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VERIFICATION OF SEVERE LOCAL STORM FORECASTS ISSUED BY THE NATIONAL SEVERE STORMS FORECAST CENTER: 1989

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National Weather Service
National Severe Storms Forecast Center

The National Severe Storms Forecast Center (NSSFC) has the responsibility for the issuance of tornado and severe thunderstorm watches for the contiguous 48 states. Watches are issued for those areas where thunderstorms are forecast to produce one or more of the following: (1) hailstones of 3/4 inch diameter or greater, (2) surface wind gusts of 50 knots or greater, or (3) tornadoes.

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ABSTRACT. The SELS Unit of the National Severe Storms Forecast Center routinely issues convective outlooks and severe local storm watches to delineate areas that are favorable for development of severe local storms. This report summarizes verification of those forecasts that were issued during 1989.

The threat of severe local storms was identified well via the second-day outlooks. Prediction of the location of subsequent events improved in the first-day outlooks. During 1989, 88% of the tornado-related fatalities and 85% of the tornado-related injuries occurred within valid severe local storm watches.

1. INTRODUCTION

The Severe Local Storms (SELS) Unit at the National Severe Storms Forecast Center (NSSFC) has responsibility for issuing convective outlooks, tornado watches and severe thunderstorm watches for the contiguous United States. Convective outlooks, which depict expected areas and densities of severe local storms in a preliminary sense, are issued daily at 0700, 1500, and 1900 UTC. Forecast periods begin at 1200, 1500, and 1900 UTC, respectively, and continue until 1200 UTC the following day. Although convective outlooks include forecasts for all thunderstorms, only forecasts of severe local storms are addressed in this report. An initial second-day severe local storm outlook is issued at 0800 UTC and updated at 1800 UTC each day. Both outlooks are valid for the 24-hr period beginning at 1200 UTC the next day. Tornado and severe thunderstorm watches are issued, as needed, to delineate areas in which conditions have become favorable for severe local storms to occur within the next few hours.

Various forms of verification of products issued by the SELS Unit have long been an important aspect of operations. Such data aid the assessment of forecast quality, identify possible areas of improvement, and provide helpful feedback concerning the progression of events during specific severe local storm episodes.

Results of these earlier verification efforts have been published by Galway (1967), Galway (1975) and Pearson and Weiss (1979). In 1982, the National Weather Service (NWS) formulated a National Verification Plan (NWS 1982) to provide guidelines for verification of the various products that are issued to the public. Verification at the NSSFC is an integral part of this national program. Leftwich (1985, 1986, 1987, 1988, 1989) summarized verification of watches and outlooks issued by the NSSFC during 1984, 1985, 1986, 1987 and 1988, respectively. This report documents verification of convective outlooks and severe local storm watches issued by the NSSFC during 1989.

2. VERIFICATION PROCEDURES

The first step in verification of any forecast is collection of both the issued forecast messages and reports of events that occurred during the forecast period. Collection of watch and outlook messages is accomplished in real-time as they are disseminated at the NSSFC. They are automatically encoded for processing via electronic computer. To qualify as a valid severe local storm event that is used in watch and convective outlook verification, reports must satisfy one of the criteria listed in Table 1. Extreme turbulence reports from aircraft are collected in near real-time via the Automation of Field Operations and Services (AFOS) system. Then, reports are manually entered into the NSSFC severe local storm event database. Otherwise, the sole source of severe local storm reports used for official (final) verification is the monthly summary entitled "Storm Data and Unusual Weather Phenomena" (Form F-8) that is submitted for each state by the various National Weather Service Forecast Offices (WSFOs). These reports are also manually entered into the NSSFC event database. Further restrictions are applied before any event data are included in the verification procedure. Multiple reports of the same event occurring within both 10 statute miles and 15 minutes of each other, and in the same county, are considered as one event. However, all tornado reports appearing in the F-8 report are included as separate events. Additional information regarding processing of severe local storm reports is given by Grenier and Halmstad (1986).

Table 1
Criteria for severe local storm events

a.	Tornado - a rotating circulation touching the ground and associated with a convective cloud.
b.	Hail equal to or greater than 3/4 inch (1.9 cm) in diameter.
c.	Thunderstorm wind gust of at least 50 knots (93 km/h).
d.	Thunderstorm wind damage.
e.	Extreme turbulence (reported by aircraft) associated with a thunderstorm.

