COMPLEMENTARY LRO GLOBAL LUNAR TOPOGRAPHY DATASETS – A COMPARISON OF 100 METER RASTER DTMS FROM LROC WAC STEREO (GLD100) AND LOLA ALTIMETRY DATA. F. Scholten¹, J. Oberst¹, K.-D. Matz¹, T. Roatsch¹, M. Wählsch¹, P. Gläser², M.S. Robinson¹, E. Mazarico⁴, G.A. Neumann⁴, M.T. Zuber², and D.E. Smith⁴, ⁵. ¹German Aerospace Center (DLR), Institute of Planetary Research, Rutherfordstr. 2, D-12489 Berlin, Germany, (frank.scholten@dlr.de), ²Technical University Berlin, Institute for Geodesy and Geoinformation Sciences, Berlin, ³School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, ⁴Solar System Exploration Division, NASA-GSFC, Greenbelt, MD, USA, ⁵Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA.

Introduction: The Lunar Reconnaissance Orbiter (LRO) is in its near-polar orbit around Moon since July 2009. Apart from other experiments it carries two instruments which provide topographic information of the entire lunar surface, i.e. the Lunar Orbiter Laser Altimeter (LOLA, [1]) and the Lunar Reconnaissance Orbiter Camera (LROC, [2]). The multi-beam LOLA altimeter offers 5 separated 5-m-diameter spots which form 5 parallel profiles along the sub-spacecraft ground track. The Wide Angle Camera (WAC) LROC instrument comprises sub-images from a 1k x 1k CCD frame in 7 different spectral bands. The ground scale from 50 km nominal orbit altitude is 75 m/pxl. WAC images from adjacent orbits overlap by about 50% at the equator.

Data Characteristics: The relative precision of LOLA spot measurements is about one decimeter (on flat surfaces) [1], almost independently from illumination conditions. Thus, multiple profiles of very precise topography measurements are acquired along entire orbit tracks. Because of the polar orbit, the spacing of tracks becomes smaller towards the poles, while substantial gaps of a few kilometers remain at low latitudes. With the significant overlap of subsequent orbits WAC offers substantial across-track stereo capability that is adequate for the systematic derivation of digital terrain models (DTM) up to 100 m grid spacing without gaps. We used the near-nadir band (604 nm) for stereo processing. With sub-pixel image matching precision a 3D point accuracy of a few tens of meters for single stereo measurements and a vertical accuracy of up to 10 m within the DTM can be expected in case of multiple coverage. But as for all image based methods illumination is a limiting factor. Therefore, WAC data of the polar regions beyond 80° northern and southern latitude are not used for stereo processing. While the WAC overlap increases from 50% at the equator towards higher latitudes, the stereo angle decreases from 30° to 6° at 80° latitude.

Previous Results: A 1 km raster DTM digital terrain model (DTM) from LROC WAC stereo data of the first 5 months of the LRO mission was derived by photogrammetric stereo processing methods [3]. Aside from polar regions it covered 96% of 80° S to 80° N [4]. The LOLA instrument team releases quarterly sets of all acquired 3D points and a gridded DTM version. The latest release (December 2010) could yet not be incorporated. Thus, for this first comparison LOLA data of the September 2010 release have been used.

Recent Results: WAC stereo data of the entire commissioning and primary mission phases have been processed systematically at full image resolution. The result is an initial 80° S to 80° N 100 m raster DTM, (GLD100, [5]) from about 60 billion points, i.e. ~15 points/100m-cell. It was derived from ~ 50,000 stereo models and covers 98.9% of 80° S to 80° N. We determined the accuracy of this DTM by a comparison with the LOLA altimeter data. We set up a comparable 100 m grid from all successful LOLA measurements (> 1 billion shots) and took the mean of those shots that fall within each 100 m DTM cell. The mean difference between GLD100 and LOLA heights is only 4 m, with a 1σ RMS of 23 m, i.e. less than one third of a WAC pixel. It is a composite of the internal measurement accuracies of both instruments and discretization effects to the 100 m DTM cells, for which we have to consider that the LOLA data were determined using LOLA-crossover-corrected orbit kernels while the WAC stereo processing is yet based upon standard reconstructed orbit kernels. Both orbit descriptions are known to be typically off up to 100 m in horizontal and few tens of meters in vertical direction. Figs. 1,2 show exemplary color-coded 60 x 60 km subsets of low and high latitudes of the GLD100 model and the respective color-coded LOLA tracks, sampled to 100 m pixels and plotted on top of the GLD100 hill-shaded relief.

Summary: While LOLA provides highly accurate topographic heights along North/South profiles with sub-meter precision for all latitudes, LROC WAC’s 100 m DTM (GLD100) offers a dense topographic dataset for |latitude| < 80° without longitudinal gaps. It serves as an ideal 3D reference for ortho-rectification of image datasets from various lunar missions and allows for a variety of geoscientific analyses, such as volume estimations, profiles in latitudinal as well as in longitudinal direction, search for old basins [6], etc.
Current results of both LRO instruments show an excellent match. No significant vertical offset could be found and the 23 m RMS of the randomly distributed vertical differences between both datasets corresponds to only one third of the WAC ground scale. At the conference we expect to present an even better match (< 10 meters) with results of the current re-processing of the GLD100 using crossover-corrected orbit kernels. Finally, a combined GLD100/LOLA dataset might serve as the global 100 m reference topography of the lunar surface for the foreseeable future.