



دانشگاه رازی

Fundamentals of synoptic meteorology

Lecture 10

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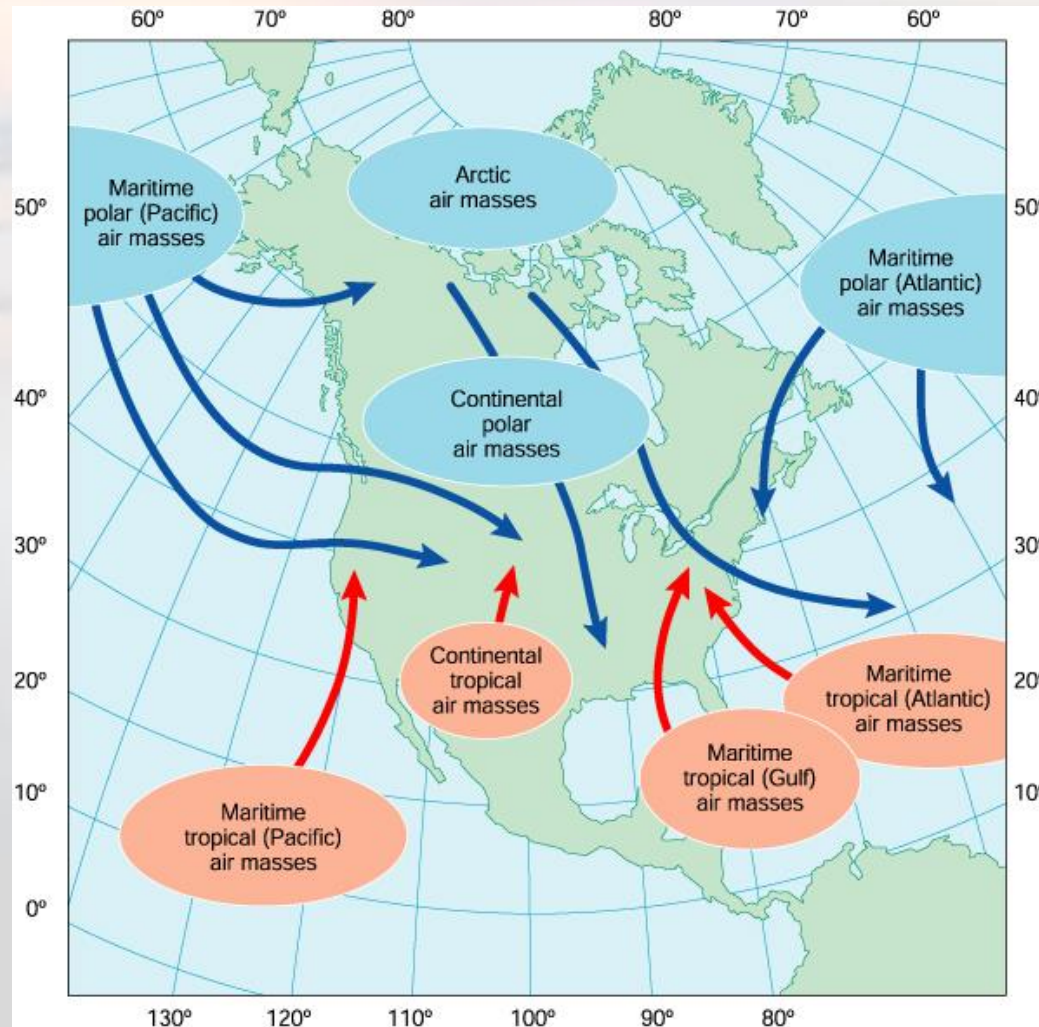


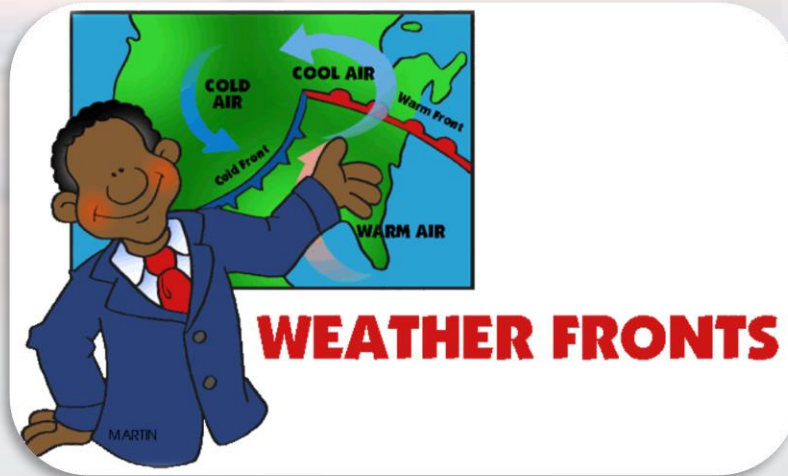
Air masses



Air masses

The combination of temperature and moisture gives us five basic air mass types:



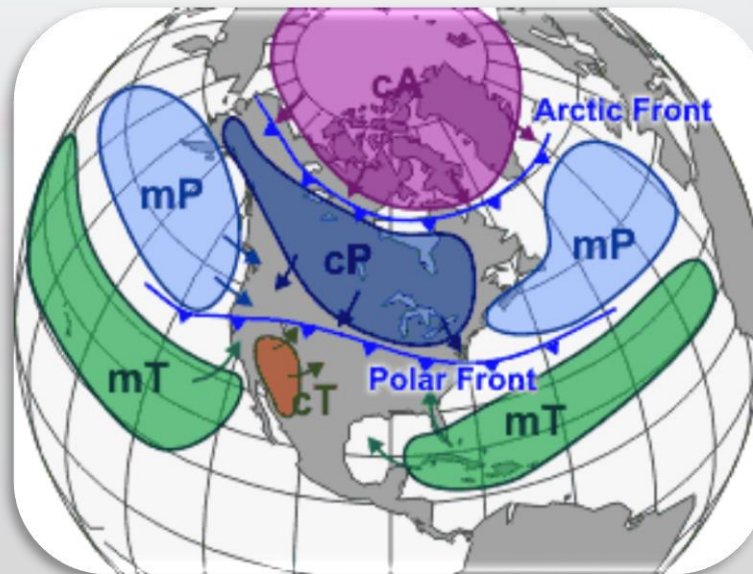


Fronts

The boundary between two different air masses is called a front

It is a region of significant horizontal gradients in temperature or humidity (almost discontinuous)

Typically 100 to 200 km wide



The movement of fronts is responsible for much of the day-to-day variability in weather conditions.

Northwest Europe receives many different air mass types, with frequent frontal passages - results in very variable weather.

Commonly associated with: Moisture gradient, Temperature gradient, Wind shift



Classification of fronts

Meteorologists classify fronts based on:

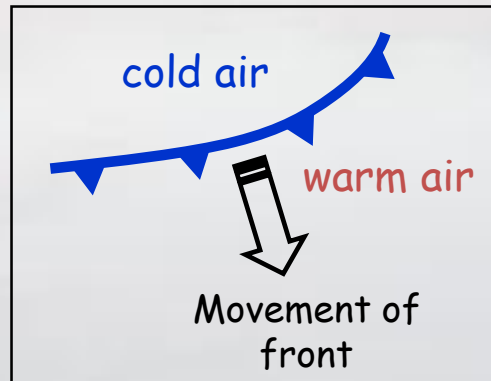
- a) the thermal and moisture characteristics of the airmasses
- b) the direction of movement of the airmasses
- c) whether the boundary between the airmasses is in contact with the ground (a surface front), or can only be found aloft (an "upper level front").

There are four types of fronts that will be described:

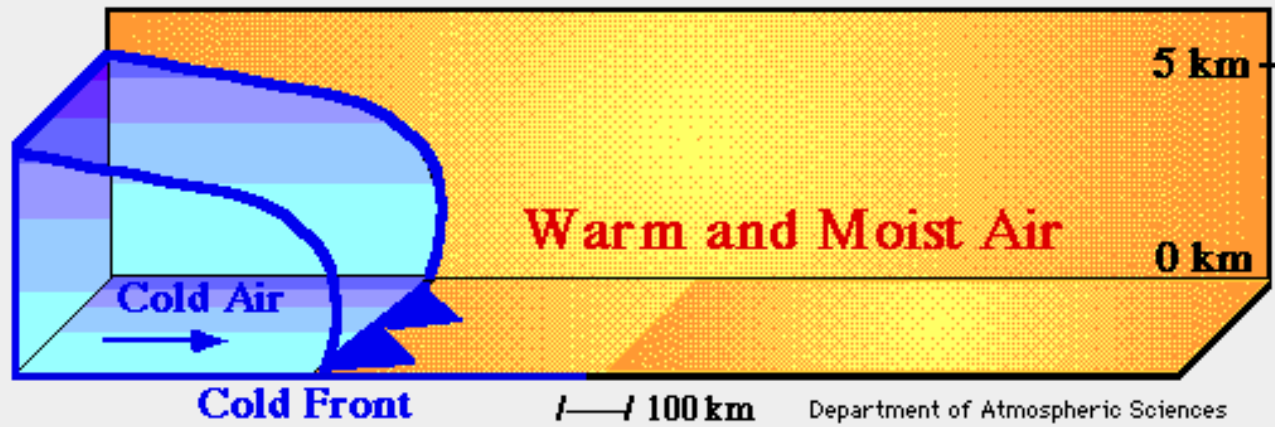
- 1-cold front
- 2- warm front,
- 3- stationary front
- 4- occluded front



Cold, dry stable polar air (cP) is replacing warm, moist, conditionally unstable subtropical air (mT)

