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Case Study of the 12 April 2020 Tornado Outbreak over the Southeastern U.S.

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by

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Abstract

This project consisted of a case study of the tornado outbreak that occurred on Easter Sunday, April 12, 2020 in the Southeastern United States. The main storm feature was an intense Quasi-Linear Convective System (QLCS, or squall line), but isolated supercell tornadoes also occurred. One goal of the project was to track the duration of each QLCS mesovortex (MV) to see if MV length had an effect on tornado production. A mesovortex is an area of rotating low pressure that is embedded at some point along a line of storms, and it can produce tornadoes (Weisman and Trapp 2003). Another goal was to examine the diameter of the circulation and magnitude of wind speeds associated with each tornado and determine whether or not circulation size plays a role in tornado size or strength. Promising results were found that support a theory that smaller, tighter circulations produce stronger tornadoes due to conservation of angular momentum.

Introduction

Easter Sunday 2020 is a day not many in the southeast US will forget soon. Tornadoes occurred in six different states, and four additional states were affected the next day. There were at least 140 tornadoes total over the two days. The first tornadoes touched down in eastern Texas just after 1400 UTC (9 AM CDT) on the 12th, and the last touched down just before 1930 UTC (3:30 PM EDT) on the 13th in Maryland. This study focused on the tornadoes in Texas, Louisiana, Mississippi, Alabama, northwest Georgia, and southeast Tennessee. Most of these tornadoes were produced by the QLCS, but some strong ones were produced by supercells in southern Mississippi. This severe weather outbreak also included widespread hail, wind, and flooding, and caused 3.5 billion dollars' worth of damage according to NOAA National Centers for Environmental Information (NCEI 2021).

Data and Methodology

Web pages from the affected National Weather Service (NWS) County Warning Areas (CWAs) about the event were utilized to gain an understanding of the tornadoes that occurred and about the event itself. An Excel spreadsheet database was created to collect information about the tornadoes in one place. This information included counties/parishes and states each tornado went through, start and end times, maximum path width and length, rating on the Enhanced Fujita (EF) Scale, and the NWS CWAs affected. Radar imagery on the UCAR Mesoscale and Microscale Meteorology Laboratory (MMM) and Iowa Environmental Mesonet (IEM) websites was analyzed to determine the parent storm type, QLCS or supercell, of each tornado and a column for that was added to the database. Statistical plots were created in order to compare various characteristics.

A map was created in ESRI ArcMap of the tornado tracks, color-coded by EF rating. PDF editing software was used to number the tornado tracks in chronological order and to further color-code by separate MVs. Color-coding was added to the database to match the map. GR2Analyst was used to analyze base reflectivity, base velocity, and Correlation Coefficient (CC) data to determine which tornadoes were caused by which MV. CC is used to locate concentrated areas of debris being lofted into the air by tornadoes. A Tornado Debris Signature (TDS) will appear as an area of low CC values. QLCS tornadoes are often difficult to locate in reflectivity so velocity and CC are relied on more heavily. Radar data from the NWS WSR-88D radars in Shreveport, LA, Jackson, MS, Columbus, MS, Mobile, AL, Montgomery, AL, Birmingham, AL, and Hytop, AL were used to cover the entire area where the tornadoes occurred.

GR2Analyst was also used to measure the diameter of the circulation (velocity couplet) for each tornado, as well as the maximum outbound and inbound velocity. This was done using the base velocity product. Those values were also recorded in additional columns in the database. Base velocity shows wind speed and the direction of the wind relative to the radar. Winds flowing away from the radar are typically depicted by warm colors (i.e., red, orange, yellow) and are associated with positive values, and winds flowing towards the radar are typically depicted by cool colors (i.e., green, blue) and are associated with negative values. The maxima were determined by locating the pixel on each side of the velocity couplet with the highest absolute value. The inbound values were subtracted from the outbound values in order to get the wind speed difference (Δv), which is a way to tell the strength of the circulation. The diameter was measured between the two maxima in order to remain consistent. More plots were created with this data.

Results

It was found that out of the 67 tornadoes analyzed, seven were from supercells and the other 60 were produced by the QLCS. One QLCS MV produced a swath of tornadoes from eastern Texas all the way to northwestern Georgia. This MV, the longest lived of the day, produced 36 tornadoes. Another MV produced two EF1 tornadoes, one on either side of the Texas-Louisiana border. As the first MV was approaching the Mississippi-Alabama border, supercells started forming in southern Mississippi. The first supercell tornado, rated EF4, tracked for over 21 miles before briefly lifting and touching down again as a new EF4 tornado which tracked for just over 68 miles. This was the most notable tornado of the day, having caused eight deaths and around 100 injuries as it decimated several Mississippi towns. It claimed the record for widest tornado in Mississippi history (NWS Jackson 2020). While that tornado was in progress, another supercell formed an EF3 tornado that tracked for over 84 miles a short distance north of its path. Both of these supercells produced additional, weaker tornadoes once the stronger ones lifted. After the first MV stopped producing tornadoes once it got to northwestern Georgia, there were no tornadoes for about 40 minutes until a new MV started producing tornadoes in western Alabama. This MV produced seven tornadoes across north-central Alabama, just north of the path the first MV took. While the new MV was progressing across Alabama, one started just south of the two MV tracks, in Tuscaloosa County, producing one EF1 tornado before making its way into northwestern Georgia where it produced four more tornadoes. While both of those were in progress, another MV produced four tornadoes in the southwestern part of Alabama and a cell embedded in the line produced one in Perry County. A supercell located out ahead of the main line of storms produced a tornado in Murray County, Georgia, just after the Tuscaloosa County tornado lifted. Adding on to all of those systems in progress, yet another MV started producing tornadoes starting in northeastern Alabama, going through the northwest corner of Georgia, and into southeastern Tennessee. This system produced five tornadoes, including an EF3 that went through eastern Chattanooga. Based on all of these events, it can be clearly inferred that longer-lasting MVs tend to produce more tornadoes, since they have more time to develop them.

