Investigating diurnal changes in the normal albedo of the lunar surface at 1064 nm: A new analysis with the Lunar Orbiter Laser Altimeter

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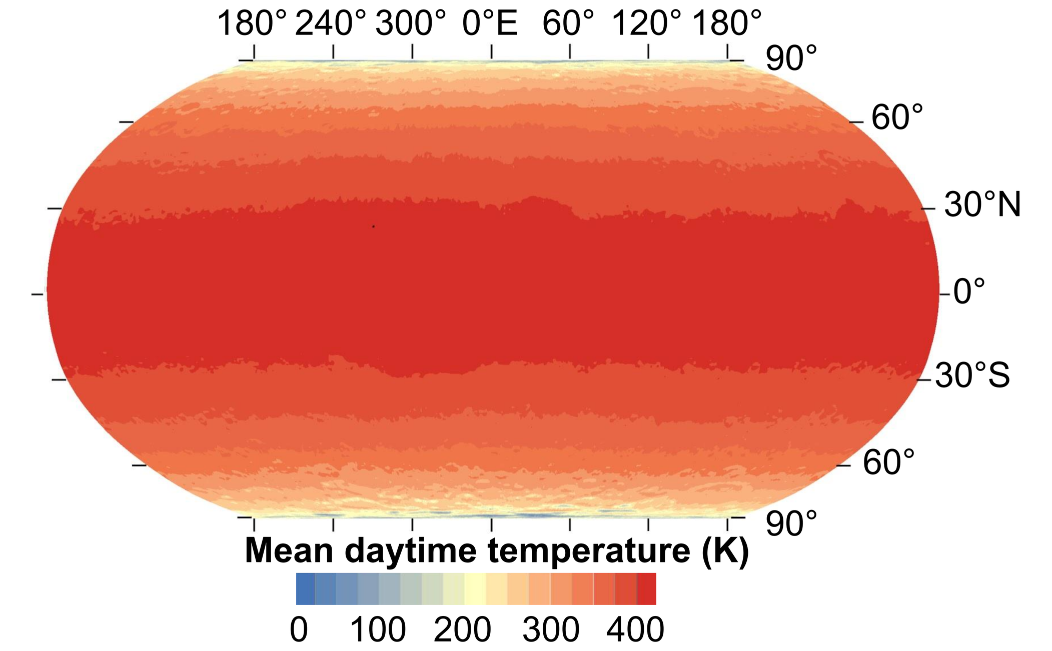
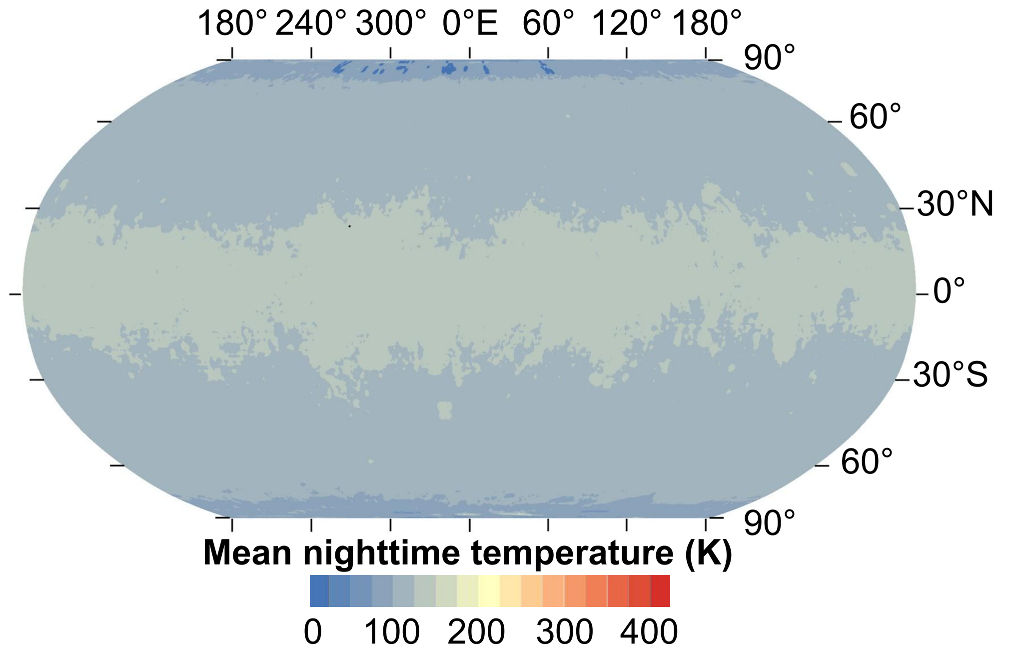
Abstract #1151

Introduction

The thermal environment of the lunar surface is extreme. At the equator, temperatures drop ~300 K between local noon and night [1].



