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Mid-South Tornado Climatology Study

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It is crucial that forecasters know when there are changes to climate, especially the climate of extreme weather phenomena. In the Mid-South, being aware of any changes in the tornado climatology will allow forecasters to provide vital, lifesaving information to those who reside in the deadliest part of the United States when it comes to tornado-related fatalities (Ashley 2008).

The primary motivation for this study is to update and enhance past research performed by Mr. Ryan Husted in 2012. The data utilized in this study span from 2007 to 2020 including all tornadoes in the National Weather Service (NWS)-Memphis County Warning Area that are stored in the NWS-Memphis tornado database (NWS 2021). Data analysis on tornadic severe weather will be conducted for events occurring since the EF-Scale was implemented (February 2007) and to enhance the past climatology study performed (Husted 2012). The past climatology study conducted terminated with tornado data in 2011, so nine new years of data will be added into this study along with the rest of the data for events that have used the EF-Scale. The next sections will discuss the data and methods used in this study, hourly distribution of tornadoes from 2007-2020, nighttime vs. daytime tornado frequency, monthly and seasonal distribution of tornadoes, EF-Scale distribution of tornadoes, frequency of outbreak vs non-outbreak days, and EF-Scale distribution of tornadoes on outbreak days vs. non-outbreak days.

Data and Methodology

Data utilized in this study are from the NWS – Memphis Tornado Database (NWS 2021). The database includes information about each tornado known to have occurred in the NWS – Memphis County Warning Area (CWA) since 1873. The database contains the start and end points of each tornado along with the damage rating, the time of each tornado, path length, and known injuries and fatalities. The time in the database is in Universal Time Coordinated (UTC) and was converted to Local Standard Time (LST) using standard conversion methods. nighttime vs. daytime classifications will be categorized as 6:00 A.M – 5:59 P.M for daytime and 6:00 P.M – 5:59 A.M for nighttime. Seasonal classifications will be based on meteorological season.

Tornadic outbreak events will be classified as six or more tornadoes on a given day. Note: Tornadoes that occurred within the same outbreak event that spanned into the previous or next day will NOT be included in the outbreak day category. Only outbreak days, not events, will be calculated in this study. For example, if eight tornadoes occurred April 1st, 2020 from 7:00-11:30 P.M, they will be used in the outbreak category. However, within the same outbreak event, if two more tornadoes occurred in the early morning hours of April 2nd, they will not be utilized in the "outbreak" classification in this study. Less than six tornadoes that occurred within the same outbreak event but on a different day will be included in the Non-outbreak category.

Hourly Distribution

Figure 1 accounts for all 276 tornadoes that occurred in the Mid-South from 2007-2020. Raw data stored in UTC (24-hour clock) was converted into LST. The data in Fig. 1 show that tornadoes occur most frequently between the hours of 5:00-6:00 P.M., in which 14.5% (40 out of 276) of the tornadoes occurred. The majority of the Mid-South's tornadoes occur in the early afternoon to evening hours from around 1:00-9:00 P.M (180 tornadoes or 65.2%) while the remaining tornadoes are somewhat evenly dispersed throughout the early morning and late-night. There seems to be a prominent drop in tornadoes in the mid-to-late morning hours of 8:00 A.M to 12:00 P.M while a considerable number of tornadoes occur in early morning hours of 12:00 – 6:00 A.M.

