

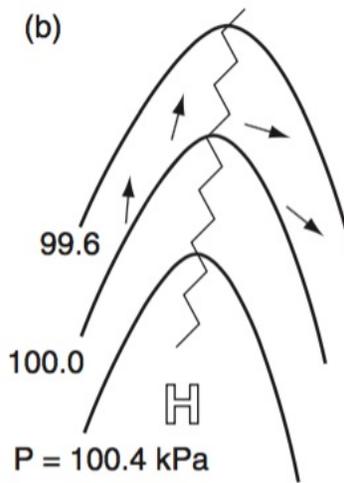
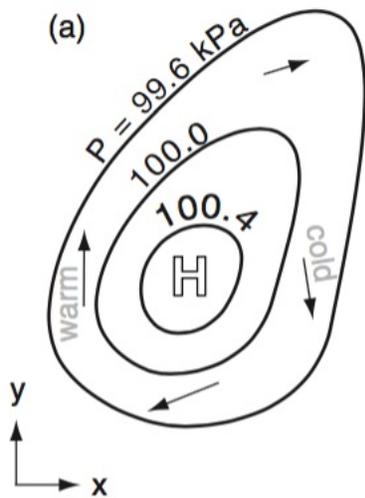


Chapter 12 Fronts & Air Masses

Chapter overview:

- Anticyclones or highs
- Air Masses
 - Classification
 - Source regions
 - Air masses of North America
- Fronts
 - Stationary fronts
 - Cold fronts
 - Warm fronts
 - Fronts and the jet stream
 - Frontogenesis
 - Drylines
 - Occluded fronts
 - Upper-tropospheric fronts

Anticyclones or Highs



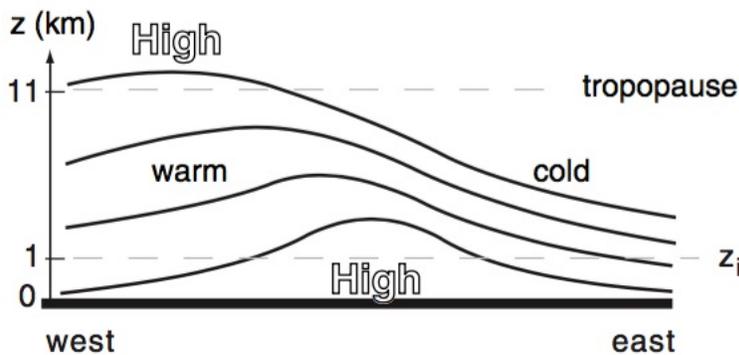
High pressure centers (highs) are identified as relative maxima in pressure (on constant height maps) or height (on constant pressure maps).

A ridge is an extended area of relatively high pressure (height).

What causes high pressure to occur at the surface?

The mechanisms that lead to the formation of high pressure include:

- the global circulation
- monsoons / seasonal temperature contrasts
- transient weather systems (Rossby waves)
- small scale features (thunderstorms, mountains)



Why are highs observed to tilt west with height?

Winds and advection around surface high

Where is cold (warm) air advection occurring relative to the surface high shown above?

How does the height of upper level pressure surfaces change as the air below warms or cools?

Role of upper level high (ridge) in creating convergence

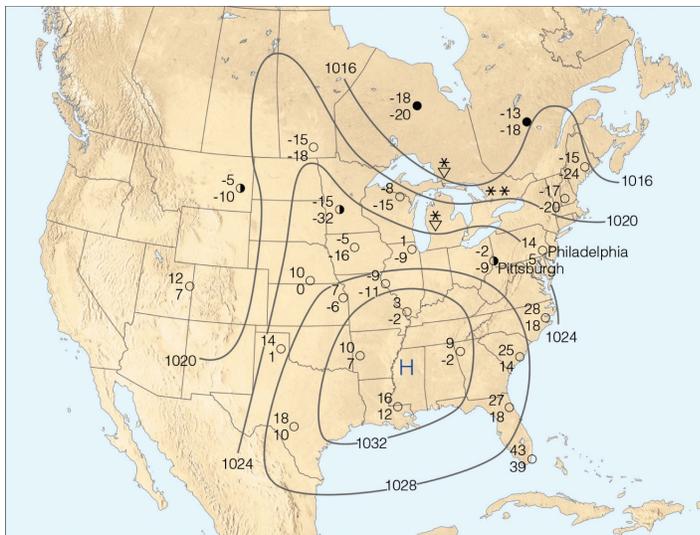
How does the gradient wind speed compare to the geostrophic wind speed in a ridge (trough)?

As air exits a ridge and moves towards a trough it slows down and convergence occurs.

As air exits a trough and moves towards a ridge it speeds up and divergence occurs.

Convergence occurs ahead of upper level ridges and divergence occurs ahead of upper level troughs.

Air Masses



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Air mass: A widespread body of air whose temperature and humidity (and other atmospheric properties) are fairly similar in any horizontal direction at a given altitude

Why are meteorologists interested in air masses?

Air Mass Classification

Table 12-1. Airmass abbreviations. **Boldface** indicates the most common ones.

Abbr.	Name	Description
c	continental	Dry. Formed over land.
m	maritime	Humid. Formed over ocean.
A	Arctic	Very cold. Formed in the polar high.
E	Equatorial	Hot. Formed near equator.
M	Monsoon	Similar to tropical.
P	Polar	Cold. Formed in subpolar area.
S	Superior	A warm dry airmass having its origin aloft.
T	Tropical	Warm. Formed in the subtropical high belt.
k	colder than the underlying surface	
w	warmer than the underlying surface	
Special (regional) abbreviations.		
AA	Antarctic	Exceptionally cold and dry.
r	returning	As in "rPm" returning Polar maritime [Great Britain]

Air masses are classified based on their temperature and humidity.

