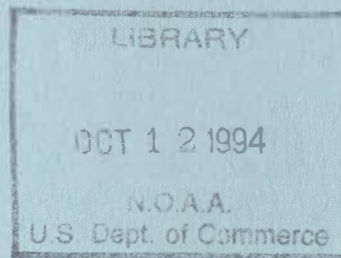


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NOAA TECHNICAL MEMORANDUM NWS NSSFC-40

**SEVERE LOCAL STORM
WARNING VERIFICATION FOR 1993**



HUGH G. CROWTHER
JOHN T. HALMSTAD
National Severe Storms Forecast Center
Kansas City, Missouri 64106-2877

JUNE 1994

**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.

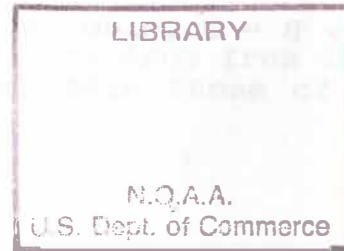
Previous issued in this series:

- 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).

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UNITED STATES
DEPARTMENT OF COMMERCE
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Service
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SEVERE LOCAL STORM WARNING VERIFICATION: 1993

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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 1993.

In the past, offices in Southern Region and Central Region have issued most of the warnings and experienced most of the severe local storm events. In 1993, local offices in those two regions accounted for nearly 80 percent of the warnings and severe local storm events.

Verification scores for 1993 showed a slight drop from those in 1992, but were still significantly higher than those of any other previous year.

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 imminent or existing severe thunderstorm or tornado.

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 Chapter C-47 of the "Weather Service Operations Manual" (1986), with included revisions by the Office of Meteorology (OM).

Routine verification of all tornado and severe thunderstorm warnings issued by offices is accomplished at the National Severe Storms Forecast Center (NSSFC) in Kansas City, Missouri. This report summarizes these verification results for the year 1993. Detailed evaluation of the results, such as comparisons among individual offices, is beyond the scope of this report.

VERIFICATION PROCEDURES

Severe local storm warning verification began in 1979. Pearson and David (1979), and Kelly and Schaefer (1982), analyzed warning verification statistics back to 1976, and in 1982 a National Verification Plan (NWS 1982) was formulated to provide guidelines for verification of all products issued to the public. The severe local storm warning verification effort at NSSFC is an integral part of this national program. Monthly and year-to-date summaries are routinely provided to national headquarters, regional headquarters, and 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. Event information is extracted from surface observations, warning messages, local storm reports (LSR'S), 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 National Severe Storms Forecast Center, and the "rough log", are transmitted via the AFOS system to local offices for review. The role of these warning and event summaries in the verification process is 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. The "rough log" is an aid for the Warning Coordination Meteorologist (WCM), Warning Preparedness Meteorologist (WPM), or severe weather focal point 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. After all sources of information have been compiled, the resulting "smooth log" and warning file become the data bases for official verification.

VERIFICATION PROCEDURES

To qualify as a severe local storm event, a report must satisfy one of the criteria listed in Table 1. General guidelines on event reporting may be found in Grenier and Halmstad (1986). For verification purposes, multiple reports of severe local storm events occurring within ten statute miles and fifteen minutes of each other, and in the same county, are recorded as one event, with the following exceptions:

- (1) all distinct tornadoes are retained as separate events
- (2) all wind events of 65 knots or greater are retained
- (3) all reports of hail with a diameter of two inches or greater are retained
- (4) all reports containing deaths, injuries, or more than half a million dollars damage are retained (Damage Category 6, or above)

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 ten statute miles and/or fifteen minutes of another report, and (3) it was the same type of non-tornadic phenomena, i.e. wind or hail (Leftwich and Lee, 1984). It was later noted that a severe wind and severe hail report from the same 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 start of the 1986 severe weather year (Grenier and Halmstad, 1986).

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 50 knots (93 km/h) or greater.
- D. **THUNDERSTORM WIND DAMAGE** which implies the occurrence of a severe thunderstorm.

Any event that occurs within a county for which a warning was issued, and during the valid period of the warning, is considered a "warned event". Thus there can be multiple "warned events" during the valid time of a given warning. Also, any type of severe event can verify either a tornado warning or a 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 warning". In order to obtain perfect verification, at least one severe local storm event must occur in each warned county.

Sparseness of population can decrease the chances that a severe weather event is reported. Schaefer and Galway (1982) addressed biases reflected in the tornado climatology across the United States, and 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 comparing verification results among local offices, and among regions that have different population densities or different meteorological regimes.

VERIFICATION MEASURES

FALSE ALARM RATIO

The False Alarm Ratio (FAR) is the number of unverified county warnings (UCW) divided by the total number of county warnings issued (TCW).

$$\frac{\text{UNVERIFIED COUNTY WARNINGS}}{\text{TOTAL COUNTY WARNINGS}}$$

PROBABILITY OF DETECTION

The Probability of Detection (POD) is the number of warned severe local storm events (WSE) divided by the total number of severe local storm events reported (TSE).

$$\frac{\text{WARNED SEVERE EVENTS}}{\text{TOTAL SEVERE EVENTS}}$$

CRITICAL SUCCESS INDEX

The Critical Success Index (CSI) is the number of warned severe local storm events (WSE) divided by the sum of the total number of severe local storm events (TSE) and the number of unverified county warnings (UCW).

$$\frac{\text{WARNED SEVERE EVENTS}}{\text{TOTAL SEVERE EVENTS} + \text{UNVERIFIED COUNTY WARNINGS}}$$

NOTE: The CSI values which appear in this report for each region, and for the nation as a whole, were computed according to the formula shown above. The CSI values for each individual station, which were transcribed from the annual printouts, were computed according to the following formula:

$$\text{CSI} = [\text{POD}^{-1} + (1 - \text{FAR})^{-1} - 1]^{-1}$$

VERIFICATION MEASURES

VERIFICATION EFFICIENCY

The Verification Efficiency (VE) is the sum of the verified county warnings (VCW) and the number of warned severe local storm events (WSE), divided by the sum of the total number of county warnings (TCW) and the total number of severe local storm events (TSE).

$$\frac{\text{VERIFIED COUNTY WARNINGS} + \text{WARNED SEVERE EVENTS}}{\text{TOTAL COUNTY WARNINGS} + \text{TOTAL SEVERE EVENTS}}$$

PERCENTAGE OF VERIFIED COUNTY WARNINGS

The Percentage of Verified county warnings (PV) is the number of verified county warnings (VCW) divided by the total number of county warnings issued (TCW). The sum of the False Alarm Ratio (FAR) and the Percentage of Verified county warnings (PV) is equal to one.

$$\frac{\text{VERIFIED COUNTY WARNINGS}}{\text{TOTAL COUNTY WARNINGS}}$$

NATIONAL VERIFICATION STATISTICS

1993

There were 14,020 severe local storm events reported across the contiguous United States in 1993. The previous highest total for the nation since records began in 1979 was 13,534 reports, in 1992.

The total of 14,020 severe local storm events was nearly five hundred (486) more than that for 1992 (a 3.6 percent increase), and marked the fifth consecutive year with an increase in the total number of severe local storm events reported across the nation. Nearly 40 percent of the severe local storm events in 1993 were in the Southern Region states, and nearly 38 percent were in the Central Region states.

The total of 16,125 county warnings was a thousand greater than the previous record of 15,124, which was established in 1992, and also marked the fifth consecutive year with an increase.

