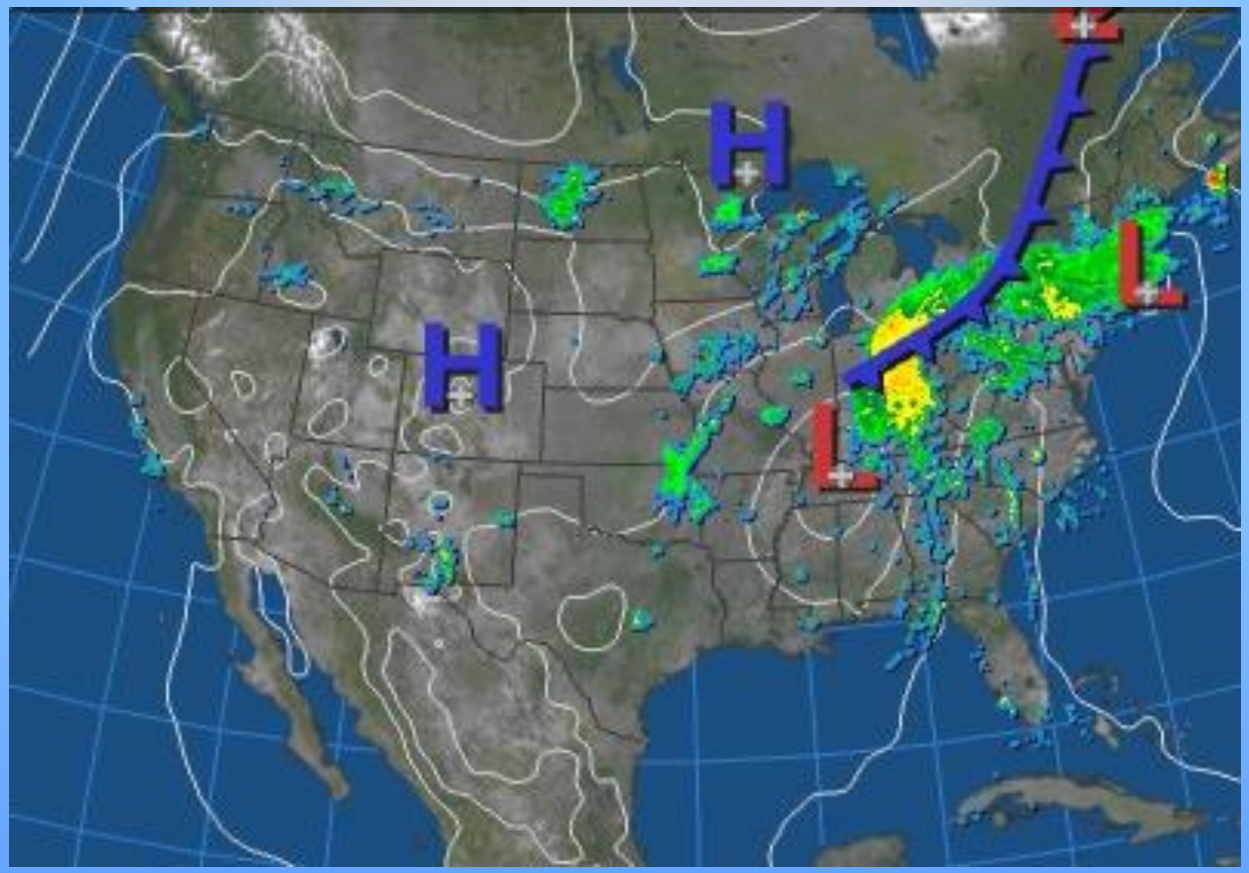
Air Masses, Fronts, and Wave Cyclones



VI. Air Masses

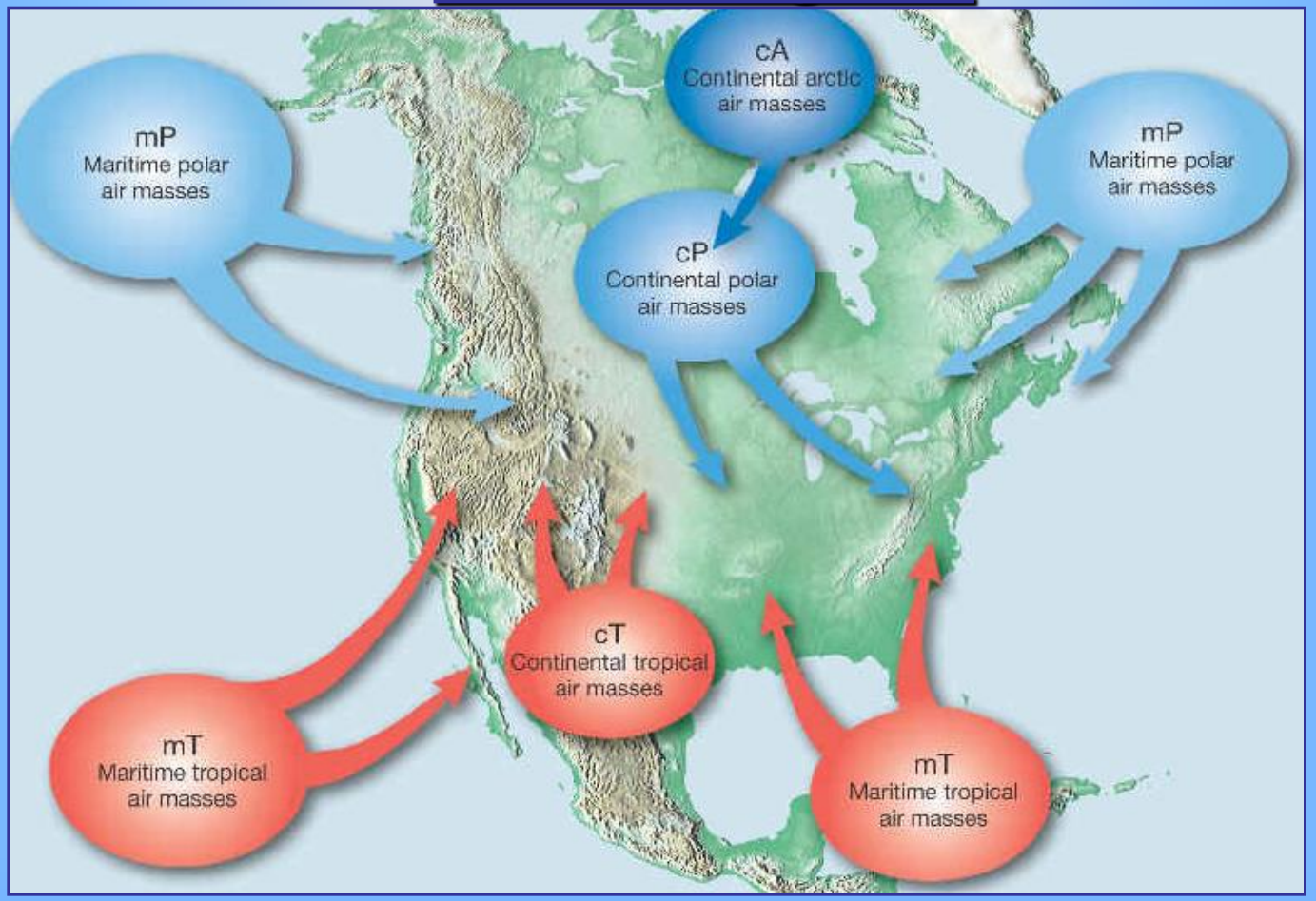
A. *An Air Mass is*:

1. An **Immense body** of air, usually 1600 km horizontally and several kilometers vertically.

2. Characterized by **uniform** physical properties at any given **altitude**. (In particular, temperature and moisture content.)

3. Air Mass Weather: Generally, they **modify** weather conditions of a region under the influence of an air mass

B. *Source Regions*

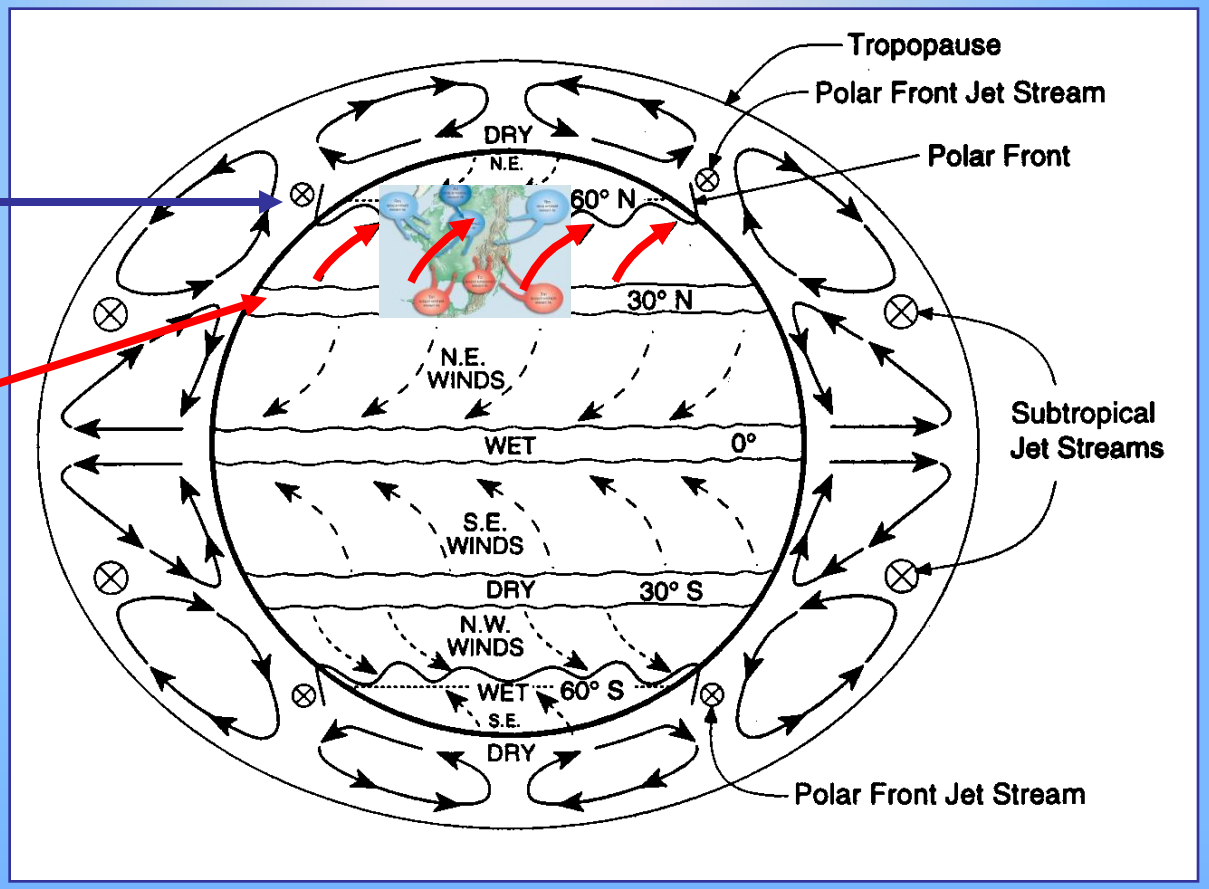


1. **The area** in which air masses originate and determines the **characteristics** must meet two criteria.
   a. First, it must be **extensive** and have physically **uniform** area.
   b. Second, the area must be characterized by a general **stagnation** of atmospheric circulation.

3. Major source regions are not found in the middle latitudes.

Subpolar latitude

Subtropical latitude



a. Middle latitudes are characterized by prevailing winds and cyclonic waves (storms).

b. Source regions are confined to subtropical and subpolar locations.

C. Air Mass Classification

1. **Depends on**:
   a. _Latitude_ of the source region (determines temperature)
   b. The nature of the surface in the area of origin (_ocean or continent_) which determines _moisture_ conditions

2. Naming Air Masses

a. Air masses are named using a two-letter code.

(1) First letter:

(a) **lowercase**

(b) Designates **moisture** characteristics

i) c for continental;

ii) m for maritime

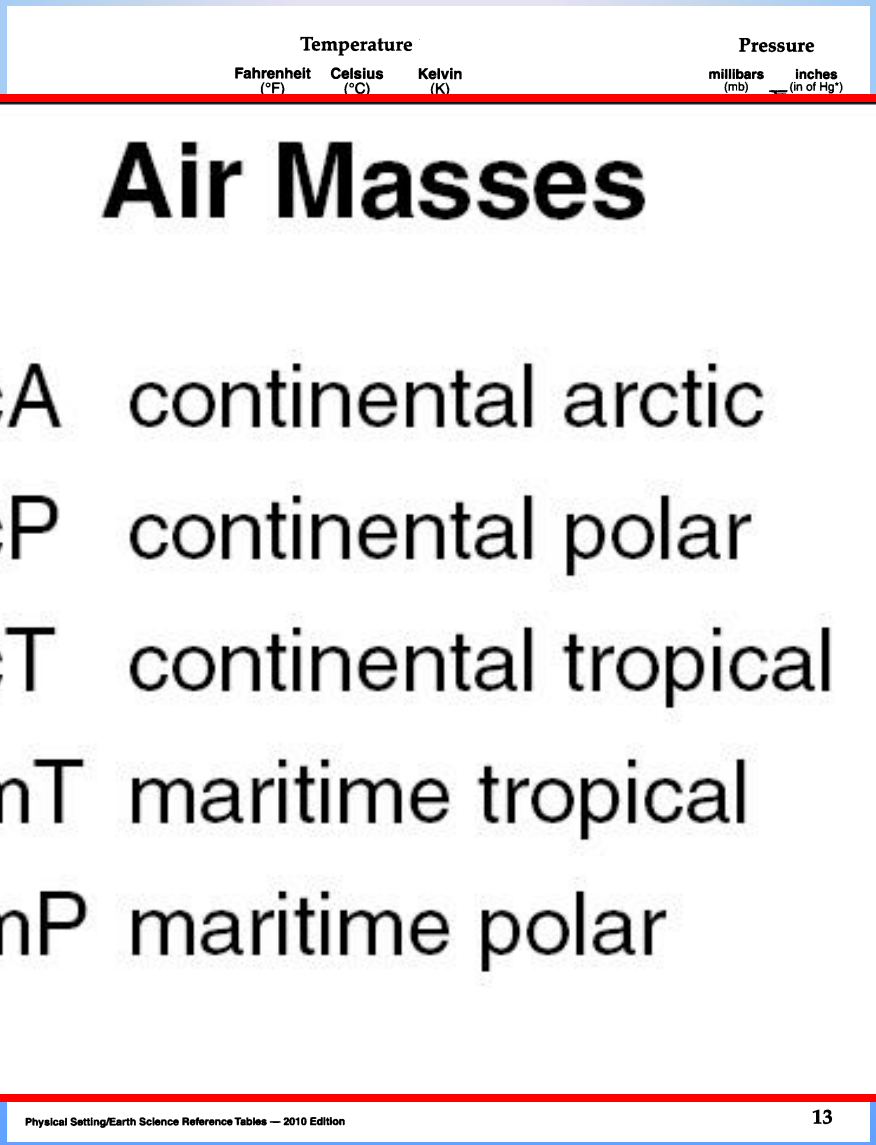
(2) Second letter

(a) **UPPERCASE**

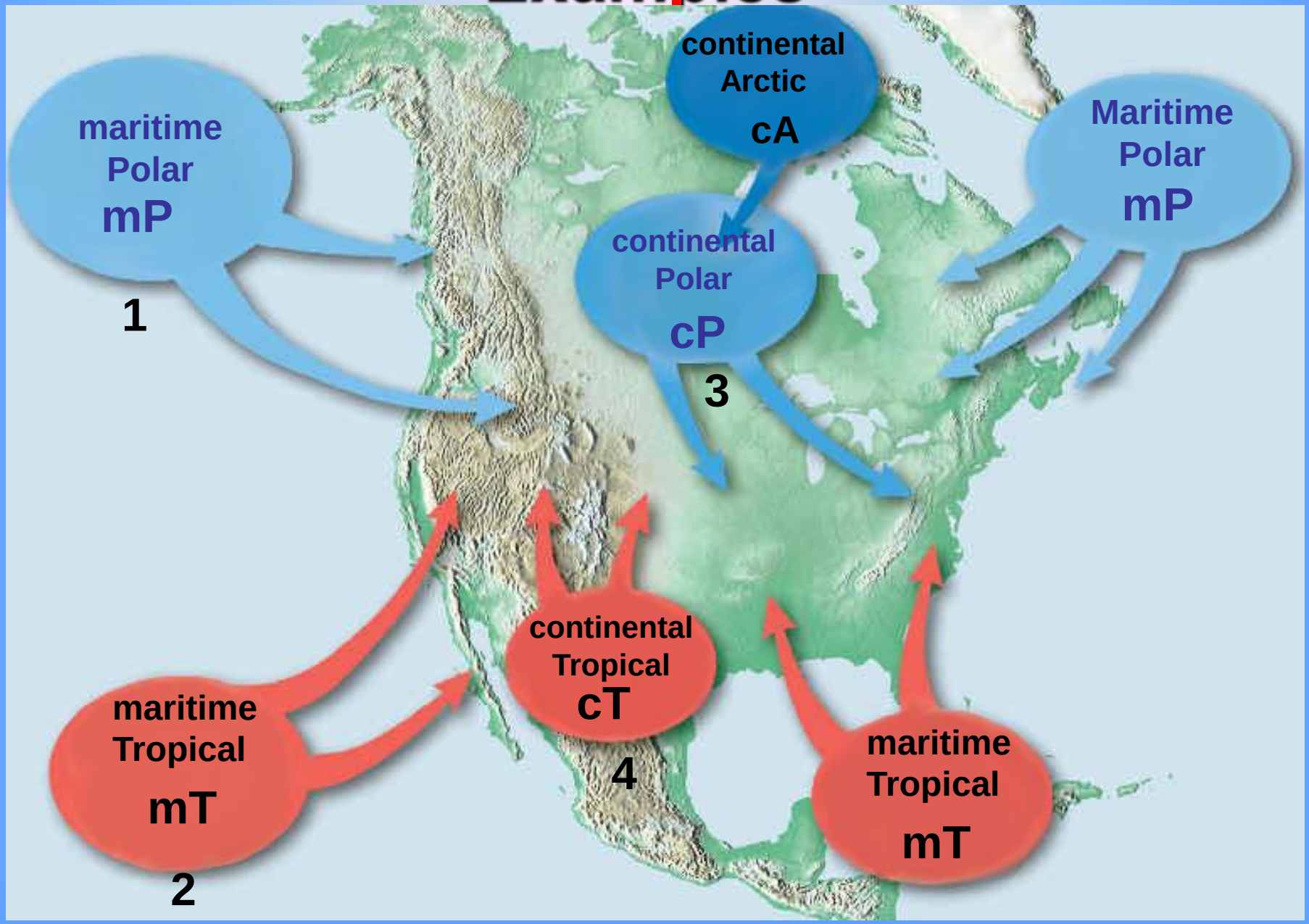
(b) Designates **temperature** conditions

(c) P for polar; A for arctic (colder than polar); T for tropical; E for equatorial

