The High-Shear, Low-CAPE SHERB parameter and its evaluation

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Presented by:

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CR Southeast SOO Group Meeting

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CIMMSE Collaboration for Improved Meteorology in the Mid-Atlantic and Southeast

Academic, operational, and government partners working together to improve meteorology

NC STATE UNIVERSITY

Background

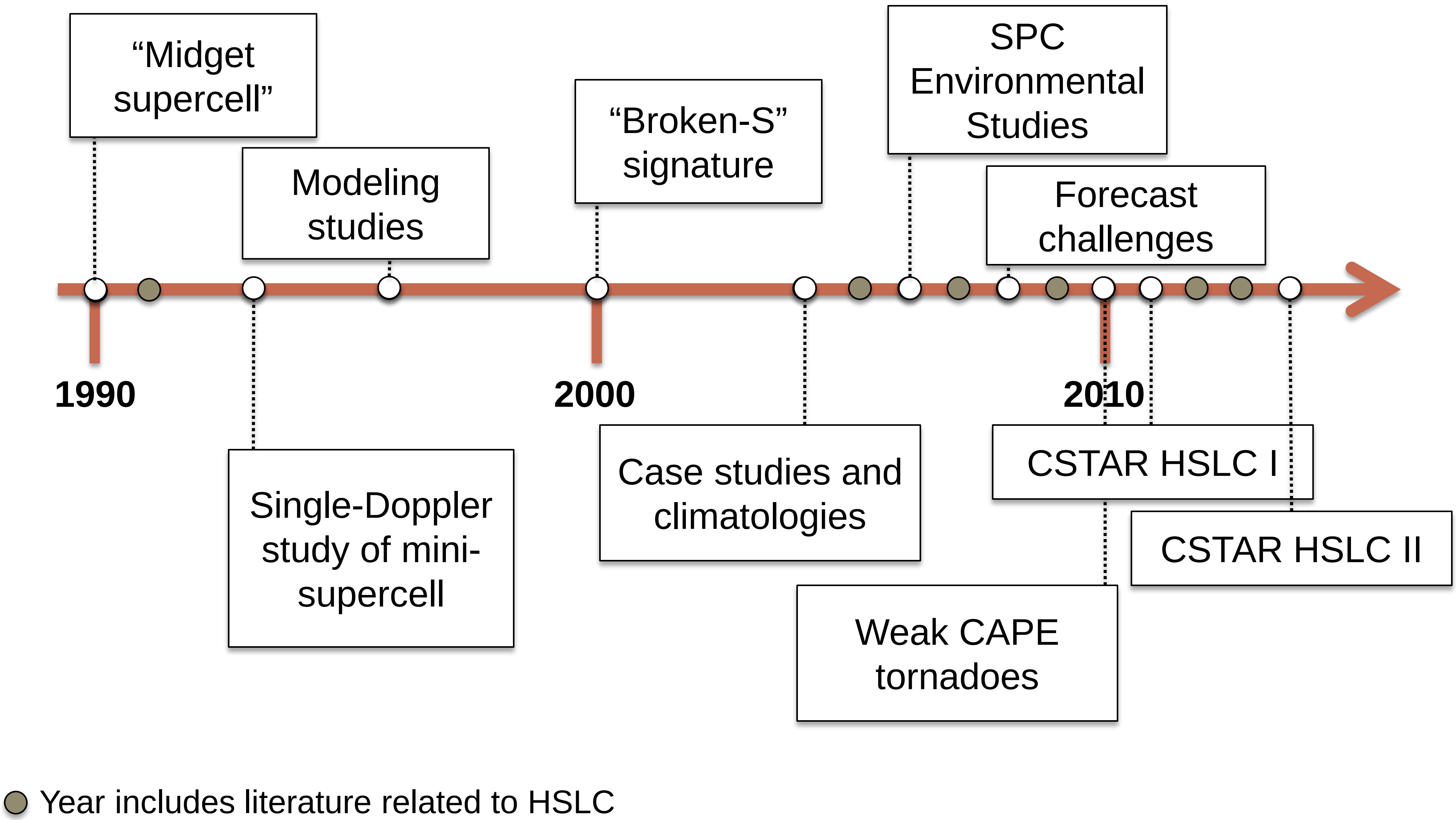
- “High” shear
  - 0-6 km layer
  - ≥ 35 knots (18 m/s)

- “Low” CAPE
  - Surface-based parcel
  - ≤ 500 J/kg

Background

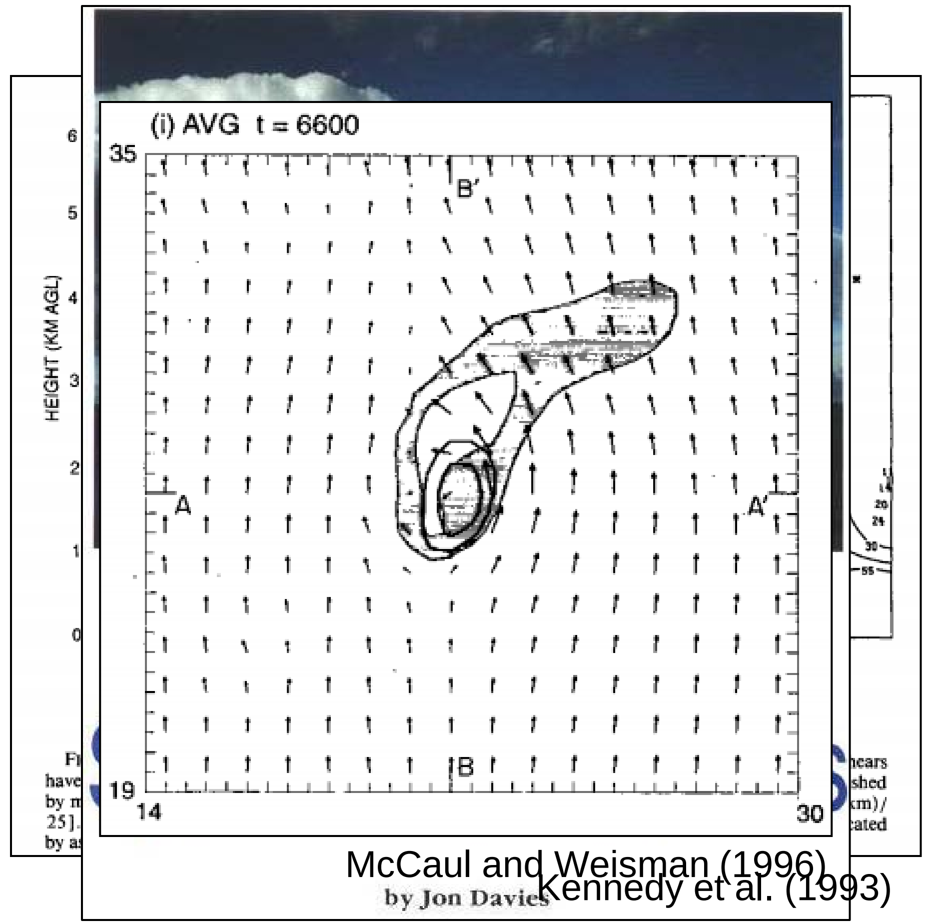
- High-shear, low-CAPE (*HSLC*) environments: **second "key subclass"** of severe weather (Schneider et al. 2006)
- Over half of significant or violent tornadoes (EF2+) associated with HSLC
- Relatively high number of missed events and false alarms
- Few operational *or* modeling studies

High-Shear, Low-CAPE (HSLC) Timeline



Early Literature (1990s)

- Shallow convection can produce tornadoes (Davies 1990)
- Tropical environments are HSLC (McCaul 1993); modeling studies produce mini-supercells (McCaul and Weisman 1996)
- Mesocyclone ~3 km deep, echo tops ~6 km (Kennedy et al. 1993)

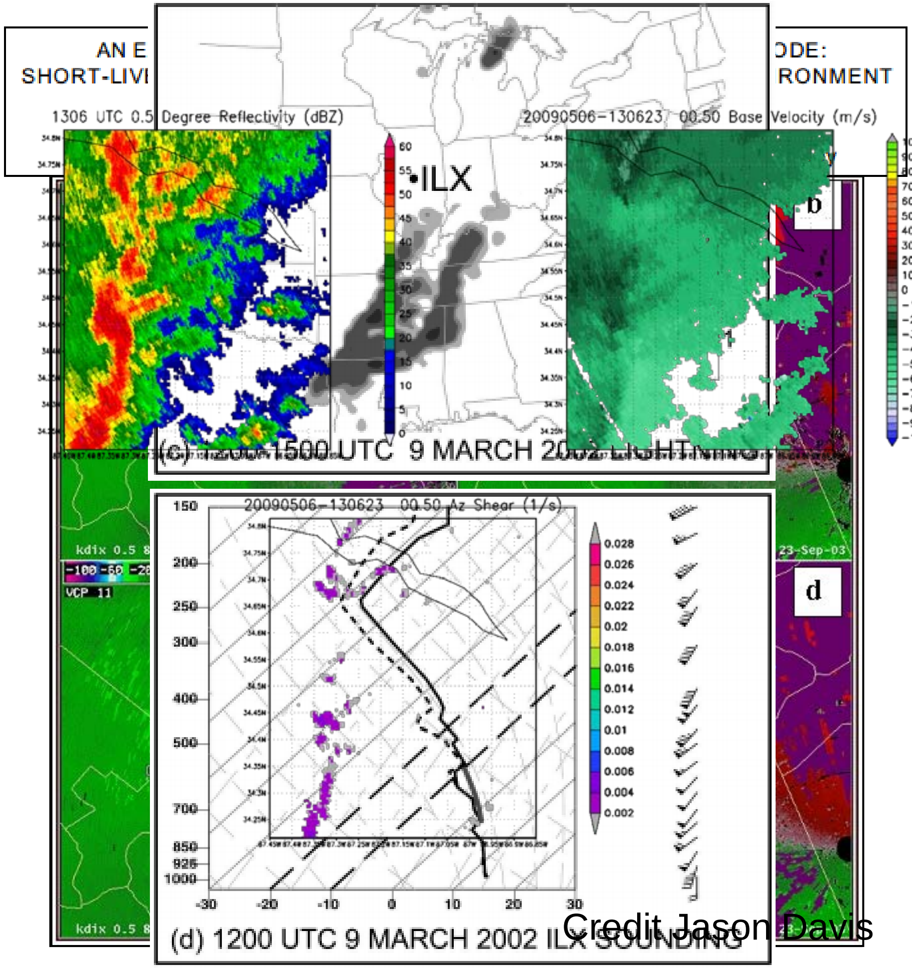


McCaul and Weisman (1996)

Kennedy et al. (1993)

Increasing Awareness (early 2000s)

- “Broken-S” signature introduced (McAvoy et al. 2000)
- Rapid tornadogenesis and other operational considerations (Cope 2004)
- Lightning rare in HSLC events due to lack of instability in mixed phase region (van den Broeke et al. 2005)

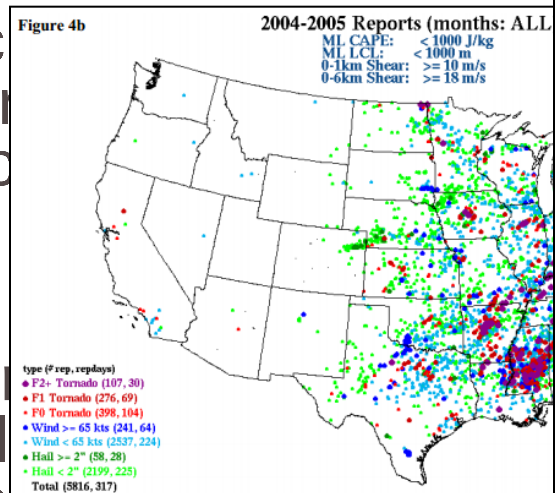


Credit Jason Davis

van den Broeke et al. (2005)

Paradigm Shift (Late 2000s)

- Tornado watc… in HSLC envir… (Dean and Sc… 2008, 2012)
- "Effective" par… designed for l… covection (Thompson et al. 2007)
- Low CAPE (defined as MLCAPE ≤ 500 J kg-1) tornadoes plentiful (Guyer and Dean 2010)



"Two ***key subclasses*** of Uni… severe weather environments… with strong deep layer shear, o… MLCAPE predominantly in th… United States, and *another* … *MLCAPE [≤ 1000 J kg… primarily in the Southeast* emerge from this analysis."

Schneider et al. (2006)

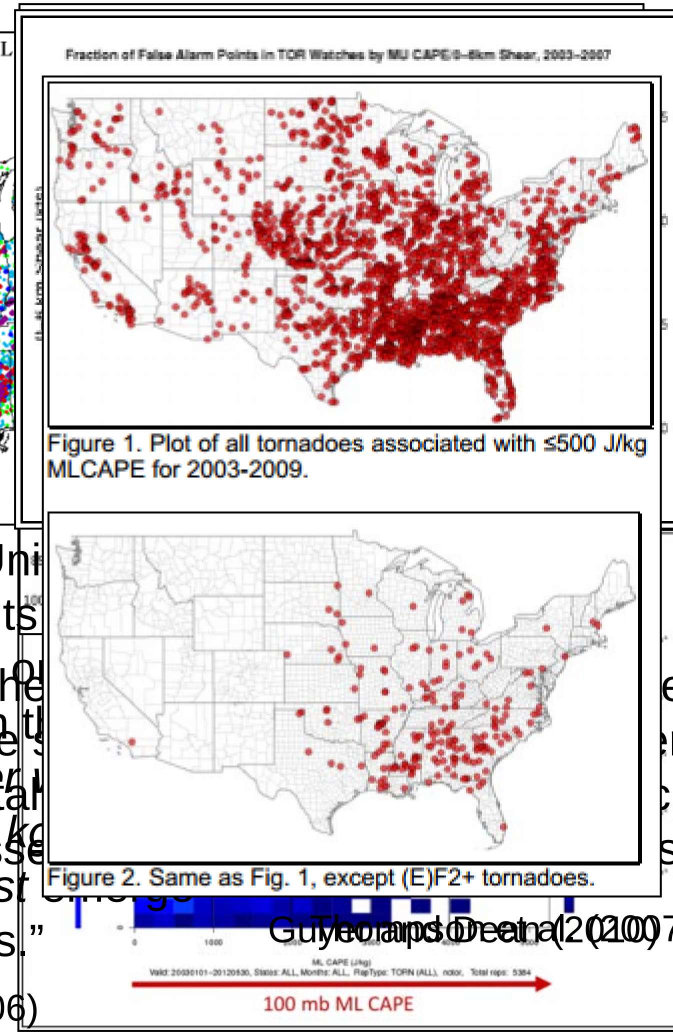


Figure 1. Plot of all tornadoes associated with ≤500 J/kg MLCAPE for 2003-2009.

Figure 2. Same as Fig. 1, except (E)F2+ tornadoes.

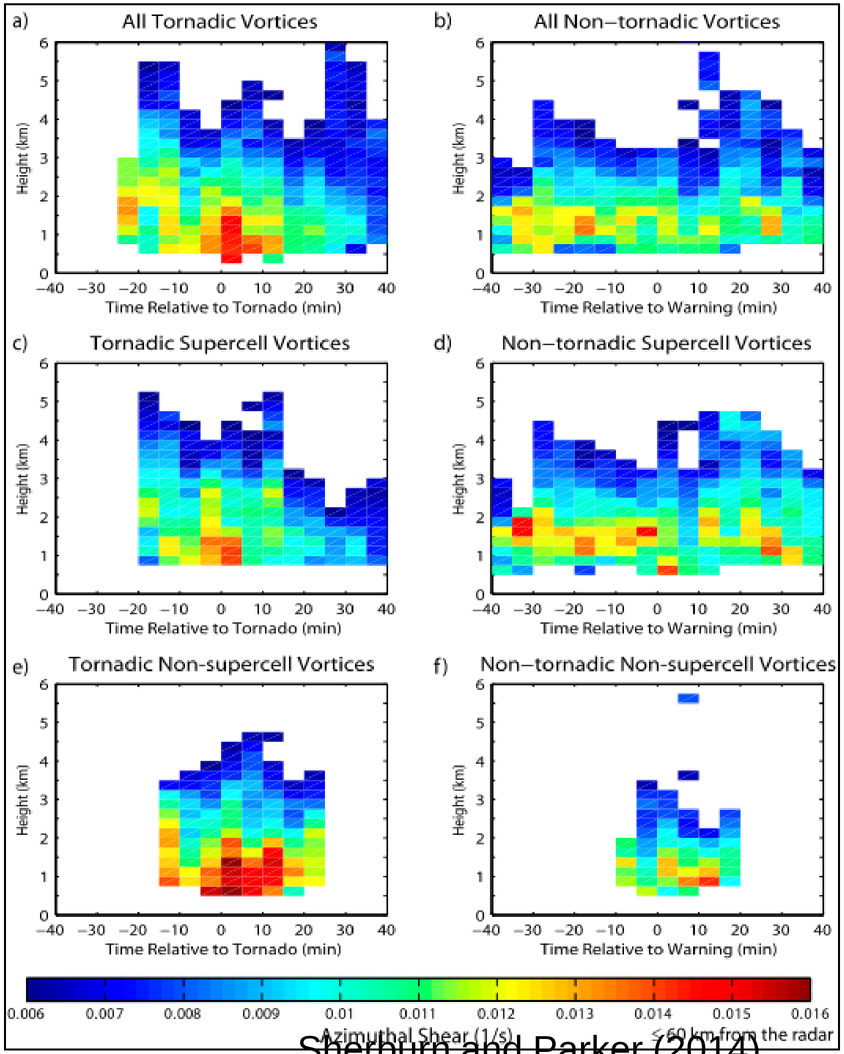
"The… the s… …ery ta… …c asso… …es …s."

Guyer and Dean (2010) / Thompson et al. (2007)

Dean and Schneider (2008, 2012)

Operational Challenges (2010s)

- Shallow, transient tornadic vortices (Davis and Parker 2014*)
- High percentage of cool season and overnight severe (Sherburn and Parker 2014*)

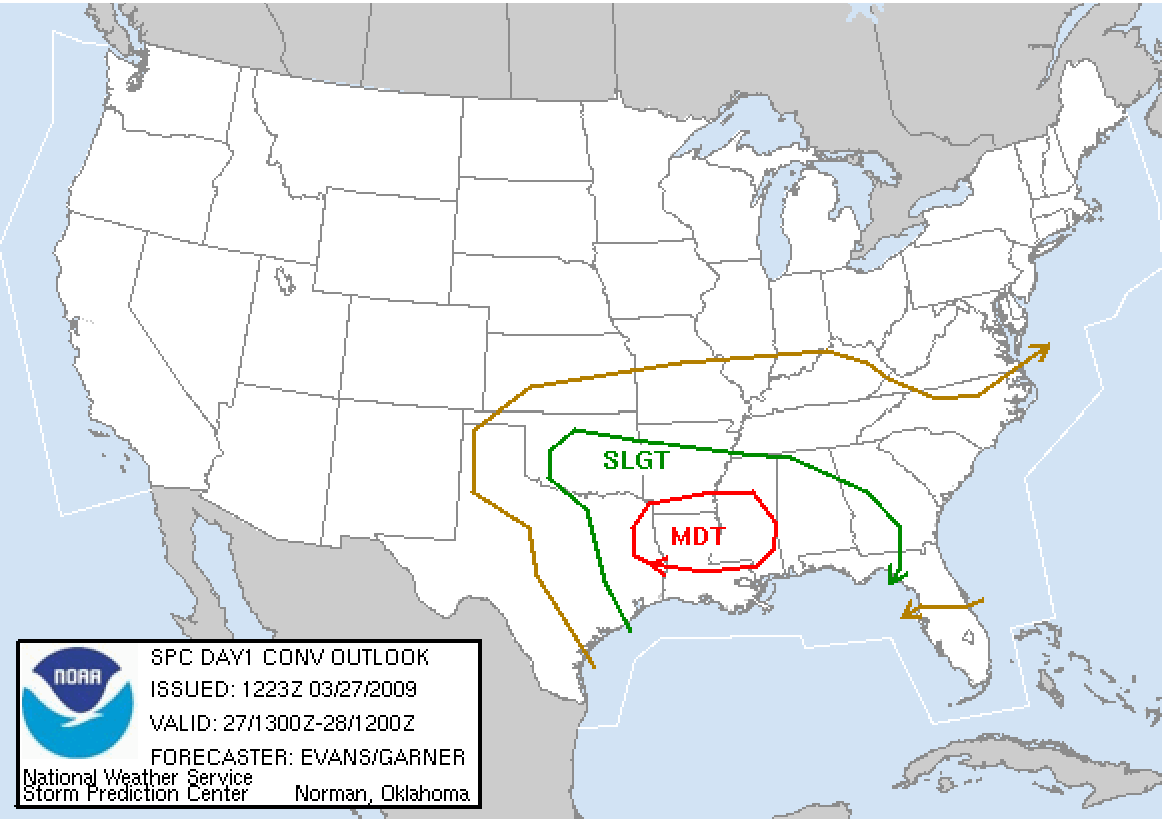


Sherburn and Parker (2014)

Davis and Parker (2014)

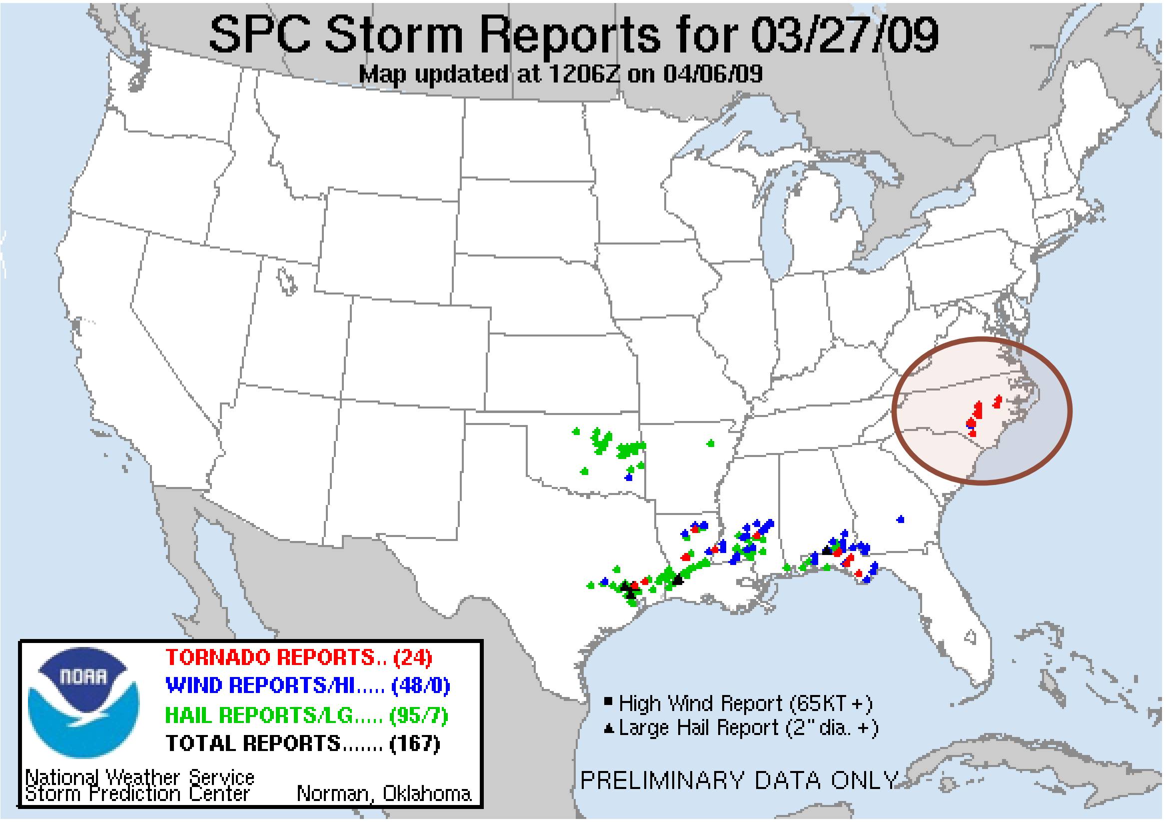
*Low CAPE defined as SBCAPE ≤ 500 J kg^{-1}

Background



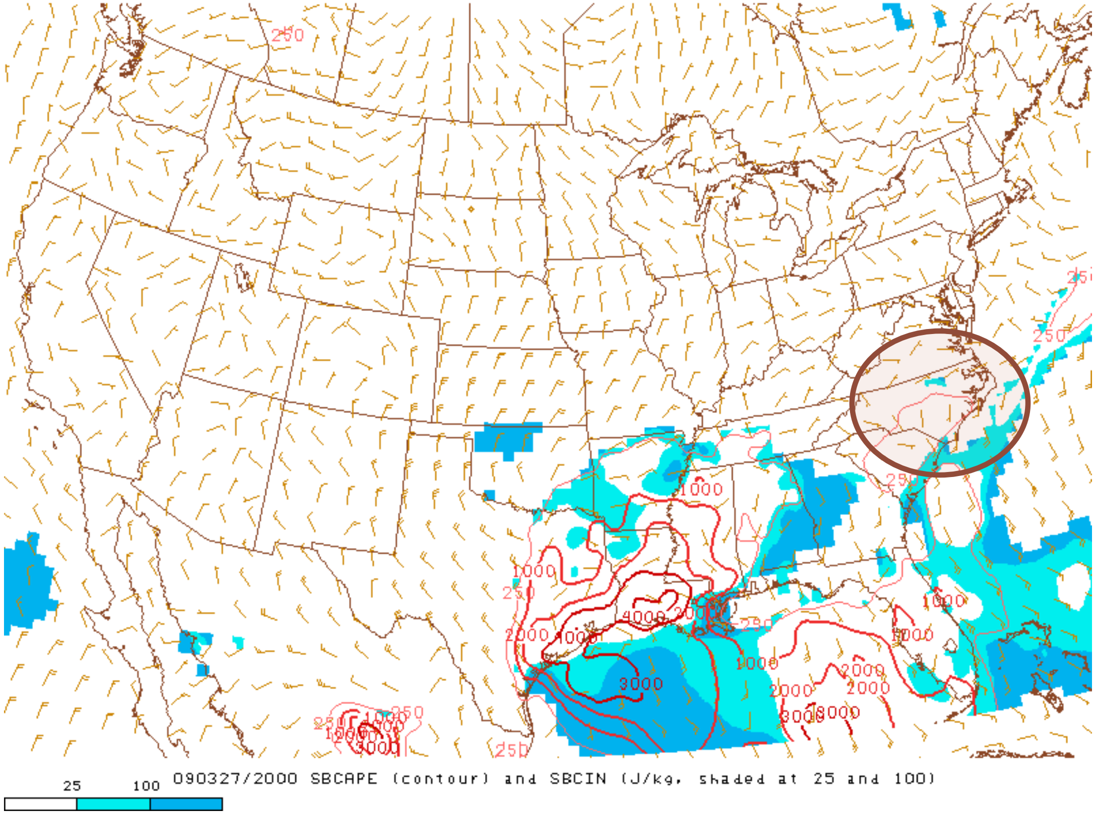
Storm Prediction Center (SPC)

