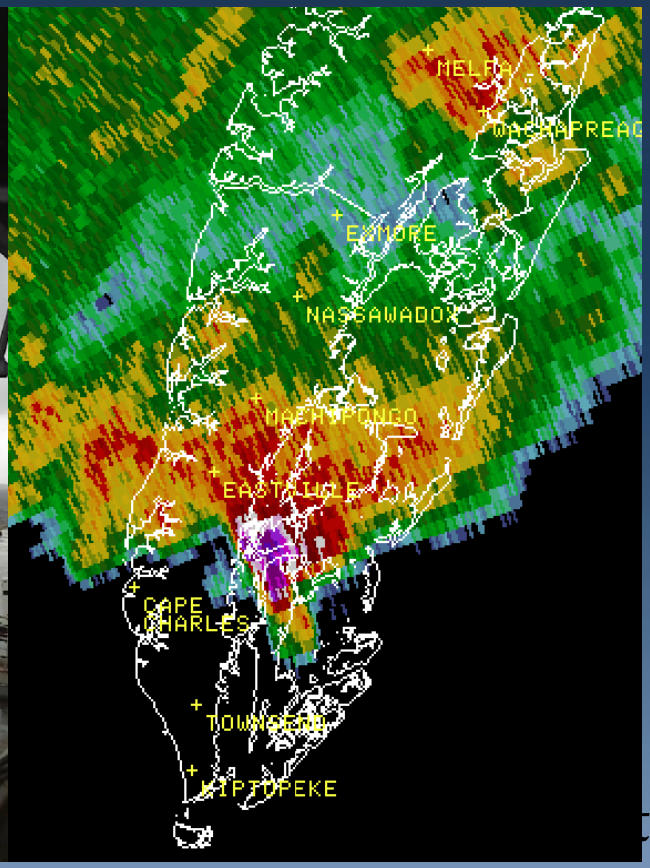
Advanced SKYWARN 2020



National Weather Service – Wakefield, VA

Website: www.weather.gov/Wakefield Twitter: @NWSWakefieldVA

Facebook: http://www.facebook.com/NWSWakefieldVA

Advanced SKYWARN

Today's Course Outline:

- In Review: NWS mission, "What to report" / Spotting tips
- Advanced weather concepts
- Instability versus Wind Shear – Finding the perfect balance. How do you arrive at the mode of convection in the forecast?
  - "The 'why' of what you observe when storm spotting"
- Radar Signatures
- Dual-Polarization Radar Concepts

The NWS Mission

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy.

NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community.

A REVIEW OF WHAT TO REPORT …

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What Info Are We Looking For?

What Makes a Storm Severe?

SEVERE THUNDERSTORM WARNING
POTENTIAL OF __ OCCURRING, OR OBSERVED

- Wind gusts of 58 mph or greater, and/or
- Hail 1 inch or more in diameter

TORNADO WARNING
POTENTIAL OF __ OCCURRING, OR OBSERVED

- A tornado
  -Tornadic storms can also produce damaging straight-line winds and large hail

What Makes a Good Report?

Answer 3 Basic Questions:

1) What Happened? … Type and Magnitude of the Event

2) When did it happen?… Also, event duration.

3). Where did it happen? … Location Referenced to City/Town, Portion of County, Major Intersection

Note: Lat/Lon info is GREAT…but not needed!

Problems Spotters Encounter

- Limited Visibility due to blockage by trees, hills, buildings, etc.
- Understanding the "big picture" of what is going on around them.
- Mobile access to radar data/Apps (improving)
- Judging distances to wind and weather phenomena… generally underestimated.

Synoptic Weather Patterns
“The Big Picture”

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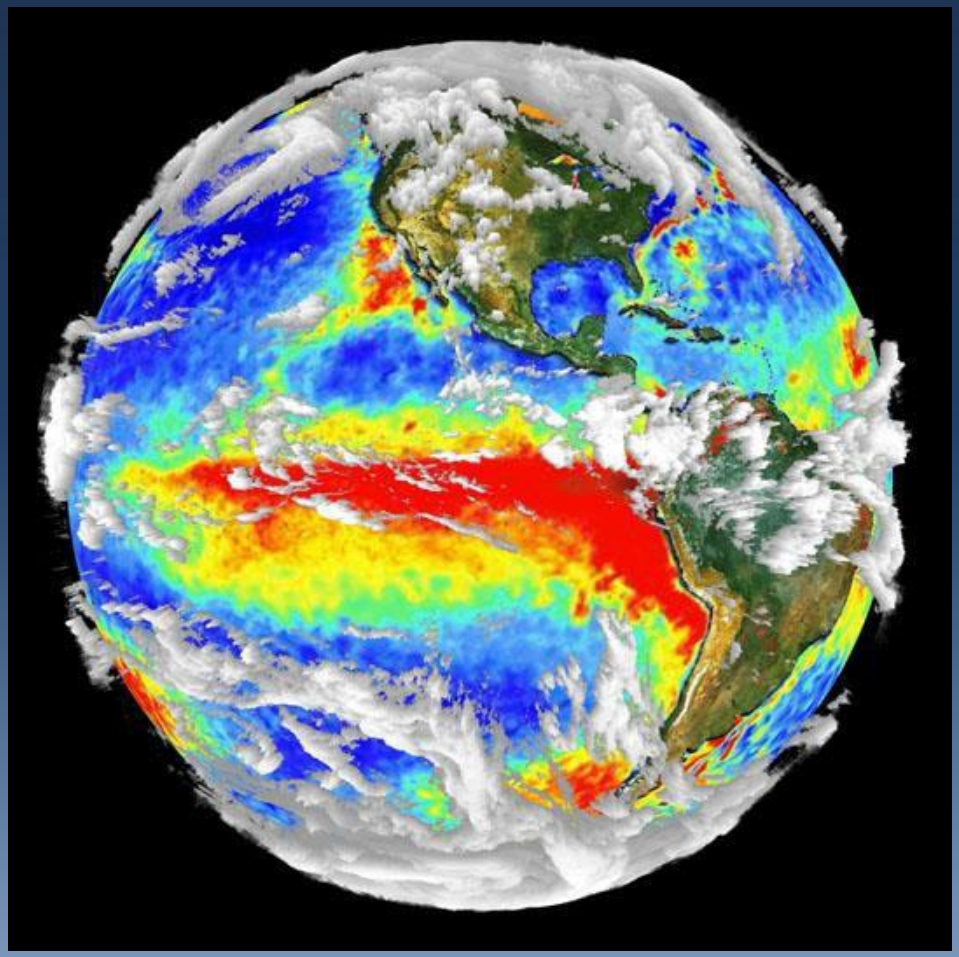
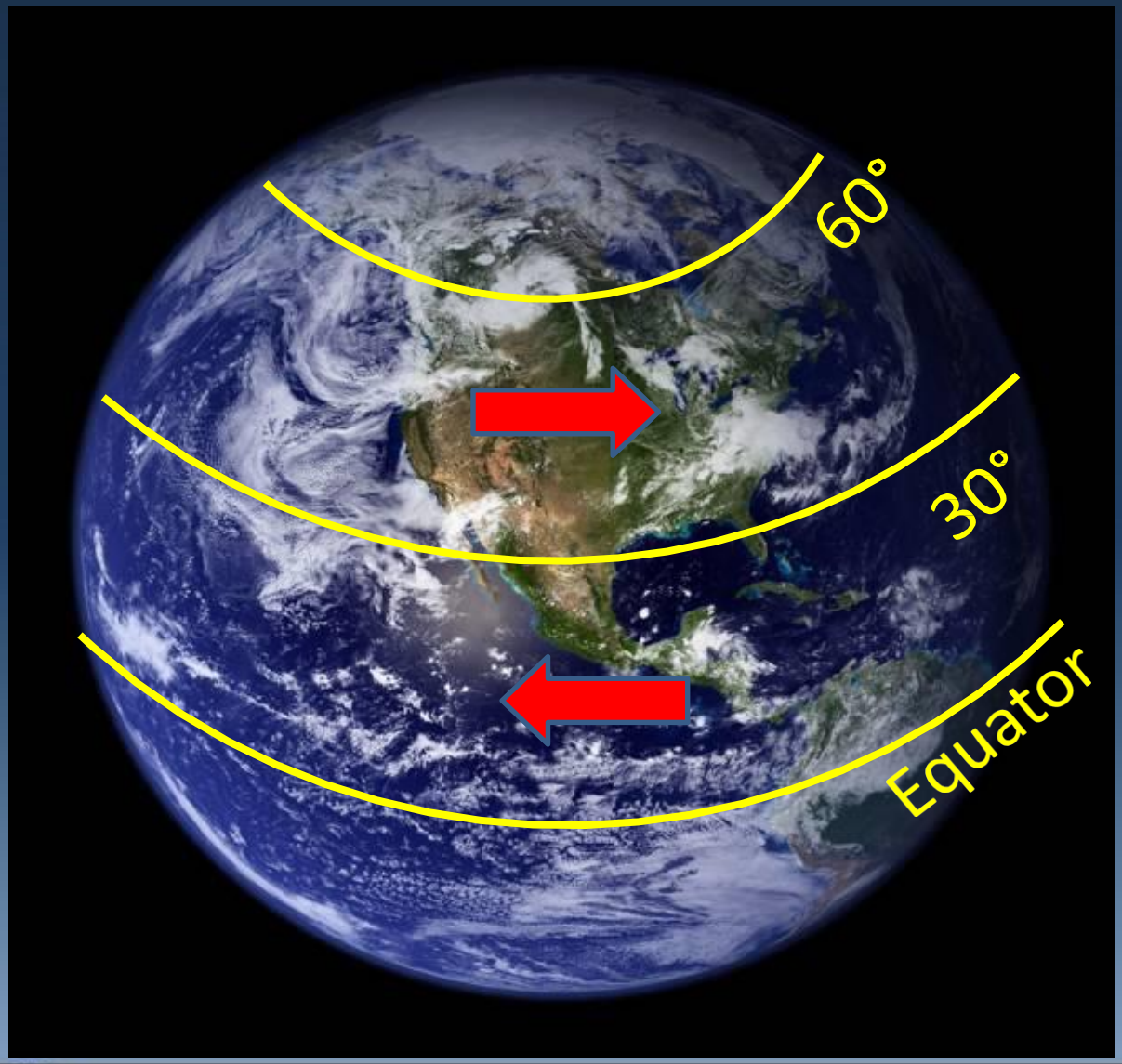
The Atmosphere



Large to Small Scale

- Global (Largest)
- Synoptic (Large)
- Mesoscale (Small)

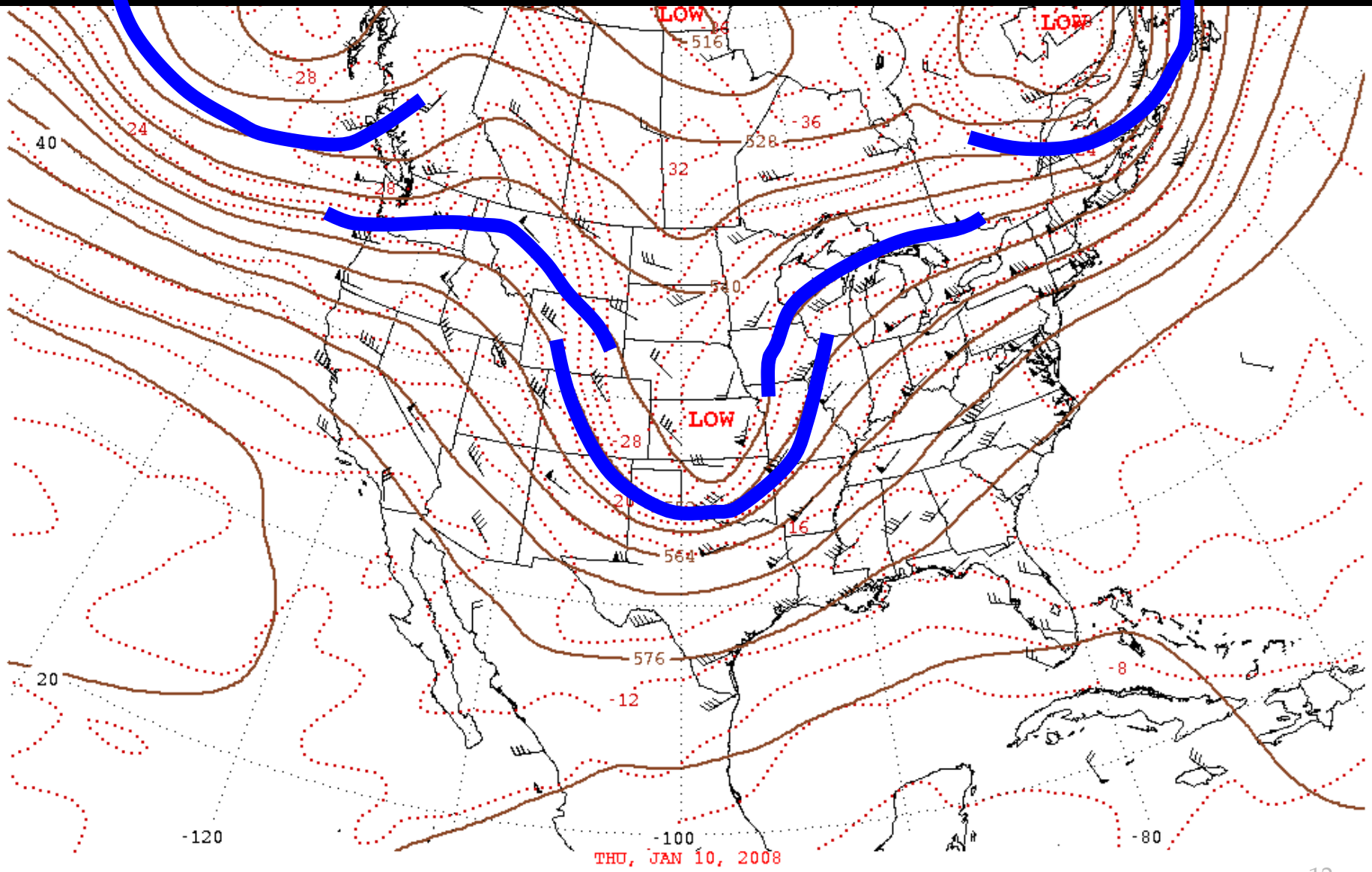
Global Weather Patterns



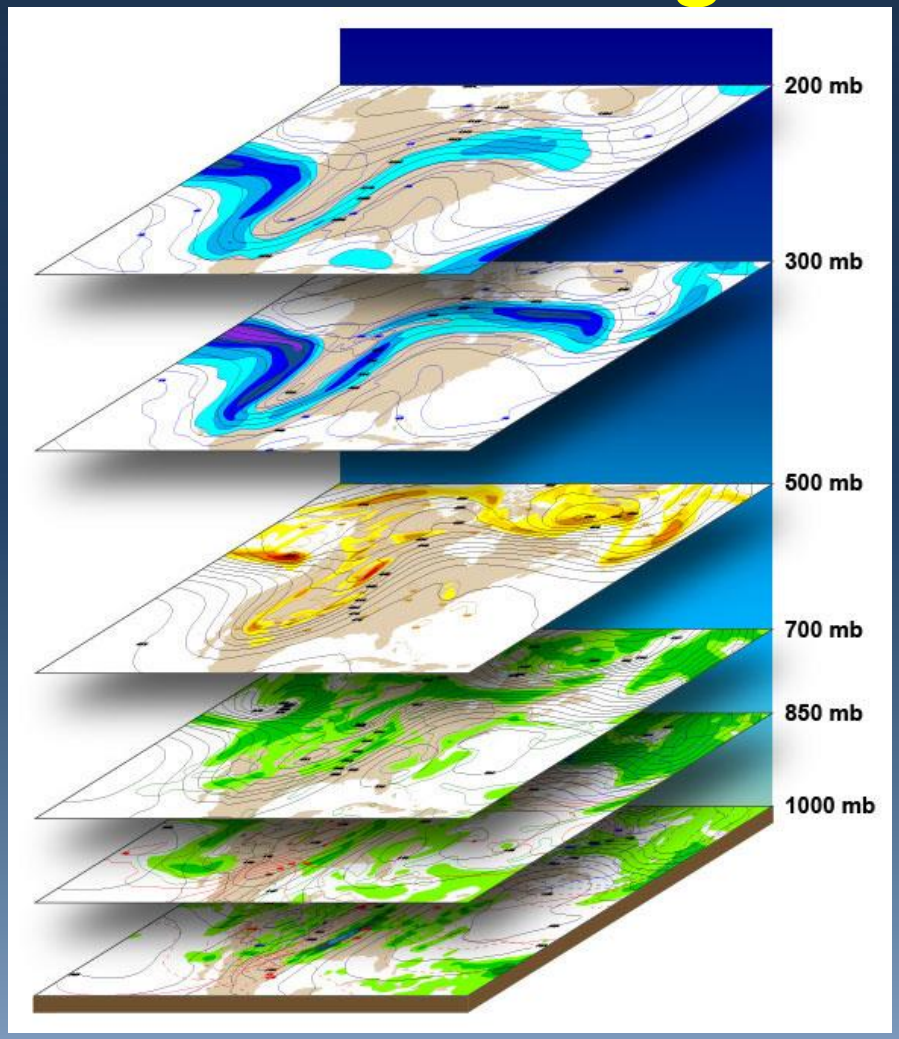
Westerlies vs. Easterlies

- Most of our weather comes from the west
- Hurricanes come from the east

Synoptic Weather Patterns



Synoptic Weather Patterns: Thinking in 3-D

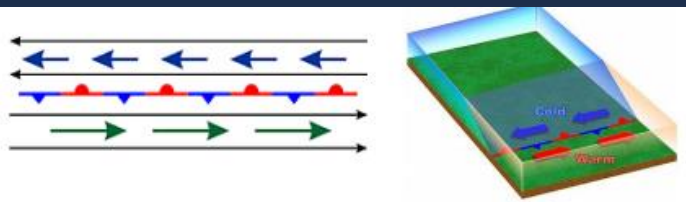


40,000 ft / 12, 000 m

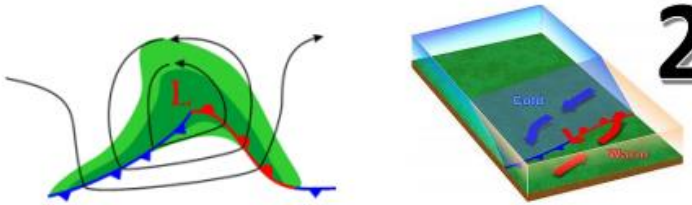
18,000 ft / 5,500 m

5,000 ft / 1,500 m

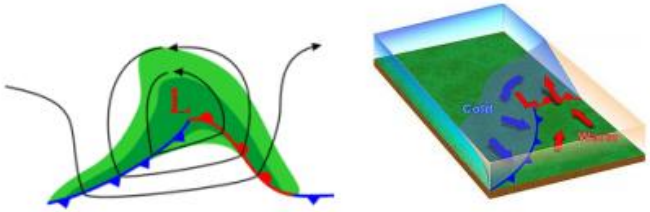
Mean Sea Level (MSL)



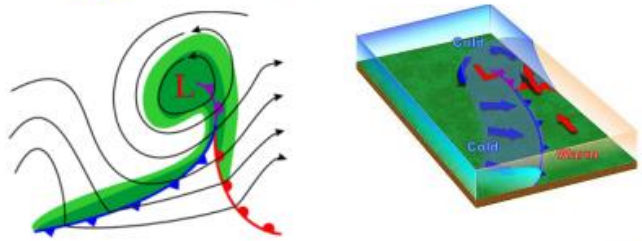
1 Boundary between warm, cooler air



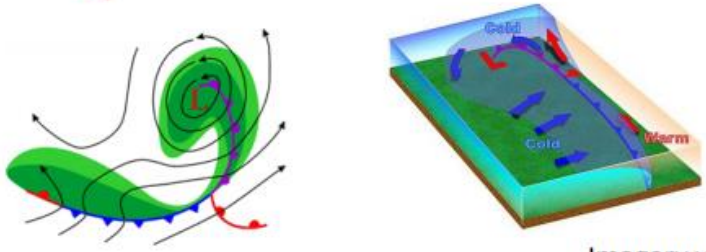
2 With upper-level impulse, surface wave forms; precipitation develops



3 Wave intensifies, fronts become better organized



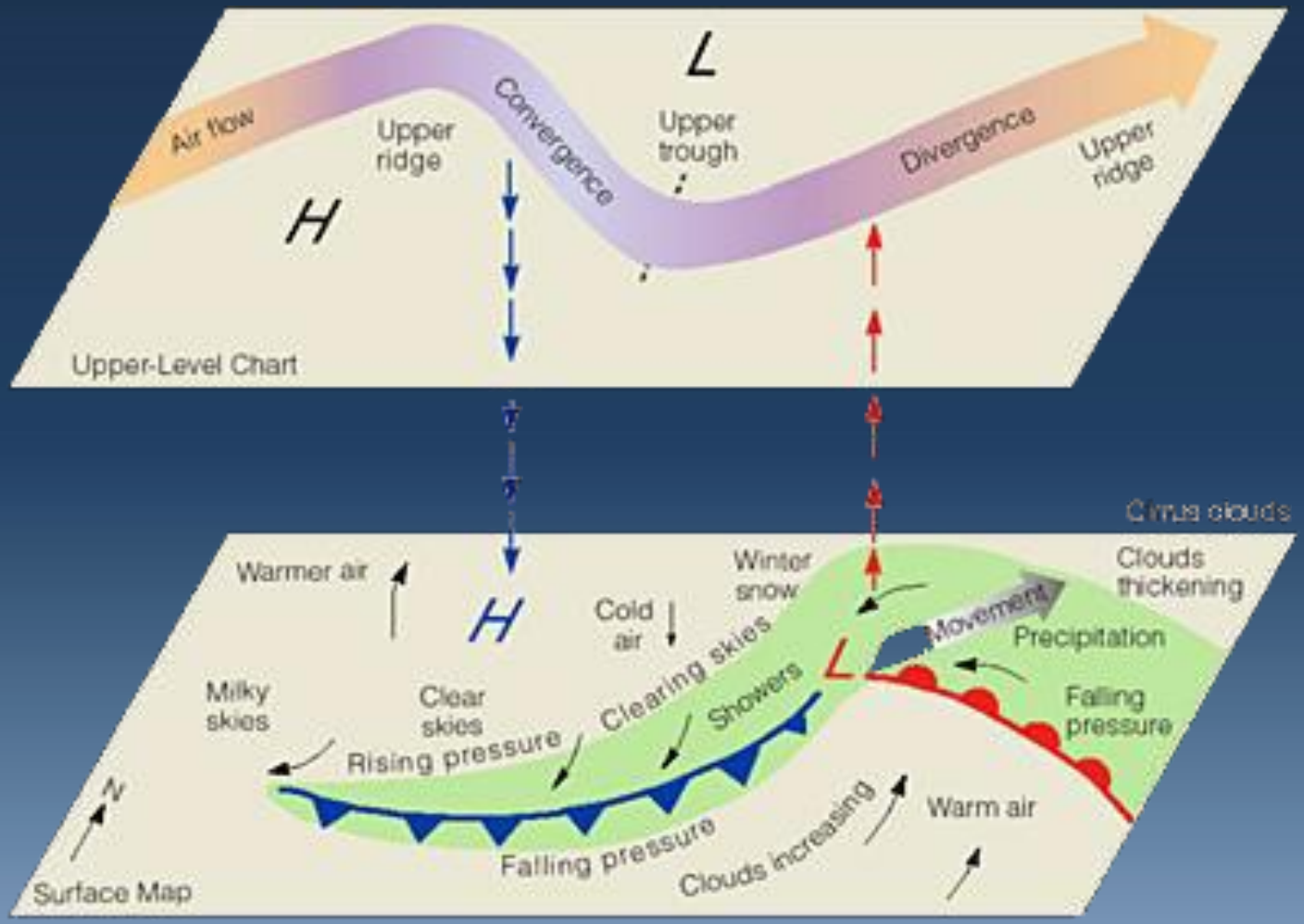
Low pressure matures. Cold front overtakes warm front and forms an occluded front **4**



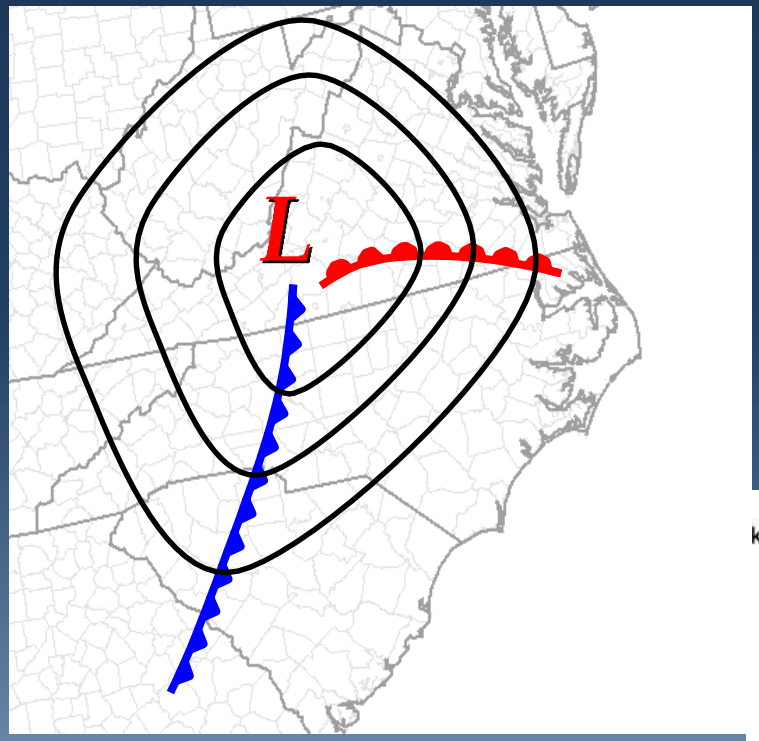
Cold front continues to advance on warm front and eventually cuts off supply of warm, moist air. Low pressure gradually dissipates **5**

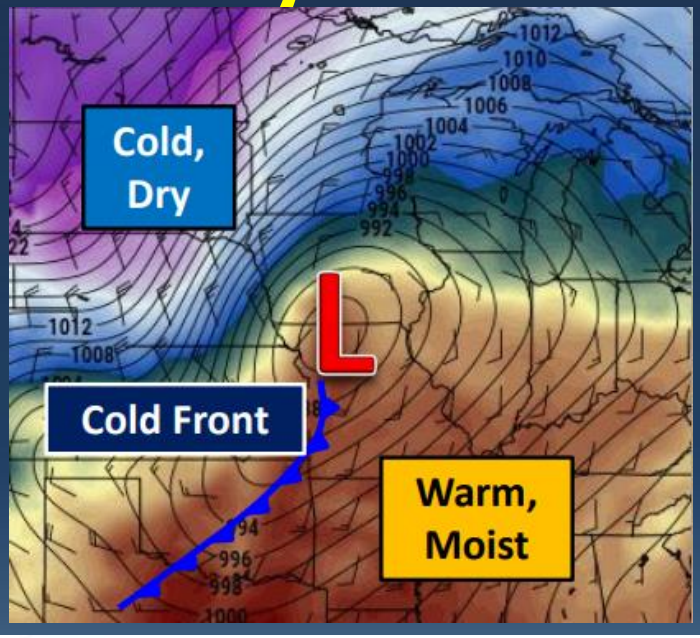
Imagery via NWS JetStream School

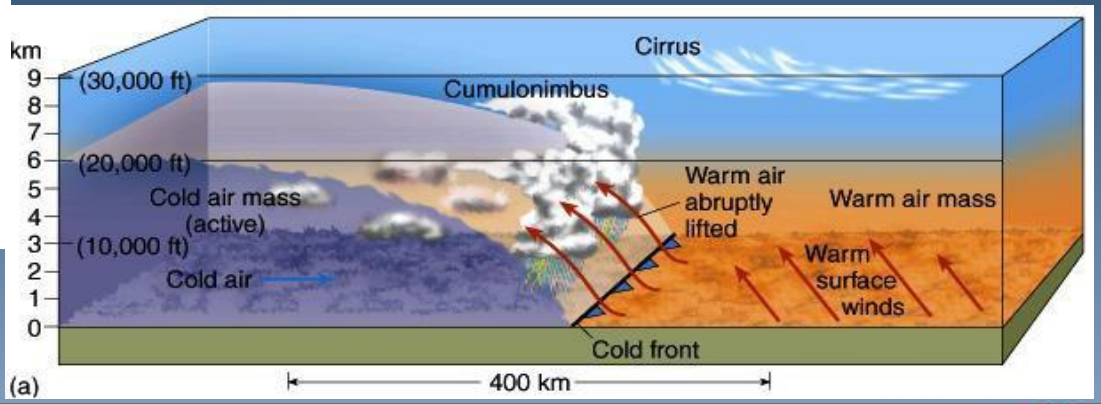
Synoptic Weather Patterns: Thinking in 3-D



Synoptic Weather Patterns:
The Low Pressure System

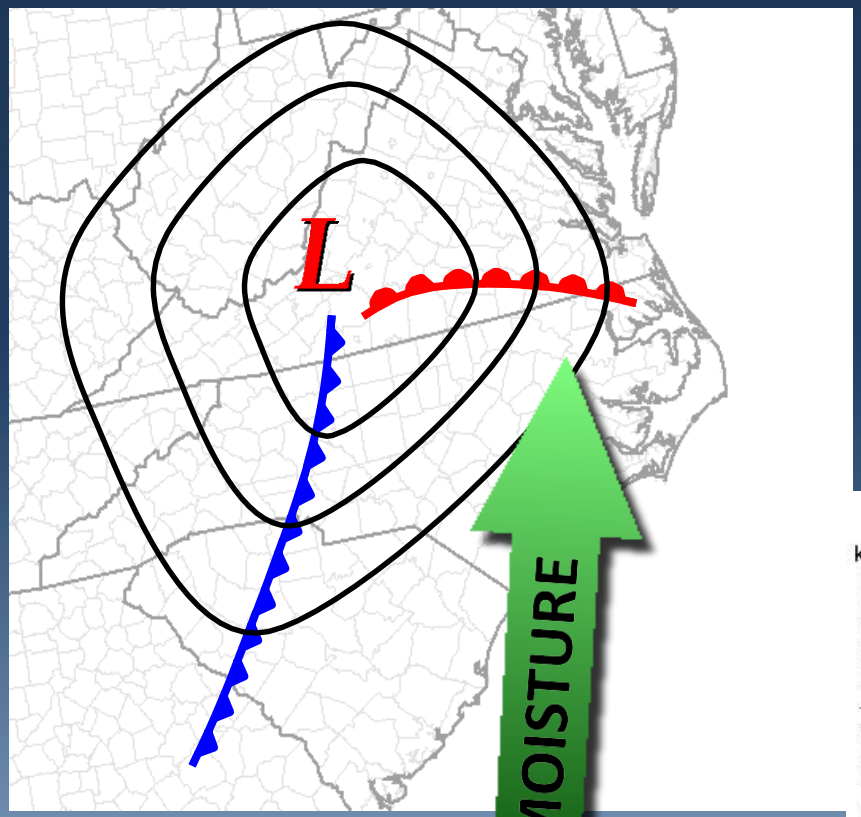




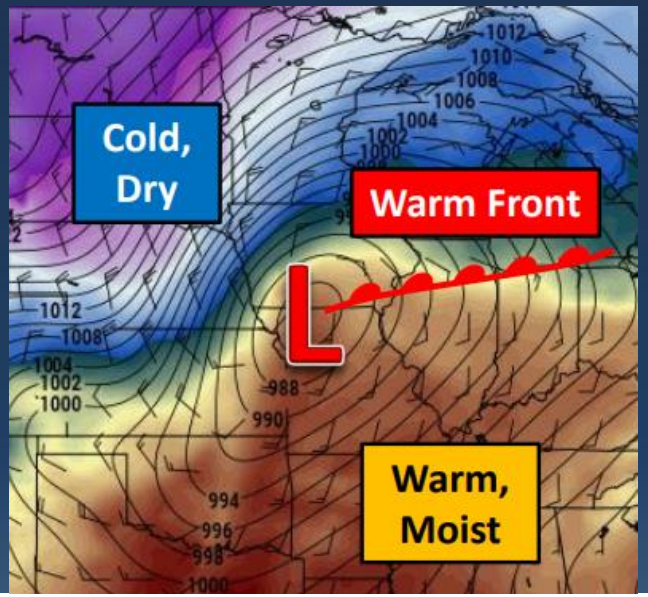


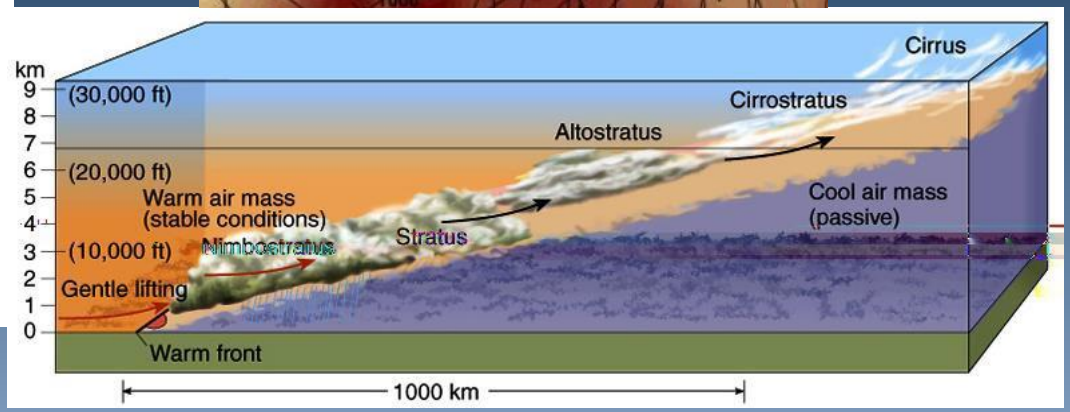
Cold Front

Synoptic Weather Patterns:
The Low Pressure System



Warm Front





Synoptic Weather Patterns:
The Low Pressure System

Why are some systems stronger than others?

