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THE KILLER TORNADO OUTBREAK OF 3 MAY 1999: APPLICATIONS OF OK-FIRST IN RURAL COMMUNITIES

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1. INTRODUCTION

The OK-FIRST program was developed, beginning in October 1996, as a formal educational outreach program of the Oklahoma Climatological Survey. The goal of OK-FIRST was to develop a transportable, agency-driven information-support system that helped public safety agencies harness the information age. The desired impact of OK-FIRST was documentable improvements in how public safety agencies (fire, police, and emergency management) responded to weather emergencies.

Today, over three years later, more than 100 public safety agencies — in support of their respective missions — have received formal training in how to access and use many new forms of environmental information via OK-FIRST (*e.g.*, data from the Oklahoma Mesonetwork, volume-scan data from 15 WSR-88Ds, and other data from the modernized National Weather Service [NWS]). By design, most communities served by OK-FIRST represented rural areas of Oklahoma (e.g., ~50% have populations of 5,000 or less). As a result of having been "modernized" by OK-FIRST, public-safety agencies across Oklahoma have achieved numerous success stories from the application of OK-FIRST data.

The most revealing testimonials about the effectiveness and robustness of OK-FIRST occurred on 3 May 1999 — a day of unparalleled killer tornadoes that impacted central and northern Oklahoma (Fig. 1). Because the meteorological community of Oklahoma (including the NWS and the broadcast media) performed superbly in dealing with the well-over 50 tornadoes, the death and injury toll was amazingly limited to 44 fatalities and 700+ injuries. This tornado outbreak was responsible for damage to or destruction of nearly 10,000 houses and buildings across the state. The impact of the storms on several rural towns was immense. The Town of Mulhall lost most of its buildings including its churches, school, and post office. In a matter of minutes, one tornado eliminated over 50% of the tax revenue for the City of Stroud by destroying its three major employers — who chose not to rebuild their facilities.

However, as major media outlets properly focused on the widespread death and destruction across heavily-populated central Oklahoma, the OK-FIRST system passed a major, critical test. For example, OK-FIRST servers shared over 36,000 files of WSR-88D information with public-safety users on 3 May. In addition, many significant, life-saving success stories from rural Oklahoma — *which did not make the national headlines* — provided convincing evidence that OK-FIRST played an important role in saving the lives of many Oklahomans on 3 May 1999. The purpose of this manuscript is to share some of these "untold stories".

2. HISTORICAL CONTEXT

During the recent past, Oklahomans have contended with lengthy droughts, severe flooding, bouts of damaging thunderstorms, and significant tornado outbreaks. Even in "more normal" periods, "non-severe" weather regularly affects human activities such as outdoor entertainment events. In addition, responses to wildfires, hazardous materials incidents, and acts of terrorism are impacted by environmental conditions. Before OK-FIRST, Oklahoma was a microcosm of the entire country in how agencies responded to emergencies in that *local decision-support systems generally suffered from a near-complete lack of current and relevant environmental information*. With OK-FIRST, Oklahomans have made great strides in local responses to weather-impacted emergencies; this manuscript documents some of this progress.

Over the past thirty years, much evidence has accumulated to suggest that the National Weather Service (NWS) was disconnected from outside agencies due to outmoded dissemination policies. Access to NWS information by local officials nationwide was cumbersome, expensive, non-intuitive, and lacked critical details. In addition, the NWS occasionally did not *receive* critical storm or flood reports and thus could not produce appropriate warnings. Morris *et al.* (2000) compiled thirty years of this evidence, including:

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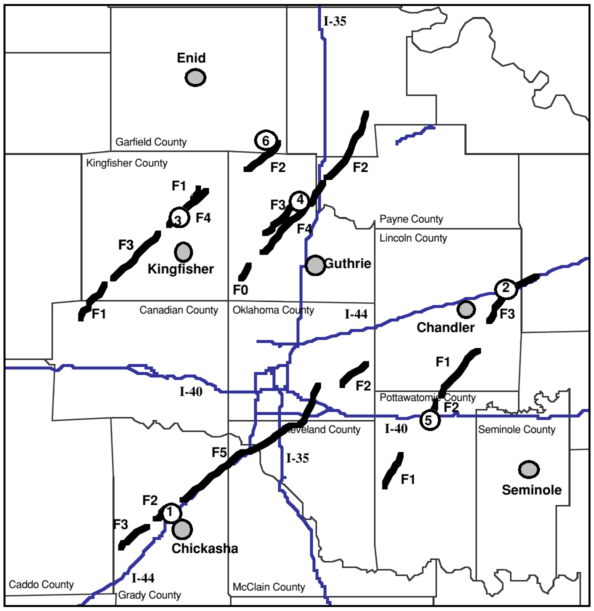

