NWS Nashville Presents

Weather101

Severe Thunderstorms

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National Oceanic and Atmospheric Administration
National Weather Service – Nashville, TN

Worldwide, there are an estimated *16 million* thunderstorms each year, and at any given moment, there are roughly *2,000* thunderstorms in progress. There are about *100,000* thunderstorms each year in the U.S. alone. About *10%* of these reach severe levels.

Severe Thunderstorms

What makes a storm “severe”?

- **Damaging winds of 58mph or higher**

- **Hail 1 inch or larger**

- **Tornado**

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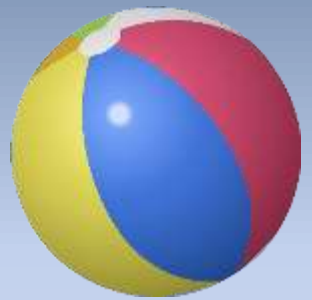
What is needed for Severe Storms?

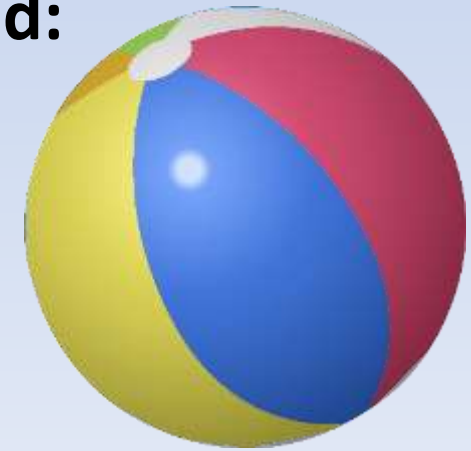
General **thunderstorms need:**

- ❑Lift
- ❑Instability
- ❑Moisture



Severe **thunderstorms need:**

- ❑MORE Instability
- ❑Wind Shear



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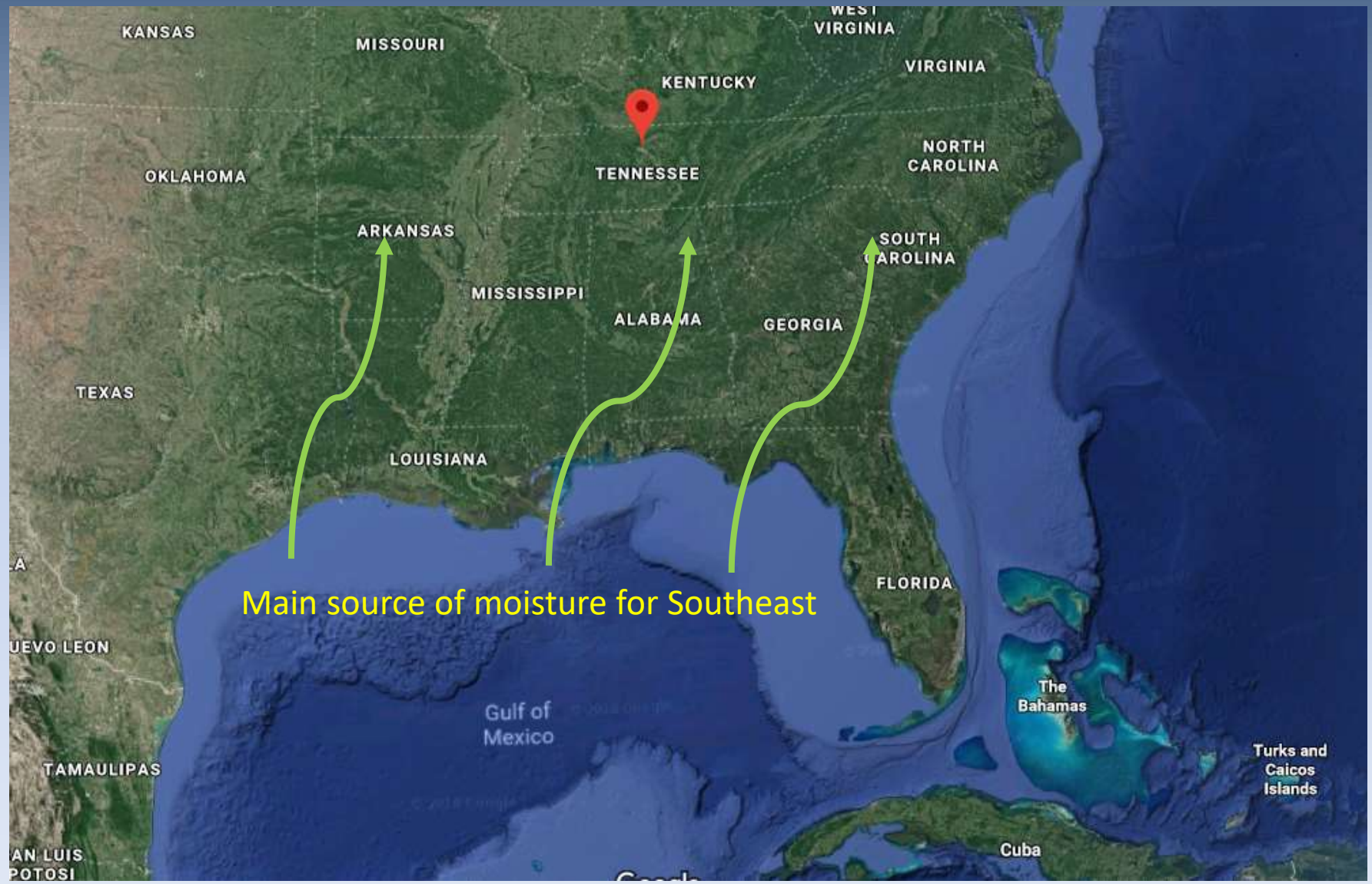
Moisture



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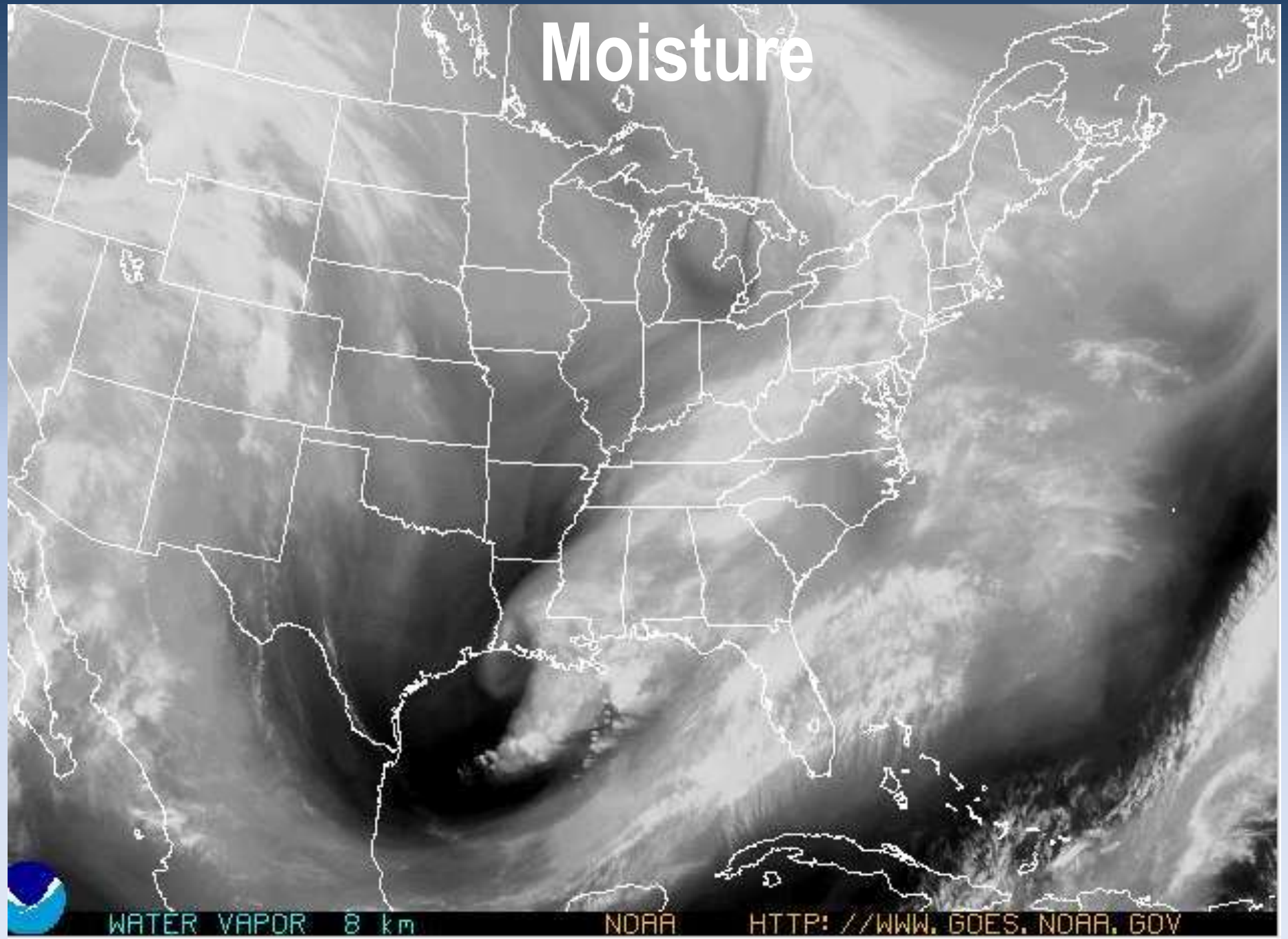
Moisture



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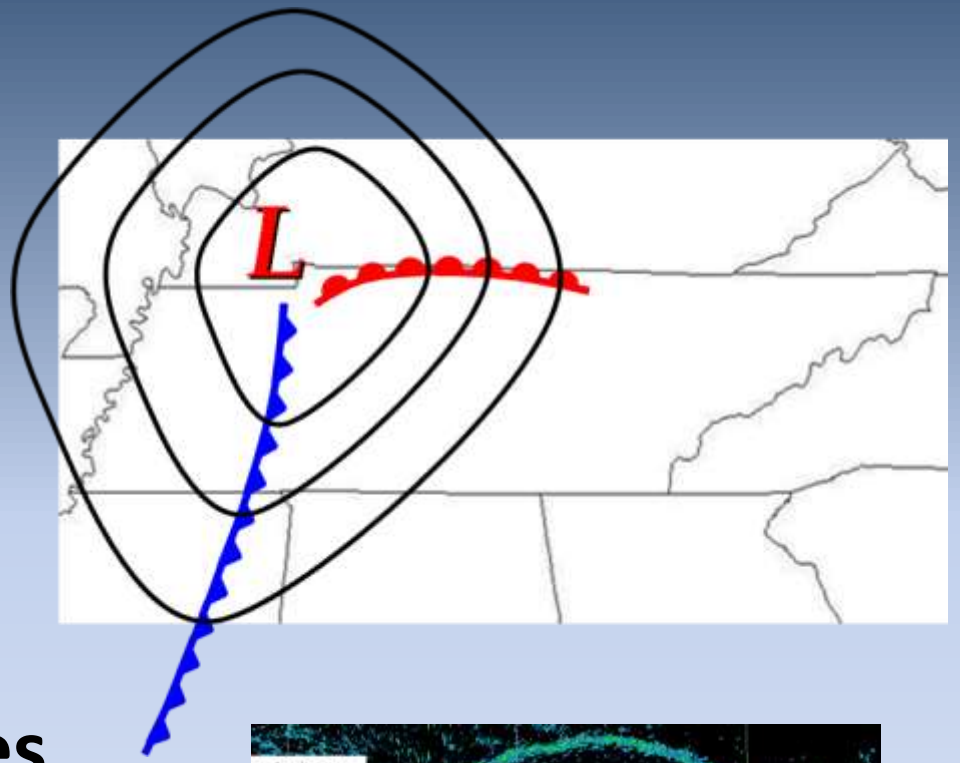
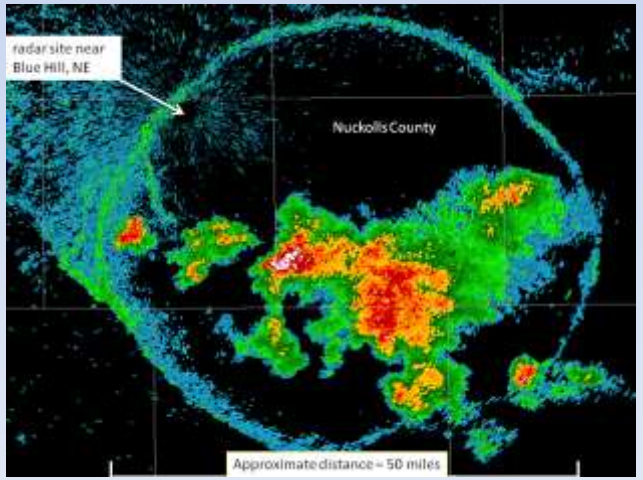
Lift

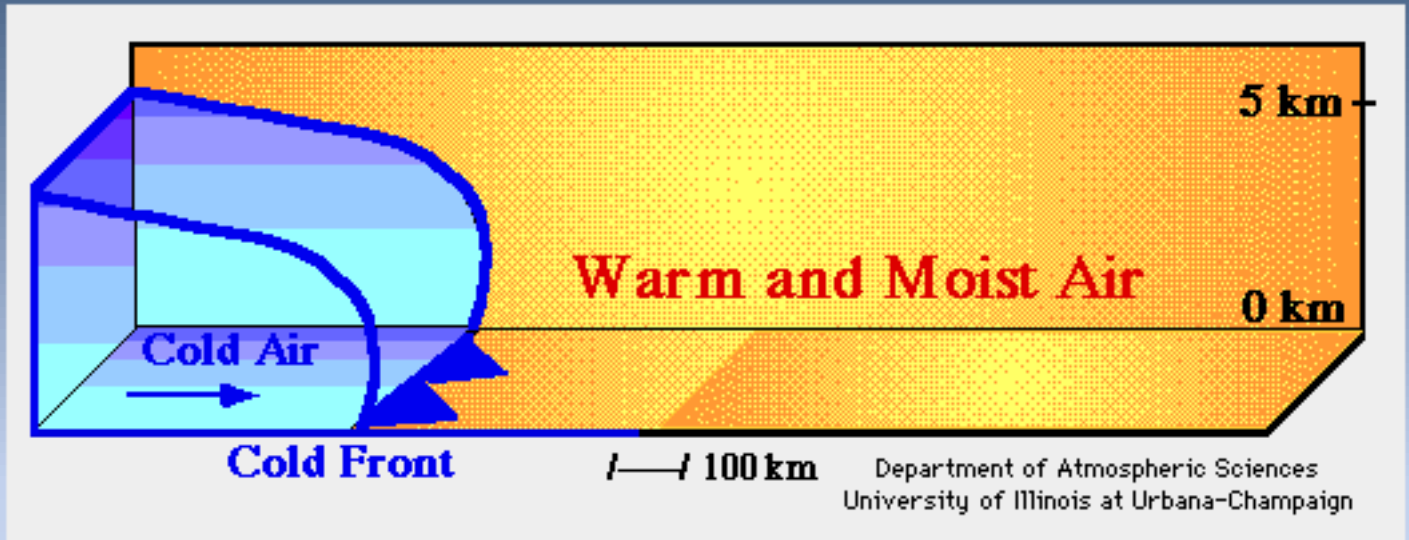
- Fronts



- Other Boundaries



Warm and Cold Fronts



Cold Front

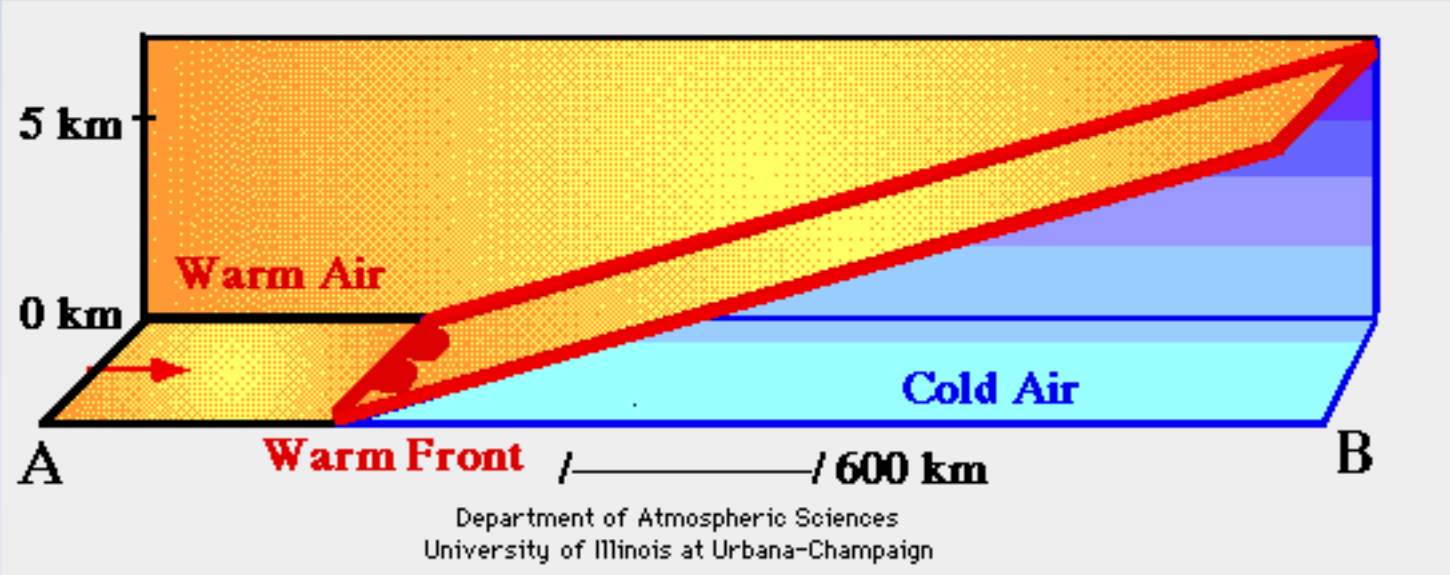
Cold Air Displaces Warm Air At The Surface