There were 8436 verified county warnings across the nation in 1993, compared to the previous record of 8168 in 1992, an increase of 268 verified warnings (3.3 percent).

There was a slight drop in verification scores across the nation between 1992 and 1993. The Probability of Detection (POD), dipped from .72 to .70, the Critical Success Index (CSI) dipped from .48 to .45, and the Verification Efficiency dipped from .62 to .61. The False Alarm Ratio rose from .46 to .48, and the Percent Verification correspondingly dipped from .54 to .52.

Although there was a slight drop off in verification scores, they were still the second best of record since records began in 1984. Figure 1 shows the scores for the False Alarm Ratio, the Probability of Detection, the Critical Success Index and the Verification Efficiency between 1979 and 1992.

NATIONAL AND REGIONAL

VERIFICATION STATISTICS

1993

REGION	ERN	SRN	CEN	WRN	U.S.
NUMBER OF OFFICES	51	56	69	32	208
TOTAL COUNTY WARNINGS	2833	6253	6571	468	16,125
PERCENTAGE OF TOTAL	17.6	38.8	40.8	2.9	100.0
AVERAGE PER OFFICE	56	112	95	15	78
VERIFIED COUNTY WARNINGS	1622	3636	3062	116	8,436
PERCENTAGE OF TOTAL	19.2	43.1	36.3	1.4	100.0
AVERAGE PER OFFICE	32	65	44	4	41
UNVERIFIED WARNINGS	1211	2617	3509	352	7,689
PERCENTAGE OF TOTAL	15.7	34.0	45.6	4.6	100.0
AVERAGE PER OFFICE	24	47	51	11	37
TOTAL SEVERE EVENTS	2792	5526	5309	393	14,020
PERCENTAGE OF TOTAL	19.9	39.4	37.9	2.8	100.0
AVERAGE PER OFFICE	55	99	77	12	67
WARNED SEVERE EVENTS	1886	4237	3578	134	9,835
PERCENTAGE OF TOTAL	19.2	43.1	36.4	1.4	100.0
AVERAGE PER OFFICE	37	76	52	4	47
FALSE ALARM RATIO	.427	.419	.534	.752	.477
PROBABILITY OF DETECTION	.676	.767	.674	.341	.701
CRITICAL SUCCESS INDEX	.471	.520	.406	.180	.453
VERIFICATION EFFICIENCY	.624	.668	.559	.290	.606
PERCENT VERIFIED	.573	.581	.466	.248	.523

REGIONAL VERIFICATION STATISTICS

(1984-1993)

...EASTERN REGION...

YEAR	TCW	VCW	TSE	WSE	FAR	POD	CSI	VE	PV
1984	1022	344	988	505	.660	.510	.250	.420	.340
1985	1387	658	1528	906	.530	.590	.360	.530	.470
1986	1445	793	1627	952	.450	.590	.400	.570	.550
1987	1029	611	1291	722	.410	.560	.400	.580	.590
1988	1452	861	1752	1082	.410	.620	.430	.610	.590
1989	1983	1004	2171	1261	.490	.580	.370	.540	.510
1990	2488	1319	2412	1568	.470	.650	.410	.590	.530
1991	2046	1162	2237	1475	.432	.659	.439	.616	.568
1992	2377	1359	2314	1609	.425	.699	.486	.636	.575
1993	2833	1622	2792	1886	.427	.676	.471	.624	.573
TOTAL	18062	9733	19112	11966					
AVERAGE	1806	973	1911	1197	.431	.626	.436	.584	.539

...SOUTHERN REGION...

YEAR	TCW	VCW	TSE	WSE	FAR	POD	CSI	VE	PV
1984	5938	1628	3272	2005	.730	.610	.230	.440	.270
1985	4625	1596	3361	2066	.660	.600	.280	.470	.340
1986	4212	1715	3494	2195	.590	.630	.330	.520	.410
1987	3883	1486	2712	1630	.620	.600	.310	.490	.380
1988	4007	1848	3019	2040	.540	.680	.380	.570	.460
1989	6057	3088	5173	3608	.490	.700	.420	.600	.510
1990	5839	3062	4938	3552	.480	.720	.440	.620	.520
1991	6735	3476	5406	3978	.484	.736	.435	.614	.516
1992	7304	4360	6602	5169	.403	.783	.542	.685	.597
1993	6253	3636	5526	4237	.419	.767	.520	.668	.581
TOTAL	54853	25895	43503	30480					
AVERAGE	5485	2590	4350	3048	.528	.701	.421	.573	.478

REGIONAL VERIFICATION STATISTICS

(1984-1993)

...CENTRAL REGION...

YEAR	TCW	VCW	TSE	WSE	FAR	POD	CSI	VE	PV
1984	5293	1319	2908	1553	.750	.530	.200	.390	.250
1985	4794	1324	2975	1612	.720	.540	.220	.410	.280
1986	4868	1623	3427	1948	.670	.570	.270	.450	.330
1987	4331	1614	3156	1847	.630	.590	.300	.480	.370
1988	2862	928	2235	1069	.680	.480	.240	.400	.320
1989	3694	1321	2845	1551	.640	.550	.280	.450	.360
1990	4987	1645	3375	1902	.670	.560	.260	.450	.330
1991	5690	2387	4558	2837	.580	.623	.334	.510	.420
1992	5029	2352	4266	2849	.532	.668	.410	.560	.468
1993	6571	3062	5309	3578	.534	.674	.406	.559	.466
TOTAL	48029	17575	35054	20746					
AVERAGE	4803	1758	3505	2075	.634	.592	.317	.461	.366

...WESTERN REGION...

YEAR	TCW	VCW	TSE	WSE	FAR	POD	CSI	VE	PV
1984	245	25	189	32	.900	.170	.070	.140	.100
1985	151	29	133	31	.810	.230	.210	.120	.190
1986	264	24	177	23	.910	.130	.060	.110	.090
1987	166	28	208	29	.830	.140	.080	.150	.170
1988	272	38	245	41	.860	.170	.080	.150	.140
1989	222	46	218	48	.790	.220	.120	.210	.210
1990	382	59	231	63	.850	.270	.110	.210	.150
1991	449	72	324	68	.840	.210	.100	.181	.160
1992	397	80	346	91	.798	.263	.137	.230	.202
1993	468	116	352	134	.752	.341	.180	.290	.248
TOTAL	3016	517	2423	560					
AVERAGE	302	52	242	56	.829	.231	.114	.198	.171

