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GLD100 - Lunar topography from LROC WAC stereo

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Abstract

The LROC WAC instrument of the LRO mission comprises substantial stereo image data from adjacent orbits. Multiple coverage of the entire surface of the Moon at a mean ground scale of 75 m/pxl has already been achieved within the first two years of the mission. We applied photogrammetric stereo processing methods for the derivation of a 100 m raster DTM (digital terrain model), called GLD100, from several tens of thousands stereo models. The GLD100 covers the lunar surface between 80° northern and southern latitude. Polar regions are excluded because of poor illumination and stereo conditions. Vertical differences of the GLD100 to altimetry data from the LRO LOLA instrument are small, the mean deviation is typically about 20 m, without systematic lateral or vertical offsets.

1. Introduction

The LOLA instrument onboard the LRO mission [4] has provided the latest and most complete topography dataset of the lunar surface with a high vertical accuracy of better than 1m. But, typically for altimetric along-track measurements from polar orbits, spacing between tracks increases towards low latitudes and forms gaps of up to a few kilometers. Raster DTMs that are derived from photogrammetric analysis of stereo image data do not suffer from such limitations if the illumination and stereo conditions are appropriate and the available dataset allows for a systematic stereo processing. The LROC WAC [1] dataset comprises an almost ideal dataset for the derivation of a near-global raster DTM [2] of high lateral and vertical resolution.

2. LROC WAC Stereo Processing

We used the entire LROC WAC dataset that has been acquired since September 2009 during LRO's nominal and science mission phases. WAC images from adjacent orbits overlap about 50% at the equator. The overlap increases towards higher latitudes while the stereo angle decreases. Near-polar regions do not provide sufficient illumination (cast shadows at low sun angles), and the stereo angles between the WAC datasets do also not allow for an accurate photogrammetric topography reconstruction. For latitudes between 80° northern and southern latitude, we finally used almost 100,000 stereo models within a systematic procedure that includes area-based image matching, 3D forward ray intersection for the calculation of about 100 billion 3D surface points, and the final derivation of the raster DTM. Analysis of the accuracy of the nominal LRO spacecraft pointing showed that its accuracy is typically within the WAC image resolution of ~75 m. It was used without further adjustment. For the LRO orbit position, we used orbit information that has been kindly provided by the LRO LOLA team and which is the result of a combined radio-tracking and cross-over analysis of LOLA measurements.

3. DTM Results

The final raster DTM (GLD100) is a map-projected representation of the lunar topography at a scale of 100 m/pxl. The multiple-coverage during the nominal and science mission phase yielded an almost complete dataset. Only small areas, covering far less than 1% of the entire area between 80° northern and southern latitude, had to be filled by interpolation. Different map projection types (equal-area, conformal, etc.) can be chosen for particular applications. Figures 1-4 show the entire GLD100 in different orthographic aspects. The absolute accuracy has been estimated within a comparison [3] with altimetry data from the LRO LOLA instrument as the current reference. No significant lateral or vertical offset could be detected. The RMS of the vertical differences is 23 m, i.e. less than one third of a WAC pixel and is partly a result of sampling effects of both datasets to the 100 meter grid, particularly in rough terrain. For flat regions, the typical RMS is only about 10 m, i.e. 0.13 WAC pixel.

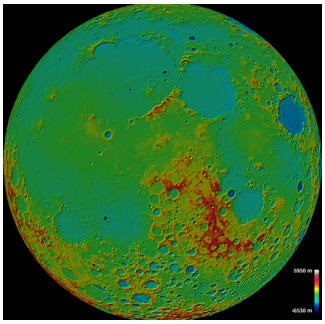

Figure 1: GLD100: Near side.

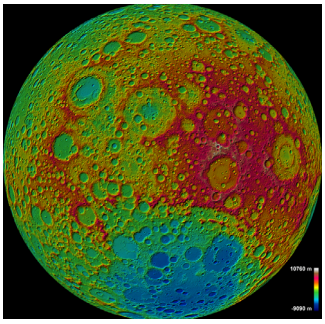

Figure 2: GLD100: Far side.

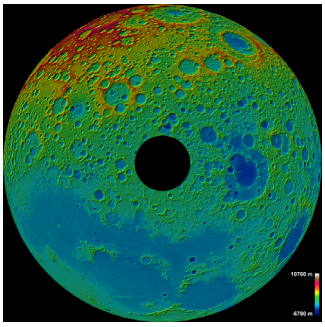

Figure 3: GLD100: Northern hemisphere.

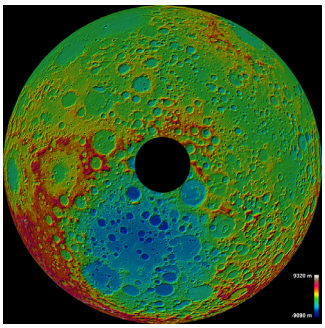

Figure 4: GLD100: Southern hemisphere.

4. Summary

The GLD100 consists of tens of thousands LROC WAC stereo models and represents a first contiguous lunar topography model for |latitude| < 80° at 100 m grid scale. 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)!

References

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