Recent Improvements to the Verification of Convective Warnings at WFO Tallahassee

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1. Introduction

Issuing convective warnings is one of the most critical functions of a Weather Forecast Office (WFO). From 2004 to 2007, WFO Tallahassee issued an annual average of nearly 300 severe thunderstorm and 100 tornado warnings. Verifying these warnings is vital to the warning process. Most importantly, it allows the forecasters to recognize that the warnings they issued were necessary, and to demonstrate the need for improvement. Tracking this information can be tedious and sometimes nearly impossible in many rural counties. Like many WFOs in the Deep South, WFO Tallahassee has many counties that are sparsely populated (Fig. 1). In the WFO Tallahassee County Warning Area (CWA), all counties have a central dispatch, or 24-hour warning point, for their emergency services. These dispatch centers are typically the initial contacts following severe weather events, to ascertain what damage, if any, occurred. Unfortunately, many of the counties throughout the CWA are rural, and their dispatch centers are frequently only aware of damage if it occurs near communities in their respective county seats.

2. Methodology

In efforts to enhance communication with the emergency management community, increase forecaster confidence in warnings, and improve warning verification statistics, a major overhaul of the WFO Tallahassee CWA (Fig. 2) contacts database was initiated. Using various web searches and information provided by county emergency managers, a contacts page (Fig. 3) was created for each county, which consists of telephone numbers of law enforcement agencies, road and highway departments, utility companies, and SKYWARN storm spotters. Accompanying the contacts page was a detailed map of highways, roads, towns, and cities for each county.

A standardized method to initiate phone contacts after each event was implemented. The first contacts listed are 911 dispatch centers and county emergency management offices, followed by municipal law enforcement, road departments, and utility companies. Typically this requires three to five calls for each warned county. It is assumed that if none of these contacts has information about a particular event, severe weather did not occur. On some occasions when the warning forecaster is confident severe weather has occurred, additional calls are made to trained SKYWARN spotters in the affected counties.

To ensure our current spotter database was accurate for the new verification program, a comprehensive review of all contacts was undertaken. This resulted in many spotters being removed from our active spotter list, primarily due to inaccurate contact data. To recruit new spotters, an online spotter training program was developed, modeled after several basic spotter training presentations given by meteorologists at WFO Tallahassee (http://www.srh.noaa.gov/tlh/spotter). This training program requires spotters to view a presentation and complete a multiple choice exam before receiving a certificate of completion. Through this process, a spotter provides contact information to the SKYWARN focal point for inclusion in the contact database. This online training resulted in the addition of 121 spotters to the database between April 2006 and July 2008, and in conjunction with live spotter training, resulted in a more comprehensive spotter contact list and increased spotter participation in online severe weather reporting programs like eSpotter.

3. Verification Process

The goal of the enhanced verification process is to improve the office's warning verification statistics, and the overall warning program, by utilizing additional local and state agencies in the CWA, augmenting verification efforts via telephone, and conducting additional damage assessments. To facilitate this objective, an integrative approach is used during each severe weather episode, which involved members of the operations and management staff. The flow chart (Fig. 4) describes how the verification process proceeded. First, as storms become severe, time permitting, affected counties are contacted to obtain ground truth reports. When a warning is issued, one or more counties are contacted within 10 to 30 minutes of the issuance time to solicit damage reports. Important ground truth reports are conveyed to the warning forecaster. Other sources of ground truth include emergency managers via 800-MHz two-way radio communications from the Alabama and Georgia counties, as well as media partners via the instant messaging system. All calls and reports for warned and unwarned storms are recorded on the severe weather event log (Fig. 5), which serves as a reference for future shifts or use during the post event analysis. Follow up calls are typically made, and sometimes passed on to the next shift to complete. In some instances, these calls must be made the next day, to confirm if any damage was reported from the county contacts. Depending on staffing and the work load, the shift leader usually delegates either an HMT or forecaster to issue a local storm report (LSR) as soon as severe weather reports have been logged, and a summary LSR at the conclusion of the event. All HMTs and forecasters are trained to utilize the LSR program.

Verification criteria have been discussed extensively by the team. Current NWS verification guidelines state that penny-size hail (3/4 of an inch) or greater verifies a warning. It was decided that requests for hail size be categorized by pea, penny, nickel, and quarter or greater. Dime-size hail was disregarded to eliminate confusion. From the Storm Data focal point's perspective, at least two downed trees and/or power lines verifies a warning. The team's ultimate decision to determine warning verification is based on other criteria, such as soil moisture, tree size, and/or storm surveys.

If significant damage occurs, the lead forecaster, SOO, WCM or MIC requests that a storm survey be conducted as soon as possible. The surveys are accomplished by available HMT, management or forecast team members. Following the storm damage assessments, a public information statement (PNS) is issued notifying the public of the extent of the storm damage. Finally, information from both the LSR and PNS are incorporated into the month's official Storm Data publication.

