Tornado Trend and Our Climate

INTRODUCTION

Tornadoes occur on every continent but Antarctica, but the most activity is in North America because the conditions that trigger tornadoes are most common here. Here, western mountains and the high plains are often snow covered in winter into the spring keeping air masses cold there while as the sun returns north, temperatures warm in the south and moisture from the warm Gulf of Mexico is readily available. As storms move inland from off the cool eastern Pacific and come down from the mountains, the jet stream tightens and often buckles, draws moisture north and spins up tornadoes. Periods with strong contrasts in air masses and temperatures are associated with an increased threat of tornadoes.

In this backgrounder we will evaluate whether during periods of increased warmth are tornadoes more or less frequent. We will look at both the data provided by the Storm Prediction Center from 1950 to the present and the data since 1973 when tornadoes were first evaluated based on the Fujita tornado intensity scale in their immediate aftermath, making their rating more accurate. Tornado detection improved with the addition of Doppler radar (NEXRAD), the growth of the trained spotter networks, local and national media, storm chasers and the public armed with cell phone cameras and access to social media. In this period, population growth and expansion outside urban areas have exposed more people and buildings to the tornadoes that once roared through open fields.

KEY TAKEAWAYS

The claim that climate change is causing more and stronger tornadoes is invalidated by the relevant trend data. The 10 year running mean had dropped 66% since the peak in the cold mid 1960s. The U.S. has not seen an EF5 tornado in 11 years, the longest such streak since at least 1950.

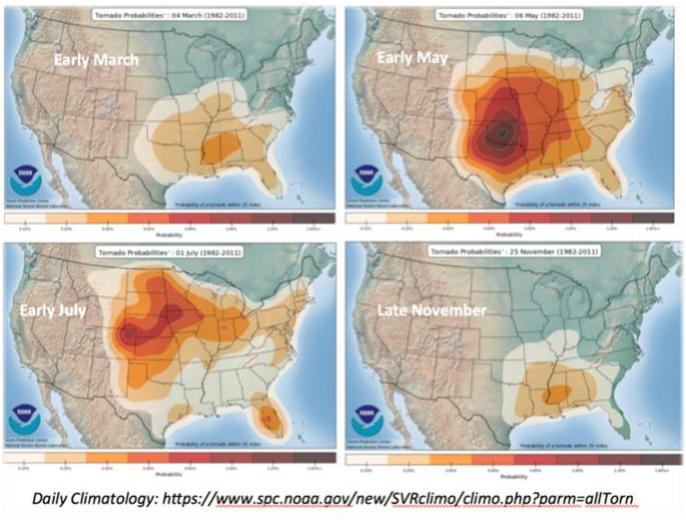
When tornados do occur, expansion of populated areas puts more property and lives at risk. Despite that fact, both inflation-adjusted and normalized tornado damage has decreased in the U.S. since 1950.

Data clearly shows tornadoes are more frequent and stronger in colder years and periods (like the 1950s to 1970s).

SEASONAL VARIANCE

The threat of tornadoes cycles across different regions of the U.S. from the Gulf coast from November to April, the Plains from May to early June, and the northern Plains and upper Midwest in June and July before most action shifts back to the southeast. Although

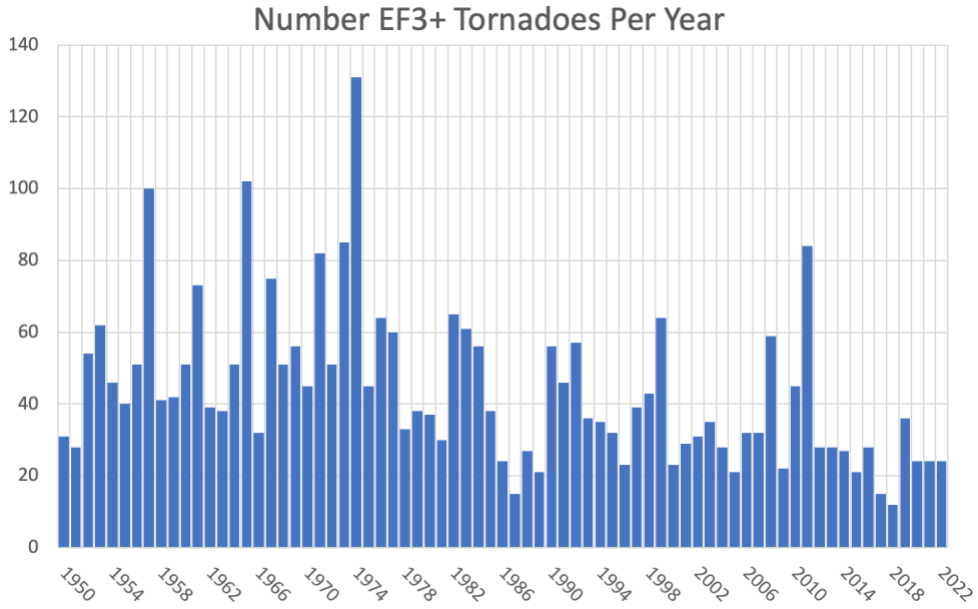
there are clearly times of the year when tornadoes are most prominent, they can occur any time given the right weather conditions.



