National Weather Service

Basic Storm Spotter Training

Gerald Satterwhite, Meteorologist
NWS Birmingham, AL

The National Weather Service (NWS)

- **Mission:** *Provide weather, water and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy.*
- Federal agency with 122 local NWS offices that serve the U.S. and its territories
- 9 national centers that cover everything from hurricanes to space weather to climate to modeling, plus regional centers that assist with hydrology and local NWS office support

weather.gov

NWS Birmingham, AL (BMX)

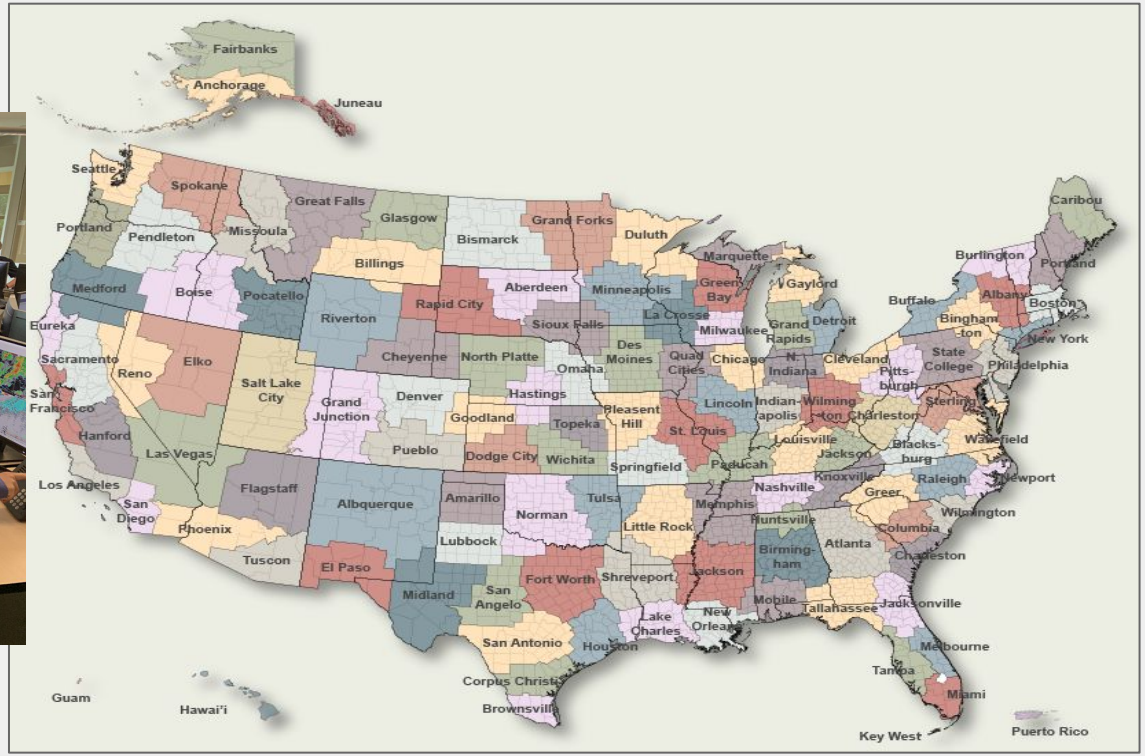
- Team of meteorologists, electronic and computer/IT technicians
- 7-day forecasts (general and hazardous)
- Aviation, hydrology, and fire forecasts
- Monitor ongoing weather
- Decision support for core partners
- Launch weather balloons x2 daily
- Survey storm damage
- GIS services
- Climate records and observations
- Outreach events
- Backup duties for Huntsville, Peachtree City, and Little Rock

NWS Birmingham, AL (BMX)

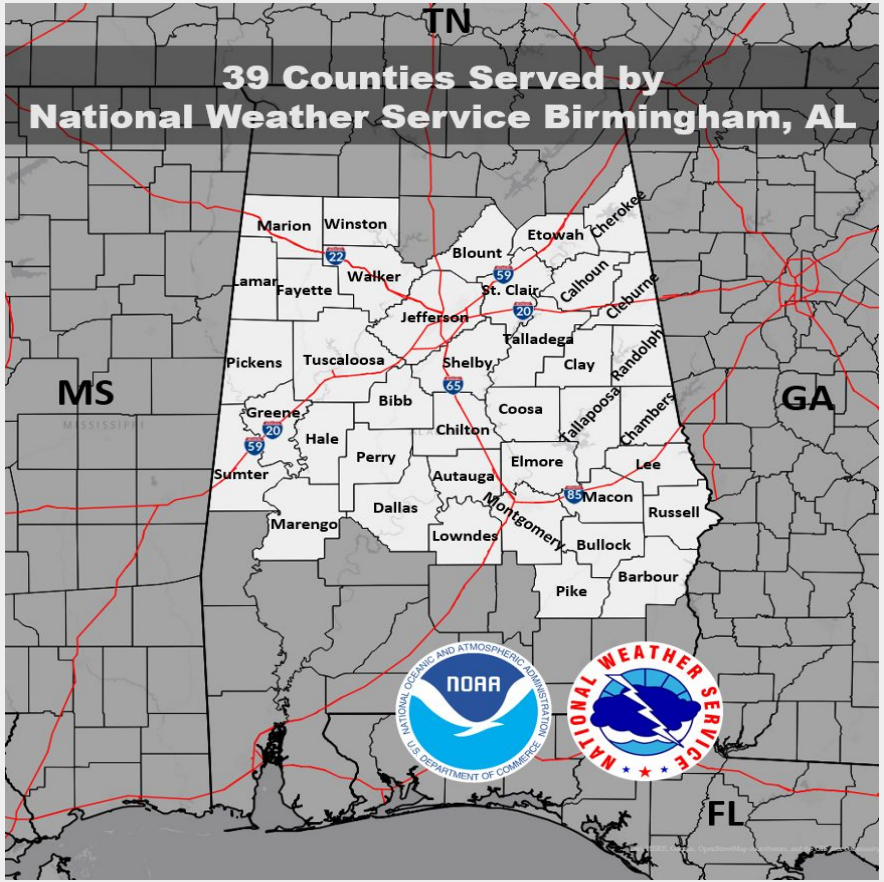
- 4 electronic and computer technicians
- 1 hydrologist
- 1 observations meteorologist
- 16 meteorologists/forecasters
- 3 managers (also meteorologists)
  - 1 Meteorologist in Charge
  - 1 Warning Coordination Meteorologist
  - 1 Science and Operations Officer
- 1 administrative

We're in-service 24/7/365

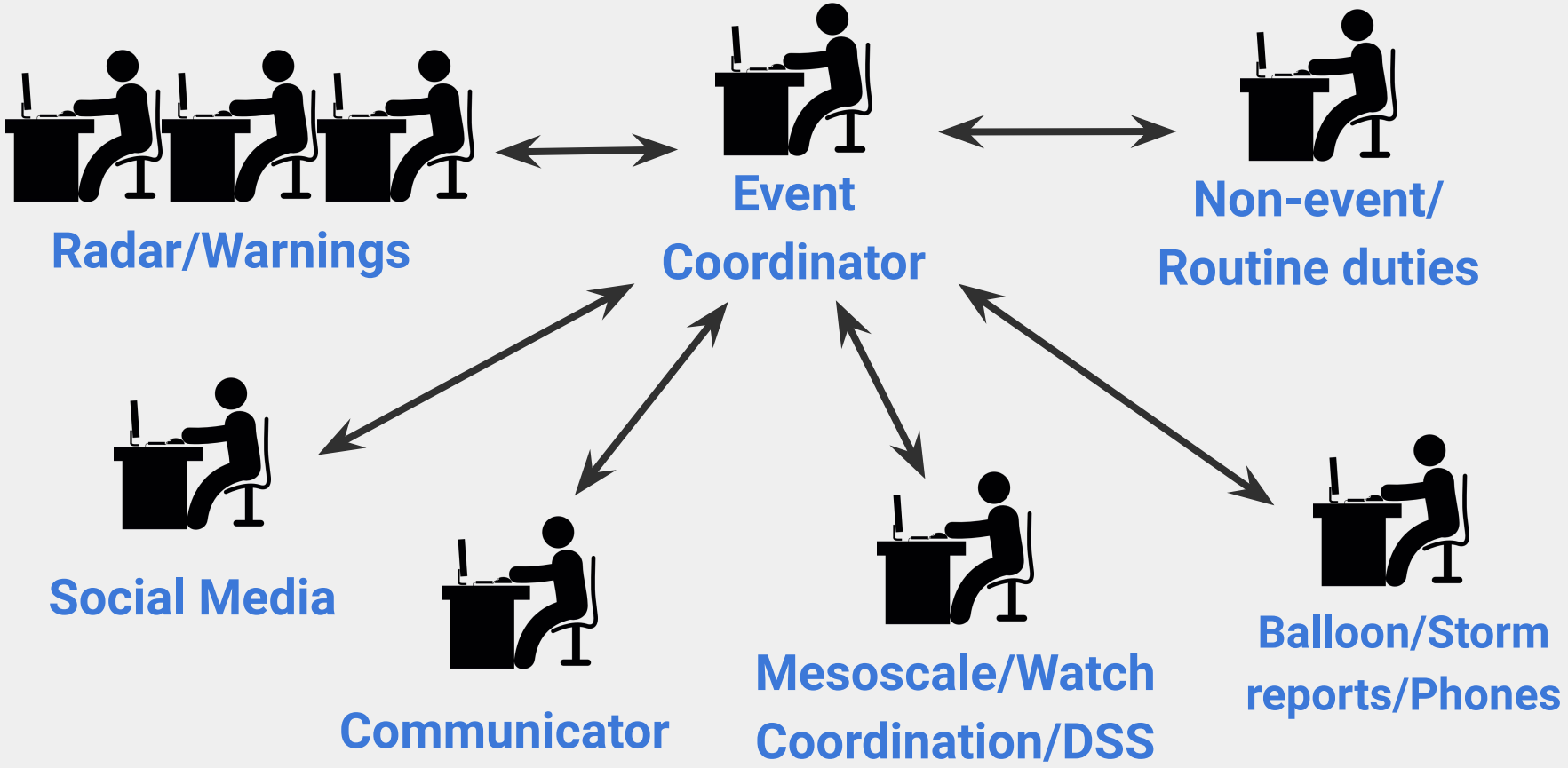
NWS Service Areas



NWS Birmingham Covers Central Alabama

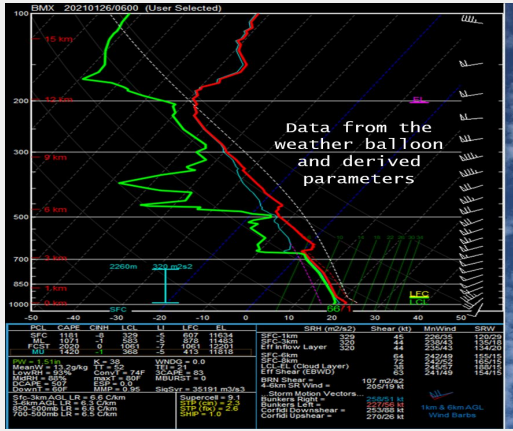


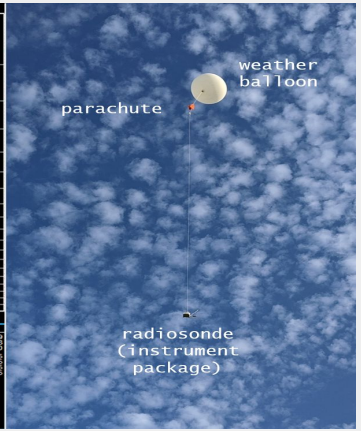
NWS Birmingham Severe Weather Operations

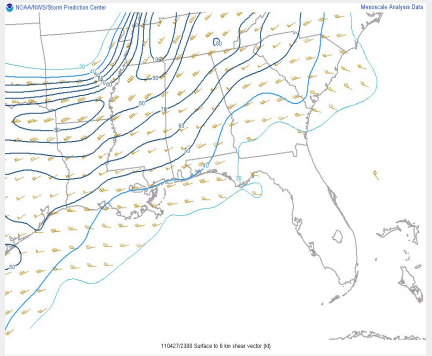


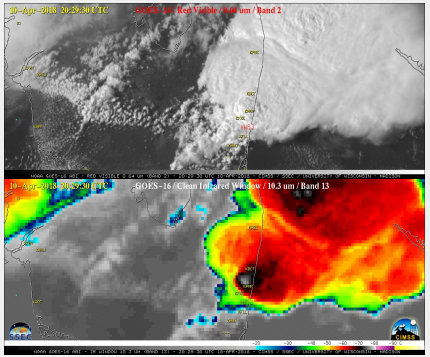
Key Tools During Severe Weather

- Weather balloon data
- Regional surface and upper-air data (mesoanalysis)
- Local weather stations
- Satellite data
- Knowledge of past events
- Short-term, high-resolution weather models
- NWS chat
- County EMAs and State EMA (Emergency Management Agency)

