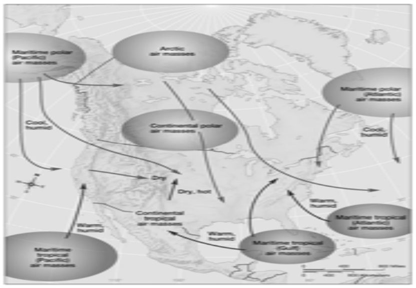
Lecture 8a: Air Masses and Fronts



- ❑ What Characterize Air Masses?
- ❑ What Define Fronts?

[redacted]

- ❑ **Air masses**

  Contain uniform temperature and humidity characteristics.

- ❑ **Fronts**

  Boundaries between unlike air masses.

Air Masses

- ❑ Air masses have fairly uniform temperature and moisture content in horizontal direction (but not uniform in vertical).
- ❑ Air masses are characterized by their temperature and humidity properties.
- ❑ The properties of air masses are determined by the underlying surface properties where they originate.
- ❑ Once formed, air masses migrate within the general circulation.
- ❑ Upon movement, air masses displace residual air over locations thus changing temperature and humidity characteristics.
- ❑ Further, the air masses themselves moderate from surface influences.

Modification of cP Air Masses

- ❑ Migrations of cP air induce colder, drier conditions over affected areas.
- ❑ As cP air migrates toward lower latitudes, it warms from beneath.
- ❑ As it warms, moisture capacity increases while stability decreases.

Source Regions

- The areas of the globe where air masses from are called source regions.
- A source region must have certain temperature and humidity properties that can remain fixed for a substantial length of time to affect air masses above it.
- Air mass source regions occur only in the high or low latitudes; middle latitudes are too variable.

Classification of Air Masses

- Air masses are classified according to the temperature and moisture characteristics of their source regions.
- Bases on moisture content: continental (dry) and maritime (moist)
- Based on temperature: tropical (warm), polar (cold), arctic (extremely cold).
- Naming convention for air masses: A small letter (***c***, ***m***) indicates the moist content followed by a capital letter (***T***, ***P***, ***A***) to represent temperature.

Five Types of Air Masses

- Theoretically, there should be 6 types of air masses (2 moisture types x 3 temperature types).
- But mA-type (maritime Arctic) does not exist.
- cA: continental Arctic

  cP: continental Polar

  cT: continental Tropical

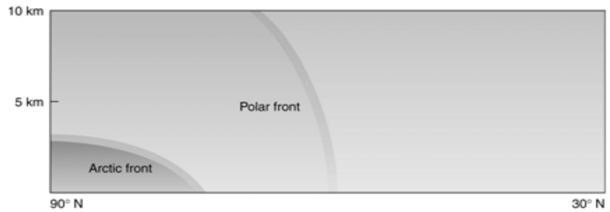
  mP: maritime Polar

  mT: maritime Tropical

Continental Polar (cP) Air Mass

- Continental Polar air masses form over large, high-latitude land masses, such as northern Canada or Siberia.
- cP air masses are cold and extremely dry.
- Wintertime cooling over these land areas cause the atmosphere to become very stable (even inversion).
- The combination of dry and stable conditions ensure that few if any clouds form over a cP source region.
- Summer cP air masses are similar to winter cP, but much less extreme and remain at higher latitudes.

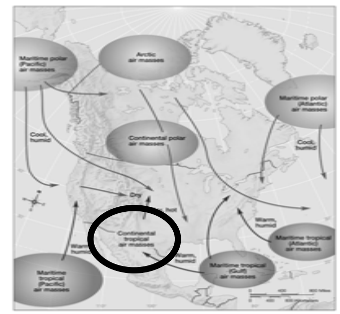
Continental Arctic (cA) Air Masses



- ***Continental Arctic (cA)*** air represents extremely cold and dry conditions as, due to its temperature, it contains very little water vapor.
- The boundary between cA and cP air is the shallow (~1-2 km) arctic front.
- cA air masses can extend as far southward as the Canadian-United State.

ESS55
Prof. Jin-Yi Yu

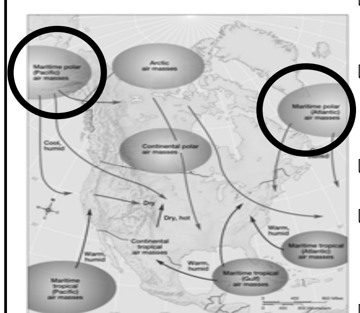
Continental Tropical (cT) Air Masses



- Mainly a summertime phenomenon exclusive to the desert southwest of the U.S. and northern Mexico.
- Characteristically hot and very dry.
- Very unstable, yet clear conditions predominate due to a lack of water vapor.
- Thunderstorms may occur when moisture advection occurs or when air is forced orographically.

ESS55
Prof. Jin-Yi Yu

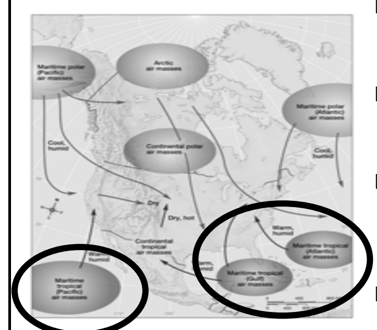
Maritime Polar (mP) Air Masses



- Maritime polar air masses form over upper latitude oceanic regions and are cool and moist.
- mP air masses form over high-latitude ocean as cP air masses move out from the interior of continents. (i.e., cP → mP).
- Oceans add heat and moisture into the dry and cold cP air masses.
- Along the west coast of the U.S., mP air affects regions during winter and may be present before mid-latitude cyclones advect over the continent.
- Along the east coast, mP air typically affects regions after cyclone passage as the mP air wraps around the area of low pressure.

ESS55
Prof. Jin-Yi Yu

Maritime Tropical (mT) Air Masses

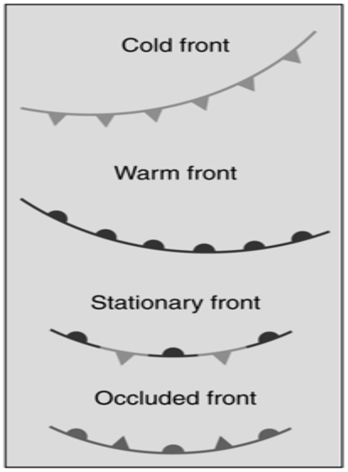


- Advection of mT air also promotes the so-called Arizona monsoon.

- Form over low latitude oceans and as such are very warm, humid, and unstable.
- mT air masses from Atlantic and Gulf of Mexico is the primary source region for the eastern U.S.
- As air advects over the warm continent in summer the high humidity and high heat occasionally combine to dangerous levels.
- mT air masses have an enormous influence on the southwestern U.S, particularly in summer.

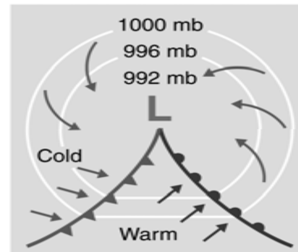
ESS55
Prof. Jin-Yi Yu

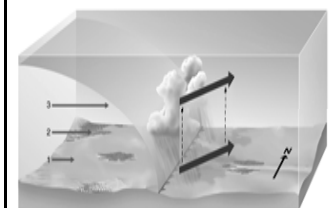
Fronts



- ❑ Fronts separate air masses and bring about changes in temperature and humidity as one air mass is replaced by another.
- ❑ There are four general types of fronts associated with mid-latitude cyclones with the name reflective of the advancing air mass.

