Final Report: Weather for Emergency Management Decision Support

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1. Background

1.1. Weather for Emergency Management Decisions Support

Weather has a significant impact on society and the economy. It is a critical driver of many decisions in emergency management such as evacuation, placement of resources, school and business closures, water resource management, and disease and contaminant containment. However, today's National Weather Service products and services do not effectively communicate its science in terms of impacts on life and property that decision-makers can use to assess and mitigate risk, and to prepare effective responses to events. Further, emergency management practices do not make optimal use of the vast amount of weather and climate information available. Typically, emergency managers do not know where to find the right information; and if they do find it, they struggle to understand it; and if they understand it, they are not certain how to take proper actions based upon it.

"Emergency management" (EM) is a community of decisions that spans federal, state and local government agencies, the private sector, non-government organizations, and actions by private citizens. Further, it spans many communities of practice including responders, transportation and communications, health and medicine, hazardous materials and environment, agriculture and food supply, energy supply, and many others. Consistent understanding of weather information and its impacts are imperative for effective emergency management decision-making. Emerging technologies such as collaboration software and mobile communications are enabling new modes of information gathering, analysis, synthesis for decision-making, and disseminating information to a wider audience with greater understanding. However, harnessing and translating weather knowledge with such technologies requires the understanding of complex needs of emergency managers, and their ability to keep pace with the rapid emergence of new science, products, and technologies.

This proposal focused on the need for NOAA National Weather Service to work closely with emergency management to make more effective use of weather and climate information by exploring the challenges of collaborating with local community Emergency Management and integrating with practices and processes that exploit NOAA's operational information in effective decision support. Specific goals of the project were to:

- Collaborate with emergency management to identify, prioritize, synthesize, and evaluate methods to enhance the infusion of weather and climate information into **decision processes for risk and crisis management.**
- Develop prototypes of an extensible, dynamic, end-to-end (science-to-decision support) system that **enables effective weather translation** and use by emergency managers, and enables measurements of effectiveness over baseline practices.
- Demonstrate the use of collaborative technologies to **facilitate knowledge exchange and situational understanding** among weather forecasters and emergency managers located at Emergency Operations Centers (EOC), geographically separated offices, and mobile locations.
- **Demonstrate an incremental and iterative prototyping** process that shows the inclusion of social science analysis and evaluation of decision support applications, technology enhancements, and infusion into practice.

1.2. Brief Introduction to Social Sciences

Critical to project is the incorporation of the social sciences that provide both the foundations and methods for evaluating and understanding human actions and societal impacts. Given their focus on society and human behaviors, the social sciences provide the methods and expertise to understand and document how the range of NWS customers receive, use, and interpret NWS data and information. With this information, project personnel can work with NWS meteorologists and climatologists to develop and test different approaches and products to insure relevance, value, and utility to users in different decision-making contexts.

Just as meteorologists and climatologists approach atmospheric science from differing perspectives, so too do the various disciplines that are classified as the social sciences have differing perspectives from which they address human behavior. While all social scientists will be proficient in quantitative and/or qualitative data collection methods and related analyses, the underlying areas of interest and expertise will vary with discipline. Table 1 provides a rather cursory but useful overview of the differences in perspective among the social science disciplines.

Table 1: The Social Sciences

Anthropology	Social organization and culture
Communications	Making and conveying meaning
Demography	Population and population dynamics
Economics	Costs, benefits, value, and behavior
Geography	People, environment, and location
Psychology	Cognitive and social processes
Sociology	Societies and behavior

1.3. Emergency Management Community Background

A major principle of WxEM is our broad definition of emergency management. The EM community is dynamic and diverse, and it includes more than the county or city EM director that many people think of at first. Each EM has his/her own set of responsibilities, decisions, and needs for weather information.

The community can be described by Emergency Support Functions (ESFs) as laid out in FEMA's National Response Framework (NRF 2008). ESFs are groupings, by functional area, of resources and capabilities that are most frequently needed in a disaster response. In addition to Emergency Managers, examples of ESFs include firefighting, public health, medical services, and public works. ESFs are used at the local, state, and federal levels. A complete list of ESFs is shown in Table 2.

Table 2: Emergency Support Functions from FEMA's National Response Framework (2008).

#1: Transportation	#9: Search and Rescue
#2: Communications	#10: Oil and HazMat Response
#3: Public Works and Engineering	#11: Ag and Natural Resources
#4: Firefighting	#12: Energy
#5: Emergency Management	#13: Public Safety and Security
#6: Mass Care, Emergency Assistance, Housing, and Human Services	#14: Long-Term Community Recovery
#7: Logistics Mgmt and Resource Support	#15: External Affairs
#8: Public Health and Medical Svc	

As can be seen, "Emergency Management" is ESF #5, verifying that it is only one part of the larger community. A common misperception about a local emergency manager (EM, ESF #5) is that he/she is the one who arrives at an incident, directs everyone on what to do, and is the leader of a response. In reality, during an incident, an EM helps manage the application of resources to other ESF leads that can be considered "emergency response managers" (FEMA IS-1). These emergency response managers, such as a fire or police chief, a public works director, or a hospital coordinator, control their resources; the EM helps them apply their resources sensibly and in a coordinated way.

NWS often considers the local EM as the only customer in this community, reflecting an incomplete understanding of the diversity and range of needs of the ESF community. Although the EM often serves as a main weather information collector and distributor, it is insufficient to only consider this one support function when developing decision support for weather. Often the available information and that provided in briefings does not communicate what the EFS needs, requiring them to interpret it to meet their needs, leading to potential misunderstandings and bottlenecks, as information is passed from NWS through the ESF community.

Depending on the incident type, various ESFs are involved, and they are all working on different problems with varying time scales. Each may need different elements of weather information at different times as their decision processes unfold. As examples, in advance of a winter storm, a power company needs to know how much ice is predicted so that personnel can increase staffing 48 hours in advance of the storm; a transportation official needs to know if rain is forecasted to fall before the storm so decisions regarding application of preventative brine to the roads a day before frozen precipitation falls can be made; and a school official will keep track of the forecast, but will ride the roads the morning of a storm to check precipitation on the ground in order to make a school closing or delay decision.

1.4 Risk Paradigm

The major underlying principle of WxEM is the risk paradigm, adapted from a National Research Council report which links the weather community (NWS, broadcast meteorologists, private sector) with the EM community (Figure 1). Emergency Managers manage risk, but in order to do so, they must know what the risk is in terms of potential impacts on their areas of concern and in terminology that makes it possible for them to understand and communicate the risk to others. Recognizing that the two elements of the risk paradigm, risk assessment and risk management, overlap, the focus of this project was on three main components: risk characterization, risk communication, and risk management.

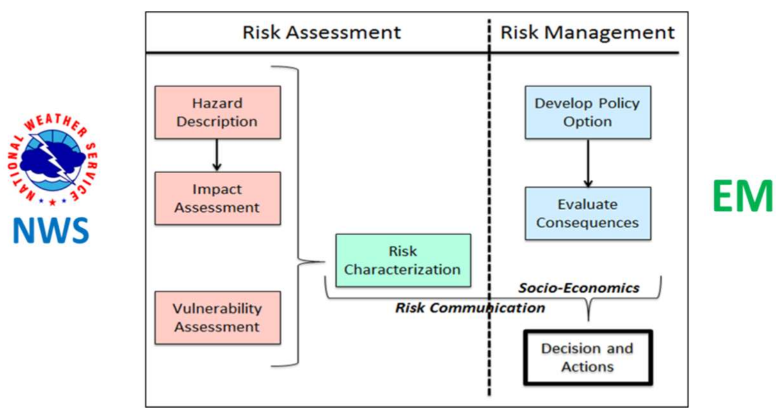


Figure 1: Risk paradigm, which connect NWS to EM through the common desire to manage risk. (Adapted from NRC 1983, 2009)

Risk Characterization

In this project, Risk Characterization focused on the NWS's ability to assemble and describe the critical risk knowledge of a convective storm that will then be conveyed to the partner communities. EM decisions and actions concerning safety (risk management) are not based on impact potential but the risk, or perceived risk, to specific lives or property. To this end, it is critical to assess how well hazard information or impacts are connected to specific risk-triggered decisions and preventive actions. This evaluation addressed three components needed to effectively characterize risk:

- *Hazard description*: From the forecaster perspective, how effective is the forecaster at communicating what the hazard is? Effectiveness may address forecaster confidence, availability of options in WarnGen, or how parts of the warning message may vary across offices.
- *Impact assessment*: From the forecaster perspective, how effective is the forecaster at communicating the impacts of the hazard?
- *Vulnerability assessment*: From the forecaster perspective, what information can be provided to help the EM assess vulnerability? Vulnerability builds on impacts, but it is more specific in timing, location, and type of damage. For example, impact tells you that trees will blow down. Vulnerability tells you what trees will be affected, how many will fall down, and at what time.

Risk Communication

The essence of communicating storm risk is the conveyance of the knowledge about the risk such that it creates a mutual understanding of the situation. Situational "awareness" may be insufficient to lead to proper decisions; knowledge is the key. These communications must address the NWS packaging and delivery of the risk message such that the partner receiving the message has the same understanding of as that intended by the creator.

- *Message packaging/receiving*: From the NWS side, one must examine the intent of the message and options that exist to package and convey the message. From the EM side, it is necessary to examine how EMs receive warning messages, what they do with that information, and what the warning tells them.
- *Message delivery*: This entails examination of 1) how effective the delivery mechanisms are in getting the message to EMs, 2) other options to deliver the message, and 3) how they compare in effectiveness in receipt and understanding, from both forecaster and EM perspectives.
- *Operational considerations:* Recognizing the operational context in which warnings are issued, undertaking assessment of how easily and consistently NWS can develop and disseminate warnings, particularly impact based warnings (IBWs), is important, including determining if other options for delivering the warning are operationally possible.
- *Confidence, competence, comfort:* In order to assess how comfortable partners are in using NWS information from various platforms, it is necessary to examine the capabilities and competence of the intended audience when using warning information, and to determine how the personal confidence of the deliverer and receiver influences the effectiveness of messaging.

Risk Management

Risk management involves the decisions and actions by the partners to protect lives and property given the understanding of the risk, other societal factors, and resource availability. Decisions and actions are undertaken both by the partners and by individuals. Ultimately it is the actions of individuals to protect themselves and others around them that matter. However, it is the decisions and actions of the partners that can be critical influences on individual actions; therefore, whatever NWS does must also facilitate and enhance their risk communications. Ambiguity in risk characterization or risk communications by the NWS can lead to misinterpretation and misunderstanding that, in turn, lead to undesired actions by the partners and individuals. This part of the evaluation assessed partner decision processes and the knowledge needed to drive decisions, as well as how well the proposed warning message meets those needs.

- *Risk Perception:* In its warnings and other products during impending severe weather, NWS provides information about potential risks. As a result, it is important to examine how this affects risk perceptions of the EMs, if NWS information, in different formats, allowed EMs to infer the appropriate level of risk to make proper decisions, and how effective NWS products, briefings, and services are in conveying risk.
- *Decision-Making:* It is essential to know what decisions EMs are making during a severe weather event and on what timeline and what knowledge is needed to make these decisions. From this it is possible to evaluate if and how NWS information changed EM decisions and what other information is needed by EMs in decision making.
- *Safety Actions:* This involves determining what actions by partners are desired by NWS through conveying risk information, assess if and how the warning intent is met, assessing what factors detract from the message intent on influencing actions.

