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A New lunar global topographic map products from Chang'E-2 Stereo Camera Image Data

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Abstract

We have finished the CE2 lunar global topographic map products generation, called as "CE2DOM2014 and CE2DEM2014". The products have a very good internal precision, planimetric displacement and height difference between neighboring images are both less than two pixels(<14m). Comparison with LRRR, the planimetric displacement is 23.9m~94 in longitude and 9.7m~53.4m in latitude, height difference is -1.0m~18.9m. Comparison with LRO WAC DEM, average of height difference is -2.8m, stdv is 116.0m. The products will be released in the future. We hope the data sets will be used for future lunar science and lunar missions planning.

1. Introduction

Recent ten years lunar mission, has mapped lunar surface in different resolution, and acquired high quality topography data, including Japanese SELENE(2007.9), Chinese Chang'E-1(2007.10), Chang'E-2(2010.10), Indian Chandrayaan-1 （2008.3） and US Lunar Reconnaissance Orbiter(2009.6) etc. Haruyama[1], Speyerer[2] and Chunlai[3] have respectively used these data sets to produce the global lunar topographic maps. These maps are usually used as base map for lunar science and lunar missions. They accurately describe lunar morphology and have opened a new era for our understanding the moon.

On October 1st, 2010, Chang'E-2 (or CE2) was successfully launched. This is the Chinese second lunar exploration. Its main objective is to acquire 1.5m and 7m spatial resolution images at 15km and 100km orbit height. These high spatial resolution images have be used to select landing site and plan Yutu rover scientific exploration route for Chang'E-3.

In this presentation, we will introduce Chang'E-2 stereo camera, its topographic data processing and products that will be released.

2. CE2 Stereo Camera and Data

Stereo camera is one of main payloads of the CE2, which uses the linear pushbroom scanning technique to capture two-line imagery of forward view and backward view along the satellite flight direction(Figure.1), stereo view angle is 7.98deg and -17.2deg respectively. The CCD detector of the camera used time delayed and integration CCD(TDI CCD), which allows five integration grade such as 16, 32, 48, 64 and 96, three gain such as 0.7, 1.0 and 2.0. The setting of integration grade is determined by the gain setting, solar illumination condition, the average reflectance of lunar surface and other factors. The spectral range of CCD stereo camera is 450~ 52m. The image width is 9.2km and 43km, the spatial resolution is 1.5m and 7m with the orbit altitude of 15km and 100km respectively. Table 1 shows the main information of stereo camera.

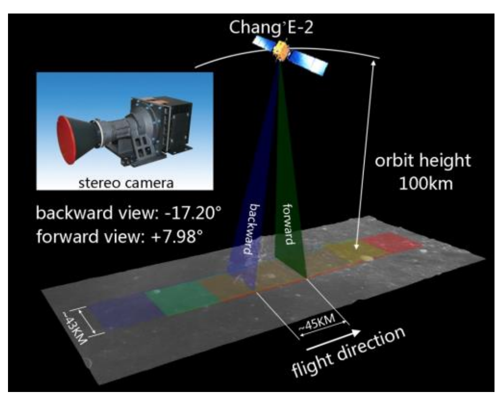

Figure.1 Imaging Principle of CE2 two-line stereo camera.

Table.1 CE2 Two-line Stereo Camera Performance

Parameter name	Parameter value
image size	6144 pixels/line(2 CCD lines)
focal length	144.3mm
stereo channels	forward:+7.98deg, backward: -17.2deg
spectral band	1 panchromatic band, 0.45μm～0.52μm
radiometric resolution	8bit
detector pixel size	10.1 μm × 10.1 μm
gain	0.7, 1.0 and 2.0
integration grade	16, 32,48,64 and 96

The first two-line imagery strip was acquired on October 24th, 2010. Up to May 23th, 2011, CE2 stereo camera has returned more than 600 imagery strips with 7m spatial resolution to earth covering the 100% lunar surface. We have selected 384 imagery strips of them to generate the global topographic map. These images have been archived with Planetary Data System (PDS) format after radiometric calibration, photometric correction and geometric processing by Ground Research and Application System(GRAS), which is the important component for the implementation of the CE2 mission.

3. Data Processing

The global topographic data processing include data organization, global adjustment, DEM(Digital Elevation Model) and DOM(Digital Orthophoto Map) generation. Now, we have generated the DEM and DOM products for the whole lunar surface. Their ground spatial resolutions are both 7m.

