

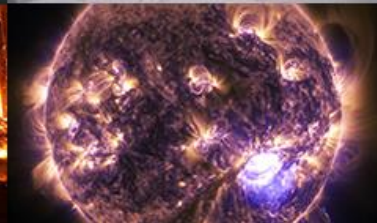
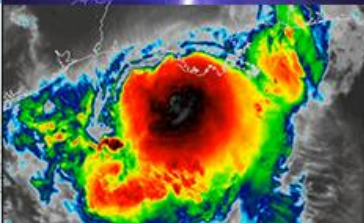


**NATIONAL  
WEATHER  
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# Weather 101: The Quasi-Linear Convective System

APRIL 21, 2025

Presenter: Adam Weiner, Meteorologist, NWS Wilmington, NC

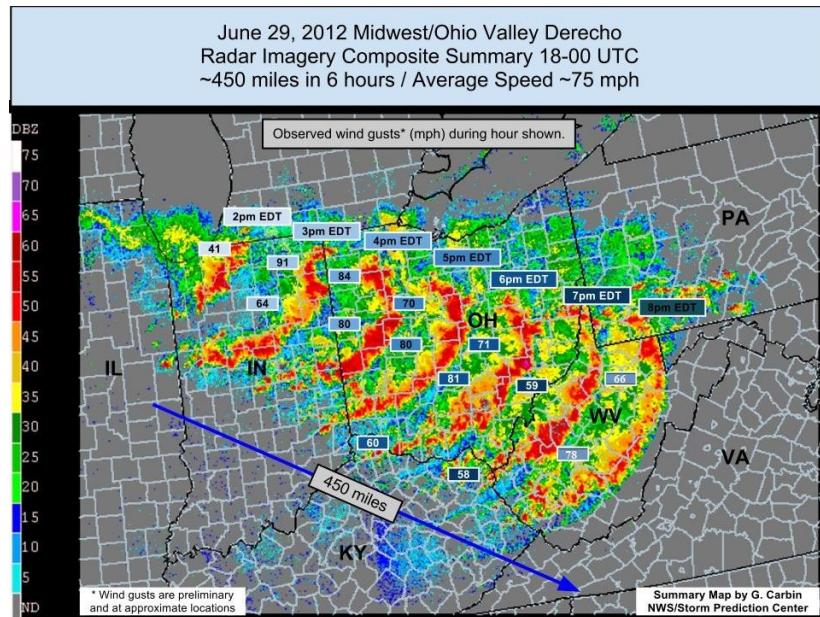




# What is a Quasi-Linear Convective System (QLCS)?



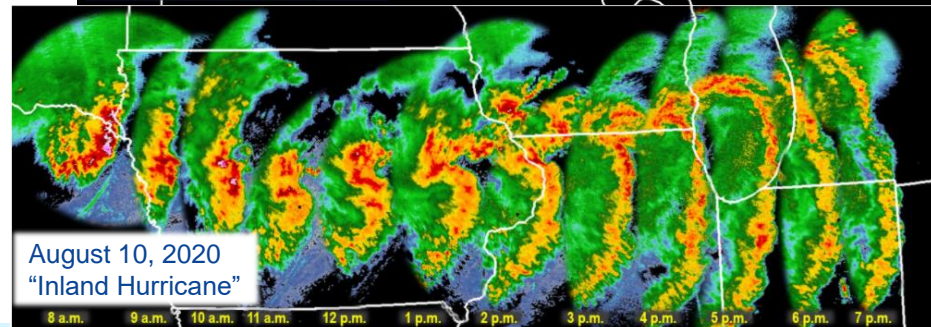
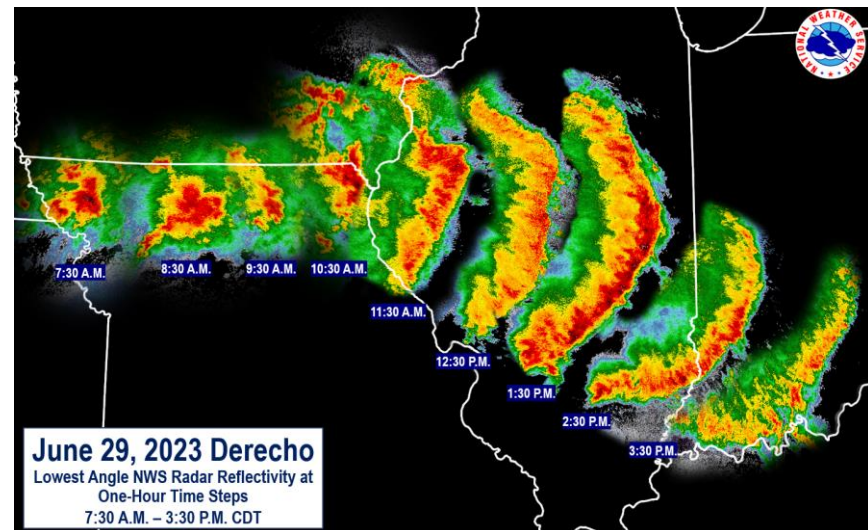
- Also known as a “squall line” or multicell line of storms or even a derecho
- Quasi-Linear = straight or arced or wavy
- Convective System = “family” of storms
- Can happen any time of year
- Can be driven by different mechanisms
- Primary hazard is damaging winds
- Hail and tornadoes are possible





# What is a Derecho?

- A particularly damaging squall line
- Swath of wind damage  $\geq 400$  miles long
- Swath of wind damage  $\geq 60$  miles wide
- Includes wind gusts of  $\geq 58$  mph along most of its length
- Includes several, well-separated gusts  $\geq 75$  mph
- Includes bowing shape

