2008
20th International Lightning Detection Conference
21-23 April • Tucson, Arizona, USA
2nd International Lightning Meteorology Conference
24-25 April • Tucson, Arizona, USA

LIGHTNING STUDIES AT FLORIDA STATE UNVIVERSITY

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1. BACKGROUND

Henry Fuelberg's lightning group at Florida State University (FSU) has been conducting lightning research since the mid 1990's. Our first project was to create climatologies of cloud-to-ground (CG) lightning for the Tallahassee National Weather Service (NWS) County Warning Area (CWA). Similar climatologies then were created for the entire Florida peninsula for Florida Power and Light Corp. (FP&L), beginning a 5 year research partnership between the two groups.

The NWS and FP&L projects focused our research on the operational applications of lightning data. These applications include creating climatologies for assessing the CG threat, predicting the occurrence of CG in the 0-24 h time range, and forecasting lightning cessation (i.e., the end of lightning).

Our focus recently has shifted to include detailed analyses of WSR-88D, numerically-derived, and lightning data. This approach permits the investigation of an individual storm's structure and evolution, and its resulting in-cloud (IC) and CG lightning patterns. We have made extensive use of Geographic Information System (GIS) techniques. This software has proved invaluable for numerous meteorological applications, and has allowed us to develop new techniques that replace some of our time consuming and more archaic procedures.

This paper describes our past, present, and future research to inform the reader of FSU's applications oriented approach to lightning related studies.

2. PAST RESEARCH

During the earliest lightning related research project at FSU, Jessica Stroupe (M.S.) developed CG climatologies that were stratified by flow regime, i.e., the vector mean wind between 1000 – 700 hPa. The Tallahassee NWS office has used these climatologies as a first guess field to make Probability of Precipitation (POP) forecasts using techniques contained in the Graphical Forecast Editor (GFE) of AWIPS (Figure 1).

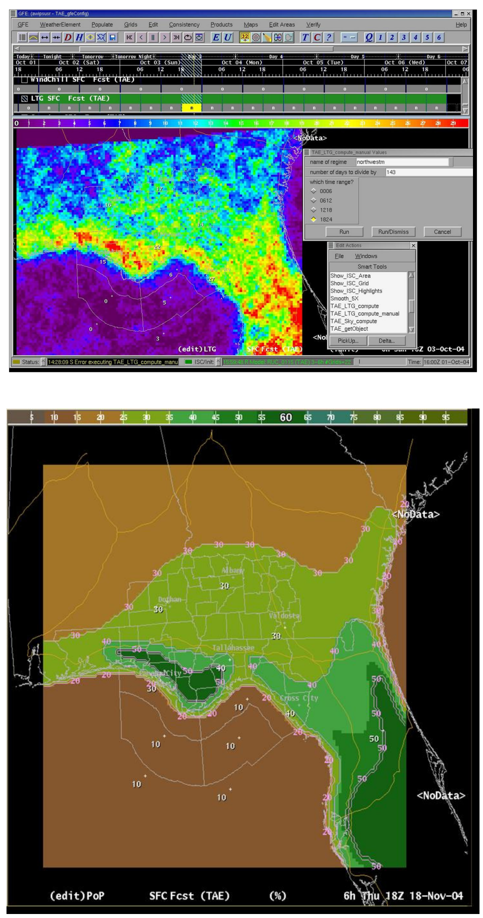

Figure 1. Top: Example of NWS graphical forecast editor (GFE) displaying climatologies of cloud-to-ground (CG) lightning in the Florida Panhandle (northwest flow). Bottom: Example

of the Probability of Precipitation (POP), in part determined from the CG climatologies.

During August 2002, FP&L began funding Phil Shafer (Ph.D.) to prepare lightning forecast guidance products. FP&L's goal was to assess personnel needs around noon each day so that sufficient line crews would be available during the late afternoon and evening hours to repair outages due to major lightning events The research evolved from creating climatologies, to statistically forecasting the occurrence and amount of CG lightning for several FP&L service areas. The original forecast equations were developed using morning rawinsonde soundings from across Florida.

To improve on this original lightning guidance scheme, Shafer then developed new equations utilizing perfect prognosis techniques based on gridded model analyses. This new probabilistic guidance scheme provides guidance at 3 h intervals and 10 km resolution as to whether lightning will occur, and if so, how much (Figure 2). Both of these products are used operationally by FP&L dispatchers during the warm season months (May – September) to make manpower decisions.