Air Masses in the ESRT



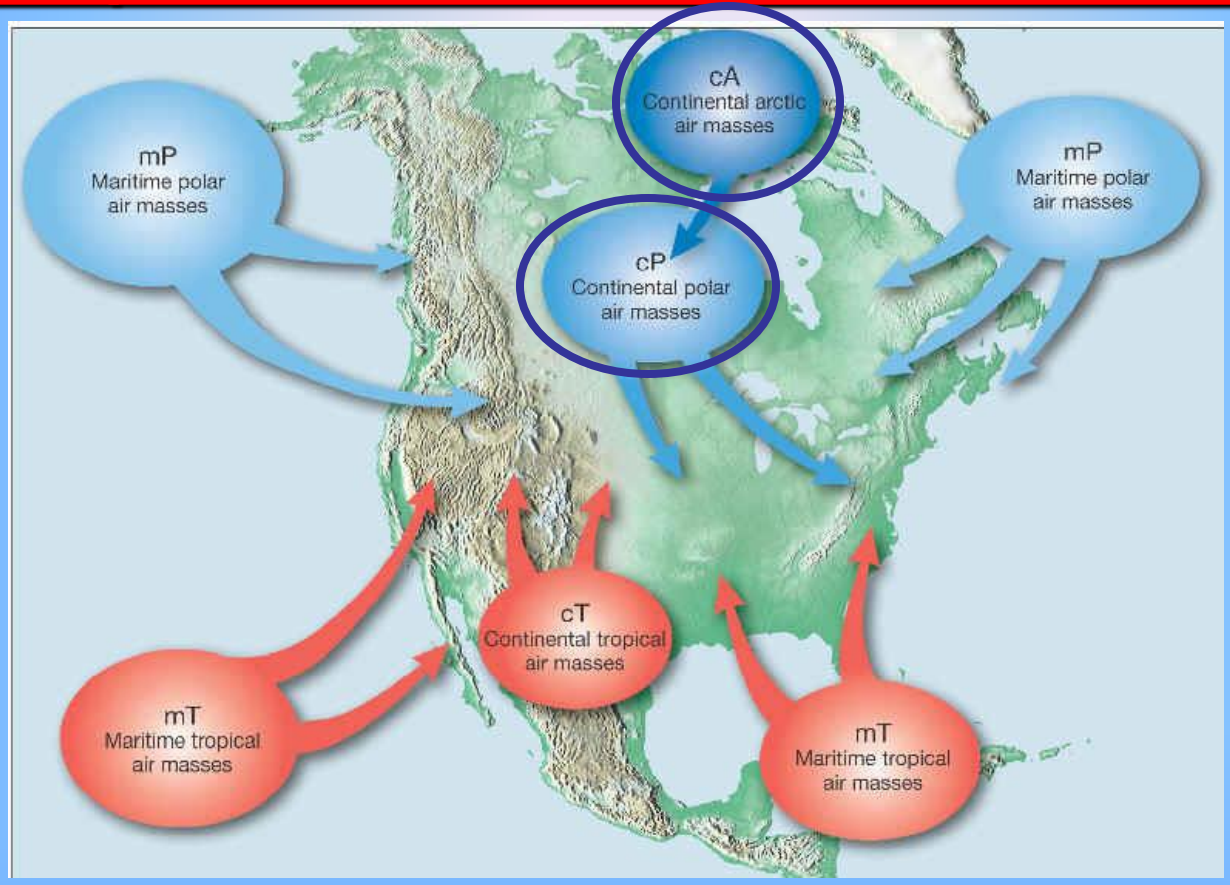
Examples


continental
Arctic
cA
maritime
Polar
mP
1
Maritime
Polar
mP
continental
Polar
cP
3
continental
Tropical
cT
4
maritime
Tropical
mT
2
maritime
Tropical
mT

D. *Modification of Air Masses*

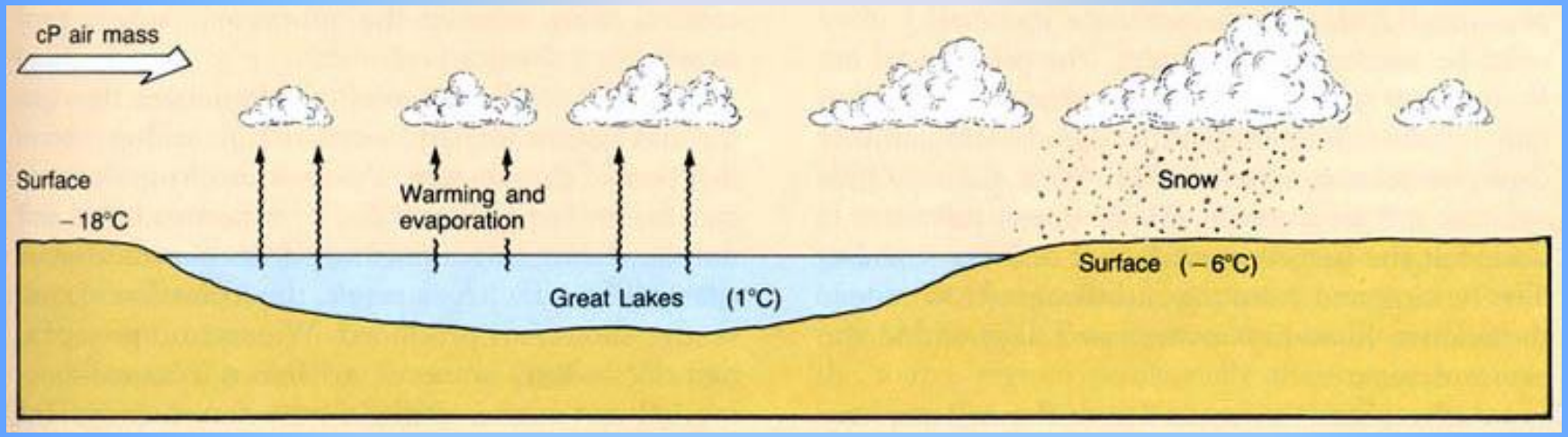
1. As an air mass moves it **modifies** the weather of the area over which it is moving.
2. As an air mass moves it gradually becomes modified by the **surface over** which it is moving
3. Cp moves over ocean (winter): Transforms to an unstable mP air mass
   a. If colder than the surface over which it moves: lowercase *k* is added after the symbol for the air mass.
   b. If warmer than the surface over which it moves: lowercase *w* is added after the air mass symbol.

E. Properties of North American Air Masses



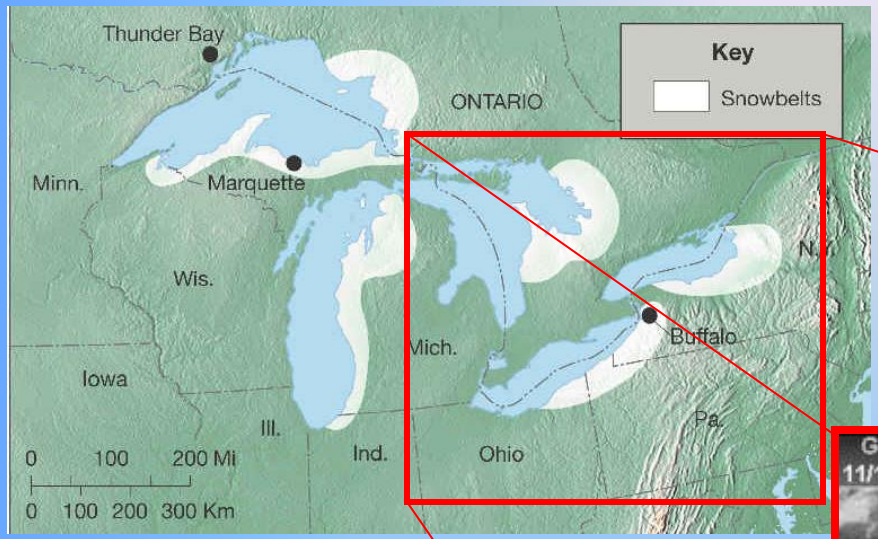
1. **Continental Polar (cP) and Continental Arctic (cA)**
   a. Associated with winter cold waves and the first fall freeze and last spring freeze
   b. Advance between Great Lakes and Rockies
   c. No topographic barriers between high latitudes and Gulf of Mexico
   d. Therefore cP and cA air can easily and rapidly extend far southward into the U.S.
   e. Associated with *Lake Effect Snows*
   f. Often ends heat waves in summer

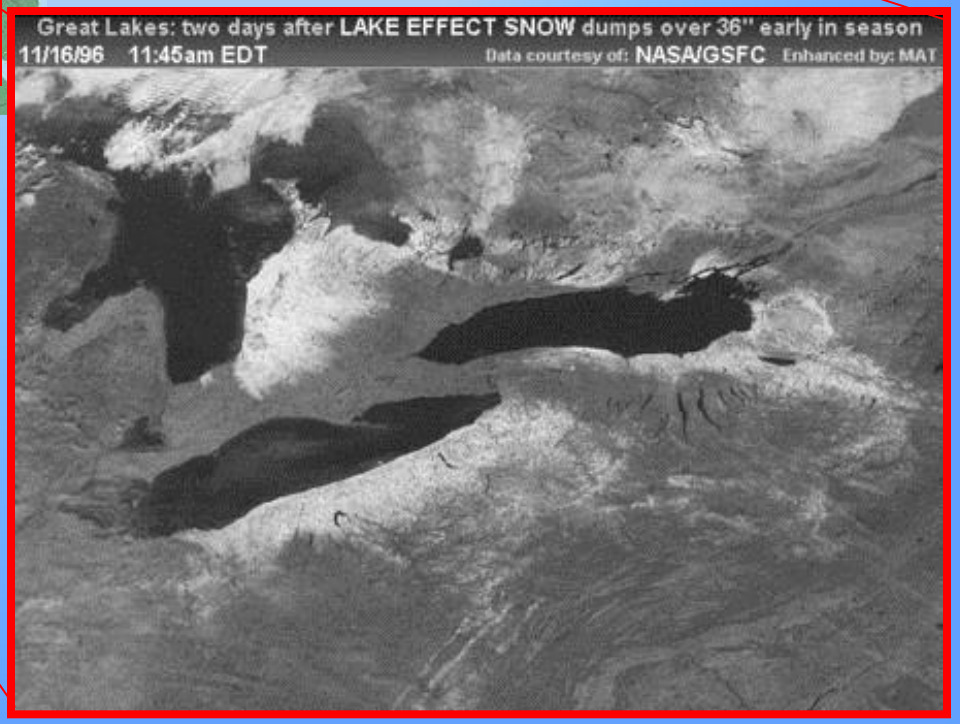
Lake Effect Snow



- cP air becomes moist as it crosses the Great Lakes in the winter.
- It becomes unstable due to the acquired moisture and by warming from below.
- The *leeward* side of the lakes receives the “lake effect snow.”

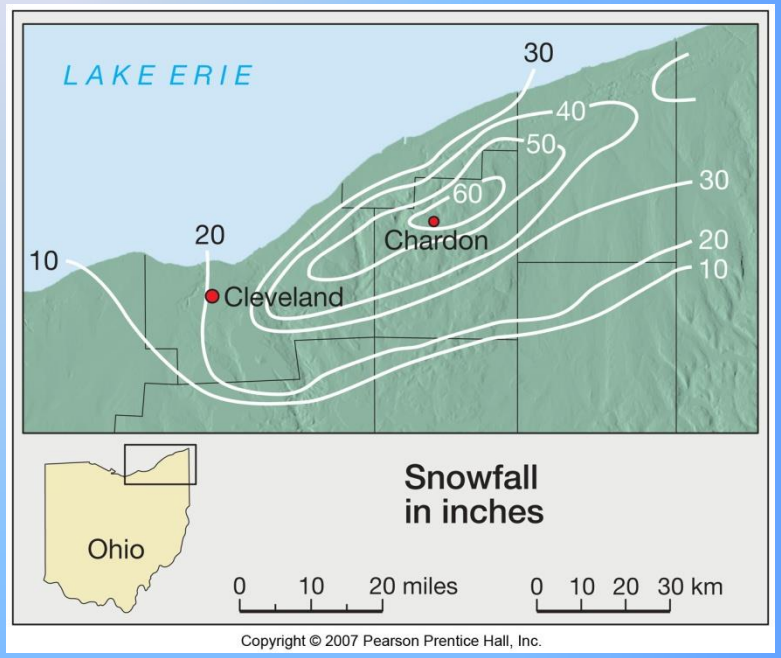
Snow Belts Due to Lake Effect Snow





Lake-Effect Snow

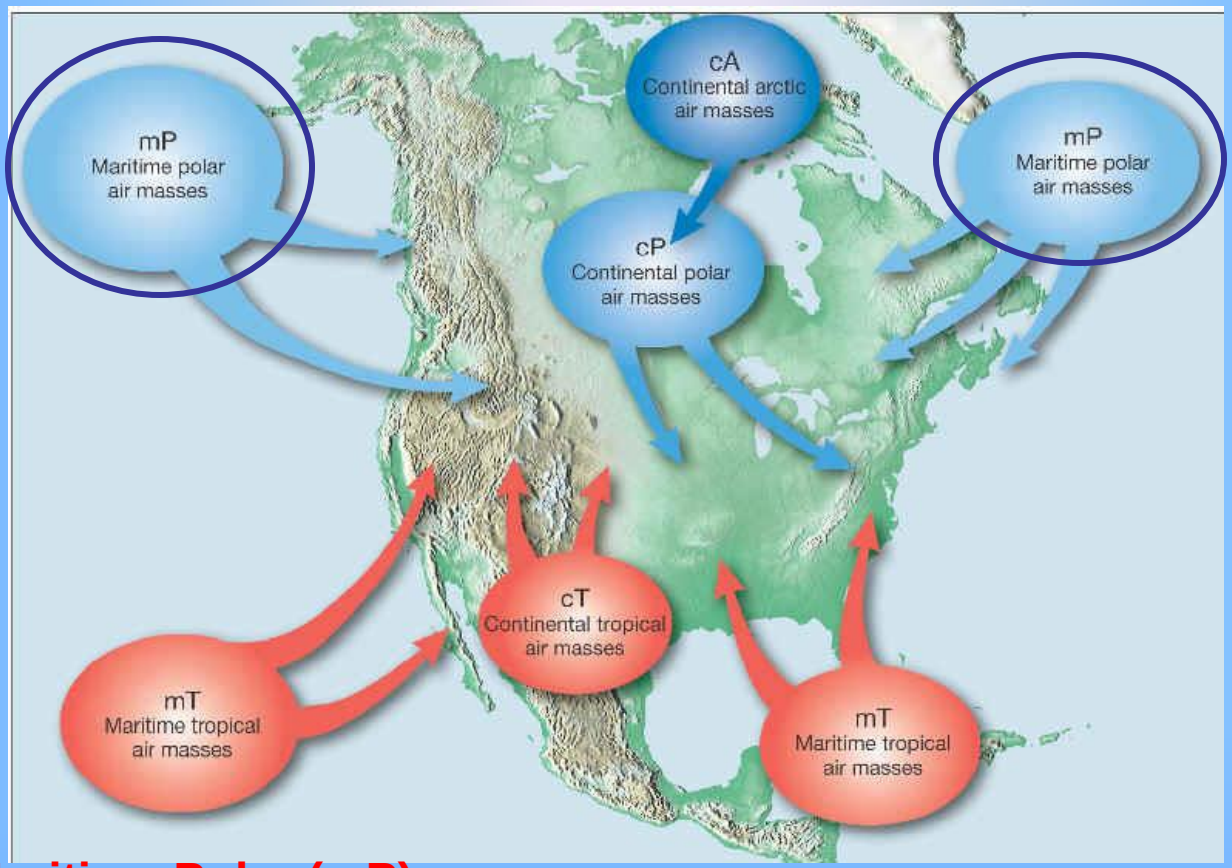
Copyright © 2007 Pearson Prentice Hall, Inc.



Copyright © 2007 Pearson Prentice Hall, Inc.

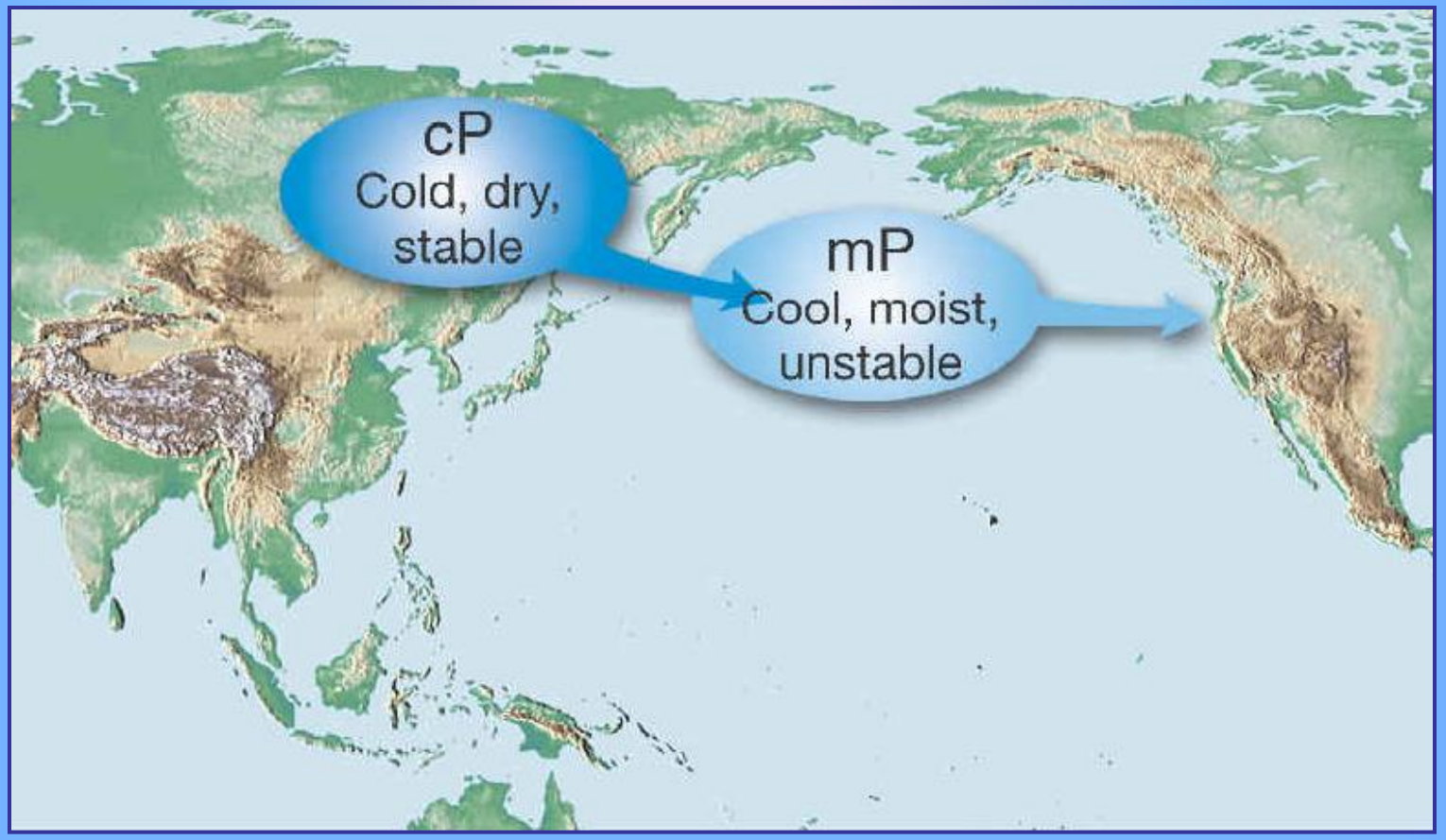
- November 9-14,1996
- 175 cm (~69 inches) of snow in Chardon, OH