4. Results

To demonstrate the success of the new verification program, the period of record was selected from July 2004 to September 2007 for all county-based warnings. Severe thunderstorm and tornado warnings were only verified by confirmed events meeting NWS warning criteria and occurring within the valid periods and counties represented by the warnings. Effective October 1, 2007, WFO Tallahassee began issuing storm-based warnings, which are specifically limited to storms affecting portions of counties, thereby minimizing the impacts on residents outside the threatened areas. Quality controlled data archived from a central database was obtained through a query method, using the "Stats on Demand" feature of the NWS Verification Web page: (https://verification.nws.noaa.gov/).

a. Severe thunderstorms

Severe thunderstorms can develop anytime of the year, but are most common from winter through early summer. Most summertime convection is sea breeze-driven, with peak activity during the mid afternoon to early evening. Pulse-severe convection can occur, especially where cells merge or sea breeze boundaries collide. Figure 6 illustrates the number of severe thunderstorm warnings that were issued for each three-month period by WFO Tallahassee.

April through June 2004 and January through March 2005 were the most active periods, with 139 and 150 warnings issued, respectively. However, less than a third of the warnings verified. Conversely, July through December 2005 were inactive, with only a quarter of the 36 warnings verified. The winter months of 2006 exhibited an increase in warnings; 58 were issued and 16 verified. Remarkable improvements in the warning verification process were realized after the implementation of the program in March 2006, when half of the 243 warnings verified during the April to June 2006 period. These enhancements were attributed to the proactive efforts of obtaining ground truth reports from the SKYWARN spotter network and county contacts, as well as ensuring storm surveys were conducted within 24 hours after the end of the severe weather events.

Severe thunderstorm events, defined as occurrences of ¾ inch or larger size hail and/or winds 58 mph or higher, for the same period of record (Fig. 7) showed a similar pattern. Of the 24 events from July through December 2005, less than half (11) of those were warned. The increasing trend in event verification began during the January to March 2006 period, with slightly more than 70 percent (18 of 25) of the events warned. Dramatic improvements were observed from April through June, with 86 percent (121 of 141) of the events warned.

Figure 8 illustrates the probability of detection (POD), critical success index (CSI) and false alarm ratio (FAR) for the months prior to and after the March 2006 implementation date. The POD, which is measured by the forecaster's accuracy in warning events (best possible score is 1 and worst possible score is 0), averaged 0.58 prior to 2006. The CSI, which is the forecaster's success in warning events, while also penalizing for missed warnings and false alarms (best possible score is 1 and worst possible score is 0), averaged 0.22 prior to 2006. Finally, the FAR, which is a measure of how often warnings were issued without verified events (best possible score is 0 and worst possible score is 1), averaged 0.71 prior to 2006. For the six-month period ending June 2006, the POD rose to 0.89, the CSI more than doubled to 0.47, and the FAR lowered to 0.50. The average lead time for all verified events increased from 10.3 minutes prior to 2006, to 12.1 minutes in 2006. During the period April to June 2006, the average lead time was 17.2 minutes.

b. Tornadoes

Climatologically, most tornadoes occur from January through March, with a secondary maximum from August through November, associated with land falling tropical cyclones. Tornado development is common during the mid to late afternoon, with a secondary peak during the late night and early morning. Figure 9 depicts the number of tornado warnings that were issued for each three-month period.

The most active period prior to March 2006 was July through September 2004 when 139 tornado warnings were issued. A study by Watson et al (2005) indicated WFO Tallahassee issued 130 warnings on 15-16 September 2004 during Hurricane Ivan. Twenty of those warnings verified, resulting in a FAR of 0.846. It was determined that the tornadoes reported were associated with nondescending mesocyclones, which provided few advanced clues to forecasters that tornadoes will develop. After a lull during the spring of 2005, there was an upward trend in warnings from July 2005 through March 2006, with 68 issued and 13 verified. A downward trend followed the program implementation with only ten warnings issued, of which none verified. It was not until the January through March 2007 period, with 40 warnings and 17 verifications. Of the 35 warnings issued during the 1-2 March 2007 tornado outbreak, which included the devastating EF4 tornado in Enterprise, AL, 19 were verified (Watson et al 2007).

Tornado events, defined as confirmed tornadoes, for the same period of record (Fig. 10) depicted a similar trend. The majority of the tornadoes reported during the summer 2004, fall 2005 and winter 2007 were warned, and occurred during major outbreaks.

The POD, CSI and FAR for the months prior to and after the March 2006 implementation date are shown (Fig. 11). With the exception of spring 2004 and 2005, the POD for warned tornado events was at or above 0.50. This trend continued through 2006 and into 2007, peaking at 89 percent during the January to March 2007 period. This marked rise in POD was during the 1-2 March 2007 tornado outbreak, when the POD was 1 (Watson et al 2007). The CSI prior to fall 2005 averaged less than 0.15, but doubled in fall 2005, largely due to warned events in December. Following a year of CSI averaging less than 0.12, January through March 2007 improved to 0.40, but fell slightly for the following three-month period. The FAR prior to fall 2005 averaged 0.90, then decreased to 0.65. Following a 12-month period of FAR which averaged 0.92, improvement was observed in winter 2007, when the FAR decreased to 0.57. Average lead time for tornado warnings prior to 2006 was 8.7 minutes. After a six-month null period, average lead time rose to 13.2 minutes for the period from October 2006 through June 2007. In fact, during the 1-2 March 2007 outbreak, the average lead time for tornado warnings was 19.8 minutes (Watson et al 2007).

