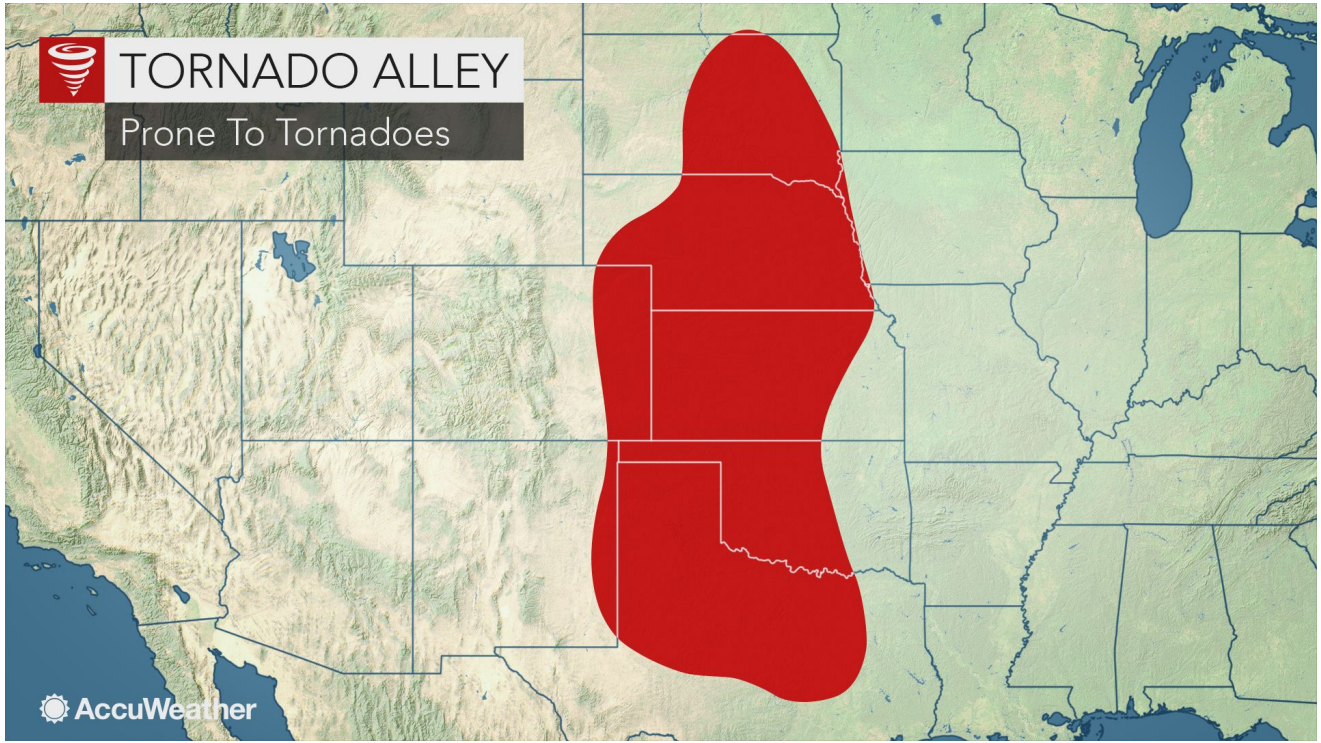
# US Tornado Trends

Kavi Krsnadas, Peyton Weber, Kayla Hamann, Soomin Kim, Allison Park, and Jakob Kim

# Why Investigate Tornadoes as a function of Latitudes?

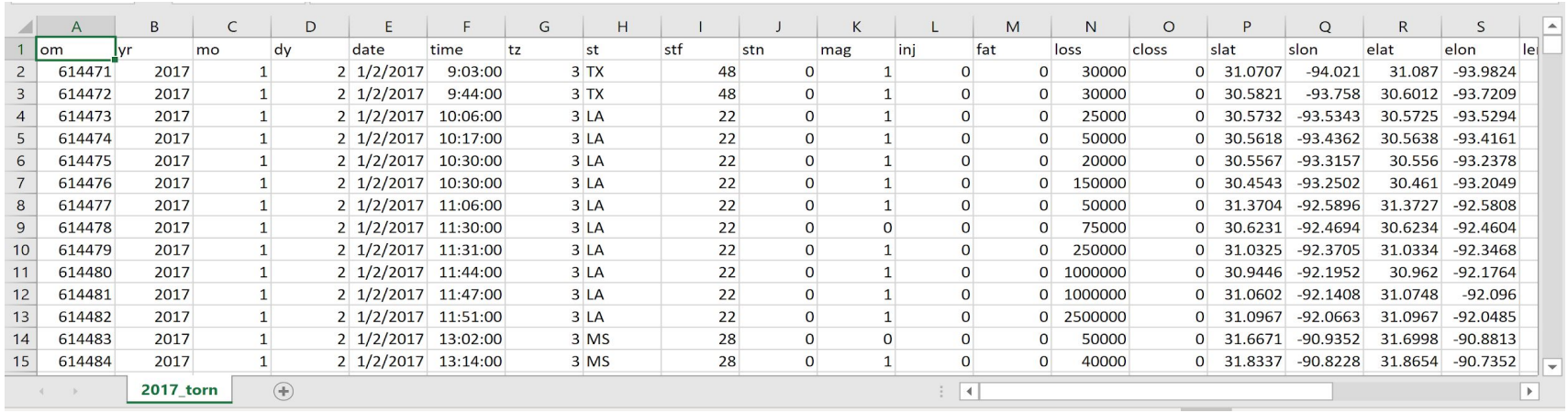


# Method

# Data Collection

- The data used was sourced from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service.
- Our project analyzed each year from 2010 to 2018.

# Original Data



| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | om | yr | mo | dy | date | time | tz | st | stf | stn | mag | inj | fat | loss | closs | slat | slon | elat | elon | le |
| 2 | 614471 | 2017 | 1 | 2 | 1/2/2017 | 9:03:00 | 3 | TX | 48 | 0 | 1 | 0 | 0 | 30000 | 0 | 31.0707 | -94.021 | 31.087 | -93.9824 | |
| 3 | 614472 | 2017 | 1 | 2 | 1/2/2017 | 9:44:00 | 3 | TX | 48 | 0 | 1 | 0 | 0 | 30000 | 0 | 30.5821 | -93.758 | 30.6012 | -93.7209 | |
| 4 | 614473 | 2017 | 1 | 2 | 1/2/2017 | 10:06:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 25000 | 0 | 30.5732 | -93.5343 | 30.5725 | -93.5294 | |
| 5 | 614474 | 2017 | 1 | 2 | 1/2/2017 | 10:17:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 50000 | 0 | 30.5618 | -93.4362 | 30.5638 | -93.4161 | |
| 6 | 614475 | 2017 | 1 | 2 | 1/2/2017 | 10:30:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 20000 | 0 | 30.5567 | -93.3157 | 30.556 | -93.2378 | |
| 7 | 614476 | 2017 | 1 | 2 | 1/2/2017 | 10:30:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 150000 | 0 | 30.4543 | -93.2502 | 30.461 | -93.2049 | |
| 8 | 614477 | 2017 | 1 | 2 | 1/2/2017 | 11:06:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 50000 | 0 | 31.3704 | -92.5896 | 31.3727 | -92.5808 | |
| 9 | 614478 | 2017 | 1 | 2 | 1/2/2017 | 11:30:00 | 3 | LA | 22 | 0 | 0 | 0 | 0 | 75000 | 0 | 30.6231 | -92.4694 | 30.6234 | -92.4604 | |
| 10 | 614479 | 2017 | 1 | 2 | 1/2/2017 | 11:31:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 250000 | 0 | 31.0325 | -92.3705 | 31.0334 | -92.3468 | |
| 11 | 614480 | 2017 | 1 | 2 | 1/2/2017 | 11:44:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 1000000 | 0 | 30.9446 | -92.1952 | 30.962 | -92.1764 | |
| 12 | 614481 | 2017 | 1 | 2 | 1/2/2017 | 11:47:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 1000000 | 0 | 31.0602 | -92.1408 | 31.0748 | -92.096 | |
| 13 | 614482 | 2017 | 1 | 2 | 1/2/2017 | 11:51:00 | 3 | LA | 22 | 0 | 1 | 0 | 0 | 2500000 | 0 | 31.0967 | -92.0663 | 31.0967 | -92.0485 | |
| 14 | 614483 | 2017 | 1 | 2 | 1/2/2017 | 13:02:00 | 3 | MS | 28 | 0 | 0 | 0 | 0 | 50000 | 0 | 31.6671 | -90.9352 | 31.6998 | -90.8813 | |
| 15 | 614484 | 2017 | 1 | 2 | 1/2/2017 | 13:14:00 | 3 | MS | 28 | 0 | 1 | 0 | 0 | 40000 | 0 | 31.8337 | -90.8228 | 31.8654 | -90.7352 | |