Background



Storm Prediction Center (SPC)

Background



Storm Prediction Center (SPC)

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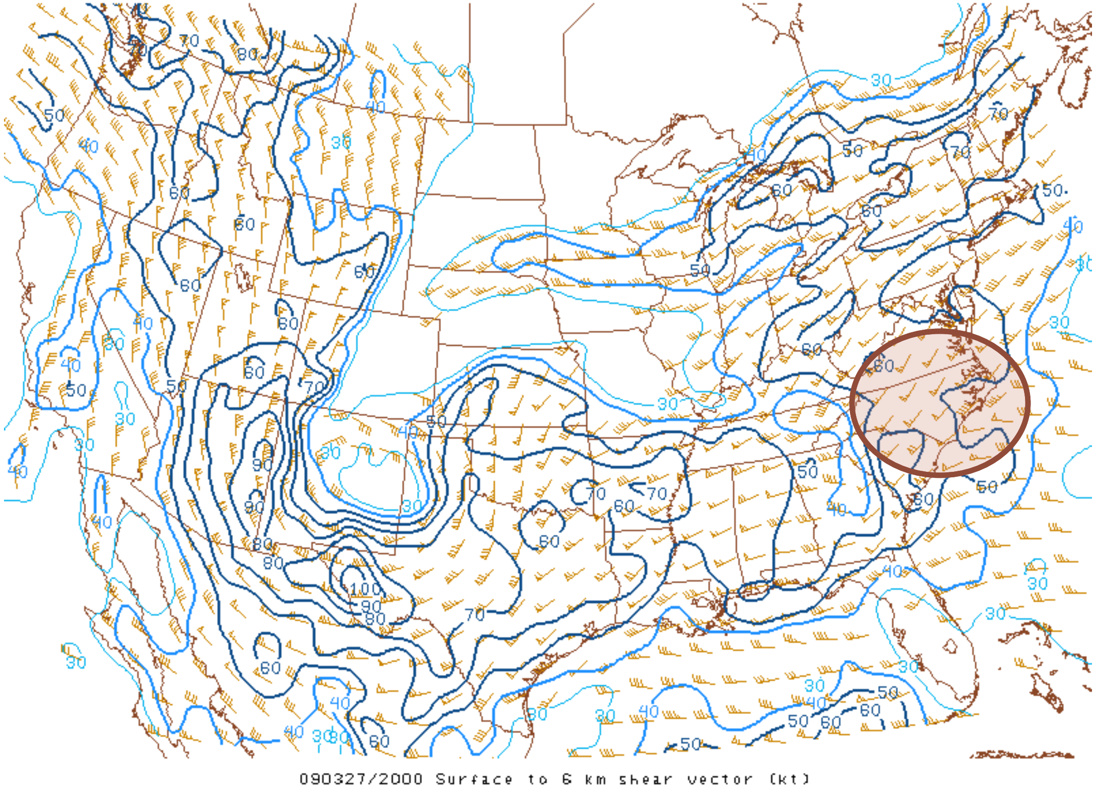
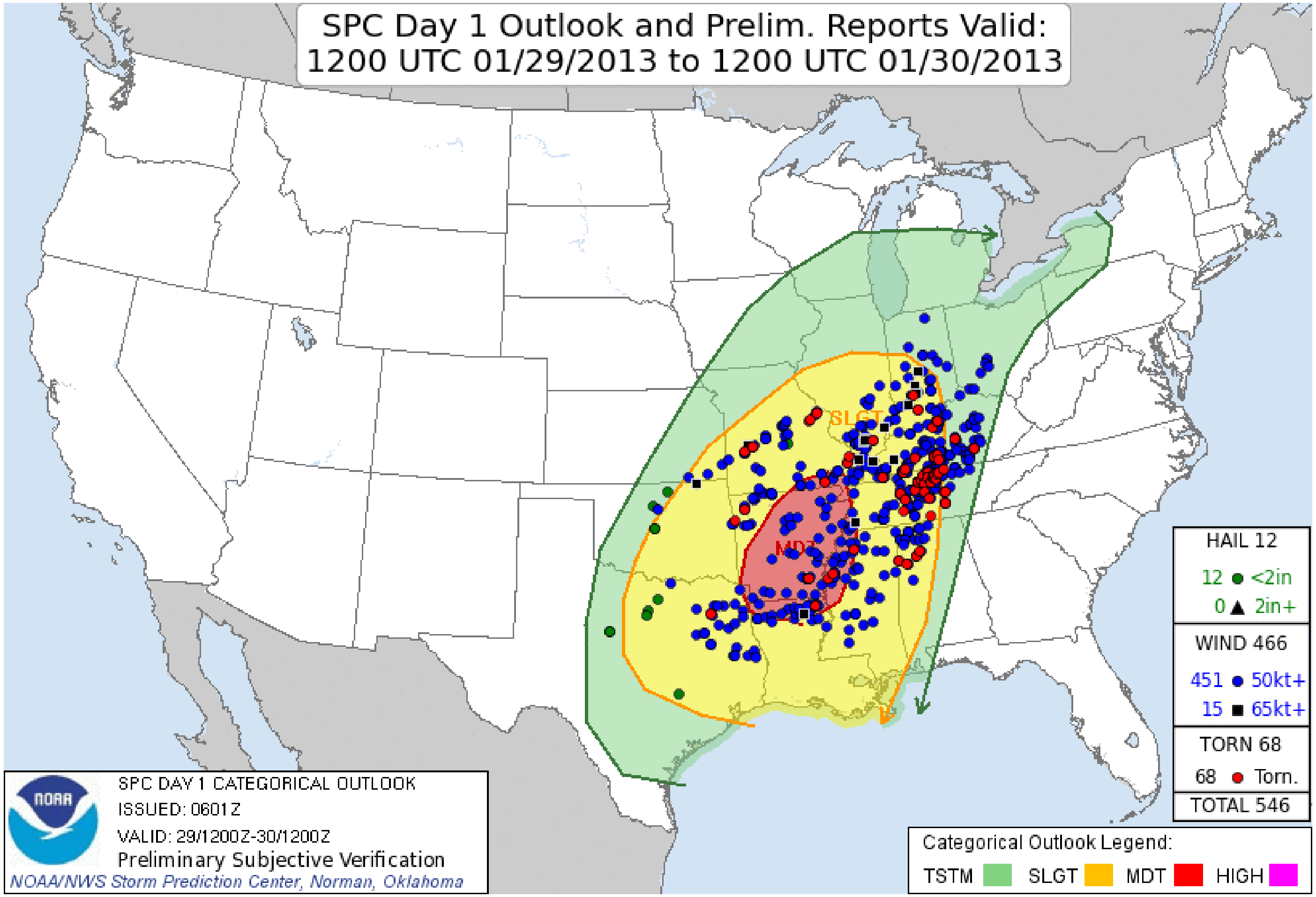


Storm Prediction Center (SPC)

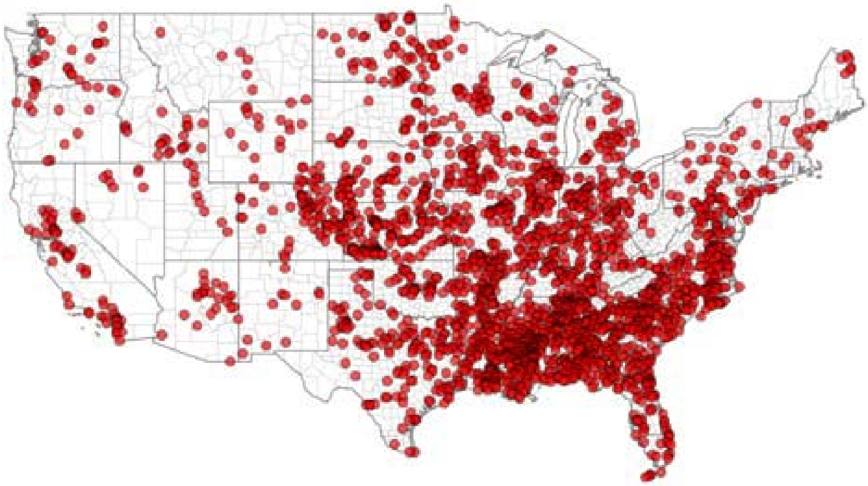
Background

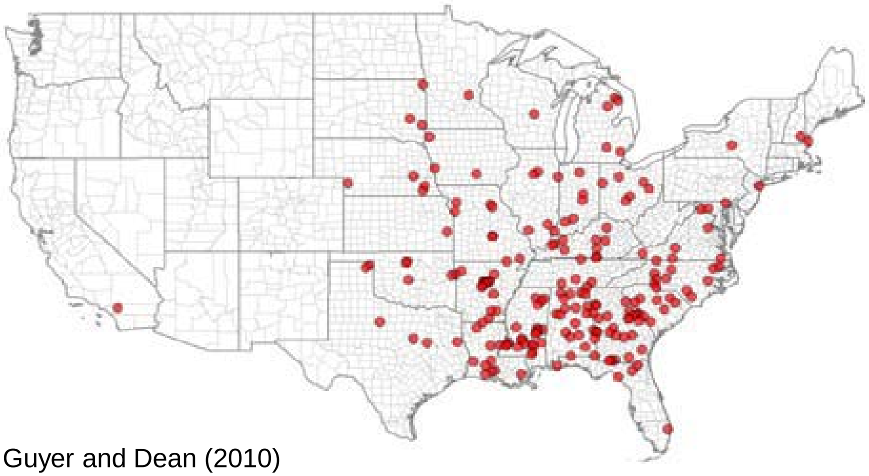


Storm Prediction Center (SPC)

Background

- Difficult to forecast
- Often cool season or nocturnal
- Challenging warning operations
- Compressed convection
- Fast storm motions
- Transient structures
- Little to no lightning

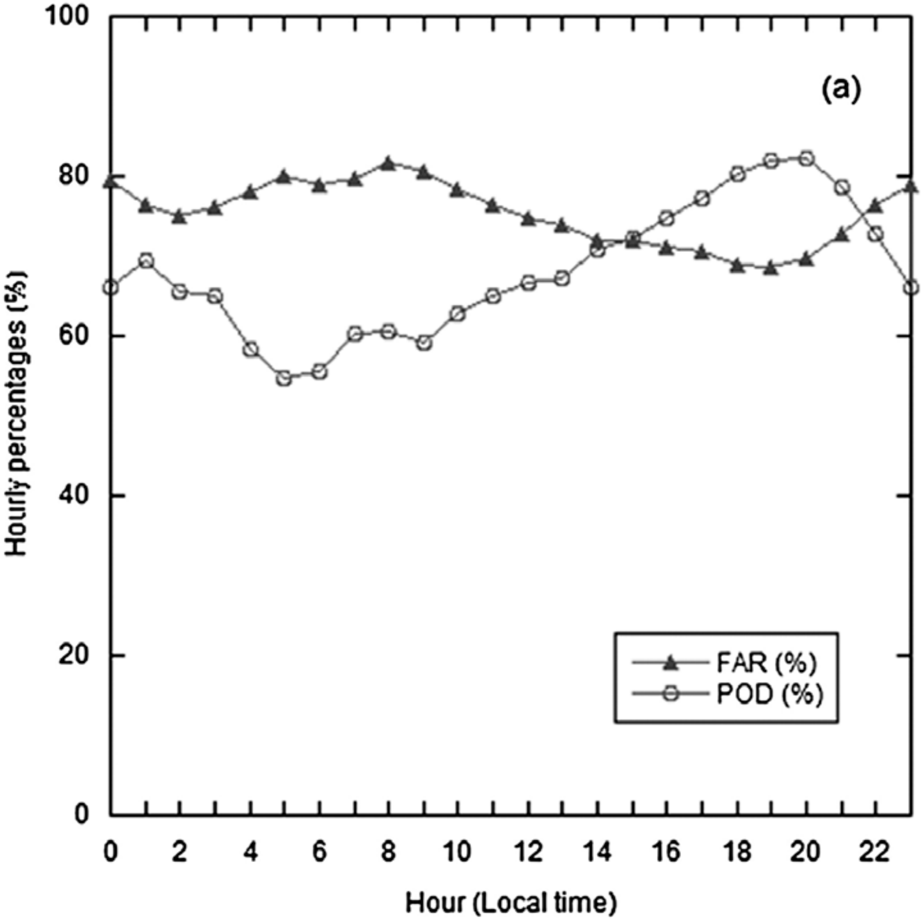


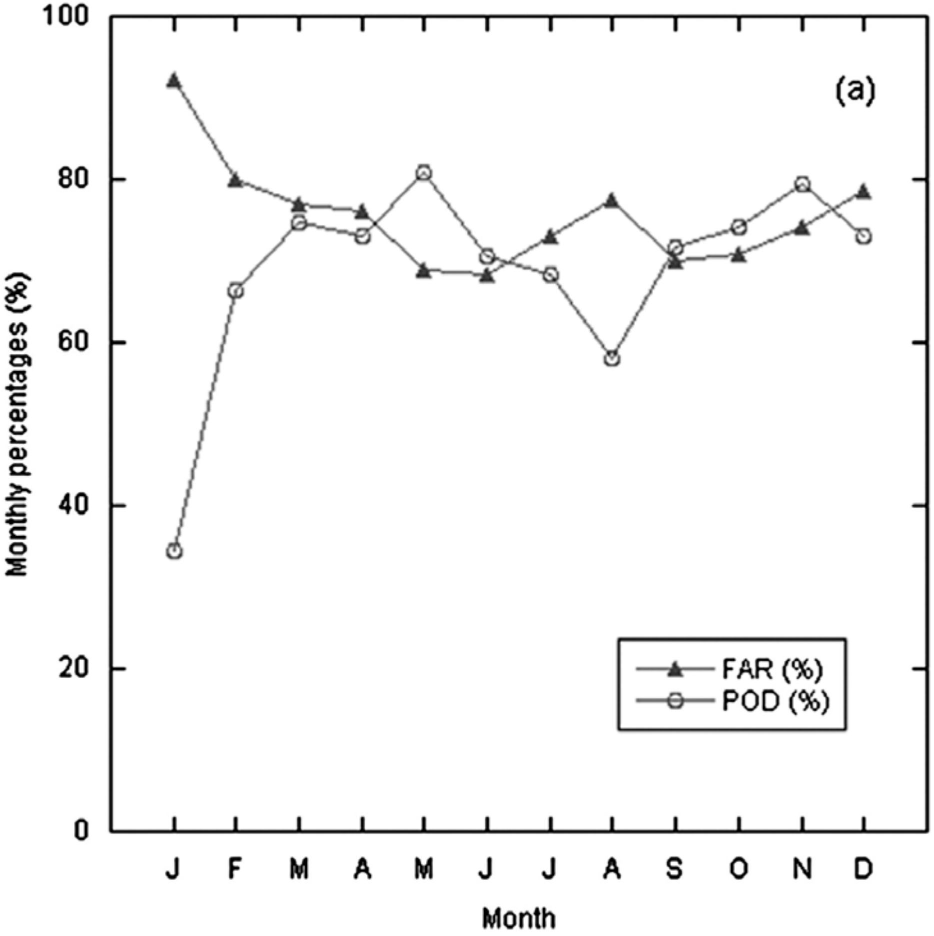


Guyer and Dean (2010)

Top: 2003-2009 tornadoes with MLCAPE < 500 J/kg
Bottom: Same, but EF2 and greater

Background

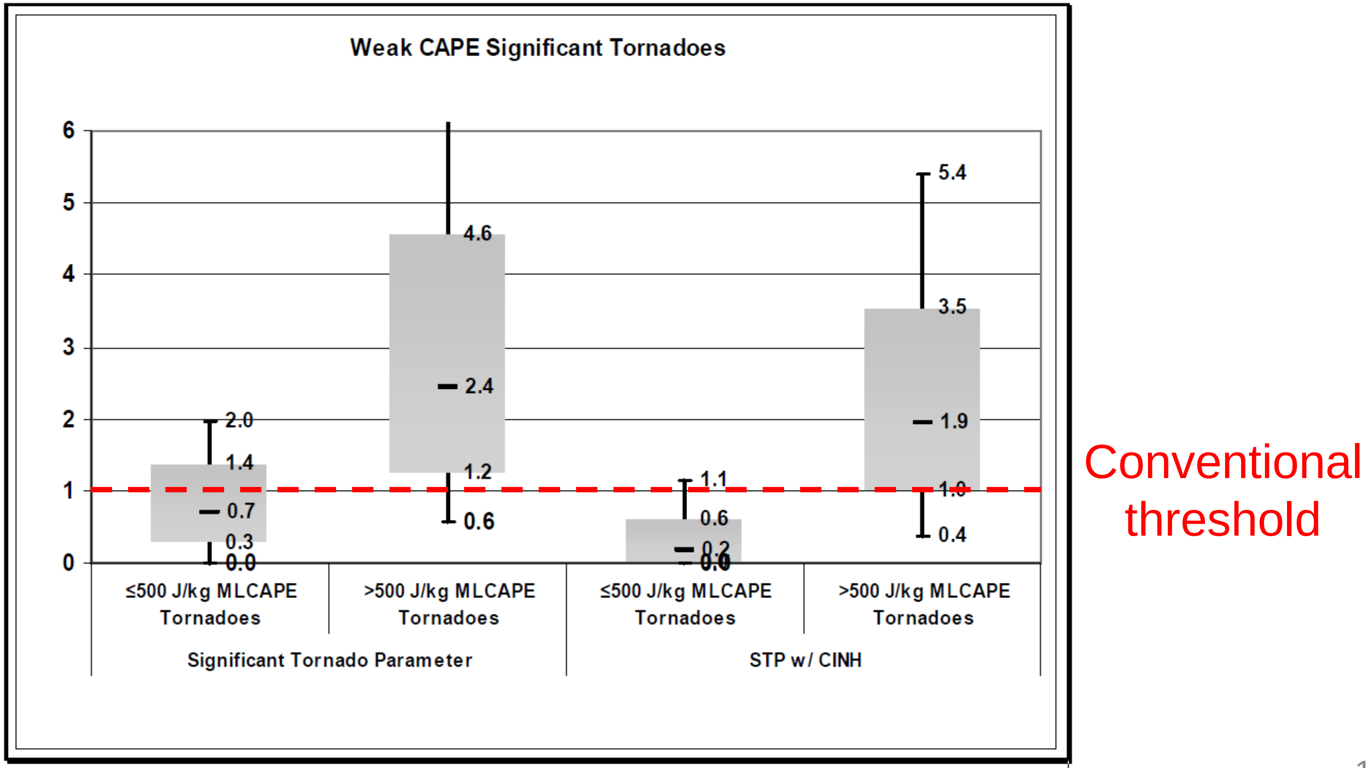




Brotzge et al. (2011)

Background

- Current forecasting tools inadequately represent risk in low CAPE environments



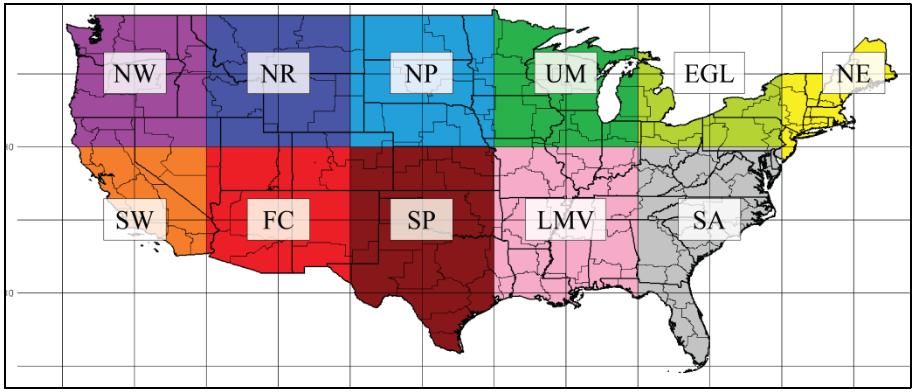
Guyer and Dean (2010)

Verification Data

- All HSLC significant severe reports and nulls across contiguous U.S. between 2006-2011
  - ***2517 HSLC Significant Severe Reports (21% of all)***
    - ***302 tornadoes, 1579 wind reports, 636 hail reports***
  - ***1316 HSLC Nulls***
- Also SPC Mesoanalysis
- Source of HSLC climatology
- Includes development dataset

Verification Methods

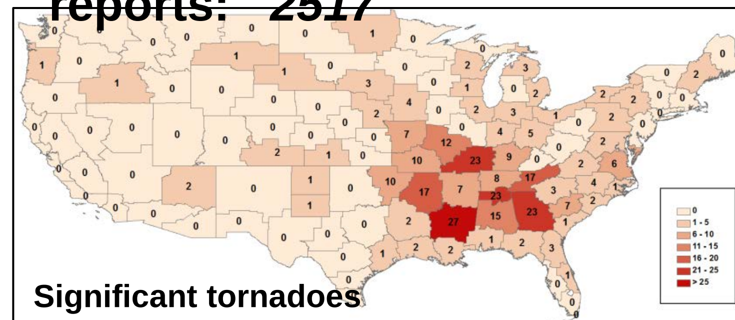
- TSS again utilized primarily
- Tested regionally



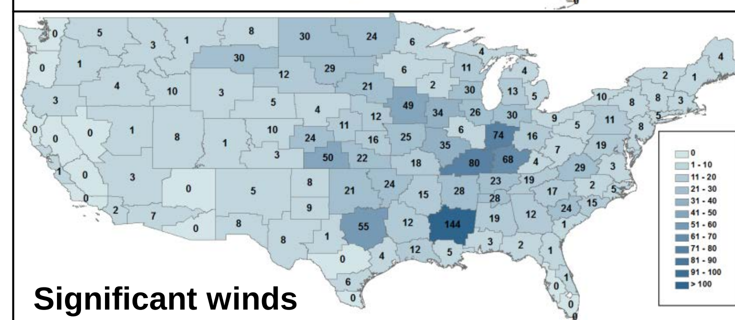
Environmental Climatology

- HSLC reports occur in nearly every CWA
- Transition from tornado/wind threat in SE/MS Valley to wind/hail threat in Plains/Midwest

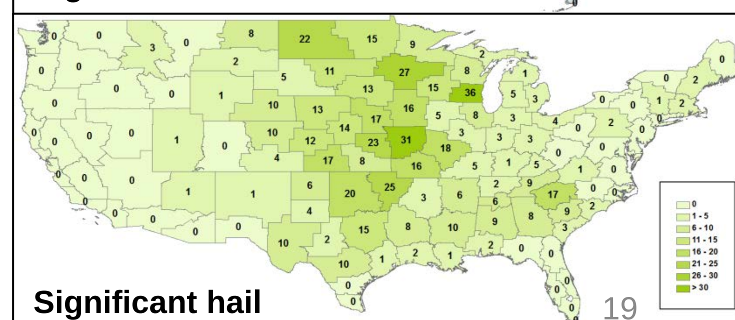
Total number of 2006-2011 HSLC significant severe reports: ***2517***