Moves More Rapidly

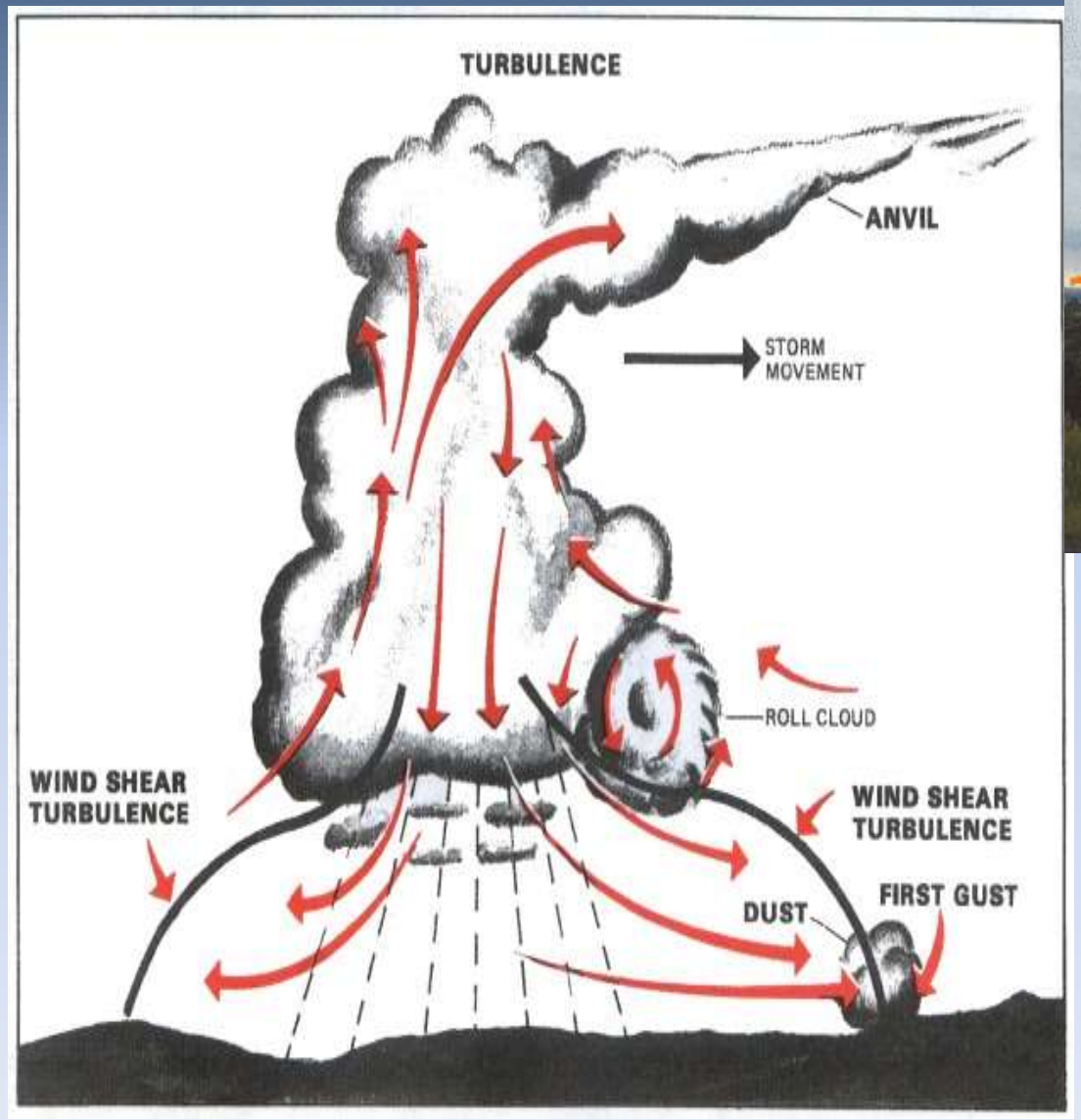
Warm Front

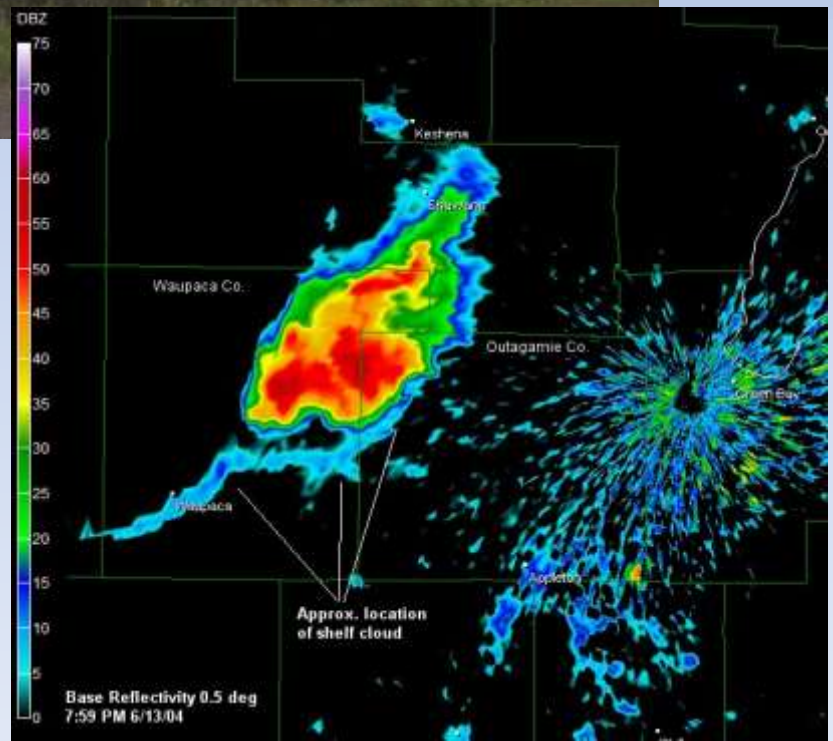
Warm Air Displaces Cold Air At The Surface

Moves More Slowly



Gust Front (other sources of lift)





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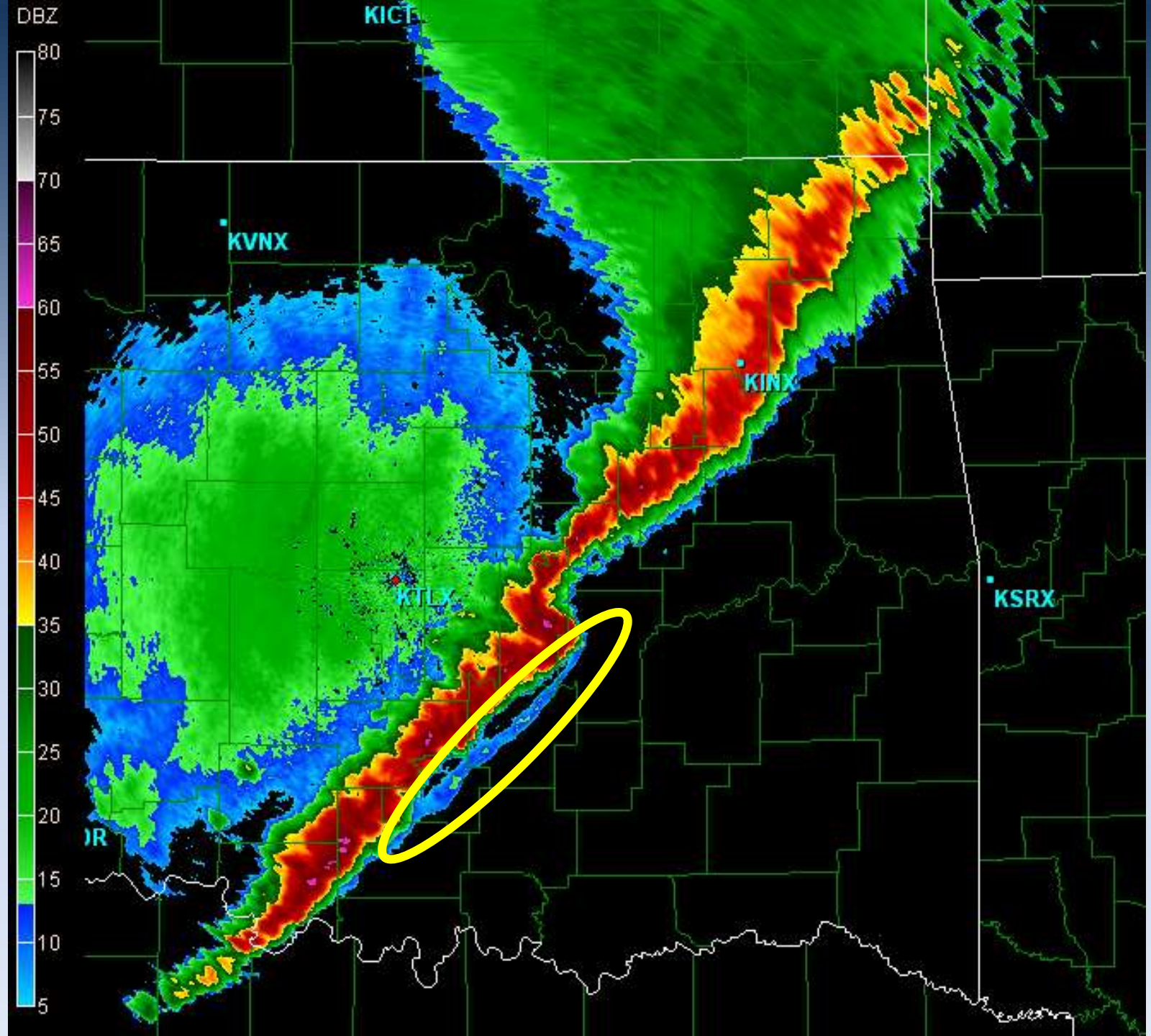
DBZ
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
KICT
KVNX
KINX
KTLX
KSRX

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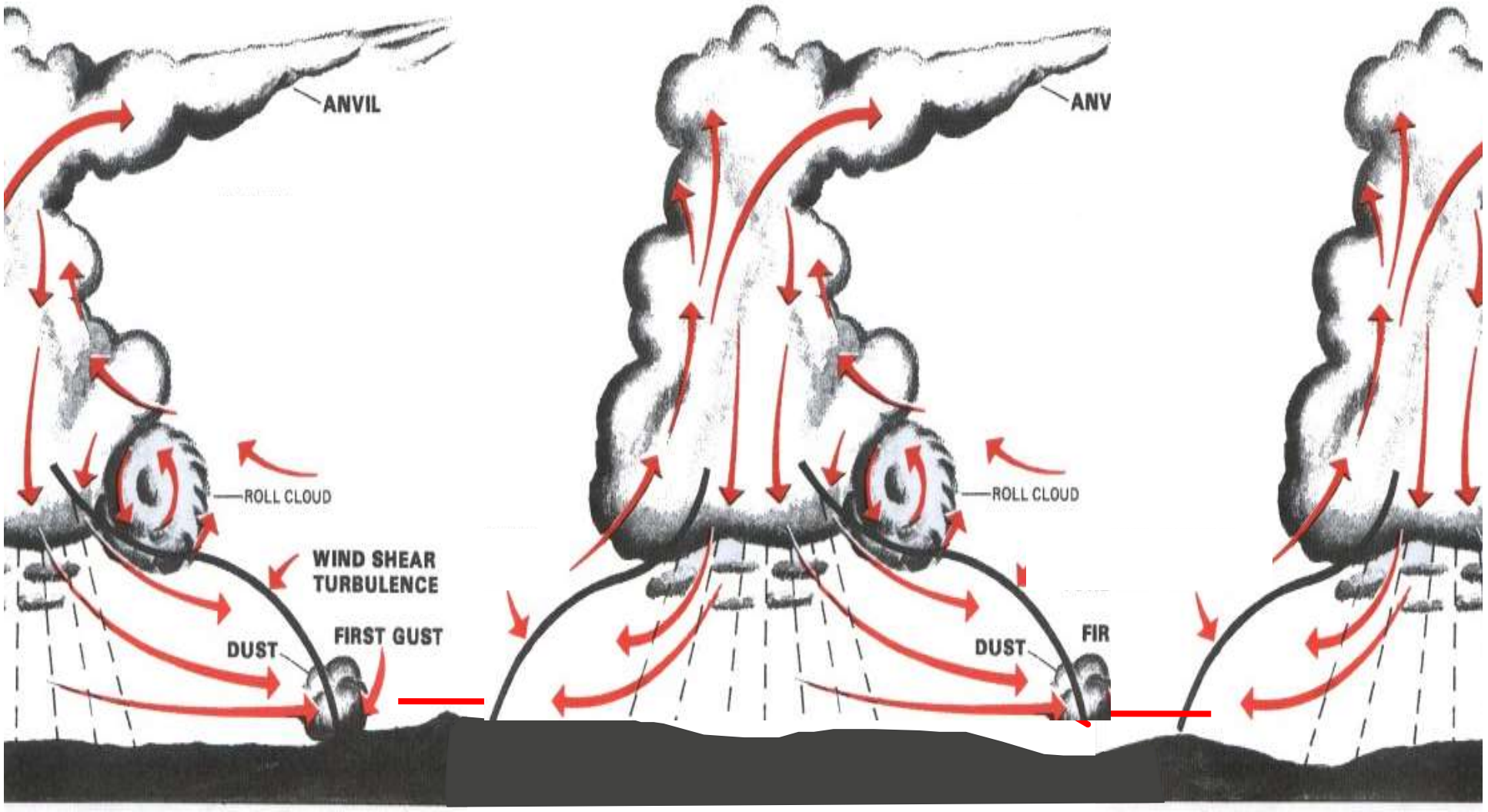
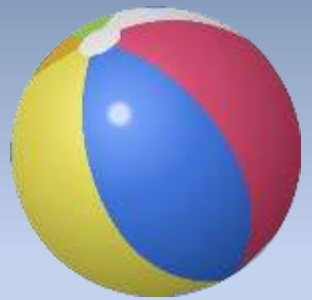
Outflow Boundary (other sources of lift)



What is needed for Severe Storms?

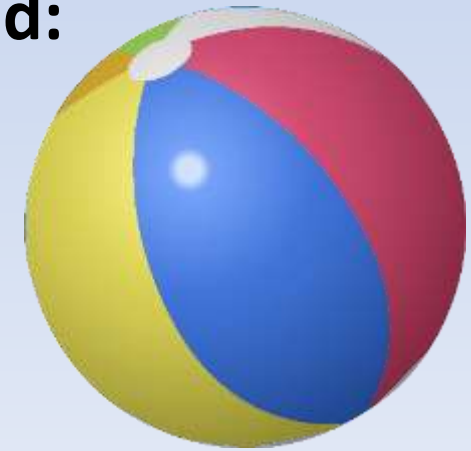
General **thunderstorms need:**

- ☑ Lift
- ☐ Instability
- ☑ Moisture



Severe **thunderstorms need:**

- ☐ MORE Instability
- ☐ Wind Shear



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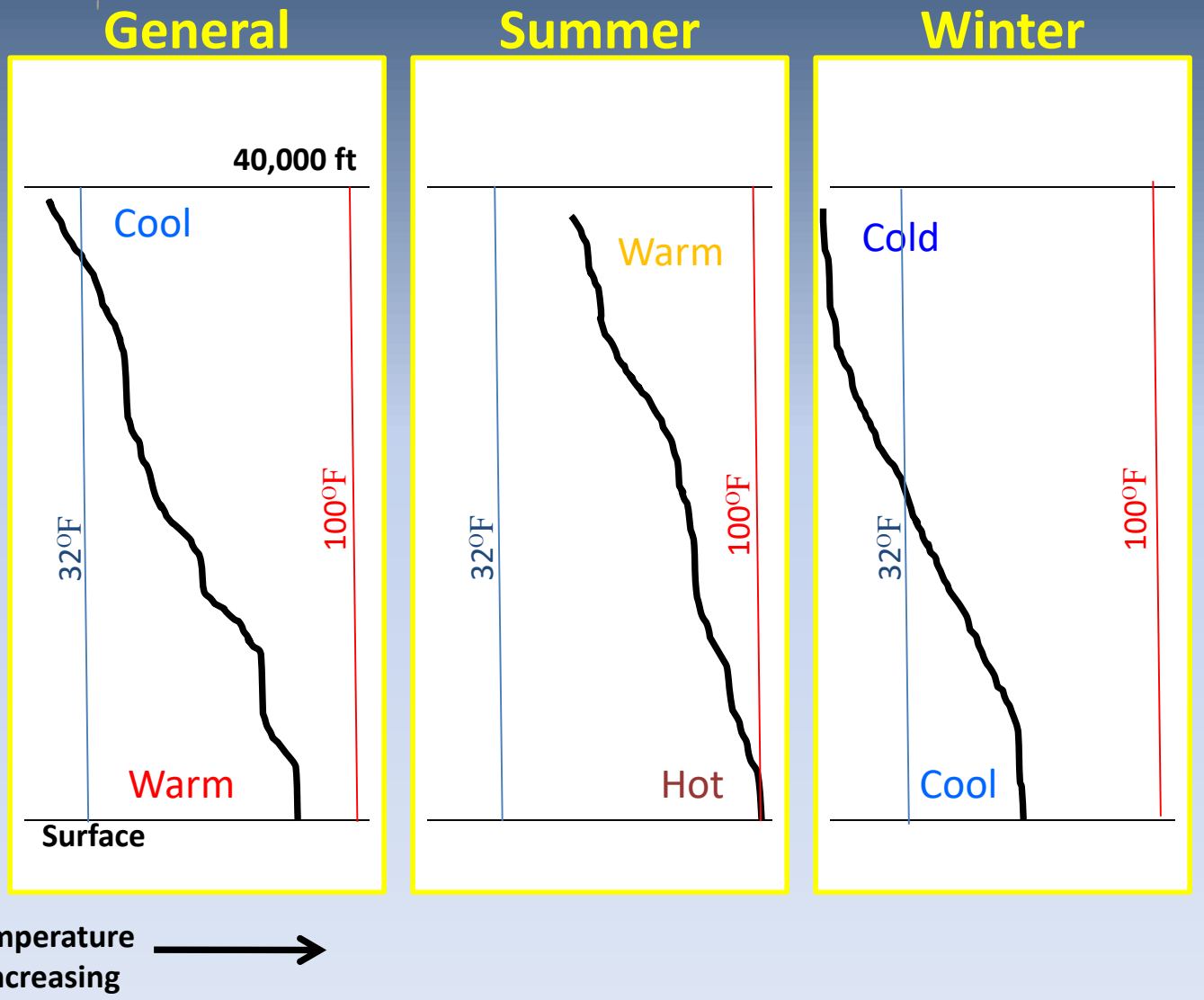
Instability



- In basic terms, the instability of the atmosphere is measured based upon how warm it is at the surface versus how cold it is aloft.
- In general, the atmosphere gets colder as you go up.
- During the summer, it is a lot hotter at the surface, but it also warm aloft
- In the winter it is colder at the surface, but it is also colder in the upper atmosphere, as well.

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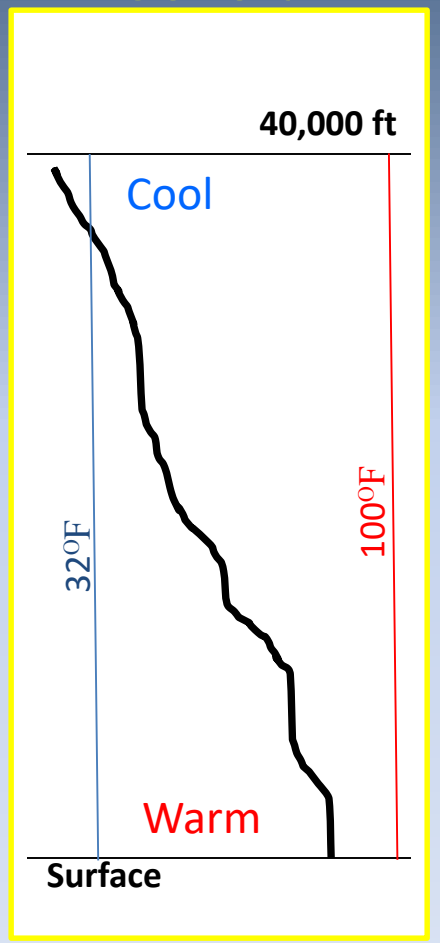
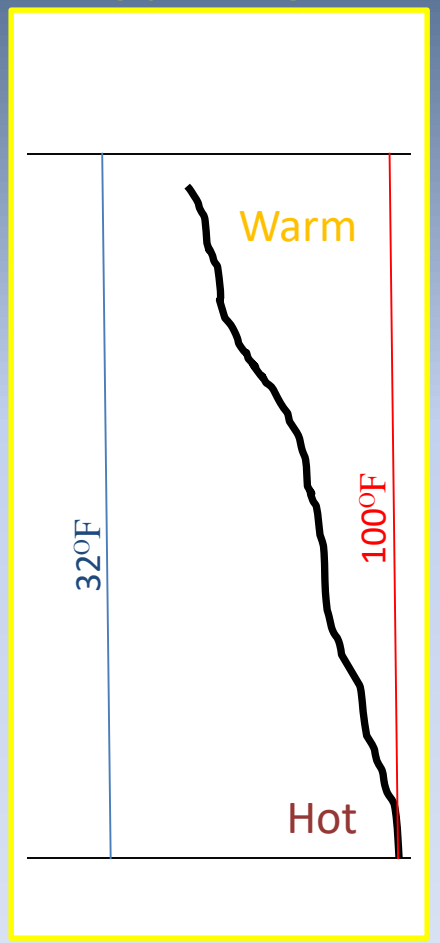
Instability

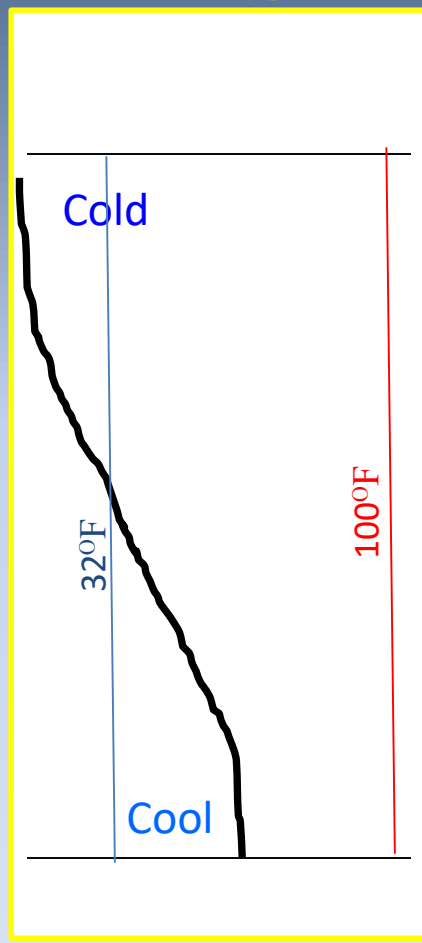
General



Summer



Winter



Temperature Increasing →

- In basic terms, the instability of the atmosphere is measured based upon how warm it is at the surface versus how cold it is aloft.
- In general, the atmosphere gets colder as you go up.
- During the summer, it is a lot hotter at the surface, but it also warm aloft
- In the winter it is colder at the surface, but it is also colder in the upper atmosphere, as well.
- How is the instability calculated?

