Abstract #1401

Advancements in Scaling Models for Ejecta Blankets of Lunar Impact Craters

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Introduction

Impact craters on the lunar surface have varying sizes, ranging from <100 meters in diameters to large impact basins hundreds of kilometers in diameter. Impact craters can be separated into two broad categories, simple craters and complex craters. McGetchin et al. (1973) [1] derived a power law expression to model the thickness of the ejected material with distance from the crater for both types of craters, which was improved upon by Housen et al. (1983) [2]. Both models use Apollo mission data to determine the thickness of the crater ejecta blankets. The accuracy of the scaling models can now be assessed, as precise topographical measurements of the lunar surface from the Lunar Reconnaissance Orbiter's (LRO) Laser Altimeter (LOLA) now exists. We primarily focused extensive accuracy testing on the McGetchin model in order to find the value of the constants applied for these models.

Methods

To provide the most accurate results for the McGetchin model constants, roughly 100 impact craters were selected across the surface of the moon. The criteria for selected impact craters was:

1. Impact craters must be larger than 1 kilometer.
2. Craters must be fresh (geologically undisturbed by processes or other impacts).

By using these criteria, craters selected ranged from a 2.6 km crater near the crater Fahrenheit in Mare Crisium, to the 96 km crater Copernicus in Oceanus Procellarum. The average crater diameter out of the selected craters was 15.2 km. The selection process was done in ArcGIS using a LRO Wide Angle Camera (WAC) mosaic map of the moon, as well as a LOLA gridded DEM to provide topographic cross sections of the moon. The resolution of the DEM was 118 meters. The selected craters are indicated on the shaded relief ma shown in figure (1).

We normalized each profile in order to compare it to the model ejecta profile (figure 2, 3). Topographic cross sections were made for a north-south and west-east profile. Each profile was then placed into MATLAB's curve fitting program with the x-axis set as crater radius measured from the crater center (ie: one crater radius was r/R=1) and the y-axis set as normalized height (figures 3, 4).