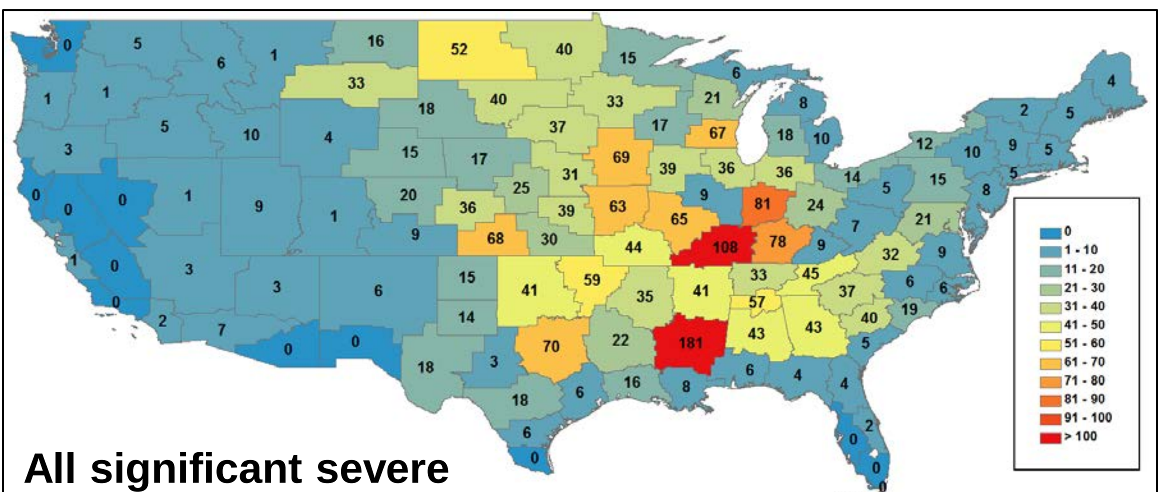
Significant tornadoes



Significant winds

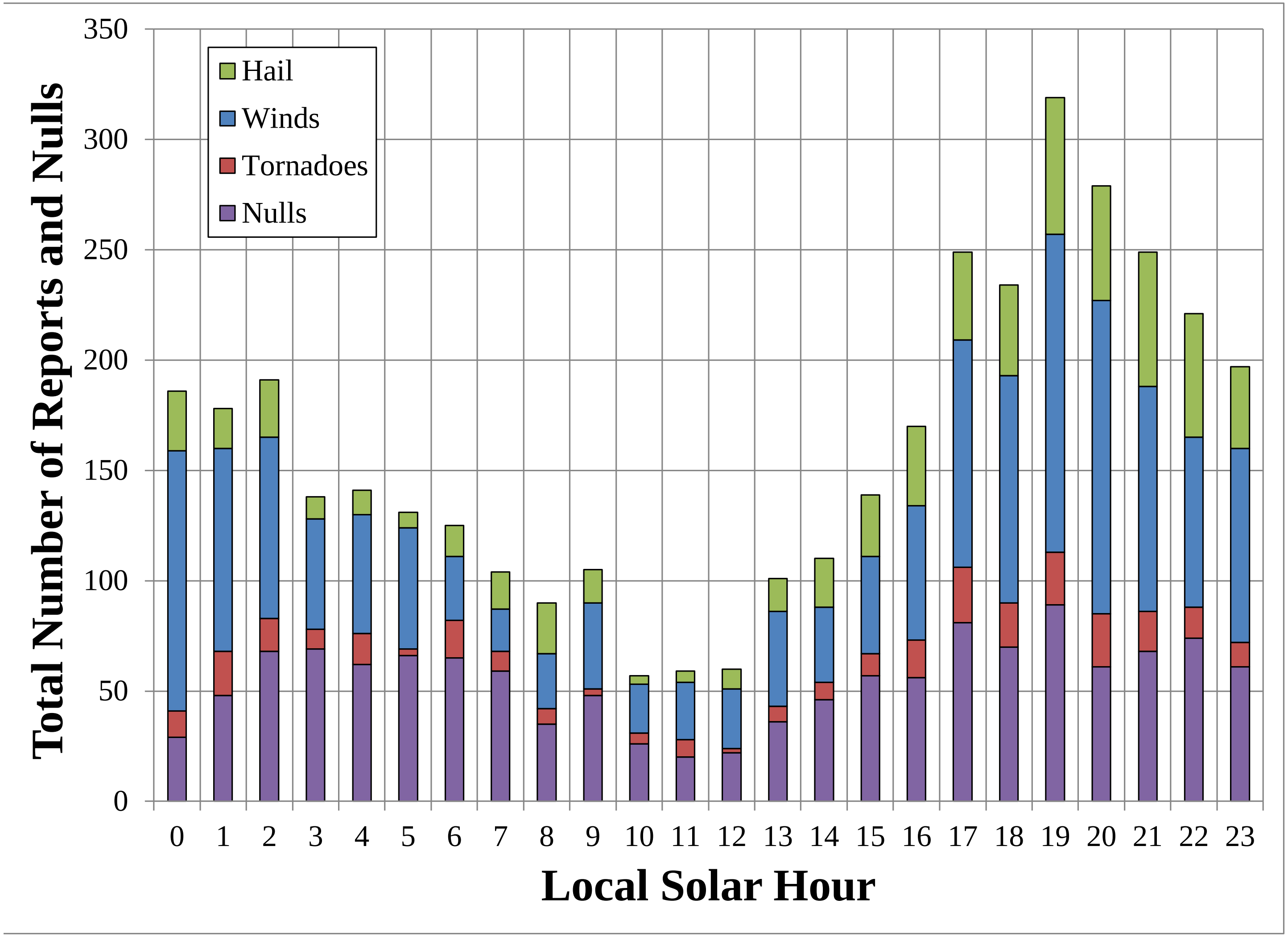


Significant hail

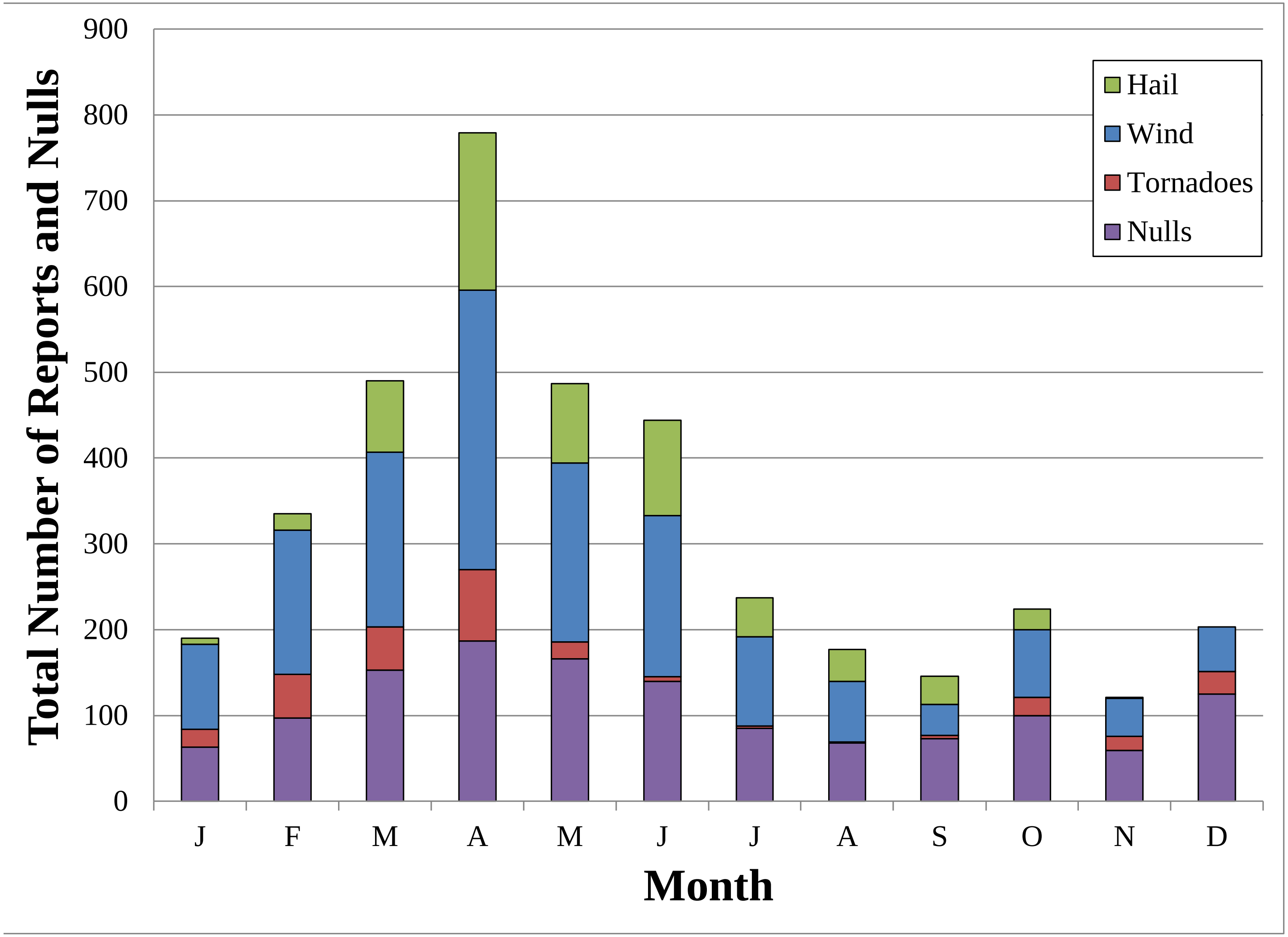


All significant severe

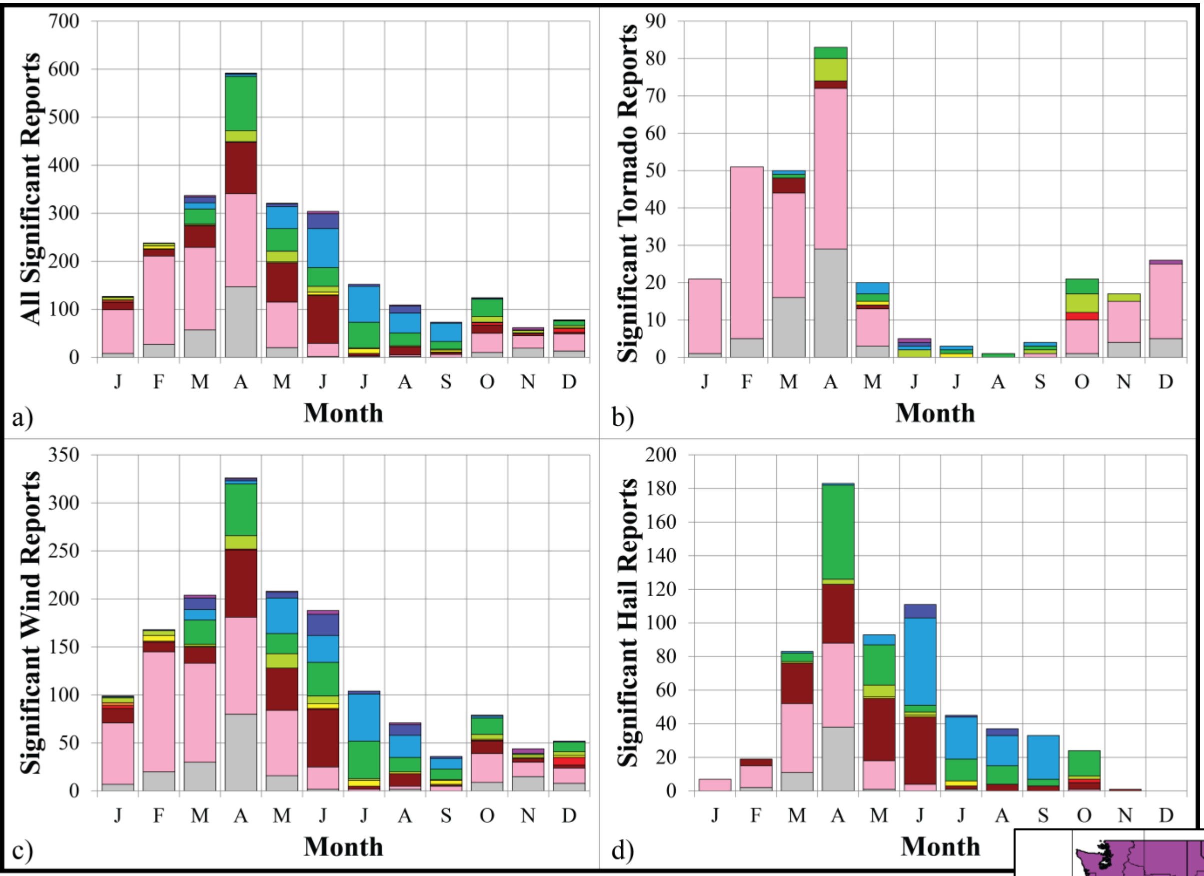
Environmental Climatology

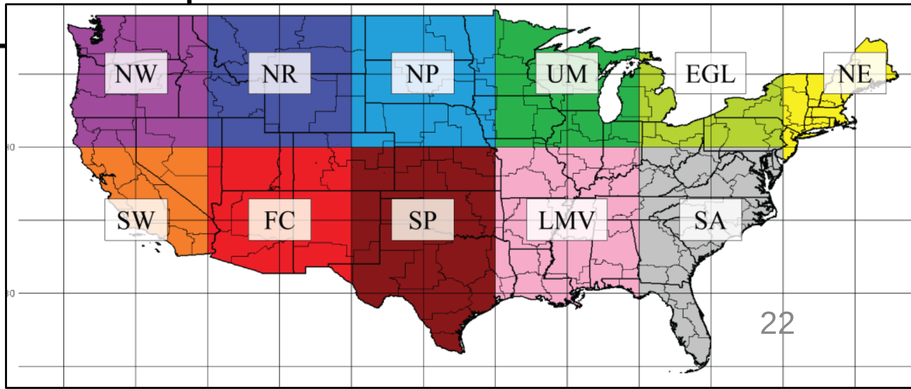


Environmental Climatology



Environmental Climatology



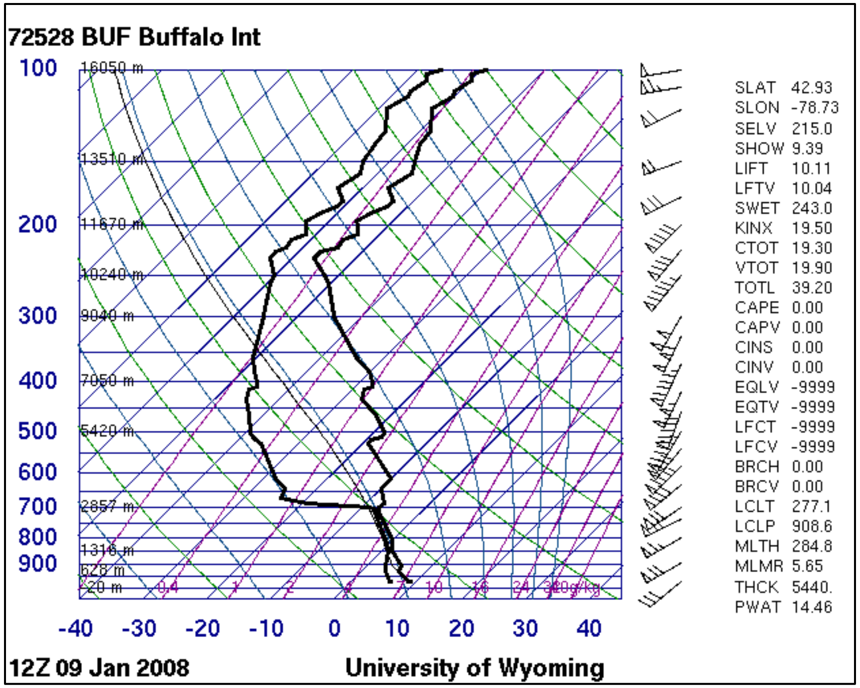


New Forecasting Techniques

- Why not use conventional composite parameters?
  - CAPE
- How to approach creation of new parameters?
  - Statistical, eyes wide open approach
  - Focus on detecting favorable environments, not forecasting convection

New Forecasting Techniques

- Product of low- and mid-level lapse rates and wind/shear magnitudes most skillful
- Why lapse rates?
- Which wind/shear magnitudes?



Launched approximately half an hour prior to significant wind event

New Forecasting Techniques

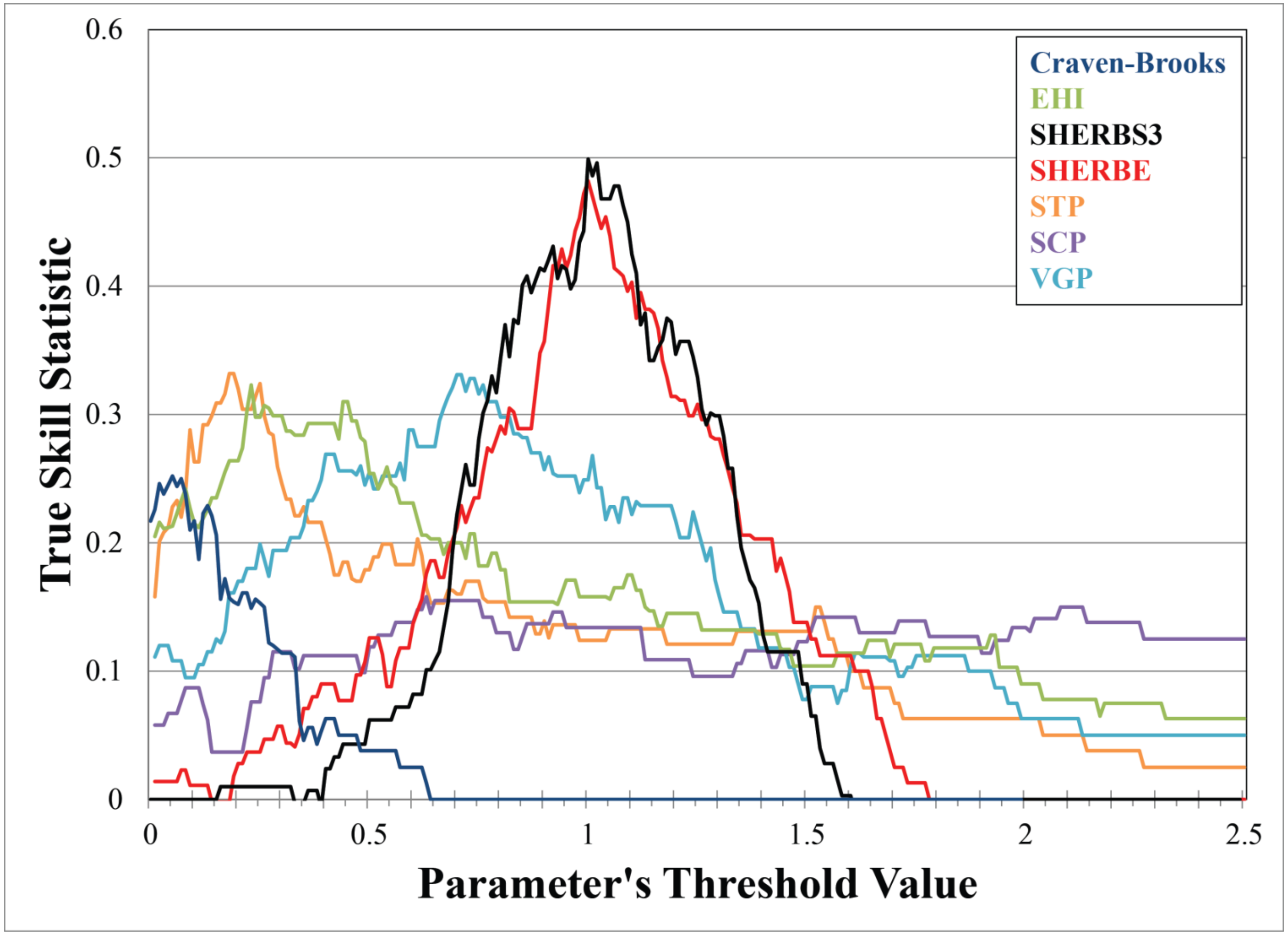
SEVERE HAZARDS IN ENVIRONMENTS WITH REDUCED BUOYANCY PARAMETER (0-3 KM SHEAR VERSION):

SHERBS3 = *(0-3 km shear magnitude / 26 m* s^{-1}*) **
(0-3 km lapse rate / 5.2 K km^{-1}*) **
(700-500 mb lapse rate / 5.6 K km^{-1}*)*

(EFFECTIVE SHEAR VERSION):

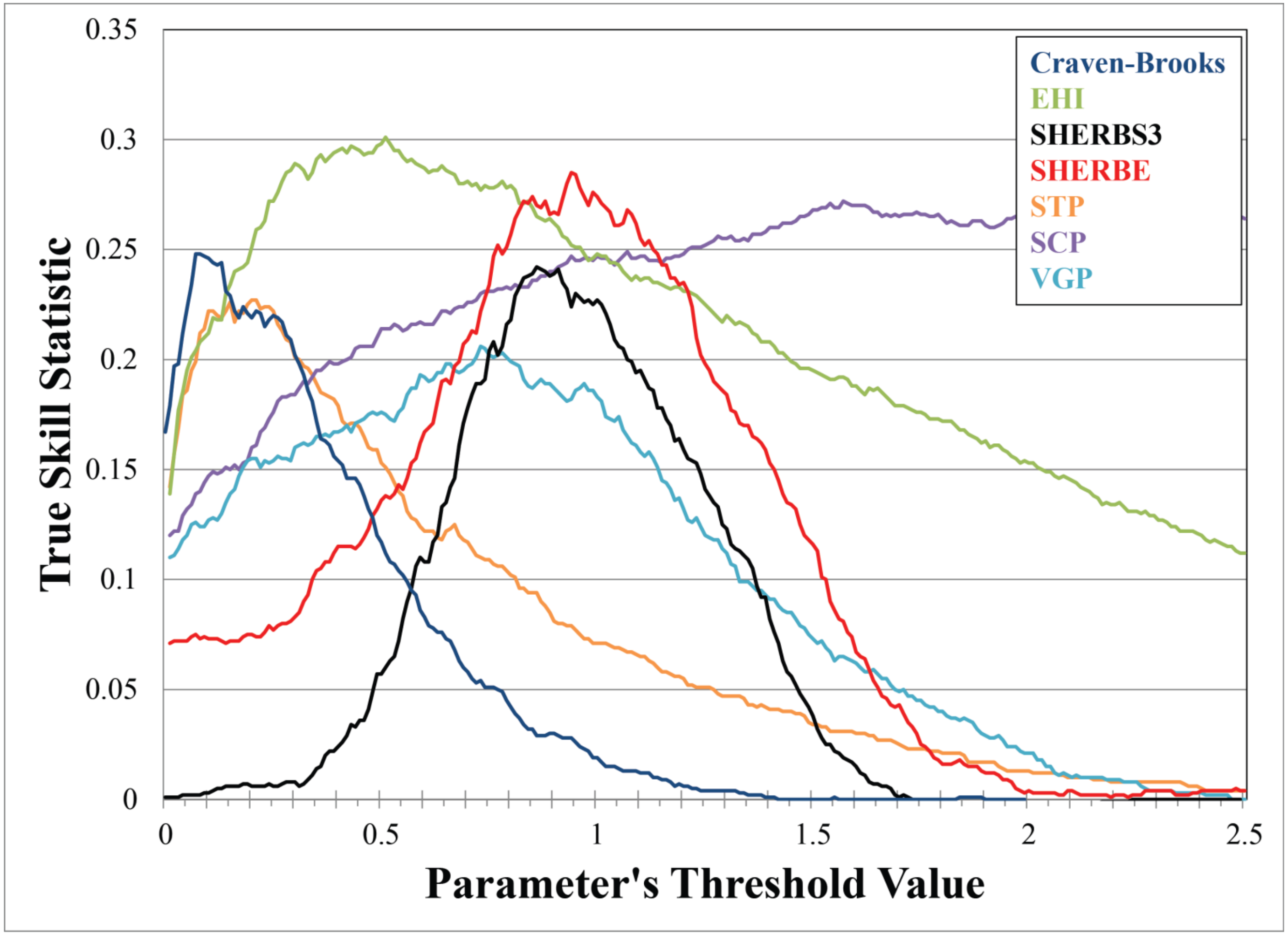
SHERBE = *(Effective shear magnitude / 27 m* s^{-1}*) **
(0-3 km lapse rate / 5.2 K km^{-1}*) **
(700-500 mb lapse rate / 5.6 K km^{-1}*)*