March. May, July and November Tornado Climatology
See https://youtu.be/z-oijdylBcQ for animation.

Tornadoes are failing to follow "global warming" based predictions.

The NOAA Storm Prediction Center ([1])provided a history of tornadoes through 2021 that showed after an active period from the 1950s to the 1970s in EF3 level intensity tornadoes, the trend in these strong storms has been down. You do see spikes in some years most notably 2011.



SPC US Annual Count of EF3+ Tornadoes 1950-2022

Note the dozen year long lull followed a very active and deadly strong La Nina of 2010/11, which like the strong La Nina of 1973/74 produced record setting and very deadly outbreaks of tornadoes.

After the 2011 spike, the years 2012, 2013, 2014, 2015, 2016 all saw below average to near record low tornado counts in the U.S. since records began in 1954. 2017 rebounded only to the long-term mean while 2018 activity returned to well below the 25th percentile. 2019 bounced to the 75th percentile with a major outbreak centered on Easter Sunday. The following three years saw it drop well below average. In 2021 a long track tornado and major deadly December outbreak occurred but the annual count remained below the 25th percentile. 2022 started strong in March and early April but activity declined as dry and warmer conditions developed in the central states. It too ended well below the 25th percentile with only 24 reported deaths for the nation.

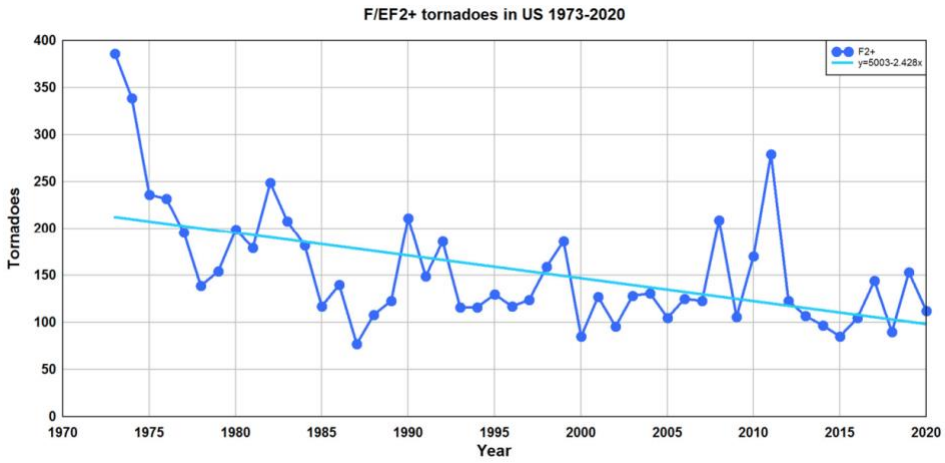
Data Reliability – Improved Detection

Coleman and Dixon (2014)[2] and others found that prior to 1973, tornadoes were likely overrated due to the use of news clippings, sensational journalism, etc. But starting in 1973, tornadoes were evaluated based on the Fujita tornado intensity scale in their immediate aftermath, making their rating more accurate. They found that indeed after NEXRAD radars went online nationwide in the early 1990s, the detection of all tornadoes, including weak ones became more likely. "*This radar system alerts the NWS to areas with possible tornadoes (including weak tornadoes), even in unpopulated areas, that the NWS would have never found before the radar system. Also, since the early 1990s, with the Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX; Rasmussen et al.)*[3] *and the movie Twister, tornado chasing has become almost ubiquitous during days with tornado risk, especially in the Great Plains. This has also reduced the likelihood of unreported tornadoes.*

Tornado Trends Since 1973

EF2+ tornadoes 1973-2020 (with linear trend)

