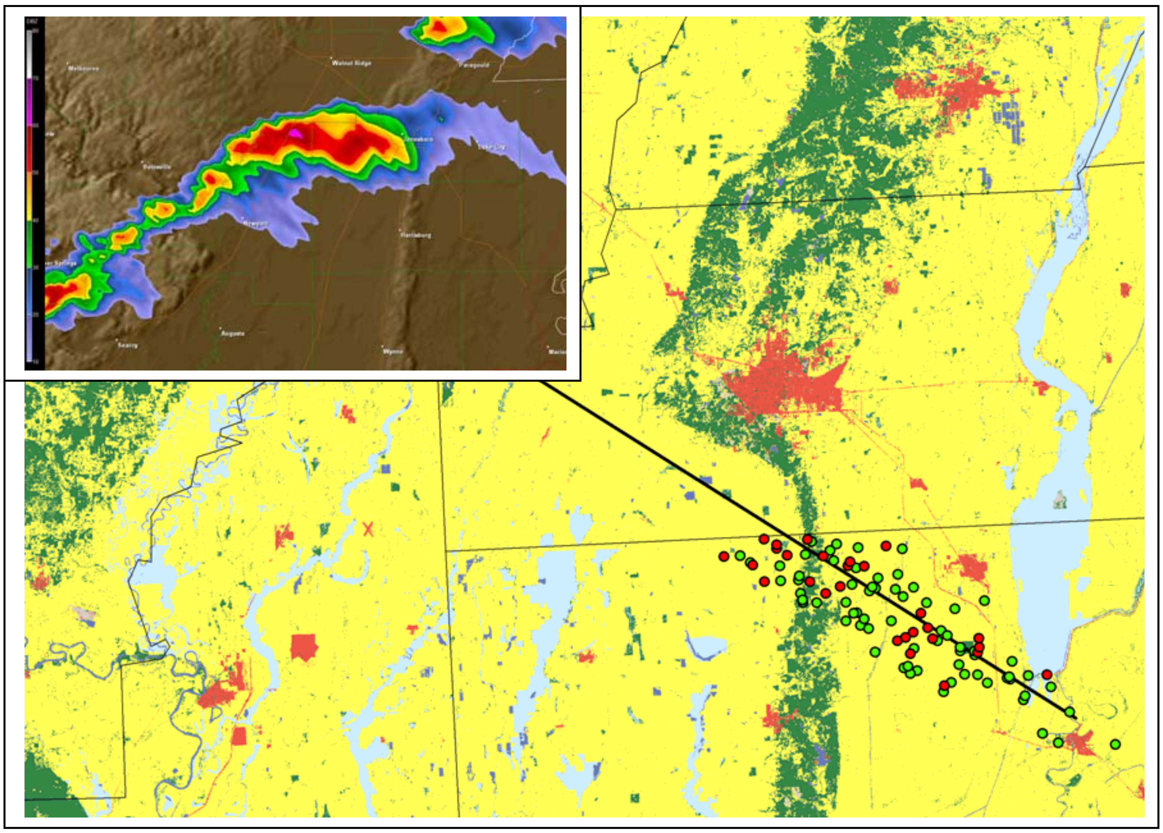
Using Lightning Data To Better Identify And Understand Relationships Between Thunderstorm Intensity And The Underlying Topography Of The Lower Mississippi River Valley



UCAR Award No.: S08-68830

University: Mississippi State University (MSU)

Name of University Researcher Preparing Report: Dr. Mike Brown

NWS Office: WFO Memphis

Name of NWS Researcher Preparing Report: Michael Scotten

Partners or Cooperative Project: Partners Project

Project Title: Using lightning data to better identify and understand relationships between thunderstorm intensity and the underlying topography of the lower Mississippi River valley

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SECTION 1: SUMMARY OF PROJECT OBJECTIVES

The main objective of this study was to better identify and understand relationships between thunderstorm intensity and the underlying topography of the lower Mississippi River valley so that better warning and forecast decisions can be made. This objective was further subdivided into the following list of specific objectives (originally seven subcategories).

1) Determine how and where the topography allows for discernable mesoscale boundaries to develop.
2) Examine how the topography affects where severe thunderstorms develop and occur.
3) Ascertain how lightning varies (spatially, temporally, and with respect to polarity) as thunderstorms transition over varying land cover/soil types and how this correlates to thunderstorm intensity and morphology.
4) Determine the alluvial valley's effects on thunderstorm initiation.
5) Establish where the effects from topography on morphology are maximized.

