QUALITY ASSESSMENT OF MARINER 10 DIGITAL ELEVATION MODELS. S. L. Wilkison[1], M. S. Robinson[1], T. R. Watters[2], and A. C. Cook[2], [1]Department of Geological Sciences, Northwestern University, Evanston, Illinois 60208, [2]Center for Earth and Planetary Studies, National Air and Space Museum, Washington D. C. 20560.

Introduction: New camera positions and orientation data [1] were used to create a new map of Mariner 10 stereo coverage [2]. The automated digital stereo analysis provides continuous topographic data with 1-2 km spatial resolution and 0.5 to 2 km vertical resolution [2]. Wilkison et al. [3] reported an analysis of crater topography using this stereo data, examining the depth to diameter ratio (d/D) for immature and mature complex craters within a DEM (digital elevation model) of the Discovery Quadrangle. The d/D results [3] agree with those of Pike [4] for mature complex craters. However, the d/D results [3] for immature complex craters diverged from that of Pike [4]. Crater depth shallows as the immature complex craters approached the pixel size of the stereo matching box, or "patch", which was typically 5 to 12 pixels (in radius), with image resolution of 1-2 km. We hypothesized that the patch size used in matching the stereo images created a smoothing effect of the topography within the DEM. To determine how the patch size was affecting the topography of the DEM, we performed a series of simple tests. These tests allow us to realistically place bounds on the accuracy and precision of the Mariner 10 DEMs.

Background and Method: As part of the process of stereo image analysis, automated digital stereo matching finds corresponding points in image pairs. Patterns of pixels from a reference image are searched for within the accompanying stereo image. This automated stereo matching process is performed by comparing pixel patterns between the images within correlation windows, or patches. Typical correlation patch sizes range from 5 by 5 pixels [5,6,7] to 9 by 9 and 21 by 21 pixels [8,9]. The matching program used with our study, the UCL "Gotcha" program, uses patch radius sizes of 5-12 (11 by 11 to 25 by 25 pixels) [10,11].

Precision within the DEMs. To better understand the quality of the Mariner 10 DEMs and to determine if the DEMs provide repeatability of the low frequency topography (relative to the patch size), we produced DEMs resulting from varying the correlation patch sizes (patch sizes 5-12). Profiles across topography are plotted to show the variation within a given elevation with different correlation patch sizes. Figure 1 shows the DEM with the location of the topography profile. Figure 2 shows the topography across this region from the 27399/166613 stereo pair. Patch sizes 5 through 12 are shown. Figure 2 indicates that the larger the patch size, the more smoothed the topography becomes; as the patch size increases, the area over which the average is determined also increases. This observation explains the trend that we observed with the d/D measurements [3]; the patch size created an artificial shallowing of crater depth. Table 1 shows d/D measurements from the profiles in Figure 2; the topography is smoothed and the d/D decrease with increased patch size. The increased noise with the smaller patch sizes is probably due to an artifact of the matching algorithm.

Accuracy within the DEMs. The smoothing trend observed from varying the correlation patch size is an effect somewhat equivalent to performing a low-pass filter on DEM data with different sized boxfilters. We tested this comparison by applying a low-pass boxfilter (with varying box sizes of 5 by 5, 7 by 7, 9 by 9, 11 by 11, 15 by 15, 21 by 21, and 35 by 35 pixels) to two DEMs. The Kilauea DEM from the Kilauea Compiled Volcanology Dataset, produced by JPL in 1992, has a resolution of 9.146 m/pixel. The Apollo 17 DEM was created from topographic data from the USGS 1:50,000 scale map of the Taurus-Littrow Valley [12], with a resolution of 10 m/pixel. Topographic profiles were measured from each of the low-pass filtered DEMs (as shown in Figure 3 and 4). Both sets of topographic profiles indicate the same trend; as the boxfilter size increases, smoothing of the topography increases (a larger boxfilter averages over a larger area). Measurements of d/D from both sets of profiles also show smoothing as box size increases. The smoothing of topography trend observed with the Mariner 10 data is also observed with these high quality "known" DEMs, indicating that the smoothing of topography is a real effect and not due to inaccuracy within the Mariner 10 DEMs.

Conclusions: We observed smoothing of topography with larger correlation patch sizes and "noise" with smaller correlation patch sizes. The low-pass boxfilter test on "known" DEMs indicate that the smoothing effect is real and not an artifact of the Mariner 10 stereo images. Future studies will include implementing different matching programs with different correlation patch sizes in the hope of decreasing the "noise" observed within the lower patch sizes, and examining specific craters on many DEMs with different patch sizes.

