Courtesy of Bruce Lee

Chapter 18
Thunderstorms

What kind of cloud type is a thunderstorm?

Why do we care about thunderstorms?

What must occur for a thunderstorm to be considered a severe thunderstorm?

What elements are required for thunderstorm formation?

A source of moisture
A conditionally unstable atmosphere
A mechanism to trigger the thunderstorm updraft

What elements are required for severe thunderstorm formation?

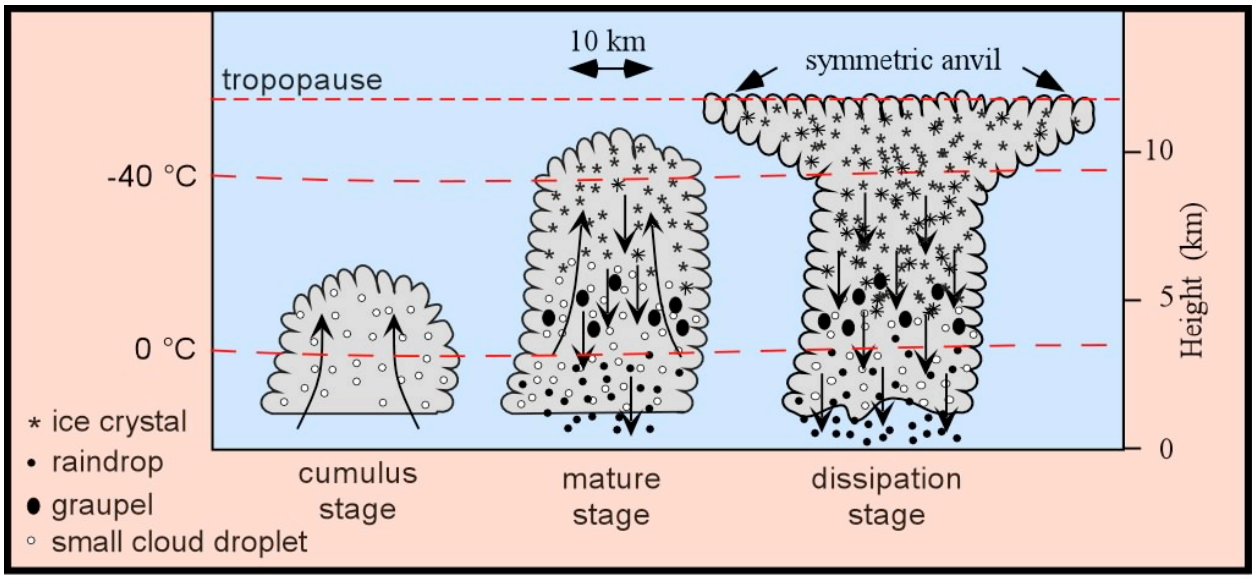
Airmass Thunderstorms

Where do airmass thunderstorms typically form?

What triggers an airmass thunderstorm?

What is the typical lifetime of an airmass thunderstorm?

What are the winds like in the environment where airmass thunderstorms form?



The Three Stages of an Airmass Thunderstorm

Cumulus stage – warm, buoyant plume of rising air

> What type of particles makeup the cloud in the cumulus stage of a thunderstorm?
>
> When do ice crystals begin to form in a thunderstorm?

Mature stage – precipitation begins to fall from the thunderstorm

> What two factors cause a downdraft to form in an airmass thunderstorm?

Where does the downdraft form in relation to the original updraft?

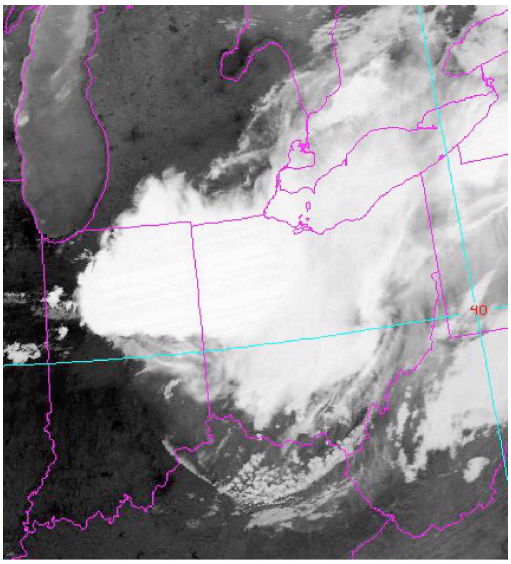
Dissipation stage – the downdraft dominates the storm

Anvil – the flat top of a thunderstorm that forms as the thunderstorm updraft hits the tropopause and spreads out horizontally

What are the characteristics of the anvil of an airmass thunderstorm?

