MERCURY STEREO TOPOGRAPHY: CONSTRUCTION OF REGIONAL TOPOGRAPHIC MAPS DERIVED FROM MARINER 10 IMAGES. S. L. Andre[1] and T. R. Watters[1], [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20013-7012, andres@si.edu.

Introduction: Much of our current understanding of geology of Mercury is based on data obtained from Mariner 10. This Mariner 10 view has provided the framework for the scientific issues and questions to be addressed by future missions to Mercury (in particular the MESSENGER mission [1]). Critical to unraveling the geologic evolution is knowledge of the topography of Mercury. The overlap and lighting conditions between the first and second Mariner 10 flybys are favorable for stereo, but little stereo analysis was done at the time of the mission [2]. More recent improvements in the control network and SPICE information for the Mariner 10 mission [3] have allowed for recent stereo studies [4,5,6]. We present the current status of the Mariner 10 stereo topography project.

Cook and Robinson [7] provided an initial analysis of the potential stereo coverage of the Mariner 10 data, including a description of the criteria they used to evaluate each stereo pair. Their study concluded that at least 1000 stereo pairs would provide some topographic data, however the height accuracy of the data could vary from ± 0.1 km to ± 1 km [7]. Data from Cook and Robinson [7] were used to identify which areas on Mercury could be automatically matched using our stereo matcher, Stereo Matching Toolkit (SMTK) [8,9,10].

Methods: Digital elevation models (DEMs) were constructed using Mariner 10 stereo pairs and stereo matching software, SMTK [8,9,10]. SMTK uses two algorithms, an adaptive least squares algorithm that matches a patch of one image to the corresponding area within a second image. Successful matches are then used to predict potential match points for surrounding locations using a region-growing algorithm.

The resulting topographic data has 1-2 km spatial resolution and vertical resolution typically better than 1 km. The lack of ground truth for Mercury results in DEMs with no absolute elevation, rather, topographic products represent relative heights.

Individual stereo pairs (i.e. Figure 1) were mosaicked to create regional topographic products (i.e. Figure 2), and then regional DEMs were combined to create quadrangle products. Some Mariner 10 stereo pairs produce DEMs with large offsets in the relative height with adjacent DEMs (the cause of which has yet to be determined but may be the result of errors in camera pointing data). These offsets in relative height require individual DEMs to be tied to the adjacent DEM, referred to as the "core" DEM. The "core" DEM is selected during the error analysis process for each individual stereo pair, and thus the DEM generated from the stereo pair with the smallest error is selected to be the core DEM and is used to "anchor" the other neighboring DEMs. Regional products were constructed by hand-laying each pair on the main mosaic. In SMTK, the quality of the point matching in a stereo pair is estimated using the error in the adaptive least squares routine for each matched point. SMTK then translates the error for the matched points into a height accuracy for each point within the DEM. We conservatively choose the highest error within the DEM to represent the overall height error. Two approaches can be taken to describe the height accuracy of a regional scale topographic product comprised of a mosaic of individual DEMs. First, the overall height accuracy of the regional DEM can be defined by the individual DEM with the poorest estimated height accuracy. This approach, however, does not reflect the height accuracy of specific areas of interest. The second approach is to generate a height accuracy map for the regional DEM based on the height accuracy of each matched point.

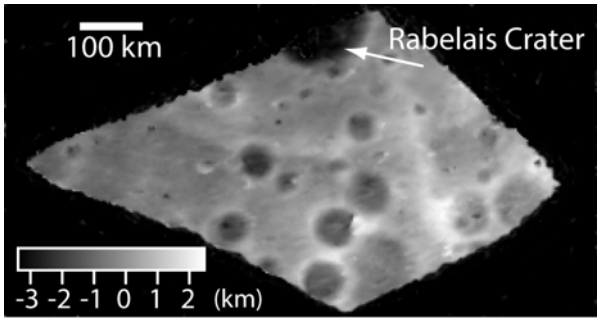

Figure 1. An example of an individual DEM generated from a Mariner 10 stereo pair, images 0027403 and 0166614, a region (59°S to 71°S, 42°W to 85°W) located in the Discovery quadrangle of Mercury. This DEM was generated using a correlation box size of 21 by 21 pixels. The spatial resolution of the DEM is 2 km, and the height error is estimated at ± 0.05 km. Heights vary from -3.4 km to 2.0 km above a reference sphere of 2439.7 km. Rabelais crater is 140 km in diameter.

