CONSTRUCTING NAC POLAR MAPS THAT OPTIMIZE LUNAR SURFACE ILLUMINATION.
D.A. Waller[1], A.K. Boyd[1], E.J. Speyerer[1], and M.S. Robinson[1], and the Lunar Reconnaissance Orbiter Camera Science Operations Center, [1]School of Earth and Space Exploration, Arizona State University, PO Box 873603, Tempe, AZ 85287-3603 (dwaller@ser.asu.edu).

Introduction: The Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Cameras [1] (NACs) collect images with 0.5-2.0 m/pix scale, depending on altitude and summation mode. The NACs have a combined 5.7º field of view (FOV) with 5 km cross-track coverage and up to 100 km down-track coverage at an altitude of 50 km.

The Moon's spin axis is inclined 1.54º with respect to the ecliptic plane causing extreme polar lighting conditions with very high incidence angles (>87º) [2]. Some massifs receive persistent illumination (only brief periods of shadow) throughout the year and are ideal targets for future robotic exploration as well as human exploration [1,3]. Surface-temperature maps derived from LRO's Diviner Lunar Radiometer Experiment [4] reveal large portions of the polar regions that are cold enough to trap water ice and other volatile materials [5]. Assuming that these volatiles are mainly derived from impacts by primitive solar system bodies, the poles are important locations for exploration.

Following the initial commissioning phase that ended in September 2009, LRO entered a quasi-circular 50-km mapping orbit, where it remained until December 2011 when it transitioned into a fixed orbit similar to the commissioning phase orbit (30 x 220 km). Both orbit configurations allow imaging of the poles roughly every two hours [6]. While the NAC FOV limits broad coverage of the polar region in a single frame, image sequences acquired over time build up broad areas of coverage.

Due to the high incidence angle at the poles, small changes in local topography and Sun azimuth drastically affect the amount and area of surface illumination. These highly variable lighting geometries makes combining images acquired at different times difficult. Due to significant shadowing changes from one orbit to the next such products have significant solar azimuth and incidence boundaries that make interpretation of the surface features difficult. To overcome these challenges numerous mosaics were produced to provide uniform lighting over smaller areas, and lighting from different orientations over the same area.

Orbital Mapping Strategies: Two orbital mapping strategies were conducted to maximize the amount of illuminated surface imaged during north and south pole summer solstices.

Stair-step mapping method: With this method the poles were imaged in a staggered, three-tier, *stair-step* pattern within 5º of the poles that repeated every three orbits. During the first orbit in the series, the surface from roughly 2.5º away from the pole on the illuminated side to 0.8º past the pole was imaged, and during the second and third orbits the surface was imaged between 4.5º and 2.5º away from the pole on the illuminated side. The Moon rotates under LRO once every ~28 days, allowing the NACs to complete one polar mosaic each sidereal month. To fill in data gaps between the successive series of *steps,* and to ensure complete polar data coverage, this process was repeated for 5 months, and the 5 maps were sequentially layered.

Concentric ring mapping method: With this method, NAC images of the surface were taken in 5 overlapping concentric rings centered on the poles [Fig. 1]. Like the *stair-step* method, this method of mapping requires ~28 days to progress across all 360º of longitude. Coverage out to 4.5º away from the pole was built up over 5 months. Unlike the *stair-step* method, the NACs image the same latitude for a 28-day mapping cycle while the Moon rotated under LRO.

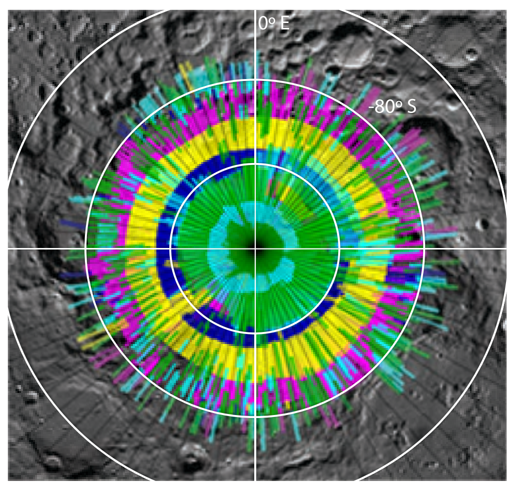

Figure 1. South pole NAC footprints from -80º to -90º latitude during 5 consecutive months represented by green, light blue, dark blue, yellow and pink footprints temporally centered on the southern summer solstice (24 September 2010). WAC basemap; 0º E is towards the top of the image.

Coverage by solstice: In 2011, a set of uncontrolled 2 m/pix mosaics of the north and south poles were constructed and released [*http://wms.lroc.asu.edu/lroc/nac_polar_mosaic*]. Coverage was restricted to images taken during the 5 months centered on northern and southern summer solstice (4 April 2010 and 24 September 2010). The mosaics were archived in 24 polar stereographic tiles in three latitude bands of 1.5º each, radiating from the poles.