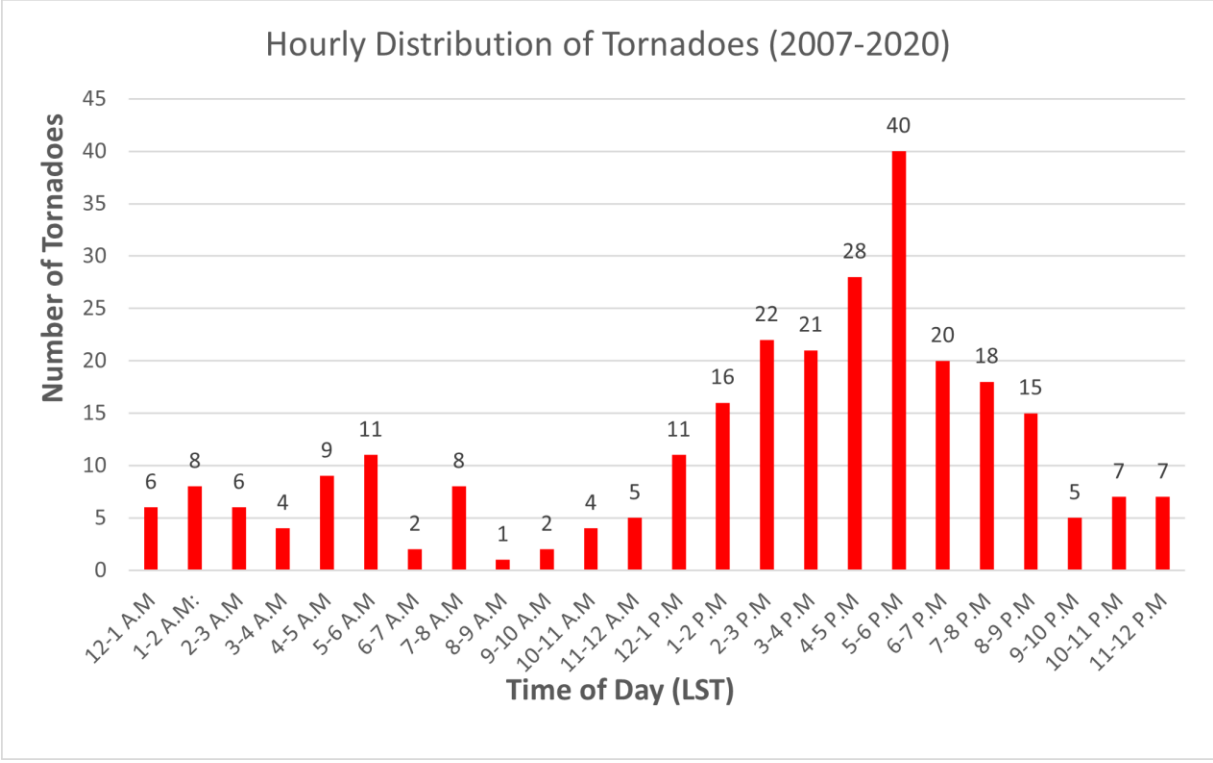

FIG. 1. Display of the hourly distribution of tornadoes in the Mid-South from 2007-2020. The number of tornadoes (vertical axis) that occurred are represented in each column of the graph based on the hour of the day they occurred in (horizontal axis.)

Nighttime vs Daytime Tornado Distribution

Based on the hourly distribution of all 276 tornadoes in the Mid-South from 2007-2020, the daytime and nighttime distribution was calculated and is shown in Fig. 2. It should be noted that a consistent time frame for evaluating daytime vs. nighttime tornado occurrences was used unchangingly throughout the year. These time classifications are from 6:00 A.M to 5:59 P.M are daytime occurrences and 6:00 P.M to 5:59 A.M are classified as nighttime occurrences. In the

Mid-South, 42% of tornadoes occur during nighttime hours, which places additional vulnerability of life and property of those within the Mid-South. Tornadoes that consistently impact the Mid-South and surrounding areas making up Dixie Alley place vulnerability upon life and property within these areas. Areas in Dixie Alley have landscape, infrastructure, and demographic vulnerabilities to severe storms (Ashley 2008). Tornadoes that occurred in the Mid-South between the hours of 10:00 P.M and 5: 00A.M are labeled as "Vulnerable Overnight Tornadoes" in this study. Seventeen percent (47/276) of tornadoes that occurred in the Mid-South from 2007-2020 occurred in this seven-hour timeframe. These 47 tornadoes place a great deal of vulnerability on the Mid-South due to many people being asleep and lacking a timely response to a weather alert via the National Weather Service or other media.

