AE33A-2841

# ANALYSIS OF GROUND-BASED OBSERVATIONS OF TLES FROM SPRITACULAR PROJECT DATABASE

**T. Daniel Walker[1], Burcu Kosar[2,3], Katrina Virts[1], Timothy Lang[4], Shing Fung[2], Sarah Bang[4], Tom Warner[5]**

[1]University of Alabama Huntsville, [2]NASA Goddard Space Flight Center, [3]The Catholic University of America, [4]NASA Marshall Space Flight Center, [5]ZT Research

**Corresponding Authors: walkertd@uah.edu, Spritacular: burcu.kosar@nasa.gov**

## Abstract

Spritacular is a citizen science project that was launched in October of 2022. It provides a space for anyone to submit their images along with observational information, i.e. time, geographic location, direction, camera setup. Along with submissions, one can also help identify different types of transient luminous events (TLEs) in the images. Since its inception hundreds of images have been submitted to the project database by its users. Not only does the database itself provide a record of observations, but these submissions allow for scientists with access to a wider array of observational platforms to obtain a better understanding of TLEs without having to chase or hunt for them. Citizen science databases come with pros and cons when dealing with observational science and trying to work across different platforms. Using this database, over one hundred sprites were found to have accurate pointing and adequate temporal resolution to match both ground based (National Lightning Detection Network [NLDN]) and satellite based (Geostationary Lightning Mapper [GLM]) sensors.

**In this presentation, we will report on a statistical analysis of sprite producing lightning flashes and include a discussion about the implications these measurements have on the search for sprites using current space based observational platforms.**

## Sample Data and Matching

* The data from Spritacular is reported as one minute data with variations in accuracy from one millisecond to five minutes. This created a problem with matching to NLDN or GLM, because so many possible matches existed within one minute.

*** In April 19, 2023 Tom Warner recorded 2 continuous hours of video with over 95 sprites with one second accuracy. These were added to the Spritacular database for our use**

*GLM matches to the TLEs were selected for their time window then down selected based on location in the accompanying image, NLDN data was then also selected based on this same information including only values within 0.3 degrees lat/lon.

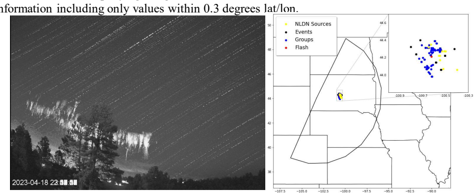
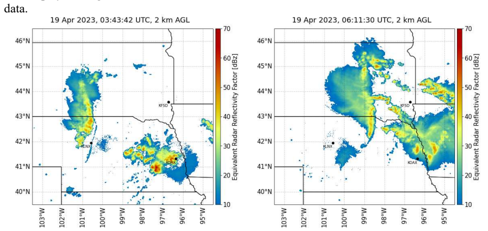



**FIGURE 1 on the left is a superposition of all the sprites from the April 19, 2023 Tom Warner Spritacular data set. FIGURE 2 on the right is of a sprite match from this data set with NLDN sources in yellow and event, group, and flash geolocation in black, blue, and red respectively.**

## Radar

An organized quasi-linear convective system (QLCS), a type of mesoscale convective system (MCS) travelled across southern South Dakota and northern Nebraska. There is a radar fine-line to the east of the QLCS in most of the gridded imagery indicating a deep, healthy cold pool produced by the storm. There's some flow contributing to maintained vigor to the south of the QLCS through the 05Z hour. All regional radars experienced a dropout during the 05 UTC hour, unfortunately. When we get data back at 0611 UTC, the entire line has weakened. The displayed images here are from before and after the window of TLEs occurrences in our data.




## GLM Data for All Flashes and TLEs

**A main goal of the project is to develop a method to statistically characterize sprite-parent flashes using optical lightning mappers, so we can potentially build a proxy global climatology for sprite-associated lightning**.

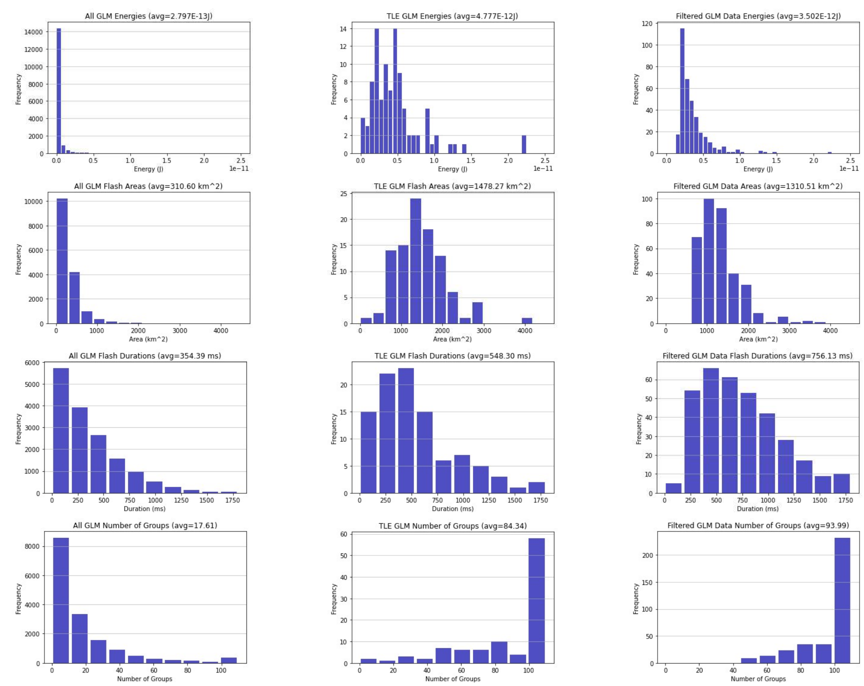
To this end we have chosen GLM as a current source of our optical lightning mapping data. Some interesting data reported from GLM are flash energy, flash area, flash duration, and the number of flash groups, which are a collection of events within a spatial and time domain.

