

Introduction

This study integrates past research methodologies along with National Lightning Detection Network (NLDN) data to analyze the lightning and severe weather hazard relationship for the 27-28 April 2011 Southeast U.S. tornado outbreak. Lightning characteristics associated with seven supercell thunderstorms that produced longtrack, significant and/or violent tornadoes are explored.

Methods

The tornado-lightning relationship is assessed by examining each storm's cloud-to-ground (CG) lightning rate characteristics accompanying tornadogenesis and tornadolysis. Lightning characteristics are also related to low-level (0-4 km) mesocyclone intensity as assessed via NWS Doppler Radar to provide insight into storm dynamics and CG lighting flash rates.



Regional Analysis

Fig. 1: Regional event analysis illustrating positive and negative polarity CG lightning flashes for the 300 km buffer centered on Birmingham, AL (19 UTC 27 April 27 2011 through 02 UTC April 28 2011).

Table 1: Lightning metric results from the 300 km regional buffer centered on Birmingham, AL (19 UTC 27 April 27 2011 through 02 UTC April 28 2011).

Total CG lightning flashes (+/-)	109,206
Total +CG flashes	5,889
Total -CG flashes	103,317
Percentage +CG flashes	5.39%
Average +CG flash polarity	24.13
Average -CG flash polarity	-19.82

Table 2: Lightning metrics for all storms examined (i.e., Storms A-G; See Figure 2)

Total CG lightning flashes (+/-)	38,44
Total +CG flashes (kA)	2,528
Total -CG flashes(kA)	35,91
Mean max. +CG stroke current (kA)	39.9
Mean maxCG stroke current (kA)	-85.49
Percentage +CG flashes (%)	7.4
Mean average -CG flash polarity (kA)	-21.54
Mean average +CG flash polarity (kA)	24.22
Avg. total CG flash rate (flashes/min)	27.9
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Relationship

Table 3: Lightning metric tornadoes D-1 and D-2 (Tuse

Total CG lightning flashes (+/-) Total +CG flashes (kA) Total -CG flashes(kA) Mean max. +CG stroke current Mean max. -CG stroke current Percentage +CG flashes (%) Mean average -CG flash polarity Mean average +CG flash polarit Avg. total CG flash rate (flashes/min)

Lightning Signatures of Long-lived Tornadic Supercells in the Southeastern U.S. on 27-28 April 2011

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Lightning/Tornado

results for aloosa, AL)	Storm D;		
	10496		
	598		
	9898		
(kA)	46.41		
(kA)	-106.57		
	5.55		
y (kA)	-20.79		
ty (kA)	23.04		

45.69

Fig. 3: Temporal lightning trend analysis throughout the lifecycle of Storm D; tornadoes D-1 and D-2 (Tuscaloosa, AL). Thick black line indicates total CG flashes; gray line with the triangle marker illustrates total -CG flashes; gray line with the square marker represents the total +CG flashes; thick gray line with no marker represents the duration of the tornado.



Table 4: Lightning trends and $('\checkmark')$ indicates experienced and

Storr	n Tornado	Local max. total CG flash rate prior to tornadogenesis	Local min. total CG flash rate coincident with tornadogenesis	Polarity shift coinciding with tornadogenesis or during tornado production	Increase in total CG flash rate coincident with tornado dissipation
Α	A-1	\checkmark	Х	Х	Х
В	B-1	\checkmark	\checkmark	Х	Х
	C-1	\checkmark	\checkmark	Х	\checkmark
С	C-2	\checkmark	\checkmark	Х	\checkmark
	C-3	\checkmark	\checkmark	Х	\checkmark
	C-4	\checkmark	\checkmark	Х	\checkmark
	D-1	\checkmark	\checkmark	Х	\checkmark
U	D-2	Х	Х	Х	Х
E	E-1	\checkmark	\checkmark	Х	Х
F	F-1	\checkmark	\checkmark	Х	\checkmark
G	G-1	\checkmark	\checkmark	Х	\checkmark





attributes associated with each storm (A-G)
d 'X' indicates not experienced).



Table 5: Storm D/tornadoes D-1 and D-2 regression analysis (R²), Pearson's productmoment correlation (r), significance testing with the t-distribution between NLDN total CG lightning flashes and rotational velocity (Vr)/azimuthal (rotational) shear (S) by Doppler radar scan elevation angle; values in **bold** font represent moderate (r = -0.5 to -0.3) strength. correlation strength; values *italicized* illustrate significant correlation values at confidence interval 95%.

		Vr (.5)	Vr (.9)	Vr (1.4)	S (.5)	S (.9)	S (1.4)
ILDN	R ²	0.240	0.234	0.425	0.035	0.062	0.120
	r	-0.489	-0.483	-0.652	-0.186	-0.249	-0.346
	Significance test with the t- distribution One-tailed; α= 0.05	-3.125	-2.974	-4.787	-1.054	-1.382	-2.052

Results

- \rightarrow The majority of storms examined illustrate a local maximum in total CG flash rate prior to tornadogenesis, a local minimum in total CG flash rate coincident with tornadogenesis, and an increase in total CG lightning flash rate coincident with tornadolysis
- \rightarrow CG lightning flashes were negative polarity lightning flashes for a majority of all storms; we speculate that this is due to the seasonality and location of the severe weather event (i.e., early spring and southeastern U.S.).
- \rightarrow Findings from this analysis corroborate prior research, which suggests that lightning attributes and their patterns can yield insight into internal storm dynamics and hazard production.
- \rightarrow Results from the total CG lightning flash/low-level mesocyclone intensity relationship were varied and inconsistent; low-level mesocyclone strength is only one of many dynamical processes that influence total CG lightning flash rate.



Fig. 4: Storm D/tornado D-2 rotational velocity (Vr) by radar elevation scan and total CG lightning flashes.