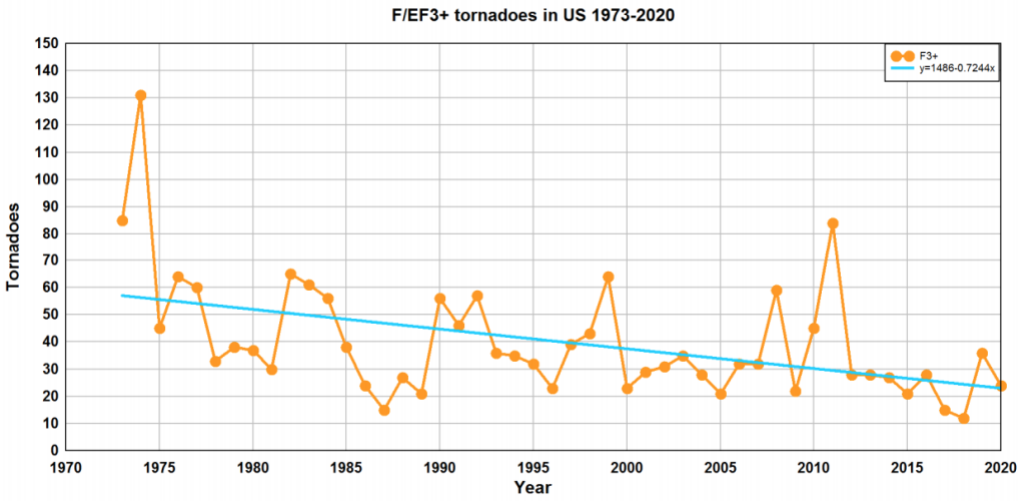
Overall trend decreases from about 205 per year in 1973 to 100 per year in 2020, a 50% decrease in significant tornadoes.



US Annual Count of EF2+ Tornadoes 1973-2020 (Coleman etal)

EF3+ tornadoes 1973-2020 (with linear trend)

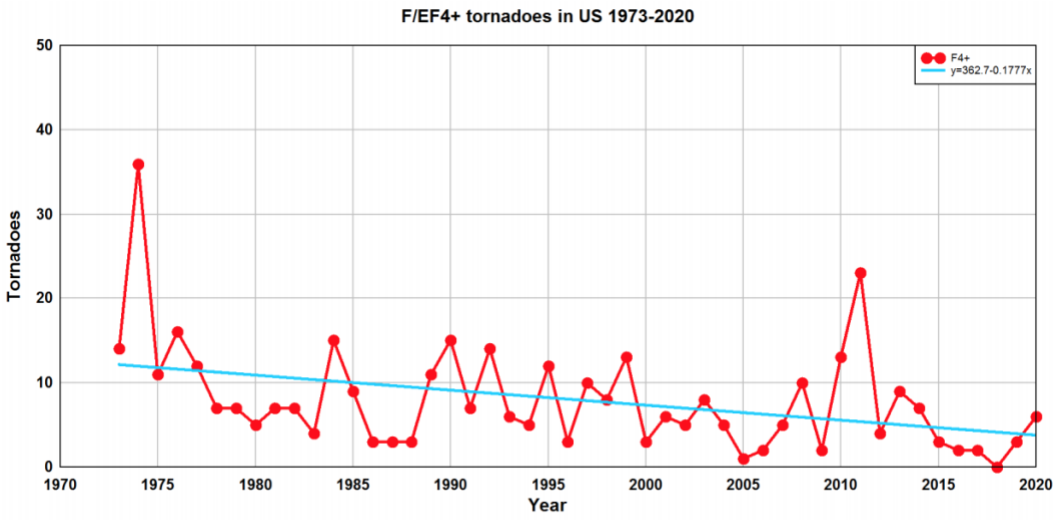
Overall trend decreases from about 59 per year in 1973 to 22 per year in 2020, a 62% decrease.



US Annual Count of EF3+ Tornadoes 1973-2020 (Coleman etal)

EF4+ tornadoes 1973-2020 (with linear trend).

Overall trend decreases from about 11 per year in 1973 to 4 per year in 2020, a 64% decrease in violent tornadoes.

