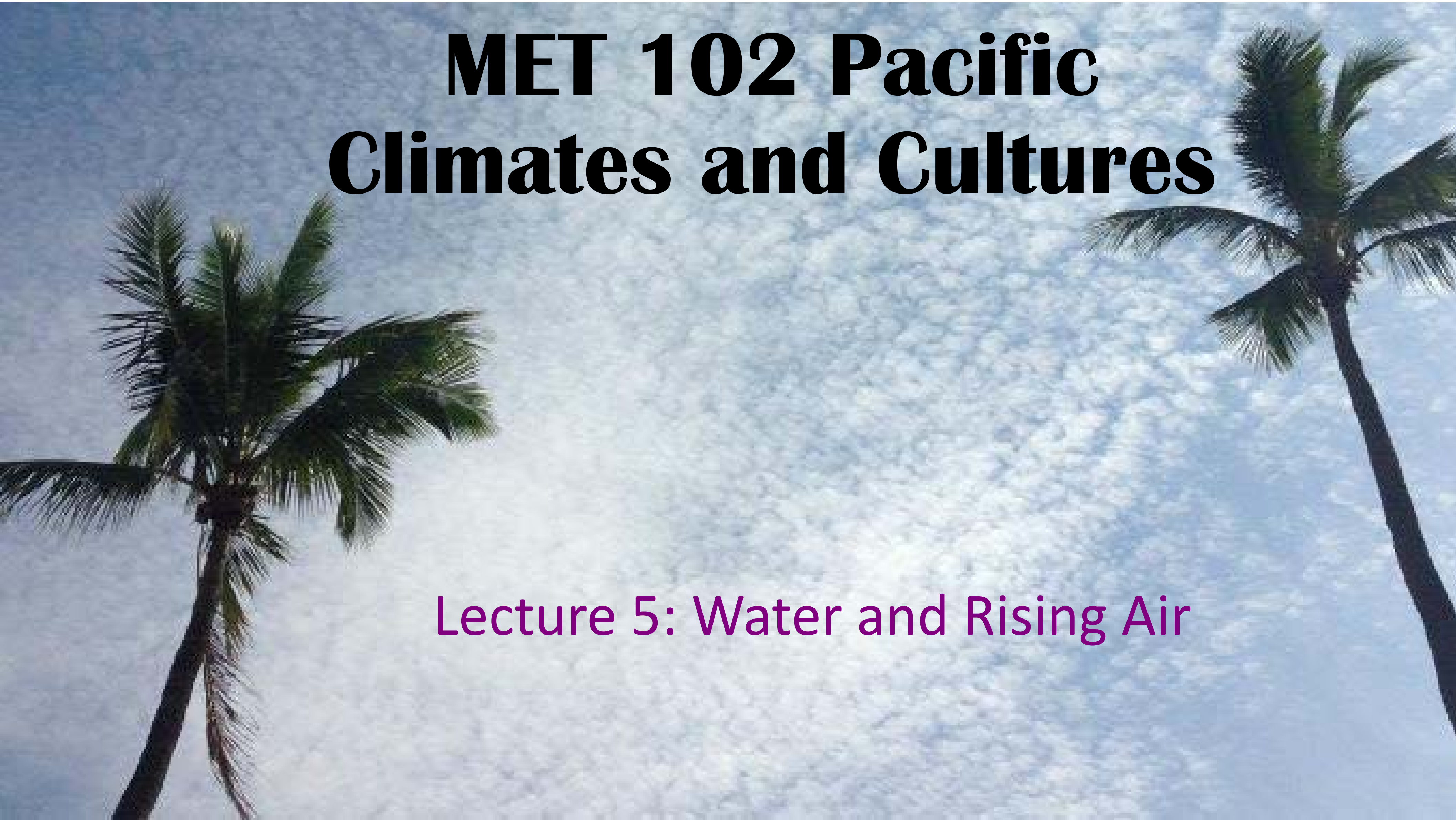
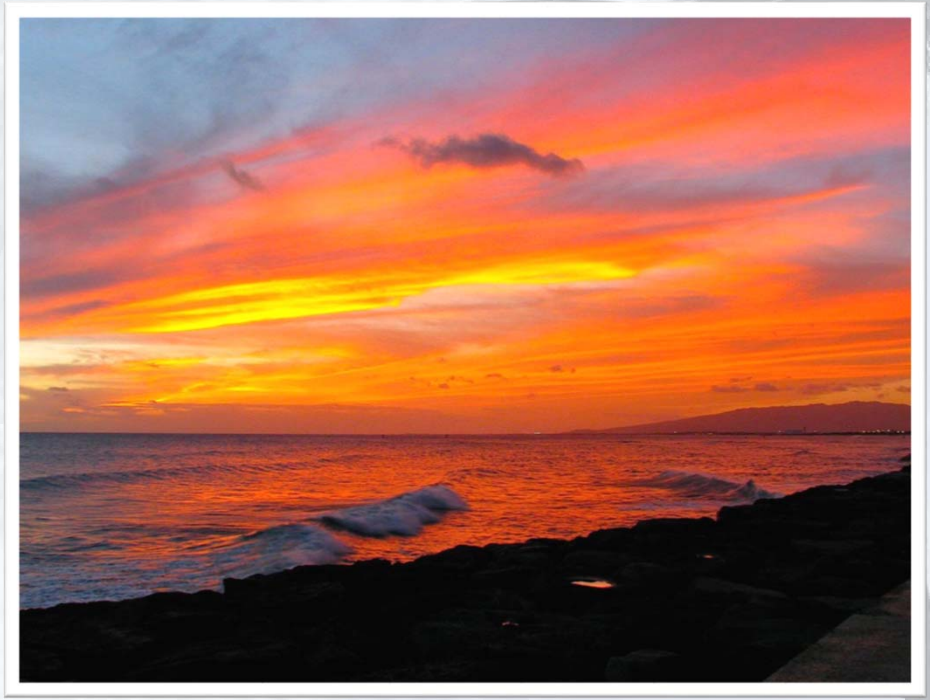
MET 102 Pacific Climates and Cultures

Lecture 5: Water and Rising Air



Discussion – Ackerman & Knox

- **What are the different ways of measure water vapor in the air?**
  - Mixing Ratio
  - Vapor Pressure
  - Relative Humidity
  - Dew Point/Frost Point



- **What are the 4 main ways are for make air rise?**
  - Orographic Lifting
  - Frontal Wedging
  - Convection (Differential Heating)
  - Convergence

Discussion – Ackerman & Knox

We're actually going to talk about these in depth on Thursday:

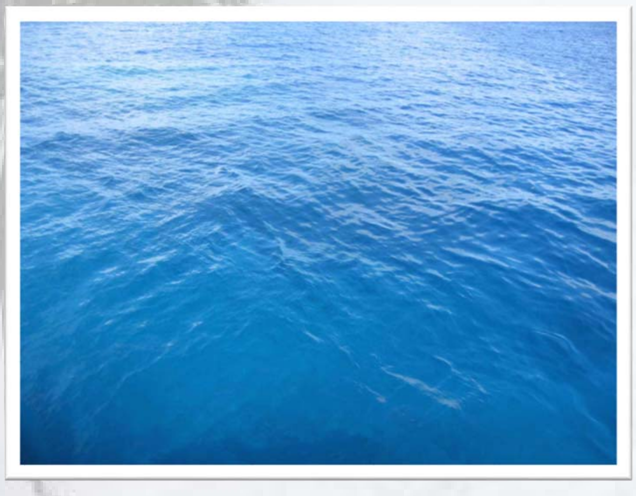
- **What are the main ways we classify clouds?**
  - Shape
  - Height in the atmosphere
  - Whether or not they rain!
- **Do you think fog happens often on the Pacific Islands? Why or why not?**
  - Fog can happen anywhere if the temperature and moisture content allow.
  - The water and air may not get cold enough on most islands to allow for fog formation, however, valley fog on high islands is a possibility ☺

