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North Georgia Lightning Mapping Array: June 24, 2015 Microburst Case Study

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***Abstract*— On June 24, 2015, a microburst occurred near the town of Tyrone, GA, about 40 km southwest of downtown Atlanta. A National Weather Service (NWS) survey team found that 100-200 trees were downed or snapped by high winds and fell onto homes, vehicles, and power lines. Minor injuries were reported, and 25 mobile homes were damaged or destroyed. The NWS Weather Forecast Office in Peachtree City issued a Significant Weather Advisory in advance of the storm, but no severe thunderstorm warning was issued. This paper will investigate trends which emerged from the total lightning data collected from the North Georgia Lightning Mapping Array (NGLMA) that day that might have aided forecasters in recognizing the storm as a microburst in the making.**

Source data from the five operational sensors within the NGLMA was retrieved and associated with the storm cell which produced the microburst. This data was analyzed and compared to various archived NEXRAD Level II and III data. The NGLMA LMA data was also compared spatially to NLDN data.

Keywords—lightning, microburst, lightning mapping array, radar

I. INTRODUCTION

Predicting the occurrence of a microburst for the purpose of issuing a severe weather warning is difficult and many microbursts, because of their rapid onset and short-lived nature, go unwarned. This was the case on June 24, 2015 about 40 km southwest of Atlanta in Tyrone, GA. A National Weather Service (NWS) survey team found that 100-200 trees were downed or snapped by high winds and fell onto homes, vehicles, and power lines. Minor injuries were reported, and 25 mobile homes were damaged or destroyed. The NWS Warning Forecast Office in Peachtree City issued a Significant Weather Advisory in advance of the storm, but no severe thunderstorm warning was issued.

Few studies have been completed that examine trends in lightning preceding a microburst. Goodman et al. [1988] found an abrupt decrease in the total flash rate associated with the collapse of the storm, which provided about 3-5 minutes of lead time of the arrival of maximum microburst outflows at the surface. As with many severe storms, a lightning jump tends to precede the microburst by several minutes, with the peak total lightning coinciding with the maximum vertically integrated liquid (VIL) and storm height [Goodman et al., 1988; Goodman et al., 2005]. Results from Buechler and Goodman [1988] suggest that any storm in a microburst environment that produces a discharge to the ground has the potential to generate an intense downdraft. Kuhlman et al. [2010] studied the charge structure of storms that produced microbursts and found that, in general, prior to the time of the downburst, lightning occurred between the upper two charge regions. There was a noted increase in lightning activity, mostly negative cloud-to-ground strikes, between the lowest two charge regions at the same time that the reflectivity core descended immediately before the microburst. All events Kuhlman et al. studied typically showed an increase in negative cloud-to-ground flash rates at the time of the microburst. Results have also shown that lightning jumps were not always associated with the microburst studied.

This study examining lighting and radar data before and during a microburst is the first data set available from the now operational North Georgia Lightning Mapping Array (NGLMA). Although only five sensors were on-line that day, several sensors short of the normal minimum for an optimal network, the data in this study is still helpful to determine if any trends in lightning data emerge before the microburst. As a confirmation of the LMA data, a comparison was also made between NGLMA data and National Lightning Detection Network (NLDN) data to confirm that data points from detected lightning events matched spatially.

II. NORTH GEORGIA LIGHTNING MAPPING ARRAY

A Lightning Mapping Array (LMA) is a system that identifies and locates, in three dimensions, the VHF radiation pulses emitted by lightning [Rison et al., 1999]. According to Goodman et al. [2005], a typical array is made up of multiple sensors, typically on the order of 10 to 12 sensors, placed throughout an area of 50 to 75 km in radius. A sensitive RF detector records VHF emissions from many points along a typical intra-cloud (IC) or cloud-to-ground (CG) lightning flash. An associated GPS receiver is used to determine the near-exact time that the signal was detected [Rison et al., 1999]. If four or more sensor locations detect a signal above a set threshold during a processing period (typically on the order of 8 to 10 microseconds), algorithms for triangulation, based on a central processing computer, can solve for the 3D location of the sources [Goodman et al., 2005]. LMAs, therefore, are able to observe total lightning, which is the combination of both IC and CG lightning [Stano et al., 2015; White et al., 2013]. Since the LMA collects more-extensive data, it has the benefit of giving a more complete picture of what is happening inside a storm [White et al., 2013].

