MAPPING SEASONAL AND DIURNAL TEMPERATURES IN THE POLAR REGIONS WITH LRO DIVINER.

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Introduction: Solar illumination in the polar regions is perpetually at high incidence angles, and consequently, the surface and near-surface thermal environment can vary in complex ways with time of day and season due to local topography. The Diviner Lunar Radiometer Experiment on the Lunar Reconnaissance Orbiter has been acquiring visible and infrared radiance measurements of the Moon for over 10 years. We have compiled this data into polar stereographic maps of temperatures poleward of 80° latitude at fixed local times and fixed subsolar longitudes to provide an overview of diurnal and seasonal temperatures of the polar regions. These maps are currently available to the community for science and mission planning (www.diviner.ucla.edu).

Data Set: Approximately ten years of nadir-pointing Diviner observations were polar stereographic projected and binned at 240 m/pixel resolution. Bolometric temperatures were calculated from the 7 IR-channels covering a wavelength range of 7.55 to 400 μm (see [1]) and split into summer and winter seasons. Maps at fixed local times in 0.25 hr increments and fixed subsolar longitude in 3.75° increments were generated. Additional details of the processing can be found in Williams et al. [2].

Polar Temperatures: The polar maps provide an overview of the mean, minimum, and maximum temperatures (Figure 1). The relatively small angle between the Moon's spin pole and the normal to the ecliptic plane of 1.54° results in regions that are permanently shadowed topographically from the Sun, however, seasonality can have a large effect on shadowing with substantially larger areas experiencing prolonged shadowing in the winter months. We find that surfaces below 110 K capable of cold trapping water increase by factors of 2.8 and 4.3 in the winter for the south and north polar regions, respectively. These seasonally shadowed regions experience ≳ 100 K variations in maximum temperatures between the summer and winter months which can have consequences for the diurnal and seasonal transport and sequestration of volatiles.

Temperatures within permanently shadowed regions (PSRs) also experience substantial variations in their amplitude extremes, that is, the difference between the maximum and minimum temperatures. For example, temperatures on the floor of Faustini vary ~30–40 K in winter, while in summer temperatures can vary by up to ~70 K.

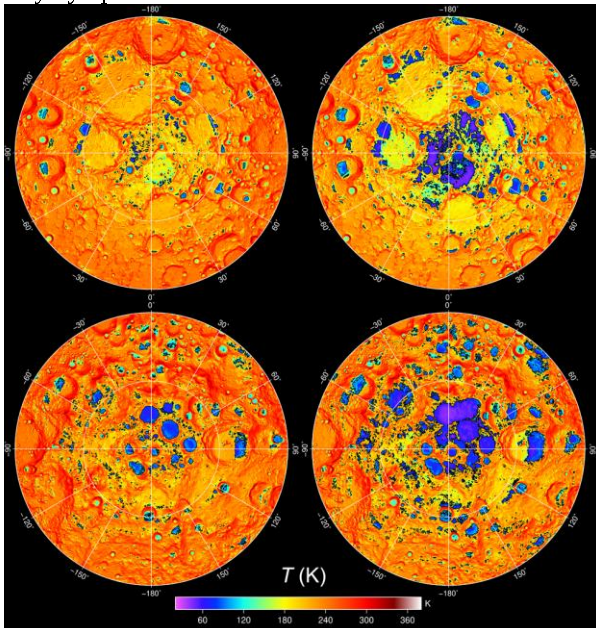

Figure 1: Maximum temperatures for the (*top*) north and (*bottom*) south polar regions for the (*left*) summer and (*right*) winter seasons. The break between cool and warm colors corresponds to ~110 K.

Implications for In Situ Exploration: The polar regions have the potential to provide areas with illumination conditions that are favorable for power generation and thermal stability with surfaces that experience extended periods of sunlight and minimal shadowing. Our maps show, however, that landing site selection and traverse planning for mobile platforms will need to contend with rapidly changing and complex illumination conditions, and seasonality should be an important consideration as surfaces of prolonged shadow and sunlight will vary seasonally. Such complexity is highlighted in Figure 2 that shows the local time at which peak temperatures were observed, along with several temperature profiles for specific select locations in the mapped area that demonstrate the diurnal and seasonal variability of

