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Tornado 1982: A Near-Record Year

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ABSTRACT

The tornado events of 1982 are reviewed. Significant and interesting aspects of the 1047 reported storms are noted. The synoptic patterns associated with four major tornado days are examined.

1. The year 1982 in statistics

For only the second time in history, the annual tornado count exceeded 1000. Even with this excessive number of storms, the number of tornado deaths was well below the annual average. With 1047 tornadoes tallied, the 1982 tornado count fell 56 short of the 1973 record. However, since the 30-year average number of tornadoes over the United States is 739, the 1982 tally was 42% above normal and represented a 34% increase in tornadoes over 1981.

Erratic is the word which best describes the pattern of tornado activity during 1982. In contrast to the all-time monthly record of 329 tornadoes which occurred during May, only one tornado was reported over the contiguous states during February (two additional storms in Hawaii kept February from having a record low number of reports). December also received a record high count of 96 tornadoes which pushed the annual total above the 1000 mark. Table 1 gives the monthly breakdown of tornado activity.

Tragically, the trend toward decreased tornado fatalities that had occurred during the past two years was reversed. Tornadoes accounted for 64 deaths during 1982. While this is a significant rise from the record low of 24 established in 1981, it is still well below the 30-year average of 104 annual deaths.

During 1982, 31 tornadoes were killers. While this is also an increase over the 14 killer tornadoes of 1981, only 3.0% of the 1982 tornadoes were killers. This was slightly below the long-term average of 3.6%.

The geographic distribution of tornadoes and tornado deaths (Fig. 1) shows that the states in "tornado alley" received a large number of twisters (Texas—203, Oklahoma—101, Kansas—58, Arkansas—79, Missouri—77). Florida, which typically ranks among the top states in number of tornadoes, did so again in 1982 as 69 twisters were tallied.

Tornadoes occurred in record numbers in three states: the 79 reports for Arkansas exceeded the 50 observed in 1973; Colorado recorded 58 tornadoes, a 38% increase over the 1976 record; and California logged 14 twisters, one more than the record 13 seen in 1978.

Arkansas led all states in tornado fatalities with 19. Other states with double digit death tolls were Illinois and Texas, both with 13. Table 2 presents a list of the individual killer tornadoes. Nineteen (30%) of the tornado deaths were mobile home related. Another four fatalities occurred when tornadoes struck occupied vehicles. Mobile homes and vehicles are the two most dangerous places to be when tornadoes are occurring (Glass *et al.*, 1980).

Tornadoes are rated with an "F-scale" (Fujita, 1981) according to the damage they produce. They are then categorized as being "weak," "strong" or "violent" (Hazen, 1890). During 1982, 23.6% of the tornadoes were strong and 0.5% (Table 3) were violent. These percentages are considerably less than the normal 33% and 2% for strong and violent categories, respectively. Typically, 68% of all tornado fatalities are caused by violent tornadoes; during 1982 only 29% of the total tornado fatalities were caused by violent tornadoes. Further, three single fatality killer tornadoes were only of weak (F0–F1) strength.

A state-by-state examination of the combined number of strong and violent tornadoes (Fig. 2) shows that these events also occurred most frequently in Texas and Oklahoma. Although over twice as many tornadoes occurred in Texas than in Oklahoma, both states had 38 tornadoes in these categories. Arkansas was the only other state receiving more than 20 strong and violent tornadoes. All three of Hawaii's tornadoes were in the strong category.

A summary of the five violent tornadoes of the year is given in Table 4. Four of the five storms occurred on the same day (2 April). One of these had an 85 km long track running from northwest to south-

TABLE 1. Monthly distribution of tornadoes, tornado fatalities and killer tornadoes.

	1982 Tornadoes	1981 Tornadoes	Mean 1953–82	1982 Fatalities	1981 Fatalities	Mean 1953–82	1982 Killer tornadoes	1981 Killer tornadoes
January	18	2	15	1	0	3	1	0
February	3	25	20	0	2	7	0	2
March	60	33	48	6	1	7	5	1
April	150	84	108	30	13	37	10	6
May	329	187	162	14	0	23	4	0
June	196	223	149	4	8	15	4	5
July	95	98	82	0	0	1	0	0
August	34	64	54	0	0	2	0	0
September	38	26	38	2	0	2	2	0
October	9	32	23	0	0	2	0	0
November	19	7	21	0	0	2	0	0
December	96	1	19	7	0	3	5	0
Annual	1047	782	739	64	24	104	31	14

east across the rural southeastern corner of Oklahoma; it was the first F5 tornado recorded in the United States since the 4 April 1977 tornado in Birmingham, Alabama. The remaining violent tornado also had a northwest to southeast track as it devastated parts of Marion, Illinois on 29 May.

The median or typical tornado track length during 1982 was 1.3 km. This is considerably shorter than the climatological median length of 3.2 km (Schaefer *et al.*, 1980). The median path width of 46 m was the same as the long-term value. The representative 1982 tornado affected 0.062 km^2.

2. The year 1982 by month

a. January

The first tornado of 1982 was a strong (F3) killer storm that occurred on 3 January at 1455 (all times are CST unless otherwise noted) in Newton, Mississippi. This tornado claimed the life of one person and injured 17 as it produced a 17.5 km path of destruction. This was the first January tornado in Mississippi in five years and the first January tornado death in the United States since 1978.

