

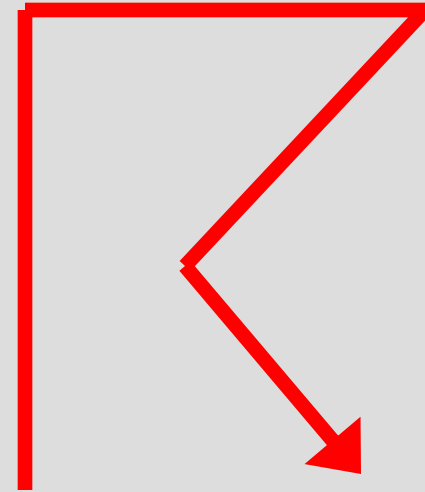
NATS 101
Section 13: Lecture 26

Thunderstorms and Severe Weather
Part I

Thunderstorm:

**A storm
containing
lightning or
thunder.**

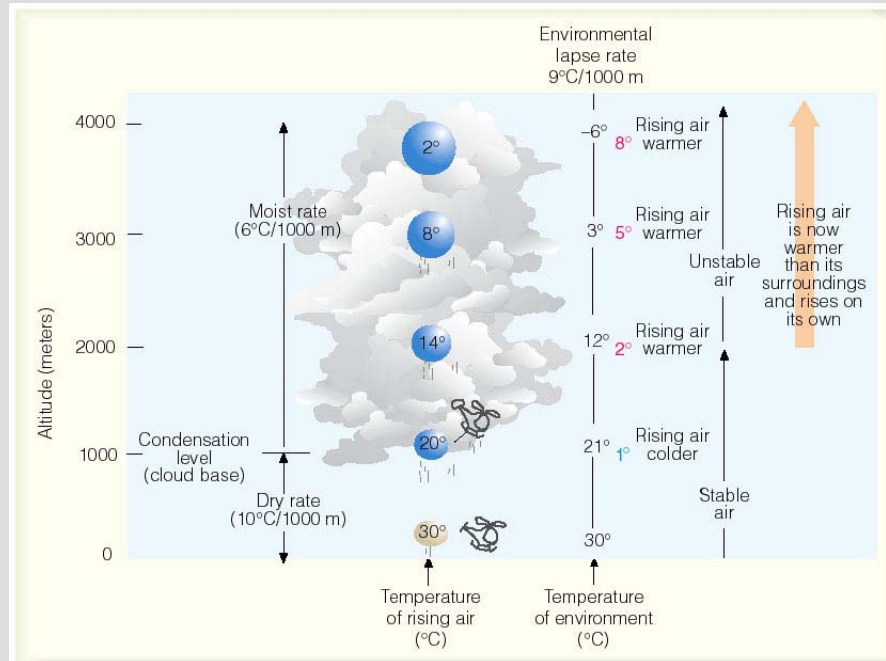
**What weather hazards are
associated with them?**



Basic ingredient for thunderstorm...

A conditionally unstable environment through a deep enough layer in the troposphere to develop a cumulonimbus cloud

Conditionally Unstable



Environmental lapse rate between the moist and dry adiabatic lapse rate.

Air does not resist upward motion *if* _____.
Unlike the absolute unstable case, this condition can happen a lot in the atmosphere!

What types of clouds are the result?

How deep convection is depends on how far up the instability goes in the atmosphere

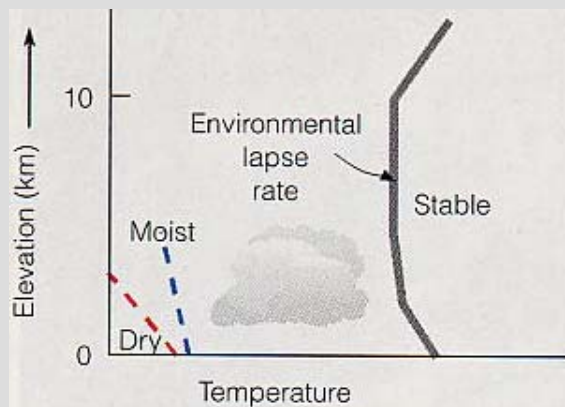
Cumulus humilis



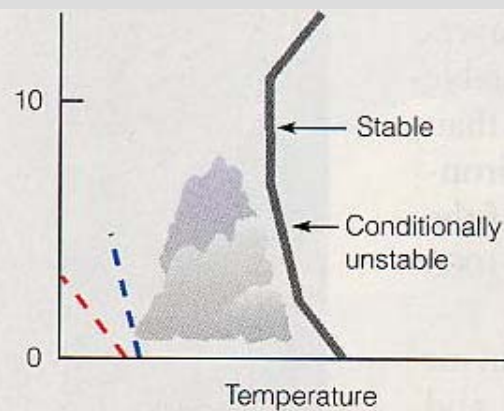
Cumulus congestus



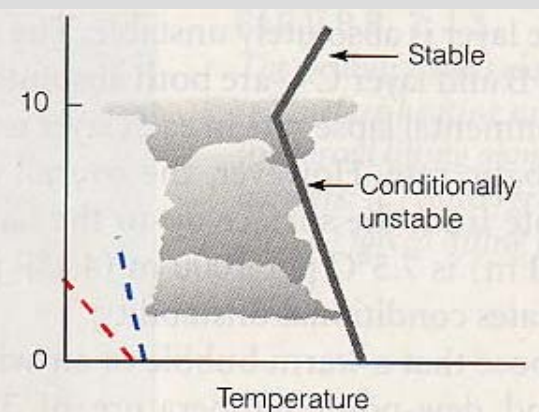
Cumulonimbus



**Conditionally unstable
in a shallow layer**



**Conditionally unstable
about midway through
troposphere**



**Conditionally unstable
nearly to the tropopause**

In meteorology, this potential energy associated with conditional instability has a special name