Research on the prediction of CG lightning continued with a CSTAR funded project by Geoffrey Wagner (Master's Student). Wagner expanded on the early stages of the FP&L research by applying newly developed GIS techniques to a different region of the county. Specifically, he focused on the CWA's of the Amarillo, Texas and Albuquerque, New Mexico NWS weather forecast offices, where topography plays a major role in convective initiation (Figure 3). The GIS techniques that he employed allowed him to incorporate topography with numerous other meteorological parameters, derived from morning soundings.

Another major focus of our research is forecasting lightning cessation, i.e., when has the last flash of a storm occurred? The biggest weather related issue affecting activities at NASA's Kennedy Space Center (KSC) is the occurrence of both IC and CG lightning. Several procedures had been developed to determine the onset, or initiation, of lightning in the Space Coast region; however, these advisories often are continued too long resulting in large monetary and manpower losses. There has been very little previous research on the topic of lightning cessation.

Geoffrey Stano (Ph.D.) recently completed a study to determine empirically if a given

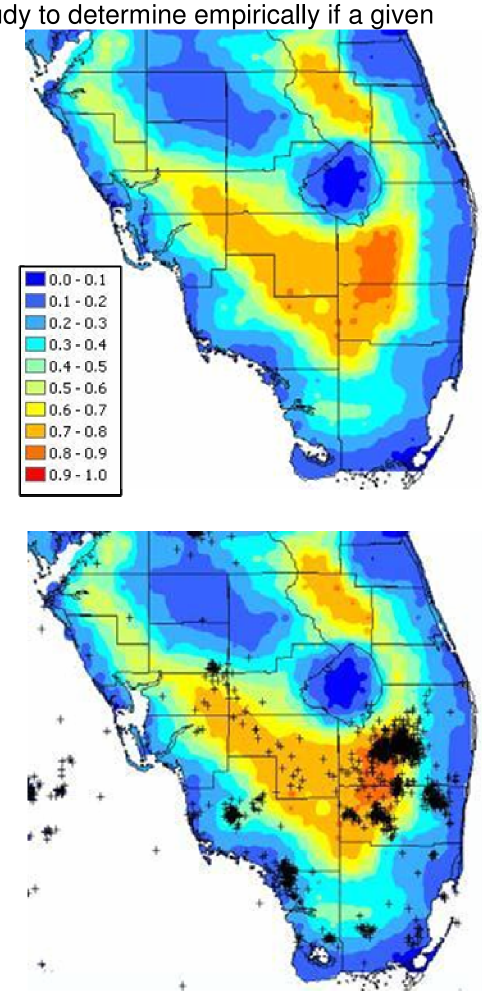

Figure 2. Top: Forecast probabilities of CG lightning, from Shafer's approach, during 2100 – 2359 UTC 17 August 2006. Bottom: Same contours as above, except with CG flashes that occurred during the same time period overlaid.

flash likely is the last of a particular storm. He investigated 116 storms by examining data from the Lightning Detection and Ranging (LDAR) network at KSC (total lightning), the National Lightning Detection Network (NLDN; CG lightning), the Melbourne (MLB) WSR-88D radar, and morning soundings from KSC. These datasets were combined and analyzed for each storm, producing a set of guidance criteria for lightning cessation.

Doctoral student Scott Rudlosky completed the last phase of the FP&L research during May 2007. Dispatchers at FP&L have observed that positive CG (+CG) lightning (i.e., that which lowers positive charge from the cloud to the ground) caused enhanced damage to their facilities. A detailed +CG climatology was developed to analyze the spatial and temporal patterns of its occurrence, along with its physical characteristics. Equations to forecast the percentage of +CG that would occur between noon and midnight also were developed using morning soundings for Tallahassee, Jacksonville, Tampa, and Miami, Florida.

