Environmental Conditions Associated with North Carolina Tornadoes

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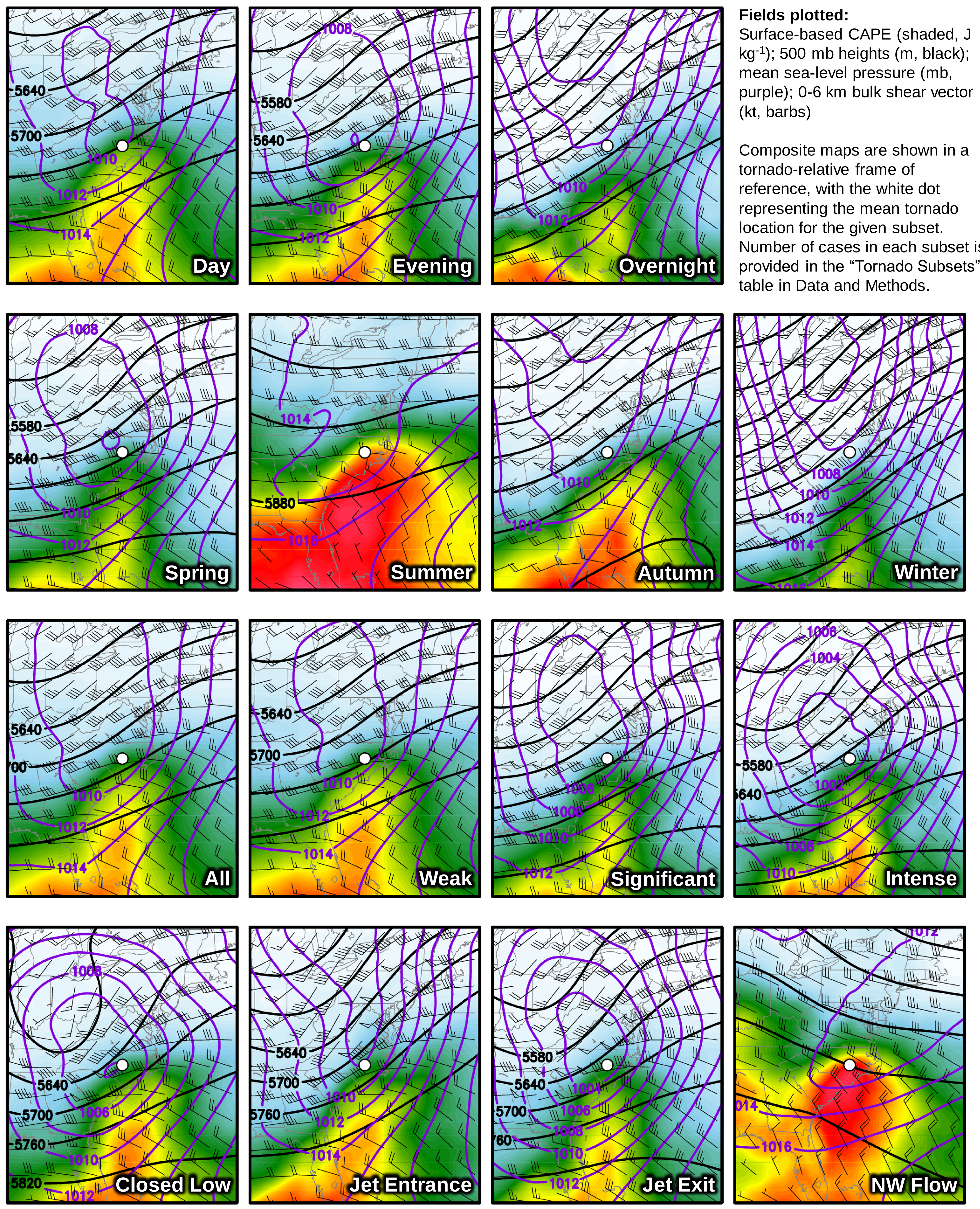
Background

