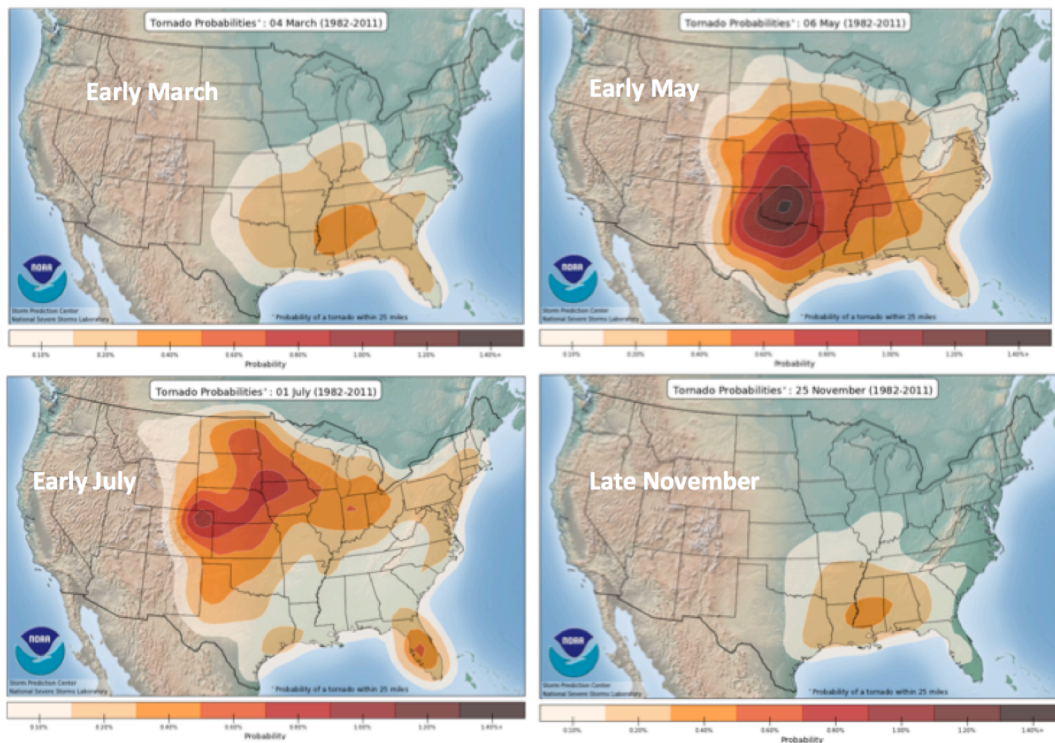


**Claim: Global warming is causing more and stronger tornadoes**

Tornadoes occur in many parts of the world, including Australia, Europe, Africa, South America, and Asia; however, about 75 percent of the world’s known tornadoes have formed in the United States. About 1,200 tornadoes hit the U.S. every year.

Although tornado season refers to the time of year when the United States sees the most tornadoes, peak tornado season varies across different regions of the U.S.- the Gulf coast from March to April, the Plains from May to early June, and the northern Plains and upper Midwest see the most tornadoes in June and July. A second season appears in the Gulf in November and December. Even though there are times of the year when tornadoes are most prominent, they can occur at any time given the right weather conditions.



Daily Climatology: <https://www.spc.noaa.gov/new/SVRclimo/climo.php?parm=allTorn>

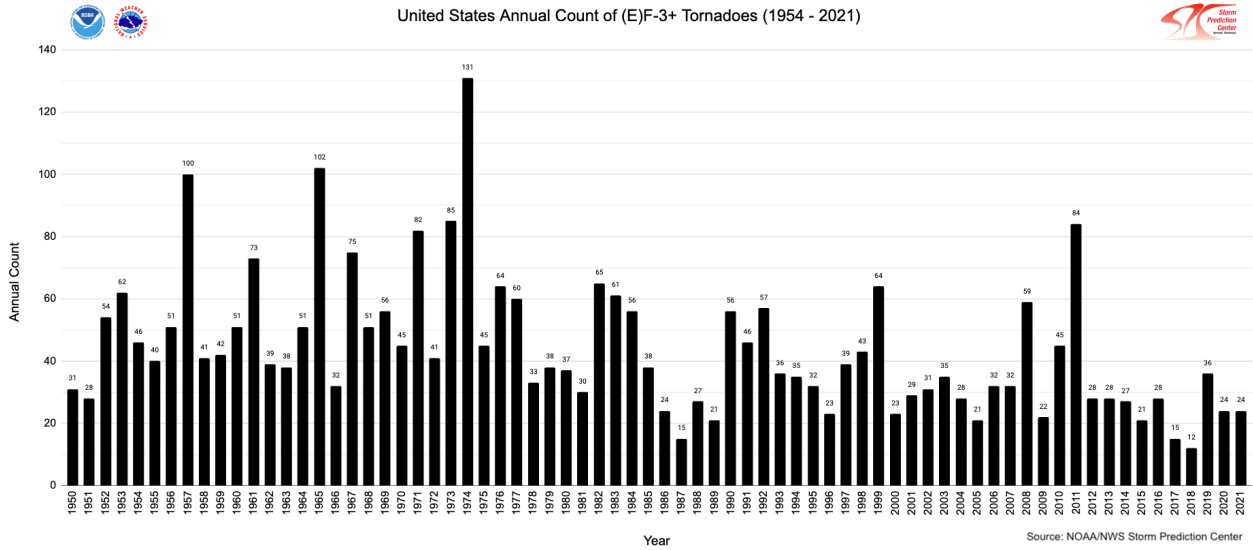
Tornadoes are more common in the United States because the conditions that spin up tornadoes are more common here because of the geography.

The western mountains and the high plains are often snowcovered 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 troughs move inland from off the cool eastern Pacific and come down from the mountains, these ingredients help spin up tornadoes.

During periods of warming are tornadoes more or less frequent?

*Tornadoes are failing to follow “global warming” based predictions. Strong tornadoes have seen a drop in frequency since the 1970s. 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 25<sup>th</sup> percentile. 2019 bounced to the 75<sup>th</sup> 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 occurred outbreak but the annual count remained below the 25<sup>th</sup> 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 25<sup>th</sup> percentile with only 18 reported deaths for the nation through early October.*

*The NOAA Storm Prediction Center provided a history of tornadoes through 2021 that showed the decline since the active period from the 1950s to 1970 in EF3 level intensity tornadoes.*

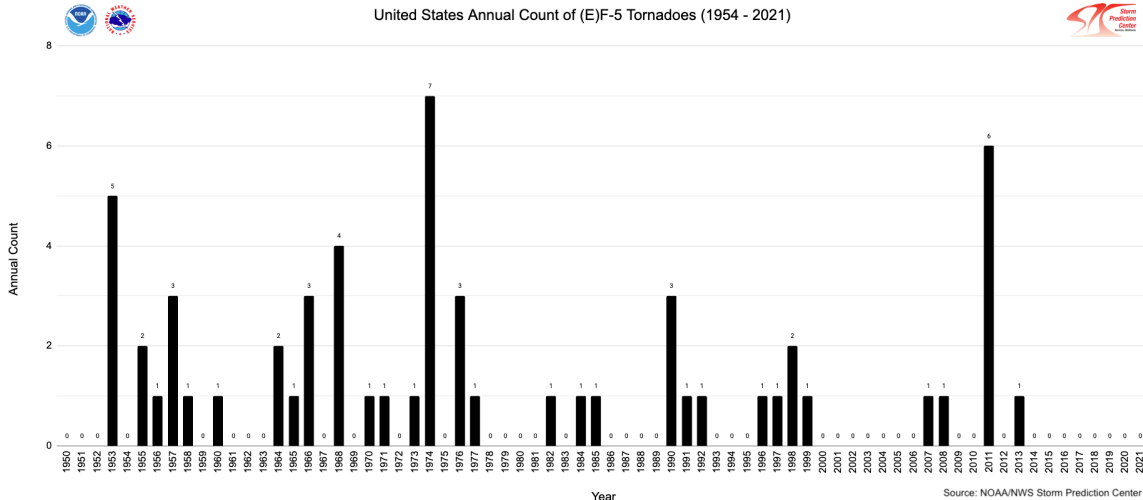


*This dozen year long lull followed a very active and deadly strong La Nina of 2010/11, which like the strong La Nina of 1973/74 produced record setting and very deadly outbreaks of tornadoes.*