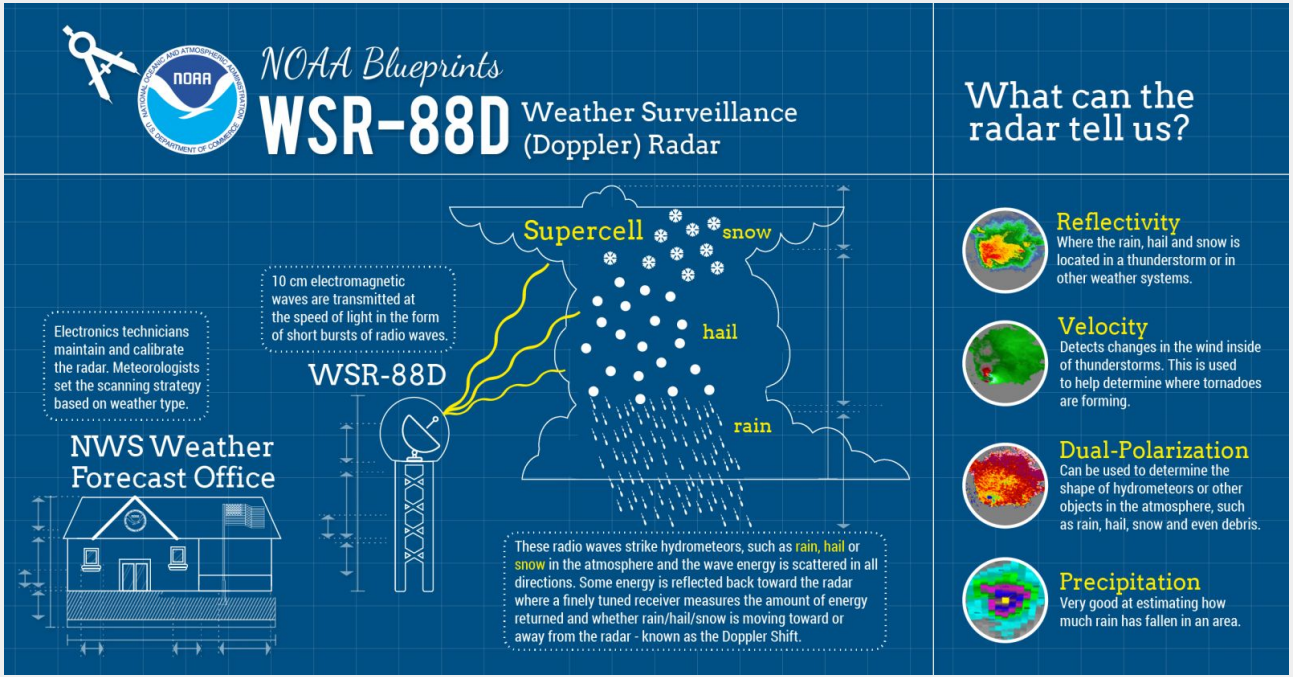




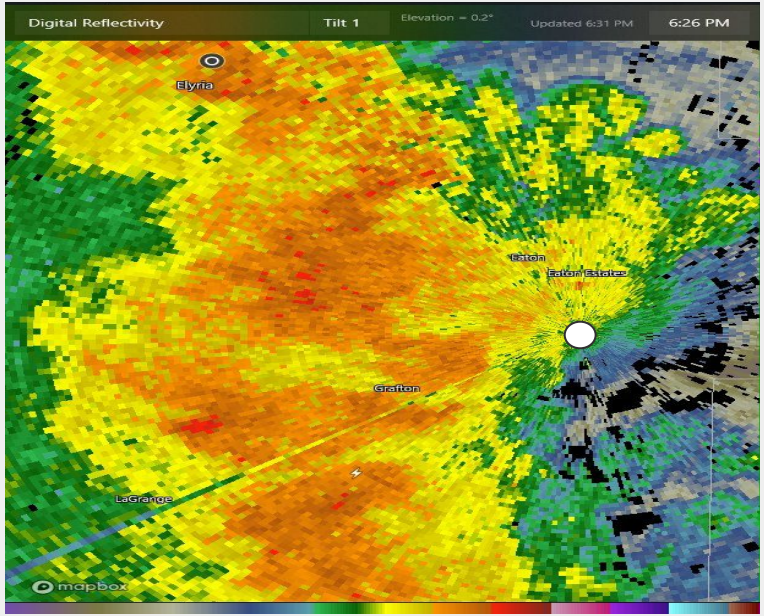




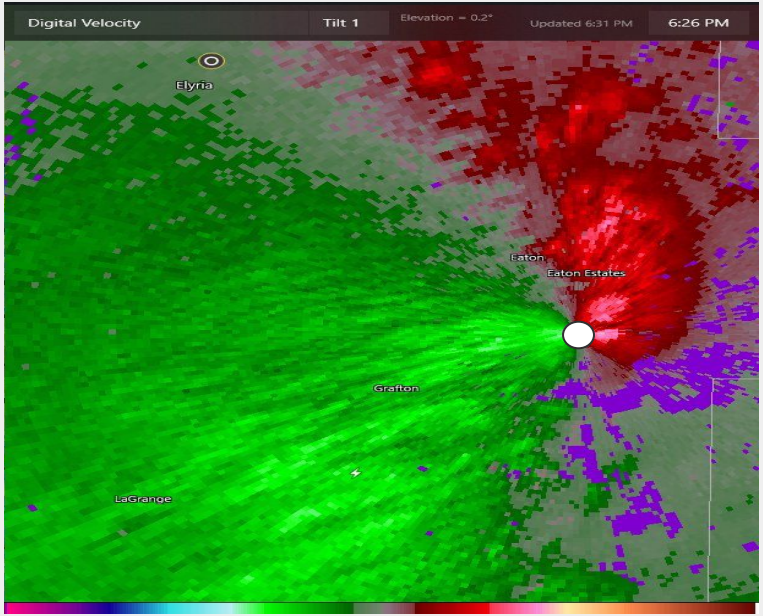
#1 Tool: Doppler Radar WSR-88D



Keep This in Mind for Later…



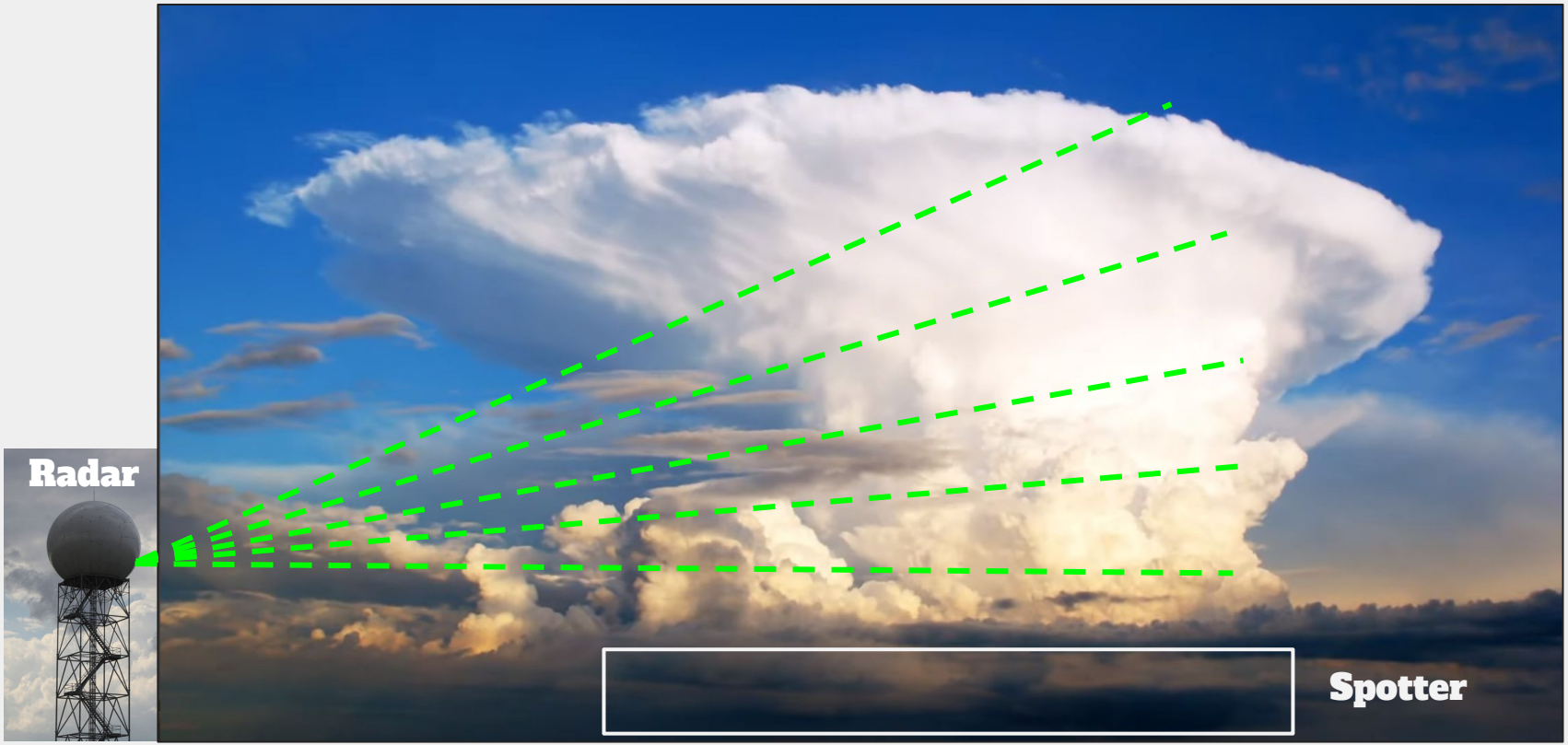
Increasing Intensity of Precipitation



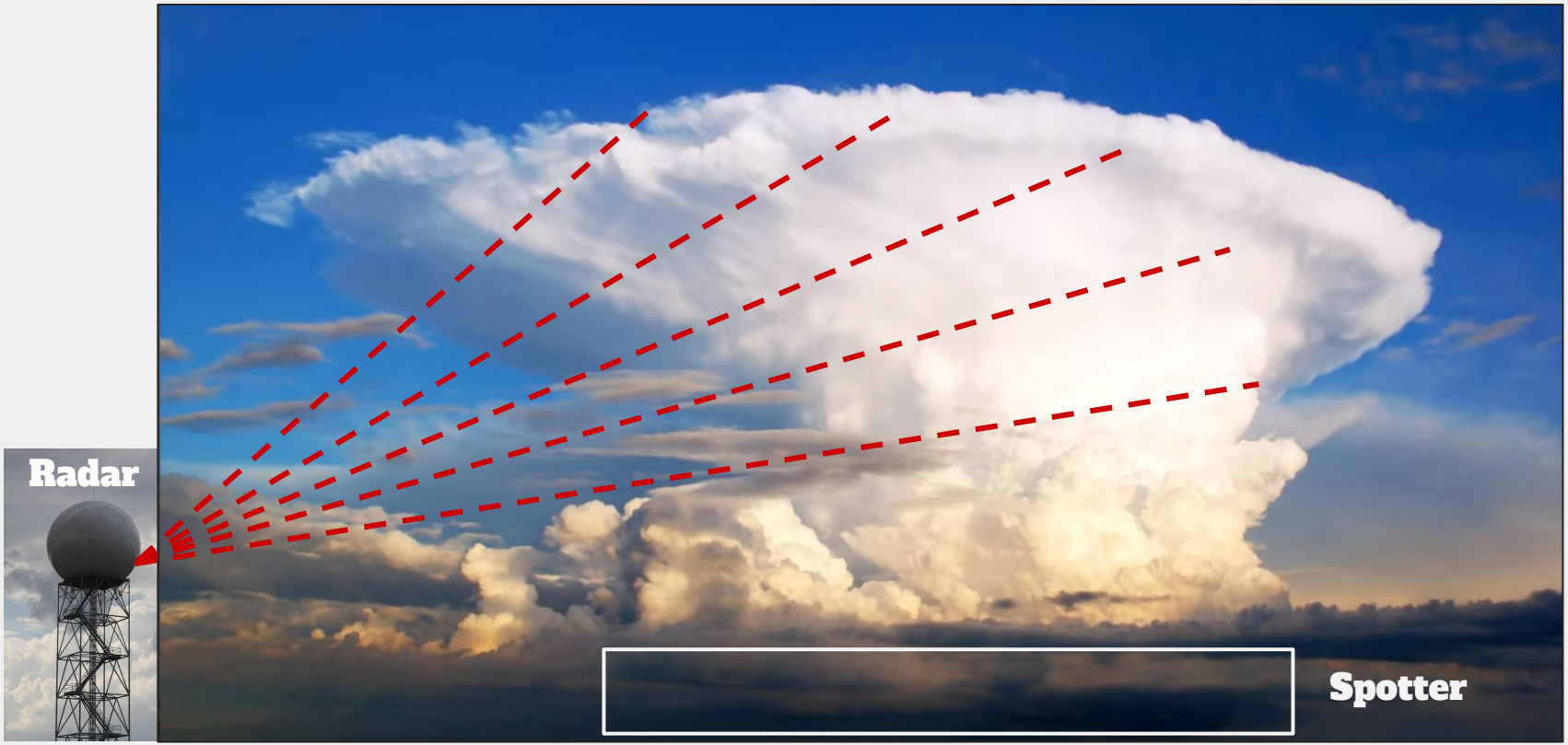
Increasing Intensity of Winds Toward Radar (green)

Increasing Intensity of Winds Away from Radar (red)

Radar Doesn't See Everything! [storm close to radar]



Radar Doesn't See Everything! [storm far from radar]



How Do Storm Spotters Assist the NWS?

- Storm spotters **supplement** almost endless data sources available to NWS meteorologists
  - The data doesn't always show exactly what's going on or how bad
- Storm spotters provide real-time **ground truth** reports that aid in assessing a storm and help guide warning decisions

⚠ Severe Thunderstorm Criteria ⚠

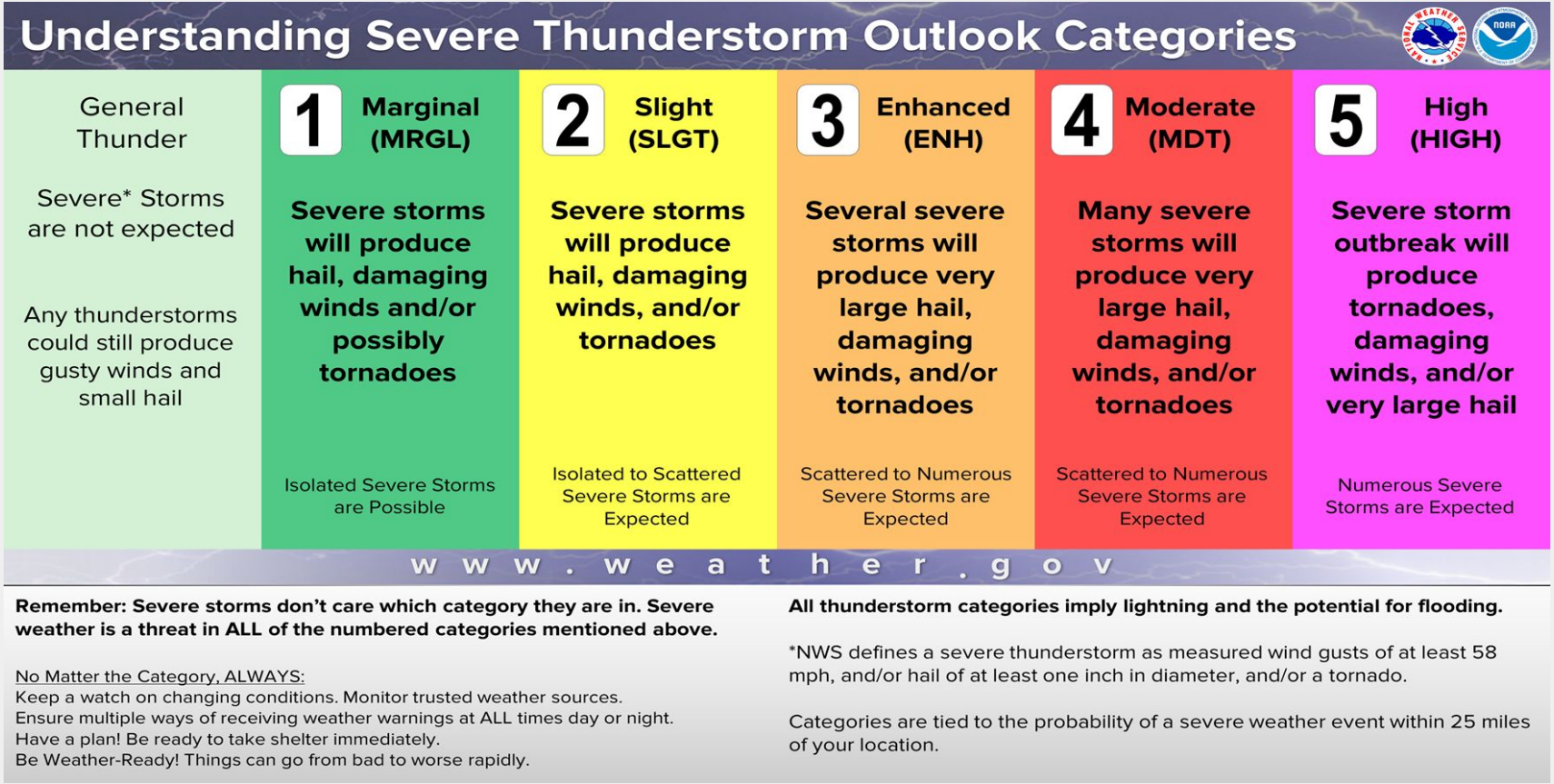
Any combination of:

- Winds of 58 mph or greater
- Hail 1” or larger in diameter
- A tornado

Other hazards:

- Lightning
- Flooding

What do the Five Risk Levels Mean?



Remember: Severe storms don't care which category they are in. Severe weather is a threat in ALL of the numbered categories mentioned above.

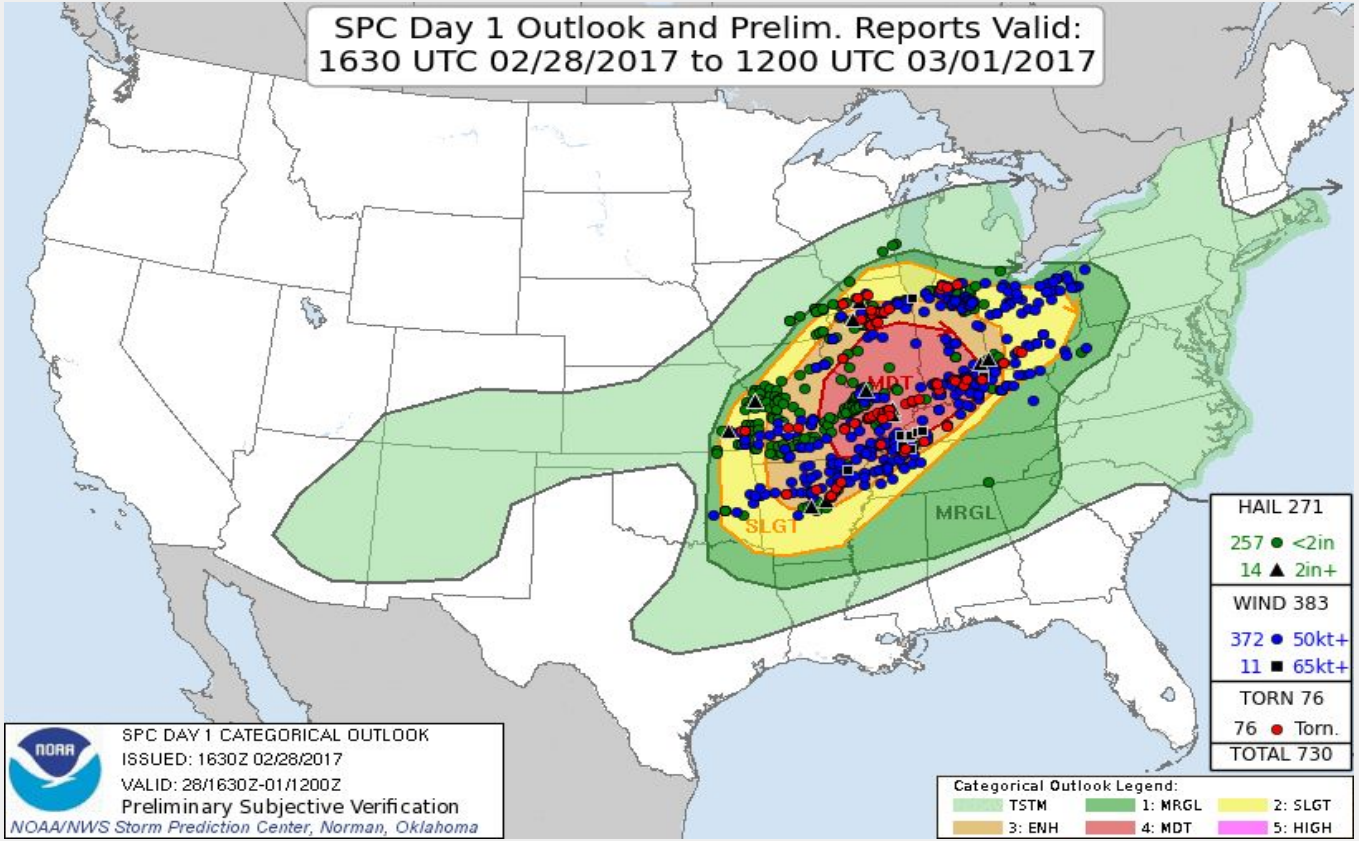
No Matter the Category, ALWAYS:
Keep a watch on changing conditions. Monitor trusted weather sources.
Ensure multiple ways of receiving weather warnings at ALL times day or night.
Have a plan! Be ready to take shelter immediately.
Be Weather-Ready! Things can go from bad to worse rapidly.