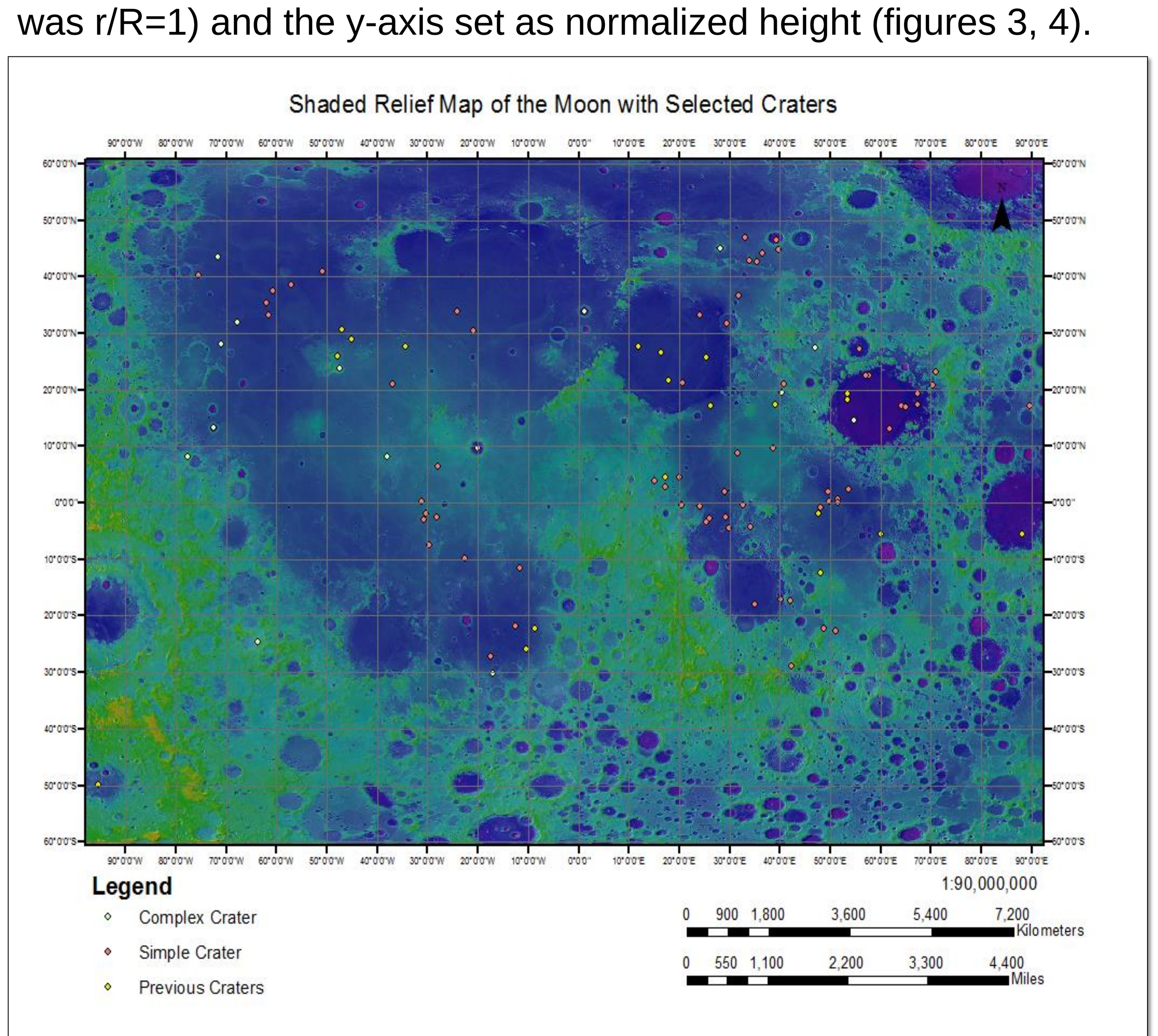

Fig. 1 – The shaded relief map shows the large area where craters for this project were selected. Many of the craters selected fall in the mare regions of the moon, as topography is flatter.

