Verification of Automatically Measured Boulder Populatons in HiRISE images

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Abstract #1893

Boulders all around
Computers measure for us
Can we find them all?

Introduction

Images taken by the High Resolution Imaging Science Experiment (HiRISE) show that meter-scale boulders and blocks are present across the entire surface of Mars [1], [2]. Quantifying estimates of these boulder populations, including their size and location, can address several outstanding questions regarding pedogenesis, surface weathering, impact processes, and mass wasting processes [3], [4]. In addition, surface analysis of hazards, such as boulders, is essential to identifying future landing sites [5]. However, manual measurement of boulder populations is time intensive, and is impractical to apply at large scales (e.g. more than a few square km of surface area). In order to examine large boulder populations, we have developed a Python-based algorithm to automatically identify, locate, and measure boulders in remote images of planetary surfaces. This set of tools and programs is collected in a python library called the Martian Boulder Automatic Recognition System (MBARS). Here we use several approaches to check the accuracy of results from MBARS.

Improvements since LPSC 2018

- Merges overlapping boulders
- Exports to GIS-ready format (Figure 2)
- Multi-threaded processing

Verification Methodology

- Measure Objects of known size (Figure 3, Table 2)
- Apply MBARS to measured populatons
  - o Manually measured (Figures 1,2,5)
  - o Automatically Measured (Figure 4)
- Compare to thermal-derived Rock Abundance (Table 1)

HiRISE Image	Derived Rock Abundance	
	MBARS	TES [6]
ESP_036437_2290	~41%	12-14%
ESP_011357_2285	~10%	0-30%

Table 1. MBARS-derived Rock Abundances compared to TES – Rock Abundance [6]. Preliminary analysis shows poor comparison between the two methods, likely due to the fact that MBARS is sensitive only to free-standing boulders, and TES is sensitive to all rock material.

References

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HiRISE image	Resolution (cm/pixel)	Lander Measurements [1]	Previous Work (m) Golombek 2008 [1]		MBARS Results (m)	
			Diameter	Height	Diameter	Height
PSP_001521_2025	25	Diameter:	2.01	1.67	2.93	2.36
PSP_001719_2025	25	2.7m	2.18	2.22	2.83	2.22
ESP_046170_2025	25	Height: 2 m	N/A	N/A	2.61	2.56

Table 2. Results from measuring the Viking Lander 1 with MBARS. All images provide results that are within 1-pixel uncertainity of the known diameter. The measured heights are less reliable. The ESP image was not available at the time the previous work [1] had been published.

