ASSESSING POSSIBLE ARTIFACTS OF M^3 GLOBAL MODE REFLECTANCE DATA. S. Li[1], P. G. Lucey[1], C. Pieters[2], and L. Gaddis[3], [1]University of Hawaii at Manoa, Honolulu, HI 96822, [2]Brown University, Providence, RI, 02912, [3]Astrogeology Science Center, USGS, shuaili@hawaii.edu

Introduction: The Moon Mineralogy Mapper (M^3) global mode reflectance data are currently the only available hyperspectral imagery of the global Moon in the visible to short-wavelength infrared region (~0.4 – 3 µm) that also have high spatial resolution (~280 m/pixel at 200 km orbit; ~140 m/pixel at 100 km orbit). The reflectance spectra from ~0.4 to 2.5 µm have been widely used to derive the mineralogical and chemical information of the lunar surface [1, 2], whereas the absorptions near 3 µm have been applied to assess the hydration level of the lunar surface [3, 4]. However, possible artifacts are observed near 0.7 µm and 2.82 µm of the M^3 global mode reflectance data, which significantly limit the science return of this dataset.

In this study, we will compare the M^3 global mode data with the M^3 target mode and SELENE Spectral Profiler (SP) data to assess the possible artifacts of the former. The M^3 target mode data have 256 spectral bands and a 10 nm wavelength interval, while the global mode data are reduced target mode data in both spectral and spatial resolution (85 bands, 2x footprint size as the target mode) [5]. Any inconsistency between the calibrated global and target model data at the same location could be indicative of artifacts. To assess the possible artifacts of M^3 data independently, we apply the reflectance spectra independently measured by the SP a point spectrometer onboard the SELENE mission that has very high signal to noise ratios (SNRs). We only work with the SP wavelength region from ~0.5 to 1.6 µm (bands 1 to 155, ~6 nm wavelength interval) that were well calibrated [6]. We calculate the ratios of DN, radiance, and reflectance of the three different measurements for each pixel. The SP spectra are systematically redder than the M^3 data due to different means of calibration [7]. A quadratic fitting is performed on the ratio spectra between M^3 and SP data to accommodate such effects. Any systematic deviations from unity in the ratio spectra could be indicative of artifacts. We can then pin down at which step of conversion from DN to reflectance the artifacts were introduced.

Methods: Two regions of interest (ROI) are selected from all available M^3 target mode images. One ROI is selected near the equator (Fig. 1) and the other is located at ~55° N (Not shown). The M^3 target mode image cubes of the two ROIs cover both highland and mare and are within the coverage of single M^3 global mode image cubes. The DN and radiance images of the M^3 global and target modes for the two ROIs are downloaded from the PDS server. The SP reflectance data are downloaded from the SELENE Data Archive website. At each ROI, all images are projected to the latitude and longitude ranges of the respective M^3 target mode image cubes using a simple cylindrical method.

We convert the M^3 radiance data to reflectance at a standard viewing geometry (30° incidence angle, 0° emergence angle, and 30° phase angle) using the same method as the M^3 team did [8], except that a new thermal correction model is applied [9]. The SP reflectance data have been corrected at a standard viewing geometry as the M^3 data and no further correction is required.

We calculate the ratios of DN, radiance, and reflectance of M^3 global and target mode data at each ROI. The reflectance ratio of M^3 global mode data and SP data is also derived. A quadratic fitting is performed on the ratio spectra of M^3 and SP data to accommodate the redder slope of the latter.

Results and Discussion: Fig. 1 shows the 750 nm maps of M^3 global and target mode data, as well as the SP data at the ROI 1 (ROI 2 is not shown). Example spectra are collected at the same spots from the three datasets and plotted in Fig. 1. The reflectance between ~ 600 nm and 900 nm, centered at ~700 nm of the M^3 global mode data is lower than that of the target mode data, while reflectance at the remaining bands is in good accordance between the two datasets, which makes the absorption centered near 1 µm of the global mode data much weaker than the target mode data (Fig. 1, the upper right plot). To further assess this possible artifact, we compare the SP and M^3 data. Although the SP spectra are much redder than the M^3 data as noted in previous studies [7], we can still see that the M^3 global mode spectra are much flatter at the wavelength range from ~600 nm to 900 nm than the SP data (Fig. 1, the lower right plot).