Cold Fronts

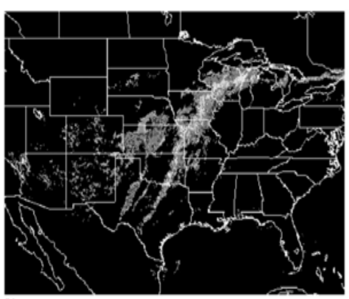




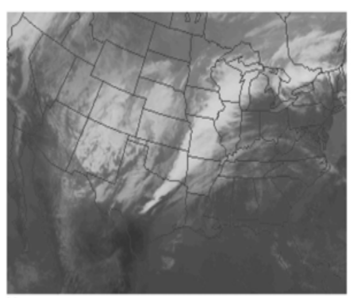
- ❑ Cold fronts form when cold air displaces warm air.
- ❑ Indicative of heavy precipitation events, rainfall or snow, combined with rapid temperature drops.
- ❑ Steep front slope, typically 1:100.
- ❑ Moving faster, up to 50 km/hr (30 mph).
- ❑ Northwesterly winds behind a cold front, and southwesterly in ahead of the front.

Radar/Satellite Views of Cold Fronts

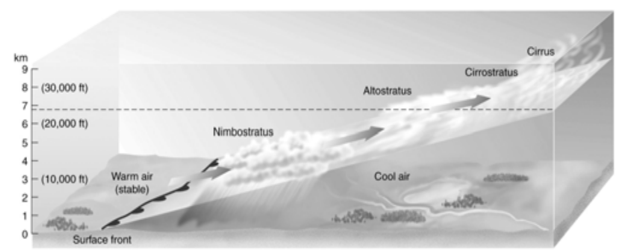
Radar Picture



Satellite Picture



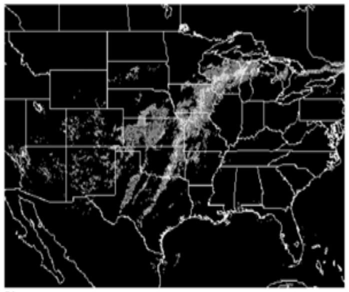
Warm Fronts



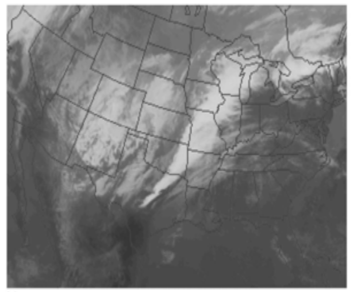
- ❑ Created when warm air displaces colder air.
- ❑ Shallow horizontal stratus clouds and light precipitation.
- ❑ Frontal fogs may occur as falling raindrops evaporate in the colder air near the surface. Sleet and freezing rain may also formed.
- ❑ Half the slope of cold fronts, typically (1:200).
- ❑ Moving slower, about 20 km/hr (12 mph).

Radar/Satellite Views of Warm Fronts

Radar Picture



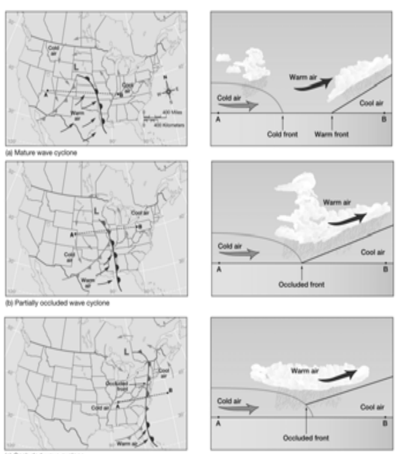
Satellite Picture



Stationary Fronts

- When two unlike air masses remain side by side, with neither encroaching upon the other, a stationary front exists.
- Fronts may slowly migrate and warmer air is displaced above colder.
- Fronts sloping over the cold air.

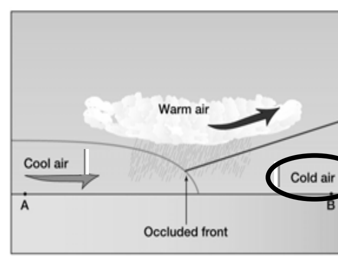
Occluded Fronts



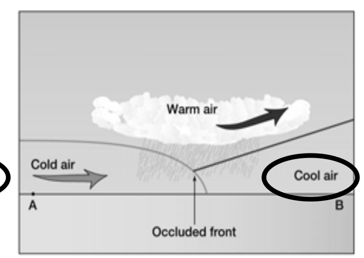
- Occlusion: the warm air is cut off from the surface by the meeting of two fronts.
- Usually, a fast-moving cold front catches a slow-moving warm front.
- A ***cold-type occlusion***: eastern half of the continent where a cold front associated with cP air meets a warm front with mP air ahead.
- A ***warm-type occlusion***: western edges of continents where the cold front, associated with mP air, invades an area in which colder cP air is entrenched.

Warm- and Cold-Type Occlusion Fronts

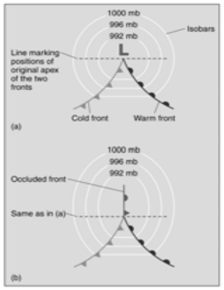
warm-type



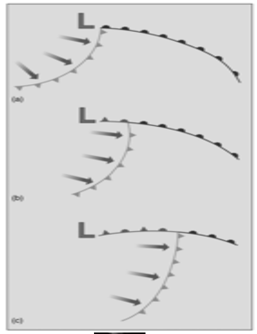
cold-type



Two Other Ways to Produce Occluded Fronts

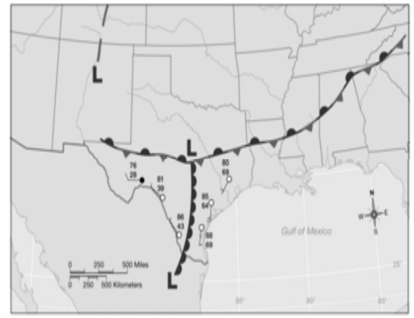


Some occlusions form when the surface low elongates and moves away from the junction of the cold and warm fronts



Some occlusions occur when the intersection of the cold and warm fronts slides along the warm front

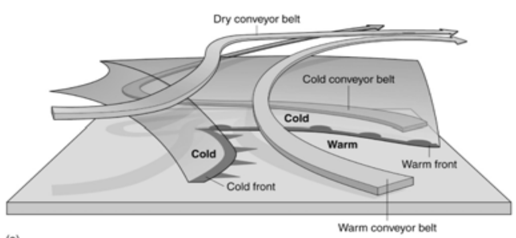
Drylines



- ❑ Because humidity is an important determinant of air density, air masses with similar temperatures but strong humidity gradients will act as fronts.
- ❑ Boundaries between dry and moister air are called ***drylines.***
- ❑ They frequently occur throughout the Great Plains and are an important contributor to storm development.

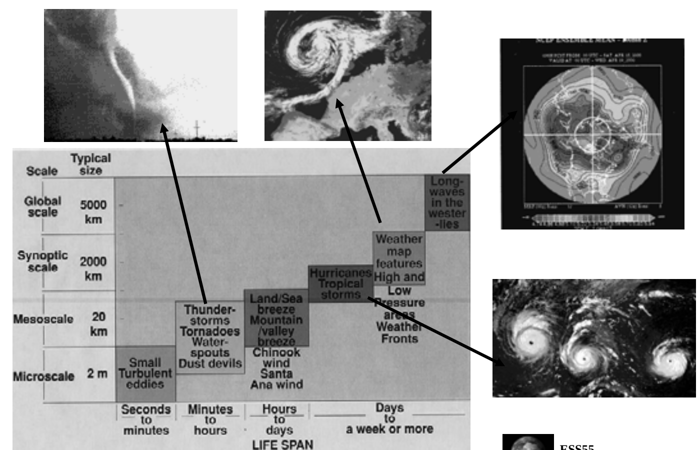
ESS55
Prof. Jin-Yi Yu

Lecture 8b: Mid-latitude Cyclones



- ❑ Life Cycle of Cyclone
- ❑ Cyclone Structures
- ❑ Steering of Cyclone

Scales of Motions in the Atmosphere



ESS55
Prof. Jin-Yi Yu

Mid-Latitude Cyclones

- Mid-latitude cyclones form along a boundary separating polar air from warmer air to the south.
- These cyclones are large-scale systems that typically travels eastward over great distance and bring precipitations over wide areas.
- Lasting a week or more.

