Capabilities and Limitations of New Lightning Data Sets in Operations

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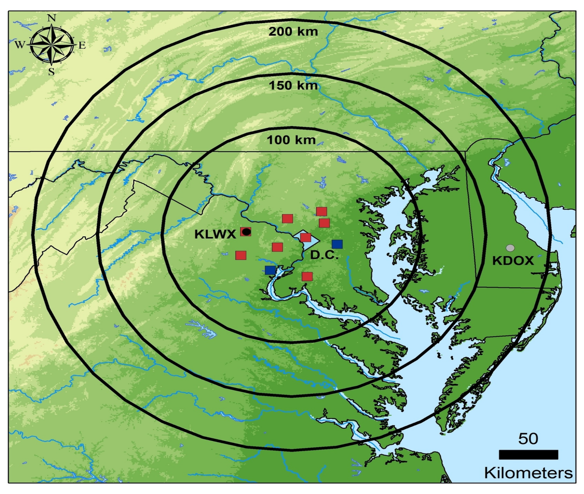
Overview

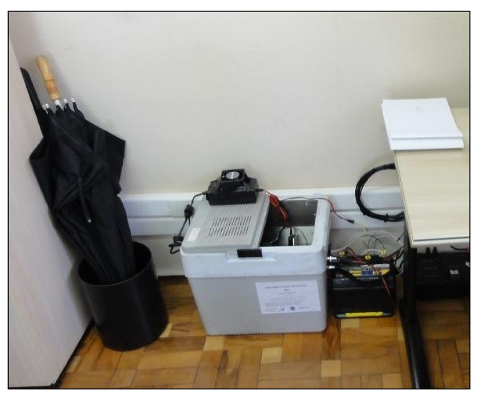
Knowledge of lightning detection network capabilities becomes more important as both the number of networks and variety of users increase. Operational weather forecast offices receive several lightning data sets in real time, and use these data to help improve convective weather forecasts. Lightning generates electromagnetic pulses that propagate as radio waves in all directions. These lightning emissions generally range from very-high frequency (VHF) and high-frequency (HF) to very-low frequency (VLF) and low-frequency (LF) emissions. Several ground-based networks monitor various portions of these frequency ranges to locate and characterize both cloud-to-ground (CG) and intra-cloud (IC) lightning. This study uses the Warning Decision Support System – Integrated Information (WDSS-II) to visualize lightning observations from the Washington D.C. Lightning Mapping Array (DCLMA), Earth Networks Total Lightning Network (ENTLN), and National Lightning Detection Network (NLDN). These lightning data are examined alongside radar and model-derived parameters to track and characterize convective storms. This study explores relationships between the ground-based lightning observations, focusing on significant convective weather outbreaks in the DCLMA domain (i.e., Washington D.C., Maryland, and Virginia region). These visualizations and statistics aim to advise National Weather Service (NWS) forecasters on the real-time application of lightning data in operations.

Lightning Sensors



DCLMA domain and sensor locations

ENTLN sensor

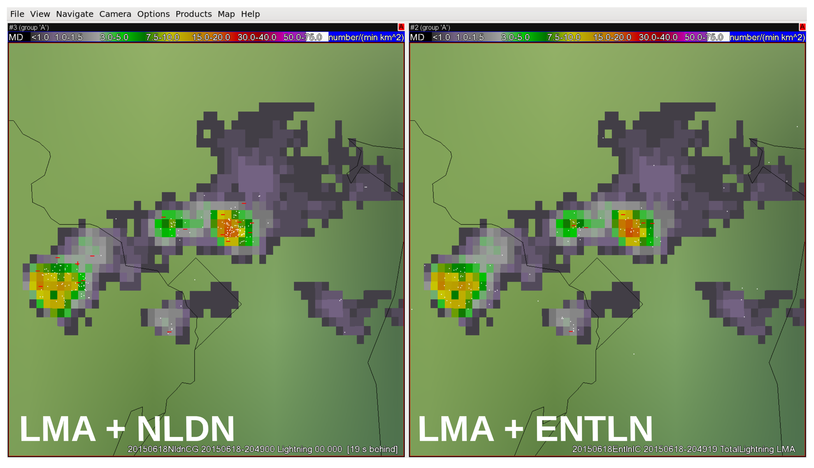


Example LMA "box" (computer)