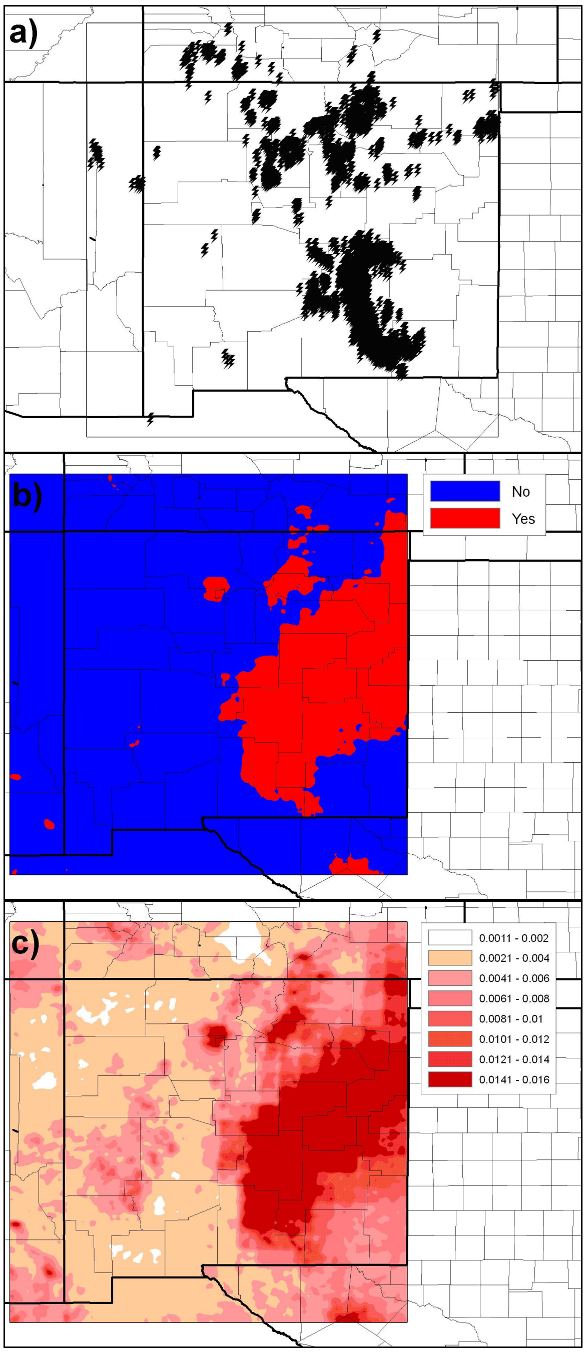

Figure 3. Example of Wagner's probabilistic and deterministic approach to forecasting CG lightning. a) Actual CG flashes, b) deterministic forecast as to whether a CG flash will occur in a given grid cell, and c) probabilities of a CG flash occurring in a given grid cell.

During Summer 2007, Scott worked with Aegis Technologies Group, Florida State University, and the Florida Division of Forestry to investigate the relationship between lightning and wildfires. Shafer's lightning guidance scheme was used to forecast lightning in the 12-24 h time range. New GIS techniques allowed wildfire, CG lightning, and precipitation datasets to be combined. By employing these new procedures individual wildfires were linked with CG lightning and precipitation measurements to determine relationships between the physical characteristics of CG lightning (i.e., multiplicity and peak current), the amount of precipitation, and wildfire initiation.

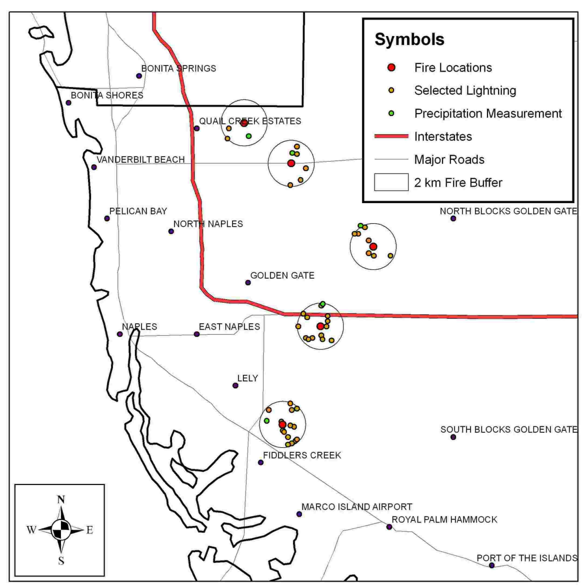

Figure 4. Illustration of the GIS process used to link wildfires to CG lightning and precipitation. Each wildfire (red dot) is associated with the nearest precipitation measurement (green dot)

and CG flashes (orange dot) if they occur within 2 km radii of the fire location.

