Air Masses and Fronts
Clouds

July 5th, 2021

Air Masses

Air Masses

- Although the troposphere is a continuous body of mixed gases that surrounds the planet, its is by no means a uniform blanket of air.
- Composed of large parcels of air that has relatively uniform properties in the horizontal dimension and moves as an entity.
- Such extensive bodies are distinct from one another.

Characteristics

To be distinguishable, air masses must meet three requirements:

1. **Dimensions**: must be large (horizontal and vertical)– typical air mass is more than 1600 km (1000 miles) across and several kilometers deep (from the surface to its top)
2. **Uniform properties** in the horizontal dimension. This means that an any given altitude in the air mass, its physical characteristics – primarily temperature, humidity, and stability – are relatively homogenous
3. **Distinct from the surrounding air**: a recognizable entity that travels as one. When it moves it must maintain its original characteristics and not be torn apart by differences in airflow.

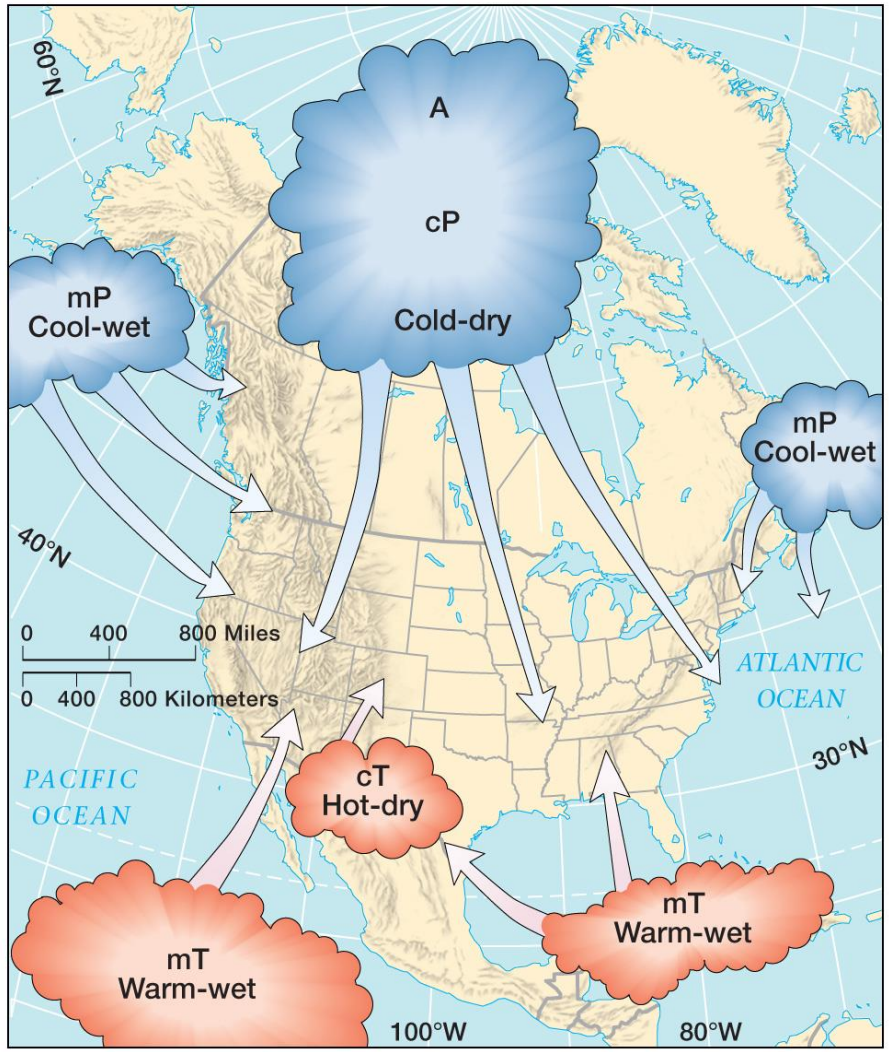
Origin

Formation occurs if air remains over a uniform land or sea surface long enough to acquire uniform properties.

Source regions—parts of Earth's surface that are particularly suited to generate air masses because they are

- Extensive
- Physically uniform
- Associated with air that is stationary or anticyclonic

Ideal sources are ocean surfaces, and extensive flat land areas that have a uniform covering of snow, forest or desert



Source Regions

- Continental (c) or Maritime (m) (Oceanic)
- Latitude: High latitude – Polar (P) or Low Latitude – Tropical (T)

Source regions may be of theorethical value than practical, as air masses can originate anywhere in the low or high latitudes, but rarely in the middlelatitudes where the persistent westerlies prevent air mass formation

But the latitude of source regions impacts:

