National Weather Service *Advanced* Storm Spotter Training

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Advanced Spotter Training Outline

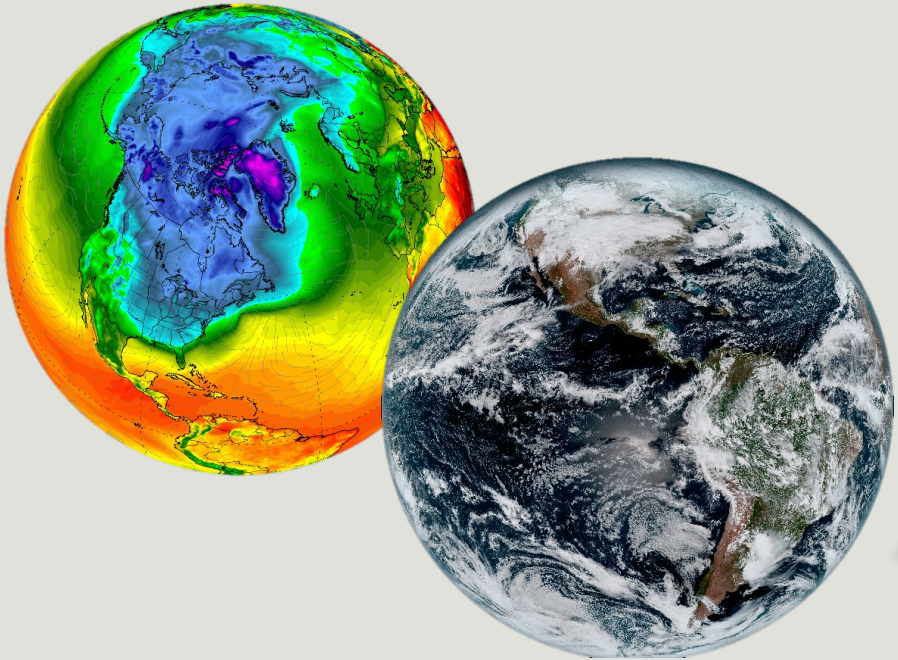
Part I

- Atmospheric features, types and scale
- Severe weather ingredients
- Using our products

Part II

- RADAR signatures
- Tornadogenesis
- Demo a severe weather event

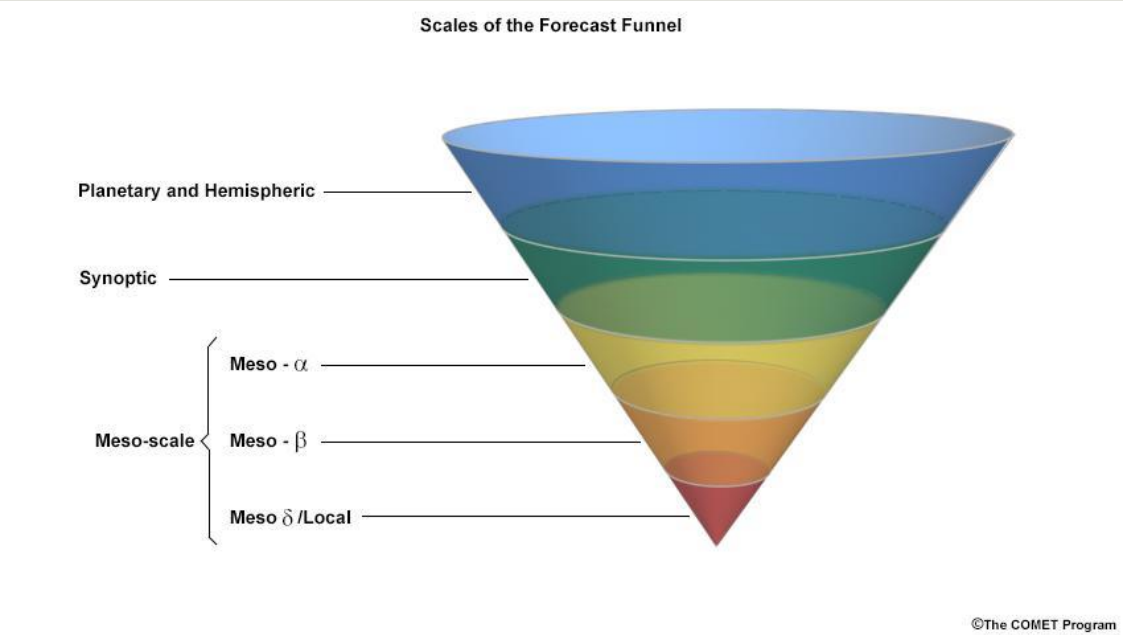
The Atmosphere



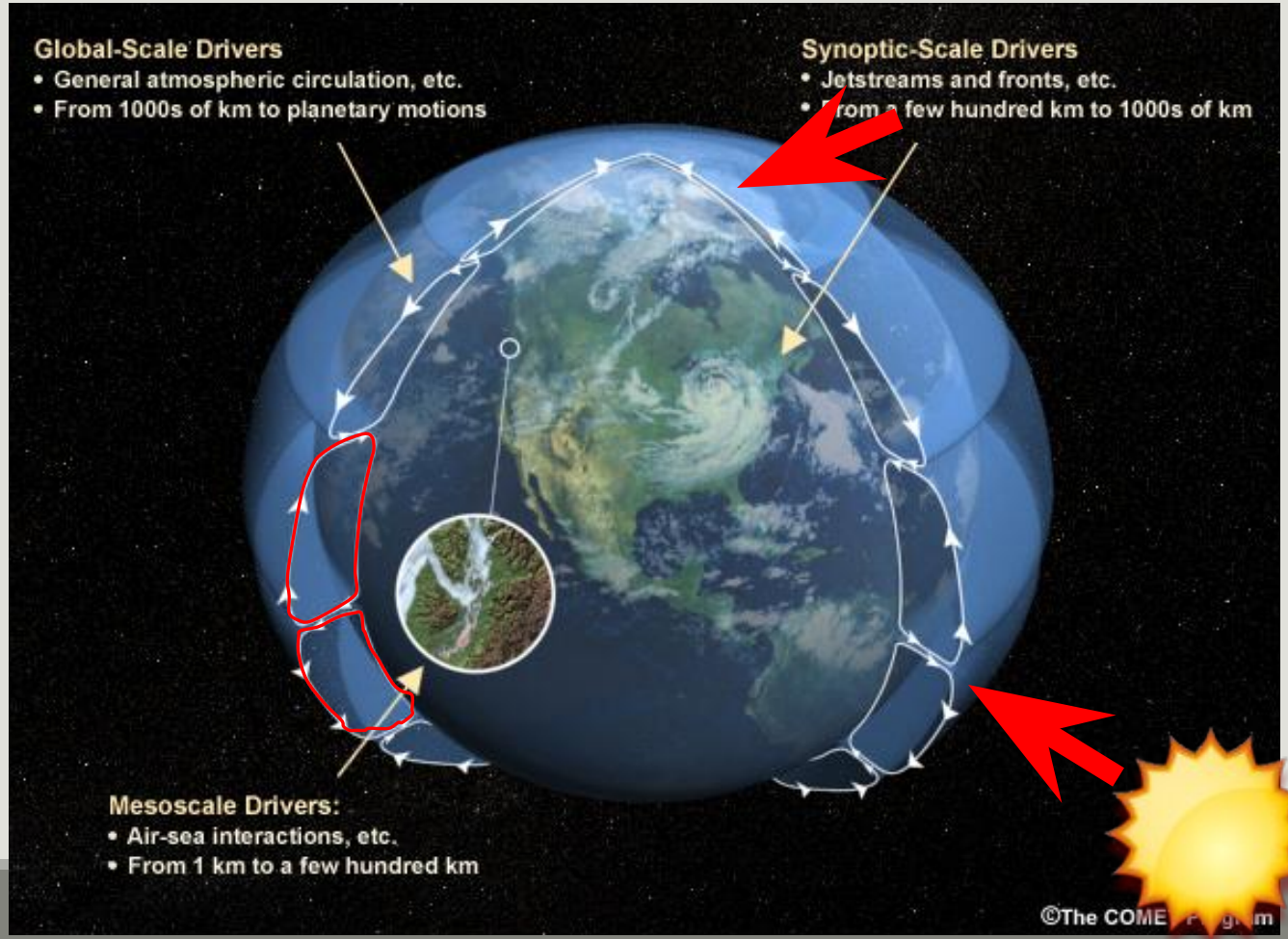
Large to Small Scale

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

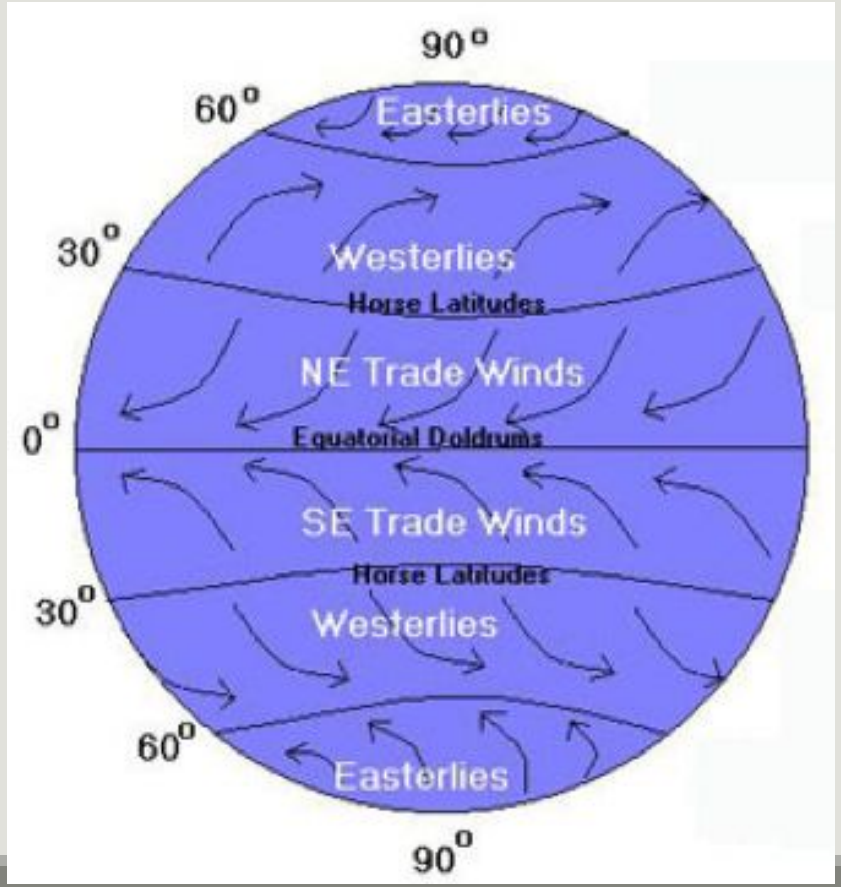
“Forecast Funnel”



Global Weather Patterns



Global Weather Patterns



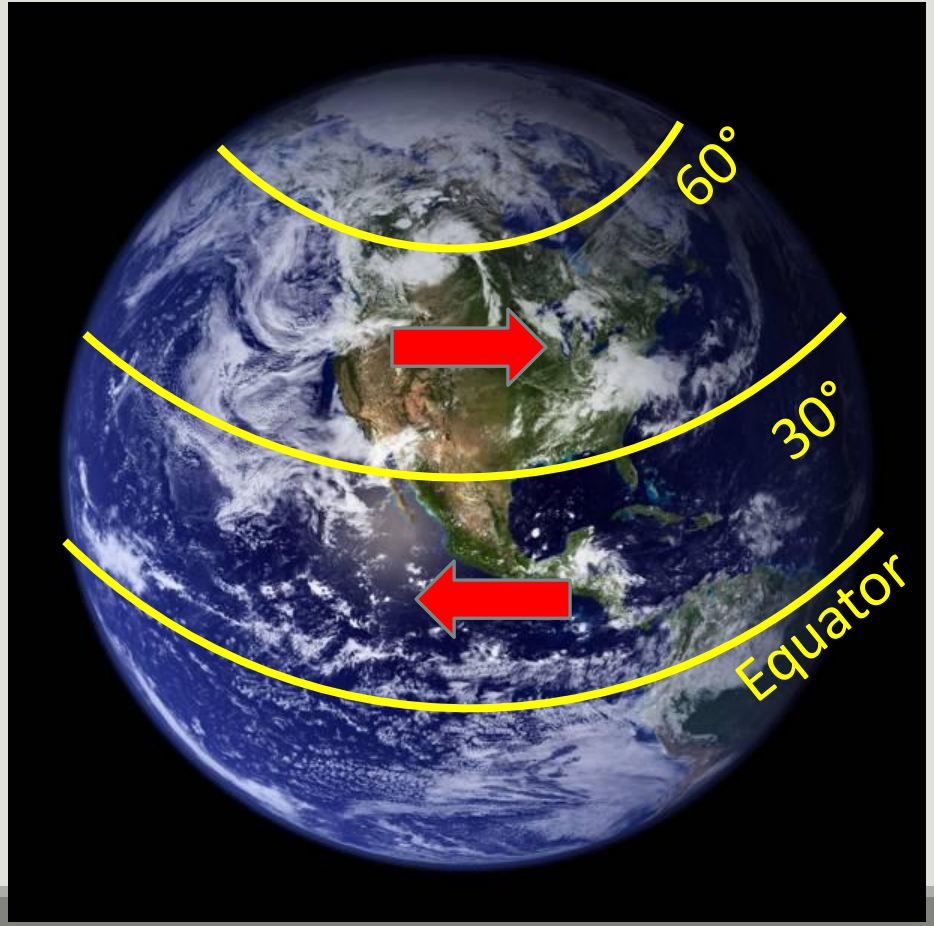
Weather Patterns should flow North to South, RIGHT?

Two More Things to Factor in:

- Rotation of the Earth
- Gravity

Coriolis Effect

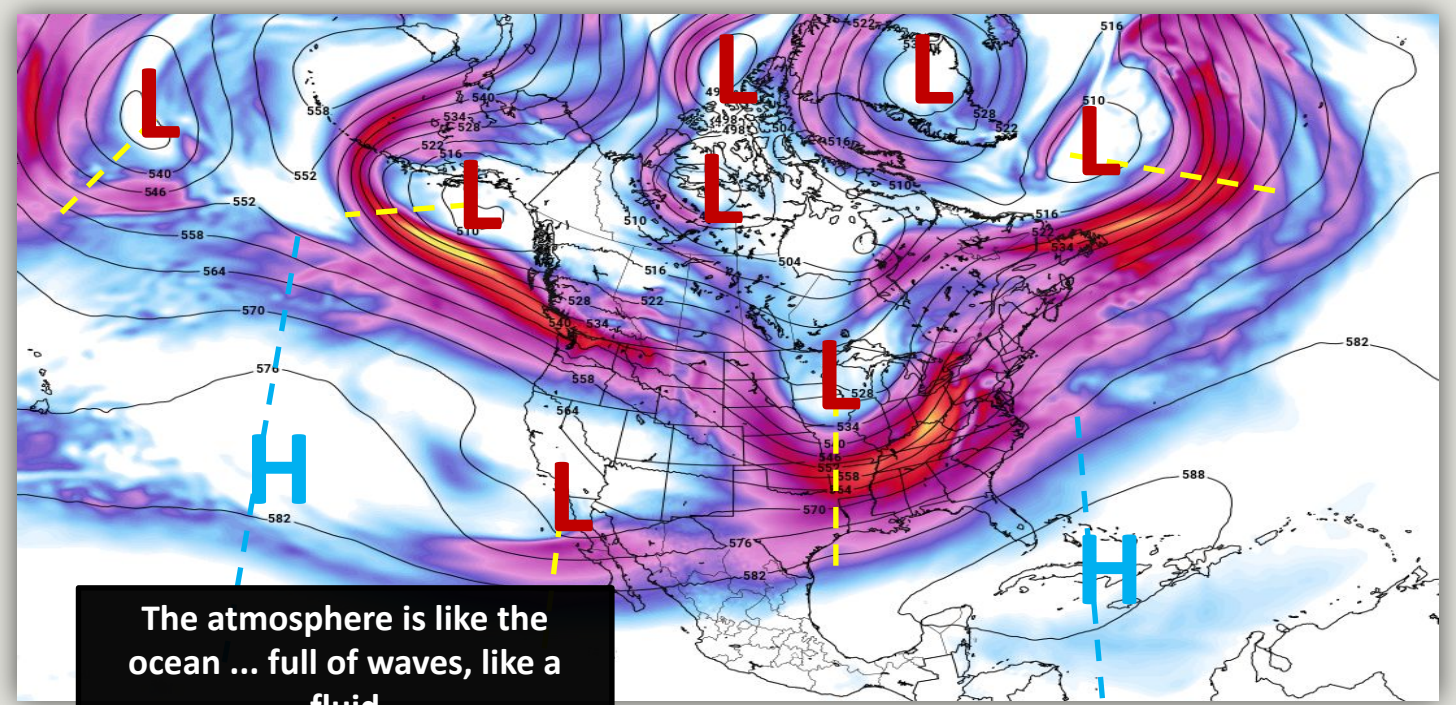
Global Weather Patterns



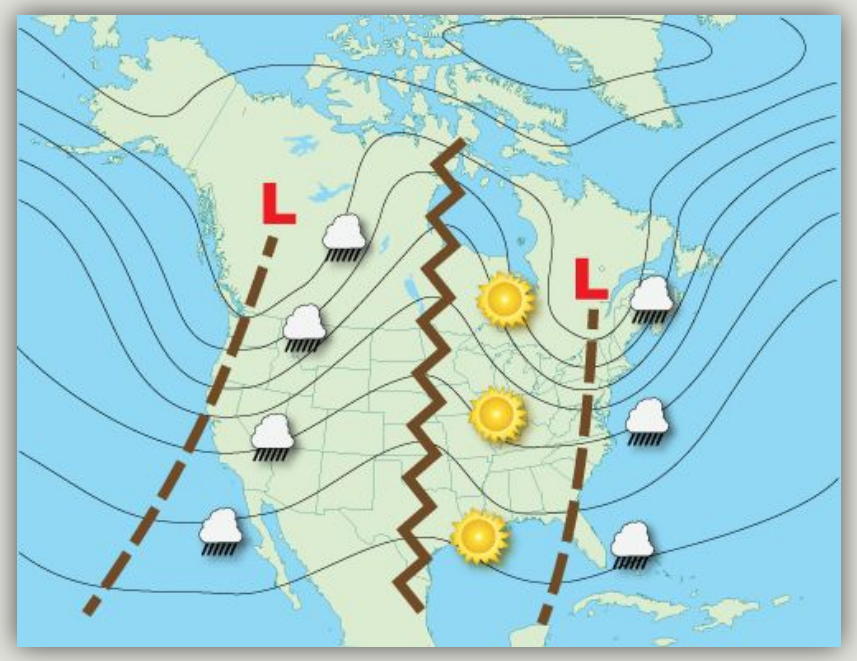
Westerlies vs. Easterlies

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

Synoptic Weather Patterns

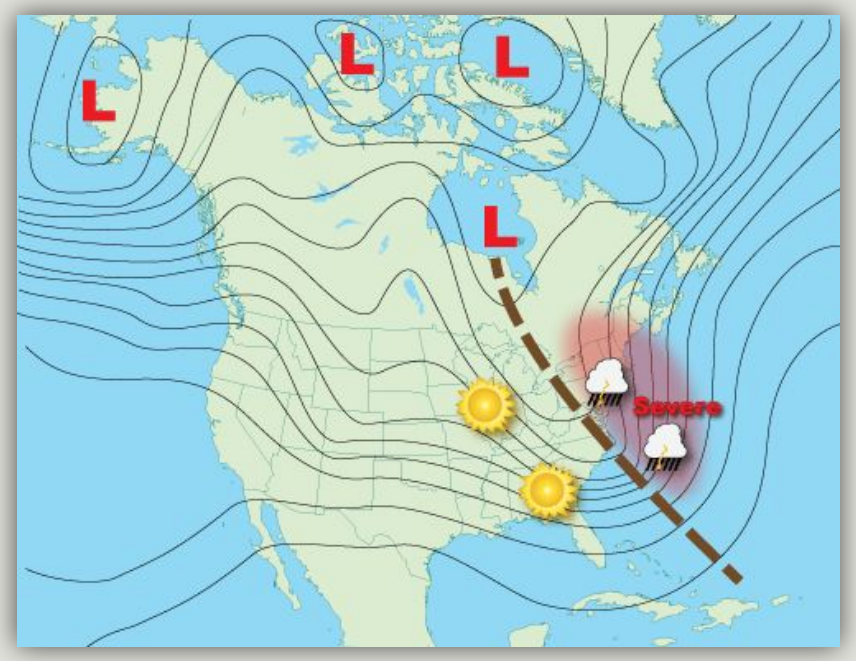


Neutrally-Tilted Troughs



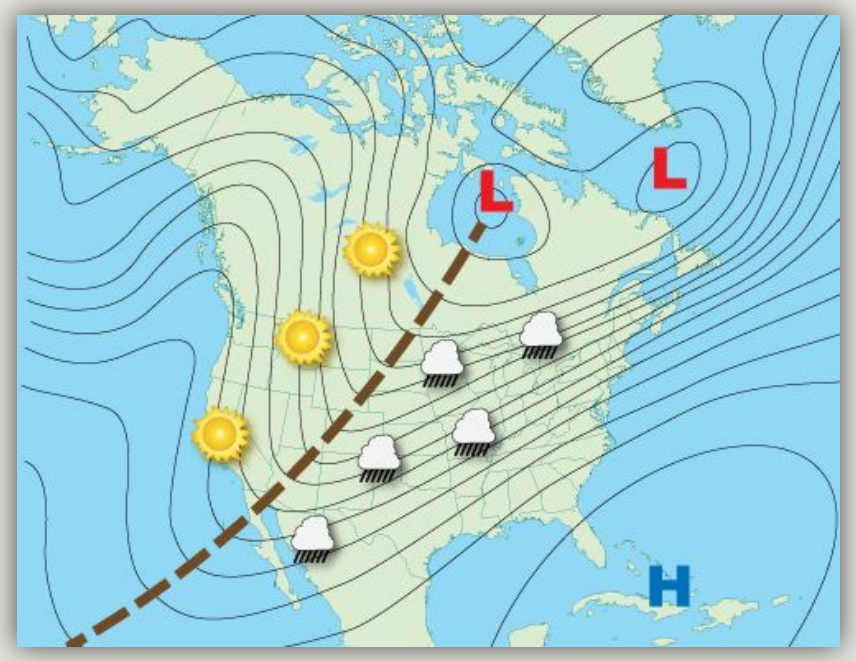
- Trough axis extends from the <u>lowest pressure north to south</u>
- Active weather occurs between the trough and downwind (eastward) ridge

Negatively-Tilted Trough



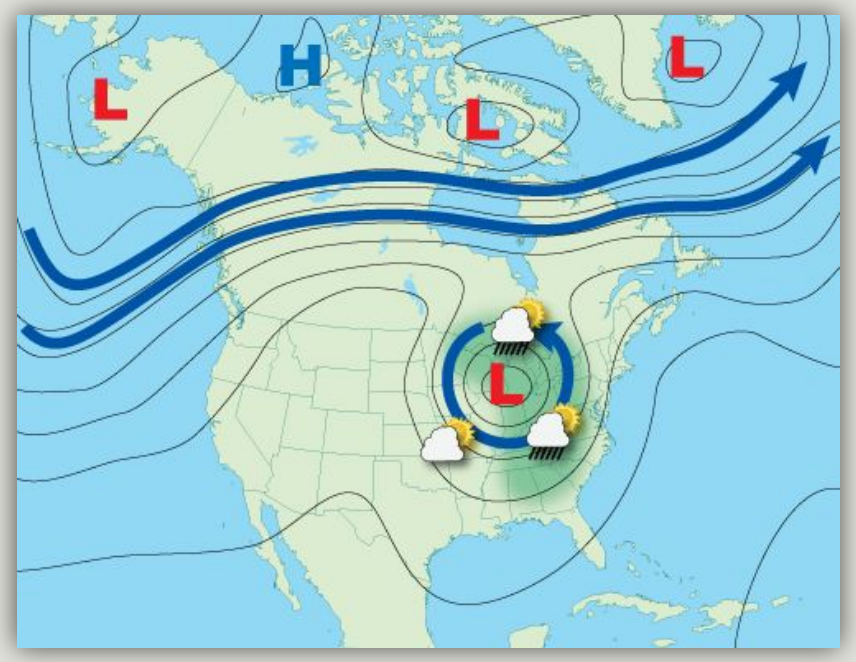
- Trough axis extends from the <u>lowest pressure northwest to southeast</u>
- Active weather + highest severe potential

Positively-Tilted Trough



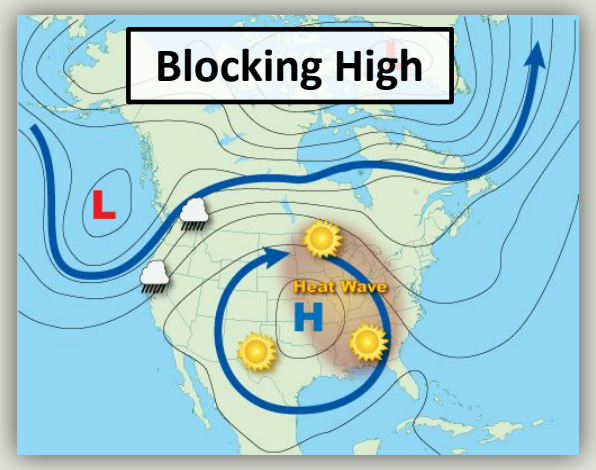
- Trough axis extends from the <u>lowest pressure northeast to southwest</u>
- Active weather can occur; still can have severe storms under the right conditions

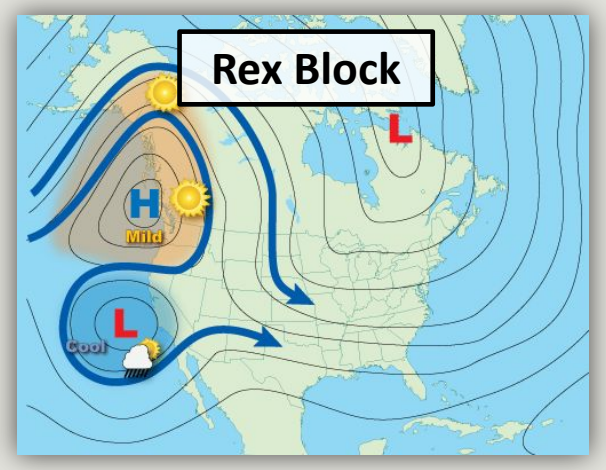
Cut-off Low

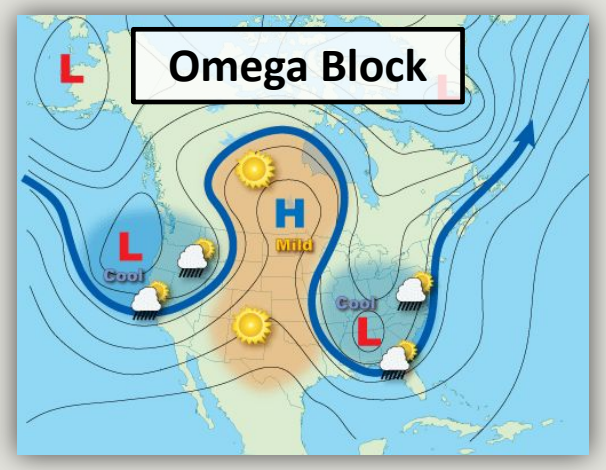


- Persistent area of low pressure removed from the steering flow
- Can meander for several days, sometimes over a week
- Produce unsettled weather

