PRELIMINARY RESULTS OF MORPHOMETRIC MEASUREMENTS FOR LUNAR CRATERS WITH DIAMETERS 1-25 KM. R. H. Hoover*[1,2], S. J. Robins[1] and B. M. Hynek[2] *rhoover@boulder.swri.edu, [1]Southwest Research Institute, 1050 Walnut St #300, Boulder, [2]Department of Geological Sciences, University of Colorado Boulder, CO 80309

Background: Impact cratering is one of the most common geologic processes across the solar system, and studying the impact craters of any particular body can provide insight into a wide variety of planetary science questions. Researching impact craters can help answer questions relating to modern day surface processes affecting a body, surface and near-surface geology, past and present impactor populations, and safety of potential landing sites. Additionally, impact cratering occurs on all solid surface bodies in the solar system, and studying variations and differences of those impact craters are important for assessing geologic differences and similarities between planetary bodies. Collecting data related to impact craters often takes a significant amount of human effort and can result in variations between researchers. But, providing the community with a large dataset can aid a variety of investigations by allowing for ease of comparison between studies and saving a significant amount of time. In this research, we present preliminary results for the morphometric properties of lunar impact craters 1-25 km in diameter (D) between ±60° latitude that can be used for future studies by the planetary community.

Motivation: Robbins recently complied a global lunar crater database, identifying the location and diameter for approximately all 1.3 million craters $D > 1$ km [1]. The purpose of this research is to semi-manually calculate the depth of each well-defined crater identified in that database to be a better reference for the community.

Methods: Three main topographic datasets are used to collect morphometric data for the lunar crater database. In this abstract, we present results for ±60° latitude, but this will be expanded upon in the future to include up to ±90° latitude. Datasets available will be used where they exist and include the Lunar Orbiter Laser Altimeter (LOLA) Reduced Data Record (RDR) data product [2] with ±90° coverage, the Kaguya DTM tied with LOLA data with ±60° coverage [3], and the Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) stereo-based topographic product with ±85° coverage [4]. Using multiple datasets for the same kinds of measurements will allow us to determine if there are different biases among the topography datasets.

Morphometric measurements were collected for crater rim elevation, surrounding surface elevation, floor depth, and crater volume, using a code which allows for a semi-automated/-manual extraction of these data. The entire Moon was divided into 20°×22.5° regions to help manage file and data volume for a total of 130 sub-regions.

Topographic data and the locations and diameters of all craters are first loaded into *Igor*. To measure each individual crater, *Igor* first draws simple, ideal circles for the crater rim, 50% of that to encompass the floor, and then 200%–300% as an annulus for the surrounding surface. The user then checks the location of the polygons to confirm the identification of each feature (e.g., can you see a crater in the topography? is it offset?) and adjust the location and size of the features as necessary. For example, if the crater rim of a nearby crater intersects the crater rim of interest, the area of intersection can be removed from the polygon identifying the crater rim to ensure that the measurement only includes the rim of the crater of interest. After checking, adjusting, or manually drawing the polygons, *Igor* runs an automated code to identify data points from the DTM and LOLA RDR within each polygon to determine the rim elevation, the crater floor elevation, and the elevation of the surround surface. These are points-within-a-polygon calculations except for the rim, where the highest points within a small neighborhood are found and saved. Additionally, any data within 1 crater radius of any other existing comparably-sized crater or smaller in the database are removed so they will not affect the depth calculations. Once these elevations have been determined, the code stores the means and standard deviations in a data table and they are used to estimate crater depth and crater volume. This method is significantly different from all recently published work of large lunar databases because those other methods relied entirely on fully automated techniques with no human interaction to extract one or up to eight profiles, instead.

Results: Collection of the depth measurements is currently ongoing, and at the time of this abstract submission it is ~90% complete for craters ±60° latitude and 0°-360° longitude. Hoover has completed measurements for craters $D = 1$–25 km for 91 of the 130 global regions and all 91 of those regions are between ±60° latitude and 0°-360° longitude. The Kaguya DTM and the LOLA RDR were used for these particular measurements, referred to as "LAD" (laser altimetry data) and "DTM" in figures.

Figure 1 displays the current set of depth versus diameter data from Kaguya and LOLA. Figure 2 displays the depth/diameter measurement vs crater diameter for Kaguya and LOLA data for the same set of craters shown in Figure 1. As seen in Figures 1 and 2, there is very good agreement between the two datasets, as one would hope and expect, though depths tend to be slightly deeper in the laser data. This is likely because the laser is good enough to capture fine-scale topography that the raster DTM cannot. This sort of mismatch will be studied once data are fully gathered, for it has implications in these sorts of measurements for any body and from any instrument.

