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BEYOND STORM-BASED WARNINGS: AN ADVANCED WAS*IS WORKSHOP TO STUDY COMMUNICATION OF PROBABILISTIC HAZARDOUS WEATHER INFORMATION

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ABSTRACT

In September 2008, the National Weather Center hosted an Advanced Weather and Society Integrated Studies (WAS*IS) workshop. This workshop was designed to bring together research meteorologists at the NOAA Hazardous Weather Testbed experimental warning program, and a group of stakeholders representing a diverse user community, to integrate societal impact research at the beginning stages of the development of new gridded probabilistic hazardous weather information. The objectives of the workshop were to: 1) introduce new technologies/directions to a diverse spectrum of potential future collaborators, 2) define and address the needs of a broad spectrum of end-users, 3) clarify and suggest new ways to communicate uncertainty and storm information via emerging technologies, 4) define new measures of success to properly assess service, including changing concepts of storm verification including close calls and false alarms, 5) provide suggestions for the evolution of the Experimental Warning Program, designing spring experiments with stakeholders goals, 6) develop ideas for new ways to change the culture within all levels of the National Weather Service to facilitate operational implementation of these concepts, and 7) create visibility and consider possible future funding opportunities for Hazardous Weather Testbed activities and stakeholder interactions. We will discuss some of the outcomes of this workshop, including the cross-over activities with the development of a Next-Generation Warning Tool for the NWS.

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1. INTRODUCTION

New technologies are rapidly providing advancements in communication and meteorology that allow for more detailed weather information, especially in regard to uncertainties within severe weather forecasting, than is currently being disseminated from the National Weather Service. The motivation behind this work is such that with additional information users would be better able to make informed decisions (Pielke and Carbone 2002). 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.

It is understood that 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. The Hazardous Weather Testbed (HWT) in Norman, OK has been used by the Warning Research and Development (WRDD) / Severe Weather Warning Applications and Technology Transfer (SWAT) group at NSSL to test possible new products that provide uncertainty of severe weather using high-resolution (spatial and temporal) grids. Testing these applications

in the development phase with forecasters (see next section for greater details) is one part of the process, but the full development of such a product also requires the incorporation of social scientists. To achieve the first steps of this integration a 3 day advanced WAS*IS workshop was held in Norman, OK. Over 50 people attended the workshop. Participants were from both the public and private sectors and from a variety of disciplines including anthropology, communications, hydrology, meteorology, psychology and sociology – many themselves coming from interdisciplinary backgrounds. In order to facilitate the discussions, all participants had been either part of a previous WAS*IS workshop (Demuth et al 2007) or worked in the development of the products within the NWS, NSSL, or the Warning Decision Training Branch. The workshop included various invited oral presentations (see Table 1), breakout groups (Table 2), panel discussions and a training scenario (Section 4a).

2. THE PROBABILISTIC HAZARD INFORMATION (PHI)

The spring 2008 experiment (Stumpf et al. 2008) was the first full test of this concept with forecasters and social scientists giving feedback in the early stages to help provide direction. We had 22 visiting forecasters in one week shifts with 13 days having an intensive operation period focused on developing probabilistic hazard information products. 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.

An example of the a product from the spring 2008 experiment is shown in Fig. 1. This figure depicts the maximum probabilities of tornado(an accumulation of the maximum probabilities from products issued) over a four hour period from two separate forecasting teams. 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.

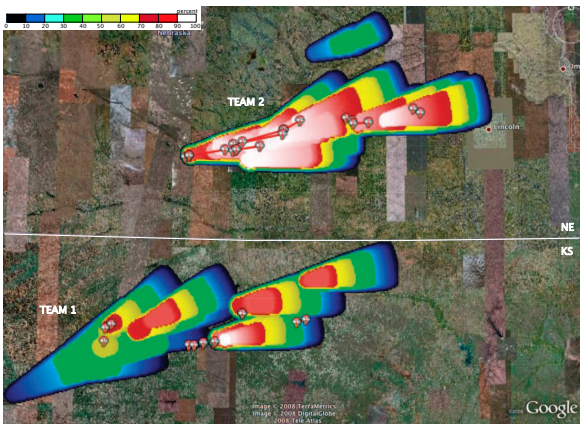

Figure 1: Accumulated (maximum) probabilites of tornado occurrence over intensive operation period (IOP) (2130 to 0130 UTC) on 29-30 May 2008. Team 1 worked storms in south central Nebraska, Team 2 worked storms in northeast and northcentral Kansas. Overlaid on Google Earth.

