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SEVERE LOCAL STORM WARNING VERIFICATION: 1984

Preston W. Leftwich, Jr. and Leo A. Grenier  
National Severe Storms Forecast Center  
Kansas City, Missouri 64106

December 1985

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**U.S. DEPARTMENT OF  
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National Severe Storms Forecast Center

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- No. 6 Severe Local Storm Warning and Event Summaries Available in AFOS. Preston W. Leftwich, Jr. and Lawrence C. Lee, January 1984, 10 p. (PB84 150291).
- No. 7 Severe Thunderstorm Cases of 1984. John E. Hales, Jr. and Hugh G. Crowther, May 1985, 88 p. (PB85 210748/AS).
- No. 8 A Minimum Assumption Tornado Hazard Probability Model. Donald L. Kelly, Joseph T. Schaefer, and Robert F. Abbey, Jr., May 1985, 30 p. (PB85 206092/AS).

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## SEVERE LOCAL STORM WARNING VERIFICATION: 1984

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ABSTRACT. Tornado and severe thunderstorm warnings are issued by local offices of the National Weather Service. Routine verification of these warnings is accomplished at the National Severe Storms Forecast Center. This report highlights verification procedures and summarizes national, regional and local verification results for the year 1984.

Stations in the Central and Southern regions issued most of the warnings and experienced most of the severe local storm events. On a national scale, verification scores continued the trend of improvement of the past two years.

### 1. INTRODUCTION

Severe local storm warnings are issued to the public by more than 200 local offices of the National Weather Service (NWS). These warnings, which are typically based on radar information and/or storm spotter reports, alert the public to an existing tornado or severe thunderstorm. Each designated area of warning responsibility is composed of counties in the vicinity of the local office. Locations of these offices and their areas of responsibility are contained in Operations of the National Weather Service (NWS, 1985). Routine verification of all tornado and severe thunderstorm warnings issued by NWS offices is accomplished at the National Severe Storms Forecast Center (NSSFC) in Kansas City, Missouri. This report summarizes these verification results for the year 1984. Detailed evaluation of results, such as comparisons among individual offices, is beyond the scope of this report.

### 2. VERIFICATION PROCEDURES

Severe local storm warning verification began at the NSSFC in 1979. Pearson and David (1979) and Kelly and Schaefer (1982) analyzed warning verification back to 1976. In 1982 the NWS formulated a National Verification Plan (NWS, 1982) to provide guidelines for verification of all products issued to the public. The severe local storm warning verification effort at the NSSFC is an integral part of this national program. Monthly and year-to-date summaries are now routinely provided to national and regional headquarters and to local offices.

The two elements necessary for verification are: (1) issued warnings and (2) event reports. Initially, both warnings and event

reports are collected in real time from the Automated Field Operations System (AFOS). Information concerning events are extracted from surface observations, warning messages, local storm reports (LSR), statements, pilot reports and state weather summaries. Additional reports may be received via telephone conversations or newspaper articles. These reports form a "rough log" of severe local storm events.

Each week, listings of warnings and event reports that have been logged and processed at the NSSFC are transmitted via the AFOS system to local offices for review. Roles of these warning and event summaries in the verification process are discussed in detail by Leftwich and Lee (1984). After reviewing these summaries, local offices send any corrections to the "rough log" to the Verification Specialist at the NSSFC. Additionally, "Storm Data and Unusual Weather Phenomena" (Form F-8) reports are reviewed as a final source of event data. In fact, these F-8 reports are the sole source of tornado reports used for official verification. After all forms of information have been compiled, the resulting "smooth log" and warning file provide data bases for official verification.

To qualify as a severe local storm event, a report must clearly satisfy one of the criteria given in Table 1. General guidelines on event reporting may be found in Leftwich and Lee (1984). Multiple reports of the same type occurring within 10 statute miles and 15 minutes of each other and in the same county are recorded as one event. All distinct tornadoes are retained as separate events.

TABLE 1  
Criteria for Severe Local Storm Events  
Used in Warning Verification

- a. Tornado - a funnel or rotating circulation touching the ground and associated with a thunderstorm.
- b. Hail equal or greater than 3/4 inch (1.9 cm) in diameter.
- c. Convective wind gust of at least 50 knots (93 km/h).
- d. Significant convective wind damage.

