Topography of Vesta from Dawn FC stereo images

Frank Preusker (1), Frank Scholten (1), Klaus-Dieter Matz (1), Thomas Roatsch (1), Ralf Jaumann (1), Carol A. Raymond (2), Christopher T. Russell (3)
(1) German Aerospace Center, Institute of Planetary Research, D-12489 Berlin, Germany (Frank.Preusker@dlr.de), (2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099, USA, (3) UCLA, Institute of Geophysics, Los Angeles, CA 90095-1567, USA

1. Introduction

The Dawn mission has completed its Survey and High Altitude Mapping Orbit (HAMO) phases at Vesta and is currently in its Low Altitude Mapping Orbit (LAMO) [1]. From the Survey orbit (altitude ~2,700 km) the Dawn Framing Camera (FC) [2] acquired 1,179 clear filter images with a mean image resolution of 256 m/pixel whereas from the HAMO orbit (~700 km altitude) there are 2,674 clear filter images with a mean resolution of 63 m/pixel. In both mapping phases the surface was imaged several times under similar illumination conditions (Sun elevation and azimuth), but different viewing conditions (by tilting the spacecraft). This allows to analyze the images stereoscopically and to construct stereo topographic maps. The topography is particularly important, because it is essential for derivation of physical properties of Vesta, precise ortho-image registration, mosaicking, and map generation of monochrome/color FC images and VIR images, quantitative geomorphologic analysis, and precise photometric analysis (from detailed local surface inclination).

2. Methods

The stereo-photogrammetric processing for Vesta is based on a software suite that has been developed within the last decade. It has been applied successfully to several planetary image data sets [3-7]. The suite comprises photogrammetric block adjustment, multi-image matching, surface point triangulation, digital terrain model (DTM) generation, and base map production.

Parameters [°]	
Differences in illumination	0-10
Stereo angle	15-50
Incidence angle	0-60
Emission angle	0-60
Phase angle	5-160

Table 1. Requirements for stereo processing.

3. Results

We constrained all HAMO clear filter images with our stereo requirements (Table 1) and achieved at least triple stereo image coverage for the entire illuminated surface. In total, about 15,000 independent multi-stereo image combinations were used to determine selected image tie points by multi-image matching for the set-up of a 3D control network of ~35,000 surface points. The control point network defines the input for the photogrammetric least squares adjustment where corrections for the nominal navigation data (pointing and position) are derived. The three-dimensional (3D) point accuracy of the resulting ground points have been improved from ±50 m to ±8 m (0.15 pixel). Furthermore we refined Vesta's spin axis orientation, formerly determined from Earth-based observations [8, 9], to: right ascension = 309.031° ± 0.01°, declination = 42.235° ± 0.01°).

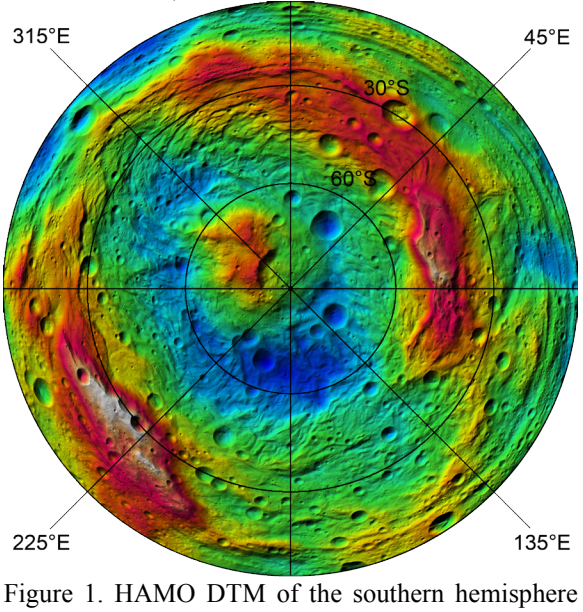

Figure 1. HAMO DTM of the southern hemisphere of Vesta in Lambert azimuthal projection.

Next, 15,000 individual multi-image matching processes at full image resolution were carried out to yield ~10.7 billion object points. The achieved mean forward ray intersection accuracy of the ground points is ±8 m.

Finally, we generated a DTM with a lateral spacing of about 100 m/pixel (48 pixel/degree) and a vertical accuracy of about 5 m (Figure 2). The HAMO DTM covers approximately 73% of Vesta's surface. Radii vary by about 80.5 km (from 212.1 to 292.6 km). The most dominant topographic feature is the large (~500 km diameter) South Pole basin Rheasilvia (Figure 1) [7].

Based on the entire HAMO DTM (Figure 2), we determined a best-fit ellipsoid (286.3/278.6/223.2 km) with its body long axis at 40.6°E w.r.t. the new reference system [1]. Compared to results from Earth-based observations [9], these values are smaller by about 4%.

4. Summary and Conclusions

We will update and refine the Vesta DTM based upon stereo-images from the LAMO and HAMO2 orbit and will present the first results at the conference. A final version of the Vesta DTM and an overall re-assessment of Vesta's geophysical properties can be expected from the analysis of the entire DAWN FC image dataset of Vesta (from Survey, HAMO, HAMO2, and LAMO orbit) when the Dawn spacecraft will have left Vesta, heading towards its next target, Ceres, the largest asteroid in the solar system.

References

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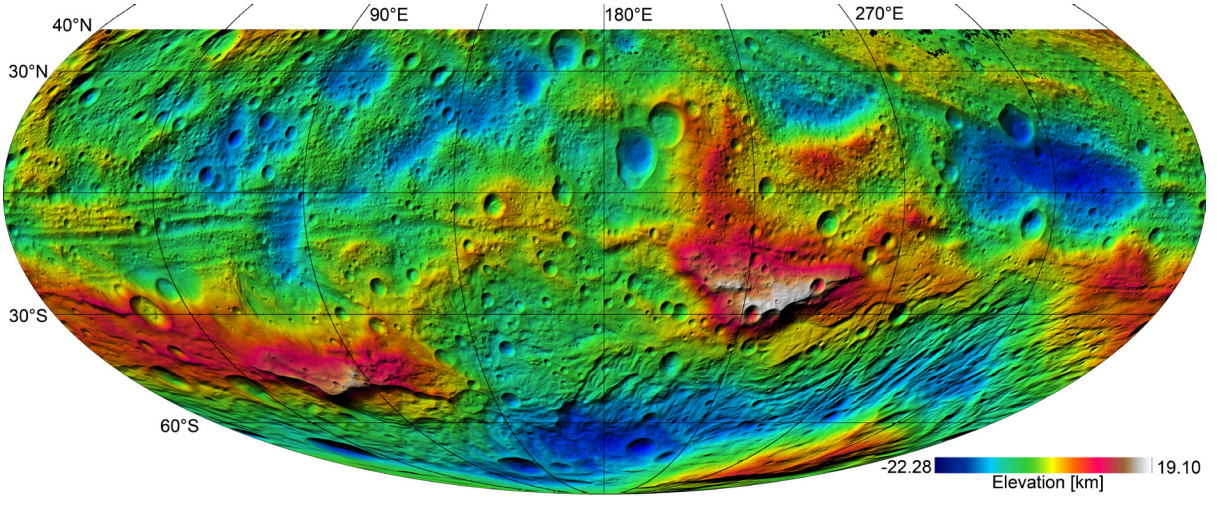

Figure 2. Global HAMO DTM of Vesta with a lateral spacing of about 100 m (hill-shaded color-coded heights) in Mollweide Projection (equal-area). Heights refer to a biaxial ellipsoid (285x285x229 km).