LA-UR-18-31760
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Title: LANL Lightning Flash Time Duration Ground Truth

Author(s): Pastis, Michael George
Bruggeman, David Alan
Nelson, Mark William
Chiswell, Steve
Pretorius, David

Intended for: Report

Issued: 2018-12-18

LANL Lightning Flash Time Duration Ground Truth

Authors: Michael Pastis[1], David Bruggeman[1], Mark Nelson[1], Steve Chiswell[2] and David Pretorius[2]

Abstract

Video cameras were used to record cloud-to-ground (CG) lightning flash events on or near Los Alamos National Laboratory (LANL) over 3 days in August, 2018. Custom scripting software was created to automatically trigger camera recording off National Lightning Data Network (NLDN) streamed reporting of CG lightning within 12 miles of LANL. Cameras were sited near meteorology towers at LANL and 4k video captures were manually reviewed to extract still sequence images from 9 identified CG flashes. A camera frame rate of 30 fps was used to estimate time durations of 33-200 milliseconds over this natural lightning dataset.

Discussion

Los Alamos, New Mexico is located within an active thunderstorm region, prompting incorporation of lightning threats into equipment safety analyses at Los Alamos National Laboratory. Storage of low-level transuranic (TRU) waste in 55-gallon drums has included postulated risks of lightning flashover from building steel to TRU drums kept in temporary storage within aluminum-framed tent domes constructed for this purpose at LANL. A lightning flash can be comprised of one or more high-amplitude, short-duration return strokes. Between these typically visible return strokes, a less visible (or invisible) lower amplitude continuing current can flow through the lightning channel (Warne et al)[3]. It is the time duration of this less visible continuing current that delivers increasing energy capable of melting a hole in a thin Faraday cage, such as a steel drum[4]. This "burnthrough" process is currently under study at Sandia National Laboratory to learn the time duration required at various current amplitudes to compromise, by burnthrough, a steel TRU waste drum at simulated lightning energies created in the Sandia Lightning Simulator. Natural lightning time durations estimated from video captures recorded in this Ground Truth study will be used as key input for comparison against the constant current time durations required for TRU drum burnthrough hole creation in tests conducted in the Sandia Lightning Simulator.

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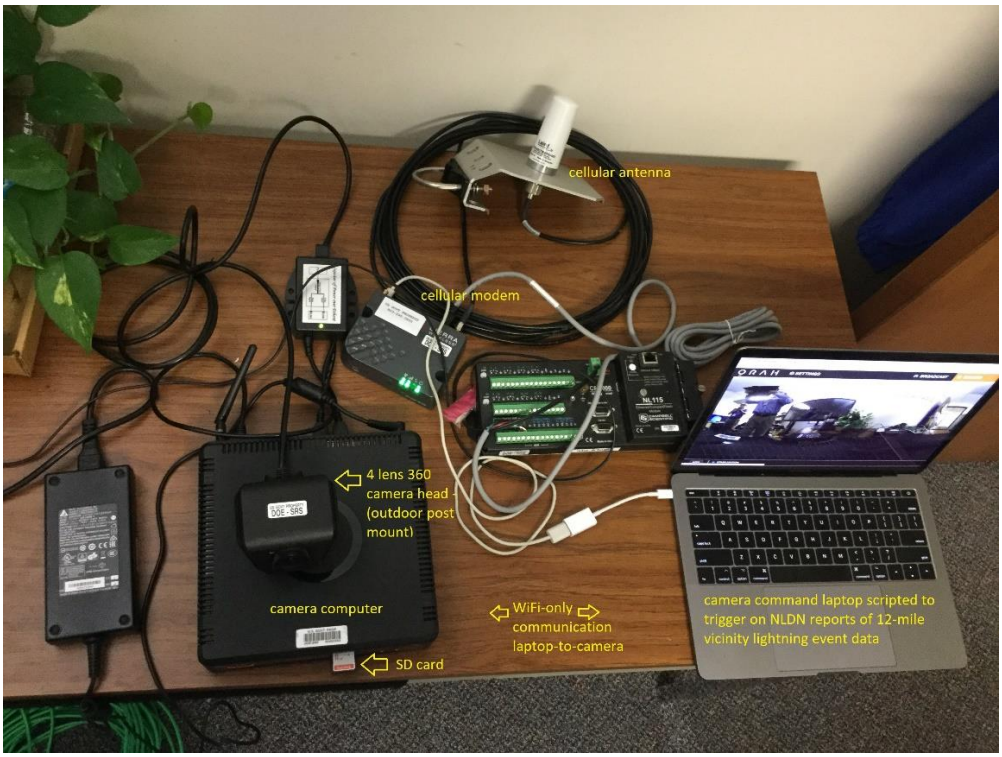
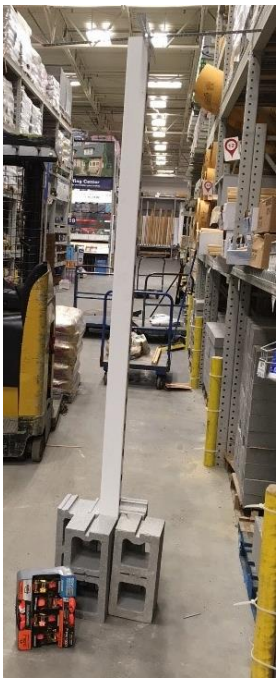
[1] Los Alamos National Laboratory, US Department of Energy
[2] Savannah River National Laboratory, US Department of Energy
[3] L. K. Warne et al, "Protection Characteristics of a Faraday Cage Compromised by Lightning Burnthrough", SAND2012-0040, January 2012.
[4] L. K. Warne et al, "Protection Characteristics of a Faraday Cage Compromised by Lightning Burnthrough", SAND2012-0040, January 2012.

