Environmental Evolution of Supercells Interacting with the Appalachian Mountains

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Introduction

- The Appalachian Mountains have considerable impact on day-to-day weather across the Eastern United States; however, there have been a limited set of studies exploring the interaction of supercells with the Appalachian Mountains
  - Climatology and case studies have analyzed supercell activity across the Appalachian subregions (Gaffin et al. 2006; Lane 2008; Stonefield et al. 2006; Prociv 2012)
- Idealized simulations of supercells interacting with terrain have been conducted to identify key controlling factors on storm evolution (Geerts et al. 2009; Markowski and Dotzek 2011; Lyza et al. 2014; Katona et al. 2016; Smith et al. 2016; Scheffknecht et al. 2017)
- There has yet to be a broad analysis of storm-scale modifications of supercells as they interact with complex terrain
- Collaborating with Atlanta, GA, Greensboro-Spartanburg, SC, Jackson, KY, Charleston, WV, Blacksburg, VA, and Morristown, TN National Weather Service offices, as well as the Storm Prediction Center
- The goal is to quantify environmental variability experienced by supercells interacting with terrain and the variability influences their maintenance and severe weather production

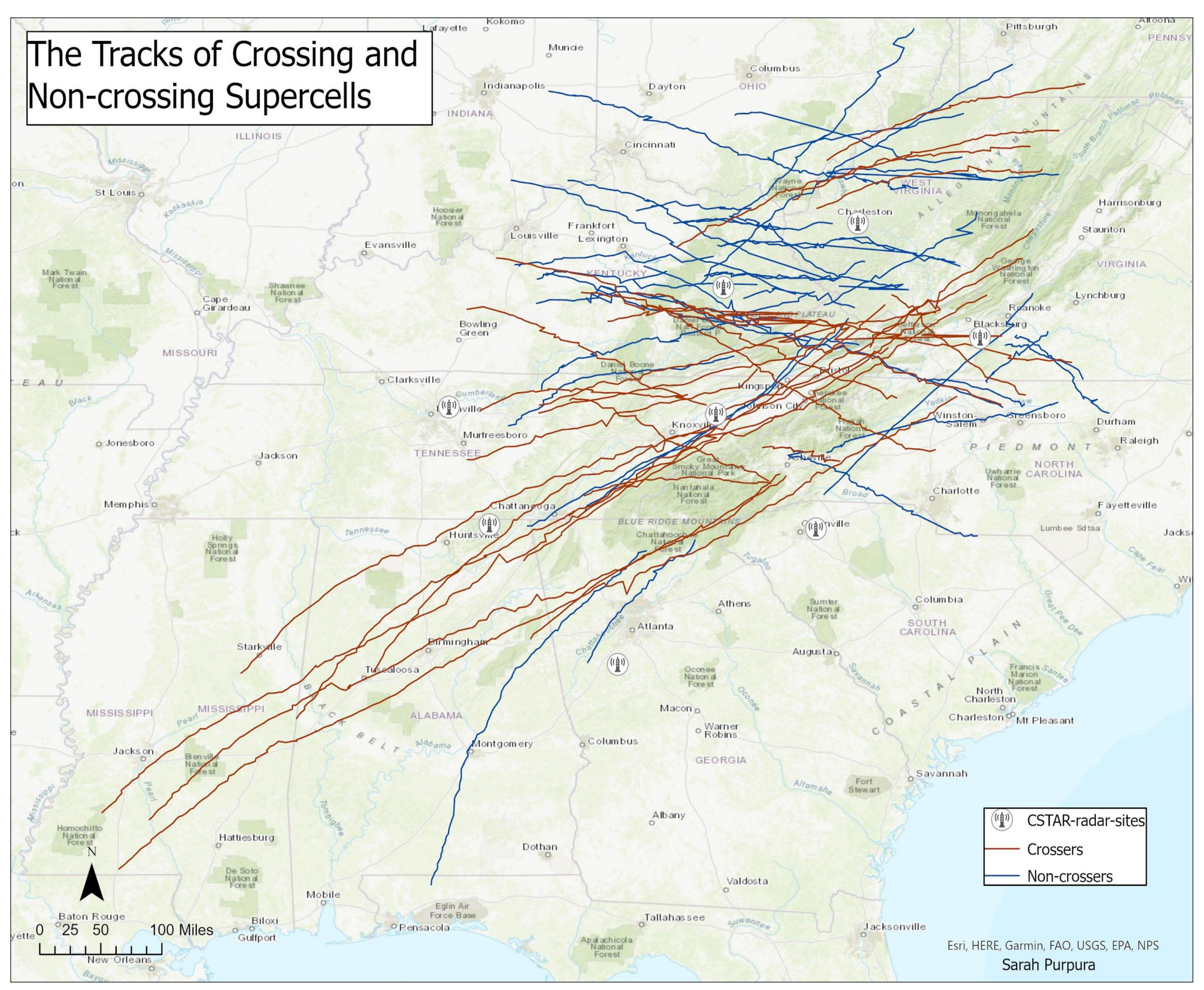

Figure 1: The 64 supercell storm tracks in the Appalachian region. Blue tracks represent the non-crossing supercells and the red tracks represent the crossing supercells.

