The use of Lightning Mapping Array data in WDSS-II

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Abstract

Lightning source data from the Oklahoma Lightning Mapping Array (LMA) has been ingested into NSSL's Warning Decision Support System - Integrated Information (WDSS-II) and is presented visually in several ways: as a dynamic three-dimensional plot of source data, as a dynamic three-dimensional grid of source densities and as various derived two-dimensional grids of source densities. Users can visualize the 3D structure of the in-cloud lightning densities, and its co-location with radar data and the various iso-therm levels. In this paper, we describe the processing of LMA data in WDSS-II and the creation of some multi-sensor products that use LMA data.

1. WDSS-II

The Warning Decision Support System – Integrated Information (WDSS-II) is the second generation of a system of tools for analyzing remotely sensed weather data in an automated manner. WDSS-II provides a platform to do research with weather data from multiple radars and multiple sensors. It provides an environment for quickly writing applications that can access real-time and archived data, do computations on that data and test the usefulness of derived information.

WDSS-II has been developed by scientists and engineers at the University of Oklahoma and the National Severe Storms Laboratory (Hondl 2002; Lakshmanan 2002). WDSS-II has three components:

- A suite of multi-sensor automated weather algorithms.
- A 4D display for visualizing multi-sensor data and algorithm outputs, to support weather forecasting and research.
- An application programming interface (API) library in C++ that supports algorithm and display developers.

The WDSS-II infrastructure libraries provide easy and unified access to data not just from different radars but also from weather satellites, weather models, surface observations, lightning and more. This provides for a great deal of flexibility for the algorithms developed using the infrastructure. The algorithms themselves use image processing, artificial intelligence and neural networks to provide automated analysis of weather events in real-time.

2. LMA

The lightning mapping array (LMA) was developed at New Mexico Tech (Krehbiel et al. 2005) and is patterned after the Lightning Detection and Ranging (LDAR) system developed at the NASA Kennedy Space Center (Maier et al. 1995). LMAs operate by detecting radiation from lightning discharges in an unused VHF television channel, in this case Channel 3 (60-66 MHz) (Krehbiel et al. 2005). Instead of telemetering high-bandwidth data to a central site to measure the time-of-arrival values, the system utilizes Global Positioning System (GPS) technology to measure the arrival times independently at each remote location. The time of the peak radiation event is recorded in every 100 microsecond window that the signal exceeds a noise threshold.

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Real-time data is decimated since bandwidth is not available to send the entire stream to a central site. The time-of-arrival measurements are sent to a remote processing location using wireless communications links and internet data connections.

The lightning density grid is a three-dimensional grid that has a resolution of 0.01 degrees in latitude and longitude and 1km in height (approximately 1kmx1kmx1km).

The remapping of lightning source data into lightning density grids is achieved using temporal averaging and spatial smoothing. All the source data that impacts a grid cell over a given time period are used to determine the lightning density at grid cell. We experimented with time periods ranging from 1 minute to 15 minutes. Spatially, we let each source impact not just the grid cell into which it falls, but all grid cells within a given radius (using a triangular neighborhood function to determine the weight of impact). In a later study, we will experiment using a gaussian or some other smooth weighting function, but we don't expect to see much of an impact. The triangular weighting function was chosen mainly for computational speed.

Because the lightning density grid is a 3D grid, it can be interrogated using the WDSS-II display using such 3D techniques as interactive cross-sections and animated fly-throughs. For the purposes of this paper, we simply show some of the results as 2D slices – as a horizontal slice at 8km above mean-sea-level, and as a vertical slice through an interesting section of the storm (See Figures 1 and 2).

It is possible to run WDSS-II algorithms on this 3D lightning density grid. In particular, it is possible to derive a vertically integrated field that indicates regions of high convection, regardless of altitude (See Figure 3).

It is also possible to map the LMA source densities to isotherm levels instead of to altitude above mean-sea-level. The isotherm levels can be obtained from numeric models such as the Rapid Update Cycle (RUC) model.