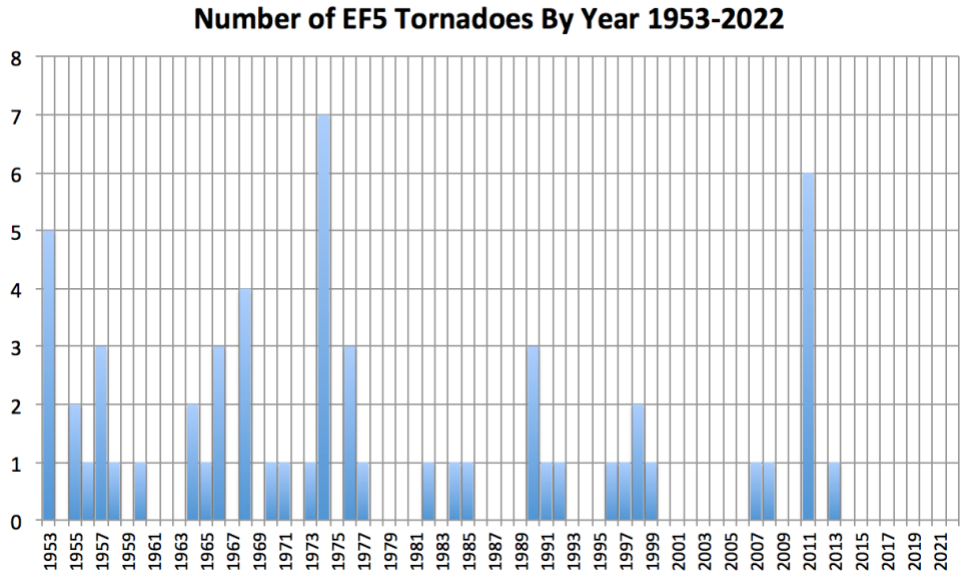


US Annual Count of EF4 + Tornadoes 1973-2020 (Coleman etal)

If we look at all tornadoes (EF0+), the linear trend in reported tornadoes has increased by more than 100% since 1951. But, almost all of this increase has been in F0 tornadoes, the type that are most likely to be found increasingly with time as explained above.

Note that the number of EF1+tornadoes has remained very steady since 1951.
Apparently, EF1+ tornadoes do enough damage that most of them are, and have always been, reported, while many EF0 tornadoes previously went unreported.
This shows up most in the weak EF0 tornado count but for storms from moderate EF1 to strong EF3+ intensity, the trend has been down despite improved detection.

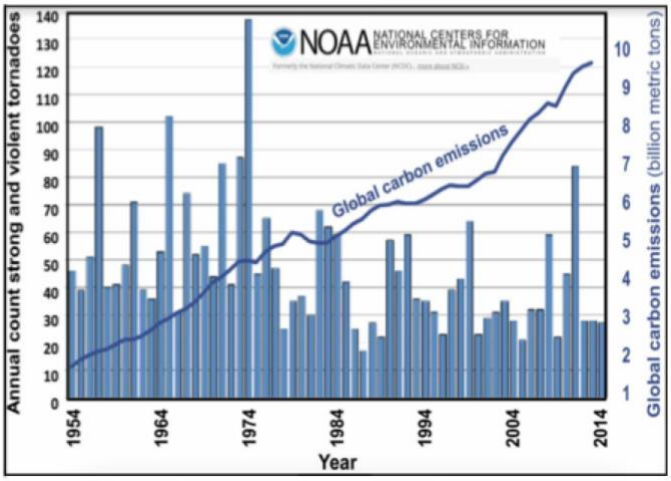
For the strongest tornadoes (EF5), there were no recorded tornadoes at that strength in 11 years, the longest stretch in the entire record.



SPC US Annual Count of EF5 Tornadoes 1953-2022 ([1])

Using NOAA data, the average number of strong to violent tornadoes (EF3+) fell from 55.9 per year in the period from 1954 to 1985 to 33.8 per year in the period 1986 to 2018. 2018 had the fewest in the entire record.

The trend runs counter to atmospheric CO2.