Once data have been compiled, various verification statistics are computed. Primary statistics are Percent Verified (PV), Probability of Detection (POD), False Alarm Ratio (FAR) and Critical Success Index (CSI). The latter three statistics were adapted from those described by Donaldson et al. (1975). Adaptations were necessary because the statistics described by Donaldson et al. considered point forecasts, whereas both watches and outlooks are area forecasts. Modifications and the computational procedures that are currently followed are discussed in detail by Weiss et al. (1980).

3. CONVECTIVE OUTLOOKS

During 1989 a total of 589 convective outlooks specified a threat of severe local storms for the current, or first, day. Figure 1 shows overall convective outlook verification statistics for the ten-year period 1980 - 1989. Verification statistics stratified by the three issuance times are given in Section A of Table 2. The two later outlooks, which are based on additional diagnostic analysis and a later run of the National Meteorological Center (NMC) numerical guidance, generally contained a higher percentage of reports (higher POD). An increase in the CSI was also observed for these later outlooks.

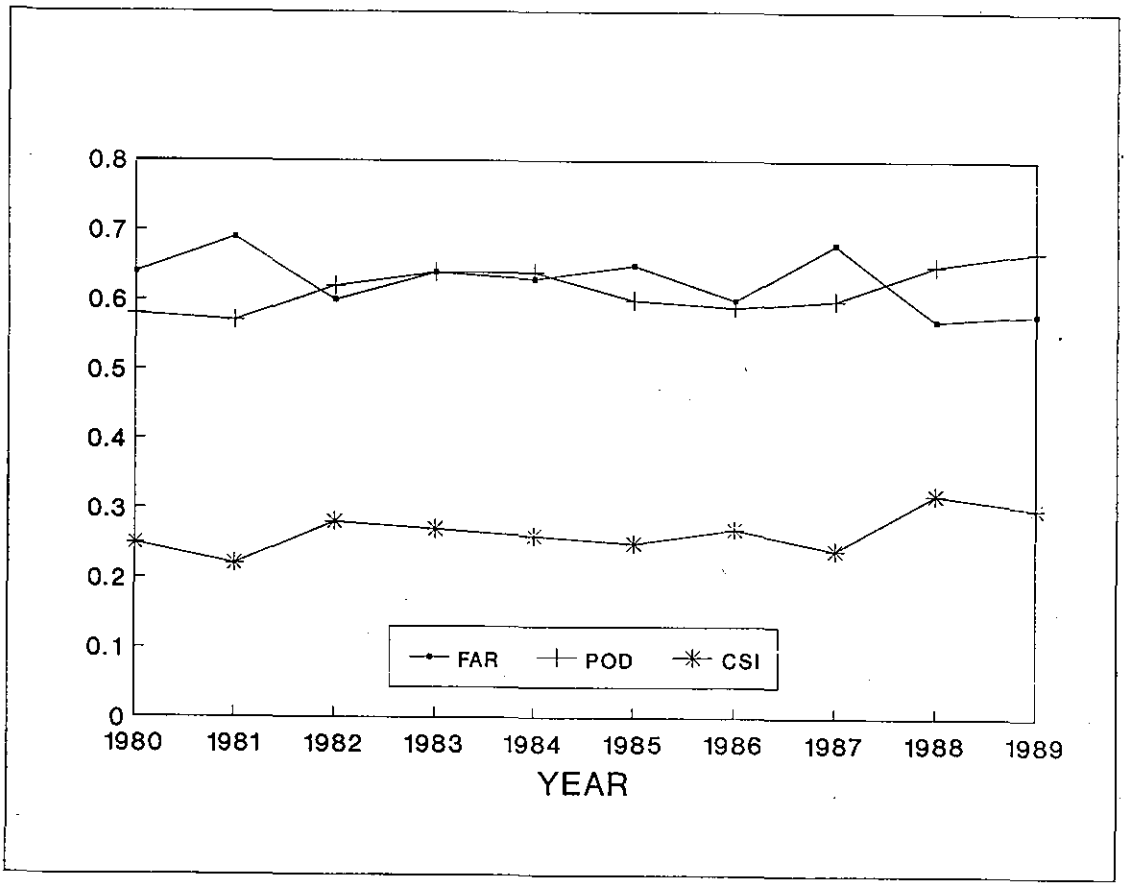

Figure 1. Convective outlook verification for the years 1980 - 1989.

