# Preliminary Results from Lunar Surface Change Detection with PyNAPLE: The 2019-01-21 Lunar Impact Flash

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**Abstract:** During the 2019-01-21 lunar eclipse a lunar impact flash was observed by more than 20 observing sites, and two published estimates were made as to the location of the impact flash. In this work we present the preliminary results from the utilizing PyNAPLE (**Py**thon **N**AC **A**utomatic **P**air **L**unar **E**valuator) with these coordinates in the search for the resultant impact crater. In total, 97 surface changes were detected, two of which being definite impact craters; however evidence suggests that they were formed during separate events to the 2019-01-21 impact.

# Introduction

While lunar impact flashes have been well documented, the luminous efficiency of the impact, currently given between $10^{-2}$ and $10^{-5}$[1], has not been fully constrained. The crater scaling relationship, which predicts crater diameter with uncertain accuracy, is also an area in which more work is required.

In order to collate a large dataset of ground truth data, PyNAPLE [2] is employed to locate the resultant craters from known lunar impact flashes. The result shown here are from the application of PyNAPLE to the 2019-01-21 lunar impact flash.

Credit: Jamie Cooper

# Method

Using the coordinate ranges shown in table 1, PyNAPLE searches Lunar Reconnaissance Orbiter NAC images to form all before/after image pairs (temporal pairs). These temporal pairs can then be aligned and divided to highlight regions where change has occurred between the two images.

| Source | Latitude | Longitude |
|---|---|---|
| AUGUR [3] | -30.03 ± 0.00013 | -68.20 ± 0.02 |
| Madiedo *et al* [4] | -29.20 ± 0.30 | -67.50 ± 0.40 |
| Zuluaga *et al* [5] | -29.43 + 0.30 -0.21 | -67.89 + 0.07 - 0.09 |

Table 1: The estimated selenographic location of the 2019-01-21 impact flash.

## Results

In total 235 images were evaluated, and all 108 viable temporal pairs were formed. From these image pairs, 97 changes were identified (Fig. 2); most of which were "splodges" (Fig. 1), and 2 resolvable craters.

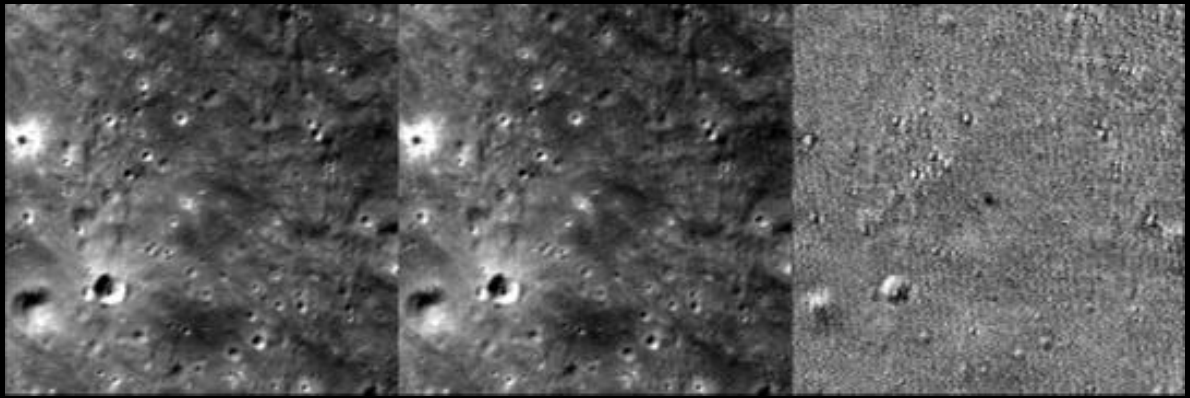


Figure 1: Before (left), after (middle), and division image (right) as an example of a "splodge" in a temporal pair. It is likely caused by an ejecta deposit from a nearby impact, or an impact below the resolvable limit.