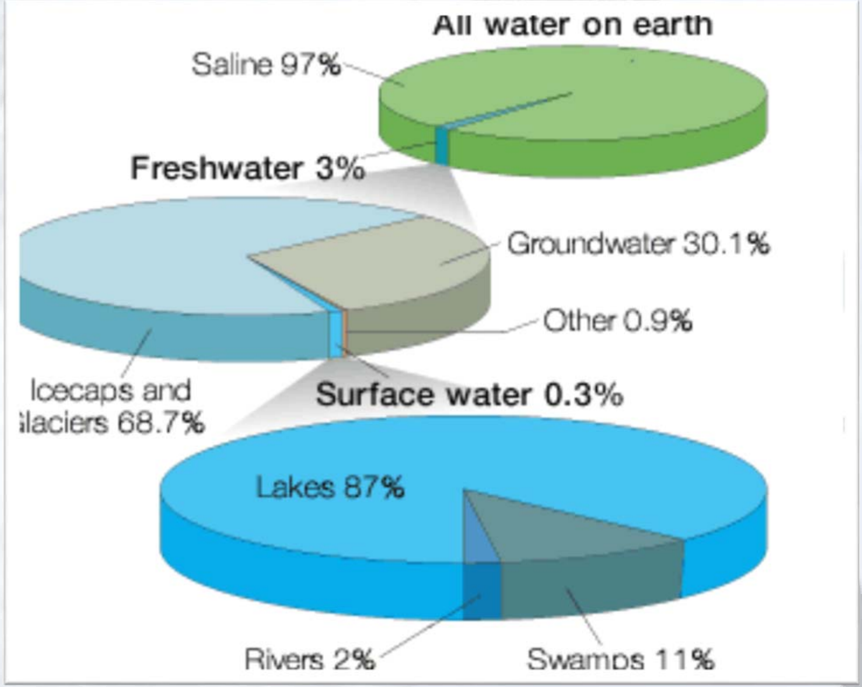
Water is Everywhere

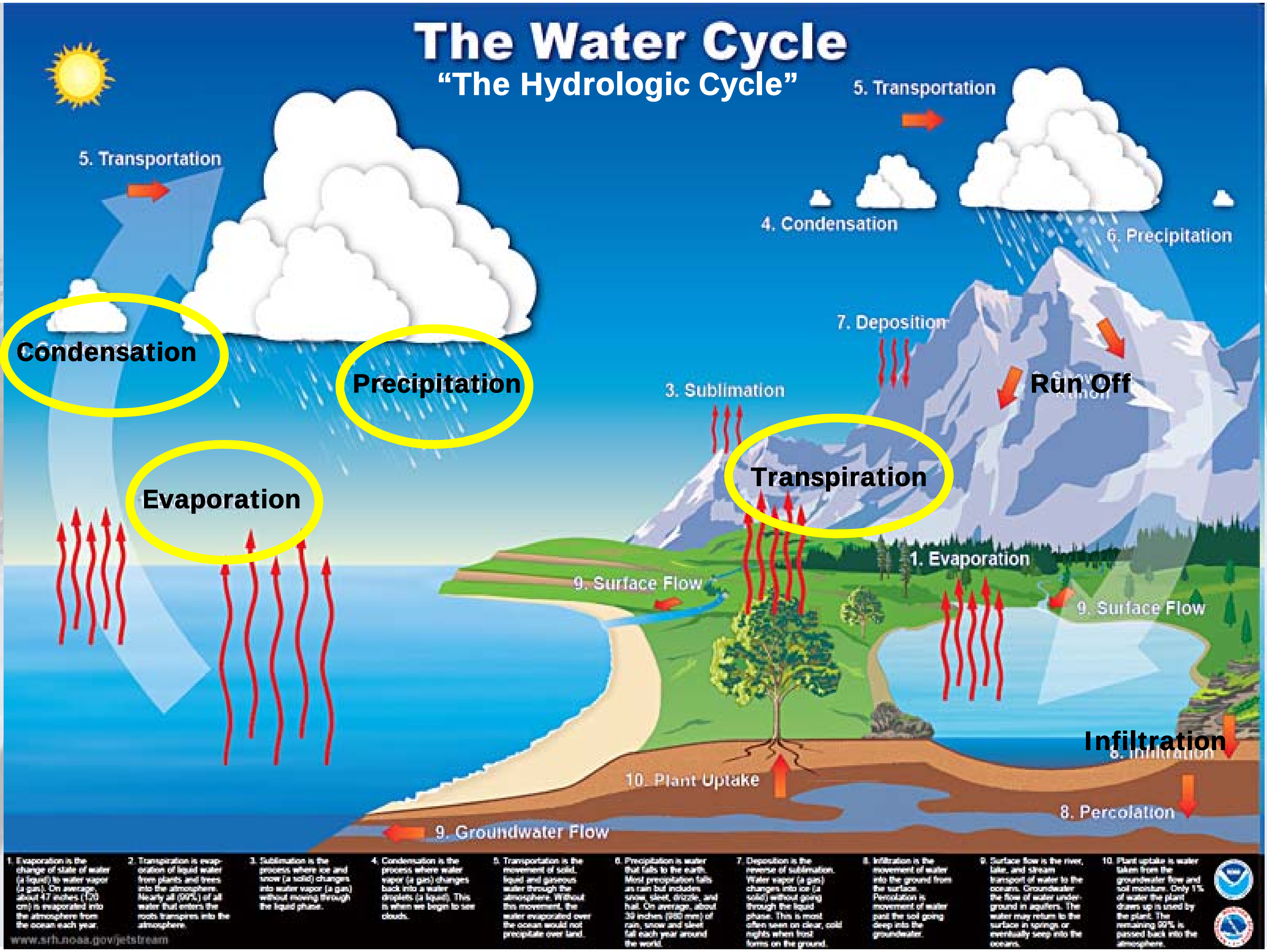
- Oceans
- Rivers/Streams/Waterfalls
- Pools/Lakes
- Air
- Soil
- Living tissue
- Snow/Ice/Glaciers

Water, water, everywhere, but not a drop to drink….

- **Oceans account for most of water (>97%)**
  - Not readily useable by humans or plants
- **Ice sheets in Antarctica and Greenland (~3%)**
- **Atmosphere has only a little (0.001%)**



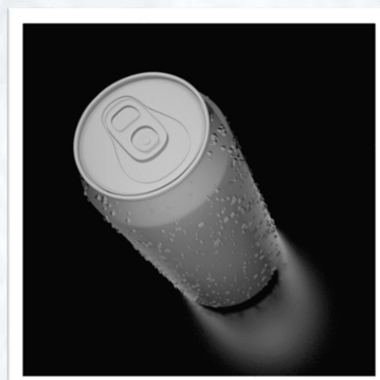


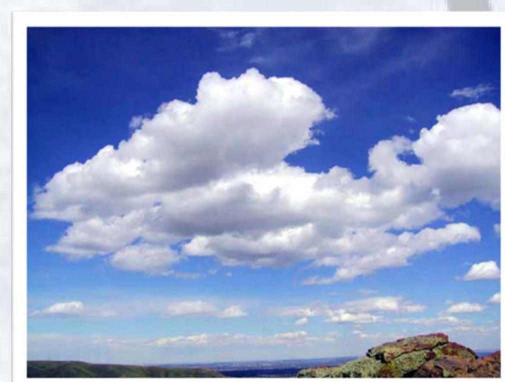

The Water Cycle
"The Hydrologic Cycle"
5. Transportation
5. Transportation
4. Condensation
6. Precipitation
7. Deposition
3. Sublimation
Condensation
Precipitation
Evaporation
Transpiration
Run Off
1. Evaporation
9. Surface Flow
9. Surface Flow
Infiltration
8. Infiltration
10. Plant Uptake
8. Percolation
9. Groundwater Flow
1. Evaporation is the change of state of water (a liquid) to water vapor (a gas). On average, about 47 inches (120 cm) is evaporated into the atmosphere from the ocean each year.
2. Transpiration is evaporation of liquid water from plants and trees into the atmosphere. Nearly all (99%) of all water that enters the roots transpires into the atmosphere.
3. Sublimation is the process where ice and snow (a solid) changes into water vapor (a gas) without moving through the liquid phase.
4. Condensation is the process where water vapor (a gas) changes back into a water droplets (a liquid). This is when we begin to see clouds.
5. Transportation is the movement of solid, liquid and gaseous water through the atmosphere. Without this movement, the water evaporated over the ocean would not precipitate over land.
6. Precipitation is water that falls to the earth. Most precipitation falls as rain but includes snow, sleet, drizzle, and hail. On average, about 39 inches (980 mm) of rain, snow and sleet fall each year around the world.
7. Deposition is the reverse of sublimation. Water vapor (a gas) changes into ice (a solid) without going through the liquid phase. This is most often seen on clear, cold nights when frost forms on the ground.
8. Infiltration is the movement of water into the ground from the surface. Percolation is movement of water past the soil going deep into the groundwater.
9. Surface flow is the river, lake, and stream transport of water to the oceans. Groundwater the flow of water underground in aquifers. The water may return to the surface in springs or eventually seep into the oceans.
10. Plant uptake is water taken from the groundwater flow and soil moisture. Only 1% of water the plant draws up is used by the plant. The remaining 99% is passed back into the atmosphere.
www.srh.noaa.gov/jetstream