The use of the risk paradigm and how to evaluate its components advanced over the course of WxEM. During the first two case studies (winter and tropical), various components of the risk paradigm were examined. In the final use case, the Central Region Impact Based Warnings demonstration, the effectiveness of all components was formally evaluated against six critical elements defined by EMs over the course of WxEM. This evaluation is discussed in Section 3.3.

2. Methodology

2.1. Four Step Iterative Process

In order to meet the needs of the EM community, it is necessary to understand what information they need, what they use, where they get it, and how it is used. It is also necessary to understand that there is a difference between *information* and *knowledge*. Information can foster knowledge, but information can also require knowledge, and sometimes rather sophisticated knowledge, when it comes to weather forecasts.

Once the processes and needs of the EM community are understood, it is then possible to work together to fill any gaps and develop products and services that can help them better carry out their duties. This can be accomplished through four iterative steps (Figure 2), each of which is described in more detail below:

1. Establish the base case
2. Determine current practices to identify gaps
3. Generate ideas as prototypes to fill gaps
4. Validate results

The iterative nature of this process means steps will be revisited periodically. What is learned in one step may require going back to previous steps because it may have been discovered, for instance, that the base case was not fully understood or that there are more gaps to identify than had initially been considered, . This does not mean that the process is never completed, but rather that flexibility must be woven into the process. As will be seen below, it becomes clear when there is enough information to move ahead and when it is necessary to go back to a previous step.

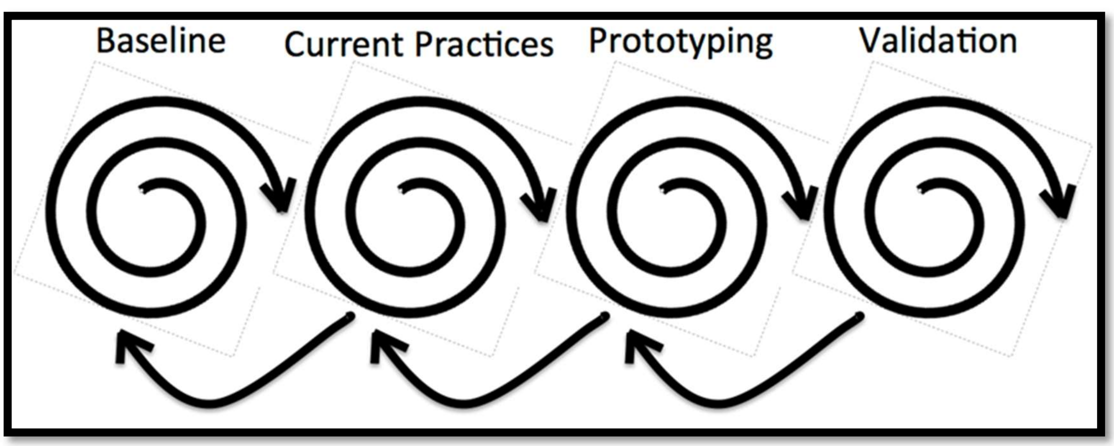


Figure 2: Four Step Iterative Process

2.1.1. Establish the base case

Establishing the base case is the first step in the iterative information gathering process. It is the foundation for understanding the thinking, reasoning, and decision processes of EMs and it guides the other iterative steps. Although the overarching goal is more effective, useful weather products for the EM community, this should not be the focus of this step. Instead to the focus is understanding the processes different EMs go through as they learn of impending severe weather as well as the information they need to make decisions at various points in time. Using a series of scenarios starting from the first indication that severe weather may be affecting an area, EMs were asked questions such as:

A. What decisions need to be made?
B. On what timeline are these decisions made?
C. Who is involved in making these decisions?
D. What knowledge do you need to know to make the decision?

Information gathering techniques for establishing the base case include focus groups using some organizational methodology such as CRC cards, interviews, and surveys. As presented later, focus groups and interviews provide in depth information with a small group or an individual, while surveys permit a larger cross-section of participants, thus providing breadth of understanding but with less depth.

By understanding what the EM thinks about and why, it is possible to begin to identify gaps between what is needed and what is provided, and between what is intended in a product and what is understood.

2.1.2. Determine current practices to identify gaps

In this second iterative step, current practices of both the EM community and the NWS were examined.

Current Practices – EM Community

While collecting information to establish the base case, information for this step was also collected since the two are closely linked. This step focuses on when, how, and where EMs collect and receive information to make their decisions. In so doing, the extent to which EMs understand the products was learned. As a result, this step required much more discussion on weather and products, and sometimes took more than one discussion with members of the EM community to understand. Sample questions we considered are:

A. From where is information obtained to make a decision?
B. Who gathers this information?
C. When is this information gathered?
D. What knowledge does the EM have about the information?
E. How does the EM use the information?
F. After showing an example of a product, what does this product tell you?
G. How will you or how do you use this information to make your decision?

Current Practices – NWS

In order to identify gaps in the next iterative step between what EMs need and what NWS provides, the current understandings and practices of forecasters were examined . Sample questions we considered are:

A. Who do you think is the audience for the information you provide?
B. What knowledge are you trying to disseminate?
C. Once you become aware of possible severe weather, when do you provide information that you think the EM community needs?
D. What knowledge are you expecting the EMs to get from what you provide?
E. Through what means are you conveying this knowledge?
F. How do you know that is the most effective way to convey it?

Identify gaps

Once current practices are delineated, it is now possible to identify gaps between the two sets of practices and processes. Two types of gaps can exist:

A. There is something EMs need, but NWS does not provide it. Example: school transportation directors need a map of hazardous road conditions during a winter weather event, but NWS does not produce this product.

B. NWS provides something that EMs need, but it is not effective, for any number of possible reasons. Example: EMs need hourly data that is available on the Hourly Weather Graph, but many cannot find it on the web page so it is not used.

2.1.3. Generate ideas as prototypes to fill gaps

The third iterative step in the information gathering process centers on filling the gaps that have been identified, or said differently, exploring ways to improve NWS products and service. Those gaps that were most critical to EM operations, as determined in establishing the base case, are those that took highest priority.

In generating ideas, several options were created to fill the gaps. These options were shown via mock-up graphics and/or text. These ideas were not always something that NWS was currently capable of producing, nor did they have to be something that NWS will necessarily end up providing. The point of generating the ideas is to get feedback from EMs and better understand their needs. As an example, work in North Carolina showed that County Emergency Managers make evacuation decisions based on the anticipated onset time of tropical storm force winds. NWS does not have such a product, but a prototype was developed by an NWS WFO, which was then shown to EMs, with questions asked about its value, usefulness and effectiveness. It is unknown when or even if this product will be available to EMs from the NWS. but its usefulness to EMs illustrates one way to fill a serious gap. More examples of prototypes are discussed in the case study section of this report.

Once prototypes were available, they were verified by again working with members of the EM community. There are various ways to do this, but structured interviews worked best at the outset. Our goal was to determine if the prototype would fill the gap if it were to be available to them. This is too broad a question to ask, however, so while showing them the prototype, various questions were asked such as:

A. What does this graphic tell you?
B. What do you think of this graphic?
C. Under what circumstances would you use it?
D. How might you want it modified and why?

The number of EMs with whom prototypes were verified varied across case studies based on the extent of the area associated with the case study and the availability of EMs. Verification was done through surveys, presentations at meetings, and other venues where members of the EM community come together.

2.1.4. Validate results

Testing prototypes with users serves to validate results. If possible, testing in a real situation is the preferred approach. If that is not possible, surveys or interviews must be used. Incorporating the prototypes into a real event allows for evidence of how the prototype would likely be used as well as how it would affect decisions and actions. Validation can be difficult to carry out depending on resources and event occurrences. For two of the use cases (winter and tropical weather) prototypes were tested in interviews and surveys. In the IBW project validation only occurred in the IBW project with the original messaging.

2.2. Methods for Gathering Information

Several methods were effective in carrying out the iterative methodology described above. These methods go beyond the more traditional route of presenting information and asking if there are questions, which can be useful under many circumstances. However, the qualitative and quantitative methods described here have been shown to provide very useful information relating to the needs of NWS partners and customers. The qualitative methods used were focus groups and interviews; the quantitative methods included surveys, both on-line and in person. Each has its own advantages and disadvantages, but together they provided a very useful approach to working through the four step iterative methodology.

2.2.1. Focus Groups

Each use case of project was initiated using focus groups, facilitated group interviews or group discussions. The discussions, statements, and comments made during focus groups provided the “data”. Indeed, the focus groups provided insight into EM areas of concern and allowed for an understanding of relationships and perspectives that EMs have under conditions of forecasted severe weather. As a result, the focus groups provided a depth and richness of information that could not be obtained from a survey. Each focus group was comprised of a relatively small number of participants, ranging from 4 to 8 and were guided, but not directed, by a moderator. The moderator kept the participants focused while at the same time allowed the conversation to flow naturally. In each use case, focus group participants represented different EM categories or, where NWS personnel participated, different responsibilities within the NWS. The purpose of this approach was to be able to map out relationships and time frames as they vary by responsibility and by stage in the event.

Unlike surveys and structured interviews, the focus groups did not have specific protocols. However, the moderator had a design comprised of questions that provided focus to the discussion but that also helped participants feel comfortable. Brainstorming, with some scenarios or questions to start the conversation, is one way to carry out a focus group. A method that has been used effectively with the EM community is CRC (Class Responsibility Collaboration) Cards, described below. Focus group discussions were audio recorded and then transcribed in order to provide for a full record. Many times, insights are gained from the recordings that may not have been captured in note-taking.

Although focus groups should be rather free-flowing, they do need to be moderated. For the purposes of this project, one useful technique to use during a focus group is an adapted form of the Class, Responsibility, and Collaboration (CRC) Card methodology (Beck and Cunningham, 1989). Originally used for object-oriented software design, CRC cards are an easy, consistent way to collect information across multiple focus groups and keep the facilitator focused on the goal of the focus group. Participants write their job title, responsibilities, and collaborators on an index card in response to a series of scenarios, and then each participant reads this information to the group (see Figure 3 for an example). This generates discussion and questions amongst the participants and facilitator, providing an immense amount of information to establish a baseline understanding and generating discussion about the responsibilities, collaborations, timelines, decisions, and concerns of partners.

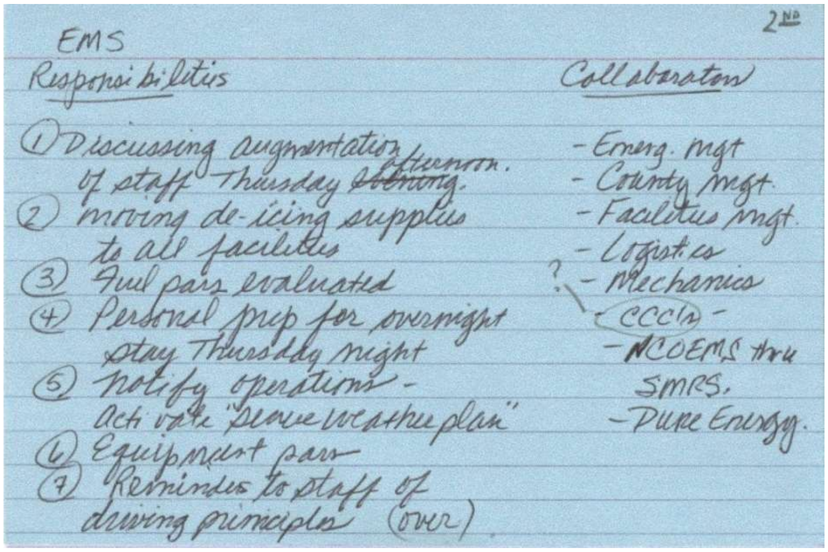


Figure 3: A sample CRC card from a focus group conducted in North Carolina for a winter weather scenario. The participant's job title is written on the top line ("EMS"), responsibilities along the left side of the card, and collaborators along the right side of the card. Extra information can be written on the back of the card.