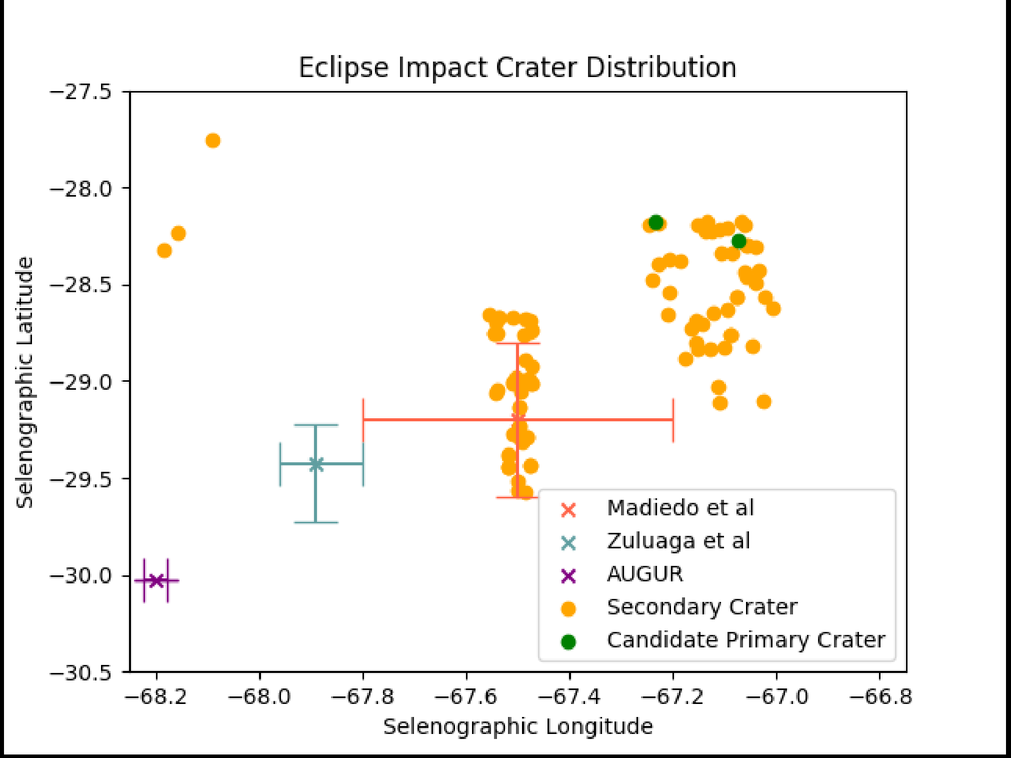
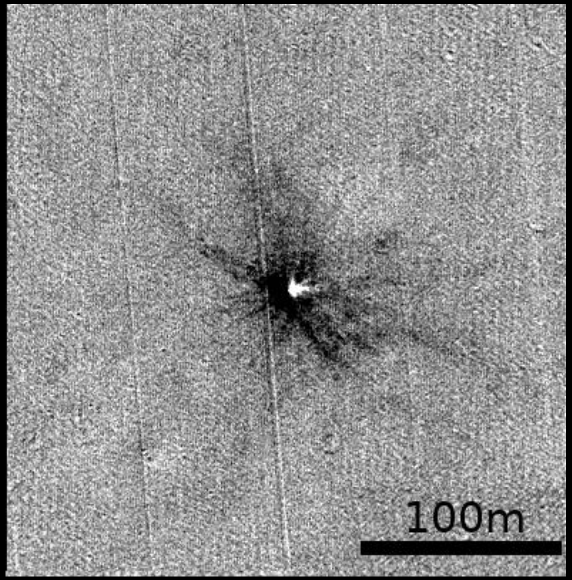



Figure 2: The locations of the identified changes compared to the locations predicted from the impact flash.

# Results

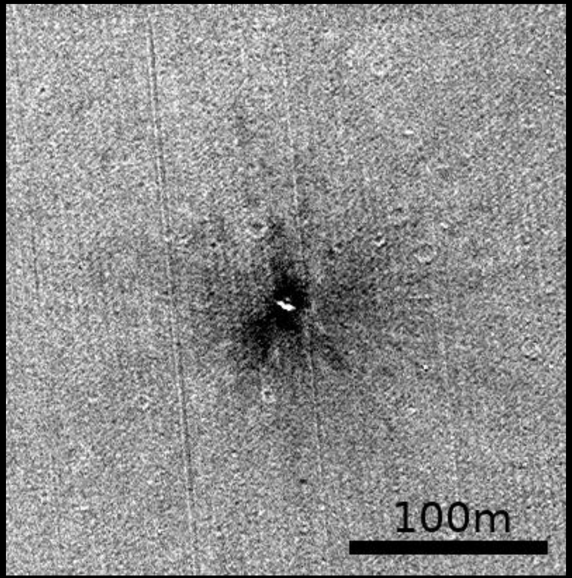



<u>Left: S28.276W67.073</u>

This crater is approximately 2.5m in diameter and was formed between 2015-10-27 and 2019-09-25. From the "butterfly" shaped ejecta blanket, we can conclude the impactor came from the south-west (bottom left of the image) at an angle between 20-45$^{o}$.

