END-TO-END PROCESSING OF CRISM ALONG-TRACK OVERSAMPLED OBSERVATIONS WITH ATMOSPHERE AND TEMPERATURE CORRECTIONS.

D. V. Politte[1], R. E. Arvidson[1], J. A. O'Sullivan[2], L. He[2], K. E. Powell[1], E. A. Guinness[1], [1]Department of Earth and Planetary Sciences, Washington University in Saint Louis, Saint Louis, Missouri, 63130, [2]Department of Electrical and Systems Engineering, Washington University in Saint Louis, Saint Louis, Missouri, 63130.

Introduction: We have developed an end-to-end approach for processing hyperspectral image data acquired with the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) hyperspectral instrument on the Mars Reconnaissance Orbiter (MRO) [1]. This approach corrects for both atmospheric effects and temperature, which allow the derivation of surface hyperspectral single scattering albedo (SSA) values at a wider range of wavelengths than previously possible, from 0.45 µm to ~3.8 µm, including the high wavelength region in which radiance contains a strong thermal contribution. The method also produces a surface kinetic temperature map for each scene, with validation by comparisons to THEMIS thermal IR observations [2] and the Curiosity rover's REMS-based surface temperatures [3].

This processing regime may be applied to scenes of any CRISM observing mode. In particular, though, processing can be greatly improved for scenes of the along-track oversampled (ATO) observing mode via these methods, allowing projections at 12 m/pixel from the baseline 18 m/pixel ground resolution [3].

Processing Methodology: The processing can be roughly broken down into two phases, the derivation of SSA hyperspectral cubes and temperature maps, and further refinement to retrieve the best estimates of SSA values in the presence of Poisson noise.

SSA Derivation First, the radiative transfer program DISORT is used to model the effects that surface and atmospheric temperatures, atmospheric pressure, and lighting and viewing geometry have on detected radiance values. (This step's simulation of aerosols and other gases implements atmospheric correction.) A lookup table is constructed which serves as a mapping from SSA and geometric values to IOF radiance values for wavelengths less than ~2.6 µm, where thermal effects are non-existent at Martian temperatures.

The next step is the derivation of temperature values for each pixel of the CRISM scene [4]. This is done via a neural network (NN) which is trained using the DISORT look-up table on knowledge of the correspondence between simulated radiances constructed from laboratory spectra, random surface temperatures, and the DISORT-based look-up table. This step is necessary to account for thermal effects in the portion of CRISM with wavelength greater than ~2.6 µm. Once trained for a given scene the NN is used with actual CRISM IOF and geometry data to retrieve a full wavelength SSA cube and a surface temperature map. Currently within DISORT computations we use the Hapke Function with modest backscattering parameters to model surface bidirectional reflection for sunlight and directional-hemispherical emission [5].

SSA Refinement The SSA values are next passed through a median filter based on the design of Eliason and McEwen [6] to remove spikes caused by, e.g., degradation of cooler function in the instrument, rather than physical phenomena on the surface.

As a final step, a maximum likelihood algorithm is applied to the filtered SSA values [3]. This algorithm both generates map-projected estimates of SSA spectra and accounts for Poisson-based noise, and the blurring effect of the instrument's spatial and spectral transfer functions. With the completion of this step, we have finished deriving sensor-space SSA hyperspectral cubes, map-projected cubes for CRISM ATO data at resolutions as high as 12 m/pixel, and surface temperature maps in sensor space and map-projected forms. Map projected product examples are shown in Figs. 1-4.

Archiving: As a service to the community, over the next year we will process and archive approximately 100 selected CRISM ATOs using this methodology, including both sensor space and map-projected data. These products will be archived using PDS4 standards [7]. This effort will serve as a pioneer PDS4 data product for CRISM with the potential to serve as a model for the later conversion of existing CRISM PDS3 archives to PDS4.

Software Availability: To facilitate the community's use of the archived results of this processing, we will additionally be providing software to facilitate data analysis. This will take the form of an update for our ENVI5.4 versions of the CRISM Analysis Tool (CAT) to be compatible with both PDS3 and PDS4 CRISM products [8].

References: [1] Murchie S. L. et al. (2007) *JGR, 112.E05S03*. [2] Christensen P. R. et al. (2004) *Space Science Reviews, 110.1-2,* 85-130. [3] Kreisch C. D. et al. (2017*) Icarus, 282,* 136-151. [4] Powell K. E. et al. (2018) these abstracts. [5] Hapke B. (2012) *Theory of Reflectance and Emittance Spectroscopy*, Cambridge University Press, New York. [6] Eliason E. M. and McEwen A. S. (1990) *Photogramm. Eng. & Remote Sens., 56.4,* 453-458. [7]. Slavney S. (2018) these abstracts. [8] MRO: CRISM (Section "Tools"), pds-geosciences.wustl.edu/missions/mro/crism.htm.