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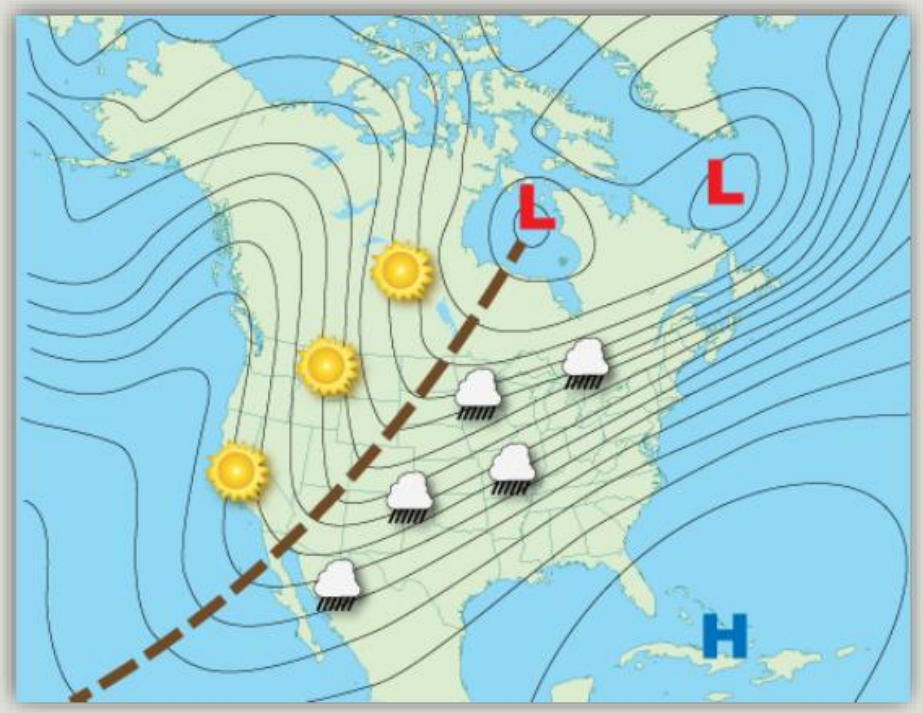
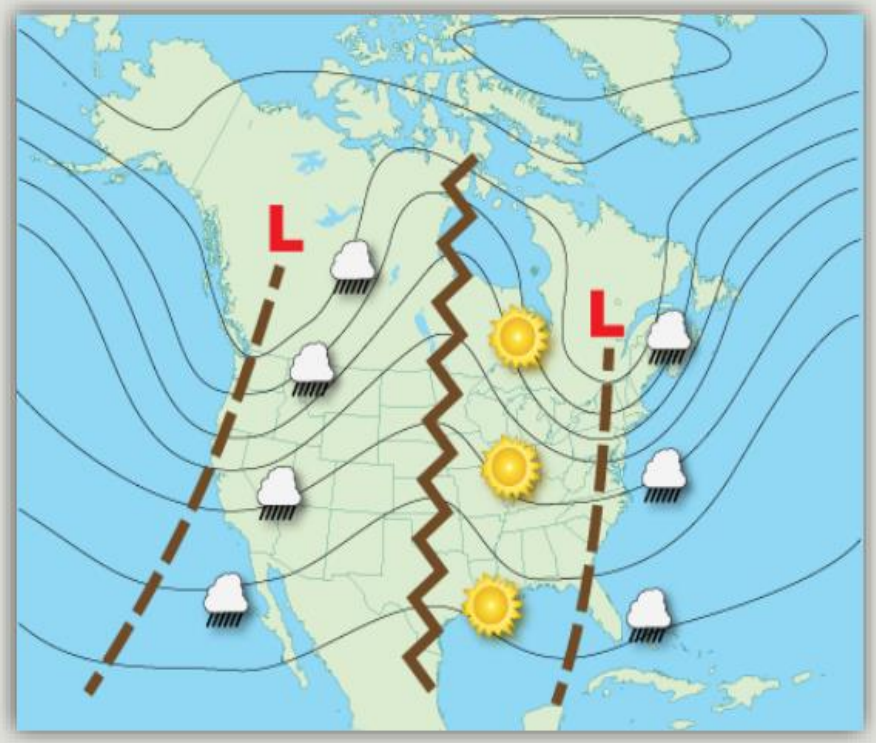
Positively-Tilted Trough



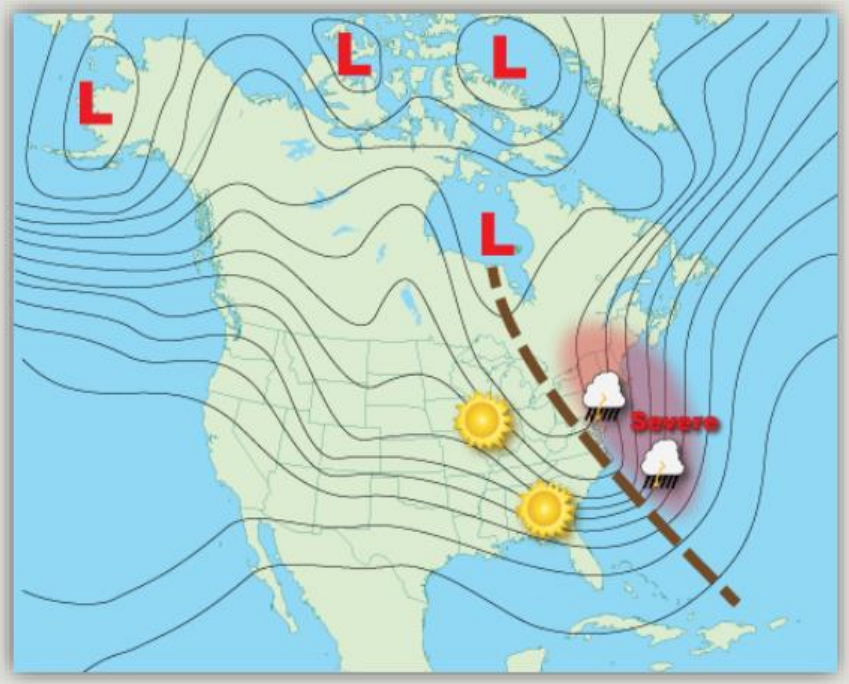
- Trough axis extends from the <u>lowest pressure northeast to southwest</u>
- Active weather can occur, but not 'too much' in the way of severe storms

Neutrally-Tilted Troughs

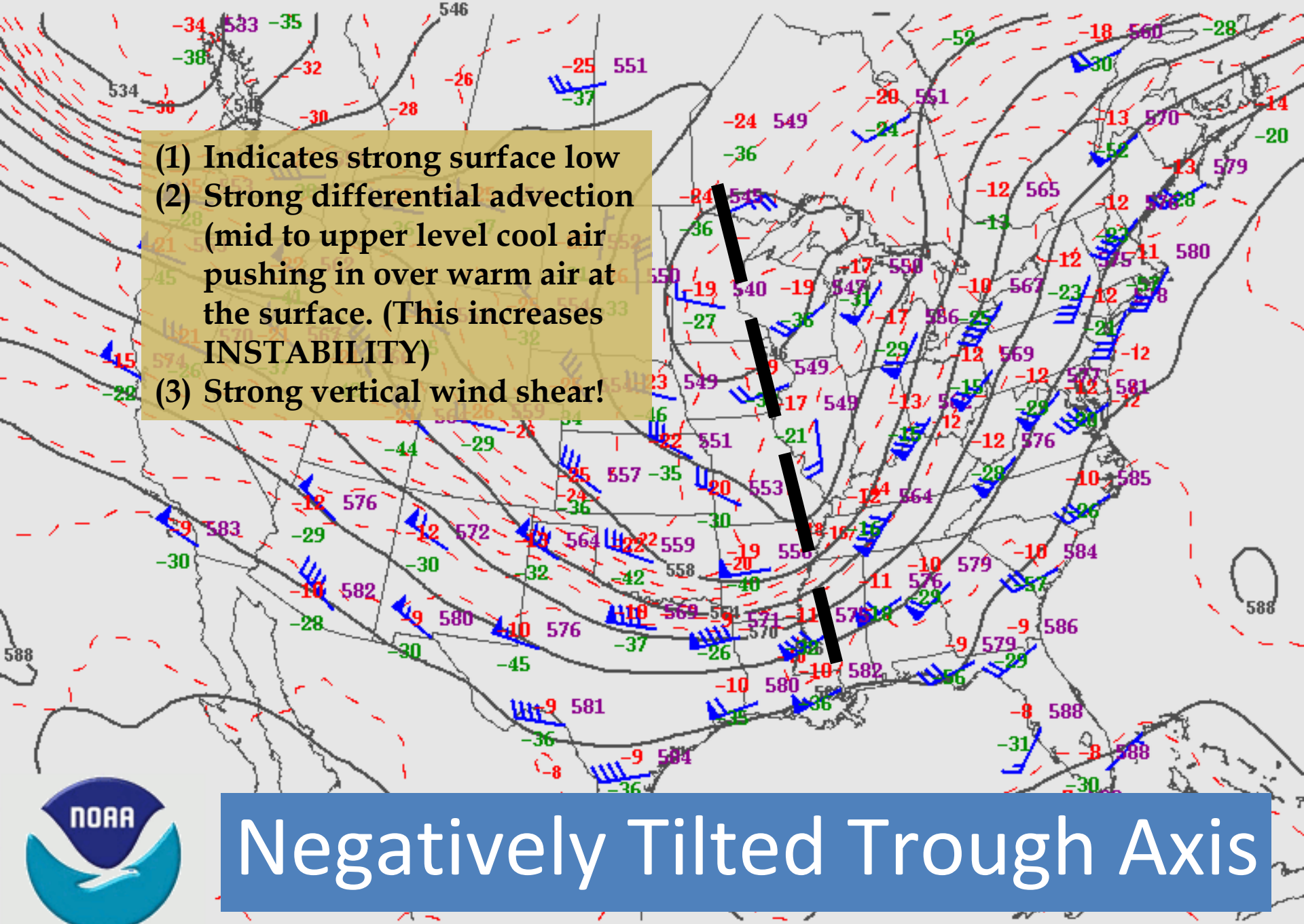


- Trough axis extends from the <u>lowest pressure north to south</u>
- Active weather occurs between the trough and downwind (eastward) ridge

Negatively-Tilted Trough



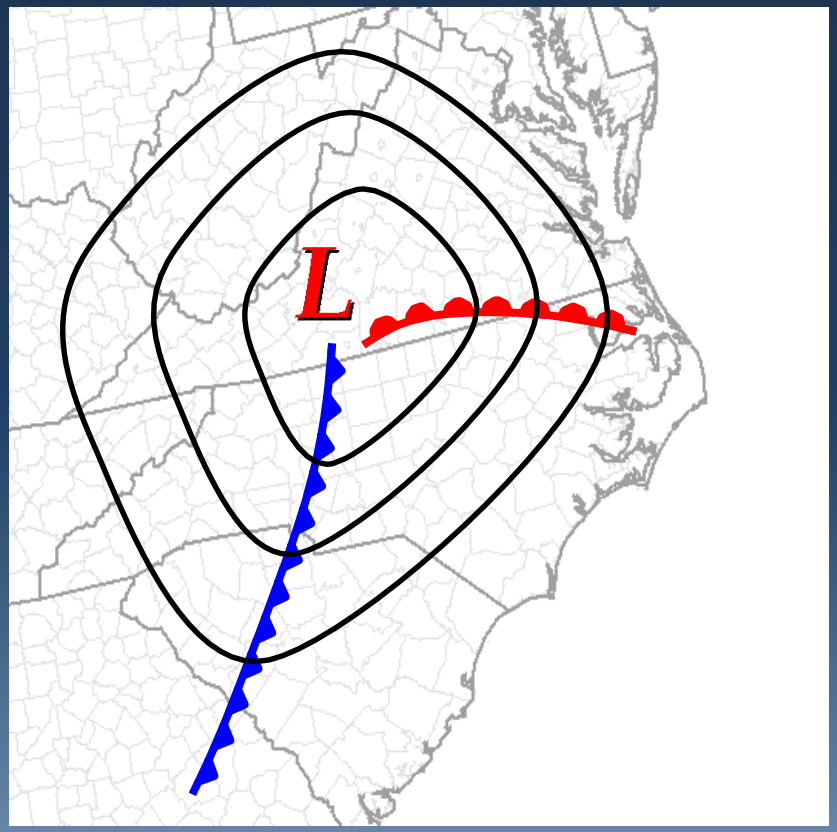
- Trough axis extends from the <u>lowest pressure northwest to southeast</u>
- Active weather + highest severe potential



Negatively Tilted Trough Axis

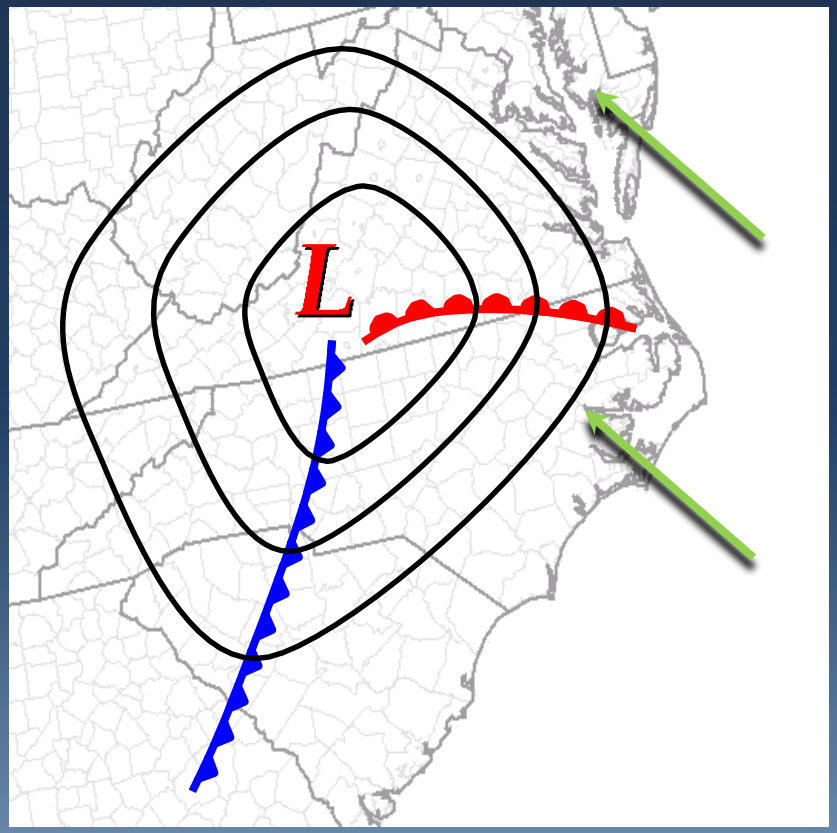
National Weather Service
Storm Prediction Center

Synoptic Weather Patterns:
The Schematics to Getting Thunderstorms



3 main ingredients for thunderstorm development?

Synoptic Weather Patterns:
The Schematics to Getting Thunderstorms



3 Main Ingredients

- Moisture
- Lift
- Instability

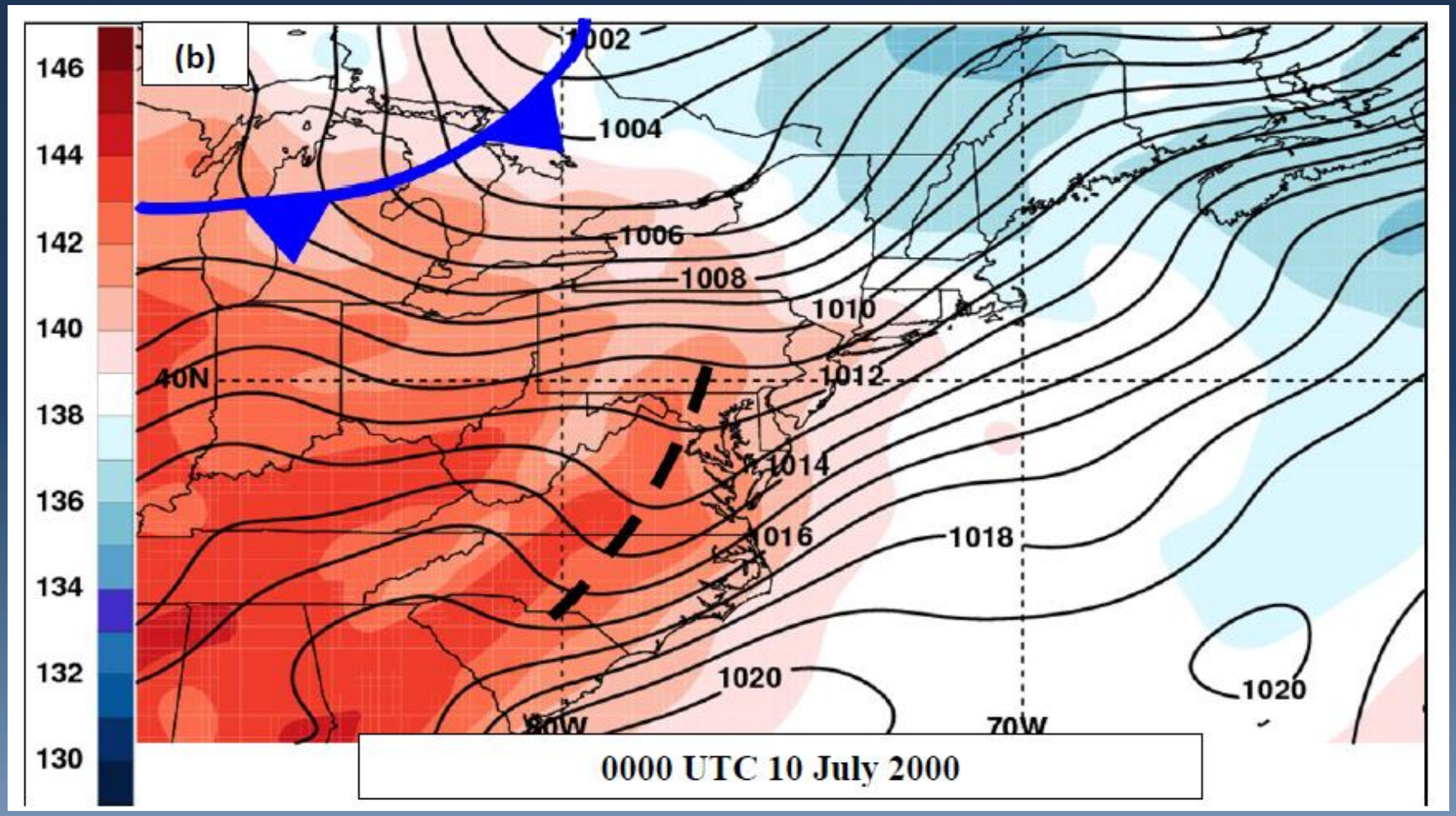
Synoptic Weather Patterns:

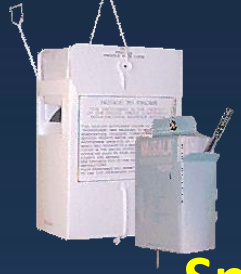
Leeside Trough (Lift)

- Stretching of a column of air as it descends on the leeward side of highly elevated terrain such as the Appalachians.
- Result is a local increase in mid-level rotation vorticity, resulting in upper level divergence.
- This can result in a localized area of low-level lift, which can develop/enhance convection.

Synoptic Weather Patterns:

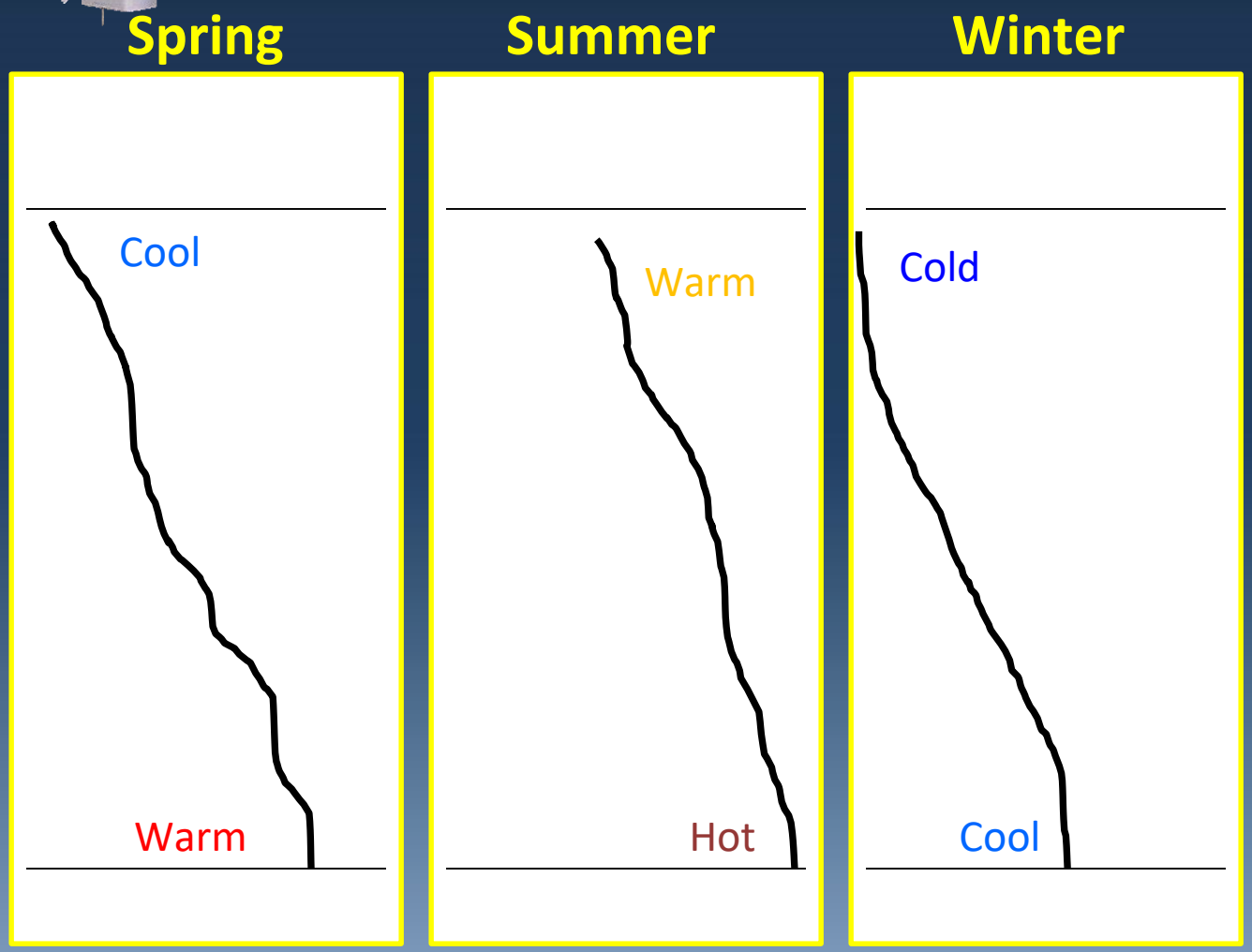
Leeside Troughing





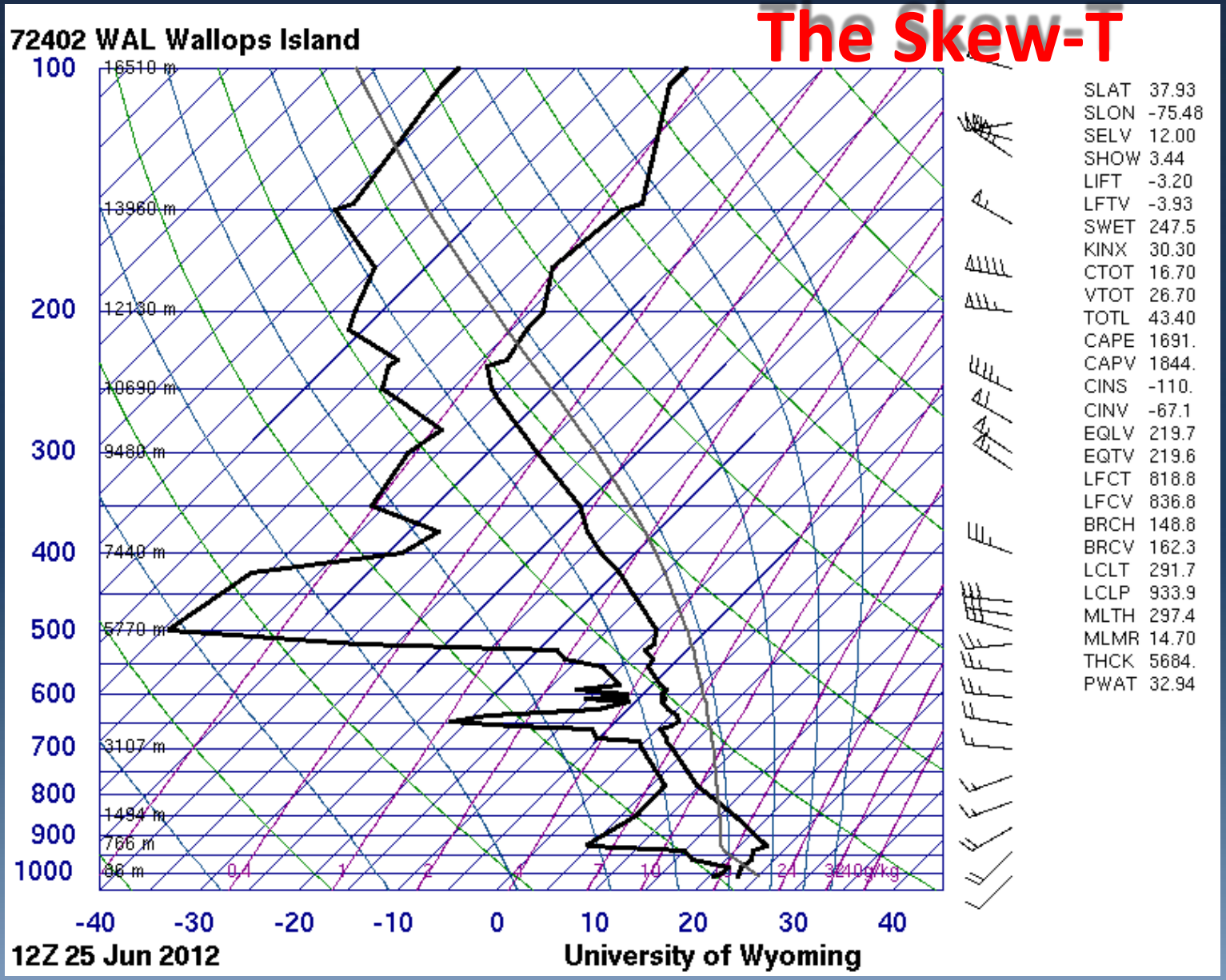
The 3-Dimensional Atmosphere

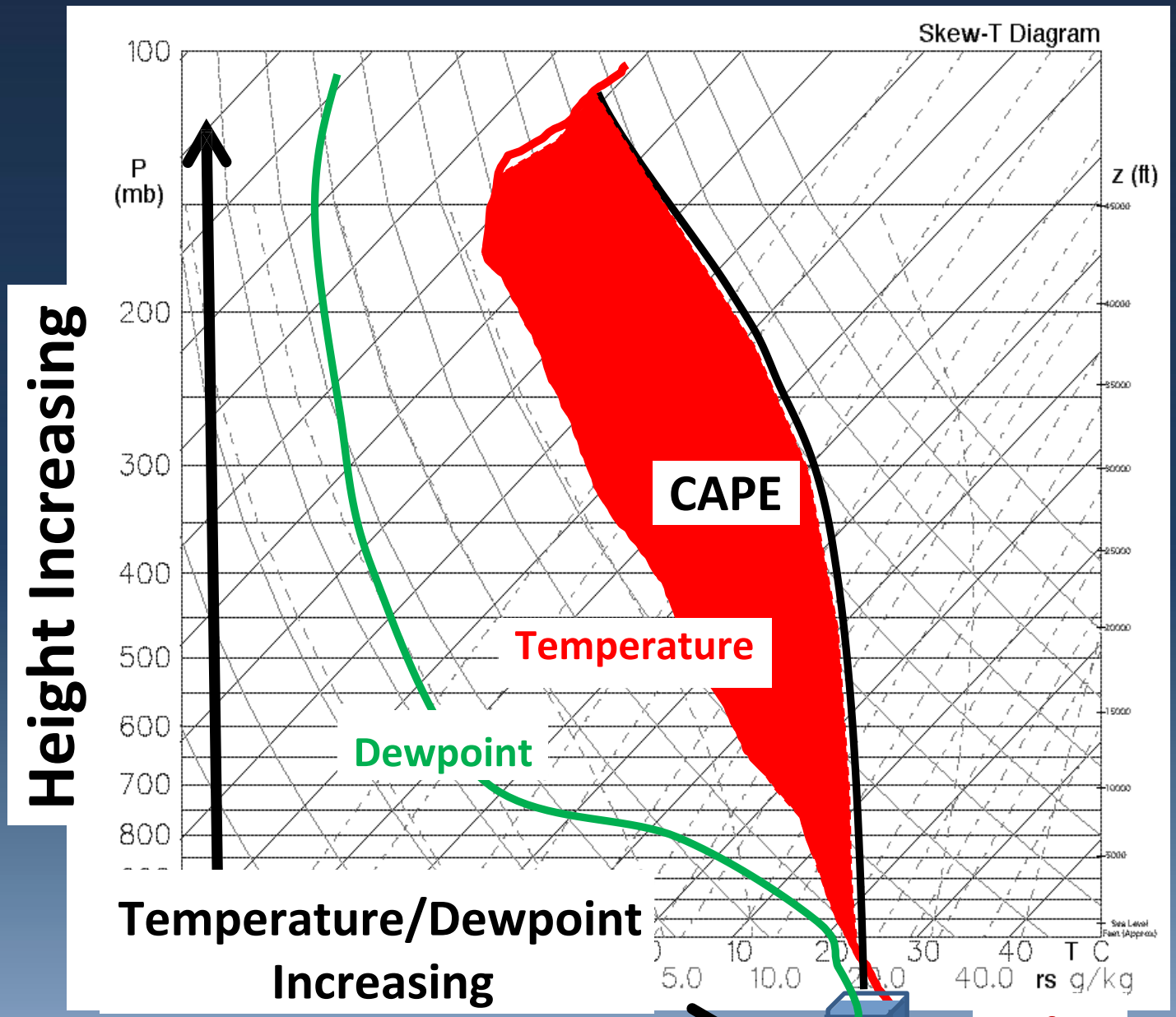
Instability



- instability is measured based upon how warm it is at the surface versus how cold it is aloft.
- 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.

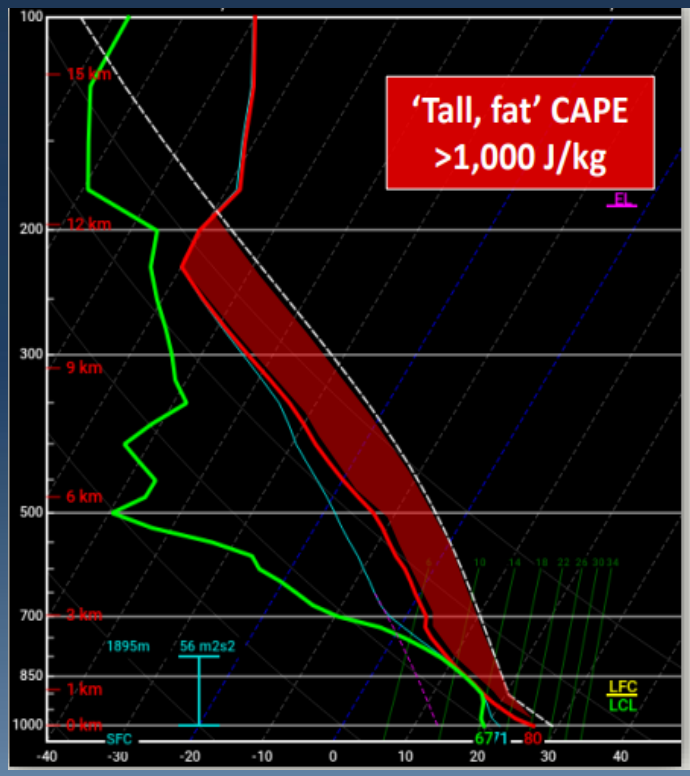
The Skew-T


72402 WAL Wallops Island
100
200
300
400
500
600
700
800
900
1000
16510 m
13960 m
12130 m
10690 m
9480 m
7440 m
5770 m
3107 m
1494 m
766 m
86 m
-40
-30
-20
-10
0
10
20
30
40
12Z 25 Jun 2012
University of Wyoming
SLAT 37.93
SLON -75.48
SELV 12.00
SHOW 3.44
LIFT -3.20
LFTV -3.93
SWET 247.5
KINX 30.30
CTOT 16.70
VTOT 26.70
TOTL 43.40
CAPE 1691.
CAPV 1844.
CINS -110.
CINV -67.1
EQLV 219.7
EQTV 219.6
LFCT 818.8
LFCV 836.8
BRCH 148.8
BRCV 162.3
LCLT 291.7
LCLP 933.9
MLTH 297.4
MLMR 14.70
THCK 5684.
PWAT 32.94

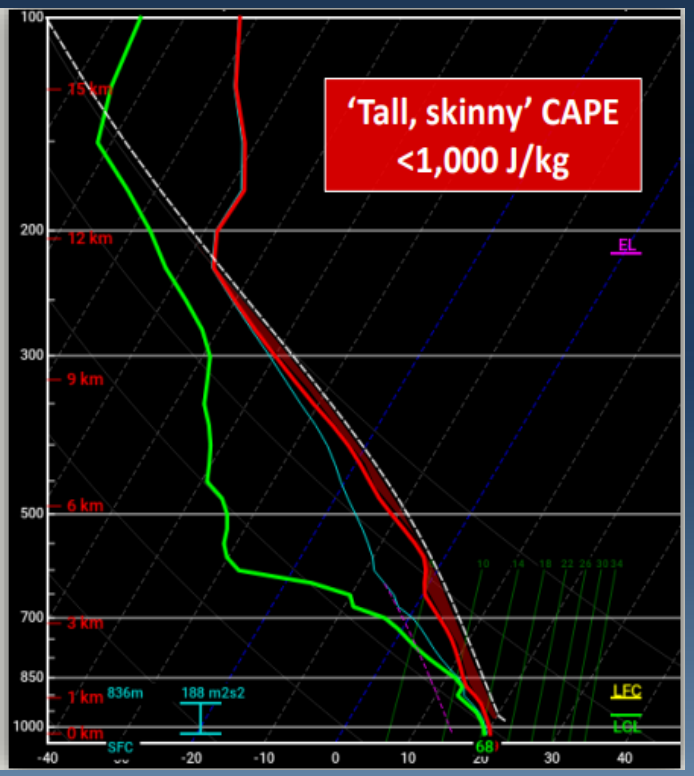

Skew-T Diagram
P (mb)
100
200
300
400
500
600
700
800
z (ft)
CAPE
Temperature
Dewpoint
Height Increasing
Temperature/Dewpoint Increasing
10
30
40
T C
5.0
10.0
40.0
rs g/kg
Surface

The 3-Dimensional Atmosphere - 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).

Website: www.weather.gov/Wakefield Twitter: @NWSWakefieldVA
Facebook: http://www.facebook.com/NWSWakefieldVA

Anvil Thickness/Texture

A thick, smooth-edged, and cumuliform Anvil (puffy, like the lower part of the storm), is an indication of A storm with a strong updraft. This would produce severe weather.

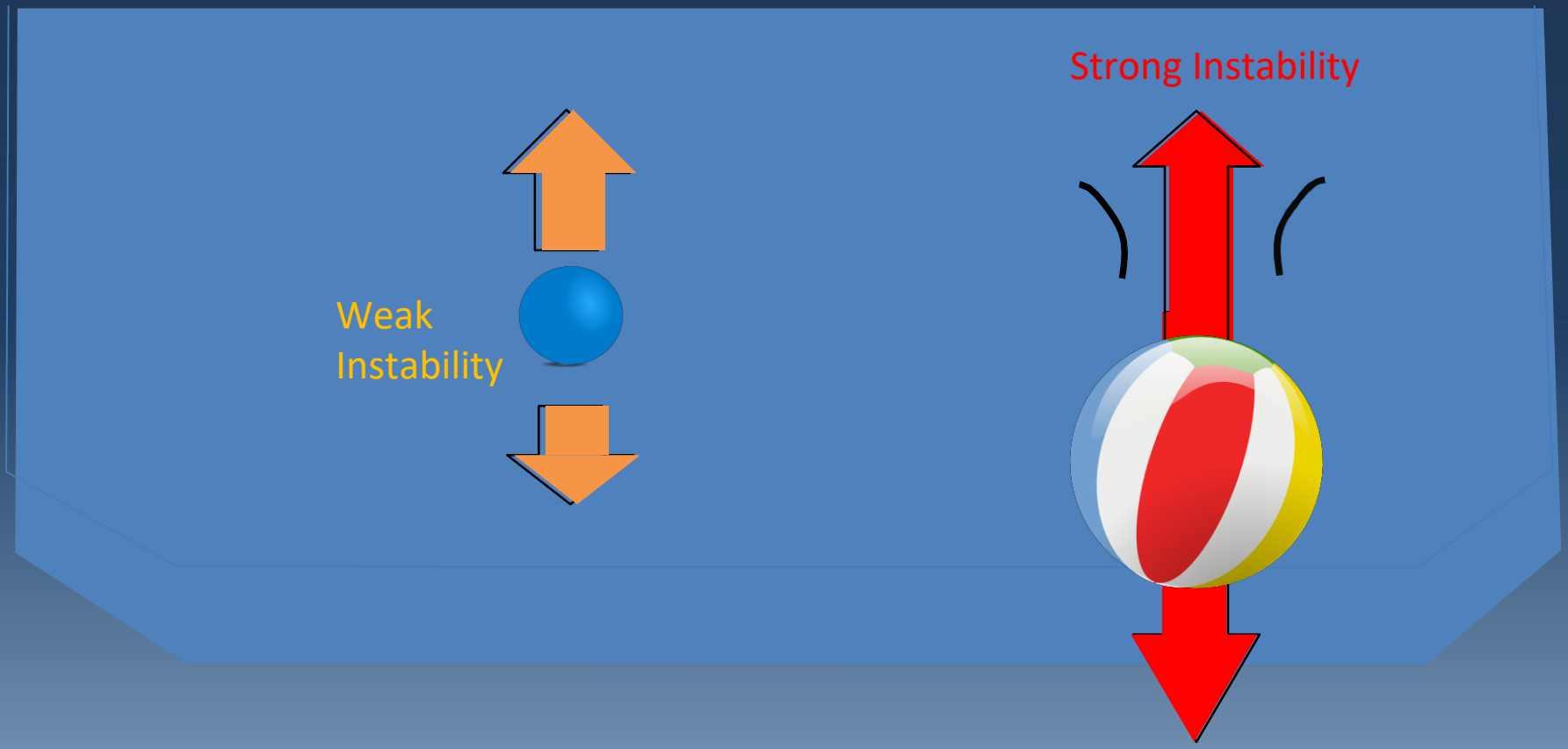
A Wispy and glaciated cirrus shield indicates an updraft that is probably not as strong. These storms are less likely to produce widespread severe weather.

