NATIONAL WEATHER SERVICE

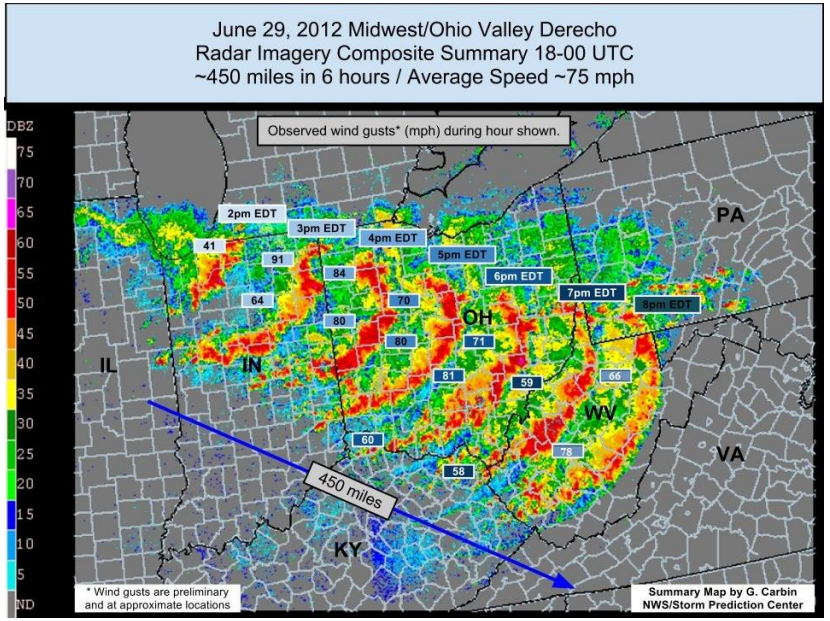
Weather 101: The Quasi-Linear Convective System

APRIL 21, 2025

Presenter: Adam Weiner, Meteorologist, NWS Wilmington, NC

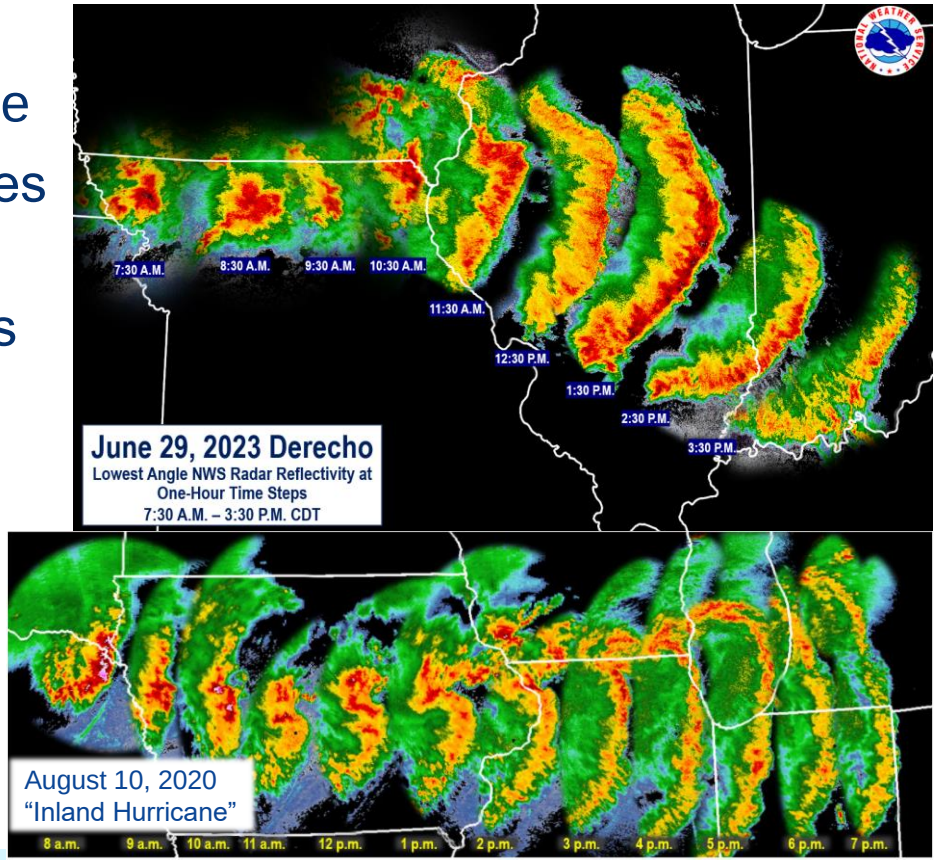
What is a Quasi-Linear Convective System (QLCS)?

- 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?

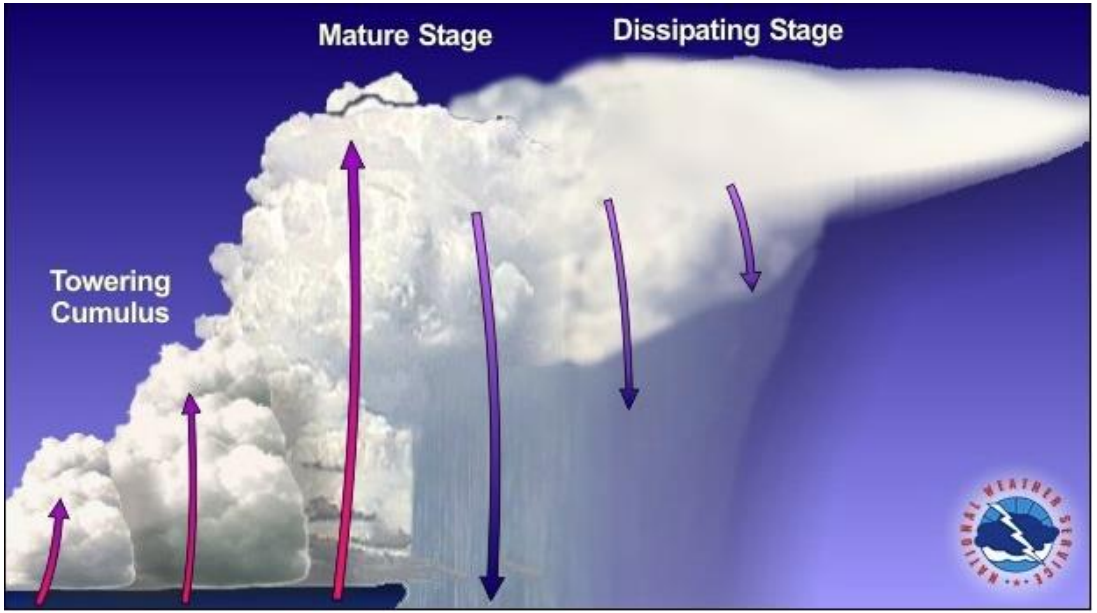
- A particularly damaging squall line
- Swath of wind damage ≥ 400 miles long
- Swath of wind damage ≥ 60 miles wide
- Includes wind gusts of ≥ 58 mph along most of its length
- Includes several, well-separated gusts ≥ 75 mph
- Includes bowing shape



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!