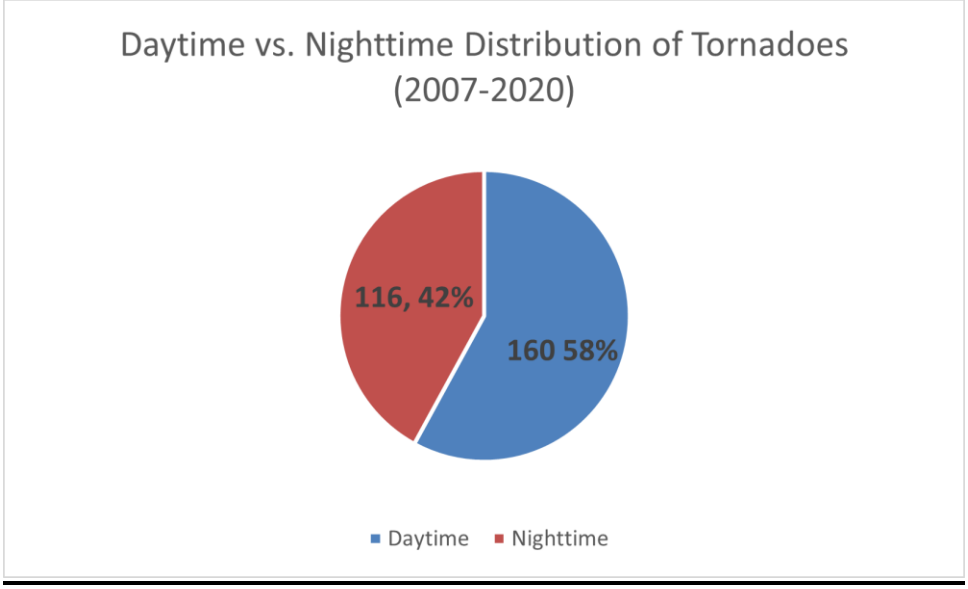

FIG. 2. Daytime vs Nighttime distribution of tornadoes in the Mid-South from 2007-2020

Monthly and Seasonal Distribution

Figure 3 displays the monthly distribution of the 276 tornadoes that the Mid-South experienced from 2007-2020. April accounts for the highest frequency of tornadoes in the Mid-South at 21% (57/276) of tornadoes over the period. April is closely followed by May which accounts for 18% (50/276) of the tornadoes. February is next with 40 tornadoes. It should be noted that, of the 40 tornadoes accounted for by the month of February, 25 of these tornadoes occurred on the "Super Tuesday" outbreak on February 5th, 2008. Disregarding this event would leave the month of February with 15 tornadoes. Behind February, the months of March and January still bring a considerable number of tornadoes, 24 and 22 respectively. It can be seen in the graph that the primary season for tornadoes in the Mid-South is the mid-to-late spring months of April and May while a noteworthy number of tornadoes frequently occur in the winter and early spring months of December through March. Tornadic activity dramatically lowers in the summer and fall months of June through November. It should also be clarified that a spike in tornadic activity in August is partly due to the outbreaks of August 31st, 2017 (seven tornadoes), and August 27th, 2020 (six tornadoes.) The seven tornadoes on August 31st, 2017 result from Hurricane Harvey, and the August 27th, 2020 outbreak is attributed to Hurricane Laura.