Mean daytime temperature (K)

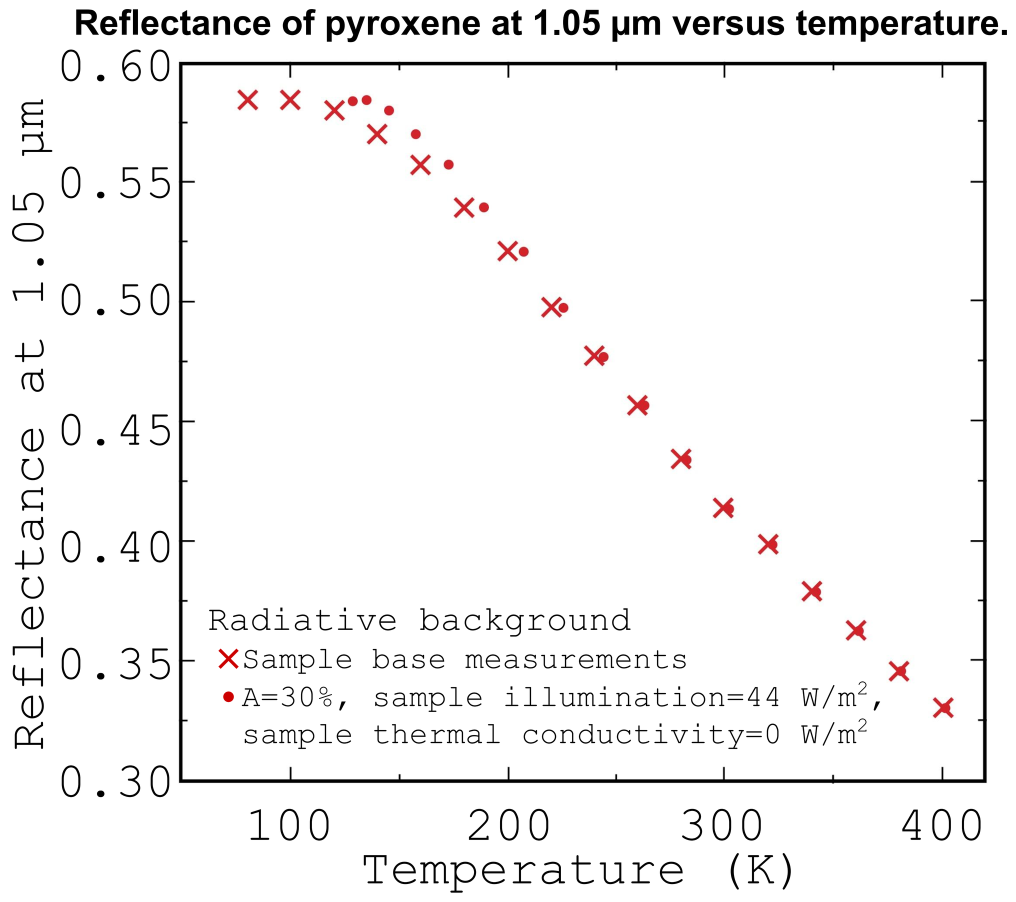


Mean nighttime temperature (K)

• Laboratory studies demonstrate that minerals common to the lunar surface (e.g., pyroxene, olivine) show spectral changes with respect to temperature in near infrared wavelengths [2–4].

• Over temperature changes equivalent to the lunar thermal environment (ΔT ≈ 300K), the reflectance of pure pyroxene samples can vary by a factor of two [4].

Reflectance of pyroxene at 1.05 μm versus temperature.



Modified from [4].