Mesoscale Convective Systems (MCSs)

Why do we care about MCSs?



What area can MCSs cover?

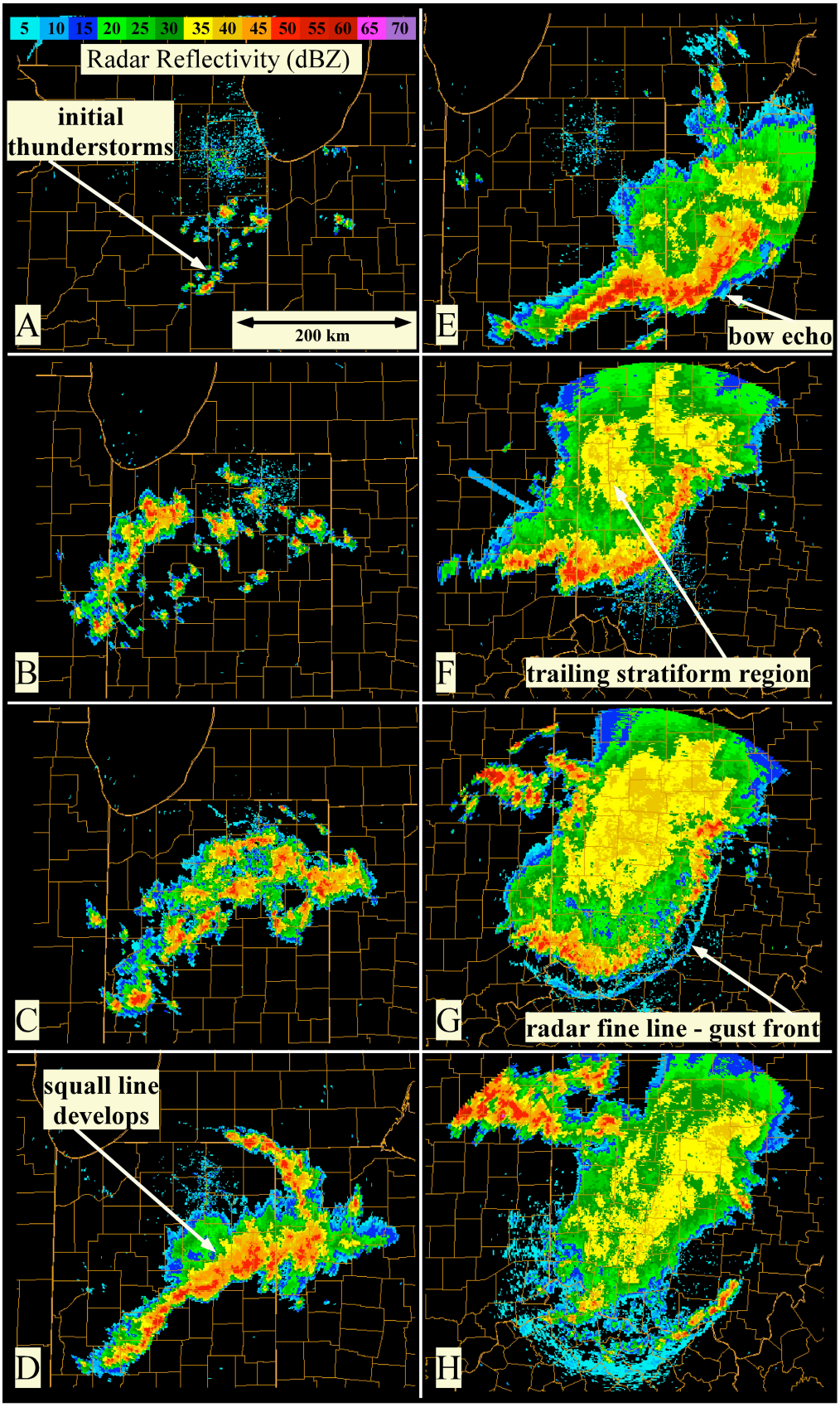
What is the typical life cycle of an MCSs?