New Forecasting Techniques



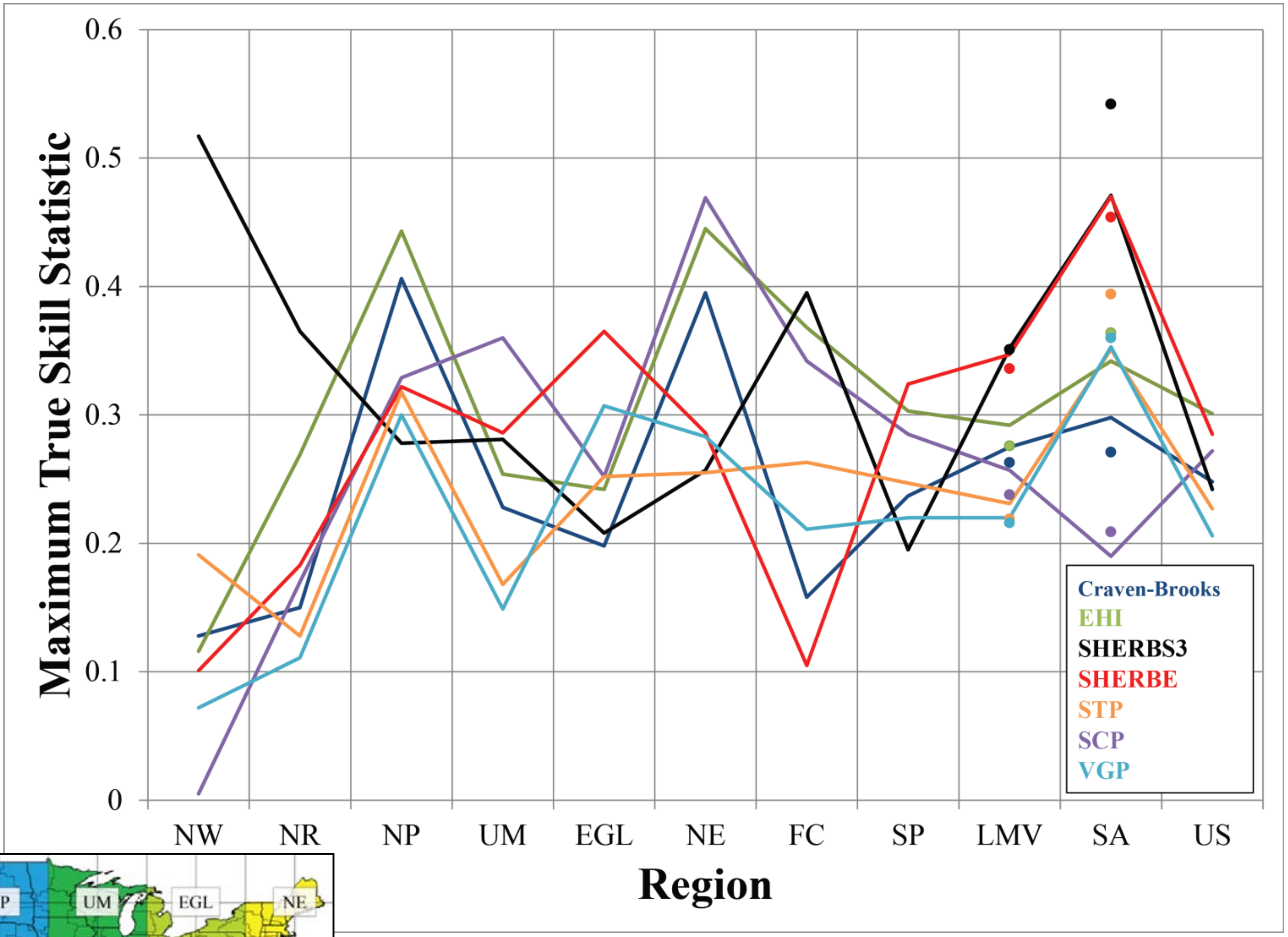
Development Dataset

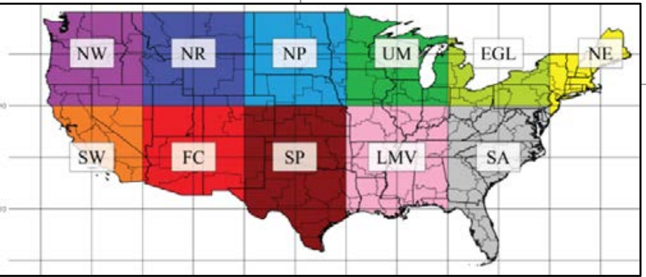
New Forecasting Techniques



Verification Dataset

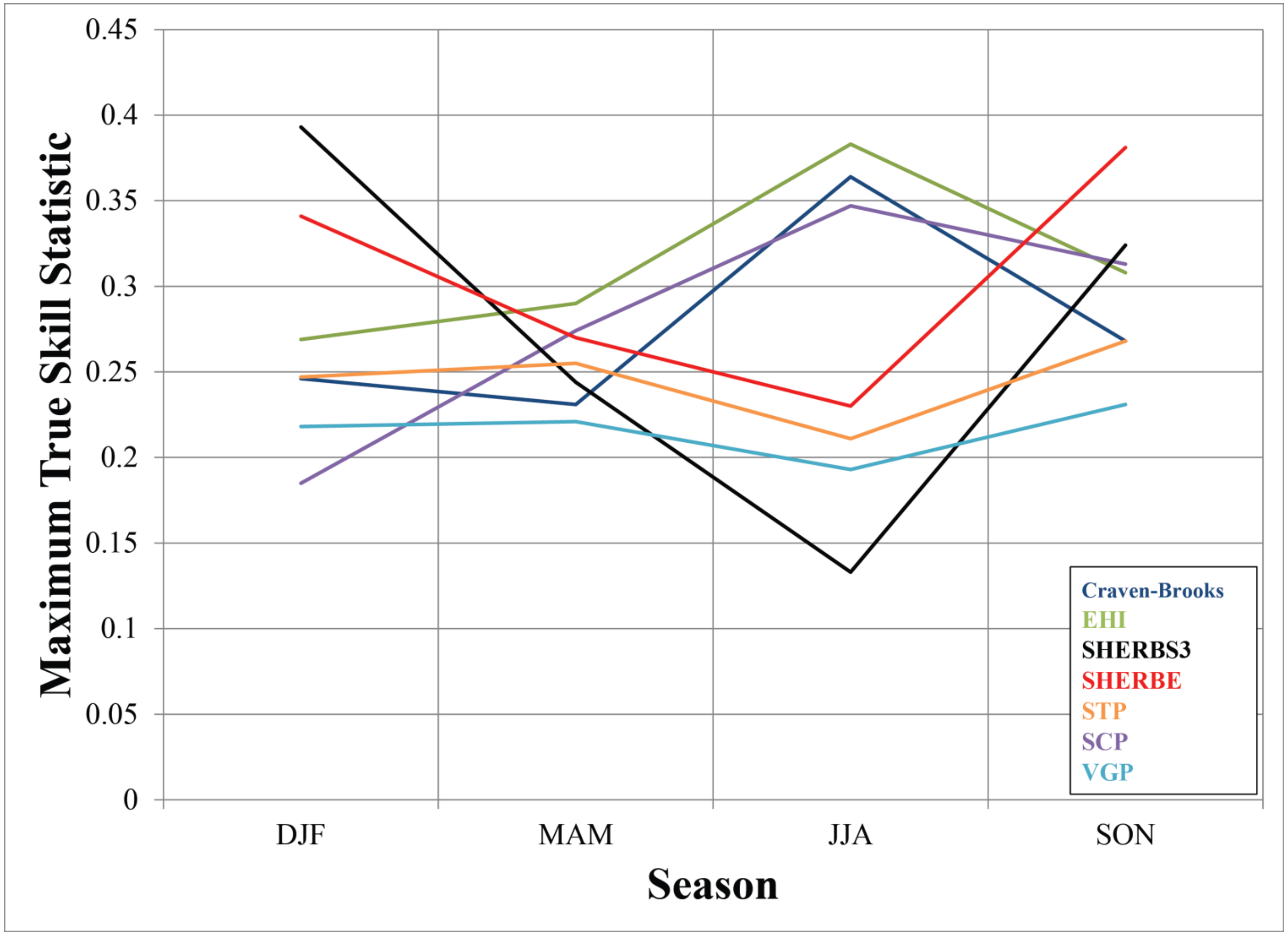
New Forecasting Techniques





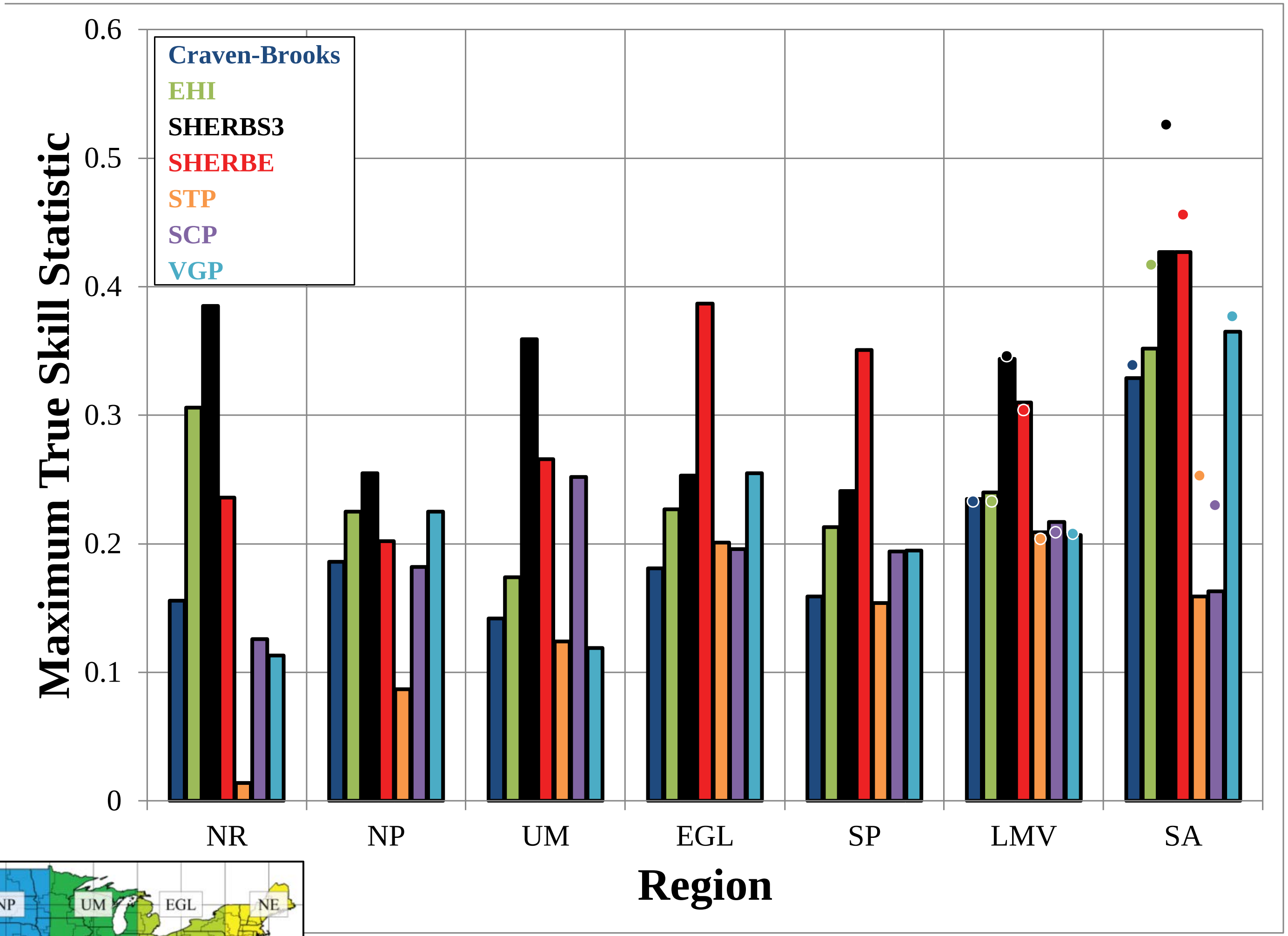
Verification Dataset

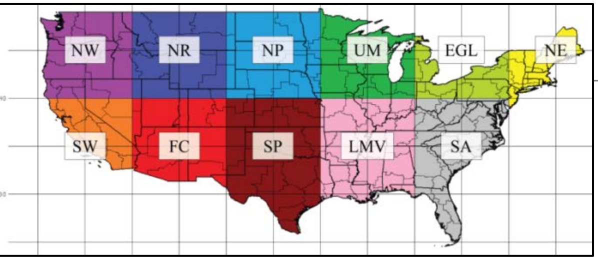
New Forecasting Techniques



Verification Dataset

Maximum TSS of Composite Parameters by Geographic Region





SHERBS3 Availability for Forecasters

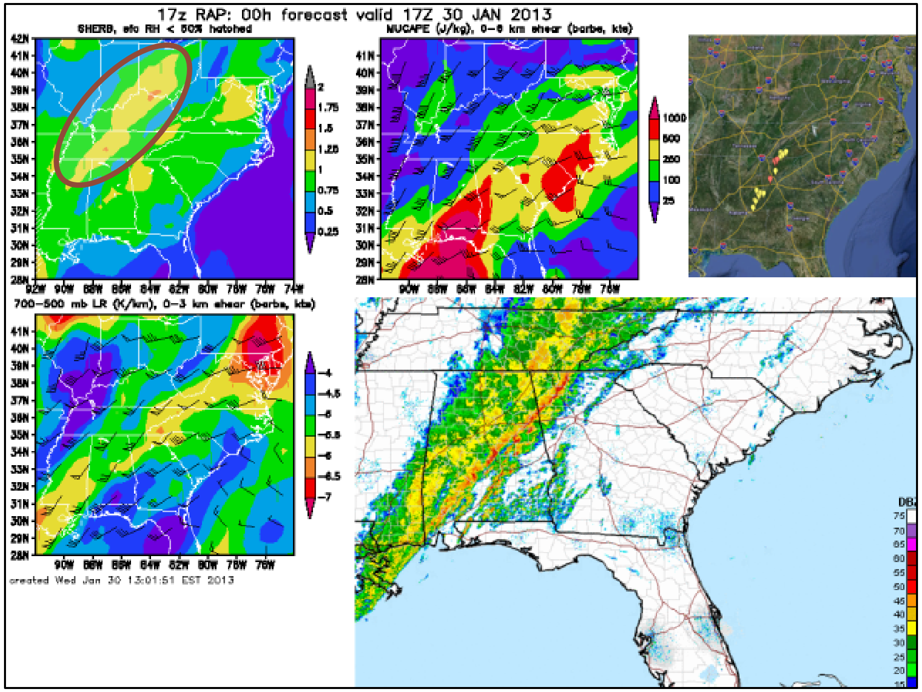
- Real-time SHERB plots from NC State
  Real-time RAP – http://storms.meas.ncsu.edu/users/mdparker/rap
  Real-time NAM – http://storms.meas.ncsu.edu/users/mdparker/nam
  Real-time GFS – http://storms.meas.ncsu.edu/users/mdparker/gfs

- SPC SHERB mesoscale analysis plots
  Nationwide SHERBS3 – http://www.spc.noaa.gov/exper/mesoanalysis/s19/sherb3/sherb3.gif
  Nationwide SHERBE – http://www.spc.noaa.gov/exper/mesoanalysis/s19/sherbe/sherbe.gif

- SHERB is expected to be added to Bufkit in an upcoming release

How *not* to use the SHERB

- To forecast convection
  - Must be used with a confident forecast of convection
  - All data points used to develop the SHERB were associated with either severe or non-severe convection
  - Therefore, ***cannot be used to forecast convection***!
- Where convection is not expected
  - Values potentially above guidance threshold where convection will not occur
- In isolation
  - Composite parameters (e.g., STP, VGP) still exhibit skill, though potentially at lower values than in high-CAPE environments



Credit Jonathan Blaes

Summary

- HSLC significant severe reports can occur in multiple regimes, and may occur at all times of the year across nearly entire U.S.
- SHERBS3 and/or SHERBE improves the forecasting skill in HSLC environments
- SHERBE is best overall parameter, regardless of environment, discriminating between significant severe reports and nulls

Primary Conclusions

- A product of lapse rates and shear is especially useful for identifying potentially severe HSLC environments
- The SHERBE is the best composite parameter in Southern Region at discriminating between significant severe reports and nulls, *regardless of environment.*

Additional Questions/Comments?
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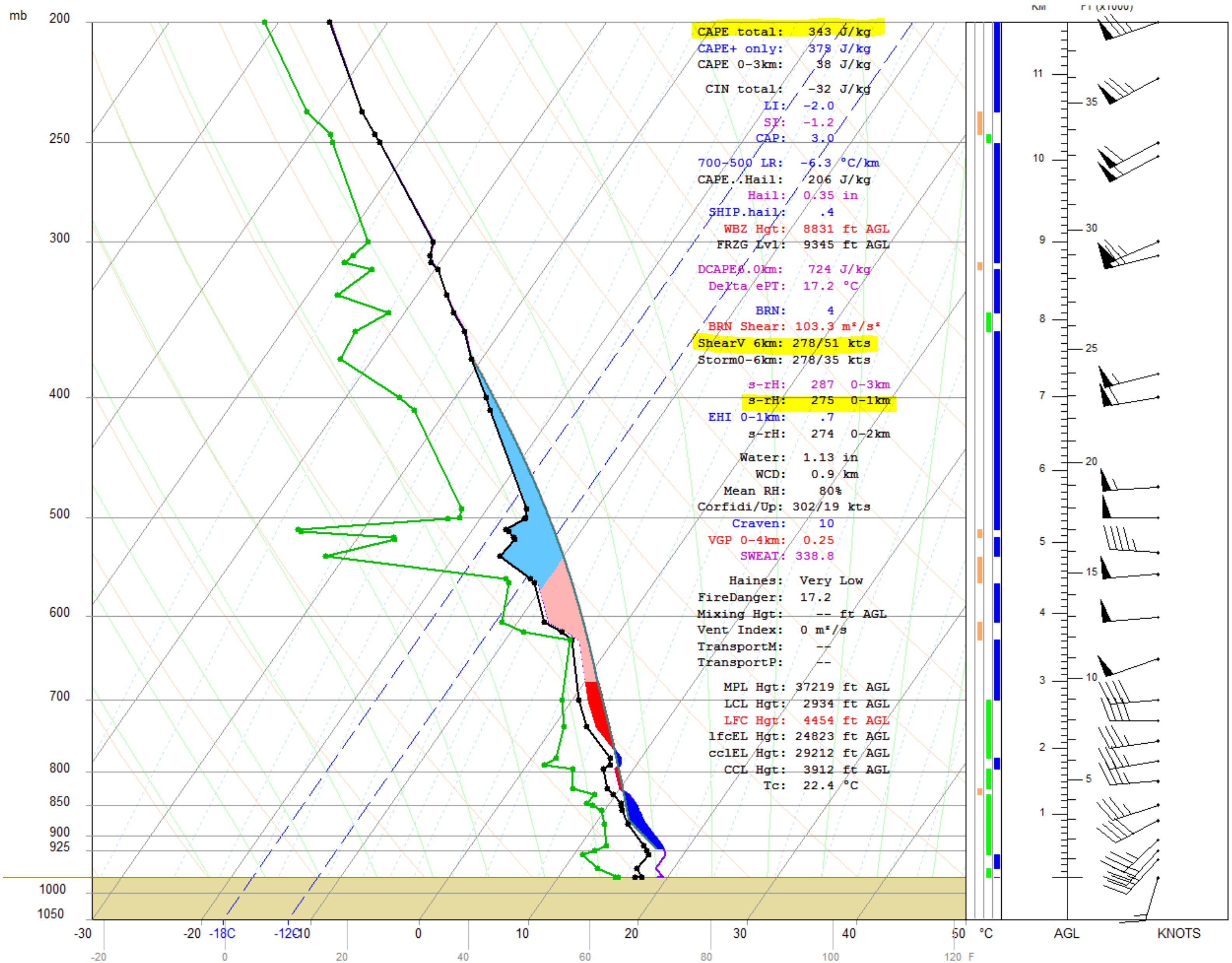
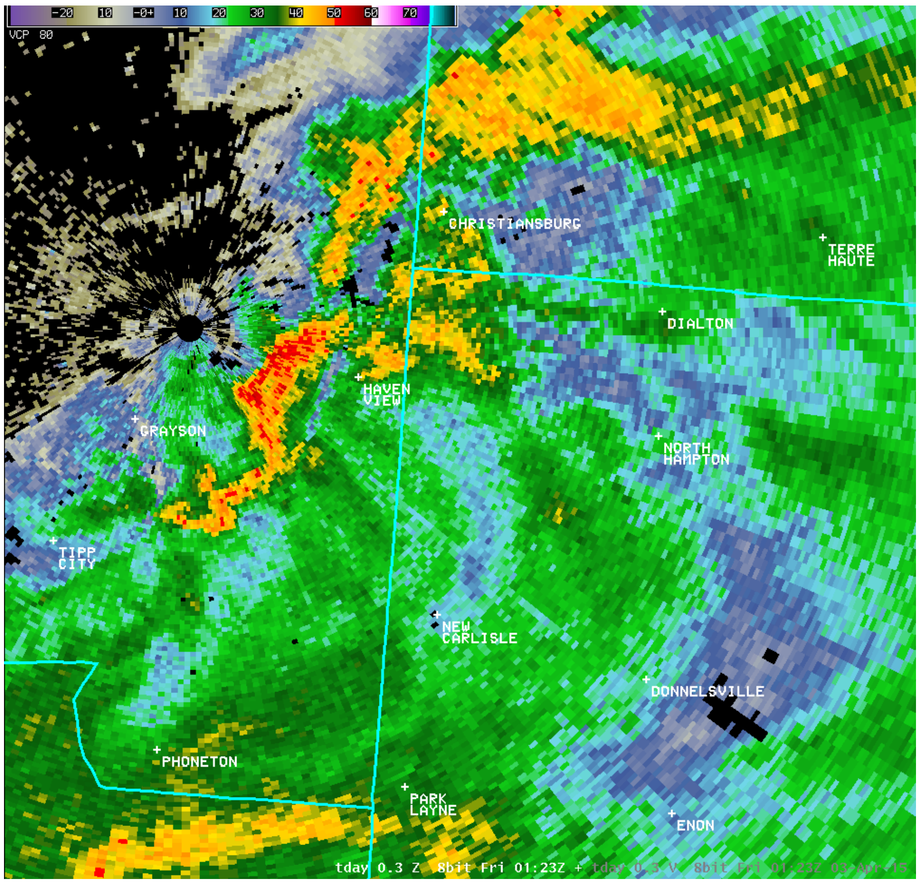
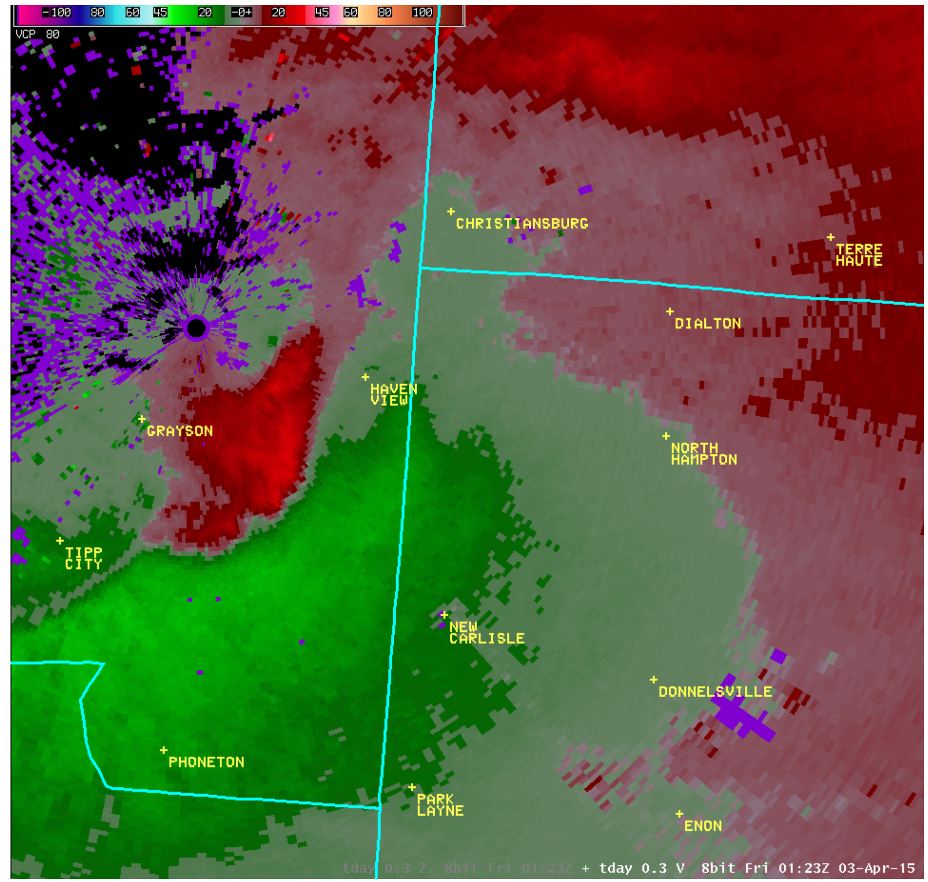
Case – April 2nd 2015 (Sherb ~1.0)