Scott also has worked extensively with the Warning Decision Support System –Integrated Information (WDSS-II) software (Lakshmanan et al. 2007) to develop new research tools and techniques. These procedures permit an even more in depth examination of storm structure and evolution as it pertains to both IC and CG lightning patterns (See accompanying conference paper entitled "Lightning and Radar Applications using WDSS-II").

3. CURRENT AND FUTURE WORK

Our current research continues to focus on operational applications of lightning data; however, the direction of the research will shift as new datasets (Polarimetric radar, the GOES lightning mapper, etc.) become available.

A portion of our current lightning prediction research is funded by COMET (Pete Saunders; Master's Student). Saunders will apply the findings of our previous lightning forecasting studies to determine whether our guidance scheme can be employed nationwide. This work will be facilitated by collaboration with several NWS WFOs. Pete will develop a scheme (similar to Shafer's) that provides reliable guidance at 3 h intervals and 10 km resolution as to the occurrence and frequency of lightning in the regions of Pueblo, CO, Pendleton, OR, and Sterling, VA. The dominant forcing mechanisms vary significantly between these regions

To develop the forecast equations for each region, Saunders will utilize logistic regression techniques to predict whether at least one CG flash will occur during specified time periods as well as the amount of lightning that is expected. Candidate predictors for the regression models such as wind, stability, and moisture parameters will be evaluated using model derived analysis data. Orography, the previous day's persistence, and morning lightning data from ongoing storms also will be included as candidate predictors. The resulting lightning prediction algorithms will provide useful guidance to the NWS WFOs.

Holly Anderson (Master's Student) is expanding on Stano's recently completed research on lightning cessation by utilizing newly developed WDSS-II algorithms that integrate radar and model-derived data with the LDAR "spark" data. These new procedures will permit her to evaluate many additional parameters that

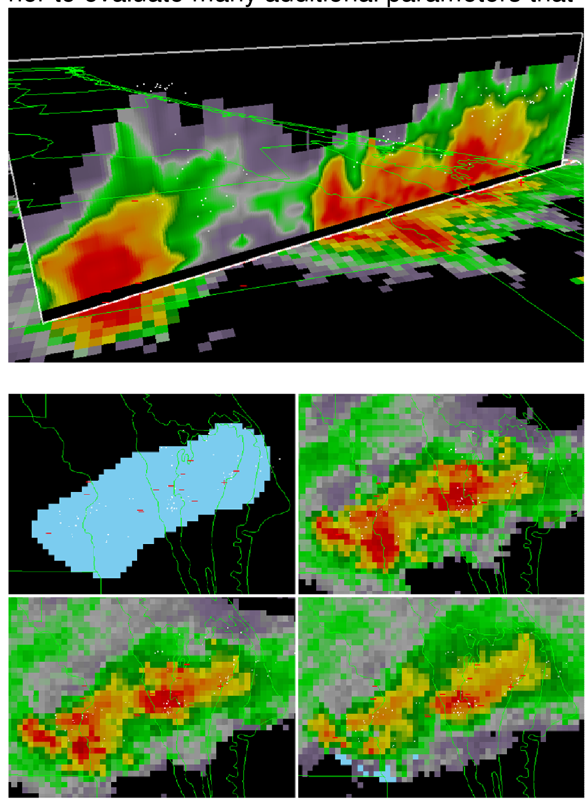

Figure 5. Depiction of the ability of the Warning Decision Support System – Integrated Information (WDSS-II) software to combine and display both WSR-88D and lightning data. Top: Cross-section view of composite reflectivity with in-cloud lightning initiation points and CG strike points overlaid. Bottom: Cluster based on 30 dBZ composite reflectivity used to track changes in any gridded field (e.g., VIL, CG flashes, etc.). Also shown are the reflectivity values at 0 C, -10 C, and -20 C.

Stano was unable to consider. Specifically, she will statistically relate various radar parameters to IC and CG flash data for storms passing within the range of the KSC LDAR network. Examples of LDAR parameters include total flash rates, their areas and densities, altitudes of flashes, flash aspect ratio (i.e., skinny vs. fat), and changes in their rates, densities, and altitudes.

