

**A REVIEW OF LUNAR POLAR LIGHTING CONDITIONS: WHAT WE KNOW NOW, AND WHAT WE WILL LEARN SOON.** D. B. J. Bussey<sup>1</sup>, <sup>1</sup>The Johns Hopkins University Applied Physics Laboratory, Laurel MD 20723 (ben.bussey@jhuapl.edu)

**Introduction:** The moon's spin axis is nearly perpendicular to the ecliptic plane. This results in illumination conditions that are likely unique in the solar system. Were one to stand at a lunar pole the Sun would traverse around the horizon once every 708 hours with the center of the Sun never deviating more than  $\pm 1.5^\circ$  from the nominal horizon. Therefore topographically low areas; such as the floors of impact craters have the possibility of being errantly shadowed. Conversely topographic high regions near the pole may be in sunlight far more than the lunar average 50%.

**Current Knowledge:** Both image data and illumination simulations using topography have provided information on the lunar polar illumination conditions

*Clementine-derived quantitative illumination maps:* The Clementine mission gave us our first comprehensive look at the lunar poles. It imaged both poles approximately once every 10 hours for 71 days. The data were acquired during summer for the northern hemisphere. From these data quantitative maps were produced for both poles [1,2]. The main conclusions from this work were that no areas near the south pole are constantly illuminated although several regions exist that receive  $>50\%$  sunlight in winter. Two of these regions, one on the rim of Shackleton and the other approximately 15 km away on a ridge, were collectively illuminated for  $\sim 98\%$  of the time (Figure 1). At the north pole, several areas on the rim of Peary crater were constantly illuminated for an entire summer day (Figure 2). It was not possible to claim if these areas would be constantly illuminated but they represent the best candidate sites. Comparing the low spatial-resolution illumination maps with high-resolution imaging data revealed that the areas that receive the most illumination were associated with relatively small topographic highs (Figure 3).

*Topographic Simulations:* Analysis of images has pros and cons. The advantages are that an image definitively shows which portion of the surface is illuminated or shadowed for a given Sun position. However it shows it only for an instant in time. Two images taken a few hours apart may show the same region to be illuminated in both. But one has to infer that it was illuminated for the entire time in between images. Illumination simulations permit the investigation of all possible lighting conditions. The ideal scenario involves using real lunar topographic data. In the 90's

there were two primary lunar-polar topographic data sets available, Goldstone radar-derived [3] and Clementine stereo [4,5]. Margot used a 600 m/pixel Digital Elevation Model (DEM) he generated using Goldstone radar data to map out areas of permanent shadow near both lunar poles.

Bussey compared simulations using the Margot data and Cook stereo with actual images [6]. He concluded that the radar-derived DEM produce the more realistic simulations but that neither data set was sufficiently accurate to produce quantitative illumination maps. Both data sets yield errors in simulations, either predicted areas to be dark when the image shows it to be light, or vice-versa. As an alternative approach Bussey used realistically shaped craters to investigate the amount of permanently shadowed regions within simple craters [7]. He concluded that simple craters as far away as  $12^\circ$  latitude from the pole can contain permanent shadow, and that the total amount of permanent shadow was far larger than previously predicted (Figure 4).

*SMART-1 AMIE data:* ESA's SMART-1 spacecraft orbited the Moon for more than a year and was thus able to observe the entire seasonal illumination variation at the poles. Analysis of AMIE image data revealed the location of a small hill close to Shackleton crater (an area previously identified as having high illumination from the Clementine data) that appeared to be constantly illuminated during a southern summer day [8].

*Kaguya Laser-derived topography:* The JAXA Kaguya spacecraft carried a laser altimeter which produced a DEM of both lunar poles. These data were used to produce quantitative illumination maps for the area within  $5^\circ$  of both poles [9]. They conclude that no areas of permanent sunlight exist at either pole.

**Future Data:** Data from ongoing and soon-to-launch missions raise the possibility of thoroughly characterizing the polar illumination conditions. The LROC instrument on Lunar Reconnaissance Orbiter will take a snapshot at a spatial scale of 100 m/pixel, of the illumination conditions of each pole every two hours. At the same time NAC images at 50 cm/pixel will reveal surface illumination conditions in unprecedented detail.

The polar DEMs produced by the Kaguya, Chandrayaan-1 and LRO missions will be of much higher fidelity than is currently available and will permit very detailed illumination studies to be conducted.