Squall line – a long line of thunderstorms in which adjacent thunderstorm cells are so close together that the heavy precipitation falls in a long continuous line

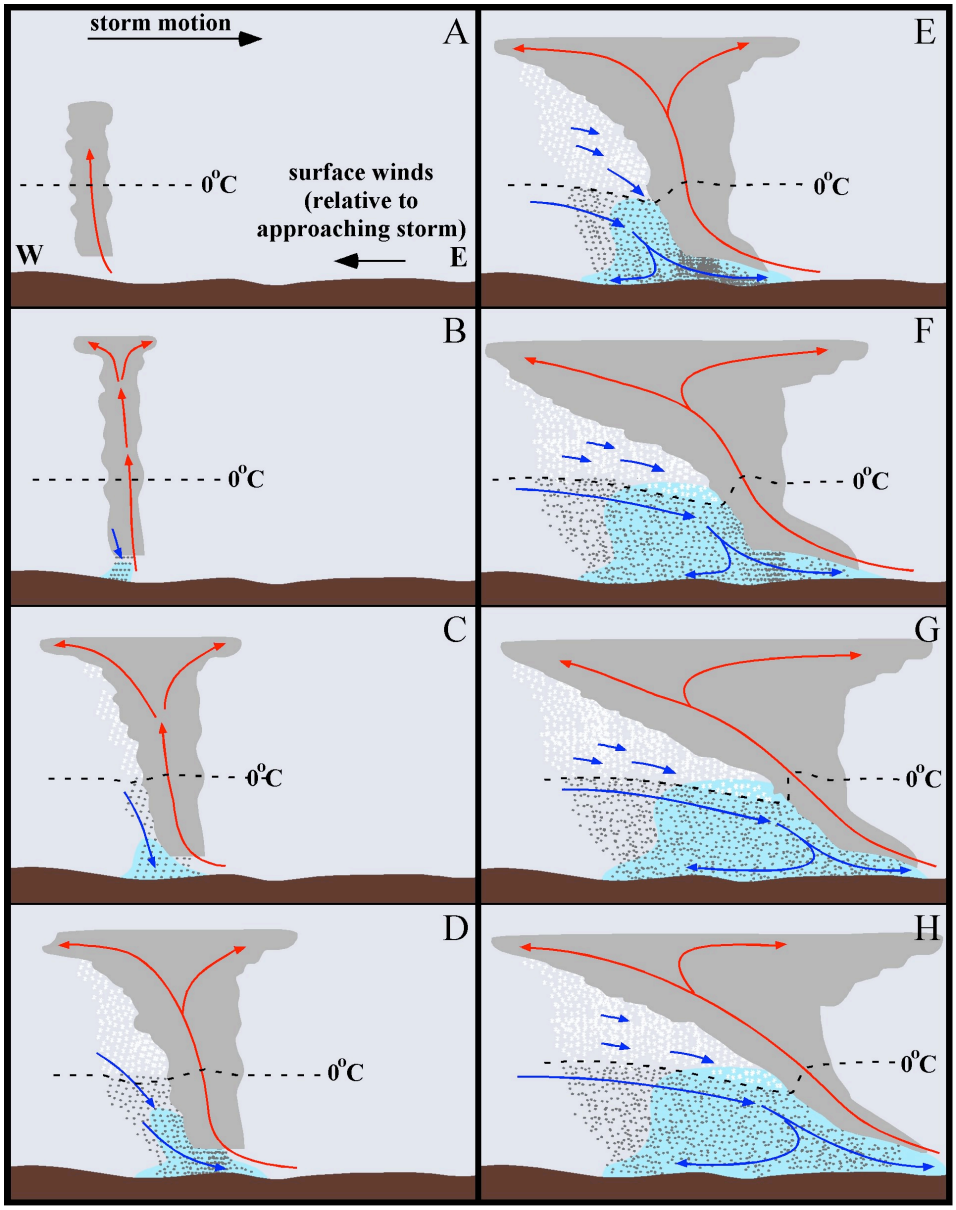
Bow echo – portion of a squall line that bows outward from MCS

