

# Clouds and Precipitation

**I. Clouds:** Clouds are a collection of trillions of extremely small (20 - 50  $\mu\text{m}$ ) water droplets or ice particles.

## **A. Cloud Formation Requirements**

- 1. Temp must drop to dew point:** Droplets can form only when the dew point has been reached and the air is saturated.
- 2. Condensation Nuclei must be present:** Water vapor must have a surface on which it can condense. In nature *dust*, *smoke*, *volcanic ash*, and/or other microscopic particles can serve as condensation nuclei.

## **B. Cloud Types**

- 1. Cirroform (cirrus):** high altitude, wispy, ice crystal clouds
- 2. Stratiform (stratus):** horizontal, *layered* clouds
- 3. Cumuliform (cumulus):** globular, puffy clouds.  
Nimbus = dark rain cloud  
Cumulonimbus = vertical, dark, cumulus rain cloud  
Nimbostratus = flat, layered dark rain cloud

**II. Fog (clouds at ground level):** Fog is essentially clouds at ground level. Fog will form whenever moist air (i.e. air with enough water vapor) is cooled to the dew point.

### **A. Radiation (Radiation Deficit) Fog:**

- Forms in flat, low areas at night – usually under still, quiet conditions.
- The natural nighttime radiation deficit results in cooling of ground (called radiation cooling)
- The cold ground cools air above it to the DEW POINT, forming fog droplets.

### **B. Advection Fog (“sideways fog”):**

- Forms when moist air moves over cold surfaces (like California’s cold ocean current)
- The moist air cools and condenses to fog.
- Fog may then move to a new area (from ocean to land)

**C. Valley Fog:** Forms where dense, cold air drains (sinks) off of the mountain slopes, settles in the a valley, and condenses.

**D. Evaporation Fog:** Forms when water evaporates from the surface of a relatively warm water body (e.g. lake, pond, etc) into much cooler air. Upon hitting the cool air it immediately condenses into fog.

**E. Upslope Fog:** Forms when moist air is pushed up a slope, cools adiabatically, and condenses into fog.

**III. Precipitation Formation (not covered):** Not all clouds produce precipitation (rain, hail, snow, etc), BUT precipitation formation can only happen in a cloud.

**IV. Air Masses:** These are large bodies of air with uniform temperature and moisture characteristics.

**A. Source Region:** The source region is where an air mass originates. When an air mass sits over a surface long enough, it will acquire the characteristics (moisture and temperature) of that surface.

**B. Classification:** Air masses are classified by the surface and latitude of the source region.

**1. Surface:** There are only two choices, *maritime* (m) and *continental* (c). Maritime air will consistently be more humid than continental air.

**2. Latitude:** There are four choices, though we will only use *polar* (P) and *tropical* (T) in class. Generally, the farther poleward the source region, the colder the air. Remember that cold air will have a lower specific humidity.

Surface	Latitude
<b>Maritime (m)</b> ocean surface	<b>Arctic (A)</b> highest latitude – near poles
<b>Continental (c)</b> land surface	<b>Polar (P)</b> ↓
	<b>Tropical (T)</b> ↓
	<b>Equatorial (E)</b> lowest latitude – near equator

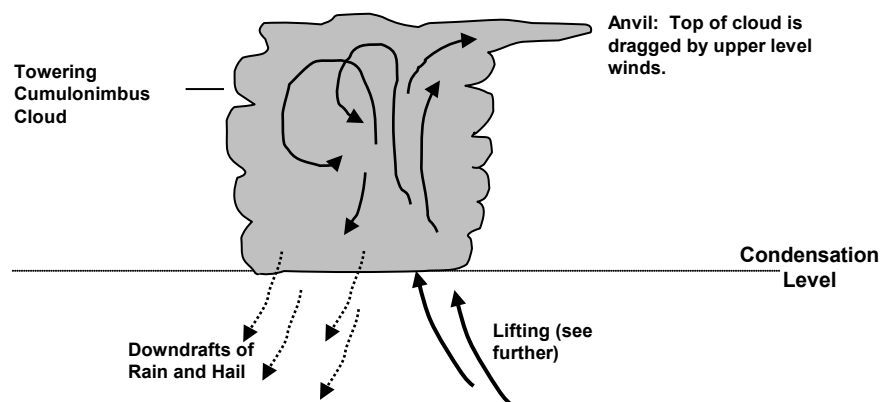
**3. Examples:** A Maritime Polar air mass would be designated as mP; a Continental Tropical air mass would be designated as cT. Which would be the wettest and the driest?

