Statistical Studies of Tornado in US

A Recent Tornado Case in New Jersey

On Sep. 1st of 2021,

An EF-3 tornado ripped several homes apart in Mullica Hill, New Jersey, as remnants of hurricane Ida slammed the entire region on Wednesday, with debris from destroyed homes traveling miles.

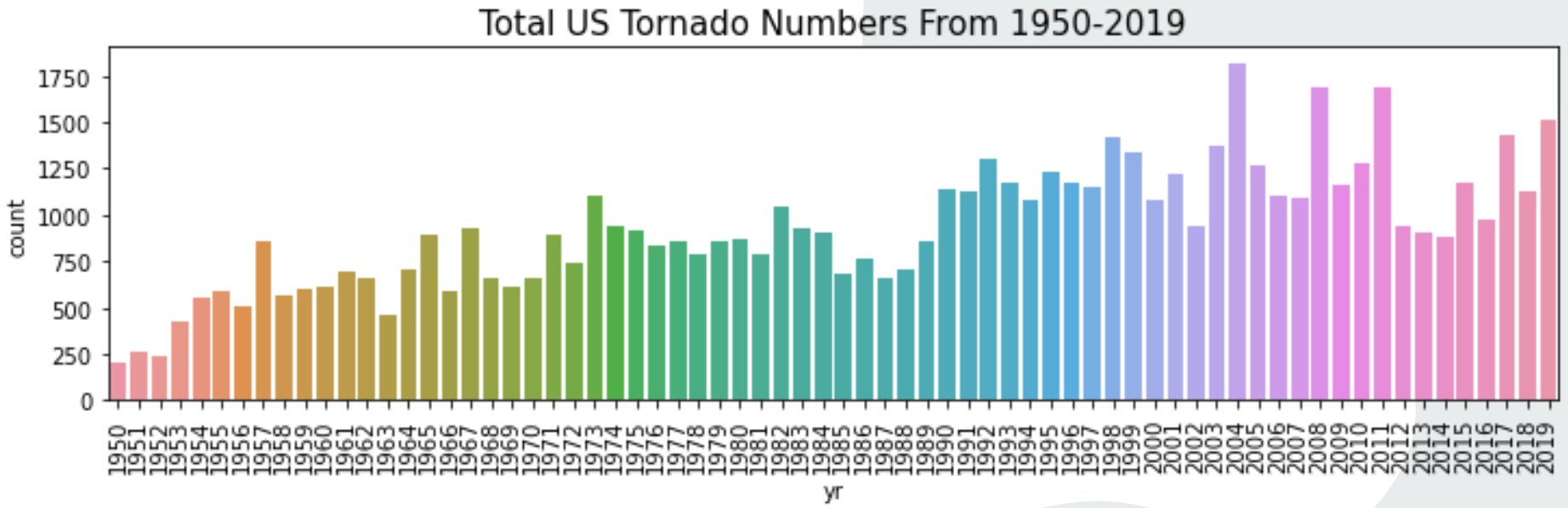
People in New Jersey were very surprised at the destructive hurricane.

Question: Is tornado rare in the east coast area of US?

US Tornado Data (1950-2019)

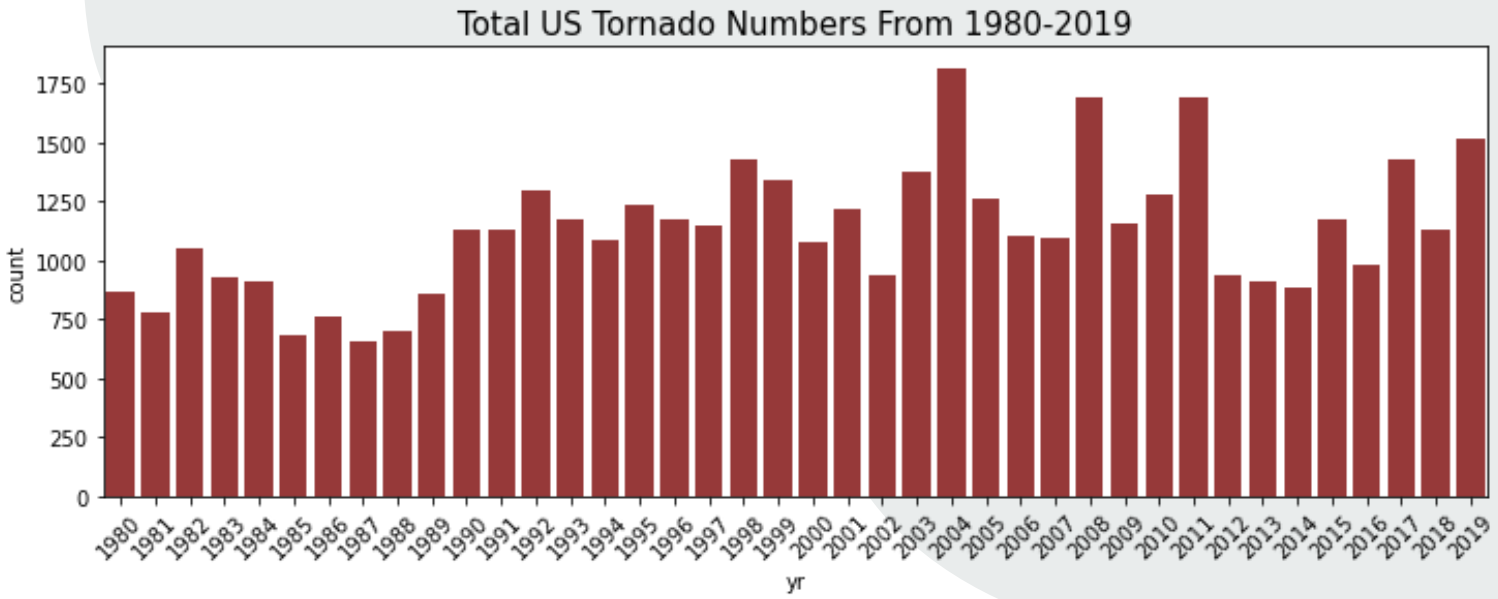
We can get historic data of tornadoes in US (1950-2019) from https://oasishub.co/dataset/usa-tornado-historical-tracks-noaa

Totally, 65,162 tornadoes were recorded during the 70 years from 1950 to 2019.



The number of tornadoes from 1950-1952 is very low. It raises the question of the reliability of data during the early years.