SECTION 2: PROJECT ACCOMPLISHMENTS AND FINDINGS

Archived Radar data were downloaded from NCDC for the years 2000-2007. These data were analyzed in order to find thunderstorms that transitioned through some portion of the alluvial floodplain and interacted with the western bluff, eastern bluff, or Crowley's ridge (a small north-south oriented ridge in the north-central portion study region. Previous research has identified these regions as potentially augmenting the mesoscale environment through changes in sensible and latent energy, PBL convergence, and augmentation of the near surface flow. In addition, a recent study has shown that the south-central portion of the eastern bluff is particularly active relative to tornado genesis (Keeney, 2009). One-hundred and three events where identified for further lightning analysis. A storms center was determined by using the digital VIL product. These centroids were used to create a storm motion path. Lightning data were extracted for regions of 5km perpendicular to the storm motion, creating a 10km swath of lightning strikes for each storm (see example, figures 1-6 below).

Lighting data for each storm were analyzed temporally for all strikes, negative strikes, and positive strikes. Of the original 103 days chosen, only seventeen showed evidence of statistically discernable changes in lightning strikes correspondent to changes in topography. The only landform that seems to have a reoccurring spatial effect on lightning is Crowley's Ridge in Northeastern Arkansas. Of the seventeen cases of discernable changes (frequency increase, decrease, and/or polarity shift) in the lightning strike data, nine of them involved Crowley's Ridge. These nine storms showed an increase in overall lightning and lightning frequency over and just after passing Crowley's Ridge. A statistical analysis of all data indicates that lightning frequency (both increasing and decreasing for all strikes, negative strikes, and positive strikes) does not change as a result of the change in topography. However, in the much smaller subset of nine events, there is some statistical indication that frequency for all strikes increases as a storm nears and transitions over Crowley's Ridge. It is recommended that future studies concentrate on this landform and the effects it may have on mesoscale processes.

Storm and related lightning example for Crowley's Ridge.

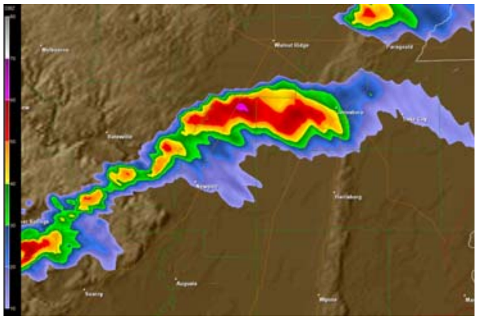
Figure 1. April, 24, 2002, 0027z
Base Ref.

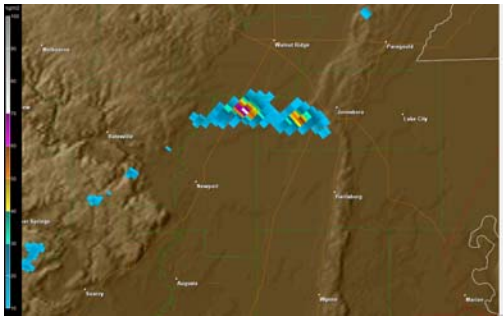
Figure 2. April, 24, 2002, 0027z
Digital VIL

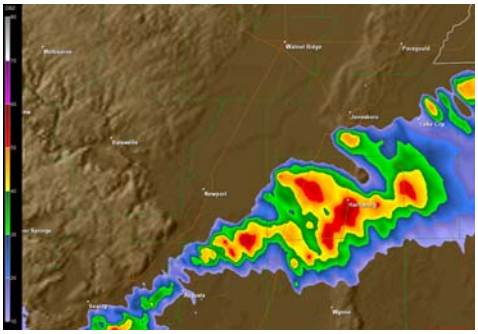
Figure 3. April, 24, 2002, 0114z
Base Ref.

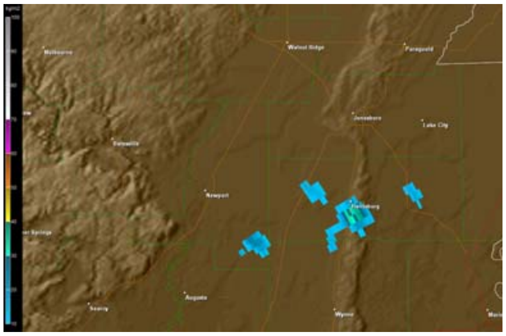
Figure 4. April, 24, 2002, 0114z
Digital VIL

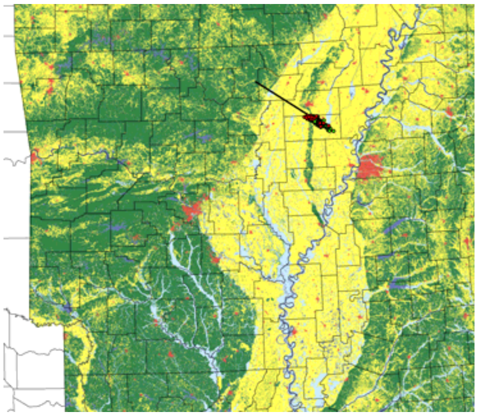

Figure 5. Alluvial Floodplain/Delta, Storm Track and Associated CG Lightning Strikes (green = negative, red = positive)