E. Properties of North American Air Masses



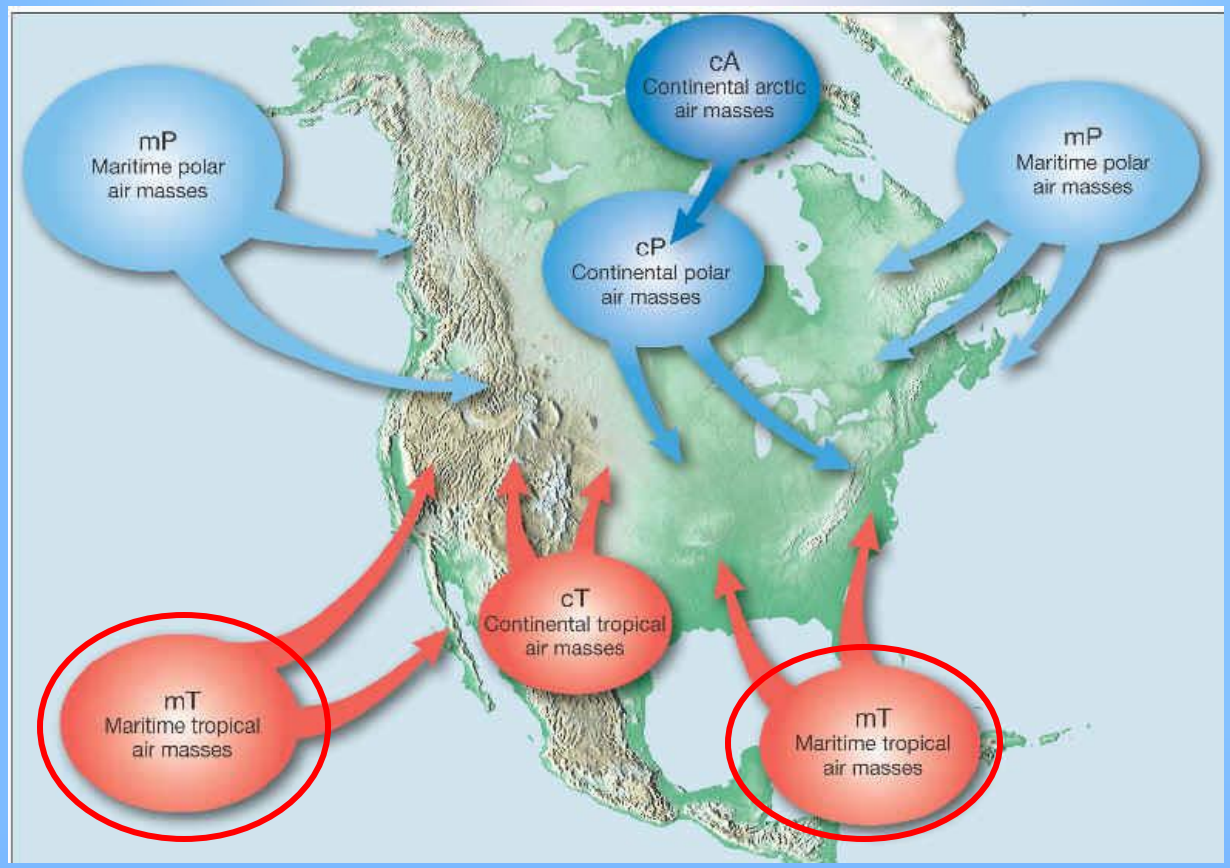
2. **Maritime Polar (mP)**
   a. Two important sources regions influence U.S. weather
   b. North Pacific (originate as cP air in Siberia)
   c. Northwestern Atlantic from Newfoundland to Cape Cod (originally cP air masses over the continent but rarely affects U.S. weather due to westerlies)
   d. Nor'easter: Winter invasion of mP air from the Atlantic due to cyclonic winds

Winter mP Air Masses



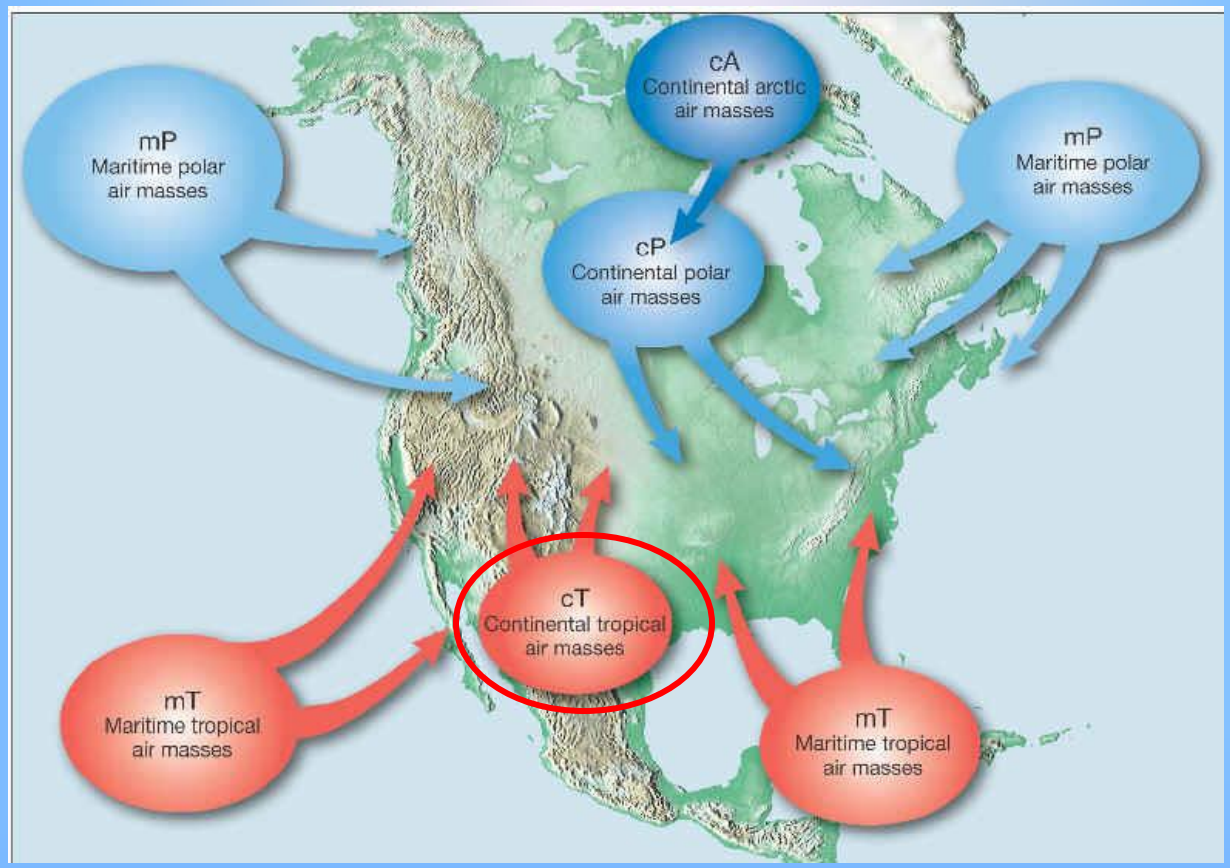
- In winter North Pacific mP air masses usually begin as Siberian cP air masses.
- The cP air is modified as it slowly crosses the ocean.

E. Properties of North American Air Masses



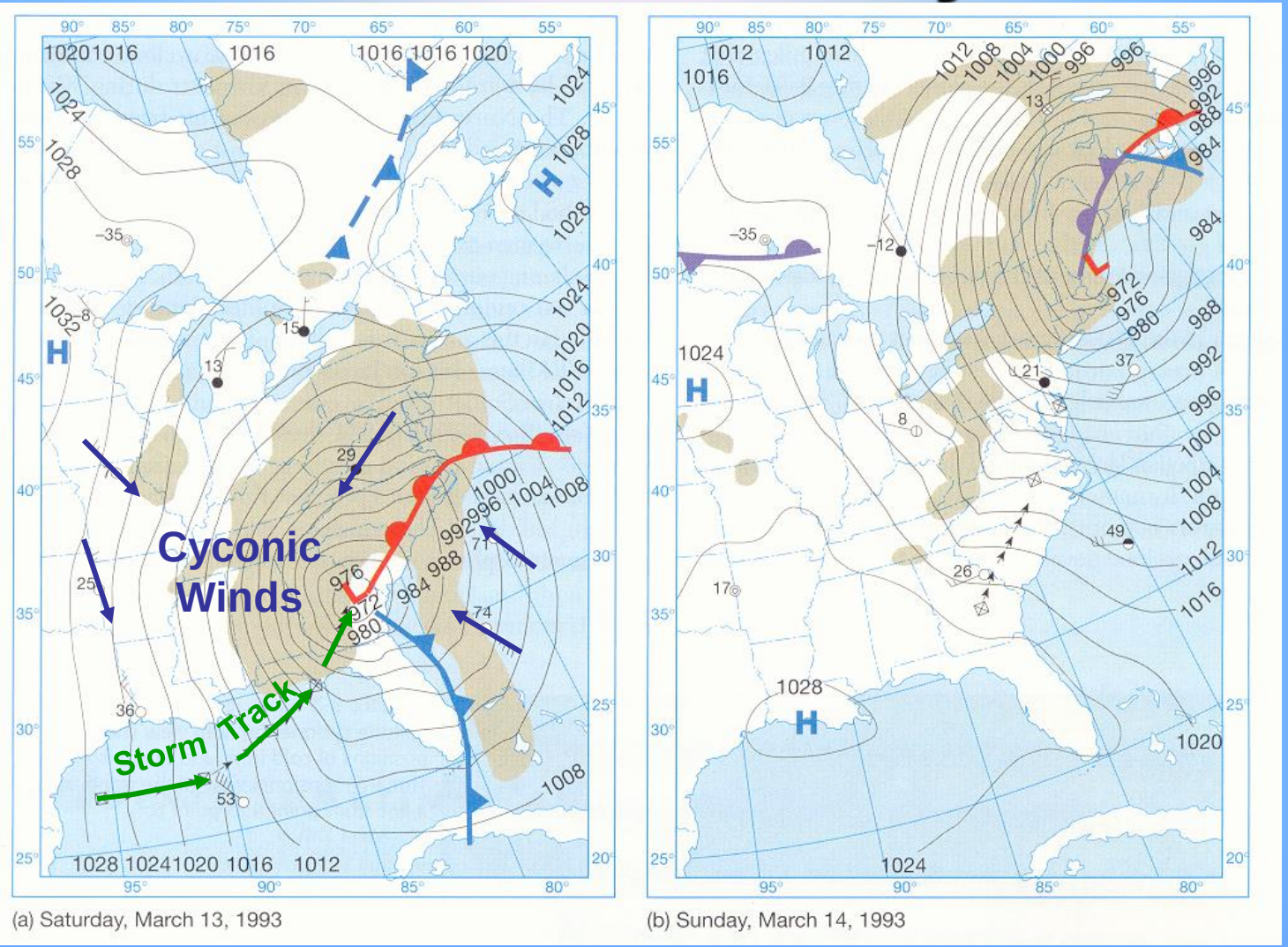
1. **Maritime Tropical (mT)**
   a. Originate over Gulf of Mexico and Caribbean Sea
   b. Often unstable (warm and moist)
   c. Winter: mT air seldom reaches the central and eastern U.S. If it does, it becomes more stable and is associated with occasional widespread precipitation (becomes mTw)
   d. Summer: Associated with hot and humid conditions with frequent cumulus development and showers or thunderstorms.

E. Properties of North American Air Masses



1. **Continental Tropical (cT)**
   a. North America has no extensive source region for cT air masses.
   b. Summer: cT air forms over northern interior Mexico and parts of the arid southwestern U.S.
   c. Unstable due to extreme temperatures but little cloud formation due to low humidity.
   d. Associated with occasional drought in the Great Plains

VII. Fronts and Wave Cyclones



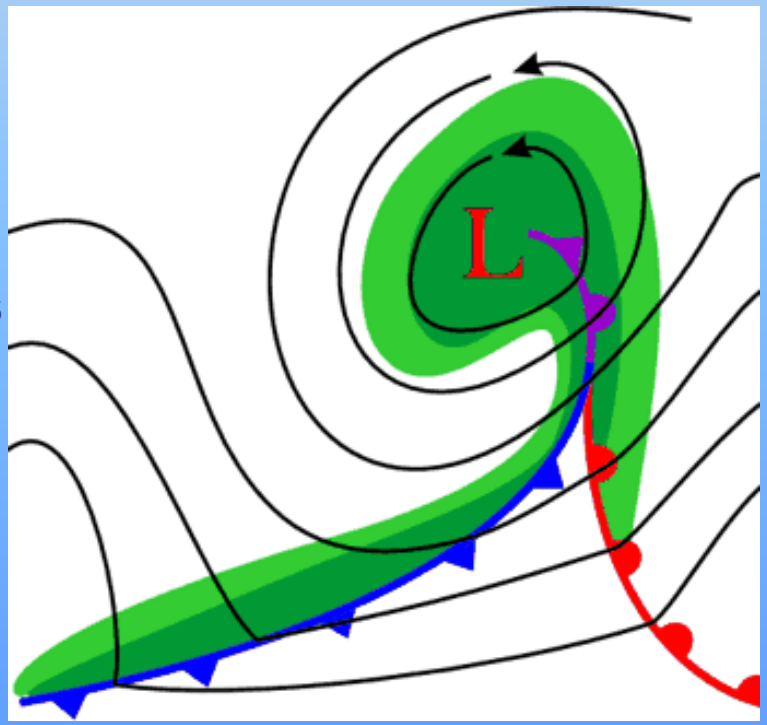
An enormous cyclonic storm formed in the Gulf of Mexico, moved northeastward and spawned tornadoes in FL and dumped huge amounts of snow from Alabama to Candada's Maritime Provinces

A. Wave Cyclones

1. The primary weather producer in the **middle latitudes** (region between Florida and Alaska in the region of the westerlies).
2. Large **low** pressure systems with counterclockwise convergent circulation. The systems generally move from **West to East**.
3. Most have a cold front and often a warm front extending from the **central area of low** pressure.

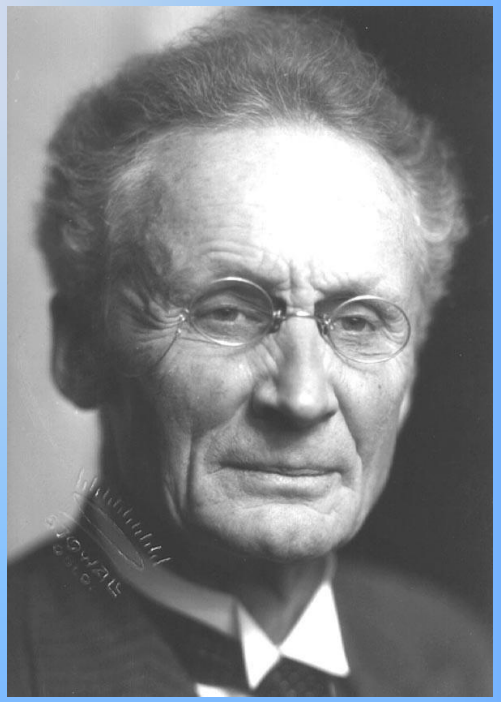
Also called:

- **low-pressure systems**
- **extratropical cyclones**
- **lows**



The First Model Was Constructed by Norwegian Scientists During WWI

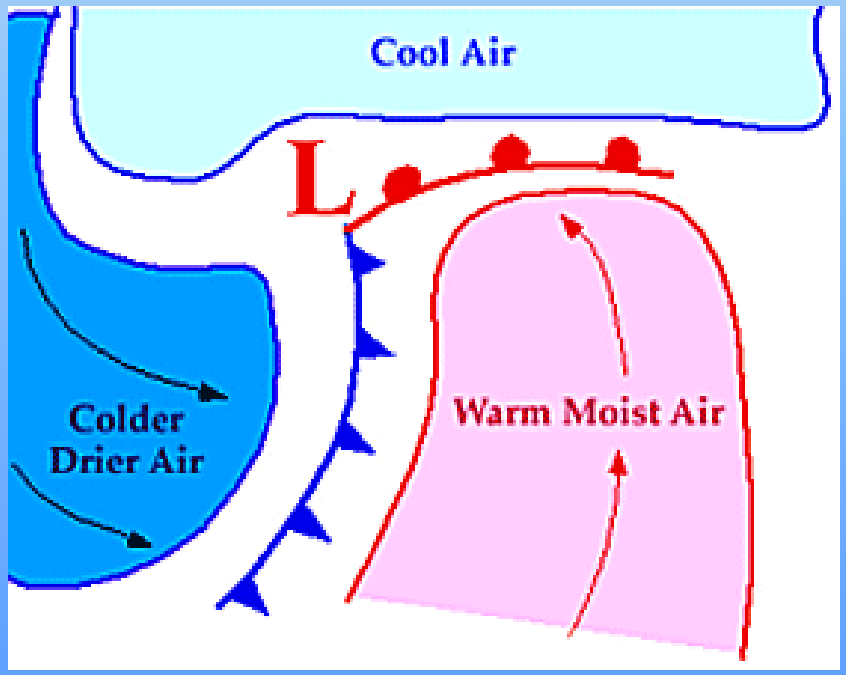
- Norwegians were cut off from weather reports from the Atlantic.
- They developed a closely spaced network of weather stations.
- Published their model in 1921.
- Their insights proved to be a turning point in meteorology.
- Their model became know as:
  - The Polar Front Theory
  - Also called Norwegian Cyclone Model



Vilhelm Bjerknes (*Bee-YURK-ness*)

B. Fronts

1. Fronts are **boundary** surfaces separating air masses of **differing** densities.
2. One air mass is usually **warmer**. Fronts can form between any two **contrasting** air masses
3. **Above** ground, the frontal surface slopes at a low angle allowing warmer air to overlie cooler air.
4. **Overrunning**: The general term applied to warm air gliding up along a cold air mass.