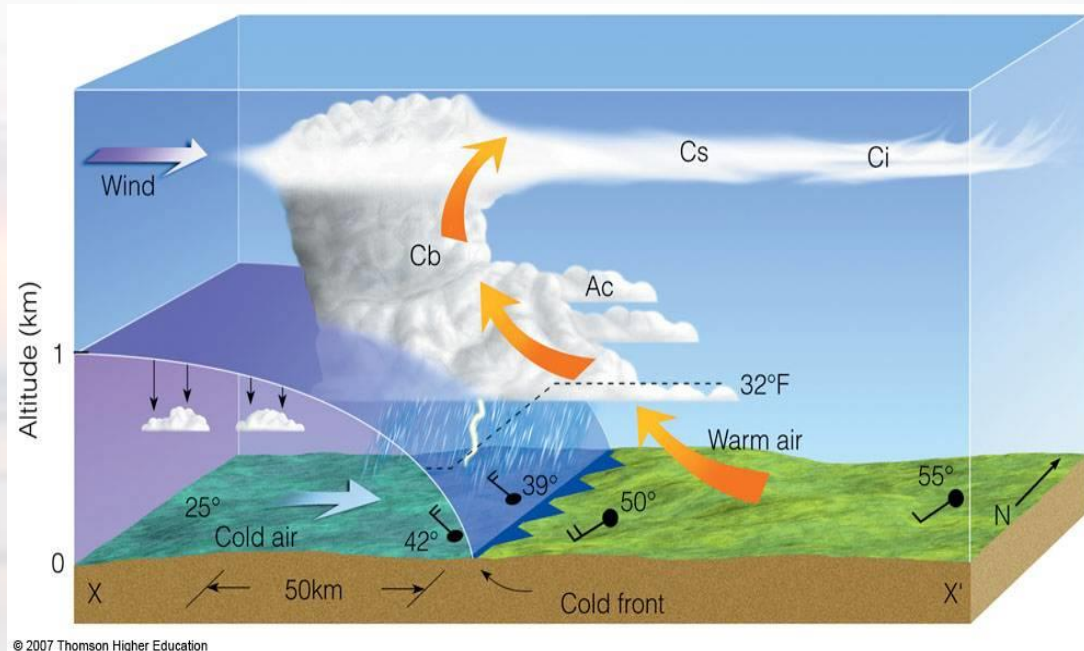


On weather maps, cold fronts are indicated by blue lines with triangles pointing in the direction of frontal motion (towards warmer air)



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Slopes of 1/50 to 1/150

Steep vertical boundary due to surface friction slowing down the surface front

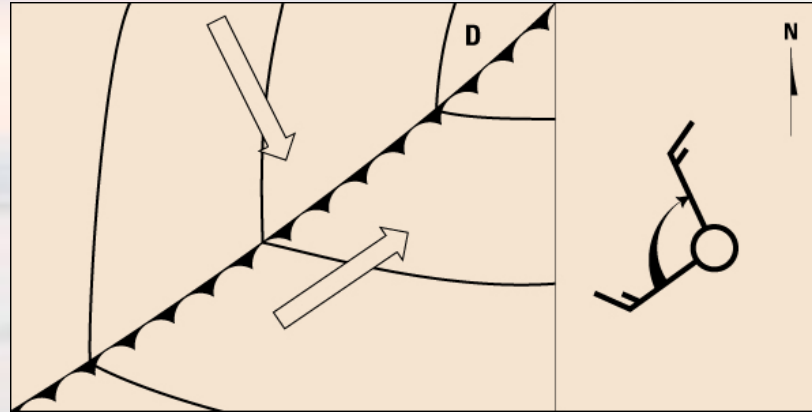
Cold, dry stable polar air (cP) is replacing warm, moist, conditionally unstable subtropical air (mT)

Has strong vertical ascent along the surface front

Strong upper level westerlies push ice crystals far ahead of the front, creating Ci and Cs in advance of the front.

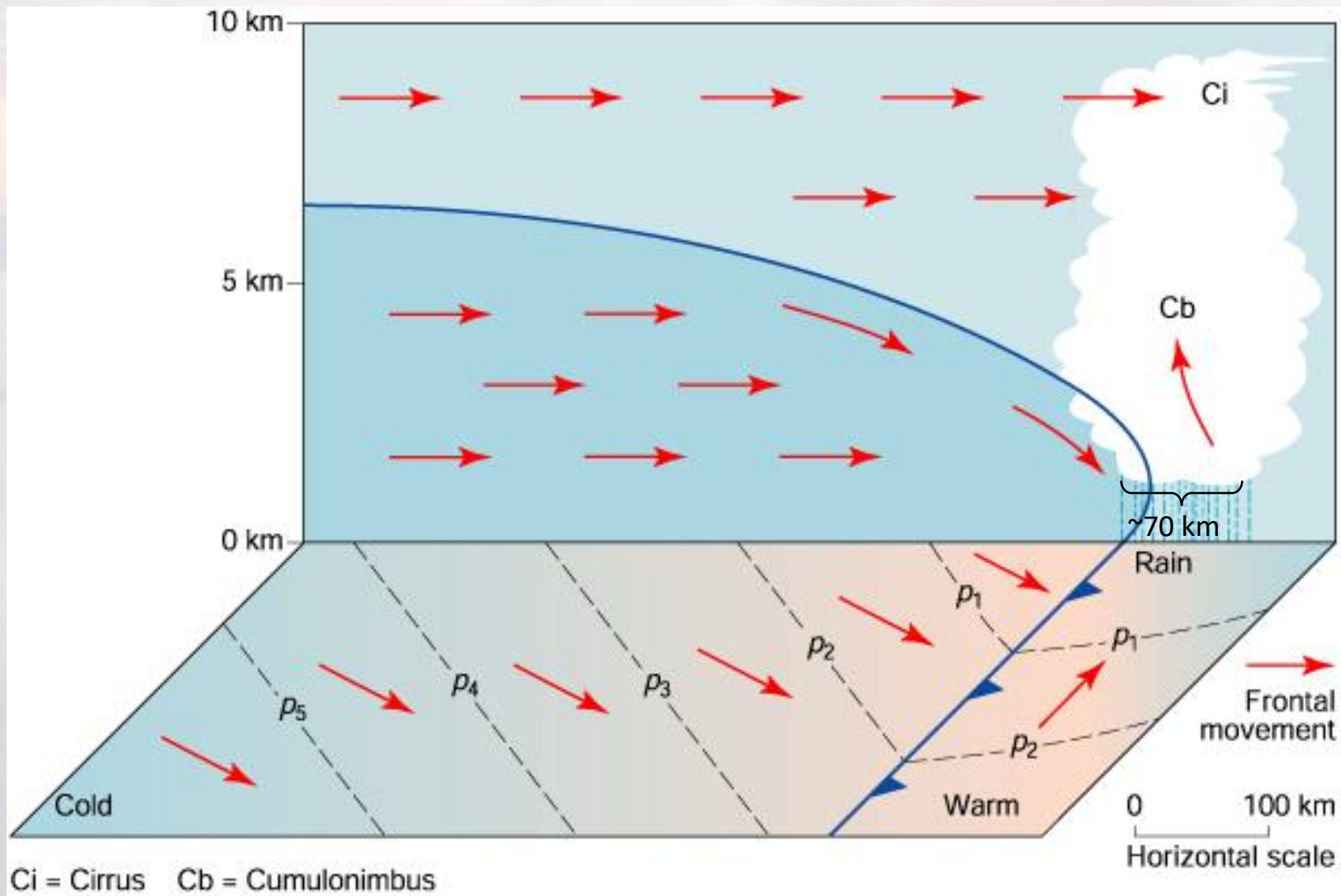
Associated with cumulus & cumulonimbus clouds ahead of the front in the warm air, producing showers and thunderstorms

usually bring cooler weather, clearing skies, and a sharp change in wind direction



On a surface pressure map, frontal location can be seen by “kinks” in the isobars, changes in wind direction from a southwesterly to a northwesterly wind, and decreases in temperature.





General weather characteristics of a cold front

Variable	Before passage	After passage
Temperature	warm	steady cooling
Dew point	high	decreases steadily
Pressure	falling steadily	steady rise
Visibility	fair to poor	good
Clouds	Ci, Cs, Cb	Cu
Precipitation	showers	clearing

Cold Front Thunderstorm Development over Great Plains



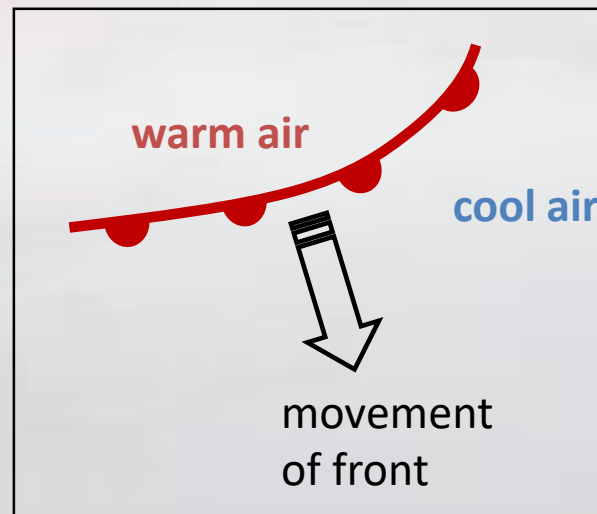
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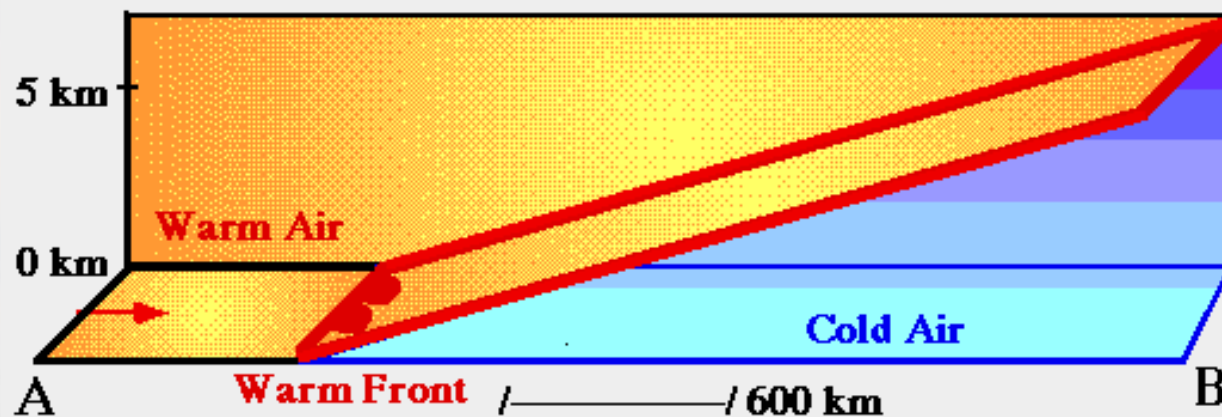
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Occurs at the leading edge of an advancing **warm, moist, subtropical air mass (mT)** from the Gulf replacing a retreating **cold, maritime, polar air mass** from the North Atlantic (mP)



Warm air behind the front overlies cold air



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Warmer, less-dense air rides up and over the colder, more-dense surface air

