ADVANCED Severe Weather Spotter Training 2023

National Weather Service Wakefield, Virginia

Severe Weather Spotter Line: 1-800-737-8624

NWS Wakefield Webpage: weather.gov/akq

@NWSWakefieldVA NWSWakefieldVA

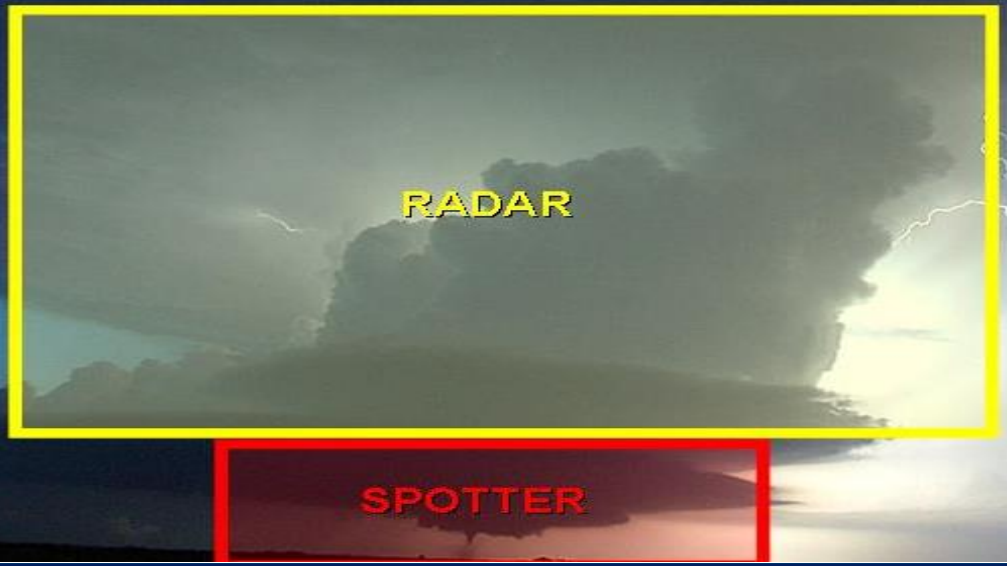
Course Information

- **Purpose –**
  - To *expand* upon material presented in the basic SKYWARN course
- **General Outline –**
  - Understanding the Atmosphere
  - Severe Weather Ingredients
  - Radar Principles, Advantages and Limitations
  - Radar and Storm Structure
    - Review of Impact-Based Warnings
  - Reporting Procedures

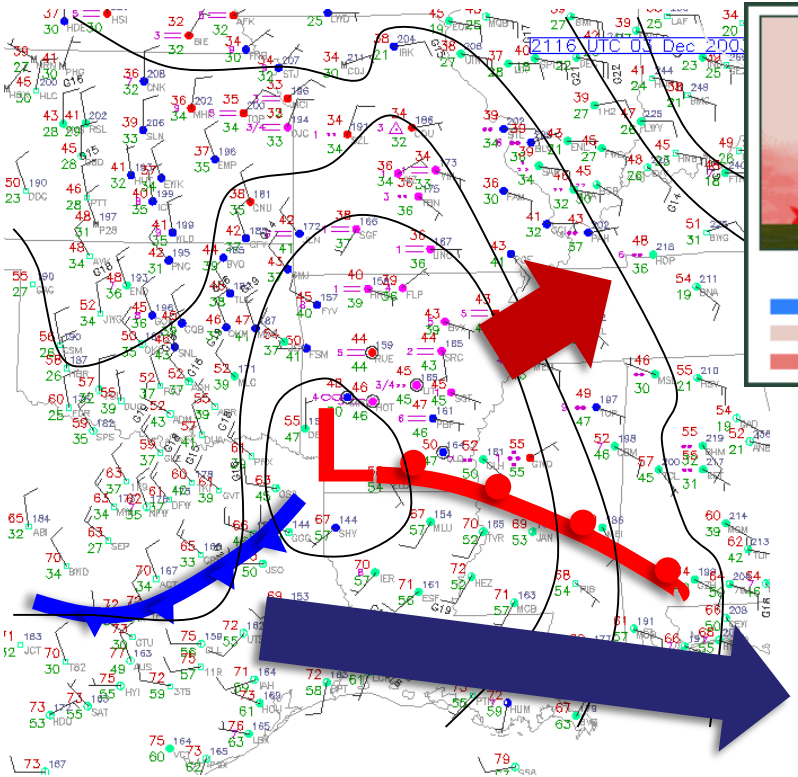
Importance of Spotters

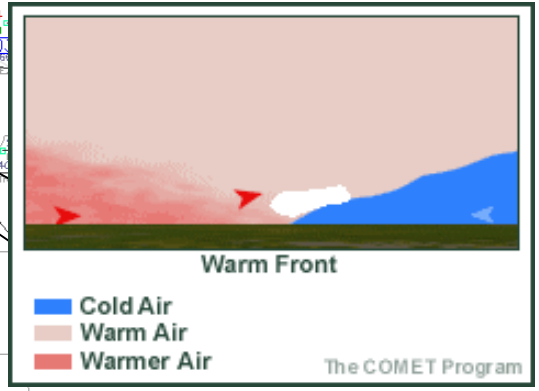
- **Provide "Ground Truth"**
  - Be our "eyes and ears" out there!
- **Detailed storm reports can…**
  - Verify warnings
  - Add value to existing/new warnings
- **Assist with post-storm analysis, research, and local training**
- **Mitigate limitations with radar coverage**

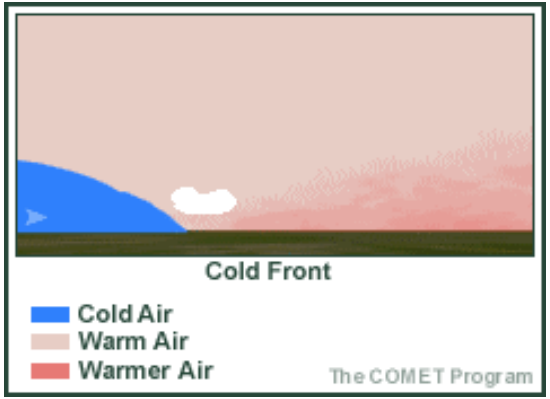
Spotters provide critical details on what's happening at ground level.



The 3-D Atmosphere







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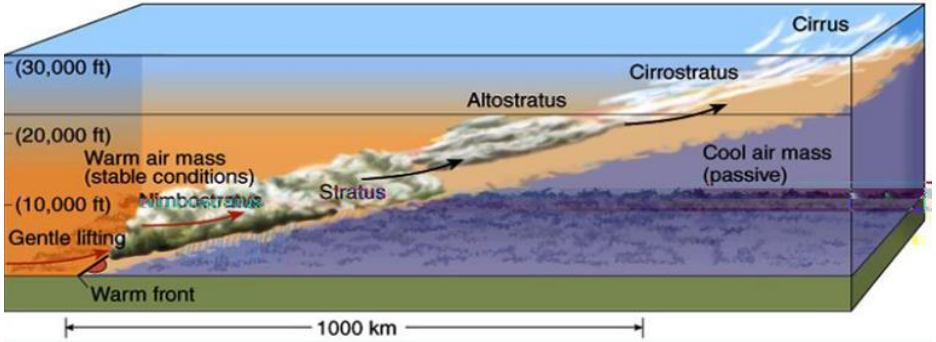
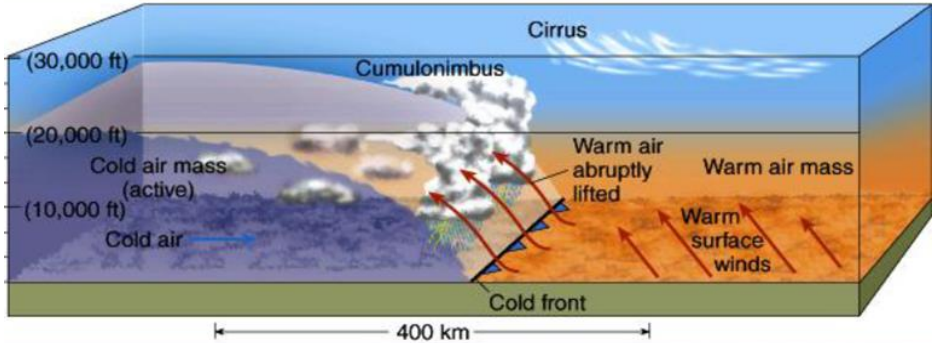


Warm Front



Cold Front

Ingredients

Thunderstorm Development

- Moisture
- Instability
- Lift “Trigger”

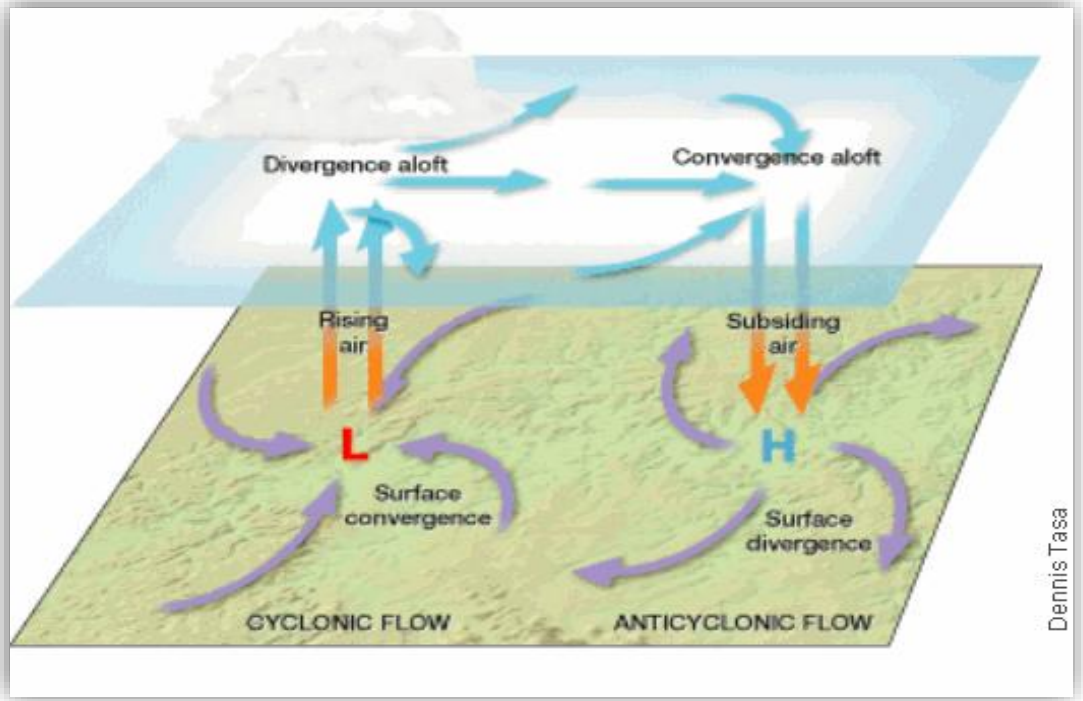
Determining Factors (severity):

- Instability
- Wind Shear

What is Stability?

- The degree to which vertical motion in the atmosphere is <u>enhanced</u> or <u>suppressed</u>

- Depending on the vertical temperature profile of the atmosphere, air will: rise, sink, remain at rest

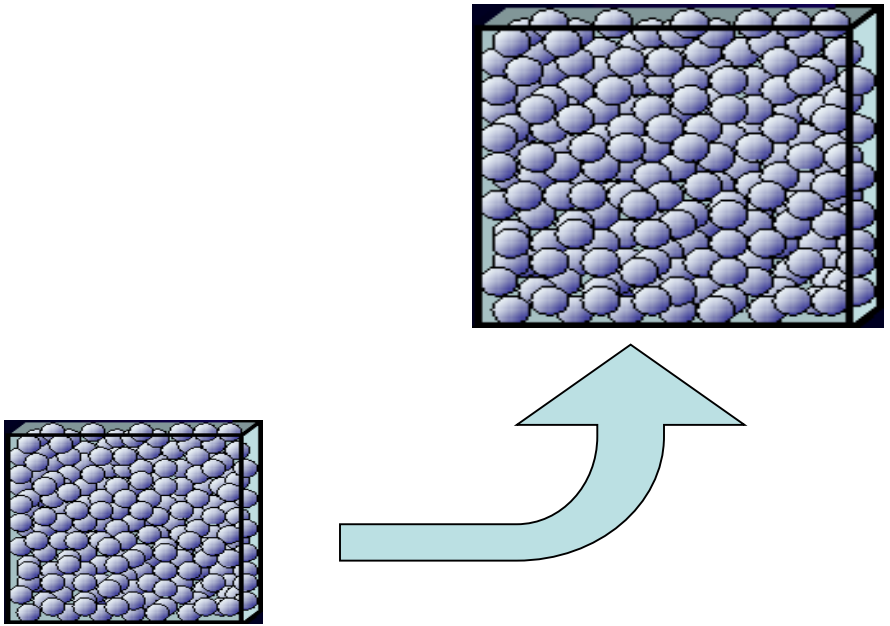


Three Types of Stability

- **Unstable Atmosphere**
  - Enhances or encourages vertical movement of air
- **Stable Atmosphere**
  - Suppress or resists vertical movement of air
- **Neutral Atmosphere**
  - Neither suppresses nor enhances vertical movement of air

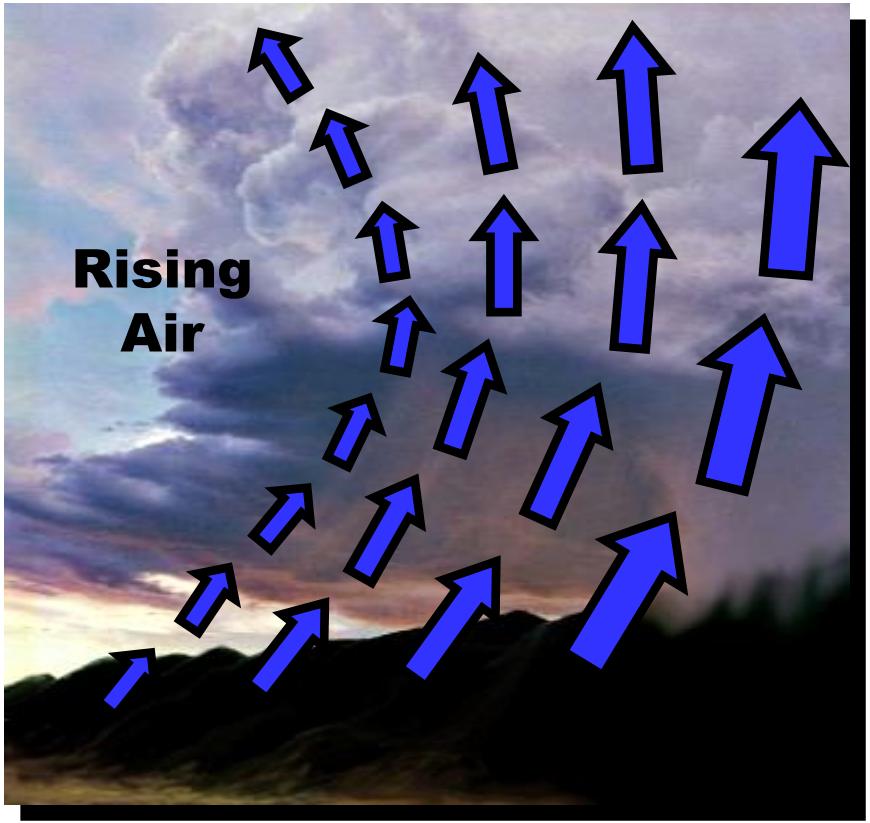
Unstable Atmosphere

- Air parcels will continue to rise



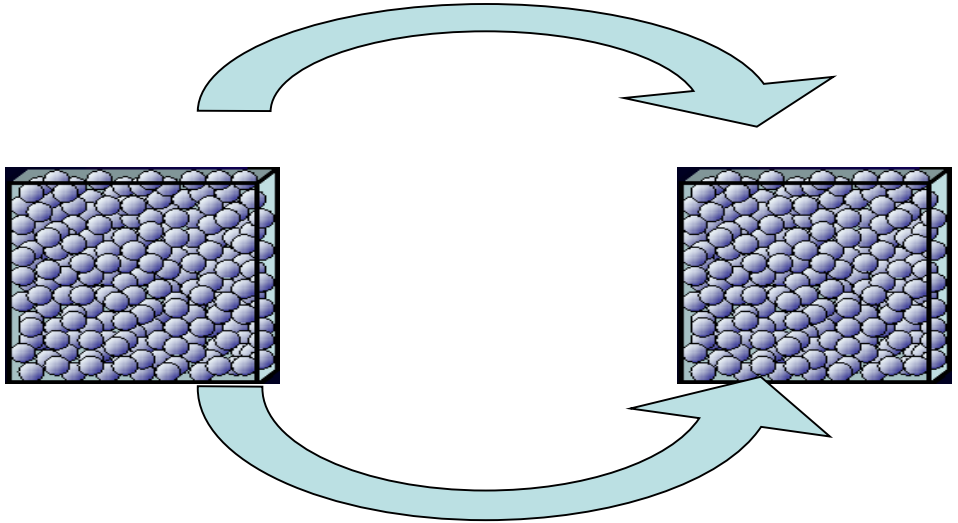
Unstable Atmosphere

- Promotes the formation and growth of vertically developed clouds, thunderstorms and tall smoke columns



