Societal Impacts of Tornadoes

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GEV 3760: Geospatial Applications in Environmental Science

Introduction

A hazard is something that threatens people and their possessions. Unlike a hazard, which is a potential threat, a disaster is an actual event that occurs. The intensity of a disaster is impacted by several factors including exposure, risk, and vulnerability. Together, these three things interact to produce varying scales of disasters. Disasters can threaten the ability to cope and can vary depending on the resilience of a community. In order to determine the threat of natural hazards like tornadoes to a certain community, its exposure to the hazard, the risk, and the vulnerability of the community must be considered. Exposure is measured by the number of people or items that may be impacts by a hazard. Risk, on the other hand, is the probability of a hazard occurring in a certain area. Risk considers the consequences of a hazard occurring. The addition factor to consider is vulnerability: the potential for loss. Vulnerability can come in many forms and relates to the number of resources, knowledge, or decisions available which allow communities to minimize the harm they experience.

Lit review & background research

Severe weather makes up 80% of the global cost of property insurance claims. Tornadoes are one form of severe weather prominent in the Unites States. Insurance loss data for tornadoes occurring between 1949 and 2006 shows that losses were highest in areas of the United States where tornadoes are most frequent (Changnon, 2009). It is also important to consider how property and wealth density of populations are impacted by tornadoes. For example, losses in the Midwest are relatively higher than the number of storm incidences in the area because of this (Changnon, 2009). As the spatial and temporal distribution of tornadoes in the US changes, factors like population density are important to consider when analyzing potential disaster. There is an eastward shift in tornado density maps in the US (Moore, 2019). Although the risk of severe thunderstorms changes due to climate, the exposure associated with these events is due to factors associated with changes in society and economy rather than climate (Strader, 2017).

Methods/techniques employed

To examine tornado trends in the United States, a 50-km grid was used to produce a tornado climatology for tornadoes of varying magnitudes. By filtering each climatology, we can see more broad trends regarding tornado frequency in various parts of the country. The climatology of all EF0+ tornadoes shows a visual of *all* tornadoes in the US, while the EF2+ shows only significant tornadoes, and EF4+ climatology shows just the most severe tornadoes. Societal vulnerability to tornado risk can be better understood when we examine the frequency of tornadoes in certain areas as well as the magnitude of the ones that occur. Risk associated with natural hazards like tornadoes is the potential threat they create. Exposure is a measure of how many people may be affected by a tornado that occurs.

To view how changing population dynamics can alter tornado exposure, an analysis was performed in which the tornado path from the 2011 Joplin, MO tornado was placed over the Philadelphia region. In this analysis we can see how the number of people impacted by the same tornado path can vary based on population density and location. This analysis allows us to

recognize changes in spatial trends of population density and how these changes can alter the impact of certain disasters.

Results, analyses, and findings

In my analysis, there are various ways in which we can view societal vulnerability to tornado risk. One way in which we can view tornado risk is through climatology across the United States. Figures 1 through 6 show various representations of tornado data. As shown in the climatology of all tornadoes of magnitude EF0 and greater (Figure 2), tornado risk is high in the Midwest and in the Southeast. However, when we represent only significant tornadoes of magnitude EF2 and greater (Figure 4), we can see that risk increases in the southeastern United States.

