DYNAMIC APERTURE TARGET TRANSFORMATION (DATT): A NOVEL AND VALUABLE METHOD FOR MINERAL DETECTION ON MARS. Honglei Lin[1], J. D. Tarnas[2], J. F. Mustard[2], Xia Zhang[1] and Xing Wu[1]. [1]Institute of Remote Sensing and Digital Earth, CAS, Beijing, 100101 (linhoml@163.com), [2]Dept. of Earth, Environmental, and Planetary Sciences, Brown University, RI, 02912.

Introduction: Recently, the Factor Analysis and Target Transformation method (FATT), which was used in TES data analysis [1] was applied to CRISM data [2]. FATT determines independent components (first 10 eigenvectors of covariance matrix) from a mixed system to model spectra in the target library. This method has the potential to test for specific minerals on Mars that exist in low abundance or complex convolutions. However, the method as applied has several key limitations: 1) Determining how to determine the eigenvectors objectively for target transformation. 2) Determining how to assess the model fits between library spectra and modeled spectra. 3) The only information returned is whether or not the analyzed CRISM scene has the specific mineral that is searched for. No information regarding the location of the mineral is generated, making it difficult to validate the results. By solving these problems, we proposed a new method termed Dynamic Aperture Target Transformation (DATT) to detect the minerals on Mars where the distribution of minerals detected with FATT can be obtained.

Method: The DATT method includes three components, which correspond to the three key issues of FATT: 1) Using the Hyperspectral signal identification by minimum error (Hysime) algorithm [3] to determine important eigenvectors objectively. 2) We normalize library and modeled spectra to allow for RMSE comparison between minerals with different reflectance scales, allowing for robust assessment of fit quality. 3) We use a dynamic aperture, as shown in Figure 1, to detect minerals from hyperspectral data on Mars. The pixels in which detections from all the differently shaped apertures intersect are considered as true detections. Rather than analyzing an entire CRISM scene for a specific mineral, we analyze specific sets of pixels within our moving and dynamically shaped aperture.

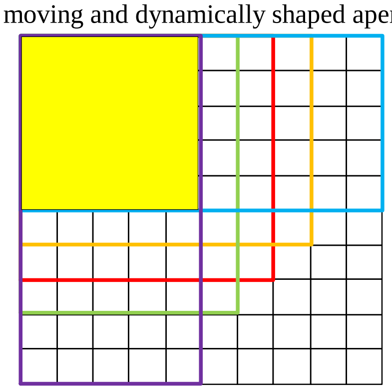

Figure 1 | The illustration of DATT. FATT is applied to all pixel subsets (blue, orange, red, green and purple) and if all the apertures return detections, the pixels in the yellow part are considered as true detections.

Data: 56 spectra of different samples (25 samples contain different fractions of magnesite and 3 samples are serpentine) collected from the RELAB spectral database were used to create a matrix to test this target transformation method. Previously analyzed CRISM images with well accepted, published mineral detections were used to validate the DATT method, including serpentine observations in FRT0000ABCB and HRL0000B8C2 [4], kaolinite/halloysite in FRT0000C9DB of Kashira crater and FRT0000ABCB [5]. DATT was also applied to scenes in the Nili Fossae region (FRT00003E12, FRT0000B438, FRT0000A4FC and FRT0000871C) to detect serpentine and magnesite. Serpentine has not been previously reported for FRT00003E12, FRT0000B438, FRT0000A4FC and FRT0000871C. All the CRISM data used in this study were photometric and atmospheric corrected with CRISM Analysis Tools [6].

Results: 1) ***Laboratory analysis***. The target library includes four spectra: serpentine and magnesite spectra, which are different from the samples used to create eigenvectors; talc and brucite, which are not used to create eigenvectors.

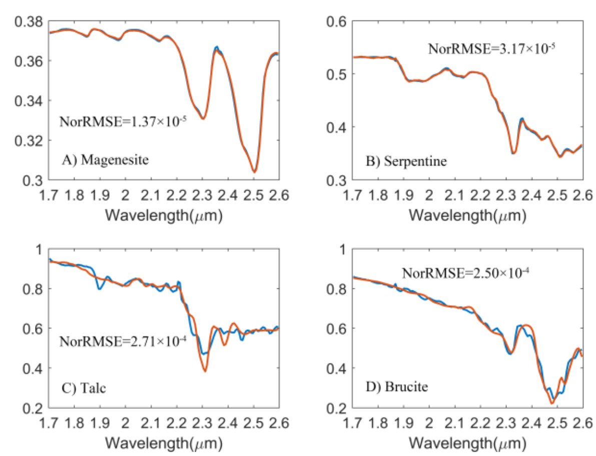

Figure 2 | The model fits. Red is the library spectrum (target) and blue is the model fit from target transformation. The magnesite and serpentine fits are detections while talc and brucite are not.

As shown in Figure 2, the magnesite and serpentine spectra are very well fit while talc and brucite cannot be fit. This is expected because there is no talc and brucite in the simulated matrix. The laboratory analysis demonstrates the target transformation method's capability to detect the specific minerals present in the data.

