Observed Low-level Cloud Morphology Associated with Tornadogenesis Events During the Southeastern United States Cool Season

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I. Introduction

- Cold season defined as the months of December, January, and February

- Tornadogenesis in the southeastern United States often occurs under a broader range of conditions than other regions

- High-Shear Low Cape (HSLC) events pose major operational forecasting challenges

- Both Quasi-Linear Convective System (QLCS) and supercell convective modes have been observed under HSLC conditions

II. Background and Motivation

- Parameterization of the convective boundary layer via Numerical Weather Prediction (NWP) (Cohen et al. 2015)

-Cloud top mixed layers are especially challenging

- Lifted Condensation Level (LCL) height and its role in HSLC environments (Rasmussen & Blanchard 1998)

- Low level thermodynamic characteristics in southeastern U.S. tornado events (Jackson & Brown 2009)

- Differences between LCL height and observed cloud base height (Craven et al. 2002)

- Importance of boundary layer relative humidity in tornadogenesis (Markowski & Richardson 2008)

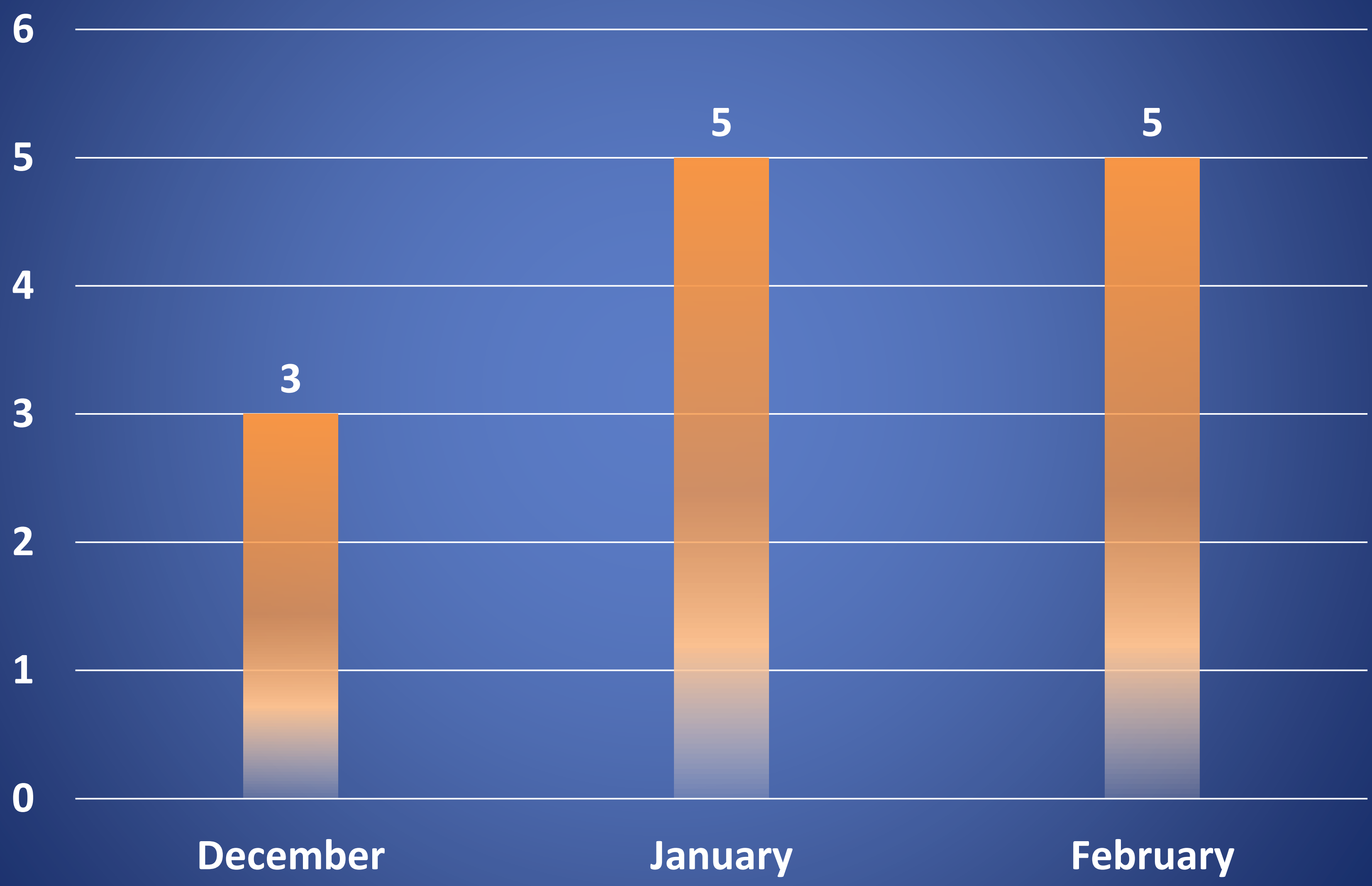
III. Methodology

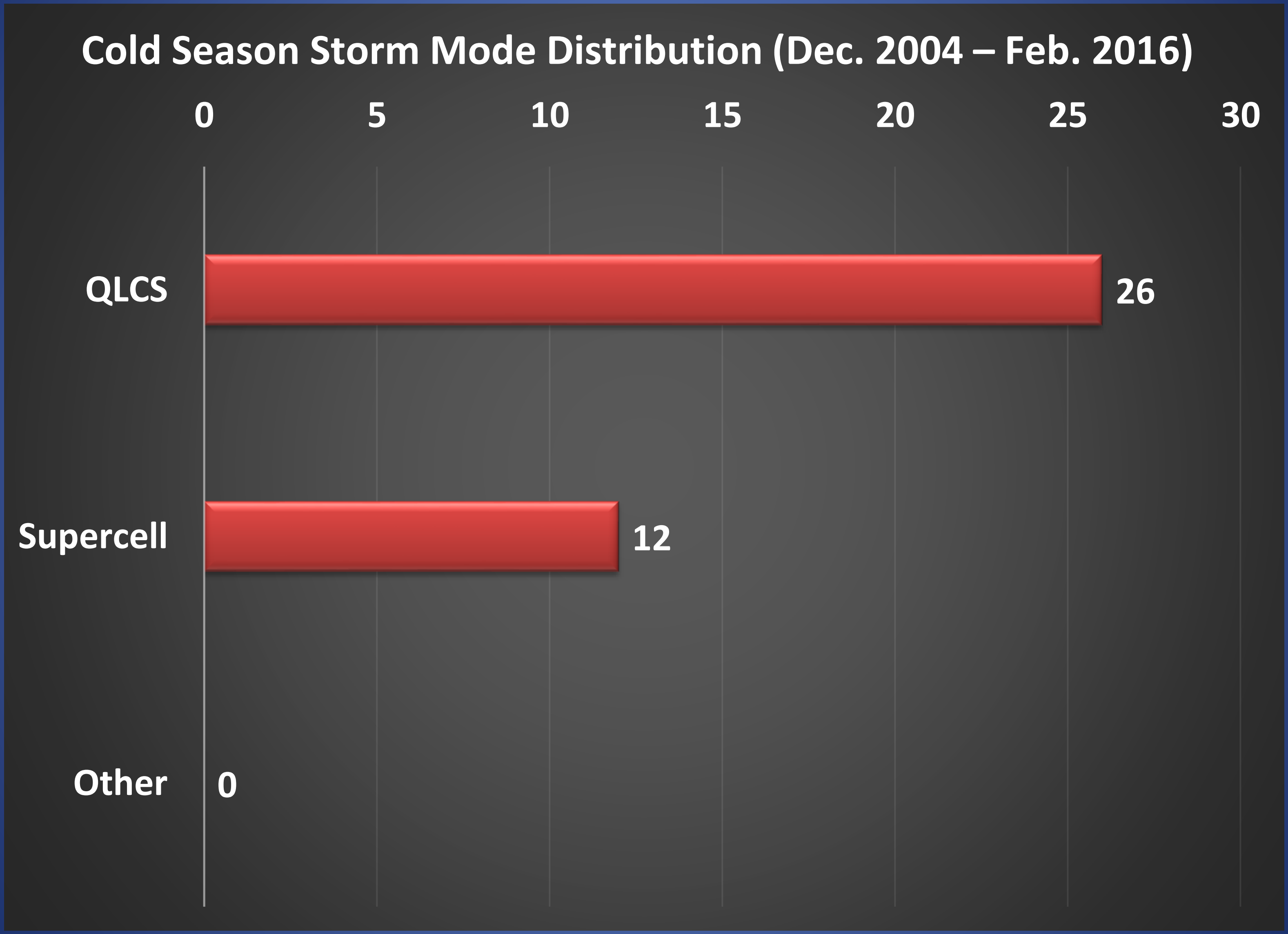
- Lidar ceilometer (University of Alabama in Huntsville (UAH) & NOAA ASOS datasets) - cloud base height, cloud fraction
- Doppler wind lidar - boundary layer profiles of wind
- 915 MHz wind profiler - turbulence (e.g., variance of vertical motion)
- Microwave profiling radiometer - water vapor
- Radiosondes
- Current cases: Alabama, Mississippi, Louisiana, Georgia, and Tennessee.

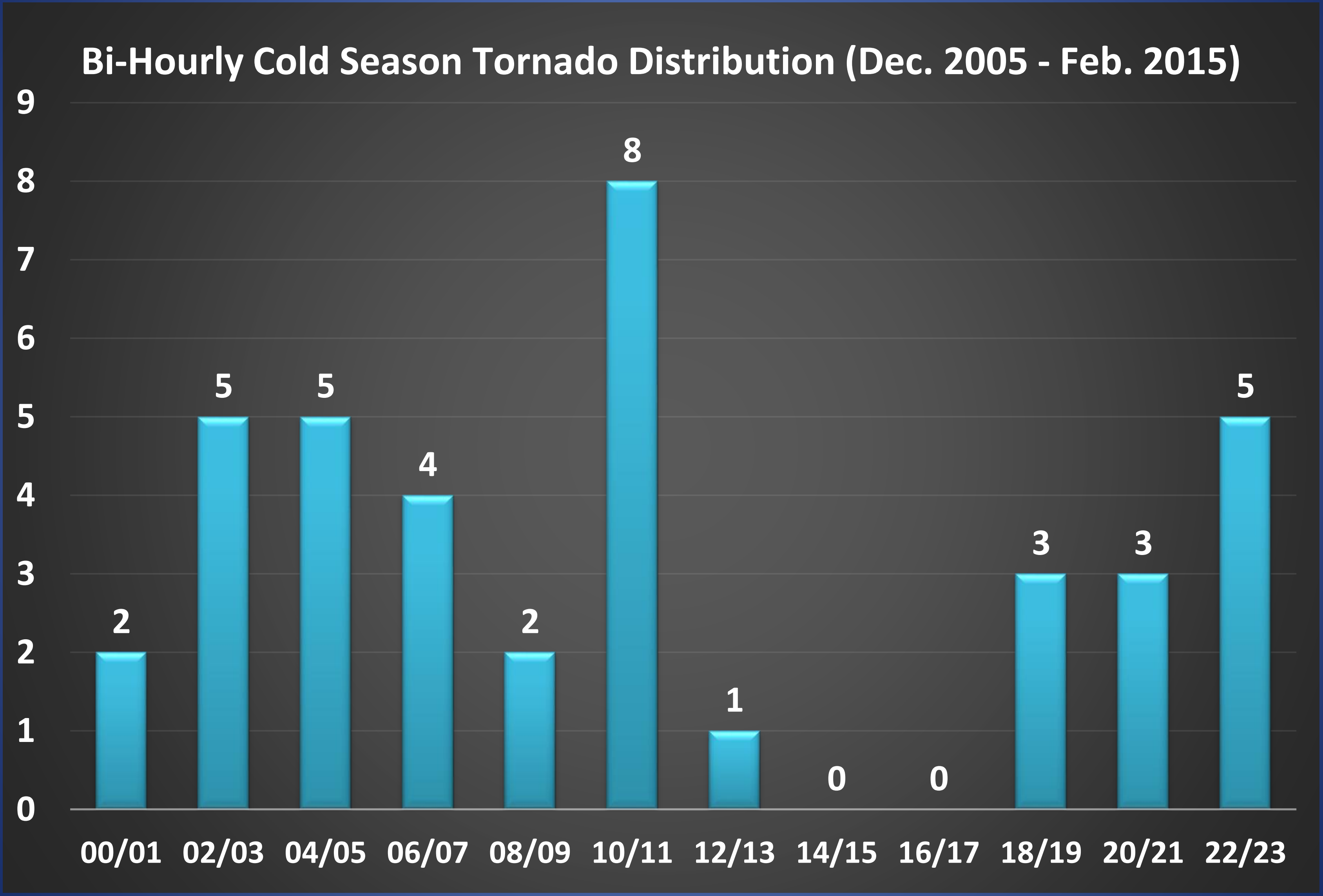
IV. Results (Preliminary)