(1) Data Organization: CE2 global mapping orbit is a polar and circular orbit around moon with the height of 100 km. We have selected 384 imagery strips for data processing. The original imagery strip covers lunar surface between 90 degrees north and 90 degrees south, about 5,455km length. Due to wide coverage, big size, and computational complexity of image data, the global surface is cut apart into 382 small blocks. The original imagery strips are split up into 6682 small image sections by the block border. There are suitable overlaps between different sections.

(2) Global Adjustment: The object of the global adjustment is to achieve a pixel mosaic level for the topographic products. Firstly, about 4,365,729 connection points(or homologous points) over the neighboring image sections are extracted by using image matching[4,5]. Then, the quality, amount and distribution of these points are automated or manually checked and modified. Finally, a combined block adjustment method based on independent models adjustment and bundle adjustment is used to construct RPC models for every image section with 5 LRRR(Lunar Laser Ranging Retroreflector) locations as control points[6]. The planimetric displacement and height difference between neighboring image sections are both less than two pixels(<14m). The global adjustment has achieved seamless connection and absolute orientation for all image sections.

(3) DEM and DOM Generation: Firstly, homologous points of each image section are extracted for each pixel by using image matching. The quality of these points are automated or manually checked and modified. Then, RPC model is used to calculate the lunar surface location for these points. A weighted distance average interpolation method is used to generate DEM for each image section. And DOM is generated by using DEM and RPC model. The spatial resolutions of DEM and DOM are both 7m. Finally, for data easy saving and management, the global surface is cut apart into 844 subdivisions(Figure.2). DEM and DOM of each image section is mosaicked and cut respectively in each subdivision.

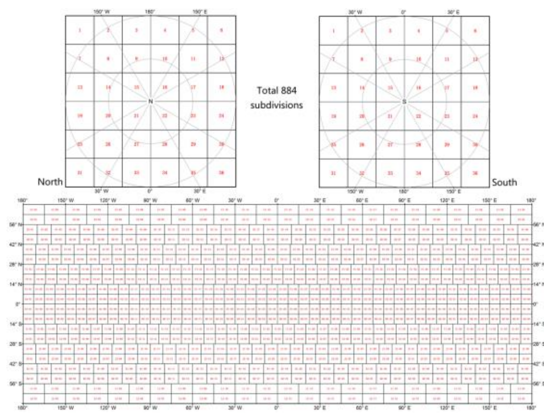

Figure.2 Subdivision Char of CE2 Lunar Global Topographic Map Products.

4. Results and Validation

Now, we have finished the lunar global topographic map products generation, called as "CE2 Orthophoto Map(CE2DOM2014,Figure.3) and CE2 Elevation Model (CE2DEM2014,Figure.3b)". The products include DOM and DEM of 844 subdivisions(Figure.4). Their spatial resolutions are both 7m. The internal precision is less than two pixels(＜14m). Each product file of DEM and DOM are respectively stored by 32bit floating number and 8bit integer number. The file sizes are respectively about 3.5GB and 900MB. The total data products exceed 3.9TB. They very detailed and accurately portray morphological features of lunar surface(Figure.5). The products will be released in the future.

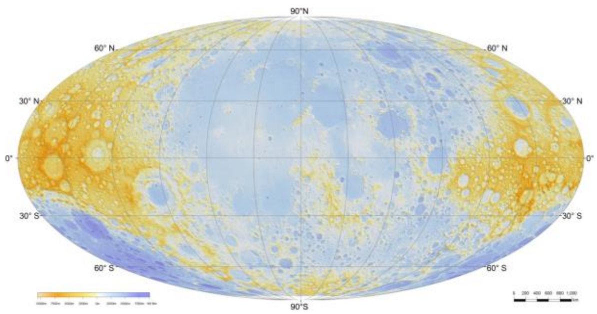

Figure.3a Color-coded topography and shaded relief Map of CE2DEM2014.

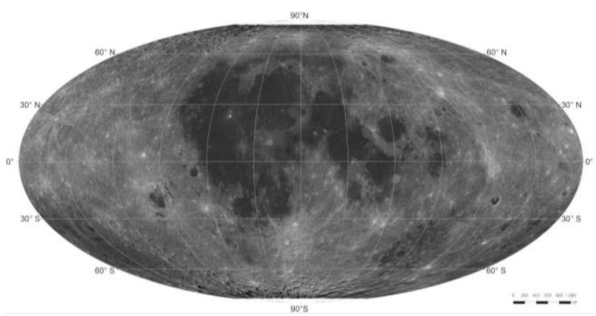

Figure.3b The Map of CE2DOM2014.

