Weak Tornadoes In The Ohio Valley: A Pre-Storm Environment Assessment

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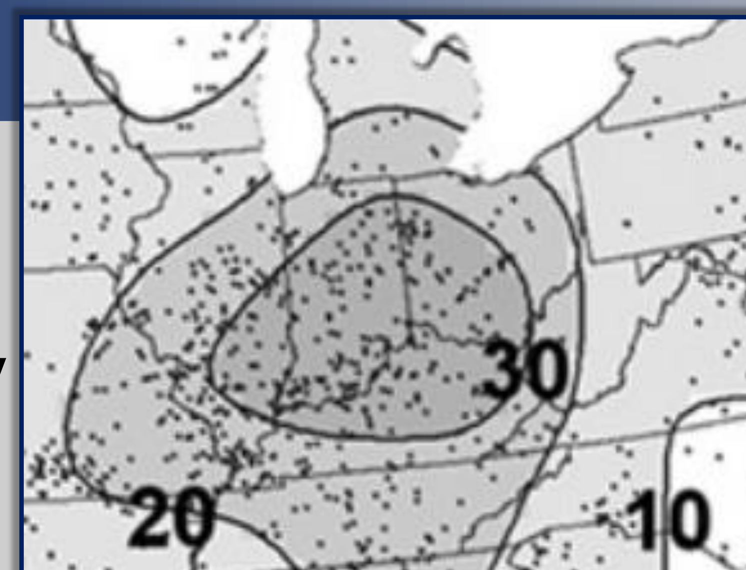
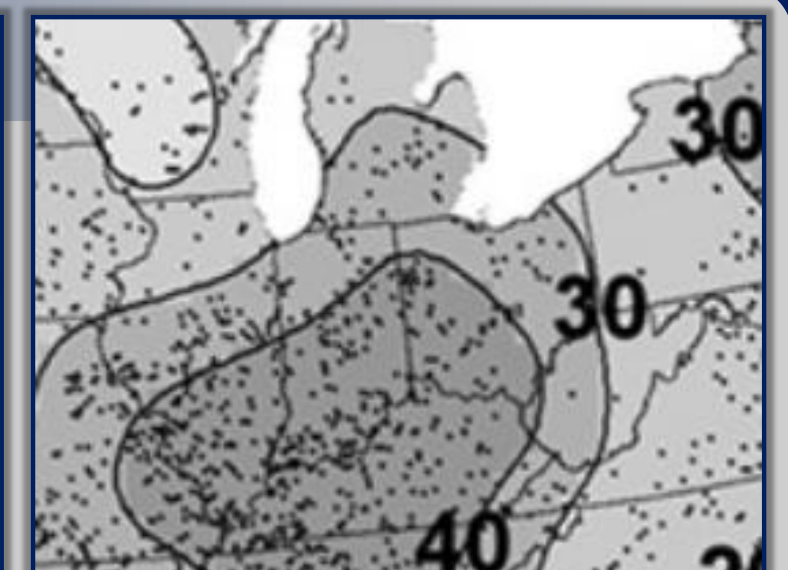
Introduction

Quasi-Linear Convective Systems (QLCSs) are a class of convection that includes bow echoes, line segments, and squall lines and are usually associated with strong straight-line winds. However, they can also be prolific tornado-producers. NSSL/SPC research suggests that the relative frequency of QLCS tornadoes, as well as those from line marginal and line right-moving supercells, is higher in the Tennessee and Ohio Valleys than anywhere else in the United States.



