LUNAR RECONNAISSANCE ORBITER CAMERA PERMANENTLY SHADOWED REGION UNCONTROLLED MOSAICS AND ATLAS E. Cisneros[1], K.N. Paris[1], R.Z. Povilaitis[1], M.S. Robinson[1], and the LROC Team, [1]Arizona State University, School of Earth and Space Exploration, PO Box 873603, Tempe AZ, 85287-3603 ecisneros@asu.edu.

Introduction: The Lunar Reconnaissance Orbiter (LRO) spacecraft entered lunar orbit in June of 2009 [1]. One of the key areas of scientific interest for the Lunar Reconnaissance Orbiter Camera (LROC) are the lunar poles, specifically permanently shadowed regions (PSRs) [2]. The LROC Narrow Angle Camera (NAC) acquires long exposure observations of PSRs at times of optimal lighting (low beta angle, respective summers) in the north and south pole regions of the Moon [3].

Acquisition of NAC PSR observations was optimized over several campaigns to maximize signal-to-noise ratio (SNR), resulting in a comprehensive dataset that is now being systematically reviewed and analyzed [4]. Given the number of PSR observations collected (7,495 NAC pairs as of 1 Jan. 2016), the majority of the data has not yet been analyzed for scientifically interesting features. To facilitate such analysis, an atlas is being compiled for PSRs above a certain size threshold (5 km diameter) that will include a zoomed-in view of the PSRs, associated meta-data, and comments regarding any features of interest. The atlas is being generated from north and south pole PSR uncontrolled mosaic products.

PSR Mosaic Processing and Assembly: As NAC PSR observations are acquired and delivered to the LROC Science Operations Center (SOC), automated processing occurs to generate Planetary Data System (PDS) Experiment Data Record (EDR) and Calibrated Data Record (CDR) products for release and archive. LROC NAC EDR observations tagged as part the of PSR campaigns are further processed from Level 0 products into Level 3 products [5], utilizing routines from the Integrated Software for Imagers and Spectrometers (ISIS) software suite [5,7]. Post-processing evaluation is performed using QGIS [8], which allows loading of individual observations on top of LOLA topography [9] and PSR boundary shapefiles to determine suitability for inclusion into the final PSR mosaic or atlas products.

Observations are acquired at a variety of pixel scales (2 to 20 meters per pixel). The final PSR mosaics are assembled from re-sampled images to 20 meters per pixel, and ordering of images is based on image quality and areal coverage of individual PSRs.

North Pole PSR Mosaics. A total of 550 NAC images were used to create a north pole PSR mosaic at 20 meters per pixel (mpp), 90° to 80° latitude and 0° to 360° longitude (**Fig. 1**) This mosaic will be merged with the existing LROC NAC North Pole RDR product to replace over-saturated illuminated polar areas. The final merged product will be release to the PDS

South Pole PSR Mosaic. A total of 2,684 NAC images were used to create a south pole PSR mosaic at 20 mpp, -90° to -80° latitude and 0° to 360° longitude **(Fig. 2).** This mosaic will be merged with the existing LROC NAC South Pole RDR product to replace over-saturated illuminated polar areas. The final merged product will be released to the PDS.

PSR Atlas: Using the extensive catalog of LROC NAC PSR images, we are creating an atlas showing full resolution views (north and south pole) of PSRs in craters with diameters >5 km. For each PSR, temporal coincident observation will be displayed at full resolution, as well as a composite best resoultion view. The atlas will include information on the size of the PSR, and any noteworthy features found in the PSR images. Initial efforts have been focused on PSR regions overlapping named craters corresponding to area of high scientific interest. Craters include Shackleton, Cabeus, Amundsen, DeForest, Faustini (**Fig. 3**), Haworth, Shoemaker, and Lovelace.

Long-term tasks include quarterly updates to the PSR Atlas PDF file, releasing north and south pole mosaic products at 20 mpp resolution as PDS RDR products, and improving coverage and quality of PSR images (replacing with images of higher SNR) [10].

Conclusions: Compilation of the Lunar PSR Atlas will provide a much needed and useful tool for the planetary science community to further facilitate study of the lunar polar regions. Coupled with the other LRO instrument data sets, a more complete understanding of the lunar poles can be pursued.