5. Summary and Conclusion

In order to improve WFO Tallahassee's warning verification program, a team of forecasters and the WCM worked together to revise the contacts for each of the 48 counties and developed an integrated warning verification process. The results of the refined warning verification program were a significant increase in the number of severe thunderstorm and tornado warnings issued, severe thunderstorm and tornado events warned, and lower FAR.

Verifying convective warnings can be a tedious and time-consuming task. An effective verification program can provide critical information to the WFO staff during a severe weather episode, by providing feedback in real time, which can then help refine future warnings and increase forecaster confidence. After the fact, it can provide a basis for improving preparation and response for the next event. Through active collaboration and cooperation with its emergency management and media partners, WFO Tallahassee will continue to meet the NWS' critical mission of issuing timely and accurate warnings to save lives.

Acknowledgments

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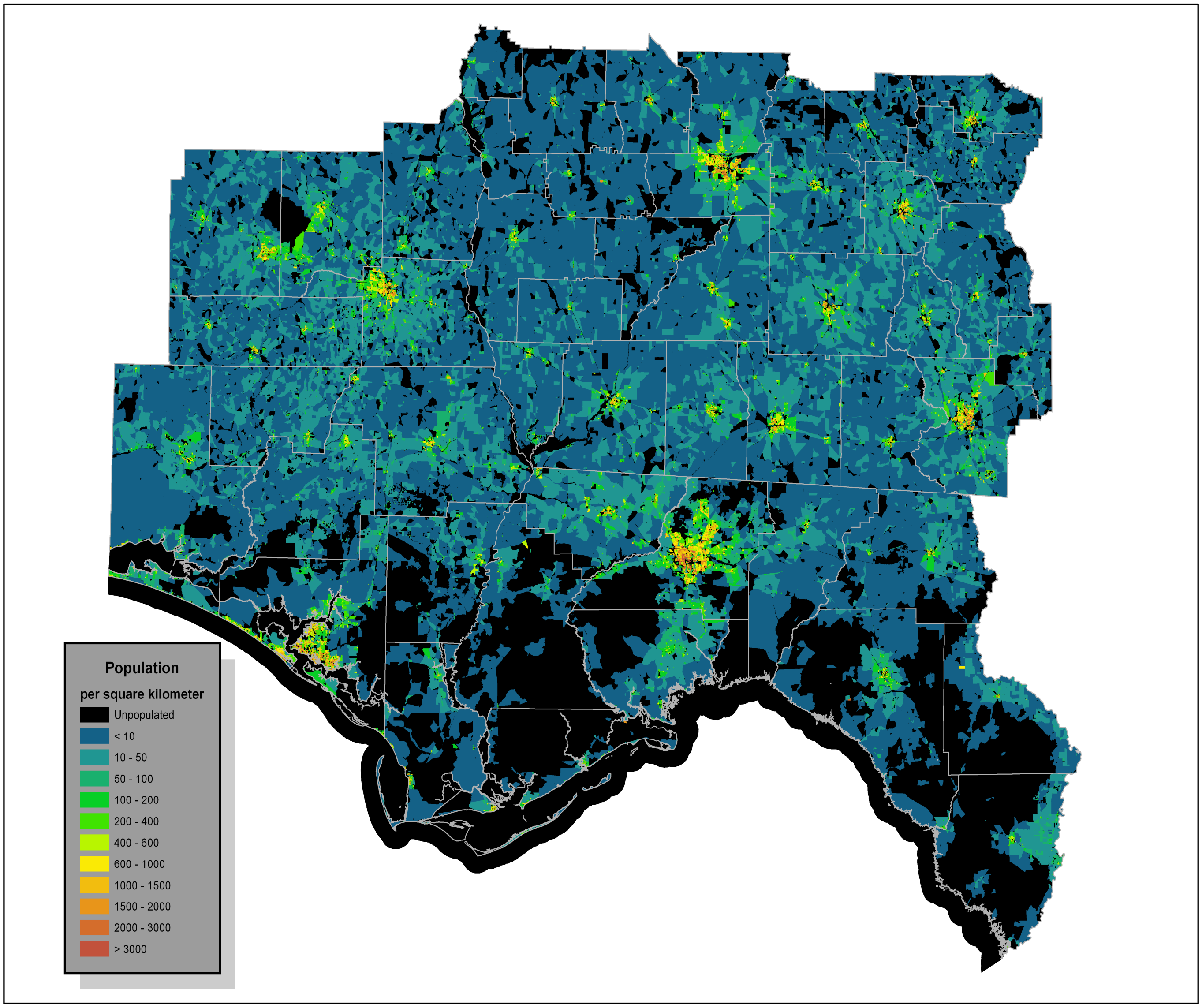

Fig. 1. Population density of the WFO Tallahassee County Warning Area based on the 2000 U.S. Census data. Image created by Parks Camp, GIS Focal Point.