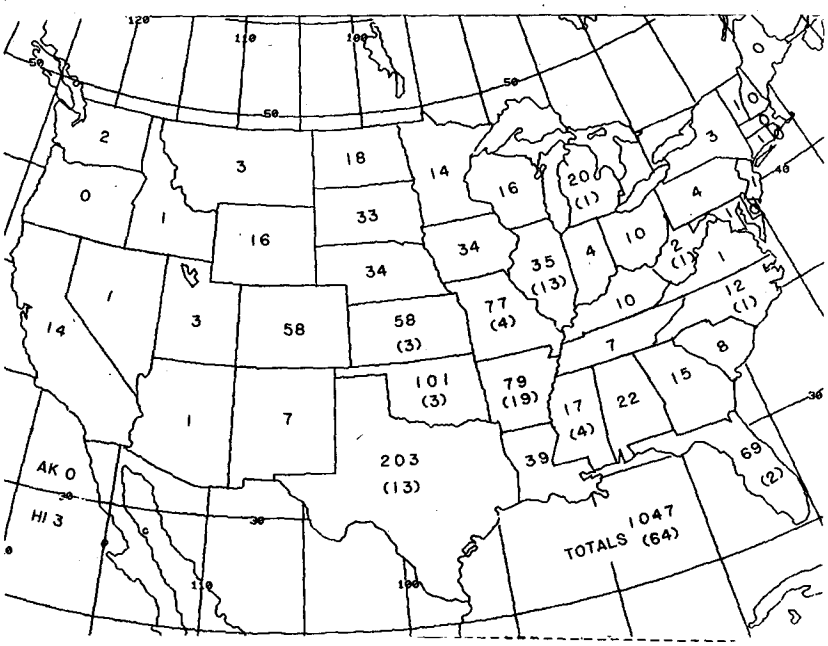

FIG. 1. Geographic distribution of tornadoes in 1982. (Total summed over states gives 1058 because of "border crossers.") Figures in parentheses are tornado deaths.

TABLE 2. Killer tornadoes during 1982.

Date	Time (CST)	Location	Deaths	Intensity	Remarks
3 Jan	1500	Newton MS	1	F3	
15 Mar	1757	Ada OK	1	F3	Mobile home
15 Mar	1815	Tyro KS	1	F3	Mobile home
15 Mar	1955	Mulberry KS-Cedar Springs MO	2	F3	Mobile home (1)
15 Mar	2030	Hallowell KS	1	F3	Mobile home
30 Mar	2030	Ina IL	1	F2	
2 Apr	1535	Dodd City TX	1	F3	
2 Apr	1600	Paris TX	10	F4	Mobile home (2)
2 Apr	1715	Forrest City AR	1	F2	Mobile home
2 Apr	1730	Ashdown AR	1	F3	
2 Apr	1730	Nashville AR	3	F4	
2 Apr	1830	Hope AR	5	F3	
2 Apr	1830	Caulfield-West Plains MO	2	F4	Vehicles
2 Apr	1855	5 East Conway AR	2	F3	
2 Apr	1920	Vidette AR	2	F3	
3 Apr	0020	Philadelphia MS	3	F3	Mobile home
11 May	1705	Friendship OK	2	F3	Mobile home
13 May	1420	Kirbyville TX	1	F3	Mobile home
28 May	0425	Morrilton AR	1	F2	Mobile home
29 May	1430	Marion IL	10	F4	
13 Jun	1410	Zebulon NC	1	F1	Vehicle
15 Jun	1515	Munith MI	1	F3	
16 Jun	1600	Morgantown WV	1	F0	Mobile home
17 Jun	2220	Denaud FL	1	F2	Mobile home
3 Sep	1530	Humble TX	1	F1	
26 Sep	0315	Basinger FL	1	F2	
2 Dec	1453	Alexander-West Little Rock AR	2	F3	Mobile home (1), Vehicle (1)
2 Dec	2115	New Baden IL	2	F3	
24 Dec	1645	Vilonia AR	1	F3	
24 Dec	1900	Eastwood MO	1	F2	Mobile home
24 Dec	1920	1 Mile North Patterson AR	1	F3	Mobile home

During January, Alabama led the nation in the number of tornadoes with eight, while there were three in Arkansas, two each in Florida and Mississippi, and single reports in California, Georgia and Louisiana. The total of 18 tornadoes during the month was three above the January normal.

b. February

After an active January, tornado activity during February was well below normal as a persistent area of high pressure prevented the northward movement of low-level moisture from the Gulf of Mexico. With only three tornadoes reported, the all-time February low of two set in 1964 was approached. It is interesting to note that two of the three tornadoes were reported in Hawaii where the annual average occurrence rate is less than one. No February tornadoes had occurred in Hawaii since 1963. The other tornado for this month occurred just north of Sarasota, Florida during the early morning hours of 17 February.

TABLE 3. Tornado frequency and deaths by intensity category, 1982.

Category	F Scale	Tornado frequency (%)	Tornado deaths
Weak	0–1	75.9	3
Strong	2–3	23.6	36
Violent	4–5	0.5	25

c. March

Tornadic activity was on the upswing in March as 60 reports were received. A major outbreak on the 15th produced 22 tornadoes: over Oklahoma (10), Kansas (8) and Missouri (4). Four killer tornadoes in this outbreak caused one fatality in each of the following towns: Ada, Oklahoma; Tyro, Kansas; Mulberry, Kansas; Hallowell, Kansas; and Cedar Springs, Missouri. The deaths in Kansas were the first March deaths in that state since 1938 when 11 people were killed. These four killer tornadoes also caused 114 injuries. One of these tornadoes touched down in Crawford County, Kansas, at 1935 CST. It killed one person and injured eight others before crossing into Vernon County, Missouri. From there it passed into Cedar County, Missouri, causing another fatality.

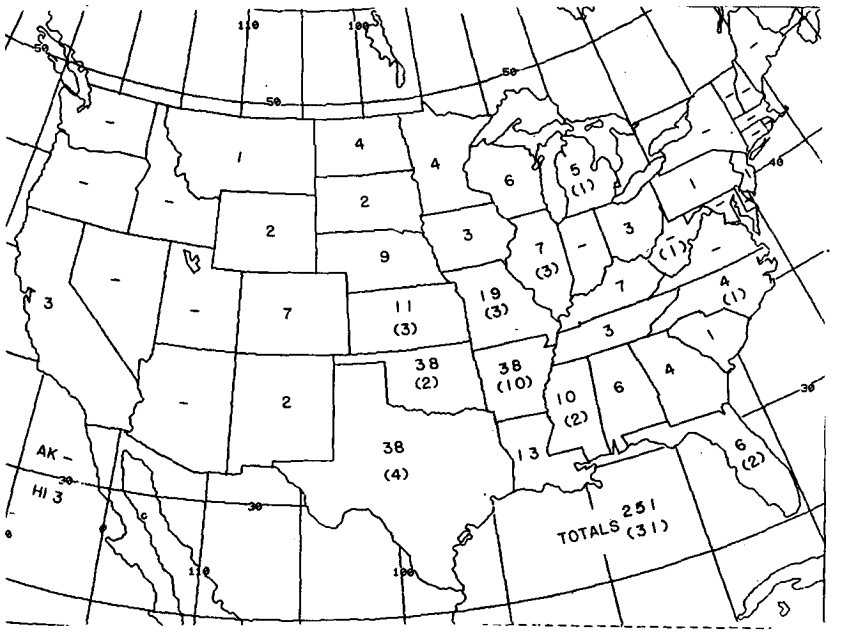

FIG. 2. Geographic distribution of "strong" and "violent" tornadoes in 1982. (Intensity F2 or greater total summed over states gives 261.) Figures in parenthesis are killer tornadoes (total summed over states gives 32).