*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 armed with cellular data and imagery as well as the proliferation of cell phone cameras and social media.*

*This shows up most in the weak EF0 tornado count but for storms from moderate EF1 to strong EF 3+ 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.*

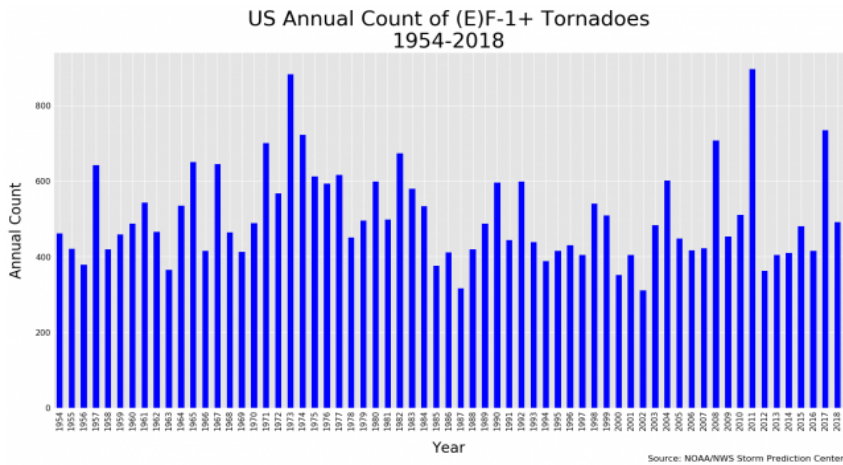


*Tornadoes like most all weather extremes are driven by natural factors with active seasons strongly correlated with stronger La Nina events and the cold phase of the Pacific Decadal Oscillation, which favors more frequent and stronger La Ninas.*

*Tornadoes have been reported on every continent but Antarctica but the most activity is in North America when cold snow covered mountains to the west and late snow cover north produces a strong contrast when spring warmth and moisture expands north from the Gulf of Mexico. The United States 20-year annual average is 1,235 and Canada near 100. Bangladesh has had 5 of the top 10 deadliest tornadoes.*

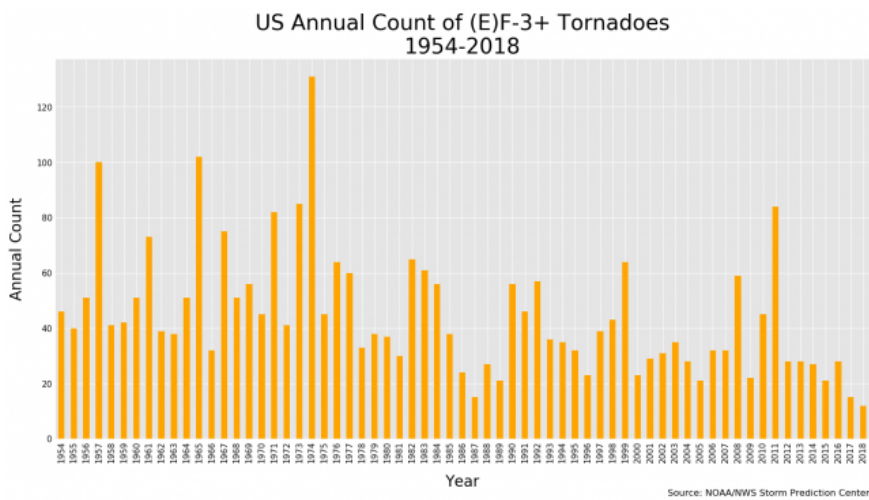
-----  
**More Details**

The US Annual count of EF1+ tornadoes shown below, more active years are clear but there is no discernible upward slope trend.



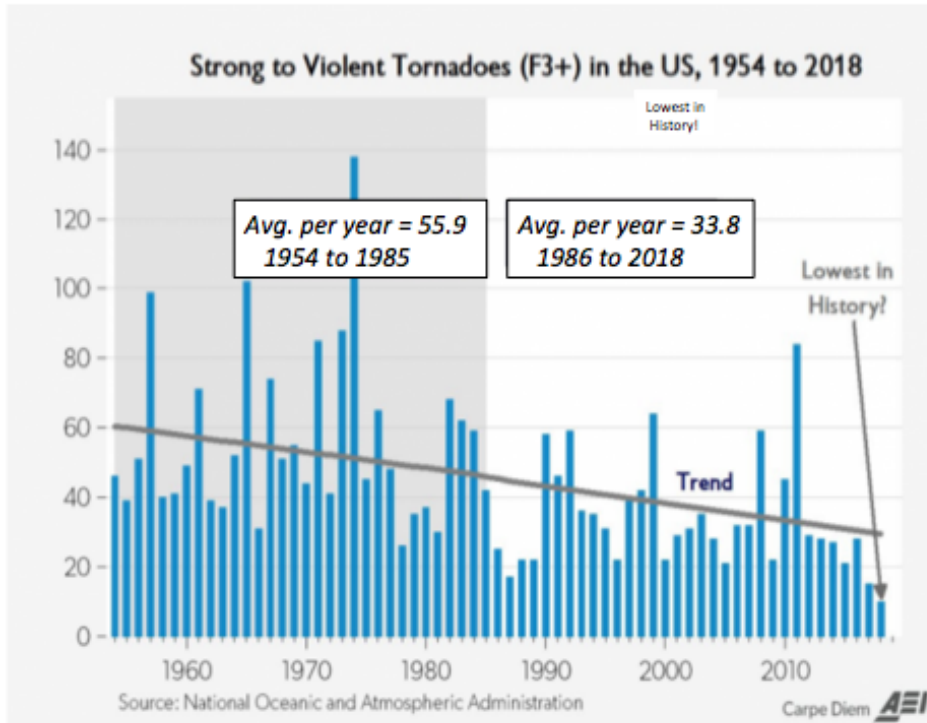
Source: Storm Prediction Center

For strong EF3+ tornadoes, there are again active years and periods. But the trend, despite better detection, has been clearly down, not up.



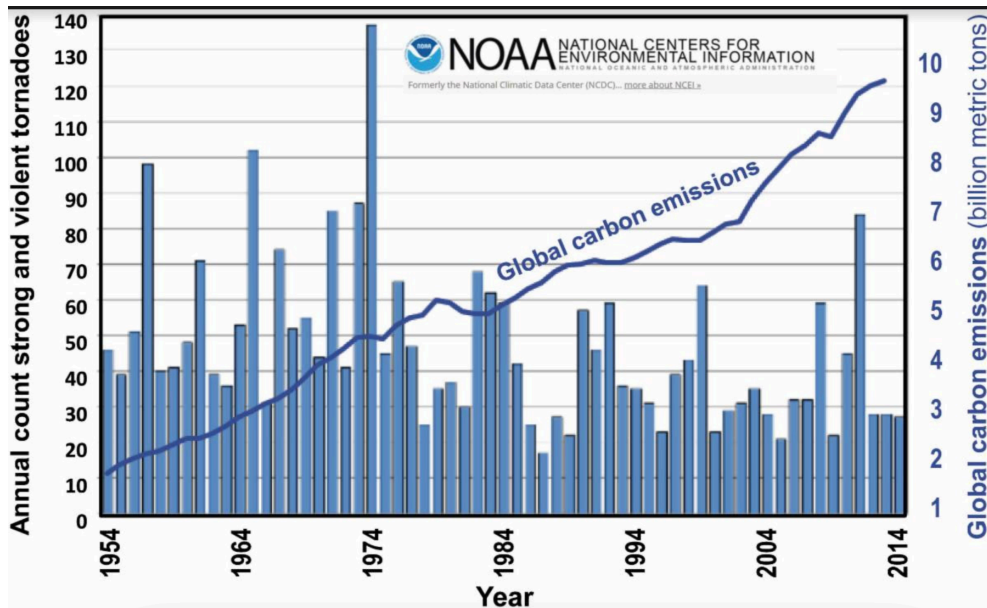
Source: Storm Prediction Center

The average number of strong to violent tornadoes 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.



