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

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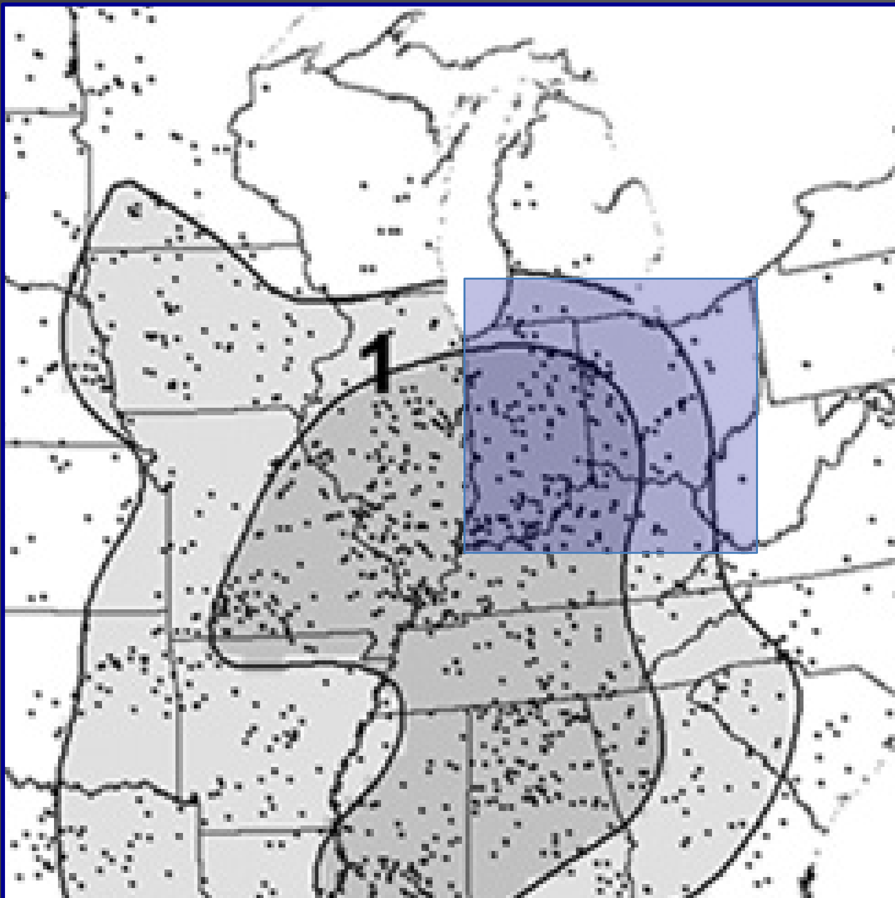
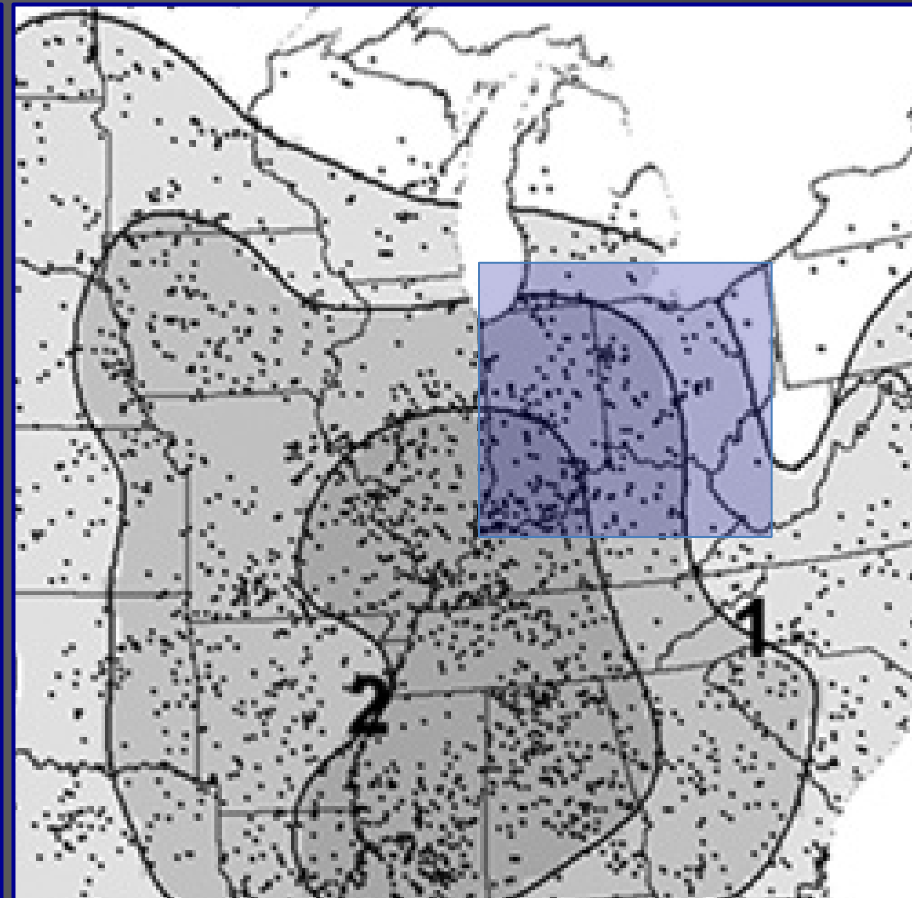
Weak Tornadoes In The Ohio Valley: The Climatology



Smith Et al. (2012)
QLCS Tornado Frequency
From 2003-2011



Smith Et al. (2012)
QLCS + Line RM + Line Marginal
Tornado Freq. From 2003-2011

Weak Tornadoes In The Ohio Valley: The Climatology

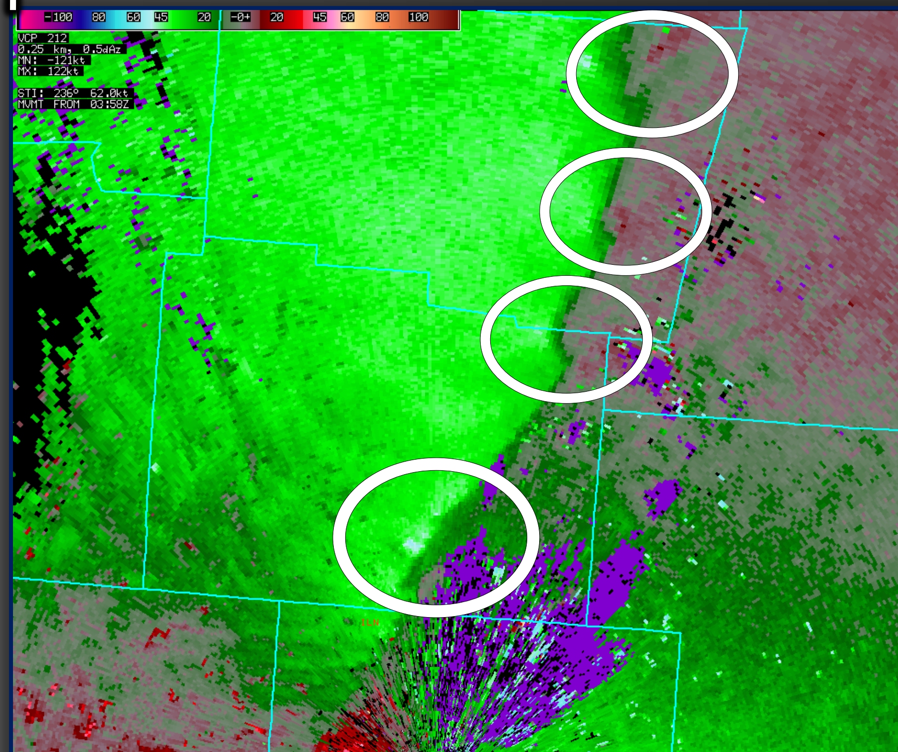
From Smith Et al. (2012):

"The greatest estimated rate of occurrence for the organized cellular tornado events is located over the central Great Plains… [while] a distinctly different distribution is found for the **linear mode tornado events**… concentrated over the **lower Ohio River Valley**…"

"A relative minimum [in cluster RMs] is noted in the… Ohio Valley, which corresponds to a **higher relative frequency of… QLCS across the Ohio Valley**."

"A distinct tendency for a **higher proportion of tornado events** resulting from linear convective modes is shown… from **the Ohio Valley** southward to the lower Mississippi Valley."

Many of the tornado-producing events in the Ohio Valley look not too dissimilar from an event like this in which many rotations appear and multiple quick spin-up tornadoes occur, creating a tremendous challenge for warning forecasters.



KILN 0.5° SRM – October 31, 2013

Greene & Clark Counties, Ohio

Weak Tornadoes In The Ohio Valley: NWS Wilmington, OH (ILN) CWA

136

Total EF0 or EF1 Tornadoes

In The National Weather Service Wilmington, Ohio (ILN) County Warning Area (CWA) Between 2009 and 2017

93

Percent of Tornadoes that are EF0/EF1

In The National Weather Service Wilmington, Ohio (ILN) County Warning Area (CWA) Over The Previous Decade

86

Number of Warned EF0/EF1 Tornadoes

In The National Weather Service Wilmington, Ohio (ILN) County Warning Area (CWA) Between 2009 and 2017

69

Events with Less than 3 minutes of Lead Time

From Warning Issuance To Tornado Touch Down

~ 51 % of tornadoes in the study (2009-2017)

Weak Tornadoes In The Ohio Valley: 2009 Through 2017

Question 1

Are there environmental modifications in the hours leading up to the event which are contributing to tornadogenesis?

Question 2

If there are important environmental changes, what are they are how significant are they?

Question 3

Will identification of these changes in real-time environments aid in an operational sense and lead to better lead-time?

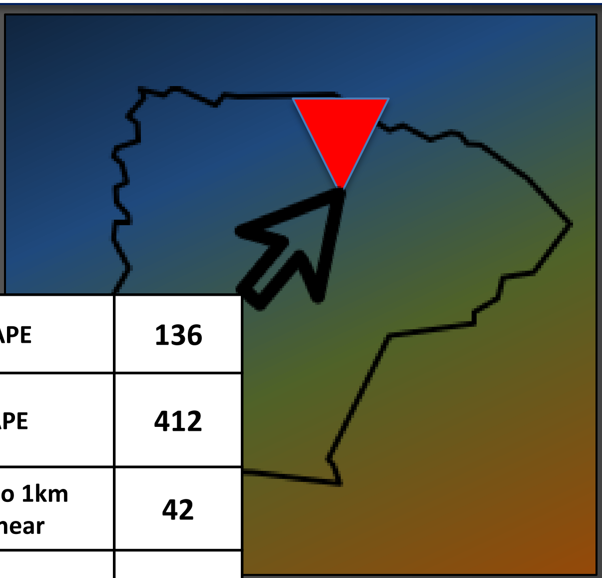
Let's Find Out...

Weak Tornadoes In The Ohio Valley: The Methodology

The Dataset

Total Number of Events 2009 to 2017	136
Total Number of Events In Which Rapid Refresh (RAP/RUC) Analysis Data Was Available	125
Final Rating of EF0	83
Final Rating of EF1	42

2012-Present: Rapid Refresh Analysis (RAP-ANL) Grids on a 13km domain
2009-2011: RUC Analysis (RUC-ANL) Grids on a 13-km domain



MLCAPE	136
SBCAPE	412
Surface to 1km Bulk Shear	42
...	...

▼ = NWS-Survey-Confirmed Tornado Location (Latitude/Longitude to A Hundredth of A Point)

T	T-1	T-2	T-3
Time of Event	1 hour before	2 hours before	3 hours before

Weak Tornadoes In The Ohio Valley: The Dataset

SBCAPE | MLCAPE | DCAPE

SBCIN | MUCAPE

0-1 km Helicity | MLLCL | SBLCL

0-3 km Helicity | SHERB

0-1 km Bulk Shear | 0-3 km Bulk Shear | 0-6 km Bulk Shear

SCP Parameter | Sfc Lifted Index

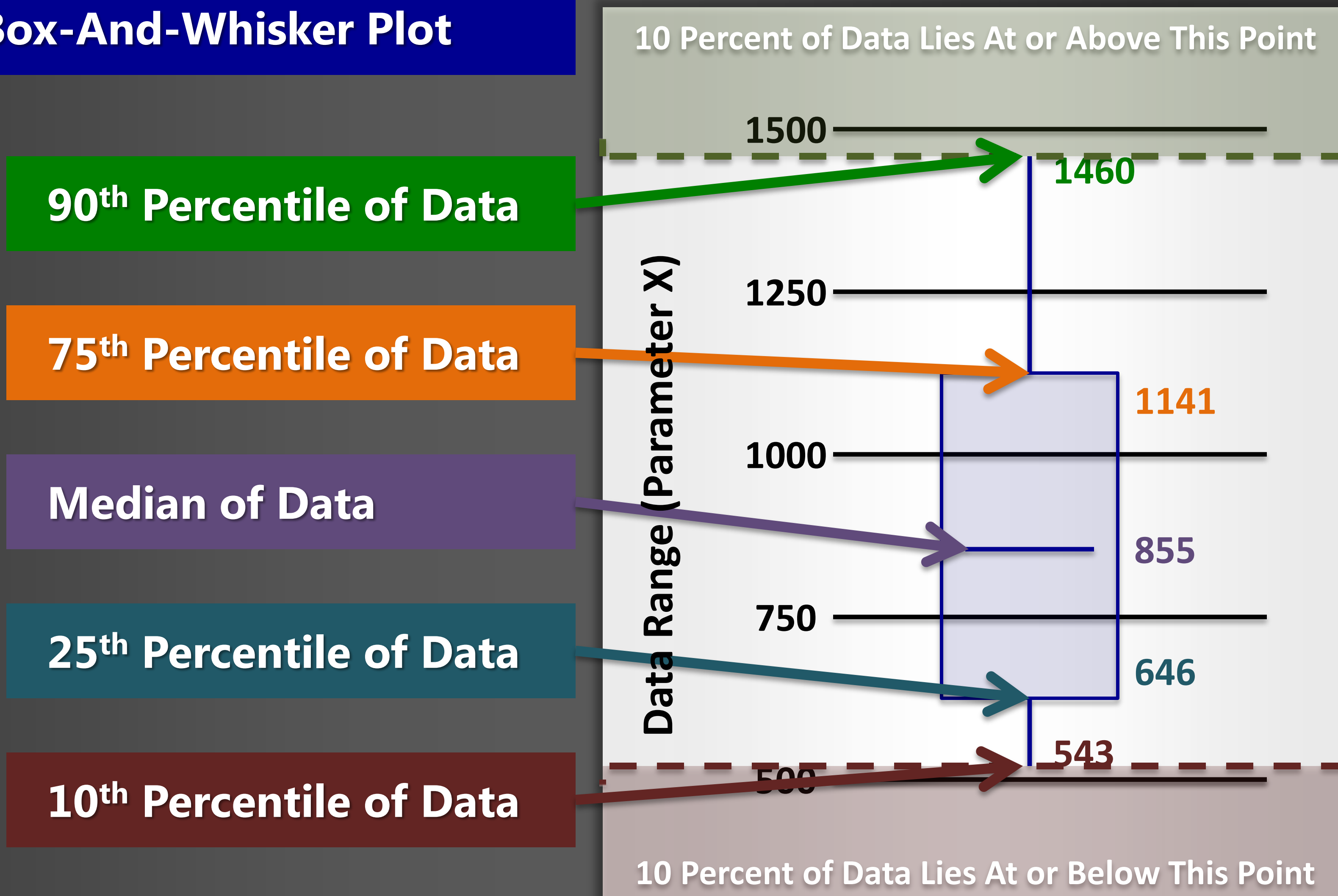
Each Parameter Magnitude Was Recorded For 4 Different Time Periods For All 125 Events, Which Puts The Approximate Total Number of Data Points Retrieved at...