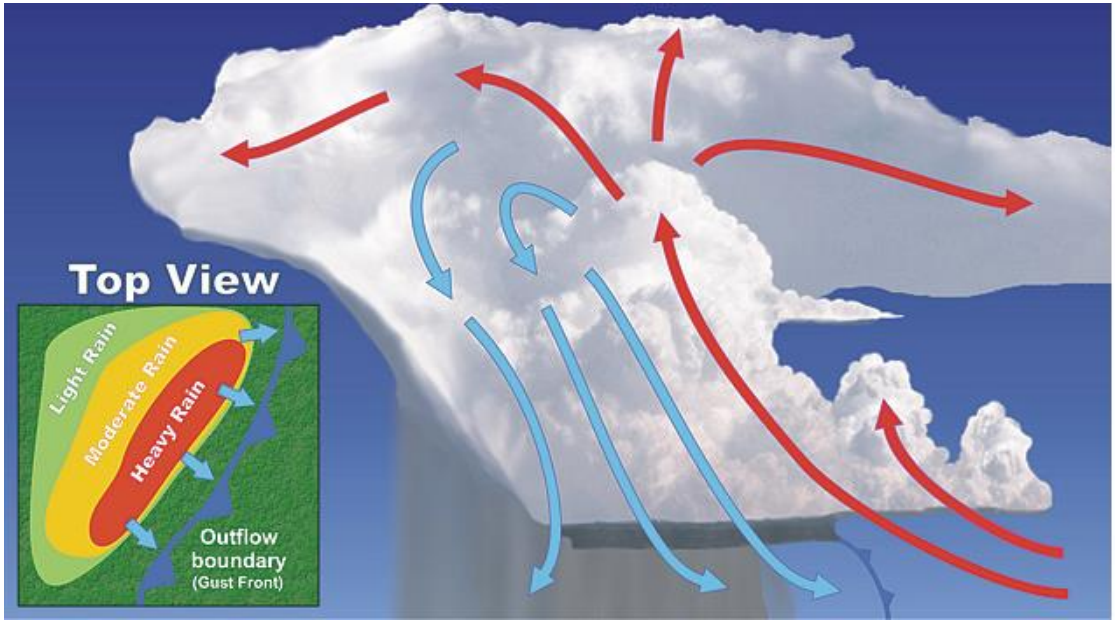
- Moisture
- Instability
- Lift

PLUS:

- Strong downdrafts leading to a sharp gust front

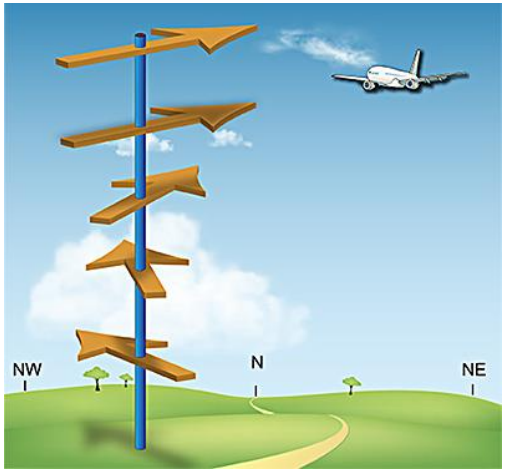
OR

- A front (cold, warm, or stationary)

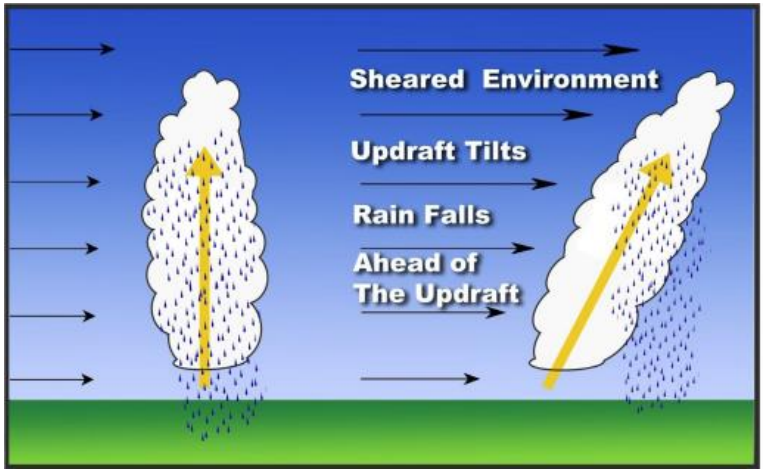


Is Anything Else Needed?

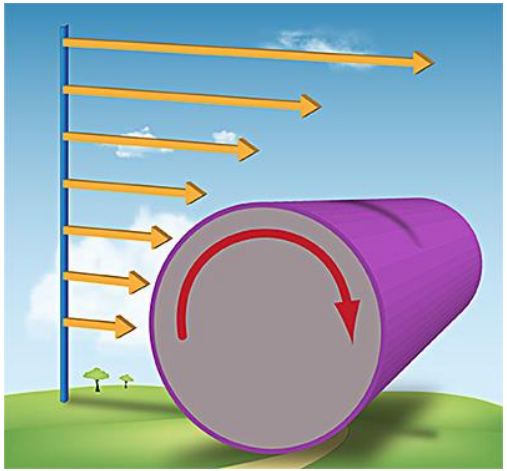
Directional Shear
Changing wind direction with increasing height