CAPE

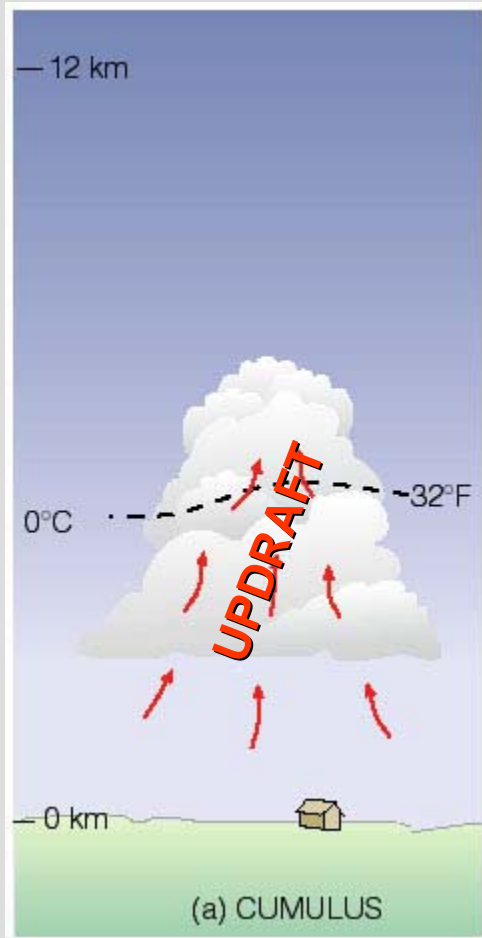
Convective Available Potential Energy

**Air mass thunderstorm
(Ordinary Cell Thunderstorm)**

“Garden variety” thunderstorm that starts out as a puffy cumulus cloud, grows into a cumulonimbus, and then quickly dissipates.

How long does this take?

Air mass Thunderstorm *Cumulus Stage*

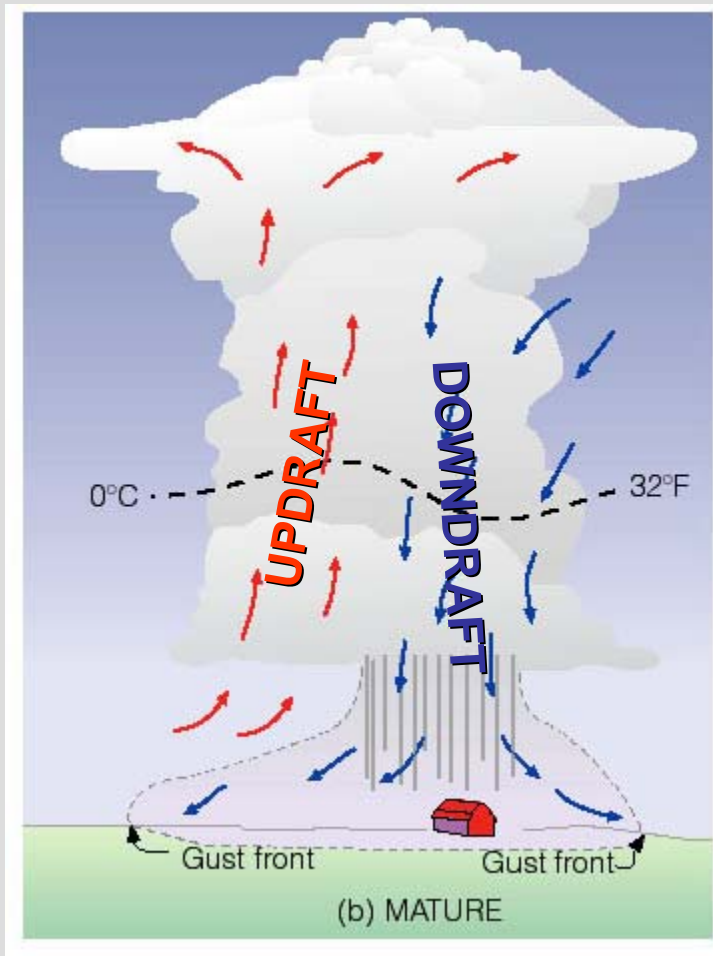


A parcel of air is lifted from surface (**updraft**)

As the parcel rises, it reaches the lifting condensation level and forms a cumulus cloud. Air continues to rise because condensation occurs.

What are some of the lifting mechanisms?

Air mass Thunderstorm *Mature Stage*



Cumulonimbus with anvil.

Cloud liquid and ice particles grow larger, eventually falling to the ground as rain.

Process draws in drier air surrounding the cloud to create a **downdraft.**

Leading edge of the downdraft is called the *gust front*.

Mature air mass thunderstorm with gust front



Gust front can provide a lifting mechanism to get other storms going.

Monsoon Thunderstorms in Arizona



Monsoon thunderstorms at Kitt Peak at mature stage with gust fronts.