DCLMA sensor

A DCLMA site in Virginia

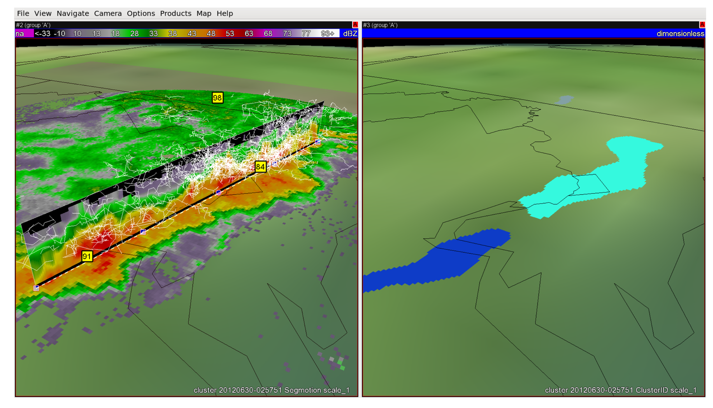
NLDN sensor



DCLMA flash extent density (FED) with NLDN (left) and ENTLN (right) cloud-ground flashes and intra-cloud pulses (left).

Cloud-ground flashes are red +/-'s while intra-cloud pulses are white dots. FED is the gray, green, and orange colors in the background. FED is determined by the number of flashes passing through a 1x1 grid point per 1 minute

Current Research Using WDSS-II

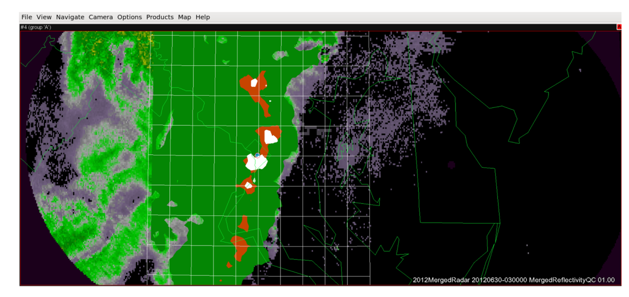


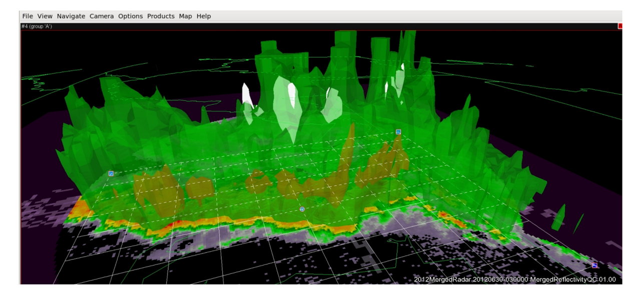
3-D cross section of reflectivity in the 2012 derecho case (left) with scale 1 clustering based off reflectivity at -20C (right)

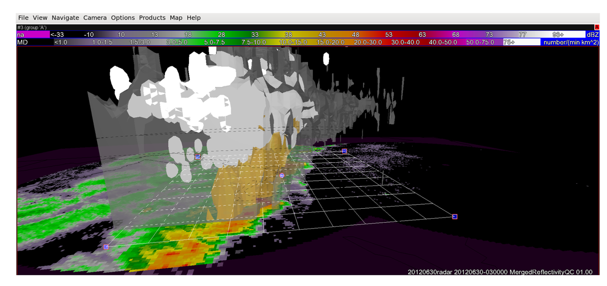
- Warning Decision Support System – Integrated Information software
- Developing database of storms with intense lightning
- Grouping storms based off radar attributes
- Merging Dover (KDOX) and Sterling (KLWX) sites for wider radar coverage
- Investigating lightning jump occurrence alongside radar parameters (REF-20C)

Isosurfacing

- These total lightning observations provide detailed insights into the structure and evolution of convective storms, extending warning lead times for severe weather