- Humidity
- Temperature
- Stability

Classification: Letter System

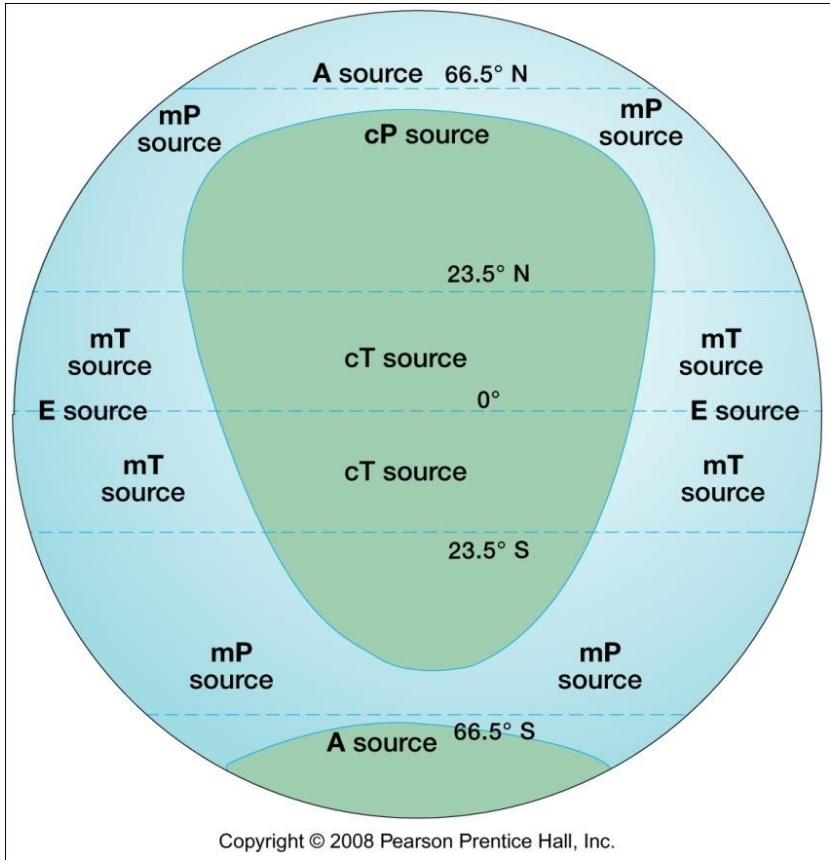
- Because source region determines properties of air masses, it is the basis for classifying them.
- Use a one- or two-letter code

First Letter – Humidity indicator	Second Letter (capitalized) – Temperature indicator	
<u>Land or water</u>	<u>Latitude</u>	
c = continental (dry air)	E = 0º – 10º	Equatorial
	T = 10º – 35º	Tropical
	P = 55º – 70º	Polar
m = maritime (moist air)	A = 70º – 90º	Arctic / Antarctic

* Middle latitudes (35º – 55º) not a major source region

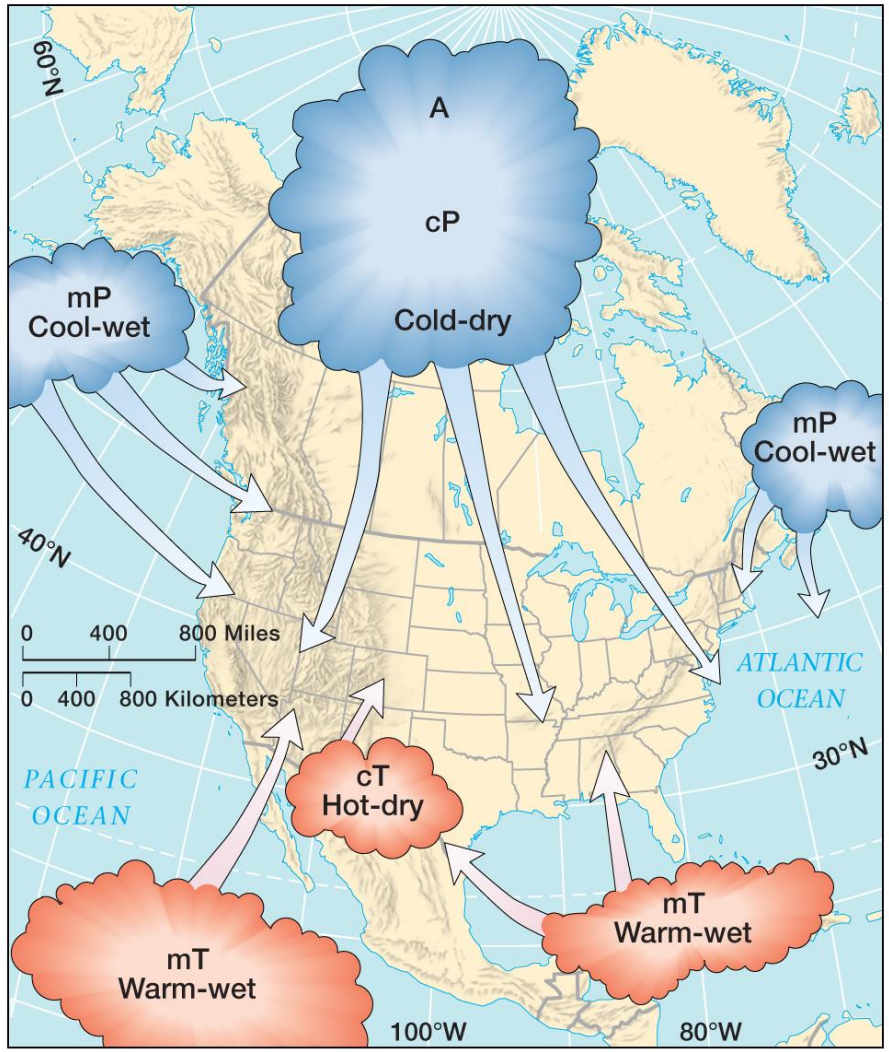
Classification: Letter System

- E – Equatorial
- mT– maritime Tropical
- cT – continental Tropical
- mP– maritime Polar
- cP – continental Polar
- A – Arctic / Antarctic