Blocking Patterns

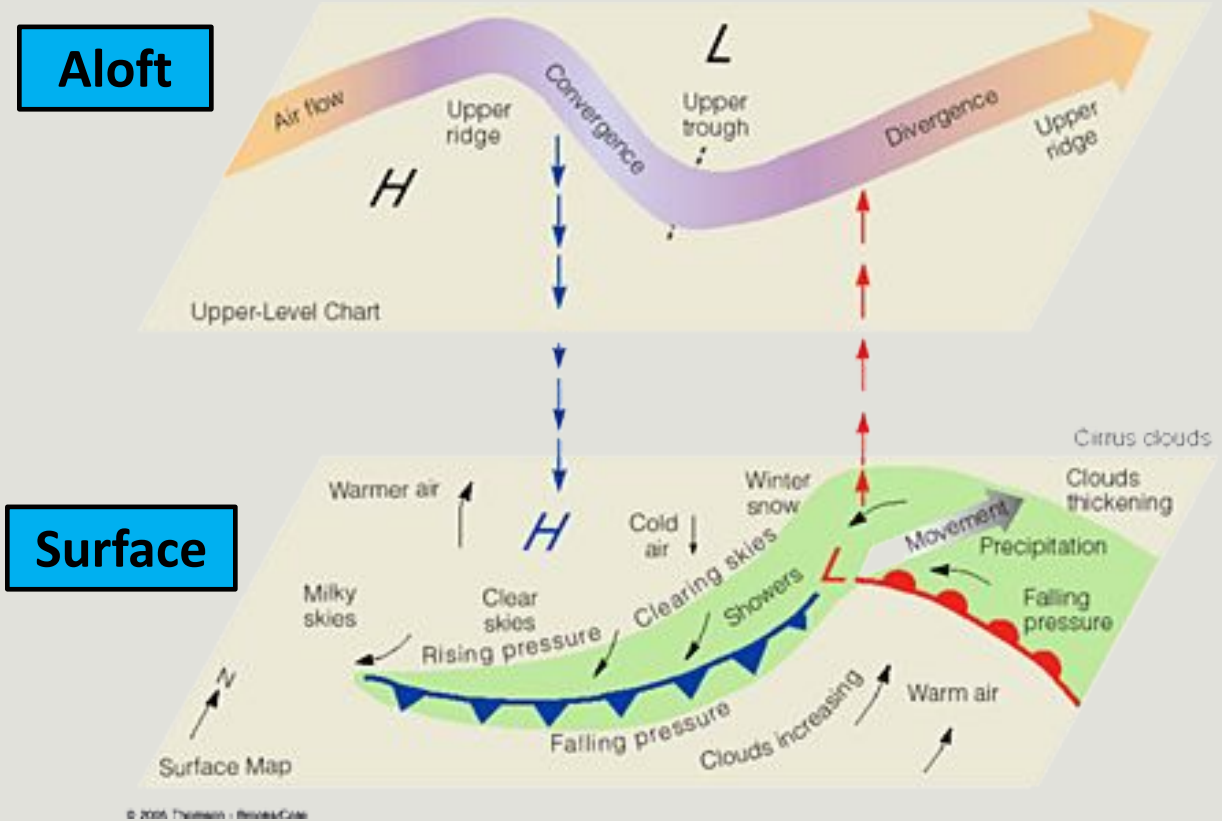


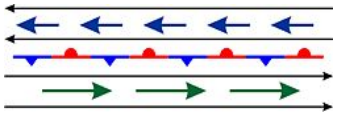


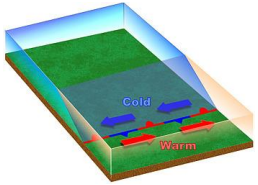


- When weather systems set up in a way that prevents progressive movement
- Result in long spans of persistent weather conditions for a given area

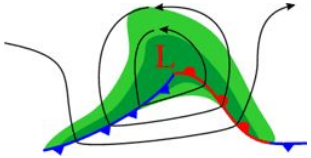
Synoptic Weather Patterns: Top-down

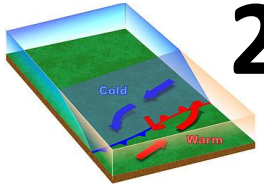




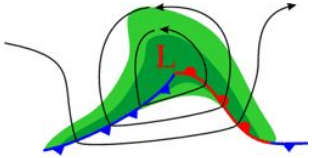


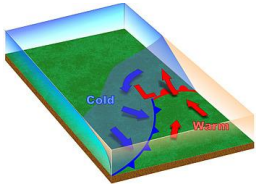
1 Boundary between warm, cooler air





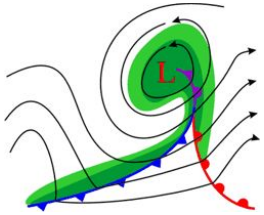
2 With upper-level impulse, surface wave forms; precipitation develops

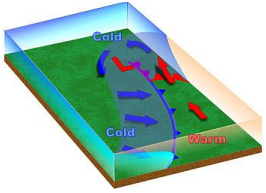




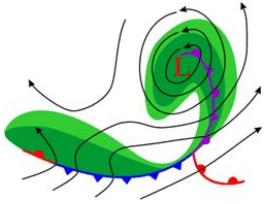
3 Wave intensifies, fronts become better organized

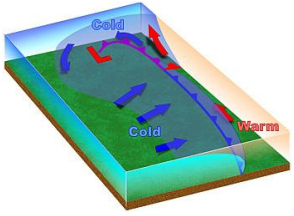
4 Low pressure matures. Cold front overtakes warm front and forms an occluded front





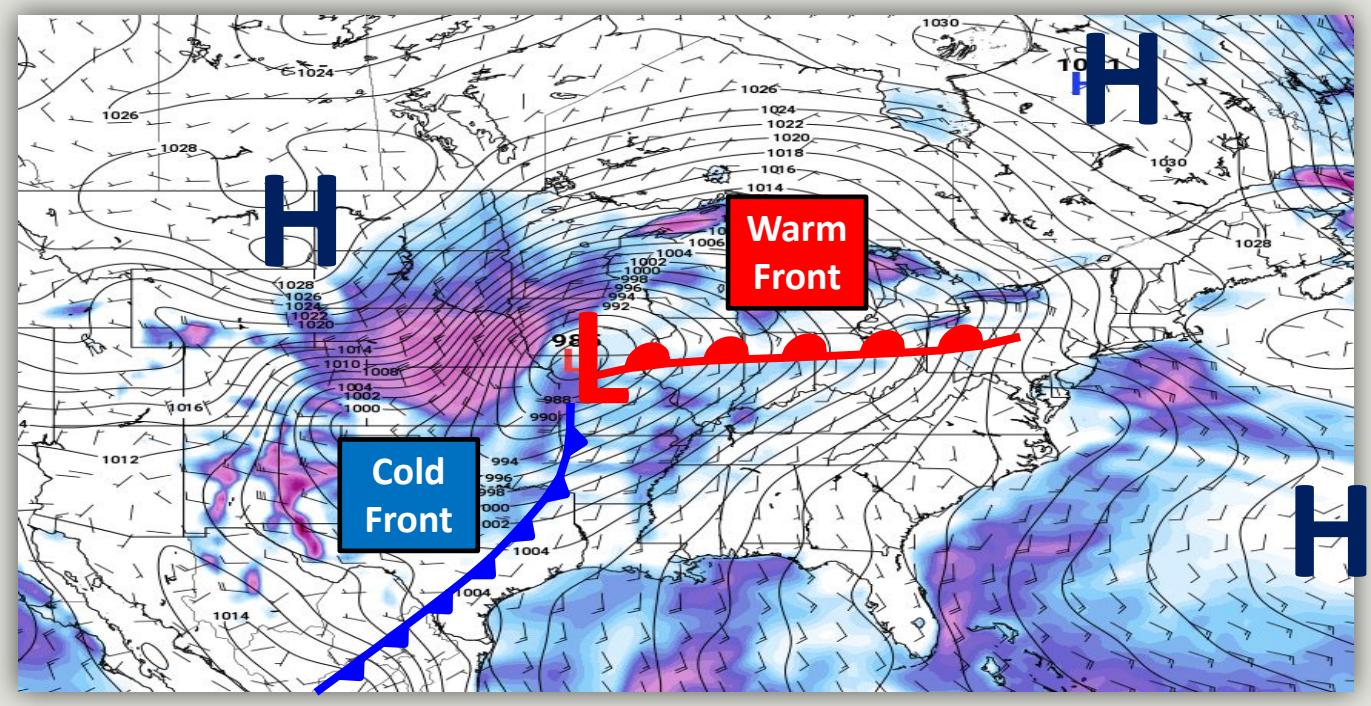
5 Cold front continues to advance on warm front and eventually cuts off supply of warm, moist air. Low pressure gradually dissipates



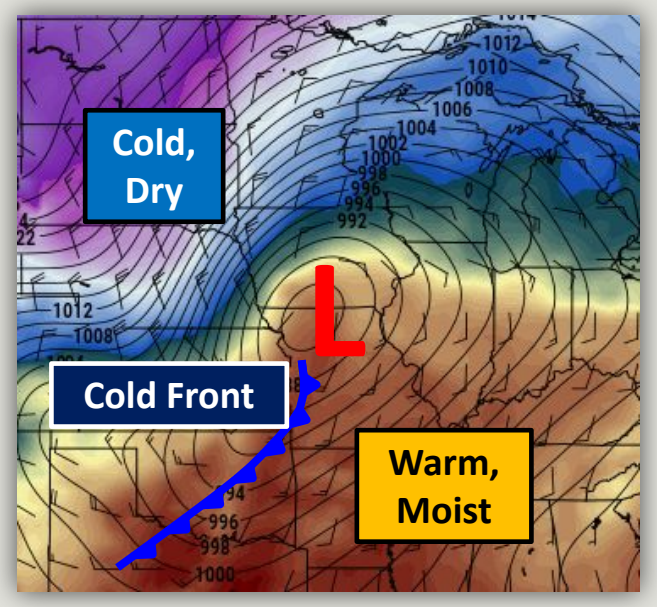


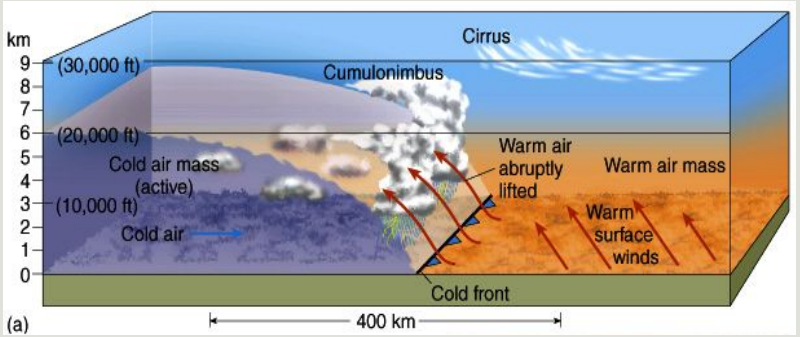
Imagery via NWS JetStream School

Features Associated with Surface Low Pressure



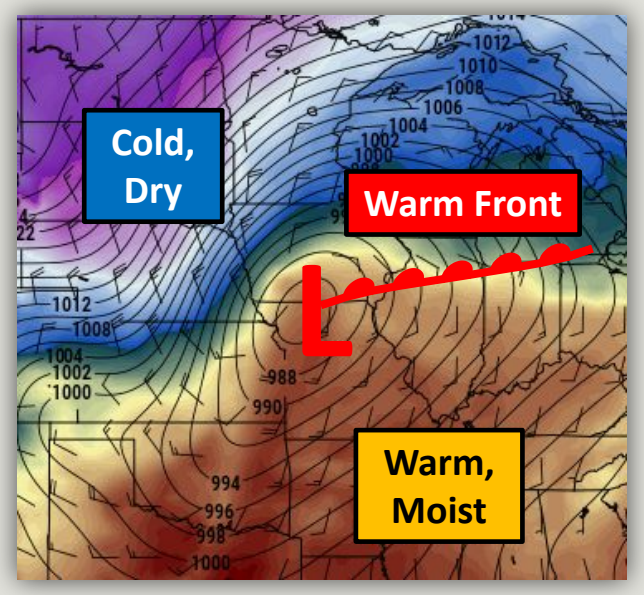
Cold Front Structure





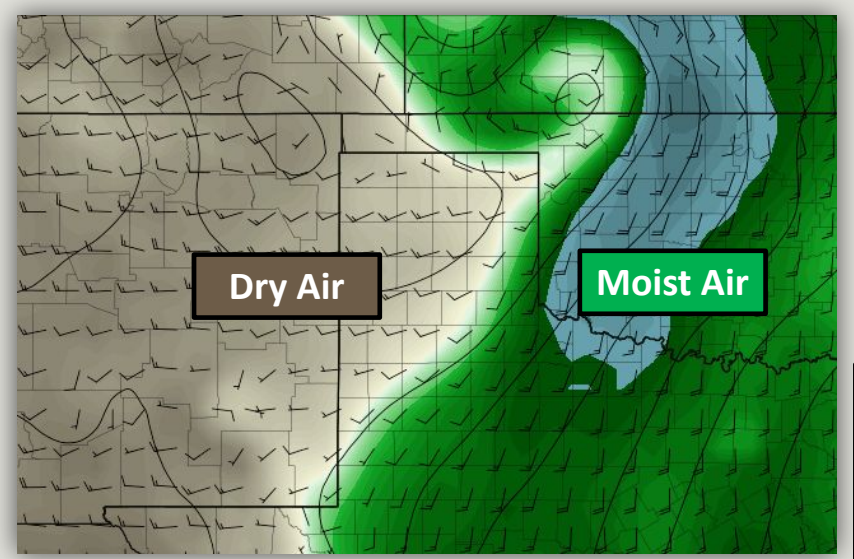
Cold front definition: A zone separating two air masses, of which the cooler, denser mass is advancing and replacing the warmer air mass

Warm Front Structure

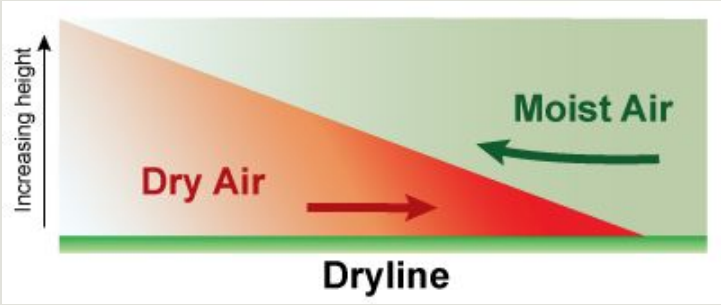


Warm front definition: A transition zone between a mass of warm air and the colder air it is replacing

Other Boundaries – Dryline

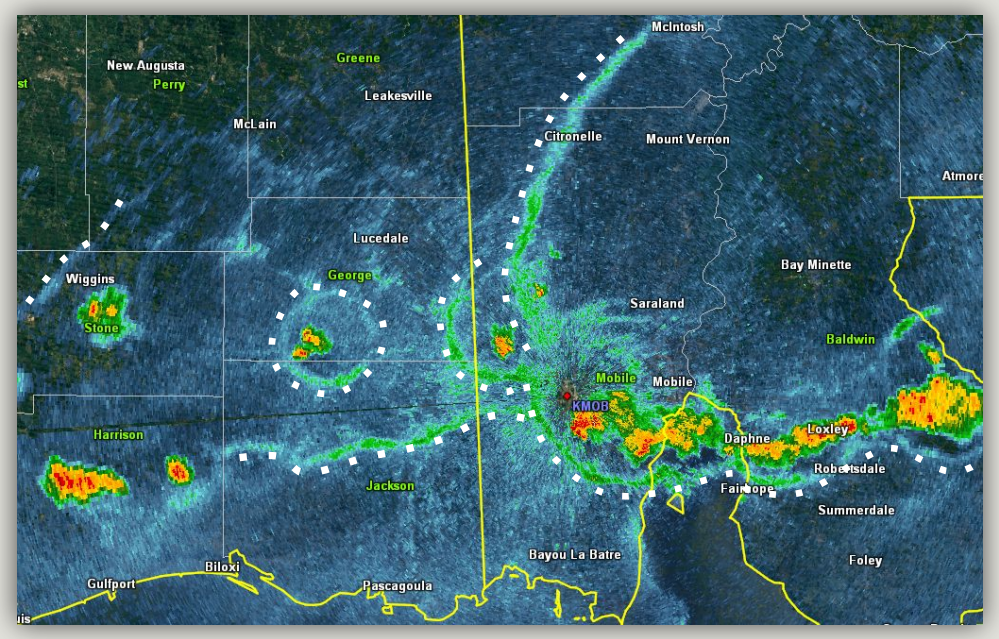


*most common in the Plains, though strong weather systems can sometimes sweep the dryline eastward into the Mississippi Valley region



Dryline definition: The boundary between a moist and dry air mass. Dry air forces moist air upward as the boundary moves eastward, which can trigger severe storms.

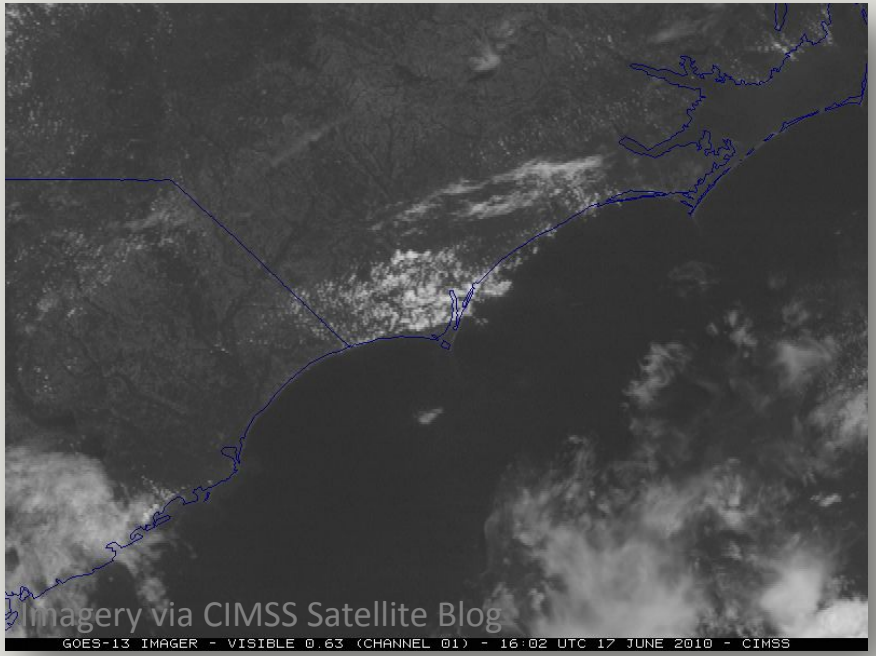
Other Boundaries – Outflow



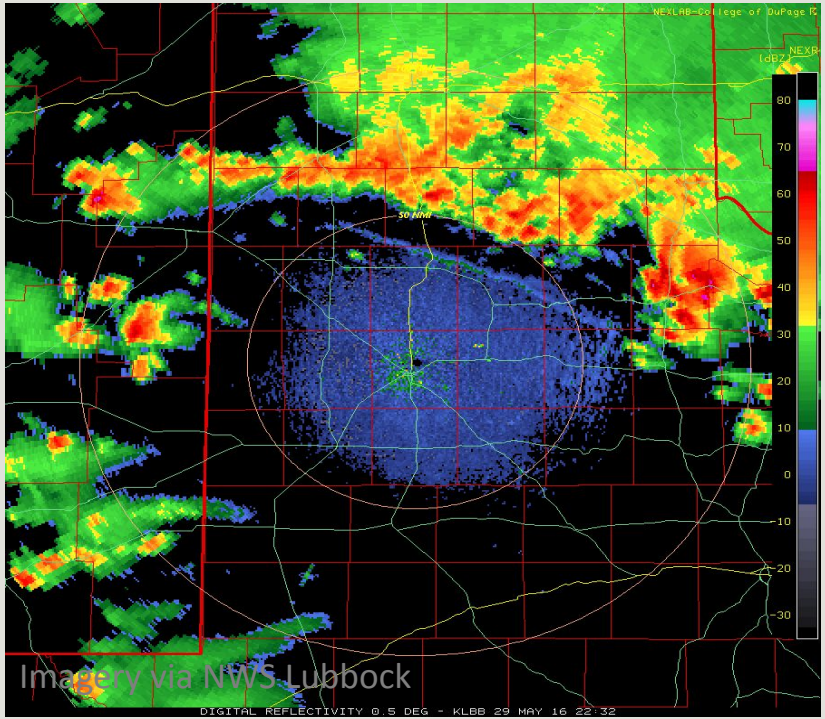
Outflow boundary definition: A small-scale boundary that separates rain-cooled air from the surrounding air

*similar in effect to a cold front. Passage is marked with a wind shift/increase and drop in temperature. These boundaries can trigger new showers and storms.