2017_torn

# Final Data

- The final data set is divided into three categories: the year, the range of latitudes, and the total count of tornadoes within that range.
- We divided the total latitude range by 50, because the latitude range covered by the United States is 50. These subgroups made handling the data easier.

```
2013    28.3562 29.334  6;
2013    29.334 30.3118  25;
2013    30.3118 31.2896 24;
2013    31.2896 32.2674 39;
2013    32.2674 33.2452 44;
2013    33.2452 34.223  64;
2013    34.223 35.2008  60;
2013    35.2008 36.1786 86;
2013    36.1786 37.1564 97;
2013    37.1564 38.1342 59;
2013    38.1342 39.112  69;
2013    39.112 40.0898  58;
2013    40.0898 41.0676 75;
```

# The Code

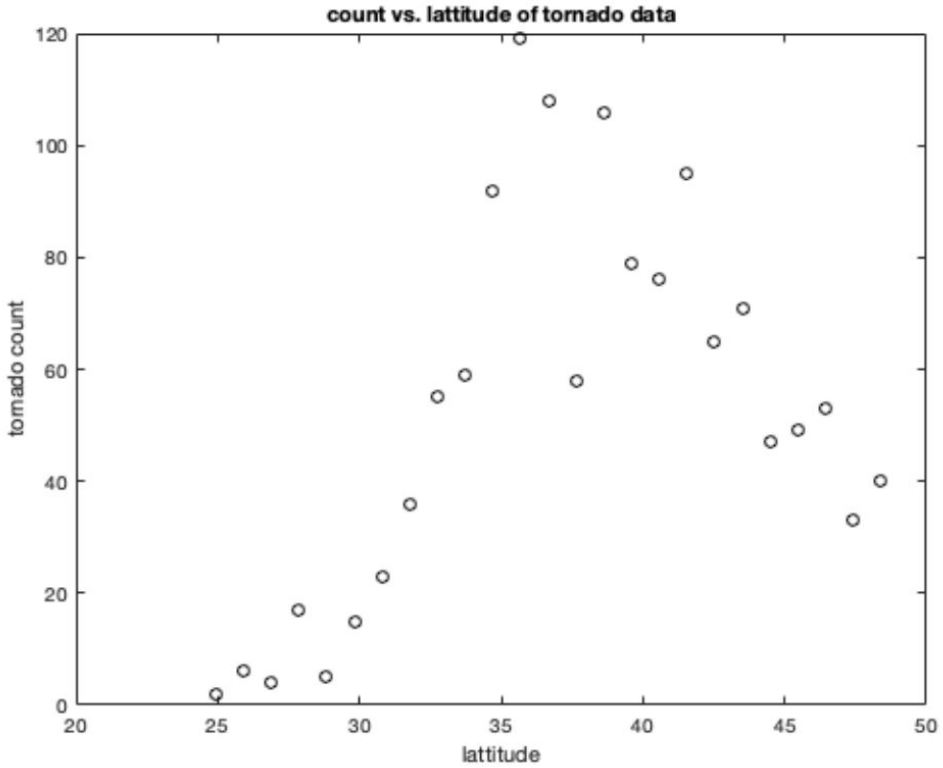
**cubic fits**

```
sumsmatrix = [M sx sx2 sx3;
              sx sx2 sx3 sx4
              sx2 sx3 sx4 sx5
              sx3 sx4 sx5 sx6];

fxy = [sy; syx; syx2; syx3];

a = sumsmatrix\fxy;

% create the cubic polynomial with these found coefficients
p3 = a(1) + a(2).*x + a(3).*x.^2 + a(4).*x.^3;

% plot this fit on the same graph as the linear fit and data points
plot(x,p3)

if (j == 2)
    X = x;

end
Y(j,1:length(y)) = y';
fits(j,1:length(y)) = p3';
```

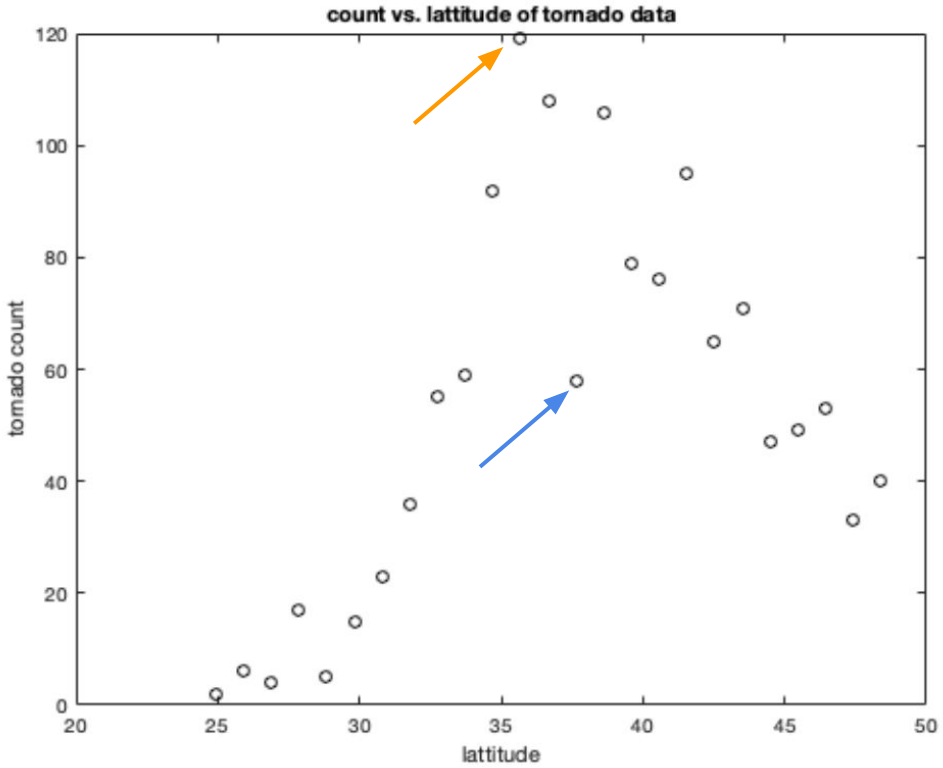
# The Fit

- We chose the a polynomial of the third-degree, because it had the best fit without attempting to make the sum of the residuals arbitrarily close to zero.
- The following equation describes the relationship between latitudes and the count of tornadoes from the data set from 2010 to 2018:
  - $p(x) = -0.0122 - 21.1552x + 1.3115x^2 - 0.0181x^3$

