Sources of Hazardous Weather Information and Decision Making at Universities During Tornado Warnings: Thesis Proposal

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Introduction

With the development of new technologies and increased meteorological understanding, tornado warnings may change due to longer lead-times[1] associated with probabilistic hazard information, meaning longer time for response but greater amounts of uncertainty about the event (Kuhlman et al., 2009; Stensrud et al., 2009). These systems will also produce increased spatial, temporal, and intensity information in customizable ways (Kuhlman et al., 2009). Different groups of stakeholders, such as university decision makers, have different hazardous weather information needs, and developing these products in socially relevant ways requires further information from these stakeholders regarding their current warning response processes, decision-making contexts, and weather information needs. This study will look at the practices university emergency managers and officials and their decision-making processes regarding emergency notification of the campus during tornado warnings. This thesis project poses four main questions

1. What sources of information do key decision makers at universities access during tornado warnings?
2. How and when do these key decision makers use these sources in decision making about notifying the campus during tornado warnings?
3. How do non-weather related contexts affect the decisions made about emergency notification of the campus during tornado warnings?

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[1] Tornado lead-time is the the amount of time between the issuance of a tornado warning and time the tornado hits" (Schumacher et al., 2010).

4. What decision support tools would improve operations, with particular focus on changes in lead-time with probabilistic warning information?

Background

Tornado information is released by the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service (NWS) in the form of outlooks, watches, and warnings (Golden and Adams, 2000). Outlooks are provided one to two days in advance of severe convective weather. Watches, with four to six hours of lead time (Stumpf et al., 2008), are distributed by the Storm Prediction Center (SPC) when there is "significant potential to experience severe thunderstorms capable of producing tornados" (Golden and Adams, 2000). Warnings are based on detection via storm spotters, radar, or other technology (Stensrud et al., 2009).

As of 2011, the products released by the NWS are storm based (SB) warnings, polygon warnings based on a set of latitudinal and longitudinal coordinates (see Figure 1). They were implemented in 2007 to replace legacy systems that warned by county. The benefits included fewer people placed under warnings, increased focus of emergency response resources to specific affected areas, and decreased time spent under warnings by those unaffected (U.S. Department of Commerce, 2007).

NOAA has a Hazardous Weather Testbed (HWT) to help forecast software developers understand how people use weather forecasting tools. Part of the HWT program consists of the Experimental Warning Program (EWP). The EWP mission develops tools that will expand upon SB warning systems to improve communication of hazardous weather information. Part of this program is the Probabilistic Hazard Information (PHI) project, which is developing new

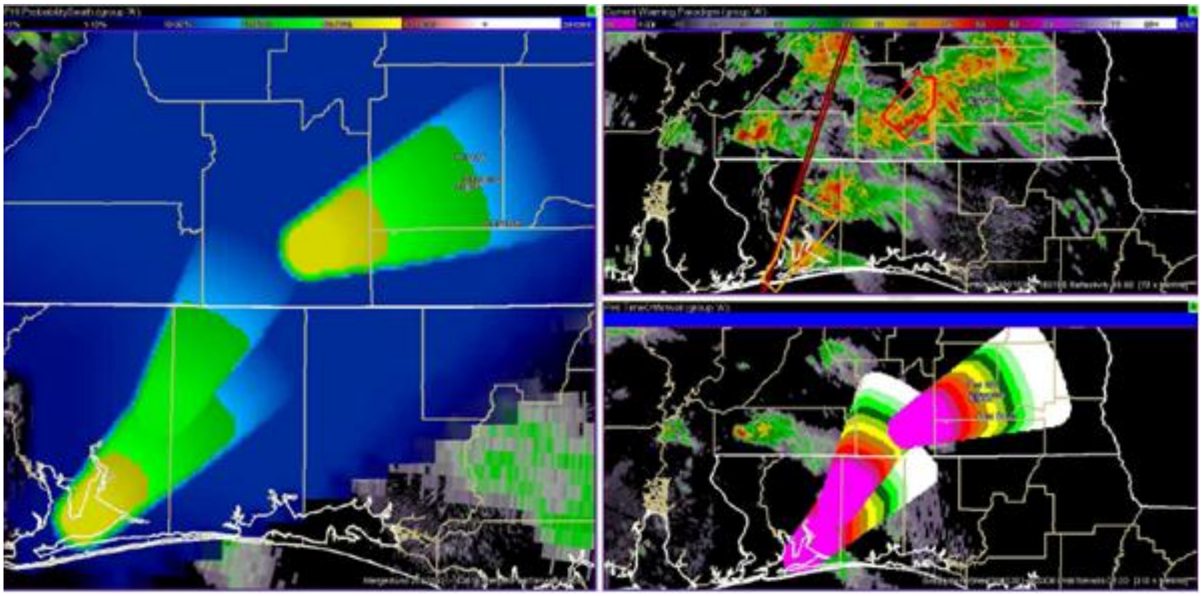

Figure 1: Probabilistic hazard information for tornados (left), current storm-based warning products from the NWS (top right), and estimated time of arrival (bottom right) (From Kuhlman et al., 2009).

products with the possibility of providing increased information to users (Kuhlman et al., 2008). These include more specific temporal, spatial, and intensity information, increased lead-time (though higher uncertainty), and continuous updates (see Figure 1). These products may be customizable in the future depending on user needs.

Social Science Woven Into Meteorology (SSWIM), part of the University of Oklahoma and NOAA's Cooperative Institute for Mesoscale Meteorological Studies (CIMMS), aims to integrate social science research methods into meteorological research and product development. In order to develop these PHI products in socially relevant ways, agencies that provide outlook, watch, and warning information need to know how specific user groups and stakeholders use their products and how current sets of information affect warning response processes and stakeholder needs. The results of this study will help the developers of PHI products understand what university administrators need. Universities are a distinct stakeholder within the warning process, and one that has been largely ignored within the research on societal aspects of forecasts and warnings.

Universities and Hazards

Universities are vulnerable to disaster. They have been affected frequently, and sometimes severely, in the past two decades (FEMA, 2003). Research suggests that universities are ill prepared for crisis (June, 2007), and a 2006 survey suggested that they may only be prepared for those events they have already experienced (Mitroff et al., 2006). Disasters on a campus can result in loss of enrollment, funding, reputation, and credibility (Kiefer et al., 2006; Mitroff et al., 2006), as well as impacts that reach much further into the surrounding community or the nation (Yamaiel, 2006). As of 2007, there were 4352 accredited Universities serving approximately 18.2 million students and employing around 3.2 million faculty and staff in the United States (Snyder and Dillow, 2010). These institutions carry a heavy burden in keeping their large populations and extensive, as well as expensive, operations safe from extreme weather events.