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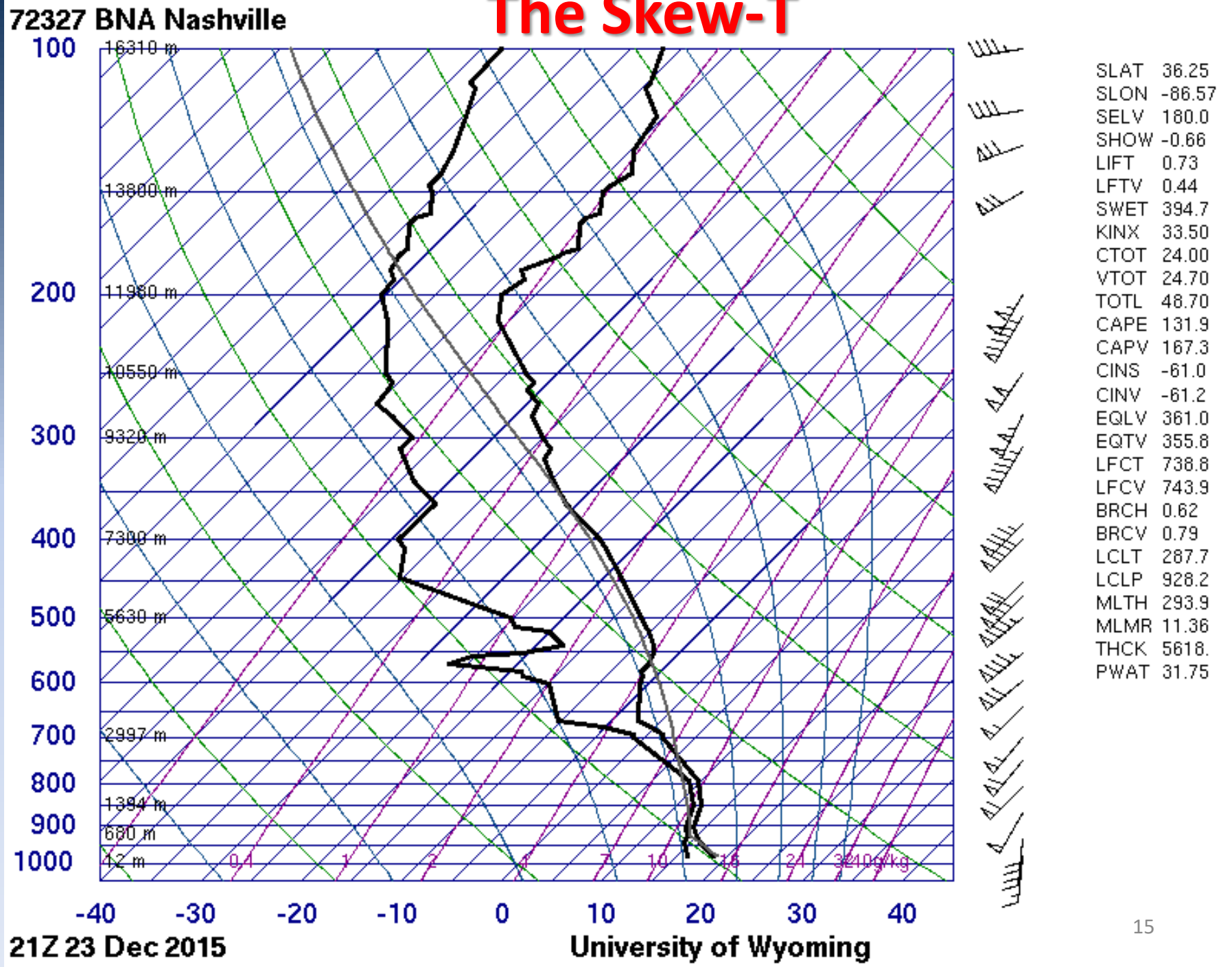
The Skew-T



SLAT	36.25
SLON	-86.57
SELV	180.0
SHOW	-0.66
LIFT	0.73
LFTV	0.44
SWET	394.7
KINX	33.50
CTOT	24.00
VTOT	24.70
TOTL	48.70
CAPE	131.9
CAPV	167.3
CINS	-61.0
CINV	-61.2
EQLV	361.0
EQTV	355.8
LFCT	738.8
LFCV	743.9
BRCH	0.62
BRCV	0.79
LCLT	287.7
LCLP	928.2
MLTH	293.9
MLMR	11.36
THCK	5618.
PWAT	31.75

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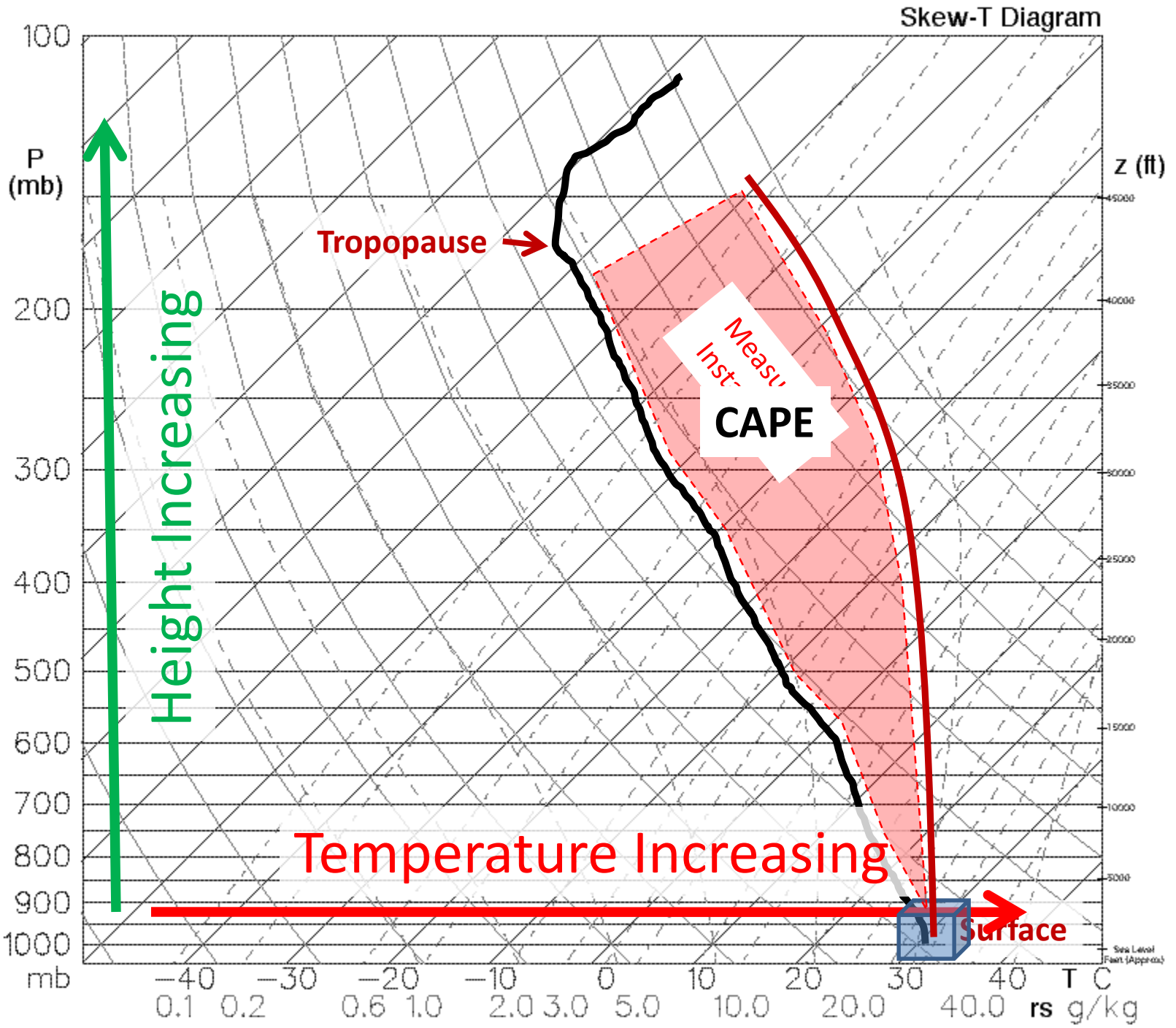
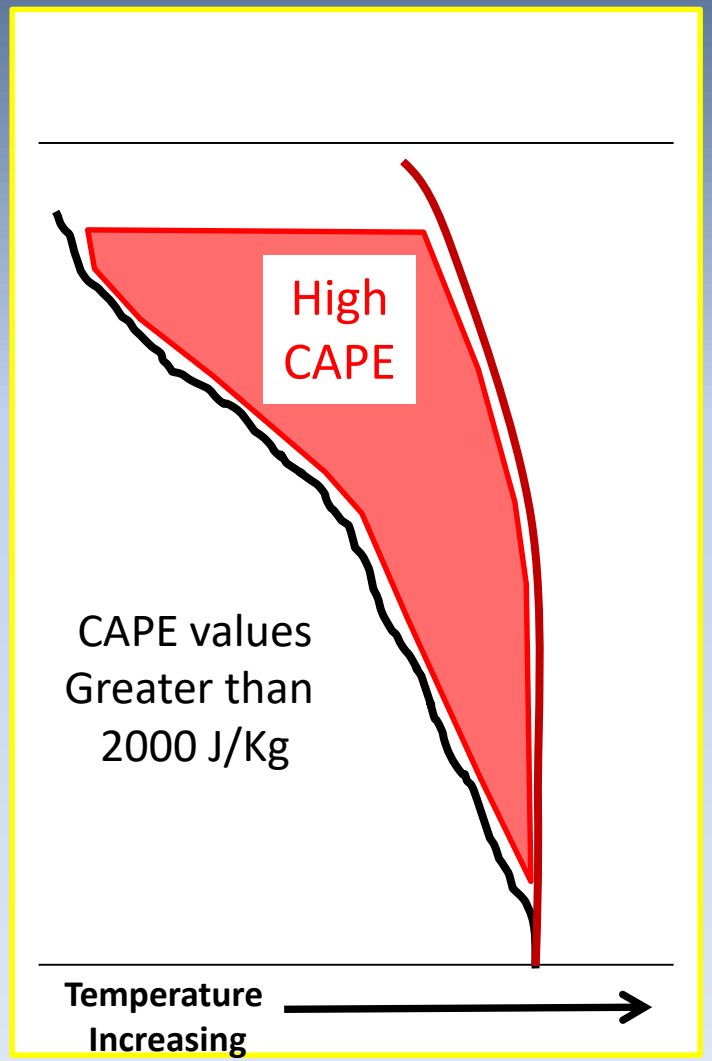
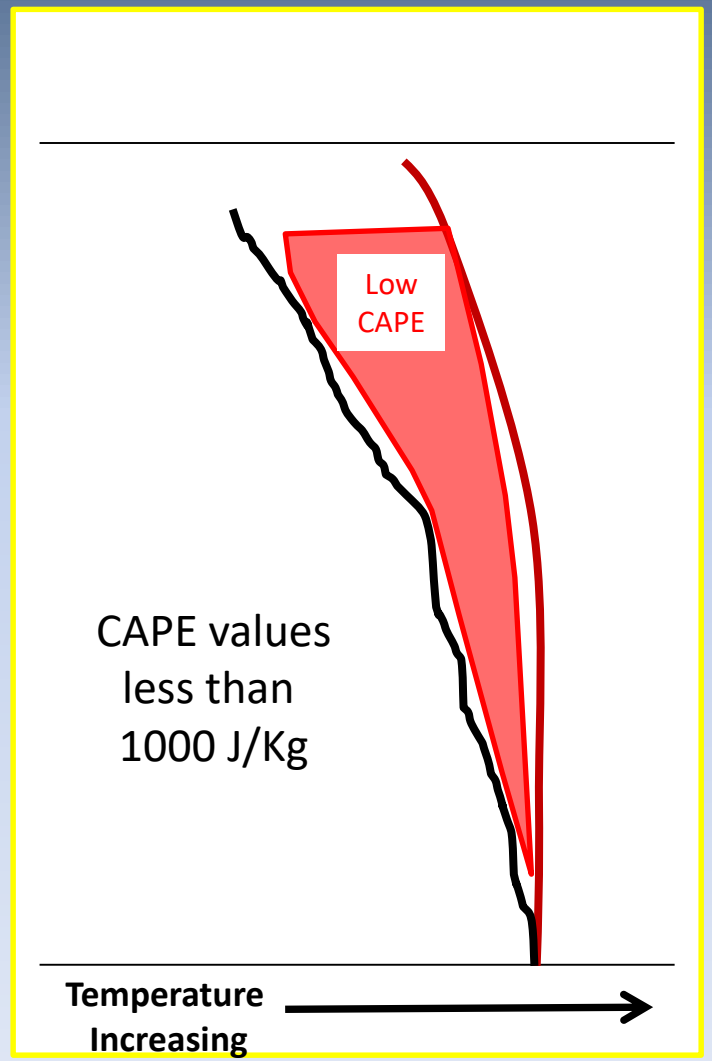

Skew-T Diagram
P (mb)
z (ft)
100
200
300
400
500
600
700
800
900
1000
mb
Tropopause
Height Increasing
CAPE
Temperature Increasing
Surface
−40 −30 −20 −10 0 10 20 30 40 T C
0.1 0.2 0.6 1.0 2.0 3.0 5.0 10.0 20.0 40.0 rs g/kg

Instability

Hot Surface/Cold Aloft

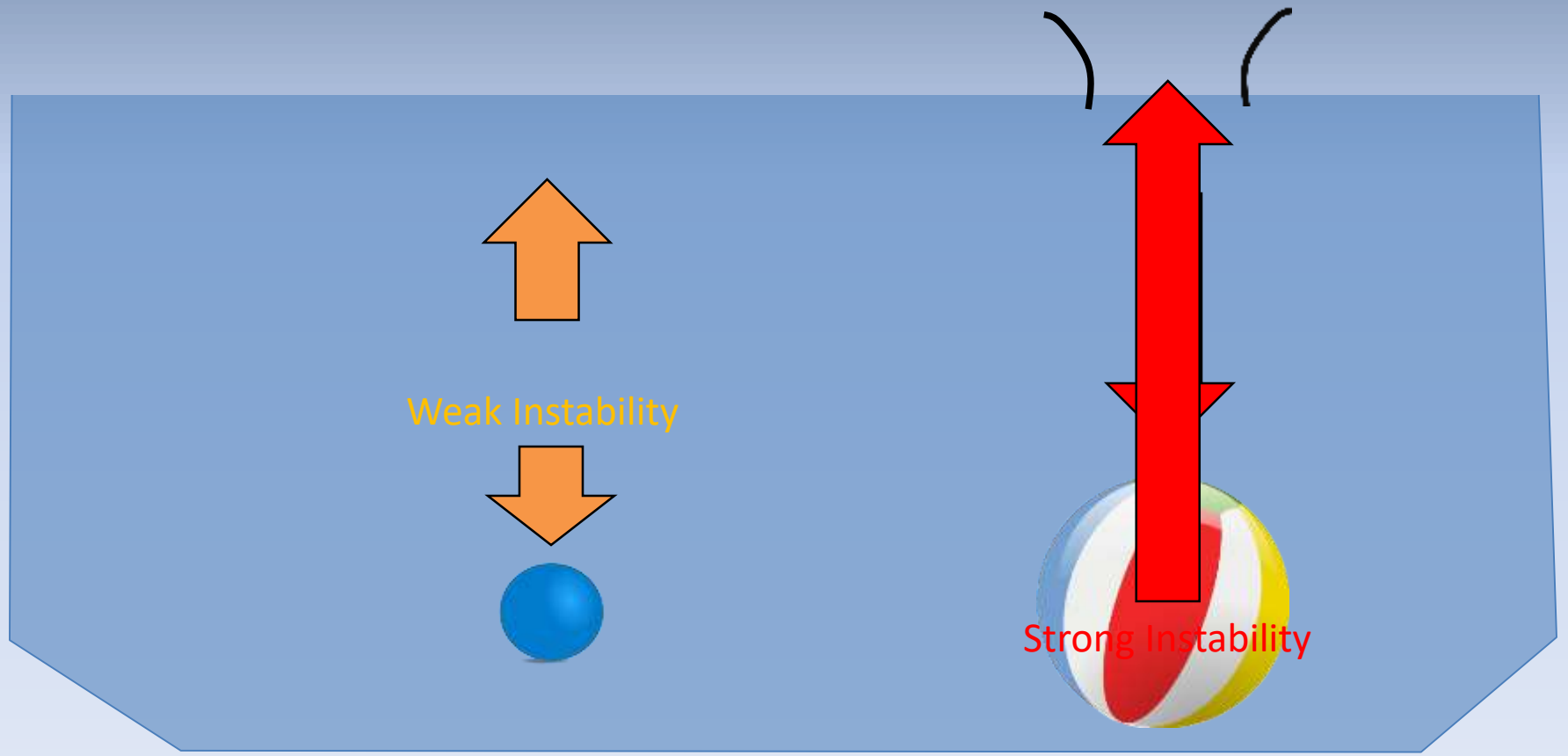


Hot Surface/Warm Aloft



- CAPE stands for the Convective Available Potential Energy
- Depending on what type of CAPE exists (tall, short, skinny, fat) will determine the type and amount of thunderstorms that are possible (potential).

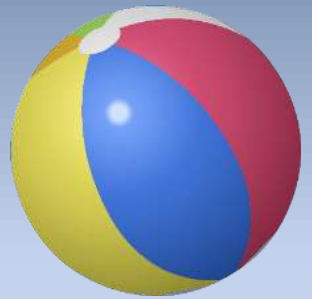
Instability



What is needed for Severe Storms?

