DERIVING A PHOTOMETRIC MODEL FOR THE MOON MINERALOGY MAPPER DATA (M^3).
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Introduction: The Moon Mineralogy Mapper (M^3), a guest instrument onboard India's Chandrayaan-1 mission to the Moon, is a 0.43 to 3.0 µm imaging spectrometer, which has mapped more than 95% of the lunar surface. All data have been processed through the M^3 calibration pipeline to apparent reflectance. Observations of the Moon have been made at different periods of the mission during which lighting conditions changed. As a consequence, an adequate photometric correction for detailed analysis of the spectra is required to correct for illumination variations. In the case of spectrometers like M^3 and Spectral Profiler onboard Kaguya mission [1], the wavelength dependence of the photometric variations must also be corrected.

Investigations of the lunar surface photometric properties have been made using different instruments from Earth [2] or space missions [3-5]. Here, we report preliminary work done using the M^3 instrument integrating all the data acquired with the instrument.

Data: In Fig. 1, we present the phase coverage of the different Optical Periods (OP), which refer to different time of observation during the mission. The first attempt to derive the photometric correction for the instrument by Hicks *et al*. [5] was done using only the OP1B data (red in Fig. 1). These data have a limited phase range and are located mainly on the nearside. In this study, we use a Lunar-Lambert correction and increase the phase angle range.

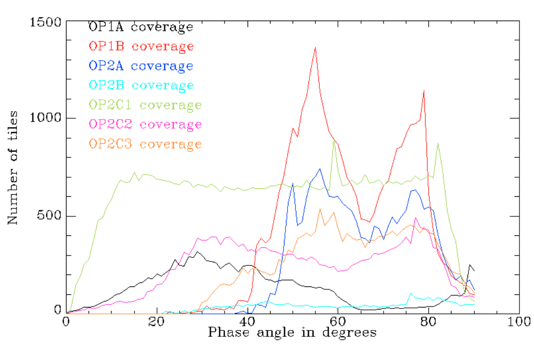

Fig. 1: Phase coverage and number of observations on a 1x1 degree mosaic of all optical periods (OP).

Although it is true that the phase coverage is well covered by 3 different OPs, only OP2C1 covers the entire phase range and the complete surface of the Moon at the same time. Other OPs have either a limited phase range or are spatially limited. We therefore focus our analysis on the OP2C1 dataset to define phase function corrections. The OP2C1 data are first binned into a 1x1 degree mosaic as shown on Fig. 2.

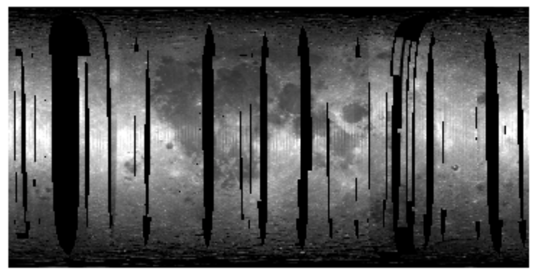

Fig. 2. OP2C1 1x1 degree mosaic.

Model: We used the empirical model of McEween *et al*. [3], which was proposed for the Clementine photometric correction and used for Kaguya. The model can be summarized as:

$$r(\lambda;i,e,\alpha)=AX_L(i,e,\alpha)\ f(\lambda;\alpha)$$

where i is the incidence angle, e the emission angle, alpha the phase angle and r the observed reflectance at wavelength λ. AX_L is the Lunar-Lambert function to correct the limb darkening.

In this preliminary work, we only focus on the determination of the f(λ) and consequently do not retrieve the parameters of the Hapke model [6] as was done for the Spectral Profiler data [4]. At first order, the phase correction is define with:

$$f(\lambda;\alpha)=r(\lambda;i,e,\alpha)/AX_L(i,e,\alpha)$$

To determine $f(\lambda;\alpha)$, we need dataset with relatively uniform albedo. The Moon is at first order divided in three albedo groups: 1) the Low Albedo Group that consist mainly of mare basalts; 2) the High Albedo Group that consist mainly of highland terrain; and 3) the Medium Albedo Group. We used the albedo group classification obtain by [4] to define the albedo group of each pixels of the M^3 data as shown on Fig. 3. Then, we derived a phase function correction for the different albedo groups observed by M^3.

For each wavelengths, we obtain several observation at a given phase angle. We then applied a median for each phase bin.

