Bridging the Watch to Warning DSS Gap with Lightning Derived Petals

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Abstract

Lightning data is being used to bridge the gap between watches and warnings at the National Weather Service (NWS) Forecast Office in Tulsa, Oklahoma. A system was devised to use lightning data every ten minutes to compute the probability that severe convective warnings will be issued. The ultimate goal is to provide Decision Support Services to emergency managers, law enforcement agencies, school systems, and others. Additionally, this process completes a smooth and continuous transition from the forecast of convection to the issuance of potential warnings: "forecast-to-warning."

Lightning data and storm motion data from ongoing convection is gathered from the NWS AWIPS database and is used to produce gridded fields of the probability of future convection. These probabilities are combined with fields for the conditional probability of being in a severe convective warning. The product of the two fields is the unconditional probability of severe convective warnings, which gradually increases as a storm approaches any particular grid point. The system bridges the gap between convective watches and warnings, enhancing the Weather Ready Nation.

The system was first developed in 2010 as a cooperative effort between Oral Roberts University and the NWS Tulsa Forecast Office. The system uses a combination of mathematical functions to produce petals or plumes of probabilities. The probabilities nearest the observed lightning are near 100% and diminish based on a gamma distribution. The gamma distribution is adjustable based on the storm motion and can also be adjusted based on meteorological parameters.

This system provides almost continuous updates on the probability of a severe convective warning to localities downstream of ongoing convection. Additionally, the system helps forecasters make short term updates to the basic probabilities of precipitation and thunder. An explanation and summary of the system will be provided along with examples of its products.

1. Introduction

Convective watches are common in the Tulsa County Warning Area (CWA. Unless they are PDS watches (Particularly Dangerous Situations), most county Emergency Managers (EMs) don't perceive a high level of concern until they feel the threat for severe weather for their area is ramping up. Radar data are available to everyone and most can tell if a thunderstorm is headed their way. However, most people do not know when to start watching nor do they have the patience to keep watching the radar data while a convective watch is in effect. Many EMs have other duties that prevent them from doing this. Since the warning is the trigger to activate operations for many EMs, they usually ask about the chance that a warning will be issued for their county during severe weather briefings or by calling the Weather Forecast Office (WFO).

At WFO Tulsa, we have been providing downscaled severe and thunderstorm warning threat information through gridded data for nearly 10 years. Thresholds are set by EMs and text message and email alerts are sent directly to the EMs when their specific thresholds are met. It allows EMs to work on other tasks until the thunderstorm threat has ramped up to their level of action. We have defined our threat grids to be the chance that a tornado or severe thunderstorm warning will be issued. The temporal range of the information is in 24 and 6 hour blocks. However in the last two years, petals have improved it to include 1 and 2 hour information.

2. The Process

Forecasting the probability of thunderstorms (ProbThunder) is a basic part of the WFO forecast process within the Graphical Forecast Editor (GFE). The conditional probability that a thunderstorm will require a severe (CondProbSvr) or tornado (CondProbTor) warning can be made based on model forecast environmental conditions. The resulting math gives the probability that a warning (ProbSvr or ProbTor) will be issued for a particular 2.5km grid.

ProbSvr= ProbThunder * CondProbSvr
ProbTor= ProbSvr * CondProbTor

Usually, the forecast of the conditional probabilities won't change much during an event unless long lived supercells are present. In most cases, the variable that changes is the probability that the thunderstorm will even occur in the next few hours. This very-near term mesoscale forecasting has led us to use observed cloud-to-ground (CG) lightning information to define where thunderstorms are then statistically propagating the thunderstorm downstream (probability petal) for a two hour forecast. This seemingly simple application of inserting observed data into the forecast process allows us to update the end product (ProbSvr and ProbTor) every 10 minutes in a database and automatically gives EMs the information on when threats are ramping up.

The petal is shaped by the cosine and gamma distribution functions. Alpha and Beta parameters are set by using storm history information such as longevity and intensity change and changes in near storm shear and instability. The focus here is on demonstrating how this is applied in WFO Tulsa's near term forecast process which bridges the gap between the watch and warning.

