NTM BINDER

NOAA TECHNICAL MEMORANDUM NWS NSSFC-33

SEVERE LOCAL STORM WARNING VERIFICATION: 1991

Leo A. Grenier and John T. Halmstad
National Severe Storms Forecast Center
Kansas City, Missouri 64106-2877

April 1992

U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

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.

NOAA Technical Memoranda in the NWS, NSSFC subseries are produced under the technical guidance of the NSSFC, Techniques Development Unit. They facilitate rapid dissemination of material of general interest in the field of severe storm meteorology. These papers may be preliminary in nature, and may be formally published elsewhere at a later date.

These papers are available from the National Technical Information Service (NTIS), U.S. Department of Commerce, Sills Building, 5285 Port Royal Road, Springfield, Virginia 22161. Price varies, $3.50 for microfiche.

Previous issued in this series:

No. 1 New Severe Thunderstorm Radar Identification Techniques and Warning Criteria: A Preliminary Report. Leslie R. Lemon, July 1977, 60 p., (PB 273049).

No. 2 A Subjective Assessment of Model Initial Conditions Using Satellite Imagery. John E. Hales, Jr., November 1978, 19 p., (PB 291593).

No. 3 Severe Thunderstorm Radar Identification Techniques and Warning Criteria. Leslie R. Lemon, April 1980, 60 p., (PB 231409).

No. 4 The Enhanced-V, A Satellite Observable Severe Storm Signature. Donald W. McCann, March 1981, 31 p., (PB 230336).

No. 5 The Operational Meteorology of Convective Weather Volume I: Operational Mesoanalysis. Charles A. Doswell III, November 1982, 160 p., (PB83 162321).

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).

NOAA TECHNICAL MEMORANDUM NWS NSSFC-33

SEVERE LOCAL STORM WARNING VERIFICATION: 1991

LEO A. GRENIER
JOHN T. HALMSTAD
National Severe Storms Forecast Center
Kansas City, Missouri 64106-2877

April 1992

UNITED STATES
DEPARTMENT OF COMMERCE
Robert A. Mosbacher
Secretary

National Oceanic and
Atmospheric Administration
John A. Knauss
Under Secretary

National Weather
Service
Elbert W. Friday, Jr.
Assistant Administrator

TABLE OF CONTENTS

	Page No.
Abstract	1
Introduction	1
Verification Procedures	1
National Statistics	5
Regional Statistics	10
Local Statistics	12
Summary	13
Acknowledgements	13
References	14
Appendix	16

SEVERE LOCAL STORM WARNING VERIFICATION: 1991

Leo A. Grenier, John T. Halmstad,
National Severe Storms Forecast Center
Kansas City, Missouri 64106-2877

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 1991.

Stations in the Southern and Central regions have issued most of the warnings and experienced most of the severe local storm events. A record number of severe local storm events were again confirmed in 1991. On a national scale, verification scores all showed improvement.

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 or imminent 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 are contained in National Weather Service Offices and Stations (NWS 1990). Areas of responsibility are defined in Weather Service Operations Manual, Chapter C-47 (1986) with included revisions by the National Weather Service Office of Meteorology (OM). 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 1991. 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 statistics 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 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 Automation of Field Operations and Services (AFOS) computer system. Information concerning events is extracted from surface observations, warning messages, local storm reports (LSR), statements, pilot reports and state weather summaries. Additional reports may be received via newspaper articles and telephone conversations. These reports form a "rough log" of severe local storm events.

Each week, listings of warnings that have been logged and processed at the NSSFC and the "rough log" are transmitted via the AFOS system to local offices for review. The roles of these warning and event summaries in the verification process are discussed in detail by Leftwich and Lee (1984), and updated by Grenier and Halmstad (1986). After reviewing warning lists, local offices send any warning corrections to the Verification Section at the NSSFC. The rough log is an aid for the Warning Preparedness Meteorologist (WPM), at each forecast office, to use in preparing "Storm Data and Unusual Weather Phenomena" (Form F-8). These F-8 reports are the sole source of event reports used in the "smooth log" for official verification. There is one exception in that real-time surface aviation observations (SAO's) containing severe weather reports are retained in the smooth log even though they may not appear in an F-8 report. After all forms of information have been compiled, the resulting "smooth log" and warning file are the data bases for official verification.

To qualify as a severe local storm event, a report must satisfy one of the criteria given in Table 1. General guidelines on event reporting may be found in Grenier and Halmstad (1986). For verification purposes, multiple reports of non-tornadic events occurring within 10 statute miles and 15 minutes of each other and in the same county are recorded as one event. With the following exceptions. All distinct tornadoes are retained as separate events. All reports of hail with two inch diameter or greater and wind events with 65 knots or greater reported speed are also retained.

Originally, a severe event was identified as a duplicate if it met the following criteria; (1) it was in the same county, (2) it was within 10 statute miles and 15 minutes of another report, (3) it was the same type of non-tornadic phenomena, i.e. hail or wind (Leftwich and Lee, 1984). It was later noted that a severe wind and severe hail report from the same severe thunderstorm caused the storm to be counted twice. In an effort to focus on the thunderstorm cell, the "same type" requirement was dropped at the beginning of the 1986 severe weather year (Grenier and Halmstad, 1986).

Table 1

Criteria for Severe Local Storm Events
Used in Warning Verification

a. Tornado - a rotating circulation touching the ground and associated with a convective cloud.

b. Hail equal 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.

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, many events can occur during one warning. Any type of severe event (Table 1) can verify either type (tornado or severe thunderstorm) warning.

In current verification procedures, the county is the basic unit of area. A warning in effect for three counties is counted as three "warned counties". At least one severe local storm event occurring during the valid period of a warning in a warned county produces a "verified county". In order to obtain perfect verification, at least one severe local storm event must occur in each warned county.

Once data have been compiled, a four-cell contingency table (Table 2) can be constructed to depict relationships between warnings and events. Various verification statistics can be computed from this contingency table. Primary statistics used in the current verification are the Probability of Detection (POD), False-Alarm Ratio (FAR), and Critical Success Index (CSI). They have been adapted from Donaldson et al. (1975).

Table 2

Two by two contingency table
depicting counts of warnings and events.

		WARNIN S	
E V E N T S		YES	NO
	YES	x	y
	NO	z	w *

x = warned events
y = unwarned events
z = unverified warnings
w = no warning, no event

* not used in calculations of verification statistics

The POD, which is a measure of the correctness of the warnings in time and space, is computed as follows:

$$POD = \frac{x}{(x + y)} \quad \text{or} \quad \frac{\text{number of warned events}}{\text{total number of events}} \qquad (1)$$

Values range from "0" to "1" with the higher score indicating a greater degree of correctness.

The FAR, a measure of overwarning, is computed by:

$$FAR = \frac{z}{(x + z)} \quad \text{or} \quad \frac{\text{number of unverified counties}}{\text{number of warned counties}} \qquad (2)$$

Values range from "0" to "1" with the lower score indicating a lesser degree of overwarning.