Processes Involving Water in the Atmosphere

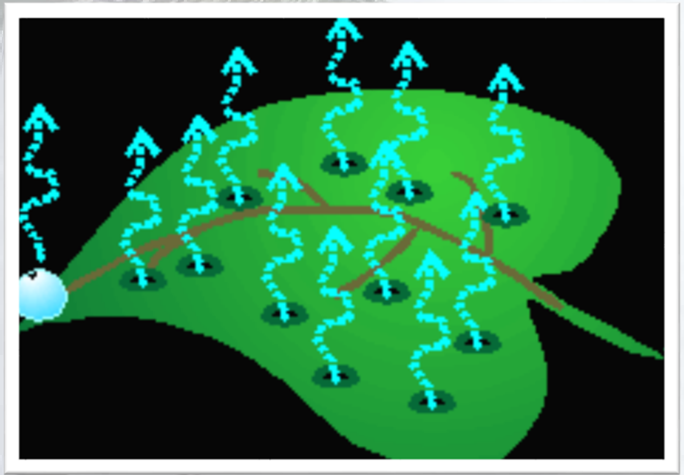
- **Evaporation – Requires Energy**
  - The process by which a liquid is transformed into a gas
  - Powered by the Sun!
  - Solar Radiation heat up the water molecules until they are "freed" from the liquid state
  - Heat is absorbed during evaporation

- **Condensation – Releases Energy**
  - The change from a gas to a liquid
  - Responsible for the formation of clouds
  - **Heat is released during condensation**





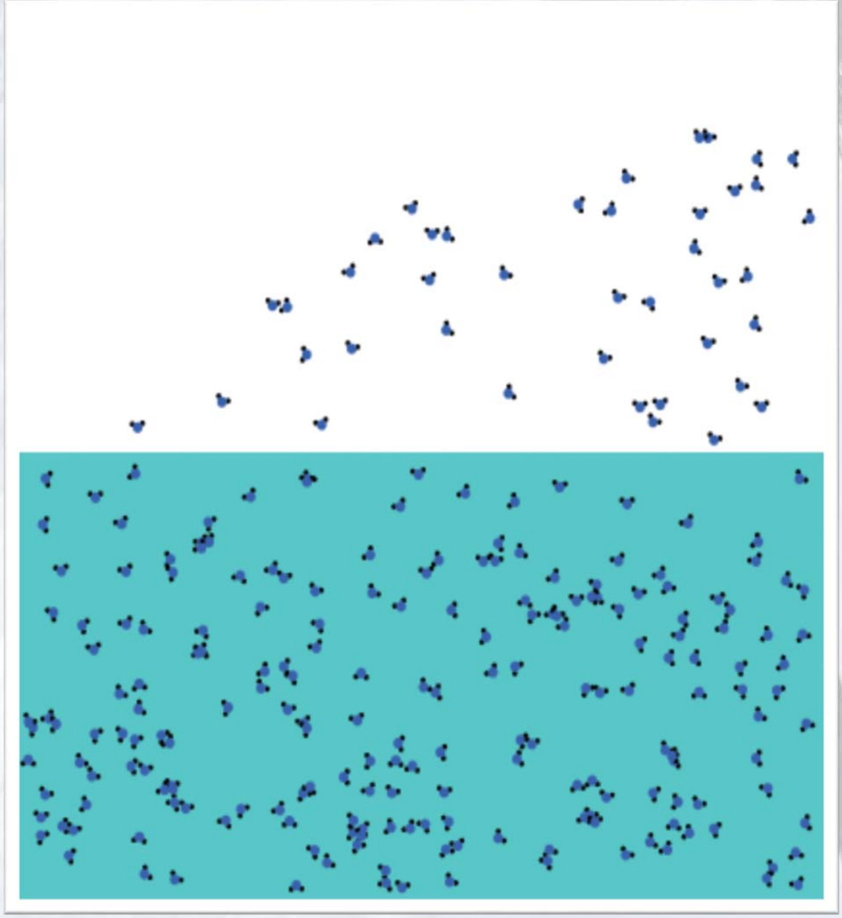
Processes Involving Water in the Atmosphere



- **Precipitation – Over Land & Oceans**
  - Falling liquid or solid in the atmosphere.
  - Returned the water to the ocean or soaks into the ground
  - Balances Evaporation
    - **Average annual precipitation equals evaporation.**
- **Transpiration**
  - The release of water vapor to the atmosphere by plants
  - Plants uptake water through their roots that fell as precipitation
  - Not as important as evaporation

Water Vapor Content of the Air

- **Humidity**
  - The general term used to describe the **amount** of **water vapor** in the air

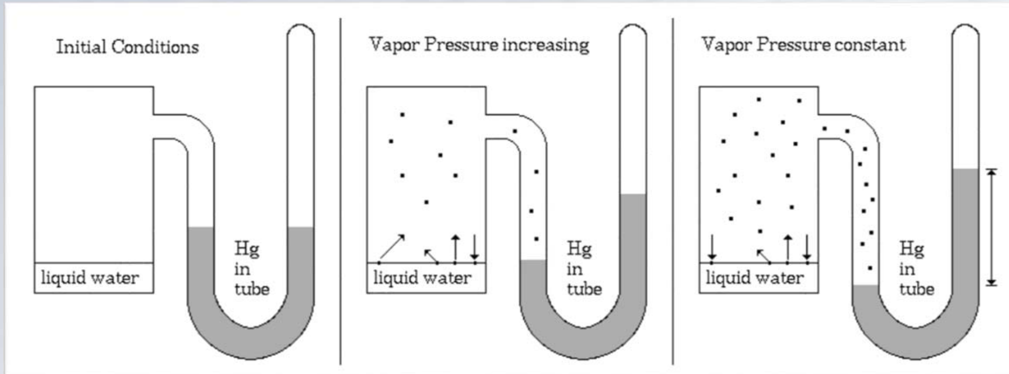


- **Other Ways of thinking about it:**
  - Mixing Ratio
  - Vapor Pressure
  - Relative Humidity
  - Dew Point/Frost Point

Mixing Ratio

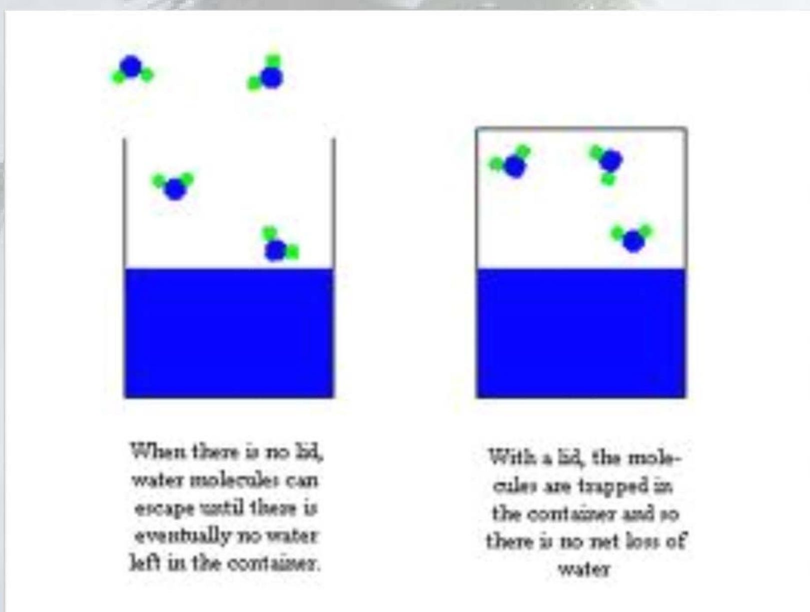
- The **MASS** of water vapor in a unit of air compared to the remaining **MASS of dry air**.
- **NOT** affected by changes in temperature and pressure!!!
- **MASS** doesn't change as a function of temperature.

$$\text{Mixing Ratio} = \frac{\text{Mass of water vapor (grams)}}{\text{Mass of dry air (kilograms)}}$$



Vapor Pressure

- That part of the **total atmospheric pressure** attributable to its water-vapor content.
- As **more water vapor** is added to dry air the vapor **pressure increases**.
- **MASS** doesn't change as a function of temperature.