Trailing stratiform region – area of less intense precipitation on rear side of a squall line

Gust front – leading edge of evaporatively cooled air



How does an MCS evolve over time?



What is the cold pool?

How does the cold pool form?

What role does the cold pool play in the formation of a squall line?

How does the cold pool alter the updrafts in an MCS?

What impact does this have on where precipitation falls?

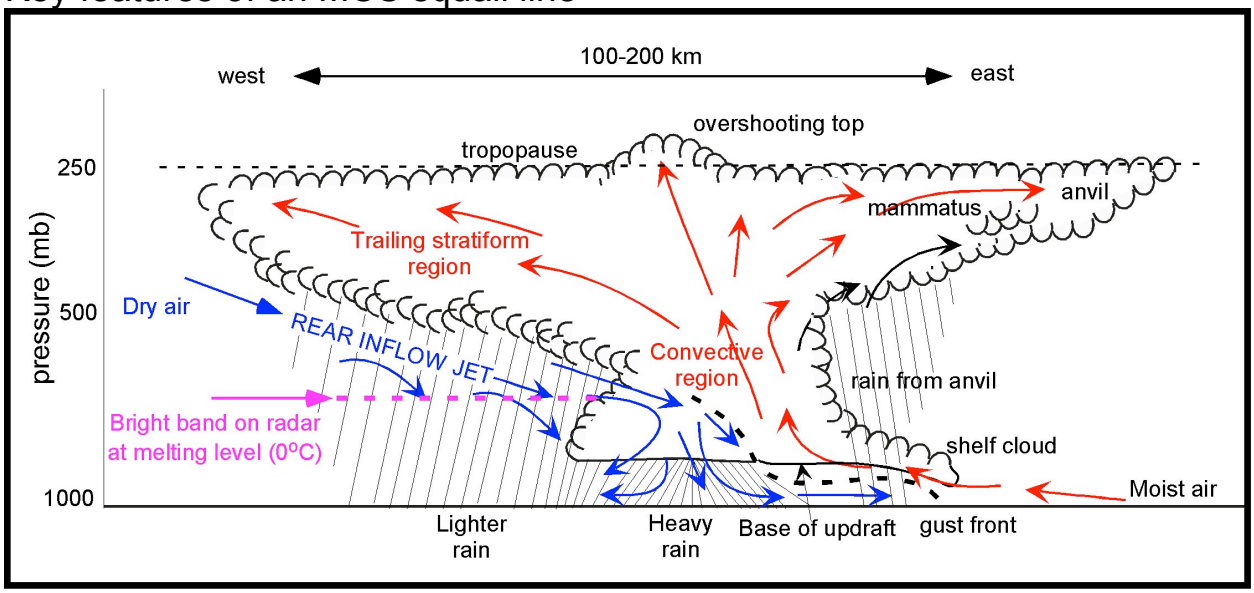
How does this alter the cold pool?

What is a shelf cloud?

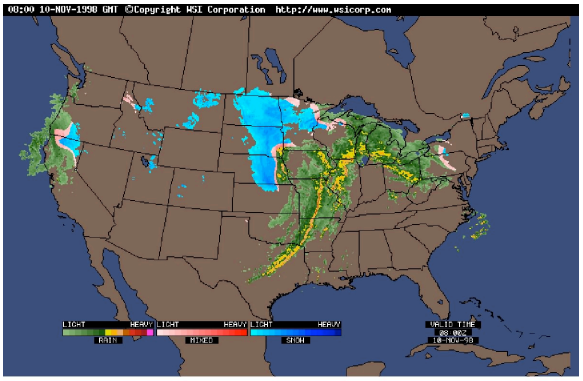
What is a radar fine line?