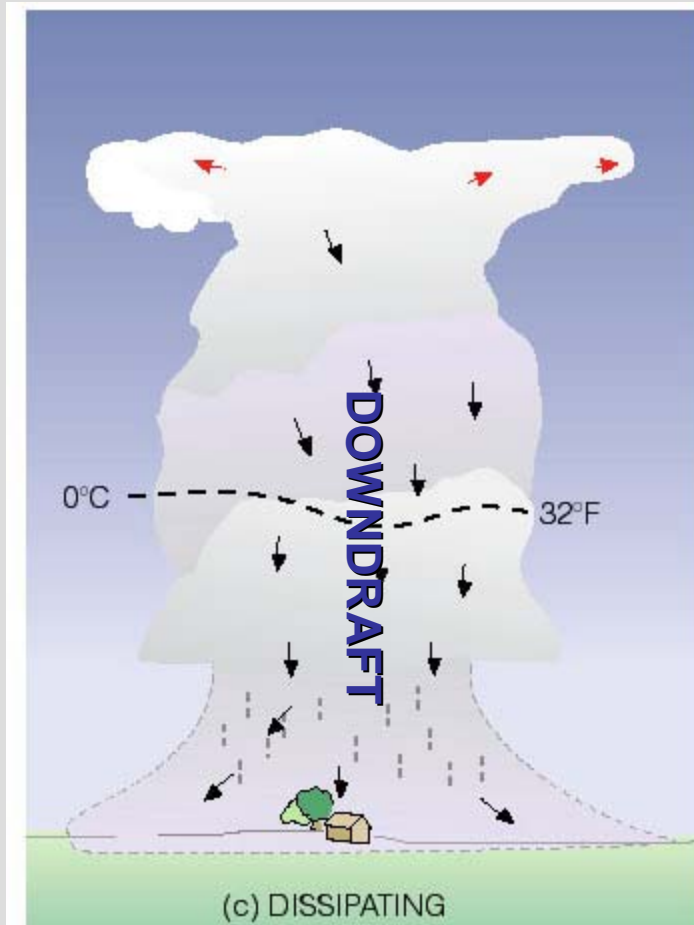
Forced by the diurnal mountain valley circulation

Form over the mountains during late morning to early afternoon

Reach mature stage by about mid-afternoon.

(Photo taken around 3pm)

Air mass Thunderstorm *Dissipating Stage*



Gust front moves far enough away from the storm to “choke off” the updraft.

Once this supply of warm, moist air from the updraft is cut off, the storm begins to weaken either by evaporation and/or by raining itself out.

**Again, the air mass thunderstorm is
the “garden variety” one...**

***To get more the more organized,
longer lived severe
thunderstorms, we need a
combination of more ingredients***

Ingredients for severe thunderstorms

INGREDIENT 1: CONDITIONAL INSTABILITY

Needs to be through the depth of the troposphere

Make the atmosphere more conditionally unstable by:

_____ near the surface
_____ aloft

INGREDIENT 2: WIND SHEAR

Change in horizontal wind speed through a vertical depth.

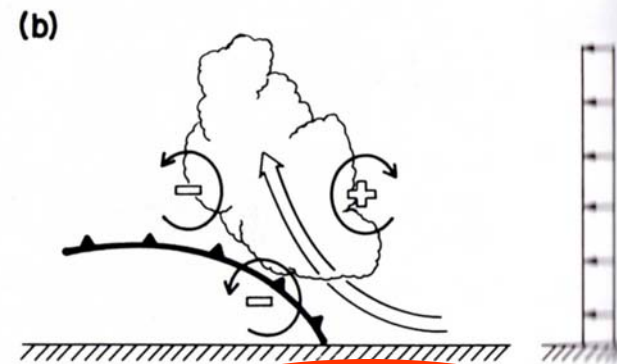
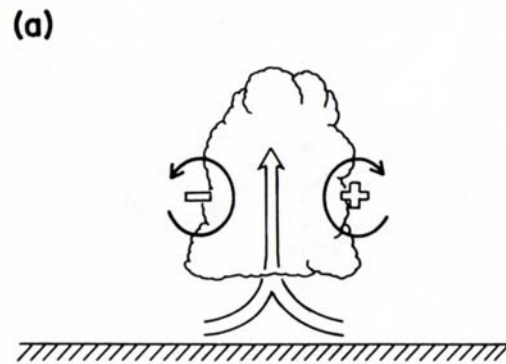
If the wind speed changes *direction* as well that's even better!

Why is wind shear a necessary ingredient for severe thunderstorms?

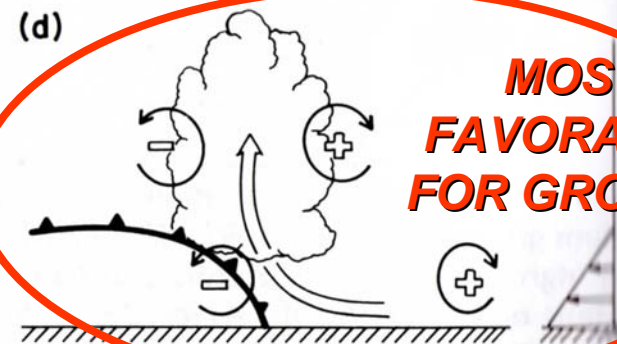
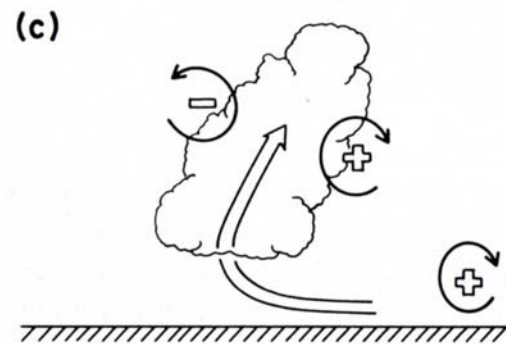
CUMULUS STAGE
Updraft only

MATURE STAGE
Updraft + downdraft

NO WIND SHEAR



WITH WIND SHEAR



MOST FAVORABLE FOR GROWTH

(Bluestein)

Wind shear allows the updraft to be maintained in the cloud and not get choked off by the downdraft—so the thunderstorm keeps receiving the warm, moist air it needs to keep growing.

