EXPLORATION OF THE LUNAR SOUTH POLE WITH LROC DATA PRODUCTS. E. J. Speyerer and M. S. Robinson, A. Boyd, R. V. Wagner, and M. R. Henriksen. School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287 (espeyerer@ser.asu.edu).

Introduction: The Lunar Reconnaissance Orbiter Camera (LROC) has acquired over a decade of observations since the mission commenced in June of 2009. One of the original, primary scientific objectives of LROC was to identify regions of permanent shadow and extended illumination. This objective was achieved with all three cameras that make up the LROC instrument: the Wide Angle Camera (WAC) and the twin Narrow Angle Cameras (NACs). Together these cameras provide multi-temporal and high-resolution imaging near the lunar poles. As of 30 January 2020, the WAC has acquired 44,202 observations within 6° of the lunar south pole, while the NACs have acquired a combined 90,990 observations. While the drift of the LRO orbit plane away from the pole has eliminated nadir observations within 2° of the poles since August 2014 (currently about 3.75° away), the extensive catalog of polar images and products will aid future polar missions in identifying ideal landing sites, hazards, as well as provide context around areas of high scientific interest.

WAC Summer Mosaics: Over the course of a month, the WAC can image nearly the entire lunar surface. By mosaicking thousands of WAC images together, the LROC team produces large scale map products such as the one shown in **Fig. 1**. These images were selected from a sequence acquired between 21 September and 23 October 2010 when the sub-solar point was lowest in the southern hemisphere (around 1.5° S) and when the angle between the Sun vector and the orbital plane of the spacecraft was minimized. With this geometry, many of the shadows are at a minimum providing a contextual view of the polar region.

WAC Polar Movies: While LRO was in the 50 km circular orbit, the WAC acquired an observation of the polar region during each opportunity (every ~2 hours). These images were individually map projected and the image sequence was converted into a movie that highlights the effects of the grazing sun angles and the effect of the lunar seasons. In total, the 8170 map projected WAC observations of the south pole are available through the LROC RDR sites (**Table 1**).

WAC Illumination Maps: Using a yearlong subset (15 February 2010 to 5 February 2011) of WAC observations, we constructed a set of illumination maps (**Fig. 1**) for each pole. Each observation was converted into a binary image indicating the illumination state at that time. The final maps were derived by taking the number of times a pixel was illuminated over the number of instances the pixel was imaged. The map highlights areas of extended illumination and regions that remain in perpetual shadow.

NAC Illumination Map: While the NAC dataset does not have the extensive multi-temporal coverage that the WAC does, due to a narrower field of view (5.7° combined vs. 90°), the NACs have acquired thousands of images over a full range of lighting conditions thus enabling the study of the polar lighting conditions at the meter scale (**Fig. 1**). To create the illumination map, the images were projected and converted into a binary image to represent the illumination state. Binary images were stacked in map space and the percent each pixel was illuminated was calculated. Since the NAC does not image the same area during every orbit, we cannot provide meaningful estimates for the length of time a feature is illuminated at this scale, but we can identify potential PSRs that have remained shadowed in all images acquired to date and regions that have remained illuminated for nearly all the observations acquired.

NAC Stereo Observations: A sequence of NAC geometric stereo observations near the south pole and several sites of interest in the region were acquired. Some portions of stereo observations have jitter due to movement of the solar array during the observation. However, several segments have been reduced into digital terrain models (DTMs). Several of these products have been controlled to laser altimeter profiles to create accurate and precise regional DTMs [1].

NAC Oblique: As the orbit extends further from the poles, the LRO spacecraft must slew to image targets close to the poles. These oblique off-nadir observations provide a contextual reference as well as the ability to visually assess the regional topography (**Fig. 2**). An example of an oblique image is shown on the following page highlighting several peaks that are received extended periods of illumination [2-4].

References: [1] Gläser et al. (2013) *PSS*, 89, p. 111-117. [2] Bussey et al. (1999) *GRL*, 26 (9), 1187-1190. [3] Mazarico et al. (2011) *Icarus*, 211, 1066-1081 [4] Speyerer and Robinson (2013) *Icarus*, 222, 122-136.

Table 1: Links to LROC Reduced Data Record (RDR) Products of the South Pole. To access the links, append the *ID* to "http://wms.lroc.asu.edu/lroc/view_rdr/"

Product	ID
WAC Summer Mosaic	WAC_ROI_SOUTH_SUMMER
WAC Polar Movies	WAC_POLAR_MOVIE_SOUTH
WAC Illumination Map (percentage)	WAC_POLE_ILL_PCT_SOUTH
WAC Illumination Map (time weighted)	WAC_POLE_ILL_TWI_SOUTH

