LRO-LAMP OBSERVATIONS OF ILLUMINATION CONDITIONS IN THE LUNAR SOUTH POLE PERMANENTLY SHADED REGIONS.

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Introduction: The south pole of the Moon is an area of great interest for exploration and scientific research because many low-lying regions are permanently shaded and are likely to trap volatiles for extended periods of time, while adjacent topographic highs can experience extended periods of sunlight. One of the goals of the Lunar Reconnaissance Orbiter (LRO) mission [1] is to characterize the temporal variability of illumination of the lunar polar regions for the benefit of future exploration efforts. We use far ultraviolet (FUV) observations made by the Lyman Alpha Mapping Project (LAMP) [2] to evaluate illumination at the lunar south pole (within 5° of the pole).

Illumination Model: Modeling using topographic data provide estimates of PSR extent and percent illumination of sunlit peaks [3]. This work is also designed to estimate the thermal balance in PSRs based on scattered sunlight, which varies diurnally and seasonally (Fig 1). The model first calculates the amount of sunlight scattered into the PSR and then determines the amount scattered to LRO using a wavelength-dependent phase angle. The initial model results used the phase angle for the LOLA wavelength of 1064 nm.

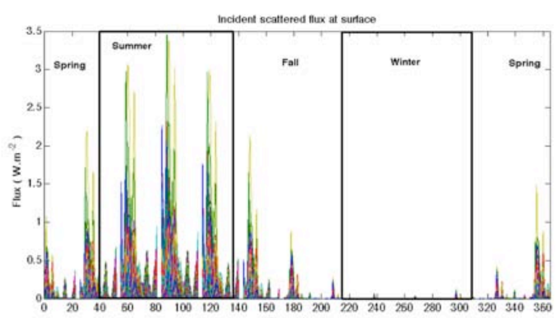

Figure 1: Incident scattered flux observed at each of the test points for Shoemaker crater. Both diurnal and seasonal variability is evident in the sunlight scattering onto the surface of the PSRs.

Mapping the South Pole in Ultraviolet: LAMP observations are made through passive remote sensing in the FUV wavelength range of 57-196 nm using reflected sunlight during daytime observations and reflected light from the IPM and UV-bright stars during nighttime observations [2,4]. In this study we focused on the region within 5° of the pole, (Fig. 2) and produced maps using nighttime data taken between September 2009 and February 2014. Summing over long time periods is necessary to obtain sufficient signal to noise. We show here several of the maps produced for this study. Many of these maps show brightness or albedo in the "Off Band" [4], or 155-190 nm, because sunlight is most evident in this wavelength range.

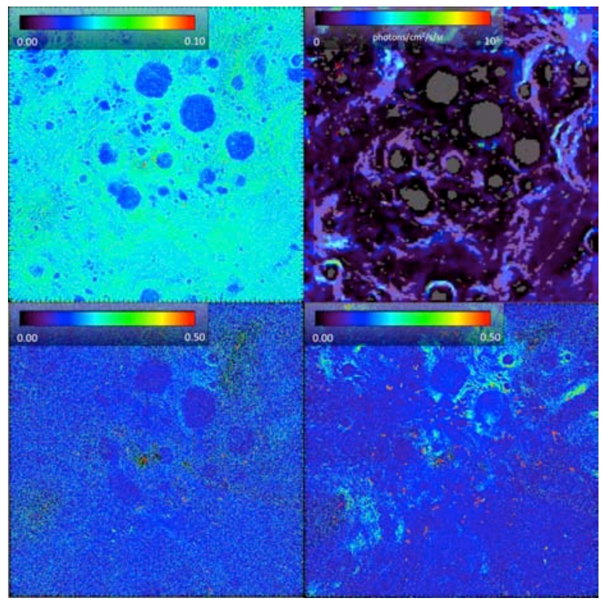

Figure 2: LAMP maps for the Lunar south pole region: (top left) LAMP daytime average 155-190 nm brightness. (top right) Average LAMP night time Lyman-α albedo maps with sza restricted to > 91°. PSRs are shaded in gray. (bottom left) Average LAMP Off Band albedo with sza restricted to > 91° and (bottom right) using no sza restriction.

LAMP observes the highest rate of scattered sunlight in two large PSRs during nighttime observations: Haworth and Shoemaker. We focus on these craters for model/data comparisons. The illumination model results shown in Figs 3 & 4 are selected to coincide with the time and location of LAMP observations (also shown) and are resampled to the LAMP map resolution. To isolate scattered sunlight observed by LAMP from reflected light from the IPM and UV-bright stars we subtract the albedo measured with a solar zenith angle (sza) > 91° from the albedo mapped using all observations. As Figs. 3 & 4 illustrate, we find that the observations of scattered sunlight do not agree with model predictions.