National Statistics

1979 Through 1993

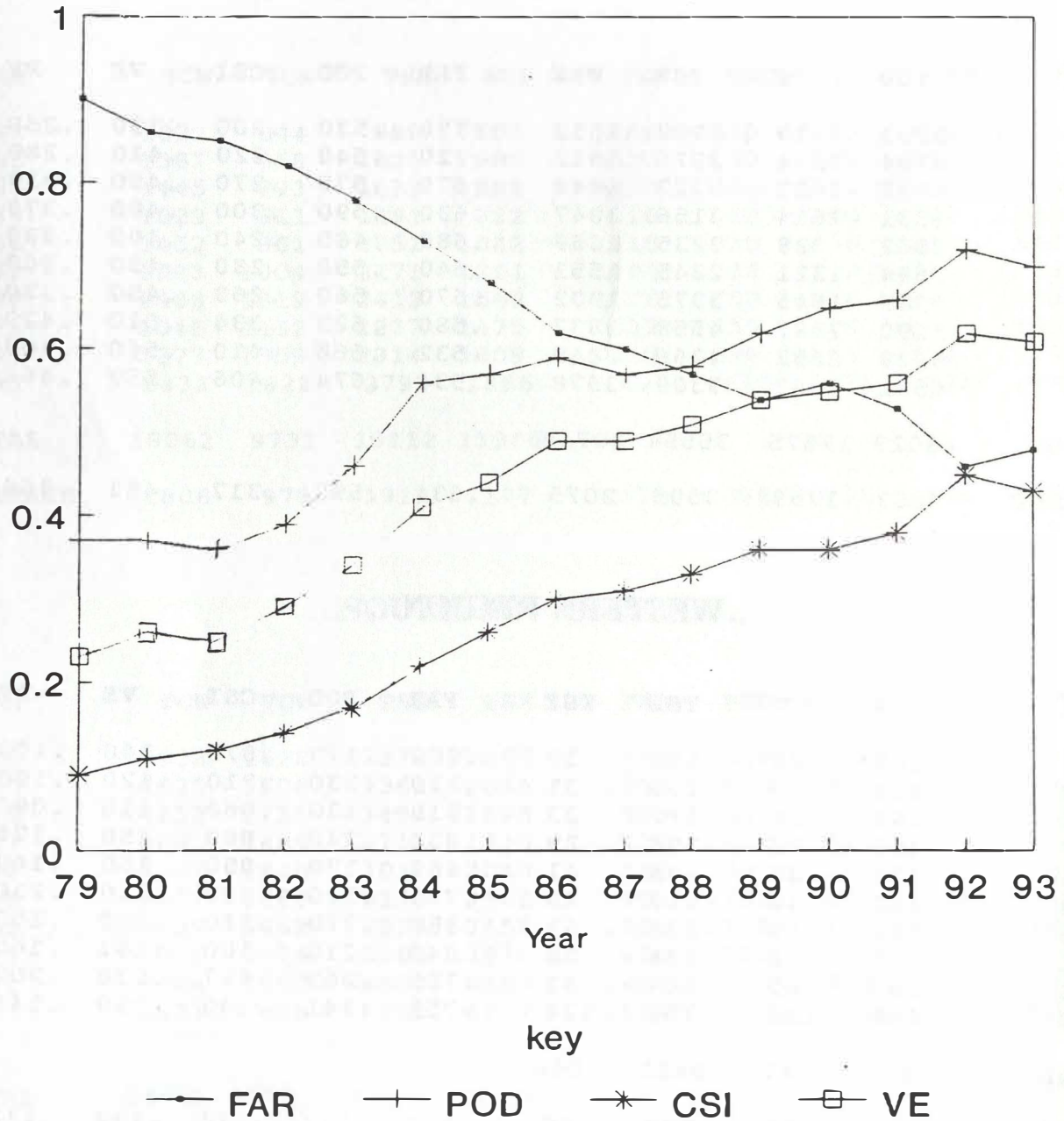
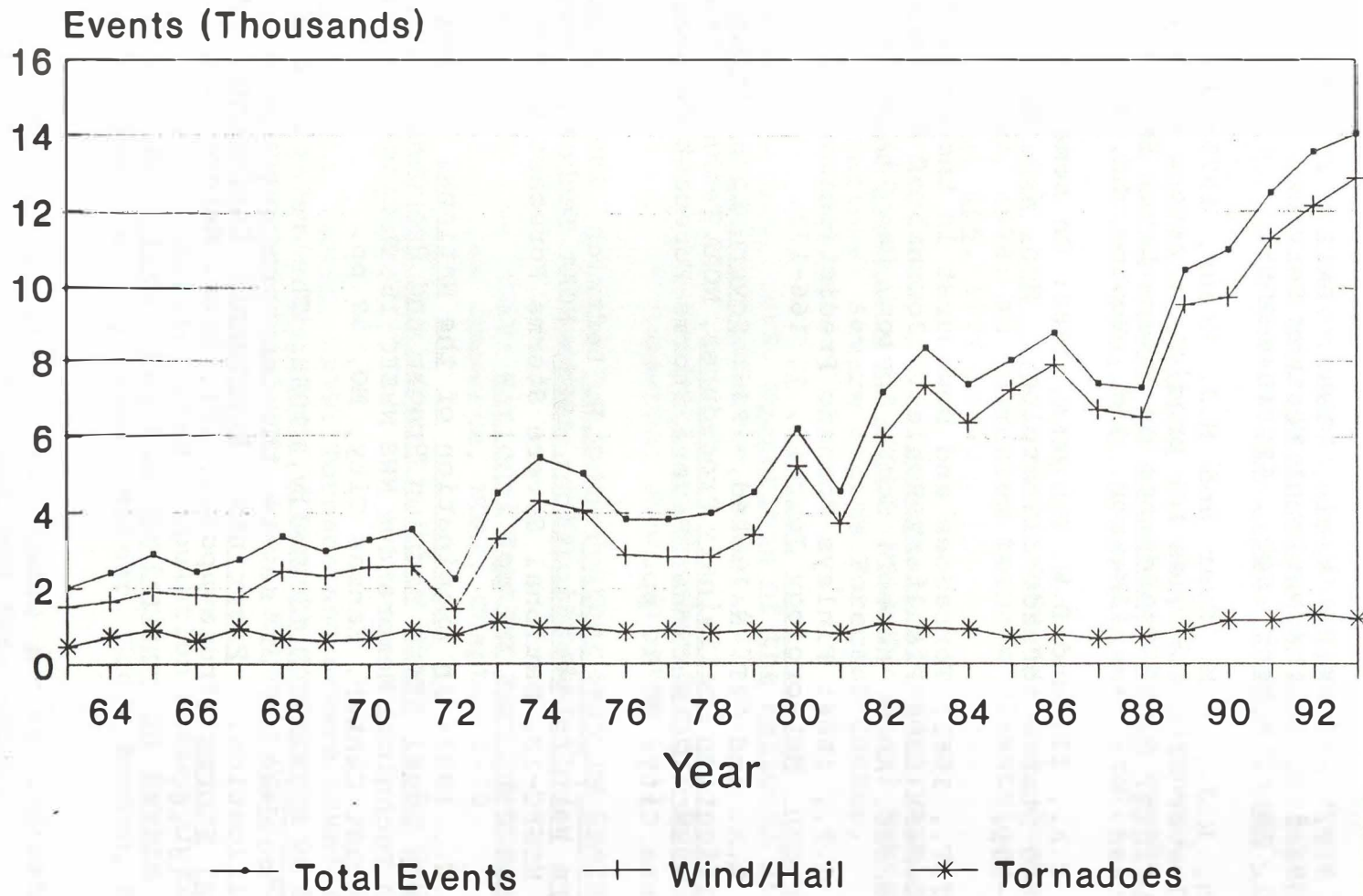


Figure 1.

SEVERE EVENTS

1963 Through 1993



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APPENDIX A

1993 VERIFICATION STATISTICS

...EASTERN REGION STATIONS...

