Seventh Symposium on Policy and Socio-Economic Research
January 22-26, 2012, New Orleans, LA
American Meteorological Society

8A.3 Weather for Emergency Management: Implications for NWS Tropical Weather Products and Services

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1. INTRODUCTION

In 2011, the National Weather Service (NWS) embarked upon a new initiative called Weather-Ready Nation. The purpose of this initiative is to increase the weather-readiness of the nation to prepare to protect, mitigate, respond to, and recover from weather-related disasters (NWS 2011). To do this, NWS is upgrading existing technologies, undertaking operational initiatives to improve current operations, and launching community-based pilot projects.

In addition, NWS is working to improve how to better communicate weather information and the resulting risk to its partners, including emergency management, and the public. To work towards this goal, NWS Offices of Science and Technology and Climate, Water, and Weather Services, local NWS forecast offices, the University of North Carolina at Chapel Hill Institute for the Environment, and East Carolina University are collaborating to better understand how to provide decision support services to the emergency management (EM) community.

The EM community, which we are broadly defining as people that make critical decisions that have a societal impact before, during, and after a hazardous event, can struggle to find appropriate weather information. If they do find it, they can have trouble understanding it and translating it to their network of decision makers; and if they do understand it, they may not be certain how to take proper actions based upon it. To work towards understanding and improving upon these issues, the collaborative project Weather for Emergency Management Decision Support (WxEM), a cooperative agreement between NWS and the University of North Carolina that began in July 2010, was established. The goal, through rapid and iterative prototyping, is to understand the potential impacts of NWS products and services on critical EM decisions by examining EM processes, collaborations, and current use of products and services. This paper will discuss the background, methodology, and findings for the WxEM tropical use case.

2. RISK PARADIGM

Because the job of an EM is to manage risk and not just hazards or impacts, a fundamental concept used in WxEM is the Risk Paradigm. It was developed by the National Research Council (1983) and is a known concept for assessing and managing risk. Figure 1 shows a diagram of the Risk Paradigm adapted from the NRC report.

The EM and NWS communities are linked through the Risk Paradigm in the common desire to manage outcomes and risks. However, a gap exists between what the NWS currently provides and what EMs need for all hazards, specifically the characterization and communication of risk. WxEM is working towards helping NWS become more aware of

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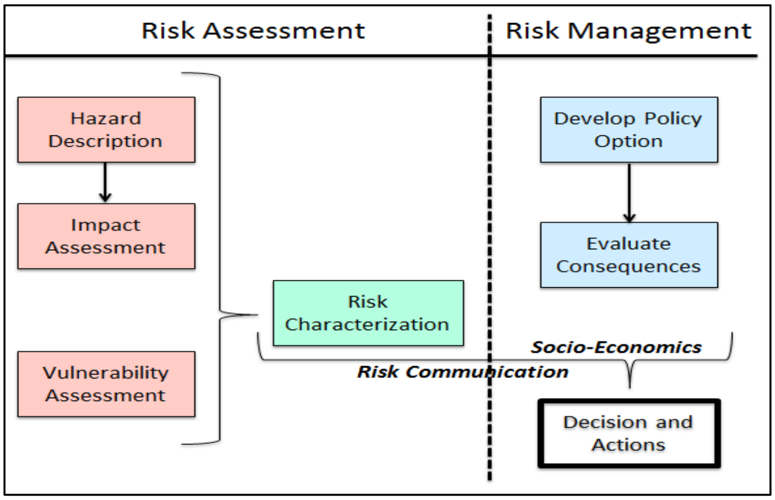

Figure 1: The Risk Paradigm. The NWS operates on the left side of the diagram providing hazard and impact information. The EM community works on the right side as they make decisions. A gap at the risk characterization link exists between NWS and EM. (Adapted from NRC, 1983).

EM operational processes, concerns, and decision points.

Three critical, interrelated components comprise the Risk Paradigm

- Risk characterization: developing and encapsulating the knowledge about the severe weather hazard, its potential impact, and its risk to life and property.
- Risk communications: packaging and delivering storm warnings (communicating) to convey the understanding of risk.
- Risk management: applying knowledge of risk and other influences to decisions yielding desired actions (societal response).

Deficiency in the effectiveness of any one of these components can have a negative influence on the desired action of an EM or the public.