Derecho – a widespread thunderstorm generated severe windstorm

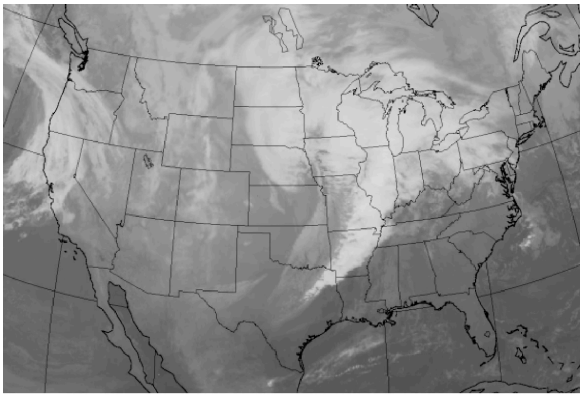
Key features of an MCS squall line



Frontal Squall Lines



Courtesy of Weather Services International Corporation

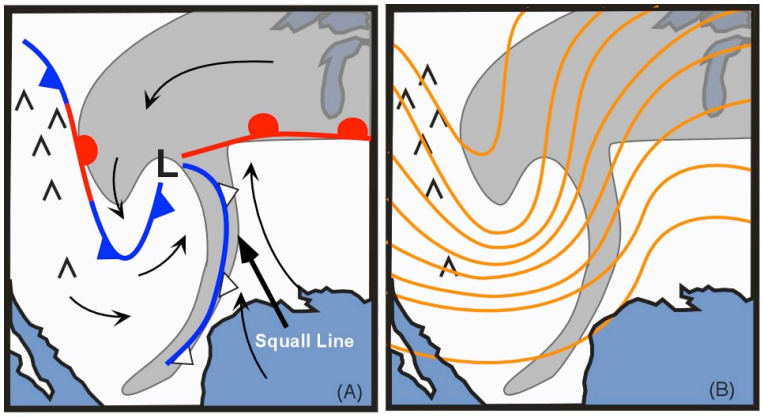


Courtesy of the Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign

What is the appearance of a frontal squall line on a radar reflectivity image?

From a satellite perspective, what part of a mid-latitude cyclone comma cloud does a frontal squall line form?

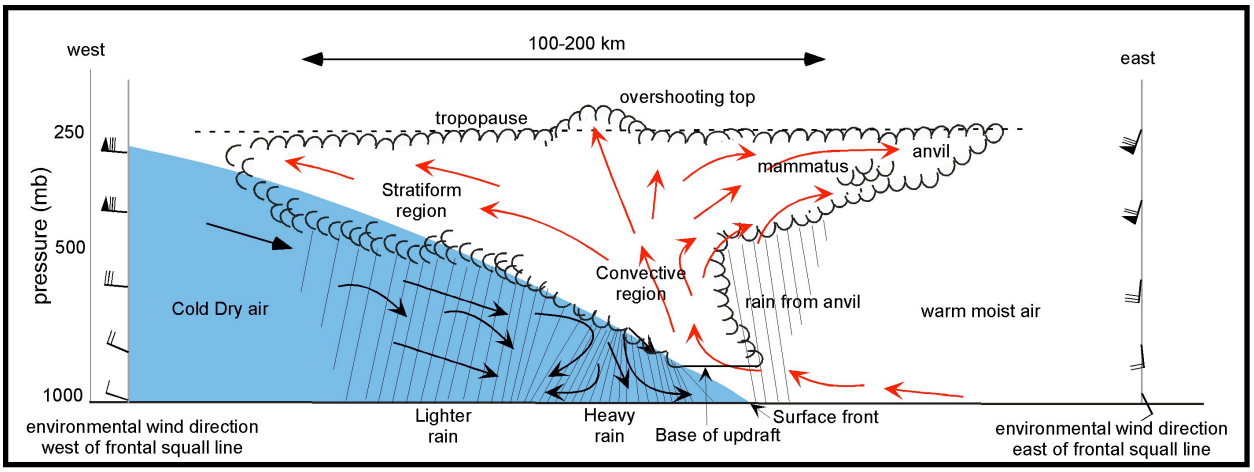
What is the lifetime of a frontal squall line?