~7000

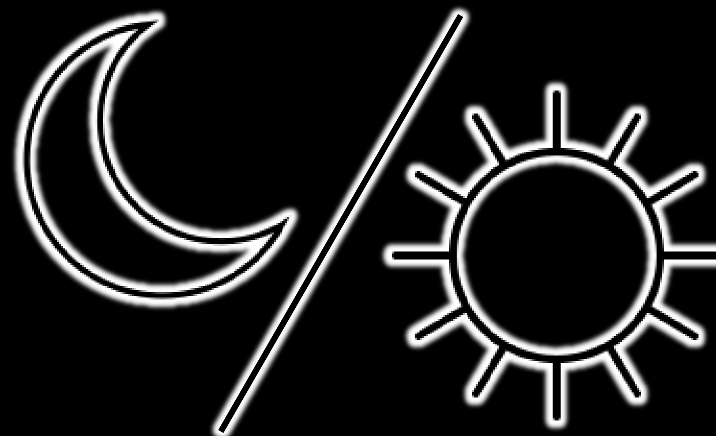
Weak Tornadoes In The Ohio Valley: Data Representation

The Box-And-Whisker Plot

Box-and-Whisker Plots Were Chosen As A Primary Method for Representing The Dataset and Distribution of Such Data Because Trends In Distribution Are Easily Identifiable and Potential Unusual Observations Become More Evident.

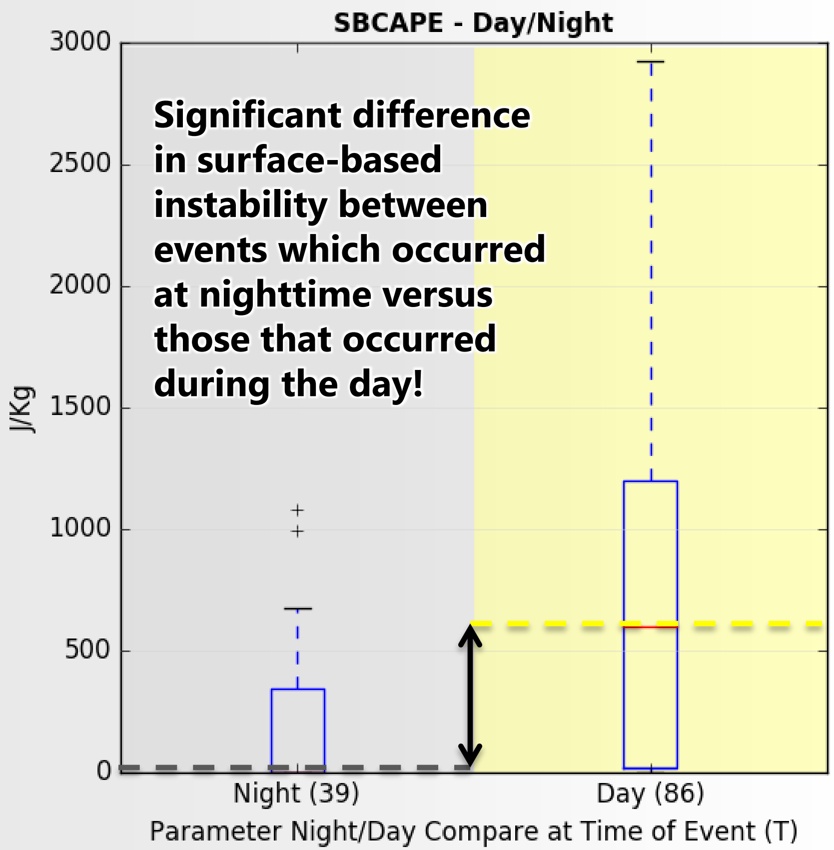


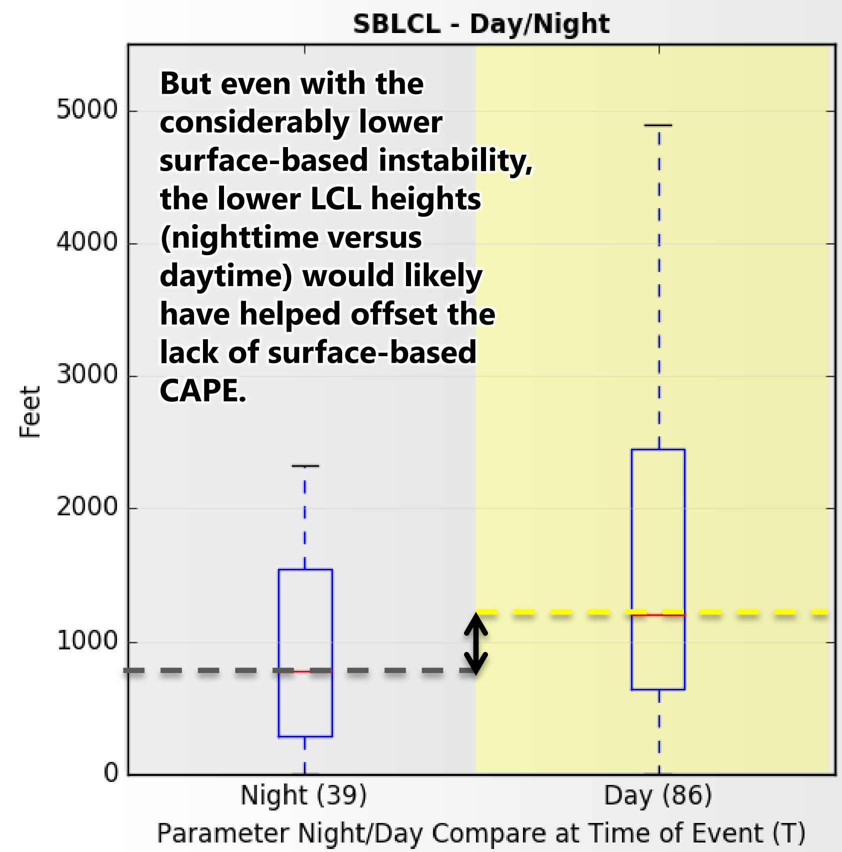
Let’s Compare Some Parameters Between Events Which Occurred At Nighttime Vs. Daytime



Parameter Comparison at Time (T)
Day Vs. Night

Total Nighttime Events: 39
Total Daytime Events: 86





Parameter Comparison at Time (T)
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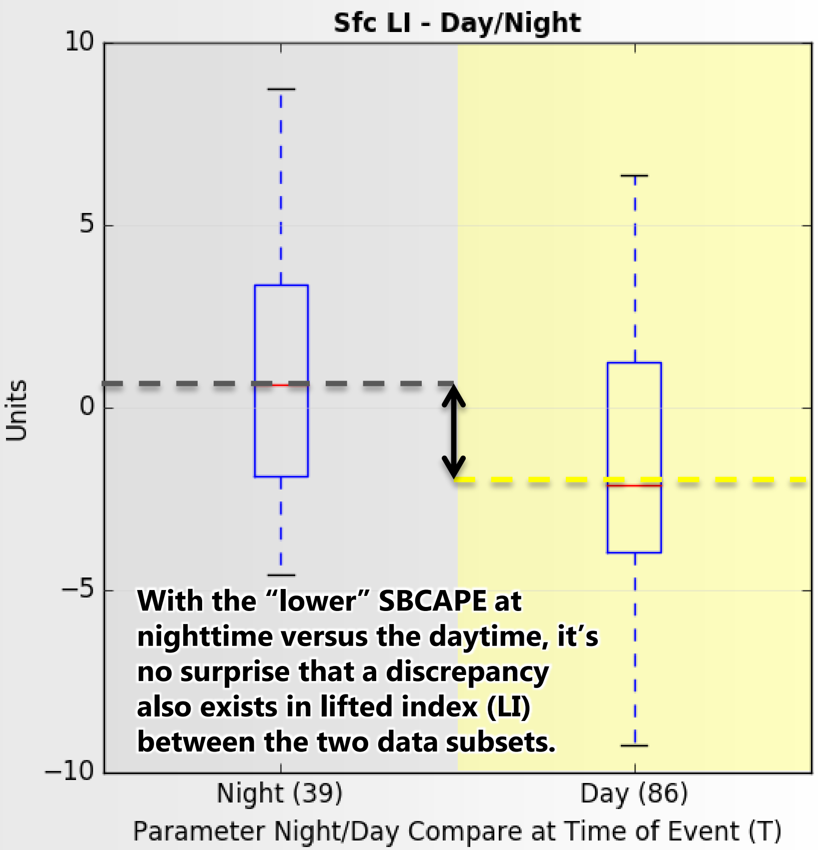
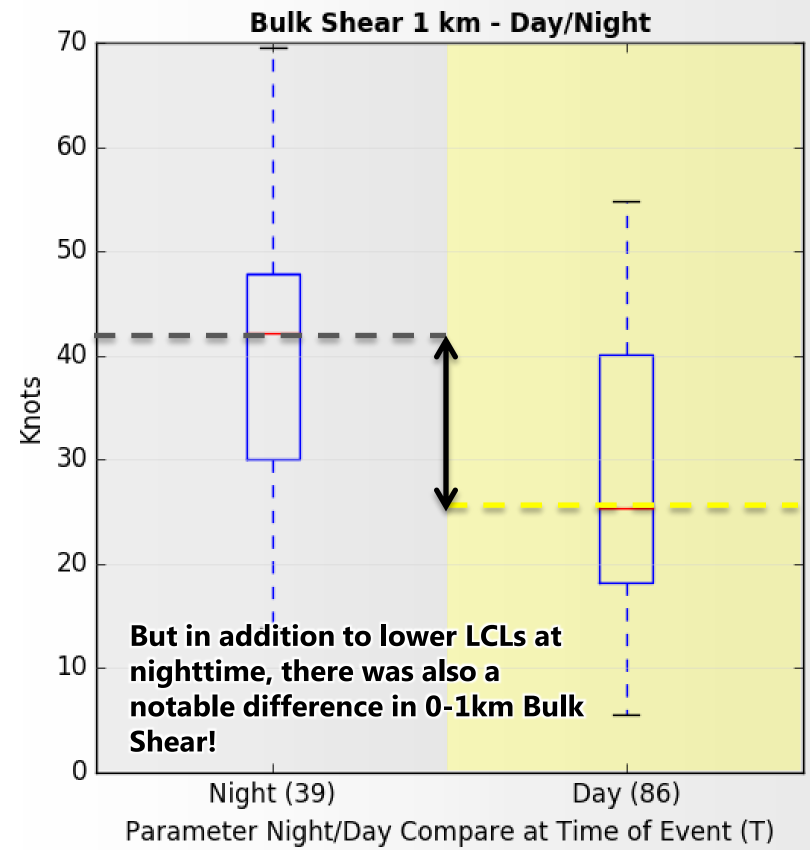
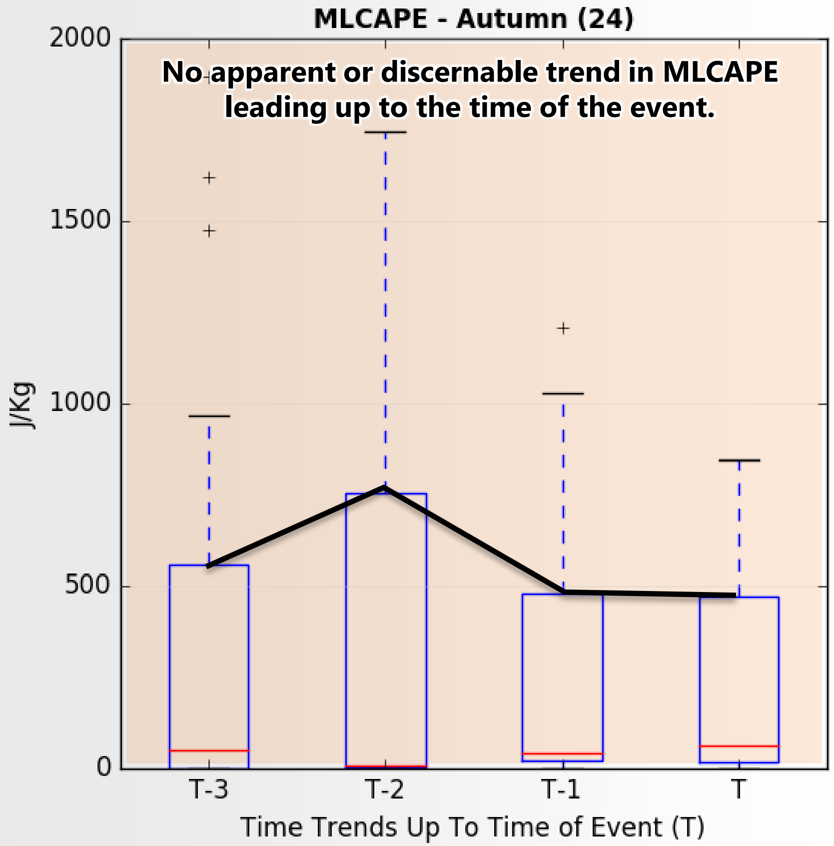


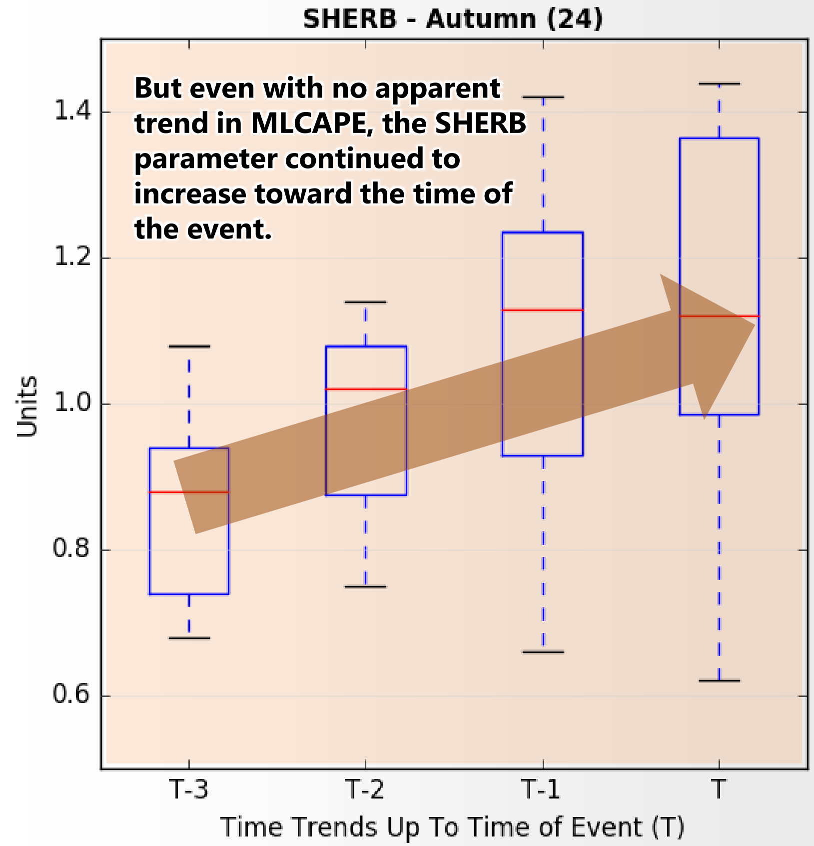


Let's Compare Some Parameters Between Events Which Occurred During The Autumn Season

Parameter Comparison at Time (T)
Autumn Seasonal Assessment (24 Events)