ESS55
Prof. Jin-Yi Yu

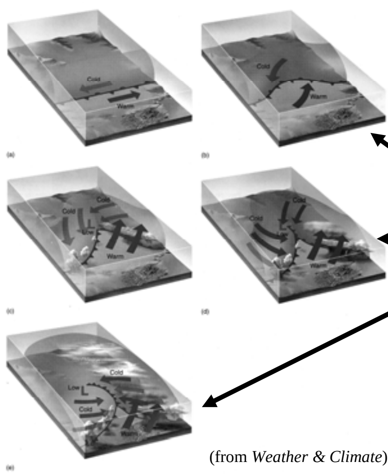
Polar Front Theory

Vilhelm Bjerknes (1862-1951)

- ***Bjerknes,*** the founder of the Bergen school of meteorology, developed polar front theory during WWI to describe the formation, growth, and dissipation of mid-latitude cyclones.

ESS55
Prof. Jin-Yi Yu

Life Cycle of Mid-Latitude Cyclone

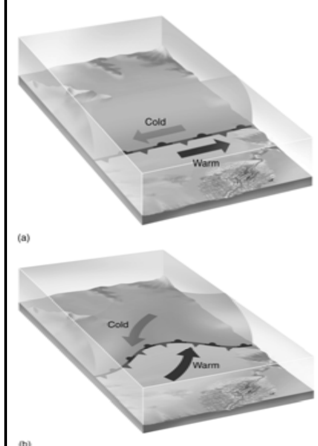


- Cyclogenesis
- Mature Cyclone
- Occlusion

(from *Weather & Climate*)

ESS55
Prof. Jin-Yi Yu

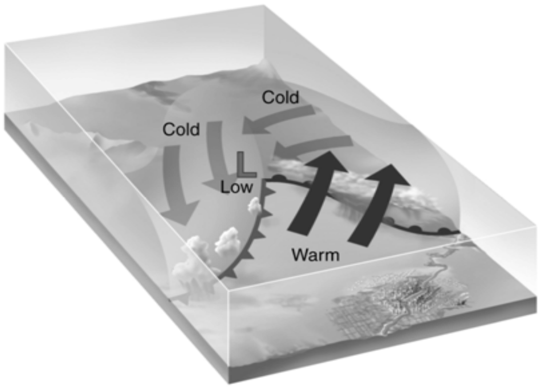
Cyclogenesis

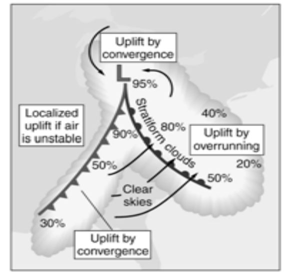


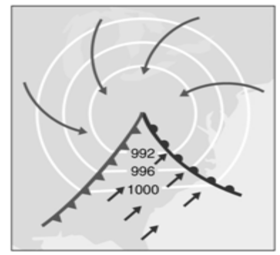
- ***Cyclogenesis*** typically begins along the polar front but may initiate elsewhere, such as in the lee of mountains.
- Minor perturbations occur along the boundary separating colder polar easterlies from warmer westerlies.
- A low pressure area forms and due to the counterclockwise flow (N.H.) colder air migrates equatorward behind a developing cold front.
- Warmer air moves poleward along a developing warm front (east of the system).
- Clouds and precipitation occur in association with converging winds of the low pressure center and along the developing fronts.

ESS55
Prof. Jin-Yi Yu

Mature Cyclone





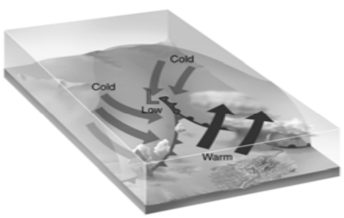


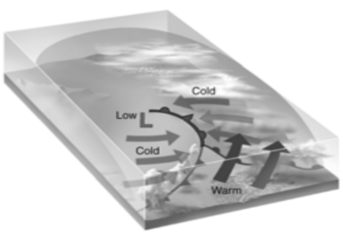
Mature Cyclones

- Well-developed fronts circulating about a deep low pressure center characterize a mature mid-latitude cyclone.
- Heavy precipitation stems from cumulus development in association with the cold front.
- Lighter precipitation is associated with stratus clouds of the warm front.
- Isobars close the low and are typically kinked in relation to the fronts due to steep temperature gradients.

ESS55
Prof. Jin-Yi Yu

Occlusion

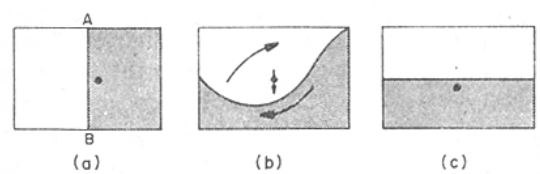




- When the cold front joins the warm front, closing off the warm sector, surface temperature differences are minimized.
- The system is in occlusion, the end of the system's life cycle.

ESS55
Prof. Jin-Yi Yu

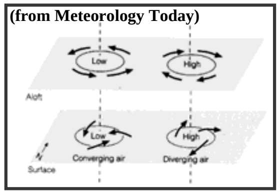
Available Potential Energy

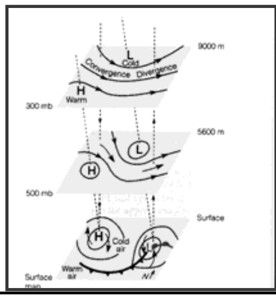


ESS55
Prof. Jin-Yi Yu

Vertical Structure of Cyclone

(from Meteorology Today)





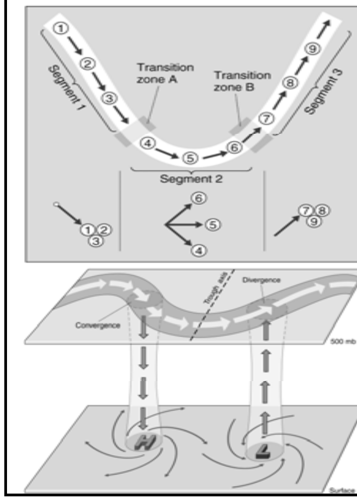
If lows and highs aloft were always directly above lows and highs at the surface, the surface systems would quickly dissipate.

When the surface pressure system does not directly beneath the upper-level trough and ridge but toward the west, surface cyclone and anticyclone can intensify and, steered by the winds aloft, move away from the region of formation.

In order for cyclones to develop, there must be upper-level divergence above the surface storm.

