

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 Reconnaissance 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].

Results to date yield 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].

We present new maps constructed from more than three years of observations by LRO's Diviner Lunar Radiometer Experiment [7], a 9 channel infra-red/visible spectrometer. Complete spatial coverage of the South Pole with many repeat observations now allows high resolution quantification of thermal extremes in PSRs.

We show both the maximum (Figure 1) and total range (Figure 2) of observed bolometric brightness temperature, which is the wavelength-integrated radiance in all seven thermal Diviner channels expressed as the temperature of an equivalent blackbody [8].

Results

Many PSRs show maximum bolometric temperatures < 100K throughout the year (Figure 1), and there are many significantly colder than this. The coldest PSRs exhibit temperatures close to the sensitivity threshold of channel 9 and thus bolometric temperatures become dependant predominantly on the brightness temperature of the longest wavelength channels (8 and 9).

Shackleton Crater: Relatively high maximum temperatures (80-110K) are seen in Shackleton, as well as a wide thermal range compared to other major PSRs, with the exception of the poleward crater wall, which exhibits a comparatively narrowed thermal range. **Haworth crater:** For some large areas in Haworth crater, maximum temperatures never appear to exceed ~40K. This is also the region with the lowest temperature range, indicating a persistently stable thermal regime. **Faustini crater:** Within Faustini a smaller crater is positioned near the northeast rim and is doubly-shadowed; shielded from minor thermal emissions by Faustini's walls. Similar to some features in Haworth, we here observe year-round thermal stability at < 50K.