# Results

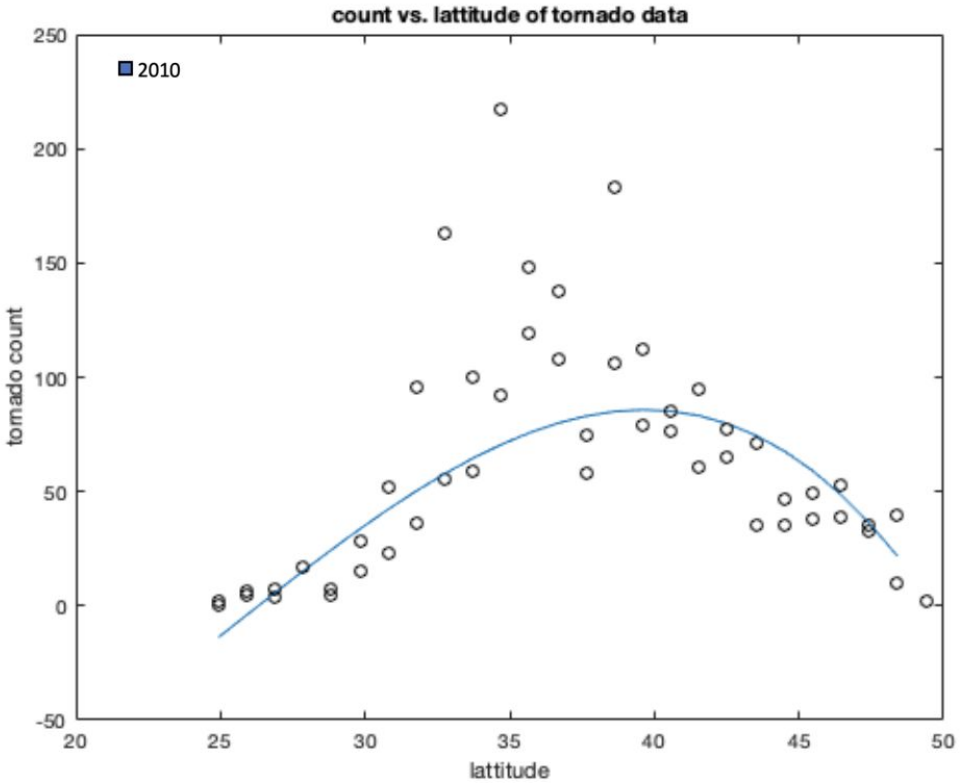



Plots of years accumulate over time



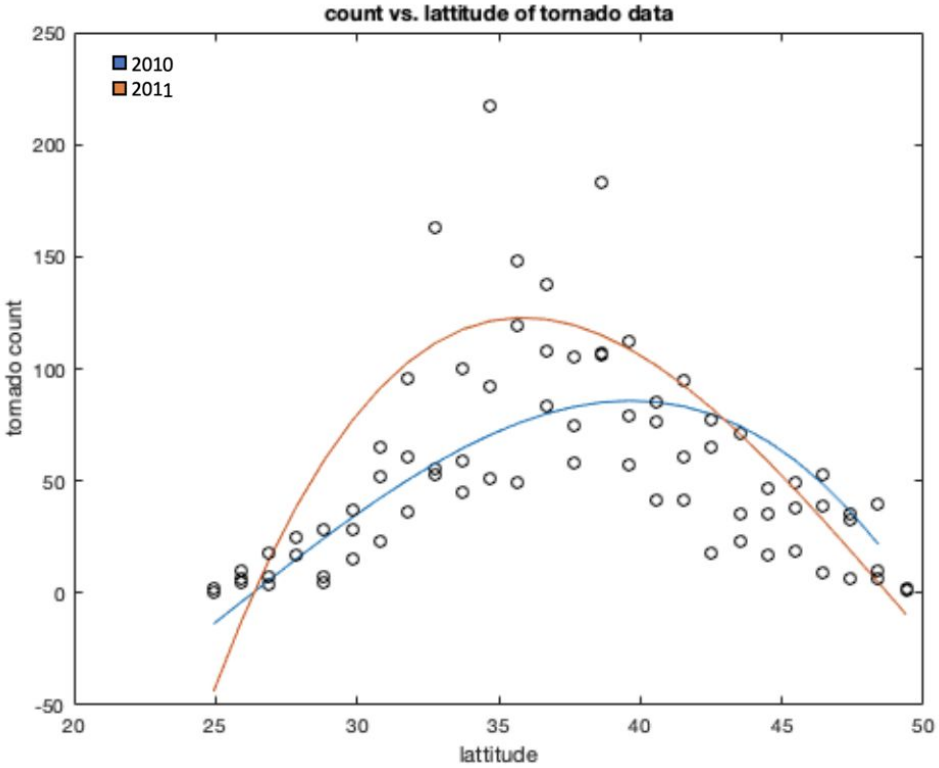

Plots of years accumulate over time

Peak: ~ 36 °
Outlier: ~ 38 °

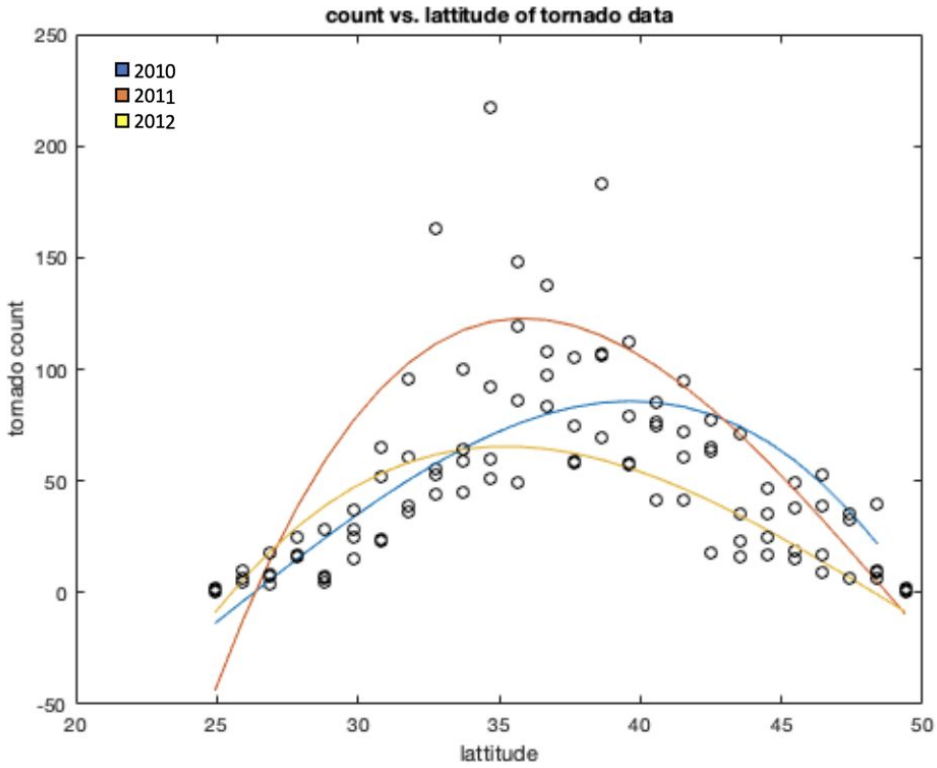


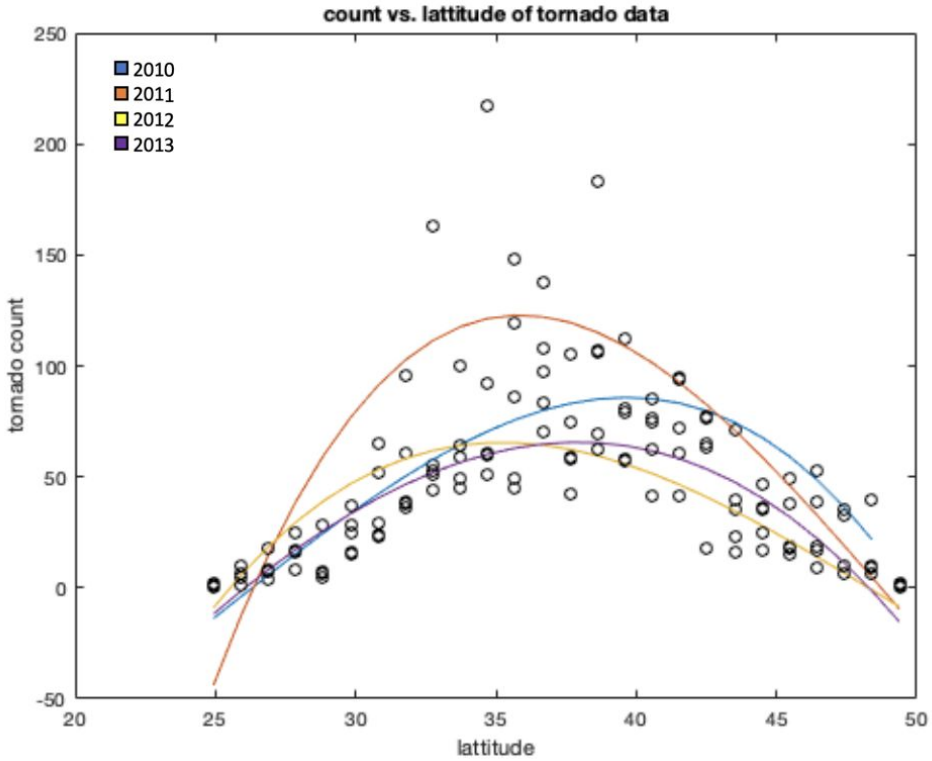

Blue curve maps the curve for **2010** shown previously

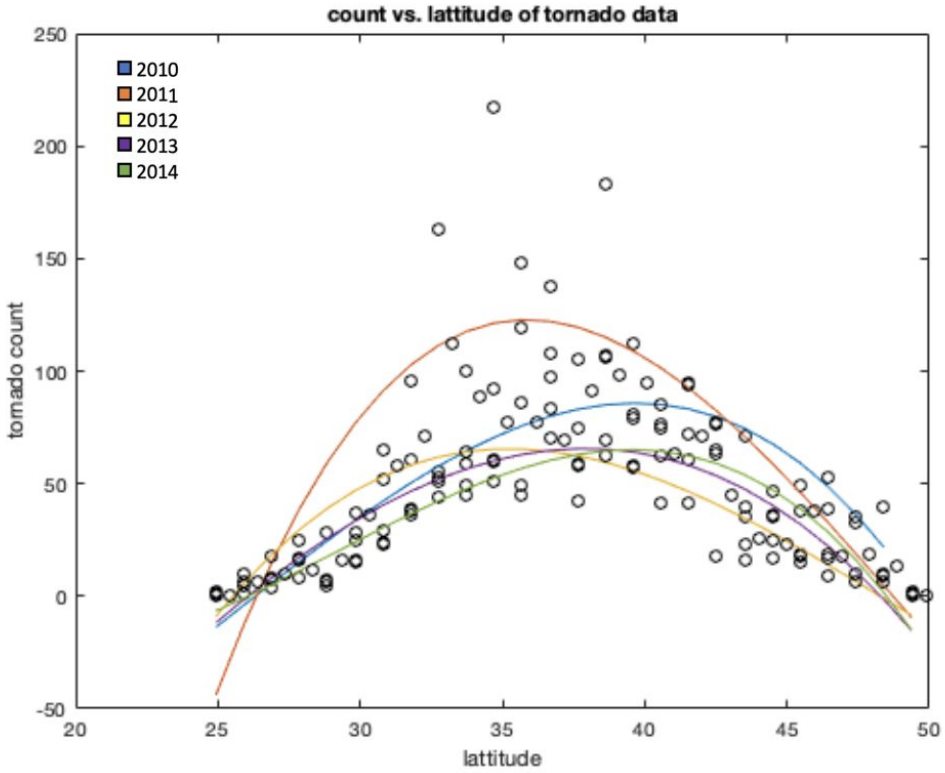
New points correspond to **2011**

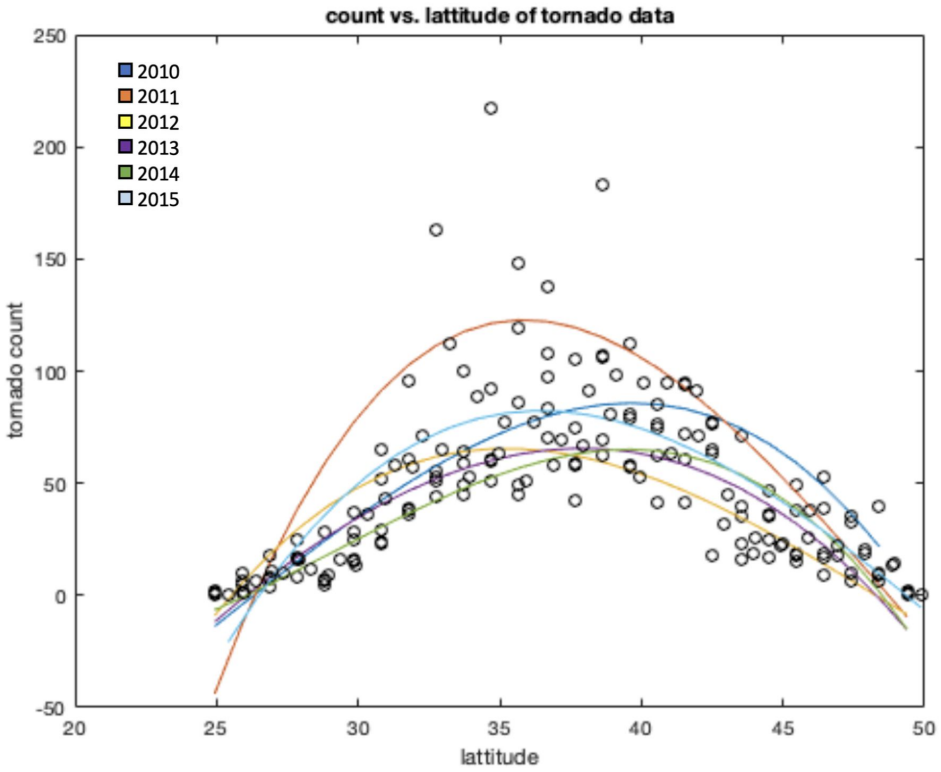



Two curves are shifted to the right/left in comparison to the other