Figure 1 shows a map of the tornado tracks as described in the previous section.

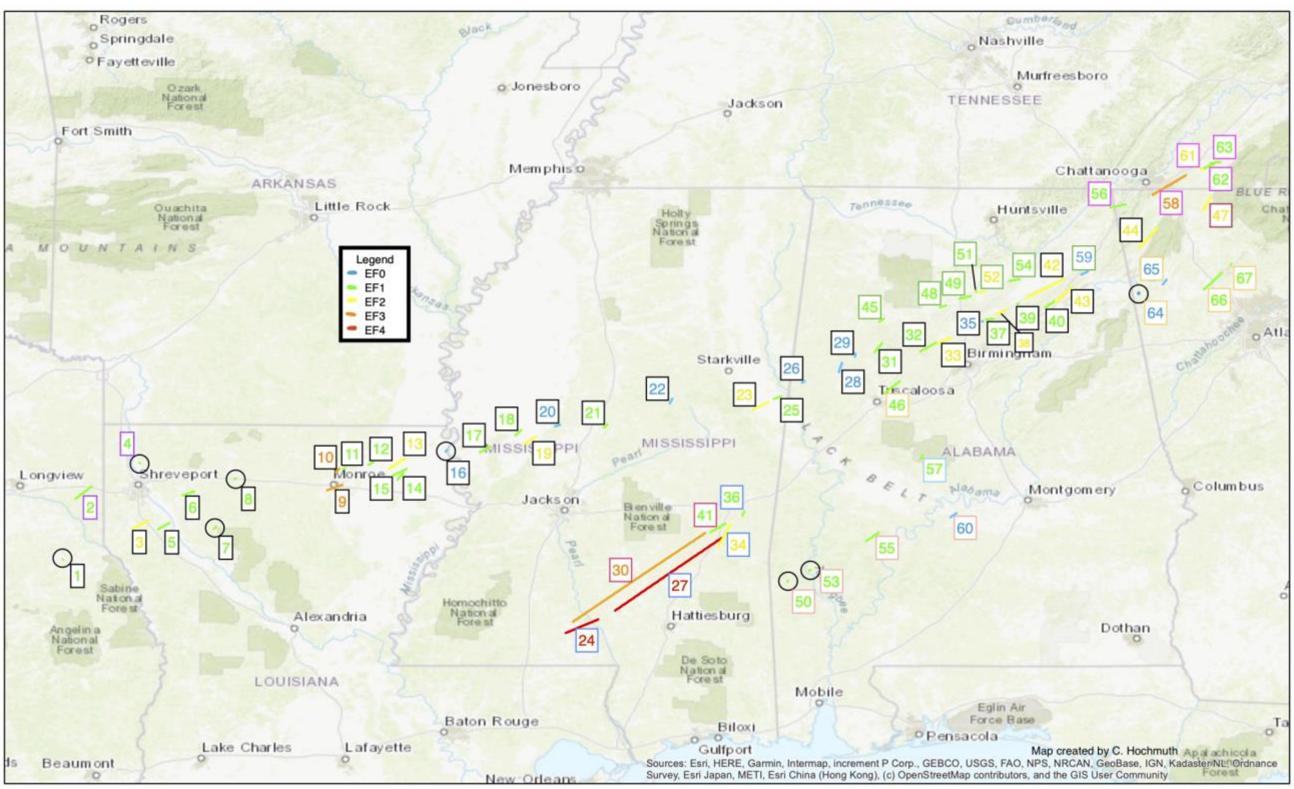

Figure 1: Color-coded map of tornado tracks in chronological order

The diameters and max wind speed difference (Δv) were measured using base velocity in GR2Analyst as described in the previous section, and some interesting results were found. Figure 2 shows a scatter plot of the diameters vs. Δv and it shows a loose negative trend. This means that circulations with higher wind speeds tended to have smaller diameters. Figure 3a shows a box plot of average diameter broken out by EF rating. It shows that tornadoes with larger diameters tend to have weaker ratings