3. METHODS

We define the EM community as those groups which fall under one of the 15 Emergency Support Functions (ESFs) that were established by FEMA's National Response Framework (2008). A listing is given in Table 1.

Table 1: Emergency Support Functions

#1: Transportation	#9: Search and Rescue
#2: Communications	#10: Oil and HazMat Response
#3: Public Works & Engineering	#11: Agriculture 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 Management and Resource Support	#15: External Affairs
#8: Public Health and Medical Services	

Note that a county or state EM -- "emergency management" -- is only one of these functions. The community is diverse and dynamic in nature, and it is important to look at the entire community to get a complete understanding of its needs.

To understand how to fill the gap in the Risk Paradigm between NWS and EMs, a four-step agile and iterative process established during the first WxEM use case on winter weather (Losego, et al., 2010) was again implemented for the tropical weather use case. In short, this approach starts with a small set of feedback from EMs to derive an assessment then continually builds upon it using flexible, collective guidance from NWS and partners to establish priorities. Iterations of testing and feedback continue until consistency of measures is achieved. The Four-Step Method used is an approach to identify and address top priority issues in a short amount of time, using few resources. The four steps include:

1. Baseline: a conceptual understanding of the responsibilities, timelines, decisions, and concerns of the EM community. Through iterations of prototyping and testing with more individuals, the baseline understanding is in constant review and modification until new information does not significantly change the understanding of the effectiveness of the risk components.
2. Current practice: establish a clear understanding of current practices of both the NWS and its partners as related to information, knowledge and decision flows. This step identifies key issues in established processes and procedures, where risk information is conveyed, and how it is used (or not used) to make decisions. This iterative step is the main mechanism to modifying the baseline understanding by identifying the gaps or shortcomings in the desired outcomes of the risk paradigm. The gaps, or findings, are used to examine underlying causes and how to explore ways to improve products or services.
3. Prototyping and verification: propose and prototype new approaches or solutions to an identified gap. This step is also iterative and may cause new actions in understanding current practices or modifications to the baseline understanding. Each iteration in this step ends with a verification that the prototype has satisfied an identified gap or need, whether that gap filling results in a desired action or not.
4. Validation: validate the results by testing against real operations or in simulations to the extent possible. This step commences when testing of prototypes has indicated positive results and the baseline modifications are minimal. Validating against reality or a simulation shows what would likely happen with the use of a new or modified product or service, and its effect on actions. During this iterative cycle, it may be necessary to circle back to any of the previous steps as new evidence dictates.

Various techniques are used to carry out the Four-Step Method, including focus groups; Class, Responsibility, and Collaboration (CRC) cards (Montz, et al. 2010, Losego, et al. 2010); semi-structured interviews conducted in person and via phone; surveys; brainstorm sessions; mockups. For the tropical weather use case 10 iterations were conducted to investigate the first three steps of the method and are listed in Table 2. The fourth step of validation in operations has not yet been completed, as an actual event or a robust exercise with historical data that is hard to reproduce would be needed.

Each of these iterations built upon our baseline understanding of EM processes and current practices of their use of weather information. Gaps emerged throughout the Four-Step Process that were addressed and verified with various prototypes (see section 5).

4. TROPICAL WEATHER USE CASE FINDINGS

Preliminary, generalized findings for the tropical weather use case conducted in North Carolina include:

1. The most important operational parameter for an EM is the onset time of tropical storm force winds in his county.

Table 2: WxEM tropical weather use case iterations conducted May-October, 2011

1	Focus groups using CRC card methodology (4 conducted, each with 4-9 participants)
2	Surveys conducted at the 2011 North Carolina EM-East Carolina University Hurricane Workshop (70 respondents)
3	Interviews of coastal North Carolina ESFs (35 phone semi-structured interviews conducted)
4	Inventories of WFO briefing web pages and third party vendor web pages
5	Nationwide NWS Warning Coordination Meteorologist (WCM) survey (98 respondents)
6	Hurricane Irene Follow-Up Interviews – EMs (12 in person semi-structured interviews in NC coastal counties)
7	Hurricane Irene Follow-Up Interviews – local NWS offices (3 in person semi-structured interviews of coastal NC offices)
8	Analysis of NWS briefings for Irene
9	Brainstorming sessions for graphics prototypes with EMs and NWS (2 conducted)
10	Prototype development and verification