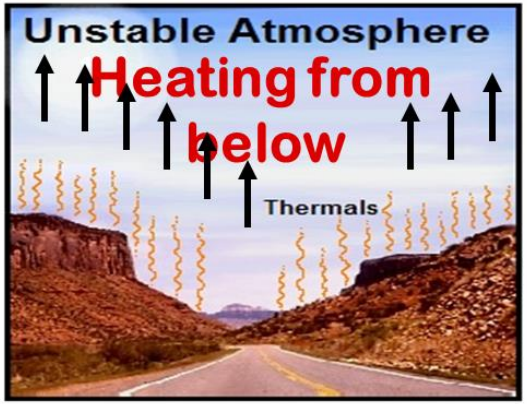
Stable Atmosphere

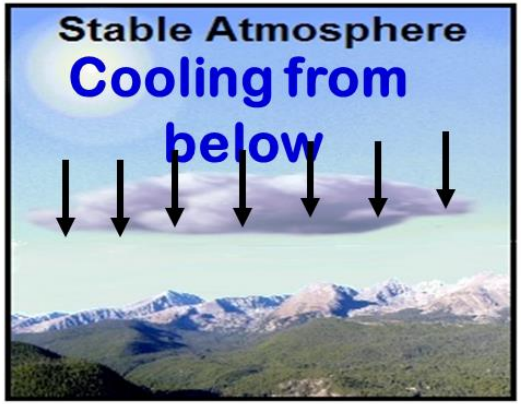
- Air parcels displaced upward (downward) will eventually return to their level of origin

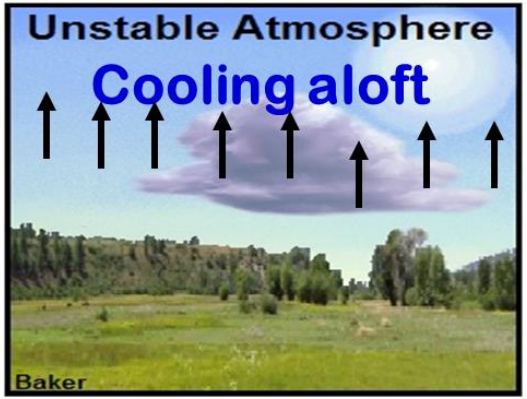


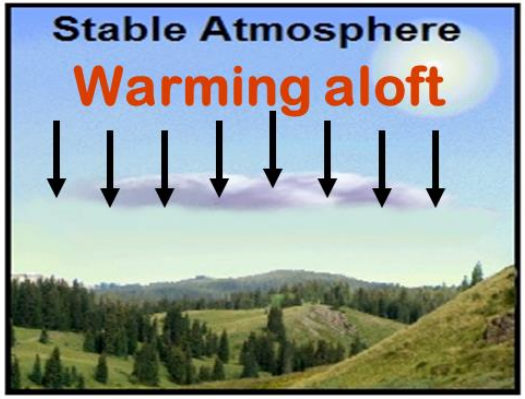
Atmospheric Stability

- 4 ways to change atmospheric stability







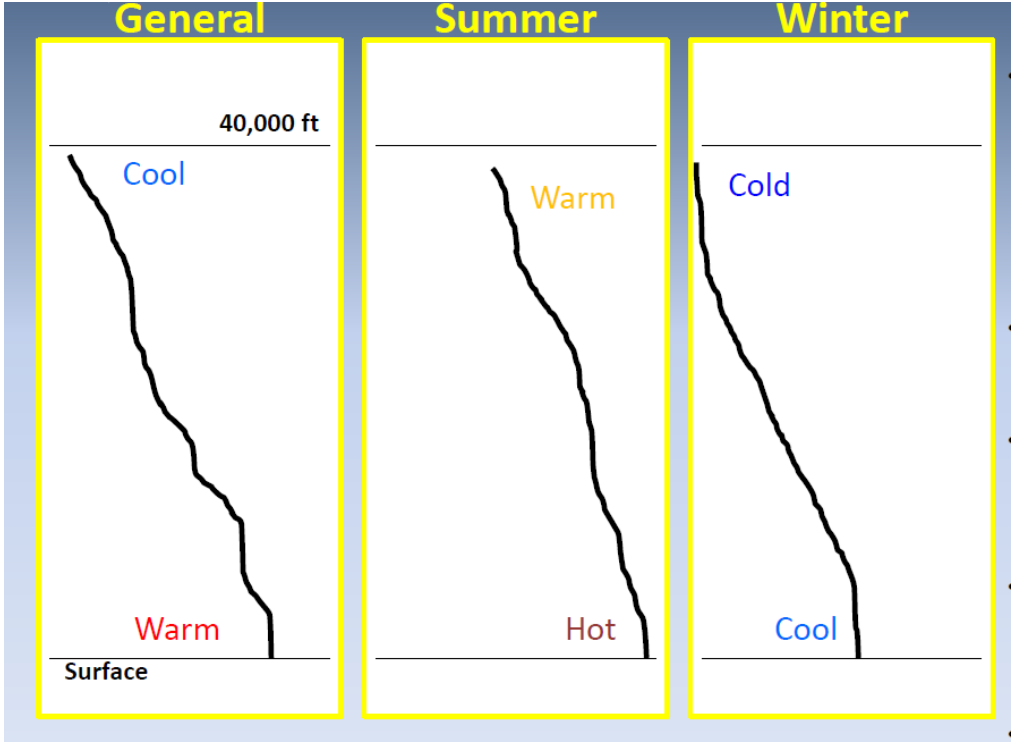


Temperature Lapse Rates

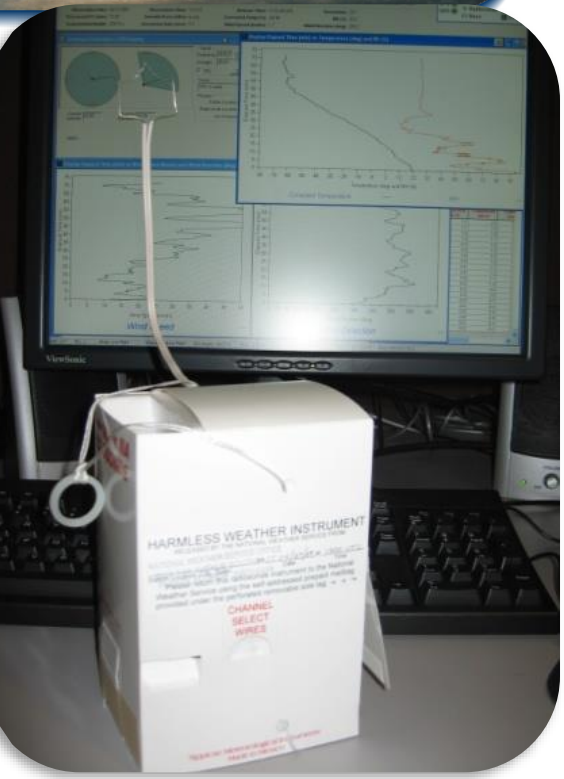
Change in Temperature

Change in Altitude

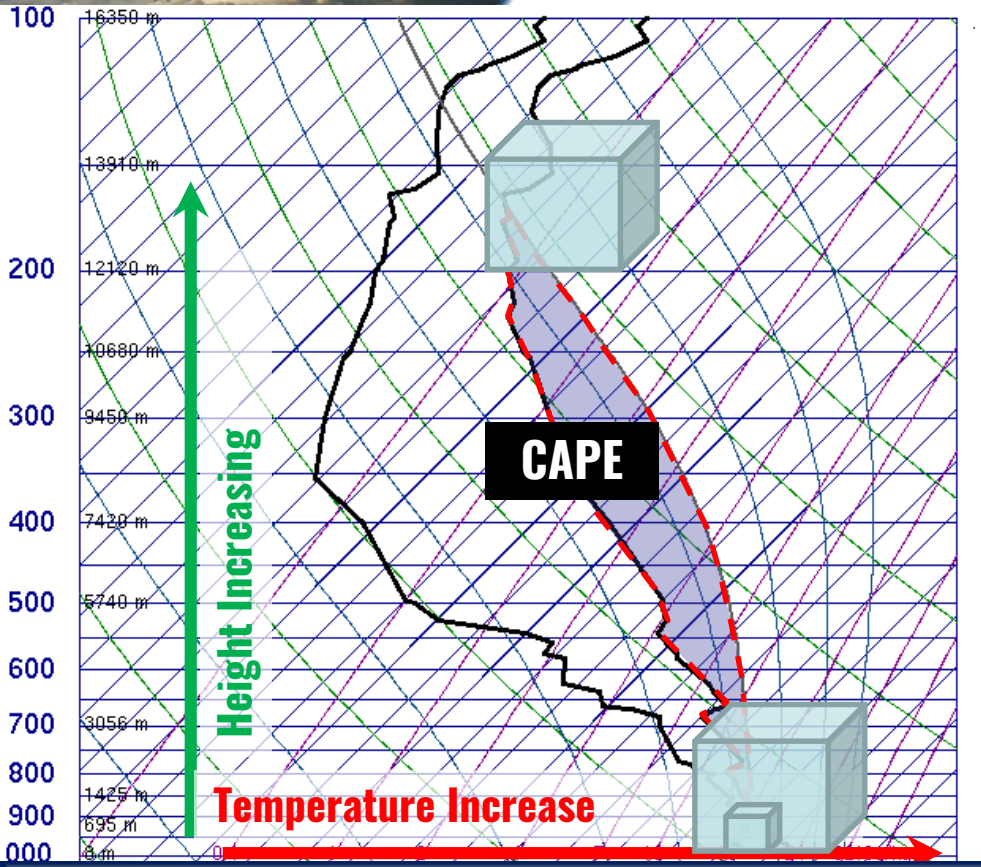
- **Instability** is based upon how warm it is at the surface vs. how cold it is aloft



Measuring Stability



Instability

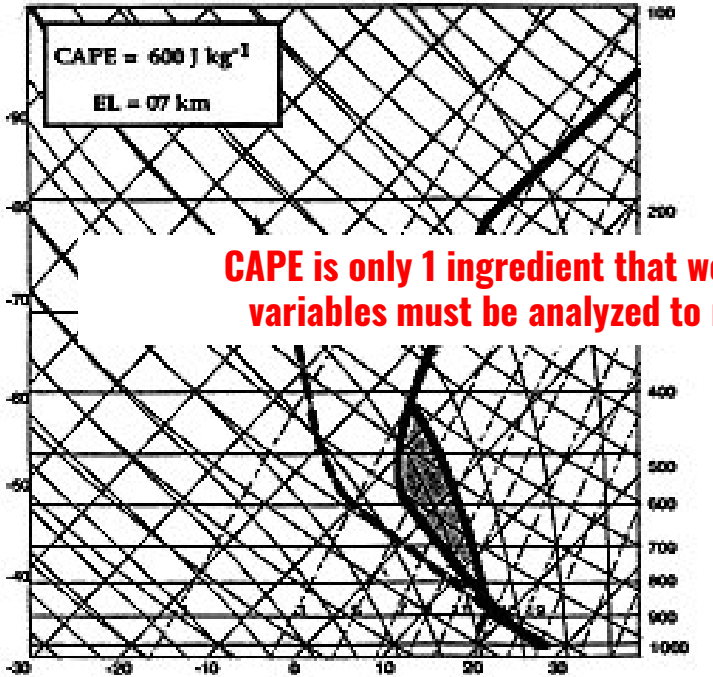


CAPE stands for the:
Convective
Available
Potential
Energy

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

High CAPE vs. Low CAPE

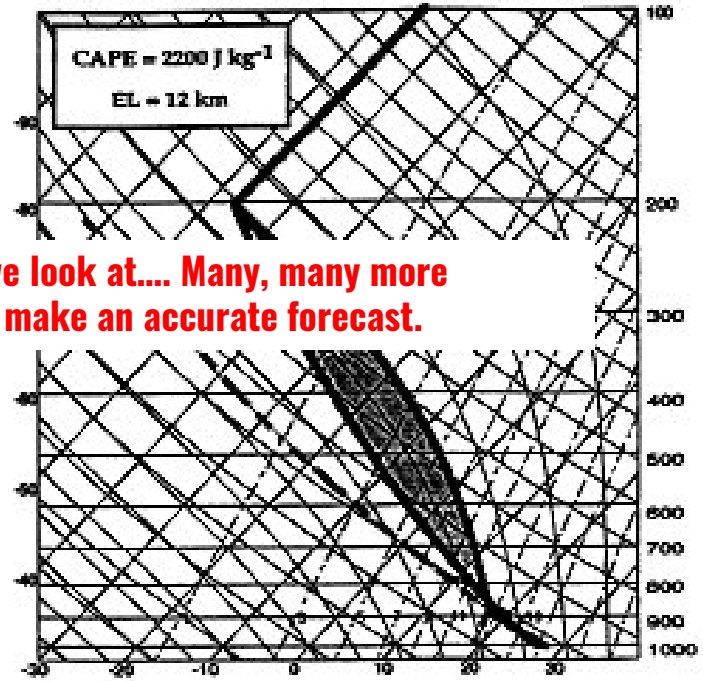
Low CAPE



- Low storm potential
- Weak lapse rate

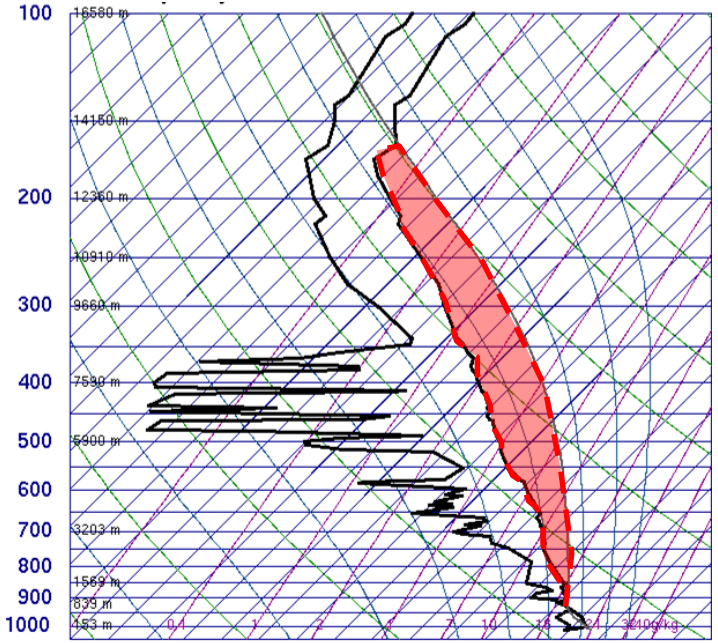
CAPE is only 1 ingredient that we look at…. Many, many more variables must be analyzed to make an accurate forecast.