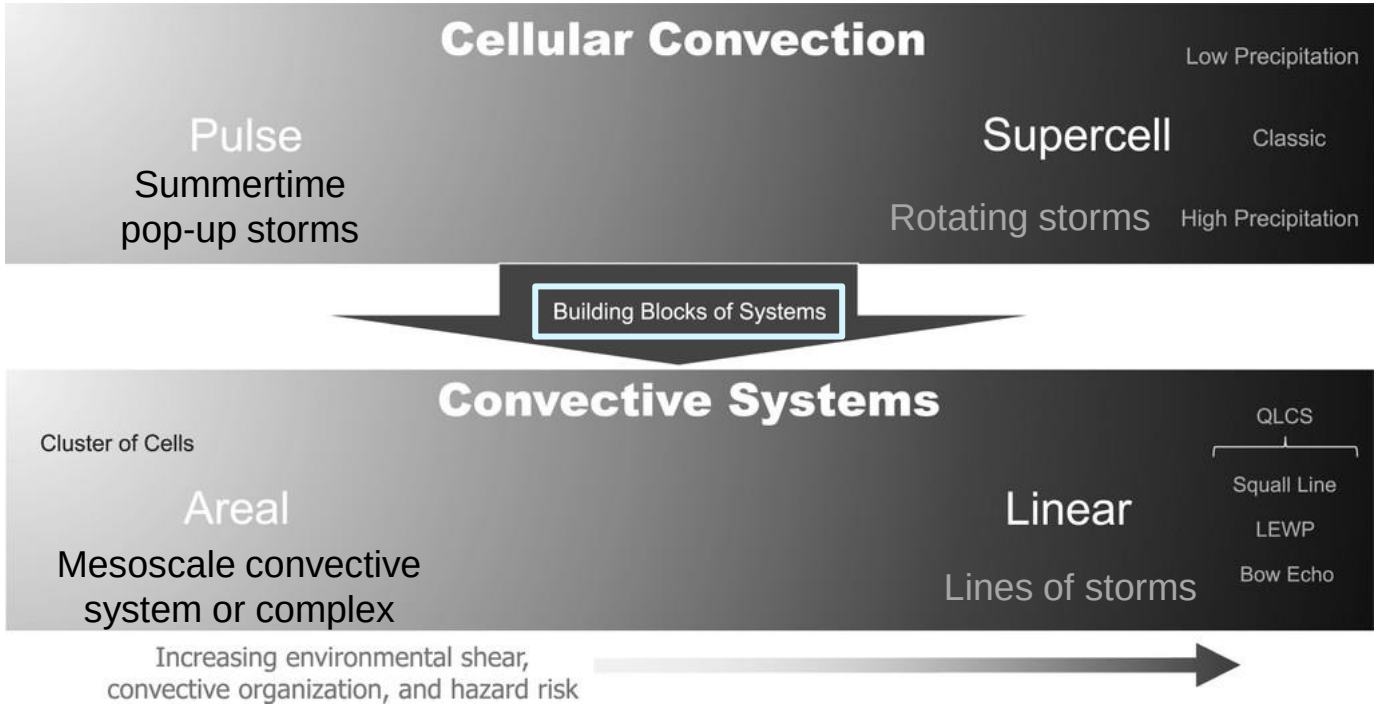
Wind shear
helps storms
↓ last longer↓



Speed Shear
Increasing wind speed with increasing height



Why Does Wind Shear Matter?

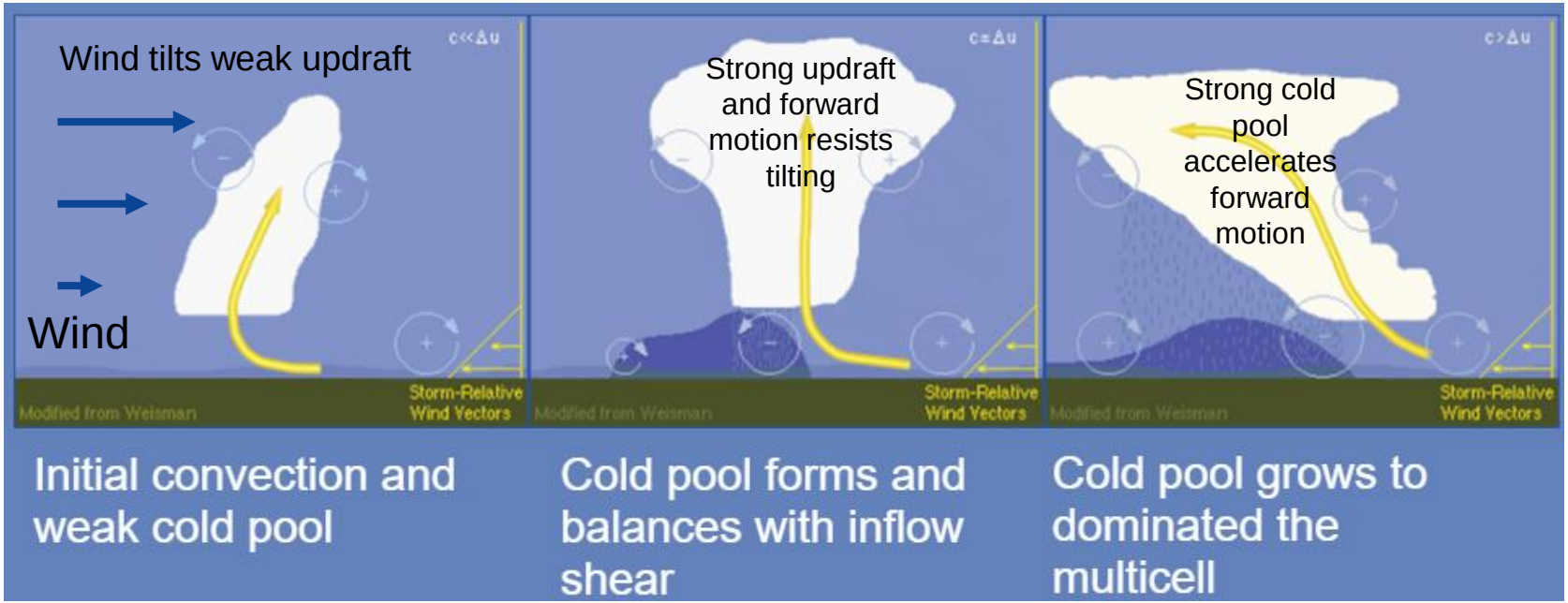


A visual depicting the spectrum of storm organization as wind shear increases. In general, stronger wind shear contributes to longer-lived storms with a greater threat for severe weather.

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 QLCSs 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.