US Tornado Data (1980-2019)



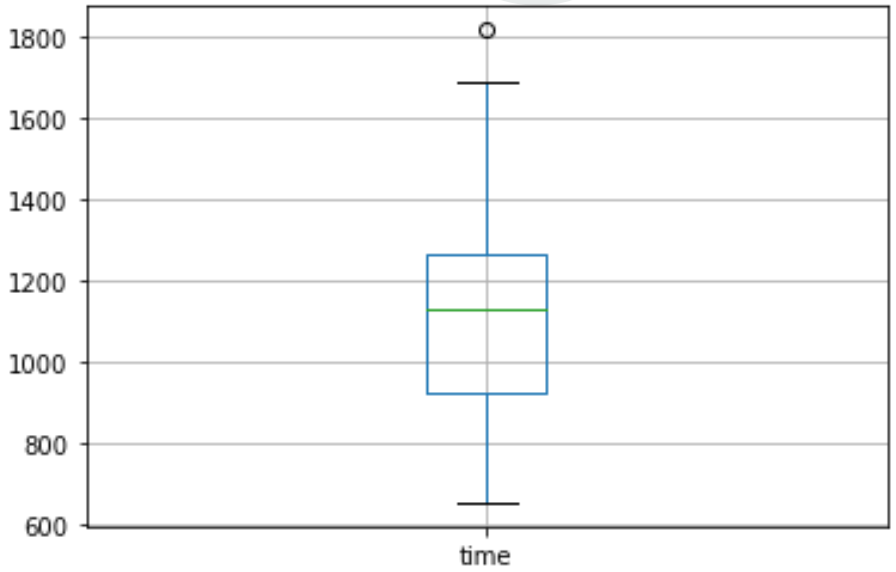
Only take data from 1980-2019, does the number of tornadoes remain same over 40 years?

Time series data stationary test
KPSS Test: p value 0.1, Not Stationary
Adfuller Test: p value 0.003, Not Stationary

Climate change causing more tornadoes in recent years?

Outliers and Prediction

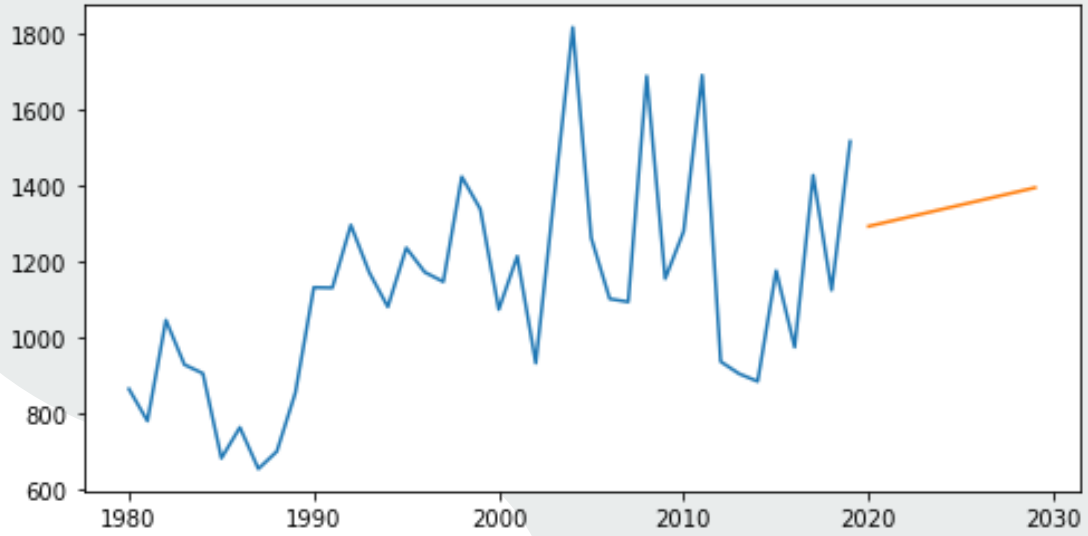
Yearly number mean: 1124
Min: 656, Max: 1817, Median: 1129
Standard deviation: 271



Boxplot

From the boxplot, the max 1817 (year of 2004) is an outlier

Future Prediction



The yearly number fits the ARIMA (0,1,1) model.

The orange line shows the middle values of the ARIMA predicted tornado number in the future

Let's Look at Each State of US:

Total Numbers of Tornadoes during 1980-2019

Rank	State	Total Number
1	Texas	5735
2	Kanas	3012
3	Oklahoma	2455
4	Florida	2286
5	Iowa	1935
6	Illinois	1888
36	New Jersey	110
51	Alaska	3
52	Washington D.C.	2

Due to significantly different size of states, just look at the total number can be misleading. We should also check the density of tornadoes in each state.

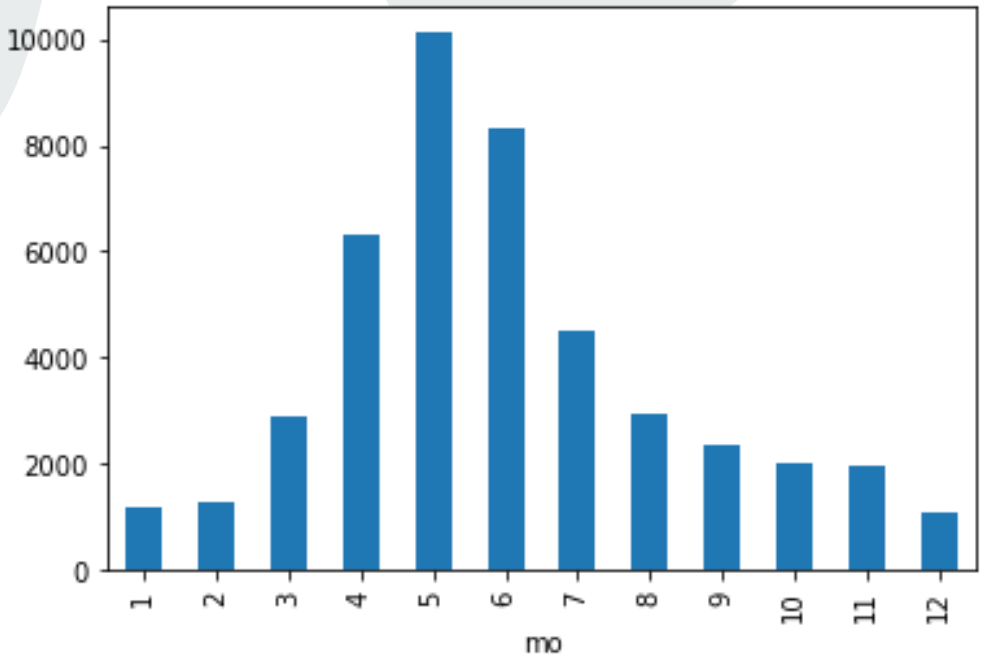
Density of Tornadoes during 1980-2019 (number/1000 square miles)

Rank	State	Total Number
1	Kansas	36.6
2	Mississippi	35.3
3	Oklahoma	35.1
4	Florida	34.8
5	Iowa	33.5
6	Alabama	31.9
17	Texas	21.4
30	New Jersey	12.6
52	Alaska	0.005

Texas is number 1 by total number. It drops to number 17 by density.