Initially more molecules leave the surface of the water than return. Over time: **number of molecules leaving = the number molecules returning**

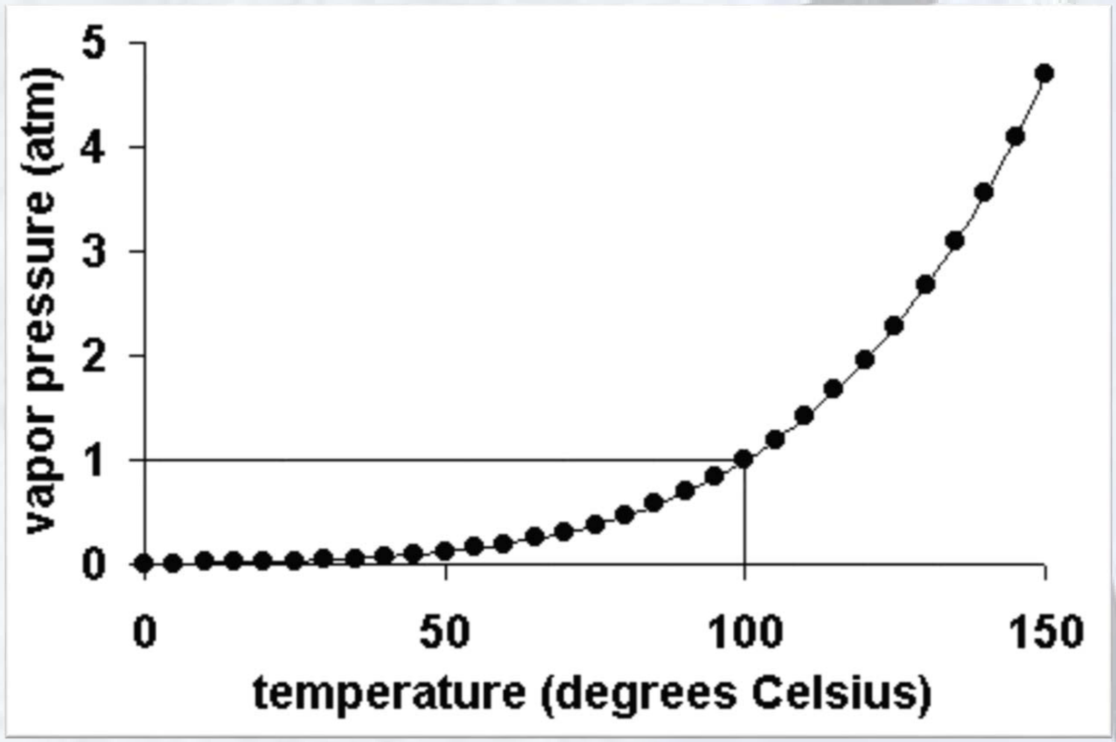
This is **SATURATION**

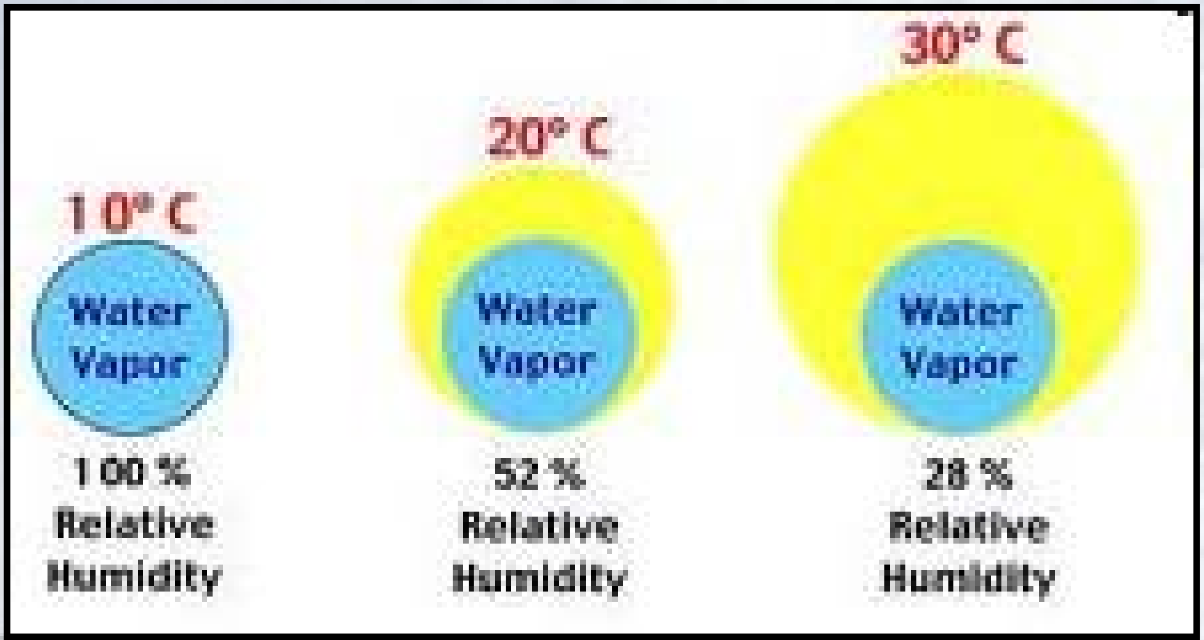
Saturation Vapor Pressure

- When air is saturated the pressure exerted by the motion of the water vapor molecules is called the **Saturation Vapor Pressure.**

- Varies as a function of **temperature**

- You can "**FIT**" more water vapor in warmer air.

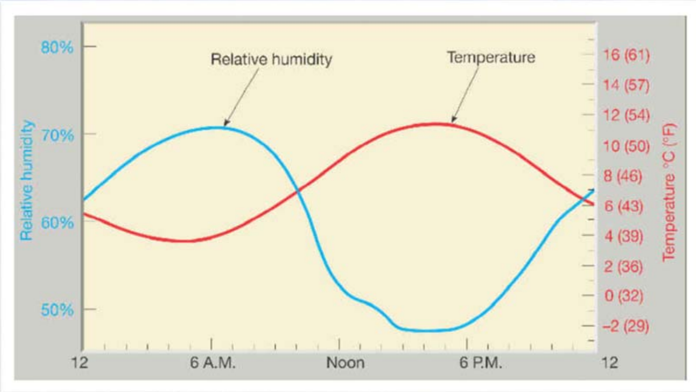


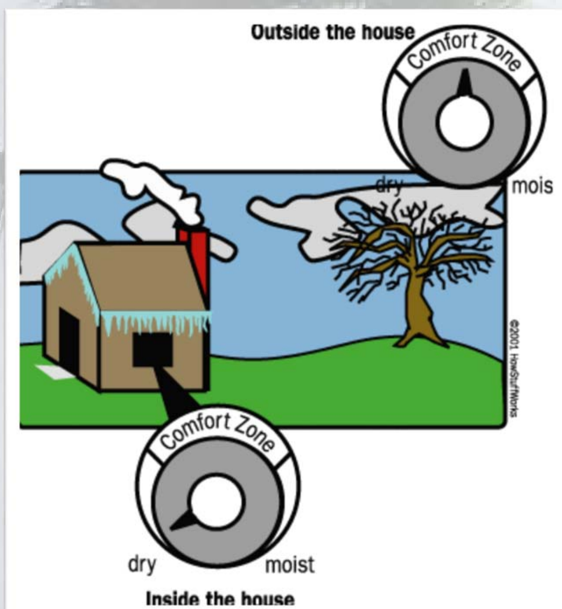


Relative Humidity

- The ratio of the air's **actual water vapor content** compared with the **amount of water vapor required for saturation** at that **temperature** and **pressure**

$$\text{Relative Humidity} = \frac{\text{Water vapor content}}{\text{Water vapor capacity}} \text{ X 100 percent}$$



