

| — The use of the North Alabama Lightning Mapping Array (NALMA) in the real-time operational warning environment during the March 2<sup>nd</sup>, 2012 severe weather outbreak in northern Alabama.

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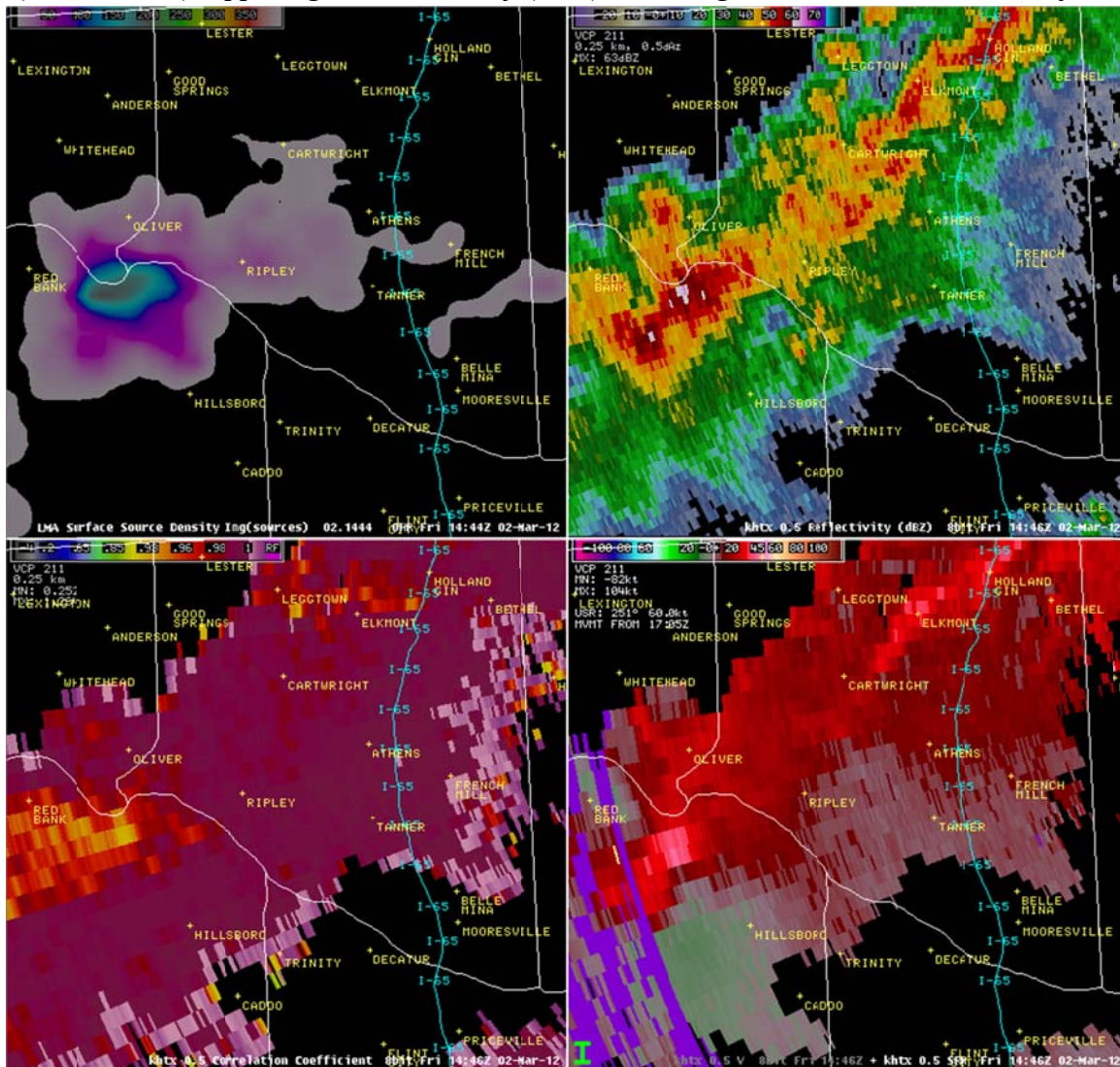
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The North Alabama Lightning Mapping Array (NALMA) is a three-dimensional very high frequency (VHF) detection network consisting of 11 sensors spread across north central Alabama and two sensors located in the Atlanta, Georgia region. The primary advantage of this network is that it detects total lightning, or the combination of both cloud-to-ground and intra-cloud lightning, instead of cloud-to-ground lightning alone. This helps to build a complete picture of storm evolution and development, and can serve as a proxy for storm updraft strength, particularly since intra-cloud lightning makes up the majority of all lightning in a typical thunderstorm. While the NALMA data do not directly indicate severe weather, they can indirectly indicate when a storm is strengthening (weakening) due to increases (decreases) in updraft strength, as the updraft is responsible for charging mechanisms within the storm. Data output are VHF radiation sources, which are produced during lightning breakdown processes. These sources are made into 2x2 km source density grids and are ported into the Advanced Weather Interactive Processing System (AWIPS) for National Weather Service (NWS) offices in Huntsville, AL, Nashville, TN, Morristown, TN, and Birmingham, AL, in near real-time. An increase in sources, or source densities, correlates to increased lightning activity and trends in updraft magnitude as long as the storm is within about 125 km of the center of the LMA network. Operationally, these data have been used at the Huntsville NWS office since early 2003 through a collaborative effort with NASA's Short-term Prediction Research and Transition (SPoRT) Center. Since then, total lightning observations have become an essential tool for forecasters during real-time warning operations. One of the operational advantages of the NALMA is the two-minute temporal resolution of the data. This provides forecasters with two to three updates during a typical volume scan of the WSR-88D radar. During a situation when a warning forecaster is not ready to issue a severe weather warning, these data can provide additional information several minutes in advance of corresponding radar data that a storm is likely to increase in intensity. This can be especially useful in situations when a warning forecaster is undecided with regards