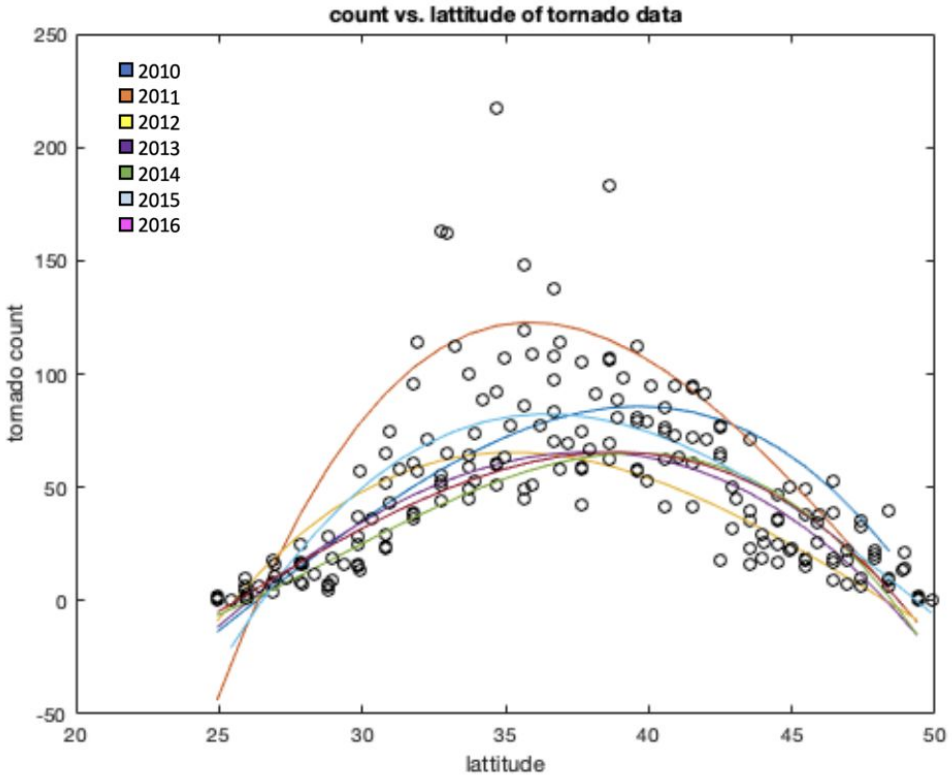

count vs. lattitude of tornado data
2010
2011
2012
tornado count
lattitude
250
200
150
100
50
0
-50
20
25
30
35
40
45
50


count vs. lattitude of tornado data
2010
2011
2012
2013
tornado count
lattitude
250
200
150
100
50
0
-50
20
25
30
35
40
45
50


count vs. lattitude of tornado data
2010
2011
2012
2013
2014
tornado count
lattitude
250
200
150
100
50
0
-50
20
25
30
35
40
45
50


count vs. lattitude of tornado data
2010
2011
2012
2013
2014
2015
tornado count
lattitude
250
200
150
100
50
0
-50
20
25
30
35
40
45
50