3. Example

In these images, the probabilities range from 0% (dark green) to 100% (purple). The Petal enhances the probabilities ahead of the observed CG Lightning and in the end product the probability of a severe thunderstorm warning (ProbSvr) Fig5.

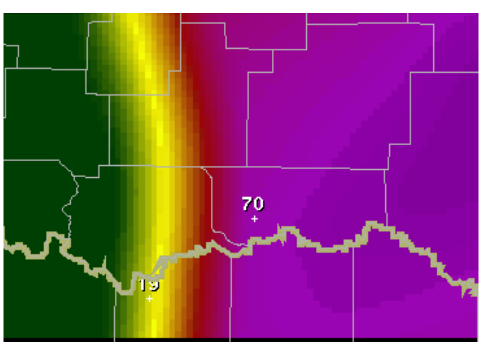

Figure 1. Original Thunderstorm Probability.

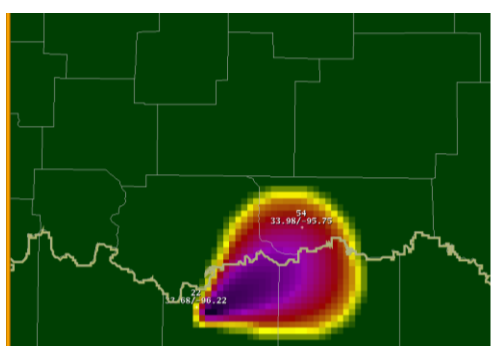

Figure 2. Petal Thunderstorm Probabilities derived from observed CG, cell history and environment.

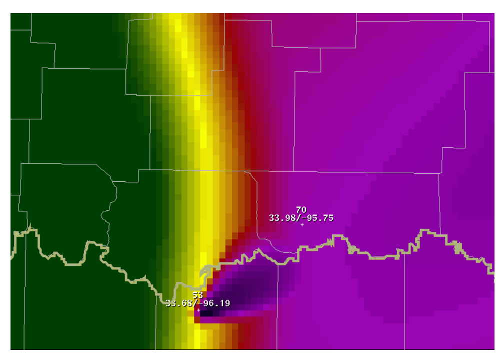

Figure 3. Resultant probabilities taken from the maximum values of Fig 1 and Fig 2.

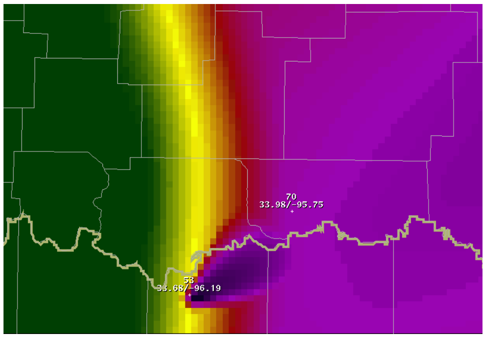

Fig 3. From above. The Petal Enhanced Thunderstorm Probability.

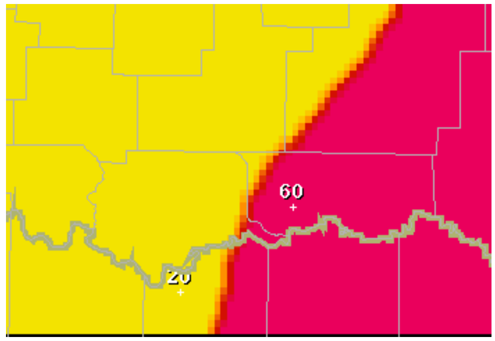

Figure 4. The CondProbSvr grid. Given a thunderstorm what is the probability a severe warning will be issued on it. A forecaster edited grid.

