Utilizing Tornado Climatology and Storm Environment Parameters to Enhance the Existing Tornado Detection Strategy in North Carolina

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Introduction

Tornadoes cause significant and costly damage to American lives and property. Mid-Atlantic tornadoes often form in challenging environments featuring weak instability and high wind shear. Therefore, it is important to investigate the conditions leading up to tornado formation to better understand precursors which can help increase the lead time and accuracy of warnings. This study to date has developed a tornado climatology (1950-2018) for the state of North Carolina with a storm type component for storms which produced significant tornadoes (≥ EF/F-2) since 1996. An analysis of the mesoscale environment and storm morphology is in progress for a selection of recent supercell thunderstorms which occurred in all seasons. After this analysis is completed, the goal is to identify commonalities and differences in the environmental conditions and storm evolution prior to the formation of each tornado. It is hypothesized that examining the radar characteristics and mesoscale environment of these storms will help update or verify local thresholds and nuances currently used for warning decisions. In turn, this can help improve warning decision-making strategies, enhance detection of tornado events, and benefit forecast offices as well as emergency managers in the state of North Carolina and other Mid-Atlantic states.

Methodology

- Updated NC tornado climatology through 2018 based on previous work completed by Campbell, Blaes, & Locklear (2015)
- Analyzed radar data to classify storms which produced significant tornadoes using Smith, et al. (2012) storm type guidelines
- Selected recent (2014-2018) significant tornado events from tornado climatology based on the following criteria:
  - Classified as supercell from previous radar interrogation
  - Dual-polarization radar data is available for event
- Investigated synoptic and mesoscale environments leading up to storm formation using mesoscale discussions, surface and upper-air maps, hodographs, and observed soundings
- Followed evolution of storm from initial formation through tornado event occurrence using archived radar data by GR2Analyst
- To be completed: Compare each case for commonalities and differences in the environment and evolution of storm leading up to tornado event

NC Tornado Climatology Update

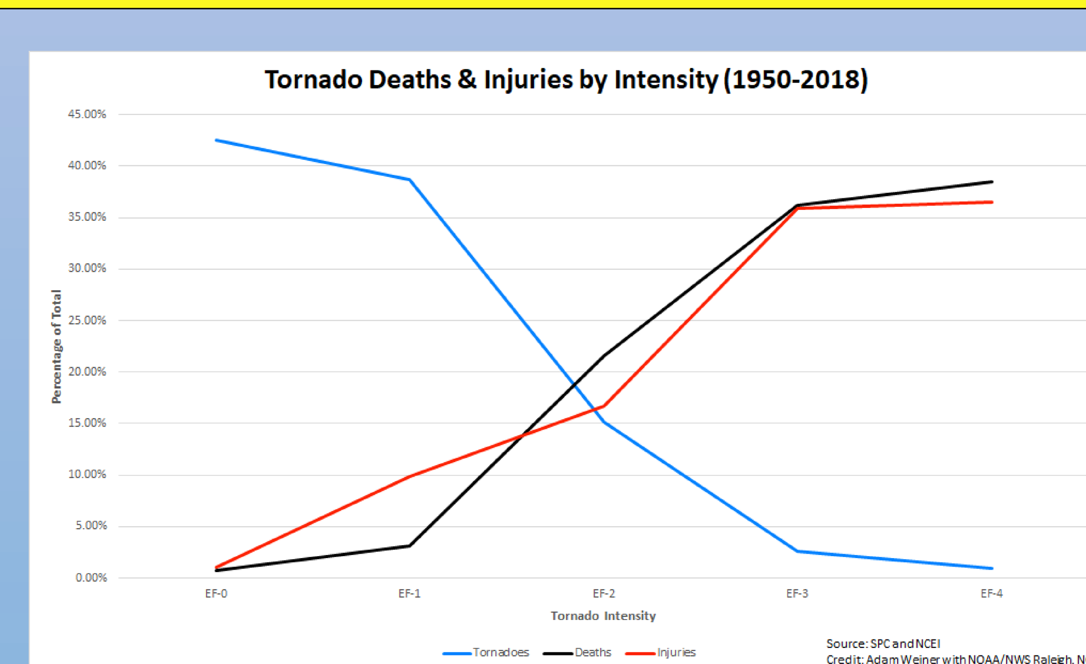

Figure 1: The inverse relationship between tornado intensity and number of deaths and injuries caused is demonstrated here.