Even though a severe local storm may occur in a particular county, sparseness of population may decrease the chances that an event is reported. Schaefer and Galway (1982) addressed biases reflected in the tornado climatology across the United States. Hales and Kelly (1985) discussed possible effects of variations in reporting of hail and thunderstorm wind gust events upon verification results. Results of these studies demand that caution be exercised in directly comparing verification results for local offices, and even regions, that have different population densities or different meteorological regimes.

Once data have been compiled, various verification statistics are computed. Primary statistics are the Probability of Detection (POD), False Alarm Ratio (FAR), and Critical Success Index (CSI) that were adapted from those described by Donaldson et al. (1975). Adaptations were necessary because the statistics described by Donaldson et al. considered point forecasts, but warnings are area forecasts.

Any event that occurs both within a county for which a warning was issued and during the valid period of the warning is a "warned event". Thus, one warning can cover many events. Any type of severe local storm event (Table 1) can verify either type (tornado or severe thunderstorm) warning. The POD, which is a measure of the correctness of the warnings in time and space, is computed as follows:

$$POD = \frac{\text{number of warned events}}{\text{total number of events}} \quad (1)$$

In current verification procedures, the county is the basic unit of area. A warning that covers three counties is counted as three "warned counties". At least one severe event occurring during the valid period of a warning in a warned county produces a "verified county". In order to obtain complete verification of a warning, at least one severe event must occur in each warned county. From these values, the FAR is computed (as a measure of overwarning) as follows:

$$FAR = 1 - \frac{\text{number of verified counties}}{\text{number of warned counties}} \quad (2)$$

These two statistics are combined to form the CSI as follows:

$$CSI = \frac{POD}{1 - FAR} \quad (3)$$

Maximum value is "1", a higher score representing better skill. When either the FAR is "1" or the POD is "0", the CSI is undefined. The CSI, which is the same as the Threat Score, is the ratio of successful predictions to the number of events and false alarms.

Two additional statistics, Percent Verified (PV) and Verification Efficiency (VE) provided additional information concerning verification of warnings. The percent verified (PV) is defined as:

$$PV = \frac{\text{number of verified counties}}{\text{number of warned counties}} \times 100 \quad (4)$$

Also, it is equivalent to  $100(1-FAR)$ . Values range from "0" to "100". Verification Efficiency represents an average of the POD and PV, and provides a straightforward measure of combined success in verifying warnings and covering events with valid warnings. It is calculated as

$$VE = 0.005 (PV + 100 \cdot POD) \quad (5)$$

and ranges from "0" to "1".

### 3. NATIONAL STATISTICS

Table 2 summarizes warning verification data for the entire United States during 1984. A total of 12,498 counties were warned via warning messages, and 7,357 severe local storm events were reported. Nationwide, approximately 56% of these events occurred in warned counties, and at least one severe local storm event was observed in 27% of the warned counties. The resulting national CSI was 0.22 and the VE was 0.41.

TABLE 2  
National Severe Local Storm Warning  
Verification Data: 1984

Warnings issued	6,646
Counties warned	12,498
County warnings verified	3,316
Severe local storm events	7,357
Warned events	4,095
FAR	.73
POD	.56
CSI	.22
% Verified	27
VE	.41

Figure 1a, b and c show the distributions of some of these statistics. Only those stations that issued at least one warning were included in these samples. Median values of national statistics were 0.804, 0.437, and 0.152 for the FAR, POD and CSI, respectively.

Figure 2 depicts the trend in national statistics over the past three years. Although the period of record is short, a definite trend of improvement is shown.

During 1984, tornadoes caused 122 fatalities and 2,181 injuries in the United States. As shown in Table 3, more than three quarters of these tornado casualties were covered by valid severe local storm warnings. Severe thunderstorm wind gusts caused another 36 fatalities and 376 injuries. Of these, 58% of the fatalities and 39% of the injuries were covered by valid warnings.