Forecasters were asked to provide feedback during shifts and post-event; the feedback from visiting forecasters addressed both the possibilities of use of PHI in the future as well as implementation concerns. 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 those threats in a proper manner to the pubic (2) warning forecaster workload issues and (3) public response problems associated with different threat percentatages."

Workshop Speakers, affiliations, and presentation titles*

Speaker	Affiliation	Presentation title
Eve Gruntfest	Univ. of Colorado	Introduction to WAS*IS and SWIM
Dave Andra	NOAA/NWS	Introduction to the Hazardous Weather Testbed
Travis Smith	CIMMS/NSSL	Introduction to Probabilistic Hazard Information
Brenda Philips	Univ. of Massachusetts	End-to-End-to-End work in CASA
Harold Brooks	NOAA/NSSL	Better Concepts for Forecast Evaluation
Kevin Scharfenberg	NOAA/NWS	Challenges Ahead
Melissa Tuttle Carr and Kevin Barjenbruch	The Weather Channel NOAA/NWS	WAS*IS Partnership Initiative: Communication between the public and private sectors
Rebecca Jennings	FEMA	Emergency Management Perspectives: Addressing vulnerable populations

Table 1: *Electronic versions of the presentations as well as the full agenda can be found online (http://ewp.nssl.noaa.gov/wasis2008/presentations.php).

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. At the same time, we realize that much of the work needed to ultimately implement the PHI products needs to be interdisciplinary with a strong social science aspect.

3. WAS*IS

The WAS*IS framework provided a clear way to begin the integration of social science into this work. WAS*IS has defined itself as a a community of "interdisciplinary community of practitioners, researchers, and stakeholders" with the ability to "examine ideas, methods, and examples related to weather-society work" (Demuth et al 2007). This workshop was developed by following the ideas and agendas of past WAS*IS workshops, but with a specific focus on the communication of the probabilistic hazard information and the social research aspects that are necessitated by it. By selecting participants that have been attendees at past WAS*IS workshops they have already been introduced to the basic tools and concepts fundamental for integrated studies and research, and, in particular, previous integrated research done be these individuals could be used as background and a stepping stone for furthering research for the PHI concept.

4. WORKSHOP GOALS AND DISCUSSIONS

The objectives of the workshop were to: 1) introduce new technologies/directions to a diverse spectrum of potential future collaborators, 2) define and address the needs of a broad spectrum of end-users, 3) clarify and suggest new ways to communicate uncertainty and storm information via emerging technologies, 4) define new measures of success to properly assess service, including changing concepts of storm verification including close calls and false alarms, 5) provide suggestions for the evolution of the Experimental Warning Program, designing spring experiments with stakeholders goals, 6) develop ideas for new ways to change the culture within all levels of the National Weather Service to facilitate operational implementation of these concepts, and 7) create visibility and consider possible future funding opportunities for Hazardous Weather Testbed activities and stakeholder interactions.

a. The Enterprise Scenario

In order to fully familiarize all workshop attendees with the PHI products they were taken through a scenario. The particular case used for the scenario was the tornado outbreak in southern Alabama and Georgia on March 1, 2007–focusing on the storms that moved across Coffee County, Alabama one of which produced a EF4 tornado in Enterprise where eight high school students were killed as wall collapsed in hallway.

Participants were separated into four groups of 10-12 people each keeping in mind a different end-user focus when reviewing the products. The four groups were: (1) County and City Emergency Management (2) Large Venue and High Vulnerability (3) Private sector and Media and (4) General Public. Each group was given a summary of the weather and example of the current products available today, starting with outlooks three-days prior and moving closer to the actual event. After a review of current products, the groups were introduced to the new gridded products beginning at 1420 UTC and taken through the entire event (5 hours) at two times real speed (Figure 2).

Each group was asked to discuss what they liked and what did not work for their particular user groups. Participants were also asked to compare the PHI products with current products issued by the National Weather Service to see what type of extra information could be extracted or where confusion may occur. In addition, each group brainstormed new ways to present and alter the new products.