The CSI, which is the same as the Threat Score, is given by:

$$CSI = \frac{x}{(x + y + z)} \quad \text{or} \quad \frac{\text{number of warned events}}{\text{sum of the events and unverified warnings}} \qquad (3)$$

Values range from "0" to "1" with the higher score indicating more skill. A graphical depiction of how the CSI reflects both the POD and FAR is given in Grenier et al. (1990).

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

$$PV = \frac{\text{number of verified counties}}{\text{number of warned counties}} \times 100 = (1 - \frac{z}{x+z}) \times 100 \qquad (4)$$

The PV is also equivalent to 100(1-FAR). Values range from "0" to "100".

Verification Efficiency represents an average of the POD and PV, and provides a straight-forward measure of combined success in verifying warnings and covering events with valid warnings. It is calculated as

$$VE = 0.005\ (PV + 100 \times POD). \qquad (5)$$

Values range from "0" to "1".

Sparseness of population can 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. More recently, Doswell and Burgess (1988) noted several problems relating to the F-scale tornado intensity rating system and the occurrence of very long track tornado events. Results of these studies demand that caution be exercised in directly comparing verification results between local offices, and regions that have different population densities or different meteorological regimes.

3. NATIONAL STATISTICS

Table 3 summarizes warning verification data for the contiguous United States during 1991. A total of 12,523 severe local storm events were reported. This is the greatest number of confirmed severe local storm events since warning verification began in 1979, and it is 1567 more than the previous high year of 1990. The counties warned total of 14,920 is also the highest annual count since 1979. Nationwide, approximately 68% of the severe local storm events occurred in warned counties, and at least one event was observed in 47% of the warned counties. The resulting national CSI was .39 with a VE of .56.

Table 3

National Severe Local Storm Warning Verification Data: 1991

Counties Warned	14,920
County Warnings Verified	7,097
Severe Local Storm Events	12,523
Warned Events	8,358
FAR	.52
POD	.67
CSI	.39
Percent Verified	47
VE	.56

Figures 1a, b, c, and d show the distributions of station statistics. Only those stations that issued at least one warning or had one event occur in their areas of responsibility were included in the raw distribution. Because stations with minimal activity tend to fall into the extremes of the raw distribution, the data were also filtered using the following criteria.

(1) FAR...contains only those stations that issued 6 or more warnings for the year.

(2) POD...contains only those stations that had 6 or more severe events occur in their area of responsibility.

(3) CSI...contains only those stations that meet the criteria in (1) or (2).

(4) VE....contains only those stations that meet the criteria in (1) or (2).

A comparison of the raw distribution to the filtered distribution is shown in Figures 1a, b, c and d respectively. Median values are shown for both the raw and <u>filtered</u> distributions of the FAR, POD, CSI and VE.

Figure 2 shows a continuation of the improving trend in the POD and VE. It also shows a resumption of improvement in the FAR and CSI from their 1990 deviation. The CSI seem to exhibit a bias in relation to the

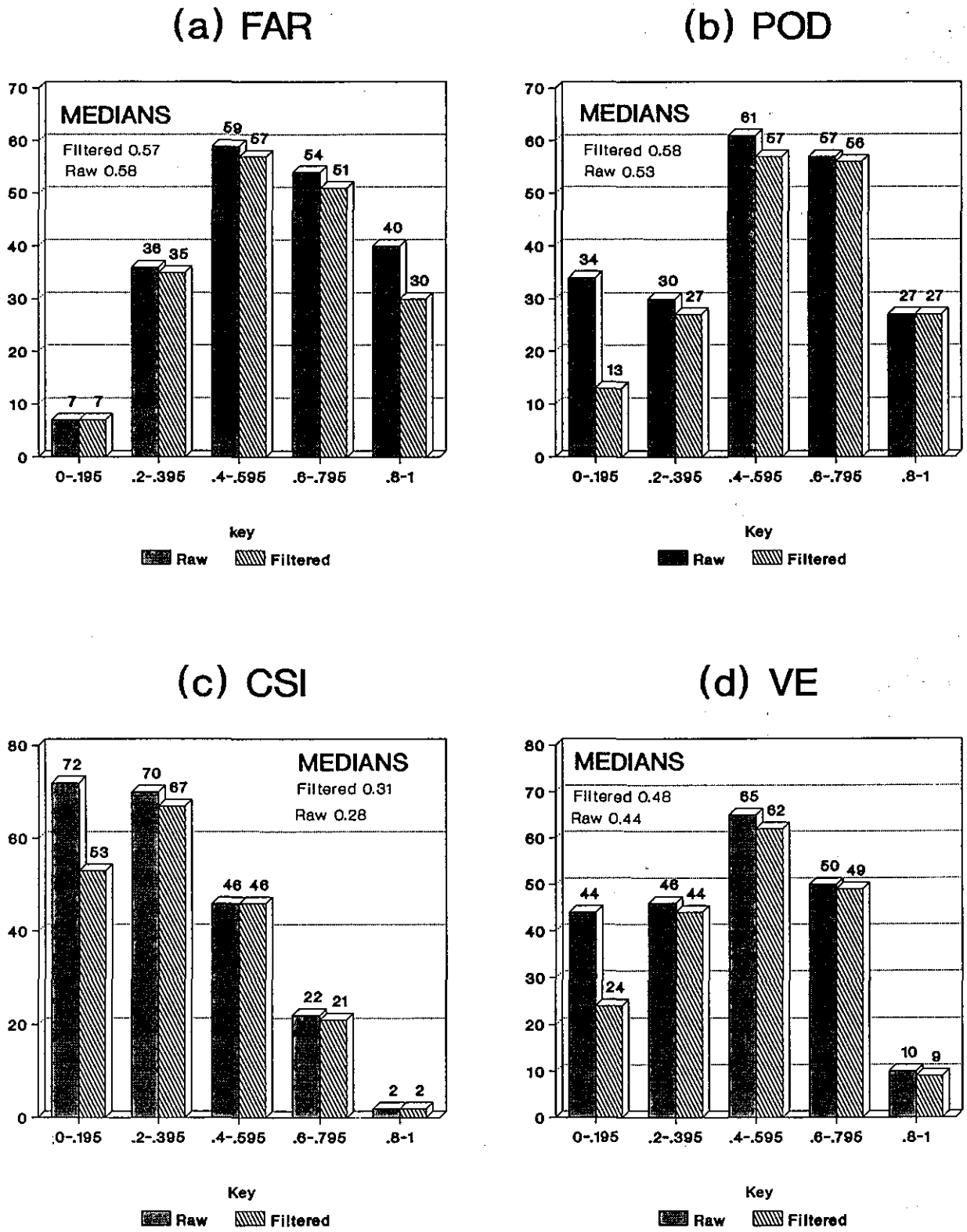


Figure 1. Frequency distributions of severe local storm warning verification statistics for 1991.

