NEAR-INFRARED PHOTOMETRY OF FUTURE LANDING SITES FROM THE LUNAR ORBITER LASER ALTIMETER (LOLA). R. T. Walker\textsuperscript{1,2}, M. K. Barker\textsuperscript{3}, E. Mazarico\textsuperscript{4}, X. Sun\textsuperscript{1}, G. A. Neumann\textsuperscript{1}, D. E. Smith\textsuperscript{1}, M. T. Zuber\textsuperscript{3} and J. W. Head\textsuperscript{4}. \textsuperscript{1}Solar System Exploration Division, NASA Goddard Space Flight Center, 8800 Greenbelt Rd., Greenbelt, MD 20771 (ryan.t.walker@nasa.gov), \textsuperscript{2}Hexagon US Federal, Lanham, MD, \textsuperscript{3}Massachusetts Institute of Technology, Cambridge, MA, \textsuperscript{4}Brown University, Providence, RI.

**Introduction:** Numerous missions from NASA and international space agencies and private companies are scheduled to land on the Moon in the next few years. These missions will collect a wealth of new data from their landing sites. Therefore, it is important to fully characterize the sites both before, during, and after the missions themselves. One useful tool for that purpose is photometry, or how the regolith reflectance changes under different illumination and viewing conditions. The reflectance behavior can reveal clues to the nature of the regolith particles and surface texture [1]. The Lunar Orbiter Laser Altimeter (LOLA) onboard the Lunar Reconnaissance Orbiter (LRO) has been making photometric measurements of the lunar surface for over 8 years by operating as a narrow-band near-infrared passive radiometer when its laser is turned off. Here, we present observations and preliminary analysis of the near-infrared phase function for several candidate landing sites.

**Data:** In its passive radiometry mode, LOLA’s laser does not operate, but instead LOLA acts as a 4-channel radiometer collecting photons at a wavelength of 1064 nm and a rate of 28 Hz with a combined footprint diameter of ~120 m from 100 km altitude. We calibrate the raw data by parameterizing and removing the effect of thermal electrons in the detectors in the absence of incident light (“dark current”). Because LOLA’s detectors are photon counters, we reference against the Kaguya (SELENE) Multiband Imager [2, 3] to obtain absolute radiance.

**Photometry:** The photometric function contains all illumination and viewing geometry effects on the observed reflectance of the lunar surface. It can be expressed as the product of a disk function that describes the brightness distribution over the lunar disk and a phase function that describes the drop in radiance as the phase angle ($\alpha$) between the Sun, lunar surface, and instrument increases [1]. We consider two phase functions for fitting our data. The first is a two-parameter function where $\eta$ gives the slope and $\rho$ the “bend” of the phase curve [4]:

$$f(\alpha) = \exp(-\eta \alpha^\rho).$$

$\eta$ was found to be inversely correlated with albedo, and $\rho$ to be correlated with surface roughness. Increased $\rho$ (i.e., smaller bend) was associated with photometric anomalies caused by high roughness due to factors like boulder fields [4]. The second phase function is a three-parameter function where $m$ and $\mu_1$ are associated with the amplitude and width, respectively, of the opposition surge and $\mu_3$ is correlated with surface roughness [5]:

$$f(\alpha) = \exp(-\mu_1 \alpha \pm m \exp(\mu_2 \alpha)) / (m + 1).$$

**Landing Sites:** Due to LRO’s orbital geometry, LOLA has good phase angle coverage in the low-to-mid latitudes, including at future targets including Reiner Gamma, Sinus Viscositatis/Gruithuisen Domes, and Mare Crisium. Our preliminary analysis of on- and off-swirl regions of Reiner Gamma shows clearly distinct phase curves, with the on-swirl phase function more closely resembling the global highlands than the surrounding maria. The two-parameter phase function shows a higher slope ($\eta$) for the off-swirl region, consistent with its lower albedo, while the difference in the bend ($\rho$) of the phase function is smaller than the uncertainty of the fit. The three-parameter phase function shows a higher amplitude ($m$) of the opposition peak and lower roughness ($\mu_2$) for the on-swirl regions, while the difference in the width ($\mu_1$) of the opposition peak is smaller than the uncertainty of the fit. Both $\rho$ and $\mu_1$ are highly sensitive to the behavior of the phase curve at low phase angles, suggesting that additional targeted slews in support of LRO’s Extended Science Mission 5 may be needed to resolve the ambiguity. We present similar analyses for Sinus Viscositatis and Mare Crisium as well, and place the results in the global context of geological factors affecting photometric properties in the near-infrared.