Based on the monthly distribution of tornadoes and the data utilized to create Fig. 3, the seasonal distribution of tornadoes in the Mid-South from 2007-2020 was calculated to create Fig. 4. Meteorological seasons were defined as **Winter** (December, January, February), **Spring** (March, April, May), **Summer** (June, July, August), and **Fall** (September, October, November). Spring leads the seasons in the highest number of tornadoes in the Mid-South accounting for 47% (113/276) of all tornadoes. Winter comes in as the second highest accounting for 29% (80/276) of tornadoes in the Mid-South. Tornado frequency dramatically drops off in summer and fall with 42 and 23 tornadoes, respectively.

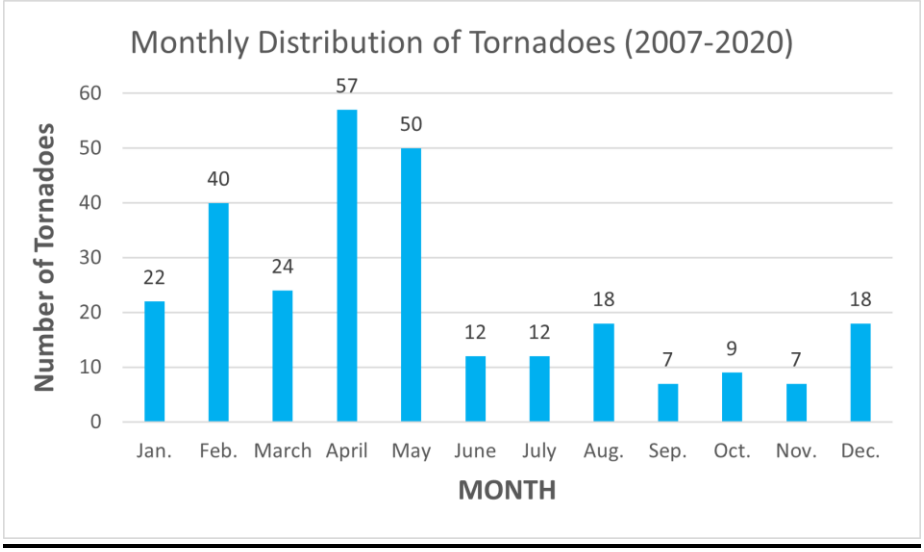

FIG. 3. Monthly Distribution of Tornadoes in the Mid-South from 2007-2020. The graph represents the frequency of tornado occurrence (vertical axis) for each month (horizontal axis.)

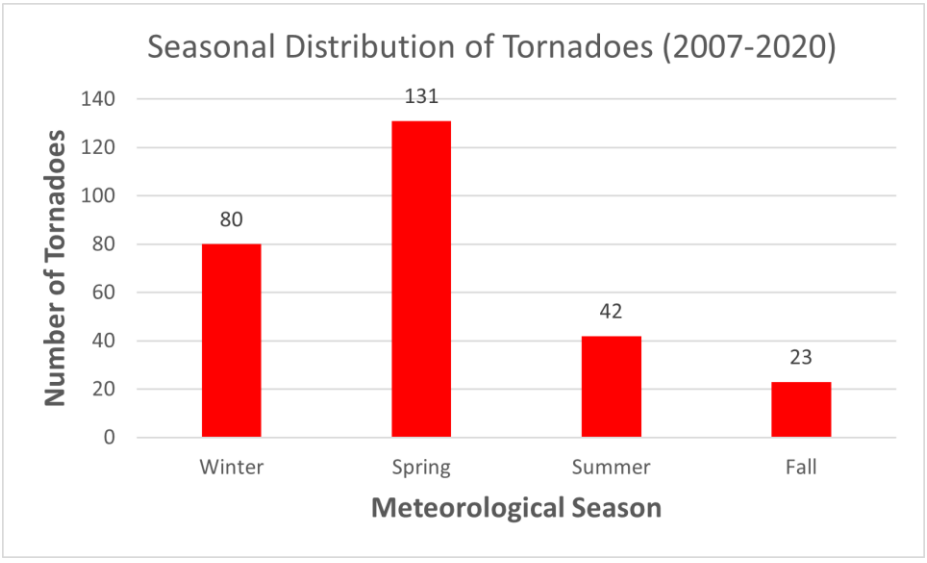

FIG. 4. Seasonal Distribution of Tornadoes in the Mid-South from 2007-2020 categorized by meteorological season. The frequency of tornadoes (vertical axis) is displayed in the chart by means of each of the four seasons (horizontal axis.)