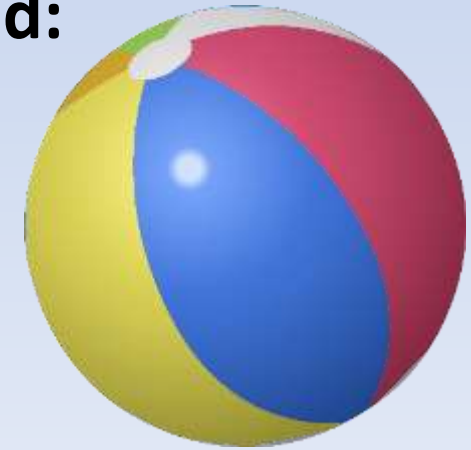
General **thunderstorms need:**

- ☑ Lift
- ☑ Instability
- ☑ Moisture

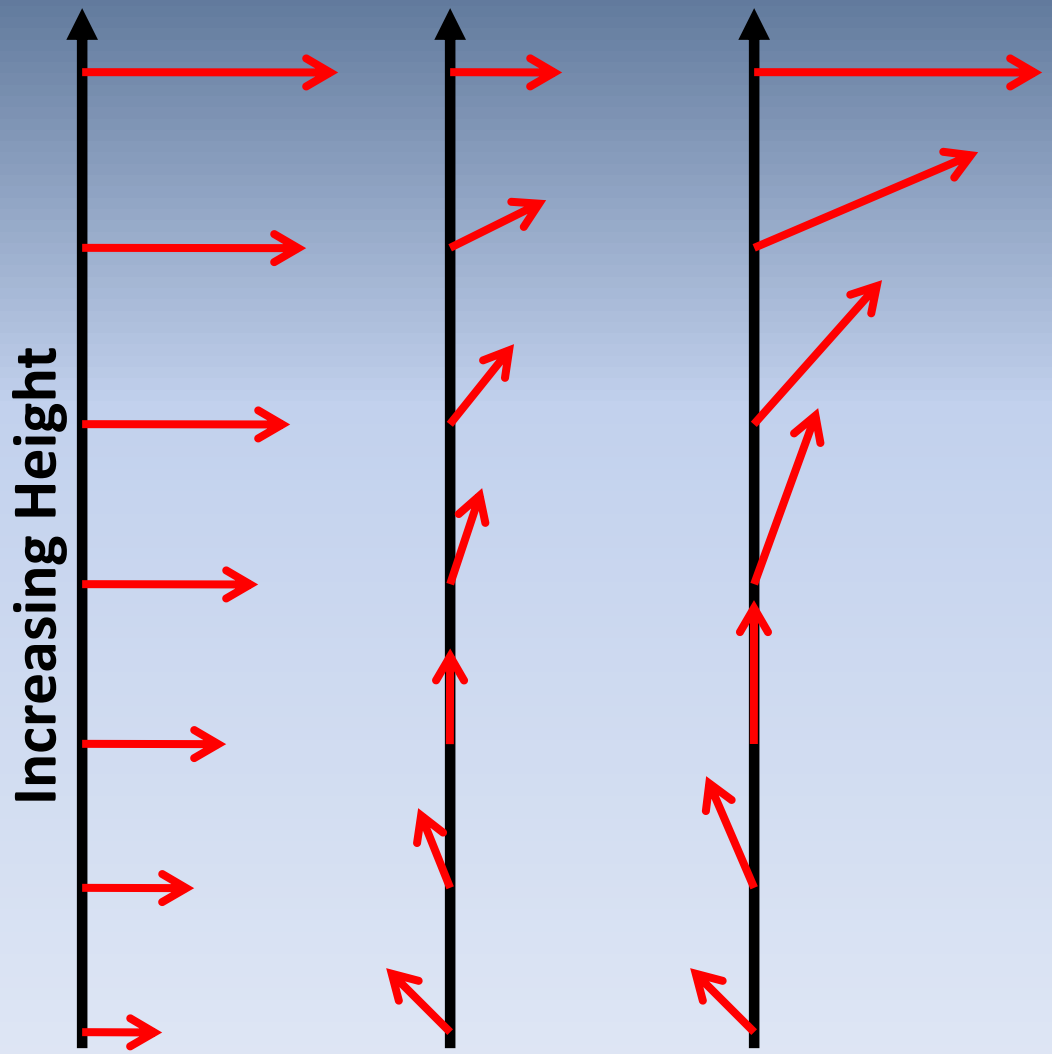


Severe **thunderstorms need:**

- ☑ MORE Instability
- ❑ Wind Shear

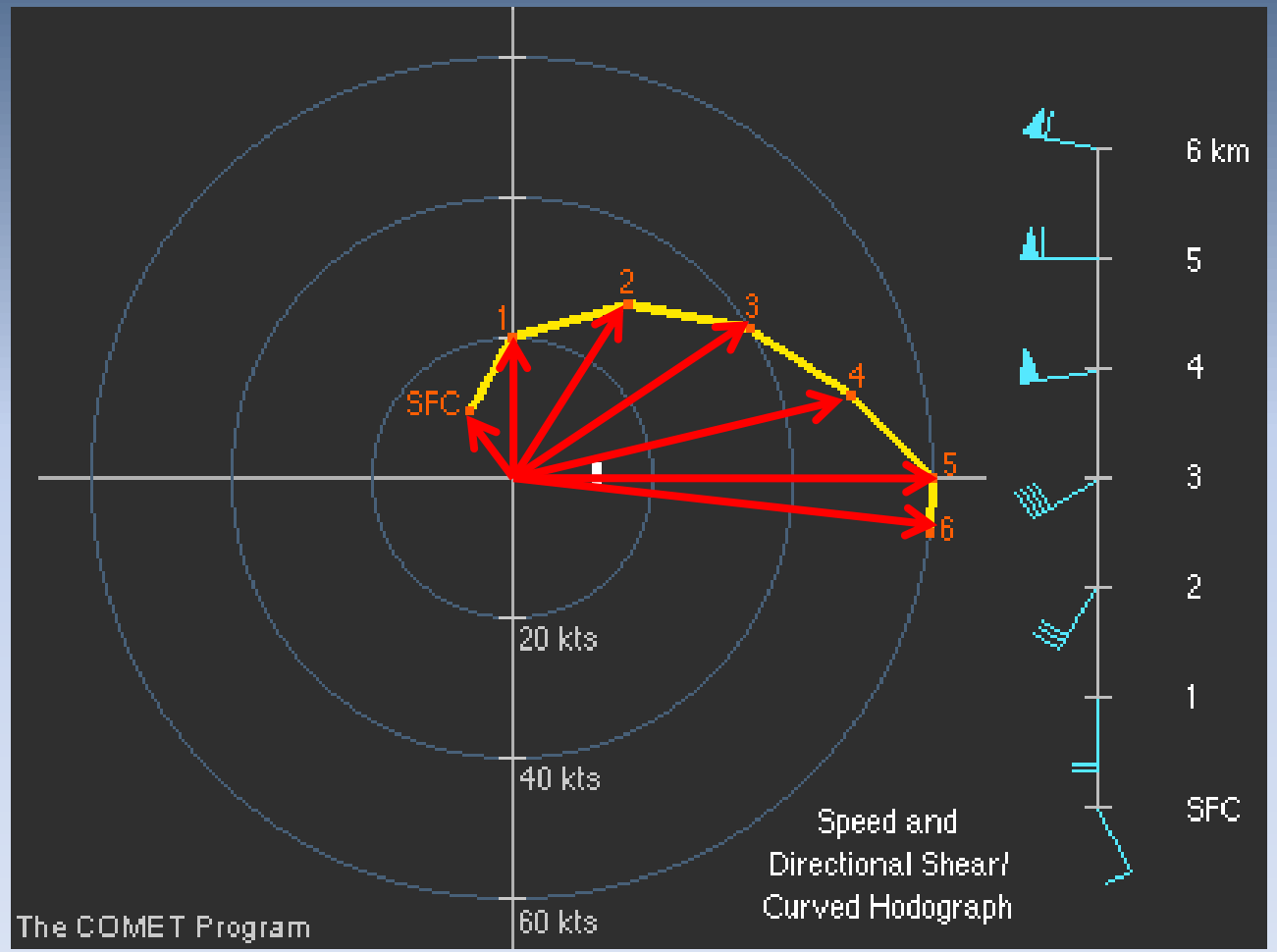


Wind Shear



- Wind shear can be calculated in three ways
- Change in wind speed with height
- Change in wind direction with height
- Change in both speed and direction with height

The 3-Dimensional Atmosphere
Wind Shear



- Wind speed is typically calculated in terms of speed and direction. The change in these is known as Helicity or Storm Relative Helicity.
- Helicity is measured at several height levels, and that determines what type of storm is likely to form or what the mode of convection will be.
- 0 to 6 km (storm motions)
- 0 to 3 km (supercells, multicell, or ordinary cell?)
- 0 to 1 km (tornadoes?)

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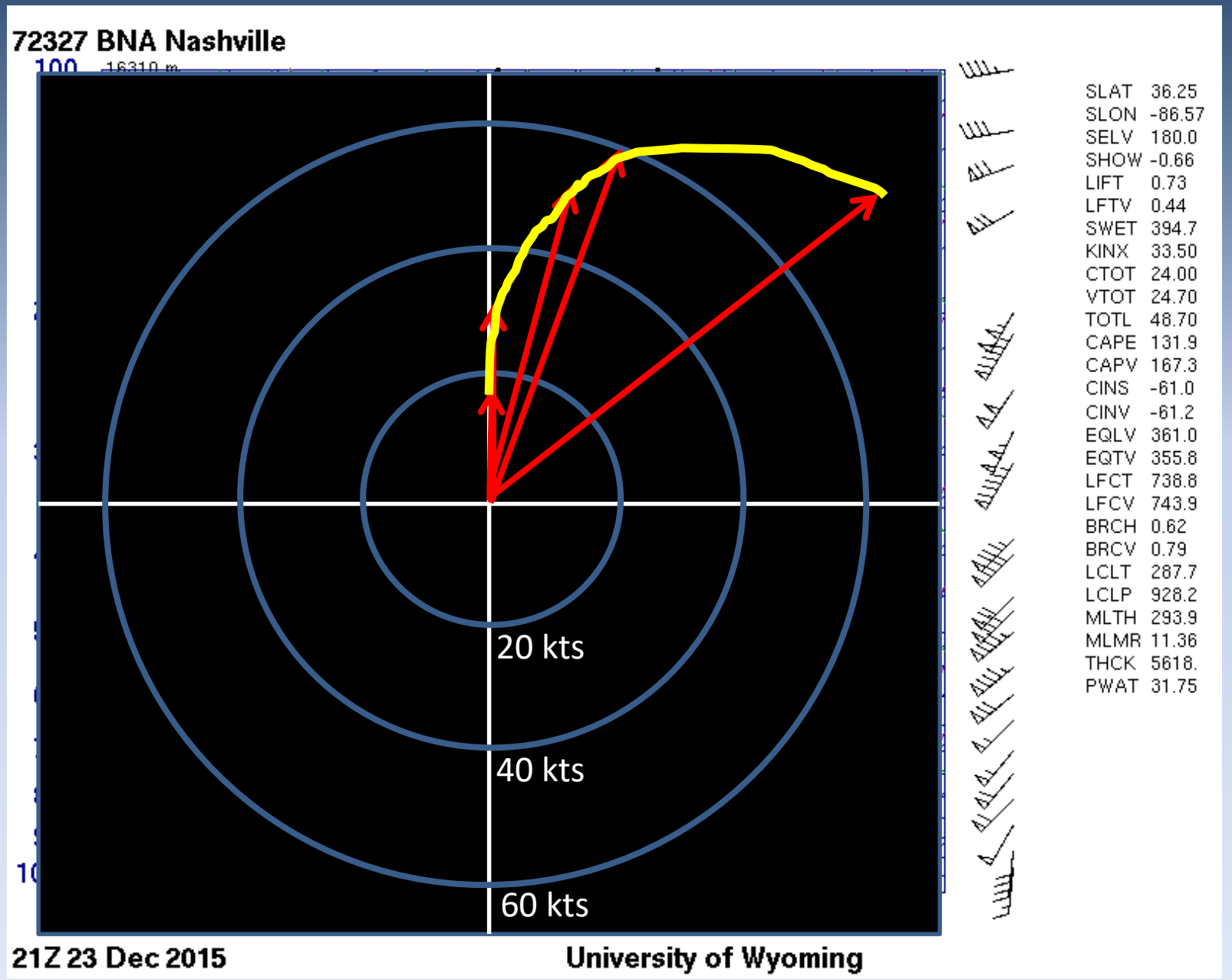
72327 BNA Nashville
16310 m
20 kts
40 kts
60 kts
SLAT 36.25
SLON -86.57
SELV 180.0
SHOW -0.66
LIFT 0.73
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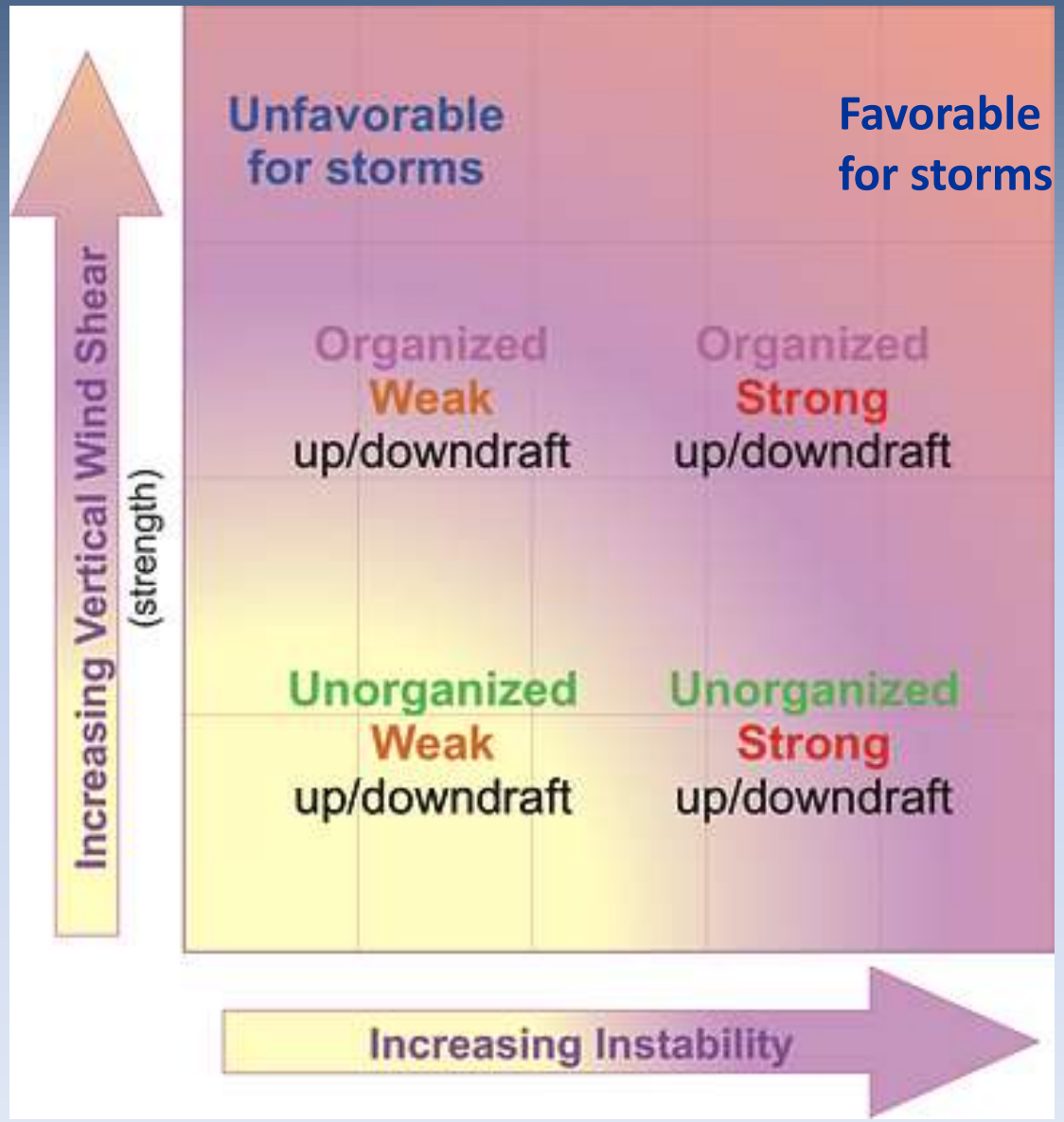
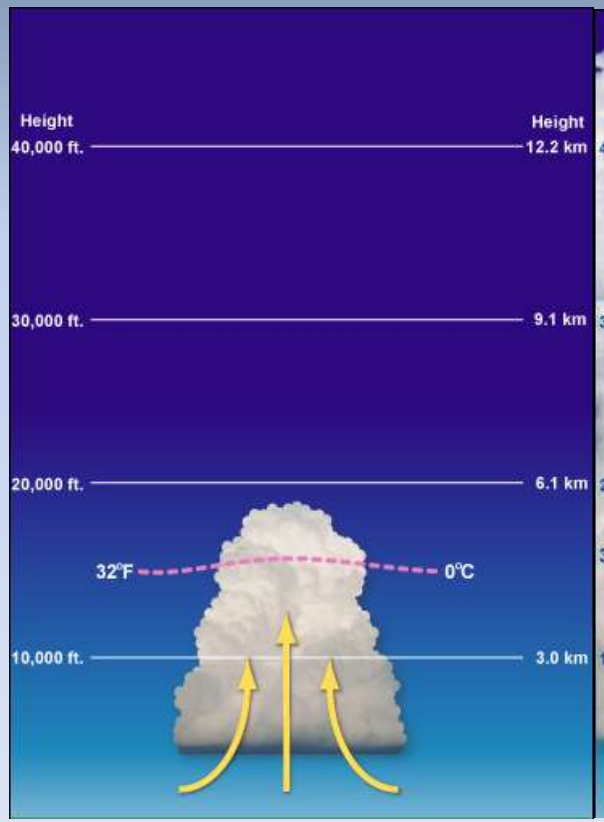
BRCH 0.62
BRCV 0.79
LCLT 287.7
LCLP 928.2
MLTH 293.9
MLMR 11.36
THCK 5618.
PWAT 31.75
21Z 23 Dec 2015
University of Wyoming

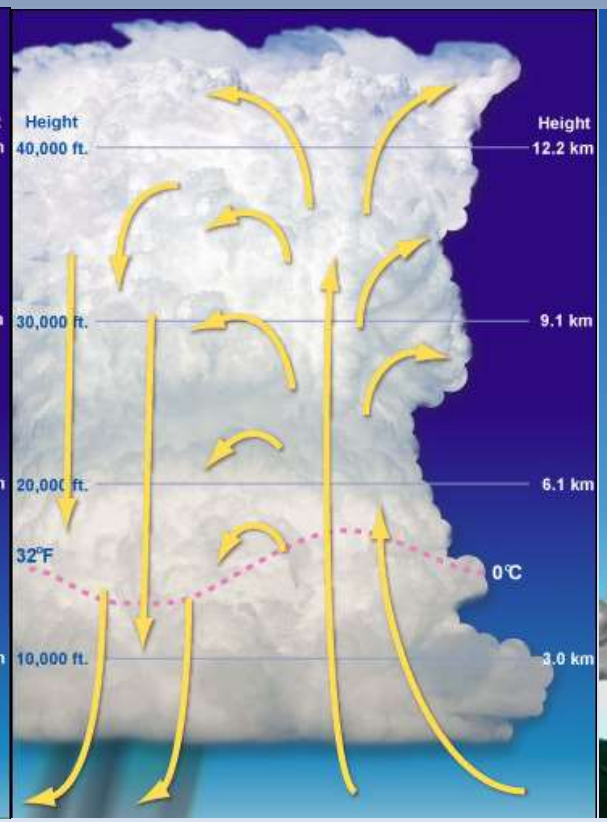
Finding the Perfect Balance
Instability versus Wind Shear

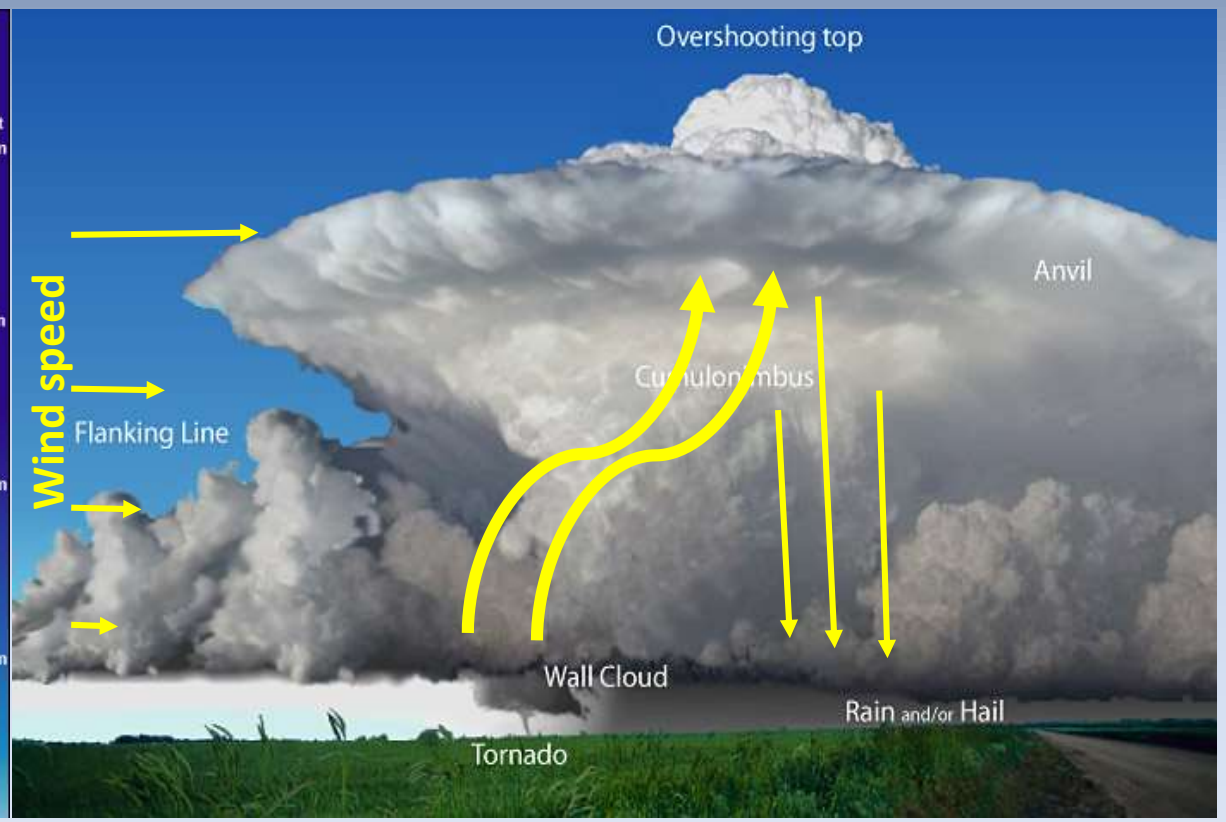


- Finding the perfect balance between instability and wind shear remains a forecast challenge.
- All about the favorable mode of convection.

