TOPOGRAPHY OF MERCURY FROM STEREO IMAGES: FIRST SAMPLES FROM MESSENGER ORBITAL MAPPING. Frank Preusker[1], Jürgen Oberst[1], David T. Blewett[2], Klaus Gwinner[1], James W. Head[3], Scott L. Murchie[2], Mark S. Robinson[4], Thomas R. Watters[5], Maria T. Zuber[6], and Sean C. Solomon[7]. [1]German Aerospace Center, Institute of Planetary Research, D-12489 Berlin, Germany (Frank.Preusker@dlr.de); [2]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA; [3]Department of Geological Sciences, Brown University, Providence, RI 02912, USA; [4]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, USA; [5]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560, USA; [6]Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139-4307, USA; [7]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, USA.

Introduction: In March 2011 the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft entered orbit about Mercury [1]. The spacecraft is equipped with the Mercury Dual Imaging System (MDIS) [2] consisting of a wide-angle camera (WAC) and a narrow-angle camera (NAC) coaligned on a pivot platform. During its first Mercury solar day (~176 Earth days), MESSENGER acquired several thousand images to create a monochrome base map using the WAC for the northern hemisphere and NAC for the southern hemisphere, respectively, from its highly eccentric orbit [3]. In September 2011, with the beginning of the second Mercury day, MESSENGER started acquiring a complementary image dataset under high emission angles (by tilting the camera), but similar Sun elevation and azimuth. The combination of both base maps enables us to analyze the images stereoscopically and to construct stereo topographic maps. The stereo topographic maps are particularly important for the southern hemisphere, most parts of which are out of range of MESSENGER's Mercury Laser Altimeter (MLA).

Methods: The stereo-photogrammetric processing for Mercury is based on a software suite that has been developed within the last decade and has been applied successfully to several planetary image data sets [4-9]. The suite comprises photogrammetric block adjustment, multi-image matching, surface point triangulation, digital terrain model (DTM) generation, and base map production [7].

Image and Stereo Coverage: We have selected images that have resolutions better than 500 m/pixel and "optimal" stereo conditions (Table 1) (~30,000 images in total), for which a stereo coverage map was compiled. From the map, we have selected two areas (Fig. 1, marked in white) to carry out topographic surface reconstructions. The first area is located in the southern hemisphere and is covered by 1,080 stereo images with a mean resolution of ~220 m/pixel, whereas the second area is located in the northern hemisphere and is covered by 1,286 stereo images with a mean resolution of ~180 m/pixel.

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

Table 1. Stereo conditions used for stereo processing.

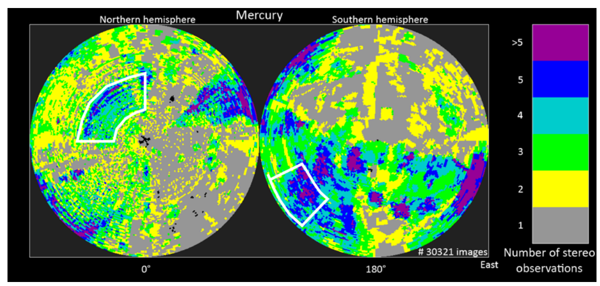

Fig. 1. Stereo coverage of MDIS images having spatial resolutions better than 500 m/pixel. Colors indicate the number of stereo observations that meet the conditions from Table 1 (status as of December 2011). The white polygons mark areas for which sample stereo analysis is reported here.

Results: Beginning with nominal navigation (pointing and position) data of the selected stereo images, we have collected ~20,000 tie points for navigation data correction using a photogrammetric block adjustment. This improves the three-dimensional (3D) point accuracy from ±750 m to ±42 m. Then 3,200 individual matching runs were carried out to yield ~1,400 million object points. The mean ray intersection errors of the ground points were ±45 m. Only triple-overlapping images were used for the matching. Finally, we have generated two DTMs with a lateral spacing of 330 m/pixel (128 pixels per degree) and a vertical accuracy of about 50 m (Fig. 2-3).

Beethoven DTM. The southern hemisphere DTM covers 2% (1.4 × 10^6 km²) of Mercury's surface and comprises a total height range of 8.4 km. One highlight of the model is the large (631 km diameter) Beethoven basin. Although the basin topography was previously reconstructed from Mariner10 stereo images [10], the accuracy and resolution of this model are far superior. Beethoven has an irregularly shaped rim and flat basin floor. The DTM shows three prominent arcuate lobate scarps in Beethoven that are subparallel to the rim and offset the basin interior fill material (Fig. 2, black arrows). One lobate scarp that cuts across the Sayat-Nova crater is closely aligned with the basin rim and indicates that the floor of Sayat-Nova has a vertical offset of approximately 870 m across the scarp.

