Experimental Warning Program: Lightning Data Experiment

Background:

Storm electrification and lightning are intimately linked to storm kinematics, microphysics, and dynamics. Charging of thunderstorms is driven by rebounding collisions of cloud and precipitation ice hydrometeors in regions where in the presence of super cooled cloud water; this process is known as noninductive charging. The charging rate is proportional to graupel volume and vertical ice mass flux (Wiens et al. 2005, Kuhlman et al. 2006, Deierling et al. 2008). The charge separation rate controls the ability of the storm to reach a electric field threshold for lightning initiation, and so controls the total lightning flash rate. Enhanced updraft will generally enhance the graupel and ice mass flux, and in turn the flash rate. Therefore, changes in the flash rate with time are expected to correlate to changes in the updraft volume and strength in the mixed phase region of the storm.

Updraft strength is crucial in setting the stage for severe weather-producing storms, a fact noted by Williams et al. (1999), who related total lightning activity to severe weather. Numerous case studies of supercell and multicell storms have noted increases in total lightning activity before (up to 25 min) or near the onset of severe weather including tornadoes, hail, and damaging wind (Steiger et al. 2007, Kuhlman et al. 2006, Goodman et al. 2005). Schultz et al. (2009) and Gatlin (2006) have explored the use of flash rate 'jump' algorithms in an operational setting as a means of flagging storms likely to produce severe weather. They found percentage of detection and false alarm rates comparable to other radar-based automated algorithms with longer lead time.

A unique advantage of total lightning data is its high temporal resolution that provides rapid (1-2 min) refreshes of map-based plots of lightning density. Trending applications will use 2 min bins of flash counts.

Lightning Data:

Data from four VHF Lightning Mapping Arrays will be incorporated in forecast and warning workflows for the duration of the project. The networks are:

* Oklahoma (OKLMA); (11 stations, min 6 needed for Quality Control to reduce false detections)
* Washington, DC (DCLMA) (11 stations, min 8 needed for QC)
* Northern Alabama (NALMA) (8 stations, min 6 needed for QC)
* Kennedy Space Center (KSCLMA) (not yet available)