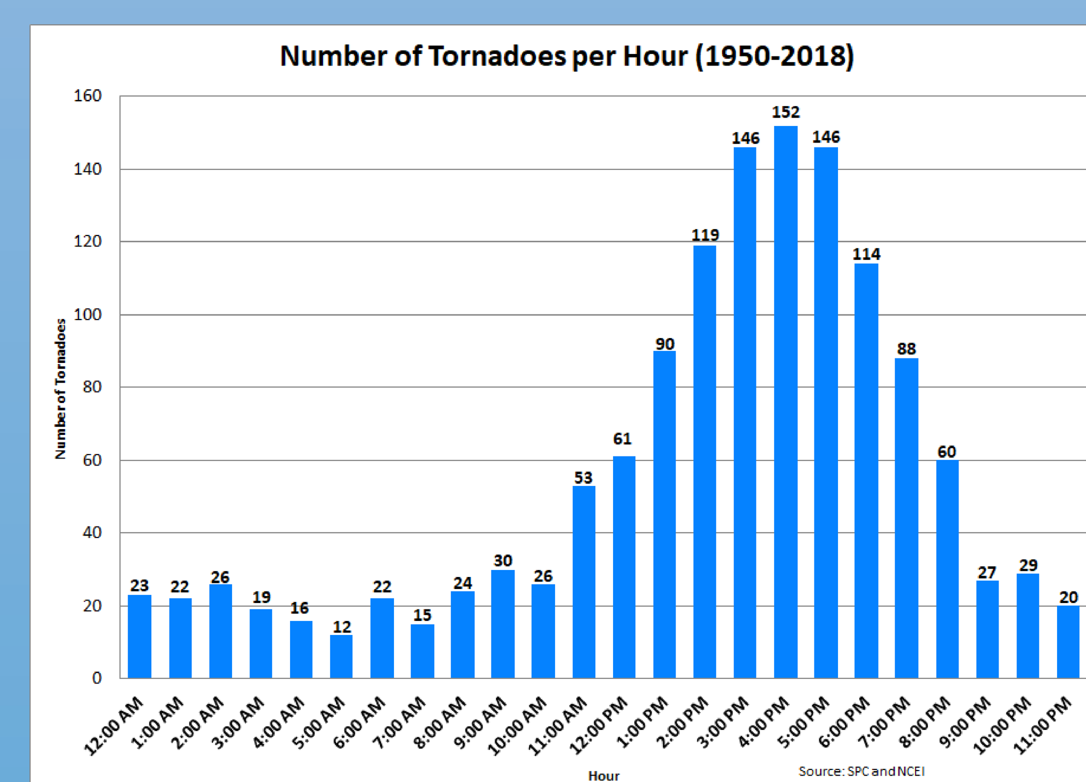

Figure 2: The primary time period for tornado formation favors mid-late afternoon while a distinct minimum is evident in the early morning hours.