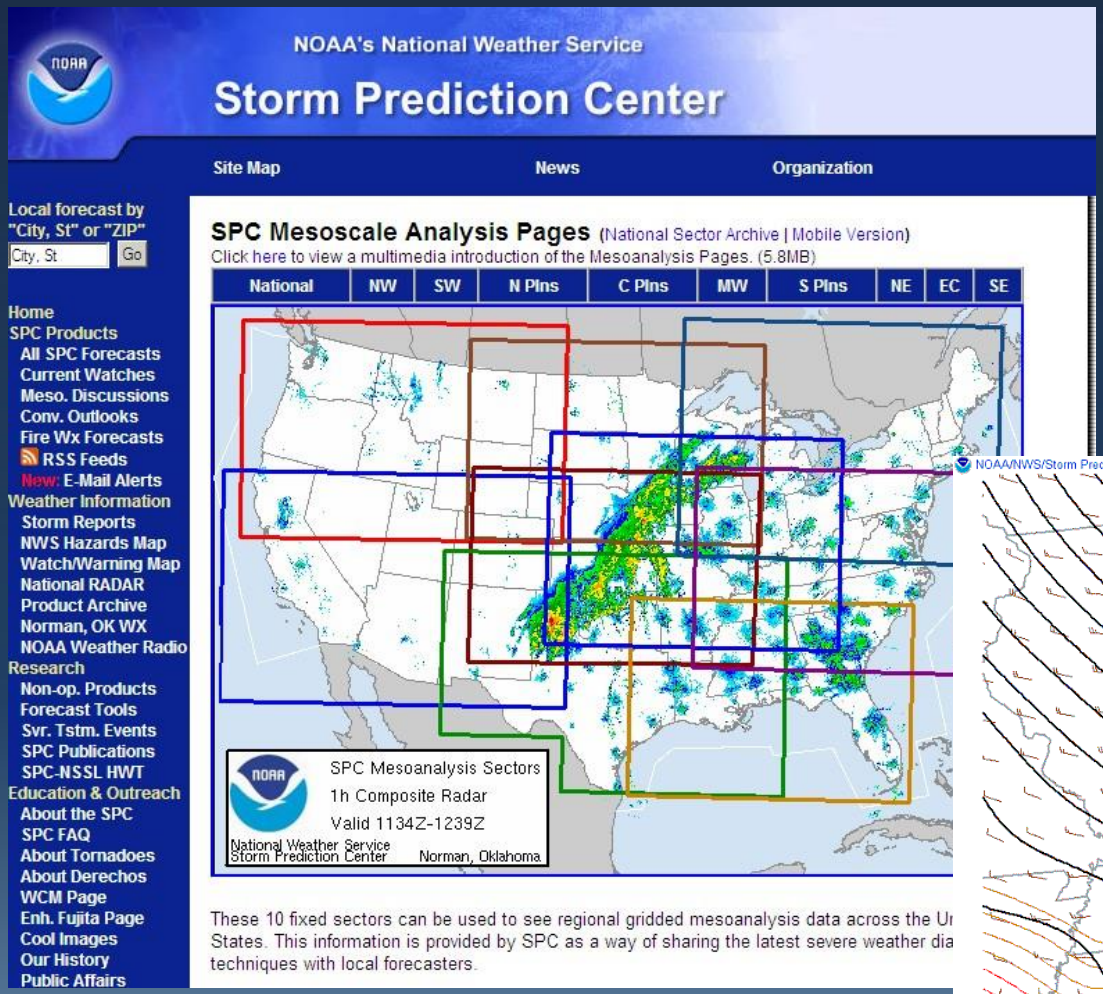
A Updraft Tower Comparison

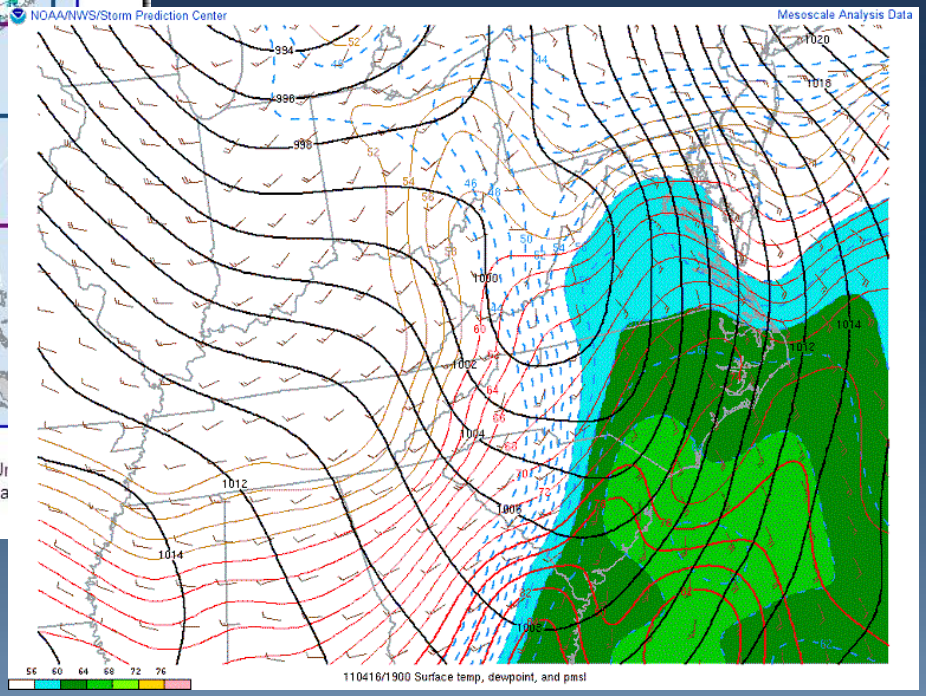
Strong Updraft (High CAPE)

Weak Updraft (Low CAPE)

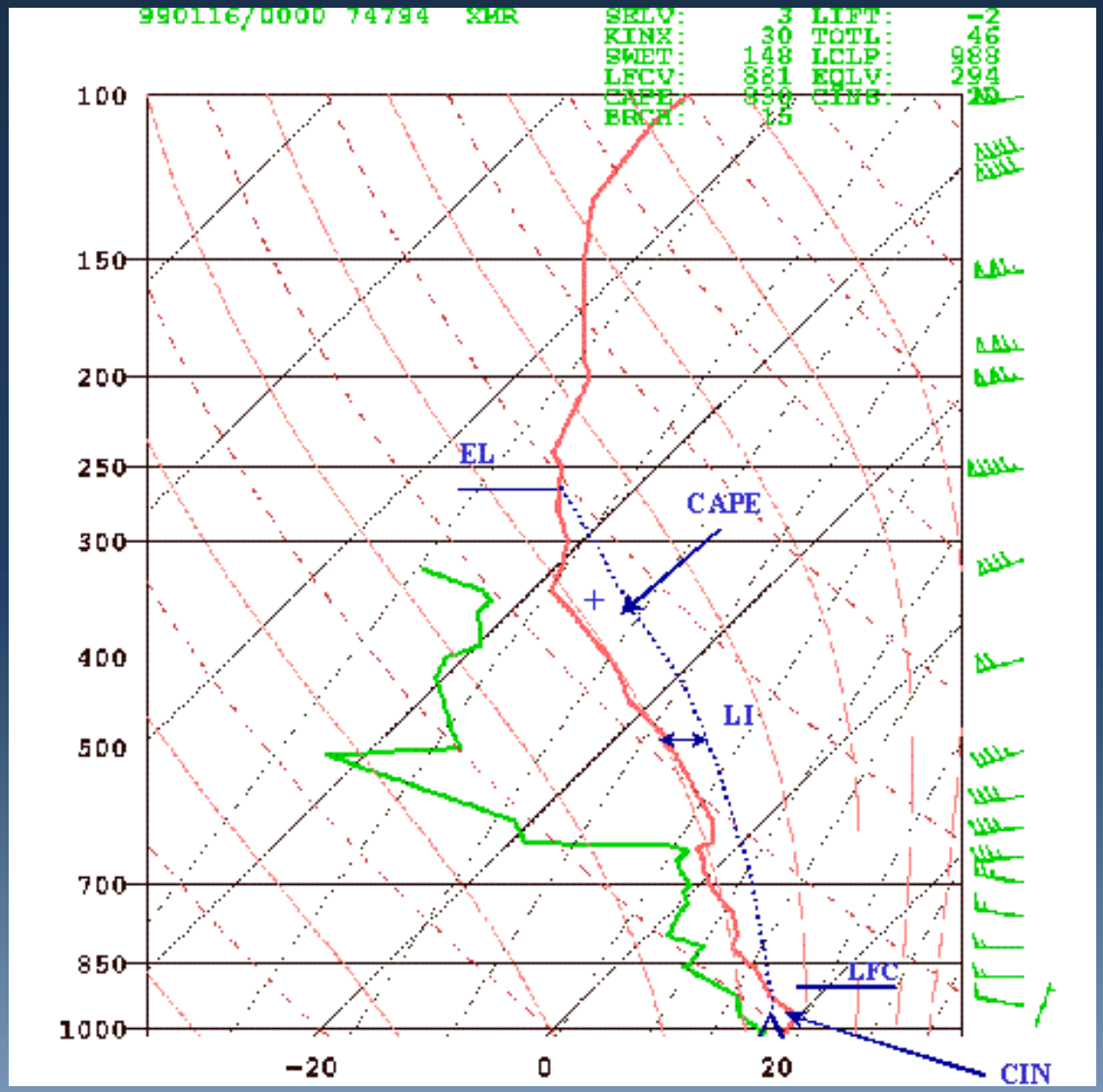
The 3-Dimensional Atmosphere Instability







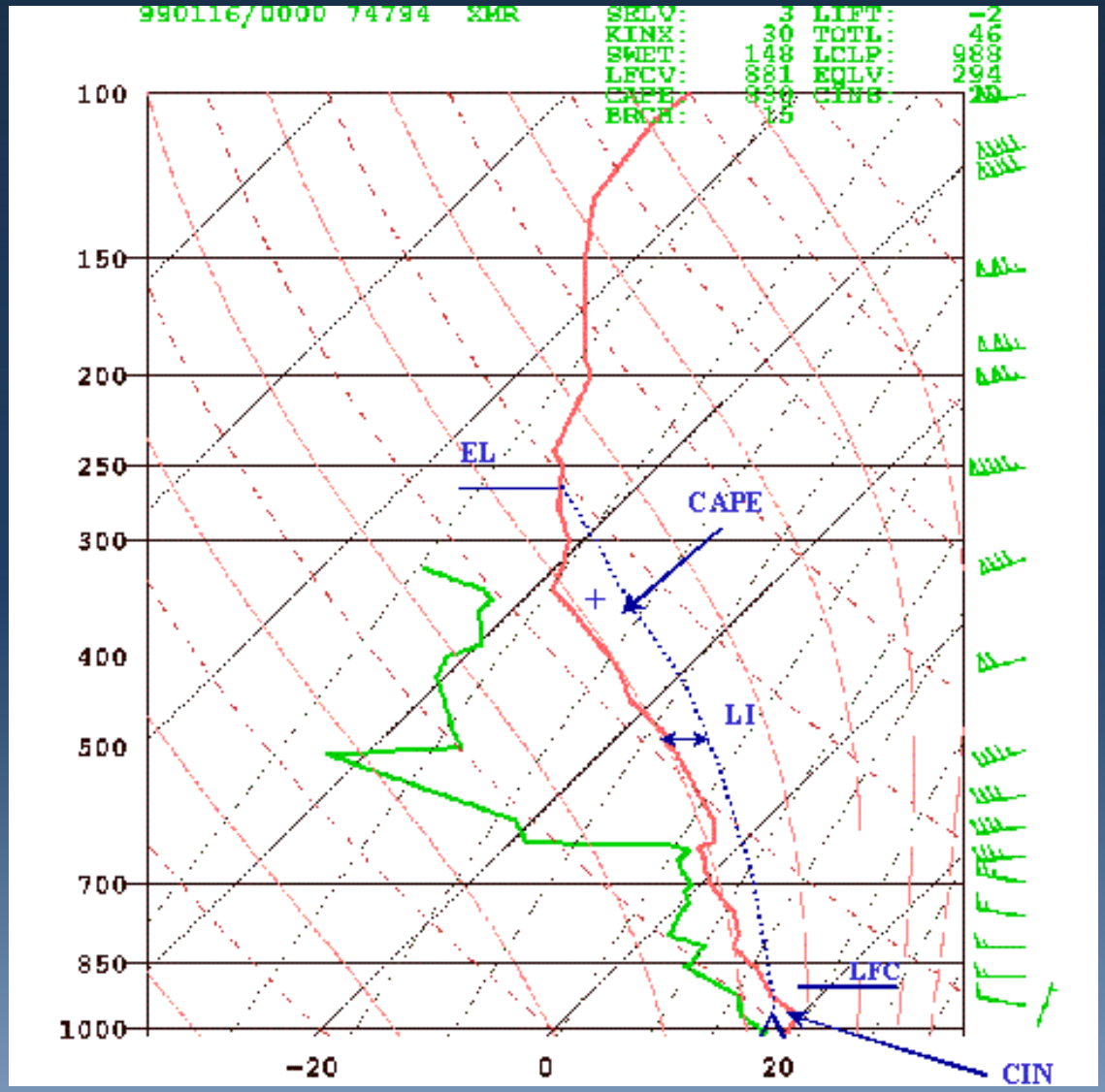
http://www.spc.noaa.gov/exper/mesoanalysis



Equilibrium Level (EL) - On a sounding, the level above the level of free convection (LFC) at which the temperature of a rising air parcel again equals the temperature of the environment. The height of the EL is the height at which thunderstorm updrafts no longer accelerate upward. Thus, to a close approximation, it represents the height of expected (or ongoing) thunderstorm tops.

Level of Free Convection (LFC) - The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

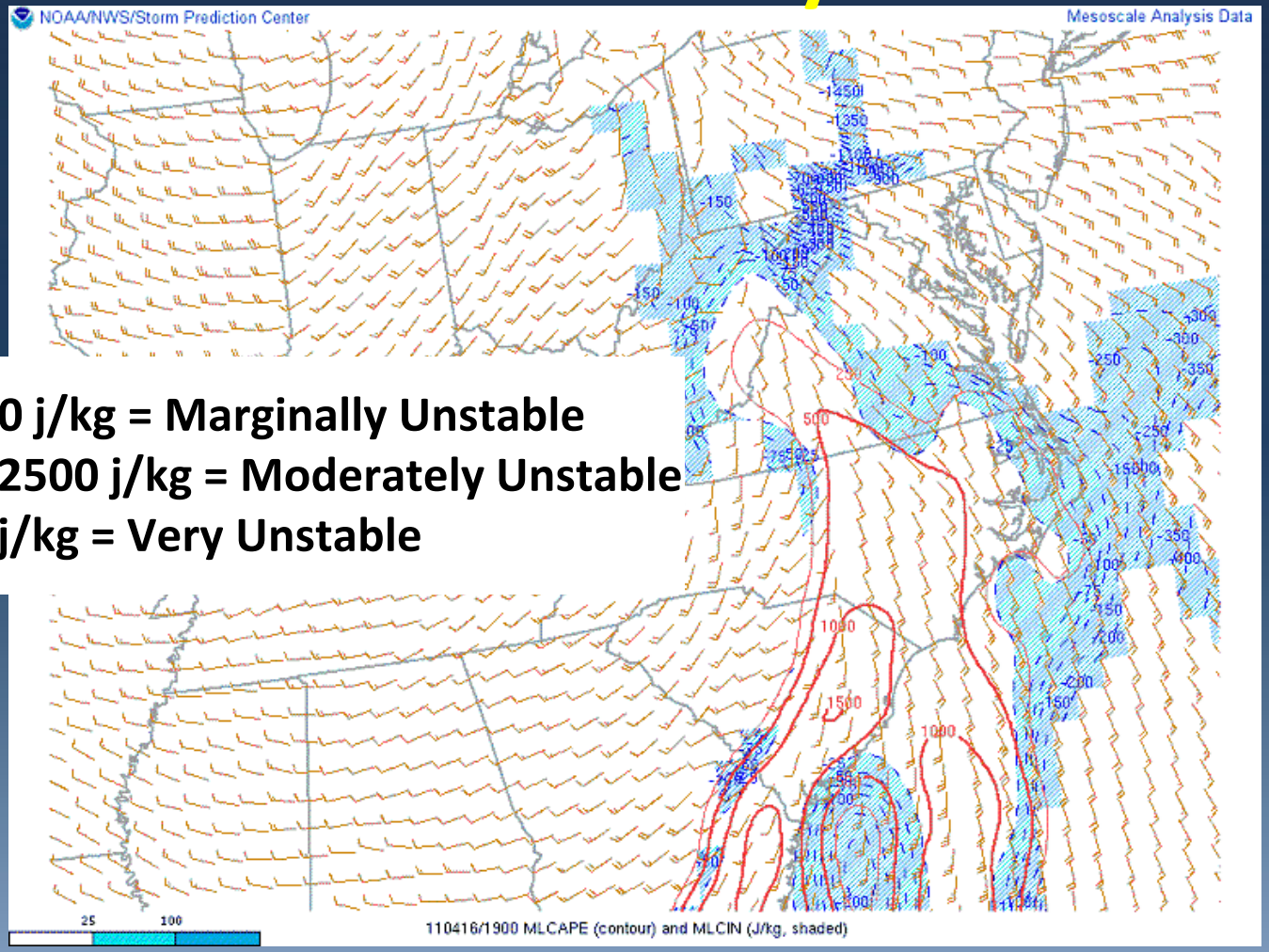
Lifted Index (LI)- A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to some higher level (around 18,000 feet, usually) and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.



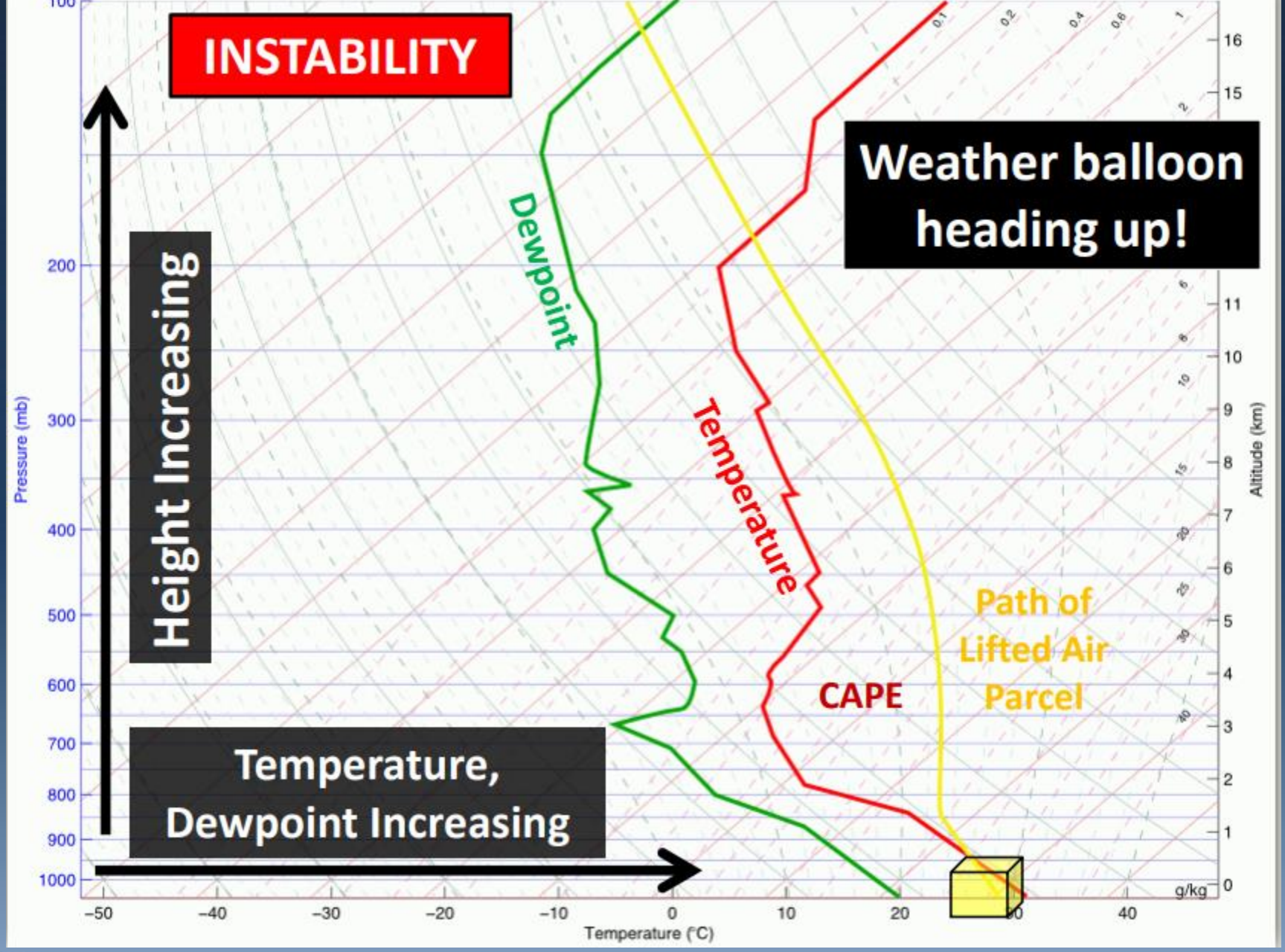
Convective Available Potential Energy (CAPE)- A measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather. Observed values in thunderstorm environments often may exceed 1000 joules per kilogram (J/kg), and in extreme cases may exceed 5000 J/kg.

Convective Inhibition (CIN) - A measure of the amount of energy needed in order to initiate convection. Values of CIN typically reflect the strength of the cap. They are obtained on a sounding by computing the area enclosed between the environmental temperature profile and the path of a rising air parcel, over the layer within which the latter is cooler than the former. (This area sometimes is called negative area.) See CAPE.

The 3-Dimensional Atmosphere Instability



0 – 1000 j/kg = Marginally Unstable
1000 – 2500 j/kg = Moderately Unstable
2500 + j/kg = Very Unstable


INSTABILITY
Weather balloon heading up!
Height Increasing
Dewpoint
Temperature
CAPE
Path of Lifted Air Parcel
Temperature, Dewpoint Increasing
Pressure (mb)
Altitude (km)
Temperature (°C)
g/kg

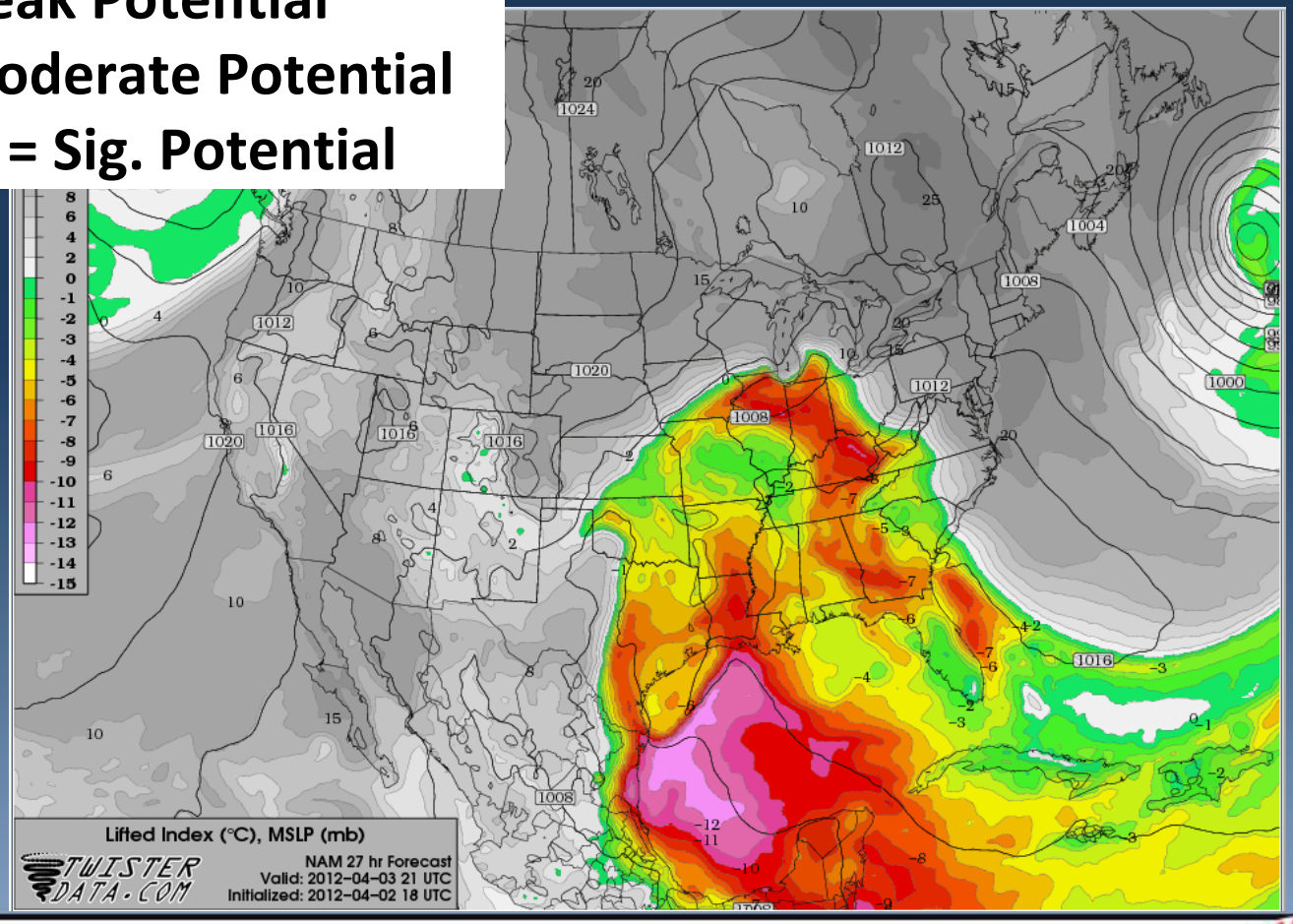
The 3-Dimensional Atmosphere
Instability

Lifted Index

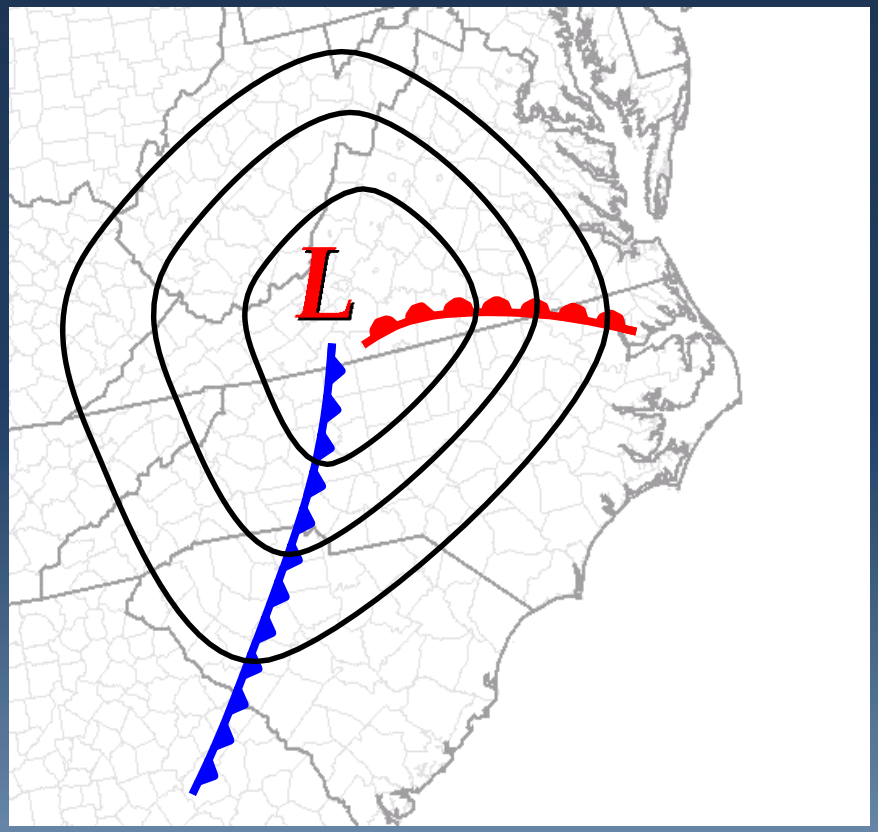
> -2 = Weak Potential

-3 to -5 = Moderate Potential

-6 or colder = Sig. Potential



The Schematics to Getting Thunderstorms



Thunderstorms

- Moisture
- Instability
- Lift Mechanism

Severe T-Storms

- Strong Instability
- Wind Shear

Understanding Rotation

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Understanding Rotation

- In order to generate a tornado, a storm needs two basic things

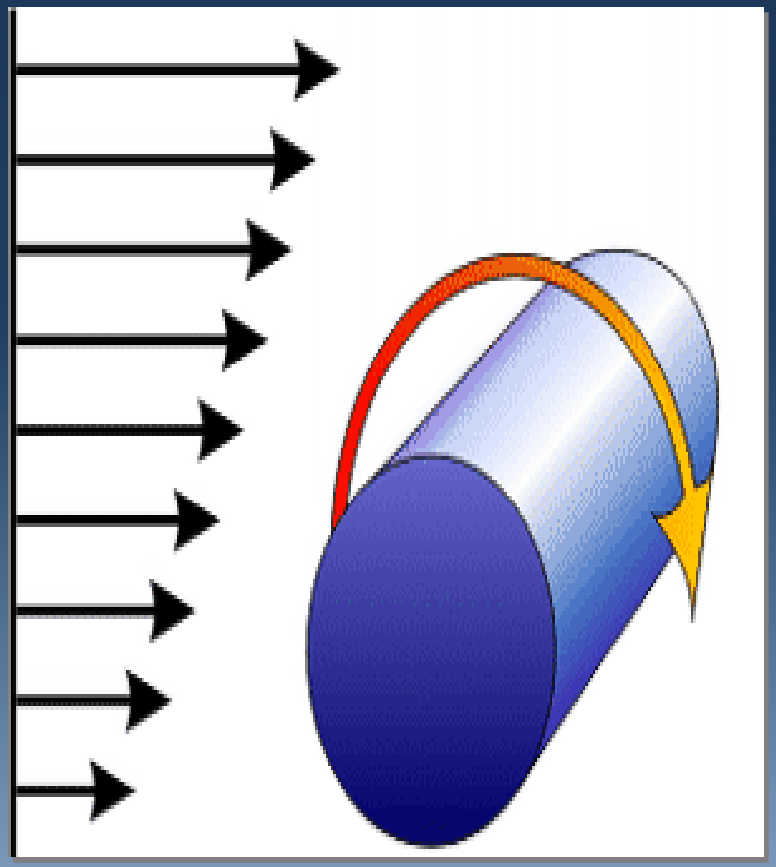
  1. Time – it must persist for an appreciable time; Need a long lived updraft that doesn't get choked by downdraft.

  2. Wind shear that translates into vertical rotation.

Wind Shear

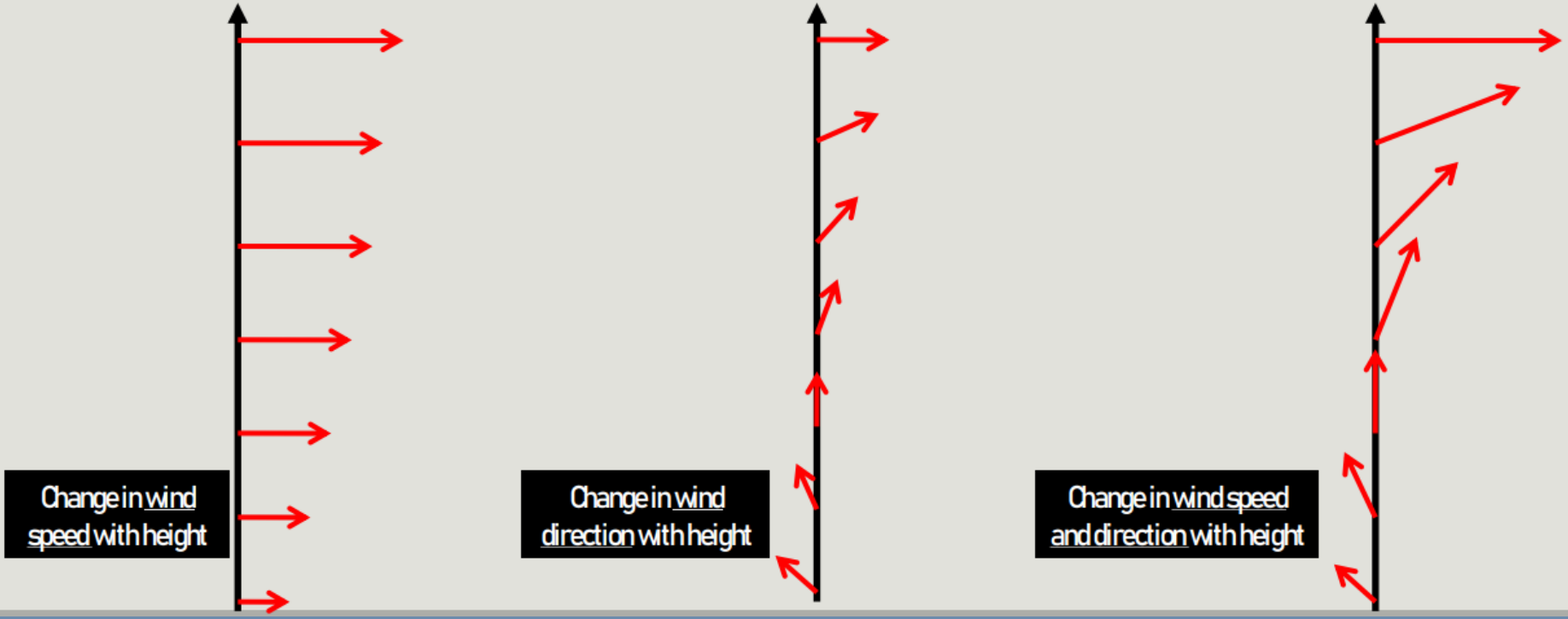
Directional wind shear

Speed wind shear



Wind Shear

Wind Shear

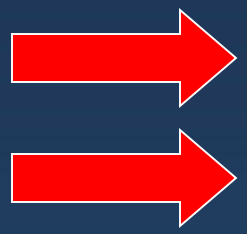


Shear

Weak

- Very little separation between updraft and downdraft. Downdraft chokes updraft causing storm be short-lived.

Strong



- Tilted Updraft & downdraft are separated, so they co-exist. Therefore, the storm lives longer.

What is a Rear Flank Downdraft (RFD)?

SKYWARN

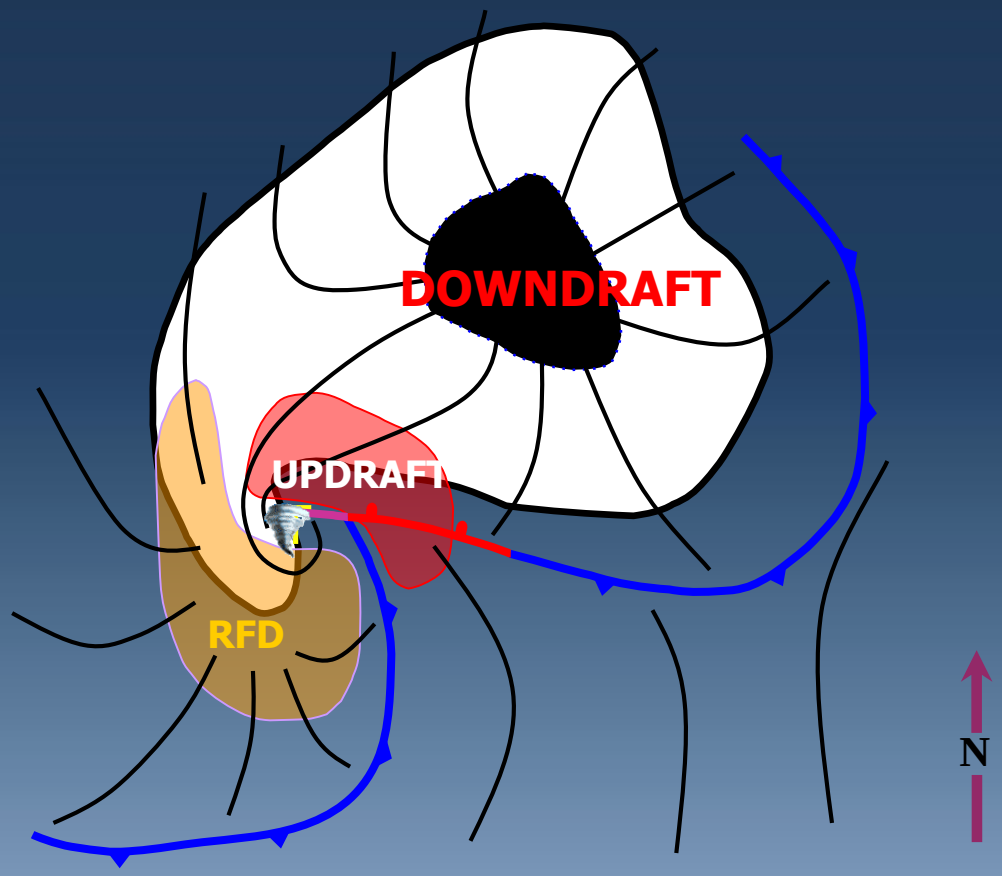
Supercell Structure/RFD

Due to favorable shear, the downdraft does NOT contaminate the updraft!