Total (Meteorological) Autumn Events: 24



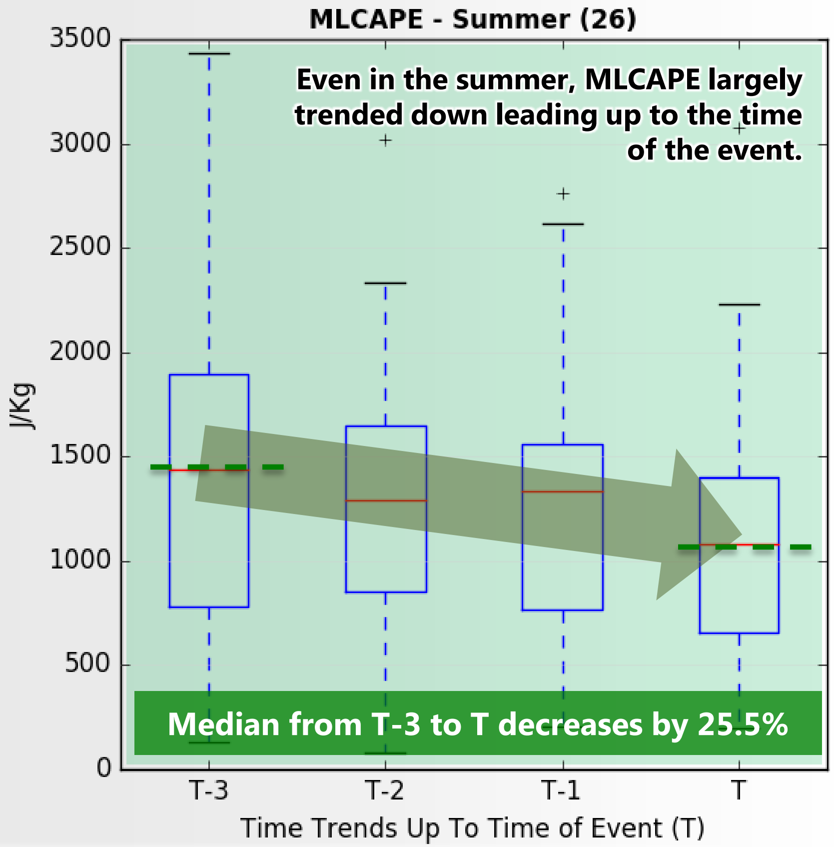


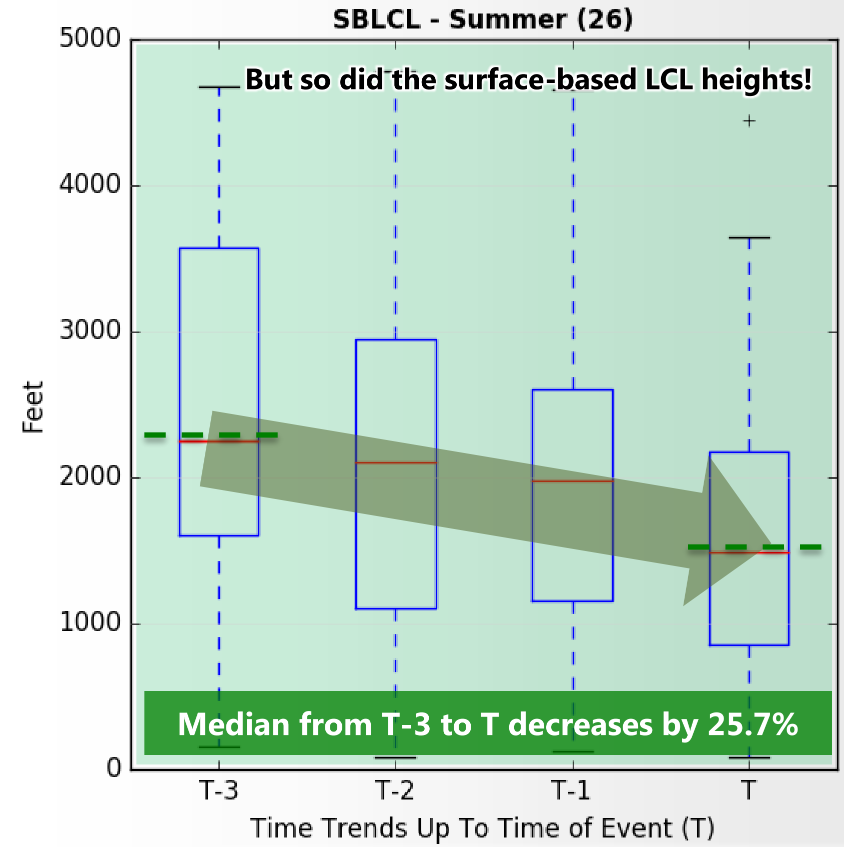
Autumn

Let's Compare Some Parameters Between Events Which Occurred During The Summer Season

Parameter Comparison at Time (T)
Summer Seasonal Assessment (26 Events)

Total (Meteorological) Summer Events: 26

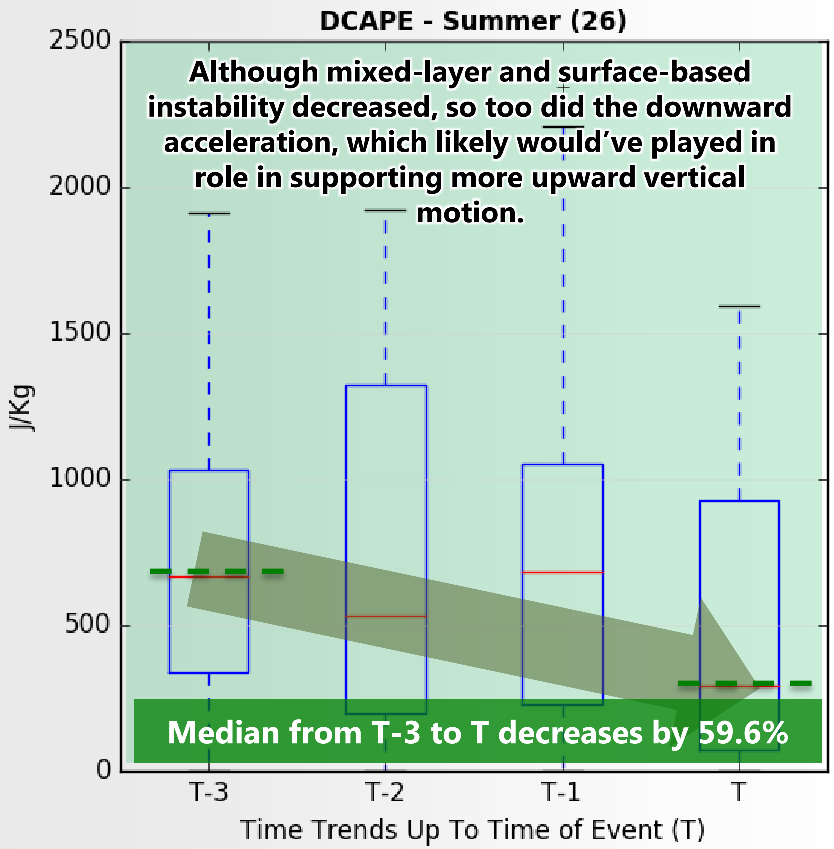


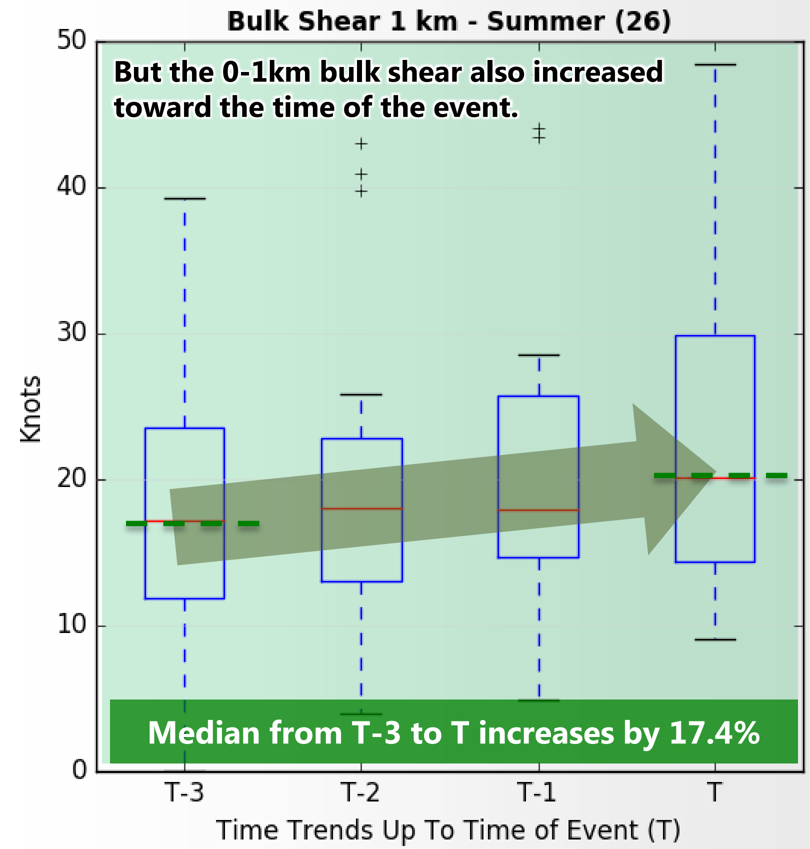


Summer

Parameter Comparison at Time (T)
Summer Seasonal Assessment (26 Events)

Total (Meteorological) Summer Events: 26



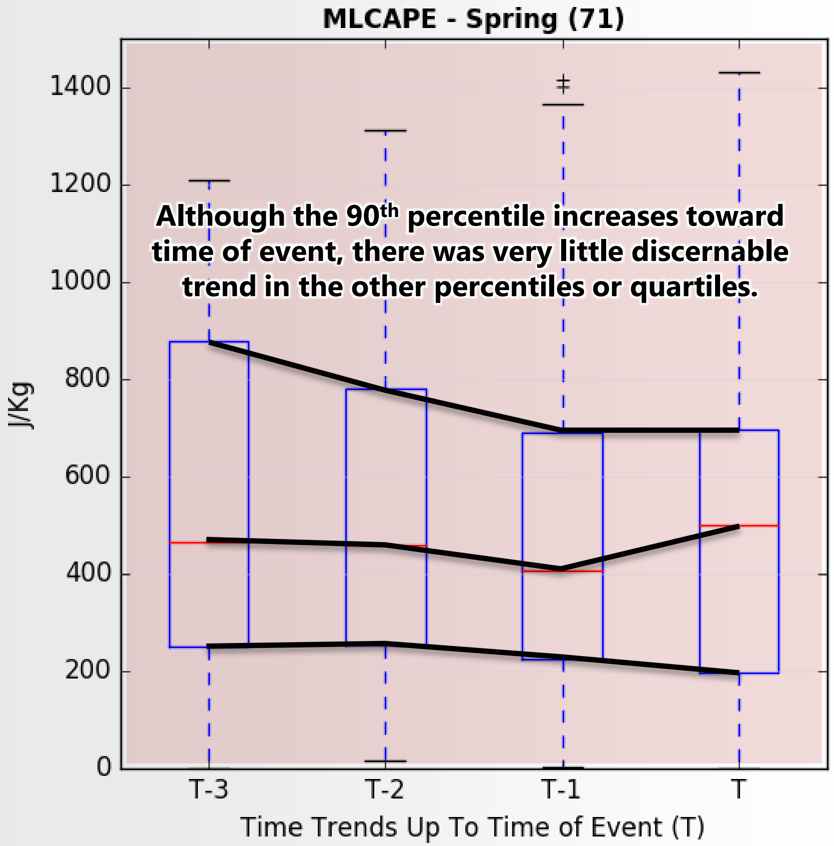


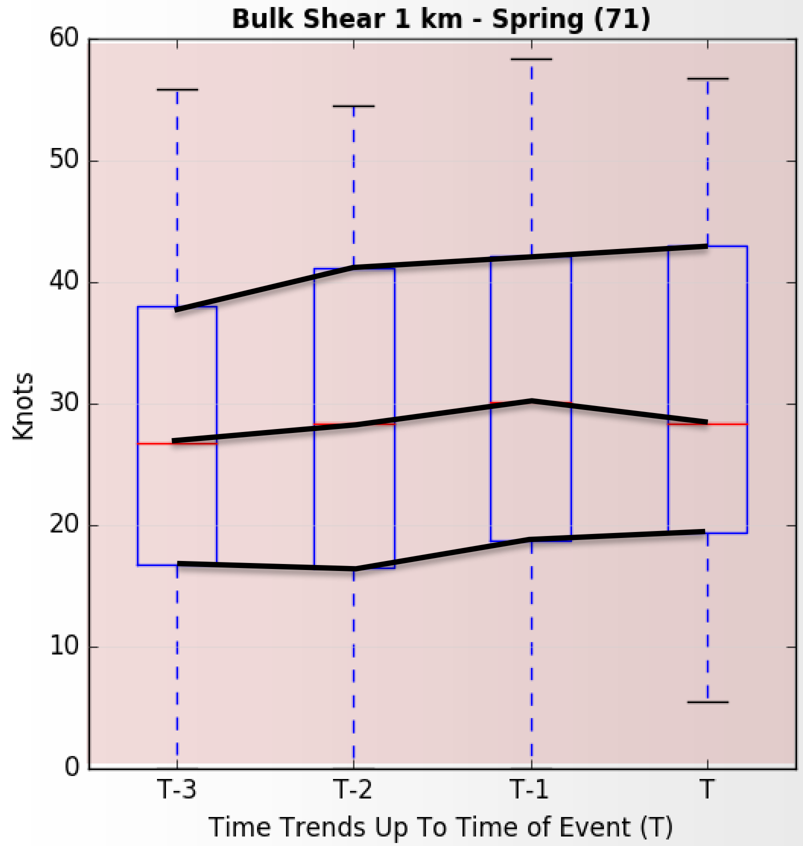
Summer

Let’s Compare Some Parameters Between Events Which Occurred During The Spring Season

Parameter Comparison at Time (T)
Spring Seasonal Assessment (71 Events)