3. Conclusions

In our analysis, we found that the vertical and horizontal structure of storms can be clearly analyzed using LMA data. In convective situations, LMA data can be used to

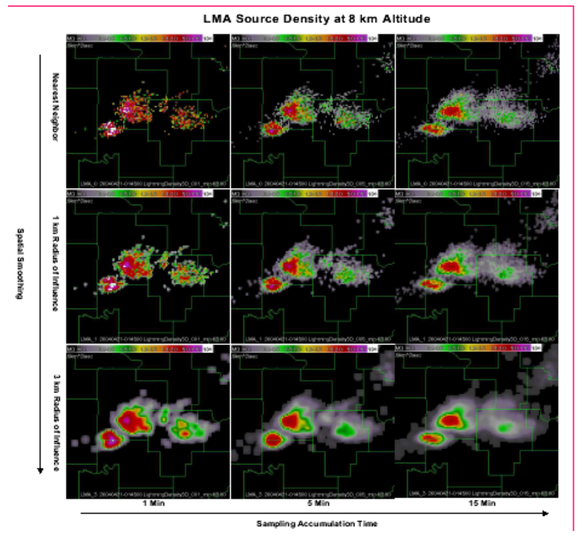

Figure 1: Visualization of time-averaged and spatially smoothed lightning source densities in WDSS-II. A horizontal slice at 8km above MSL is shown.

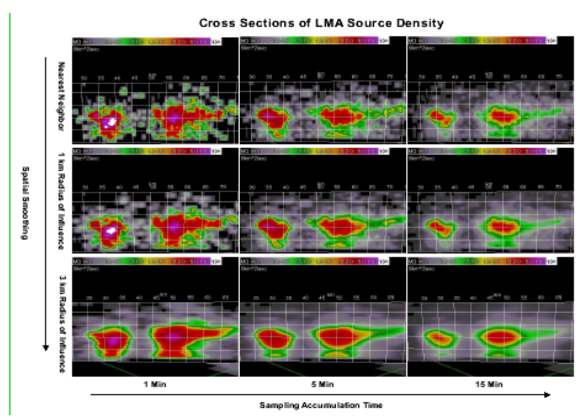

Figure 2: Visualization of time-averaged and spatially smoothed lightning source densities in WDSS-II. A vertical slice through an interesting part of the storm is shown.

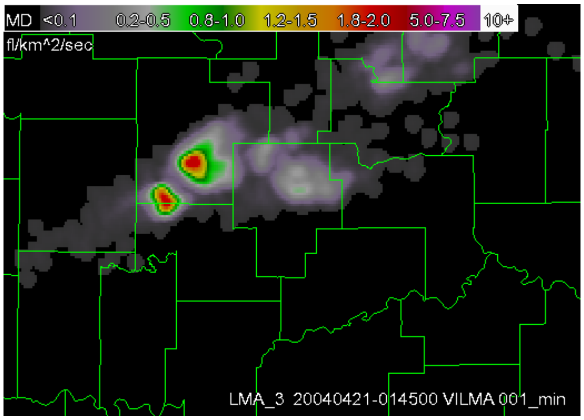

Figure 3: Vertically integrated LMA ("VILMA") image shows regions of convection regardless of altitude.

fill in information that is missing due to base-radar scanning geometry or anamalous propagation. To analyze the structure of severe storms, we recommend one of the following two strategies:

- Average LMA data over 1 minute with source data given a 3km radius of influence.
- Average LMA data over 15 minutes with source data given a 1km radius of influence.

The 1-minute/3km strategy is more appropriate for finding the snapshot of the storm, while the 15-minute/1km strategy is more appropriate for finding longer-term structures.

The nearest-neighbor strategy is useful only over relatively long averaging time periods – at smaller time ranges, the structure of the data is not clearly apparent. We recommend that a nearest neighbor strategy not be used.

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