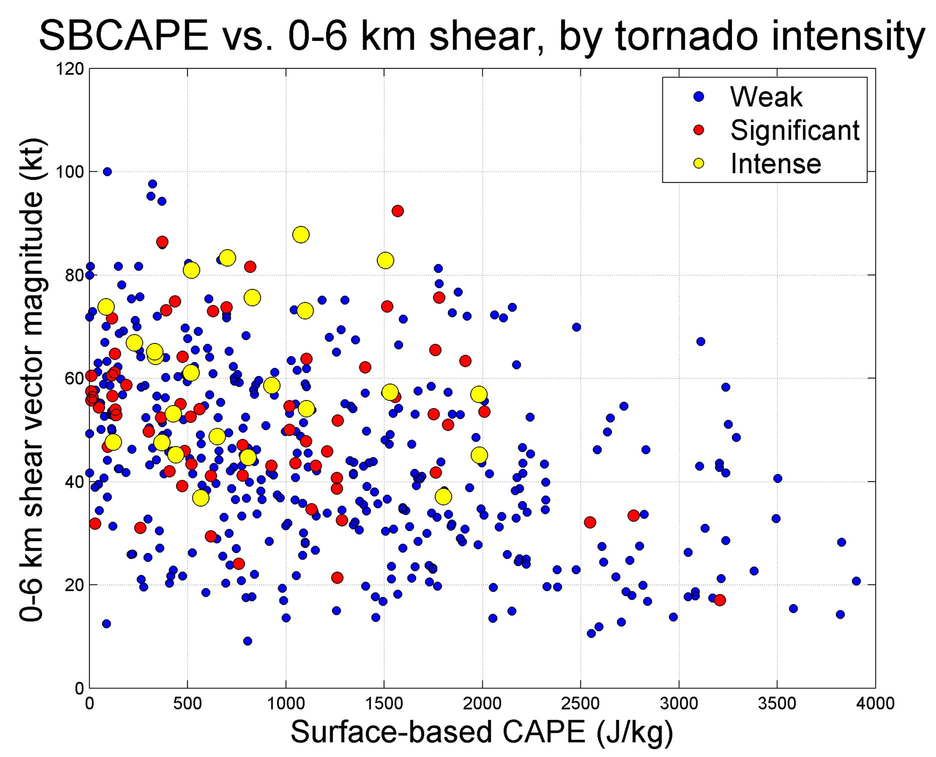
North Carolina's location, with its frequent exposure to mid-latitude cyclones and proximity to the Atlantic Ocean and the Gulf of Mexico, provides many of the ingredients necessary for the production of severe convection, including tornadoes. Recently, a tornado climatology focusing on the distribution and attributes of tornadoes across North Carolina from 1950 to 2014 was completed, providing a wealth of information on the location, character, and impact of these storms. This work aims to build upon that database by exploring the environmental conditions present at the time of all North Carolina tornadoes from 1979 through 2014.

