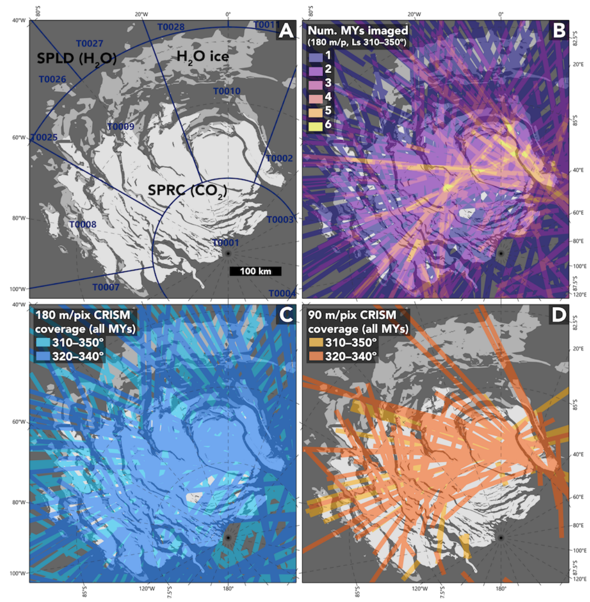

Figure 1. A) CRISM map tile mosaic scheme (blue) over a simplified map of major south polar ice deposits derived from [2, 3]. **B)** Counts of available inter-annual comparisons provided by 180 m/pix CRISM mapping data (HSP, MSP) for L_S = 310–350º. **C)** Coverage provided by liberal and conservative L_S constraints on 180 m/pix data across all MYs. **D)** Coverage provided by liberal and conservative L_S constraints on 90 m/pix (MSW) data, which were only acquired during MY 28.

The strip-independent corrections in this pipeline are still applicable to observations at higher latitudes, but due to the lack of radiometrically controlled reference strips near the poles, the spectral optimization is not. We are exploring alternative approaches to this balancing framework while testing preliminary mosaics of independently processed strips. Additionally, the map tile pipeline exclusively uses CRISM's Multispectral Survey (MSP) and Hyperspectral Mapping (HSP) observing modes, which both offer 180 m/pix spatial resolution. To achieve resolutions exceeding 90 m/pix, we are also generating separate mosaics from Multispectral Window (MSW) data. Both types of mosaics provide 72 SWIR channels sufficient for distinguishing the types of features identified by [7].

Data Coverage: Due to intra-annual variation in seasonal CO_2 ice cover that obscures perennial polar ice deposits, it is important to filter constituent observations of polar mosaics by Mars season, which is denoted by areocentric solar longitude (L_S). In the south, the retreat of seasonal ice starts around L_S = 310º, is entirely removed by L_S = 330º, and begins to advance again around L_S = 350º [9, 10]. Additionally, inter-annual variation can be observed in residual ice exposures due to the progression of erosional processes that sculpt ice morphology; polar mosaics for individual Mars Years (MYs) [11] can therefore be compared to track this surface evolution [e.g., 12].

We conducted a series of overlay analyses to assess the completeness of SPRC coverage corresponding to a variety of MY/L_S constraints applied to CRISM mapping data. We found that there were an insufficient number of observations taken in individual MYs to provide adequate coverage for inter-annual comparisons over more than two summers (Fig 1B). However, compiling observations within a single L_S range across all MYs yields extensive coverage of the SPRC and surrounding water ice (Fig. 1C–D), even by MSWs, which were only acquired in summer of MY 28. We expect that because inter-annual changes in SPRC ice are generally observed at scales much smaller than 180 m/pix, they will not significantly affect the consistency of mosaics that aggregate MSP/HSP observations across MYs.

Preliminary MSW Mosaic: All observations (globally) of the HSP, MSP, and MSW class types have now been passed through the strip-independent processing pipeline that applies spectral outlier filtering and a series of corrections: ratio-shift, Lambertian photometric, "volcano scan" atmospheric, and spectral smile [8]. To generate a preliminary MSW mosaic (Fig. 2), all processed strips within the desired L_S range (310–350º) were map projected and stacked with decreasing dust optical depth [13]. Finally, summary parameters of ice-related spectral features were calculated according to [14]. In this mosaic, dark windows can be seen across the SPRC and its margins show consistent outlines, suggesting seasonal ice is not widespread in constituent strips. Future work will investigate whether the L_S constraint can be expanded and in addition to generating 180 m/pix mosaics to expand SPRC coverage.