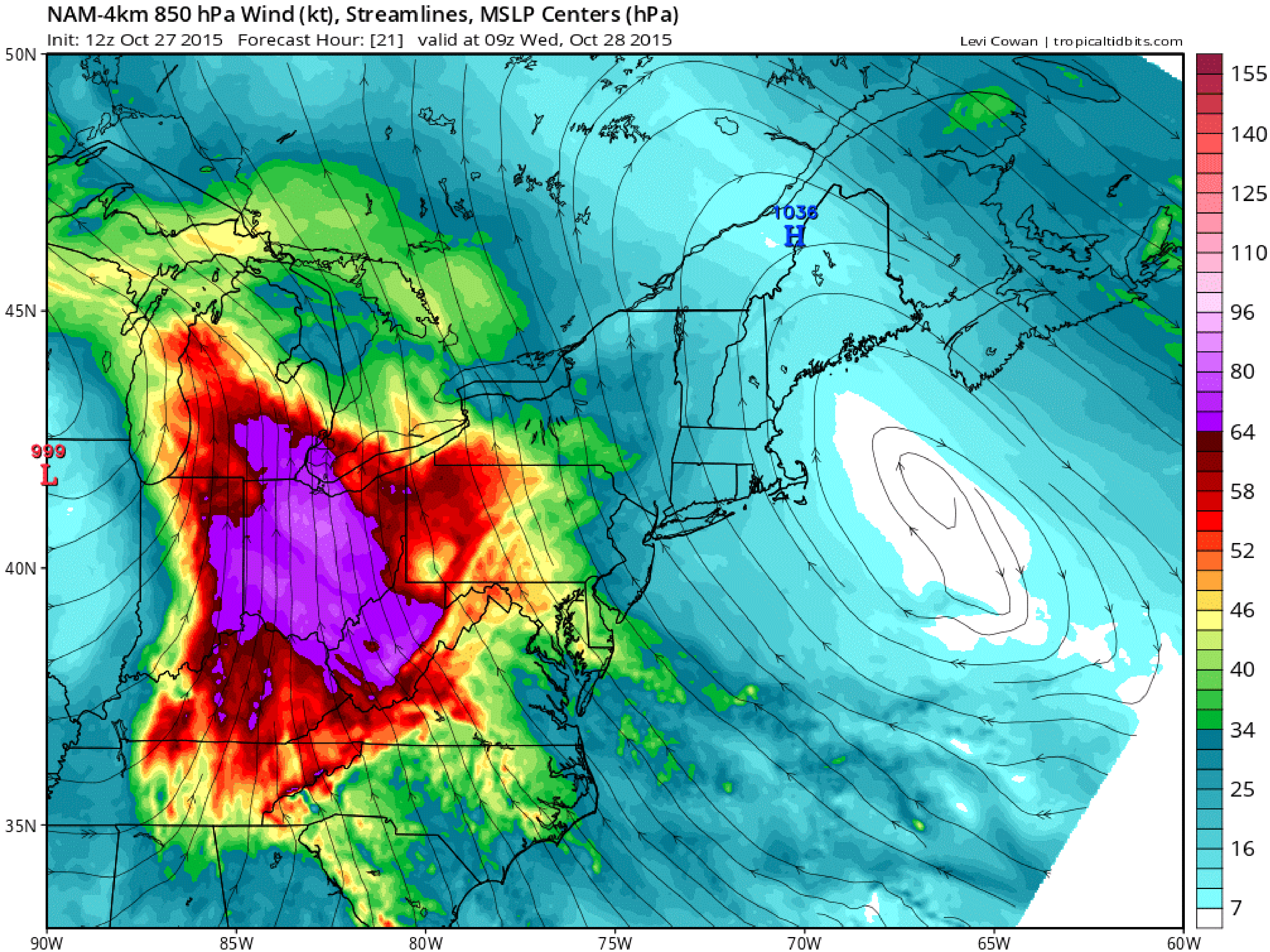


TDAY Z/SRM Loops

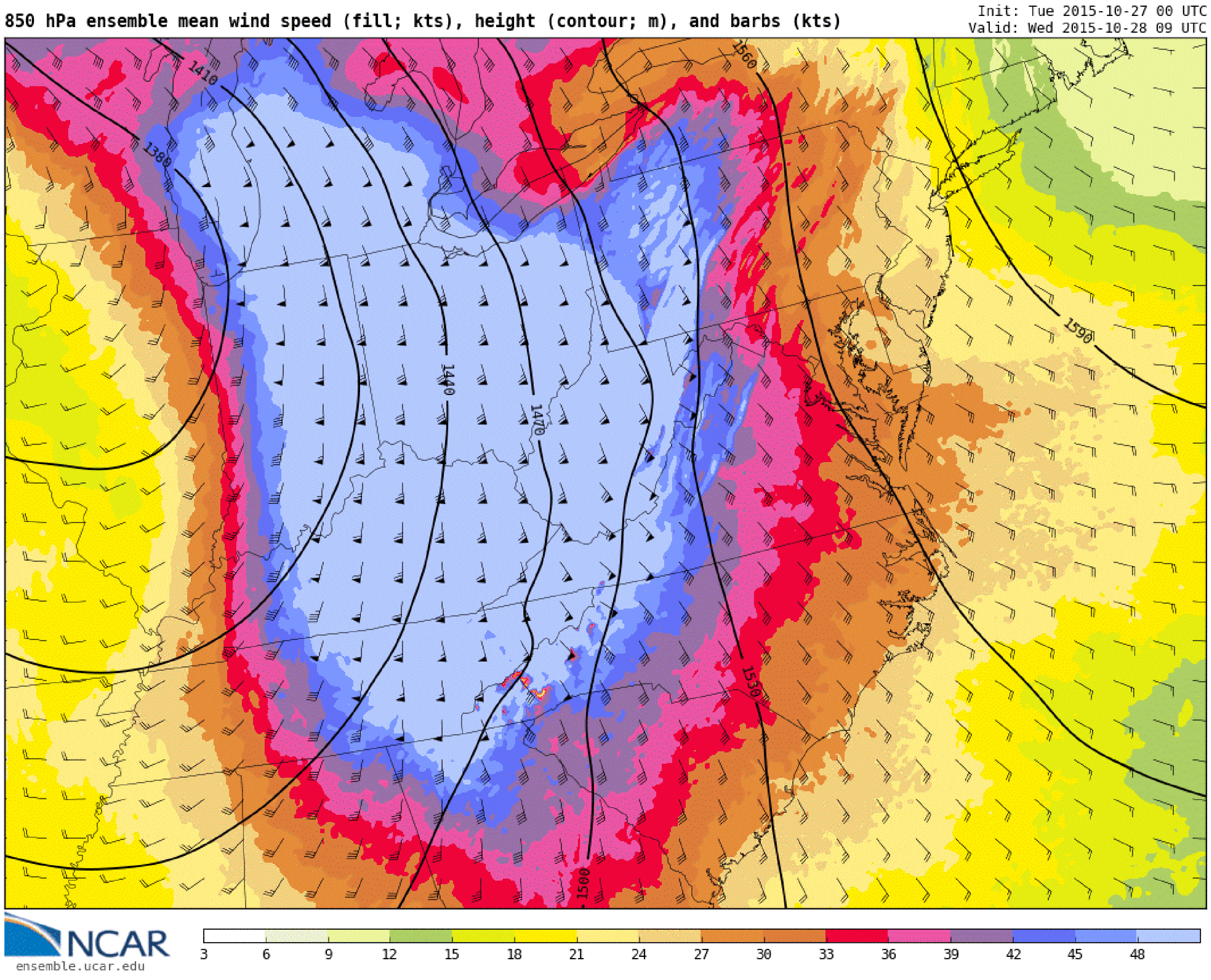




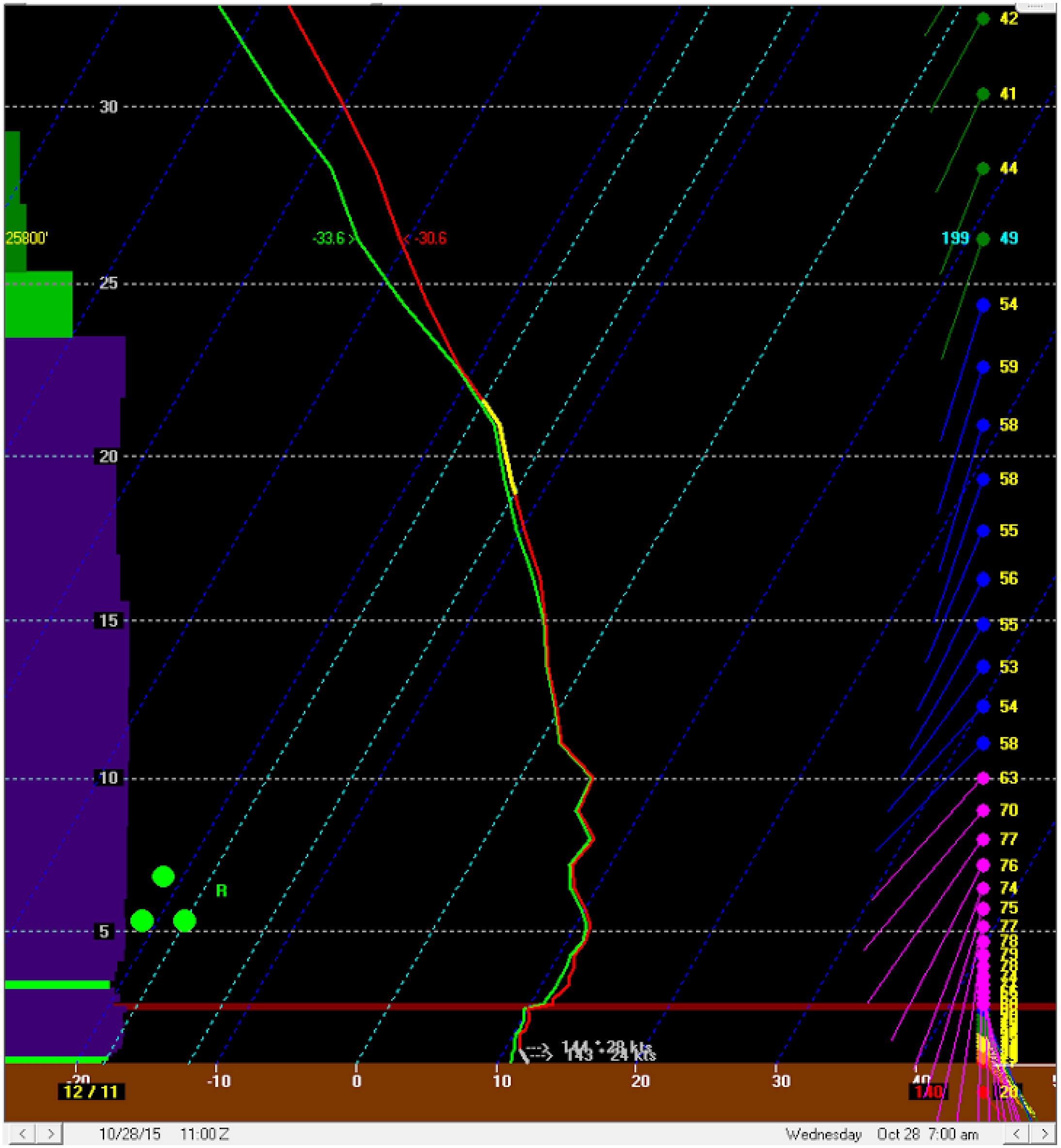
Oct 28 2015 NAM4km 850mb Winds (F21)



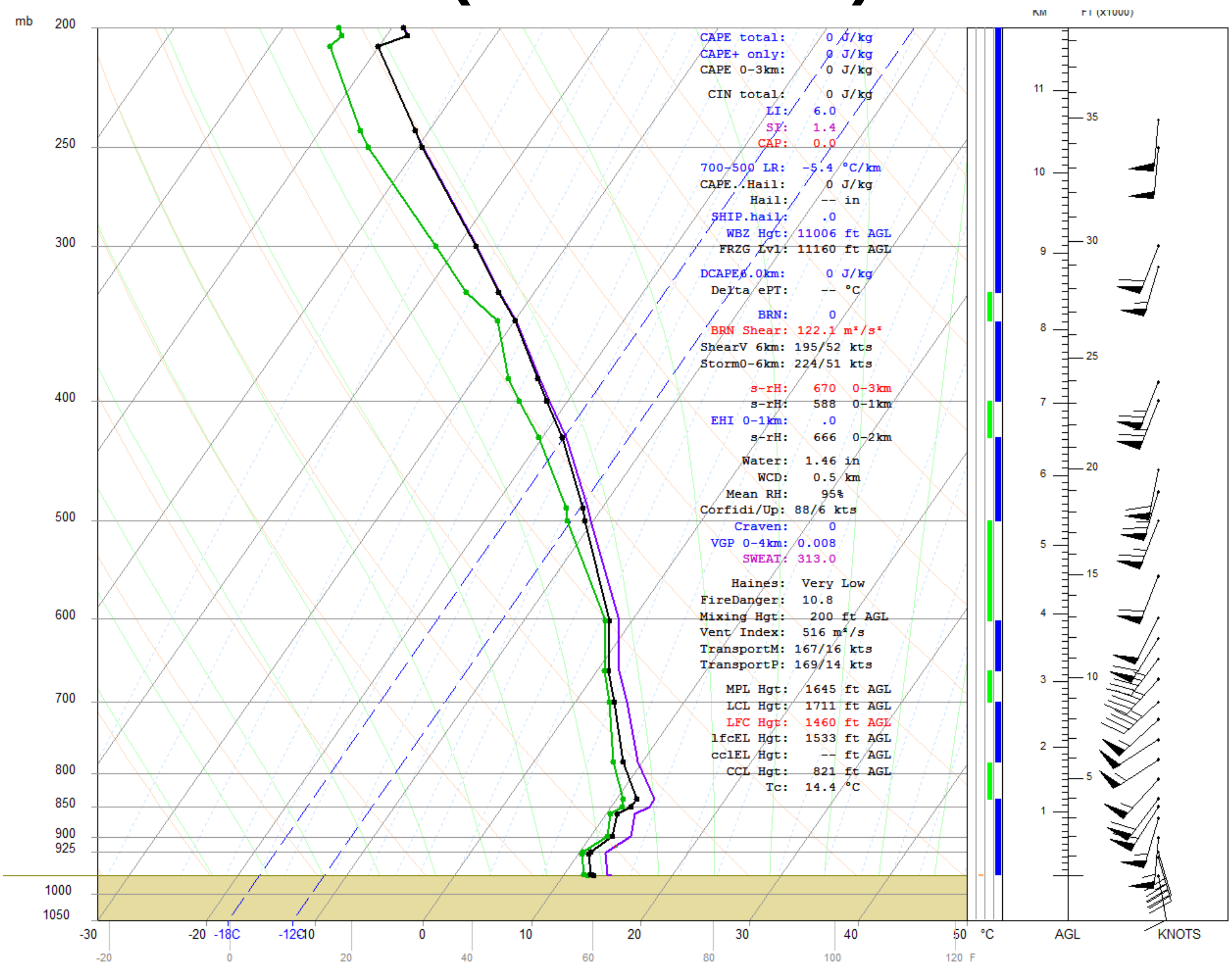
Oct 28 2015 NCAR Ensemble 850mb Winds (F21)



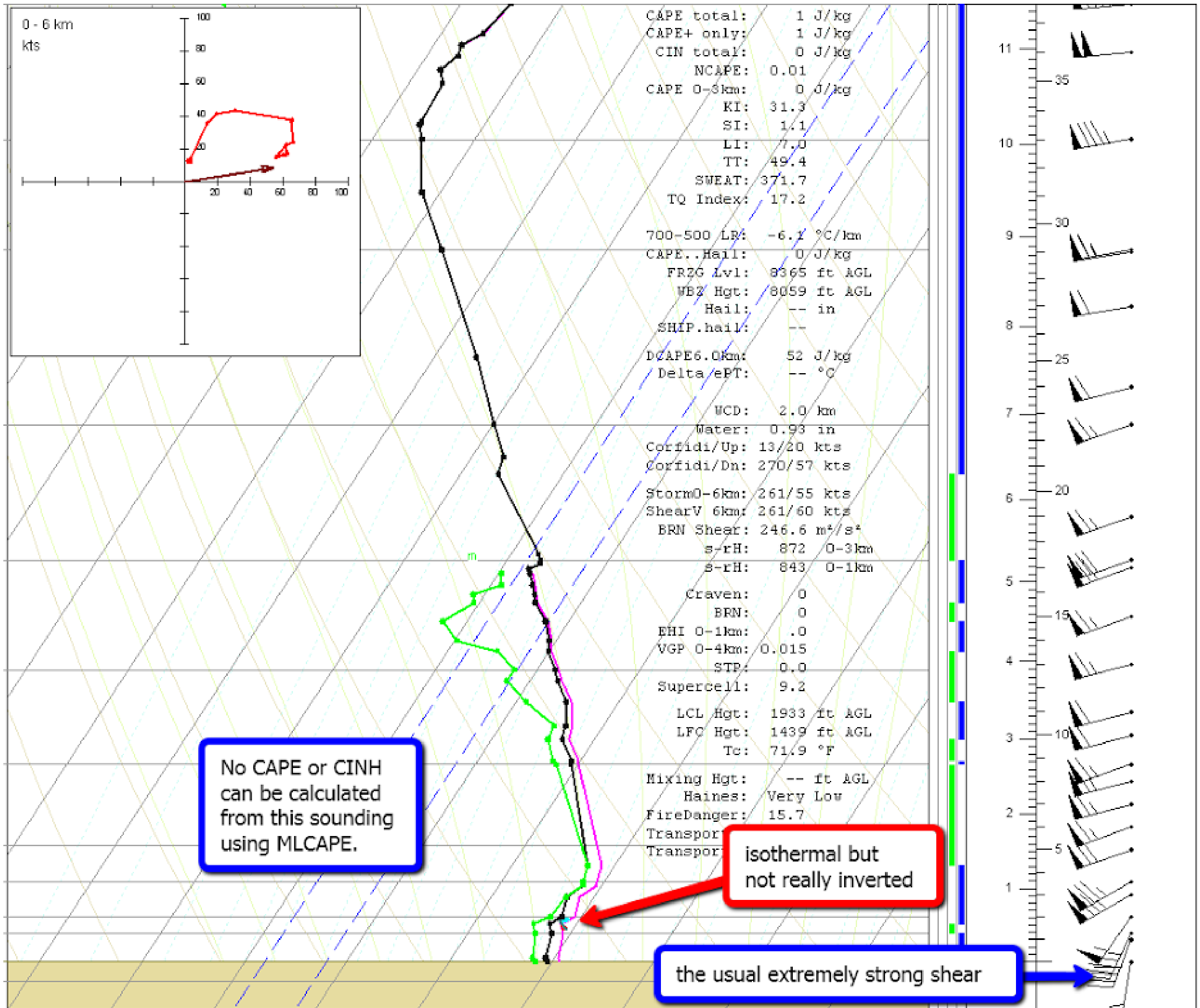
Oct 28 2015 NAM Fcst Sndg at KCMH



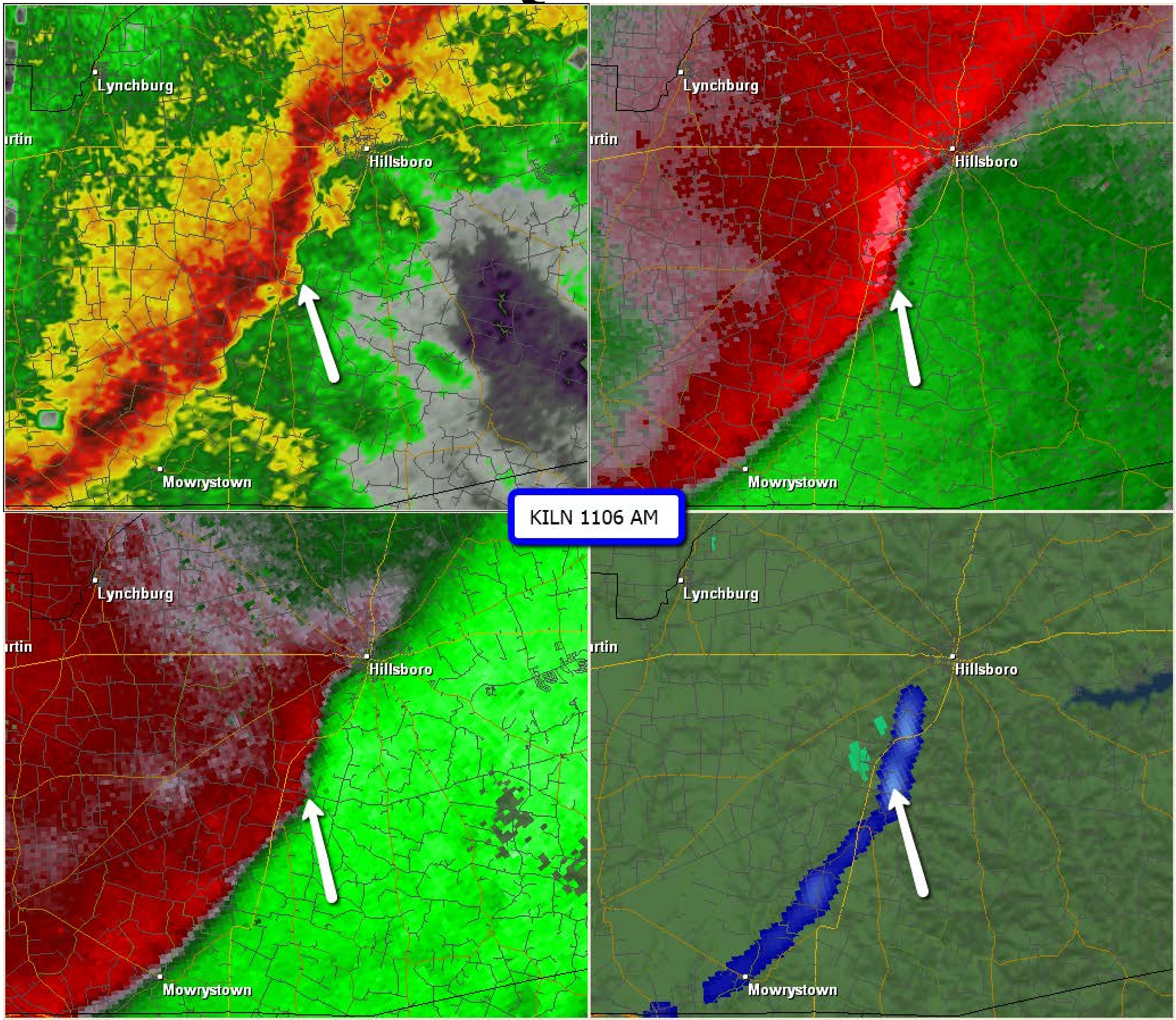
Oct 28 2015 ILN Sndg – Null (SHERB 0.51)



Jan 2012 – SHERB >1



Evolution of QLCS Mesovortex



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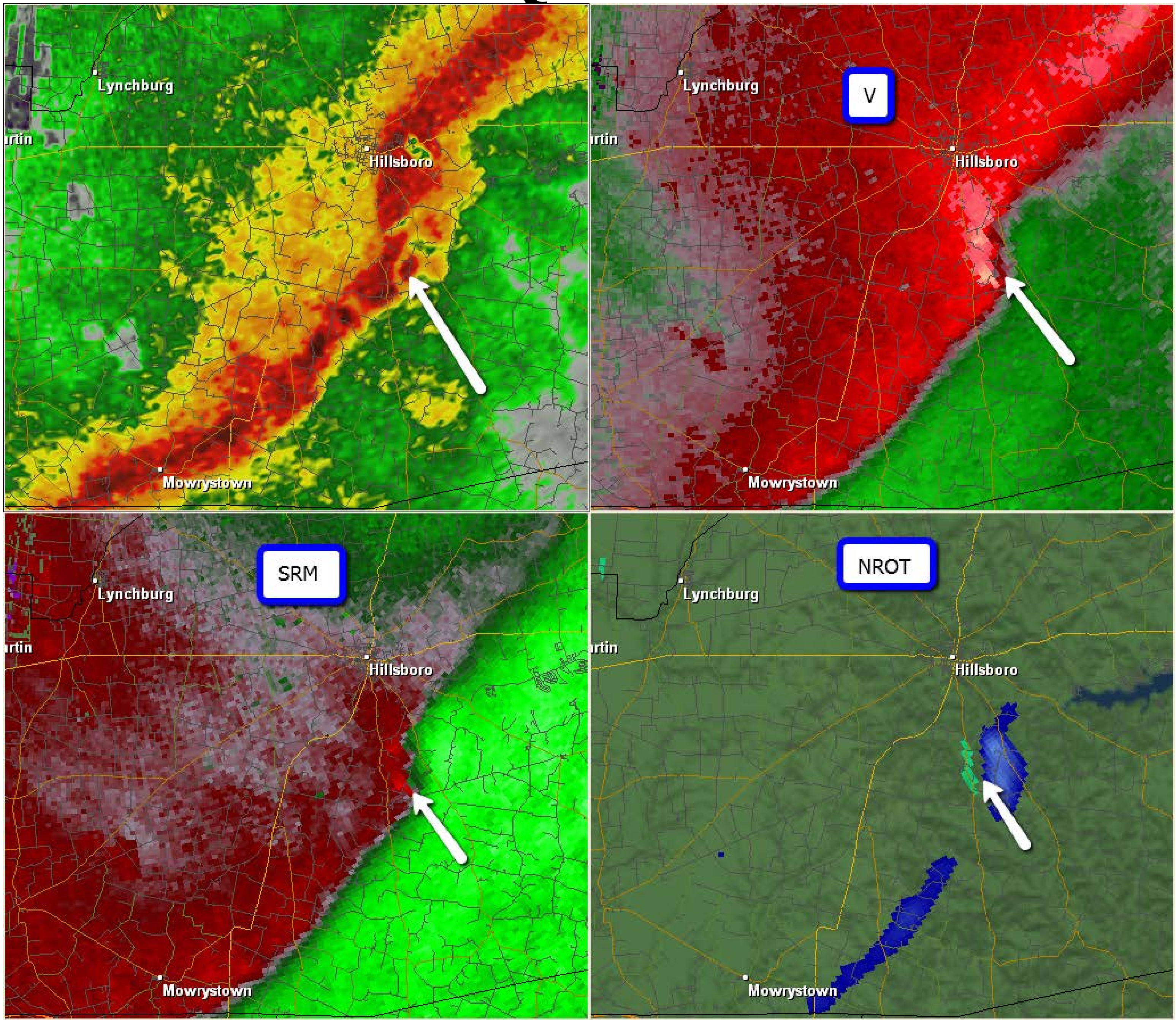
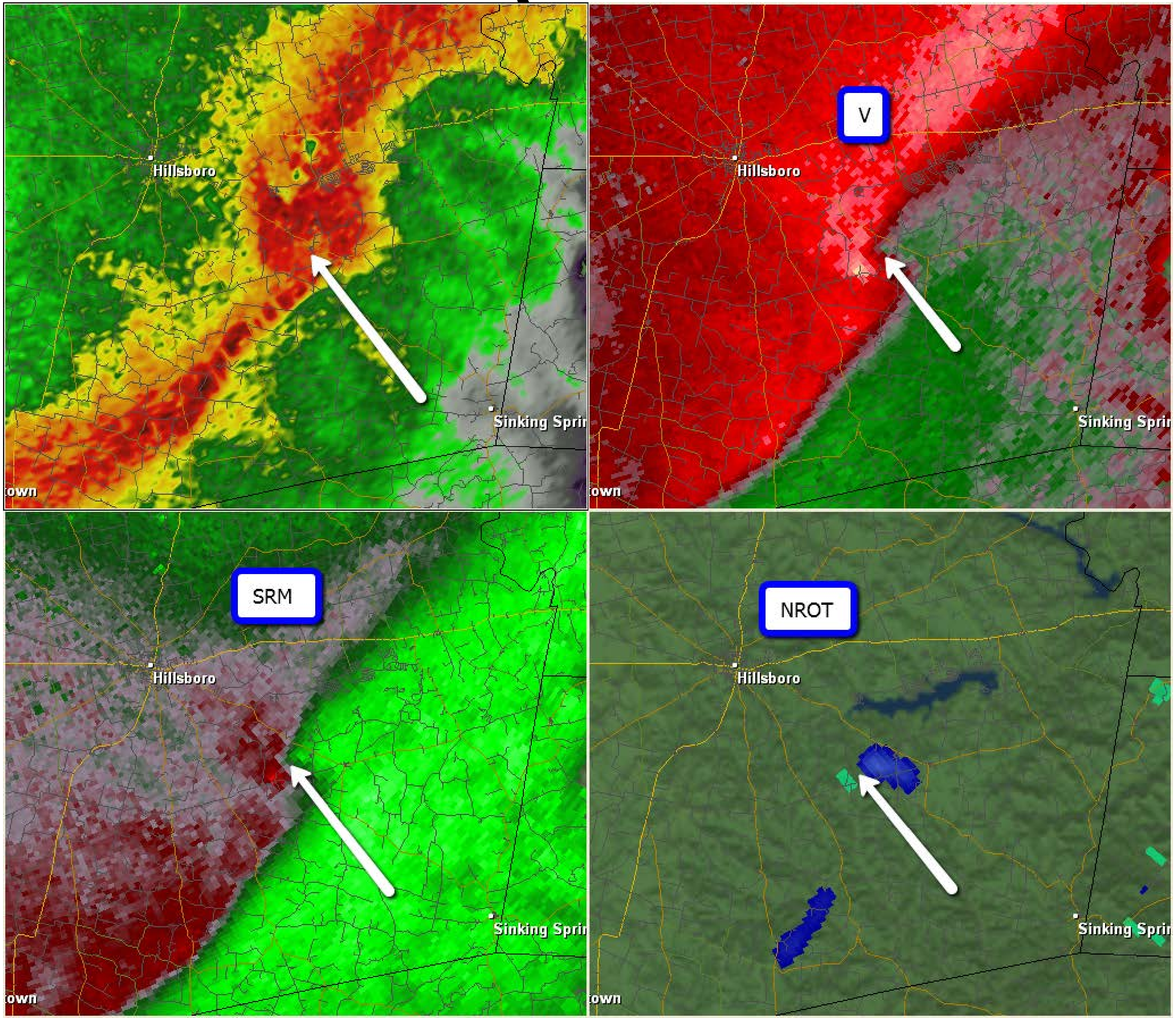