Shear helps to organize storms







Little to No Shear	Lots of CAPE, Little Shear	Lots of CAPE, Lots of Shear

Case Study

Saturday February 24, 2018

https://www.spc.noaa.gov/exper/archive/event.php?date=20180224

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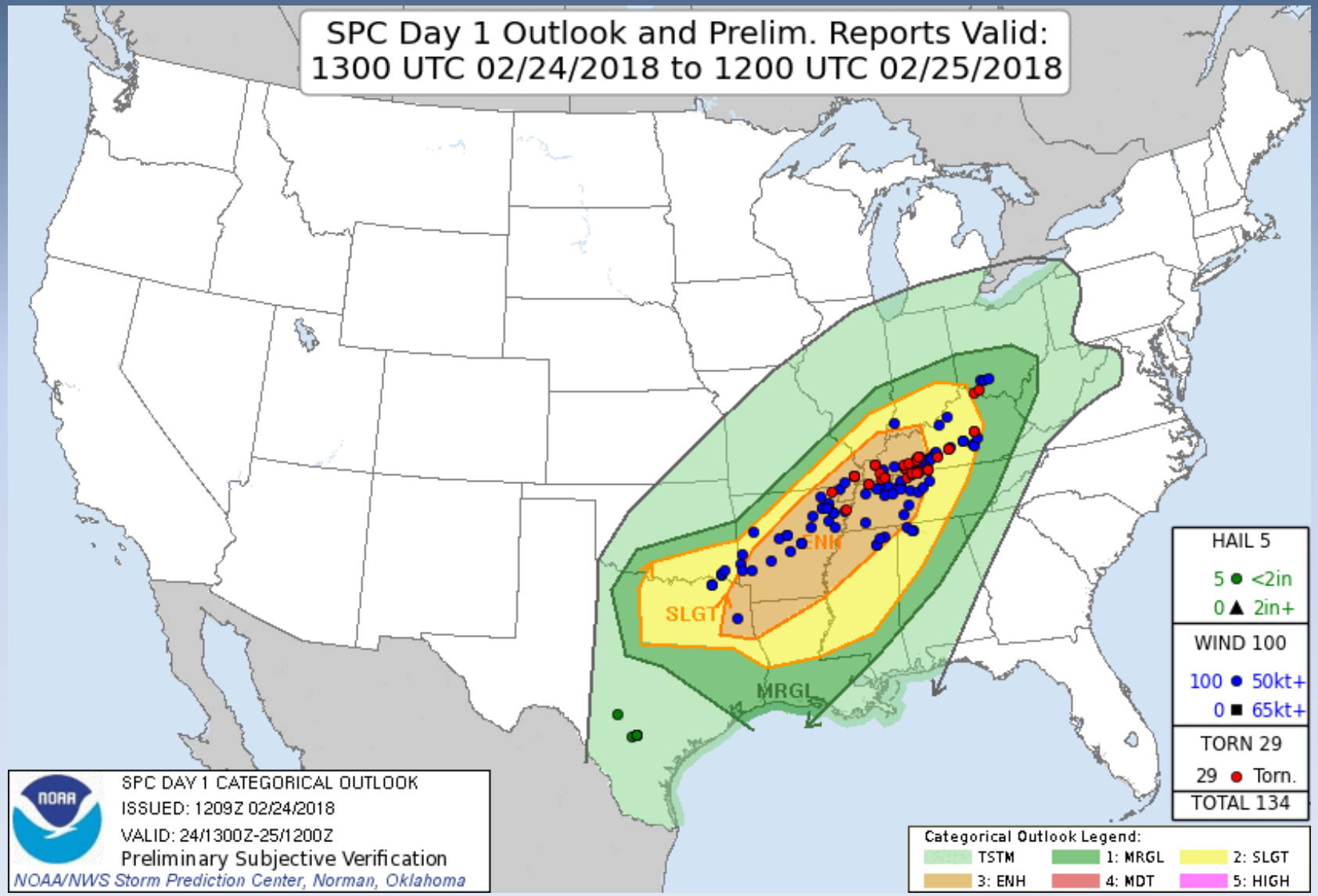
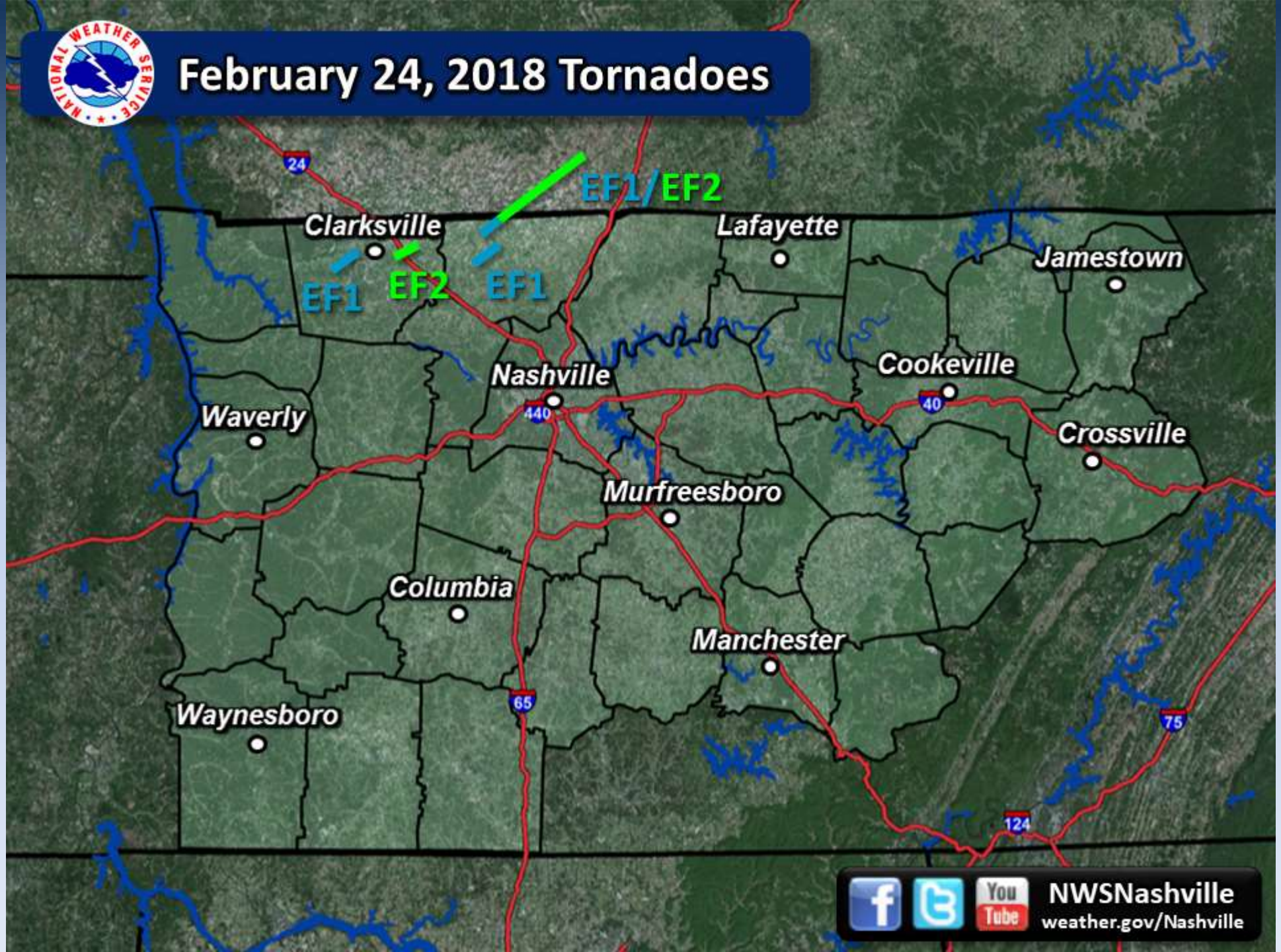

SPC Day 1 Outlook and Prelim. Reports Valid:
1300 UTC 02/24/2018 to 1200 UTC 02/25/2018
ENH
SLGT
MRGL
HAIL 5
5 <2in
0 2in+
WIND 100
100 50kt+
0 65kt+
TORN 29
29 Torn.
TOTAL 134
Categorical Outlook Legend:
TSTM
1: MRGL
2: SLGT
3: ENH
4: MDT
5: HIGH
SPC DAY 1 CATEGORICAL OUTLOOK
ISSUED: 1209Z 02/24/2018
VALID: 24/1300Z-25/1200Z
Preliminary Subjective Verification
NOAA/NWS Storm Prediction Center, Norman, Oklahoma


February 24, 2018 Tornadoes
EF1/EF2
EF1
EF2
EF1
Clarksville
Lafayette
Jamestown
Nashville
Cookeville
Waverly
Crossville
Murfreesboro
Columbia
Manchester
Waynesboro
24
440
40
65
75
124
NWSNashville
weather.gov/Nashville

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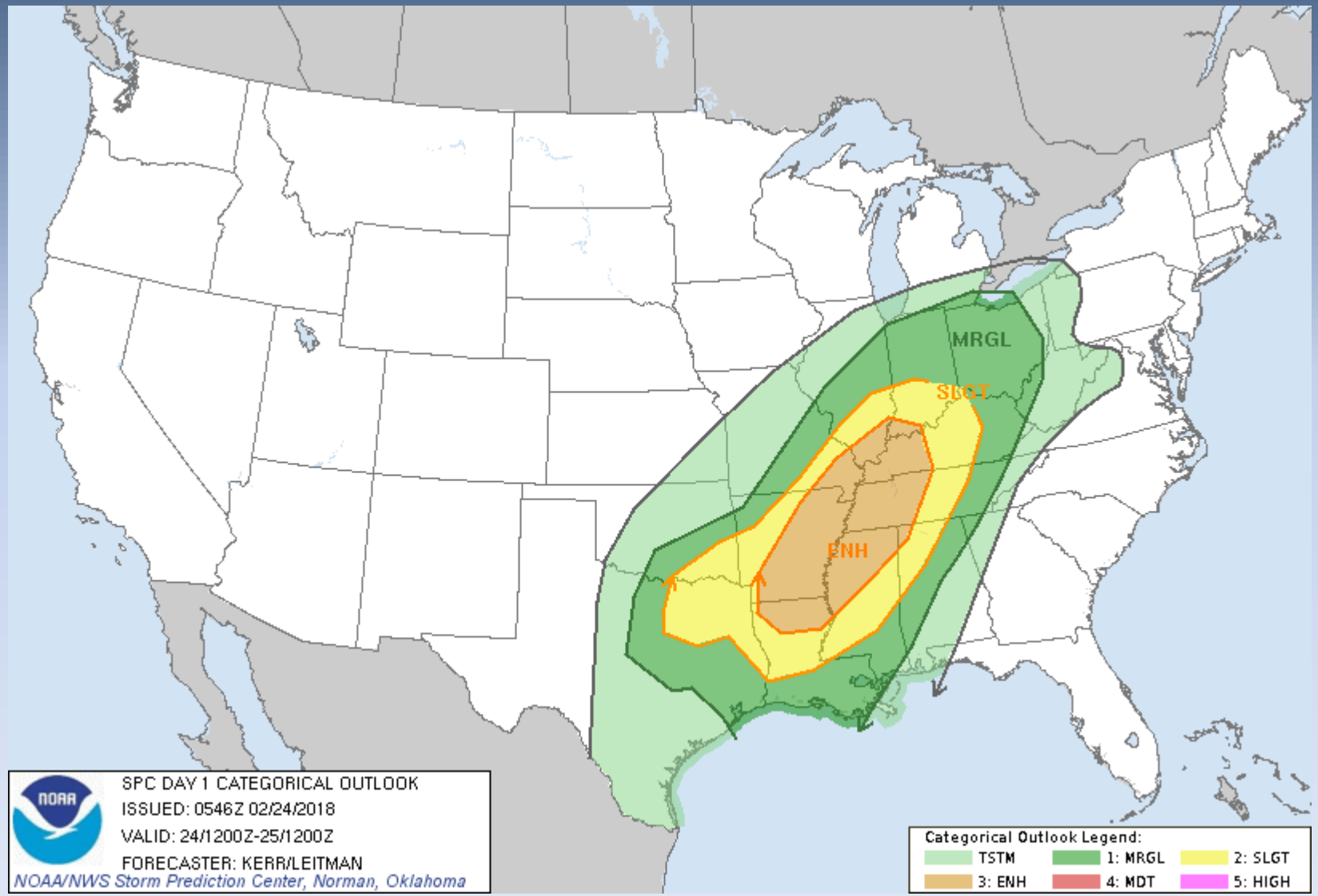
SPC Day 1 Outlook
6 AM 2/24/18



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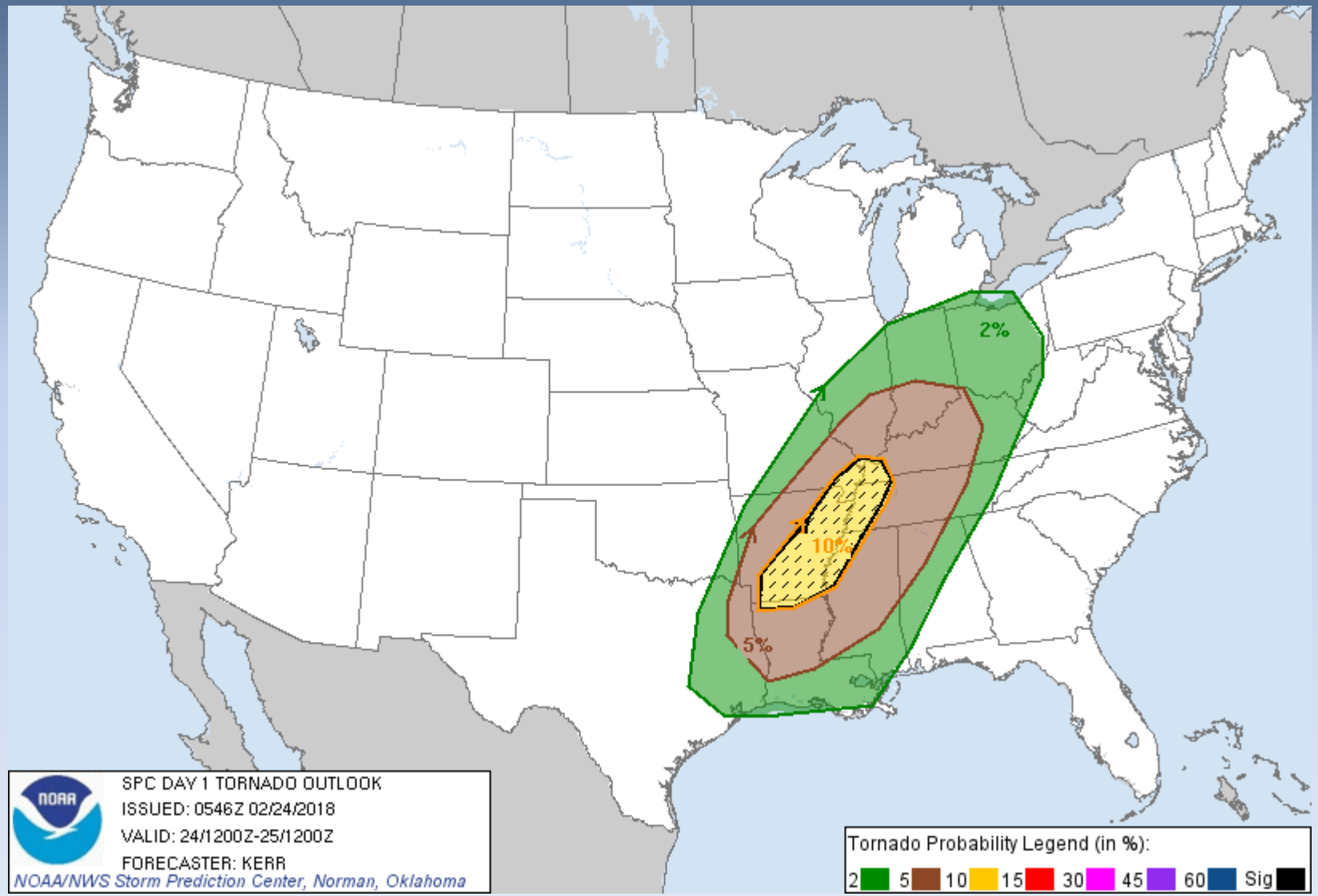
SPC Probabilistic Tornado Graphic
6 AM 2/24/18