This persistent tornado then moved on to St. Clair County at 2050 where it lifted back into the clouds after a 113 km journey.

The rare tornado that occurred in Utah on the 29th was the first March tornado there since 1907. Also an unseasonable tornado in Wisconsin on the 30th injured two people in Juneau County as it traced a 35 km long intermittent path across parts of three counties. On that same day, an F2 tornado caused one death and injured three in Ina, Illinois.

During March, Oklahoma and Kansas had the most tornadoes with 11 each, followed by six in both Texas and Missouri. The tornado death total for the first three months of 1982 stood at seven, but the worst was yet to come.

d. April

The 150 tornadoes reported in April made it the fourth most active April in the past 33 years. No April since 1974 had as many twisters. More than one-third of the total tornadoes reported during the month occurred in a 10 h period beginning at 1400 on 2 April. On that date, the central part of the United States was bombarded by the most destructive and widespread tornado activity of 1982, as 206 severe thunderstorms were reported, including 55 tornadoes. It was the biggest outbreak of severe thunderstorms since 3 April 1974 when 148 tornadoes killed 315 people.

Included in the 2 April 1982 episode was a powerful F5 storm which was at times 2.4 km wide. This storm left a 85 km track across extreme southeast Oklahoma. Although 29 people were injured, miraculously, no one was killed by this violent multi-vortex storm. In Broken Bow, Oklahoma a 2 × 4 board[1] was driven into an oak tree while a motel sign was carried aloft to be found later 48 km away in Arkansas.

Almost 20% (10) of the tornadoes on 2 April were

[1] A construction stud of rectangular cross section, nominal dimensions 1½″ × 3″ (3.8 cm × 7.6 cm).

TABLE 4. Violent tornadoes in 1982.

Date	Time (CST)	Location	Intensity	Path length (km)	Path width (m)	Deaths	Injuries
2 Apr	1530	Speer–Eagletown OK	F5	82	805	0	29
2 Apr	1600–1630	Paris–Detroit TX	F4	37	229	10	170
2 Apr	1730	Horatio–Nashville–Blevins AR	F4	72	183	3	23
2 Apr	1815–1835	Tecumseh–West Plains MO	F4	32	457	2	28
29 May	1405–1432	Carterville–Marion IL	F4	27	366	10	181

killer storms. Thirty fatalities and 383 injuries were tallied as communities and towns in 11 states were devastated during this episode of tornadic activity. It is probable the death toll would have been much higher without the accurate and timely tornado watches as well as warnings that were issued. The National Severe Storms Forecast Center issued 14 tornado watches that captured 93% of the tornadoes and all of the killer tornadoes on this day.

Paris, Texas, a town of 25 000 located about 129 km northeast of Dallas, was the hardest hit location. At 1600 LT an F4 tornado (Fig. 3) entered the northwest suburbs and moved rapidly eastward across town. Ten people were killed and 170 injured along this storm's 37 km track. Damage (Fig. 4) was nearly $50 million and over 1000 residents of Paris were left homeless. Warnings were issued well in advance of the time the tornado touched down.

About one-half hour before Paris was struck, another tornado (F3) claimed the life of a woman in nearby Dodd City, Texas. This fatality brought the Texas tornado death toll to 11 for this day.

Fourteen tornado related deaths occurred in Arkansas on 2 April. This was the most fatalities in that state during a single April day since 19 April 1968. Five people were killed in Hope, Arkansas when a tornado (F3) hurled a huge oak tree onto their home (Fig. 5). There were three deaths in Nashville, Arkansas, two each in Vidette and Conway, and single fatalities in Forrest City and Ashdown.

At 1815, a violent (F4) tornado touched down in south central Missouri and produced a 32 km track that stretched from just east of Tecumseh to West Plains. Two people were killed (one in Caulfield and one in West Plains) and 28 injured as this storm moved northeastward at nearly 27 m s^{-1}. More than 20 homes were damaged and 200 cars parked in a used car lot were destroyed.

Shortly before midnight on 2 April, a strong tornado (F3) touched down in central Mississippi, near Carthage, and moved eastward. As this storm roared through Philadelphia, Mississippi a short time later, three persons were killed when their mobile home was destroyed. This incident brought the death toll from this major outbreak to 30.

The remainder of April continued on the active side, but no additional tornado deaths occurred. State tornado totals that were in double digits for the month were 27 in Texas, 22 in Arkansas, 18 in Missouri, 14 in Louisiana, 11 in Oklahoma, and 10 in Florida. One tornado on 2 April traversed parts of Texas, Oklahoma and Arkansas. Many of the 21 states which experienced tornadoes in April exceeded their normal for the month. Most notable were the 22 tornadoes in Arkansas which was almost four times above their normal for the month.

FIG. 3. Paris, Texas tornado of 2 April 1982. This tornado cut a 180–275 m wide path across the north side of Paris, Texas. The event, rated at F4, caused 10 deaths and produced $50 million in damage (Photo by Mark Gail, Paris NEWS, Courtesy of Tom Grazulis).

FIG. 4. Devastation along the path of the Paris, Texas tornado. Shown are the remains of mobile homes, trucks and warehouses (Photo by Mark Gail, Paris NEWS, Courtesy of Tom Grazulis).

FIG. 5. All five members of a family were killed when a huge oak tree crushed their home, south of Hope, Arkansas. The family was huddled under a mattress at the center of the house as the F3 tornado approached from the west (Photo by Billy Burton, Hope STAR, Courtesy of Tom Grazulis).