**V. Thunderstorm Cell or Convection Cell (the classic view):** Occurs in unstable conditions where moist air is lifted rapidly. Lifting can be frontal, convective, or orographic.



**Process:** (1) Moist air lifted and cooled rapidly, (2) lifting condensation level is reached, (3) condensation occurs, (4) clouds and precipitation form, (5) rain and hail often caught in updrafts, (6) and massive buildup of rain and hail finally fall, creating down drafts. (7) Storm dissipates when no moisture remains.

**Thunderstorm Cell (side view)**

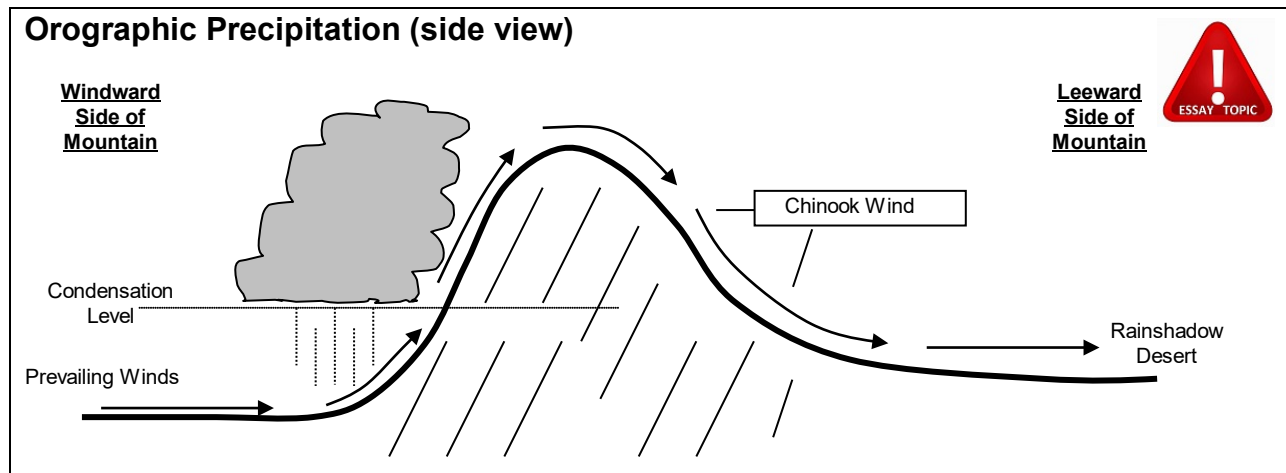


## VI. Three Lifting Mechanisms (What makes air go upward?)

### A. Orographic Lifting (air collides with mountain barrier and rises):



- When air collides with mountain it is lifted upward (in other words, it has no way to go but up and over)
- The lifting air cools adiabatically on its way upslope
- This commonly leads to condensation, cloud formation, and precipitation.
- When winds commonly come from the same direction, they are called prevailing winds. The side of the mountain facing “toward” the oncoming wind is called the windward side, while the side where the wind is “leaving” is called the leeward side.
- Rainshadow deserts are found on leeward sides of mountains, because air masses almost always arrive on the leeward side drier than they started (cause rain on the windward side dries out the air).
- Chinook winds (downhill winds) often occur on leeward slopes, because the air heats adiabatically on its downslope journey...



### B. Convective Lifting (air sits on warm surface, heats, and rises):

- Convective lifting will occur when air sits on a warm surface, heats, expands, and rises (this is called the buoyant force)
- Even though it is warm, the lifting parcel will cool adiabatically on its way up.
- This results in condensation, cloud formation, and precipitation.
- Tropical and monsoon rains are almost always convective.
- Arizona monsoon occurs in late summer as moist air from Pacific or Sea of Cortez moves over the hot surfaces of southern Arizona. This causes explosive thunder storms and occasionally flash floods.

**C. Frontal Lifting (cold and warm collide – warm goes UP!):** When two air masses collide, the warmer air mass will always be forced up. The boundary between two air masses (where they meet) is often sharply defined and referred to as a front.