Relative QLCS Tornado Event Frequency (%, 2003-2011) (From Smith et al. 2012)



Relative QLCS+ Line RM+ Line Marginal Tornado Event Frequency (%, 2003-2011) (From Smith et al. 2012)

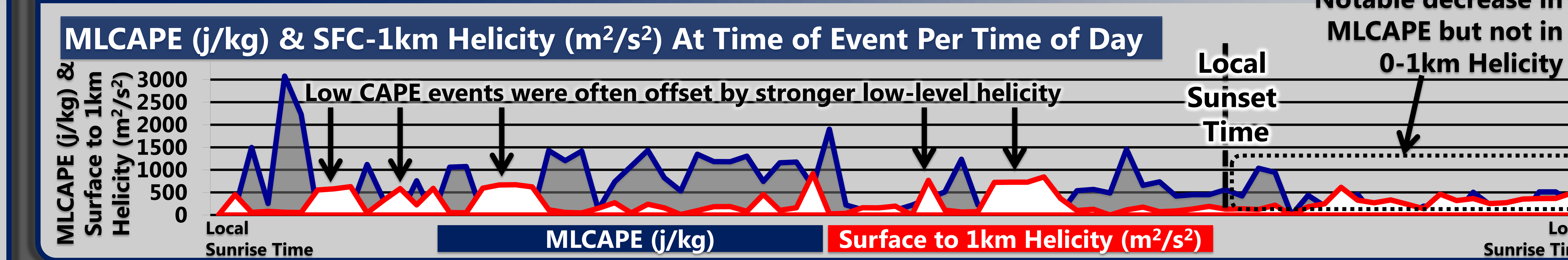
Because of the relative frequency of these types of events in the region, which are often short-lived and on the low-end of the EF-Scale (EF0 or EF1), warning decisions are sometimes made with little to no lead time, owing to the rapid process of tornadogenesis and dissipation. Identification of key environment changes in the near-storm environment is vital to understanding what setups may be most conducive to producing these types of tornadoes.

Methodology of Study

- Archived Rapid Refresh (RAP) model analysis data (13-km grid-spacing) was studied from weak tornado environments in the NWS ILN service area of southeastern Indiana, southwestern Ohio, and northern Kentucky from 2009 to 2017 – 125 events.
- Pre-storm environments were investigated utilizing 16 different RAP analysis fields, including stability, shear, and moisture parameters in the hours prior to EF0 and EF1 tornado development.
- Time trends of each parameter were categorized by season and time of day, and relationships were identified for each variable through time.
- The data collection methodology yielded over 6000 data points. Parameters were assessed with regards to positive or negative correlations to tornado development time – including by season, time of day, and storm mode.
- Trends of individual stability and shear parameters were also compared to each other to assess degree of correlation – both with and without respect to time.

EF0/EF1 Tornado Events In Study 2009-2017

Time of Day Comparison

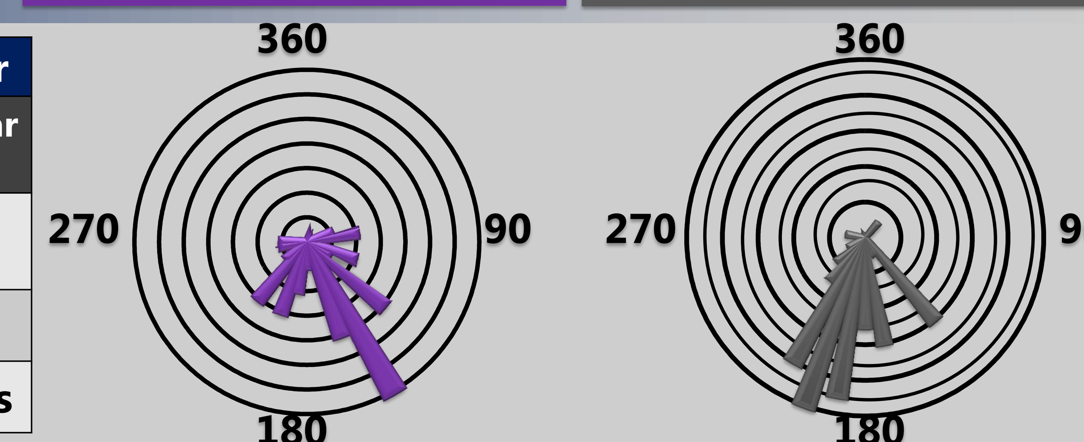


Surface Observation Assessment

The "weaker" shear events generally had winds that were more backed at the surface, indicating that the lack of stronger flow was augmented, in many cases, by more low-level directional shear.