Fig. 2. The County Warning Area of Responsibility for WFO Tallahassee.

Leon County, FL Contacts	
COUNTY DISPATCH AND EMERGENCY MANAGEMENT **EMERGENCY MANAGER:**	
LAW ENFORCEMENT	
LEON COUNTY SHERIFF:	**TALLAHASSEE POLICE CHIEF:**
ROADS AND HIGHWAYS **FDOT REGION 4 (MIDWAY, FL):** **LEON COUNTY HIGHWAY DEPARTMENT:** **TALLAHASSEE CITY MAINTENANCE:**	
POWER COMPANIES **CITY OF TALLAHASSEE UTILITIES:**	
HEADQUARTERS:	**NORTH & EAST LEON COUNTY:**
SOUTH LEON COUNTY:	**NORTHWEST LEON COUNTY:**

Fig. 3. Leon County, Florida Contacts Page, which includes emergency management, law enforcement, highway departments, and power companies. Phone numbers were removed for security purposes.

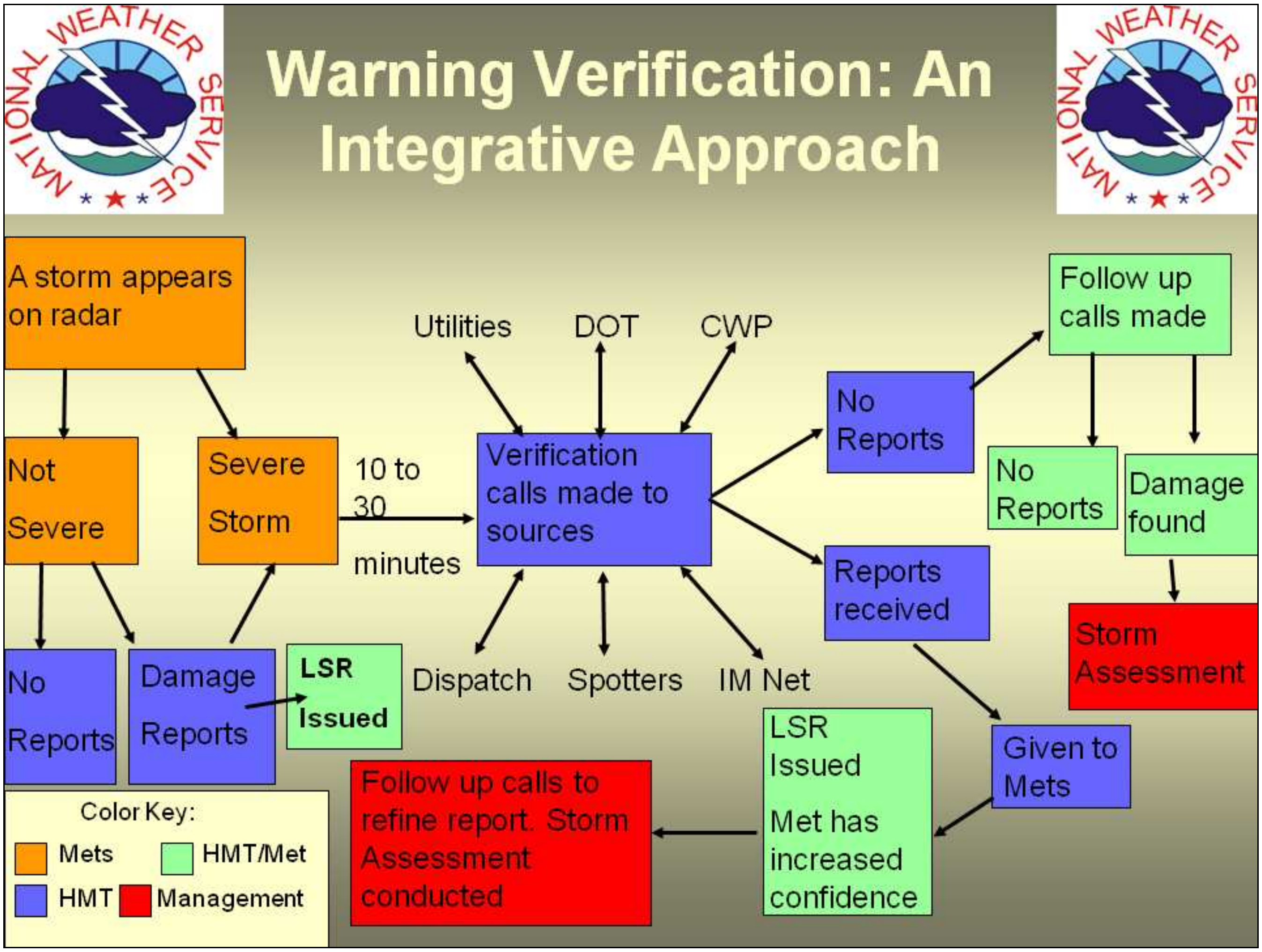

Fig. 4. Flow Chart describing the WFO Tallahassee integrative approach to warning verification.

