8A.2

EXPERIMENTAL PROBABILISTIC HAZARD INFORMATION IN PRACTICE: RESULTS FROM THE 2008 EWP SPRING PROGRAM

Kristin M. Kuhlman [1,2,*], Travis M. Smith[1,2], Gregory J. Stumpf[1,2],
Kiel L. Ortega[1,2] , and Kevin L. Manross[1,2]

[1]Cooperative Institute for Mesoscale Meteorological Studies, Norman, Oklahoma
[2]National Severe Storms Laboratory, Norman, Oklahoma

ABSTRACT

The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) has recently transitioned to "storm-based" warnings from county-based warnings. These warnings are increasingly used by graphical applications for television, the Internet, and cell phones to better communicate specific information about hazardous weather. With the rapid updates in technology and communication, the NWS can continue to build upon the storm-based warnings to better communicate specifics in uncertainty, space, and time to advanced and special-need users.

During the 6 week period of 27 April-7 June 2008, the NOAA Hazardous Weather Testbed in Norman, OK hosted multiple visiting NWS and Environment Canada forecasters for the Experimental Warning Program. The forecasters had the opportunity to issue probabilistic guidance on several real-time severe weather events across the continental United States and an archive event from 13 August 2007 in northeast North Dakota. Each forecaster was asked to identify areas of a storm where a threat was possible, either at the current time or near future (less than 60 min) and determine a probability associated with that threat (current and at a chosen future time). The project focused on three different threats: Tornado, Hail (greater than .75 in), and Wind (greater than 50 kts). Probabilistic hazard forecasts made throughout the six week period and from the archive event will be compared to storm data as well as the high resolution data from the Severe Hazards Analysis and Verification Experiment (SHAVE) to determine skill and reliability of the forecasts and how this guidance should be updated for future use. In addition, feedback from visiting forecasters concerning product use and workload as well as societal impacts of such products are discussed.

1. INTRODUCTION

New technologies that provide advancements in communication as well as in the field of meteorology allow for more information to be conveyed from forecasters, especially in relation to severe weather, than is currently being disseminated from the National Weather Service. Additional information could be provided regarding uncertainty of severe weather using high-resolution (spatial and temporal) grids. However, the science and verification methods are not fully developed and it is imperative that applied researchers as well as forecasters take a leading role in the development of such products.

The Hazardous Weather Testbed (HWT) and the Warning Research and Development (WRDD) / Severe Weather Warning Applications and Technology Transfer (SWAT) group at NSSL work on warning scale (0-2) hour nowcasting challenges for convective weather. The spring 2008 experiment (Stumpf et al. 2008) provided our first real test of these developmental products collaborating with 22 visiting forecasters in one week shifts. These products have the possibility of providing more information from forecasters than the current storm-based warning system can alone, including:

- More specific regarding time (when storm will affect location, when it will end);
- More specific regarding space (smaller aerial coverage advects with storm);
- More specific intensity estimates;
- Defines type of threat (wind, hail, tornado, lightning);
- Defines the temporal, spatial, and intensity uncertainties of the threats. Allows for longer lead-times, though with higher uncertainty;
- Updates continuously in real-time to reflect changes in storm motion and evolution.

---

[*] *Corresponding author address:* Kristin M. Kuhlman, NSSL/WRDD, National Weather Center, David L. Boren Blvd, Norman, OK 73072; email: kristin.kuhlman@noaa.gov

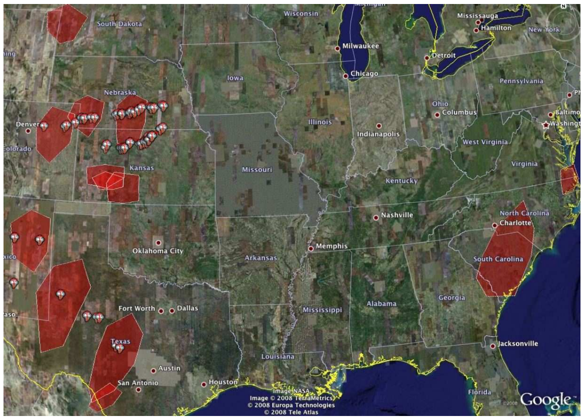

Figure 1: Geographic locations (red shaded areas) of the 13 PHI domains during the spring experiment (includes only those outside Oklahoma, where evaluating either the Phased Array Radar or the CASA radar network was the main objective of the forecasters), overlaid on Google Earth.