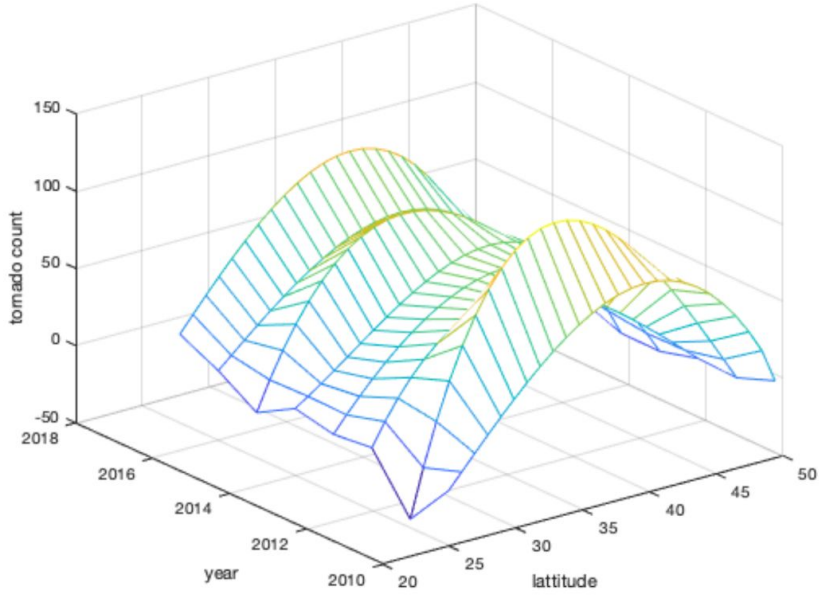
# Aggregate Plot

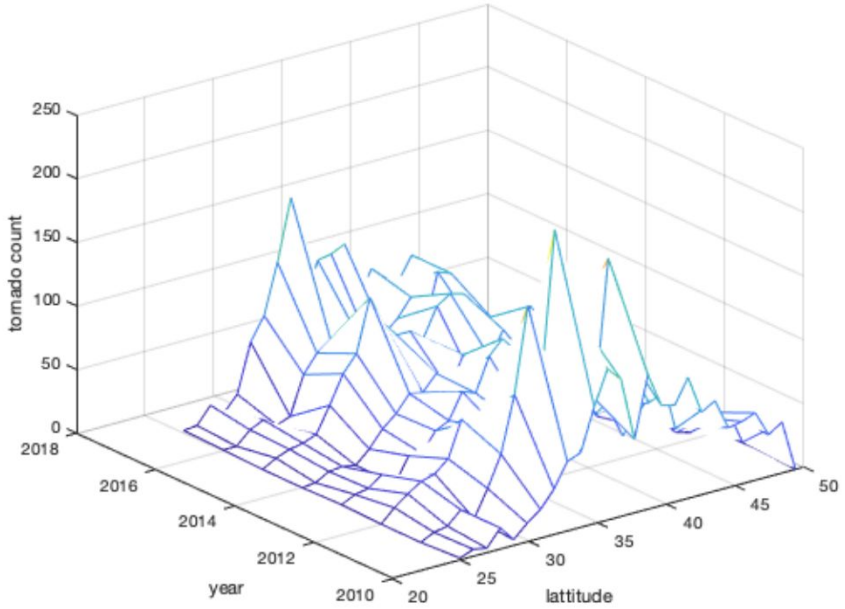



Curve for **2011** (orange) sticks out relative to other years

General trend where it peaks from 33 ~ 40 °

# 3D Graphs


150
100
50
0
-50
tornado count
2018
2016
2014
2012
2010
year
20
25
30
35
40
45
50
lattitude

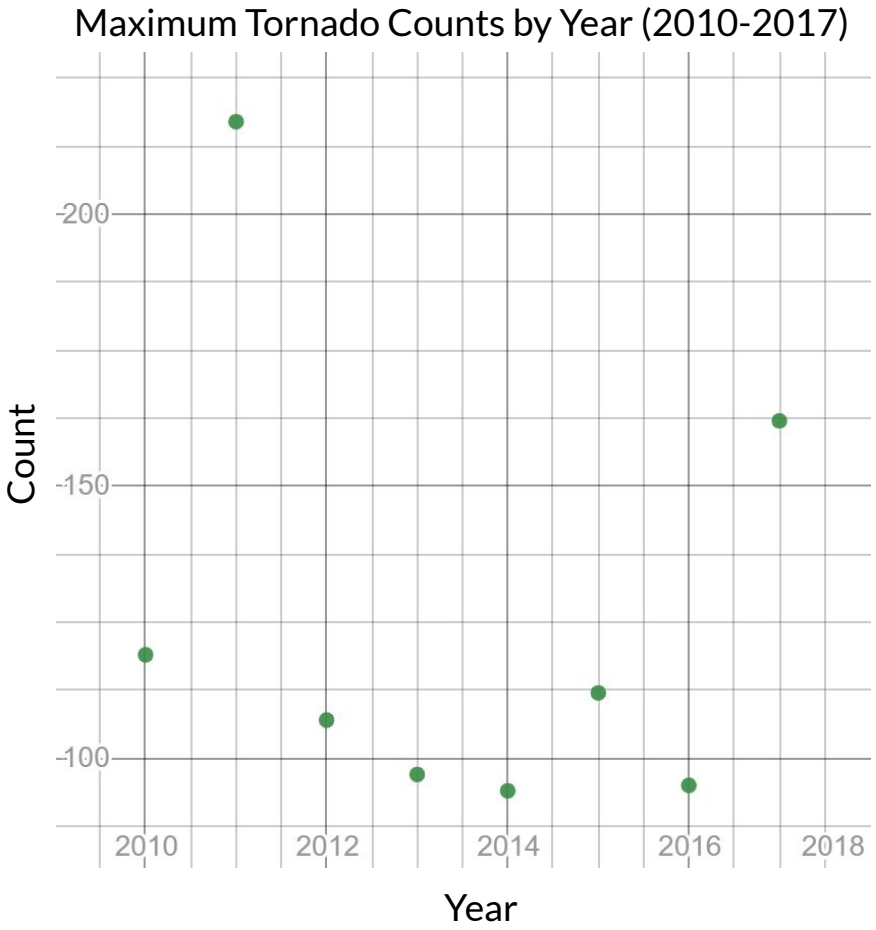

250
200
150
100
50
0
tornado count
2018
2016
2014
2012
2010
year
20
25
30
35
40
45
50
lattitude

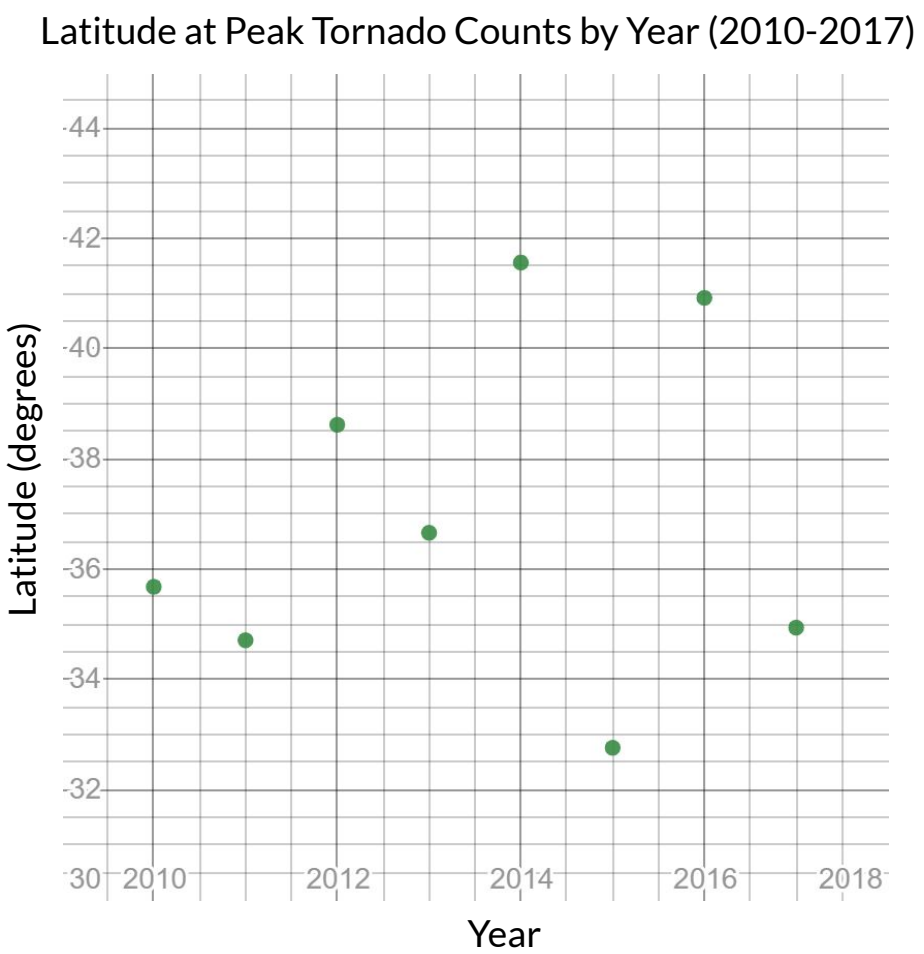
# Year VS. Year (2010-2017)