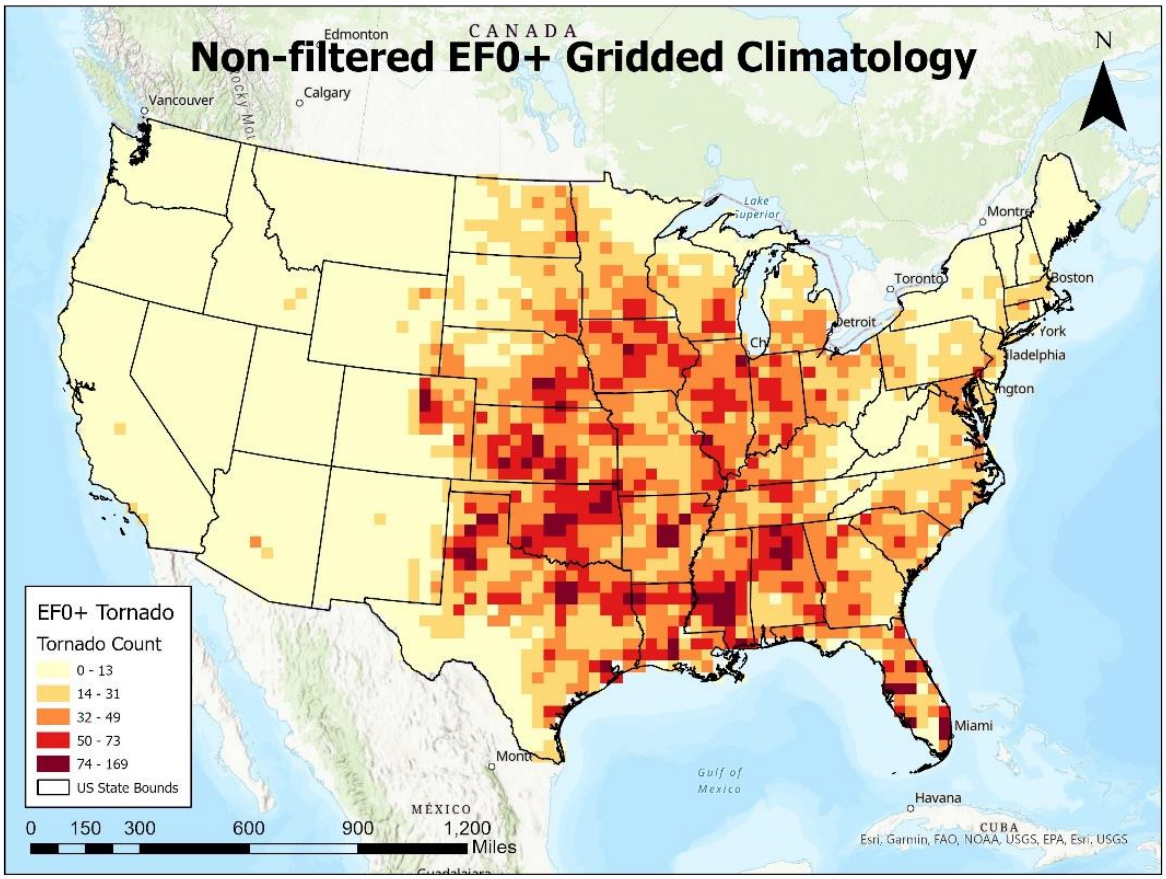

Figure 1. Number of tornadoes occurring in the US within 50-km grids from 1955-2021.

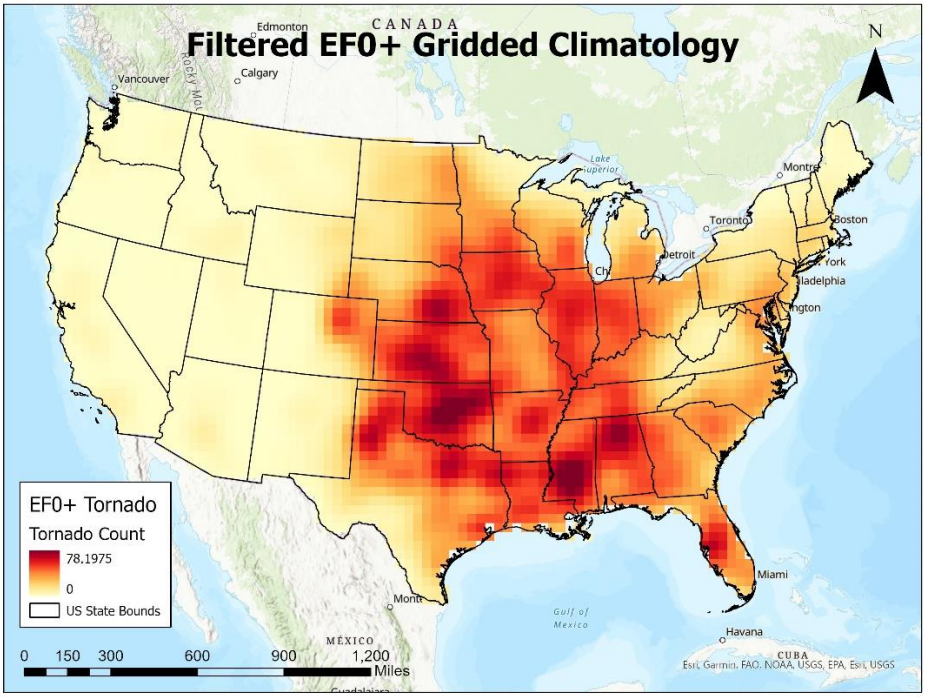

Figure 2. Tornado count between 1955 and 2021 in the US.

