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Search NCDC

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U.S. Tornado Climatology

*National Climatic Data Center
Asheville, North Carolina
Updated 10 April 2008*

- [Overview](#)
- [Tornado Alley](#)
- [Timing](#)
- [Historical Records and Trends](#)
- [State Maps](#)
- [Deadliest U.S. Tornadoes](#)
- [Special Reports](#)
- [Links to Additional Information](#)

Overview

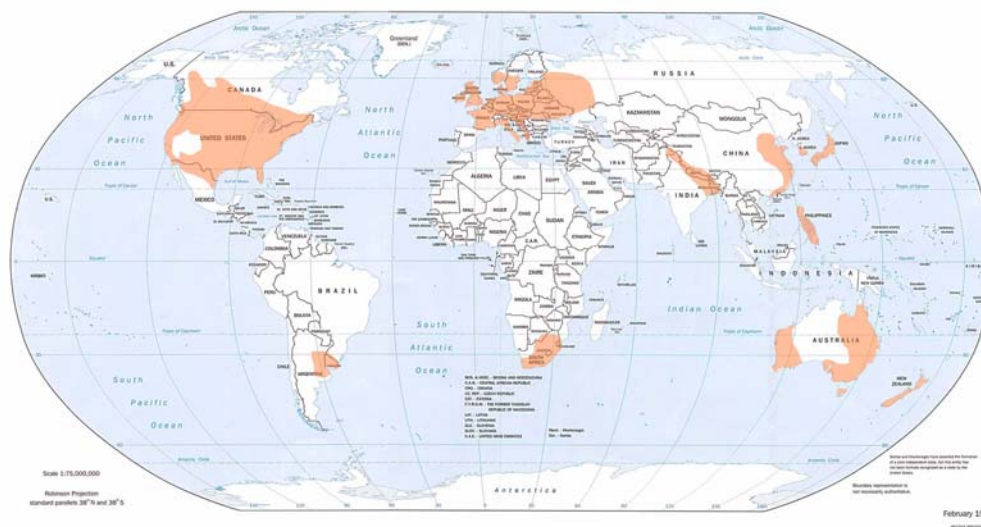
Because a tornado is part of a severe convective storm, and these storms occur all over the Earth, tornadoes are not limited to any specific geographic location. In fact, tornadoes have been documented in every one of the United States, and on every continent, with the exception of Antarctica (even there, a tornado occurrence is not impossible). In fact, wherever the atmospheric conditions are exactly right, the occurrence of a tornadic storm is possible. More on the conditions necessary for tornado formation can be found at the [NOAA National Severe Storms Laboratory Tornado Page](#).

However, some parts of the world are much more prone to tornadoes than others. Globally, the middle latitudes, between about 30° and 50° North or South, provide the most favorable environment for tornadogenesis. This is the region where cold, polar air meets against warmer, subtropical air, often generating convective precipitation along the collision boundaries. In addition, air in the mid-latitudes often flows at different speeds and directions at different levels of the troposphere, facilitating the development of rotation within a storm cell. Interestingly, the places that receive the most frequent tornadoes are also considered the most fertile agricultural zones of the world. This is due in part to the high number of convective storms delivering needed precipitation to these areas. Simply as a result of the large number of convective storms and the favorable environment, the odds

are increased that some of these storms will produce tornadoes.

In terms of absolute tornado counts, the United States leads the list, with an average of over 1,000 tornadoes recorded each year. A distant second is Canada, with around 100 per year. Other locations that experience frequent tornado occurrences include northern Europe, western Asia, Bangladesh, Japan, Australia, New Zealand, China, South Africa and Argentina. In fact, the United Kingdom has more tornadoes, relative to its land area, than any other country. Fortunately, most UK tornadoes are relatively weak. [[Encyclopaedia Britannica Article](#)]

Regions of the world with increased likelihood of experiencing tornadoes.



[Larger Map](#)



[top of the page](#)

Tornado Alley

In the United States, there are two regions with a disproportionately high frequency of tornadoes. Florida is one and "Tornado Alley" in the south-central U.S. is the other. Florida has numerous tornadoes simply due to the high frequency of almost daily thunderstorms. In addition, several tropical storms or hurricanes often impact the Florida peninsula each year. When these tropical systems move ashore, the embedded convective storms in the rain bands often produce tornadoes. However, despite the violent nature of a tropical storm or hurricane, the tornadoes they spawn (some as water spouts) tend to be weaker than those produced by non-tropical thunderstorms.