Outflow Boundaries in Action (GIF)
--via Satellite and RADAR--

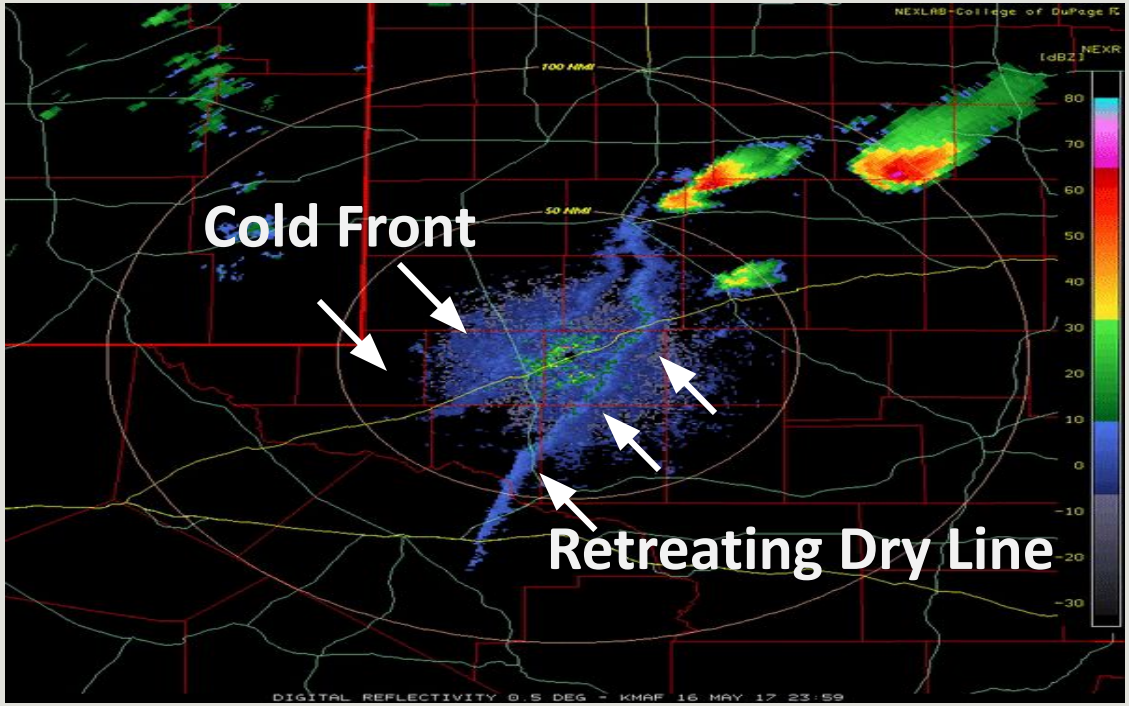


Imagery via CIMSS Satellite Blog

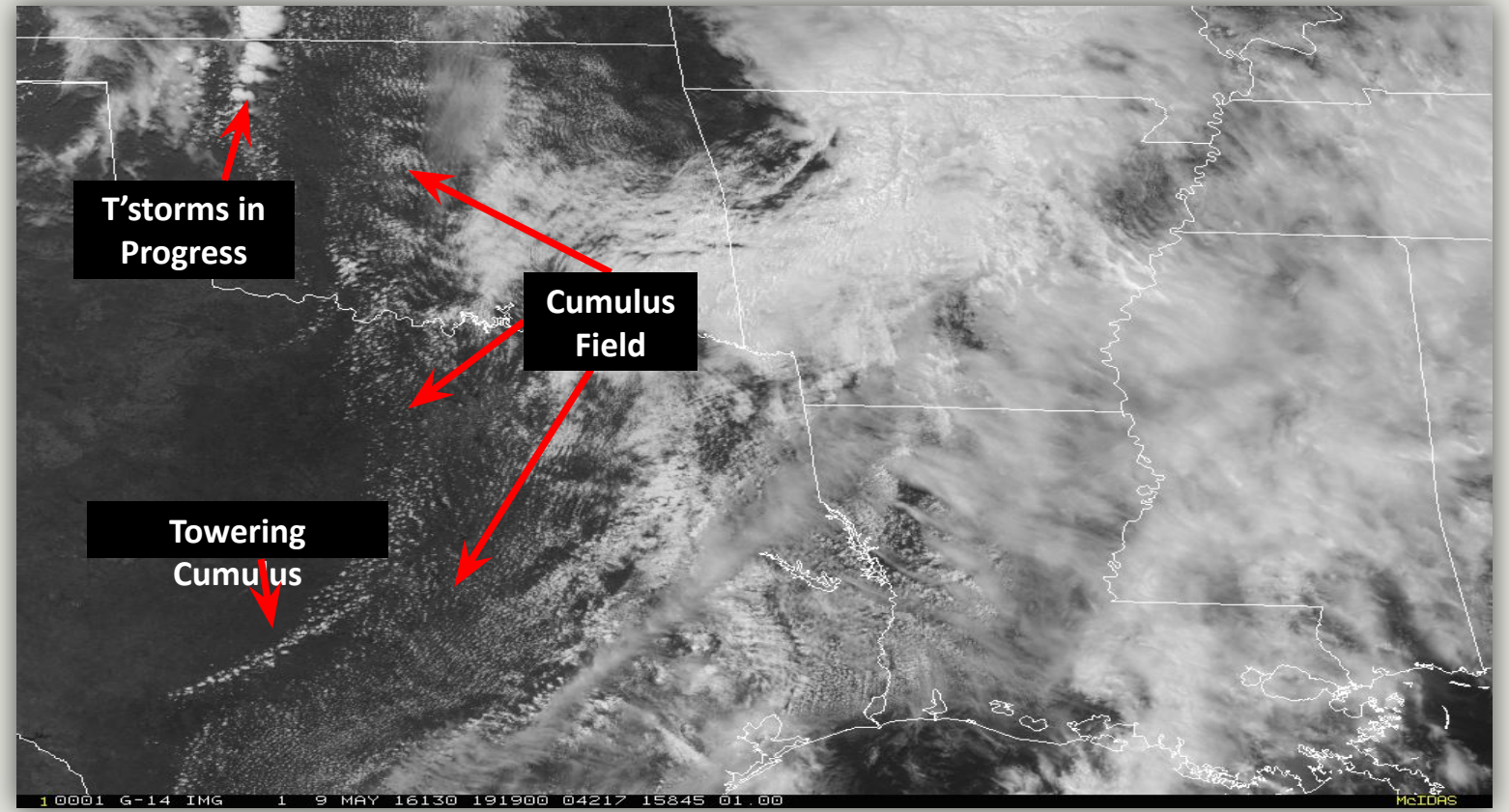


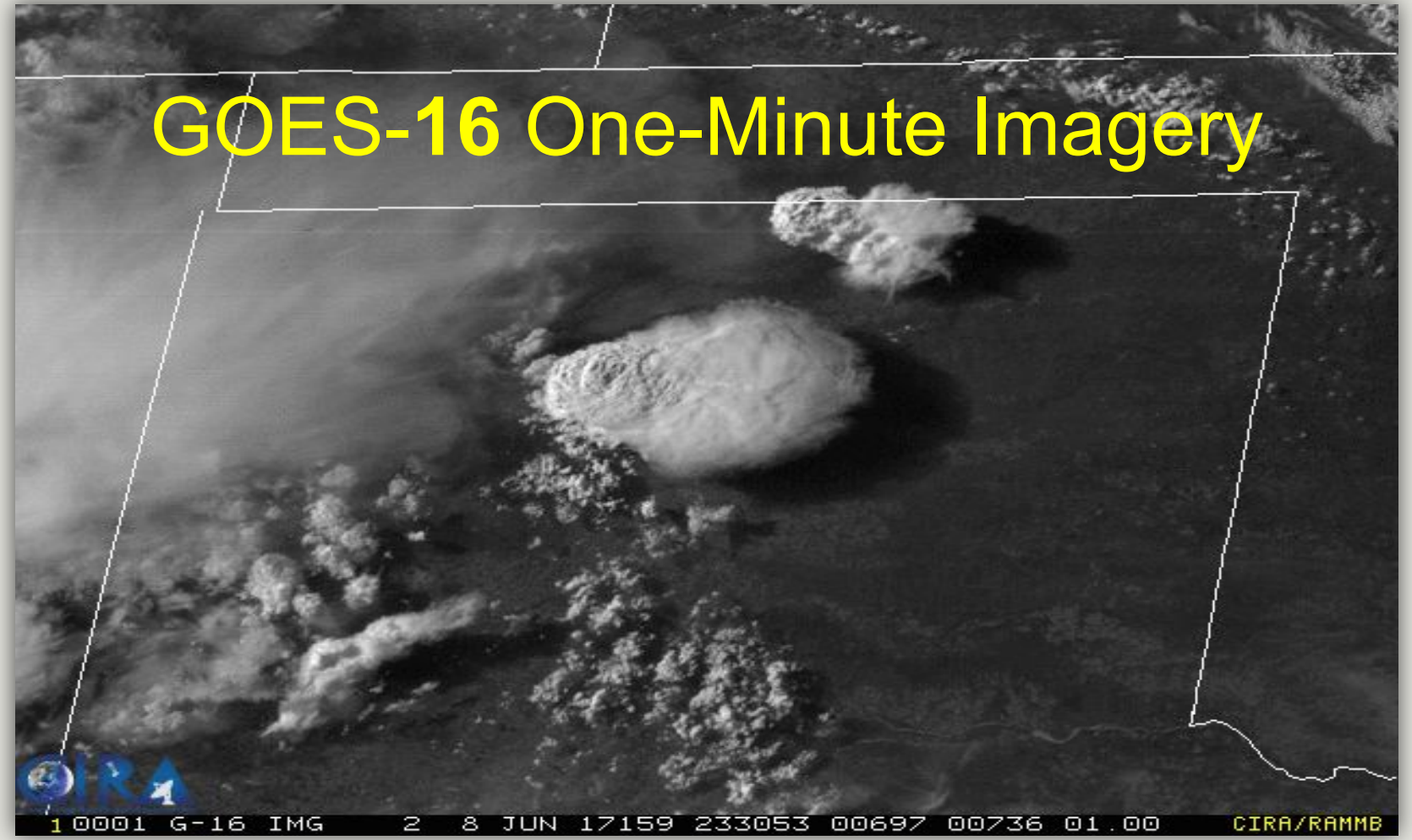
Imagery via NWS Lubbock

Collision of 2 Boundaries
--Interesting Things Happen at the Boundaries--



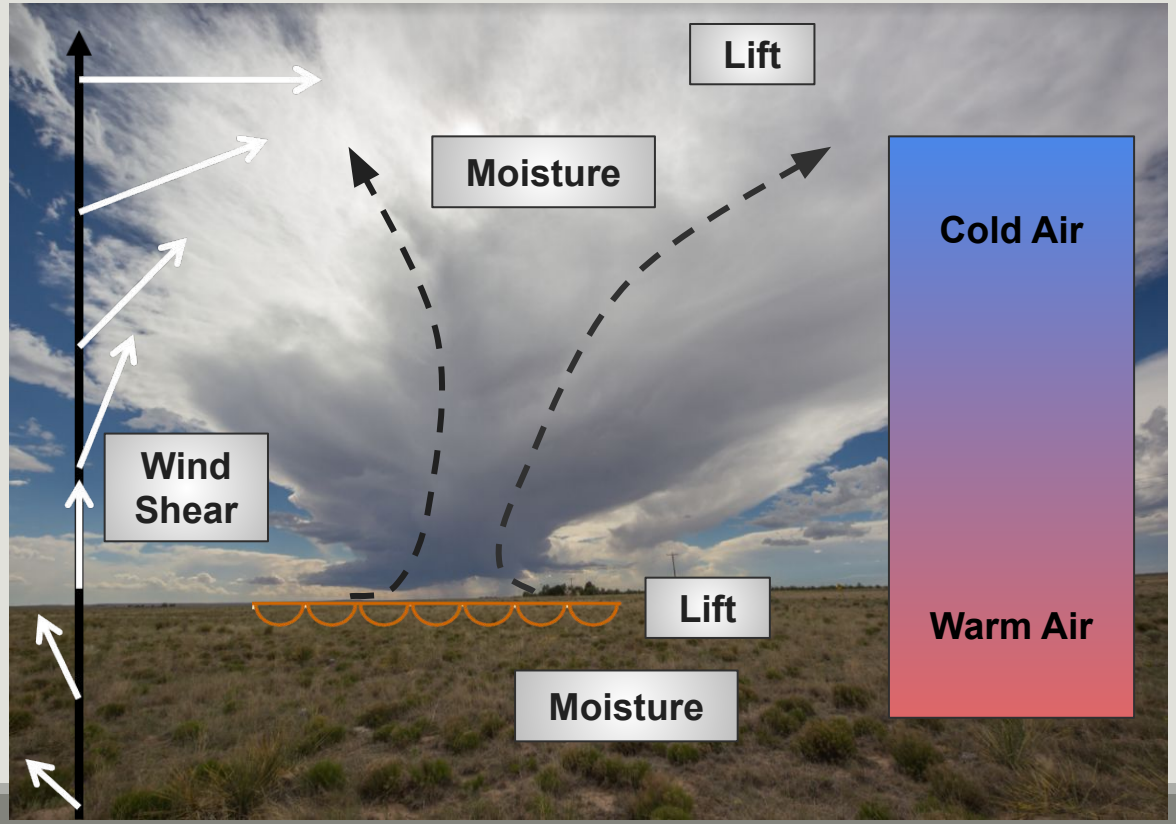
Stages of Activity



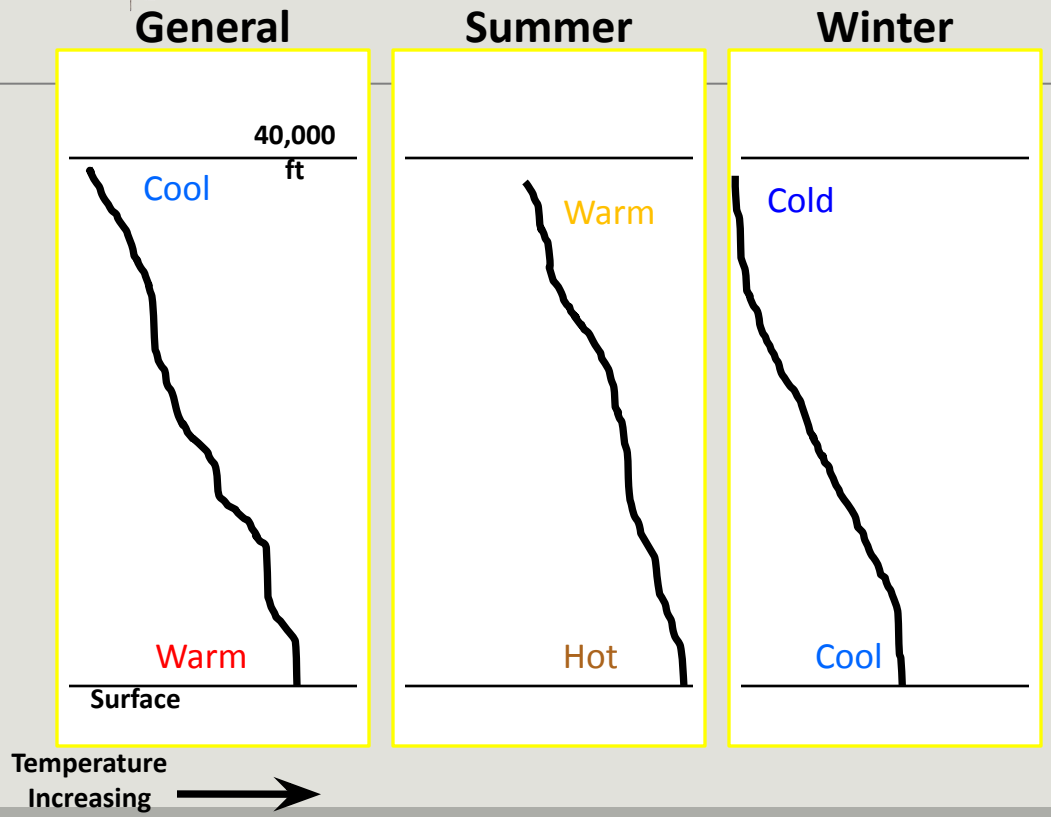

GOES-16 One-Minute Imagery
1 0001 G-16 IMG 2 8 JUN 17159 233053 00697 00736 01.00
CIRA/RAMMB

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



The 3-Dimensional Atmosphere Instability



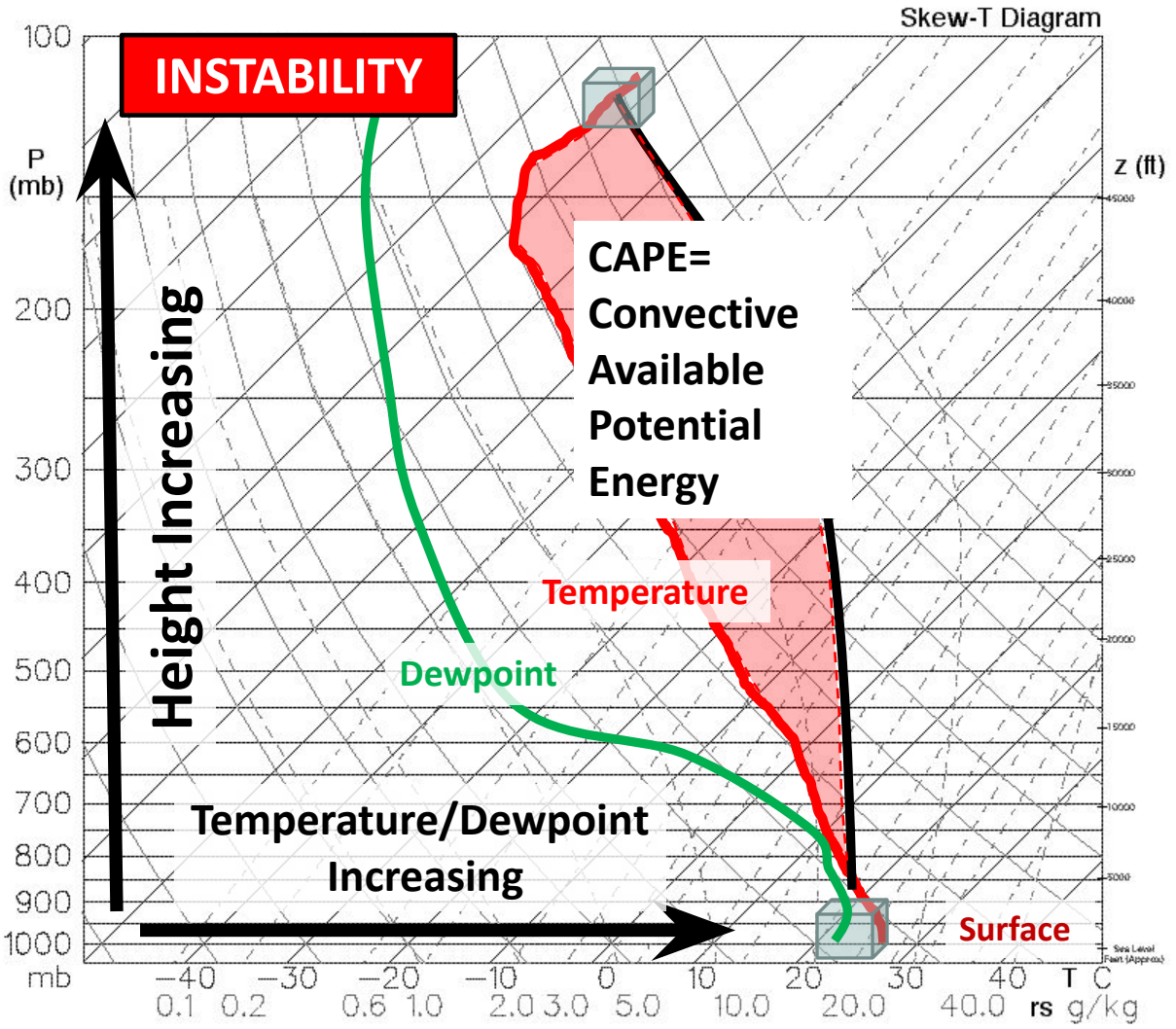
In basic terms, the instability of the atmosphere is measured based upon how warm it is at the surface versus how cold it is aloft.

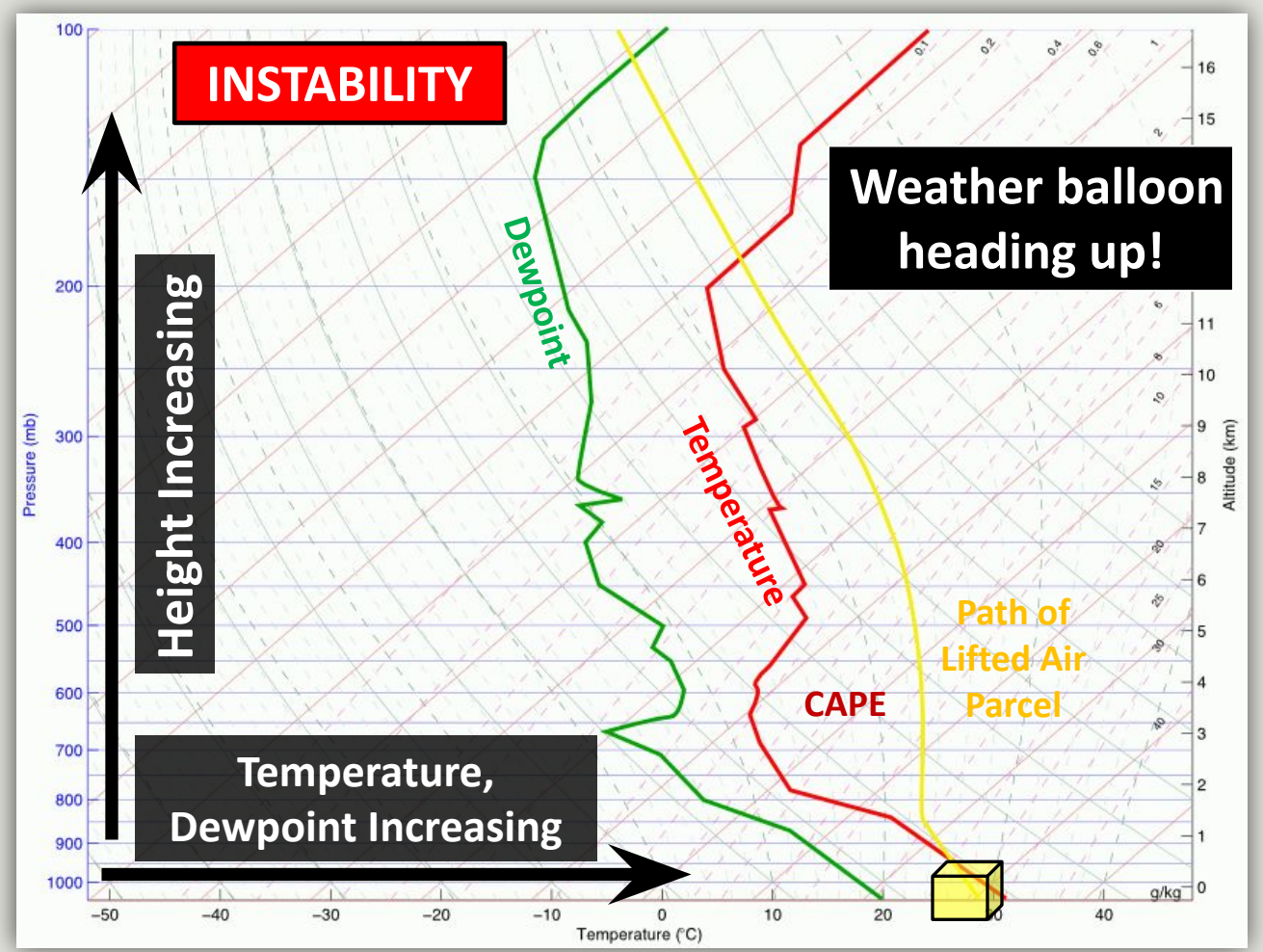
In general, the atmosphere gets colder as you go up.

During the summer, it is a lot hotter at the surface, but it also warm aloft

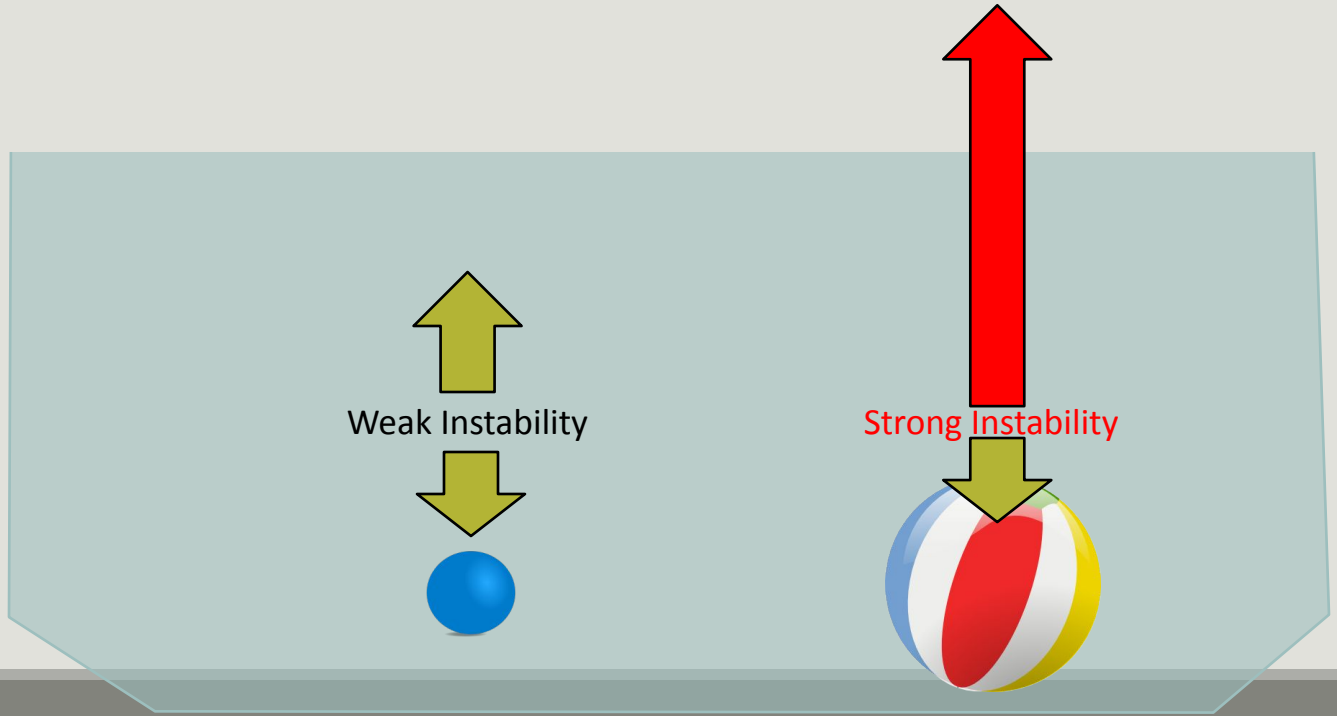
In the winter it is colder at the surface, but it is also colder in the upper atmosphere, as well.

How is the instability calculated?

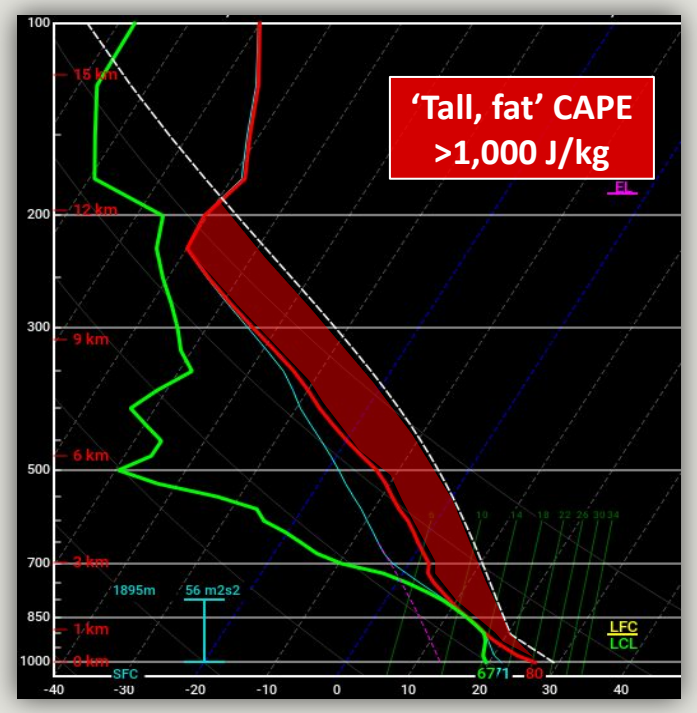

Skew-T Diagram
INSTABILITY
P (mb)
z (ft)
Height Increasing
CAPE= Convective Available Potential Energy
Temperature
Dewpoint
Temperature/Dewpoint Increasing
Surface
100
200
300
400
500
600
700
800
900
1000
mb
−40 −30 −20 −10 0 10 20 30 40 T C
0.1 0.2 0.6 1.0 2.0 3.0 5.0 10.0 20.0 40.0 rs g/kg

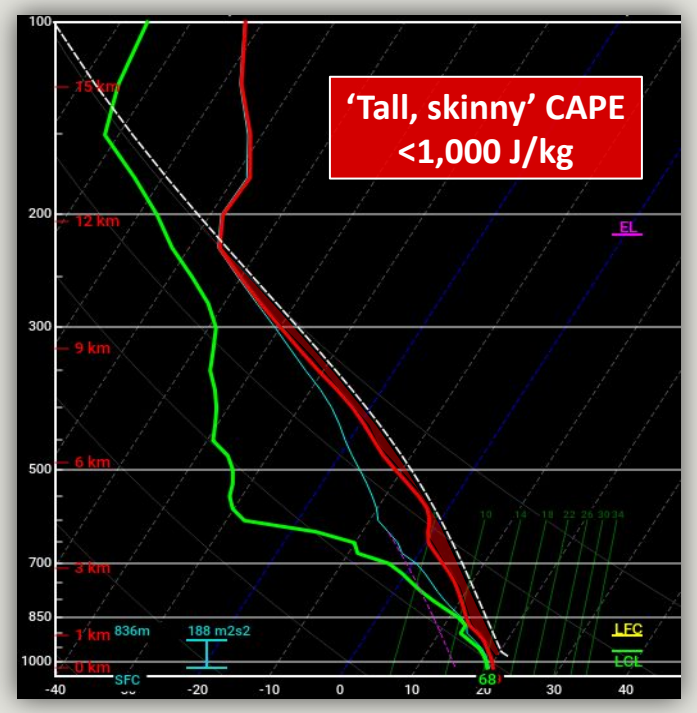

INSTABILITY
Weather balloon heading up!
Height Increasing
Temperature, Dewpoint Increasing
Dewpoint
Temperature
CAPE
Path of Lifted Air Parcel
Pressure (mb)
Temperature (°C)
Altitude (km)
g/kg