All thunderstorm categories imply lightning and the potential for flooding.

*NWS defines a severe thunderstorm as measured wind gusts of at least 58 mph, and/or hail of at least one inch in diameter, and/or a tornado.

Categories are tied to the probability of a severe weather event within 25 miles of your location.

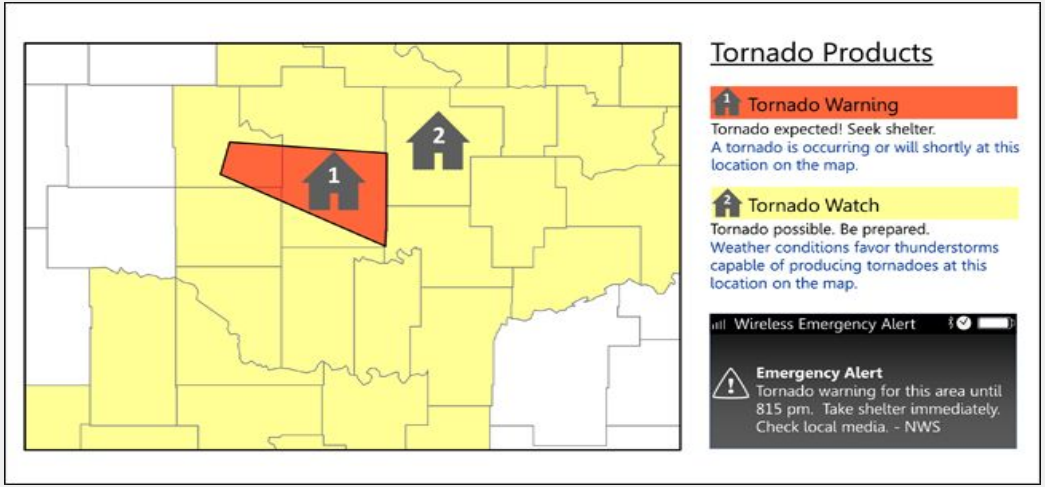
Severe Storms Can Happen with ANY Risk Level



Watch vs. Warning

Watch: Conditions are favorable for the development of severe storms over the next several hours. *Know where to shelter and stay up-to-date!*

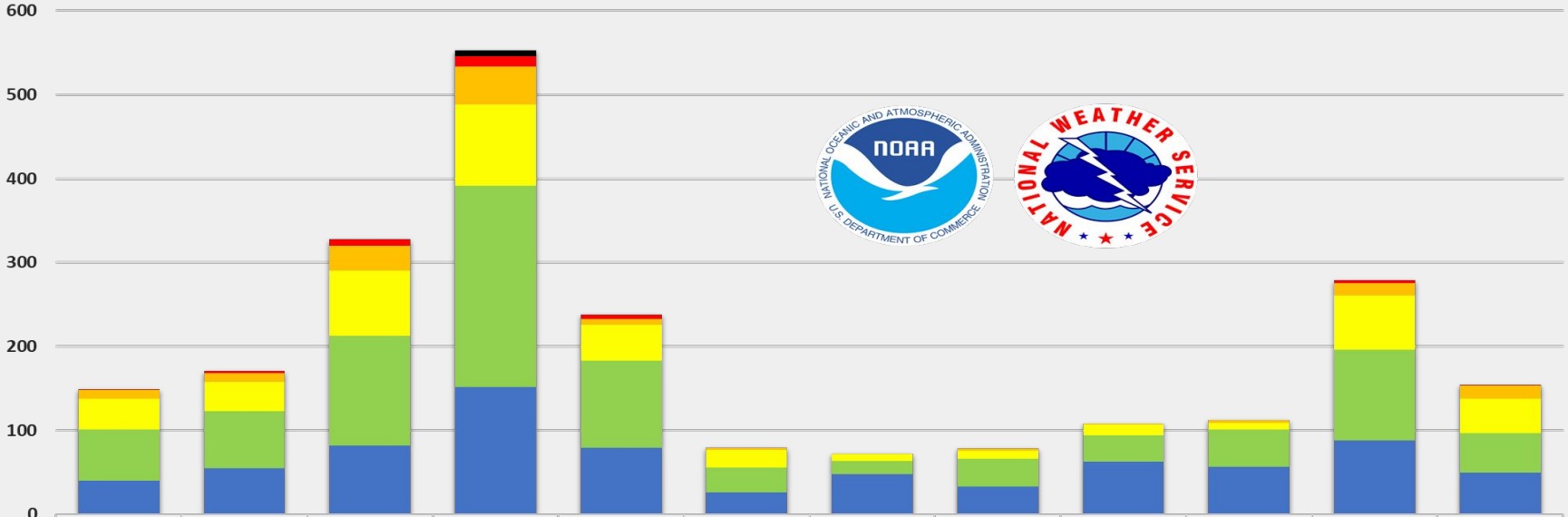
Warning: Severe weather is likely very soon or has been reported with a storm about to affect your area. *Take shelter!*



An Analogy…

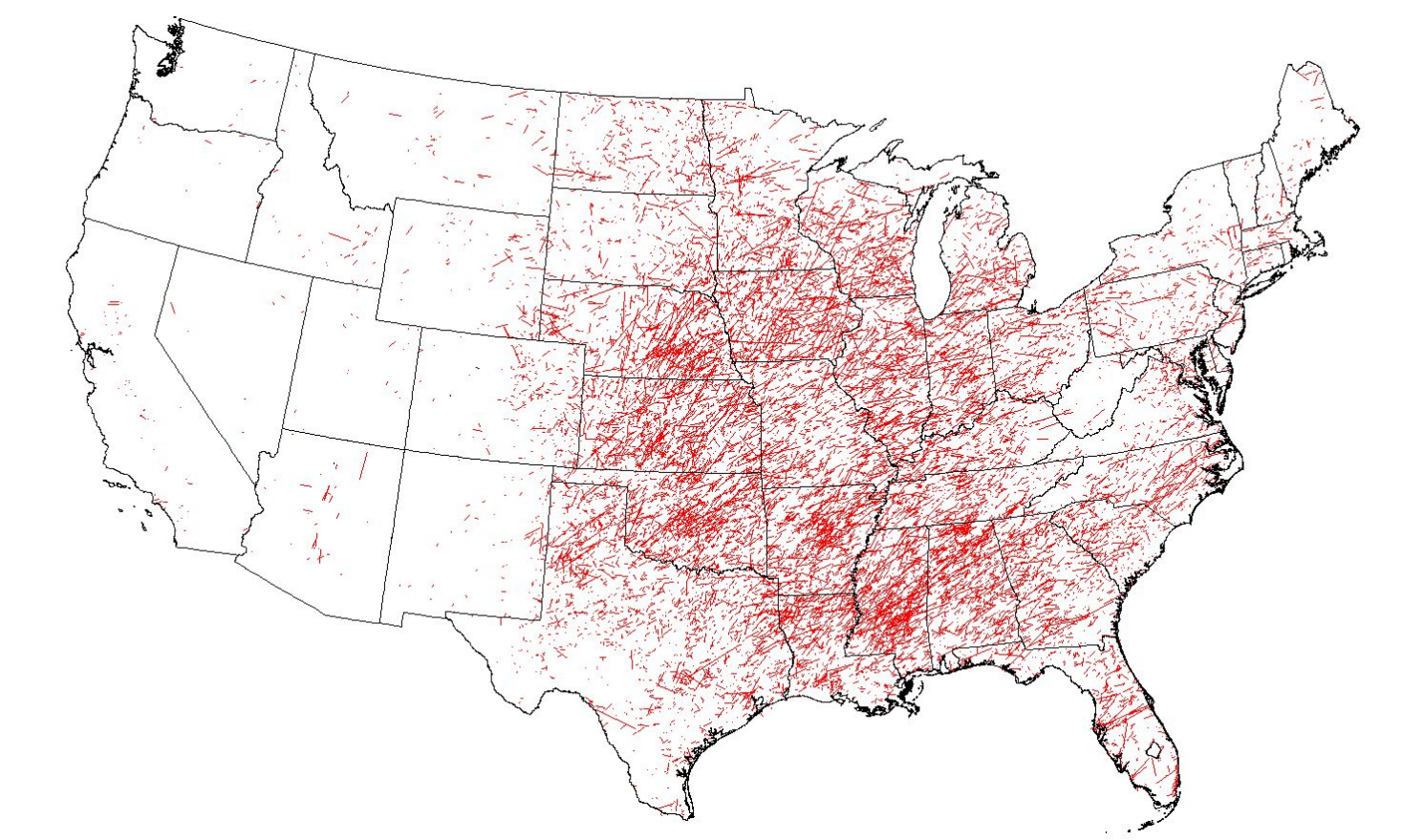

WATCH VS WARNING
TACO WATCH
Watches indicate that conditions are favorable for a taco (tornado) to develop.
TACO WARNING
Warnings indicate that a taco (tornado) has developed and has been spotted in your area.

Alabama Tornado Ratings & Counts by Month
Years 1950-2021



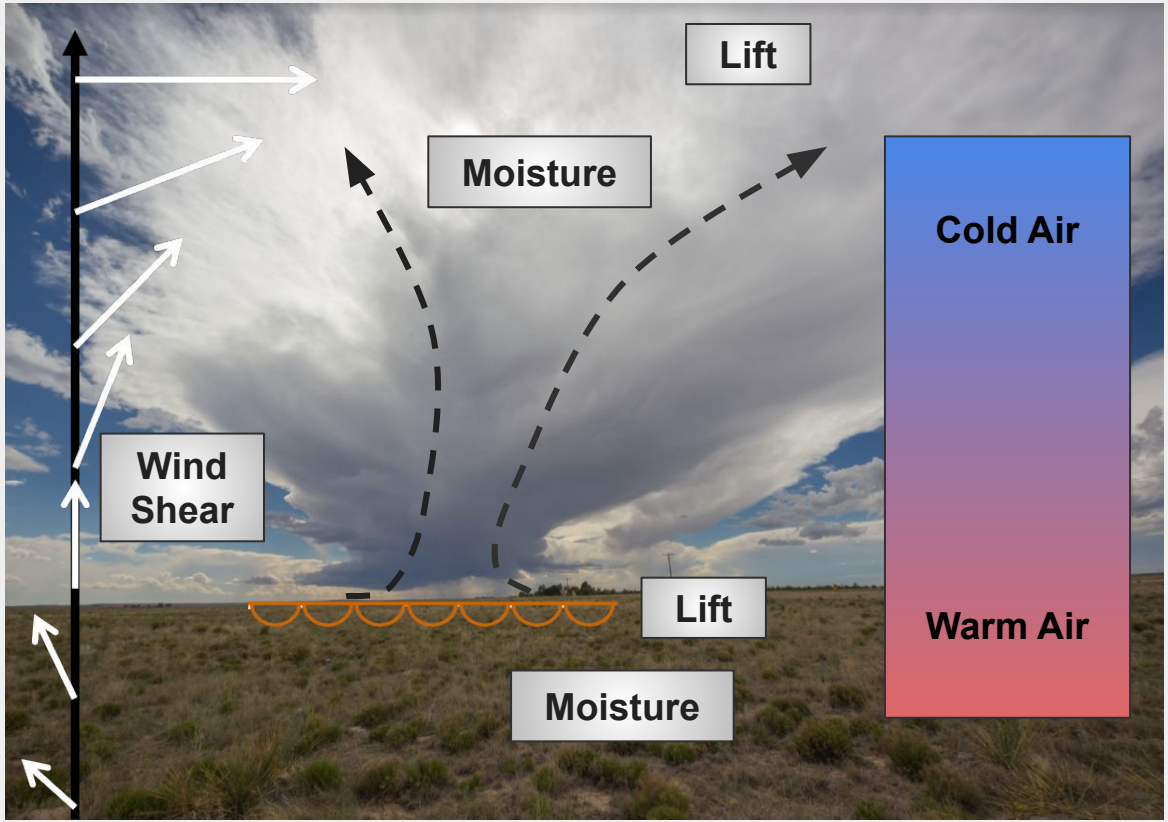
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
EF5	0	0	0	7	0	0	0	0	0	0	0	0
EF4	1	3	8	13	5	0	0	0	0	0	4	1
EF3	10	10	30	45	7	2	0	2	1	3	14	15
EF2	37	35	77	97	43	21	8	10	13	8	65	41
EF1	61	68	131	239	104	30	16	33	31	44	108	47
EF0	40	55	82	152	79	26	48	33	63	57	88	50
Total	149	171	328	553	238	79	72	78	108	112	279	154

CONUS Tornado Tracks 1950-2021 - Tornado Alley?

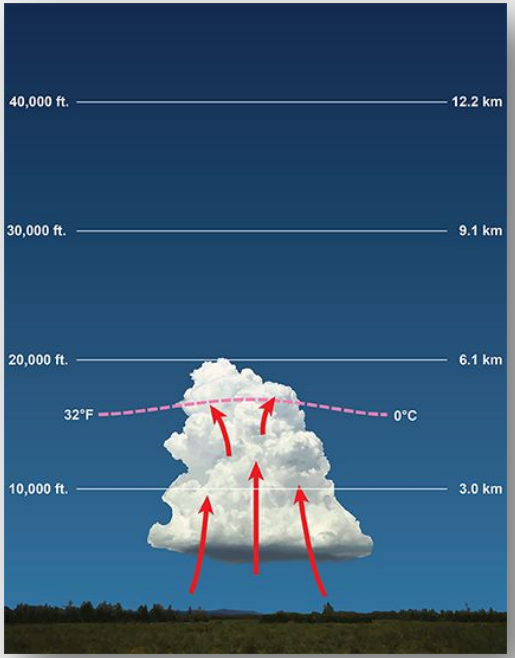


Severe Thunderstorm Ingredients

- **Lift**
  - Front or boundary, terrain flow, surface heating or convergence, upper trough
- **Instability**
  - Warm air at low levels, cold air aloft
- **Moisture**
- **Wind Shear**
  - Change in wind speed and/or direction with height

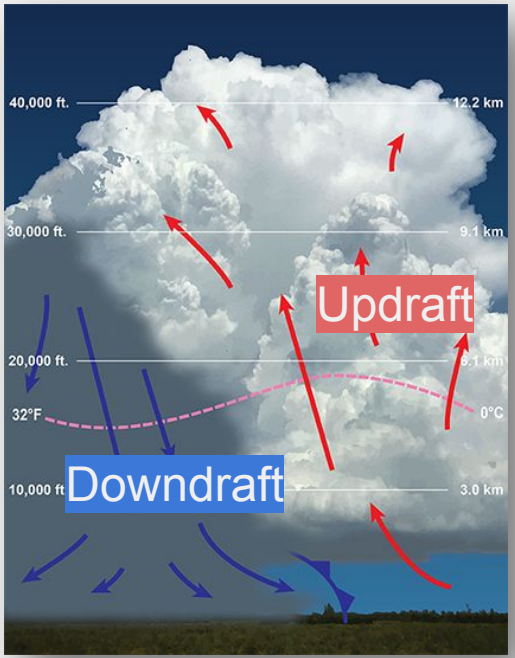


Thunderstorm Stages



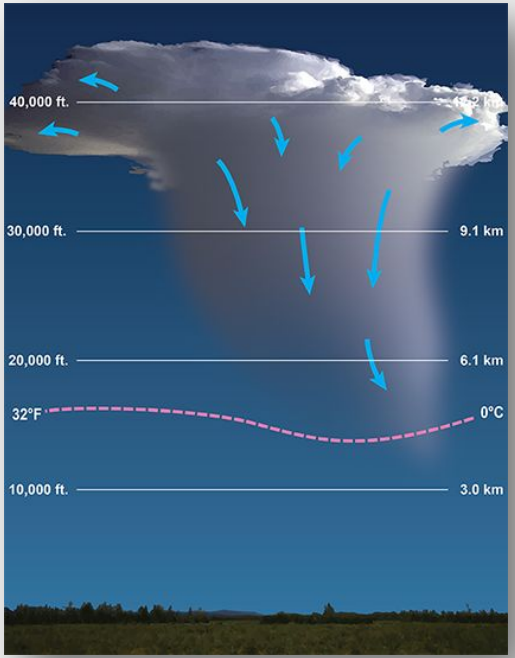
Updraft dominates

Cumulus cloud grows vertically



Updraft and downdraft coexist

Precipitation and hazards

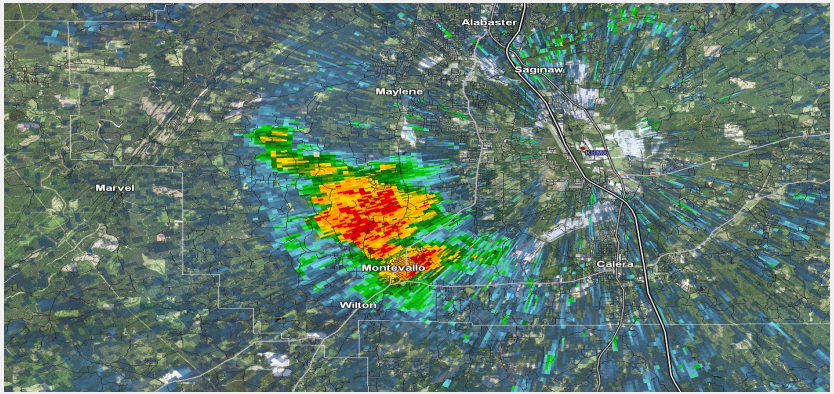


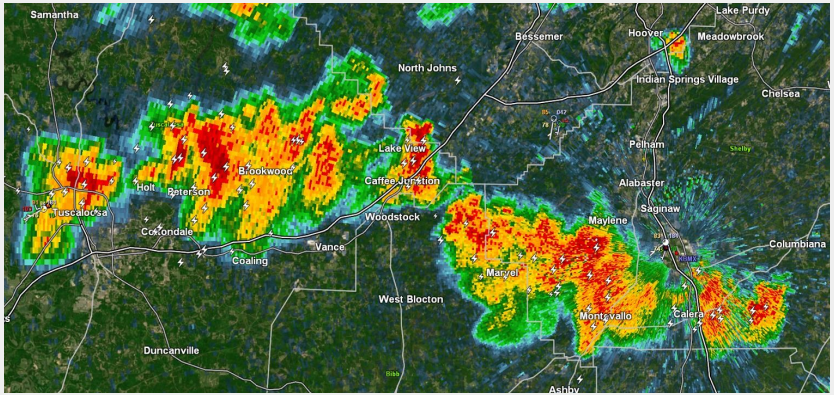
Downdraft dominates

Remnant anvil cloud

Cloud and Storm Progression [GIF]