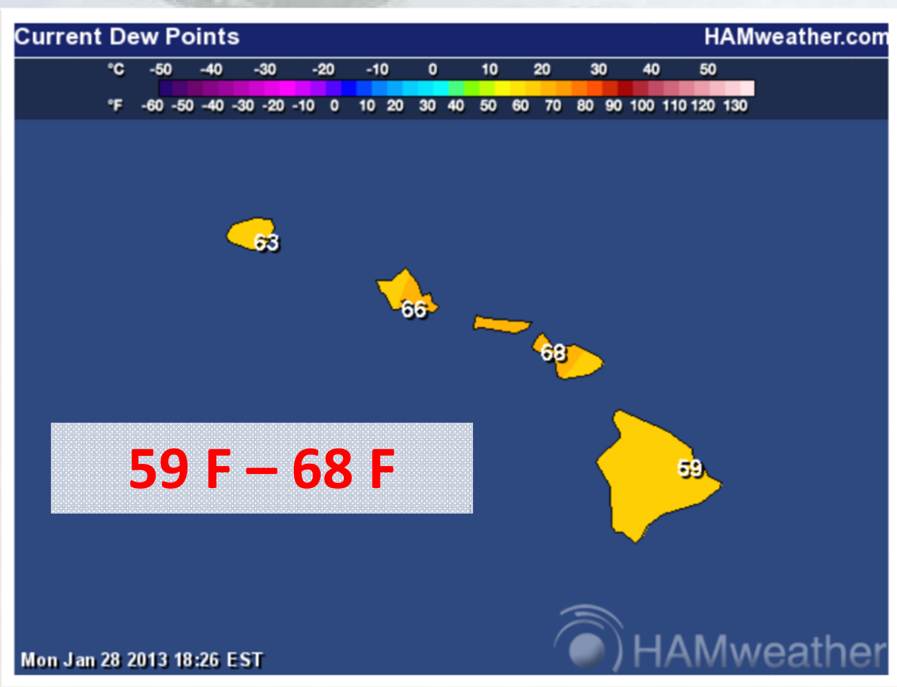


Natural Changes in Humidity

1. Daily changes in temperatures (daylight verses nighttime temperatures)

2. Temperature changes that result as air moves **horizontally** from one location to another

3. Temperature changes caused as air moves **vertically** in the atmosphere

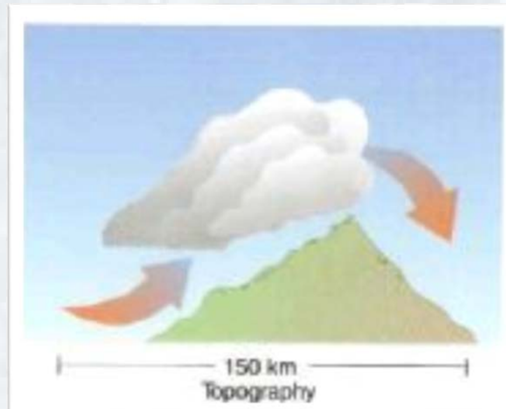


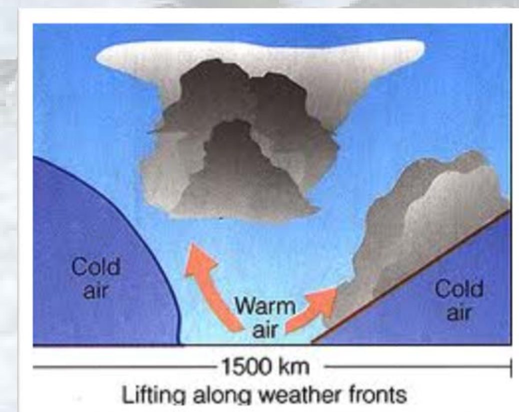
Dew Point Temperature

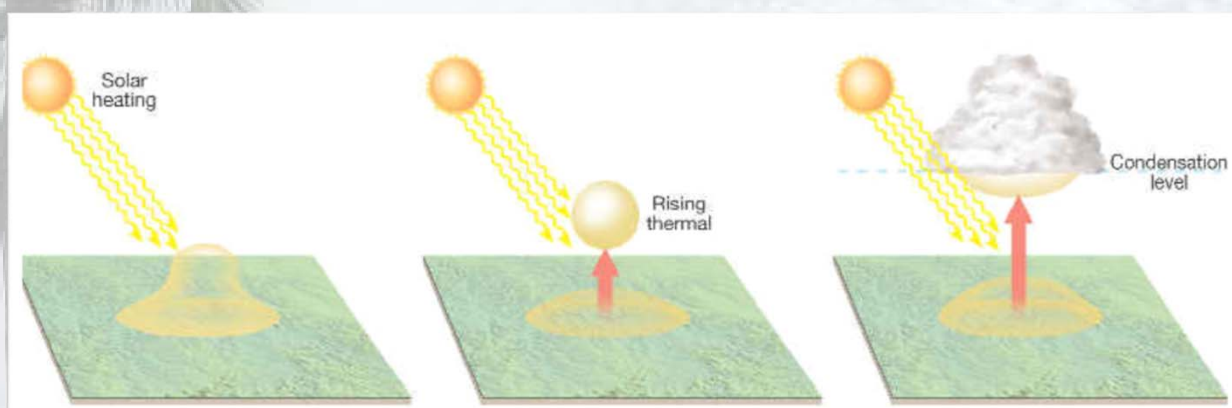
- The **temperature** at which air needs to be **cooled** to reach **saturation**
- It is a measure of the **actual moisture content** of a parcel of air.
- The term **dew point** stems from the fact that during the night objects at the surface often cool below the dew-point are a coated with dew.
- When the dew point exceeds **~65F** it is considered humid by most people
- A dew point above **75F** is considered unbearable.