WSO	ST	TCW	VCW	UCW	TSE	WSE	FAR	POD	CSI	VE	PV
ABE	PA	17	14	3	20	15	.176	.750	.646	.784	.824
ACY	NJ	24	17	7	21	18	.292	.857	.634	.778	.708
ALB	NY	121	75	46	157	34	.380	.217	.529	.392	.620
AVL	NC	58	18	40	41	18	.690	.439	.222	.364	.310
AVP	PA	42	25	17	34	26	.405	.765	.503	.671	.595
BDL	CT	49	35	14	59	43	.286	.729	.564	.722	.714
BDR	CT	10	9	1	18	12	.100	.667	.621	.750	.900
BGM	NY	44	30	14	62	41	.318	.661	.505	.670	.682
BKW	WV	39	26	13	35	29	.333	.829	.586	.743	.667
BOS	MA	18	13	5	18	13	.278	.722	.565	.722	.722
BTV	VT	63	51	12	97	80	.190	.825	.691	.819	.810
BUF	NY	47	24	23	30	24	.489	.800	.453	.623	.511
BWI	MD	34	14	20	40	20	.588	.500	.292	.459	.412
CAE	SC	58	19	39	47	19	.672	.404	.221	.362	.328
CAK	OH	72	31	41	57	32	.569	.561	.322	.488	.431
CAR	ME	0	0	0	1	0	.000	.000	.000	.000	.000
CHS	SC	21	10	11	18	10	.524	.556	.345	.513	.476
CLE	OH	55	39	16	48	34	.291	.708	.549	.709	.709
CLT	NC	93	48	45	81	55	.484	.679	.415	.592	.516
CMH	OH	83	42	41	84	43	.494	.512	.341	.509	.506
CON	NH	30	9	21	27	9	.700	.333	.187	.316	.300
CRW	WV	74	47	27	59	46	.365	.780	.538	.699	.635
CVG	OH	104	64	40	121	74	.385	.612	.442	.613	.615
DAY	OH	52	35	17	61	37	.327	.607	.469	.637	.673
EKN	WV	50	33	17	39	35	.340	.897	.614	.764	.660
ERI	PA	54	40	14	60	52	.259	.867	.665	.807	.741
GSO	NC	88	36	52	75	41	.591	.547	.305	.472	.409
GSP	SC	56	38	18	78	50	.321	.641	.492	.611	.679
HAR	PA	65	39	26	74	41	.400	.554	.405	.576	.600
HAT	NC	26	15	11	32	21	.423	.656	.443	.621	.577
HTS	WV	119	89	30	136	96	.252	.706	.570	.725	.748
ILG	DE	17	5	12	13	5	.706	.385	.200	.333	.294
ILM	NC	60	43	17	61	50	.283	.820	.619	.769	.717
IPT	PA	17	12	5	13	3	.294	.231	.607	.500	.706
LYH	VA	24	4	20	18	6	.833	.333	.125	.238	.167
MFD	OH	17	12	5	24	19	.294	.792	.595	.756	.706
NYC	NY	87	38	49	61	45	.563	.738	.378	.561	.437
ORF	VA	28	7	21	28	10	.750	.357	.172	.304	.250
ORH	MA	15	10	5	12	10	.333	.833	.588	.741	.667

APPENDIX A

1993 VERIFICATION STATISTICS

...EASTERN REGION STATIONS...

WSO	ST	TCW	VCW	UCW	TSE	WSE	FAR	POD	CSI	VE	PV
PHL	PA	38	13	25	26	15	.658	.577	.273	.438	.342
PIT	PA	180	96	84	149	108	.467	.725	.444	.620	.533
PVD	RI	8	2	6	3	3	.750	1.000	.250	.455	.250
PWM	ME	14	7	7	21	7	.500	.333	.250	.400	.500
RDU	NC	218	131	87	199	147	.399	.739	.496	.667	.601
RIC	VA	77	30	47	74	35	.610	.473	.272	.431	.390
ROA	VA	26	6	20	16	5	.769	.312	.153	.262	.231
ROC	NY	10	7	3	14	10	.300	.714	.547	.708	.700
SYR	NY	58	39	19	70	54	.328	.771	.561	.727	.672
TOL	OH	28	20	8	34	25	.286	.735	.568	.726	.714
WBC	DC	197	131	66	183	132	.335	.721	.529	.692	.665
YNG	OH	48	24	24	40	30	.500	.750	.429	.614	.500
RGNL	AVG	56	32	24	55	37	.427	.676	.471	.624	.573
U.S.	AVG	78	41	37	67	47	.477	.701	.453	.606	.523

KEY TO ABBREVIATIONS

ST = STATE
WSO = WEATHER SERVICE OFFICE
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APPENDIX A

1993 VERIFICATION STATISTICS

...SOUTHERN REGION STATIONS...

WSO	ST	TCW	VCW	UCW	TSE	WSE	FAR	POD	CSI	VE	PV
ABI	TX	118	68	50	111	76	.424	.685	.455	.629	.576
ABQ	NM	47	9	38	15	4	.809	.267	.125	.210	.191
ACT	TX	50	19	31	36	23	.620	.639	.313	.488	.380
AGS	GA	61	11	50	33	14	.820	.424	.145	.266	.180
AHN	GA	72	21	51	37	21	.708	.568	.239	.385	.292
AMA	TX	299	232	67	334	286	.224	.856	.687	.818	.776
AQQ	FL	13	7	6	14	7	.462	.500	.350	.519	.538
ATL	GA	137	36	101	75	38	.737	.507	.209	.349	.263
AUS	TX	74	48	26	70	58	.351	.829	.572	.736	.649
BHM	AL	136	32	104	79	34	.765	.430	.179	.313	.235
BNA	TN	128	106	22	143	109	.172	.762	.658	.793	.828
BPT	TX	17	14	3	22	15	.176	.682	.595	.744	.824
BRO	TX	8	2	6	9	2	.750	.222	.133	.235	.250
BTR	LA	34	13	21	15	13	.618	.867	.361	.531	.382
CHA	TN	27	22	5	44	22	.185	.500	.449	.620	.815
CRP	TX	29	17	12	34	19	.414	.559	.401	.571	.586
CSG	GA	56	37	19	66	37	.339	.561	.435	.607	.661
DAB	FL	56	11	45	27	14	.804	.519	.166	.301	.196
DRT	TX	13	8	5	17	12	.385	.706	.490	.667	.615
ELP	TX	5	1	4	10	1	.800	.100	.071	.133	.200
EYW	FL	8	1	7	5	1	.875	.200	.083	.154	.125
FMY	FL	0	0	0	35	22	.000	.629	.629	.629	.000
FSM	AR	187	69	118	104	82	.631	.788	.336	.519	.369
FTW	TX	395	268	127	423	335	.322	.792	.576	.737	.678
GLS	TX	21	7	14	12	7	.667	.583	.269	.424	.333
HOU	TX	124	61	63	89	69	.508	.775	.431	.602	.492
HSV	AL	45	34	11	37	15	.244	.405	.578	.598	.756
JAN	MS	224	131	93	150	136	.415	.907	.552	.714	.585
JAX	FL	105	25	80	53	26	.762	.491	.191	.323	.238
LBB	TX	82	69	13	84	72	.159	.857	.738	.849	.841
LCH	LA	90	28	62	49	29	.689	.592	.256	.410	.311
LIT	AR	294	213	81	276	247	.276	.895	.668	.807	.724
MAF	TX	147	130	17	171	148	.116	.685	.777	.874	.884
MCN	GA	85	55	30	105	59	.353	.562	.430	.600	.647
MEI	MS	90	42	48	51	45	.533	.882	.439	.617	.467
MEM	TN	121	45	76	94	46	.628	.489	.268	.423	.372
MGM	AL	40	11	29	38	13	.725	.342	.180	.308	.275
MIA	FL	57	9	48	34	12	.842	.353	.122	.231	.158
MLB	FL	59	22	37	46	25	.627	.543	.284	.448	.373

APPENDIX A

1993 VERIFICATION STATISTICS

...SOUTHERN REGION STATIONS...