Where to look for severe thunderstorms (in central and eastern U.S.)

In the vicinity of a mid-latitude cyclone

Strong upper level winds from the north and west

Surface winds from the south to southeast (a low-level jet)

Fronts, particularly in front of and at a cold front. What is this called?

Drylines: transition zone between dry cT air and moist mT air

Very common in the southern Great Plains.

THESE CAN ENHANCE:

1. THE VERTICAL WIND SHEAR
2. CONDITIONAL INSTABILITY (i.e. CAPE)

More Organized Severe Thunderstorm Types

In approximate order of severity

Multicell thunderstorms

Squall lines

Mesoscale Convective Complexes

Supercells

Less severe



Most severe

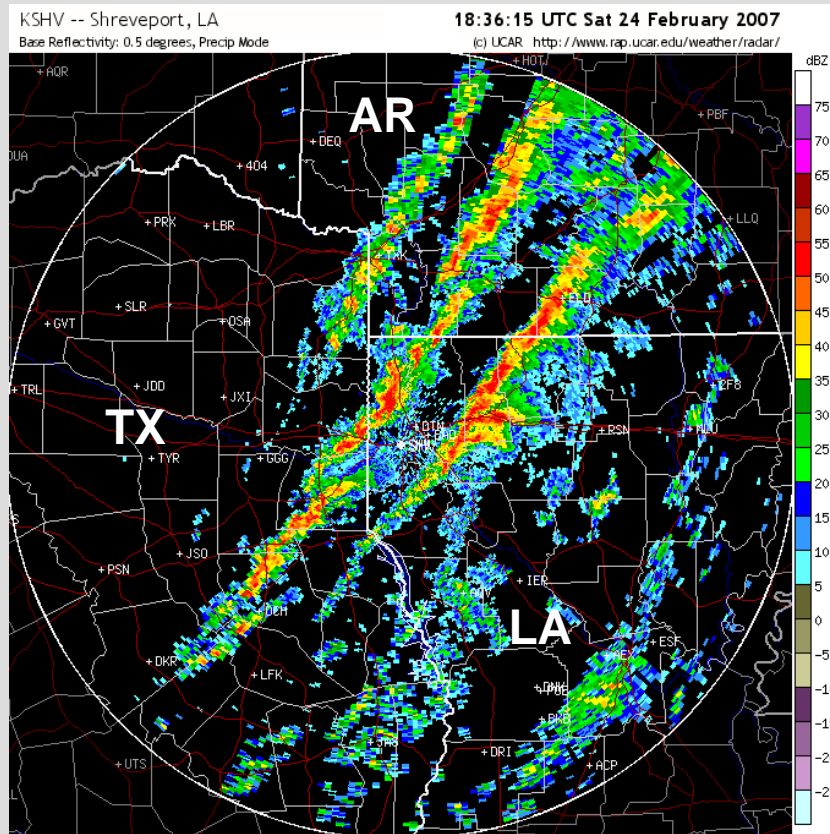
Multicell Thunderstorms



In moderate shear, thunderstorms can get a bit more organized, numerous and have longer lifetimes.

Note the tilted structure of the anvil with respect to the cloud base—this indicates _____

Squall Line



Squall lines on radar image in the warm sector of Colorado low. (February 2007 Case)

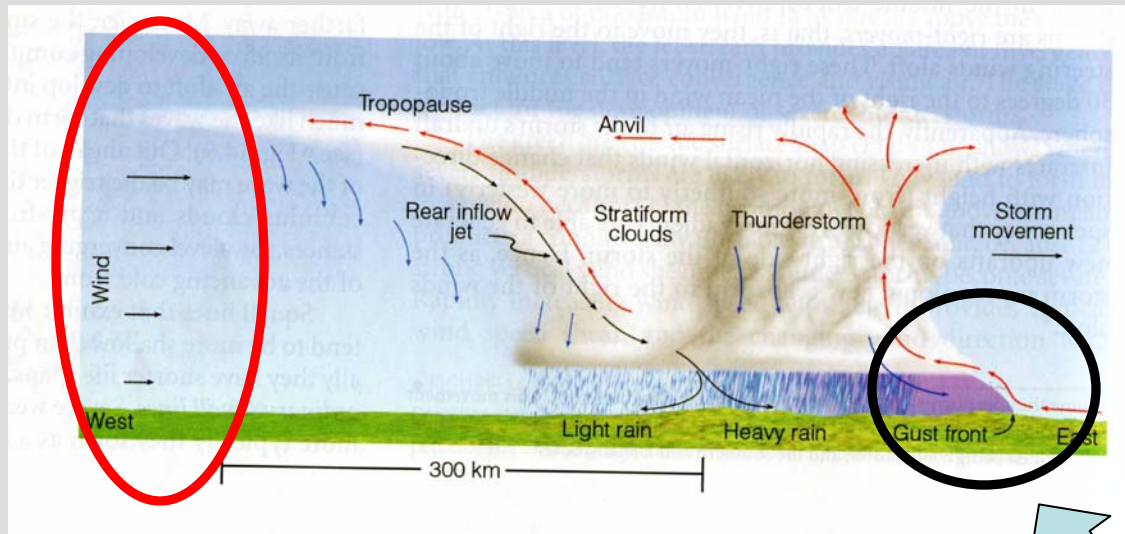
Line of thunderstorms that can be hundreds of miles long.