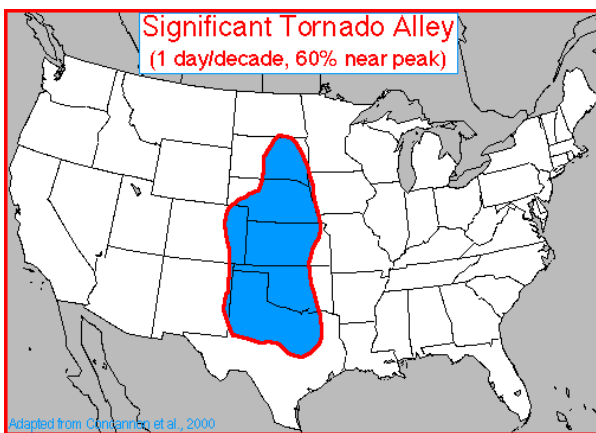
Tornado Alley is a nickname given to an area in the southern plains of the central U.S. that

consistently experiences a high frequency of tornadoes each year. Tornadoes in this region typically happen in late Spring and occasionally the early fall. The Gulf Coast area has a separate tornado maximum nicknamed "Dixie Alley" with a relatively high frequency of tornadoes occurring in the late fall (October through December).

Strong to violent tornadoes (those of EF3 or stronger on the [Enhanced Fujita Tornado Damage Intensity Scale](#)), are relatively rare, and do not typically occur outside the United States. Although the boundaries of Tornado Alley are debatable (depending on which criteria you use - frequency, intensity, or events per unit area), the region from central Texas, northward to northern Iowa, and from central Kansas and Nebraska east to western Ohio is often collectively known as Tornado Alley. Meteorologically, the region known as Tornado Alley is ideally situated for the formation of supercell thunderstorms, often the producers of violent (EF2 or greater) tornadoes.

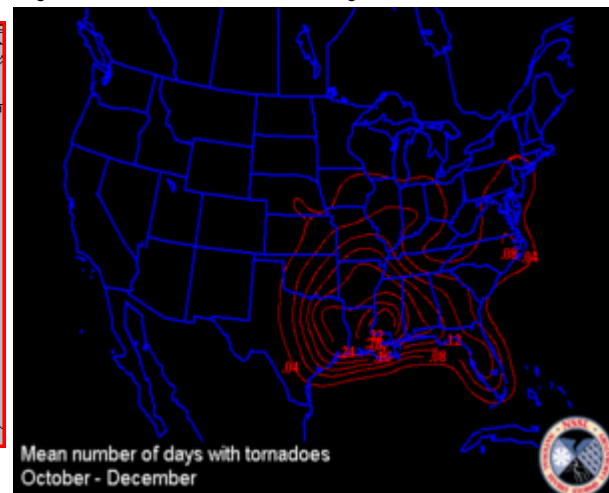
Overall, most tornadoes (around 77%) in the U.S. are considered weak (EF0 or EF1) and about 95% of all U.S. tornadoes are below EF3 intensity. The remaining small percentage of tornadoes are categorized as violent (EF3 and above). Of these violent twisters, only a few (0.1% of all tornadoes) achieve EF5 status, with estimated winds over 200 mph and nearly complete destruction. However, given that on average over 1000 tornadoes hit the U.S. each year, that means that 20 can be expected to be violent and possibly one might be incredible (EF5).

U.S. Tornado Frequency and Tornado Alley




[Click for larger image of Tornado Alley](#)

From [Concannon et al, 2000](#)



[Click for larger image of Dixie Alley](#)