WFO TAE Severe Weather Call Log

Date ________

Time of call ______EDT/EST **Time of Event ______EDT/EST**

County _____________ **State ____________**

Person speaking to ____
(name/affiliation)

Location ____

Report (circle all applicable):

Hail: Pea Penny Nickel Quarter Golf Ball Larger __________

Wind: <40mph 40-50mph 50-57mph >57mph Higher _______

Tornado Downburst Funnel Cloud Water Spout

Damage: #Trees Down _____ **Power outage: #Poles Down _____**

Property Damage ____

Injuries ______ **Fatalities _______**

Other information:

Your Initials ______ **LSR sent □**

Fig. 5. WFO Tallahassee Severe Weather Event Log, which is used to record reports during and after severe weather events.

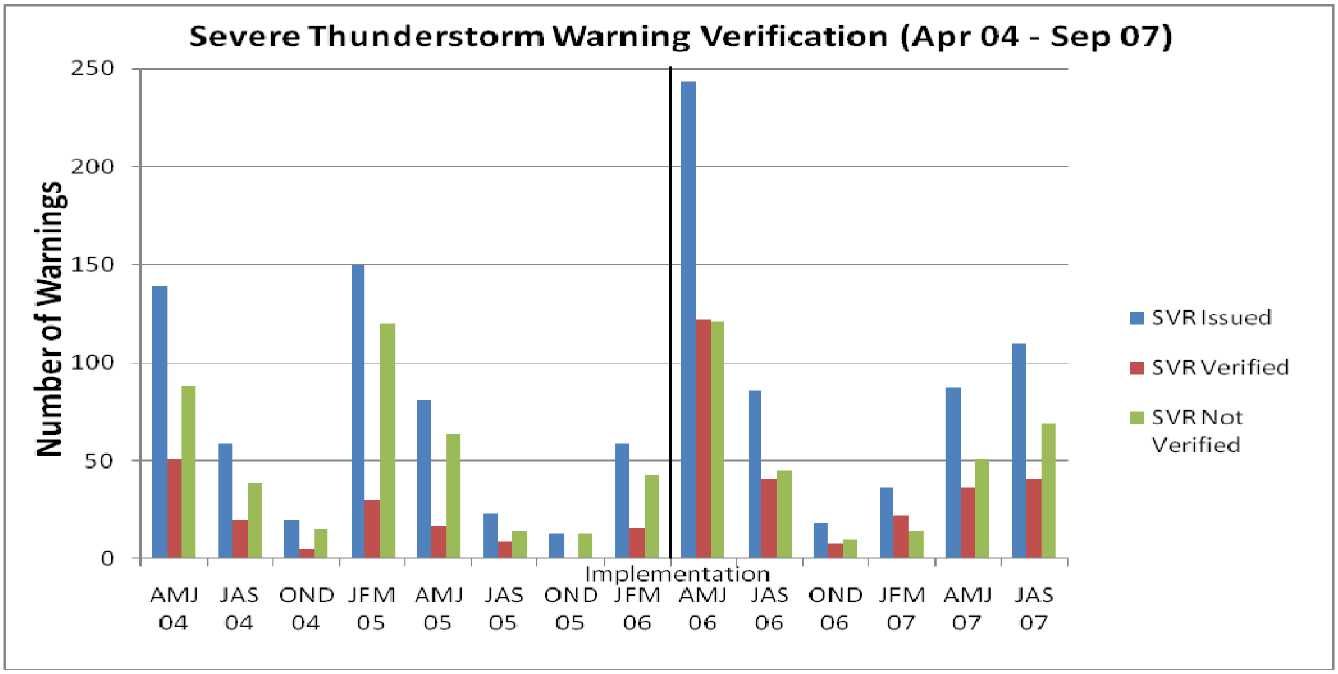

Fig. 6. Severe thunderstorm warnings (SVR) issued for the months before and after the implementation date (black vertical line) of March 2006. The blue bar is the number of warnings issued, red bar is the number of verified warnings, and green bar is the number of warnings not verified.