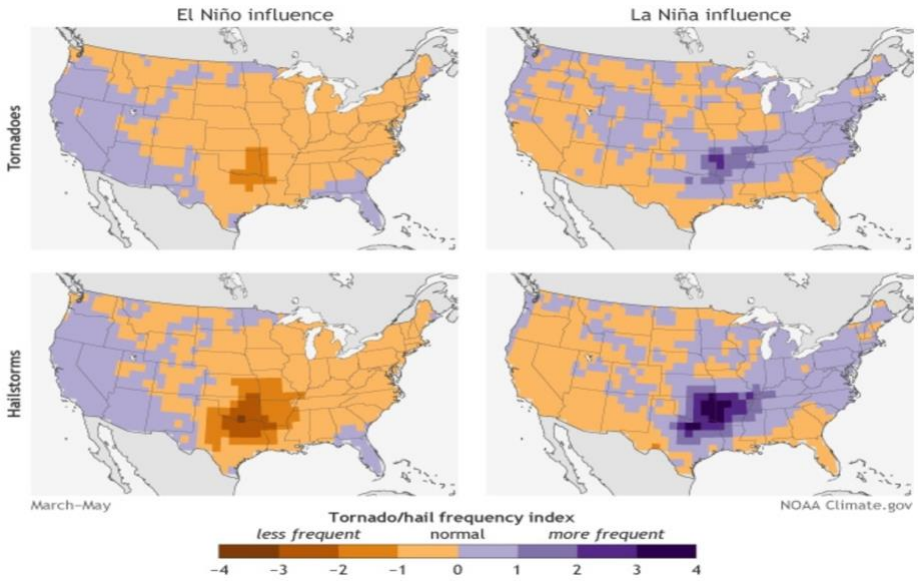


SPC EF3 vs CO_2 per year

ENSO (AND PDO) ROLE IN TORNADO SEASONS

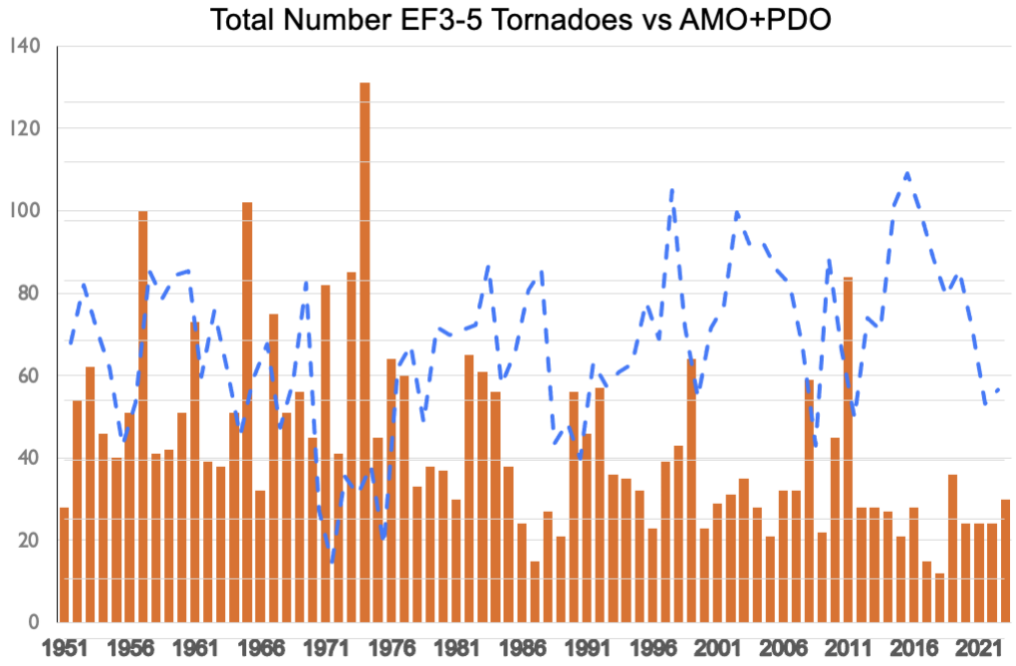
Schaefer (2000)[4] showed Tornado outbreaks of significance occur most frequently in La Nina years, which are favored when the North Pacific is cold (the Pacific Decadal Oscillation is cold) as it was in the 1950s to the mid 1970s and more recently 1999, 2008,

2010 and 2011. The downward trend results from the 1977 Tropical Pacific Central Tendency Shift from La Nina to El Nino.



SPC Tornado frequency versus El Nino and La Nina

Note below how the number of strong tornadoes corresponds to cycles in the Pacific Decadal Oscillation (NOAA CPC) in the Pacific, which determines the favored state and relative strength of ENSO (El Nino or La Nina). The negative PDO favors La Ninas, which produce a jet stream pattern that favors more significant tornado outbreaks and as a result, more active seasons. See how dips in the PDO usually correspond with an increase in strong tornadoes.



The annual count and death toll in the strong La Nina of 2011 was the highest since the “Superoutbreak” in the strong La Nina year of 1974. Population growth and expansion outside urban areas have exposed more people to the tornadoes that once roared through open fields.

The activity also relates to the Atlantic water temperatures. The cold Atlantic years when combined with a cold Pacific coincides with colder land temperatures on average and the spring warmth as the days lengthen that emerges from the Gulf of Mexico provides stronger contrasts resulting in stronger storms and accompanying severe weather.

