INVESTIGATING DIURNAL CHANGES IN THE NORMAL ALBEDO OF THE LUNAR SURFACE AT 1064 NM: A NEW ANALYSIS WITH THE LUNAR ORBITER LASER ALTIMETER. Ariel N. Deutsch[1], Gregory A. Neumann[2], James W. Head[1], Paul G. Lucey[3], [1]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence RI 02912 (ariel_deutsch@brown.edu), [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771, [3]Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, Honolulu, HI, 96822.

Introduction: Surface temperatures on the Moon vary ~300 K between local noon and night at the equator [1]. We are interested in how these extreme thermal variations may affect the reflectance of the lunar surface given that lab studies demonstrate that pyroxene shows temperature-related spectral changes in NIR wavelengths [2–4]. For almost a decade, the Lunar Orbiter Laser Altimeter (LOLA) [5,6] has been acquiring measurements of the Moon's surface reflectance at a wavelength of 1064 nm, which is coincident with a diagnostic absorption feature of pyroxene due to the presence of Fe^{2+} in the M2 site of the crystal [7]. Here we are interested in how the surface reflectance of the Moon as measured from orbit by LOLA changes during the extreme temperature fluctuations experienced by the surface over the course of a lunar day.

Methods: We analyze the surface albedo of the Moon using the highest quality calibrated LOLA data, acquired by Detector 3 on Laser 1 [8]. The LOLA data are analyzed for differences in mean normal albedo during the cycle of the lunar day by sorting the data into two groups based on the local time at which the data were acquired: mid-day (11:00–13:00) and morning/evening (06:00–07:00 and 16:00–17:00). These two groups are chosen to represent times at which surface temperatures are at a maximum and minimum, respectively, and times for which LOLA data exist. We target regions of interest (ROIs) within the mare and highlands between 65°S and 65°N, latitudes between which temperature fluctuations are greatest. Each ROI is only 1° x 1° in spatial extent, representing surface areas that are ~30 km x 30 km depending on the specific location.

Results: *Maria.* Of the 65 mare regions analyzed to date, 78% display an inverse relationship between normal albedo and temperature, which is approximated by local hour. The overall change in normal albedo is relatively low, on the order of a few % change detected by co-adding the LOLA data that features single shot uncertainty of 12% [5]. *Lunar highlands.* For the 383 highland sites analyzed so far, there is no statistically significant temperature-dependent reflectance change detected; only ~49% of ROIs show a decrease in normal albedo during local mid-day.

Discussion: The ROIs that show lower mean albedos during mid-day are consistent with laboratory studies that observe a temperature-dependent spectral change for common lunar minerals [2–4]. Of particular interest are previous laboratory measurements of returned lunar soils, which revealed a change in relative reflectance with temperature of ~1% or less per 100 K near-IR wavelengths [4]. This is similar to what we observe in the majority of mare ROIs.

It is possible that we do not detect a temperature-dependent albedo change in the highlands due to a variety of factors. Surfaces low in iron will show a weaker change because iron is responsible for the temperature-dependent absorption near 1064 nm [4]. The reflectance may also be affected by grain size, where particularly fine-grained regions have a decreased reflectance in comparison to a region of similar composition with larger grains [12,13]. Finally, mature soils show less contrast due to the attenuating effect of submicroscopic iron that has accumulated through time [10,11].

Conclusions: Here we provide the preliminary results of a new analysis investigating diurnal changes in the normal albedo of the lunar surface. Our statistical analysis, incorporating over 200,000 individual LOLA shots, suggests that temperature variations do have a measurable effect on the normal albedo of the surface at 1064 nm wavelength in the maria, and this may be due to temperature-induced spectral changes. However, the diurnal differences discussed here are only on the order of a few % change in normal albedo, indicating that temperature changes do not have a large effect on measurements of the lunar surface at the sensitivity of the LOLA instrument. An ability to understand how the lunar surface varies with temperature will provide important constraints for future remote sensing observations [14,15]. Such observations can help constrain the relative abundance of particular minerals (here, pyroxene) that exhibit a change in spectral reflectance with temperature independent of spectroscopic methods.

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