Secondary downdraft forms at rear of storm – called the Rear Flank Downdraft (RFD)

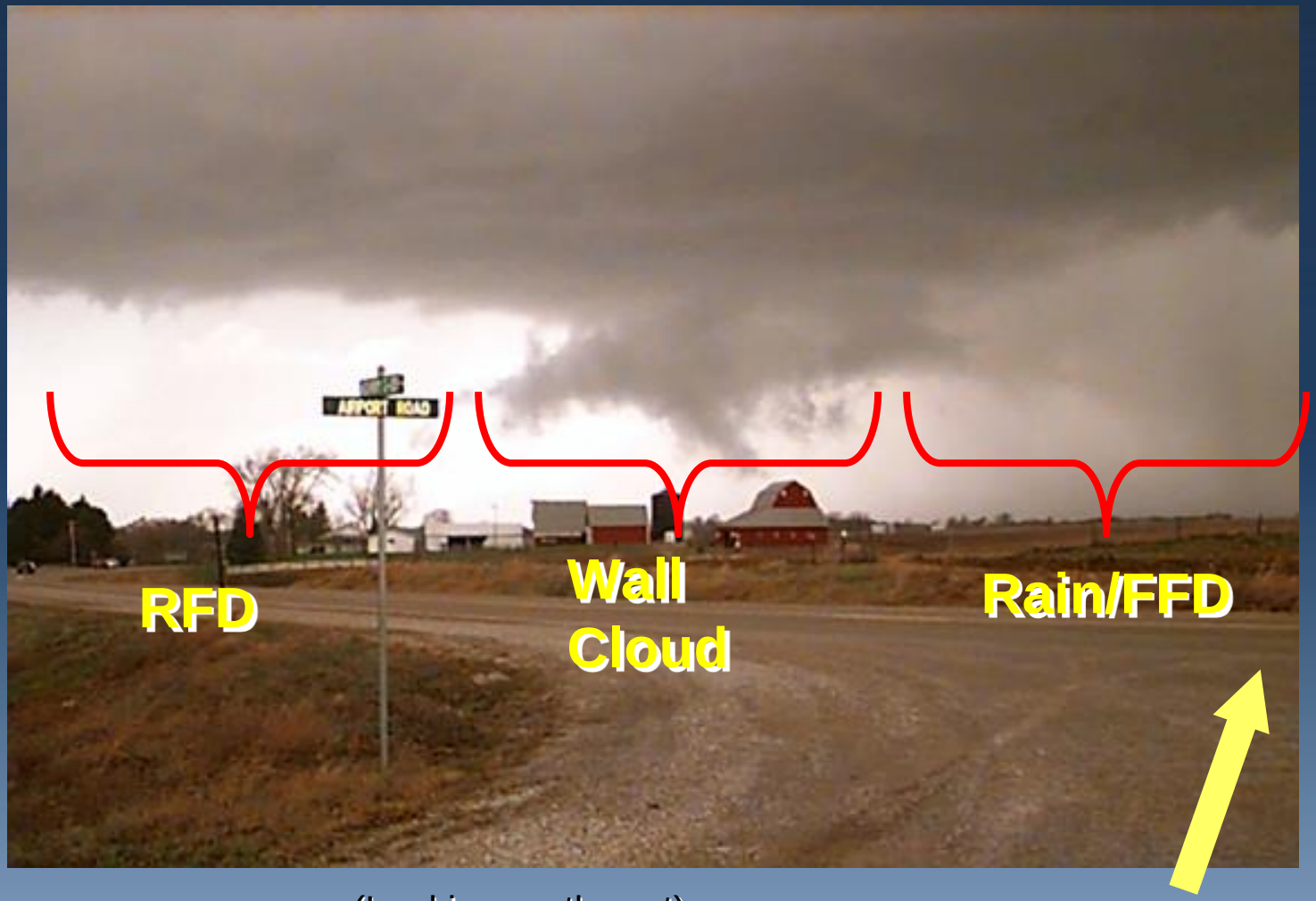
Rear Flank Downdraft

- Crucial to tornado development
- Downdraft on backside of updraft tower
- Wraps around updraft to tighten circulation



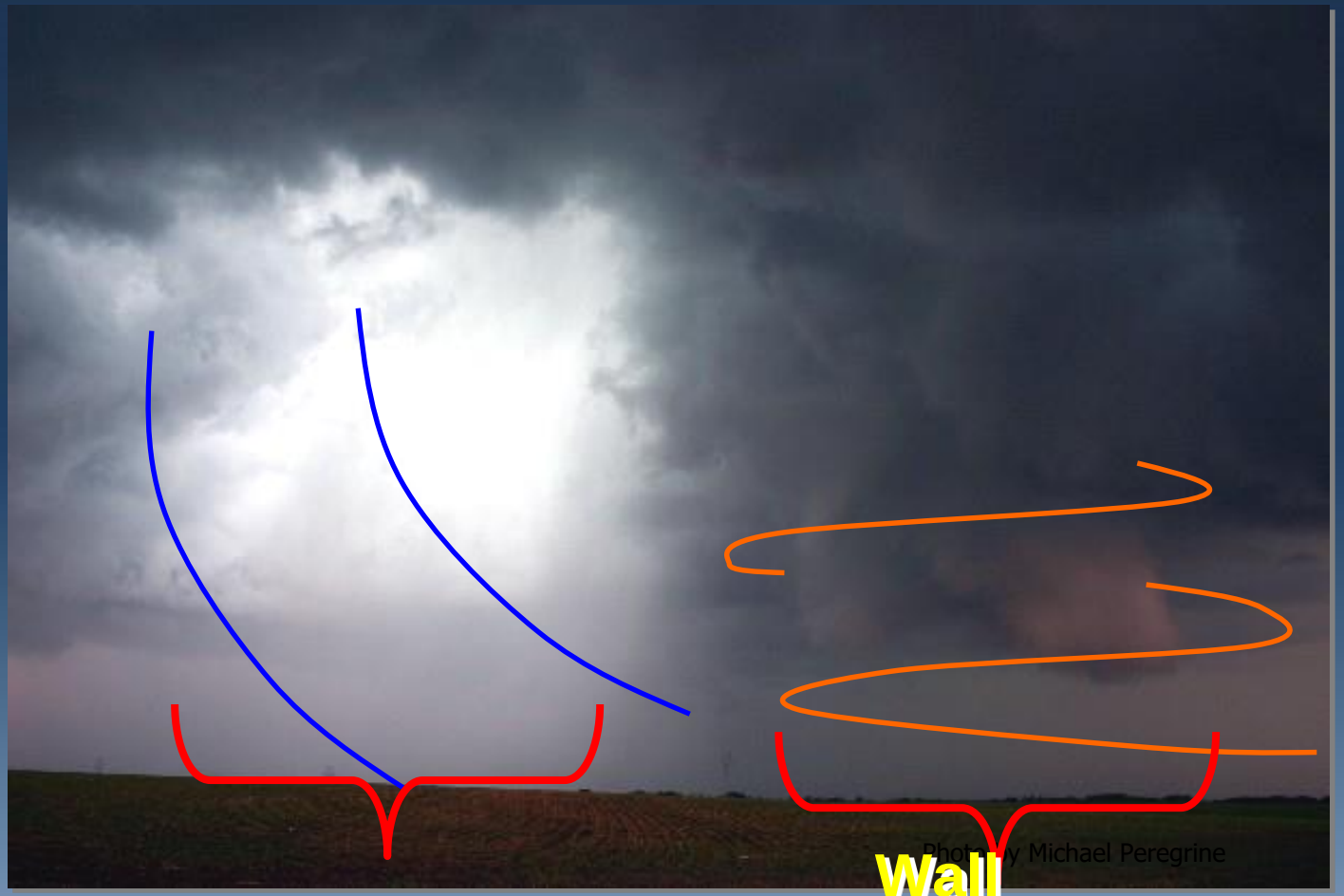
(Top view)

Rear Flank Downdraft



(Looking northwest)

Rear Flank Downdraft



Rear Flank Downdraft

Signs of Rotation

Spiral bands or striations in the clouds serve as a rotation indicator!

Mesocyclone Development

Rotating updraft within the Rain-Free Cloud Base

Present with <u>all</u> Supercells!

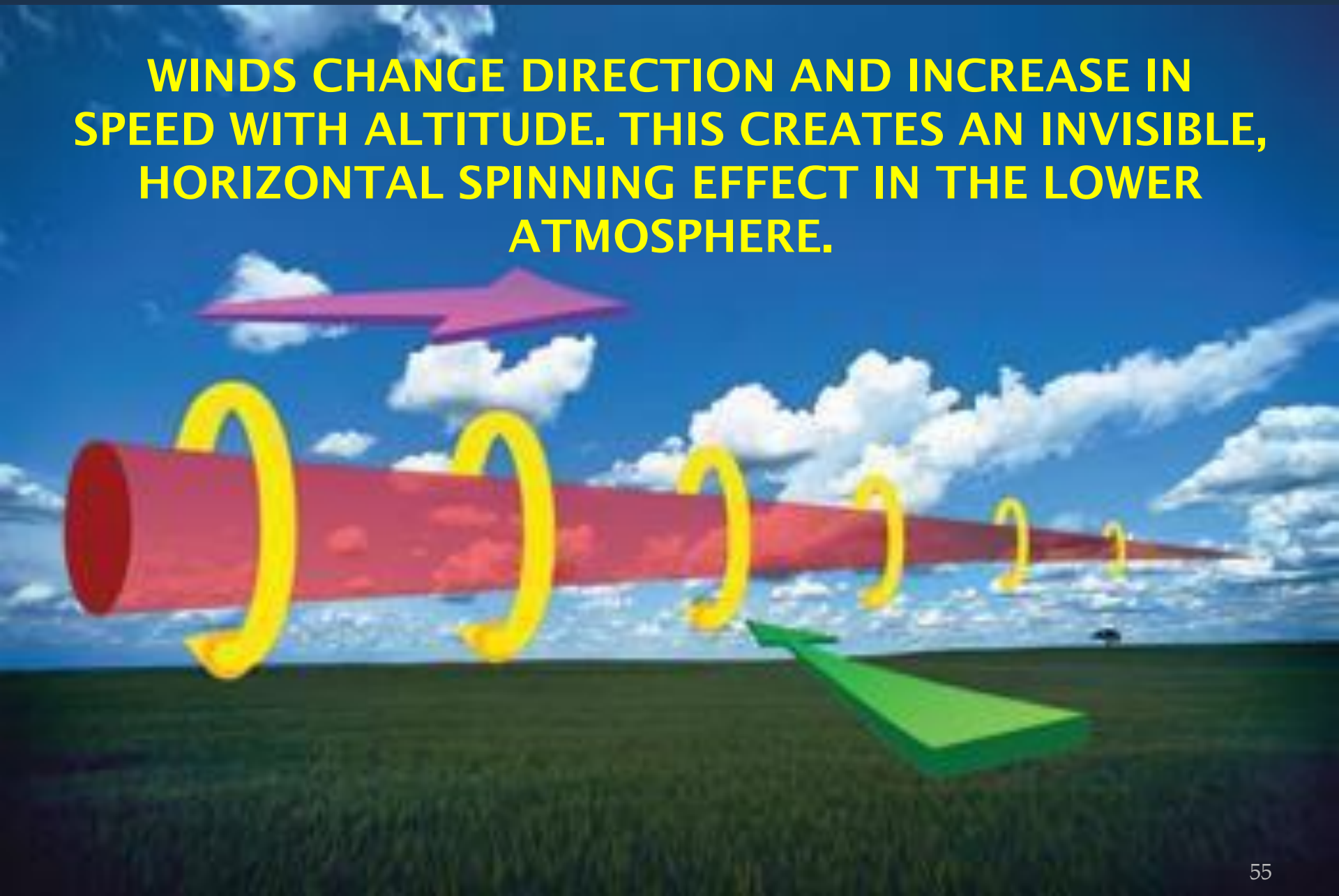
How does mesocyclone develop and how can it last for 1 hour or more?

Mesocyclone

Mesocyclone gets it energy from vertical wind shear concentrated in the lowest 10,000 feet of the atmosphere

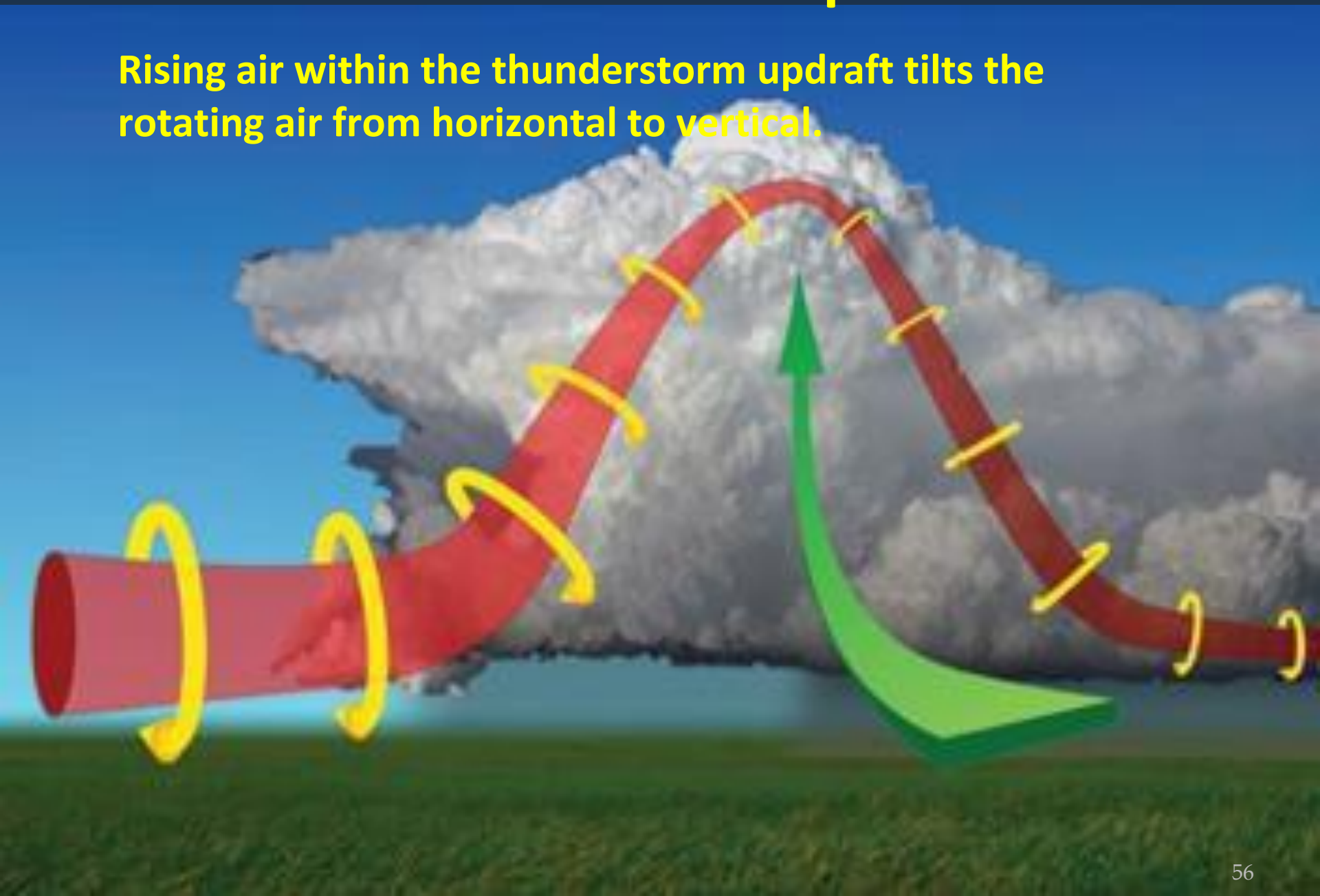
Wind Shear

WINDS CHANGE DIRECTION AND INCREASE IN SPEED WITH ALTITUDE. THIS CREATES AN INVISIBLE, HORIZONTAL SPINNING EFFECT IN THE LOWER ATMOSPHERE.

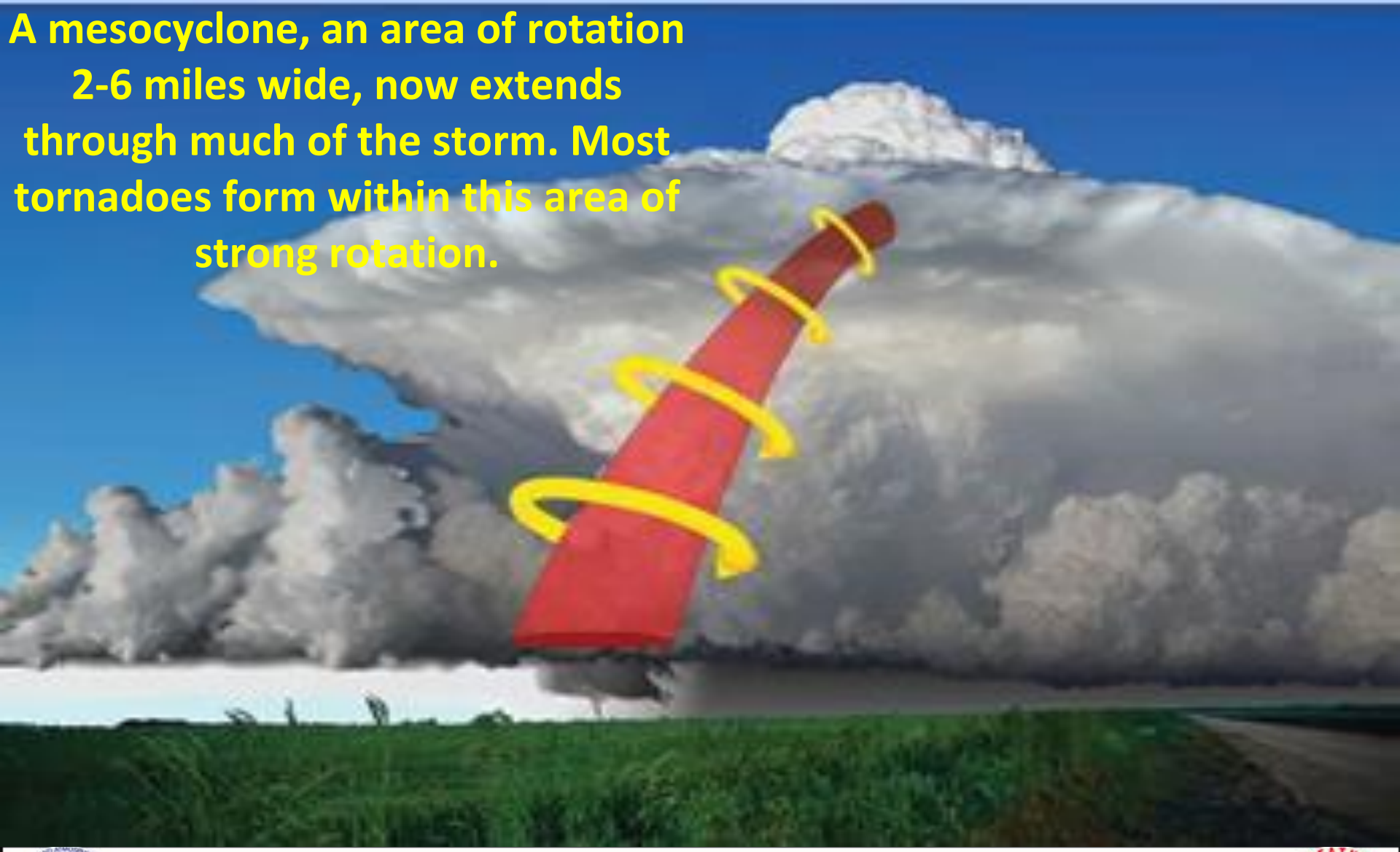


Wind Shear and Updraft

Rising air within the thunderstorm updraft tilts the rotating air from horizontal to vertical.



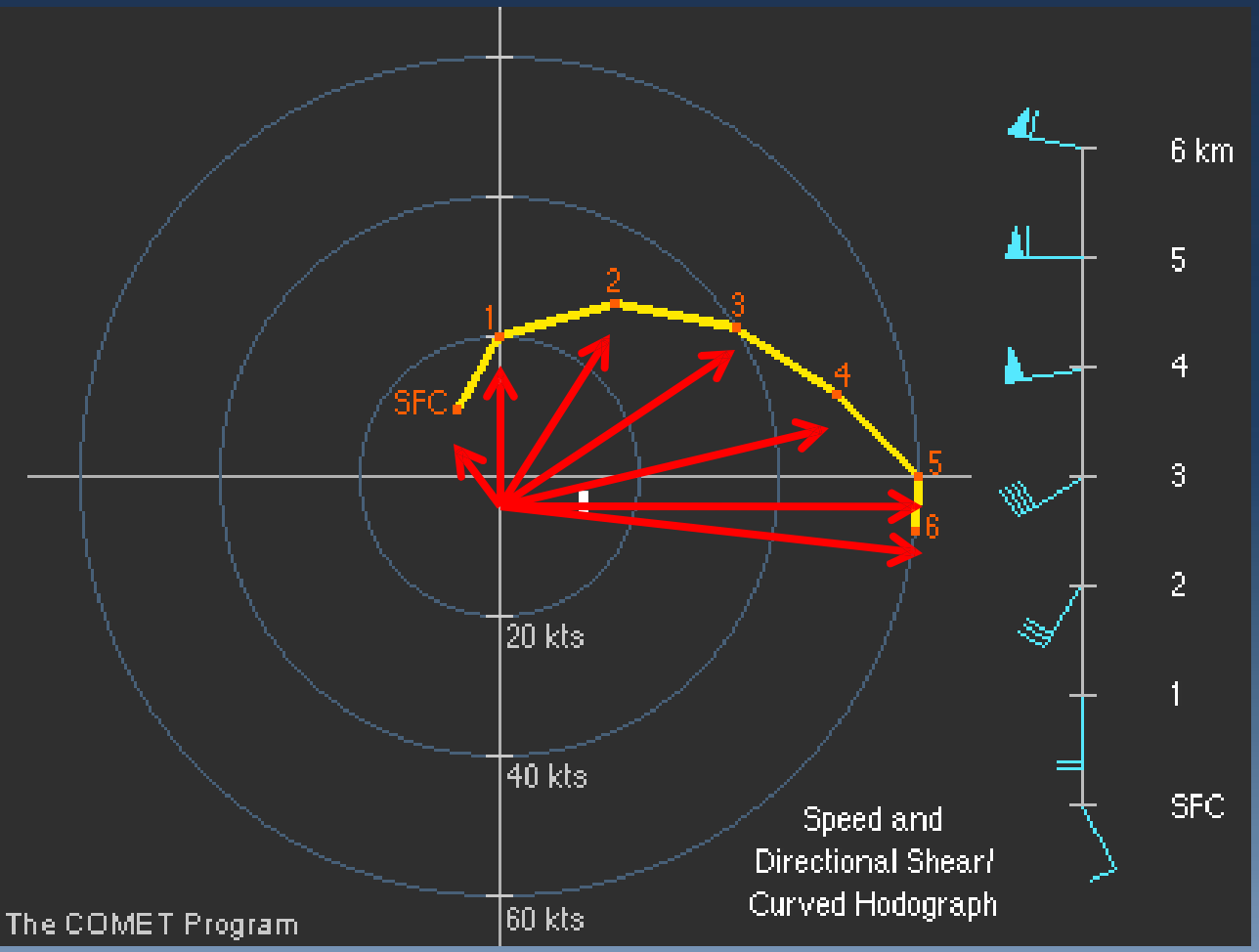
Mesocyclone Formation



A mesocyclone, an area of rotation 2-6 miles wide, now extends through much of the storm. Most tornadoes form within this area of strong rotation.

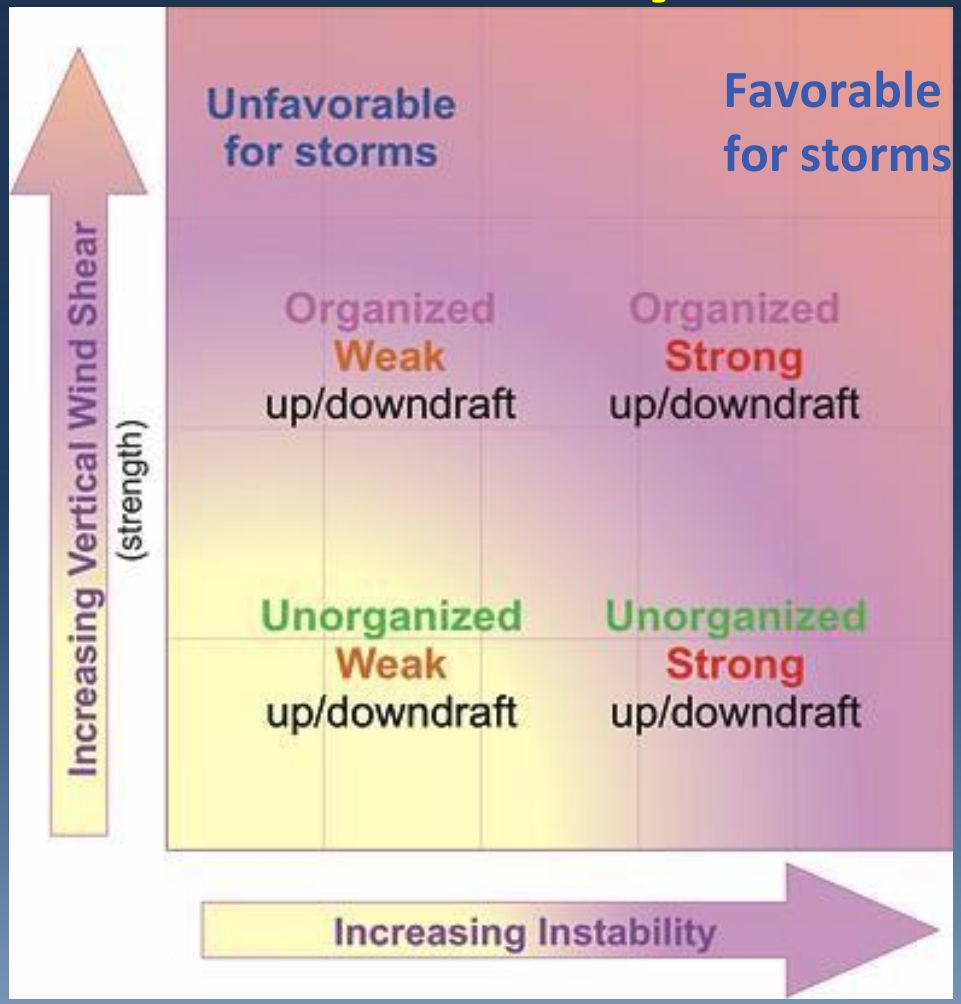
The 3-Dimensional Atmosphere

Wind Shear



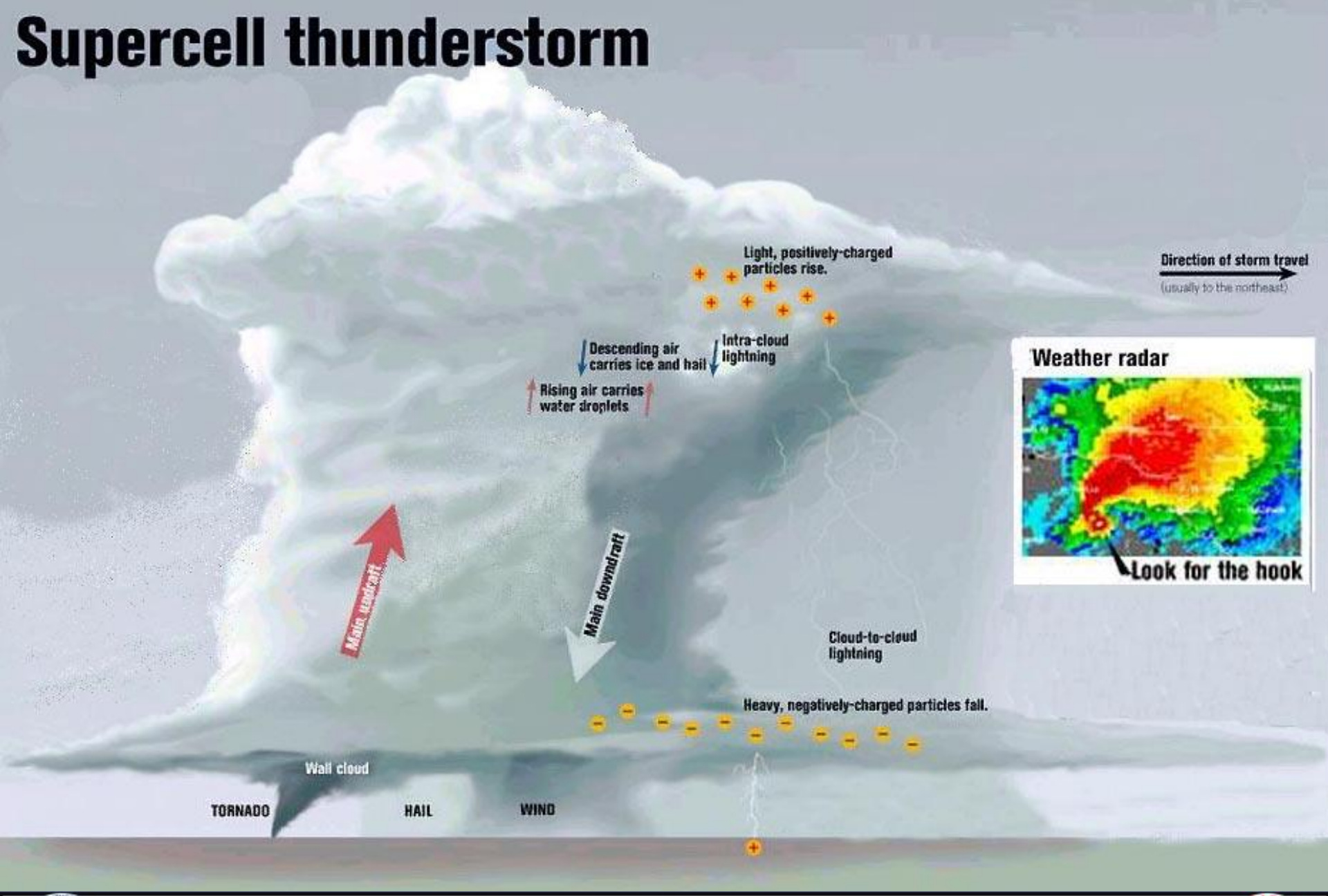
- Wind speed is typically calculated in terms of speed and direction. The change in these is known as **Helicity or Storm Relative Helicity**.
- Helicity is measured at several height levels, and that determines what type of storm is likely to form or what the mode of convection will be.
- 0 to 6 km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

Finding the Perfect Balance - Instability versus Wind Shear



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

Supercell thunderstorm



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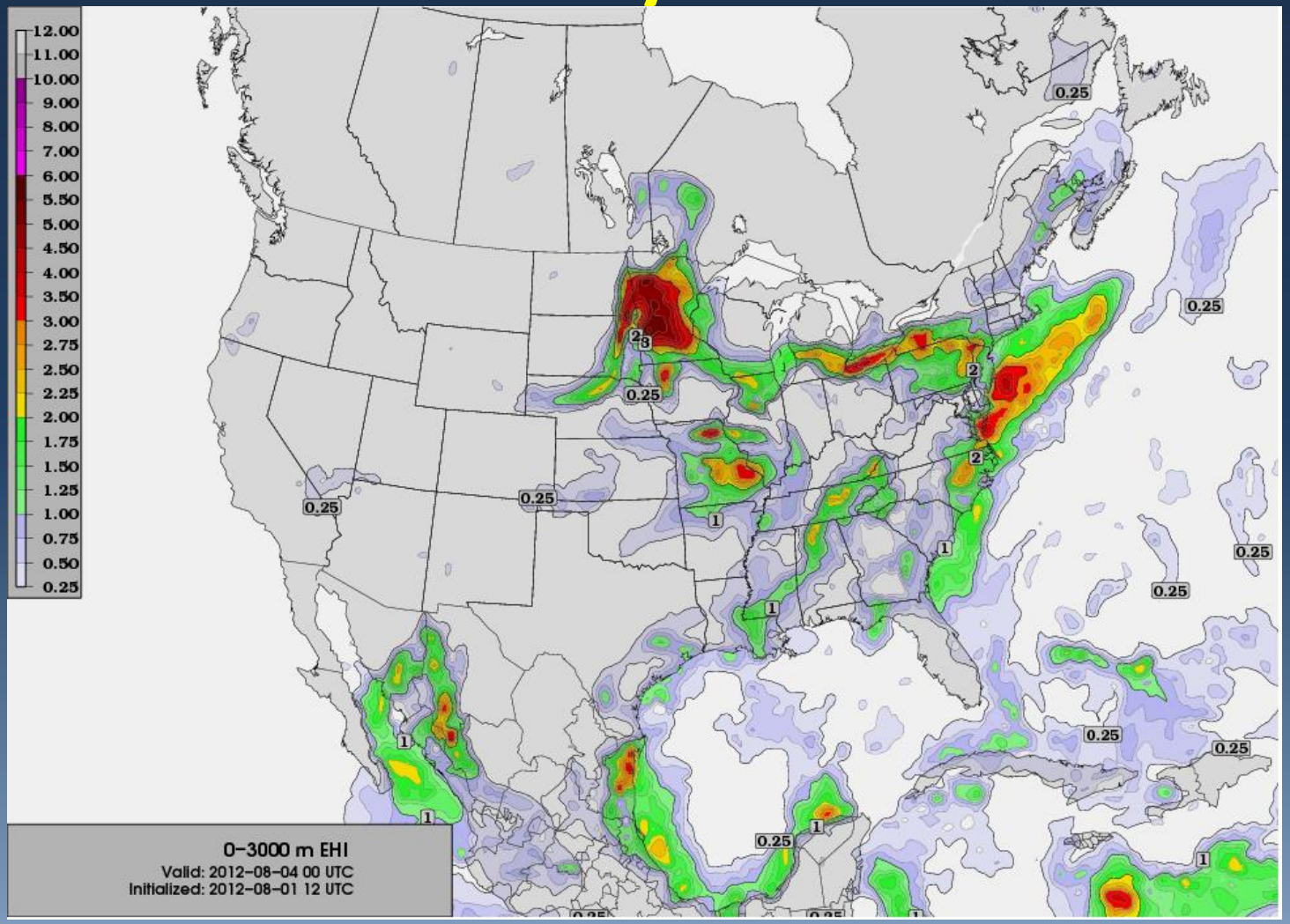
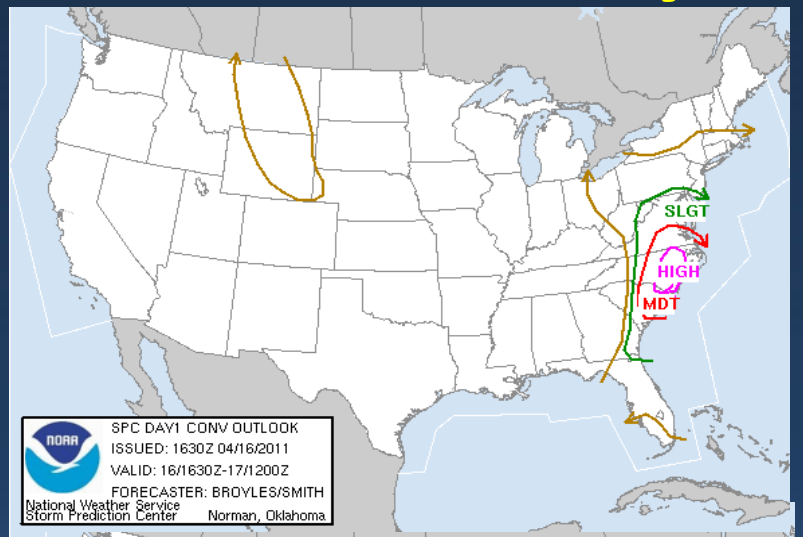
Finding the Perfect Balance - Instability versus Wind Shear

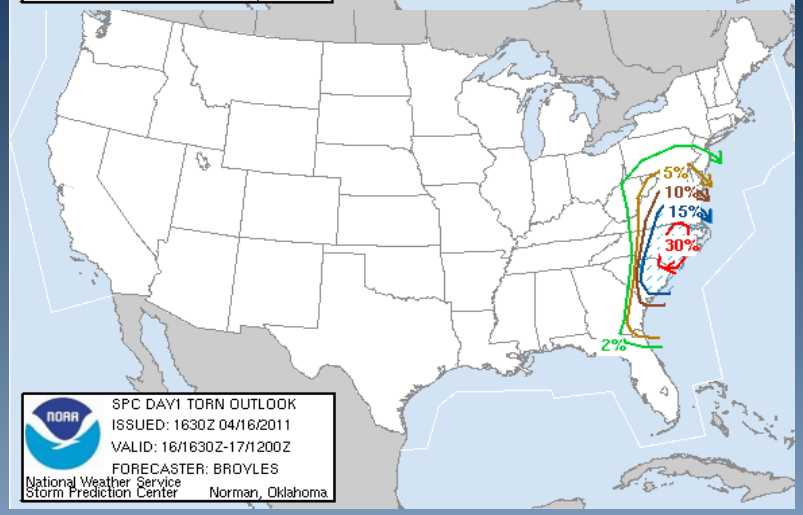


- Certain products like the Energy Helicity Index (EHI) can help you determine the mode of convection.
- EHI > 4 (rare)
  Strong storms likely
- EHI 1 – 3
  Supercell potential
- EHI < 1
- Low
- (sub-severe storms still possible)

Finding the Perfect Balance

Instability versus Wind Shear





...TORNADO OUTBREAK EXPECTED THIS AFTERNOON AND EARLY THIS EVENING ...

A VIGOROUS UPPER-LEVEL TROUGH WILL MOVE INTO THE OH AND TN VALLEYS TODAY AS A WELL-DEFINED 70 TO 85 KT MID-LEVEL JET ROUNDS THE BASE OF THE TROUGH AND NOSES INTO THE CAROLINAS. THE JET WILL CREATE STRONG DEEP LAYER SHEAR PROFILES WHICH WILL BE VERY FAVORABLE FOR SEVERE STORMS AND TORNADOES THIS AFTERNOON. AT THE SFC A COLD FRONT WILL MOVE QUICKLY EWD ACROSS THE SRN APPALACHIAN MOUNTAINS. AHEAD OF THE FRONT...MODERATE DESTABILIZATION WILL LIKELY TAKE PLACE TODAY ALONG A MOIST AXIS WHERE SFC DEWPOINTS WILL BE IN THE MID TO UPPER 60S F. STRONG THUNDERSTORMS SHOULD INITIATE ON THE WRN EDGE OF THE MOIST AXIS IN THE WRN CAROLINAS AND RAPIDLY INCREASE IN COVERAGE EARLY THIS AFTERNOON.