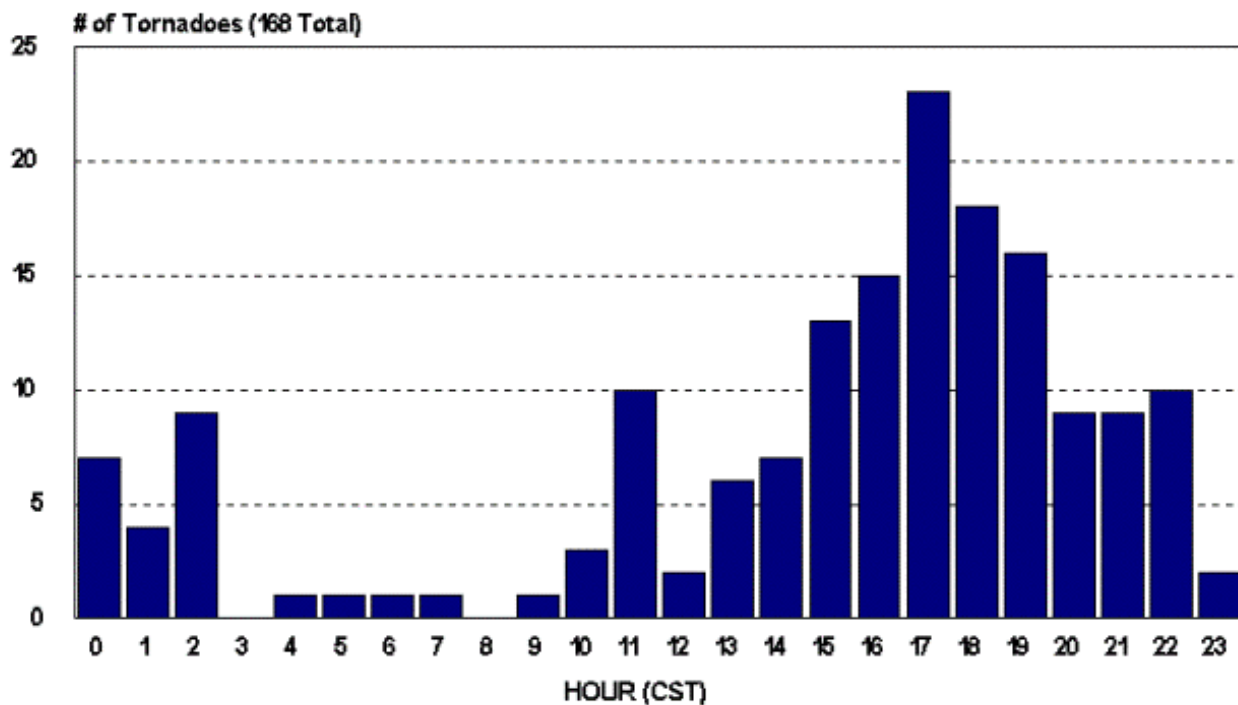
Note: Tornado Alley has no agreed upon boundaries, these are just two representations based upon different criteria.

 [top of the page](#)

Timing

Because most tornadoes are related to the strength of a thunderstorm, and thunderstorms normally gain most of their energy from solar heating and latent heat released by the condensation of water vapor, it is not surprising that most tornadoes occur in the afternoon and evening hours, with a minimum frequency around dawn (when temperatures are lowest and radiation deficits are highest). However, tornadoes have occurred at all hours of the day, and nighttime occurrences may give sleeping residents of a community little or no warning.