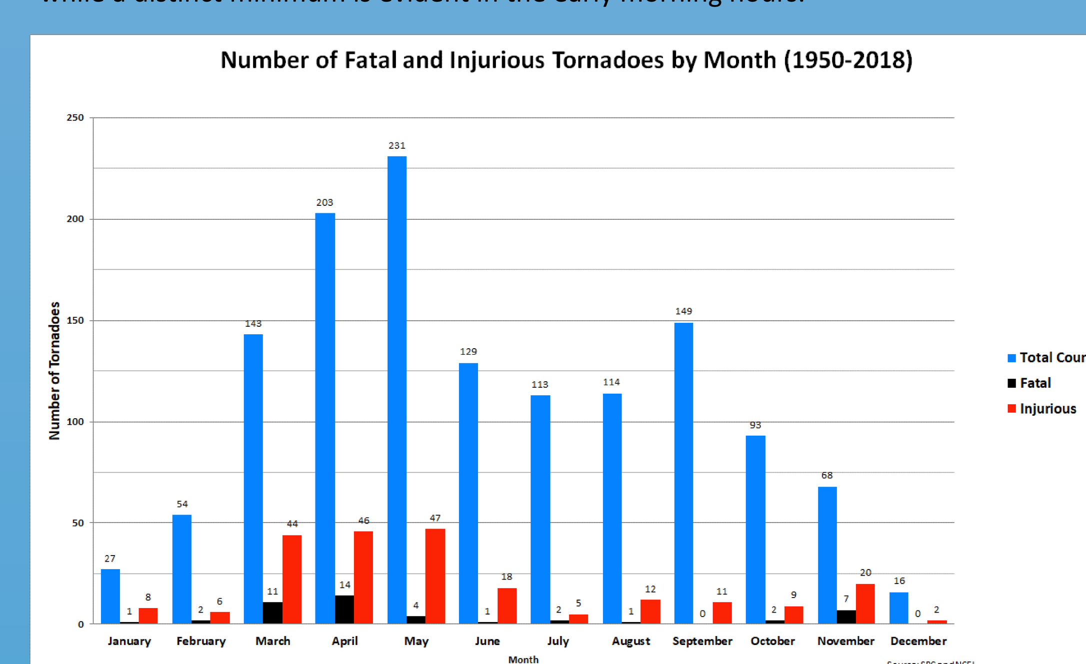

Figure 3: A clear peak in tornado count and associated casualty-producing tornadoes occurs during the Springtime severe weather season with a secondary peak in the Fall.

Selected References

Campbell, R., Blaes, J., & Locklear, B. (2015, October). A Detailed Climatology of Central North Carolina Tornadoes. *National Weather Association 40th Annual Meeting*. Poster presented at 2015 NWA Annual Meeting, Oklahoma City, OK

Smith, B. T., Thompson, R. L., Grams, J. S., Broyles, C., & Brooks, H. E. (2012). Convective Modes for Significant Severe Thunderstorms in the Contiguous United States. Part I: Storm Classification and Climatology. Weather and Forecasting, 27, 1114-1135. doi:10.1175/WAF-D-11-00115.1

Case Study #1: Beaufort County, April 25, 2014

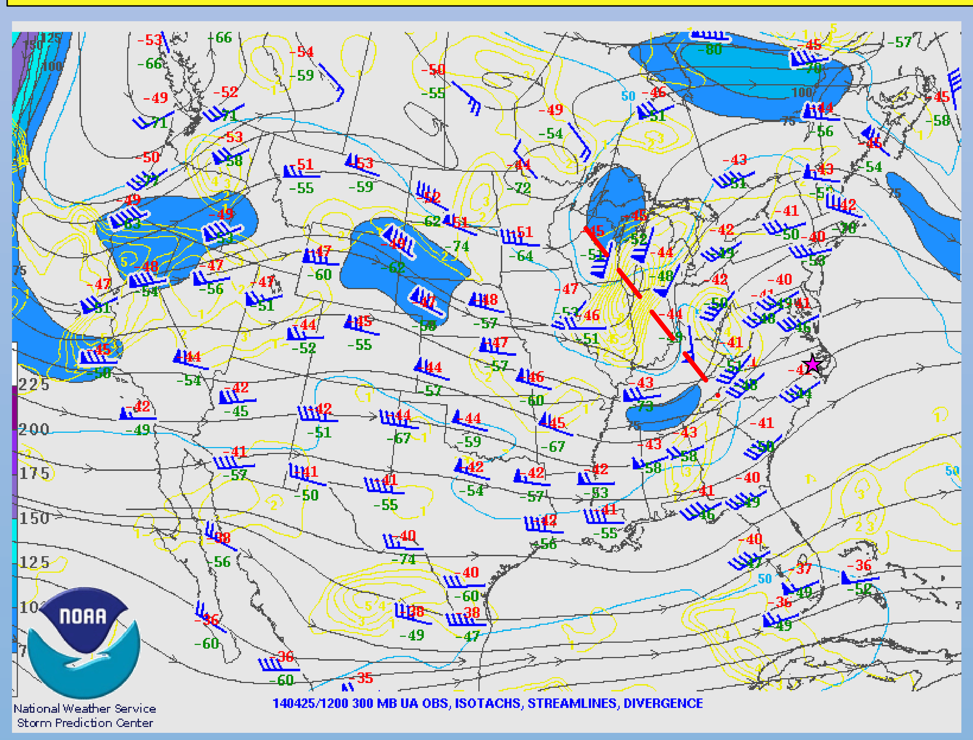

Figure 4a: 300 MB upper-air chart at 25/12Z, including divergence (yellow contours). Focus on shortwave over IL/IN.