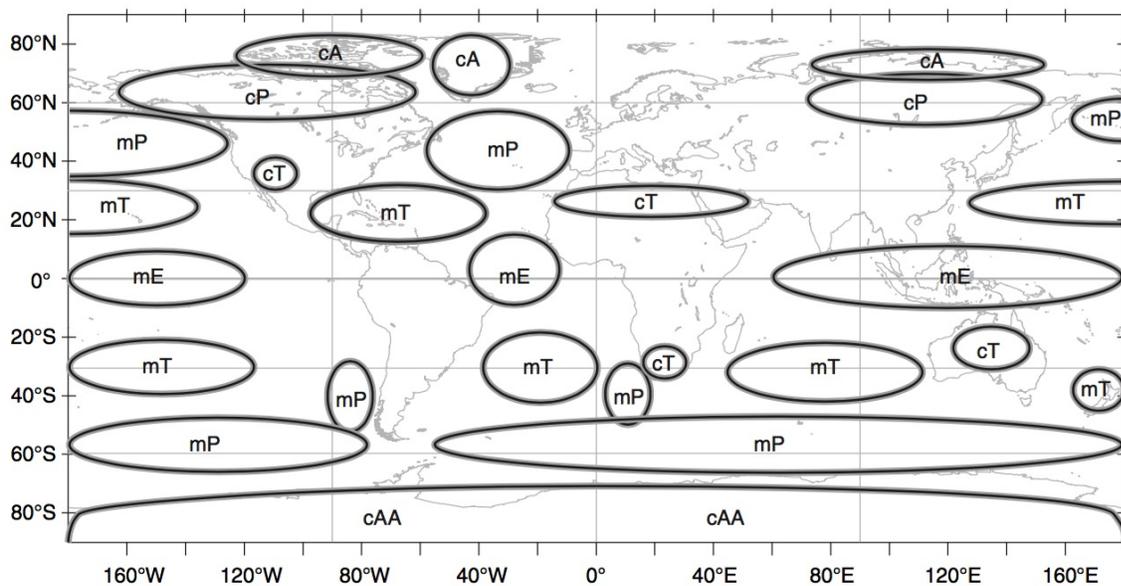
The four most common air masses to impact weather in North America are:

- continental polar (cP)
- maritime polar (mP)
- continental tropical (cT)
- maritime tropical (mT)

In the winter continental Arctic (cA) air masses can also impact weather in the United States.

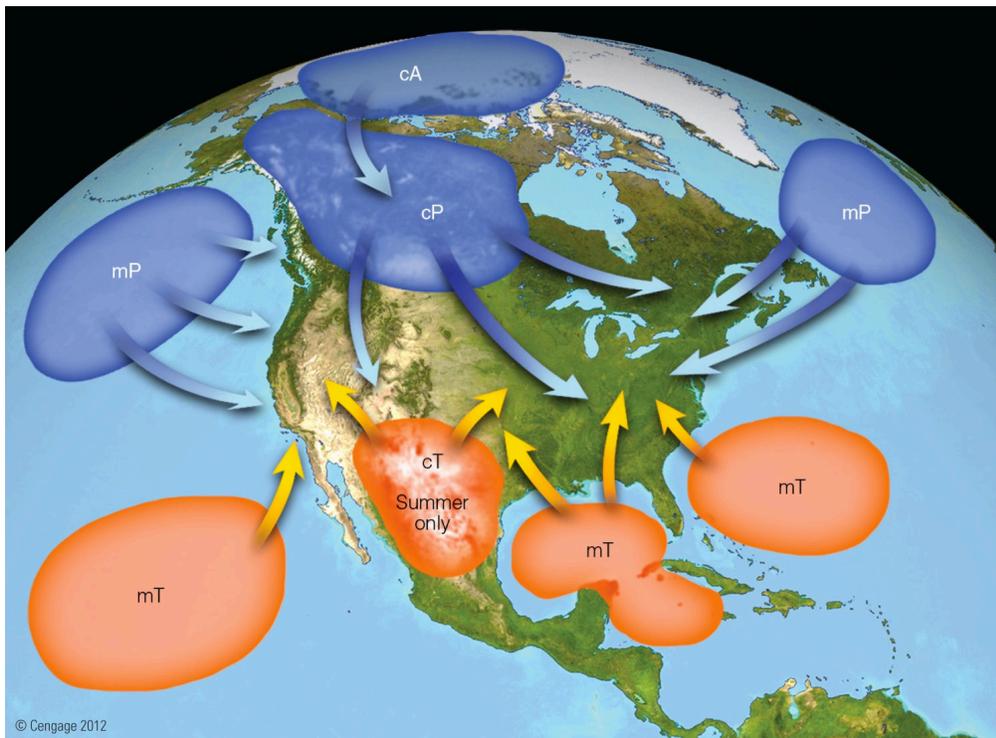
What temperature and moisture characterize these air masses?

Air Mass Source Regions



What features of a source region allow for the formation of air masses?

Transient weather patterns will cause air masses to move out of their source region.



What happens to an air mass once it moves out of its source region?

- modification due to surface fluxes
- modification due to flow over mountains

Air Masses of North America

Continental Polar (cP) and Continental Arctic (cA) Air Masses

Where do cP and cA air masses form?

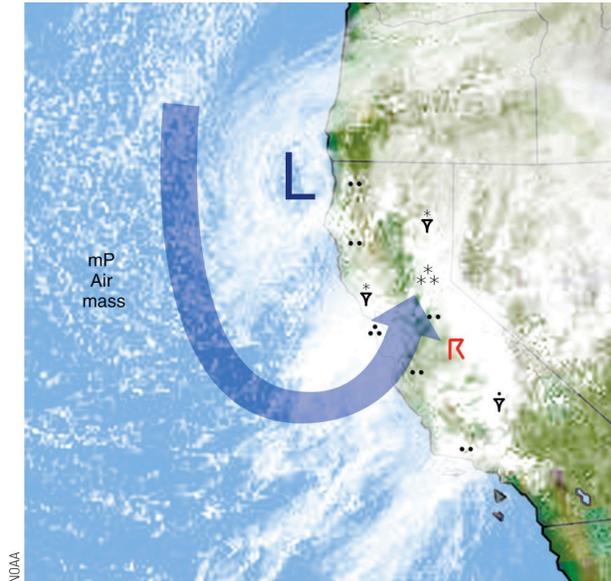
What are the defining characteristics of cP and cA air masses?