**Fronts are continued on next page...**

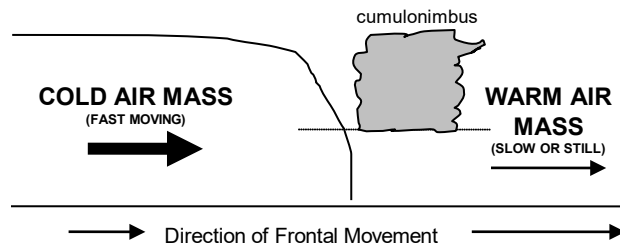
*TIP: Review online notes before every lecture! TIP: Review your notes as soon as possible after every lecture!*

## 1. Cold Front

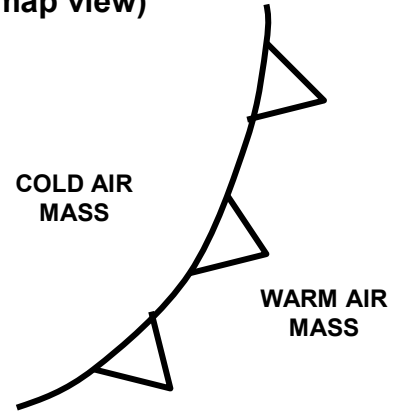


- Occurs when fast moving cold air overtakes and rides beneath warm air
- Lifting is rapid, resulting in towering (vertically developed) cumulonimbus clouds
- Precipitation is intense and short lived; weather is clear and cold after.
- A squall line is a line of thunderstorms along a cold front

### Cold Front (side view)



### Cold Front (map view)

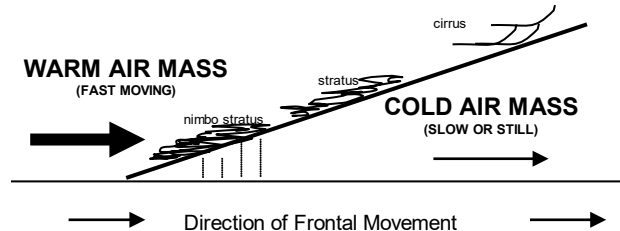


## 2. Warm Front

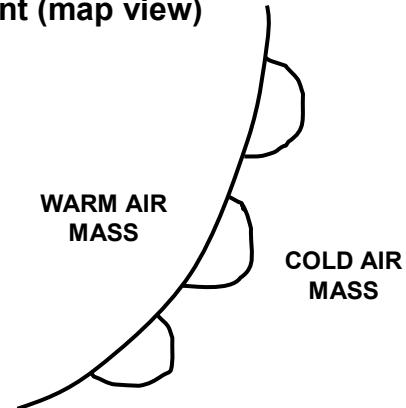


- Occurs when warm air overtakes and rides above cold air
- Lifting is slow, resulting first in cirrus clouds, then stratus and nimbo stratus
- Precipitation lasts longer and is fairly gentle; weather is clear and warm after.

### Warm Front (side view)



### Warm Front (map view)



#### CRITICAL CONCEPT REVIEW

Lifting is a critical step in the precipitation process. Air can be lifted three ways:

Orographic Lifting (air is pushed up a mountain)

Frontal Lifting (cold air pushes up warm air)

Convective Lifting (air heats, expands, and rises)

**Sample Questions:** Questions similar to these will be on your exam. As you study you should anticipate how I might use these questions to create new questions on the same concepts.

1	Which type of air mass will definitely hold the <b>highest</b> amounts of water vapor?    A. cP    B. mP    C. cT    D. qT    E. mT
2	Which type of air mass will definitely hold the <b>lowest</b> amounts of water vapor?    A. cP    B. mP    C. cT    D. qT    E. mT
3	What causes Chinook winds to heat?
4	What will cause instability (unstable conditions)?
5	Which cloud is generally associated with cold fronts and/or extremely unstable conditions? A. nimbostratus    B. stratus    C. lenticular    D. towering cumulonimbus    E. cirrus
6	What are the basic differences between a warm front and a cold front?
7	What is required for clouds to form?
8	Possible Essay/Diagram Question: Be prepared to diagram and/or explain BOTH cold AND warm fronts.
9	Possible Essay/Diagram Question: Be prepared to diagram and explain orographic lifting, orographic precipitation and all related processes.
10	Possible Essay/Diagram Question: Be prepared to diagram and/or explain how a thunderstorm cell works.

**GOOD NEWS!!!** The practice questions above - plus *many, many* more – can be found in the online practice quizzes discussed in your syllabus and in class. You can take each quiz multiple times, and each time you will get some new questions. Once submitted, the quizzes are graded automatically, with the correct answers provided immediately. ***This is a great way to prepare for the exams!!!***