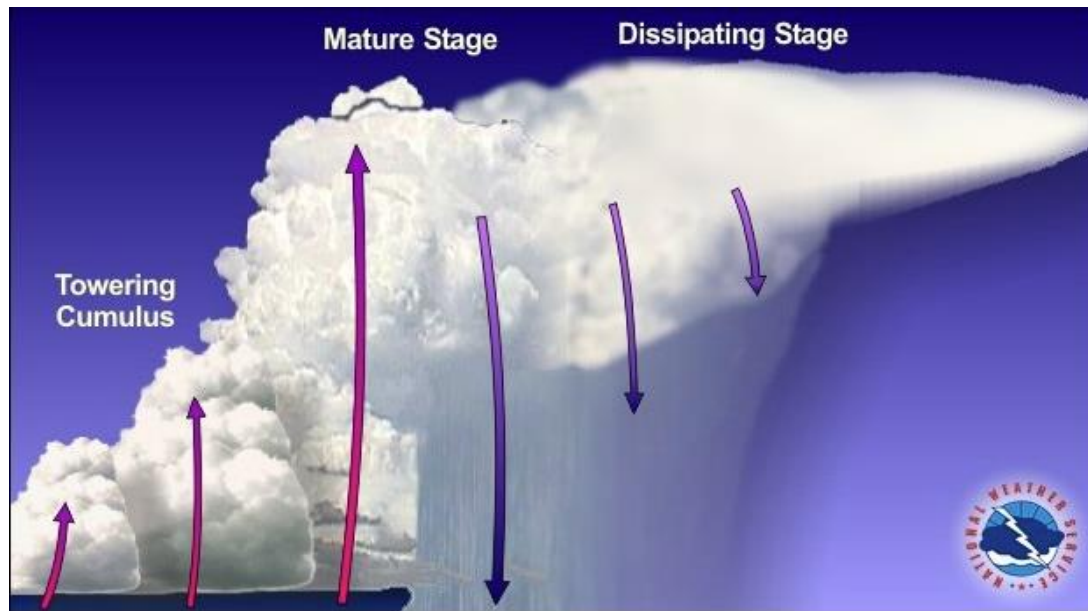




# Poll Question 1: How Do Storms Form?

What ingredients are **needed** for any thunderstorm to form?

- Moisture
- Instability
- Lift



# How Do Squall Lines Form?

ALL of the ingredients for thunderstorms are needed!

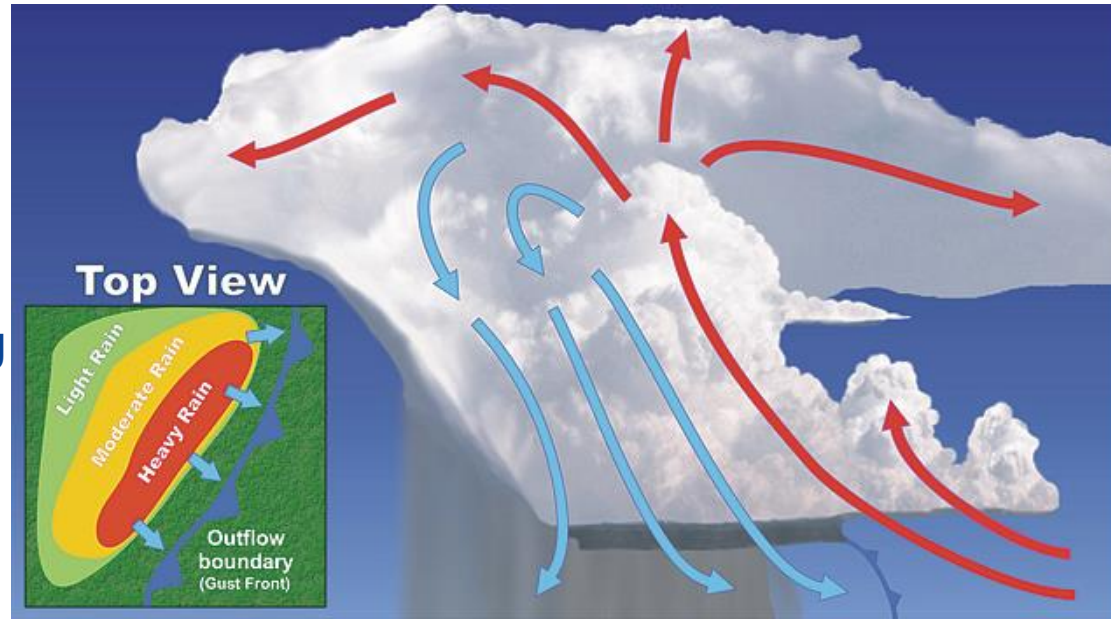
- Moisture
- Instability
- Lift

PLUS:

- Strong downdrafts leading to a sharp gust front

OR

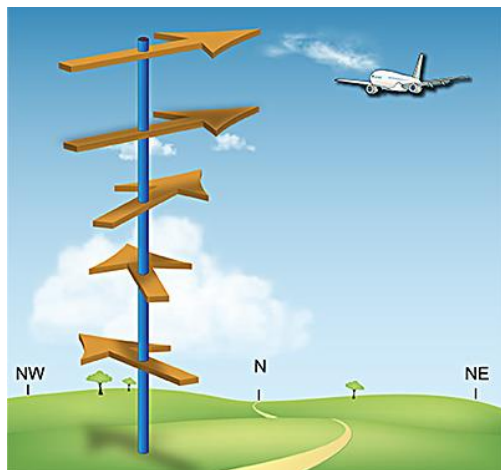
- A front (cold, warm, or stationary)



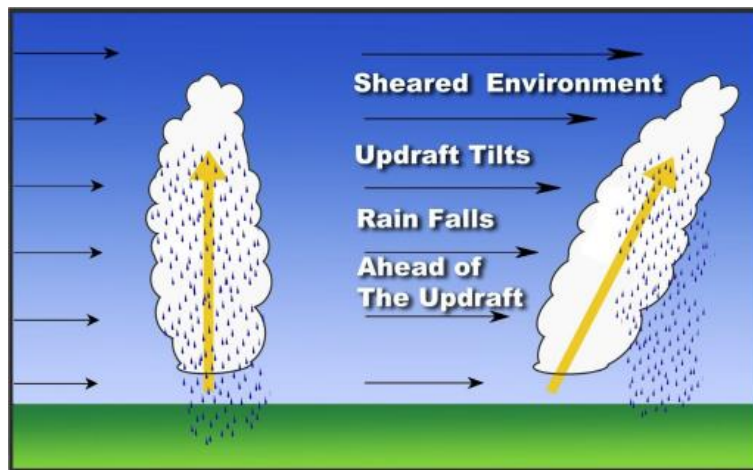
# Is Anything Else Needed?

