Abstract #1736

ERROR ANALYSIS OF LUNAR BOULDERS SIZES

J. Y. Shah[1], S. Mazrouei[1], R. R. Ghent [1,2]

[1]University of Toronto, ON, Canada, [2]Planetary Science Institute, AZ, USA,

jahnavi.shah@mail.utoronto.ca

Introduction

- Boulder size-frequency distributions (SFD) play a key role in understanding small-scale erosion processes and the rate at which rock become regolith [1,2].
- Lunar Reconnaissance Orbiter (LRO) Narrow Angle Camera (NAC) images (resolution: 0.5-1 m/pixel, ~60º-80º incidence angle) are used to map boulders.

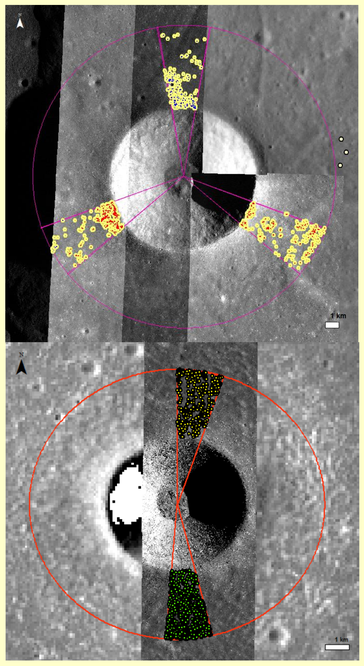


Fig.1:: Boulder counts 1 radii out from the crater rim. Top: Avery crater, 1.4ºS, 81.4ºE, diameter = 9 km, NACs M1123064231, M1156044386, M192424474. Bottom: Crater in Mare Humorum, 319.207ºE, -24.051ºN, diameter = 5.6 km, NACs M114220623.

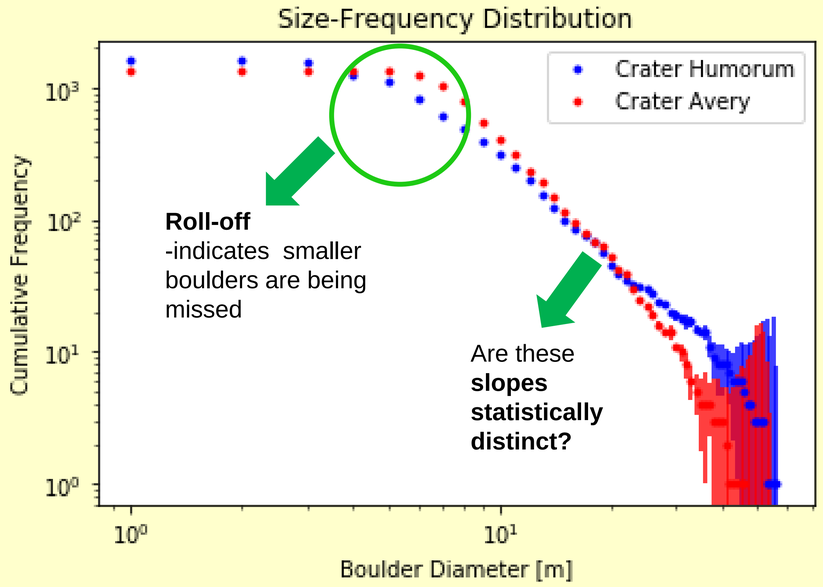


Fig.2: Cumulative size-frequency distributions of boulders around Avery and Humorum craters. :

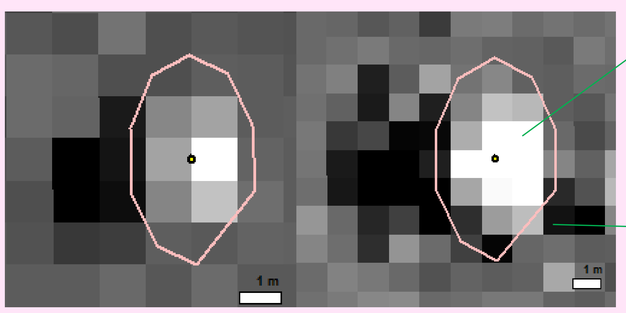
- Slope of cumulative SFD is of interest ⟶ varies for rock populations that have experienced different levels of comminution [3].

Objectives:

- **Determine smallest boulder size that can be mapped with confidence**
- **Quantify the effect of size uncertainties for all boulder diameters**

Methods

- Ellipse fitting tool in ArcMap CraterTools is used to map boulders. Semi-major and minor axes are recorded; the height is assumed to be equivalent to the minor axis.
- Use rectangle fitted inside an ellipse to determine uncertainty in boulder diameters.
- Volume of ellipsoid is larger than volume of rectangular prism which leads to an overestimation of sizes. The uncertainty comes from this volume discrepancy.
- Our results give an upper bound on the boulder size error.