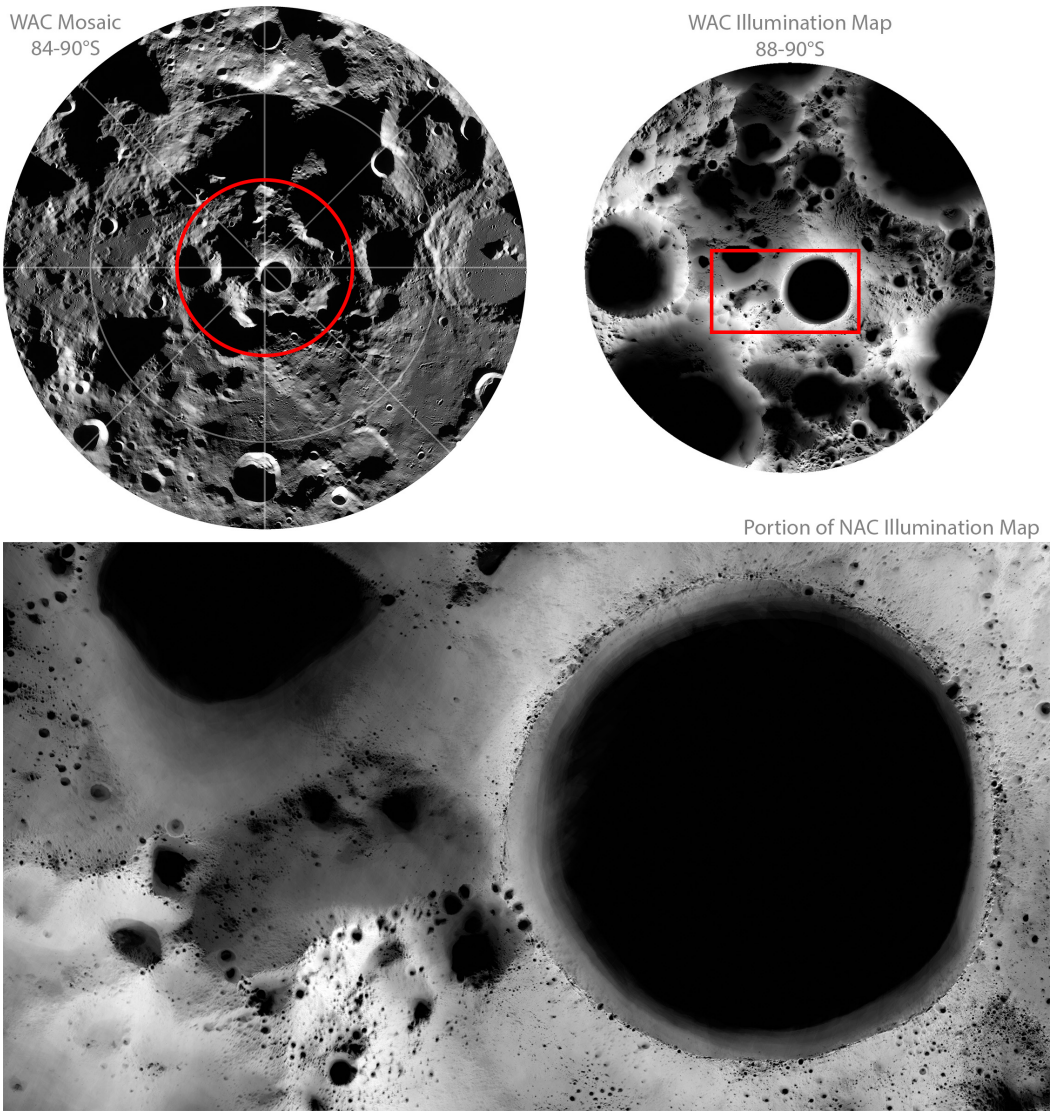

Fig. 1- Example LROC WAC mosaic cropped to within 6° of the lunar south pole along with WAC and NAC illumination maps of the region. The WAC illumination map covers the region enclosed by the red circle in the basemap while the 44 x 24.5 km portion of the NAC illumination map covers the region highlighted by the red box in the WAC illumination product.

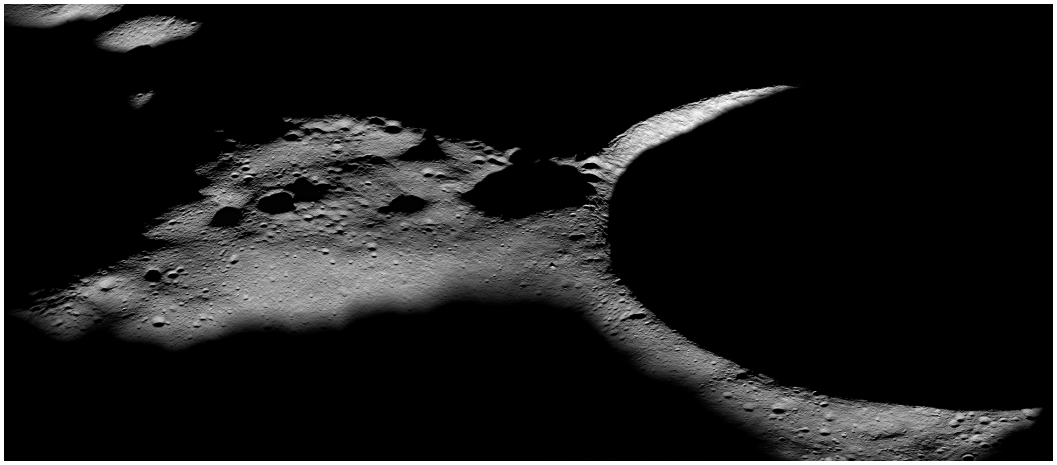

Fig. 2- NAC Oblique (M1322065387L/R) of the rim of Shackleton crater (right side) and the illuminated ridge heading toward de Gerlache crater (left). The image is approximately 30 km across.