Understanding Severe Thunderstorm Risk Categories

THUNDERSTORMS (no label)	1 - MARGINAL (MRGL)	2 - SLIGHT (SLGT)	3 - ENHANCED (ENH)	4 - MODERATE (MDT)	5 - HIGH (HIGH)
No severe* thunderstorms expected	**Isolated severe thunderstorms possible**	**Scattered severe storms possible**	**Numerous severe storms possible**	**Widespread severe storms likely**	**Widespread severe storms expected**
Lightning/flooding threats exist with all thunderstorms	Limited in duration and/or coverage and/or intensity	Short-lived and/or not widespread, isolated intense storms possible	More persistent and/or widespread, a few intense	Long-lived, widespread and intense	Long-lived, very widespread and particularly intense
• *Winds to 40 mph* • *Small hail*	• *Winds 40-60 mph* • *Hail up to 1"* • *Low tornado risk*	• *One or two tornadoes* • *Reports of strong winds/wind damage* • *Hail ~1", isolated 2"*	• *A few tornadoes* • *Several reports of wind damage* • *Damaging hail, 1 - 2"*	• *Strong tornadoes* • *Widespread wind damage* • *Destructive hail, 2" +*	• *Tornado outbreak* • *Derecho*

* NWS defines a severe thunderstorm as measured wind gusts to at least 58 mph, and/or hail to at least one inch in diameter, and/or a tornado. All thunderstorm categories imply lightning and the potential for flooding. Categories are also tied to the probability of a severe weather event within 25 miles of your location.

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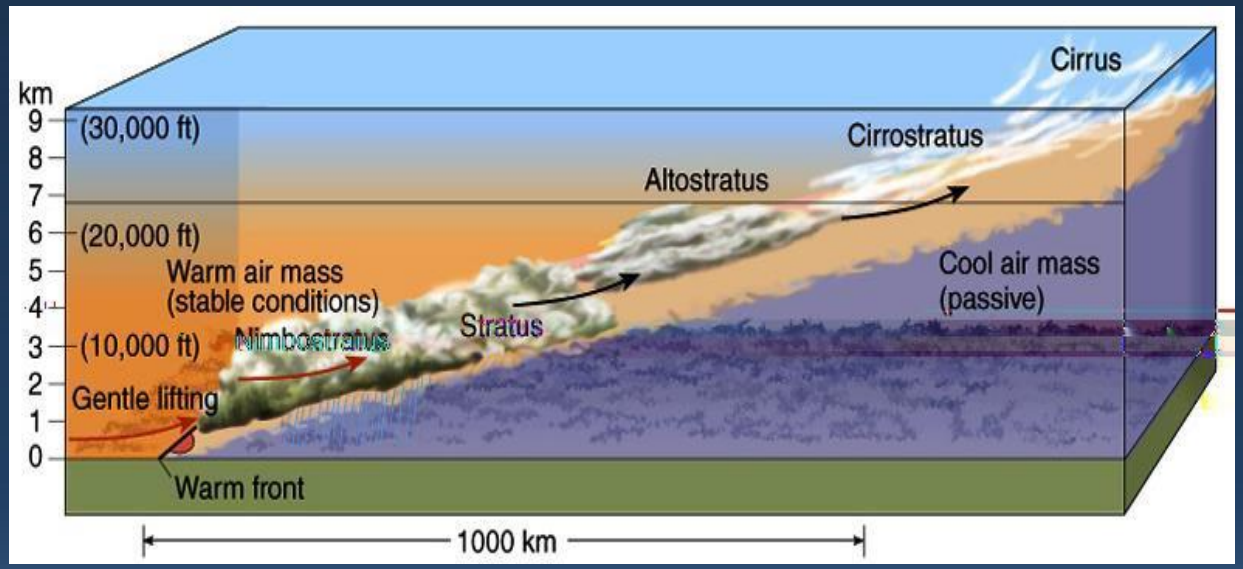
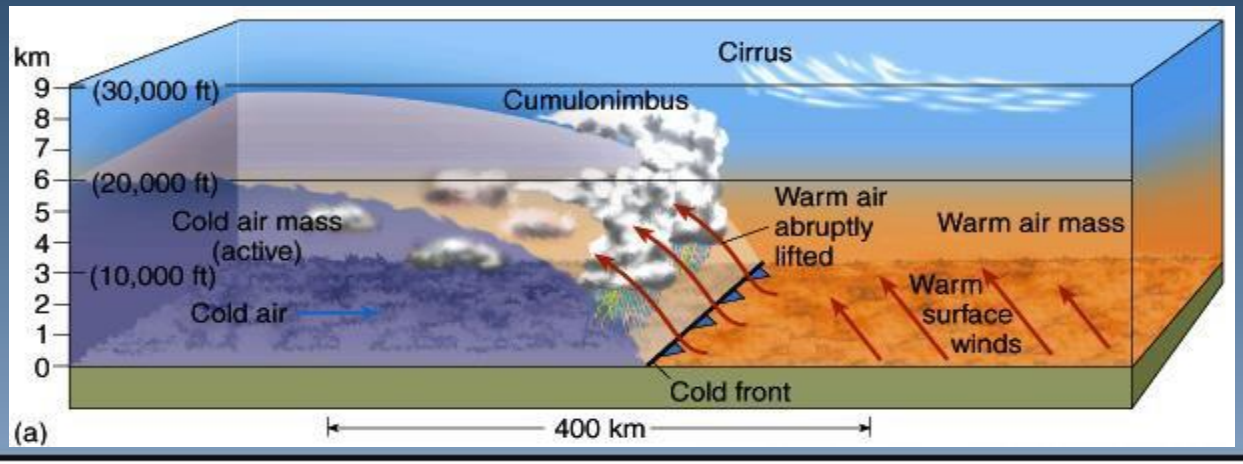
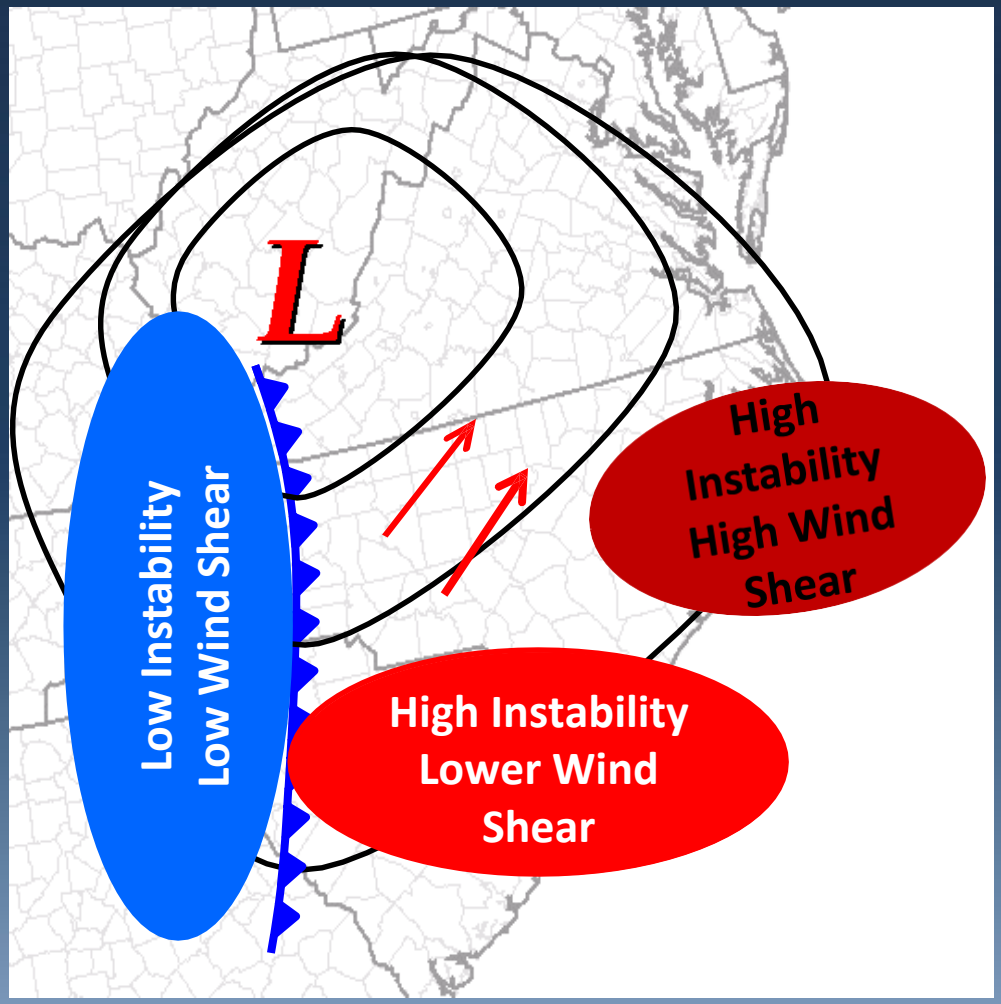
The 3-Dimensional Atmosphere
Location of that Perfect Balance



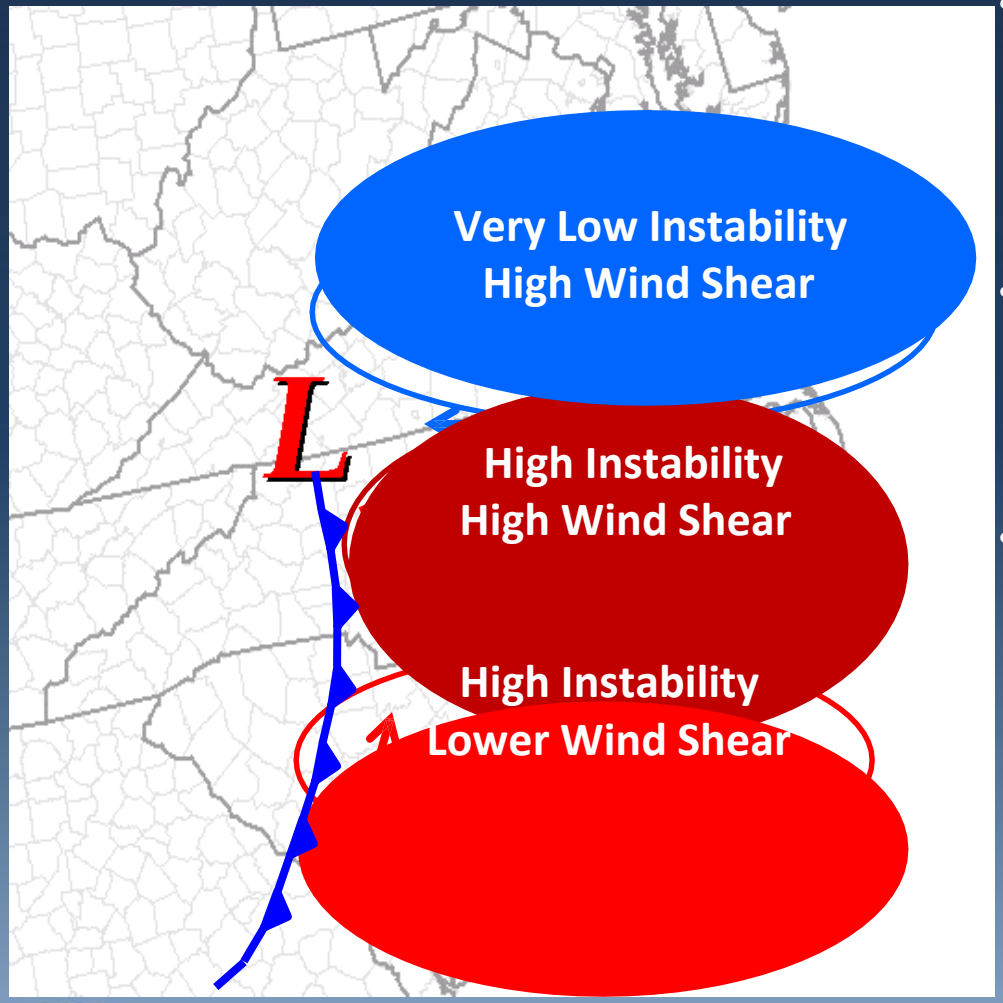


The 3-Dimensional Atmosphere
Cold Front



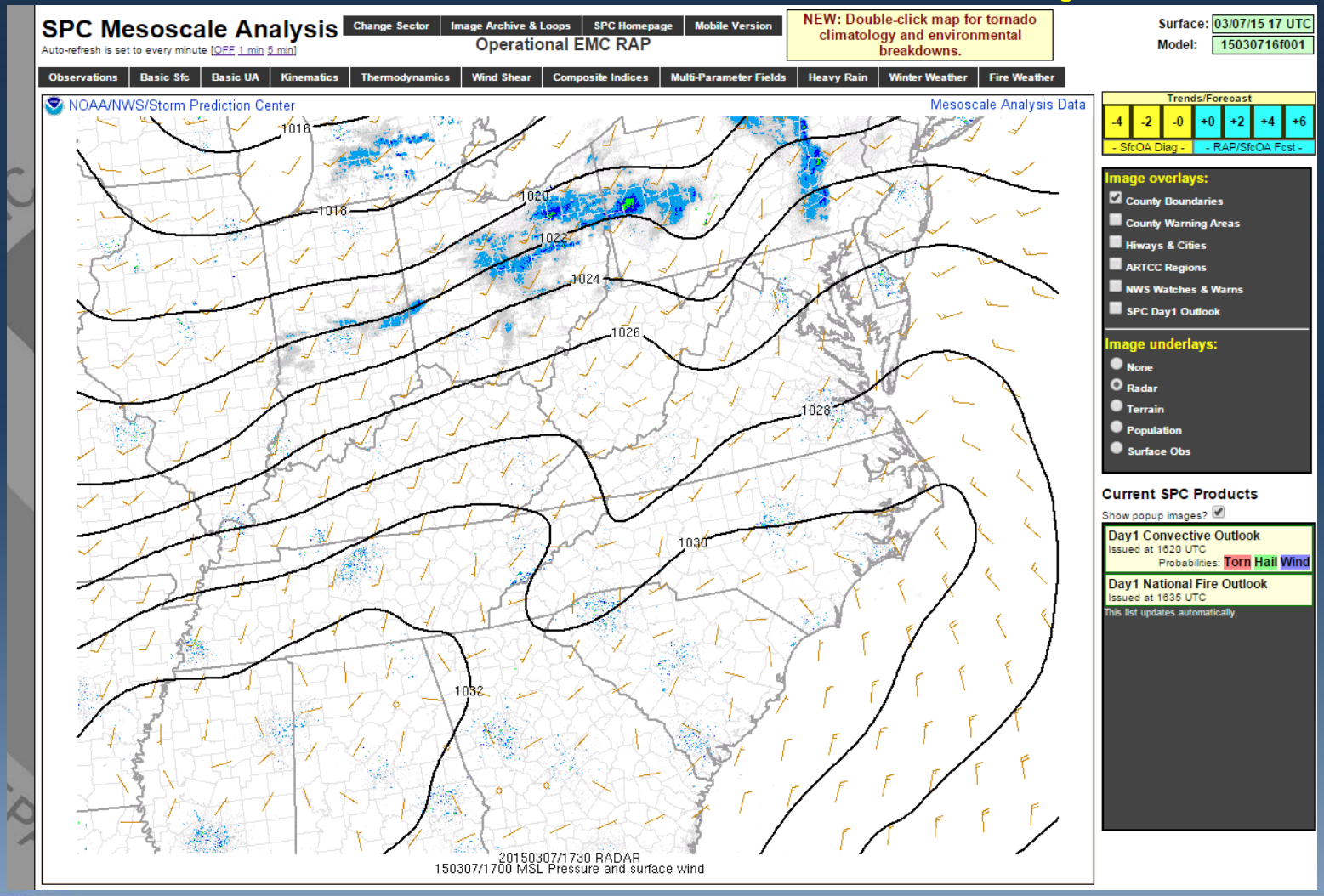
- Cold Fronts are characterized by an abrupt wind-shift from the south to the northwest as you go from east to west.
- Ahead of the cold front, generally there is unstable air with high wind shear.
- Behind the cold front the air is colder, drier and virtually no instability or wind shear.

The 3-Dimensional Atmosphere
Warm Front



- Warm fronts are typically characterized by a distinct wind-shift to the south to east as you go from south to north.
- North of the warm front the wind shear can remain high, but the instability decreases significantly.
- South of the warm front the airmass is unstable with high wind shear.

Instability, Wind Shear, and Lifting Mechanisms
Where Can I Get Help?



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What We Observe When Spotting Plains versus The Southeast

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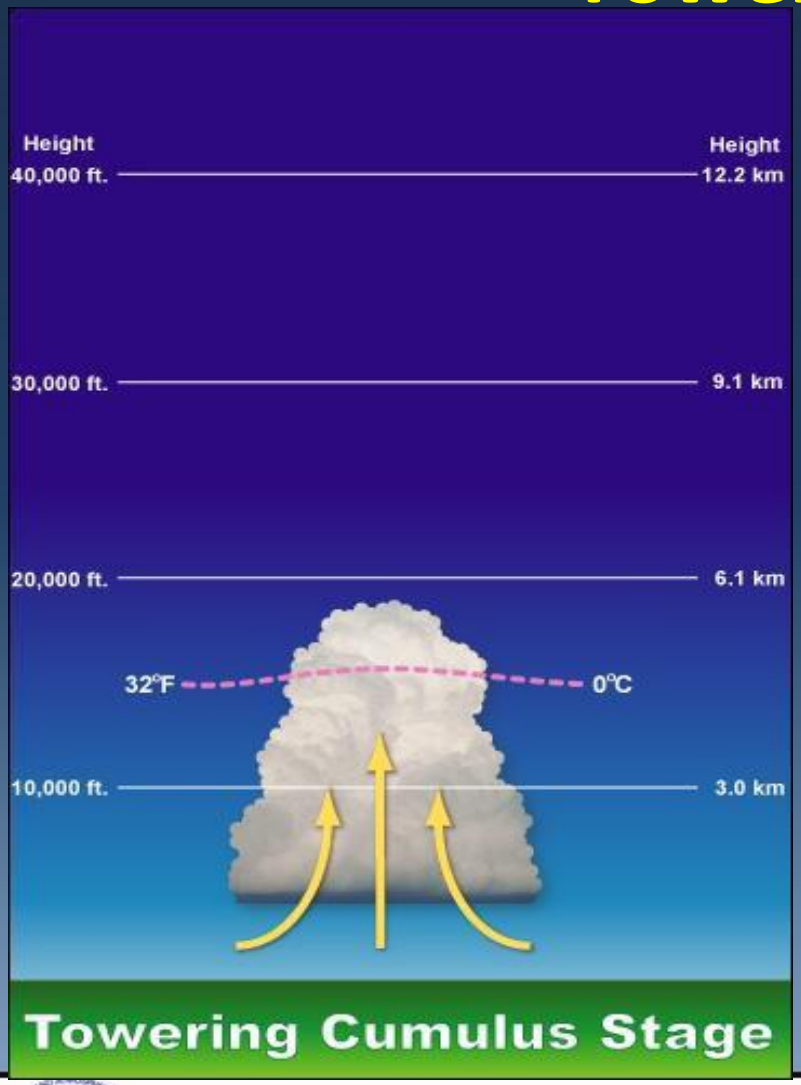
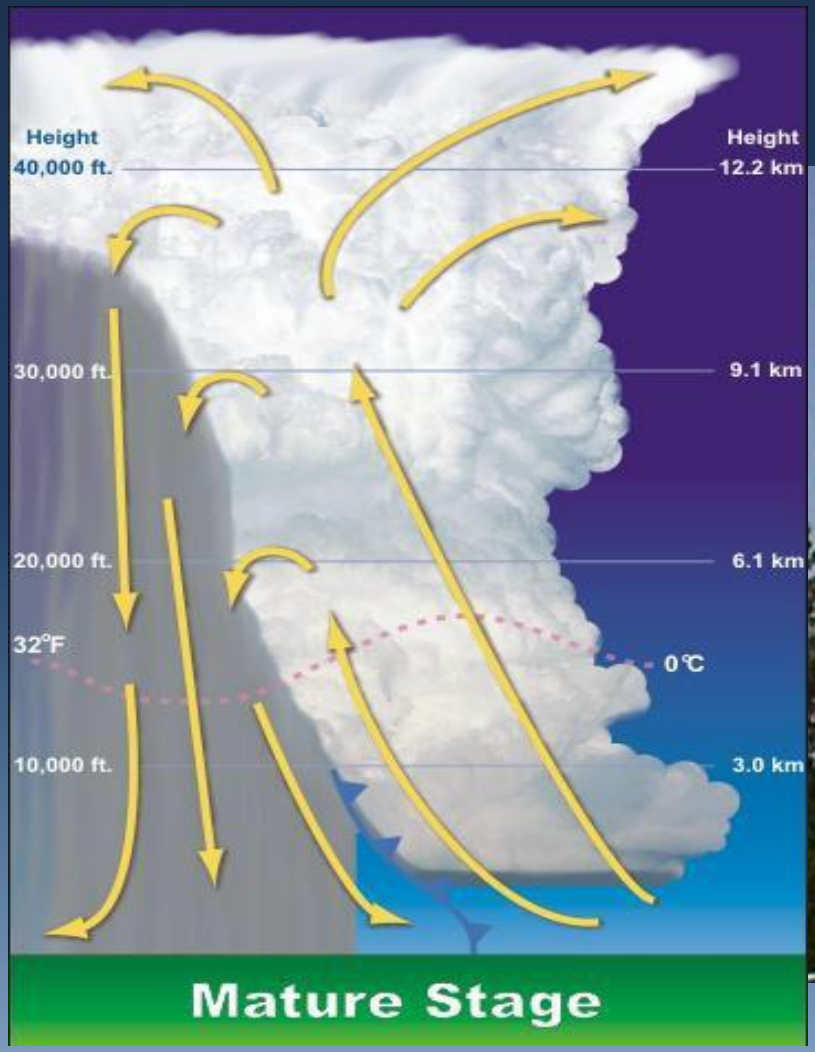
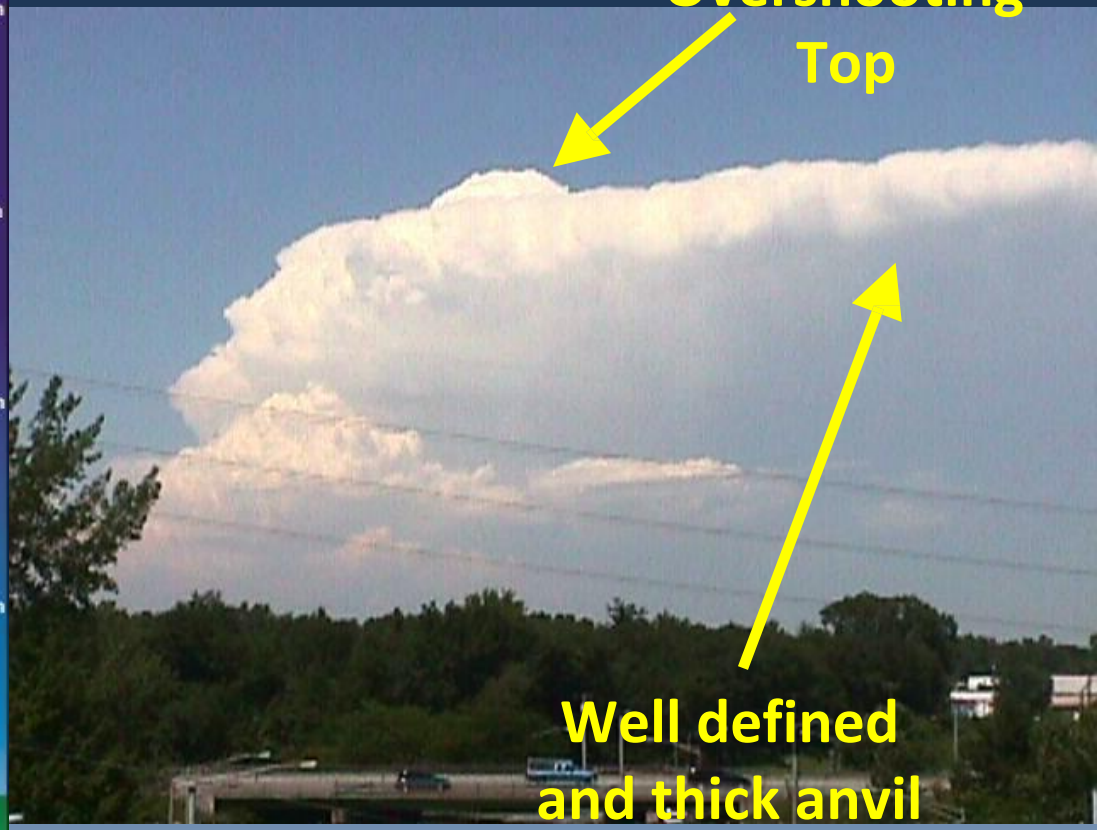
What We Observe When Spotting Towering Cumulus

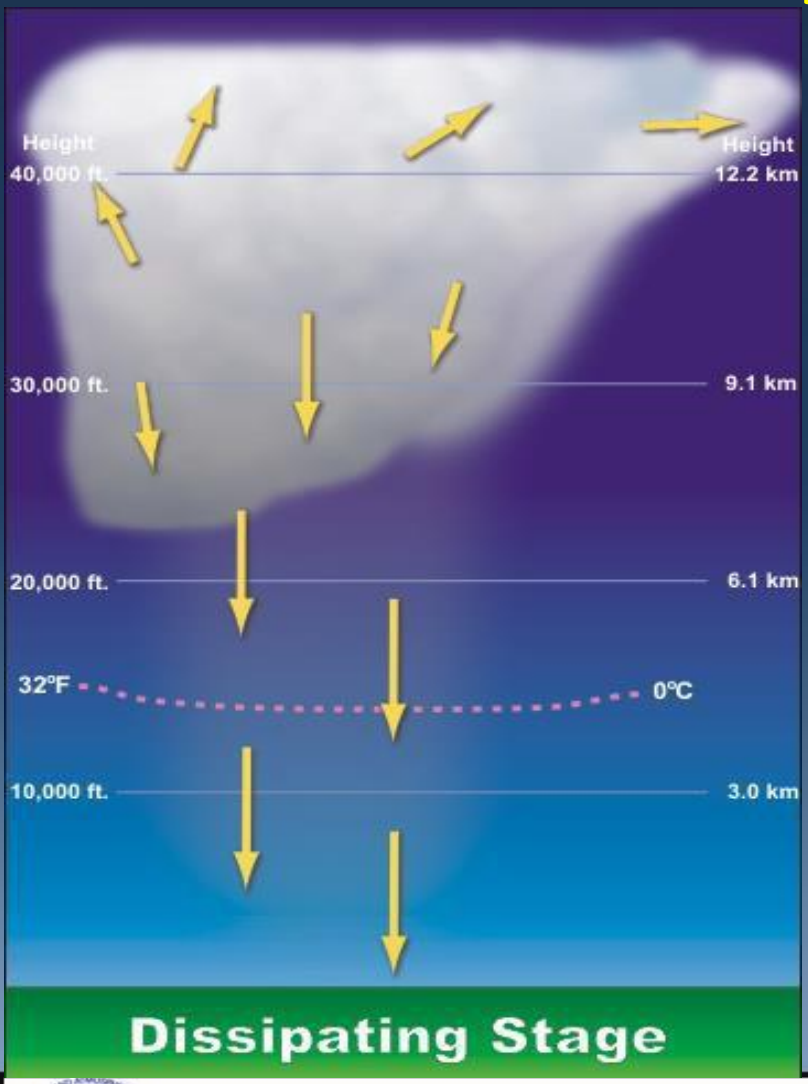


What We Observe When Spotting Mature Stage

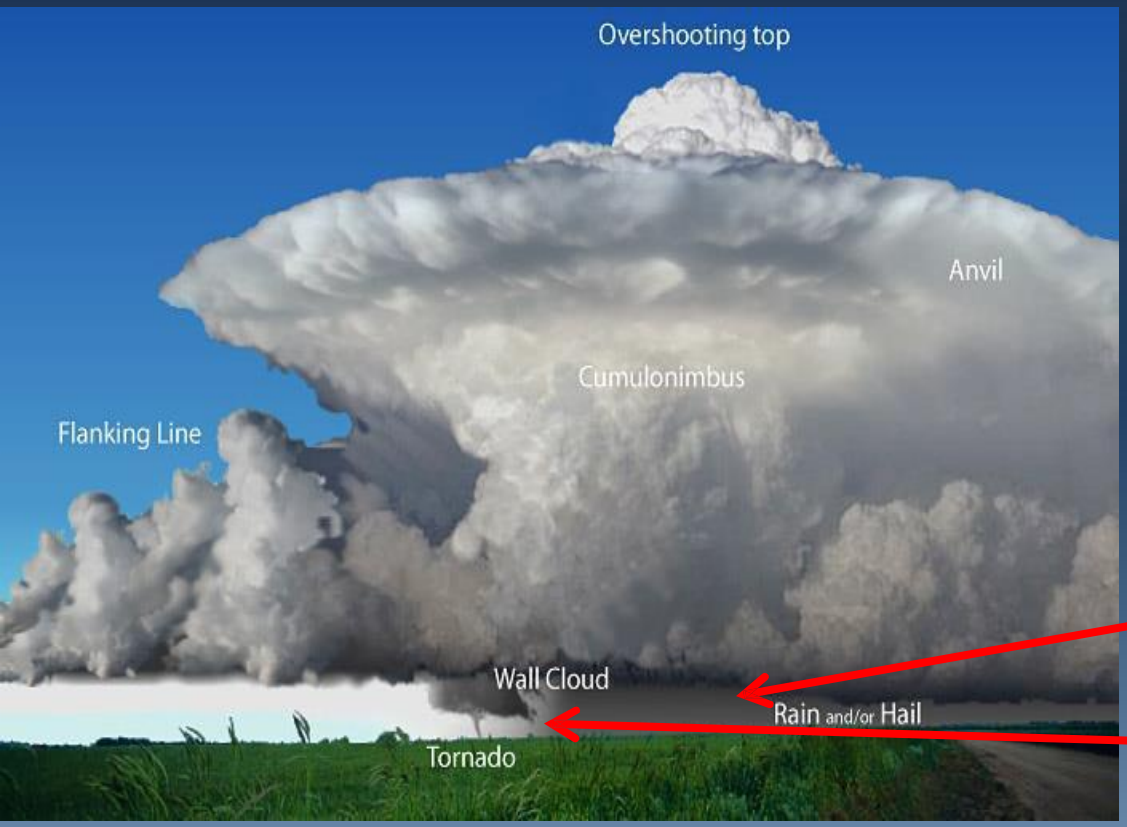


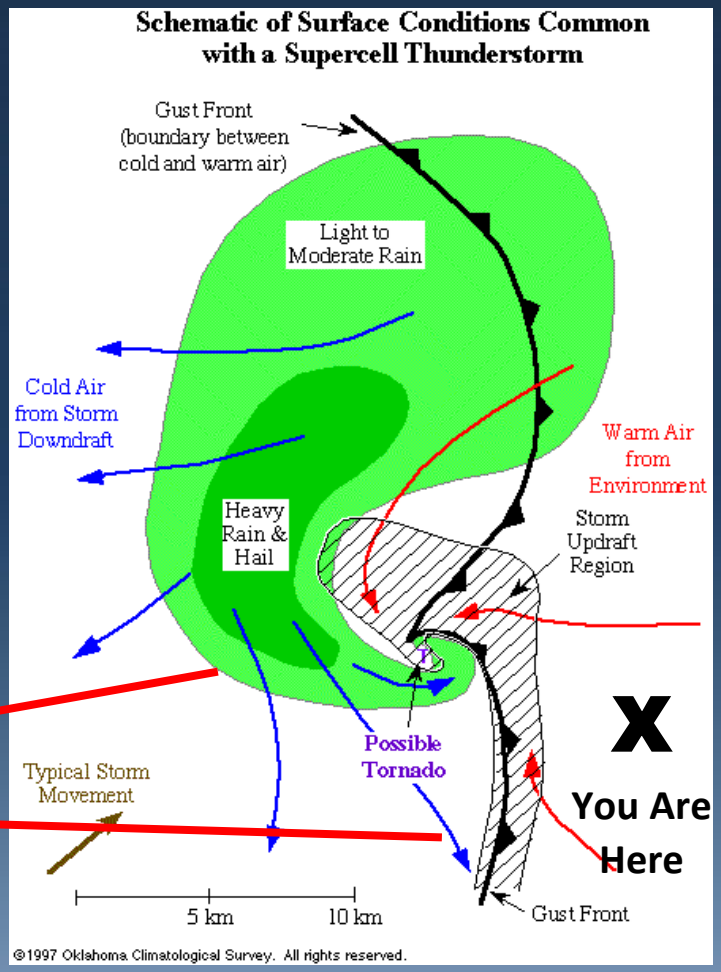


What We Observe When Spotting Dissipation Stage



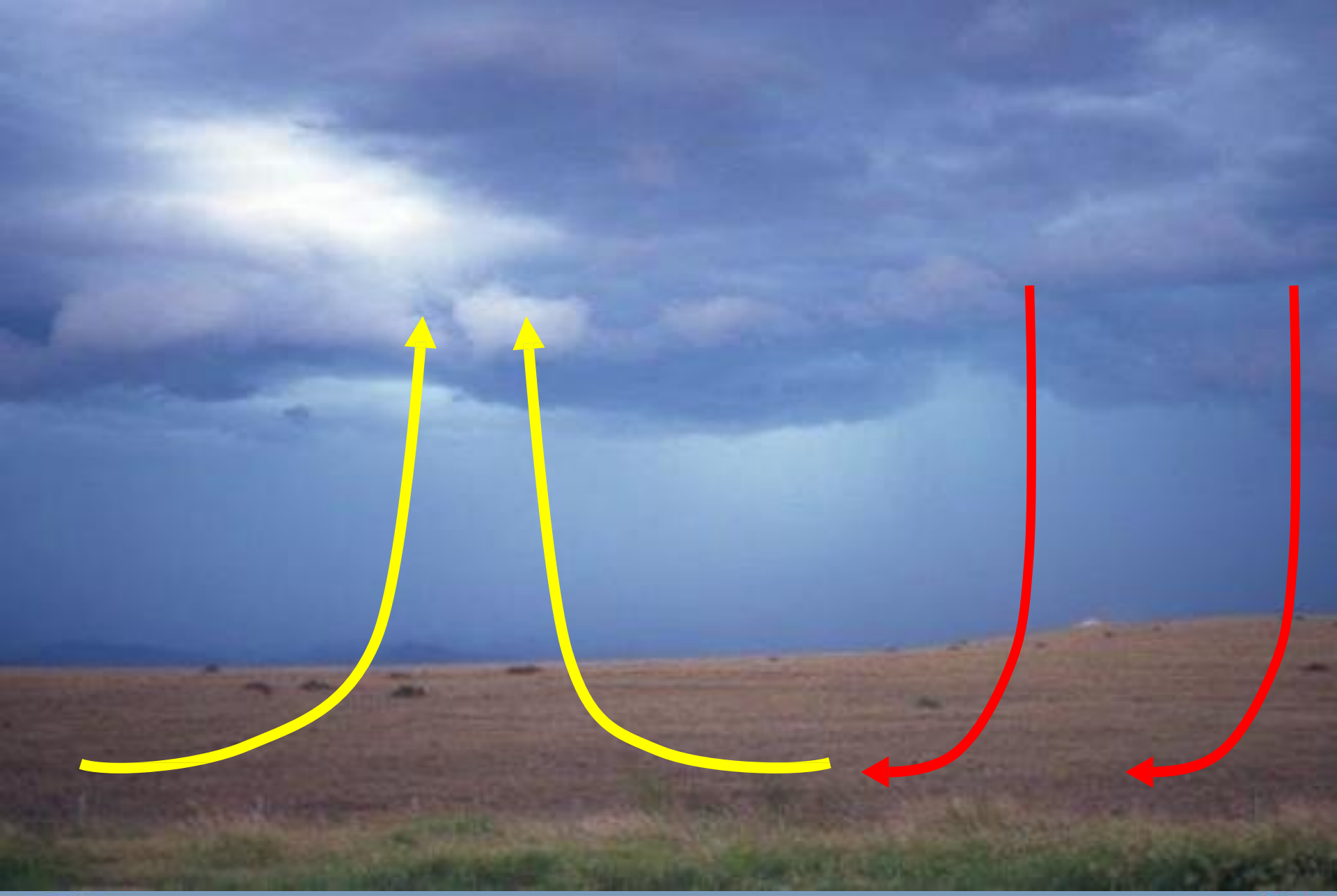
What We Observe When Spotting: Supercell

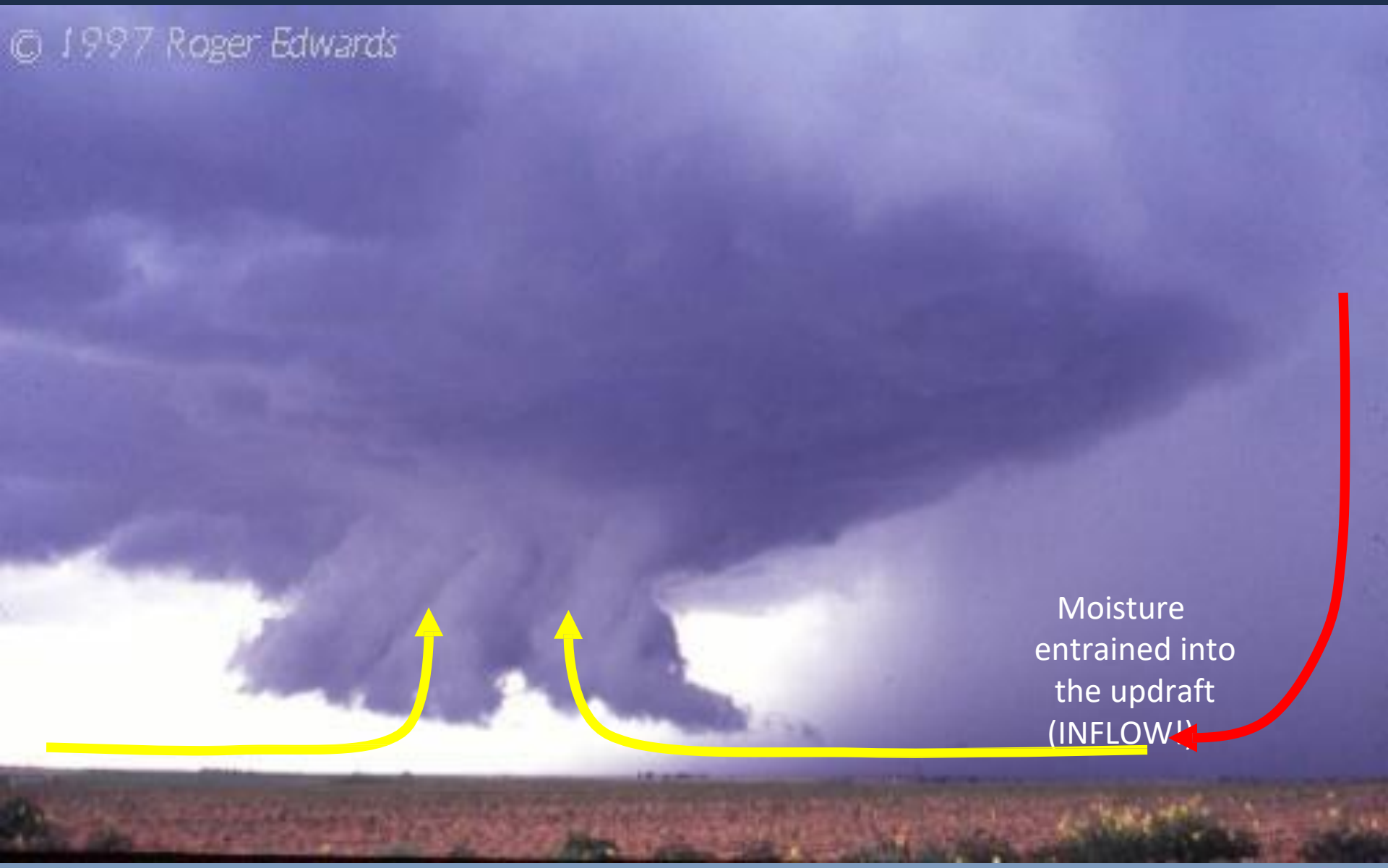




What We Observe When Spotting: Wall Cloud

- A wall cloud is the base of an updraft.
- Slopes down towards the precipitation.
- Organized Rotation?