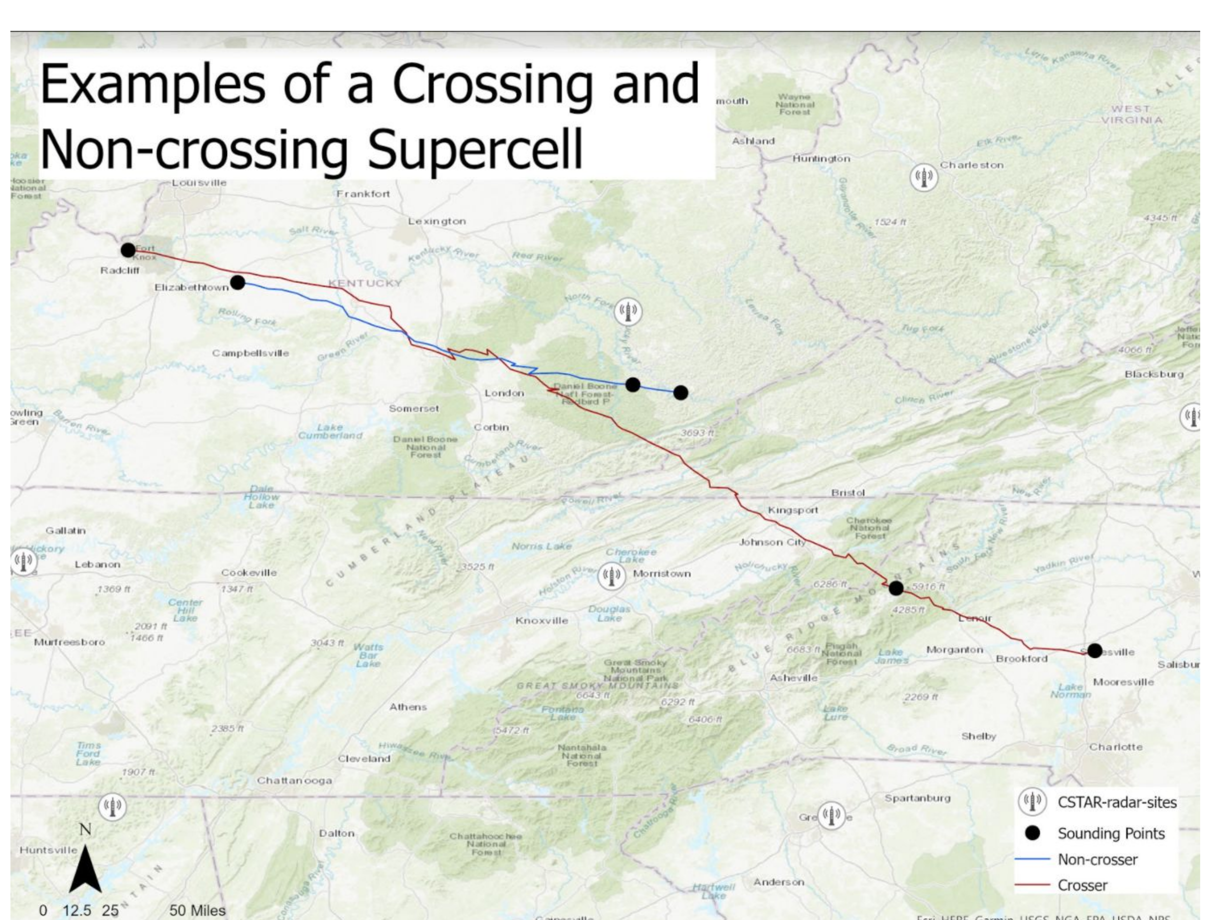

Figure 2: Examples of a crossing supercell (red track) and a non-crossing supercell (blue track). The black circles represent where a sounding was pulled for the upstream peak, and downstream sounding