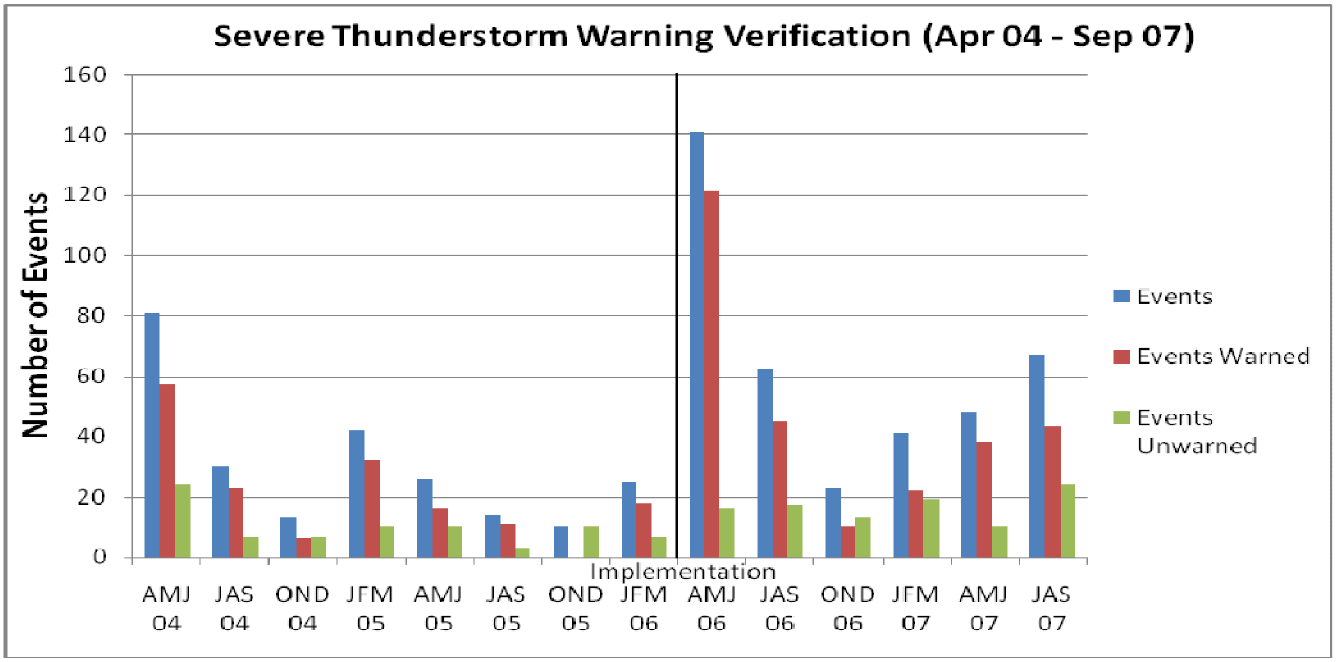

Fig. 7. Severe thunderstorm events reported for the months before and after the implementation date (black vertical line) of March 2006. The blue bar is the number of events, red bar is the number of warned events, and green bar is the number of unwarned events.

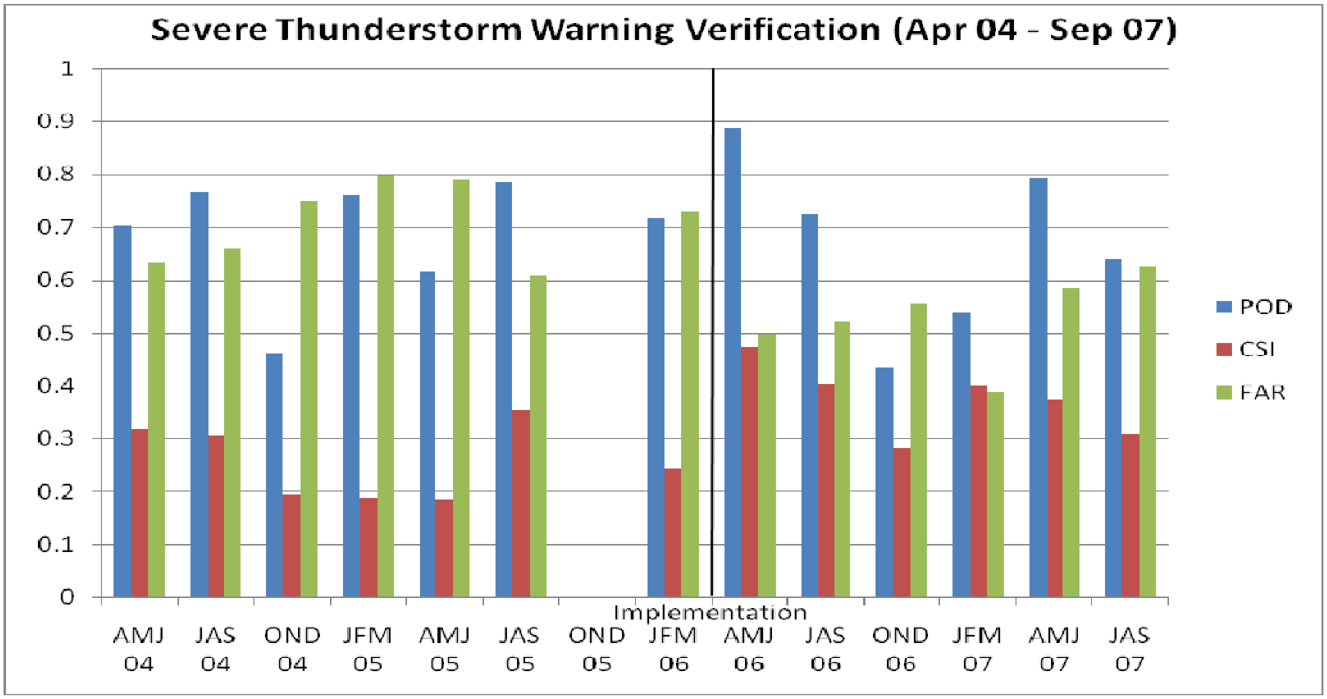

Fig. 8. Probability of detection (POD), critical success index (CSI), and false alarm ratio (FAR) for the months before and after the implementation date (black vertical line) of March 2006. The POD is the blue bar, CSI is the red bar, and FAR is the green bar.

