DIGITAL ELEVATION MODEL OF MERCURY. A. C. Cook [1], M. S. Robinson[2], T. R. Watters [1] and G. Franz[1], [1]Center for Earth & Planetary Studies, National Air and Space Museum, Washington D.C. 20560, USA (Email: tcook@nasm.si.edu), [2]Northwestern University, 1847 Sheridan Road, Locy Hall 309, Evanston, IL60208, USA.

Introduction: Work has been completed on semi-automatically stereo matching all available Mariner 10 [1,2] stereo pairs [3,4]. The resulting matched image coordinates are converted into longitude, latitude, and height points, known as digital terrain models (DTMs). Software is under development to mosaic the DTM tiles together to form a large area raster height map, or Digital Elevation Model (DEM), of one quarter of the planet's surface. We present a preliminary DEM mosaic of Mercury generated from a subset of our available dataset.

Method: A photogrammetrically refined set of camera positions and orientations [5] were used initially to determine a list of candidate stereo pairs according to a set of stereo criteria [6]. To stereo match each image pair initially it is necessary to manually select 3-20 seed points between left and right images. This defines a geometric affine transform between the two images for use by the automated stereo matcher. The matcher software, "Gotcha" [7] utilizes a patch-based correlation algorithm to find identical points between left and right images with sub-pixel accuracy. Image pairs are matched 12 times using correlation patch radii from 1 to 12 pixels. Small patches yield DEMs with high spatial resolution, but suffer increased topographic noise due to poor correlation, in particular in low surface texture areas. Large correlation patches are less affected by noise, but tend to blur spatial detail more than smaller patch sizes [8]. This is a common problem to all DEMs generated using widely used patch-based stereo matchers and can affect crater depth to diameter measurements [9]. Experiments are under way to combine different patch size results together to achieve best spatial resolution, and least topographic noise.

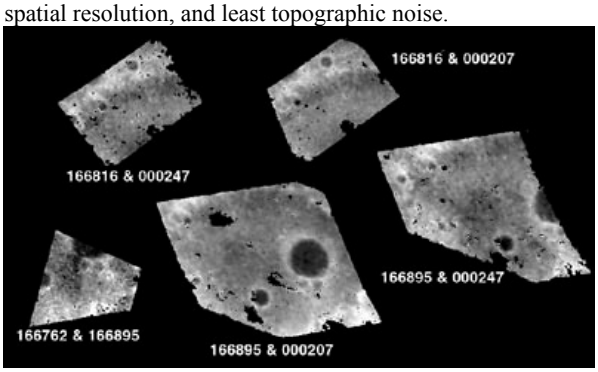

Fig 1 Five grey scale DEMs of the northern half of the Beethoven basin. Black is –3.0 km, white is +2.0 km.

To convert stereo matcher pixel coordinates into longitude, latitude, and height (a DTM), the coordinates are passed through a stereo intersection camera model using previously determined camera positions and orientations, based upon a photogrammetrically refined Mariner 10 control net [5]. The DTMs generated have then to be combined to generate a map projected DEM mosaic (Fig 2). The DTMs vary in height accuracy and can contain local topographic errors from badly detected image reseaux and stereo matcher errors due to image noise. In addition, errors in camera position and orientation can cause slight vertical offsets and first order tilts. In our software a weighted average DEM is first generated from all DTMs, and then each DTM tile is fitted to this to compensate for offset and tilt. The process is then repeated iteratively a specified number of times. When combining DTMs we utilize weights based upon the average topographic noise present in each DTM, and the offset of the photogrammetric error (skew) for each matched point with respect to the mean photogrammetric error for the whole DTM.

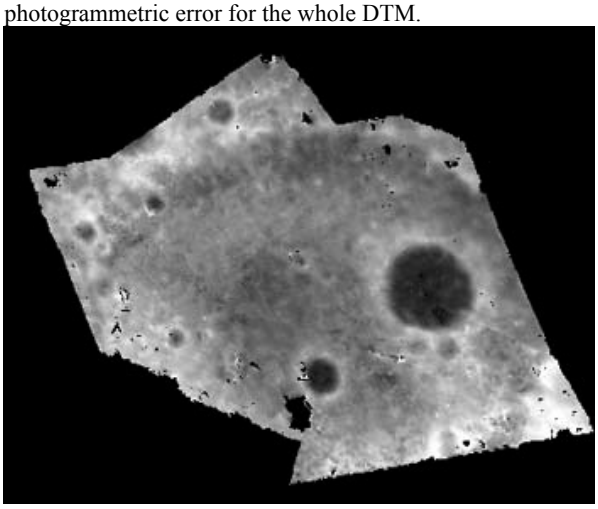

Fig 2 DEM mosaic of the northern half of the Beethoven basin composed of DEMs from Fig 1. Note the depression just inside the northern rim.

Results: 1709 image pairs proved suitable for stereo matching from a group of 483 images. Stereo pairs that proved unsuitable for inclusion in the DEM mosaic include those with image data gaps, where the overlap was too small, or where a line or pixel offset has occurred in one of the images creating an artificial topographic step. At the time of writing our DEM mosaicking software is undergoing modification in order to optimize the use arrays large enough to mosaic the above DTMs together, however a preliminary large area DEM mosaic was generated in February 2001 (Fig 3).