TABLE 3  
Severe Local Storm-Related Fatalities and Injuries  
Covered by Valid Warnings

	Tornado		Severe Thunderstorm	
	Fatalities	Injuries	Fatalities	Injuries
Total Number	122	2181	36	376
Occurring Within Valid Warnings	93	1688	21	147
% Covered by Warnings	76	77	58	39



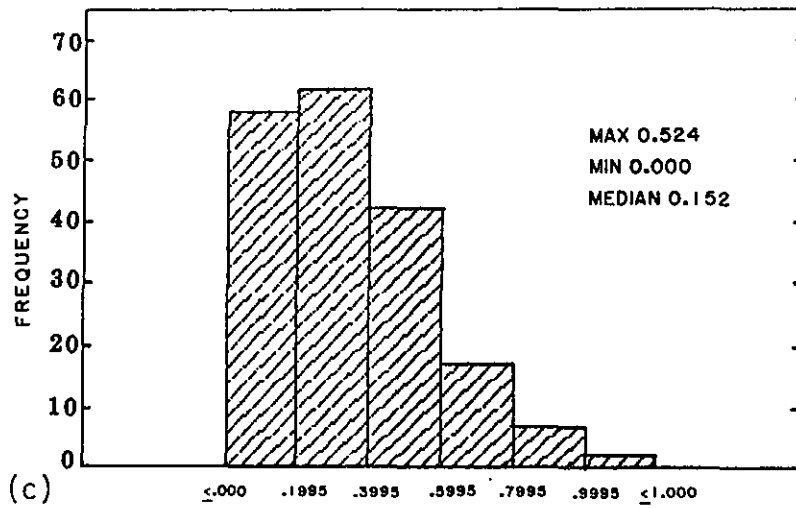
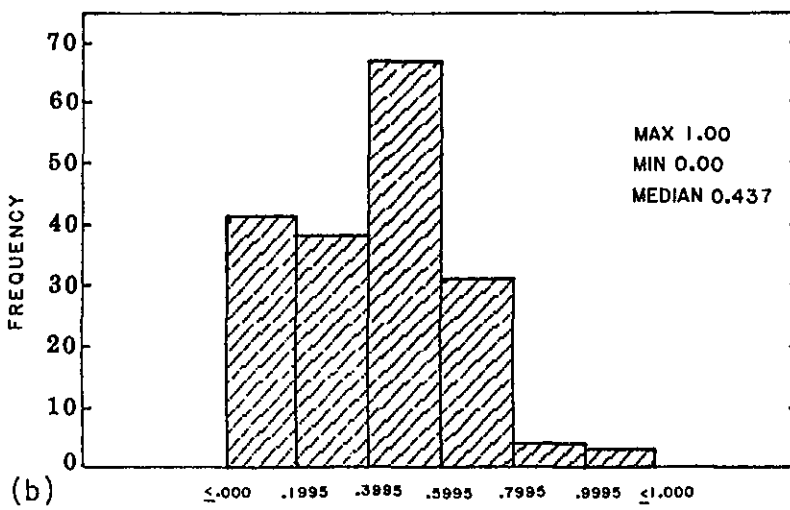
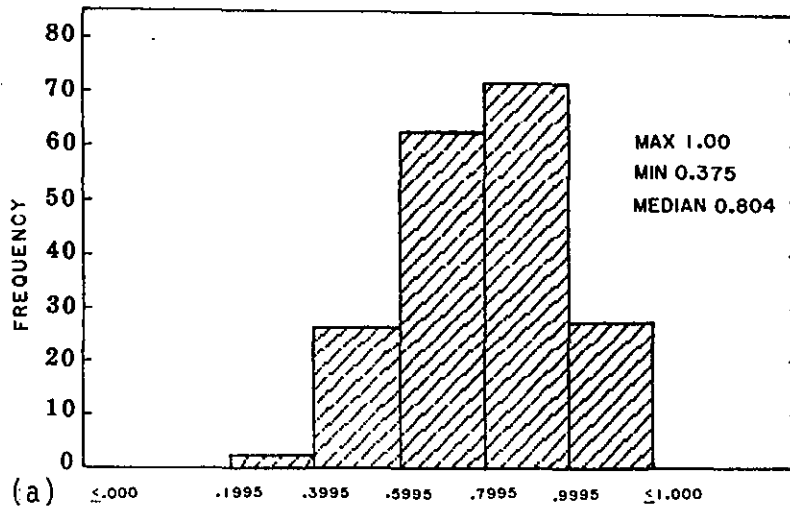


Figure 1. Frequency distributions of severe local storm warning verification statistics for 1984: (a) FAR, (b) POD, and (c) CSI.