There were 164 initial (issued at 0800 UTC) second-day outlooks that specified a threat of severe local storms for the following day. A threat of severe local storms was initiated or retained in 181 updated outlooks issued at 1800 UTC. Verification of these outlooks is given in Section B of Table 2. In general, updates clearly improved the initial outlooks in terms of POD and CSI. A slight improvement in FAR was attained. A substantial improvement in the 1989 second-day outlooks over the previous year was noted. For example, the 1989 POD for 0800 UTC of .49 compares to a value of .37 in 1988, while the 1800 UTC value of .57 represents a considerable improvement from the 1988 POD of .49.

Comparison of second-day outlooks with first-day outlooks shows noteworthy improvement in values of POD with little change in FAR. This results in higher values of CSI for successive outlooks. Improvement in POD and little change in FAR results from second-day outlooks being, on the average, smaller in area than first-day outlooks. Second-day outlooks are based almost entirely on indications derived from numerical model guidance, which emphasizes synoptic-scale features. For the first-day outlooks important information is obtained from mesoscale analysis as well as later runs of numerical guidance. Generally, a larger area of threat is evident in mesoscale analyses than in numerical guidance alone. Also, such subsynoptic-scale analysis leads to better placement of outlook areas. Increased area and better placement of outlook areas combine to produce similar values of FAR and higher values of POD and CSI.

Table 2
Verification scores for severe local storm outlooks during 1989

A. First-Day

Issue Time (UTC)	Number Issued	POD	FAR	CSI
0700	192	.63	.59	.29
1500	200	.69	.57	.31
1900	197	.71	.58	.31
All	589	.67	.58	.30

B. Second-Day

Issue Time (UTC)	Number Issued	POD	FAR	CSI
0800	164	.49	.59	.24
1800	181	.57	.57	.28
All	345	.53	.58	.26

4. SEVERE LOCAL STORM WATCHES

During 1989 the SELS Unit issued 772 severe local storm watches. Of these, 261 were tornado watches and 511 were severe thunderstorm watches. The total of 772 was the most watches issued in one year, greatly exceeding the previous high of 574 in 1987. There were 10408 severe local storm events during 1989, 856 of them being tornadoes. In terms of the total number of events, this was the most active season on record (Grenier et al. 1990). Also, the mean area contained in severe local storm watches in 1989 was 23139 square nautical miles, the lowest on record. The most active severe local storm season, together with a reduction of average watch size resulted in issuance of a greater number of watches.

Issuance of tornado watches denotes the threat of severe thunderstorms as well as tornadoes. Analysis of this aspect of forecasting is obtained via verification of all watches and all severe local storm events considered together. Trends in some of these statistics for the period 1980-1989 are shown in Figure 2. Issuance of tornado watches emphasizes an additional threat of tornadoes. To assess tornado watches separately, additional verification of tornado watches is done considering tornadoes only. That is, a tornado watch is considered to be verified only when a tornado occurs within the valid time period and within the watch area. Statistics computed in this manner are shown in Figure 3 for the period 1980-1989.

As shown by Table 3, skill was shown during 1989 in distinguishing severe local storm situations which have a greater threat of tornadoes from situations when tornado development is not likely. While at least one tornado occurred in 47% of the tornado watches, only 14% of the severe thunderstorm watches contained tornadoes. Tornado watches also reflected an increased threat of severe local storms as only 13% of them did not contain any reported events.

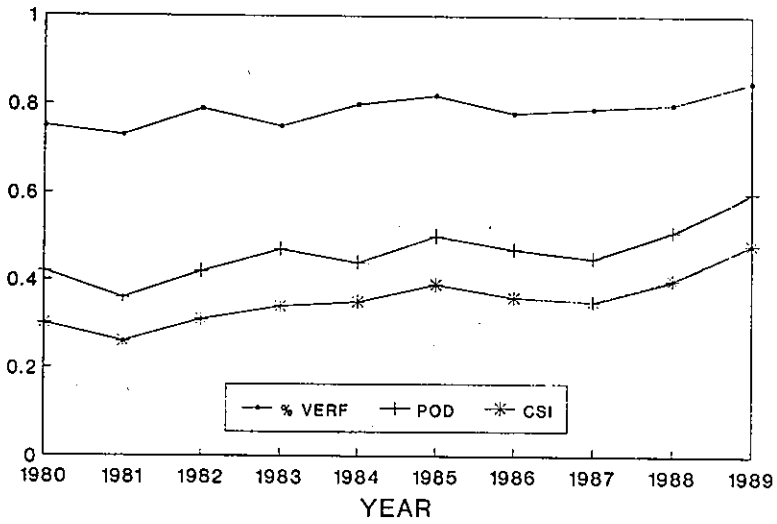

Figure 2. Verification for all severe local storm watches issued during the period 1980-1989.