© 1997 Roger Edwards
Moisture entrained into the updraft (INFLOW!)

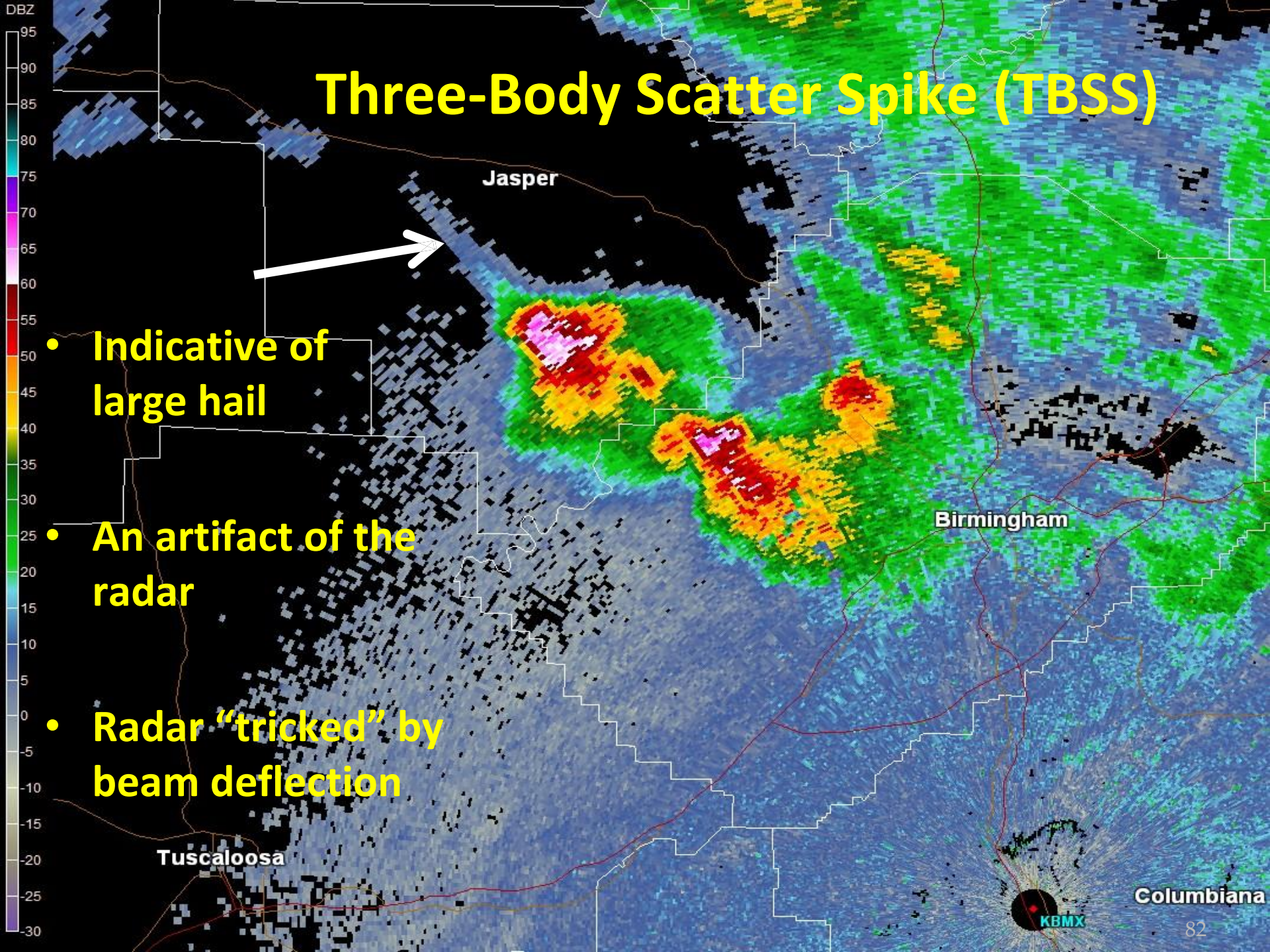
What We Observe When Spotting Shelf Cloud

- A shelf cloud is the leading edge of a gust front that is moving out and away from the precipitation.
- Downward sloping away from the precipitation.
- Not rotating!

When the cool air from the
downdraft reaches the surface....
... it creates the outflow which pushes forward and
provides lift for clouds to form (along the black line.

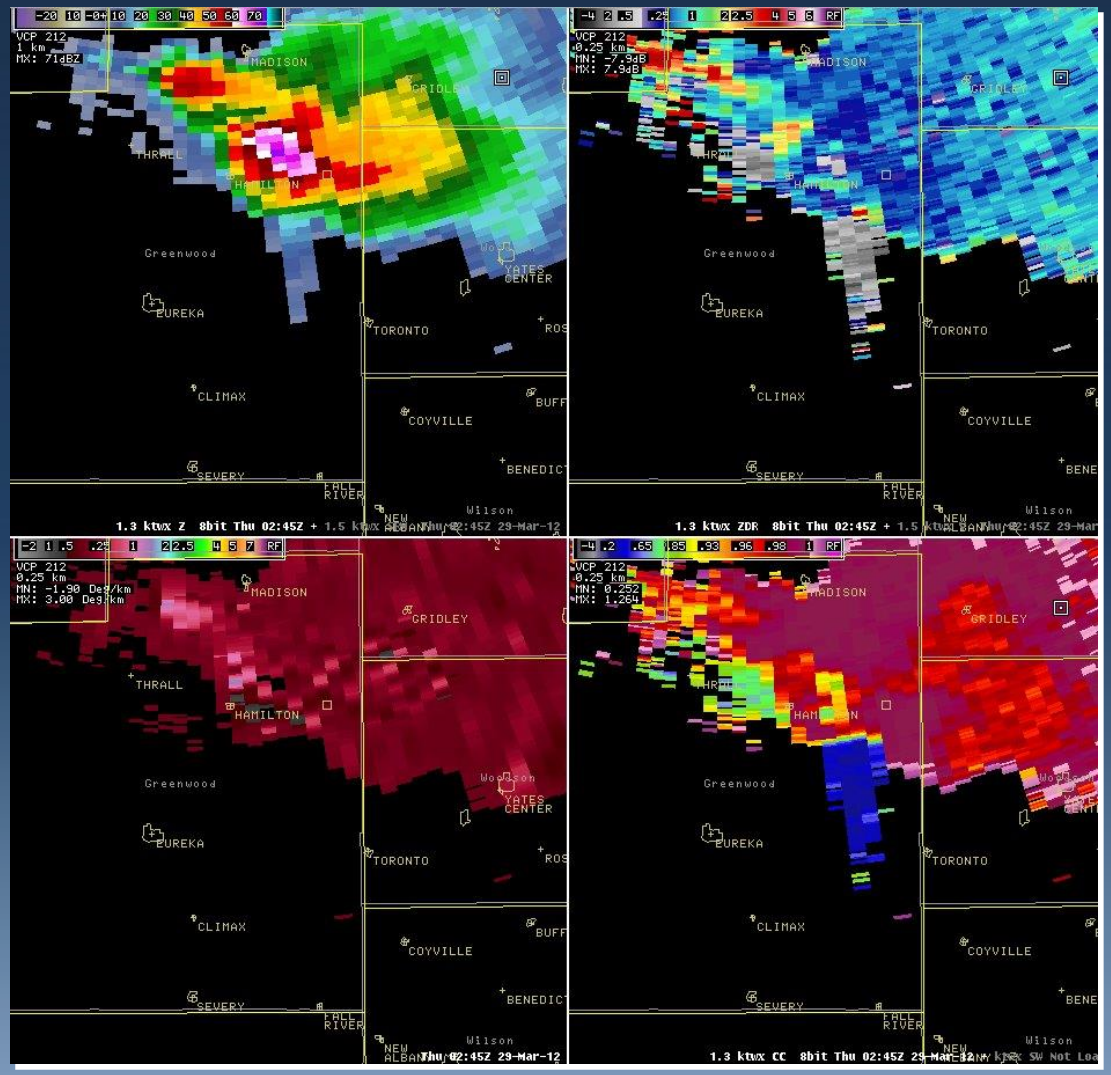
Common Radar Signatures

Three-Body Scatter Spike (TBSS)



- Indicative of large hail
- An artifact of the radar
- Radar "tricked" by beam deflection

Another Example of TBSS



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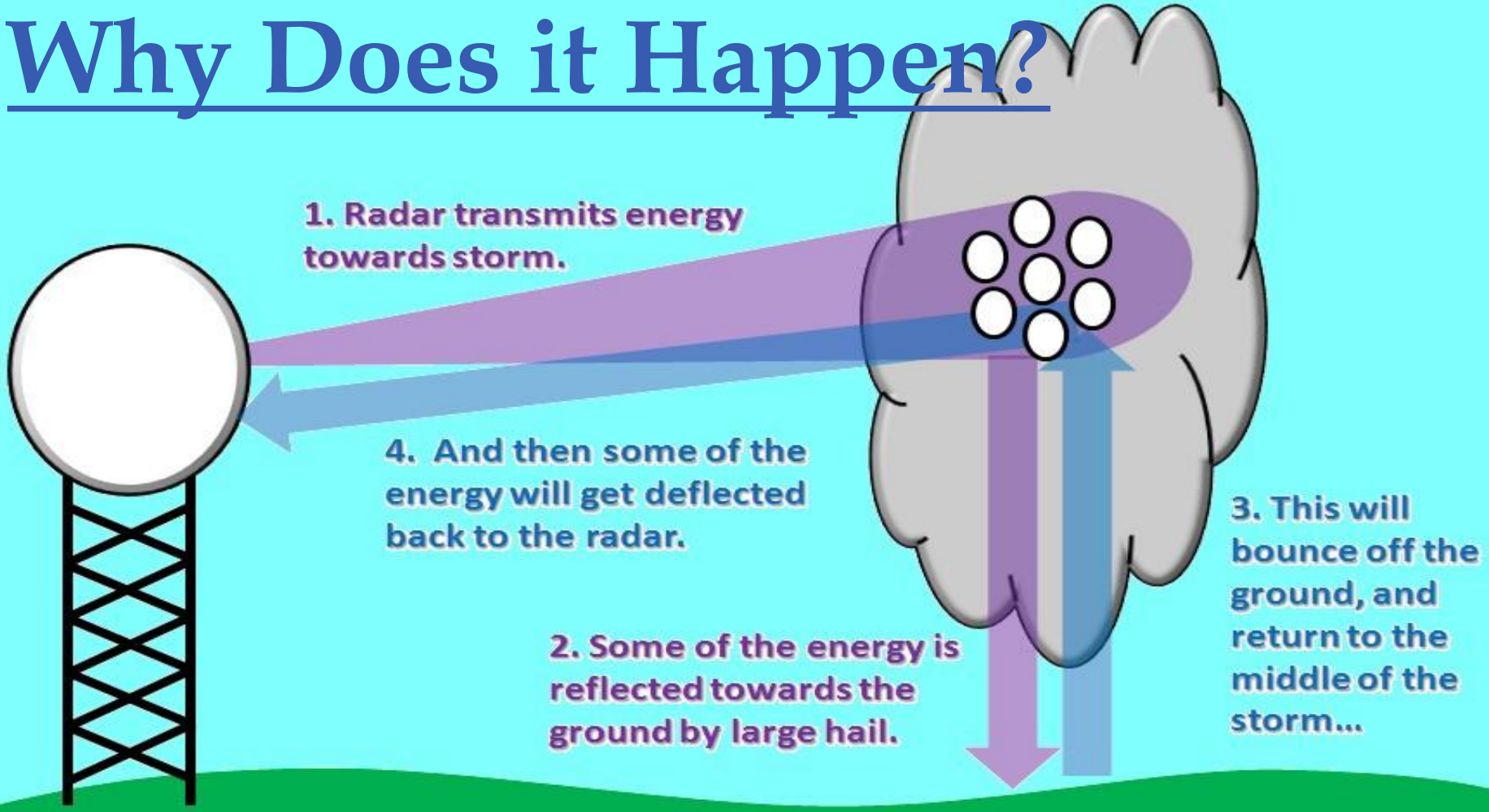
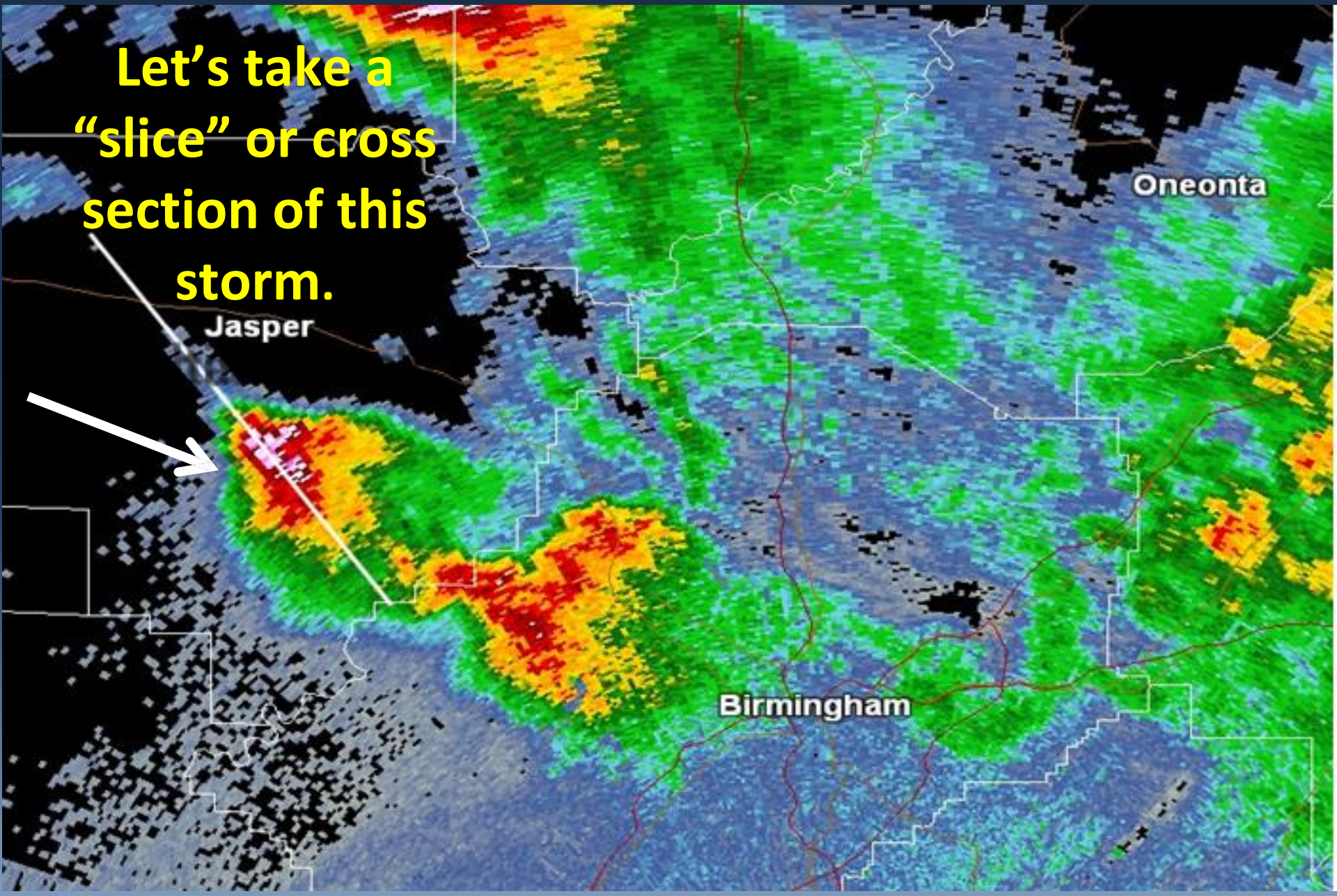
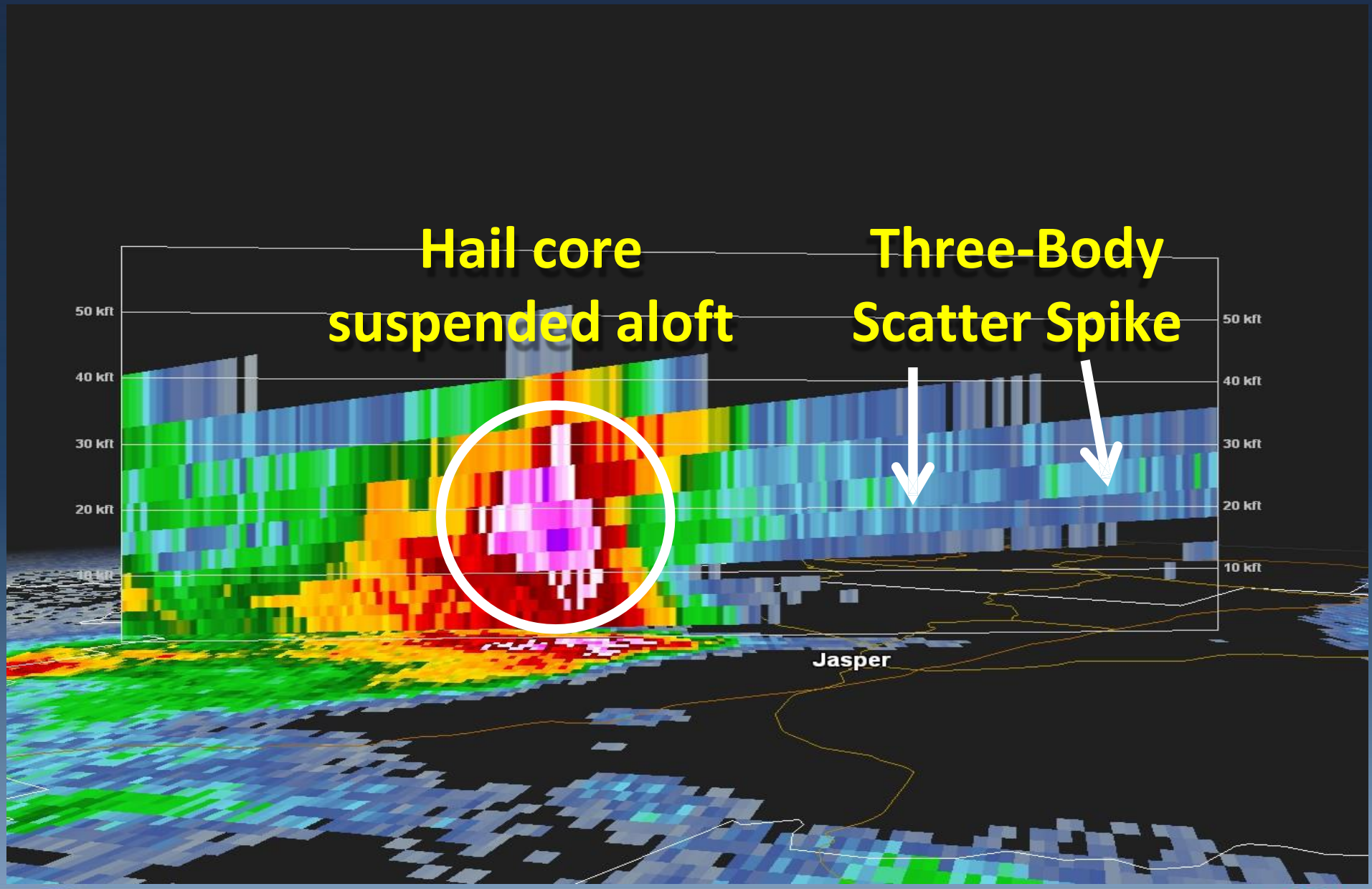
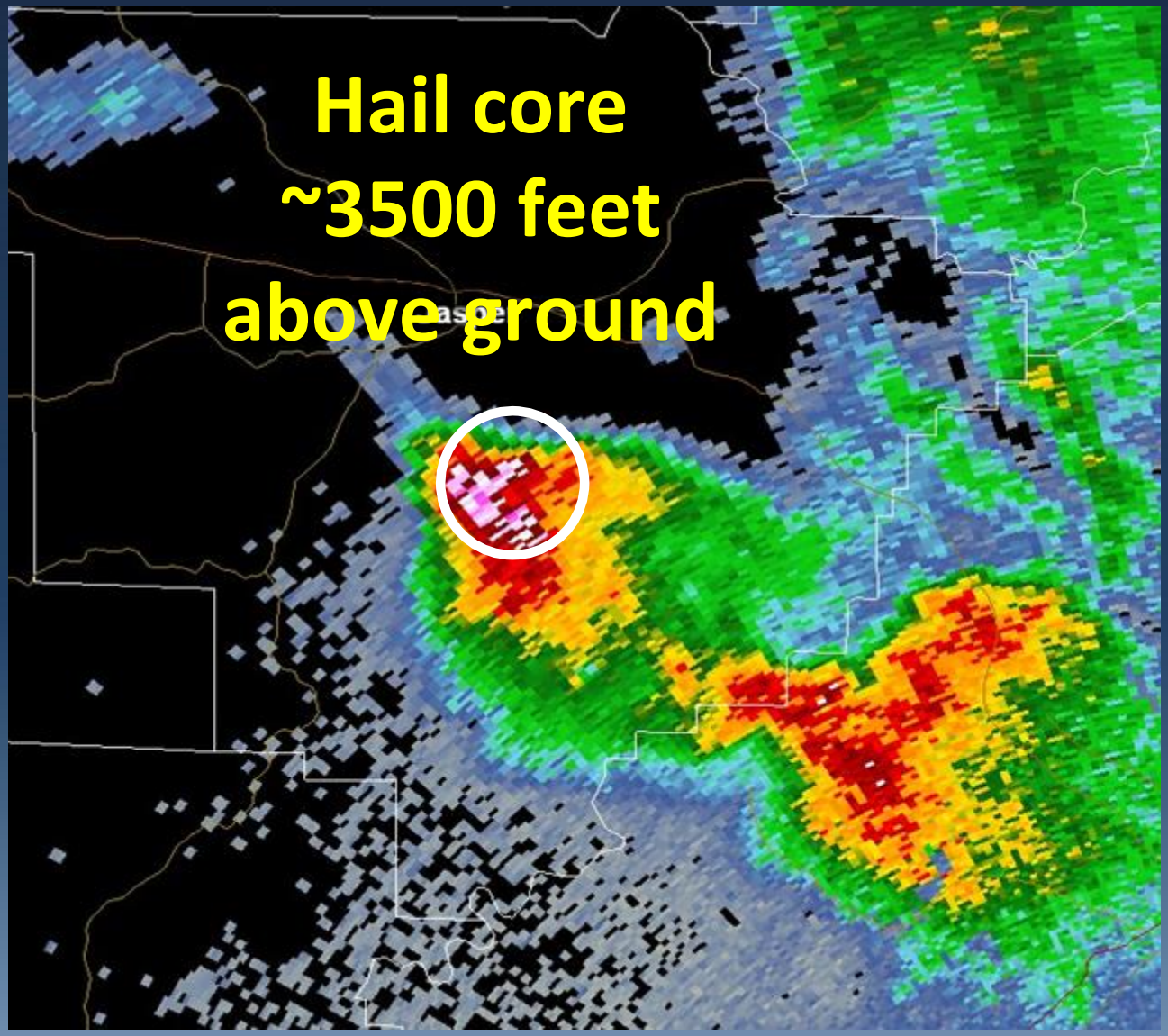
Why Does it Happen?

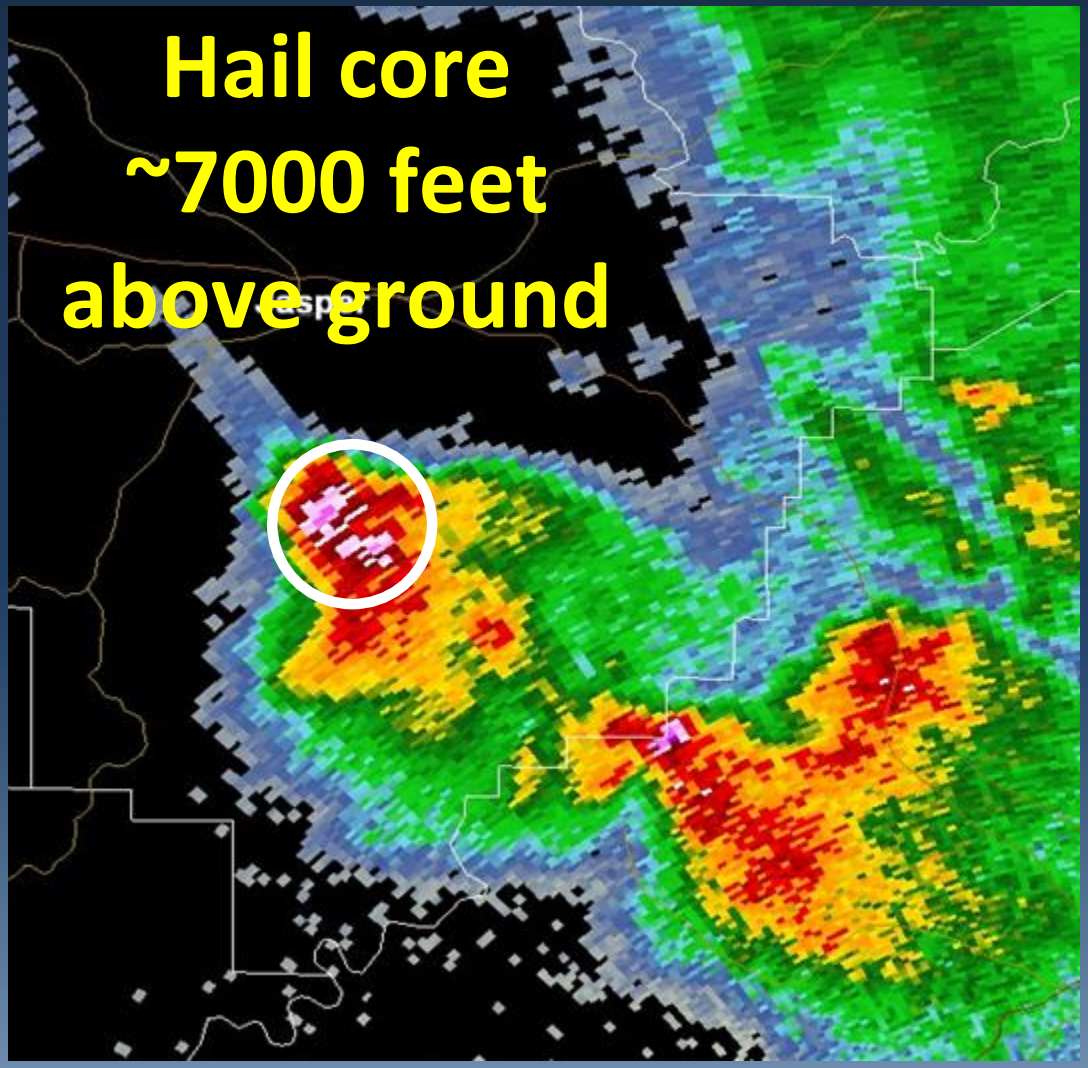


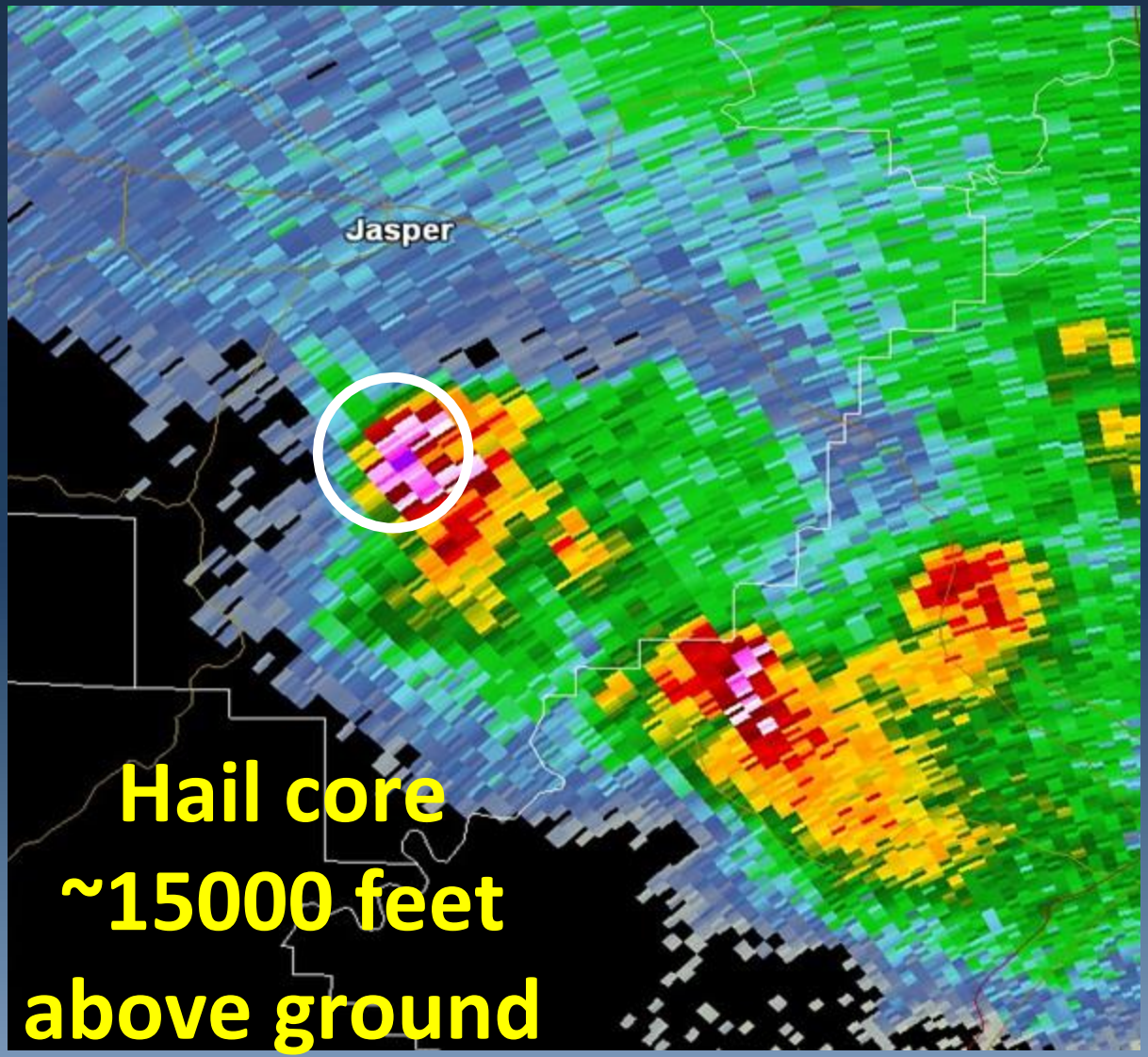
The extra time that it takes for the deflected energy to travel to the ground and back produces a false radar echo that extends like a spike along a line from the radar to the storm.