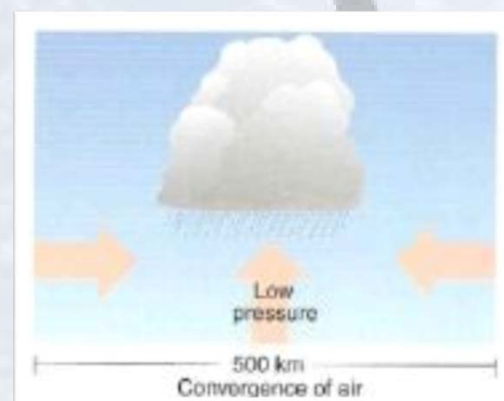
Processes that Lift Air

1. Orographic Lifting
2. Frontal Wedging
3. Convergence
4. Localized Convective Lifting (differential heating)

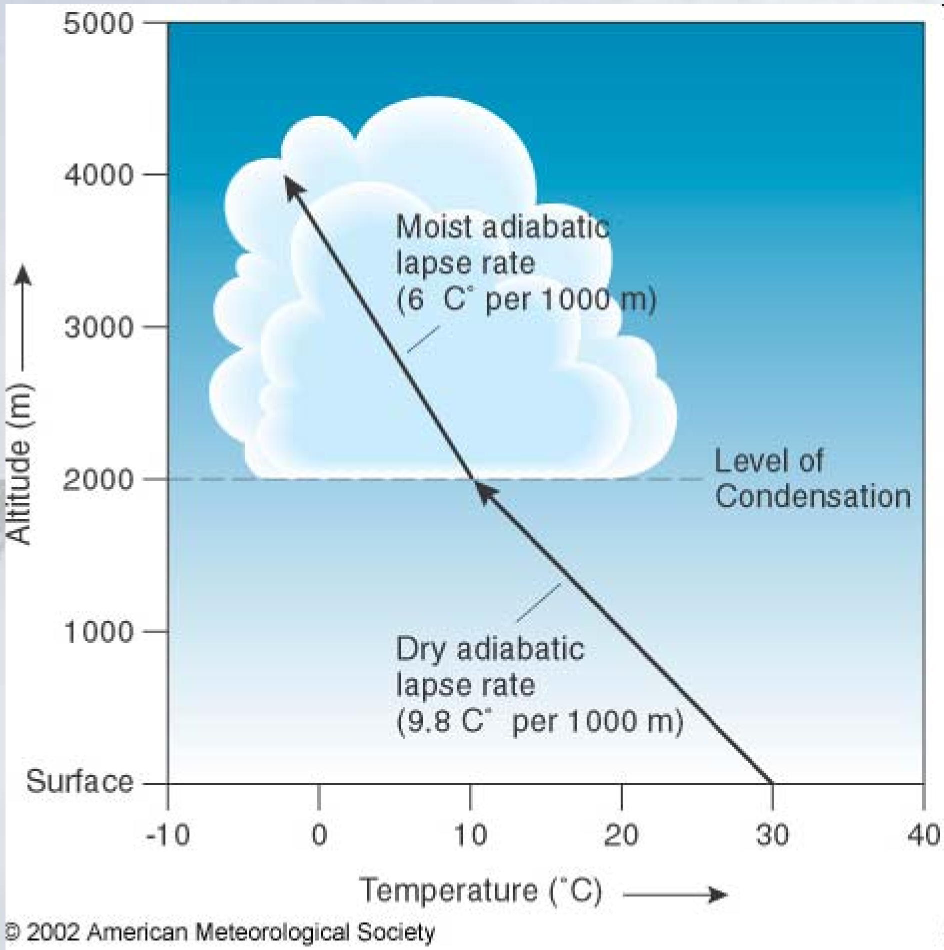




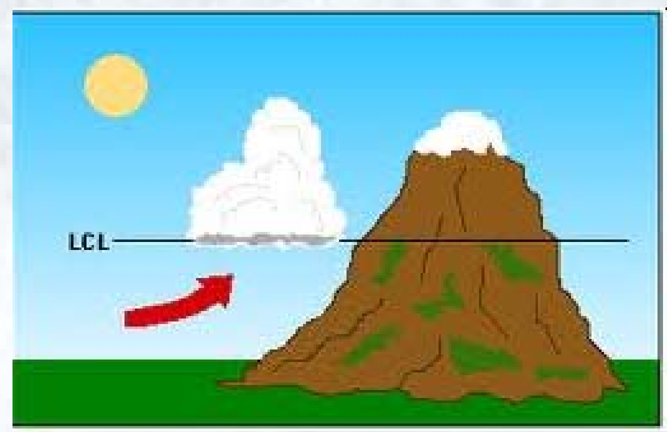




Lifted Condensation Level (LCL)



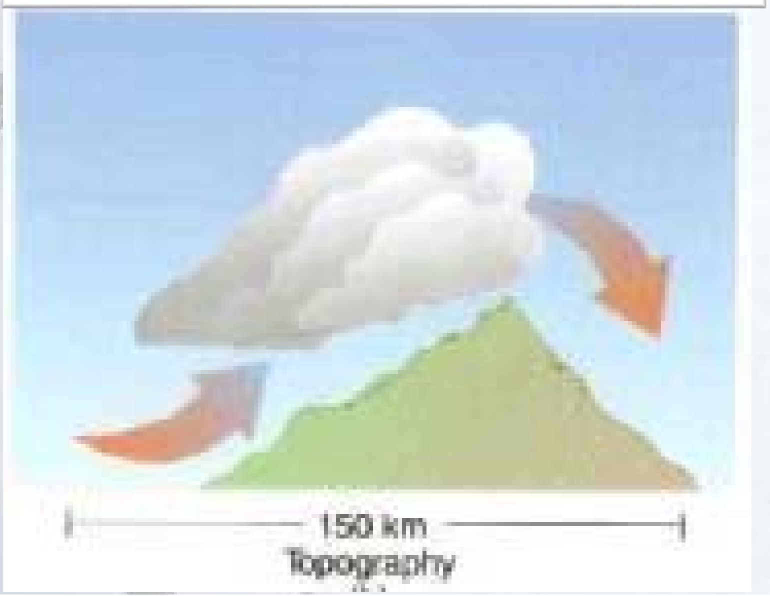
- The height at which rising air that is cooling at the dry adiabatic rate becomes saturated and **condensation** begins.

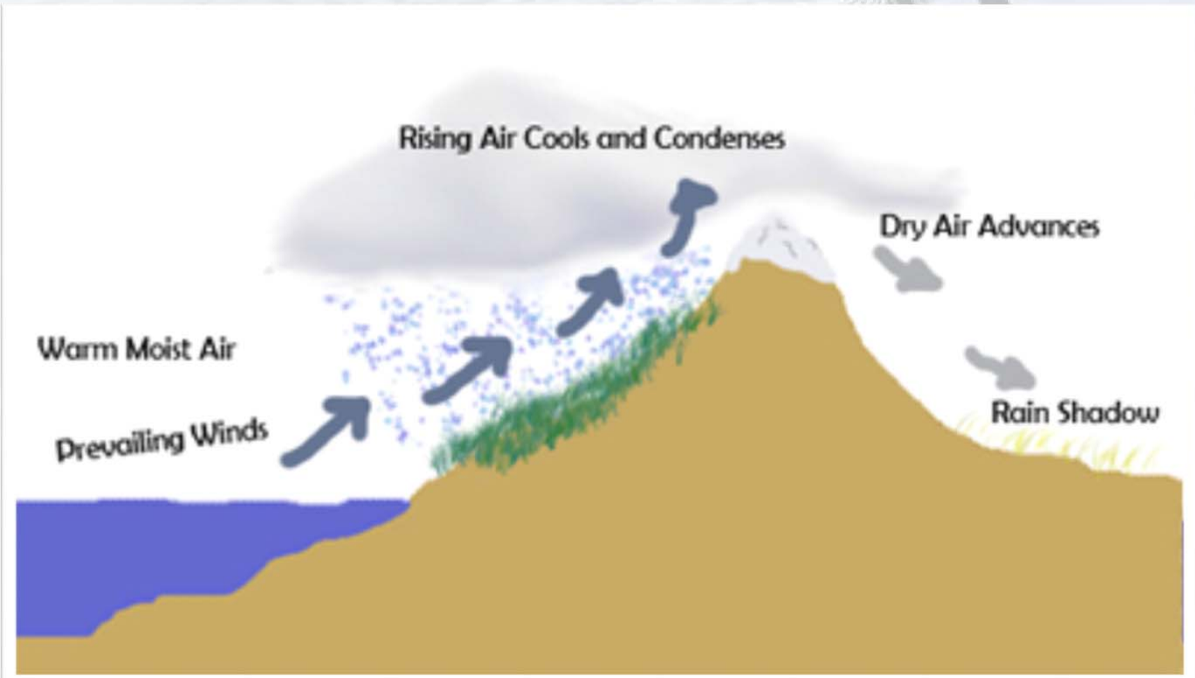


Why most clouds have FLAT bottoms!!!

Orographic Lifting

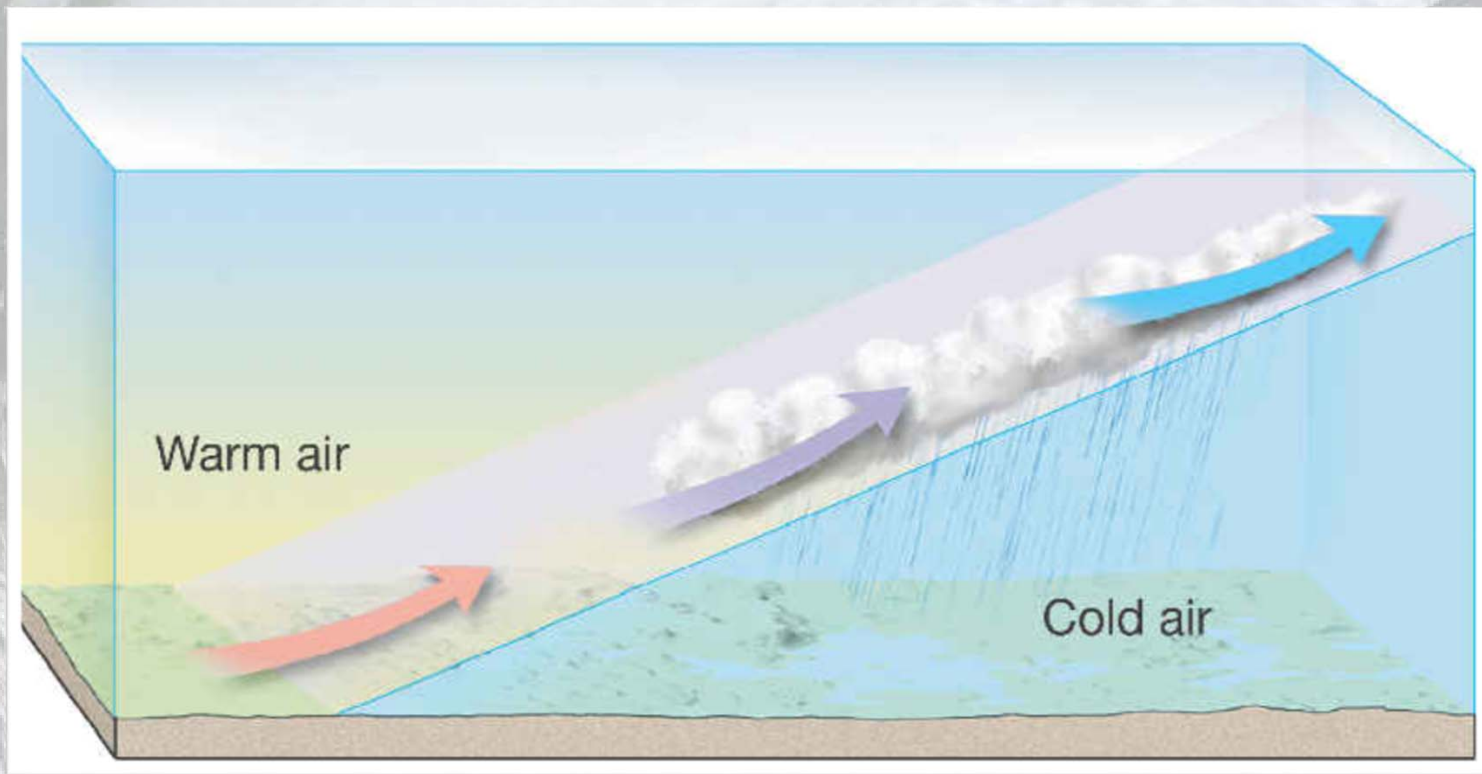
- Air is **forced to rise over** a mountainous or topographic barrier
- Rain shadow desert