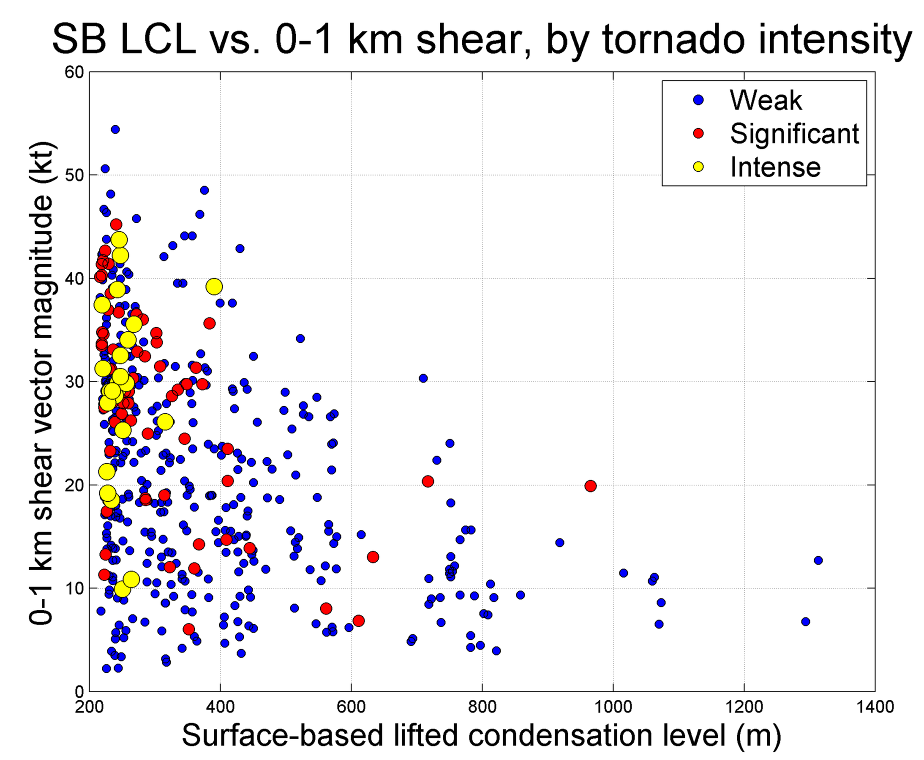
Results: Composite Maps and Parameter Distributions