Instrumentation

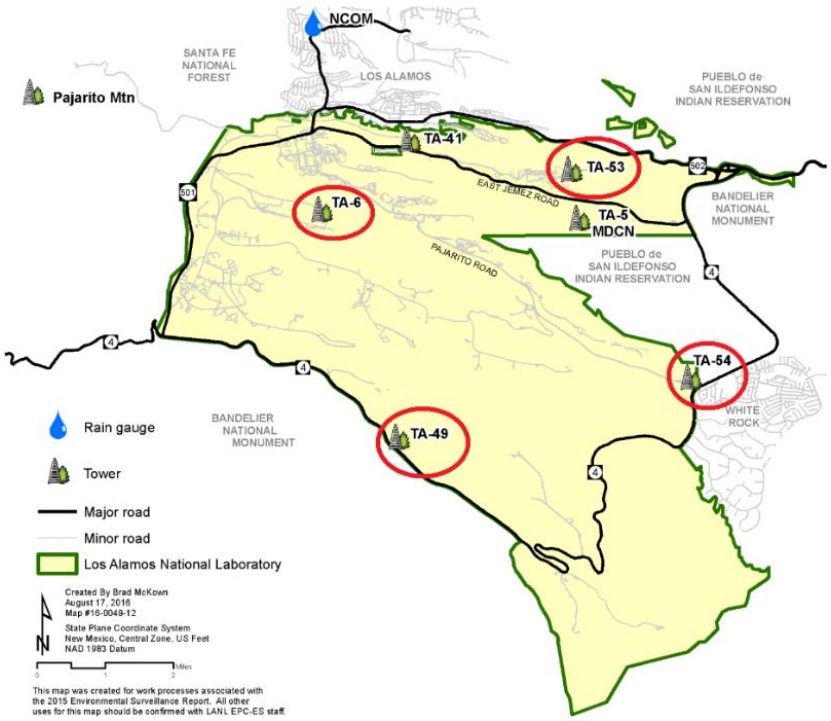
Four 360-cameras recording 4k video (Orah 4i) were installed near 4 meteorology towers at LANL atop 8' plastic posts to record panoramic cloud-to-ground (CG) lightning flash events in 30 fps video files. Automated remote software triggering initiated camera data file recording when streamed data feeds from the National Lightning Data Network (NLDN) reported lightning CG detection within 12 miles of LANL. Camera heads were mounted outdoors under domed plastic weatherheads and connected via Cat 6 ethernet cable to camera control computers housed inside plywood instrument sheds near each met tower. Locations for each met tower are shown in Figure 1; also shown is the software-triggered instrumentation used to record video captures. A meteorology website html flag was switched On or Off by a custom program monitoring streamed NLDN lightning CG flash data. A Curl script executed on a laptop at the remote camera site created a lightning trigger by pinging the html flag, then communicated via WiFi to the nearby camera computer to start and stop data recording, typically one or two hours in total duration. Remote access to the meteorology website html flag was achieved through a 4G cellular modem (Sierra Airlink RV50) and a 2 dBd 4G/3G Multiband Omnidirectional Antenna (Campbell Scientific 32262).