Time of Tornado Occurrence (1980-2019)

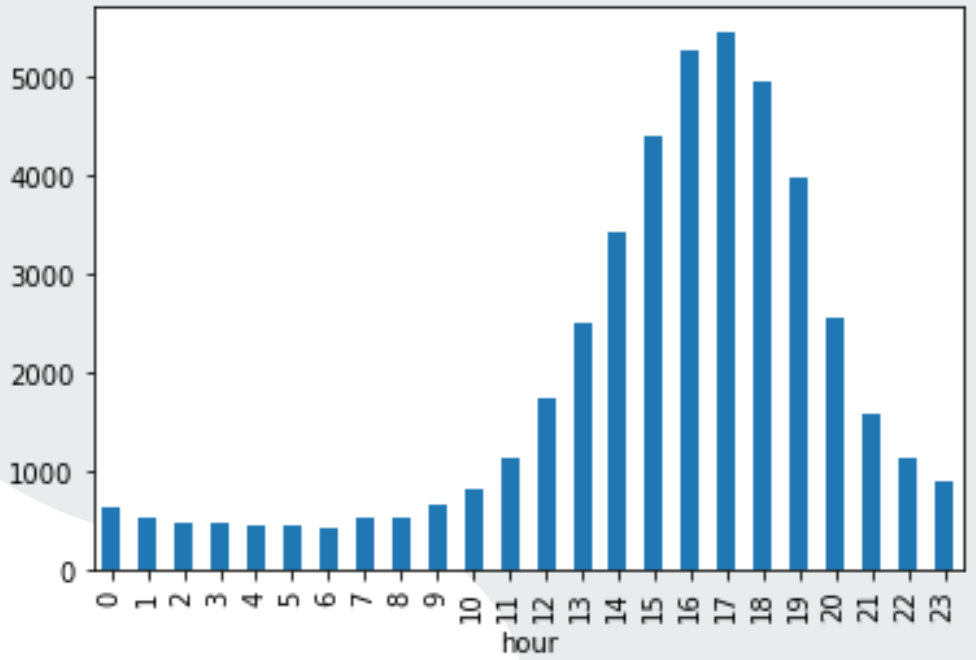
Tornadoes by month



May is the month when most tornadoes occurred.

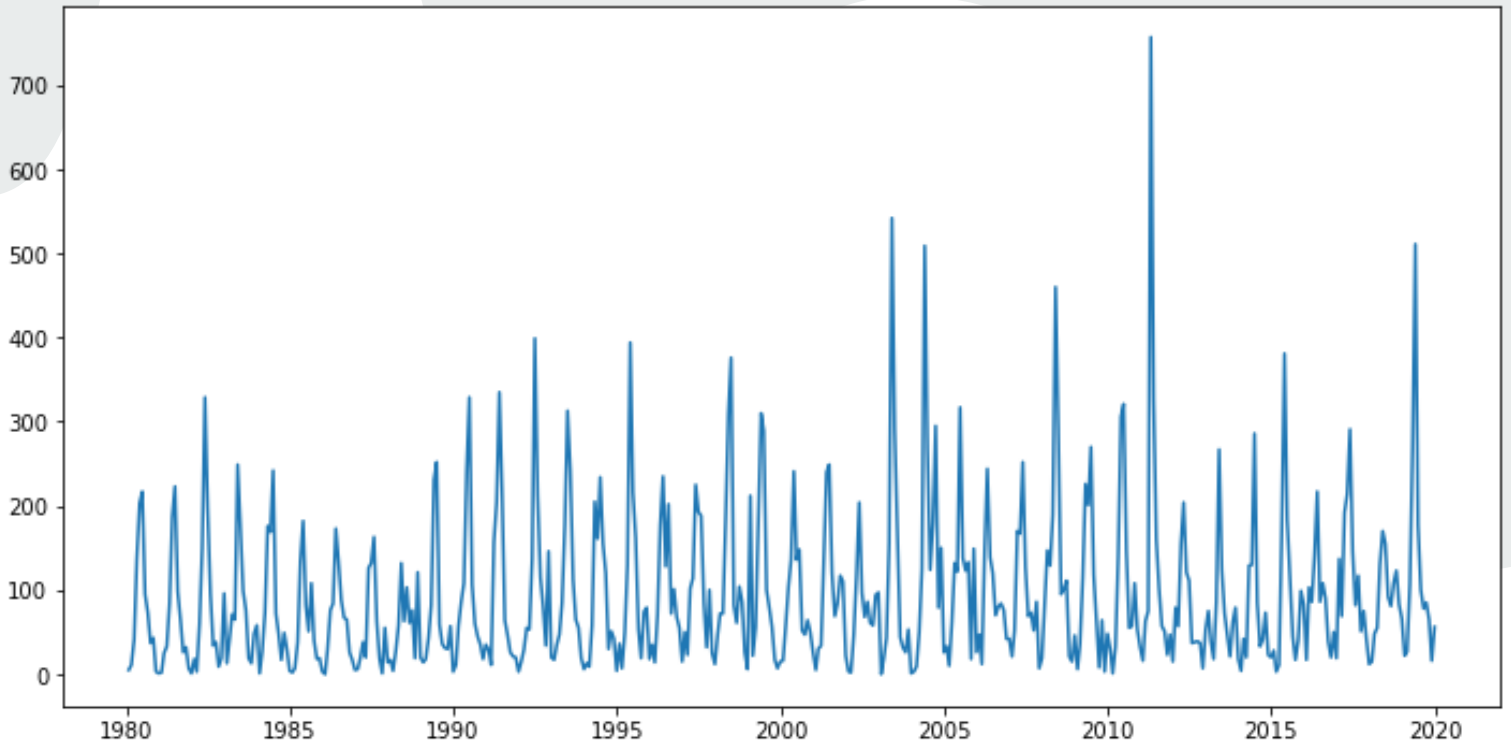
Winter is the season tornadoes most inactive.