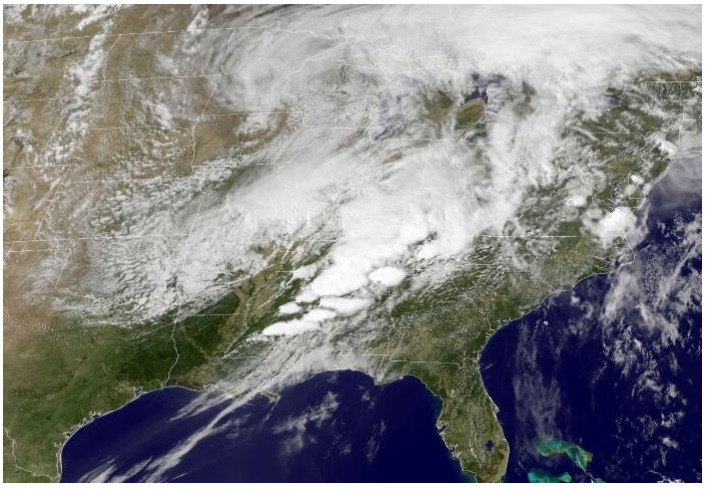
The Superoutbreak of 2011

The 2011 Superoutbreak was the largest, costliest, and one of the deadliest tornado outbreaks ever recorded, affecting the Southern, Midwestern, and Northeastern United States and leaving catastrophic destruction in its wake. In total, 362 tornadoes were confirmed in 21 states in this one event.

Widespread and destructive tornadoes occurred on each day of the outbreak, with April 27 being the most active day with a record of 218 tornadoes touching down that day. Four of the tornadoes were destructive enough to be rated EF5, which is the highest-ranking possible on the Enhanced Fujita scale; typically these tornadoes are recorded about once each year. 348 people were killed as a result of the outbreak. In Alabama alone, 238 tornado-related deaths were confirmed. April 27, 2011's 317 fatalities were the most tornado-related fatalities in the United States in a single day since the "Tri-State" outbreak on March 18, 1925 (when at least 747 people were killed).

This event was the costliest tornado outbreak and one of the costliest natural disasters in United States history (even after adjustments for inflation), with total damages of approximately $11 billion (2011 USD).

Shown below is a satellite image during 2011 outbreak (source NOAA):



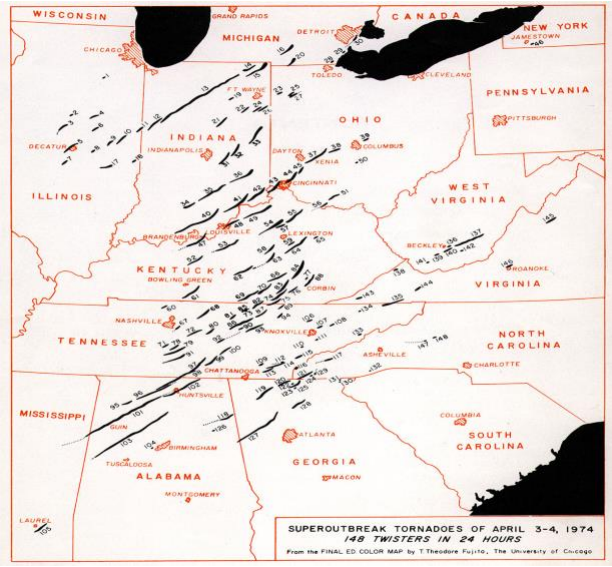
2011 Tornado Outbreak

The deadly 2011 Joplin, Missouri tornado followed in May. It was a catastrophic EF5-rated tornado that struck late in the afternoon of Sunday, May 22, 2011. It was the third tornado to strike Joplin since May 1971. Overall, the tornado killed 158 people (with an additional three indirect deaths), injured some 1,150 others, and caused damages amounting to a total of $2.8 billion. It was the deadliest tornado to strike the United States since the 1947 Glazier–Higgins–Woodward tornadoes, and the seventh-deadliest overall. It also ranks as the costliest single tornado in U.S. history.

The Superoutbreak of 1974

The 1974 Super Outbreak was the second-largest tornado outbreak on record for a single 24-hour period, just behind the 2011 Superoutbreak. It was also the most violent tornado outbreak ever recorded, with 30 F4/F5 tornadoes confirmed. From April 3 to April 4, 1974, there were 148 tornadoes confirmed in 13 U.S. states and the Canadian province of Ontario. The entire outbreak caused more than $600 million (1974 USD) in damage in the United States alone, and extensively damaged approximately 900 square miles along a total combined path length of 2,600 mi (4,184 km).

The 1974 Super Outbreak remains one of the most remarkable severe weather episodes of record in the continental United States. The outbreak far surpassed previous and succeeding events in terms of severity, longevity, extent, and death toll, with the notable exception of the 2011 Super Outbreak.