The 3-Dimensional Atmosphere
Instability

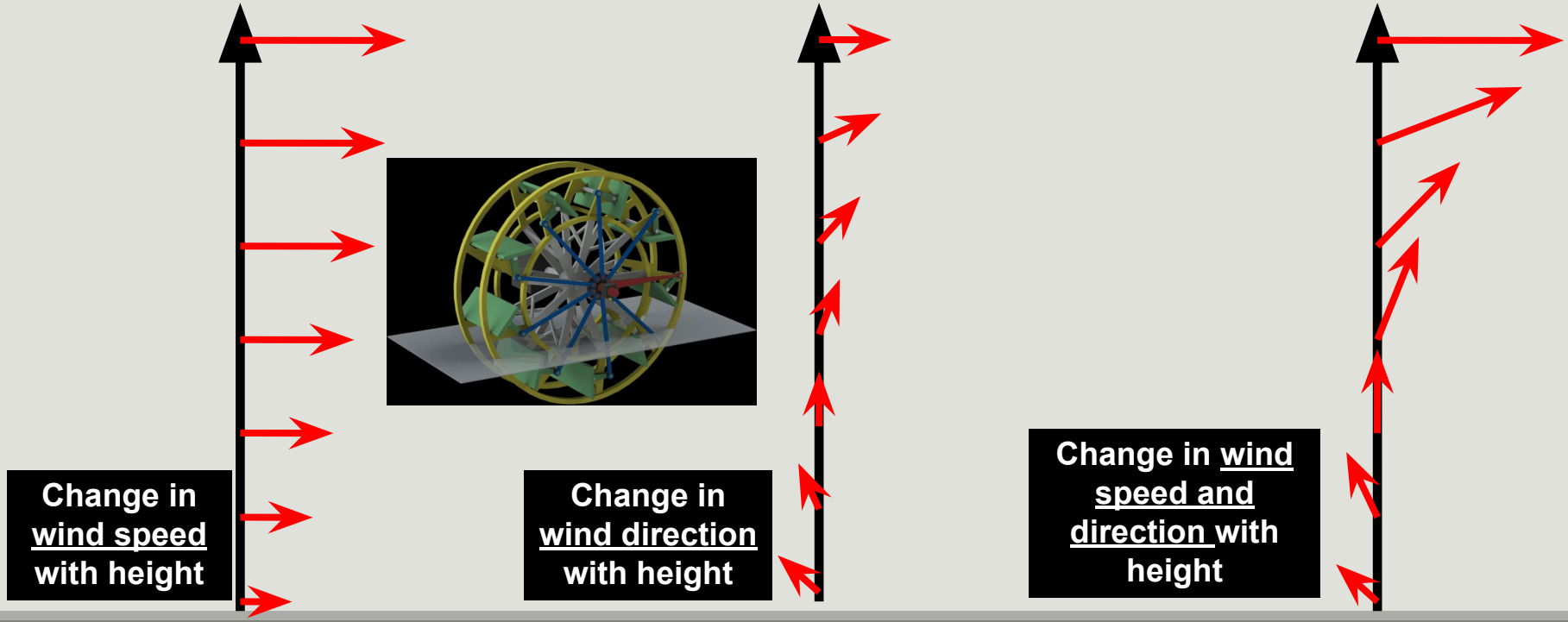


Instability - Weak vs. Strong CAPE

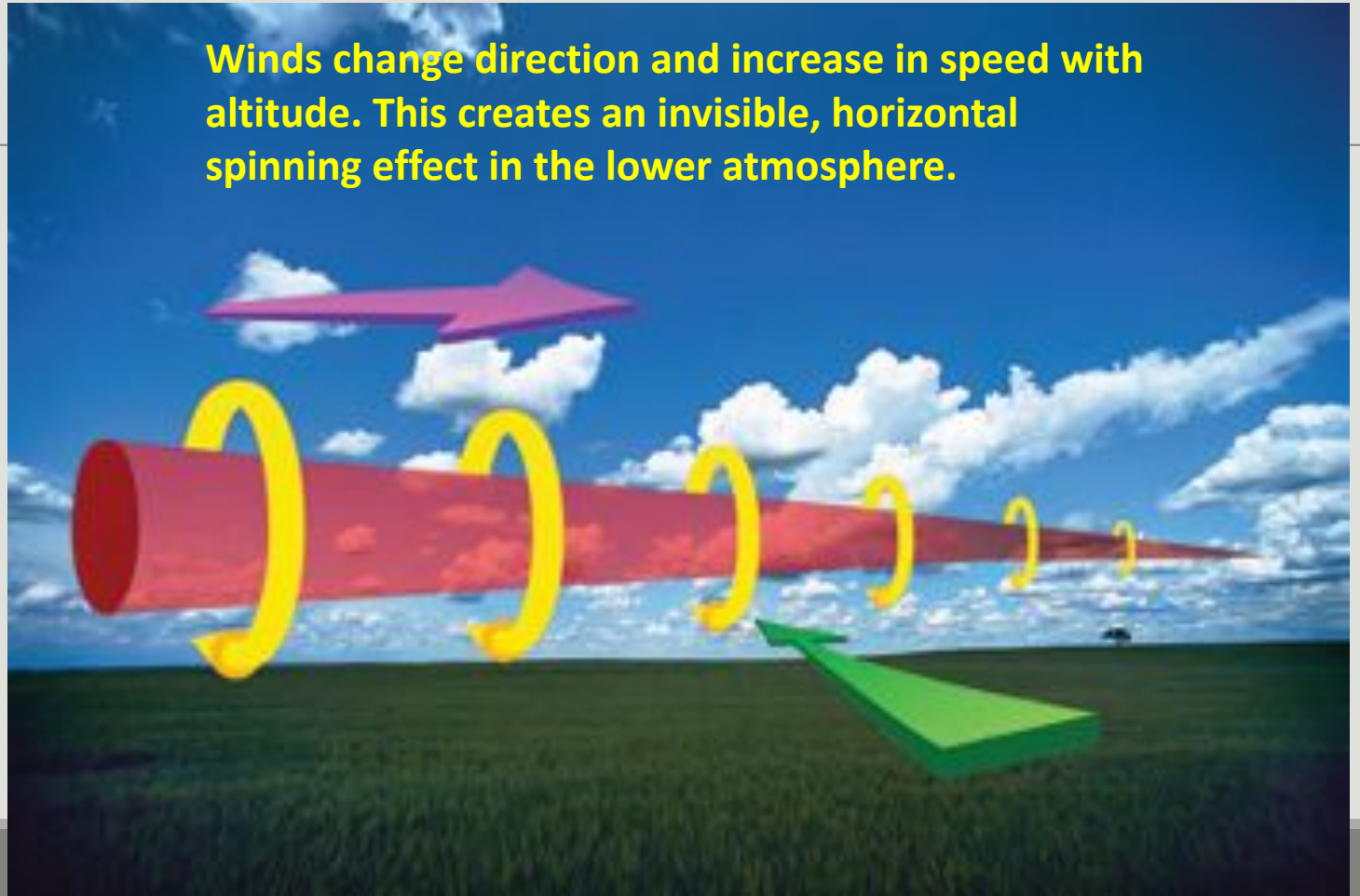




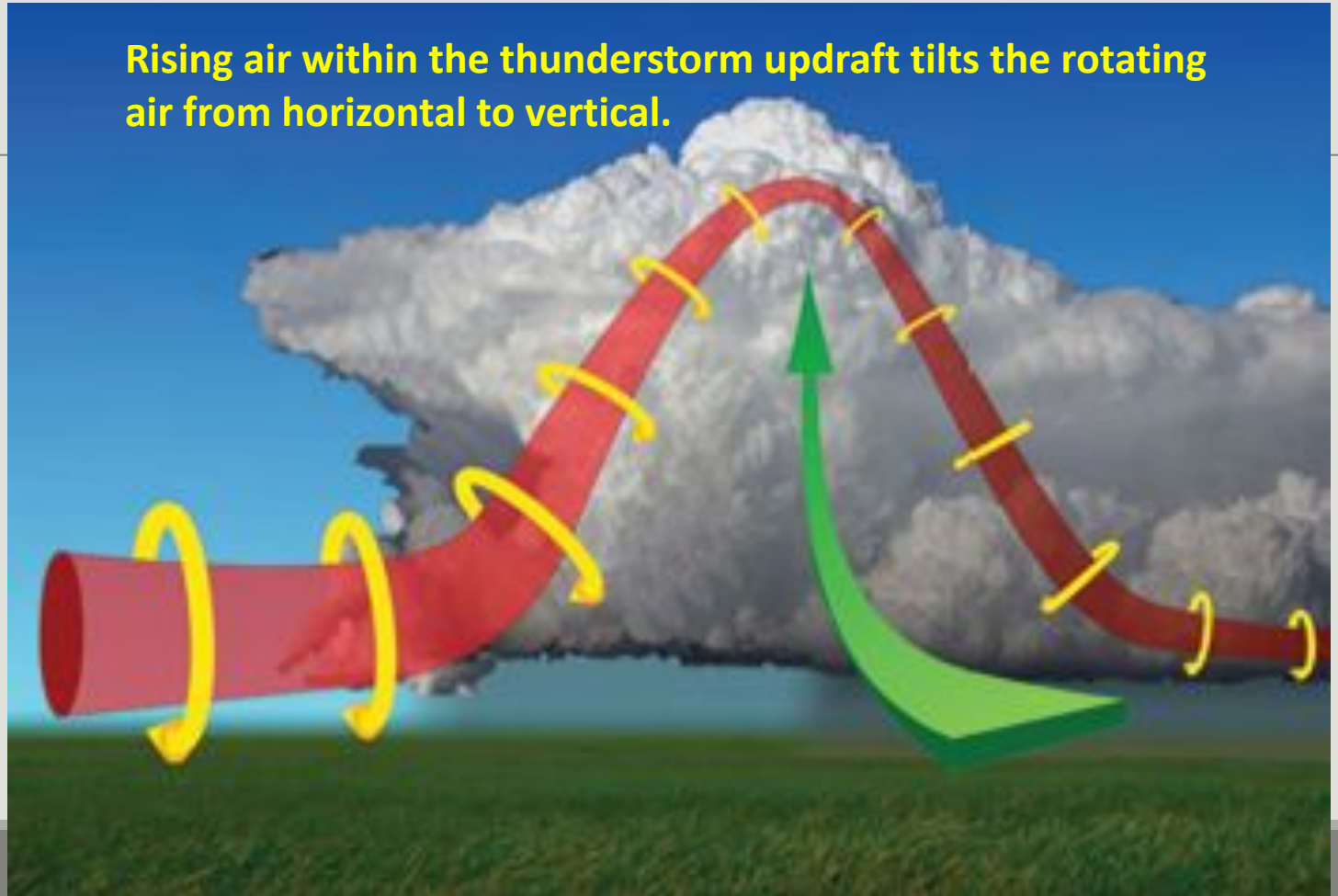
Wind Shear


Change in wind speed with height
Change in wind direction with height
Change in wind speed and direction with height

Wind Shear


Winds change direction and increase in speed with altitude. This creates an invisible, horizontal spinning effect in the lower atmosphere.

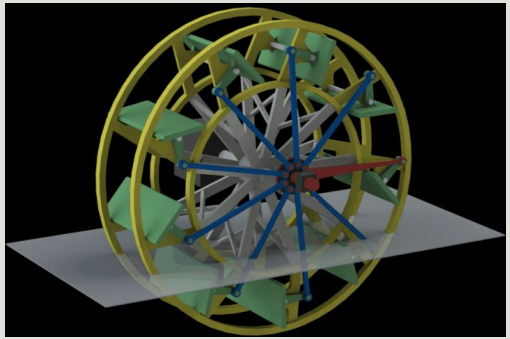
Wind Shear and Updraft



Mesocyclone Formation

Bulk Shear

- Difference in wind vectors (speed + direction) between 2 levels.
- >35 kts of bulk shear between the surface and 6 km above the surface means supercells can form.
  - *(if there is instability, lift, and moisture)*
- Wind shear between the surface and 3 km and surface and 1 km also important.



Storm Relative Helicity

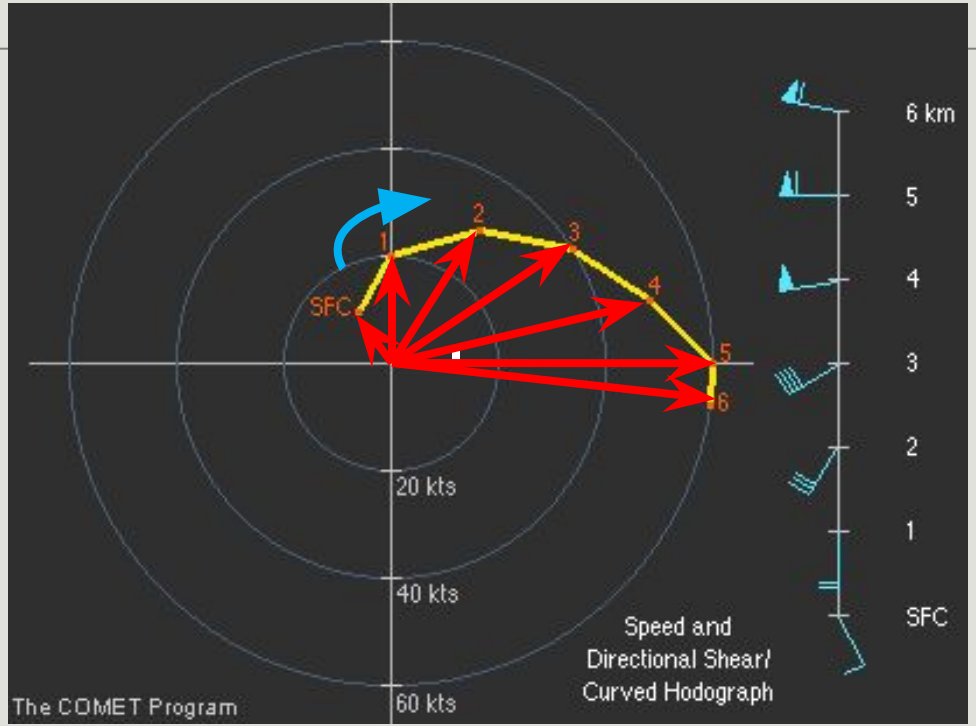
- Potential for updraft rotation
- Required for corkscrew/helix-shaped flow

Storm Relative Helicity

Indicator of streamwise vorticity (spin): football spiral

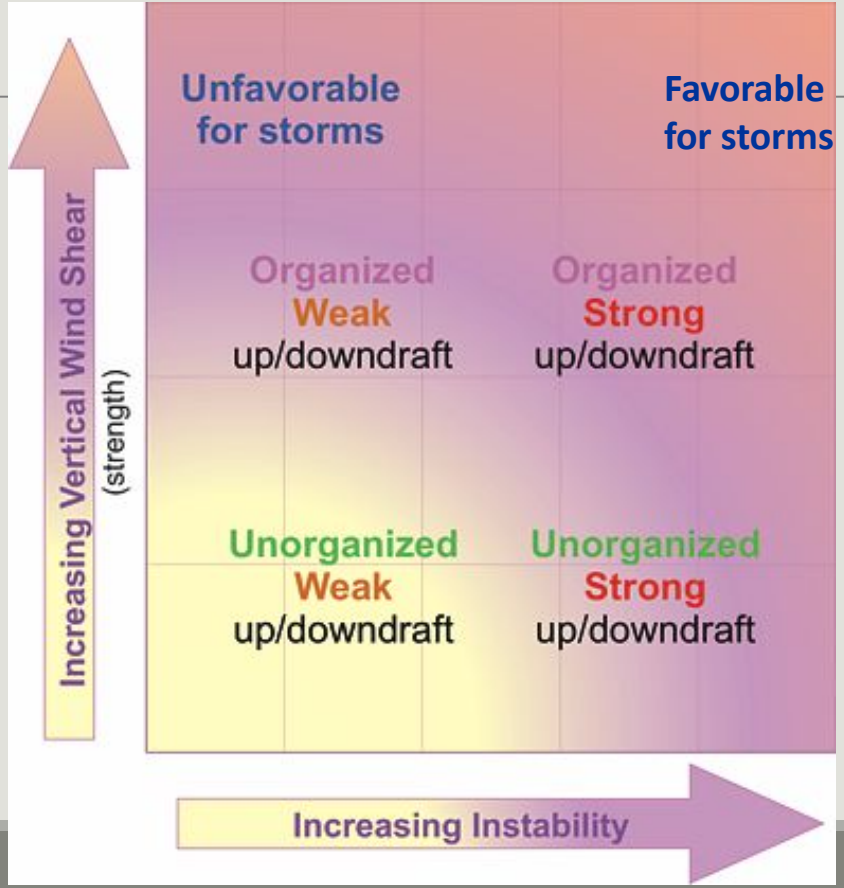
Instead of crosswise vorticity: frisbee

Storm-Relative Helicity



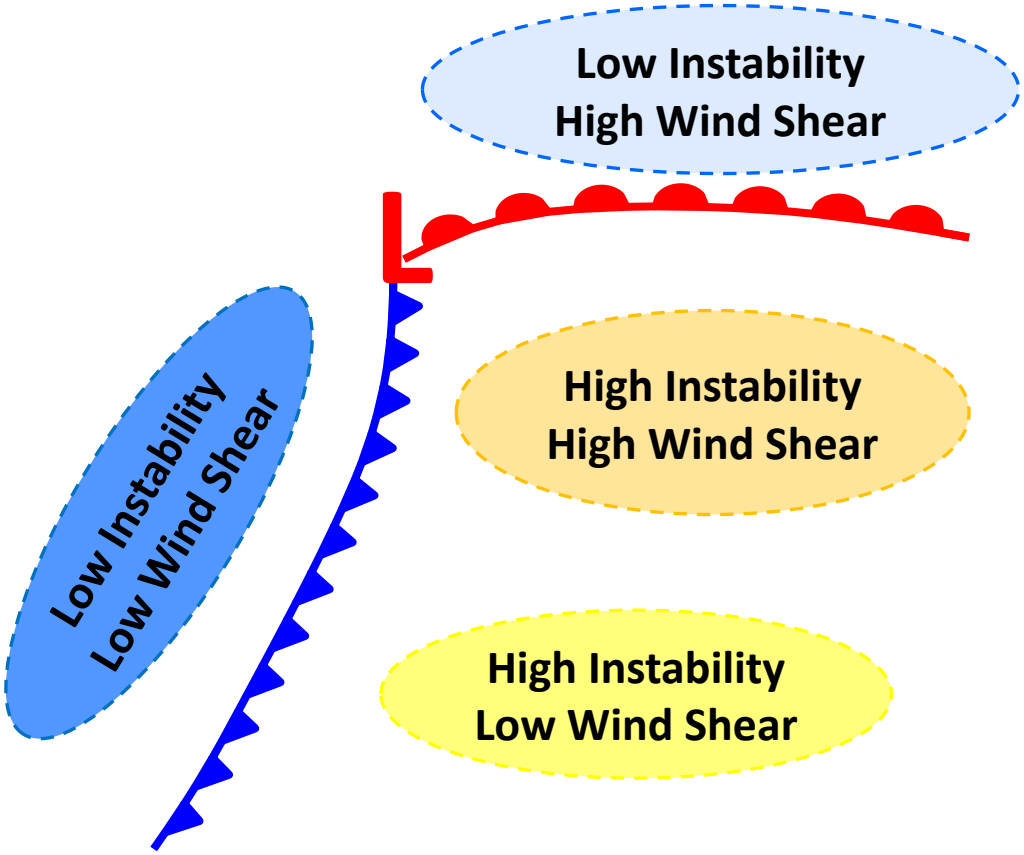
- Observed via a hodograph
- Wind vectors (length based on speed) drawn at multiple heights
- Hodograph connects the tips of these vectors
- Look for long hodograph (deep layer shear) and curved shape at low-levels (typically the left side)

Finding the Perfect Balance
Instability versus Wind Shear



Finding the perfect balance between instability and wind shear remains a forecast challenge.

All about the favorable mode of convection.



Typical surface low setup.

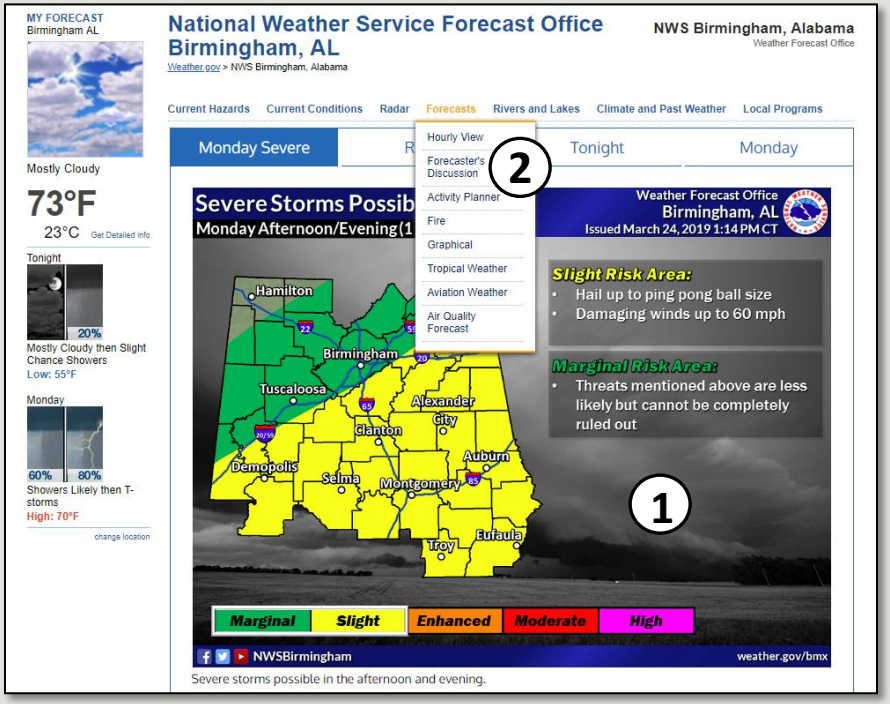
Lifting Condensation Level (LCL)

- Measure of height of cloud base
- Function of near-ground humidity—related to temperature-dew point difference
- Lower LCL = less humid environment = downdraft temperature won't be as cool relative to environment compared to if the LCL was high

Low LCL: favorable for tornadoes

High LCL: favorable for straight-line winds

weather.gov/bmx



2

--Slight Risk of severe storms Monday afternoon to evening w/ large hail and damaging wind potential--

A shortwave trough will move from the Midwest toward the Central Appalachian region on Monday while a secondary shortwave trough moves from the Southern Plains into the Southeastern CONUS. The secondary trough will be the primary factor in Monday's severe threat.

The primary forecast complication is with respect to upstream precipitation that is forecast to move into the northwestern part of the forecast area early morning Monday. It appears that this activity should begin weakening as it continues eastward, setting the stage for a lingering boundary/differential heating zone. As the secondary impulse arrives during ensuing daytime heating, we'll be looking at an increasingly unstable air mass with support for renewed convection. Pending this scenario, strong to severe storms could occur during the afternoon and evening hours.

Surface flow ahead of the associated cold front won't be ideal for rapid or significant recovery/advection of higher-dew point air, though guidance continues to agree with a corridor of upper 50s to around 60 dews arriving by/into the afternoon hours. This will coincide with peak daytime heating, aiding in ample surface-based and mixed-layer CAPE for strong to severe convection given bulk shear of ~40-50 knots. A look at forecast soundings across Central Alabama show a low-level inverted-V profile with steep lapse rates. This will support a risk of damaging winds up to 60 MPH. A plume of mid-level dry air moving into the base of the trough + some overlap of the convective area and leading edge colder 500mb temperatures will supply mid-level lapse rates in the mid-upper 6 degrees C range. This will support a risk of severe-caliber hail. Given the unidirectional flow, a tornado threat isn't evident at this time. Due to limited vertical moisture content and surface convergence, we shouldn't see a high number of severe-caliber storms.

Types of Tornado Warnings

```
BULLETIN - EAS ACTIVATION REQUESTED
Tornado Warning
National Weather Service Birmingham AL
158 PM CST SUN MAR 3 2019

The National Weather Service in Birmingham has issued a

* Tornado Warning for...
  Central Lee County in east central Alabama...
  Northwestern Russell County in southeastern Alabama...

* Until 245 PM CST.

* At 158 PM CST, a severe thunderstorm capable of producing a tornado
  was located near Tuskegee National Forest, or 9 miles south of
  Auburn, moving east at 60 mph.

  HAZARD...Tornado.

  SOURCE...Radar indicated rotation.

  IMPACT...Flying debris will be dangerous to those caught without
           shelter. Mobile homes will be damaged or destroyed.
           Damage to roofs, windows, and vehicles will occur.  Tree
           damage is likely.

* Locations impacted include...
  Auburn, Phenix City, Opelika, Smiths, Smiths Station, Ladonia,
  Beauregard, Bleecker, Griffen Mill, Bibb City, Monterey Heights,
  Chewacla State Park, Ladonia Sports Complex, Marvyn and Bartletts
  Ferry Dam.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

TAKE COVER NOW! Move to a basement or an interior room on the lowest
floor of a sturdy building. Avoid windows. If you are outdoors, in a
mobile home, or in a vehicle, move to the closest substantial shelter
and protect yourself from flying debris.

&&

LAT...LON 3239 8544 3250 8544 3250 8549 3253 8556
      3268 8511 3267 8509 3265 8509 3265 8511
      3263 8508 3262 8509 3258 8507 3251 8500
      3249 8499 3247 8500 3245 8499
TIME...MOT...LOC 1958Z 252DEG 53KT 3246 8552

TORNADO...RADAR INDICATED
HAIL...<.75IN

$$
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Severe Weather Statement
National Weather Service Birmingham AL
207 PM CST SUN MAR 3 2019

ALC081-113-032045-
/O.CON.KBMX.TO.W.0023.000000T0000Z-190303T2045Z/
Lee AL-Russell AL-
207 PM CST SUN MAR 3 2019

...A TORNADO WARNING REMAINS IN EFFECT UNTIL 245 PM CST FOR CENTRAL
LEE AND NORTHWESTERN RUSSELL COUNTIES...

At 206 PM CST, a confirmed large and extremely dangerous tornado was
located near Society Hill, or 10 miles southeast of Auburn, moving
east at 55 mph.

This is a PARTICULARLY DANGEROUS SITUATION. TAKE COVER NOW!

HAZARD...Damaging tornado.

SOURCE...Radar confirmed tornado.

IMPACT...You are in a life-threatening situation. Flying debris may
         be deadly to those caught without shelter. Mobile homes
         will be destroyed. Considerable damage to homes,
         businesses, and vehicles is likely and complete destruction
         is possible.

Locations impacted include...
Auburn, Phenix City, Opelika, Smiths, Smiths Station, Ladonia,
Beauregard, Bleecker, Griffen Mill, Bibb City, Monterey Heights,
Chewacla State Park, Ladonia Sports Complex, Marvyn and Bartletts
Ferry Dam.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

To repeat, a large, extremely dangerous and potentially deadly
tornado is on the ground. To protect your life, TAKE COVER NOW! Move
to a basement or an interior room on the lowest floor of a sturdy
building. Avoid windows. If you are outdoors, in a mobile home, or in
a vehicle, move to the closest substantial shelter and protect
yourself from flying debris.

&&

LAT...LON 3239 8544 3250 8544 3250 8549 3253 8556
      3268 8511 3267 8509 3265 8509 3265 8511
      3263 8508 3262 8509 3258 8507 3251 8500
      3249 8499 3247 8500 3245 8499
TIME...MOT...LOC 2006Z 258DEG 48KT 3247 8538

TORNADO...OBSERVED
TORNADO DAMAGE THREAT...CONSIDERABLE
HAIL...<.75IN
```

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Severe Weather Statement
National Weather Service Birmingham AL
209 PM CST SUN MAR 3 2019

ALC081-113-032045-
/O.CON.KBMX.TO.W.0023.000000T0000Z-190303T2045Z/
Lee AL-Russell AL-
209 PM CST SUN MAR 3 2019

...TORNADO EMERGENCY FOR southern Lee County and northern Russell
County...