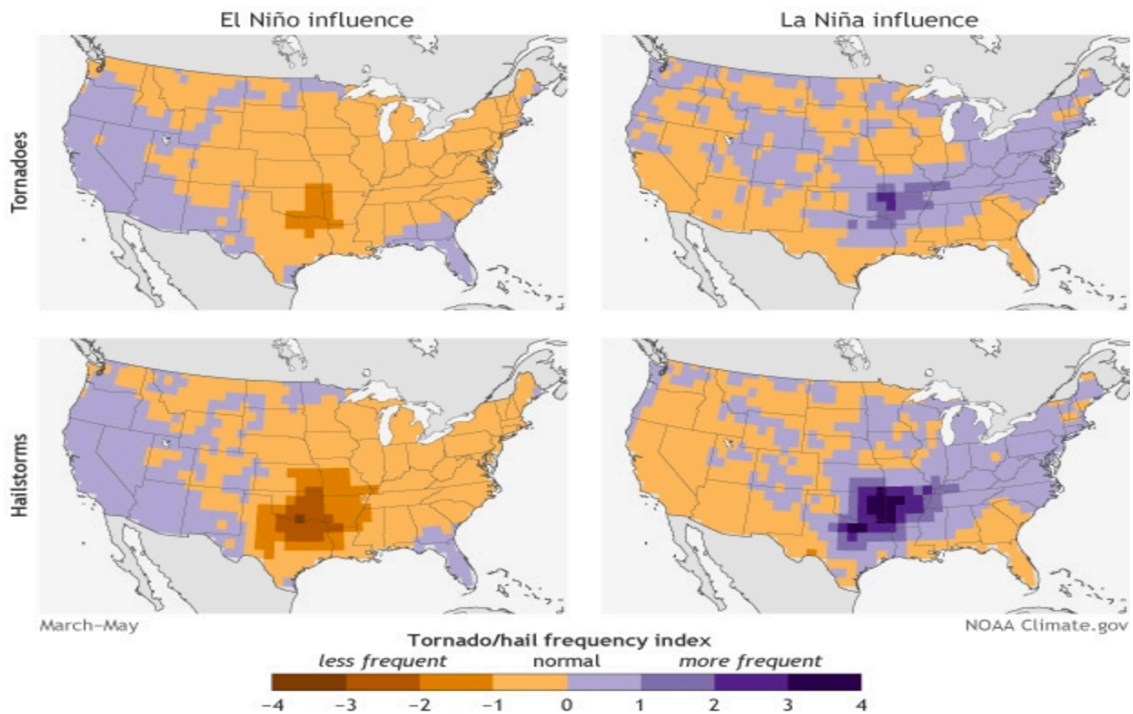
Source: Storm Prediction Center NOAA

The trend runs counter to atmospheric CO2.



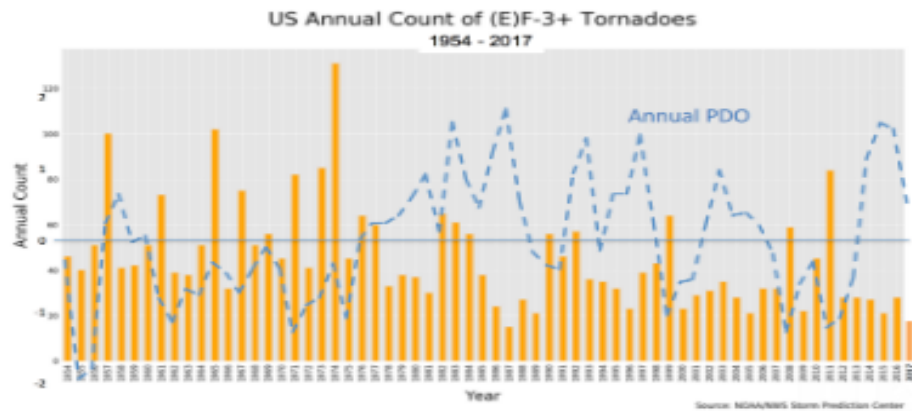
## ENSO (AND PDO) ROLE IN TORNADO SEASONS

Tornado outbreaks of significance occur most frequently in La Nina years, which are favored when the 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.



Source: Storm Prediction Center

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.



Source: Storm Prediction Center

The 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 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.

The event affected Alabama and Mississippi the most severely, but it also produced destructive tornadoes in Arkansas, Georgia, Tennessee and Virginia and affected many other areas throughout the Southern and Eastern United States. In total, 362 tornadoes were confirmed in 21 states from Texas to New York to southern Canada.

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.

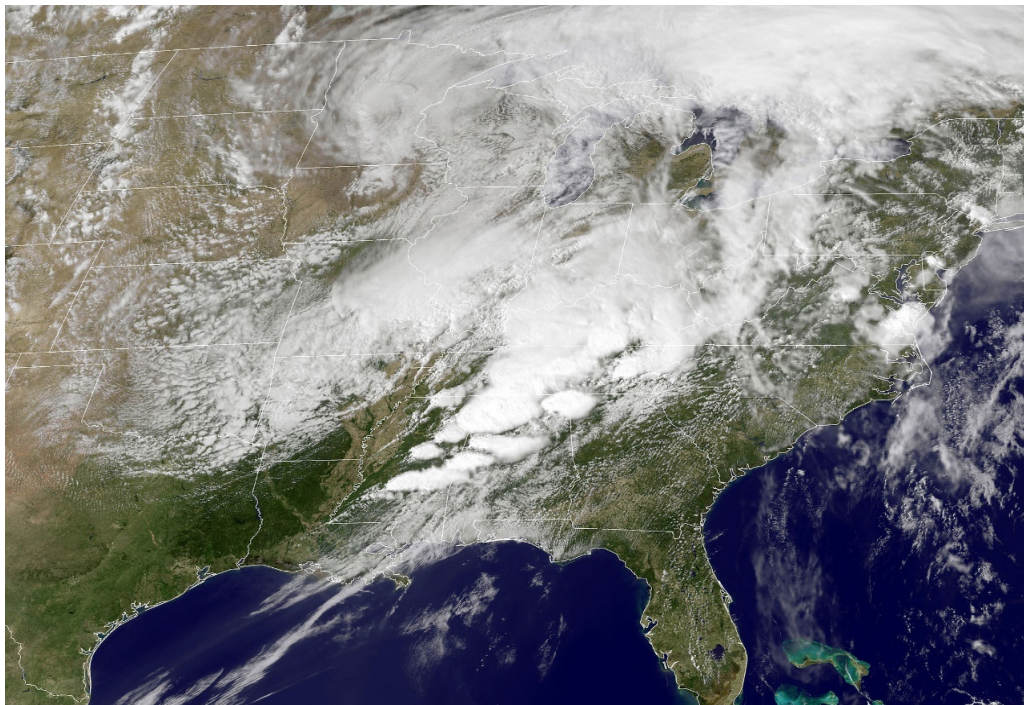
348 people were killed as a result of the outbreak, which includes 324 tornado-related deaths across six states and an additional 24 fatalities



caused by other thunderstorm-related events such as straight-line winds, hail, flash flooding or lightning. 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):



The 2011 Joplin tornado was a catastrophic EF5-rated tornado that struck Joplin, Missouri, 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.

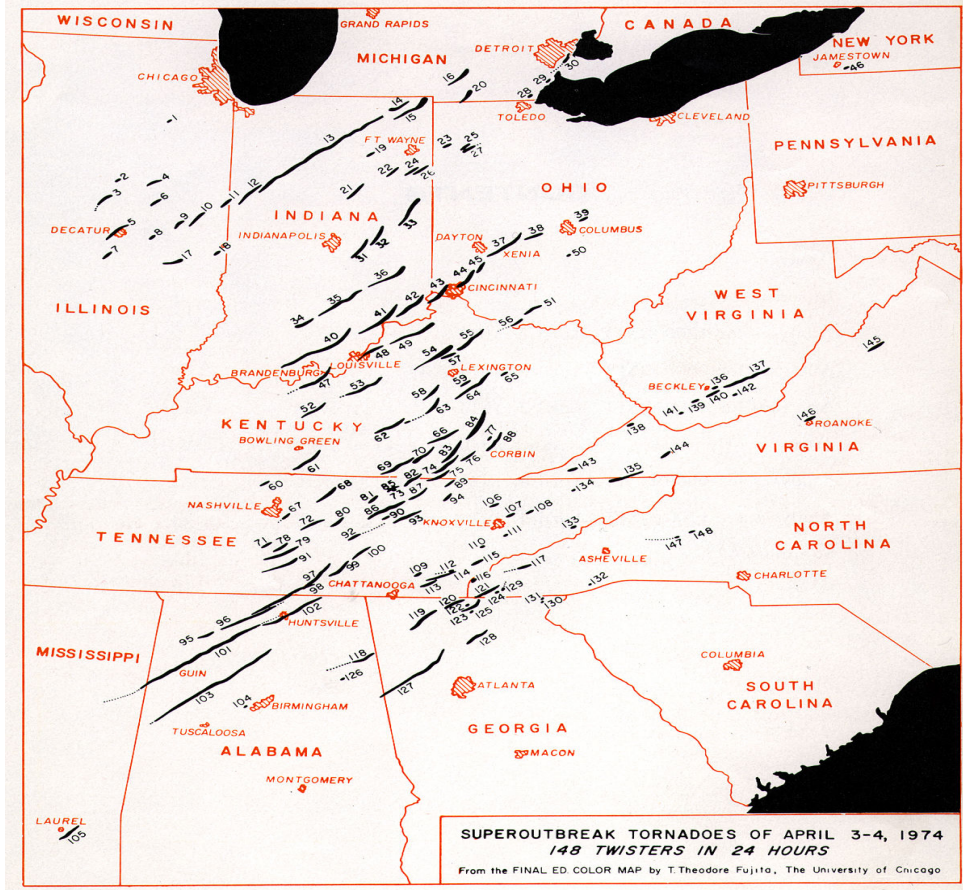
It was the first F5/EF5 tornado in Missouri since [May 20, 1957](#), when an F5 destroyed several suburbs of [Kansas City](#). It was only the second F5/EF5