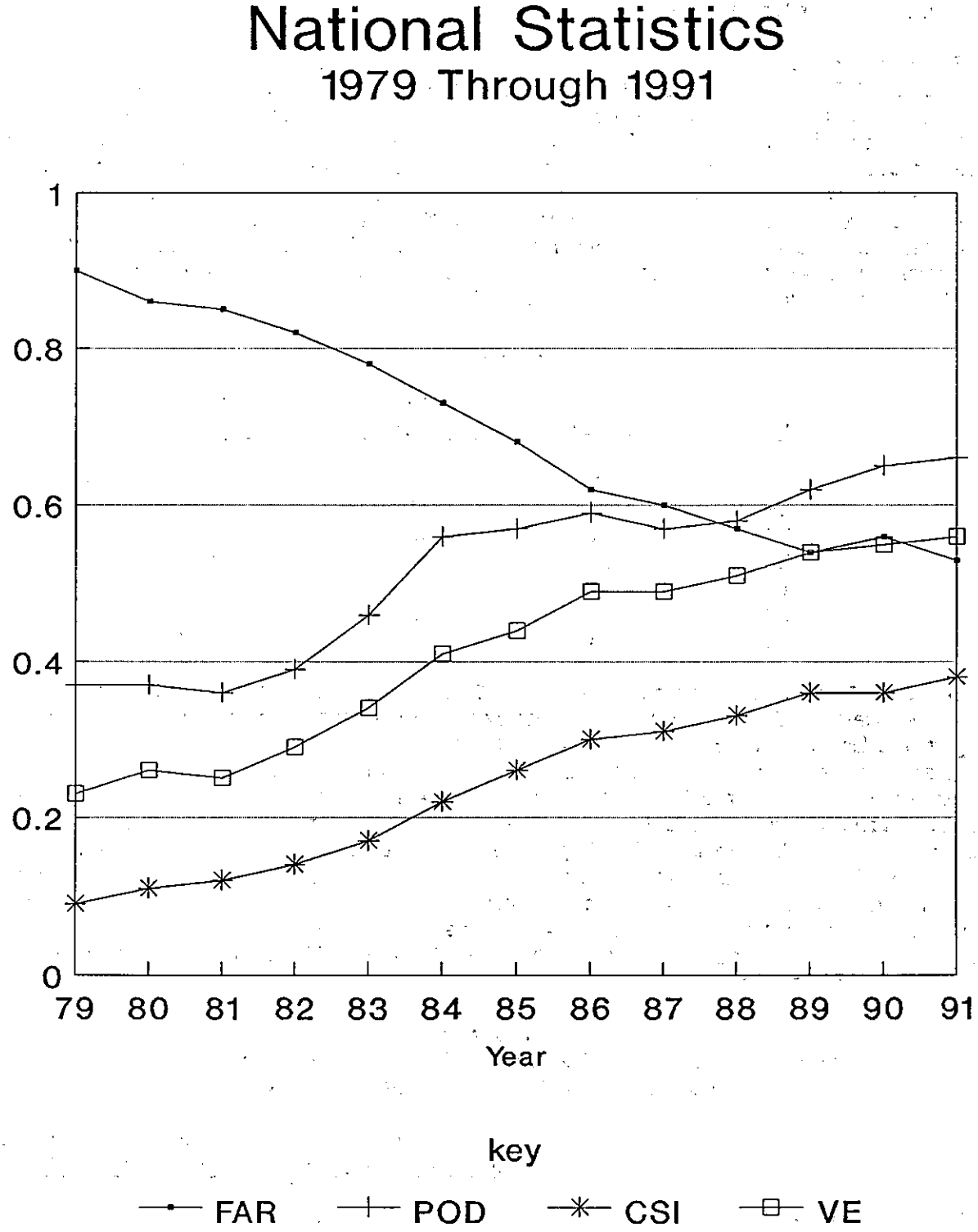


Figure 2. Severe Local Storm Warning Verification.

frequency of events (Gilbert 1884). This may be present in this instance and would be consistent with the new record total of severe local storm events in 1991.

Tornadoes totaled 1132 in 1991, only 1 below the record high of 1133 set in 1990. This 1991 total exceeds annual totals for every other year since 1950, and is 328 above the 30-year annual average (1961-1990) of 804. Additionally, Table 4 lists 7 states which set new records for tornado totals. Colorado and Kansas both exceeded their previous annual high totals by 18. New Mexico nearly doubled its previous high with an increase of 17. It is noteworthy that Minnesota recorded 37 tornadoes, only 4 shy of its all time record of 41 set in 1981. The 192 tornadoes that were recorded in Texas, ranks third for that state and is 40 less than their record of 232 set in 1967.