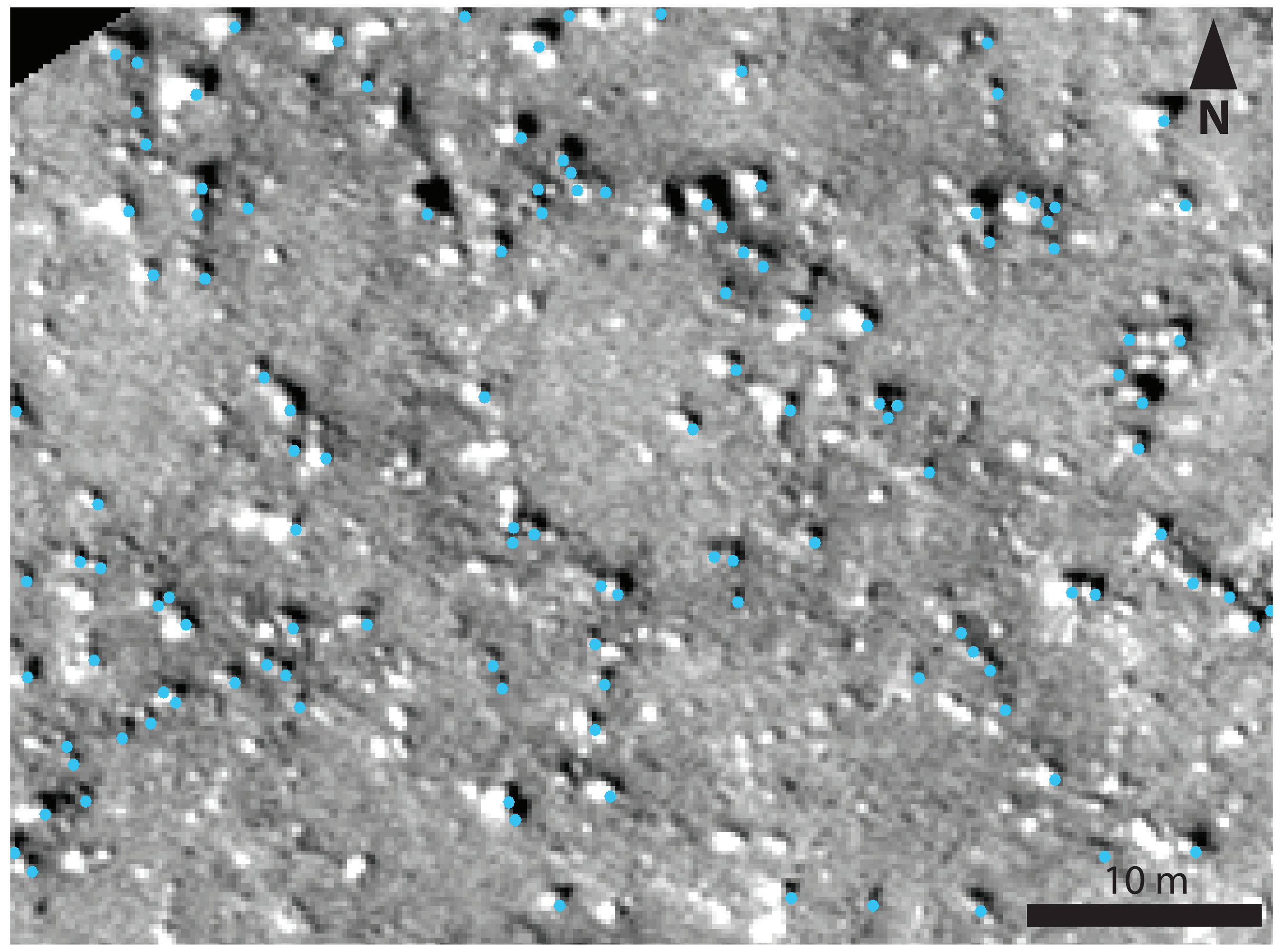

Figure 1. Image subset of PSP_007718_2350 ("Image 10" in other figures) with blue dots showing MBARS-detected boulders, North is up and the sun is coming from the southwest. This image highlights several challenges to accurate detection including boulders without shadows, boulders with overlapping shadows, boulders with incorrectly split shadows.