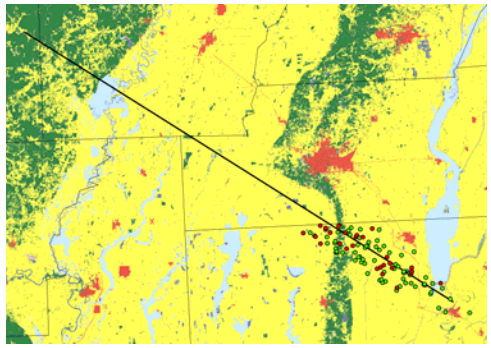

Figure 6. Same as left, zoomed to storm track

SECTION 3: BENEFITS AND LESSIONS LEARNED: Operational Partner Perspective

This project has strengthened the partnership between NWS Memphis and MSU by actually integrating research into operations. The project has sparked interest in future research projects and enhanced recruitment of students to become forecasters. MSU has committed to continue sending us their best students for the volunteer and SCEP program and encourages their graduates to apply for openings in our office. The most significant lesson learned is that great collaboration is needed between the NWS and universities to expand knowledge in the field of meteorology. Further research is needed to improve forecasts and warnings.

The results indicating that Crowley's Ridge in Northeast Arkansas has a profound effect on thunderstorms and lightning morphology will act to guide forecasters and researchers to provide greater focus on this location in the future. Specifically, forecasters will concentrate on this landform for thunderstorm initiation and possible intensification or weakening based on lightning trends as storms transition across or along this feature. These results will allow for better warning decisions with more lead time and fewer false alarms as well as more detailed and thorough short term forecasts for this area. Not to mention, forecasting of precipitation chances and amounts near this landform may improve resulting in higher verification scores. The end result of these findings will be better service to customers.

One minor problem NWS Memphis encountered was getting lightning data. The lightning data set obtained for this project took up a huge amount of disk space and could not be easily downloaded for analysis. Fortunately, NWS Memphis worked with NWS Tallahassee and Florida State University to get this data as compressed tar files on a web site so that it could be easily accessed.

SECTION 4: BENEFITS AND LESSIONS LEARNED: University Partner Perspective

The results are too numerous to list. Given the past research in this region, we did expect to identify a greater topographic influence on storm electrification. However, more work is certainly warranted, as a more broad approach (lightning climatology versus individual storm lightning production) may better identify topographic effects on thunderstorms. Regardless of the statistical outcome, we have plenty of new material to present to students through professional talks and lectures.

With changes to the WSR-88D (most recently the Build 10 update), I often lean on the forecasters, the SOO, and the MIC of NWS Memphis to help me find the appropriate information to present in the classroom. When NWS Memphis sends their forecasters to participate in the Southeast Severe Storms Symposium, they always take extra time (during breaks, during lunches, and after the event) to talk with and encourage our students. Our students have participated in the volunteer and SCEP programs with NWS Memphis. Their office brought a student volunteer from University of Memphis to MSU's Southeast Severe Storms Symposium this year and has encouraged him to consider our program. I think that speaks very highly our professional relationship. Another student volunteer at NWS Memphis is currently enrolled at MSU.

It was a pleasure working with NWS-Memphis, relationships were strengthened and new projects were developed. There was a slight delay in receiving the funding (delay was on the MSU side of the funding and not UCAR or Comet).

SECTION 5: PRESENTATIONS AND PUBLICATIONS

An abstract for publication and oral presentation has been submitted to the Southeast Severe Storms Symposium (September, 2009). A second abstract for publication and poster presentation has been submitted to the National Weather Associations annual meeting (October, 2009, Roanoke, VA)

SECTION 6: SUMMARY OF UNIVERSITY/OPERATIONAL PARTNER INTERACTIONS

This project was definitely a success with both MSU and NWS Memphis working together to incorporate research into operations. To begin, tasks were assigned to each partner with MSU in charge of identifying events of interest, performing quantitative analysis, and producing results. NWS Memphis was in charge of obtaining lightning data, assisting with quantitative analysis, and helping to generate the final poster.

To complete the project, MSU first identified individual storm events which originated in and/or transitioned through the study region using archived Level II NEXRAD data between 2001 and 2006 from the NCDC archive. Beginning and ending points for each storm were created using VIL centroid values from each storm. Lightning data (CG) from Florida State University obtained by NWS Memphis were then extracted for a 10 km swath centered on the line of each thunderstorm path. MSU then performed qualitative data analysis to get results. Both parties will be preparing the final oral presentation for the 2009 Southeast Storm Symposium and a poster presentation for the 2009 NWA Annual Meeting. Ultimately, NWS Memphis will use the findings from the study to improve forecast and warning operations.