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COOL SEASON TORNADOES IN THE SOUTHEAST U.S.

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1. INTRODUCTION

Severe convection, particularly that which produce tornadoes, has historically been viewed as a springtime warm season characteristic. However, over the southeast United States, cool season tornadoes are increasingly being viewed as a unique and significant winter characteristic. Several recent studies, including Wasula et al (2004) and Guyer et al. (2006), indicate that not only are cool season tornadoes a frequent occurrence in the southeast United States, but that the majority of tornadoes happen between the months of November and February.

In order to understand the characteristics of cool season tornadoes, the criteria necessary for thunderstorm development and tornadoes was compared between the warm season and cool season. Various commonalities and contrasts between the two were noted. In addition, datasets of cool season tornadoes were analyzed to find climatological trends for Georgia in particular. These climatology and seasonal characteristics were used to develop a primitive set of forecast guidelines for cool season tornadoes.

2. ANALYSIS

The Storm Prediction Center severe weather events database, also known as SVRPLOT (Hart, 1993; available at http://www.spc/noaa.gov/software/svrplot2/) and NCEP/NCAR reanalysis data (Kalnay et al., 1996) were used to establish trends for tornadoes from 1988 to 2007 across Georgia during the cool season, defined here as November 1 to February 29. All tornado intensities, (E)F0 through (E)F5, were considered.

Analysis of the SPC database showed that cool season tornadoes accounted for approximately 33% of all tornadoes across Georgia, but nearly 50% of all (E)F3 and (E)F4 events (Figure 1). In addition, cool season tornadoes accounted for over one-third of all tornado deaths and injuries and over one-fourth of total tornado property damage (Figure 2). Cool season tornadoes were also more likely to occur overnight than their warm season counterparts (Figure 3).

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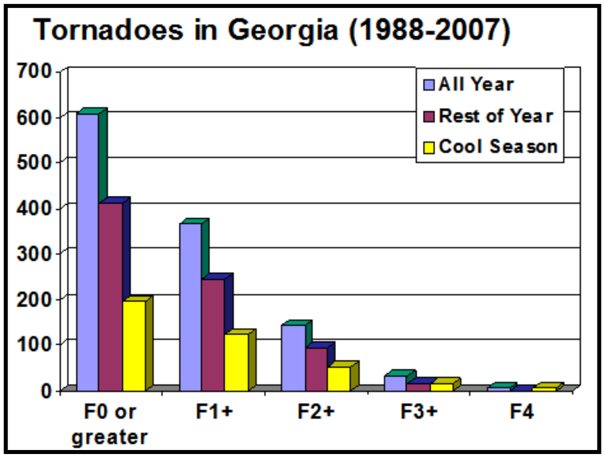


Figure 1: Tornadoes in Georgia by (E)F scale.

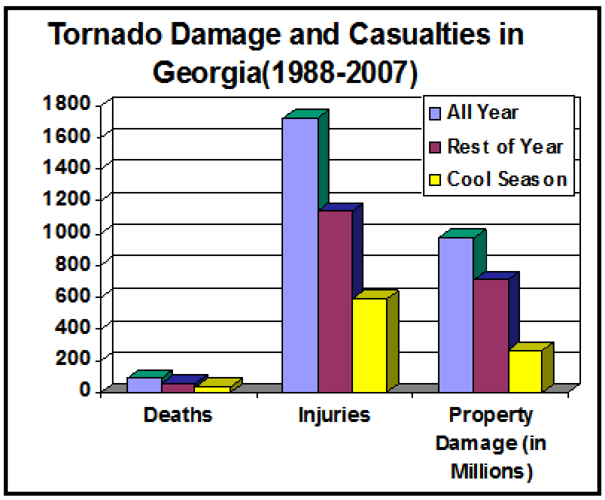
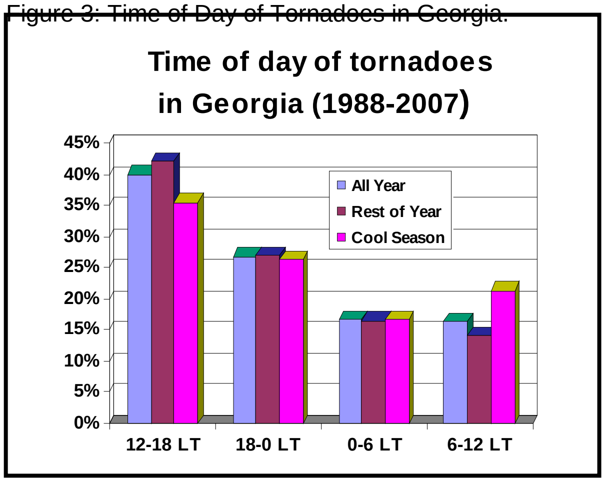


Figure 2: Tornado damage and casualties in Georgia.