Simplified Classification of Air Masses

Type	Code	Source Regions	Source Region Properties
Arctic/Antarctic	A	Antarctica, Arctic Ocean and Fringes, and Greenland	Very cold, very dry, very stable
Continental Polar	cP	High-latitude plains of Eurasia and North America	Cold, dry, very stable
Maritime polar	mP	Oceans in vicinity of 50° – 60° N and S latitude	Cold, moist, relatively unstable
Continental tropical	cT	Low-latitude deserts	Hot, very dry, unstable
Maritime tropical	mT	Tropical and subtropical oceans	Warm, moist, of variable stability
Equatorial	E	Oceans near the equator	Warm, very moist, unstable



Movement and Modification

Some air masses remain in a source region indefinitely.

Movement prompts structural change:

- Thermal modification—heating or cooling from below
- **Dynamic modification**—uplift, subsidence, convergence, turbulence
- Moisture modification—addition or subtraction of moisture.

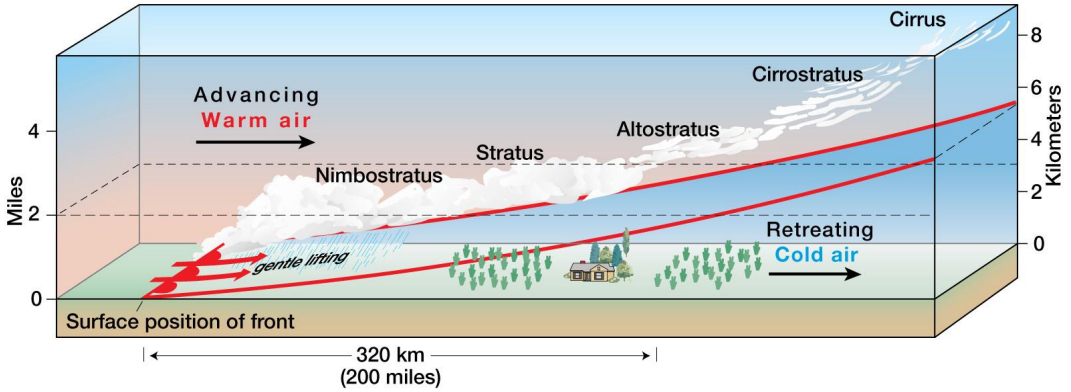
Moving air mass modifies the weather of the region it moves through.

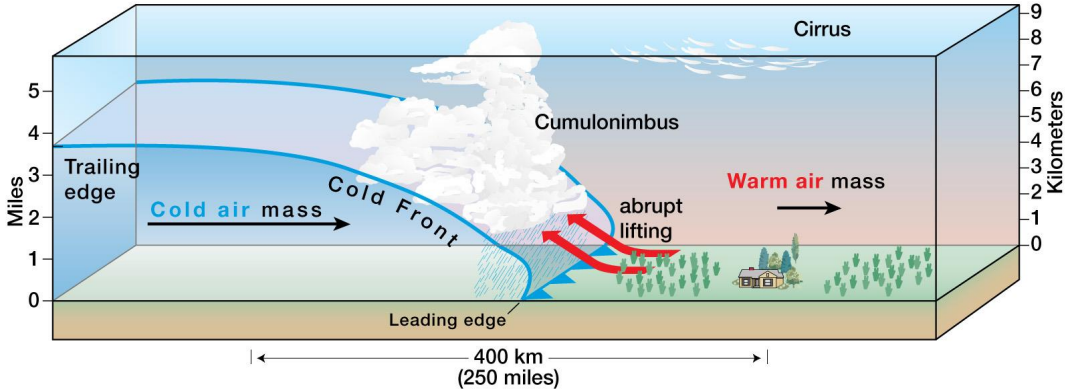
Fronts

Fronts

A boundary zone of discontinuity between unlike air masses (when ***unlike*** air masses meet they do not mix readily) but the properties of air change rapidly.

1. It's narrow but three-dimensional.
2. Typically several kilometers wide (even tens of kilometers wide).
3. Functions as a barrier between two air masses, preventing their mingling except in this narrow transition zone.
4. Though all primary physical properties are involved in a front, ***temperature*** provides the most conspicuous difference.
5. Fronts lean, which allows air masses to be uplifted and adiabatic cooling to take place.
    1. Lean so much, closer to horizontal than vertical.
    2. Always slopes so that warmer air overlies cooler air.
6. Fronts move in association with the direction of the more active air mass, which displaces the less active.





Fronts

Term was coined in WW1 by Norwegian meteorologists (V.Bjerknes and Jacob Bjerknes) who considered the clash between unlike air masses to be similar to confrontation between **opposing armies**

The more aggressive air mass advance at the expense of the other, there is some mixing of the two, but air masses tend to retain their separate identities

Cold front forms where an advancing cold air mass meets warmer air

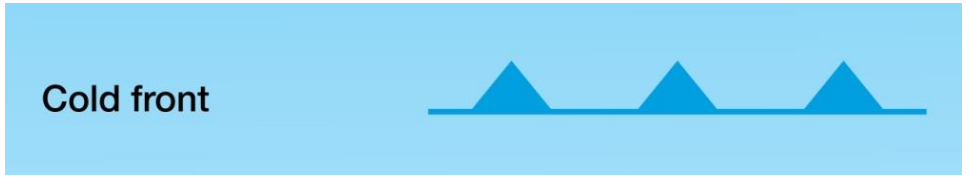
Warm front forms where an advancing warm air mass meets colder air

In both cases there is warm air on one side of the front and cold air on the other, with a fairly abrupt temperature gradient between them

Air masses may have different densities, humidity levels, wind patterns, and stability

Fronts may remain stationary for a few hours or even days, but generally is in constant motion, shifting the position of the boundary

Cold Fronts



The leading edge of a cool air mass actively displacing warm air mass.