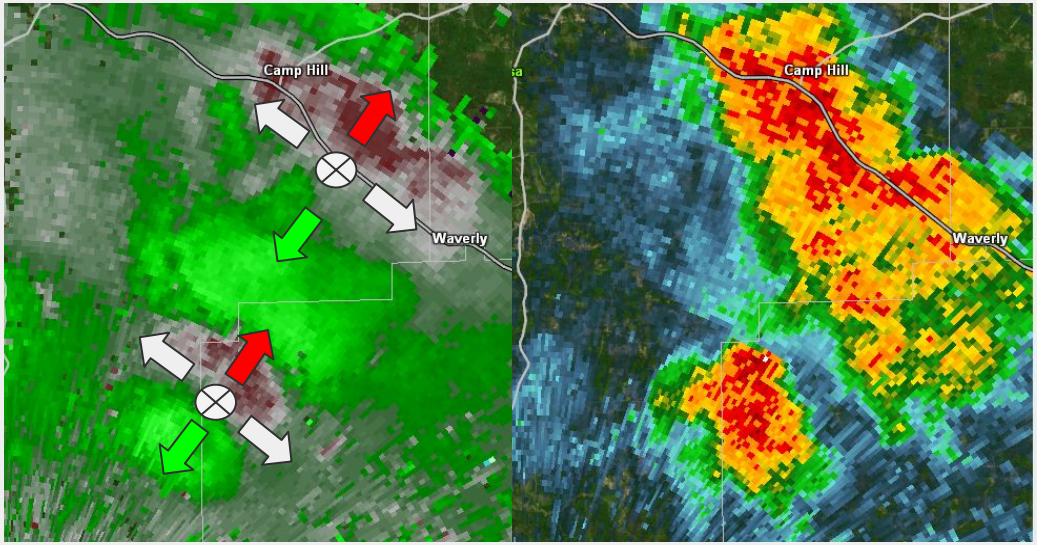
Single Cell vs. Multicell Storms





Summertime Single & Multicell Storms: Downbursts

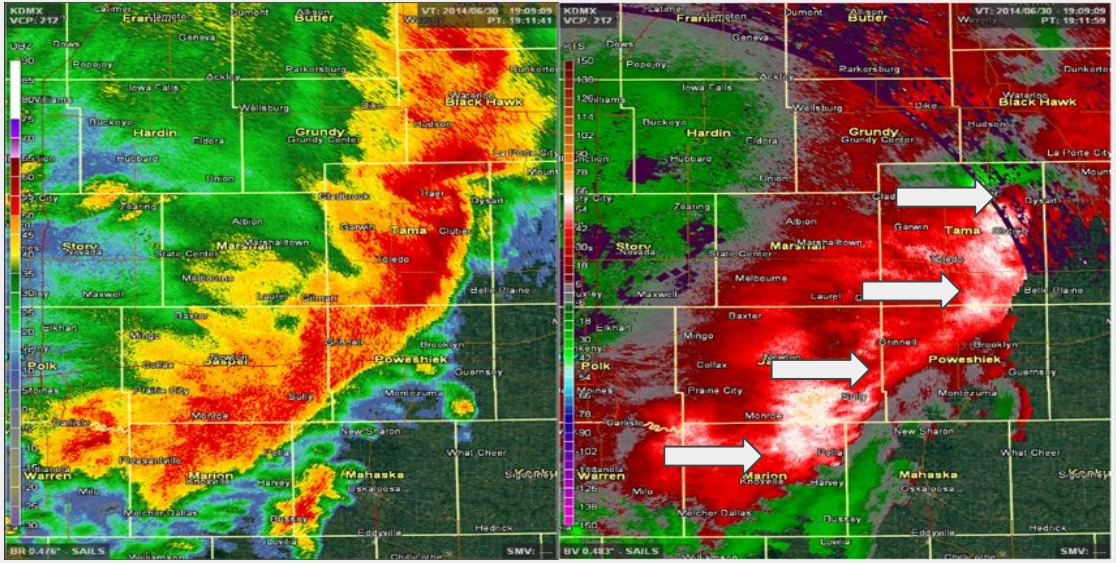
- Downbursts occur when a concentrated area of heavy rain and strong winds descend from a collapsing thunderstorm
- Winds fan outward 360 degrees once hitting the ground and can be damaging (straight-line winds)
- Very common in Alabama during the summer



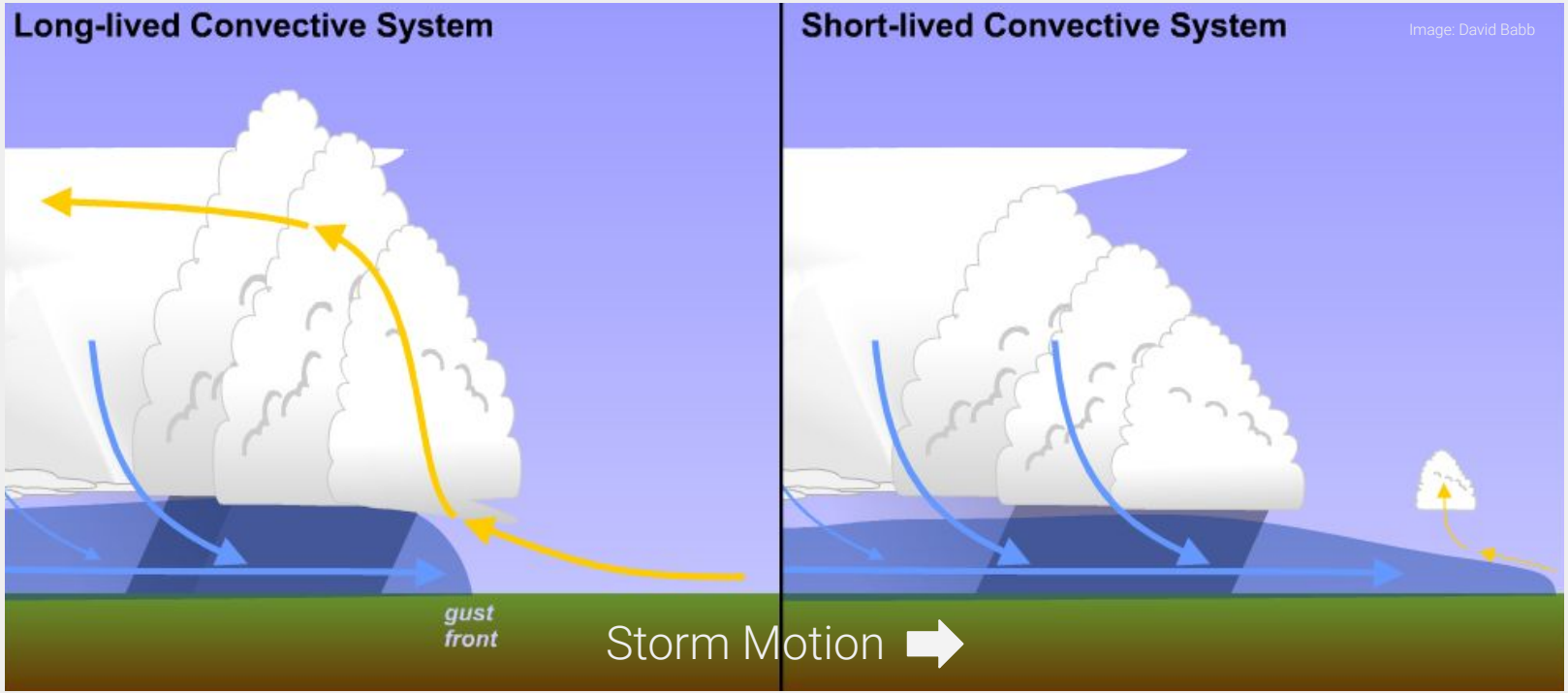
Downburst Timelapse [video]

Squall Line

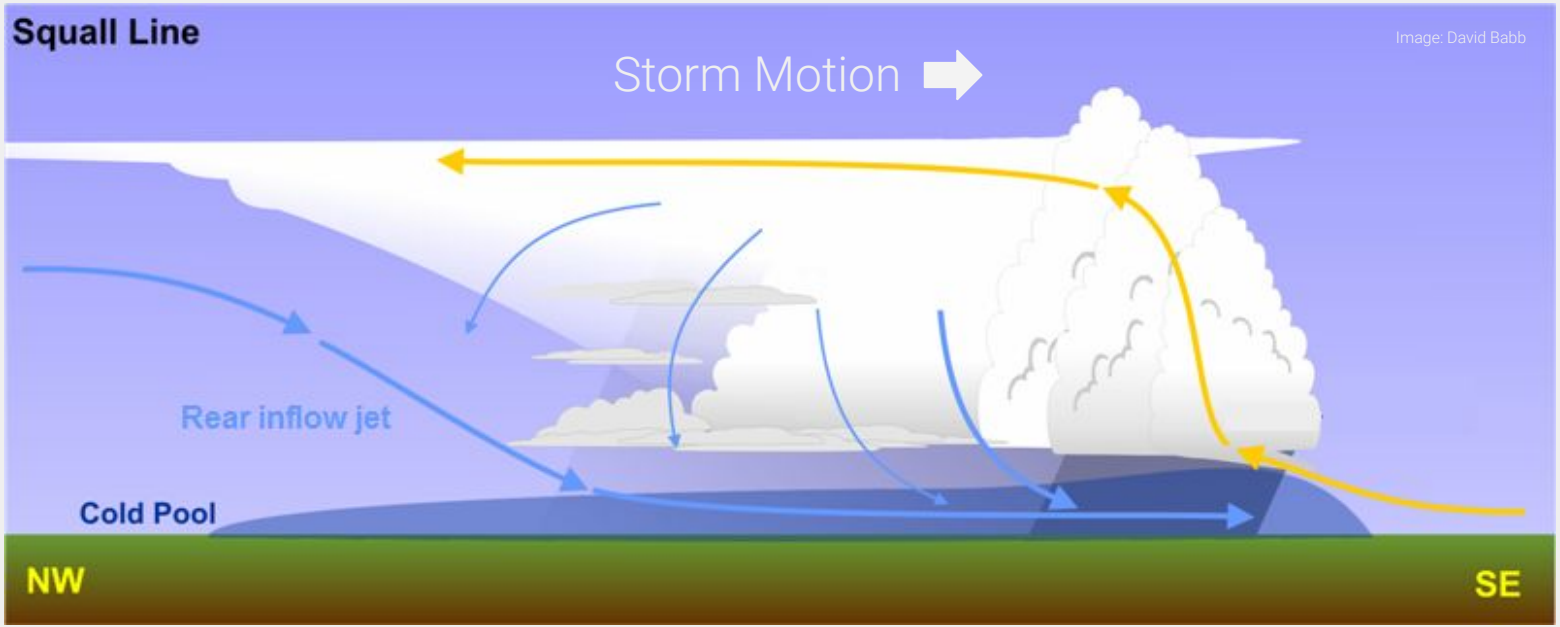
- Produce straight-line winds (winds moving in a single direction)
- Strong winds, sometimes damaging, are focused near the leading edge of the storms or may push ahead of the storms
- Strong winds result from the storm's forward motion and storm-generated outflow



Squall Line Structure

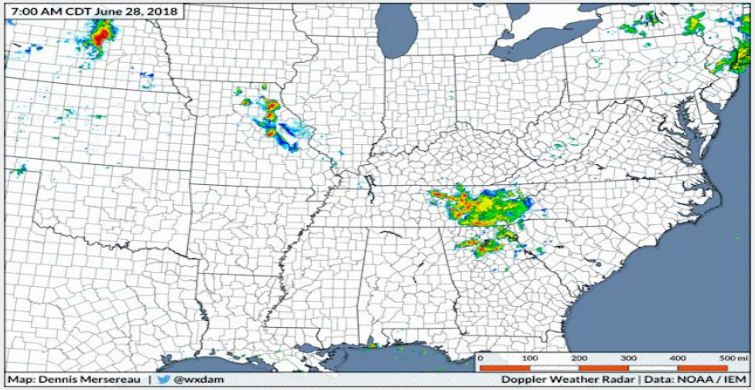


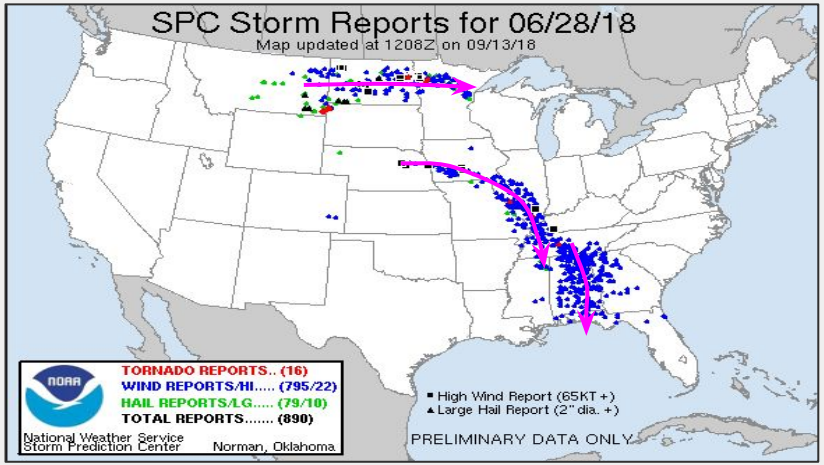
Squall Line Structure



Powerhouse Squall Line: Derecho

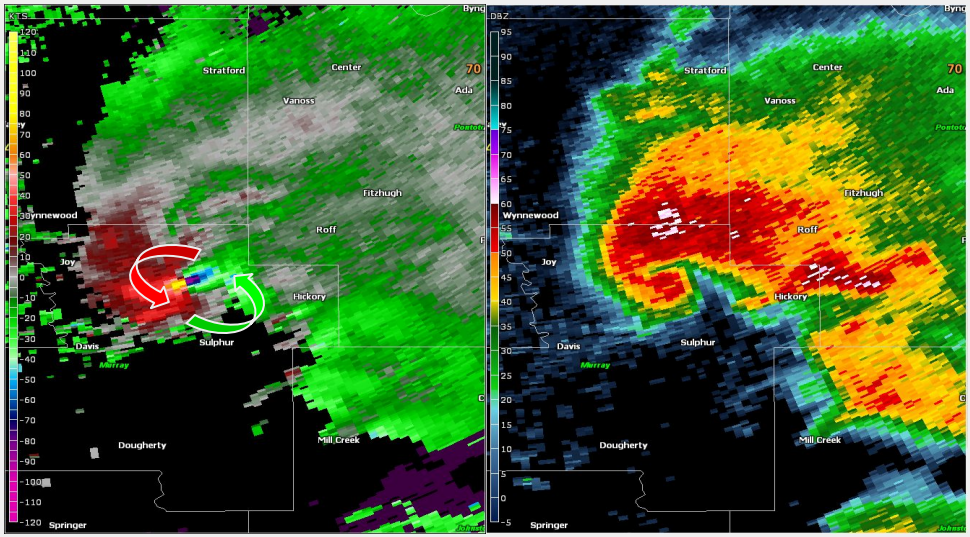
- Occur during the summer
- Produce swaths of damaging to destructive straight-line winds
- Can also produce tornadoes and large hail
- **Criteria:** consistent (time and area) wind damage and/or 58+ mph wind reports over a 250+ mile path
- Most recent Alabama derecho was on June 28, 2018