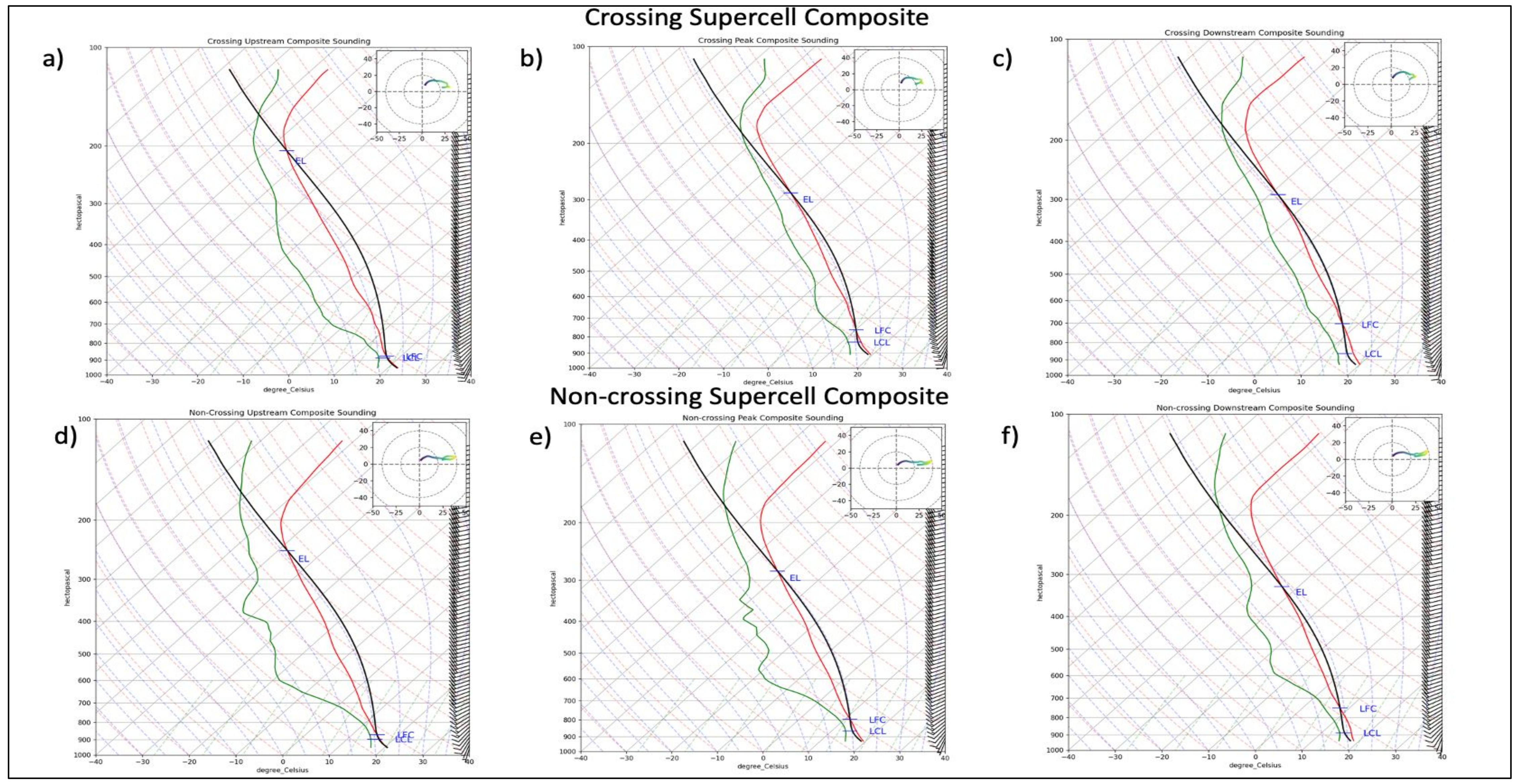

Figure 3: Composite soundings of crossing and non-crossing supercell sounding images. 2a and 2d are RUC/RAP proximity sounding pulled from the initiation point of each supercell, 2b and 2e are RUC/RAP proximity sounding pulled from the peak