Focus groups in general, and CRC cards specifically, made it possible to document who talks with whom in the EM community and to learn what type of information they are receiving and passing on, and why. An example of a network for a winter weather scenario in which the storm is two days out is shown in Figure 4. As can be seen, while much of the communication comes from the county EM director, the network is large and complicated, illustrating how easily information might be miscommunicated, backed up, or even lacking within this network.

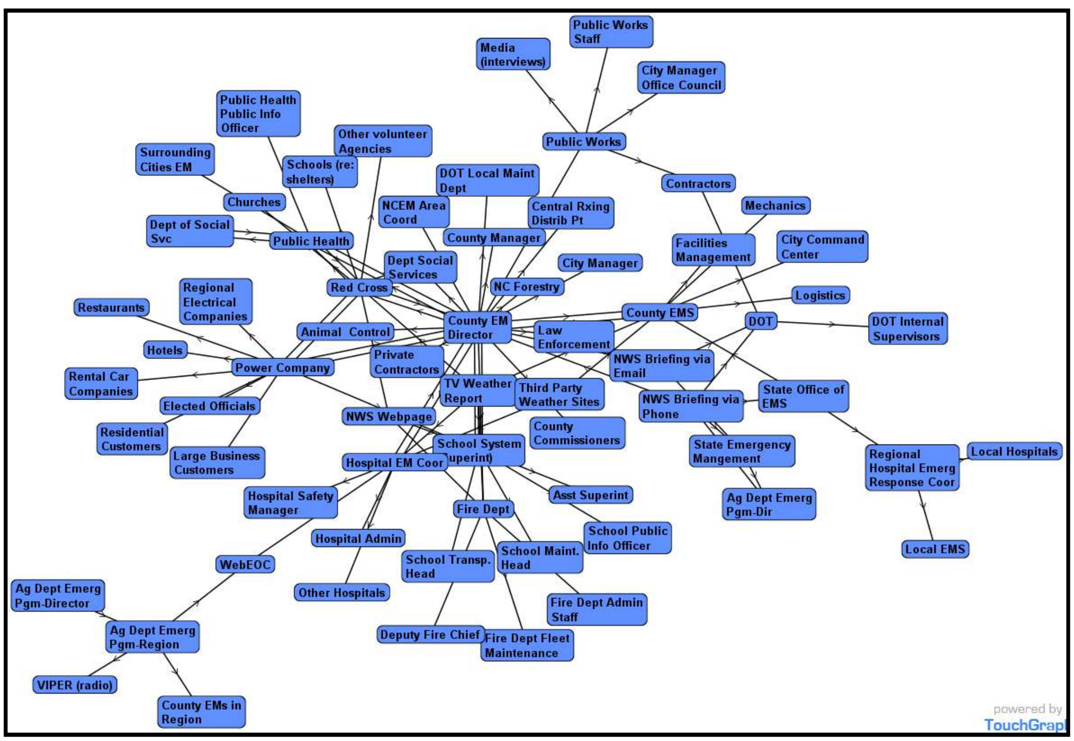


Figure 4: Flow of information two days before a winter storm event.

2.2.2. SEMI-STRUCTURED INTERVIEWS

Following the focus groups in which we obtained information with respect to the base case and current practices, and therefore identified some gaps, we explored specific topics that arose or discussed prototypes through semi-structured interviews (SSI). The main goal of SSIs was learn more about current practices by probing various topics and issues that were brought up during the focus groups. This also allowed us to continue to build on our base case.

In preparation for a SSI, the interviewer developed a list of open-ended, non-leading questions and topics to be addressed during the interview (i.e., an interview guide). A particular benefit of using SSI is that it can be used by multiple interviewers at different sessions because the interview guide developed beforehand lays out instructions and questions. However, in each interview, it was helpful to also allow for discussion that strayed from the planned topics. Thus, in addition to the planned questions, the interviewer asked many questions "on the fly" as the discussion proceeded, allowing the interviewer to probe new information and form a better understanding of customer needs. It also allowed the interviewees to express their views from their perspective.

Initial SSIs focused on processes, timelines, and needed information. An example of our analysis of the results from one SSI is shown in Figure 5. In addition, we held semi-structured interviews using prototypes that had been developed in association with the project. In those cases, an interview guide was also developed, but discussion was allowed to stray from the script. In some cases we went back to participants in earlier SSIs. In other cases, we arranged for SSIs with those who had not yet been involved in the project. Questions that were asked in these SSIs included what the prototype told them, whether or not they thought it would be useful and changes they might make, among other questions. More is provided on this as we discuss the individual case studies.

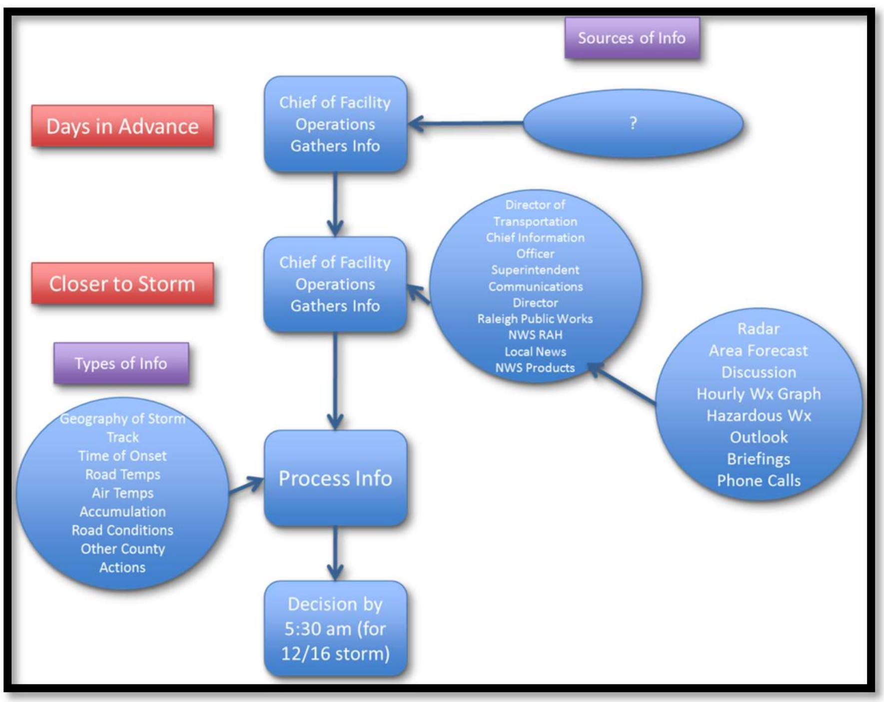


Figure 5: Documentation of results from semi-structured interview

2.2.3. SURVEYS

Surveys have two characteristics that differ from focus groups and interviews. First, they can readily be administered to a large number of people, so the results provide a more broad-based view than do the other methods. Second, the responses can be tallied and, assuming the sample size is sufficient, analyzed using statistical tests. Even without statistical tests, the results provide quantitative evidence of trends. At the same time, surveys do not allow for the depth of a focus group or interview, so the mixed methods approach used here was effective. In addition, it is difficult to insure useful response rates, though there are ways to minimize this problem, discussed below.

Surveys can be undertaken at any point in a given project. They might be used first, before the focus groups, to identify areas of general concern or misunderstanding. They might be used after the focus groups to determine how widely some of the findings are shared. They might be used after the interviews, again to see how widely the findings are shared. And they might be used to present prototypes of graphic and text products, after the interviews, to determine how effective or useful respondents believe them to be. As is detailed below, we undertook surveys at different times in the project for different use cases, depending on our needs. In addition, we directed the surveys to different groups (EMs, Forecasters, School officials), depending on the use case and the questions we were addressing. We also administered surveys differently, at different stages of the project. Some were on-line surveys, using survey software, and sending the link to the survey to the relevant population we wanted to survey. In other cases, we embedded survey questions into presentations, using the clicker audience response system, and in still others, we administered surveys to participants in conferences who came by our exhibit table.

Summary

The three methods for data collection discussed here – focus groups, semi-structured interviews (in person and via phone), and surveys – were the primary methods used during WxEM to gather information. Other methods, such as observation and brainstorming were employed as well, as appropriate situations presented themselves. Each of these methods is useful at one time or another for talking with and better understanding partners' responsibilities, decision points, and processes.

3. *Case Studies*

Three in-depth case studies were conducted during WxEM: winter weather, tropical weather, and the Central Region Impact Based Warnings demonstration. Knowledge, methods, and results of each of the case studies build on the previous one, allowing us to test and verify our methods and general findings. While the goals of each case study are similar, they were adapted as the project proceeded to build in lessons and findings from our previous work as well as specifics associated with the different events we were addressing. Findings specific to each case are discussed in the individual case study reviews below. A summary of lessons learned is in Section 4.

3.1 WINTER WEATHER CASE STUDY

Most of the winter weather case study was conducted from July 2010-March 2011. A follow up effort took place during the winter of 2011-2012, but priorities soon shifted to the tropical use case and to the Central Region Impact Based Warnings demonstration project.

Goals:

- Establish methodologies for collecting information from partners
- Learn about EM processes, decisions, and responsibilities during a winter event
- Establish a network of who talks to whom and when during an event
- Identify gaps between what partners need and what NWS provides
- Develop and verify prototypes to address gaps

Methods and Iterations

The list in Table 3 details the methods used as the use case proceeded. The initial focus groups facilitated our understanding of the baseline and of current practices. As we moved through the semi-structured interviews, gaps in information and knowledge availability were identified, but so too were gaps in our understanding of current practices. Thus, as we moved through the stages shown in the table, we moved back and forth among the steps in the iterative process so that we sufficiently set the base line and understood current activities before moving ahead to prototypes. Testing of the prototypes began early in 2011.

Table 3: Methods and Iterations for the Winter Weather Use Case

Major Iterations	Date Conducted
Focus Group #1-3: Multiple ESFs, total of 12 participants	July 2010-Sept 2010
Semi-structured interview #1 w/Buncombe County School Officials	September 2010
Survey at NCEMA Conference	October 2010
Semi-structured interviews at NCEMA Conference	October 2010
WxEM Panel Discussion at NCEMA Conference	
Semi-structured interview #2 w/Buncombe County School officials	October 2010
Semi-structured phone interviews with 6 districts	November 2010
Survey of school officials	December 2010
Introductory meeting with NWS Raleigh staff	December 2010
Semi-structured phone interviews with 4 districts after snowfall	December 2010
Semi-structured interviews with 6 school districts - current practices	January 2011
Multiple surveys (10) of school officials for prototype feedback	February 2011
Semi-structured interview #3 w/Buncombe County School officials-prototypes	February 2011
Verification simulations with 7 schools	March 2011

Findings

After conducting the initial focus groups with various ESFs to establish critical decisions, collaborators, and timelines, three sub-groups that have a major societal impact emerged for winter weather: power companies, the Department of Transportation, and schools. We narrowed our focus to schools since we identified them as the most underserved by weather information.

