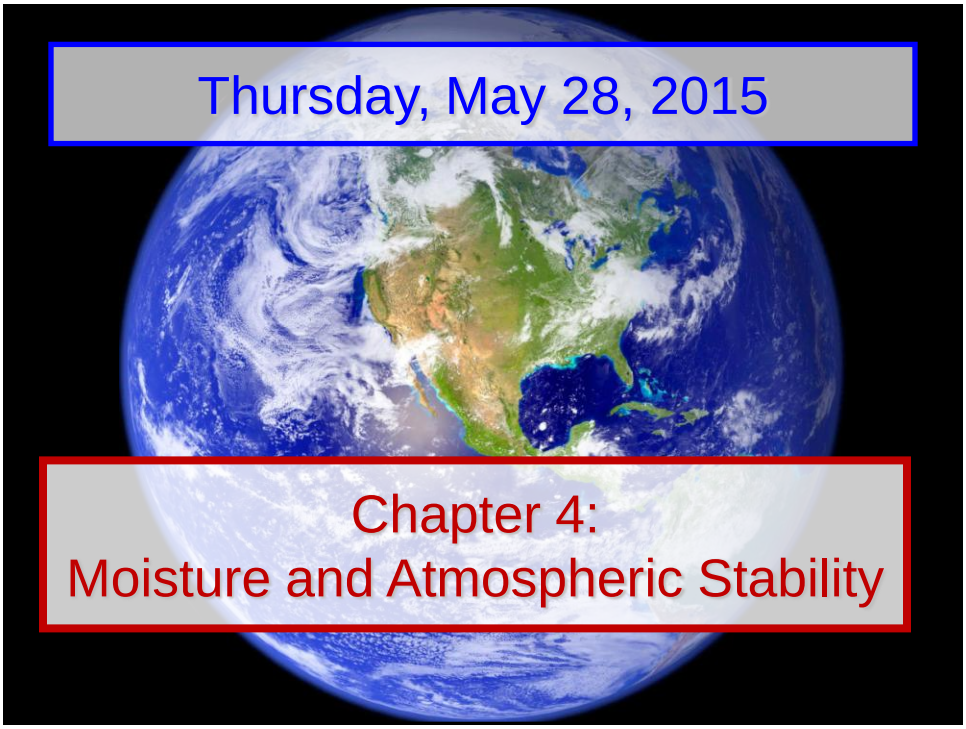


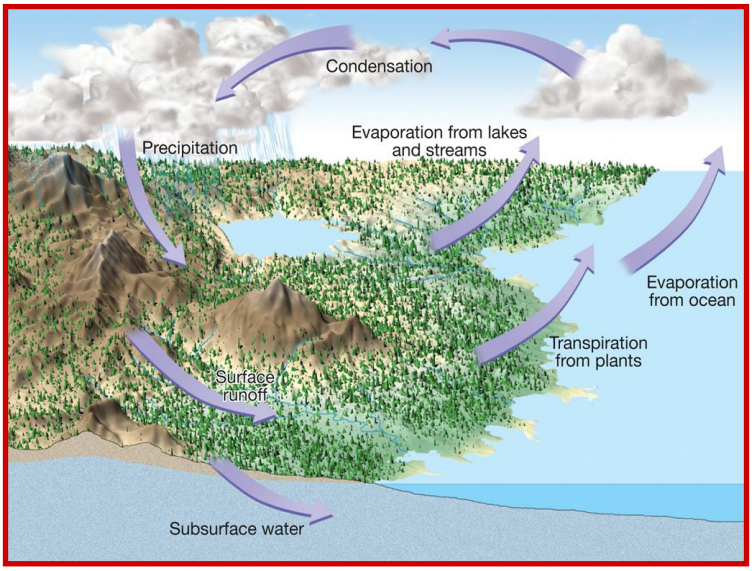
Chapter 4:
Moisture and Atmospheric Stability

