NEW MOSAICKED DATA PRODUCTS FROM THE LROC TEAM. R. V. Wagner, E. J. Speyerer, M. S. Robinson, and the LROC Team. School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-3603 (rvwagner@asu.edu).

Introduction: The Lunar Reconnaissance Orbiter Camera (LROC) consists of two imaging systems. The Wide Angle Camera (WAC) is a seven-band imager with a 60° field of view (FOV) in color mode, and a 90° FOV in monochrome mode. The WAC acquired images with a nadir pixel scale of 75 m from a 50 km near-circular orbit from 2009 through 2011, and nadir pixel scales ranging from 50-300 m from a 30×180 km orbit since December 2011. The Narrow Angle Camera (NAC) consists of two line-scan cameras aimed side-by-side with a combined 5.7° FOV, and pixel scales of 0.5-2 m (0.5 m from 50 km altitude) [1].

The LROC Science Operations Center has released over one million NAC and WAC raw images since 2009. Subsets of these images were used to produce digital maps and mosaic products, publicly released through NASA's Planetary Data System (PDS), to aid scientists and engineers in planning future lunar missions and addressing key science questions. This abstract describes Reduced Data Record (RDR) products released since 2012 (previous releases are described in [2]). The RDRs can be accessed from the LROC WMS server at http://wms.lroc.asu.edu/lroc or downloaded at http://lroc.sese.asu.edu/data.

Monthly WAC Mosaics: Every 28 days the WAC FOV covers nearly every point on the Moon (Fig. 1). We created a set of 62 monochrome (643 nm band) global mosaics, each containing all the illuminated nadir-looking images from ~1 month of orbits, mosaicked in precedence of lowest incidence angle (angle between Sun and zenith). These mosaics are archived in simple cylindrical projection at 1 km/px. The images in these and all other WAC mosaics described here were photometrically normalized using the equations described in [3].

No-Slew Nearside Dawn Mosaic: The No-slew mosaic (90°W to 90°E) was constructed from images acquired from two weeks in Dec 2010, where the LRO spacecraft was held nadir-pointing to produce a nearly seamless large incidence angle mosaic of the nearside. Small inter-image gores were filled in with images with similar lighting geometry (from June 2011 and Dec 2011). The incidence angle at the equator ranges from 69°-84° (Fig. 2).

Farside Dusk Mosaic: This is a sister product to the no-slew mosaic, covering the area from 90°E to 270°E with a similar range of incidence angle. Because the lighting geometry almost repeats itself on a six-month cycle at a given longitude, this mosaic was made with a lighting direction opposite from that of the no-slew mosaic in order to match the incidence angle range as closely as possible (Fig. 2). The primary layer of images was from June-July 2011, with inter-image gores (including some from spacecraft slews) filled by images from July 2010, Jan 2011, Jan 2012, and June 2012. Incidence angle at the equator ranges from 70°-87°.

WAC Morphology Basemap: The LROC team re-released the WAC global morphology mosaic [4] with updated camera pointing, a new photometric correction, and an updated image selection at the poles.
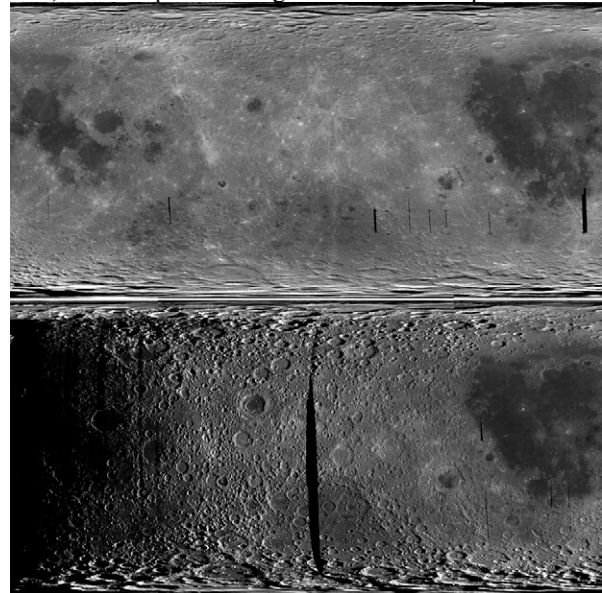

Figure 1: Example WAC monthly mosaics from October (top) and December (bottom) 2012. Gores are areas where there is no nadir-looking WAC coverage for that month.
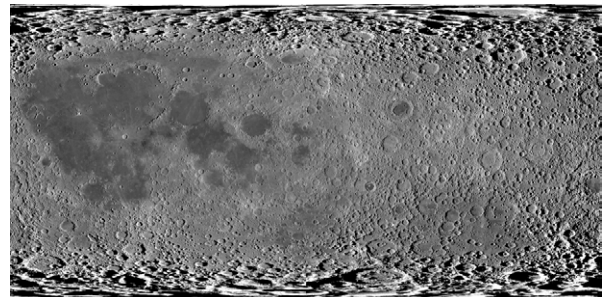

Figure 2: The nearside dawn (*left half*) and farside dusk (*right half*) high-incidence-angle mosaics.

Polar NAC Mosaics: These mosaics are updates of the previously-released NAC polar mosaics [2,4], with the pixel scale improved to 1 m and additional images added to improve lighting consistency. The new mosaics use images from northern and southern summer,

where the sub-solar latitude is on the pole-ward side of the equator. Images with pixels scales >1.25 m are used only to fill in gores, regardless of their lighting geometry. The mosaics use 1590 and 1293 NAC images for the north and south poles, respectively (Fig. 3).