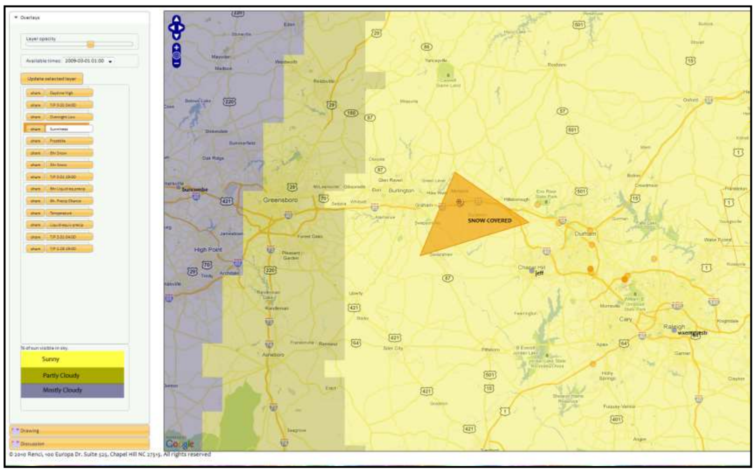
Throughout the various iterations listed in Table 3, we first established a baseline of schools' current processes and their use of weather information from which we worked to identify gaps in information. We did this by conducting multiple interviews in nine counties[1] in central and western North Carolina by phone or in person before any winter storms occurred as well as after storms. The counties were chosen to provide examples of urban and rural districts, different geographic settings, and different levels of interaction with their NWS Weather Forecast Office. We also conducted a statewide on-line survey of school personnel who make the decision to close schools. Of the 115 school districts, 58 completed the survey. Findings include:

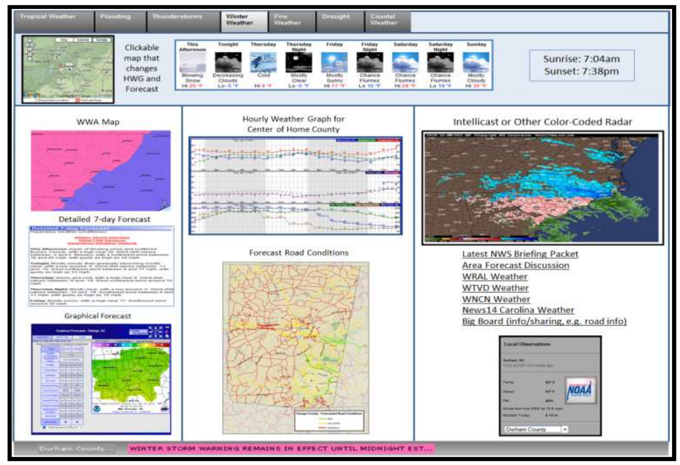
- The decision to close schools is based on the safety of 16-year old drivers
- Forecast of their most critical parameter, road conditions, is not available for most roads
- School staff drive the roads from 3-5am to determine conditions but have no way to share observations or forecasts
- School staff have little to no training in meteorology, yet interpret weather and advise on critical decisions

[1] In North Carolina, school districts are county-based.

- Location-specific onset time of wintry conditions is crucial for school closing decisions, but this is hard to find and interpret, and the information provided does not work well with the timelines of schools
- Most school representatives are unfamiliar with useful NWS products, e.g., Hourly Weather Graph
- Relevant information needs to be in one place for easy access on the web

The information gleaned from the focus groups, interviews, and survey was then used to develop prototypes to translate what we learned about the processes involved in school closure decision-making into products that might more directly meet their needs. Figure 6 shows two of these prototypes.





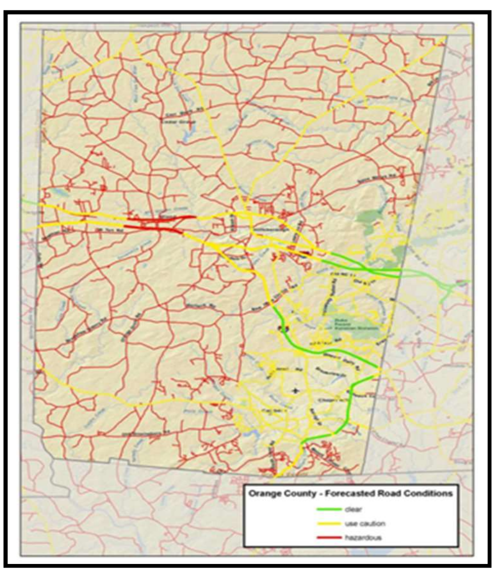


Figure 6:
Top left: EMs prefer relevant information to be placed in one easy-to-use and find location. Currently they are not aware that many products exist, and can have difficulty finding ones they are familiar with.

Top right: Big Board, a prototype map conferencing system developed at UNC RENCI, allows users to view and annotate various map layers and share with others.

Bottom left: At 9pm the night before a storm, schools reps would like to receive the forecast of road conditions for 4am the next day. Combining this information with what they see when they “ride the roads” is the most critical information they need to make their decision.

After testing these prototypes with the initial group of schools who participated in the interviews, we visited several more to verify our findings and present the prototype ideas. Many of our findings were confirmed, and new ideas emerged.

We intended to validate some of our findings during the winter of 2011-2012 but the mild North Carolina winter in 2011-12 did not provide any opportunities. However, the findings of this use case, and the methods established to gather information laid the foundation for the tropical weather and Central Region Impact Based Warnings demonstration case studies.

Recommendations for Future Work

In addition to following up on validation of the findings when severe winter weather occurs, it will be important to test our processes and findings in other states. What we found in North Carolina may or may not be the case in other states, and the NWS works with ESFs everywhere. Thus, it is not yet apparent that our findings can be generalized such that they provide a foundation for action on the part of NWS regarding products and services for school decision-makers.

3.2 Tropical Weather Use Case

As detailed in the proposal, tropical weather was defined as a use case for this project. Given the hurricane risk that coastal North Carolina faces and the complex of factors that affect decision-making in this area, the choice of tropical weather as a use case was simple.

Goals:

- Provide an understanding of emergency management (EM) critical decisions, processes, timelines, and the knowledge needed to support the decisions during tropical weather
- Identify gaps and ways to improve the information flow between the National Weather Service (NWS) and the EM community.
- Mature further the methodologies used in the winter weather use case to gather information

Methods and Iterations

As with the winter use case, we undertook focus groups to develop the baseline and our understanding of current practices (iterations are listed in Table 4). The results of the focus groups were supplemented with surveys and interviews. Throughout the duration of this use case, we were able to take advantage of several workshops and conferences at which EMs gather to administer surveys. In addition, we inventoried web pages to understand what information is available from various sources as well as how different NWS offices present information for EMs. In addition, recognizing that all WCMs do not communicate similarly with EMs in their service areas, we administered a nationwide survey to EMs in all NWS WFOs, with 98 responses. Once the baseline was developed and current practices understood, the basics of a prototype were developed. Throughout this use case, we worked very closely with the WFOs in North Carolina the service areas of which include coastal counties. The prototype that was tested was, in fact, developed by personal in one of the WFOs.

Table 4: Iterations conducted during the tropical weather use case.

#	Iterations	Date Conducted
1	Focus Groups #1-4: Multiple ESFs, total of 24 participants	May 2011
2	Survey conducted at ECU Hurricane Workshop	May 2011
3	Phone interviews of 35 ESF reps (no county EM directors)	July-Aug 2011
4	Inventoried third party vendor sites	July 2011
5	Inventoried all NWS EM Briefing web pages nationwide	July 2011
6	In-person interviews of 12 coastal county EM directors-after Irene	September 2011

7	Survey of all WCMs nationwide	September 2011
8	In-person interviews of 3 coastal WFOs that serve NC –after Irene	September 2011
9	Brainstorming session for gap filling prototypes conducted at 2 WFOs with local EMs	October 2011
10	Prototype verification with EMs at conferences	Multiple dates 2011 and 2012

While this use case was underway, Hurricane Irene made landfall in North Carolina. This provided an opportunity to hold post-event interviews with both NWS and County personnel to understand what information was made available in what forms and now that was received by the partners. Because this is a much more weather-savvy group than school administrators, the findings from this use case are much more detailed than with the winter use case.

<u>Findings</u>

The following Findings evolved from the iterations and represent topics that were consistently mentioned as priority issues in information and knowledge conveyance. There are gaps that were identified between hazard identification provided by the NWS and risk communications that enable emergency managers to make decisions. The findings are presented in order of importance as indicated by emergency managers.

1. The most important operational parameter for emergency management is the onset time of tropical storm force winds in their jurisdiction. Closely related to this parameter are the end time and duration of the winds. Most of the critical operational decisions that have to be made are based on the forecasted onset or arrival time of tropical force winds, from which EMs back up in time to assure that particular operations can be completed before conditions are too hazardous, as defined by these winds. These include actions such as the time to a) complete evacuations, b) staff and resource shelters, c) pull emergency vehicles off the road, and d) initiate bridge closures.
    - There is no clear NOAA/NWS product that provides wind Onset Time, though it can be inferred from several products such as the Hourly Weather Graph. EMs indicate they have difficulty inferring this parameter from current products, presenting a major problem to their operations.
    - Evaluation of current practice in North Carolina showed that most emergency managers use HURREVAC to derive the wind onset time from the "blue" 34kt line, and then use the decision arc capability to backup in time for decisions. It is also generally perceived by EMs that the wind information in HURREVAC is inaccurate. As a result either by experience or word of mouth, mental adjustments are made to wind speed and timing, and this varies by the user. In comparison to WFO guidance received, HURREVAC wind timing may differ by four hours or more, which can be significant when trying to complete operations during daylight hours.
    - The EMs must explain timing information to county decision makers. Inconsistency of information on the most crucial parameter causes some issues with differing perceptions and reduces the confidence with other information provided by NHC and NWS.
    - One WFO attempted to provide onset times for wind speeds in a graphic. Though the graphic itself was initially hard to understand by some users, the information was very well received by all EMs interviewed. Onset time information needs to be consistent, easy to grasp, easily accessible, and have some ability for EMs to relate to their locations.

2. Other wind products do not meet the needs of EMs, though they are very important to their decision-making.
    - All wind probability products receive little use by EMs. When EMs use these products, they are not very confident in their use for a variety of reasons. Examples of reasons include that the products are too confusing, too broad-stroked, and not operationally relevant. In addition, it was recognized that wind graphics provide a broad-stroke indication of the spread of wind extent, but, at best, they have marginal value for operations. While wind probabilities do give some sense of the uncertainty, which is something EMs want, the current probability conveyance is not used operationally.
    - Important wind information for EMs is sustained winds (consistent across products with 2 minute averaging to reduce over prediction of onset time).
    - All winds should be in local time and in mph, not knots and GMT. Though knots and GMT time are understood, using these units requires the EM to change the products before further dissemination.
    - Having forecast timing of other wind levels is operationally useful. Though there is no consistency, we found gale force, 45mph, 58mph, and hurricane force winds would have operational use. Higher than hurricane force added little additional operational meaning.
    - At higher speeds, information on wind gusts is needed, as it is generally understood that gusts will cause the damage to trees, houses, power distribution, and other infrastructure. Having gust information gives EMs a sense of the magnitude and spread of damage to be expected.