High CAPE



- Higher storm potential
- Steep lapse rate

CAPE and Thunderstorms

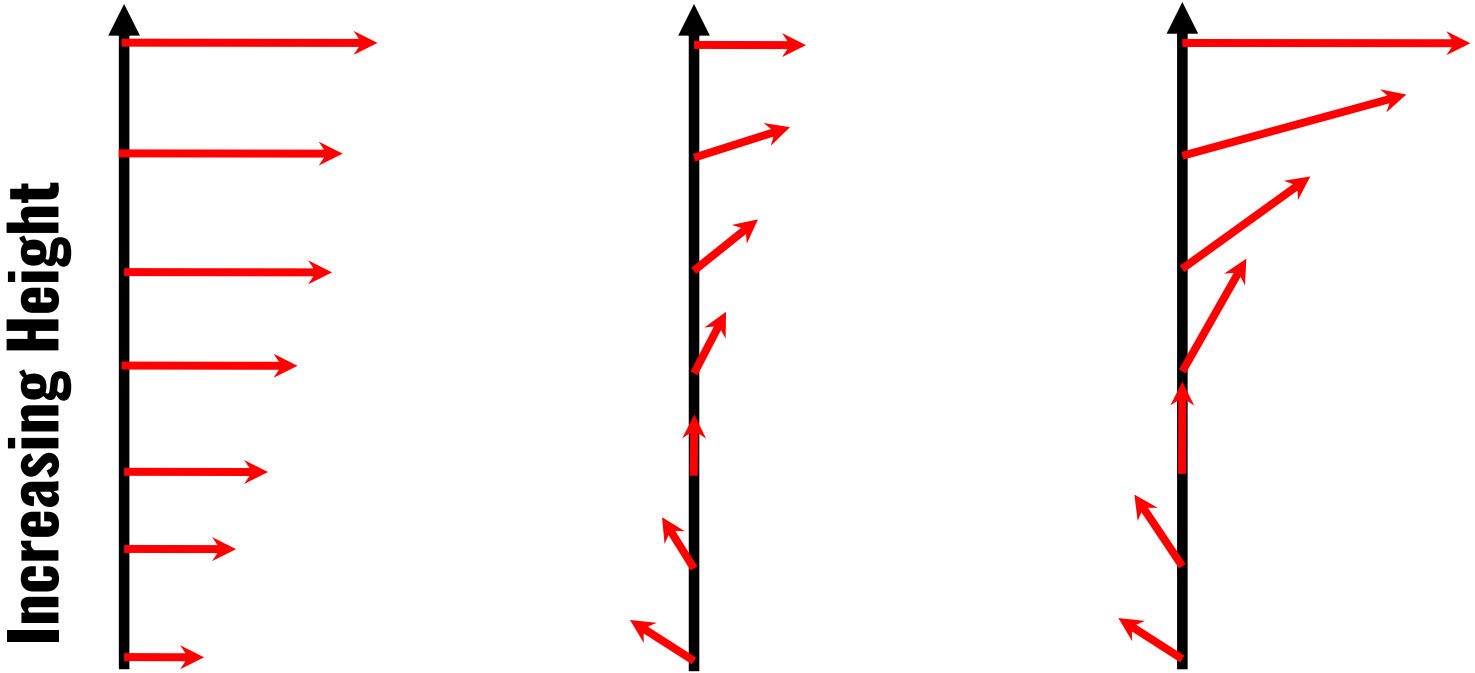


Wind Shear: What is it?

Change in wind speed with height

Change in wind direction with height

Change in wind speed and direction with height

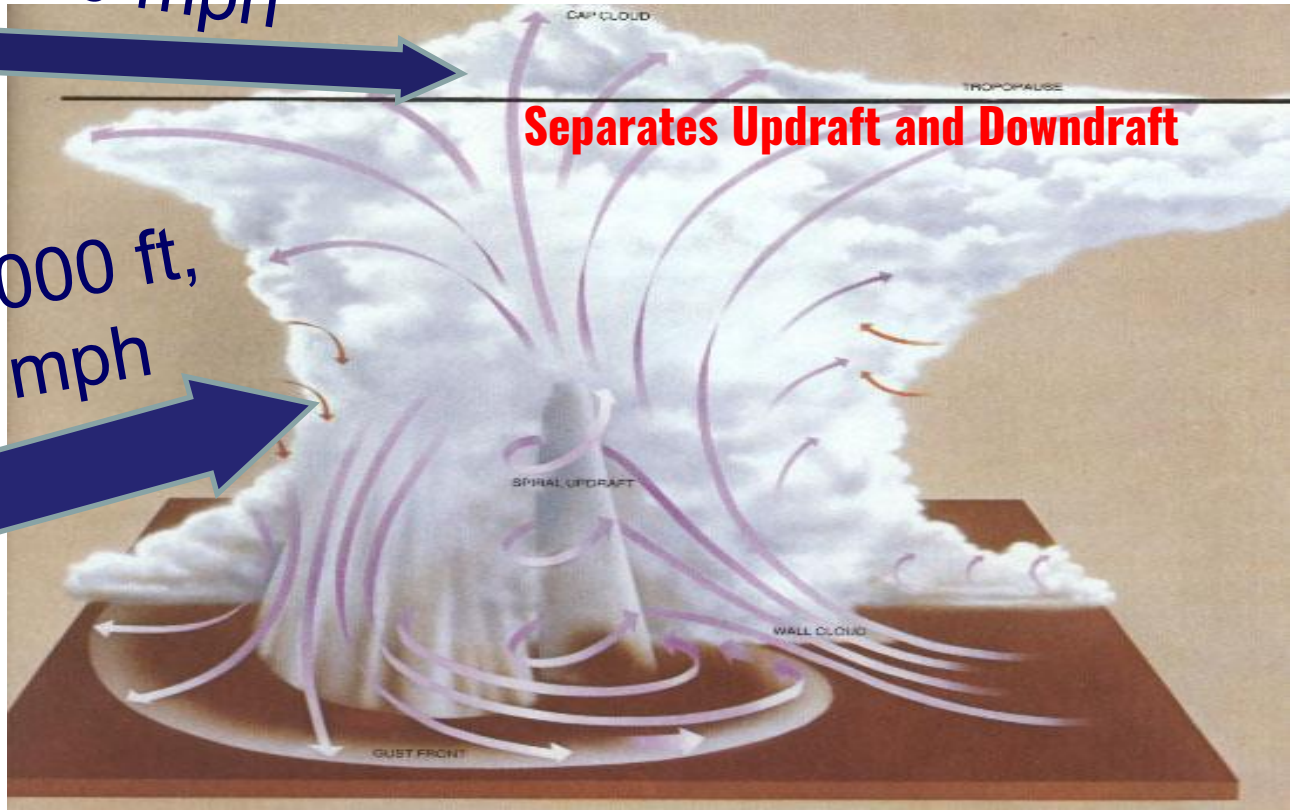


Why Wind Shear?

40,000 ft,
90 mph

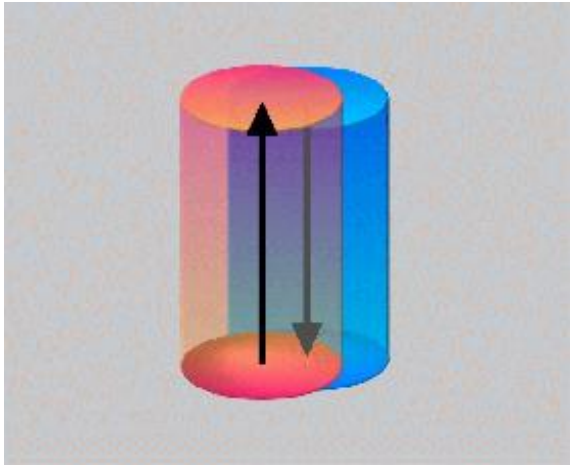
Separate Updrafts and downdrafts allow the storm to keep refueling.

10,000 ft,
60 mph



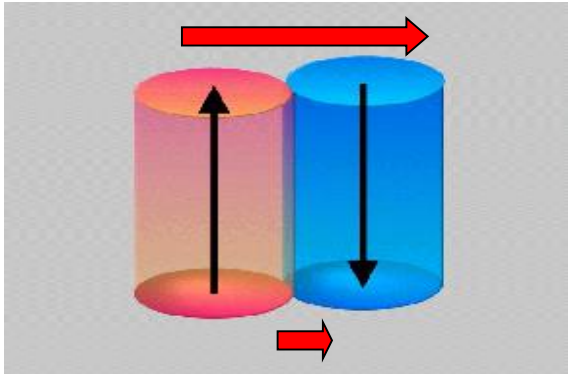
Wind Shear

Weak



Downdraft chokes updraft causing storm be short-lived

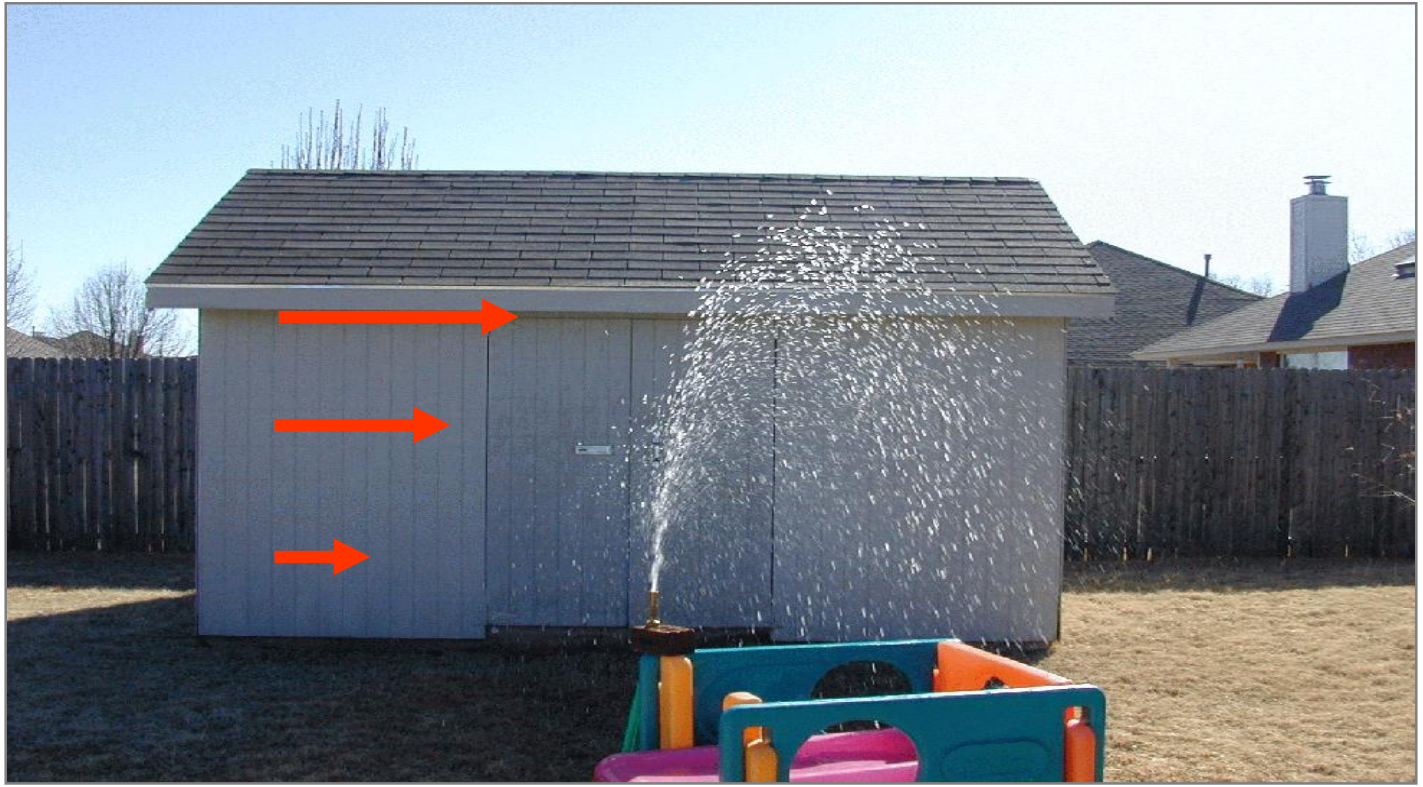
Strong



Updraft & downdraft are separated, the storm lives longer

Updraft in Weak Wind SPEED Shear

Updraft in Strong Wind SPEED Shear

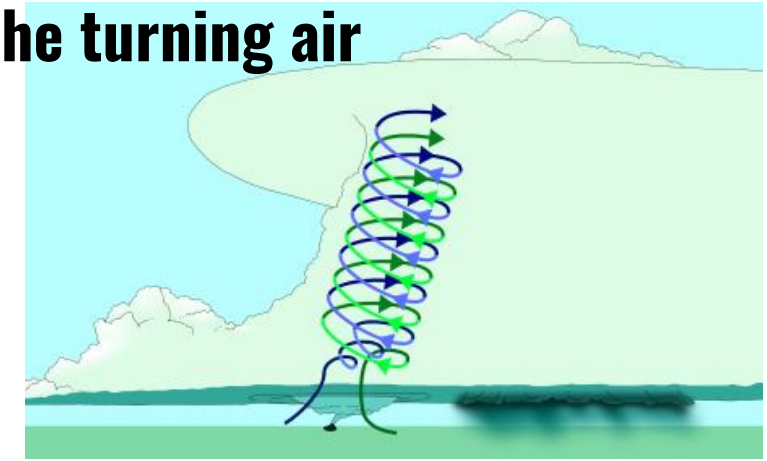


Wind Shear & Supercells

Wind shear gets the air turning

The **updraft** bends the turning air upward.

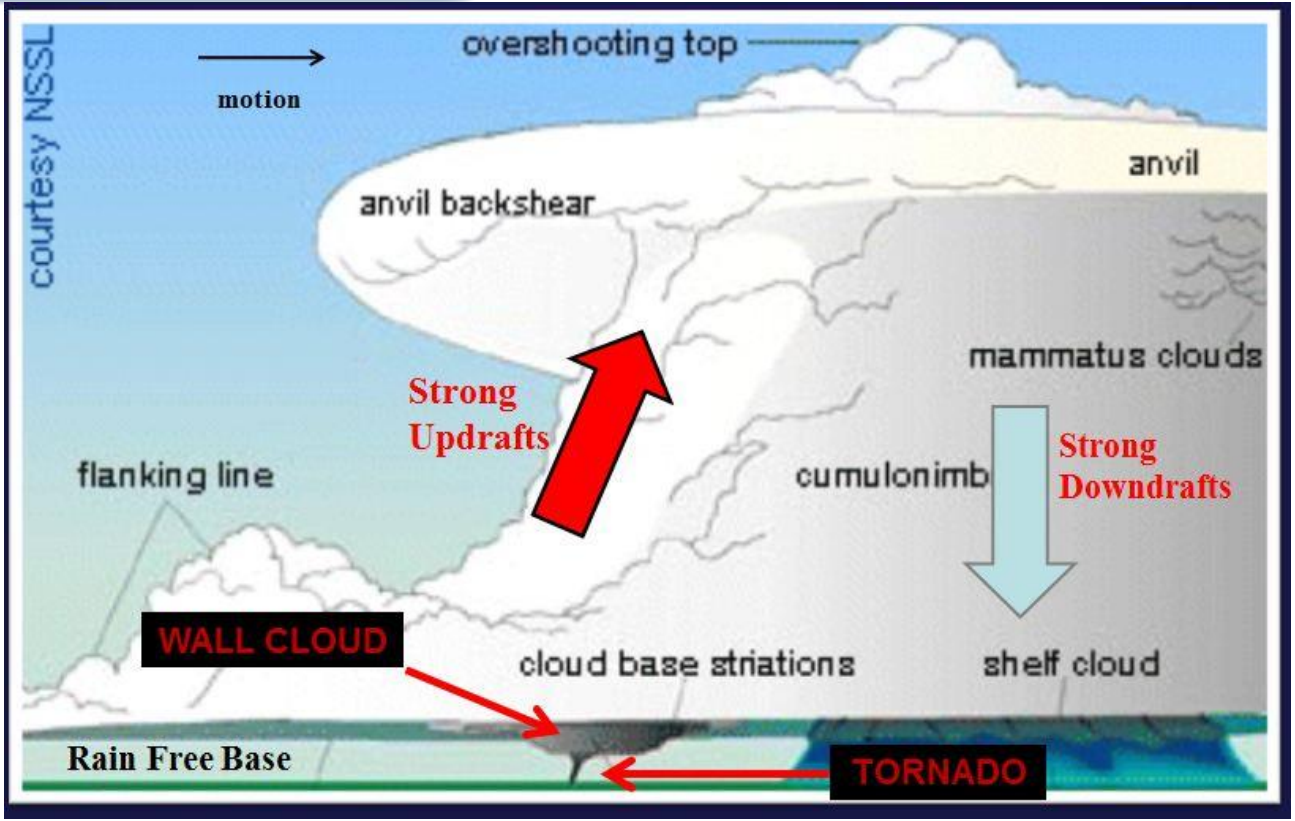
The **updraft** begins spinning with the turning air



Wind shear is quantified using terms like ***Helicity*** and ***Bulk Shear***

Supercell – Rotating Updraft

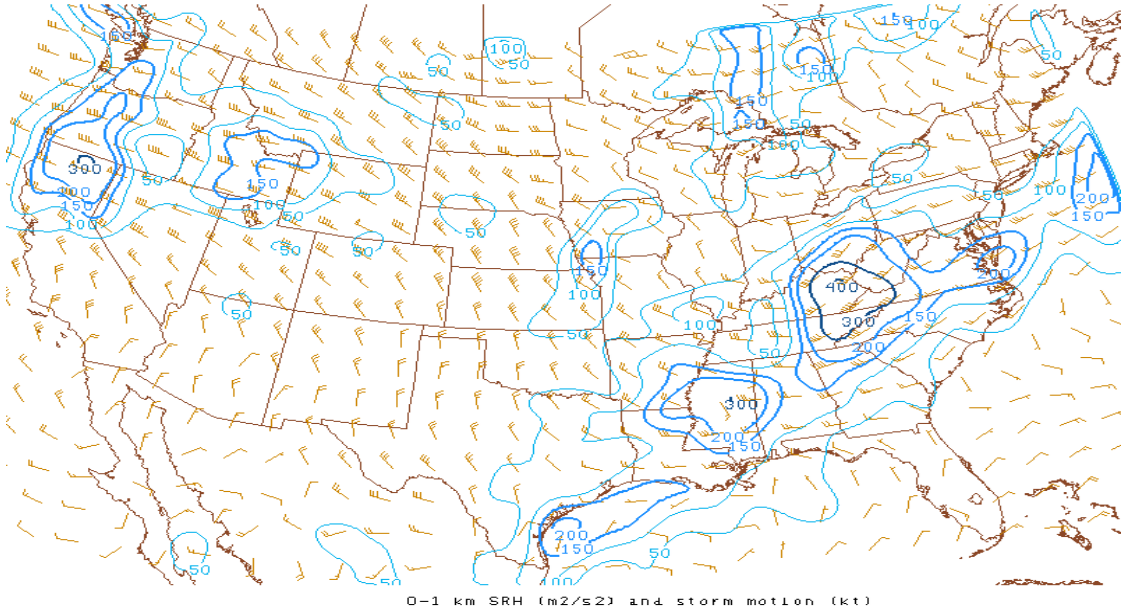
Supercell Thunderstorm



Same Ingredients as a basic Thunderstorm.