to a warning situation, as NALMA provides additional insight into the storm's evolution between volume scans. On the morning of 2 March 2012, these data again provided utility in helping to assess and anticipate the potential for severe weather. Figure 1 is a four panel display from AWIPS preceding the initial severe thunderstorm and tornado warnings that morning. The upper left panel consists of NALMA data during the two-minute interval ending 1444 UTC (8:44 AM CST). The remaining panels contain data from the 0.5 degree elevation scan of the KHTX (Hytop, AL) WSR-88D at 1446 UTC (846 am CST): upper right is reflectivity (dBZ), lower right is storm-relative velocity,



| lower left is correlation coefficient (CC).

At this time, a line of showers and thunderstorms was aligned generally from southwest to northeast across this area, stretching from northern Lawrence County through Limestone County, Alabama. Just south of the town of Oliver and east of Red Bank, reflectivity values were around 60-65 dBZ and source density values were just over 200, indicating the areas of heaviest rainfall and strongest updraft, respectively. A broad area of cyclonic rotation and moderately low CC values were also evident in northern Lawrence County. At this same time, the KHTX 3.4 degree elevation scan (corresponding to about 24 kft AGL and temperatures around -20C in this area) indicated maximum reflectivity values around 55 dBZ, which is near generally accepted empirical values for severe hail (Figure 2 upper right). While a synthesis of the data suggested that hail was present in the storm, the lack of a deep core of relatively high reflectivity values and only moderately low CC values indicated that the hail was not likely at severe criteria (1 inch or greater). With radar data not yet suggesting severe hail was present and with no severe weather reports from nearby storm spotters, a warning was not issued at this point. However, model data and mesoscale analyses suggested the storm was moving into a more favorable environment for storm organization, and strengthening was considered possible. NALMA data from 1446 UTC made it clear that the storm was indeed undergoing strengthening. In Figure 2, a sudden increase can be observed in source densities, with total values climbing to over 400. This represented more than a 200% increase in just two minutes, indicating the increase in total lightning and inferring the strengthening updraft within the storm.



