The Role of Ground-Truth Reports in the Warning Decision-Making Process during the 3 May 1999 Oklahoma Tornado Outbreak

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ABSTRACT

During the devastating Oklahoma tornado outbreak that began just after 1600 central daylight time (CDT) on 3 May 1999, timely ground-truth reports of severe weather played a critical role in the warning decision-making process at the National Weather Service (NWS) Weather Forecast Office (WFO) in Norman, Oklahoma. Reports from storm spotters, emergency managers, media crews, and law enforcement officers went directly to the WFO staff via amateur (ham) radio, the National Warning System (NAWAS), and telephone. Warning forecasters also viewed live images of tornadoes as they were broadcast continuously by local television stations. These timely reports and the ability to communicate in real time with observers in the field provided NWS warning forecasters with valuable information to combine with Doppler radar data. Reports not only contributed to timely warnings but also enabled forecasters to add more detail and credibility to critical warning messages. The unprecedented warning service provided during this event demonstrated the effectiveness of a fully integrated warning decision and dissemination system and contributed to saving hundreds of lives.

1. Introduction

Severe-thunderstorm and tornado warnings are issued by meteorologists at National Weather Service (NWS) Weather Forecast Offices (WFOs), usually on a county-by-county basis (or equivalent), when the preponderance of evidence suggests that a storm or group of storms will produce large hail, damaging winds, or tornadoes. The meteorologist collects data from a variety of sensors, primarily Doppler weather radar, and combines those data with eyewitness reports from observers in the field. The decision to issue a warning is made when the meteorologist has enough indication, from this combination of data and reports, that a severe weather event is taking place or will soon occur.

Field reports can originate from a variety of sources, such as storm spotters trained by NWS staff, law enforcement officials, mobile television crews, storm chasers, and the general public. Reports can reach the WFO in a number of ways, including amateur (ham) radio, the National Warning System (NAWAS), television broadcasts, telephone, and computer.

The most valuable reports are detailed, timely, and accurate, allowing the warning forecaster to combine them with radar data during the warning decision-making process. Such reports also can be incorporated into the narrative portion of a warning to add more credibility and detail, and they can be relayed immediately through warning dissemination systems to supplement warnings already in effect.

During the outbreak of nearly 70 tornadoes during the afternoon and early nighttime hours of 3 May 1999, in parts of Oklahoma and southern Kansas, real-time reports played an especially vital role in the warning decision-making process and in the quantity, quality, and credibility of severe-weather information disseminated by the NWS, law enforcement, emergency managers, and media. An overview of the event is provided by Thompson and Edwards (2000).

2. The role of spotters and amateur radio

Hundreds of storm-spotter classes are conducted every year by meteorologists and technicians from NWS WFOs around the United States. Classes are most often arranged by local emergency management officials and the WFO Warning Coordination Meteorologist. Class schedules are often announced on the WFO's weather radio programs, on the WFO Web site, and on local commercial radio and TV public service programs. Spotters are taught basics of thunderstorm development and visible clues associated with severe thunderstorm and tornado development and evolution. Spotters are

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also trained in reporting procedures to ensure their observations are relayed to the WFO to be part of the warning decision-making process.

Many spotters use amateur radio for communications among themselves and within coordinated spotter networks. Spotters and network control operators also use amateur radio to communicate directly with volunteer operators working among warning forecasters in the WFO. One of the primary roles of the WCM is to establish communication links between the WFO and spotter groups and to establish procedures for notifying network control operators and WFO base-station volunteer operators prior to a severe weather operation. A key notification tool at WFO Norman is the thunderstorm outlook, issued routinely at least two times per day during the thunderstorm season. Outlooks are disseminated through traditional means and by volunteer operators or ham-licensed WFO staff on several amateur radio repeater link systems.

The first of 70 tornado warnings issued by forecasters at WFO Norman on 3 May 1999 was based on the combination of Doppler weather radar data and several timely spotter reports of the development and evolution of a rotating wall cloud north of Lawton, Oklahoma. The nearest Weather Surveillance Radar-1988 Doppler (WSR-88D) was located approximately 60 km southwest of Lawton. These first eyewitness, ground-truth reports and more than 100 subsequent reports during the event were passed from NWS-trained spotters directly to WFO Norman via amateur (ham) radio.

An extremely reliable amateur radio network, consisting of three linked repeaters, was established by the Southwest Independent Repeater Association (SWIRA) in 1992. This system serves most of the southwest quadrant of the WFO Norman county warning area (CWA) in southwest Oklahoma and western sections of north Texas. It was a primary tool used by spotters to pass reports to forecasters at WFO Norman and for spotters to receive updated radar and warning information from the WFO where ham operators had direct access to WSR-88D and other meteorological data. Members of mobile media crews, some of whom have their own amateur radio licenses, also contacted WFO Norman through the SWIRA link system to report tornado development and to update tornado locations. Many residents within range of the SWIRA repeaters, along with emergency managers, other local officials, and the media, monitored scanners or their own ham receivers during the event to take advantage of the information exchange between spotters and forecasters.