EF-Scale Distribution

Figure 5 is a graphical display of the number of tornadoes in each EF-Scale category. The number of tornadoes in each category adopts a negative linear relationship as the EF-Scale ranking increases. Forty-five percent (125 of the 276) of tornadoes in the Mid-South were classified as EF-0 tornadoes. There a considerable amount of EF-1 and EF-2 tornadoes that contribute to the total 276. EF-3, EF-4 and EF-5 categories make up a slim portion of the tornadic activity accounting for only 5% of the total tornado occurrences in the Mid-South.

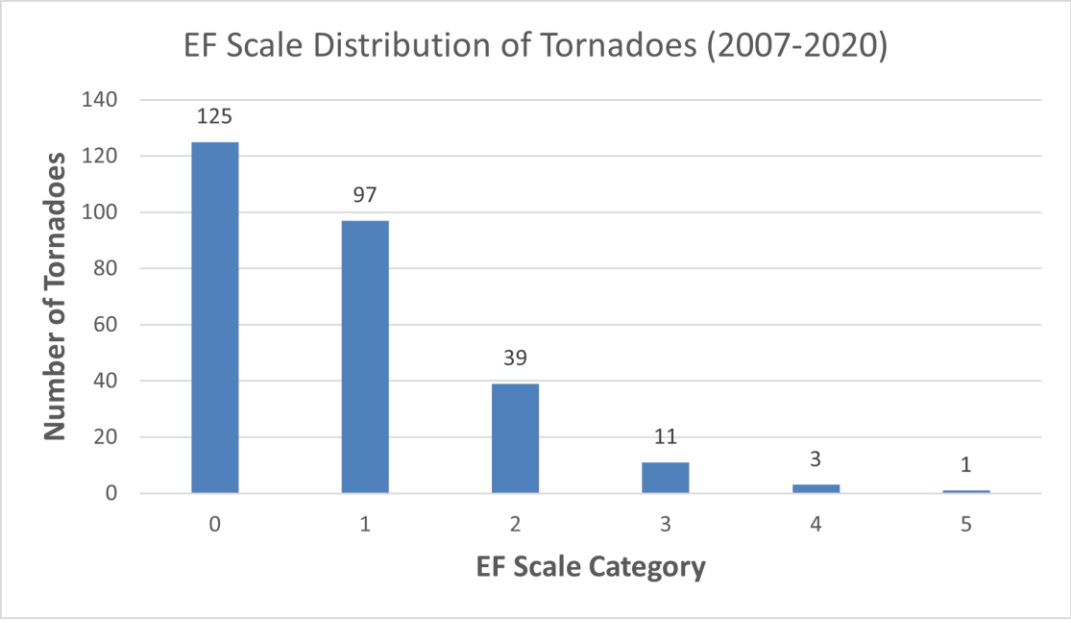

FIG. 5. EF-Scale Distribution of tornadoes in the Mid-South from 2007-2020. Each EF Scale category is represented by the horizontal axis, corresponding to the frequency of tornado occurrences within each scale category (vertical axis.)

Outbreak vs. Non-Outbreak Climatology

Outbreak Days in the Mid-South (2007-2020)

This study examined the occurrence of outbreak and non-outbreak days within the Mid-South. The 276 tornadoes that the Mid-South experienced from 2007-2020 happened over the course of 101 days equating an average of about 2.7 tornadoes per tornadic day. However, breaking these data down into individual outbreak and non-outbreak days shows that forecasters need to focus on outbreak days. In the "Data and Methodology" section of this report specifies the criteria that denotes a certain day to be either outbreak (6 or more tornadoes) or non-outbreak. The Mid-South tornado database has 90 non-outbreak days and 11 outbreak days. On non-outbreak days, 59.8% (165/276) of tornadoes occurred. In contrast, 40.2% (111/276) of the tornadoes occurred on the 11 outbreak days.