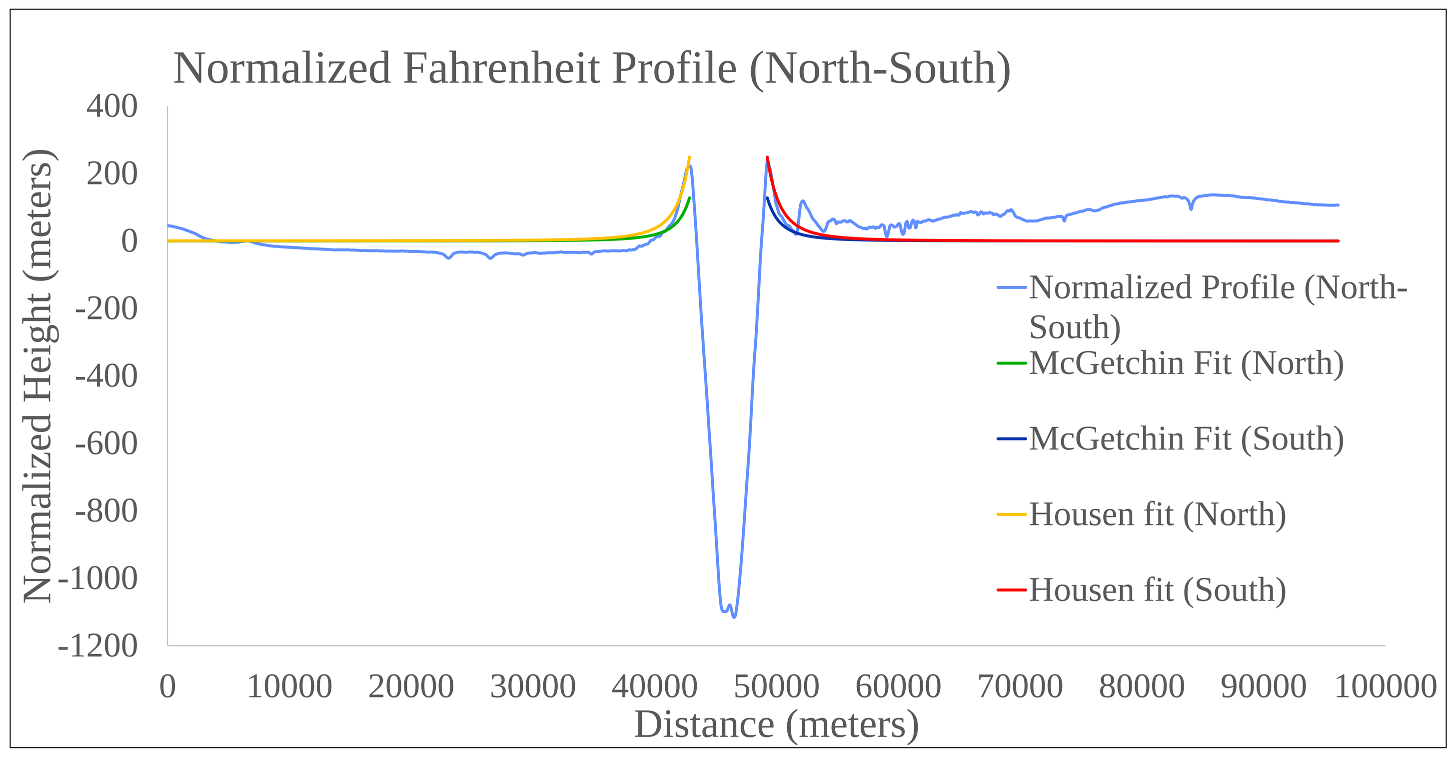

Fig. 2 – A north-south cross section view of the 6 km crater Fahrenheit. Both the McGetchin model and Housen model have been applied to this profile with the Housen model providing a near perfect fit to the cross section profile. The McGetchin model shows an underestimated fit for both sides of the profile.