Maximum Tornado Counts and Corresponding Latitudes by Year:

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| Peak | 119 | 217 | 107 | 97 | 94 | 112 | 95 | 162 |
| Latitude | 35.68 | 34.71 | 38.62 | 36.66 | 41.56 | 32.76 | 40.92 | 32.94 |

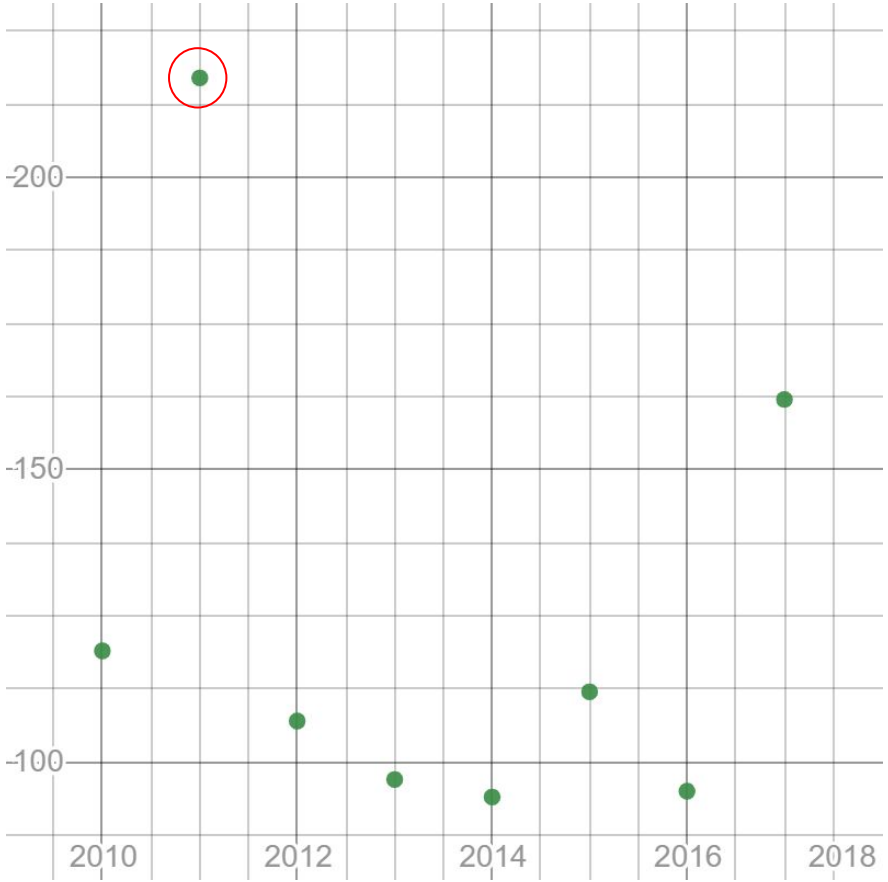
# Year VS. Year (2010-2017)