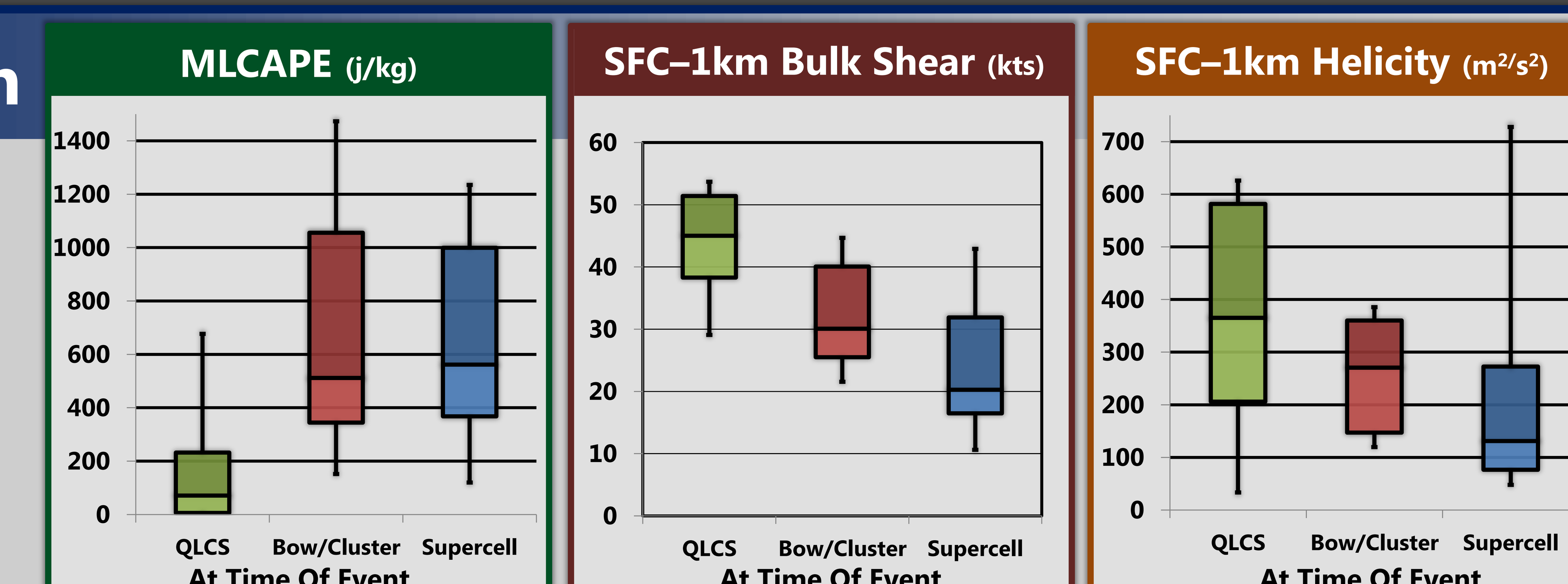
Surface Wind Direction & 0-1 km Bulk Shear

Parameter	Bulk Shear <25kts	Bulk Shear >25kts
Most Prominent Surface Wind Direction	150°	200°
Avg. Surface Wind Direction	162°	188°
Avg. Surface Wind Speed	9 knots	15 knots