FIG. 6. The F3 Altus tornado. This 11 May storm crossed Altus Air Force Base causing $200 million worth of damage (Photo courtesy of Howard B. Bluestein, University of Oklahoma, Severe Storms Intercept Project).

e. May

Three hundred twenty-nine tornadoes were reported in 28 states during the month. This total set a record for any month, far exceeding the previous record of 274 established in May 1965. The greatest number of tornadoes occurred on 11 May (36) and 12 May (35), but tornadoes were reported on all but three days of the month (1, 2, and 8 May). Although tornado occurrences during May were more than twice (203%) the normal of 162, the death toll was held to 14—nine less than the May average of 23.

In the 8 h period ending at midnight on 11 May, southwestern Oklahoma was struck by 18 tornadoes. One of these tornadoes claimed the lives of two people in Friendship, Oklahoma as their mobile home was demolished. This huge (1.9 km wide in places) multivortex storm was one of four tornadoes on that day which displayed an unusual track running from southeast to northwest. At about 1700 that evening, a strong (F3) tornado touched down just southeast of Altus, Oklahoma (Fig. 6), moved northeast through the east part of town then across Altus Air Force Base. This storm resulted in damage to property of an estimated $200 million. The Air Base bore the brunt of the storm where 70 buildings and 30 aircraft were damaged or destroyed. Many structures and vehicles that escaped the fury of the tornado were pelted by large, irregularly shaped hail that measured as large as 10 cm square by 2.5 cm thick. An estimated 6000 vehicles were damaged or demolished by the tornado or hail. There were 41 injuries, but luckily this tornado resulted in no fatalities.

One day later, 12 May, was the most active tornado day of the month. There were 35 storms reported, all confined to Texas. Although many of the twisters were rated strong and several people were injured, no fatalities occurred on this day.

The next day, 13 May, twelve tornadoes were reported in southeast Texas. One tornado (F3) struck just north of Beaumont, killing a mobile home resident at Kirbyville, Texas. On 28 May, one person was killed by a tornado (F2) that hit Morrilton, Arkansas.

The most deadly tornado in May occurred in Williamson County, Illinois on 29 May. Ten people were killed and 181 were injured by a violent (F4) tornado which produced a 27 km intermittent path. The town of Marion suffered a direct hit. All 10 deaths occurred there. The storm left near total destruction in its wake as 161 homes and 47 businesses were destroyed. About 1000 people were left homeless in Marion as a result of this massive storm that produced damage of nearly $100 million.

In addition to setting the all-time record for the greatest number of tornadoes in any month, May set several other records. The Marion tornado on 29 May produced the first May tornado fatality in Illinois

since 1968. Further, the total of 10 deaths was the most reported in Illinois in May since 1917 when 106 people, including 101 by the infamous Mattoon tornado, were killed (Root, 1917).

Over half of the 1982 Texas tornadoes occurred during May. The 123 tornadoes far exceeded the previous May record of 71 set in 1981. Further, this was the highest tally that has been reported in Texas during any month except September 1967 when 124 tornadoes occurred, many in association with Hurricane Beulah. The 56 tornadoes in Oklahoma were the most that have been observed in that state in any month except in May 1960 when 61 were reported.

Kansas ranked third in the number of tornadoes in May with 28, the most reported in Kansas in any month since May 1965 when 35 occurred.

Other states that exceeded their average were Missouri with 19, Iowa with 17 and both Nebraska and Illinois with 15. The 15 in Illinois broke the previous May record of 11 set in 1960.

f. June

The tornado season continued in full swing through the month of June with at least one tornado reported each day. This statistic for June matches the record set in 1980. Since twisters were reported each day during the last 23 days of May, one or more tornadoes occurred in the United States on 53 consecutive days! In all, there were 196 tornadoes reported during June.

There were four tornado fatalities during the month. On 13 June, a weak (F1) tornado touched down briefly in Zebulon, North Carolina and killed the driver of a car that was picked up and slammed into a wall. This was the first June death in North Carolina since records began in 1916. On 15 June, a strong (F3) tornado in Munith, Michigan claimed the life of a boy who was blown from a second story porch and fatally injured. The following day, an infant in Morgantown, West Virginia was killed when a tree that was downed by a tornado crushed a trailer. This was the first June tornado death in that state since 1944 and only the sixth killer tornado in West Virginia since reliable data were established in 1916. On 17 June, a strong (F2) tornado produced a 13 km track west of Lake Okeechobee in Florida. This twister caused considerable damage to citrus crops and damaged or destroyed several mobile homes. A man was killed and his sister seriously injured when the tornado threw them from their house trailer.

Texas, again, led the nation in total tornadoes in June with 36, but was closely followed by Colorado with 31. This was an all-time monthly record for Colorado and greatly exceeded the previous record of 21 set in July 1979. Florida's total of 23 tornadoes broke the old record of 21 for June, established in 1972. North Carolina also set a new record for June with six tornadoes, breaking the earlier record of five set in both 1977 and 1978. A tornado in Idaho on 30 June was the first to be reported there in June since 1972.

On the opposite end of the scale, several states deserve mention because of the absence of tornadoes during this month. It was the first June ever that Minnesota had no tornadoes. Also, for the first June since 1961, there were no twisters in Wisconsin and for the first June since 1968 there were none in Illinois.

g. July

Tornado activity began to subside during July as the atmospheric flow pattern became more typical of summer. Although 95 (13 more than normal) tornadoes were reported, they were spread over 28 days and 22 states. For the second consecutive year there were no killer storms in July. Only two tornadoes reached the strong (F2 or greater) category.

On 9 July, an organized outbreak of severe weather produced 14 tornadoes, and numerous large hail and wind damage reports from the Dakotas to Oklahoma. Heavy downpours of rain with this system induced flash flooding in many parts of Kansas and Oklahoma.

On 6 July, a severe thunderstorm produced a downburst in southeast South Dakota that caused extensive property damage and injured 10 people in Sioux Falls. Winds were estimated at 56 m s^{-1} with an official peak wind gust of 36.6 m s^{-1} recorded at the National Weather Service Forecast Office. During July, South Dakota had 16 tornadoes, Florida 13, and both Colorado and North Dakota 12.

h. August

August was the first month since February that the total number of tornadoes fell below normal. The 34 reports were the lowest August total since 1967 and well below the monthly average of 54. Except for three F2 tornadoes, all were weak (F0, F1) in intensity. For the first time in 31 years, Texas reported no tornadoes in August. An exception to this downward trend occurred in South Dakota where six tornadoes broke the previous August record of five set in 1973 and 1969.