Motivating question

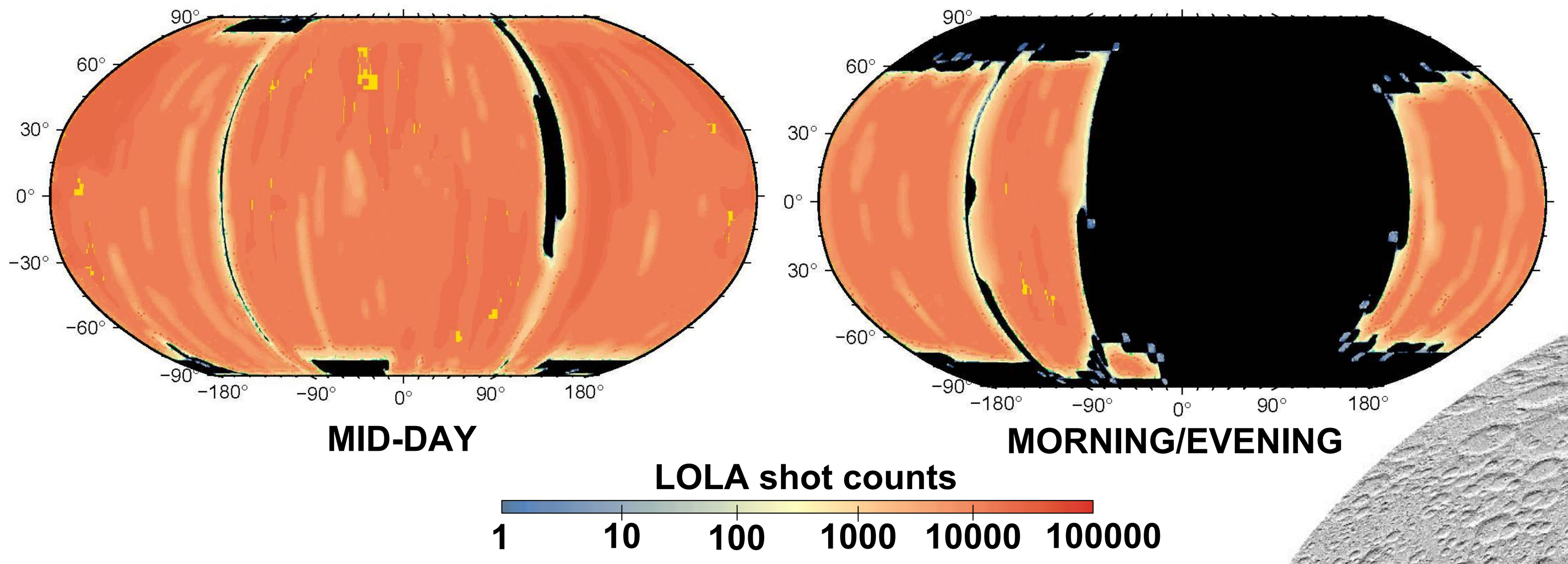
How does the surface reflectance of the Moon as measured from orbit by LOLA change during extreme temperature fluctuations experienced by the surface over the course of a lunar day?

Methods

Here we analyze the LOLA data [5] for differences in mean normal albedo during the cycle of the lunar day.

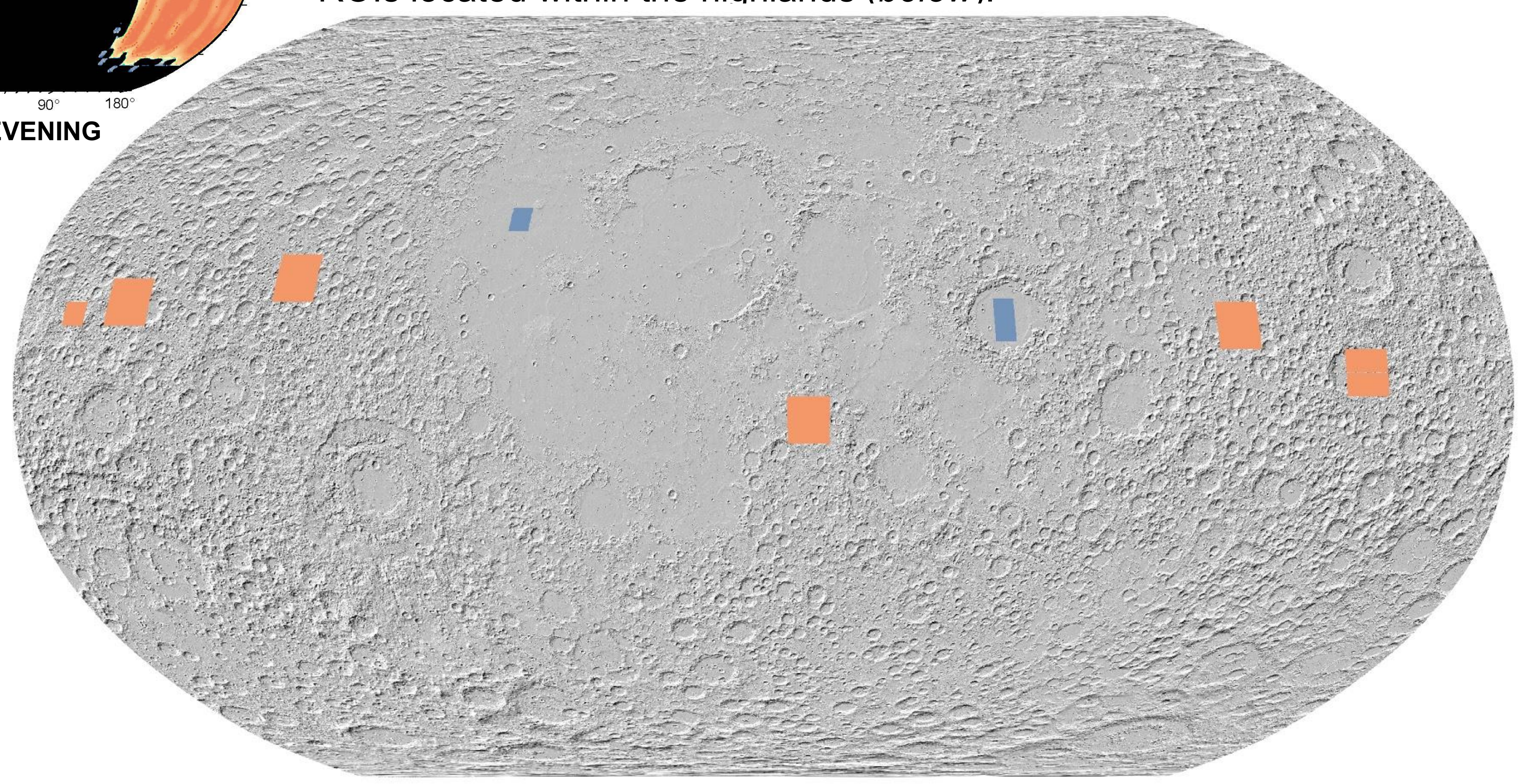
Two groups are selected to represent maximum and minimum surface temperatures:

- Mid-day: 11:00–13:00
- Morning/Evening: 06:00–07:00; 16:00–17:00



We target 1° x 1° regions of interest (ROIs) within the mare and highlands between 65°S and 65°N, latitudes between which temperature fluctuations are greatest.

To date, our analysis includes 65 ROIs located within the maria and 383 ROIs located within the highlands (*below*).



ROIs analyzed in the: Mare, Highlands

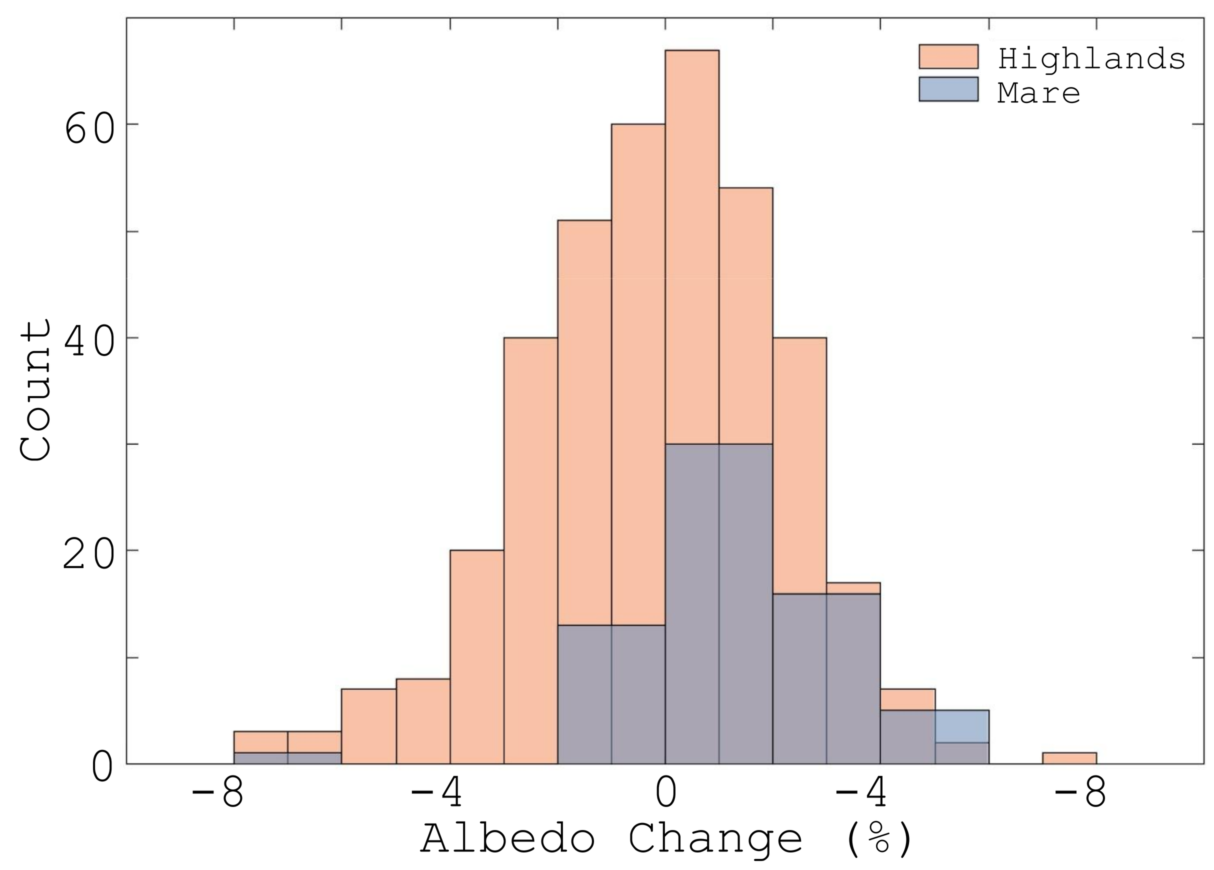
Basemap is LOLA hillshade in Robinson projection.