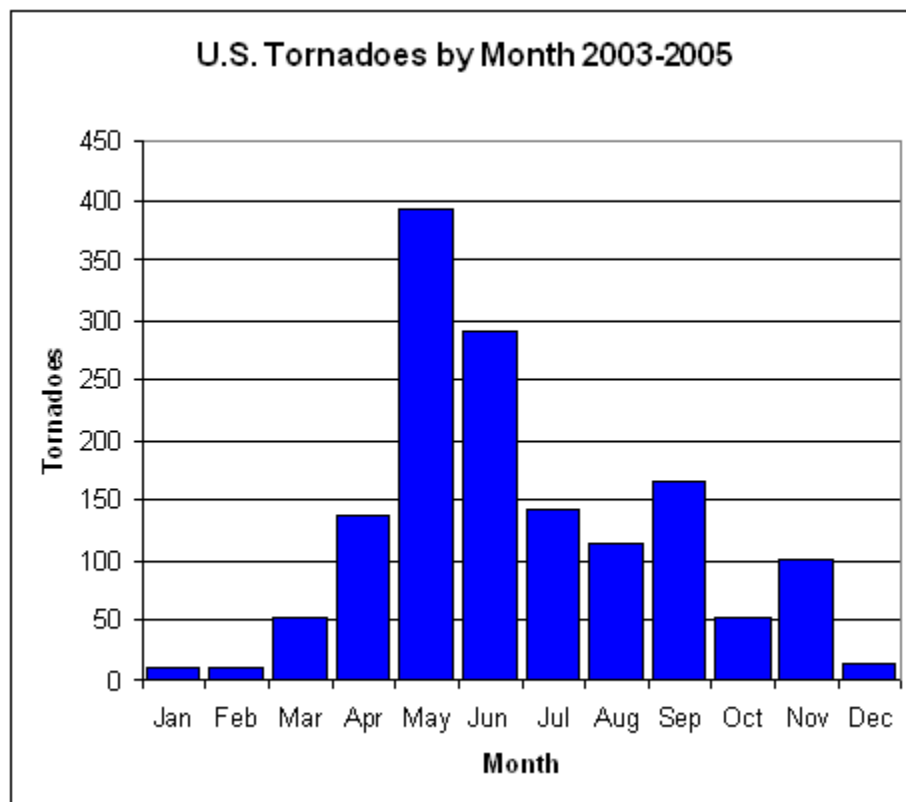
Tornado Occurrence by hour of day for the St. Louis Weather Forecast Office County Warning Area



In addition, tornadoes occur throughout the year. Because a tornado may occur at any time of the day or year somewhere in the U.S., there really is no national tornado "season" (as there is with Atlantic hurricanes). Instead, each region may experience increased tornadic potential at different times of the year. Like with the diurnal pattern, for the United States (and hemisphere) as a whole, the months in which tornadoes are most likely correspond to the times of year with increased solar heating and strong frontal systems. Regionally, the frequency of tornadoes in the United States is closely tied with the progression of the warm season when warm and cold air masses often clash. Most of the early spring tornadoes in the U.S. tend to occur in the Southeast and South Central regions. Gulf States, such as Mississippi and Louisiana are the frequent recipients of tornadoes from February to April.

Late spring tornadoes generally spread a bit farther north, often into Kansas, Nebraska and the Tennessee Valley region. By mid-summer, most of Tornado Alley is active and tornadoes may occur throughout the U.S. Late summer tends to bring some of the stronger tornadoes into the upper Midwest and Ohio valleys, and the pattern shifts back southward into the late autumn. The fewest tornadoes are documented during the winter months. Although rare, deadly winter outbreaks do occur.

Average tornado frequency by month of year 2003-2005



 [top of the page](#)

Historical Records and Trends

Oldest Known Photograph of a Tornado (1884)



[Click to visit NOAA Photo Library Page](#)

One of the main difficulties with tornado records is that a tornado, or evidence of a tornado must have been observed. Unlike rainfall or temperature, which may be measured by a fixed instrument, tornadoes are ephemeral and very unpredictable. If a tornado occurs in a place with few or no people, it is not likely to be documented. Unfortunately, much of what we know as tornado alley was very sparsely populated until the 20th century, and so it is possible that many significant tornadoes may never have made it into the historical record.