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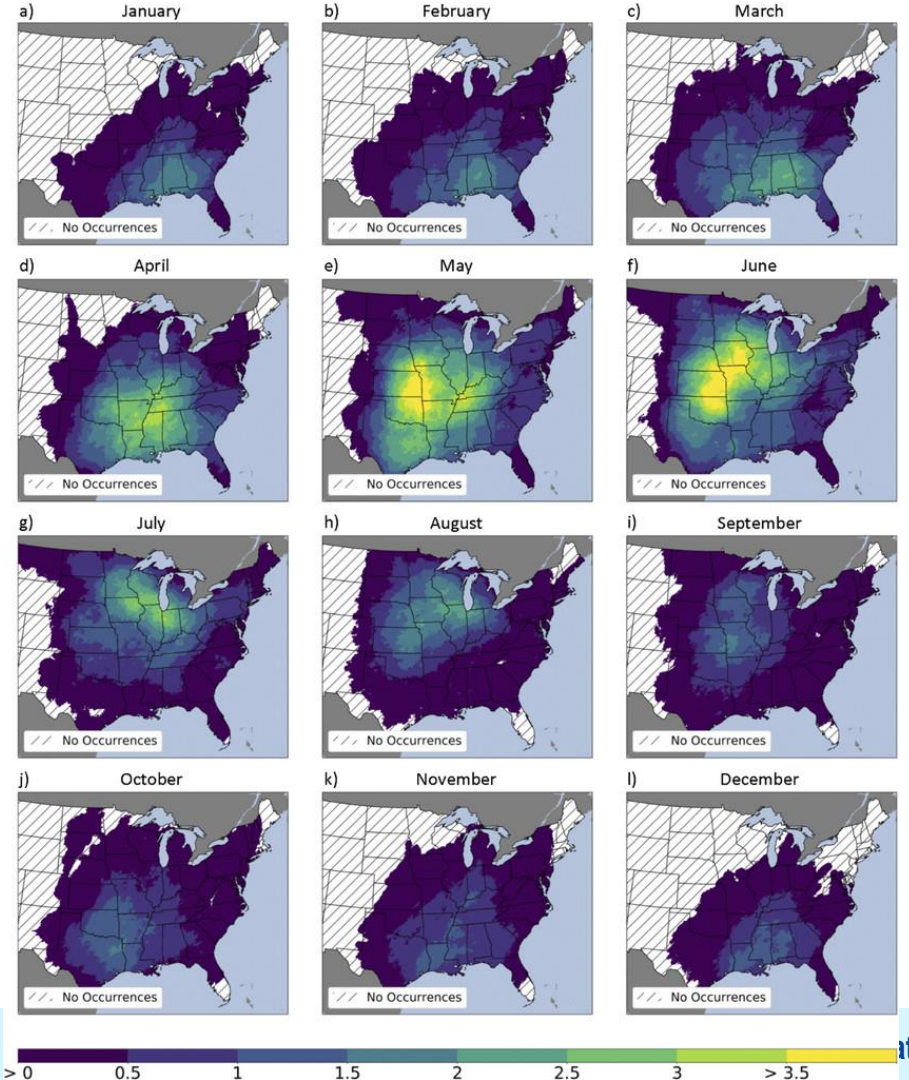

Cool Season vs. Warm Season Squall Lines

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 QLCSs are more destructive?

Do you think QLCSs 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).