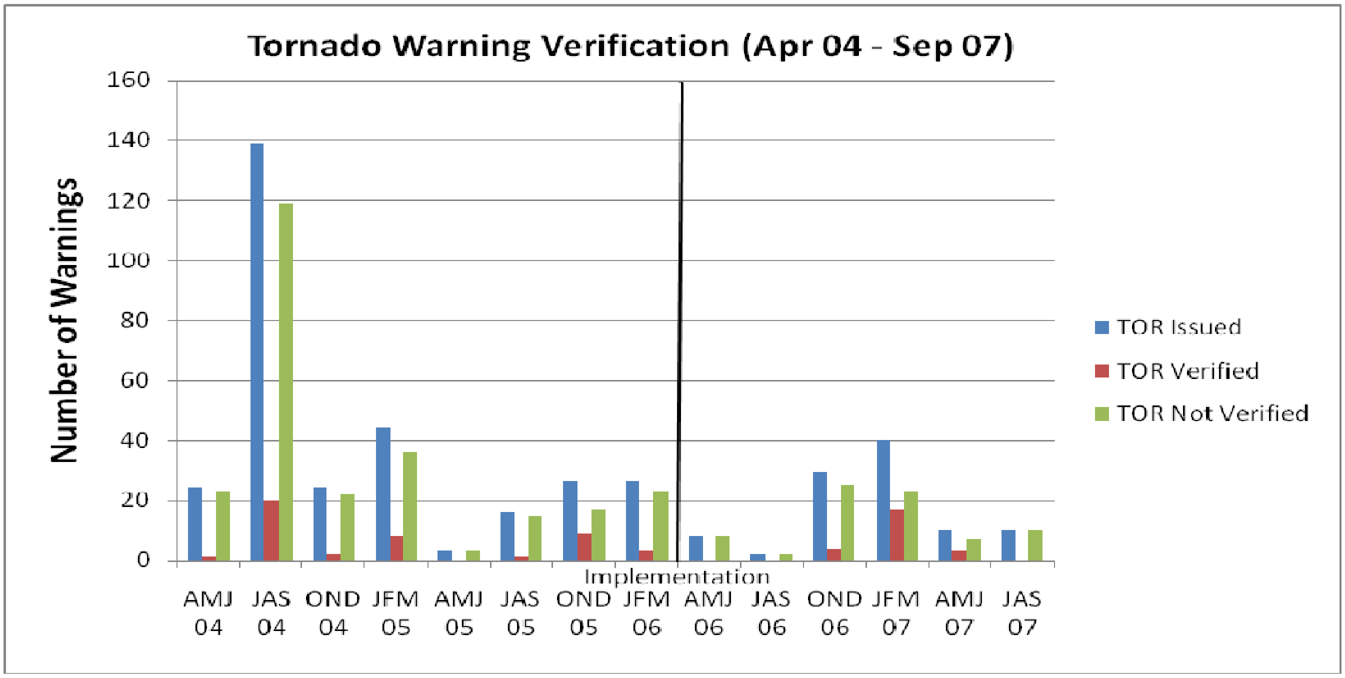

Fig. 9. Tornado warnings (TOR) issued for the months before and after the implementation date (black vertical line) of March 2006. The blue bar is the number of warnings issued, the red bar is the number of verified warnings, and the green bar is the number of warnings not verified.

