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The Spatial Distribution of Lunar Impact Flashes

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Abstract

Plotting the longitudinal and latitudinal distributions of observed lunar impact flashes shows that they differ substantially to impact distributions as predicted theoretically[1]. Observationally, no flashes are seen in the Moons polar regions, and there is a sharp fall in impact flux in the ±10° longitudinal degree range. 1.8 times as many impact flashes are observed Moon's western hemisphere than the eastern. A range of effects could cause this disparity. These include a light from impact flashes near the Moon's limb being blocked by topographic shielding, by observers avoiding viewing areas of the Moon illuminated by the sun, and lunar albedo.

1. Introduction

With a thorough literature search, we compiled a list of 530 observed impact flashes into a central database, see:

https://www.impactflashdatabase.com.

The majority of these were from observations by NASA[2] and NELIOTA[3], although 20% of impacts were recorded by small observing programs and amateurs. Of these, 470 have their impact coordinates quoted to the nearest degree.

It was decided to re-examine the distribution of all observed impacts on the Moon's surface as this had previously been done with only with 108 observed flashes[4] and with little discussion about observational bias. Some variation was to be expected, the synchronous rotation state of the Moon causes its leading edge to intercept 1.3 times more than the trailing edge [5], though differing sources suggest this effect may be somewhat larger. The equatorial regions of 0°-30° were expected to have 10%[5] more impacts than the 60°-90° polar regions, due to meteoroids being more likely to be in the plane of the solar system.

2. Results and Discussion

Figure 1's most notable feature is the extreme drop off in flash flux at the poles, no flashes being observed beyond 60° north or south. Whilst this was to be expected, as discussed above, it should only cause a 10% decrease, which would result in a far less extreme drop off in flux than what was observed.

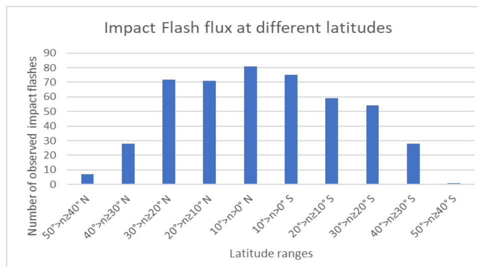

Figure 1. *Histogram of lunar impact flash flux versus latitude with 10° wide bins.*

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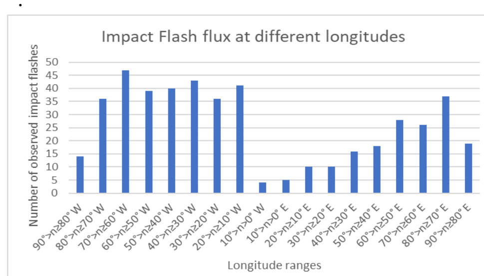

Figure 2. *Histogram of lunar impact flash flux versus longitude with 10° wide bins.*

One factor in this drop off is impactors on the lunar limbs having their flashes light blocked from Earth's view by the Moons topography. This alone cannot explain the decrease in impact flash flux though, as highland areas, nearer the limb, have far milder drops in impact flux than polar areas.

It is likely that the primary cause of the flux decrease is the shape of the Moon's illumination during its crescent phase. Observatories avoid observing near the dayside, due to it causing a high numbers of false positives in flash detection programs and from the decrease in contrast between the flash and the background glare. The crescent shape means that the poles are more illuminated than the equatorial region, discouraging polar observations. While this trend is reversed in the gibbous phase of the Moon, the majority of observing programmes only take recordings when the Moon is under 50% illuminated. Observing the poles also results in having less of the Moon in your field of view when compared to equatorial regions.

Figure 2 shows two notable features, a large drop off in impact flux in the ±10° longitude range, and a disparity between the number of flashes in the eastern and western hemispheres. The former effect is likely caused by the Moon's dayside glare issues. Again most observatories will wish to observe the portion of the Moon as far from the dayside as possible to reduce light pollution. This means that observing regions near the east and west limbs are more preferable than the central longitudinal region, which is never the area furthest from the dayside.

The leading edge effect, where more impactors strike this edge, is unlikely to be the sole cause of the disparity between the number of impacts observed in the longitudinal hemispheres. The effect predicts 1.3 times[5] as many flashes in the western hemisphere, whereas figure 2 shows the west had 1.8 times more impactors than the east. It should be noted there is still some debate about just how strong the leading edge effect is. For example, a 2010 paper by Ito *et al*[6] says that ray crater distributions imply that the western hemisphere has 1.7 ± 0.2 times as many impacts than the east, but examining NEO's only indicates the west having 1.32 ± 0.01 as many impacts as the east.

Another likely explanation for more flashes being spotted in the western hemisphere than expected is observational bias. For nights where the Moons eastern hemisphere is in earthshine and thus likely to be observed, moonrise tends to fall in the early hours of the morning, a less sociable time for most observers. Hence one would expect more observations of the western hemisphere as this is more convenient to monitor for most people.

A third factor affecting perceived impact flux could be albedo. We calculated that the mean albedo of the Moons western hemisphere is 10.5%, whilst the eastern hemispheres is 13.5%. The west's lower albedo allows for a higher contrast between the flash and background and thus makes the fainter ones easier to detect.

3. Conclusion

The observed distribution of lunar impact flashes does not reflect the expected distribution of impactors across the lunar surface. It instead may stems from observational bias and difficulties in observing certain regions of the Moon. It should be possible to either attempt to calibrate out this effect, for example by recording the number of hours spent examining the Moon, or to utilize the ALFI software[7] (in development) to extend the ability to look for impact flashes closer to the terminator, and on the dayside of the Moon.

Acknowledgements

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