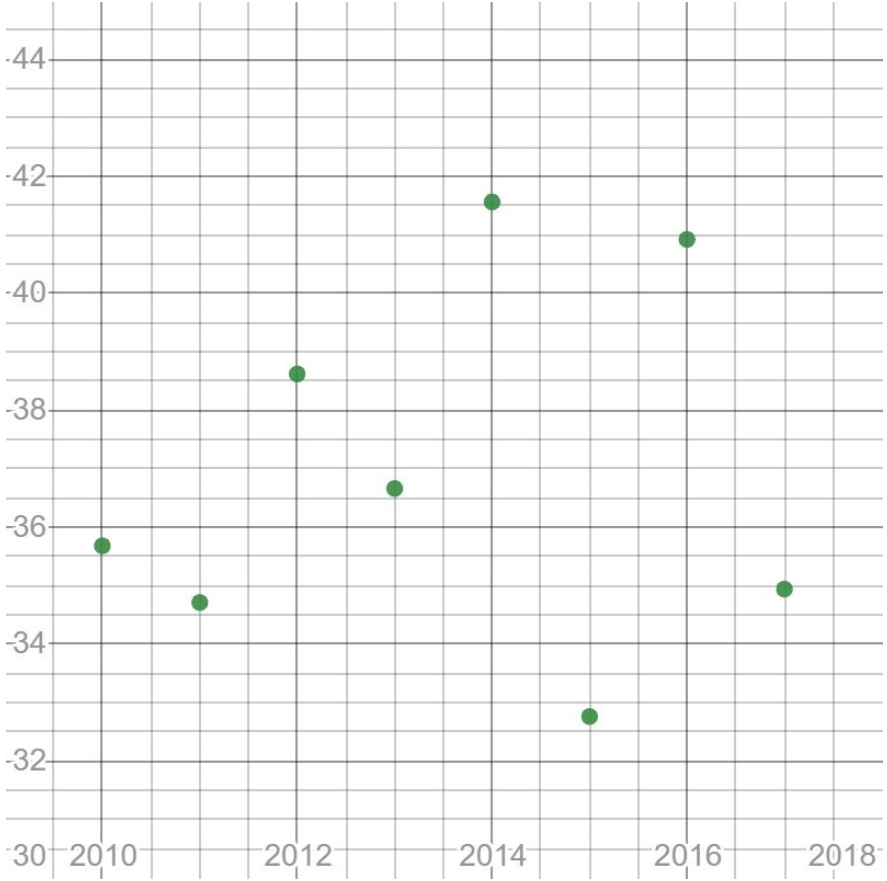



# Year VS. Year (2010-2017)

Comparison of Maximum number of Counts

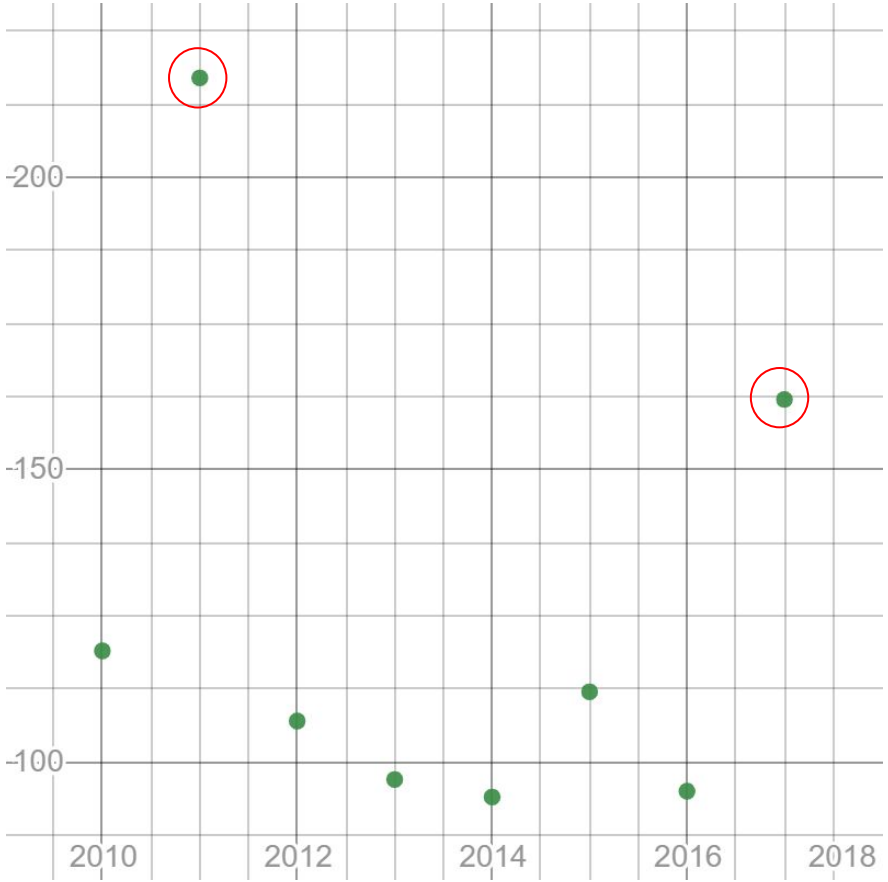



Comparison of Correlating Latitudes

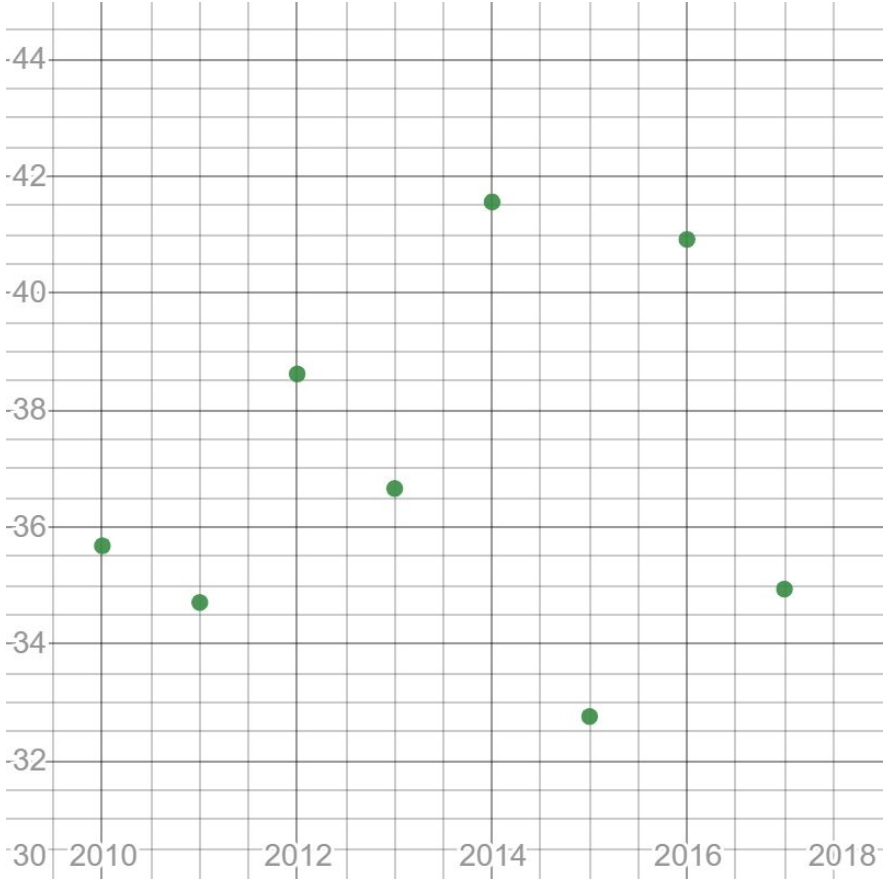


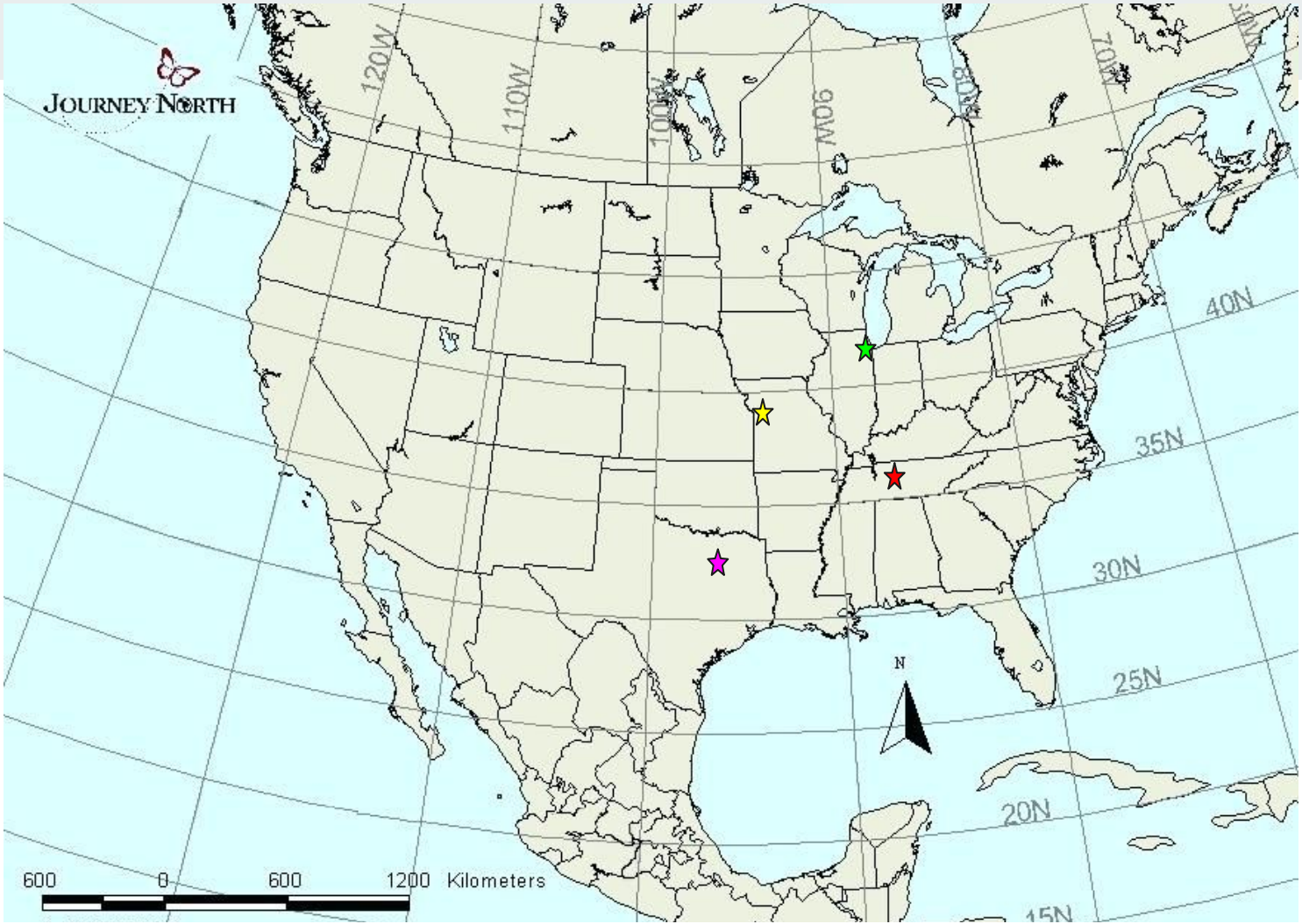
# Year VS. Year (2010-2017)