Tornadoes by hour of a day



Late afternoon is the time when tornado is most active
Early morning is the time when tornado most unlikely to occur

Monthly Occurrences in US (1980-2019)



Zero Occurrence:

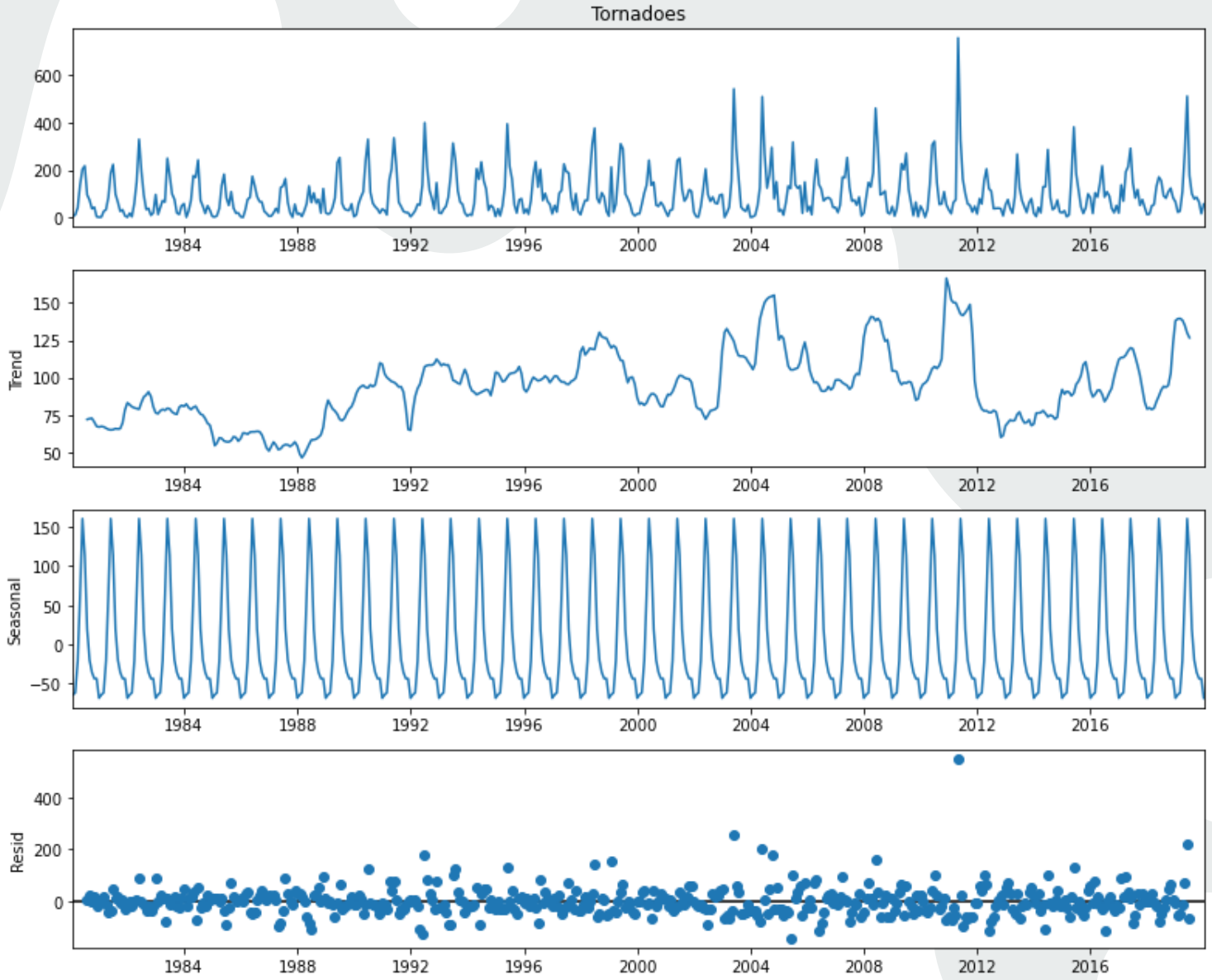
1986-01and 2003-01

Most Occurrences:

2011-04, 757
2003-05, 542
2019-05, 511
2004-05, 509

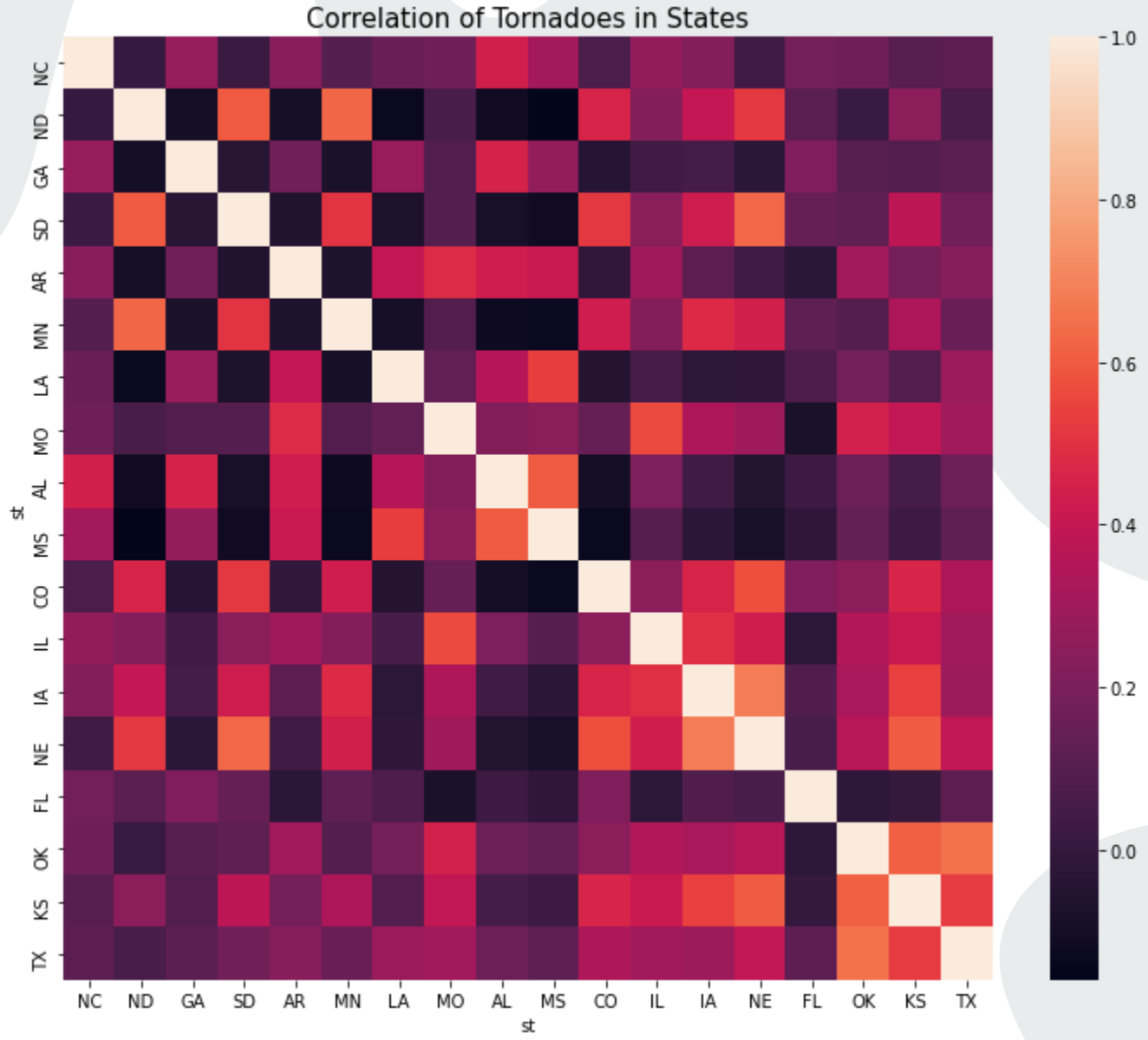
2011-04 is an obvious outlier, climate scientists need to understand what happened in that month

Seasonal Decomposition of Monthly Tornado Numbers



2011-04 is an outlier, we can see it clearly from the noise component.

Pearson Correlation of Tornadoes in Different States



Positive Correlations of Nearby States

Nebraska-Iowa: 0.687
Texas-Oklahoma: 0.652
Nebraska-South Dakota: 0.620
North Dakota-South Dakota: 0.597

Slightly Negative Correlations of Distant States

North Dakota-Mississippi -0.160
Minnesota-Alabama -0.130
Minnesota-Mississippi -0.127

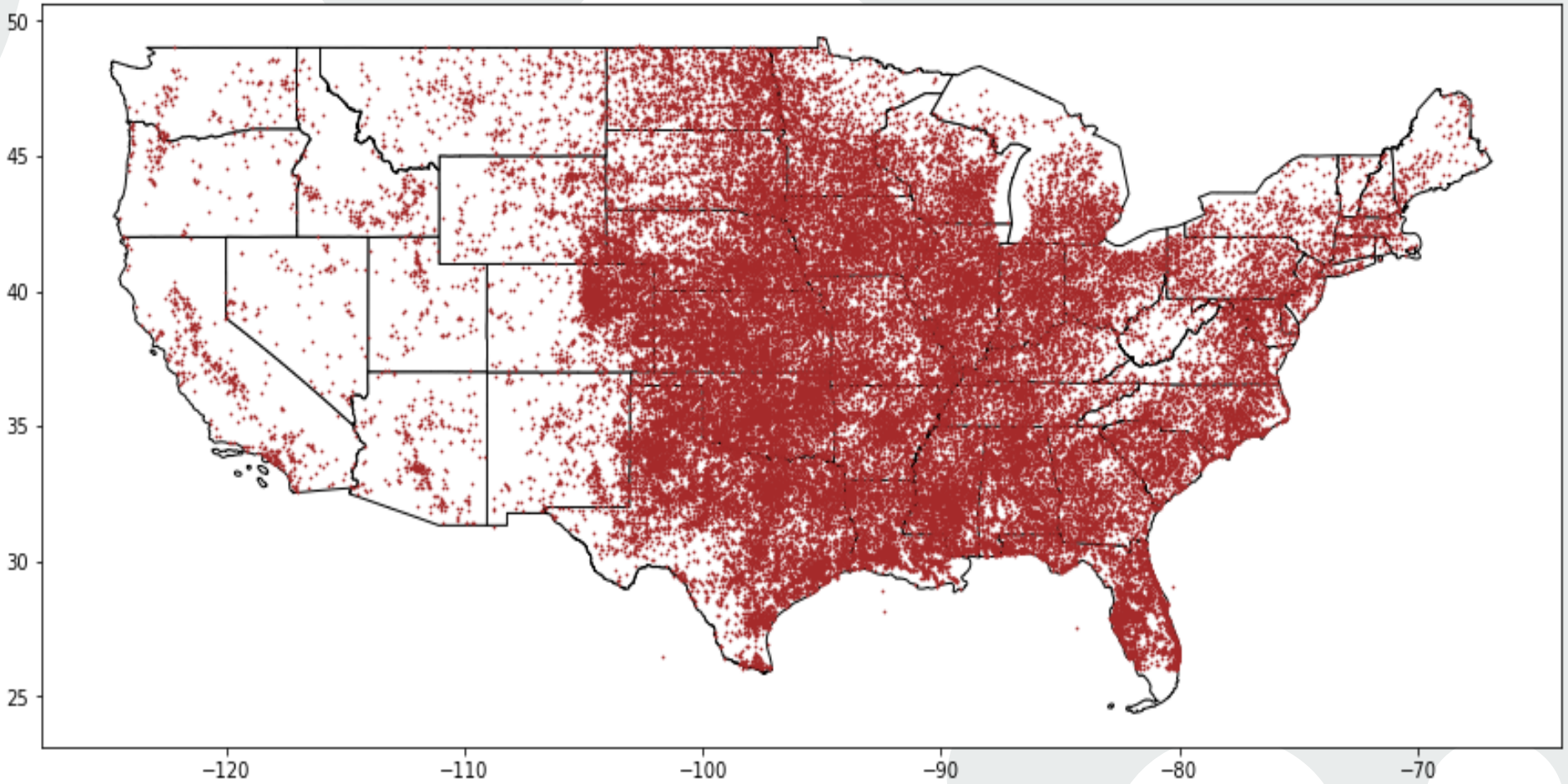
Details of Monthly Data of States (1980-2019, 480 months)