Cold front tends to become steeper as it moves forward and usually develops a protruding nose a few hundred meters above the ground

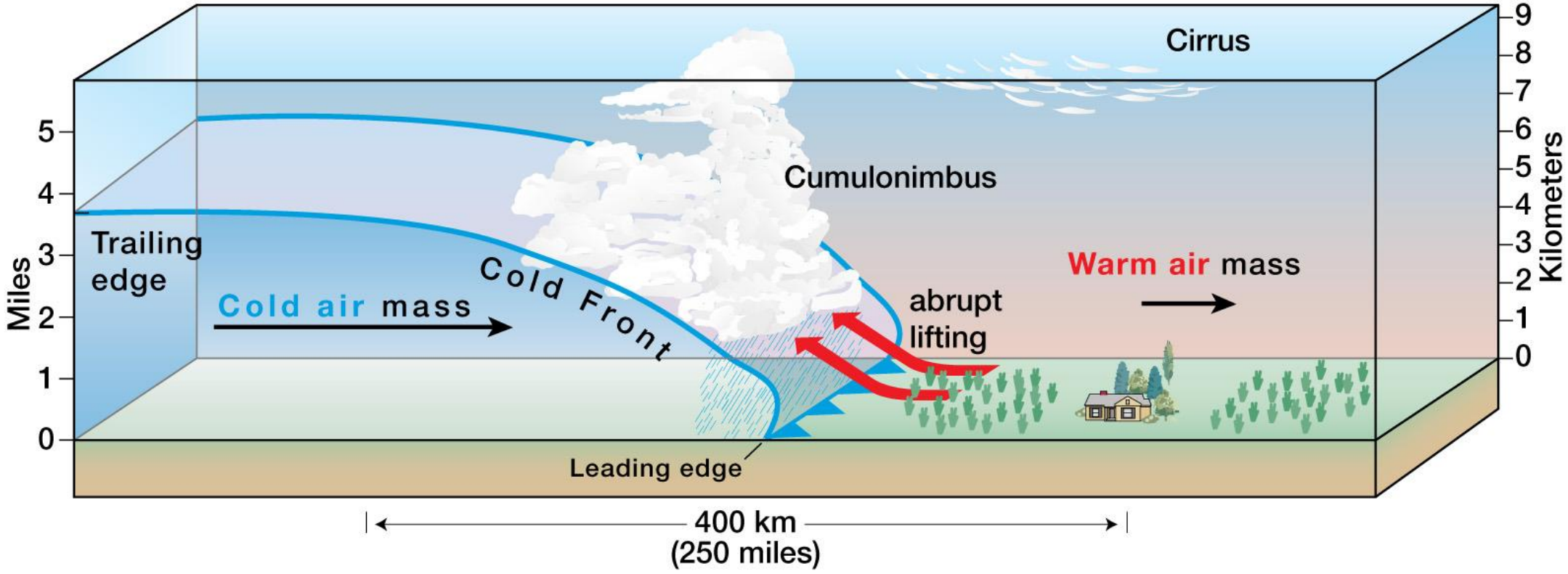
Brings cold air and moves faster than warm front.

Leads to rapid lifting of warm air, which makes it unstable and thus results in blustery and violent weather along cold front.

Vertically developed clouds, such as cumulonimbus, with considerable turbulence and precipitation.

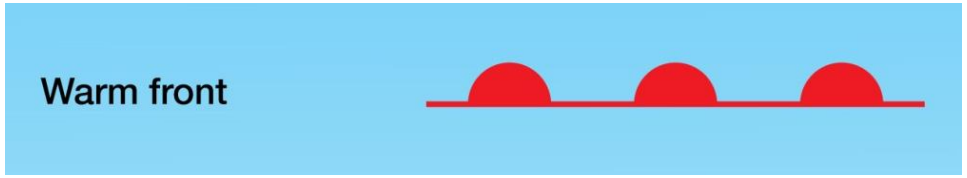
Clouds and precipitation concentrated along and immediately behind the ground-level position of the front.