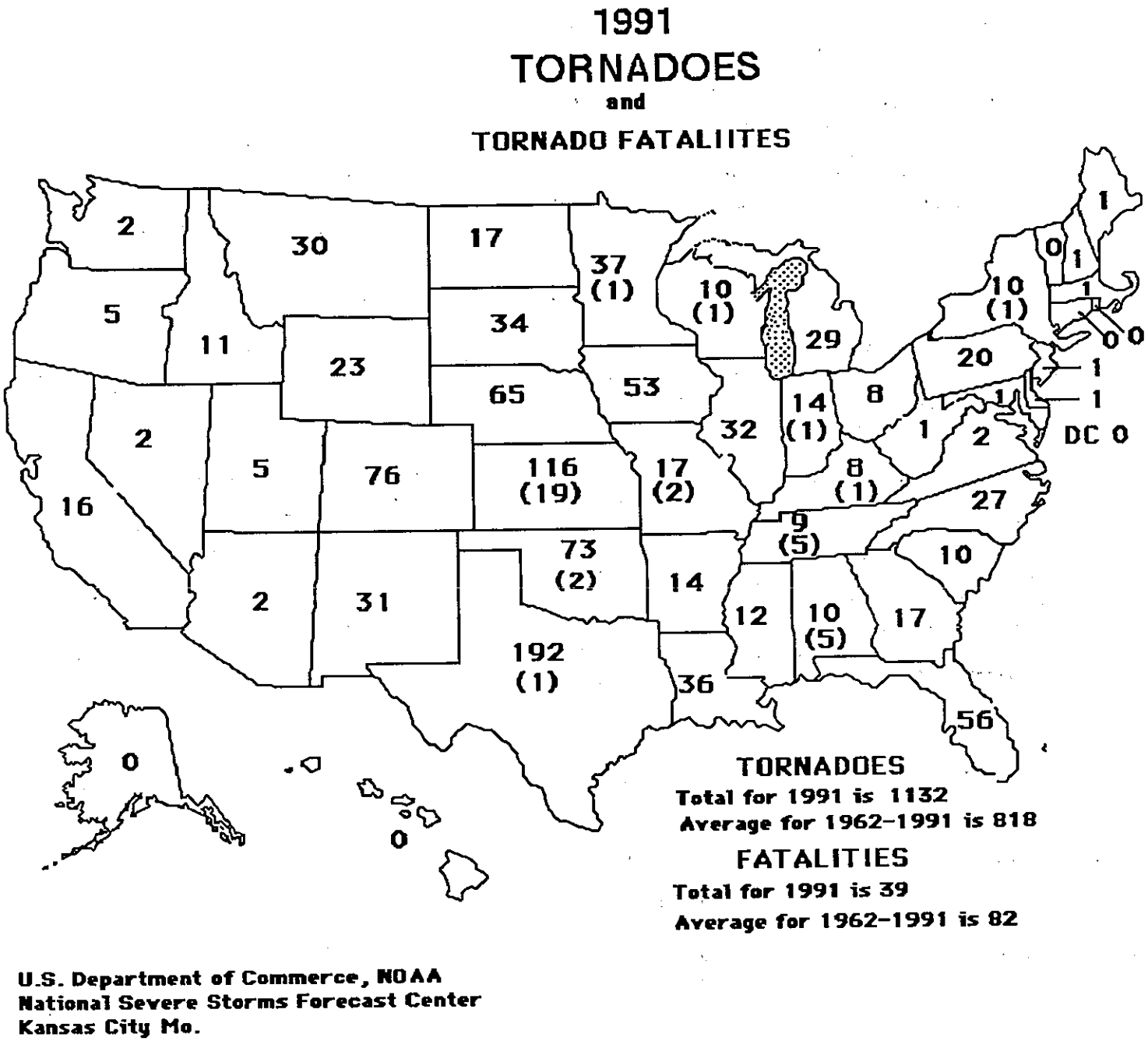
Table 4

State	New Record	Previous Record	Previous Year
CA	16	14	1978, 1982
CO	76	58	1982
ID	11	10	1986
KS	116	98	1955
MT	30	20	1988
NM	35	18	1972
OR	5	4	1984

During 1991, tornadoes caused 39 fatalities and 864 injuries in the United States. For the sixth successive year the annual fatality and injury totals are significantly lower than the 30-year annual averages of 82 fatalities and 1688 injuries. This is especially noteworthy when considering that tornado totals have exceeded the 30-year annual average by 40 percent in both 1990 and 1991. As shown in Table 5, 97 percent of all tornado fatalities and 80 percent of all tornado injuries occurred within a valid severe local storm warning. Severe thunderstorm wind gusts caused another 34 fatalities and 491 injuries. Of these, 59 percent of the fatalities and 64 percent of the injuries were within a warned area. Figure 3 shows the 1991 distribution of tornadoes and fatalities by state.

Table 5
Severe Local Storm-Related Fatalities and Injuries
Relative to Valid Warnings: 1991

	Tornado		Severe Thunderstorm	
	Fatalities	Injuries	Fatalities	Injuries
Total Number	39	864	34	491
Within Valid Warnings	38	691	20	316
% Within Warnings	97	80	59	64



U.S. Department of Commerce, NOAA
National Severe Storms Forecast Center
Kansas City Mo.

Figure 3. Map of Tornadoes/Fatalities for 1991.

Figure 4 shows the number of event reports received in three categories for a 30-year period (1962-1991). While the number of tornadoes has remained relatively steady, the number of wind/hail reports and the total events have generally been increasing. The 1991 severe local storm events total of 12,523 is 2.9 times greater than the 1979 total, with large increases occurring since 1988. One might have interpreted the 1987 and 1988 decline in event totals as a leveling trend, but they were relatively quiet severe weather years. Additionally, the changes in the "duplicate" definition may have contributed to this result. It now appears that the increasing trend in total events remains with us.

4. REGIONAL STATISTICS

Table 6 summarizes warning verification data for the four contiguous NWS regions. Maps depicting the states included within each region are contained in Operations of the National Weather Service (NWS 1985). Similar to previous years, Central and Southern regions accounted for more than 79 percent of the national total of severe local storm events. This is in agreement with the climatologies by Kelly et al. (1978) and Kelly et al. (1985). Accordingly, these regions typically issue more warnings. Consistent percentage contributions of each region to the national totals for each variable are noted again during 1990. For example, the Central Region issued 38.1% of the county warnings. This region also had 33.6% of the verified counties, 36.4% of the severe events and 33.9% of the warned events. Figure 5 shows a regional distribution of severe local storm warnings and events as compared to the national total.

Table 6

Regional severe local storm warning verification data: 1990. Numbers in parentheses are percentages of national totals for each item.

	Central	Eastern	Southern	Western
Counties Warned	5690 (38.1)	2046 (13.7)	6735 (45.2)	449 (3.0)
County Warnings Verified	2387 (33.6)	1162 (16.4)	3476 (49.0)	72 (1.0)
Severe Local Storm Events	4556 (36.4)	2237 (17.9)	5406 (43.1)	324 (2.6)
Warned Events	2837 (33.9)	1475 (17.7)	3978 (47.6)	68 (0.8)
FAR	.580	.432	.484	.840
POD	.623	.659	.736	.210
CSI	.334	.439	.435	.100
Percent Verified	41	56	51	16
VE	.510	.616	.614	.181