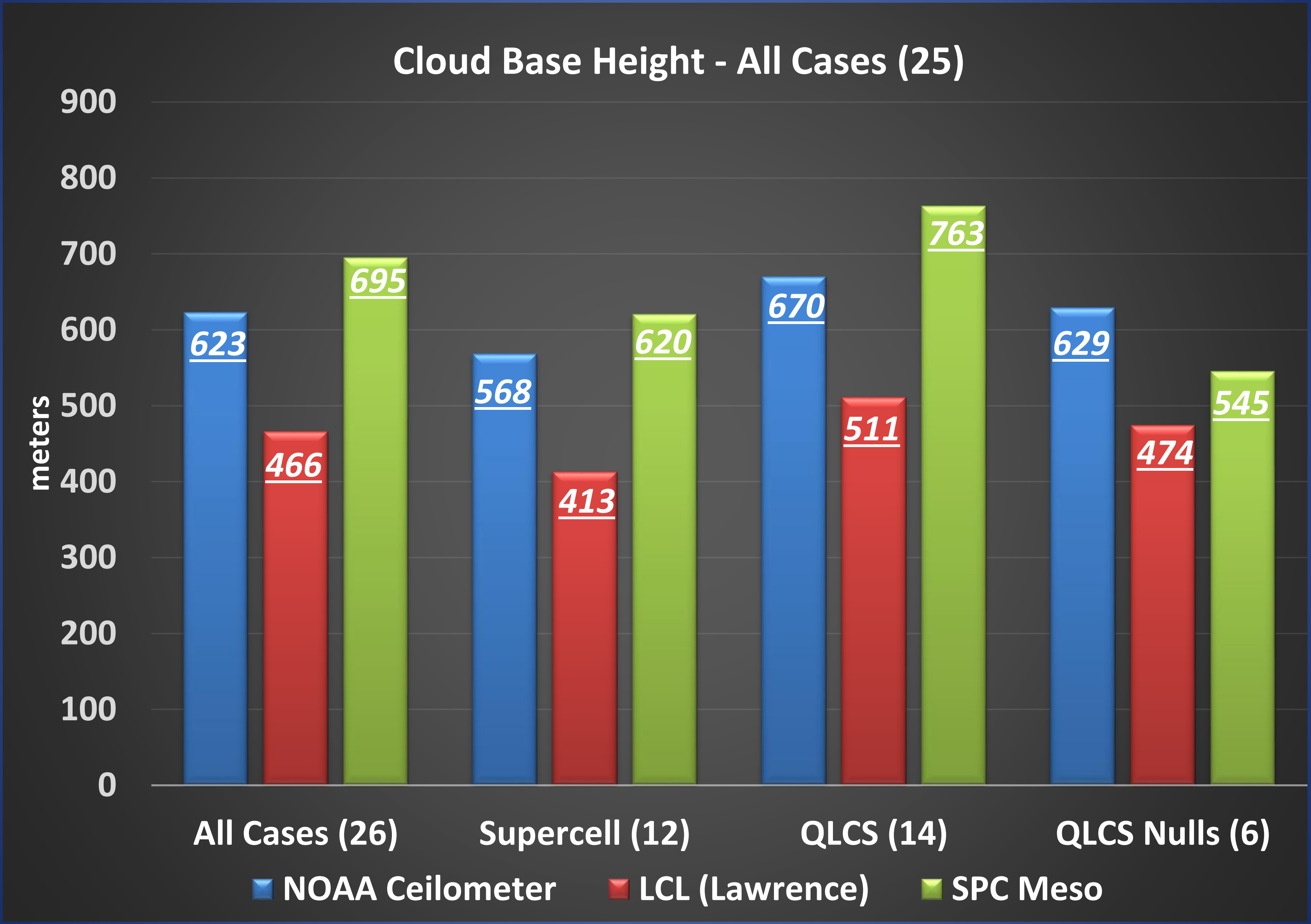
- Cold season tornadoes in the southeast display a much broader range of temporal occurrence
- Cloud base height tends to be <800 meters
- QLCS cases had the highest observed cloud base height in the study
- QLCS cases had highest storm relative helicity
- Cloud cover tends to dominate southeast cold season tornado days hours in advance of tornado genesis

Cold Season Tornado Days Within 120 km of ARMOR Radar (December 2004-February 2016)