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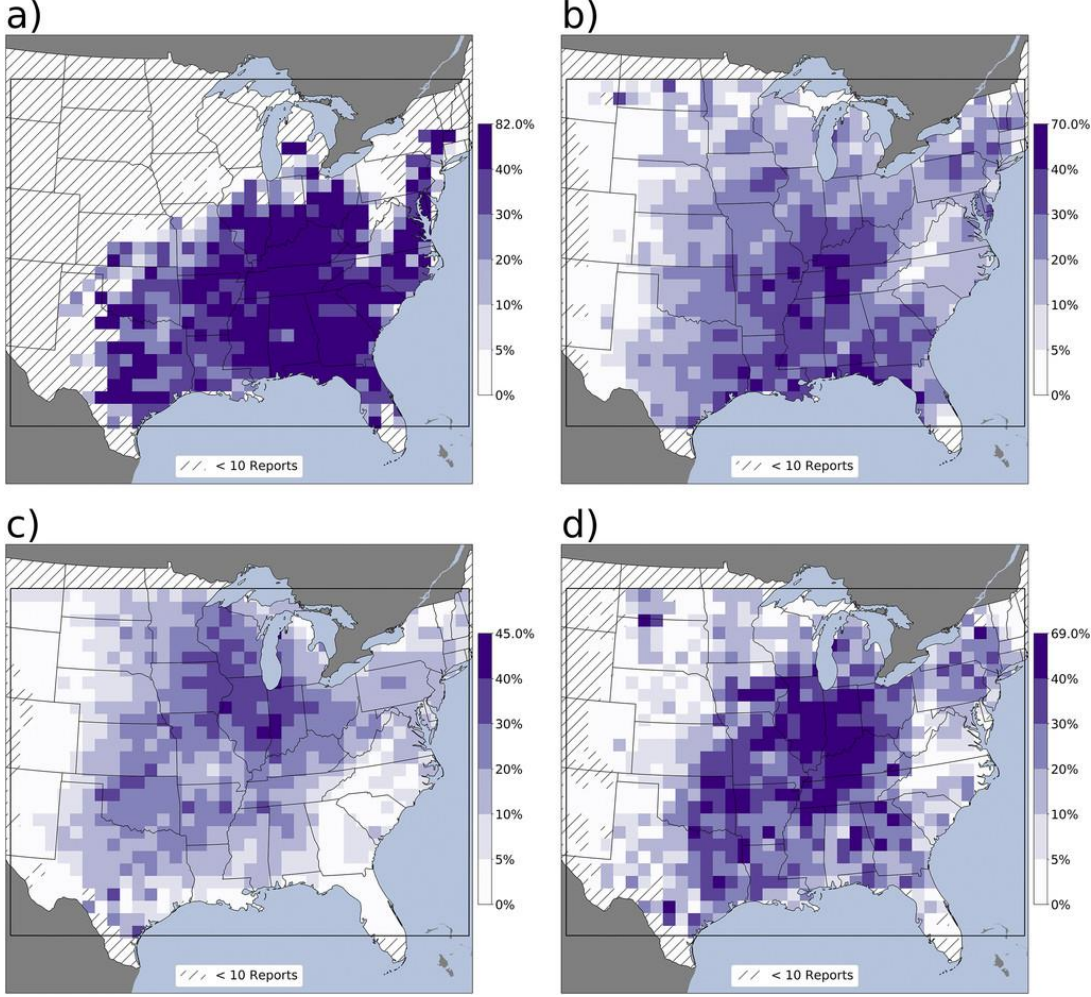