Form along the cold front or ahead of it in the warm sector

Heavy precipitation on the leading edge and then light rain behind.

Multiple lines may form, with the leading line being the most severe.

Idealized squall line thunderstorm structure

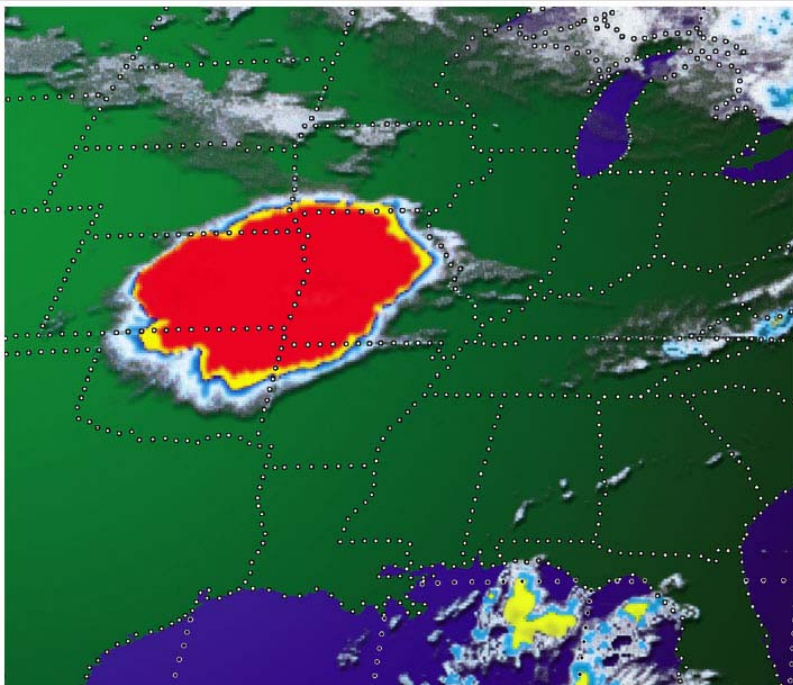


Note the wind shear profile



Shelf cloud at leading edge of squall line

Mesoscale Convective System (MCS)