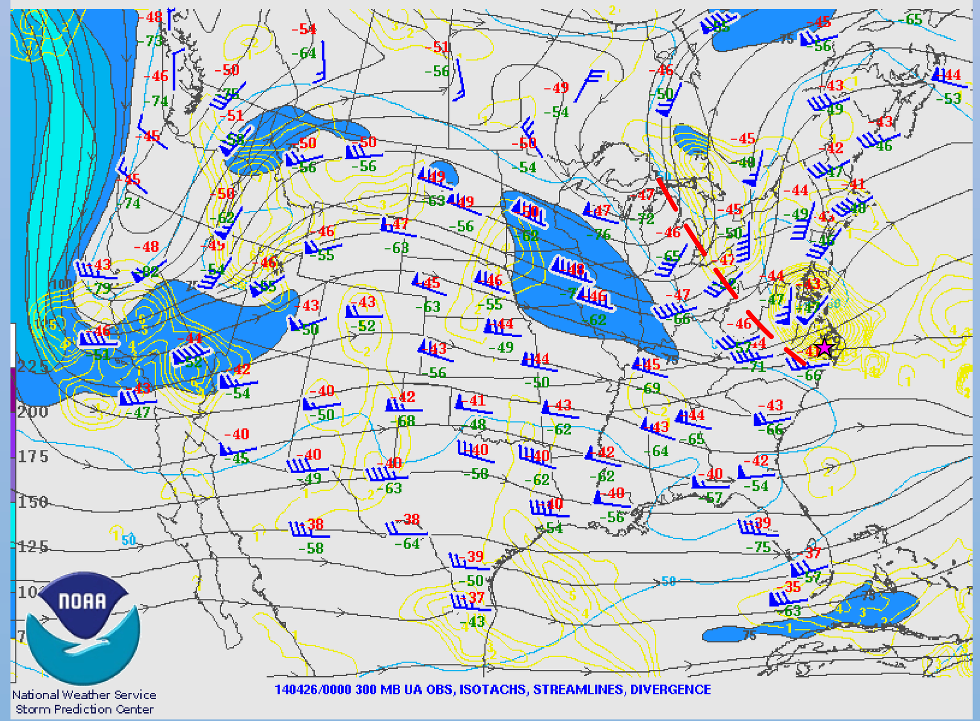

Figure 4b: 300 MB upper-air chart at 26/00Z, including divergence (yellow contours). Focus on divergence over NC.