<u>Right: S28.178W67.234</u>

While the crater may appear to have a larger diameter of approximately 12.7m, due to the relatively small radius of the ejecta blanket, it is likely that the true diameter is 5.1m. The appearance of a larger impact structure is believed to be due to partial collapse of the slope on which the impact is located. The symmetrical pattern of the ejecta blanket implies the impact took place above 45$^{o}$ incidence.



# Discussion

It is believed that neither of these craters are the primary impact crater for the 2019-01-21 impact flash. This conclusion is based on a few main factors.

Impactor energy calculations performed in literature on the 2019-01-21 impact flash calculate that the resultant crater formed should be between 5-16m [4,5], above the observed size of these two craters.

The craters themselves are also located more than 6σ outside the predicted coordinates in both latitude and longitude.

The area searched by PyNAPLE was not the complete area encompassed by the coordinates, as only regions with temporal pair coverage can be analysed. The area with temporal pair coverage was only 30.5%, leaving a 69.5% chance the crater did not coincide with a temporal pair covered region, to be found once new LRO NAC images are released of the search space.

There are however no known observed impact flashes which could correspond to the formation of these craters.

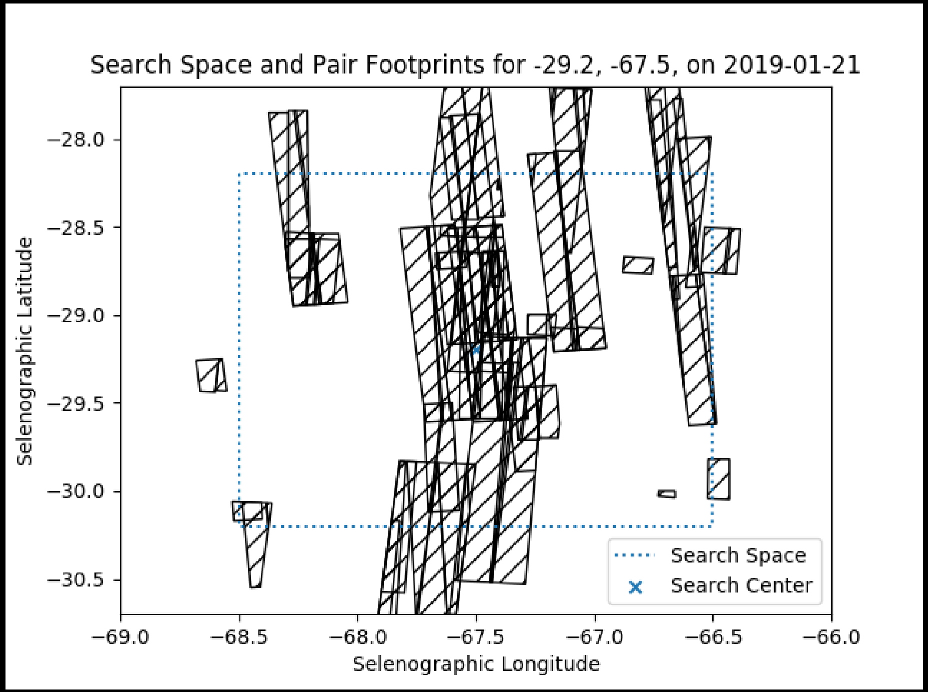



Figure 3: The footprints of the temporal pairs formable in the search space.

# References

[1] Ortiz, J.L., et al (2015) MNRAS, 454, 1, 334-352

[2] Sheward, D., et al (2019) EPSC-DPS 2019 Abstract 1032-1

[3] Larson, R., et al (2019) EPSC-DPS 2019, Abstract 1193-3

[4] Madiedo, J.M., et al (2019) MNRAS, 486(3), 3380-3387

[5] Zuluaga, J., et al (2019) MNRAS, 492(1), 1432-1449

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