Let's take a "slice" or cross section of this storm.
Jasper
Oneonta
Birmingham

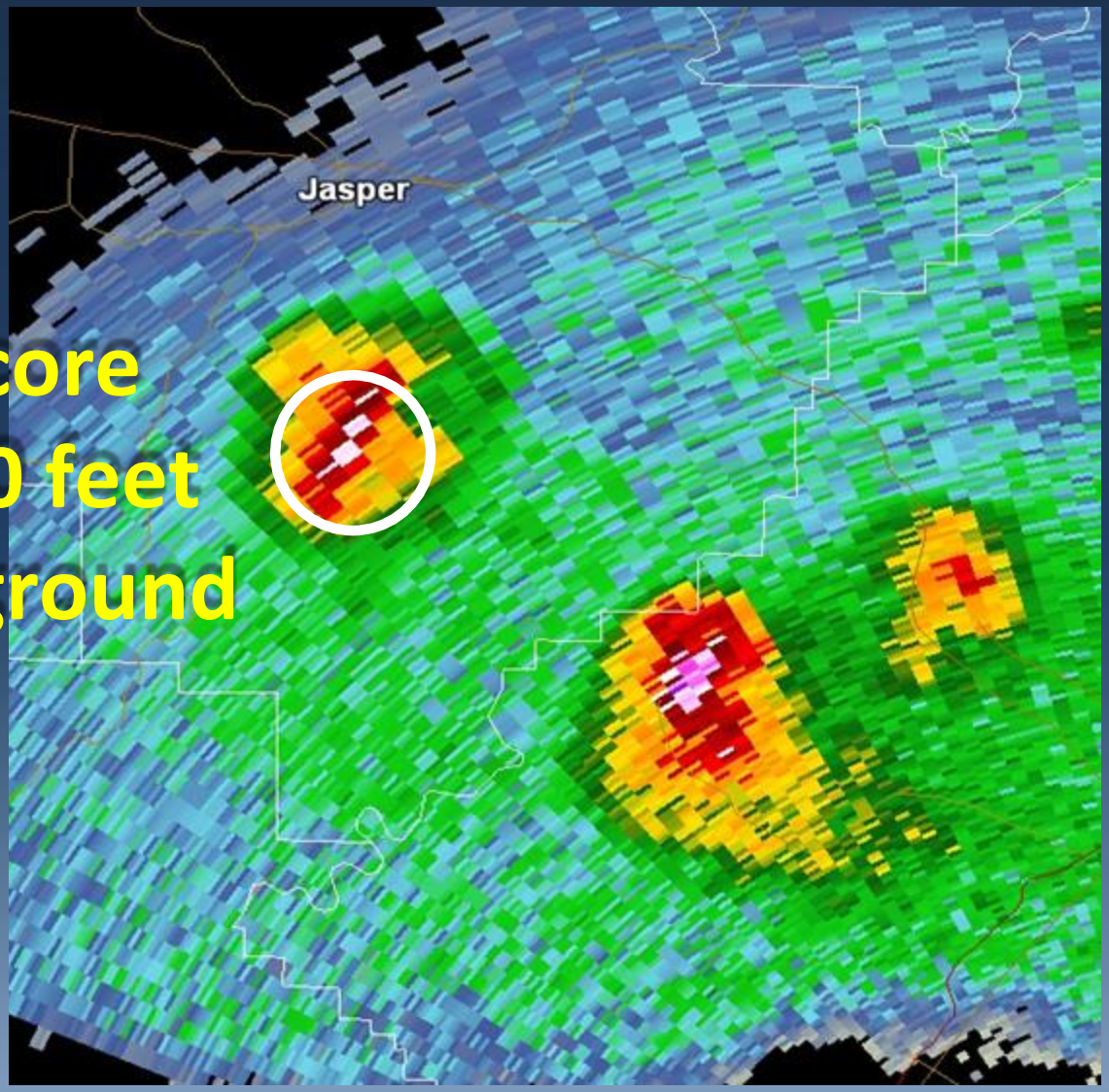

Hail core
suspended aloft
Three-Body
Scatter Spike
50 kft
40 kft
30 kft
20 kft
10 kft
Jasper


Hail core
~3500 feet
above ground

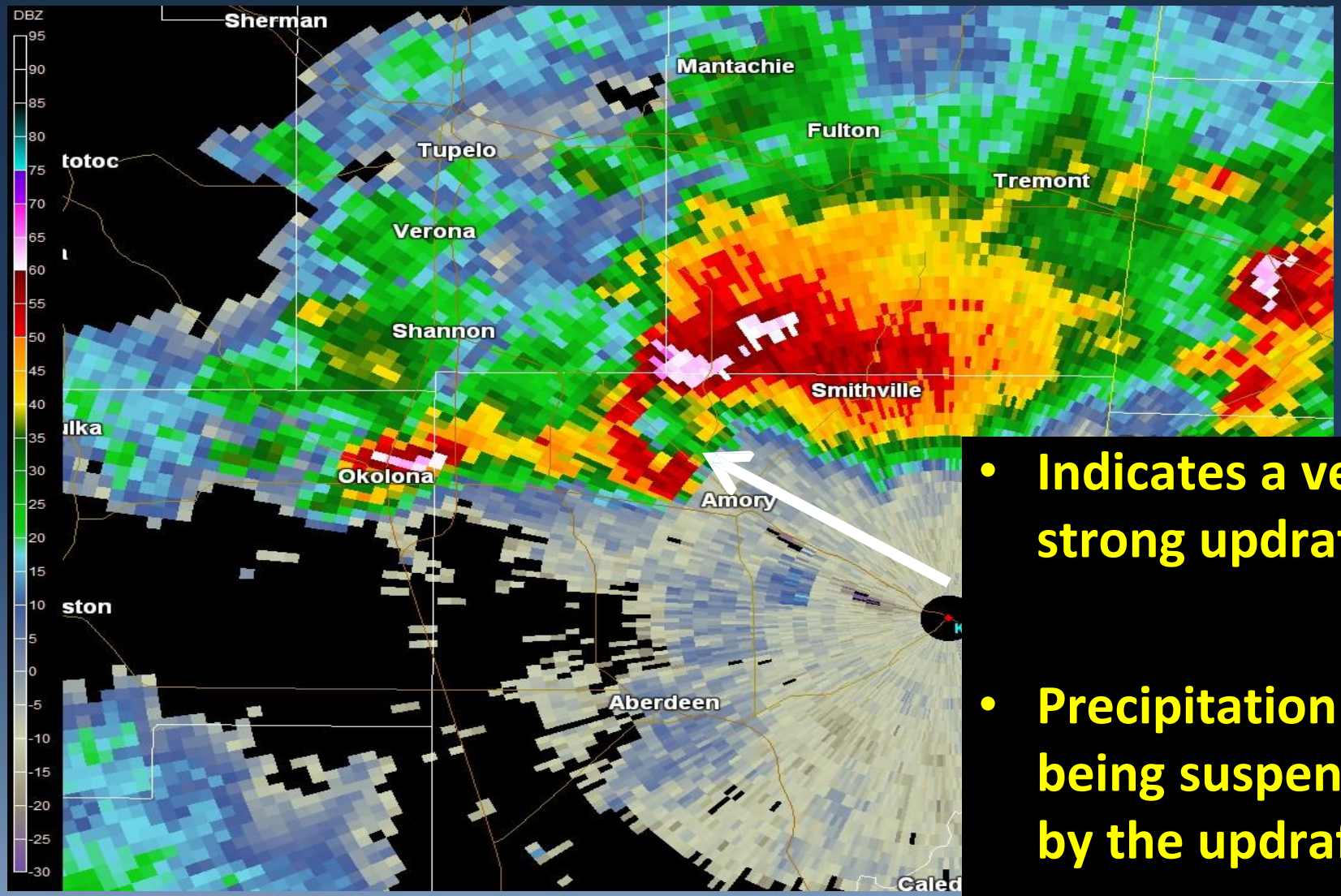

Hail core
~7000 feet
above ground


Jasper
Hail core
~15000 feet
above ground

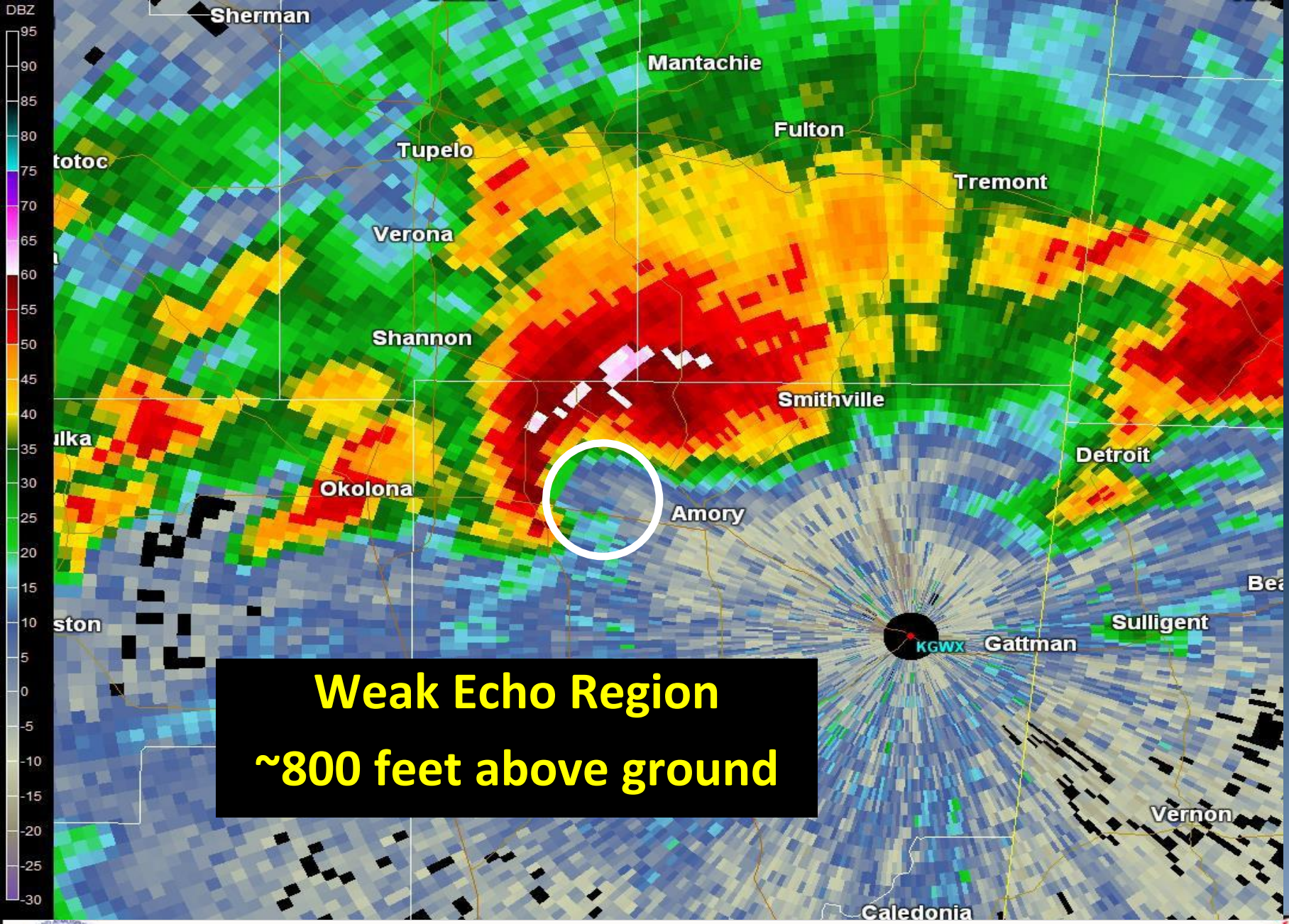
Hail core
~29000 feet
above ground



Bounded Weak Echo Region (BWER)



- Indicates a very strong updraft
- Precipitation is being suspended by the updraft



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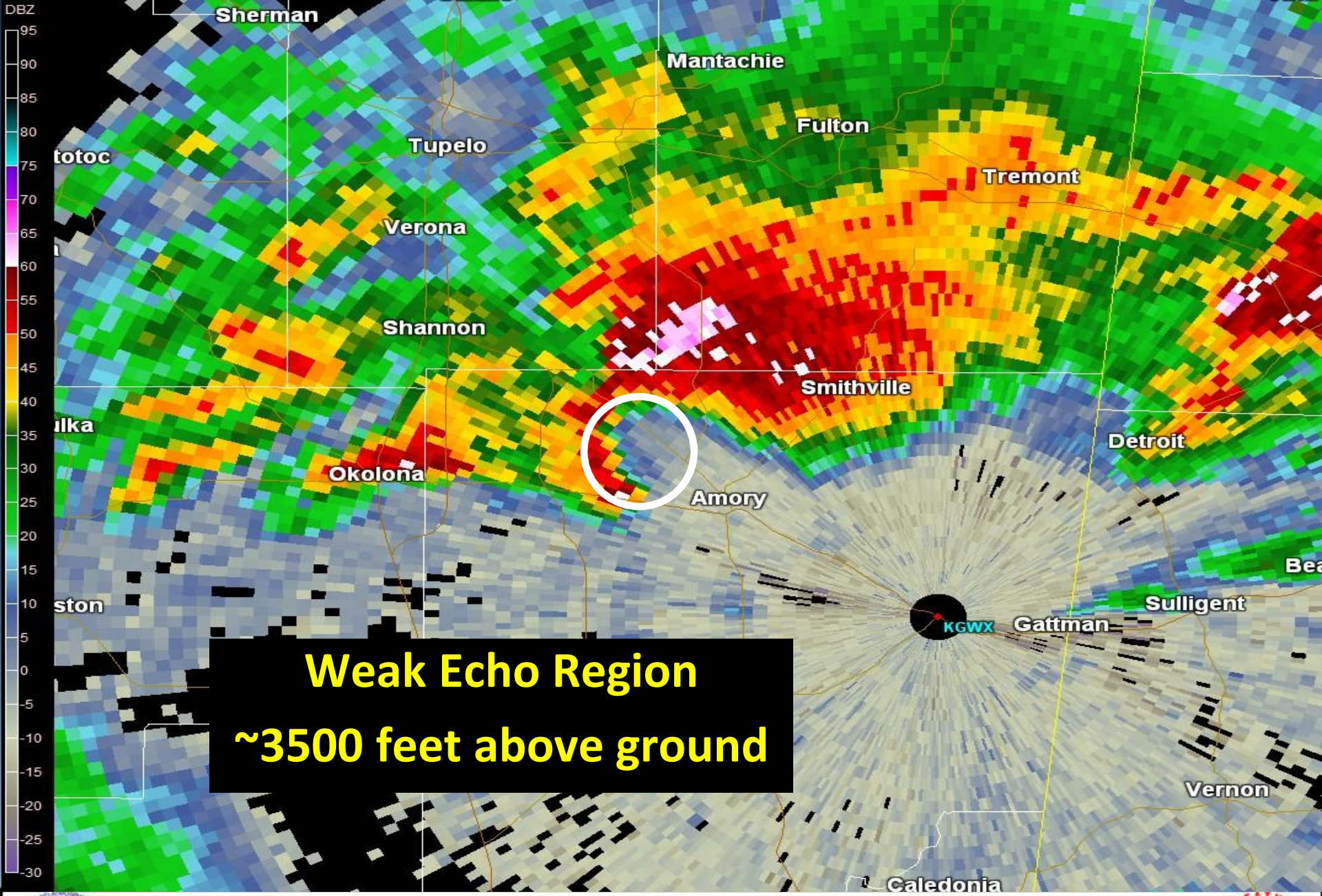

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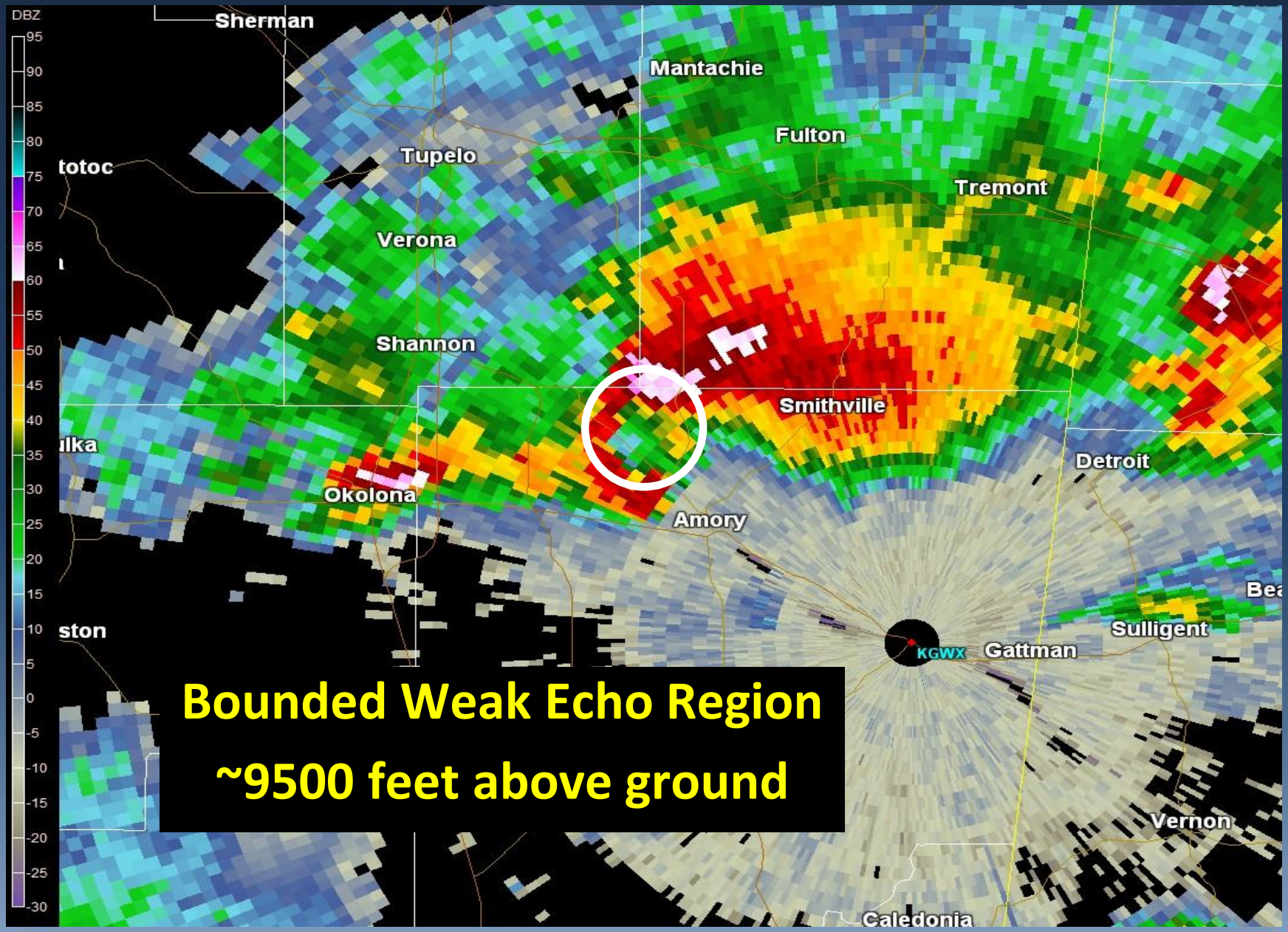
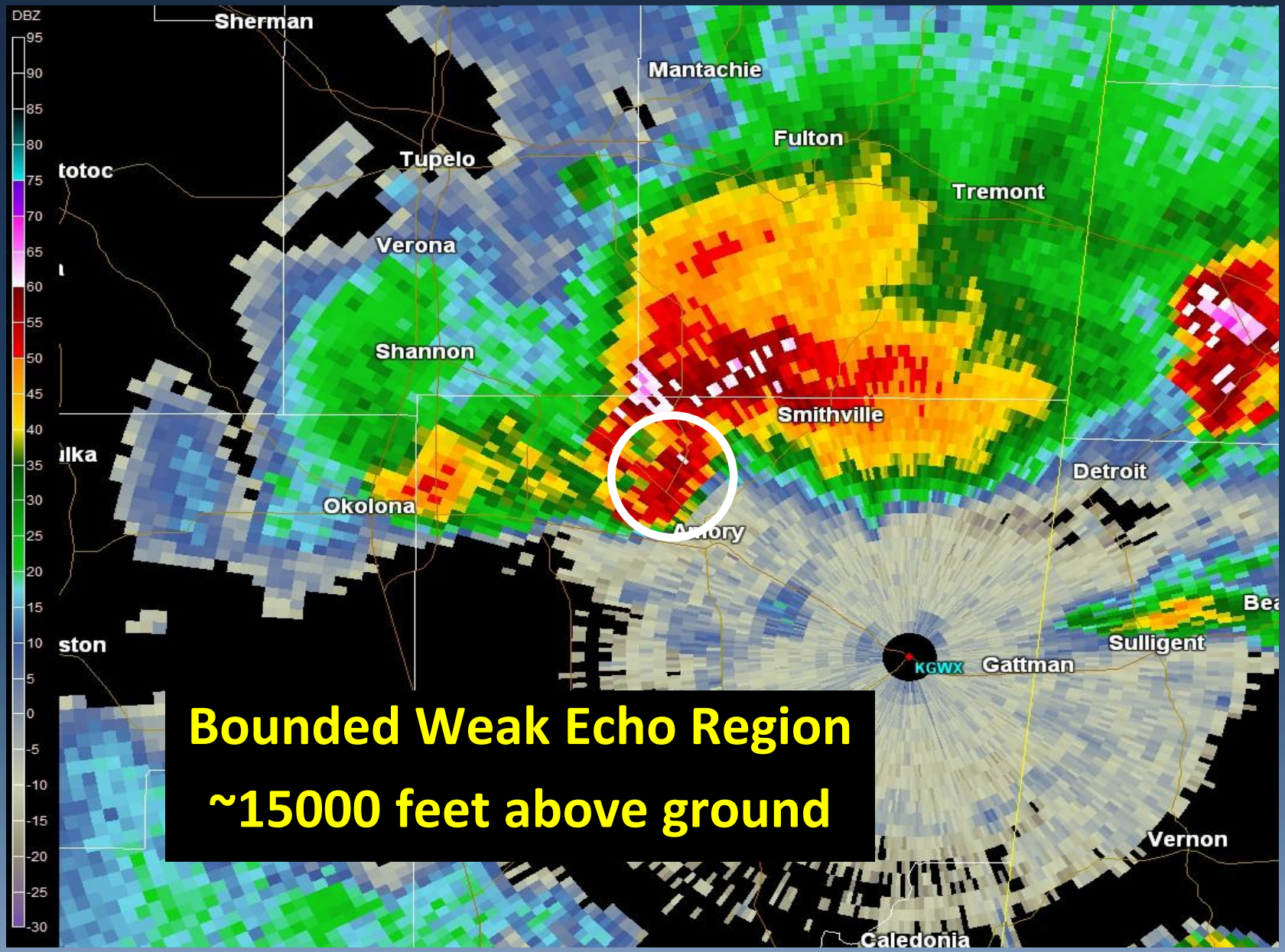


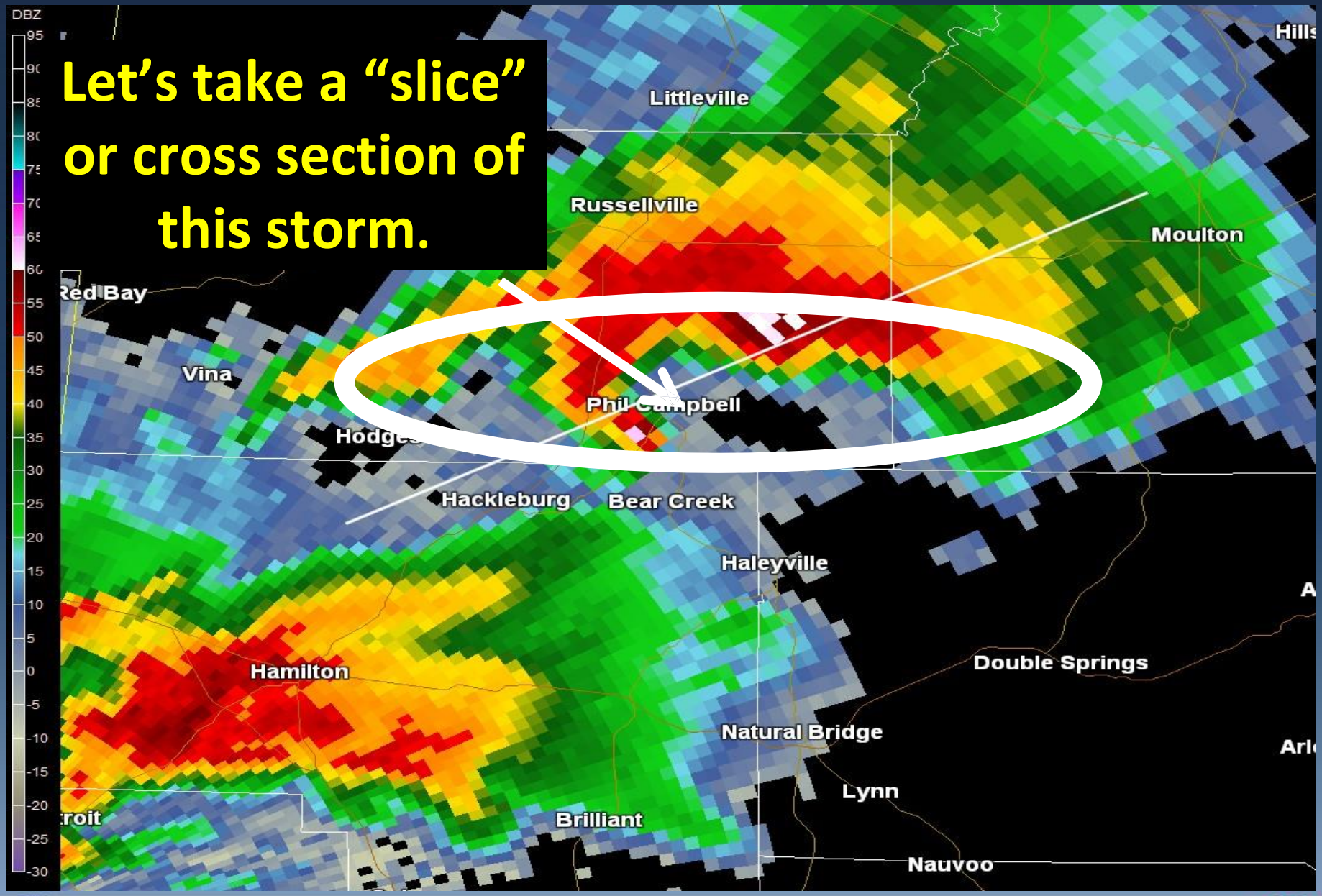
Bounded Weak Echo Region

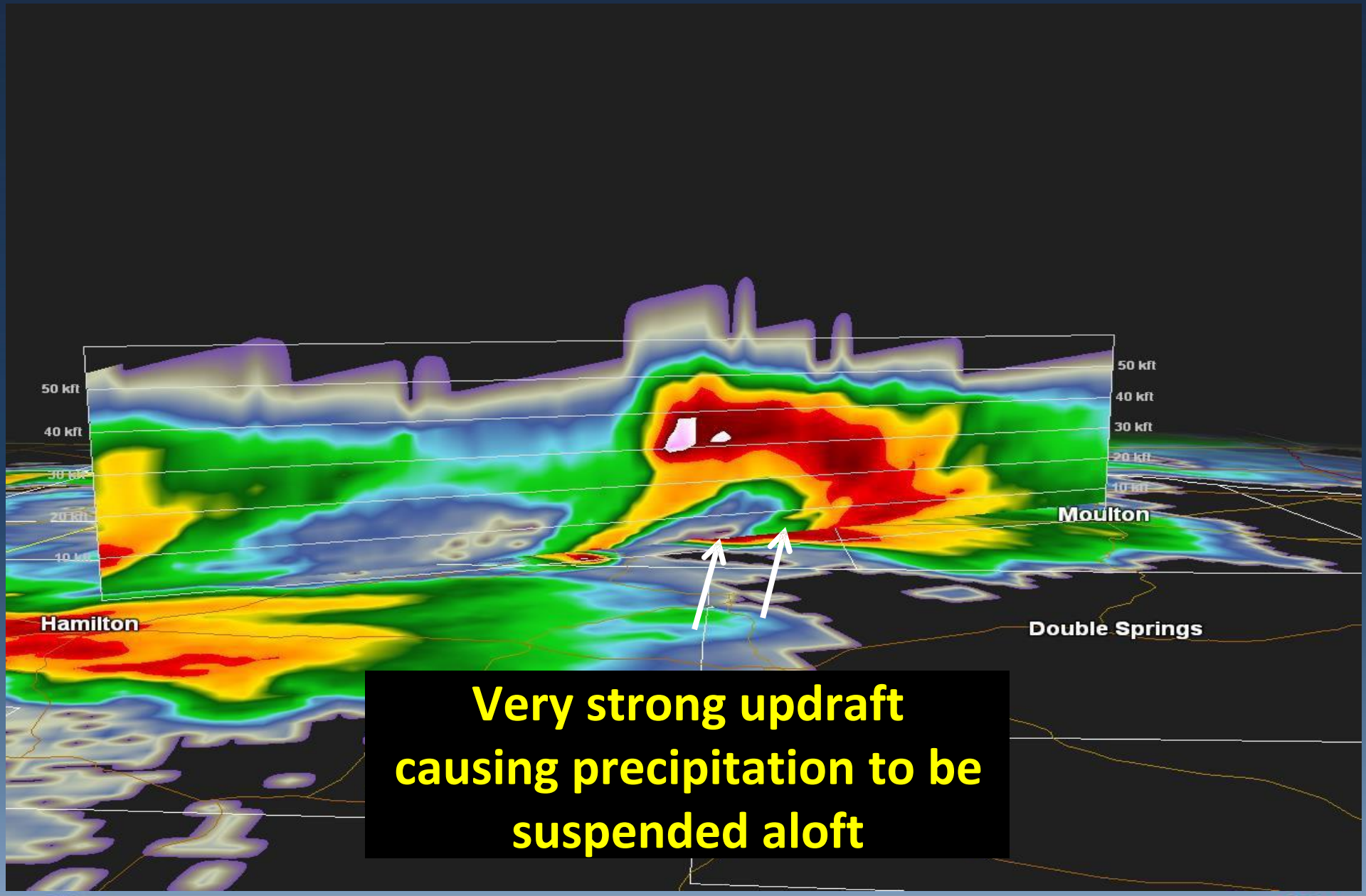
~9500 feet above ground



Bounded Weak Echo Region

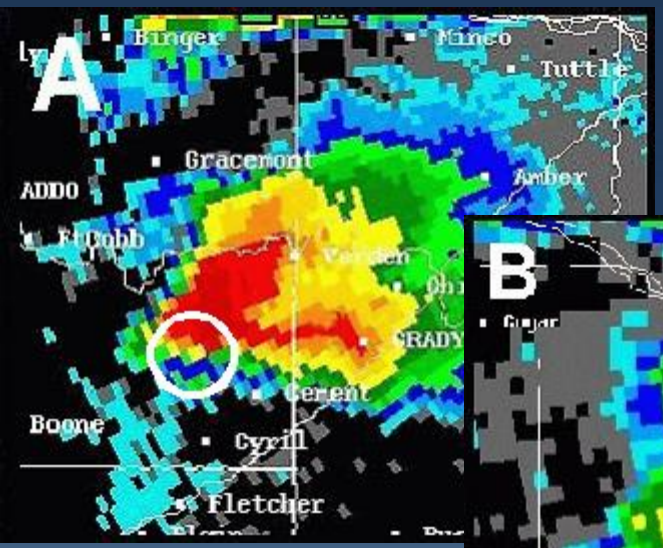
~15000 feet above ground

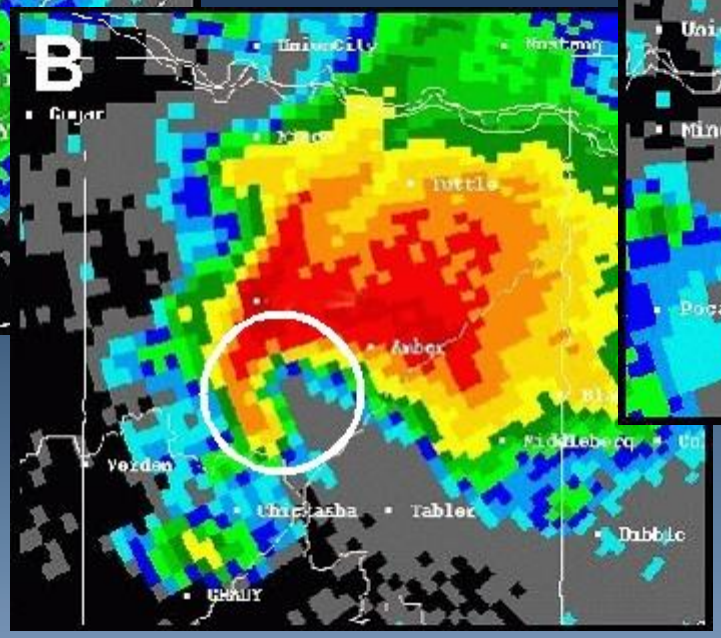

Let's take a "slice" or cross section of this storm.
DBZ
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
Littleville
Russellville
Moulton
Red Bay
Vina
Phil Campbell
Hackleburg
Bear Creek
Haleyville
Hamilton
Double Springs
Natural Bridge
Lynn
Brilliant
Nauvoo


50 kft
40 kft
30 kft
20 kft
10 kft
Hamilton
Moulton
Double Springs
Very strong updraft causing precipitation to be suspended aloft

Tornadic Supercell Evolution

A. Early Stage





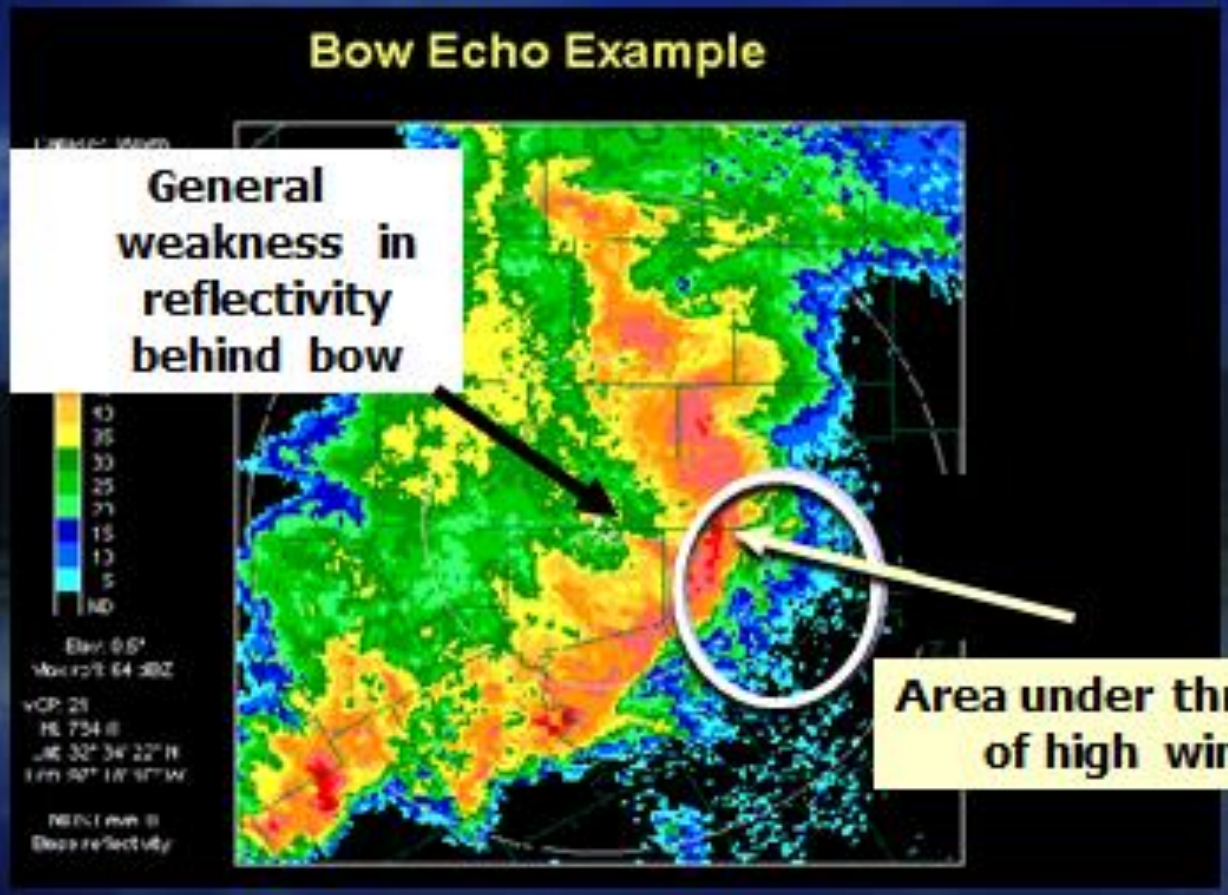
B. Developing hook

C. Mature Stage

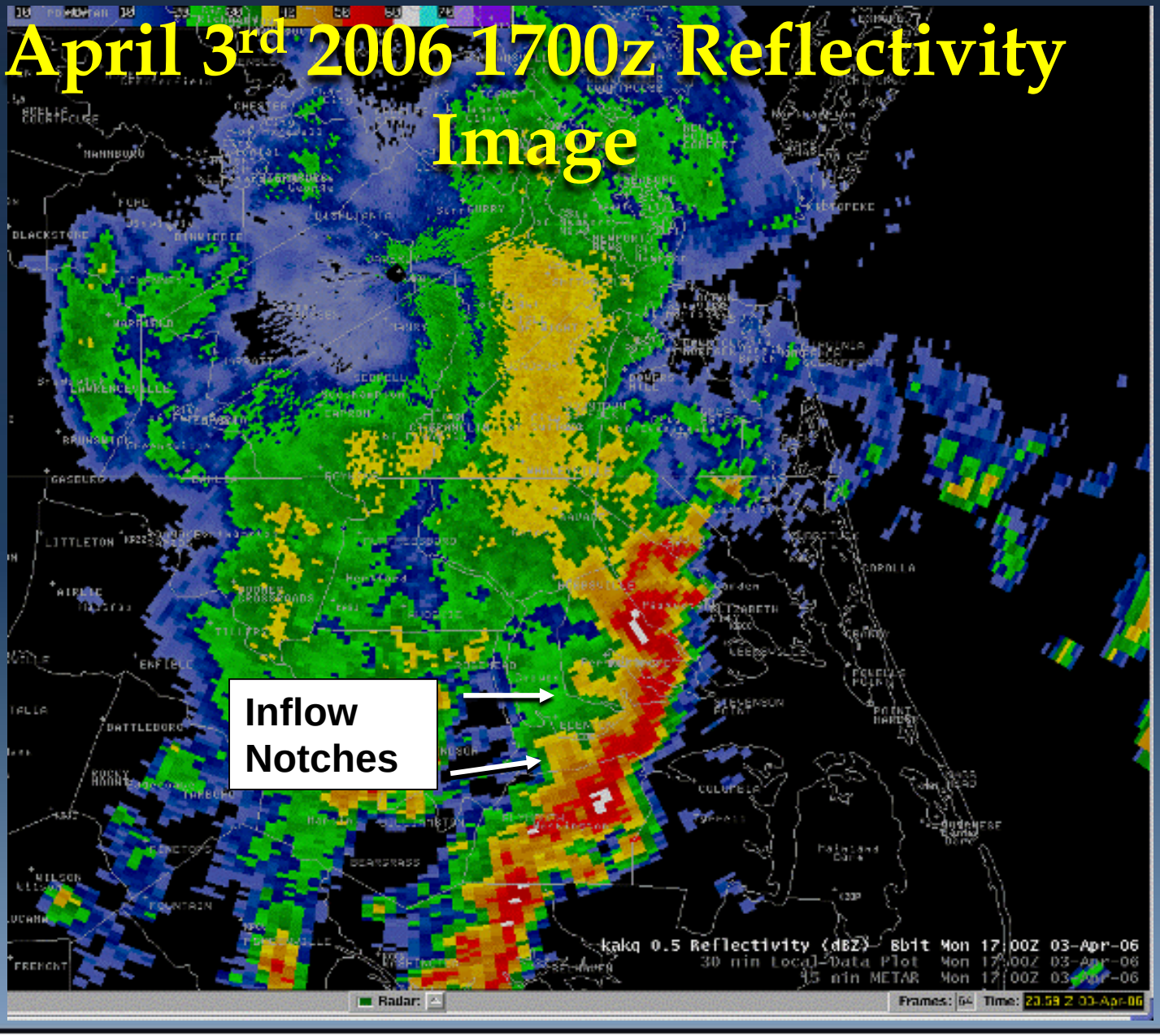
SQUALL LINES

Bow Echo Signatures

(Bowing Line Segments)