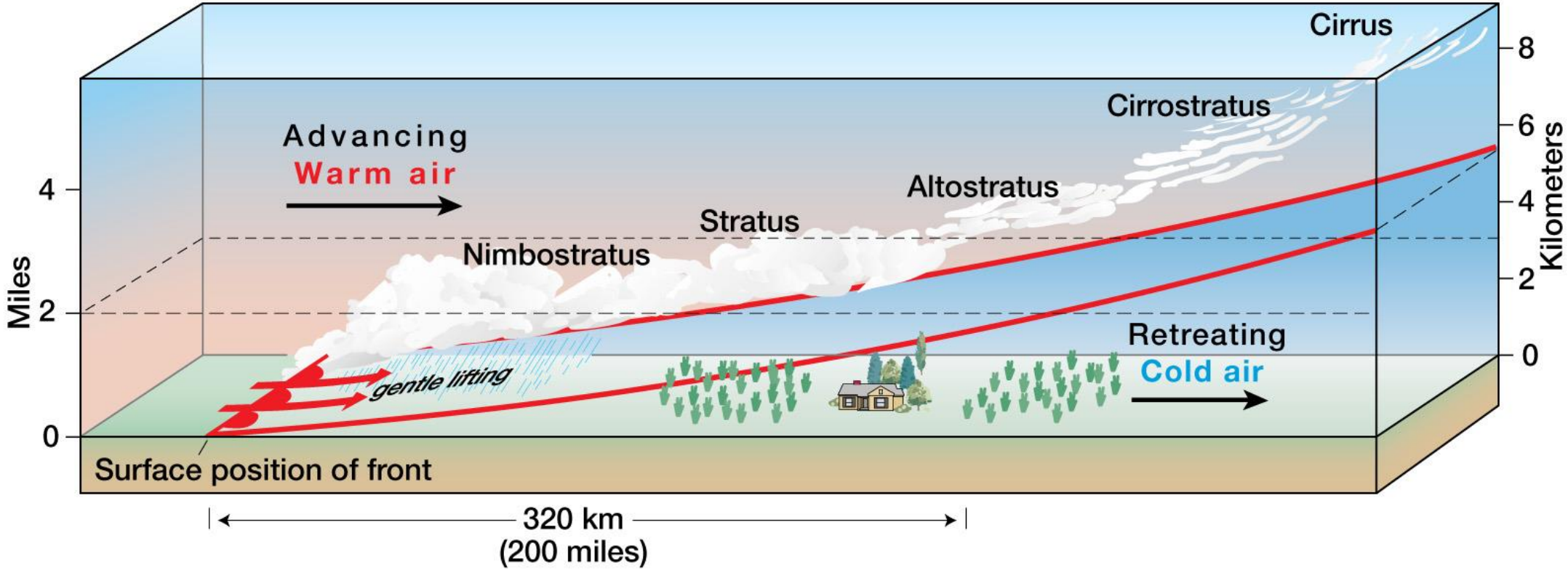
Precipitation is usually of higher intensity but shorter duration than warm fronts.



Warm Fronts

- The leading edge of an advancing warm air mass
- Brings warm air, which rises above the retreating cold air, cooling adiabatically.
- Results in clouds and precipitation, usually broad, protracted, and gentle, without much convective activity.
- Unstable rising air can result in showery and even violent precipitation, but precipitation tends to occur broadly and is likely to be more protracted and gentle.
- Weather maps show ground-level position of warm front; precipitation usually falls ahead of this position.

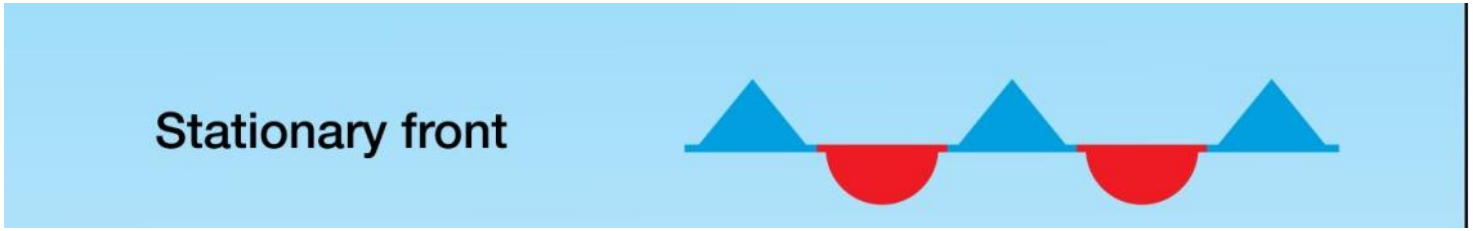




Stationary Fronts

The common “boundary” between two air masses in a situation in which neither air mass displaces the other.

Difficult to generalize about the weather along such a front, but often gently rising air produces limited precipitation similar to what you would find along a warm front.