What type of weather is experienced in the mid-latitudes when a cP or cA air mass moves into this region?

How do cP air masses differ between winter and summer?

How do mountains alter the impact of cP and cA air masses?

Maritime Polar (mP) Air Masses

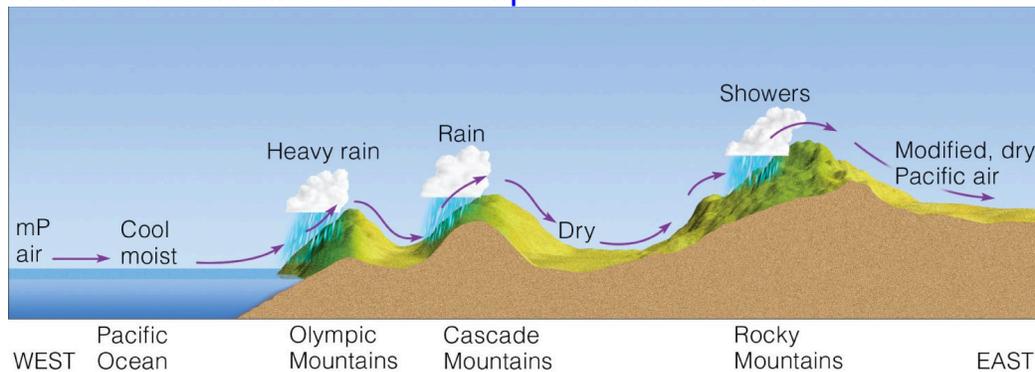


Where do mP air masses form?

What are the defining characteristics of mP air masses?

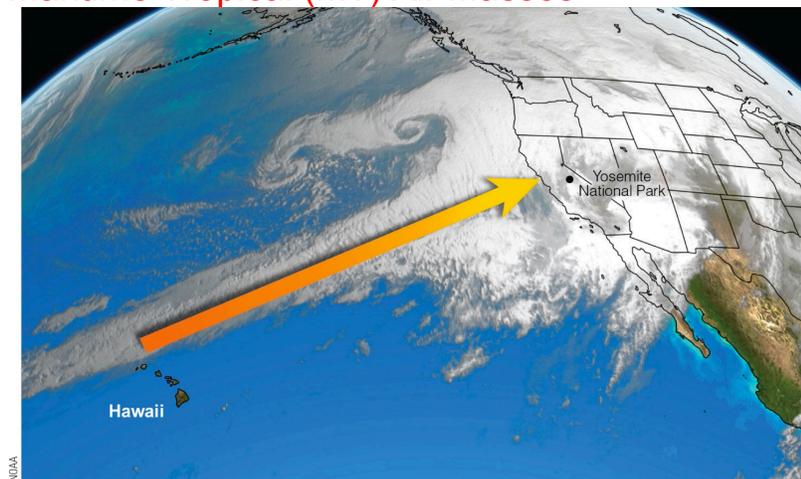
What type of weather is experienced in the mid-latitudes when an mP air mass moves into this region?

How do mountains alter the impact of mP air masses?



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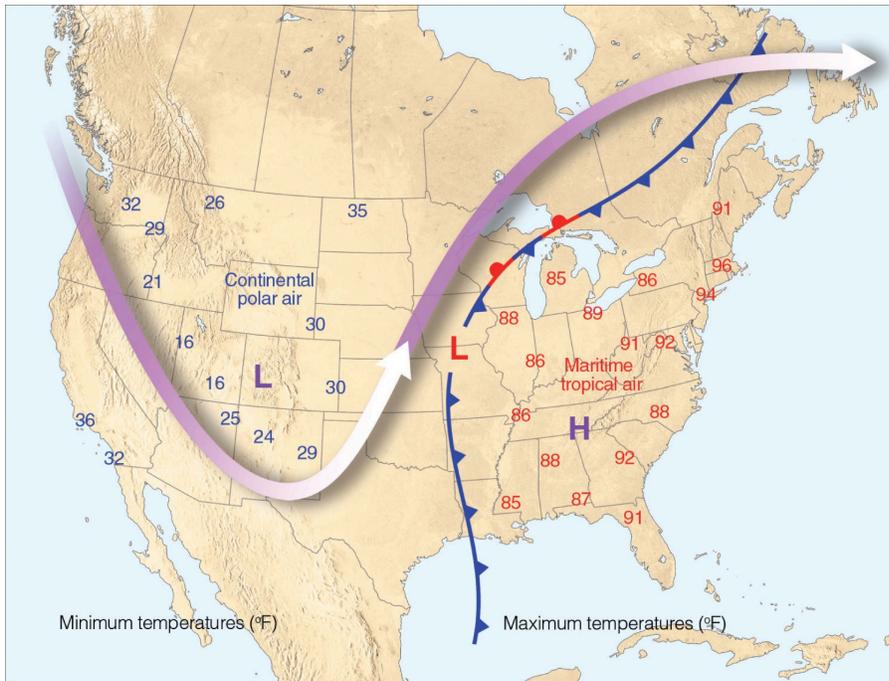
Maritime Tropical (mT) Air Masses



Where do mT air masses form?

What are the defining characteristics of mT air masses?

What type of weather is experienced in the mid-latitudes when an mT air mass moves into this region?