WSO	ST	TCW	VCW	UCW	TSE	WSE	FAR	POD	CSI	VE	PV
MOB	AL	77	10	67	29	12	.870	.414	.110	.208	.130
NEW	LA	98	19	79	31	19	.806	.613	.173	.295	.194
OKC	OK	864	700	164	951	831	.190	.874	.725	.844	.810
PBI	FL	63	12	51	21	10	.810	.476	.157	.262	.190
PNS	FL	31	13	18	30	14	.581	.467	.283	.443	.419
ROW	NM	9	1	8	21	8	.889	.381	.094	.300	.111
SAT	TX	82	31	51	45	33	.622	.733	.332	.504	.378
SAV	GA	72	46	26	73	50	.361	.685	.494	.662	.639
SHV	LA	556	378	178	504	471	.320	.935	.649	.801	.680
SJT	TX	55	19	36	46	26	.655	.565	.273	.446	.345
TBW	FL	273	117	156	188	127	.571	.676	.355	.529	.429
TLH	FL	22	11	11	29	12	.500	.414	.293	.451	.500
TRI	TN	10	2	8	20	2	.800	.100	.071	.133	.200
TUL	OK	337	264	73	351	317	.217	.903	.723	.845	.783
TUP	MS	54	22	32	34	23	.593	.676	.341	.511	.407
TYS	TN	57	29	28	53	30	.491	.566	.366	.536	.509
VCT	TX	39	28	11	38	36	.282	.947	.690	.831	.718
RGNL	AVG	112	65	47	99	76	.419	.767	.520	.668	.581
U.S.	AVG	78	41	37	67	47	.477	.701	.453	.606	.523

KEY TO ABBREVIATIONS

ST = STATE
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APPENDIX A

1993 VERIFICATION STATISTICS

...CENTRAL REGION STATIONS...

WSO	ST	TCW	VCW	UCW	TSE	WSE	FAR	POD	CSI	VE	PV
ABR	SD	87	53	34	93	71	.391	.763	.512	.689	.609
ALO	IA	87	47	40	96	58	.460	.604	.399	.574	.540
ALS	CO	0	0	0	5	1	.000	.200	.200	.200	.000
APN	MI	25	18	7	23	19	.280	.826	.625	.771	.720
BFF	NE	172	41	131	74	43	.762	.581	.203	.341	.238
BIS	ND	83	30	53	71	33	.639	.465	.255	.409	.361
CNK	KS	201	103	98	142	123	.488	.866	.475	.659	.512
COS	CO	126	59	67	98	73	.532	.745	.404	.589	.468
COU	MO	110	49	61	85	55	.555	.647	.358	.533	.445
CPR	WY	45	23	22	33	24	.489	.727	.429	.603	.511
CYS	WY	57	22	35	39	22	.614	.564	.297	.458	.386
DBQ	IA	40	17	23	46	25	.575	.543	.313	.488	.425
DDC	KS	338	212	126	275	246	.373	.895	.584	.747	.627
DEN	CO	285	102	183	207	120	.642	.580	.284	.451	.358
DLH	MN	25	8	17	22	9	.680	.409	.219	.362	.320
DSM	IA	320	103	217	229	123	.678	.537	.252	.412	.322
DTW	MI	16	9	7	22	11	.437	.500	.360	.526	.563
DTX	MI	2	0	2	0	0	1.000	.000	.000	.000	.000
EVV	IN	129	100	29	125	102	.225	.816	.660	.795	.775
FAR	ND	33	13	20	40	17	.606	.425	.257	.411	.394
FNT	MI	30	15	15	25	16	.500	.640	.390	.564	.500
FSD	SD	135	58	77	151	67	.570	.444	.279	.437	.430
FWA	IN	64	31	33	43	33	.516	.767	.422	.598	.484
GJT	CO	5	0	5	8	0	1.000	.000	.000	.000	.000
GLD	KS	225	168	57	243	209	.253	.860	.666	.806	.747
GRB	MI	24	7	17	19	9	.708	.474	.220	.372	.292
GRI	NE	265	102	163	153	109	.615	.712	.333	.505	.385
GRR	MI	39	25	14	38	29	.359	.763	.535	.701	.641
HON	SD	110	24	86	84	30	.782	.357	.157	.278	.218
HTL	MI	23	7	16	18	11	.696	.611	.255	.439	.304
ICT	KS	270	155	115	239	209	.426	.874	.530	.715	.574
IND	IN	218	93	125	188	102	.573	.543	.314	.480	.427
INL	MN	18	5	13	15	5	.722	.333	.179	.303	.278
ISN	ND	16	10	6	16	11	.375	.687	.487	.656	.625
JKL	KY	64	46	18	61	47	.281	.770	.592	.744	.719
LAN	MI	9	1	8	17	2	.889	.118	.061	.115	.111
LBF	NE	135	67	68	118	79	.504	.669	.399	.577	.496
LEX	KY	53	26	27	50	27	.509	.540	.346	.515	.491
LND	WY	0	0	0	4	0	.000	.000	.000	.000	.000

APPENDIX A

1993 VERIFICATION STATISTICS

...CENTRAL REGION STATIONS...

WSO	ST	TCW	VCW	UCW	TSE	WSE	FAR	POD	CSI	VE	PV
LNK	NE	51	18	33	35	22	.647	.629	.292	.465	.353
LOT	IL	156	60	96	96	73	.615	.760	.343	.528	.385
LSE	WI	31	17	14	34	23	.452	.676	.434	.615	.548
MCI	MO	273	148	125	207	168	.458	.812	.482	.658	.542
MKX	WI	111	33	78	57	29	.703	.509	.231	.369	.297
MKG	MI	18	11	7	18	15	.389	.833	.545	.722	.611
MLI	IL	76	25	51	72	35	.671	.486	.244	.405	.329
MQT	MI	10	0	10	6	0	1.000	.000	.000	.000	.000
MSN	WI	76	43	33	87	62	.434	.713	.461	.644	.566
MSP	MN	117	36	81	56	37	.692	.661	.266	.422	.308
OFK	NE	71	33	38	45	35	.535	.778	.410	.586	.465
OMA	NE	110	52	58	103	66	.527	.641	.374	.529	.473
PAH	KY	100	44	56	103	51	.560	.495	.304	.468	.440
PIA	IL	125	69	56	108	84	.448	.778	.477	.657	.552
PUB	CO	129	30	99	58	30	.767	.517	.191	.321	.233
RAP	SD	147	47	100	113	59	.680	.522	.247	.408	.320
RFD	IL	65	23	42	44	25	.646	.568	.279	.440	.354
RST	MN	63	18	45	47	23	.714	.489	.220	.373	.286
SBN	IN	45	15	30	30	16	.667	.533	.258	.413	.333
SDF	KY	123	50	73	83	47	.593	.566	.310	.471	.407
SGF	MO	106	38	68	74	46	.642	.622	.294	.467	.358
SHR	WY	17	11	6	18	11	.353	.611	.458	.629	.647
SPI	IL	126	47	79	73	52	.627	.712	.324	.497	.373
SSM	MI	5	0	5	5	0	1.000	.000	.000	.000	.000
STC	MN	36	13	23	32	16	.639	.500	.205	.426	.361
STL	MO	288	203	85	292	239	.295	.818	.610	.762	.705
SUX	IA	12	4	8	23	5	.667	.217	.152	.257	.333
TOP	KS	198	125	73	172	139	.369	.808	.549	.714	.631
VTN	NE	2	0	2	3	0	1.000	.000	.000	.000	.000
RGNL	AVG	95	44	51	77	52	.534	.674	.406	.559	.466
U.S.	AVG	78	41	37	67	47	.477	.701	.453	.606	.523

APPENDIX A

1993 VERIFICATION STATISTICS

...WESTERN REGION STATIONS...