Results: Mariner 10 stereo topography has been used in a number of geologic investigations. These include measuring the relief on tectonic features such

as lobate scarps and high-relief ridges, identifying degraded impact basins, characterizing the long wavelength topography of impact basins, and determining crater depth/diameter relationships [4,5,6]. Beyond these studies (completed using individual stereo pairs and in limited examples, regional products), we wish to complete regional DEMs and a final hemispheric-scale DEM from all the Mariner 10 stereo pairs. We are currently working to complete the quadrangle products. Imaged quadrangles with either incomplete coverage or DEMs with very poor height accuracy (≥ 700 m) include Bach, Borealis, and Victoria. Reasonable DEM quality and spatial coverage exists for Beethoven, Kuiper, and Shakespeare quadrangles. Imaged quadrangles with the best stereo coverage and DEM quality include Discovery, Michelangelo, and Tolstoj.

Future Work: Our ultimate goal is to release a complete topographic product of the Mariner 10 stereo coverage with an accompanying map showing height accuracy by region.

References: [1] Solomon et al. (2001) *Planet. Space Sci.* 49,1445-1465. [2] Strom et al. (1975) *J. Geophys. Res.* 80, 2345-2356. [3] Robinson et al. (1999) *J. Geophys. Res.* 104, 30847-30852. [4] Watters et al., (2002) *Geophys. Res. Lett.* 29, doi:10.1029/2001GL04308. [5] Watters et al. (2004) *Geophys. Res. Lett.* 31, doi:10.1029/20003GL019171. [6] Andre et al. (2005) *Geophys. Res. Lett.* 32, doi:10/1029/2005GL023627. [7] Cook and Robinson (2000) *JGR 105*, 9439-9443. [8] Andre et al. (2004) *LPSC 35*, Abstract #2057. [9] Andre et al. (2003) *Eos, Trans. AGU* 84, F964. [10] Andre et al. (2007) in preparation.

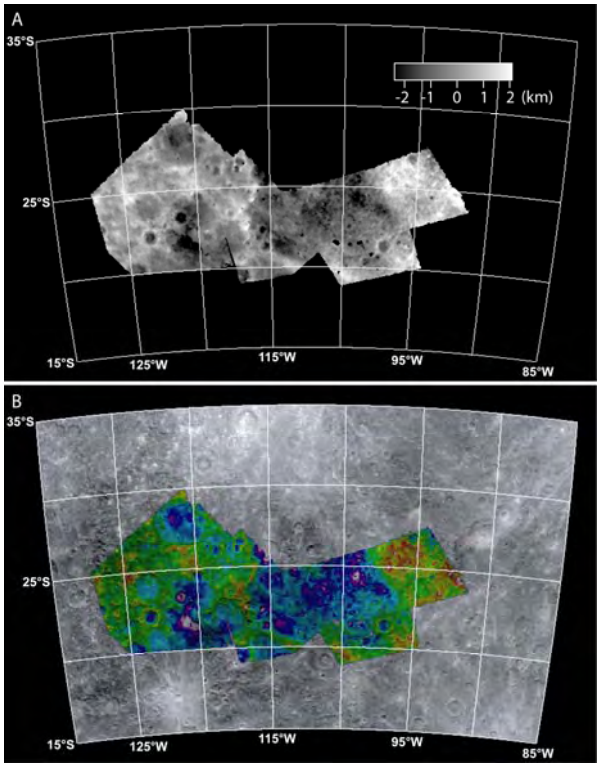

Figure 2. (A) An example of a regional DEM constructed by hand-laying individual stereo pairs onto a core stereo pair DEM. This area shows a section of the Michelangelo quadrangle (19°S to 32°S, 90°W to 118°W). This mosaic consists of 6 individual stereo pairs that were each generated using a correlation box size of 21 by 21 pixels in SMTK. The spatial resolution of the DEM is 2 km, and the height error is estimated at ± 0.5 km. Heights vary from -2.5 km to 2.0 km above a reference sphere of 2439.7 km. (B) A color version of the DEM overlaid on a Mariner 10 second encounter mosaic.