Comparison of Maximum number of Counts




Comparison of Correlating Latitudes






Pink = Dallas @ 33 degrees

Red = Nashville @ 36 degrees

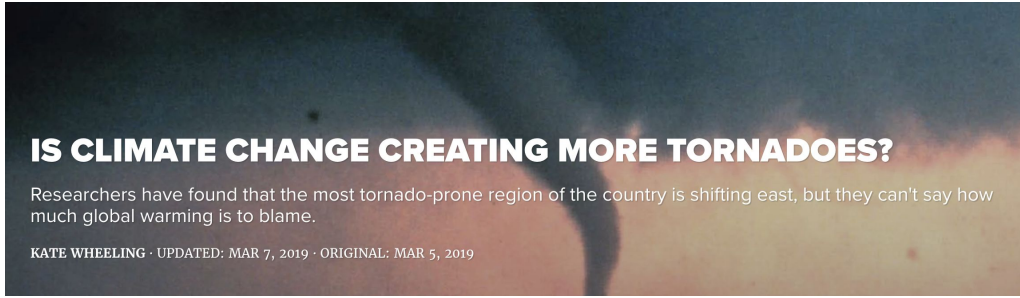
Yellow = Kansas City @ 39 degrees

Green = Chicago @42 degrees

| Yearly Maximum Degrees Latitude: |
|---|
| 33 |
| 33 |
| 35 |
| 36 |
| 37 |
| 39 |
| 41 |
| 42 |

# Further Studies

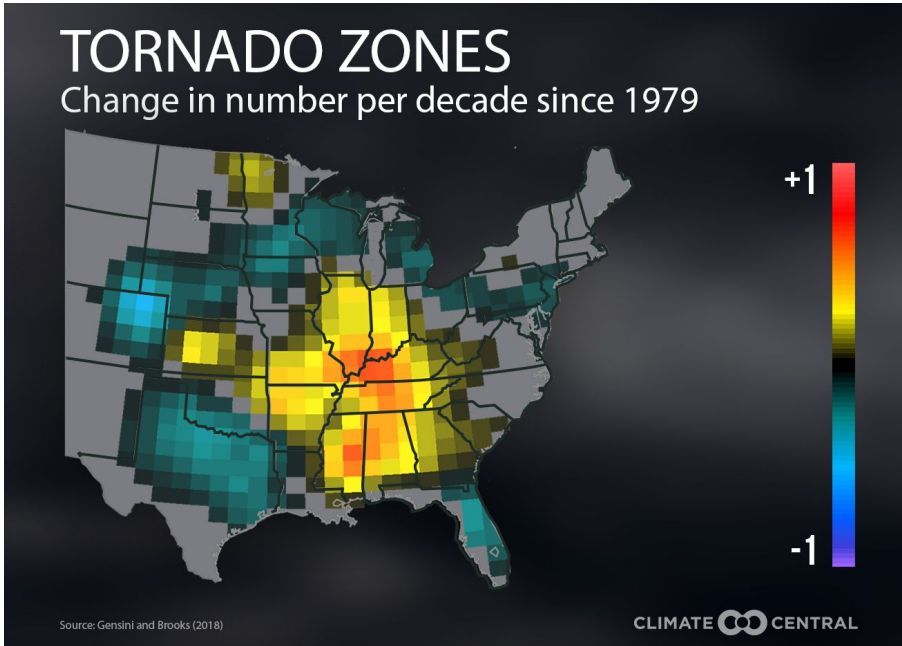
- More years to identify greater trends / patterns
- Confounding factors like observation challenges and landscape
- Separate data by:
  - distance
  - levels
- Investigate irregularities, like the low point at 36.5 in 2010 & 2011



# Further Studies

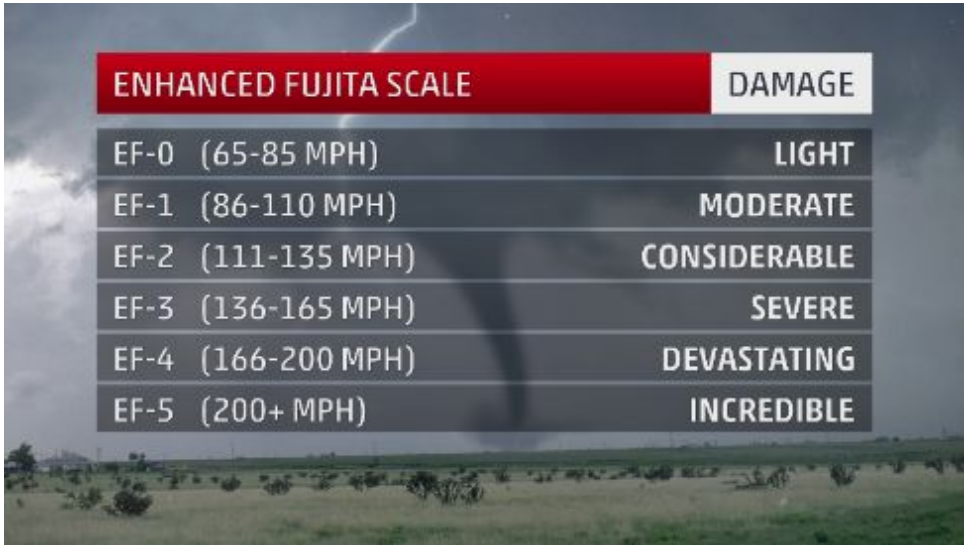
**"Tornado Alley" may be shifting to the densely-populated Southeast, study shows**

- More years to identify greater trends / patterns
- Confounding factors like observation challenges and landscape
- Separate data by:
  - distance
  - levels
- Investigate irregularities, like the low point at 36.5 in 2010 & 2011



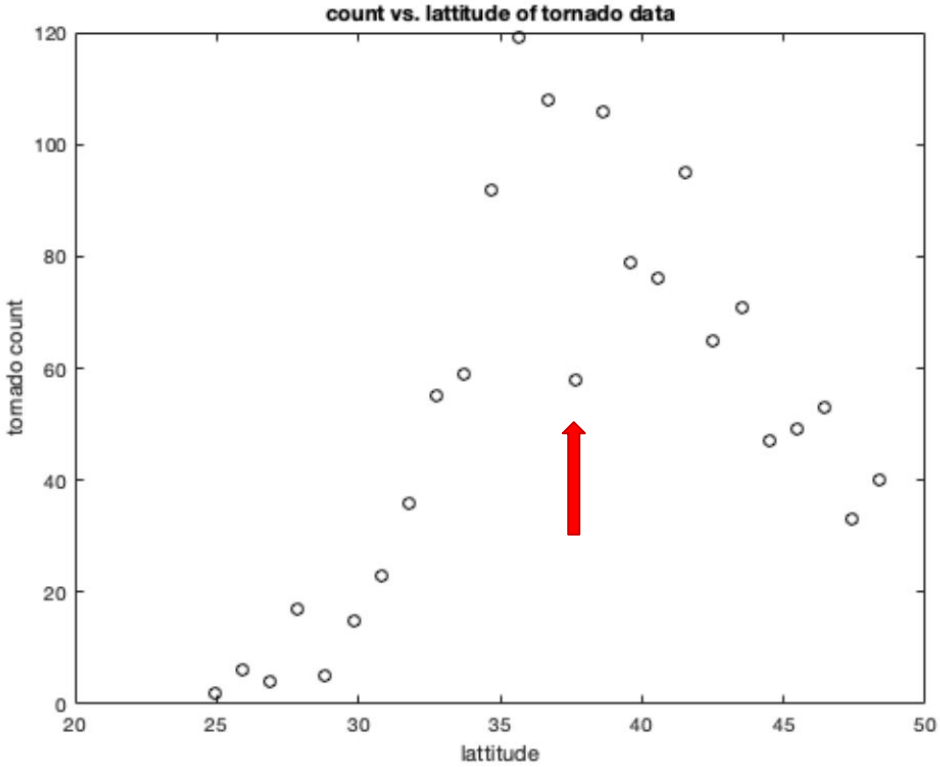
# Further Studies

- More years to identify greater trends / patterns
- Confounding factors like observation challenges and landscape
- Separate data by:
  - distance
  - levels
- Investigate irregularities, like the low point at 36.5 in 2010 & 2011



# Further Studies

- More years to identify greater trends / patterns
- Confounding factors like observation challenges and landscape
- Separate data by:
  - distance
  - levels
- Investigate irregularities, like the low point at 36.5 in 2010 & 2011



# Sources

Data

https://www.spc.noaa.gov/wcm/#data

Fitting a Polynomial / Least squares

http://mathworld.wolfram.com/LeastSquaresFittingPolynomial.html

https://neutrium.net/mathematics/least-squares-fitting-of-a-polynomial/