a) automated lightning trigger and camera control system



b) camera pole

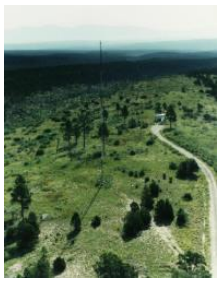


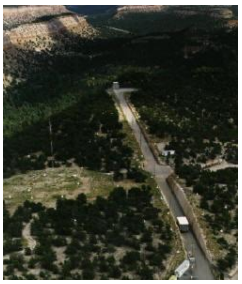
c) met tower sites marked in red depict lightning camera locations

d) TA-53 met tower

Figure 1: Automated camera control system, camera pole assembly, and installed locations at 4 meteorology tower sites (instrument sheds not pictured)


TA-6


TA-49


TA-53

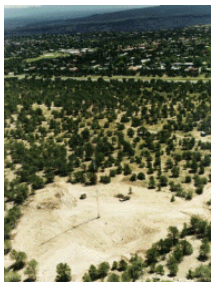

TA-54

Figure 2: Views of met tower sites housing installed lightning camera systems

Data and Results

Panoramic 360 video data was recorded during thunderstorms occurring August 9-11, 2018. Over this 3-day period, 9 total CG lightning flashes were observed in camera data files retrieved from TA-6 and TA-49 met towers, as shown in Table 1, Table 2 thumbnails, and in larger stills available in a separate Appendix. Discrete flashes were found manually through visual and audible screening of each video file, which recorded several hours of video in 9 minute file increments. Reviewed TA-53 video files did not evidence observable CG flashes and no data files were recorded at TA-54. It is speculated camera head overheating may have occurred from continuous operation over the 3-day period, causing subsequent camera shutdown at all sites. Time-date stamps for video data files generated by the camera electronics appeared to be several hours disparate from local time and were not reconciled to NLDN CG flashes seen in Figure 3 from the same time period. Each CG flash captured on video was analyzed for flash duration by counting the number of frames CG return strokes were visible over each lightning flash event, using approximately 33 ms per frame based on the 30-frame-per-second capture rate.

Flash Number and met site	Approximate Date	Total Number of Frames	Estimated Duration of Flash (milliseconds)
1 (TA-6)	8/9/2018 afternoon	4	133
2 (TA-6)	8/9/2018 afternoon	1	33
3 (TA-49)	8/10/2018 evening	5	167
4 (TA-49)	8/10/2018 evening	6	200
5 (TA-49)	8/10/2018 evening	1	33
6 (TA-49)	8/11/2018 evening	5	167
7 (TA-49)	8/11/2018 evening	1	33
8 (TA-49)	8/11/2018 evening	1	33
9 (TA-49)	8/11/2018 evening	4	133

Table 1: Visually identified CG flashes and duration from video files recorded at LANL, Aug 9-11, 2018.

