THERMAL EXTREMES IN PERMANENTLY SHADOWED REGIONS AT THE LUNAR SOUTH POLE

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Introduction: Permanently shadowed regions (PSRs) persist at the lunar poles due to the Moon's low axial tilt. Crater interiors and other topographic depressions act as cold traps and may offer conditions suitable for long-term stability of surface volatiles [1]. Evidence from recent observations of the lunar poles by instruments aboard NASA's Lunar Reconaissance Orbiter is focused on isolating potential signatures of such volatiles, following the detection of water and other volatiles after the LCROSS impact into Cabeus crater [2].

However, the body of results to date yeilds a relatively inconclusive answer to the question of volatile abundance at the surface, with most techniques indicating either a very thin veneer of water ice frost [3] or signatures that may also represent freshly exposed/weathered regolith [4, 5, 6].

Here we present new maps constructed from more than three years of observations by LRO's Diviner Lunar Radiometer Experiment, a 9 channel infrared/visible spectrometer. Complete spatial coverage of the South Pole with many repeat observations allows high resolution quantification of diurnal, seasonal and total thermal extremes. These data prompt discussion regarding thermophysical properties of regolith and the consequences for the potential presence and stability of volatiles in PSRs.

Method: We plot brightness temperatures measured between July 5th 2009 and December 15th 2012 onto a 120m per pixel polar stereographic grid between 90°S and 85°S. Statistics are calculated for each bin, including the maximum and minimum temperatures observed. Diviner channels 8 (50 – 100 μm) and 9 (100 – 400 μm) are most sensitive to surface temperatures of 43 – 69K and < 43K, respectively [7]. We therefore extract channel 8 maximum and channel 9 minimum brightness temperatures to constrain thermal extremes polewards of 85°S.

Results: Stark temperature contrasts in Figure 1 (upper panel) clearly delineate PSRs from surrounding terrain, with many PSRs showing maximum channel 8 brightness temperatures < 100K throughout the year. The coldest PSRs exhibit minimum channel 9 brightness temperatures below 20K (Figure 1, lower panel). Thermal extrema within PSRs may be goverened by regolith/volatile properties, heat flow from the interior and non-solar radiation sources, e.g. thermal radiation from other surfaces in line of sight. A variety of thermal behaviours are observed for South Pole PSRs (Figure 2), which are likely to be due primarily to differences in thermophysical properties of the surface material.

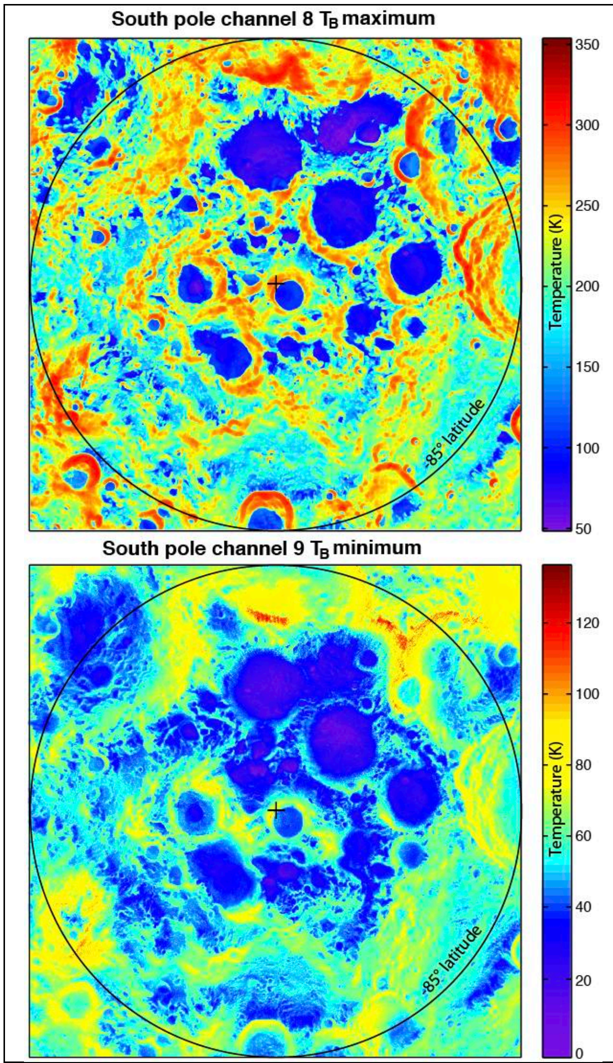

Figure 1: Maximum Diviner channel 8 and minimum channel 9 brightness temperatures measured at the lunar south pole.

The lowest brightness temperatures we observe are in Haworth, Shoemaker and Faustini craters (Figure 2).