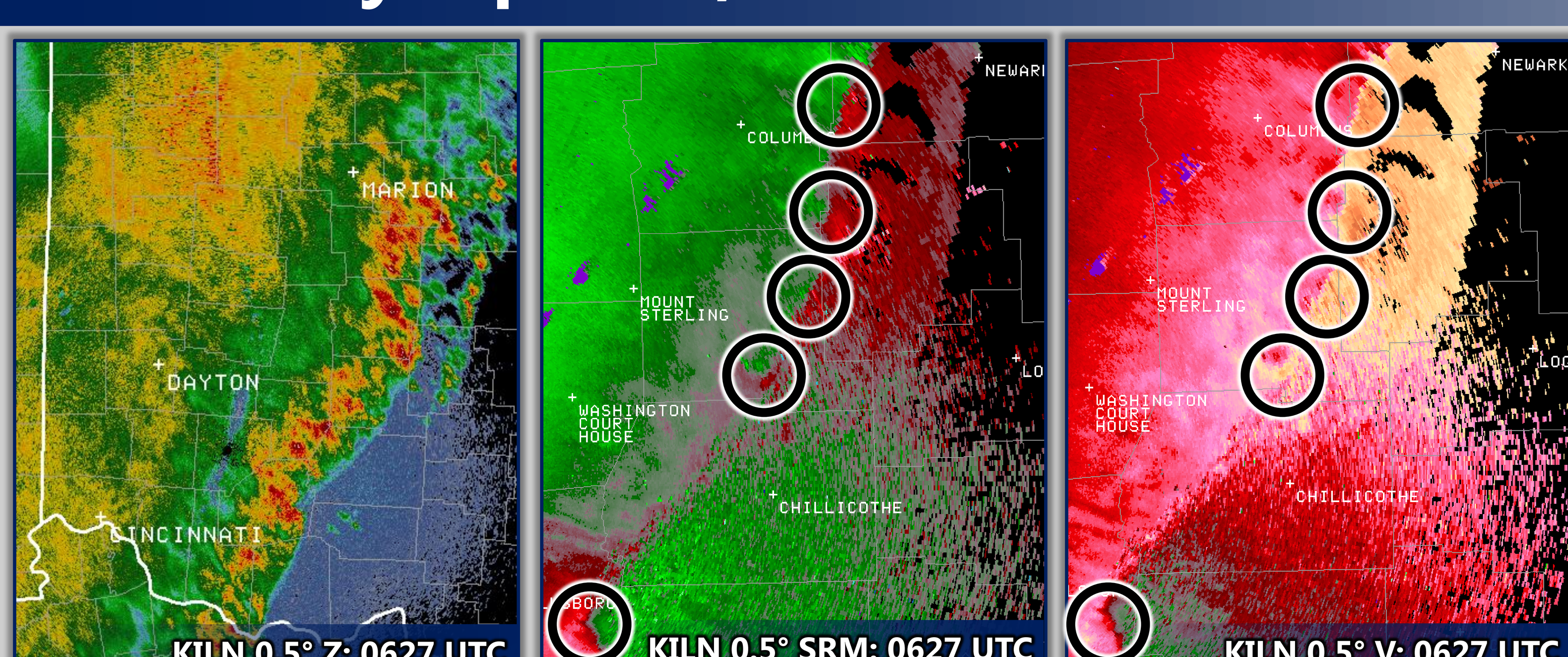


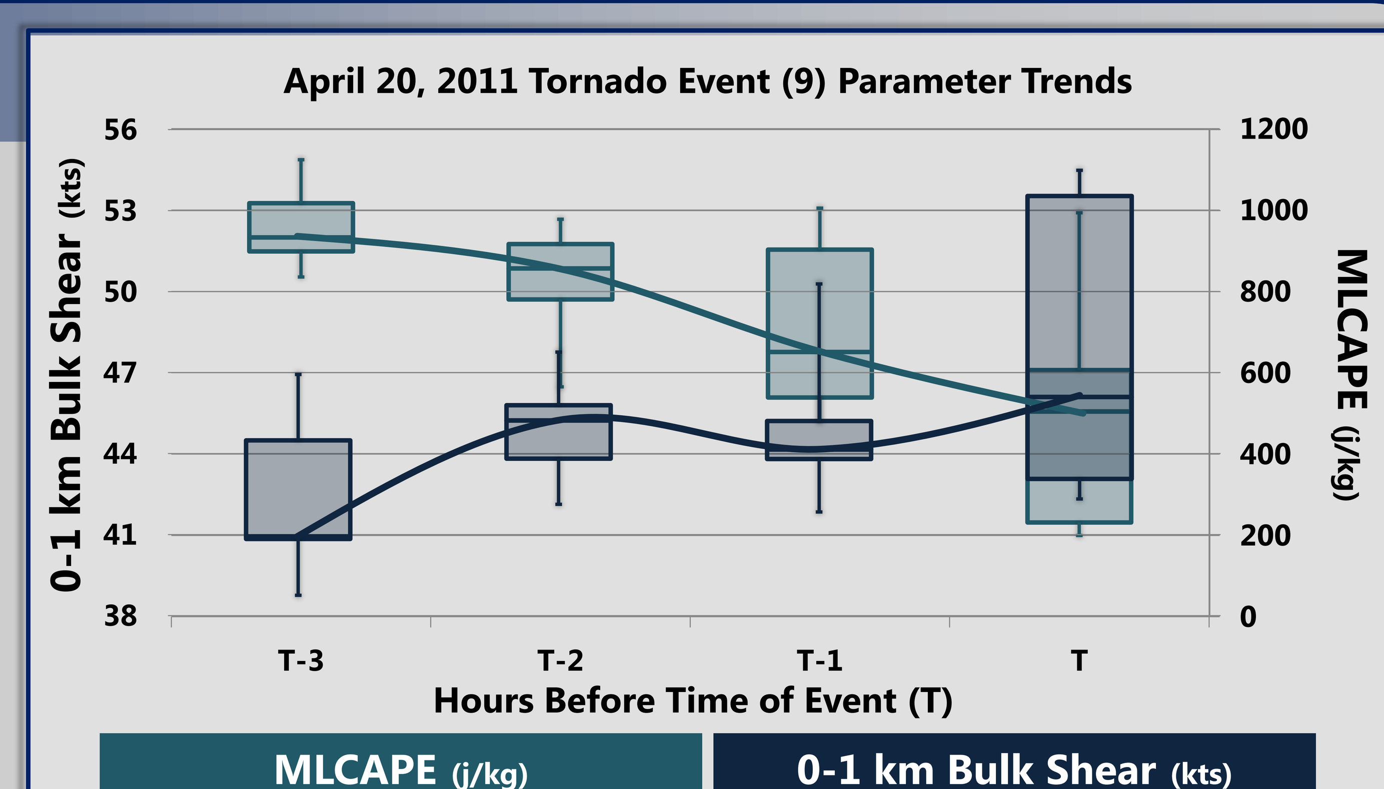
Storm Mode Comparison

A comparison of storm modes shows a clear delineation in instability and shear parameters at the time of the event between QLCS, bows/clusters, and supercells. QLCS tornado environments were characterized by generally lower instability and higher shear and helicity values than were environments that led to bow/cluster or supercell tornadoes.



Case Study: April 20, 2011





Average Parameter Trends From T-1 to T (% Change): 9 Total Events		
SB LCL Height (ft.)	SHERB Parameter	SB LI
- 11%	+ 4%	- 17%

During the late evening hours on the 19th into the early morning hours of the 20th, a weakening QLCS tracked eastward through the Ohio Valley, including right through the heart of the NWS Wilmington, OH (ILN) county warning area (CWA):

- The event produced 11 total tornadoes (including two EF2s) within the NWS ILN CWA.
- Numerous circulations appeared on radar velocity along the leading edge of convection (along the shear axis), many of which were evident on radar only very briefly before dissipating.
- Of the 9 weak tornadoes (EF0s and EF1s), 7 of them were determined to have been on the ground for 3 minutes or less. Of those 7 events, 4 of them were estimated to have been on the ground for 1 minute or less.

