2015

Measuring Unique Structures Within Sprite Halos

Michael Morrison
Florida Institute of Technology

Burcu Kosar
Florida Institute of Technology

Nicholas Spiva
Florida Institute of Technology

Measuring Unique Structures Within Sprite Halos

Michael Morrison, Burcu Kosar, and Nicholas Spiva

Faculty Advisor: Dr. Ningyu Liu, Dept of Physics and Space Sciences, Florida Institute of Technology

Background:

Transient luminous events (TLEs) are electric discharges that occur above thunderclouds and have been categorized into several classes: elves, halos, sprites, and jets.

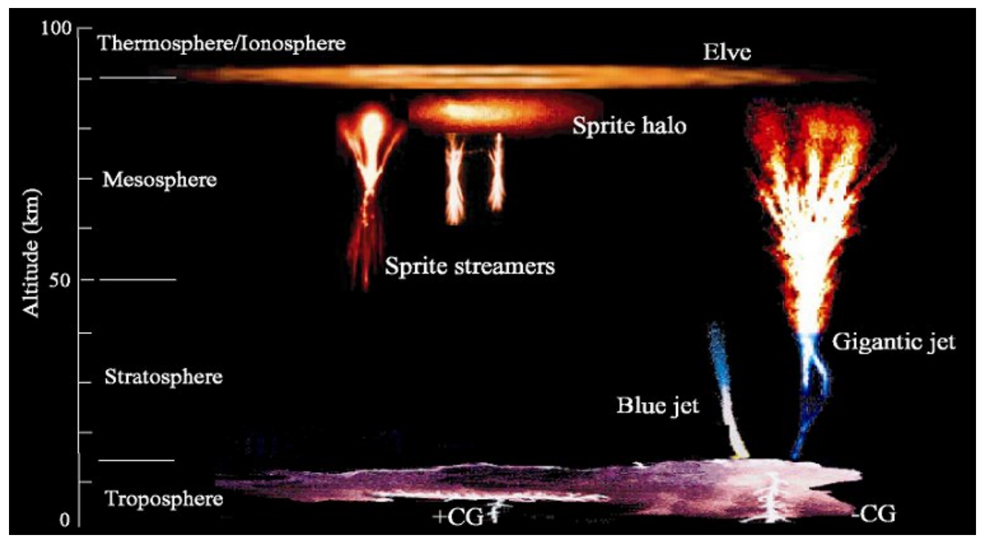
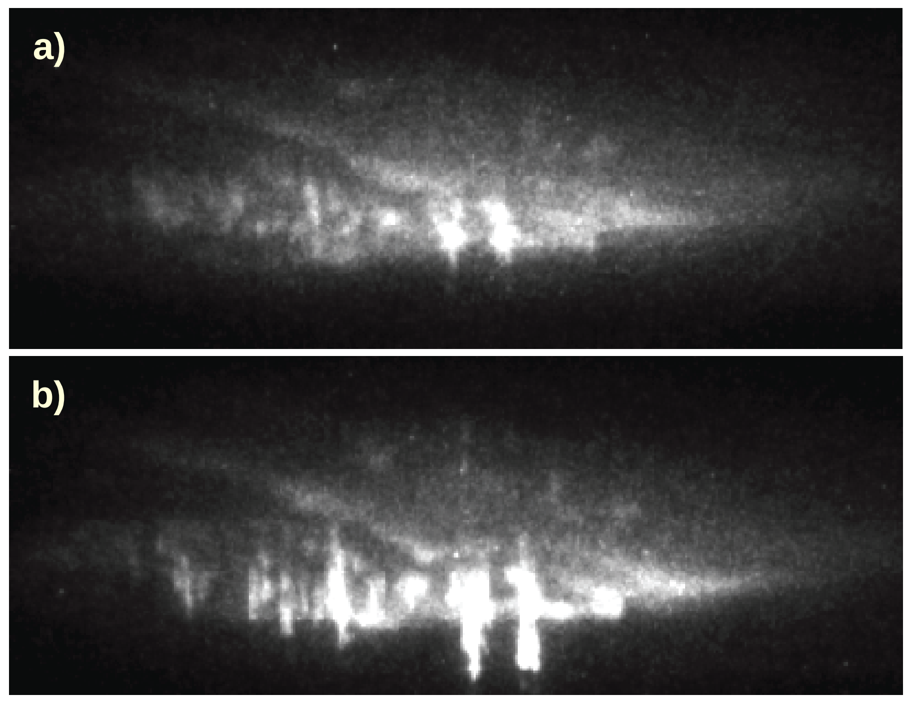


Figure 1: Diagram of TLE's shown to scale.