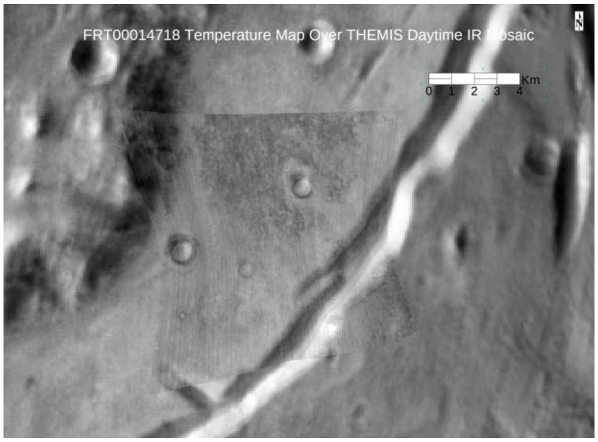

Figure 1. Temperature map for CRISM observation FRT00014718 (over Margaritifer Chaos) overlaid onto a THEMIS thermal IR brightness map.

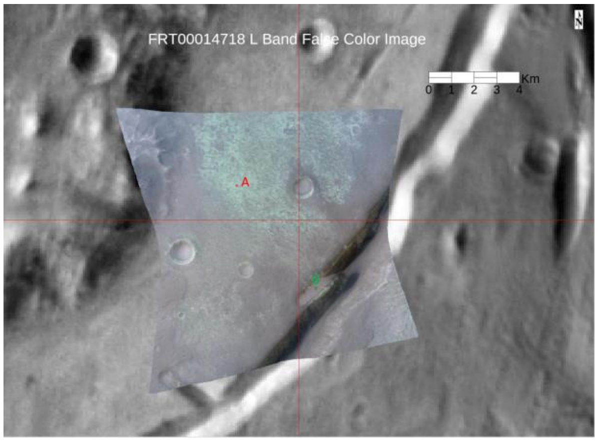

Figure 2. False color image for the CRISM scene. Spectra for locations A and B are shown in Fig. 3.

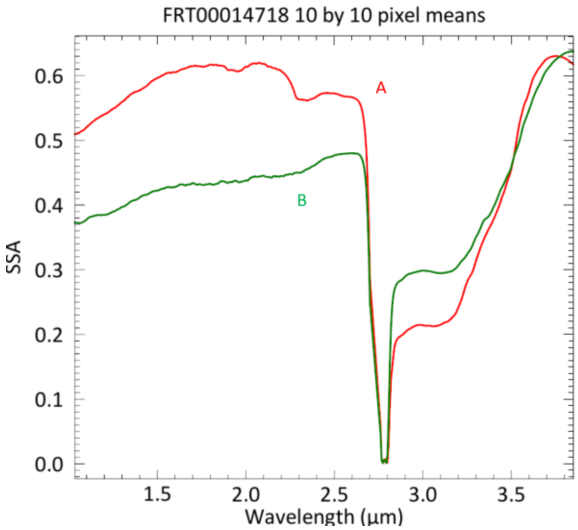

Figure 3. Spectra retrieved for locations A and B with thermal effects removed. Values close to zero correspond to wavelengths for which data are not transmitted. Note absorption features for location A, which are consistent with the presence of hydrated smectites.

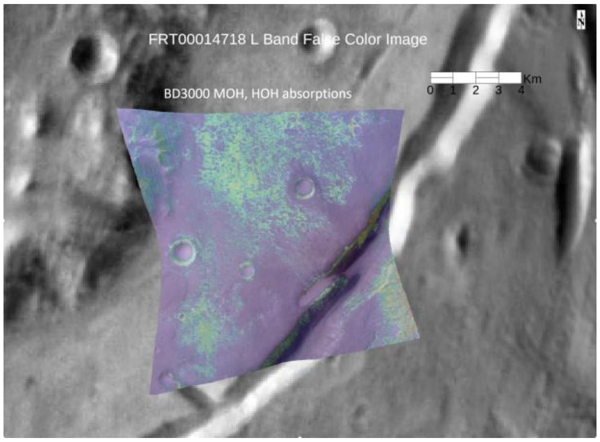

Figure 4. Map of the 3 μm water and OH related absorption, which cannot be accurately produced without removing thermal effects. Note high values (i.e., cyan colors) in smectite-bearing localities.