We find that the anomalous reflectance from ~600 nm to 900 nm is present in all pixels of the M^3 global mode data. We calculate the spectral ratios between M^3 global and target mode data, as well as M^3 global mode and SP data at the two ROI regions. The reflectance ratios indicate that an artifact centered near 700 nm exists in the M^3 global mode reflectance data (Fig. 2). The sharp artifact of SP data near 900 nm (Fig. 1) was pointed out due to features in the solar spectrum during calibration [6]. We do not see such features in the empirical polisher used to remove artifacts of M^3 data (Dark green lines in Fig. 2) [8] and also not in the smooth shape correction curves that were used to correct the artifacts introduced by the increase of sensor temperatures [5]. We do not see such an artifact in the DN ratios but only in the radiance and reflectance ratios of the M^3 global and target mode data (black lines in Fig. 2), suggesting that the artifact might be introduced in any of these steps: nonlinearity correction, lab scattered light correction, flat field correction, and dark signal subtraction, when converting the DN to radiance. The variations near 0.9 µm, 1.2 µm, and 1.6 µm in the DN ratio of ROI 1 (Fig. 2) could be due to the phase angle difference between the M^3 global and target mode data. These variations are not seen in the radiance and reflectance ratios after calibration (Fig. 2, the top plot). Further study is required to understand how the artifact was generated, and consequently how we can remove it.

An anomalous kink is also observed at 2.82 µm (band 81) of the M^3 global mode reflectance data when comparing with the target mode data (Fig. 1, the upper rigth plot). The reflectance ratios between M^3 global and target mode data suggest that this anomalous kink exists in all pixels of the M^3 global mode data (The red lines in Fig. 2). Similar to the artifact near 700 nm, this kink is introduced when converting DN to radiance. Further study is required to understand how this kink is introduced.

The artifact near 700 nm of the M^3 reflectance data could distort the strength and center of the 1 µm absorption, which may result in large uncertainties in estimating the abundance of pyroxene and olivine, and bring difficulty in assessing the speciation of pyroxene (i.e., high or low Ca). Corrections of the artifact near 700 nm in M^3 global mode data will significantly enhance the science return.

Some of the previous studies misinterpreted the kink at 2.82 µm as water absorptions [e.g., 10]. Although the absorption at 2.82 µm could be indicative of water, the kink could distort the absorption strength and result in large uncertainties in quantitative assessment of water content. It is suggested that the 2.82 µm band (band 81) NOT be used as an indicator of the presence of water until a correction can be made.

References: [1]. P. G. Lucey *et al.*, *JGR*, (1998). [2]. C. M. Pieters, *JGR*, (1983). [3]. S. Li, R. E. Milliken, *Sci. Adv.*, (2017). [4]. C. Pieters *et al.*, *Science*, (2009). [5]. R. O. Green *et al.*, *JGR*, (2011). [6]. S. Yamamoto *et al.*, *IEEE* (2014). [7]. S. Besse *et al.*, *Icarus*, (2013). [8]. S. Lundeen *et al.*, M3 ISIS, (2011). [9]. S. Li, R. E. Milliken, *JGR*, (2016). [10]. T. B. McCord *et al.*, *JGR*, (2011).

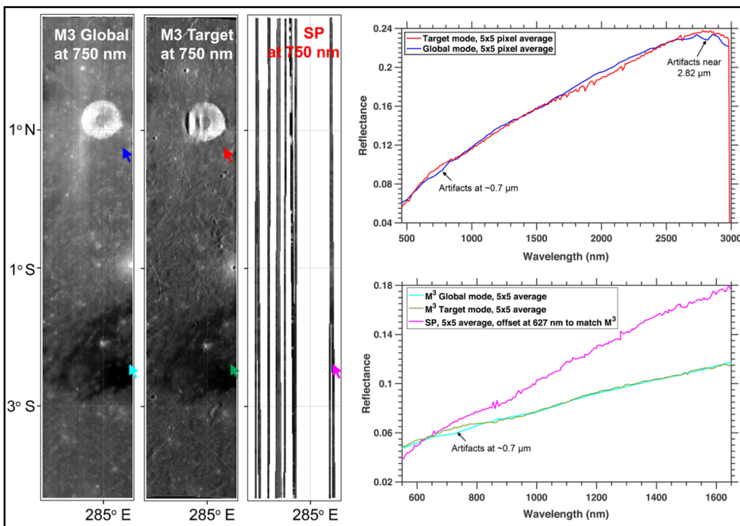

Fig. 1. 750 nm reflectance maps of M^3 global and target modes and Spectral Profiler (SP) at ROI 1; example spectra were collected at pixels pointed by the arrows to indicate two possible artifacts in the M^3 global mode data; spectra were colored the same as the arrows to indicate their locations.

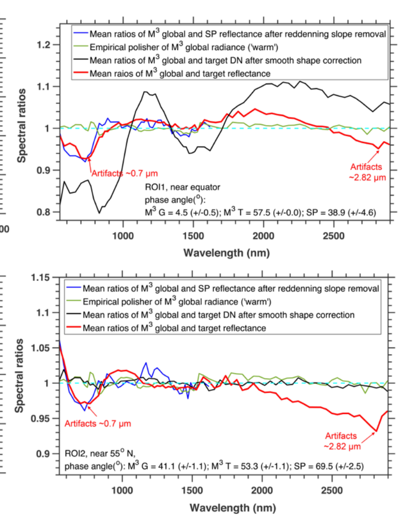

Fig. 2. Ratios of M^3 global and target mode data, M^3 global mode and SP data at two different study regions; two possible artifacts were labeled.