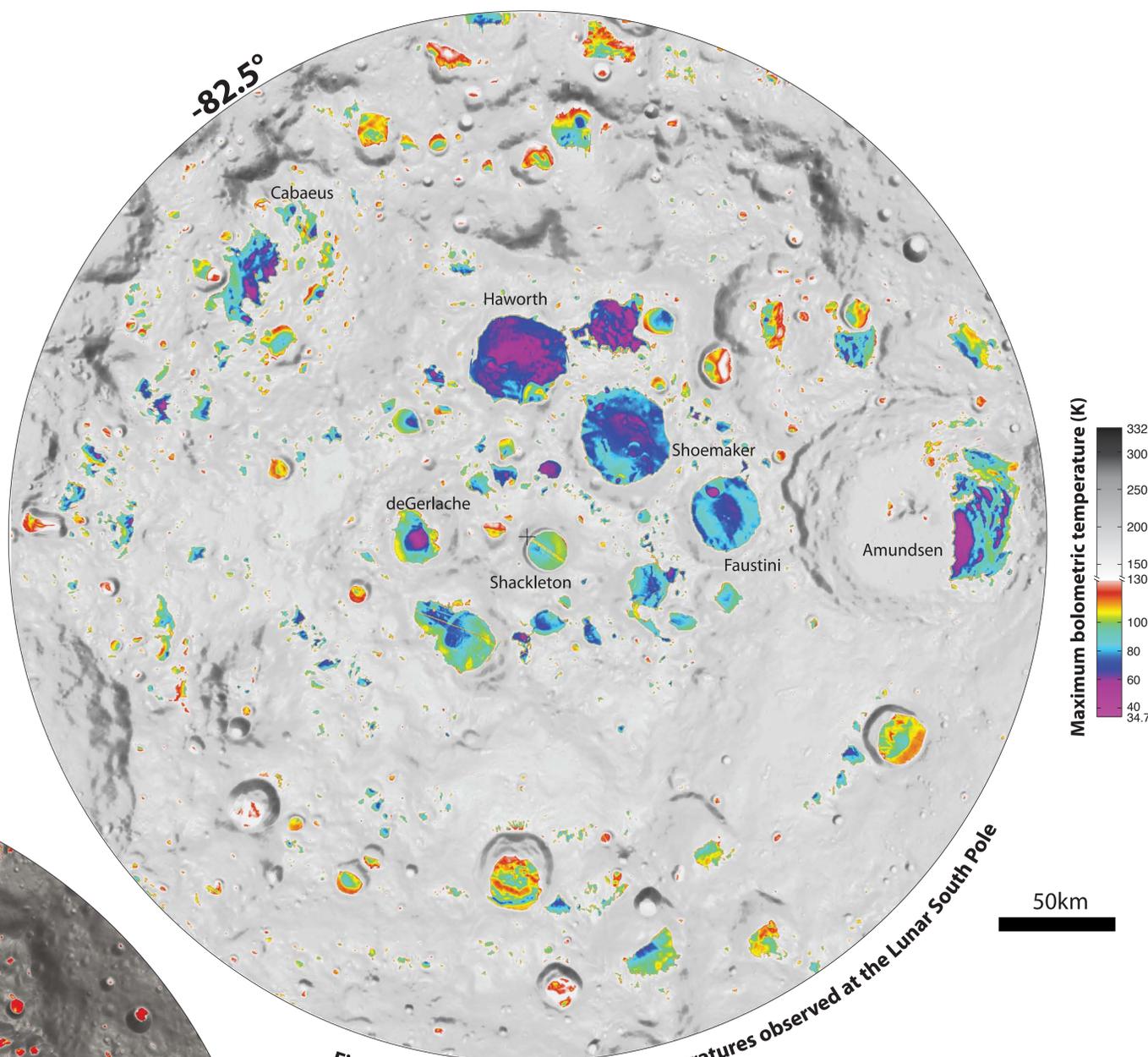


Figure 1: Maximum bolometric temperatures observed at the Lunar South Pole

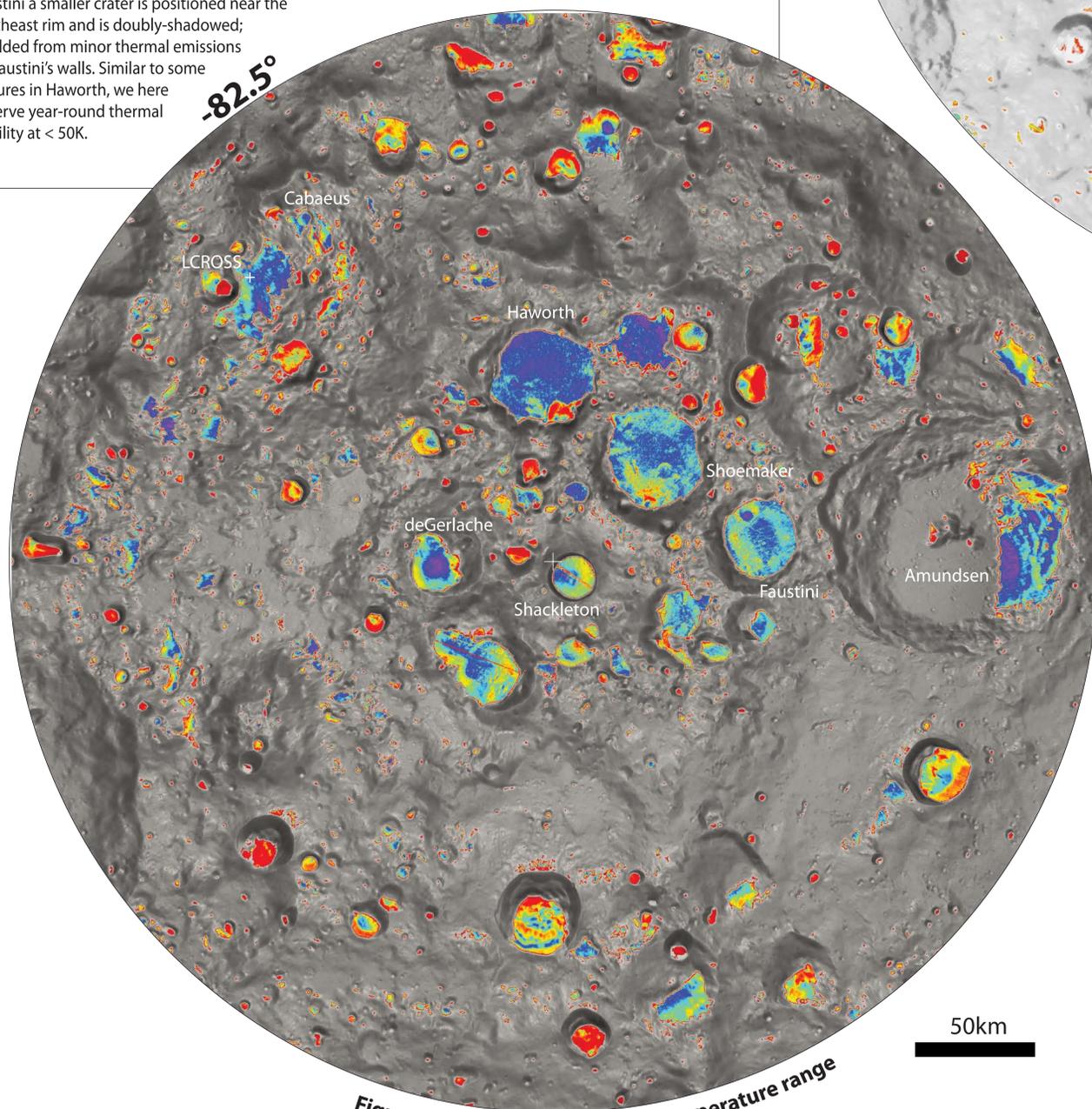


Figure 2: Observed bolometric temperature range

Correlation with LOLA albedo

Recent albedo (1064nm) measurements by the Lunar Orbiter Laser Altimeter (LOLA) show that there is some correlation between high albedo and low temperatures (Figure 3). However, not all cold places are bright, and many bright places are also warm.

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

Further investigation requires isolation of super cold areas and correlation of bolometric temperature with albedos from both LOLA and LAMP (alpha Lyman) albedo. Consideration of sub-pixel effects is important since limited surface expression of volatiles, i.e. a sparse surface or sub-surface distribution, may have little effect on apparent albedo at the scale of measurement footprints.

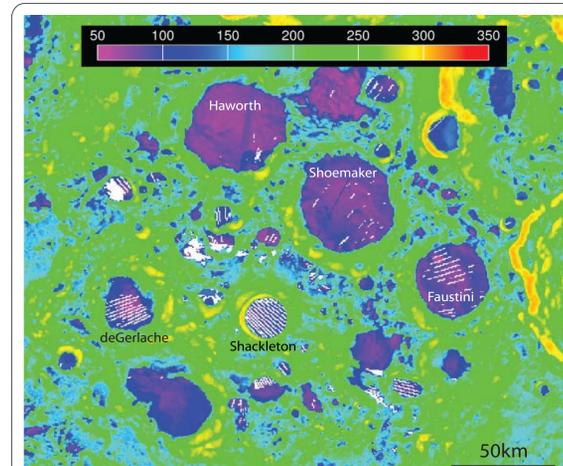


Figure 3: Diviner Channel 8 maximum brightness temperature at the South Pole. White pixels are where LOLA 1064nm albedo is > 0.375 and brightness temperatures are commensurate with a surface never above 130K.

Acknowledgement

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References

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