3. Relevant information needs to be presented more simply and found in one easy location on the web and in briefing packages.
    - Information must be more direct and to the point. Often, information tries to explain and justify the forecast which is too much detail for EMs to use in such emergency situations. A general idea of what, when and how much impact is anticipated is all that is needed. In other words, EMs want NWS to characterize the hazard and help connect it to risk.
    - EMs currently search across and within multiple websites (NWS, NHS, and other websites) for critical information, in part to determine their confidence in forecasts and in part to find usable information in a useful format. As an event unfolds, there is less time to do this. Some information on NWS sites is hard to find, hard to use or interpret, and therefore it is not used. Putting pertinent information in one spot in an organized manner will save time, and assure that recommended information is used.
    - In general, harder to find information may not be used. Examples of this include hourly weather graphs and P-Surge.
    - EMs need information that connects pertinent risk parameters to operations that deal with impacts. The NWS, EMs, or both, make these connections with mixed results, in turn leading to mixed meaning and usability.
    - Some information is too general to be operationally useful or it is generally misunderstood. This information should be filtered out.
    - Some non-NWS sites are used solely because the information as it is presented is easier to understand and can be disseminated more easily. Lessons need to be learned from these sites and should then be incorporated into NWS because going to multiple sites or products takes too much time.
    - Some graphic or text products incorporate too much detail or present the information in ways that only meteorologists understand. For example, products that try to relate the best guess and uncertainty at the same time require the EM to interpret the meaning of

both. EMs will revert to or perhaps erroneously extrapolate a simple text explanation rather than use many of the provided products.

4. EMs would first like to get a point of reference forecast for all key parameters, and then deal with the uncertainty of those forecasts as it relates to operations. All information should be provided in this sequence as far out in time as possible, even if it highly uncertain. (Decision-making, in general, is a process where conceptual understanding is developed by looking at a variety of information until a confidence level in the meaning is achieved).
    - The overwhelming prevailing preference is to have the NWS's best deterministic guess, followed by a sense of certainty (versus uncertainty). Operationally, this places a reference in time and space for addressing anticipated hazards. In so doing, it is acceptable to have more error further out and have it change with each updated forecast. Not having information in this manner, that is, a best guess then uncertainty, leads to confusion or misunderstanding because a clear reference point is not shared.
    - EMs indicated that receiving uncertainty information such as probabilistic information before they understand the hazard causes confusion, misinterpretation and lowers confidence in the forecasts. Having a range of possibilities helps in developing a concept and is preferred over probabilities. Having only the worst case is not helpful; instead the worst case needs to be included with the best guess. However, when given no other ways to understand uncertainty, probabilities might be used to build the conceptual understanding, but more likely someone will ask the WFO for an interpretation. In general, interpretation of probability as shown on most products is not well understood and not used much if at all.
    - EMs depend heavily on spaghetti model plots found on non-NWS sites to understand the uncertainty of the model track and gain confidence in their decisions. This information is not available on NOAA/NWS sites. At the same time, we found many EMs using these model plots to erroneously explain the cone of uncertainty.

5. The cone of uncertainty is understood by most EMs, but it is not useful for operations. Because the media shows this product it creates more problems for EMs than any other weather product because they have to explain it.
    - EMs understand that the track is not real, and the cone should be considered. However, almost all EMs and their clients default to the track black line for the point of reference and struggle with everyone interpreting the right forward quadrant, its impact area, and forward speed.
    - How the cone is derived is not understood by all EMs. Some think that is created by the tracks from the spaghetti models. EMs also report that others think the cone encompasses the distance that winds come out from the center of the storm.
    - Consensus recommends eliminating the cone plot entirely and replacing it with a graphic showing the potential impacted area, variability within the impact area, and consensus track. This is more operationally significant. Track uncertainty is not nearly as significant as impact area uncertainty.
    - Some EMs would find it more useful to have the centerline become a fatter black line to indicate that the track is more uncertain the further out in time it is. In addition, the cone is too wide to be useful. EMs can deal with the uncertainty of the track if it is connected to wind impact uncertainty.

6. Surge information is currently not used significantly in operational decisions.

- MOMs or MEOWs are not being used for operations, though most EMs know they exist. The EMs indicated low confidence in using these products. Some glance at them, and very few may even run scenarios if they have people to do so. Among the reasons for not using them are that they are hard to find and they are too broad to be useful. The prevailing reason for not using them, though, is that the areas indicated as surge areas are usually already covered in operational decisions based on wind. These decisions are already made when MOMs/MEOWs are supposed to be used.
- When queried about training on MOMs and MEOWs, EMS seem to understand them already and indicated that more training likely would not have much impact on utility.
- Having MOM/MEOW results in a more accessible format to increase usability is likely to increase utility.
- EMs want a track specific surge forecast 72 hours or more before landfall, even if it has significant error. The absolute level is not as important as knowing there is going to be inundation, where, and when. It is understood and accepted that it may change radically with each new track forecast. Having this information, even if it is uncertain, is better than having no information at all to make sure all pertinent areas are included in operational decisions.
- P-Surge is not used due to its lack of timeliness and not being easy to find. Further, this information is more relevant with greater spatial resolution, and perhaps as a downloadable product to overlay on local vulnerability information such as infrastructure and population.
- Currently, inundation at any level is more significant than surge forecasts with high accuracy of height. If surge is to be relevant, it must be available sooner and be much more resolved spatially so it can be connected to features on the ground. Surge could be a more important part of the decisions if provided in a time frame and at a resolution more relevant for operational decisions.
- Surge information is used to plan for operations after the storm for infrastructure restoration. Information on anticipated duration of surge is important and having a capability of surge animation would be helpful as EMs explain potential impacts to decision makers.
- Besides surge, it is important in some locations to have wave height, direction, and duration information. Locally, these parameters are understood to cause significant beach erosion.
- EMs would like to see tide information presented, as they report that it always comes up for discussion in relation to surge. Without it, many people interpret the tide interaction from other sources.

7. Information needs to be consistent and more locally relevant than is currently provided in most products.
    - EMs report that some information is not consistent across NWS products such as the arrival time of tropical storm force winds that is found in HURREVAC (based on NWS/NHC forecasts) and the onset time predicted by a local WFO. Precipitation estimates from various products were reported as another cause for concern. Such inconsistent information causes confusion for EMs.
    - EMs report that most of the information they receive, such as surge and rainfall information, is not sufficiently localized o be operationally useful. While some information can be deduced at higher resolutions, i.e. zoomed in, we found little evidence that EMs take the time to try to localize information for themselves.

- Products needing to be more finely localized and timed include surge, winds, and precipitation.

8. Other related weather events of importance include: inland flooding, tornadoes, and marine forecasts. Though they are important, they did not come up in our interviews consistently or as a high priority. However, the counties we focused on, with a few exceptions, could have inland flooding issues that impact operations due to road or bridge closures. As a future use case, inland and near coastal flooding would certainly be a significant issue for the counties in this tropical storm study.

<u>Prototype Development</u>
Through the iterations outlined above we were able to establish a baseline of EM and WFO practices and developed findings of gaps linking the two. Based on these findings and gaps, WFO Wilmington and WxEM created several prototypes that are shown in Figures 1-3. These prototypes were presented to coastal EMs at a statewide conference in October to verify that they were addressing the EMs' needs.

In Finding 1, the need for tropical storm force wind Onset Time was identified. Having heard this finding during earlier iterations, personnel at WFO Wilmington developed the prototype on the left in Figure 6, following Hurricane Irene. Feedback received from EMs suggested that while the information provided was on target, the graphic was difficult to understand. The graphic on the right represents a means of portraying the same information more explicitly. Although no structured survey was undertaken to gauge EM perceptions of the value and usability of these prototypes, reactions at the North Carolina Emergency Management Conference in which they were presented were overwhelmingly favorable. Additional work is needed to hone in on details such as what wind levels are most needed and when, what spatial and temporal resolutions are most needed, which datasets available to WFO's should be used to produce this information, and what communication mode(s) should be used?

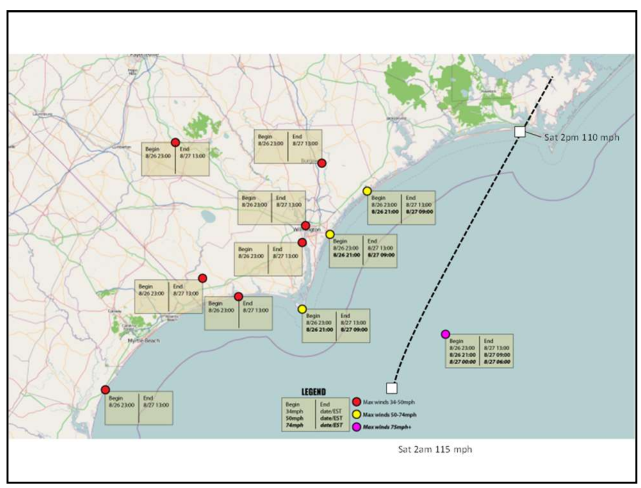


Figure 6: Onset time of tropical storm force winds graphics. Left – example from WFO during Irene. Right – modified version of WFO graphic with additional wind fields.

A second example was generated to address Finding 5 where the requirement is to connect the storm track to storm "impacts" (Figure 7). This has not been validated yet, and subsequent work should hone in on details needed such as what parameters or impact(s) are most desired, what time intervals are operationally significant, and what resolution in time and space are relevant? Despite these needs, the graphic addresses issues that were identified by EMs as creating operational problems.

Figure 7: an early prototype of the track forecast and cone of uncertainty overlaid with tropical storm force wind probabilities to show the extent of impacts of the winds beyond the cone.

A third prototype was developed by WFO Wilmington to addresses several findings and bring together much of the information that EMs want to know in advance of a tropical event into one short, concise, easy to read, text product (Figure 8). As above, this has not been systematically tested, but given what we know about EM needs, it is proposed that this product be available in a point and click format so that the information can be retrieved for any part of a county quickly. Initial feedback on this product from EMs is that it would be an extremely useful product to have that would help them get the information they need very easily without searching various sites.