WSO	ST	TCW	VCW	UCW	TSE	WSE	FAR	POD	CSI	VE	PV
AST	OR	1	0	0	1	0	1.000	.000	.000	.000	.000
BFL	CA	1	1	0	1	1	.000	1.000	1.000	1.000	1.000
BIL	MT	84	25	59	60	29	.702	.483	.226	.375	.298
BOI	ID	48	9	39	42	11	.812	.262	.123	.222	.188
EKO	NV	1	0	1	2	0	1.000	.000	.000	.000	.000
FAT	CA	13	0	13	2	0	1.000	.000	.000	.000	.000
FCA	MT	5	1	4	7	1	.800	.143	.091	.167	.200
GEG	WA	17	2	15	8	2	.882	.250	.087	.160	.118
GGW	MT	36	9	27	19	11	.750	.579	.212	.364	.250
GTF	MT	62	17	45	39	21	.726	.538	.222	.376	.274
HLN	MT	16	4	12	13	3	.750	.231	.136	.241	.250
HVR	MT	6	0	6	6	1	1.000	.167	.000	.083	.000
INW	AZ	0	0	0	1	0	.000	.000	.000	.000	.000
LAS	NV	2	1	1	4	1	.500	.250	.200	.333	.500
LAX	CA	2	2	0	15	2	.000	.133	.133	.235	1.000
LWS	ID	0	0	0	7	0	.000	.000	.000	.000	.000
MFR	OR	2	0	2	4	0	1.000	.000	.000	.000	.000
MSO	MT	27	3	24	17	4	.889	.235	.082	.159	.111
OLM	WA	2	0	2	0	0	1.000	.000	.000	.000	.000
PDT	OR	6	0	6	2	1	1.000	.500	.000	.167	.000
PDX	OR	14	2	12	10	1	.857	.100	.063	.125	.143
PHX	AZ	40	15	25	29	15	.625	.517	.278	.435	.375
PIH	ID	12	5	7	17	4	.583	.235	.177	.310	.417
RDD	CA	3	1	2	3	1	.667	.333	.200	.333	.333
RNO	NV	1	1	0	6	1	.000	.167	.167	.286	1.000
SAN	CA	0	0	0	1	0	.000	.000	.000	.000	.000
SLC	UT	29	12	17	57	19	.586	.333	.226	.361	.414
SMX	CA	0	0	0	1	0	.000	.000	.000	.000	.000
TUS	AZ	36	6	30	13	5	.833	.385	.132	.225	.167
YKM	WA	0	0	0	2	0	.000	.000	.000	.000	.000
YUM	AZ	0	0	0	2	0	.000	.000	.000	.000	.000
SLE	OR	2	0	2	2	0	1.000	.000	.000	.000	.000
RGNL AVG		15	4	11	12	4	.752	.341	.180	.290	.248
U.S. AVG		78	41	37	67	47	.477	.701	.453	.606	.523

APPENDIX B

TORNADO STATISTICS FOR 1993

There were 1173 tornadoes in 1993, the second highest total in 45 years of records. It was a distant second to the 1297 tornadoes in 1992, but well above the totals of 1133 tornadoes in 1990 and 1132 tornadoes in 1991.

The year featured a tornado outbreak in the southeastern U.S. on February 21st, tornadoes in Florida associated with the "Storm of the Century" the night of March 12th, a violent (F-4) tornado which killed seven persons near Tulsa OK on April 24th, and a violent (F-4) tornado which killed four persons near Petersburg VA on August 6th.

There were sixteen killer tornadoes in 1993. The sixteen tornadoes killed 33 persons, injured 647 others, and caused more than 200 million dollars property damage. They accounted for more than two thirds of the 944 tornado-related injuries in the year, and for sixty percent of the 330 million dollar damage total.

The tornado which struck East Tulsa and Catoosa OK on the 24th of April killed seven persons, injured 100 others, and caused 100 million dollars damage. The tornado which struck Petersburg VA on the 6th of August killed four persons, injured 246 others, and caused 48 million dollars damage.

The total of 33 tornado deaths in 1993 was well below the thirty year average (1963-1992) of 82 deaths, and the lowest total since 1988, a year in which just 702 tornadoes were reported.

Thirteen of the thirty-three persons killed (39 percent) were in mobile homes at the time of the tornado, and seven other persons killed (21 percent) were in vehicles.

There were just six violent (F-4) tornadoes in 1993, however, those six tornadoes accounted for 12 of the 33 deaths (36 percent), for 361 of the 944 tornado-related injuries (38 percent), and for 161 million of the 330 million dollar damage total (49 percent).

There were 735 weak (F-0) tornadoes (62.7 percent), 321 weak (F-1) tornadoes (27.4 percent), eighty-one strong (F-2) tornadoes (6.9 percent), and thirty strong (F-3) tornadoes (2.6 percent).

As was the case in 1992, nearly half of the tornadoes in 1993 occurred during June and July. There were a record 238 tornadoes in July, and the total of 316 tornadoes in June was the third highest of record.

APPENDIX B

TORNADO STATISTICS FOR 1993

There was a shift in tornado activity toward the north central states in 1993. There were a record 85 tornadoes in South Dakota, including 42 in June and 21 in July, and a record 47 tornadoes in Minnesota.

The total of 28 tornadoes in Virginia was also a state record, and Idaho equalled their record with eleven tornadoes.

...STATE RECORDS...

STATE	1993 TOTAL	AVERAGE (1962-1992)	OLD RECORD AND THE YEAR
IDAHO	11 TORNADOES	3 TORNADOES	11 IN 1991
MINNESOTA	47 TORNADOES	21 TORNADOES	41 IN 1981
SOUTH DAKOTA	85 TORNADOES	29 TORNADOES	63 IN 1965
VIRGINIA	28 TORNADOES	6 TORNADOES	22 IN 1975

The first tornado of the year touched down in Smith County of north central Texas at 4:10 AM (CST) on January 4th. The last tornado of the year was one which touched down near the town of Luling, in Saint Charles Parish of southeastern Louisiana, at 3:55 PM (CST) on December 13th.

The number of tornadoes in 1993 was the second highest of record, yet the number of tornado deaths was the eighth lowest of record.

There has been, over the years, a gradual increase in the number of tornadoes reported, a sign that there is a greater awareness of tornadoes by the general public.

The gradual decrease in the number of tornado deaths over the years indicates that severe weather warnings are being communicated to the public more quickly and accurately, and the people are more knowledgeable of what precautions to take during a tornado.