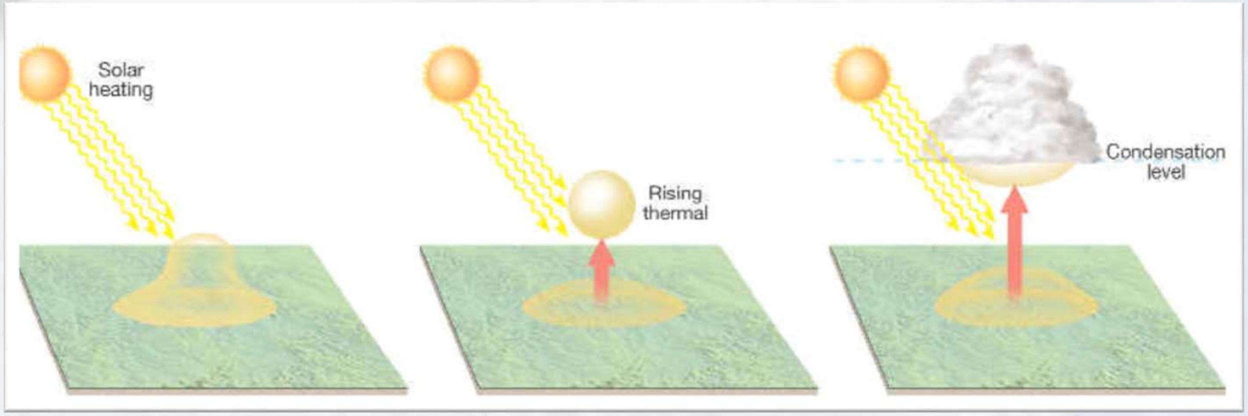
Frontal Wedging

- Warmer, **less dense air**, is forced over cooler, denser air
- **Front** – when warm and cold air collide



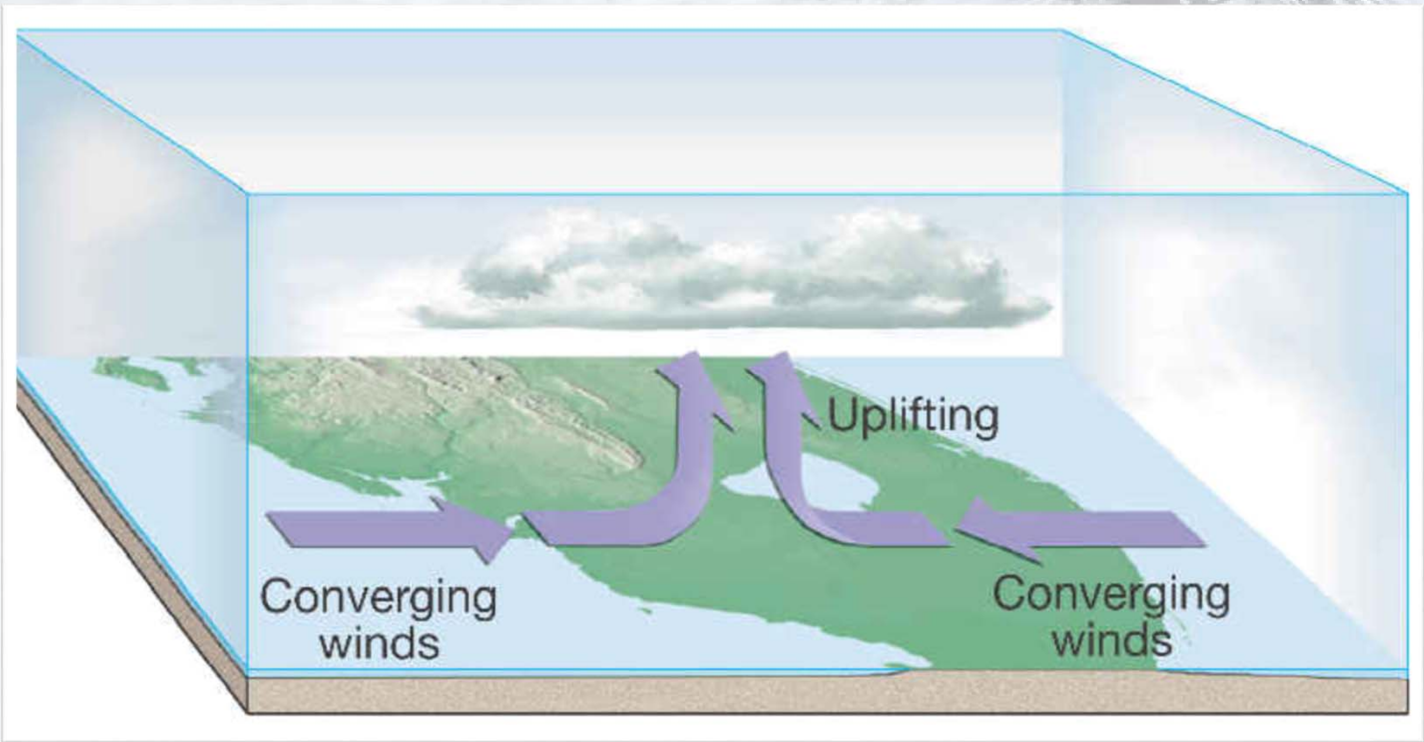
Localized Convective Lifting

- **Unequal heating** of Earth's surface causes pockets of air to be warmed more than the surrounding air.
- Buoyant parcels (**thermals**) of hot air rise.
- After reaching the **LCL** they form clouds.

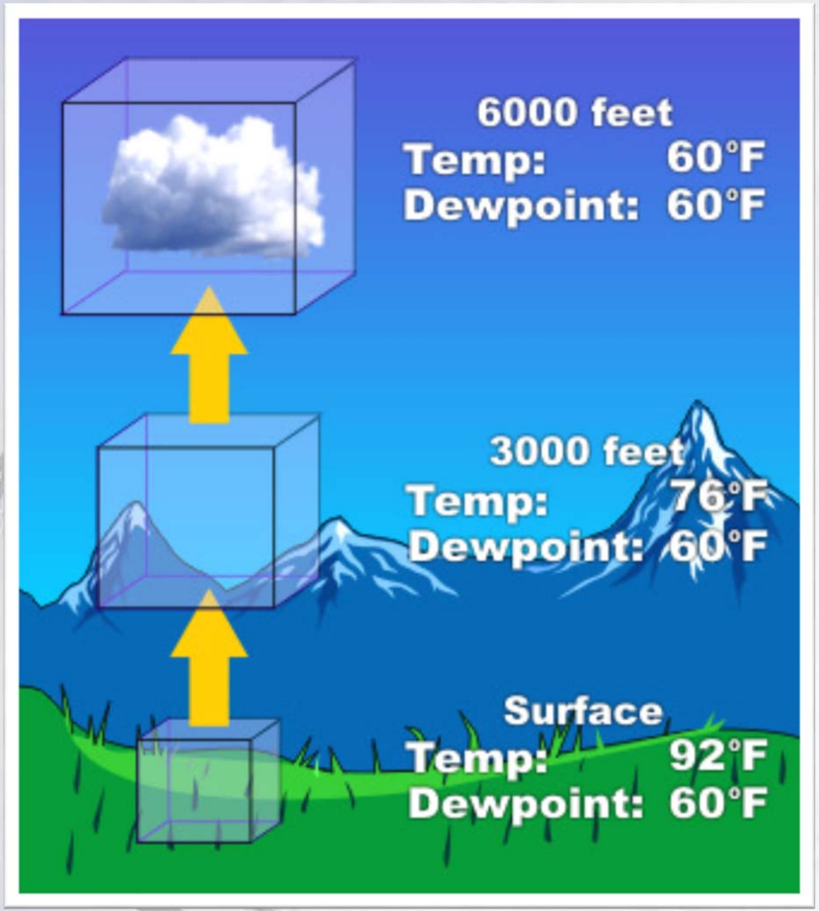


Convergence

- When air flows in from **more than one direction** (not a front) can collides
  - It cannot go down.
  - It goes up.
- Often happens over slands and other egions where two bodies of water are ocated closely ogether