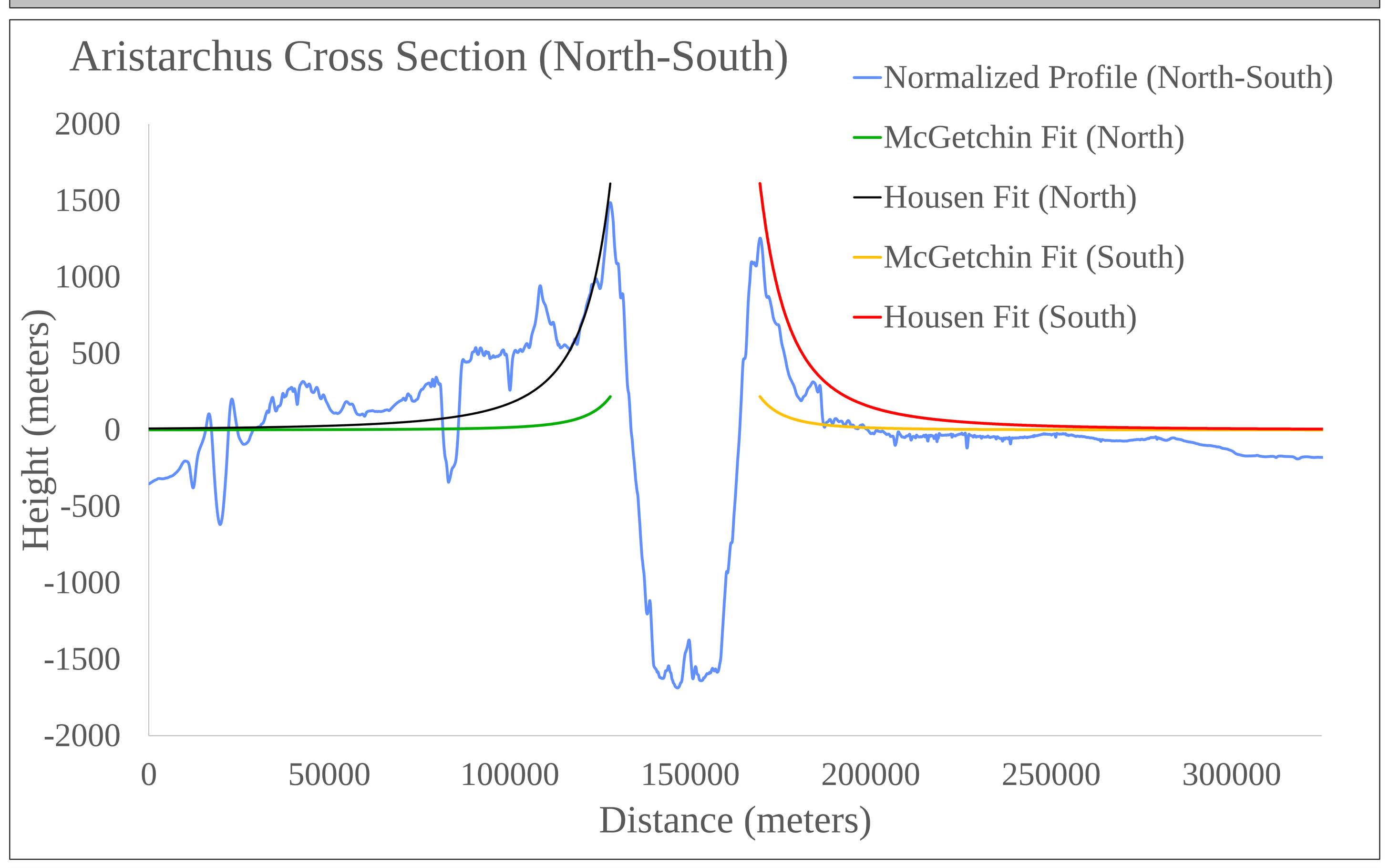

Fig. 3 – A north-south profile of the 40 km crater Aristarchus located in the Oceanus Procellarum. Both the McGetchin and Housen models have been applied to the crater. The Aristarchus plateau affects the topography in this region to the north and west. The profile has an adequate fit on the north side, but is overestimated on the south profile. The McGetchin profile completely fails in this situation.