Because processed LMA data from the central computer updates every minute, one of the most useful applications of LMA data is its ability to perform minute-by-minute analysis of a storm and to follow and provide total lightning data on the entire lifecycle of a storm cell [Liu and Heckman, 2011]. According to Liu and Heckman [2011], testing using LMA data alongside radar data has displayed an increase in warning times and forecast confidence. The LMA's faster update time means that not only can the NWS potentially use the data to issue earlier warnings, but that these warnings may also be more type-specific and include less error [Metzger & Nuss, 2013; White et al., 2013]. According to White et al. [2013], the LMA's total lightning data can provide insight on the inner workings of the storm which can be helpful in areas such as providing some predictive ability for both the potential of the occurrence of a tornado as well as clues to the possible intensity of the storm. As stated by Stano et al. [2015], LMA installations may have many other unique meteorological applications. For example, Stano's study [2015] has shown LMA data to be valuable for uses such as evacuating outdoor events before inclement weather and directing air traffic to routes with the least turbulence.

The NGLMA is centered on downtown Atlanta and currently (as of February 2016) consists of nine operational sensors with installation plans for three more in the coming months. Fig. 1 shows a map of sensor locations. During the period under study, five sensors were operational. These five sites are labeled "SSRC", "KFFC", "Yerkes", "Clairmont", and "Oxford" in Fig. 1.

III. METHODS

Data from several radars, including the TDWR at Hartsfield-Jackson airport, KMXX at Maxwell AFB in eastern AL (205 km from Tyrone, GA), and KJGX Robins AFB southeast of Atlanta (145 km from Tyrone), were used in this study. Radar data from the Peachtree City radar (KFFC) was not used because parts of the storm containing the microburst fell within KFFC's cone of silence. This caused forecasters at the NWS office to switch to other radars during operations.

In this study, storm tracking information from Level III radar data was used to determine the center of the storms beginning at 2128 UTC and ending at 2200 UTC. For the first several radar images in the time window, from 2128-2137 UTC, the storm that would eventually produce the microburst around 2145 UTC was composed of two separate but merging storms. In order to quantify the storm center for the merging storms, the coordinates of an area approximately halfway between the storm-track centers of each cell was used.

The next step was to create a box around the storm center so that only lightning data source points that fell within the box were used in the analysis (Fig. 2).

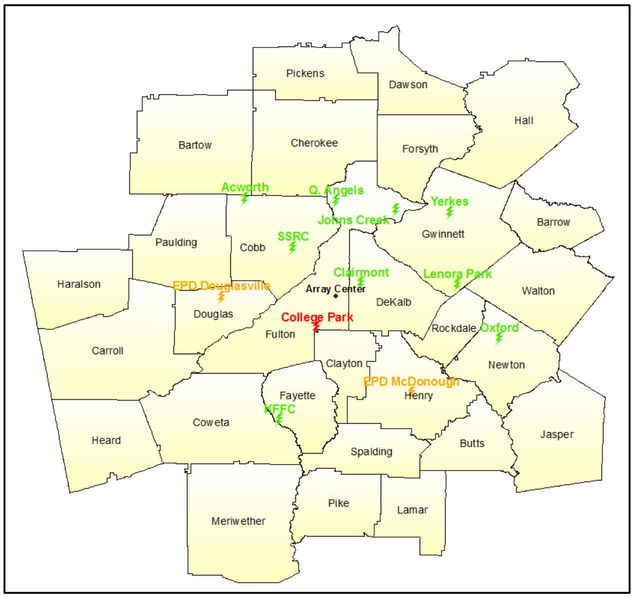

Fig. 1: Map of NGLMA locations. The center of the array is indicated by the black dot. Green: operational sites (9), orange: sites that are confirmed and waiting installation (2), red: looking for a site (1).

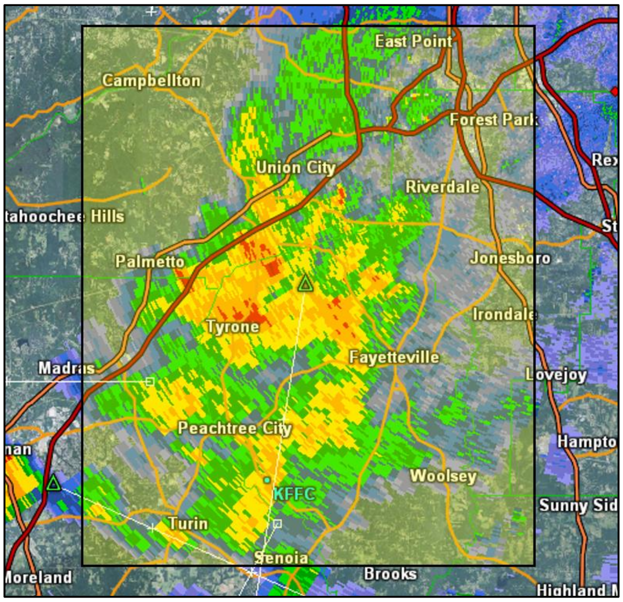

Fig. 2: TDWR image from 2137 UTC showing base reflectivity data and storm tracking information (white line). Green triangle in center of map northeast of Tyrone is the storm center. Yellow box shows 0.4°x0.4° bounding box around storm center.