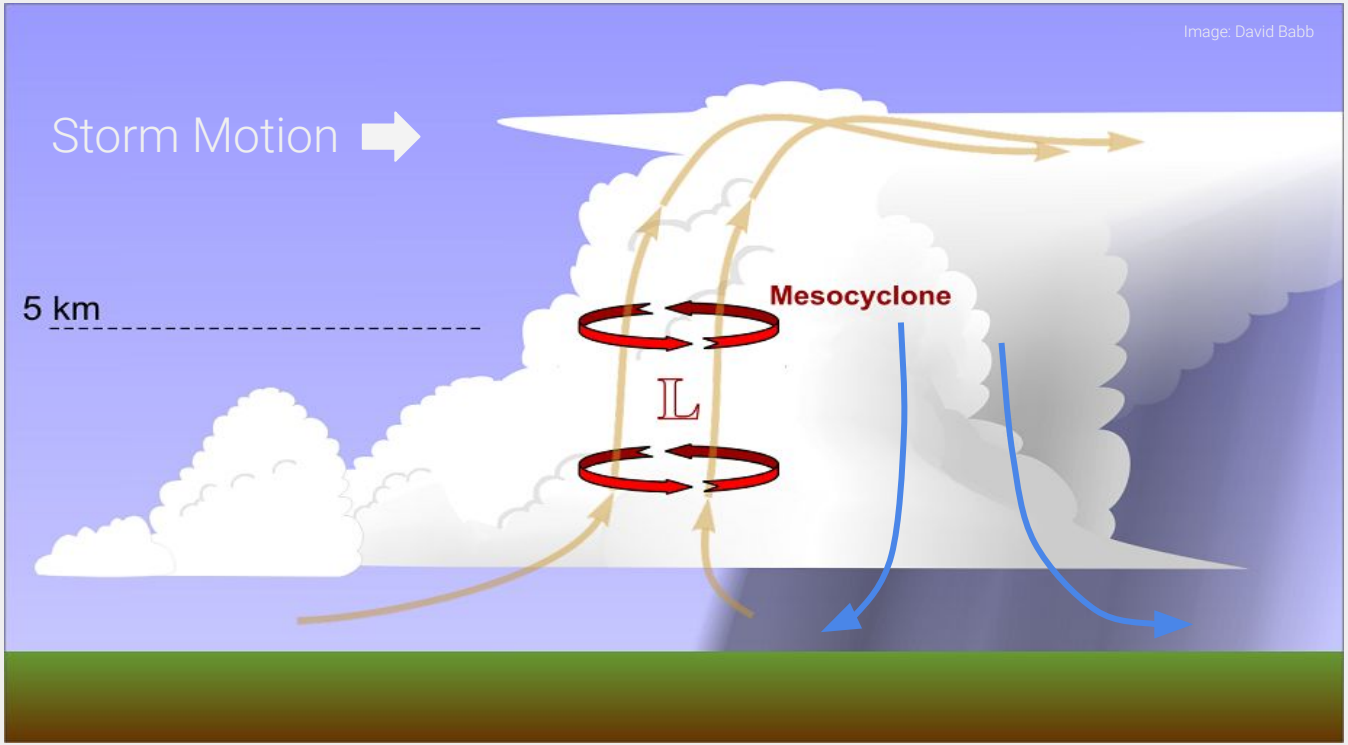


Supercell

- A storm with a **rotating** updraft
- Occur across a broad spectrum of atmospheric setups and storm characteristics
- A single supercell can produce one or more tornadoes
  - Short lived to long track
  - Weak to violent
  - Yards to over a mile wide
- Small to giant hail



Supercell Structure



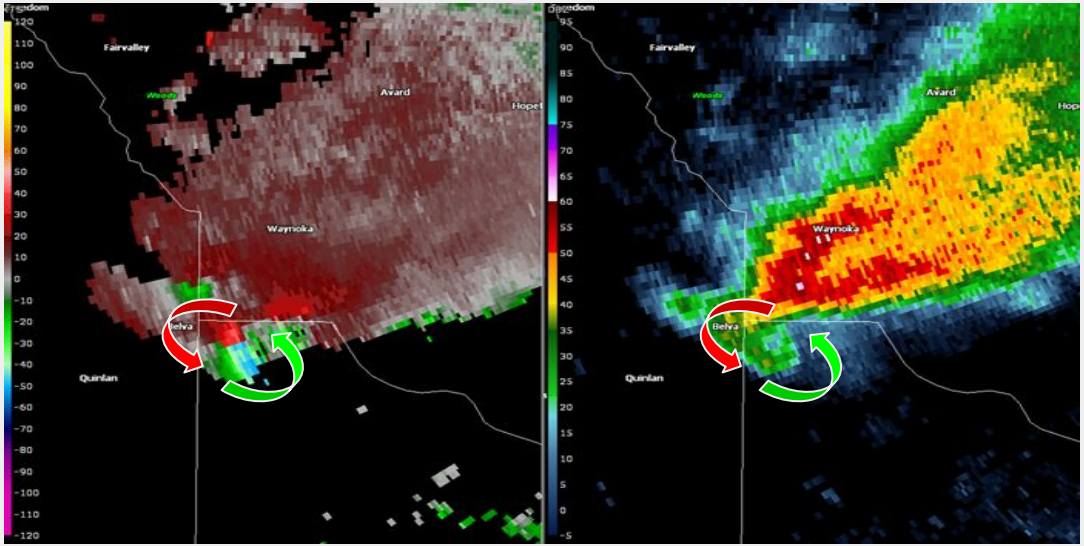
Mesocyclone is the name for a rotating updraft

Supercell Thunderstorm Engine

Supercomputer animation courtesy Dr. Leigh Orf. UW-Madison

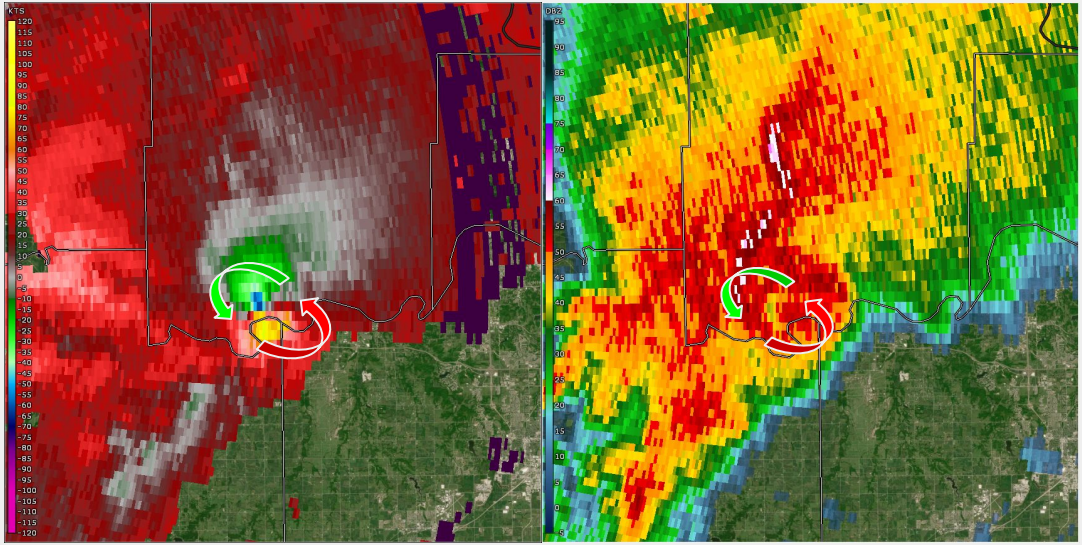
Low-precipitation Supercell

- Low moisture content environment
- Highly visible and sculpted updraft and tornado if occurring
- Hook echo may be faint or not visible on radar
- Rare in Alabama



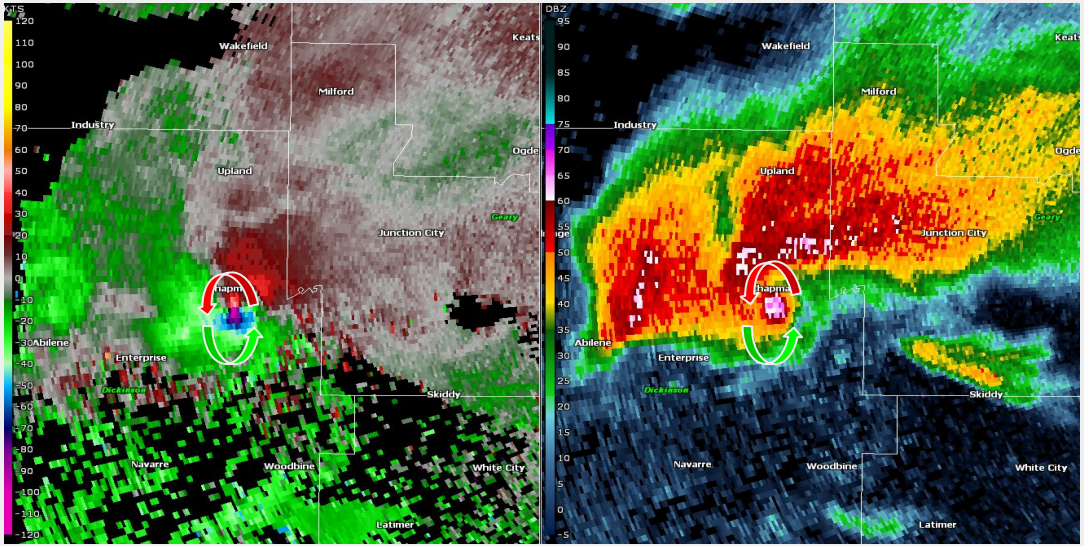
High-precipitation Supercell

- High moisture content environment
- Difficult-to-see or fully obscured tornado if occurring (rain-wrapped)
- Hook echo is usually hard to discern unless viewing velocity
- Common in Alabama



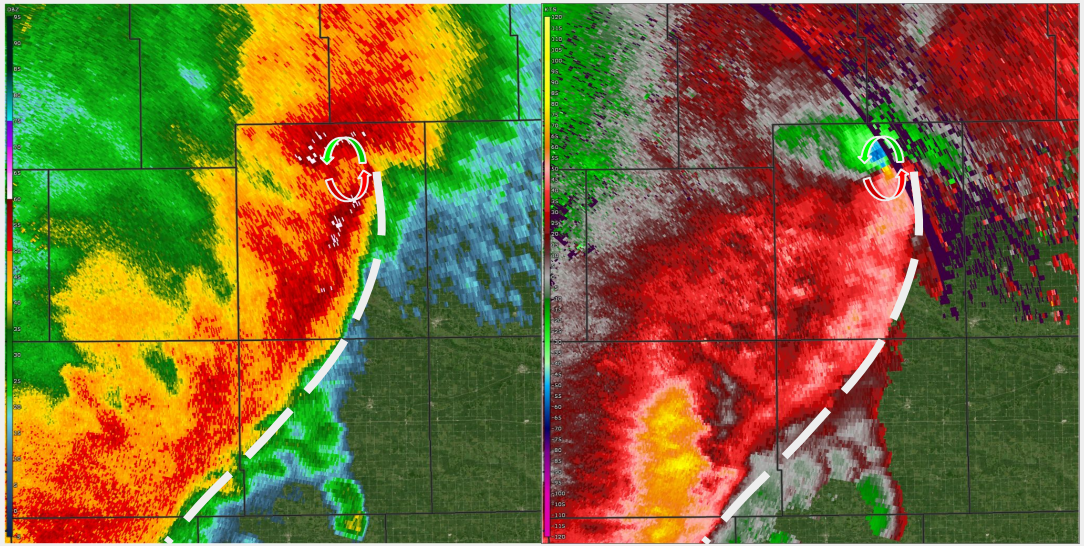
Classic Supercell

- Easy-to-see or fairly visible updraft and tornado if occurring
  - Rain and hail can eventually obscure; transition from classic to HP
- Prominent hook echo on radar
- Observed in Alabama



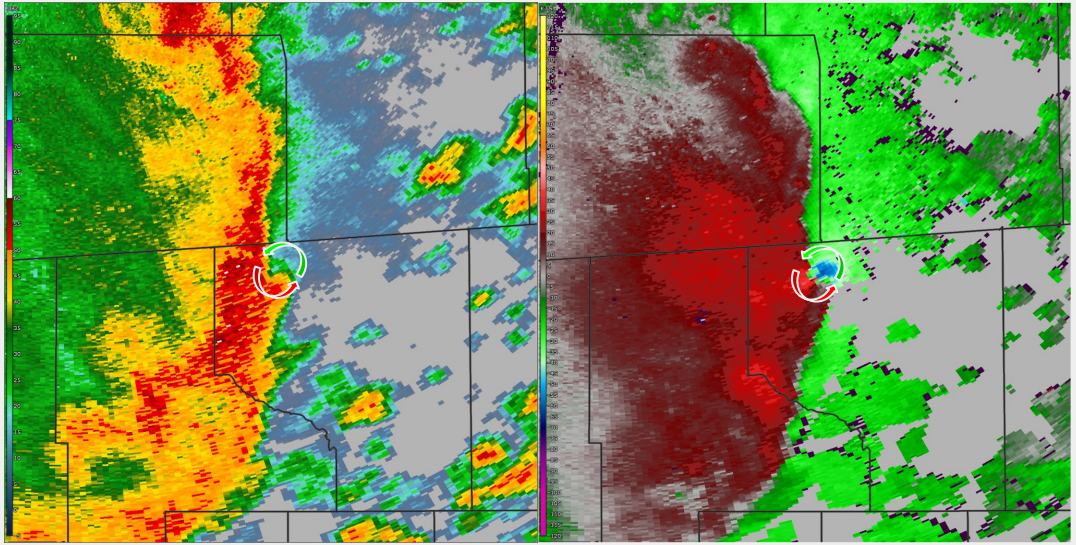
Line w/ Line-embedded Supercell

- Distinct supercell storm within a larger line of storms
- Supercell either forms along the line or merges after initially being ahead of the line
- Difficult-to-see or fully obscured tornado if occurring (rain-wrapped)
- Observed in Alabama



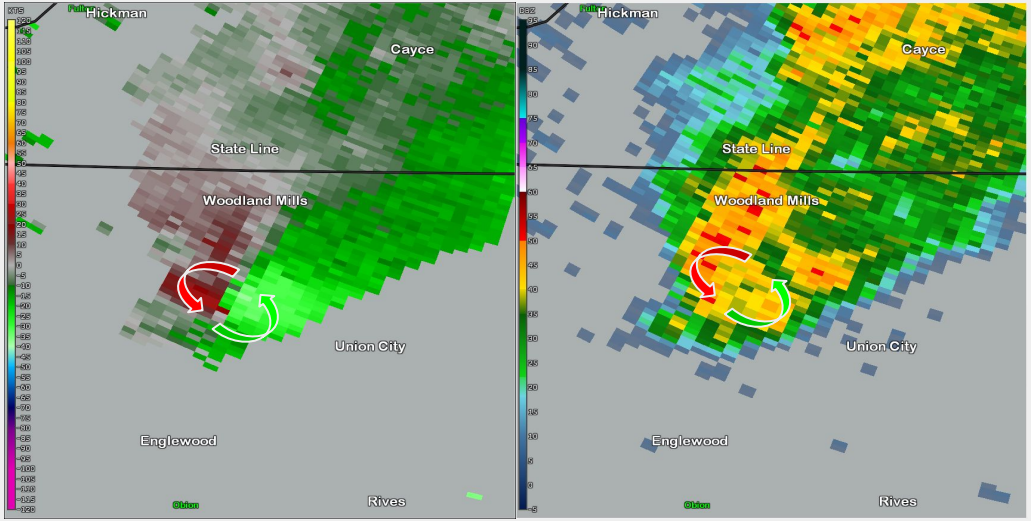
Line w/ Front Edge Knob Supercell

- Forms at kinks/notches along a line of storms
  - Look for surges of inbound and outbound winds
- Difficult-to-see or fully obscured tornado if occurring (rain-wrapped)
- Observed in Alabama

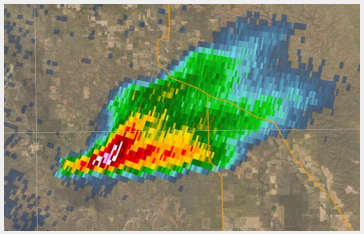


Mini/Low-topped Supercell

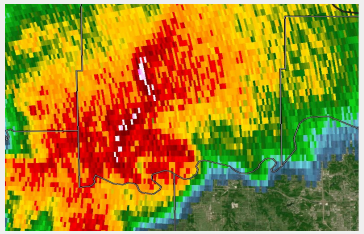
- Smaller and not-as-tall type of supercell
- High wind shear, low instability environment
- Very limited lightning or none at all
- Observed in Alabama



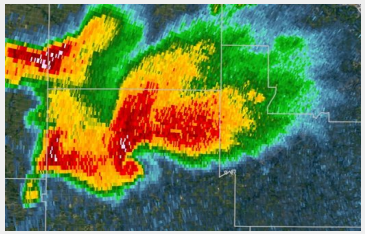
Side-by-Side Comparison [radar]



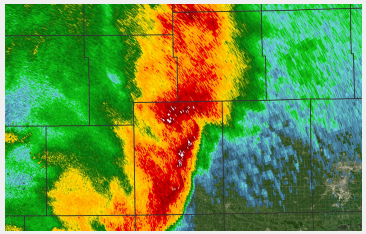
LP Supercell



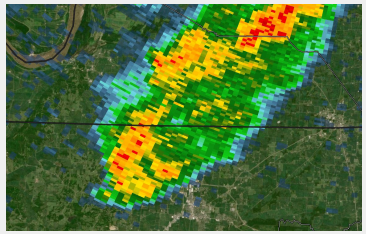
HP Supercell



Classic Supercell



Line-embedded Supercell



Mini/low-topped Supercell

In many cases, velocity data is needed to assess whether a storm is a supercell. Location of the rotating updraft/mesocyclone favors the southwest part of the storm.