The Higher Education Act of 2008 (Public Law 110-315) requires the immediate notification of students and staff in the event of a situation which threatens the community's health or safety if an university is to be considered a Title IV institution, or one which can provide federal loans to their students. There are multiple forms of these communication systems, including text messaging via cellular phones, siren systems, and the use of LED lighting or displayed notifications, among others (Schneider, 2010). Yet, in order to activate these systems, the university campus must first become aware of the threat through communication with external or internal sources and make decisions regarding their course of action.

Universities are complex organizations and these decisions are made with a set of contexts where severe weather plays one important role.

Literature Review

This thesis depends on literature drawn from five particular sets of research ranging from broad theoretical frameworks geographers use in hazards research to specific approaches relevant to applied geography within emergency management: 1) warning response models and theories, 2) weather forecast uncertainty, 3) tornado warning lead-times, 4) emergency management weather information use, and 5) university emergency management.

Warning Response Models

Warning Systems Model and the Public Model of Warning Response

Mileti and Sorenson (1990) propose that warnings are released in a linear process through three subsystems: the detection subsystem, the management subsystem, and the response subsystem. Hazards are predicted, detected, and monitored by the detection subsystem that then relays that information to the management subsystem. The management subsystem decides who, where, when, and how to warn the public, and constructs the message. Warnings are disseminated through official channels and received by the public. The public model of warning response then follows a sequence of six stages: 1. hearing the warning; 2. understanding the warning; 3. believing the warning; 4. personalizing the warning; 5. confirming the warning; and finally 6. deciding to respond. No research has integrated universities into these subsystems, but Schumacher et al.'s study of a tornado in Northern Colorado (2010) found that the public model of warning response is applicable to the decision-making processes of university officials.

While the Mileti and Sorenson (1990) public model of warning response has been empirically sound (Donner, 2007), changes within the system such as new technologies, news coverage, private detection services, and use of global positioning systems have resulted in increasing amounts of information available (Rodriguez et al., 2007; Sorenson and Sorenson, 2007). With the introduction of these new technologies, users are not passive receivers of information but rather active seekers, deciding what information to access (Rodriguez et al., 2007), and the official channels are no longer the only place to receive information, which means the systems on which these models were built are no longer top-down (Dow and Cutter, 1998; Hayden el at., 2007). Research has explored the multiple sources of weather information people access in their daily lives (Hayden et al., 2007; Lazo et al., 2009; Van Bussum, 1999) and emergency managers, for example, have a number of sources of information available to them and seek out particular types of information depending on the time within the storm (Baumgart et al., 2008; League et al., 2010). Hayden et al. (2007) argue that warning systems now need to use multiple sources to provide information to all users, making the systems more responsive to real world situations. The Mileti and Sorenson (1990) model also fails to take into account the processes that lead an individual to make decisions regarding protective action, including the decision to take no action.

The Protective Action Decision Model

The Protective Action Decision Model (PADM) (Lindell and Perry, 2004, pp. 45-65) takes into account the processes of deciding how to respond to a warning and what information to access. PADM follows a sequence of eight stages of decision making (see Figure 2). After the predecisional process of hearing and understanding the warning, and individual's decision to respond begins with the process of risk identification (Lindell and Perry, 2004, pp. 50-51). The individual then goes through a process of risk assessment that can be influenced by the proximity, certainty, severity, and immediacy of the hazard (Lindell and Perry, 2004, pp. 51-54).

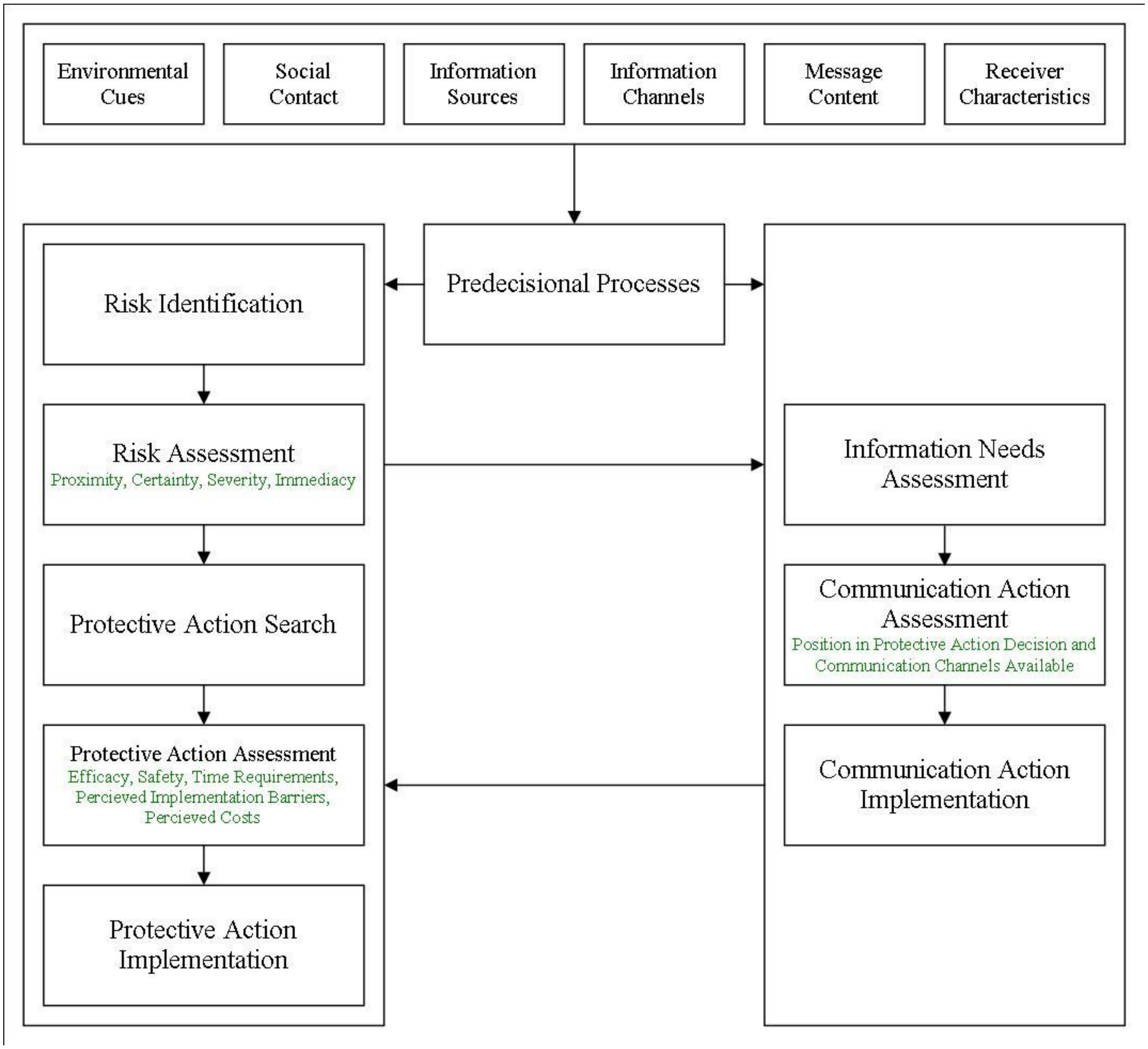

Figure 2: The Protective Action Decision Model (adapted from Lindell and Perry, 2004). Influences on the stages shown in green.