Although the number of tornadoes was relatively low, severe thunderstorms produced numerous reports of large hail, high winds and heavy rain that resulted in extensive damage to property and crops in the central part of the country. South Dakota was hardest hit. Reports of 7 cm diameter hail were common in the western counties of Lawrence, Butte and Fall River on 23 August as a strong thunderstorm system moved through that area. Over 75% of the corn crop was destroyed in parts of Butte County and

a girl was injured by the hail when she was caught in the storm.

Repeated downpours of rain from heavy thunderstorms produced more than 305 mm of rain in eastern sections of Kansas City, Missouri on 12–13 August. Four deaths were attributed to the serious flooding that resulted from this storm.

i. September

There was a slight increase in tornado activity during September with a total of 38 reported. This total was equal to the normal number for September.

A weak (F1) tornado at Humble, Texas (a few kilometers north of Houston) resulted in one fatality on 3 September. This was the first September tornado death in Texas since 1967 and only the fourth killer tornado to occur in Texas during September since records began in 1916.

In the early morning of 26 September, a tornado (F2) touched down southwest of Vero Beach, Florida killing one person in Basinger. This tornado also injured several people and did considerable damage to mobile homes and other dwellings.

On 12 September, the most active day of the month, a strong weather system which had produced three tornadoes in Louisiana during the preceding evening moved northeast during the night. Shortly after sunrise, it spawned the first of four tornadoes reported in northern Mississippi. Later in the day, a separate storm system produced a band of severe weather from central Oklahoma to the western Great Lakes.

Strong winds and large hail raked the Oklahoma City area for about an hour and a half during the evening of 14 September. Although there were no fatalities, considerable damage was inflicted by this intense storm.

j. October

Only nine tornadoes were reported during the month, and all of them occurred during the first eight days. On 8 October, an unseasonably strong weather system moved across the Central Plains and produced four tornadoes and several reports of high winds and large hail. One small tornado (F1) struck just south of the Kansas City International Airport and flying debris did considerable damage to a shopping center in Parkville, Missouri.

Iowa, with two tornadoes on 6 October, led the states in the number of October tornadoes. These tornadoes were both weak (F0) and did only minor damage to farm outbuildings.

The total of nine tornadoes was well below the October normal of 23 and even further below October 1981 when 32 twisters were tallied. However, this sharp decline was not an indicator that the 1982 tornado season was winding down.

k. November

A marked increase in the number of tornadoes in November was a preview of coming December events. Although the total of 19 for the month was two below normal, a tornado outbreak in southern California set records for that state that are worthy of discussion.

On 9 November, a strong weather system entered the California coast and produced an intense line of thunderstorms from Santa Barbara to just north of San Diego. This storm system produced seven tornadoes and large hail that did extensive property damage in Los Angeles, Orange, Ventura and Riverside counties. Shortly before noon, Pacific Standard Time, a strong (F2) tornado traversed the Van Nuys area. Damage to one department store alone was estimated to be a quarter of a million dollars. Half an hour later, the second strong (F2) tornado of the day struck Long Beach. This twister produced a swath of damage 16 km long and 1 km wide.

Luckily, there were no fatalities and no known injuries from this rare outbreak that raked Southern California for nearly 6 h. No tornado had been reported in California in November since 1966 and the seven observed on 9 November set a new record for the month and an all-time record for the most in a single day.

l. December

December 1982 will long be remembered as the month when Mother Nature seemed to disregard climatology. As a result, many previous tornado frequency records were shattered.

The stage was set for the first December episode of tornadoes in late November when an intense low pressure system moved across California from the Pacific Ocean. As this system moved eastward into the Plains on 1 December strong thunderstorms produced numerous reports of damaging wind, large hail and several tornadoes from central Oklahoma to northeast Missouri. There were no deaths, but more than 20 persons were injured. Severe weather continued through the night as the squall line moved slowly eastward.

An extended period of tornadic activity began in Arkansas shortly after noon on 2 December. The activity spread and developed northeastward into Missouri and Illinois during the afternoon and evening. Redevelopment of the storms in Arkansas the following morning (3 December) resulted in the National Severe Storms Forecast Center keeping tornado watches posted for portions of Arkansas for 27 consecutive hours beginning at noon 2 December.

Around 1500 on 2 December, a strong (F3) tornado developed in central Arkansas and moved northeastward, killing a mobile home resident in Alexander and the driver of an automobile in West Little Rock. Late that evening another strong (F2) tornado struck a mobile home park in New Baden, Illinois, killing two people and injuring over 60.

The following three weeks in December were relatively tranquil with no significant severe weather noted. However, on 23 and 24 December, Arkansas and Missouri were again the target of tornadoes. During this second major outbreak in December, portions of Arkansas were in tornado watches for 23½ consecutive hours. One person was killed in Vilonia, Arkansas and another fatality occurred in a mobile home just north of Patterson, Arkansas.

Southern Missouri was also hit hard by tornadoes, high winds and heavy rain on 24 December. One of these tornadoes played an important part in an interesting, but tragic story. On 2 December a tornado (F2) in Carter County, Missouri demolished the home of an elderly couple. Both escaped serious injury. Nineteen days later, this couple moved into a mobile home on the site of their former house. On Christmas eve, the mobile home was destroyed by a tornado. The wife was seriously injured and the husband became the 63rd tornado fatality of 1982.

The total of 96 tornadoes in December greatly exceeded the previous December record of 61 set in 1967. The normal for the month is 19. The 46 tornadoes in Arkansas were the most there in any month of 1982. Further, the total was more than four times the December record of 10 tornadoes established for Arkansas in 1978. Missouri also reported more tornadoes in December than in any other month of 1982. The Missouri total of 30 shattered the December 1967 record of 8. Seven tornado fatalities during the month were the most in any December since 1967, when 10 were recorded.

The last tornado in 1982 was reported 13 km south of Milan, Georgia at 0215 EST on 29 December.

3. Significant tornado outbreaks

Successful forecasting of tornado activity depends largely upon the identification of an atmospheric structure conducive to the initiation and explosive growth of convection (Schaefer *et al.*, 1982). Essentially, this is done by examining certain meteorological fields at the surface and upper air levels. While radar and satellite data assist the meteorologist in determining important changes in the atmospheric structure, the examination of key synoptic parameters (Miller, 1972) is essential to isolate areas of unstable air masses which are apt to be subjected to upward vertical motions sufficient for the release of potential instability (House, 1963).