- **Movement of water through the atmosphere**
  - **The Hydrologic Cycle**
- **States of matter and Changes of state**
  - **Evaporation & Condensation**
  - **Latent heat vs. Sensible heat**
- **Humidity & Relative Humidity**
  - **Relative Humidity and saturation**
  - **Dew point temperature**
- **Adiabatic temperature change**
  - **Cooling & Condensing**
- **Lifting Processes**
  - **Orographic**
  - **Frontal wedging**
  - **Convergence**
  - **Convective uplift**
- **Stability & Instability**

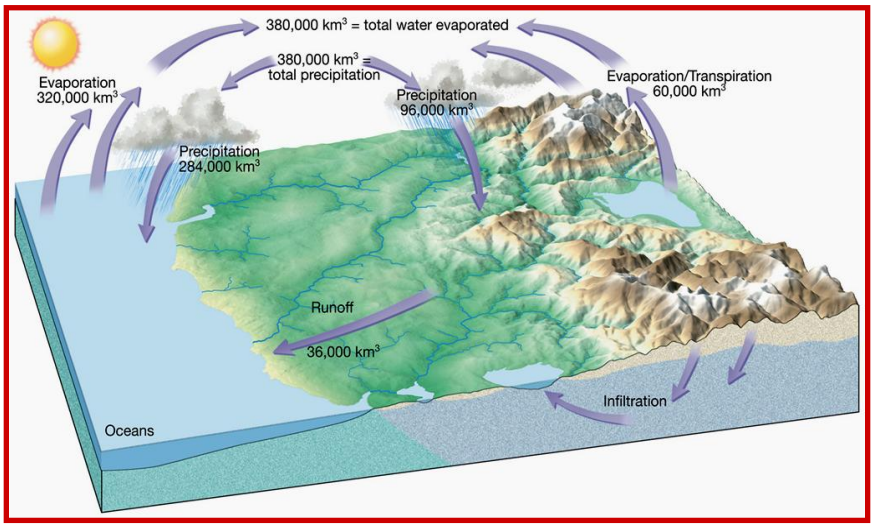
Water

- **Water**
  - **Only abundant liquid on Earth**
  - **Characteristics**
    - Easily changes states
    - On Earth found in all 3 states
    - Its solid state is less dense than liquid
    - High heat capacity
- **The Hydrologic Cycle**
  - **Movement of water on Earth**
    - surface → atmosphere → surface (etc.)

Hydrologic Cycle



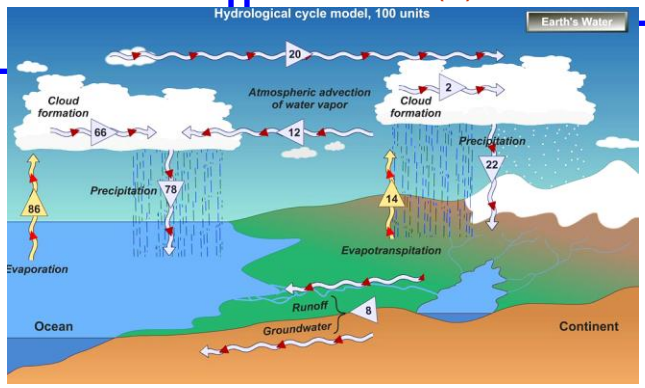
Hydrologic Cycle



Hydrologic Cycle Balance

- **Leaving surface:**
  - **Oceans 86% (evaporation)**
  - **Land 14% (transpiration and evaporation)**
- **Cloud formation:**
  - **Oceans (66% oceans, 12% land)**
  - **Land (20% oceans, 2% land)**
- **Precipitation:**
  - **Oceans 78%**
  - **Land 22%**

