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

Zachary Barney
NOAA/OAR National Severe Storms Laboratory
zachary.barney@noaa.gov

Joseph M. Berry IV
Cooperative Institute for Severe and High-Impact Weather Research and Operations, University of Oklahoma
NOAA/OAR National Severe Storms Laboratory
joseph.berry@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

Kristin Calhoun
NOAA/OAR National Severe Storms Laboratory
kristin.calhoun@noaa.gov

Doug Kennedy
NOAA/OAR National Severe Storms Laboratory
doug.kennedy@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
ORCID: 0000-0002-5077-6259

Vicente Salinas
Cooperative Institute for Severe and High-Impact Weather Research and Operations, University of Oklahoma
NOAA/OAR National Severe Storms Laboratory

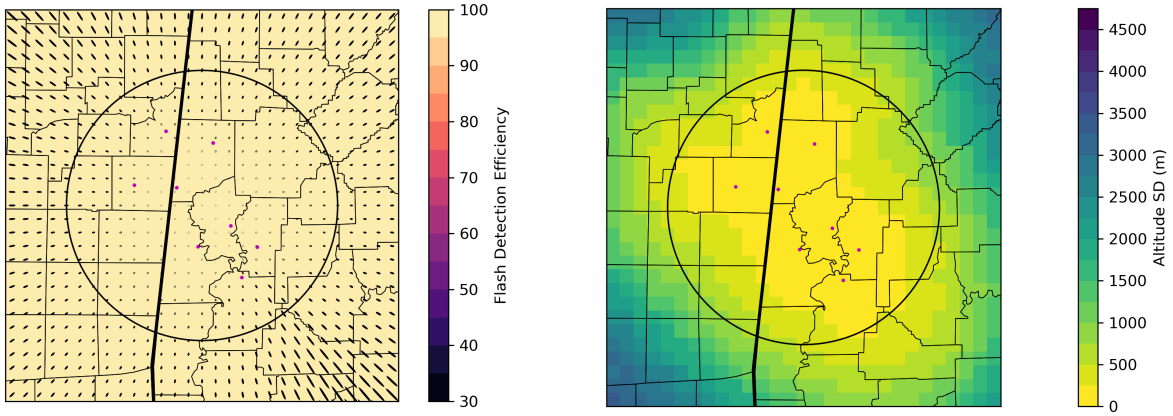
ORCID: 0000-0002-7690-6154
vicente.salinas@noaa.gov
Michael Stock
Cooperative Institute for Severe and High-Impact Weather Research and Operations, University of Oklahoma
NOAA/OAR National Severe Storms Laboratory
michael.stock@noaa.gov

1.0 Data Set Description

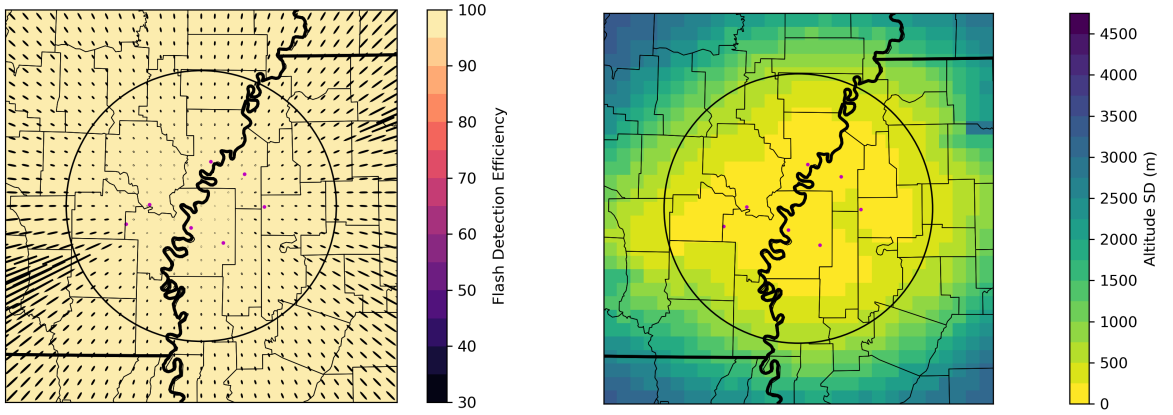
- Introduction: Lightning Mapping Array (LMA) sensors were deployed at pre-designated locations for each IOP. The array consisted of up to 8 NSSL sensors and 1 TTU sensor, as listed in each Level 2 file header. The network was operated by National Oceanic and Atmospheric Administration / Office of Atmospheric Research / National Severe Storms Laboratory and OU / CIWRO staff. Data set includes Level 1 (VHF sources) files. Additionally, IOP 4 was near the NALMA domain and includes sources identified by NALMA (Lang et al. 2020).
- Creation date: 18 May 2023
- Data Status: Final
- Time period: All deployments between 8 February and 8 May, 2023. 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