...A TORNADO WARNING REMAINS IN EFFECT UNTIL 245 PM CST FOR
SOUTHEASTERN LEE AND NORTHWESTERN RUSSELL COUNTIES...

At 209 PM CST, a confirmed large and destructive tornado was located
near Griffen Mill, or 11 miles southeast of Auburn, moving east at 60
mph.

TORNADO EMERGENCY for southern Lee County and northern Russell
County. This is a PARTICULARLY DANGEROUS SITUATION. TAKE COVER NOW!

HAZARD...Deadly tornado.

SOURCE...Radar confirmed tornado.

IMPACT...You are in a life-threatening situation. Flying debris may
         be deadly to those caught without shelter. Mobile homes
         will be destroyed. Considerable damage to homes,
         businesses, and vehicles is likely and complete destruction
         is possible.

Locations impacted include...
Phenix City, Smiths, Smiths Station, Ladonia, Bleecker, Griffen Mill,
Bibb City, Monterey Heights, Ladonia Sports Complex, Marvyn and
Bartletts Ferry Dam.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

To repeat, a large, extremely dangerous, and potentially deadly
tornado is on the ground. To protect your life, TAKE COVER NOW! Move
to an interior room on the lowest floor of a sturdy building. Avoid
windows. If in a mobile home, a vehicle or outdoors, move to the
closest substantial shelter and protect yourself from flying debris.

&&

LAT...LON 3242 8540 3250 8544 3268 8511 3267 8509
      3265 8509 3265 8511 3263 8508 3262 8509
      3258 8507 3251 8500 3249 8499 3247 8500
      3245 8499
TIME...MOT...LOC 2009Z 252DEG 53KT 3248 8533