Superoutbreak Tornadoes - Source: Ted Fujita[5], University of Chicago

Outbreaks with fifteen or more F4/EF4 and F5/EF5 tornadoes						
Outbreak	**Year**	**Country**	**F4/EF4**	**F5/EF5**	**Total**	**Deaths**
1974 Super Outbreak	1974	US, CAN	23	7	30	315
1965 Palm Sunday tornado outbreak	1965	US	18	0	18	271
May–June 1917 tornado outbreak	1917	US	14	1	15	383
2011 Super Outbreak	2011	US, CAN	11	4	15	324

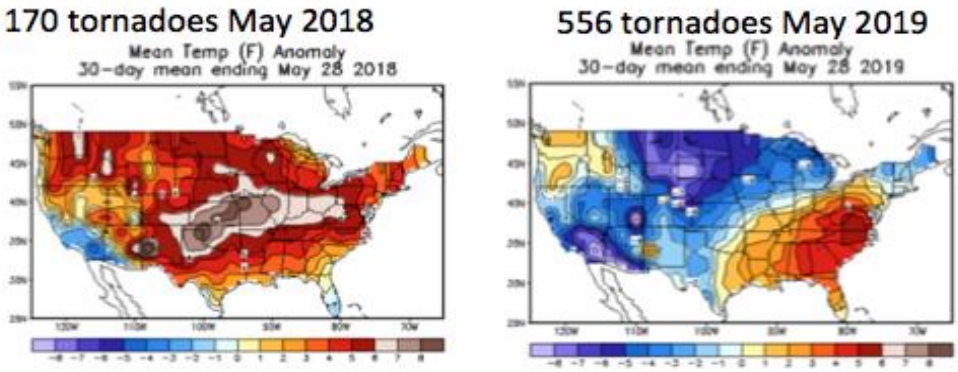
Superoutbreaks with 15 or more EF4 and EF5

RECENT SEASONS

With the exception of the La Nina years of 2008 and 2011, the years from 1999 to 2022 were well below the long term mean with most in the lowest 25th percentile.

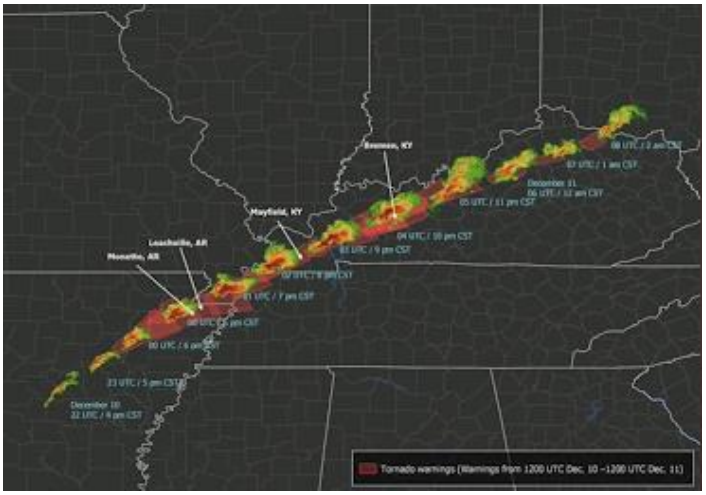
A near record-low 928 tornadoes occurred in the U.S. in 2018. Tornadoes bounced back in 2019. 2019 was a cold winter and spring in much of the nation (except the southeast). By Mid-May, the deep and very cold western trough helped pump up a warm southeast ridge and produced a zone of strong thermal contrast in the central states in a region called 'tornado alley'. This generated many strong storm systems with heavy precipitation. 13 straight days of tornado outbreaks brought the monthly tornado totals to 556 in May.

Claims in the media that these storms were the result of global warming are not supported by the facts. The quiet May of 2018 with 170 May tornadoes was warm compared to the May 2019, which had strong temperature contrast in a configuration favoring strong storms and tornadoes. May 2019 had 556 tornadoes.



2018 May versus 2019 May

2020 after a cold April led to tornado outbreaks, action ended with warming temperatures and the season ended up in the lowest 25th percentile. In 2021, a persistent absence of an active storm track into the nation that resulted in a western drought, there were fewer tornado outbreaks again this year. December was more active with the worst event, a long track tornado.