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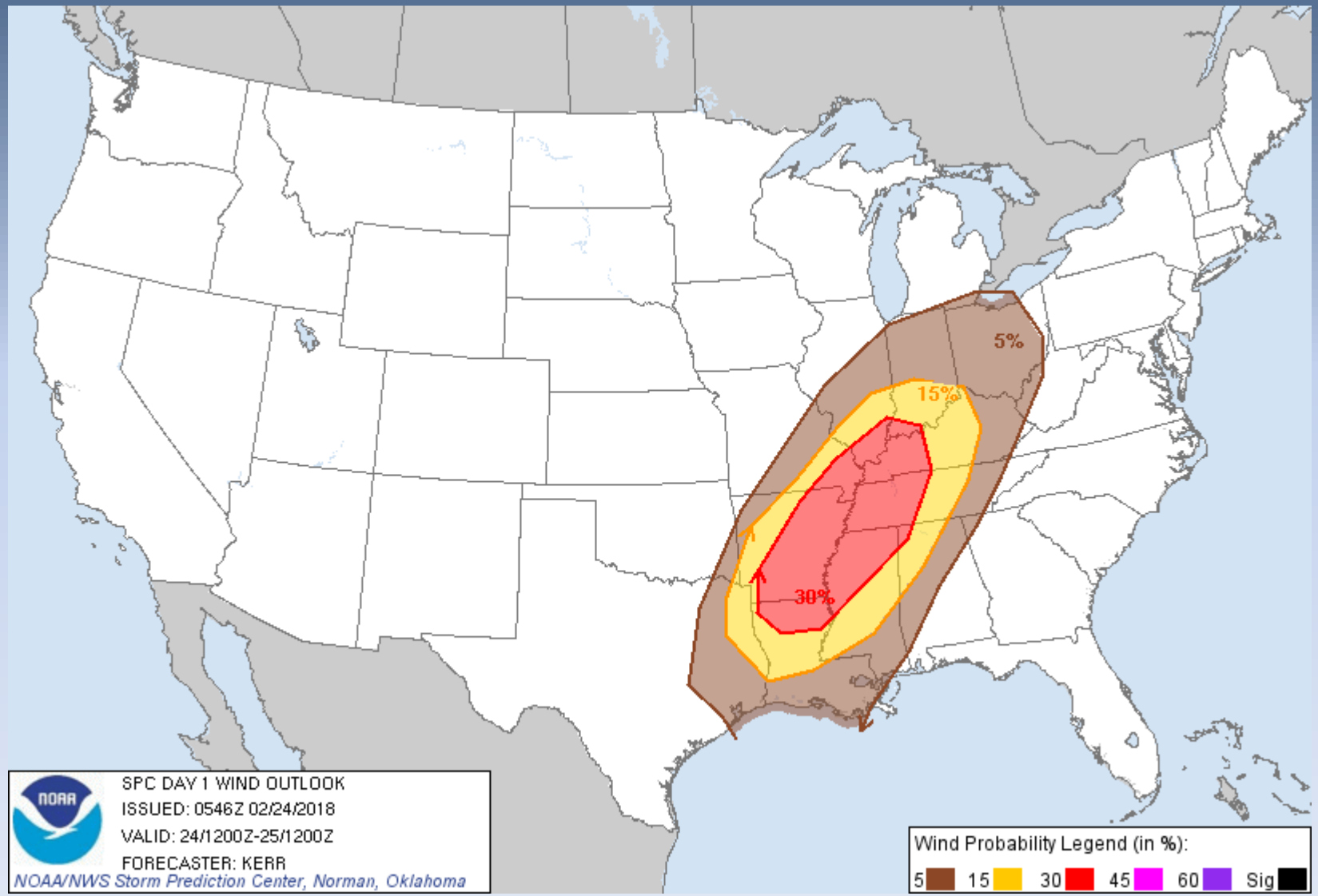
Probabilistic Damaging Wind Graphic
6AM 2/24/18



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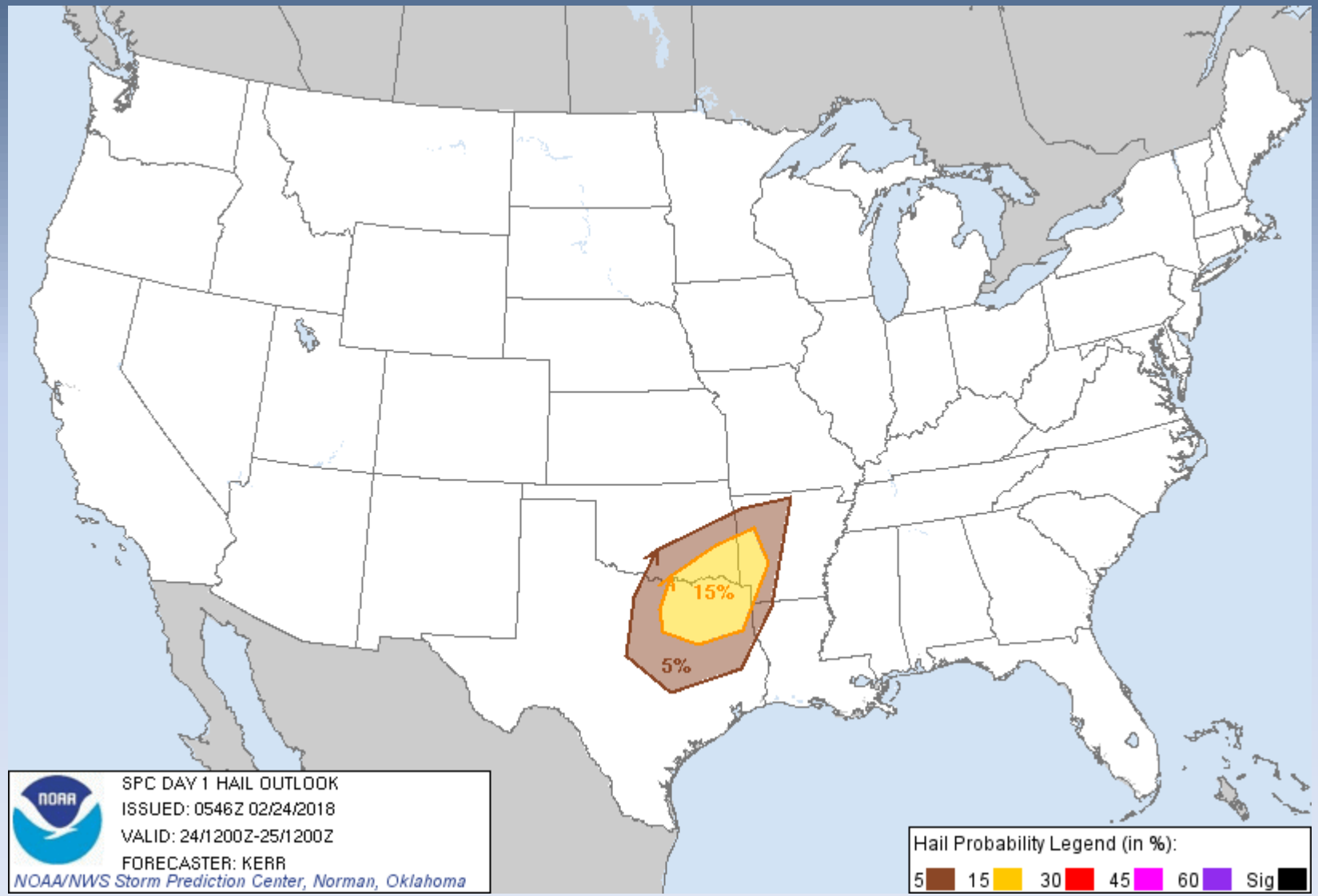
Probabilistic Large Hail Graphic
6 AM 2/24/18



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According to SPC our main threats were Damaging Winds & Tornadoes

Our Large Hail threat was low

Now, let's look at why…

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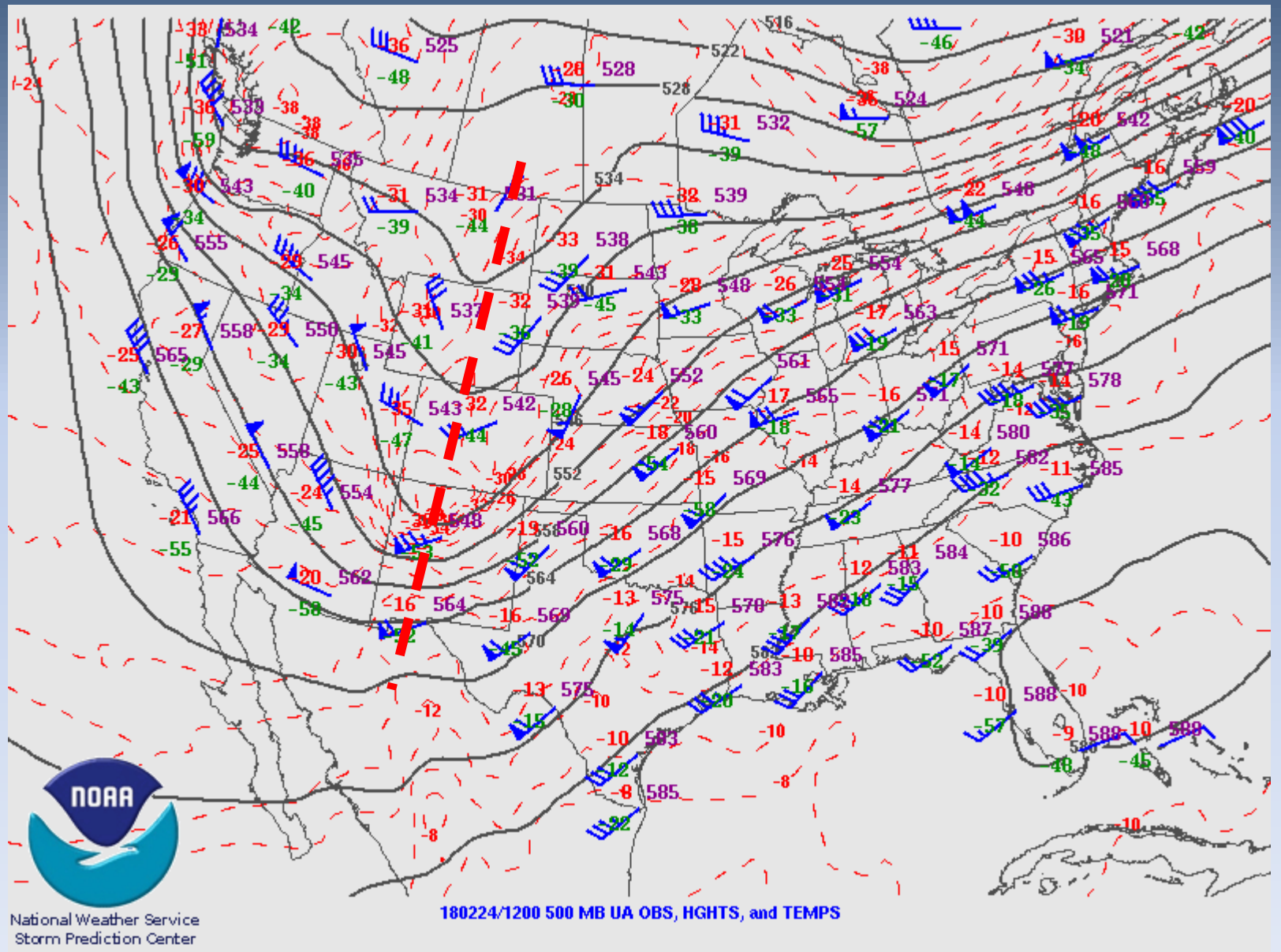
500 mb Heights 6 AM 2/24/18



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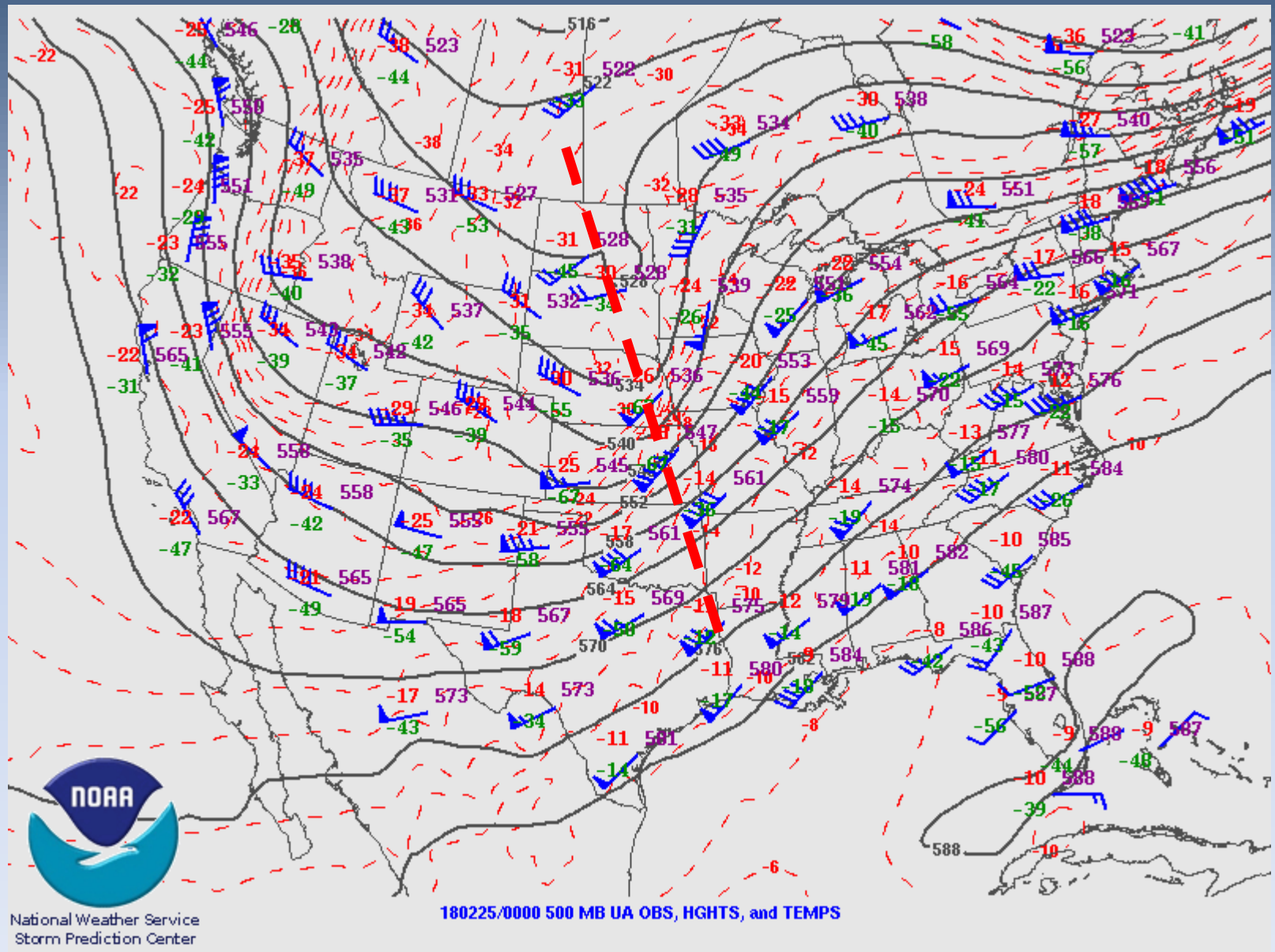
500 mb Heights 6 PM 2/24/18



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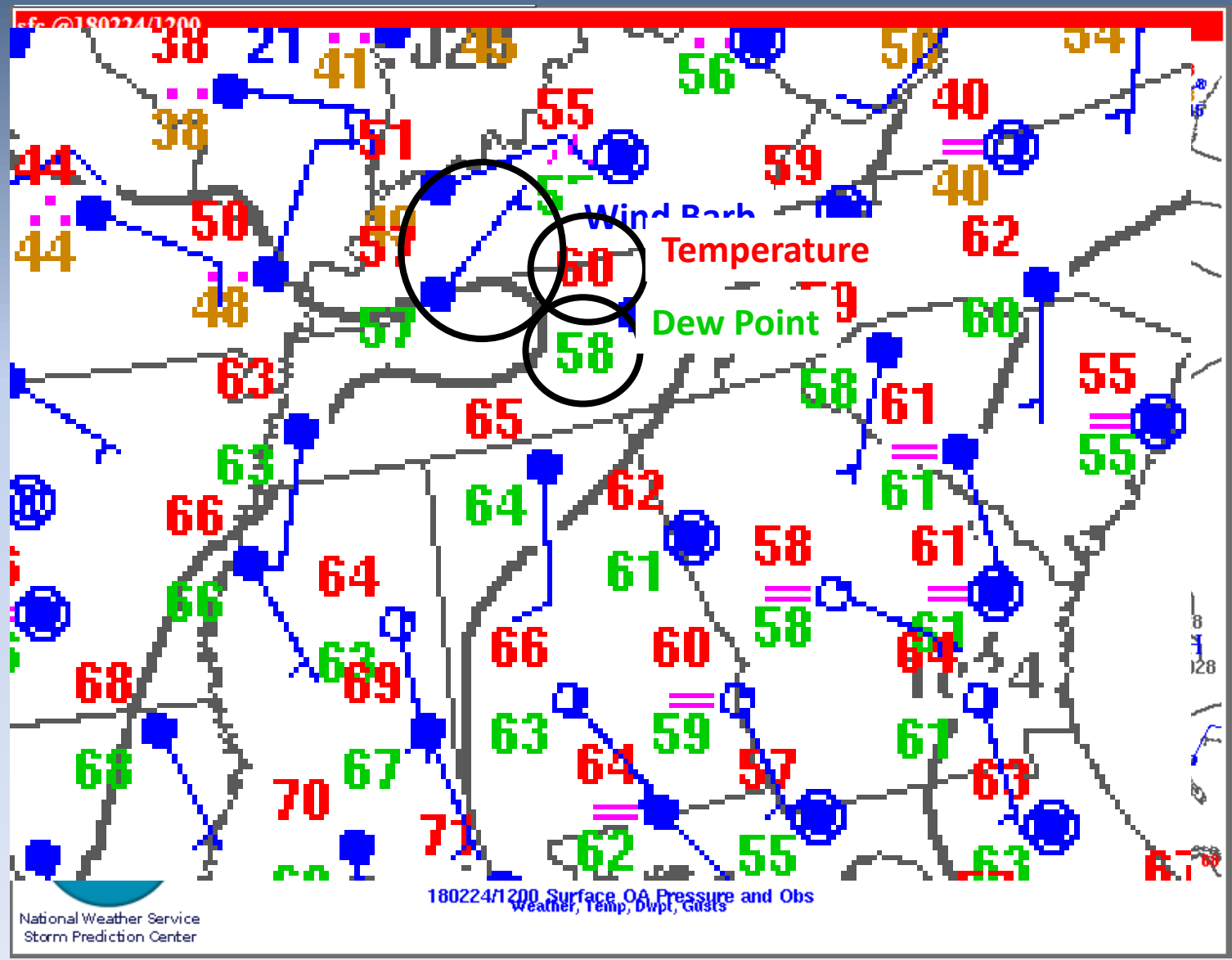
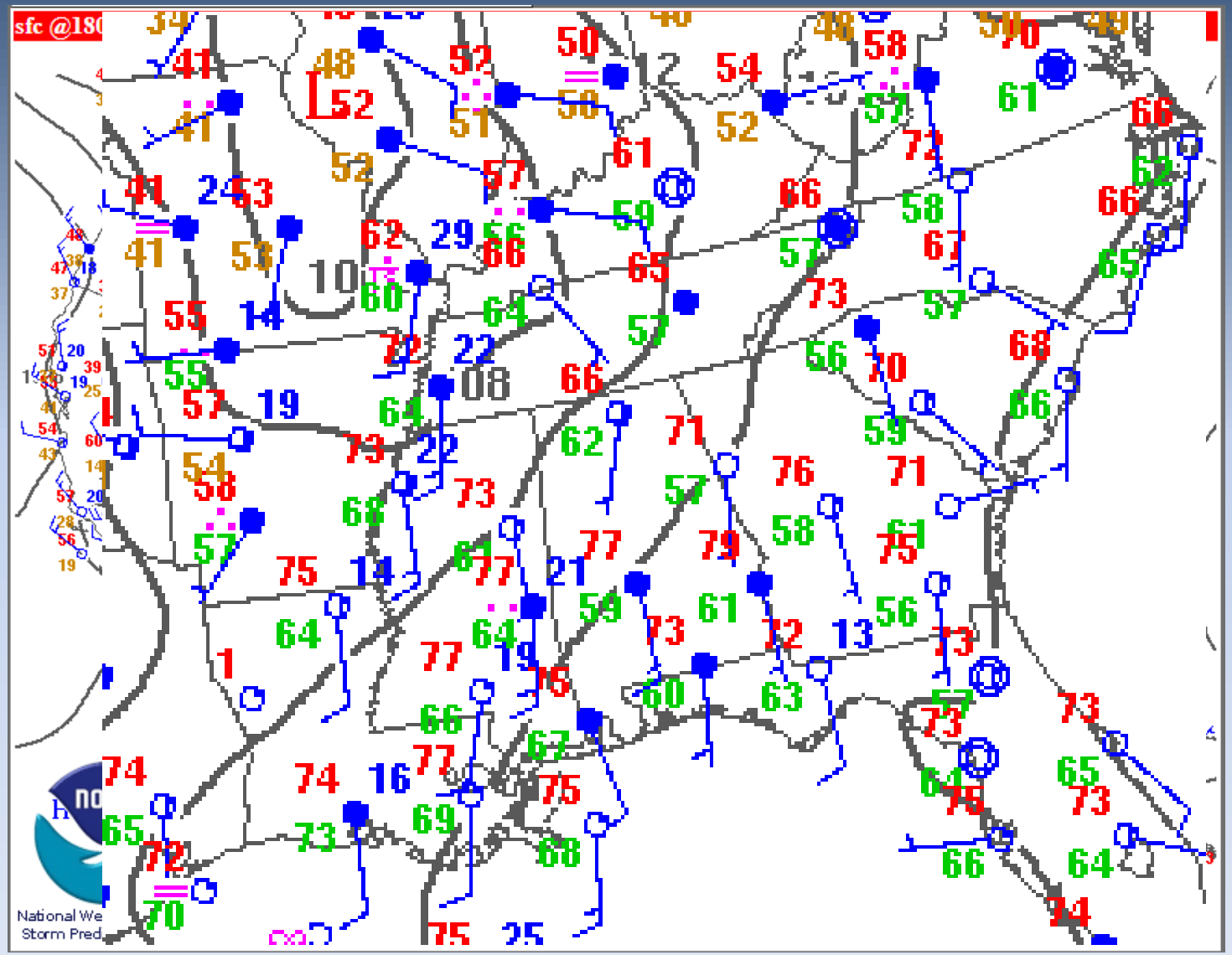
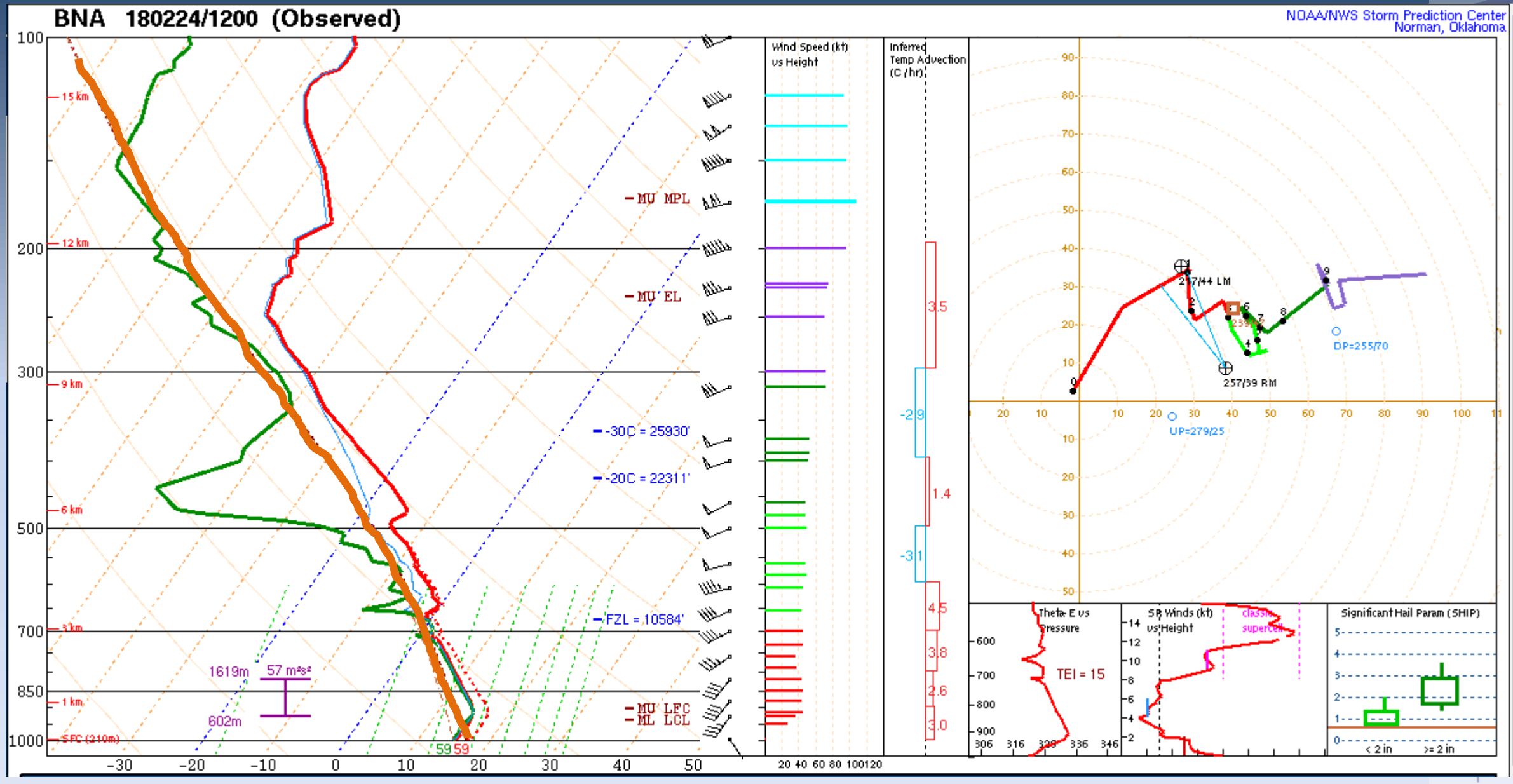
Surface Analysis 6 AM