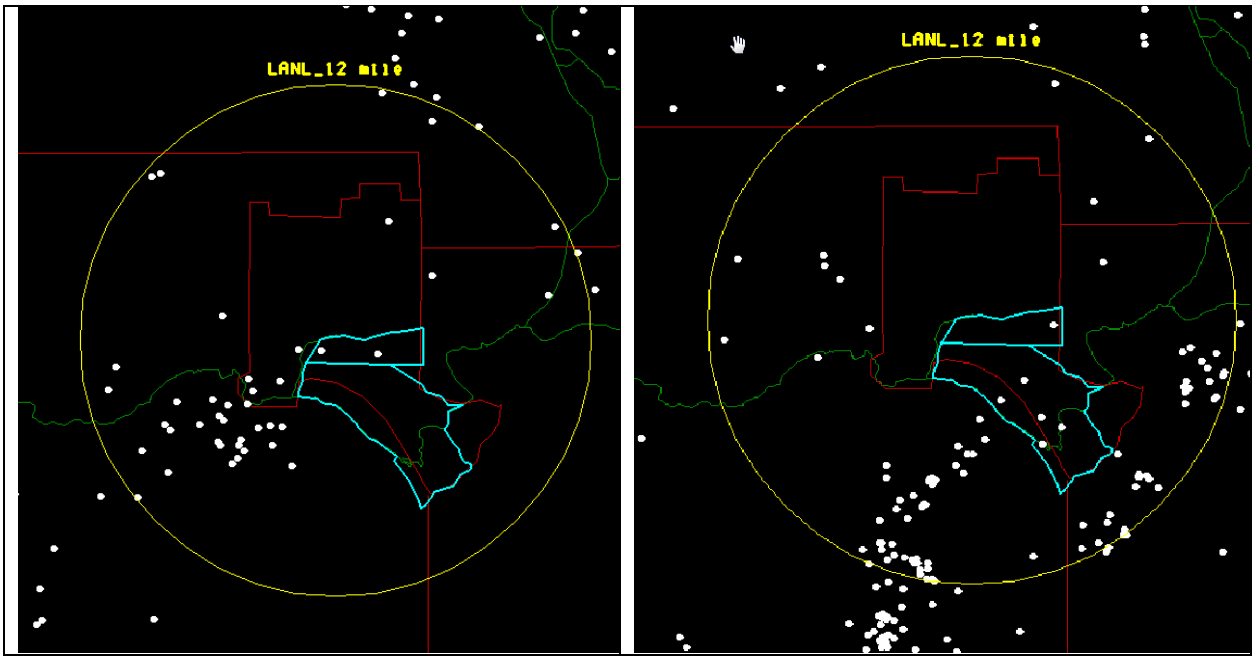
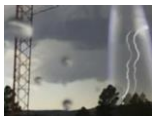
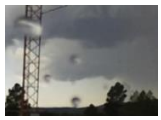
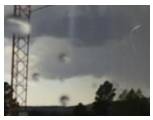


Figure 3: Mapping of NLDN CG flash data from 1200 Aug 9 to 1200 Aug 10 (left) and 1200 Aug 10 to 1200 Aug 11 (right) on and near LANL boundary outlined in cyan.

Flash							
1							
2							
3							
4							
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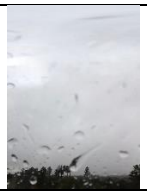
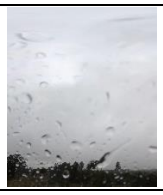
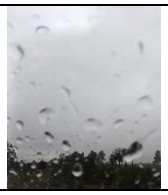
6							
7							
8							
9							

Table 2: Thumbnail frame-by-frame stills of CG flashes captured Aug 9 -11 on or near LANL.

References

1. L. K. Warne et al, "Protection Characteristics of a Faraday Cage Compromised by Lightning Burnthrough", SAND2012-0040, January 2012.