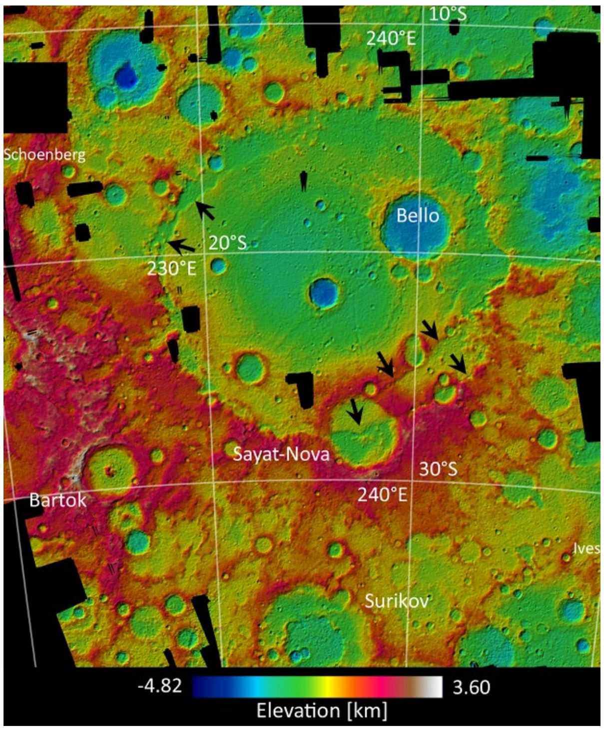

Fig. 2. Beethoven DTM (hill-shaded color-coded heights) with a lateral spacing of 330 m in stereographic (conformal) projection centered at Beethoven basin (20°S, 236°E). Black areas are gaps in the current stereo coverage. Updated versions of this model will be available at the time of the conference.

Strindberg DTM. The second DTM is located in the northern hemisphere, covers 3% (2.3 km²) of Mercury's surface and comprises a total height range of 6.8 km. The DTM with its large area coverage overlaps with MLA coverage and is currently being studied in terms of instrument alignment and Mercury librations (see companion abstract [11]). Construction of additional DTMs is ongoing.

Conclusion: With the completion of the second-day monochrome stereo base map, expected in May 2012, we have the opportunity to reconstruct most of Mercury's surface except for permanently shadowed areas near the poles. Laser altimeter profiles with their superior height precision will be used to remove ambiguities regarding absolute elevations and trends in long-wavelength topography [11]. In addition, limb topography [12] will be used to cross-check absolute elevations for the southern hemisphere where no laser altimeter data are available.

References: [1] Solomon S .C. et al. (2011) *EPSC-DPS Joint Meeting Abstracts and Program*, Abstract EPSC-DPS2011-430. [2] Hawkins S.E., III, et al. (2007) *Space Sci. Rev., 131*, 247-338. [3] Becker K. et al., (2011) *AGU Fall meeting*, Abstract P41A-1589. [4] Giese B. et al. (2006) *Planet. Space Sci., 54*, 1156–1166. [5] Gwinner K. et al. (2009) *Photogram. Engineering Remote Sensing, 75,* 1127–1142. [6] Oberst J. et al. (2010) *Icarus, 209,* 230–238. [7] Preusker F. et al. (2011) *Planet. Space Sci., 59,* 1910–1917. [8] Preusker F. et al. (2012) *Planet. Space Sci.,* submitted. [9] Scholten F. et al. (2012) *JGR,* submitted. [10] Cook A. C. et al. (2001) *JGR, 105*, 9429–9443. [11] Stark A. et al. (2012) *LPS, 43*, this meeting. [12] Elgner S. et al. (2012) *LPS, 43*, this meeting.

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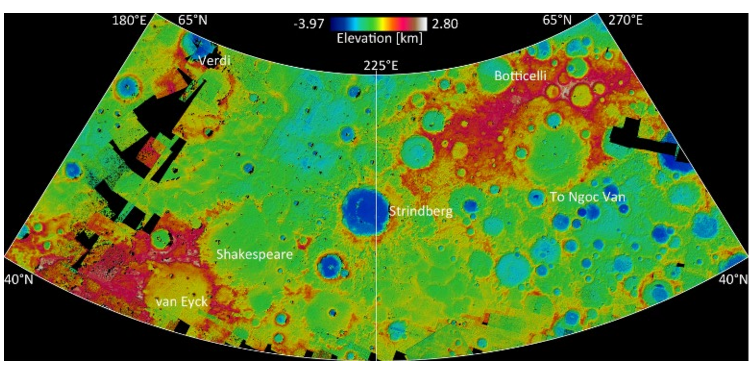

Fig. 3. Strindberg DTM (hill-shaded color-coded heights) with a lateral spacing of 330 m in Lambert two-parallel (conformal) projection. Black areas are gaps in the current stereo coverage. Updated versions of this model will be available at the time of the conference.