## Directional Shear

Changing wind direction with increasing height

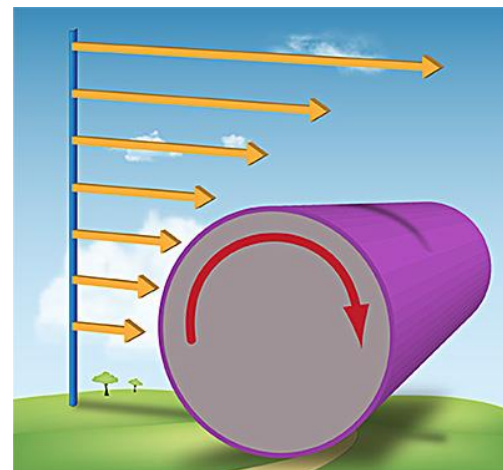


Wind shear  
helps storms  
↓ last longer ↓

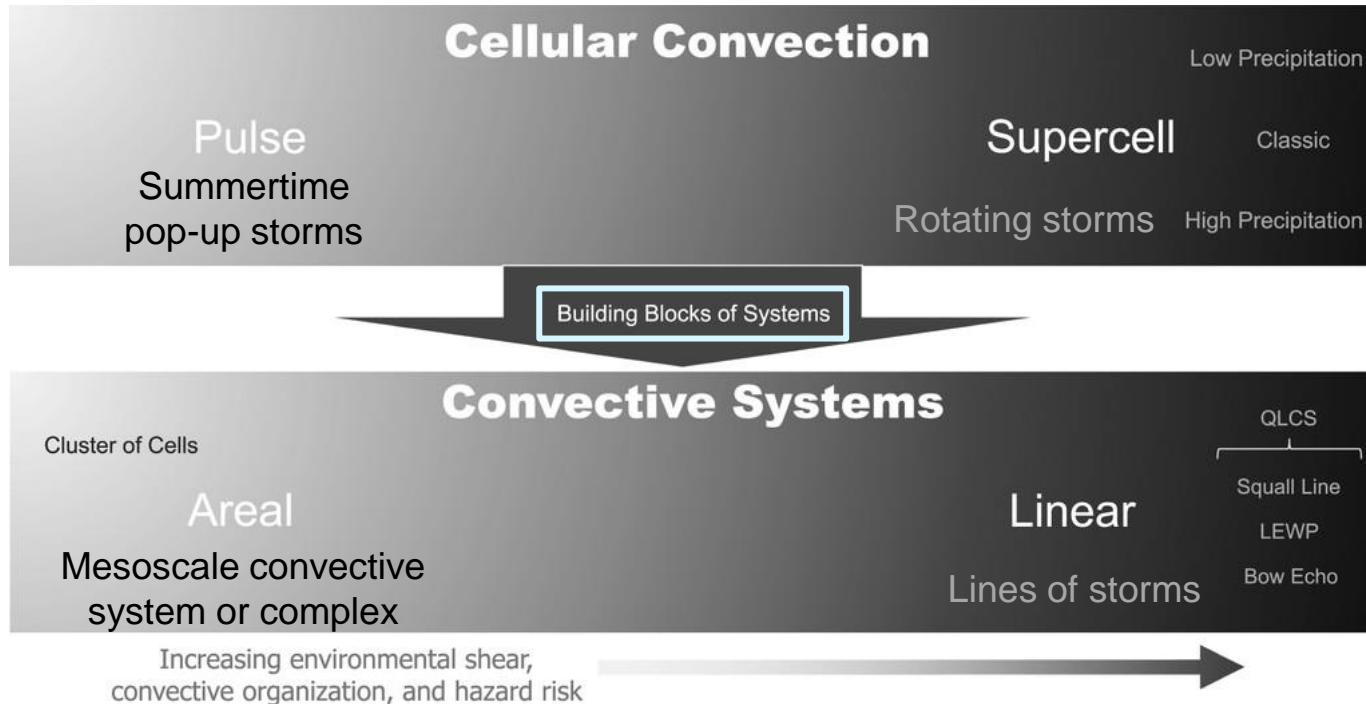


## Speed Shear

Increasing wind speed with increasing height



# Why Does Wind Shear Matter?



A visual depicting the spectrum of storm organization as wind shear increases. In general, stronger wind shear contributes to longer-lived storms with a greater threat for severe weather.

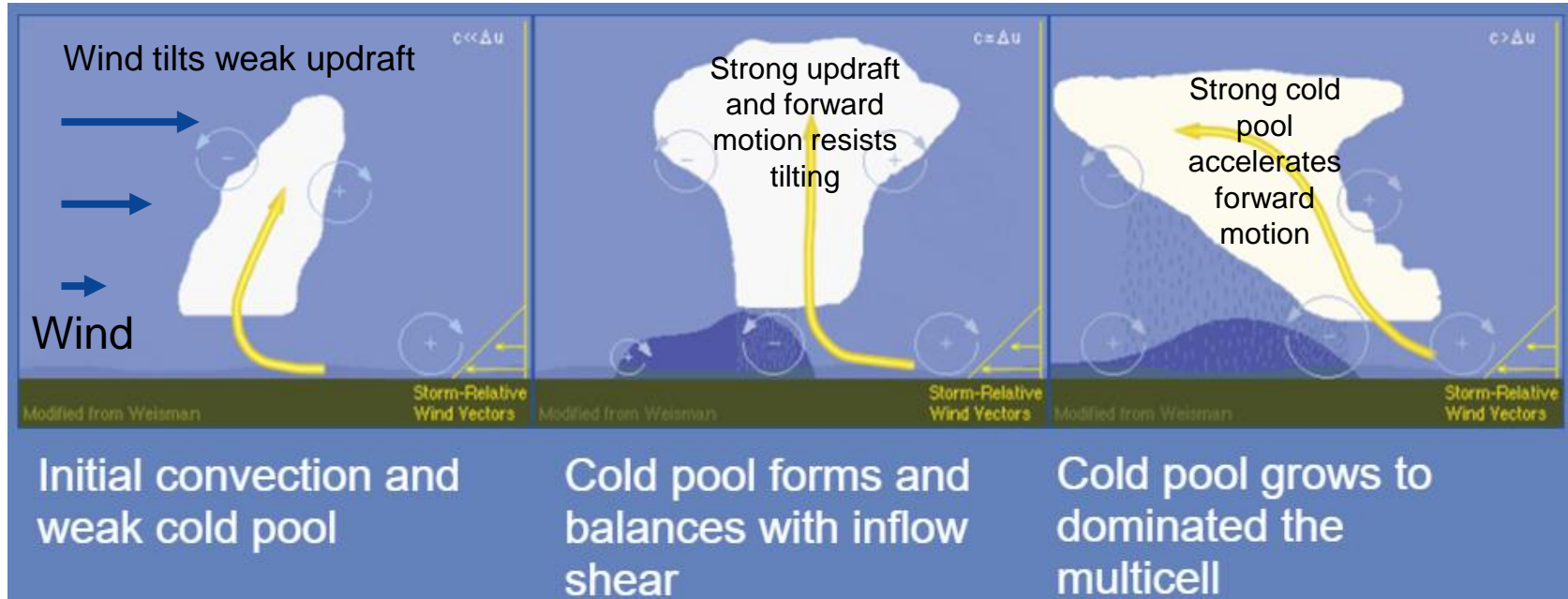
Source: A Climatology of Quasi-Linear Convective Systems and Their Hazards in the United States by Ashley, Haberlie, and Strohm (2019)  
<https://doi.org/10.1175/WAF-D-19-0014.1>



# Squall Line Forcing: Cold Pool Effects



**Definition:** A cold pool is the rain-cooled air that falls out of a shower or thunderstorm. It acts as a dome of high pressure which can push warm, moist, unstable air upward at its leading edge, fostering new thunderstorms. It can also lead to a line of storms decaying as the updraft becomes increasingly tilted.