2) ***CRISM data analysis.*** We empirically define a normalized RMSE threshold for CRISM data to be 1.50×10^{-4}. We present DATT analysis of CRISM scenes with previous detections of Fe/Mg phyllosilicates (serpentine), Al-phyllosilicates (kaolinite/halloysite) and carbonates (magnesite). Figure 3 shows serpentine detections in FRT0000ABCB and HRL0000B8C2. The detections are consistent with previous manual identifications (Figure 3C). Goudge et al. [5] determined the kaolinite/halloysite abundance distribution in Kashira crater with CRISM, and validated with TES data. Our detections are consistent with their abundance distribution (Figure 4A). The Nili Fossae region is thought to contain saponite/talc and magnesite. Our recent work using sparse unmixing analysis supports the existence of serpentine [7], as does the DATT analysis. Serpentine detections using DATT in this region are shown in Figure 5.

Conclusion and discussion: The proposed method has the potential to detect mineral distributions on Mars. Even though DATT obtains accurate results, there are some issues that need to be addressed, including characterization of the accepted normalized RMSE for detection of different minerals and reduction of output false detections through integration of DATT and sparse unmixing. These improvements will further increase the robustness of DATT analysis.

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References: [1] Bandfield, J.L. et al. (2000) *JGR-Planet*, 105, 9573–9587. [2] Thomas, N.H. et al. (2017) *Icarus*, 291, 124–135. [3] Bioucas-Dias, J.M. et al. (2008) *TGRS*, 46, 2435–2445. [4] Ehlmann, B.L. et al. (2009) *JGR-Planet*, 114, 538–549. [5] Goudge T.A. et al. (2015) *Icarus*, 250, 165–187. [6] Mustard, J.F. et al. (2005) *Science*, 307, 1594–1597. [7] Lin, HL. et al. (2018), *submitted to Planetary and space sciences*.

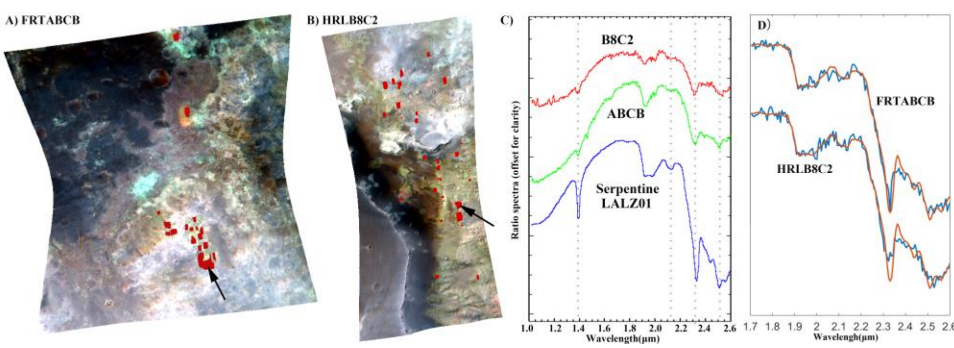

Figure 3 | DATT testing. serpentine detections of A) FRTABCB and B) HRLB8C2. C) The ratio spectra collected from FRTABCB and HRLB8C2 [4]. D) The detections fit where blue is CRISM target transform data and red is laboratory target spectra.

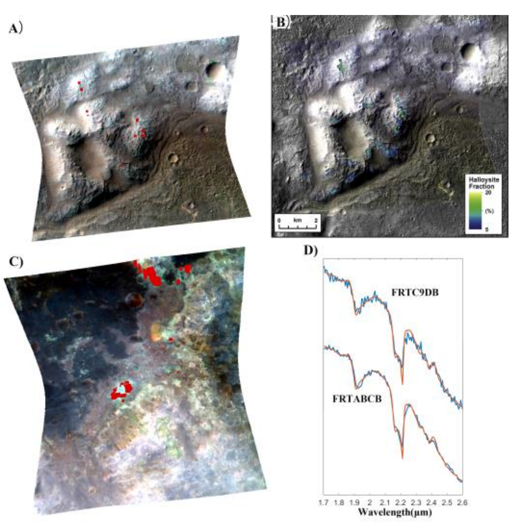

Figure 4| DATT Testing. A) Kaolinite detection in FRTC9DB. B) Kaolinite/halloysite abundance [5]. C) Kaolinite detection in FRTABCB. D) Model fits of kaolinite.

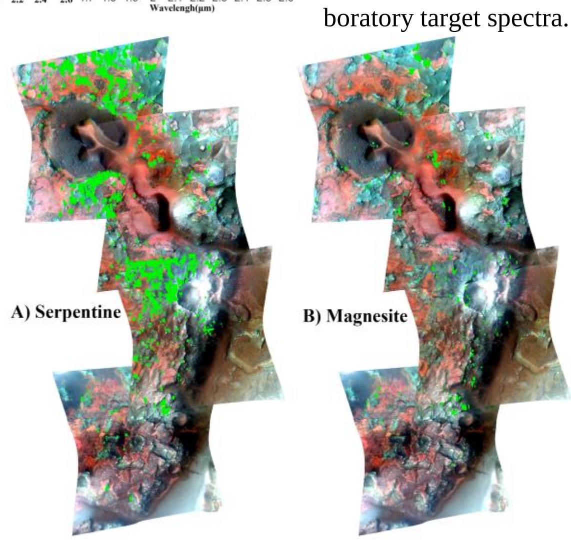

Figure 5| DATT detections (green) in Nili Fossae regions. A) Serpentine. B) Magnesite.