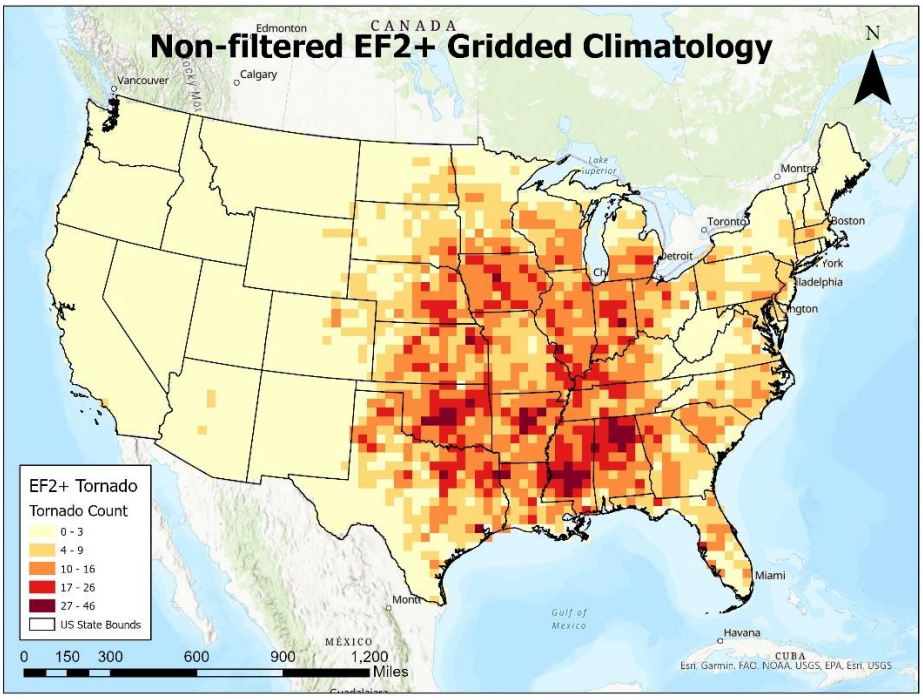

Figure 3. Number of tornadoes of magnitude EF2 or greater within 50-km grids between 1955-2021.

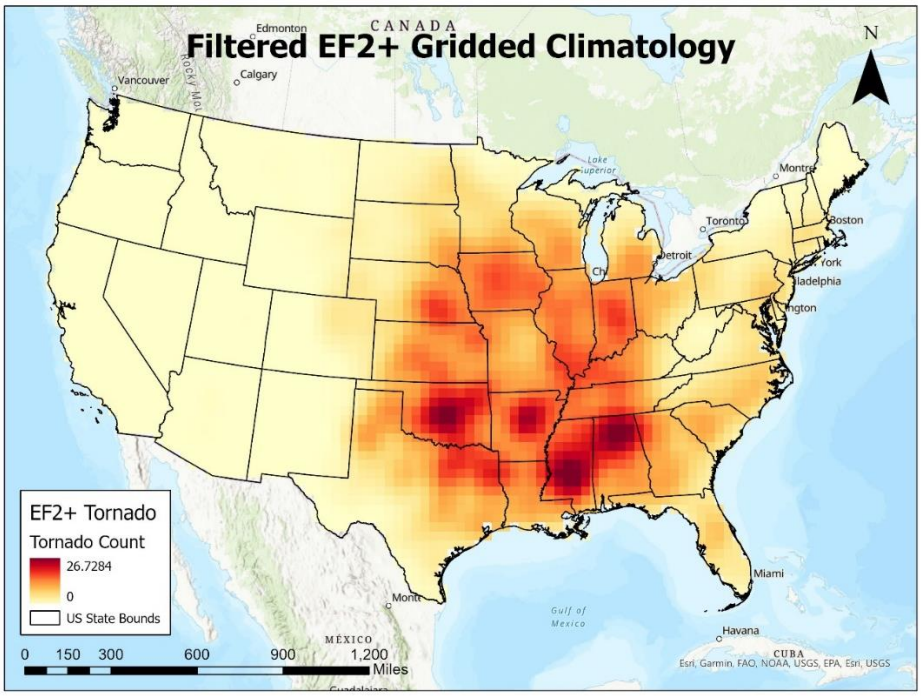

Figure 4. Smoothed representation of tornado count of magnitude EF2 or greater tornadoes across the US between 1951-2021.