Point and Click Tropical Hazard Summary

```
TROPICAL HAZARD FORECAST
NATIONAL WEATHER SERVICE WILMINGTON NC
445 AM EDT FRI AUG 26 2011

NCZ106
COASTAL PENDER-
POINT FORECAST: 2 MILES NW TOPSAIL BEACH NC
34.38°N 77.68°W
445 AM EDT FRI AUG 26 2011

...HURRICANE WARNING IN EFFECT...
...FLASH FLOOD WATCH IN EFFECT FROM 2 PM EDT THIS AFTERNOON THROUGH
SATURDAY AFTERNOON...
...HIGH RIP CURRENT RISK IN EFFECT THROUGH THIS EVENING...

WINDS
        TROPICAL STORM BEGIN........1600 EDT FRI 8/26/11
        HURRICANE BEGIN.............0100 EDT SAT 8/27/11
        HURRICANE END...............0900 EDT SAT 8/27/11
        TROPICAL STORM END..........1500 EDT SAT 8/27/11
PEAK WINDS
        SUSTAINED.....50 MPH
        GUST..........70 MPH
PRECIPITATION
        STORM TOTAL RAINFALL...4 TO 6 INCHES
COASTAL FLOODING
        STORM SURGE...........4 TO 6 FT
        STORM TIDE............5 TO 7 FT
SURF
        SURF HEIGHT...........7 TO 9 FT
        RIP CURRENT RISK......HIGH
WIND THREAT............LOW
TORNADO THREAT.........LOW
INLAND FLOOD THREAT....MODERATE
COASTAL FLOOD THREAT...LOW

TIDE INFORMATION AT TOPSAIL INLET

        HIGH TIDE 2.7 FEET AT 5:39 AM FRIDAY
        LOW TIDE 0.1 FEET AT 12:21 PM FRIDAY
        HIGH TIDE 3.7 FEET AT 6:17 PM FRIDAY
        LOW TIDE 0.2 FEET AT 1:20 AM SATURDAY
```

Figure 8: a prototype of a point and click tropical product that shows much of the information the EMs need during a tropical event.

Recommendations for Future Work

The tropical weather use case provides a great deal of information on which future work should be based, if NWS is to be successful in providing g the information needs of its partners. Much of the future work involves testing the prototypes presented above is a systematic manner so as to develop meaningful and applicable results. In addition, additional prototypes based on the findings that were not addressed fully should be developed and tested. This would include exploring ideas for surge, tropical web pages, communication, and collaboration. Once developed, the prototypes should be presented to EMs in \VA and SC to verify that they are useful to EMs. Since EMs in these states are unfamiliar with the project, they will provide relatively unbiased feedback on the prototypes. Using their feedback, additional iterations on the prototypes can be carried out. Once it has been verified by EMs that the prototypes are providing the information that EMs need, validation of the prototypes, should be completed. This can be done through a formal exercise with EMs or during an actual event to determine if the prototypes influence operations or decision-making and improve the connection from hazard identification to risk management

Issues with communication effectiveness in the form of messages, collaboration, and communication modes are in need of exploration. Often the information needing to be conveyed is available but does not transfer well to the recipient. Many issues arose in support of this finding, but need further clarification. Some of these are discussed in earlier findings.

- Many counties and WFOs are experimenting with social media, namely Facebook. Social media technologies are showing promise in reaching a growing segment of the population, but the effectiveness is an open question. We found, for example, that consistency of information and marketing of Facebook sites need to be coordinated between the EMs and NWS to avoid confusion and duplication of effort.
- In our iterations, we did not find any EM that was using the Hurricane Local Statement for operations. According to the WFOs, considerable time is put into this product. Further exploration is needed to investigate the use of this product.
- Emerging use of cell phones by EMs is forcing some messaging to be shorter and in modes of text messages, twitter, chat, and Facebook. These messages need to be investigated for effectiveness and EM population coverage. These modes need to be in comparison to more standard approaches of webpages, email, PowerPoint, phone calls, and weather radio.

Collaboration between the NWS and EMs, with the purpose of developing a common understanding of weather hazards and risks, shows promise but requires new work modes and resources. Utility of collaboration capabilities needs further exploration

3.3 Central Region Impact-Based Warnings Demonstration Project

During the last case study of the WxEM project, the team evaluated the effectiveness of experimental Impact Based Warnings (IBW) in Central Region. More details about the experiment can be found at http://www.crh.noaa.gov/images/crh/IBW/Resources/IBW1pager.pdf . As we are still working with CR on this project via our new NOAA award, this section is not final.

WxEM Goals

- Evaluate the effectiveness of the Impact-Based Warnings (IBW) for tornado and severe thunderstorms from the perspective of EMs and forecasters
- Test methodologies in an operational setting to complete step four of our iterative method, validation.

- Transfer methods to NWS personnel

The iterations conducted during the evaluation are included in Table 5 (see next page). An evaluation of IBW was conducted using a matrix that scored the effectiveness of each of the six critical elements identified by EMs against the components of the risk paradigm (Tables 6-8). Findings and recommendations are shown in Table 9.

Table 5: Iterations conducted during the IBW case study

#	Iteration Name	Iteration Description
1	Pre-IBW March EM Focus Groups	One EM focus group was conducted in each of the five IBW areas in mid-late March before IBW warnings were operational. The focus groups were conducted by WFO staff with guidance from the WxEM team. The goal of the focus groups was to establish a baseline understanding of EMs' decisions, processes, and usage of weather information before they began using IBWs.
2	Pre-IBW March EM Phone Spot Check	93 EM and media partners in the IBW test area were contacted via phone by WxEM team members to determine if the outreach for IBW was effective, i.e., did partners know about IBW and if so, what did they know.
3	Pre-IBW Missouri EMA Conference	A paper survey (77 completed) and multiple instant response surveys (119) during breakout sessions were administered at the Missouri EM conference April 4-5. Informal interviews (10) were also conducted at the NWS booth. The goal was to establish a baseline understanding of EMs decisions, processes, and thoughts on IBW before any IBWs were issued.
4	Pre-IBW Forecaster Interviews	Forecasters at three of the five IBW offices were interviewed in early April before any IBWs were issued. The goal was to establish a baseline understanding of forecaster processes and gather initial thoughts on IBW.
5	April 14 EM Interviews	Shortly after the April 14 tornado outbreak in Kansas, EMs were interviewed in person (17) and via phone (8) to learn about the processes of EMs during the outbreak in general and if and how IBWs were used for the event.
6	April 14 Media Interviews	Shortly after the April 14 tornado outbreak in Kansas, eight media partners (TV and radio) were interviewed in person to learn about media processes during the outbreak in general and if and how IBWs were used for the event.
7	April 14 Forecaster Interviews	Shortly after the April 14 tornado outbreak in Kansas, forecasters at the WFOs in Topeka and Wichita were interviewed to learn about the warning process and how IBWs were used and if they impacted forecaster decisions.
8	April 27 EM Interviews	At least two brief and weak tornadoes occurred on April 27 in the Topeka CWA. Nine EM partners – some had tornado warnings issued for their county, others didn't – were contacted to see if and how they used IBWs.
9	May 19 EM Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. EMs from two counties that were affected were interviewed to see if and how they used IBWs.
10	May 19 Media Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. Two TV media partners were interviewed to see if and how they used IBWs.
11	May 19 Forecaster Interviews	Eight non-supercell tornadoes, with somewhat unexpected severity, occurred in the Wichita CWA on May 19. The warning forecaster for NWS Wichita was interviewed to learn about his warning process and use of IBWs.
12	August Forecaster Survey	A forecaster survey was administered to IBW offices in August to gauge forecasters' opinion and comfort level on various gaps identified in early iterations. 51 responses were received. Preliminary results were used to inform focus groups conducted later in the month.
13	August EM Focus Groups	One EM focus group was conducted at each of the five IBW offices in late August. The goal was to address gaps that were identified in early iterations and to discuss ideas for prototypes to address these gaps.
14	August Forecaster Focus Groups	One forecaster focus group was conducted at each of the five IBW offices in late August. The goal was to address gaps that were identified in early iterations and to discuss ideas for prototypes to address these gaps.
15	KEMA EM Survey	Paper surveys were administered at the Kansas EM conference in mid-September. The goal was to gather feedback from EMs on gaps identified in earlier iterations to help inform prototype development.
16	Non-IBW EM Survey	A survey for EMs in five non-IBW areas in Central Region was administered in late September. The goal was to gather feedback on IBW, various gaps identified in earlier iterations, and the warning system in general from a new group of EMs to use as comparison to EMs involved in IBW. 252 responses were received.
17	Non-IBW Forecaster Survey	A survey for forecasters in five non-IBW offices in Central Region was administered in late September. The goal was to gauge non-IBW forecaster feedback on gaps that were identified in earlier iterations. This survey matched the one given to IBW forecasters in early August. 28 responses were received.

Matrix Evaluation

Table 6: Evaluation of effectiveness within the risk characterization component of the Risk Paradigm.

		A	B	C
		Risk Characterization		
		Hazard Description	Impact Assessment	Vulnerability Assessment
1	Threat and its magnitude	4	3	1
2	Timing	2	2	1
3	Location	2	2	1
4	Duration	2	2	1
5	History	2	2	1
6	Confidence	3	3	1

Risk Characterization (Table 6): ability of the NWS to assemble and describe the critical risk knowledge of an event that will be conveyed to partners. Three subcomponents make up risk characterization: hazard description, impact assessment, vulnerability assessment.

Hazard Description – From the forecaster perspective, how effective is the forecaster at communicating what the hazard is? Effectiveness may deal with forecaster confidence, availability of options in WarnGen, or how parts of the warning message may vary across offices. This section does not reflect how warnings are perceived by EMs. Note that there is a wide range of perceptions and opinions from forecasters on what EMs actually do, their role in the time leading up to the event, and how NWS should serve the EM community.

Cell 1A (threat and its magnitude): Rank 4 – IBW is very effective at communicating the threat, or hazard, that the forecaster is trying to convey. This is accomplished by the "Hazard" section of IBW warnings, which clearly state what the forecaster is expecting or what has been reported, e.g., damaging tornado, ping pong size hail, 60 mph wind gusts, developing tornado.

IBW is very effective at allowing the forecaster to convey the magnitude of the threat via damage threat tags (significant, catastrophic), and forecasters like having the ability to convey this information. 76% of IBW forecasters thought that the damage threat tags conveyed the threat's magnitude "well" or "very well." Until now it was difficult to clearly state how severe the forecaster thought the damage threat was, so all tornado warnings sounded the same regardless of how severe. The predefined terminology for damage threat tags and formatting of IBW give forecasters a way to express their concern and more effectively communicates this information. Terminology, such as the damage threat tag "significant" should be improved. [Iterations 4, 12, 14]

Cell 2A (timing): Rank 2 – From the forecaster perspective of characterizing risk using timing, IBW is ranked somewhat effective. IBW itself did not change or improve upon how timing information is communicated when compared to standard warnings, so this ranking of 2 applies to the standard warning as well. Timing information is provided in warnings in phrasing such as "At 630 PM CDT…A confirmed large and extremely dangerous tornado…", but the forecaster is not being specific on what time it will affect specific locations.

Pathcasts were a major point of discussion with forecasters, as EMs said that specific timing information is a critical missing element to current warnings. Even though the use of pathcasts is an option in WarnGen, no IBW offices use it. In a survey, 64% of IBW forecasters said that they were only "somewhat comfortable” or “not at all comfortable” using WarnGen storm motion to provide time of arrival to specific locations, while 90% said “no” or they were “not sure” that pathcast should be provided in warnings. These numbers can be misleading however, without taking into consideration focus group discussion about IBW forecaster feelings on pathcasts. During discussion, most forecasters were comfortable and willing to use pathcasts if they could build in location and timing fuzziness to the pathcast. For example, instead of saying that the tornado will arrive in Salina at 6:45 PM they would be more comfortable saying that the tornado will be around the Salina area or near Salina at 6:40-6:50 PM. Forecaster survey indicated that pathcasts should be valid for 15-30 minutes.