Total (Meteorological) Spring Events: 71

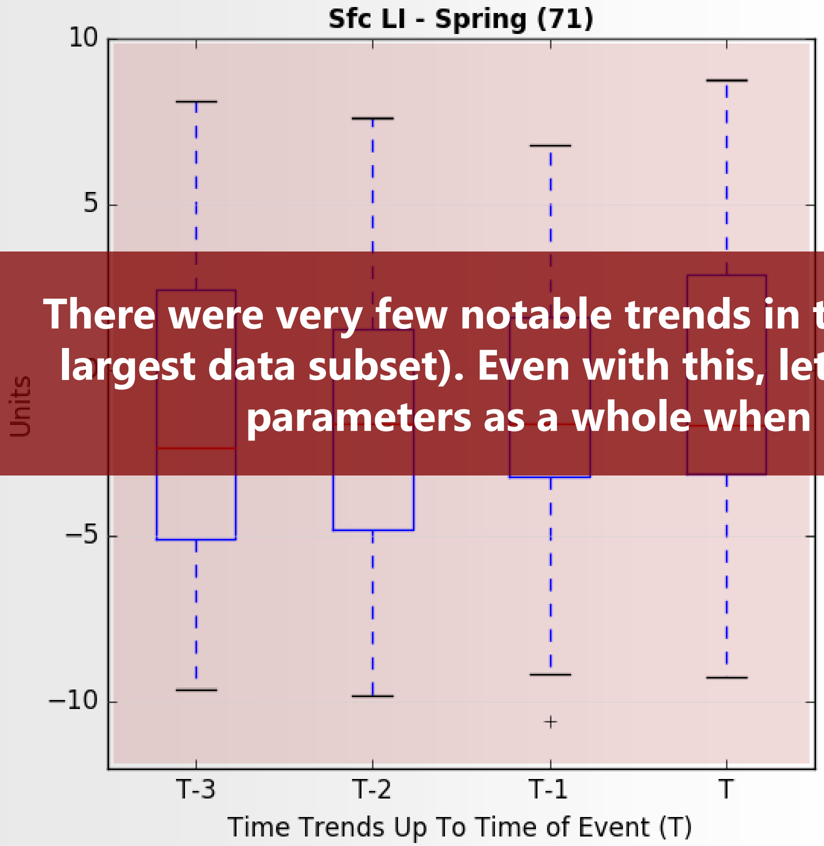


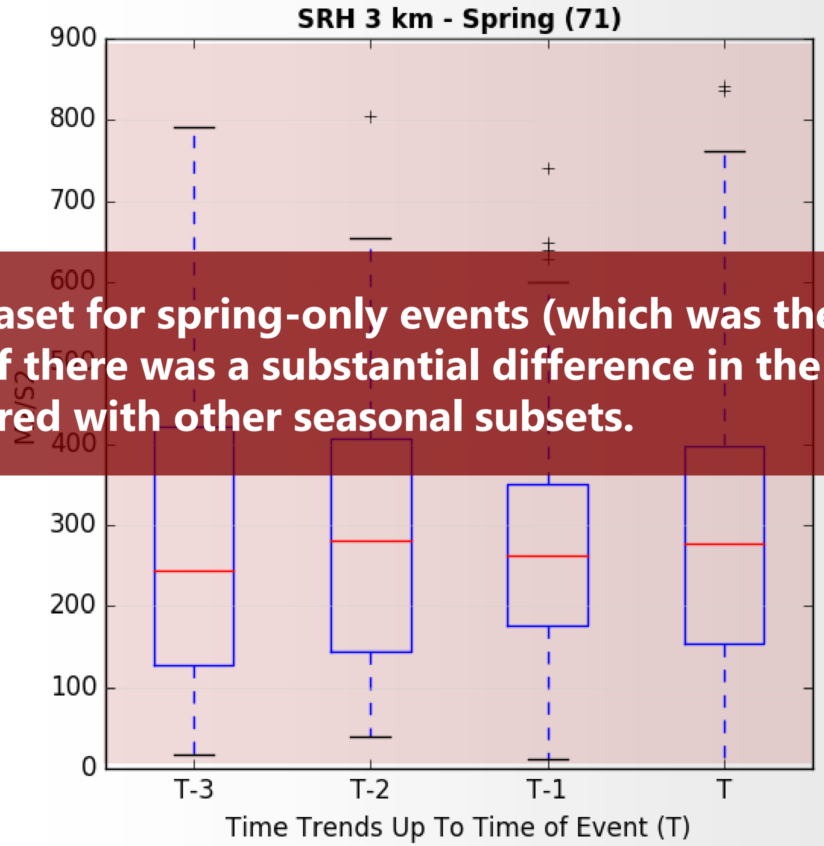


Spring

Parameter Comparison at Time (T)
Spring Seasonal Assessment (71 Events)

Total (Meteorological) Spring Events: 71

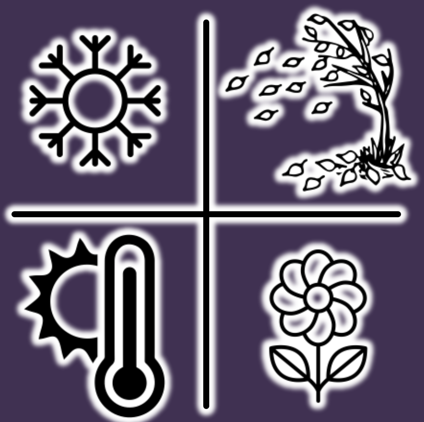




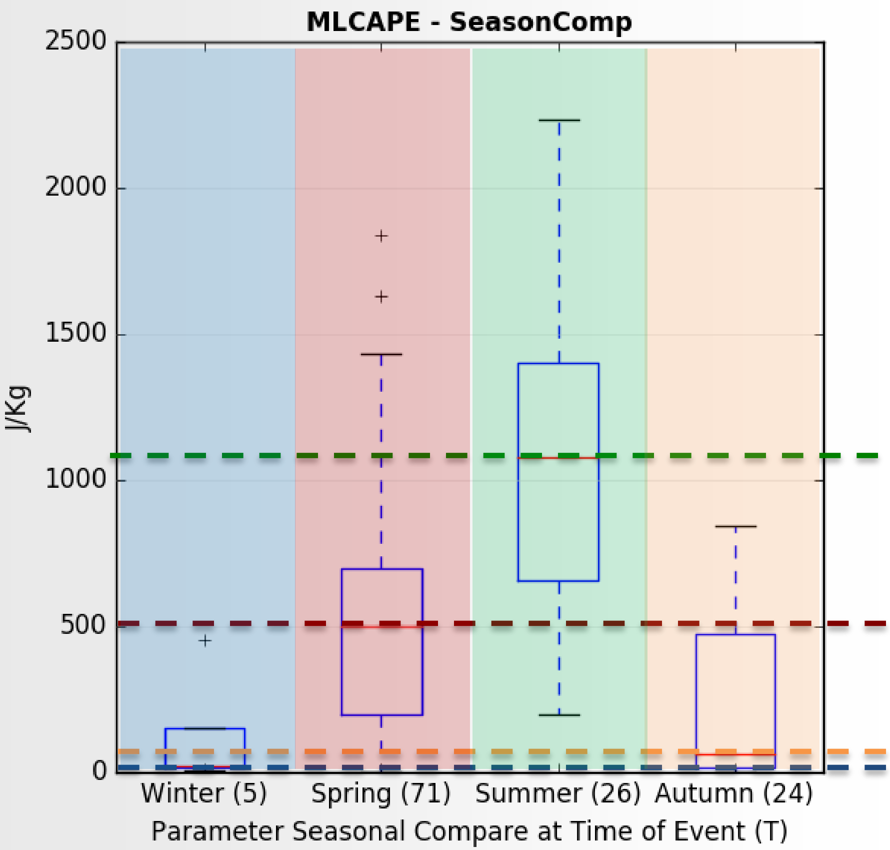
There were very few notable trends in the dataset for spring-only events (which was the largest data subset). Even with this, let's see if there was a substantial difference in the parameters as a whole when compared with other seasonal subsets.

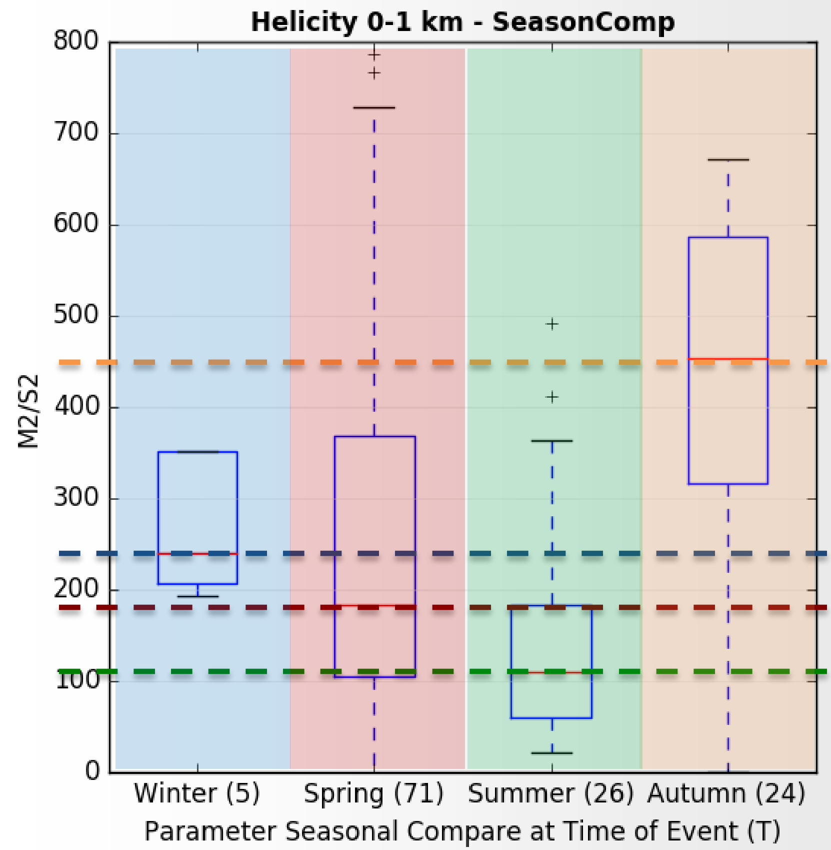
Spring

Let’s Compare Some Parameters of Events Between The Seasons At Time of Event (T)



Parameter Analysis at Time (T) Seasonal Comparison

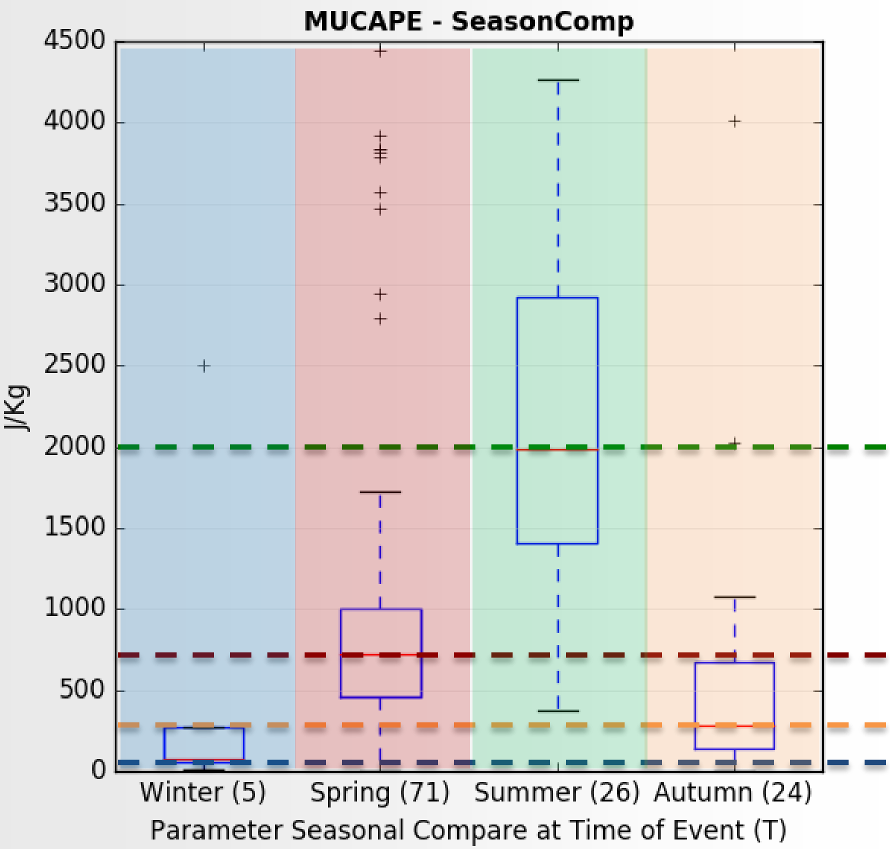


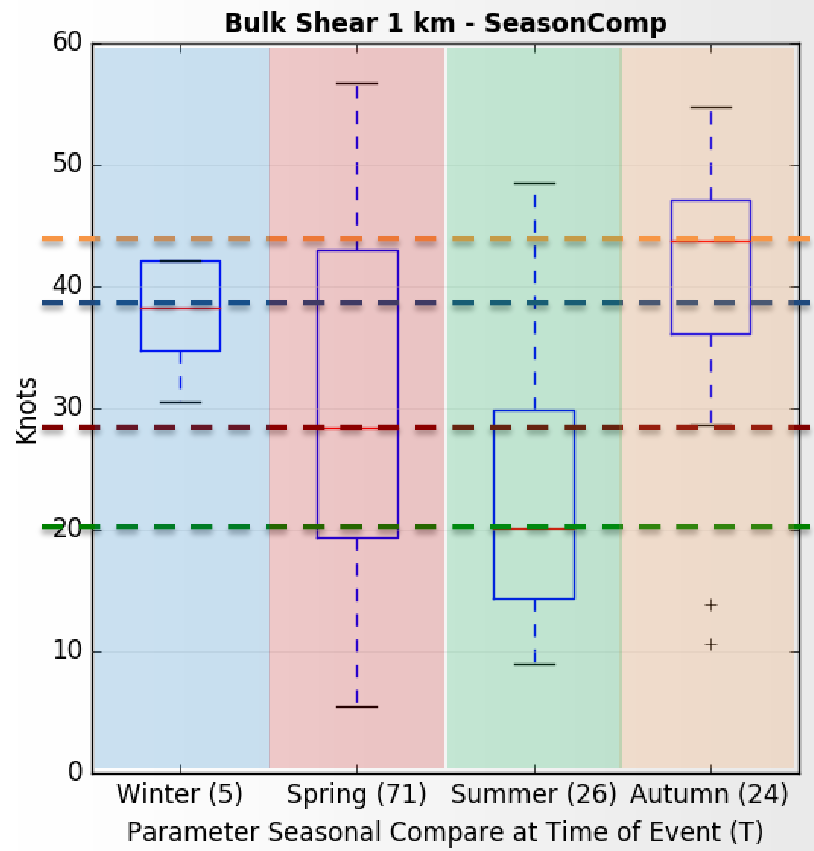


- - - = median value of seasonal subset at time of event (T)

Season Comparison

Parameter Analysis at Time (T) Seasonal Comparison

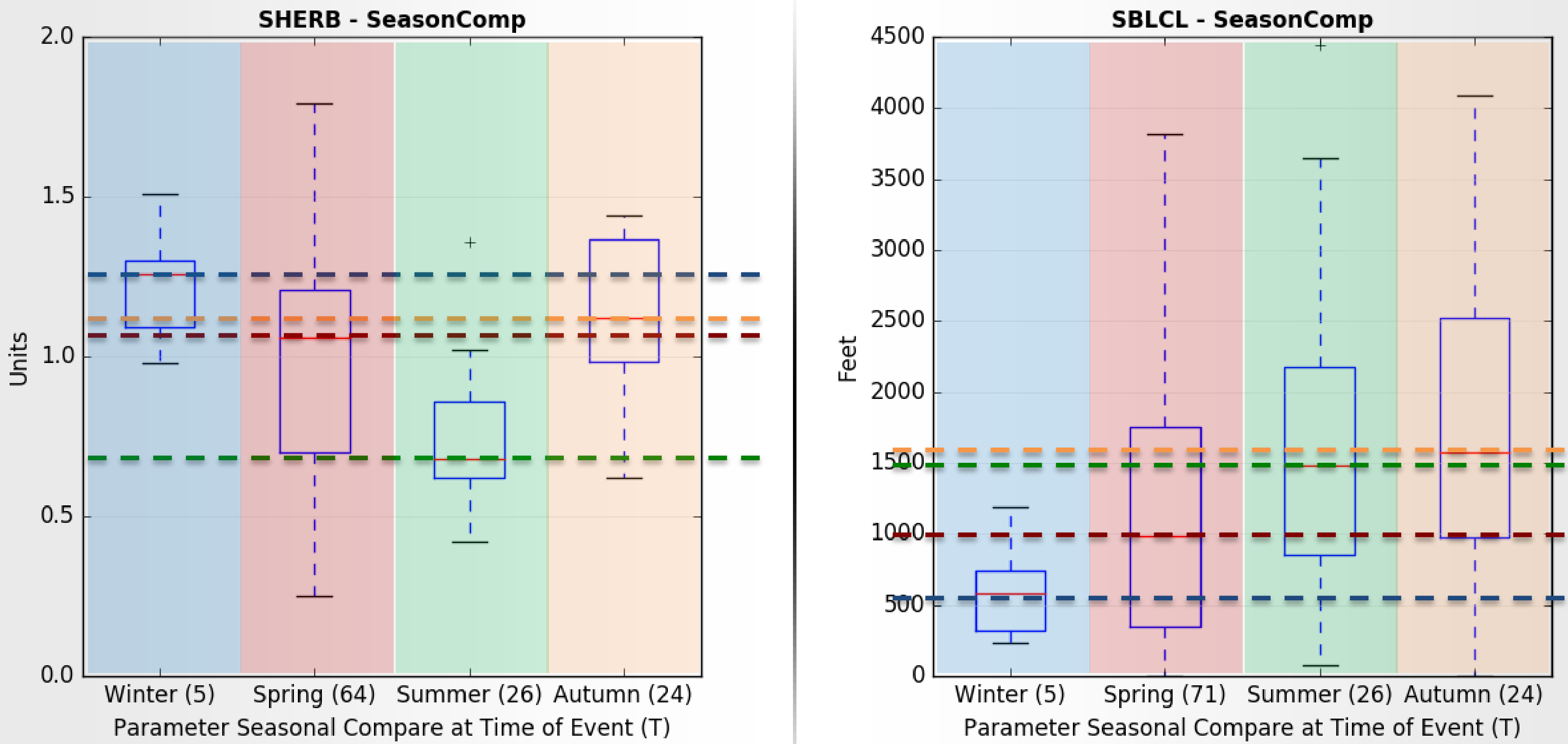




- - - = median value of seasonal subset at time of event (T)