Results

MARE

• 78% of ROIs in the mare display an inverse relationship between normal albedo and temperature (*right*).

• The overall measured change in normal albedo is relatively low, on the order of a few % change.



Caption.

HIGHLANDS

• There is no statistically significant temperature-dependent reflectance change detected.

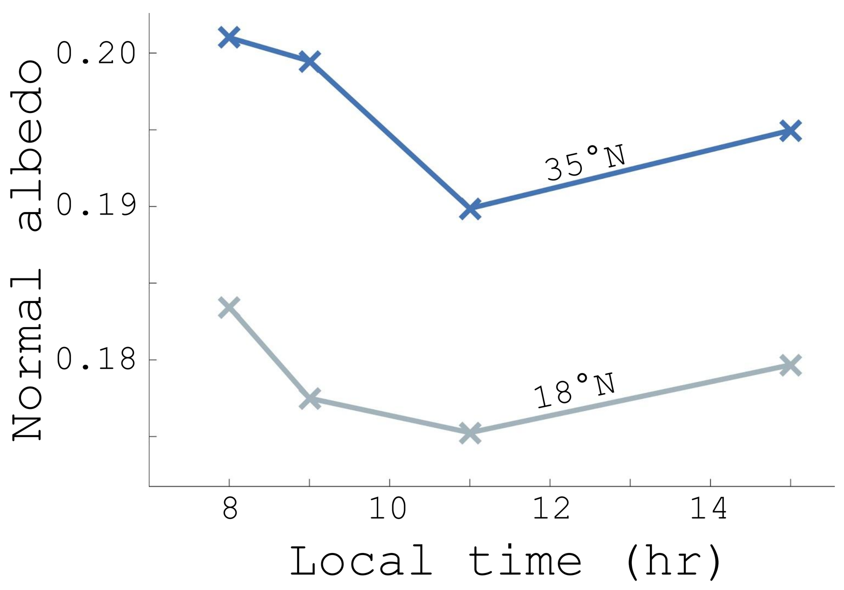
• Only ~49% of ROIs show a decrease in normal albedo during local mid-day (*left*).

Temperature-dependent albedo change

• The albedo change measured in the maria is consistent with laboratory studies [2–4].

• Previous laboratory measurements of returned lunar soils revealed a change in relative reflectance with temperature of ~1% or less per 100 K near-IR wavelengths [4].

The normal albedo of regions within the maria tends to decrease during local mid-day, when temperatures are highest.



No temperature-dependent albedo change

• It is possible that we do not detect a clear temperature-dependent albedo change in the highlands due to a variety of factors:

1. Surfaces that are low in iron will show a weaker change because iron is responsible for the temperature-dependent absorption near 1064 nm [4].
2. The reflectance may be affected by grain size effects, where particularly fine-grained regions have a decreased reflectance in comparison to a region of similar composition with larger grains [6,7].
3. Mature soils show less contrast due to the attenuating effect of submicroscopic iron that has accumulated through time [8,9].

Conclusions

• Our statistical analysis, incorporating over 200,000 individual LOLA shots, suggests that temperature variations 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.

• The diurnal differences are only on the order of a few % change in normal albedo, indicating that temperature changes do not have a large effect on LOLA measurements.

• An ability to understand how the lunar surface varies with temperature will provide important constraints for future remote sensing observations of the Moon [e.g., 10,11].

• 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.

References

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