5. Types of Fronts

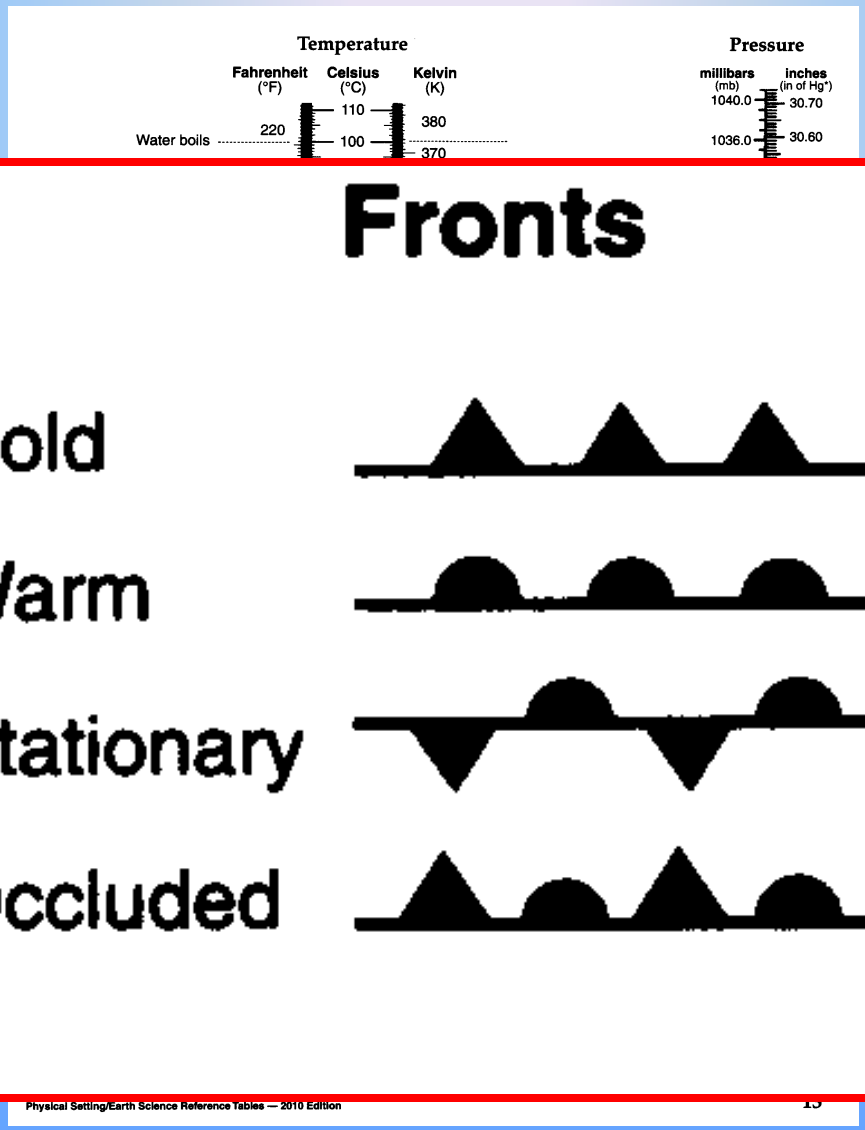
Warm Fronts

Cold Fronts

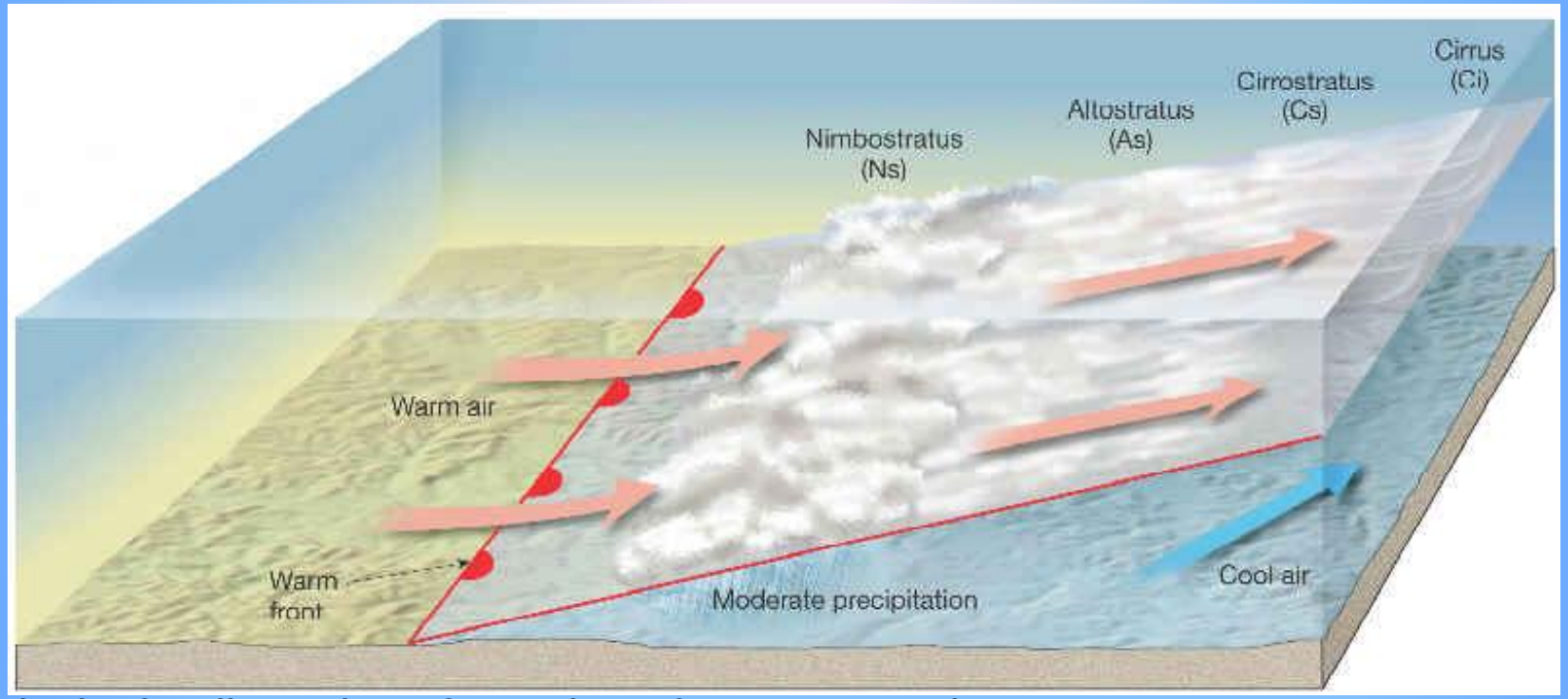
Stationary Fronts

Occluded Fronts

Front Symbols in the *ESRT*



a. Warm Front



(1) The leading edge of an advancing **warm** air mass.

(2) As the warm air **collides** with the cooler and receding air mass, friction with the ground slows the advance of the surface position of the front. The result is a **gentle** slope of 1:200 (1 km height for every 200 km ahead of the surface location)

(3) The **slow** rate of advance and low slope produces light to moderate precipitation over a large area, ahead of the surface position of the front.

(4) Preceded by cirrostratus clouds (“halo”) and cirrocumulus (“mackerel sky’)

(5) After the front passes temperatures gradually **increase**.

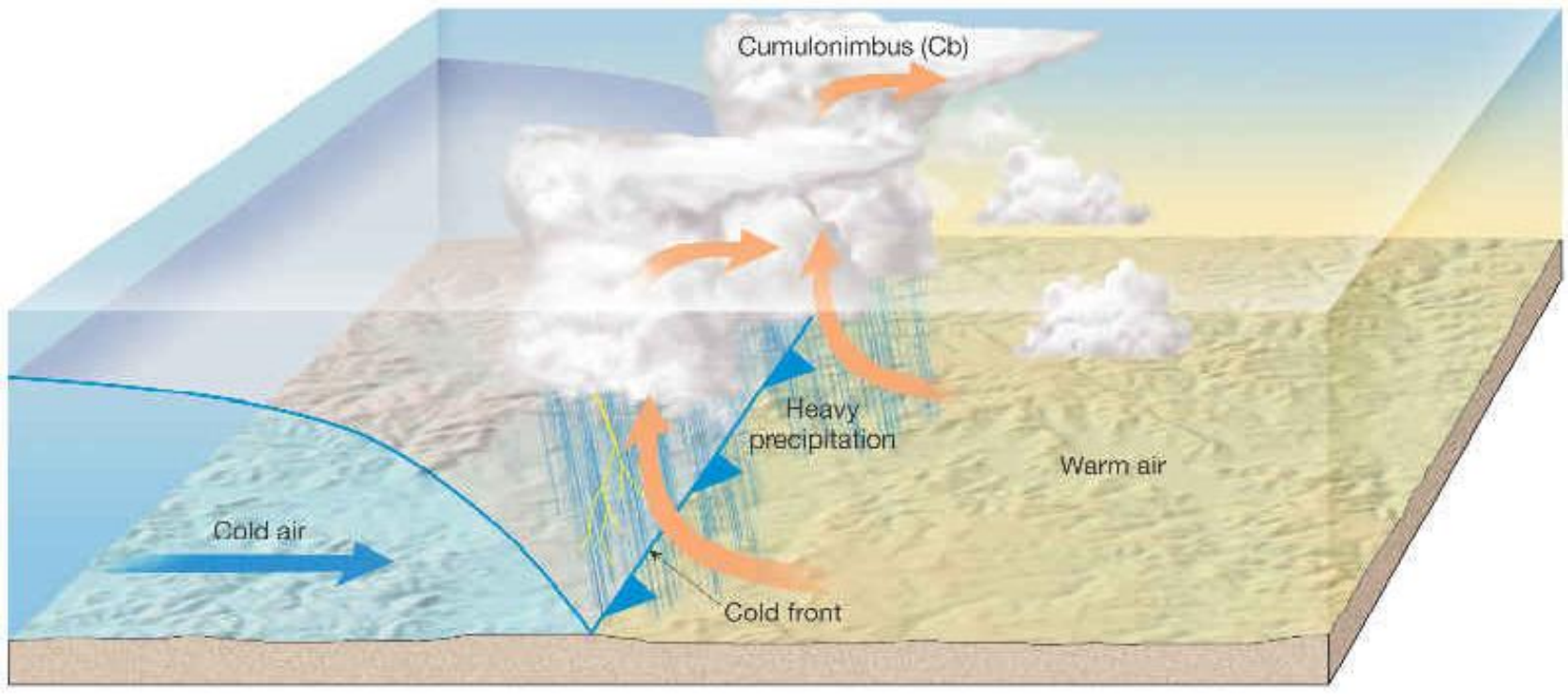
Clouds Ahead of a Warm Front

cirrocumulus

cirrostratus

- http://www.classzone.com/books/earth_science/terc/content/visualizations/es2002/es2002page01.cfm?chapter_no=visualization

b. Cold Front



(1) The leading edge of an advancing **cold** air mass.

(2) Friction with the ground **slows** the surface position of the front causing it to steepen as it advances.

(3) Approximately twice as steep as a warm front (1:100).

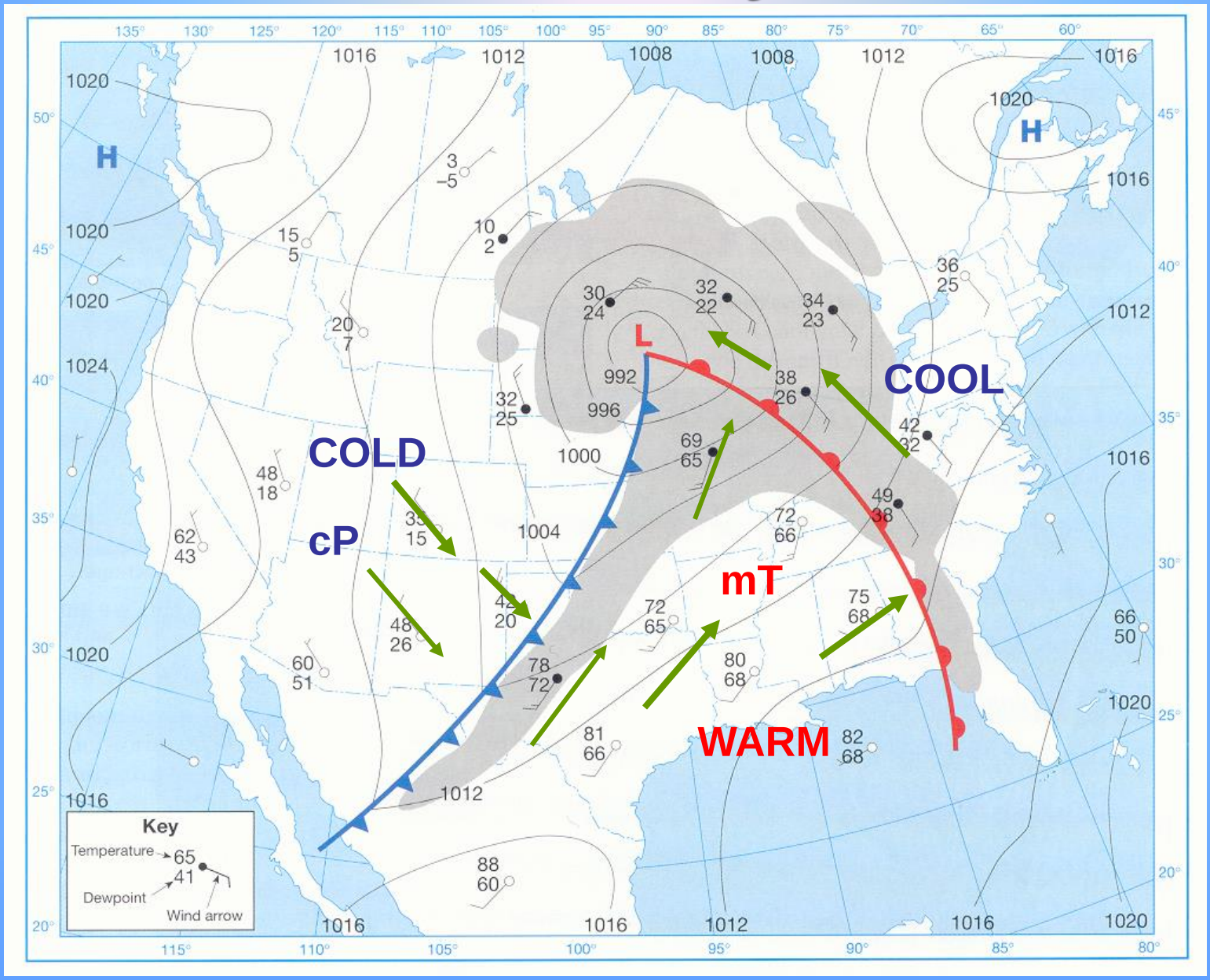
(4) Advances at a **faster** rate (≈ 35 km/hr) than a warm front (25 ≈ km/hr).

(5) Forceful **lifting** results in cumuloform clouds with heavy precipitation (often cumulonimbus with associated thunderstorms.

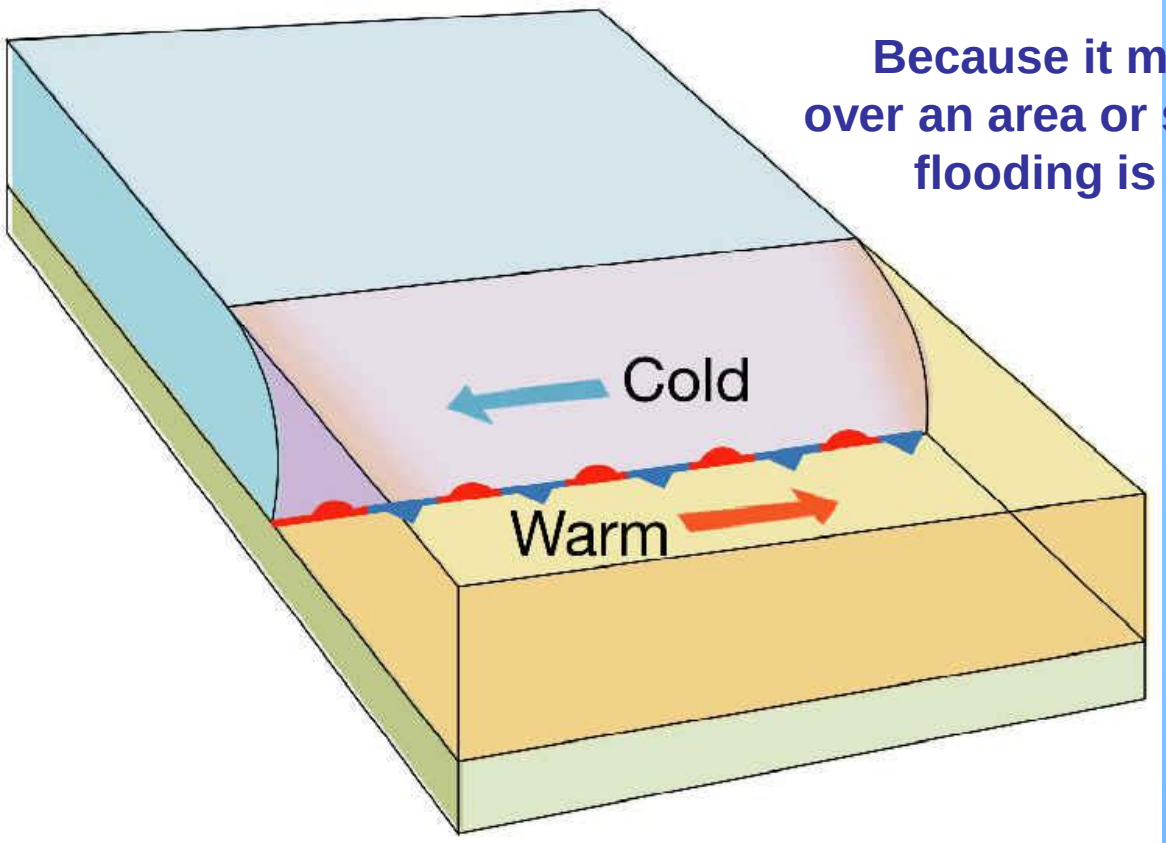
(6) Often preceded by altocumulus clouds. Followed by **colder** temperatures.

- http://www.classzone.com/books/earth_science/terc/content/visualizations/es2002/es2002page01.cfm?chapter_no=visualization

Mid-Latitude Cyclone



c. Stationary Front



Because it may remain over an area or several days, flooding is possible

(1) Produced by **horizontal** air flow on either side of the front resulting in **no** movement of the frontal boundary.

(2) Overrunning occurs resulting in gentle to moderate precipitation.

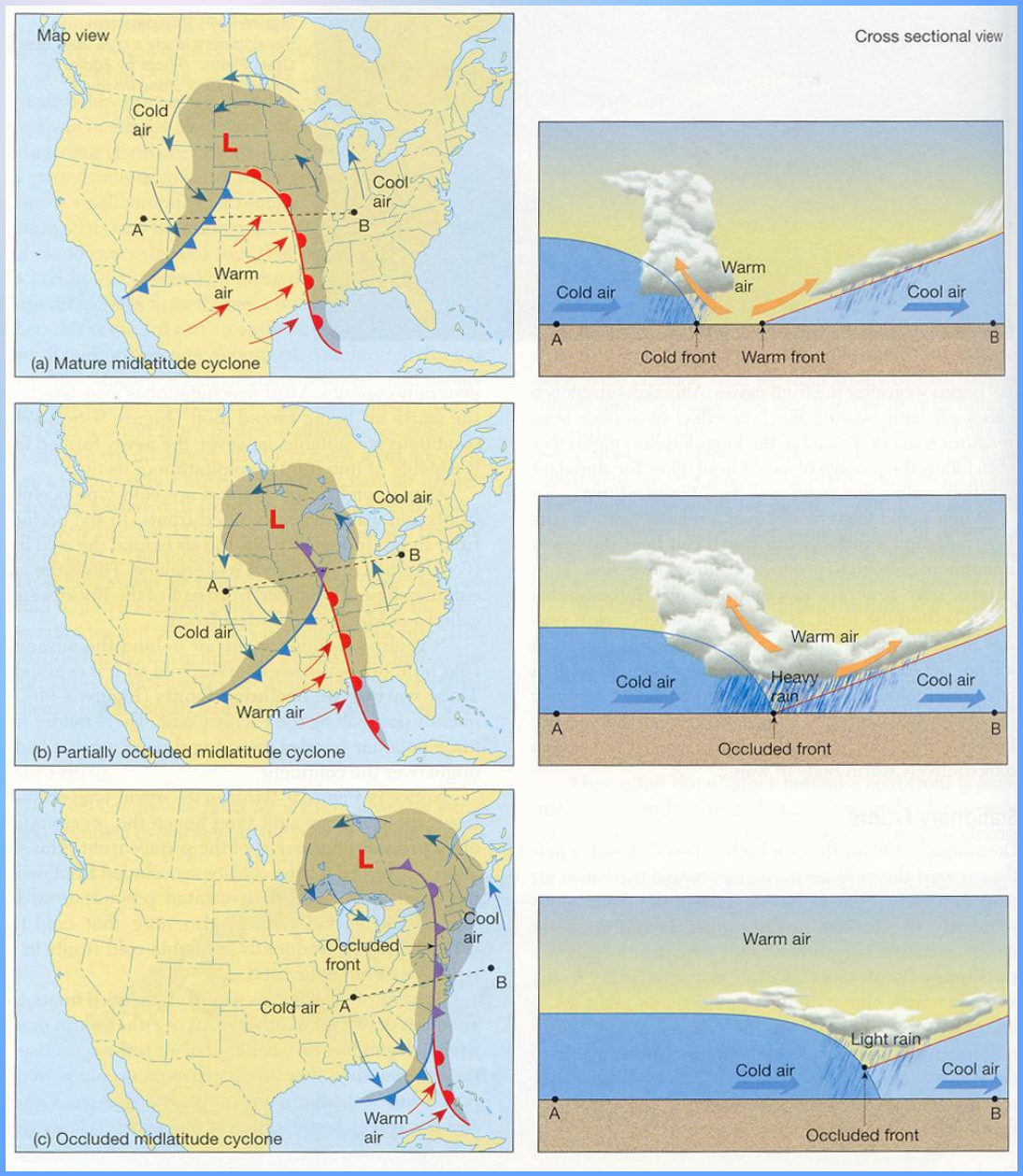
(3) **Wind shear** on either side of the front ultimately is responsible for the formation of a low pressure center and a wave cyclone.

d. Occluded Front

(1) Produced when an rapidly advancing cold front _overtakes_ and _merges_ with a warm front.

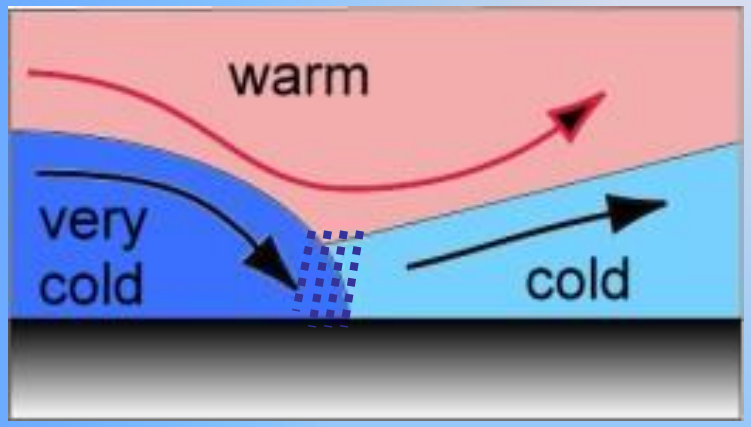
(2) A _new front_ forms between the advancing cold air and the air over which the warm front is sliding.