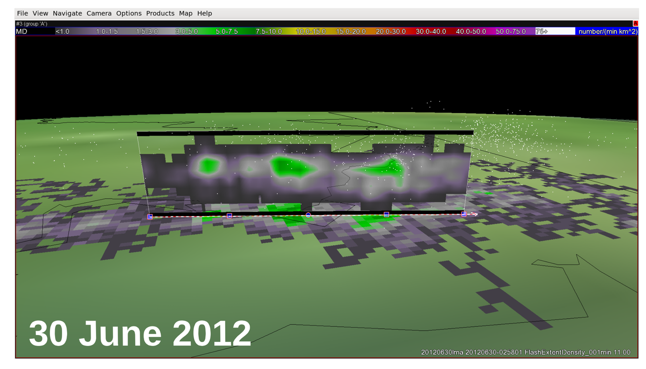


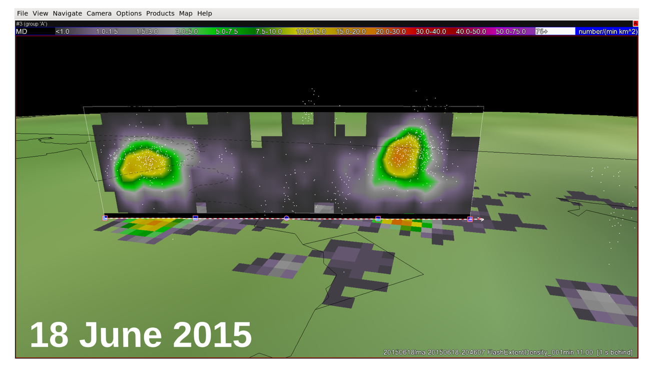




Green & oranges are reflectivity while the white is LMA flash extent density showing the most intense portions of the storm