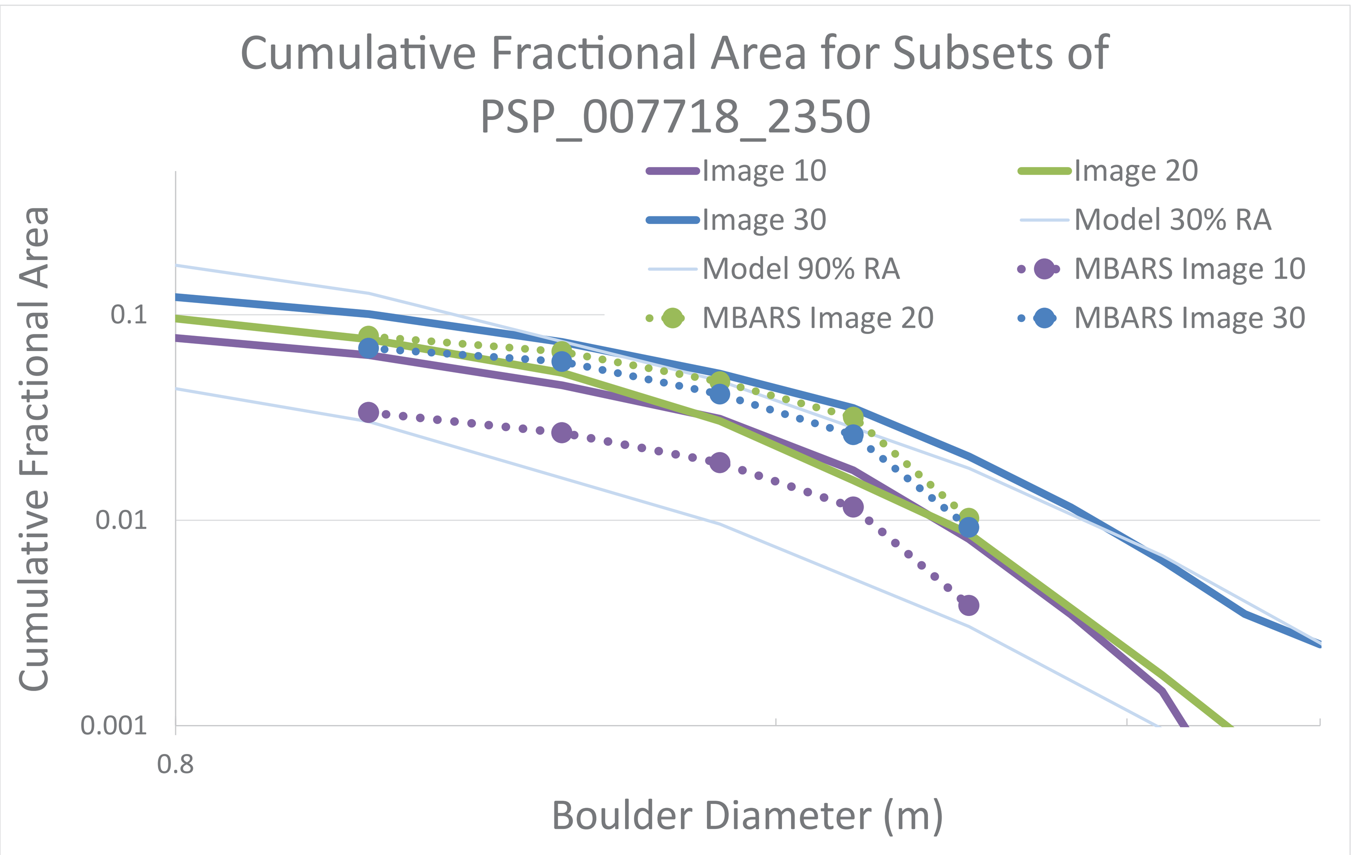

Figure 2. Comparison between the CFA of MBARS analysis and manual analysis of subsets of PSP_007718_2350. Both the overall trend and values for the CFA are well matched between the two methods. Image 10 shows the most disparity, possibly due to a large number of shadow-less boulders (Figure 2).