Image mosaicking order was based on [4]: first sort the images by sub-solar latitude in 0.5° bins, then sort each bin by the difference between the sub-solar longitude and the longitude of the center of the end of the image closest to the sub-solar point. Additionally, pole-crossing images were trimmed to remove the part of the image on the opposite side of the pole from the sub-solar point. To tweak the automated list to get the final image order, a 100 m/px preview mosaic was created using all images, with each pixel selected from the image with the lowest incidence angle at that point. This process is unsuitable for making the final mosaic, as it leaves some edge-of-image artifacts, but it produces a "best possible" reference image that can be used to find places where the automatic layering order is suboptimal. The images at problem spots were manually reordered to result in uniform lighting.

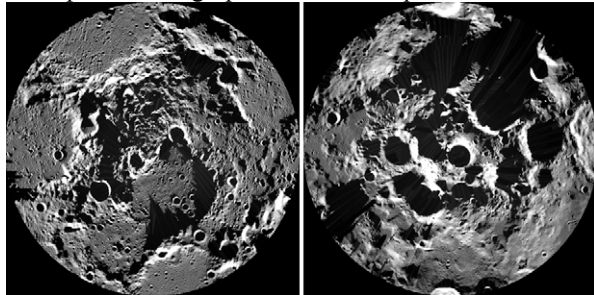Both the north and south pole mosaics are archived in 40 polar stereographic tiles at 1 m/px.

Figure 3: North (*left*) and south (*right*) polar NAC mosaics, each covering from 85.5° to the pole.

Lunar North Pole Mosaic (LNPM): The LRO Extended Mission orbit, with an apoapsis of ~180km over the north pole, allows for coverage with consistent lighting out much further than 4.5° from the pole (Fig. 4). We produced a 2 m/px mosaic from 60°N to the north pole, and are working to extend it further. This product can be browsed on the LROC website at lroc.sese.asu.edu/gigapan/.

A series of "collar" imaging campaigns were executed to build up coverage for the LNPM [2]; for one-month periods, the NACs would image a specific latitude band on every orbit (or every other orbit). Due to the high orbital altitude in the far northern hemisphere, NAC footprints on adjacent orbits overlap, so this imaging sequence produces seamless mosaics with consistent lighting at a given latitude. By using 17 partial and complete collars, taken over a 2-year period, combined with the 90-85.5° north pole mosaic, along with

a handful of images to fill small gores, we produced a 681 gigapixel mosaic consisting of 10,581 mostly low-incidence-angle NAC images, extending out to 60° [5].

Future Expansions: Below 60°N, the orbital altitude is too low, and the orbit tracks too far apart, to support continuous collar imaging campaigns. We will use the large archive of existing images at those latitudes to produce a high-sun mosaic out to around 40-45°N, supplemented with a campaign to target the scattered gores where we do not already have coverage under appropriate lighting conditions. Ordering for these images will use a similar scheme to that of the polar mosaics described above. The gore-filling campaign is estimated to finish sometime in 2015.

At the south pole, it is harder to extend the polar mosaic, as the Extended Mission orbit is lower over the south pole (~30km) than it was during the 50km near-circular orbit. It is not possible to take collar image sequences due to the small image footprints, so any extension will use images acquired from many different time periods. Work is ongoing to select images and target gores for this extended south pole mosaic, with the intent of creating a 1 m/px product that goes out past 80°S, perhaps as far as 70°S.
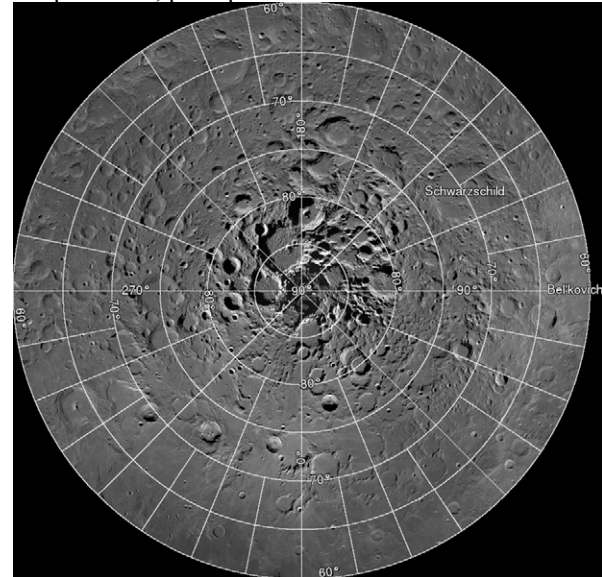

Figure 4: A zoomed-out view of the annotated version of the Lunar North Pole Mosaic. The inner-most latitude circle roughly corresponds to the north pole mosaic in Figure 3.

References: [1] Robinson et al. (2010) *Space Sci. Rev*. DOI: 10.1007/s11214-010-9634-2. [2] Henriksen et al. (2013), LPS XXXXIIII, Abstract #1676. [3] Sato et al. (2014), *JGR*, DOI: 10.1002/2013JE004580. [4] Speyerer et al. (2011), LPS XXXXII, Abstract #2387. [4] Waller et al. (2012), LPS XXXXIII, Abstract #2531. [5] http://lroc.sese.asu.edu/posts/738