Values of POD for various intensities of tornadoes during 1989 relative to valid severe local storm watches are given in Table 4. A tornado is considered to have occurred within a valid watch if any portion of its track occurred within a valid watch area. Intensities of tornadoes are indicated by F-scale (Fujita 1981) values ranging from "0" (weakest) to "5" (most violent). During 1989, 54% of the weak (F0-F1) tornadoes occurred in valid watches, while 91% of the violent (F4-F5) tornadoes occurred in valid watches. For strong and violent tornadoes, which caused 82% of the tornado-related fatalities during 1989, the Probability of Detection was 0.72. The POD for all tornadoes was 0.57.

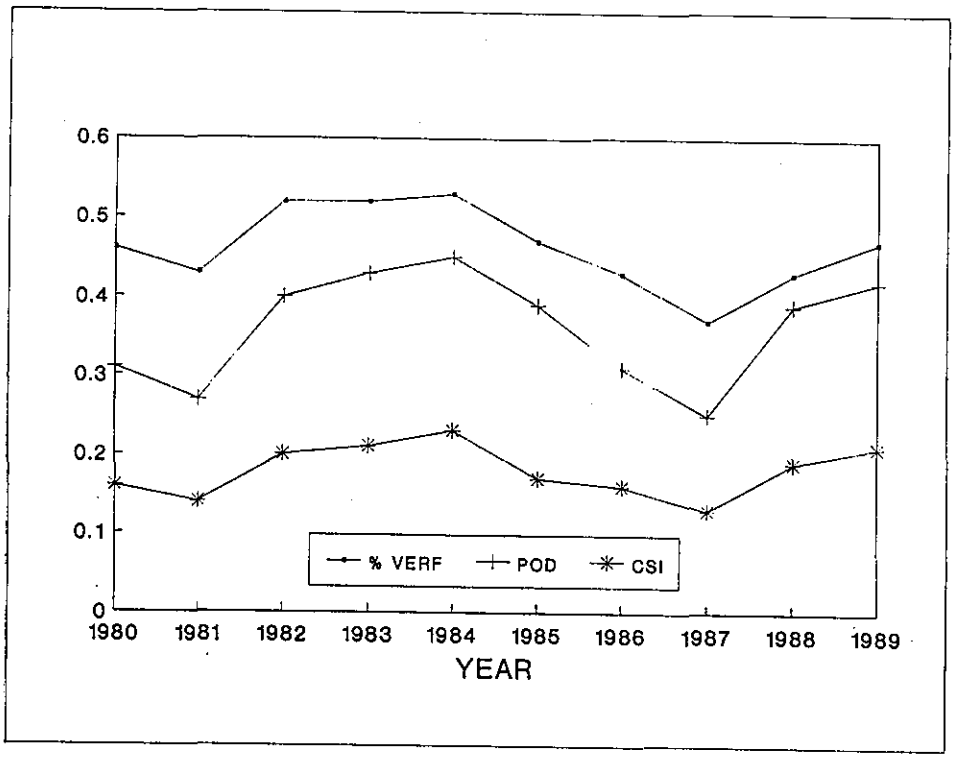

Figure 3. Verification of tornado watches via tornadoes only for the period 1980-1989.

Table 3
Frequencies of severe local storms in valid watches, 1989

Watch Type	Number Issued	Observed Tornado	Only Other Severe Types	No Severe
Tornado	261	47%	40%	13%
Severe Thunderstorm	511	14%	70%	16%

Table 4
Probability of Detection (POD) for various intensities (F-scale) of tornadoes relative to valid severe local storm watches during 1989

	Weak (F0-F1)	Strong (F2-F3)	Violent (F4-F5)	Strong/Violent (F2-F5)	All (F0-F5)
Total	733	112	11	123	856
In WW	399	78	10	88	487
POD	0.54	0.70	0.91	0.72	0.57

Strong and violent (F2-F5) tornadoes consistently pose an increased threat to life and property. Values of POD for all, weak (F0-F1) and strong/violent (F2 - F5) tornadoes for the period 1980-1989 are shown in Figure 4. The closeness of the POD for all tornadoes to the POD for weak tornadoes reflects the high percentage of weak tornadoes. POD values for strong/violent tornadoes, which have remained near 0.7 for the last three years, are consistently higher than values for weak tornadoes. Results for the past several years have been consistent with the earlier findings of Ostby and Higginbotham (1982).