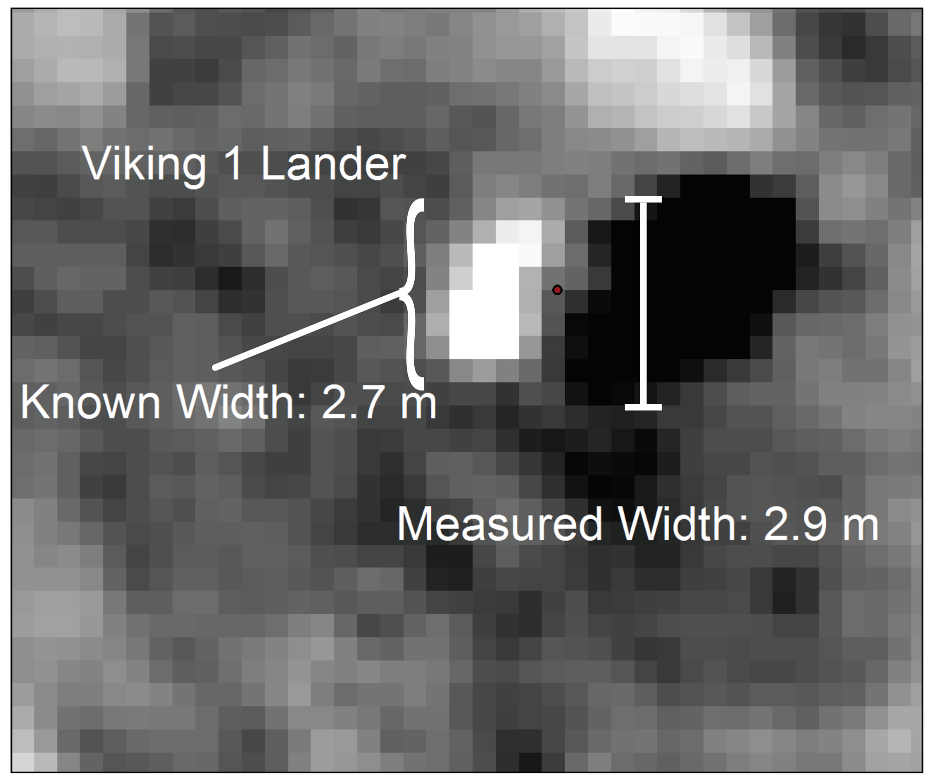

Figure 3. Subset of HiRISE image PSP_001521_2025 showing the Viking Lander 1 in the vicinity of Chryse Planitia. The lander has a known width of 2.7 m, and MBARS measures the width at 2.9 m for this image. This is within the 1 pixel uncertainty (25 cm) of these results. Measurements from other images are shown in Table 1.

