**MOLA DATA MAY INTRODUCE SIGNIFICANT ARTIFACTS IN CRATER DIAMETERS.** S. J. Robbins[1,2], and B. M. Hynek[2,3], [1]APS Department, UCB 391, University of Colorado, Boulder, CO 80309, [2]LASP, UCB 392, University of Colorado, Boulder, CO 80309, [3]Geological Sciences Department, UCB 392, University of Colorado, Boulder, CO 80309.

**Introduction:** The Mars Orbiter Laser Altimeter (MOLA) operated for 5 years aboard the Mars Global Surveyor craft, returning over 500 million data points detailing the topography of Mars. With a vertical accuracy of ~30 cm and a spot size of ~75 m, the data have been compiled to provide the first planet-wide topographic maps of Mars. These data allow the critical characteristic of crater depth to be calculated, and it provides a precise estimate of the crater diameter without visual biases (*e.g.*, shadow or albedo effects). However, after determining the diameters of over 32,000 craters from the Thermal Emission Infrared Spectrometer (THEMIS) daytime IR mosaics and comparing them with MOLA-derived diameters, we have determined that there is an unforeseen systematic offset, biasing MOLA-derived diameters to be larger by ~1 km. This observation is relatively independent of crater diameter.

**Crater Catalog:** For other research [1] we created a catalog of craters $D >\sim 2.5$ km over a large region of Mars (15.0% of the planet's surface). Creating the catalog was a two-step process. First, we visually identified all >~2 km-diameter craters in THEMIS day IR [2] mosaics (~230 m/px) or Viking MDIM if THEMIS data were not available. The rims were traced using *ArcGIS*'s "streaming" tool to create an $N^{\text{th}}$-order polygon. At least 5 points were used for each crater's rim, with the average having 30 points. These polygons were then fit via a non-linear least-squares circle-fit and an ellipse-fitting algorithm, saving the diameter, major and minor axes, centroid (as the crater's center), ellipse eccentricity and tilt, and the number of points used. All polygons were also saved.

The second step used MOLA 1/128°-gridded topography (~500-m resolution) [3] to determine crater depth and diameter. Each crater that had been identified in the THEMIS or Viking mosaics was isolated in MOLA data and three polygons were manually created in *Igor Pro* software, identifying the highest portions of the rim, the surrounding surface, and the deepest sections of the crater floor. The rims were fit with the same routines described above, initially to serve as a validation/comparison. In addition, the averages and standard deviations of each polygon were saved as estimates of the rim height, pre-impact surface, and floor depth. All polygons were also saved.

If the MOLA-derived diameter was significantly different from THEMIS, the crater was analyzed a second time to verify the result. The threshold for checking was $D_{\text{MOLA/THEMIS}} < 0.75$ for all diameters, and $D_{\text{M/T}} > 1.5$ for $D \geq 3$ km and $D_{\text{M/T}} > 2$ for $D < 3$ km. A histogram of the ratio of the derived diameters is shown as Figure 1, and it is clear that there is a shift to larger diameters in the MOLA-derived results, relative to THEMIS.

**Completeness of the MOLA vs. THEMIS Craters:** Due to the finite resolution of the MOLA instrument and gaps in its coverage, more craters were able to be analyzed in THEMIS data than MOLA, and the relative completeness was size-dependent: Approximately 97.3% of craters >10 km can be analyzed in MOLA data; approximately 93.6% of craters 5-10 km can be analyzed in MOLA data; this drops to 82.9% that can be analyzed that are 2.5-5 km in diameter and only 62.0% for craters smaller than 2.5 km. We excluded craters that either (a) could not be seen in the MOLA data, or (b) have too few non-interpolated pixels to be accurately analyzed - this is generally fewer than 5-10 px across.

**Further Analysis of Relative Offsets within Our Catalog:** Figures 2 and 3 show the absolute and relative diameter difference between the MOLA- and THEMIS-derived diameters. Every crater is plotted as red scatter, and the data are binned with error bars indicating the standard deviation from the mean within each bin. The plots that the absolute offset generally averages ~0.5-1.0 km larger for the MOLA diameters, and this is fairly independent of crater diameter. However, a difference of 1 km for a crater that is 1 km in size (from THEMIS) will result in a relative increase of 100% in crater size in MOLA data, as shown in Figure 3. This becomes fairly insignificant for craters $D > 20$ km as a ~2-5% offset, but it is still statistically important.

**Verification with Other Databases:** To determine whether this was a systematic error in our own methods as opposed to a real phenomenon within the data, we obtained pre-release crater databases of THEMIS-derived crater diameters in the Northern Hemisphere (courtesy of Dr. Nadine Barlow, personal communication. [4]) and MOLA-derived crater diameters in the Southern Hemisphere (courtesy of Dr. Tomaz Stepinski, personal communication, [5]). We then correlated these with our database, which spanned regions of both hemispheres. We set the threshold for a match between craters as within 0.15° latitude and longitude, and within 35% of the other catalog's diameter (if multiple matches were present, we used the closest in terms of location). We then determined the differences in diameters and binned these differences (as in Figure 1), shown in Figures 4 and 5.

Figure 4 shows results from 4496 craters that were determined to be the most likely matches between the two THEMIS-derived databases. The shape of the histogram is close to a Gaussian; the mean is 1.02±0.07 and the mode is centered on perfect agreement (at the 1%-level) between the two databases. We believe this indicates that there is not a systematic bias in our algorithms, otherwise we would expect our diameters to be significantly smaller than Dr. Barlow's.

