



Uncovering Pennsylvania's Extended Tornado Climatology

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Abstract:

Pennsylvania averages 17 tornadoes per year (1993-2022). Official records for tornadoes began in 1950. However, many tornadoes occurred before then, including the deadliest tornado to affect the state, an F4 in 1944 that killed 26 people across Washington, Fayette, and Greene Counties. Before 1950, data existed in many different publications but had never been combined into one unified database. This study documents a total of 1207 tornadoes between August 23, 1724, and April 1, 2023. A criterion was established from source data to help determine tornadic activity and uncover previously unlisted tornadoes. Newspaper reports were vital to help document these unlisted tornadoes and help accurately plot the paths of existing confirmed tornadoes. Hotspot and heat map analyses were created to highlight the areas with the greatest concentration of tornadoes. The results show that southwestern and southeastern Pennsylvania has the most concentration of tornadoes, possibly due to population biases.

Data and Methods:

Data Sources:

- Damage Assessment Toolkit (DAT)
- Storm Prediction Center (SPC) ONETOR
- Significant Tornadoes 1680-1991
- Early American Tornadoes 1586-1870
- Newspapers.com
- Weather Bureau Monthly Weather Review (MWR) 1871-1949

Data Processing:

- Pre-1950 data manually mapped in Google Earth
- Post-1950 data was imported to Google Earth as a KMZ and quality controlled.

Challenges and Corrections:

- No KMZ or reliable track data for pre-1950
- Undocumented tornadoes were found while searching the newspapers.
- Grazulis only listed/rated F2 or stronger tornadoes from 1871 to 1949
- Unrated tornadoes (1724-1949) assigned EF-scale ratings based on available damage indicators

Visualization Process:

- KMZ converted to shapefile and uploaded into ArcGIS Pro
- Hotspot analysis and heatmap were made to visualize tornado frequency

Conclusions:

Pennsylvania is a tornado-prone state. All 67 counties in the state have recorded at least six tornadoes. Westmoreland County has had at least 59 tornadoes since 1724, the most for any county in the state. Upon running a hotspot analysis, a few hotspots show where tornadoes have occurred the most. Below are the most notable hotspots in no particular order.

- Westmoreland County extending northwest into Allegheny County to Pittsburgh
- Central Beaver County
- Southeastern Mercer County, near Hermitage
- South Central Crawford County near Custards
- Eastern Erie County from Union City to Corry
- Eastern York to western Lancaster Counties near Columbia
- Bucks County
- Central Luzerne County, right over Wilkes-Barre

References:

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- Ludlum, D.M., 1970, Early American Tornadoes 1586-1870: Boston - Mass, American Meteorological Society.
- Monthly Weather Review NOAA Central Library, <https://library.noaa.gov/Collections/Digital-Collections/Monthly-Weather-Review> (accessed May 2023).
- Ncei Storm events database: National Centers for Environmental Information, <https://www.ncdc.noaa.gov/stormevents/> (accessed May 2023).
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- Storm Prediction Center maps, graphics, and Data Page Storm Prediction Center, <https://www.spc.noaa.gov/wcm/> (accessed May 2023).

Results



Figure 1: A map showing all known tornadoes in Pennsylvania from 1724-April 2023. Colors are based on rating. Green = EF-0, Blue = EF-1, Yellow = EF-2, Orange = EF-3, Red = EF-4, Purple = EF-5, Grey = EF-Unknown

