Comparing High-Shear, Low-CAPE Supercell Weather Events in the Southeastern United States vs. The Great Plains

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Introduction

Supercell thunderstorms in a high-shear, low-CAPE (HSLC) environment are a phenomenon in which anomalously high vertical wind shear compensates for a lack of convective available potential energy (CAPE). These events are not very common, but when they do occur they are prolific producers of severe weather. The initial conditions, severity, and longevity of HSLC supercell cases differ depending on their location in the United States.

Fig. 1: United States map depicting the location and date of each HSLC supercell case (Southeastern U.S. is blue, Great Plains is red)

This study aims to quantify this difference by assessing and comparing HLSC cases in the Southeastern United States to HSLC cases in the Great Plains. A total of 10 HSLC cases were observed between 2016 and 2021. 5 cases were from the Southeastern United States, and 5 cases were from the Great Plains.

Methods

To analyze the mesoscale and storm-scale components of each high-shear, low-CAPE supercell, the following data and methods were used:

- Potential supercell events were first identified from the Storm Prediction Center Severe Weather Event Database (10 in total where used; Fig. 7)
- Archived WSR 88-D radar data was used to identify the supercells in each case
- Severe storm reports were collected from the NCEI Storm Events Database and SPC Storm Reports Archive
- Near-storm sounding profiles were collected from archived RAP model analyses
- MetPy package used to calculate sounding parameters

Results

	Southeastern US		Great Plains	
Parameter	Average	Standard Deviation	Average	Standard Deviation
Mixed-Layer CAPE (J/kg)	587.74	908.4	904.78	735.83
Mixed-Layer CIN (J/kg)	-17.36	29.96	-30.32	28.65
0-1km Shear (m/s)	13.19	6.77	9.50	8.41
0-3km Shear (m/s)	19.10	7.17	17.71	3.44
0-6km Shear (m/s)	29.74	7.06	26.66	5.35
0-500m SRH (m^2/s^2)	61.16	30.92	40.12	37.90
0-1 km SRH (m^2/s^2)	102.30	48.63	73.36	65.56
0-3 km SRH (m^2/s^2)	142.66	53.07	135.42	26.55
SHERBS3	0.60	0.29	0.72	0.14
SHERBE	0.34	0.47	0.45	0.21

Fig. 2: Table showing the average and standard deviation of multiple severe weather sounding indices for the Southeastern U.S. vs. Great Plains HSLC supercells