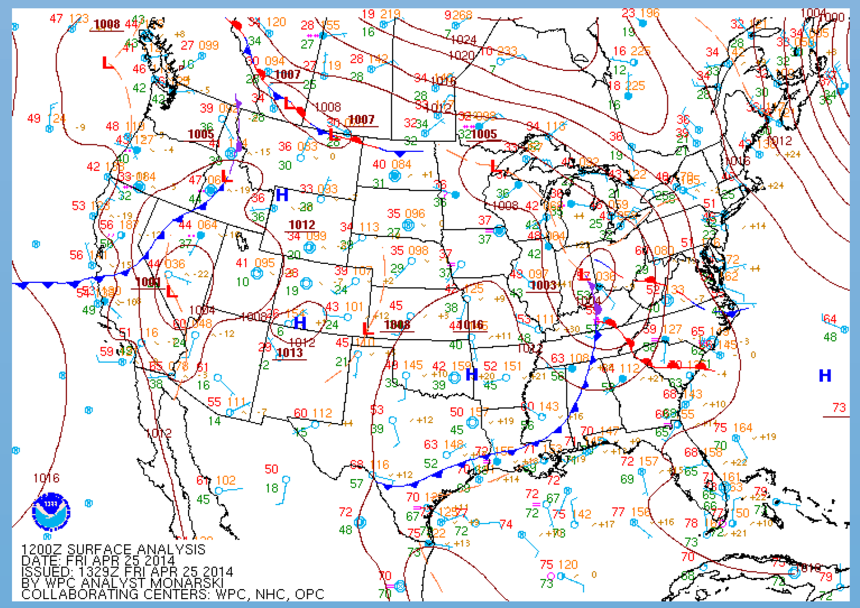

Figure 5a: Surface analysis at 25/12Z. Focus on warm front over SC and advancing cold front over the Southeast.

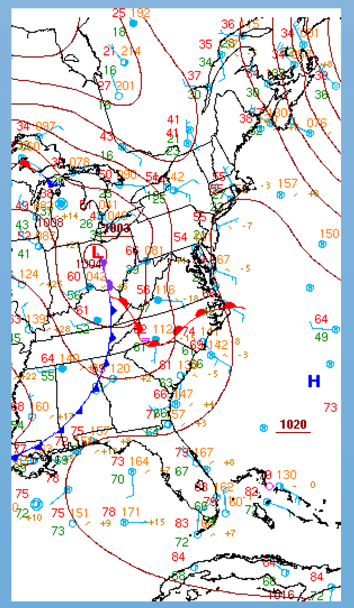

Fig. 5b: 25/15Z surface analysis. Warm front surges past Beaufort Co.

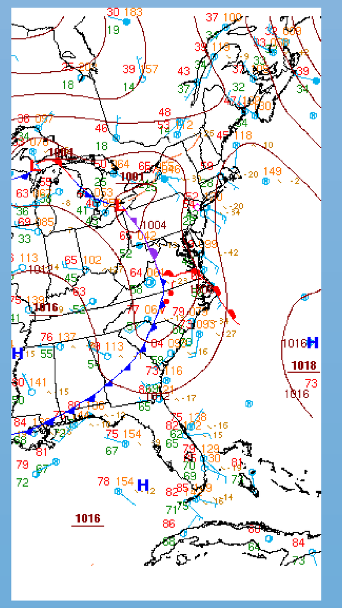

Fig. 5c: 25/21Z surface analysis. Squall line analyzed near triple point

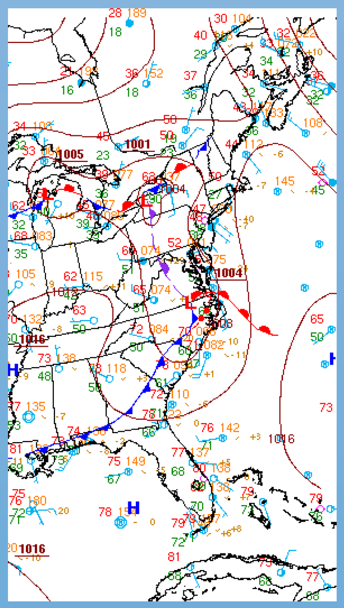

Fig. 5d: 26/00Z surface analysis. Cold front and squall line nearing coast.

Synoptic/Mesoscale Environment Highlights

- Sharp 300 MB shortwave trough resulted in region of intense upper-level divergence over eastern NC (Fig. 4b)
- Low-level jet of 40-45 knots at 850 MB and 925 MB transported Atlantic moisture into eastern NC
- Triple-point low formed and enhanced low-level wind shear late in day (Fig. 5d)

Radar Highlights

- Initial storm and a secondary storm formed off outflow boundary from morning showers and tracked NE
- The initial storm split into northern and southern parts, followed by a rapid strengthening of the southern storm
- The secondary storm merged with the southern storm and became tornadic thereafter

Work In Progress

- Four additional cases from April 2014, February 2016, May 2017, and November 2018 will be analyzed
- Commonalities and differences between synoptic/mesoscale environments, convective initiation mode, and storm morphology will be analyzed and compared with current tornado detection strategies
- Future Work: Assessing warning lead time and predictability of storms