Title: NSSL Deployable Lightning Mapping Array Data

Author(s)

Vanna C. Chmielewski (lead),
NOAA/OAR National Severe Storms Laboratory
120 David L. Boren Blvd.
Norman, OK 73072
ORCID: 0000-0002-3065-4801
vanna.chmielewski@noaa.gov
Kristin Calhoun
NOAA/OAR National Severe Storms Laboratory
kristin.calhoun@noaa.gov
Doug Kennedy
NOAA/OAR National Severe Storms Laboratory
doug.kennedy@noaa.gov
Zachary Barney
NOAA/OAR National Severe Storms Laboratory
zachary.barney@noaa.gov
Vicente Salinas
Cooperative Institute for Severe and High-Impact Weather Research and Operations, University of Oklahoma
NOAA/OAR National Severe Storms Laboratory
vicente.salinas@noaa.gov
Jacquelyn Ringhausen
Cooperative Institute for Severe and High-Impact Weather Research and Operations, University of Oklahoma
NOAA/OAR National Severe Storms Laboratory
jacquelyn.ringhausen@noaa.gov
Eric Bruning
Texas Tech University
Box 41053
Lubbock, TX 79409
eric.bruning@ttu.edu
ORCID: 0000-0003-1959-442X
Kelcy Brunner
Texas Tech University
Box 41053
Lubbock, TX 79409
kelcy.brunner@ttu.edu

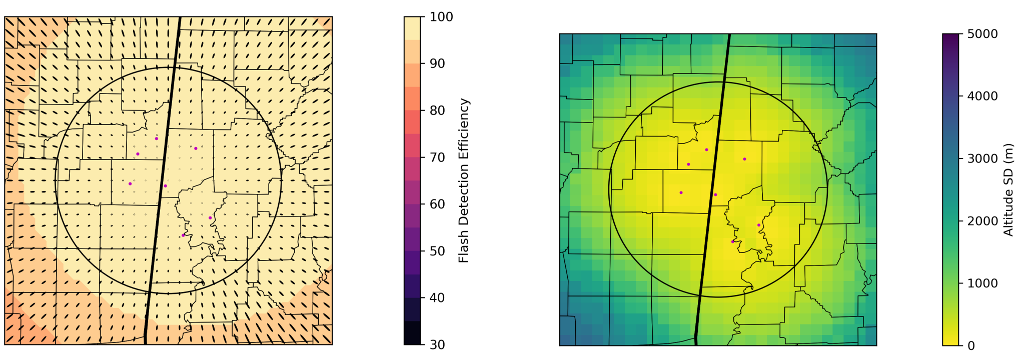
1.0 Data Set Description

- Introduction: Lightning Mapping Array (LMA) sensors were deployed at pre-designated locations for each IOP. The array consisted of up to 7 NSSL sensors and 1 TTU sensor, as listed in each Level 2 file header. The network was operated by National Oceanic and Atmospheric Administration / Office of Atmospheric Research / National Severe Storms Laboratory and OU / CIWRO staff. Data set includes Level 1 (VHF sources) files. Additionally, IOPs 2 and 3 were near the NALMA domain and include sources identified by NALMA (Lang et al. 2020).

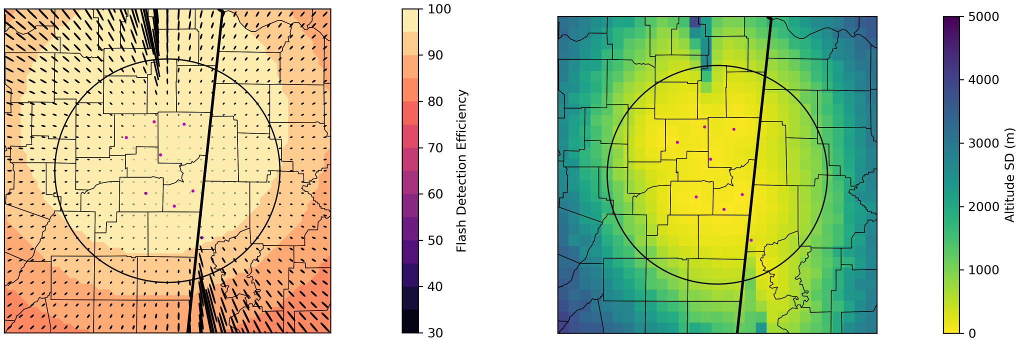
- Creation date: 18 April 2022
- Update date: 11 October 2022
- Data Status: Final
- Time period: All deployments between 1 March and 30 April, 2022. Approximately 48 hours of data collection per IOP.
- Physical location of the measurements: As listed in each Level 1 file header
- Data file intervals: 10 minutes