TORNADO...OBSERVED
TORNADO DAMAGE THREAT...CATASTROPHIC
HAIL...<.75IN
```

Halftime! 10-minute Break

⚠ Severe Thunderstorm Criteria ⚠

Any combination of:

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

Other hazards:

- Lightning
- Flooding

Understanding Severe Thunderstorm Outlook Categories

General Thunder	1 Marginal (MRGL)	2 Slight (SLGT)	3 Enhanced (ENH)	4 Moderate (MDT)	5 High (HIGH)
Severe* Storms are not expected Any thunderstorms could still produce gusty winds and small hail	**Severe storms will produce hail, damaging winds and/or possibly tornadoes**	**Severe storms will produce hail, damaging winds, and/or tornadoes**	**Several severe storms will produce very large hail, damaging winds, and/or tornadoes**	**Many severe storms will produce very large hail, damaging winds, and/or tornadoes**	**Severe storm outbreak will produce tornadoes, damaging winds, and/or very large hail**
	Isolated Severe Storms are Possible	Isolated to Scattered Severe Storms are Expected	Scattered to Numerous Severe Storms are Expected	Scattered to Numerous Severe Storms are Expected	Numerous Severe Storms are Expected

w w w . w e a t h e r . g o v

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.

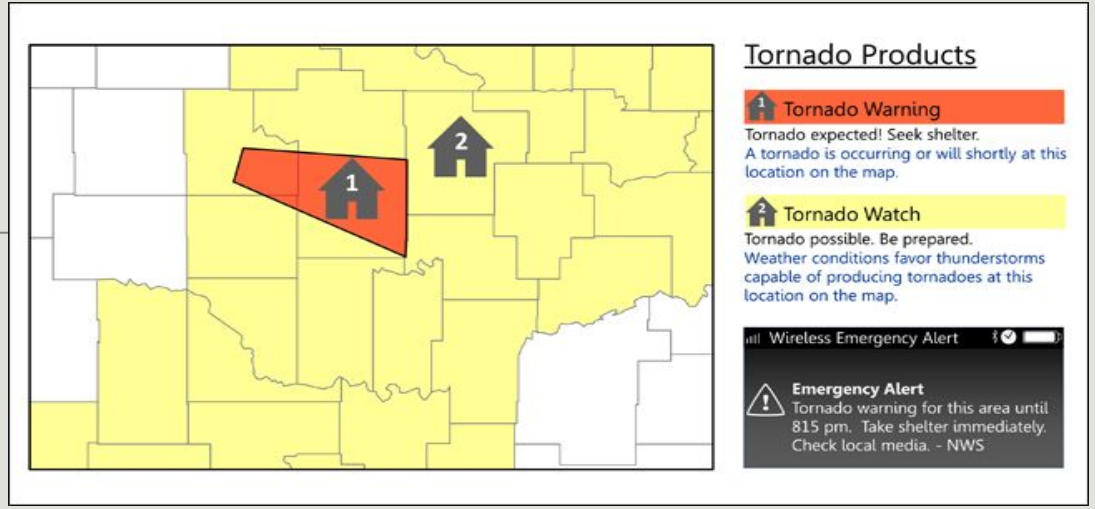
*NWS defines a severe thunderstorm as measured wind gusts of at least 58 mph, and/or hail of at least one inch in diameter, and/or a tornado.

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

Watch vs. Warning

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

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



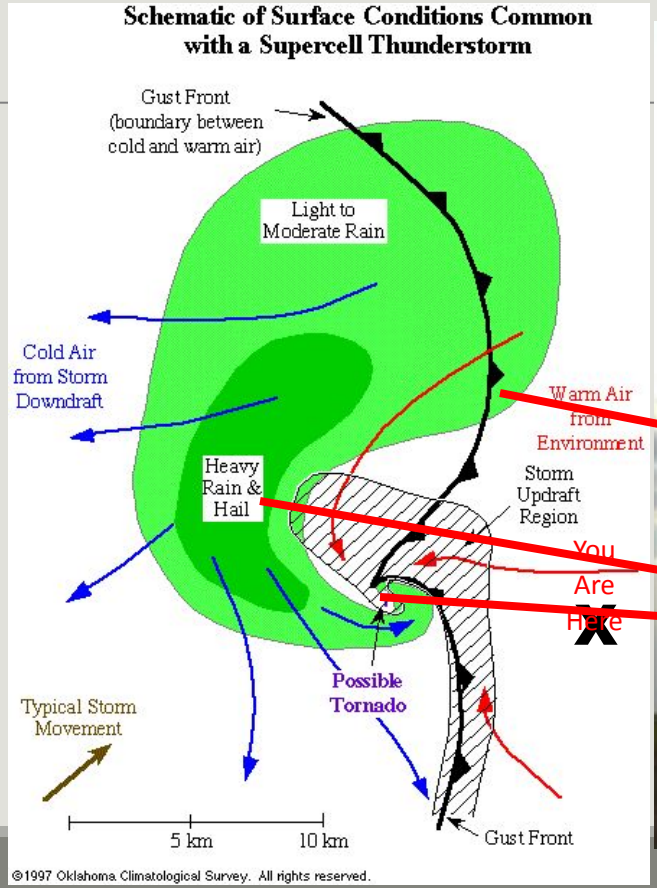
What to Report

- **Strong or damaging winds** (Details about any damage. Estimated or measured wind?)
- **Hail** (Measure with a ruler or reference a common item such as a coin or sports ball)
- **Flooding** (≥ 6” in depth. Is the water standing or flowing? Are lives or property in danger? Rapidly rising waterways?)
- **Rotating wall cloud, funnel cloud, or tornado** (What is the distance and direction from your location? More on these features coming up.)

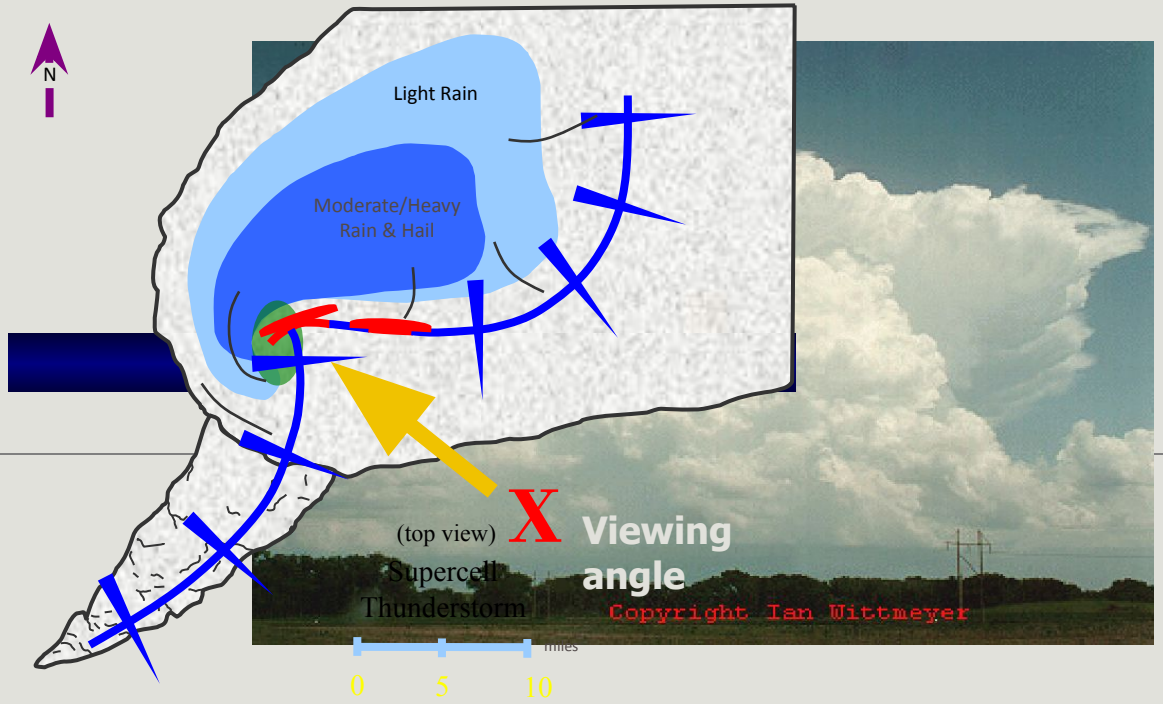
Do not relay reports of what you are seeing/hearing on television or on your app.



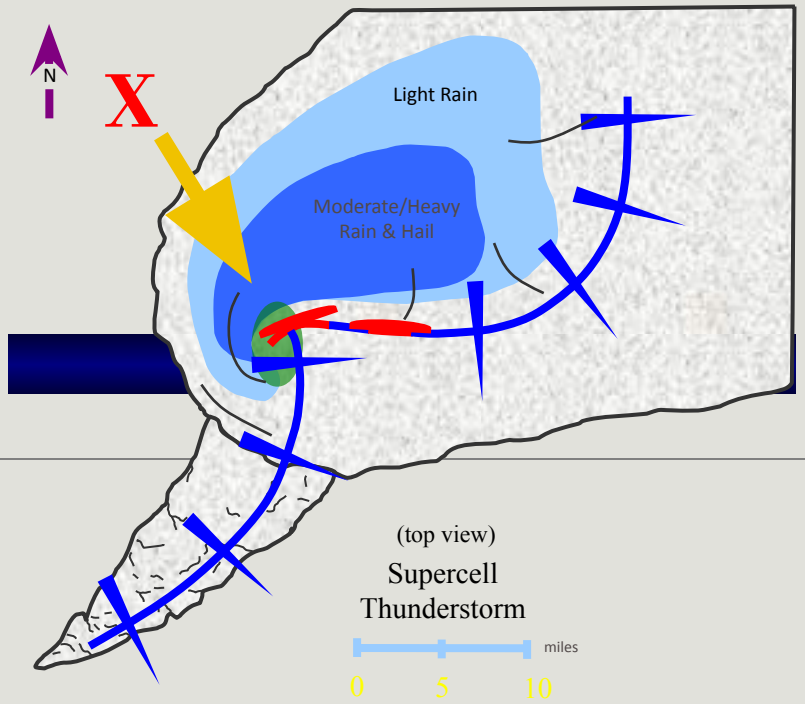

What We Observe When Spotting Supercell



Spotter Location

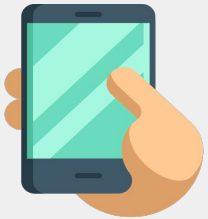


NOT Ideal Spotter Location



Wall Cloud -> Tornado Evolution

Ways to Report to the NWS

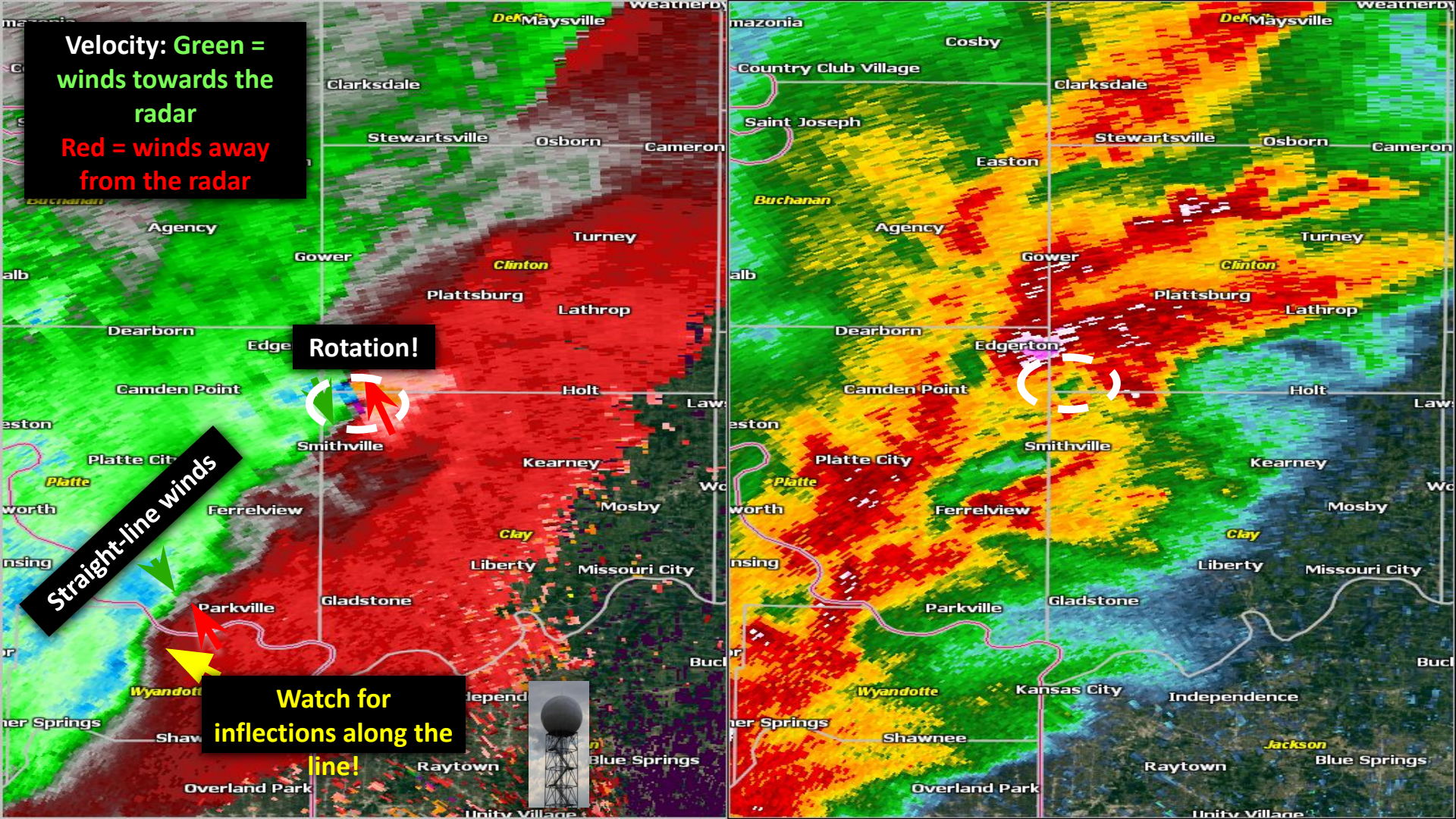


Phone
(205-664-3010, option 2)

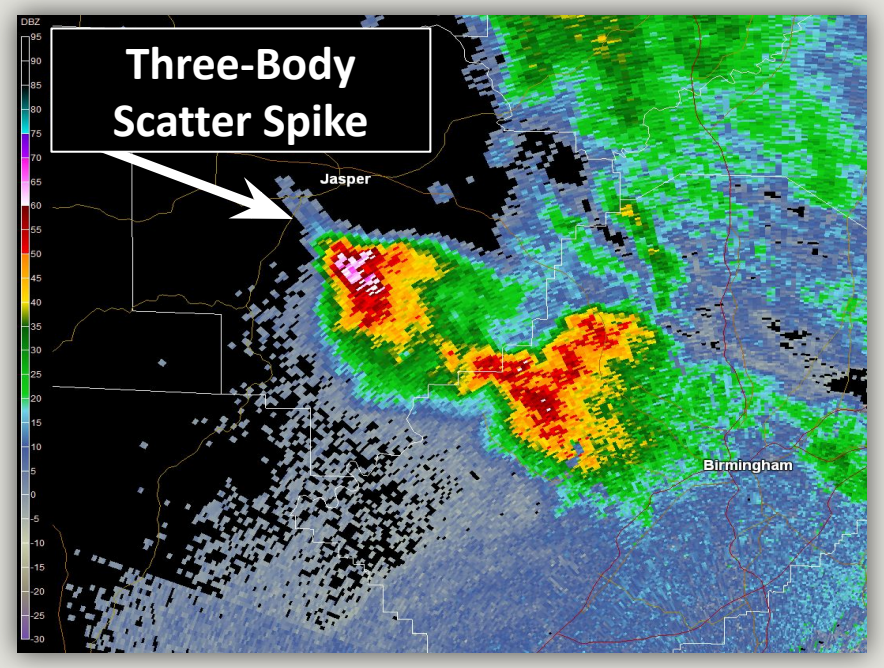
Twitter and Facebook
Direct message or tag us
Also use #alwx

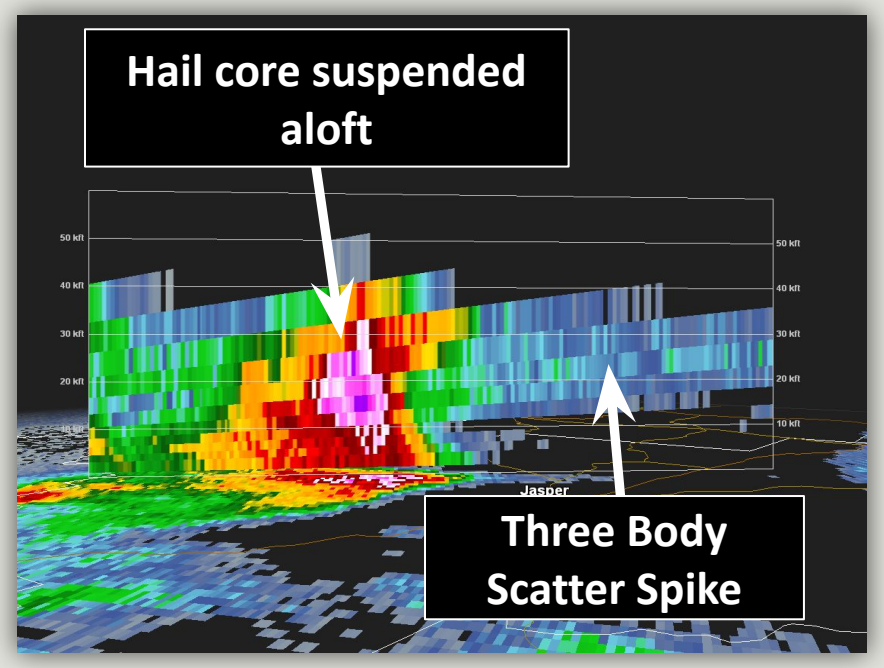
weather.gov/bmx/submitstormreport