Season Comparison

Parameter Analysis at Time (T) Seasonal Comparison



- - - = median value of seasonal subset at time of event (T)

Season Comparison

Let's Compare Some Parameters Between EF0 and EF1 Rated Tornadoes

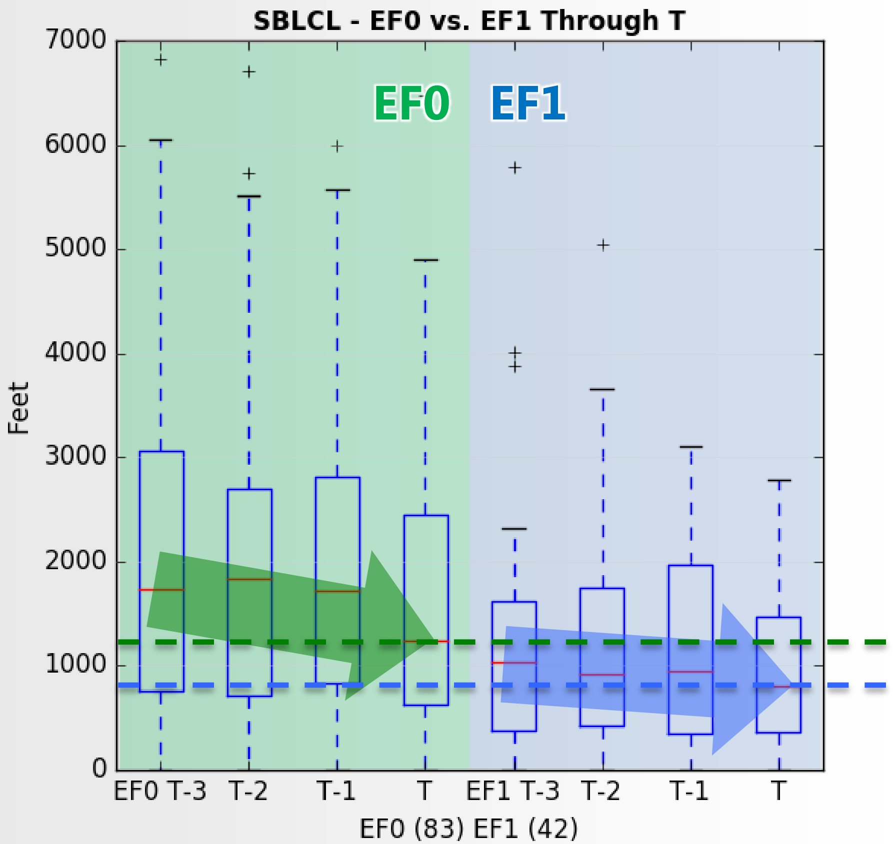
EF0

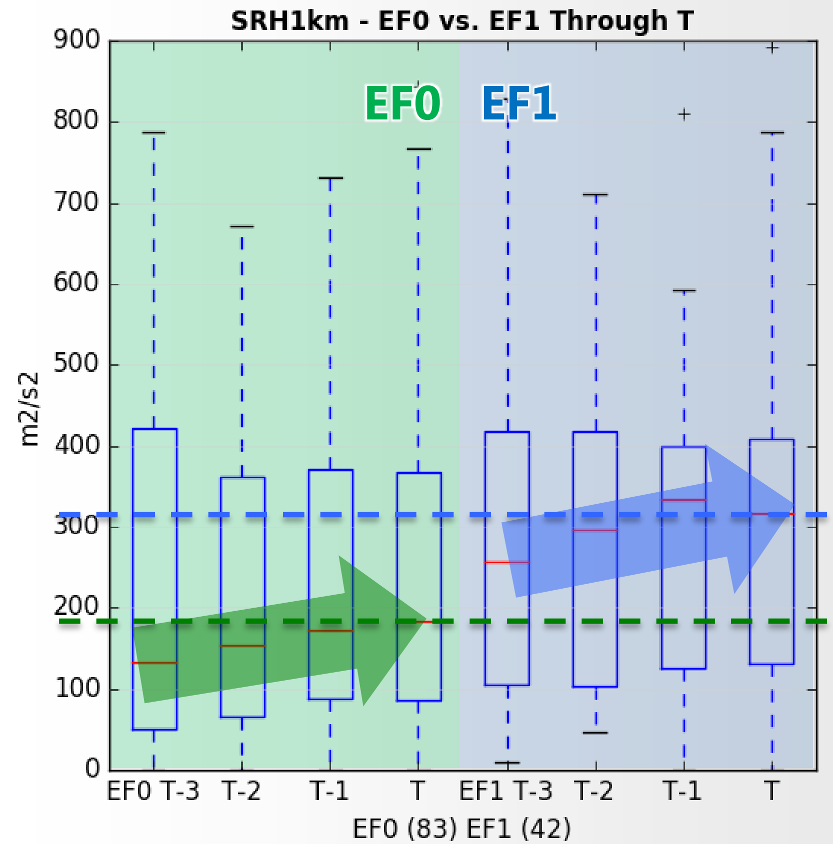
vs.

EF1

Parameter Analysis Through Time
Final Rating Comparison (EF-Scale)

In comparison of parameters between events that were rated EF0 vs. EF1, both time trends of parameters and analysis of said parameters at time of event (T) revealed some very interesting trends.

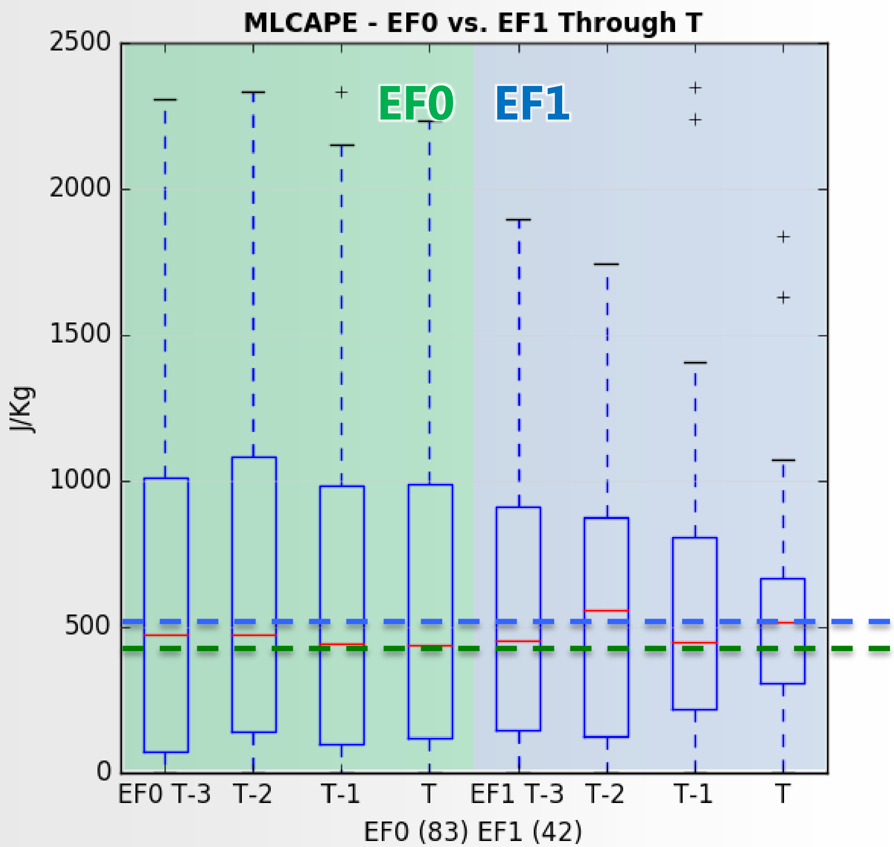


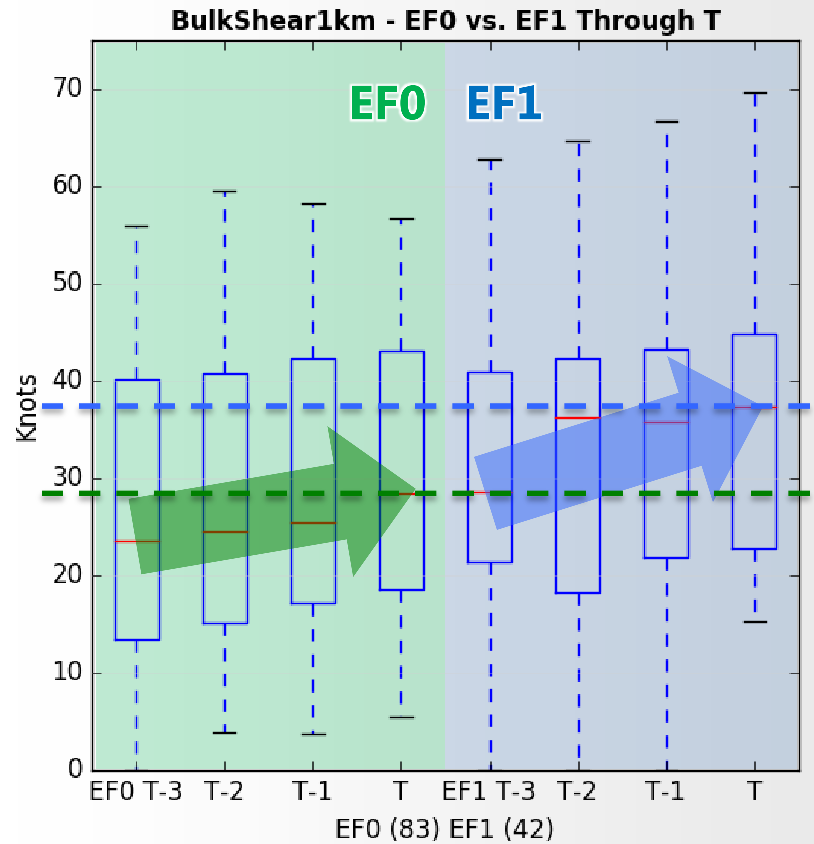


Final Survey-Rated Event Comparison

Parameter Analysis Through Time
Final Rating Comparison (EF-Scale)

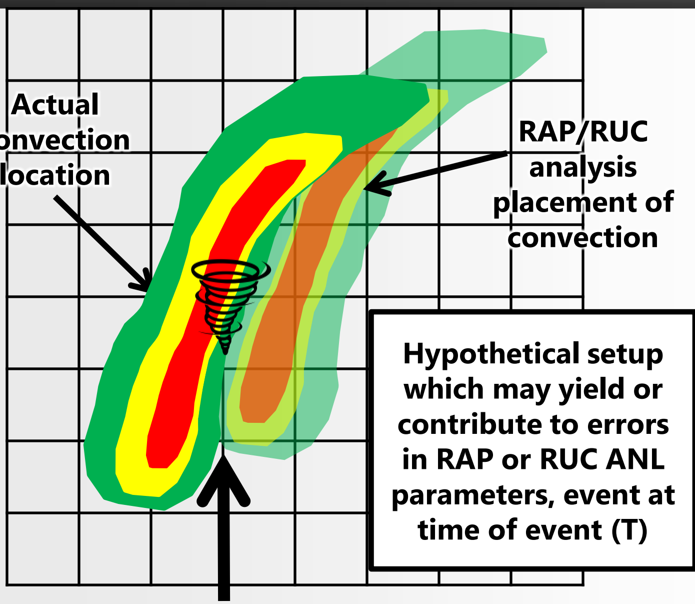
Again, there is no glaring trend for MLCAPE for either data subset, but, as expected, 0-1km Bulk Shear increased for both rated events towards time of event (T).





Final Survey-Rated Event Comparison

Trends of Decrease in Instability As Event Nears
An Artifact of Model Convective Feedback or Reality?



Although this study rounded times to the previous hour (up to :50 past the hour), RAP/RUC analysis errors in placement of convection may yield drastic errors in instability (and other fields).