(3) Complex weather that is often a combination _cold front & warm front_ conditions results.



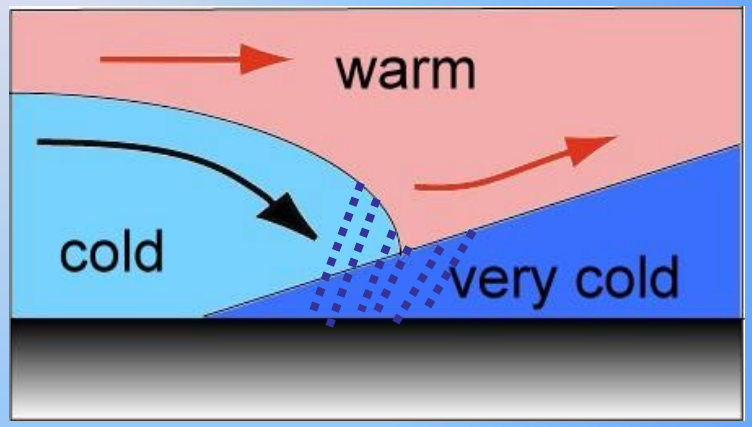
Types of Occluded Fronts

Cold-Type Occluded Front



- Air behind the cold front is colder than the air it's overtaking.
- This the most common type east of the Rockies
- Front aloft lags behind the surface position.
- Weather is similar to cold front weather.

Warm-type Occluded Front



- Air behind the advancing cold front is warmer than the air its overtaking
- Frequently occurs along the Pacific Coast where mp air overtakes cold air that formed over the continent.
- Warmer upper air arrives before the surface front (along with the precipitation).

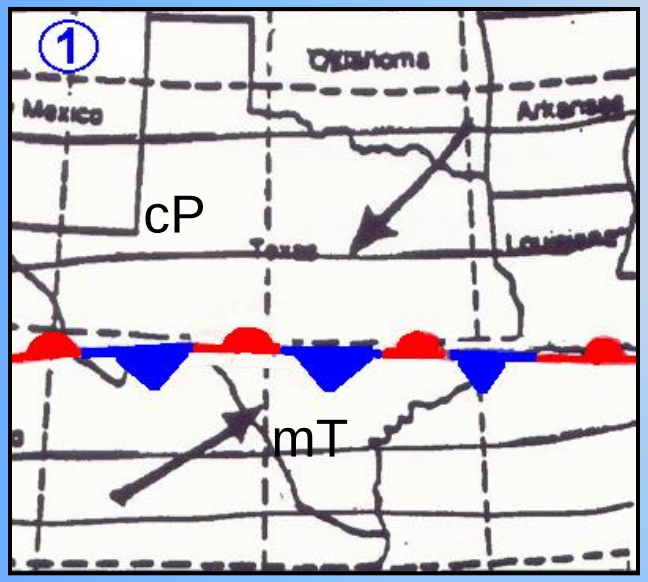
Good Morning 1.25.13 ☺

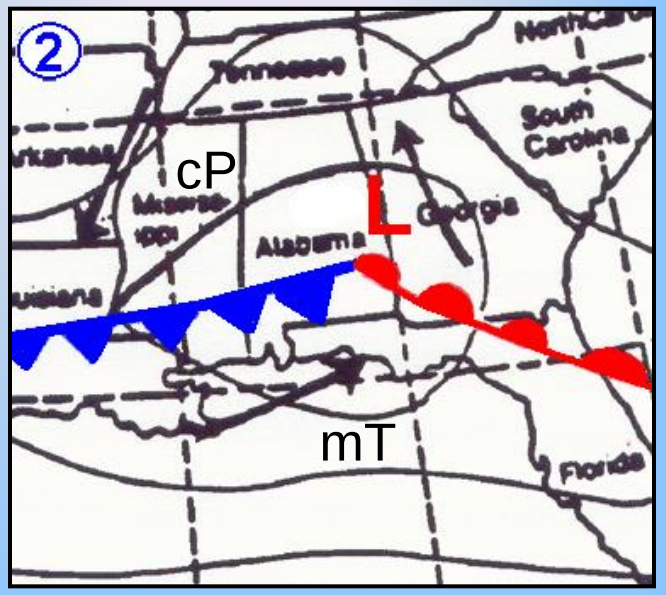
- Please begin: Do Now
- Notes: “The Life of a Wave Cyclone” (review)
- Can you find any fronts or Wave Cyclones on a current weather map?
- Can you make a weather forecast?
  - American Meteorological Society
- Go over HW: The Cyclonic Wave Wksheet #1-16
- Go over UPCO questions next period
- Reminder: CL.com due next Tuesday
- HW: Upper Level Chart for Jan. 24

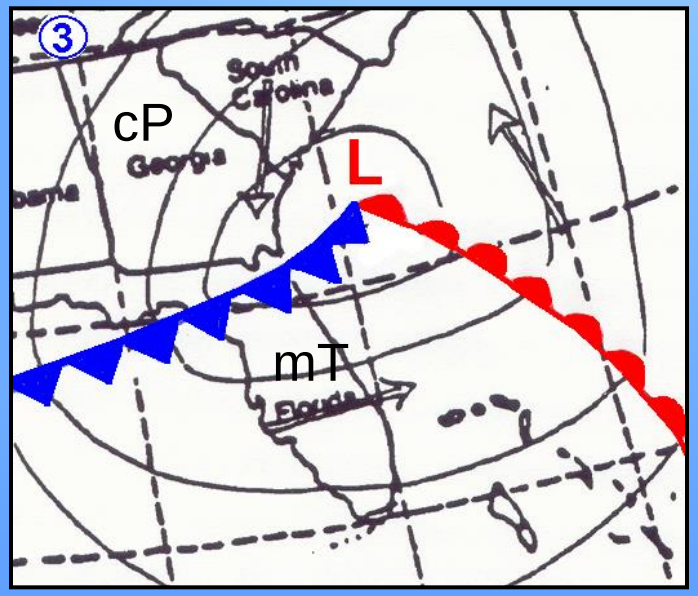
The Life Cycle of a Mid-latitude Cyclone

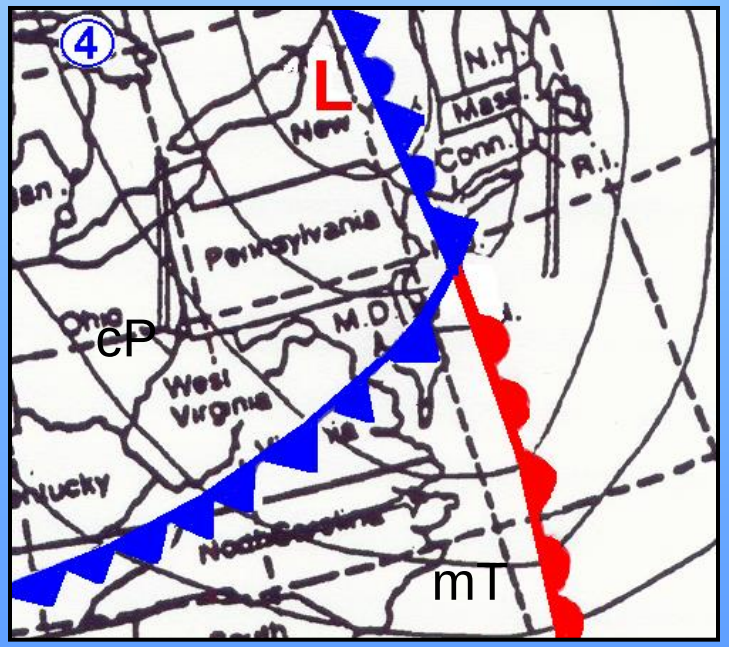
Cyclone formation is called Cyclogenesis

Cyclogenesis (label on your own ditto!)



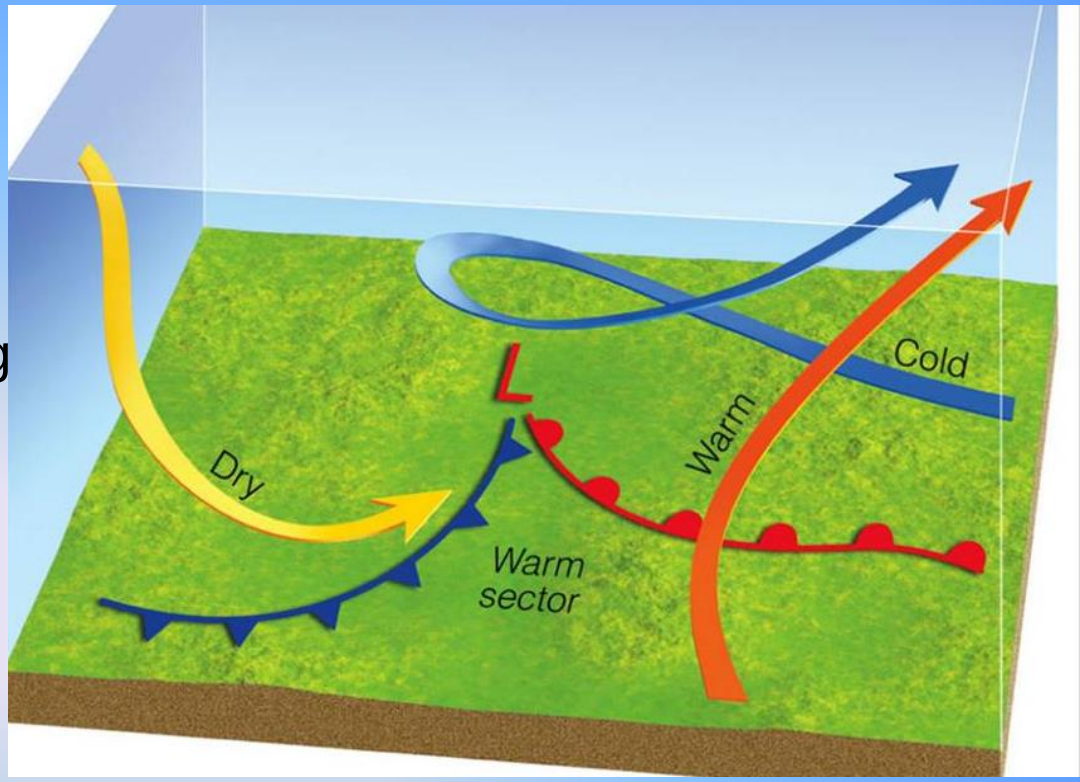




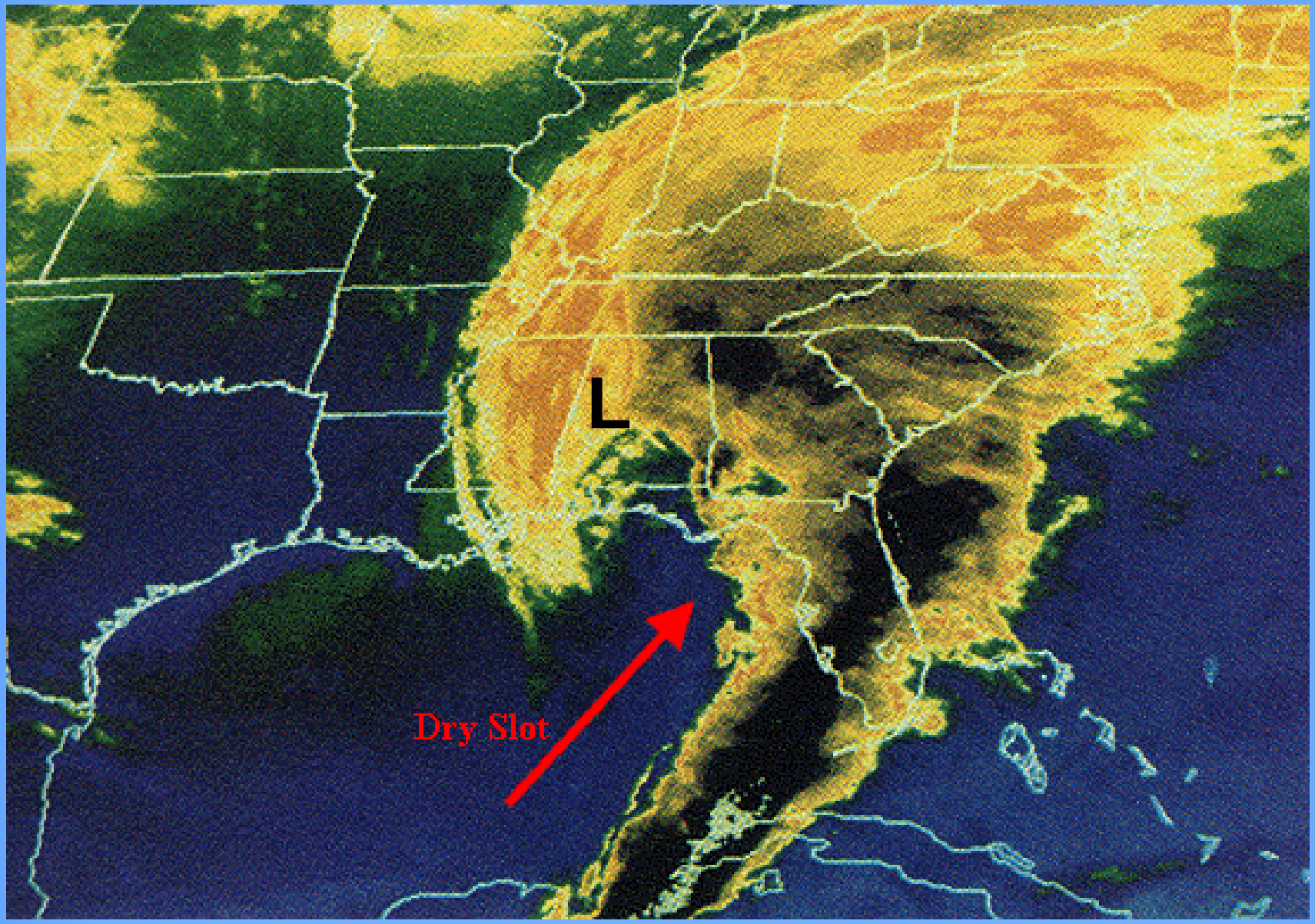


Warm conveyor belt -
Originates at low levels in the warm sector

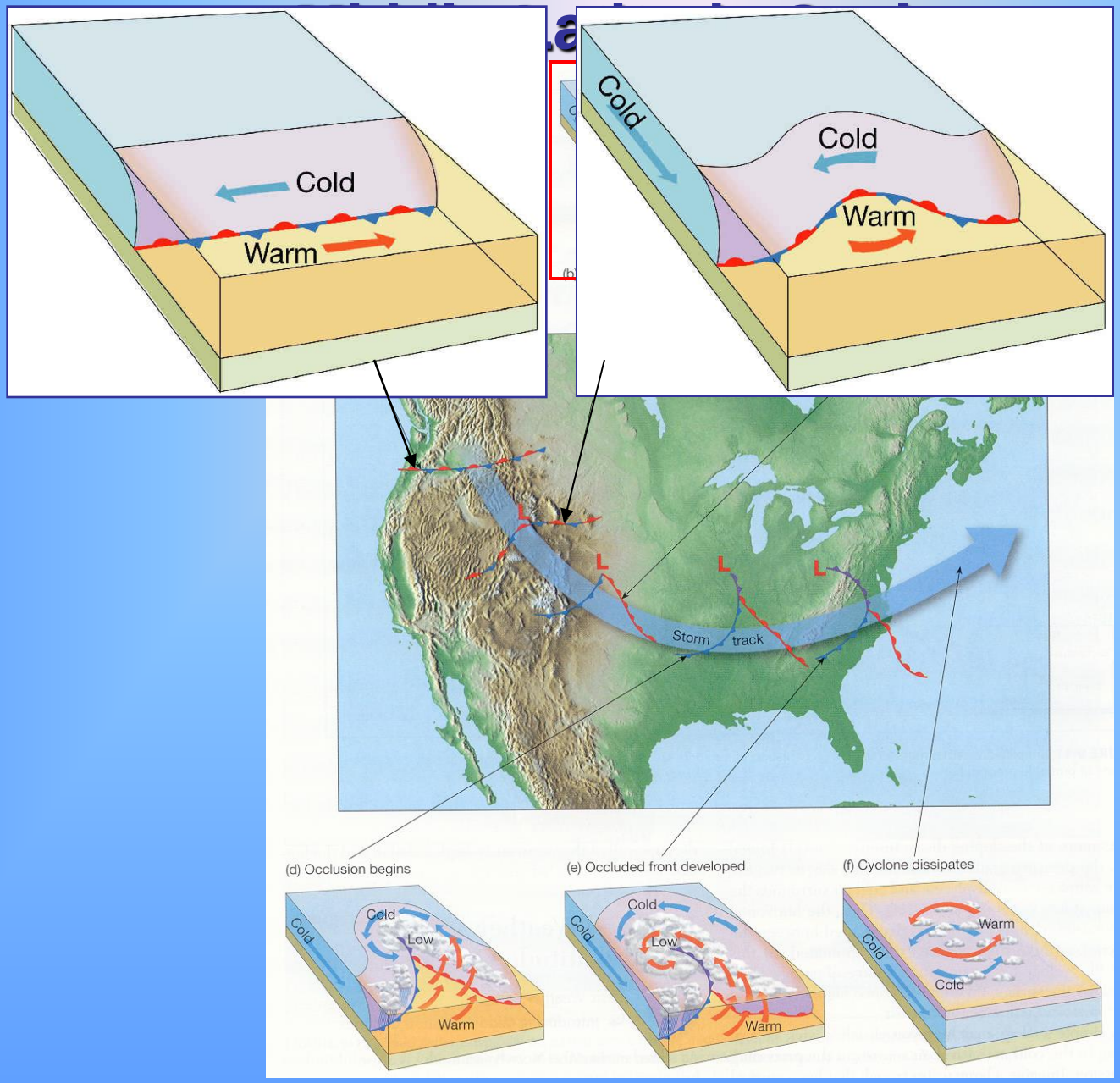
Dry conveyor Belt -
Originates at upper levels and descends to the surface
Often produces a region of clearing skies behind the cold front.
Here is an example of the clearing produced by the cold, dry air descending to the surface



