Improving Spatial coverage of Lightning Mapping Arrays (LMAs) for GLM validation

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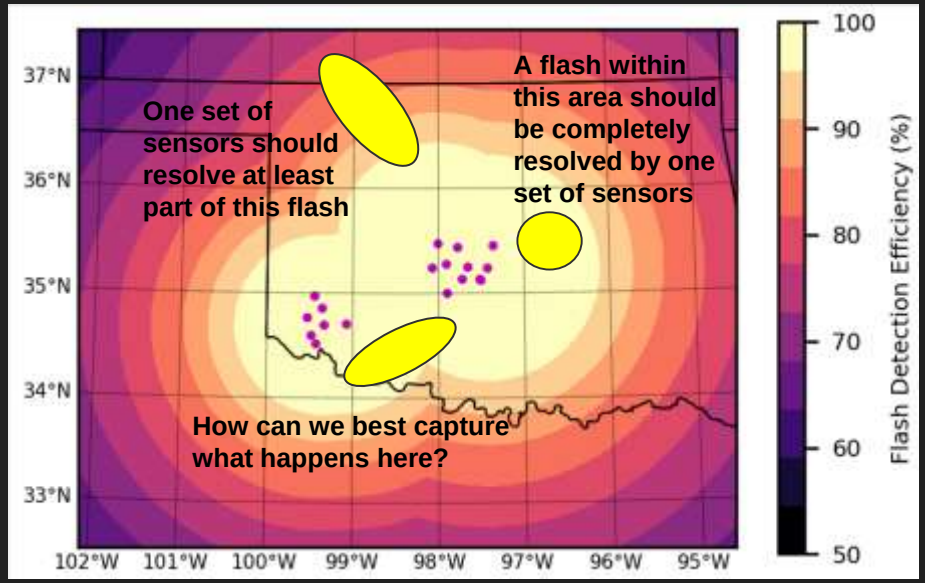
LMAs provide the altitude of lightning channels, flash extent and flash areas needed for GLM validation.

Each LMA has a limited spatial domain - which means limited physical and meteorological diversity by any one network

Goal: Find the best way to improve coverage

OKLMA has two clusters of sensors separated by ~150 km, which is useful for examining methods to merge LMA data

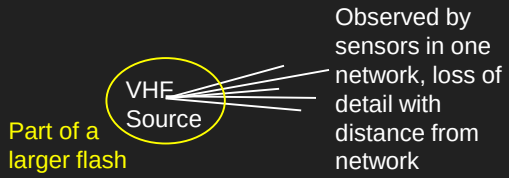


OKLMA Domain: What should be expect?

Extending network coverage with nearby networks

Purely Independent

Use the closest network's solutions (VHF sources and flashes) for each grid cell



The good: Predictable performance

The bad: Two different representations of flashes in spots, limit on flash details away from chosen network

Fully Unified

Allow sensors from each network to be queried for the best VHF solutions

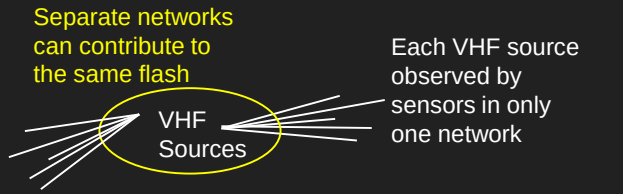
The good: Extended, continuous coverage area

The bad: Computation cost

The ugly: May not perform as expected

Combination

Sources found independently, then combined for gridded flash products

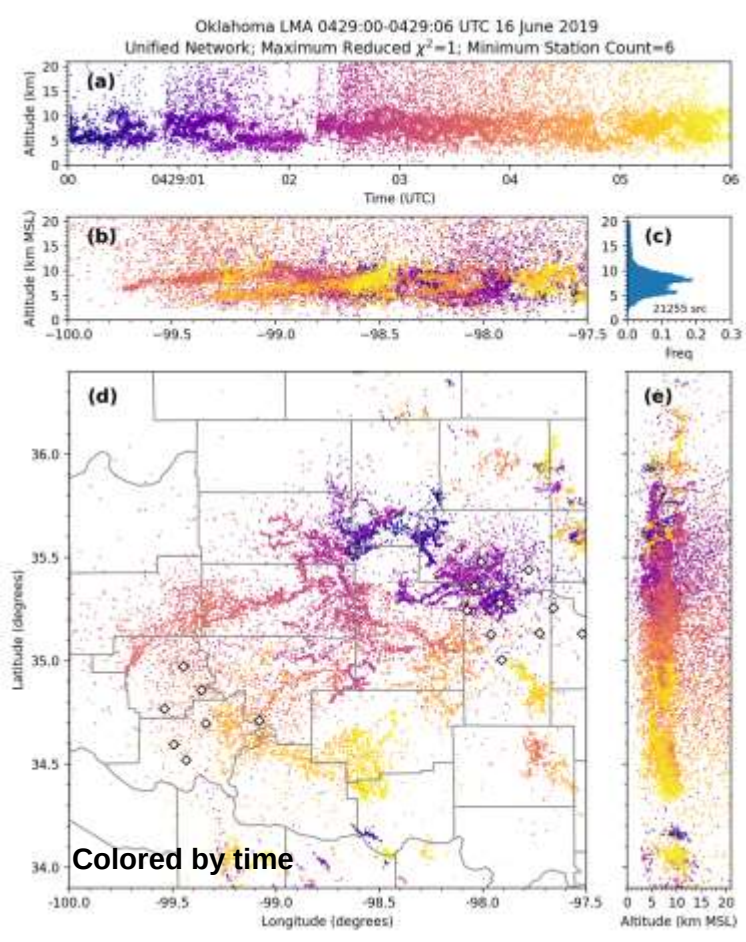


The good: Extended coverage area, low computation cost

The bad: Potential double counting of sources

Fully Unified

21,255 VHF sources (≥6 stations)
10,828 with ≥7 stations



Performance Comparison

Images: 6 seconds from a QCLS passage over the OKLMA network

More noise when processed as a fully unified system: 29% of VHF sources had χ^2>1 (19% for combination)