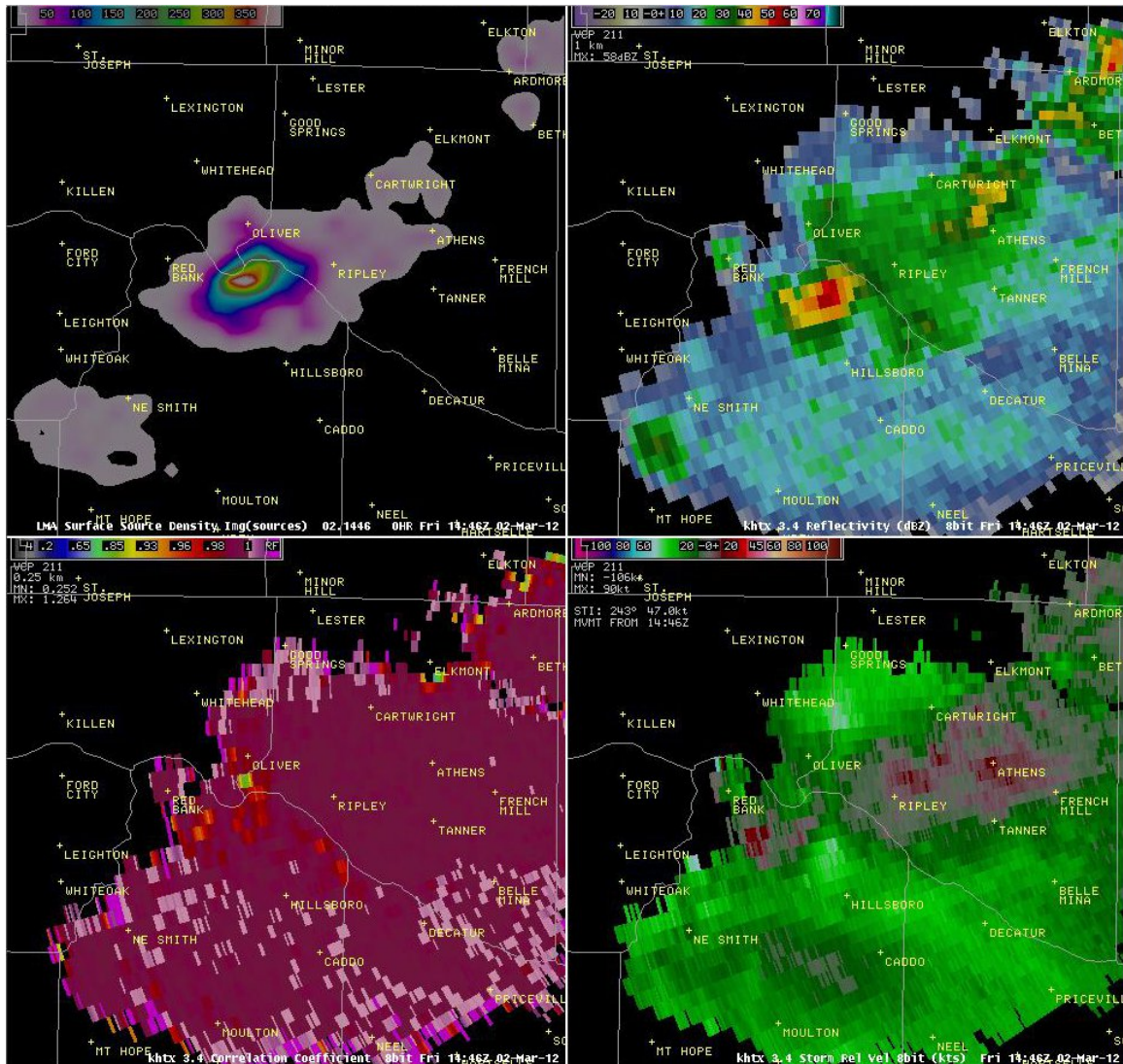


Figure 2. Clockwise from upper left: NALMA vertically integrated source density data (1446 UTC), 3.4 degree KHTX Reflectivity (dBZ), 3.4 SRM (kts), 3.4 Correlation Coefficient (phv). Radar data are at 1446 UTC.

With this new information in mind and other criteria (e.g. relatively high dBZ values, and moderately low CC values) suggesting thresholds for severe weather were close, the forecaster issued the first severe warning of that morning at 1451 UTC. At 1505 UTC, the first severe weather report of quarter size (1 inch) hail was received at the Huntsville, AL NWS office. As the storm moved further downstream, hail up to the size of golf balls (1.75 inches) and 70 mph winds were reported by local law enforcement at 1512 UTC. This storm also produced a tornado in the Canebrake community just south of Athens beginning at 1510 UTC, which continued along an approximate 34 mile path through Limestone and Madison Counties, producing up to EF-3 scale damage

Overall, the NALMA data showed the typical rapid increase in values before the onset of severe weather, including hail, and then the decrease in values before the tornado developed. Importantly, these data allowed for extra warning lead time in this particular situation, perhaps the full 14 minutes before the first severe weather report was received. This represented a particularly good case, in which the NALMA data served as an

important decision support tool, indicating that a storm was likely to undergo rapid strengthening, and that a warning was necessary.