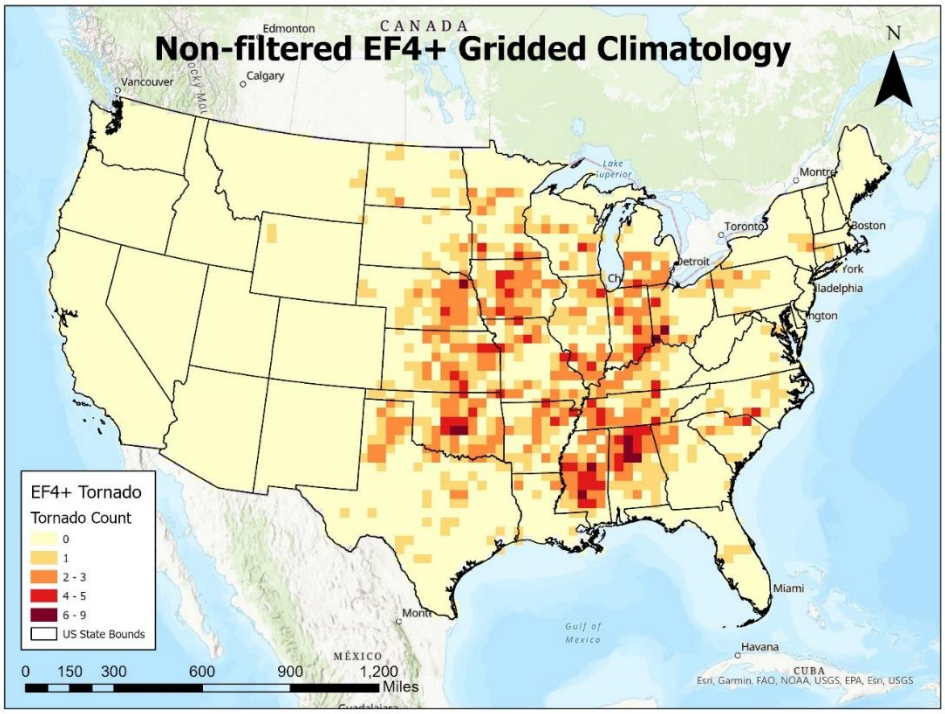

Figure 5. Number of EF4 or greater tornadoes in the US between 1951-2021 within 50-km grids.

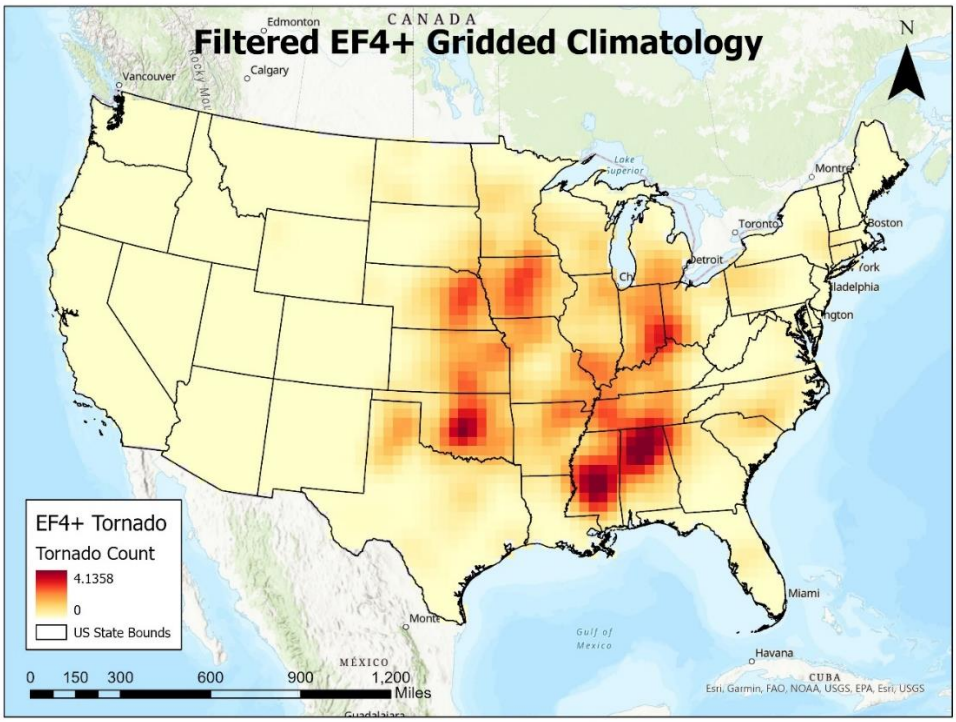

Figure 6. Smoothed representation of tornado count of EF4 and greater magnitude tornadoes in the US between 1951-2021.

Tornado exposure, as mentioned previously, has more to do with the number of people or assets in an area. One way to view changes in tornado exposure is by analyzing changes in population density. In Figure 7, the number of people who would have been impacted by this tornado path in 1990 in the suburbs of Philadelphia would have been 20,374 people. However, Figure 8 shows that the number of people who would have been impacted by this exact same tornado path would be 30,863 if it had occurred in 2020. This analysis shows how tornado exposure increases as the population density of certain areas increases. This analysis teaches us as an insurance company that the potential disasters associated with tornadoes involves more than simply the number of tornadoes that may occur in an area, but that we must also take into account the population dynamics in certain areas.