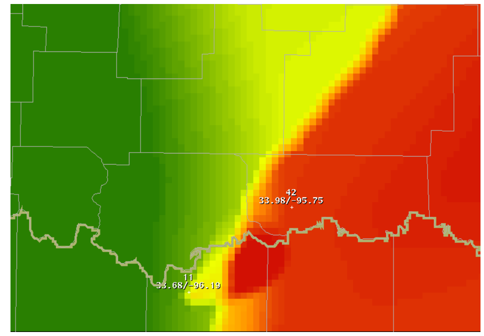

Figure 5. The product of Fig 3 and Fig 4 is the probability of a severe thunderstorm warning. Note the yellow and dark red enhancement in the petal area.

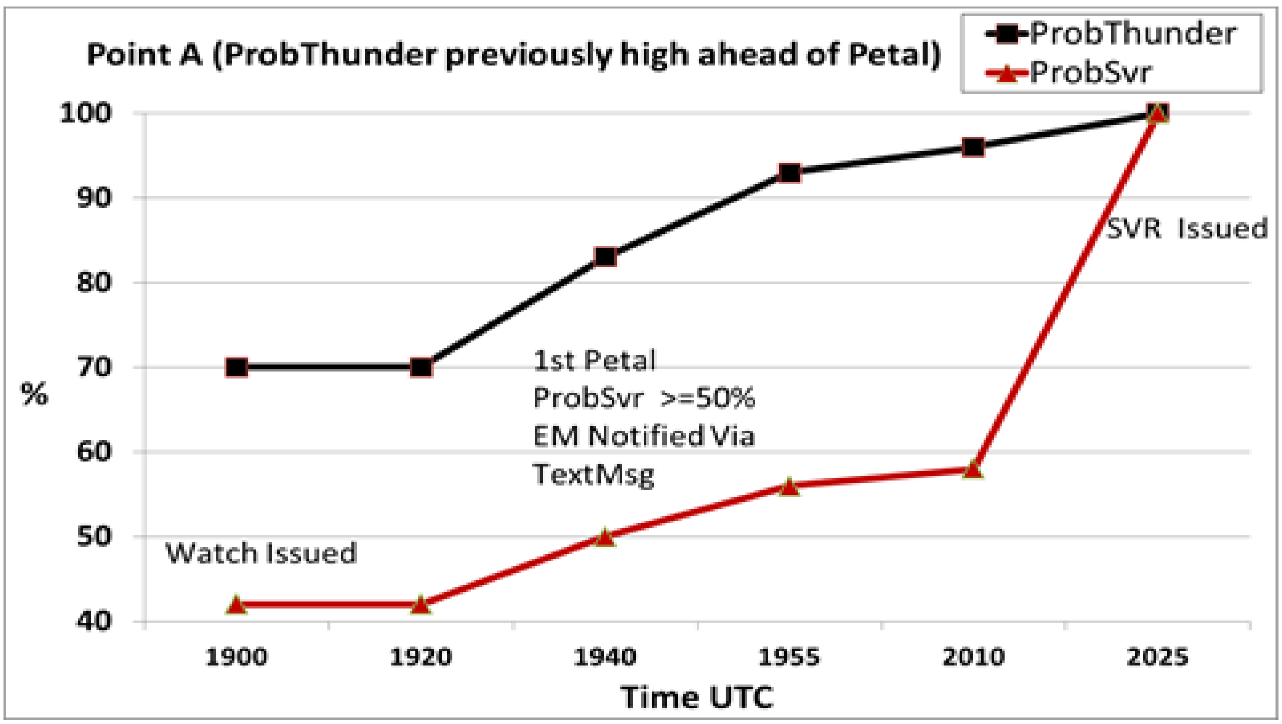

Figure 6. Time Series of a point in the petal for this event. When the SVR is issued the probabilities go to 100%. The ramp up in the probabilities from 1920 to 2010 UTC is due to the petals.

4. Verification and Conclusion

The verification for this event had an average brier score of 0.21 with 82% of the grids inside the petals being verified (within 10km of CG). Total lightning would provide better observation points and petal shape can be improved by using additional environmental variables and better methods of cell tracking.