We hope that these advancements will result in a higher level of service to all users through better communication about the threat in time, space, and intensity. In addition, we envision this concept as helping to bridge the gap between the current deterministic ”warn-on-detection” system and a future probabilistic ”warn-on-forecast” through use of ensembles of numerical models.

2. THE PROBABILISTIC HAZARD INFORMATION EXPERIMENT

The spring 2008 was the first full test of this concept with forecasters and social scientists giving feedback in the early stages to help provide direction. Testing the probabilistic hazard information (PHI) was the main objective on 13 days of the Spring Experiment. The geographic locations of the domains are shown in Fig. 1. Throughout all the events, the forecasters generally worked in teams of at least two and were asked to maintain three separate threat areas for each storm: Tornado, Hail (greater than .75 in), and Wind (greater than 50 kts). If this work level became too much for a team to handle competently, they were instructed to drop the wind threat area. Each forecasting team was responsible for determining (a) the area of the immediate threat (b) the probability of that threat occurring within said area now and at a future time (determined by the forecaster) and (c) storm motion (speed and direction) and associated uncertainty within.

In addition to the real-time experiments all of the visiting forecasters worked through an archive event from 13 August 2007. Two of the 13 real-time cases are discussed in more detail below.

a. CASE A: 29 May 2008

29 May 2008 provided one of our very few outbreak days with multiple long-lived tornadic supercells. A shortwave trough dug into the base of a standing long wave over the western states and ejected over the Plains at a time coincident with peak heating. As the warm front lifted northward and the dryline overtook the warm front from the west, a widespread area severe storms formed over north central Kansas and southern Nebraska where CAPE values of 2500-4000 J kg^{-1}, and 50 to 60 knot mid level flow accompanied the shortwave trough.

The Intensive Operation Period (IOP) began at 2130 UTC, with storms already in progress. The first team of two forecasters (Team 1 on Fig. 2) worked within the Goodland NWSFO county warning area (CWA) and a second team two forecasters focused on storms within the Hastings CWA (Team 2 on Fig. 2). The teams tested the workload by issuing probabilities for hail, tornado, and straight line winds for each of 3 different storms each, resulting in 9 threat areas that each team needed to maintain. Threats from one storm often overlapped those of another storm.

Operations were enhanced by the Situation Display (Fig. 3) which showed live video streaming from storm chasers in both CWAs. The Hastings team worked a storm produced multiple (EF0, EF1, and EF2) tornadoes near Kearney, NE, while the Goodland team received occasional tornado reports from Sheridan to Rooks Counties (EF1 and EF0) (Fig.2). The Goodland storms found deeper moisture and began producing more significant tornadoes near Jewell and Mitchell Counties, KS, just after the IOP ended near 0130 UTC.

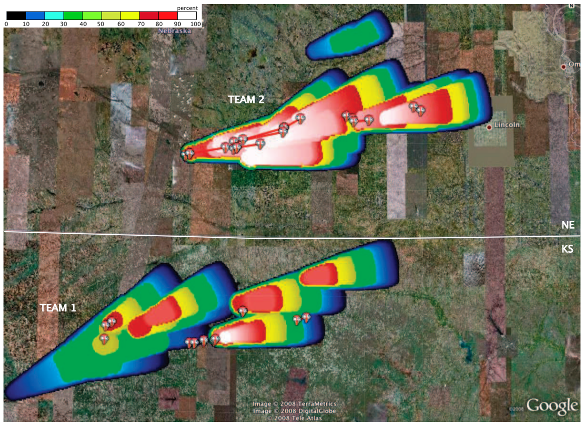

Figure 2: Accumulated (maximum) probabilites of tornado occurrence over intensive operation period (IOP) (2130 to 0130 UTC) on 29-30 May 2008. Team 1 worked storms in south central Nebraska, Team 2 worked storms in northeast and northcentral Kansas. Overlaid on Google Earth.