# Poll Question 2: When Do QLCSSs Occur?



Is there a certain time of year when these seem to occur more often?

- Winter
- Spring
- Summer
- Fall

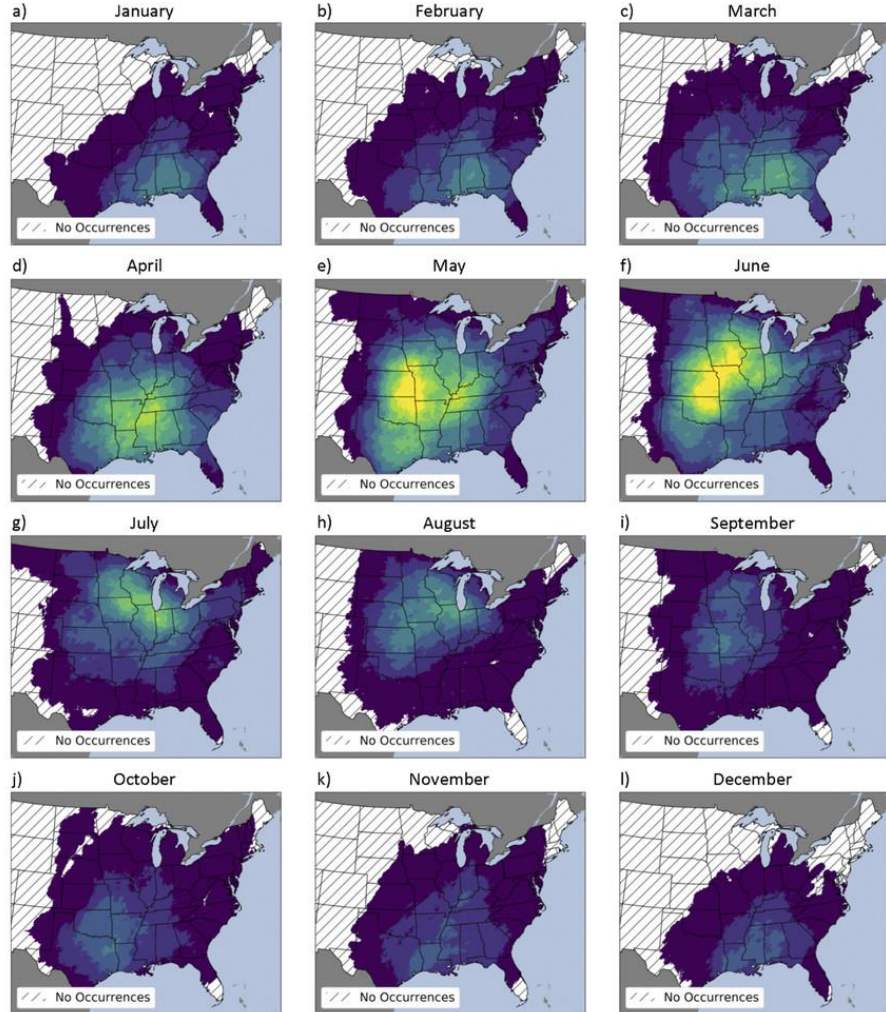


# Poll Question 2: When Do QLCSs Occur?

Mean monthly QLCS counts (1996-2017) depict a peak occurrence **between April and July**, translating from the lower Mississippi Valley in April northward into the Midwest during the summer.

Source: A Climatology of Quasi-Linear Convective Systems and Their Hazards in the United States by Ashley, Haberlie, and Strohm (2019)

<https://doi.org/10.1175/WAF-D-19-0014.1>





# Cool Season vs. Warm Season Squall Lines



## Fall/Winter/Spring

- Weak to moderate instability
- Strong cold front
- Strong wind shear
- Typically Central Plains & Midwest through Southeast US
- Often preceded by tornadic and hail-producing supercells
- Rarely derecho-producing



## Summertime

- Strong instability (hot/humid)
- Strong downdraft/gust front
- Weak wind shear
- Typically High Plains to the Mid-Atlantic and Northeast
- May be preceded by disorganized pop-up storms
- Occasionally derecho-producing





## Poll Question 3:

# Which QLCs are more destructive?

Do you think QLCs are more destructive in the warm season or the cool season?

- Warm Season (May – September)
- Cool Season (October – April)







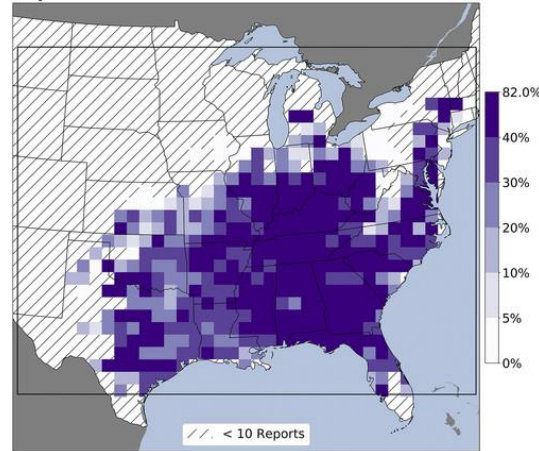
# Poll Question 3: When are QLCS's more destructive?

Percent of severe weather reports caused by QLCSs in 80x80 km grid boxes on a seasonal basis. (a) winter covers Dec-Feb, (b) Spring covers Mar-May, (c) Summer covers Jun-Aug), and (d) Fall covers (Sept-Nov). Explore a breakdown of each severe weather hazard in the linked paper below (Figs. 11-15).