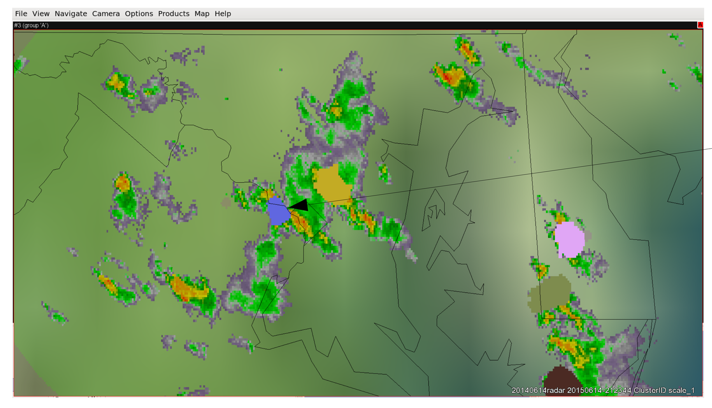
Height Comparisons



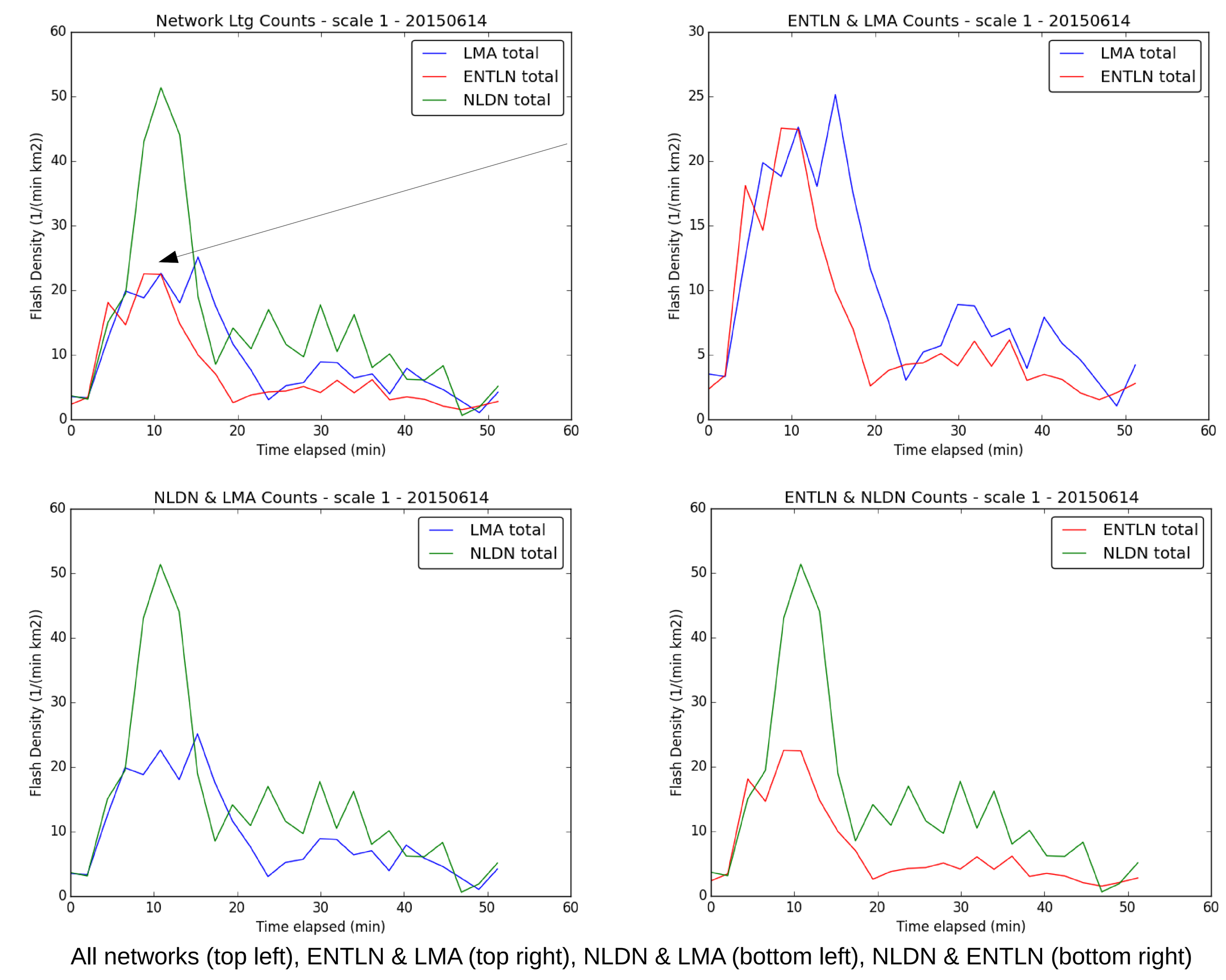


- Comparing heights between DCLMA sources and ENTLN intra-cloud portions
- Found improvement in the agreement between the DCLMA and ENTLN heights from 2012 to 2015
- Evaluating different networks on how they perform in WDSS-II's lightning jump algorithm
  - Currently based off 2-sigma jump with a threshold of 10 flashes

June 14th, 2015 Case

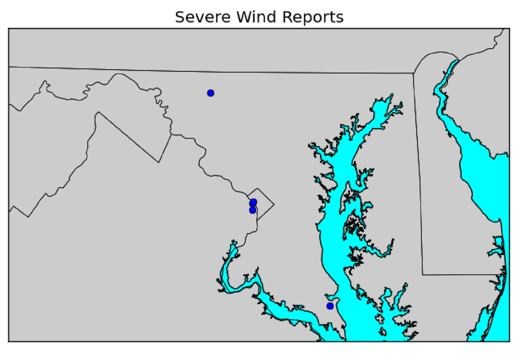


- Examined borderline severe weather case
- Tracked only one large reflectivity cluster instead of multiple smaller storms



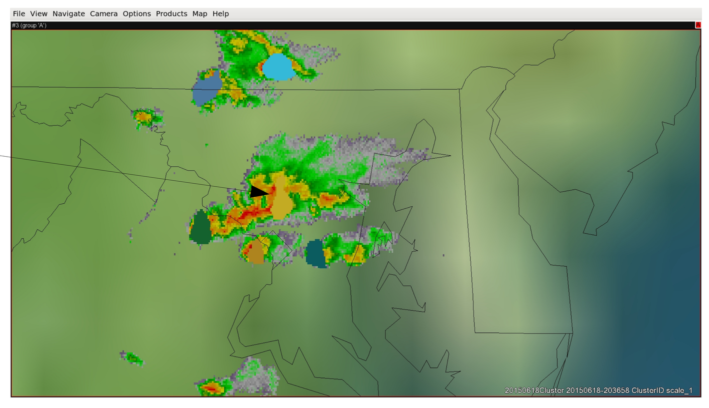
All networks (top left), ENTLN & LMA (top right), NLDN & LMA (bottom left), NLDN & ENTLN (bottom right)