Interestingly, during a survey of non-IBW forecasters that *do* use pathcasts, only 15% (compared to 64% of IBW forecasters) said that they were “somewhat comfortable” or “not at all comfortable” using WarnGen storm motion to provide time of arrival to specific locations, while only 26% of non-IBW forecasters (compared to 90% of IBW forecasters) said “no” or they were “not sure” that pathcast should be provided in warnings. [Iterations 12, 14, 17]

<u>Cell 3A (location)</u>: Rank 2 – From the forecaster perspective of characterizing risk using location, IBW is ranked somewhat effective. Like timing, IBW itself did not change or improve upon how location information is communicated when compared to standard warnings, so this ranking of 2 applies to the standard warning as well. Location information is provided in warnings in the “Locations impacted include…” section of the warning. Warnings also indicate where the storm or tornado was located shortly before the warning is issued and a direction of movement.

The location information is closely linked to the timing and pathcast discussion in the previous section. EMs need to know at what location and time a storm will occur; neither of these is currently specific enough to be very effective in helping EMs. [Iterations 12, 14, 17]

<u>Cell 4A (duration)</u>: Rank 2 – From the forecaster perspective of characterizing risk using duration, IBW is ranked somewhat effective. Like timing and location, IBW itself did not change or improve upon how duration information is communicated when compared to standard warnings, so this ranking of 2 applies to the standard warning as well. Duration of an event can be implied from the expiration time of the warning. However, this information is not localized to an EM’s area, but rather for a larger area of warning. [Iteration 14]

<u>Cell 5A (history)</u>: Rank 2 – From the forecaster perspective of characterizing risk using history, IBW is ranked somewhat effective because some information on history can be included in the “Source” bullet (e.g., Spotter confirmed large tornado) and the timing and location line (e.g.,…dangerous tornado was located just south of Argonia…). However, forecasters commented during focus groups that the ability to add a spotter report was removed for IBW, making IBW less effective than a standard warning. Forecasters were in favor of adding a bullet into IBW to allow them to add spotter reports to the warning. [Iteration 14]

<u>Cell 6A (confidence)</u>: Rank 3 – From the forecaster perspective of characterizing risk using confidence, IBW is ranked very effective. The damage threat tags options that forecasters can assign – none, significant, or catastrophic – allows forecasters to express their confidence of the threat’s magnitude in the warning. This confidence is implied and not state directly, however, and is only for threat and magnitude and none of the other critical elements.

In IBW severe thunderstorm warnings, the phrase “Tornado…Possible” is an available option, but forecasters have varied opinions on when, why, and how it should be used. Some say they use it when they have low confidence that a tornado may occur, while others think of it for use in describing a time frame (imminent or in 30 minutes). Others think it should be used if the tornado will be weak (e.g., QLCS situation). Some forecasters think that usage of the phrase is confusing to EMs, yet 72% of IBW forecasters said they would use it in a warning. [Iterations 4, 5,12, 14, 17]

Impact Assessment – From the forecaster perspective, how effective is the forecaster at communicating the impacts of the hazard?

<u>Cell 1B (threat and its magnitude)</u>: Rank 3 – From the forecaster perspective of using the threat and its magnitude to assess impact, IBW is effective. Through IBW, the forecaster has the ability to relate what will be impacted, such as houses, cars, and power, by the threat. However, forecasters noted

during focus groups and surveys that they felt that the impact statements weren't as well aligned as they could be with the damage threat tags and the actual impacts the storm would cause. For example, many thought that the impact statement for the base tornado warning (where no damage threat tag is used) was too severe sounding. Using that wording for weak tornadoes, and cold air funnels specifically, forecasters felt was not reflective of potential damage. Several forecasters mentioned that they did not think the hail damage impacts and damaged tree branch sizes were accurate either. Some forecasters also wondered what effect using the same impact statements over and over would have on their effectiveness. [Iterations 4, 5, 7, 11, 12, 14, 17]

<u>Cell 2B-5B</u>: Rank 2 – From the forecaster perspective of using timing, location, duration, and history to assess impact, IBW is somewhat effective. As noted in the previous section, IBW did not change how any of these critical elements were characterized, so the ranking of 2 applies to the standard warning as well. Without more specific timing, location, duration, and history information it is difficult for forecasters to give provide less generic impact information.

<u>Cell 6B (confidence)</u>: Rank 3 – Forecasters were somewhat confident in using the current impact statements, so they are ranked as effective. Impact statements need to be adjusted as discussed in the threat and magnitude section. [Iterations 4, 5, 7, 11, 12, 14, 17]

Vulnerability Assessment – From the forecaster perspective how effective is the assessment of vulnerability? Vulnerability builds on impacts, but it is more specific in timing, location, and type of damage. For example, impact tells you that trees will blow down. Vulnerability tells you what trees will be affected, how many will fall down, and at what time. Vulnerability assessment is not exclusively NWS's job, but NWS needs to give EMs the right information for them to be able to evaluate vulnerability.

<u>Cells 1C-6C</u>: Rank 1 – IBW is not at all effective in communicating vulnerability across any of the critical elements because the warnings do not provide guidance on exactly where and when the threat will happen. Assessing vulnerability is not only NWS's job, but the warnings as they are do not help EMs assess vulnerability.

Table 7: Evaluation of effectiveness within the risk communication component of the Risk Paradigm.

		D	E	F	G
		Risk Communication			
		Message Package/Receiving	Message Delivery	Operational Considerations	Confidence, Competence, Comfort
1	Threat and its magnitude	3	3	2	4
2	Timing	2	2	2	2
3	Location	2	2	2	2
4	Duration	2	2	2	2
5	History	2	2	2	2
6	Confidence	3	2	2	4

Risk Communication – Explanation of Rankings

Risk communication (Table 7): The risk communication part of the risk paradigm is where NWS and EM come together and information is being handed off from NWS to EM. The goal is to convey risk knowledge about the event so that it creates a mutual understanding of the situation.

Message Packaging/Receiving – From the NWS side, examine the intent of the message and options that exist to package and convey the message. From the EM side, examine how EMs receive warning messages, what they do with that information, and what the warning tells them.

Cell 1D (threat and its magnitude): Rank 3 – From the NWS perspective, threat and its magnitude are effectively communicated through the IBW messaging packaging. IBW provides text in a format that uses spacing to differentiate various headings. This formatting allows the intent of the message, including the threat (hazard) and its magnitude (damage threat tag), to be conveyed in a way that is easier to find than in a block of text. Overall, forecasters seemed satisfied with the mechanism to select threat and magnitude information within WarnGen.

From the EM perspective, threat and its magnitude are effectively communicated through the IBW messaging receiving. EMs are able to identify the threat and its magnitude in various sections of the warning, although improvements should be made to move the section at the bottom of the warning that includes whether the tornado is observed or radar indicated, the tornado damage threat, and hail tags closer to the top of the page. The NWS's intent with this section is to convey important information, but since it's at the bottom it can go unnoticed or unread due to time restrictions. [Iterations 4, 5, 7, 11, 12, 14, 17]

Cell 2D (timing): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, timing information is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. From the NWS side, options exist that would allow forecasters to better convey timing information if the pathcast option in WarnGen is used.

From the EM perspective, timing information is critical. EMs take the warning message, and along with other tools such as radar, try to deduce their own time of arrival of the storm to their location. This indicates a major gap between what EMs need and what NWS provides. [All iterations]

Cell 3D (location): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, location information is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. From the NWS perspective, not many options exist to improve upon conveying location information within IBW since it is a text product. A graphical product would be ideal for conveying this information. In the meantime, it would be helpful if the way in which location information is listed across WFOs was consistent. Currently, WFOs may list many cities, or a few, and they may list them in the order that they are affected or in alphabetical order. In a survey, about 75% of forecasters thought that cities/towns should be listed by expected time of arrival. [All iterations]

From the EM perspective, timing information is critical. EMs take the warning message, and along with other tools such as radar, try to deduce their own time of arrival of the storm to their location. This indicates a major gap between what EMs need and what NWS provides.

Cell 4D (duration): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, duration information is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. Is there an option within WarnGen to list duration? [All EM iterations]

From the EM perspective, duration is important so EMs know when they will be able to go out and assess damage safely. They currently have to infer this information from information in the warnings and their interpretation of radar.

Cell 5D (history): Rank 2 – As noted in the risk management evaluation (previous section) of IBW, information about storm history is not well conveyed in NWS warnings, so it is ranked as somewhat effective within the message packaging. Forecasters noted that in the standard warnings before IBW they were able to add a bullet with storm spotter information, and they would like to have this option available to them for IBW warnings. As with location, few options exist within a text product to effectively convey history information. [All EM iterations]

From the EM perspective, the history of the storm provides EMs with a better feel for what may impact them and increases their confidence. Many EMs get storm history from NWSChat or the SPC storm reports page, but some users of warnings (e.g., 911 dispatchers) depend solely on text products.

Cell 6D (confidence): Rank 3 – NWS could more clearly convey their confidence level in IBW, although there are not many options within WarnGen to do so. IBW allows forecasters to convey and implied confidence in several parts of the warnings (e.g., source, damage threat, observed/radar indicated).

From the EM perspective, EMs are searching for confidence levels from forecasters. They may be able to get this through other means such as NWSChat, but IBW does not directly provide this information. Terms that EMs are using to imply confidence, such as the damage threat tags, are open to interpretation.

Message Delivery – Examine how effective the delivery mechanisms are in getting the message to EMs, other options to deliver the message and how they compare in effectiveness in receipt and understanding (forecaster and EM perspective).

Cell 1E (threat and its magnitude): Rank 3 – The delivery mechanism for IBW is text pushed out to users through methods such as iNWS, NWSChat, EMWIN, etc. Using text to communicate the threat and its magnitude is effective, however this information could also be communicated effectively through graphics.

Cells 2E-6E: Rank 2 – The delivery mechanism for IBW is text pushed out to users through methods such as iNWS, NWSChat, EMWIN, etc. Using text to communicate timing, location, duration, history, and confidence is somewhat effective, but not ideal. It is very difficult to visualize much of this data after reading it in text, so a graphical product needs to be developed to convey this information.

Operational Considerations – Assess how easily and consistently NWS can develop and disseminate IBWs, determine if other options for delivering the warning are operationally possible.

Cells 1F-6F: Rank 2 – Both NWS and EMs have operational considerations to think about when issuing and receiving IBWs. From the NWS perspective, we did not hear any forecasters say that clicking the added options in WarnGen caused delay in issuing the warning. Some stated that having to think about which damage threat tag to use, and its associate impact statement, did cause them to stop and think for a few moments about what they were about to communicate was aligned with what they thought the storm would produce. This was especially true when deciding to use the catastrophic damage threat tag instead of significant.

From the EM perspective, we found that quite a few EMs do not actually read tornado warnings (IBW or standard), so this contributed to the somewhat effective ranking. Some EMs said that they do not read the warnings because they are out in their trucks spotting and don't stop to read warnings. Others said that just knowing a tornado warning was issued was enough for them, and they are busy enough doing other things to stop and read the warning. A remaining question is whether more EMs would make the effort to read the warnings if they contained more useful information, such as pathcasts, or were in a graphical format that better catered to providing information on the six critical elements.