**References:** [1] Bussey D. B. J. et al. (1999) *GRL*, 26, 1187 [2] Bussey D. B. J. et al. (2005) *Nature* 434, 842 [3] Margot J. L. (1999) *Science*, 284, 1658. [4] Cook A. C. et al. (2000) *JGR*, 105, 12023, [5] Rosiek M. R. et al. (1999) *LPSC XXX*, #1853 [6] Bussey D. B. J. et al. (2001) *LPS XXXII*, Abstract #1907. [7] Bussey D. B. J. et al. (2003) *GRL*, V30 #6, 1278, [8] Josset J-L. et al. (2007) *ILEWG9*, #220 [9] Noda H. et al. (2008) *GRL*, 35, L24203

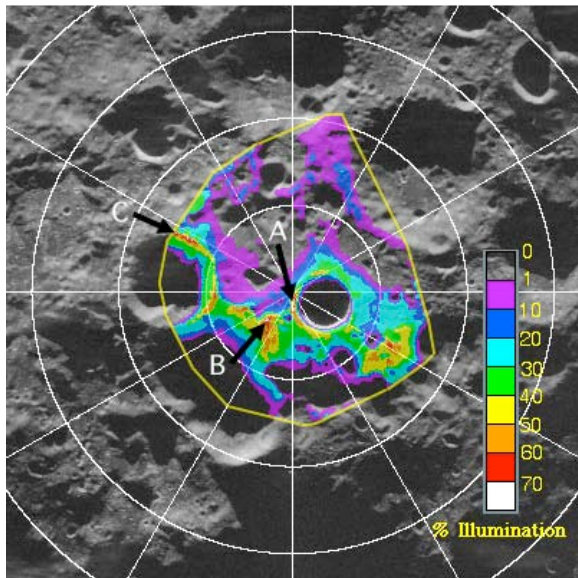


Figure 1. South pole quantitative illumination map derived from Clementine UVVIS data [1].

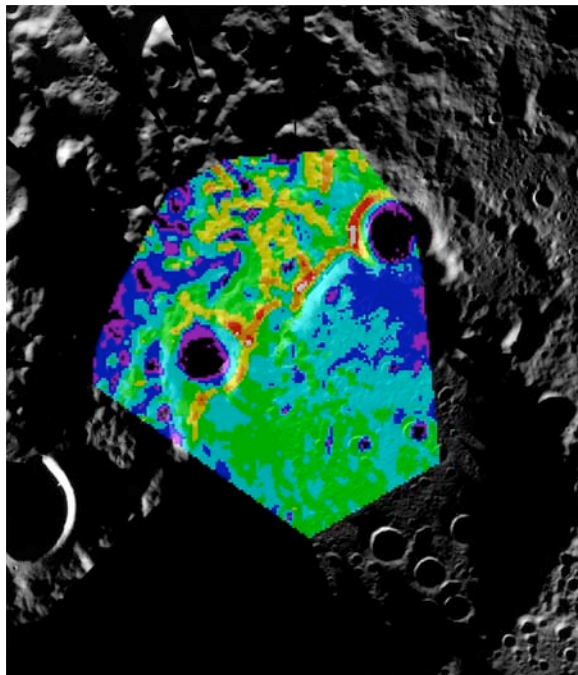


Figure 2. North pole quantitative illumination map [2].

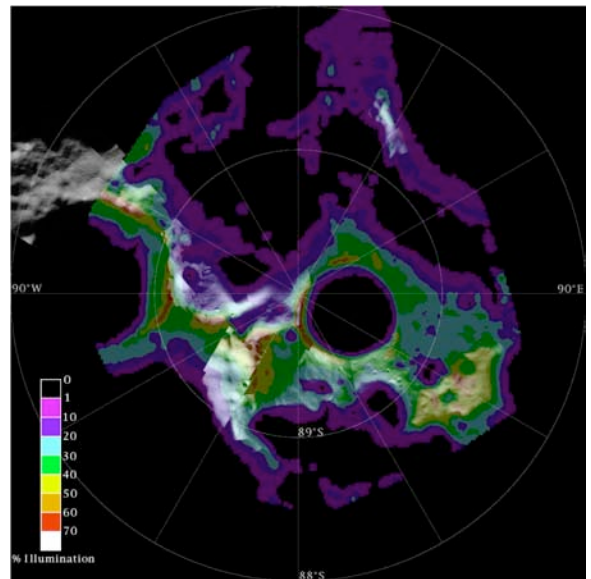


Figure 3. South pole illumination map overlaid on top of a Clementine hi-res mosaic.

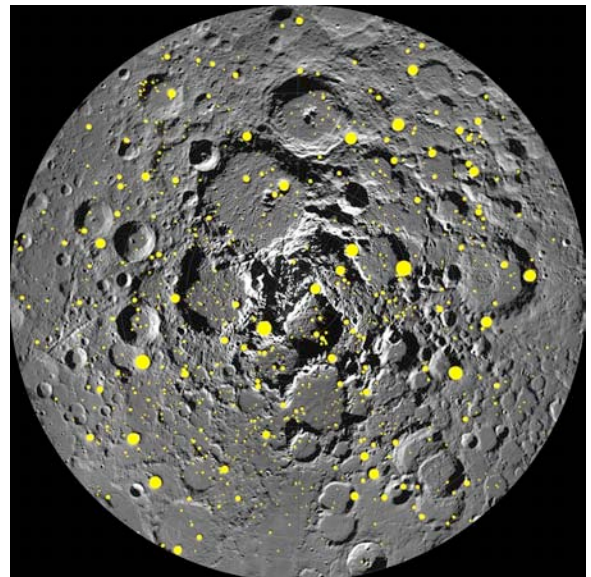


Figure 4. Map showing simple craters near the north pole that contain permanent shadow.