Produces clouds and precipitation well in advance of the front

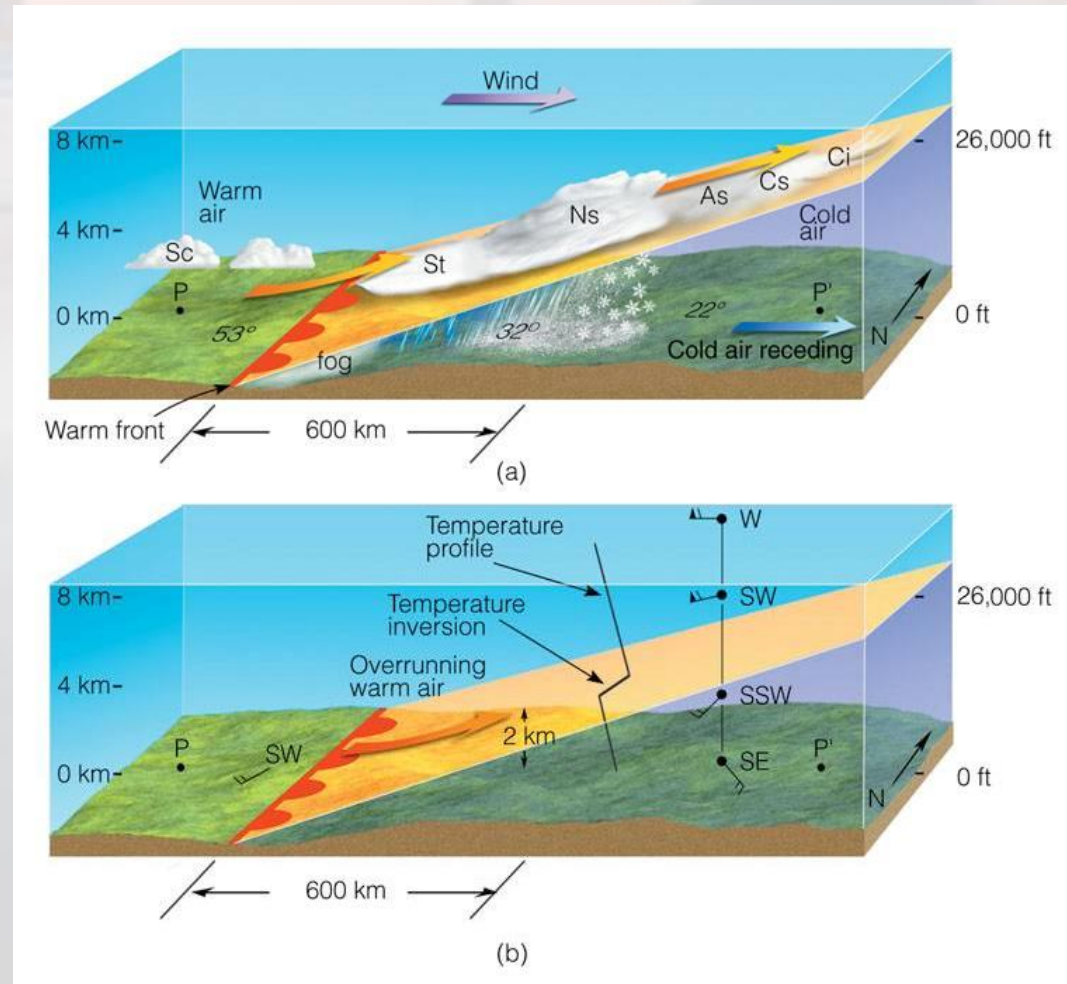
Move slower than cold fronts

Gradual warming and veering of the wind from the S to SW when the front passes

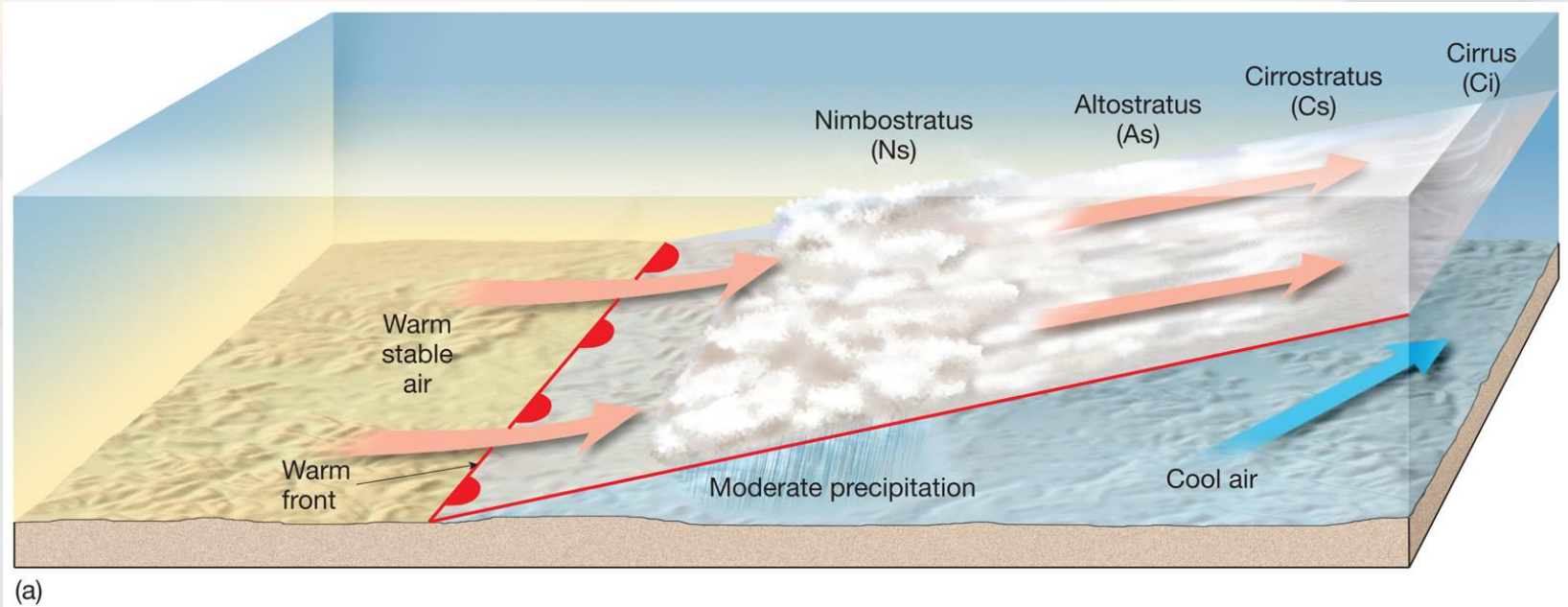
Convection depends on stability and humidity of the warm air behind of the front

If below freezing, snow or freezing rain may occur

Slope is typically $< 1/200$



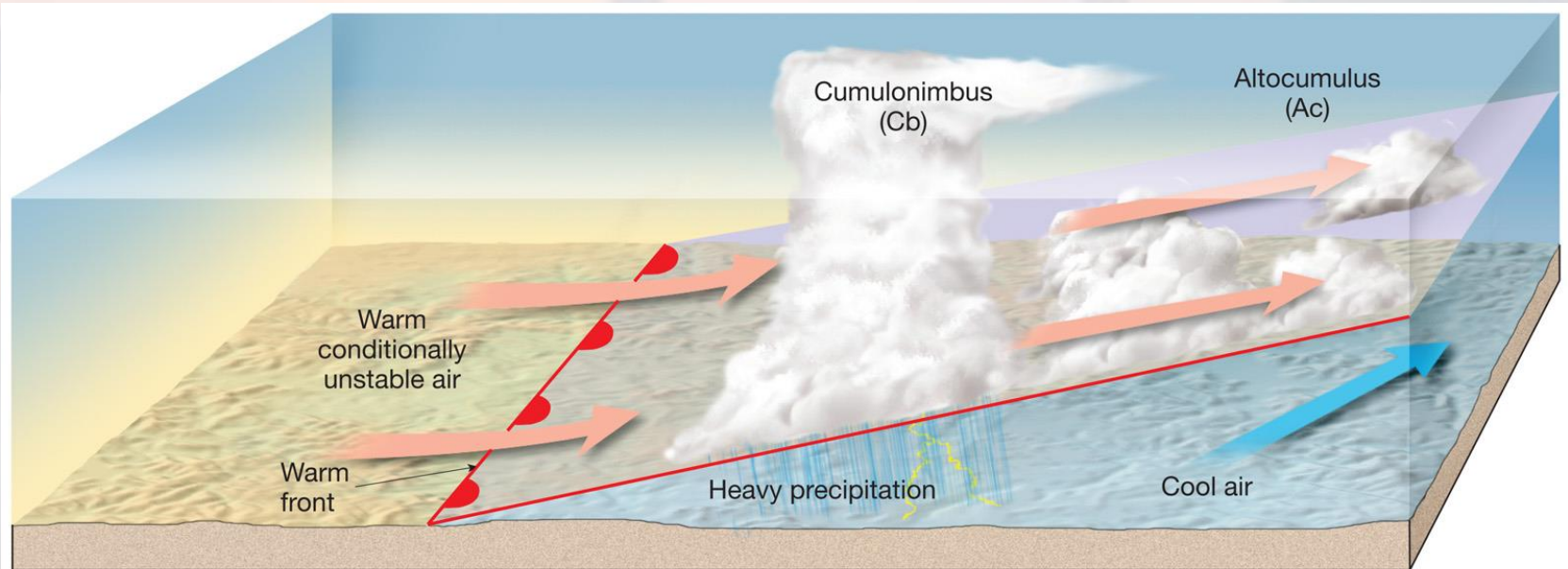
Warm stable air



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Stable: clouds will be layered

Warm conditionally unstable air

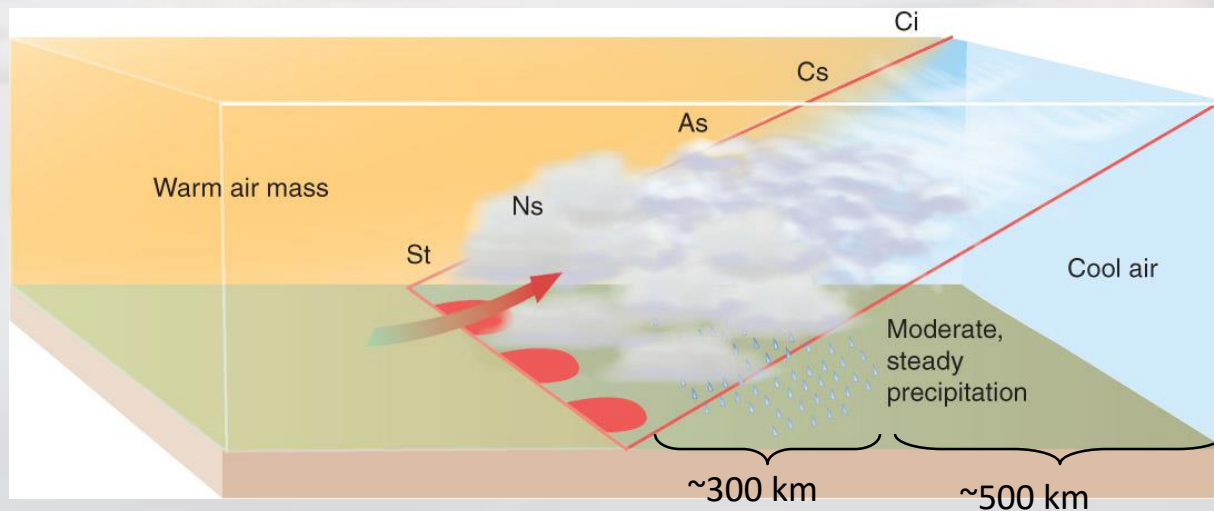


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Unstable: Thunderstorms

warm front is associated with a broad cloud and precipitation shield that may extent hundred of kilometers ahead of the surface front

although they can trigger thunderstorms, warm fronts are more likely to be associated with large regions of gentle ascent (stratiform clouds and light to moderate continuous rain).