tornado in Missouri history dating back to 1950. It was the deadliest U.S. tornado since the [April 9, 1947](#) tornado in [Woodward, Oklahoma](#), the seventh-deadliest in U.S. history. It was also the first single tornado since the [June 8, 1953](#) F5 tornado in [Flint, Michigan](#), to have 100 or more associated fatalities.

### **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, which lasted from April 25 to 28 and killed a total of 324 people.



Source: Ted

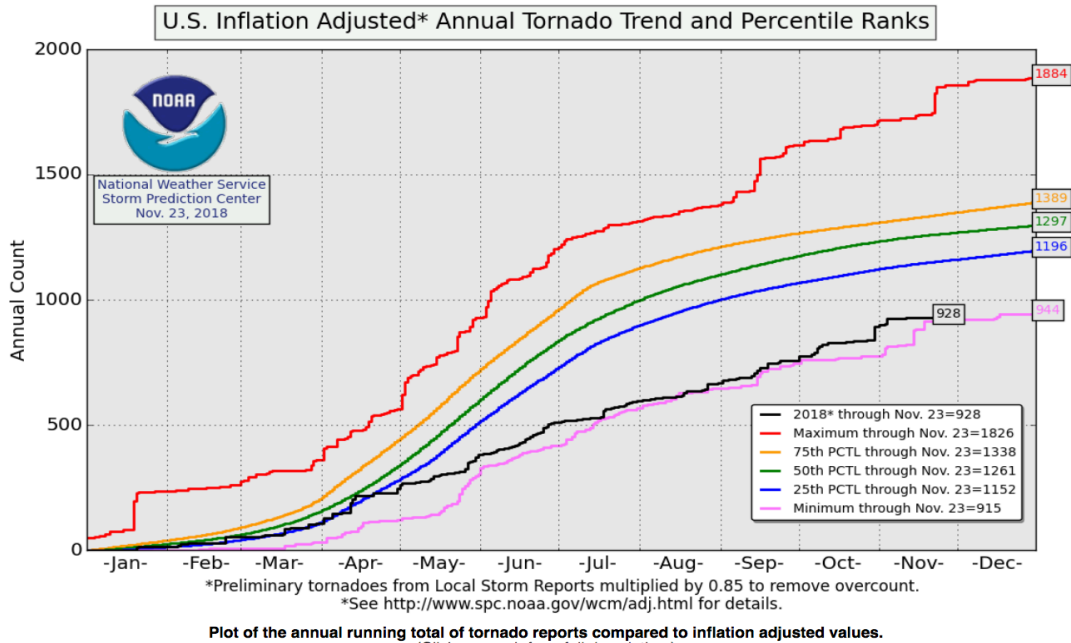
Fujita, University of Chicago

The bottom line is that tornado frequency and major outbreaks relate to natural cycles both short and long term in the oceans that produce jet stream patterns that favor or suppress tornado outbreaks of significance in the U.S. Hence, the claim that global warming is causing more and stronger tornadoes is invalidated by the relevant empirical data. However, when tornadoes do occur, expansion of populated areas puts more property and lives at risk. Fortunately, improved tornado detection and warnings, coupled with the addition of storm shelters and improved building codes do help mitigate the death tolls and property damage associated with tornadoes.

### **RECENT SEASONS**

### **THE TRANQUIL 2018 SEASON**

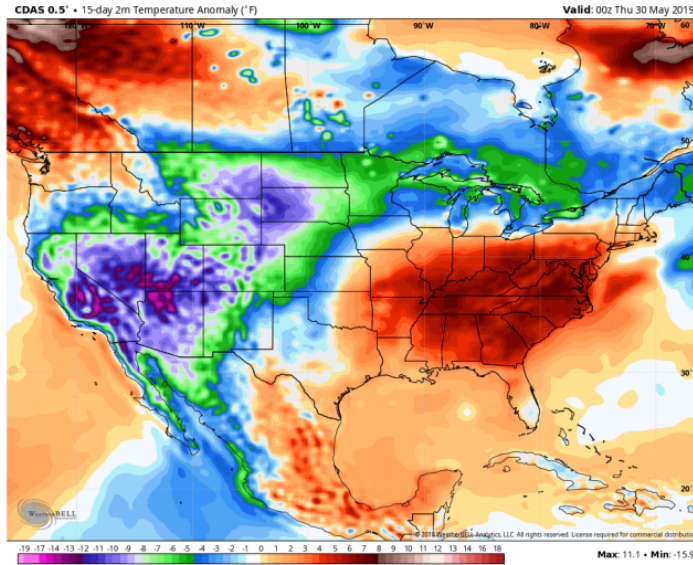
A near record-low 928 tornadoes (inflation adjusted) formed in the U.S. in 2018, according to the National Oceanic and Atmospheric Administration’s Storm Prediction Center (SPC).



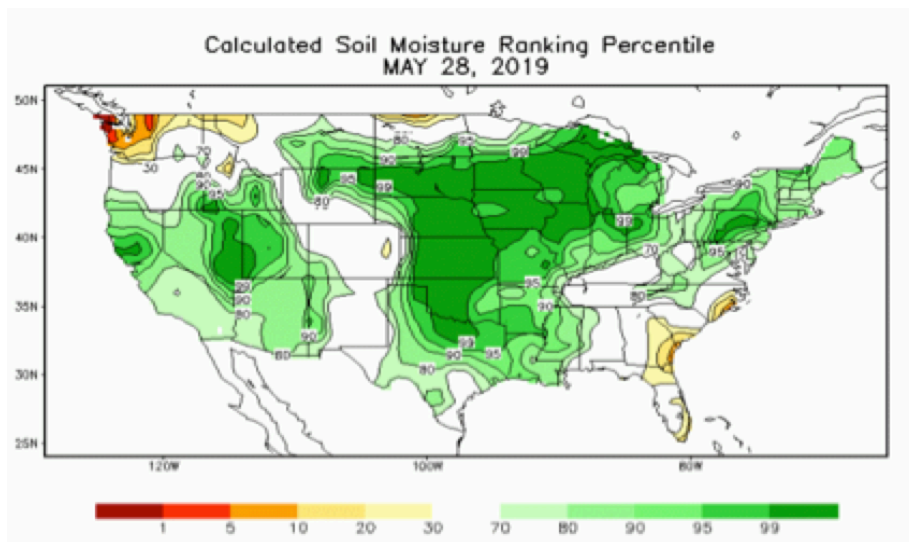
## THE ACTIVE SPRING OF 2019

Just like the hurricane impact spike in 2017 and 2018 after a record almost 12-year period without a landfalling major hurricane, tornadoes bounced back big-time after 7 quiet years ending in 2018. 2019 was a cold winter and spring in much of the nation (except the southeast). In the cold air, heavy snowpack persisted in the west through May and into June in places.

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.



With frequent heavy rains and melting snows, soil moisture reached historic levels - above the 99% percentile in parts of the central U.S.