Side-by-Side Comparison [updraft & tornado visual]

LP Supercell

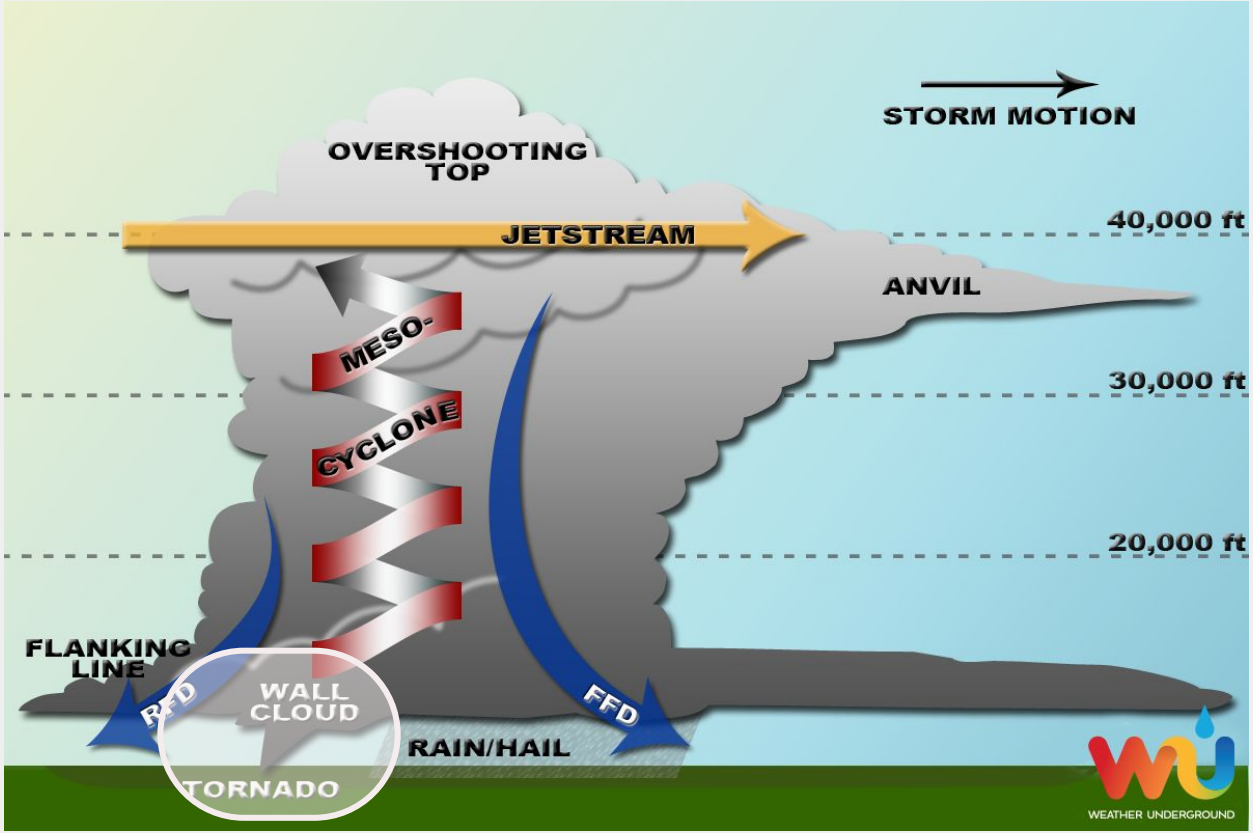
HP Supercell

Classic Supercell

Let’s Look at Low Level Storm Structure on the Warm Side

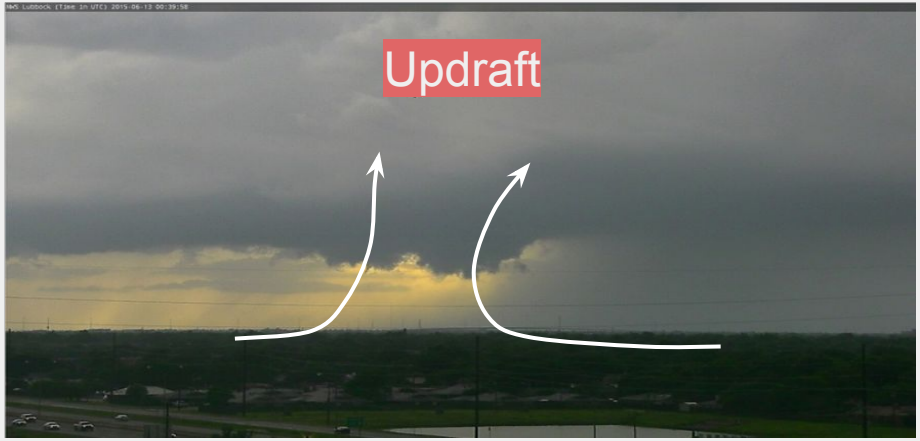
Key features coming up:

- Wall cloud
- Funnel cloud
- Tornado
- Scud cloud



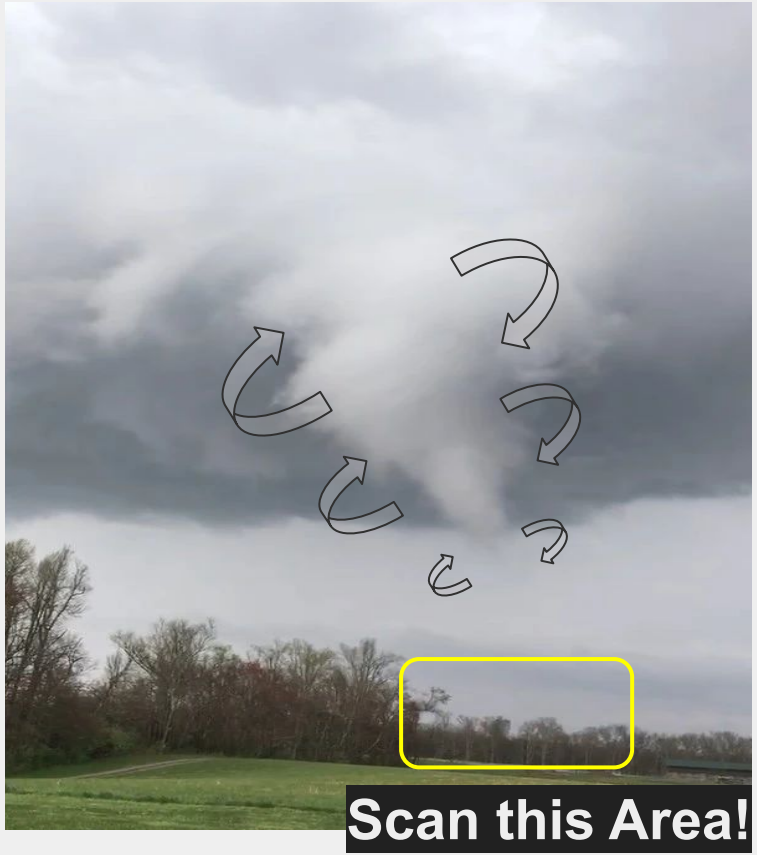
Wall Cloud

- An attached, persistent, and blocky lowering, indicative of a strong updraft overhead
- Some wall clouds may exhibit rotation and upward motion
- The presence of a wall cloud does not guarantee a tornado will happen
- How is it **changing**? Faster and lower to the ground or getting weaker and more broad?



Funnel Cloud

- A rotating funnel extending from the bottom of a storm but **not yet reaching the ground**
- Usually becomes smooth/laminar in appearance
- Indication that conditions are right for the storm to produce a tornado, though a tornado is still not guaranteed
- **Confirm rotation** and **rising motion**
- Scan the ground for signs of debris/contact with the ground

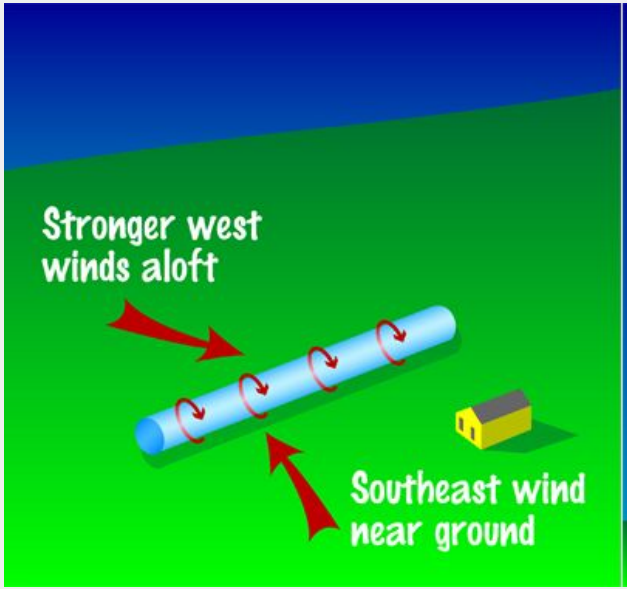


Tornado

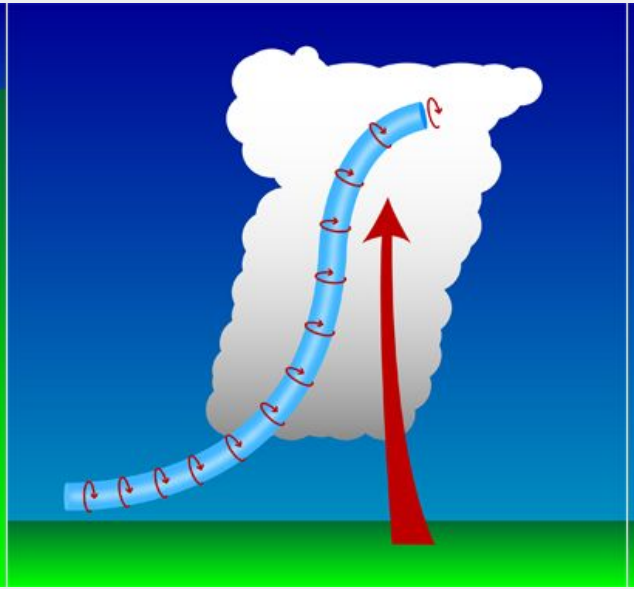
- When the funnel cloud comes **in contact with the ground**
- The tornado may not be fully condensed (the cloud you see); look for debris near the ground
- If you think what you see is a tornado, **confirm** rotation and rising motion

Rotating Wall Cloud > Funnel Cloud > Tornado

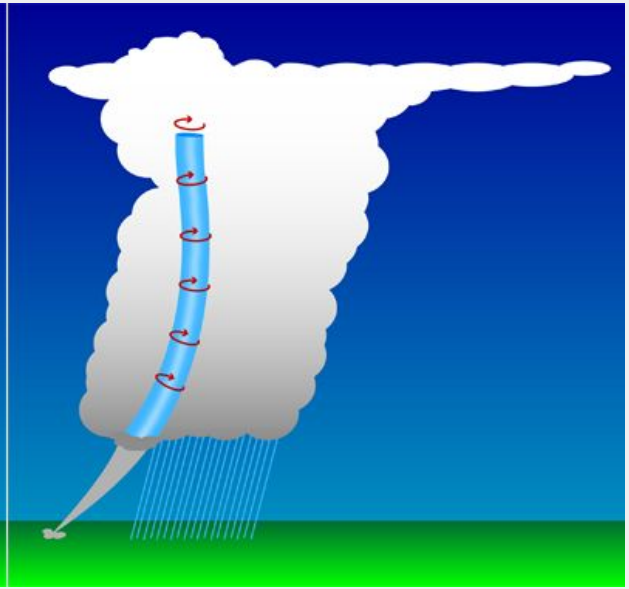
Tornadogenesis is a Delicate Process



Horizontal vortex due to wind shear

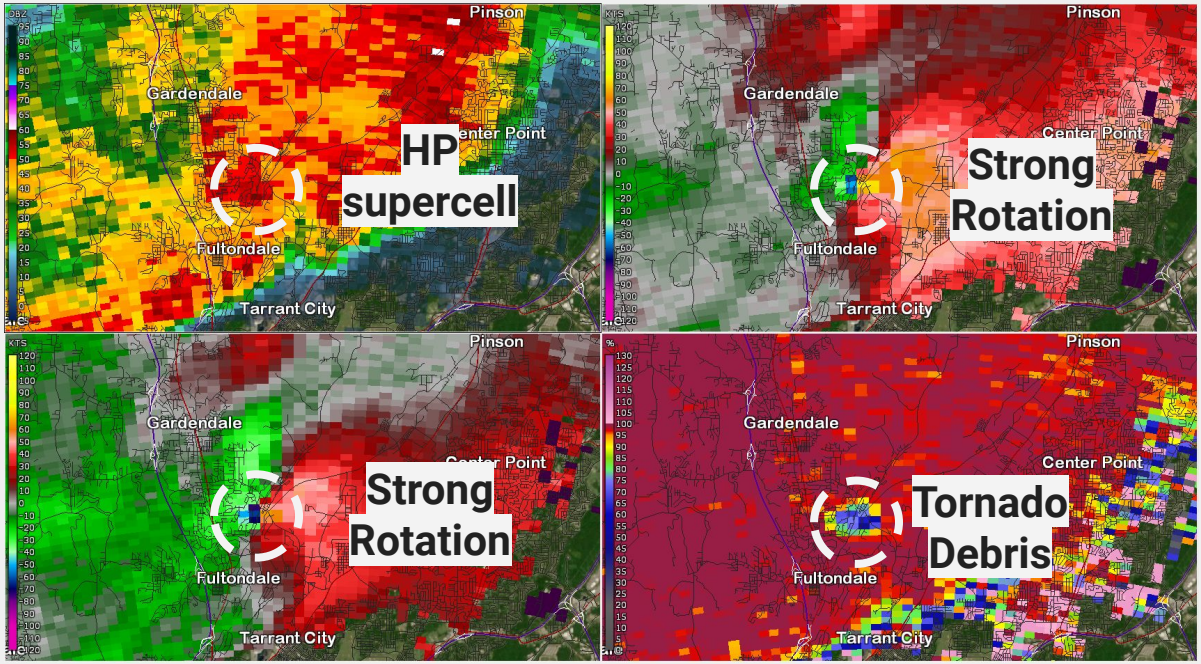


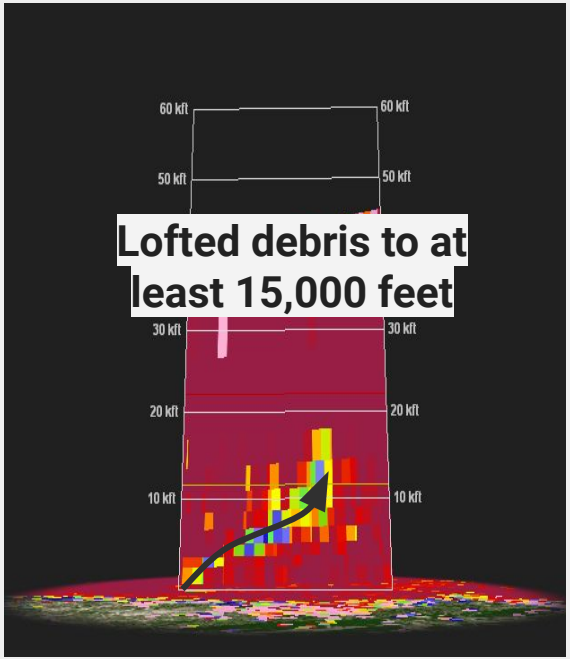
Vortex tilted vertically and stretched by the updraft of a storm



Vortex stretching continues and additional vorticity is ingested near the ground. Several variables must line up for a tornado to form