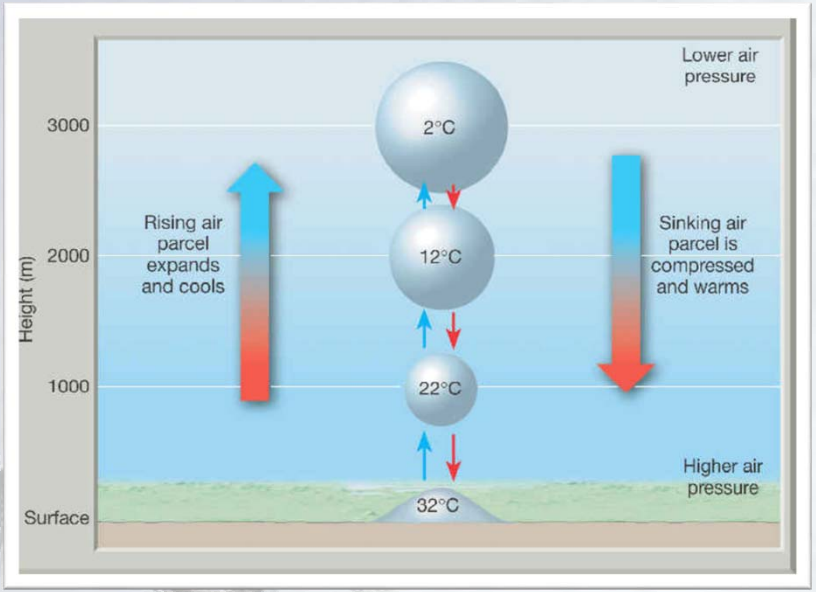


Air Parcels… What are they?



- **A Parcel is an imaginary volume of air**
  - Typically a few hundred cubic meters in volume
  - Acts independently of the surrounding air
  - It is assumed that no heat is transferred into, or out of it
  - **HIGHLY IDEALIZED**
- **We use them to talk about the likelihood that air will rise up or sink down.**
  - We need to know this if we want to predict if clouds will form.

Adiabatic Temperature Changes

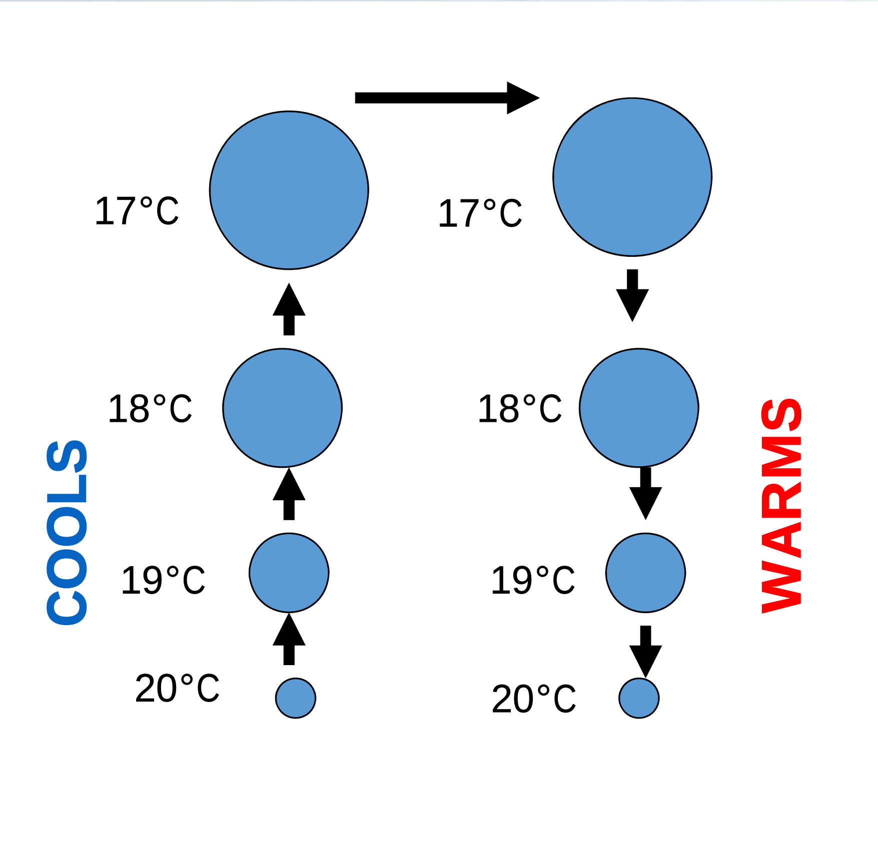


- When heat is neither added nor subtracted
- Result when air is compressed or allowed to expand

When air is allowed to **expand**, it **COOLS**.

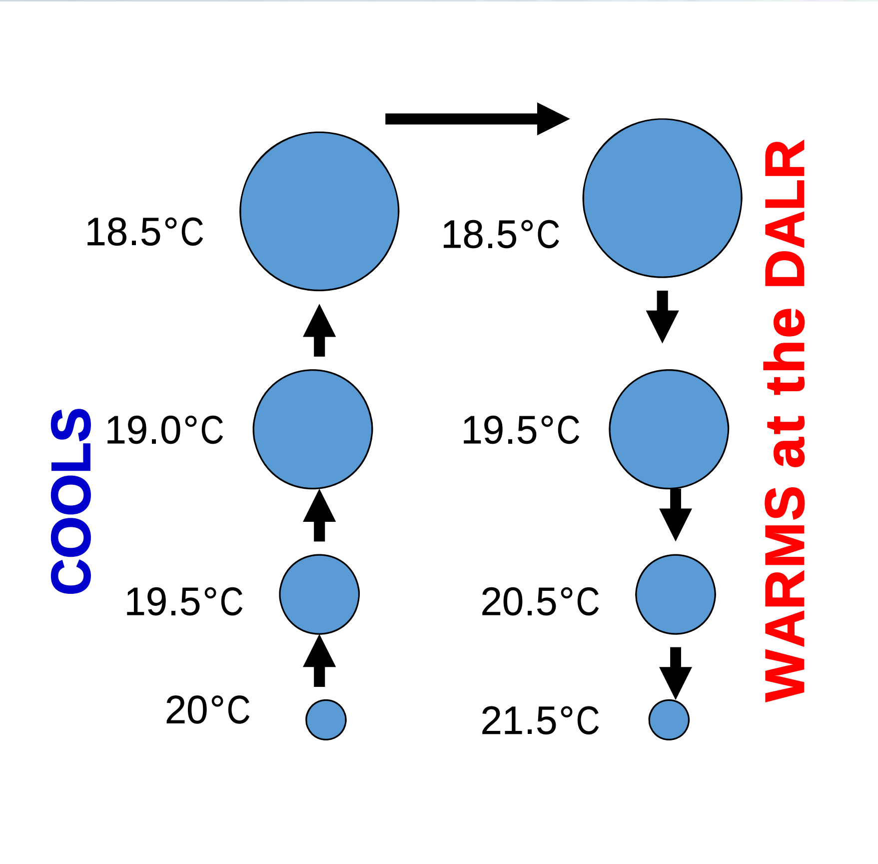
When air is **compressed**, it **WARMS**.

Dry Adiabatic Lapse Rate



- The change in temperature due to a change in altitude of a **non-condensing parcel**
- Abbreviated **DALR**
- DALR = 1°C/100m
- DALR = 10°C/1000m
- DALR = 5.5°F/1000ft

Wet Adiabatic Lapse Rate



- The change in temperature due to a change in altitude of a **condensing parcel**
- Abbreviated **WALR**
- WALR = ~0.6°C/100m
- WALR = ~6°C/1000m
- WALR = ~3.3°F/1000ft