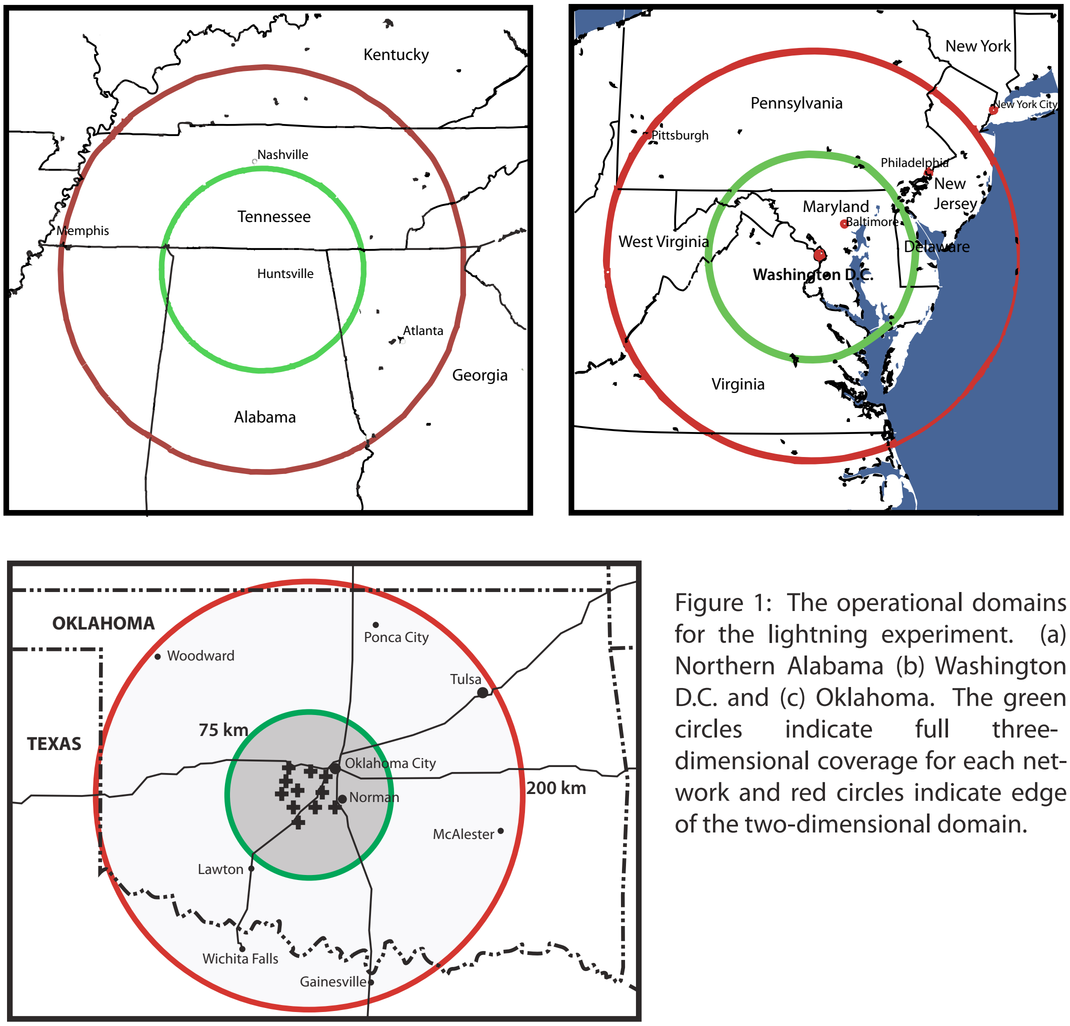

Figure 1: The operational domains for the lightning experiment. (a) Northern Alabama (b) Washington D.C. and (c) Oklahoma. The green circles indicate full three-dimensional coverage for each network and red circles indicate edge of the two-dimensional domain.

The LMA networks (Krehbiel et al, 2000) are Global Positioning System (GPS) based, time of arrival systems, that map lightning by measuring the time at which an electromagnetic signal produced by a developing lightning channel arrives at each station. As lightning propogates it emits very high frequency radiation, each detection by the network is classified as a 'source point' (Fig. 2). Each LMA system can map up to 12000 sources per second, with an individual flash containing anywhere from one to a few hundred source points. The signal propogation is line-of-sight such that distant sources below the horizon are not detected, thus limiting the detection range of the networks as indicated in Fig. 1. Typical measurement errors are within 6-12 m in the horizontal, 20-30 m in the vertical and 30-50 nanoseconds.

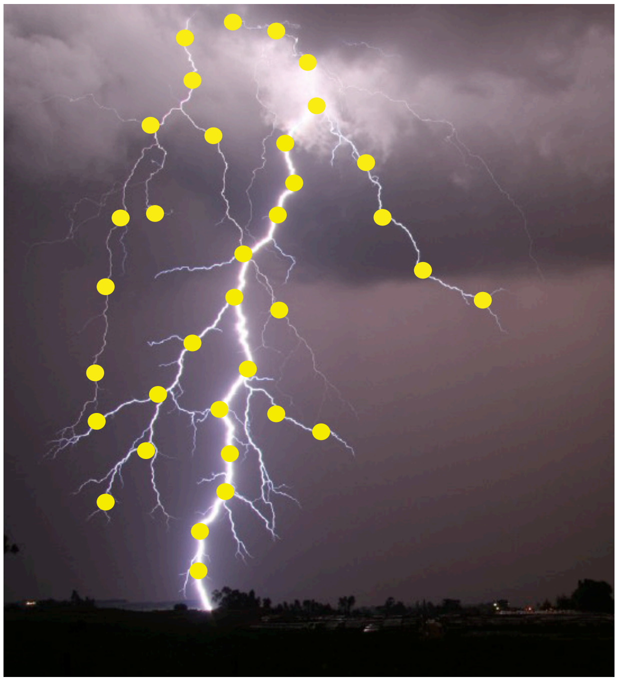

Fig. 2: Conceptual model for LMA detections from a lightning flash.
Yellow circles represent VHF source points detected by the LMA.

Data from the OKLMA Array is processed by NSSL into ASCII format and combined with data from the other three networks. Data from the DCLMA and NALMA are delivered in ASCII format every two (2) minutes over an LDM feed from the NSSTC, Huntsville, AL. WDSSII is used to process the data (Lakshmanan et al, 2007). WDSS-II provides a mechanism for associating LMA source trends with multi-sensor based cell features, and therefore a hook for testing out trending applications.

Products for this Spring: (see final page for reference sheet)
* 1 km vertically integrated LMA source count (density product)
* 10 km vertically integrated LMA source count (GOES – Global Lightning Mapper proxy)
* VHF source rate trending, associated with storm cells
* CG Lightning probability algorithm

Forecasters should evaluate the following factors:
* Ability of flash rate trends and other lightning data to contribute to warning decision making
* Utility of lightning data in radar-poor areas
* Impact of the ~2 min time resolution
* Comparison of lower and higher space resolutions for GOES-Global Lightning Mapper (GLM) proxy evaluation
* Relationships with other multi-sensor derived products, including storm-classification, hail size and circulation algorithms, as well as convective initiation, convective overshoot, and enhanced-V algorithms using visible and infrared channel satellite data.