Following a similar procedure to Goodman et al. [2005], the coordinates for a 0.4° by 0.4° bounding box (0.2° in each direction from center) centered around the coordinate center of the storm for each update of the radar was calculated. The latitude and longitude for each source data point was tested to see if it fell within the bounding box. Points outside of the box were eliminated from the analysis.

For this first analysis, source data, which are individual pieces of a flash, were not combined into flash data and no polarity data was analyzed. Trends in source data were compared with storm attribute data, including VIL and VIL density (VILD), maximum dBZ (dBZM), and storm heights obtained from the Level III data of KMXX and KJGX (no storm attribute data was available for the TDWR).

IV. RESULTS AND DISCUSSION

The environment of June 24, 2015 was characterized by extremely high instability (Fig. 3) for the region in June.

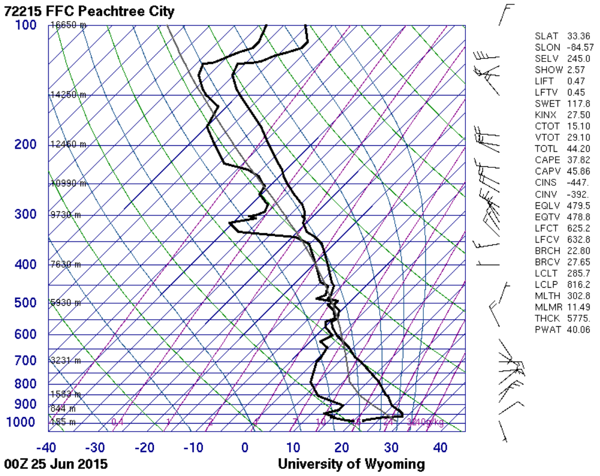

Fig. 3: Skew-t from 00Z on June 24, 2015

Although observed surface-based CAPE (SBCAPE) in the sounding, taken at 00Z on June 25 at Peachtree City, was less than 100 J/kg, RAP model-based analyses (from SPC) in the pre-storm environment, later in the day, indicated SBCAPE values over 4000 J/kg, well above the 90th percentile and maximum moving average of SBCAPE values for that date.

Vertical wind shear was weak during the event, with 0-6 km shear well less than 30 kts. With the high instability, vigorous convection developed that day and propagated slowly west along with the mean 850-500 mb easterly flow. In particular, the 00Z sounding indicates an "inverted-V" type sounding with deep dry air from 600 mb down to near 950 mb with very steep lapse rates. This type of profile is quite favorable for dry-microburst types soundings. It is hypothesized that this event was a hybrid microburst that shared characteristics of both wet and dry microbursts.

Fig. 4 show the time series of the lightning source count from the NGLMA along with the radar derived parameters VIL, storm height, maximum dBZ, and VIL density from both KMXX and KJGX. The LMA data is plotted as rolling three minute averages plotted every one minute. LMA source counts grew rapidly from 2126 UTC to 2133 UTC, increasing from 7 sources per minute to 53 sources per minute. Immediately after the peak source count is reached, a rapid decline starts and continues until