Radar Analysis of Ongoing Tornado



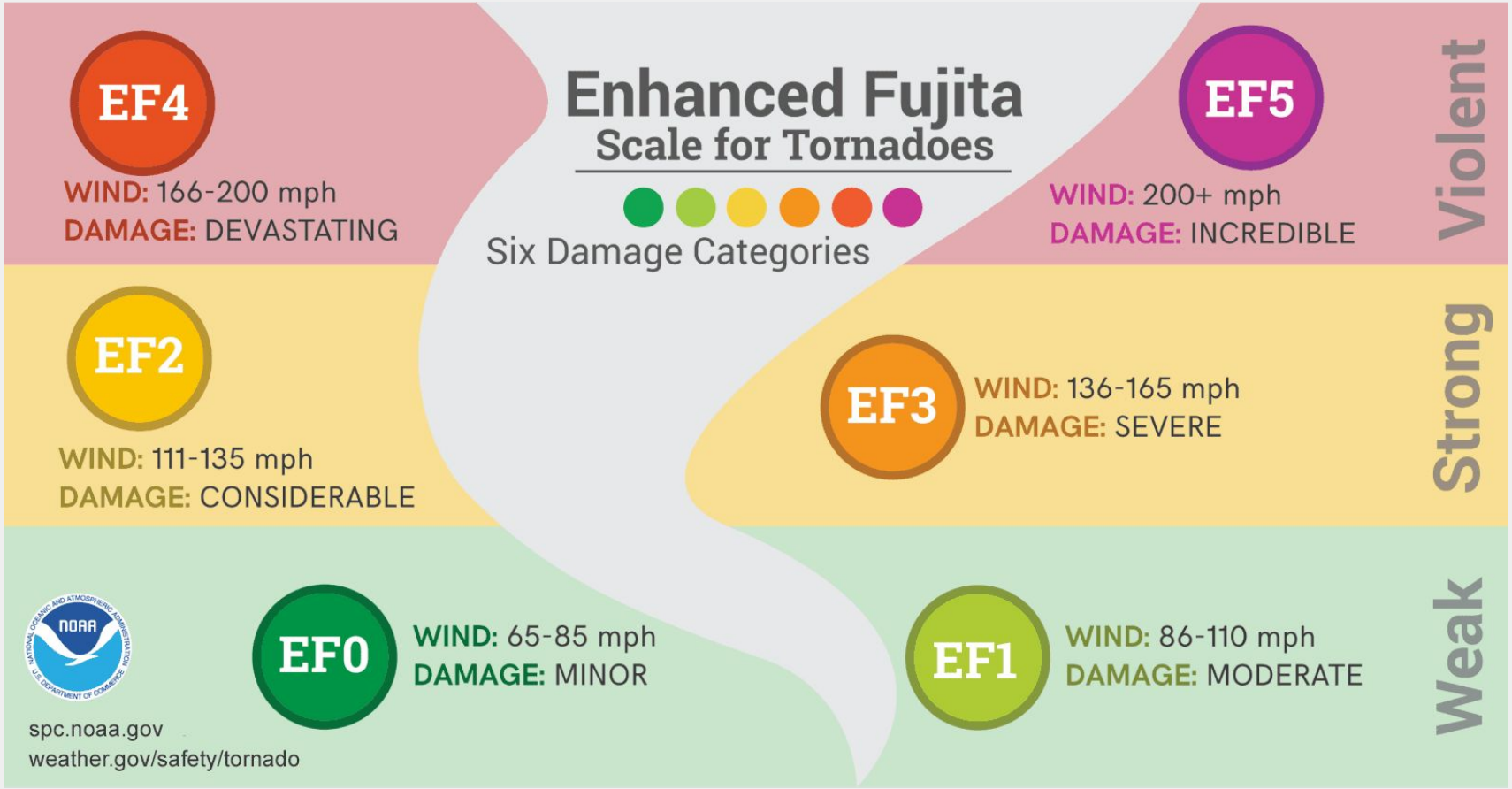


Radar typically only sees rotation associated with the mesocyclone, not the tornado itself. But, there are exceptions.

Classic Supercell Evolving into HP with Tornado [video]

The Power of a Tornado [video]

NWS Meteorologists Survey & Rate Damage



Damage Varies Along & Across a Tornado's Path

Tornado Safety: Taking Shelter from a Tornado

Good locations:

- Interior room, hallway, stairwell, or closet on the lowest floor of a sturdy building.
- Community shelters.
- Basement.
- NSSA/ICC 500 compliant shelters.

Bad locations:

- Large, open rooms.
- Rooms with windows.
- Manufactured homes.
- RVs and campers.
- Tiny homes.
- Vehicles.

Lowest Floor, Interior Room Example

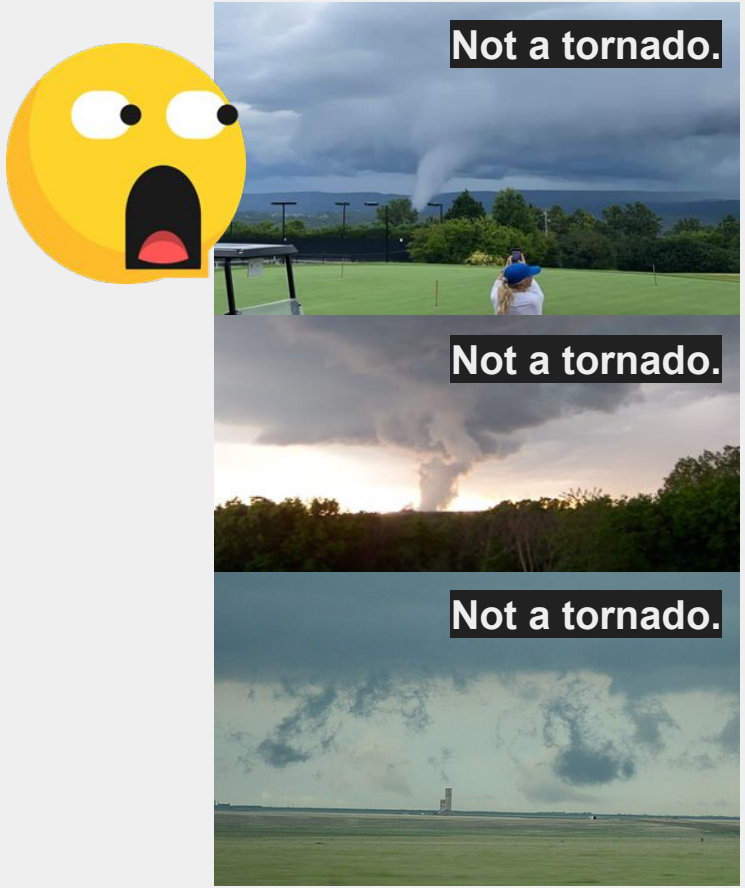
Don’t forget:

- Shield yourself
  - Helmet, hard-soled shoes, heavy blanket
- Whistle or airhorn
- Flashlight
- Phone

Tornado Look-Alikes: Scud Clouds

- Low-hanging and usually ragged cloud feature
- They meander or slowly rise
- They **DO NOT RAPIDLY ROTATE**; thus, not a funnel cloud or a tornado and are harmless

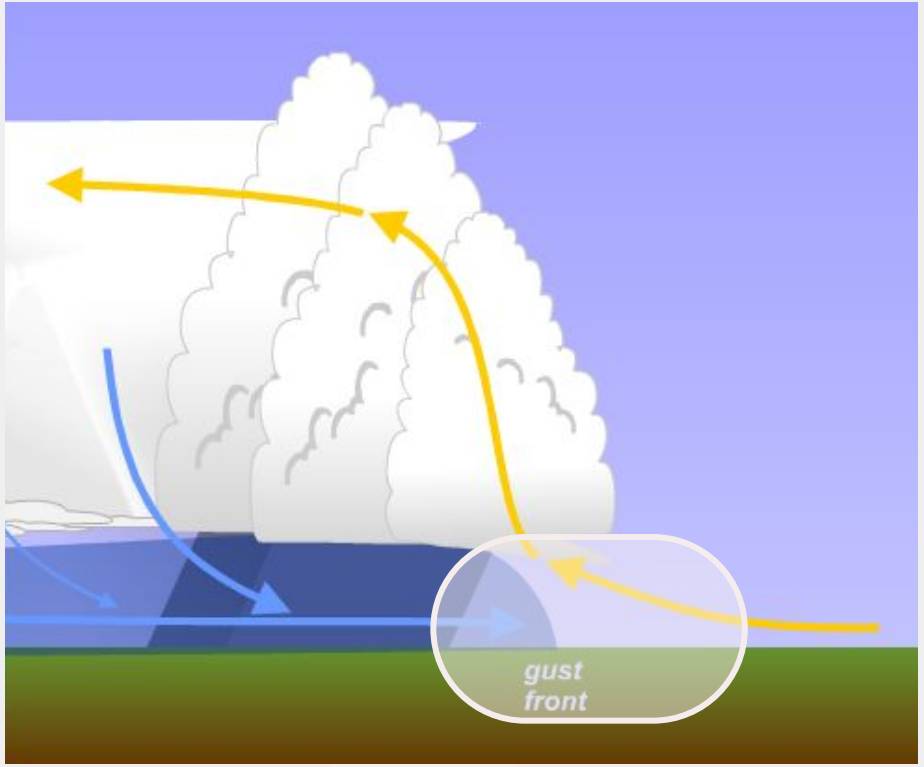
- *An exception is scud rising at or near a rotating wall cloud. Watch closely in this case!*



Now to the Cool Side…

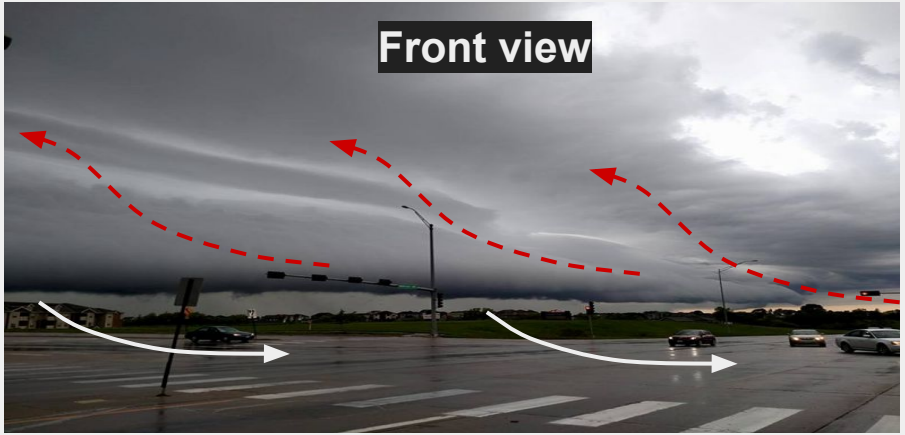
Key feature coming up:

- Shelf cloud

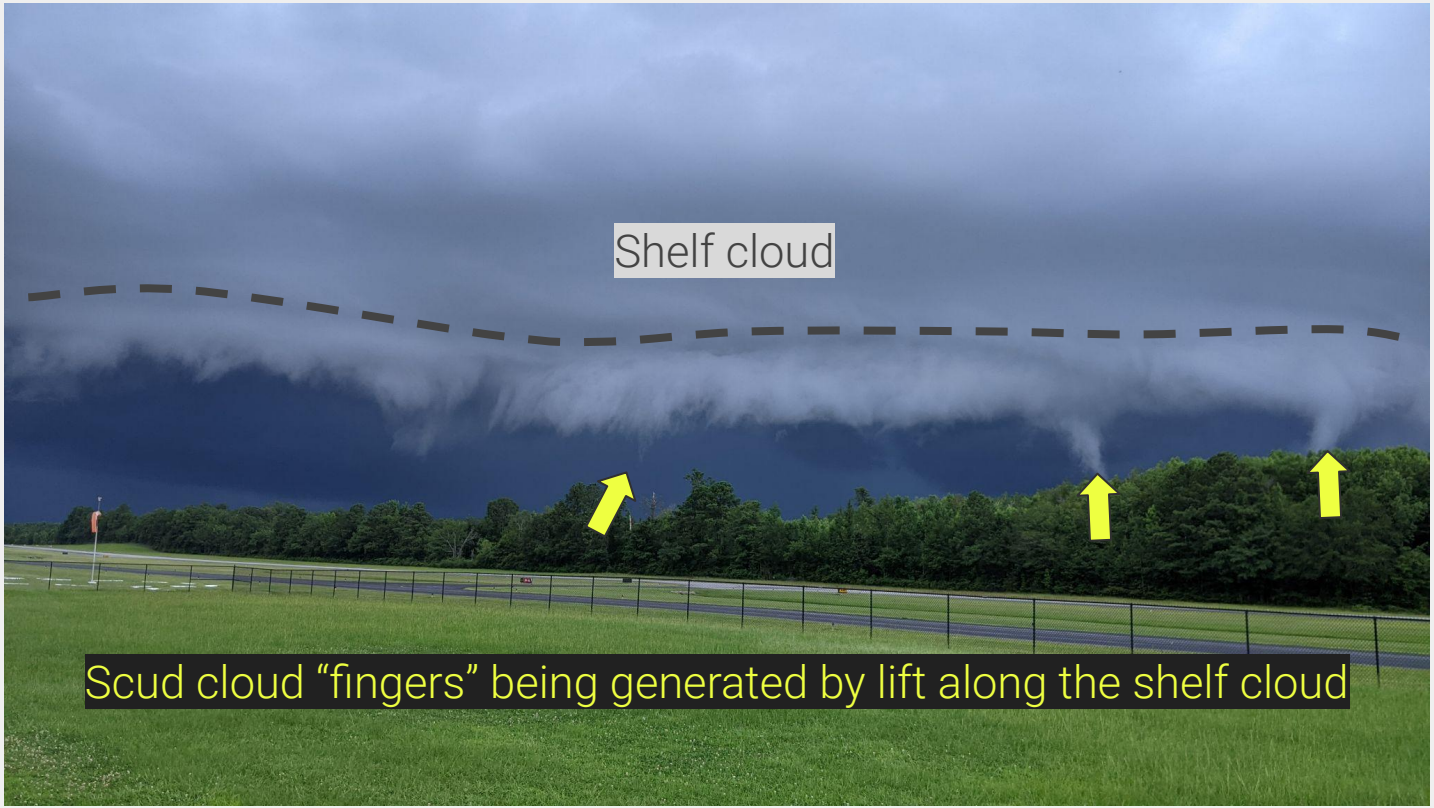


Shelf Cloud

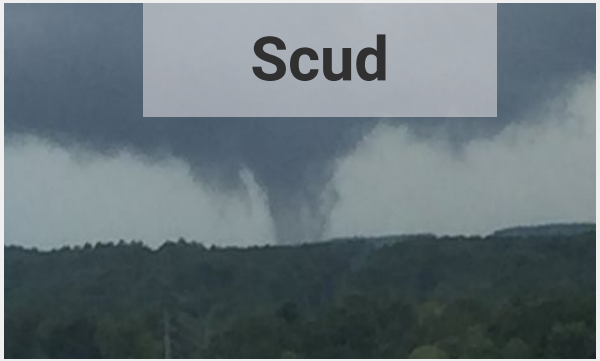
- A long, low-hanging and sloped horizontal cloud
- Marks the leading edge of the gust front/rain-cooled air
- Turbulent eddies can occur underneath the shelf cloud with rising motion on the leading edge. **This turbulent motion is not tornadic!**



Shelf Cloud w/ Scud Elements

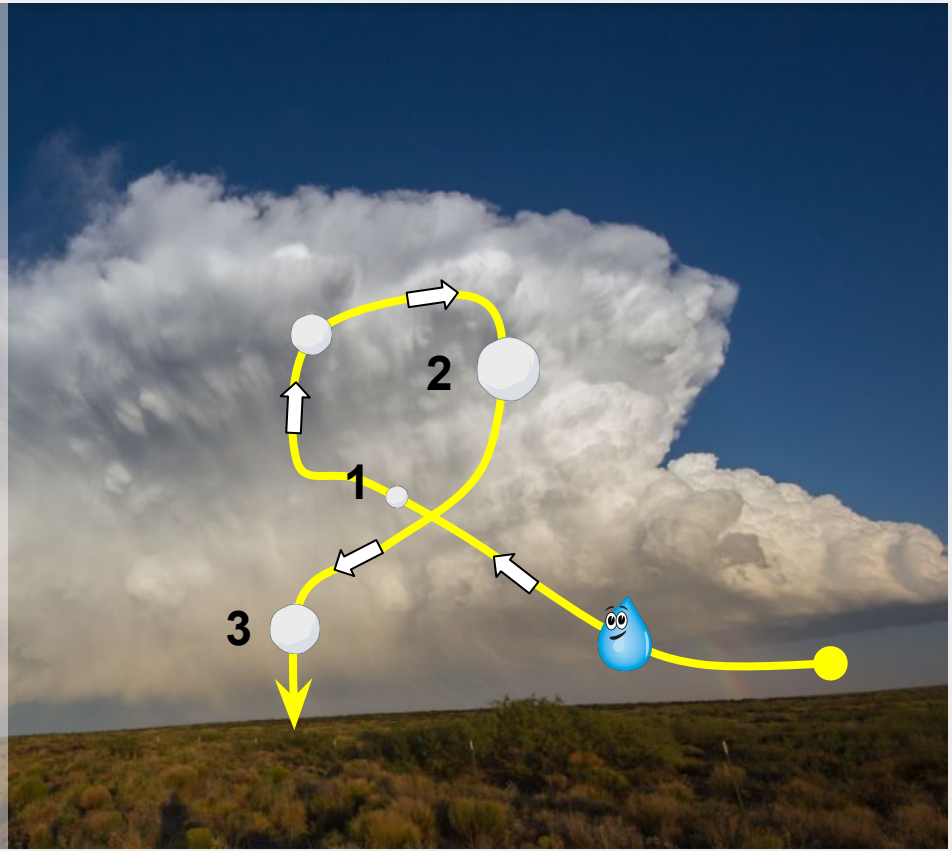


Side-by-Side Comparison



How Hail Forms

1. Water droplets in the storm cloud freeze as they move upward.
2. Hailstones, suspended by the updraft, grow larger as they collide with supercooled water droplets.
3. The hailstones get too heavy and fall to the ground. Their size is dependent on updraft strength and time suspended aloft.