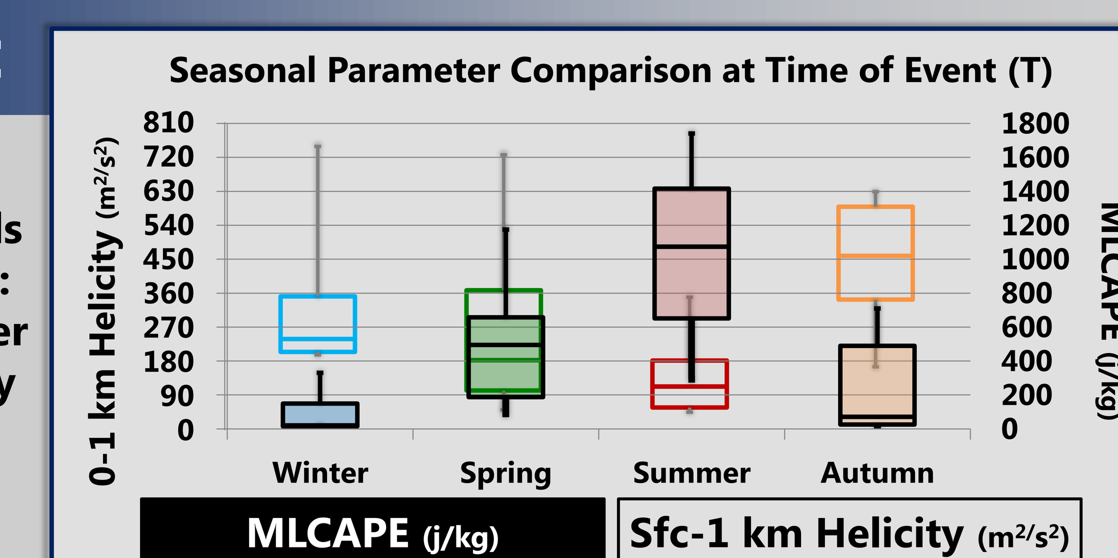
Official NWS Storm Survey Damage Photo

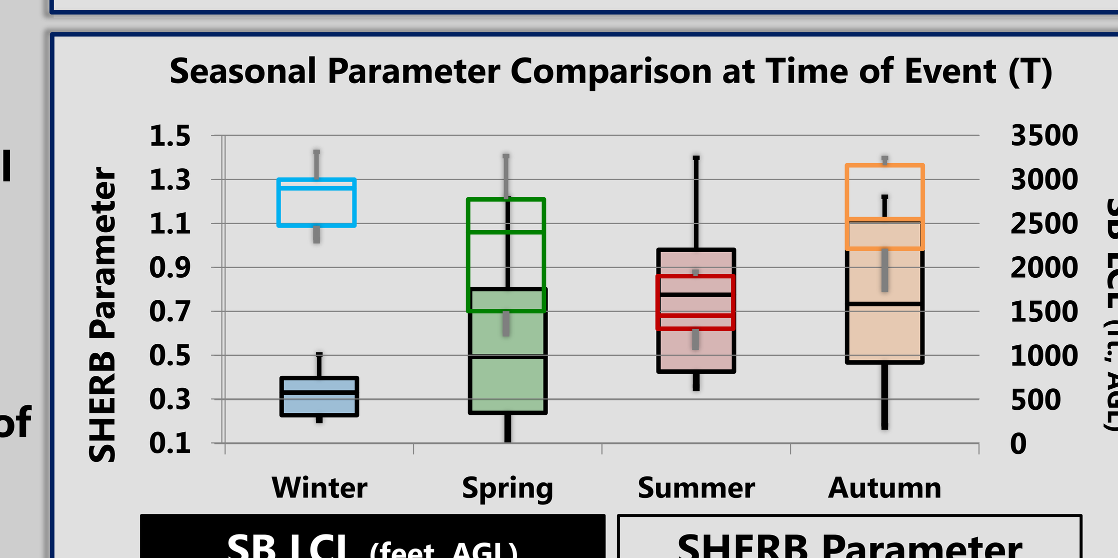
April 20, 2011

Seasonal Assessment

A comparison of environmental parameters season-by-season reveals a distinct difference in several fields:

- The lack of instability in the winter and autumn months was offset by substantially higher 0-1 km helicity, on average.
- The SHERB (Severe Hazards in Environments with Reduced Buoyancy) parameter highlights the predominance of high shear/low CAPE events in the cool season (autumn, winter) in comparison to the warm season.
- The lower LCL heights in the cool season (compared to the warm season) illustrates the likelihood of cool season environments being aided by a generally more-moist boundary layer (higher RH).





Acknowledgements

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