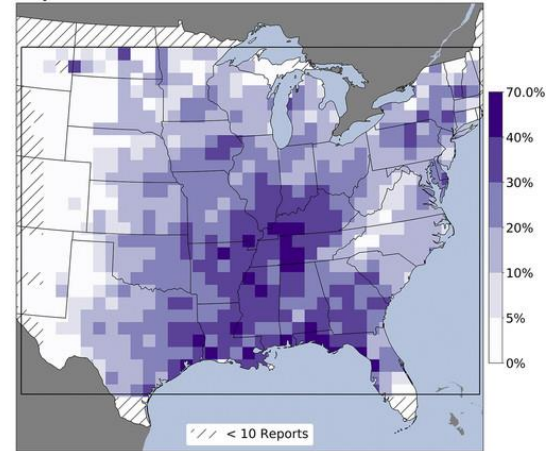
Source: A Climatology of Quasi-Linear Convective Systems and Their Hazards in the United States by Ashley, Haberlie, and Strohm (2019)

<https://doi.org/10.1175/WAF-D-19-0014.1>

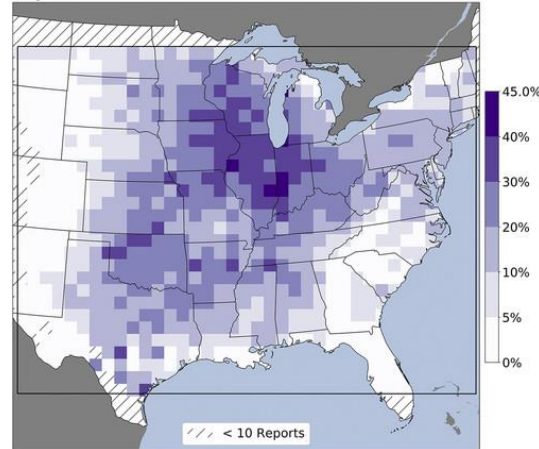
a)



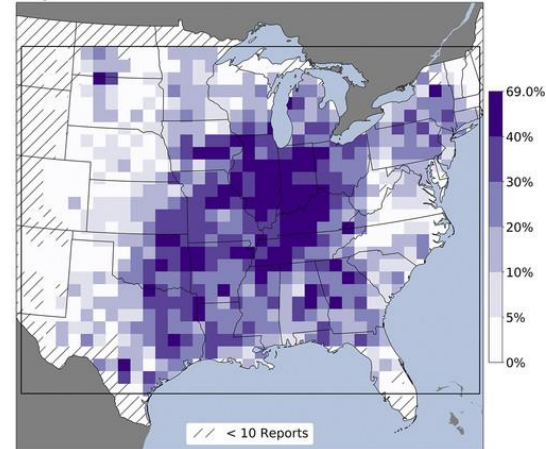
b)



c)

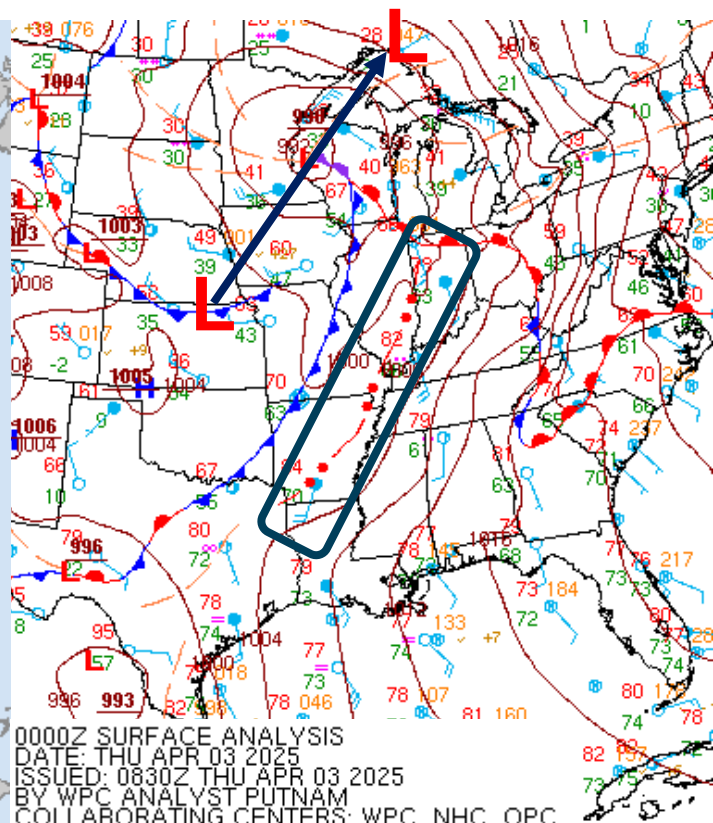
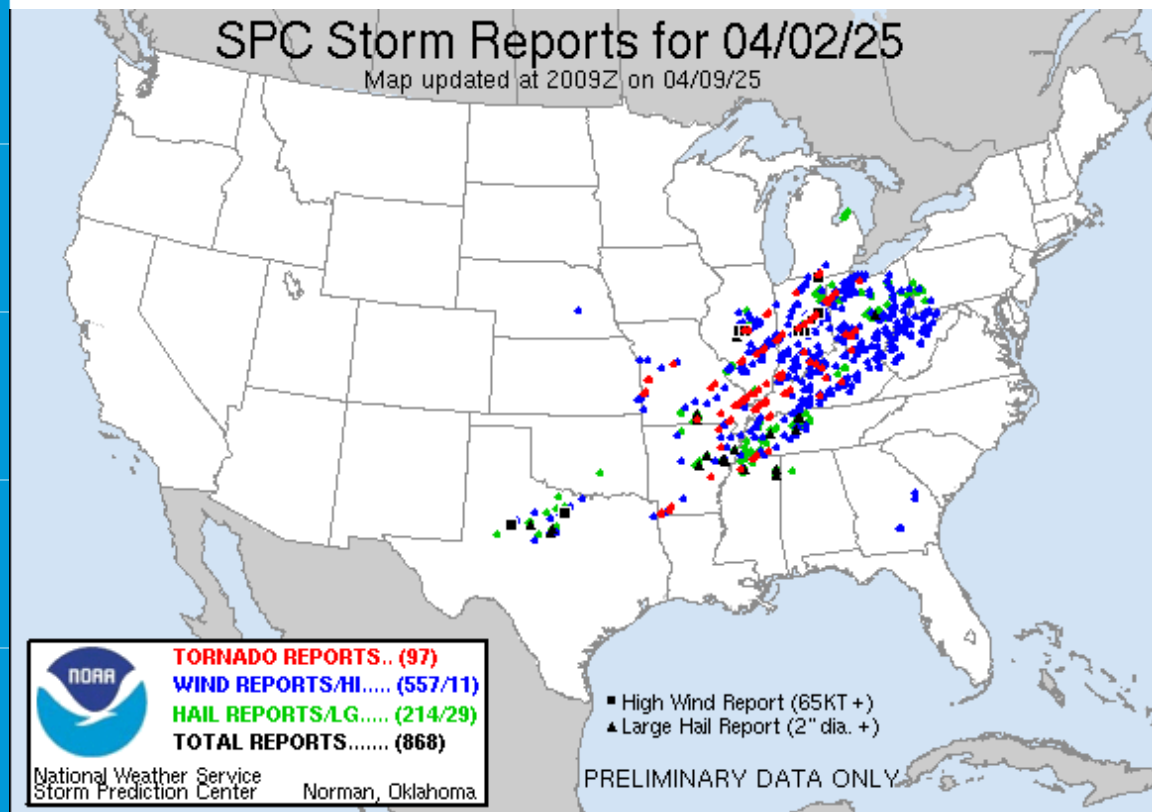


d)