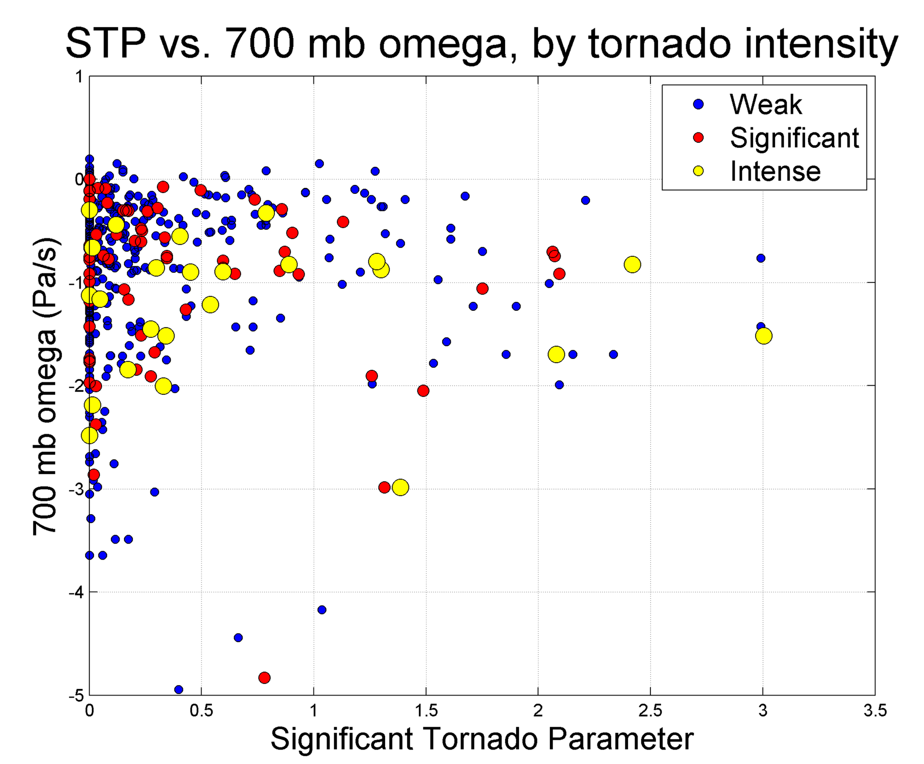


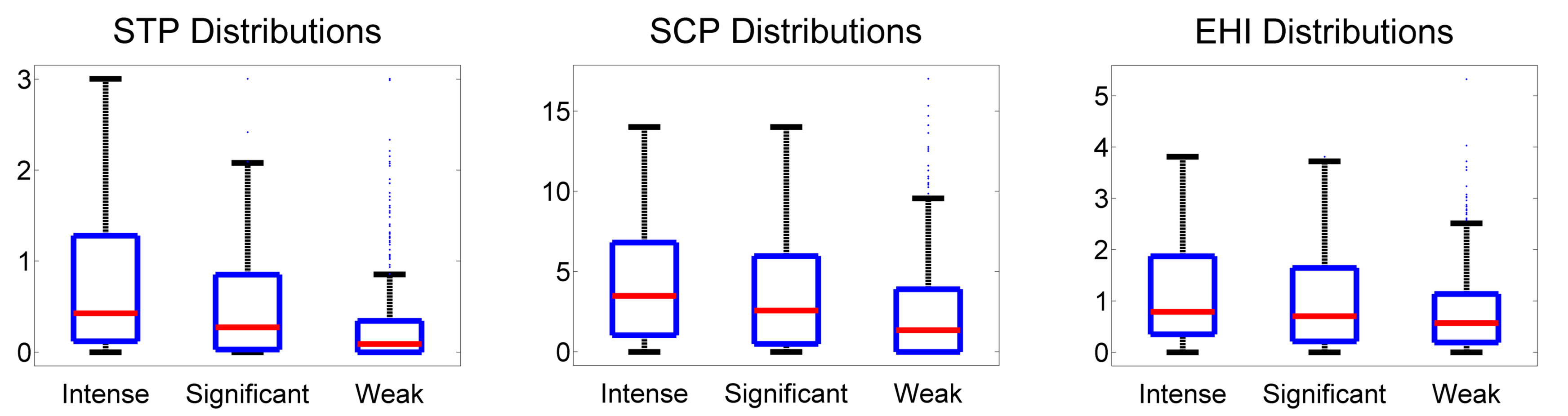
Fields plotted:
Surface-based CAPE (shaded, J kg^{-1}); 500 mb heights (m, black); mean sea-level pressure (mb, purple); 0-6 km bulk shear vector (kt, barbs)

Composite maps are shown in a tornado-relative frame of reference, with the white dot representing the mean tornado location for the given subset. Number of cases in each subset is provided in the "Tornado Subsets" table in Data and Methods.









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Reference
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Data and Methods

Environmental conditions for each tornado occurring within North Carolina from 1979 through 2014 were determined using the North American Regional Reanalysis (NARR; Mesinger et al. 2006) dataset, which is available every three hours. The NARR has a horizontal grid spacing of 32 km and 29 vertical levels.

The North Carolina tornado database was segregated by time of day, season, tornado intensity, and synoptic pattern. Primary comparisons were associated with tornado intensity, ranging from weak (EF0 or EF1) to intense (EF3 or EF4). Tornado-relative composite maps were generated by averaging the plotted fields over all tornadoes within the given subset.

Tornado Subsets (Number in subset)

Time of Day	Season	Intensity	Pattern
Day (309) Evening (199) Overnight (29)	Spring (283) Summer (131) Autumn (90) Winter (33)	Weak (≤EF1, 433) Significant (EF2+, 104) Intense (EF3+, 26)	Closed Low (92) Jet Entrance (93) Jet Exit (159) Northwest Flow (47)

Results: Environment Breakdown

Environment breakdown	*Low MLCAPE (≤ 1000 J kg^{-1})*	*High MLCAPE (> 1000 J kg^{-1})*
Low 0-6 km shear (< 18 m s^{-1})	Weak: 36 (8%) Significant: 4 (4%) Intense: 0	Weak: 103 (24%) Significant: 6 (6%) Intense: 0
High 0-6 km shear (≥ 18 m s^{-1})	***Weak: 168 (39%)*** ***Significant: 56 (54%)*** ***Intense: 16 (62%)***	Weak: 126 (29%) Significant: 38 (36%) Intense: 10 (38%)