elevation of each supercell, 2c and 2f are RUC/RAP proximity sounding pulled from the dissipation point of each supercell

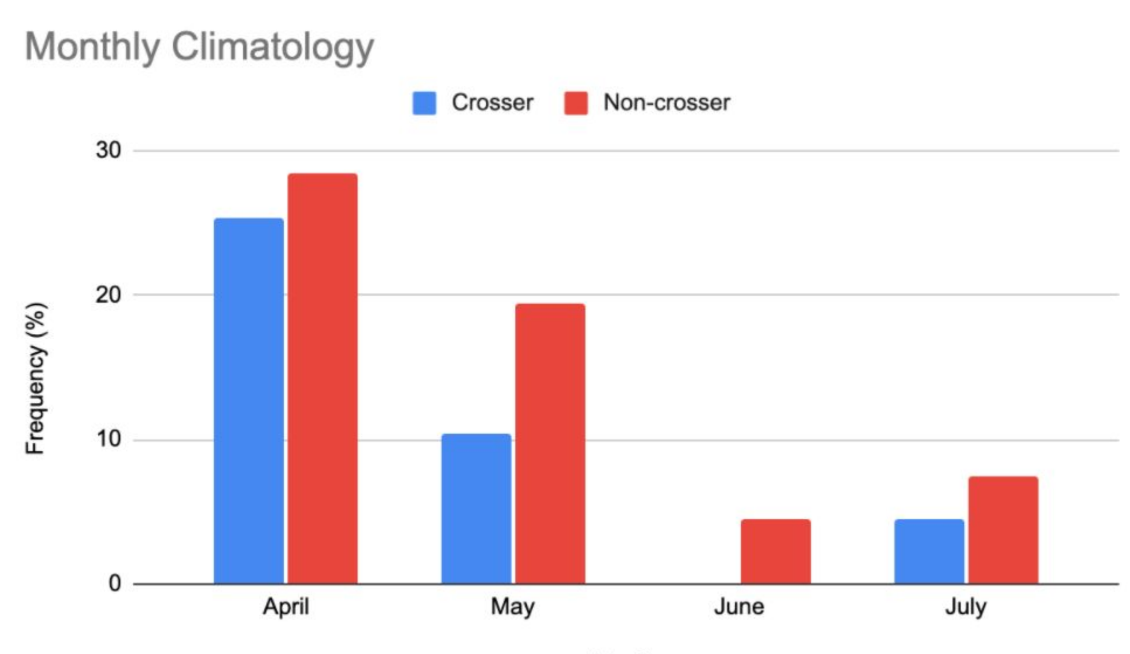

Figure 4: The monthly frequency of the of the supercells. Blue represents crossers and red represents non-crossers.

