ILLUMINATION MODELING OF THE LUNAR POLES, AND ITS BENEFITS TO EXPLORATION AND SCIENCE INVESTIGATIONS. Erwan Mazarico[1], Joseph B. Nicholas[2]. [1] Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA (erwan.m.mazarico@nasa.gov); [2] Emergent Space Technologies, Greenbelt, MD 20770, USA.

Introduction: The modeling of illumination conditions based on a terrain shape model is an important tool for science and exploration. While spacecraft imagery (e.g. LROC) can provide ground truth at very high resolution, a numerical model can benefit mission planning and scientific analysis, as it alleviates the sampling limitations inherent to data collection (time span, including future; consistency or extent of spatial coverage). The Lunar Orbiter Laser Altimeter (LOLA) acquired the first near-complete, high-resolution, and accurate topographic dataset over the lunar poles [1], which significantly improved the fidelity of computational efforts [2], compared to previous work based on ground-based radar data [3]. Recent interest and renewed questions related to the presence, distribution, and transport of lunar volatiles in the polar regions make continued efforts in illumination modeling critical to interpreting scientific data.

Data and Methods: Recent LOLA maps have excellent coverage in the polar areas, with >85% and 92% pixels containing LOLA measurements poleward of 65° latitude at 240m/pixel, in the north and south respectively. The coverage above 85° at 60m/pixel is >77% and >89%, and allows excellent accuracy over the most promising sites for future landed missions.

The horizon approach detailed in [2] consists of pre-computing the angular elevation of the limiting topography (horizon) in every azimuthal direction from every point in the study region. While this first step is very time-consuming, it considerably speeds up the computation of illumination conditions from an extended source at any given time. This method thus enables large-scale simulations with hourly timesteps over multiple decades.

Illumination Products: Multiple types of outputs from the illumination models are of interest. Of course, with the Sun as the illumination source, maps of average solar illumination and average solar incident flux can be obtained, as well as the resulting maps of permanently shadowed regions.

Considering the Earth as a source, maps of Earth visibility can be obtained, and inform key design decisions for lunar polar landers that require Earth communication as they explore permanently shadowed regions for instance [4].

New Use Cases: With such maps having been produced at various resolutions and over various regions by researchers in recent years [2,5,6], it may appear that except for mission-specific studies, illumination models have been exhausted in terms of usage. However, it is important to note that the ability to compute the illumination conditions at any time and place also permits the computation of supporting information to calibrate or analyze scientific data. For example, the illumination state of the surface along each LOLA profile can be computed, which is important near the poles where longitude and local solar time are not good proxies for illumination state. The illumination states can also be easily computed before and after the acquisition time, to define an effective local time. When investigating possible time-variable signals in the LOLA active radiometry [7], such results can help select specific data, such as pre-dawn points.

Other illumination sources can be considered during scientific data analysis. In particular, the LAMP instrument onboard LRO measures the UV starlight reflected off the Moon at several wavelengths [8]. While most of the incident radiation originates from the diffuse galactic background, bright UV stars do have seasonal impact on the incident flux [9]. Using an illumination model to compute the exact incident flux for every night-side LAMP measurement may help further refine the data calibration, and analysis of time-variable signals in particular.

The UV glow of the Earth during certain periods of the lunar month at the poles can also increase the background from its average value, and can be taken into consideration with more complex source modeling (extended source with time-variable surface irradiance).

Current illumination models can be extended to compute single-scattered flux. With additional but limited complexity compared to extensive thermal models [10], predictive scattered flux in PSRs can be advantageous for observation planning [11], image photometric calibration, and data interpretation [12].

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