Haworth crater: For some large areas in Haworth crater, TB8 maximum temperatures never appear to exceed ~50K. This is also the region with the lowest range of brightness temperatures, indicating a persistantly stable thermal regime.

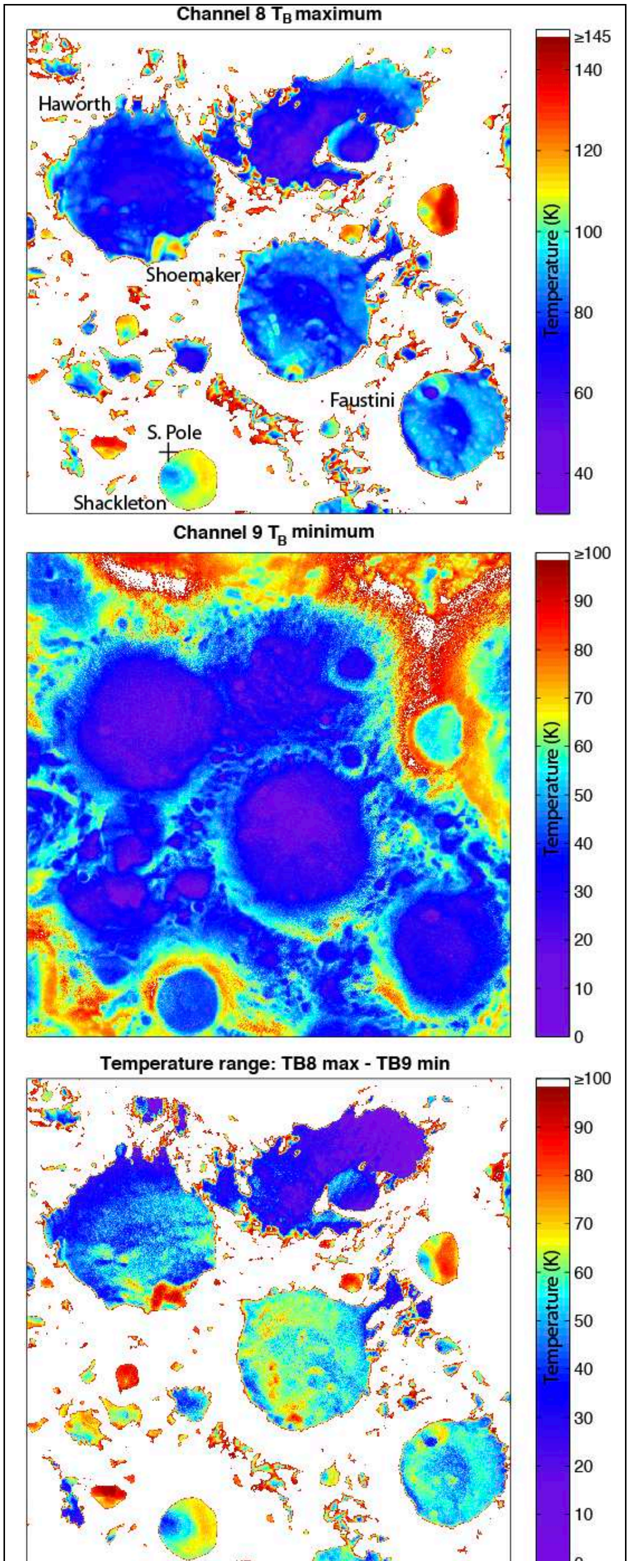

Figure 2: Enlarged portions of Figure 1 to view temperature range within major South Pole PSRs. Top: Channel 8 T_B maximum, Center: Channel 9 T_B minimum, Lower: Brightness temperature range in PSRs.

Faustini crater: Within Faustini crater a small crater is positioned near the northeast rim and is doubly-shadowed; sheilded from minor thermal emissions by Faustini's walls. Similar to some features in Haworth, we here observe year-round thermal stability at < 50K.

Shackleton crater: Relatively high maximum and minimum brightness temperatures are seen in Shackleton, as well as a wide thermal range compared to other major PSRs, with the exception of the pole-ward crater wall, which exhibits a comparatively narrowed thermal range.

Plausible causes of Shackleton's high 1064nm albedo (as measured by the Lunar Orbiter Laser Altimeter, LOLA) and low ultraviolet albedo (as measured by LAMP) include regolith brightening by mass wasting, the effects of space weathering at low temperatures or minor amounts of surface ice [3, 5]. However, a recent comparison of Shackleton's LOLA albedo with a broad crater population sampled from PSRs and equatorial regions suggest that it is not anomalously bright, suggesting that surface volatiles are not required to explain its appearance [4].

Our continuing efforts comprise in-depth, high spatial and temporal resolution studies of the thermal behaviour in specific PSRs to constrain the thermophysical properties of surface materials.

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