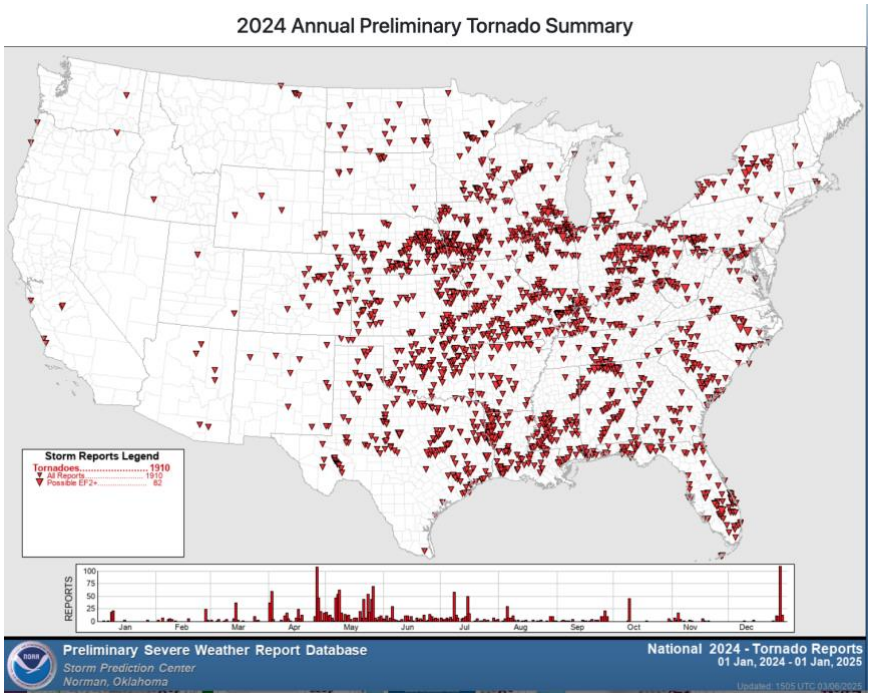


2021 long track tornado combined radar images

Despite the December storms, the year ended again below the 25th percentile. Despite the less than normal tornadoes, 2021 had 103 tornado related fatalities with the long track December event. This is the highest number of tornado fatalities in a year since 2011 and the 4th most since 1991.

The 2022 after an active early season, the number of tornadoes dropped to below the 25th percentile in mid-summer and continued below 25th percentile despite the spikes at the start and end of November and in mid December.

2024 featured a severe weather spike with 1019 tornadoes. The midwest was especially hard hit.



NORMALIZED DAMAGE HAS DECLINED

In terms of damage, Roger Pielke Jr. has shown the normalized U.S. tornado damage continues to decline and has been at exceptionally low levels since the active 2011 season The period from 2015 to 2020 years had the 2nd lowest normalized tornado damage of any 5-yr period since 1950. Roger updated the damage chart after 2021(6) after it showed a slight bounce due to La Ninas but the trend long term remains down.

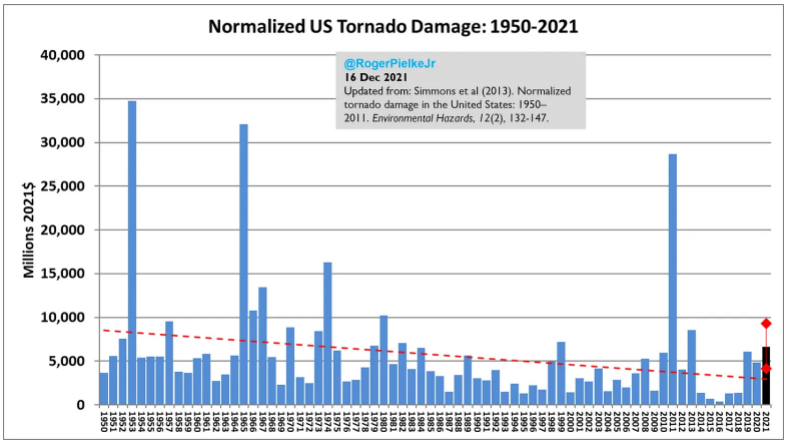


Figure 32: Normalized US Tornado Damage 1950-2021

The number of deaths per year compiled by Brooks and Doswell[7] and Grazulis and updated by SPC shows the decline on deaths as warnings, awareness and preparedness have saved lives even as populations and property at risk increased.

Summary:

The claim that climate change is causing more and stronger tornadoes is invalidated by the relevant trend data, which shows a decline in all but the weakest tornadoes. After 1973 when tornadoes were evaluated based on the new Fujita tornado intensity scale, the data has been most assuredly more accurate. Population growth and expansion outside urban areas have exposed more people to the tornadoes that once roared through open fields. Tornado detection improved with the addition of Doppler radar (NEXRAD), the growth of the trained spotter networks, storm chasers and the public with cell phone cameras and access to social media.

Even with this improved detection, the trend since 1973 for all but the weakest tornadoes is down. Coleman examined strong tornadoes (EF2+ intensity levels) and found there was a 50% decline in the annual numbers from 1973 to 2020. The count for EF3+ storms showed a 62% decline, EF4+, a 64% decline. The U.S. has not seen an EF5 tornado in almost 10 years, the longest such streak since at least 1950.

The expansion of populated areas puts more property and lives at risk. However, both inflation-adjusted and normalized tornado damage has decreased in the U.S. since 1950, providing good support and consistency for claims that overall incidence of strong tornadoes has decreased."