The next stage is the protective action search in which individuals identify possible actions to take from memory, communication with other people, or information seeking (Lindell and Perry, 2004, pp. 55-56). Once a set of actions is determined, an individual goes through a process of protective action assessment (Lindell and Perry, 2004, pp. 56-60). Possible actions are compared based on efficacy, safety, time requirements, perceived implementation barriers, and perceived costs. Options that are most suitable are then considered as to whether or not action needs to be taken immediately in the protective action implementation stage (Lindell and Perry, 2004, pp. 60-61).

Embedded within these stages of response are processes of information seeking (Lindell and Perry, 2004, pp. 61-63). When an individual realizes that they lack sufficient information regarding the hazard or protective actions to take, they go through a stage of information needs assessment to determine the information needed to reduce uncertainty (Lindell and Perry, 2004, p. 61). Next they determine where to get the information through communication action assessment (Lindell and Perry, 2004, p. 62). Sources of information will vary depending on the stage of the protective action decision and the channels of communication that are available. Once individuals have a communication plan, they go through the final stage, communication action implementation to determine if they need the information then and to find the information Lindell and Perry, 2004, pp. 62-63). This final stage can return to the previous two stages if information or channels are insufficient to meet their needs.

Cognitive and Conditional Factors

Response to hazards is not entirely dependent on communication of information and rational processes of decision making, as the public response model and PADM assume. People may make decisions that seem completely irrational, but are based in a set of cognitive or situational factors that play a part in the actions taken (see Figure 3) (Tobin and Montz, 1997). Cognitive factors are internal attitudinal and psychological aspects of an individual that shape their perceptions of nature and risk. Conditional factors are external socioeconomic and physical aspect, both real and perceived. Cognitive and conditional factors interact and influence one another. For example, mitigation attempts by the government, such as flood management, may

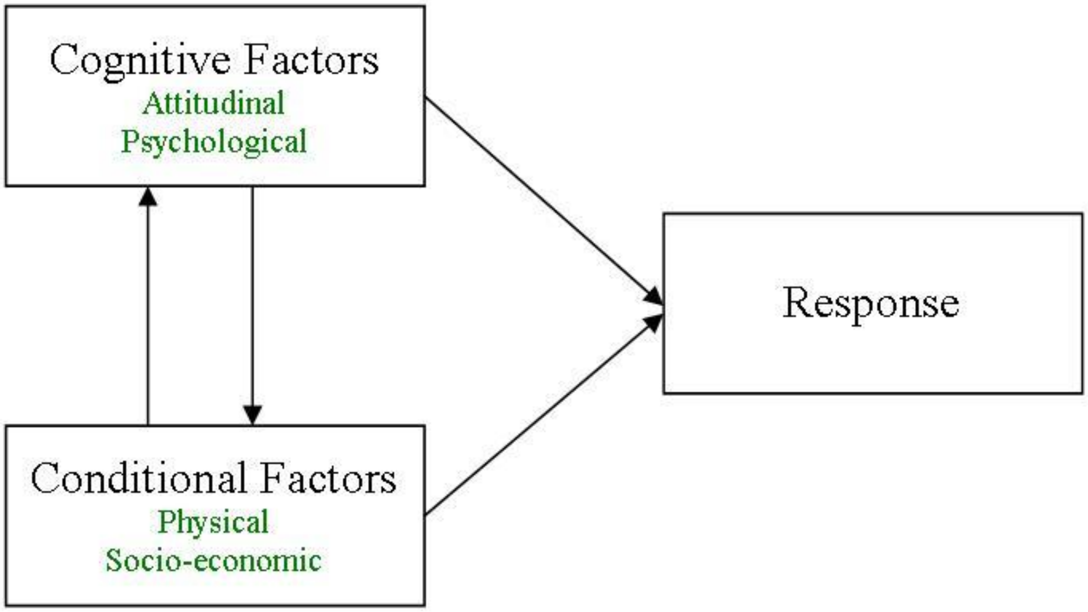

Figure 3: Cognitive and conditional factors role in response to hazards (from Tobin and Montz, 1997). Influences on these factors shown in green.

result in the perception that floods are no longer a hazard, thereby changing attitudes towards floods. For emergency managers, a change in attitude about flooding due to mitigation has been shown to be a reason for decreased monitoring of rainfall in favor of monitoring weather capable of producing tornados (Donner, 2008).

Utility Models and "Bounded Rationality"

Conventional economic theory suggests that people make purely rational decisions based on maximizing the utility of situations (Burton et al., 1993). This can be represented in expected utility models. Possible scenarios are represented as a matrix, with expected costs and losses for each scenario based on the uncertainty in the situation. According to the expected utility model, individuals will make the decision that ensures the least losses. In an alternative theory, the subjective expected utility model, individuals subjectively view outcomes and costs are assessed based on personal perceptions. Individuals will still act to minimize losses, though from a subjective point of view.

Expected utility models suggest that individuals understand all the facts, actions, and consequences of a decision. This is not always the case. Individuals work within a limited set of information and options. Even if all the facts are present, individuals may not be capable of processing all possible sets of information. They may also be working toward alternative sets of goals than purely economic outcomes. Individuals are thus using "bounded rationality," working within their bounds of information, options, potential outcomes, and social, cultural, or individual perceptions of what is important (Burton et al., 1993; Tobin and Montz, 1997). For example, Palm (1981) found that simply disclosing information to buyers in California that real estate was located within a "special study zone," previously termed a "geologic hazard zone," did not have a significant impact on purchase. The expected response, that buyers would refrain from purchases in hazardous zones or implement mitigation efforts if provided information, were not realized because of misunderstandings of the terminology, the credibility of the provider of the information, the way the information was presented, and perceptions of important factors in real estate purchases, namely that price and resale value were more important than proximity to a hazard zone.

PADM can, in turn, be affected by bounded rationality. The bounded rationality of individuals can determine warning response and the decisions made regarding protective action. For example, assessment of information is restricted to the capabilities of the individuals to understand it, which may be a product of their experience, training, perceptions of the information, or its quality. Misunderstandings can result in a domino effect throughout the rest of the warning response, resulting in what may appear to be an irrational response (Baumgart et al., 2008).