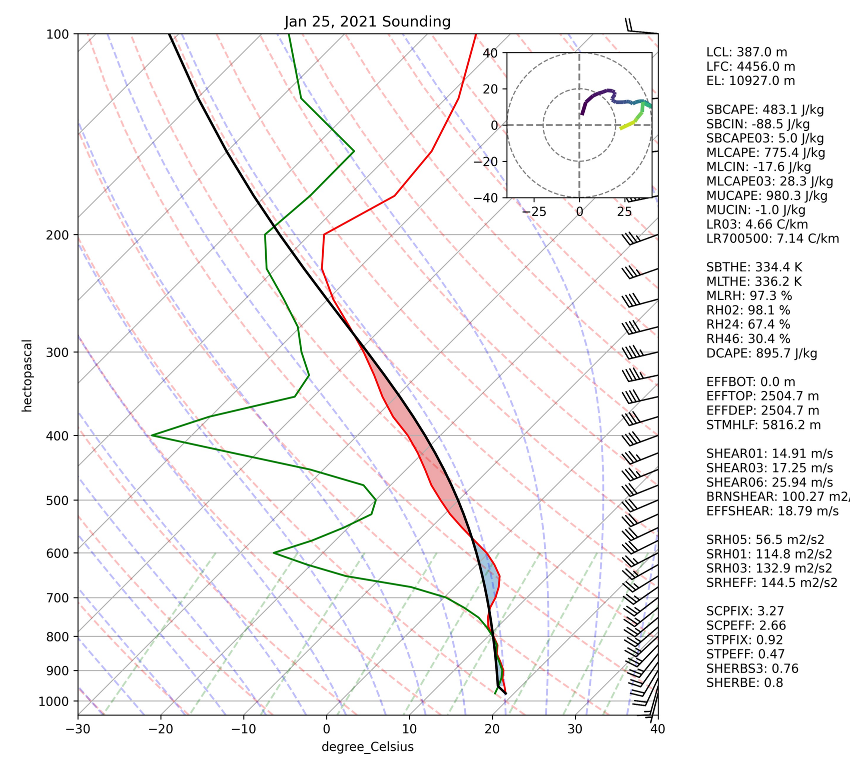

Fig. 3: Representative skew-T log-p sounding profile for Southeastern U.S. HSLC supercells

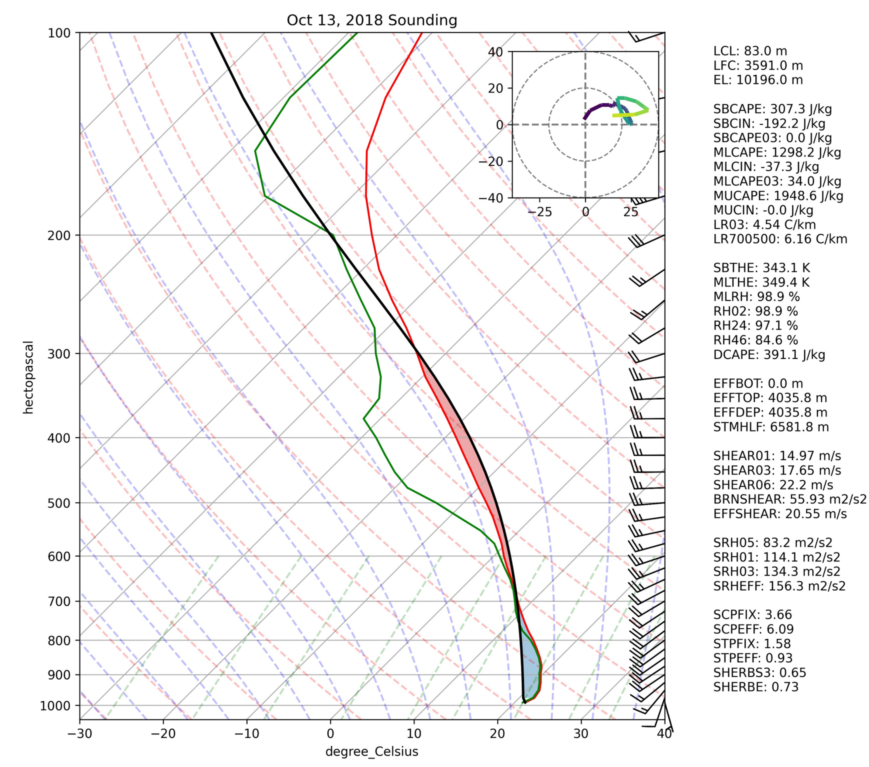

Fig. 4: Representative skew-T log-p sounding profile for Great Plains HSLC supercells

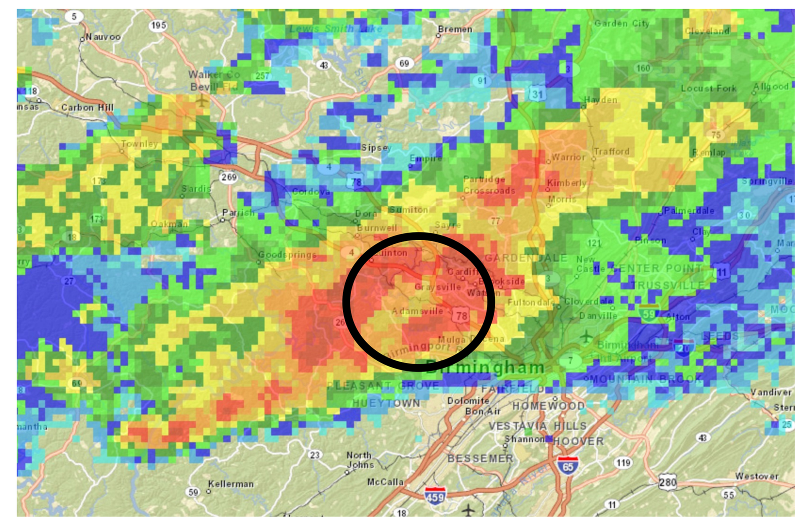

Fig. 5: Radar image of 01/25/2021 Southeastern U.S. HSLC supercell (specific supercell is circled)