2. With knowledge of this timing operational decisions, such as when to begin evacuation and open shelters, are made. There is no standard NWS product that easily or clearly depicts this parameter.
3. There are several additional findings on winds. For example, wind probability products receive little use by EMs because they are too broad-stroked and not operationally relevant. Also, the timing of other wind speeds (e.g., 25 mph) other than tropical storm force is operationally useful.
4. As in all hazards, EMs would like to see relevant information presented simply in one easy-to-find location. Currently EMs search across sites (NWS and non-NWS) scouring for the critical information that they need.
5. EMs want a point of reference forecast for key parameters first to have a benchmark to work from, then a sense of the uncertainty and range of possibilities.
6. The cone of uncertainty produced by the National Hurricane Center is not useful for operations. It is too broad to be useful, difficult to explain its meaning to others, and does not convey that impacts exist outside of the cone. EMs know that the track is uncertain, so they would rather see a graphic showing areas of potential impacts for key parameters.
7. Information needs to be consistent and more locally relevant. For example, how the wind speed is averaged (1-minute vs. 2-minute) varies across tools that EMs use, causing confusion and could cause differences on the order of hours in arrival times of critical wind levels.
8. Surge information is not significantly used in operational decisions because it is released too late (48 hours before landfall) well after many decisions (e.g., evacuation start time) have been made. Even though there is a high degree of uncertainty, having a surge forecast released at 72 hours before landfall would be more useful operationally because it gives EMs a reference point from which to work. Having inundation at any level is more significant than surge forecasts with a high accuracy of height. Tools such as the Maximum Envelope of Water (MEOW) and Maximum of MEOWs (MOM) are not generally used for operations in North Carolina because they are hard to find and not useful for local operations.
9. Inland and near coastal flooding are issues that should be studied as part of this use case in the future.
10. Issues with communication effectiveness in the form of messages, collaboration, and communication modes are in need of further exploration. For example, web pages

and briefing packages can provide a great deal of value to EMs, but can have many issues in context, timing, and consistency.

5. TROPICAL WEATHER USE CASE PROTOTYPES

To address some of the gaps identified in the findings several prototypes were created and then verified with the EM community. Two examples of many suggested prototypes are shown in Figures 2 and 3.

Figure 2 is an example showing a map of the onset time of tropical storm force winds for various locations in a county. A map with similar information was produced by the NWS Wilmington, NC office during Hurricane Irene. EMs gave very positive feedback for the map because it provided information on the start and end times of tropical storm force winds that had not been readily available before for decision making.

Figure 2: Prototype showing a map with the onset and ending time of tropical storm force winds for various locations.

Figure 3 is a prototype generated in collaboration with NWS Wilmington that shows the presentation of critical information, such as the timing of wind arrival, surge height, and precipitation amounts, in one brief, simple text product. The text product in practice would be generated for the location a partner chooses on a map. Presenting information in this simple manner allows the EM to receive critical information without searching a web page. It also allows the EM to easily share this information and utilize it in an incident action plan.

Point and Click Tropical Hazard Summary

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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
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Figure 3: Prototype showing a hazard summary for tropical weather listing critical parameters for EMs (provided by NWS Wilmington).

6. NEXT STEPS

There are several next steps for WxEM. They include the continuation of prototyping for key issues in the winter and tropical use cases, both in North Carolina and other states. This will allow the 4-Step Method to be tested outside of North Carolina and provide an opportunity to compare findings.

A second objective is to develop guidance to transfer the 4-Step Method to NWS offices so that they can begin to gather information from the EM community. This will enable the local offices to reach out to partners to learn about their critical decisions, processes, and current use of weather information in order to identify and address gaps in their area.

Another objective is to explore and understand effective communication and collaborations.

This includes examining the NWS web page and briefing packages, as well as how and why collaborations will be used.

These steps will be integrated into collaborations with various NWS pilot and demonstration projects.

7. CONCLUSIONS

The EM community is complex, diverse, and ad hoc, and generally its members have very little formal weather training. EMs manage risk, not hazards or impacts, and can struggle to find, understand, and translate weather information into knowledge they need to manage risk. A gap currently exists between what the NWS provides, which is generally hazard and impact information, and what the EM community needs – risk characterization and communication. To improve how to characterize and communicate risk to the EM community NWS needs to work towards a better understanding of their partners' critical decisions, processes, and use of weather information. With this understanding, NWS can work with their partners towards improving decision support.

8. **REFERENCES**

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