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Determining Lunar Polar Illumination Conditions using Kaguya & LRO Topography

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Introduction: The lunar poles experience extreme variations in illumination conditions due to the small angle between the lunar spin axis and the ecliptic plane. Near the lunar poles areas of permanent shadow and near-permanent sunlight can both occur, within close proximity of each other. These characteristics make these regions particularly attractive for explora-tion (manned or robotic) and possible resource utilization.

Permanently shadowed, 'cold traps', where temperatures can be less than 40 K [2], may contain deposits of water ice and other volatile materials. Water, if available in significant quantities, could support a long-term human presence. In close proximity to these extremely cold locales, points of near-continuous illumination offer favorable conditions for powering surface operations. These locations offer extended periods of sunlight and earth communication, and reasonably stable surface temperatures [3]. These factors have the potential to simplify the challenges faced during future exploration of the lunar poles.

Background on Polar Lighting Studies: The extent of permanent shadow and near-continuous illumination over the lunar poles has been previously modeled with several data sets (e.g., [3-8]). More recent lighting models have used laser altimetry data collected by the Selene/Kaguya to simulate polar lighting conditions and integrate/reconcile these models with optical data sets [6, 8]. The recent availability of the Lunar Orbiter Laser Altimeter (LOLA) dataset from the Lunar Reconnaissance Orbiter (LRO) has allowed refinement of the initial illumination models derived from topographic data sets. Recent work [9] exploits LOLA's data characteristics constructing illumination models and provides a perspective of both lunar poles at 240 meters/pixel. However, despite derivation from data with higher resolutions these more recent models show points of near-continuous illumination consistent with those initially observed in [3-5].

LOLA and Kaguya Illumination Modeling: The LOLA illumination model was composed using the methods from [6]. Illumination maps are generated for a specific Moon-Sun geometry by tracing rays from the Sun to each point on the gridded terrain dataset. Maps of mean illumination are constructed by sum-ming modeled shadows over time. These maps show the locations of near-continuous illumination as well as the extent of permanent shadow. Modeling with LOLA topography suggests the extent of predicted permanent shadow has increased from previous estimates, but the locations and characteristics of highly illuminated points are consistent with the results of previous stud-ies [1-4].

Average illumination maps provide a macroscopic view of the lunar polar environments however, more detailed analysis of specific locations and determining the potential to navigate from one area of interest to another considering lighting limitations is fundamental toward evaluating the plausibility of polar exploration. Analysis of lighting over time is the first step toward this goal. Analysis of local topography, and more detailed illumination models considering optimum height for energy capture are being explored. These data will aid in the development of mission constraints for future exploration.

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