2.2 Socio-Economic Impacts of Storm-based Warnings

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1. INTRODUCTION

The National Oceanic and Atmospheric Administration's National Weather Service (NWS from here on) is planning to implement a major change to convective warnings including tornado, severe thunderstorm, and flash flood warnings. Up until now, these warnings have included entire counties or parishes. Under this county-based system, the risk of severe weather was often only high for a small portion of the area actually warned, and large segments of the population were sometimes needlessly warned to take shelter from the storm. The NWS is planning to change to smaller, "storm-based" warnings. The area under warning is defined by a set of latitude and longitude points. These defined areas are easily ingested by graphical applications such as Geographic Information Systems (GIS) and allow interactivity with other data fields such as radar reflectivity, county borders, roads, topography, etc. (Waters, 2005).

In this paper we identify several policy and socio-economic challenges to the implementation of storm-based warnings. Policy makers require both statistically sound and understandable performance metrics. Storm-based warnings require a change in verification methodology to match the change in warning methodology (Browning, 2002). Another challenge is to provide service for the portion of the public that receive warnings over the radio. This service is limited by the ability to describe the storm location and movement in a text format. The importance of location accuracy must be balanced by the ability of the user of the information to understand the location.

A critical element of the change to storm-based warnings is a strong commitment to collaboration between the NWS, academia (both in weather and social sciences), emergency managers, broadcast meteorologist, and private sector companies involved in the dissemination of warnings. This collaboration will help ensure that storm-based warnings are both effective and properly utilized, resulting in successful protection of life and property.

2. SOCIO-ECONOMIC IMPACTS

The storm-based system will make possible the warning of small portions of individual counties or adjoining counties, exactly matching the perceived area of threat. Some studies have shown that numerous county warnings over the course of an event have a "numbing" effect among the public (Schmidlin, 1997). Currently, warnings are issued for entire counties or parishes even if only a small portion of the county is forecast to be impacted by the storm. This is especially problematic in the western U.S. where counties are considerably larger than some states in the eastern U.S. (San Bernardino County California is 13 times larger than the state of Rhode Island). The storm-based system will make possible the warning of small portions of individual counties or adjoining counties, only warning that portion of the population in the path of the storm.

During 2005, several NWS Forecast Offices (WFOs) participated in a test to demonstrate the use of these smaller-than-county areas for convective warnings with several positive outcomes. During the test period, the offices averaged a reduction of 70 percent in the area covered by warnings. Emergency management and other disaster response agencies served by these warnings were able to focus their limited resources on smaller areas. Forecasters reported the ability to communicate tornado threats to the public with increased specificity, accuracy, and clarity. "One of the clearest and most consistent conclusions of social science research is that the warning message itself is one of the most important factors in determining the effectiveness of a warning system." (Mileti and Sorensen, 1990)

A recent scientific study by University of Oklahoma Economics Professor Dan Sutter concluded Storm-Based warnings will save the economy *hundreds of millions* of dollars in reduced cost of sheltering (Sutter, 2006).

3. DISSEMINATION

Storm-based warnings are well placed to take advantage of modern dissemination technologies. New technologies, such as Geographic Information Systems (GIS), Digital Emergency Alert System (DEAS), Common Alerting Protocol (CAP), Valid Time Event Coding (VTEC), Extensible Markup Language (XML), Real Simple Syndication (RSS) and others can be leveraged to disseminate digital graphical data such as storm-based warnings directly to large portions of the population in real time.

The NWS has partnered with Department of Homeland Security's Federal Emergency Management Agency (FEMA), numerous telecommunications companies, Internet service providers, and radio and

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television stations to develop and test the Digital Emergency Alert System.

The new Digital Emergency Alert System (DEAS) could be used to send the graphical storm-based warnings over a variety of media including digital television, personal digital assistants (PDAs), cell phones, and basic telephone service via reverse 911 capabilities. The Association of Public Television Stations (APTS) and the Department of Homeland Security (DHS) recently successfully demonstrated the ability to transmit data over the digital broadcast signal of public television stations. Currently, 99 percent of American household receive a signal from one or more public television stations (FEMA APTS DEAS Fact Sheet, 2006).

Studies of public response to warnings show that the majority of the American public obtains weather information via television. For instance, 85 percent of the survivors of the April 8, 1998 tornado in Birmingham, Alabama reported becoming aware of the approaching tornado via television (Legates, 1999). While 70 percent reported receiving warning via television during the May 4, 2003 tornadoes in Kansas, Missouri, and Tennessee, with an even larger percentage (76 percent) reported hearing warning sirens (Paul, 2003).

In many communities the public also relies heavily on siren systems (Paul, 2003). Some cities have recently purchased siren systems capable of selectively alerting neighborhoods. Instead of sounding sirens for an entire metropolitan area, with storm-based warnings emergency managers could selectively sound sirens only for those in path of a dangerous storm.