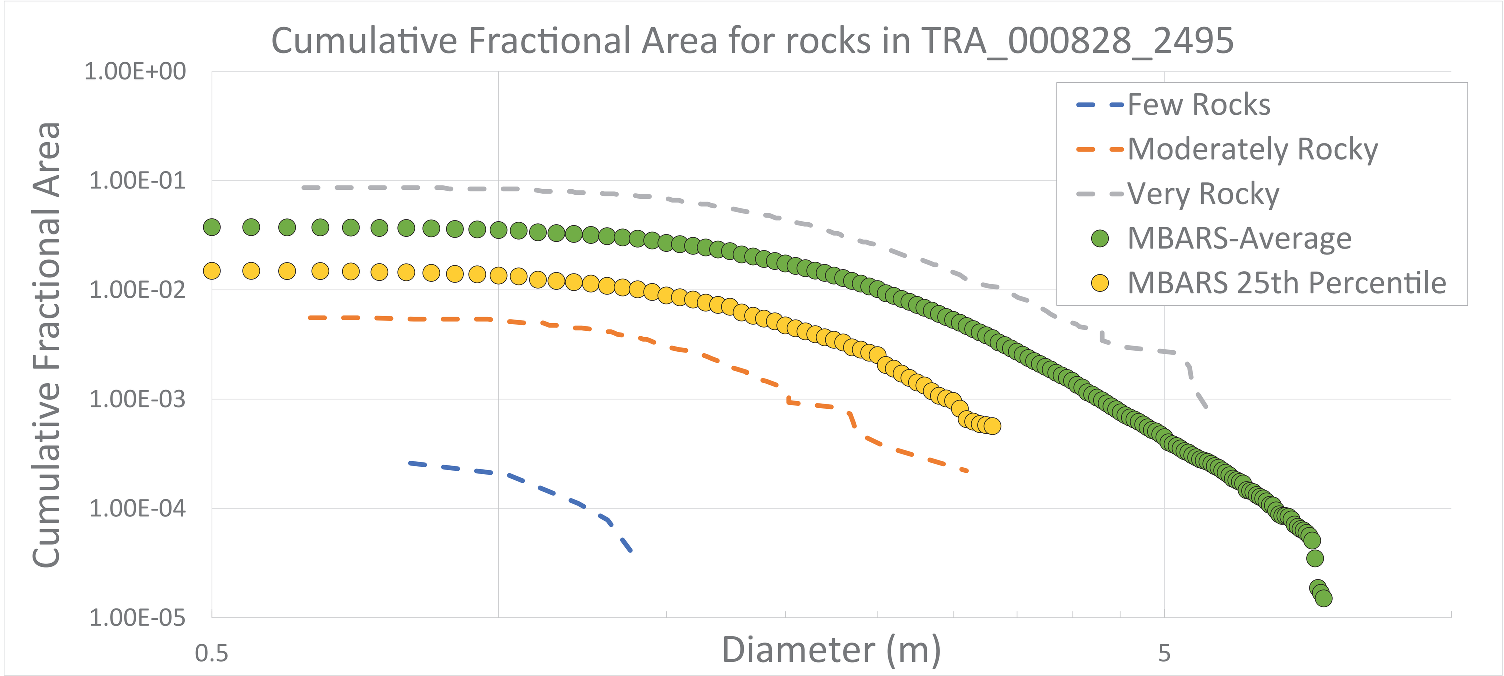

Figure 4. Comparison between MBARS results and results published by Golombek in 2008 [1]. The three lines marked Few Rocks, Moderately Rocky, and Very Rocky are from Figure 17 in Golombek's work. MBARS is accurately recreating both the overall rock trend and the CFA as observed by Golombek.

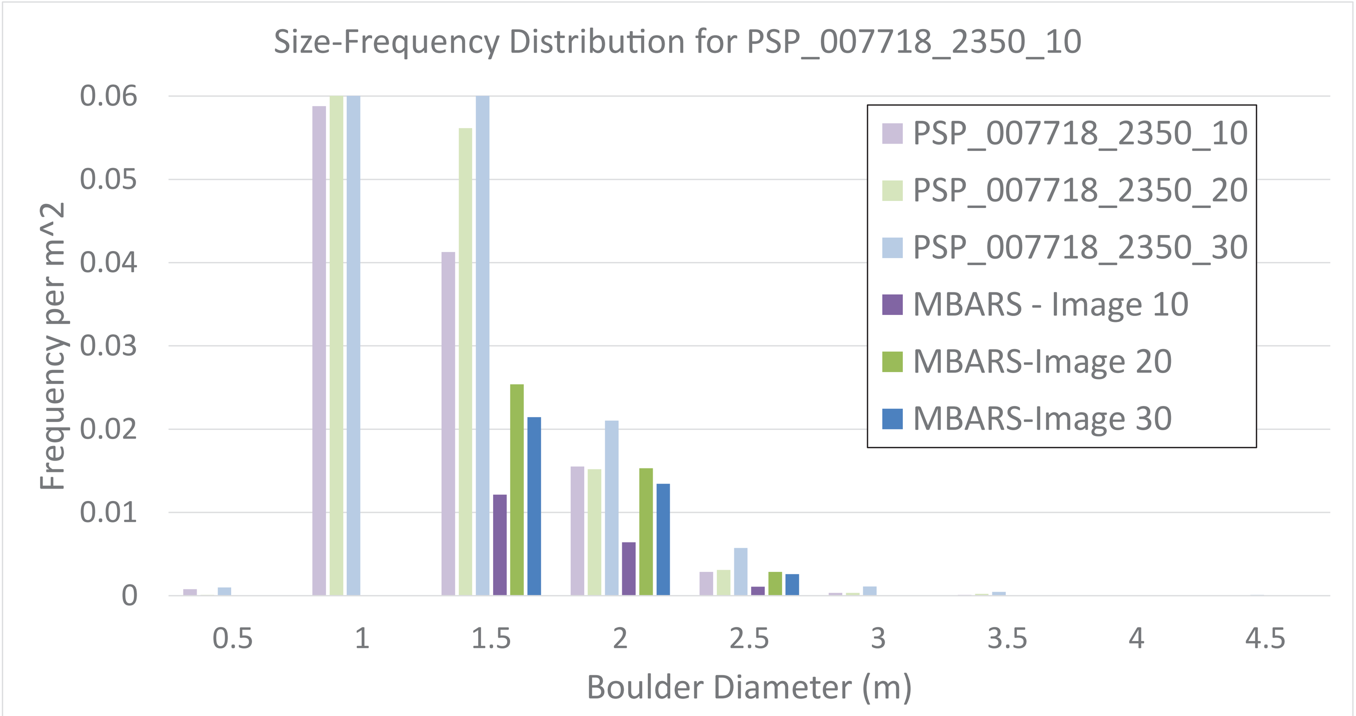

Figure 5. Comparison between the SFD of MBARS analysis of subsets of PSP_007718_2350 and manual analysis. Clear disparities exist below 1.5 m, this is due to roll off due to HiRISE resolution. Between 2 and 3 meters this effect is less apparent, though the small areal sample size may make larger boulders less