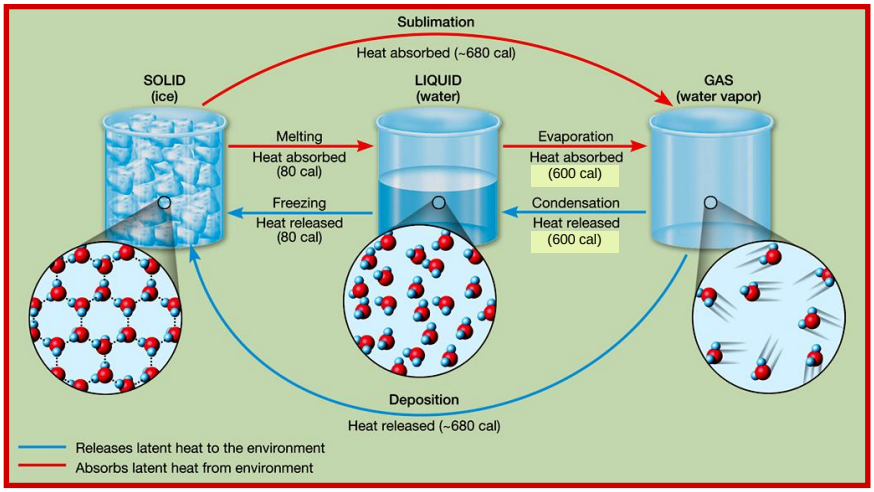
- **Advection (horizontal movement)**
  - **Oceans LOSE**
    - **20% out**
    - **12% in**
  - **Land GAINS 8%**
- **Runoff (surface and subsurface)**
  - **Balance (8%) returns to oceans**



Changes in State

- **States:**
  - Solid
  - Liquid
  - Gas
- **Changes in State**
  - Take in Energy: ENDOTHERMIC
    - Melting: 80 calories (solid → liquid)
    - Evaporation: 600 calories (liquid → gas)
    - Sublimation: 680 calories (solid → gas)
  - Give off Energy: EXOTHERMIC
    - Freezing: 80 calories (liquid → solid)
    - Condensation: 600 calories (gas → liquid)
    - Deposition: 680 calories (gas → solid)

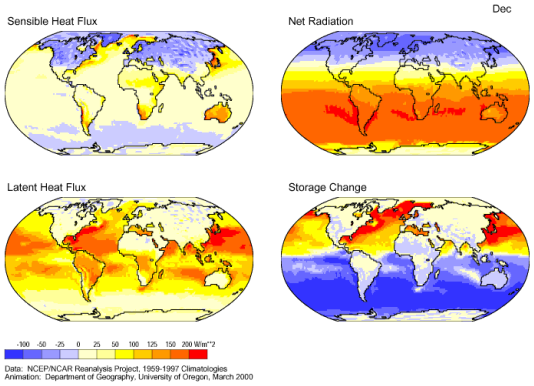
Changes in State



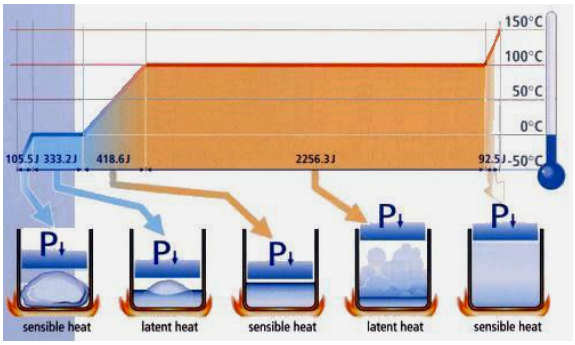
Changes in State

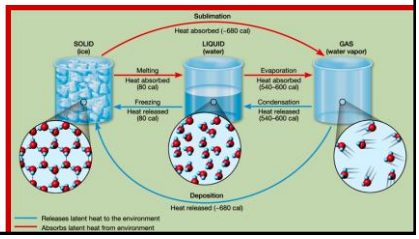
- **Calorie**
  - energy needed to increase the temp of 1 gram of water by 1 °C
- **Latent heat vs. Sensible Heat**
  - Latent heat, or hidden heat, is heat that is taken up and stored when a substance changes state (no sensation of heat)
  - Sensible heat is the kind of heat you can feel