Figure 3: The Situational Awareness display (background) that displayed streaming video from chasers, local news stations, and data from radars when available. Forecaster workstations are shown, WDSSII (Hondl et al. 2007) and AWIPS, are in the foreground.

b. *CASE B: 4 June 2008*

The IOP on 4 June 2008 lasted from 2215 to 0030 UTC. Strong instability and vertical shear combined with increasing low-level flow along a stationary front allowed for long-lived supercell storms to form and move east-northeast along the frontal boundary in northeast Colorado and southwest Nebraska. One team of three forecasters worked the event and concentrated on all 3 threats (severe hail, severe wind, and tornado) for the storms in the northeast Colorado/southwest Nebraska region. One team member monitored the near-storm environment and interrogated the base radar data using AWIPS, while the other team member created the probabilistic hazard forecast grids. The team members switched roles about halfway through the IOP. The forecasters were moved directly into this event from working radar archive without much preparation and found it difficult to catch up to the current state. The accumulated maximum probabilities from the forecast team as well as the tornado tracks from storm data are shown in Fig. 4.

c. *Forecaster Feedback*

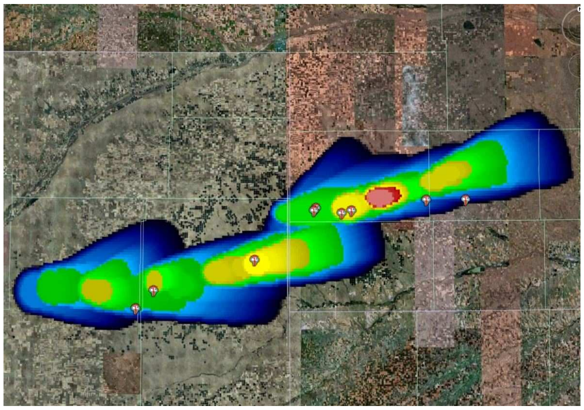

Figure 4: As in Fig. 2, accumulated probabilities and tornado tracks across northeast Colorado and southwest Nebraska for 4 Jun 2008.

Forecasters were asked to provide feedback during shifts, post-event, and also through written guest entries on the "EWP Blog" (Stumpf et al. 2008). The feedback from visiting forecasters addressed both the possibilities of use of PHI in the future as well as implementation concerns.

In general, concerns were voiced nearly every week over the work load. The forecasters were asked to consider not only an entire new concept of hazard communication, but also to complete this work on a unfamiliar software system. The Warning Decision Support System -Integrated Information (WDSSII; Hondl et al. 2007) was used to interrogate storms and to create the probabilistic hazard information grids. Many forecasters assumed the software would be easier to use and more stable in an operational environment, though there were still concerns about difficulties anticipating short-term changes in storm motion and intensity. Nearly everyone reported it was not easy to keep the creation polygons visually separate when working all 3 hazards at once on the same storm, and therefore hard to work with them. Specific excerpts from forecasters are included below:

"I can envision the additional value that the probabilistic forecasts could provide to some customers especially for values below some 'threshold' that might trigger a warning. For example, tornado probability trends for a supercell could give an EM [emergency manager] or TV weather person some insight on the likelihood that a storm may subsequently have a tornado warning issued on it."

"Being able to issue probabilistic information should provide much more useful information to our partners and more sophisticated users. Conveying information probabilistically will allow some of our more advanced users to get into the head of the warning forecaster."

"I found the process likely [to be] confusing to the public. The primary limiting factors ... in my opinion include, (1) quantifying the specific threats and expressing