References: [1] Robinson M. S. et al. (1999) *JGR, 104*, 30847-30852. [2] Cook A. C. and Robinson M. S. (2000) *JGR, 105*, 9429-9443. [3] Wilkison S. L. et al. (2000) *LPSC XXXII*, #2118. [4] Pike R. (1988) in *Mercury*, pp165-273. [5] Schenk P. M. and Moore J. M. (1995) *JGR, 100*, 19009-19022. [6] Schenk P. M. et al. (1997) *GRL, 24*, 2467-2470. [7] Schenk P. M. and Moore J. M. (2000) *JGR, 105*, 24529-24546. [8] Oberst et al. (1996a) *LPSC XXVII*, p. 973. [9] Oberst et al. (1996b) *Planet. Space Sci*, *44*, 1123-1133. [10] Day et al. *International Archives of Photogrammetry and Remote Sensing, XXIX, B4*, 801-808. [11] Thornhill et al. (1993) *JGR, 98*, 23581-23587. [12] Preliminary Topographic Map of Part of the Littrow Region of the Moon, March 1972, USGS Flagstaff, [13] Watters T. et al. (this volume).

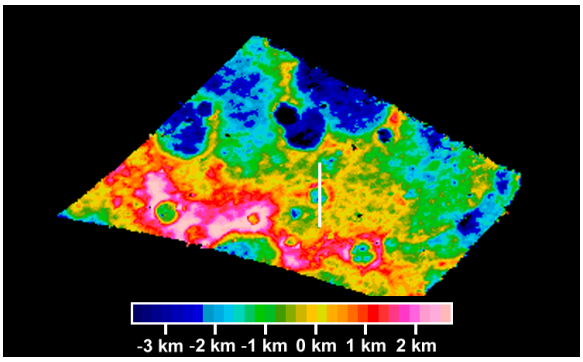

Figure 1. Color-coded digital elevation model generated using Mariner 10 stereo pair 27399 and 166613 [13]. The white line indicates the location of the topographic profile shown in Figure 2. The elevations are relative to the 2439 km radius reference sphere.

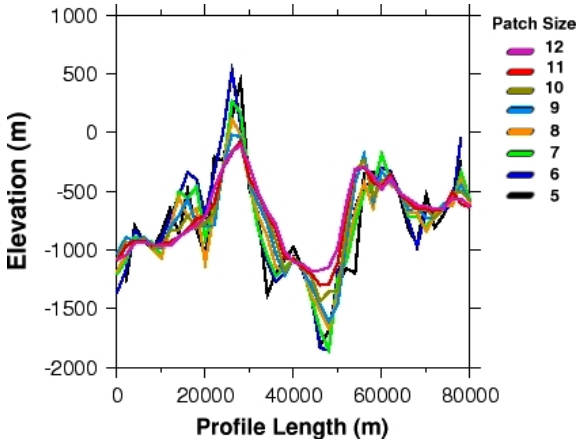

Figure 2. Comparison between topographic profiles taken from DEMs generated with different correlation patch sizes. The profile location is shown in Figure 1.

Table 1. d/D ratios determined from the topographic profiles shown in Figure 2. The location of the crater is shown in Figure 1.

Patch Size	
5	0.0803
6	0.0800
7	0.0756
8	0.0636
9	0.0570
10	0.0481
11	0.0437
12	0.0382

Figure 3. Comparison between topographic profiles taken from a DEM filtered with varyingly sized low-pass boxfilters. Shown is a profile of topography measured from a DEM from the Kilauea Volcanology Compiled Dataset by JPL, 1992. Spatial resolution of the DEM is 9.146 m/pixel.

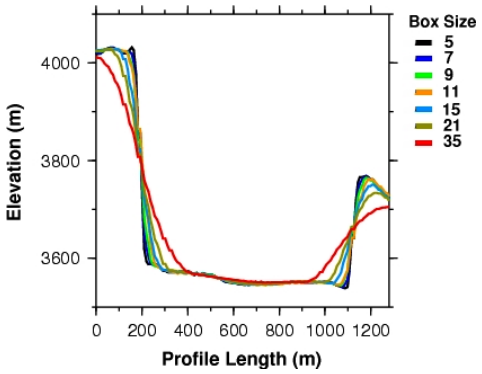

Figure 4. Comparison between topographic profiles taken from a DEM filtered with varyingly sized low-pass boxfilters. Shown is a profile of topography measured from a lunar crater (Mocr) from a DEM derived from the USGS 1:50,000 scale map of the Taurus-Littrow Valley [12]. Spatial resolution of the DEM is 10 m/pixel.