State	NC	ND	GA	SD	AR	MN	LA	MO	AL	MS	CO	IL	IA	NE	FL	OK	KS	TX
count	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
mean	2.2	2.3	2.3	2.5	2.6	3.0	3.3	3.3	3.5	3.6	3.7	3.7	3.9	4.0	4.8	5.1	6.3	11.9
std	4.5	5.3	5.1	6.1	6.5	6.5	5.6	7.0	7.1	7.0	7.5	8.0	7.4	8.0	5.6	12.0	13.1	17.9
min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
50%	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	3.0	1.0	1.0	4.0
75%	2.0	2.0	2.0	2.0	2.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	5.0	4.0	6.0	5.0	7.0	16.2
max	47	43.0	53.0	76.0	66.0	70.0	44.0	72.0	101	67.0	59.0	74.0	57.0	77.0	55.0	104	125	127

Many states have a median value of 0, the max value is often more than 10 times of the mean value.
It means most of time tornadoes are quiet, but suddenly they explode at some time, with many occurrences in a short period.

Tornado Map-1

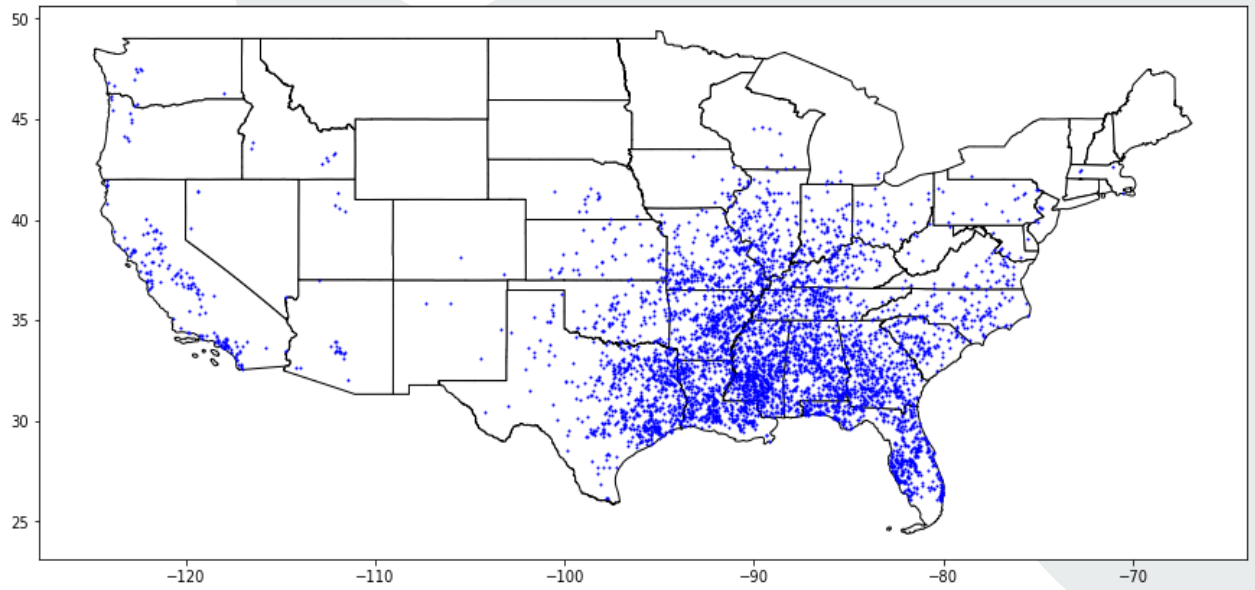
All Tornadoes in Contiguous US (1980-2019)



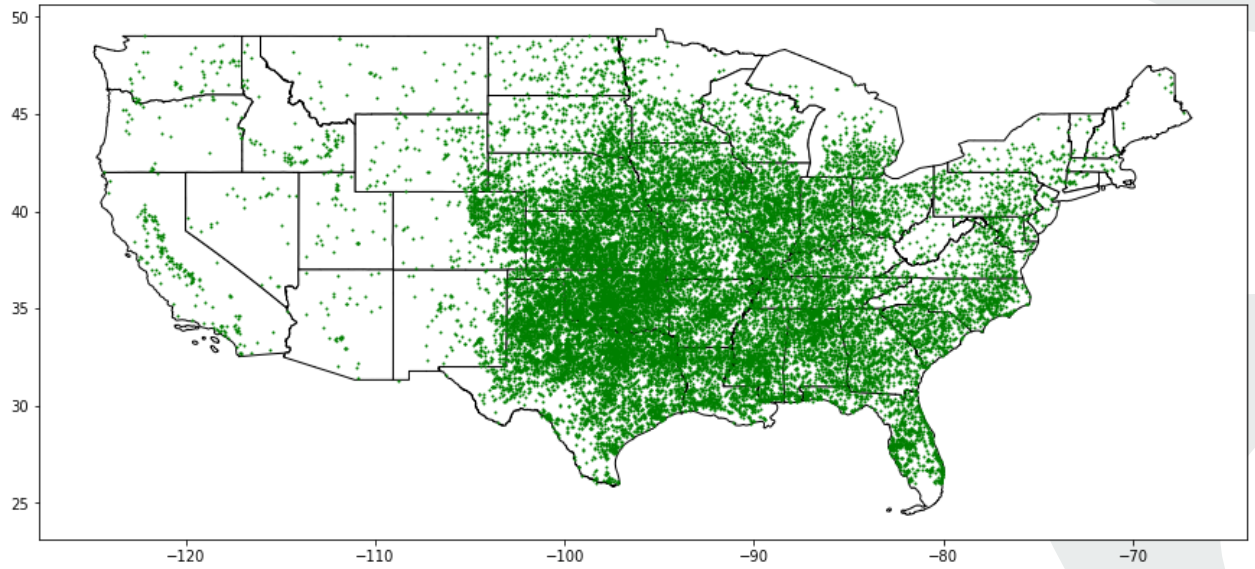
One spot means one starting place of tornado.