Discussion: A set of unique DTM tiles has been produced, each containing the relative topography in localized regions across Mercury's surface. The DTM tiles are being mosaicked to form a large area DEM covering one quarter of the planet's surface with 2 km spatial resolution. Alternative large area topographic datasets for Mercury are unlikely other than perhaps from increased Earth-based radar altimetry around the equator [10], from future radar interferometry [11], or until spacecraft revisit Mercury at the end of this decade [12,13]. Experiments are underway to improve our DEM mosaicking technique such that it will preserve both good height accuracy and spatial resolution DTMs, whilst using lower quality DTMs to fill in gaps. This dataset when completed will be released to the planetary science community. Several localized DEMs are already available from the following web site:

http://www.nasm.edu/ceps/research/cook/topomerc.html

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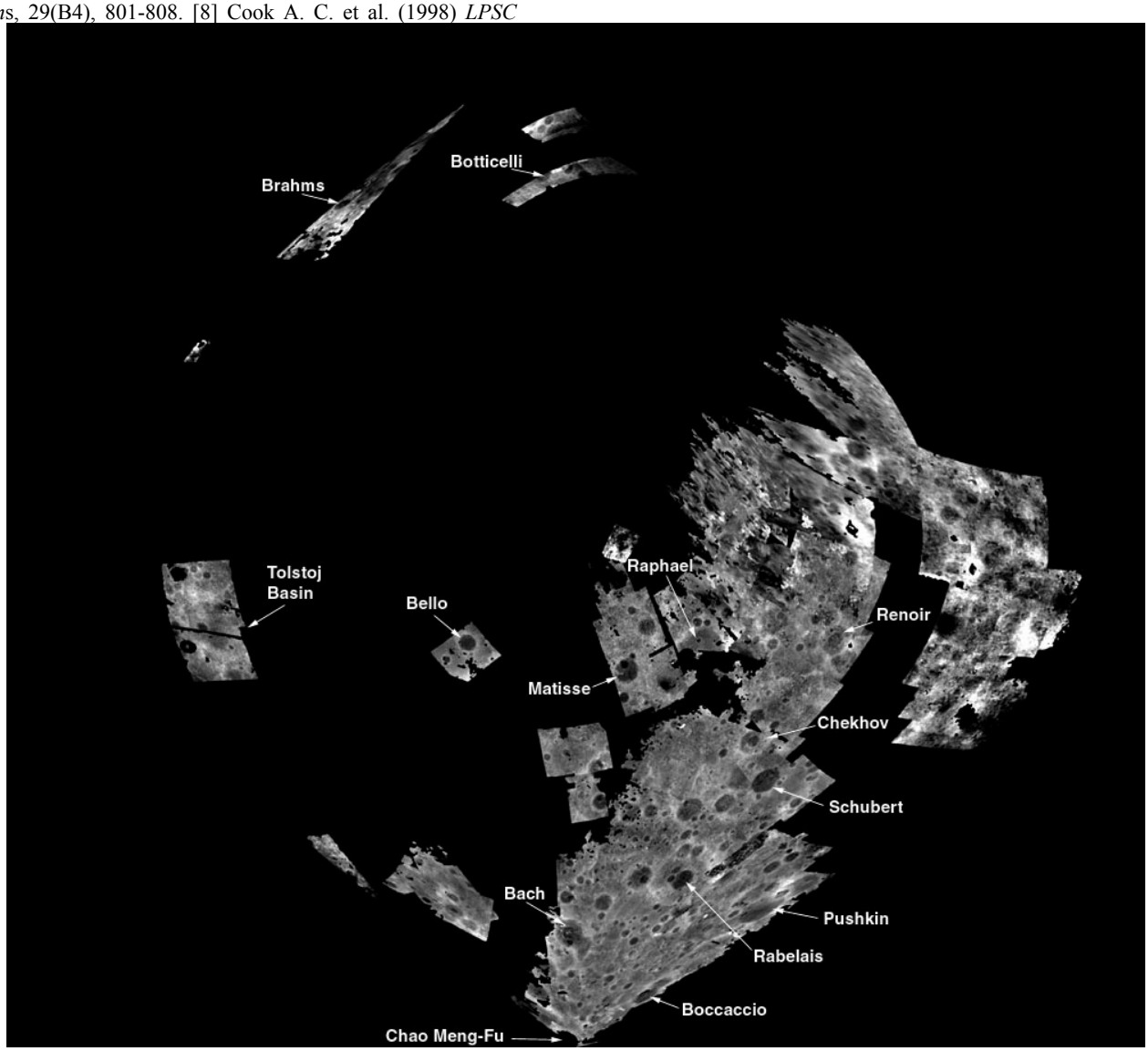

Figure 3 DEM mosaic generated from ~700 stereo pairs (sinusoidal equal-area projection, 200W-0W, 90N-90S, black= -3.2km, white =+3.2km). The region on the extreme right suffers from poor quality stereo. When complete the DEM mosaic will have fewer gaps and most of the left quadrant and equatorial region will be filled in.