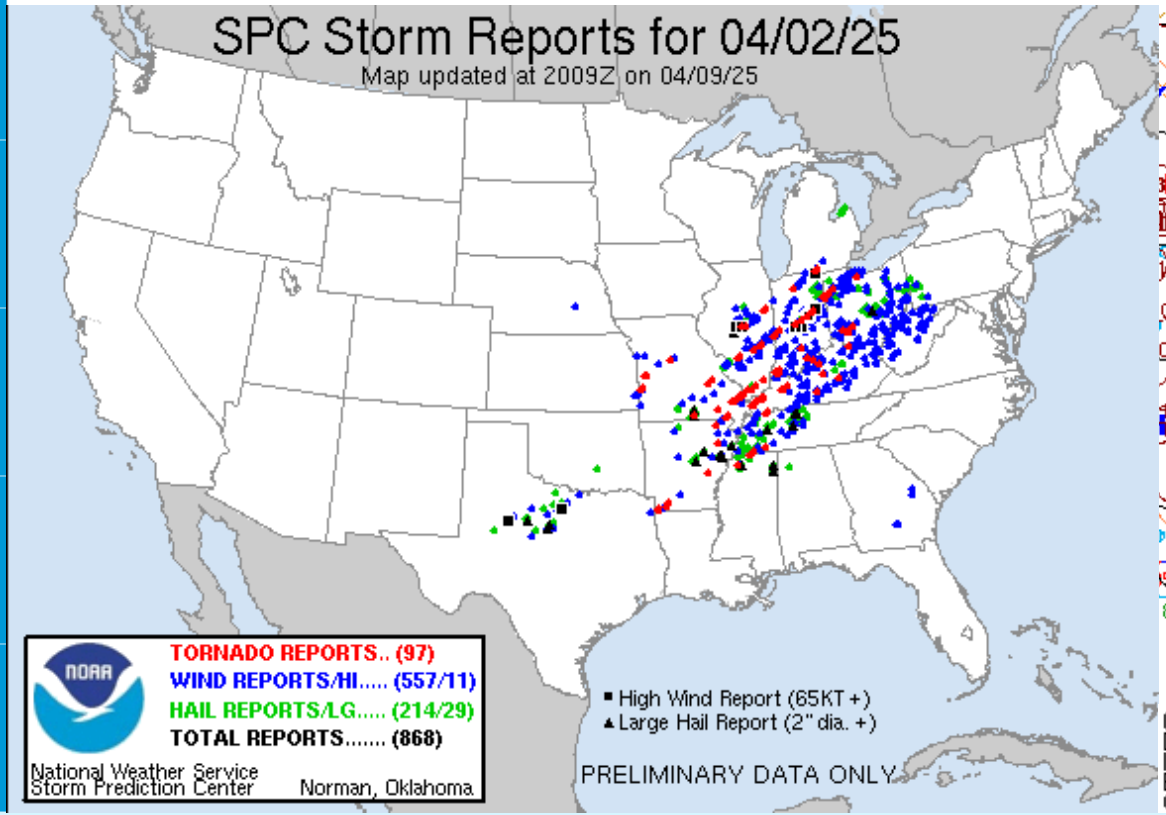
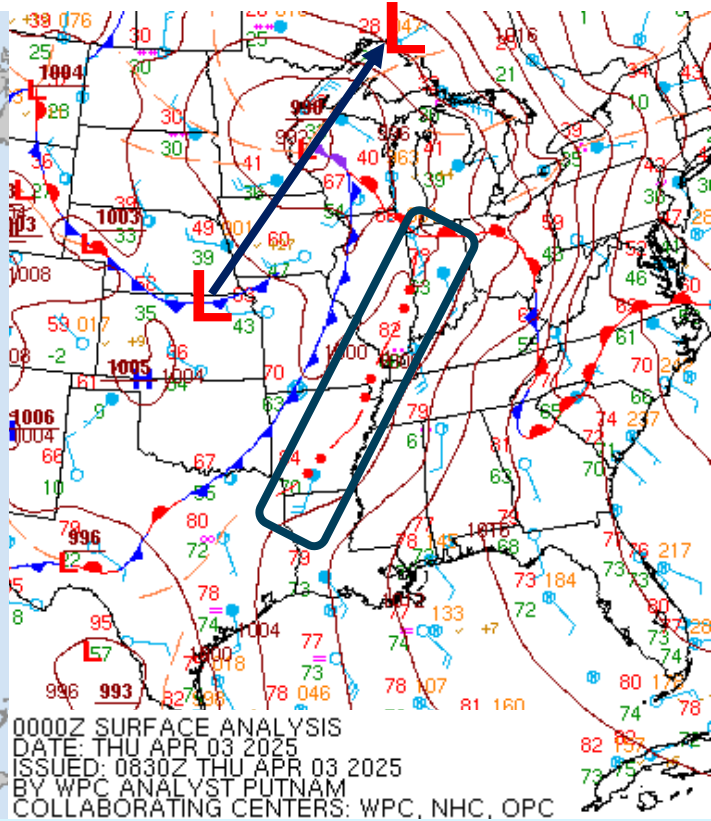
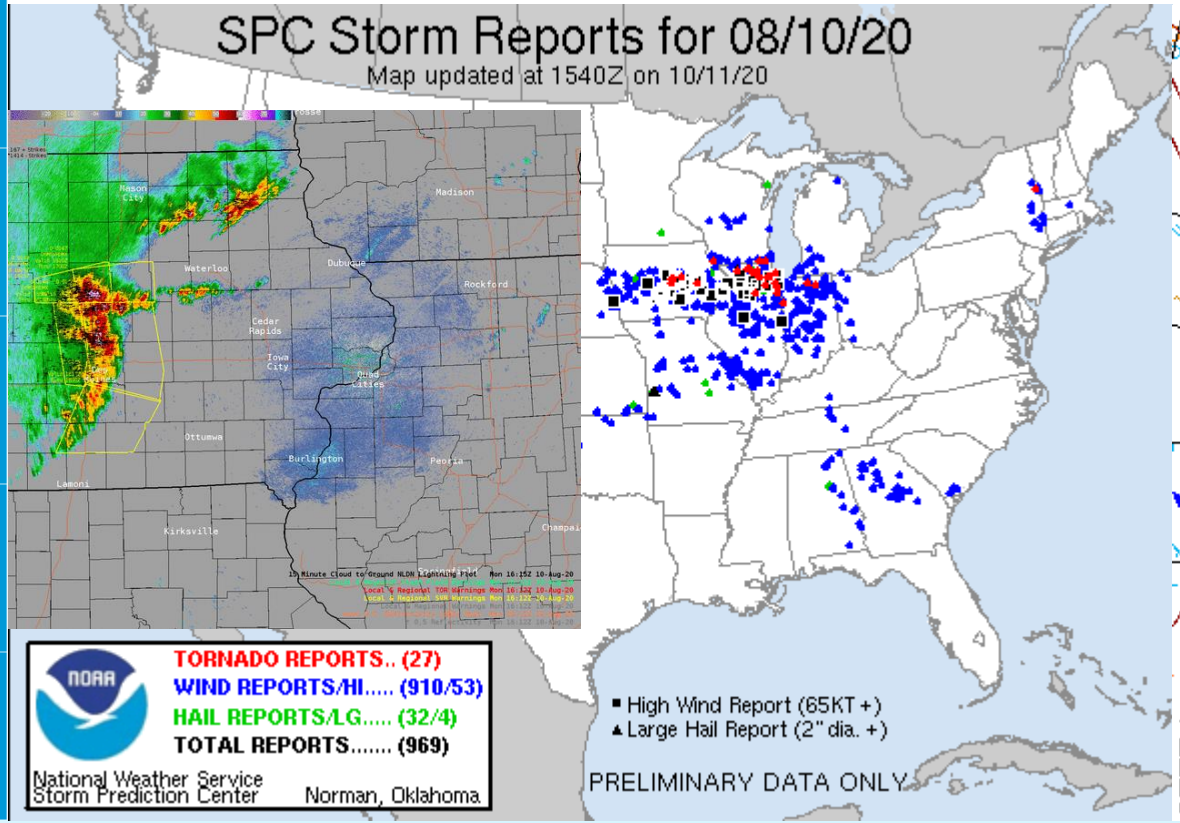