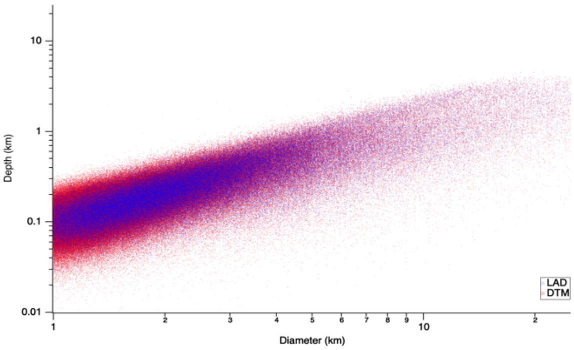

Figure 1: Depth versus diameter plot of craters ±60° latitude and 0°-360° longitude. The red (DTM) and blue (LAD) data are shown with significant transparency to help show the relative point density at any given area of the graph.

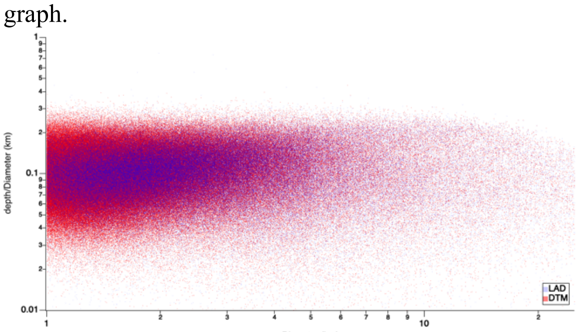

Figure 2: d/D vs diameter measurements for the same data as in Figure 1.

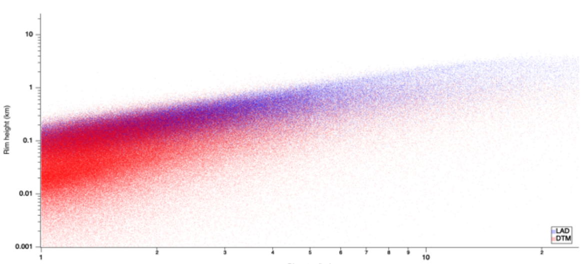

Figure 3: Crater rim height vs diameter for the same data.

Our data set also includes information about rim heights of craters which can be used to help understand the evolution and degradation processes of craters on the Moon. Figure 3 displays those data. Due to data resolution, LAD better captures small-scale structure along the rim so almost always returns a larger rim height than the DTM data.

Depth vs diameter ratios are calculated for each crater, too. Table 1 shows the average d/D ratio, calculated from rim to floor for varying geologic time periods.

	Avg d/D LAD	Avg d/D DTM
Copernican	0.107	0.113
Eratosthenian	0.107	0.107
Eratosthenian-Imbrian	0.147	0.144
Imbrian	0.110	0.111
Imbrian-Nectarian	0.095	0.095
Nectarian	0.105	0.105
Pre-Nectarian	0.109	0.108

Table 1: Average d/D from LOLA and DTM data for different aged units calculated from the Unified Geologic Map of the Moon [5].

Diameter (km)	Avg d/D LAD	Avg d/D DTM
1-6	0.107	0.107
6-11	0.112	0.112
11-16	0.109	0.107
16-21	0.098	0.097
21-26	0.083	0.080

Table 2: Average d/D from LOLA and DTM data for different size craters.

The average d/D ratio varies by diameter as shown in Table 2. The average d/D for all craters collected thus far is 0.107, which is lower than previously reported averages [6,7,8] but in agreement with the most recently published lunar d/D ratios that report a range of 0.06-0.16 averages using a dataset more similar in size to our dataset [9]. Inclusion of a mix of crater preservation states and secondary craters likely contribute to the discrepancies in depth and will be explored in the future. Some potential, additional reasons that can account for the variations in observed d/D ratios include dataset size and methodology.

Ongoing Data Collection: Measurements for craters $D > 1$ are still ongoing and will be expanded to include craters poleward of ±60° latitude and craters >25 km elsewhere. Once completed, a more in-depth analysis will be conducted to compare variations in d/D between geologic units, size, latitude and longitude. These results will be complied and presented at LPSC. Separation by morphologic state will not be completed by LPSC.

References: [1] Robbins, (2019) *JGR Planets* **124:4**, 871-892. [2] Neumann, (2009) *Lunar Orbiter laser Altimeter Raw Data Set*, LRO-L-LOLA-3-RDR-V1.0, NASA Planetary Data System, 2010. [3] Baker et al., (2016) *Icarus* **273**, 346-355. [4] Wagner et al., (2015) *46th LPSC* Abstract #1473. [5] Fortezzo et al., (2020). *51st LPSC* Abstract #2760 [6] Stopar et al., (2017) *Icarus* **298**, 34-48 [7] Feoktistova and Ipatov (2021) *EMP* **125:1** [8] Rubanenko et al., (2019) *Nature Geoscience* **12**, 597-601 [9] Wu et al., (2021) *GRL* ***49:20.***