Probability and Uncertainty in Weather Forecasts and Warnings

Forecasts are inherently uncertain and the NWS wants to communicate weather information most effectively (National Research Council, 2006). The agency is working on new ways to communicate uncertainty in its public forecasts. While studies have shown that the exact definition of the forecasted event is commonly misunderstood (Gigerenzer et al., 2005; Murphy et al., 1980), the probabilities are understood (Murphy et al. 1980) and are a preferred method of receiving forecast information (Baker, 1995; Morss et al., 2008; Nadav-Greenberg and Joslyn, 2009). Other studies have found that uncertainty is best communicated through the use of frequencies, such as 1 in 200 (National Research Council, 2006). Uncertainty in forecasts has also been shown to improve decision making compared to deterministic forecasts (Nadav-Greenberg and Joslyn, 2009; Roulston et al., 2006), but these tend to be in idealized experimental designs that do not take into account other variables.

In a review of existing literature, the National Research Council (2006) concluded that there is a great deal of complexity in decision making under uncertainty based on the decision maker's experience, personality, risk threshold, contexts, and other sources of information. Because of this, no information product is "one size fits all" and products should be developed based on different stakeholder needs and wants. University decision makers represent one of these sets of stakeholders, and while this study will not examine the ways in which these decision makers use uncertainty to make decisions or the preferred methods of communicating this uncertainty, it will look at the way increased lead-time as a product of uncertainty may alter and change decisions and the contexts in which they are made.

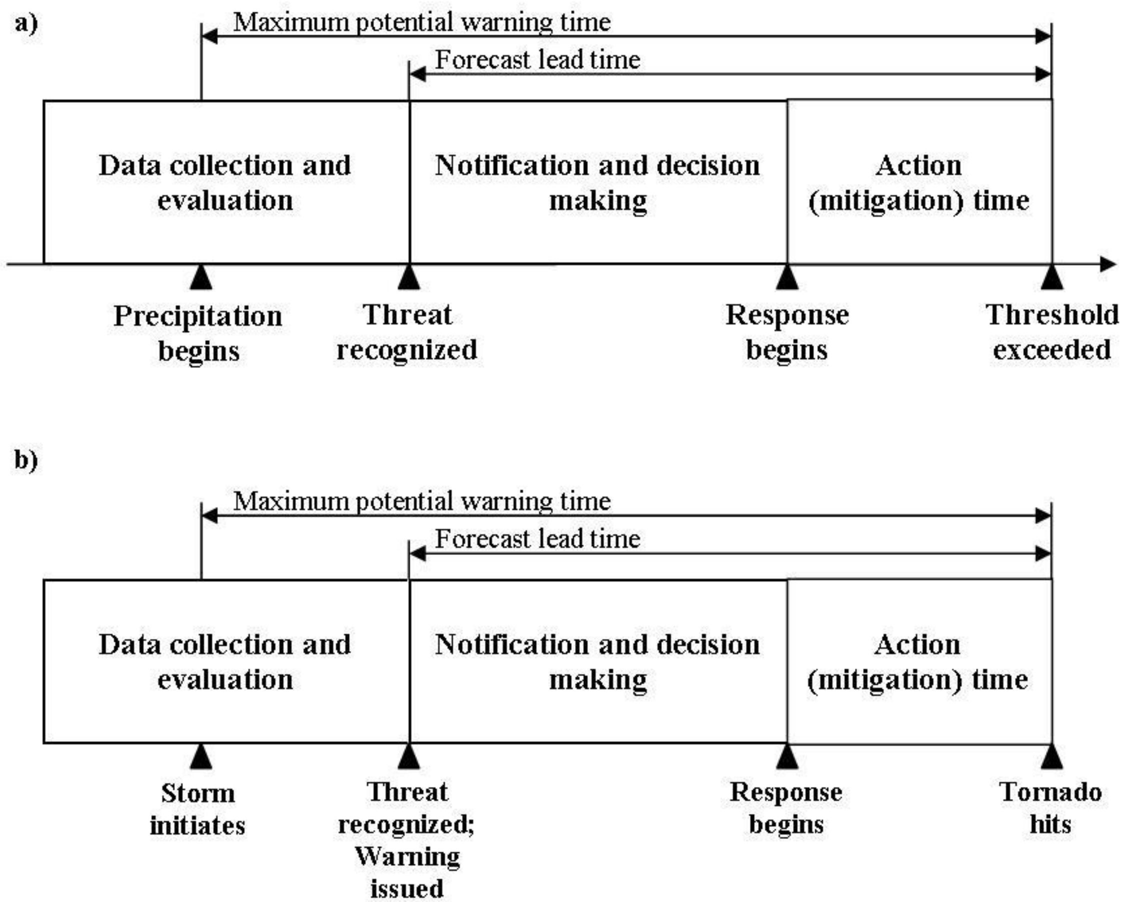

Figure 4: Models of lead time for a) floods (Pingell et al., 2005) and b) tornados (Schumacher et al., 2010).

Lead-Time

Lead-time is the amount of time between issuance of a warning by the NWS and the time the tornado hits (Schumacher et al., 2010). Lead-time provides the time necessary to initiate preparedness plans and take action prior to a hazard (Carsell et al., 2004). Carsell et al. (2004) created a model timeline for a flood warning system including detection of the event, analysis of the data, notification of emergency response personnel, decision making, and response. This model was modified by Pingel et al. (2005) to represent the lead-time in a flood warning system (Figure 4a), that was further modified by Schumacher et al. (2010) for tornado warnings (Figure 4b). While Figure 4 shows general models of data collection and evaluation, notification and decision making, and action, the time spent in any one of these stages impacts the time spent in the next. Therefore, the longer it takes to make decisions regarding protective action, for example to redisseminate the warning, the less time available for action to be taken (Carsell et al., 2004; Schumacher et al., 2010).

Probabilistic forecasts of tornados can increase current lead-times. A goal of the NWS is to increase tornado lead-time, and current lead-times have increased to an average of 13 minutes (Golden and Adams, 2000). Studies have varied in defining ideal lead-times from 15 minutes to 34.3 minutes (Ewald and Guyer, 2002; Hoekstra et al., 2010), and have shown that there is little benefit for lead-times longer than 15 minutes in terms of fatalities (Simmons and Sutter, 2008).

New research efforts aim to increase lead-times by orders of magnitude. For example the Warn-On-Forecast and Probabilistic Hazards Information systems are in development that will possibly increase lead-times by up to one to two hours, though these longer lead-times will be accompanied by greater uncertainty (Kuhlman et al., 2008; Stensrud et al., 2009). While the work done thus far has examined preferences and fatalities using current lead-times, the new tornado warning systems in development could alter the contexts in which people make decisions and respond. Little work thus far has taken into account the shift in warning response and decision making that may occur as a result of significantly longer tornado lead-times coupled with probabilistic hazard information, particularly within complicated operations like university emergency management. This thesis aims to understand the current uses of information, decision-making processes, and contexts in which these decisions are made by university officials in order to recognize what this change in warnings means for these stakeholders and how it can be developed with their input.