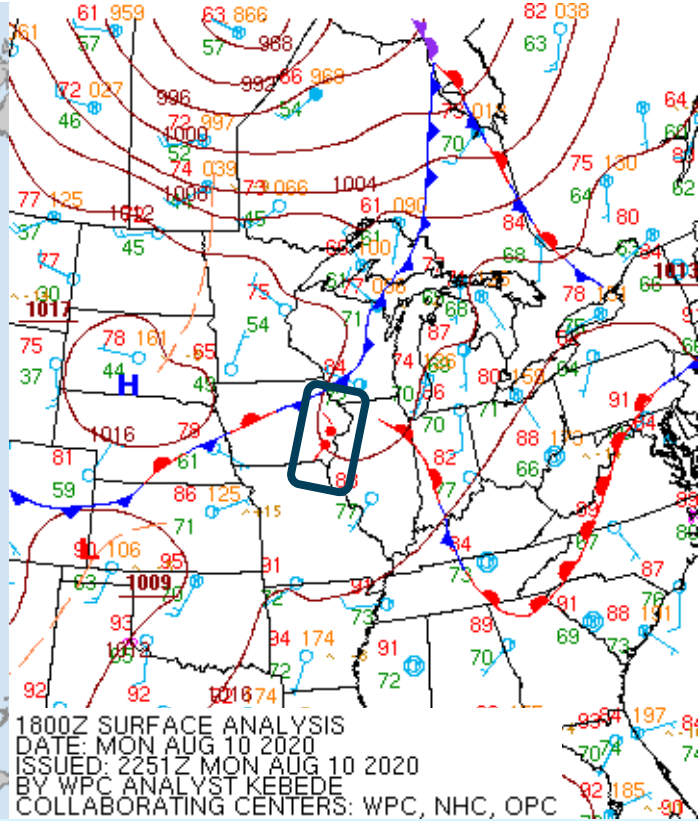
Cool Season QLCS: April 2, 2025





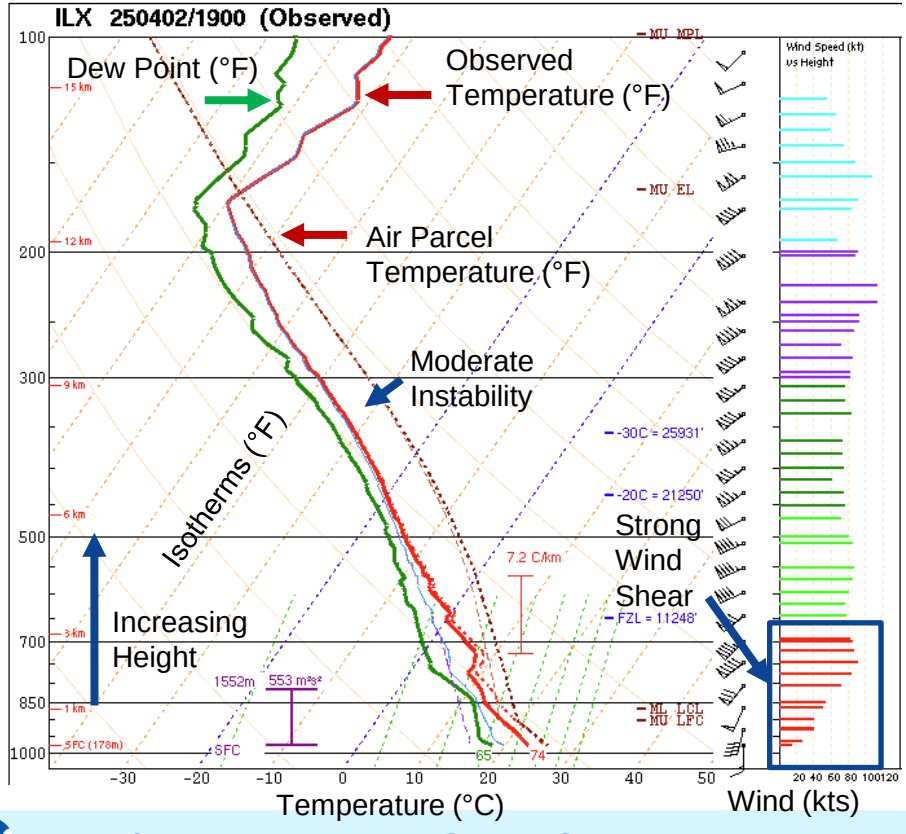
Warm Season Derecho: August 10, 2020



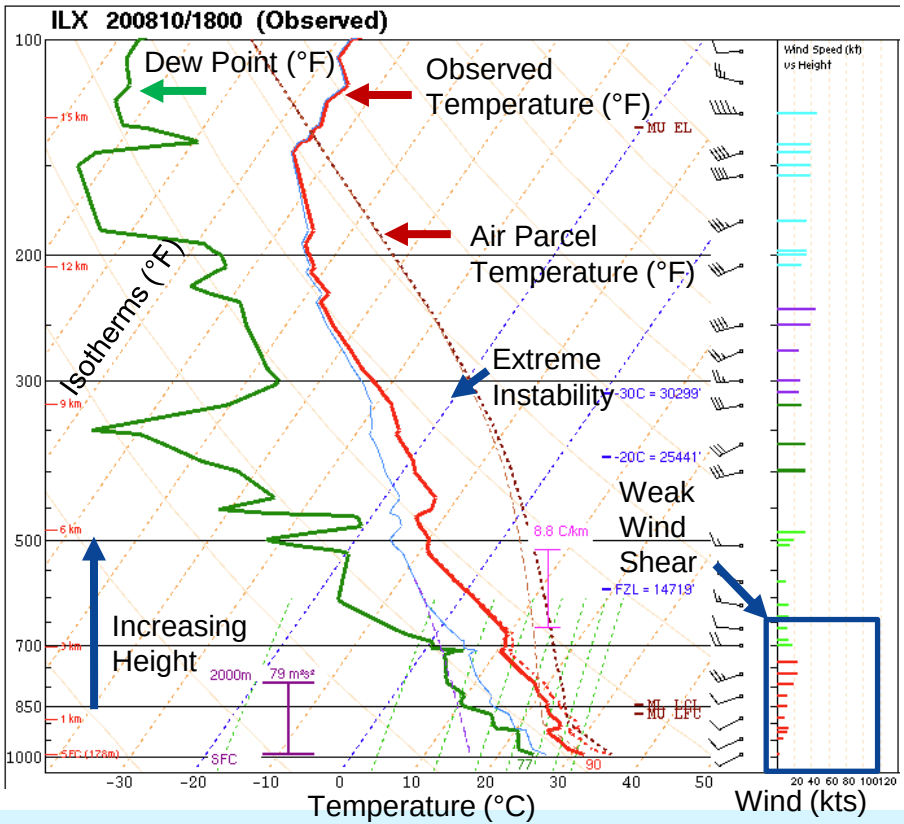


Atmospheric Differences

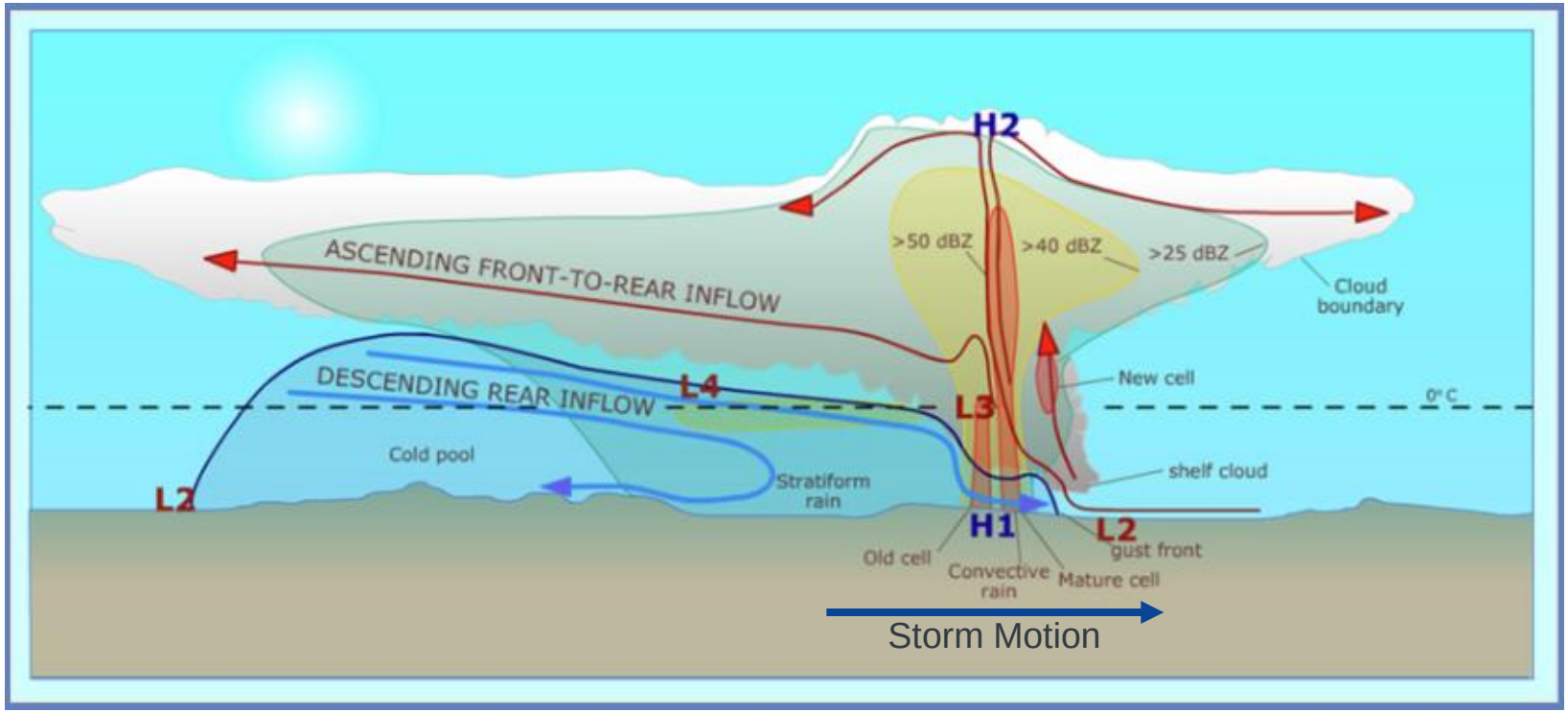
April 2, 2025 – Lincoln, IL



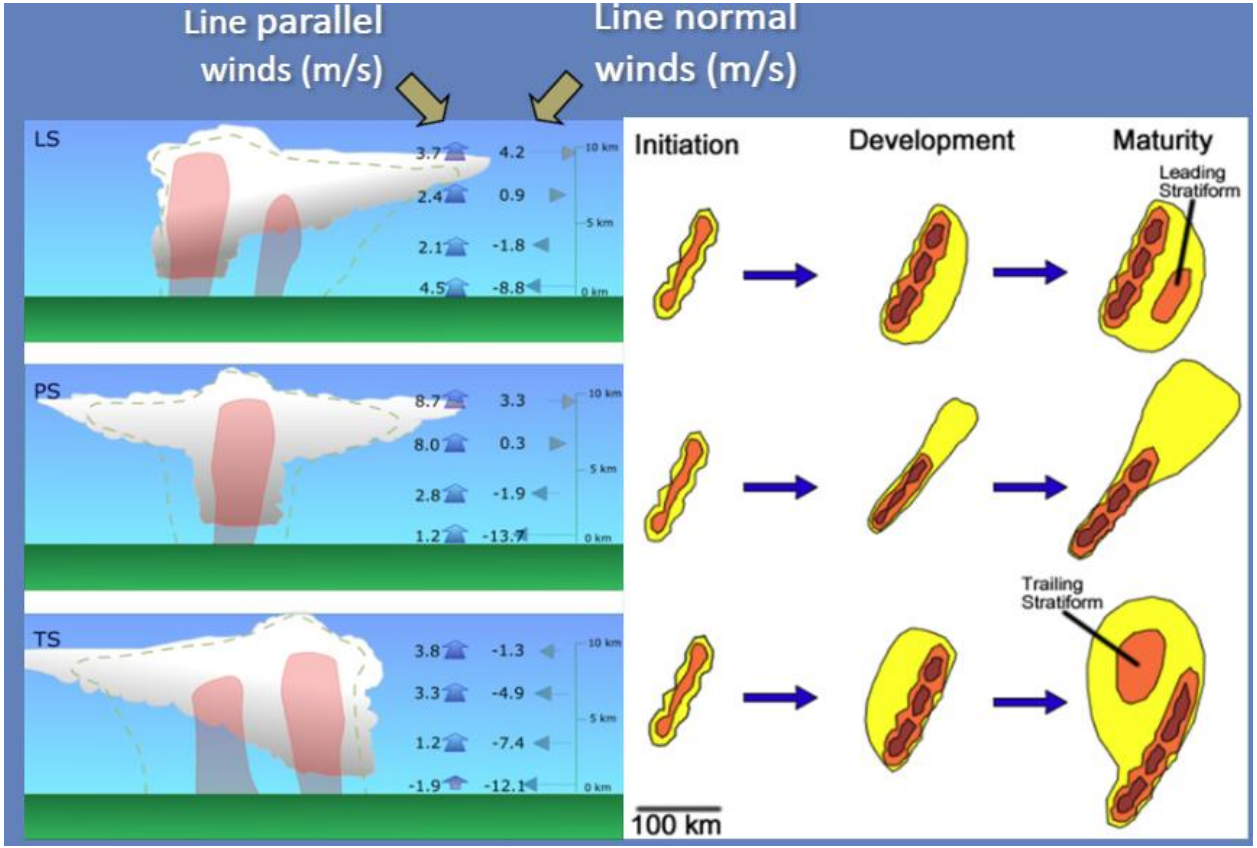
August 10, 2020 – Lincoln, IL



Squall Line Vertical Cross-Section



Squall Line Structures

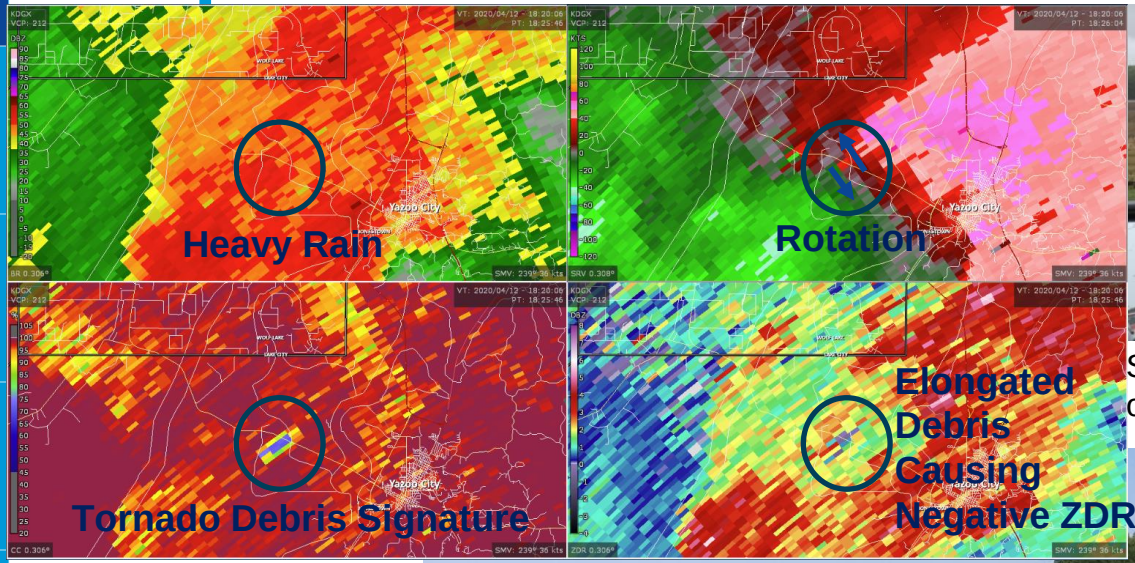


The wind direction relative to the squall line with increasing height determines where the supply of low-level unstable air for continued storm development is located and where precipitation is blown relative to the updrafts.