APPENDIX B**TORNADO STATISTICS FOR 1993****...KILLER TORNADOES...**

DATE	TIME	LOCATION	MAG	KIL	INJ	DAMAGE
FEB 21	1610	LENOIR CITY, TN	F-3	1	55	\$1 MIL
FEB 21	2000	CEDARTOWN, GA	F-3	1	35	\$1 MIL
FEB 22	0020	CONCORD, GA	F-2	1	2	\$1 MIL
MAR 12	2338	CHIEFLAND, FL	F-2	3	10	\$10 MIL
MAR 13	0020	LACROSSE, FL	F-1	1	4	\$1 MIL
MAR 13	0020	MOUNT DORA, FL	F-2	1	60	\$1 MIL
APR 08	1420	GRAND ISLE, LA	F-2	3	39	\$10 MIL
APR 24	1850	TULSA-CATOOSA, OK	F-4	7	100	\$100 MIL
MAY 07	1805	WILSON LAKE, KS	F-4	1	6	\$1 MIL
MAY 09	1330	WYLIE, TX	F-2	1	63	\$20 MIL
JUN 09	1620	CALN, PA	F-1	1	-	-----
AUG 06	1530	PETERSBURG, VA	F-4	4	246	\$48 MIL
AUG 09	0235	LITTELFORK, MN	F-0	2	-	-----
SEP 03	1415	BATAVIA, NY	F-1	2	-	-----
OCT 18	1810	EMORY, TX	F-2	1	-	-----
OCT 30	0530	ALBANY, GA	F-2	3	27	\$12 MIL

APPENDIX B**TORNADO STATISTICS FOR 1993****...VIOLENT (F-4) TORNADOES...**

DATE	TIME	LOCATION	KIL	INJ	DAMAGE
APR 24	1850	TULSA-CATOOSA, OK	7	100	\$100 MIL
MAY 05	2027	HUGOTON, KS	-	-	\$1 MIL
MAY 07	1805	WILSON LAKE, KS	1	6	\$1 MIL
JUN 07	1630	LYONS, SD	-	5	\$10 MIL
JUN 07	1640	MADISON, SD	-	4	\$1 MIL
AUG 06	1530	PETERSBURG, VA	4	246	\$48 MIL

...TORNADOES BY F-SCALE...

MONTH	F-0	F-1	F-2	F-3	F-4	SUM	KIL	INJ	DMG
JANUARY	11	5	1	-	-	17	-	-	3 M
FEBRUARY	15	11	1	7	-	34	3	135	20 M
MARCH	28	17	3	-	-	48	5	88	24 M
APRIL	47	25	11	1	1	85	10	192	123 M
MAY	105	49	16	5	2	177	2	82	45 M
JUNE	196	85	18	12	2	313	1	50	20 M
JULY	183	48	8	3	-	242	-	12	8 M
AUGUST	70	34	5	2	1	112	6	261	53 M
SEPTEMBER	34	24	7	-	-	65	2	52	14 M
OCTOBER	30	17	8	-	-	55	4	44	16 M
NOVEMBER	13	4	2	-	-	19	-	14	6 M
DECEMBER	3	2	1	-	-	6	-	4	---
TOTAL	735	321	81	30	6	1173	33	974	332 M

APPENDIX B**TORNADO STATISTICS FOR 1993****...TORNADO TOTALS BY STATE (1950-1993)...**

STATE	1993	TOTAL	AVERAGE	RECORD AND YEAR
ALABAMA	8	867	19.7	45 IN 1957
ARIZONA	8	150	3.4	17 IN 1972
ARKANSAS	17	838	19.1	78 IN 1982
CALIFORNIA	13	205	4.7	20 IN 1992
COLORADO	71	1067	24.3	81 IN 1992
CONNECTICUT	1	60	1.4	8 IN 1973
DELAWARE	5	48	1.1	6 IN 1992
FLORIDA	85	1932	43.9	97 IN 1975
GEORGIA	21	836	19.0	46 IN 1961
IDAHO	11	112	2.6	11 IN 1993
ILLINOIS	34	1117	25.4	107 IN 1974
INDIANA	10	869	19.8	49 IN 1990
IOWA	51	1325	30.1	71 IN 1990
KANSAS	113	2068	47.0	116 IN 1991
KENTUCKY	11	350	8.0	34 IN 1974
LOUISIANA	12	1078	24.5	79 IN 1992
MAINE	2	79	1.8	11 IN 1971
MARYLAND	6	124	2.8	13 IN 1992
MASSACHUSETTS	0	134	3.1	12 IN 1958
MICHIGAN	11	701	15.9	39 IN 1974
MINNESOTA	47	798	18.1	47 IN 1993
MISSISSIPPI	12	1005	22.8	62 IN 1988
MISSOURI	43	1132	25.7	79 IN 1973
MONTANA	19	230	5.2	30 IN 1991
U.S. TOTAL	1173	33120	752.7	1297 IN 1992

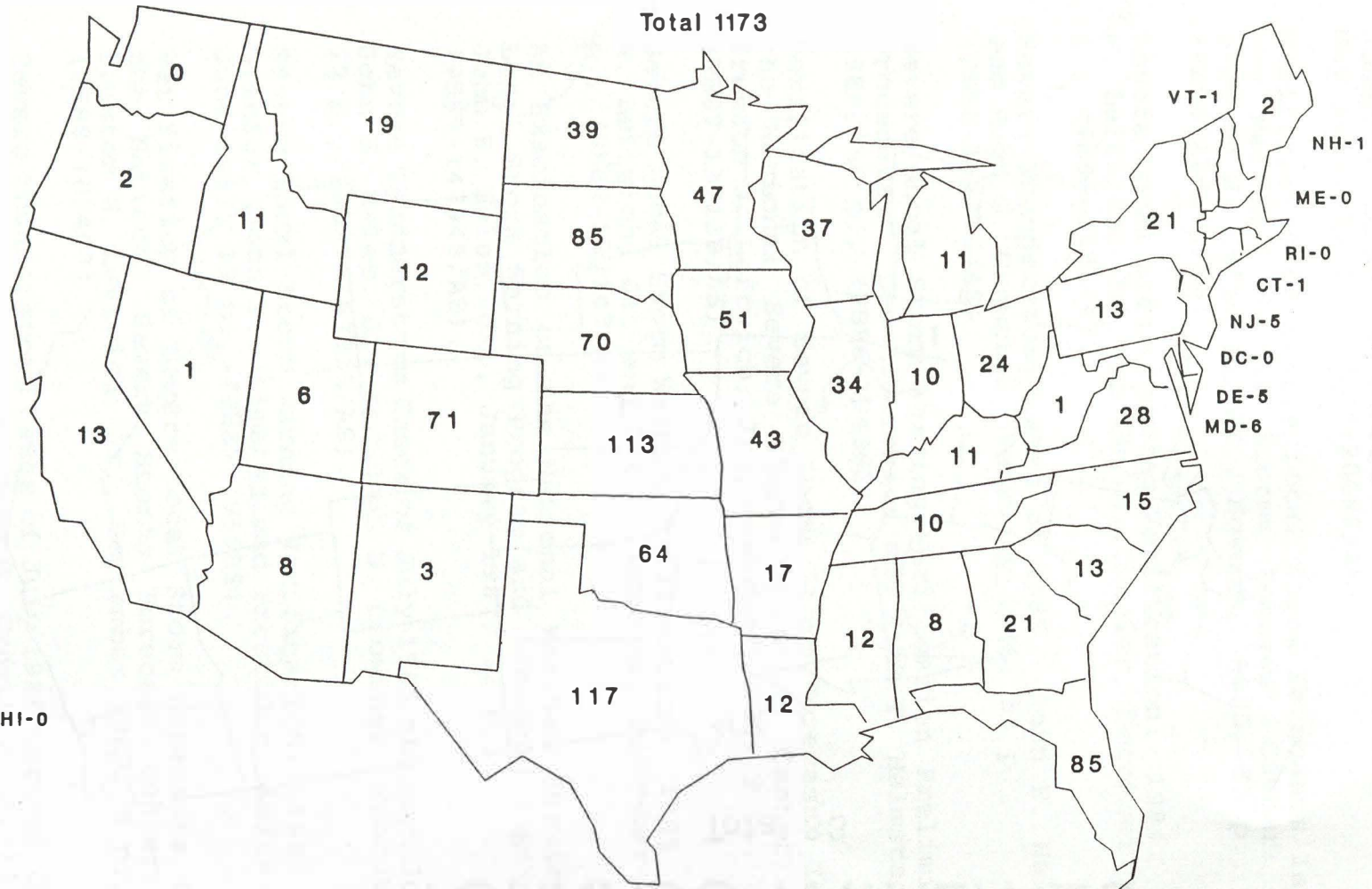
APPENDIX B**TORNADO STATISTICS FOR 1993****...TORNADO TOTALS BY STATE (1950-1993)...**