Figure 1. Approximate damage paths and Fujita damage ratings for many of the tornadoes in central Oklahoma on 3 May 1999. Gray circles locate emergency management offices discussed in the text. Numbered circles denote areas impacted by decisions based on OK-FIRST: 1. Chickasha Municipal Airport; 2. City of Stroud and Tanger Outlet Mall; 3. Town of Dover; 4. Town of Mulhall; 5. I-40 exit near Shawnee. Adapted from NOAA (1999).

- In a U.S. Weather Bureau report entitled "The National Research Effort on Improved Weather Description and Prediction for Social and Economic Purposes" (1964), a select panel concluded that "informed decisions on the part of users of weather information are needed if such information is to be translated into beneficial actions." The panel also found that research in improving the link between meteorological service and the users of weather information was markedly deficient. The report stated that several major user groups received little or no attention from the meteorological community (U.S. Weather Bureau 1964).
- While local NWS offices issued tornado warnings with adequate lead time, 42 lives (20 at one church) were lost during the 27 March 1994 Palm Sunday Tornado Outbreak. Though warnings were disseminated using NOAA Weather Radio, local officials and citizens at risk did not receive notification because of the "limited resources many rural county emergency managers and law enforcement officials had at their disposal for receiving the emergency messages and enacting their response plans" (National Oceanic and Atmospheric Administration 1994).

The $4.5 billion modernization of the NWS of the 1990s exacerbated this data-telecommunications problem by producing vast amounts of high-quality, county-scale information with no viable delivery mechanism to those ultimately responsible for making life-and-death decisions. In addition, rural areas — traditionally under served by telecommunications and technology — were at especially high risk. Consequently, local officials made weather-impacted decisions without adequate information (*e.g.*, storm spotters were deployed precariously because coordinators lacked information about storm location, movement, and intensity).

The NWS improved its infrastructure to take advantage of advanced observation platforms like NEXRAD and satellites and modern computer workstations. Despite dramatically improved forecasting and warning capabilities and tremendous data resources *within* the federal government, many of the associated benefits were beyond the financial reach of local officials (Crawford *et al.* 1999). Time after time during the past 15-20 years, the NWS made correct decisions involving the issuance of severe weather warnings based upon timely and modern information. Yet, because adequate dissemination systems *designed for local officials* did not exist, decisions affecting the protection of citizens frequently were made without the benefit of critical and local information.

3. HISTORY OF OK-FIRST

The OK-FIRST "information support system", introduced by Crawford et al. in 1998, was intended to fill a recognized "service void" in Oklahoma's weather-warning system by building information bridges between the modernized NWS and the unmet, but critical need for information in rural areas during emergencies. It was built upon successes in implementing the Oklahoma Mesonetwork and its K-12 educational outreach program known as EARTHSTORM (McPherson and Crawford 1996).

Critical design decisions included evolving OK-FIRST into a "web-based" decision support system (Morris 1998) built around Internet browsers, plug-in software (Wolfinbarger *et al.* 1998a,b), and extensive feedback from front-line users (Morris *et al.* 1999). Morris and Duvall (1999) provided a subjective evaluation while James *et al.* (2000) provided an objective and independent evaluation of the impact that OK-FIRST was beginning to have. In addition, the crowning evaluation-achievement to date has been the finalist-status accorded to OK-FIRST by the John F. Kennedy School of Government at Harvard University (Morris *et al.* 2000). Their "Innovations In American Government" program placed OK-FIRST in the top 25 of 1609 innovative programs reviewed during 1999.