200 Calories of M&M's



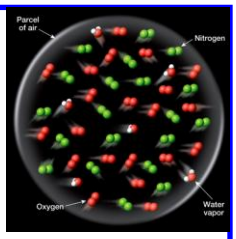
Latent Heat





Humidity

- **Humidity: in general, the amount of water vapor in the air**
- **Absolute Humidity: the mass of water vapor in a given volume of air**



$$\text{Absolute Humidity} = \frac{\text{mass of water vapor (grams)}}{\text{volume of the air (cubic meters)}}$$

- **But while Absolute Humidity is an important measurement, it does not represent the BEST WAY to consider humidity…**

RELATIVE HUMIDITY

Relative Humidity

- **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)**

- **Relative Humidity: the ratio of Absolute Humidity compared with the Air's Capacity (at a certain temperature)**

$$\text{Relative Humidity} = \frac{\text{mass of water vapor (grams)}}{\text{capacity of the air (grams) (based on temperature)}}$$

- **Saturation: the point where the air can no longer contain any additional water vapor**
  (water condensing = water evaporating)

Relative Humidity

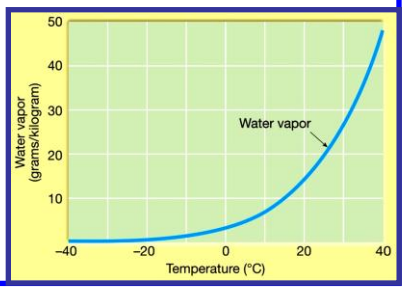
Relative humidity is based on the IDEA that…

Warmer air holds more moisture than Cold air

This is NOT A TRUE STATEMENT!

The air actually holds the same amount, hot or cold, but because of the changes in Water Vapor Pressure… it appears to work as stated above.

For our class purposes… we can use the IDEA in all our work.



Relative Humidity

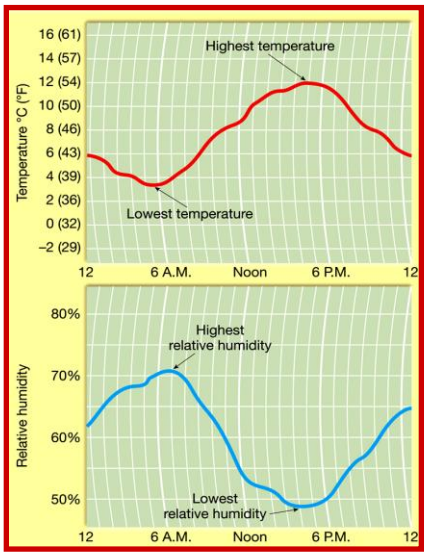
- **How will relative humidity change if…**

1. **Add moisture to the air (same temperature)**
2. **Remove moisture from the air (same temperature)**
3. **Increase the temperature (same moisture)**
4. **Decrease the temperature (same moisture)**

Relative Humidity

Natural Changes in Relative humidity

- **Daily march of Temperature**
  - **Day vs. Night**
- **Horizontal Air Movement (Advection *aka Wind*)**
  - **Air moving from one location to another (air masses)**
- **Vertical Air Movement (Stability / Instability)**
  - **Rising air expands (pressure) and cools**

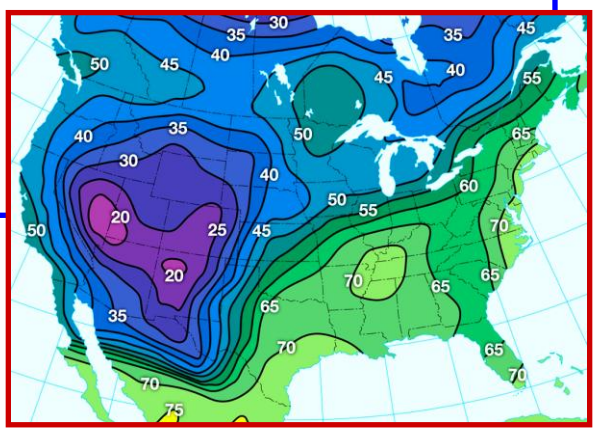


Dew Point Temperature

- **Dew Point Temperature: the temperature where the current air parcel will reach saturation (based on the absolute humidity)**