# Cool Season QLCS: April 2, 2025



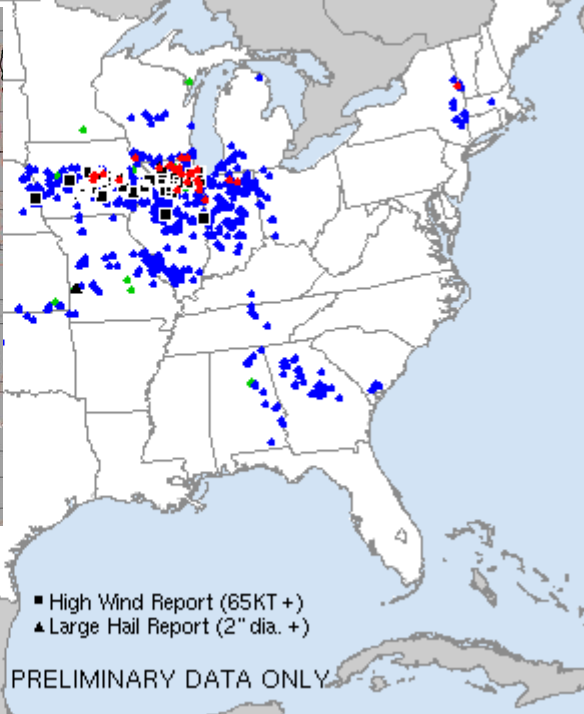
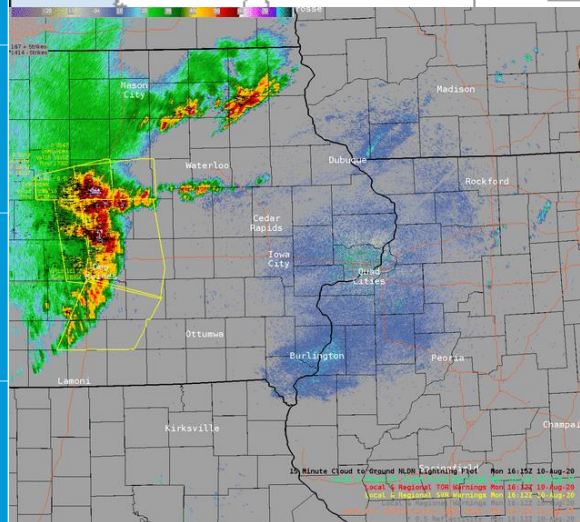


# Warm Season Derecho: August 10, 2020



## SPC Storm Reports for 08/10/20

Map updated at 1540Z on 10/11/20

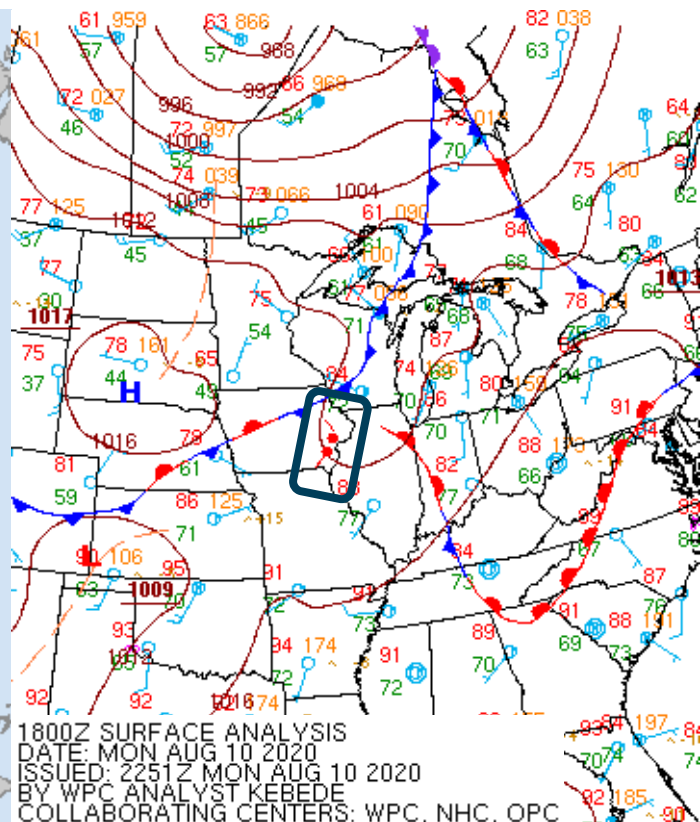


- High Wind Report (65KT +)
- ▲ Large Hail Report (2" dia. +)

PRELIMINARY DATA ONLY

**TORNADO REPORTS.. (27)**  
**WIND REPORTS/HI..... (910/53)**  
**HAIL REPORTS/LG..... (32/4)**  
**TOTAL REPORTS..... (969)**

National Weather Service  
Storm Prediction Center  
Norman, Oklahoma



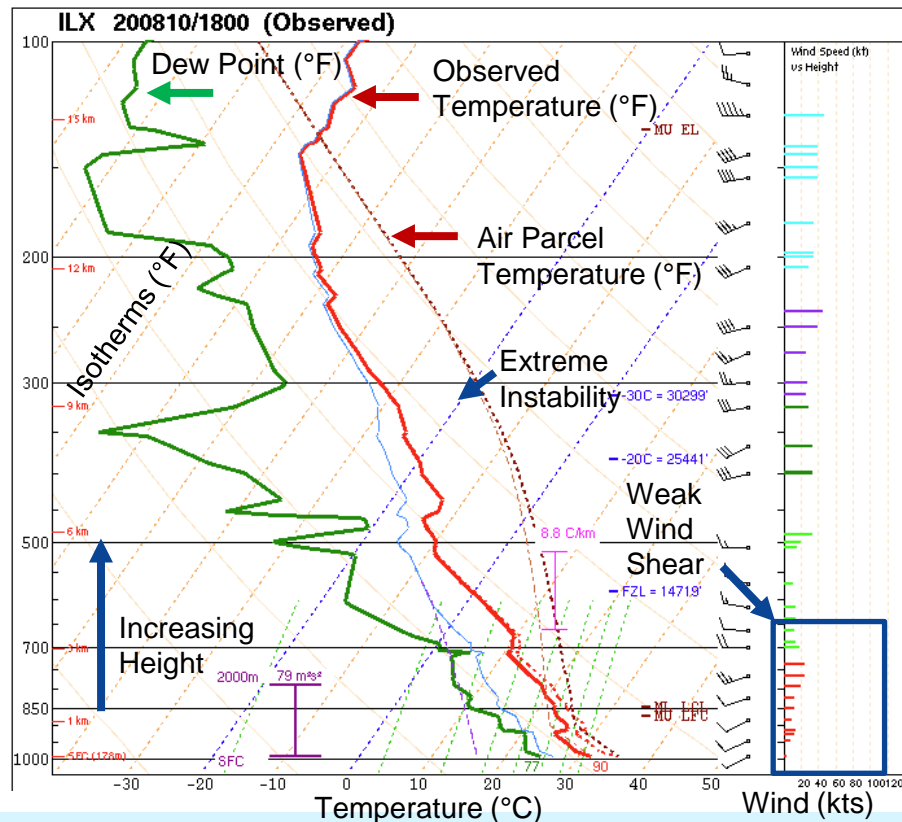
1800Z SURFACE ANALYSIS  
DATE: MON AUG 10 2020  
ISSUED: 2251Z MON AUG 10 2020  
BY WPC ANALYST KEBEDE  
COLLABORATING CENTERS: WPC, NHC, OPC