4. TESTIMONIALS FROM 3 MAY 1999

As a result of using the OK-FIRST system, many rural public-safety officials have become proactive rather than reactive when dealing with weather-impacted situations. Stellar examples of this new approach to their duties were revealed through life-saving actions which resulted from decisions made during the 3 May 1999 tornado outbreak — significant stories that did not receive widespread media attention. For example,

- Steve Chapman, Emergency Management Director for the City of Chickasha, used information from OK-FIRST to discern the municipal airport was threatened by one of the first tornadoes of the day. He evacuated the Chickasha airport (location "1" in Fig. 1) — a full fifteen minutes before the tornado struck. No fatalities or injuries resulted.

- Later that evening, when another tornado demolished an outlet shopping mall in Stroud (location "2" in Fig. 1), all stores had been vacated. Ben Springfield, Lincoln County Emergency Manager, was provided frequent radar updates from OK-FIRST, and notified Stroud 30 minutes in advance.

- People in their homes in rural areas also were more secure thanks to the actions of emergency managers that day. After the storms hit the Oklahoma City area, residents in rural areas received minimal attention from the media; local news focused much of their coverage upon the devastation and recovery operations in and near Oklahoma City. One of Springfield's assistants monitored OK-FIRST radar displays and relayed updates every five minutes on radio frequencies received by scanner. Potential victims received the information and took shelter. Springfield later said that many of these people would otherwise not have taken shelter had it not been for the trustworthy information on their scanner.

- In Kingfisher County, the town of Dover (location "3" in Fig. 1) was hit hard, with two-thirds of the homes destroyed or damaged. Danny Mastalka, Director of Kingfisher County Emergency Management, caused emergency vehicles (police, sheriff, and game warden officials) to traverse the streets to warn citizens 10 to 20 minutes prior to the storm. The lone fatality in Dover was an individual who chose not to take immediate action after receiving the warning.

- Rescue workers themselves were targets of the storms. A tornado completely destroyed the small community of Mulhall in Logan County (location "4" in Fig. 1). Rescue workers set up a command center to manage the recovery operations. John Lewis, Logan County Emergency Manager, saw successive tornadoes following similar paths on his OK-FIRST system (Fig. 2). He alerted the command post to move their operations — twice. As a result, the rescue workers did not themselves become victims of the storms. In his letter of 10 May 1999, Lewis stated:

  > "When police and rescue crews arrived at the first Logan County damage site near the City of Crescent, one of the first tasks was to open the highway sufficiently to get an ambulance through from Crescent to the hospital in Guthrie. All efforts were to get that ambulance moving with a critically injured tornado victim. About the time they succeeded, a second tornado approached in the dark. The ambulance and the tornado moved on intersecting paths. Emergency management, aware of both events, was able to stop the ambulance until the tornado passed just in front of it."

  Practically every structure in Mulhall, a community of 945 citizens, was destroyed, including the town's only water tower which had stood since the 1920s. Yet, because local warnings were provided by two law enforcement units driving through town and dispatched based on OK-FIRST data, only one injury resulted.

- In Seminole County, Emergency Manager Herb Gunter radioed a warning to a caravan of emergency vehicles responding to the Oklahoma City area. Gunter noticed that a tornado was developing (Fig. 3) and would cross an interstate highway ahead of them. The law enforcement convoy closed the highway (location "5" in Fig. 1) so that neither they nor other vehicles would drive into the storm.

- In far northeast Oklahoma, as attention remained focused on the killer tornadoes, heavy thunderstorms brought flood-producing rains to Ottawa and surrounding counties on the night of May 3rd (Fig. 4). Terry Durborow, Emergency Management Director for the City of Miami, used OK-FIRST to "help protect the public in a timely manner."

Thus, it would seem that OK-FIRST played an important role in saving the lives of many Oklahomans on the night of 3 May 1999. In addition, because first-responders themselves were also in grave danger, the use of OK-FIRST prevented