The data in this study revealed many instability fields decreasing from T-3 up to T, but was this an artifact of incorrect placement of ongoing convection or an actual reality? If it was a reality, let's see the difference in fields between events in which instability was increasing from T-1 to T vs. decreasing during this same time frame…

From Smith Et al. (2012):

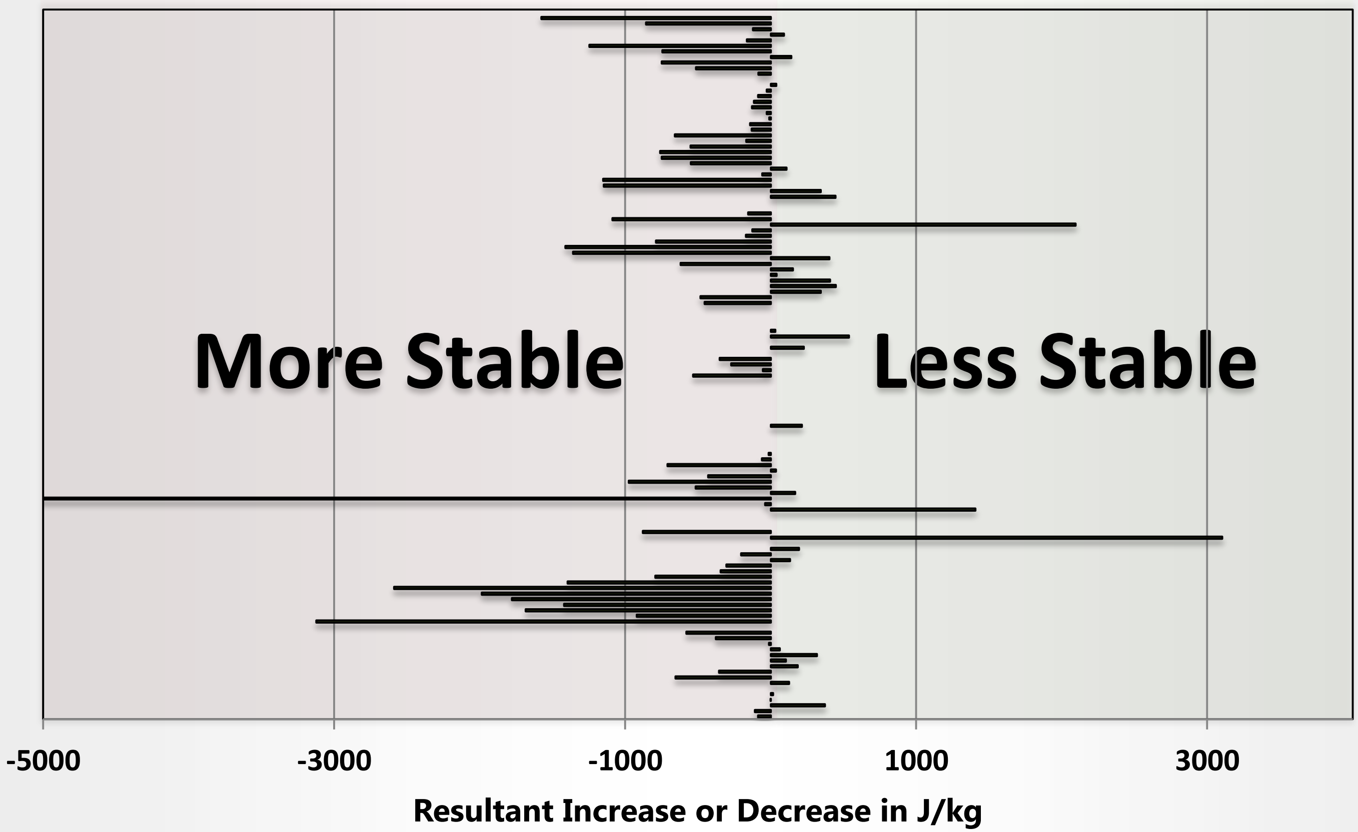
"As with any attempt at assigning single point variables to represent a storm environment, concerns regarding the accuracy and representativeness of the data must be considered…"

From Frey Et al. (2016):

In recent years, the availability of reanalysis data to characterize the mesoscale environment every hour has sparked a series of tornado climatology studies with different areas of focus… [and] several discussions in the literature (e.g., Brooks et al. 1994; Potvin et al. 2010) debate the appropriateness of various measures of "proximity" storm environments. The higher spatial and temporal resolutions available from RUC analysis provide more accurate representations of storm environments than the rawinsonde dataset, but it is worth noting that severe thunderstorms sometimes occur in the immediate vicinity of baroclinic zones, so that even a minor error… in placement can result in large errors."

Low-Level (In)stability Trends From T-1 to T
All Events

Difference Between Change in SBCAPE and Change in SBCIN From T-1 to T



Surface - 1km Bulk Shear % Change MLCAPE Inc. v. Dec. T-1 to T

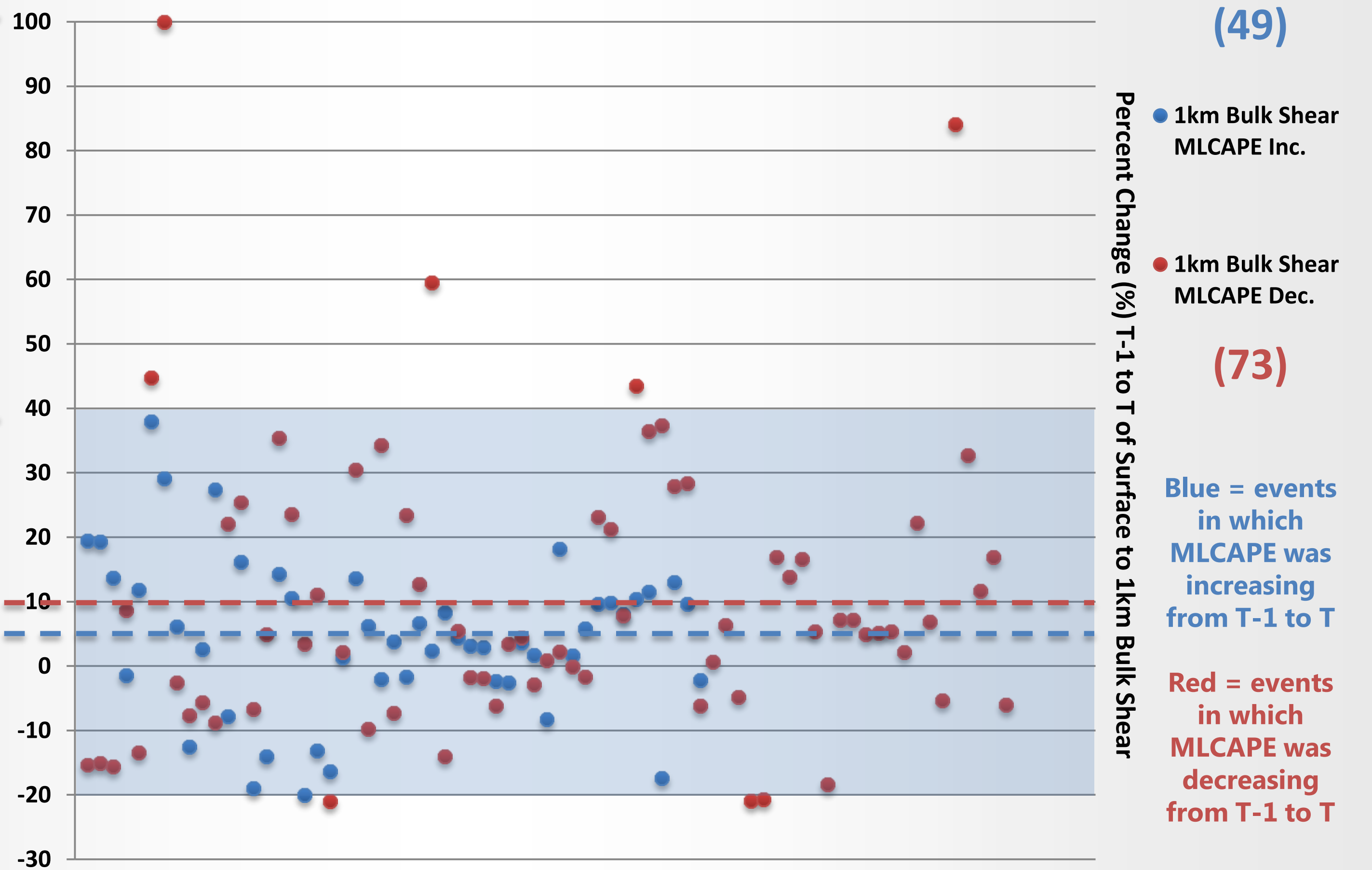
If low level instability was REALLY decreasing (in actuality, not just according to an analysis), would the bulk shear/helicity fields show a difference between events in which instability was decreasing vs. increasing?

0 of 49 Cases Had Sfc-1km Bulk Shear Increase More Than 40% From T-1 to T

5 of 73 Cases Had Sfc-1km Bulk Shear Increase More Than 40% From T-1 to T

Average: + 9.7%

Average: + 4.5%



Blue = events in which MLCAPE was increasing from T-1 to T

Red = events in which MLCAPE was decreasing from T-1 to T

* There were 3 events in which MLCAPE data was not available in the analysis grids.

Surface - 1km Helicity % Change MLCAPE Inc. v. Dec. T-1 to T

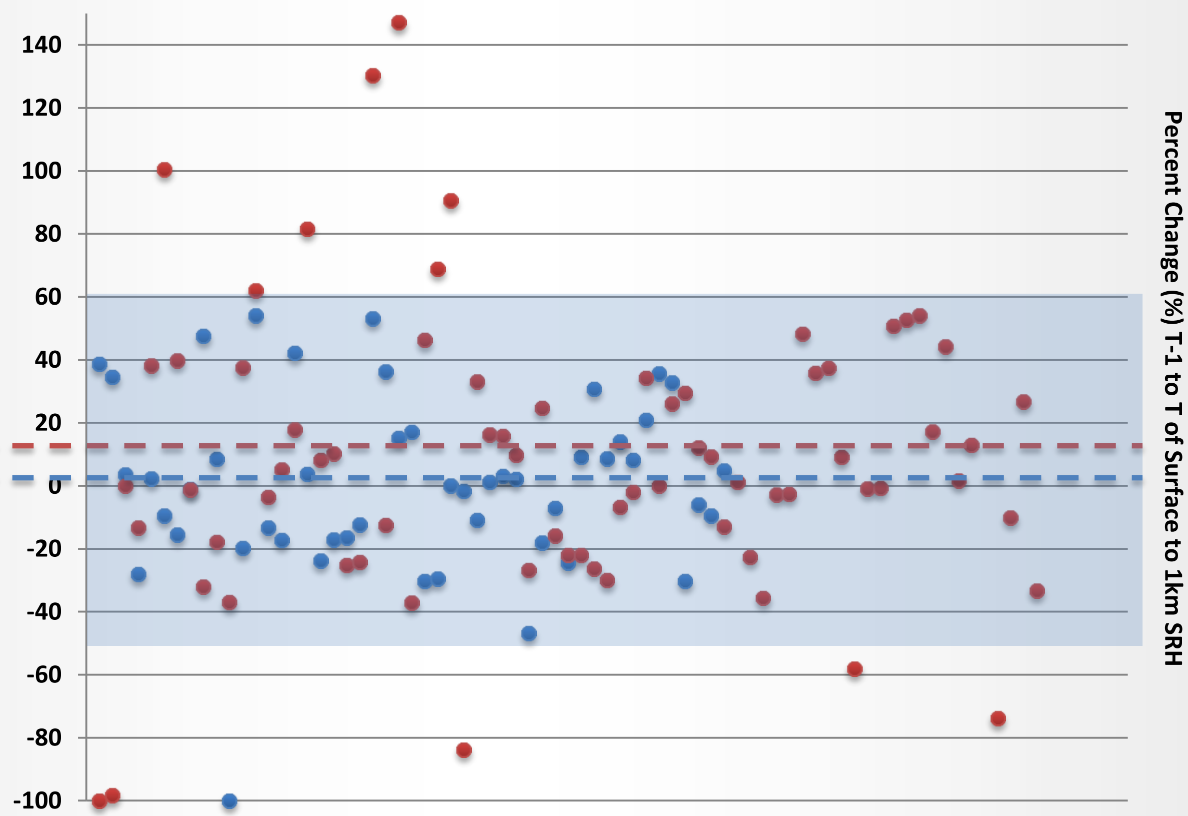
If low level instability was REALLY decreasing (in actuality, not just according to an analysis), would the bulk shear/helicity fields show a difference between events in which instability was decreasing vs. increasing?

Cases In Which Surface to 1km Helicity Increased:
53.1%

Cases In Which Surface to 1km Helicity Increased:
53.4%

Average: + 11.4%

Average: + 0.8%

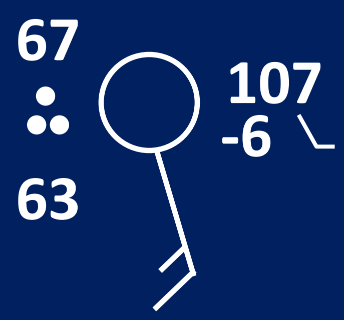


Blue = events in which MLCAPE was increasing from T-1 to T

Red = events in which MLCAPE was decreasing from T-1 to T

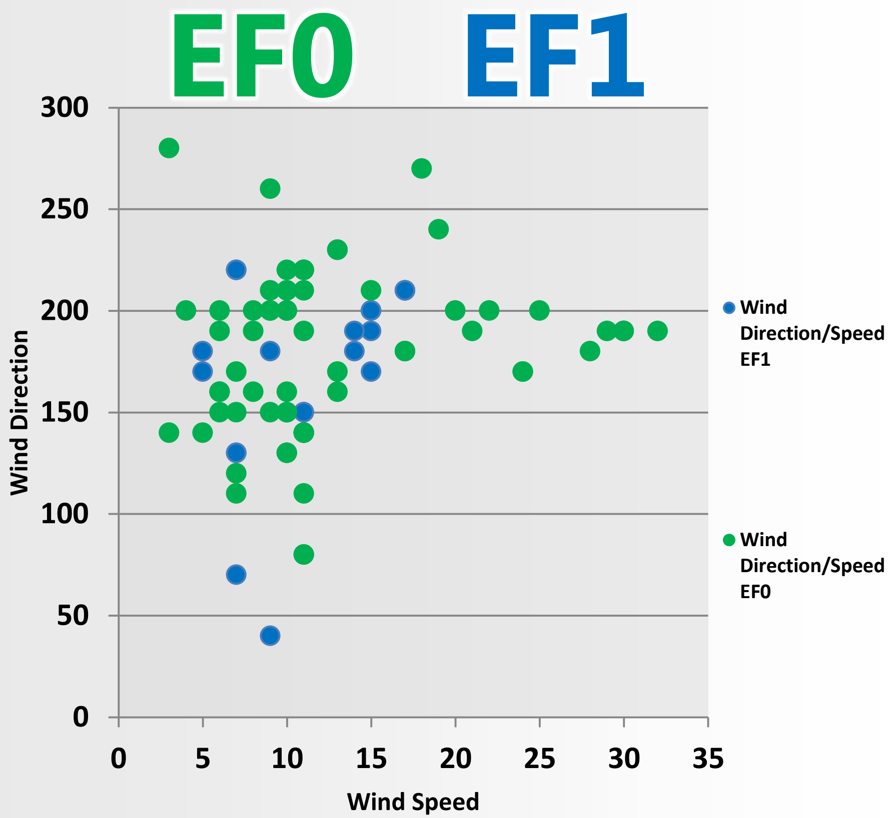
* There were 3 events in which MLCAPE data was not available in the analysis grids.