are usually preceded by cirrus first (1000 km ahead), then altostratus or altocumulus (500 km ahead), then stratus and possibly fog.

behind the warm front, skies are relatively clear (but change gradually)

General weather characteristics of a warm front

<i>Variable</i>	<i>Before passage</i>	<i>Region of front</i>	<i>After passage</i>
Temperature	cool, slowly warming	steady rise	warmer
<i>Dew point</i>	<i>steady rise</i>	<i>steady</i>	<i>increases, then steady</i>
Pressure	usually falling	levels off	slight rise, followed by fall
<i>Visibility</i>	<i>poor</i>	<i>improving</i>	<i>fair</i>
Clouds	Ci, Cs, As, Ns, St, fog	stratus	Clearing with scattered Sc
<i>Precip</i>	<i>light to moderate, can be SN or RA</i>	<i>drizzle or nothing</i>	<i>usually none</i>

Light rain, warm front



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Stationary front



Marked by alternating blue lines & blue triangles (pointed in the direction of the warmer air) and red lines & red semi-circles (pointed in the direction of the cooler air)

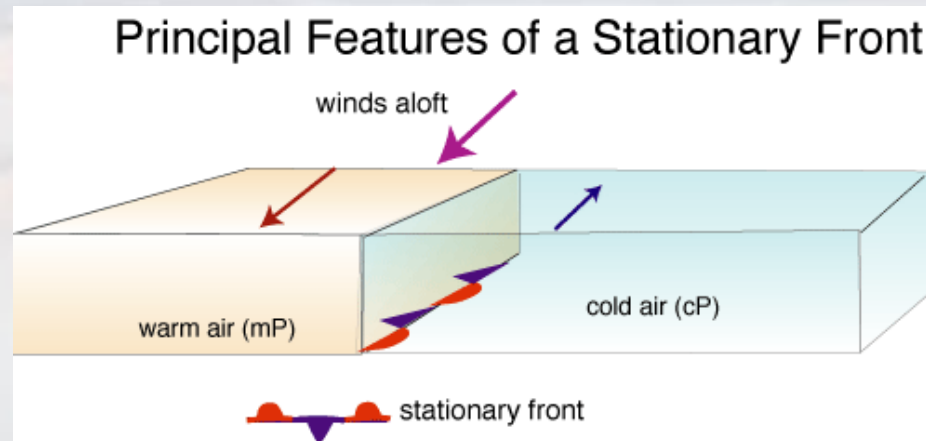
Usually noted as *quasi*-stationary as it is rarely ever completely stationary (Remains in roughly the same location) . It tends to meander a bit



In the mid-latitudes, typically separates cold dense cP air from milder mP air

Sometimes neither the warm air or cold air wins the battle, and we get a stationary front (stalemate).

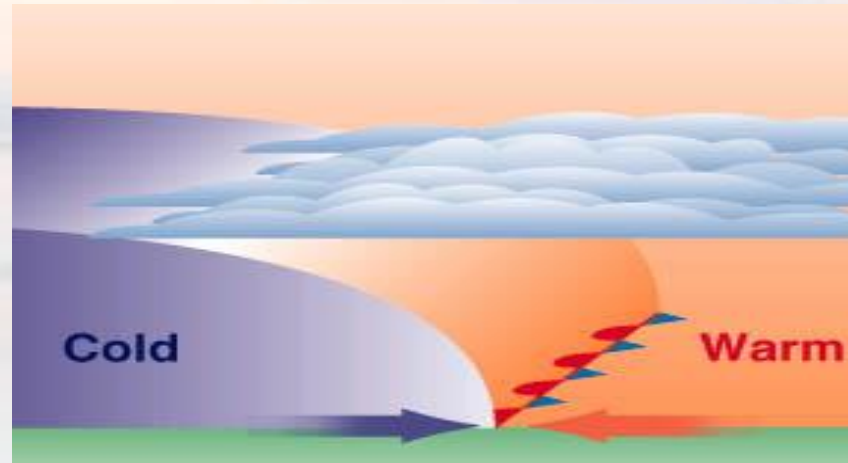
Air flow is parallel to the line of the front.



Gentle to moderate precipitation, but possible floods if the front remains in the one place for too long.

Winds blow parallel to the front but in opposite directions on the two sides of the front.

Often associated with a wide region of clouds and rain or snow on the cold side of the front.

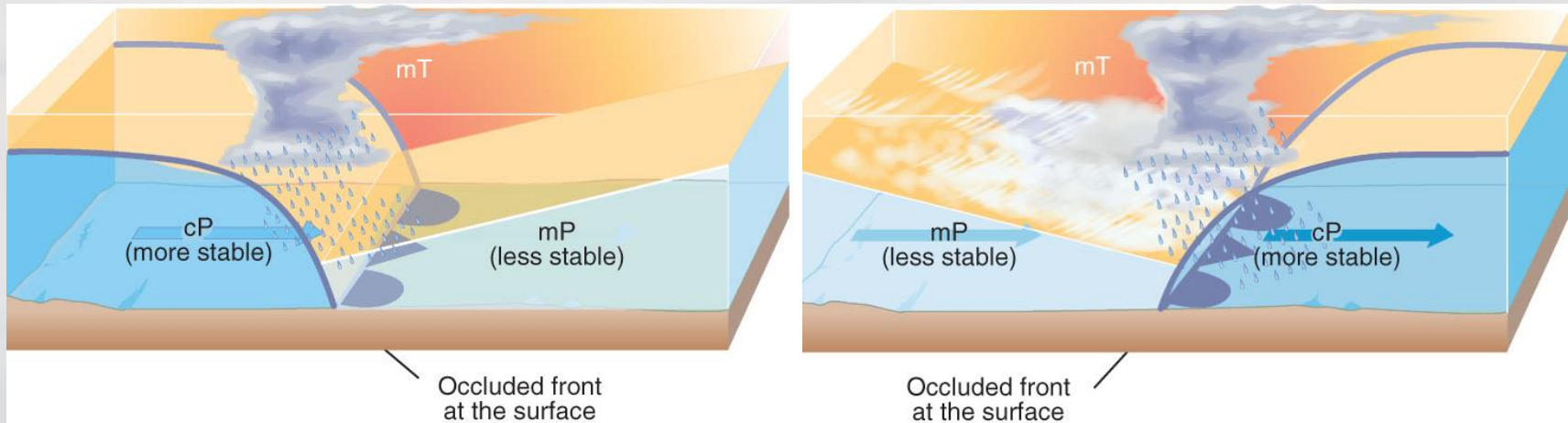


Seen often along mountain ranges when cold air cannot make it over the ridge.

Occluded Fronts



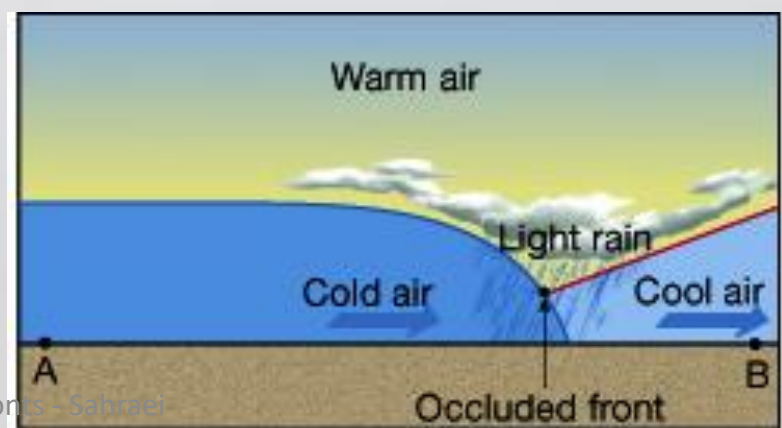
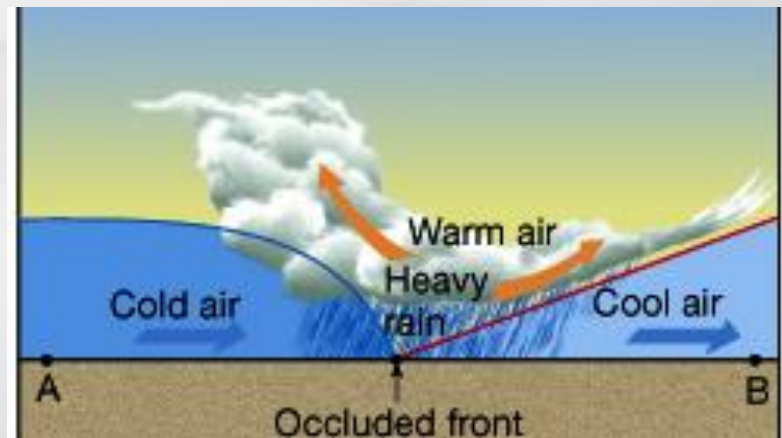
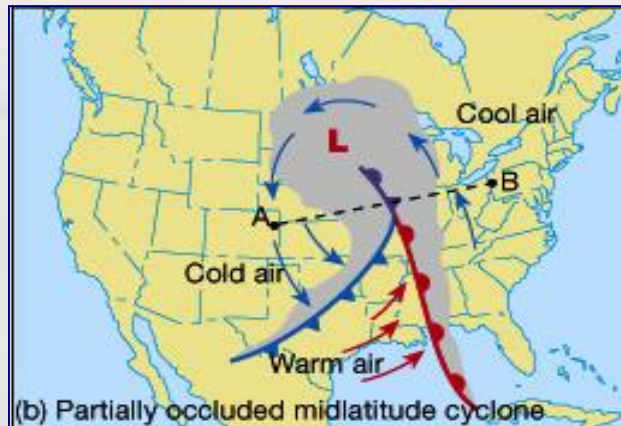
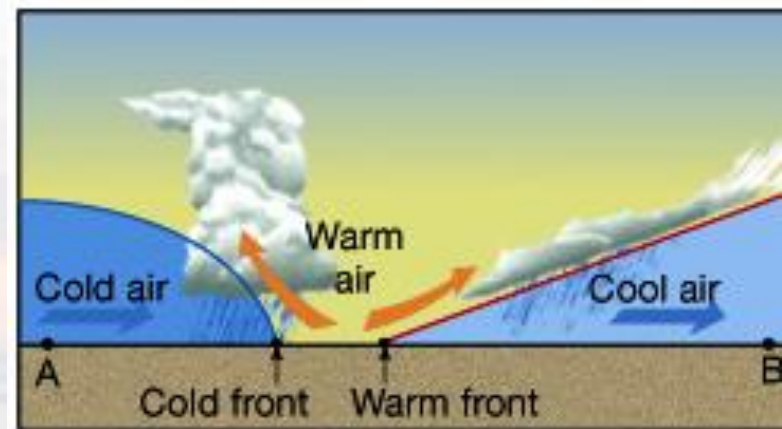
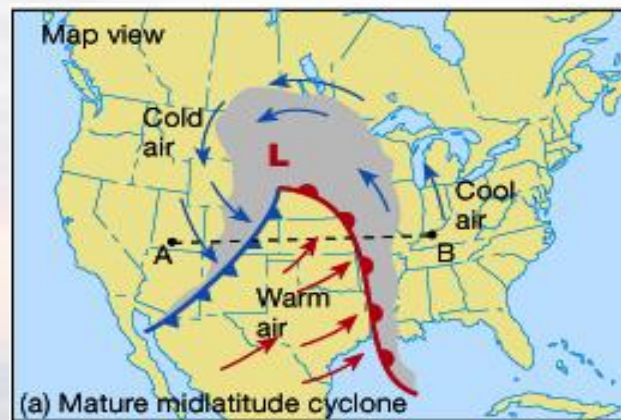
In general cold fronts move faster than warm fronts, and may thus catch up with a warm front ahead - the result is an **occluded front**