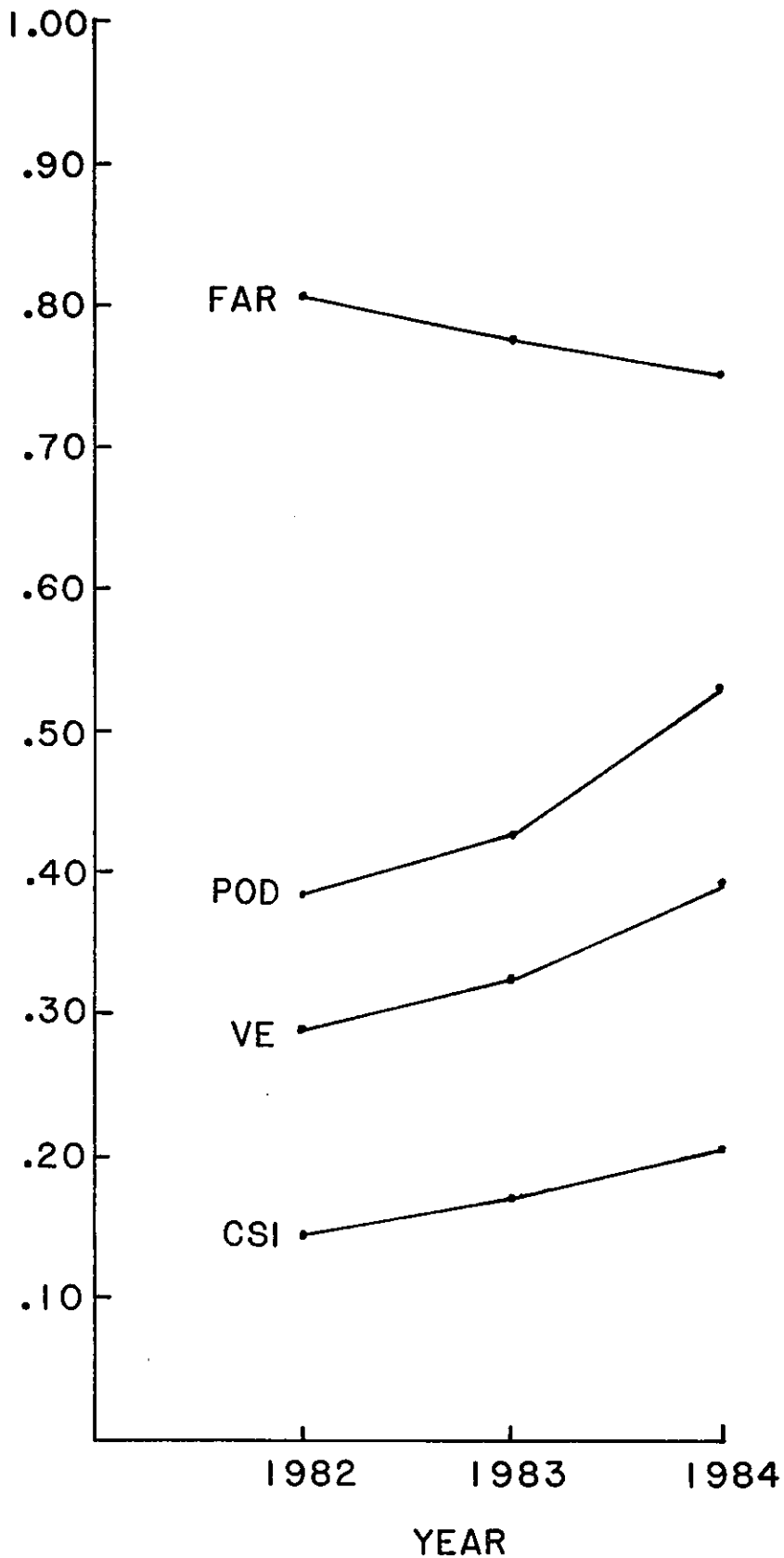


Figure 2. National severe local storm warning verification statistics for the years 1982-1984.