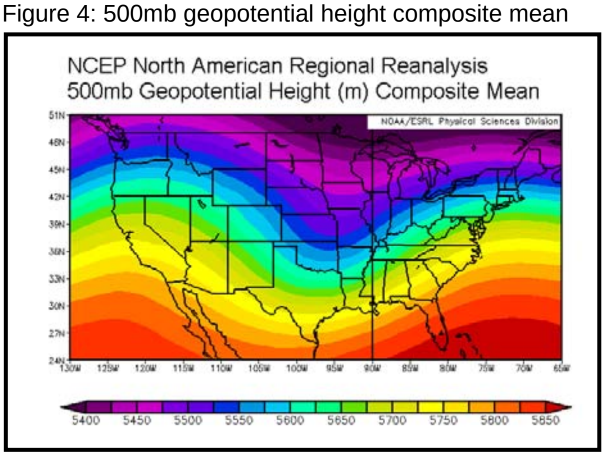
Composite means, based on NCEP/NCAR reanalysis data, of various synoptic environment and severe weather parameters were computed and displayed on a map. The composite maps and data from individual events confirmed that the ingredients for cool season tornadoes are identical to that of the classic transitional or warm season tornadoes, namely lift, moisture, instability, and deep vertical wind shear.

Figure 3: Time of Day of Tornadoes in Georgia.



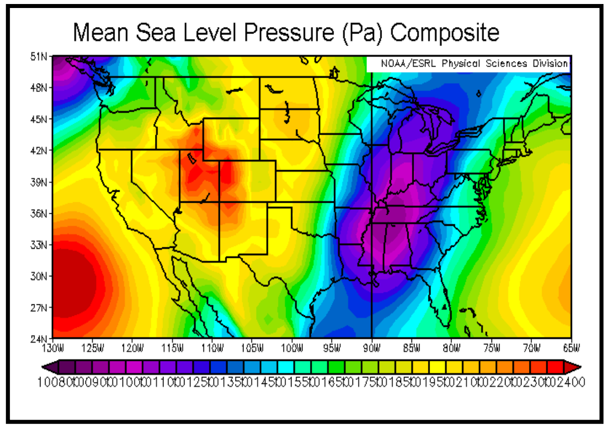
In terms of the synoptic scale environment, deep 500mb or 850mb troughs were not always present (Figure 4). At the surface (Figure 5), a minimum in composite mean sea level pressure was located over the mid-south, near the Alabama, Mississippi, and Tennessee border. There is also some indication in the composite mean sea level pressure map of a surface trough running east to west from the minimum low pressure area across middle Georgia and into South Carolina, as well as a east to west oriented surface ridge located to the north of the trough. This may be indicative of the cold air damming that often sets up in this location east of the southern Appalachians.

Figure 4: 500mb geopotential height composite mean



for all cool season tornado dates used in this study.

Figure 5: MSL pressure composite mean for all cool season tornado dates used in this study.



Severe weather parameters such as vertical wind shear and instability were also examined. Anomalously strong 850mb-surface wind shear across the southeast was nearly always present in Georgia tornado events (Figures 6 and 7). The area of strong wind shear tended to propagate from the north-central Gulf coast into the Carolinas during the event. Composite analysis of convective available potential energy (CAPE) revealed values that were quite low across Georgia during cool season tornado events, with mean CAPE below 500 J/kg statewide (Figure 8).

Based on the finding from Wasula et al. that composite mean 200mb flow was stronger and at a lower latitude in the most active tornado-producing cool seasons, a correlation was attempted between ENSO cycle and the number of cool season tornadoes over Georiga. No relationship between El Nino or La Nina and the amount of tornadic activity during the cool season in Georgia were noted using this 20 year dataset.

3. FORECASTING GUIDELINES

Using this analysis and the findings of the aforementioned studies, basic forecasting guidelines for tornadoes specifically during cold season and within the southeastern United States were formulated. The guidelines are expressed similarly to any tornado producing day, based on the finding that the same ingredients (lift, moisture, instability, and vertical wind shear) are needed for the development of cold season tornadoes as classic transition or warm season tornadoes.