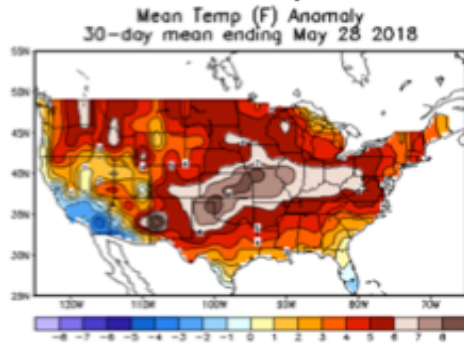


In the presence of abundant moisture, when heat energy built in the southeast ridge, the thunderstorms became increasingly severe, a phenomenon meteorologists call the 'ring-of-fire'. 13 straight days of tornado outbreaks brought the monthly tornado totals to 556 in May.

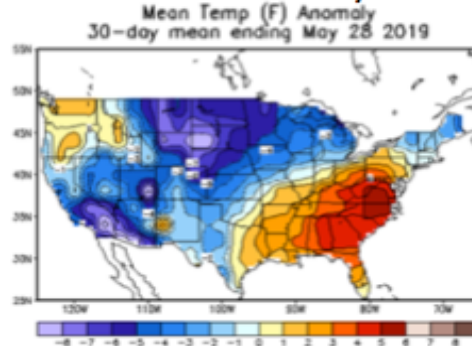
Claims in the media that these storms were the result of climate change/global warming are not supported by the facts. As noted above, 2018 was among the quietest tornado seasons – (with just 170 tornados in

May) compared to 556 in May 2019. The quiet 2018 had a very warm May compared to the extremely active May in 2019, which had strong contrast.

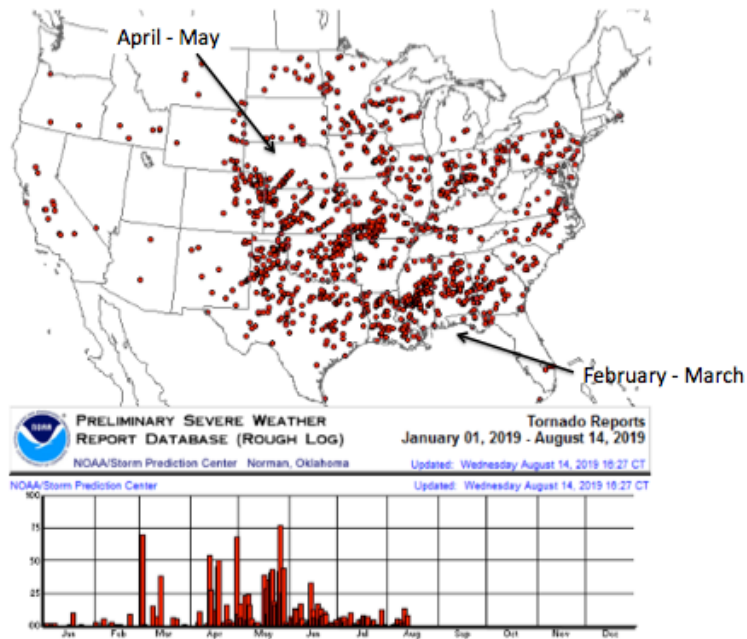
**170 tornadoes May 2018**



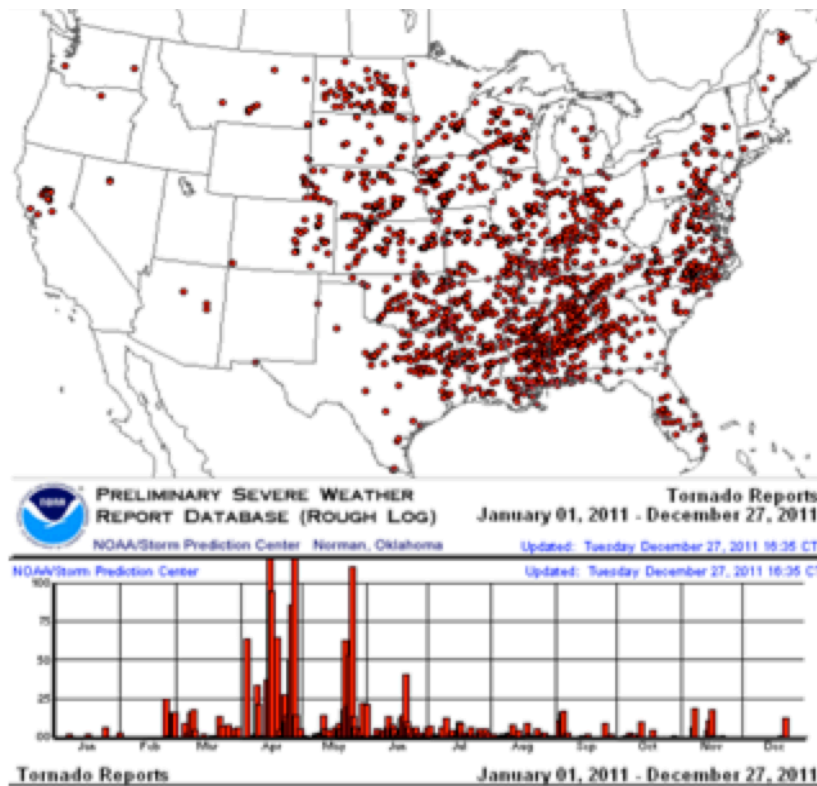
**556 tornadoes May 2019**



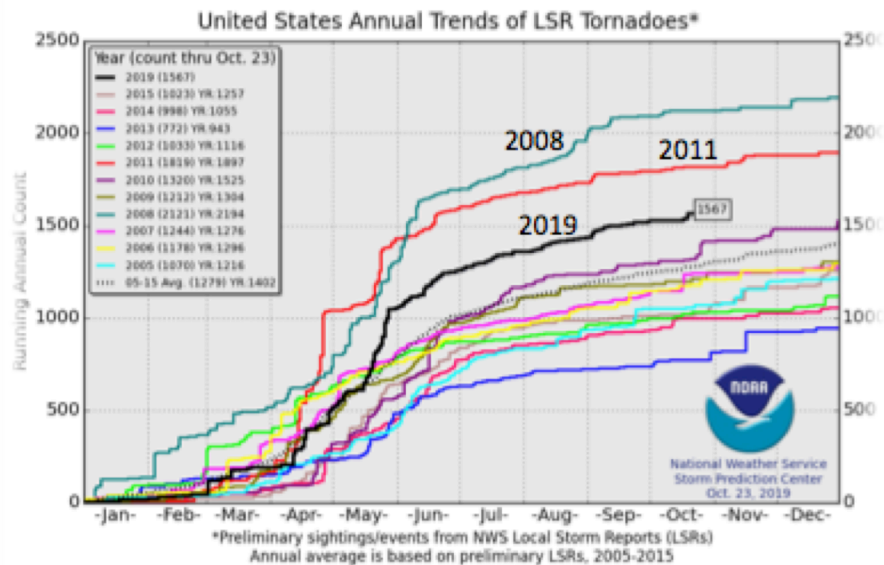
2019 became very active, a throwback to 2011. The early season in 2019 was active in the Gulf, fitting climatology. After April, action shifted to the central states and points east then subsided in June.