#### 4. REGIONAL STATISTICS

Table 4 summarizes warning verification data for the four NWS regions. Maps depicting the states included within each region are contained in Operations of the National Weather Service (NWS, 1985). Severe local storm events were more numerous in the Central and Southern Regions than in the other two regions. This is in agreement with the climatologies by Kelly et al. (1978) and Kelly et al. (1985). Accordingly, these regions typically issue more warnings. A striking feature is the rather consistent percentage contributions of each region to the national totals for each variable. For example, the Southern region issued almost half (47.5%) of the county warnings during 1984. This region also had 49.1% of the verified counties, 44.6% of the severe events and 49.1% of the warned events.

TABLE 4  
Regional Severe Local Storm Warning Verification Data: 1984  
\*Numbers in parentheses are percentages of national totals for each item.

	Eastern	Central	Southern	Western
Warnings Issued	566 ( 8.5)*	2846 (42.8)	3126 (47.1)	108 (1.6)
Counties Warned	1022 ( 8.2)	5293 (42.3)	5938 (47.5)	245 (2.0)
County Warnings Verified	344 (10.4)	1319 (39.8)	1628 (49.1)	25 (0.7)
Severe Local Storm Events	988 (13.5)	2908 (39.3)	3272 (44.6)	189 (2.6)
Warned Events	505 (12.4)	1553 (37.8)	2005 (49.1)	32 (0.7)
% Verified	34	25	27	10
FAR	.66	.75	.73	.90
POD	.51	.53	.61	.17
VE	.42	.39	.44	.14
CSI	.25	.20	.23	.07

#### 5. LOCAL STATISTICS

Appendix A lists severe local storm warning verification data for local NWS offices. Station names for the call-letter identifiers are listed in Appendix A of Operations of the National Weather Service (NWS, 1985). This list includes those offices that either issued at least one severe local storm warning or recorded at least one severe local storm event within its area of responsibility during 1984. A warning is counted for the office issuing that warning. A severe local storm event is counted for the office in whose area of responsibility that event occurs. As an example, office A issues a warning for a county in the area of responsibility of office B. Then, three severe local storm events occur in that county during the valid period of the warning. Office A is credited with a warned county, and office B is credited with three warned events. This counting procedure can result in an office that issues no warnings (e.g., ROW in the Southern Region) having a POD greater than zero in Appendix A.

From one office to another there are often wide variations in numbers such as warnings issued and severe local storm events. Computed statistics reflect differences in both severe local storm reporting and meteorological regimes, as well as the warning skills of the forecasters. As stated previously, these factors demand that caution be exercised in any comparisons made among verification results from the various offices.

## 6. SUMMARY

All verification of tornado and severe thunderstorm warnings issued by local NWS offices is accomplished at the National Severe Storms Forecast Center. Monthly and year-to-date reports containing summaries of all warnings and events and various verification statistics are provided for national, regional and local use. This report documents national, regional and local verification results for the year 1984.

Although the period of record is only three years, verification statistics have shown trends of improvement. The Central and Southern regions contribute most of the warnings and observed events in national totals. Varying population density and differing meteorological regimes are among many factors that influence verification results. Such factors demand caution in direct comparisons of verification statistics among regions or local offices.

## 7. ACKNOWLEDGEMENTS

The authors thank Beverly D. Lambert for her technical assistance in preparing this report. Steven J. Weiss, NSSFC, and Robert M. Thompson, NWSH, provided reviews of the manuscript.

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APPENDIX A  
Severe Local Storm Warning Verification for NWS Offices: 1984