The relationship of certain key parameters is depicted in composite charts for four significant tornadic events during 1982. Patterns are different in each of the four situations, but key relationships do exist for all the events. Surface discontinuities such as frontal systems and dew-point gradients are depicted since upward motion is frequently optimized near surface boundaries (Maddox *et al.*, 1980). Areas of potential instability are delineated by the Lifted Index (Galway, 1956; Doswell *et al.*, 1982). The lower level wind field is depicted by the 850 mb jet stream which helps provide upward vertical motion at low levels (Bonner, 1966). When combined with the surface dew-point temperature field, the low-level wind pattern indicates areas where a maximum of low-level moisture convergence is likely. This is frequently a precursor of intense thunderstorm development (Hudson, 1971). The influence of the upper-level wind field pattern in determining vertical motion fields is indicated by the 500 mb jet. The juxtaposition of the upper and lower level jet streams is often instrumental in isolating tornado threat areas (Beebe and Bates, 1955; McNulty, 1978).

a. 15 March 1982

The first significant outbreak of tornadoes in 1982 occurred on 15 March as features conducive for tornadogenesis quickly evolved during the late afternoon. The composite chart (Fig. 7) depicts significant parameters at 1800 CST on March 15.

During the preceding 12 h, the air mass over the area that experienced the most destructive tornadoes (southeast Kansas, northeast Oklahoma, southwest Missouri) underwent a pronounced change. The 13°C surface isodrosotherm moved northward from the Red River of northern Texas to near the Kansas–Nebraska border. With the approach of an intense cold trough at the 500 mb level, rapid destabilization of the air mass changed the Lifted Index from zero to −6 over the affected area.

The area of maximum severe thunderstorm development coincided with the intersections of the 500 mb jet axis (oriented from the Texas panhandle eastward into southern Illinois) and the 850 mb jet (oriented from eastern Texas northward into western Missouri). The maximum wind speed at the 850 mb level was 21 m s^{-1} in southeastern Oklahoma, while the jet at 500 mb showed a 36 m s^{-1} isotach maximum moving across northern Oklahoma.

Tornado activity was most pronounced from 1700 through 2300 CST under the left front quadrant of the 500 mb jet maximum from extreme northeast Oklahoma into central Missouri. This area was also under a strong cold advection pattern at 500 mb. A smaller area to the right side of the 500 mb jet axis in east-central Oklahoma (around Ada, Oklahoma)

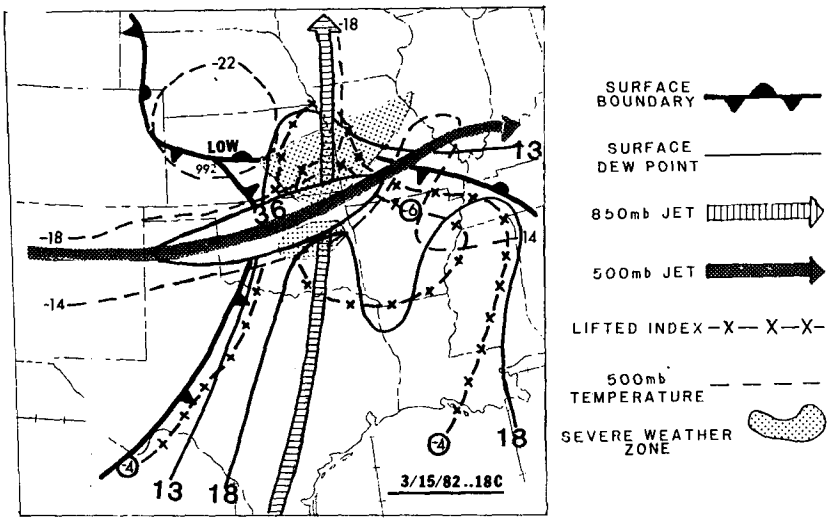

FIG. 7. A "composite" chart indicating significant synoptic parameters for 1800 CST 15 March 1982—legend is on right-hand side of figure.

experienced brief, but damaging tornadoes from 1700–2000 CST. This second area coincided with a narrow axis of low-level moisture in which surface dew-points reached 18°C and where the low-level convergence field was maximized due to the action of the low-level jet.

b. 2 April 1982

It is rare that the atmospheric structure is such that an outbreak of destructive tornadoes can occur over an extensive area. The largest tornado outbreaks since 1960 occurred on 11 April 1965 (71 tornadoes) and April 3–4, 1974 (148 tornadoes). The 2 April 1982 outbreak which produced 55 tornadoes had a pattern of key parameters that closely resembled those outbreaks. These outbreaks were all characterized by 1) a rapidly deepening surface low pressure area encompassing a relatively large area of the central United States, and 2) a negatively tilted upper trough with a large zone of upper-level diffluence between the subtropical and polar jets. Also, the mid-level polar jets had an isotach maximum exceeding 46 m s^{-1}. The final feature was 3) a rapidly destabilizing air mass featured by a northward surge of surface dew points greater than 15°C resulting in the Lifted Index ranging from −4 to −10 over a broad area.

Fig. 8 shows significant parameters that existed at 1200 CST 2 April. This was about the time that severe thunderstorms began to develop along the western limit of the depicted severe weather area. A rapidly deepening surface low was located over southeast South Dakota with a dryline arcing southward into north-central Texas. Low-level moisture shown by surface dew points of 13°C or greater, stretched northward across the mid-Mississippi Valley into southern Minnesota. A wedge of very unstable air was positioned from eastern Texas into western Iowa. At the middle levels of the troposphere, a subtropical jet was oriented west-to-east from northern Texas into Alabama, while a polar jet curved northward from the Texas panhandle to southwest Minnesota with a jet maximum of 52 m s^{-1} moving across Oklahoma.