STATE	1993	TOTAL	AVERAGE	RECORD AND YEAR
NEBRASKA	70	1618	36.8	88 IN 1990
NEVADA	1	46	1.1	8 IN 1987
NEW HAMPSHIRE	1	71	1.6	9 IN 1963
NEW JERSEY	5	104	2.4	17 IN 1989
NEW MEXICO	3	377	8.6	31 IN 1991
NEW YORK	21	236	5.4	25 IN 1992
NORTH CAROLINA	15	568	12.9	38 IN 1973
NORTH DAKOTA	39	779	17.7	52 IN 1976
OHIO	24	639	14.5	61 IN 1992
OKLAHOMA	64	2259	51.3	101 IN 1982
OREGON	2	42	1.0	5 IN 1991
PENNSYLVANIA	13	424	9.6	33 IN 1985
RHODE ISLAND	0	7	0.2	3 IN 1986
SOUTH CAROLINA	13	383	8.7	23 IN 1973
SOUTH DAKOTA	85	1103	25.1	85 IN 1993
TENNESSEE	10	474	10.8	44 IN 1974
TEXAS	117	5303	120.5	232 IN 1967
UTAH	6	76	1.7	6 IN 1984
VERMONT	1	32	0.7	5 IN 1962
VIRGINIA	28	243	5.5	28 IN 1993
WASHINGTON	0	53	1.2	4 IN 1972
WEST VIRGINIA	1	81	1.8	6 IN 1974
WISCONSIN	37	808	18.4	43 IN 1980
WYOMING	12	427	9.7	42 IN 1979
U.S. TOTAL	1173	33120	752.7	1297 IN 1992

1993 TORNADES

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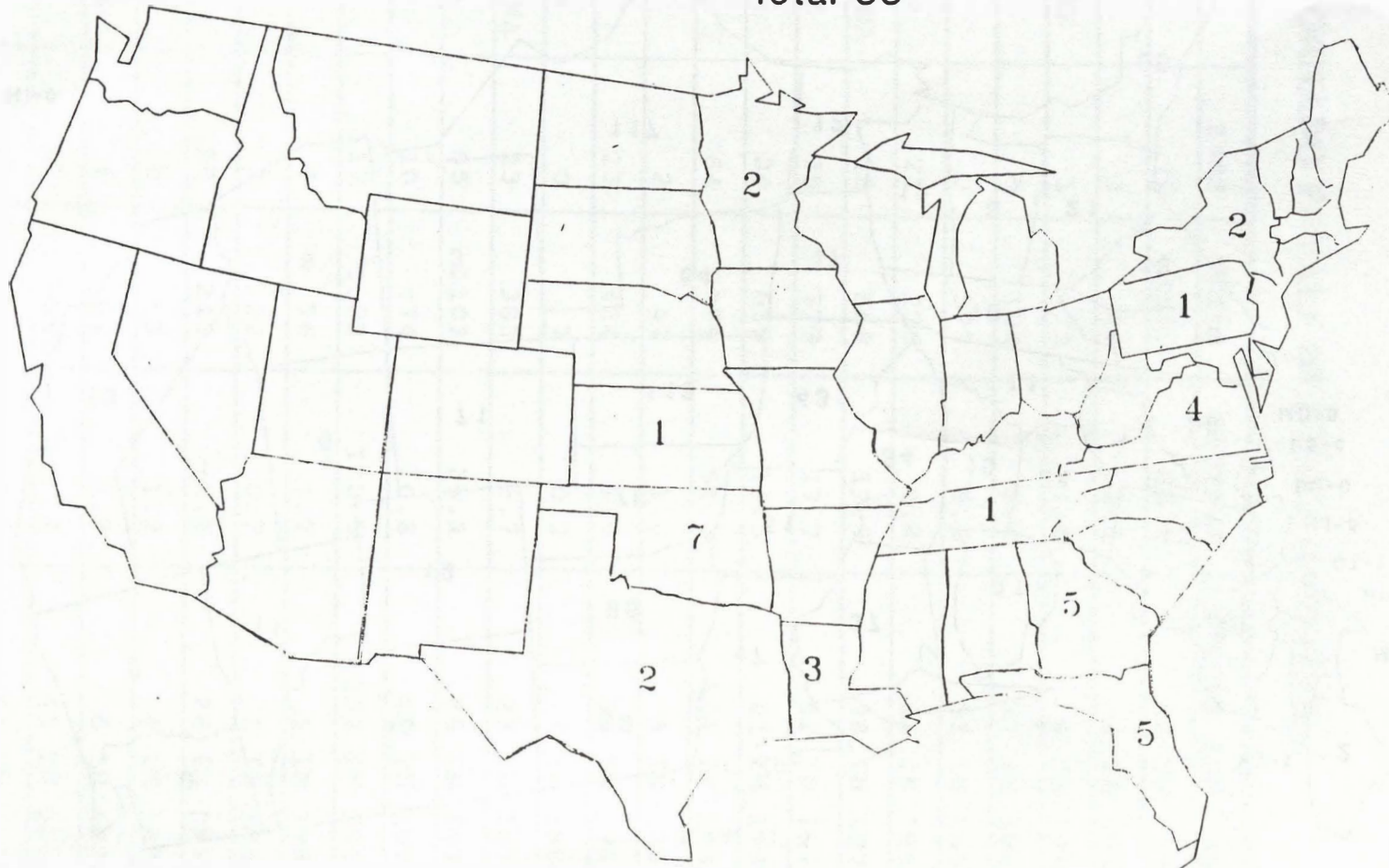
Total 1173



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1993 TORNADO FATALITIES

Total 33



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- 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).
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- 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).
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- 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).
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- 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).
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- 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).
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- No. 33 Severe Local Storm Warning Verification: 1991. Leo A. Grenier, John T. Halmstad, April 1992, 28 p., (PB92-185982/AS).
- No. 34 Verification of Severe Local Storm Forecasts Issued By the National Severe Storms Forecast Center: 1991. Richard W. Anthony and Preston W. Leftwich, Jr., May 1992, 12 p., (PB92-186063).
- No. 35 Verification of Severe Local Storms Forecasts Issued By the National Severe Storms Forecast Center: 1992. Richard W. Anthony, June 1993, 14 p., (PB93-216844).
- No. 36 Severe Thunderstorm Cases of July 1991 thru June 1992: John E. Hales, Jr. and Kevin L. Polston, June 1993, 200 p., (PB93-227460).
- No. 37 Severe Local Storm Warning Verification: 1992. Hugh C. Crowther, and John T. Halmstad, May 1993, 27 p., (PB93-227452).
- No. 38 Verification of Severe Local Storms Forecasts Issued By Richard W. Anthony, May 1994, 20 p., (PB94-195898).
- No. 39 Severe Thunderstorm Cases of July 1992 Through June 1993. Kevin L. Polston and John E. Hales, Jr., April 1994, 417 p. (PB-196227).

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