GLD100 – THE GLOBAL LUNAR 100 METER RASTER DTM FROM LROC WAC STEREO MODELS.

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Introduction: The Wide Angle Camera (WAC) of the Lunar Reconnaissance Orbiter Camera system (LROC, [1,2]) provides image data with substantial across-track stereo coverage. After commissioning (until September, 2009) and the primary mission (until September 2010) LRO is now in its science mission phase. While the commissioning phase was characterized by an elliptical orbit (45-190 km altitude), the primary mission and the first months of the science mission phase provide a circular orbit, with orbit altitude varying about a mean of 50 km.

Image Characterization and Stereo Conditions: The LROC WAC consists of a 1k x 1k CCD frame which is split up into sub-frames for seven different spectral bands. Subframes consists of 14 lines with 704 pxl/line, while subframes form an image strip ("push-frame" principle). Single WAC images within an orbit cover 10° of latitude. For WAC stereo processing we use the near-nadir band (604 nm). From nominal 50 km orbit altitude LROC WAC image have a 75 m/pxl ground scale. WAC images from adjacent orbits have approximately 50% overlap and 30° stereo angle at the equator. The stereo angle decreases to 6° at 80° latitude.

Stereo Processing:. Area-based image matching procedures are applied to overlap of WAC images from adjacent orbits. Combining image coordinate pairs, camera calibration, camera alignment, and spacecraft orientation data (reconstructed orbit and pointing) we derived ground points by 3D forward ray intersection [3]. Because of illumination conditions (cast shadows/ low sun angles) and poor stereo conditions (polar orbits typically yield small stereo bases at high latitudes) images acquired in latitudes higher than 80° are excluded from stereo image processing.

Previous Results: From early photogrammetric processing of WAC stereo data of the first 5 months of the LRO mission (3 months commissioning and first 2 months of the primary mission phase) we obtained a 1 km raster WAC digital terrain model (DTM) which covered already 96% of the lunar surface [4].

Recent Results: WAC stereo data of the entire primary mission phase have been used for a systematic processing towards a 100 m raster DTM (Fig. 1). Due to multiple coverage (global coverage under different illumination within each month), local gaps that appear in shadow areas were reduced significantly.

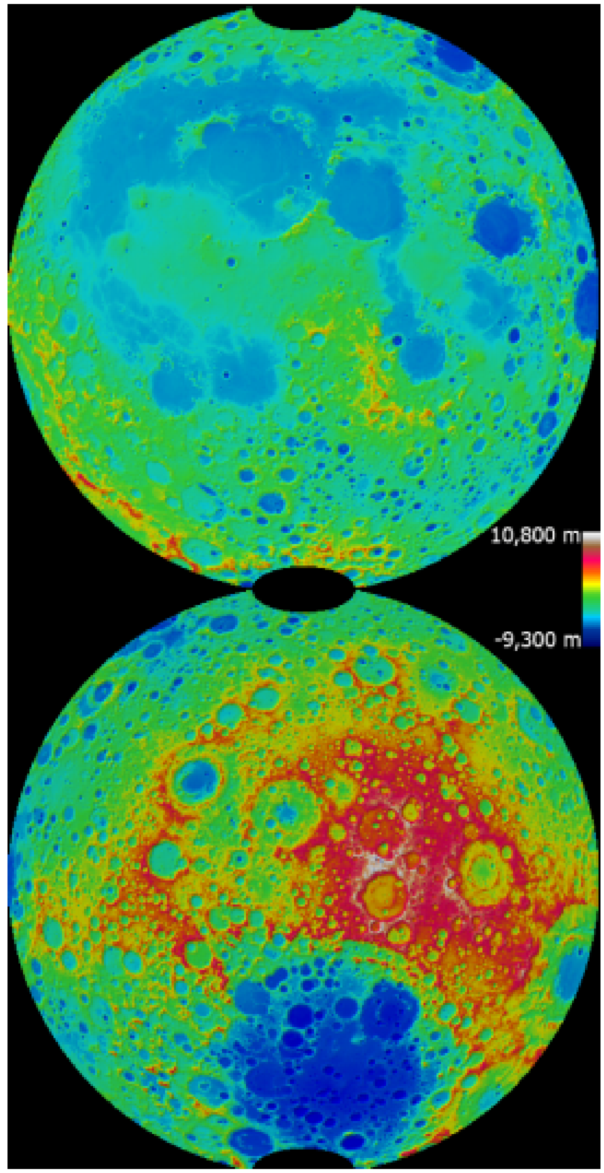

Fig. 1: LROC WAC DTM (GLD100), 100 m grid, near side (top) and far side (bottom), Lambert Azimuthal projection