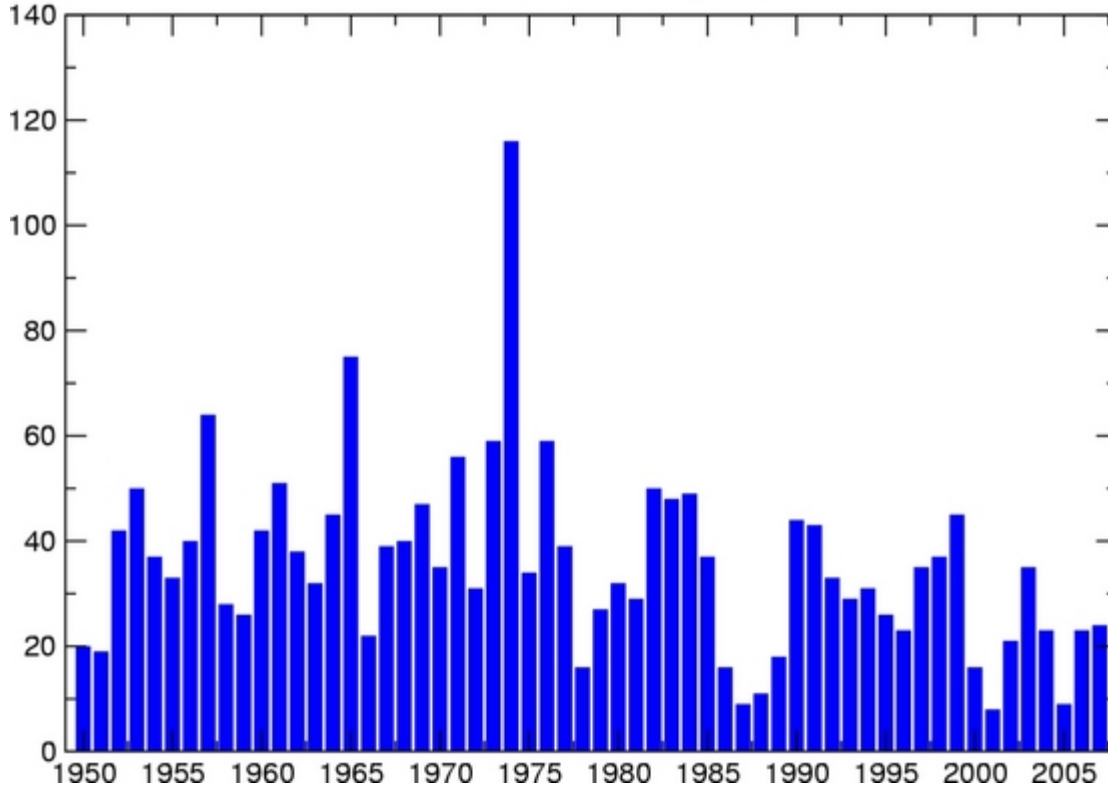
Much early work on tornado climatology in the U.S. was done by John Park Finley in his book *Tornadoes*, published in 1887. While some of Finley's safety guidelines have since been refuted as dangerous practices, the book itself remains a seminal work in tornado research. The University of Oklahoma has created a pdf copy of the entire book and made it accessible at: [John Finley's 'Tornadoes'](#)

Today, nearly all of the United States is reasonably well populated, or at least covered by NOAA's Doppler weather radars. Even if a tornado is not actually observed, modern damage assessments by NWS personnel can discern if a tornado caused the damage, and if so, how strong the tornado may have been. This disparity between tornado records of the past and current records contributes a great deal of uncertainty regarding questions about the long-term behavior or patterns of tornado occurrence. In addition, even today many smaller tornadoes still may go undocumented in places with low populations or inconsistent communication facilities.

With increased national doppler radar coverage, increasing population, and greater attention to tornado reporting, there has been an increase in the number of tornado reports over the past several decades. This can create a misleading appearance of an increasing trend in tornado frequency. To better understand the true variability and trend in tornado frequency in the US, the total number of strong to violent tornadoes (EF3 to EF5 category on the Enhanced Fujita scale) can be analyzed. These are the tornadoes that would have likely been reported even during the decades before Doppler radar use became widespread

and practices resulted in increasing tornado reports. The bar chart below indicates there has been little trend in the frequency of the strongest tornadoes over the past 55 years.

**Number of Strong to Violent (F3-F5) Tornadoes
U.S. (March-August)**



[Click to enlarge image](#)

 [top of the page](#)

State Occurrence Maps

The maps below give tornado statistics by state.

	1998	1999	2000	2001	2002	2003	2004	2005*
Overall Total	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large
Strong-Violent Total	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A
Overall Total per 10,000 Square Miles	Small Large	Small Large	Small Large	Small Large	Small Large	N/A N/A	N/A N/A	N/A N/A

Strong-Violent Total per 10,000 Square Miles	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A	N/A N/A
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* Preliminary Data

	1990	1991	1992	1993	1994	1995	1996	1997
Overall Total	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large
Strong-Violent Total	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	N/A N/A	N/A N/A
Overall Total per 10,000 Square Miles	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large
Strong-Violent Total per 10,000 Square Miles	Small Large	Small Large	Small Large	Small Large	Small Large	Small Large	N/A N/A	N/A N/A

Long Term Averages By State 1953-2004	Small-for quick view	Large-for printing
Overall Average	small	large
Overall Average per 10,000 Square Miles	small	large
Strong-Violent Average	small	large
Strong-Violent Average per 10,000 Square Miles	small	large
US Annual Very Strong (F3-F5) Tornado Count, 1950-2003	small	large