University Emergency Management

Hazardous weather information use and decision making by emergency management and other community decision makers, including university officials, is only beginning to be the focus of research (Baumgart et al., 2008; League et al., 2010; Morss and Ralph, 2007; Schumacher et al., 2010). While previous research efforts have focused on the preparedness, planning, and recovery phases of university emergency management (Collins et al., 2008; Curtis et al., 2006; Farber, 1982; Friesen and Bell, 2006; Hartzog, 1981; Human et al., 2006; Johnson, 2007; Kiefer et al., 2006; Osburn, 2008; Wilson, 1992) relatively little has focused on actual response to hazardous weather situations (Schumacher et al., 2010; Sherman-Morris, 2010; Zdziarski, 2001). This thesis builds on existing studies and provides new understanding of the contexts in which university officials make notification decisions during tornado warnings.

Universities are communities with their own particular sets of complexities in emergency management decision making (DOE, 2010). With large geographical spread, services such as utilities plants and law enforcement, small businesses on the campus, and residential housing, universities can resemble small towns that are embedded into larger communities. Some universities manage satellite operations and research facilities that can be geographically distant from the main campus. University borders are mostly uncontrolled, and its people and resources are in constant flux. University populations are legally autonomous and the individuals are capable of making their own decisions, yet the institution's decisions can influence or direct an individual's decision. Amidst these complexities, universities are legally responsible to disseminate warnings to the campus when there is a threat (Public Law 110-315). Given this responsibility, their roles in current warning systems theories and their processes of decision making during tornado warnings are unclear.

Conclusion

While research has been done to create models of warning systems and response, few studies have situated universities within these systems or investigated the validity of existing warning response models and bounded rationality theory for decision makers at universities. Understanding the processes in which university officials make decisions, and the way their sources of information and unique contexts and concerns in emergency management affect those decisions, can provide information for the socially relevant development of new tornado warning products and insight into the effects of a new warning paradigm on university decision making and response.

Research Design and Methodology

This study will examine three case studies of Universities that have been placed under a tornado warning during the spring severe storm season of 2011. Because of the complex structures of Universities, this thesis focuses on one element of the decision-making process. It seeks detailed description and explanations of decision making from multiple perspectives of university staff and partners involved in the redissemination of warning information through emergency notification systems.

Sampling Method

University case studies to be analyzed will be chosen during the spring severe storm season of 2011. Severe weather will be monitored via products released by the NWS through the use of the GovDelivery service, an email service that provides governmental updates from multiple agencies. These services provide email updates of NWS products, including outlooks

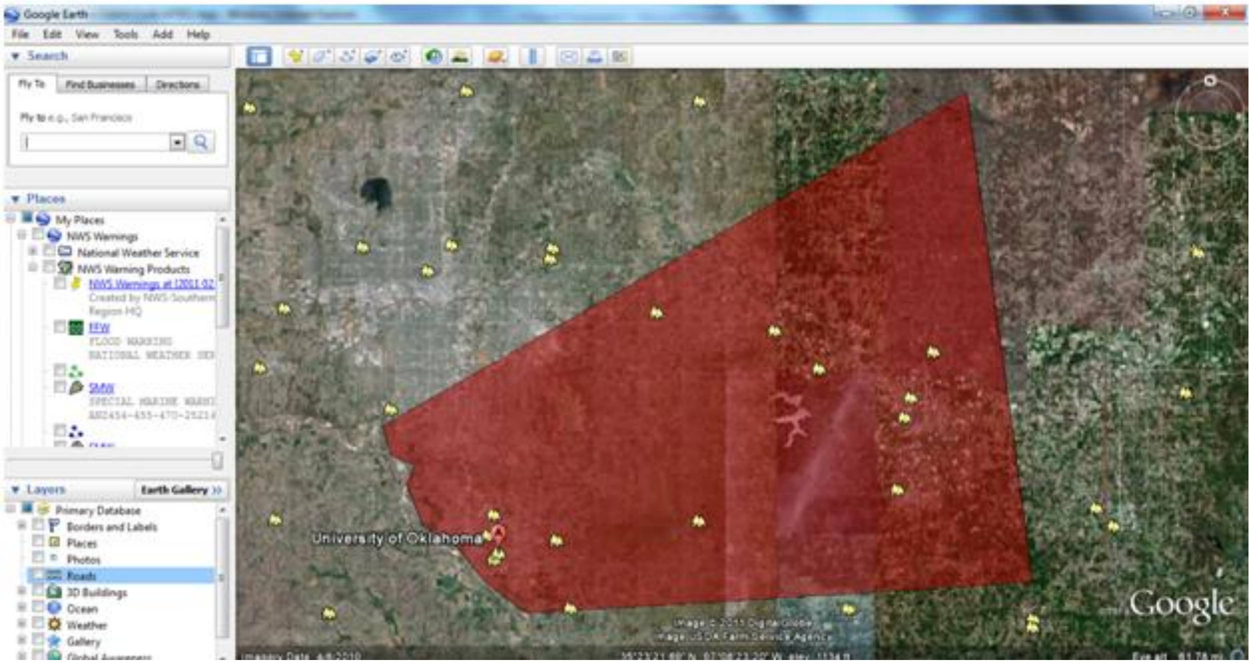

Figure 5: Example of an archived warning polygon in Google Earth with the University of Oklahoma displayed. The example is the Norman, OK tornado on May 10, 2010. (KML file from http://mesonet.agron.iastate.edu/current/severe.phtml)

and warnings. SPC Day 1, 2, 3 and 4-8 Convective Outlooks provide advanced notification of possible severe weather up to eight days in advance. SPC Tornado/Severe Thunderstorm Watches send notification when a watch is released by the NWS.