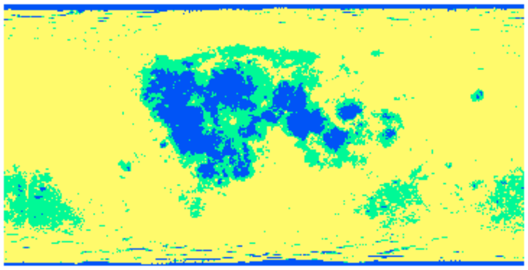

Fig. 3: Sub-groups classification of the M3 data set. Yellow is the High Albedo Group, blue is Low Albedo and green is the Medium Albedo.

Results and Discussion: In Fig. 4, we present the fit of the M^3 observations during OP2C1 at 750 nm. We use a 2^{nd} order polynomial to fit each group. The fit was performed between 5 and 75 degrees to avoid complexity of the phase function outside this range. The Low Albedo Group and High Albedo Group (green and red fits) present similar characteristic between 5-30 degrees. Low Albedo Group is not represented for phase angle greater than 40 degrees and they start to deviate from the High Albedo Group at 30 degrees. This deviation can be the result of an under sampling of the Low Albedo Group at higher phase angles. The Medium Albedo Group presents different characteristic at low phase angle. After 50 degrees, the Medium Albedo Group is similar to the High Albedo Group. We note that the Medium Albedo Group as much more noise than the other groups. This might be related to the nature of the Medium Albedo Group, which consist of mare and highland terrains.

The orange curve represents the fit of all the data set regardless of albedo groups. As expected, the phase function increase towards short phase angle and decrease toward long phase angle. However, we notice a particular flat curve at phase angle higher than 60 degrees. More work need to be done to determine if this is an artifact related to the sampling of the data or a particularity of the phase function.

We will focus our efforts for the Level 2 delivery to PDS of the M3 data, which include the photometric correction. In particular, we need to define accurately and quantitatively the differences between the albedo groups to define one global photometric correction, or two global photometric corrections, for High Albedo Group and Low Albedo Group.

References: [1]Matsunaga et al (2008), GRL, [2] Buratti et al (2011), JGR, accepted, [3]McEwen et al (1998), LPSC XXIX, Abstract #1466, [4]Yokota et al (2010), LPSC XXXXI, Abstract #2532, [5]Hicks et al (2011), JGR, revision submitted, [6] Hapke (1993), Cambridge Univ. Press

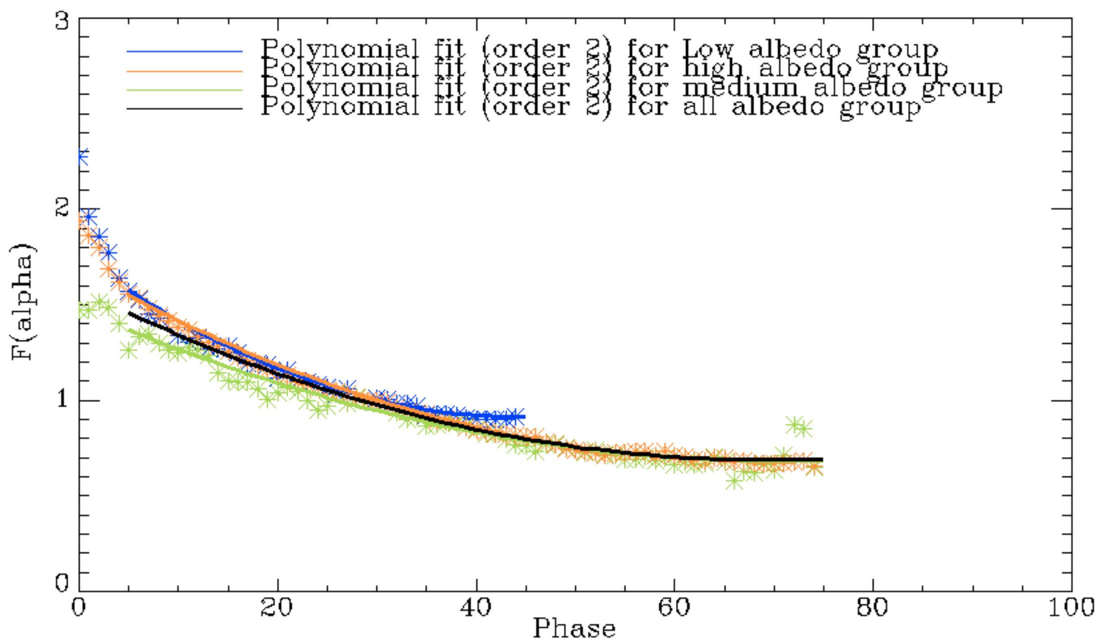

Fig. 4: Phase function fit for the three different type of terrain (orange: High Albedo Group, blue: Low Albedo Group, green: Medium Albedo Group) at 750 nm. The three groups are normalized to 1 at 30 degrees phase angle to facilitate comparisons.