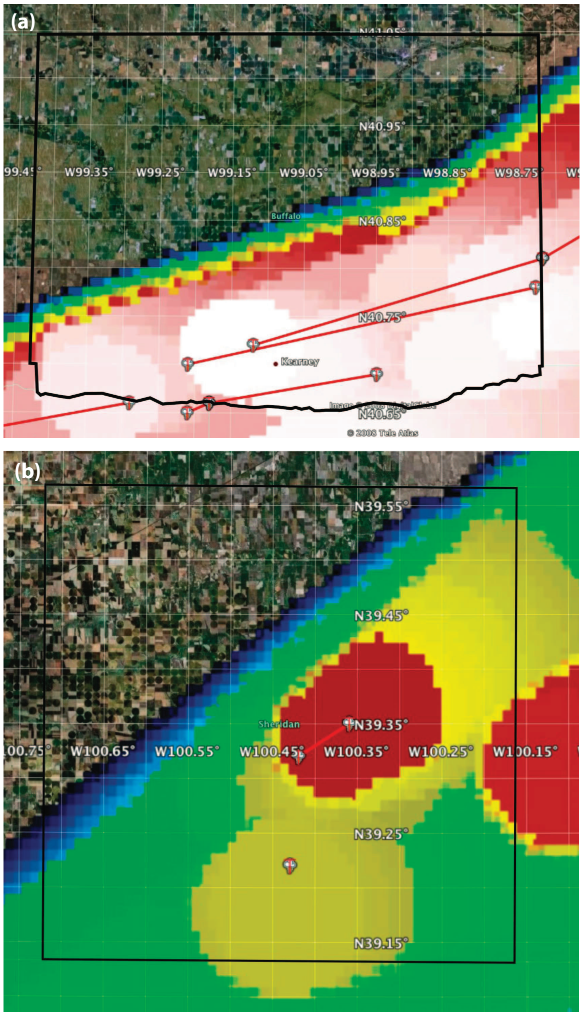

Figure 5: Zoomed in accumulated probabilistic hazard information and tornado tracks from StormData on 29 May 2008 overlaid in Google Earth. (a) Buffalo County, NE. (b) Sheridan County, KS.

those threats in a proper manner to the pubic (2) warning forecaster workload issues and (3) public response problems associated with different threat percentatages."

Based on this feedback as well as previous concerns we have begun collaborations with social science. As part of this collaboration the HWT hosted an Advanced Weather and Society (WAS*IS) workshop 15-17 September 2008 (Gruntfest et al. 2009). The workshop brought together meteorologists from the EWP and the NWS with social scientists and stakeholders representing a broad spectrum of end-users. This workshop was designed to integrate societal impact research at the beginning stages of development of this concept.

d. Evaluation of PHI

Evaluation of the current PHI products is necessary in order to determine the next steps of development. During the 2008 spring experiment, however, forecasters were given very little guidance in determining initial and future probabilities associated with the hazards. Future experiments must include some type of statistical guidance for background probabilities relative to a specific area. In order to test data from this past spring, an assumption was made that the probabilities were chosen in reference to roughly a 5 km grid. This is a big assumption and most likely incorrect (forecaster feedback indicates that they were typically choosing probabilities based on the entire threat area); still, it will provide a basis to judge the current data and to compare with future experiments. At this time, it has only been tested within the tornado PHI on 29 May 2008. A zoomed in view of the maximum PHI grid values as well as the actual tornado tracks in Buffalo County, Nebraska and Sheridan County, Kansas are shown in Fig. 5. The area was sectioned off into roughly 4.5km (E-W) by 5km (N-S) grids with each square assigned a representative probability and a yes or no event signifier (e.g., yes tornado or no tornado within the square). From this data, a reliability diagram was produced (Fig.6). The diagram confirms that probabilities were too large relative to the observed frequency. However, more data is needed in order to make any statistically significant statements.

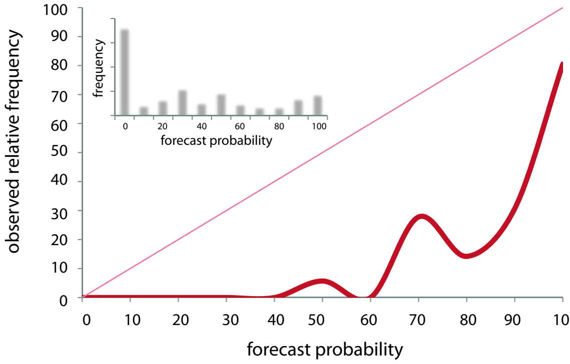

Figure 6: Reliability diagram of tornado hazard information from 29 May 2008 (thick red line) based on gridded data from Buffalo and Sheridan Counties. Thin red line is 1:1 line of conditional even relative frequency is equal to the forecast probability (a well-calibrated forecast) . Inset box indicates frequency of forecast.

3. DISCUSSION AND CONCLUSIONS

At present, very little research addresses the specific needs of lead time and warning accuracy for different user types. For instance, if a tornado threat exists various end-users will have completely different needs for lead time and accuracy:

- A healthy individual in a well-built home.

- A family with small children or elderly person in an apartment.
- A family in a manufactured/mobile home.
- A ”community gatekeeper” responsible for the safety of large groups of people.

The false alarm rate increases with additional lead-time due to uncertainties with storm evolution. However many user groups may be able to utilize the probabilistic (uncertainty) information to plan a course of action.