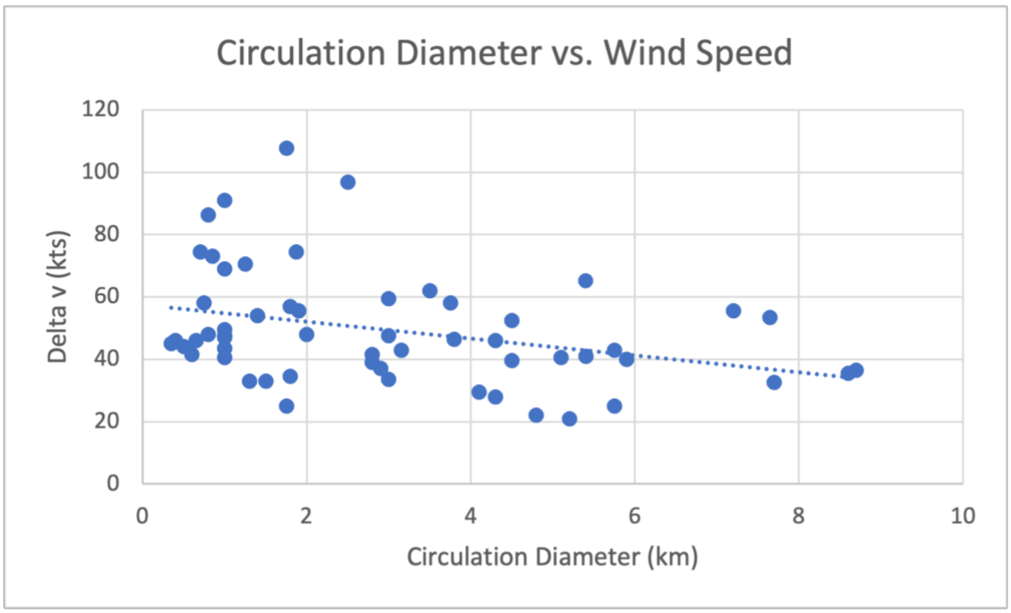

Figure 2: Scatter plot of circulation diameter vs. maximum wind speed difference (Δv)

and those with smaller diameters tend to have stronger ratings. Figure 3b has the average diameter broken out by parent storm type, and the supercell tornadoes have a smaller average diameter than QLCS tornadoes. This correlates with Figure 3a because the supercell tornadoes tended to have higher EF ratings. There are a lot of variables that go into these results and the results do not completely prove the theory, but it is a promising trend that will need more research to confirm it. Radar variables such as range and beam height have an effect on how a storm looks on radar, but they were deemed unnecessary to include in this study due to negligible changes in results. Measuring the diameter of the circulations was somewhat subjective, because some interpretation had to be utilized when a velocity couplet was not clearly visible. Some tornadoes were excluded from the diameter vs. wind speed study due to ambiguous couplet features.

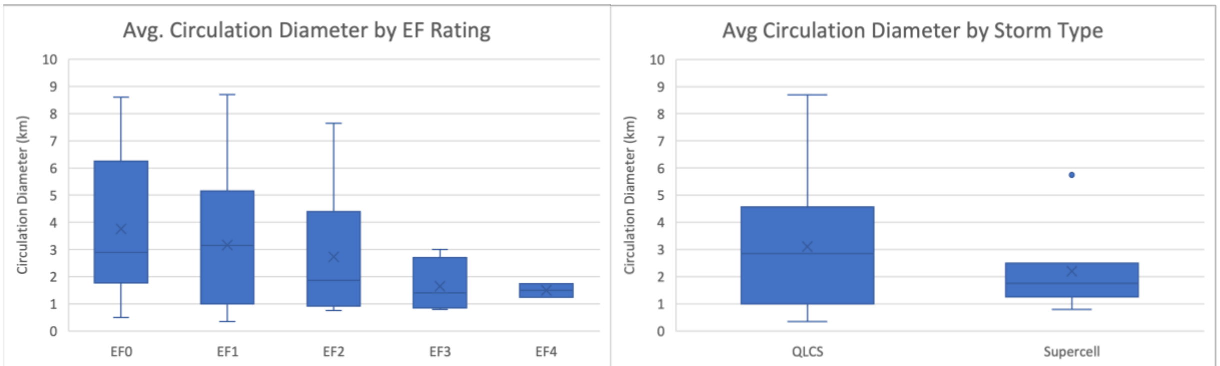

Figure 3a (left): Box plot of average circulation diameter based on EF rating
Figure 3b (right): Box plot of average circulation diameter based on parent storm type

Conclusions

This case study gave an overview of the tornado outbreak of Easter 2020, as well as some interesting analysis results. It showed that longer-lived MVs tend to produce more tornadoes, as evidenced by the longest MV which produced 36 and the next longest, which was quite a bit shorter in duration, that produced seven. It also showed a promising trend in circulation diameter vs. wind speed: that storms with larger circulation diameters tended to be weaker in wind speed and EF rating. This would agree with the law of conservation of angular momentum, AKA the ice skater effect, which says that a broader area of rotation would spin more slowly than a tighter one. These results would need to be backed up by additional research and possibly a larger study with a larger sample size of tornadoes. It would be a good idea to try to find a better way to get more accurate data points for the maximum inbound and outbound velocities and perhaps a better way to measure the diameter.

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