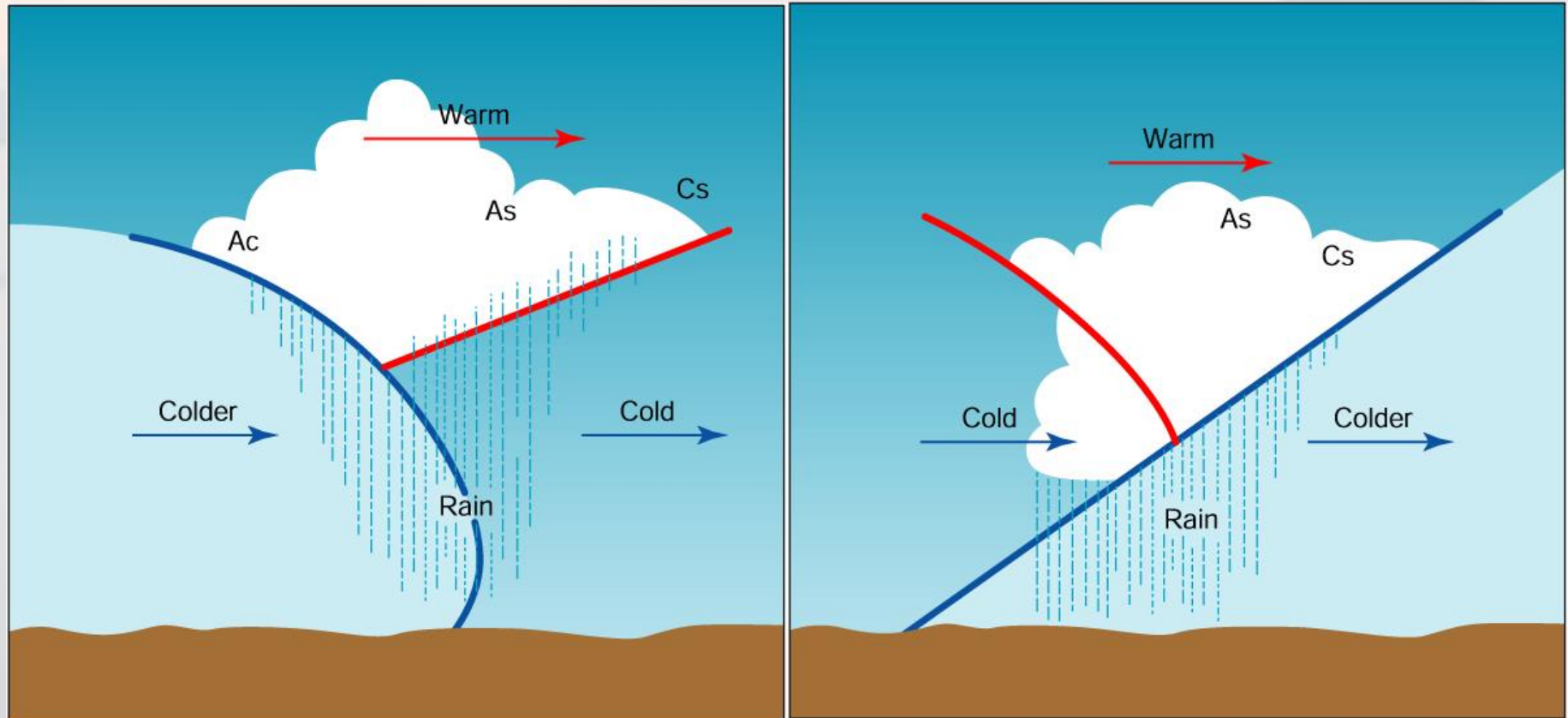
Involve 3 air masses

2 polar air masses at the surface, usually mP and cP

1 tropical air mass, mT that has been lifted entirely off the surface, and is occluded or hidden from the surface weather map

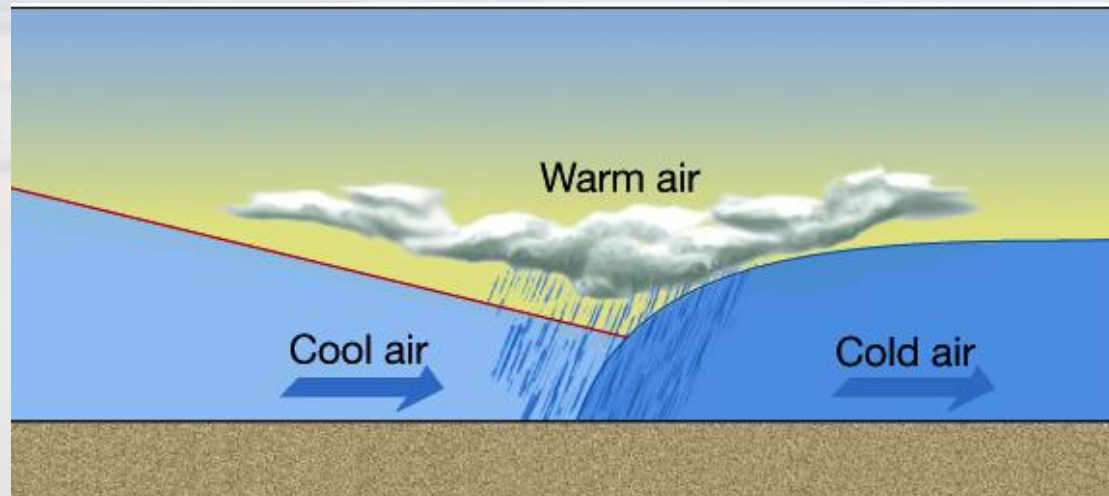


There are two types of occluded fronts: **warm** and **cold**, depending on whether the air behind the cold front is **warmer** or **cooler** than the air ahead of the warm front



Warm Occlusion

Warm-type occluded front - warm front overtakes cold front. e.g. Along the Pacific coast. Mild maritime polar air invades frigid continental polar air.

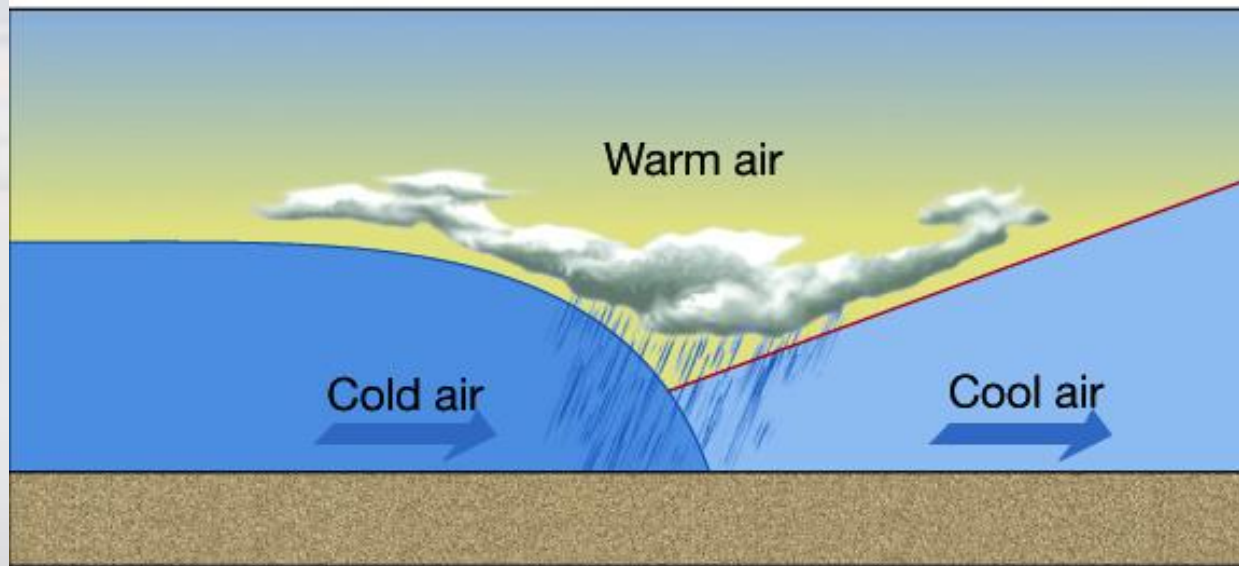


Warm occlusions form on the west coast of the U.S. and Europe, when the air mass behind the front is usually from the ocean, mP.