At the peak of the tornado outbreak, when the most devastating tornado was demolishing parts of the Oklahoma City metropolitan area, ham radio also played a valuable emergency communications role. Conventional telephone service was interrupted over much of the area, and cellular telephone facilities became so jammed by volume that service was unavailable at times.

3. National Warning System

NAWAS is a direct-access telephone system managed by the Federal Emergency Management Agency in cooperation with state emergency management agencies. NAWAS provides a voice communications network for key emergency management, law enforcement, and NWS entities within each state, as well as links among adjacent states. In Oklahoma, NAWAS provides an efficient voice link among NWS WFOs, Oklahoma Highway Patrol (OHP) troop communications centers, and selected emergency management operations centers. WFOs contact appropriate OHP troops and emergency managers via NAWAS when warnings are issued to ensure their receipt. In turn, OHP and emergency managers use NAWAS to contact the WFO to relay reports from mobile units or phoned in by the public.

During the 3 May 1999 outbreak, one forecaster from the Norman WFO remained in constant contact with OHP via NAWAS for approximately 1.5 h to coordinate on the large, violent tornado that followed a 60-km path along Interstate Highway 44 (I-44) from north of Chickasha to Oklahoma City. This coordination provided OHP officers with information they needed to keep motorists out of danger on I-44 and brought valuable firsthand OHP reports directly to the WFO for use in warnings and supplemental information provided by the NWS.

4. Television

Severe-weather coverage is among the highest priorities of broadcast media, but the primary Oklahoma television stations have made extraordinary commitments to timely severe-weather coverage. They have invested significant resources, not only in their own radar equipment, but also in modern, mobile-intercept technology. During severe-weather events, intercept teams take to the field with a mission of providing live, firsthand coverage of developing and ongoing severe weather. Viewers in Oklahoma are accustomed to seeing live telecasts of tornado evolution as severe-weather outbreaks unfold.

Severe-weather coverage by the primary stations on 3 May 1999 was unprecedented. Weather-team members remained on the air without commercial breaks to relay warnings to viewers and to provide live telecasts of developing and mature tornadoes. These images were transmitted from mobile ground-intercept units consisting of on-air staff, professional storm chasers, and camera crews and, in some cases, from station-owned helicopters, which provided incredible views of the largest tornado as it bore down on Oklahoma City. Meanwhile, at the local television stations, on-air staff provided detailed displays of radar imagery and emphasized tornado safety precautions. Simulcasts of these programs on several area commercial radio stations proved to be a valu-

able source of information via battery-operated radios where power failures occurred and for motorists.

Forecasters and ham operators at the Norman WFO also had access to these telecasts via a television set located adjacent to the ham-radio base station and NAWAS telephone. The primary reason for adding a television to the WFO operations area was to take advantage of the live coverage provided by the Oklahoma City stations during severe-weather outbreaks.

5. Telephone communications

Because of the magnitude of the 3 May 1999 event, conventional telephone communication was of limited value. WFO staff did, as usual, use the telephone to coordinate with neighboring WFOs, with the NWS Storm Prediction Center, and with some emergency managers. The staff also made calls to spotters and local officials in less-affected parts of the CWA to gather severe weather reports after the fact.

6. Summary and implications

Ground-truth reports of developing and ongoing severe-weather events during the 3 May 1999 tornado outbreak via amateur radio, NAWAS, and television provided critical information to NWS warning decision makers. These reports, when combined with WSR-88D and other meteorological data by well-trained meteorologists, contributed to timely, accurate, and credible warnings.

For example, a tornado warning issued at 2217 CDT to extend an earlier warning for Noble County, Oklahoma, contained the following spotter report and detail as a particularly devastating tornado was entering the town of Mulhall: ''At 10:17 p.m. CDT, a one-mile tornado was reported near Mulhall, moving northeast at 30 mph. This tornado will cross Interstate 35 near or south of Perry.''

Timely dissemination of warnings, radar information, and ground-truth reports helped to save hundreds of lives and to reduce the number of injuries. Estimates by Brooks and Doswell (2002) of lives saved during this outbreak range between 540 and 700. This event clearly demonstrated the overall effectiveness of a fully integrated warning decision and dissemination system and the effectiveness of a multisystem communications center within the NWS WFO. The consistent, accurate, timely, and credible warnings and reports provided through multiple dissemination sources form one of the clearest illustrative examples of the ingredients cited by Mileti and Sorenson (1990) as necessary for maximum public response to warnings.

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