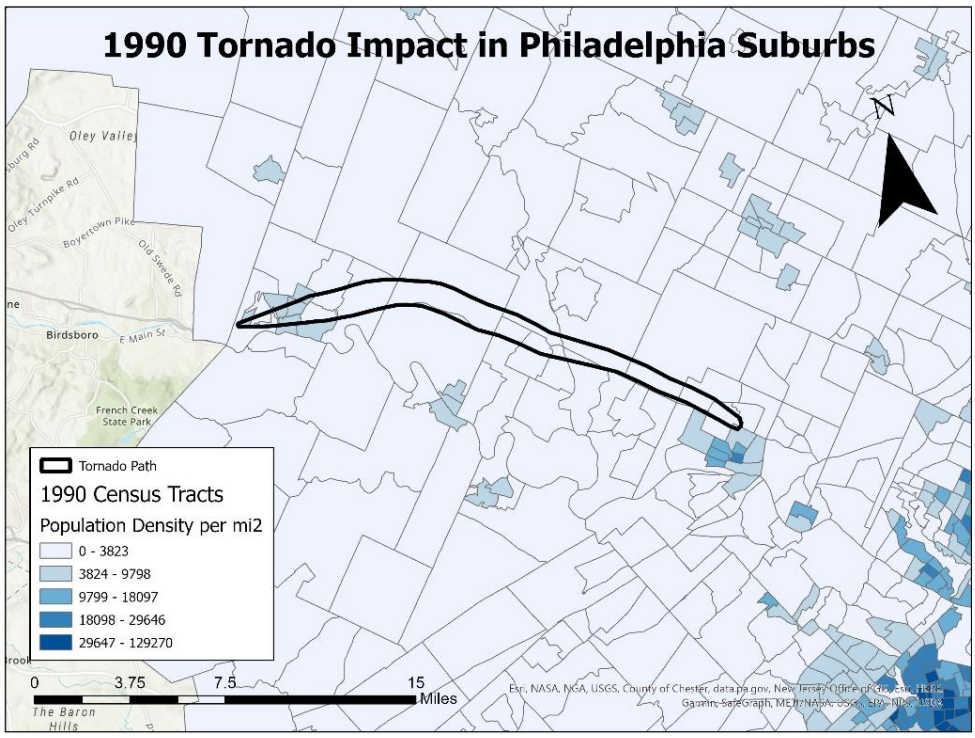

Figure 7. 2011 Joplin MO tornado path placed over Philadelphia suburb in 1990. Number of people impacted: 20,374 people

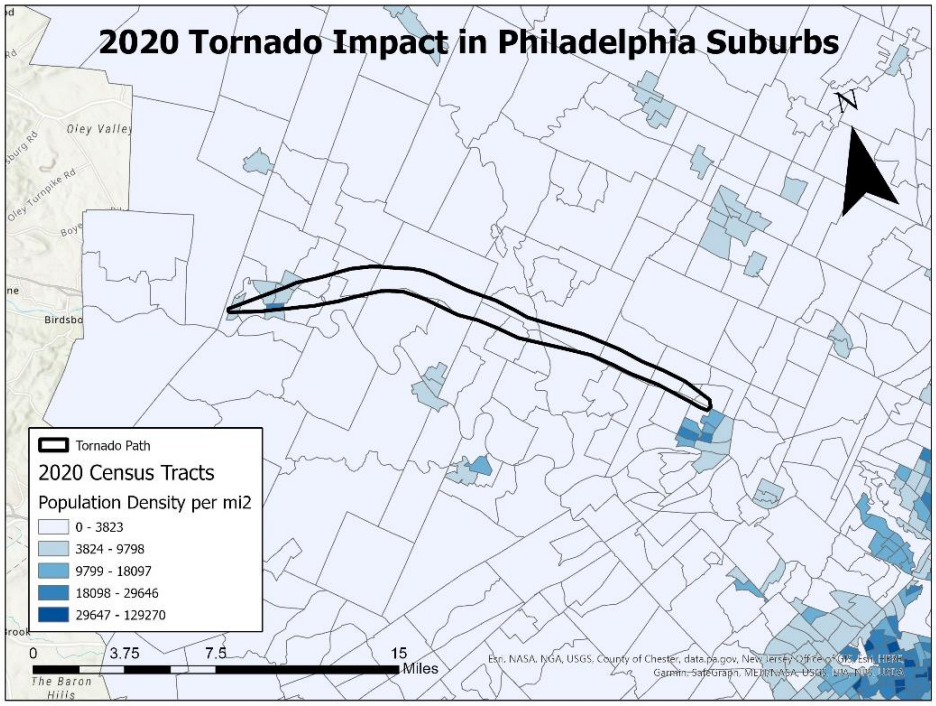

Figure 8. 2011 Joplin MO tornado path in the Philadelphia suburbs in 2020. Number of people impacted: 30,863 people

Furthering this consideration of population dynamics, tornado exposure can also be altered by trends in populations. For example, phenomenon like urban flight or suburban sprawl can leave voids in city centers. This can change the impact that severe weather events like tornadoes can have on people. In Figure 9, we can see the same Joplin tornado path placed over the downtown area of Philadelphia. In 1990, this tornado path would have impacted 150,530 people. However, as population patterns changed, Figure 10 shows us that this path would have impacted 138,247 people had it occurred in 2020. Although population in the Philadelphia region increased between 1990 and 2020, the distribution of this population changed, lessening the exposure this specific area would have been subjected to.