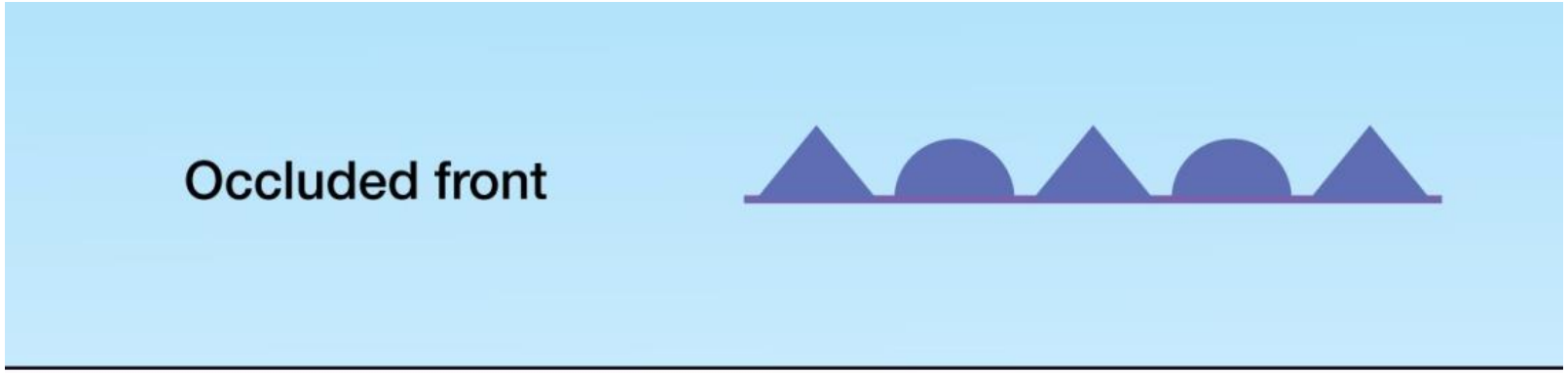


Occluded Front

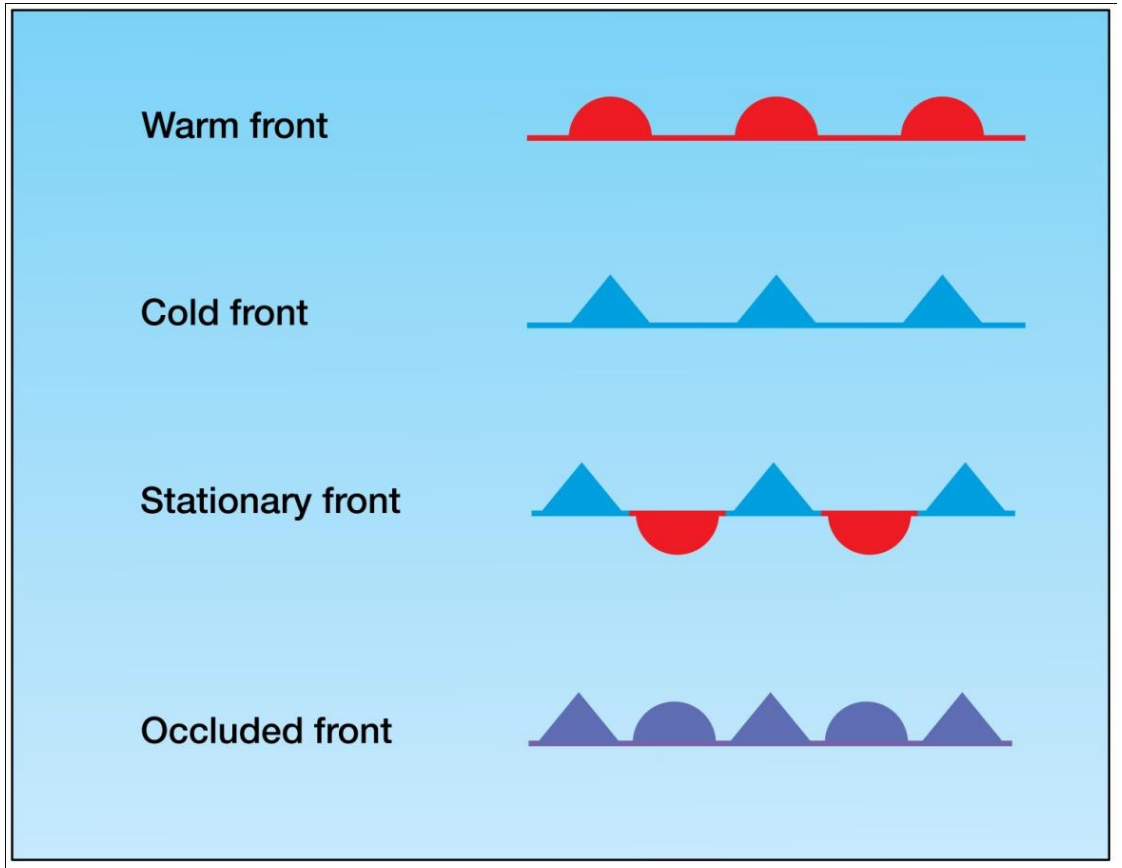
A complex front formed when a cold front overtakes a warm front

As the two fronts come closer together, the warm sector at the ground is increasingly displaced, forcing more and more warm air aloft

Occlusion results in short periods of intensified precipitation and wind until all the warm air is forced aloft and the ground-level low pressure center is surrounded on all sides by cool air.



Symbols on a Weather Map



Clouds

Clouds

Classifying Clouds

- Clouds are classified on the basis of two factors:
  - Form
  - Altitude

Classifying Clouds

- **Cloud form**
  - Cirriform clouds

    Latin *cirrus*, “a lock of hair”
  - Stratiform clouds

    Latin *stratus*, “spread out”
  - Cumuliform clouds

    Latin *cumulus*, “mass” or “pile”