But add significant amounts of speed and directional shear

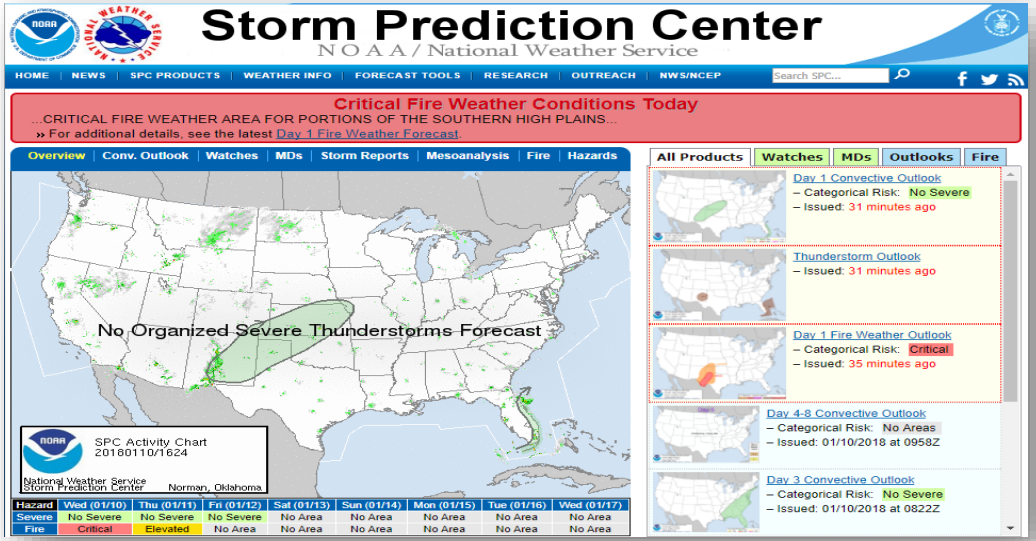
Measuring Wind Shear

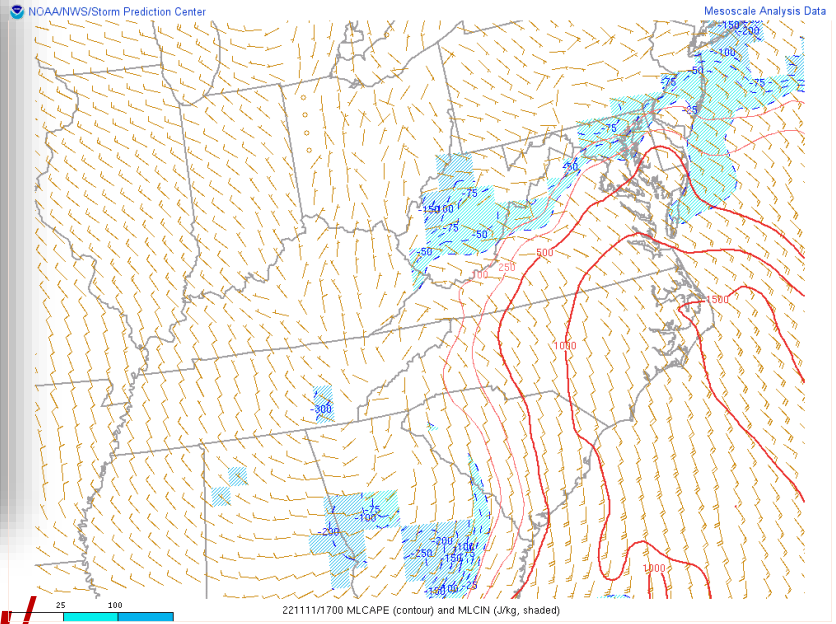


HELICITY FACTS:

- Measured at several height levels
- Aids in determining storm type and expected "convective mode"
- 0-6 km = Storm Motion
- 0-3 km = Storm Type
- 0-1 km = Tornadoes?

Storm-scale/Environment Information readily available!





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

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

Evaluate Storm: Upper Levels

Strong Updraft indicated by:

Overshooting Top

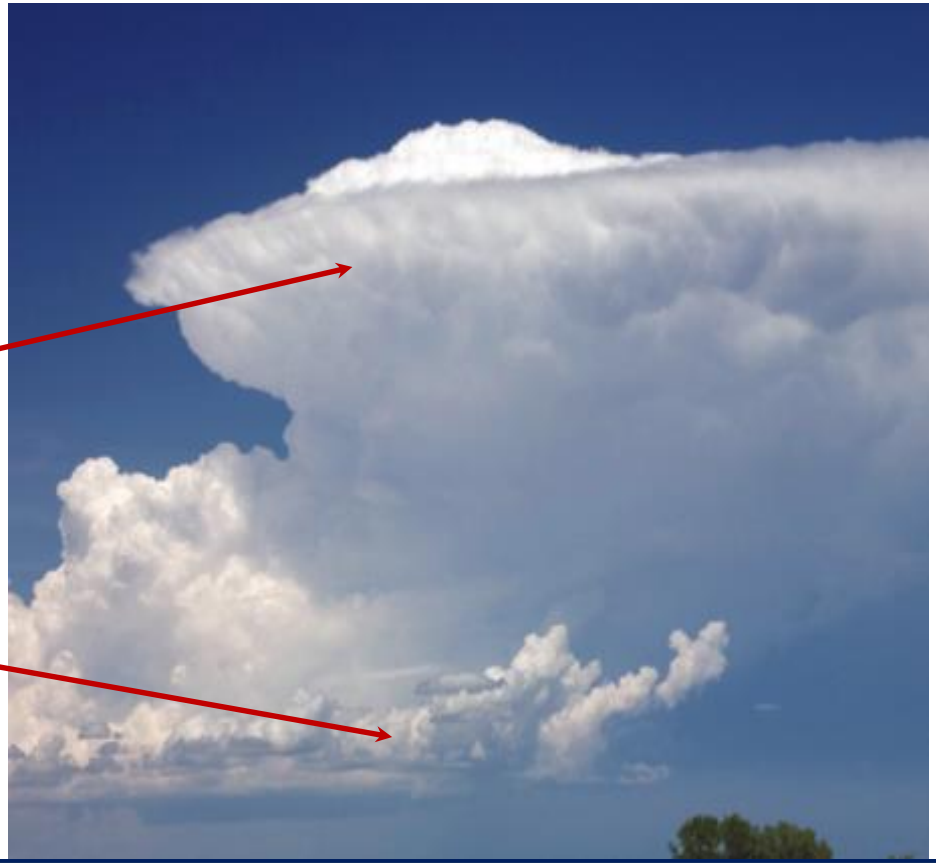
Thick, cumuliform anvil

Evaluate Storm: Mid Levels

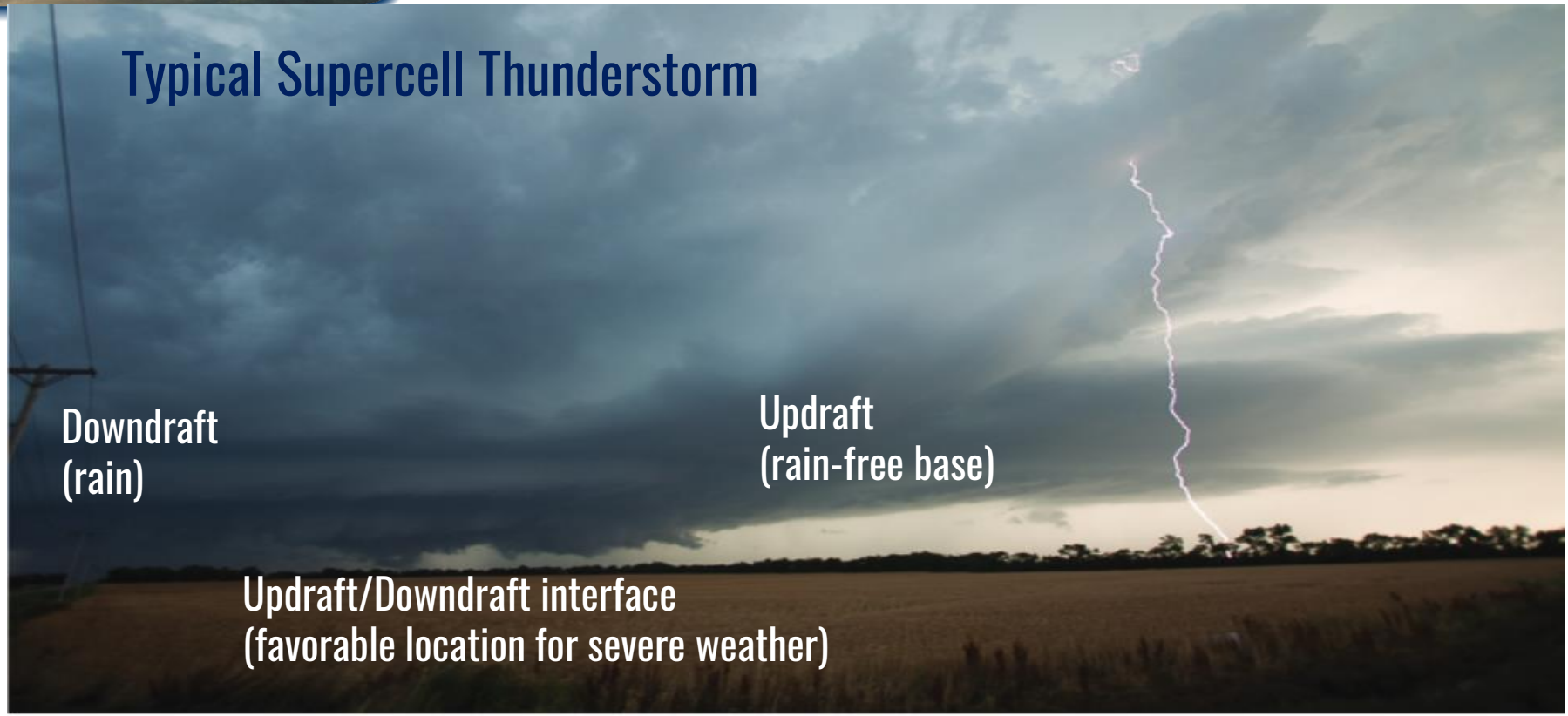
Stronger Storms:

Main Storm Tower
- Hard, sharp cauliflower look

Presence of a flanking line
- Greater storm organization

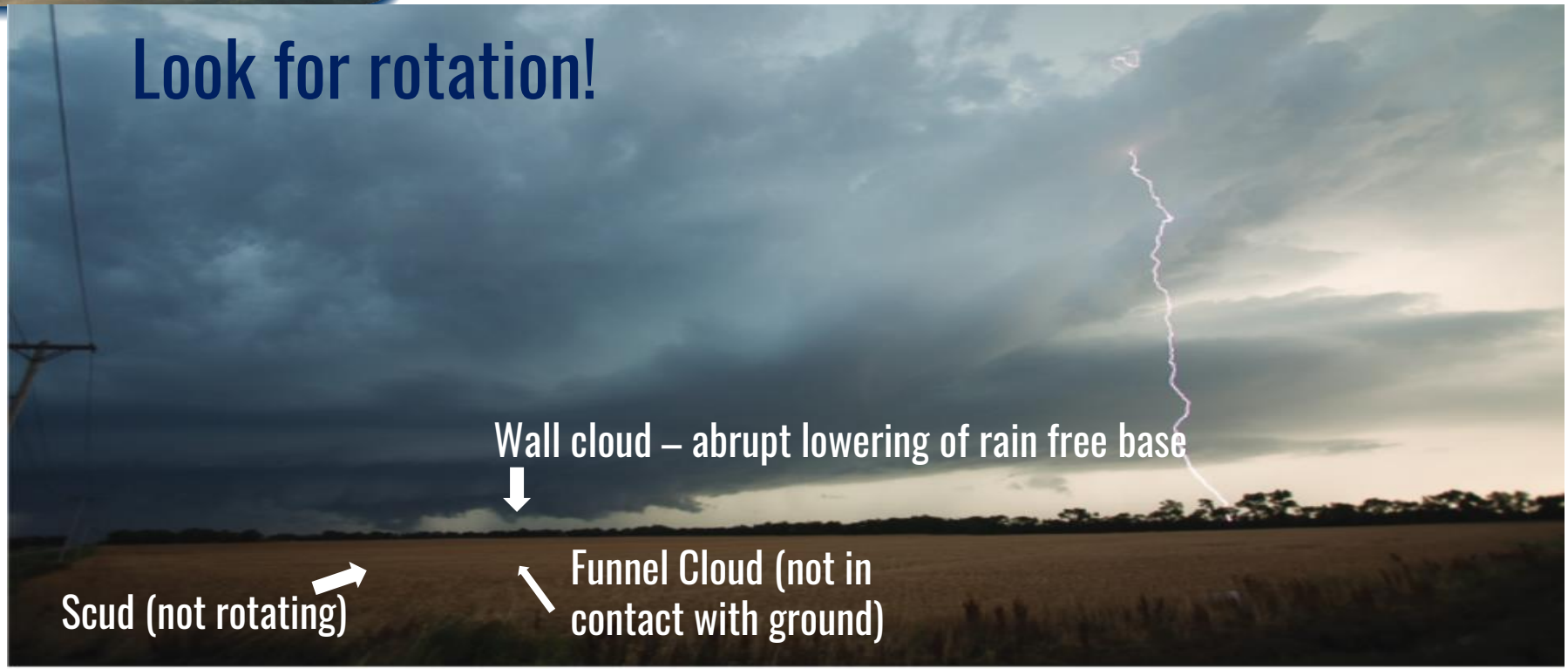


Evaluate Storm: Low Levels



Lower level storm features, including the updraft and downdraft area. Photo by Jim LaDue.

Evaluate Storm: Low Levels



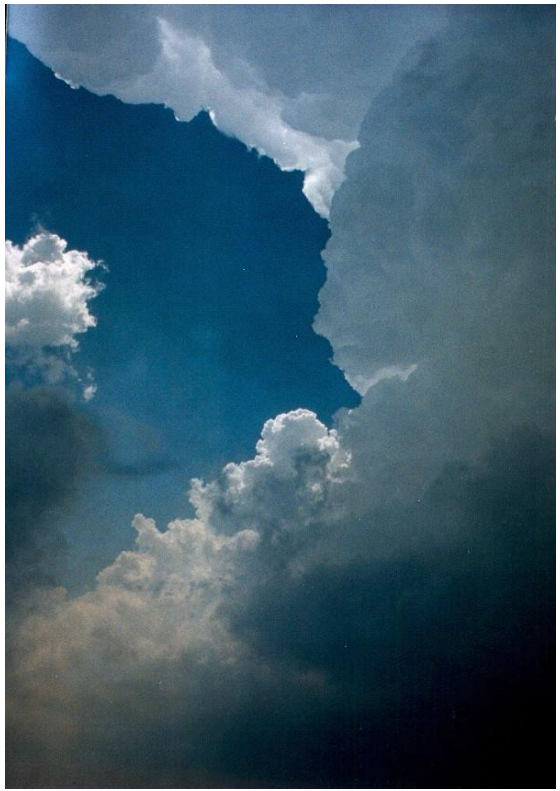
Lower level storm features, including the updraft and downdraft area. Photo by Jim LaDue

Wall vs. Shelf Clouds

Wall cloud
Rotates along a vertical axis

Shelf cloud
Rotates along a horizontal axis

Strong or Weak Updraft?



Strong!
Sharp, bubbly towers with a cauliflower look to it.