Evolution of QLCS Mesovortex



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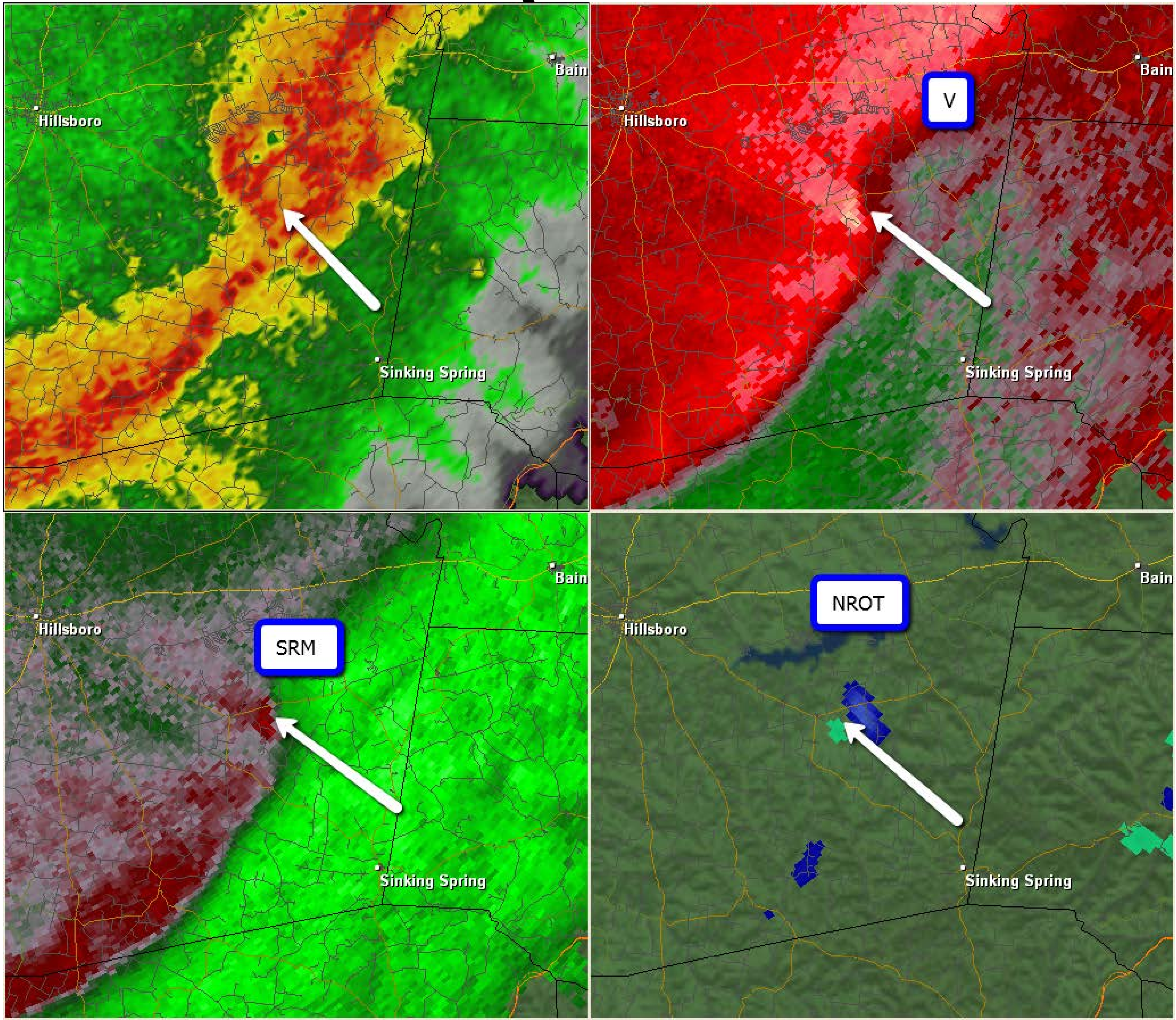
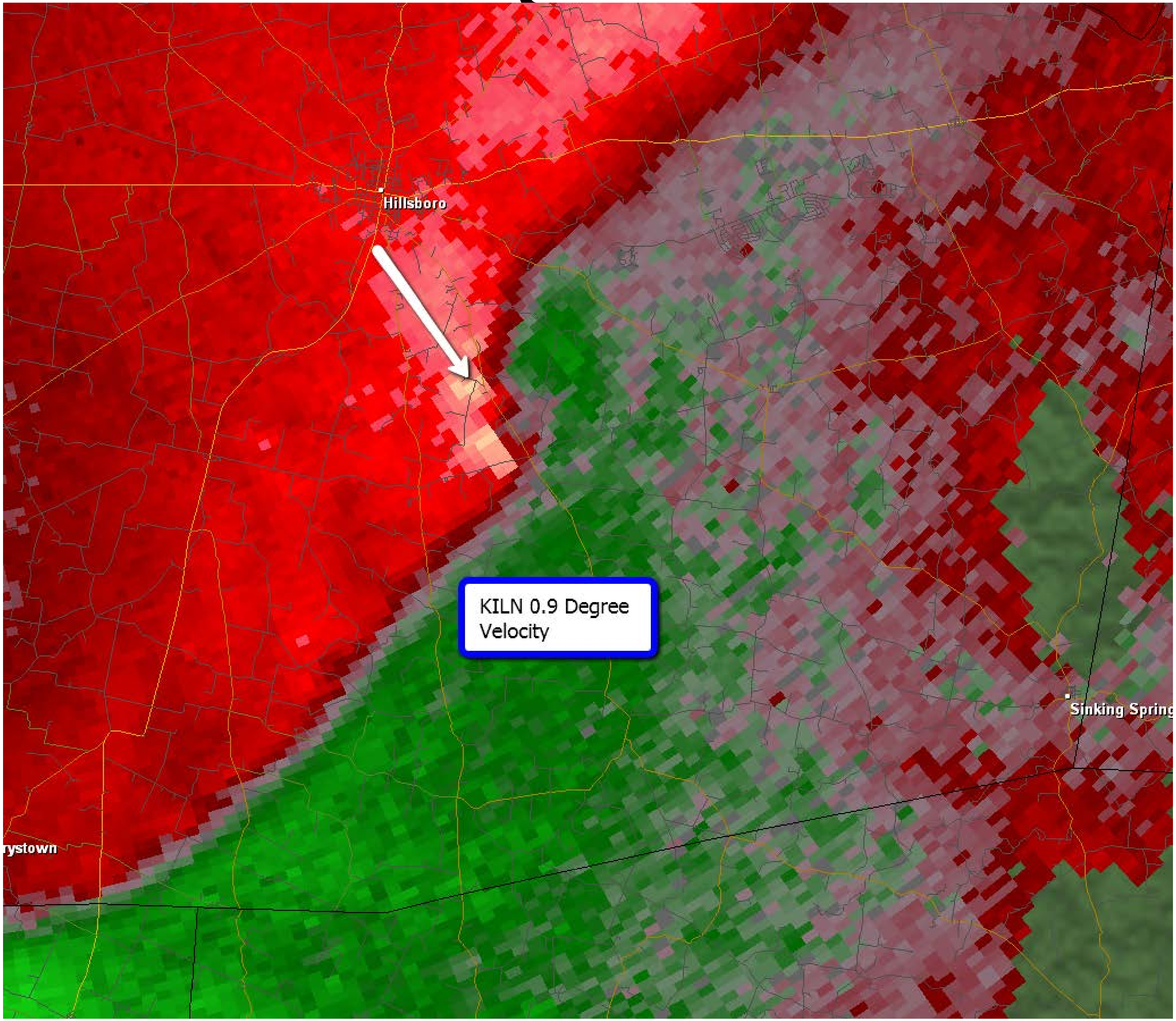
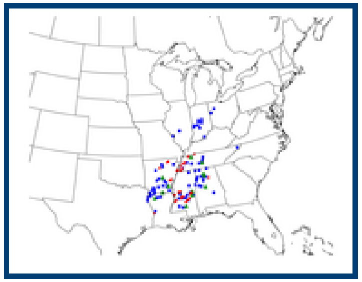


Evolution of QLCS Mesovortex

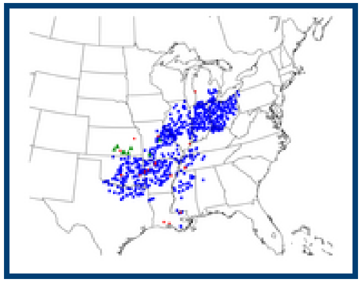


Halloween 2013 – Analogs at F72

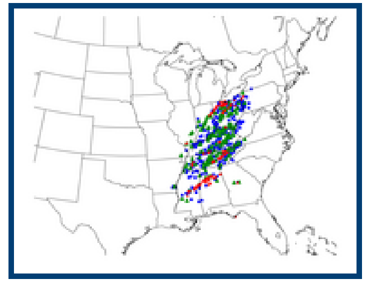
1. 19941128/0000



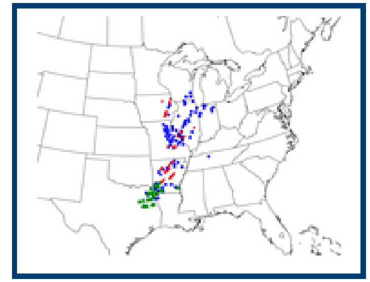
2. 19981110/1200



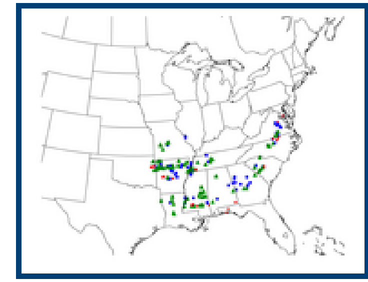
3. 20021110/1800



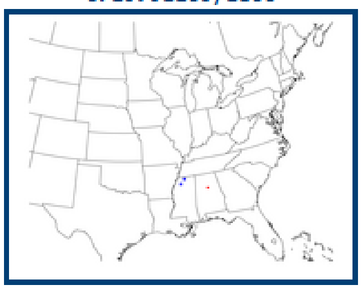
4. 19881116/1200



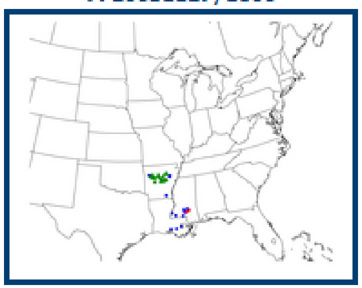
5. 19951027/1200



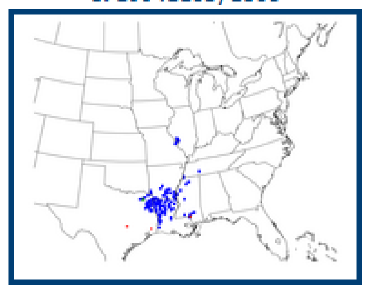
6. 19791109/1800



7. 20031127/1800

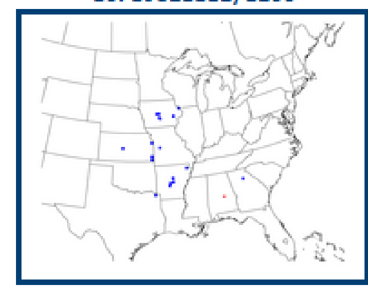


8. 19941105/1800



9. 19931105/0600

10. 19821112/1200



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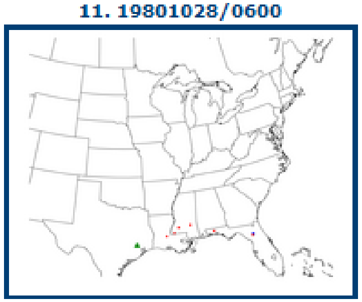

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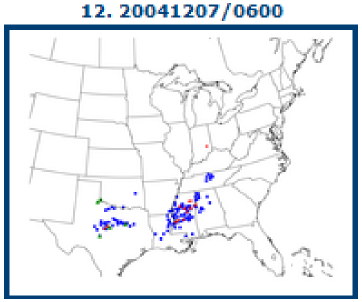

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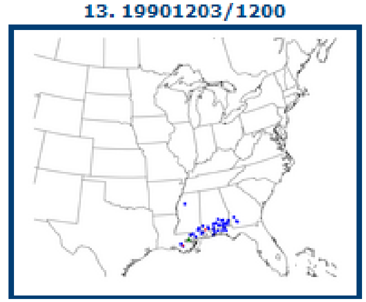

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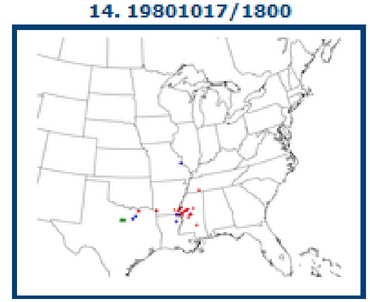

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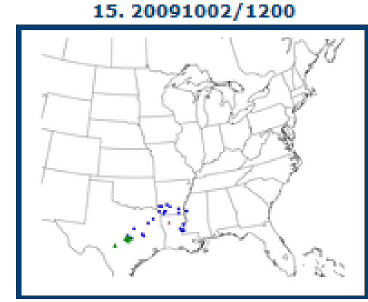
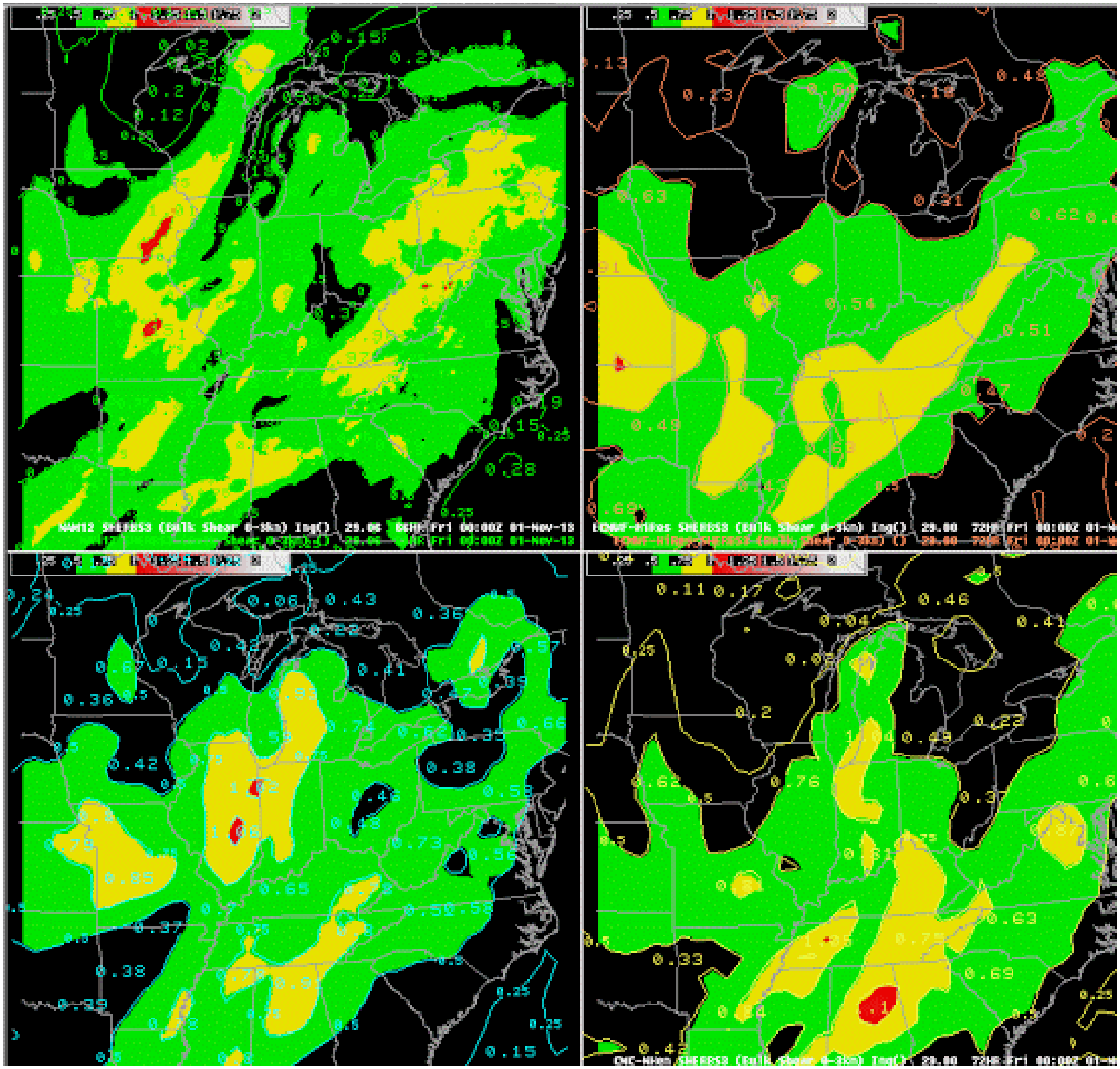
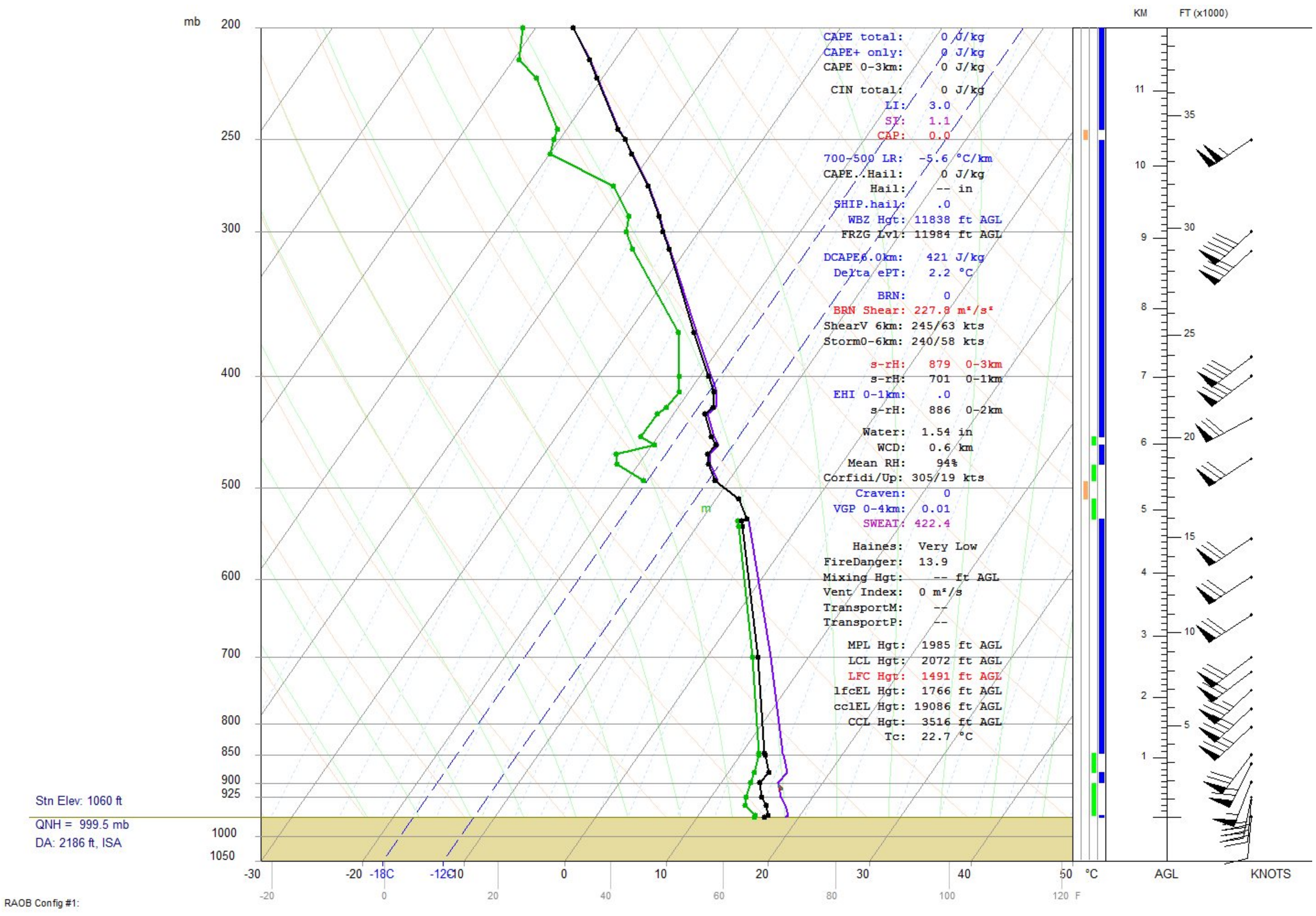