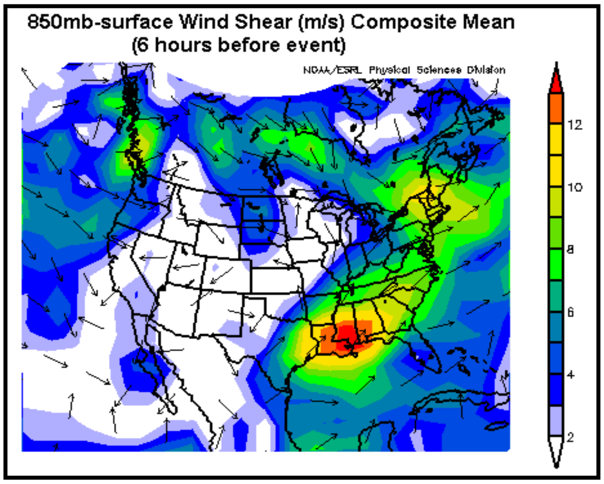


Figure 6: 850mb to surface wind shear magnitude composite mean for 6 hours prior to all cool season tornado dates used in this study.

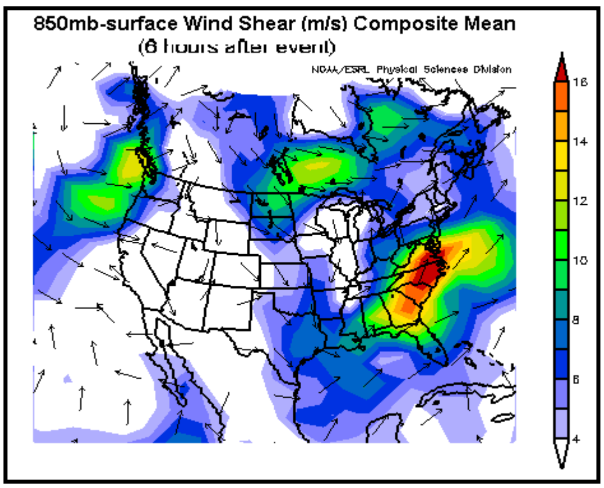


Figure 7: 850mb to surface wind shear magnitude composite mean for 6 hours following all cool season tornado dates used in this study.

Some positive CAPE is necessary for tornado development, but even low amounts (well under 500 J/kg) are sufficient if enough vertical wind shear is present. Vertical wind shear requirements appear more stringent than that of instability. Storm-relative helicity values measured over the 0 to 1km layer should be at least 200 m^2/s^2 during the cool season. In cases of high instability (CAPE > 2000 J/kg), 0 to 1 km helicity values of 125 m^2/s^2 should be sufficient for tornado development.

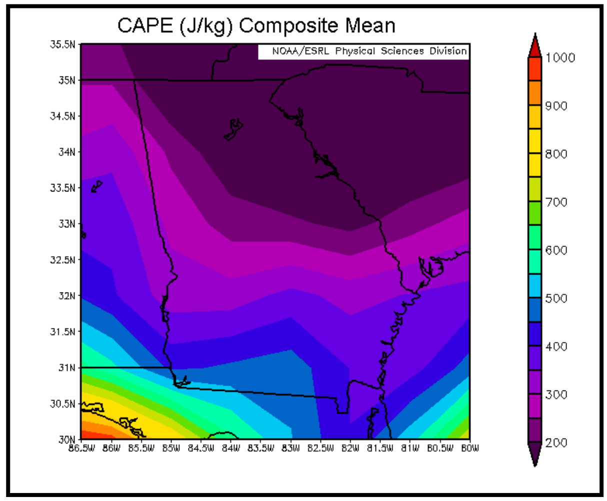


Figure 8: Composite mean of CAPE for all cool season tornado dates used in this study.

4. SUMMARY

Through the course of the study, it became evident that cool season tornadoes represent a significant fraction of tornadoes throughout the entire year, and an even greater fraction when damage and casualties are considered. In addition, the intensity of cool season tornadoes is by no means less on average than their warm season counterparts. Cool season tornadoes tend to occur when high environmental storm-relative helicity combines with relatively modest instability. Perhaps because of this lesser dependency on CAPE, which tends to peak in the afternoon, and greater reliance on vertical wind shear, which can be enhanced by a strengthening low level jet overnight, tornadoes in the cool season are more likely to develop or persist through the nighttime hours. Traditional predictors of severe weather and tornadic activity, such as strong surface low pressure or a deep 500 mb trough, were not observed in many of the significant cool season tornado outbreaks in the southeast in recent decades

These findings highlight the importance of understanding the mechanisms that can lead to tornado development in the cool season and realizing the extent to which tornadoes impact the area during the cool season.

5. REFERENCES

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