Now Let's Take A Look At Surface Obs…

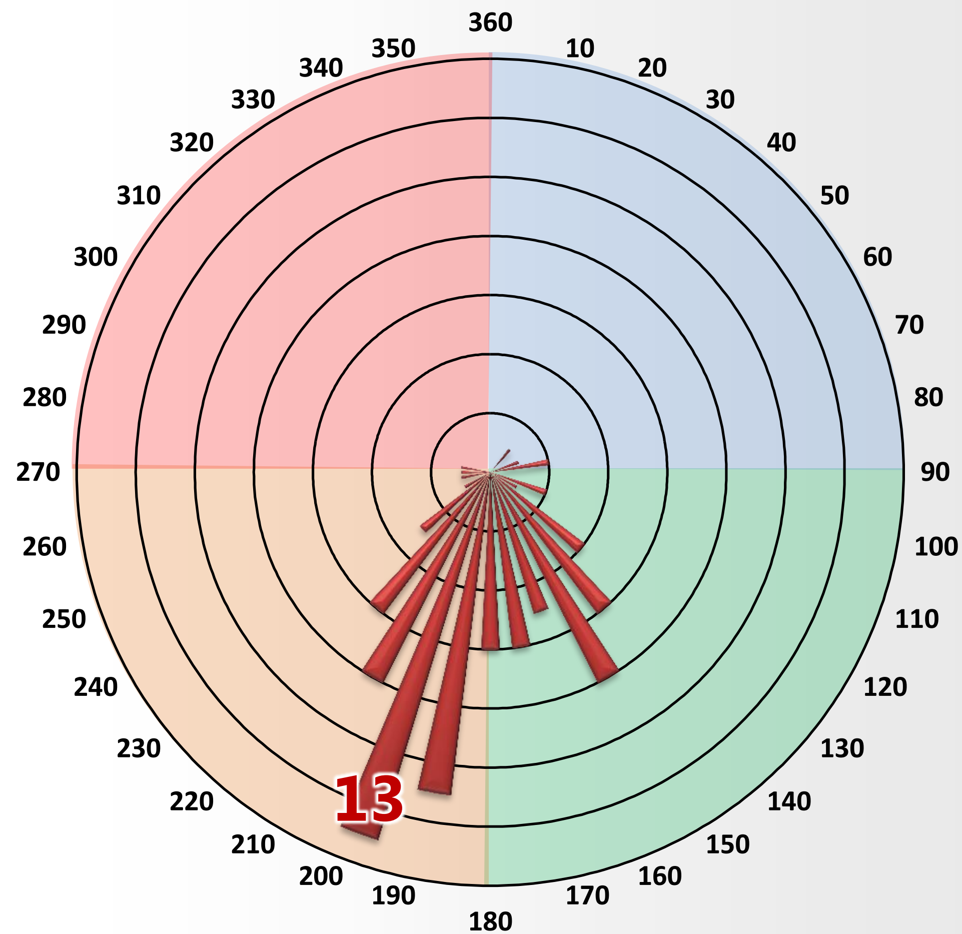


From Nearby Convectively Uncontaminated Observations

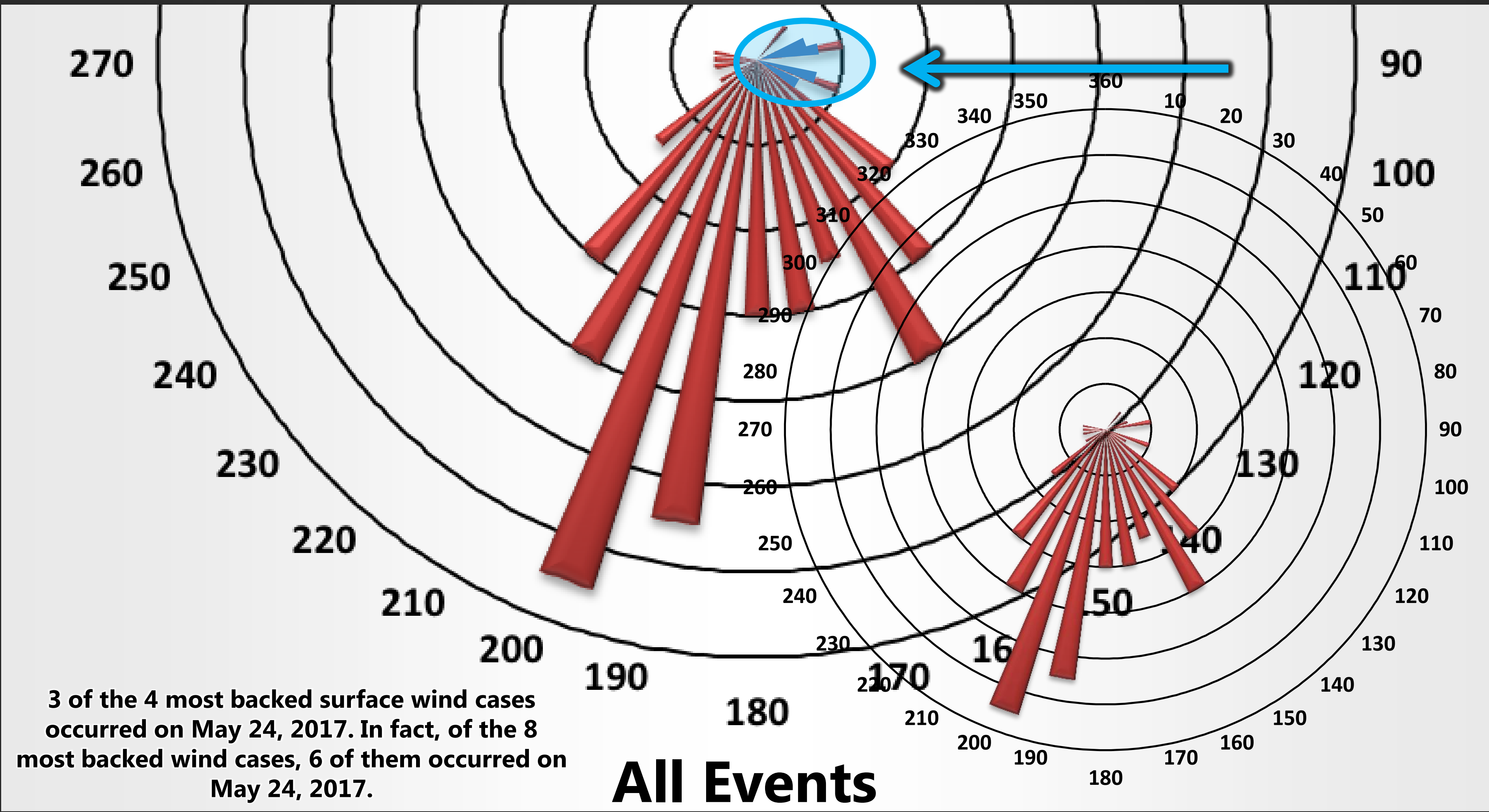
Surface Wind Direction at Closest Uncontaminated Surface Observation (87 Total Observations)



Surface Wind Directions: All Events



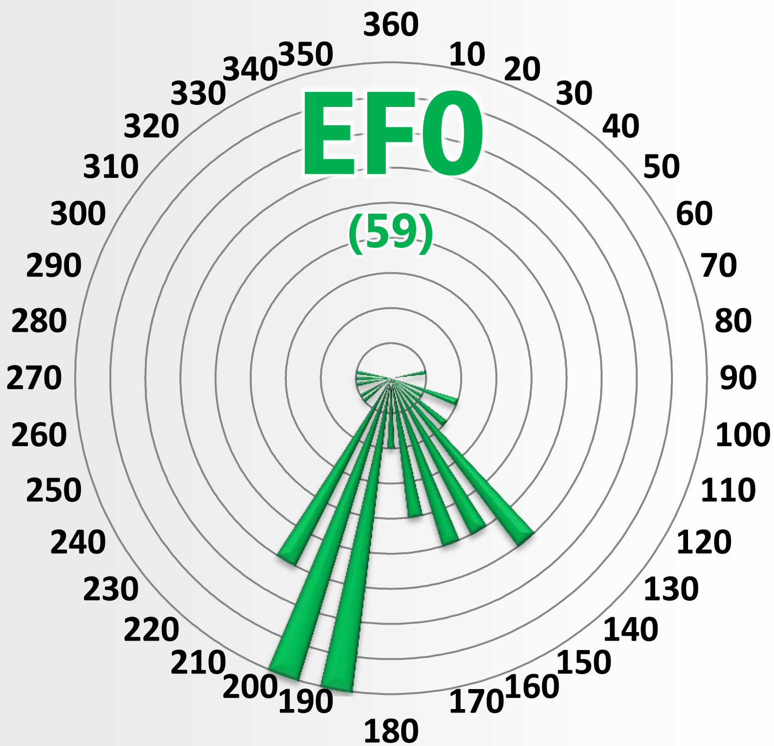
Surface Wind Direction at Closest Uncontaminated Surface Observation May 24, 2017

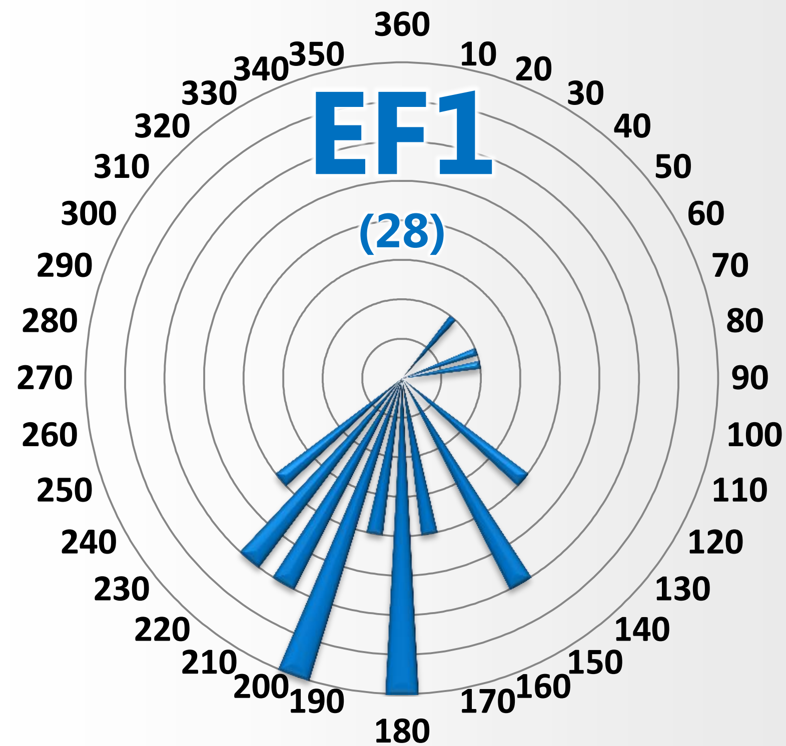


3 of the 4 most backed surface wind cases occurred on May 24, 2017. In fact, of the 8 most backed wind cases, 6 of them occurred on May 24, 2017.

All Events

Surface Wind Direction at Closest Uncontaminated Surface Observation (87 Total Observations)



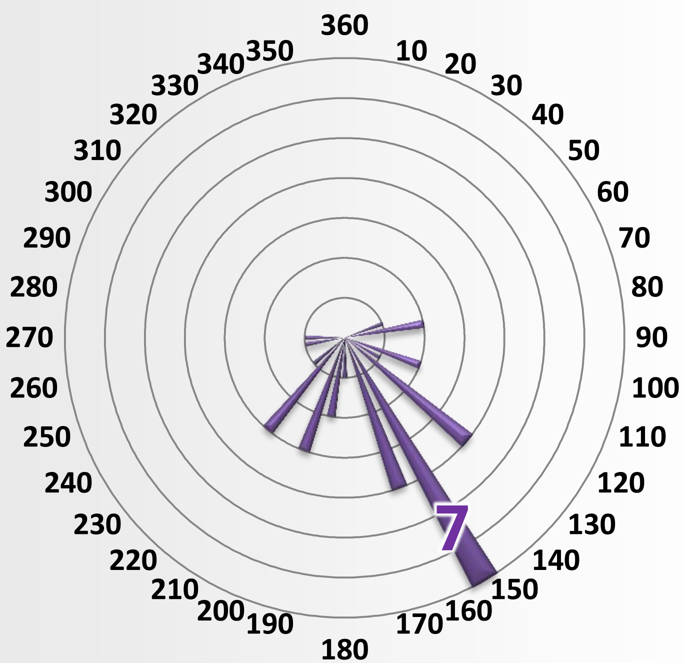


- 1 case with a surface wind direction less 100°
- 4 cases with wind greater than 230°
- Average surface Td: 9.3°

- 3 cases with a surface wind direction less than 100°
- 0 cases with surface wind greater than 230°
- Average surface Td: 7.7°
- 3 of the 4 most backed surface wind events were EF1 cases

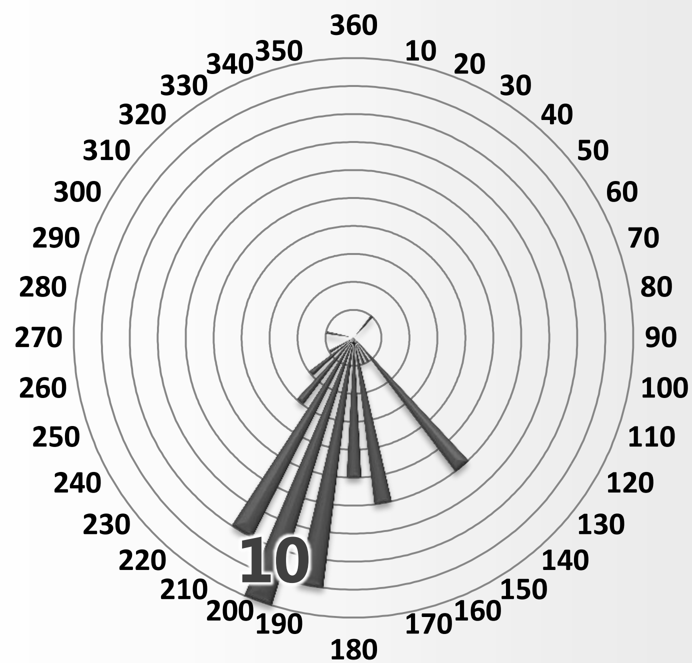
Surface Wind Direction at Closest Uncontaminated Surface Observation Compared With 0-1 km Bulk Shear

0-1 km Bulk Shear Less Than 25 kts (33)



- Most prominent surface wind direction was 150° (7 events)
- Average surface wind direction: 162°
- Average surface wind speed: 9 knots
- Average Td: 8.2°

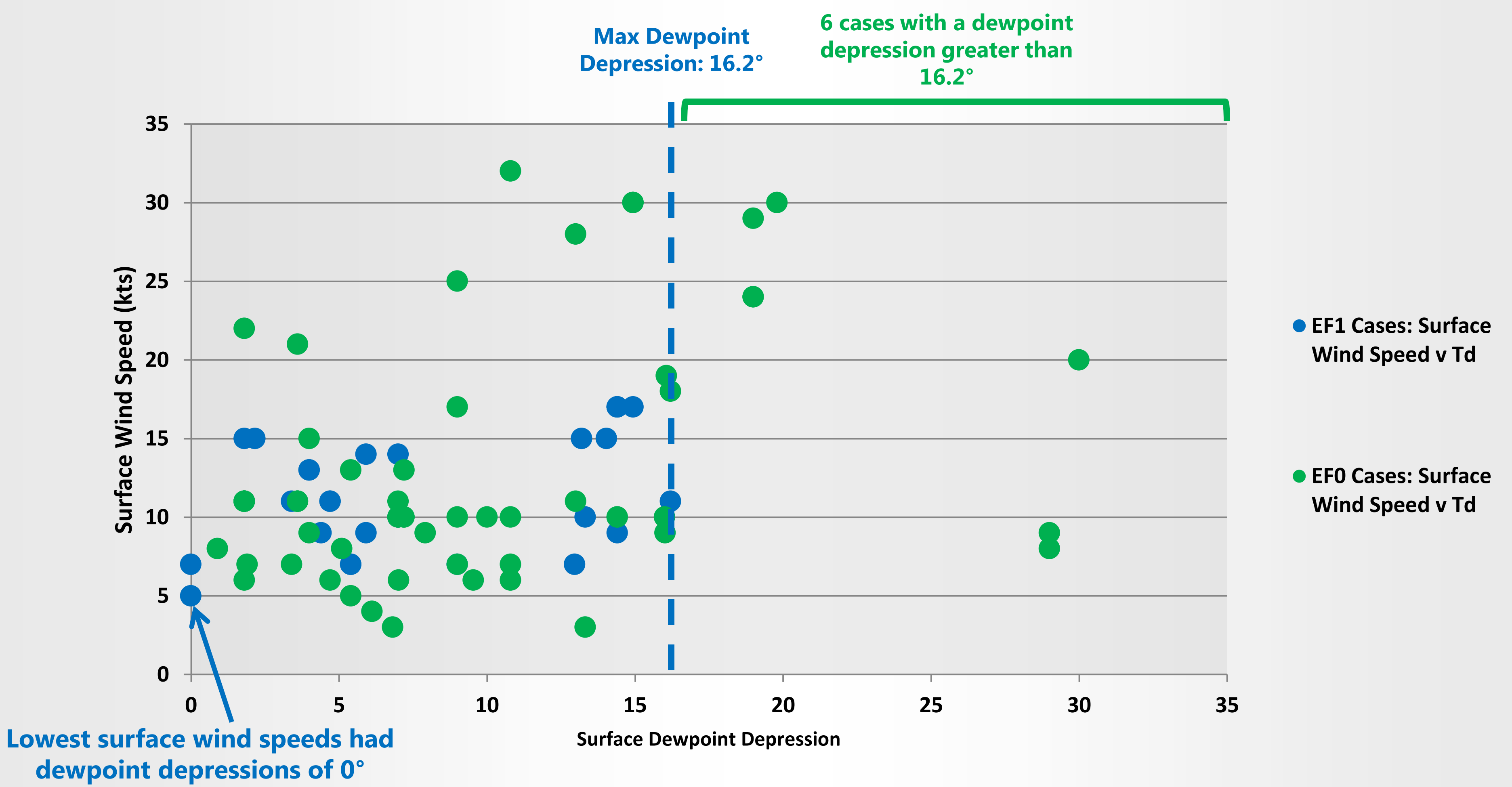
0-1 km Bulk Shear Greater Than 25 kts (54)