Station Call Letters	Severe Local Storm Events	EASTERN REGION		PV	FAR	POD	VE	CSI
		Warnings Issued	Counties Warned					
ABE	18	7	12	33	.67	.56	.44	.26
ACY	1	5	9	11	.89	1.00	.56	.11
ALB	32	8	15	53	.47	.34	.44	.26
AVL	13	5	11	9	.91	.08	.08	.04
AVP	3	1	3	0	1.00	.00	.00	-
BDL	10	6	14	43	.57	.60	.52	.33
BDR	7	1	3	0	1.00	.00	.00	-
BGM	8	2	3	33	.67	.13	.23	.10
BKW	2	4	8	13	.87	.50	.32	.11
BOS	9	9	11	18	.82	.22	.20	.11
BTV	2	3	3	0	1.00	.00	.00	-
BUF	22	14	28	43	.57	.59	.51	.33
BWI	19	14	30	7	.93	.21	.14	.05
CAE	80	60	95	41	.59	.64	.53	.33
CAK	30	18	25	40	.60	.50	.45	.29
CAR	4	0	0	-	-	.00	-	-
CHS	38	25	48	40	.60	.74	.57	.35
CLE	13	10	17	47	.53	.62	.55	.36
CLT	26	11	24	25	.75	.27	.26	.15
CMH	23	20	22	50	.50	.52	.51	.34
CON	11	5	5	0	1.00	.09	.05	-
CRW	10	3	4	25	.75	.20	.23	.13
CVG	6	4	5	20	.80	.17	.19	.10
DAY	12	9	15	33	.67	.42	.38	.23
EKN	12	6	12	25	.75	.42	.34	.19
ERI	1	9	13	0	1.00	.00	.00	-
EWR	2	3	13	15	.85	1.00	.58	.15
GSO	39	16	24	62	.38	.54	.58	.41
GSP	74	37	60	38	.62	.72	.55	.33
HAR	11	12	30	10	.90	.27	.19	.08
HAT	28	5	6	33	.67	.50	.42	.25
HTS	5	1	2	50	.50	.20	.35	.17
ILG	10	8	8	38	.62	.60	.49	.30
ILM	57	25	43	33	.67	.53	.43	.25
IPT	2	1	1	0	1.00	.00	.00	-
LYH	2	1	2	0	1.00	.50	.25	-
MFD	2	2	2	0	1.00	.00	.00	-
NYC	23	21	53	15	.85	.44	.30	.13
ORF	24	7	43	44	.56	.92	.68	.43
ORH	8	5	7	14	.86	.13	.13	.07
PHL	10	8	10	30	.70	.30	.30	.18
PIT	28	11	26	35	.65	.61	.48	.28
PVD	1	2	4	50	.50	.00	.25	-
PWM	10	6	11	46	.54	.50	.48	.31
RDU	123	73	123	62	.38	.66	.64	.47
RIC	33	14	25	48	.52	.39	.44	.28

ROA	13	12	22	18	.82	.46	.32	.15
ROC	4	4	5	0	1.00	.00	.00	-
SYR	26	10	26	54	.46	.69	.62	.43
TOL	25	11	14	43	.57	.32	.38	.22
WBC	13	6	12	8	.92	.08	.08	.04
YNG	3	6	15	0	1.00	1.00	.50	-

Station Call Letters	Severe Local Storm Events	CENTRAL REGION		PV	FAR	POD	VE	CSI
		Warnings Issued	Counties Warned					
ABR	18	88	151	6	.94	.39	.23	.05
ALO	65	40	65	43	.57	.59	.51	.33
ALS	2	0	0	-	-	.00	-	-
APN	3	4	6	33	.67	.33	.33	.20
BFF	13	51	71	10	.90	.46	.28	.09
BIS	42	49	89	21	.79	.43	.32	.17
CHI	53	32	64	31	.69	.47	.39	.23
CIR	2	0	0	-	-	.50	-	-
CNK	78	51	85	53	.47	.74	.64	.45
COS	22	67	93	12	.88	.50	.31	.11
COU	106	102	209	32	.68	.76	.54	.29
CPR	20	18	19	37	.63	.35	.36	.22
CYS	18	21	30	23	.77	.44	.34	.18
DBQ	21	15	18	44	.56	.38	.41	.26
DDC	26	34	67	24	.76	.69	.47	.22
DEN	95	132	242	18	.82	.58	.38	.16
DLH	52	62	110	28	.72	.65	.47	.25
DSM	150	131	215	28	.72	.46	.37	.21
DTW	20	38	61	15	.85	.40	.28	.12
EVV	74	25	73	31	.69	.49	.40	.24
FAR	88	69	151	32	.68	.73	.53	.28
FNT	23	34	54	13	.87	.44	.29	.11
FSD	79	107	248	14	.86	.46	.30	.12
FWA	15	8	23	22	.78	.40	.31	.16
GJT	4	0	0	-	-	.00	-	-
GLD	43	47	77	19	.81	.44	.32	.16
GRB	44	33	56	32	.68	.50	.41	.24
GRI	72	51	141	28	.72	.65	.47	.25
GRR	15	9	15	40	.60	.47	.44	.28
HON	51	54	95	18	.82	.43	.31	.15
HTL	6	5	5	40	.60	.33	.37	.22
ICT	114	120	206	32	.68	.71	.52	.28
IND	64	59	90	42	.58	.58	.50	.32
INL	17	17	24	33	.67	.53	.43	.26
ISN	20	33	49	26	.74	.70	.48	.24
JKL	14	15	33	27	.73	.64	.46	.24
LAN	25	17	23	30	.70	.32	.31	.19
LBF	46	66	97	33	.67	.57	.45	.26
LEX	20	9	17	53	.47	.45	.49	.32
LND	4	2	2	50	.50	.50	.50	.33
LNK	25	22	31	19	.81	.36	.28	.14