TABLE 6-1 The International Classification Scheme for Clouds

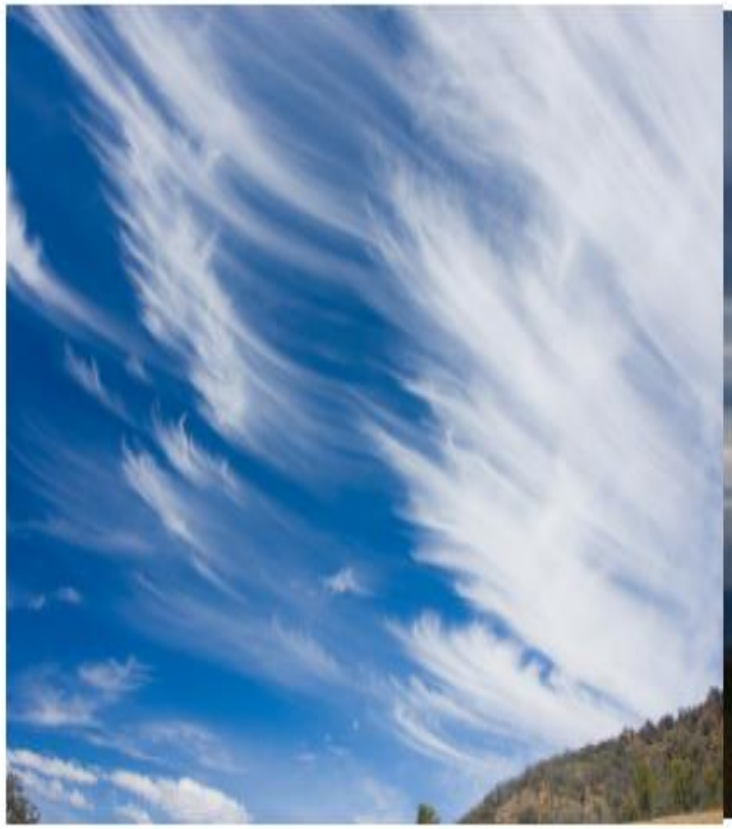
Family	Type	Form	Characteristics
High	Cirrus	Cirriform	
	Cirrocumulus	Cirriform	Thin, white, icy
	Cirrostratus	Cirriform	
Middle	Altocumulus	Cumuliform	Layered or puffy; made of liquid water
	Altostratus	Stratiform	
Low	Stratus	Stratiform	General overcast
	Stratocumulus	Stratiform	
	Nimbostratus	Stratiform	
Vertical	Cumulus	Cumuliform	Tall, narrow, puffy
	Cumulonimbus	Cumuliform	

Cloud Forms

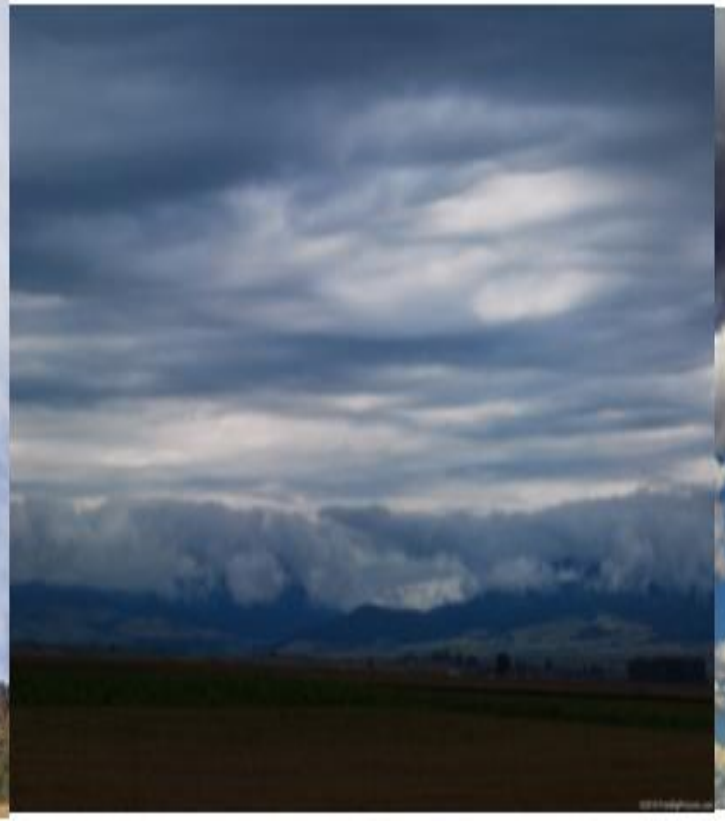
Three ***forms*** of clouds:

- **Cirriform clouds**—a thin, wispy, and composed of ice crystals rather than water particles; it is found at high elevations (altitudes).
- **Stratiform clouds**—appear as grayish sheets or layers that cover most or all of the sky, rarely being broken into individual cloud units.
- **Cumuliform clouds**—massive and rounded, usually with a flat base and limited horizontal extent, but often billowing upward to great heights.

- Pure forms:
  - **Cirrus cloud**—high cirriform clouds of feathery appearance.
  - **Cumulus cloud**—puffy white cloud that forms from rising columns of air.
  - **Stratus cloud**—low clouds, usually below 6500 feet (2 km), which sometimes occur as individual clouds but more often appear as a general overcast.