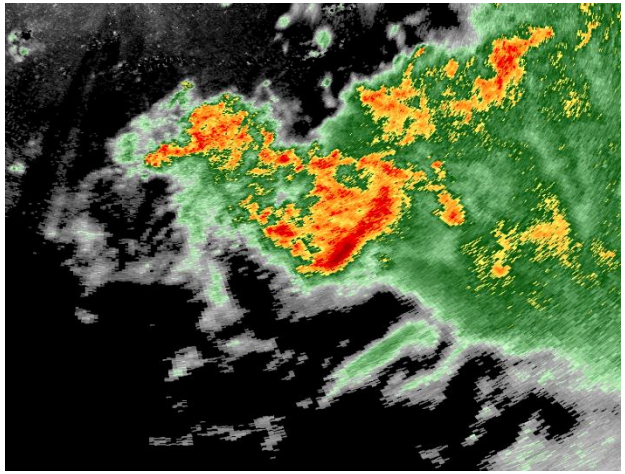
Strong or Weak Updraft?

Weak!
Fuzzier look to the cloud. Parts are translucent and edges are not nearly as sharp.

Shelf or Wall Cloud?

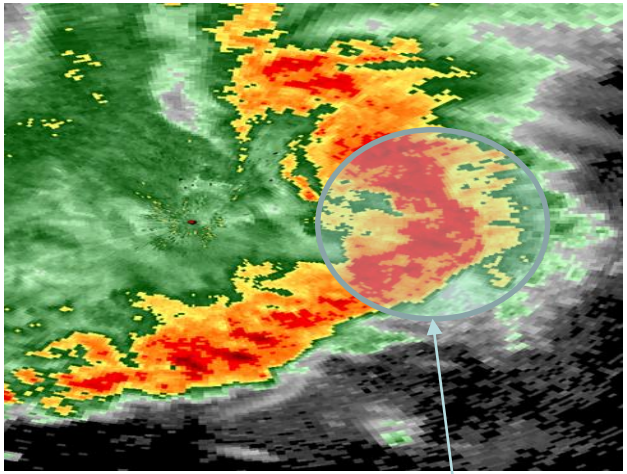
Wall cloud
Lowering of the rain free base. If there was video you would be able to observe rotation around a vertical axis

Storm Type



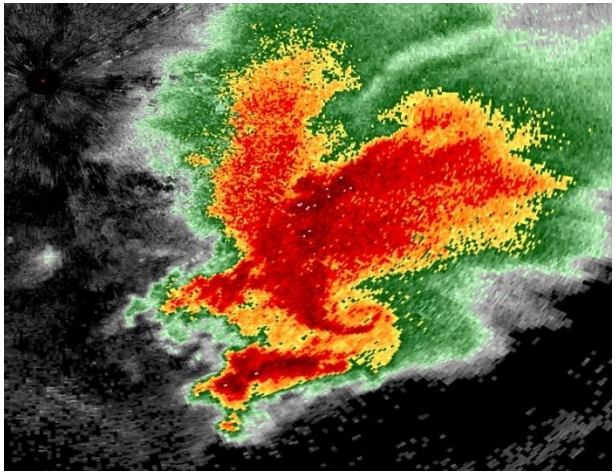
Multi-Cell Cluster

- Downburst Winds
- Hail
- Flash Flooding
- Tornadoes (usually low)



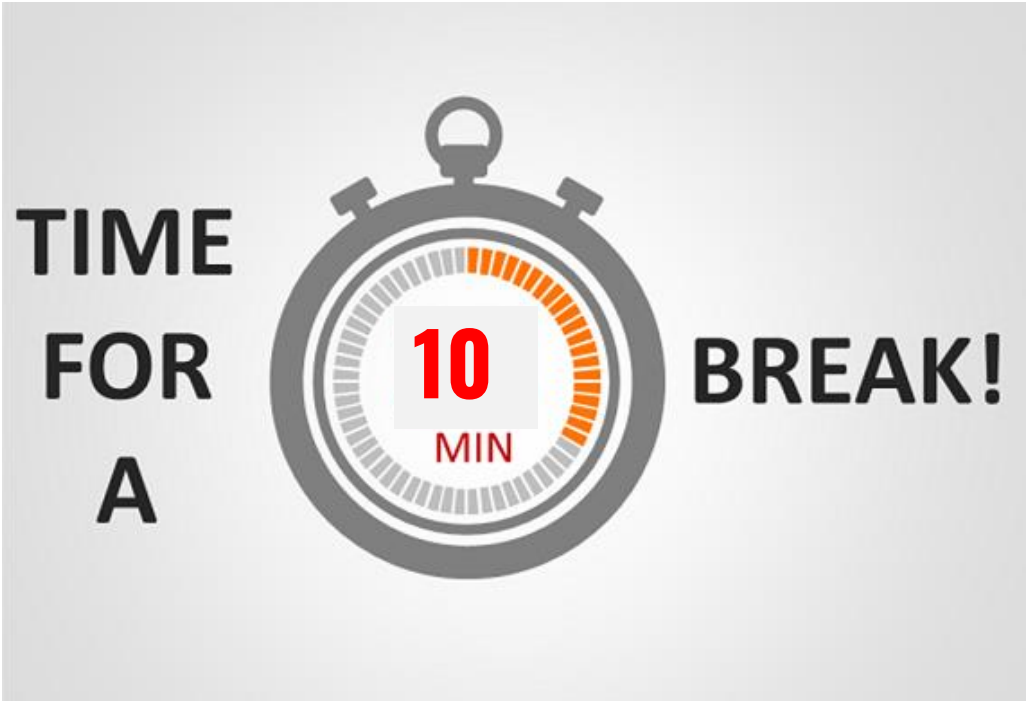
Multi-Cell Bow Echo

- Damaging Winds (especially apex!)
- Isolated Tornadoes
- Flash Flooding
- Hail (usually low)



Supercell

- Tornadoes
- Large Hail
- Damaging Winds
- Flash Flooding


TIME
FOR
A
10
MIN
BREAK!

What is Radar?

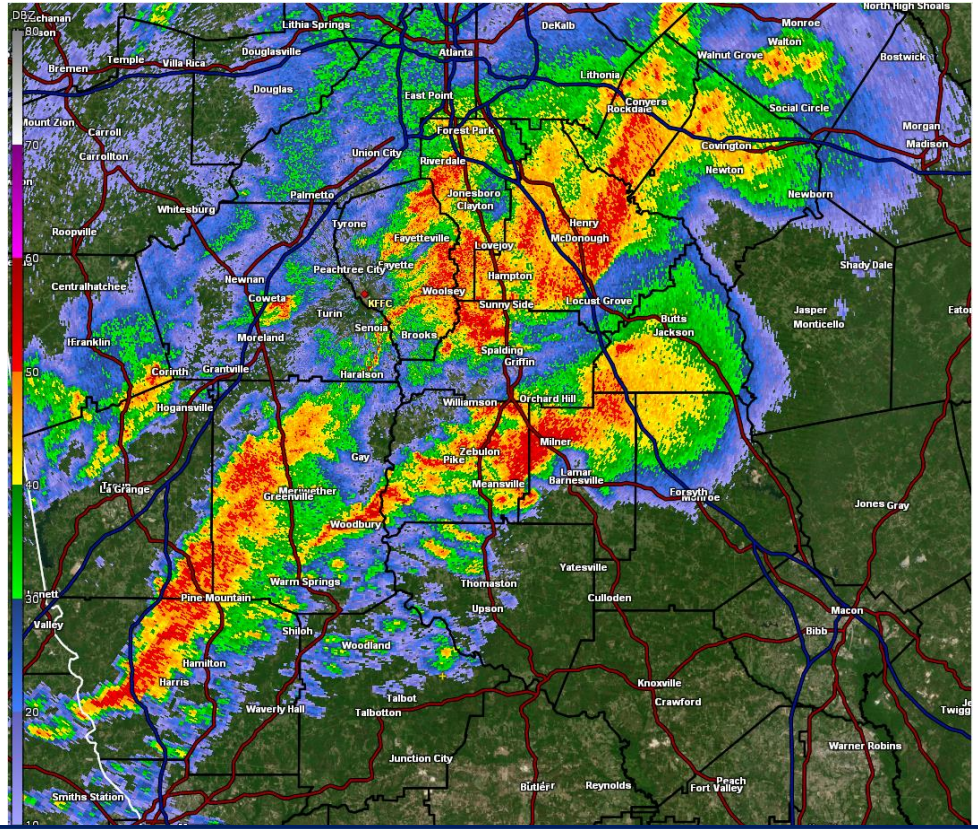
- **Radio Detection and Ranging**
  - Detects the distance to and power returned from a target
- **Weather radar is designed to detect targets made of water**

Raindrop, snowflake, hail, insect, dust, etc.

- Many brief microwave pulses per second are transmitted
- In between the pulses, the radar is "listening" for a reflected signal, or "echo"
- The amount of reflected signal received is called reflectivity

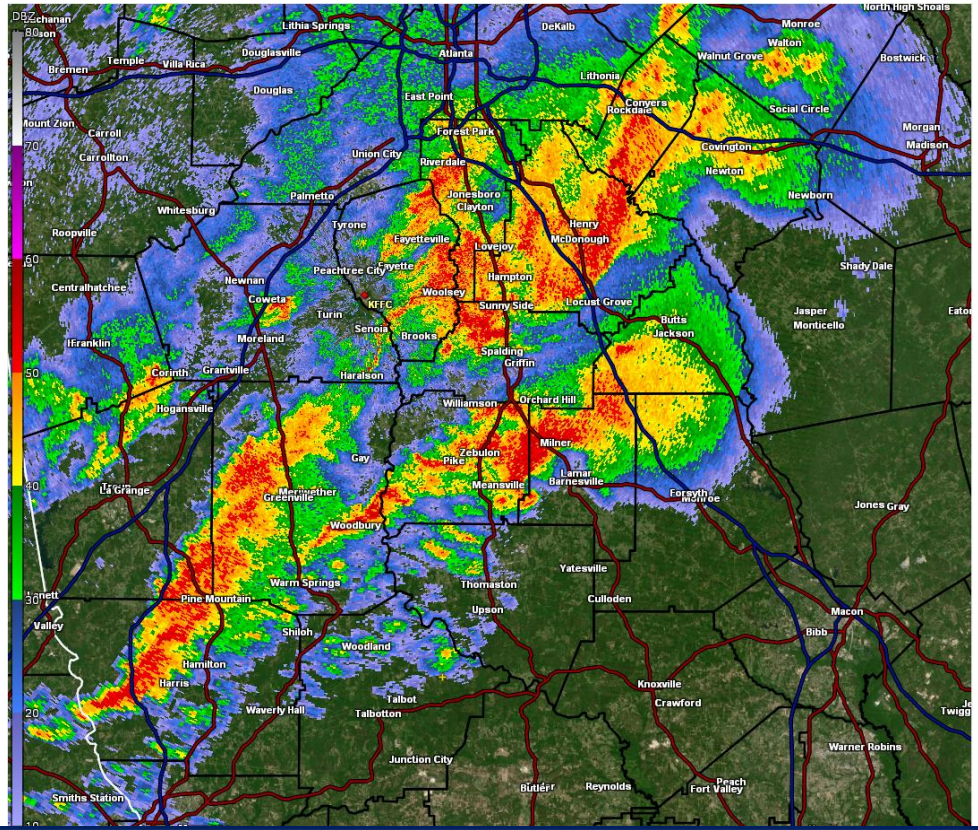
What is Reflectivity?

- The higher the reflectivity, the heavier the rainfall
- Colors are used to display low and high reflectivity
  - Warm colors = high
  - Cool colors = low
  - Always use the color legend
- Threats seen: Heavy rain, hail, snow
  - Can also see birds, insects, leaves (tornado debris)

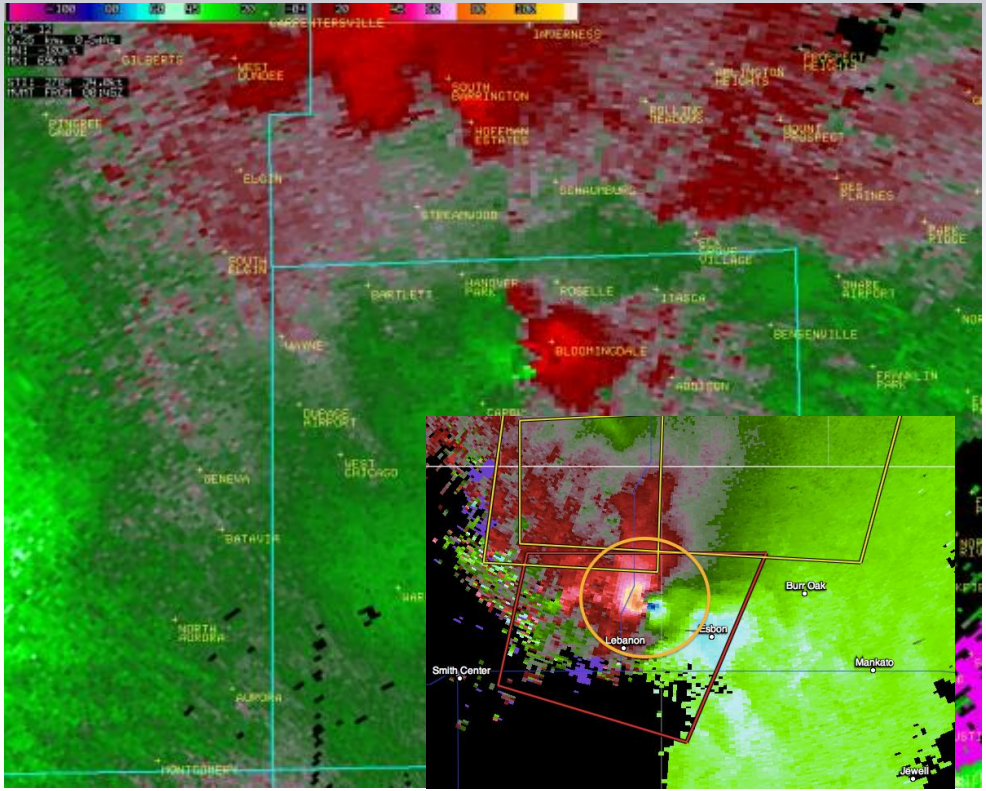


The Doppler Effect

- Doppler effect is a change in frequency of a moving object
- Targets moving toward the radar are colored green
- Targets moving away from the radar are colored red
- The brighter the color, the stronger the wind
- Threats seen: Damaging wind, tornadoes



Velocity



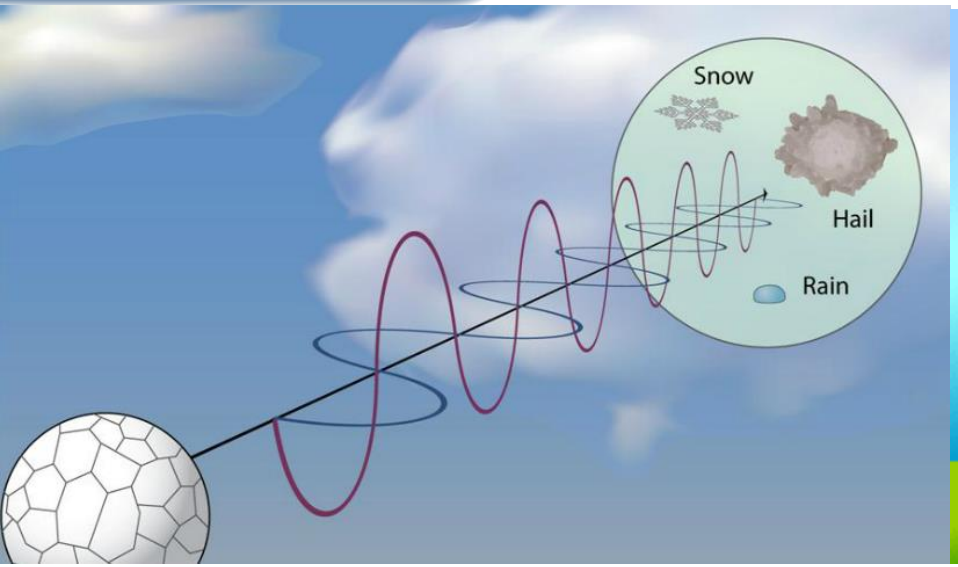
Base Velocity and **Storm Relative Velocity**

What separates storm relative motion from base velocity is the motion of storms are "subtracted" from the overall flow of the wind.

Green = Motion towards the radar
Red = Motion away from the radar

Couplet: Intense outbound winds next to intense inbound wind.