- Most prominent surface wind direction: 200° (10 events)
- Average surface wind direction: 188°
- Average surface wind speed: 15 knots
- Average Td: 9.6°

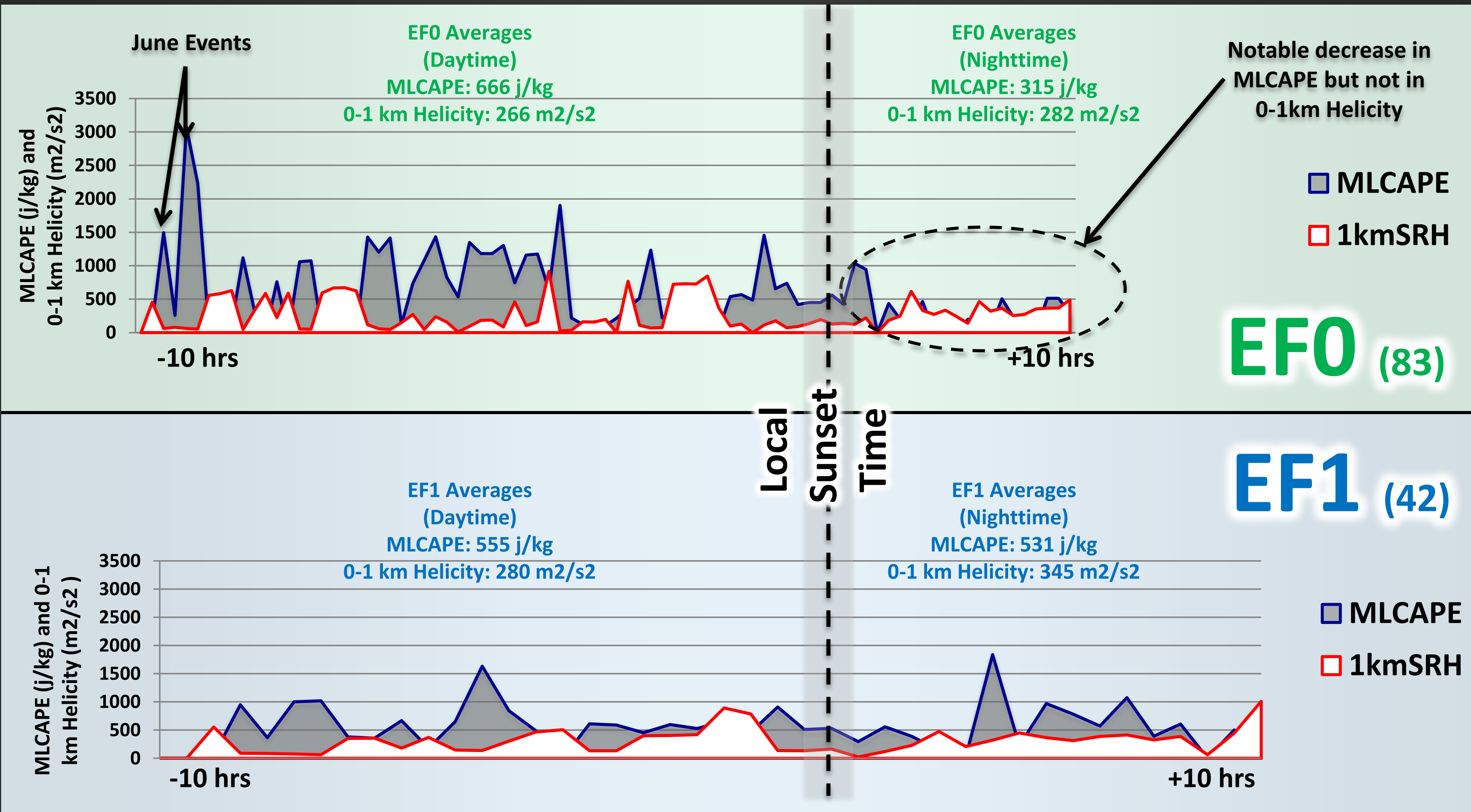
* Important Note: Calm Wind (00000kt) Observations Were Not Included In The Above Wind Rose Plots

Comparison of Surface Wind Speeds to Dewpoint Depressions (°)
From Uncontaminated Nearby Surface Observations
(87 Total Observations)



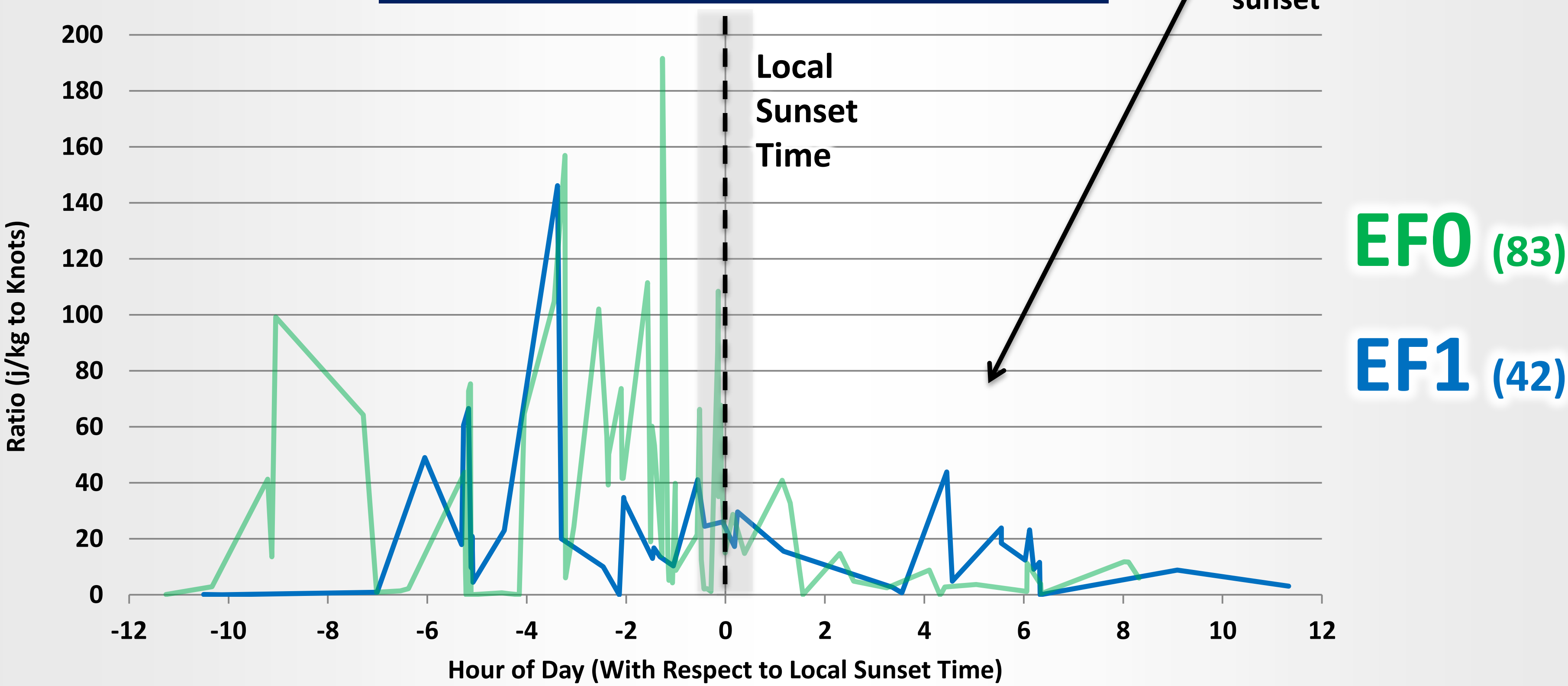
Now Let's Compare Some Instability, Shear, and Moisture Parameters With Respect To The Time of Day

A Comparison of 0-1km Helicity & MLCAPE EF0 vs. EF1 Cases At Time of Event (T)



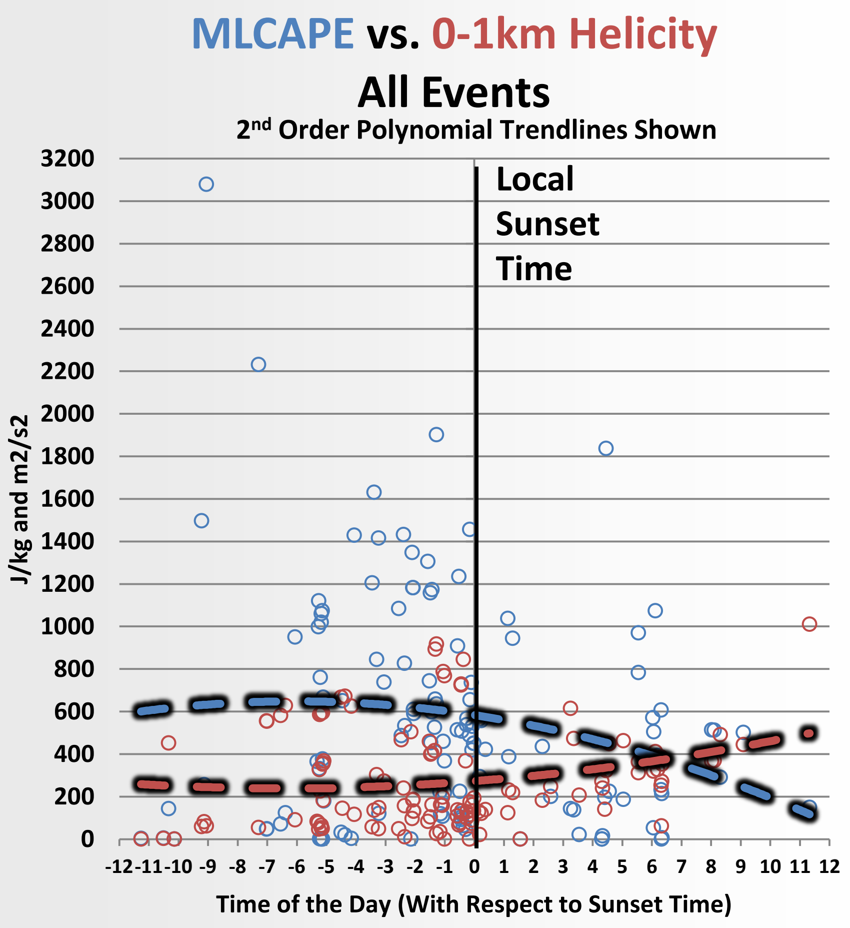
A Comparison of MLCAPE & 0-1 km Bulk Shear EF0 vs. EF1 Cases At Time of Event (T)

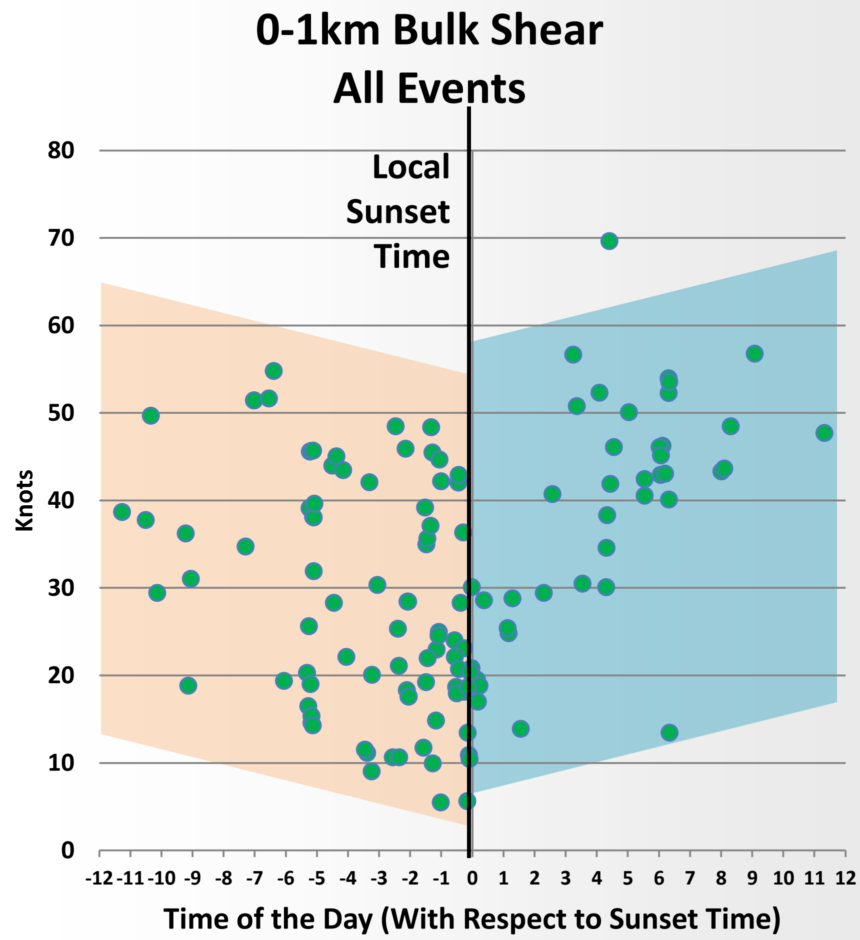
Ratio of MLCAPE to 0-1km Bulk Shear At Time of Event (T)



Parameter Comparisons: A Time of Day Perspective

(At Time of Event, T)





Preliminary Study Conclusions

- The lack of surface-based or mixed-layer instability did not preclude the occurrence of tornadoes (20% of events had less than 100 j/kg of MLCAPE at time of event).
  - Median SHERB value in events where MLCAPE was 100 j/kg or less was 1.25 (compared to just 0.98 for MLCAPE greater than 100j/kg)

- Day vs. Night Comparison– lower instability at night was countered with lower SB/ML LCL heights and higher 0-1 km Bulk Shear.

- Decrease in instability leading up to the time of the event was <u>independent</u> of season or time of day or final rating.
  - But so too was the decrease in downward acceleration-supporting CAPE (DCAPE).

- Decrease in surface-based or mixed-layer LCL heights leading up to the time of the event was <u>independent</u> of season or time of day (except in Autumn cases where MLLCL actually increased towards time T).

Preliminary Study Conclusions

- Although the dataset of mixed-layer instability showed a sharp decrease after sunset, 0-1 km Bulk Shear and 0-1 km Helicity tended to remain constant or even increase slightly. This was true for both EF0- and EF1-rated cases.

- In the cases in which 0-1 km Bulk Shear was less than 25kts, surface winds from nearby uncontaminated observations tended to be lighter but more backed than in cases where there was more than 25kts of 0-1 km Bulk Shear. Additionally, in weaker low level bulk shear cases, the surface dewpoint depressions were generally lower.

- There was no apparent trend or substantial correlation of 0-6 km Bulk Shear, SCP, or 0-3 km Helicity with season, time of day, or final rating.

- There was no apparent trend or substantial correlation of parameters in spring (most-likely owing to the wide-array of environments possible between March and May – i.e. any particular trends in one type of environment (high shear/low CAPE) may have been muted by a correspondingly high CAPE low shear event that exists in the same time period).

Thank You!
Any Questions?

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