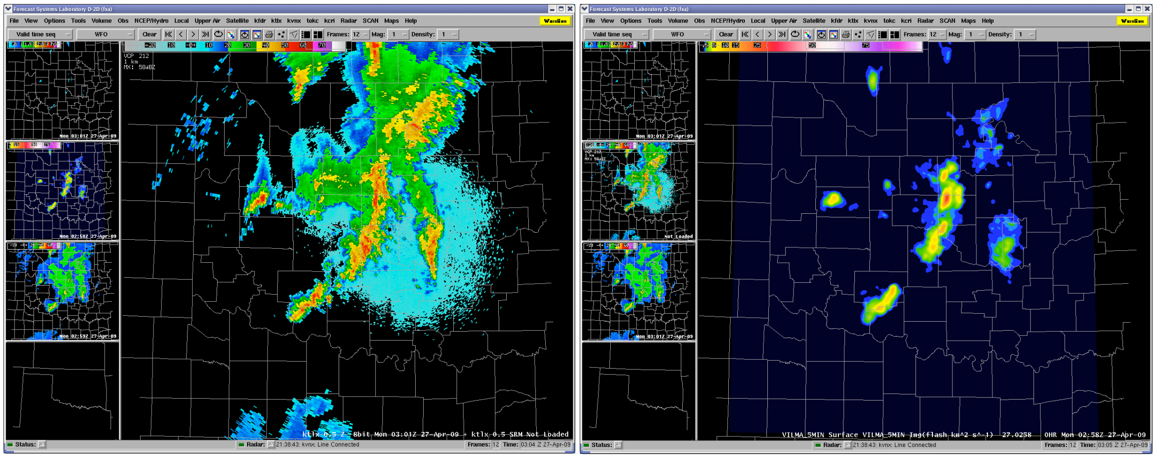

Fig. 3: Example of product within AWIPS. Left: 0.5 degree reflectivity from KTLX Right: VILMA lightning product at same time period.

References:

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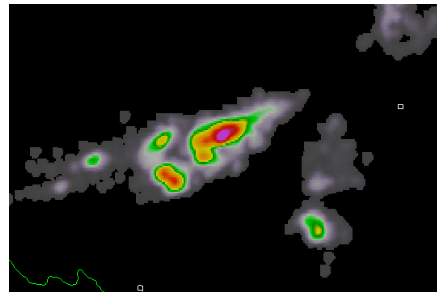
LIGHTNING PRODUCT REFERENCE SHEET



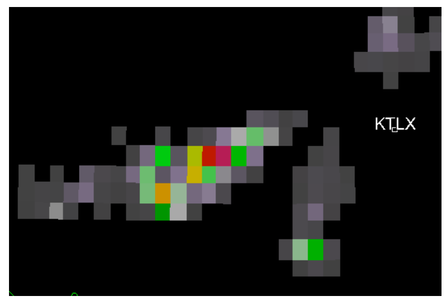
VILMA: Vertically Integrated Lightning (from Lightning Mapping Array); 1 km grid spacing

Units: # per km^2 per min

5 min product = average of last 5 min of data

15 min product = average of last 15 min of data

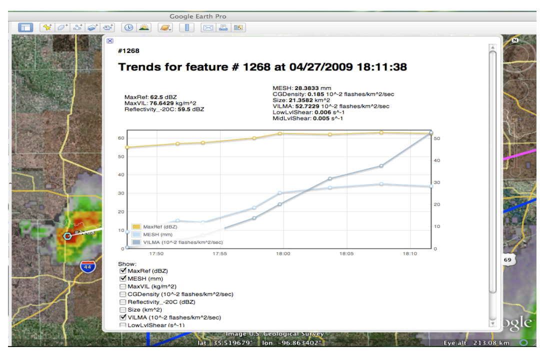
update every 2 min



GLM proxy: VILMA product interpolated to 10 km grid to replicate lightning as seen from the optical sensor from the GOES-R satellite

5 min product

updates every 2 min



Trend product: Currently only available in Google Earth. Cell based tracking. Displays 5 min VILMA product along with other multi-radar derived products.

Updates approx. every 5 min

CG lightning density:

CG lightning density for cloud-to-ground strike locations only. 5 min and 15 min averages updated every 5 min. NLDN (+ or -) strike location product available.

CG probability: area and likelihood (%) that a storm will produce CG lightning 30 min the future.