Figure 6 represents the total number of tornadoes and the percentage the non-outbreak and outbreak days. However, this figure does not consider the relative frequency of the outbreak vs non-outbreak days. Even though 165 (59.8%) of tornadoes occurred on non-outbreak days while 111 (40.2%) of them occurred on outbreak days, the number of days in each category is not accounted for. In order to normalize the data, the total number of tornadoes was divided by the number of days (outbreak or non-outbreak days) to calculate the data shown in Fig. 7. The normalized numbers show there is an average of 1.8 tornadoes (165/90) on non-outbreak days and an average of 10.1 tornadoes (111/11) on outbreak days. This normalized data clearly shows that outbreak days are a significant contributor to the number of tornadoes the Mid-South receives. To put it in perspective, in the past thirteen years, 111 of the total 276 tornadoes the Mid-South occurred only on 11 days. So, even though the majority occur on non-outbreak days, that can be assumed because 89% of the total days in question are non-outbreak days. The remaining 11% of days are outbreak days which accounts for 40.2% of the tornadoes in the Mid-South since 2007.

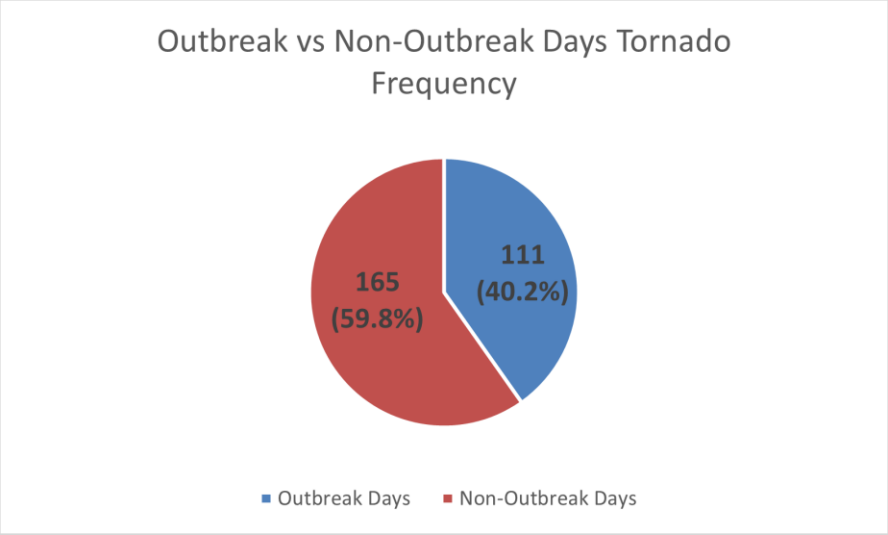

FIG 6. Display of the 276 tornadoes from 2007-2020 in terms of outbreak and non-outbreak days. 165 occurred on non-outbreak days while 111 occurred on outbreak days.

EF-Scale Distribution | Outbreak vs Non outbreak Days

Figures 8 and 9 visualize the EF-Scale distribution of tornadoes in the Mid-South regarding both outbreak and non-outbreak days separately. There are almost double the number of EF-0 tornadoes on non-outbreak days than outbreak days. (80 on non-outbreak days and 45 on outbreak days) A similar trend can be found within the EF-1 category with 59 occurring on non-outbreak days and 38 on outbreak days although the difference is less dramatic. The trend starts to shift when viewing stronger tornadoes. In the EF-2 category, there are only three more in the non-outbreak (21) than in the outbreak category (18.) This is notable because there are considerably more non-outbreak days than outbreak days. There are more EF-3, EF-4, and EF-5 tornadoes on outbreak days than on non-outbreak days. The outbreak days account for seven EF-3 tornadoes, two EF-4 tornadoes, and one EF-5 tornado (the only the past 14 years.) This

contrasts with the non-outbreak category that accounted for only four EF-3 tornadoes, one EF-4, and no EF-5 tornadoes. These trends in data are notable given that almost 90% of tornadic activity days are non-outbreak days. The majority of our higher EF-Scale rated tornadoes (EF-3+) occur on outbreak days.