For this study, preliminary 25 m/pix mosaics were produced using data from the 2011 south and north pole summer solstice periods (February through June 2011 and July through November 2011, respectively). Images were restricted to emission angles <10º and incidence angles <120º. Mosaics consisted of radiometrically calibrated, polar stereographic mapped images binned into 1-week increments [Fig. 2].

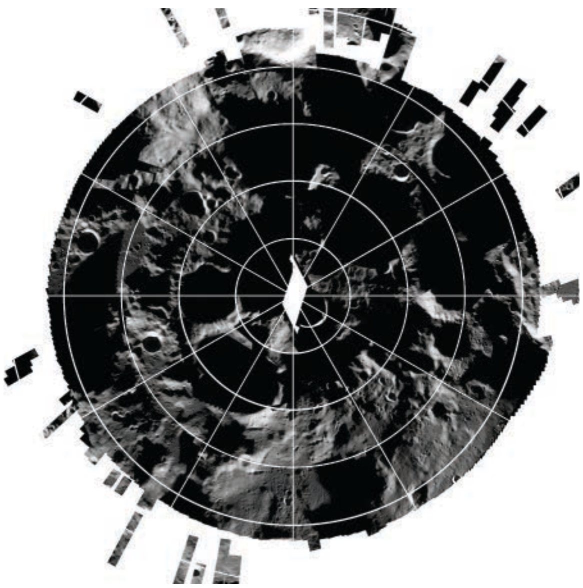

Figure 2. Uncontrolled 25 m/pix south pole NAC summer mosaic with data from -85º to -90° latitude. NAC images were restricted to 5 months (July through November 2011) centered on the southern summer solstice. 0º E is towards the top of the image.

Priority by sub-solar longitude: An alternate mosaic generation technique was proposed to optimize uniform viewed illumination of the poles. Similar to the mosaics restricted by the period centered on the summer solstice, the images used in these mosaics were restricted to the summer season. NAC images were also restricted by emission angles < 10º and incidence angles <120º. Valid NAC images from the entire mission were considered and coverage consisted of data restricted by a sub-solar latitude of 0.75 to 1.5 for the north pole and -1.5 to -0.75 for the south pole. These local noon mosaics were constructed from 36 radiometrically calibrated, polar stereographic map projected NAC mosaics, each varying with only 10º sub-solar longitude. Mosaics using 30º, 20º and 10º of illuminated surface centered on each local noon mosaic were stacked sequentially to optimize coverage and uniformity. This alternate product not only increased the amount of uniform coverage in the mosaic, but also shows more illuminated surface area [Fig. 3].

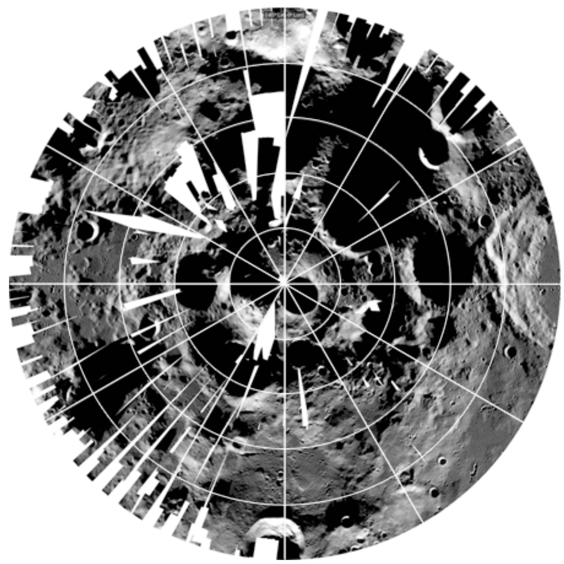

Figure 3. Uncontrolled 25 m/pix south pole NAC noon mosaic with data coverage from -85º to -90°. NAC images were binned by 10º of sub-solar longitude, and stacked with increased priority as the sub-solar longitude approached the imaging longitude. 0º E is towards the top of the image.

Future Work: Products are currently being constructed that reflect morning and evening illumination conditions using the technique of restricting the data coverage by sub-solar longitude.

References: [1] Robinson M.S. et al., (2010) *Space Sci Rev. 150,* 81-124. [2] Ward W.R., (1975) *Science 189*, 377 [3] Bussey D.B. et al., (1999) *Geophys. Res. Let. 26*, 1187-1190 [4] Paige D.A., et al., (2010) *Space Sci. Rev. 150*, 125 [5] Paige D.A. et al., (2010) *Science 330*, 479-482 [6] Tooley C.R. et al., (2010) *Space Sci. Rev. 150,* 23-62.