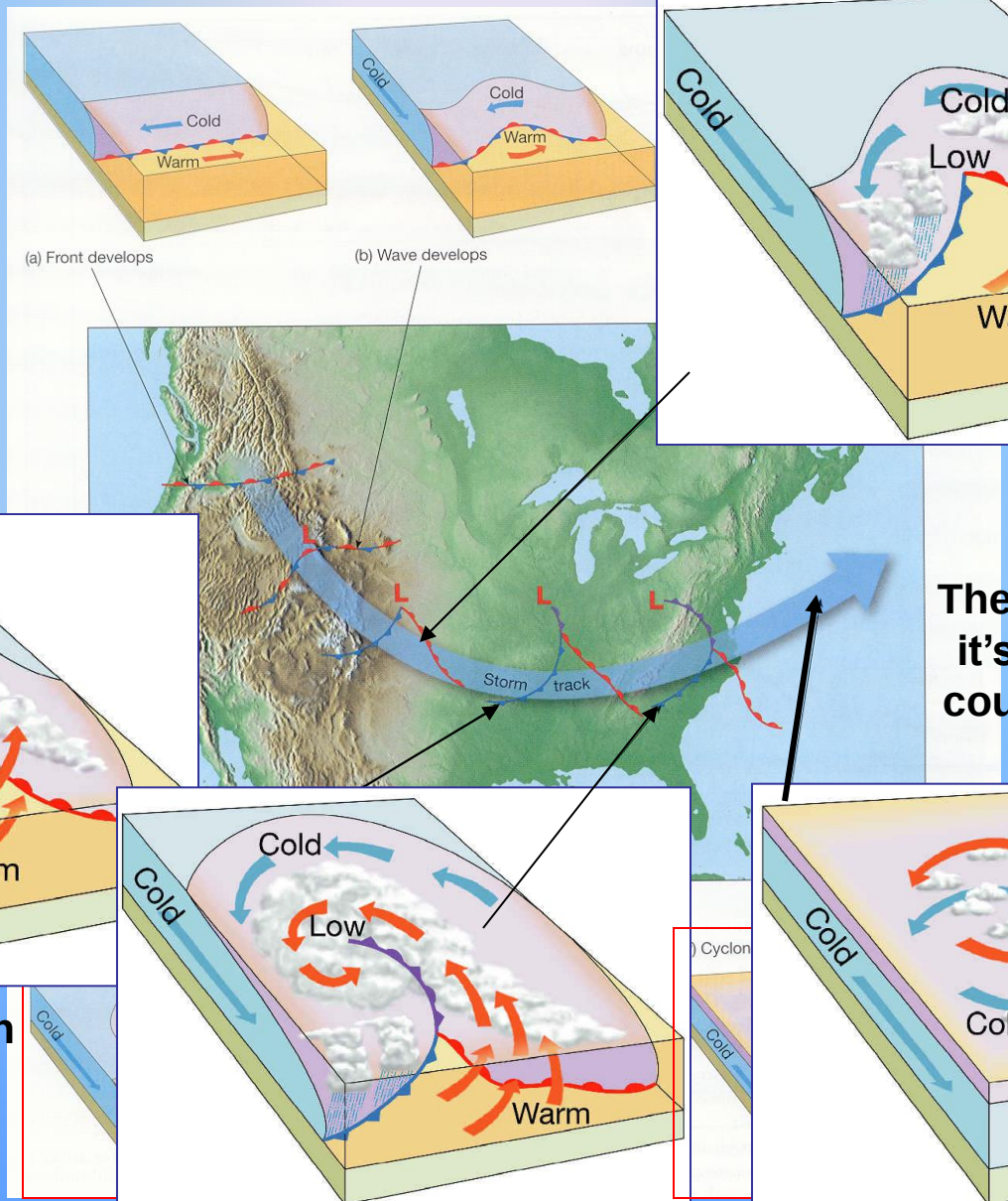
Cold Conveyor Belt -
originates NE of low, swirls into the low at then ascends to upper levels


L
Dry Slot

Stages in the Formation of a



Stages in the Formation of a Middle-Latitude Cyclone



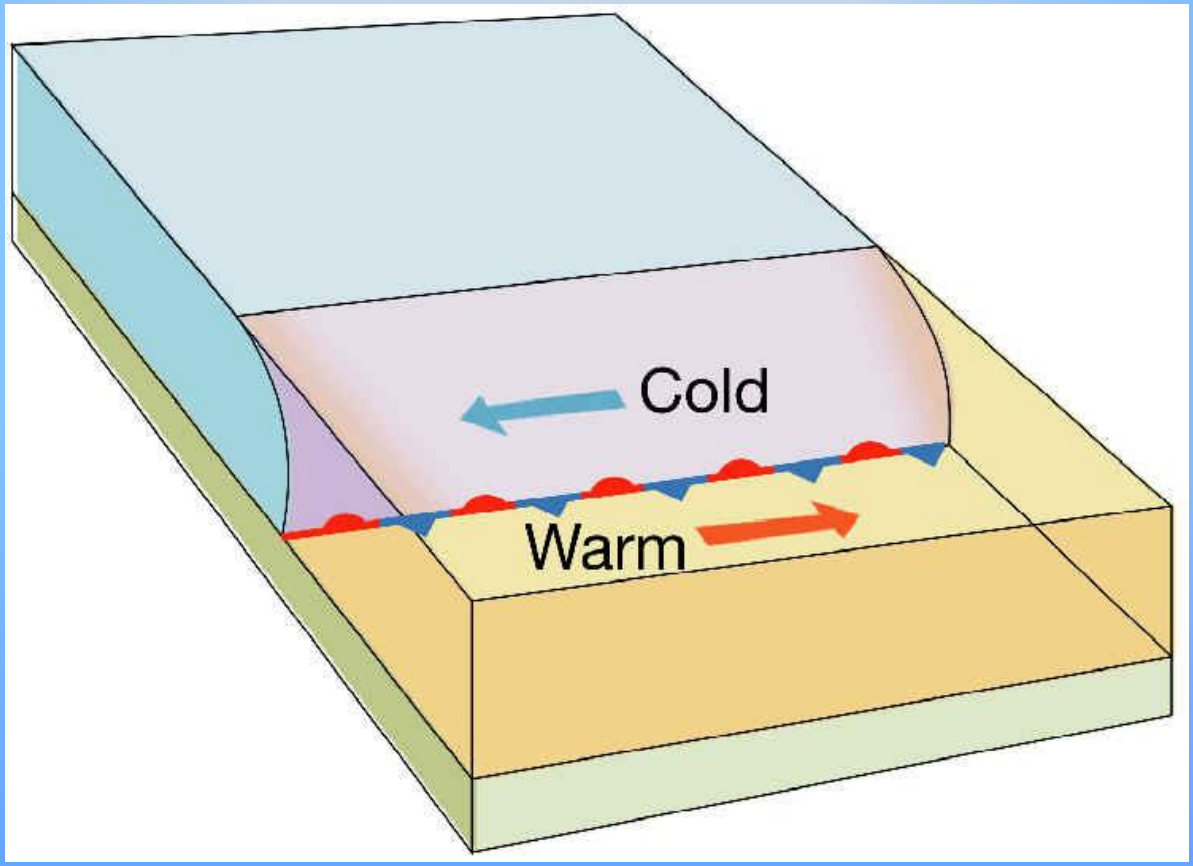
The storm has used up it's source of energy counterclockwise flow ceases to exist.

Storm Intensifies with Heavy Precipitation

Summary

A. The Life Cycle of a Wave Cyclone

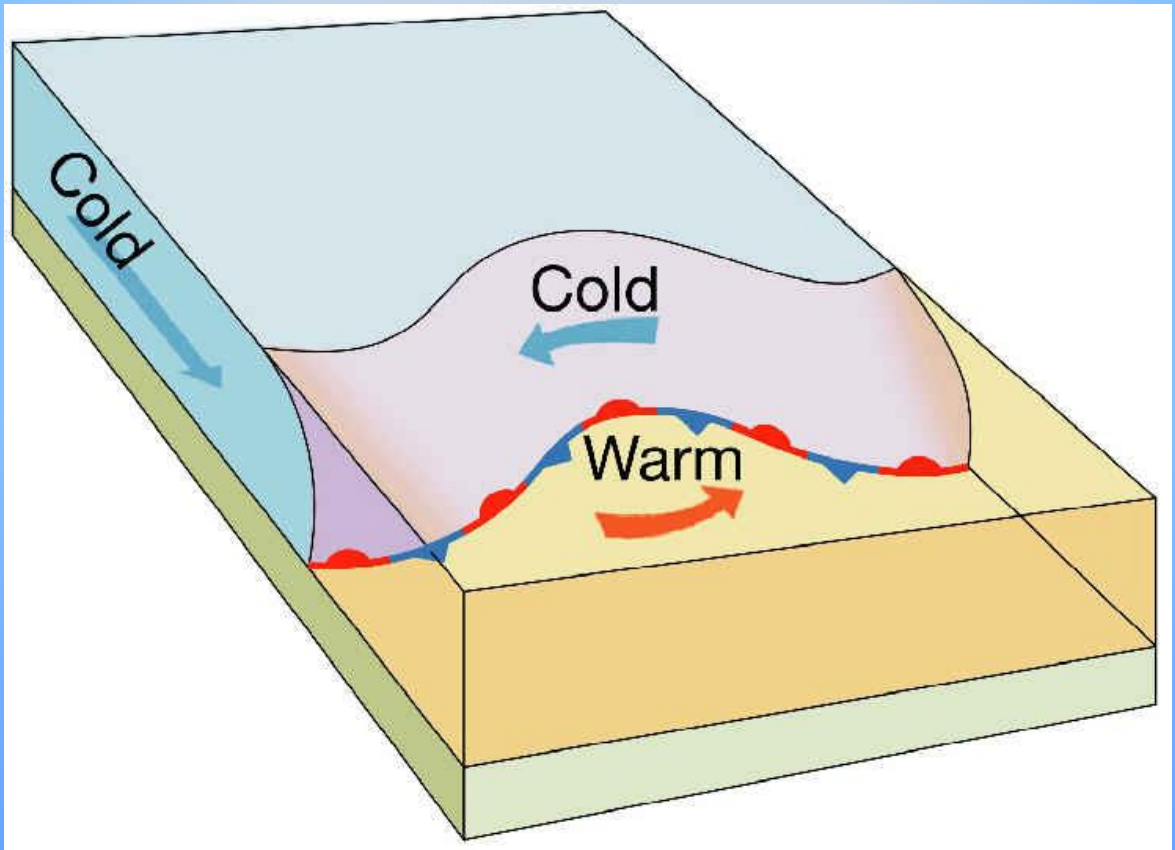
1. The front Develops (Stationary)



Summary

A. The Life Cycle of a Wave Cyclone

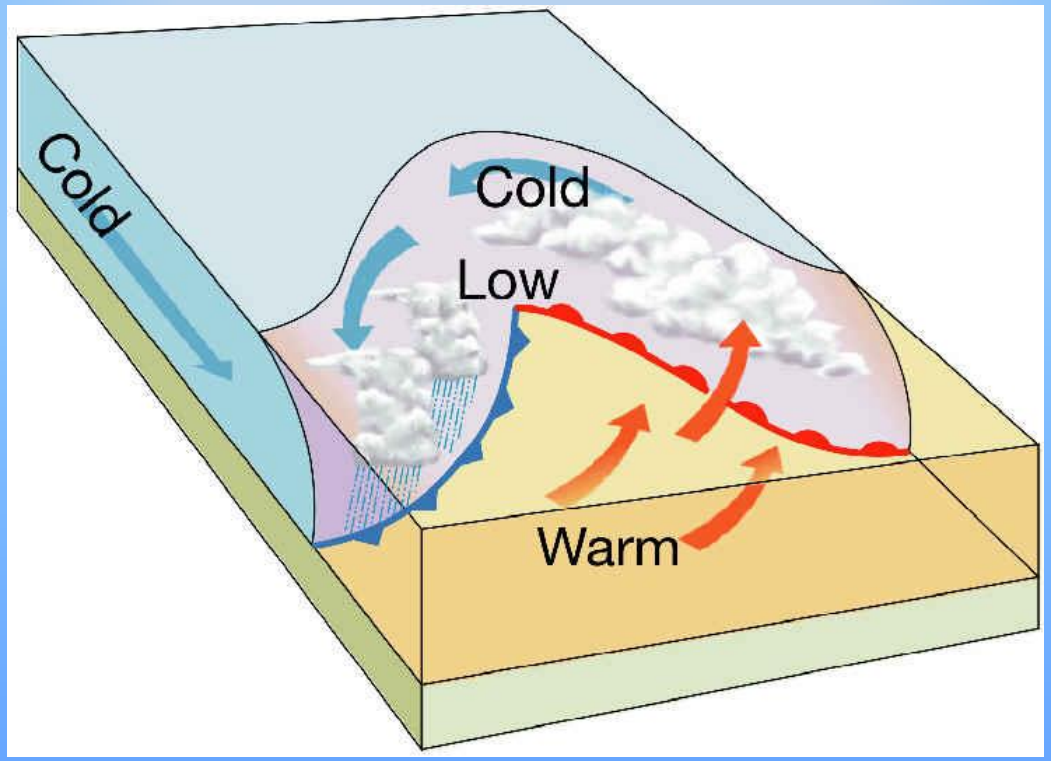
2. A wave Develops (Stationary)



Summary

A. The Life Cycle of a Wave Cyclone

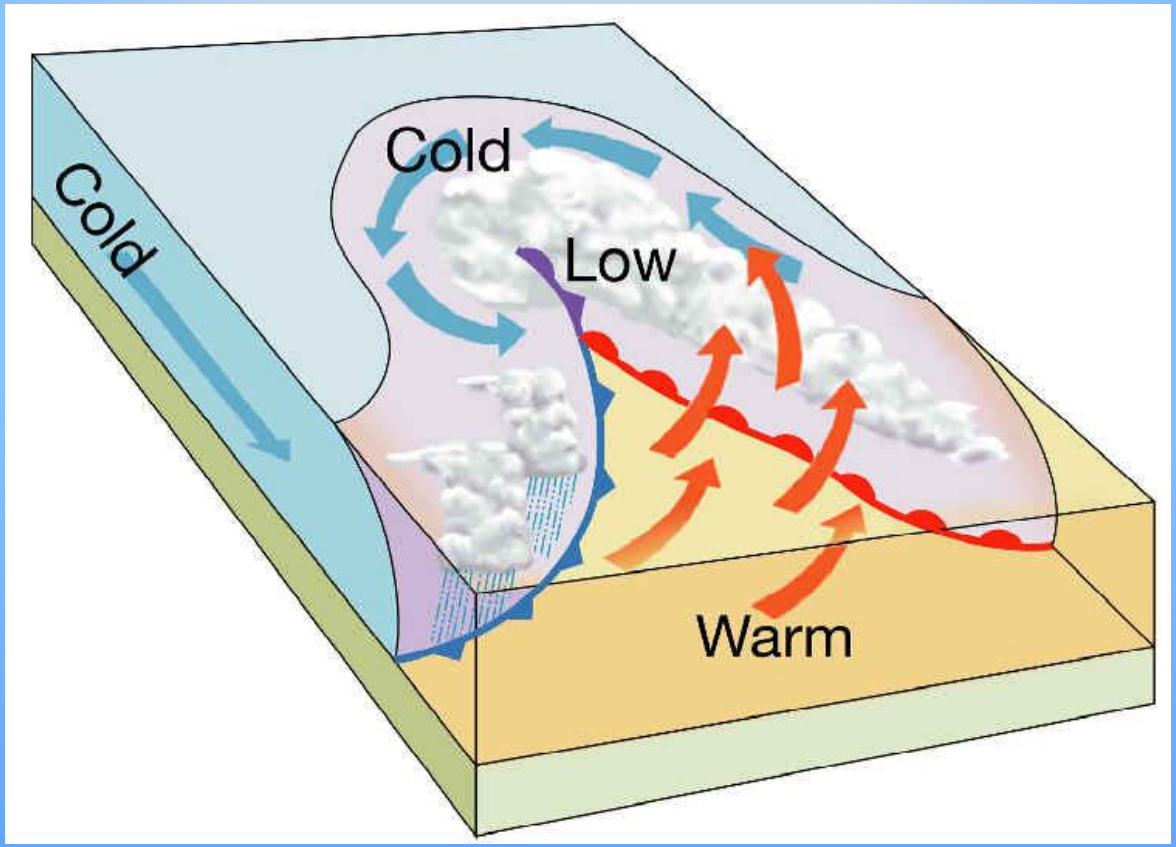
3. **Cyclonic** Circulation is established