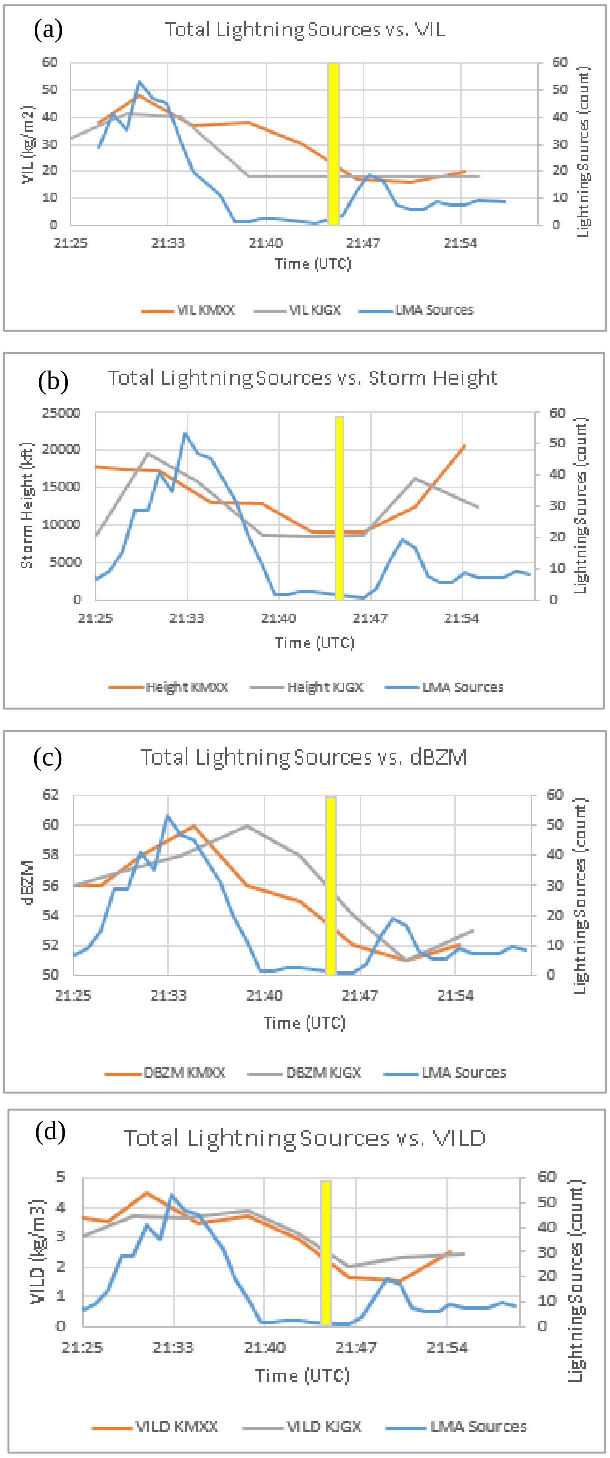

Fig. 4: Time series plots of NGLMA (blue) and (a) VIL from KMXX (orange) and KJGX (gray). Approximate time of the microburst (2145 UTC) is indicated by yellow box. (b) Storm height from KMXX (orange) and KJGX (gray). (c) Maximum reflectivty from KMXX (orange) and KJGX (gray). (d) VIL density from KMXX (orange) and KJGX (gray).

a minimum is reached seven minutes later. This minimum occurs shortly before the time of the microburst (around 2145, when the local storm report was received). VIL, VILD, storm heights and the maximum reflectivity also reach a maximum near the time of the peak source count and then decrease in the minutes before the microburst occurs.

NGLMA source points were also compared to NLDN flash data (IC and CG) that fell within the bounding box to examine if the NGLMA source points were consistent spatially with the NLDN flash data. Overall the NGLMA data matched well spatially with the NLDN data (Fig. 5), providing some verification that the NGLMA network is working properly.

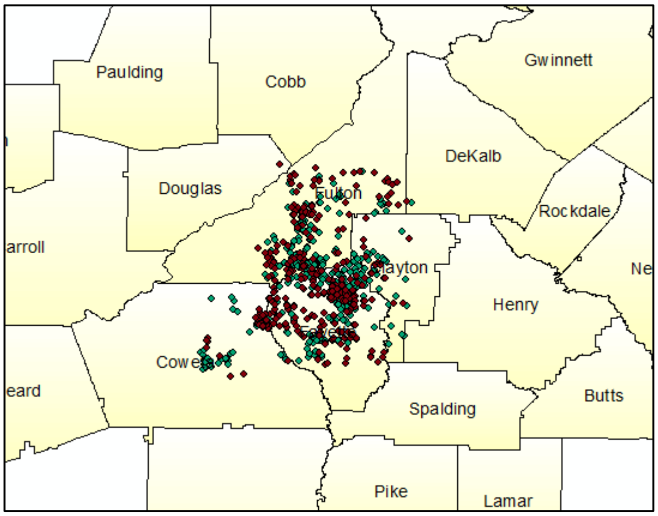

Fig. 5: NLDN IC and CG flashes (green dots) and NGLMA source points (red dots) for 2128-2136 UTC.

V. DISCUSSION AND CONCLUSIONS

Although only five LMA sensors in the NGLMA were collecting data on June 24, 2015, the trends in our source data is consistent with previous studies and may have been useful to the forecaster in anticipating a microburst. Lightning sources increased rapidly about 10 minutes before the microburst, then an aburpt decrease in sources occurred less than 10 minutes before the microburst. Used in association with the slower updating radar derived parameters that also showed indications that the storm was collapsing, the rapid decline in source counts could have indicated to a forecaster that a microburst was imminent. This may have led the forecaster to issue a severe thunderstorm warning.

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