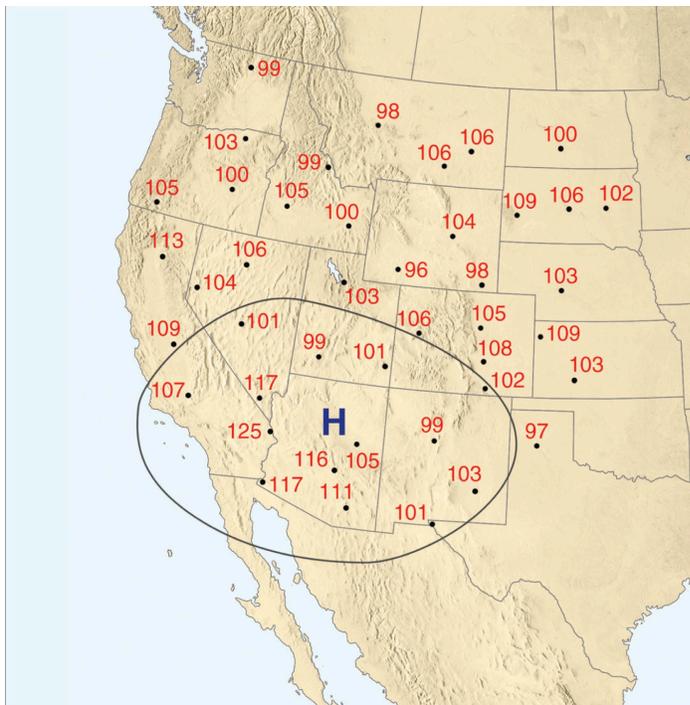


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What is the impact of mT air masses originating in the Gulf of Mexico?

What large-scale pressure feature is often responsible for bringing mT air masses into the central and eastern United States?

Continental Tropical (cT) Air Masses



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Where do cT air masses form?

What are the defining characteristics of cT air masses?

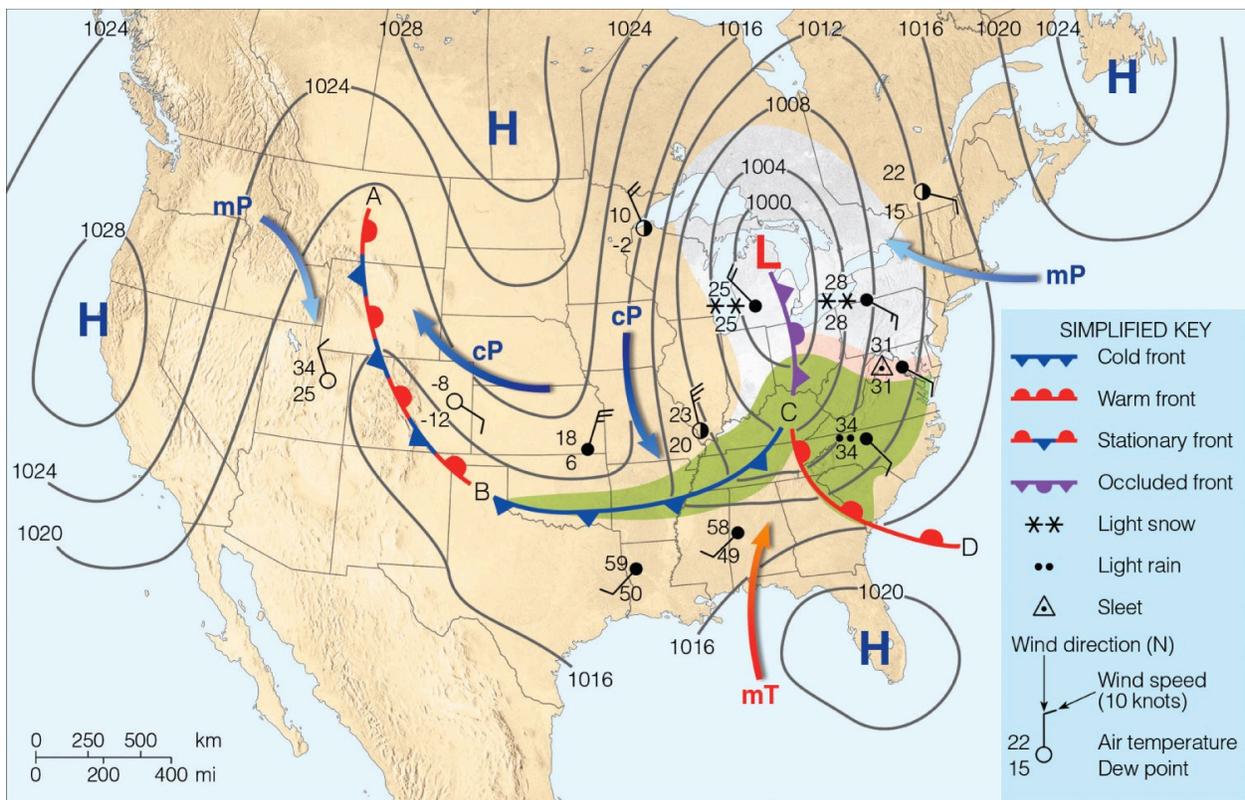
What type of weather is experienced in the mid-latitudes when a cT air mass moves into this region?

Fronts

Front: A boundary (or transition zone) between two air masses of different density

Fronts are characterized by:

- large horizontal temperature gradients
- large horizontal moisture gradients
- strong horizontal wind gradients
- relative minimum in pressure
- clouds and precipitation
- kinks in isopleths (isobars, isotherms) on weather maps



Notice that the fronts shown above separate different air masses and that the fronts are located in areas of relatively low pressure.

What types of fronts are present on the weather map above?

The following symbols are used to indicate fronts on weather maps.

Cold Front



Warm Front



Stationary Front



Occluded Front



Dry Line



Fronts move in the direction the frontal symbols point.

In order to locate a front look for:

- Change in temperature
- Change in absolute humidity
- Shift in wind direction
- Pressure and pressure changes
- Cloud and precipitation patterns

Stationary Fronts

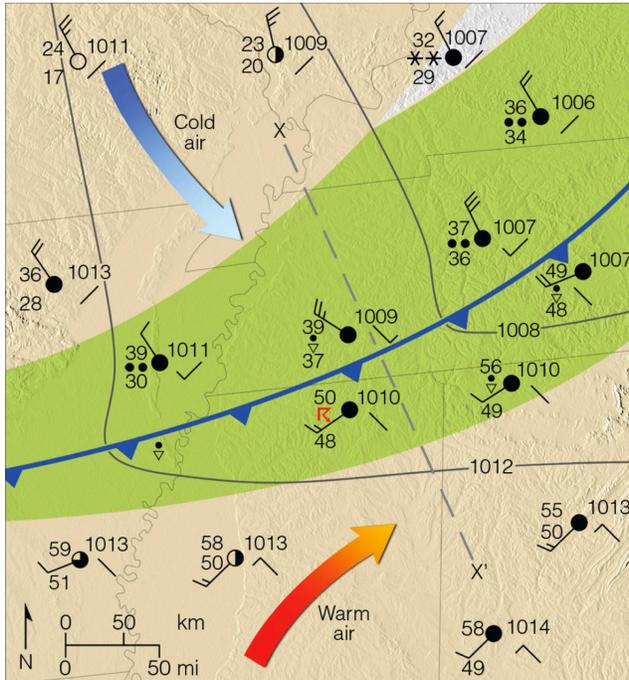
Stationary front: A front with essentially no movement.