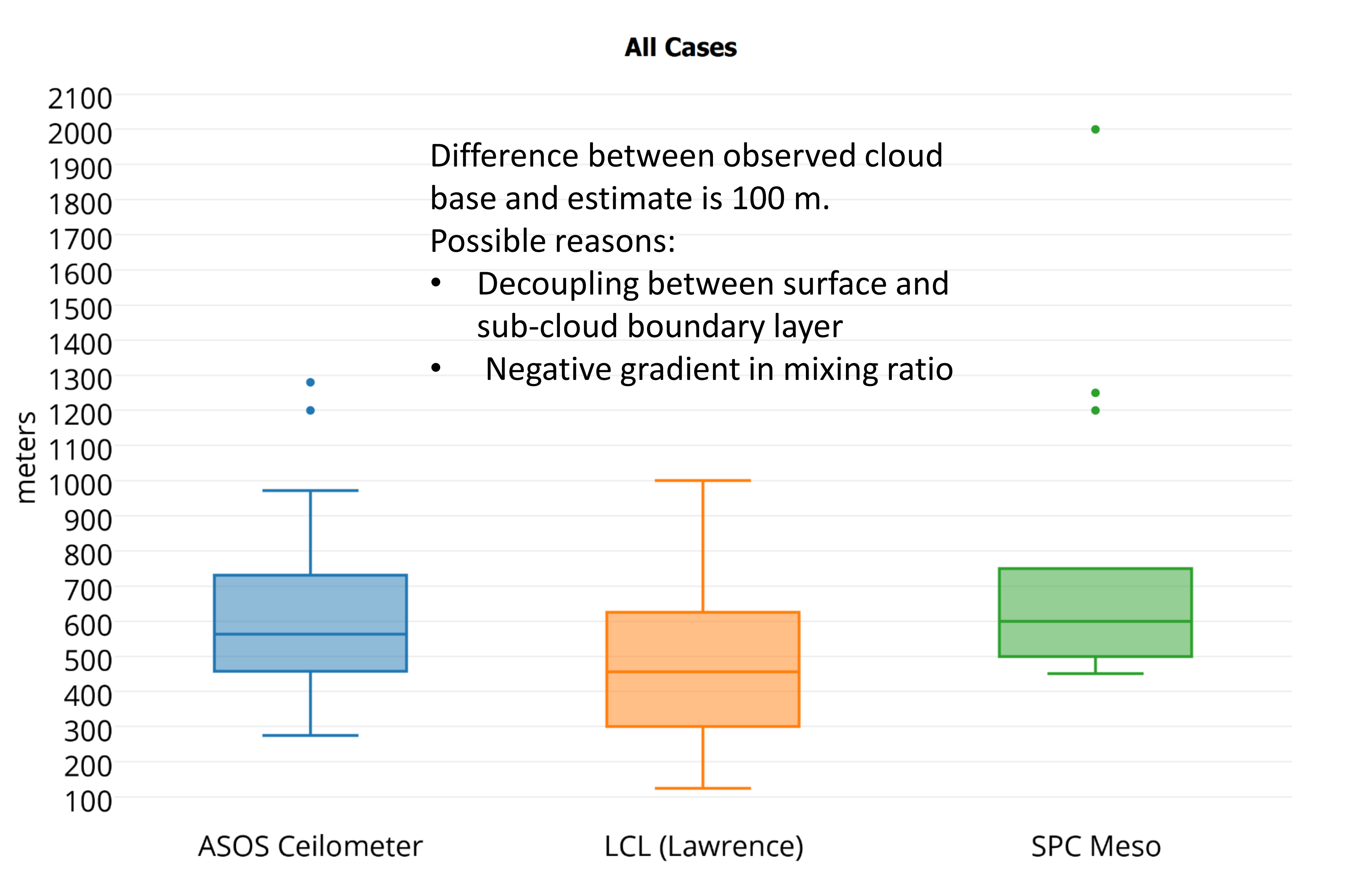


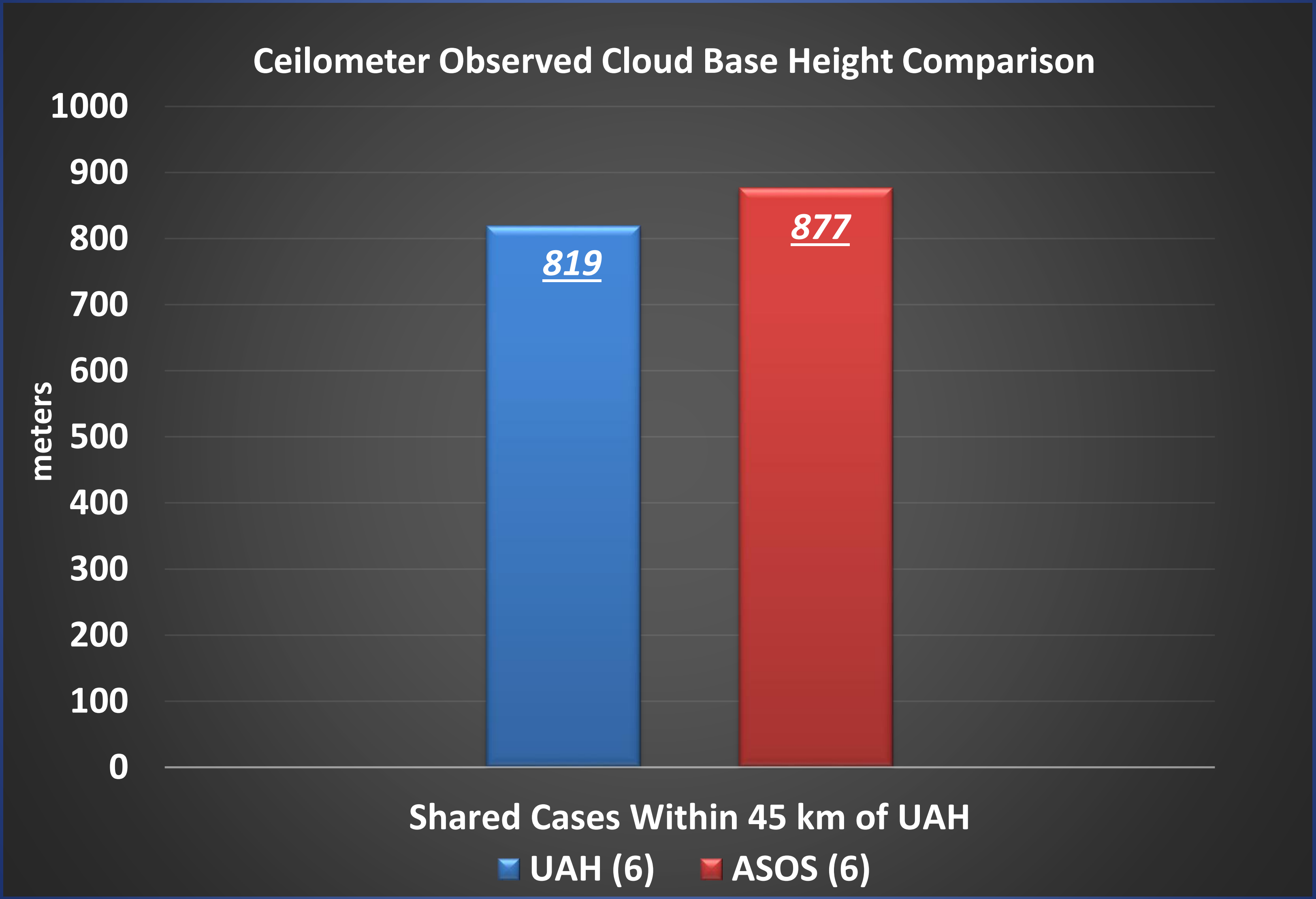

Cold Season Storm Mode Distribution (Dec. 2004 – Feb. 2016)
0
5
10
15
20
25
30
QLCS
26
Supercell
12
Other
0