April 3rd 2006 1700z Reflectivity Image



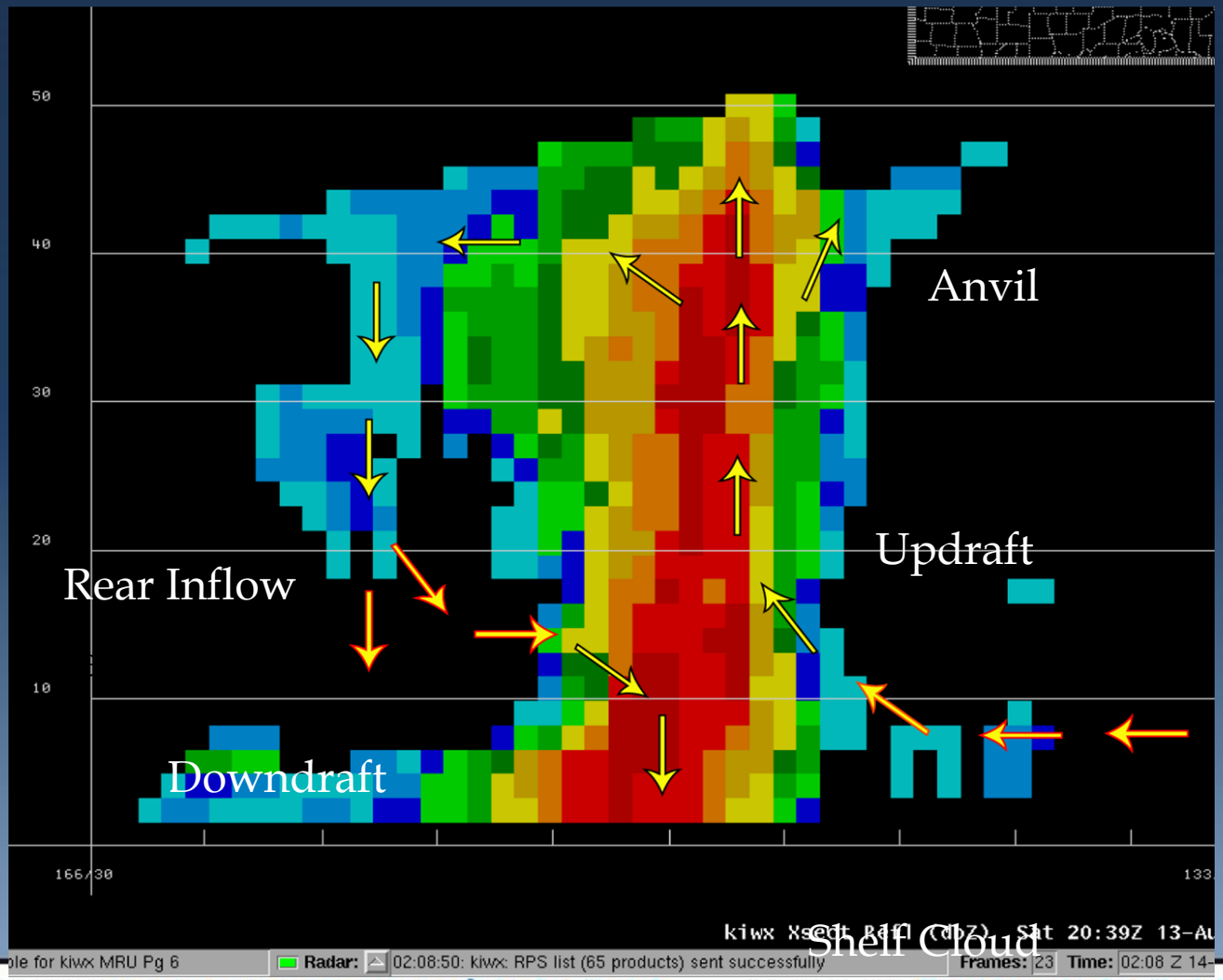
Website: www.weather.gov/Wakefield Twitter: @NWSWakefieldVA

Facebook: http://www.facebook.com/NWSWakefieldVA

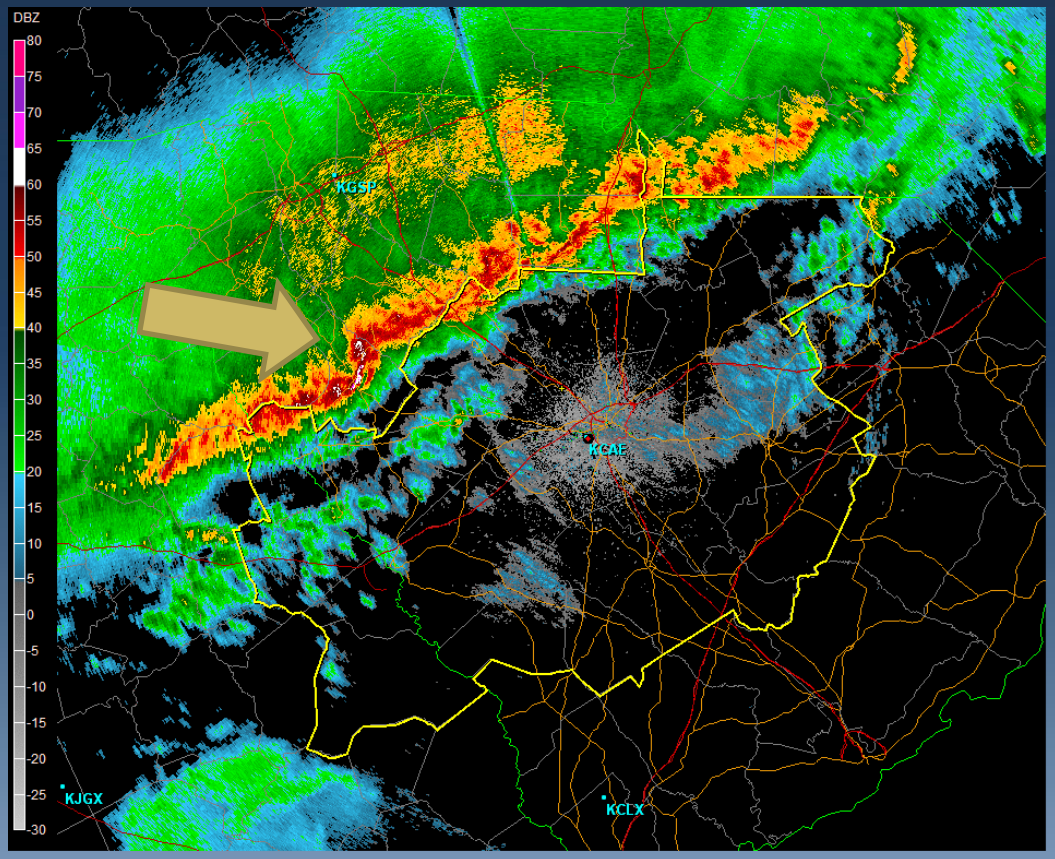
Multiple Cell Storms - Linear (Squall Line)

Moderate to Strong Shear, Moisture and Instability

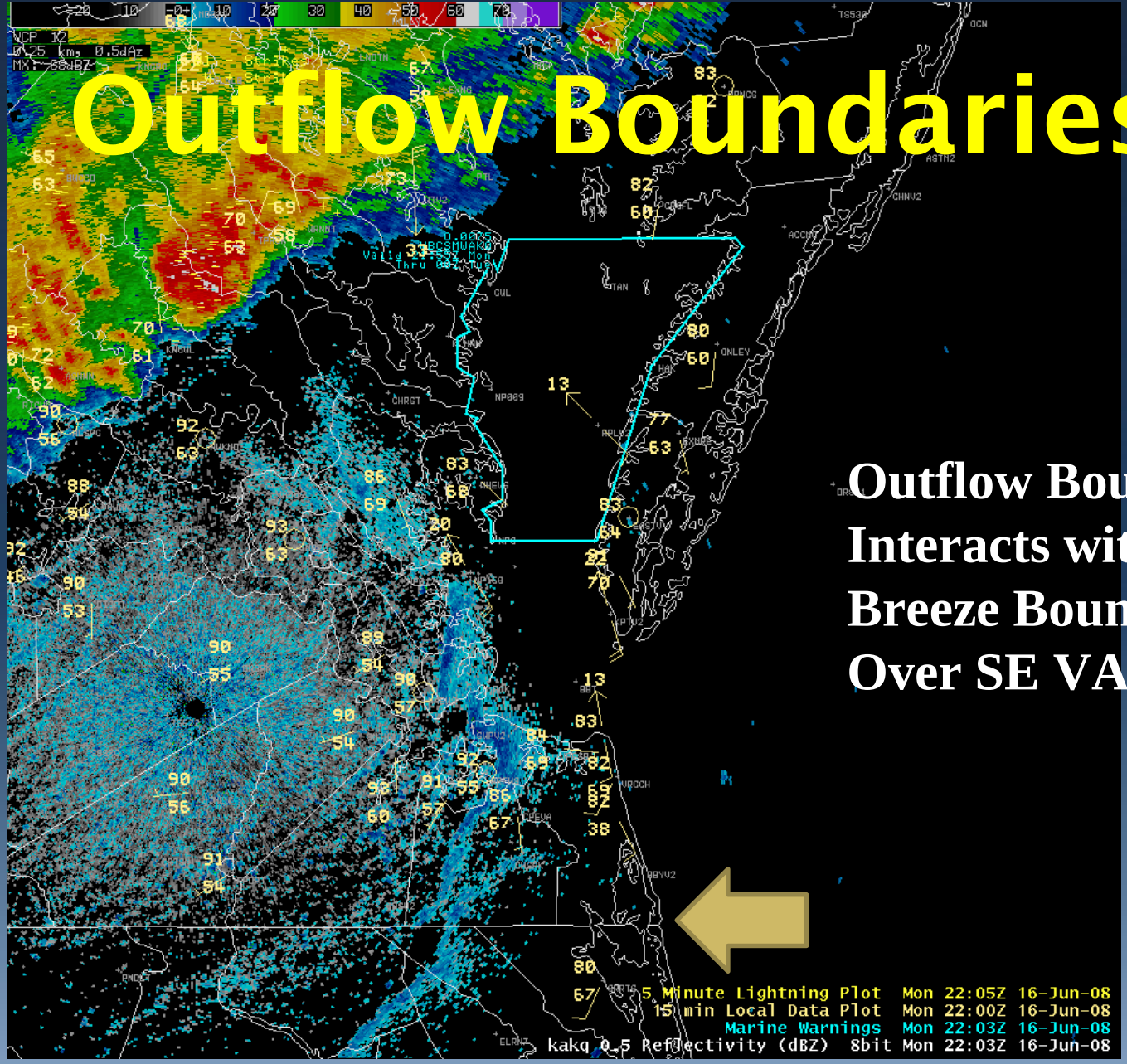
Radar Cross Section



2/28/11 – Columbia, SC



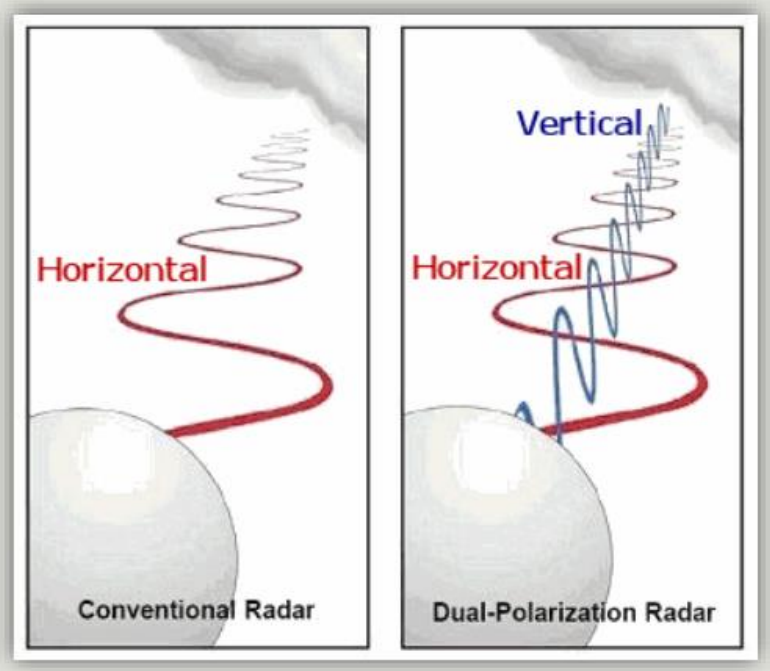
Outflow Boundaries

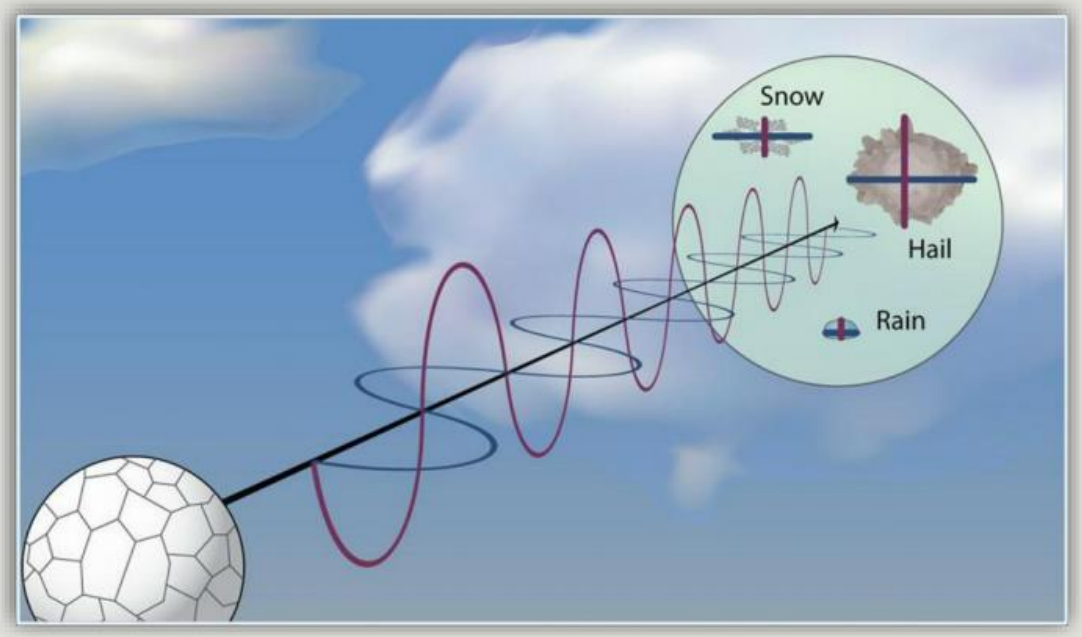


Outflow Boundary Interacts with Sea Breeze Boundary Over SE VA

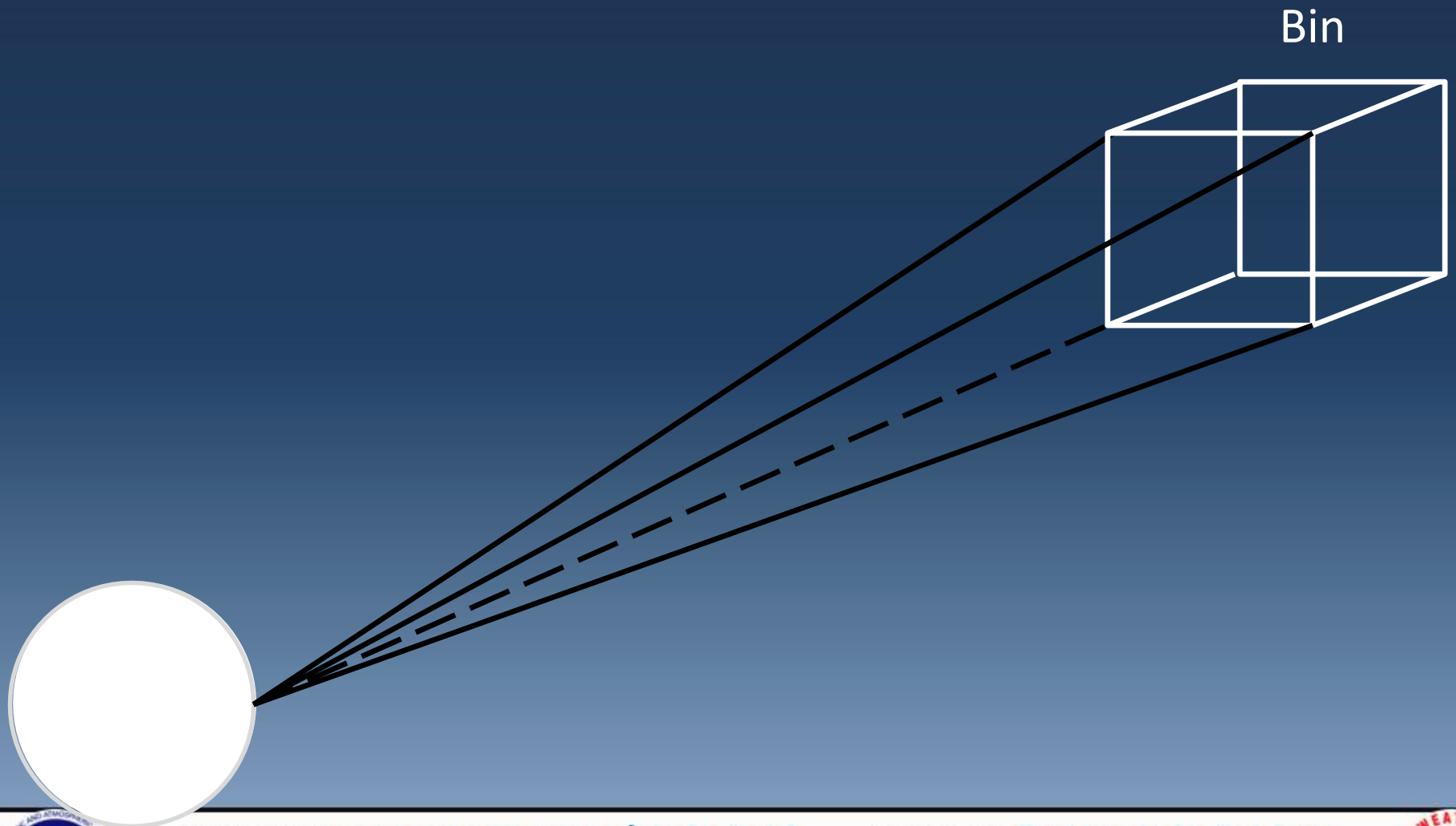
Dual Polarization Concepts

Dual Polarization

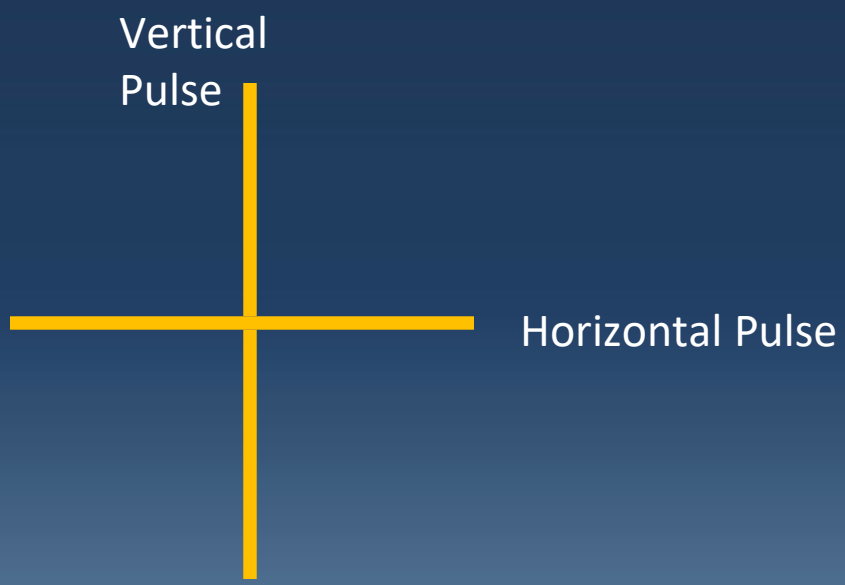




Dual Polarization

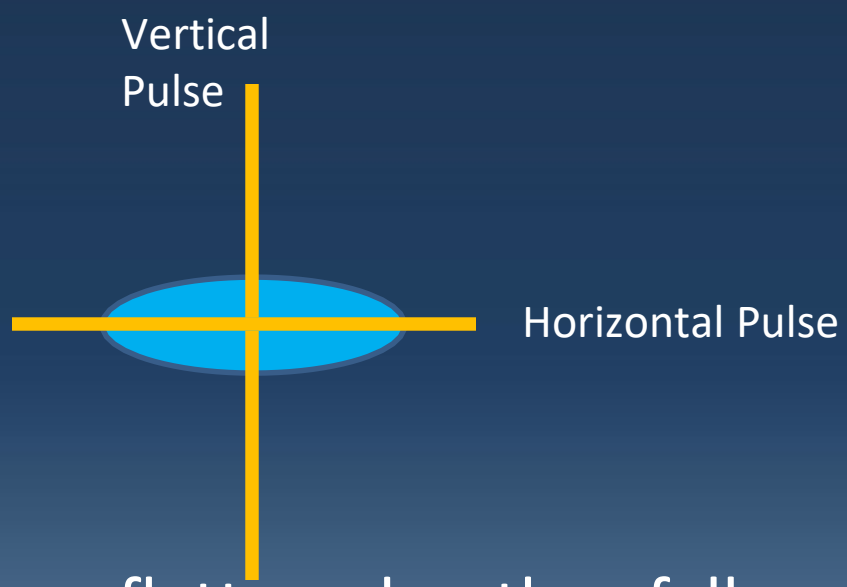


Dual Pol: The Cross Section



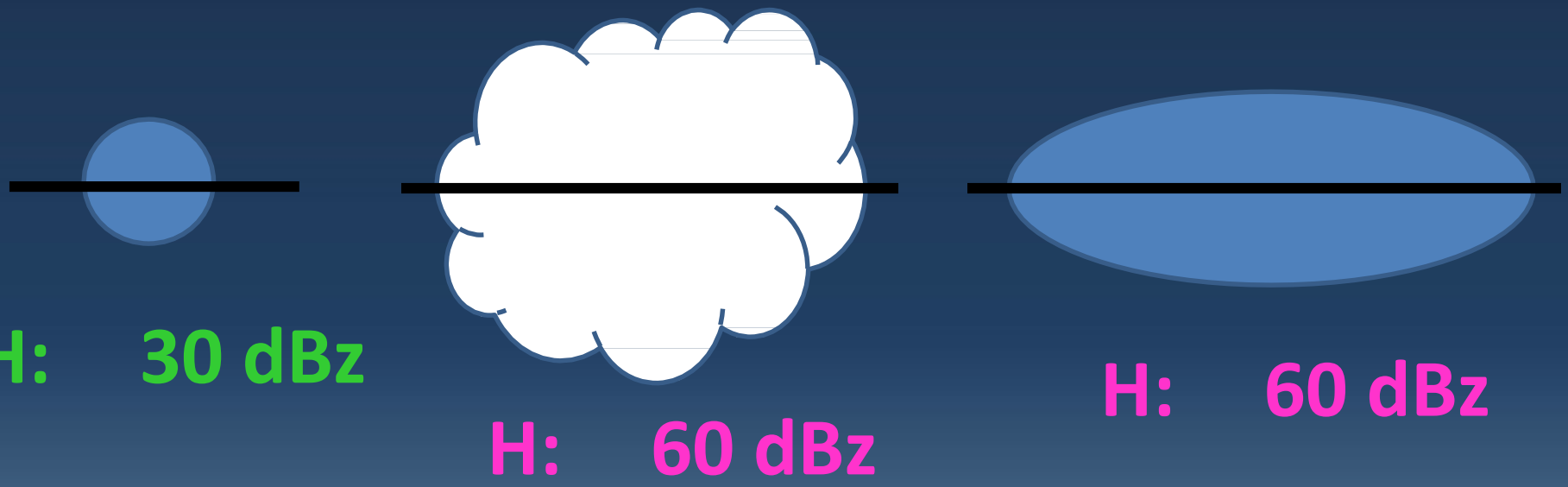
Targets measured in a ratio: Example:
Hail stone of 3" X 3" Ratio: 3 to 3 or 1 to 1
or the target has the same height and width

Dual Pol: The Cross Section

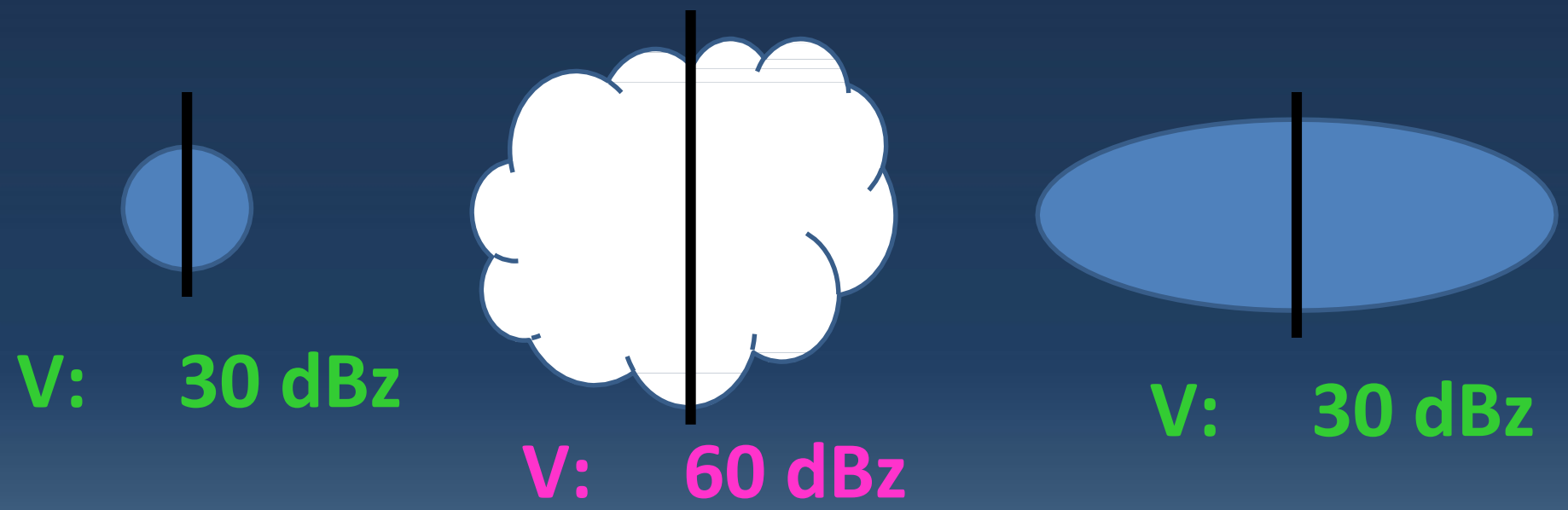


Raindrops are flattened as they fall
Targets measured in a ratio:
Example: width of 3, height of 1 or a ratio of 3 to 1

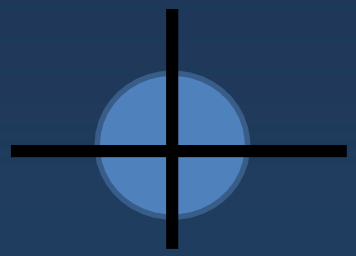
Horizontal Scanning



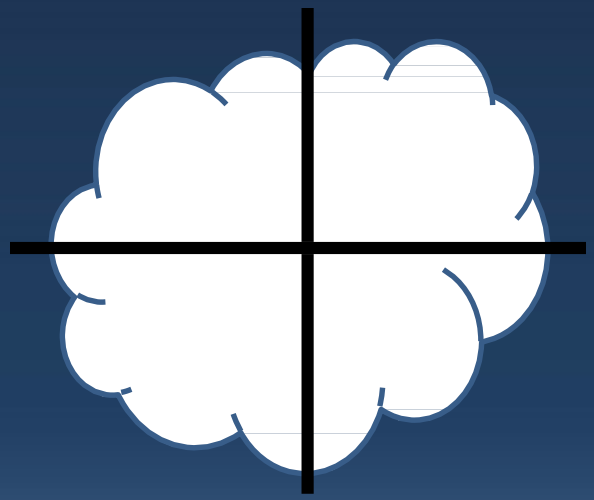
Vertical Scanning



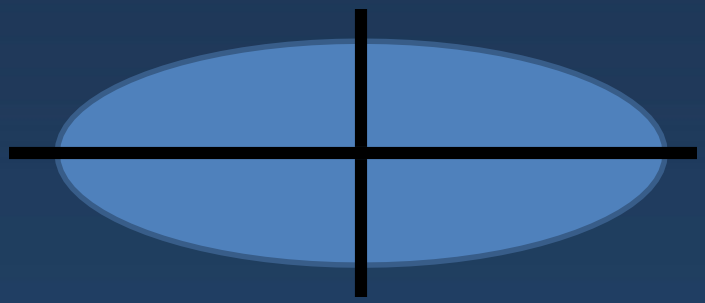
Horizontal and Vertical Scanning



H: 30 dBz
V: - 30 dBz
0 dBz



H: 60 dBz
V: - 60 dBz
0 dBz

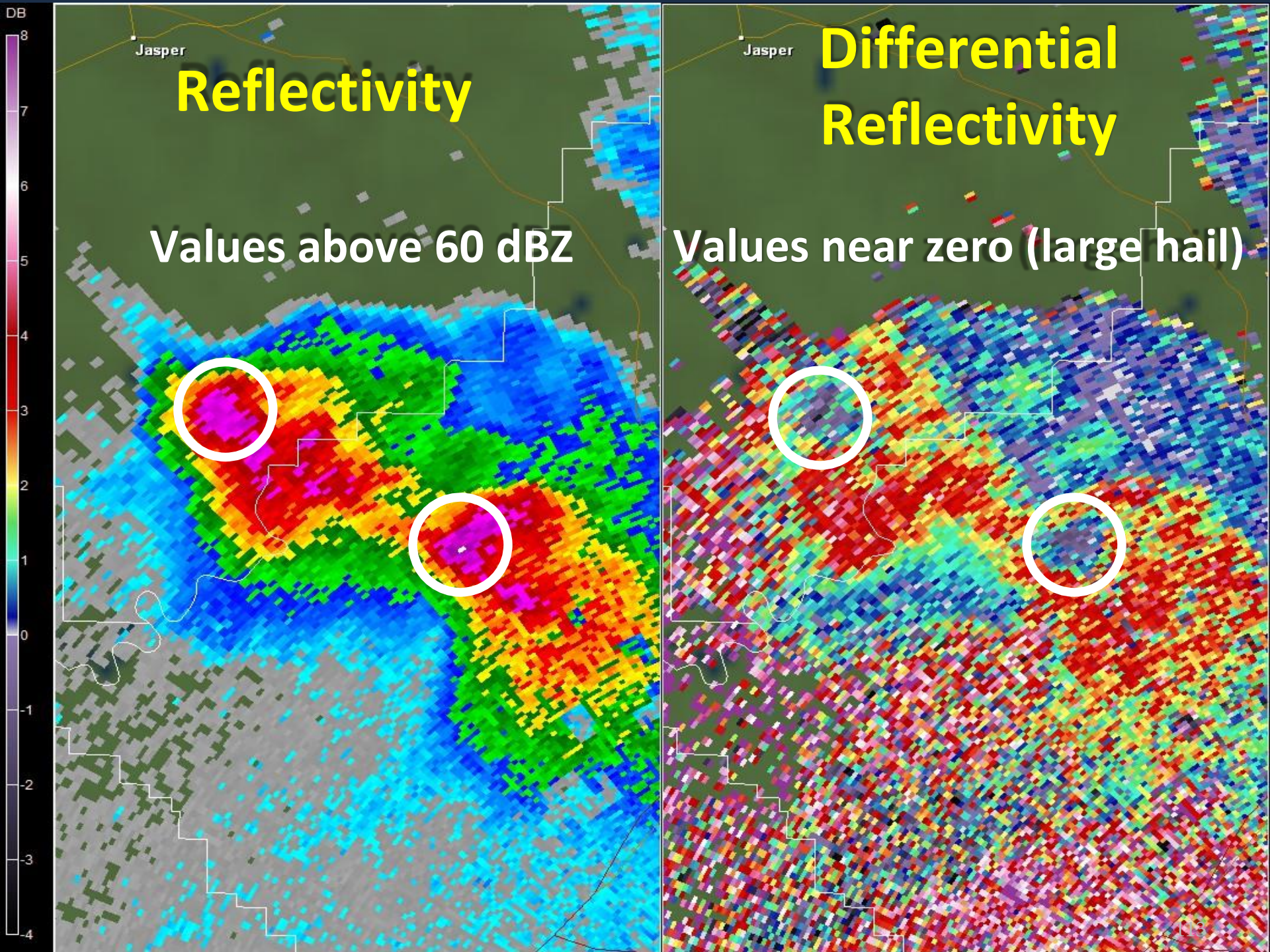


H: 60 dBz
V: - 30 dBz
30 dBz

Small Drops

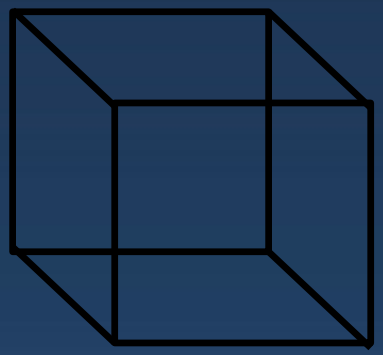
Hail

Large Drops


DB
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
Jasper
Reflectivity
Values above 60 dBZ
Jasper
Differential Reflectivity
Values near zero (large hail)

Dual Polarization

Bin



Rain

Hail

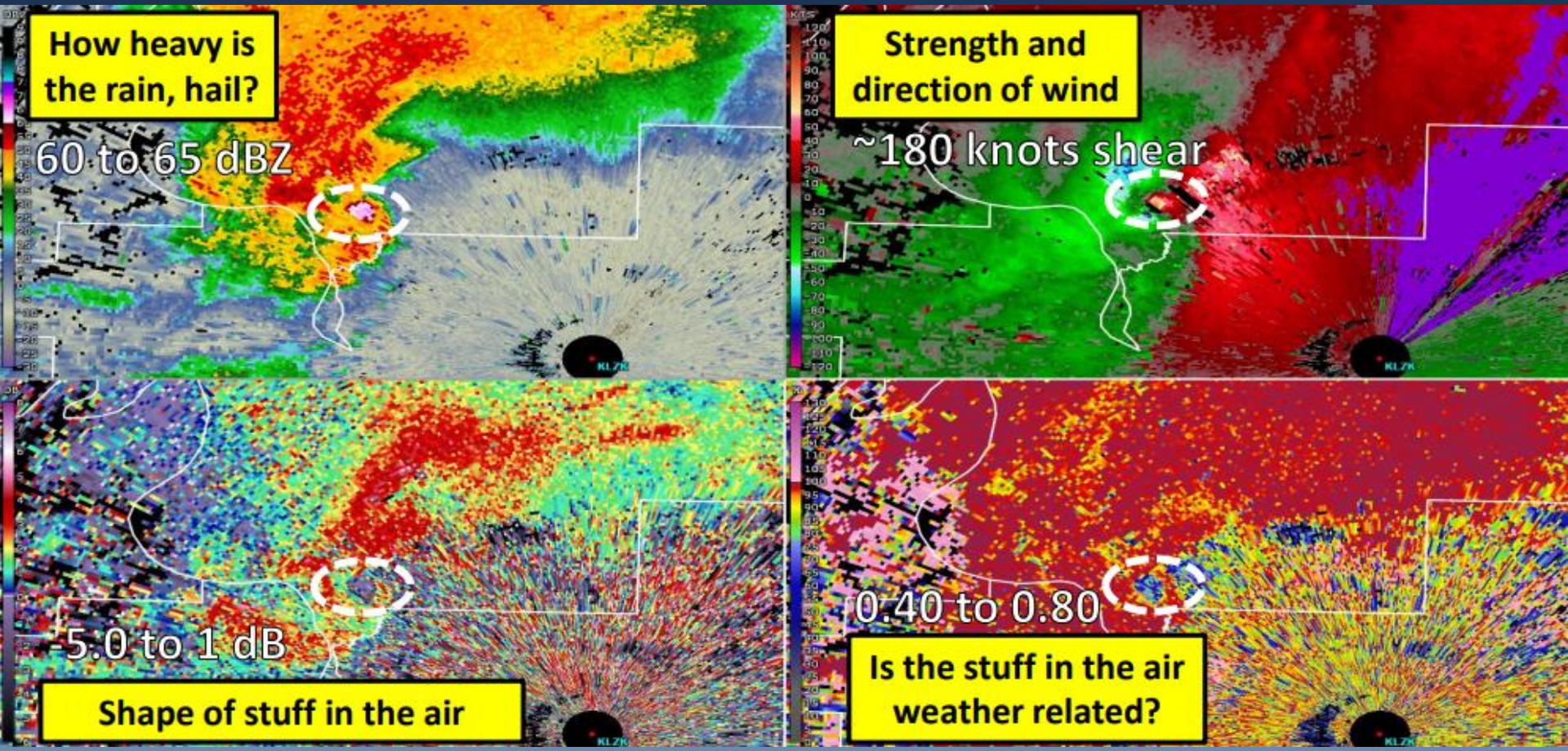
Debris

Wood, Insulation, Leaves, Twigs, Paper, etc.

Correlation Coefficient

- Radar has to distinguish between all "objects" in a given bin and calculate ratios of all targets
- When you have all different kinds of targets in a bin, and their ratios are not correlated… the CC of that bin is LOWERED

Tornado Debris Signature



Dual Polarization Online

- **Public Training Aid (Non-Meteorologist training):**
  - https://training.weather.gov/wdtd/courses/dualpol/Outreach/
- Online Module by WDTB on each product
- Non-technical courses available for media & non-meteorologists (more technical courses also available if preferred)

Instability, Wind Shear, and Lifting Mechanisms
Where Can I Get Help?

http://training.weather.gov/wdtd/courses/dualpol/Outreach/

http://www.weather.gov/akq/SKYWARN

http://www.spc.noaa.gov/exper/mesoanalysis/

http://weather.uwyo.edu/upperair/sounding.html

http://www.weather.gov/akq/SevereParameters

http://www.weather.gov/akq/Brief

Thank You! Questions/Comments?

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

757-899-2415 - akq-report@noaa.gov

National Weather Service

Wakefield, VA

Weather.gov/Wakefield

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