We can see why Texas is not among the states having highest density of tornado occurrence

Tornado Map-2

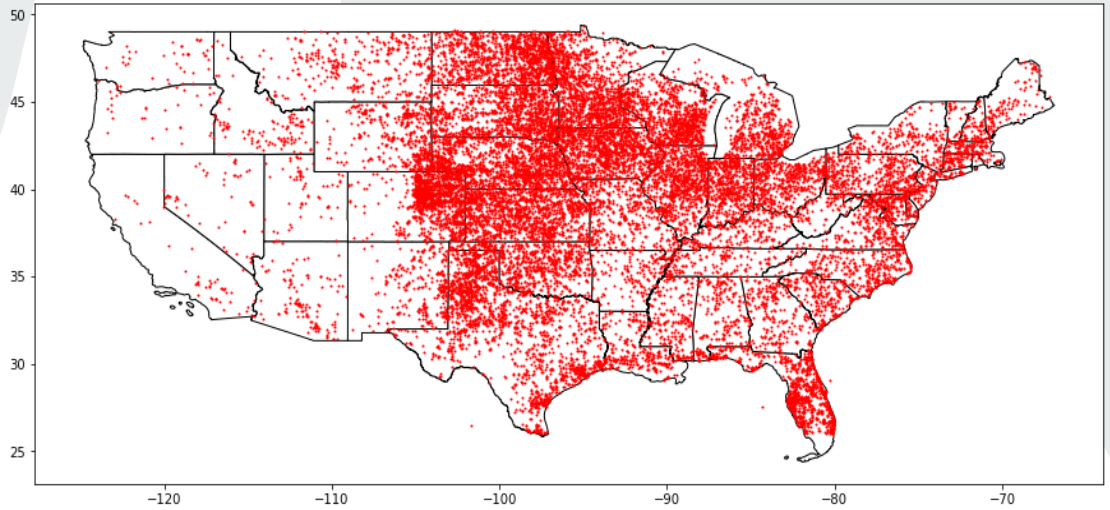


Winter Tornadoes in US (1980-2019)
(Dec,. Jan. and Feb.)

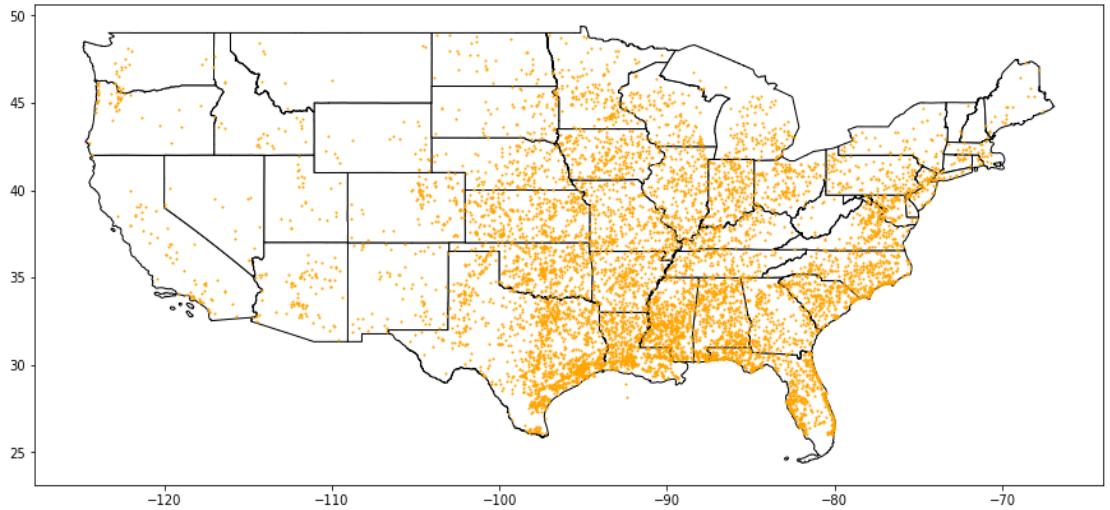


Spring Tornadoes in US (1980-2019)
(Mar., Apr. and May)

Tornado Map-3



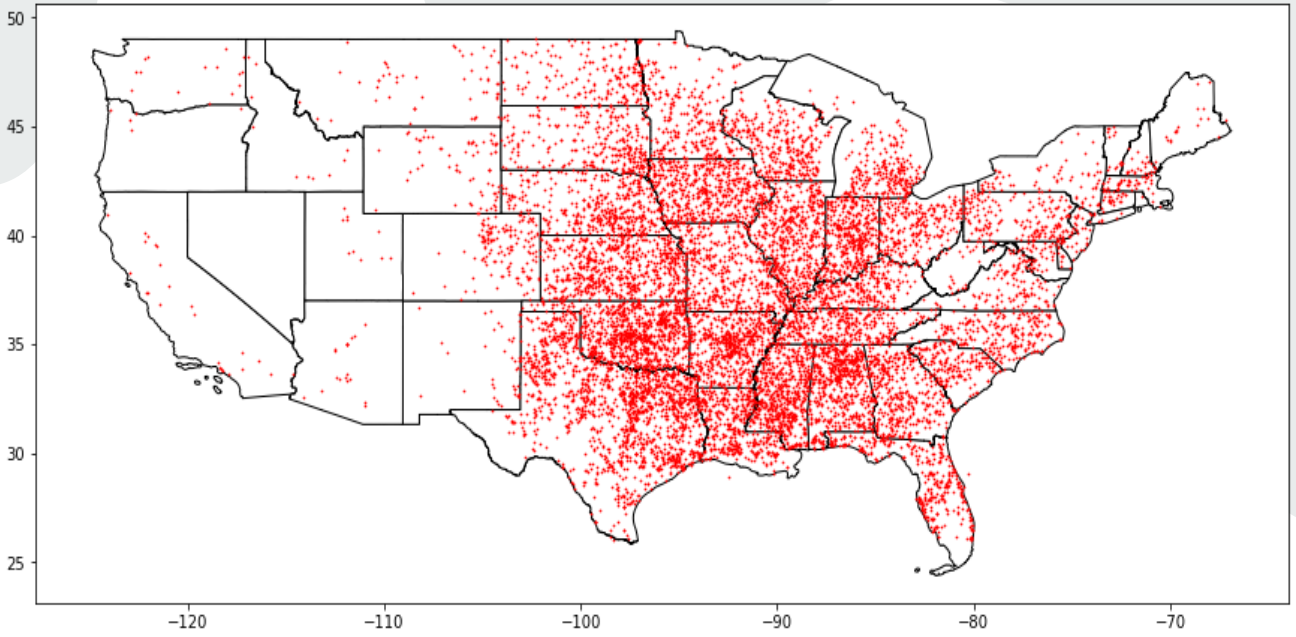
Summer Tornadoes in US (1980-2019)
(Jun., Jul. and Aug..)