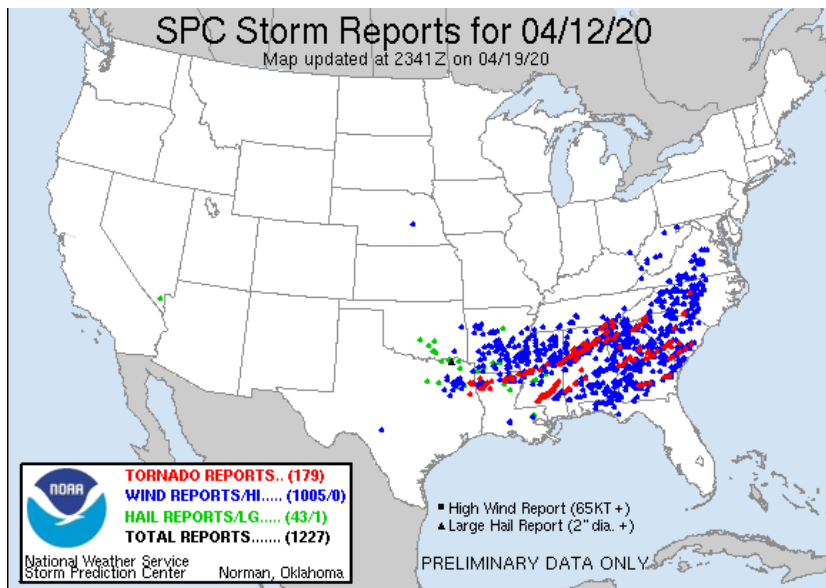
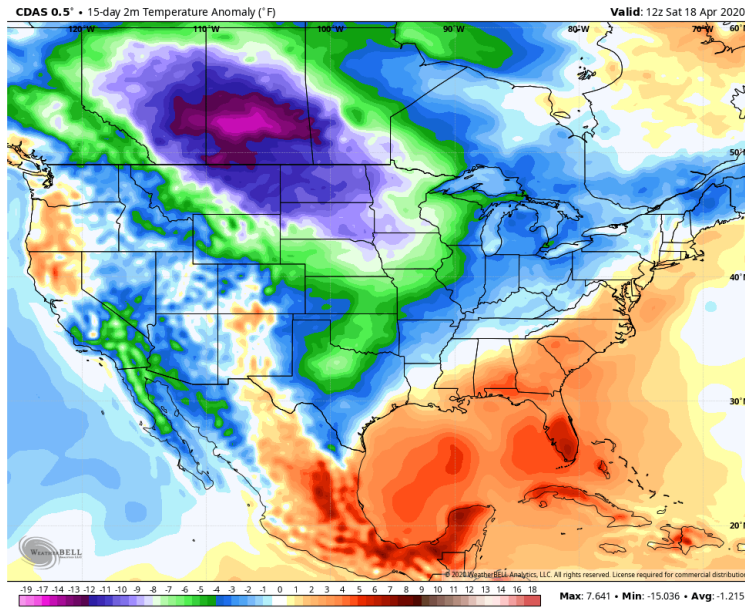
In 2011, the last La Nina, the U.S. had very extreme severe weather in the spring. It too quieted in June.



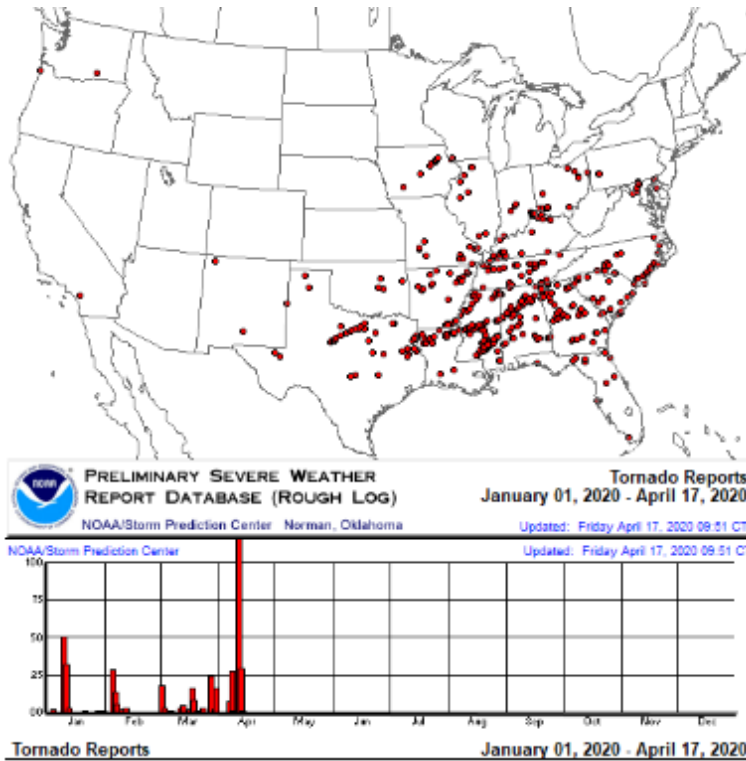
2019 trailed 2008 (like 2011 a La Nina) and 2011.



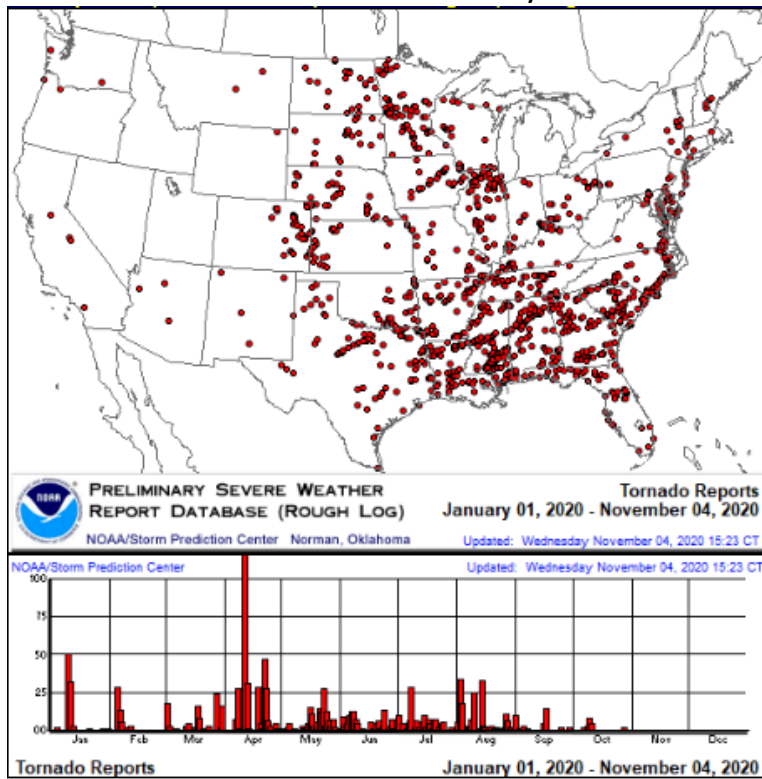
# 2020 WAS SIMILAR IN MID-APRIL

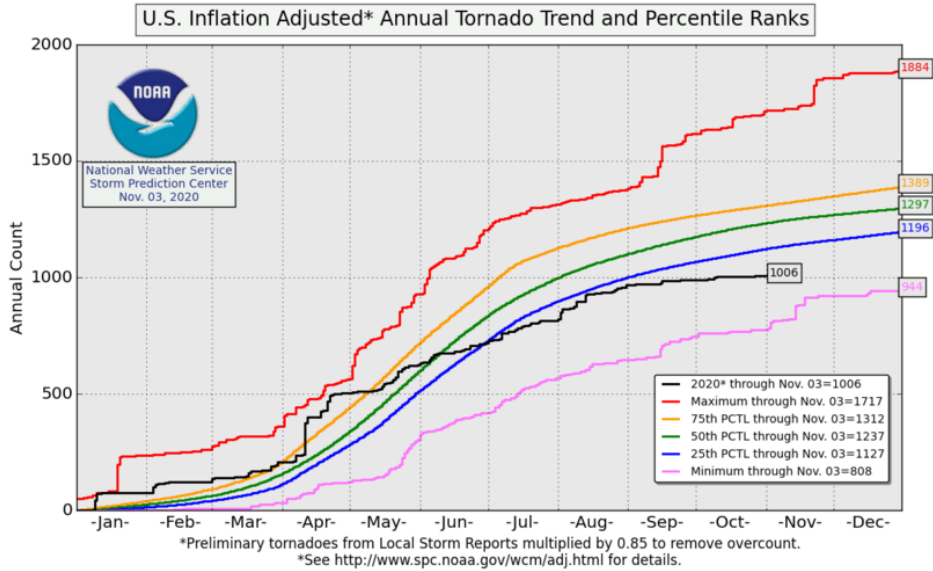






As the temperature contrast diminished activity diminished.





It dropped below the 25th percentile.

## 2021 Another Quiet Year But a Deadly December

With a persistent absent of an active storm track into the nation that resulted in a western drought, there were fewer tornado outbreaks again this year. The worst outbreak occurred in December.