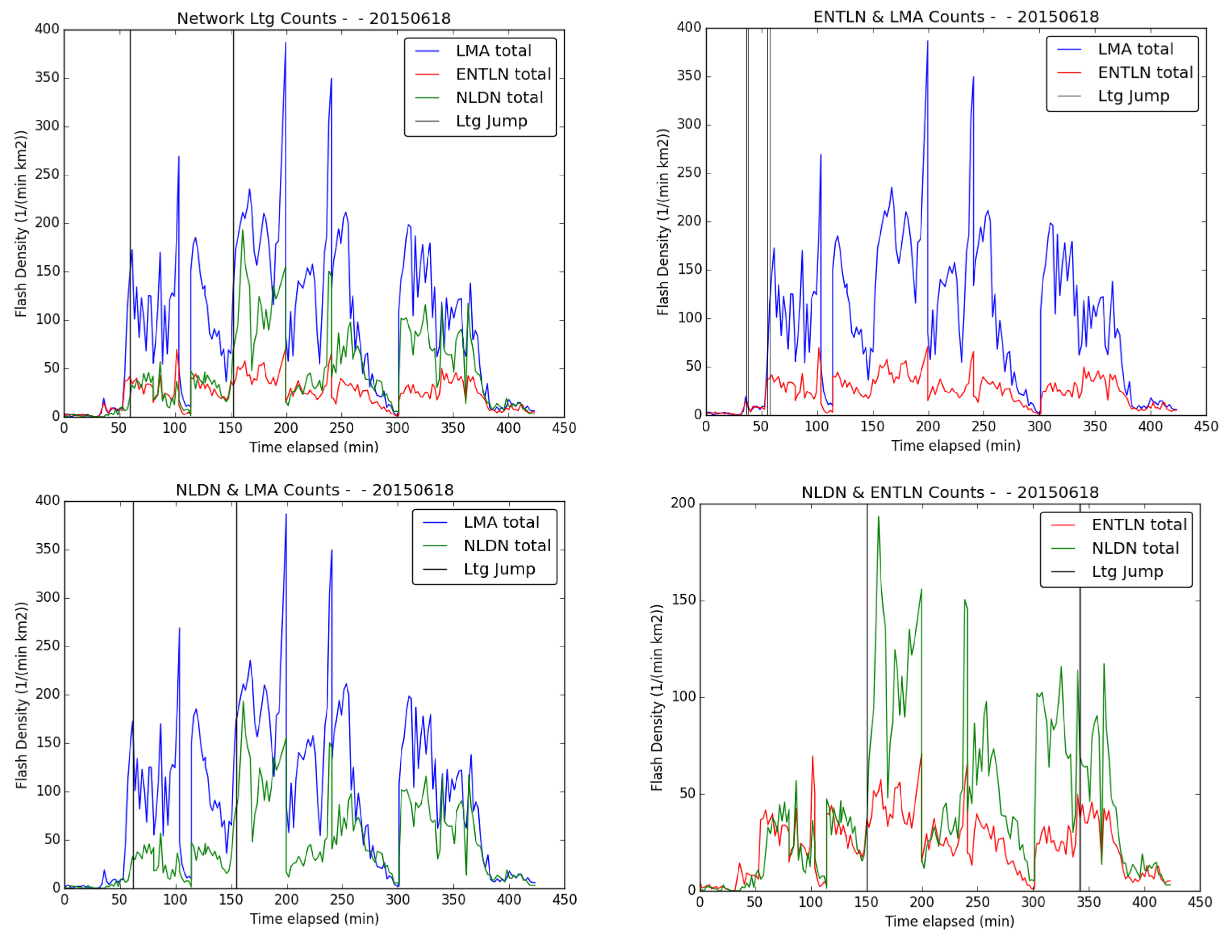
- Lightning jump algorithm did not report a jump because the storm had not existed long enough as one large cluster
- Approximately 10-15 minutes after flash densities spiked, two severe wind events reported



June 18th, 2015 Case

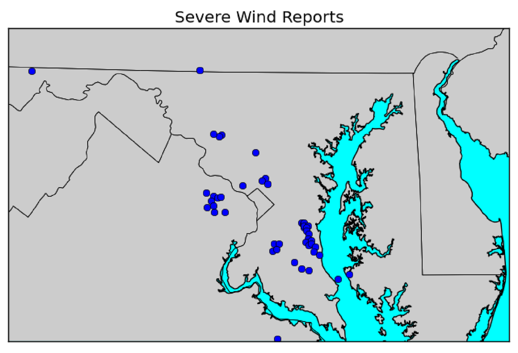
- Manually examined storm clusters and selected those lasting longer than one hour within the DCLMA range
- Storm clustering based on Reflectivity-20C