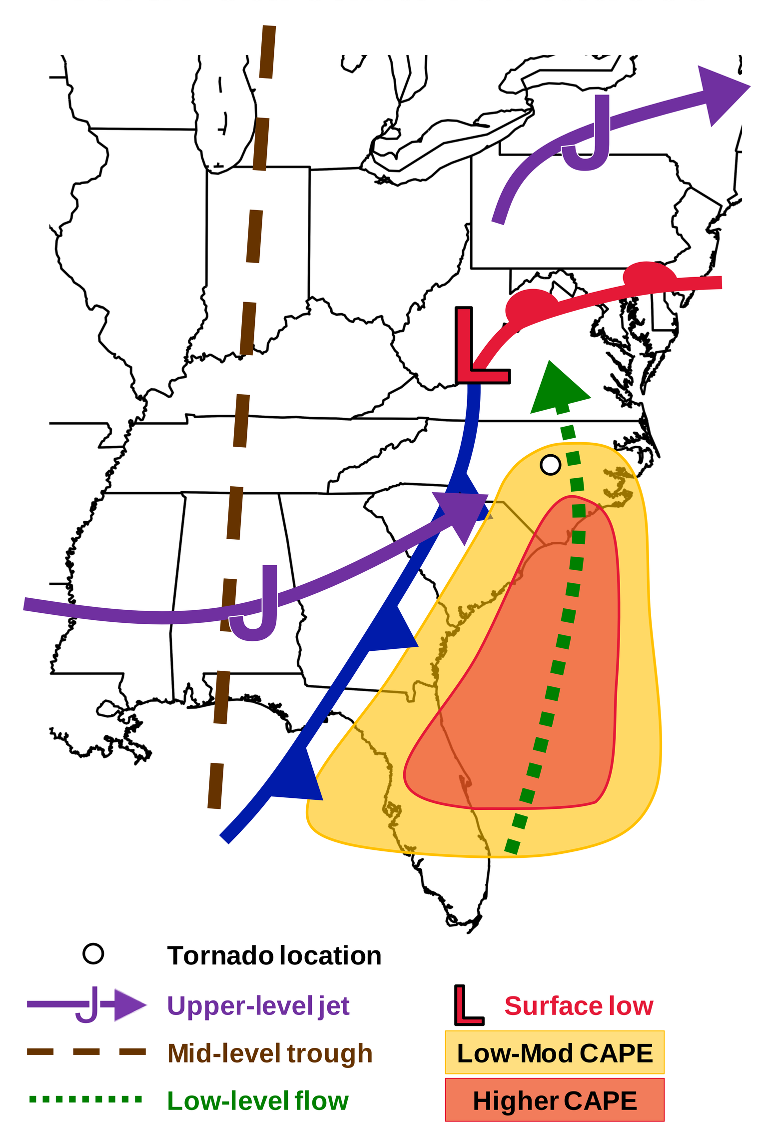
Future Work

This study primarily focused on documenting the range of environments capable of producing tornadoes within NC, including associated diagnostic parameter values.

Future work will aim to elucidate the relationships between the timing, intensity, and synoptic patterns associated with NC tornadoes and tornado outbreaks.

Conclusions

Conceptual Diagram: Significant North Carolina Tornadoes



Tornadoes occur often across North Carolina, with associated setups ranging from strongly-forced wintertime cyclones to relatively quiescent summertime patterns. ***The following environmental characteristics are generally observed during significant tornado events***:

- An upstream mid- and upper-level trough, which may be a closed low
- An approaching and/or departing upper-level jet streak *OR* strong difluence east of upper-level jet
- A potent surface cyclone or trough, of which the tornado occurs in the warm sector or along the attendant cold front
- An instability axis extending from the south to near the tornado location
- An area of enhanced vertical shear extending from the north to near the tornado location
- Strong low-level and deep-layer vertical shear, with CAPE less than 1000 J kg^{-1} common near the tornado