What direction are the surface (upper level) winds relative to a stationary front?

What type of weather is associated with a stationary front?

Cold Fronts

Cold front: A front where cold (polar or Arctic) air is advancing and replacing warm (tropical) air

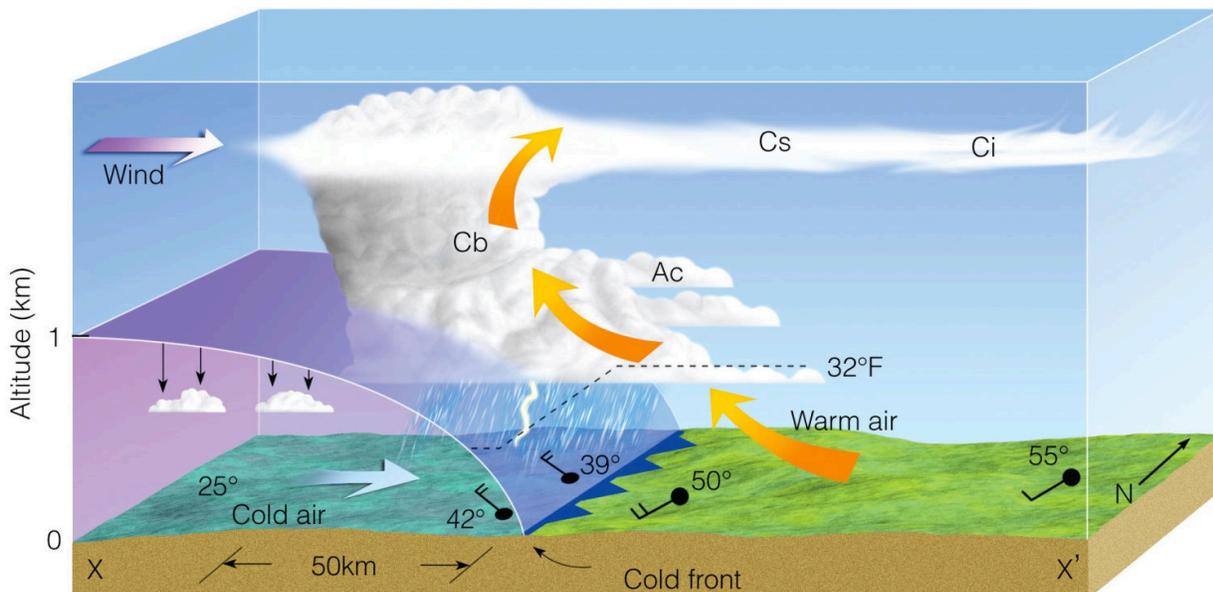


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How will the weather change as a cold front approaches and then passes a given location?

- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?

Where do clouds and precipitation form relative to a cold front?



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Why do clouds and precipitation form along fronts?

What determines how steep a frontal surface will be?

What impact does this have on the distribution of clouds and precipitation associated with the front?

▼ **TABLE 11.2** Typical Weather Conditions Associated with a Cold Front in Winter in the Northern Hemisphere

WEATHER ELEMENT	BEFORE PASSING	WHILE PASSING	AFTER PASSING
Winds	South or southwest	Gusty, shifting	West or northwest
Temperature	Warm	Sudden drop	Steadily dropping
Pressure	Falling steadily	Minimum, then sharp rise	Rising steadily
Clouds	Increasing Ci, Cs, then either Tcu ⁺ or Cb ⁺	Tcu or Cb	Often Cu, Sc ⁺ when ground is warm
Precipitation	Short period of showers	Heavy showers of rain or snow, sometimes with hail, thunder, and lightning	Decreasing intensity of showers, then clearing
Visibility	Fair to poor in haze	Poor, followed by improving	Good, except in showers
Dew point	High; remains steady	Sharp drop	Lowering

*Tcu stands for towering cumulus, such as cumulus congestus; whereas Cb stands for cumulonimbus. Sc stands for stratocumulus.

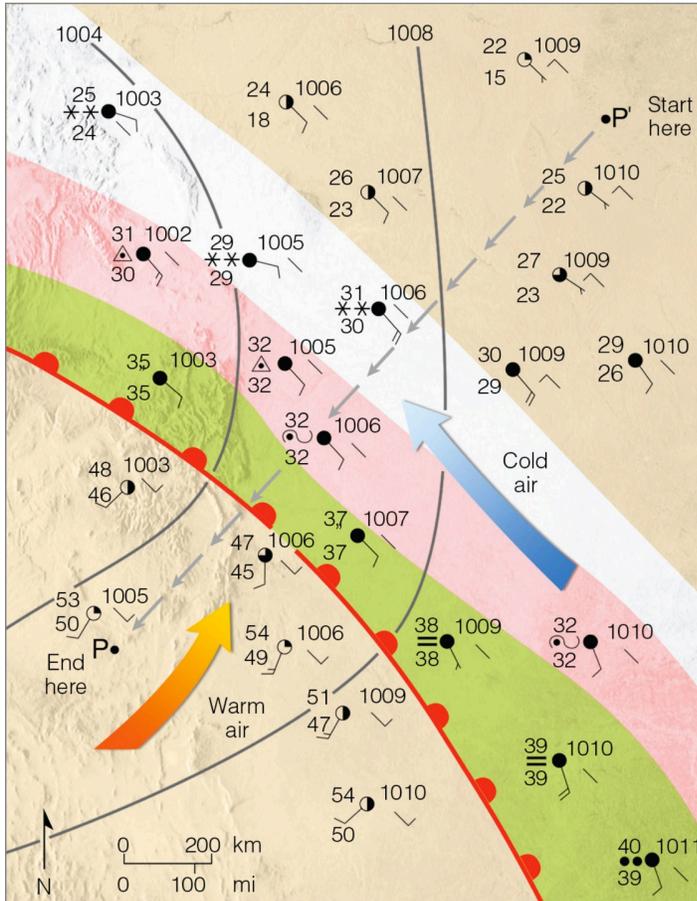
The actual weather observed when a cold front passes varies from front to front and can also differ regionally.