Another operational is issues is the use of "Tornado…Possible" in IBW severe thunderstorm warnings. EMs first indicated that this was an issue in interviews and surveys before IBW became operational because some EMs must activate sirens any time "tornado" is mentioned in a warning. Interpretation of what the phrase meant was varied amongst EMs, and how and when it should be used varied amongst forecasters. This phrasing needs to be addressed.

Confidence, Competence, Comfort – Assess how comfortable partners were in using IBWs, examine the capabilities and competence of the intended audience when using warning info, determine how the personal confidence of the deliverer and receiver influence the effectiveness of messaging.

Cell 1G (threat and its magnitude): Rank 4 – Based on the limited number of events for IBW, EMs that read the warnings were comfortable using the IBW information to receive threat and magnitude information.

Cells 2G-5G: Rank 2 – IBW did not change how any of these parameters were conveyed, so the warning is somewhat effective at conveying this information as it relates to EM confidence, competence, and comfort.

Cell 6G: Rank 4 – As discussed in other sections, EM confidence increased when NWS used the damage threat tags because forecasters were giving EMs some idea of potential severity. Forecasters overall seemed confident in their decisions to use the damage threat tags, as the warning forecaster had an open discussion with other forecasters when using the significant or catastrophic tags.

Table 8: Evaluation of effectiveness within the risk management component of the Risk Paradigm.

		H	I	J
		Risk Management		
		Risk Perception	Decision-Making	Safety Actions
1	Threat and its magnitude	3	3	0
2	Timing	2	1	0
3	Location	2	1	0
4	Duration	2	1	0
5	History	2	2	0
6	Confidence	3	3	0

Risk Management (Table 8): decisions and actions taken by EMs to protect lives and property based on their understanding of risk, societal factors, and resource availability. The understanding of risk is bases on the risk characterization and communication by NWS.

Risk Perception: Examine how risk is perceived by the EMs when reading an IBW, if IBW allowed EMs to infer the appropriate level of risk to make proper decisions, and how effective IBWs are in conveying risk.

Cell 1H (threat and its magnitude): Rank 3 – IBW is effective at conveying the risk of the threat, as the damage threat tags and hazard sections of the warning give EMs a sense of the threat's magnitude unlike standard warnings. However, some interpretation by EM is still going on (e.g., what does "significant" really mean?), so there is room for improvement in communicating the risk of the threat. According to the surveys conducted at the Kansas EM conference, ~75% of EMs think damage tags will convey urgency (note: not necessarily risk) to the public. EMs say this is helpful to EM because people may take action that they otherwise would not have. [All EM iterations]

Cells 2H-5H: Rank 2 – IBW did not change how timing, location, duration, or history is communicated in warnings. These critical elements are not being well communicated, so they are only somewhat effective in communicating risk to EM. [All EM iterations]

Cell 6H (confidence): Rank 3 – To EMs, damage threat tags are an indicator of confidence of the forecasters, so an EM's confidence also increases. When significant and catastrophic damage threat tags are used they are effective indicators of risk to EMs. In a survey conducted before IBWs were operational, EMs said that the primary way IBWs will help is that they will give EMs a better sense of forecaster confidence, which in turn increases EM confidence. [All EM iterations]

Decision-Making: Examine what decisions EMs are making during a severe weather event and on what timeline, what knowledge is needed to make these decisions, evaluate if and how IBW changed EM decisions, what other information is needed by EMs in decision making.

Cell 1I (threat and its magnitude): Rank 3 – IBW is effective in providing threat and magnitude information for decision-making, but improvements to the warning, such as the wording for the damage threat tags could be improved. We had a limited number of cases in which to evaluate how IBW contributed to decision making, but we did find one decision made by an EM due to the catastrophic damage threat tag: an EM director had his fire department move all of their trucks out of the path of the approaching storm so that if the town got hit they could still respond. [All EM iterations]

Cells 2I-4I: Rank 1 – IBW did not change how timing, location, or duration is communicated in warnings. These critical elements are not being well communicated, so they are not at all effective in helping EM decision-making. [All EM iterations]

Cell 5I (History): Rank 2 – IBW provides some information on history to EM via the Source and the opening time/location/hazard sentence. However, this history is limited since it only talks about the most recent spotting or radar indication of the storm. Also, it can be hard to visualize this information from text information. [All EM iterations]

Cell 6I (Confidence): Rank 3 – IBW damage threat tags increase the confidence of EMs for decision making because EMs feel that tags are an indicator of forecaster confidence. The more confidence a forecaster conveys, the more confidence an EM has in their own decision making.

Safety Actions: Determine what actions by partners are desired by conveying risk information, assess if and how the warning intent reaches and influences behavior, assess what factors detract from the message intent on influencing actions.

All Cells: Rank 0 – Do not know enough to make evaluation. Due to the limited number of cases in 2012, we do not feel that we have enough information to really know if safety actions were influenced by IBW. Were any actions changed due to IBW?

Findings and Recommendations (preliminary as of December 2012)

Table 9: Findings and recommendations, by risk paradigm component, from the CR IBW case study.

Risk Paradigm Components	Findings	Recommendations
Hazard	a. There are 6 critical elements that EMs need to know to understand risk and make decisions. EMs currently do not receive all of this information. If they do receive it, it can be difficult to interpret and apply to operations. 1. Threat/magnitude 2. Timing 3. Location 4. Duration 5. History 6. Forecaster confidence b. IBW gives forecasters a way to express their confidence and anticipated severity, which a standard warning does not allow.	a. Time, location, duration have a significant impact on EMs understanding of risk and therefore their preparedness and response. These parameters are not addressed in IBW. These need to be addressed as the next level of priority. Example: Forecasters should use pathcasts in warnings or develop another tool to communicated time, location, and location. Issuing discrete timing and location information is not necessary; issuing approximate timing and location information is acceptable.
Impact	a. In the limited number of events in 2012, many forecasters stated that they thought the impact statements should be examined and adjusted. Many were not sure if all of the impacts described were commensurate with the potential of the storm, especially on the low end (base and significant) impact statements. b. EMs think that the impact statements are more useful for the public than they are for EMs, as currently written. EMs like the impact statements for the purpose of informing the public. c. EMs prefer to get a “best guess” from NWS and then a qualitative description of the uncertainty.	a. Impact statements need to be more thoroughly examined to make operationally useful for EM and forecasters
Vulnerability	a. Vulnerability is not explicitly addressed by NWS so EMs can have difficultly connecting the information NWS does provide to vulnerability	a. For effectiveness EMs and NWS need to dialog on how to connect specifics

	and risk. b. There is disagreement amongst personnel on where NWS's job in describing vulnerability ends and the EMs job begins. c. Data sets to assess vulnerability or risk are not readily available to EM or NWS (e.g., population and critical infrastructure)	to vulnerability to determine risk. Hazard and impacts need to be characterized better to get to vulnerability.
Message Packaging and Receiving	a. Forecasters like the new IBW template, but there are parts of the old templates, such as the ability to type in information that is not canned, that they'd like to see in the IBW template. b. Forecasters had some hesitancy in deciding when to elevate a warning from base to significant and from significant to catastrophic. This was due in part to the newness of IBW and forecaster consideration in making the impact match what they thought was going to happen. c. Forecasters like having the ability to express severity through a tiered system. d. EMs feel that the word "significant" is overused in NWS products, so it doesn't have much of an impression on them anymore.	a. From EM perspective, tiering conveys better levels of risk and confidence, though its total effectiveness is uncertain due to lack of events. R: Continue exploring the use of IBW tiering. b. Word "significant" is overused – another word needs to be used. c. Move tags at bottom to the top of the warnings d. Clarify with forecasters and EMs the difference between "Radar indicated" vs. "Radar confirmed" e. Reformat warning for clarify and emphasis
Message Delivery	a. EMs are starting to use social media such as Facebook. b. EMs rely heavily on NWSChat to understand the message itself as well as the tone of message.	a. Warnings need to be communicated in other modes (iNWS, NWSChat, Facebook) than a text message.
Operational Considerations	a. Many county EM directors do not read a warning message because they are out spotting, so IBWs don't influence them much unless they listen to a dispatcher read it over the radio. b. EMs that do read the warning message can have trouble finding the information they need amongst the other details, such as preparedness statements and impact statements, that while useful for the public, can make the message long. c. EMs say something is needed between a watch and a warning because there is normally several	a. Consideration of creating something that goes between a watch and a warning is warranted to enable EMs to better prepare in time and space rather than just waiting for the warning to happen. b. Consider breaking message into two pieces: short part with most important details first,

	hours between the two, so when a warning is issued it can happen suddenly.	then go to second part for details. iNWS is on the right track, but also needs to be done for other modes of communication.
Competence, Comfort, Confidence	a. The level of competence, comfort, and confidence in using IBW could have been higher with more outreach. Many in the EM community that use warnings, such as dispatchers, were not aware of IBW. b. EMs take cues, correct or not, from NWS actions. For example, if a phone briefing is going to be held versus a briefing that is only emailed then EMs' sense of severity immediately increases. c. Every county has their own siren policy. These range from activating sirens when a severe thunderstorm warning includes "Tornado…Possible" to only activating when a tornado is observed, regardless of whether a warning is issued or not.	a. Improve outreach, such as developing a better web page to explain IBW and increasing distribution of information, to EM to increase competence and understanding. b. Consideration of formalizing the informal conveyance of confidence and increase in risk. EMs currently take cues from differences in action by NWS (e.g., phone briefings vs. emailed briefings). c. If one doesn't exist already, develop inventory each county's tornado siren policy and what triggers (criteria and who turns it on) siren. Know how the warning message is reaching the person that activates the siren. Example: "Tornado…Possible" tag and how jurisdictions use this information: do they activate their sirens for this tag?
Risk Perception	a. EMs indicate that they are missing vital pieces of information to truly assess risk. They are interpreting the information as best they can, but would prefer to get an easy-to-understand "best guess" from NWS.	- No recommendation for NWS. Taking into consideration the previous recommendations will help improve risk perception by EM.
Decision-Making	a. We did not have enough events in 2012 to fully assess whether IBW made a difference in EM decision making. However, one example of a	- No recommendation for NWS. Taking into consideration the previous recommendations will

	decision that was taken as a direct result of IBW was on April 14 when a county EM director moved all the fire trucks and ambulances in one of his cities to an area out of the potential path of a tornado because the "catastrophic" damage threat tag was used for the county to his west. The tornado lifted before reaching his county, but the tag caught his attention, told him it was a serious situation, and lead to the decision. b. Many factors can go into an EM's decision making process beside weather information, including politics and past experience.	help improve decision-making by EM.
Safety Actions	a. With very few events in 2012, we were not able to fully assess safety actions taken as a result of IBW.	- No recommendation for NWS. Taking into consideration the previous recommendations will help improve safety actions by EM.

4. Lessons Learned

1. Based on agile and iterative development, we established methodologies for interacting with and understanding partner needs that NWS can use.
2. NWS can be much more targeted in their products and services to meet EM needs.
3. The understanding of the EM communities varies widely across NWS personnel.
4. The Risk Paradigm is an effective framework for connecting NWS to the EM community.
5. Information flow from NWS to the EM community results in an intricate social network with numerous potential bottlenecks and miscommunication.
6. The EM community is not receiving the information they really need to make decisions.
7. The six critical elements that EMs need from NWS to make decisions are: what is the hazard/how big, timing, location, duration, history, and forecaster confidence.

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