LSE	28	23	38	34	.66	.54	.44	.26
MCI	65	49	69	26	.74	.37	.32	.18
MKE	97	106	189	30	.70	.66	.48	.26
MKG	9	11	13	23	.77	.33	.28	.16
MLI	15	18	37	13	.87	.40	.27	.11
MOT	10	8	21	5	.95	.10	.08	.03
MSN	91	79	149	25	.75	.56	.41	.21
MSP	66	66	148	21	.79	.36	.29	.15
OFK	58	55	107	23	.77	.55	.39	.20
OMA	52	53	95	24	.76	.56	.40	.20
PIA	17	32	71	10	.90	.53	.32	.09
PAH	22	1	1	0	1.00	.50	.25	-
PUB	17	51	70	3	.97	.18	.11	.03
RAP	41	46	89	12	.88	.32	.22	.10
RFD	14	12	19	26	.74	.36	.31	.18
RST	60	41	87	26	.74	.45	.36	.20
SBN	9	4	6	17	.83	.33	.25	.13
SDF	51	63	142	18	.82	.20	.19	.11
SGF	79	64	124	30	.70	.57	.44	.24
SHR	18	9	10	10	.90	.17	.14	.07
SPI	38	47	91	15	.85	.40	.28	.12
SSM	6	2	4	0	1.00	.00	.00	-
STC	31	19	35	14	.86	.36	.25	.11
STL	244	177	445	32	.68	.71	.52	.29
SUX	30	23	33	30	.70	.47	.39	.23
TOP	69	48	93	28	.72	.49	.39	.22
VTN	2	2	2	0	1.00	.00	.00	-

Station Call Letters	Severe Local Storm Events	SOUTHERN REGION		PV	FAR	POD	VE	CSI
		Warnings Issued	Counties Warned					
ABI	23	22	34	15	.85	.44	.30	.12
ABQ	3	16	28	4	.96	.00	.02	-
ACT	53	42	58	41	.59	.57	.49	.31
AGS	26	24	35	11	.89	.35	.23	.09
AHN	89	40	136	46	.54	.85	.66	.43
AMA	35	33	59	20	.80	.46	.33	.16
AQQ	1	4	4	0	1.00	.00	.00	-
ATL	90	81	202	19	.81	.57	.38	.17
AUS	32	30	46	20	.80	.31	.26	.14
BHM	102	163	288	19	.81	.66	.43	.18
BNA	79	100	294	11	.89	.39	.25	.09
BPT	28	85	142	5	.95	.25	.15	.04
BRO	5	12	21	0	1.00	.00	.00	-
BTR	24	13	27	33	.67	.54	.44	.26
CAO	3	0	0	-	-	.00	-	-
CHA	23	16	31	23	.77	.30	.27	.15
CRP	9	26	50	8	.92	.44	.26	.07
CSG	34	34	64	25	.75	.47	.36	.20
DAB	8	28	39	8	.92	.38	.23	.07
DRT	3	6	6	17	.83	.67	.42	.15