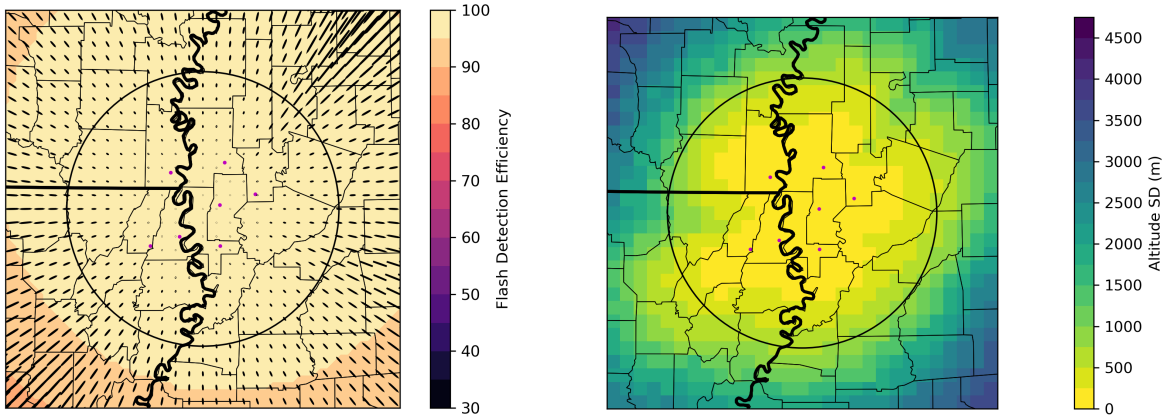
- Each sensor records the timing and amplitudes of passively-received VHF (60-66 MHz) emissions by lightning (and any other sources) in 80 microsecond windows. Using time of arrival techniques, the sources of these emissions map out the three dimensional structure of lightning flashes in space and time. 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:



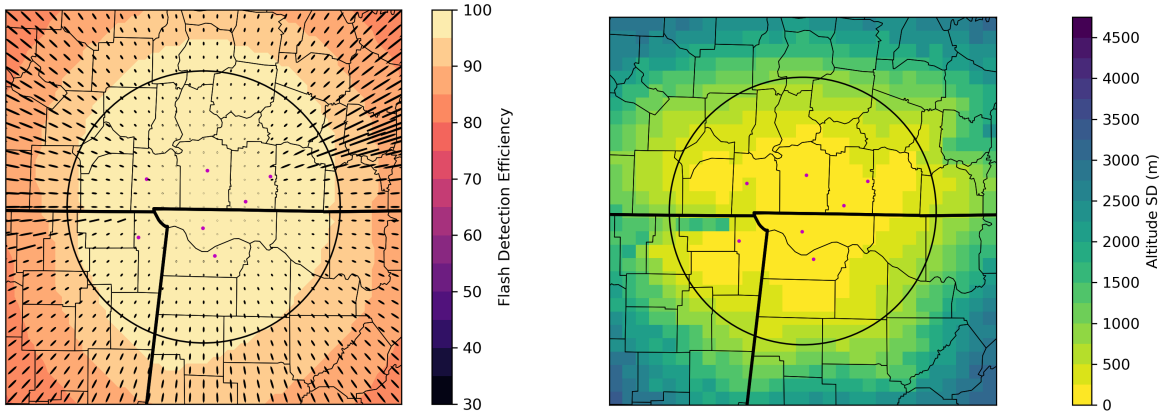
IOP1, 15-17 February 2023. Left: Estimated flash detection efficiency based on local VHF noise thresholds and covariance ellipse of horizontal errors based on instrument uncertainty for sources with at least 5 stations contributing and a 7 km (MSL) source. Right: Altitude standard deviation based on instrument uncertainty. 100 km radius from the centroid of the array shown on both images.