Backdoor cold front: A cold front that moves into an area from the east or northeast

Cold air damming: Cold air that gets trapped near the surface by mountains

Warm Fronts

Warm front: A front where warm (tropical) air is advancing and replacing cold (polar or Arctic) air



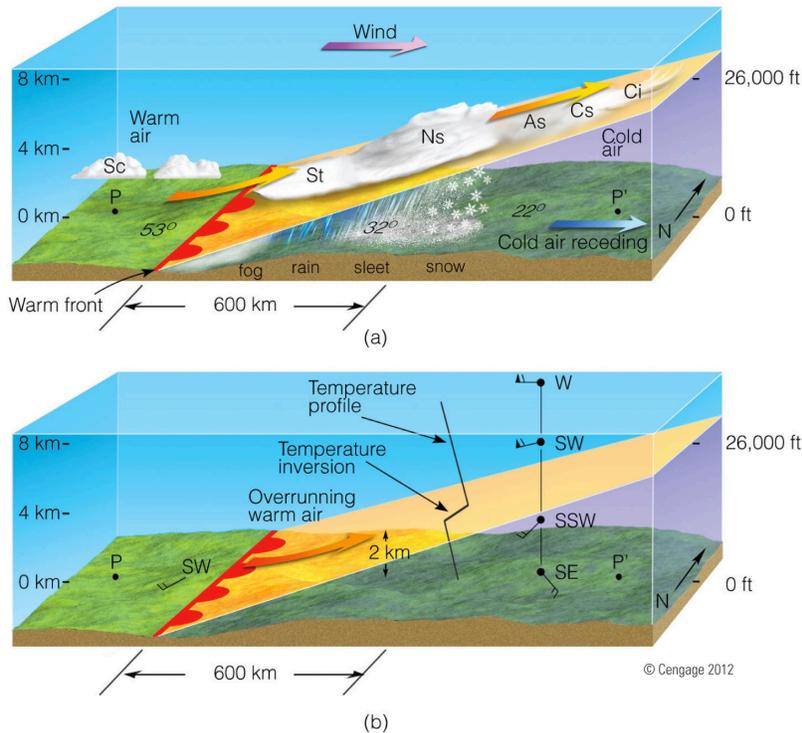
How will the weather change as a warm front approaches and then passes a given location?

- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?

How does the speed of movement of a warm front compare to that of a cold front?

Why does the speed differ between these types of fronts?

How does the slope of a warm front compare to the slope of a cold front?



Where do clouds form relative to a warm front?

Overrunning: Warm, less dense air rising over cold air

Why does a frontal inversion exist ahead of the warm front?

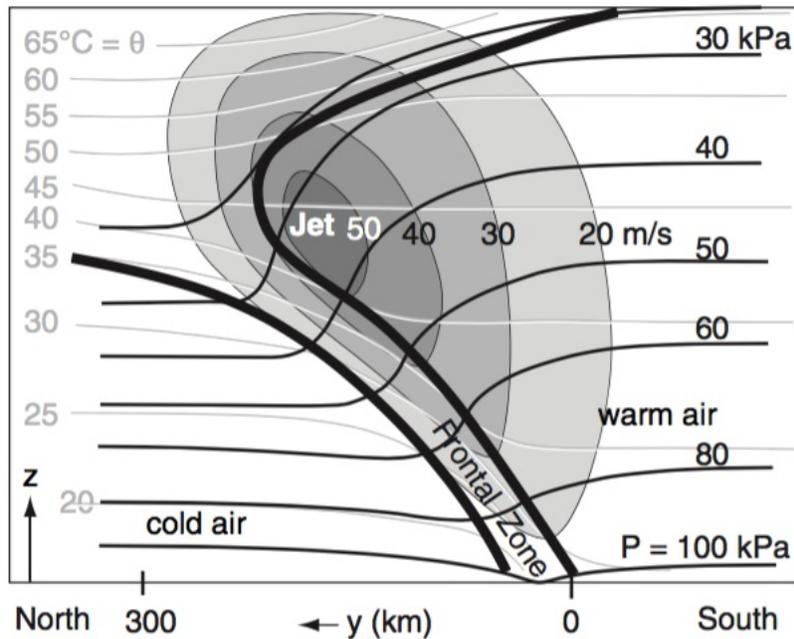
Would you expect a frontal inversion to be associated with a cold front?

How does the wind direction change with height ahead of a warm front?

▼ TABLE 11.3 Typical Weather Conditions Associated with a Warm Front in Winter in the Northern Hemisphere

WEATHER ELEMENT	BEFORE PASSING	WHILE PASSING	AFTER PASSING
Winds	South or southeast	Variable	South or southwest
Temperature	Cool to cold, slow warming	Steady rise	Warmer, then steady
Pressure	Usually falling	Leveling off	Slight rise, followed by fall
Clouds	In this order: Ci, Cs, As, Ns, St, and fog; occasionally Cb in summer	Stratus type	Clearing with scattered Sc, especially in summer; occasionally Cb in summer
Precipitation	Light-to-moderate rain, snow, sleet, or drizzle; showers in summer	Drizzle or none	Usually none; sometimes light rain or showers
Visibility	Poor	Poor, but improving	Fair in haze
Dew point	Steady rise	Steady	Rise, then steady

Fronts and the Jet Stream



The large temperature gradient associated with fronts indicates that there is a large thermal wind effect near fronts.