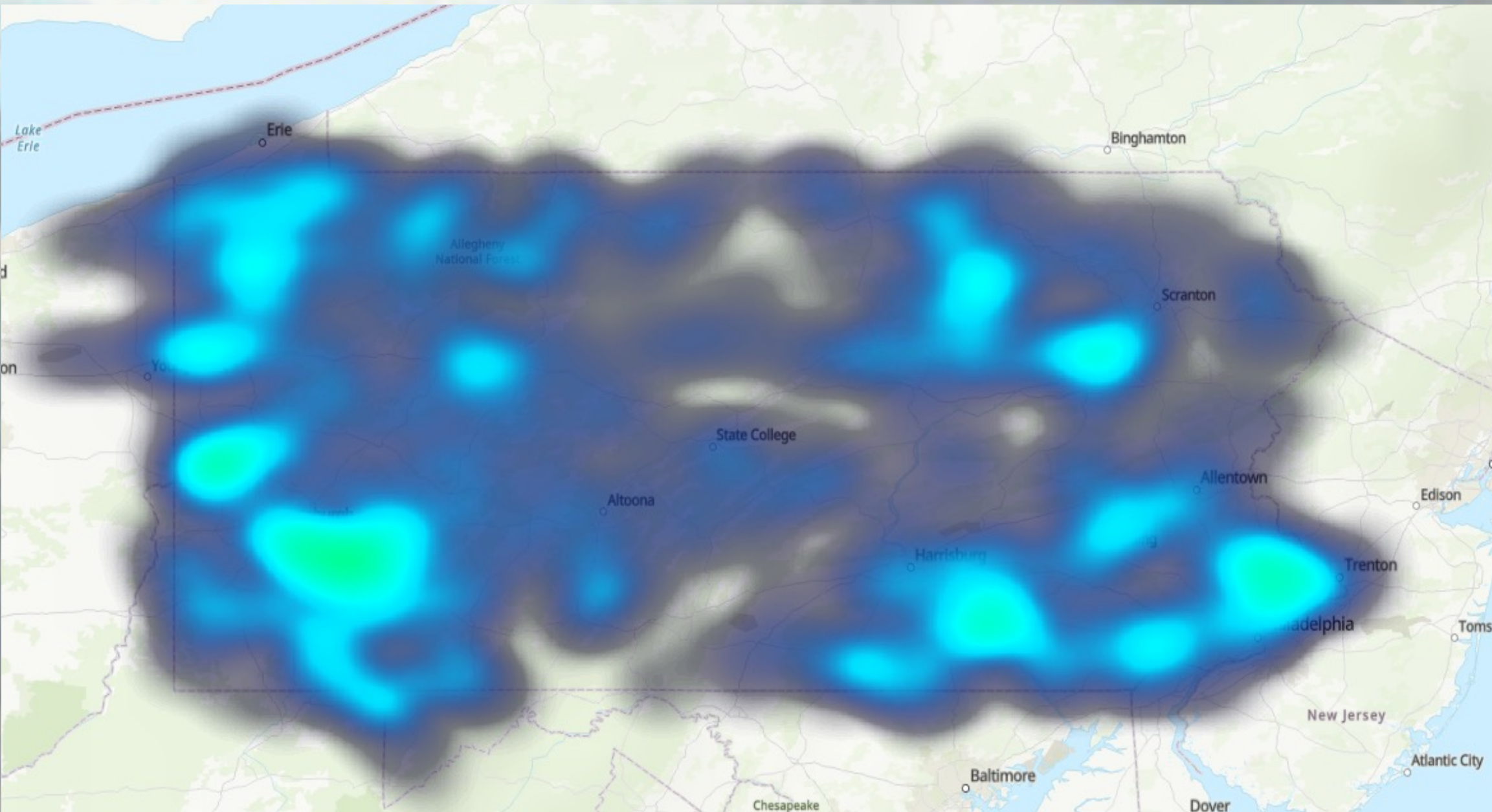


Figure 2: Heat map showing where tornadoes are most common. Brighter colors mean more tornadoes in that area.

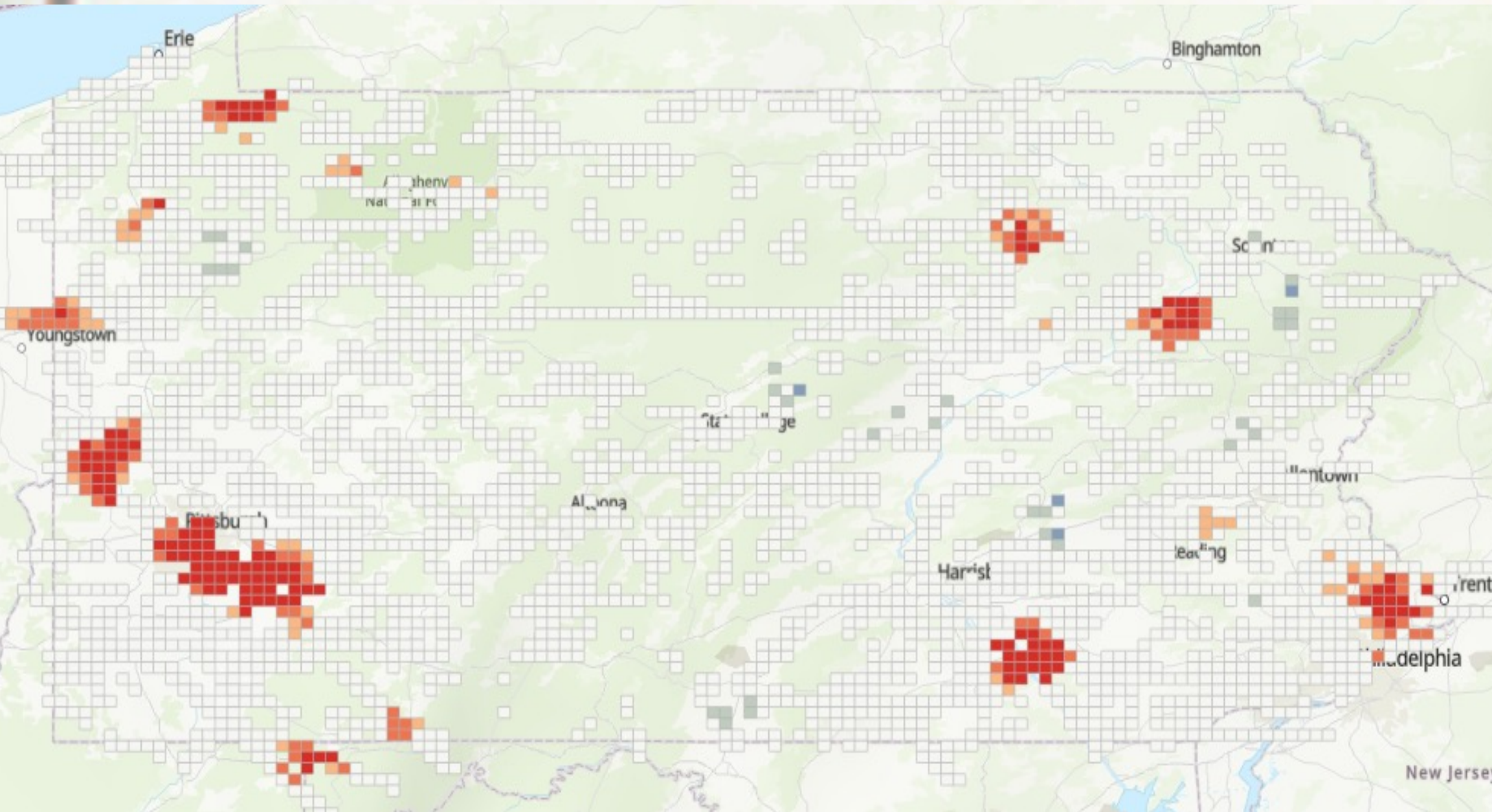


Figure 3: A hotspot map showing where tornadoes are most common. Red and orange means more tornadoes.