ESS55
Prof. Jin-Yi Yu

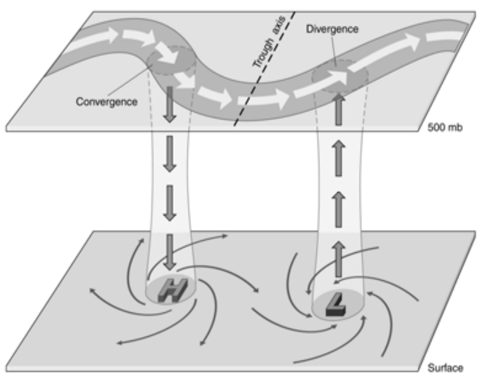
Vortocity and Divergence



- ❑ Increasing vorticity in the zone between a ridge and a trough leads to upper air convergence and sinking motions through the atmosphere, which supports surface high pressure areas.
- ❑ Decreasing vorticity in the zone between a trough and a ridge leads to upper air divergence and rising motions through the atmosphere, which supports surface low pressure areas.

ESS55
Prof. Jin-Yi Yu

Rossby Wave and Surface Cyclone/Anticyclone



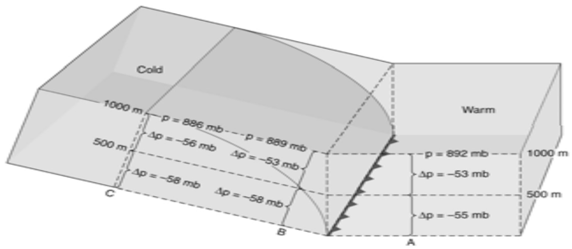
ESS55
Prof. Jin-Yi Yu

Steering of Mid-Latitude Cyclones

- ❑ The movement of surface systems can be predicted by the 500 mb pattern.
- ❑ The surface systems move in about the same direction as the 500 mb flow, at about 1/2 the speed.
- ❑ Upper-level winds are about twice as strong in winter than summer.
- ❑ This results in stronger pressure gradients (and winds), resulting in stronger and more rapidly moving surface cyclones.

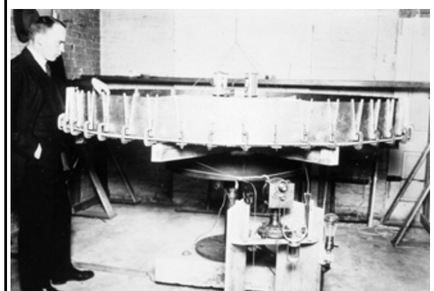
ESS55
Prof. Jin-Yi Yu

Trough and Cold Front



- ❑ Upper air troughs develop behind surface cold fronts with the vertical pressure differences proportional to horizontal temperature and pressure differences.
- ❑ This is due to density considerations associated with the cold air.
- ❑ Such interactions also relate to warm fronts and the upper atmosphere.

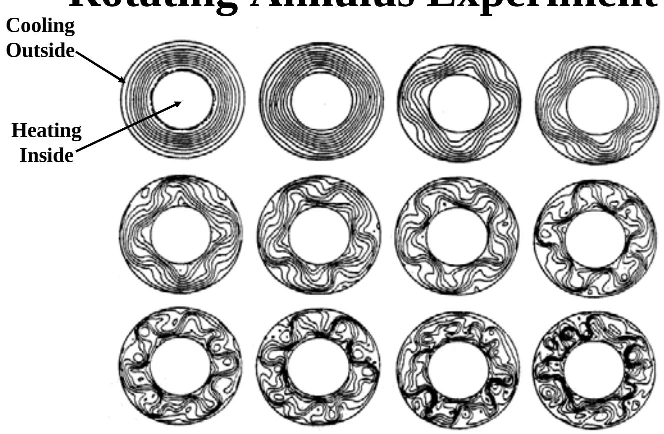
New Understanding of Cyclone after WWII



Carl Gustav Rossby (1898-1957)

- ❑ Carl Rossby mathematically expressed relationships between mid-latitude cyclones and the upper air during WWII.
- ❑ Mid-latitude cyclones are a large-scale waves (now called Rossby waves) that grow from the "baroclinic" instabiloity associated with the north-south temperature differences in middle latitudes.

Rotating Annulus Experiment

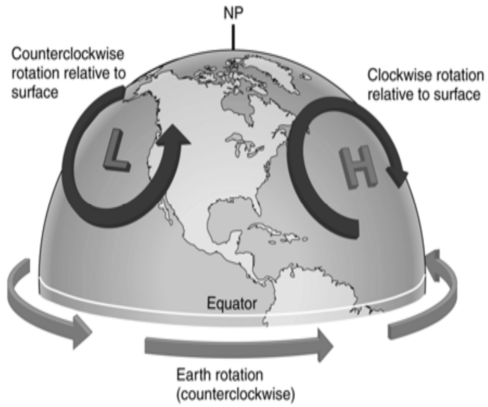


(from *"Is The Temperature Rising?"*)

Parameters Determining Mid-latitude Weather

- ❑ Temperature differences between the equator and poles
- ❑ The rate of rotation of the Earth.

Rossby Wave



Vorticity

- ❑ The rotation of a fluid (such as air and water) is referred to as its vorticity.

Absolute Vorticity (viewed from space)

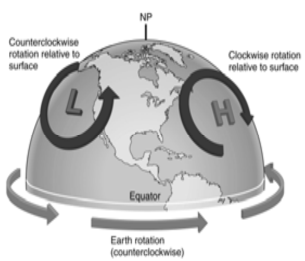
=

Earth (or Planetary) Vorticity

+

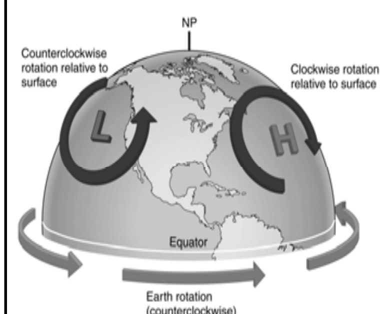
Relative Vorticity (relative to the Earth)

Earth (Planetary) Vorticity



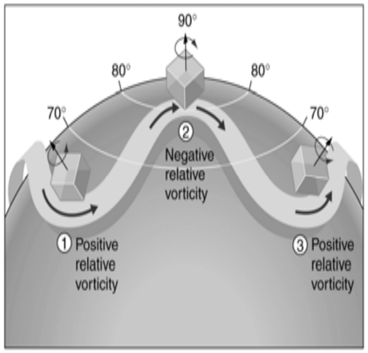
- ❑ Earth vorticity is a function solely of latitude.
- ❑ The higher the latitude, the greater the vorticity.
- ❑ Earth vorticity is zero at the equator.

Relative Vorticity



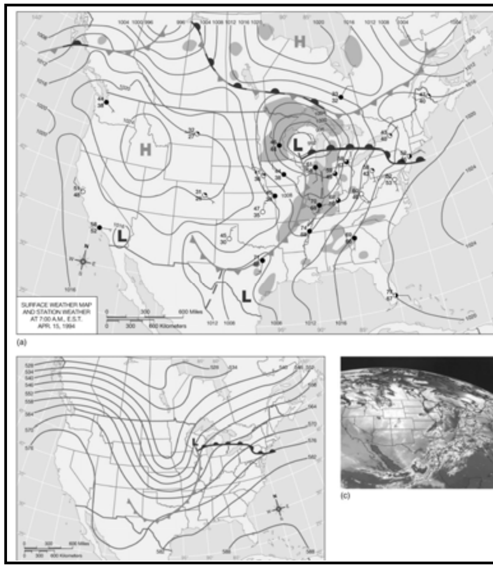
- ❑ Air which rotates in the direction of Earth's rotation is said to exhibit positive vorticity.
- ❑ Air which spins oppositely exhibits negative vorticity.