Dual-Polarization Radar

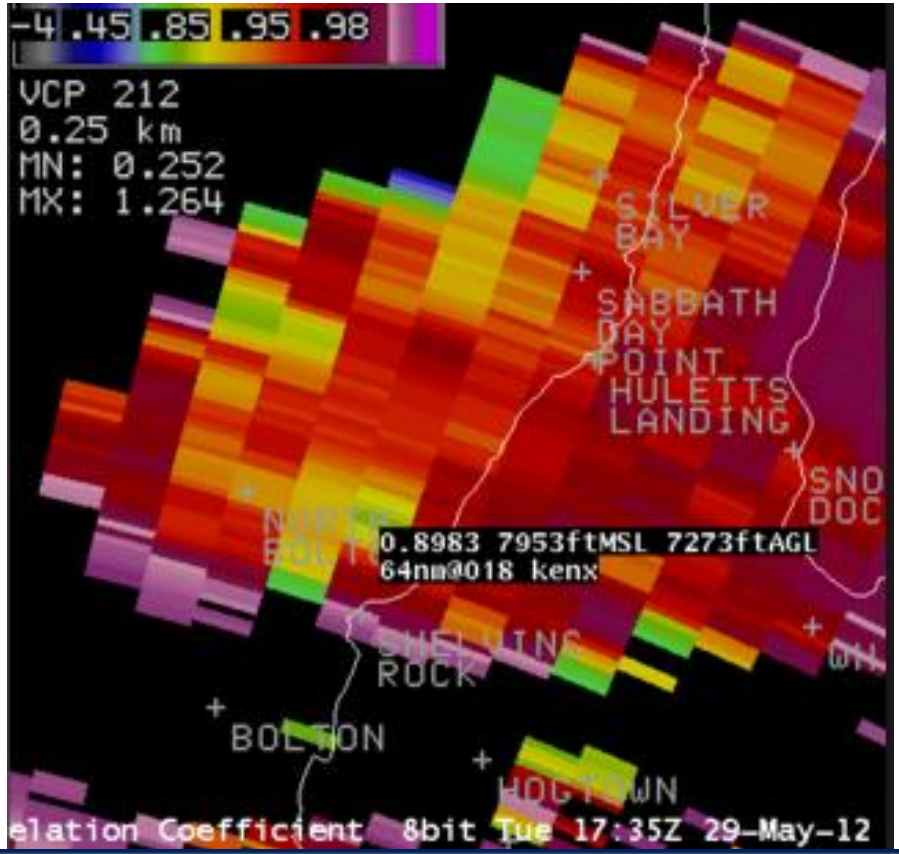


- Radar waves <u>polarized</u> horizontally ***and*** vertically
- Can see the size and shape of weather and non-weather targets
- Threats seen: Hail, heavy rainfall, tornado debris

Correlation Coefficient

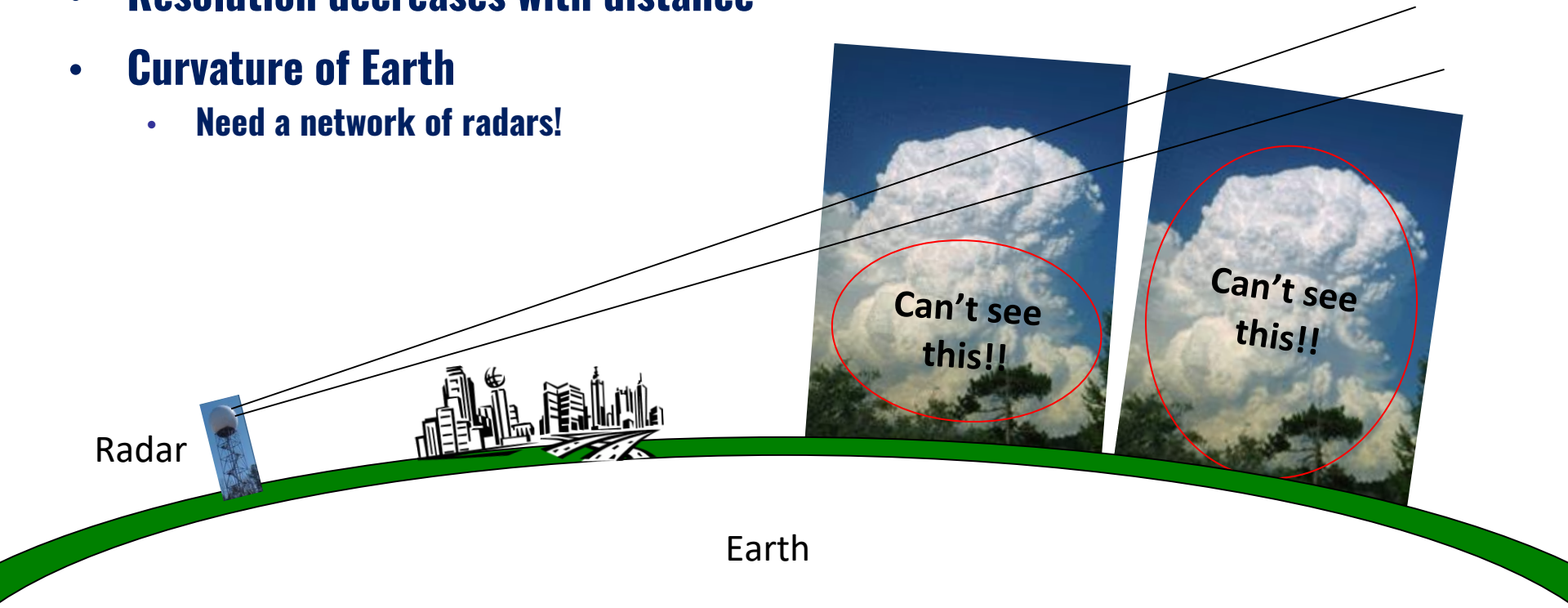
- A correlation between the reflected horizontal and vertical power returns

- Good indicator of hydrometeor diversity
  - High values = Uniform targets (rain)
  - Low values = Other targets mixed in (hail, debris, bugs, etc.)



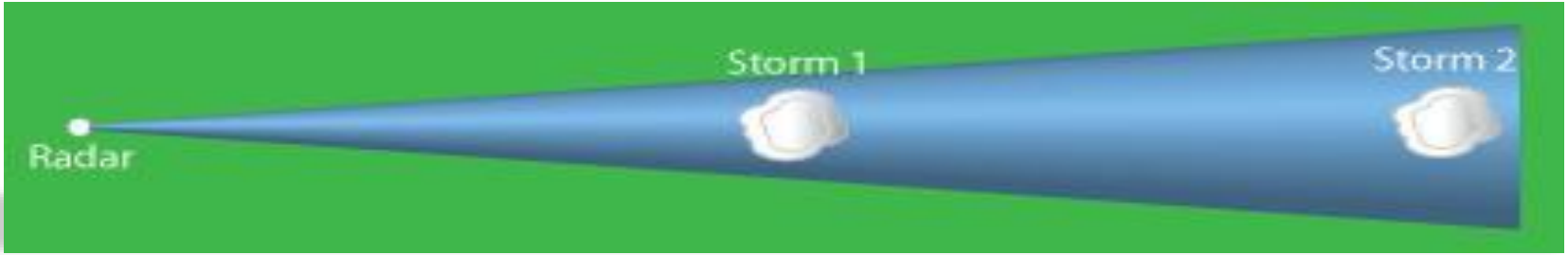
Limitations of Radar

- **Resolution decreases with distance**
- **Curvature of Earth**
  - **Need a network of radars!**



Limitations of Radar

Beam Spreading:



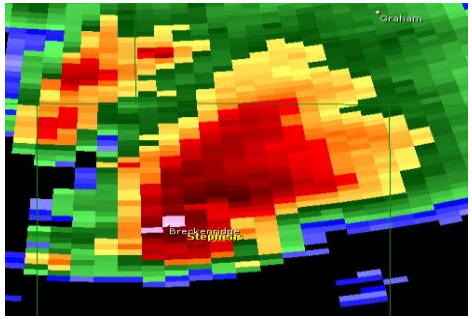
- Beam spreads nearly 1,000 ft. for every 10 miles of travel.

  At 60 miles from the radar the beam is over 6,000 feet wide.
  At 120 miles from the radar the beam is well over 2 miles wide.

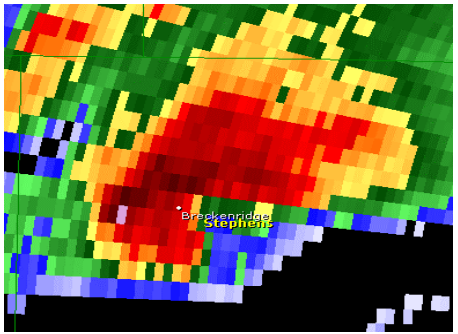
Beam spreading affects resolution capability of the radar!

Small scale features which can be easily discerned near the radar often become obscured at greater distances.

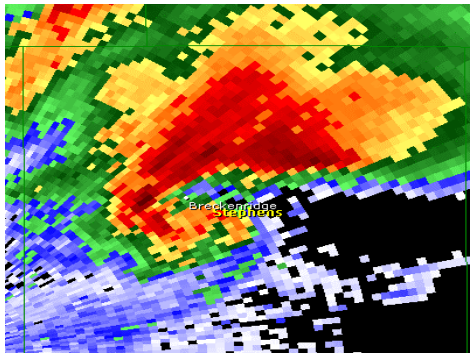
Effects of Beam Spreading:
Same Storm w/ 4 different Radars



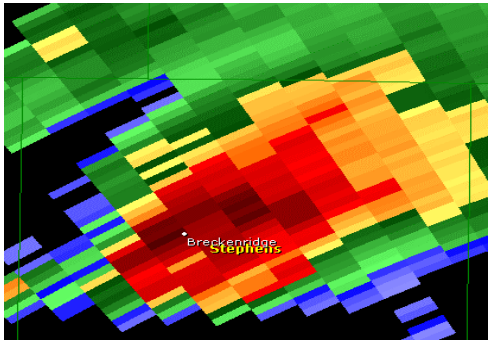
112 miles / 11,200 ft.



94 miles / 8,300 ft.



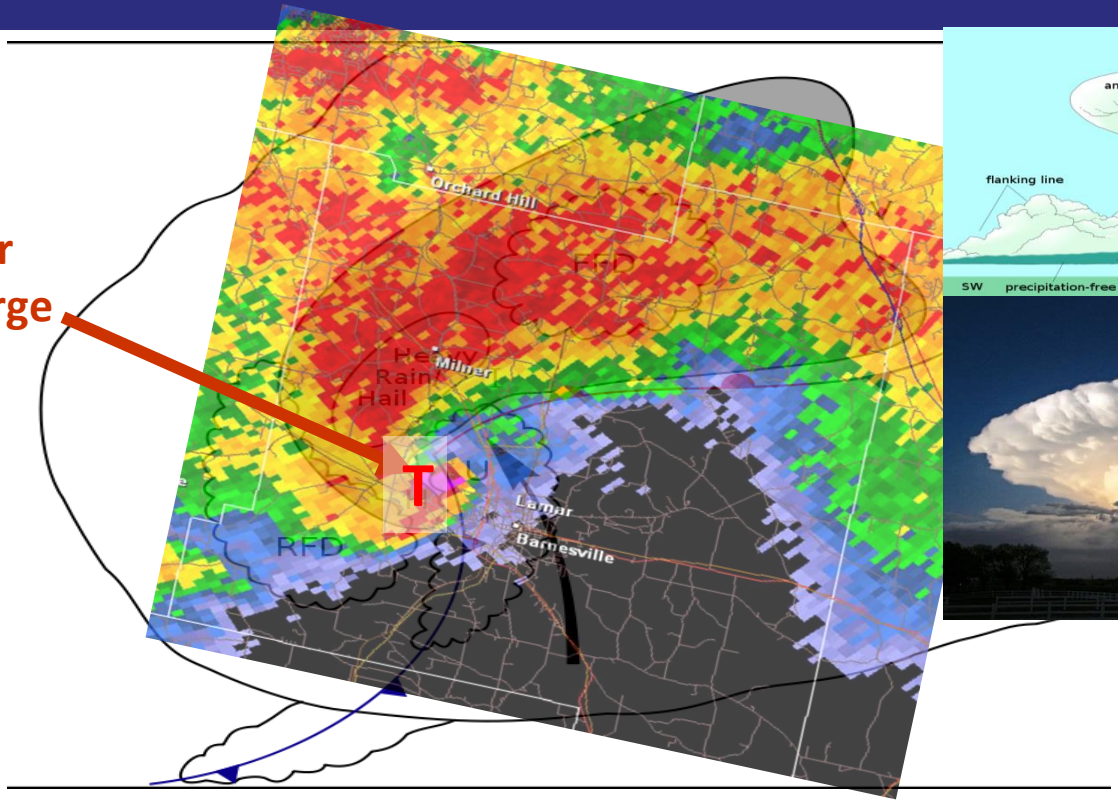
25 miles / 1,700 ft

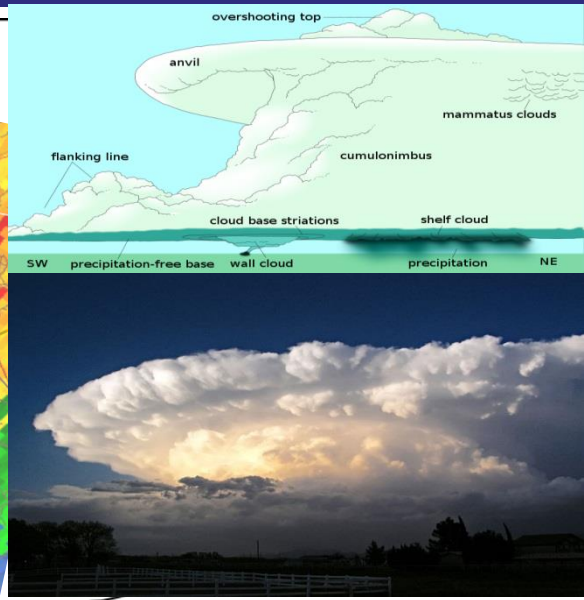


167 miles / 21,000 ft.

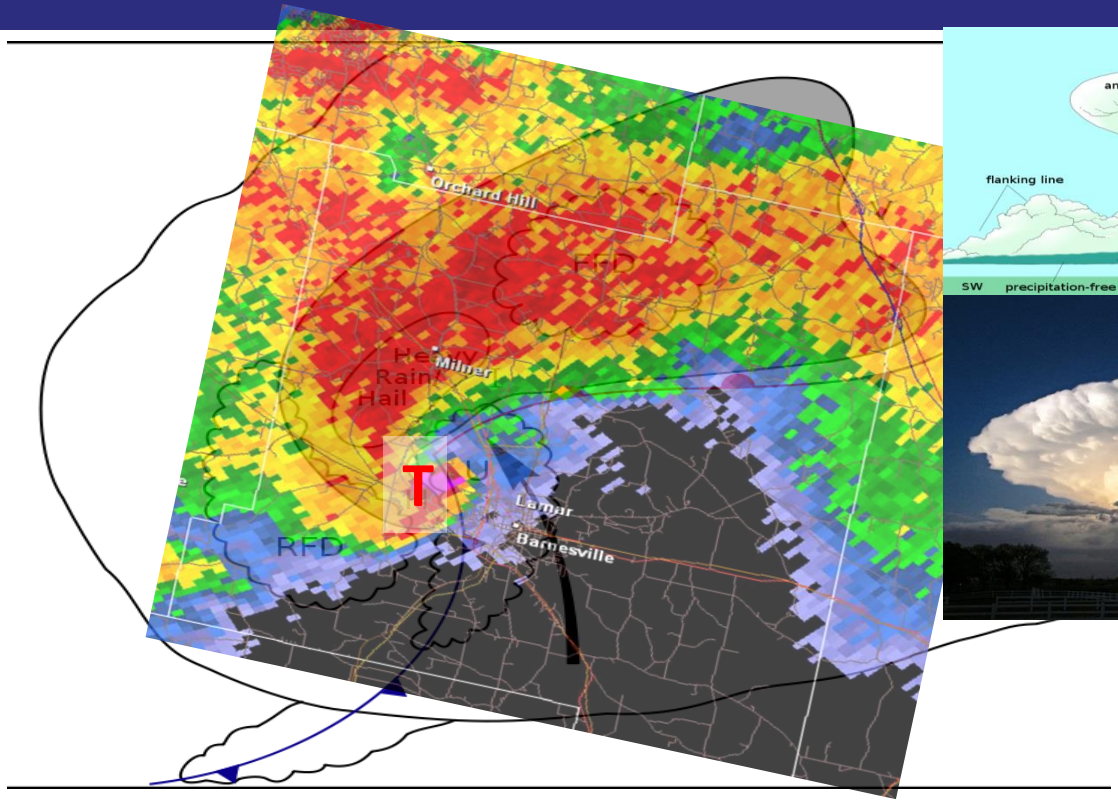
Storm Structure - Reflectivity

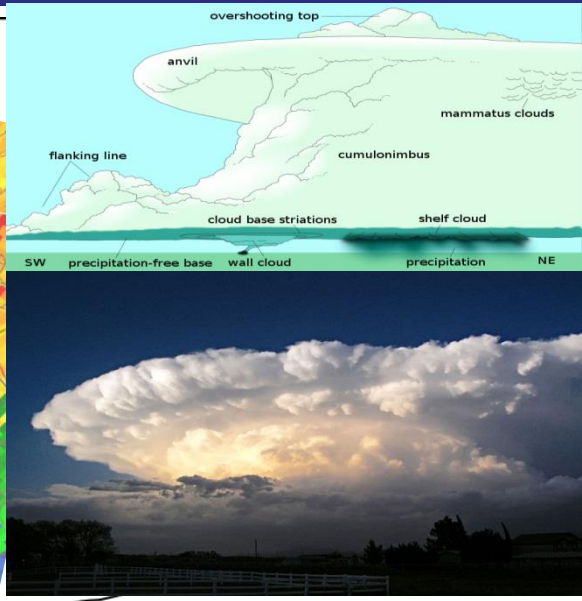
Most likely area for damaging wind, large hail and tornadoes