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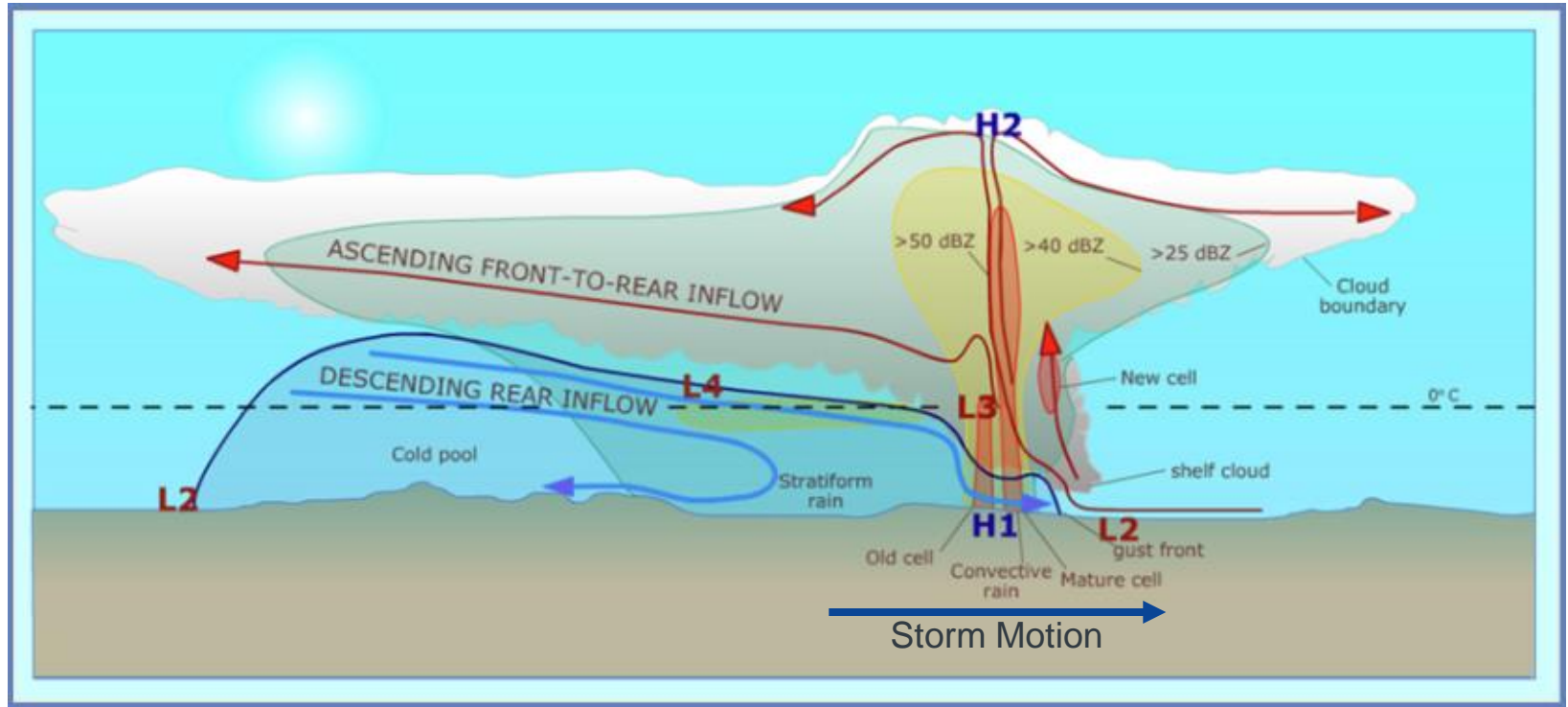