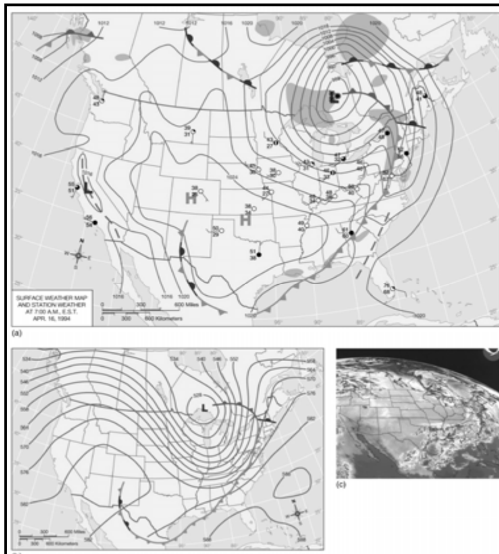
Vorticity and Rossby Wave



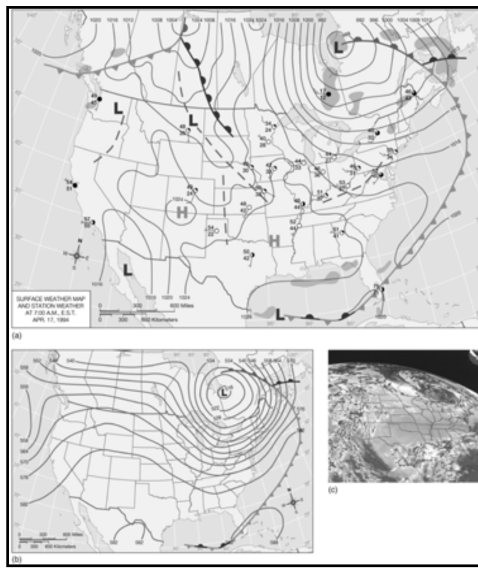
- Rossby waves are produced from the conservation of absolute vorticity.
- As an air parcle moves northward or southward over different latitudes, it experiences changes in Earth (planetary) vorticity.
- In order to conserve the absolute vorticity, the air has to rotate to produce relative vorticity.
- The rotation due to the relative vorticity bring the air back to where it was.

An Example

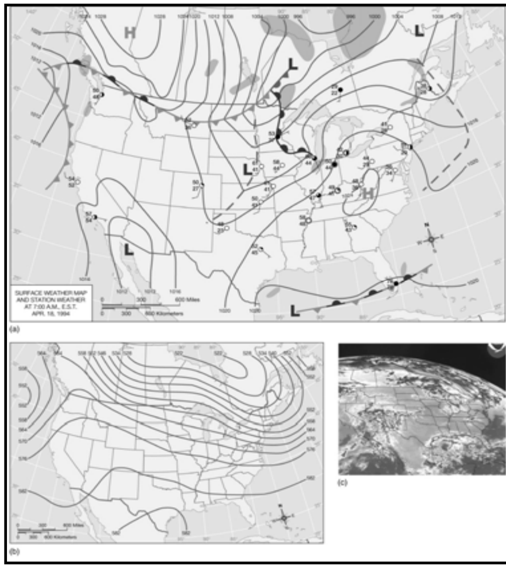




- ***April 16*** - The northeastward movement of the storm system is seen through a comparison of weather maps over a 24-hour period
- Occlusion occurs as the low moves over the northern Great Lakes
- In the upper air, the trough has increased in amplitude and strength and become oriented northwest to southeast
- Isobars have closed about the low, initiating a cutoff low



- ***April 17*** - Continual movement towards the northeast is apparent, although system movement has lessened
- The occlusion is now sweeping northeastward of the low, bringing snowfall to regions to the east
- In the upper air, continued deepening is occurring in association with the more robust cutoff low



- *April 18* -The system has moved over the northwestern Atlantic Ocean, but evidence persists on the continent in the form of widespread precipitation
- The upper atmosphere also shows evidence of the system, with an elongated trough pattern

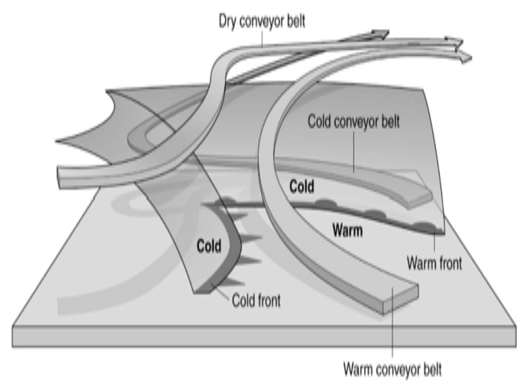
Steering of Mid-Latitude Cyclones

- ❑ The movement of surface systems can be predicted by the 500 mb pattern.
- ❑ The surface systems move in about the same direction as the 500 mb flow, at about 1/2 the speed.
- ❑ Upper-level winds are about twice as strong in winter than summer.
- ❑ This results in stronger pressure gradients (and winds), resulting in stronger and more rapidly moving surface cyclones.

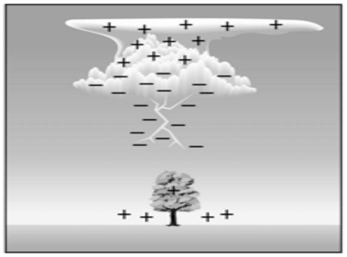
Typical Winter Mid-latitude Cyclone Paths

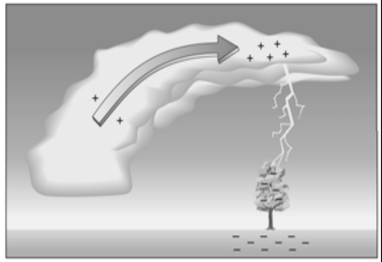
- ❑ ***Alberta Clippers*** are associated with zonal flow and usually produce light precipitation.
- ❑ ***Colorado Lows*** are usually stronger storms which produce more precipitation.
- ❑ ***East Coast*** storms typically have strong uplift and high water vapor content.

Modern View of Mid-latitude Cyclones



Lecture 8c: Lightning, Thunder, and Tornadoes





- ❑ Lightning and Thunder
- ❑ Thunderstorm
- ❑ Tornadoes

Lightning

❑Cloud-to-Cloud Lightning

- ✓ **80% of all lightning**
- ✓ **Electricity discharge happens within clouds**
- ✓ **Causes the sky to light up uniformly (sheet lightning)**

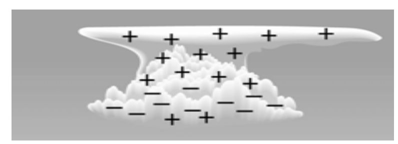
❑Cloud-to-Ground Lightning

- ✓ **20% of all lightning**
- ✓ **Electricity discharge happens between cloud base and ground**

Major Sequence for Lightning

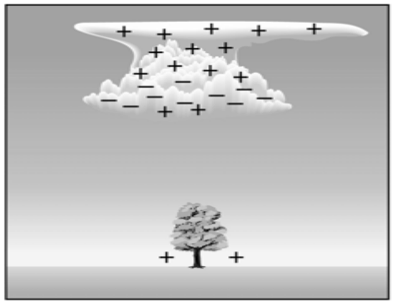
- ❑ Electrification of a cloud: Charge Separation
- ❑ Development of a path through which the electrons can flow
- ❑ Discharge: Lightning

Charge Separation in Clouds



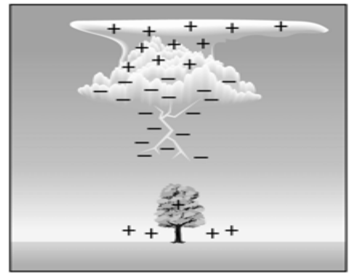
- ❑ Positive charges in the upper portions of the cloud; Negatively charges in lower portions; Small packet of positive charges in the cloud base.
- ❑ lightning occurs only in clouds that extend above the freezing level ➔ charge separation is related to ice crystals.
- ❑ Lighter crystals collide with heavy hailstones in the cloud.
- ❑ The lighter crystals are positively charged and move to upper portions of the cloud.
- ❑ The heavy hail stones are negatively charged and move to the lower portion of the cloud.