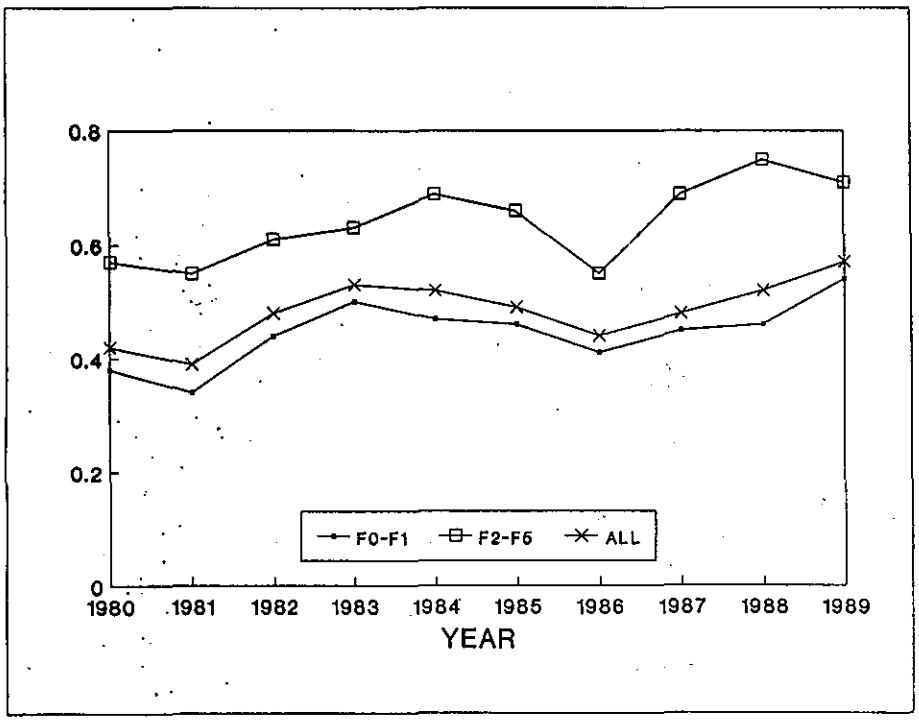

Figure 4. Annual values of Probability of Detection (POD) for weak, strong/violent, and all tornadoes, respectively, for the years 1980-1989.

During 1989, there were 13 tornadoes that caused at least one fatality. Of these 13 "killer" tornadoes, 9 occurred within valid severe local storm watches. Further statistics concerning severe local storm events resulting in fatalities and injuries are given in Table 5. During 1989, tornadoes caused 50 fatalities in the United States. Severe thunderstorm winds caused 29 additional fatalities. In regard to tornado-related fatalities, 44 of 50 (88%) occurred within valid watches. Nineteen (66%) of the 29 fatalities resulting from thunderstorm wind gusts occurred within valid watches. Valid severe local storm watches contained 85% of tornado-related injuries and 69% of injuries attributable to other severe thunderstorms.

Table 5

Severe local storm-related fatalities and injuries in 1989

	Tornado		Severe Thunderstorm	
	Fatalities	Injuries	Fatalities	Injuries
Total	50	1270	29	505
Occurring within valid watches	44	1083	19	347
% Within Watches	88	85	66	69

5. SUMMARY

Severe local storm outlooks and watches are issued by the SELS Unit of the NSSFC. These products identify areas in which development of severe thunderstorms and/or tornadoes is likely. Verification of these products is done routinely for purposes of feedback to the forecasters and quality control of issued products.

There was little difference in the FAR between second-day and first-day severe local storm outlooks. However, the location of severe local storm occurrence (as reflected in the POD) was better predicted by the first-day outlooks.

For severe local storm watches, ability was exhibited in distinguishing the added threat of tornadoes from that of hail or wind gusts. During 1989, 88% of the tornado-related fatalities and 85% of the tornado-related injuries occurred within valid severe local storm watches.

6. ACKNOWLEDGEMENTS

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