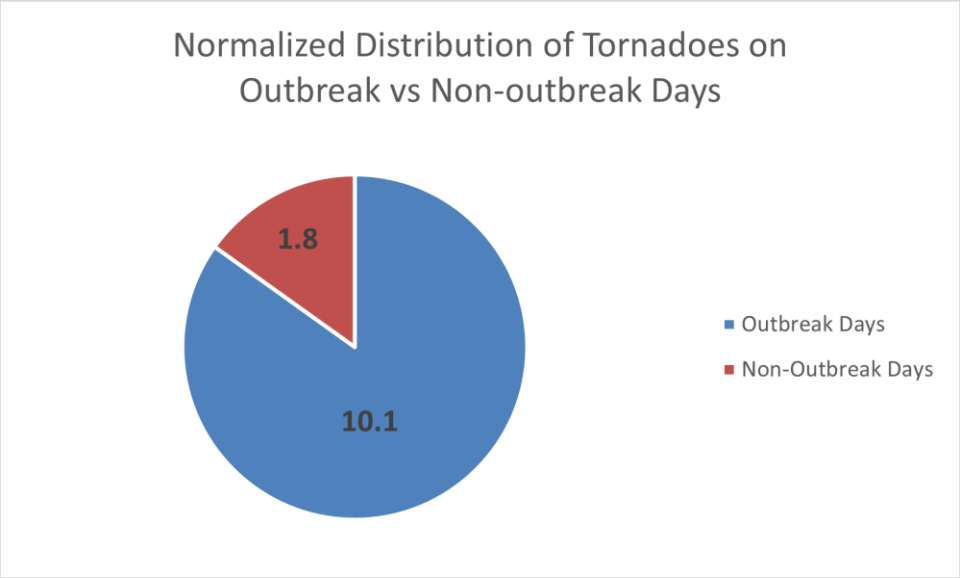

FIG. 7. Normalized number of tornadoes per tornadic day in the Mid-South from 2007-2020 in terms of outbreak vs non-outbreak days.