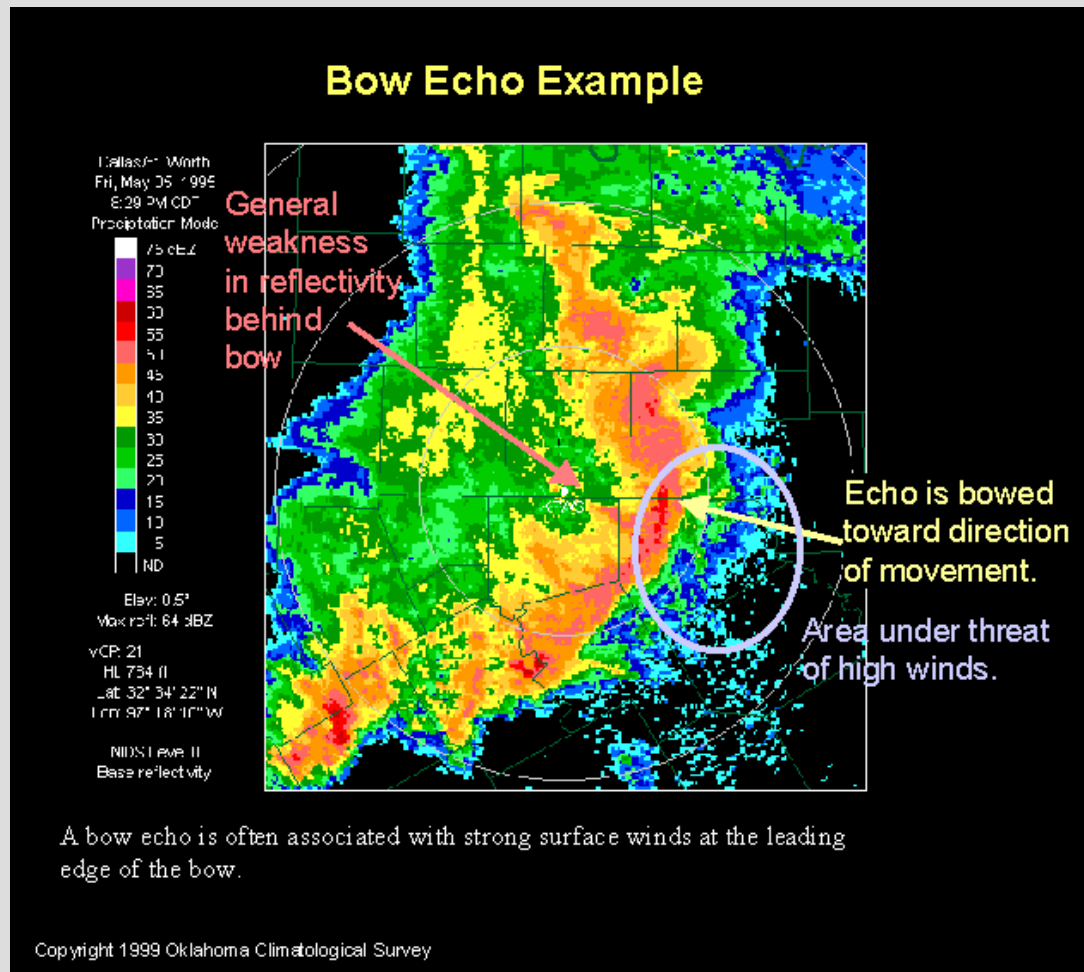


A number of individual thunderstorms cluster together to form a giant circular convective weather system.

Can be the size of an entire state!

Most common in summer, originating from convection which forms over mountains (the Rockies in the case of U.S.)

Derecho or Straight Line Wind



Bow echoes are typically found in well developed mesoscale convective complexes.

These produces very strong (straight line) winds which can potentially exceed hurricane force (75 mph).

Called a derecho
(*Spanish = straight ahead*)

SUPERCCELL

**A BIG ISOLATED
THUNDERSTORM THAT
CONSISTS OF A ROTATING
UPDRAFT.**

**THE MOST SEVERE TYPE
OF THUNDERSTORM!**

Ingredients for a supercell

INGREDIENT 1: HIGH “CAPE”

Make the atmosphere more conditionally unstable by:

_____ near the surface
_____ aloft

INGREDIENT 2: LARGE HELICITY

Helicity is essentially the *wind shear*, or change in horizontal wind speed and direction, through a vertical depth.

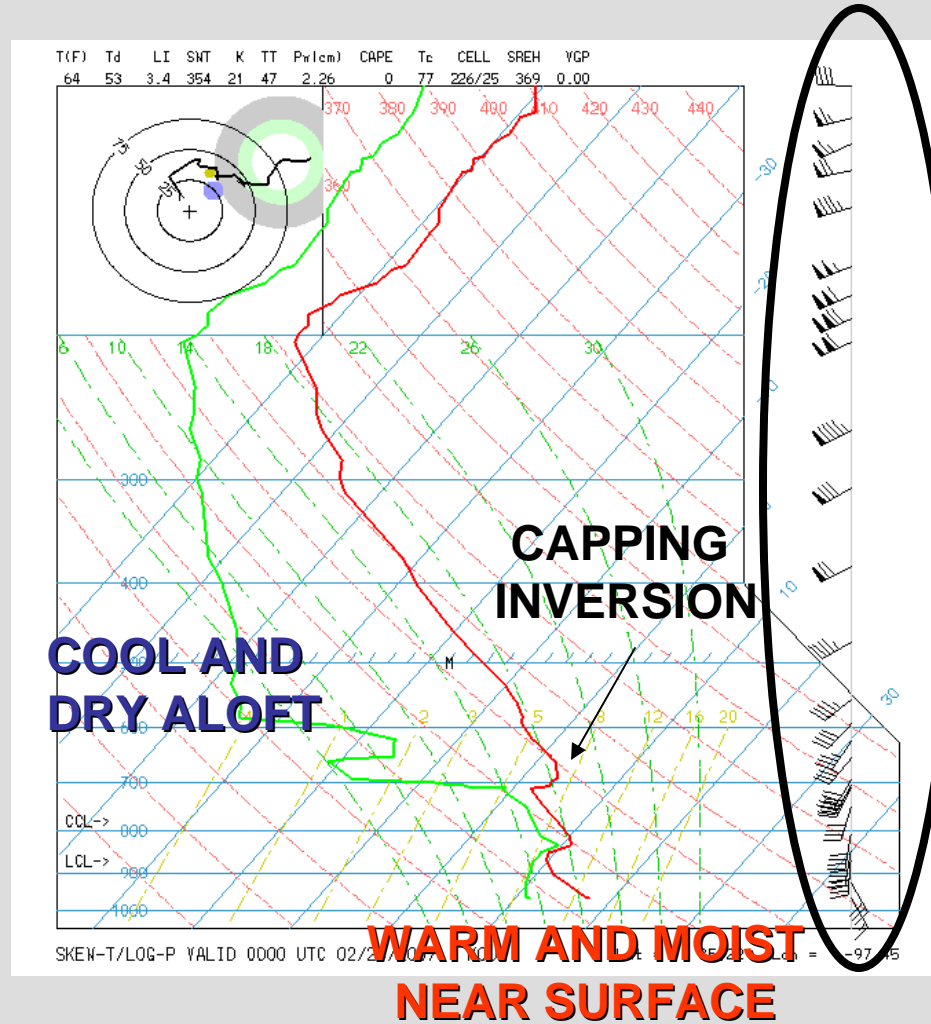
NECESSARY FOR THE STORM TO ROTATE!