Cirriform clouds



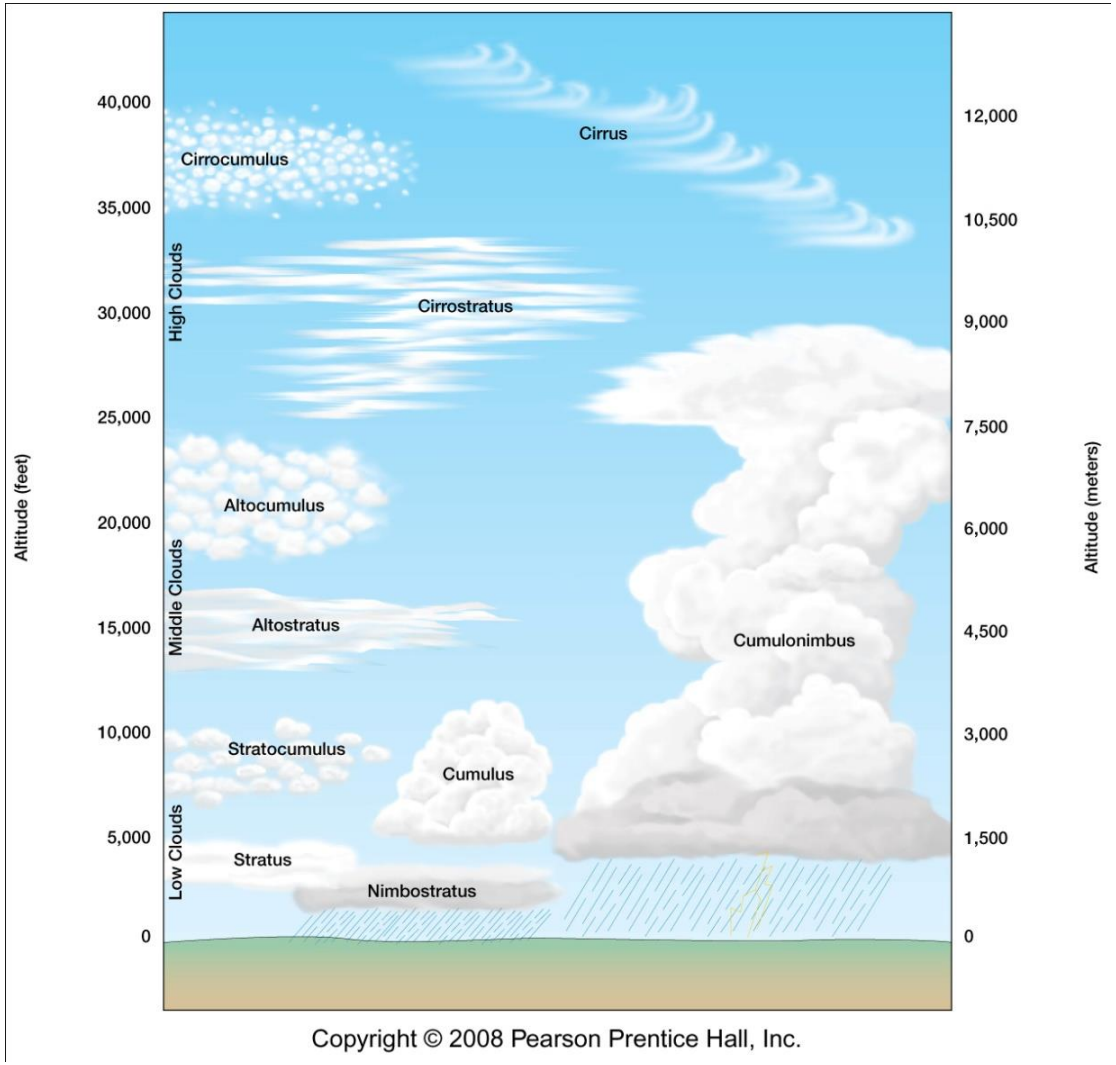
Stratiform clouds

Cumuliform clouds

Sub-Classification

These 3 cloud forms are subclassified into 10 types based on shape.

- One type may evolve into another.
- Three of these 10 are purely one form, while the other 7 are combinations of these three.
- Three pure forms:
  - Precipitation comes only from clouds that have "**nimb**" in their name; specifically, nimbostratus or cumulonimbus.
    - **Cumulonimbus cloud**—cumuliform cloud of great vertical development often associated with a thunderstorm.
    - **Nimbostratus cloud**—a low, dark cloud, often occurring as widespread overcast and normally producing precipitation.



Subtypes of Cloud Forms

- High clouds
- Middle clouds
- Low clouds
- Clouds of vertical development

Cloud Families

Four categories based on altitude:

High clouds

- Altocumulus clouds—found above 6 kilometers (i.e., cirrus clouds).
- Because of the small amount of water vapor and low temperature at such altitudes, these clouds are thin, white, and composed of ice crystals.
- Included here are the cirrus, cirrocumulus and cirrostratus.
- Tell us weather systems are approaching.

Middle clouds

- Between about 2 and 6 kilometers (i.e., altoculus and alto stratus).
- These may either be stratiform or cumuliform and are composed of liquid water.
- Includes **altocumulus** and **altostratus**.
- The puffy **altocumulus** usually indicate settled weather conditions, whereas the lengthy **altostratus** are associated with changing weather.

Low clouds

- Formed below 2 kilometers (i.E., Stratocululus and nimbostratus).
- Sometimes occur as individual clouds, but more often appear as a general overcast.
- Low cloud types include **stratus, stratocumulus**, and **nimbostratus**.
- These low clouds are often widespread and are associated with somber skies and drizzly rain.

Clouds with vertical development

- These are the cumulus clouds
- These grow upwards from low bases to heights as much as 15 kilometers (60,000 feet)
- Their horizontal spread is usually very restricted
- They indicate very active vertical movements in the air
- The relevant types are ***cumulus***, which usually indicate fair weather, and ***cumulonimbus***, which are storm clouds.

Extra Credit

Take pictures or screenshots of different cloud types and paste them in a word document.

Extra credit: 2 points towards Exercises.