Again, this experiment and the development of PHI is in the very early stages. Currently, many resources are focused toward increased use of data assimilation and ensemble models in short-term forecasts the output of this will be probabilistic. The long term goal of this project is to develop methodology and applications that employ statistical guidance combined with multi-radar, multi-sensor data, which, in the future, will work as a framework that can be applied to a “Warn-on-Forecast” system.

4. ACKNOWLEDGEMENTS

The 2008 EWP Spring Program wouldnt be possible without contributions from a number of individuals and organizations. Those from the National Oceanic and Atmospheric Administration (NOAA) include: the National Severe Storms Laboratory (NSSL) Radar Research and Development Division and the NSSL Warning Research and Development Division; the National Weather Services Meteorological Development Laboratory (MDL); the NWS Warning Decision Training Branch, and the NWS Weather Forecast Office in Norman, OK. The HWT management committee members (Dave Andra, Mike Foster, Joe Schaefer, and Jeff Kimpel), Kevin Kelleher (NSSL), and Stephan Smith (MDL) were instrumental in providing the necessary resources to make the EWP spring experiment happen. This work has been primarily funded via sources from the National Severe Storms Laboratory, the National Weather Service Meteorological Development Laboratory, and via NOAA-OU Cooperative Agreement NA17RJ1227.

We thank our National Weather Service and international operational meteorologists, most who traveled to Norman, for participating as evaluators in this experiment (and we also thank their local and regional management for providing the personnel). They are David Blanchard (WFO Flagstaff, AZ), Mike Cammarata (WFO Columbia, SC), Ken Cook (WFO Wichita, KS), Andy Edman (NWS Western Region HQ), Bill Rasch (WFO Billings, MT), Craig Shoemaker (WFO Tucson, AZ), Bryan Tugwood (Environment Canada, Toronto, ON), David Schmidt (Environment Canada, Edmonton, AB), Ria Alsen (Environment Canada, Toronto, ON), Dave Hotz (WFO Morristown, TN), Daniel Porter (WFO Albuquerque, NM), Ron Przybylinski (WFO St. Louis, MO), Dan Miller (WFO Duluth, MN), Jonathon Howell (WFO Memphis, TN), Steve Rogowski (WFO Sterling, VA), Steve Hodanish (WFO Pueblo, CO), Ryan Knutsvig (WFO Elko, NV), Dave Patrick (Environment Canada, Winnipeg, MB), Eric Stevens (WFO Fairbanks, AK), Kevin Brown (WFO Norman, OK), Mark Melsness (Environment Canada, Winnipeg, MB), Brad Colman (WFO Seattle, WA), Jon Hitchcock (WFO Buffalo, NY), George Phillips (WFO Topeka, KS), Chris Sohl (WFO Norman, OK), and Milovan Radmanovac (Hydrometeorological Service of Serbia).

References

Gruntfest, E., K. M. Kuhlman, K. A. Scharfenberg, and G. J. Stumpf, 2009: Beyond Storm-Based Warnings: An Advanced WAS*IS Workshop to study communication of probabilistic hazardous weather information. *Extended Abstracts, 4th Symp. on Policy and Socio-Economic Research*, Phoenix, AZ, Amer. Meteor. Soc.

Hondl, K. D., V. Lakshmanan, T. M. Smith, G. J. Stumpf, 2007: Warning Decision Support System - Integrated Information (WDSS-II) Progress and Plans. *Extended Abstracts, 23rd Conf. on Interactive Information Processing Sys.*, San Antonio, TX, Amer. Meteor. Soc., 6.3.

Stumpf, G. J., T. M. Smith, K. L. Manross, and D. Andra, 2008: The Experimental Warning Program 2008 spring experiment at the NOAA Hazardous Weather Testbed. *Extended Abstracts, 24th Conf. on Severe Local Storms*, Savannah, GA, Amer. Meteor. Soc., 8A.1.

Manross, K. L., T. M. Smith, J. T. Ferree, G. J. Stumpf, 2008: An on-demand user interface for requesting multi-radar, multi-sensor time accumulated products to support severe weather verification. *Extended Abstracts, 24th Conf. on Interactive Information Processing Sys*, New Orleans, LA, Amer. Meteor. Soc., P2.13.