Where do frontal squall lines typically form?

How do the winds change from the surface to aloft ahead of a frontal squall line?

What are the key features of a frontal squall line?



What mechanism is responsible for lifting the conditionally unstable air to its level of free convection (LFC) in a frontal squall line?

Overshooting top – the portion of the updraft that penetrates the tropopause

What causes the anvil of a squall line to form?

Why do mammatus clouds form?

Supercell Thunderstorms

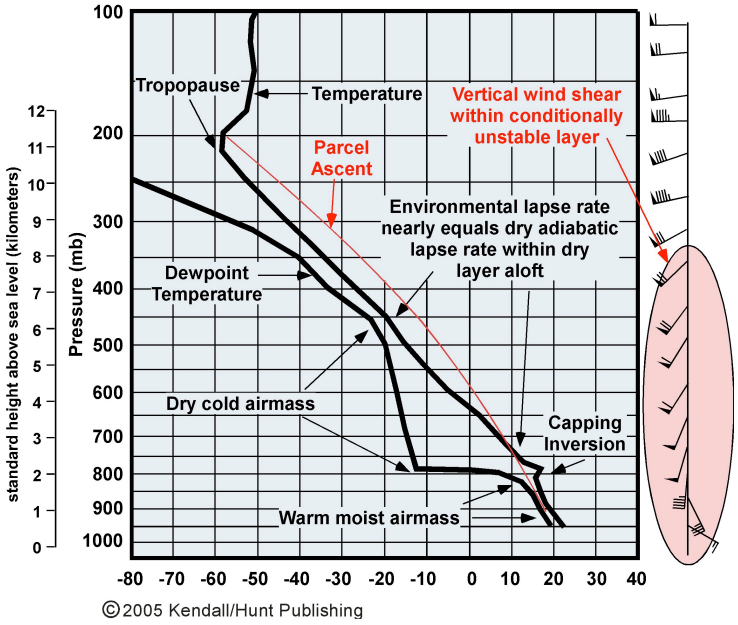
Supercell thunderstorm – a rotating thunderstorm

Supercell thunderstorms are responsible for creating the majority of the most dangerous severe thunderstorm weather and strongest tornadoes that form in the United States.

How strong is the updraft in a supercell thunderstorm?

What conditions are required for a supercell thunderstorm to form?

How can conditional instability develop in the atmosphere?



CAPE – convective available potential energy

What does CAPE tell us about the strength of an updraft in a thunderstorm?

What is the source of warm, moist air at low levels in this sounding?

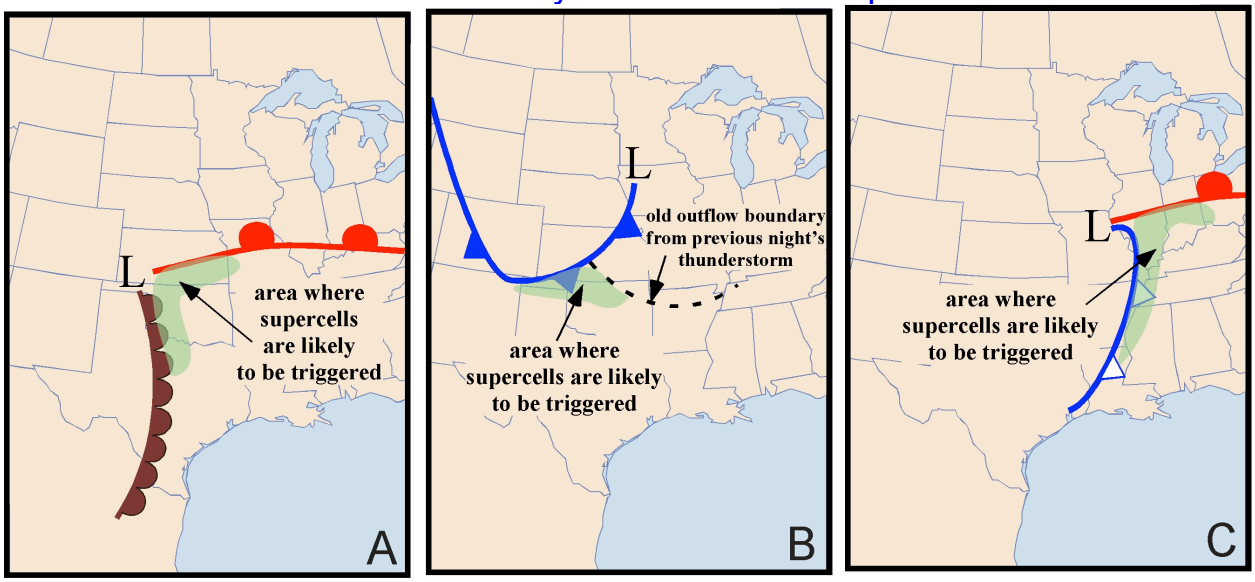
What is the source of cold, dry air at upper levels in this sounding?