2.0 Instrument Description

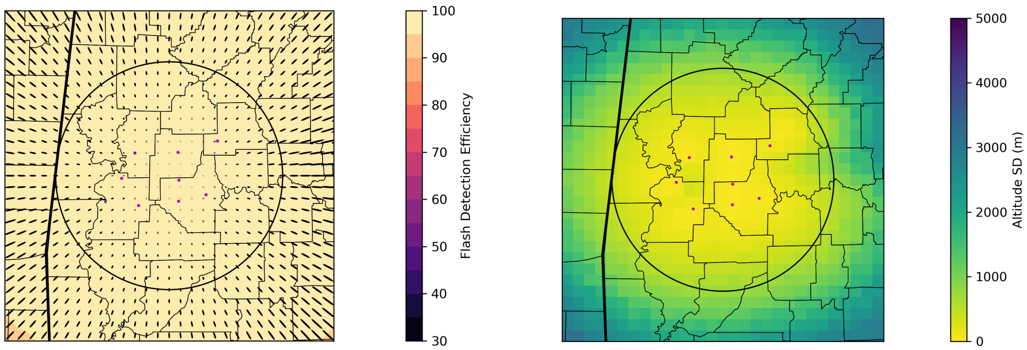
- Each sensor records the timing and amplitudes of passively-received VHF (60-66 MHz) emissions by lightning (and any other sources) in 80 microsecond windows. Using time of arrival techniques, the sources of these emissions map out the three dimensional structure of lightning flashes in space and time. The method of data collection and method for performance estimations below can be found in Thomas et al. 2004 and Chmielewski and Bruning 2016.
- Instrument photos: https://www.flickr.com/photos/noaanssl/sets/72157719674219692/with/51371051850/
- Estimated network performance:



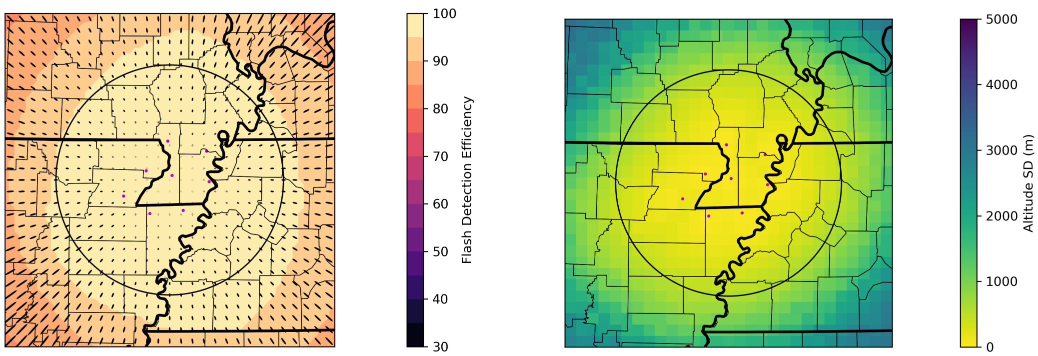
IOP1, 21-23 March 2022. Left: Estimated flash detection efficiency based on local VHF noise thresholds and covariance ellipse of horizontal errors based on instrument uncertainty. Right: Altitude standard deviation based on instrument uncertainty. 100 km radius from the centroid of the array shown on both images.



IOP2, 29-31 March 2022



IOP3, 4-6 April 2022



IOP4, 12-14 April 2022

3.0 Data Collection and Processing

- Data was collected from each sensor immediately following each IOP, and processed shortly thereafter.
- All data from the NSSL/TTU array was processed using lma_analysis v10.14.5R. All NALMA data was processed as described in Lang et al. Combination included for IOPs 2 and 3 as in the separated method of Chmielewski et al. 2022.