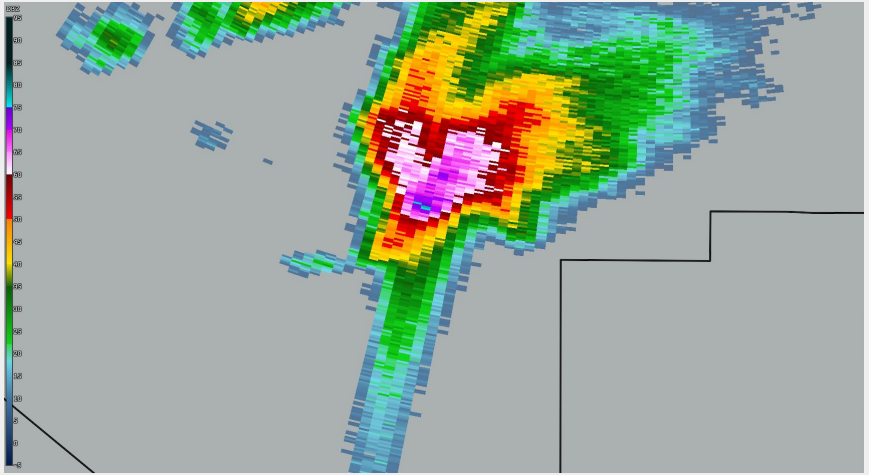
Hail Sizes

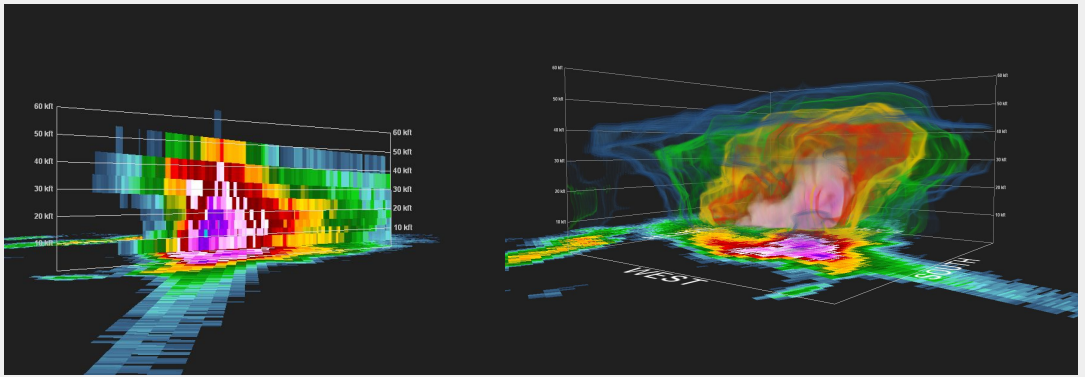
Hailstone size	Measurement		Updraft Speed	
	in.	cm.	mph	km/h
bb	< 1/4	< 0.64	< 24	< 39
pea	1/4	0.64	24	39
dime	7/10	1.8	38	61
penny	3/4	1.9	40	64
nickel	7/8	2.2	46	74
quarter	1	2.5	49	79
half dollar	1 1/4	3.2	54	87
walnut	1 1/2	3.8	60	97
golf ball	1 3/4	4.4	64	103
hen egg	2	5.1	69	111
tennis ball	2 1/2	6.4	77	124
baseball	2 3/4	7.0	81	130
tea cup	3	7.6	84	135
grapefruit	4	10.1	98	158
softball	4 1/2	11.4	103	166

Reporting Hail Sizes

Hail Spike & Hail Core on Radar

- Hail spike: false echoes that extend away from the hail core
  - Indication of very large hail or a high volume of smaller hail
- Large hail in Alabama is most common in the spring
- USA record 8” in diameter Vivian, SD July 23, 2010
- Alabama record 5” in diameter March 19, 2018





Flood Safety: Turn Around, Don’t Drown

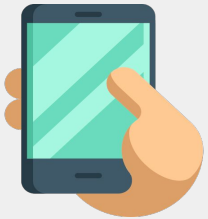
A top weather-related killer in the United States

- Over half of flood-related deaths occur when a vehicle enters flood waters
- You can’t see underwater hazards
- You don’t know if the ground underneath the road is compromised
- You can underestimate the power of flowing water

Lightning Safety: Head to Shelter

- Go to a building or hard-topped vehicle
- Lightning can strike several miles from a storm
  - It does not need to be raining where you are for lightning to be a danger
- Can be fatal or leave you with lifelong injuries
- Wait 30 minutes after the last rumble of thunder or flash of lightning before resuming outdoor activities

Ways to Report to the NWS



Phone
(205-664-3010, option 2)

Twitter and Facebook
Direct message or tag us
Also use #alwx

weather.gov/bmx/submitstormreport

Amateur radio K4NWS (Alabama Emergency Response Team)

What to Report to the NWS

Strong winds or wind damage

- Downed trees or large branches
- Damage to structures
- Measured wind speeds

Hail of any size

- Measure with a ruler or reference a common item (coin or sports ball)
- Report the size of the largest hailstone
- Any damage?

Flooding

- Flowing water ≥ 6” in depth or standing water ≥3’
- Waterways at or beyond bankfull
- Focus on areas where flooding is uncommon
- Are lives or property at risk?

Lowerings such as…

- **Rotating** wall cloud
- Funnel cloud
- Tornado

How to Report to the NWS

Hello, this is Meso Cyclone. I'm a trained spotter. High winds hit the Longleaf Pine neighborhood in Chelsea a few moments ago, about 5:50 pm. There are multiple pine trees uprooted and there are at least two homes damaged by fallen trees on Pine Bark Drive. No injuries that I'm aware of.

Be concise and accurate:
who, what, when, and where

Safety first!

Photos and video are a plus

Trained Spotter Pro Tips

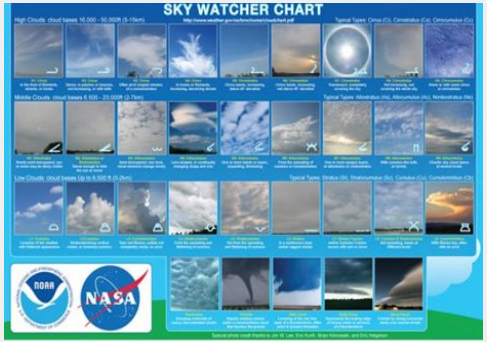
- You know the saying: **“safety first!”**
- **Be timely, objective, accurate, and concise when reporting**
- Storms in Alabama can be hard to read. Terrain, trees, low/chaotic cloud bases, and low visibility are all challenges
- To better pinpoint what kind of feature you are viewing, know your **position** relative to the storm and what **type** of storm you are looking at
- Remain aware of the situation around you

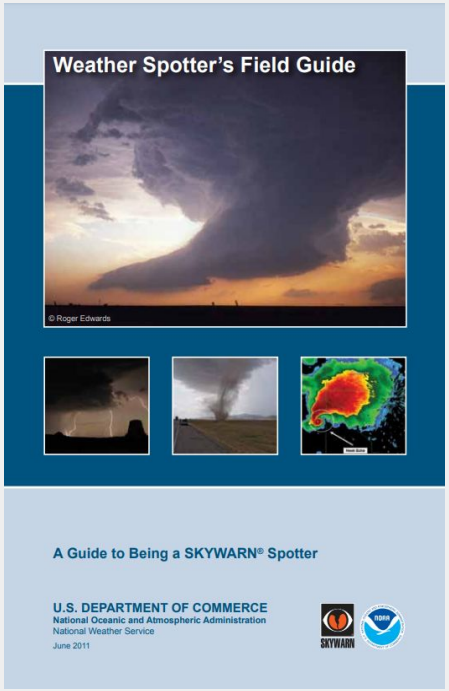
Additional Materials

Visit our SKYWARN page for useful links and information:

weather.gov/bmx/skywarn

- This entire presentation as a PDF
- Supplemental training and reference materials





What Do You See? #1

Scenario: It's mid July. You observe this patch of clouds meandering just above the treeline as thunder rolls in the distance. As you closely watch, you notice some rising and sinking motion and even parts of the cloud that appear to spin. There is a risk for severe weather in the forecast.

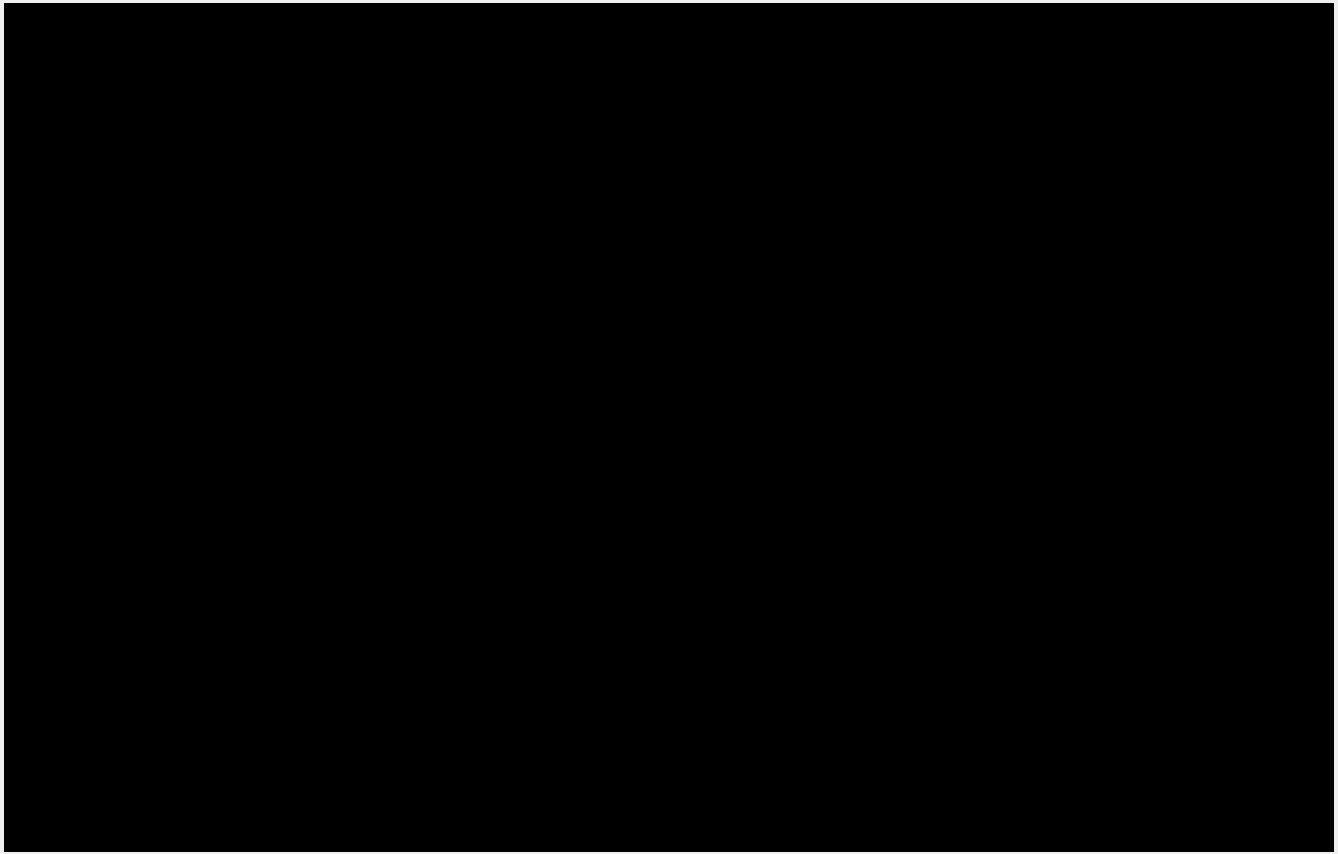
What Do You See? #2

Scenario: It's a warm day in November. A storm is passing by your community. You plot your location on your radar app. and see that you are on the south side of the storm. You are looking northward at a lowering. The radar app. shows broad rotation.

What Do You See? #3

Scenario: It's early June and this long cloud is hanging low to the ground as it rapidly moves toward your location. You see a dark wall immediately behind this long cloud. Rising motion is very noticeable on the leading edge with chaotic motion underneath. After this feature passes, the temperature drops several degrees and heavy rain/gusty winds arrive.

What Do You See? #4 [video]



Video: Steven Banks

What Do You See? #5

Scenario: You observe this large lowering and can tell that there's rotation, rising motion, and nearby scud clouds. Your radar app. shows a tornado icon and someone driving along the highway yells tornado!

What Do You See? #6

Scenario: It's the middle of July. You observe this patch of clouds just above the treeline. As you closely watch, you notice parts of the cloud slowly moving in different directions but no discernable rotation. There is a risk for severe weather in the forecast. You check your radar and see clusters of thunderstorms in your area.

What Do You See? #7

Scenario:

You hear the sound of hail. As it comes to an end, you go outside to measure the size of the hail so you can report it to the NWS. There's an assortment of different sized hailstones.

What Do You See? #8 [video]

What Do You See? #9

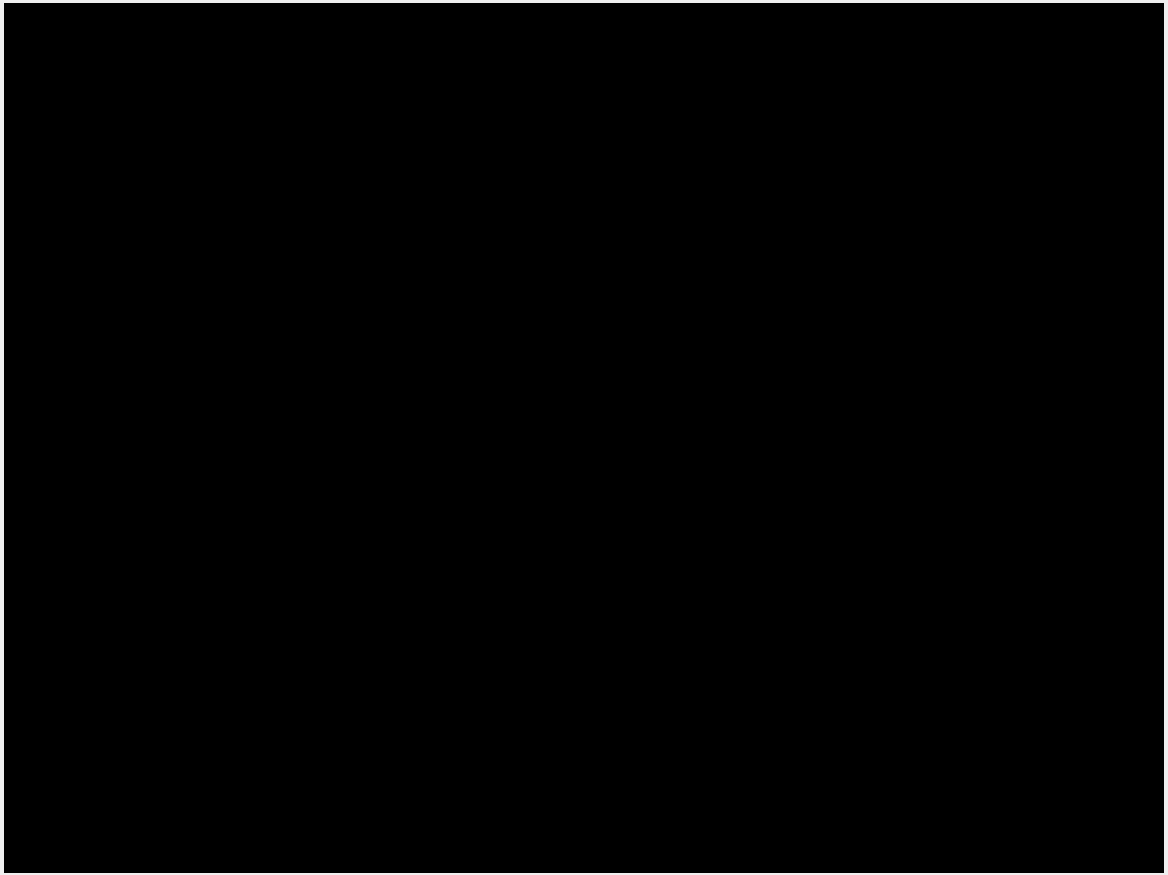
Scenario: You're enjoying an afternoon on the lake but notice the sky is darkening. You check your radar app. and see there are storms nearby. You notice this cloud is close to the ground with other wisps of clouds that are forming next to it and slowly rising.

What Do You See? #9

Scenario: A tornado-warned storm is passing by your location. You see a lowering with discernable rotation. The feature doesn't seem to be rapidly getting closer to the ground at the moment but it is at least halfway to the ground.

What Do You See? #10 [GIF]

What Do You See? #11 [video]



Video: Ali Hughes-Garrett

National Weather Service

Basic Storm Spotter Training

Thanks for Attending!
Questions or Curiosities?

Gerald Satterwhite, Meteorologist
NWS Birmingham, AL