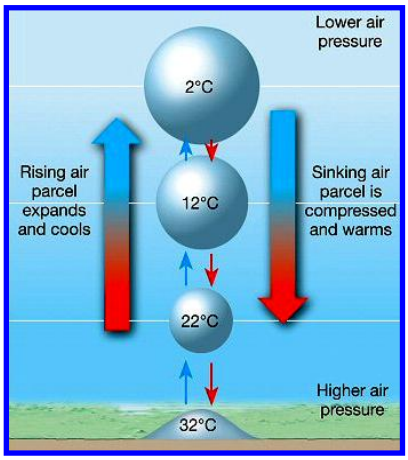
Cooling occurs naturally as:

- **Dew**
- **Fog**
- **Clouds**



Adiabatic Cooling

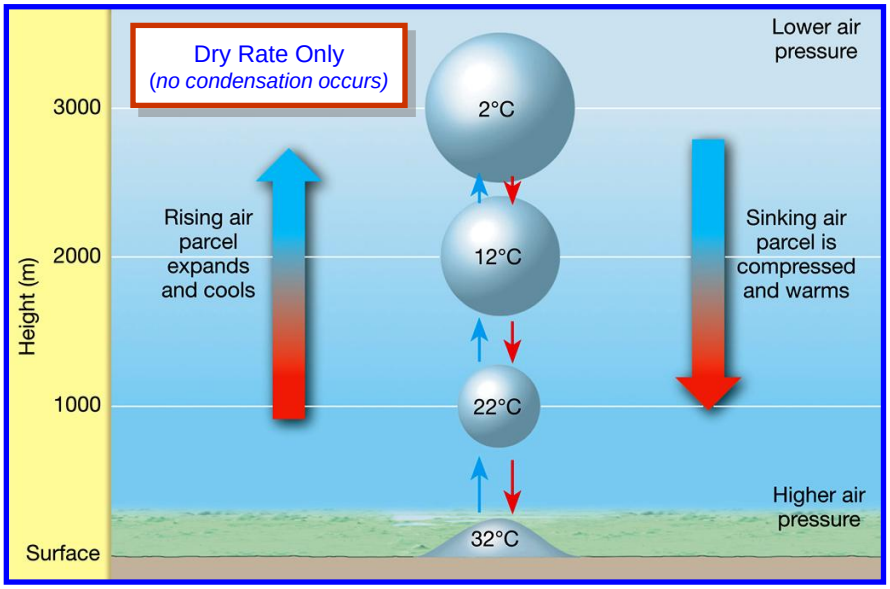
- As a parcel of air moves upward it experiences successively lower and lower pressure…
- And because the pressure is lower, the air expands…
- As air expands, it cools (lower internal density)
- Adiabatic Cooling:
  AIR RISES → EXPANDS → COOLS