Bi-Hourly Cold Season Tornado Distribution (Dec. 2005 - Feb. 2015)
9
8
7
6
5
4
3
2
1
0
2
5
5
4
2
8
1
0
0
3
3
5
00/01
02/03
04/05
06/07
08/09
10/11
12/13
14/15
16/17
18/19
20/21
22/23

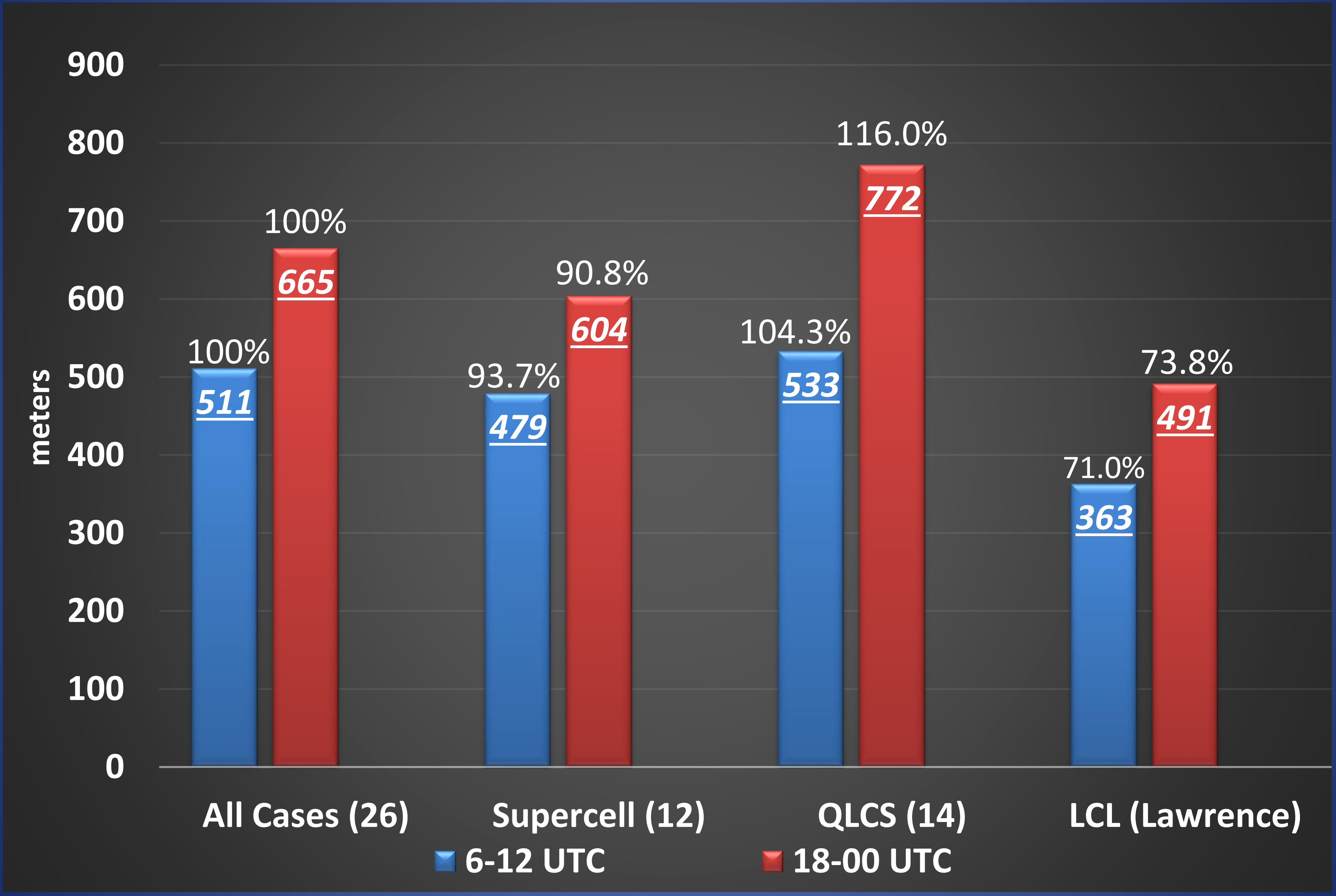

Cloud Base Height - All Cases (25)
900
800
700
600
500
400
300
200
100
0
meters
623
466
695
568
413
620
670
511
763
629
474
545
All Cases (26)
Supercell (12)
QLCS (14)
QLCS Nulls (6)
NOAA Ceilometer
LCL (Lawrence)
SPC Meso