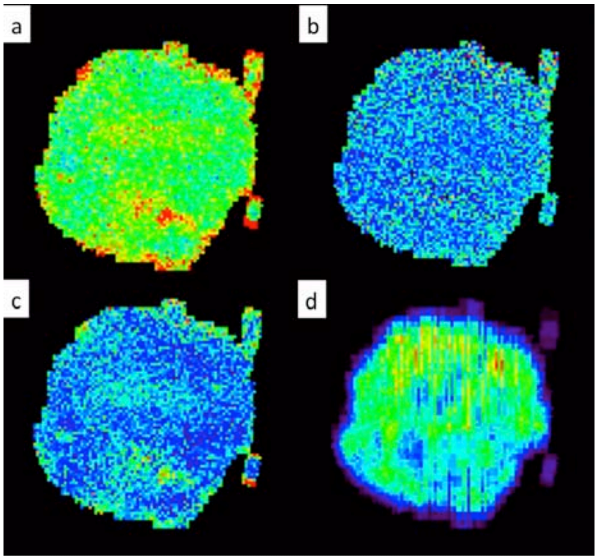

Figure 3: LRO-LAMP Off Band maps of Haworth crater (a) using all nighttime data with no sza restriction, (b) using the same data with limiting sza > 91°, and (c) the total difference between (a) and (b). (d) Illumination map predicting the flux of scattered sunlight to LRO using simulations from the location and time of LRO-LAMP observations interpolated to the LAMP map spatial resolution.

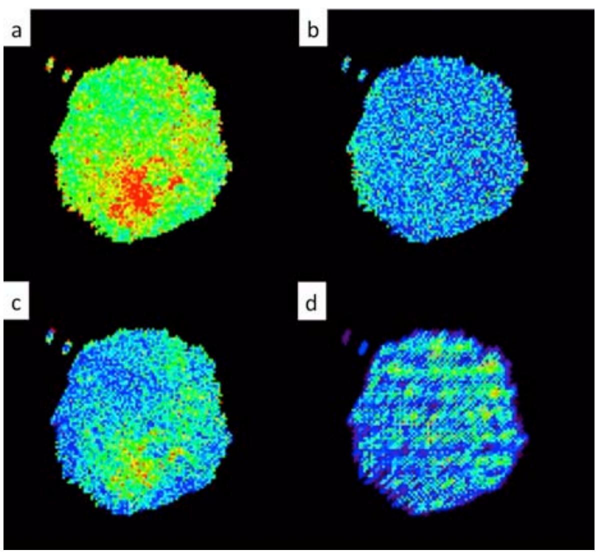

Figure 4: LRO-LAMP Off Band maps of Shoemaker crater (a) using all nighttime data with no sza restriction, (b) using the same data with limiting sza > 91°, and (c) the total difference between (a) and (b). (d) Illumination map predicting the flux of scattered sunlight to LRO using simulations from the location and time of LRO-LAMP observations interpolated to the LAMP map spatial resolution.

Comparison with Model and LRO Datasets: The LAMP maps do not correlate well with the illumination model results. This could be due to a combination of the following:

- Limitations of the spatial resolution of the model compared to topographic variations.
- Differences in surface albedo.
- Differences in the phase function at FUV wavelengths vs 1064 nm.

However, preliminary results comparing LAMP maps with other LRO datasets show a correlation between LAMP observations of scattered sunlight and Diviner measurements for maximum temperature (Fig. 5). Our next step is to investigate if the phase function is the primary source of difference between the model and LAMP observations.

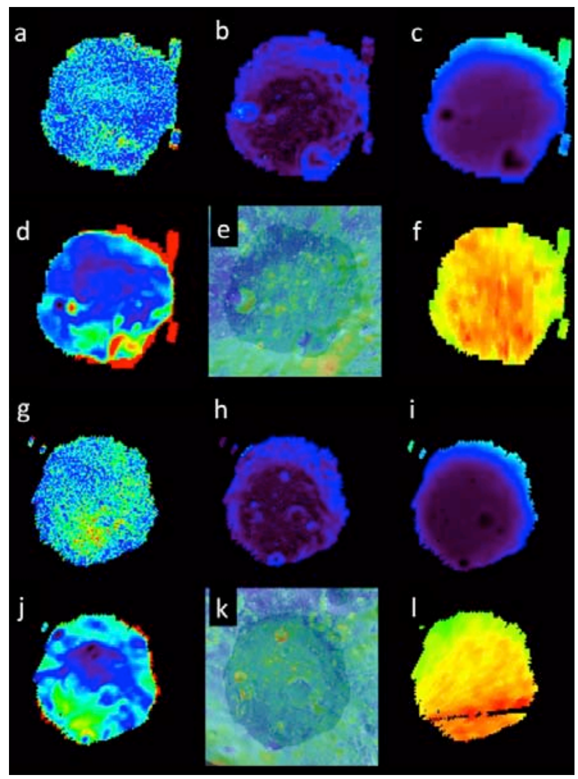

Figure 5: Comparison of LAMP maps of scattered sunlight with other LRO datasets for Haworth (a)-(f) and Shoemaker (g)-(l): (a) & (g) LAMP excess albedo showing scattered sunlight; (b) & (h) slopes from LOLA topography; (c) & (i) elevation from LOLA topography; (d) & (j) maximum temperature measured by Diviner; (e) & (k) mini-RF circular polarization ratio; (f) & (l) LOLA normal albedo.

References: [1] Chin et al. (2007) SSRv, 129, 391-419. [2] Gladstone et al. (2010) SSRv, 150, 161-181. [3] Mazarico et al. (2011) Icarus, 211, 1066-1081. [4] Gladstone et al. (2012) JGR, 117, E00H04.