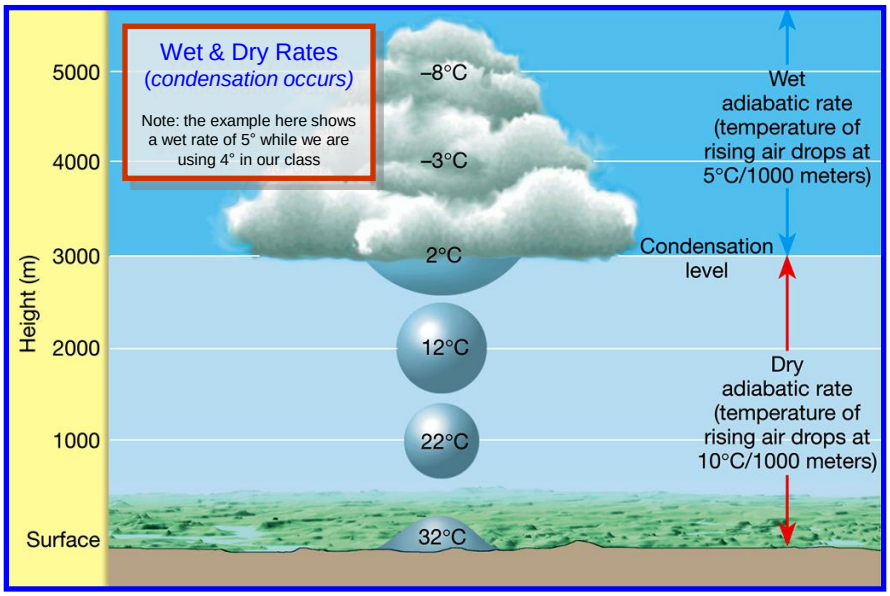
Adiabatic Cooling

- **Adiabatic Cooling:**
  - AIR RISES → EXPANDS → COOLS
  - AIR SINKS → COMPRESSES → WARMS
    - *The Rate is NEGATIVE as you rise (it gets cooler)*
    - *The Rate is POSITIVE as you descend (it gets warmer)*
  - **Dry Adiabatic Rate:** (this happens both rising and descending)
    10°C / 1000m *or* *5.5°F / 1000'*
    - Dry rate = NO CONDENSATION OCCURING
  - **Wet Adiabatic Rate (average):** (this happens while RISING ONLY)
    5°C / 1000m *or* *2.3°F / 1000'*
    - Wet Rate = Dry rate + RELEASE OF LATENT HEAT (*from CONDENSATION*)
    - The wet rate VARIES with the latent heat content of the air

Adiabatic Cooling

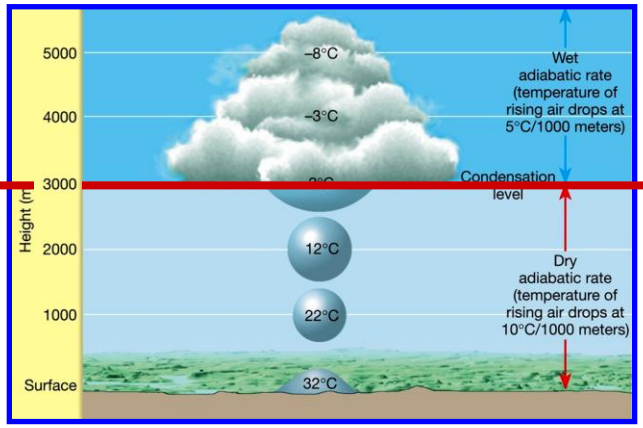


Adiabatic Cooling



Lifting Level

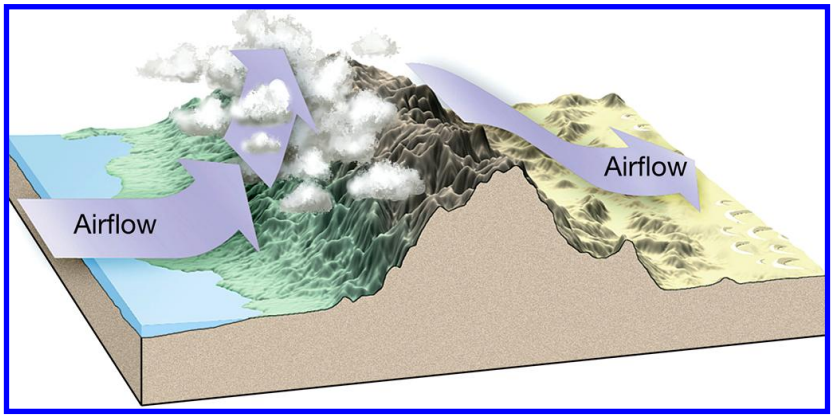
- **Condensation Lifting Level:**
  The altitude where a parcel of air reaches saturation (due to adiabatic cooling)