 [top of the page](#)

Deadliest Tornadoes

Most tornadoes do not result in death, and of those that do, most claim only a few lives. Also, as a result of improved forecasting and early warning systems, the death toll from tornadoes has dropped significantly over the years, despite increasing populations in

tornado-prone areas. Unfortunately, super-violent tornadoes are still documented, some with exceptional death tolls. Interestingly, a number of these devastating tornadoes have occurred outside of Tornado Alley, and several at times of day or year not normally associated with violent tornadoes. Although all of most deadly tornadoes occurred prior to the invention of the Fujita Scale, historical records of their damage have led them to be classified as either F4 or F5.

The ten deadliest documented tornado events					
Rank	Date	Estimated intensity*	State	Injuries (Deaths)	Remarks
1	March 18, 1925	F5	MO, IL, IN	2027 (695)	Tri-State Tornado Wikipedia Entry Tornado Project Page The Weather Channel
2	May 6, 1840	Unkn.	LA, MS	109 (317)	hit Nachez, MS NWS information Nachez Free Trader article Wikipedia Information Tornado Project Page
3	May 27, 1896	F4	MO, IL	1000 (255)	The Great St. Louis Tornado NOAA Library article St. Clair County, IL reports Tornado Project Page The Great Cyclone. SIU Press St. Louis American Local History Network
4	April 5, 1936	F5	MS	700 (216)	hit Tupelo, MS NWS information Tornado Project Page
5	April 6, 1936	F4	GA	1600 (203)	hit Gainesville, GA Tornado Project Page About N. Georgia
6	April 9, 1947	F5	TX, KS, OK	970 (181)	Norman, OK NWS WFO Tornado Project Page
7	April 24, 1908	F4	LA, MS	770 (143)	hit Amite, LA and Purvis, MS Tornado Project Page

8	June 12, 1899	F5	WI	200 (117)	hit New Richmond, WI Summary by Don Lloyd Tornado Project Page
9	June 8, 1953	F5	MI	844 (115)	hit Flint, MI Tornado Project Page
10	May 11, 1953	F5	TX	597 (114)	hit Waco, TX Wikipedia Entry Tornado Project Page
10	May 18, 1902	Unk.	TX	230 (114)	hit Goliad, TX Wikipedia Entry
* All events occurred prior to the implementation of the Fujita Scale, and intensities are estimated based on historical documentation.					

 [top of the page](#)

Special Reports

- [U.S. Tornado Overview - 2008](#)
- [Tornado FAQ \(from Storm Prediction Center\)](#)
- [Worldwide Weather and Climate Events \(historical reports by month\)](#)
- [1998-1999 Tornadoes and a Long-Term Tornado Climatology \(Aug 2000 Update\)](#)
 - [Midwest Tornadoes--June 2001](#)
 - [Climate Watch--April 2001 \(Tornado Info\)](#)
- [Summary of Major US Events for 2000 \(PDF format\)](#)
 - [Alabama Tornadoes--December 2000](#)
 - [Fort Worth Tornadoes--March 2000](#)
 - [Georgia Tornadoes--February 2000](#)
 - [Oklahoma, Kansas Tornadoes--May 1999](#)
- [Arkansas, Tennessee Tornadoes--January 1999](#)
 - [The Enhanced Fujita Tornado Scale](#)
- [California Flooding and Florida Tornadoes--February 1998](#)
 - [Texas Tornadoes--May 1997](#)
 - [Tornadoes and Flooding--March 1997](#)
- [Fort Smith, Arkansas Tornado--April 1996](#)
 - [Galva, IA Tornado--June 1994](#)
 - [Super Outbreak of April 1974](#)
 - [Tri-State Tornado of March 1925](#)

Links to other information

- [NOAA Storm Prediction Center Tornado FAQ](#)
- [Tornado Climatology from NOAA NSSL](#)

- [Tornadoes in Bangladesh and East India](#)
- [Historical Tornado Cases for North America](#)
- [Wikipedia: Historic Tornadoes in the United States](#)
 - [The Tornado Project](#)

 [top of the page](#)

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 [top of the page](#)

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