A NEW SCENE DEPENDENT ATMOESPHERIC TRANSMISSION FOR ENHANCEMENT OF CRISM VOLCANO SCAN CORRECTION. Y. Itoh[1], M. Parente[1], [1]Department of Electrical and Computer Engineering, University of Massachusetts Amherst MA 01003; yitoh@engin.umass.edu;

Introduction: The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [1] on board of Mars Reconnaissance Orbiter has made significant contributions on revealing many detailed aspects of surface mineralogy of Mars, owing to significant efforts made on calibration and atmospheric correction to retrieve accurate surface reflectance. The atmospheric correction algorithm used in the current pipeline, so called "volcano scan" [2, 3, 4], assumes a Beer-Lambert model and divide each I/F spectrum of Targeted Reduced Data Record version 3 (TRR3) by a scaled transmission spectrum derived from the ratio of a spectrum at the summit of Olympus Mons with one at its base. The current version of the algorithm selects the optimal atmospheric transmission data in the Ancillary Data Record (ADR) to take the spatial and temporal variations in the filter positions and the other atmospheric conditions into account [5, 6, 7]. However, some residuals still persist; they are small in magnitude but large enough to corrupt spectral absorption features [8], indicating such variations are not fully modeled. Our atmospheric compensation algorithm learns the spatial and temporal variations of the atmosphere from the image itself and significantly improves the quality of retrieved surface reflectance. Our current approach can accommodate more scenarios than the method in our early work [9] can.

Derivation of atmosphere transmission from the image: The contribution of atmosphere is mixed with that of surface in TRR3 I/F spectra. The isolation of atmospheric transmission is challenging since surface reflectance is unknown a priori and needs to be estimated. Our method assumes that the light propagation through the atmosphere is modeled by the Beer-Lambert model and that the surface reflectance is approximately modeled by the corrupted linear spectral mixing model [10] in the logarithmic domain. The estimation of atmospheric transmission is performed by a model inversion formulated as a minimization problem, in which a modified version of sparse unmixing with adaptive background [10] is simultaneously conducted to estimate the surface reflectance and model parameters. The inversion is performed in the logarithmic domain since the contribution of atmosphere under the Beer-Lambert model is linearly separable and easier to handle. The candidate phases (endmembers) that may compose surface are selected from CRISM spectral library, RELAB spectral database [11], U.S. Geological Survey (USGS) spectral library (splib06) [12], and CRISM Type Spectra Library [13], which in total 686 spectra are used for constructing a library matrix. With such a big library, it would be reasonable to assume that all the possible phases are included. The transmission spectra in the ADR are also used for the initialization of the transmission spectrum to stabilize the optimization algorithm. Note that a scaling parameter for the transmission spectrum is also obtained for each pixel as a byproduct, which is then used for removing the effect of transmission on the TRR3 I/F spectrum by applying the Beer-Lambert law.

The computation is performed column-by-column due to wavelength shift caused by smile effect. The uniformity of the atmospheric transmission over each column is required. Unlike our early work [9], our method could work even when there is no unremarkable spectrum in the column and the condition of 1.9μm water bands is not required, but the surface needs to be sufficiently well modeled via the mixing model and all the phases at each pixel needs to be included in the library.

Comparison of corrected spectra: We applied our algorithms to 27 scenes where spectra in the CRISM Type Spectra Library are located. The wavelength over 1.0-2.6μm is considered. The computational time for processing each image was about one hour in our environment. Fig. 1 shows some comparisons of I/F spectra corrected by our algorithm (red) and ones corrected by volcano scan method using the CRISM Analysis Toolkit (CAT) software (version 7.3.1) (blue). The empirical selection of the transmission spectra is used for CAT and photometric correction is not applied. Spectra at the top and middle are examples of spectra with some significant absorptions and ones at the bottom are relatively featureless ones in each image. Our method significantly removes the small fluctuations over the 1.2-1.8μm and residuals of the triplet features of carbon dioxide around 2.0μm wavelength region. It also removes artifacts around 1.1 and 1.2μm wavelength regions. The absorption feature at 2.4μm is removed or attenuated in Fig. 1(a) and (b) since it is present everywhere in the images (even in the unremarkable spectra at the bottom) and thought of as the contribution of water ice aerosol [14], while small absorption features could be weakened (2.23μm of top and middle spectra in Fig. 1(b)).