The density of the 3D ground points was maximized by stereo processing at full image resolution (60-90 m/pxl). A total number of ~44,000 stereo models within the primary mission provided more than 56 billion points (~1,500 points/km^2, ~15 points/100m-cell). The mean relative accuracy is indicated by the 3D forward ray intersection error, i.e. 18 m (1σ) which corresponds to 0.24 WAC pixel. Points with a relative accuracy >50 m have been excluded from the final model. With primary mission stereo data 99.44% of 80° S to 80° N has been covered. Additional 0.4% of coverage could be achieved by integration of 5 billion points from processing of thousands of lower resolution commissioning phase stereo models. These data fill remaining local gaps, mostly left due to lack of high-resolution image texture in flat Mare regions on the near side. Thus, only 0.16% of the 80° S to 80° N lunar 100 m raster DTM (GLD100) needed to be filled by interpolation, mainly in high-latitude shadow areas. The total elevation range of GLD100 extends to 20,000 m. The lowest elevation is found within a small crater in the Antoniadi Basin at 70.34° S, 187.60° E (below -9,200 m). The highest elevations (up to 10,770 m) appear near crater Engelhardt at 5.42° S, 201.38° E. The absolute accuracy has been estimated making a first comparison [5] with altimetry data from the LRO LOLA instrument [6] as the current reference. The datasets do not show any significant lateral or vertical offset. The RMS of the vertical differences is 23 m, i.e. less than one third of a WAC pixel. Fig. 2 shows an exemplary color-coded 120 x 120 km subset of the GLD100 model, and the respective color-coded LOLA data (PDS release, September 2010), sampled to 100 m pixels and plotted on top of the GLD100 hill-shaded relief.

Summary: The GLD100 consists of ~50,000 stereo models and represents the first contiguous lunar topography model for |latitude| < 80° at 100 m grid scale. Since it is based upon imagery it allows for a variety of geoscientific analyses, such as precise volume estimations, profiles in latitudinal as well as in longitudinal direction, etc. It also serves as an ideal 3D reference for ortho-rectification of image datasets from various lunar missions. A comparison with LRO LOLA altimetry data instrument shows a good match without significant offsets. The RMS of the randomly distributed vertical differences is 23 m (0.3 WAC pxl)

Outlook: For further quality improvement we will replace low-resolution commissioning phase data by stereo models of the current science mission phase. While LOLA data benefit from crossover-corrected orbit kernels, this initial GLD100 is (by the time of writing) based upon standard reconstructed orbit kernels. The first official version of the GLD100 that will be presented at the conference will also be based on crossover-corrected kernels. Until a formal PDS release which is scheduled for summer 2010 (as a whole and as separated tiles), requests from the science community for specified latitude/longitude ranges of the GLD100 will be satisfied on a best effort basis. As a final step, the derivation of a combined GLD100/LOLA product is planned. It might serve as *the* global 100 m reference topography of the lunar surface for the foreseeable future.

References: [1] M.S. Robinson et al. (2005) *LPSC XXXVI,* #1576. [2] M.S. Robinson et al. (2010) *Space Sci. Rev.,* 150: 81–124, DOI 10.1007/s11214-010-9634-2. [3] F. Scholten et al. (2005) *PE&RS,* 71(10), 1143-1152. [4] F. Scholten et al. (2010) *LPSC XLI,* #2111. [5] F. Scholten et al. (2011) *LPSC XLII,* #2080 (this conf). [6] D.E. Smith et al. (2010) *Geophys. Res. Let.*, Vol. 37, L18204, DOI 10.1029/2010GL043751.

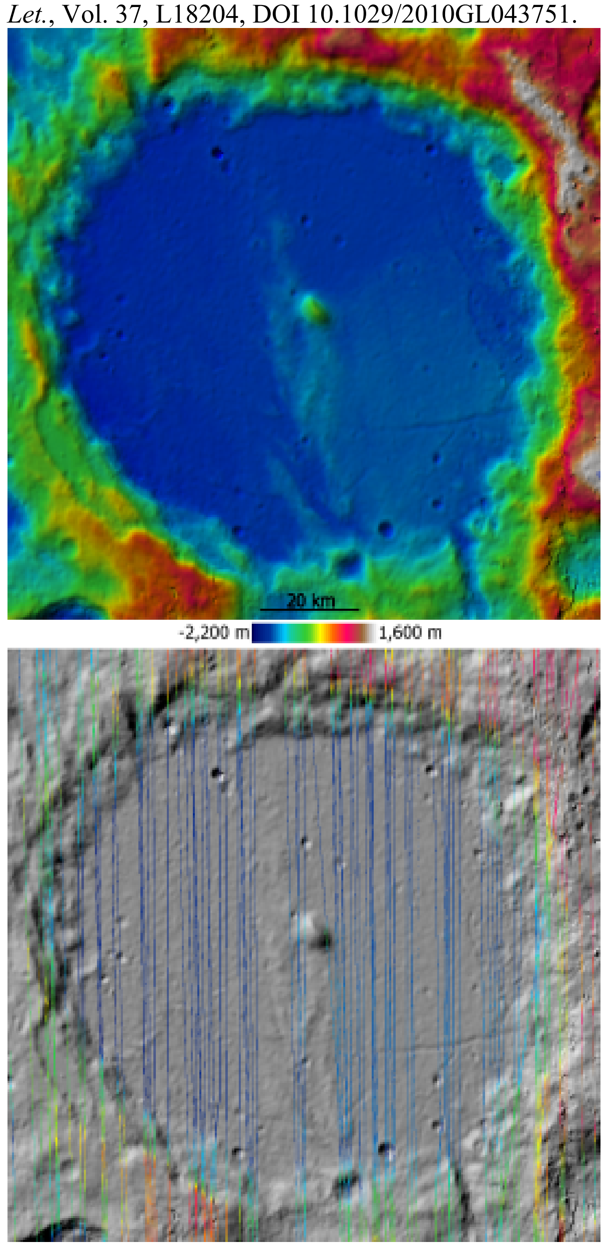

Fig. 2: Alphonsus Crater (13° S, 3° W). Top: Color-coded hill-shaded relief from LROC WAC 100 meter raster DTM (GLD100). Bottom: Color-coded LOLA tracks (PDS release, September 2010), on top of the GLD100 hill-shaded relief.