Sprites and halos are TLEs caused by a similar mechanism, and they can occur together as a pair or separately. Sprites form above strong positive cloud-to-ground lightning strikes. The lightning strike forms a quasi-static electric field that accelerates electrons in the mid-atmosphere [*Barrington-Leigh et al.*, 2001]. The result is an ionization wave, called a streamer that propagates downward at speeds up to ten percent the speed of light. Halos are relatively homogenous optical emission in the shape of a pancake.

During a summer campaign in 2008, Stenbaek-Nielson and McHarg captured TLEs at 10,000 frames per second using two Phantom 7 imagers [*Stenbaek-Nielsen et al*., 2010] On July 4, a halo and sprite were captured outside Socorro, New Mexico containing a unique wave structure within the halo. The structure could be a gravity wave travelling through the mesosphere. This gravity wave could be the secondary cause of sprite streamer formation.



Figures 2: Development of wave structure within the sprite halo

Method:

Sprite streamer heads have a known size ranging from 10-100 meters in width; therefore, streamer heads can be used to measure size of the other components within the same event. The relative size of a streamer head can be found by plotting the intensities of a pixel row passing through the center of the streamer head. The resulting graph should form a Gaussian distribution with the half-width, or standard deviation, representing the radius of the head. The length of the wave was measured using MATLAB. A pixel counter was stretched between the ends of the wave. The ends of the wave were determined by where the pixel intensities equaled the intensity of the halo. This pixel lengths were converted to meters using the standard deviations obtained for the two streamer heads.

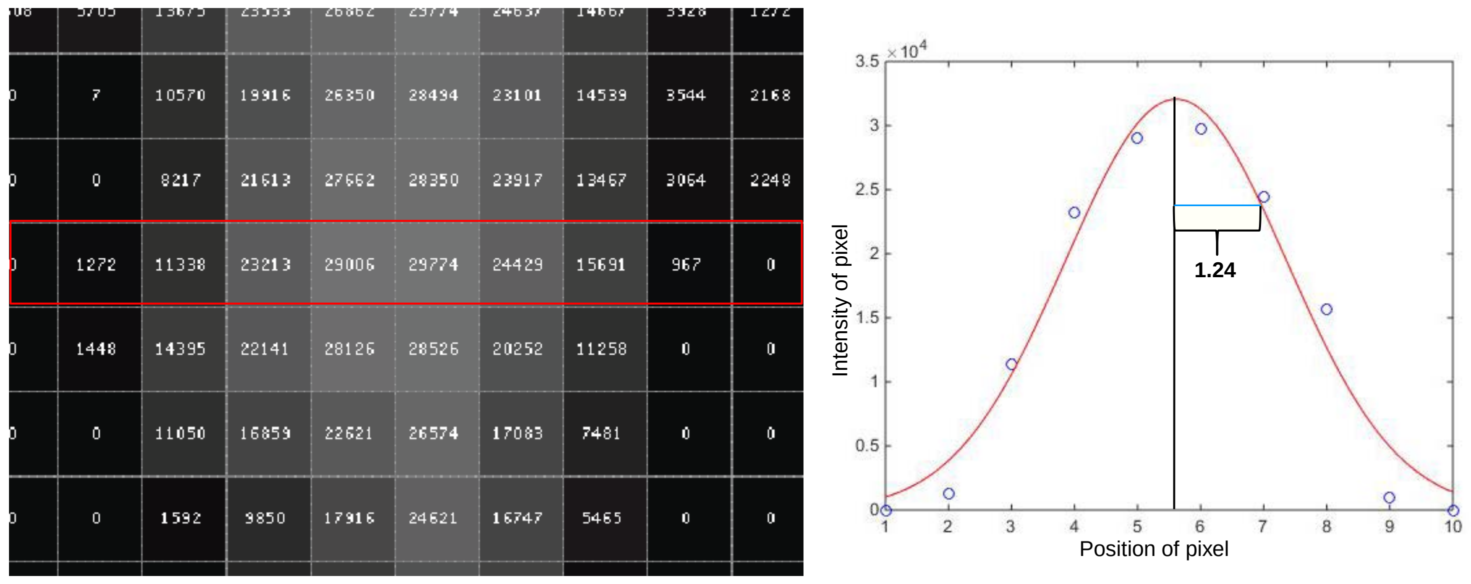


Figure 3: Array of pixel intensities for Streamer Head 1 (left). The pixel intensities in the red box were plotted and fitted with a Gaussian distribution to determine the standard deviation (right).