Positively Charged Ground



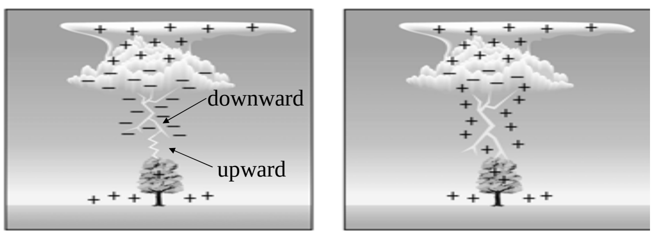
- The negative charge at the bottom of the cloud causes a region of the ground beneath it to become positively charged.
- The positive charge is most dense on protruding objects, such as trees, poles, and buildings.

Step Leaders



- The dry air is a good electrical insulator, so a flow of current can not occur.
- For cloud-to-ground lightning to occur, a ***stepped-leader*** must emanate from the cloud base.
- The leader is essentially an ionized particle chamber about 10 cm (4 in) in diameter which forks repeatedly from a main channel.
- Each section travels about 50 m in a microsecond (a millionth of a sec).
- The sections continue until contact is made with an unlike charged area (the ground).

Return Strokes

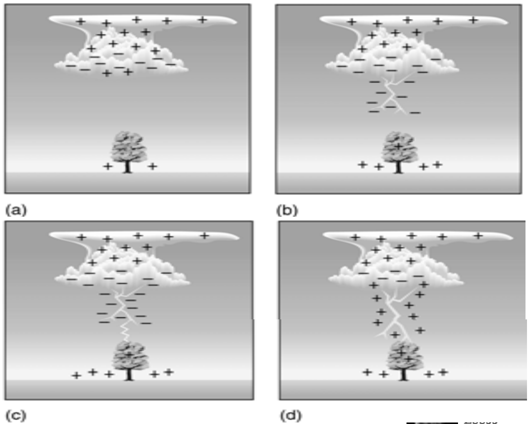


- Upon connection, electrons flow resulting in an illuminated ***return stroke.***
- Although the electrical current is from the cloud to the ground (moves downward), the return stroke is in the opposite direction (move upward).
- The upward return stroke happens so fast, our eyes can not resolve its upward direction.

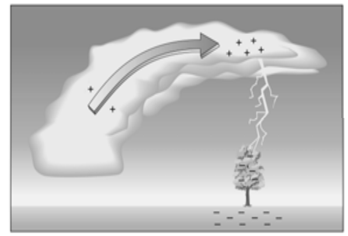
Flashes

- Usually more than one stroke is needed to neutralize all negative ions.
- Another leader, or ***dart leader***, is initiated and a return stroke follows.
- Dart leader moves downward faster than step leader.
- The process is repeated about 2-3 times on average.
- Individual strokes are almost impossible to detect.
- We call a combination of all strokes a ***lightning flash.***

Development of Lightning



Negative and Positive lightning Strokes



- ❑ Most of the lightning are negatively charged cloud-to-positively charged ground (negative lightning).
- ❑ But there are also positively charged cloud-to-negatively charged ground (positive lightning).
- ❑ When high-level winds are strong, thunderstorm clouds become tilted and produce the positive lightning.

❑ The positive lightning can be twice as strong as the negative lightning.

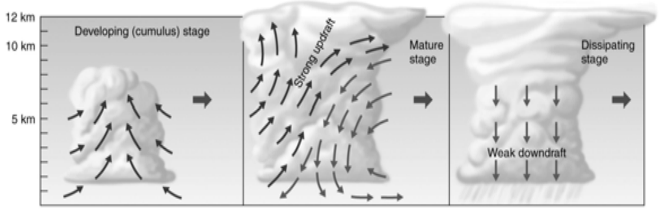
Thunder

- ❑ The lightning stroke can heat the air through which it travels to 30,000ºC (54,000ºF), which is 5 times hotter than the surface of sun.
- ❑ This extreme heating causes the air to expand explosively, thus initiating a shock wave that become a booming sound wave (thunder) to travel outward.
- ❑ It takes 3 seconds for thunder to travel 1 km (5 seconds to travel 1 mile).

Thunderstorms

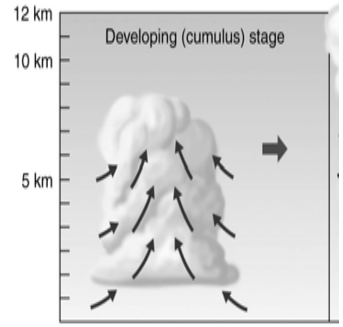
- ❑ A thunderstorm is a storm containing lightning and thunder, and sometime produces gust winds with heavy precipitation and hail.
- ❑ The storm may be a single cumulonimbus cloud, or several thunderstorm may form into a cluster.
- ❑ Two types of thunderstorm: (1) air mass thunderstorm (self-extinguishing) and (2) sever thunderstorm (self-propagating).

Air Mass Thunderstorms



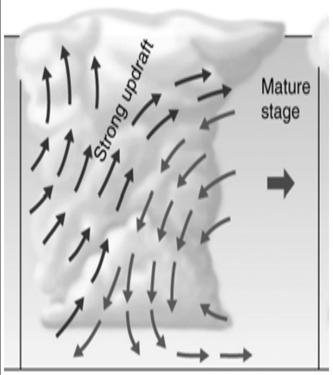
- Air mass thunderstorms are contained within uniform air masses (away from fronts) but they are localized.
- Air mass thunderstorms are self-extinguished and are short lived phenomena (less than an hour).
- An air mass thunderstorm normally consists of a number of individual cells, each undergoing a sequence of three distinct stages: developing (cumulus), mature, and dissipative.

Cumulus (Developing) Stage



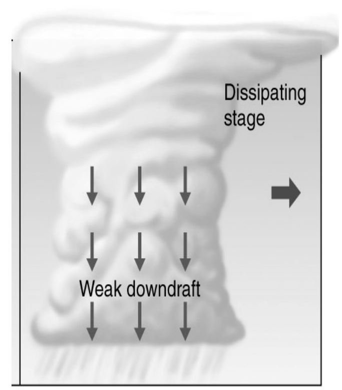
- This begins with unstable air rises often as some surfaces undergo more rapid heating than others.
- Only updrafts are present as air rises and adiabatically cools.
- At first, the cumulus clouds grow upward only for a short distance, then they dissipate (because of re-evaporation)
- Eventually, enough water vapor will be present to sustain vertical cloud development which occurs between 5-20 m/sec (10-45 mph)
- When precipitation begins to fall, the storm enters its next stage.

Mature Stage



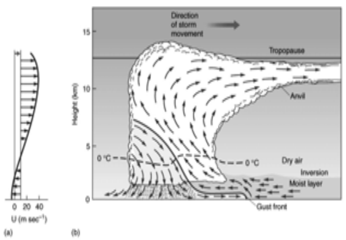
- The ***mature stage*** is marked by precipitation and the presence of both up and down drafts.
- Downdrafts are initiated through frictional drag associated with falling precipitation.
- This is also a time of lightning and thunder.
- Cloud tops are formed where the atmosphere is stable.
- An anvil head may occur as high speed winds blow ice crystals downstream.
- Updrafts dominate the interior portions of the storm while downdrafts occur toward the edges.

