Using Temperature Constraints to Identify Potentially Traversable Permanently Shadowed Regions at the Lunar South Pole

G. D. Tolometti[1], V. T. Bickel[2,3], E. C. Czaplinski[4], H. M. Sargeant[5], and D. A. Kring[6,7]. [1]Department of Earth Sciences, University of Western Ontario, London, Ontario, Canada. [2]Department Planets & Comets, MPS, Göttingen, Germany, [3]Department of Earth Sciences, ETH Zurich, Zurich, Switzerland, [4]Arkansas Center for Space and Planetary Sciences, University of Arkansas, USA, [5]School of Physical Sciences, The Open University, Milton Keynes, UK, [6]Center for Lunar Science and Exploration, Lunar and Planetary Institute, USRA, Houston, TX, USA, [7]NASA Solar System Exploration Research Virtual Institute, Houston, TX, USA. (gtolomet@uwo.ca)

1. Introduction

Presence of water ice in permanently shadowed regions (PSRs) [e.g., 1, 2] makes them attractive locations for future robotic and human exploration of the lunar south pole

Regolith properties of select PSRs have been evaluated in previous work through studying boulder tracks [3]. The results suggest that the PSRs are at least as traversable as highlands and mare terrain at depths of ~0.28 - 1 m.

Temperature conditions strongly influence distribution of water ice in regolith [4], therefore the regolith mechanical properties could be mainly correlated with temperature conditions.

In this work, annual maximum and average temperature data is used to identify PSRs with similar thermal conditions to those previously found to be potentially traversable [3].

2. Methods

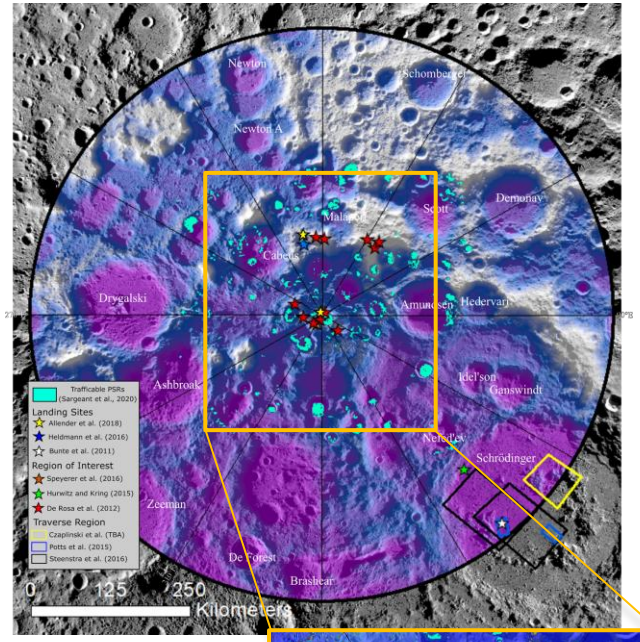
Potentially traversable PSRs from [3] can be characterized with the following thermophysical properties:

- **Max temp 160 - 200 K & Avg temp 90 - 130 K**
- **Area >0.15 km^2**
- **Within PSR boundary from [5]**

We overlaid Diviner max and avg temperature maps [6,7] with a map of PSRs and identified all south polar PSRs that meet all of the above criteria (see Fig. 1 & 2).

Based on the assumptions in [3,8] and assuming that temperature is the only factor affecting PSR trafficability, these PSRs might be traversable as well (i.e., they might feature sufficient bearing capacity at depths >~0.28 m [3]).

We identified several proposed traverses that are near these potentially traversable PSRs, and further ranked these PSRs using a series of auxiliary data products, such as the Ice Favorability Index, PSR Accessibility, and sunlit polar regolith strength estimates [9,10,11].



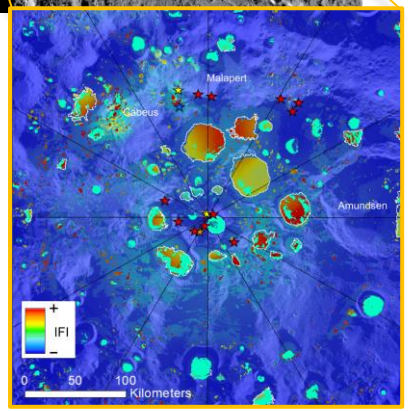


Figure 1. (above) Map of the lunar south pole with highlighted PSRs that exhibit similar annual max and avg temperatures as those studied in [3] (turquoise shapes). Maps were generated in ArcGIS© using LRO NAC 75-90º DEM (2m/pixel) and polar WAC Mosaic imagery [12]. Proposed landing sites and regions of interest for future missions are highlighted [13,14,15,16,17,18].

Figure 2. (right) A close up view of the south polar region from ~-85-90ºS where the trafficable PSRs are overlain onto polar WAC Mosaic imagery. The ice favorability index map [9] is shown, where red represents increased likelihood of ice.

3. Results

- We identified 372 potentially traversable PSRs at the south pole.
- The identified PSRs are distributed evenly across the south polar region and range in size (<1 km^2 to >100 km^2).
- The identified PSRs align well with areas that indicate a high likelihood of ice [e.g. 2,9,19].
- Numerous proposed landing sites and regions of interest for future missions are located near to likely traversable PSRs [e.g. 13,14,18].
- The trafficable PSRs fall under accessible cold traps mapped by [20] where slopes are <25°.

4. Conclusions

The temperature conditions of 372 lunar south polar PSRs are similar to those that have been deemed to be potentially traversable, and therefore are also potentially traversable. Numerous proposed landing sites and traverses are located near to potentially traversable PSRs and have a high likelihood of ice.

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