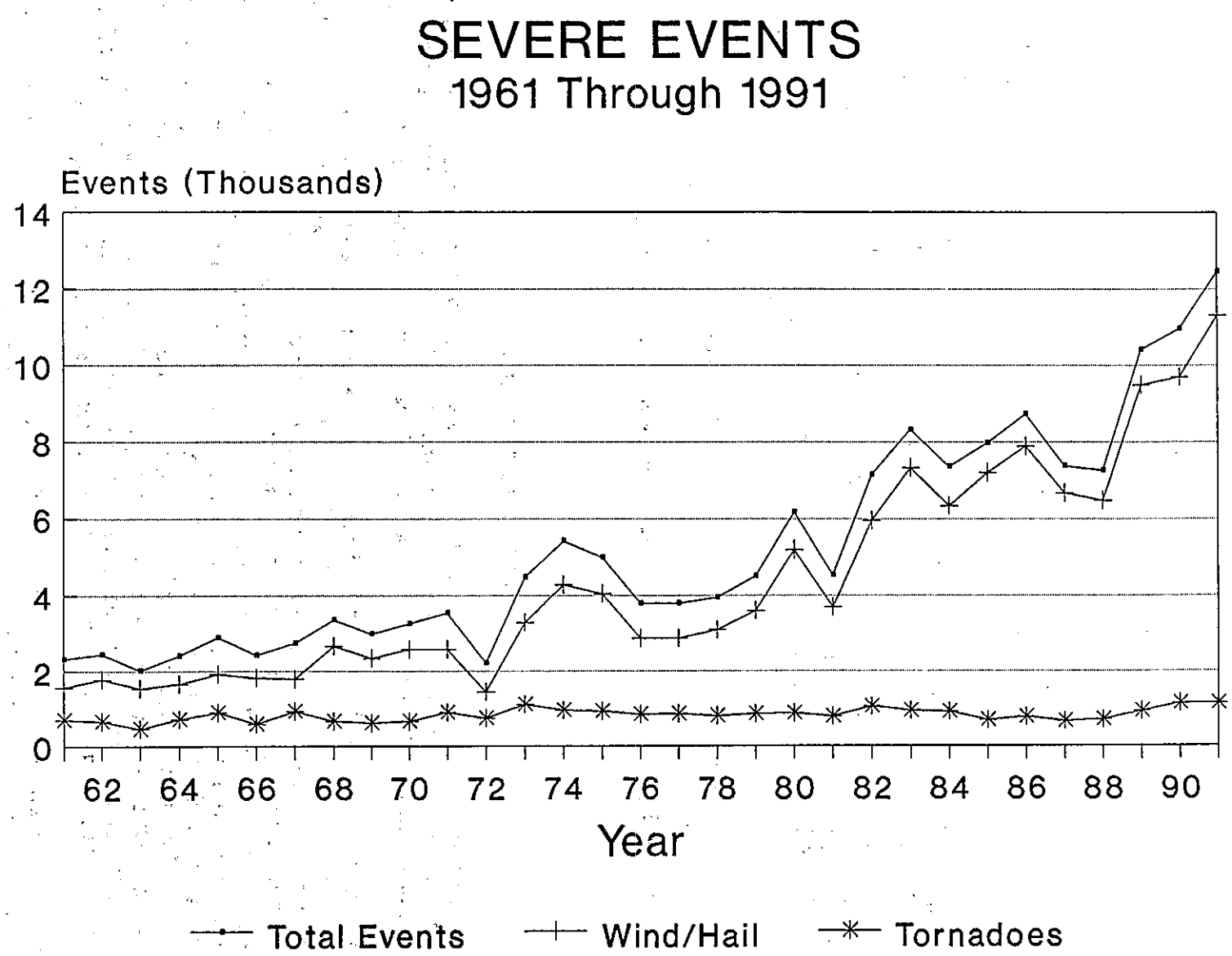


Figure 4. Annual severe event totals.

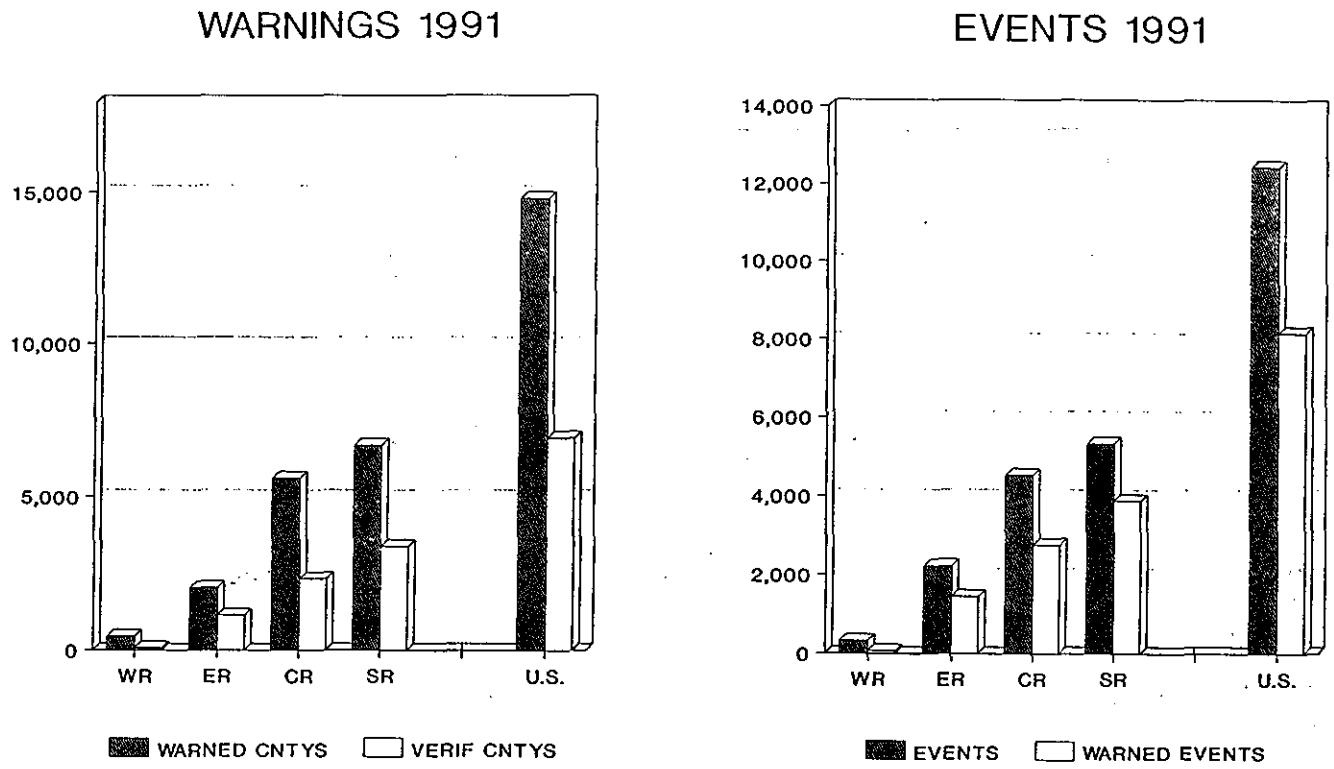


Figure 5. Warning and Event distributions by region.

5. LOCAL STATISTICS

The appendix lists severe local storm warning verification data for local NWS offices. Station names for the call-letter identifiers are listed in the National Weather Service Offices and Stations (NWS 1990).

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 1991. 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 accounting procedure can result in an office that issues no warnings having a POD greater than zero in Appendix A.

There are often wide variations in numbers such as warnings issued and severe local storm events from one office to another. 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 of verification results with those of other offices. Furthermore, users of the results must be aware that no single statistic, such as the CSI, can adequately measure the performance of an offices warning program (Schaefer 1990).

6. SUMMARY

Official 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 1991.

Since 1979, verification statistics have generally shown continued improvement through 1991. The only deviations are in the POD for years 1981 and 1987, and in the 1990 CSI and FAR. 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. Any direct comparisons of verification statistics among regions or local offices are not appropriate (Schaefer 1990).

7. ACKNOWLEDGMENTS

The authors thank Deborah Haynes for her outstanding technical assistance in preparing this report. Also, many thanks to Steven J. Weiss, of the National Severe Storms Forecast Center and Dr. Preston W. Leftwich, Jr. of the Scientific Services Division, Central Region Headquarters for their reviews of the manuscript.

8. REFERENCES

Donaldson, R.J., R.M Dyer and M.J. Kraus, 1975: An objective evaluator of techniques for predicting severe weather events. Preprints, Ninth Conference on Severe Local Storms (Norman, OK), Amer. Meteor. Soc., Boston, MA, 395-402.

Doswell, C.A., III and D.W. Burgess, 1988: On some issues of United States tornado climatology. Mon. Wea. Rev., 116, 495-501.

Gilbert, G.F., 1884: Finleys Tornado Predictions. American Meteorology Journal, 1, 166-172.

Grenier, L.A. and J.T. Halmstad, 1986: Severe Local Storm Warning Verification Preliminary Procedures, NOAA Technical Memorandum NWS NSSFC-12, National Severe Storms Forecast Center, Kansas City, MO, 10 pp.

_____, _____ and P.W. Leftwich, 1990: Severe Local Storm Warning Verification: 1989, NOAA Technical Memorandum NWS NSSFC-27, National Severe Storms Forecast Center, Kansas City, MO, 20 pp.