When severe weather is predicted, the issuance of warnings by the NWS will be monitored through the use of the Iowa Environmental Mesonet, an archive of NWS warnings that can be exported as Keyhole Markup Language (KML) files into Global Information Systems. Warning files will be uploaded into Google Earth and using the search tool within Google Earth, the location of universities and colleges will be displayed (see Figure 5). Search terms will include “university.” By zooming in on the warning polygon, searches are prioritized to those closest to the region automatically within the Google Earth programming. This data will be cross-referenced with the university’s website and campus maps to avoid inaccuracies. When a university or college is located within the warning polygon, it will be sampled for contact regarding participation in the research. The archive of the warnings also makes available

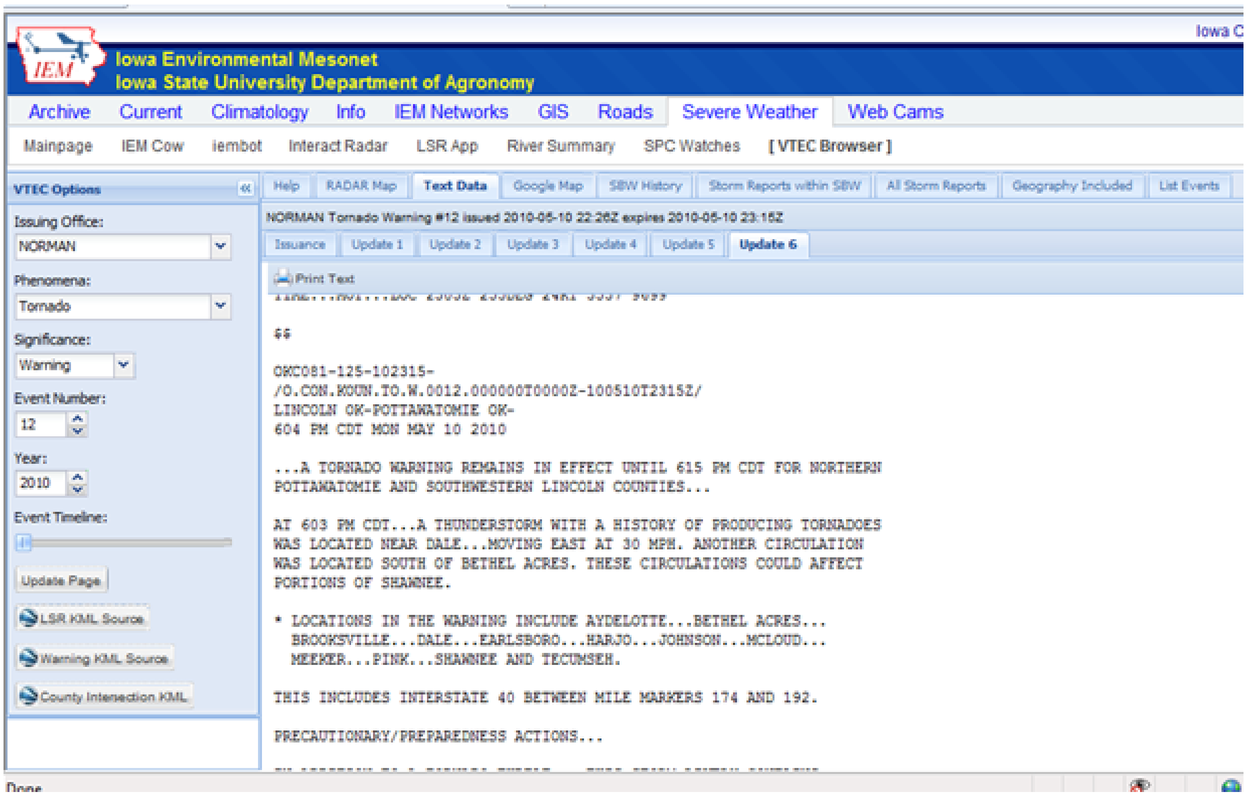

Figure 6: Example of NWS text warning from the Iowa Environmental Mesonet displayed in Mozilla Firefox. The example is the Norman, OK tornado on May 10, 2010. (http://mesonet.agron.iastate.edu/current/severe.phtml)

a copy of the text warning product released by the NWS, which provides additional spatial, temporal, and intensity information about the storm (Figure 6).

The sampling methodology will constrain the selection of cases to state universities that have a campus population over 5000 students, and are Title IV institutions. The public status of universities was determined by Hartzog (1981) to be a unifying factor in planning for emergencies. The campus population over 5000 was determined in a previous study (Hartzog, 1981) to be a large enough population to constitute a need for emergency planning. Campus population will be determined through the use of Internet searches on the institution's website for demographic information. Title IV institutions are legally required to provide emergency notification to students at the time of a threat on campus, and were thus chosen as they are those most likely to provide emergency notification during tornado warnings (Public Law 110-315).

The Title IV status of institutions will be determined through a search of the Federal School Codes supplied by the Federal Application for Student Financial Aid program.

These sampling methods will give insight into actual behavior during a warning rather than planned, perceived, or possible behaviors, and unlike previous studies done on tornado response at universities (Schumacher et al., 2010), data collection will take place as soon as possible after the event. The questions of the research request participants to remember times, locations, sources of information, and decisions during a tornado warning affecting their institution's campus. These methods of sampling ensure the most complete recollection of memory possible while maintaining ethical and legal guidelines.

Initial interviews will be with the emergency manager at the institution. Because of the differences among universities, the title and department of the emergency manager can vary between institutions, including the University Police Department, Department of Environmental Health and Safety, Office of the President, and others. The emergency manager will be determined on a case-by-case basis through the use of internet searches. If the emergency manager cannot be determined through internet search, the institution will be contacted and asked for the department where the emergency manager is located. In the instance that the institution does not have a designated emergency manager, the individual responsible for monitoring the weather will be determined.

After the determination of the emergency manager (or equivalent positions) snowball sampling will be used to determine the key decision makers in the emergency notification process for each university. Participants will be asked to identify decision makers, both on and off campus, who will then be contacted to request participation in the study. Additional decision makers may include administrative positions, food and housing services, police departments, local or county emergency managers, or weather information providers. Snowball methods are used because of the unique structures of universities and will ensure that sampling methods for participants are relevant to the individual institution. Snowball sampling provides a more complete analysis of each institution's decision-making process by identifying as many decision makers as possible for each institution.

Data Collection

Data collection will take place through the use of semi-structured interviews with participants. Semi-structured interviews provide a series of questions and topics for discussion, but will also allow unexpected information and themes to be explored on a case-by-case basis. Because Universities and severe weather information have not been studied in detail, this data collection process will allow for the participants to provide their perspectives on information sources and warning response but also allow for the collection of data considered important by the researcher from analysis of the literature on emergency management, warning response, and the dissemination of warnings.

Interviews with participants will consist of multiple parts during one interviewing session, which will take place over the telephone or in person. Participants will be asked for demographic information about the institution including their role in the institution, weather monitoring at the institution, and emergency notification systems. The next three parts of the interview will investigate decision making, communication, and sources of information during the tornado warning with regards to the redissemination of warnings. This will include questions regarding factors beyond weather information that influenced decision making, possibly including technological limitations, the hierarchy of the institution, institutional policies, the relationship between the institution and its local surroundings, time of the warning, events on campus, and others that may not be recognized at this time. The last portion of the interview will ask the decision maker what other information would be helpful in making future decisions the next time there is a tornado warning. This portion of the interview will include scenario based questions regarding the effect of varying lead-times coupled with probabilities of impact phrased in familiar terminology following the structure of probability of precipitation. This terminology is used to investigate complex and abstract concepts of products under current development in ways that are more familiar to today's weather information users. See Appendix 1 for a preliminary list of interview questions. These questions will be reviewed to determine places where the questions should be reworded or removed.