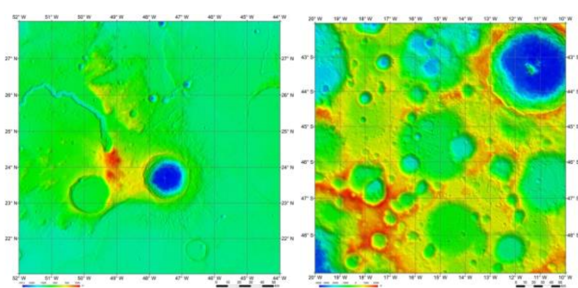

Figure.4 Color-coded topography and shaded relief Maps of subdivisions(Left subdivision code is F117, in mare, and Aristarchus crater at the map center. Right code is F117, in highland, Tycho crater at the map upright corner).

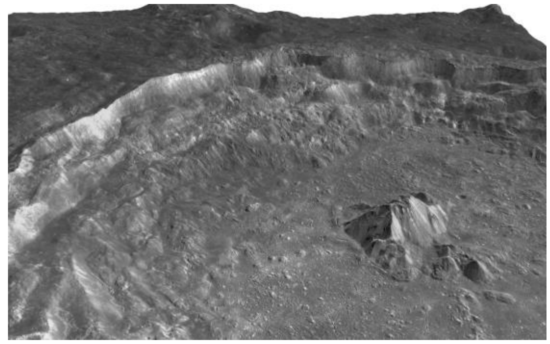

Figure.5 3D perspective view of Tycho crater (In the figure, the collapses of the crater sidewall because of gravity and central peak are clearly seen.).

In order to validate and value CE2 global topographic map products, we compare our results with five LRRR locations and LRO WAC DEM. The results shows:1) Comparison with LRRR, the planimetric displacement is 23.9m~94(stdv 57.2m) in longitude and 9.7m~53.4m(stdv 37.6m) in latitude, height difference is -1.0m~18.9m(stdv 10.1m). 2). Comparison with LRO WAC DEM, average of height difference is -2.8m, stdv is 116.0m (Figure.6).

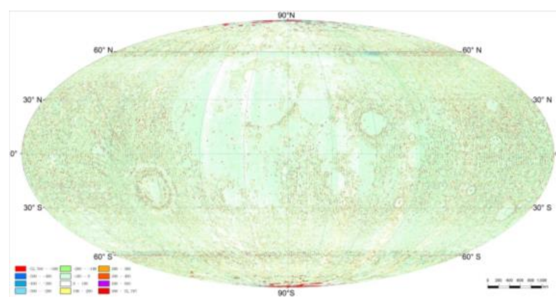

Figure.6 Height Difference between CE2DEM2014 and LRO WAC DEM.

5. Conclusion

We have generated the CE2 lunar global topographic map products, called as “CE2DOM2014 and CE2DEM2014”. The products are a global and seamless data sets. Their internal precision is very good, and also have a good external precision compared with LRRR locations and LRO WAC DEM. The data sets have been archived with Planetary Data System (PDS) format and will be released in the future. We hope the CE2 lunar global topographic map products will be used for future lunar science and lunar missions planning.

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Reference

[1] Haruyamal, J., Ohtake, M., and Matsunaga, T., et al: DATA PRODUCTS OF SELENE (KAGUYA) TERRAIN CAMERA FOR FUTURE LUNAR MISSIONS, 45th Lunar and Planetary Science Conference (2014), Abstract1304#.

[2] Scholten, F., Oberst, J., and Matz, T., et al: GLD100: The near-global lunar 100 m raster DTM from LROC WAC stereo image data, J. Geophys. Res., Vol. 117, E00H17, doi:10.1029/2011JE003926.

[3] Li, L.C., J.J Liu, L.C., and Ren, X., et al: The Global Image of the Moon by the Chang'E-1:Data Processing and Lunar Cartography, Sci China Earth Sci, 40(3):294-306, 2010.

[4] David, G. L.: Object recognition from local scale-invariant features, International Conference on Computer Vision, Corfu, Greece, pp. 1150-1157, 1999.

[5] Heipke, C., Schmidt, R., and Brand R.: Performance of automatic tie point extraction using HRSC imagery of the Mars Express mission, International Archives of Photogrammetry and Remote Sensing, 35(B4):846–851, 2004.

[6] Wang, Z.Z.: Principles of Photogrammetry (with Remote Sensing), Press of Wuhan Technical University of Surveying and Mapping, Publishing House of Surveying and Mapping, Beijing, 575 pages, 1990.