During the 15 h following the 1200 CST chart, severe thunderstorms surged eastward ahead of the dryline to Ohio and Alabama, but the most destructive tornadoes occurred during the late afternoon from the Red River area of northeast Texas and southeast Oklahoma into much of Arkansas. These killer storms, which reached the F5 intensity level, developed to the north of the subtropical jet and west of the low-level jet where the maximum instability of −10 existed. The storms moved into Arkansas along a boundary created by rain-cooled air from earlier thunderstorm activity. Other tornadoes, mostly of lesser intensity, occurred in Missouri, Illinois and western Tennessee where the air mass instability ranged from −4 to −8. Severe thunderstorms continued to move eastward during the night in the area of strong upper level diffluence located north of the subtropical jet stream.

c. 29 May 1982

Strong thunderstorm activity over parts of the middle Mississippi Valley persisted during the early morning hours of 29 May 1982 and helped set the stage for severe thunderstorm development later that day. At 0600 CST (Fig. 9) a surface low was centered over northern Missouri, with a warm front reaching eastward into Lake Erie and a cold front trailing

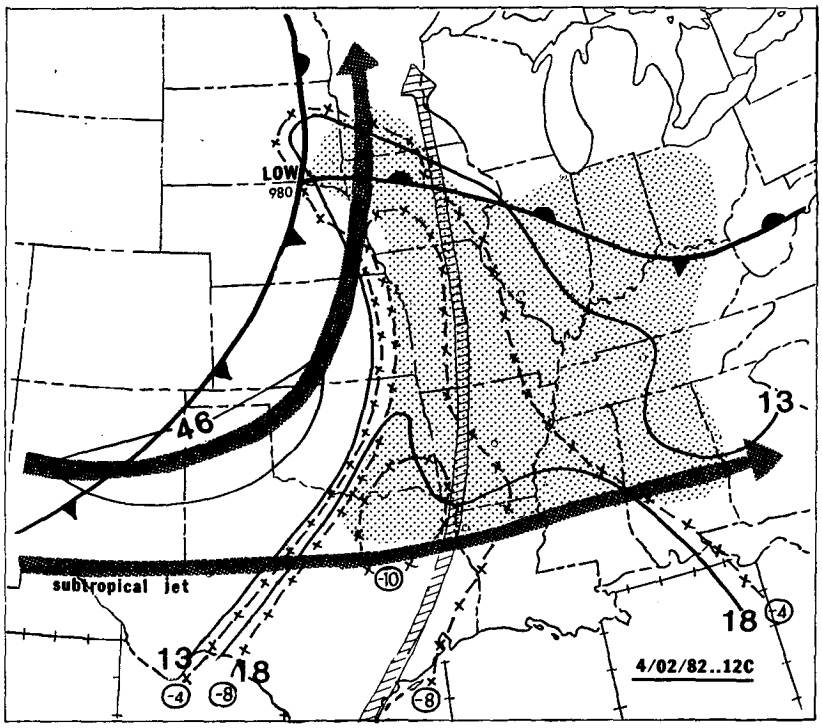

FIG. 8. Composite chart for 1200 CST 2 April 1982 (legend as in Fig. 7).

southwest into west Texas. Warm, moist unstable air (−8 lifted index) dominated the warm sector of the system with 21°C surface dew-points occurring as far north as southern Illinois. The nocturnal convection in the warm sector left a low-level air mass discontinuity (outflow boundary) from southern Missouri across northern Kentucky. A 26 m s^{-1} southwesterly low-level jet from eastern Oklahoma into southern Illinois maximized convergence along the outflow boundary and provided for continued regeneration

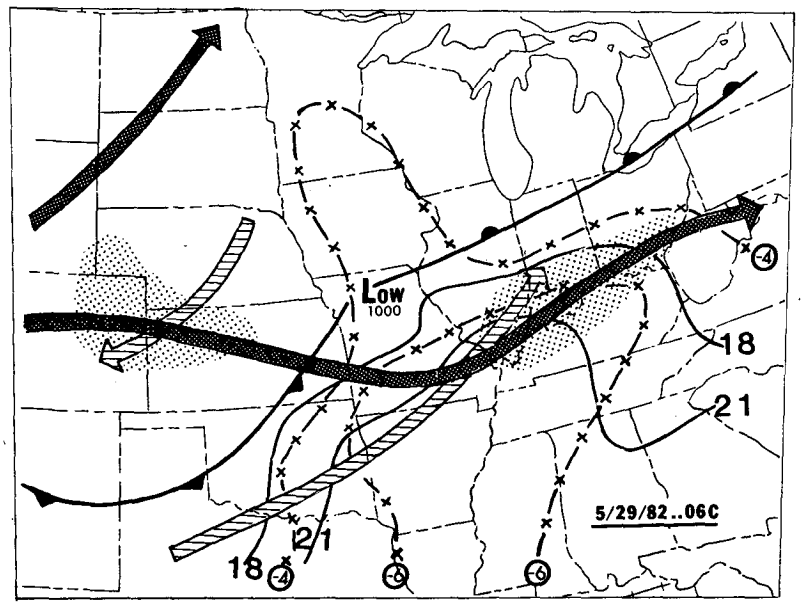

FIG. 9. Composite chart for 0600 CST 29 May 1982 (legend as in Fig. 7).

of activity along and north of the boundary. Convective development was aided by a slow-moving short-wave trough aloft and a branch of the middle level jet (23 m s^{-1} maximum) traversing portions of the Mississippi and Ohio Valleys. Unlike severe storm outbreaks earlier in the spring in which convective development was intimately related to the primary upper level jet and cold core aloft, this case is representative of many late spring and summer outbreaks in which low-level forcing and subtle synoptic features aloft play major roles.

The upper short-wave trough and associated surface low moved slowly eastward into Indiana and weakened somewhat during the evening of 29 May. Four distinct convective mesosystems moved from southern Illinois across northern Kentucky, southern Indiana and southern Ohio during the 18 h period from 0600 CST through 2400 CST 29 May, producing 46 severe storm reports including the F4 Marion, Illinois tornado.

A separate area of severe thunderstorms developed over the high plains of Colorado during the afternoon and drifted eastward into Kansas during the night, producing 19 severe storm reports. The activity formed in marginally unstable air (Lifted Index of −2) to the north of the surface cold front in a zone of low-level upslope flow. A very weak middle-level short-wave trough moving across the northern Rockies during the time of maximum diurnal heating contributed to the severity of the storms. As discussed by Doswell (1980), High Plains severe thunderstorms often occur with these conditions, behind a southward moving cold front after the surface system has moved eastward toward the Mississippi Valley.

d. 24 December 1982

Meteorological parameters were arranged in similar patterns twice during December so that episodes of severe thunderstorms and tornadoes occurred in Arkansas and Missouri on both 2 December and 24 December. The Christmas Eve outbreak is represented by Fig. 6 which depicts significant parameters at 1800 CST 24 December.