Algorithm Methodology

- Modeled after method in Golombek 2008 [1]
- Shadowed areas identified via intensity thresholding
- Shadows outlined via watershed
- Ellipses fit with Orthogonal Distance Regression
- Boulder width and height interpreted from shadow geometry (Figure 6)

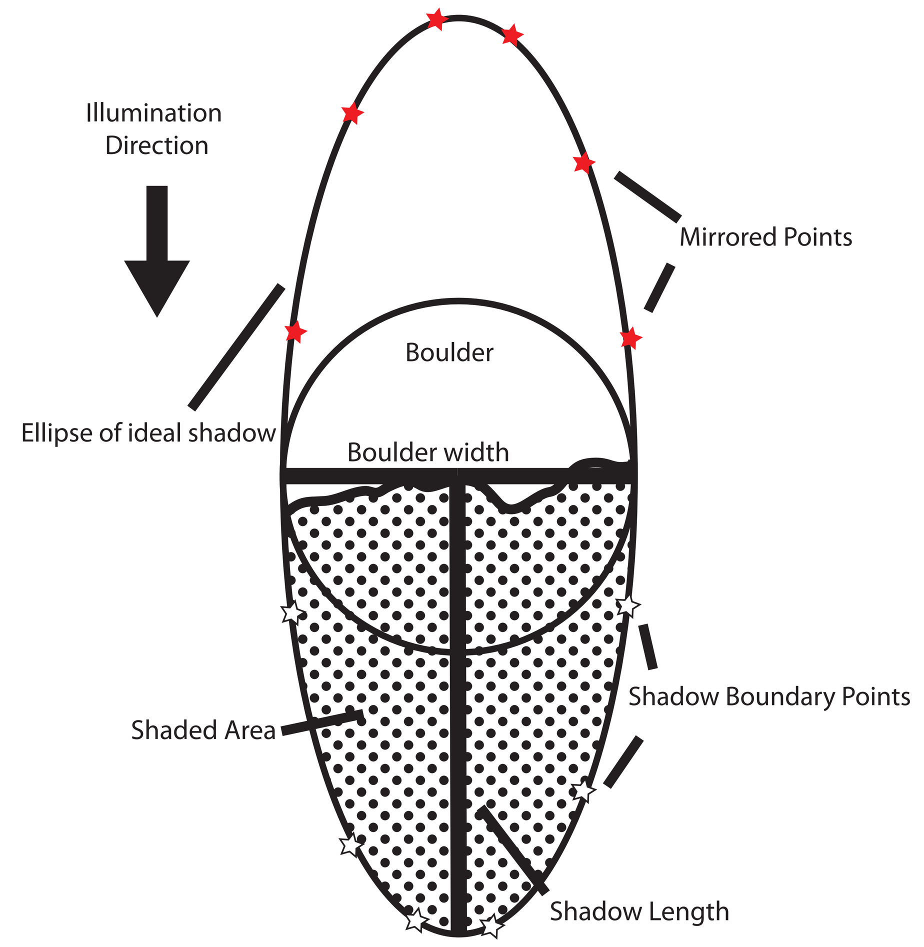

Figure 6. Our model geometry for individual boulders and fitting method. On flat ground with the sun coming from the north, a spheroidal boulder casts a half-elliptical shadow (umbra+penumbra) where the minor axis is equal to the boulder diameter and the semi-major axis determined by the boulder height. We mirror points along the shadow boundary (white stars) across the sunward end of the shadow to map the outline of the full ellipse (red stars).

Conclusions & Future Work

- MBARS is accurately measuring individual objects (Figure 3, Table 2)
- MBARS measurements match previous algorithms (Figure 4)
- MBARS measurements compare well with manual results (Figures 1,2,5)

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