As a result the polar jet stream is located above fronts.

Frontogenesis

Frontogenesis: A strengthening of a front as the temperature contrast across the front increases

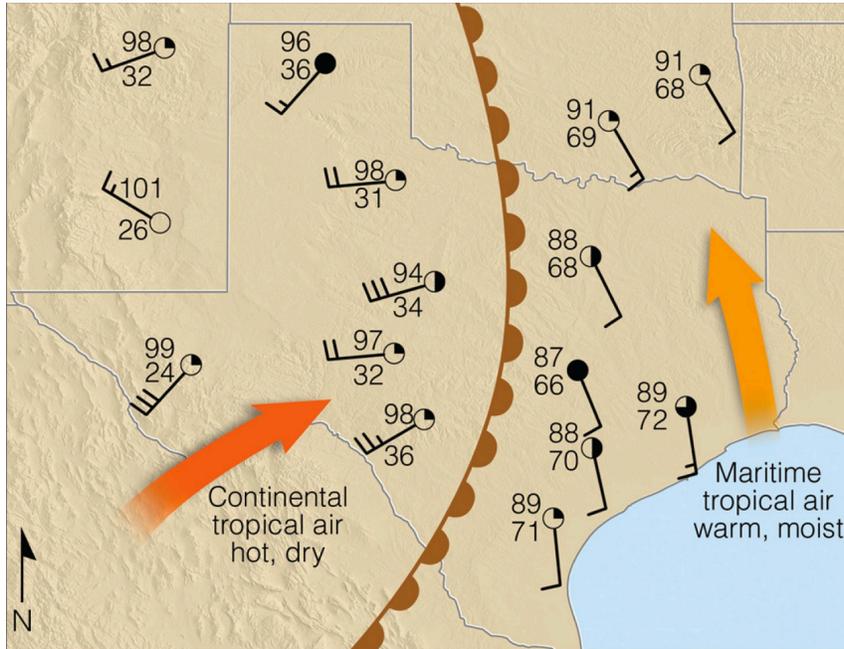
Frontolysis: Weakening or dissipation of a front as the temperature contrast across the front lessens

What processes lead to frontogenesis (frontolysis)?

- kinematics
- thermodynamics
- dynamics

Drylines

Dryline: A boundary that separates moist (maritime) and dry (continental) air



How does the weather change across a dryline?

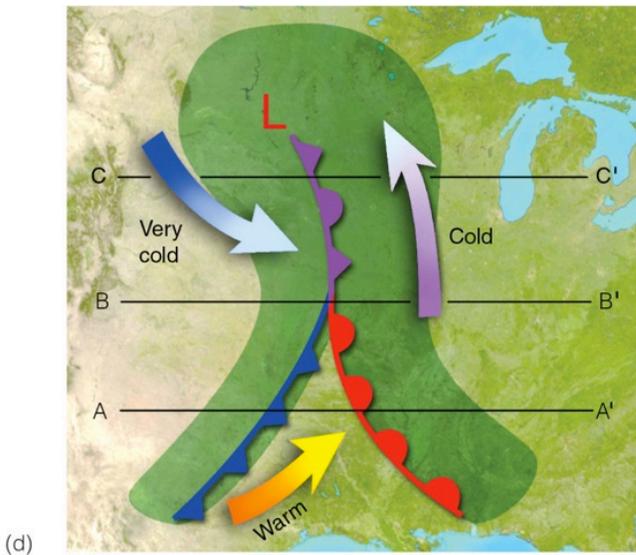
- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?

Where in the United States are drylines most often observed?

Occluded Fronts

Occluded front: A front that forms when a cold front catches up to and overtakes a warm front

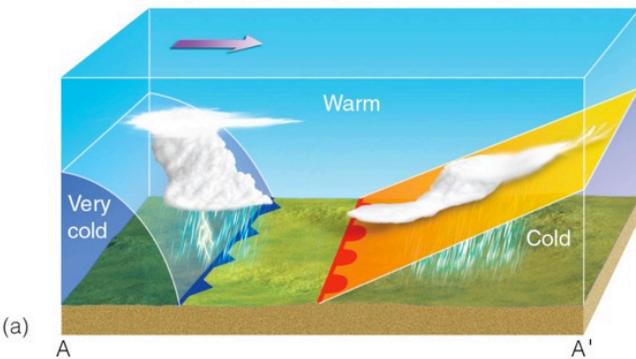
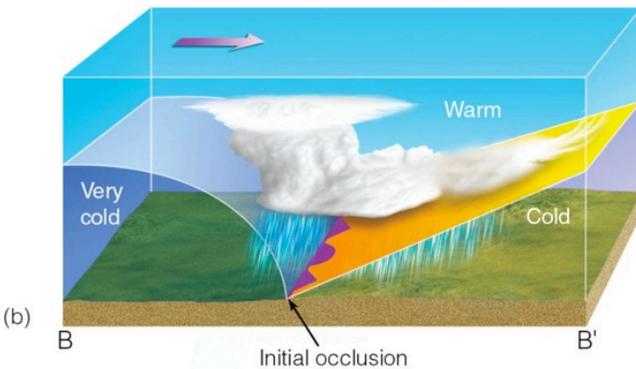
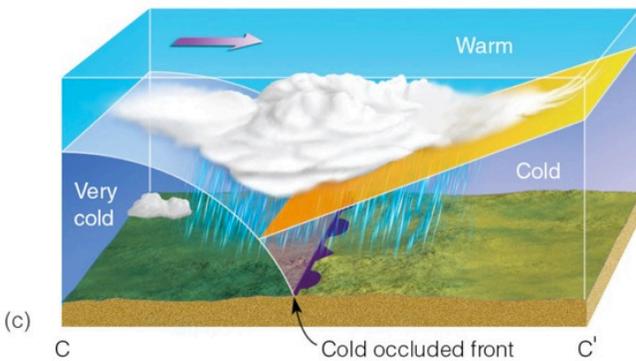
What causes a cold front to catch up to a warm front?