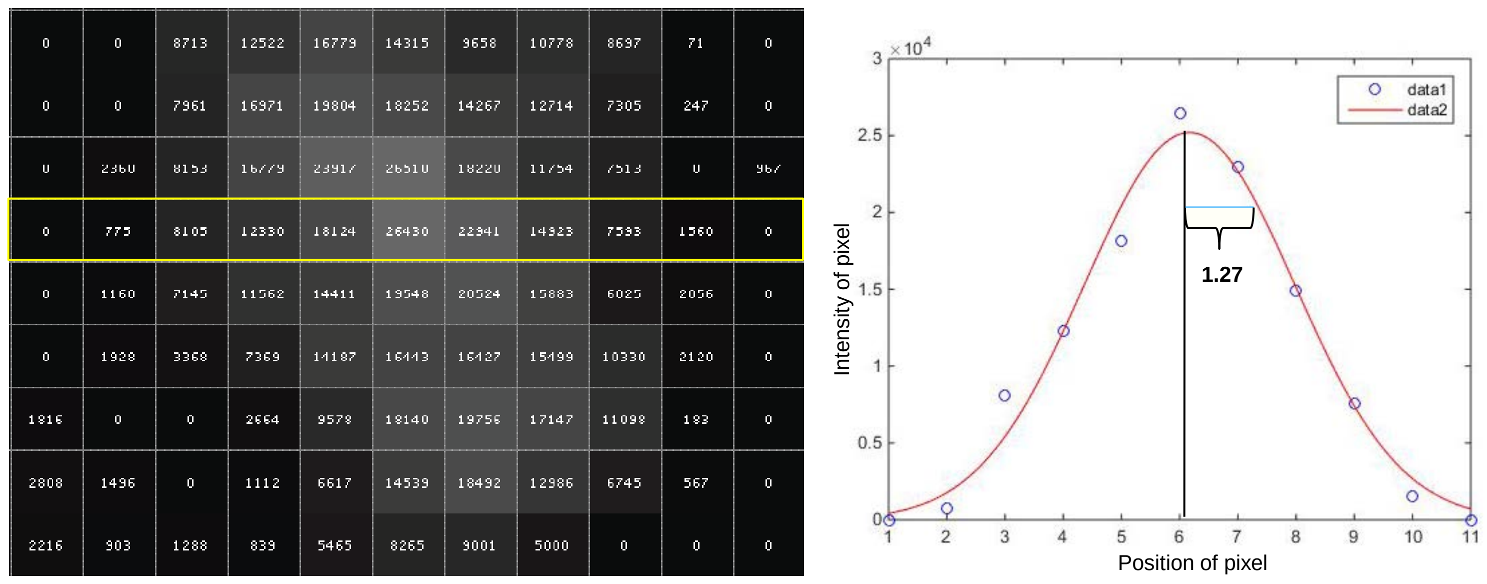


Figure 4: Array of pixel intensities for Streamer Head 2 (left). The pixel intensities in the yellow box were plotted and fitted with a Gaussian distribution to determine the standard deviation (right).

Results:

According to the Gaussian fits, the standard deviations of Streamer 1 and Streamer 2 were 1.24 ± 0.005 pixels and 1.27 ± 0.005 pixels. Both lengths were used to meter the wave. The length of each part of the wave was measured using streamer widths of 20 meters and 100 meters. This generated an acceptable range for the length of each section of the wave.

Tables 1 & 2: Length (m) of the wave using a streamer head radius of 1.27 pixels per 100 meters (top) and 1.27 pixels per 20 meters (bottom).

	Section 1	Section 2	Section 3
Image 1	4643.307		
Image 2	5779.528		
Image 3	6307.874	2012.598	2932.677

	Section 1	Section 2	Section 3
Image 1	928.6614		
Image 2	1155.906		
Image 3	1261.575	402.5197	586.5354

Tables 3 & 4: Length (m) of the wave using a streamer head radius of 1.24 pixels per 100 meters (top) and 1.24 pixels per 20 meters (bottom).

	Section 1	Section 2	Section 3
Image 1	4755.645		
Image 2	5919.355		
Image 3	6460.484	2061.29	3003.629

	Section 1	Section 2	Section 3
Image 1	951.129		
Image 2	1183.871		
Image 3	1292.097	412.2581	600.7258

Conclusions & Future Work:

Now that we have a range of lengths for the wave, we are planning to use these values in a streamer simulation to model whether gravity waves can initiate streamer formation.

In addition, lighting data from the parent storm should be acquired to conduct a star-field analysis on the event. Altitude angle and the azimuth of the event are already determined. This would provide an accurate comparison for the results above, and provide more precise lengths.

Also, more sprite events containing similar structures need to be identified and analyzed.

References:

H. C. Stenbaek-Nielsen, R. Haaland, M. G. McHarg, B. A. Hensley, and T. Kanmae (2010), Sprite initiation altitude measured by triangulation, *Geophys. Res.*, doi:10.1029/2009JA014543

C. P. Barrington-Leigh, U. S. Inan, and M. Stanley (2001), Identification of sprites and elves with intensified video and broadband array photometry, *J. Geophys. Res.*, 106(A2), 1741–1750, doi:/10.1029/2000ja000073.