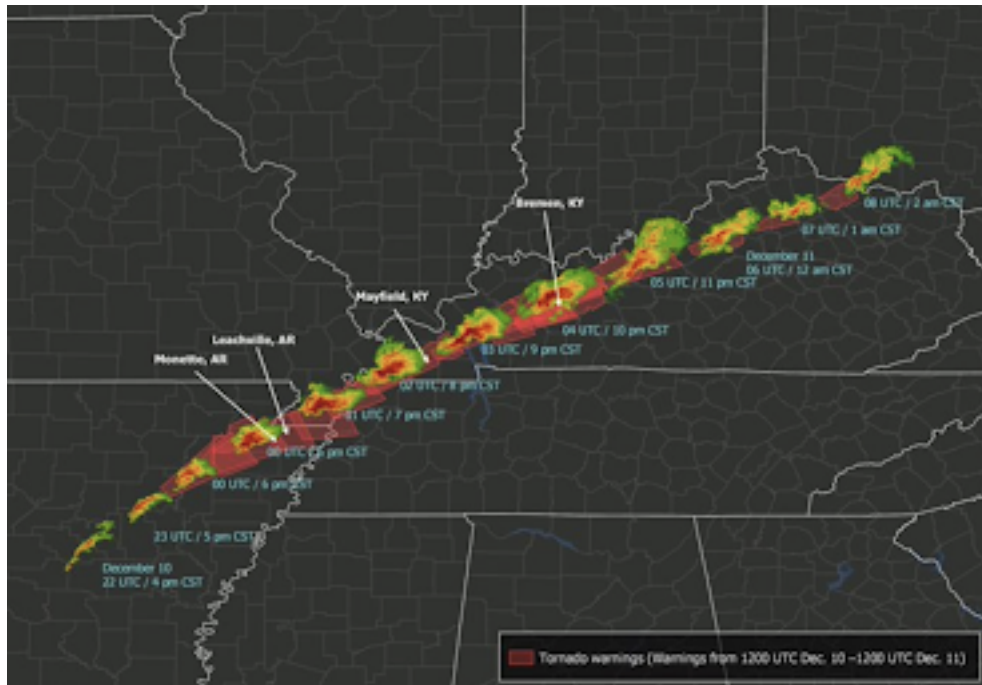
Dr. Spencer reported the outbreak included "Potentially record-setting tornado last night had a track 220+ miles long across AR, MO, TN, and KY.



Mike Smith added:

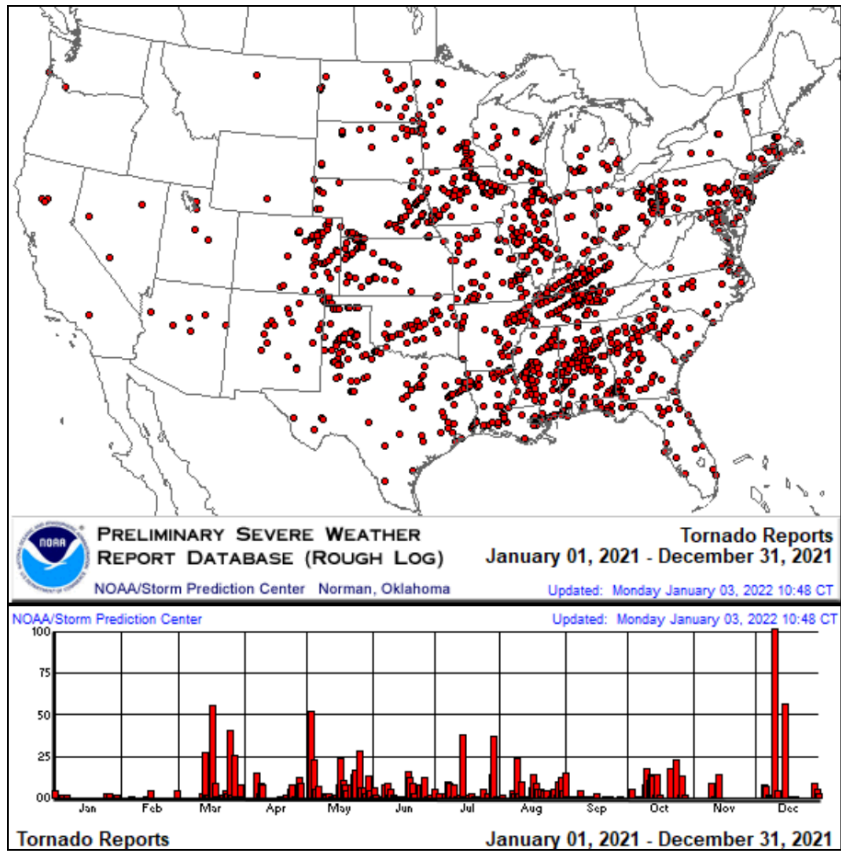
The path that originates in Arkansas and ends in eastern Kentucky is likely one of the longest tornado tracks in history if storm chaser reports that it was a continuous tornado are correct.

Here is a map of the tornado/rotation path.

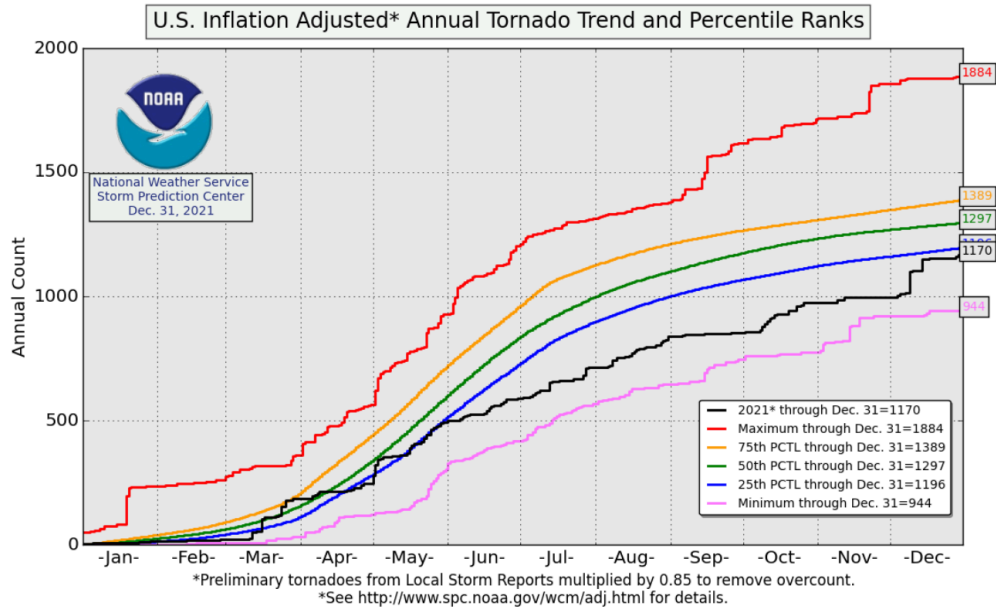


See Mike Smith's review of the storms in his post storm [post](#) "**Nighttime tornadoes are deadly.** The combination of violent tornadoes with darkness is, tragically, the recipe for a mass casualty tornado outbreak." Mike has a long history of covering severe weather and is author of [Warnings, the Story how science tamed the weather.](#)

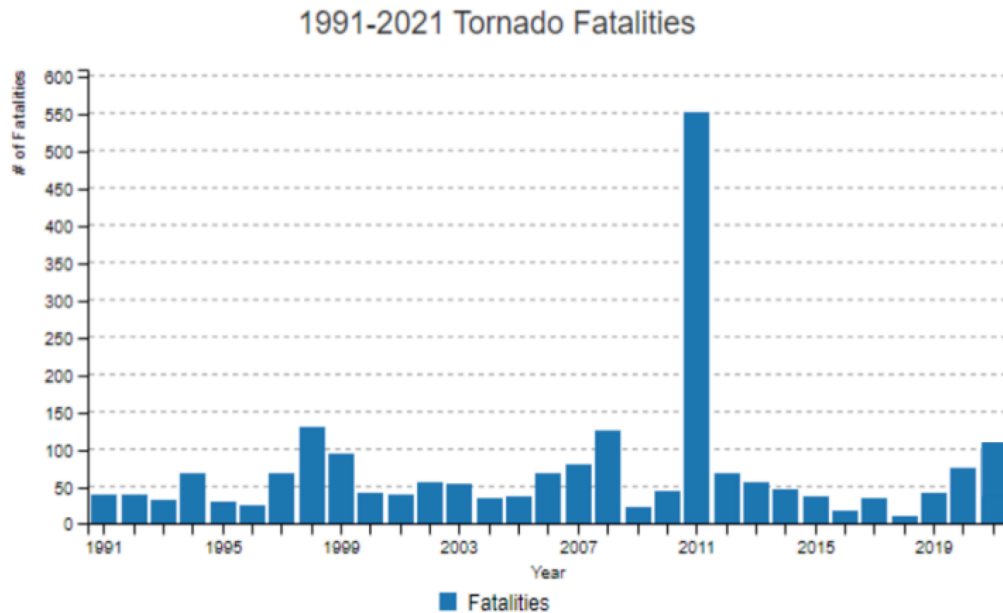
See the quiet year before December.