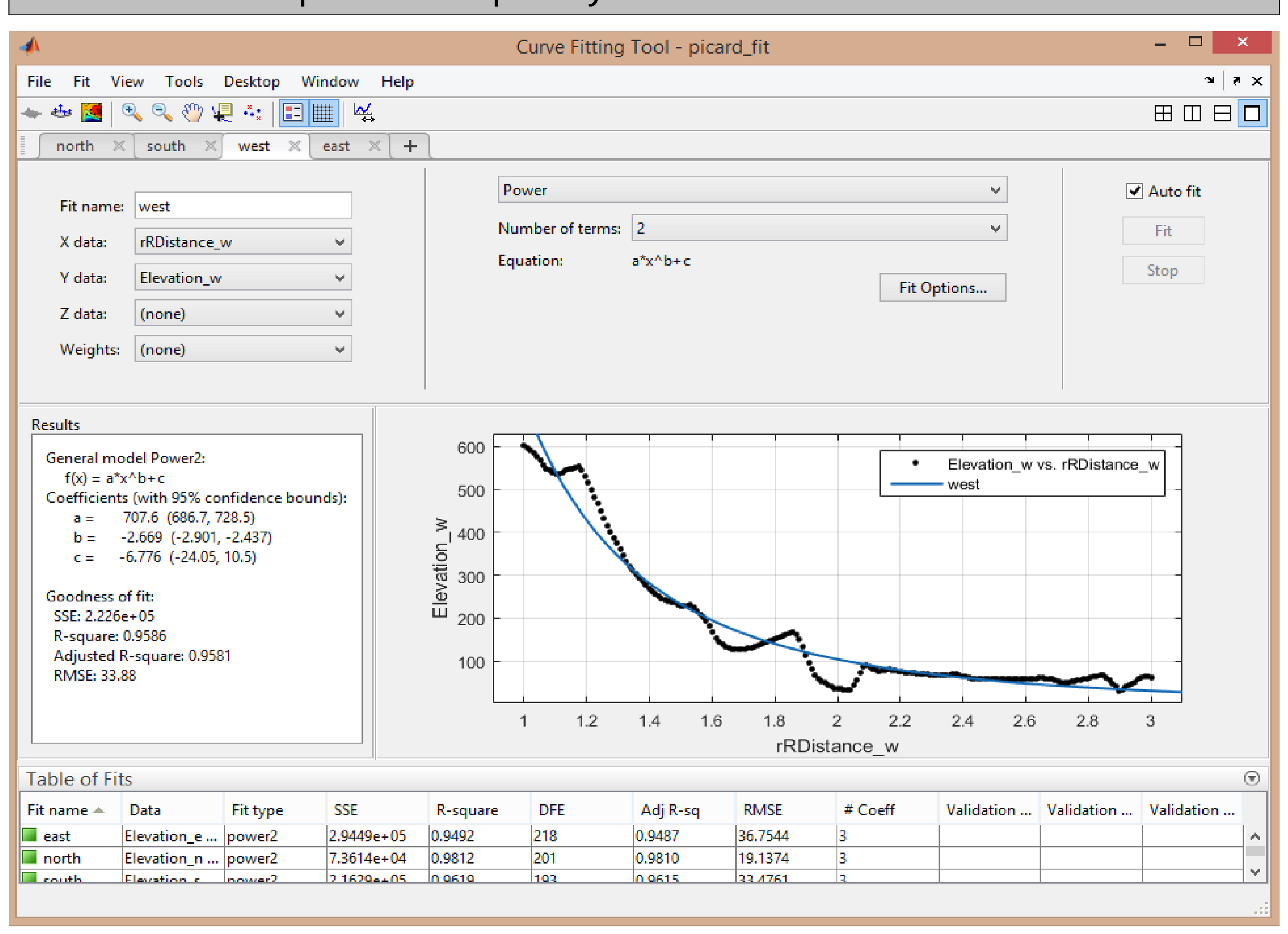

Fig. 3 – The accuracy test for the 23 km crater Picard's west ejecta profile. The x-axis is set at the measured distance in crater radii from the crater, such that, r/R=2 is a full crater diameter from the crater center. The constant *c* is added into the power law to give a more accurate fit in order to make up for the normalized elevation.

Preliminary Results

In our analysis of both models, we found that the McGetchin model, written as,

$$t = A * R\left(\frac{r}{R}\right)^{-B} \text{(Simple Craters)}$$

$$t = A * R^{0.74}\left(\frac{r}{R}\right)^{-B} \text{(Complex Craters)}$$

where *A* is the multiplier constant, *B* is an exponent constant, *R* is the radius and *r* is a measured distance from the crater; underestimates the rim height for simple craters, and totally fails when applied to complex craters. The Housen model, when applied, has an adequate fit for simple craters, while providing a range of adequate, overestimation and underestimates for complex craters. Results found during the accuracy testing of the McGetchin model show a difference in the multiplier constant by a factor of 2.75 with new values determined to be 0.110±0.0053 and a exponent value of 4.06±0.61 for simple craters. Initial results for the value of complex craters show a difference by a factor of nearly five with new multiplier and exponent values of 0.6954±0.0528 and 3.22±0.59 respectively. The initial multiplier results determined are also more consistent with measurements of rim heights [3].

