PRELIMINARY ANALYSIS OF TRANSIENT LUNAR PHENOMENA CATALOG DATA. A. C. Cook[1] and M. Grande[1], [1]Institute of Mathematics and Physics, University of Aberystwyth, Penglais, Aberystwyth, Ceridigion, Wales, SY23 1BZ, United Kingdom, atc@aber.ac.uk.

Introduction: With recent interest in Transient Lunar Phenomena (TLP) and lunar out-gassing theories [1-3], the TLP catalogs of Middlehurst [4] and Cameron [5] are frequently quoted in references. However there are many issues that affect the quality of TLP reports and observer interpretation of the Moon's surface, which may not be appreciated fully. Therefore as part of collaboration between Aberystwyth University, and amateur astronomers from the British Astronomical Association (BAA) and the Association of Lunar and Planetary Observers (ALPO), many TLP sites are being re-examined under the same illumination (to within ±0.5º), and where possible libration, of the conditions under which the TLP were seen originally. This will establish the normal appearances of the features concerned. However in order to achieve this we have had to compile a new catalogue of TLP reports based upon the earlier catalogs, Cameron's extended catalog [6], and more recent ALPO and BAA TLP reports. Although the Cameron catalogs include observational weights, recent publications about atmospheric dispersion, turbulence [7] and shadow effects [8] show how these can contribute to mis-interpretation of TLPs, and imply that many of these rankings could be doubtful. We are therefore re-evaluating all the weights, but in the short term have produced some preliminary frequency plots.

Method: In order to populate the new combined catalog, a sub-directory structure was created containing year, feature, month, day, UT range, and observer. Into each lower subdirectory are entered scanned copies of many of the original TLP reports, and a machine readable summary file of each observation. With a total of 1804 TLP reports entered so far manually, this process has been lengthy. However a directory listing has been used to produce records for the histograms used in this abstract, albeit initially without weights.

To reduce observational bias and selection effects, observations from two of the most prolific TLP reporters have been deselected, and so too have observations made during the Apollo and Clementine missions. Observations have also been removed if the quoted dates and UT, from the source catalogs, appear to indicate that the Moon was observed in daylight, or was below the horizon, as seen from the observing site. 1313 remaining TLP reports are used in this analysis.

Results:

Frequency of TLP versus time of the year. All selected reports were placed into appropriate data bins (4 bins per month). The temporal distribution of TLP reports in Figure 1 shows some smoothness in the x-axis direction that we would not expect to see if TLPs occurred (or observers perceived) randomly in time. A slight dip is seen in the middle of the year and this is due to the majority of northern hemisphere observers experiencing poor visibility of the Moon in Summer months – this is confirmed when we use routine non-TLP observations. The most prominent peak (> 2 standard deviations) is towards the end of April, and some of the TLP included here were described by Sir William Herschel as reddish glows in Earthshine [9]. This peak occurs over the time span of the Lyrid meteor shower; however many of the other TLP reports that fall in this slot seem unrelated to what one might expect from meteor impact events in terms of descriptions and non-random geographical locations. Furthermore other higher ZHR showers do not show up in the TLP statistics at all.

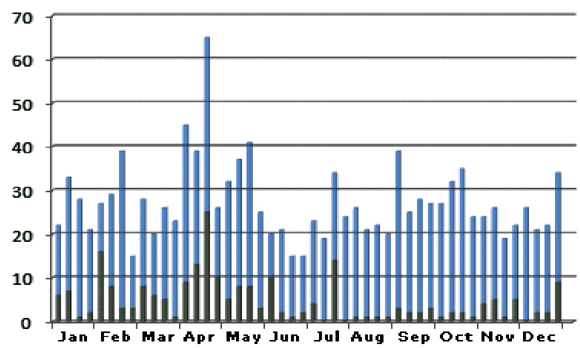

Fig 1. Frequency of TLP versus time of the year. Blue includes all reports and black is for TLP in Earthshine only.

Frequency of TLP versus the sub-solar longitude. Figure 2 has been produced to see if there are any connections between TLP and the position of the Moon in its orbit, especially passages through the Earth's magnetosphere [10]. In the histogram we can see that an initial peak is caused by Earthshine TLP, so this maybe a selection effect – many observers study the Moon in the evening, and Earthshine is best seen between a few days after New Moon (<+180º sub-solar longitude) and First Quarter (<+90º sub-solar longitude). Passages through the Earth's magnetopause, and bow-shock should occur at approximately ±25º and ±56º [10] respectively either side of the sub-solar longitude of 0º. However there is no clear discernable evidence for this amongst the noise in the histogram and instead we see broad peaks that also show up in a control non-TLP data and are probably feature selection effects.

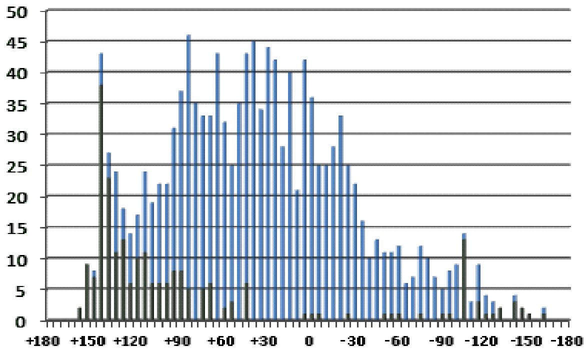

Fig 2. Frequency of TLP versus sub-solar longitude. Blue includes all reports and black is for TLP in Earthshine only.