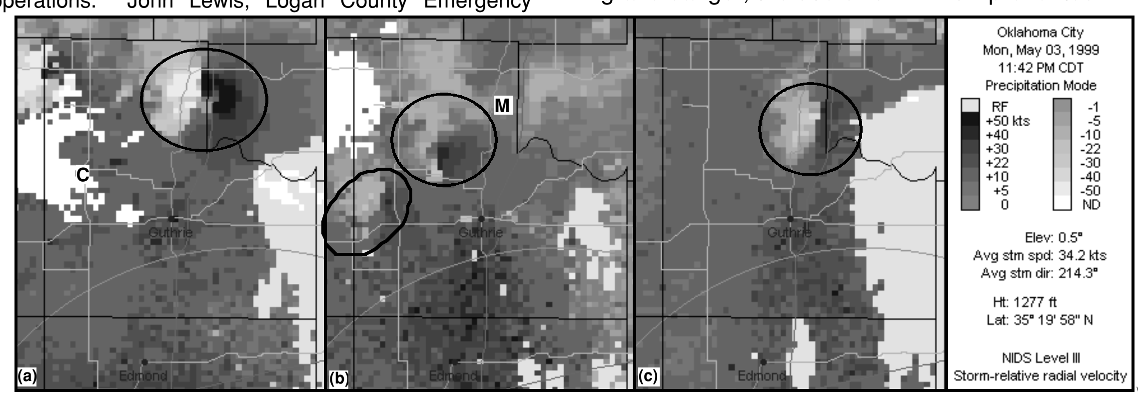

Figure 2. Storm-relative radial velocity from the Oklahoma City WSR-88D at (a) 0317 UTC (b) 0412 UTC and (c) 0442 UTC on 4 May 1999. Logan County Emergency Management used color versions of these images minus annotations added for clarity in this manuscript. Circled areas highlight tornadic supercells (*i.e.,* radial velocity couplets). Light thin lines denote various highways. The circled storm in (a) first hit the Crescent area [marked by "C" in (a)]and then the town of Mulhall [denoted by "M" in (b)]. Crescent is sandwiched between two tornadic supercells in (b) that followed similar tracks. The storm depicted in (c) is the southwest storm just entering Logan County in (b).

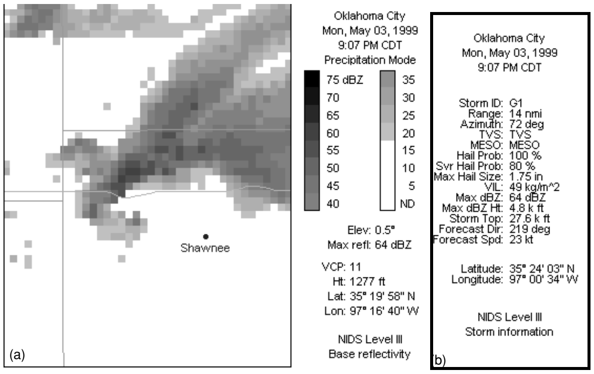

Figure 3. OK-FIRST images used by Seminole County Emergency Management to warn emergency vechicles. A hook echo in base reflectivity from the Oklahoma City WSR-88D at 0307 UTC (a) crosses interstate highway I-40 while a cursor read-out of storm attribute information (b) provides more detailed information.

even greater tragedies from occurring.

5. SUMMARY

As a result of operational successes on 3 May 1999 and many other situations, OK-FIRST has become a catalyst for change in many local governments. Local officials are empowered to close bridges during floods, save property in wildfires, improve evacuations after hazardous spills, and protect audiences at outdoor events. Other benefits include more efficient scheduling of public-works projects and information for police and fire investigations. An independent evaluator concluded (James *et al.* 2000) that OK-FIRST changed the behavior of its graduates and their approach to decision-making — for the better.

Because OK-FIRST is widely used, the NWS following the May 3rd event recommended national replication of a technology like OK-FIRST. Congress also authorized a national prototype to be built from OK-FIRST (Kloesel et al. 2000a,b).

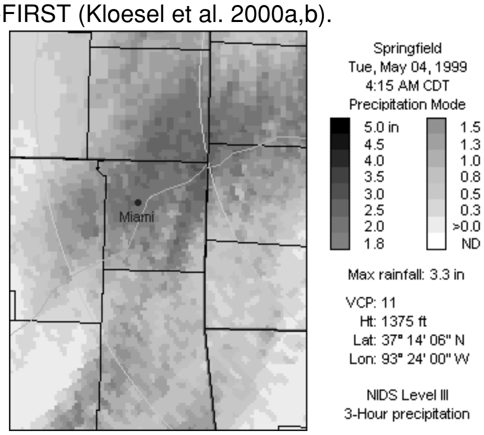

Figure 4. Three-hour rainfall accumulation from the Springfield radar, indicating more than 3 inches in Ottawa County near Miami. The corresponding flash flood guidance value was 2.2 inches.

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