References:

[1] Tooley, C.R. et al. (2010) Lunar Reconnaissance Orbiter Mission and Spacecraft Design. Space Sci Rev, 150:23-62. [2] Robinson, M.S. et al. (2010) Lunar Reconnaissance Orbiter Camera (LROC) Instrument Overview. Space Sci Rev, 150:81-124. [3] Koeber, S.D., and Robinson, M.S. (2013) LROC Observations of Permanently Shadowed Regions, Lunar and Planetary Science Conference, XLIV, abstr. 2588. [4] Koeber, S.D, Robinson, M.S., and Speyerer, E.J. (2014) LROC Observations of Permananetly Shadowed Regions of the Moon, Lunar and Planetary Science Conference, XLV, abstr. 2811. [5] NASA Plane-

tary Data System (2009) Planetary Data System Standards Reference, version 3.8. [6] Becker, K.J. et. al. (2013) ISIS Support for NASA Mission Instrument Ground Data Processing Systems, Lunar and Planetary Science Conference, XLIV, abstr. 2829. [7] Anderson, J.A. et. al (2004) Modernization of the Integrated Software for Imagers and Spectrometers, Lunar and Planetary Science Conference, XXXV, abstr 2039. [8] QGIS Development Team (2015) QGIS Geographic Information System, Open Source Geospatial Foundation Project, http://qgis.osgeo.org [9] Neumann, G. A. (2011), Lunar Reconnaissance Orbiter Lunar Orbiter Laser Altimeter Reduced Data Record and Derived Products Software Interface Specification, ver. 2.42. http://imbrium.mit.edu/DOCUMENT/RDRSIS.PDF. [10] Bowman-Cisneros, E and Eliason, E (2011) LROC RDR Data Product Software Specification v1.4, http://lroc.sese.asu.edu/data/LRO-L-LROC-5-RDR-V1.0/LROLRC_2001/DOCUMENT/RDRSIS.PDF.

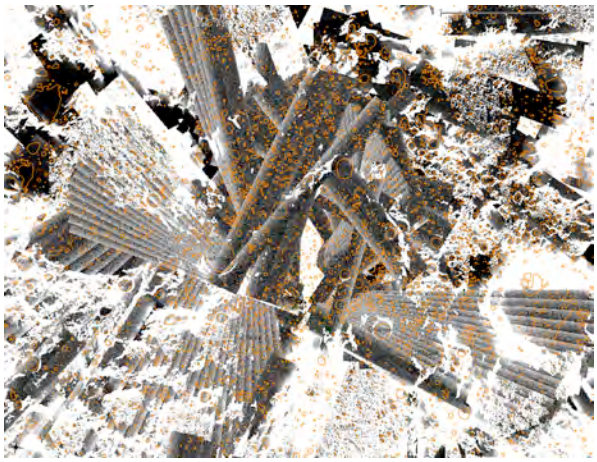

Figure 1: LROC NAC North Pole PSR mosaic at 20 mpp.

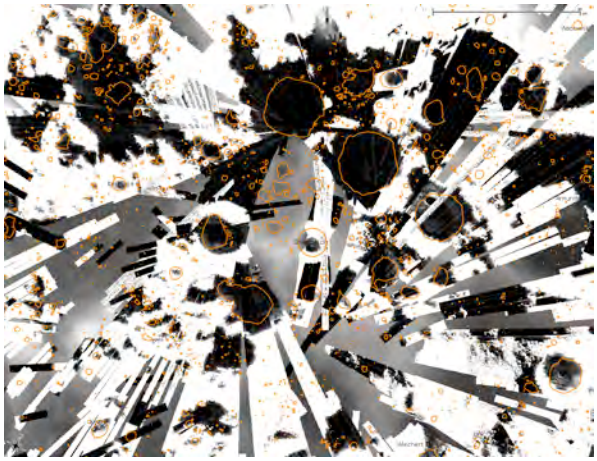

Figure 2: LROC NAC South Pole PSR mosaic at 20 mpp.

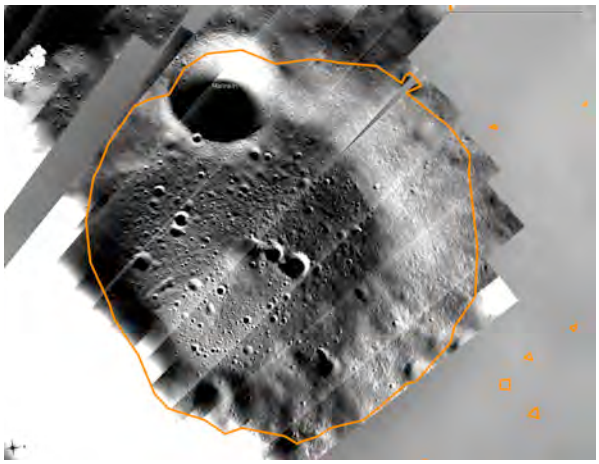

Figure 3: Example of temporally coincident NAC observations of Faustini Crater (-87.18°, 84.31°) – DN values stretched to enhance PSR region, orange line marks boundary of PSRs.