**The plots below show the energy, area, duration and group number data for all GLM flashes during this period on the left with the TLE GLM matched flashes in the middle.**

Of particular note here is the discrepancy between energies and number of groups between the two datasets. Of all flashes seen by GLM the "typical" flash is lower energy and much smaller number of groups. In the case of groups the TLE data maxes out the group count which is 101 due to error in data processing that only allows the group numbers to go so high before rolling over into a new flash.

**Parameters were chosen such that a filter of the full GLM data during the period would keep intact ninety percent of the TLE GLM matches**

- **Flash Energy: 1.8E-12 Joules**
- **Flash Area: 750 km²**
- **Flash Duration: 150 ms**
- **Number of Groups: 44 groups**




## Data Filter and Results

During the 2 hour period where TLEs were observed there were a total of 16007 GLM flashes. Using the parameters filter the following results were achieved:

**Number of Matches: 350**

**True Positive: 62 False Positive: 288**

**True Negative: 15644 False Negative: 13**

**Prob. Of Detection: 0.827 False Alarm Rate: 0.823**

**Crit. Succ. Index=0.171**

The Spritacular data was taken as the "true data"

- **True Positive** is defined as a match within +/- 1 seconds, +/- 0.3° lat/lon.
- **False Positive** is a hit with the filter that does not have a match within the TLE dataset. These false positives in a sense represent the number of similar flashes that do not create TLEs assuming all TLEs within the observation window would be observed.
- **True Negative** is a GLM source that falls below our filter parameters
- **False Negative** is a Spritacular TLE with no matching GLM data

**The plots below show the energy, area, duration, and group number data for the filtered GLM flashes during this period on the right.**

Note that in the filtered data the low end of the high energy flashes are much more prevalent than in the TLE GLM flashes. These higher energy sources while frequent do not seem to produce TLEs. Our filter would then seem to "oversample" the low end of the filtered data. Other distributions with the filter look similar to the their TLE GLM counterparts.

## Spritacular

***What is Spritacular?***

Spritacular is a participatory science project that aims to collect observations of sprites and other optical phenomena occurring above the thunderstorms - collectively known as Transient Luminous Events (TLEs). Over the last two decades, good quality cameras have become increasingly affordable which allowed more people than ever before to have access to the tools capable of documenting these powerful atmospheric events. Because of this, Spritacular project strives to establish a collaborative bridge among communities that are actively engaged in chasing these elusive phenomena and the researchers of atmospheric and space electricity.

***Why do we need a TLE database?***

The database generated from these observations will lay the groundwork for the first-ever event catalog of TLEs that will significantly complement current and future science missions by providing ground-based observational data. Not only that, scientific community will be presented and benefit from the exceptional imagery of sprites/TLEs captured by our community. This database will serve as an invaluable resource for researchers allowing them to find interesting cases, perform studies in conjunction with other scientific data, and conduct broad statistical studies.

***What is participatory science?***

Simply put, it is science for all! NASA Science Mission Directorate defines it as "a form of open collaboration in which individuals or organizations participate voluntarily in the scientific process". The database that we generate through Spritacular will not only lead to opportunities for joint studies across many science disciplines, but it will also create paths for collaboration among communities!

***Want to learn more?***

## Summary

1) **We were able to use the Spritacular TLE database to match occurrences with GLM and NLDN data.**

   Using the GLM data associated with these TLE, parameters were determined by which we could filter a larger GLM dataset to see how well we could reproduce our TLE data. We determined that the main filter parameter that was sufficient to create a proxy data set was the energy filter. Unsurprisingly, the higher energy GLM sources had larger areas, longer flash times, and more groups.

2) **Future Work:**

   -NLDN filter
   -Storm morphology
   -Characteristics of parameters evolution
   -Similar TLE observations to test filters
   -Develop global climatology of sprite-associated lightning
   -Fine tune the filter parameters such that the FAR is reduced so that the confidence in the POD will be high even thought the probability may be low

## Acknowledgements

We acknowledge data provided by amateur photographers and citizen scientists and curated in collaboration with the Spritacular project that is funded by NASA Citizen Science Seed Funding Program grant 80NSSC21K0795. Also special thanks to Sarah Stough for radar analysis.