Fall Tornadoes in US (1980-2019)
(Sep., Oct. and Nov.)

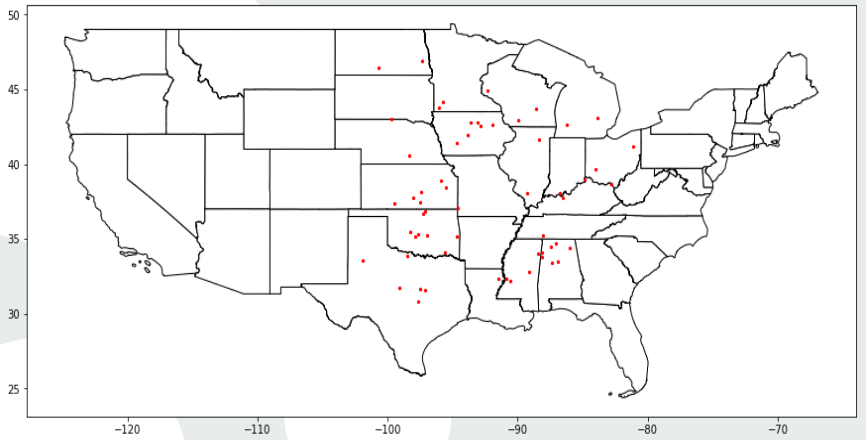
Tornado Map-4

Strong Tornadoes (Category 2 or above) in Contiguous US (1980-2019)



One spot means the starting place of a strong tornado (category 2 or above)

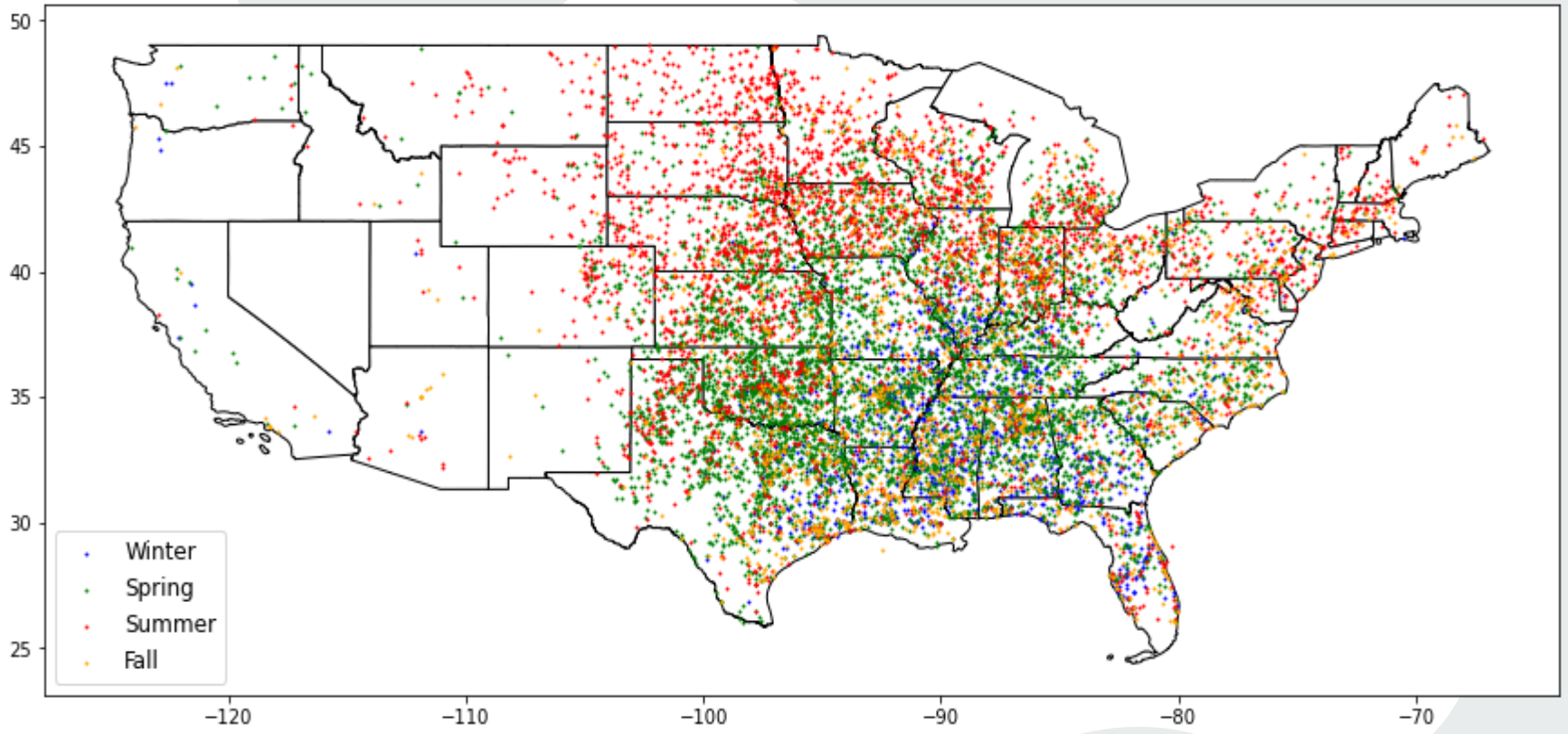
Strongest Tornadoes (Category 5) in Contiguous US (1980-2019)



Category 5 tornadoes only happened in the middle part of US

Tornado Map-5

Strong Tornadoes in Contiguous US (1980-2019)



In summer strong tornadoes more likely occur in north area while winter and fall tornadoes mostly occur in south.

Summary

1. US is a country with many tornado occurrences. The average number of tornado is more than1100 per year during 1980-2019.
2. The middle area of US (east of Rocky Mountains and west of Appalachia Mountains) receives most of the tornado attacks, especially the most powerful tornados (category 5) only happened in this area.
3. The east coast of US also sees significant number of tornadoes, although less than the middle area of US.
4. The west of US is unlikely to have tornadoes, the numbers are much lower.
5. Tornadoes happen most often in spring and summer. In summer it is more often in north area of US and the other seasons more often in south area of US.
6. Tornadoes happen more often in late afternoon than other time of the days. The early morning is the time when tornadoes most unlikely to occur.