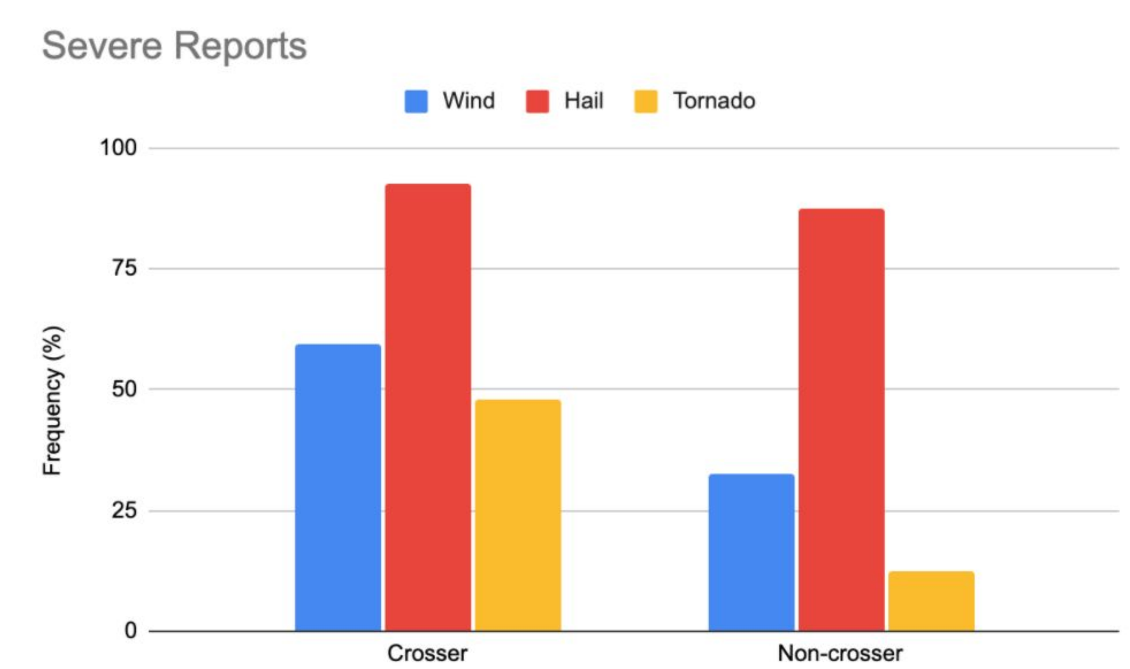

Figure 5: The frequency of the of the severe reports produced by the supercells. Blue represents crossers, red represents non-crossers, and yellow represents the total.

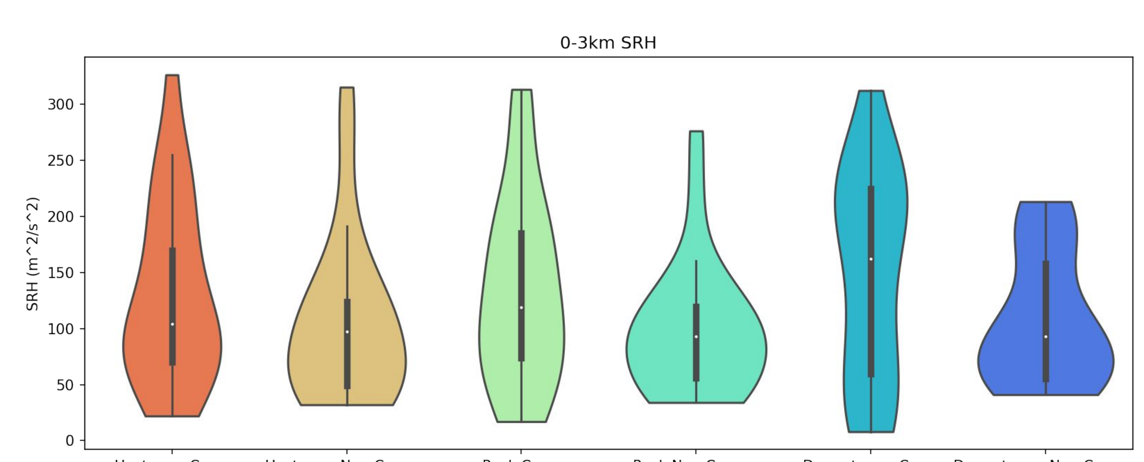

Figure 6: Distribution of 0-3 km SRH in relation to the upstream point of the crossers, upstream point of the non-crossers, peak point of the crossers, peak point of the non-crossers, the downstream point of the crossers, downstream point of the non-crossers