Figure 5 shows results from 3664 craters that were determined to be the most likely matches between the two MOLA-derived databases. The shape of the distribution is significantly different from Figure 4, weighted strongly towards Dr. Stepinski calculating larger diameters than us (which are again larger than the THEMIS-derived diameters), with the mode at 7% larger (the mean is 1.10±0.10). We believe this indicates that our observed bias is a real phenomenon, and the magnitude of the offset varies between researchers.

**Conclusions:** After analyzing over 32,000 Martian craters, over 25,000 of them in both THEMIS and MOLA data, and comparing our results with two other independent researchers, we believe that there is a significant, systematic bias towards deriving larger crater diameters in MOLA data than THEMIS data. This increase corresponds to ~2-4 MOLA px increase, which could be due in part to the steep inner slope giving a poor data return, and the true rim peak being interpolated outwards by 1 px in radius. Because of MOLA's importance in crater research, this bias needs to be better understood, quantified, and taken into account when using MOLA data for deriving morphometric crater properties.

**References:** [1] Robbins, S.J. et al. (2008) *11th MCC*, online only. [2] Christensen, P.R. et al. (2001) *JGR*, *106*, 23823-23871. [3] Smith D.E. et al. (2001) *JGR, 106,* 23689-23722. [4] Barlow, N.G. (2007) *10th MCC*, online only. [5] Stepinski, T.F. (2007) *10th MCC*, online only.

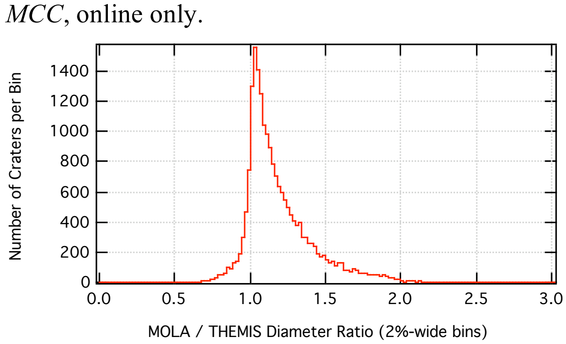


**Figure 1:** Histogram of the relative difference between our two diameter derivations (THEMIS- and MOLA-based). Mode is 1.02.

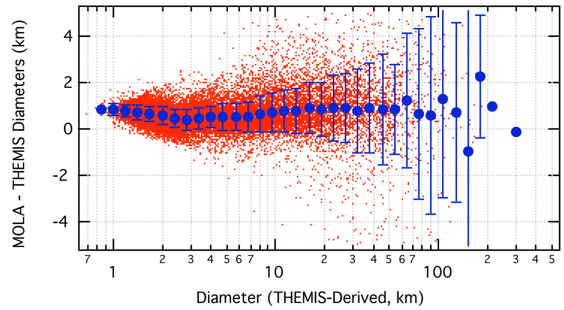


**Figure 2:** Scatter plot with overlaid bins showing the absolute diameter difference between our two derivations vs. our THEMIS-derived diameters.

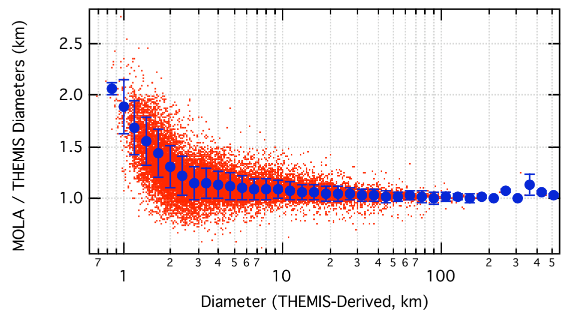


**Figure 3:** Scatter plot with overlaid bins showing the relative diameter ratio between our two derivations vs. our THEMIS-derived diameters.

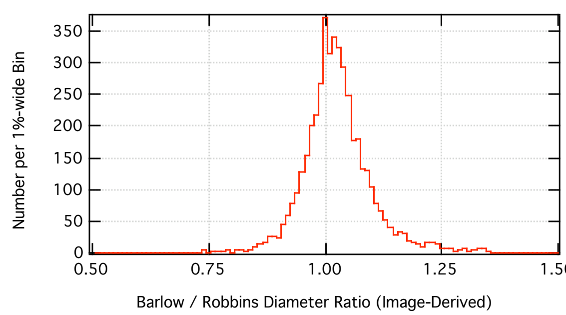


**Figure 4:** Histogram showing the differences between crater diameters from Dr. Barlow's database vs. ours (both THEMIS-derived diameters). Mode is 1.00.

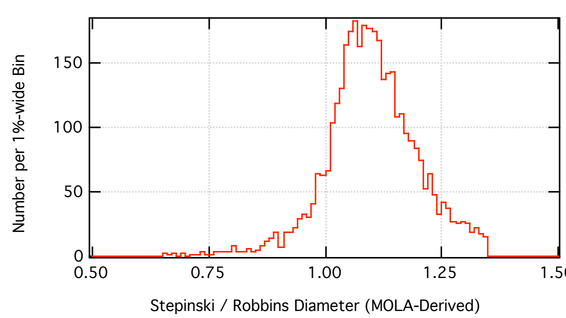


**Figure 5:** Histogram showing the differences between crater diameters from Dr. Stepinski's database vs. ours (both MOLA-derived diameters). Mode is 1.07.