Comparison of Cloud Base Height Among Three Sources



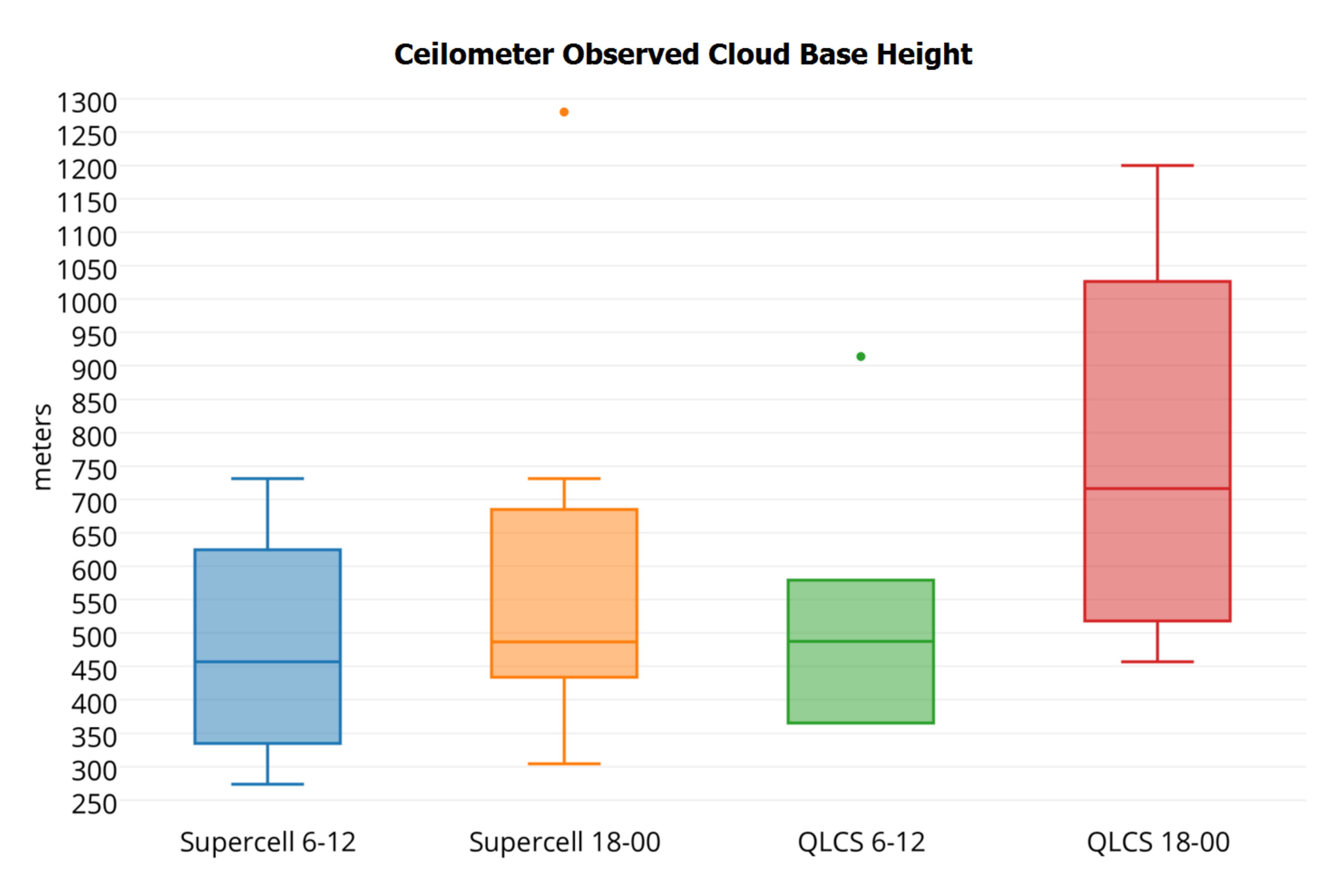

Ceilometer Observed Cloud Base Height Comparison
meters
1000
900
800
700
600
500
400
300
200
100
0
819
877
Shared Cases Within 45 km of UAH
UAH (6)
ASOS (6)