Lifting Processes

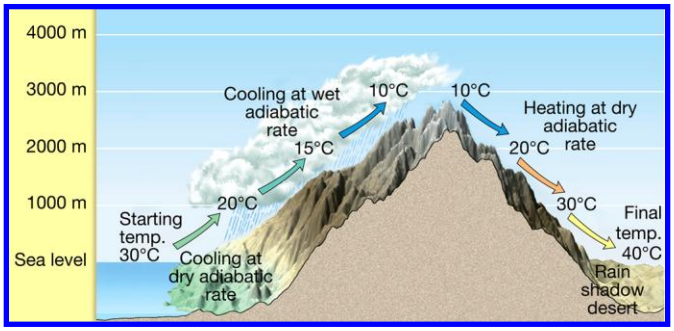
- **Orographic lifting**
  - Air is forced to rise over a barrier (i.e. mountain)
- **Frontal wedging**
  - Warmer (less dense) air is forced over cooler (heavier, more dense) air in a Warm Front
- **Convergence**
  - Air crashing into other air masses (forces air to rise up)
- **Convective uplift**
  - Unequal surface heating causes localized pockets of air to rise (warmer air rises)

Orographic Uplift

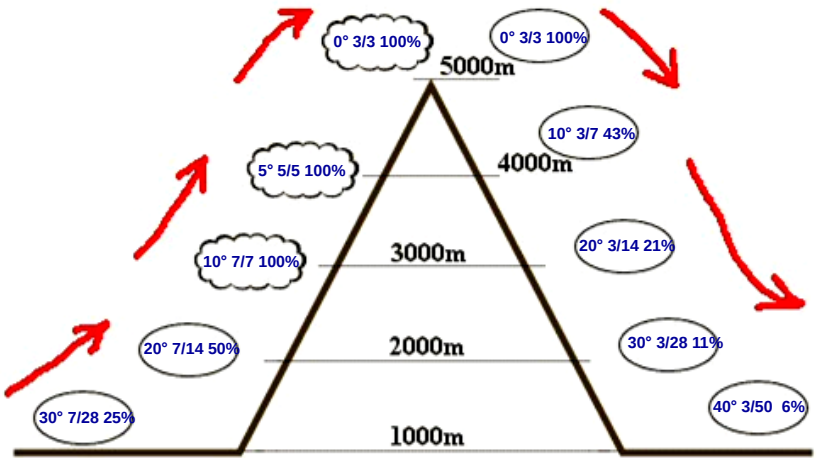


The Snow Eater

- **Chinook Winds (the snow eaters):**
  - **A Chinook Indian term describing the winds from the mountains which swiftly will melt (eat) a tremendous amount of snow in the leeward valleys**
- **Rain Desert:**
  - **A more generic term for this condition found all around the earth**