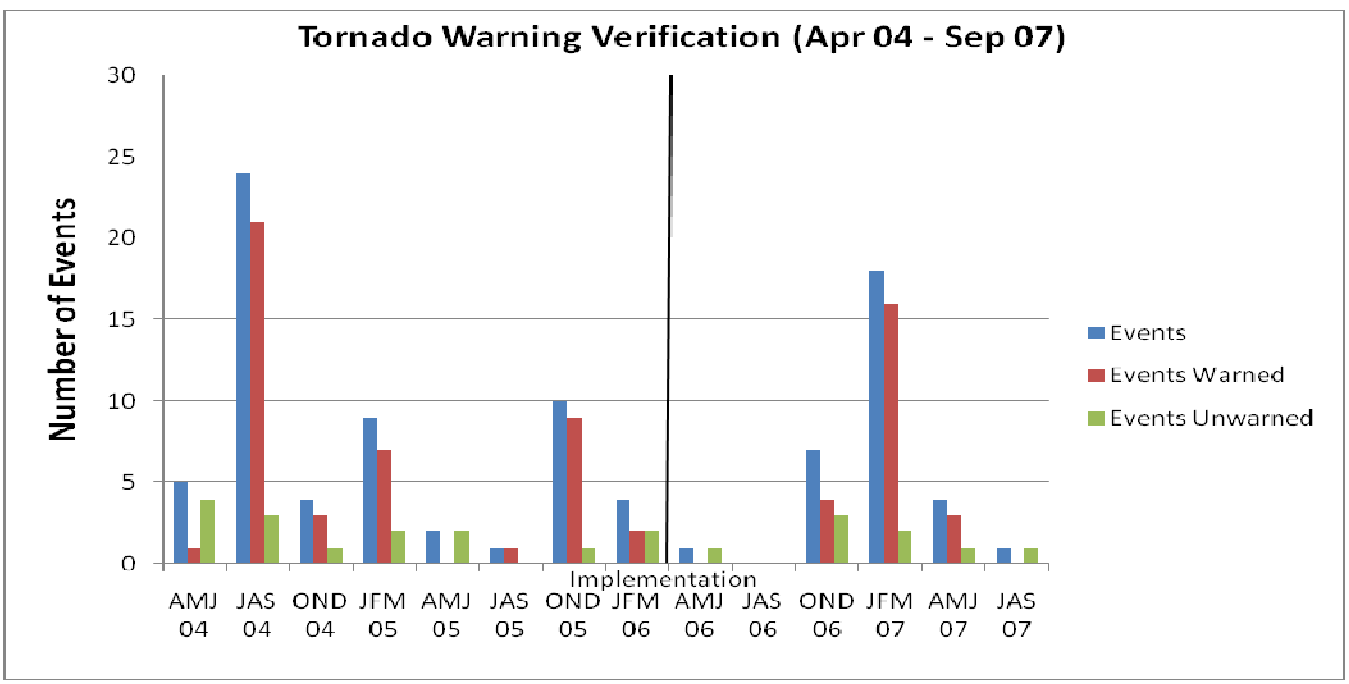

Fig. 10. Tornado events reported for the months before and after the implementation date (black vertical line) of March 2006. The blue bar is the number of events, red bar is the number of warned events, and green bar is the number of unwarned events.

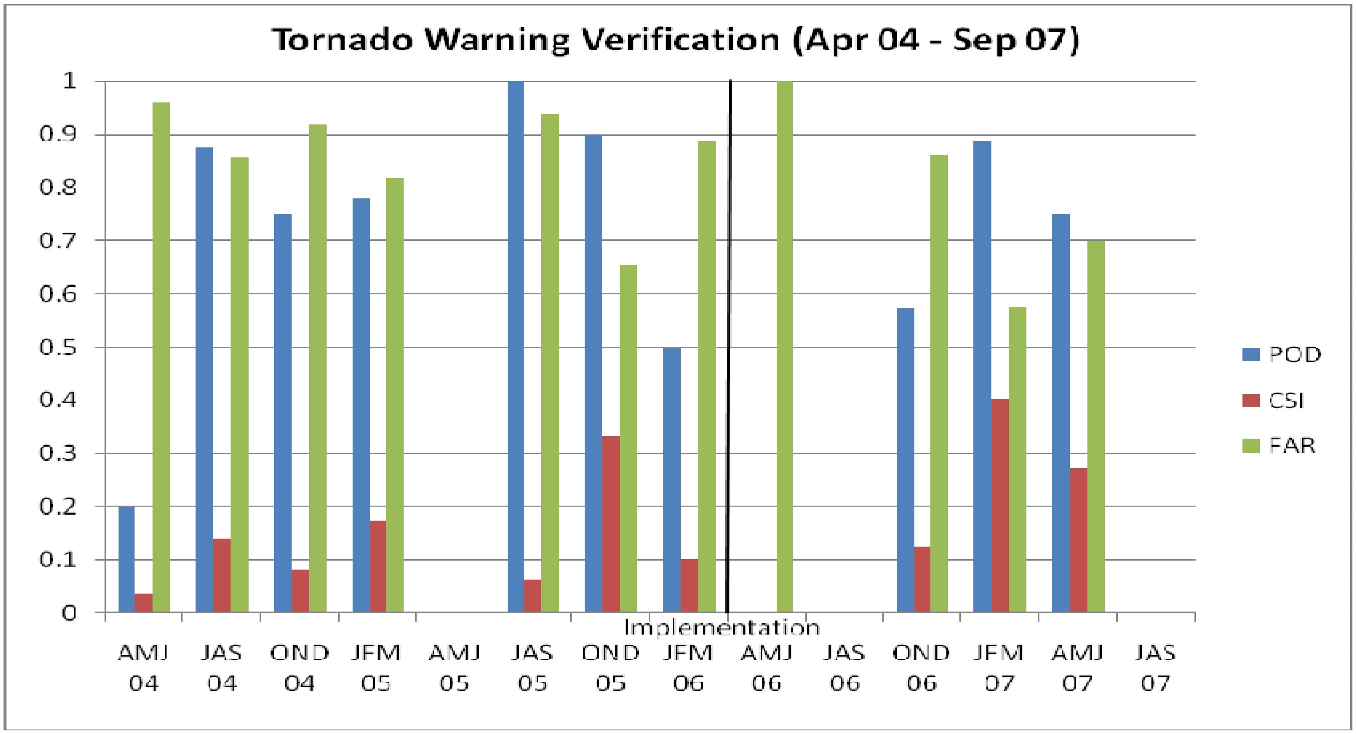

Fig. 11. Probability of detection (POD), critical success index (CSI), and false alarm ratio (FAR) for the months before and after the implementation date (black vertical line) of March 2006. The POD is the blue bar, CSI is the red bar, and FAR is the green bar.