Appendix 1: CG flashes edited from 4k

Flash 1 Images

Frame 1

Frame 2

Frame 3

Frame 4

Flash 2 Image

Flash 3 Images

Frame 1

Frame 2

Frame 3

Frame 4

Frame 5

Flash 4 Images

Frame 1

Frame 2

Frame 3

Frame 4

Frame 5

Frame 6

Flash 5 Image

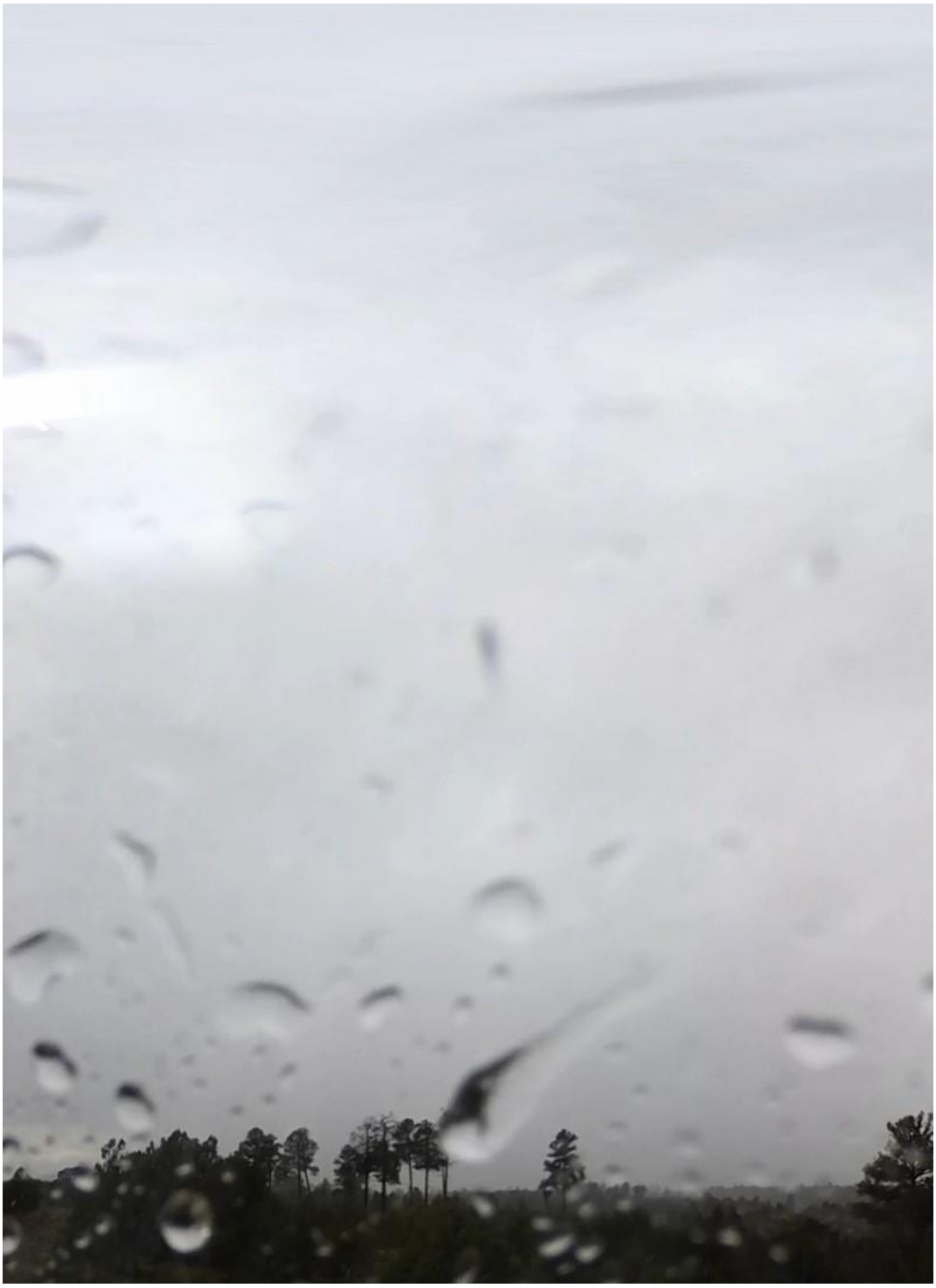
Frame 1

Flash 6 Images

Frame 1

Frame 2

Frame 3



Frame 4

Frame 5

Flash 7 Image

Flash 8 Image

Flash 9 Images

Frame 1

Frame 2

Frame 3

Frame 4