Surface Analysis 6 PM



Weather101


BNA 180224/1200 (Observed)
NOAA/NWS Storm Prediction Center
Norman, Oklahoma
MU MPL
MU EL
-30C = 25930'
-20C = 22311'
FZL = 10584'
MU LFC
ML LCL
1619m
57 m²s²
602m
SFC (210m)
Wind Speed (kt) vs Height
Inferred Temp Advection (C/hr)
3.5
-2.9
1.4
-3.1
4.5
3.8
2.6
3.0
257/44 LM
257/39 RM
DP=255/70
UP=279/25
Theta-E vs Pressure
TEI = 15
SR Winds (kt) vs Height
Significant Hail Param (SHIP)
< 2 in
>= 2 in

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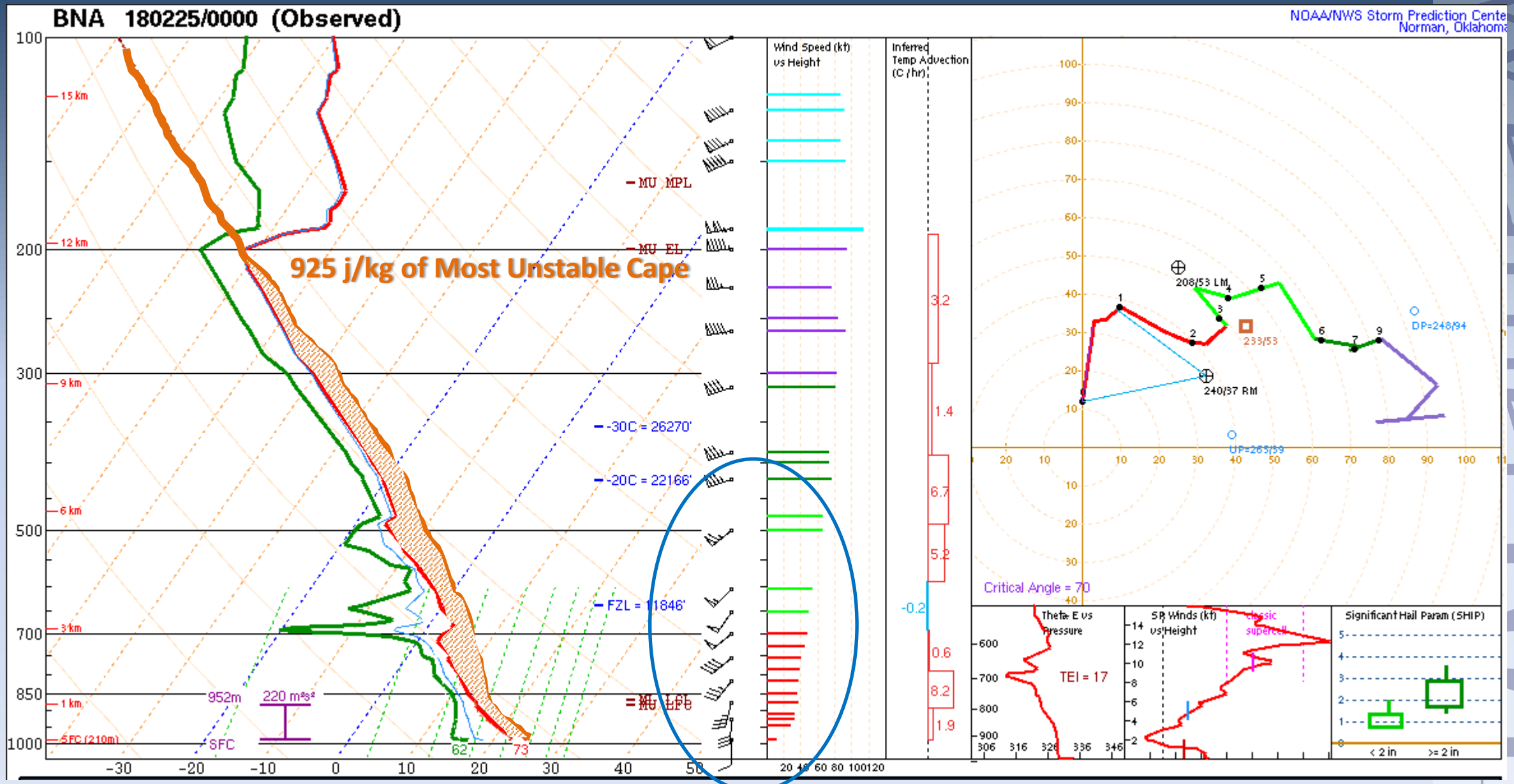
BNA 180225/0000 (Observed)
NOAA/NWS Storm Prediction Center
Norman, Oklahoma
925 j/kg of Most Unstable Cape
MU MPL
MU EL
-30C = 26270'
-20C = 22166'
FZL = 11846'
MU LCL
MU LFC
952m
220 m²s²
SFC
62
73
Wind Speed (kt) vs Height
Inferred Temp Advection (C/hr)
3.2
1.4
6.7
5.2
-0.2
0.6
8.2
1.9
208/53 LM
233/53
240/37 RM
DP=248/94
UP=265/59
Critical Angle = 70
Theta-E vs Pressure
TEI = 17
SR Winds (kt) vs Height
Classic supercell
Significant Hail Param (SHIP)
< 2 in
>= 2 in

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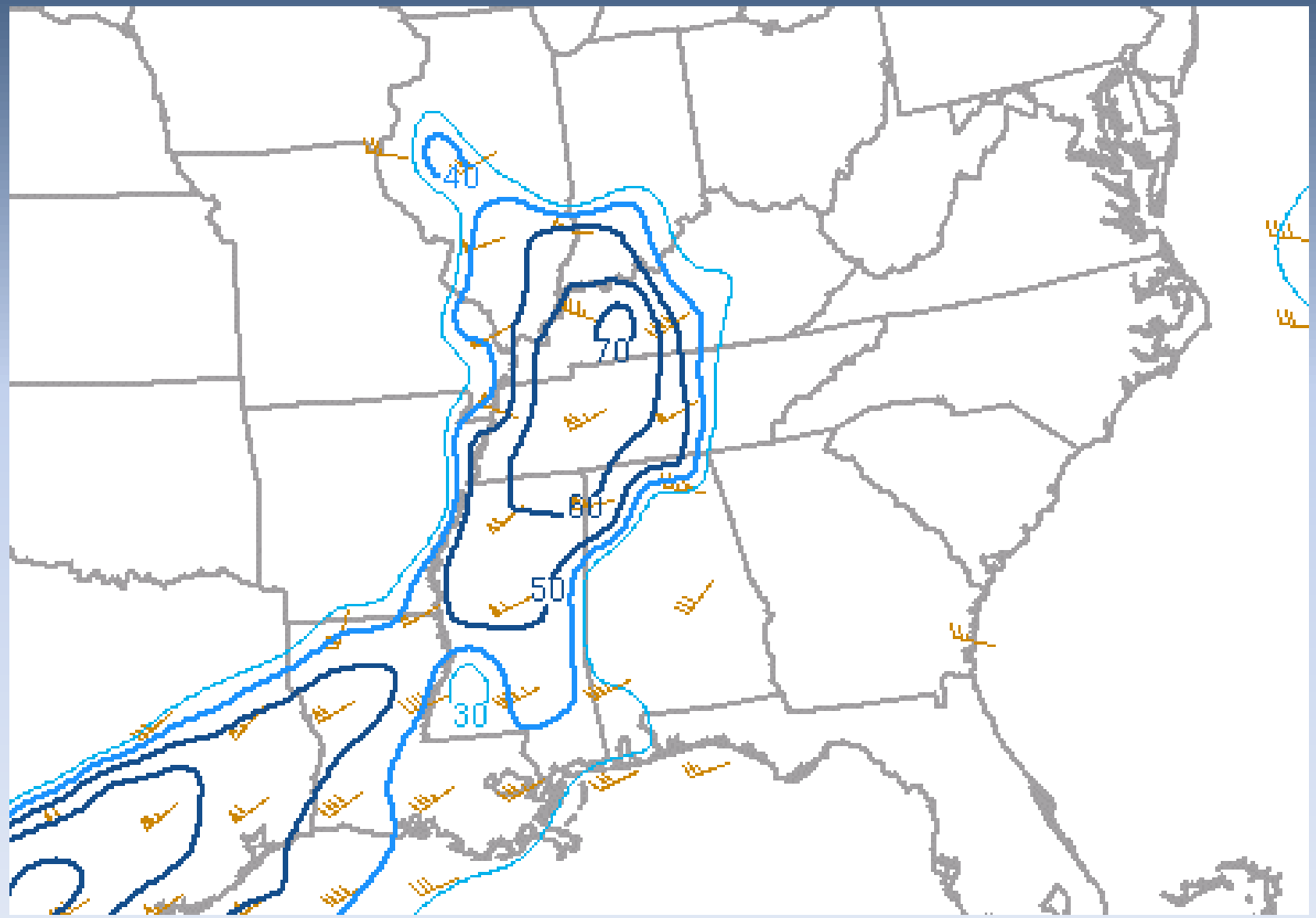
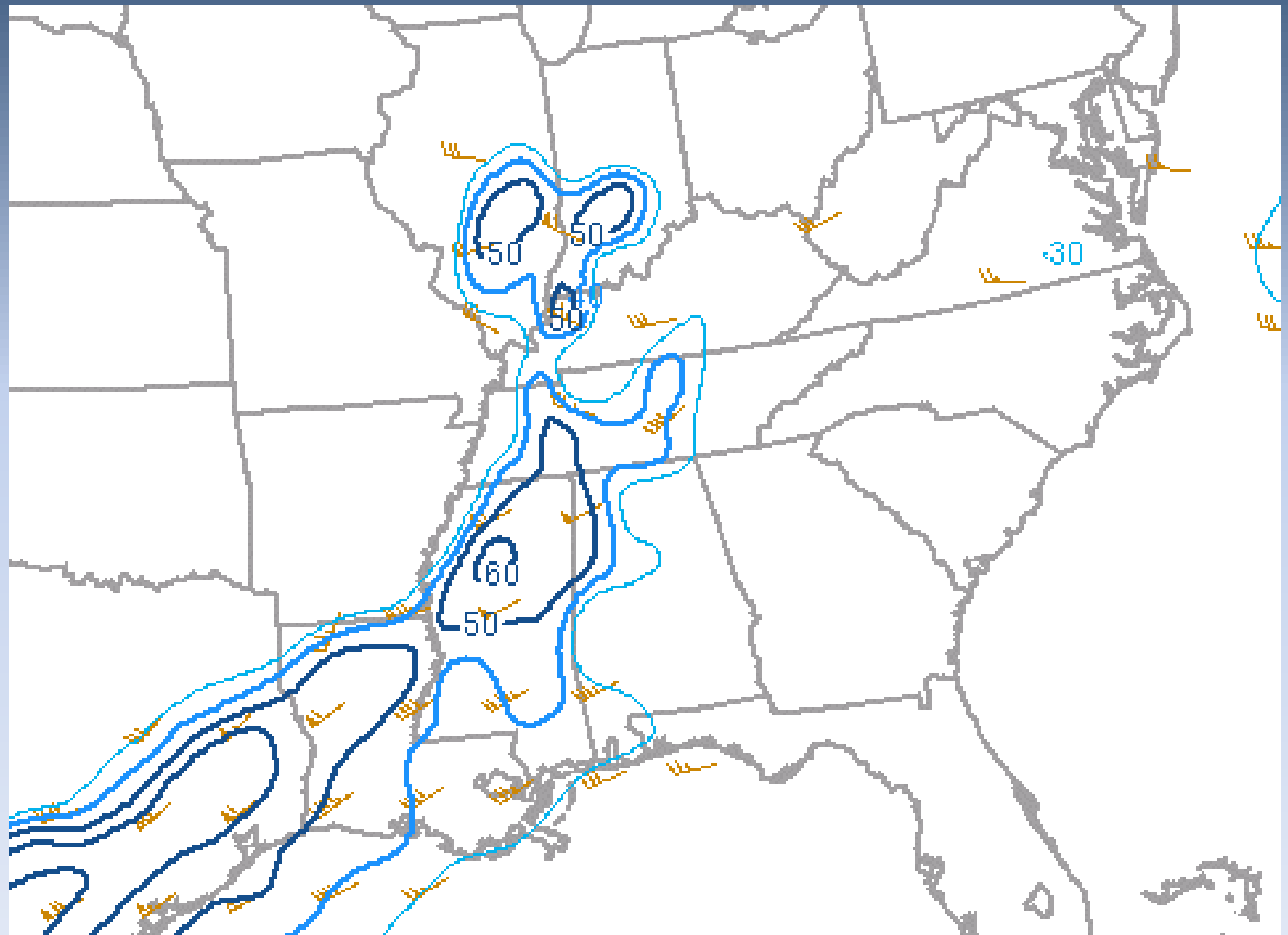
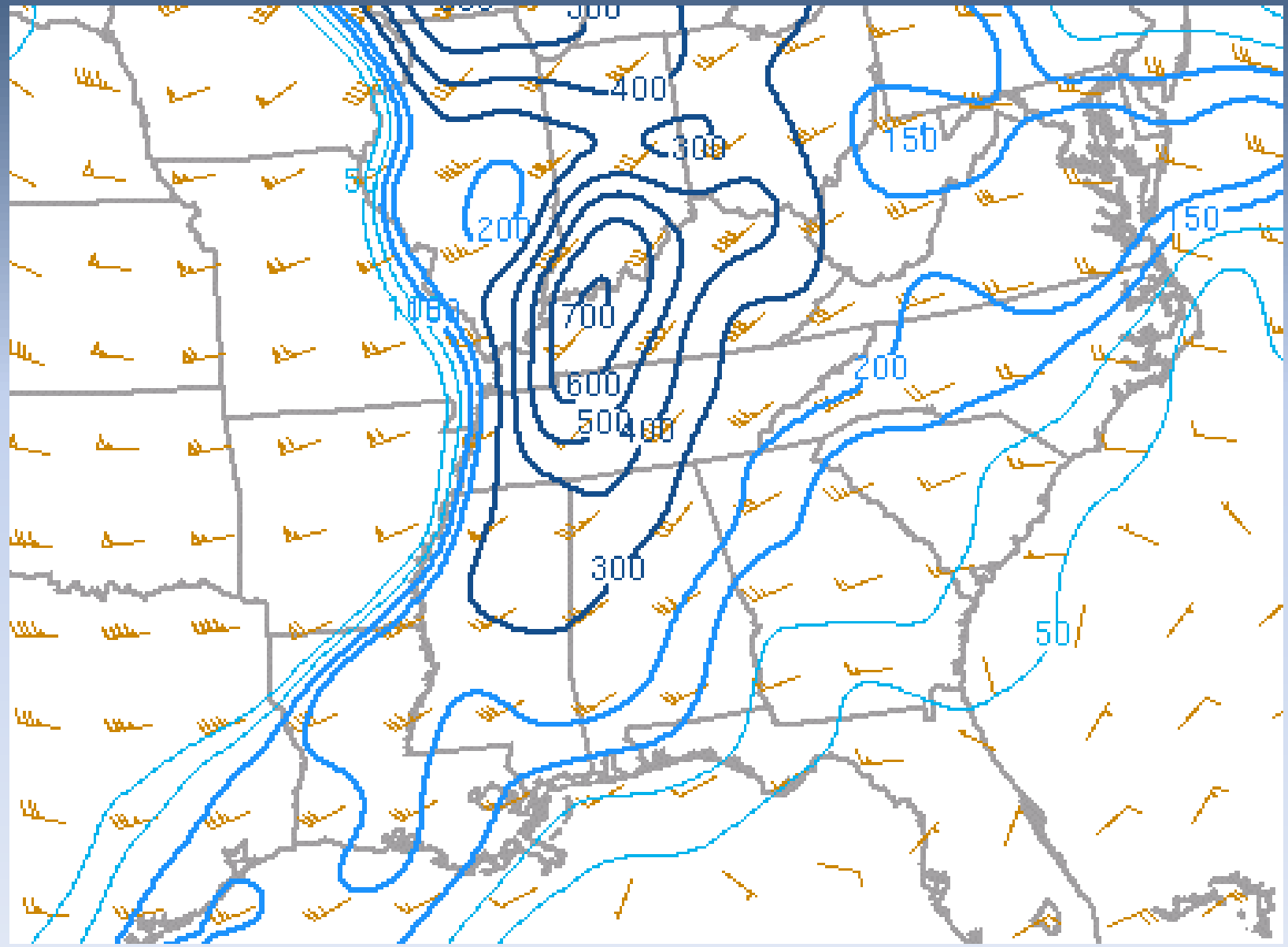
Effective Bulk Shear at 8 PM