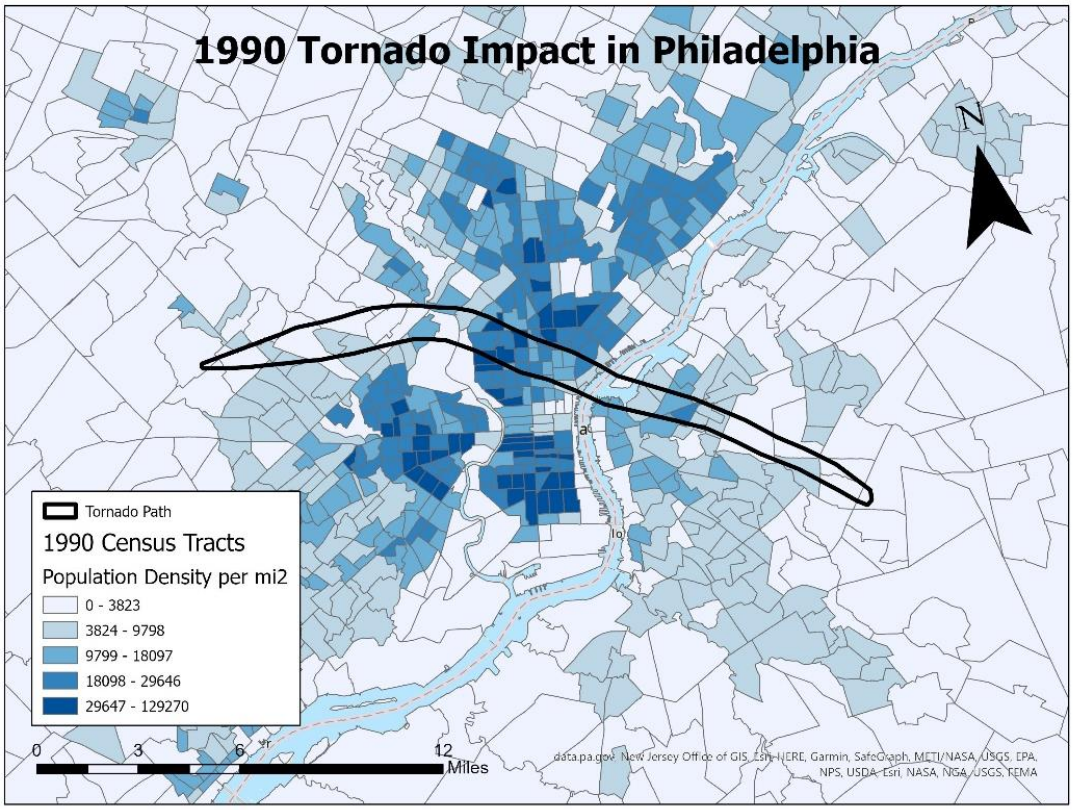

Figure 9. 2011 Joplin MO tornado path over Philadelphia in 1990. Number of people impacted: 150,530 people