Have weather like warm fronts where mT and mP air masses meet

Cold Occlusion

Cold-type occluded front - cold front overtakes warm front. e.g. East of Rockies. Expect heavy rain - warm air is forced aloft.



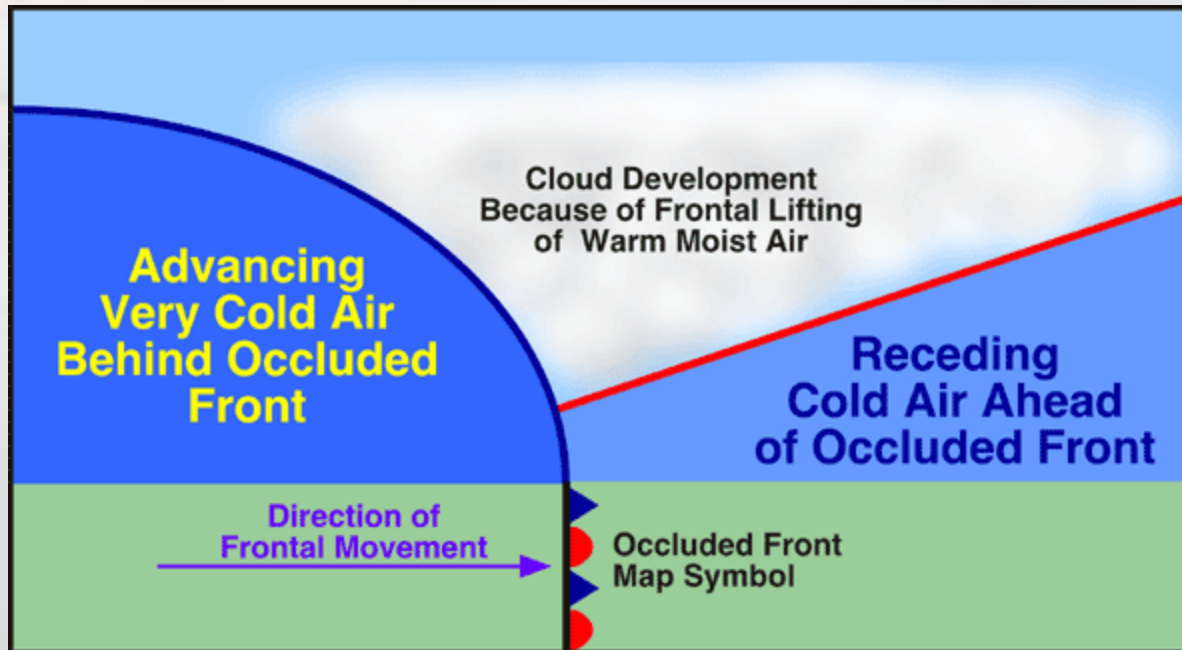
Cold occlusions frequently form in the eastern half of the U.S., with mP ahead and cP behind the front.

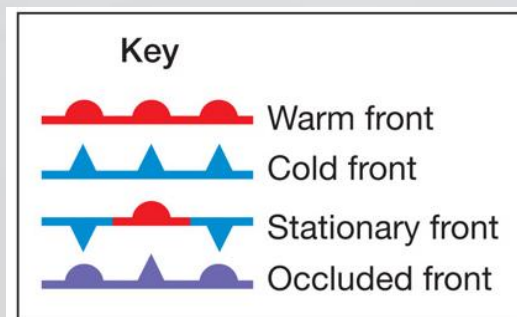
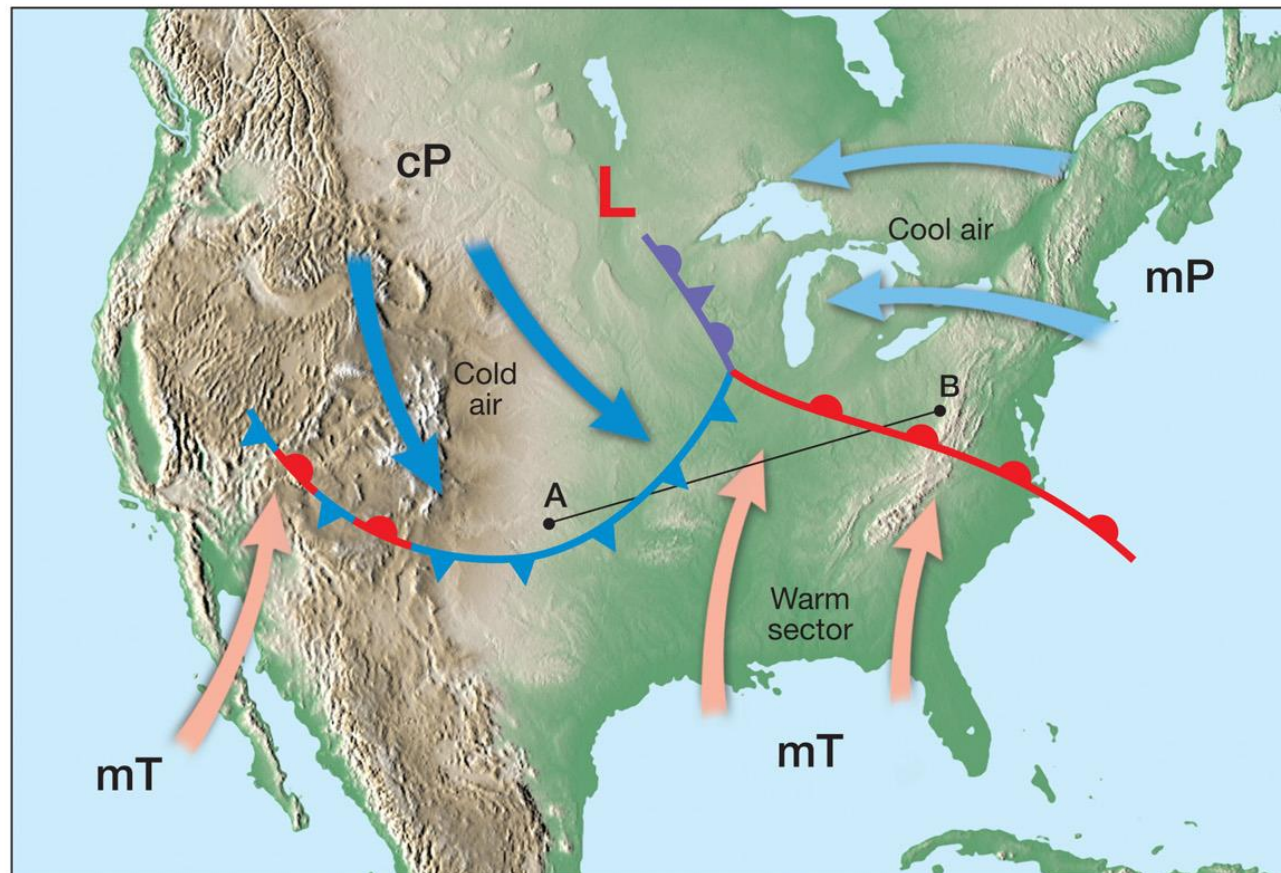
weather like cold fronts where mT and mP air masses meet

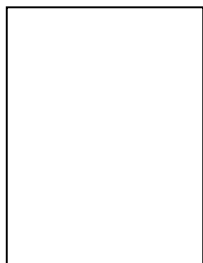
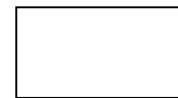
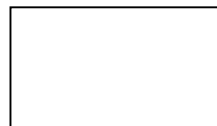
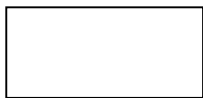
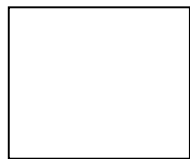
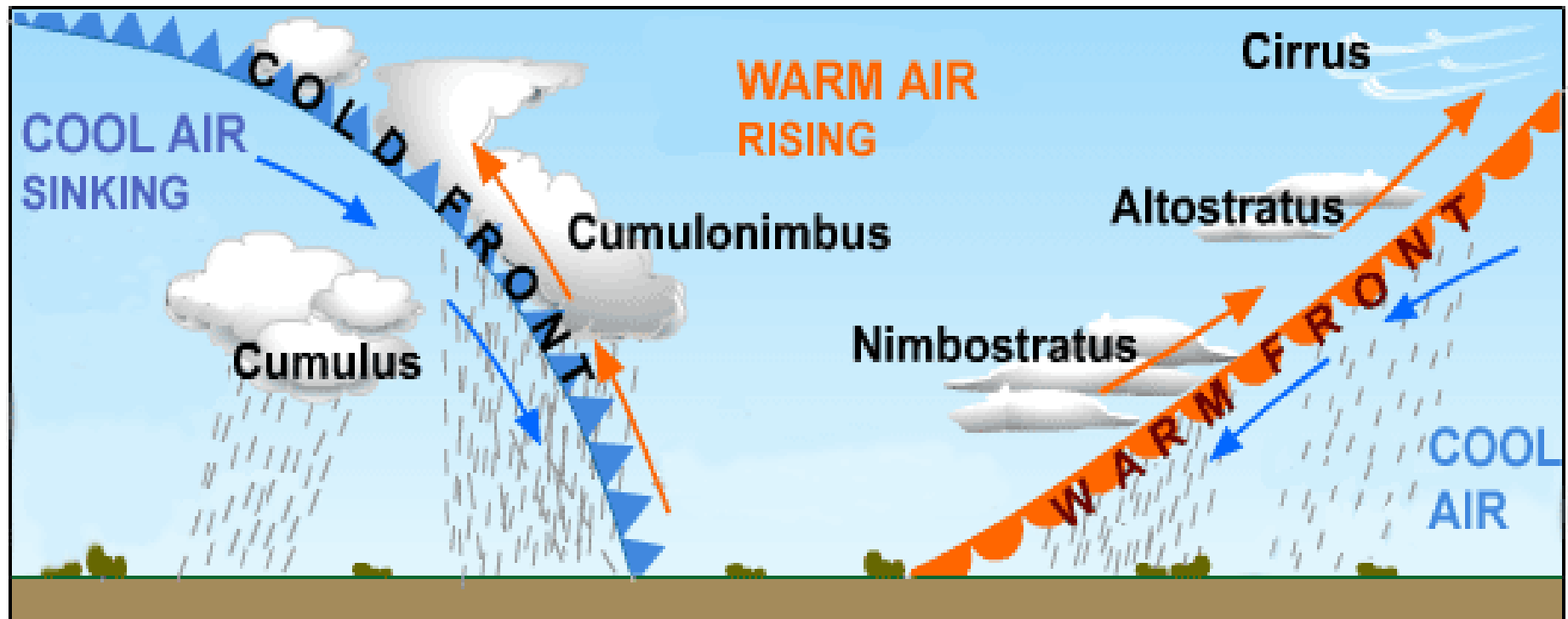


Cold occlusions are the more common type in the UK.