Data Analysis

Data analysis will be done in two parts. The first part will be detailed descriptions of the case studies. A template will be made that allows comparison between the cases. These will consider multiple factors which played a role in the event including sources of information, communication structures at the institution, decisions made during the warning, and factors leading to those decisions, both weather and non-weather related. The second portion of analysis will be comparisons between cases, including thematic analysis based on the PADM and bounded rationality theoretical frameworks, similarities and differences in decision-making processes and contexts, and future needs of weather information. The second part of the analysis will be used to make recommendations for future studies and formulate preliminary hypotheses on universities and tornado warnings.

Both individual analysis and comparisons of case studies will produce decision-making timelines, showing when information sources are accessed, internal and external communication, and decisions made throughout the duration of warnings. Individual case studies will produce timelines specific to those cases while comparisons will produce general models of timelines, if applicable. These general models can later be used to produce hypotheses about decision making by university officials for future studies.

While this study will not explain how every university official makes decisions during tornado warnings, the results will provide evidence of how information is used in decision making by specific cases of university decision makers. This information will be used to make recommendations to weather product developers at the HWT in the development of new tornado warning products, with particular emphasis on the impacts of increased lead-time with probabilistic hazard information. Meteorological research has been a technologically driven process, and the development of products has been top-down without the input of social science research and stakeholder perspectives. This study will help to narrow the gap between research and operations by bringing the perspective of a subset of weather information stakeholders, university decision makers, to the attention of meteorological researchers.

Presentation of Results

Preliminary results will be presented to the Weather Warnings and Communication Conference on June 23-24, 2011 in Oklahoma City, OK in collaboration with a similar project on K-12 schools by Stephanie Hoekstra, and at the American Anthropological Association Annual Conference on November 16-20, 2011 in Montreal, QC, Canada in collaboration with Dr. Heather Lazrus and Stephanie Hoekstra. Results will be presented to the funding agency at the EWP Brown Bag Lunches, a forum for the discussion of research and developments pertaining to the HWT. Results will also be presented to the Warn-On-Forecast Annual Workshop in 2012, as the results will be of interest to the Warn-On-Forecast project, which works closely with the HWT. Participants will be offered copies of the final project and the results will be presented to the International Association of Emergency Managers University and Colleges Caucus Workshop in 2011 if there is interest from the workshop organizers and available funding. Abstracts will be submitted to the American Meteorological Society Annual Conference and Association of American Geographers Annual Conference for 2011 depending on available funding.

Schedule for Research

Semester	Research Activities
Spring 2011	-Approval of proposal -Approval of IRB application -Case selections -Interviews
Summer 2011	-Completion of interviews -Data analysis -Abstract accepted for Weather Warnings and Communication Conference in Oklahoma City, OK on June 23-24, 2011 -Follow-up interviews if necessary
Fall 2011	-Completion of follow-up interviews if necessary -Completion of data analysis -Begin thesis write up -Abstract accepted for American Anthropological Association Annual Conference in Montreal, QC, Canada on November 16-20, 2011
Spring 2012	-Complete thesis write up -Thesis defense -Presentations of research at American Meteorological Society and Association of American Geographers annual meetings

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Appendix 1: Interview Script

Hello, my name is Amy Nichols and I am working on a research project for Social Science Woven into Meteorology in collaboration with the National Oceanic and Atmospheric Administration's Hazardous Weather Testbed. I am a graduate student in the Department of Geography and Environmental Sustainability at the University of Oklahoma. This research will be part of a master's thesis requirement and the results will be provided to Hazardous Weather Testbed to be used in the development of new tornado warning tools and products.

You were previously contacted to request your participation in this research and you have signed a consent form agreeing to this interview. If you have any questions regarding this consent form, please ask at any time.

If they agreed to be recorded:

On your consent form you agreed to have this interview recorded. To maintain confidentiality, please use department names or titles instead of names of people in your responses. If you do not wish to have this interview recorded please inform me and I will turn the recorder off. Do you still consent to have this interview recorded?

We are now ready to begin the interview. You may request to end this interview at any time. Any information given will remain confidential. The interview will take approximately one hour to complete. If any questions are unclear, please let me know and I will clarify.

Confirmation of Involvement

1) Were you on duty at the time of the tornado warning on (insert date and time)?
   If no...

   a. Were you involved or consulted in making decisions at your institution regarding the emergency notification of students during the tornado warning?
      If yes...

      i. What time did you become involved in making decisions at your institution during the tornado warning?
      If no...

      (Go to *Thank You Statement B*.)

2) At any time during the warning, were you aware that the National Weather Service had issued a warning for your area?
   If no...

   (Go to the *Thank You Statement B*)

Demographic Information

3) What is your role or position at your institution?
4) What are your responsibilities at your institution?

5) How long have you held your position at your institution?
6) What are the main hazardous weather threats your institution faces?
7) Using only their titles, who is responsible for monitoring the weather at your department?
    a. Is this person responsible for monitoring the weather for all departments and offices at your institution?
        If no...
        i. Using only their titles, who else is responsible for monitoring the weather at your institution?
8) Does you institution usually activate emergency notification systems during hazardous weather warnings?
9) Only supplying their title, who authorizes activation of the emergency notification systems?
10) Only supplying their title, who activates the emergency notification systems?
    If they are the responsible party...
    a. What types of emergency notification systems (for example sirens, text messages, email, PA systems, etc.) does your institution usually operate during tornado warnings?
    b. How long does activation of those emergency notifications take?
    c. If known, how long does it take for those emergency notifications to reach their intended audience?
    d. If known, how many people/much of campus do those emergency notification systems reach?
    e. Which, if any, of those emergency notification systems are text or verbally based?
        If text or verbally based emergency notification systems are used...
        i. Only supplying their title, who creates the content of the message?
            If the participant is the responsible party...
            1. Are previously written message templates used for text or verbal emergency notification systems?
    f. What types of emergency notification systems does your institution operate that are not used during a tornado warning?
        i. Why are these emergency notification systems not activated during a tornado warning?
        ii. What barriers are there to using these systems during a tornado warning? For example, technological problems, does not reach campus fast enough, does not notify enough people?

Recent Warning Experience

Prior to Warning

11) Prior to the tornado warning, were you aware of the possibility of hazardous weather at your institution?
    If yes...
    a. When did you become aware of the possibility of hazardous weather at your institution?
    b. How did you learn that there was the possibility of hazardous weather at your institution?

c. What actions did you take to prepare for the possibility of hazardous weather at your institution?
d. Who did you communicate with about the possibility of hazardous weather at your institution?
    i. When did you communicate with them?
    ii. Why did you communicate with them?
e. Were campus notification systems used to notify the campus of the possibility of hazardous weather?