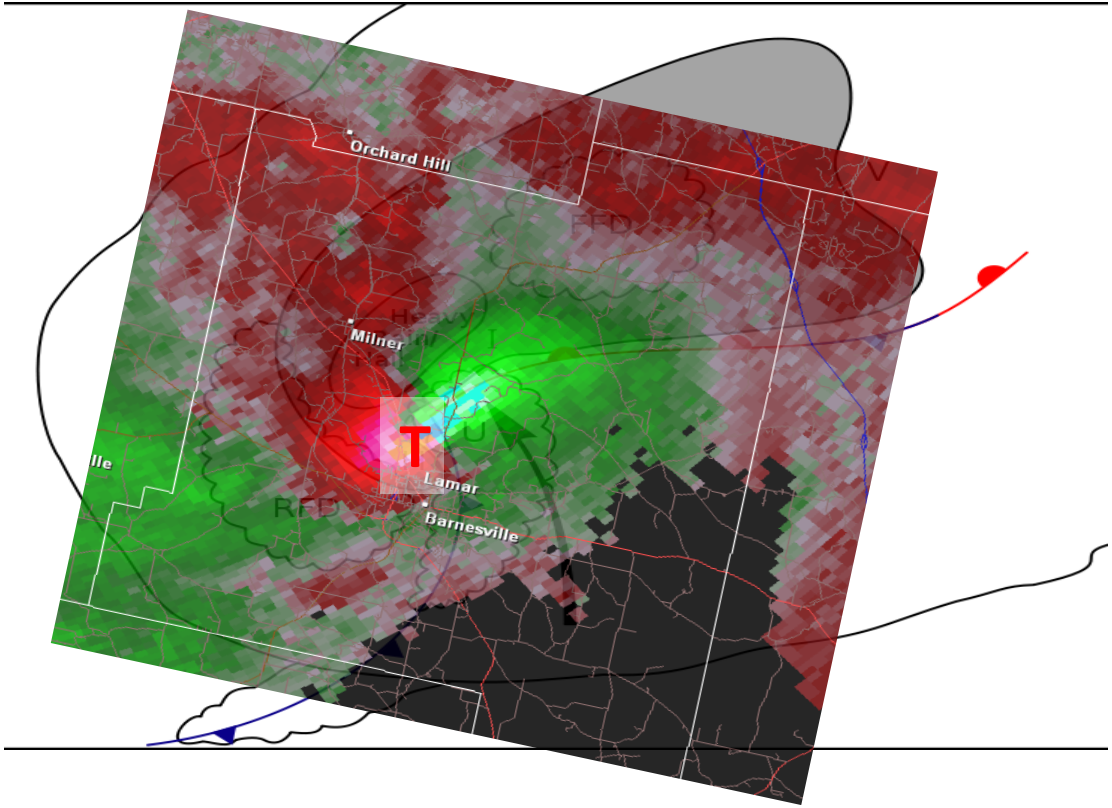


Storm Structure - Reflectivity

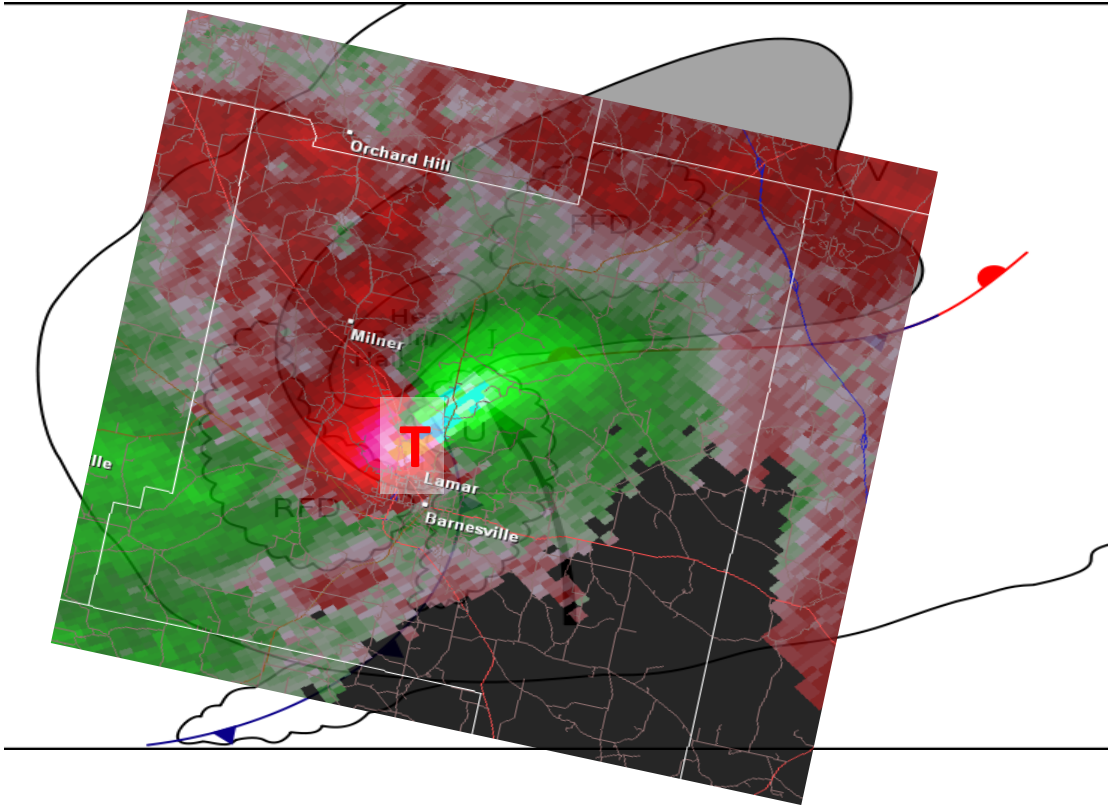




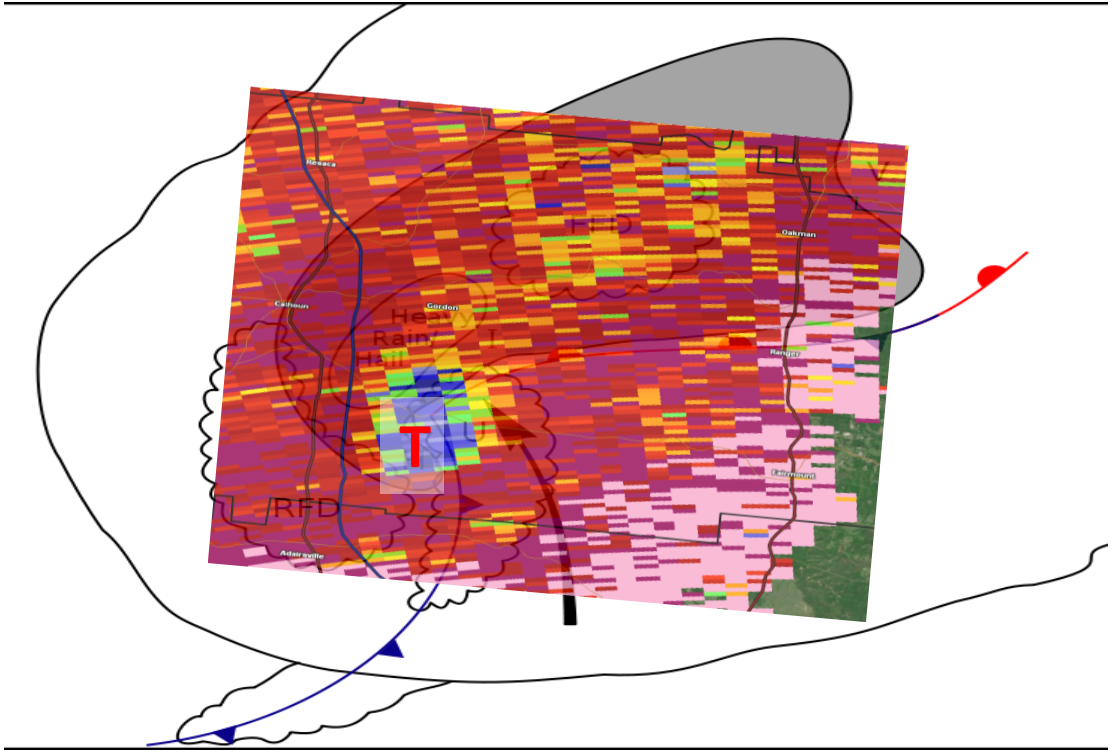
Storm Structure - Velocity



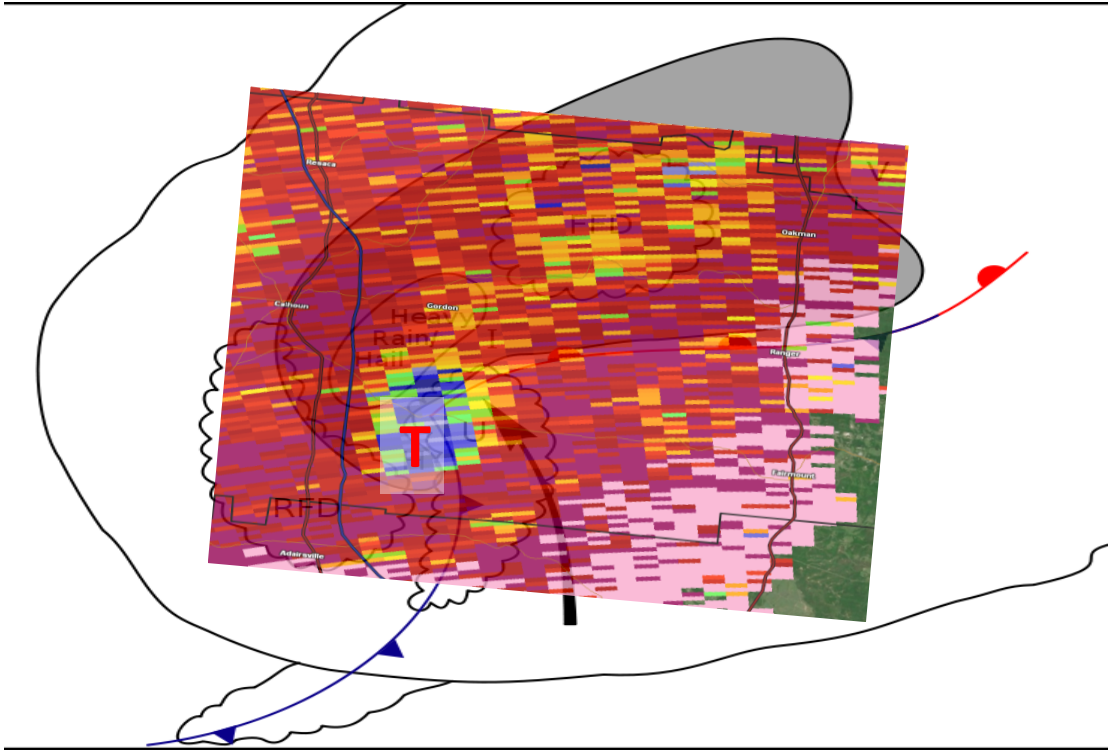
Storm Structure - Velocity



Storm Structure – Dual-polarization



Storm Structure – Dual-polarization



Impact-Based Warnings

Tags

Tags will appear at the bottom of Tornado and Severe Thunderstorm Warnings, and in the Severe Weather Statements that update the warnings.

In a *Severe Thunderstorm Warning*, tags will be used to define:

- hail size
- wind speed
- possible tornado (if necessary)

In a *Tornado Warning*, two types of tags can be used:

- Tornado tag (always used)
  - radar indicated
  - observed
- Damage threat tag (optional)
  - considerable damage
  - catastrophic damage

Tags will appear in NWSChat

(4:39:41 PM) nwsbot: LSX issues Tornado Warning [tornado: RADAR INDICATED, hail: <.75 IN] PRODUCING A TORNADO WAS LOCATED NEAR BROWNSTOWN...AND MOVING EAST AT 55

Tornado Tag	
TORNADO...RADAR INDICATED	Evidence on radar and near storm environment is supportive, but no confirmation.
TORNADO...OBSERVED	Tornado is confirmed by spotters, law enforcement, or radar (tornado debris signature).
Tornado Damage Threat Tag	
No Tag	Use most of the time, when tornado damage is possible within the warning polygon. Tornado duration generally expected to be short lived.
TORNADO DAMAGE THREAT...CONSIDERABLE	Use rarely, when there is credible evidence that a tornado, capable of producing considerable damage, is imminent or ongoing. Tornado duration generally expected to be long lived.
TORNADO DAMAGE THREAT...CATASTROPHIC	Extremely rare. A severe threat to human life and catastrophic damage from a tornado is occurring, and will only be used when reliable sources confirm a violent tornado. Tornado duration generally expected to be long lived.
Tornado Tag in Severe Thunderstorm Warnings	
TORNADO...POSSIBLE	A severe thunderstorm has some potential for producing a tornado although forecaster confidence is not high enough to issue a Tornado Warning.

Purpose:
Impact Based Warnings

Meteorology: Newer (88D/Dual-Pol) Radar technology & products can affect NWS warning decision-making

Social Science: Small, yet critical, wording changes in Warnings & Follow-up statements (SVS)

- Hazard/Source/Impacts/Tags

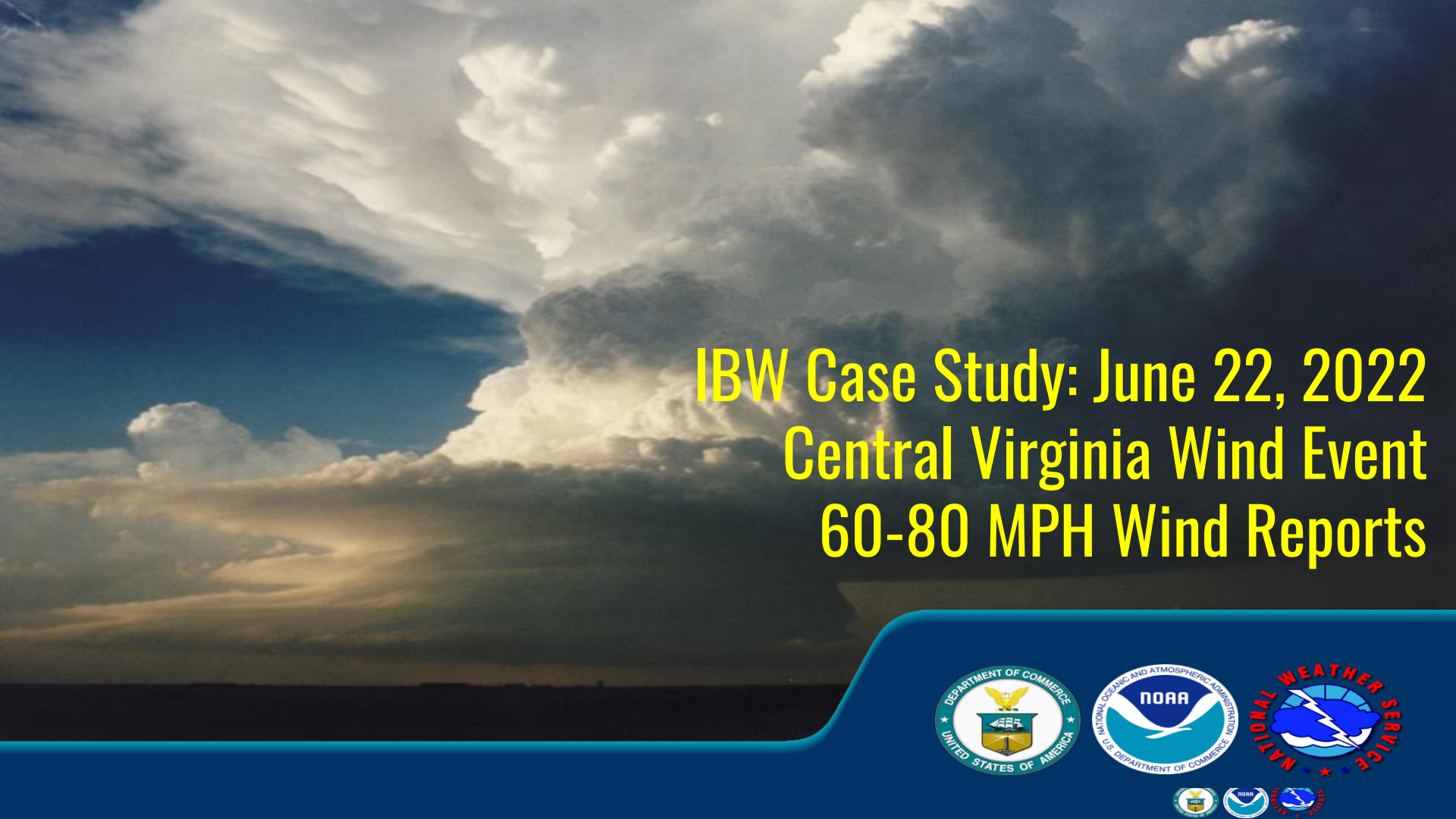
Media & Public: easier to key in on the most important parts of warning (threats & impacts)

Impact-Based Severe Thunderstorm Warnings

Currently, a severe thunderstorm is classified as a storm that can produce 58 mph or greater winds and/or 1" or larger hail. Beginning August 2nd, 2021, Severe Thunderstorm Warnings will have Impact Based Warning (IBW) Tags when 70+ mph winds are possible.