On both 2 and 24 December a deep closed low developed at the 500 mb level over New Mexico and western Texas. In response to this upper air pattern, low-level moisture surged northward through Arkansas and Missouri into Illinois. Even though December ranks among the months least likely to experience tornadic activity, it is apparent that the parameters in Fig. 10 resemble a typical springtime pattern.

The severe thunderstorms were concentrated in a north–south axis coincident with the axis of the low-

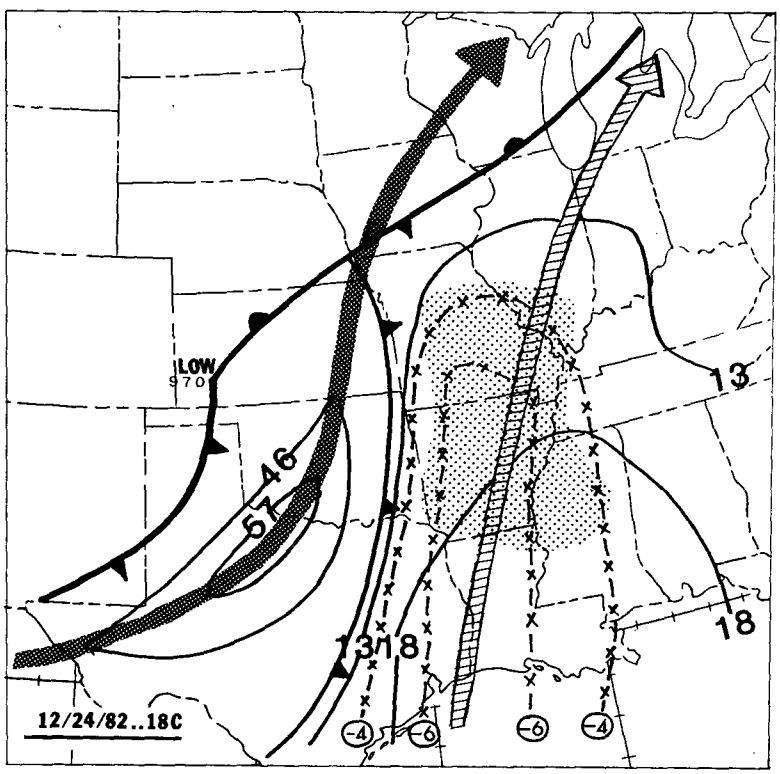

FIG. 10. Composite chart for 1800 CST 24 December 1982 (legend as in Fig. 7).

level moisture and low-level jet where the Lifted Index reached −6. Thunderstorms developed during the afternoon ahead of a slowly moving dryline as a 500 mb jet maximum of 57 m s^{-1} moved north-northeast across central Oklahoma. This jet "max" provided a favorable right rear quadrant where upward vertical velocities became maximized over the unstable air mass, resulting in numerous tornadoes including three killer tornadoes in Arkansas and southern Missouri.

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REFERENCES

Beebe, R. G., and F. C. Bates, 1955: A mechanism for assisting in the release of convective instability. *Mon. Wea. Rev.*, **83,** 1–10.

Bonner, W. D., 1966: Case study of thunderstorm activity in relation to the low level jet. *Mon. Wea. Rev.*, **94,** 167–178.

Doswell, C. A., III, J. T. Schaefer, D. W. McCann, T. W. Schlatter and H. B. Wobus, 1982: Thermodynamic analysis procedures at the National Severe Storms Forecast Center. *Preprints 9th Conf. Weather Forecasting and Analysis,* Seattle, Amer. Meteor. Soc., 304–309.

Fujita, T. T., 1981: Tornadoes and downbursts in the context of generalized planetary scales. *J. Atmos. Sci.*, **38,** 1511–1534.

Galway, J. G., 1956: The lifted index as a predictor of latent instability. *Bull. Amer. Meteor. Soc.*, **37,** 528–529.

Glass, R. I., R. B. Craven, D. J. Bregman, B. J. Stoll, N. Horowitz, P. Kerndt and J. Winkle, 1980: Injuries from the Wichita Falls tornado: Implications for prevention. *Science,* **207,** 734–738.

Hazen, H. A., 1890: *The Tornado.* N. D. C. Hodges Publ., New York, 86–88.

House, D. C., 1963: Forecasting tornadoes and severe thunderstorms. *Meteor. Monogr.,* No. 27, Amer. Meteor. Soc., 141–155.

Hudson, H. R., 1971: On the relationship between horizontal moisture convergence and convective cloud formation. *J. Appl. Meteor.*, **10,** 755–767.

Maddox, R. A., L. R. Hoxit and C. F. Chappell, 1980: A study of tornadic thunderstorm interactions with thermal boundaries. *Mon. Wea. Rev.*, **108,** 322–326.

McNulty, R. P., 1978: On upper tropospheric kinematics and severe weather occurrences. *Mon. Wea. Rev.*, **106,** 662–672.

Miller, R. C., 1972: Notes on analysis and severe storm forecasting procedures of the Air Force Global Weather Central. Air Weather Service Tech. Rep. 200 (Rev), Air Weather Service, Scott Air Force Base, IL 62225, 190 pp.

Root, C. J., 1917: The tornadoes of May 26 and 27, 1917. *Climatological Data, Illinois Section,* Weather Bureau, U.S. Department of Agriculture, Vol. 21, p. 40.

Schaefer, J. T., L. R. Hoxit and C. F. Chappell, 1982: Thunderstorms and their mesoscale environment. *Thunderstorms: A Social, Scientific and Technological Documentary,* Vol. 2, *Thunderstorm Morphology and Dynamics,* E. Kessler, Ed. [U.S. Government Printing Office, Washington, D.C. 20402], 123–210.

——, D. L. Kelly and R. F. Abbey, Jr., 1980: Tornado track characteristics and hazard probabilities. *Wind Engineering,* Vol. 1, J. E. Cermak, Ed., Pergamon Press, 95–109.