It brought the annual count up to near the 25<sup>th</sup> percentile



2021 had 103 tornado related fatalities. This is the highest number of tornado fatalities in a year since 2011 and the 4th most since 1991.



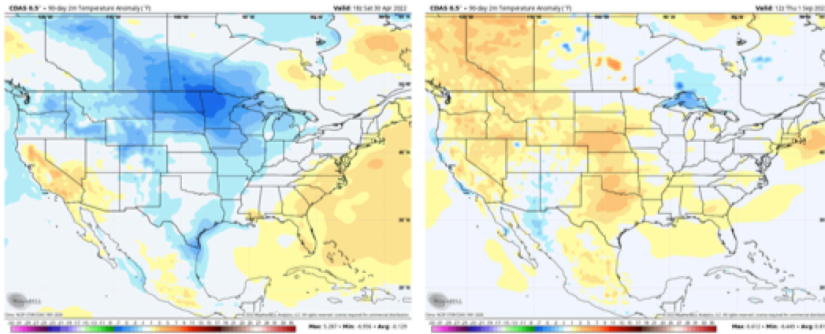
2021 had 103 tornado related fatalities. This is the highest number of tornado fatalities in a year since 2011 and the 4th most since 1991.

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

**2022 - STRONG START BUT THEN QUIET AS DRY WARM WEATHER DEVELOPS**

With late cold north and warmth building southeast, strong thunderstorms and tornadoes moved through the south in the early season. Warmth and dryness developed west and north in the summer eliminating the contrast that generates an active storm track and associated jet stream induced shear that spins up tornado activity.

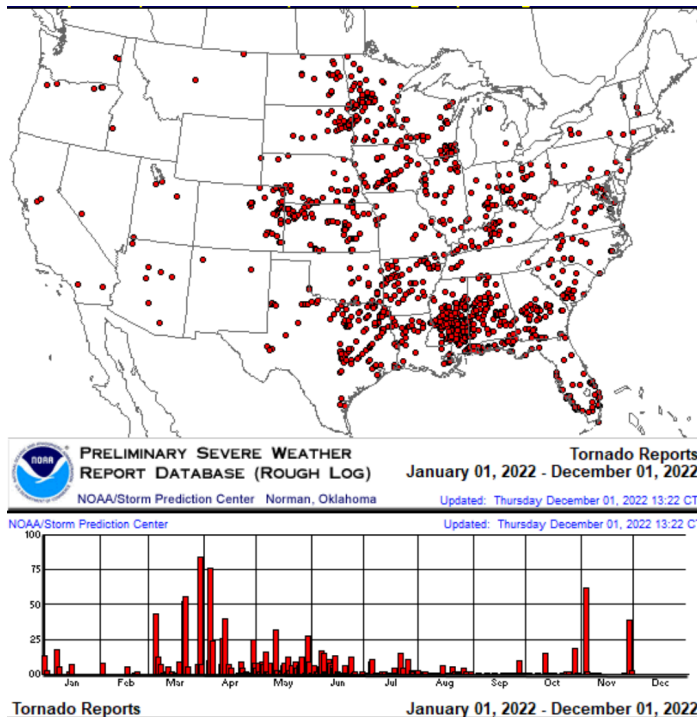
## 90 Day Temperature Anomalies



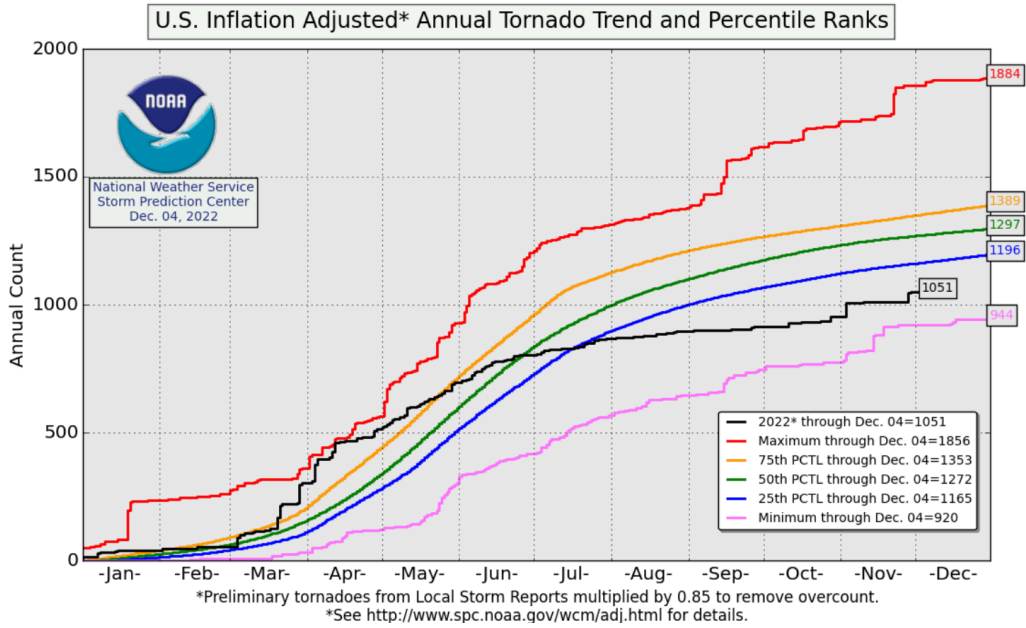
March, April, May

June, July, August

Though smaller scale clusters were seen north, the number of tornadoes dropping off after May.

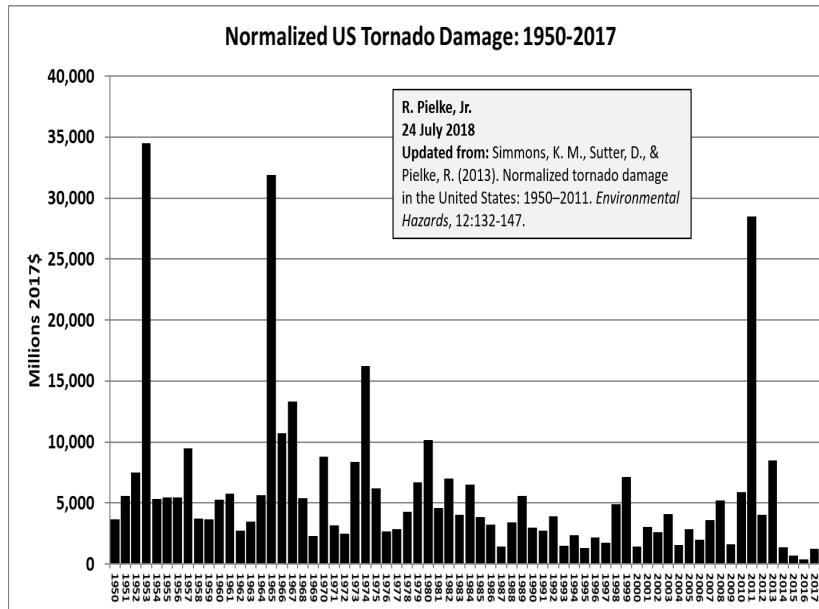


The number of tornadoes which had reach the record total year in early April dropped to below the 25<sup>th</sup> percentile in mid-summer and continues lower among the 25% in November despite spikes at the start and end of the month.



## 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 for the last 5 years. The past 5 years have 2nd lowest normalized tornado damage of any 5-yr period since 1950 (1997 #1). 2016 had least, 2015 2nd least, 2017 3rd least, 2018 near record-low tornadoes.



**Authors:**

**Joseph D’Aleo**

BS, MS degrees in Meteorology, University of Wisconsin  
 ABD Air Resources NYU  
 Professor of Meteorology and Department Chair, Lyndon State College  
 Certified Consultant Meteorologist, Fellow of the AMS, Councilor at the AMS, Chair of the AMS Committee on Weather Analysis and Forecasting  
 Co- founder and Chief Meteorologist at The Weather Channel, Chief Meteorologist at WSI, Hudson Seven LLC, WeatherBell Analytics LLC

**Anthony Lupo**

IPCC Expert Reviewer  
 Professor, Atmospheric Science, University of Missouri  
 Ph.D., Atmospheric Science, Purdue University  
 M.S., Atmospheric Science, Purdue University