Identify boulders as bright, sun-facing pixels adjacent to dark, shadowed pixels.

Ellipse "cuts off" one or more edges of the boulders.

Fig.3: Examples of boulder mapping using ellipses in ArcMap.

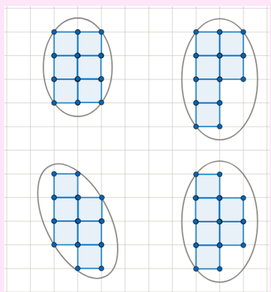


Fig.4: Rectangle fitted inside an ellipse for different pixel arrangements, for a boulder defined by 6 pixels.

Conclusions and Future Work

- Monte Carlo runs show a small difference between original and mean slopes.
- Avery crater (slope = -3.120) is different from Humorum crater (slope = -2.305).
- Uncertainties on boulder sizes are one-sided, therefore we need to sample from a distribution other than a normal/Gaussian distribution (e.g. lognormal distribution).

Acknowledgements & References

We thank Jeff Plescia for the Hadley Rille data and NASA for support of the LRO mission.

References: [1] Gault et al. (1972) *LSC III*, 2713-2744. [2] Hörz et al. (1975) *Moon, 13,* 235-258. [3] Hartmann (1969) *Icarus, 10,* 201-213. [4] Melosh (1984) *Icarus, 59,* 234-260. [5] Ghent et al. (2014) *Geology, 42,* 1059-1062. [6] Li et al. (2017) *PSS, 146,* 30-39. [7] Shoemaker (1965) *JPL Tech. Report #32-700*, 76-134. [8] Arvidson (1979) *Icarus, 37,* 467-474. [9] Watkins et al. (2017) *LPS XLVIII,* Abstract #1245. [10] Bart and Melosh (2010), *Icarus, 209,* 337-357. [11] Demidov and Basilevsky (2014) *Sol. Syst. Res., 48,* 324-329.

Results

- Calculations show an error range of 14-36% on boulder sizes.
- Error calculations performed for boulders with diameter ~2-5 m (2-10 pixels).
- This can be extended to larger boulders because uncertainty is independent of size (depends on rectangle-to-ellipse ratio).

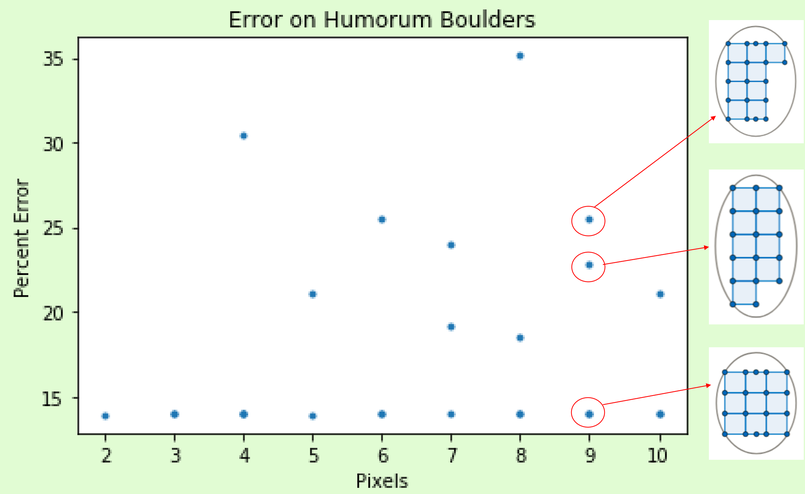


Fig.5: Range of error for boulder sizes in range of 2-10 pixels (~1-5 m). Different error values for a given pixel number is a result of different pixel arrangements as shown to the right.

Testing distinctness of slope

- Assume a normal error distribution and randomly sample from that distribution for each point in the original data, for multiple runs. Take μ = original boulder size and σ = uncertainty on size (10-40%).
- Slope of the linear range in SFD is calculated for each run, in order to compare to original slope.
- For errors in range of 30-40%, the distribution of slope spreads out more compared to the lower uncertainty values.