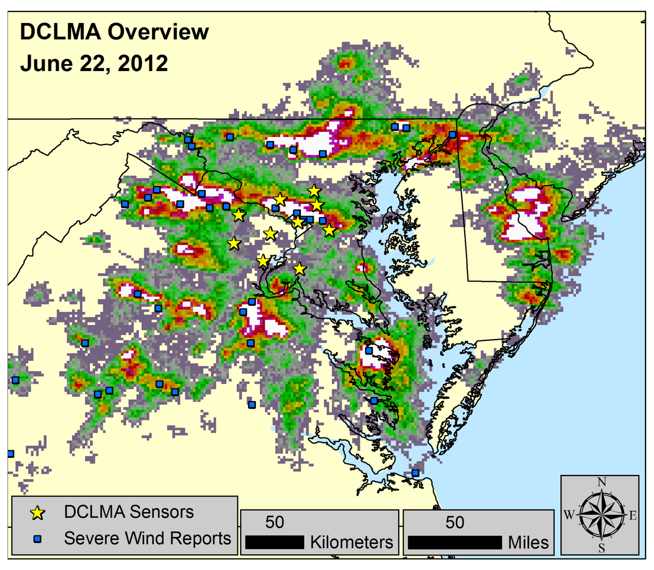
All networks (top left), ENTLN & LMA (top right), NLDN & LMA (bottom left), NLDN & ENTLN (bottom right)

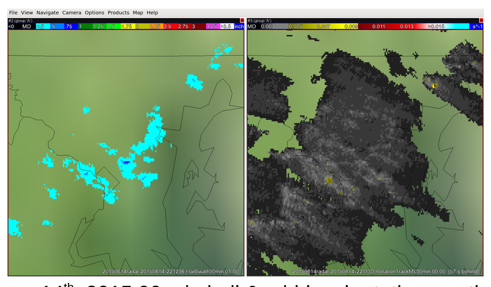
- Graphed different combinations of the networks to evaluate how they define lightning jumps within severe and non-severe storms
- Manually combined 4 storm clusters into one spatially and temporally coherent storm



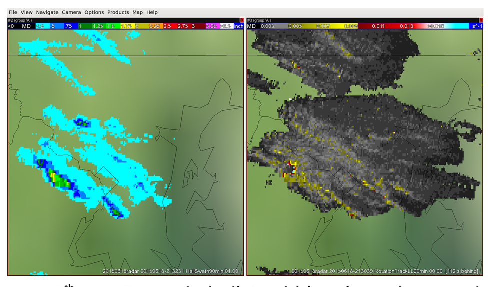
Future Plans

- Use total lightning observations to provide detailed insights into the structure and evolution of convective storms and help protect life and property
- Lightning is already becoming a very useful tool for NWS forecasters in determining storm strength and increasing the lead time for severe weather such as tornadoes, hail, and wind

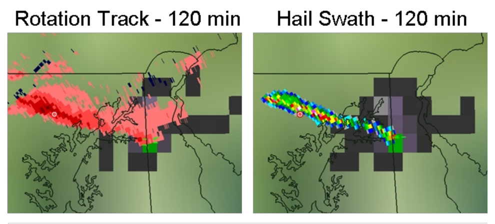


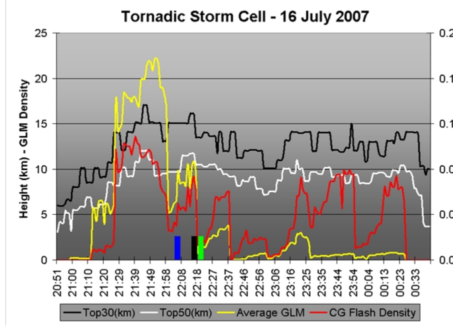


June 14th, 2015 90 min hail & mid-level rotation swaths



June 18th, 2015 90 min hail & mid-level rotation swaths





What's next?

- Continue to refine these lightning and radar data sets and promote their use in NWS operations
- Compile total lightning network archives and document significant severe weather, lightning induced structural damage, and any lightning casualty events
- Track storms using different radar attributes and/or lightning to better define storm features
- Tweak lightning jump algorithm specifications to better identify the lightning jump signature that often precedes severe weather

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