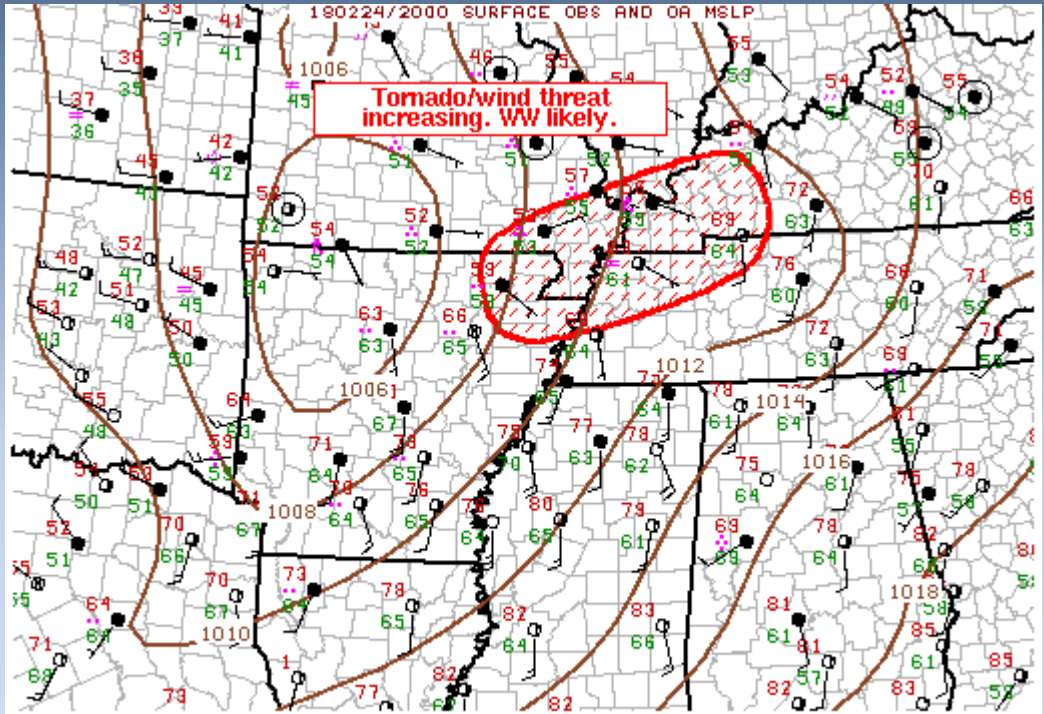
Effective Bulk Shear at 9 PM



0-1km Storm Relative Helicity 9PM



Mesoscale Discussion 2pm



SPC MCD #0091

Probability of Watch Issuance...80 percent

SUMMARY...Tornado threat will increase across northeast AR into western KY/TN into the early evening hours. Tornado watch will likely be issued soon.

DISCUSSION...Surface low continues to track east-northeast across northern AR along a slowly advancing warm front that currently is draped from western KY into northern AR north of BVX. 20z sounding from LZK exhibits a very moist and adequately buoyant sounding for robust deep convection, with very strong shear, supportive of supercells and organized line segments. This environment is gradually spreading northeast and supercell/tornado threat should increase toward the confluence of the MS/OH River region over the next several hours. Tornado watch appears warranted for this evolution and will likely be issued soon.

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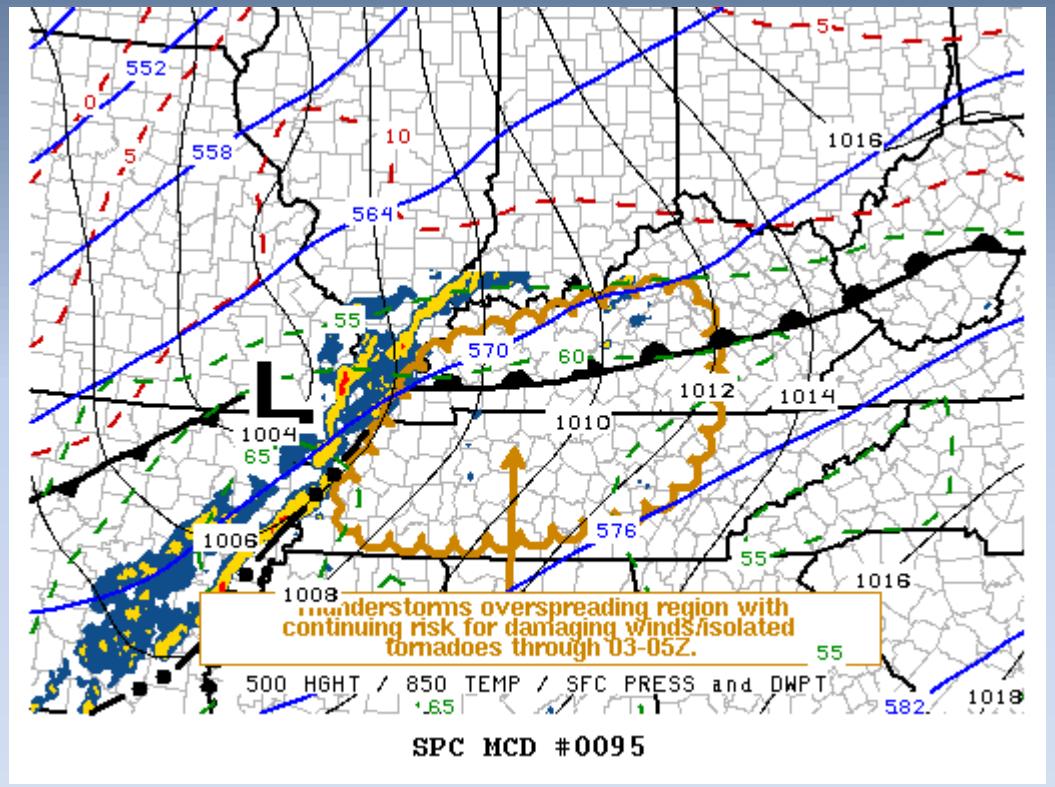
Mesoscale Discussion 6:40 PM



SPC MCD #0095

The severe weather threat for Tornado Watch 5 continues.

SUMMARY...The risk for damaging wind gusts and isolated tornadoes is expected to continue with thunderstorms overspreading western into central Kentucky and Tennessee through 9-11 PM CDT. A new tornado watch will probably be needed prior to the 03Z scheduled expiration of tornado watch 5.

DISCUSSION...While the primary surface low development begins to take shape across portions of the Upper Midwest, the southern edge of elongated deepening surface troughing extending to the south is forecast to shift east of the Mississippi River into central Kentucky and middle Tennessee between now and 03-05Z. This is where large-scale forcing for ascent is maintaining vigorous convective development, along and just south of a slow moving warm frontal zone. In the presence of at least weak conditional instability, and strong to extreme low-level shear near a 50-70 kt 850 mb speed maximum, this may continue to support the evolution of low-level mesocyclones within stronger convection, accompanied by locally enhanced, damaging wind gusts and perhaps a couple of additional tornadoes.

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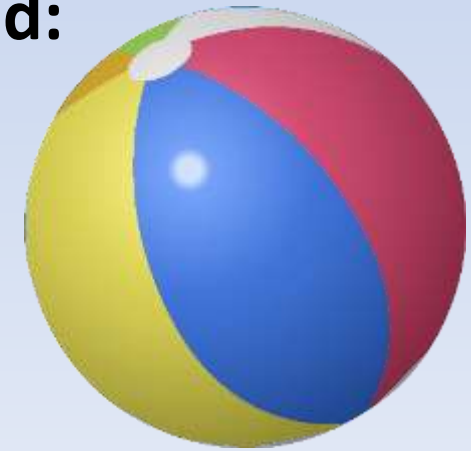
What is needed for Severe Storms?

General **thunderstorms need:**

- ❑Lift
- ❑Instability
- ❑Moisture

Severe **thunderstorms need:**

- ❑MORE Instability
- ❑Wind Shear



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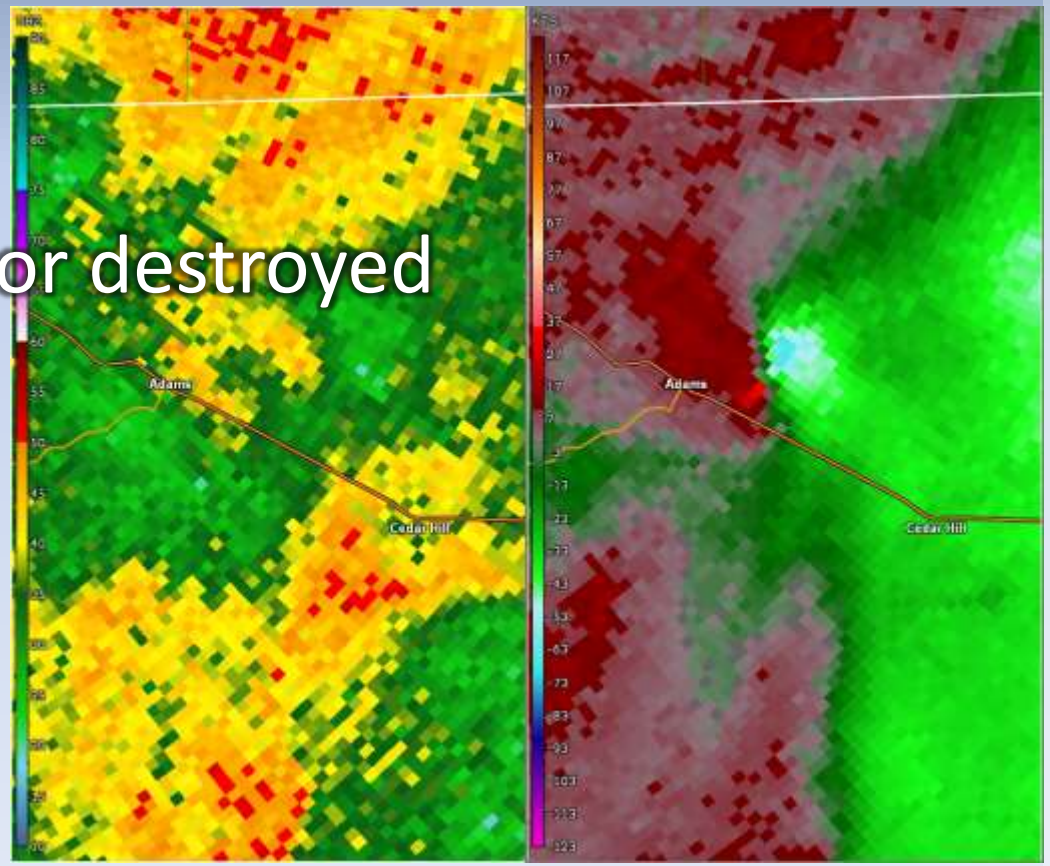
Event Overview for Middle Tennessee

- Low CAPE/ High Shear event
- 2 EF2 Tornadoes
- 2 EF1 Tornadoes
- 2 Injuries
- Numerous houses damaged or destroyed



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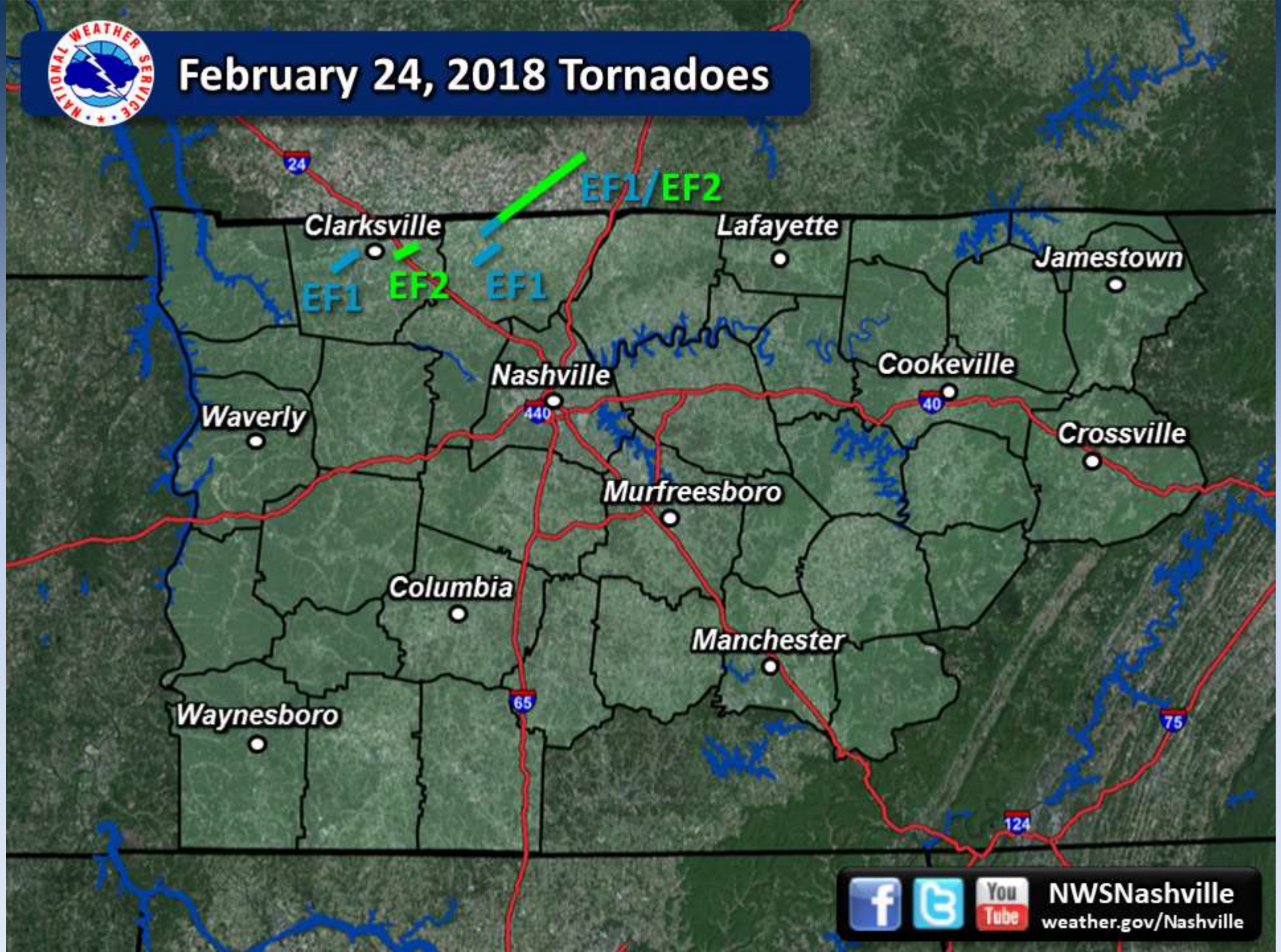
February 24, 2018 Tornadoes
EF1/EF2
EF1
EF2
EF1
Clarksville
Lafayette
Jamestown
Nashville
Cookeville
Waverly
Crossville
Murfreesboro
Columbia
Manchester
Waynesboro
24
440
40
65
75
124
NWSNashville
weather.gov/Nashville

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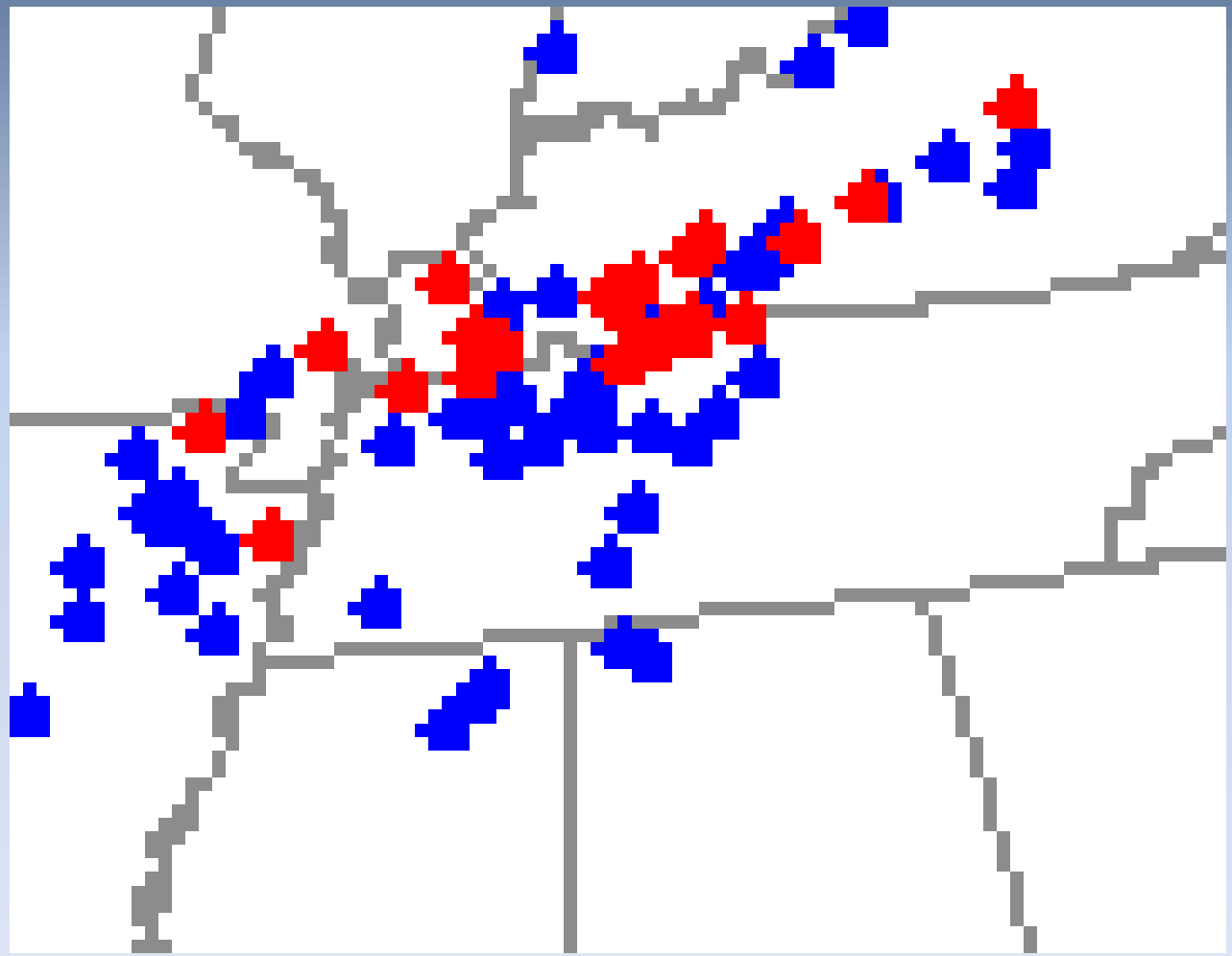
Damage



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Enjoy this class?

Join one of our online or in person Spotter Classes this Fall.

https://www.weather.gov/ohx/skywarn

Also, come to KenTenn on Saturday, November 3rd in Hopkinsville, KY

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