Fig. 2 shows the comparison of our results with numerator spectra in Targeted Empirical Data Record (TER) I/F data stored in the CRISM Type spectra library. It can be seen that our method is improving the quality of the signal even with TER I/F spectra, especially over 1.2-1.8μm and 2.0μm wavelength regions, while retaining the shape and position of spec-

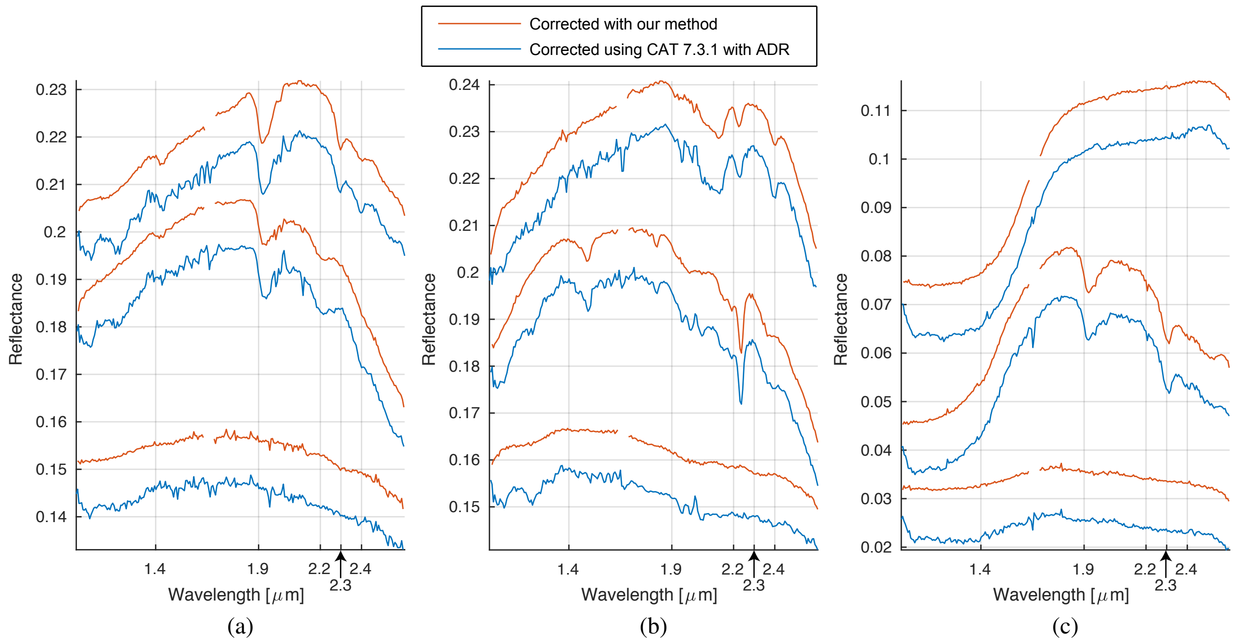

Figure 1: Comparison of corrected I/F spectra by our method (red) and by volcano scan in CAT software (blue); (a) the pixel coordinates (sample,line) of spectra are (95,96) (top), (174,426) (middle), and (395,382) (bottom) in FRT0000A425, (b) (382,125) (top), (105,136) (middle), and (116,374) (bottom) in FRT000098B2, and (c) (187,98) (top), (262,312) (middle), and (367,114) (bottom) in FRT00003E12. Spectra are shifted for clarity. The blank around 1.6μm indicates those channels are removed before processing because it is known to be a detector boundary.

tral absorption features. These results indicates that our method can be applied to a variety of scenes.

Future work: We are working on improving the response of the algorithm when I/F atmospheric contributions to the spectra include significant amounts of water vapor, water ice, or carbon dioxide ice, where small artifact can be produced.

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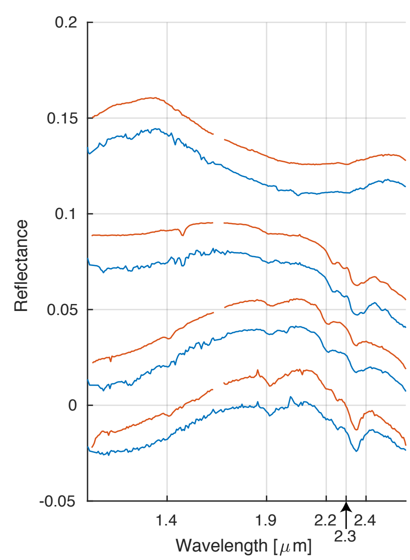

Figure 2: Comparison of corrected I/F spectra by our method (red) with the numerator ones in CRISM Type Spectra Library (blue). From top to bottom, minerals compared are low-calcium pyroxene, prehnite, illite/muscovite, and epidote. Spectra are shifted for clarity. These spectra are averaged over pixels in the square window. Refer to [13] for their exact sizes.