Summary

A. The Life Cycle of a Wave Cyclone

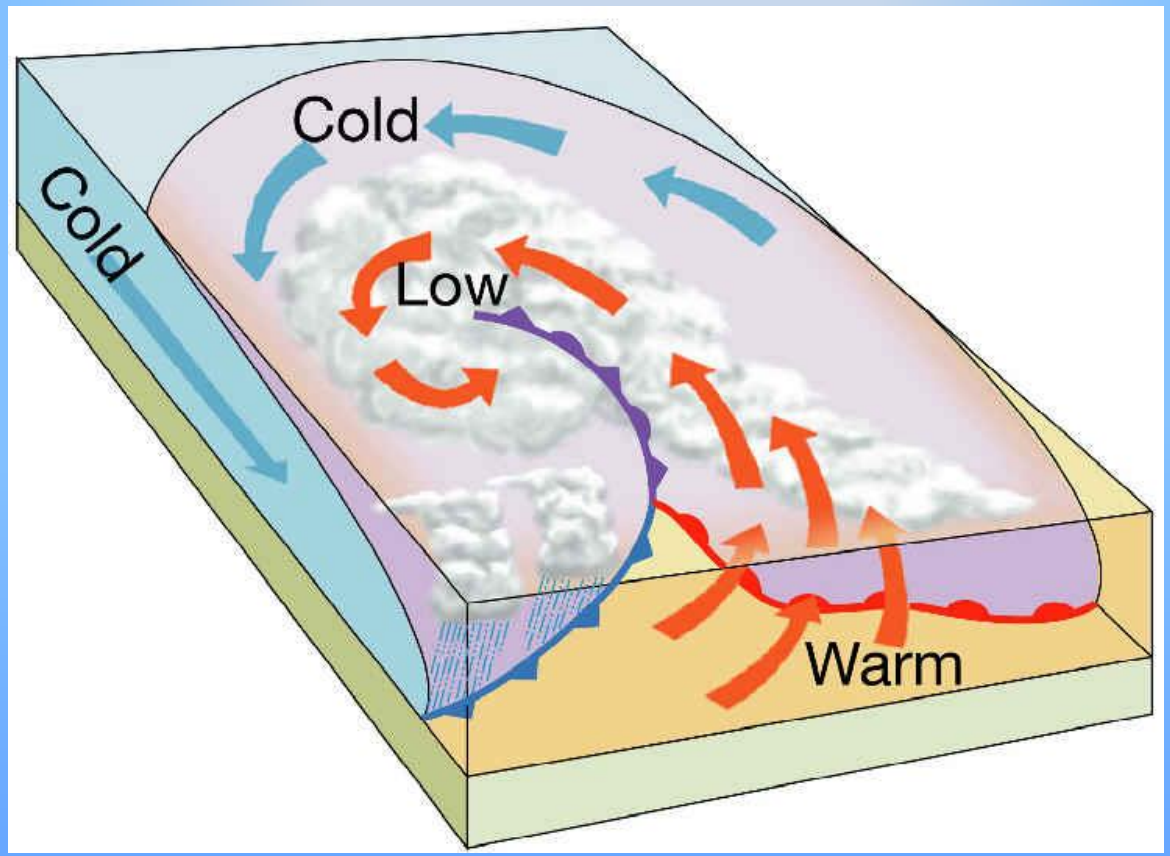
4. **Occlusion** begins



Summary

A. The Life Cycle of a Wave Cyclone

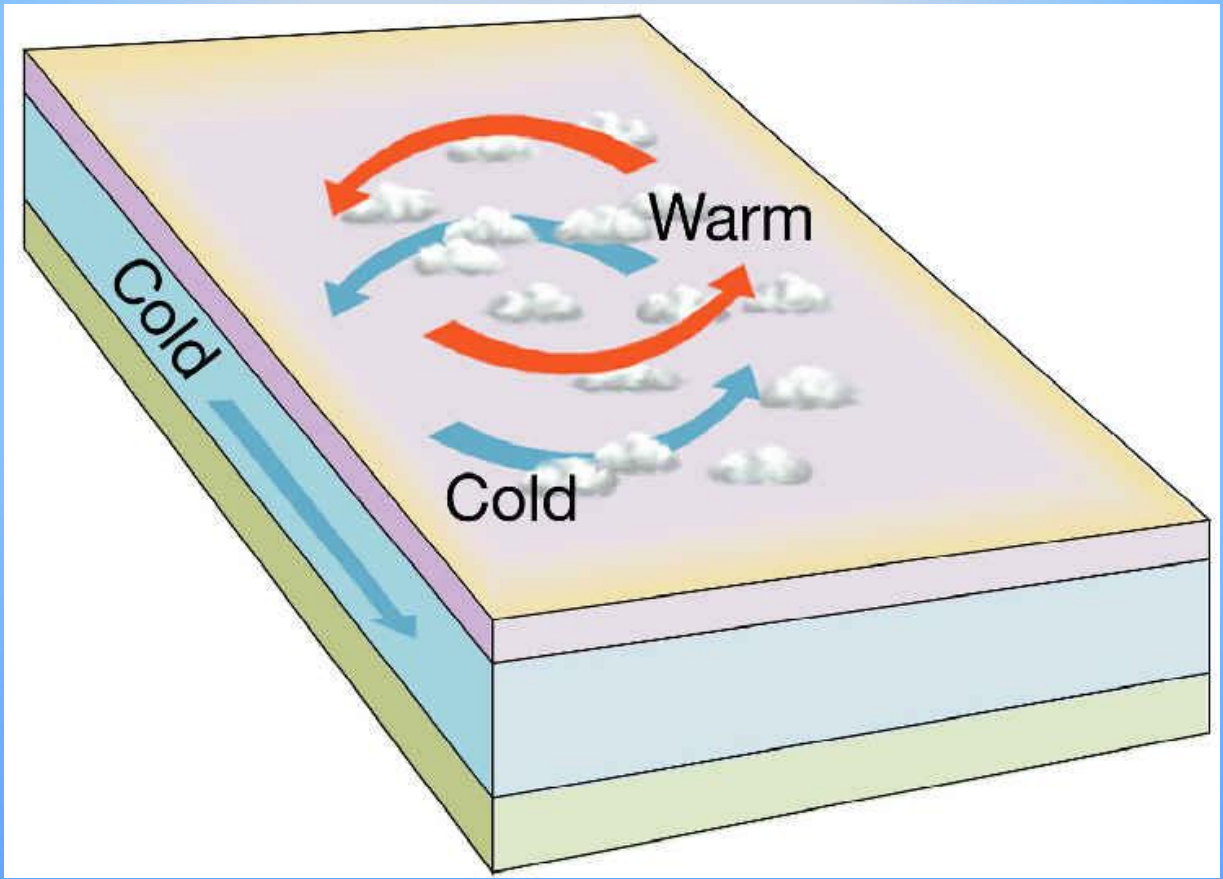
5. The occluded front is developed



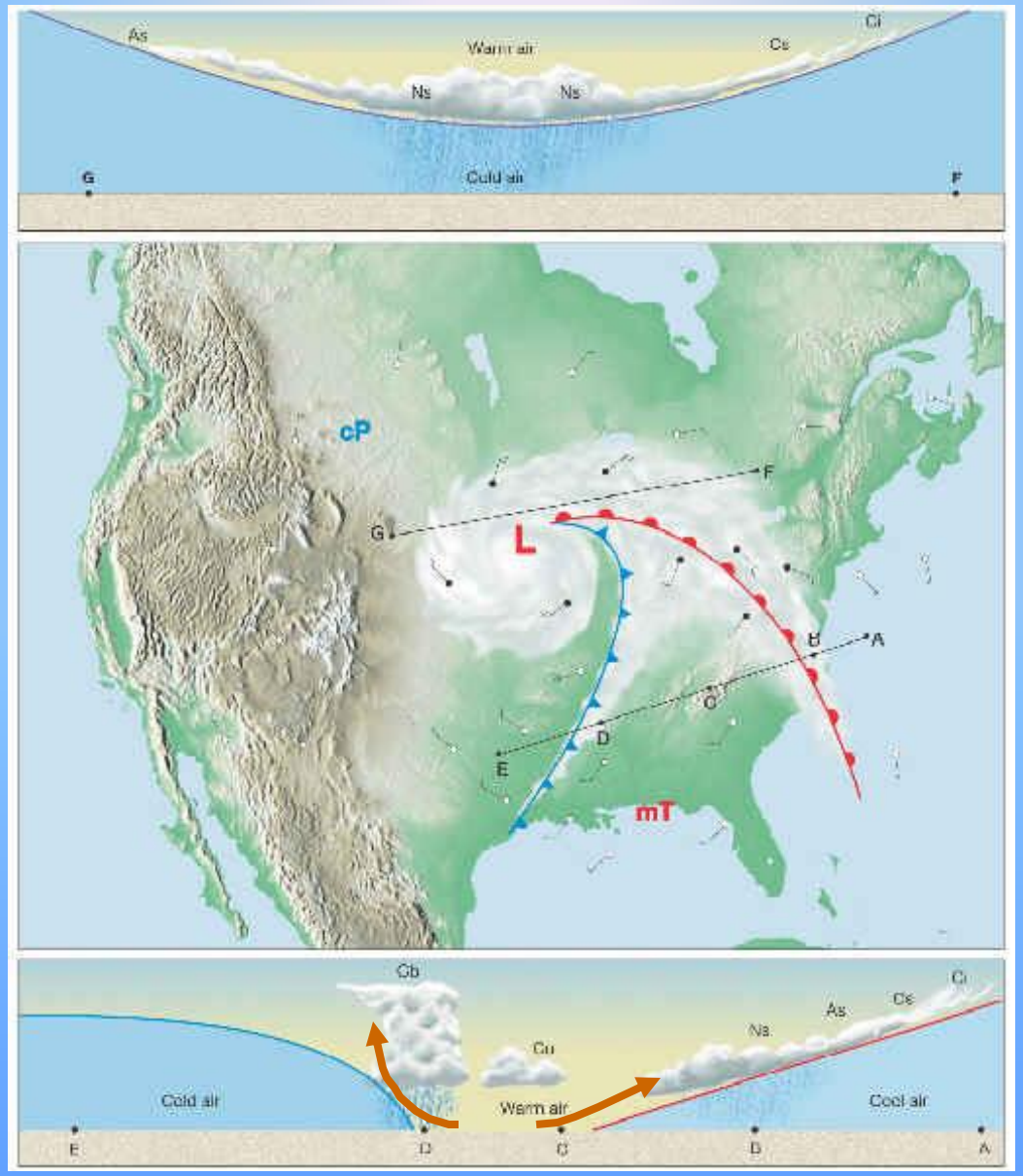
Summary

A. The Life Cycle of a Wave Cyclone

6. The cyclone **dissipates**



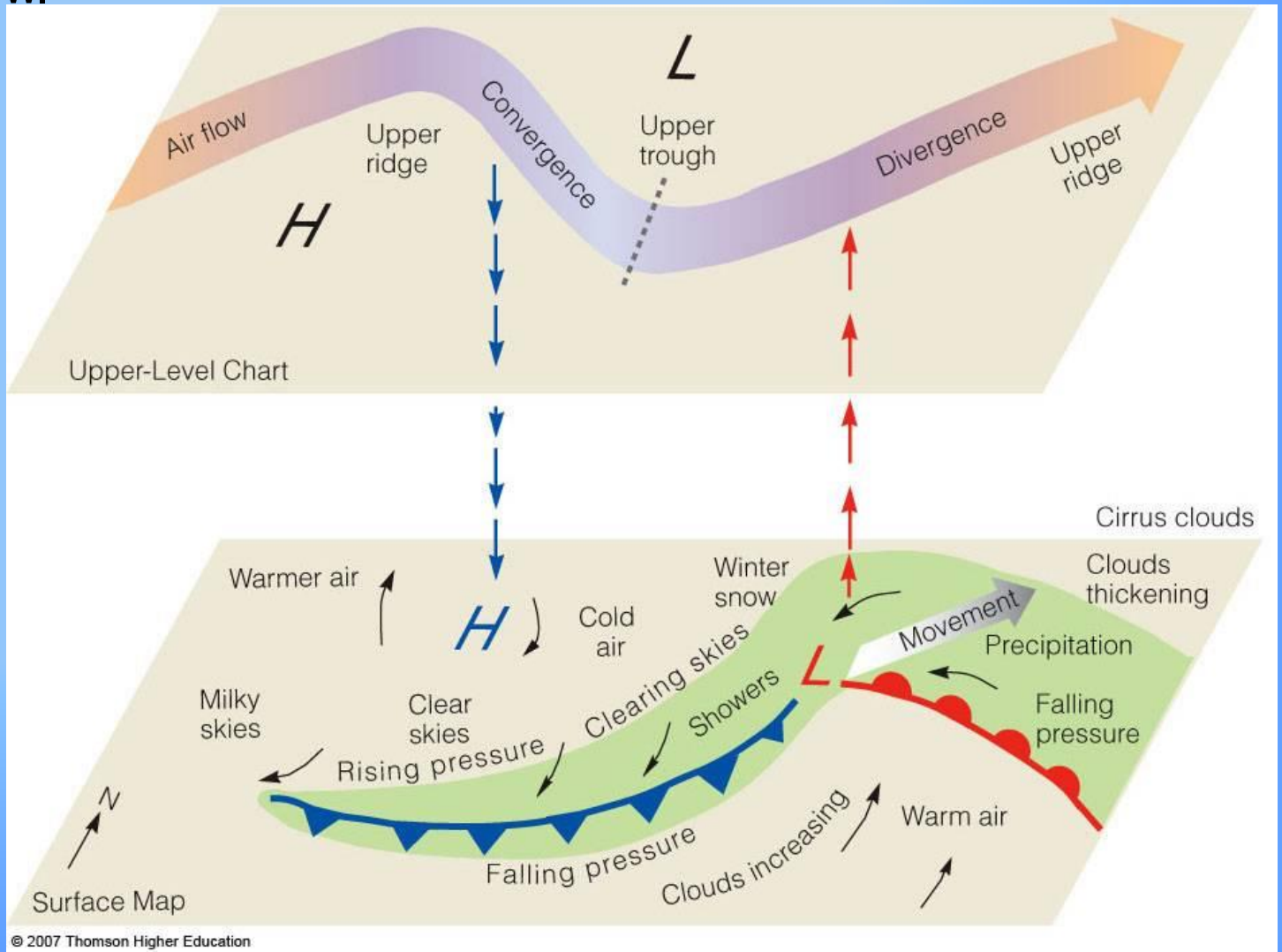
Cloud Patterns Associated with Cyclones



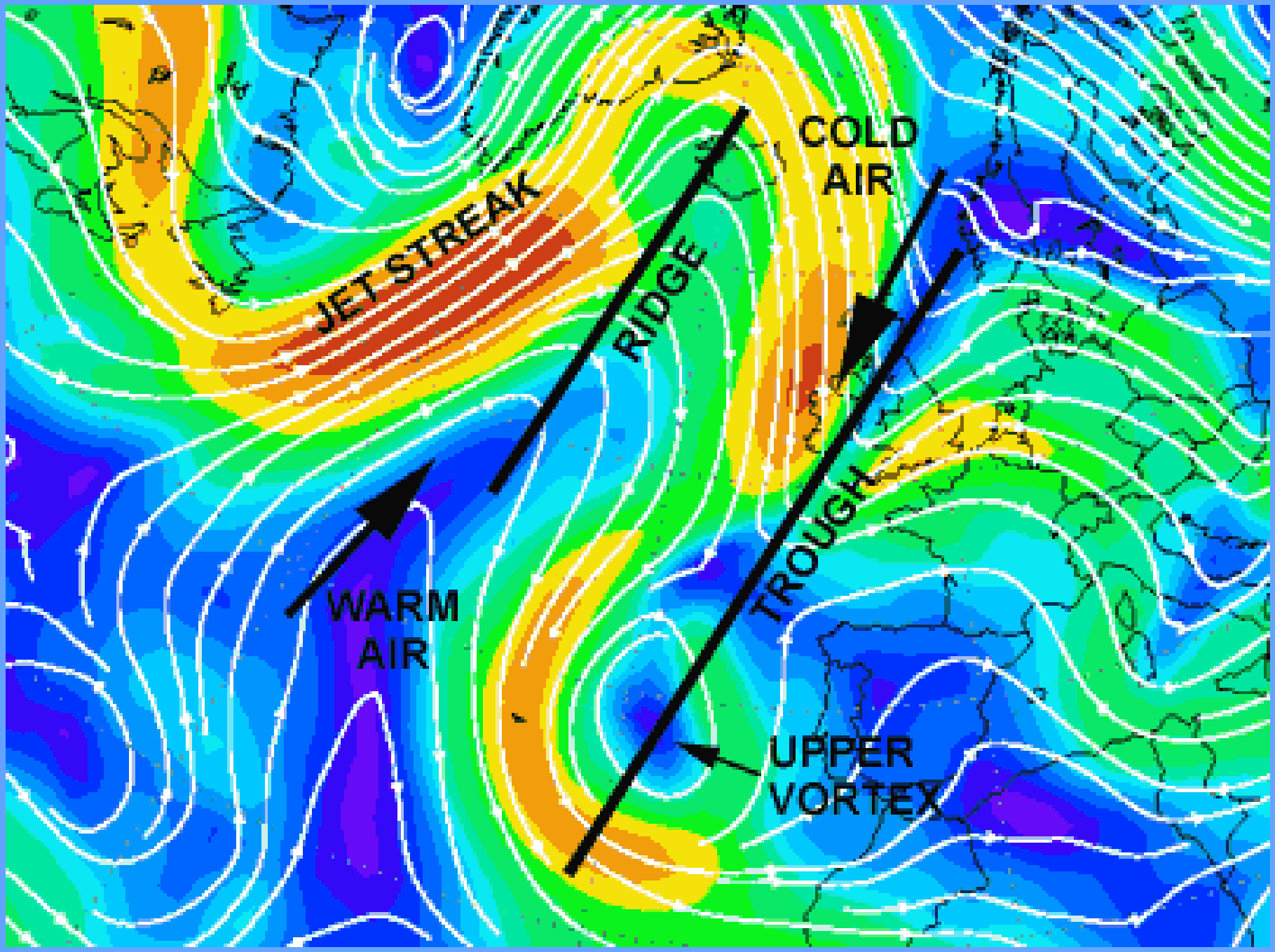
Good Morning! 1.29.13

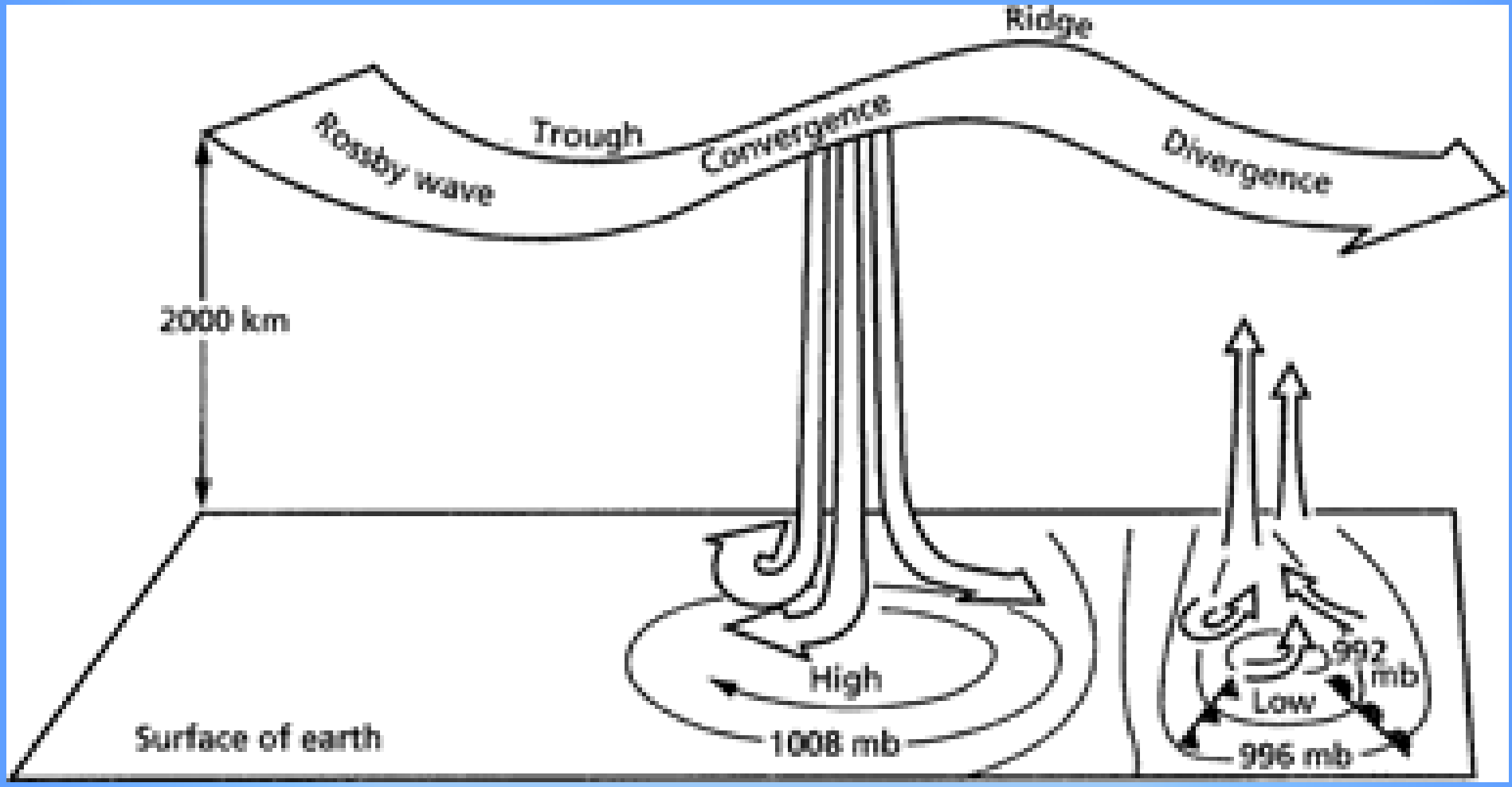
- Reminder: CL.com due today by 4 pm
- Dittos: Set 2 –Key to Weather Symbols due Wednesday
- Exam Friday
- Today return exam, Upper air Maps Notes

• Usually need to have a disturbance at the surface (area of lower pressure) normally along the polar front
• Also need upper-level support - a short wave with associated upper-level low/trough must be situated such that the upper-level low is to the northwest of the surface low.