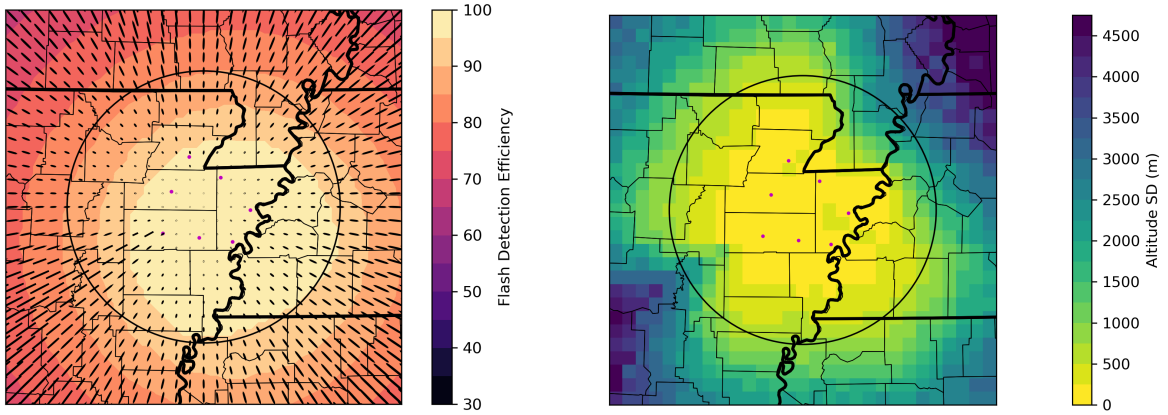
IOP2, 2-3 March 2023



IOP3, 23-25 March 2023



IOP4, 30 March - 1 April 2023



IOP5, 3-5 April 2023

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 IOP 4 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 IOP 2 there was a failure with the GPS cable on sensor H resulting in untrustworthy timing, so H was removed from processing. 7/8 station network.
    - During IOP 3 there was a hard drive failure with sensor H, 7/8 station network.
    - During IOP 4 there was an issue with the antenna connectivity on sensor B, and there were sporadic issues with GPS satellites with sensors B and R. They were largely not coincident, so most periods had 6 or 7 sensors of the 8 contributing. Additionally the NALMA network was operational throughout the period.
    - During IOP 5 there was an issue with the antenna connectivity on sensor B, 7/8 station network

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, Kent Knopfmeier, Derek Stratman, James Glover and Anthony Lyza for their assistance with data collection. The authors thank the Greensboro Municipal Airport (AL), Dee River Ranch (Cochrane, AL), the city of Epes, AL, the city of Eutaw, AL, North Pickens County Airport (Reform, AL), Cedar Ridge Bed and Breakfast (Macon, MS), Columbus-Lowndes County Airport (MS), Demopolis Sportsplex (AL), Flying Y Aero (Tutwiler, MS), Arkansas Post National Memorial (Gillett, AR), Cleveland Regional Airport (MS), the city of Elaine, AR, Henry Long (Rosedale, MS), Lee Academy (Clarksdale, MS), Billy Free Airport (Dumas, AR), Dale Bumpers Wildlife Refuge (St. Charles, AR), Humphreys County, MS, Little RV Park at Transylvania (LA), Sharkey-Issaquena Academy (Rolling Fork, MS), the city of Eudora, AR, Valley Park Baptist Church (MS), the city of Hollandale, MS, Poverty Point World Heritage Site, Oak Grove Lingo Community Center (LA), Loretto Sports Complex (TN), Pickwick Landing State Park (TN), the city of Savannah, TN, Alabama Music Hall of Fame (Muscle Shoals, AL), Lawrenceburg-Lawrence County Airport (TN), Central High School (Florence, AL), the city of Burnsville, MS, the city of Waynesboro, TN, Harrisburg Elementary School (AR), the city of Blytheville, AR, Osceola Community Center (AR), Paragould Kirkfield Airport (AR), the city of Marked Tree, AR, Headstart (Joiner, AR), the city of Leachville, AR, and Jonesboro Municipal Airport (AR) for hosting instruments. The authors also thank the other entities not listed here willing to host throughout the domain but not visited this season.