Using the radar, model-derived, and lightning parameters, the lightning initiation scheme developed by Wolf (2006) will be inverted and examined as a potential method for predicting lightning cessation. Holly's research will provide useful guidance to KSC regarding when it is safe to resume normal outdoor activity after a lightning advisory has been issued. This research will be automated through the further development of new algorithms within WDSS-II.

The WDSS-II software is an integral tool for both our current and future research. New algorithms will be developed within WDSS-II to automate the combination of datasets and their analysis. These techniques will allow large numbers of lightning and radar datasets to be interrogated quickly using statistical software such as SPSS. This will permit an analysis of storm structure and evolution outside of the typical case study framework.

Our research recently has expanded to include the parameterization of lightning within forecast models. NOx produced by lightning (LNOx) is an important factor in the formation of tropospheric ozone. Chemical transport models such as WRF-Chem can simulate some aspects of ozone's (O_3) chemistry, but to produce accurate O_3 concentrations, it is important to accurately specify the LNOx. Current doctoral student Amanda Hansen is working to develop a module for WRF-Chem that parameterizes lightning and the resulting formation of NOx by lightning.

New GIS techniques will continue to be developed and utilized during many current and future research projects. GIS also will be investigated as a tool for publishing these newly developed products on our website.

4. CONCLUSIONS

The Fuelberg Lightning Group at Florida State University continues to stay on the cutting edge of operational lightning research. Our research fits into four general categories--forecasting CG lightning in the 0-24 h time range, forecasting lightning cessation, relating lightning and precipitation to the initiation of wildfires, and analyzing the relationship between environmental conditions and lightning patterns within severe and non-severe storms. Our research has benefited both the public (NWS, NASA, KSC) and private (FP&L) sectors.

The use of newly developed GIS techniques, algorithm creation within the WDSS-II software, and collaborations with the public and private sectors will continue to allow the FSU lightning group to remain on the cutting edge of operational lightning research. These tools and procedures are being developed with new datasets in mind (e.g., GOES lightning mapper and polarimetric radar), so that they can be evaluated as they become available.

5. REFERENCES

Lakshmanan, V., T. Smith, G. J. Stumpf, and K. Hondl, 2007: The warning decision support system - integrated information (WDSS-II). Weather and Forecasting, 22, No. 3, 592-608.

Lericos, T. P., H. E. Fuelberg, A. I. Watson, and R. L. Holle, 2002: Warm season lightning distributions over the Florida peninsula as related to synoptic patterns. *Wea. Forecasting*, **17**, 83-98.

Rudlosky, S.D., and H. E. Fuelberg, 2007: Characteristics of positive cloud-to-ground lightning. *M.S. Thesis*, Florida State University.

___, and ___, 2007: The relation between lightning and wildfires in Florida, *Third Conference on Meteorological Applications of Lightning Data*, American Meteorological Society (AMS), New Orleans, Louisiana, Jan 21 – Jan 23, 2008, **P2.6**.

Shafer, P. E., and H. E. Fuelberg, 2006: A statistical procedure to forecast warm season lightning over portions of the Florida peninsula. *Wea. Forecasting*, **21**, 851-868.

___, and ___, 2007: A perfect prognosis scheme for forecasting warm season lightning over Florida. Accepted by *Mon. Wea. Rev*.

Smith, J. R., H. E. Fuelberg, and A. I. Watson, 2005: Warm season lightning distributions over the northern Gulf of Mexico coast and their relation to synoptic-scale and mesoscale environments. *Wea. Forecasting*, **20**, 415-438.

Stano, G. T., 2007: Developing empirical lightning forecast guidance for the Kennedy Space Center. *Ph.D. Dissertation*, Florida State University.

Wagner, G. A., H. E. Fuelberg, D. Kann, R. Wynn, and S. Cobb, 2005: A GIS-based approach to lightning studies for west Texas and New Mexico. *Second Conference on Meteorological Applications of Lightning Data*, American Meteorological Society (AMS), Atlanta, Georgia, Jan 30 – Feb 1, 2006.

Wolf, P., 2006: Anticipating the initiation, cessation, and frequency of cloud-to-ground lightning utilizing WSR-88D reflectivity data, available from the author at NWS Jacksonville FL.

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