What is the role of the capping inversion in supercell formation?

How do the winds change with height in an environment that will support supercell development?

Low level jet – strong southerly low level winds that extend from the surface to a maximum altitude of 3 km

How is air near the surface initially lifted to form a supercell thunderstorm?



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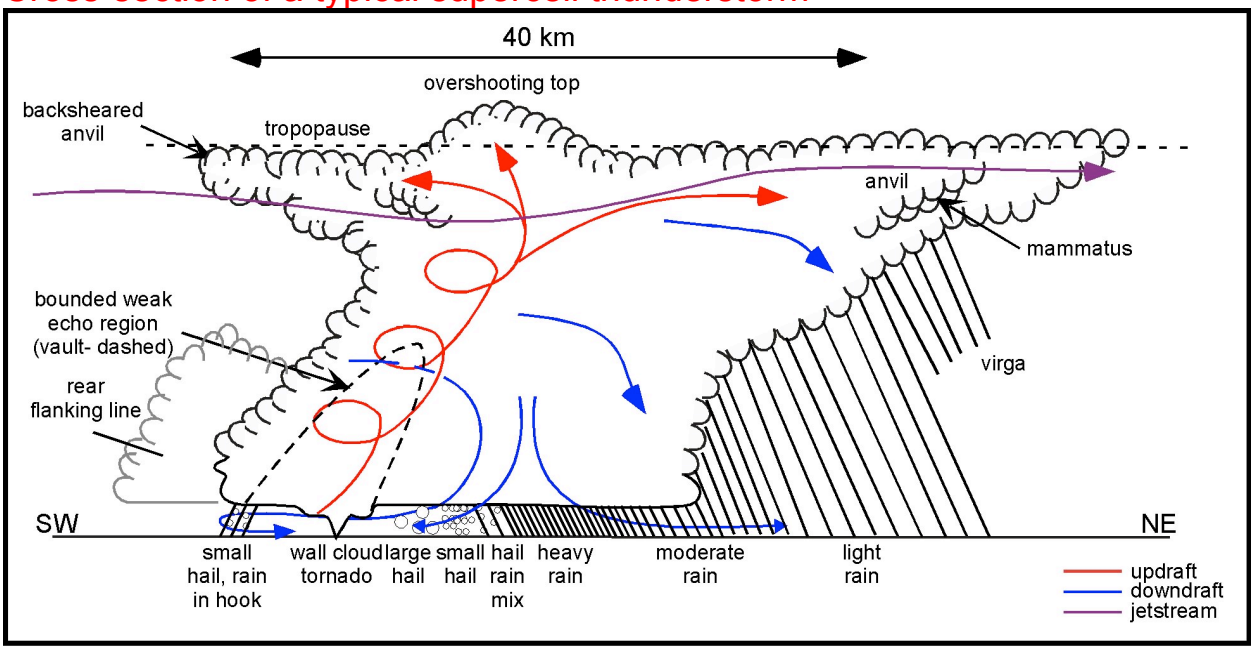
Supercells typically first form where airmass boundaries intersect.