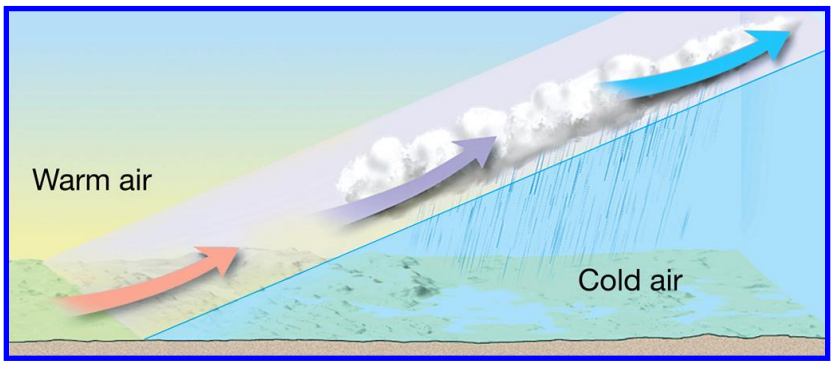
Rain Desert



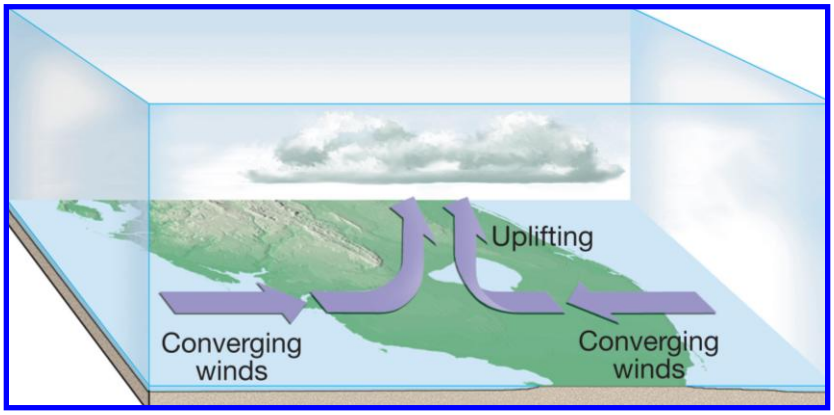
Air begins → 30° and 28%RH → → → Air ends up → 40° and 6%RH

Significantly hotter and drier

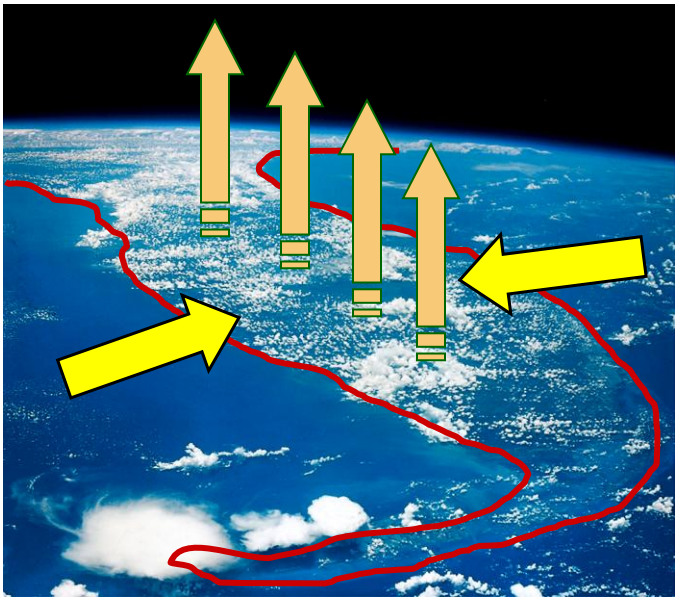
Frontal Wedging



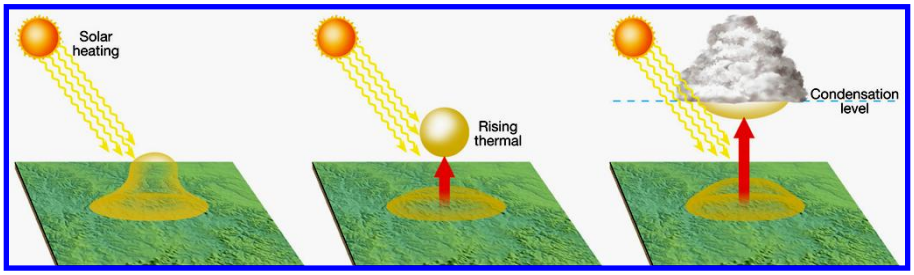
Convergence



Convergence



Convective Uplift



Stability & Instability

- **Stable Air**
  - Air parcel is cooler than surrounding air, if forced up… it will tend to return after (sink back)
- **Unstable Air**
  - Air parcel is warmer than surrounding air, if forced up… it will continue to rise until it becomes the same temperature as the surrounding air
- **Uplift**
  - Vertical upward movement of air
- **Subsidence**
  - Vertical downward movement of air