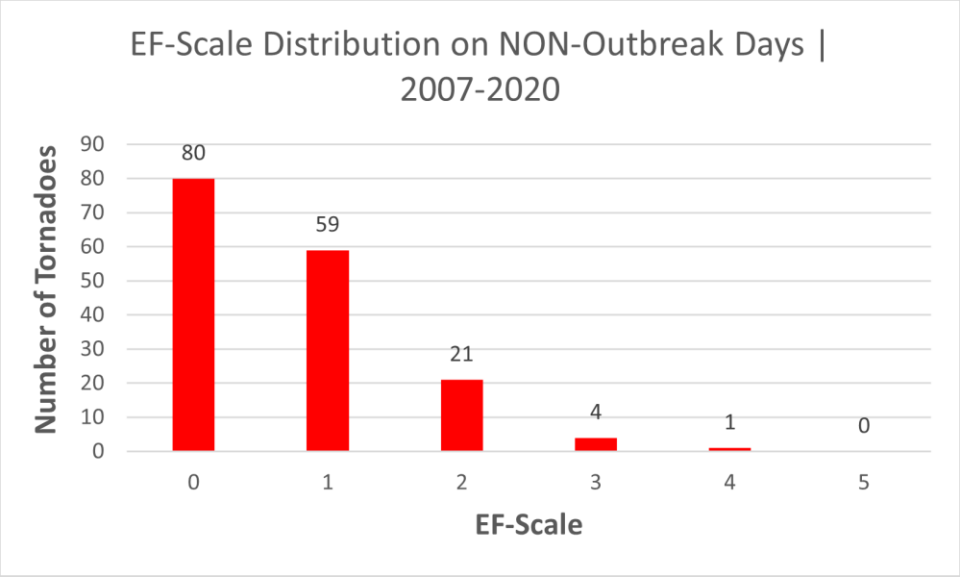

FIG 8. EF-Scale Distribution of tornadoes in the Mid-South from 2007-2020 on non-outbreak days only.

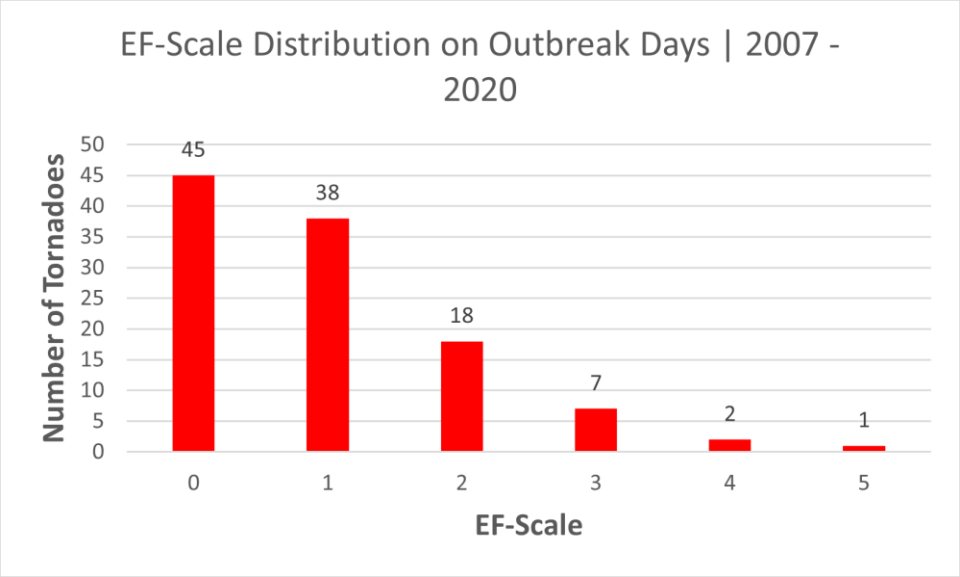

FIG 9. EF-Scale Distribution of tornadoes in the Mid-South from 2007-2020 on outbreak days only.

Summary and Key Takeaways

With the introduction of new technology, the implementation of the EF-Scale tornado classification system, and the importance of severe weather preparedness in the Mid-South, there is undoubtedly reason for an updated climatology study on tornadic activity. Before comparisons and trends can be distinguished from new parameters and datasets with past reports, accurate data acquisition and representation must be performed. It is the hope of this study that forecasters, proper authorities, and the public can be more informed to help preserve the life and property of those residing in the Mid-South. Forecasters will undoubtedly utilize new and updated data to shape their understanding of severe weather and the future trends it may take.

Tornado outbreak days have a big impact on the Mid-South as shown in this study. One-hundred eleven tornadoes occurred on only 11 days within the past thirteen years. The “Super Tuesday” outbreak of February 5, 2008 accounts for 25 of these tornadoes, still leaving a large portion of tornadoes accounted for by the other outbreak days. This study shows the importance of these days that could potentially bring harm to residents of the Mid-South that are already particularly vulnerable to tornadic activity. EF-Scale distribution of outbreak days shows that more strong and violent tornadoes occur on these days. Providing updated data could directly impact the lives of those in the Mid-South. The NWS relies on such data to provide severe-weather analysis and outreach.

References

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