ELP	1	3	6	0	1.00	.00	.00	-
ESF	11	4	7	43	.57	.55	.49	.32
EYW	0	1	1	0	1.00	-	-	-
FMY	3	0	0	-	-	.00	-	-
FSM	74	110	206	23	.77	.58	.41	.20
FTW	264	150	274	43	.57	.67	.55	.36
GLS	2	22	37	0	1.00	.00	.00	-
HOU	44	74	133	12	.88	.59	.36	.11
HSV	61	64	144	27	.73	.64	.46	.24
JAN	71	95	152	20	.80	.47	.34	.16
JAX	25	36	81	9	.91	.32	.21	.07
LBB	11	12	19	16	.84	.36	.26	.12
LCH	29	39	74	16	.84	.38	.27	.13
LIT	173	186	265	26	.74	.47	.37	.20
MAF	5	25	37	5	.95	.40	.23	.05
MCN	61	52	105	33	.67	.61	.47	.27
MCO	13	23	45	11	.89	.54	.33	.10
MEI	23	34	55	22	.78	.65	.44	.20
MEM	150	167	351	14	.86	.33	.24	.11
MGM	87	85	122	43	.57	.66	.52	.35
MIA	17	30	42	9	.91	.29	.19	.08
MOB	58	76	124	27	.73	.64	.46	.23
NEW	38	36	71	20	.80	.58	.39	.17
OKC	509	302	568	58	.42	.79	.69	.50
PBI	7	25	29	3	.97	.29	.16	.03
PNS	10	28	48	12	.88	.50	.31	.11
ROW	5	0	0	-	-	.20	-	-
SAT	60	91	157	11	.89	.50	.31	.10
SAV	32	31	71	17	.83	.44	.31	.14
SHV	531	213	573	59	.41	.83	.71	.52
SJT	13	12	21	9	.91	.15	.12	.06
SPS	18	29	38	16	.84	.67	.42	.15
TBW	39	27	41	10	.90	.13	.12	.06
TLH	3	12	16	6	.94	.33	.20	.06
TRI	4	4	12	0	1.00	.00	.00	-
TUL	107	164	295	19	.81	.56	.38	.16
TUP	24	49	75	15	.85	.38	.27	.12
TYS	11	15	45	4	.96	.18	.11	.04
VCT	8	25	34	9	.91	.88	.49	.09

WESTERN REGION

<u>Station</u> <u>Call Letters</u>	<u>Severe Local</u> <u>Storm Events</u>	<u>WarnIngs</u> <u>Issued</u>	<u>Counties</u> <u>Warned</u>	<u>PV</u>	<u>FAR</u>	<u>POD</u>	<u>VE</u>	<u>CSI</u>
BFL	1	1	1	0	1.00	.00	.00	-
BIL	23	22	43	21	.79	.48	.35	.17
BOI	23	7	21	19	.81	.17	.18	.10
EKO	1	0	0	-	-	.00	-	-
ELY	4	0	0	-	-	.00	-	-
EUG	1	0	0	-	-	.00	-	-
FAT	1	0	0	-	-	.00	-	-

FCA	2	0	0	-	-	.00	-	-
GEG	1	0	0	-	-	.00	-	-
GTF	10	17	37	8	.92	.50	.29	.08
HLN	7	0	0	-	-	.00	-	-
HVR	1	0	0	-	-	.00	-	-
LAS	12	7	8	25	.75	.17	.21	.11
LAX	10	9	16	0	1.00	.00	.00	-
LMT	1	0	0	-	-	.00	-	-
LWS	3	6	18	6	.94	.67	.37	.05
MSO	1	3	7	0	1.00	.00	.00	-
OLM	1	0	0	-	-	.00	-	-
PDT	2	1	4	0	1.00	.00	.00	-
PDX	5	1	1	0	1.00	.00	.00	-
PHX	16	12	13	8	.92	.06	.07	.04
PIH	14	5	27	11	.89	.29	.20	.09
RNO	2	2	3	0	1.00	.00	.00	-
SAN	0	2	2	0	1.00	-	-	-
SLC	34	4	34	0	1.00	.00	.00	-
TUS	11	8	9	22	.78	.27	.25	.14
WMC	1	0	0	-	-	.00	-	-
YKM	0	1	1	0	1.00	-	-	-
YUM	1	0	0	-	-	.00	-	-

No. 9 Verification of Severe Local Storm Forecasts Issued by the National Severe Storms Forecast Center: 1984. Preston W. Leftwich, Jr., November 1985, 9 p. (PB86 128105/AS).

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