References: [1] Byrne (2009) *Annu. Rev. Earth Planet. Sci. 37,* 535–560. [2] Thomas et al. (2016) *Icarus 268,* 118–130. [3] Piqueux et al. (2008) *JGR 113*(E8). [4] Douté et al. (2007) *Plan. & Space Sci. 55,* 113–133. [5] Montmessin et al. (2007) *JGR 112,* E08S17. [6] Murchie et al. (2007) *JGR 112,* E05S03. [7] Cartwright et al. (2021) LPSC 52, 2169. [8] Seelos et al. (2019) LPSC 50, 2635. [9] Calvin et al. (2017) *Icarus 292*, 144–153. [10] Piqueux et al. (2015) *Icarus 251*, 164–180. [11] Piqueux et al. (2015) *Icarus 251*, 332–338. [12] Thomas et al. (2020) *Icarus 341*, 113625. [13] Montabone et al. (2015) *Icarus 251*, 65–95. [14] Viviano-Beck et al. (2014) *JGR 119*, 1403–1431.

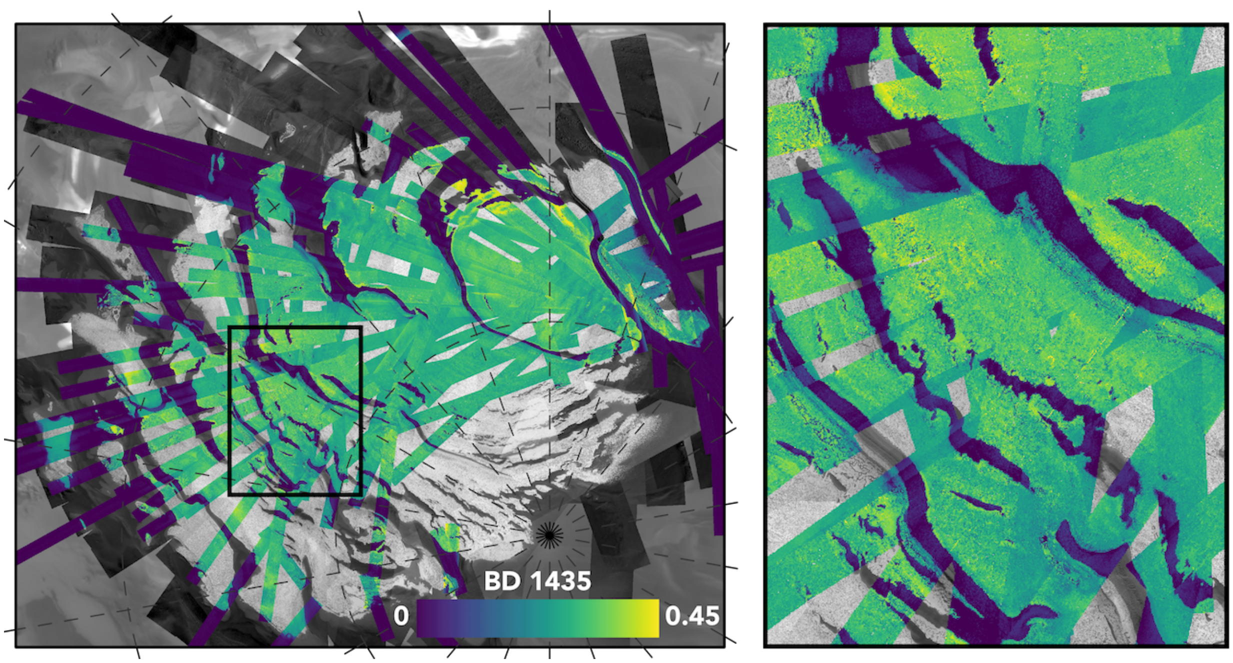

Figure 2. Preliminary 90 m/pix mosaic of CRISM MSW data with detail at right. The BD1435 product parameterizes the 1.435 µm absorption associated with CO_2 ice. Basemap: CTX mosaic by [2]. See Fig. 1 for scale & grid values.