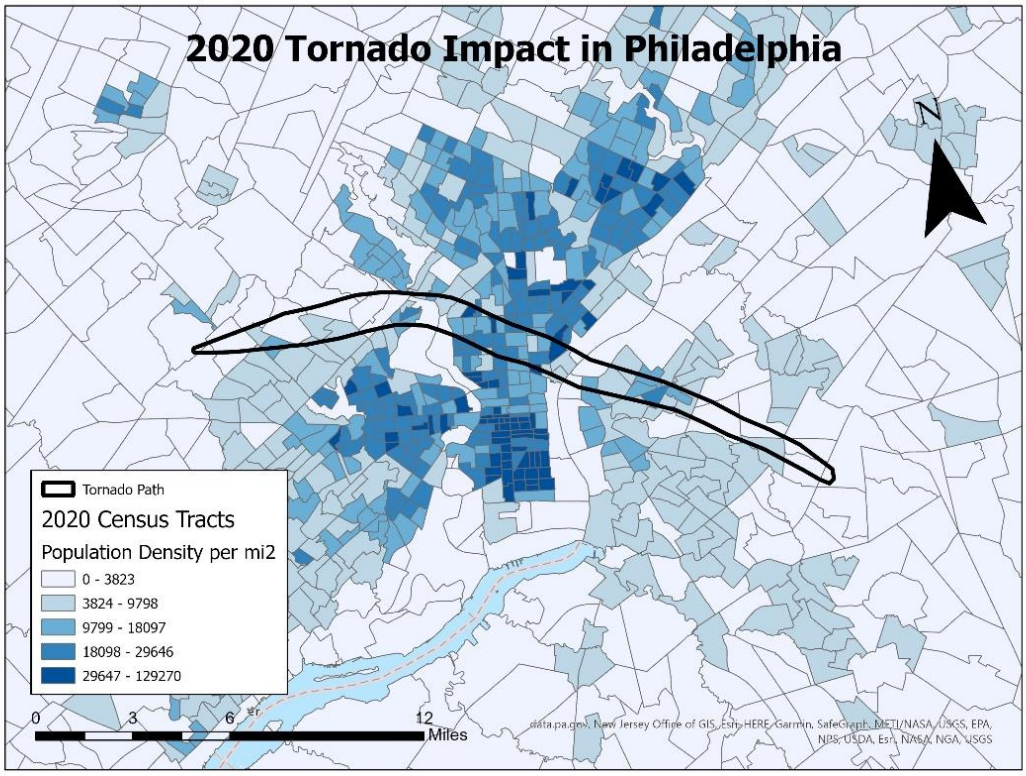

Figure 10. 2011 Joplin MO tornado path placed over Philadelphia in 2020. Number of people impacted: 138,247.15 people

Important to consider when trying to understand tornado risk in the United States is the number of tornadoes that occur. Figure 11 shows that the number of tornadoes overall seems to be increasing since 1955. However, this could be due to the fact that more tornadoes are seen and reported in recent years compared to previously. This idea is supported by the fact that the number of significant and severe tornadoes has seemed to decrease since that same time. Between 1955 and 2021, less than 1% of all tornadoes recorded in the US have been of magnitude EF4 or greater. Furthermore, as seen in Figure 12, there seems to be a slightly negative trend in the number of fatalities resulting from tornadoes since 1955.

The trends in Figure 11 show that there has been an increase in tornadoes overall from 1955 to 2021. However, when it is broken down to also show EF2+ and EF4+ tornadoes separately, we can see that there has not been an increase in significant tornadoes. This could be due partly because more tornadoes are spotted and reported in recent years compared to previously.

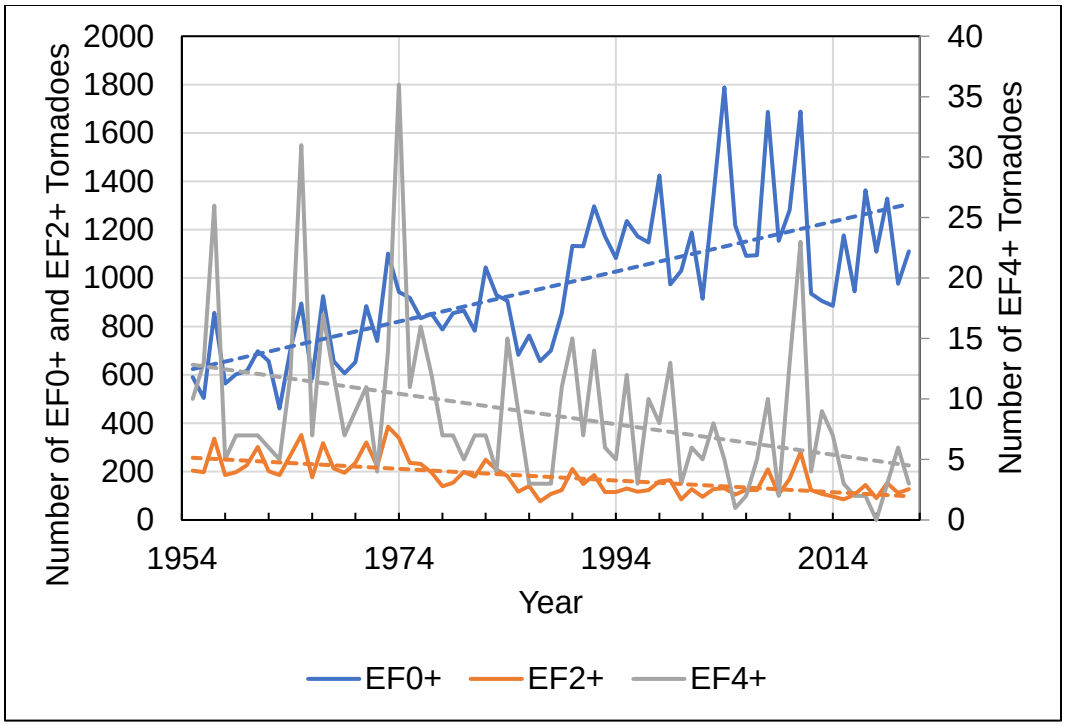

Figure 11. Number of tornadoes per year from 1955 to 2021. EF0+ line shows all recorded tornadoes. EF2+ shows only significant tornadoes of magnitude EF2 or greater. EF4+ shows the number of severe tornadoes, magnitude EF4 or greater.