4.0 Data Format

All Level 2 data is stored in tabular, fixed-width formatted files compressed with gzip within the YYYYMMDD directories by IOP date. Fixed width formatting described in each file header. Each file contains 10 minutes of VHF events observed by the LMA and is titled following a LYLOUT_YYMMDD_HHMMSS_0600.dat.gz naming convention. Each file has a series of header lines at the top of the file including analysis version, active stations, analysis criteria, summary information, creation date and formatting information. Data is preceded by by a "*** data ***" line. If no data is found, either through lack of weather or sensor issues, only the file header will be present in the file.
** Column Names and Descriptions **
0: Time of VHF event – UTC second of the day
1: lat – decimal degrees
2: lon – decimal degrees
3: altitude – in meters above MSL
4: Reduced Chi^2 – Reduced chi^2 of the Marquart least squares solution for the VHF event
5: power – emitting power of the VHF event in dBW
6: mask – bitwise mask of the contributing stations to the VHF event solution in the order given by the Stations mask order line. Note that station masks masks are not unique in combined datasets of IOPs 2 and 3

5.0 Data Remarks

- PI's assessment of the data:
    - During IOP1 only 7 sensors were operating and sensor drop out occurred at 2330-0000 UTC which reduced sensitivity but still produced viable solutions at flash level
    - Early during IOP2 there were issues with station R's GPS lock, but location was resolved by the beginning of lightning activity in the domain
- Dataset updated on October 10, 2022 to include as solutions with at least 5 contributing sensors. Initial dataset upload included only those with at least 6.

6.0 References

- Chmielewski, V. C., and Bruning, E. C. (2016), Lightning Mapping Array flash detection performance with variable receiver thresholds, J. Geophys. Res. Atmos., 121, 8600–8614, doi:10.1002/2016JD025159.
- Chmielewski, V. C., Blair, J., Kennedy, D., MacGorman, D., & Calhoun, K. M. (2022), A comparison of processing methods for the Oklahoma lightning mapping array. Earth and Space Science, 9, e2021EA002081. https://doi.org/10.1029/2021EA002081
- Lang, Timothy, Richard Blakeslee, Matthew Wingo, William Rison, Daniel Rodeheffer, and Paul Krehbiel. 2020. North Alabama Lightning Mapping Array (NALMA) [30 March 2000 UTC - 31 March 0600 UTC; 5 Apr 22 0600-1900 UTC]. Dataset available online from the NASA Global Hydrometeorology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/NALMA/DATA101

- Thomas, R. J., Krehbiel, P. R., Rison, W., Hunyady, S. J., Winn, W. P., Hamlin, T., and Harlin, J. (2004), Accuracy of the Lightning Mapping Array, J. Geophys. Res., 109, D14207, doi:10.1029/2004JD004549.

7.0 Appendix

- Keywords: Atmospheric Electricity, Lightning, Lightning Mapping Array, Thunderstorm
- Acknowledgements: The authors thank Sean Waugh, Madeline Diedrichson, Martin Satrio, Clarice Satrio, Kent Knopfmeier, Thea Sandmael for their assistance with data collection. The authors thank the North Pickens County Airport, Dee River Ranch, Cedar Ridge Bed and Breakfast, Black Prairie Wildlife Area, Starkville Parks and Recreation, Columbus-Lowndes County Airport, Southern Star Congregation School, the city of Epes, AL, the city of Eutaw, AL, the city of Amory, MS, Infinity Ranch Stables, the city of Okolona, MS, Houston Municipal Airport, Craig Air Field, Orville Fire Department, Thomaston Municipal Center, Demopolis Sportsplex, Greensboro Municipal Airport, Marion State Fish Hatchery, Maplesville Rest Area, Auburn University Black Belt Research and Extension Center, Paragould Kirk Field Airport, Rector High School, Campbell City, MO, Fisher Delta Research Center, Caruthersville Memorial Airport, Blytheville Parks and Recreation, the city of Leachville, and Kennett Regional Airport for hosting instruments. The authors also thank the other entities not listed here willing to host throughout the domain but not visited this season.