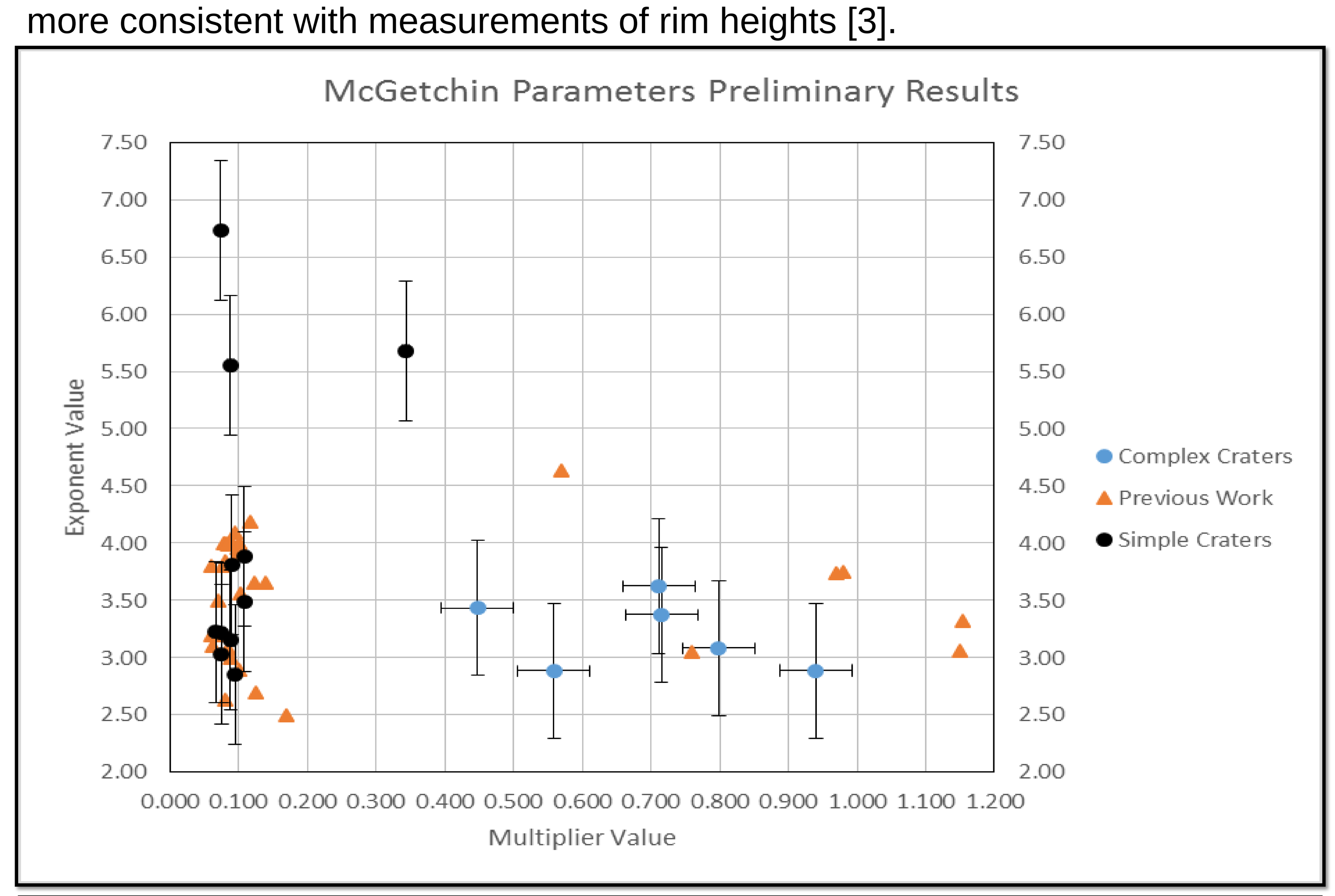

Fig. 4 – Preliminary results of the McGetchin model accuracy testing. Simple crater values are shown clustered on the left hand side in the bracketed range of 0.08 to 0.11. Previous work from Kumar et al. (2011) shows simple craters clustered within this range as well with few outliers in the initial results. Complex craters show a large range in values over the multiplier values, but shows a smaller range in exponent values.

Future Work

Future work of the research includes producing results for the rest of the craters. The results from the remaining craters will be used to finalize the constant values for the McGetchin model in order to provide an adequate fit for all future craters. Consideration of structural elements will be considered for future models as well, as ejecta material consists of roughly 20% of rim material [3]. The Housen model will also be examined in order to determine what constants will be adjusted in order to provide consistently accurate fits to complex craters.

Acknowledgments

Funding for this project was provided by the Hooper Undergraduate Research Fund (HURA) at Northern Arizona University. Special thanks to Dr. Kring of LPI for allowing this work to be continued.

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