Occlusion is part of the cycle of frontal development and decay within mid-latitude low pressure systems.





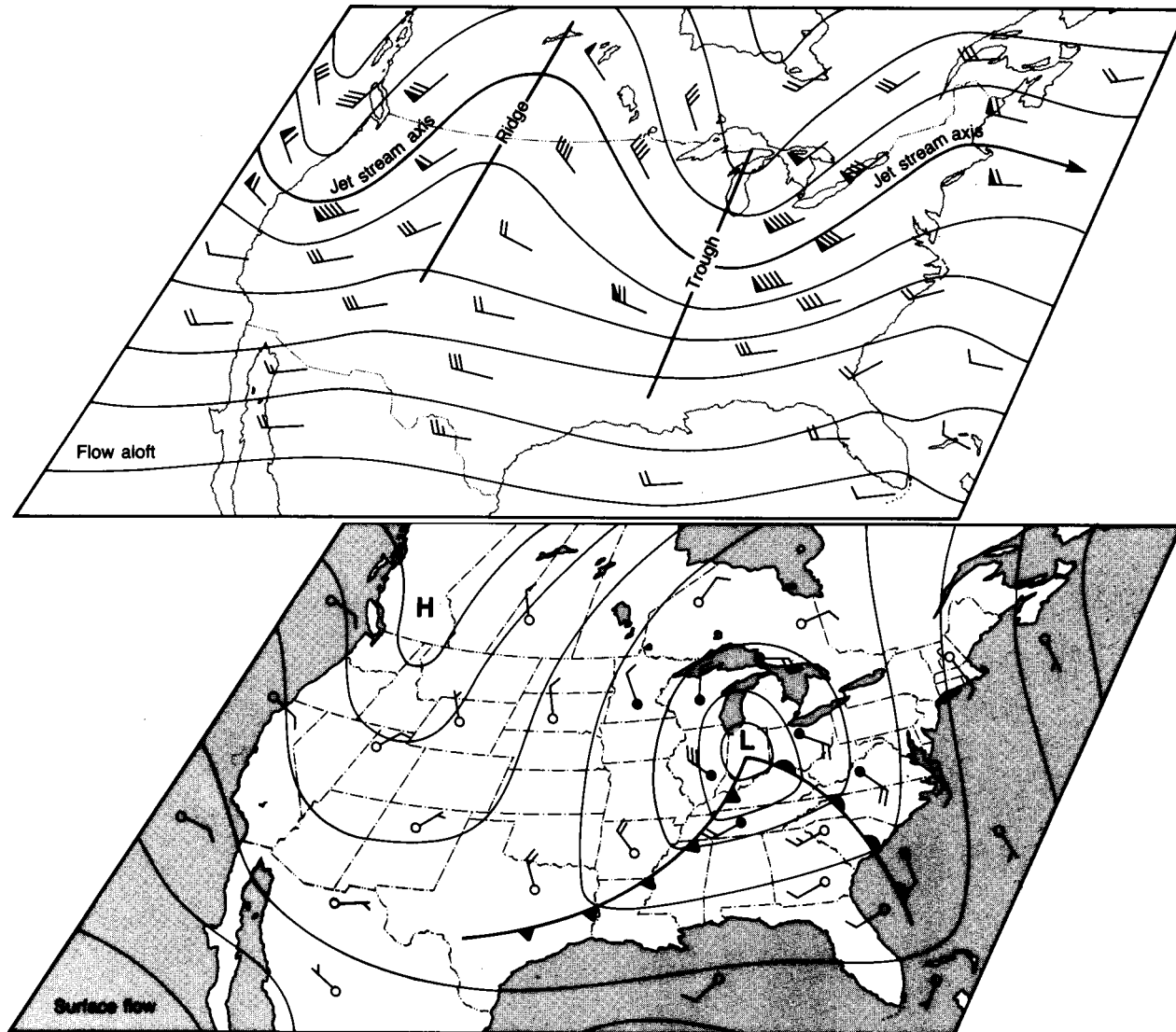


West



East

Want to look at the connection between surface patterns and upper level wind flow

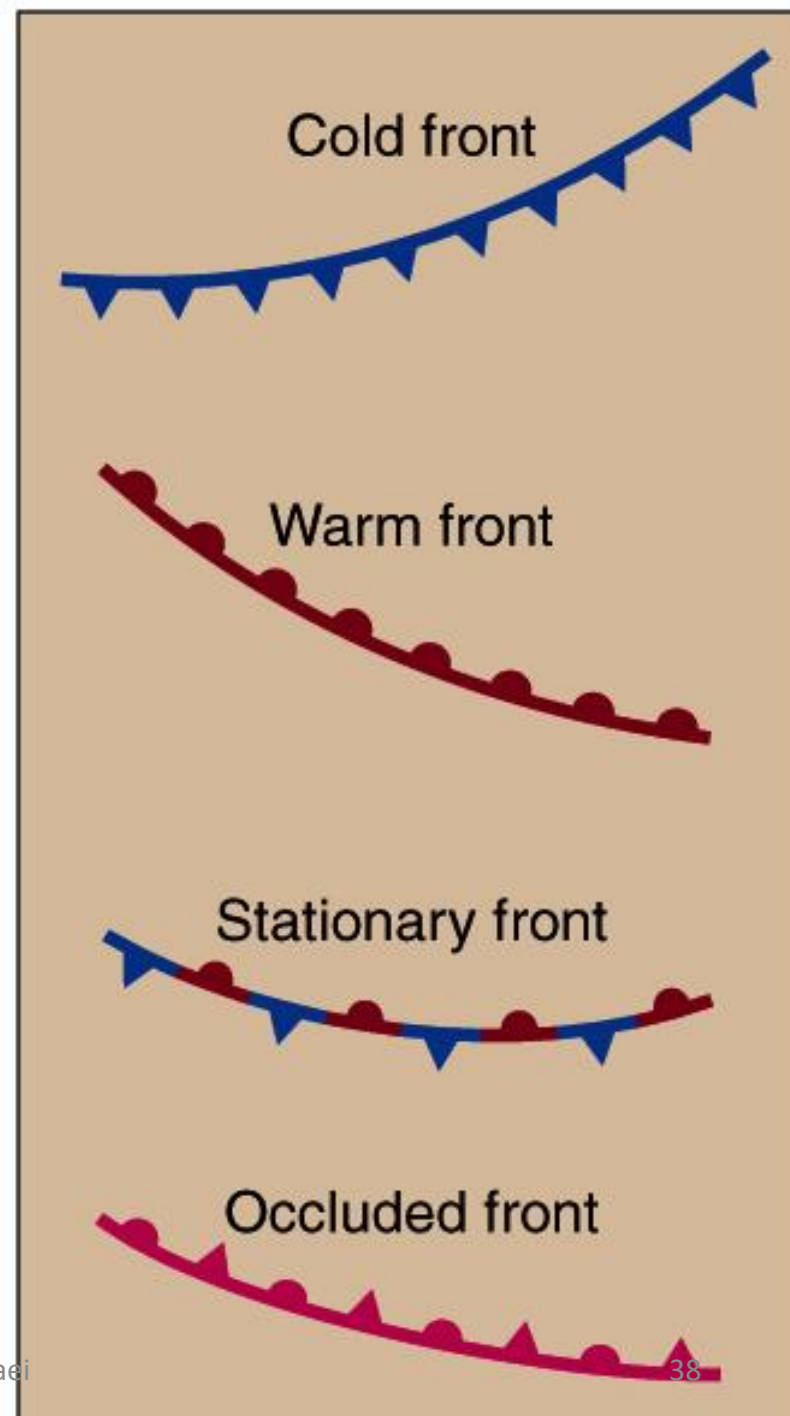


Fronts

narrow zone separating air masses of differing characteristics

typically only 50 to 100 km wide
narrow enough that they can be represented by lines on surface analysis charts

typically located in pressure troughs
fronts are characterized according to the character of the air mass moving



Passing of a cold front:

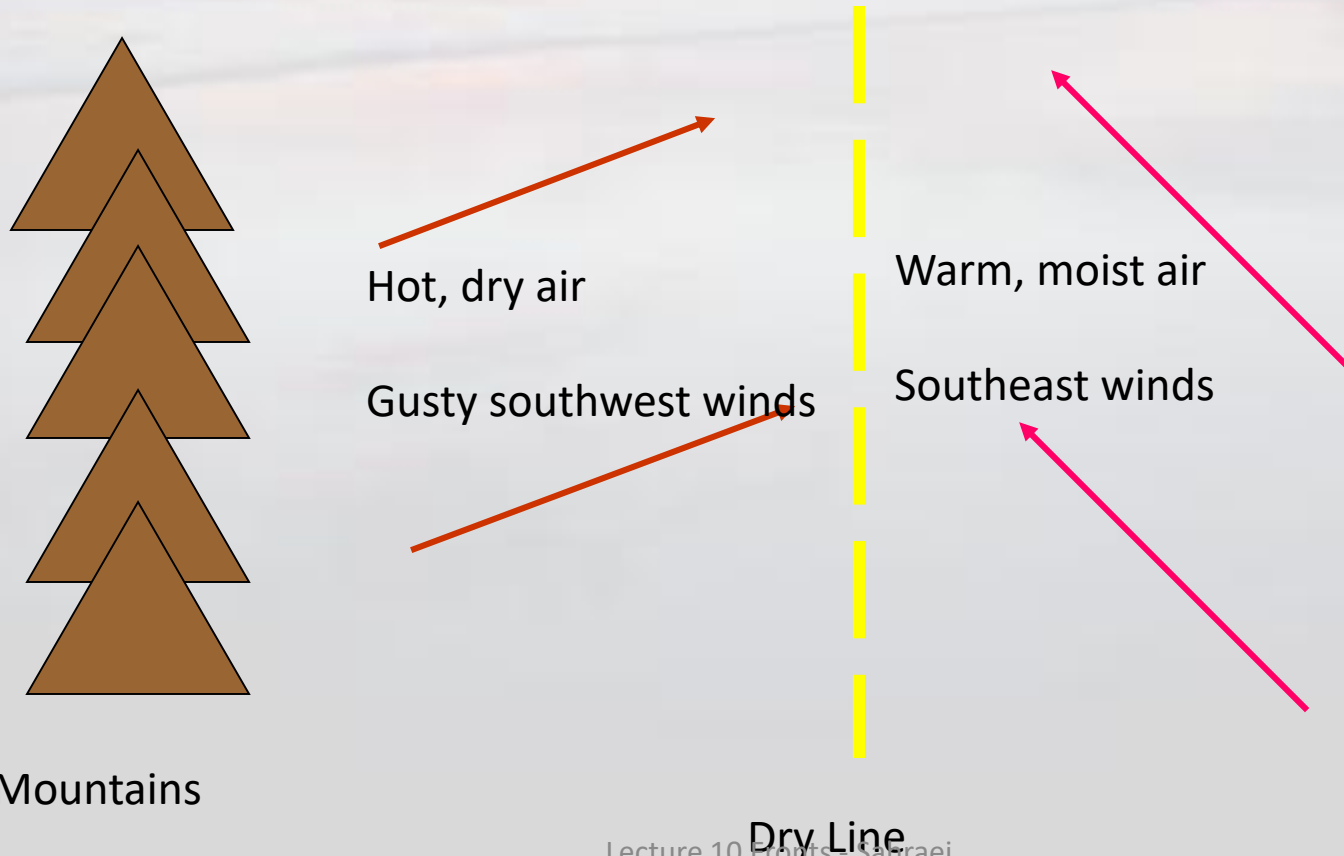
Variable	Before Passage	After Passage
Clouds	Towering cumulus; Cb; stratocumulus	Fast – convection, rapid clearing
Pressure tendency	Falling steadily	Rapid rise
Temperature	High, peaking near front	Falling – may be gradual or rapid, depending on front
Dewpoint	Relatively high	Decreasing rapidly
Wind direction	SE to SW, veering to parallel at front	NW
Precipitation	Showers and thunderstorms just ahead of and with passage	Fast – rapid end to precip Slow – continuous precip for several hours
Visibility	Lowering	Fast – rapid improvement Slow – gradual improvement
Ceiling	Lowering	(same as above)