Frequency of TLP versus local solar altitude. Dust explanations of TLP have been discussed by Dollfus [11] and Mills [12], and it is well known that electrostatic lunar dust activity is stronger around sunrise, than at sunset [13]. The plot in Figure 3 reveals such a peak in TLP activity at the terminator followed by a subsequent fall off. This is another observational selection effect though as it has also been found in non-TLP observation histograms. However it is interesting to note that the prolific TLP site of Aristarchus [1] does not have such a surge of activity at on the terminator. A small peak in TLP activity can be seen on the night side, mostly from Aristarchus, when the sun is ~65° below the horizon. This might be related to optimum visibility issues in Earthshine, i.e. when the illuminated terminator is far from the crater, thus reducing glare, and when the Moon is a greater angular distance above the horizon, resulting in less scatter and absorption.

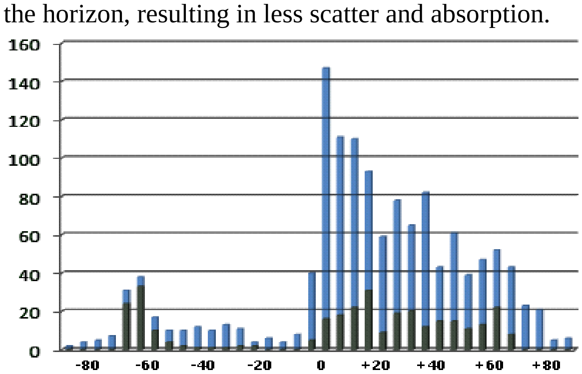

Fig 3. Frequency of TLP versus the altitude of the Sun at the TLP site. Blue is all reports and black is Aristarchus only.

Frequency of TLP versus local time. Figure 4 can be used to see how some of the solar altitude results are related to local lunar time of day. The peak in TLP reports occurs at sunrise and is approximately five times higher than at sun set. Non-TLP data shows a similar peak at sunrise, though a sharper fall off in distribution. Aristarchus, the most active TLP site [1], does not exhibit such a pronounced peak at sunrise, as do other features, and has a slower decay rate in TLPs over the lunar day, before tapering off by noon.

Discussion: We are presently engaged in revising observational weights in order to assist in more reliable interpretations of catalog TLPs. The histograms so far do not provide compelling evidence for, or against, TLP. In a limited way though we can provide information to address some existing criticisms about TLP. For example, although atmospheric spectral dispersion [7] may explain some false color TLP observations, we find that more than 50% of observations were made with the Moon above 30° in altitude.

Re-analysis of the weights on archived catalogued TLPs, and the methodical time difference lunar imaging technique of Crotts [1] may eventually be able to prove/disprove white light and other types of TLP.

References: **[**1] Crotts, A.P.S. (2007), arXiv:0706.3954v1, [2] Shultz, P.H. *et al.* (2006) *Nature*, 444, 184-186, [3] Fidani, C. (2008), *EGU2008-A-11236*, [4] Middlehust, B.M. *et al.* (1968) NASA *TR-277*, [5] Cameron, W.S. (1978), *NASA-TM-79399*, [6] Cameron, S.W. (2006), Lunar Transient Phenomena Catalog Extension, http://alpo-astronomy.org/lunar/ltp.html , [7] Sheehan, W. and Dobbins, T. (1999), *Sky and Telescope*, 118-123, [8] Lena, R. and Cook, A. (2004), *JBAA*, 114, 136-139, [9] Herschel, W. (1787), *Phil. Trans. Roy. Soc. Lon.*, 77, 229-232, [10] Cameron, S.W. and Gilheany, J.J. (1967), *Icarus*, 7, 29-41, [11] Dolffus, A. (2000), *Icarus*, 146, 430-443, [12] Mills, A.A. (1970), *Nature*, 225, 929-930, [13] Auer, S. and Berg, O.E. (2008), *EPSC2008*, #00352.

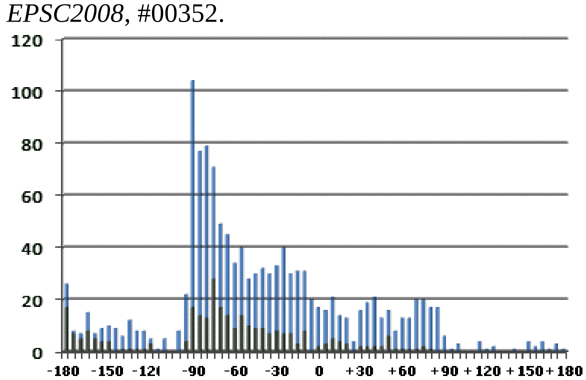

Fig 4. Frequency of TLP versus local time (expressed in degrees, -90º = sunrise, 0º = noon, +90º = sunset, and +/-180º = midnight) at each TLP site. Blue includes all reports and black is for TLP in Aristarchus only.

Acknowledgements: We would like to thank the BAA and ALPO for use of their observations, and also for helpful past discussions with former ALPO TLP coordinators: Winifred Cameron and David Darling.