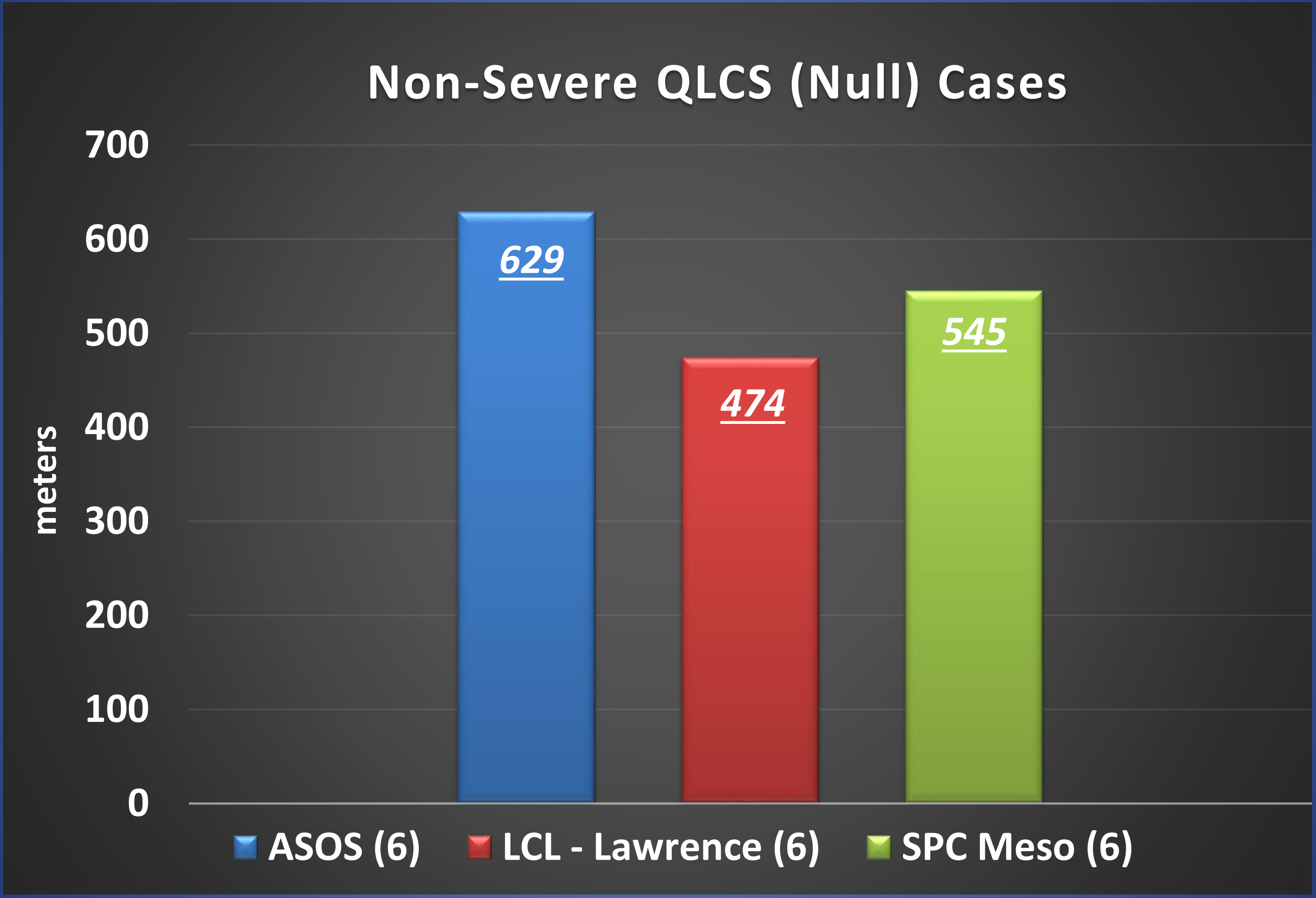
Ceilometer Observed Cloud Base Height



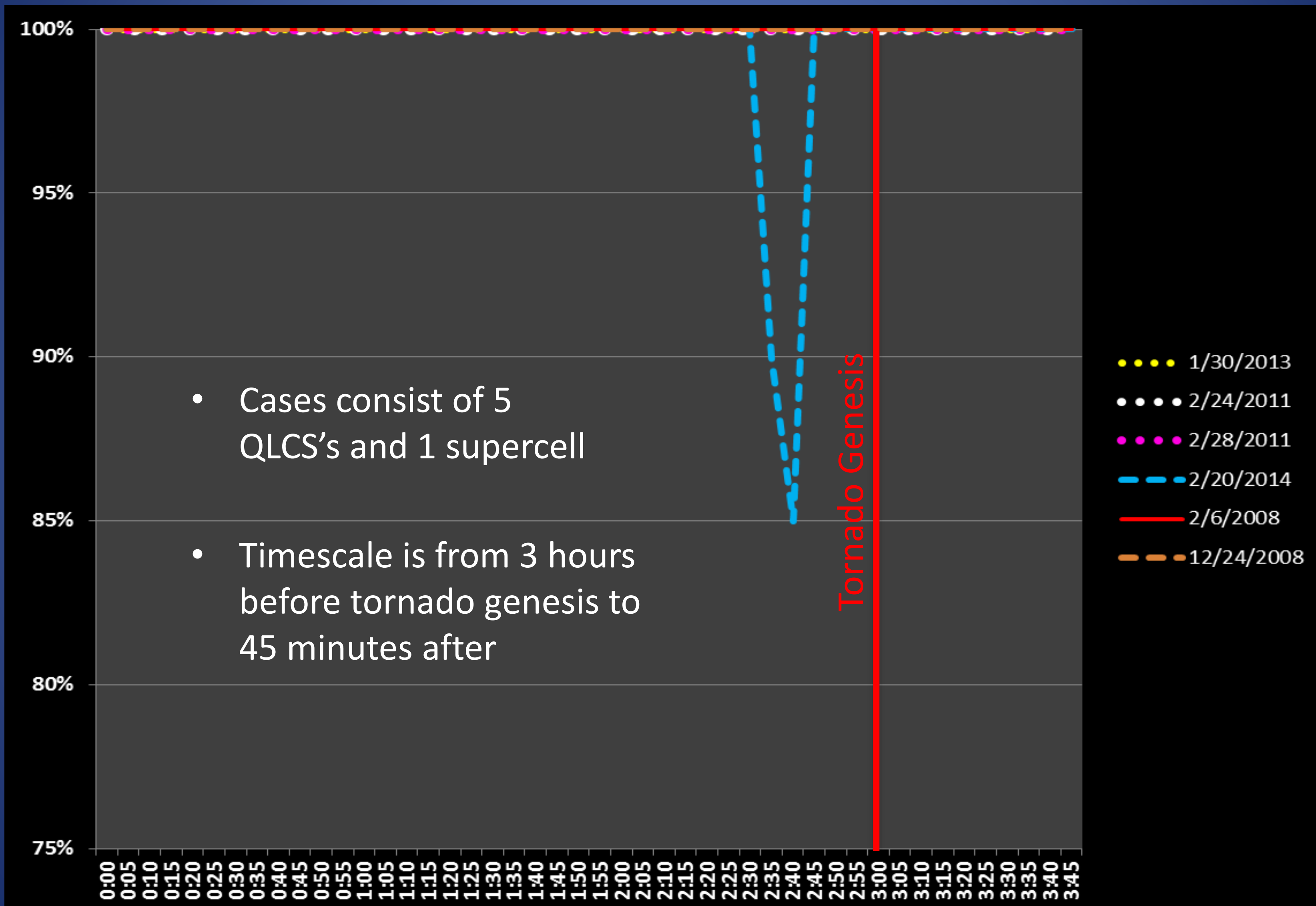
Daytime and Nocturnal Tornado and Storm Mode Distribution