Passing of a warm front:

Variable	Before Passage	After Passage
Clouds	Low stratiform near front Ci -> Cs -> As -> Ns	Clearing: widely scattered convection
Pressure tendency	Falling	Fairly steady
Temperature	Rising	High; fairly uniform, steady
Dewpoint	Increasing as front approaches	High; fairly uniform, steady
Wind direction	E-SE	S-SW
Precipitation	Steady, continuous precip up to 300 miles ahead of front	Scattered
Visibility	Lowering rapidly in precip	Improvement
Ceiling	(same as above)	Rising

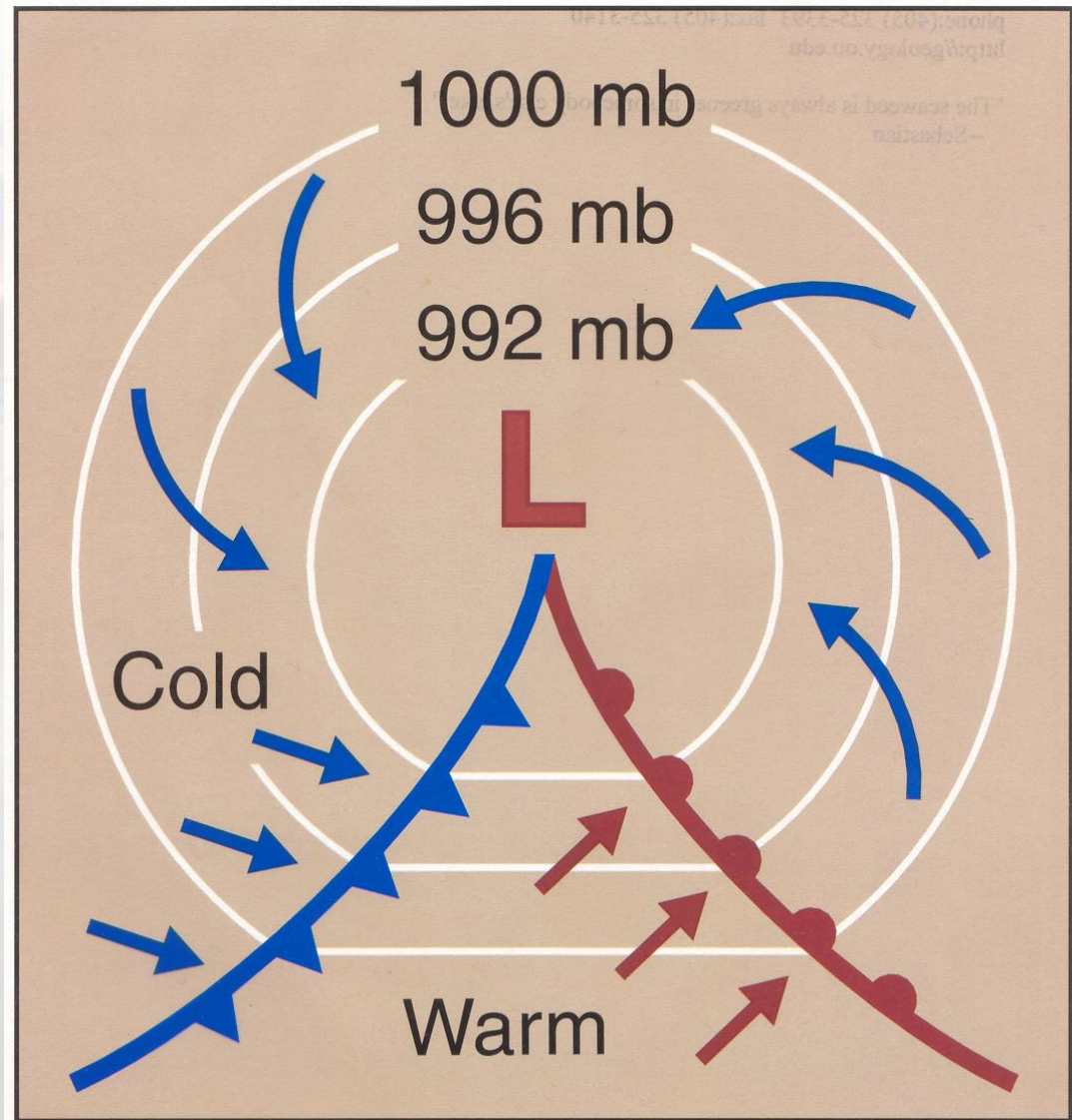
Dry Line:

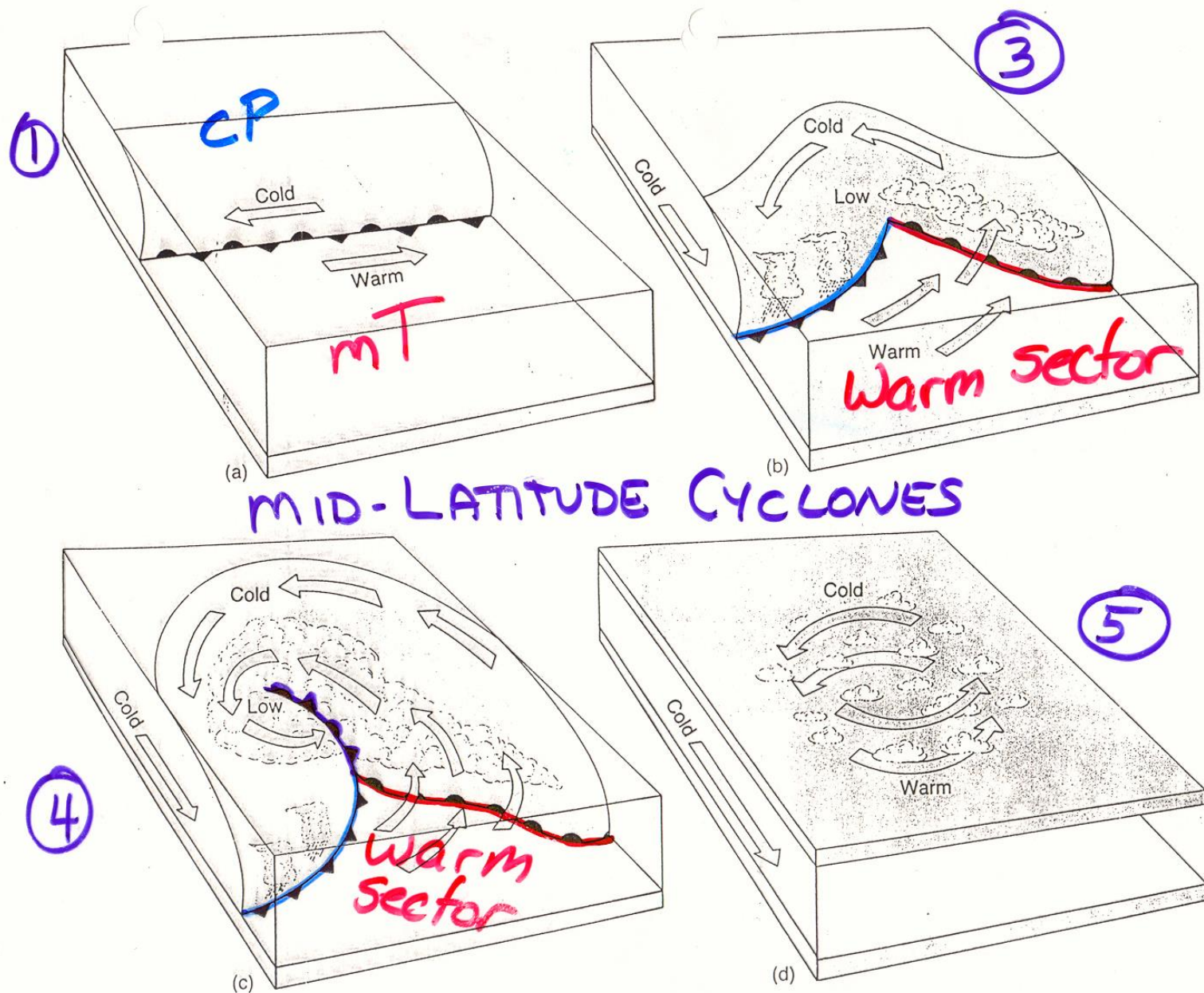
- boundary that separates moist air mass from a dry air mass
- also called “Dew Point Front”
- most commonly found just east of the Rocky Mountains; rare east of the Mississippi River
- common in TX, NM, OK, KS, and NE in spring and summer



Idealized, simplified surface cyclone:

- ✓ cool air ahead of warm front
- ✓ warm sector between cool and cold air
- ✓ cold air behind the cold front





Stages in the life cycle of a middle-latitude cyclone as proposed by J. Bjerknes.
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