Dissipative Stage



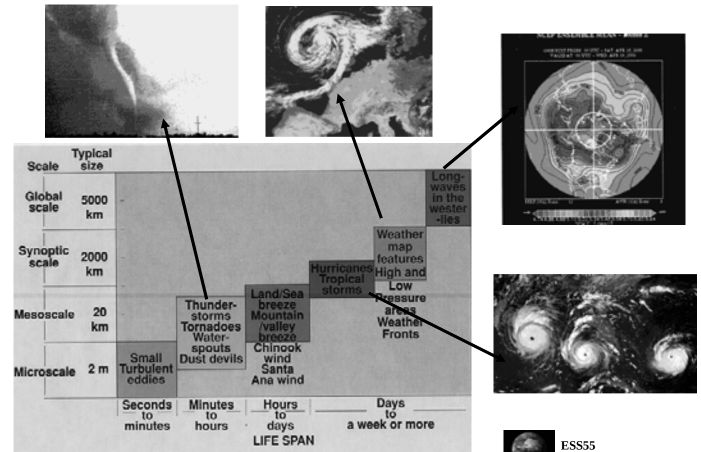
- The ***dissipative stage*** occurs when downdrafts dominate airflow within the thunderstorms.
- This suppresses updrafts and the addition of water vapor.
- Precipitation then ceases and the cloud eventually evaporates.

Severe Thunderstorms



- ❑ Occur when winds exceed 93 km/hr (58 mph), have large hailstones (1.9 cm; 0.75 in) or produce tornadoes.
- ❑ These systems differ from air mass thunderstorms in that the up and downdrafts support each other to intensify the storm.
- ❑ Particular atmospheric conditions must persist across the mesoscale (10-1000 km) for severe thunderstorms to develop.
- ❑ Atmospheric conditions supporting severe thunderstorms include wind shear, high water vapor content in lower portions of the troposphere.

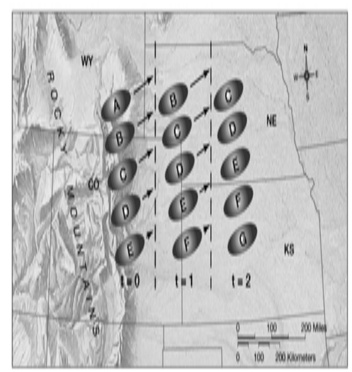
Scales of Motions in the Atmosphere



Mesoscale Convective Systems

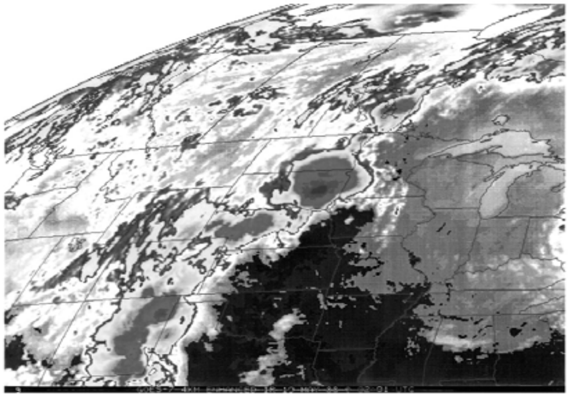
- ❑ Clusters of severe thunderstorms are called ***mesoscale convective systems (MCSs***).
- ❑ MCSs occur as squall lines, or as circular clusters called ***mesoscale convective complex's (MCCs).***
- ❑ Individual storms develop in concert in a situation which propagates additional thunderstorms.
- ❑ Many MCSs have life spans from up to 12 hrs to several days.
- ❑ Severe thunderstorms may also form from individual ***supercells*** which contain only one updraft (supercells may also be a part of an MCS).

Mesoscale Convective Complex



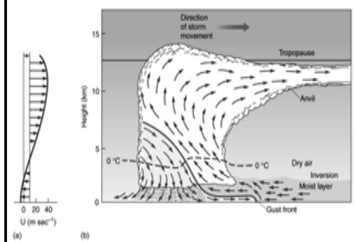
- ❑ MCCs account for the greatest amount of severe weather in the U.S. and Canada.
- ❑ Circular clusters of thunderstorms which are self propagating in that individual cells create downdrafts which interact to form new cells.
- ❑ Colder, denser downdrafts spread across the surface and help force warm, moist surface air aloft.
- ❑ This ***outflow boundary*** initiates a new cell.
- ❑ The entire system typically propagates eastward.

Mesoscale Convective Complex



ESS55
Prof. Jin-Yi Yu

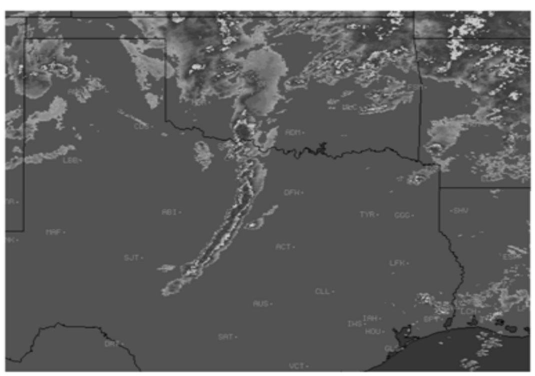
Squall Line Thunderstorms



- Bands may be as long as 500 km (300 mi) usually about 300-500 km (180-300 mi) in advance of cold fronts.
- Strong vertical wind shear is essential to the development of these prefrontal waves as it ensures that updrafts will be positioned ahead of the downdrafts.
- This feeds moisture into the system which is also aided by gust front propagation ahead of the situation.

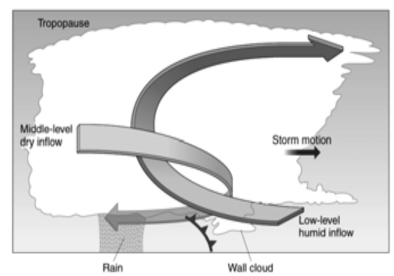
ESS55
Prof. Jin-Yi Yu

Squall Line Thunderstorms



ESS55
Prof. Jin-Yi Yu

Supercell Storms



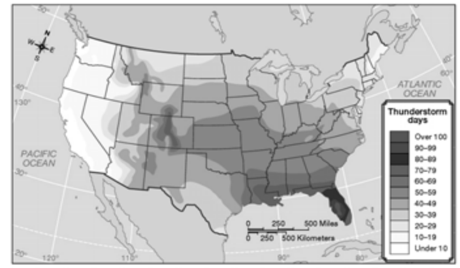
- Although supercells consist of a single cell they are typically more violent than MCCs or squall lines.
- Strong wind shear is responsible for wrapping up and downdrafts around each other in these tornado producers.
- This creates large-scale rotation which is typically absent from MCCs and squall lines.

ESS55
Prof. Jin-Yi Yu

Downbursts and Microbursts

- ❑Strong downdrafts can create deadly gusts of winds, called downbursts.
- ❑ Downbursts can be mistakenly considered as tornadoes.
- ❑ When downbursts have diameters of less than 4 km, they are called microbursts.
- ❑ Microbursts are dangerous to airplanes.

Distribution of Thunderstorms



- ❑ Thunderstorms develop where moist air is forced aloft.
- ❑ Occurs frequently in the tropics, nearly daily in some locations.
- ❑ In the U.S., most frequent region is the Gulf South.