Amateur radio K4NWS (Alabama Emergency Response Team)


Velocity: Green = winds towards the radar
Red = winds away from the radar
Rotation!
Straight-line winds
Watch for inflections along the line!
Maysville
Clarksdale
Stewartsville
Osborn
Cameron
Agency
Turney
Gower
Clinton
Plattsburg
Lathrop
Dearborn
Edgerton
Camden Point
Holt
Smithville
Platte City
Kearney
Ferrelview
Mosby
Clay
Liberty
Missouri City
Gladstone
Parkville
Wyandotte
Kansas City
Independence
Shawnee
Raytown
Blue Springs
Overland Park
Cosby
Country Club Village
Saint Joseph
Easton
Buchanan
Jackson

Three Body Scatter Spike > Large Hail

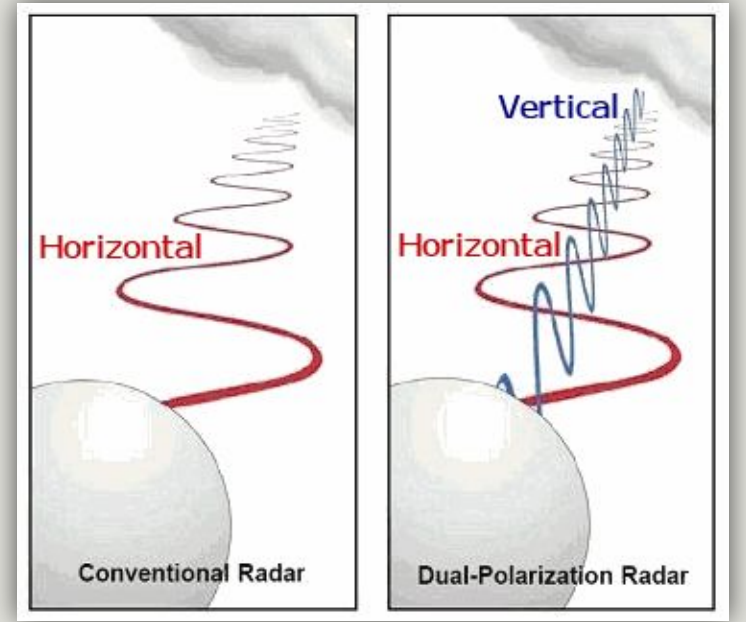


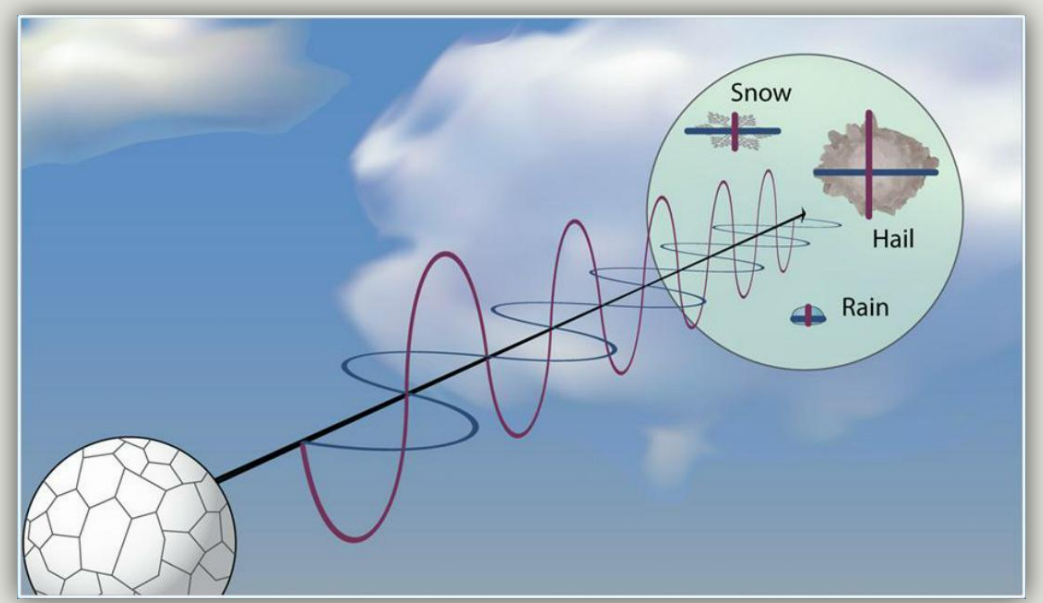


Hailstone size	Measurement		Updraft Speed	
	in.	cm.	mph	km/h
bb	< 1/4	< 0.64	< 24	< 39
pea	1/4	0.64	24	39
	1/2	1.3	35	56
dime	7/10	1.8	38	61
penny	3/4	1.9	40	64
nickel	7/8	2.2	46	74
quarter	1	2.5	49	79
half dollar	1 1/4	3.2	54	87
walnut	1 1/2	3.8	60	97
golf ball	1 3/4	4.4	64	103
hen egg	2	5.1	69	111
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

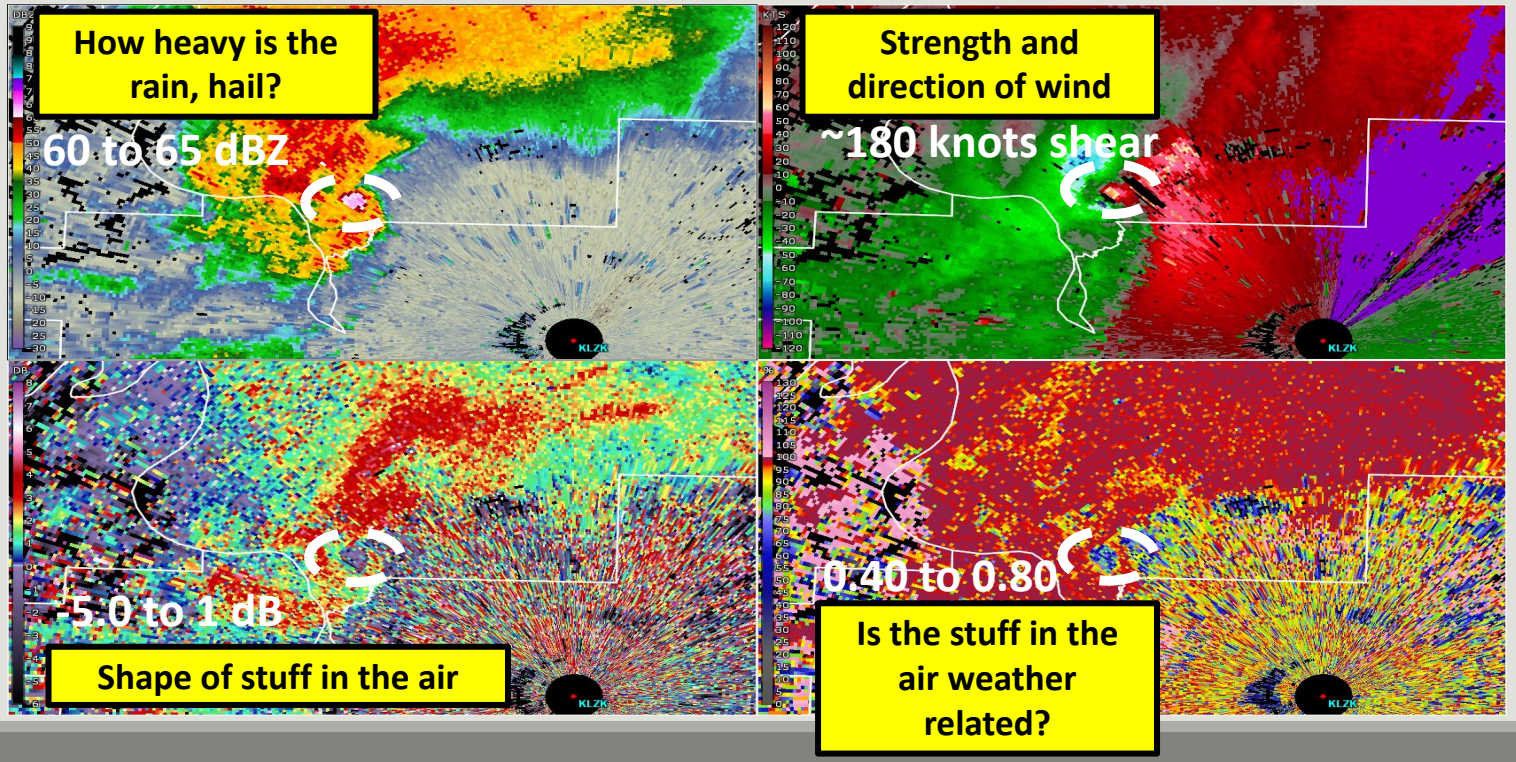
Vertical Wind Speed for Different Hail Sizes (updraft speeds)

Dual-polarization Radar





Confirming Tornado Debris on RADAR

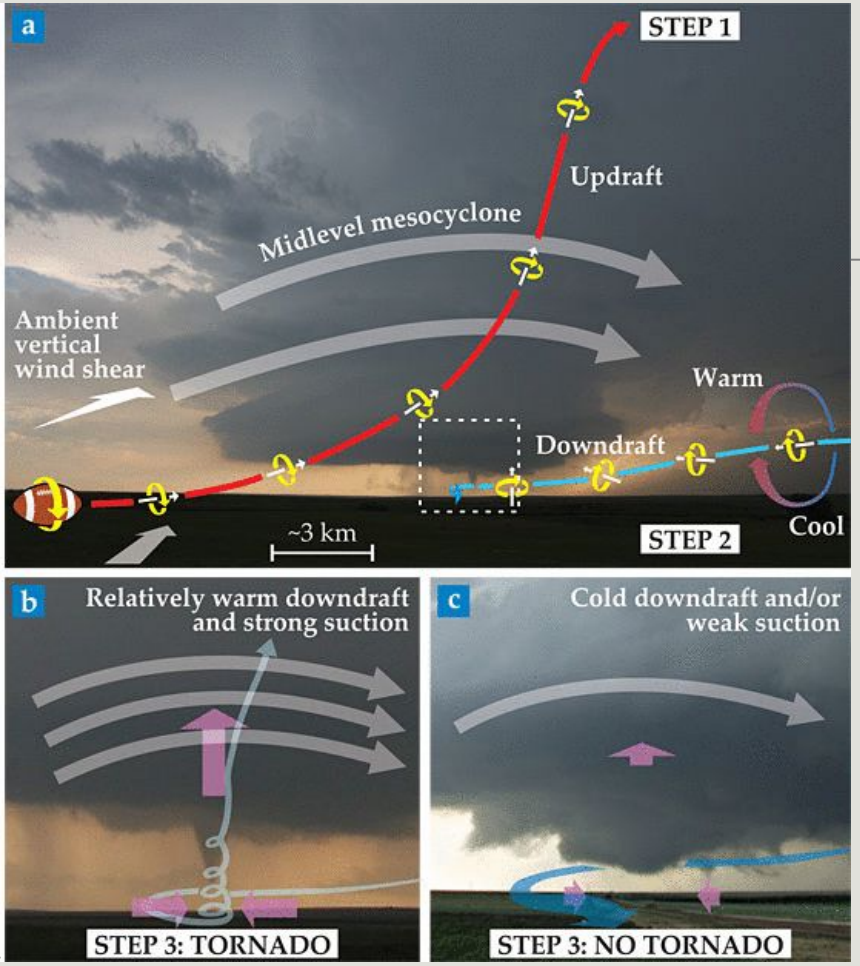


BEWARE: Not all ‘Blue’ on CC is Tornado Debris!
--This takes a trained eye--

It could be…

- Contaminants in the inflow region
- Hail
- Noise in the data
- Non-uniform beam filling
- Terrain, communication towers, buildings, wind farms, etc.

At minimum we must use a combination of reflectivity, velocity, and CC + RADAR scans over time and depth.



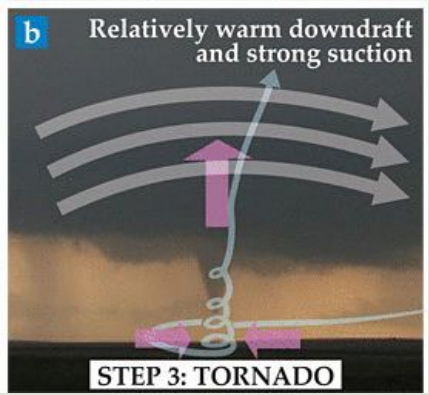
Markowski and Richardson 2014

Tornado pet peeves

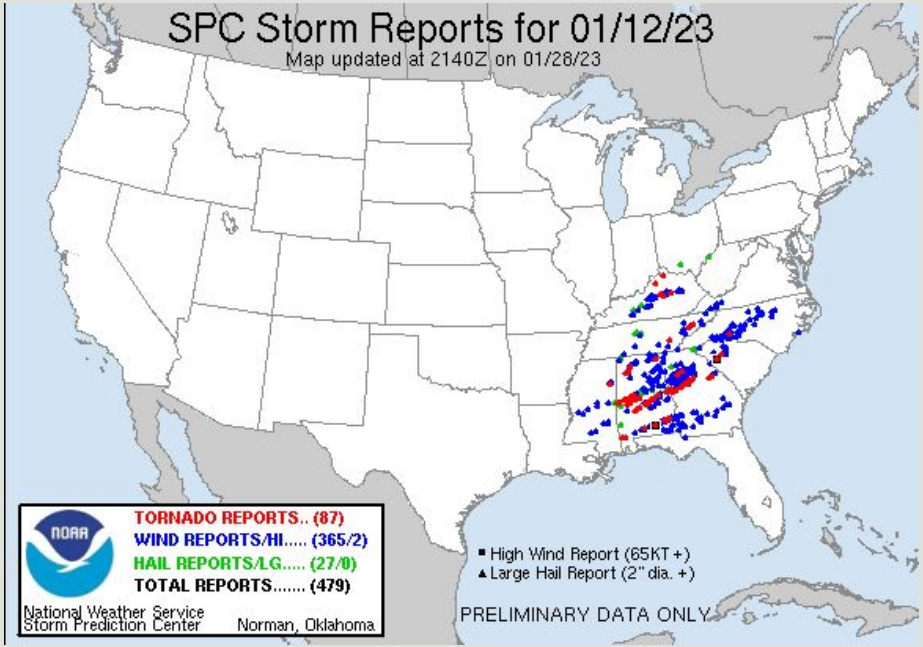
Tornadoes do not actually “touch down” and “lift”, they “spin up” and “dissipate”.

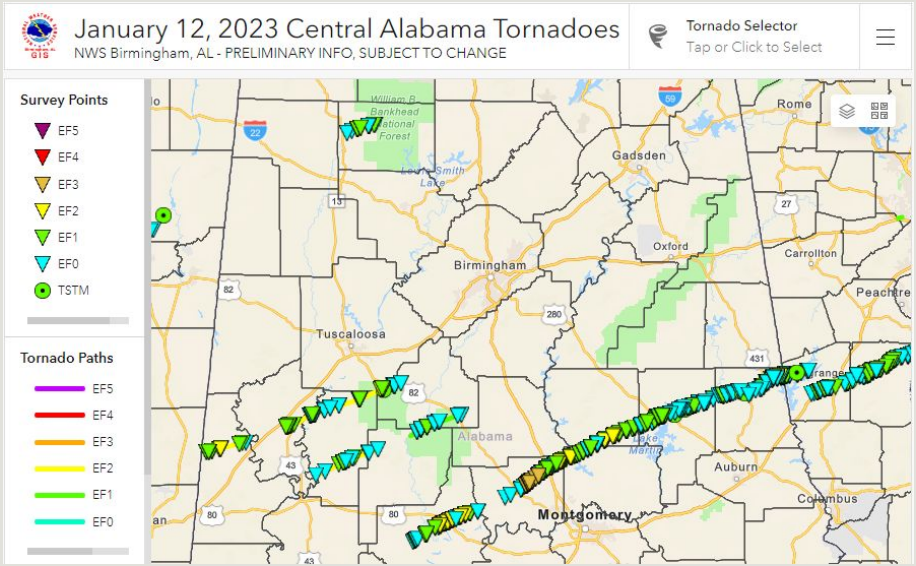
“The tornado was up in the tree tops but not on the ground”

- Weakest part of the tree is the top



January 12, 2023 Case Review (Multiple strong long track tornadoes)

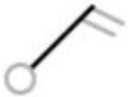




Observed wind speed	0-2 kts (0-2 mph)	3-7 kts (3-8 mph)	8-12 kts (9-14 mph)	13-17 kts (15-20 mph)	18-22 kts (21-25 mph)	23-27 kts (26-31 mph)	28-32 kts (32-37 mph)	33-37 kts (38-43 mph)	48-52 kts (55-60 mph)	53-57 kts (61-66 mph)	58-62 kts (67-71 mph)
Rounded to the nearest 5	0 kts	5 kts	10 kts	15 kts	20 kts	25 kts	30 kts	35 kts	50 kts	55 kts	60 kts
Plotted as											

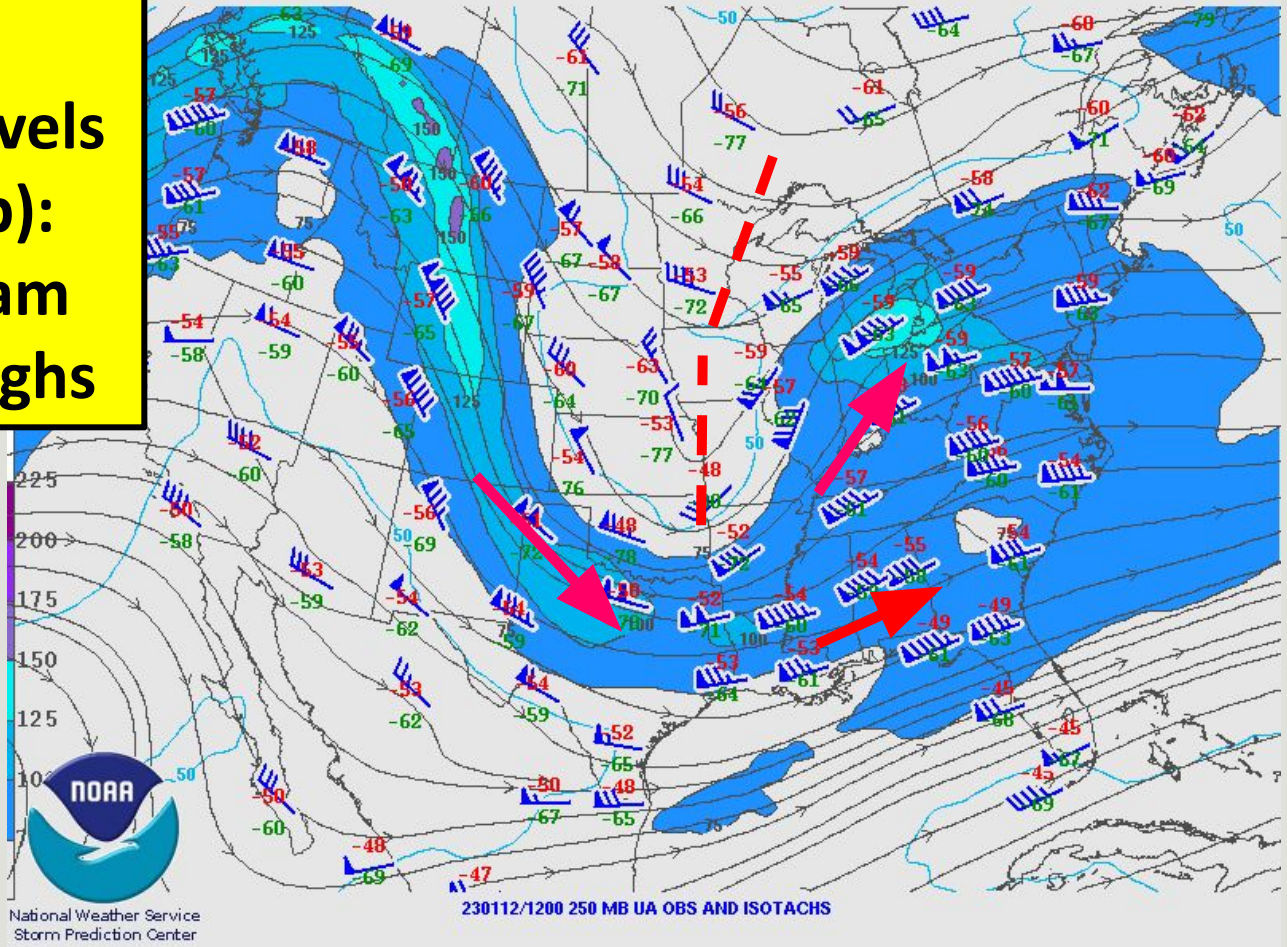
Wind FROM 340° (NNW)

Wind FROM 040° (NE)



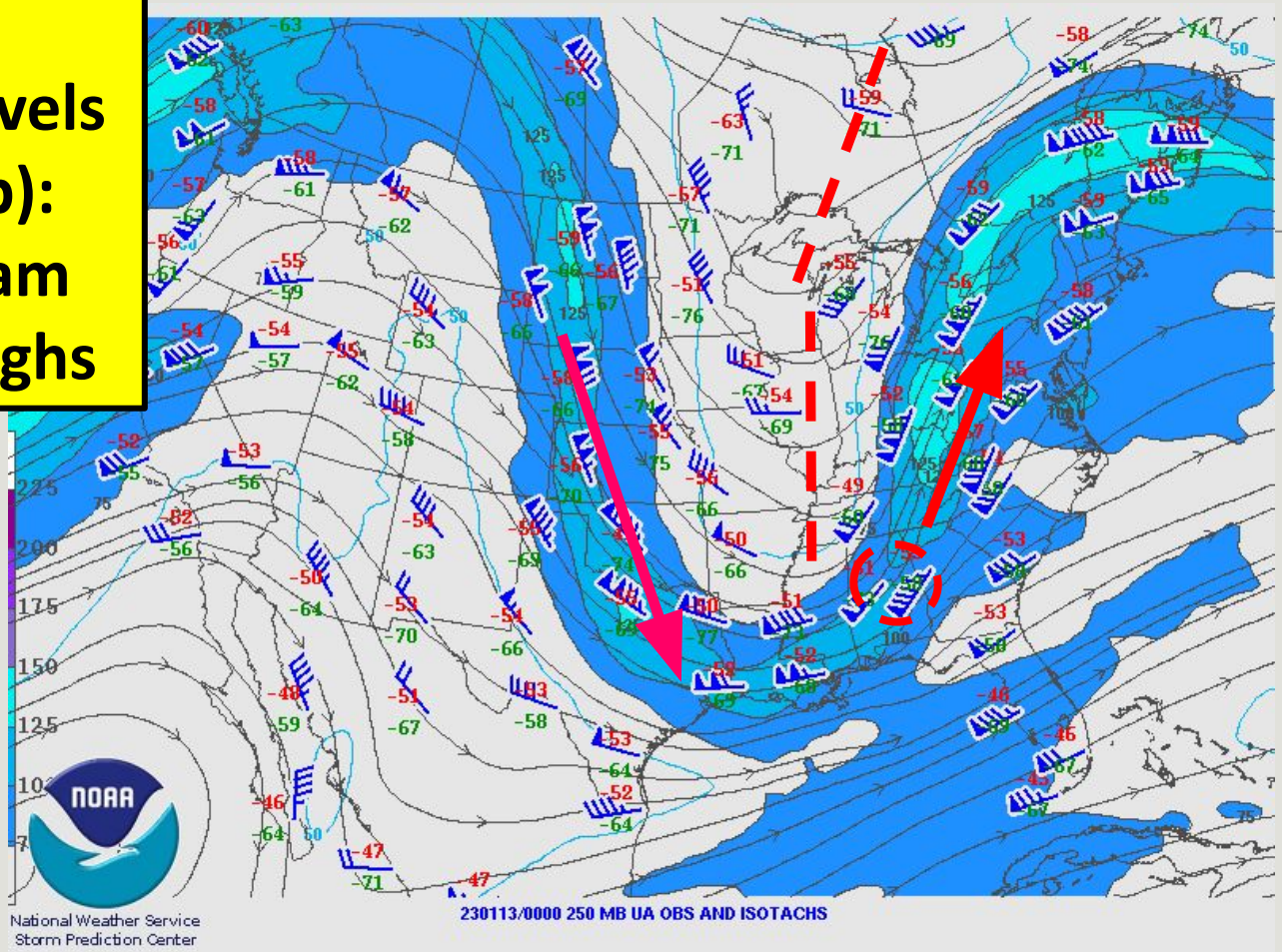
Wind FROM 190° (S)

6a: Upper-levels (250mb): jet stream and troughs

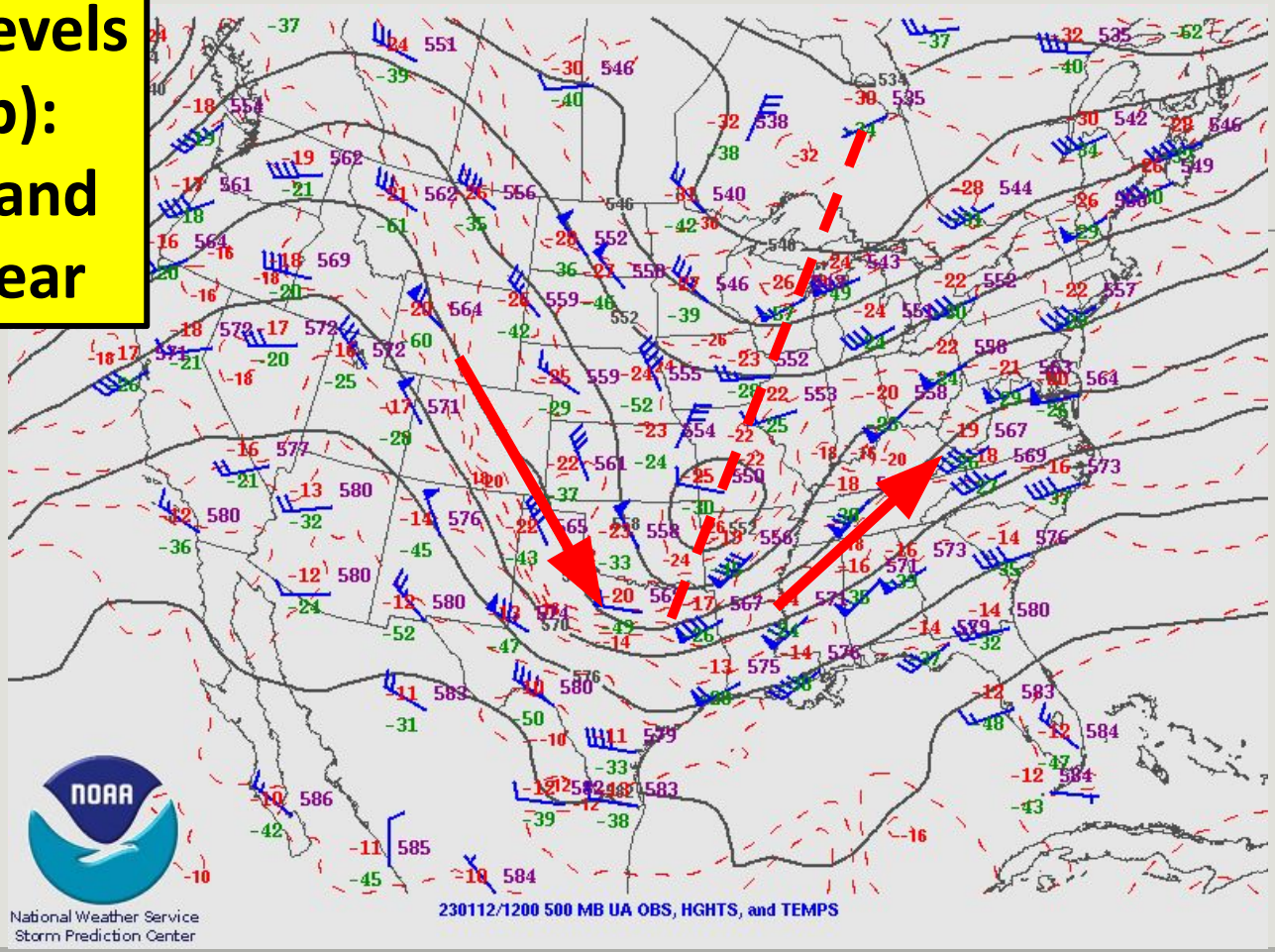