Daytime/Nocturnal Ceilometer Observed Cloud Base Height by Storm Mode

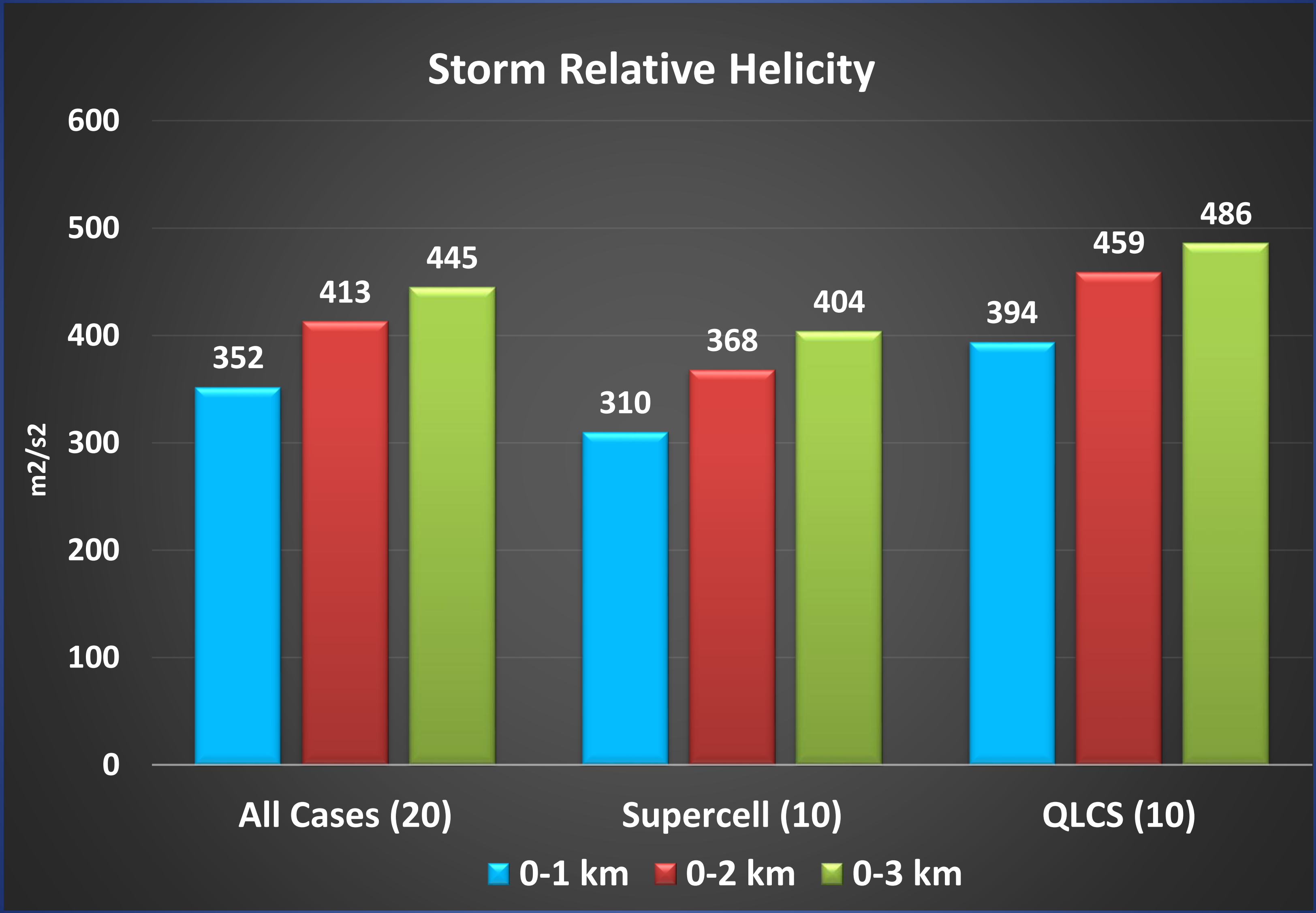



Non-Severe QLCS (Null) Cases
meters
700
600
500
400
300
200
100
0
629
474
545
ASOS (6)
LCL - Lawrence (6)
SPC Meso (6)

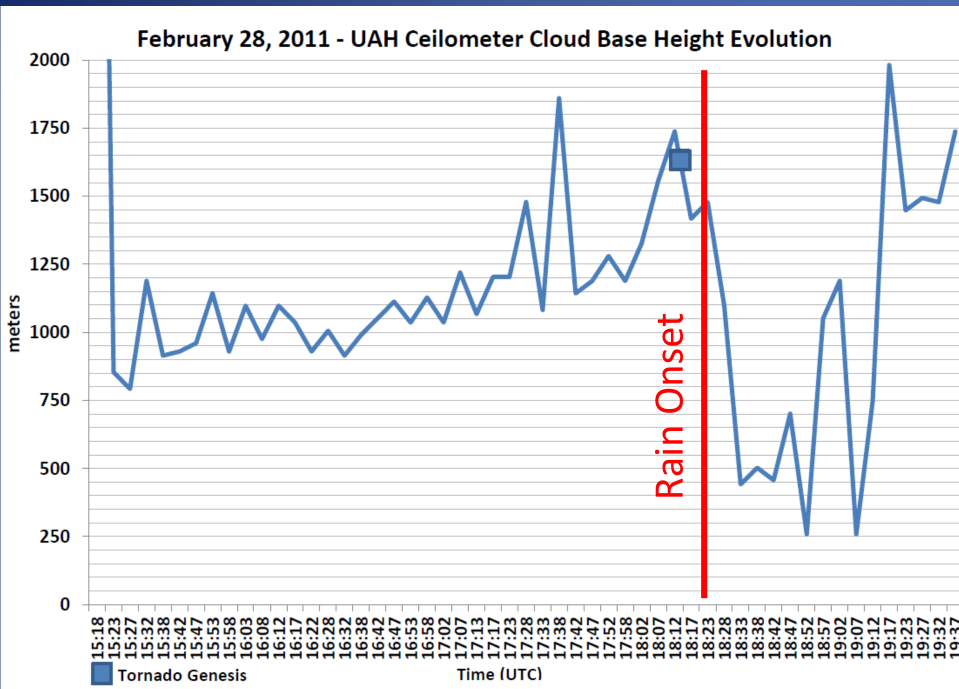
Time Series of Ceilometer Observed Cloud Fraction



915 MHz and VAD Wind Profiler Derived Storm Relative Helicity

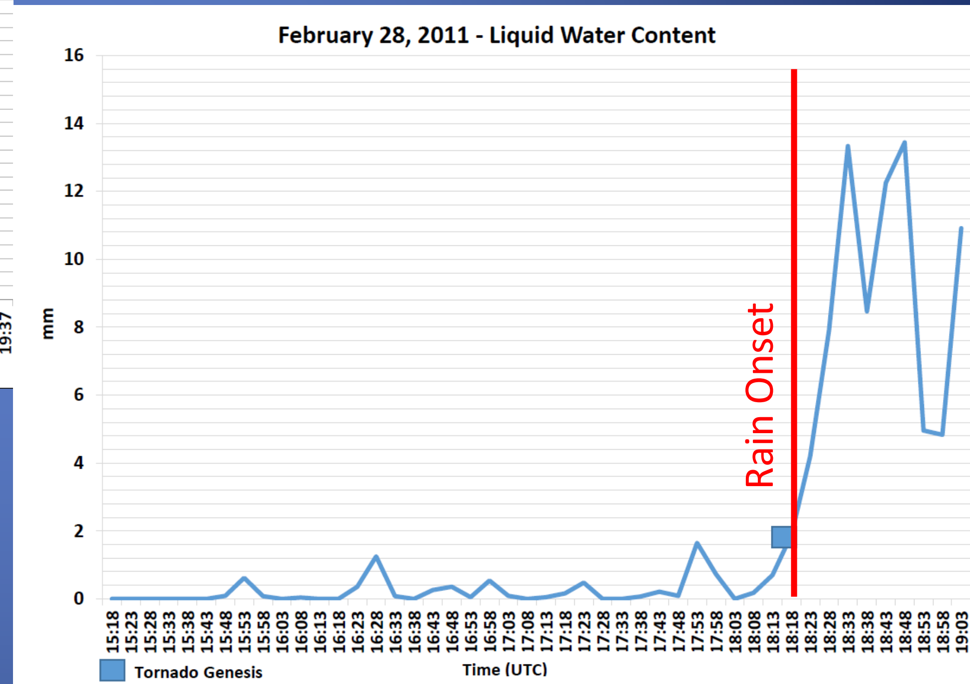


February 28, 2011 QLCS Tornado Genesis Case



Ceilometer observed cloud base height

Onset of rain results in rapid decline in fields…



MPR observed liquid water content

V. **Conclusions**

- Stratification of the low cloud deck often results due to strong advection
- Low clouds prevail for at least three hours prior to southeast cold tornadoes indicating common cloud-top mixed layers
- Day/night difference of SRH
- Importance of cloud climatology to NWP validation

VI. Future Work

- Continue adding additional ceilometer cases to improve statistics
- Study mixed layer characteristics via radiosondes
- Compare radiosonde and ceilometer observations

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