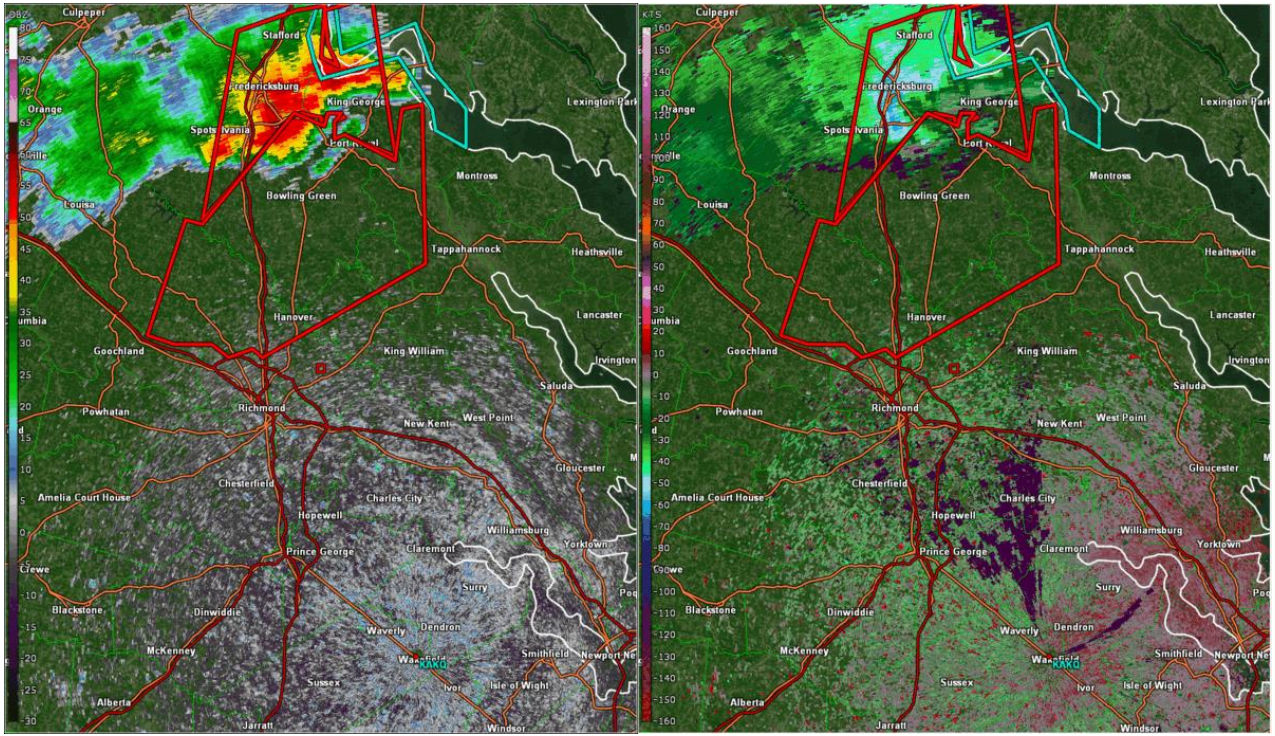
Maximum Wind Speed:	Maximum Hail Size:	New IBW Tag	Dissemination
 58 – 70 mph	 1" to 1.5" (Quarter to ping pong ball)	No new tag; identical to current warnings	No change from current method
 70 – 80 mph	 1.75" to 2.5" (Golf ball to tennis ball)	Tagged: "Considerable" Damage Threat	No change from current method
 80 + mph	 2.75" or greater (Baseball size or greater)	Tagged: "Destructive" Damage Threat	Will alert on cell phones as WEA through IPAWS

www.weather.gov www.weather.gov/wrn



IBW Case Study: June 22, 2022
Central Virginia Wind Event
60-80 MPH Wind Reports

2-panel Loop from AKQ Radar:
2:30 to 4:40 PM EDT (10 minute increments)



Initial Severe Thunderstorm Warning

BULLETIN - IMMEDIATE BROADCAST REQUESTED
Severe Thunderstorm Warning
National Weather Service Wakefield VA
224 PM EDT Wed Jun 22 2022

The National Weather Service in Wakefield has issued a

* Severe Thunderstorm Warning for...
  Northwestern King and Queen County in east central Virginia...
  Northwestern Westmoreland County in east central Virginia...
  Caroline County in north central Virginia...
  Hanover County in central Virginia...
  Northwestern King William County in east central Virginia...
  Northwestern Essex County in east central Virginia...

* Until 315 PM EDT.

* At 224 PM EDT, severe thunderstorms were located along a line
  extending from near Nanjemoy Creek to near Potomac Creek to near
  Spotsylvania, moving south at 45 mph.

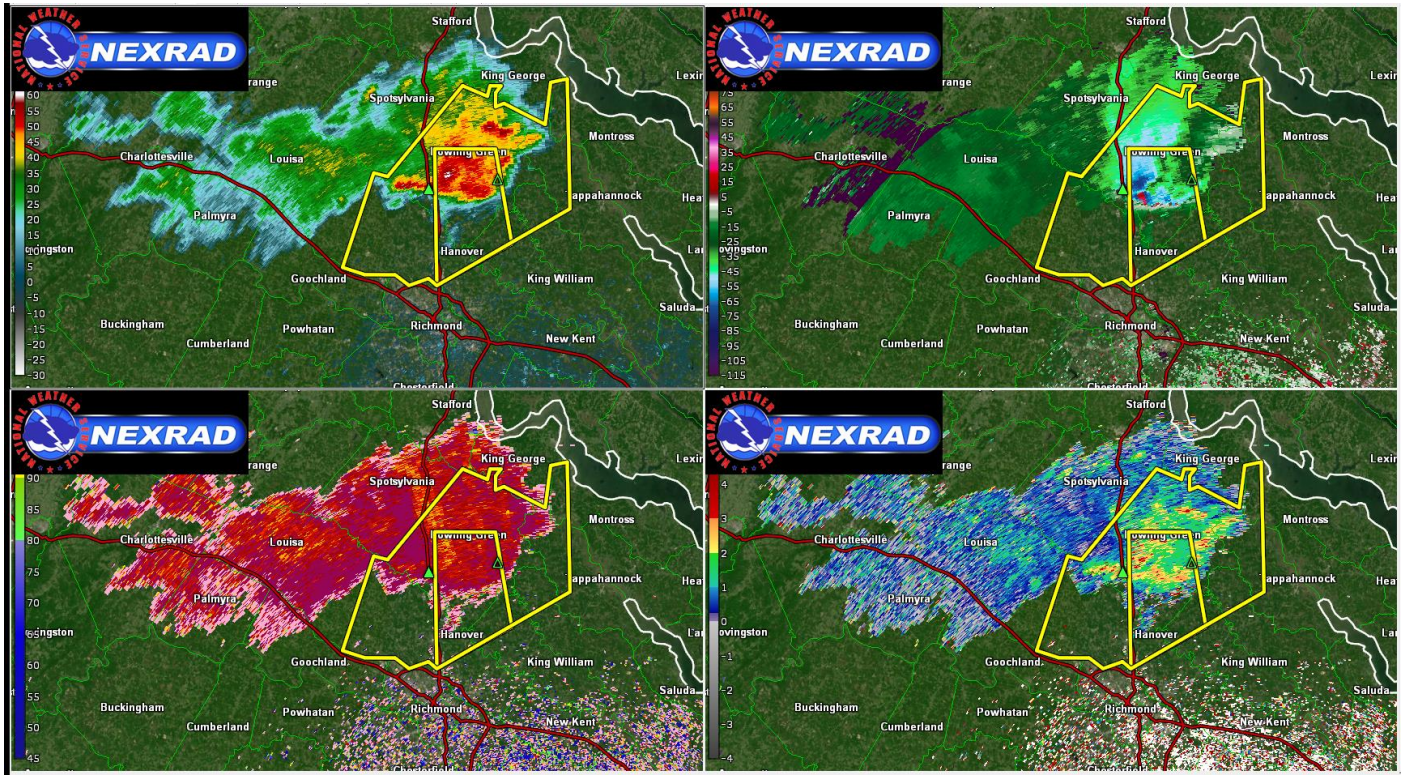
  HAZARD...60 mph wind gusts and quarter size hail.

  SOURCE...Radar indicated.

  IMPACT...Minor damage to vehicles is possible. Expect wind damage
           to trees and powerlines.

* Severe thunderstorms will be near...
  Bowling Green and Port Royal around 250 PM EDT.
  Milford, Fort A.p. Hill, Ladysmith and Loretto around 255 PM EDT.
  Montpelier around 305 PM EDT.
  Dawn and Kings Dominion around 310 PM EDT.
  Ashland, Randolph Macon College, Hanover, Beulahville, Newtown and
  Mangohick around 315 PM EDT.

4-panel from Radar:

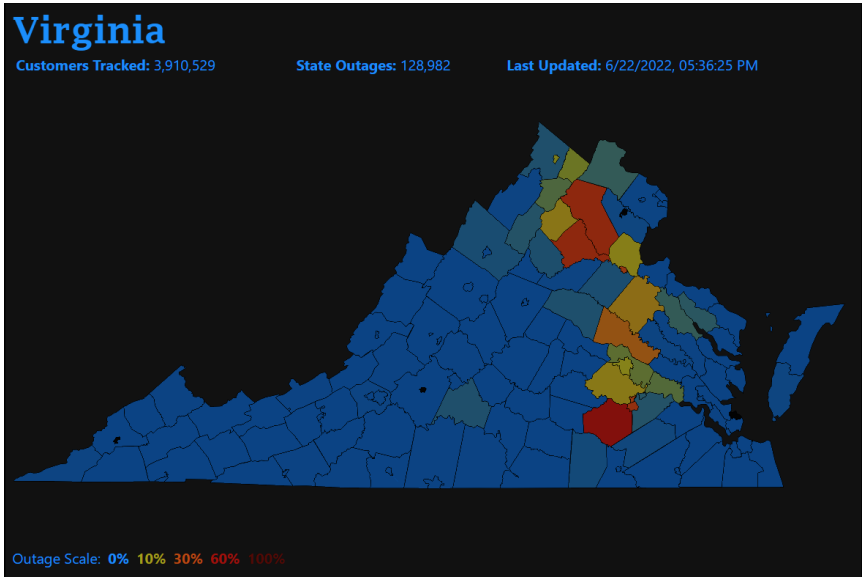


Follow-up Warnings Issued at 2:53-3:08 PM EDT

“Destructive” Tagged Severe Thunderstorm Warning
(radar indicated 80+MPH winds)

```
BULLETIN - EAS ACTIVATION REQUESTED
Severe Thunderstorm Warning
National Weather Service Wakefield VA
308 PM EDT Wed Jun 22 2022

The National Weather Service in Wakefield has issued a

* Severe Thunderstorm Warning for...
  The City of Richmond in central Virginia...
  Chesterfield County in central Virginia...
  The City of Colonial Heights in central Virginia...
  The City of Hopewell in south central Virginia...
  The northeastern City of Petersburg in south central Virginia...
  Southeastern Goochland County in central Virginia...
  Henrico County in central Virginia...
  Southwestern Caroline County in north central Virginia...
  Hanover County in central Virginia...
  Northwestern King William County in east central Virginia...
  Southeastern Powhatan County in central Virginia...

* Until 400 PM EDT.

* At 307 PM EDT, severe thunderstorms were located along a line
  extending from near Mangohick to near Montpelier, moving south at
  40 mph.

  THESE ARE DESTRUCTIVE STORMS FOR THE RICHMOND METRO AND
SURROUNDING AREAS.

  HAZARD...80 mph wind gusts and quarter size hail.

  SOURCE...Radar indicated.

  IMPACT...Flying debris will be dangerous to those caught without
           shelter. Mobile homes will be heavily damaged. Expect
           considerable damage to roofs, windows, and vehicles.
           Extensive tree damage and power outages are likely.
```

Storm Aftermath



Thousands of Power Outages in Richmond Metro area

Storm Surveys

Traditionally a NWS role but…

- We (NWS) may not have enough resources to effectively handle large tornado outbreaks (Aug 4, 2020 (Isaias) & April 16, 2011)
- County EMs or deputies often accompany NWS on surveys. Why not train and work together as a team?
- Help EMs better understand NWS language, and the importance and requirements of a storm survey
- Most importantly, can provide the NWS with a “first look” assessment

Storm Surveys

What should I focus on when I arrive at the scene?

* Damage assessments *should not* focus exclusively on what has been destroyed. It is equally important to consider what was not destroyed.

Storm Survey Training

The most intense damage usually is only a small portion of the whole damage swath. For example, damage associated with EF-5 winds may only account for 2% or less of the overall damage.

Storm Survey Training

- A weak tornado entering a community might do its worst damage early in its track through the community and seem to weaken

Storm Survey Training

- A strong tornado would pick up a “debris load” as it interacted with structures such that damage could increase as it tracked farther into the community.

Storm Survey Training

Was it a tornado or microburst?

- Converging vs. diverging damage: airflow near the surface is predominantly inward vs. fan shaped

- A tornado damage track tends to be long and narrow

- A microburst is usually brief in duration and results in a short and broad damage swath.

Storm Survey Training

Diverging Damage Pattern

Storm Survey Training

Converging Damage Pattern

What to Report

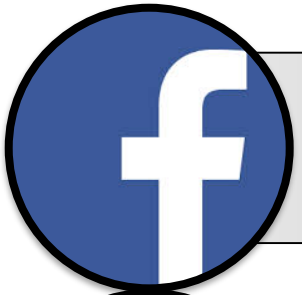
- Measured or Estimated Winds 50+ mph
- Wind Damage (downed trees/tree limbs, power lines, cars, etc.)
- Tornadoes/Waterspouts
- Funnel Clouds
- Significant Flooding (roads impassable/closed, water into homes/businesses, etc.)
- Hail (of any size)…report largest size!

How to Report

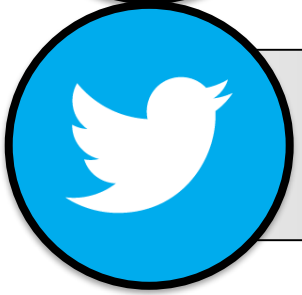
Web:
http://weather.gov/AKQ

Phone (unlisted):
(757) 899-2415

E-mail:
AKQ-Report@noaa.gov



Facebook:
NWSWakefieldVA



Twitter:
@NWSWakefieldVA

Send us a Report Online: https://www.weather.gov/akq/reportWX

www.weather.gov/AKQ/SKYWARN

- Register as a spotter to enter our database
- Receive your spotter certificate
- May infrequently be contacted for severe weather reports

SKYWARN

UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NATIONAL WEATHER SERVICE

This certifies that **Your Name** having fulfilled the requirements

of the Basic SKYWARN Observation Course on 7/27/2022, is hereby awarded this

Certificate of Completion

and is recognized as an Official

Skywarn Trained Observer

Jeff Orrock
Meteorologist-in-Charge
National Weather Service
Wakefield, VA

Eric Seymour
Meteorologist
National Weather Service
Wakefield, VA