https://www.spc.noaa.gov/obswx/maps/

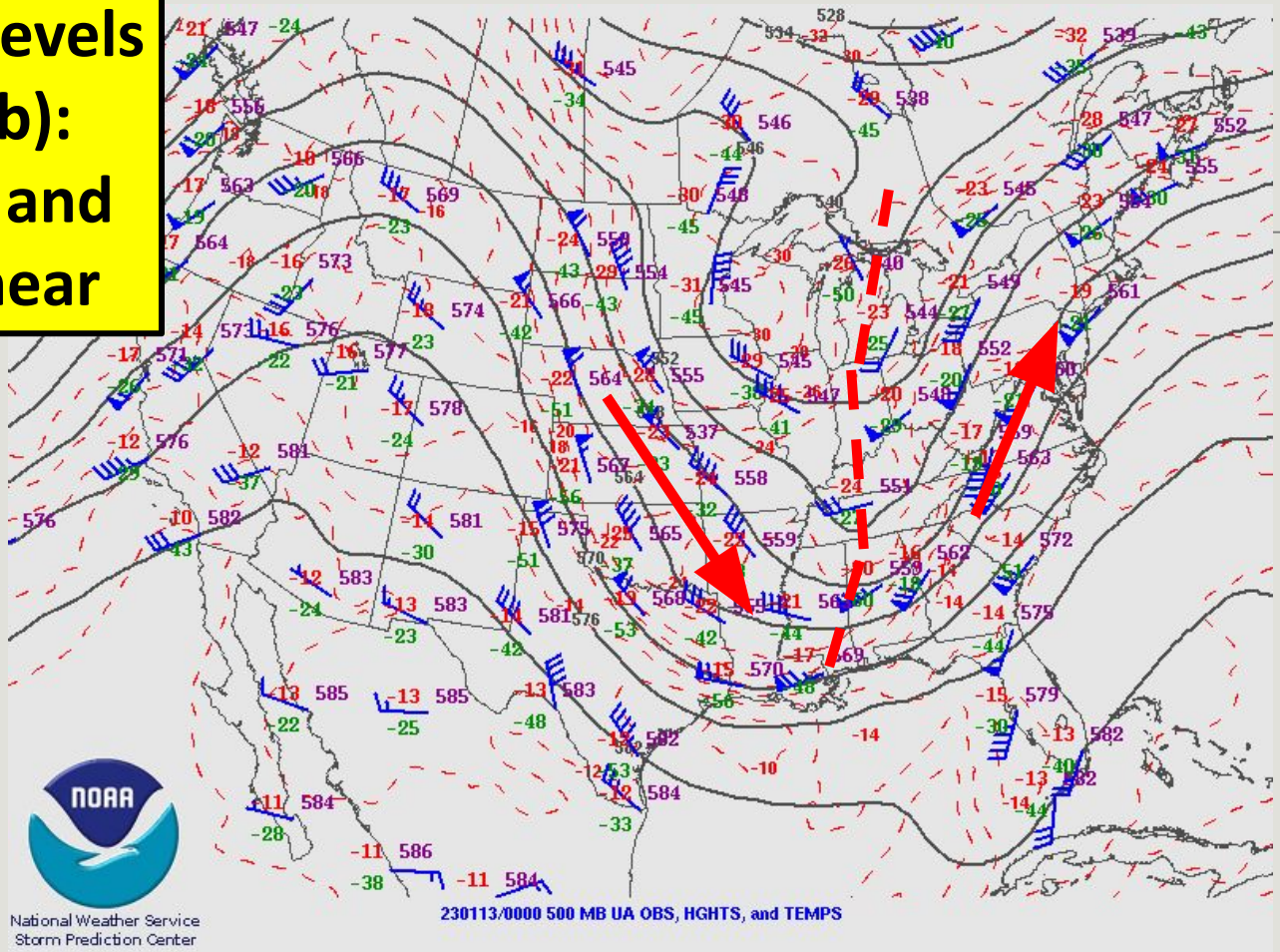
6p: Upper-levels (250mb): jet stream and troughs



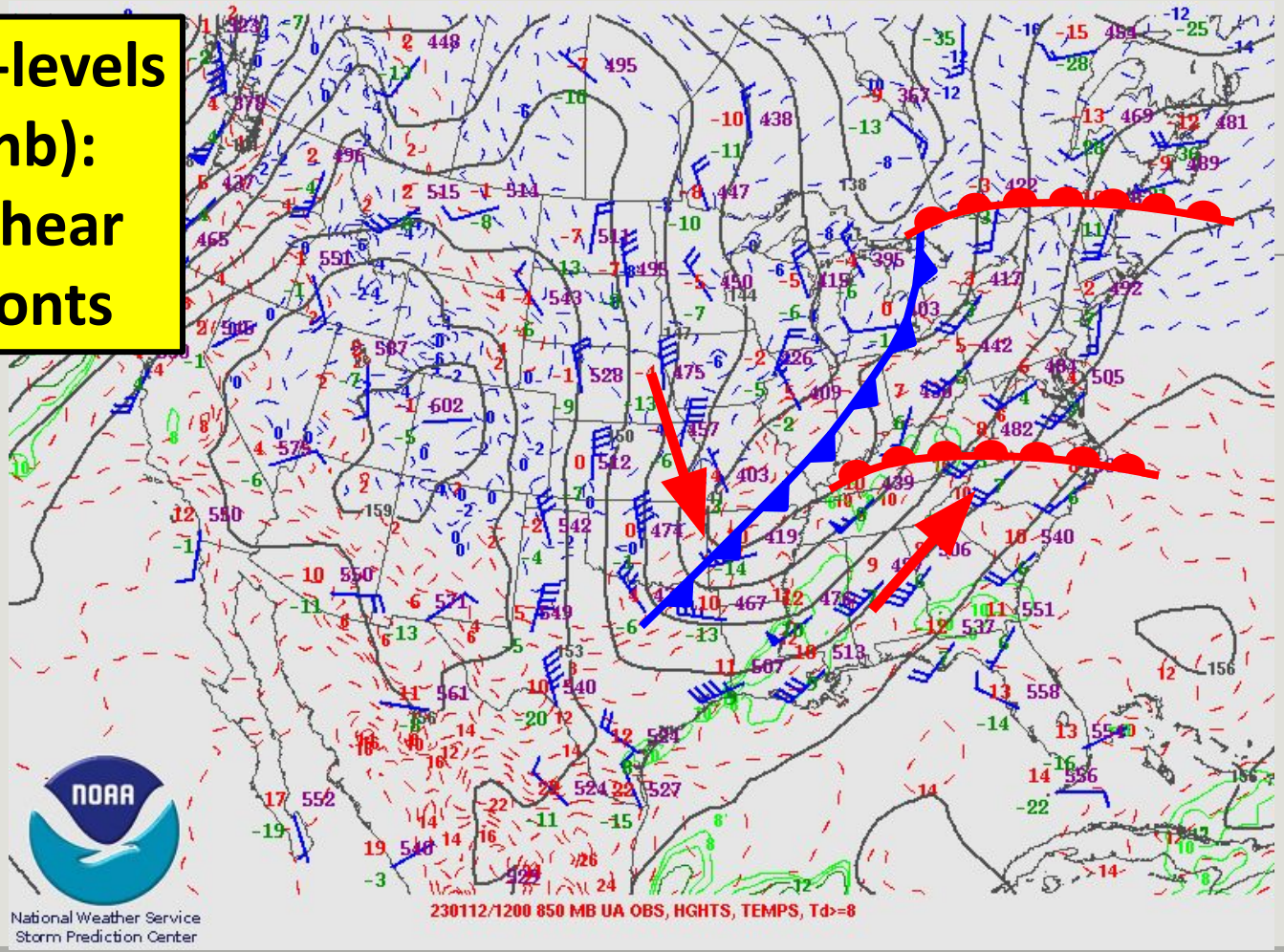
6a: Mid-levels (500mb): troughs and wind shear



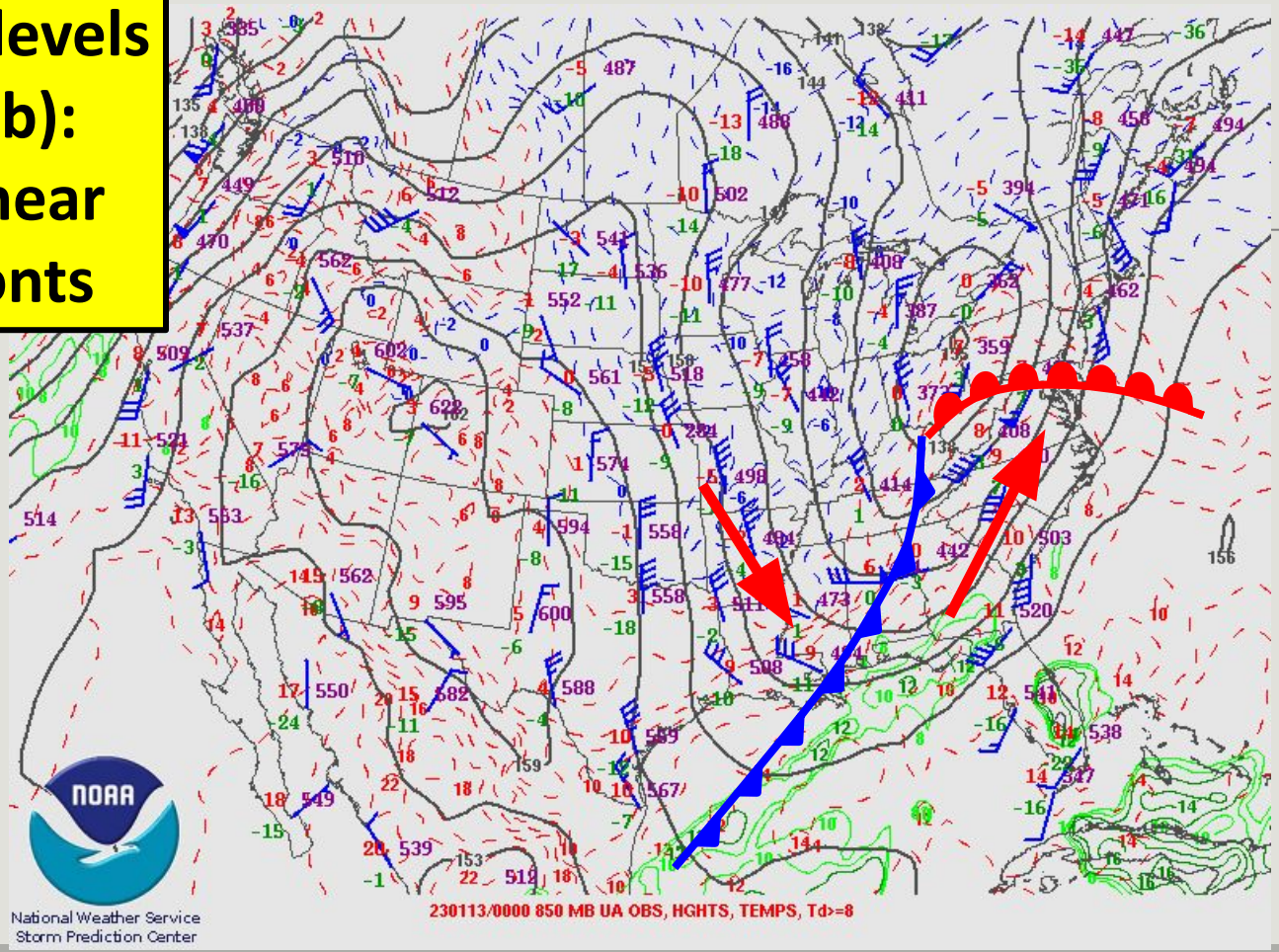
6p: Mid-levels (500mb): troughs and wind shear



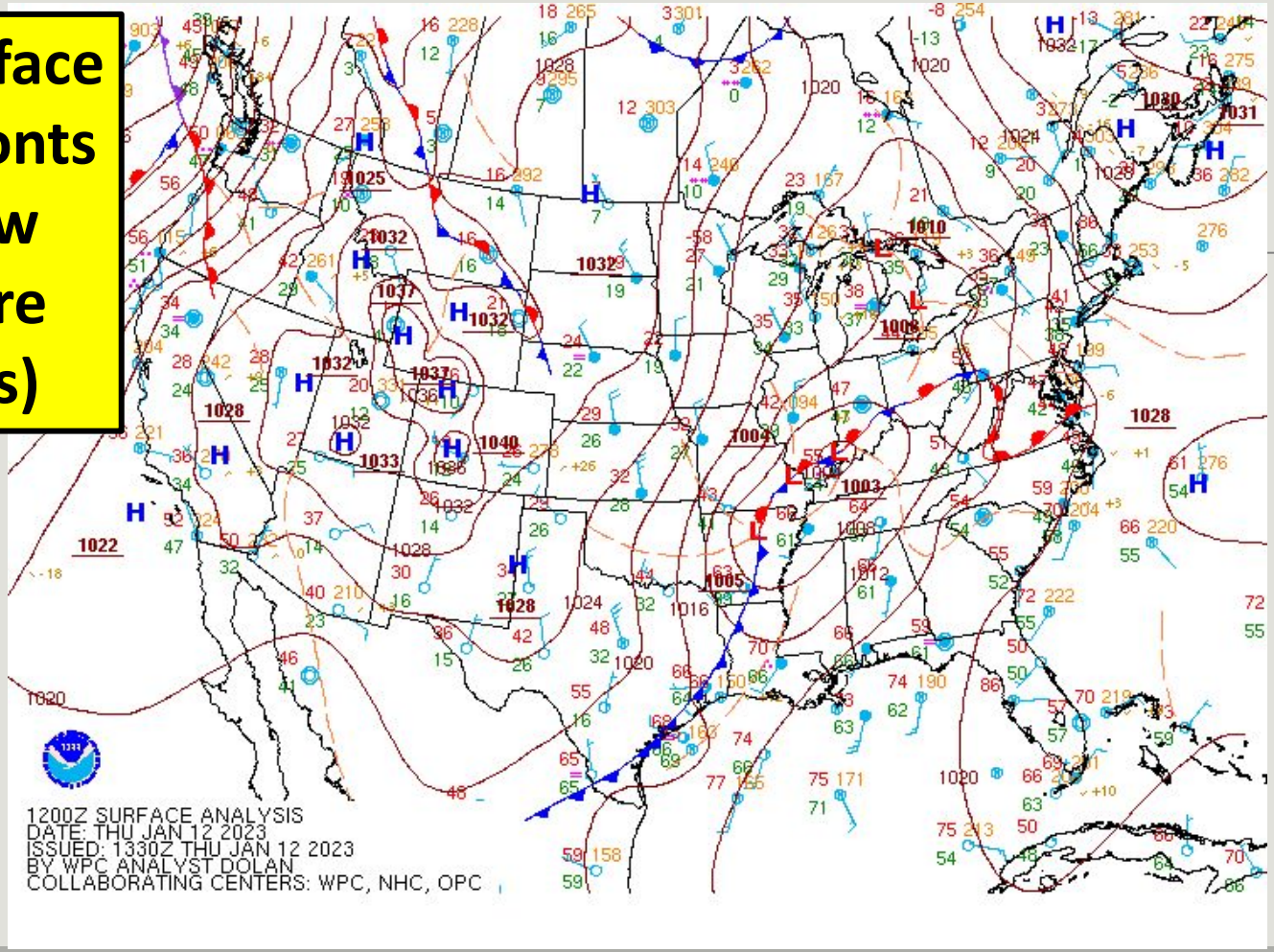
6a: Low-levels (850mb): wind shear and fronts



6p: Low-levels (850mb): wind shear and fronts

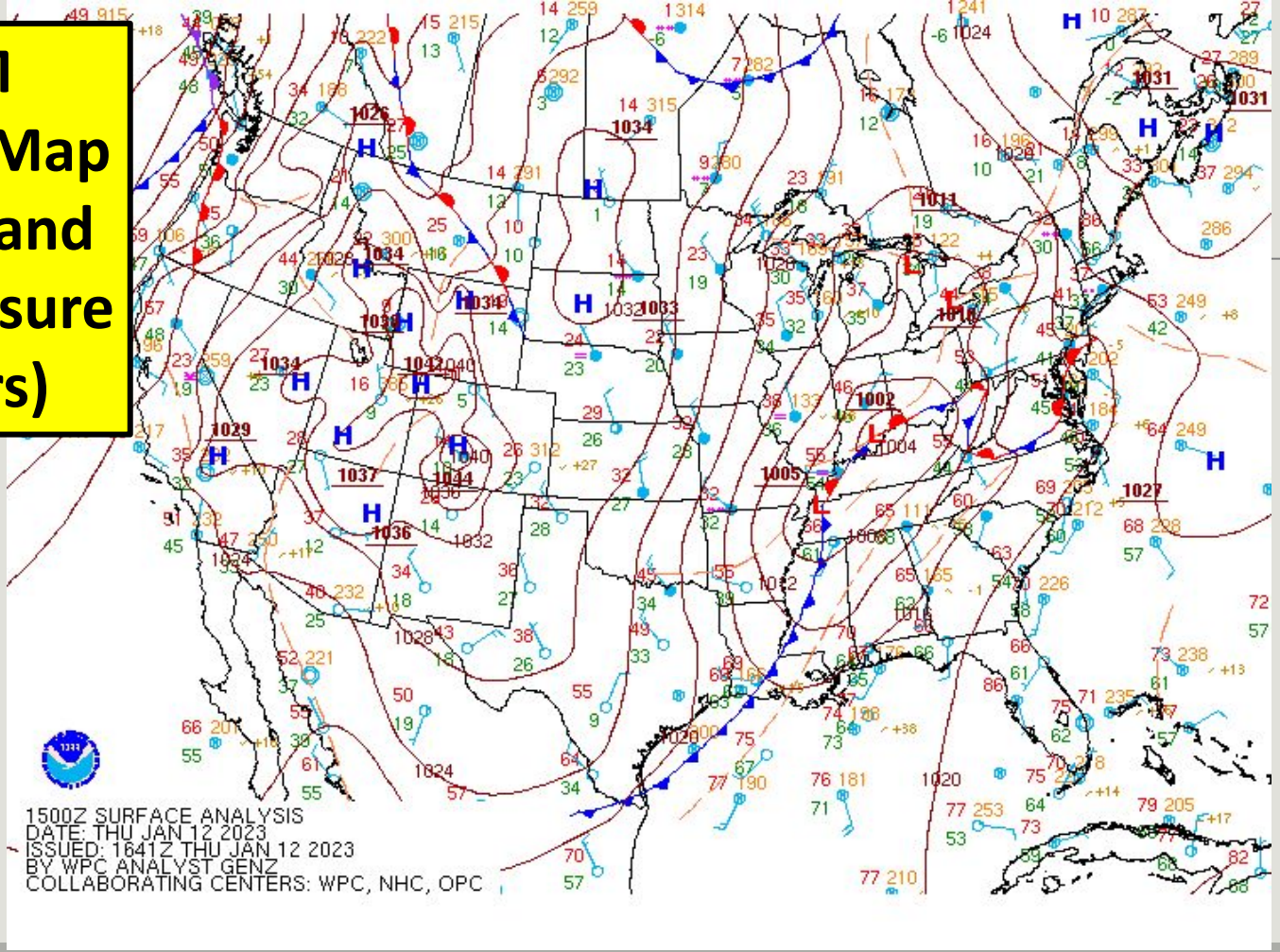


6AM Surface Map (Fronts and low pressure centers)

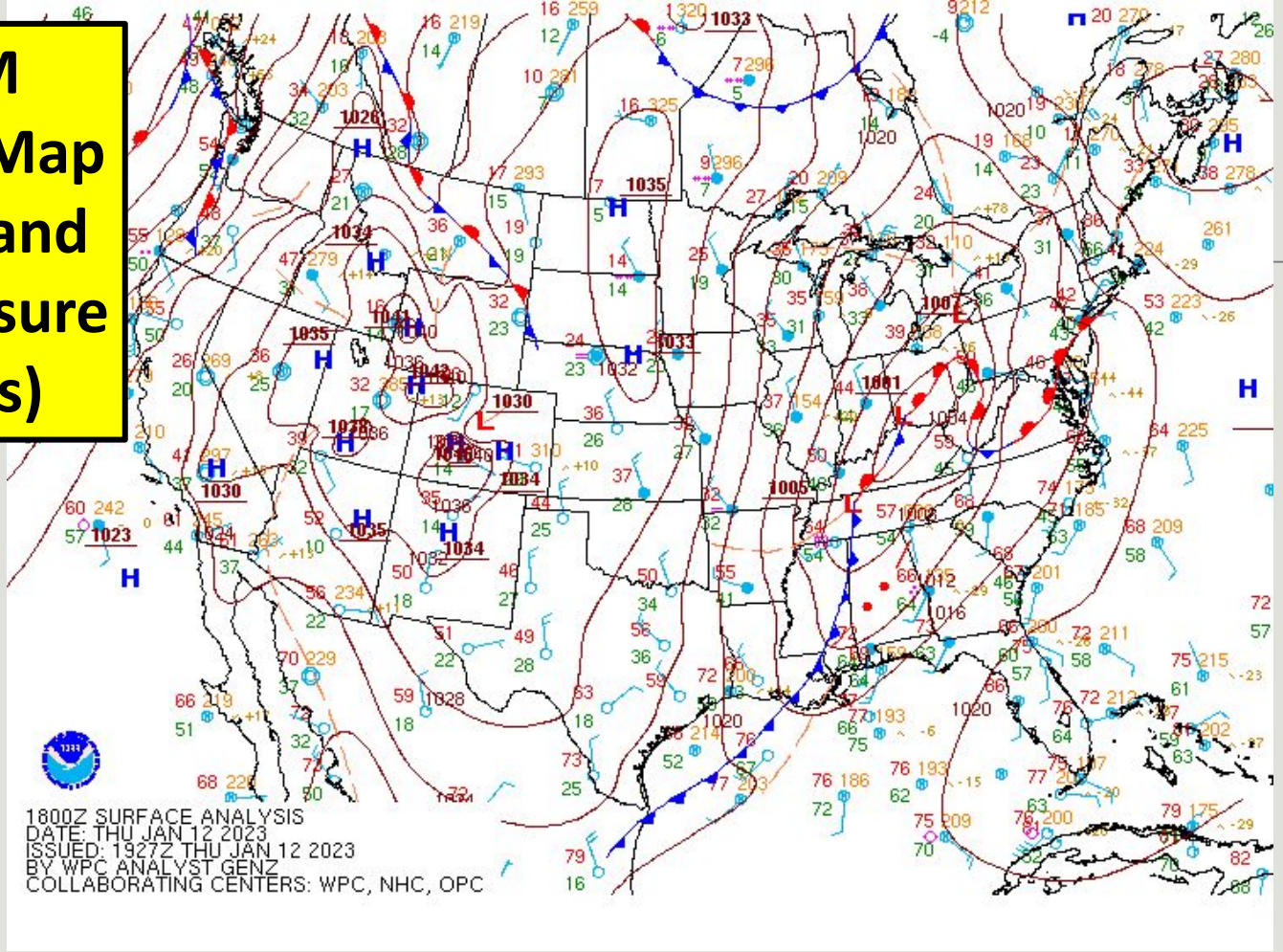


https://www.wpc.ncep.noaa.gov/html/sfc2.shtml

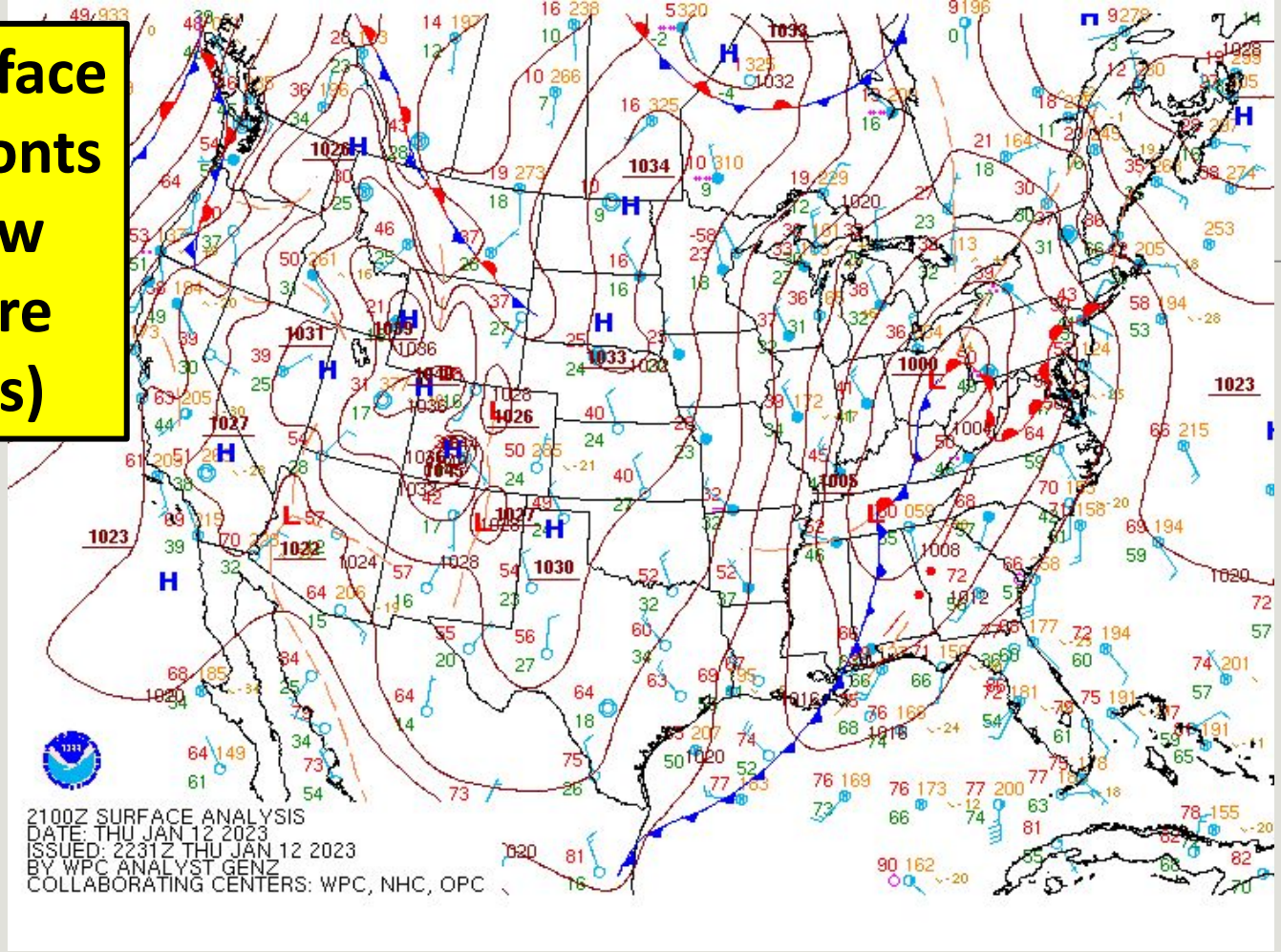
9 AM Surface Map (Fronts and low pressure centers)



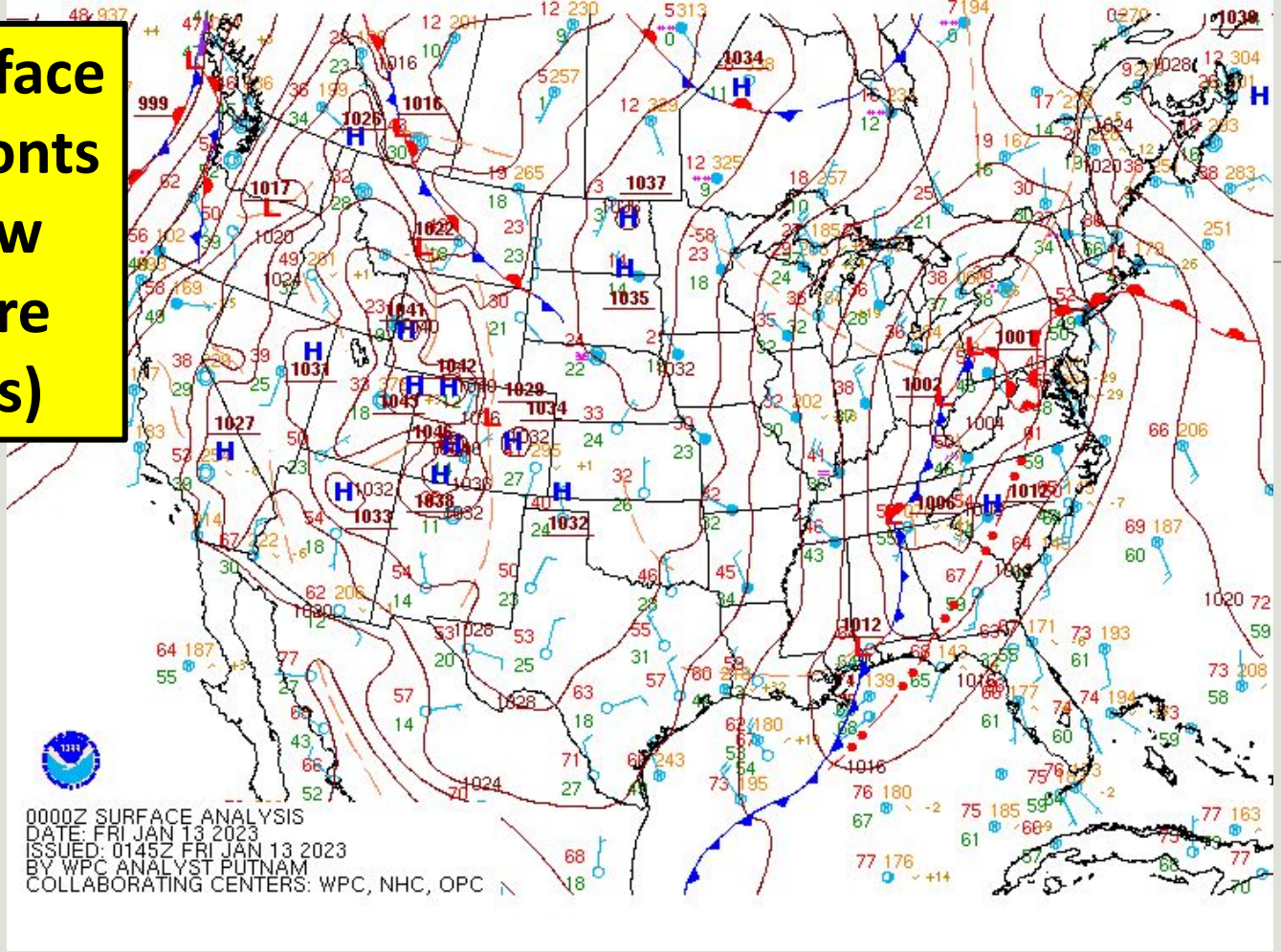
12 PM Surface Map (Fronts and low pressure centers)



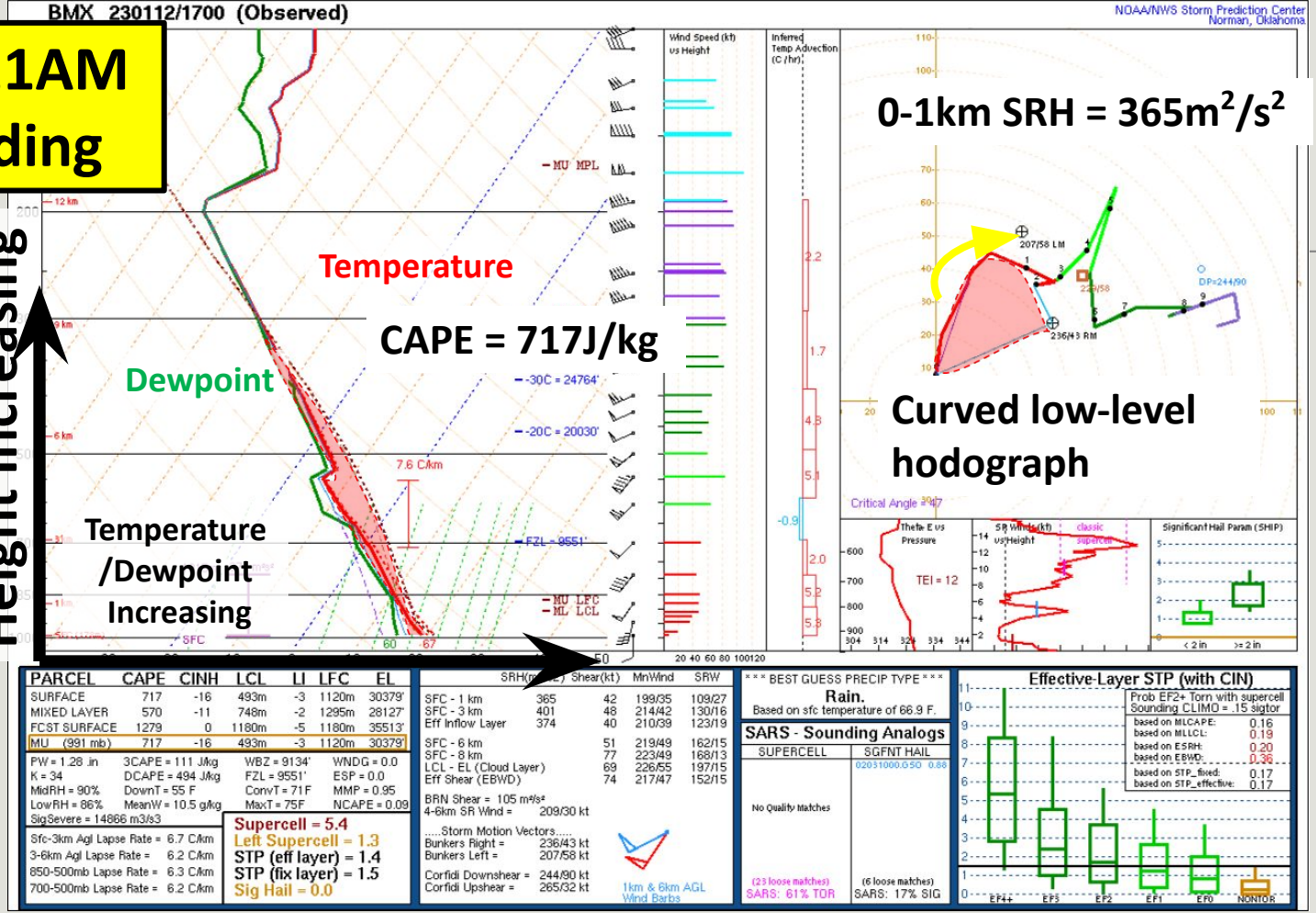
3PM Surface Map (Fronts and low pressure centers)



6PM Surface Map (Fronts and low pressure centers)



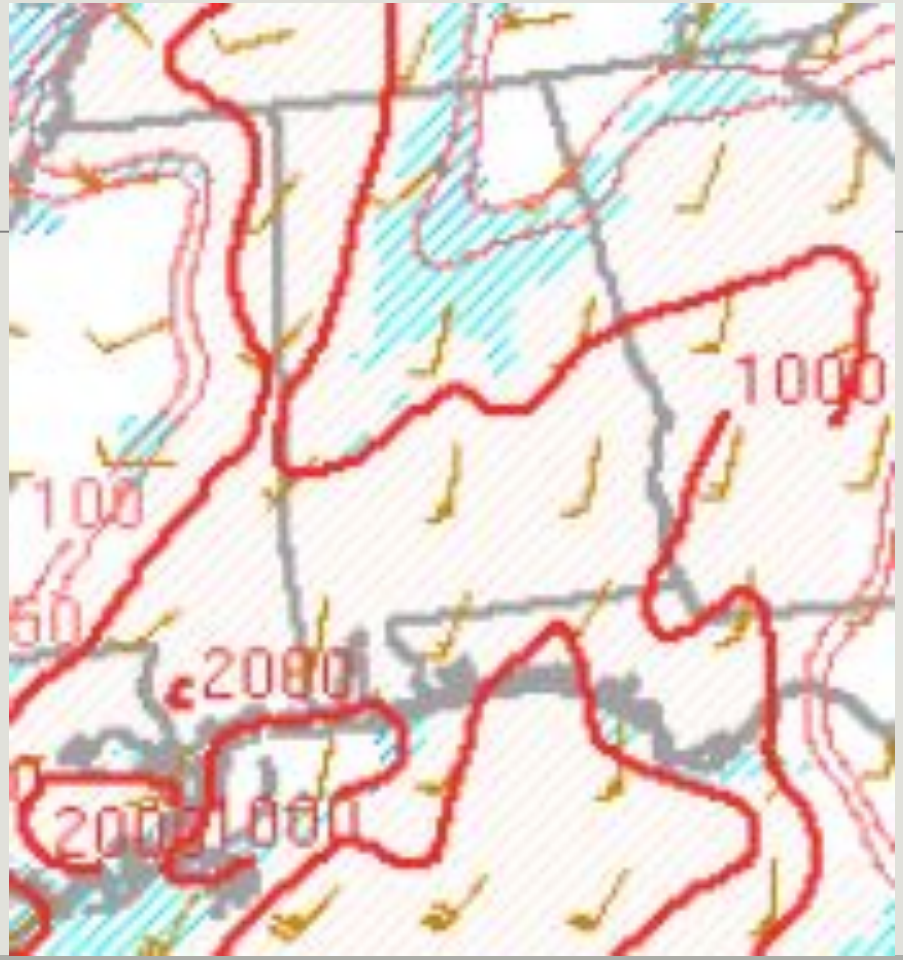
BMX 11AM Sounding



https://www.spc.noaa.gov/exper/soundings/

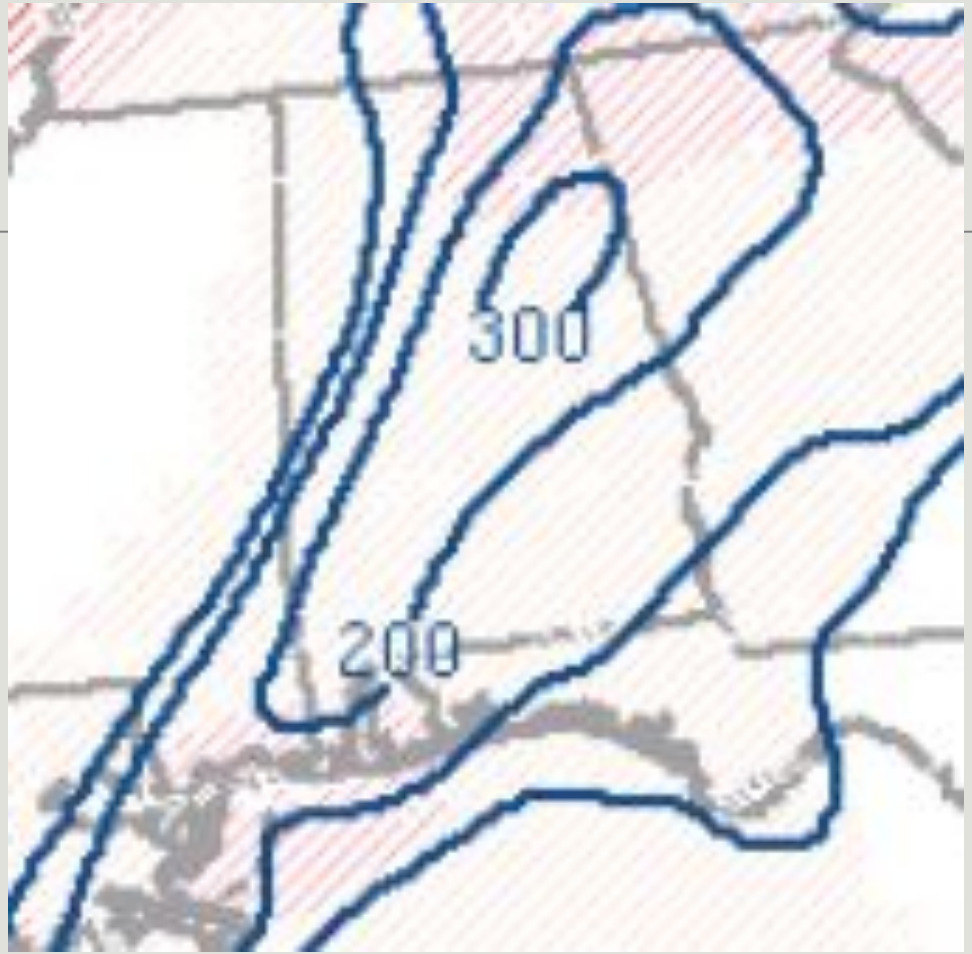
Convective Available Potential Energy (CAPE): ~1000 J/kg

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



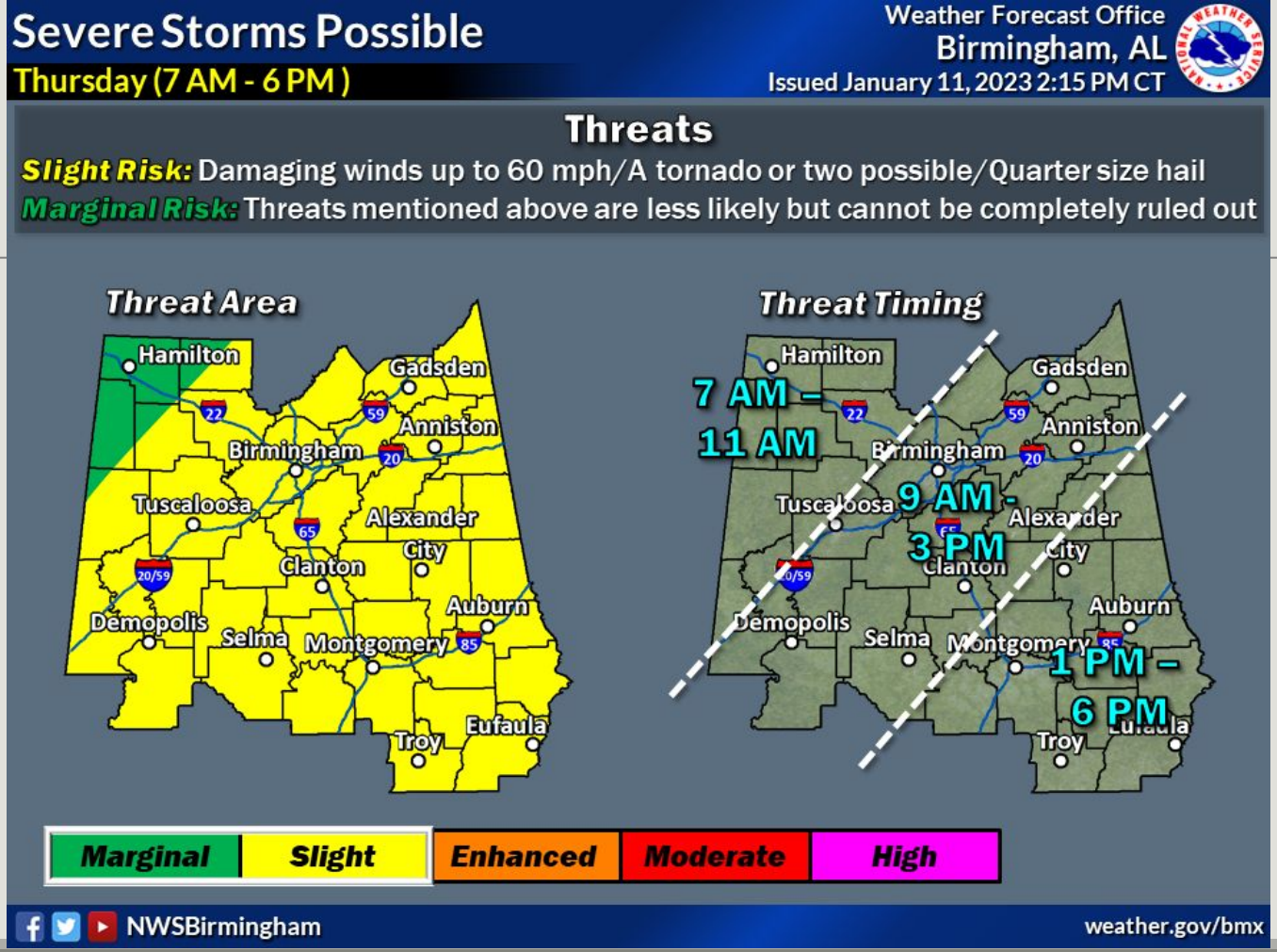
0-6km bulk wind shear: ~70 kts

Effective storm relative helicity (SRH): ~200-300 m^2/s^2

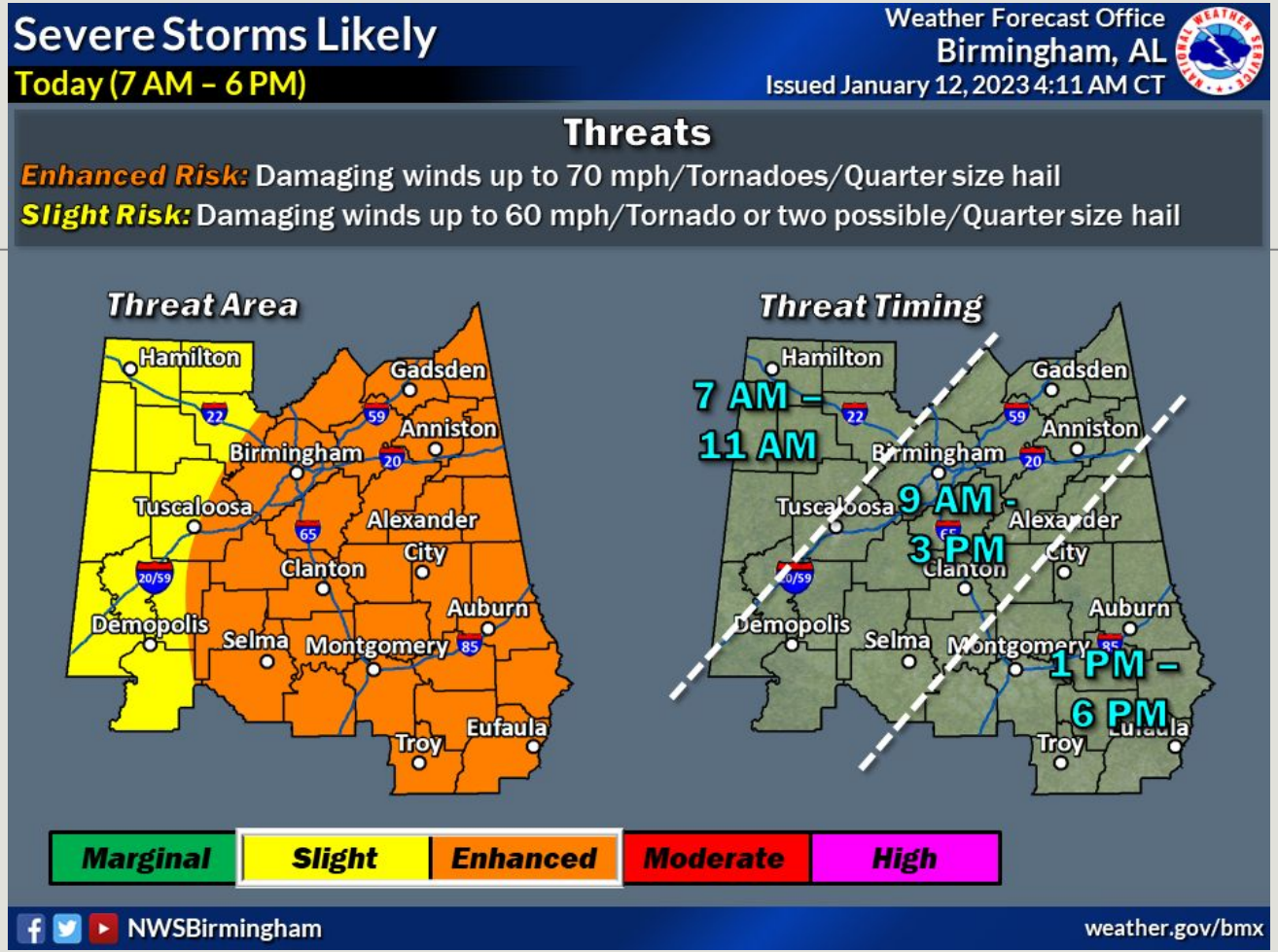


Significant Tornado Parameter (STP): ~1-2

Severe Weather Outlook



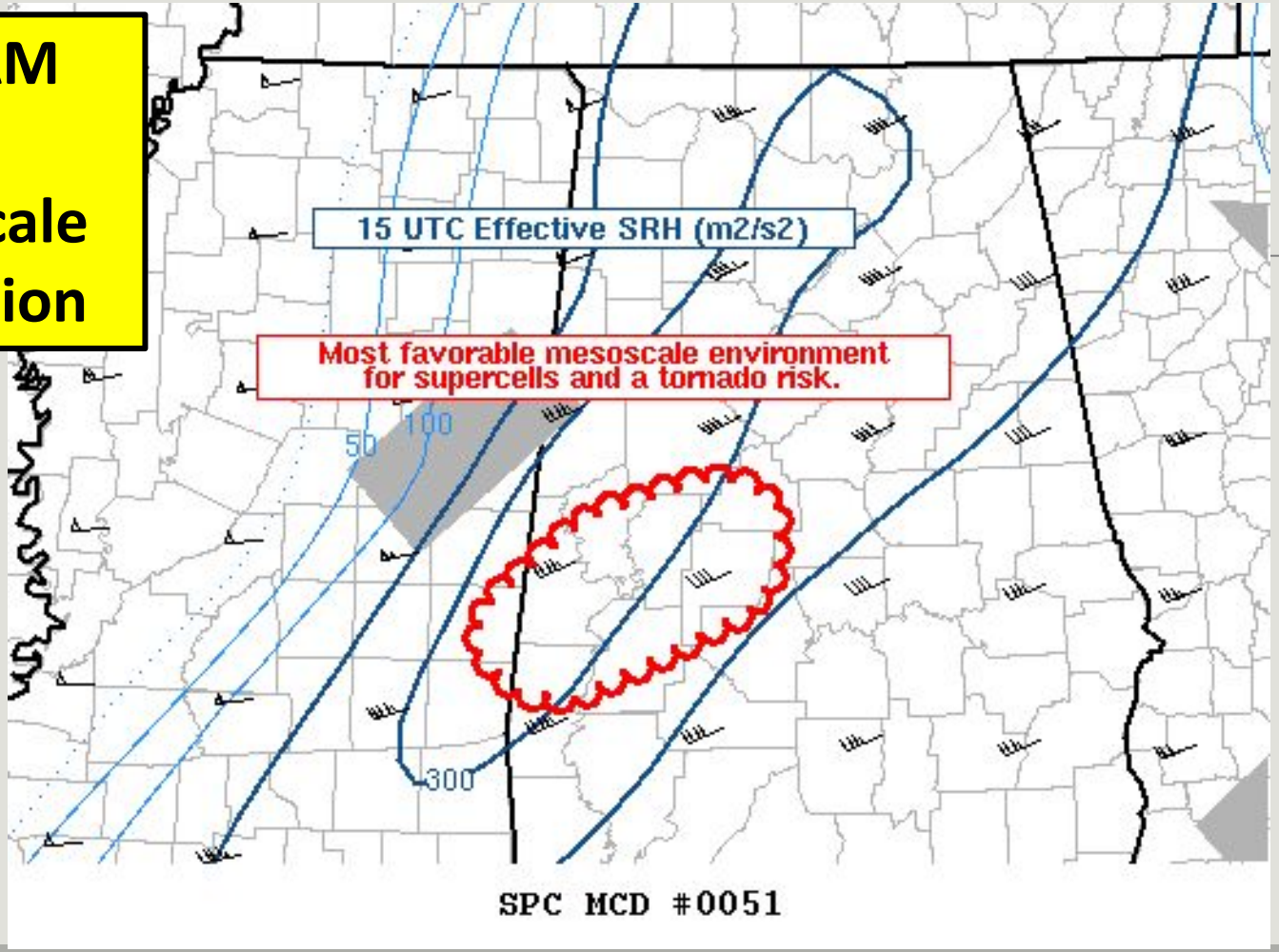
Severe Weather Outlook



6:38 AM SPC Mesoscale Discussion

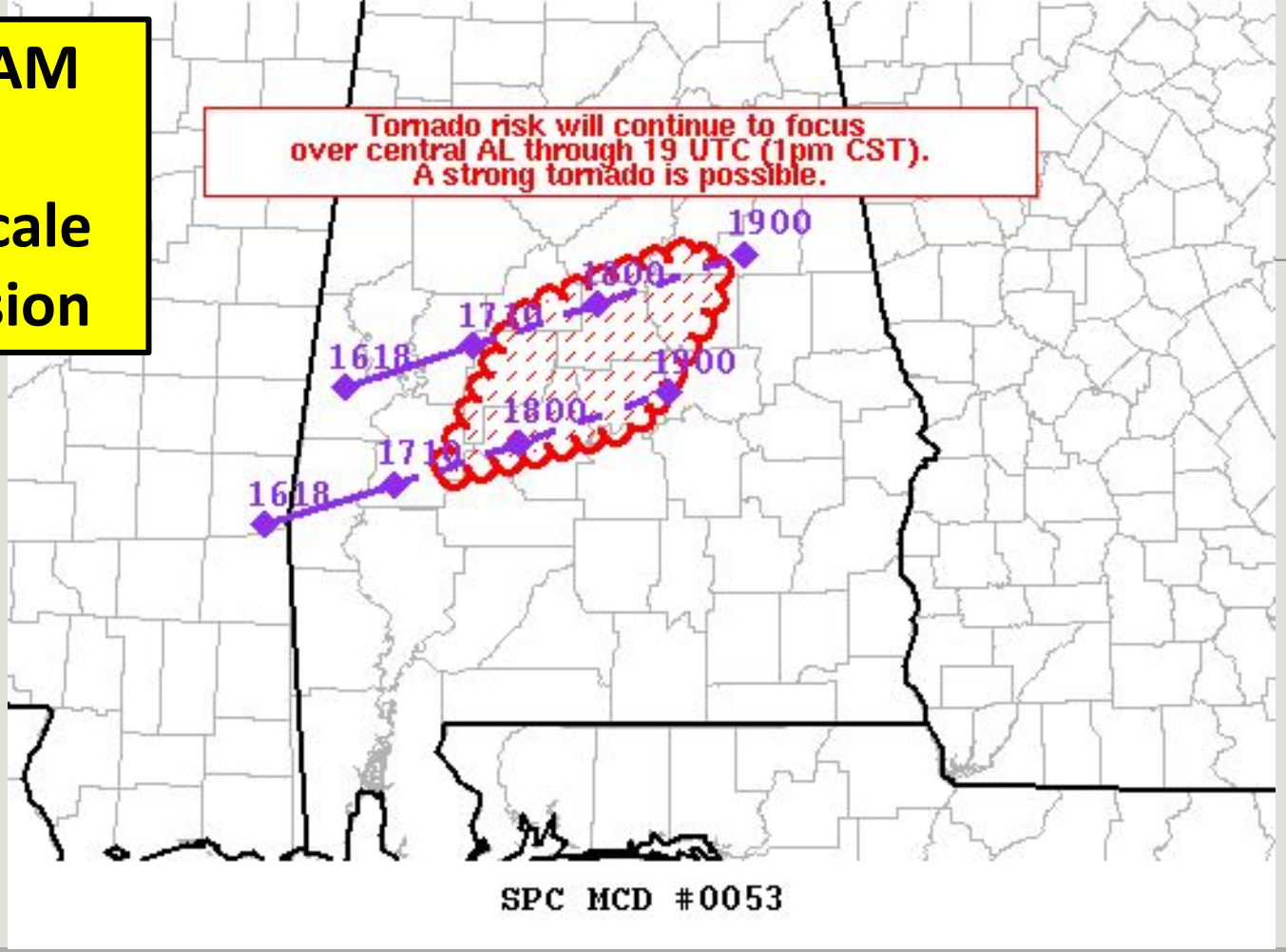
6:55 AM SPC Tornado Watch

9:54 AM SPC Mesoscale Discussion

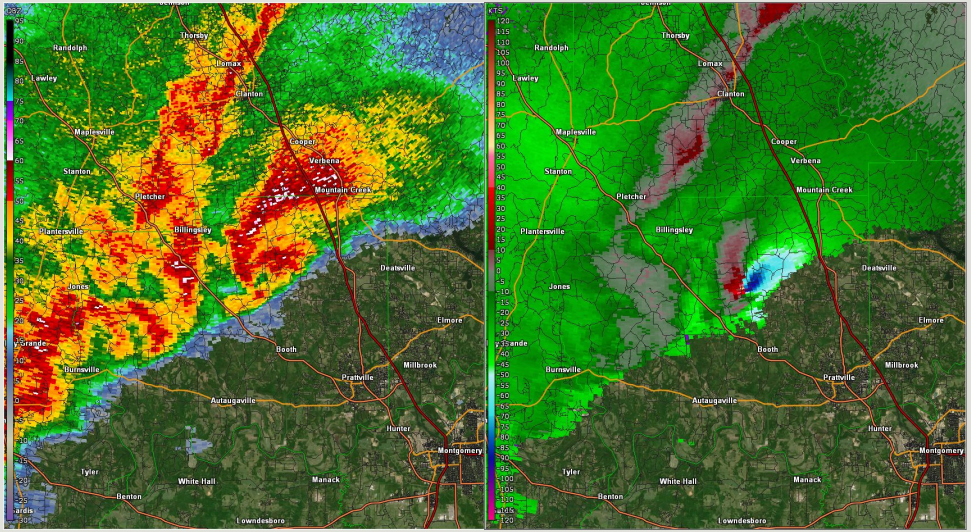


10:20 AM SPC Tornado Watch

11:36 AM SPC Mesoscale Discussion



Radar Images



Further Training

- COMET MetEd Modules (https://www.meted.ucar.edu/index.php)
  - Hundreds of free modules about all kinds of meteorological topics
- SPC Video Lecture series (https://www.spc.noaa.gov/exper/spcousom/)
  - Collection of lectures on severe storms from Storm Prediction Center forecasters and others given to a University of Oklahoma class
- NWS Warning Decision Training Branch Radar Applications Course (https://training.weather.gov/wdtd/courses/rac/outline.php) and Warning Operations Course (https://training.weather.gov/wdtd/courses/woc/severe.php)
  - Choose the “Web version” of each module which doesn’t require a login

jason.davis@noaa.gov

Additional Materials

Visit our SKYWARN spotter page for useful links and information: weather.gov/bmx/skywarn

- This presentation in PDF format
- Spotter schedule
- Training materials
- Brochures and guides
- Certificate > weather.gov/bmx/skywarncertificate