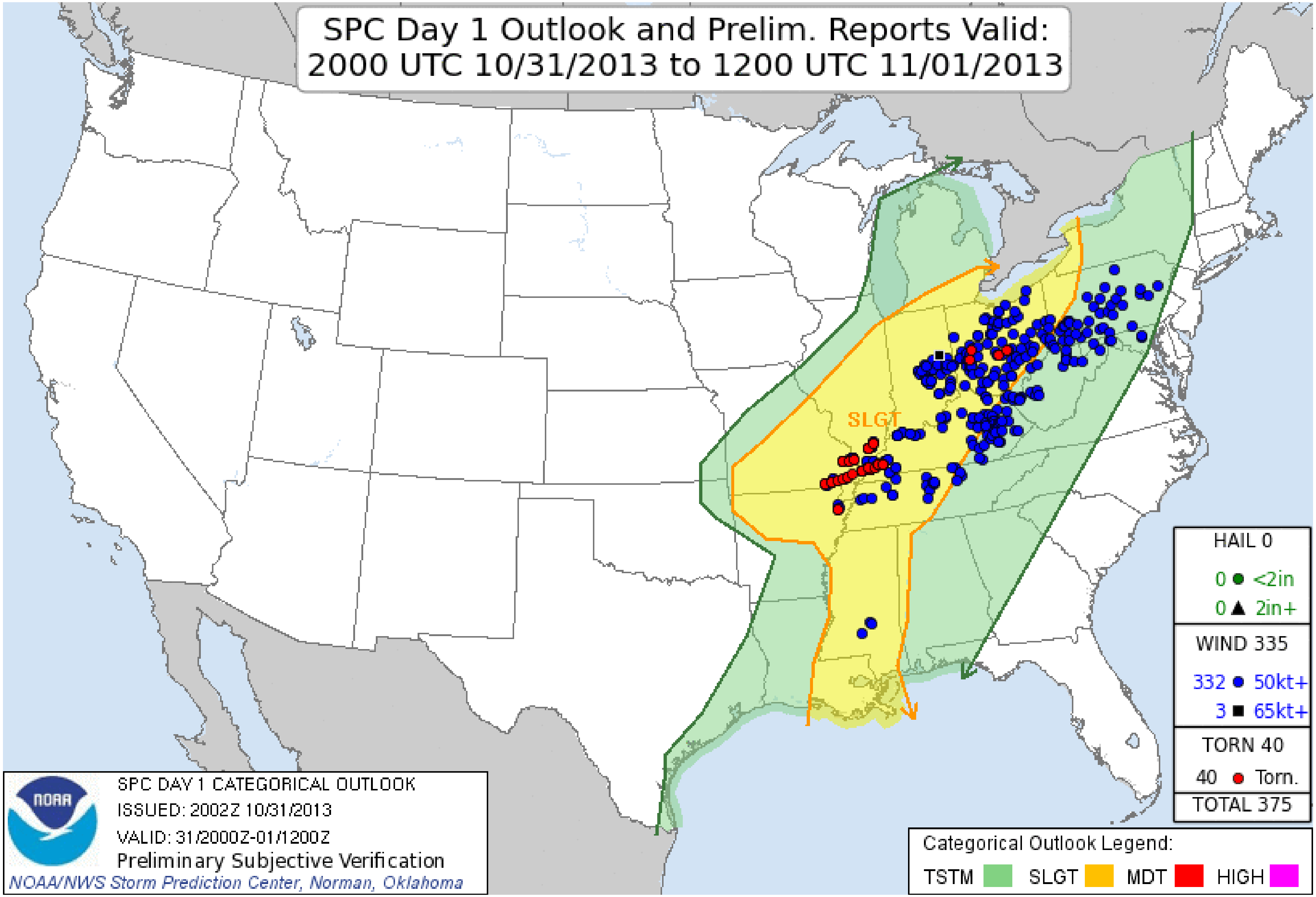
Halloween 2013 – SHERB Fcst Evolution



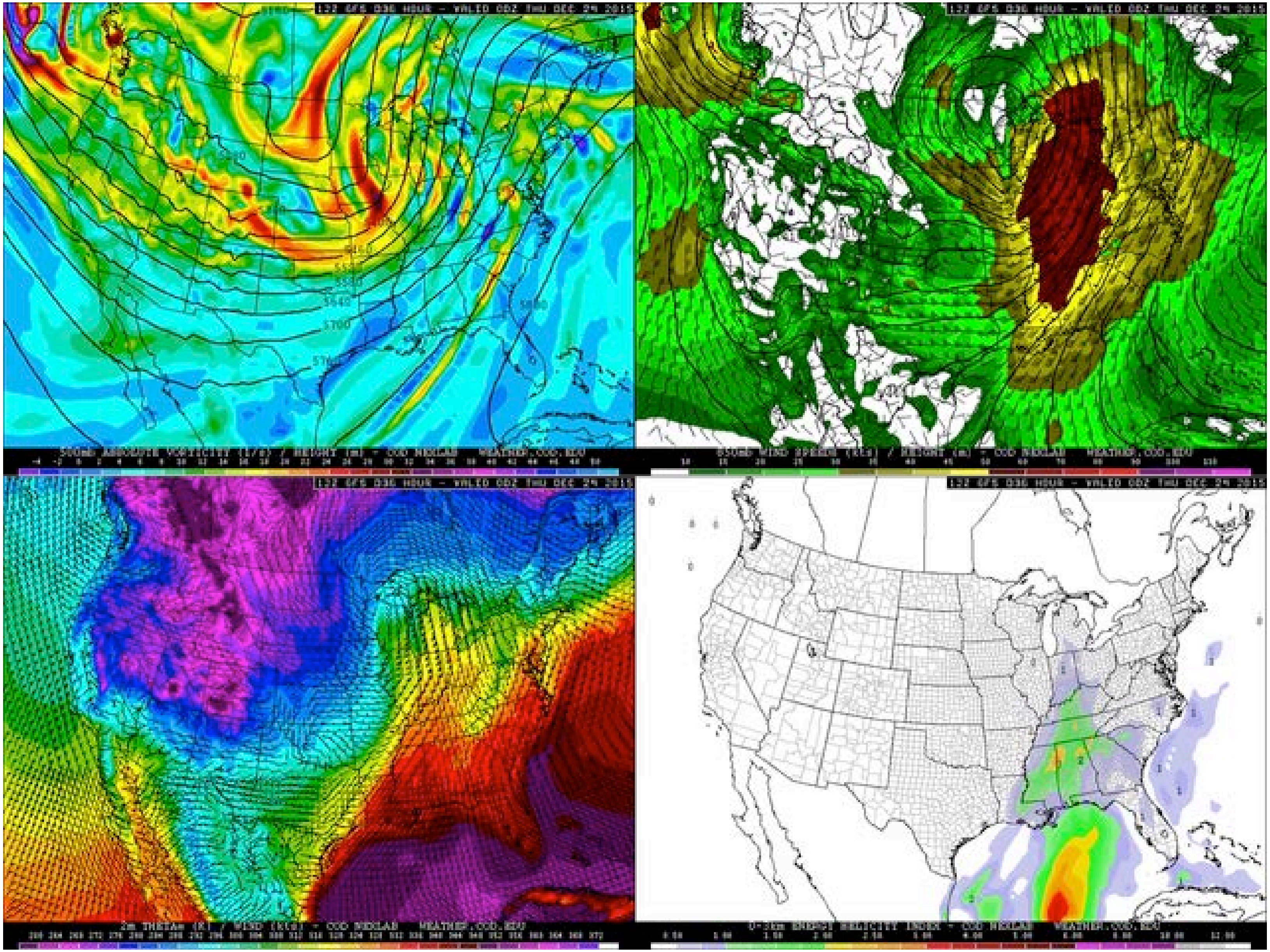
Scary Trick or Treat Sounding



Halloween 2013 – Storm Reports



Dec 23 2015 – NAM F39



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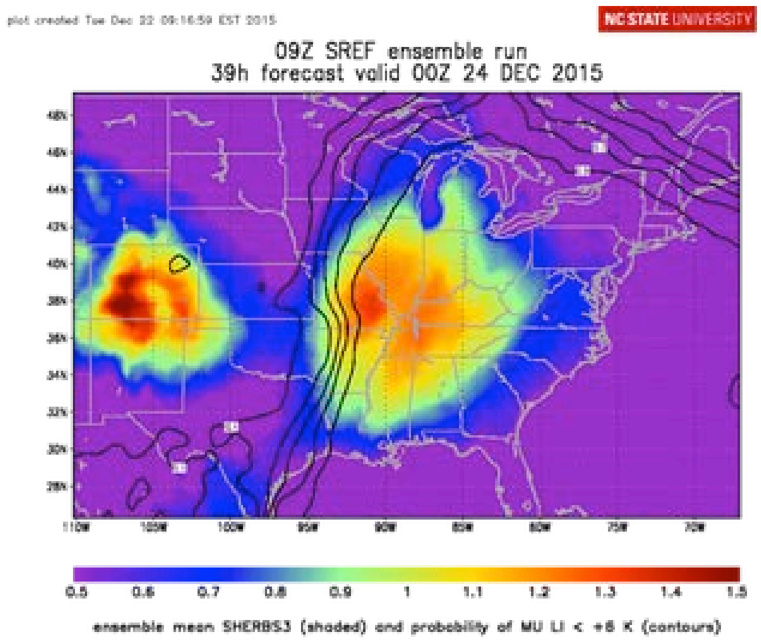
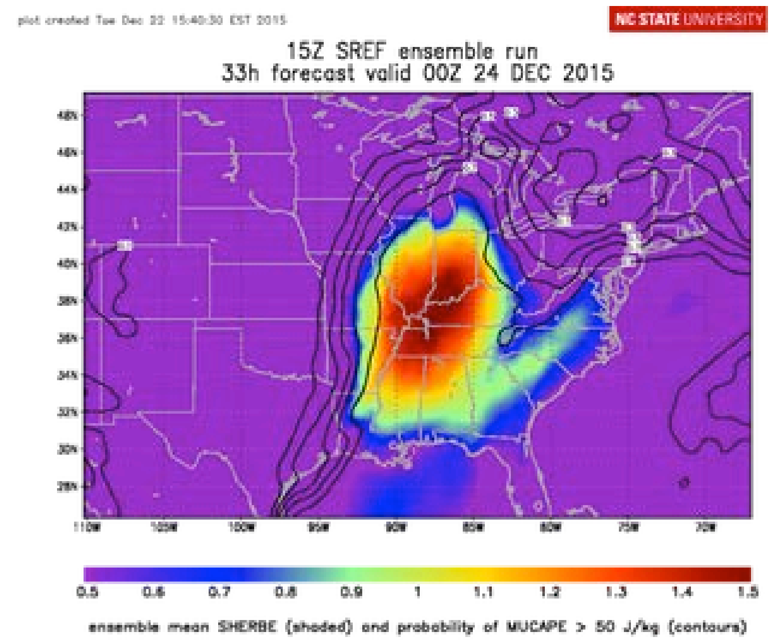
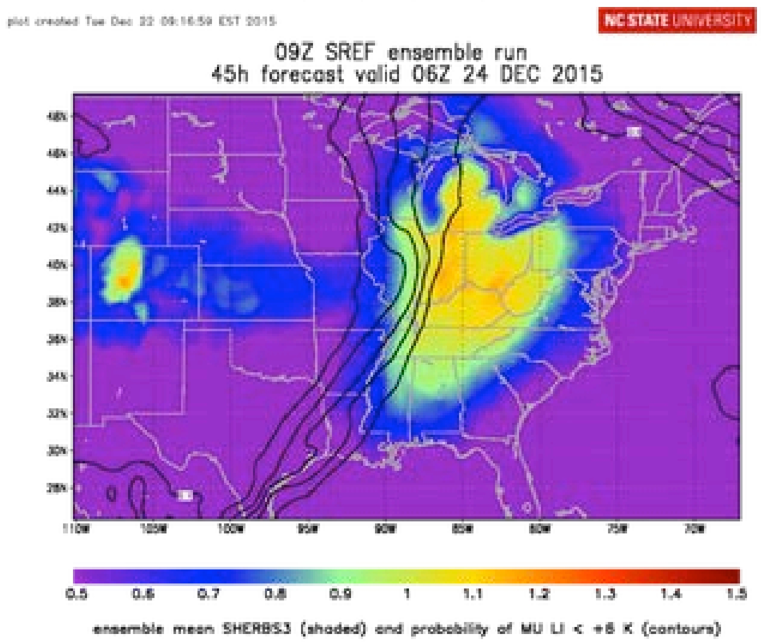
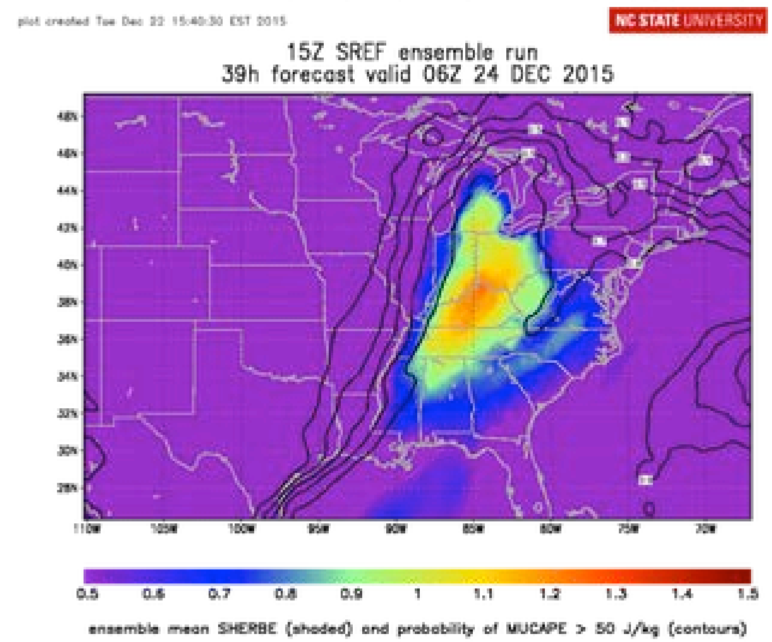
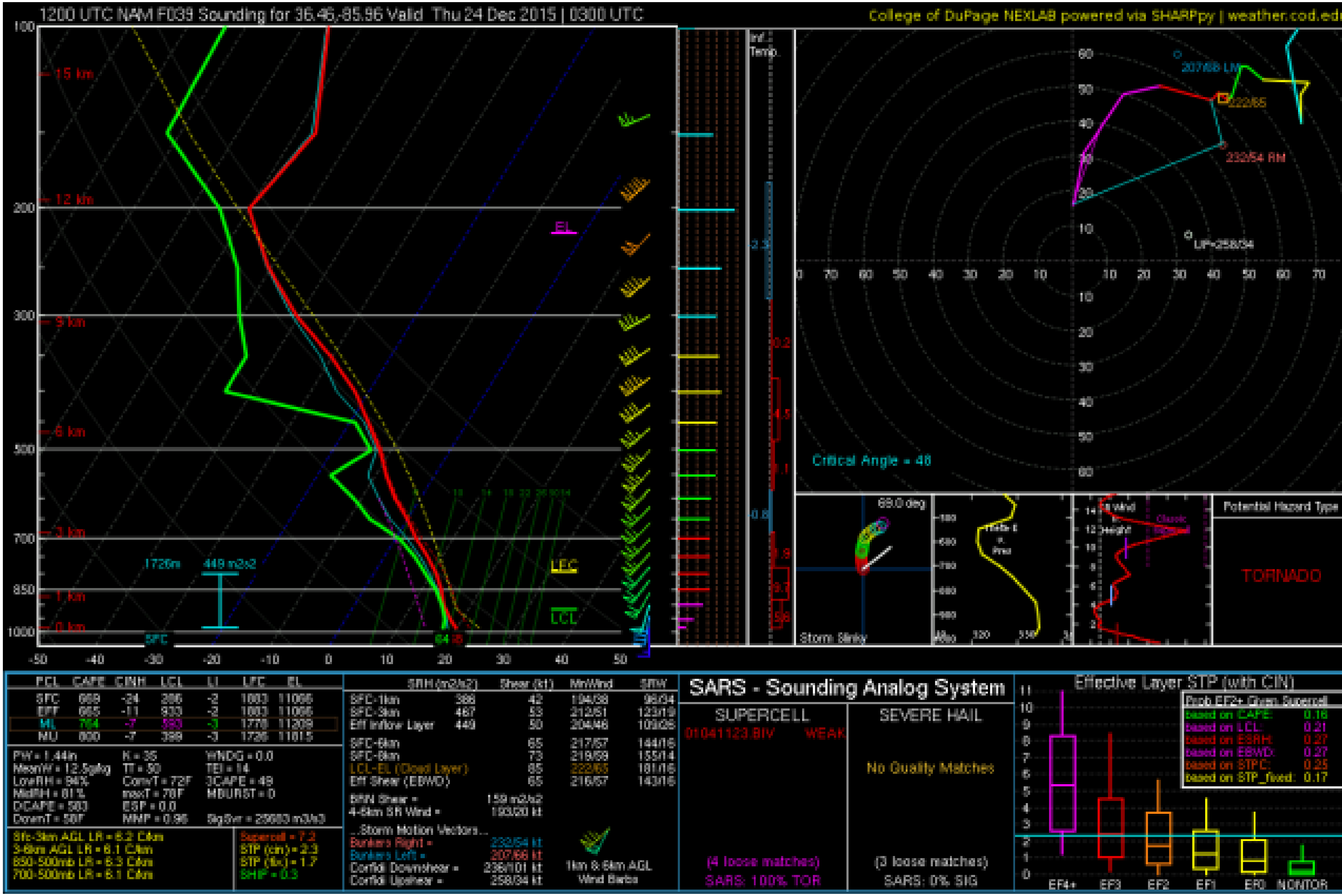




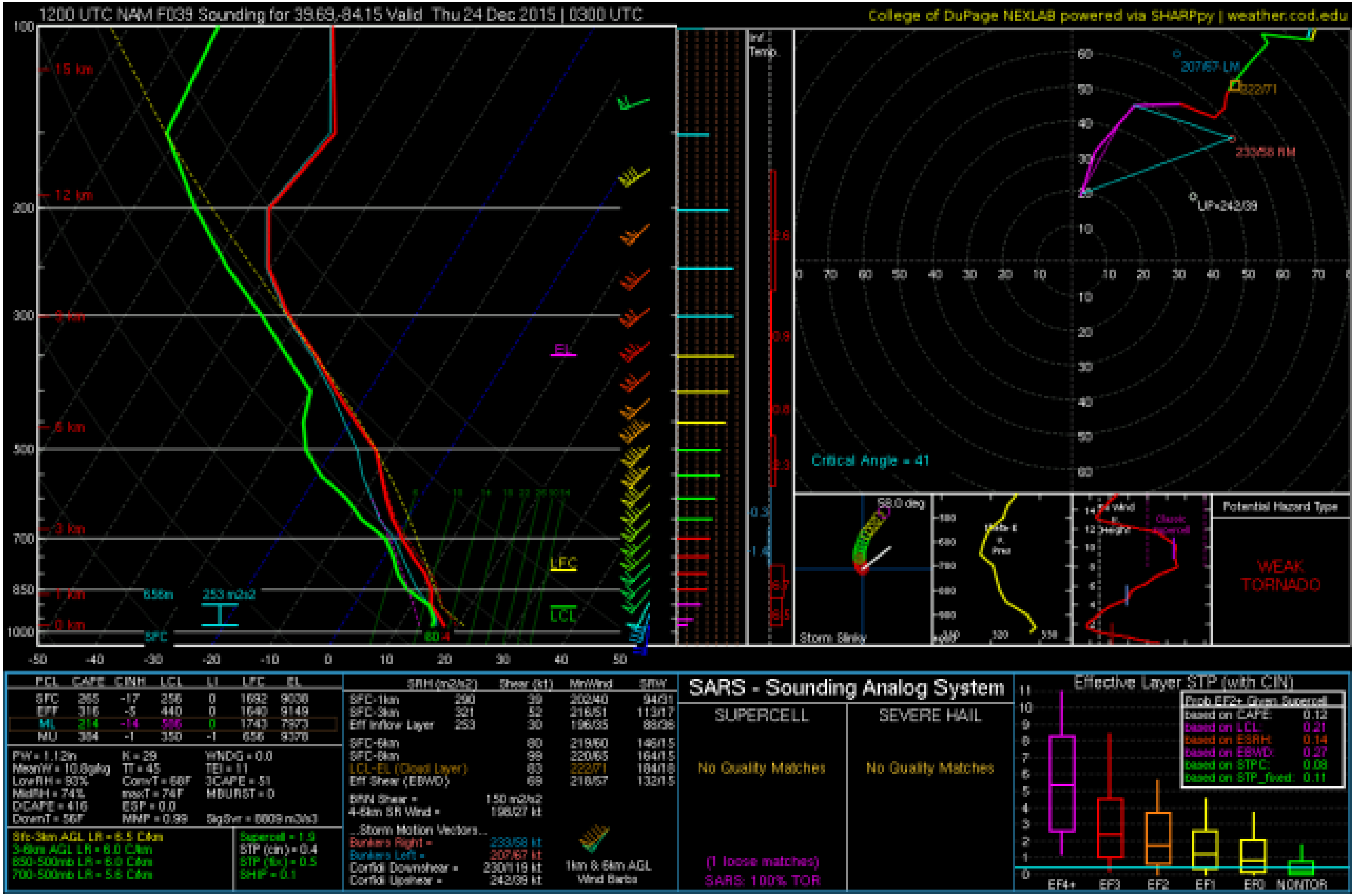




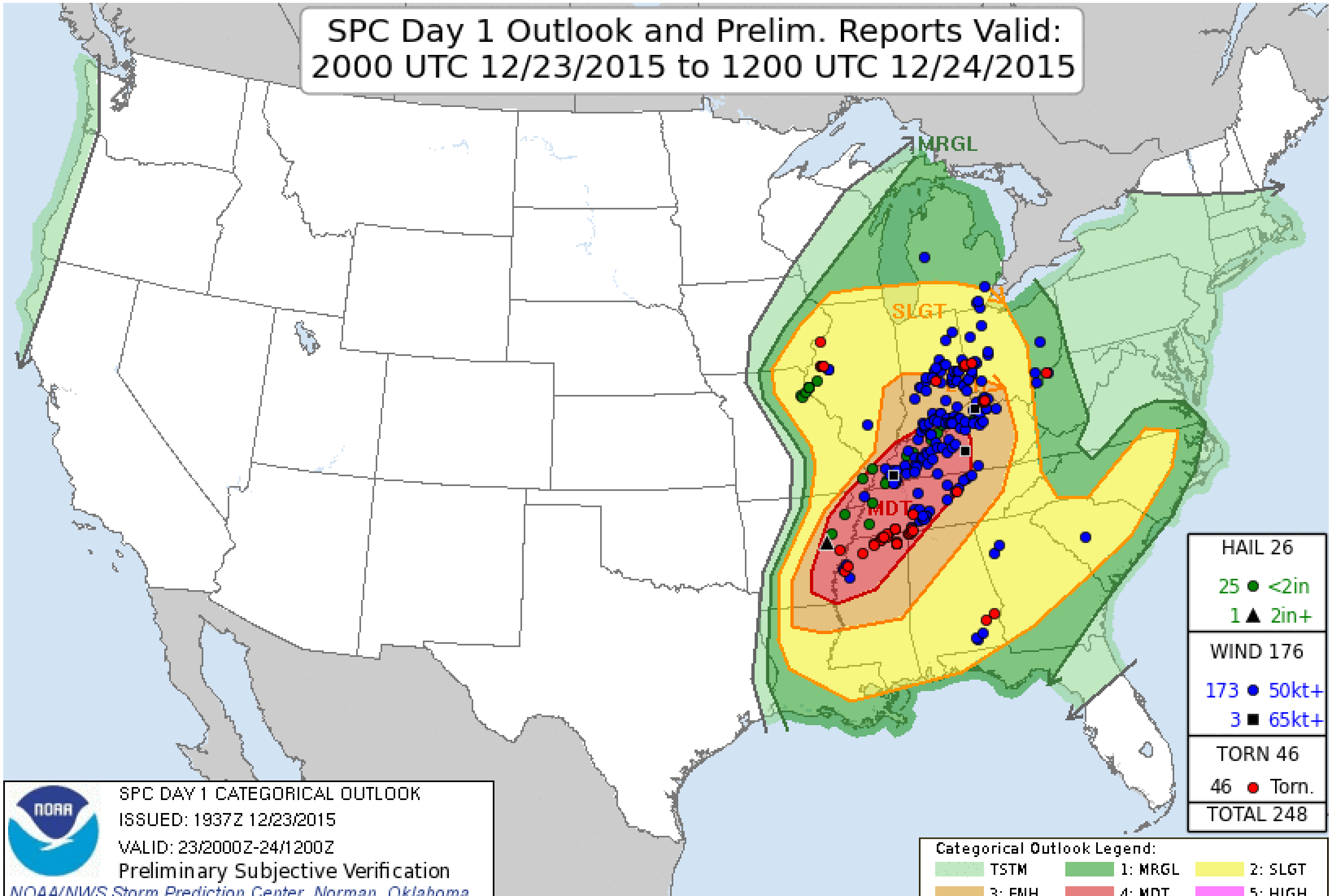
Dec 23 2015 – NAM F39 (Cntl TN)



Dec 23 2015 – NAM F39 (Cntl OH)



DEC 23 2015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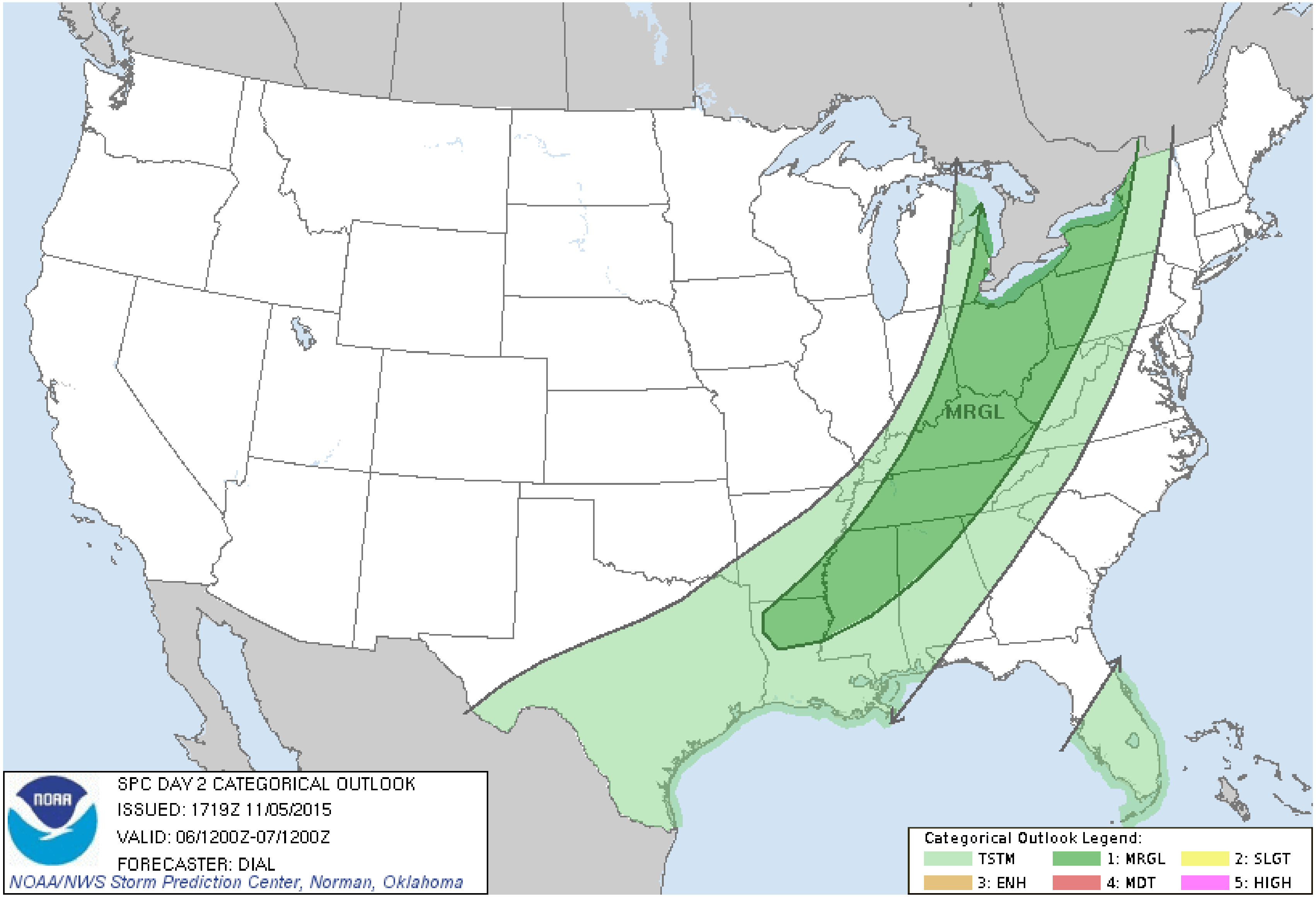
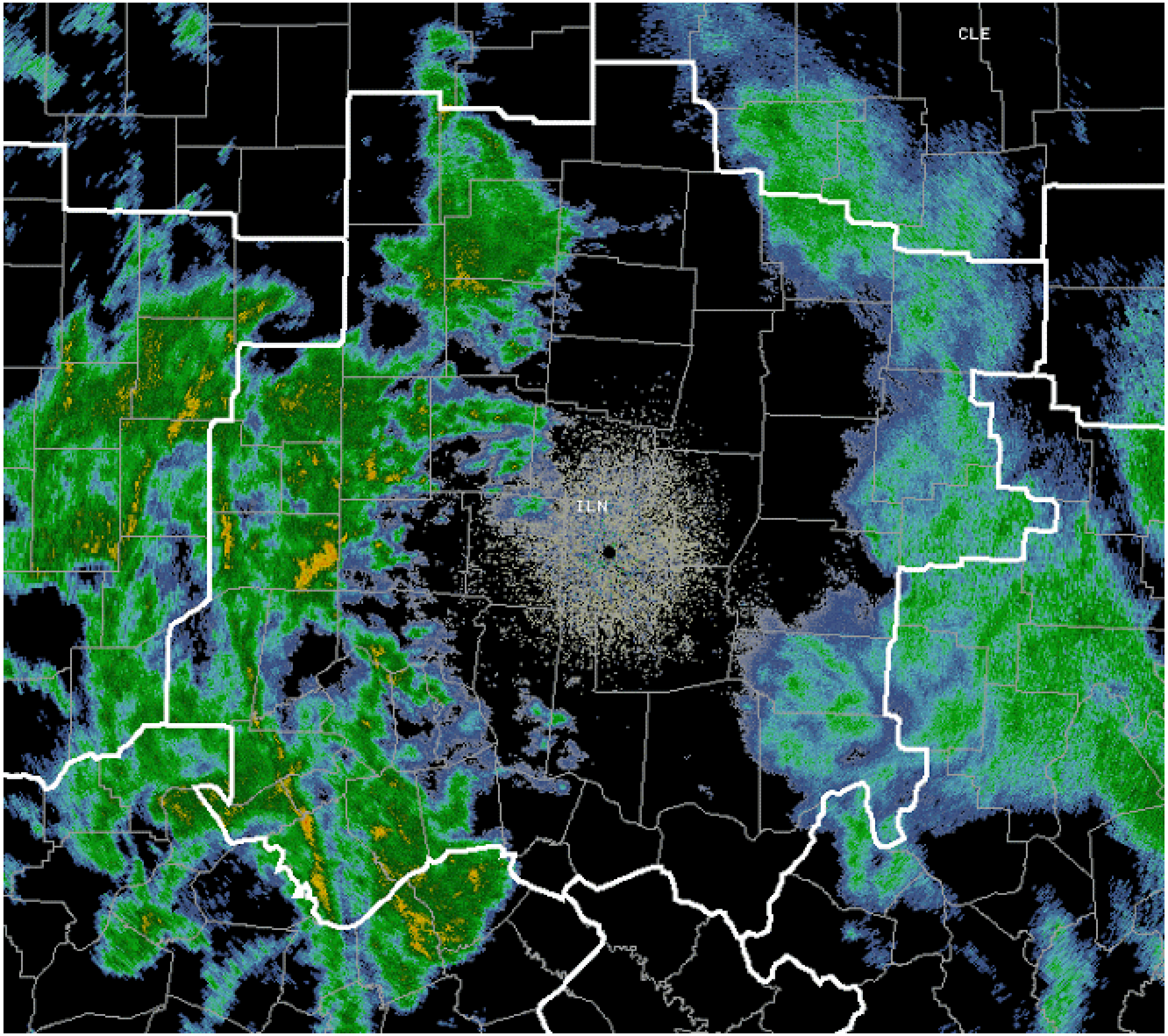
2000 UTC 12/23/2015 to 1200 UTC 12/24/2015
MRGL
SLGT
MDT
HAIL 26
25 <2in
1 2in+
WIND 176
173 50kt+
3 65kt+
TORN 46
46 Torn.
TOTAL 248
SPC DAY 1 CATEGORICAL OUTLOOK
ISSUED: 1937Z 12/23/2015
VALID: 23/2000Z-24/1200Z
Preliminary Subjective Verification
NOAA/NWS Storm Prediction Center, Norman, Oklahoma
Categorical Outlook Legend:
TSTM
1: MRGL
2: SLGT
3: ENH
4: MDT
5: HIGH