(NEW) INGREDIENT 3: A CAPPING INVERSION

An inversion that occurs near about 800-mb. Only a few strong updrafts break through the cap and utilize the enormous amount of convective available potential energy

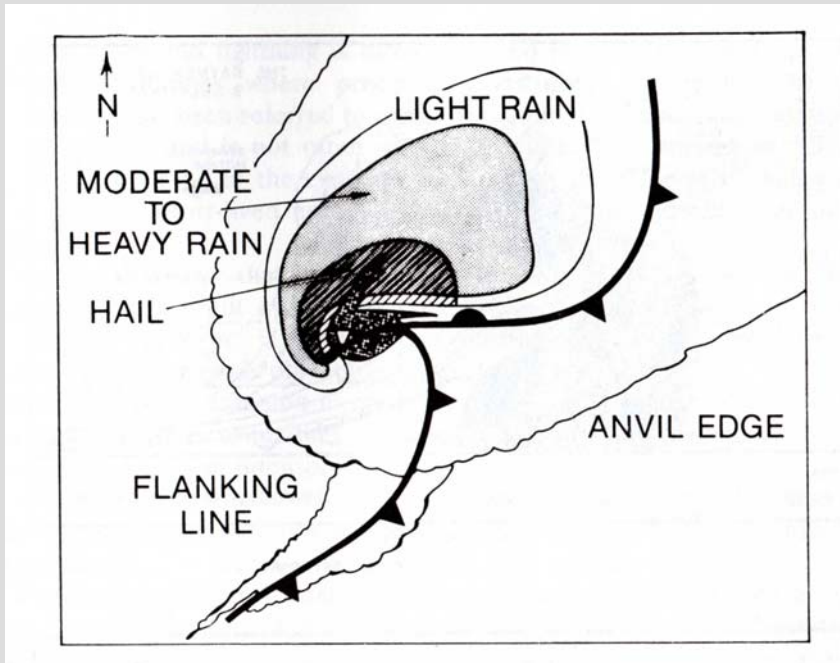
THE SIGNATURE FOR SUPERCELLS!

What is this sounding called??



**WIND
DRASTICALLY
CHANGES IN
SPEED
AND DIRECTION
WITH HEIGHT**

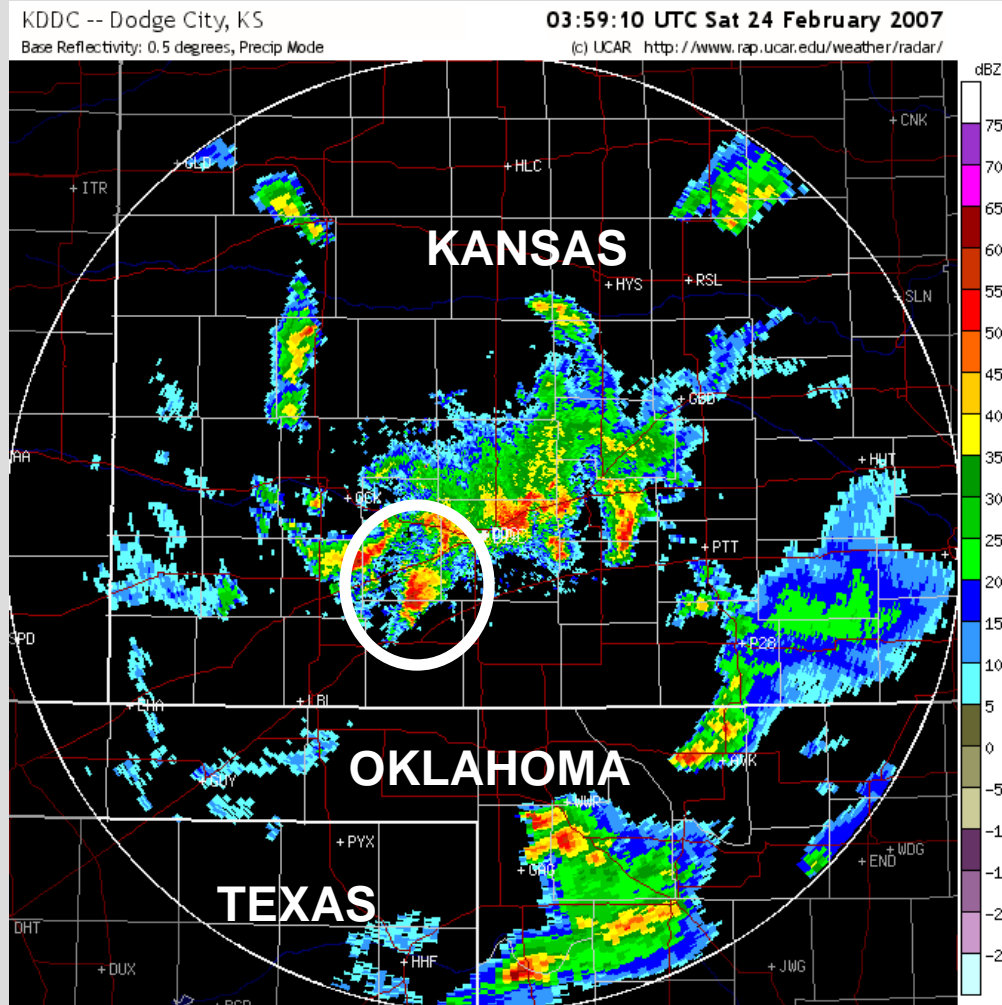
Supercell structure



(Bluestein)

The fronts in this case indicate the gust fronts.