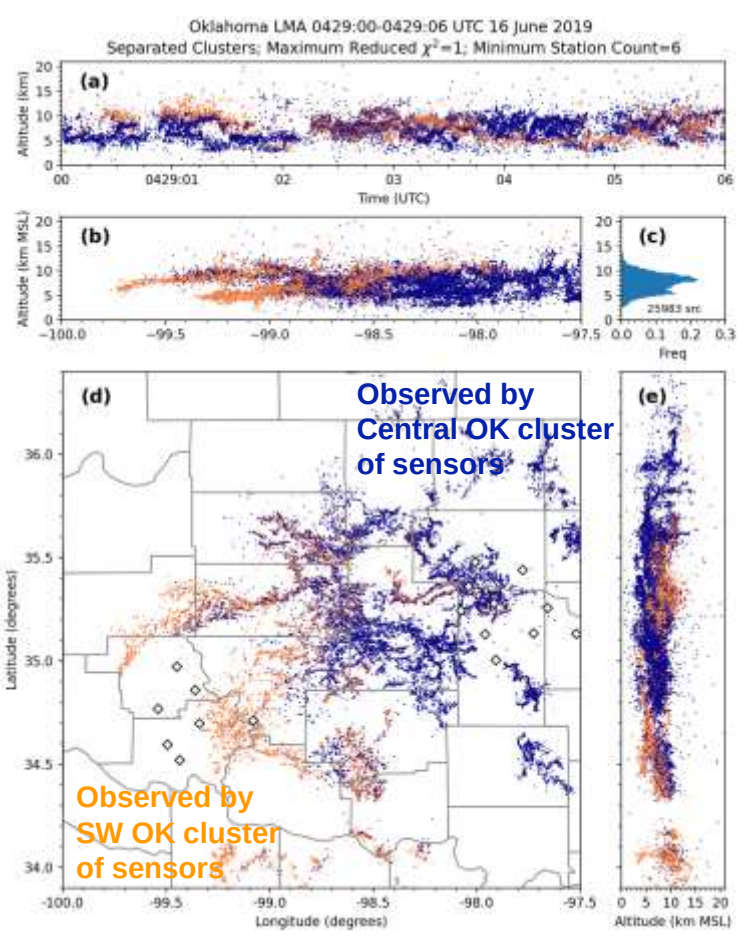
Increasing minimum number of stations removed noise, but also halved source counts.

Combination method: 1-3% of sources observed by either set of sensors were duplicates (within 640 ns and 0.5 km)

Combination method took **96% less** computational time than the fully unified over the 6 hr period of QCLS passage

Combination

25,983 VHF sources (≥6 stations)



How much does it matter on the scale of resolved flashes?

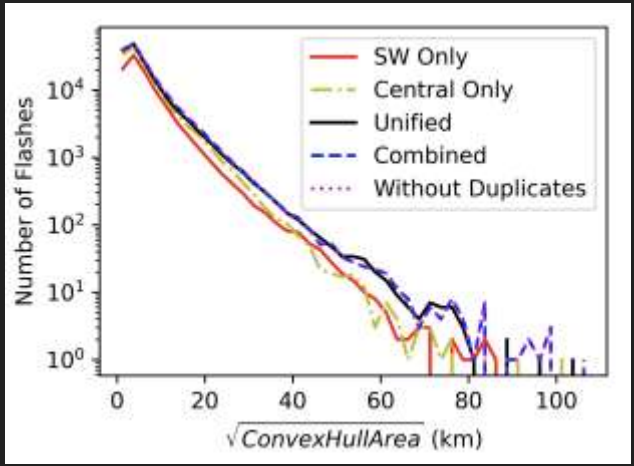
Combined method records:

- More flashes
- More area in flashes
- Larger flashes

Flash sorting used lmatools with
Max χ^2: 1
Min # stations: 6
Max separation: 0.15 s, 3 km
Max duration: 3 s
Min source count: 10

Slightly more small flashes are grouped when well-mapped duplicate sources are included than when they are removed

Distribution of flash sizes over full 6 hr QLCS passage



	Percentage Difference over most active 3 hrs		R^2 of per minute values	
	Combined vs. Unified	With vs. without duplicate sources	Combined vs. Unified	With vs. without duplicate sources
Total flash counts	2.95% (**116,875 vs. 113,516**)	0.35%	0.835	0.998
Total flash areas	6.86% (8.6 vs. 8.0 million km^2)	0.02%	0.836	0.9998
Average flash areas (per minute)	4.21% (4,519 vs 4,336 km^2)	-0.25%	0.78	0.999

Targeted Observations

Additional portable LMA sensors: 7 at NSSL, 3 at TTU, plus others (NASA's RELAMPAGO setup) can easily be used to:

- Target areas of known GLM difficulties or uncertainties
- Expand an existing network's coverage area for geographic or meteorological diversity

To expand an existing network's coverage it may be advantageous to set up a full, secondary cluster as an independent network. VHF sources from each can then be combined to grid combined flash products. Benefits found with OKLMA:

- Significantly reduced processing time compared to a fully unified network
- Reduced noise compared to a fully unified network
- Better spatial coverage than either cluster independently

Above: TTU; Below: NSSL (in production)