Tornadoes


- ❑ Tornadoes are zones of extremely rapid, rotating winds beneath the base of cumulonimbus clouds.
- ❑ Strong counterclockwise (in N.H.) winds originate in relation to large pressure gradients over small spatial scales.
- ❑ Pressure differences may be as much as 100 mb over a few tenths of km.

Tornado Characteristics

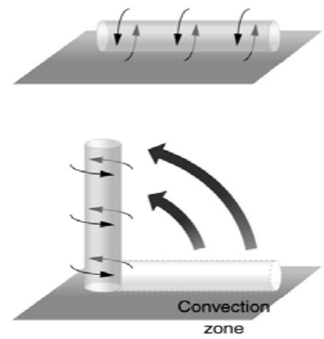
- ❑Typically have diameters of about 100 yards but may be much larger.
- ❑ Usually a short lived phenomena lasting only a few minutes, but some have lasted for hours.
- ❑Movement is generally about 50km/hr (30 mph) over an areas about 3-4 km (2-2.5 mi) long.
- ❑Winds may be as low as 65 km/hr (40 mph) or as high as 450 km/hr (280 mph).
- ❑Come in wide range of shape and size.

Tornado Formation

- Common to frontal boundaries, squall lines, MCCs, supercells and tropical cyclones.
- Most violent tornadoes are associated with supercells

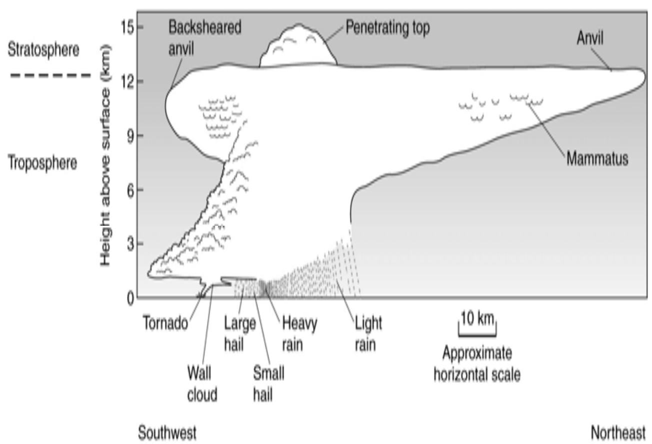
ESS55
Prof. Jin-Yi Yu

Supercell Tornado Development



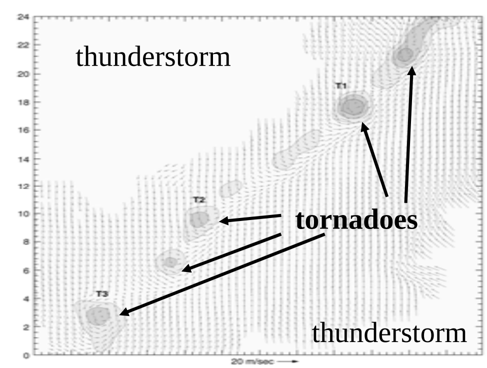
- Vertical wind shear creates a horizontal vortex.
- The vortex is tilted vertically by strong updrafts and forms a mesocyclone.
- The vortex stretches downward when the mesocyclone intensified.
- A wall cloud is formed under the cloud base, which then develops into a tornadoes.
- Only about 1/2 of all mesocyclones actually spawn a tornado

ESS55
Prof. Jin-Yi Yu



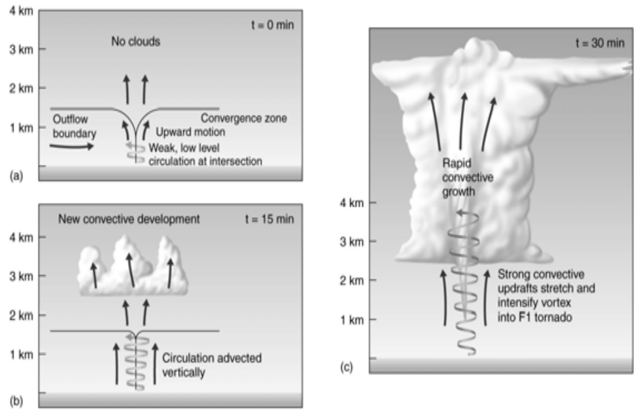
ESS55
Prof. Jin-Yi Yu

Nonsupercell Tornado Development I



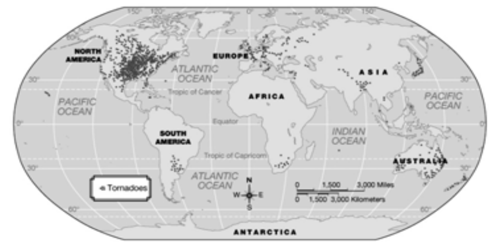
ESS55
Prof. Jin-Yi Yu

Nonsupercell Tornado Development II



ESS55
Prof. Jin-Yi Yu

Location and Timing of Tornadoes



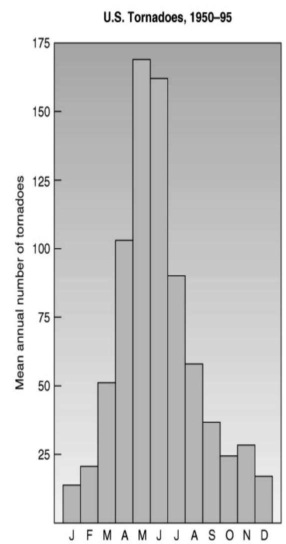
- ❑ The U.S. is the world leader in tornado production.
- ❑ This results from the regular interaction between the air mass from the Gulf of Mexico and the air mass from the polar continent.
- ❑ The absence of topographic barriers ensures regular mixing and the production of violent storm systems.

ESS55
Prof. Jin-Yi Yu

Tornado Alley

- ❑ The vast majority occur in ***Tornado Alley***, a region from the southern Plains to the lower Great Lakes.
- ❑ Texas has the highest tornado frequency of any state.

ESS55
Prof. Jin-Yi Yu



Tornado Season

- ❑ May is the month of highest frequency while June is a close second.
- ❑ Many states show tornado peaks during different months, however, late spring is the time of greatest overall activity.
- ❑ It is the season when air mass contrasts are especially strong.

ESS55
Prof. Jin-Yi Yu

Tornado Damage

- Winds, not pressure change, cause the greatest amount of damage.
- Flying debris causes the greatest amount of injuries.
- Some tornadoes have multiple suction vortices which may account for rather selective damage patterns.
- Tornadoes are classified using the Fujita scale which ranks tornadoes based on damage.

ESS55
Prof. Jin-Yi Yu

Fujita Intensity Scale

Table 11–2 Fujita Intensity Scale

	Intensity	Wind Speed (km/hr)	Wind Speed (mph)	Typical Amount of Damage
weak	F0	< 116	< 72	Light: Broken branches, shallow trees uprooted, damaged signs and chimneys.
	F1	116–180	72–112	Moderate: Damage to roofs, moving autos swept off road, mobile homes overturned.
strong	F2	181–253	113–157	Considerable: Roofs torn off homes, mobile homes completely destroyed, large trees uprooted.
	F3	254–332	158–206	Severe: Trains overturned, roofs and walls torn off well-constructed houses.
violent	F4	333–419	207–260	Devastating: Frame houses completely destroyed, cars picked up and blown downwind.
	F5	420–512	261–318	Incredible: Steel-reinforced concrete structures badly damaged.
	F6	>513	>319	Inconceivable: Might possibly occur in small part of an F4 or F5 tornado. It would be difficult to identify the damage done specifically by these winds, as it would be indistinguishable from that of the main body of the tornado.

ESS55
Prof. Jin-Yi Yu