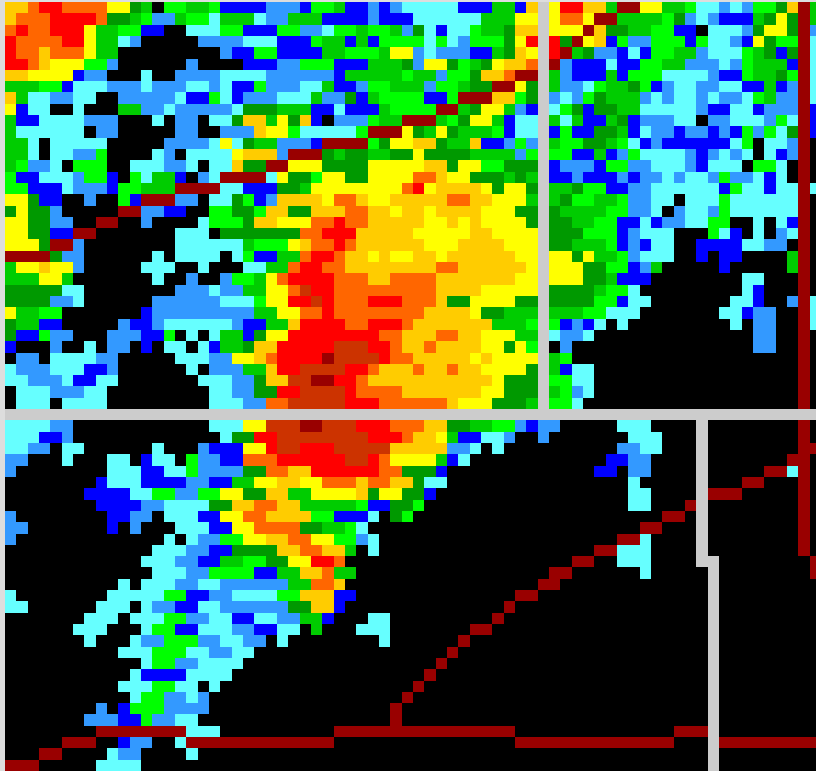
Supercells on radar



**NOT big long
squall lines!**

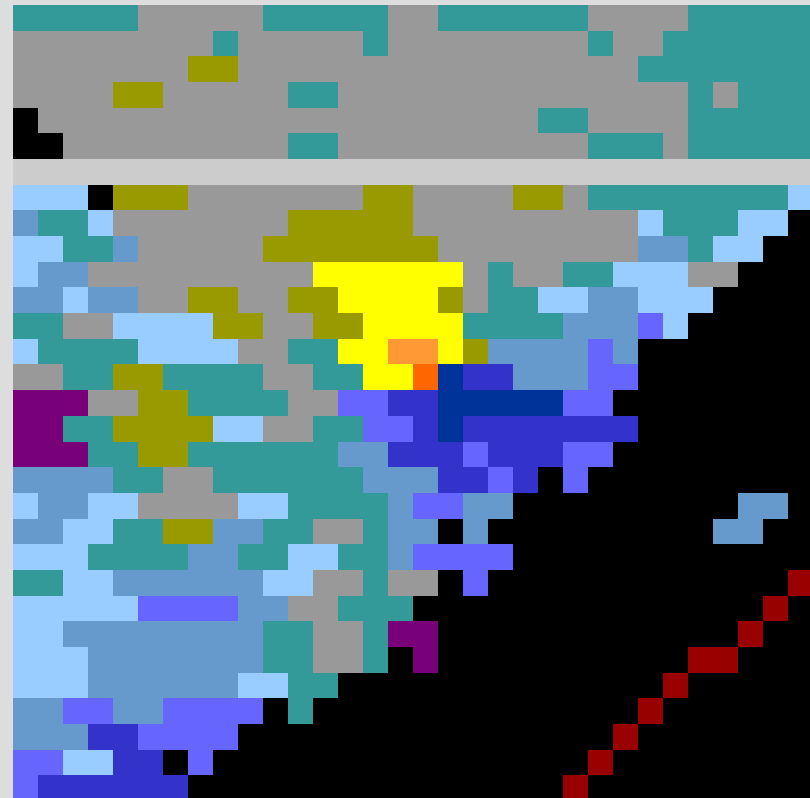
**Get compact and
isolated rotating
cells!**

RADAR REFLECTIVITY



DOPPLER WIND VELOCITY

YELLOW = AWAY FROM RADAR
BLUE = TOWARD RADAR



Summary of Lecture 26

A thunderstorm is a storm containing lightning or thunder. Associated weather hazards include heavy rain, hail, high winds, and tornadoes.

Basic ingredient for a thunderstorm is a conditionally unstable environment deep enough to develop cumulonimbus clouds.

The air mass thunderstorm is the “garden variety” thunderstorm that forms in an environment of low vertical wind shear and lasts an hour or less.

Cumulus stage: Updraft only

Mature stage: Updraft + downdraft with gust front.

Dissipating stage: Updraft ceases, storm rains out or evaporates

Wind shear allows the updraft to be maintained in a cumuliform cloud, allowing the thunderstorm to keep growing and have a long lifetime.

Severe thunderstorms include: multicell, squall line, mesoscale convective complex, and supercell. Know the differences between these types.

Reading Assignment and Review Questions

Reading: Chapter 14 (cont.)

Chapter 14 Review Questions

Review: 1,2,3,4,5,6,7,23,25 (8th ed.)

1,2,3,4,5,6,9,11,12,14,15,29,35 (9th ed.)

Thought: 1-3,9

Problems and Ex.: 1,5