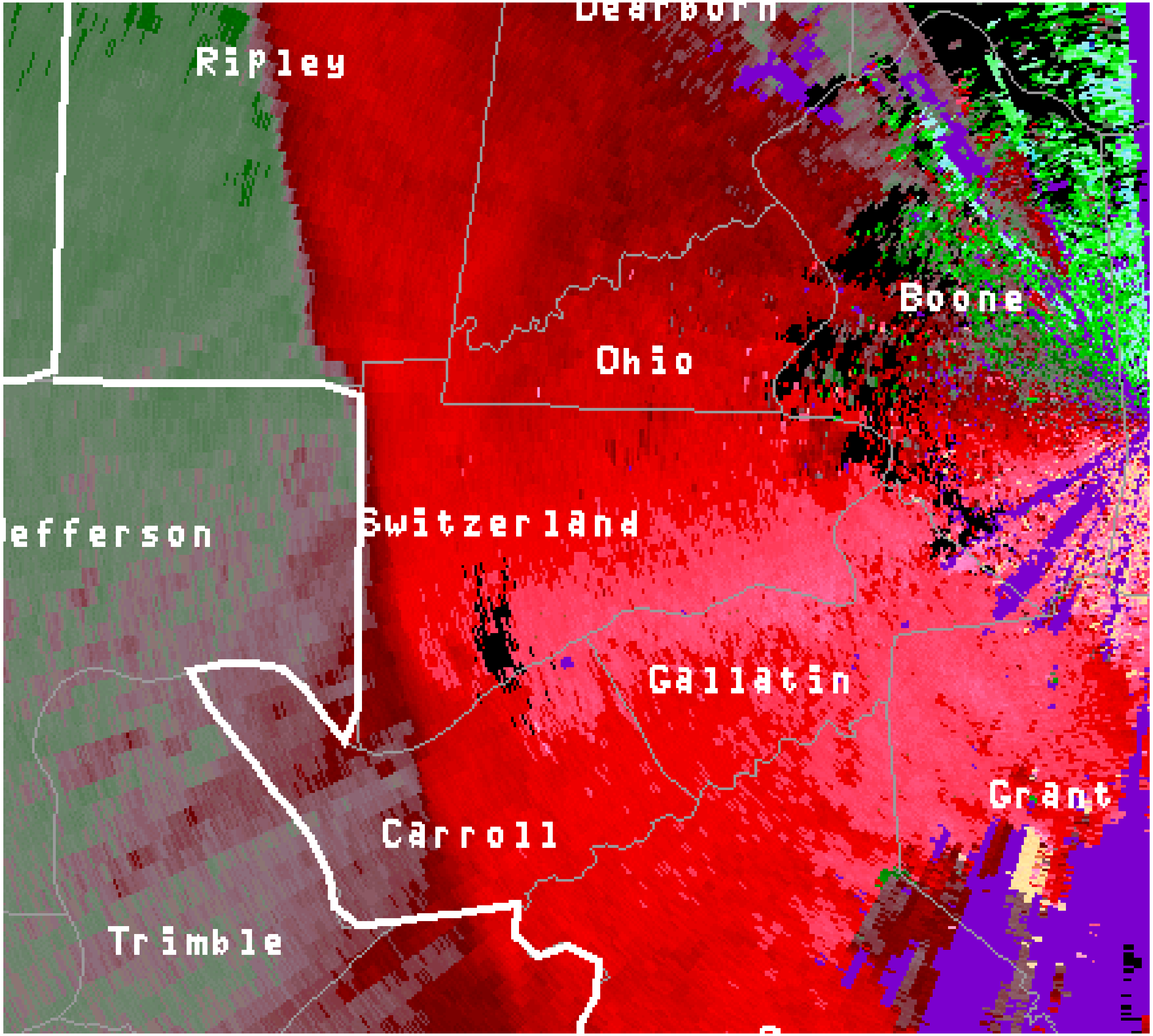
Nov 6th 2015 SWODY2



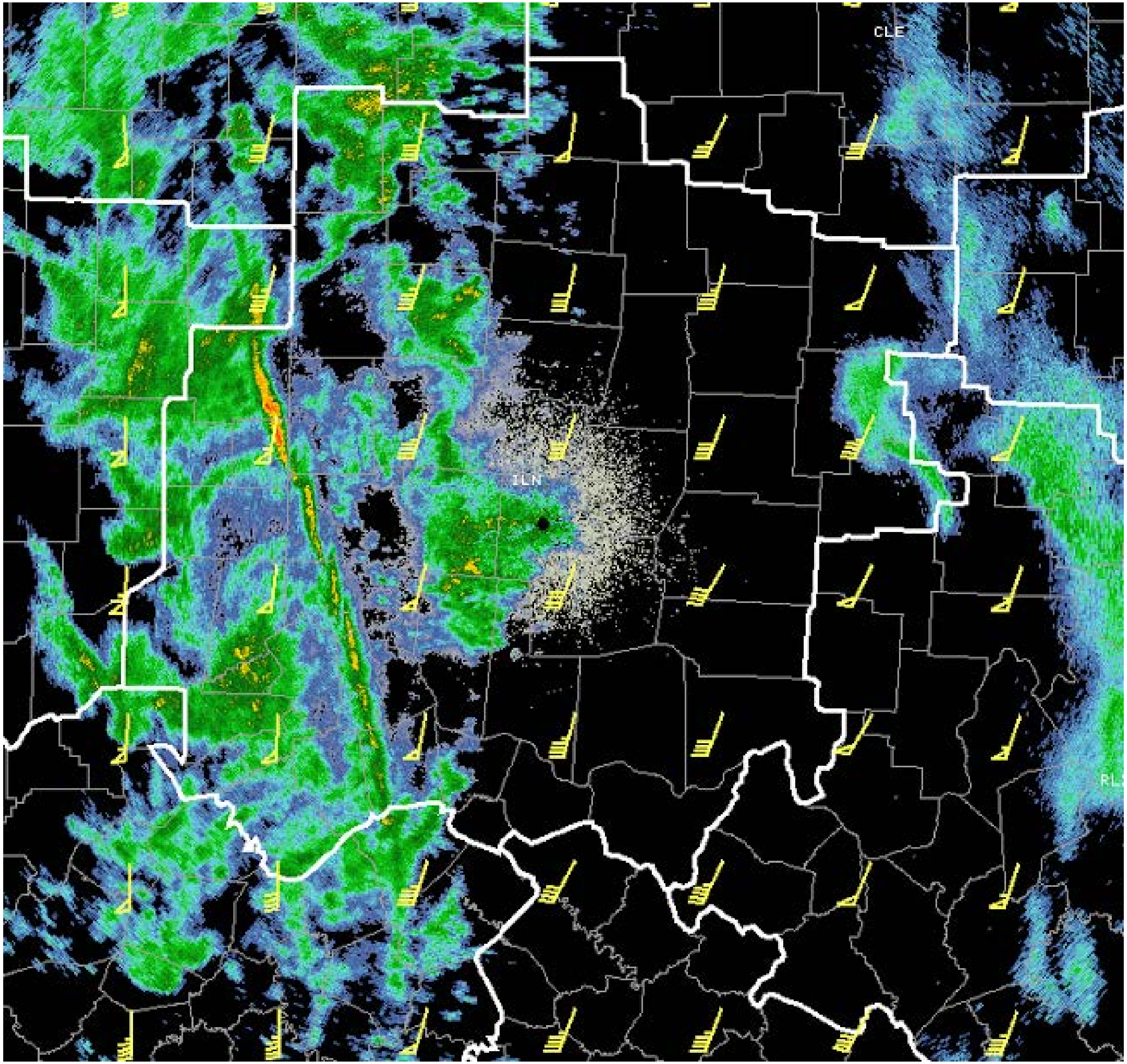
Nov 6th KILN Reflectivity



Nov 6th 2015 TCVG SRM

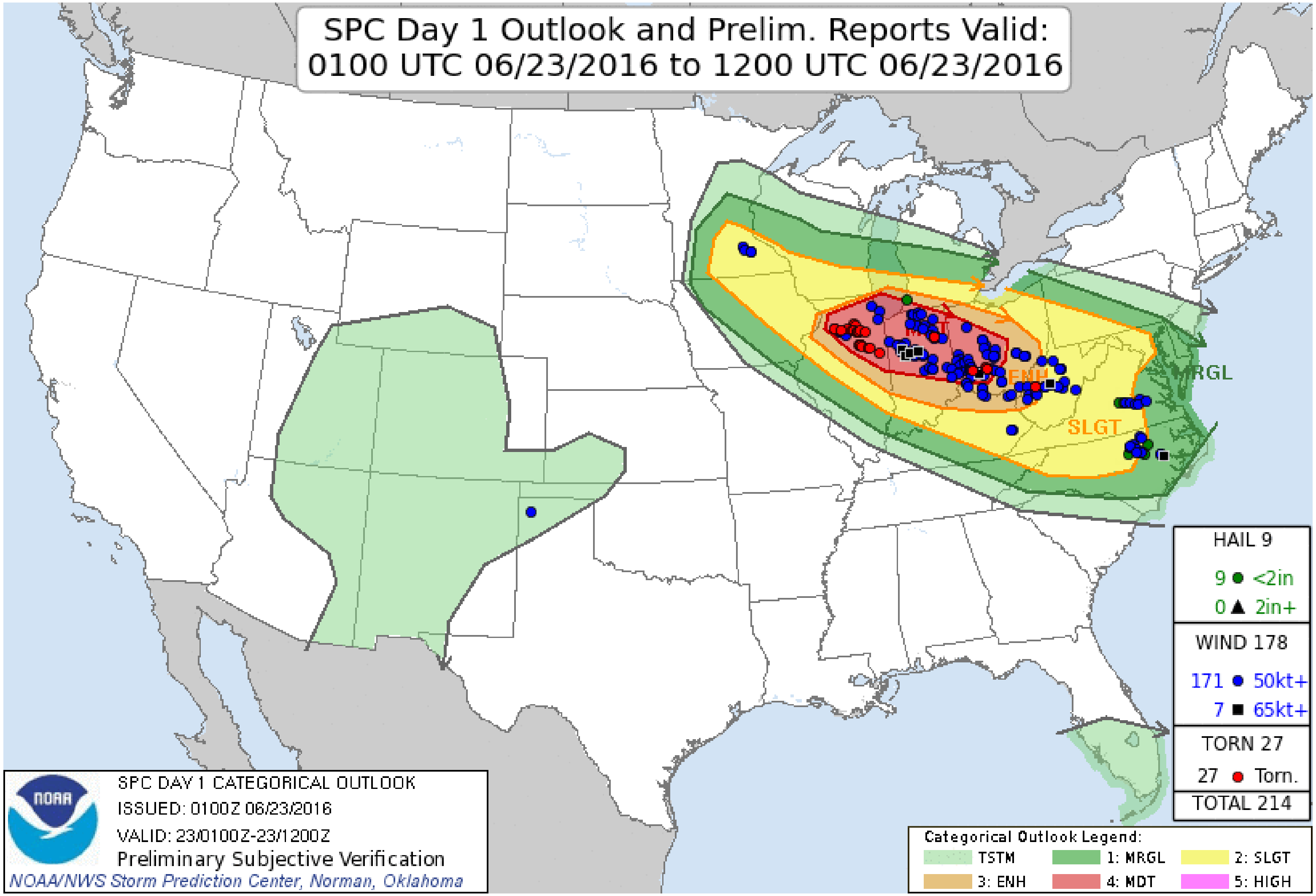


Nov 6th 2015 0-1km Shear Vector

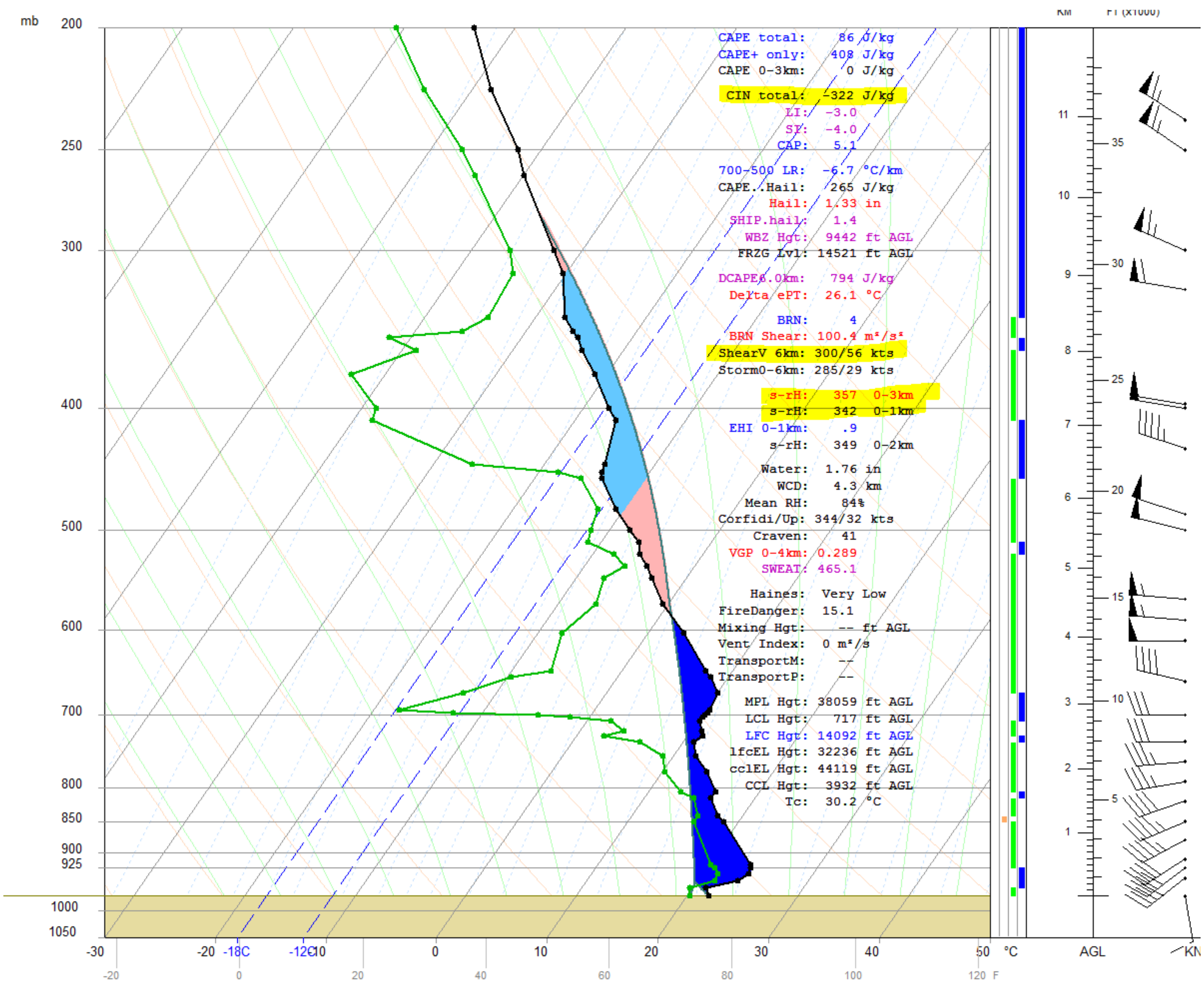


Results:
Case Study 3: Severe Event

Jun. 23, 2016: 2am – 3am

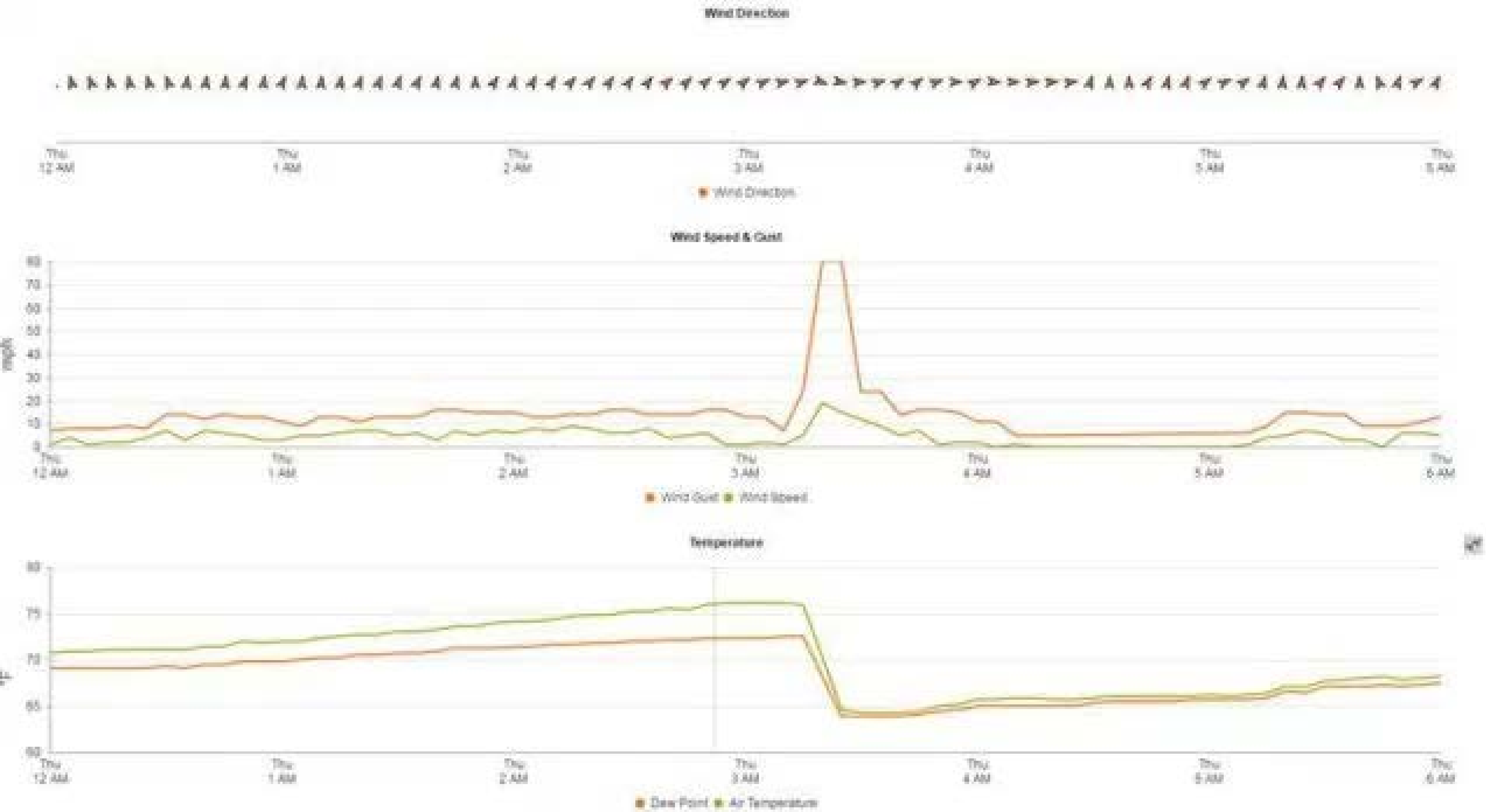


Results:
Case Study 3: Severe Event



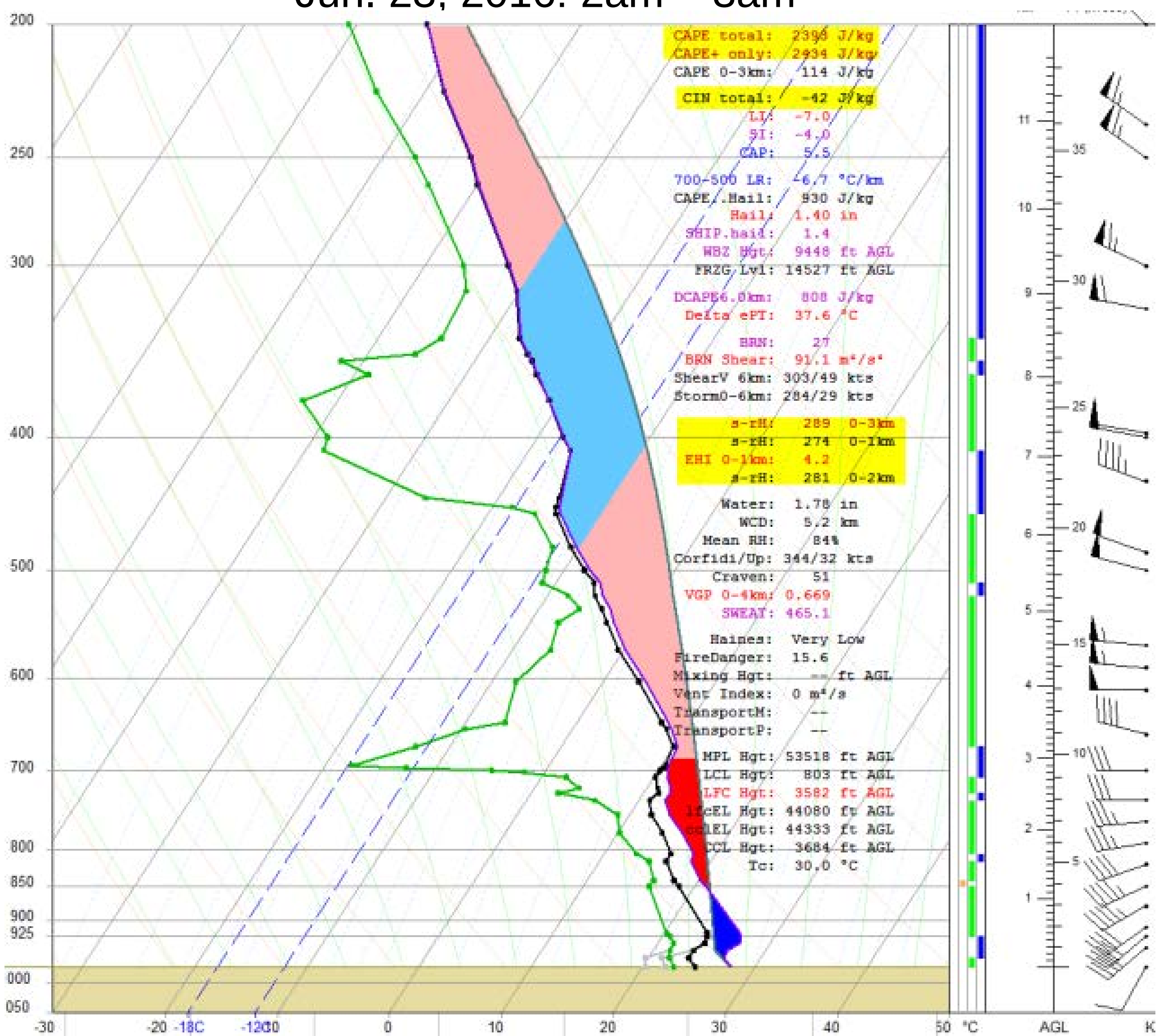
Results:
Case Study 3: Severe Event

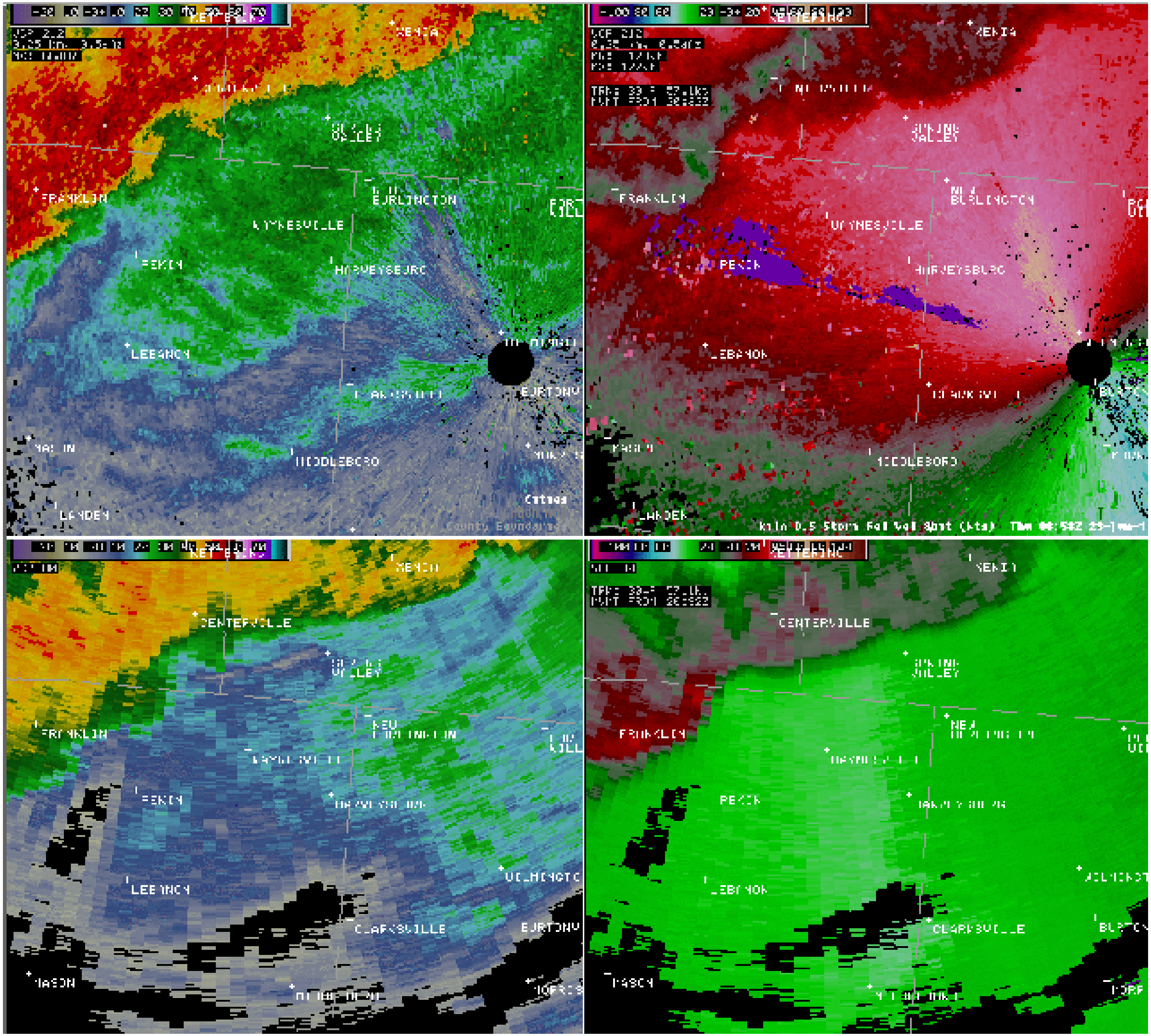
Jun. 23, 2016: 2am – 3am



Results:
Case Study 3: Severe Event

Jun. 23, 2016: 2am – 3am




XENIA
SPRING VALLEY
FRANKLIN
PEKIN
LEBANON
HARVEYSBURG
MIDDLEBORO
LANDEN
CENTERVILLE
CLARKSVILLE
MASON
KETTERING
County Boundaries