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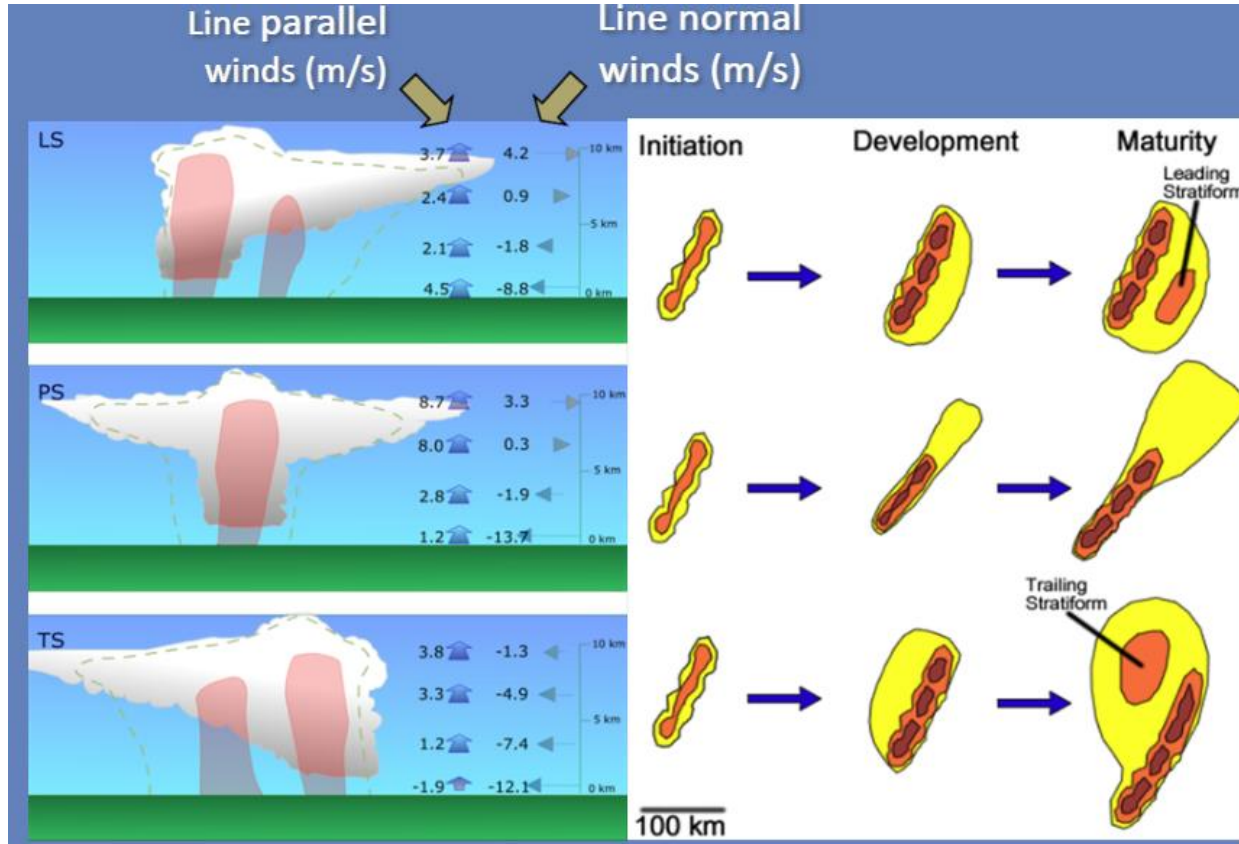




# Squall Line Vertical Cross-Section



# Squall Line Structures



The wind direction relative to the squall line with increasing height determines where the supply of low-level unstable air for continued storm development is located and where precipitation is blown relative to the updrafts.



# Squall Line Hazards: Straight-Line Winds



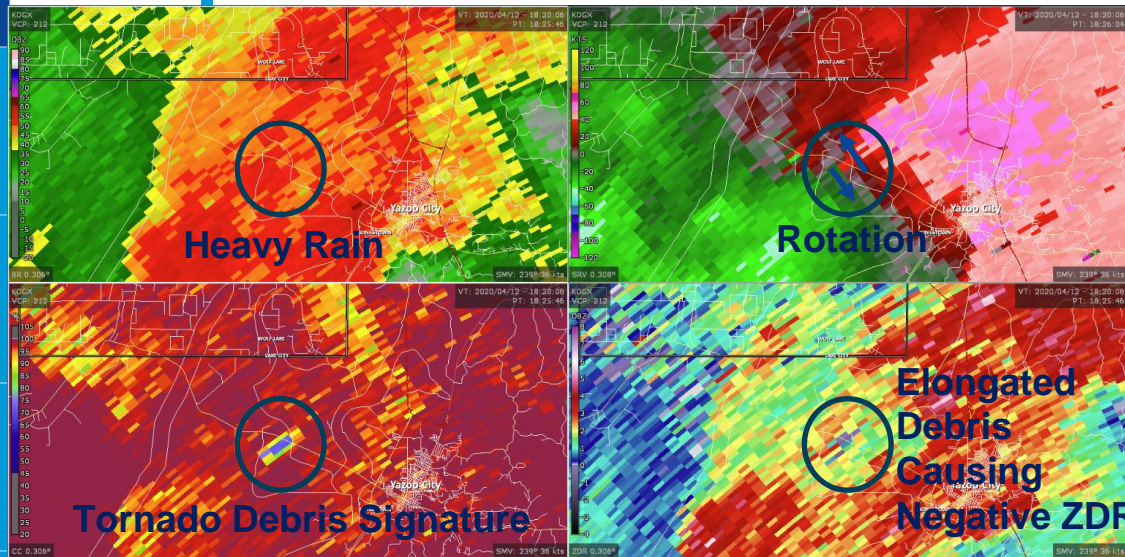
Wind damage observed in eastern Iowa in the wake of a derecho on August 10, 2020. Source: NWS Storm Surveys, accessible here: [https://www.weather.gov/dvn/summary\\_081020](https://www.weather.gov/dvn/summary_081020)







# Squall Line Hazards: Tornadoes



Structure damage west of the Yazoo County Airport on April 12, 2020. Source: [Derrick James on X](#).



Barn damage rated at the EF-2 level northeast of the Yazoo County Airport on April 12, 2020. Source: NWS Storm Survey, image accessible via the [Damage Assessment Toolkit](#).

An EF-2 Tornado affected Yazoo County, MS during the April 12, 2020 “Easter Sunday Outbreak” and was embedded in the middle of a squall line.







# Poll Question 4:

## Where is the safest place to be?

With destructive winds and tornadoes being the most common threats, where is the safest place to be when a squall line is approaching?

- In a vehicle
- On a boat
- In an interior room on the lowest floor of a building
- Under a tree
- In a basement or storm cellar



# Squall Line Safety: Notification and Shelter

## THUNDERSTORM WATCH

A Severe Thunderstorm Watch is issued when **a severe thunderstorm is possible**.

Stay tuned to forecast updates, monitor sky conditions, and know where to take shelter.

**Be Prepared.**

## THUNDERSTORM WARNING

A Severe Thunderstorm Warning is issued when **a severe thunderstorm is happening or about to happen**.

Take shelter immediately!

**Take Action!**

## Thunderstorms can escalate quickly.

Clear skies can quickly turn dark and ominous, whether due to pop-up thunderstorms or squall lines. Be prepared!



Set up a way to get weather warnings on your phone



When alerted to a storm, get inside a sturdy building immediately



Stay away from windows once indoors



If a building isn't nearby, get inside a vehicle



## Your Safe Place from Extreme Wind



During high winds, tree damage is expected. You are safest indoors, away from windows, in an interior room. Prevent damage to your property by trimming loose branches and parking away from trees.

weather.gov



## Spending Time Outdoors?



Be Aware of the Forecast Before You Head Out



Know How You Will Receive A Warning If One Is Issued



Know Where The Nearest Shelter Is Located



When Action Needs to be Taken, **DON'T WAIT!**

weather.gov/thunderstorm



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# Questions or Comments?

Adam Weiner, Meteorologist, NWS Wilmington, NC  
[adam.weiner@noaa.gov](mailto:adam.weiner@noaa.gov)

To download this presentation:  
<https://www.weather.gov/ohx/weather101presentations>