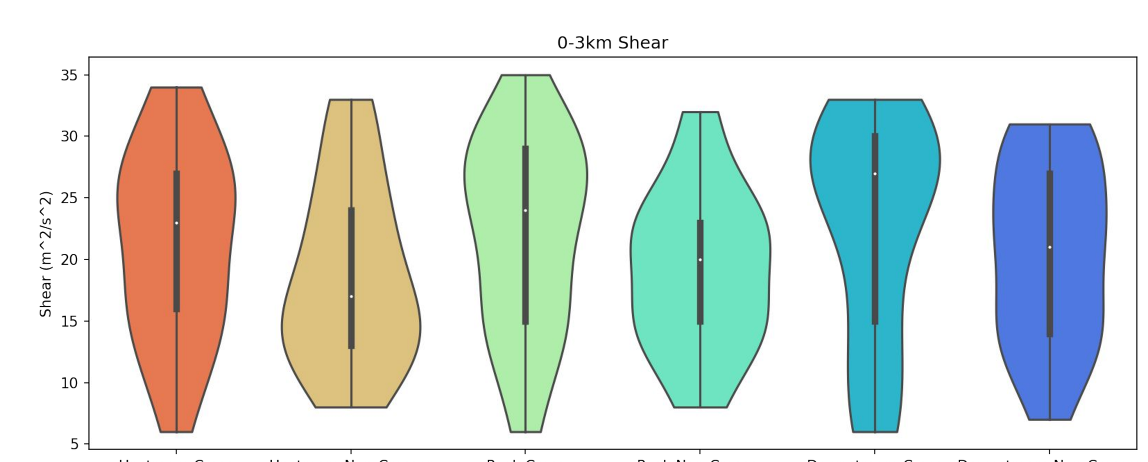

Figure 7: Same as figure 6, but for 0-3 km bulk shear

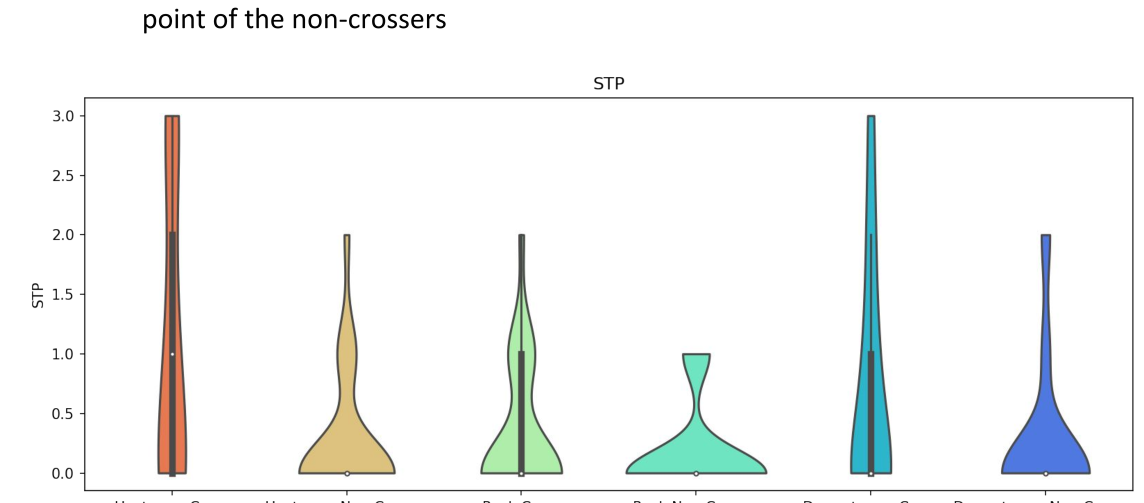

Figure 8: Same as figure 6, but for STP

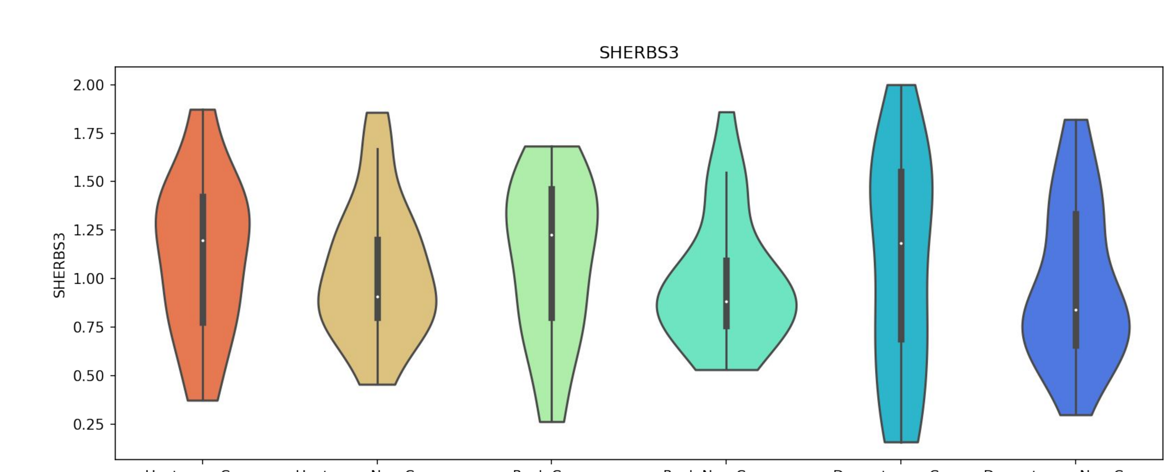

Figure 9: Same as figure 6, but for SHERBS3

Methods

- Total of 64 supercells collected by manual examination of radar on days of isolated supercells in the Appalachian Mountains (Fig. 1). Supercells occurred between April and July and between the years of 2008 and 2019
  - 26 crossing supercells
  - 38 non-crossing supercells
    - Crossing supercells had to have a distinct 'up and over' pattern in relation to elevation and also cross the entirety of either a) the Cumberland Plateau, b) the Allegheny Mountains, or c) the Blue Ridge
- RAP/RUC 0-h model analyses were used to create near-storm proximity soundings at three locations throughout each storm's lifetime: upstream of terrain, peak elevation, and downstream of terrain (Figs. 2-3)
  - Total of 61 analyzed supercells sounding data collected due to missing data for some of the case dates
    - 25 crossing supercells
    - 36 non-crossing supercells
- Parameters calculated include:
  - LCL, LFC, and EL heights
  - The height of 0°C, the height of -20° C, and the wet-bulb zero height
  - 0-1 and 0-3 km SRH; 0-1, 0-3, and 0-6 km bulk vertical wind shear
  - Surface-based, mixed-layer, and most-unstable CAPE and CIN
  - STP, SCP, and SHERBS3
    - SHERB3 helps to identify potential for significantly severe weather production for supercells in high shear, low CAPE environments, common in the southeastern United States