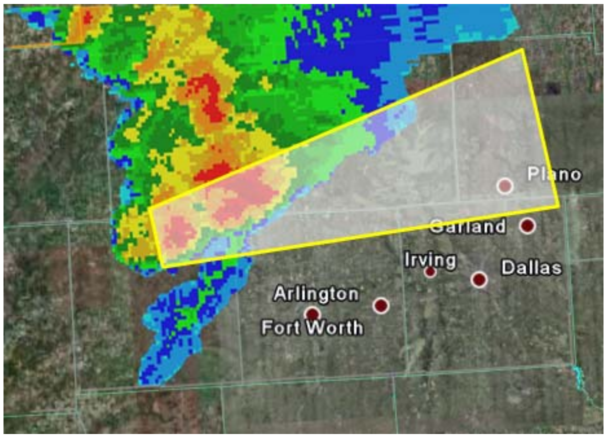

Figure 1: Most of the Dallas/Fort Worth metroplex is correctly omitted from this storm-based tornado warning. New siren system selectively activated.

Existing internet technologies such as Extensible Markup Language (XML) and Real Simple Syndication (RSS) could be used to push storm-based warnings over the internet and directly to e-mail. The current NWS display of weather radar data called RIDGE (Radar Integrated Display with Geospatial Elements) allows the radar image to be combined with geospatial elements such as topography maps, highways, and county boundaries. RIDGE also adds the ability to overlay storm-based warnings issued by NWS Forecast Offices (Stellman, 2005). These displays are currently displaying the warning polygons of highest threat.

This combination of digital dissemination technologies has the potential of directly reaching a much larger portion of the population. Although difficult to quantify, there is potentially a tremendous positive impact of increasing the direct dissemination of warnings to the public. An analysis of casualties during 1986 to 1999 reveals that tornadoes occurring during the night are much more dangerous than comparable tornadoes during the day. Fatalities were 66% lower, and injuries were 47% lower during the day than at night (Simmons and Sutter 2005). Alerting the sleeping population through direct dissemination of warnings would likely result in a significant reduction in loss of life.

The text portion of the warning is still vital for the radio listening audience (including NOAA Weather Radio). Many television stations also simulcast the audio over local radio station during warning events. The challenge is to improve on the service currently provided to the listening public. Some changes have already occurred, with some warnings including directional delimiters (e.g., “A Tornado Warning is in effect for Southwestern “X” County). Also, format changes to include additional communities, landmarks, and even highway mile markers will be reviewed by partners in the media and private sector during testing in 2007.

To ensure that the format of storm-based warnings meet the needs of both the public and private sector, Texas A&M University hosted a collaborative technical workshop on December 5-6, 2006. The purpose of this workshop was to facilitate a discussion between the public sector (NWS, FEMA, and emergency managers) and private sector companies to set technical format requirements for these new storm-based warnings. Additional information on the outcome of this workshop is available from the authors.

4. PERFORMANCE MEASURES

New performance metrics and goals are needed to implement storm-based warnings beginning as early as October 2007. The current system of performance measures will no longer be relevant. Although the same types of measures the public already understands will be used, new baseline goals for these storm-based measures are being developed using data from the test in 2005. The three primary types of measures are storm-based warning:

- Accuracy (was the event forecast?)
- Lead Time (how much advance notice?)
- False Alarm Rate (did the event occur when it was forecast – or not?).

The new storm-based metrics will allow us to better measure true forecaster performance because the storm-based warnings will exactly match the area of perceived threat. The forecasters will know they are evaluated on their ability to forecast the developing threat and the movement of the storm without regard to the location of the county boundaries (Browning, 2002). In addition, public trust in severe weather warnings will increase because the public will come to understand that they are specifically threatened when a warning is issued.

The NWS will maintain internal statistics on reduction in area warned to demonstrate the continued economic benefit of the move to storm-based warnings. Performance metrics will also continue to evolve as knowledge of the public perception of warnings grows. Important studies such the ongoing National Science Foundation funded study "The Warning Project: Toward Improved Warnings for Short Fuse Weather Events" will increase our knowledge of public perception of warnings (Benight, 2005).

5. FUTURE ACTIVITIES

During the upcoming year, considerable outreach activity within the NWS is planned prior to the implementation of storm-based warnings. This planned change will not work unless it works for private sector vendors of NWS warnings, emergency managers, and the media. Over the next few months several meetings and briefings are planned to gather input on important aspects the dissemination of storm-based warnings.

NWS forecasters must also be capable of producing quality storm-based warnings prior to implementation. This will involve gathering input on important aspects of the concept of operations, insuring that software is developed to support operations, and to develop and deliver high quality forecaster training.

Communication is crucial between all parties, and the authors encourage input from all parties. The e-mail address is included for the lead author.

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