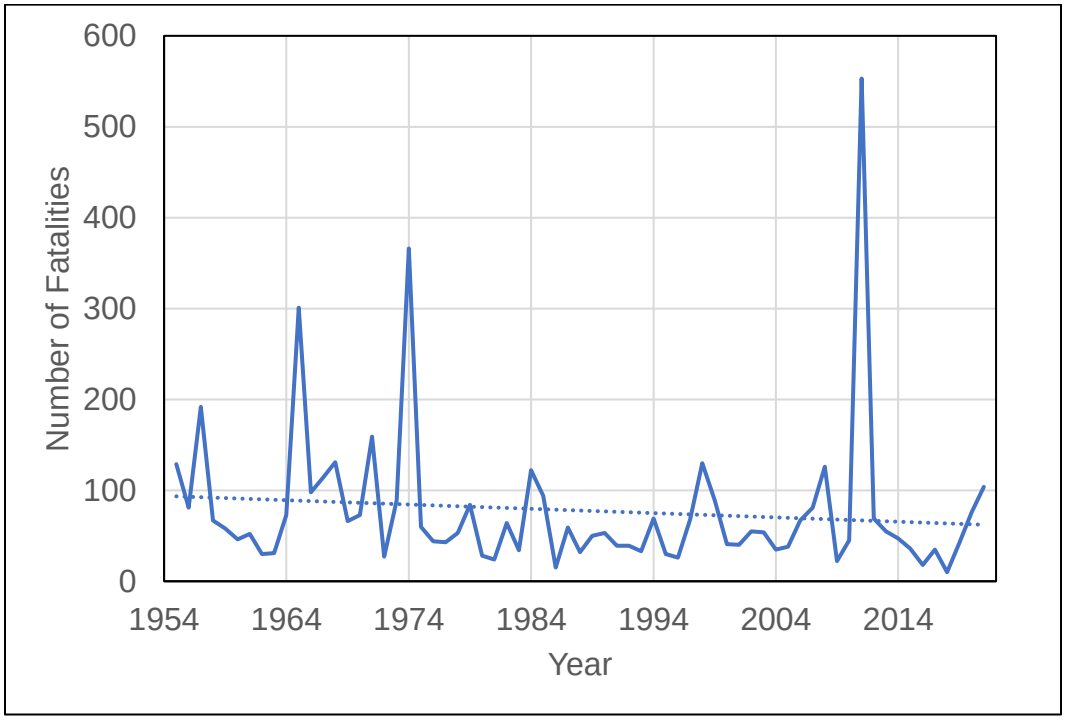

Figure 12. Number of fatalities per year that result from tornadoes.

Tornadoes are classified based on wind speeds and related damage. Figure 6 shows that severe tornadoes of magnitude EF4+ are most common in the southeast United States and Oklahoma. This could be because these areas have more people and more assets that areas in the great plains of the US. As we see in Figure 2, there are plenty of tornadoes occurring in the Midwest and the plains, but this is not where the majority of significant or severe tornadoes occur. In comparing Figures 2, 4, and 6 we can see that it may be increased exposure, meaning more people and more assets, that increase the disaster associated with tornadoes that hit in more southern parts of the US.

Conclusions and recommendations

As an insurance company, it is important to consider not just the risk associated with the number of tornadoes that occur, but also the exposure and how it can be altered by the population density of the area in which a tornado might hit. Additionally, insurance can play a very important role in decreasing the vulnerability of certain populations by increasing their ability to cope with a disaster like a tornado. Analyses like these can allow an insurance company to understand what factors can increase the intensity of a disaster. These analyses allow me to recommend that when analyzing how disasters are created, companies must consider not just risk but also exposure and vulnerability. Knowing how likely it is for a tornado to occur does not cover all of the bases in terms of predicting disaster intensity. We must analyze population dynamics, recognizing things like population density and spatial trends in these populations. Further, vulnerability can be both physical and social. In determining the potential impact of a tornado on society, we must also pay attention to social vulnerabilities including race and socioeconomic status which can both play a big part in increasing disaster risk.

Works Cited

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Moore, Todd W., and Tiffany A. DeBoer. "A review and analysis of possible changes to the climatology of tornadoes in the United States." *Progress in Physical Geography: Earth and Environment* 43.3 (2019): 365-390.

Strader, Stephen M., et al. "Projected 21st century changes in tornado exposure, risk, and disaster potential." *Climatic Change* 141 (2017): 301-313.