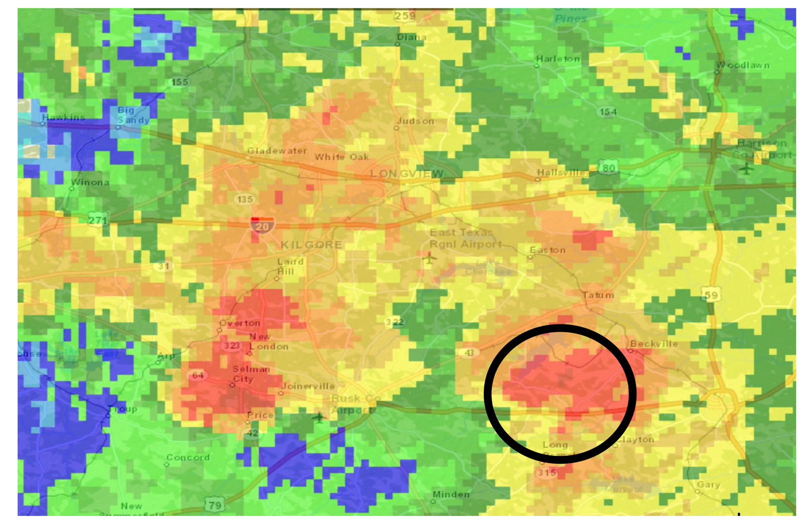

Fig. 6: Radar image of 10/13/2018 Great Plains HSLC supercell (specific supercell is circled)

	Date of Case	Longevity of Supercell (UTC)	Convective Organization
Southeastern U.S.	Feb. 14, 2016	18:50 - 19:50	Primarily quasi-linear with supercell formation near the end
	Jan. 22, 2017	20:20 - 21:00	Broken squall line with noticeable areas of rotation throughout
	Dec. 16, 2019	17:00 - 18:00	Two major squall lines with apparent supercell formation
	Dec. 23, 2020	04:00 - 05:50	Spread out areas of convection with rotation occurring in some areas
	Jan. 25, 2021	03:50 - 05:10	East-west oriented squall lines with a few areas of supercell formation
Great Plains	Oct. 9, 2018	20:00 - 21:30	Large squall line with apparent bow-echo shape; little rotation
	Oct. 13, 2018	19:00 - 22:30	Small patches of convection with some areas of rotation present
	Feb. 6, 2019	03:00 - 05:20	One thin squall line with very few areas of rotation
	Nov. 14, 2020	00:30 - 03:30	Small patches of convection with very little apparent rotation
	Oct. 12, 2021	00:00 - 02:00	Large squall line with slight areas of rotation throughout

Fig. 7: Table showing the longevity and convective outlook for each supercell case

Key Differences

- The Southeastern U.S. cases had more marginal thermodynamics (lower average CAPE and CIN) than the Great Plains supercells
- The Southeastern U.S. cases had stronger dynamical support via higher average vertical wind shear in both low-level and deep-layer shear
- The Southeastern U.S. cases contained higher low-level storm relative helicity
- The Great Plains had a higher value for both SHERB indices, signaling higher potential for severe weather production
- Convection is more focused in the Southeastern U.S., while it is more spread out in the Great Plains

Summary

- Overall, stronger upper- and lower-level dynamical forcing is present for HSLC supercells in the Southeastern U.S. than in the Great Plains
  - Quantified via higher average vertical wind shear and storm relative helicity values for all layers
- HSLC supercells in the Great Plains have weaker dynamical forcing, but higher instability
  - Evaluated via higher average CAPE values and SHERB index values

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