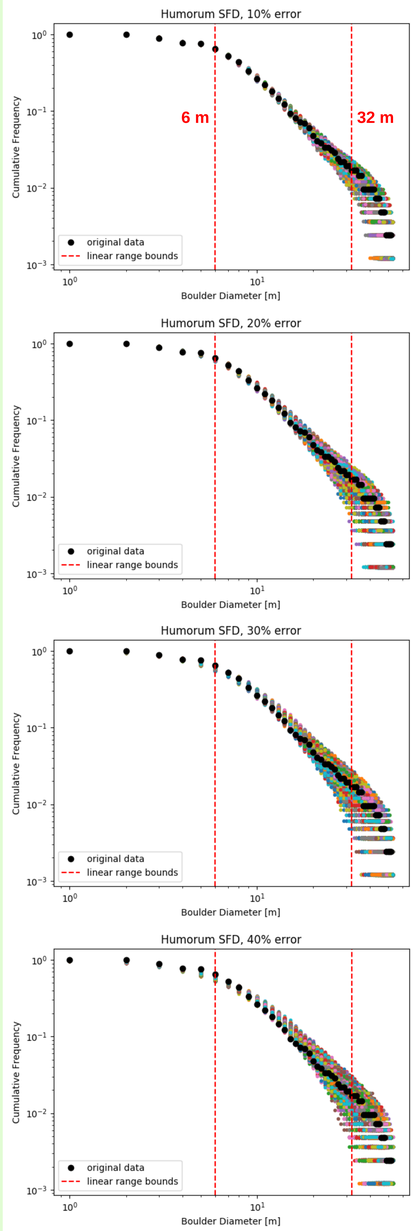


Fig.6: SFDs of Humorum boulders after applying 10-40% error (top to bottom) to each boulder size. The black points represent the original data, and each set of coloured points represent a different sampling run (out of 10,000 runs).

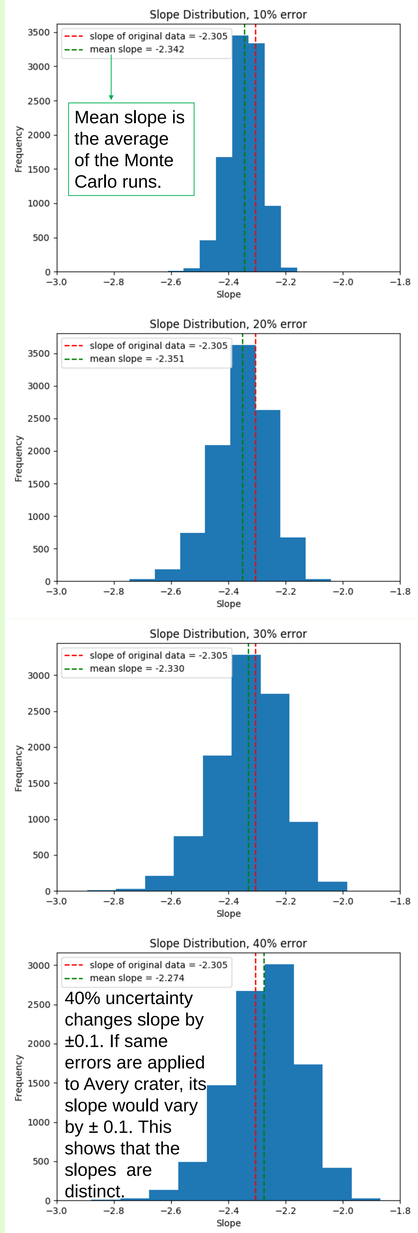


Fig.7: Distribution of slope of linear range calculated for each run (total 10,000 runs) for different size uncertainties applied (10-40% top to bottom.

Comparison with mass wasting

- Slope of linear region in boulder SFD for Hadley Rille was calculated (Fig.8, top):
  - Region ❶: -2.831
- The linear region can be separated into 3 different sections (Fig.8, bottom) which yields different slope measurements:
  - Region ❷: -1.725
  - Region ❸: -3.310
  - Region ❹: -7.512

Focusing on slope of Region 1, Rille data is separable from impact cratering results.

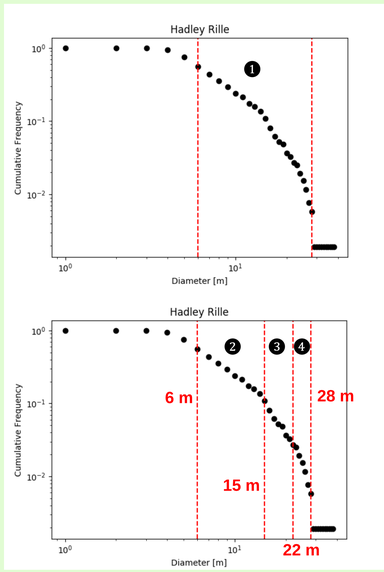


Fig.8: Cumulative SFD of Hadley Rille, 26.69ºN, 4.12ºE. Data courtesy of Jeff Plescia, JHU/APL.