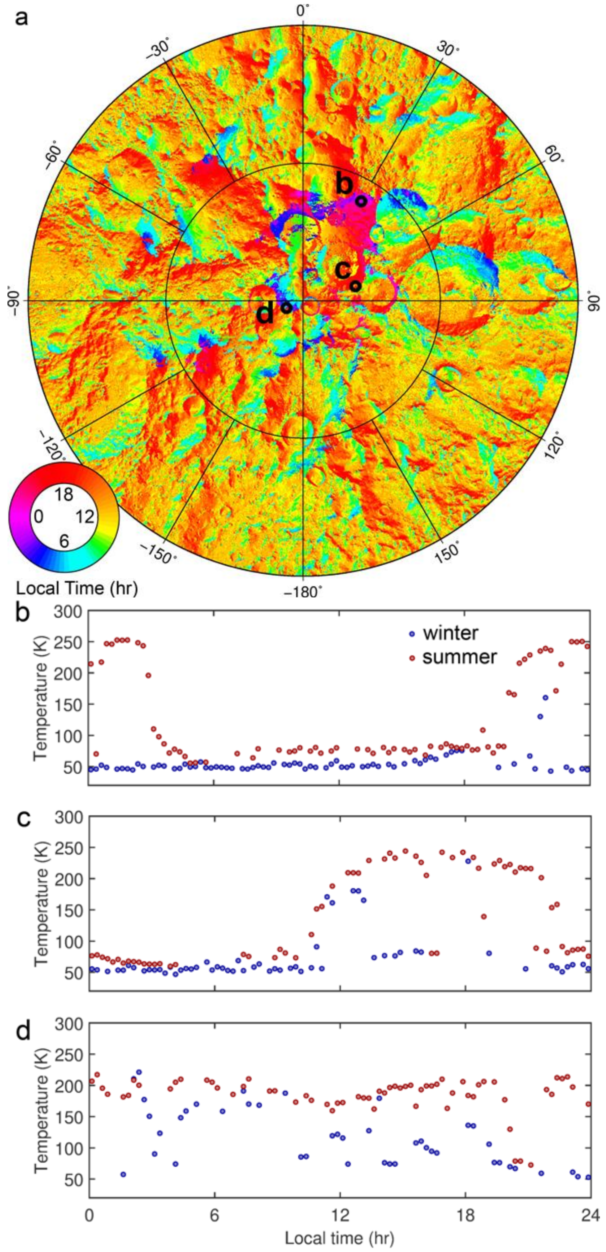

Figure 2: (a) Local time at which peak temperatures were observed in the summer south polar region and diurnal temperature profiles for (b) 85.8°S, 30.0°E (c) 88.0°S, 75.0°E, and (d) 89.3157°S, −114.06°E. Locations of (b–d) are denoted with black circles and labeled in (a). The location in (d) has been identified by Gläser et al. [3] using Lunar Orbiter Laser Altimeter digital terrain modeling as a surface with high average illumination on a ridge between the craters Shackleton and de Gerlache and is designated “Connecting Ridge C2.”

temperatures. The example in Figure 2b shows how peak temperatures can occur in the nighttime when the surface is illuminated by the Sun across the pole from the dayside. In this location (85.8°S, 30.0°E), peak temperatures are centered on the midnight hour in the summer. In winter the surface is illuminated briefly, seen as a spike in temperature > 150 K around 21 hr. The location in Figure 2c (88.0°S, 75.0°E) also experiences only brief periods of illumination in winter, around 12 and 18 hr. Illumination in summer between 11 and 23 hr, is disrupted with brief periods of cold temperatures (before and after 18 hr) as shadows sweep across the surface. Figure 2d shows the temperatures on a ridge between Shackleton and de Gerlache craters that has been identified as a location with high average illumination (e.g. [3][4][5]). Summer temperatures are systematically high, ~200 K; however, a decrease in temperatures at ~20–22 hr shows a period of local time that experiences shadowing, and winter months experience interspersed periods of illumination and shadowing.

The potential for extreme and rapid temperature changes presents challenges for the design of long-term habitats and other structures and need to be accounted for in the selection of locations and construction materials, as designs will need to accommodate large amounts of thermal expansion and contraction and associated fatigue stresses with thermal cycling [6][7].

The stringent engineering and operations requirements for mission planning precludes the reliance on one-dimensional regolith models to establish thermophysical properties of the regolith and local thermal conditions, as has been successfully done at lower latitudes (e.g., [8][9]). Future missions instead will require the use of three-dimensional regolith thermophysical models (e.g., [1]) that aim for improved treatment of reradiation and high-order reflections, which play a more dominant role in the lunar polar thermal environment than at lower latitudes, due to diurnal and seasonal shadowing.

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