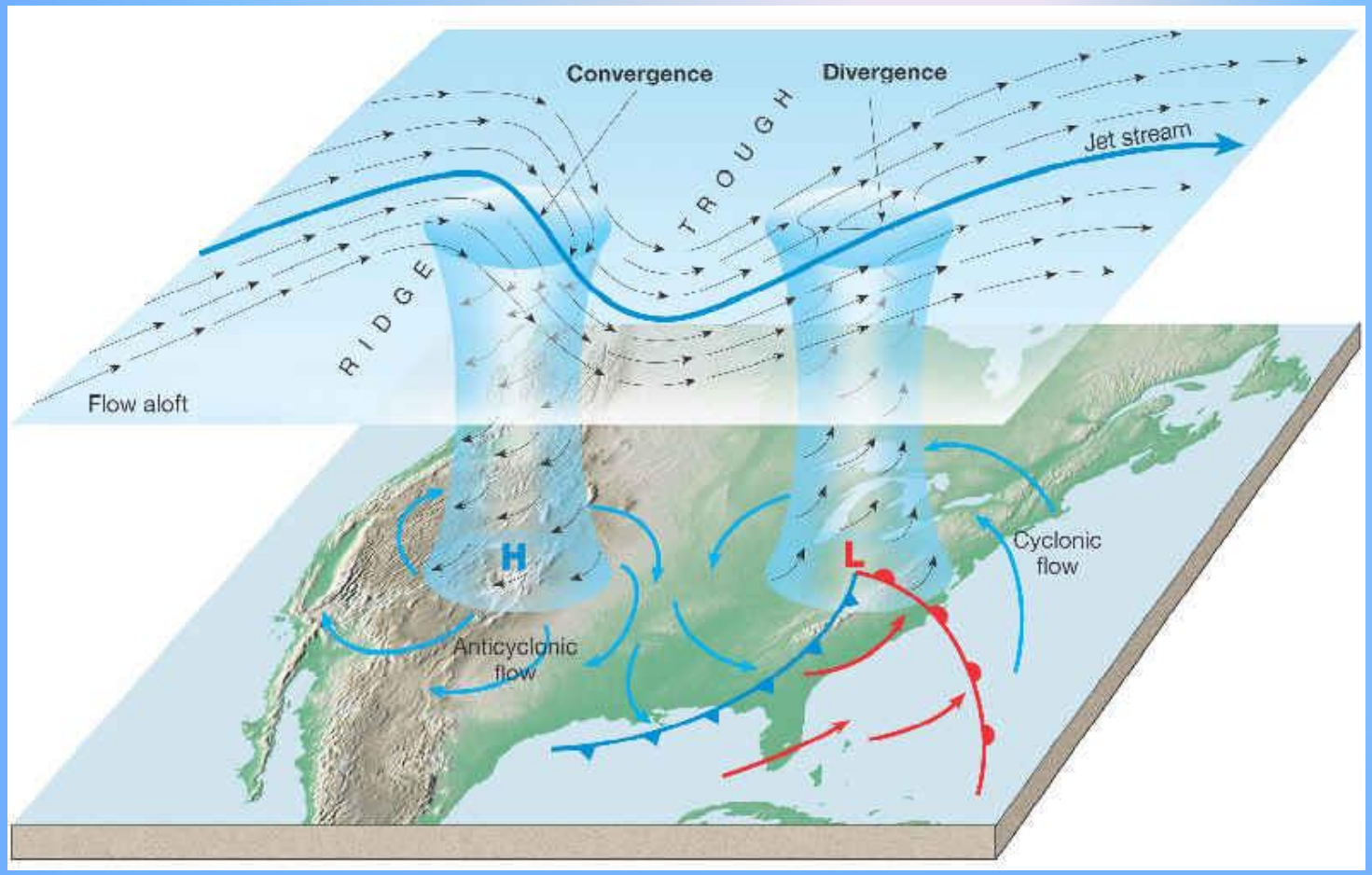

L
Ridge
H
Trough
L
H


JET STREAK
RIDGE
COLD AIR
TROUGH
WARM AIR
UPPER VORTEX


Ridge
Trough
Convergence
Rossby wave
Divergence
2000 km
High
1008 mb
992 mb
Low
996 mb
Surface of earth

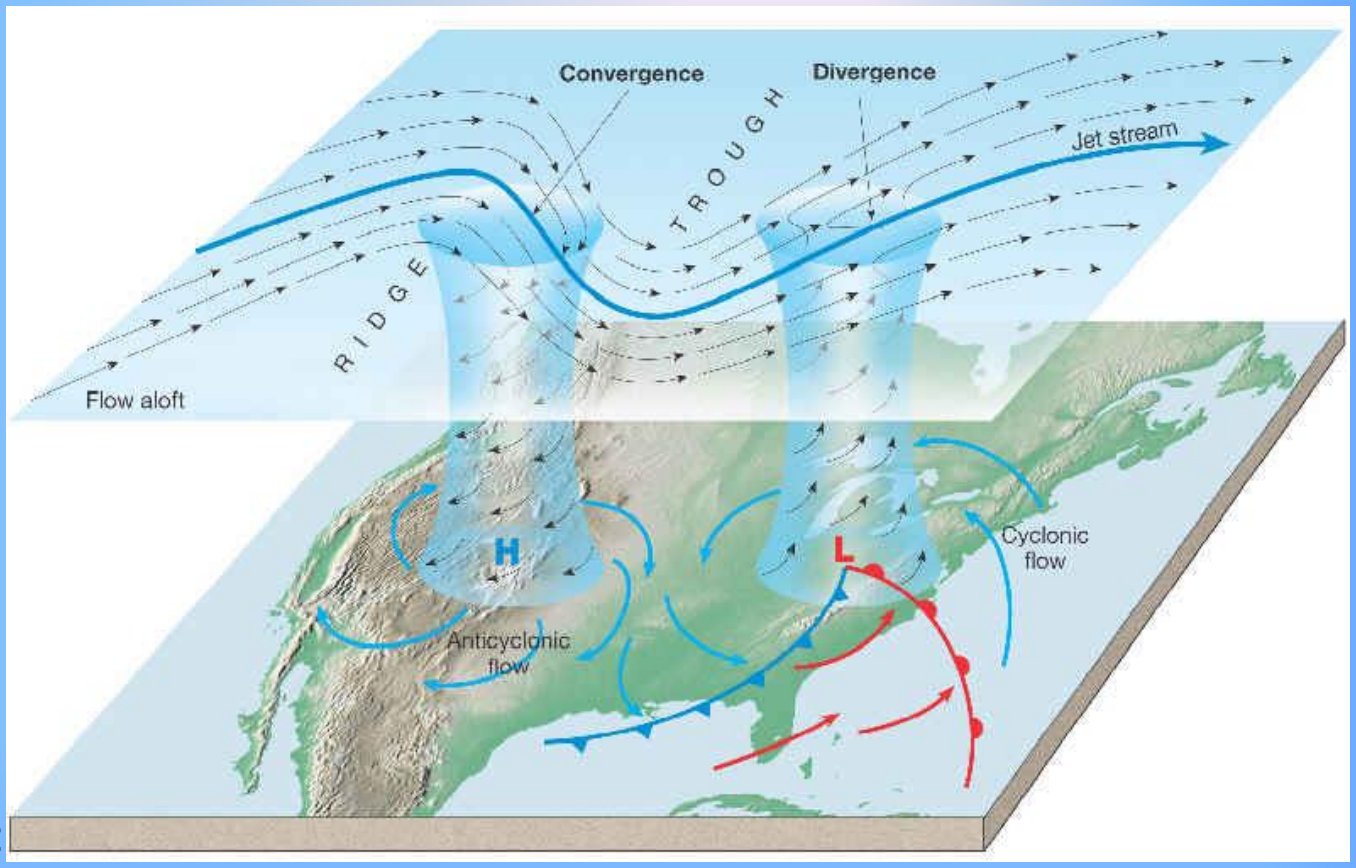

DEJA VU
THURSDAY SETUP
H
Heavy Rain
Threat

B. Interaction of Cyclones and Anticyclones



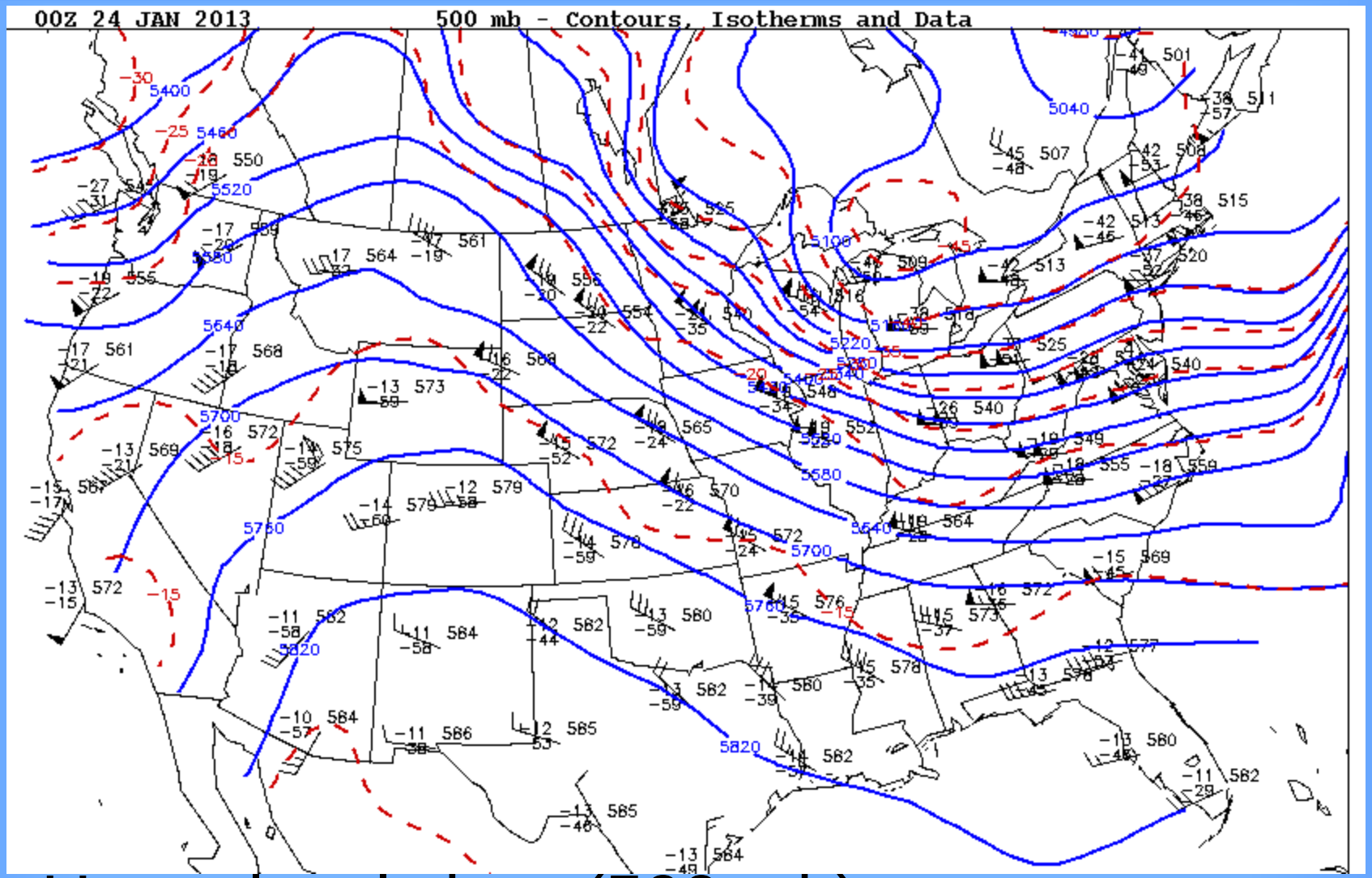
1. Typically found adjacent to one another (surface air from a high feeds the low)
2. For a middle-latitude wave cyclone to form:
   a. Cyclonic flow must be established
   b. Inward flow of air near the surface must be supported by outflow aloft

3. Convergence and Divergence of Air



a. <u>Upper Air Ridge</u>:
   (1) Slowing of the jet stream results in *speed convergence* (pileup of air).
   (2) Supports a surface high (anticyclone) located downstream from the ridge
   (3) Convergence aloft results in divergence at the surface.

b. Upper <u>Air Trough</u>
   (1) Jet stream winds accelerate and stretch out (*speed divergence*).
   (2) Located slightly ahead of the upper-air low pressure trough axis.
   (3) Surface cyclones form below a trough in the polar jet stream a continue to develop downstream from these upper-level waves.



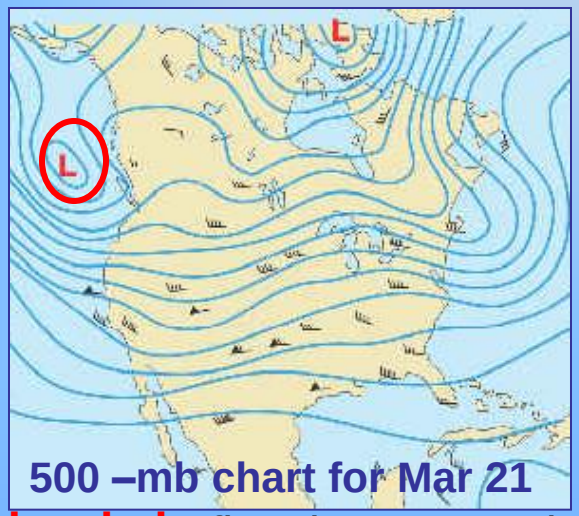
- Upper level chart (500 mb)
- Where is the jet stream?
- Where is a Trough and Ridge?

4. Vorticity

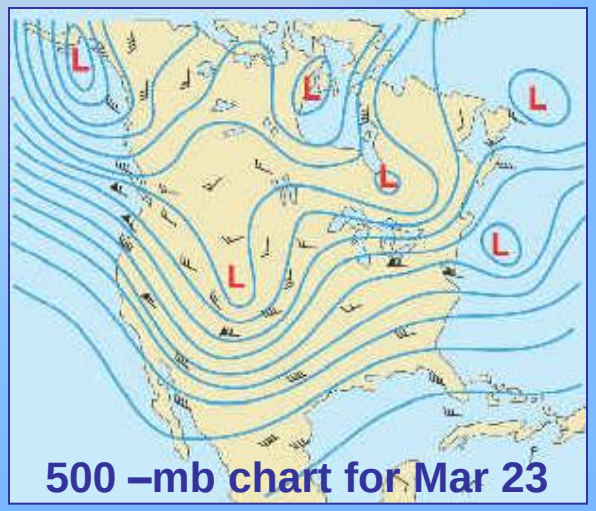
a. The tendency of air to **spin** in a whirlpool-like vortex
b. Waves in the jet stream causes **rotation** of the air masses
c. Air mass south of jet stream near the ridge develops **anticyclonic** flow
d. Air mass north of jet stream near the trough develops **cyclonic** flow

C. Storm Tracks

Movement of cyclone from March 21 -24



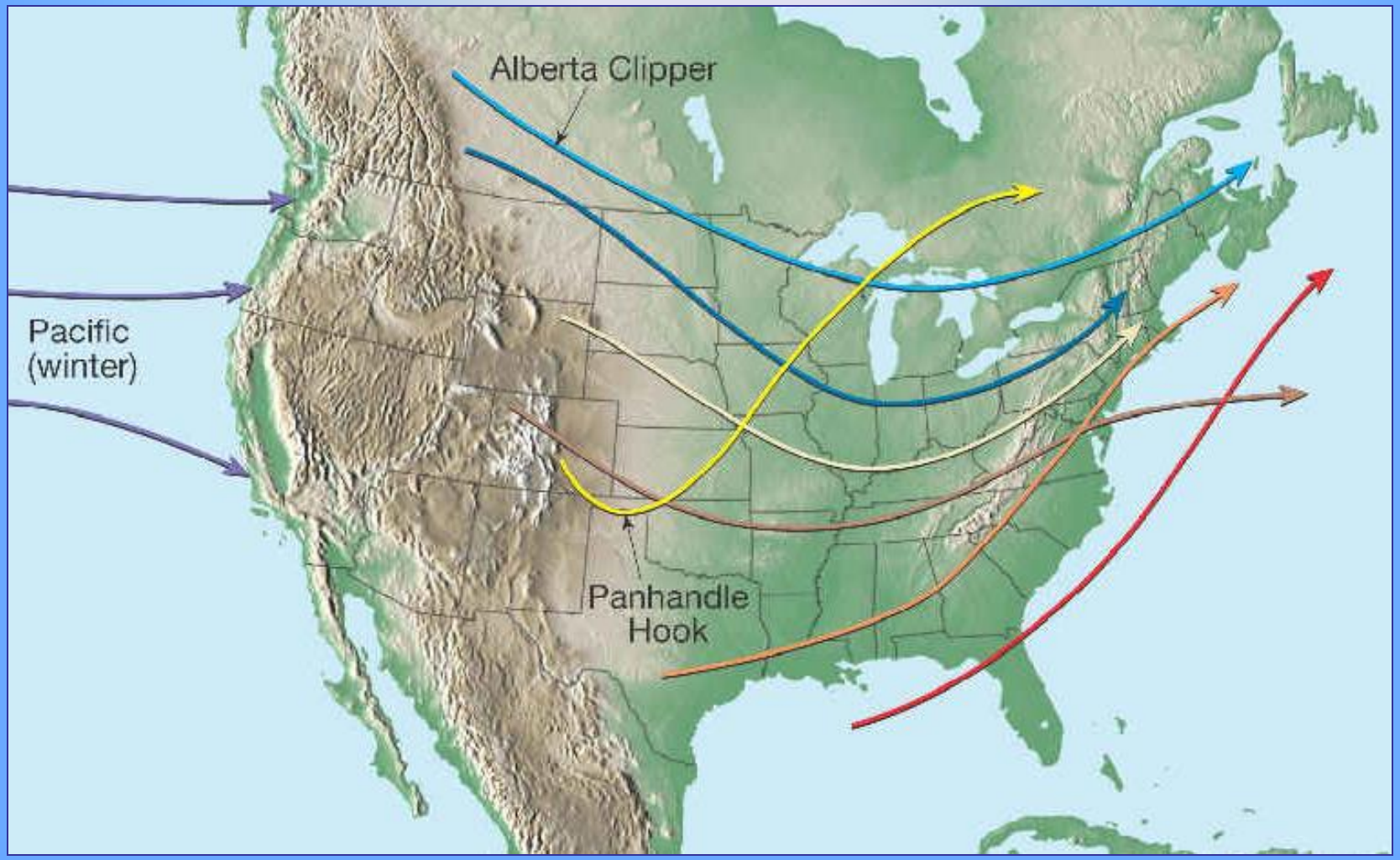
500 –mb chart for Mar 21



500 –mb chart for Mar 23

1. **Upper-level air** flow has a steering effect on cyclonic movement. Directions are influenced by 500 millibar contours
2. Rate is normally 20 to 50 km/hr (**higher** speeds occur in the winter with higher pressure gradients).
3. Cyclones tend to migrate toward the **northeast**
4. **Anticyclones** are embedded between cyclones and travel northeastward with the cyclones.

Typical Storm Tracks

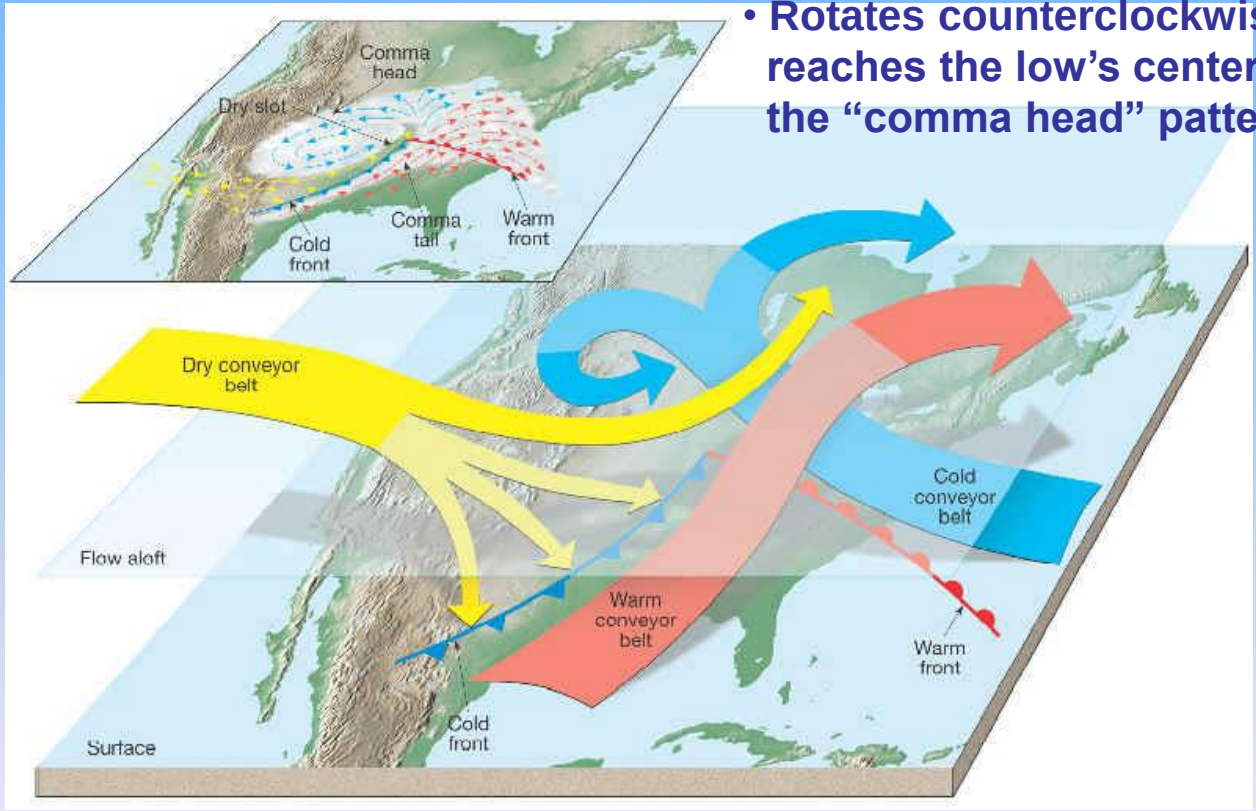


A New View: The Conveyor Belt Model

Dry Conveyer Belt: Starts in upper troposphere and splits upon entering the cyclone. One branch sinks behind the cold front (cold and dry conditions) and the other maintains westerly flow which forms the *dry slot* separating the head and tail of the comma.

Cold Conveyor Belt:

- Starts Ahead of the warm front and flows west into the center.
- Picks up moisture as if flows under the warm conveyer belt.
- Rotates counterclockwise when it reaches the low's center and produces the "comma head" pattern of clouds



Warm Conveyor Belt: Warm moist air moves into the warm sector and rises due to convergence. A wide band of clouds with precipitation forms.

Wave Cyclone