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

Squall Line Hazards: Tornadoes



Structure damage west of the Yazoo County Airport on April 12, 2020. Source: Derrick James on X.

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.

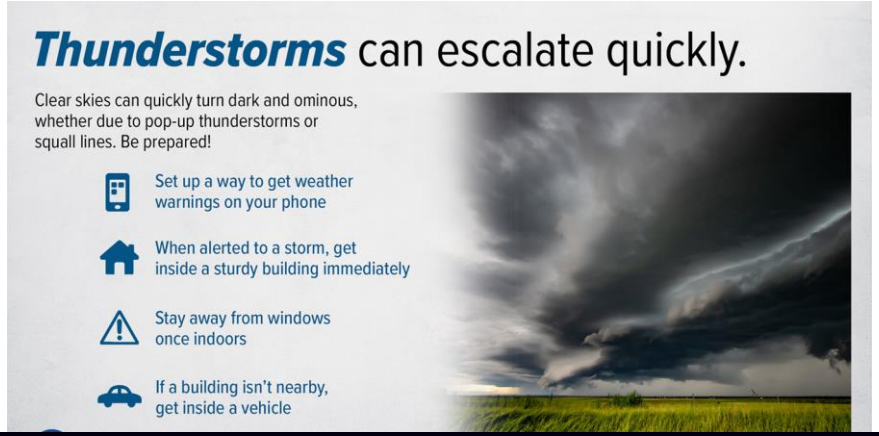
Barn damage rated at the EF-2 level northeast of the Yazoo County Airport on April 12, 2020. Source: NWS Storm Survey, image accessible via the Damage Assessment Toolkit.

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



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Questions or Comments?

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