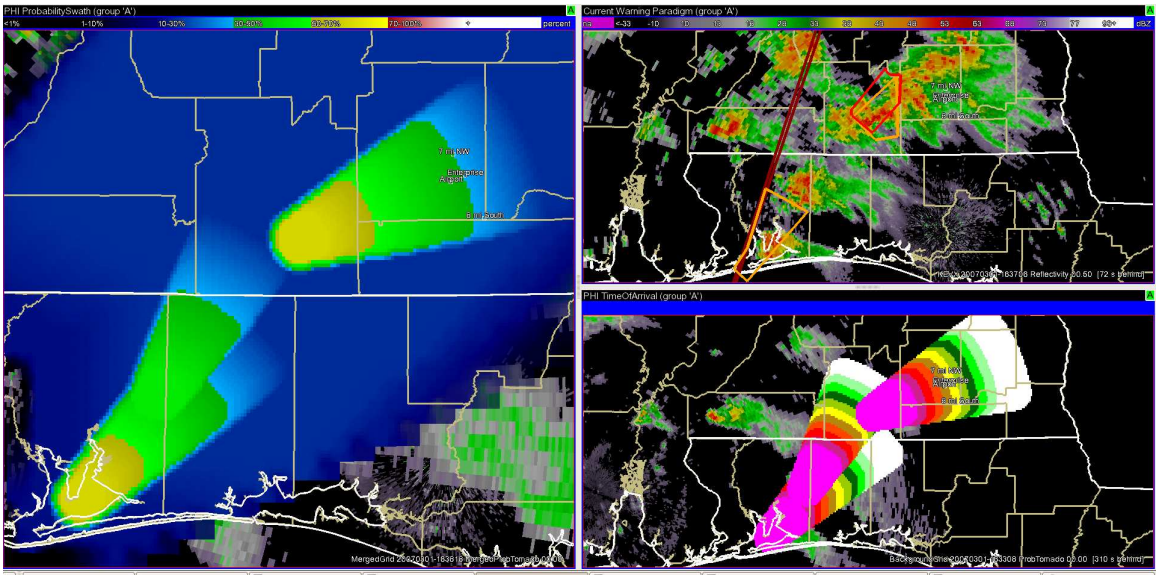

Figure 2: Products and radar for southern Alabama at 1636 UTC as shown to each workshop group during the scenario. Left panel: probabilistic hazard information for tornadoes (probabilities in reference to color scale on panel). Top right: Current products issued by the NWS including tornado watch and warning areas as issued on 1 Mar 2007. Bottom right: possible time of arrival product as developed from forecaster grids.

b. Breakout groups and discussion

In the day and a half following the scenario much of the time was spent in breakout groups discussing and developing solutions to many of the problems that came up during the scenario. In particular, the subjects of vulnerability, storm verification, communication and preparedness were common themes (see Table 2).

5. RECOMMENDATIONS

Various levels of recommendations were made at the end of the workshop. These included taking advantage of webinars and Emergency management conferences in order to educate specific and more advanced user groups. Also, it was highly encouraged to continue work in interdisciplinary fields such as communications, graphic design, and psychology to develop the best possible products as we move forward. Another idea visited numerous times was the communication of uncertainties through probabilities and how the public understands the message. Two separate avenues were proposed for this: 1) to develop surveys to determine what people (general public) takes away from probabilities now and 2) work closely with Elementary school and higher education to help ensure that probabilities with respect to weather will be better understood in the future.

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.

6. ACKNOWLEDGEMENTS

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We thank our attendees for their valuable input throughout the workshop.

Breakout Subject	Associated Questions
Vulnerability and Cultural groups	How do we handle the spectrum of user vulnerability without being overwhelmed by it? People in different cultural groups make decisions differently, how do we deal with these issues?
Verification	Do the current measures of skill really capture how well we are doing? What do we aim for? What socially relevant verification measures can we develop and use?
Communication	How do we turn our uncertainty information into a clear consistent message? What terminology can be most effective?
Preparedness	How can we best stress the need for action before the storm arrives? Long-term (months) to short-term (hours) What kind of training and education is required to ensure appropriate delivery and understanding of the product to various end-users?

Table 2: Breakout subjects and questions.

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