Cross-section of a typical supercell thunderstorm



Key features of a supercell thunderstorm:

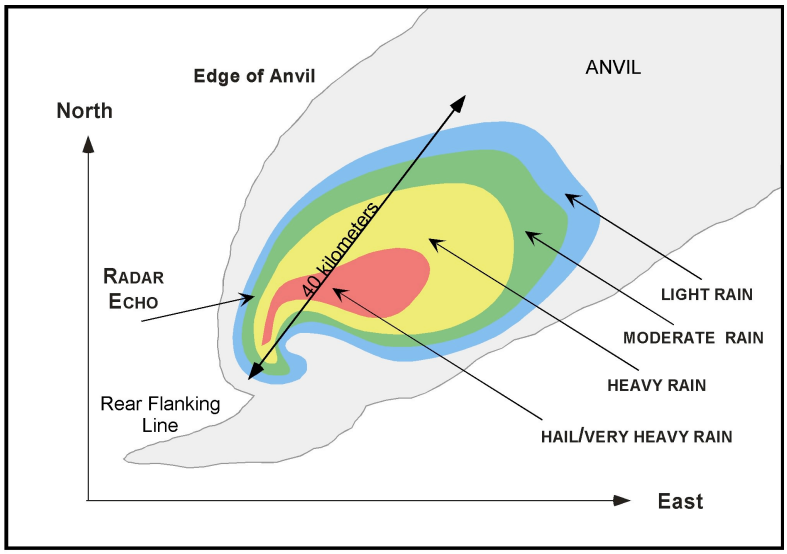
- Tilted updraft
- Overshooting top
- Anvil
- Rain free base
- Bounded weak echo region
- Wall cloud
- Mammatus
- Virga
- Rear flanking line

Wall cloud – a lowered cloud base in the vicinity of the updraft that is often observed to be rotating

Why is there a rain free base near the updraft?

Bounded weak echo region – an area of low reflectivity on a radar image of a supercell thunderstorm

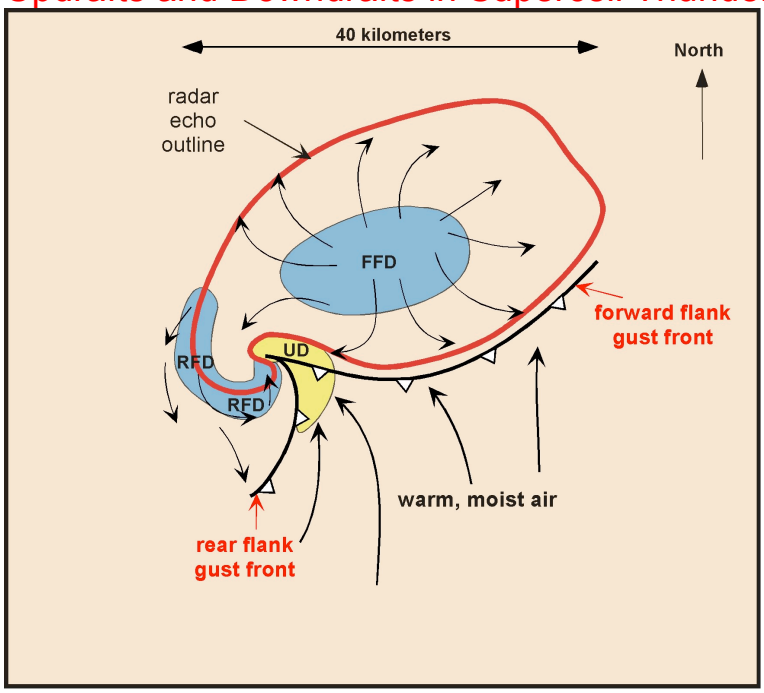
Where does precipitation fall in a supercell thunderstorm?



What causes this distribution of precipitation in a supercell?

What types of precipitation would you observe as a supercell thunderstorm approaches and passes over you?

Updrafts and Downdrafts in Supercell Thunderstorms



UD – updraft

FFD – forward flank downdraft

RFD – rear flank downdraft

Gust fronts mark the leading edge of FFD and RFD air at the surface.

What causes the FFD and RFD to form?

New thunderstorm cells form along the RFD gust front.