  - 0-3 and 0-6 km lapse rates
  - Surface and mid-level θ_e
  - DCAPE

Results

- Overall, April has the highest frequency of both crossing and non-crossing supercells, followed by May. June had the lowest frequency of both crossers and non-crossers and then increases in July (Fig. 4)
- Hail was the most reported severe threat out of all of the supercells (Fig. 5)
  - Crossers had a higher frequency of producing severe wind and tornadoes
- The parameters that seemed to distinguish between crossers and non-crossers:
  - The lowest 3 km of SRH and shear (Figs. 6-7)
  - The STP and SHERBS3 (Figs. 9-10)
  - CAPE and CIN, regardless of the parcel being used, did not show any difference between the crossers and non-crossers (Fig. 8)
- Peak elevation environments are the start of different trends in crossers vs. non-crossers
  - CAPE decreased at the peak point and is likely due to less relative humidity found at higher elevations
  - SRH and shear tended to have higher values at the peak. This could indicate that higher elevations could increase the shear and SRH, which may help to sustain the supercell

Future Work

- Synoptic analysis
  - 300 hPa, 500 hPa, 850 hPa, surface patterns, and boundaries
    - To identify pattern differences between crossing vs. non-crossing cases
- Begin statistical analyses on various subgroups to identify if there are any statistical differences between these groups
  - Crossing vs. non-crossing (and subcategories)
  - Climatological groups (April vs. May, etc.)
  - Associated severe reports
  - Differences in the subgroups for individual CWAs