    If yes…

    i. Which systems were used?
    ii. Why were these systems used?
    iii. When were they activated?
    iv. Who activated them?
    v. What information was distributed?
    vi. Are notification systems typically used to notify the campus of the possibility of hazardous weather?

    If no…

    vii. Are notification systems typically used to notify the campus of the possibility of hazardous weather?
f. What sources of weather information did you use to make these decisions about the possibility of hazardous weather at your institution?
    i. When did you access these sources of weather information?
    ii. Why did you use these sources of weather information?
    iii. What did you learn from these sources of weather information?
g. What other factors were considered in making these decisions about the possibility of hazardous weather at your institution?

Initial Response

12) Regarding the tornado warning on (insert date and time), how did you learn your institution was under a tornado warning?
    a. Why did you use this source to learn about the tornado warning?
    b. What did you learn from this source of information?
    c. Is this different than your usual source of information regarding tornado warnings?

        If yes...

        i. What is your usual source of information regarding tornado warnings?
        ii. Why was this not your source of information on (insert date and time of warning)?
13) At what time did you learn your institution was under a warning on (insert date and time)?
14) What were you doing when you learned your institution was under the tornado warning?
    a. How did this influence your perceptions of the tornado warning?
    b. How did this influence your decisions about the tornado warning?
15) What was your first action after learning your institution was under the tornado warning?

16) At what time was your first action after learning of the tornado warning?
17) Using only their title, who did you first communicate with after learning of the tornado warning?
    a. What method did you use to communicate with them?
    b. What information was communicated?
    c. Why did you communicate with this person?

Re-dissemination of Information

18) What systems of emergency notification were activated during the tornado warning, if any?
    If none...
    a. Why were systems of emergency notification not activated for this event?
    (Go to *End of Event*)
    If yes…
    b. Were there problems in disseminating the information?
        i. What problems did you encounter in disseminating the information?
        ii. How were these problems resolved?
    If different from answers to question 11.a...
    c. Why were (insert unmentioned emergency notification systems) not used during this tornado warning?
19) When were notification systems activated during the tornado warning?
20) If known, how long did dissemination/activation of the emergency notification systems take?
21) Which textual or verbal emergency notification systems were activated during the tornado warning?
    If textual or verbal information was disseminated...
    a. What was the content of the message?
    b. When was it written?
    c. Who wrote the message?

Course of Incident

For this portion of the interview, I am going to ask you walk me through your decision-making process over the course of the tornado warning with regards to the emergency notification of the campus. I will ask about what actions were taken, who you communicated with, sources of information, and additional factors influencing your decisions. I am going to create a timeline of events from this information. Please be as specific as you are comfortable with.

(For each response to question 22 ask questions 23-25)

22) What actions did you take over the course of the tornado warning regarding emergency notification of students?
23) Using only their title, who did you communicate with over the course of the tornado warning regarding emergency notification of the campus?
    a. What method did you use to communicate with them?
    b. What information was communicated?

c. Why did you communicate with this person?

24) What sources of weather information did you use to make decisions through the course of the tornado warning, if any?
    a. When did you access these sources of weather information?
    b. Why did you use these sources of weather information?
    c. What did you learn from these sources of weather information?
25) What other factors were considered in making decisions about emergency notification of the campus during the tornado warning? For example, special events on campus or off-campus populations.
    a. How did these factors influence the decisions made about emergency notification of the campus?

End of Event

26) What sources did you use to learn that the tornado warning was over?
    a. Why did you use these sources?
    b. When did you use these sources?
    c. What did you learn from these sources?
27) What time did you learn that the tornado warning was over?
28) What actions did you take when you learned that the tornado warning was over?
29) Using only their title, who did you communicate with when you learned the tornado was over?
    a. What method did you use to communicate with them?
    b. What information was communicated?
    c. Why did you communicate with this person?
30) Did you notify the campus that the tornado warning was over?

    If yes...
    a. What methods were used to notify the campus that the tornado warning was over?
        i. Why were these methods used to notify the campus that the tornado warning was over?

Future Weather Information Needs

31) What information would have improved performance of your job during the tornado warning?
32) Would increased lead-time have changed the decisions you made during the course of the warning?

    If yes...
    a. What amount of lead-time would have changed the decisions you made?
    b. How would increased lead-time change the decisions you made?

    If no...
    c. Why would increased lead-time not change the decisions you made?
33) If you were provided increased lead-time but a decreased probability that the tornado would occur, would this change the decisions you made? For example, you are informed that there is a 30% chance of a tornado striking your institution two hours from now; would this change the decisions you made?

    If yes...

a. How would this change the decisions you made?
b. What actions could you take with this information that you were unable to take during the tornado warning on (insert date and time)?

34) You are informed that there is a 70% chance that a tornado will strike your institution in 15 minutes; would this change the decisions you made?

If yes...

a. How would this change your response?
b. What actions could you take with this information that you were unable to take during the tornado warning on (insert date and time)?

35) Do you have any further comments you wish to include?

36) Would you consent to being contacted for follow-up questions or clarification?

If yes...

a. What is your preferred method to receive a consent form for follow-up questions?

Snowball Sampling

As part of my research methods I am using a technique called snowball sampling. For this technique, participants are requested to provide information regarding possible additional participants for the study. This technique ensures that all relevant decision-makers are contacted regarding your institutions response to the tornado warning. During this interview you indicated that you contacted (list the titles of those mentioned in the interview).

37) Which of these people were involved or consulted in making decisions about emergency notification of the campus during the tornado warning?
38) Are there any additional people you recommend I speak with who were involved or consulted in making decisions about emergency notification of the campus during the tornado warning?

Thank You Statement A

This concludes the interview. If you have any questions or comments regarding this interview please contact me at Amy.C.Nichols-1@ou.edu or (352)328-1190. If you have any questions for my advisor, please contact Dr. Eve Gruntfest at egruntfest@ou.edu. Thank you for your time and cooperation.

Thank You Statement B

Because this research is about hazardous weather warning response by institutions of higher education, this concludes the interview. If you have any questions or comments regarding this interview please contact me at Amy.C.Nichols-1@ou.edu or (352)328-1190. If you have any questions for my advisor, please contact Dr. Eve Gruntfest at egruntfest@ou.edu. Thank you for your time and cooperation.

Appendix 2: List of Acronyms

Name	Acronym
Cooperative Institute for Mesoscale Meteorological Studies	CIMMS
Experimental Warning Program	EWP
Hazardous Weather Testbed	HWT
Institutional Review Board	IRB
National Oceanic and Atmospheric Administration	NOAA
National Weather Service	NWS
Probabilistic Hazard Information	PHI
Protective Action Decision Model	PADM
Social Science Woven Into Meteorology	SSWIM
Storm Prediction Center	SPC