Hales, J.E., and D.L. Kelly, 1985: The relationship between the collection of severe thunderstorm reports and warning verification. Preprints, Fourteenth Conference on Severe Local Storms (Indianapolis, IN), Amer. Meteor. Soc., Boston, MA, 13-16.

Kelly, D.L., and J.T. Schaefer, 1982: Implications of severe local storm warning verification. Preprints, Twelfth Conference on Severe Local Storms (San Antonio, TX), Amer. Meteor. Soc., Boston, MA, 459-462.

_____, _____, and C.A. Doswell, 1985: Climatology of non-tornadic severe thunderstorm events in the United States. Mon. Wea. Rev., 113, 1997-2014.

_____, _____, R.P. McNulty, C.A. Doswell, and R.F. Abbey, 1978: An augmented tornado climatology. Mon. Wea. Rev., 106, 1172-1183.

Leftwich, P.W. and L.C. Lee, 1984: Severe local storm warning and event summaries available in AFOS. NOAA Technical Memorandum NWS NSSFC-6, National Severe Storms Forecast Center, Kansas City, MO, 10 pp.

National Weather Service, 1985: Operations of the National Weather Service. U.S. Dept. of Commerce, NOAA, 237 pp.

National Weather Service, 1986: Weather Service Operations Manual, U.S. Dept. of Commerce, NOAA, Chapter C-47.

National Weather Service, 1982: National Verification Plan. U.S. Dept. of Commerce, NOAA, 81 pp.

Pearson, A.D. and C.L. David, 1979: Tornado and severe thunderstorm warning verification. Preprints, Eleventh Conference on Severe Local Storms (Kansas City, MO), Amer. Meteor. Soc., Boston, MA, 567-568.

Schaefer, J.T. and J.G. Galway, 1982: Population biases in tornado climatology. Preprints, Twelfth Conference on Severe Local Storms (San Antonio, TX), Amer. Meteor. Soc., Boston, MA, 51-54.

_____: The critical success index as in indicator of warning skill. Weather and Forecasting, 5, 570-575.

Appendix A

Severe Local Storm Warning Verification for NWS Offices: 1991

* * * KEY FOR COLUMN HEADINGS * * *

STN	=	STATION CALL LETTERS
WRND CNTYS	=	WARNED COUNTIES
VERF CNTYS	=	VERIFIED COUNTIES
TOT EVNTS	=	SEVERE LOCAL STORM EVENTS
WRND EVNTS	=	WARNED EVENTS
FAR	=	FALSE ALARM RATIO
POD	=	PROBABILITY OF DETECTION
CSI	=	CRITICAL SUCCESS INDEX
VE	=	VERIFICATION EFFICIENCY

CENTRAL REGION

STN	WRND CNTYS	VERF CNTYS	TOT EVNTS	WRND EVNTS	FAR	POD	CSI	VE
ABR	120	71	109	88	.408	.807	.518	.694
ALO	70	34	85	41	.514	.482	.319	.484
ALS	0	0	3	0	.000	.000	.000	.000
APN	40	22	37	25	.450	.676	.435	.610
ARB	11	4	0	0	.636	.000	.000	.364
BFF	210	27	44	27	.871	.614	.119	.213
BIS	123	59	106	67	.520	.632	.275	.550
CHI	132	64	97	74	.515	.763	.421	.603
CNK	191	141	210	172	.262	.819	.635	.781
COS	67	51	98	75	.239	.765	.617	.764
COU	86	26	67	26	.698	.388	.205	.340
CPR	39	6	13	4	.846	.308	.114	.192
CYS	99	26	55	27	.737	.491	.206	.344
DBQ	53	19	44	25	.642	.568	.282	.454
DDC	191	89	140	111	.534	.793	.415	.604
DEN	334	112	200	119	.665	.595	.273	.433
DLH	106	35	81	43	.670	.531	.256	.417
DSM	193	64	165	78	.668	.473	.242	.397
DTW	42	21	80	40	.500	.500	.333	.500
EVV	85	63	99	69	.259	.697	.561	.717
FAR	122	45	89	51	.631	.573	.284	.455
FNT	50	30	73	39	.400	.534	.394	.561
FSD	106	43	111	54	.594	.486	.284	.447
FWA	43	26	40	31	.395	.775	.514	.687
GJT	0	0	1	0	.000	.000	.000	.000
GLD	100	56	108	77	.440	.713	.457	.639
GRB	43	24	43	24	.442	.558	.387	.558
GRI	167	41	109	52	.754	.477	.193	.337
GRR	33	15	52	23	.545	.442	.289	.447
HON	112	31	74	33	.723	.446	.206	.344

HTL	16	12	19	16	.250	.842	.658	.800
ICT	255	171	232	195	.329	.841	.595	.752
IND	137	55	117	62	.599	.530	.296	.461
INL	46	10	20	12	.783	.600	.190	.333
ISN	49	20	41	24	.592	.585	.317	.489
JKL	49	33	39	33	.327	.846	.600	.750
LAN	27	17	54	29	.370	.537	.408	.568
LBF	85	14	48	16	.835	.333	.124	.226
LEX	12	9	24	11	.250	.458	.398	.556
LND	7	2	10	3	.714	.300	.171	.294
LNK	45	9	22	9	.800	.409	.155	.269
LSE	18	8	16	9	.556	.562	.330	.500
MCI	110	51	106	60	.536	.566	.342	.514
MKE	75	37	84	56	.507	.667	.396	.585
MKG	20	9	30	12	.550	.400	.269	.420
MLI	59	25	68	36	.576	.529	.308	.480
MQT	29	9	10	9	.690	.900	.300	.462
MSN	56	24	41	24	.571	.585	.329	.495
MSP	112	53	102	68	.527	.667	.383	.565
OFK	102	26	54	30	.745	.556	.212	.359
OMA	163	40	65	40	.755	.615	.213	.351
PAH	39	19	44	21	.513	.477	.318	.482
PIA	94	36	57	45	.617	.789	.347	.536
PUB	46	4	16	4	.913	.250	.069	.129
RAP	107	46	84	54	.570	.643	.347	.514
RFD	40	10	13	9	.750	.692	.225	.358
RST	43	14	53	18	.674	.340	.199	.333
SBN	75	49	75	64	.347	.853	.587	.753
SDF	80	30	65	29	.625	.446	.256	.407
SGF	130	63	91	72	.515	.791	.430	.611
SHR	7	1	7	2	.857	.286	.105	.214
SPI	99	19	35	20	.808	.571	.168	.291
SSM	3	1	2	2	.667	1.000	.333	.600
STC	57	21	56	26	.632	.464	.259	.416
STL	208	88	133	97	.577	.729	.366	.543
SUX	25	15	31	23	.400	.742	.496	.679
TOP	187	92	158	102	.508	.646	.387	.562
VTN	0	0	1	0	.000	.000	.000	.000