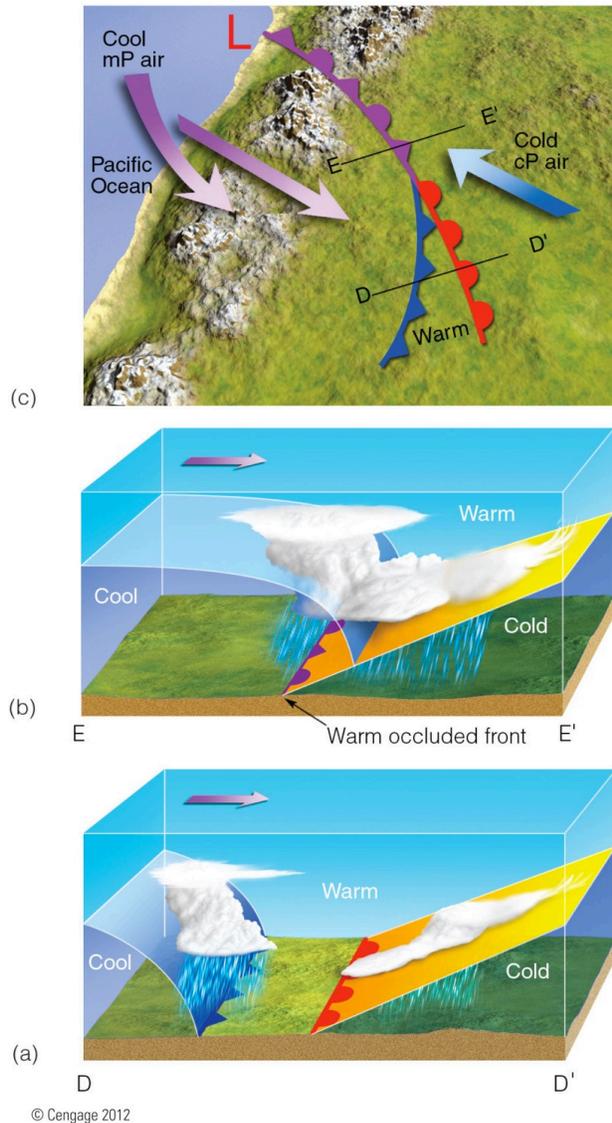


Cold occlusion: An occluded front with colder air behind the occluded front

How does the weather change as a cold occluded front approaches and passes a given location?

- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?





Warm occlusion: An occluded front with colder air ahead of the occluded front

How does the weather change as a warm occluded front approaches and passes a given location?

- How do the clouds and precipitation change?
- How does the temperature change?
- How does the dew point temperature change?
- How do the winds change?
- How does the pressure change?

What are the differences between a cold and warm occluded front?

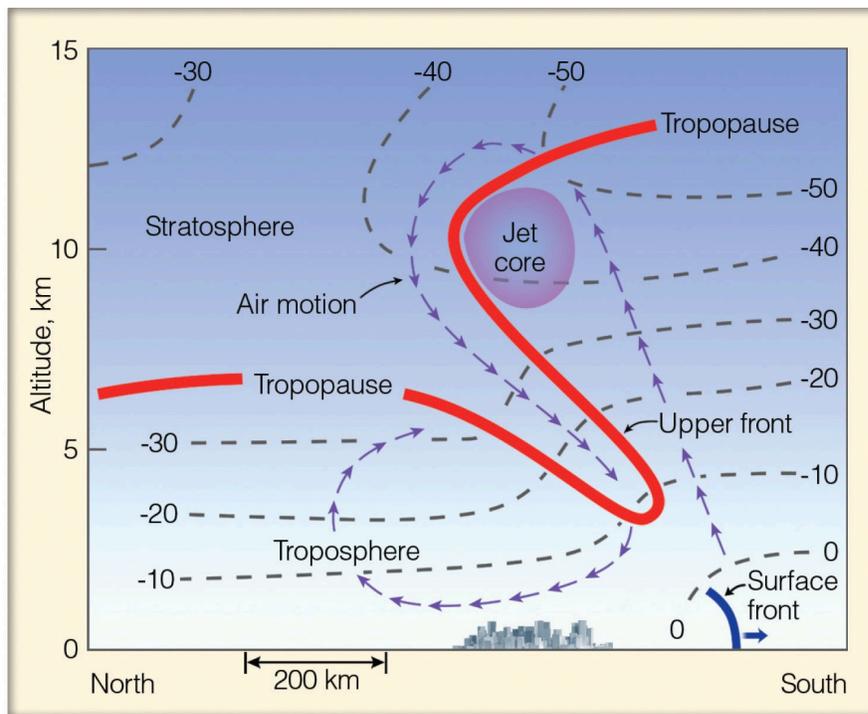
- How does the position of the upper level front differ?
- How does the temperature differ across these types of fronts?

▼ **TABLE 11.4** Typical Weather Most Often Associated with Occluded Fronts in Winter in North America

WEATHER ELEMENT	BEFORE PASSING	WHILE PASSING	AFTER PASSING
Winds	East, southeast, or south	Variable	West or northwest
Temperature			
(a) Cold-type occluded	Cold or cool	Dropping	Colder
(b) Warm-type occluded	Cold	Rising	Milder
Pressure	Usually falling	Low point	Usually rising
Clouds	In this order: Ci, Cs, As, Ns	Ns, sometimes Tcu and Cb	Ns, As, or scattered Cu
Precipitation	Light, moderate, or heavy precipitation	Light, moderate, or heavy continuous precipitation or showers	Light-to-moderate precipitation followed by general clearing
Visibility	Poor in precipitation	Poor in precipitation	Improving
Dew point	Steady	Usually slight drop, especially if cold-occluded	Slight drop, although may rise a bit if warm-occluded

Upper-Tropospheric Fronts

Upper-tropospheric (or upper level) front: A front that is present aloft that may or may not extend all the way to the surface



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What is the relationship between upper air fronts, the tropopause, and polar jet stream?

Where is air rising (sinking) relative to the upper air front and jet stream?