EASTERN REGION

STN	WRND CNTYS	VERF CNTYS	TOT EVNTS	WRND EVNTS	FAR	POD	CSI	VE
ABE	10	6	25	7	.400	.280	.236	.371
ACY	25	14	17	15	.440	.882	.521	.690
ALB	111	84	175	136	.243	.777	.622	.769
AVL	13	3	18	4	.769	.222	.128	.226
AVP	8	4	14	4	.500	.286	.222	.364
BDL	29	20	30	26	.310	.867	.624	.780
BDR	9	9	12	12	.000	1.000	1.000	1.000
BGM	69	37	65	49	.464	.754	.456	.642

BKW	8	6	8	7	.250	.875	.677	.812
BOS	18	7	17	13	.611	.765	.347	.571
BTV	24	17	29	22	.292	.759	.578	.736
BUF	61	41	52	43	.328	.827	.589	.743
BWI	69	16	50	20	.768	.400	.172	.303
CAE	71	25	60	27	.648	.450	.246	.397
CAK	54	36	61	37	.333	.607	.465	.635
CAR	0	0	4	0	.000	.000	.000	.000
CHS	38	25	34	31	.342	.912	.619	.778
CLE	55	45	58	48	.182	.828	.699	.823
CLT	29	18	28	19	.379	.679	.480	.649
CMH	67	38	49	38	.433	.776	.487	.655
CON	30	12	23	13	.600	.565	.306	.472
CRW	51	28	52	33	.451	.635	.417	.592
CVG	97	71	99	79	.268	.798	.618	.765
DAY	53	31	44	33	.415	.750	.489	.660
EKN	47	36	61	53	.234	.869	.683	.824
ERI	47	42	72	62	.106	.861	.781	.874
GSO	35	21	38	21	.400	.553	.404	.575
GSP	42	31	67	35	.262	.522	.441	.606
HAR	59	35	106	53	.407	.500	.372	.533
HAT	33	4	18	4	.879	.222	.085	.157
HTS	34	22	41	26	.353	.634	.471	.640
ILG	27	3	13	4	.889	.308	.089	.175
ILM	44	12	36	13	.727	.361	.184	.312
IPT	13	11	26	20	.154	.769	.675	.795
LYH	11	0	03	1.000	.000	.000	.000	.000
MFD	17	9	12	10	.471	.833	.479	.655
NYC	96	52	97	71	.458	.732	.452	.637
ORF	36	20	34	21	.444	.618	.413	.586
ORH	8	4	15	4	.500	.267	.211	.348
PHL	46	26	66	41	.435	.621	.420	.598
PIT	146	86	169	135	.411	.799	.513	.702
PVD	2	1	2	1	.500	.500	.333	.500
PWM	13	8	28	15	.385	.536	.401	.561
RDU	41	13	42	12	.683	.286	.177	.301
RIC	9	3	20	4	.667	.200	.143	.241
ROA	8	0	02	1.000	.000	.000	.000	.000
ROC	26	18	24	20	.308	.833	.608	.760
SYR	22	19	45	33	.136	.733	.657	.776
TOL	39	29	44	35	.256	.795	.624	.771
WBC	103	37	93	36	.641	.387	.229	.372
YNG	43	27	39	30	.372	.769	.528	.695

SOUTHERN REGION

STN	WRND CNTYS	VERF CNTYS	TOT EVNTS	WRND EVNTS	FAR	POD	CSI	VE
ABI	163	49	82	56	.669	.683	.264	.429
ABQ	20	8	19	5	.600	.263	.189	.333
ACT	71	26	55	32	.634	.582	.290	.460

AGS	58	3	22	3	.948	.136	.039	.075
AHN	99	46	71	49	.535	.690	.384	.559
AMA	309	178	262	215	.424	.821	.512	.688
AQQ	8	2	7	2	.750	.286	.154	.267
ATL	140	50	139	57	.643	.410	.236	.384
AUS	90	36	68	44	.600	.647	.328	.506
BHM	113	49	75	50	.566	.667	.356	.527
BNA	66	40	85	43	.394	.506	.381	.550
BPT	58	21	52	28	.638	.538	.276	.445
BRO	46	11	19	9	.761	.474	.189	.308
BTR	93	20	44	19	.785	.432	.168	.285
CAO	0	0	3	2	.000	.667	.667	.667
CHA	25	16	31	16	.360	.516	.400	.571
CRP	57	13	23	13	.772	.565	.194	.325
CSG	94	81	132	89	.138	.674	.608	.752
DAB	23	6	13	5	.739	.385	.184	.306
DRT	5	2	5	2	.600	.400	.250	.400
ELP	5	1	16	3	.800	.187	.107	.190
ESF	0	0	7	6	.000	.857	.857	.857
FMY	0	0	21	11	.000	.524	.524	.524
FSM	106	53	76	59	.500	.776	.437	.615
FTW	423	286	417	350	.324	.839	.599	.757
GLS	35	9	15	12	.743	.800	.242	.420
HOU	131	25	59	31	.809	.525	.163	.295
HSV	57	21	46	22	.632	.478	.263	.417
JAN	355	134	188	148	.623	.787	.343	.519
JAX	62	22	53	26	.645	.491	.259	.417
LBB	122	95	123	106	.221	.862	.692	.820
LCH	190	33	50	29	.826	.580	.154	.258
LIT	200	156	235	185	.220	.787	.644	.784
MAF	138	71	129	91	.486	.705	.424	.607
MCN	86	64	92	68	.256	.739	.589	.742
MEI	157	91	114	98	.420	.860	.530	.697
MEM	116	53	100	59	.543	.590	.347	.519
MGM	68	50	83	62	.265	.747	.589	.742
MIA	36	7	23	7	.806	.304	.135	.237
MLB	57	16	37	20	.719	.541	.227	.383
MOB	69	28	46	32	.594	.696	.345	.522
NEW	172	28	64	28	.837	.437	.135	.237
OKC	1091	695	818	732	.363	.895	.593	.748
PBI	19	2	15	2	.895	.133	.063	.118
PNS	17	11	14	11	.353	.786	.550	.710
ROW	17	8	32	15	.529	.469	.307	.469
SAT	114	32	62	36	.719	.581	.233	.386
SAV	79	44	90	47	.443	.522	.369	.538
SHV	499	358	525	467	.283	.890	.659	.806
SJT	84	26	46	30	.690	.652	.266	.431
SPS	101	43	71	52	.574	.732	.368	.552
TBW	188	96	141	107	.489	.759	.439	.617
TLH	5	3	14	3	.400	.214	.187	.316
TRI	10	2	18	2	.800	.111	.077	.143
TUL	250	203	254	220	.188	.866	.721	.839

TUP	97	38	65	46	.608	.708	.337	.519
TYS	19	6	24	7	.684	.292	.179	.302
VCT	22	9	16	9	.591	.562	.310	.474

WESTERN REGION

STN	WRND CNTYS	VERF CNTYS	TOT EVNTS	WRND EVNTS	FAR	POD	CSI	VE
AST	0	0	1	0	.000	.000	.000	.000
BFL	0	0	4	0	.000	.000	.000	.000
BIL	150	22	69	24	.853	.348	.115	.210
BOI	32	6	25	4	.812	.160	.094	.175
EKO	0	0	1	0	.000	.000	.000	.000
EUG	1	0	00	1.000	.000	.000	.000	.000
FAT	26	0	06	1.000	.000	.000	.000	.000
FCA	0	0	1	0	.000	.000	.000	.000
FLG	0	0	1	0	.000	.000	.000	.000
GEG	0	0	6	0	.000	.000	.000	.000
GGW	30	4	34	5	.867	.147	.075	.141
GTF	39	3	19	3	.923	.158	.055	.103
HLN	2	0	09	1.000	.000	.000	.000	.000
HVR	6	0	03	1.000	.000	.000	.000	.000
INW	0	0	1	0	.000	.000	.000	.000
LAS	1	0	01	1.000	.000	.000	.000	.000
LAX	13	4	10	2	.692	.200	.138	.261
LWS	8	1	4	1	.875	.250	.091	.167
MFR	4	3	5	2	.250	.400	.353	.556
MSO	2	0	02	1.000	.000	.000	.000	.000
OLM	3	0	00	1.000	.000	.000	.000	.000
PDT	1	1	6	3	.000	.500	.500	.571
PDX	9	4	18	1	.556	.056	.052	.185
PHX	24	11	19	7	.542	.368	.257	.419
PIH	20	3	17	4	.850	.235	.101	.189
RDD	0	0	1	0	.000	.000	.000	.000
RNO	6	0	04	1.000	.000	.000	.000	.000
SAC	6	0	01	1.000	.000	.000	.000	.000
SAN	3	0	02	1.000	.000	.000	.000	.000
SEA	3	1	4	1	.667	.250	.167	.286
SLC	46	6	29	6	.870	.207	.087	.160
SLE	0	0	1	0	.000	.000	.000	.000
SMX	0	0	2	0	.000	.000	.000	.000
TUS	4	0	08	1.000	.000	.000	.000	.000
YKM	6	2	3	2	.667	.667	.286	.444
YUM	4	1	7	3	.750	.429	.187	.364

No. 8 A Minimum Assumption Tornado Hazard Probability Model. Joseph T. Schaefer, Donald L. Kelly, and Robert F. Abbey, May 1985, 30 p., (PB85 20692/AS).

No. 9 Verification of Severe Local Storm Forecasts Issued by the National Severe Storms Forecast Center: 1984. Preston W. Leftwich, Jr., November 1985, 23 p., (PB86 128105/AS).

No. 10 Severe Local Storm Warning Verification: 1984. Preston W. Leftwich, Jr. and Leo A. Grenier, December 1985, 14 p., (PB86 148244).

No. 11 Severe Thunderstorm Cases of 1985. John E. Hales, Jr. and Hugh G. Crowther, February 1986, 51 p., (PB86 164340/AS).

No. 12 Severe Local Storm Warning Verification Preliminary Procedures. Leo A. Grenier and John T. Halmstad, April 1986, 16 p., (PB86 194362).

No. 13 Verification of Severe Local Storm Forecasts Issued by the National Severe Storms Forecast Center: 1985. Preston W. Leftwich, Jr., November 1986, 9 p., (PB87 137139/AS).

No. 14 Severe Local Storm Warning Verification: 1985. Preston W. Leftwich, Jr. and Leo A. Grenier, December 1986, 16 p., (PB87 137147/AS).

No. 15 An Examination of the National Weather Service Severe Local Storm Warning Program and Proposed Improvements. John E. Hales, Jr., January 1987, 32 p., (PB87 147948/AS).

No. 16 Severe Thunderstorm Cases of July 1985 through June 1986. John E. Hales, Jr. and Hugh G. Crowther, February 1987, 72 p., (PB87 163911/AS).

No. 17 Severe Local Storm Warning Verification: 1986. Leo A. Grenier, John T. Halmstad and Preston W. Leftwich, Jr., June 1987, 19 p., (PB87 195939).

No. 18 Verification of Severe Local Storm Forecasts Issued by the National Severe Storms Forecast Center: 1986. Preston W. Leftwich, Jr., September 1987, 9 p., (PB88 101407).

No. 19 Severe Thunderstorm Cases of July 1986 through June 1987. John E. Hales, Jr. and Hugh G. Crowther, April 1988, 83 p., (PB88 214085).

No. 20 Severe Local Storm Warning Verification: 1987. Leo A. Grenier, John T. Halmstad and Preston W. Leftwich, Jr., June 1988, 19 p., (PB88 241393).

No. 21 Verification of Severe Local Storm Forecasts Issued by the National Severe Storms Forecast Center: 1987. Preston W. Leftwich, Jr., December 1988, 11 p., (PB89 159719/AS).

No. 22 Severe Thunderstorm Cases of July 1987 thru June 1988. John E. Hales, Jr. and Hugh G. Crowther, April 1989, 92 p., (PB89 206411/AS)

No. 23 Severe Local Storm Warning Verification: 1988. Leo A. Grenier, John T. Halmstad and Preston W. Leftwich, Jr., June 1989, 26 p., (PB89 226310/AS).

No. 24 Verification of Severe Local Storm Forecasts Issued by the National Severe Storms Forecast Center: 1988. Preston W. Leftwich, Jr., September 1989, 18 p., (PB90-140211/AS).

No. 25 A Dyad of Papers Concerning Joint Verification of Severe Local Storm Watches and Warnings During Tornado Events: Preston W. Leftwich, Jr. and John E. Hales, Jr., January 1990, 36 p., (PB90-219387/AS).

No. 26 Severe Thunderstorm Cases of July 1988 thru June 1989: John E. Hales, Jr. and Hugh G. Crowther, April 1990, 106 p., (PB90-226424/AS)

No. 27 Severe Local Storm Warning Verification: 1989. Leo A. Grenier, John T. Halmstad and Preston W. Leftwich, Jr., May 1990, 25 p., (PB90-248592)

No. 28 Verification of Severe Storms Forecasts Issued by the National Severe Storms Forecast Center: 1989. Preston W. Leftwich, Jr. and Richard W. Anthony, September 1990, 17 p., (PB91-132472/AS)

No. 29 Severe Thunderstorm Cases of July 1989 thru June 1990: John E. Hales, Jr. and Hugh G. Crowther, April 1991, 131 p., (PB91-201392)

No. 30 Severe Local Storm Warning Verification: 1990. Leo A. Grenier, John T. Halmstad, May 1991, 32 p., (PB91-227520)

No. 31 Verification of Severe Local Storm Forecasts Issued By the National Severe Storms Forecast Center: 1990. Preston W. Leftwich, Jr. and Richard W. Anthony, October 1991, 12 p., (PB92-124452/AS)

Severe Local Storm Warning Verification: 1991

ERRATA

In the Appendix, all of the following listed stations should have;

(1) zero for Warned Events, and (2) 1.000 for FAR.

Eastern Region	Western Region		
LYH	EUG	FAT	HLN
ROA	HVR	LAS	MSO
	OLM	RNO	SAC
	SAN	TUS	