

## CHAPTER 4: Moisture and Atmospheric Stability

- Movement of water through the atmosphere
  - The Hydrologic Cycle
    - 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
    - Movement of water between Earth's surface and atmosphere
  - Hydrologic Cycle Balance - **UNDERSTAND THE FLOWS AND GENERAL NUMBERS**
    - 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
- States of matter and Changes of 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)
- 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
- Humidity & Relative 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

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

- Vapor pressure and saturation
  - Vapor Pressure: that part of the total atmospheric pressure attributable to its water-vapor content
  - Saturation: the point where the air can no longer contain any additional water vapor (water condensing = water evaporating)
- **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)

**OR**

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

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

- How will relative humidity change if...
  1. Add moisture to the air (same temperature).....*RH% will INCREASE*
  2. Remove moisture from the air (same temperature)... *RH% will DECREASE*
  3. Increase the temperature (same moisture)..... *RH% will DECREASE*
  4. Decrease the temperature (same moisture)..... *RH% will INCREASE*

#### 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: the temperature where the current air parcel will reach saturation (based on the absolute humidity)

- Cooling occurs naturally as:
  - Dew
  - Fog
  - Clouds
- Adiabatic temperature change
  - 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:
  - 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 OCCURRING

- Wet Adiabatic Rate (average): (this happens while RISING ONLY)  
4°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
- Condensation Lifting Level: The altitude where a parcel of air reaches saturation
- Lifting Processes
  - Orographic lifting
    - Air is forced to rise over a barrier (i.e. mountain)
      - 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
  - 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)
- Stability & Instability
  - Stable Air
    - Air parcel is cooler than surrounding air, if forced up... it will tend to return (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

## Chapter 5: Condensation and Precipitation

- Condensation
  - Formation of Condensation
    - Saturated Air
    - Condensation Nuclei
  - Results of condensation
    - Clouds
    - Fog
    - Dew
- Clouds
  - Cloud Classification
    - Cirrus
    - Cumulus
    - Stratus
  - Cloud Descriptions
    - High Clouds (over 6,000m)
      - Cirrus
      - Cirrostratus
      - Cirrocumulus
    - Middle Clouds (2,000 to 6,000m)
      - Altocumulus
      - Altostratus
    - Low Clouds (below 2,000m)

- Stratus
- Stratocumulus
- Nimbostratus
- Vertical Development
  - Cumulus Clouds
  - Cumulonimbus

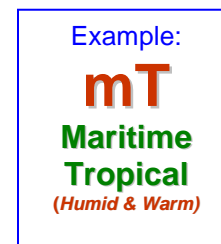
#### Formation of Condensation

- 1) The Air must be SATURATED
    - Condensation Lifting Level
    - Dew Point Temperature
    - 100% Relative Humidity
    - Saturation
  - 2) Condensation Nuclei are needed
- 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 OCCURRING
    - Wet Adiabatic Rate (average): (this happens while RISING ONLY)
      - 4°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
  - Condensation Nuclei
  - Results of Condensation
    - Clouds , Fog or Dew
  - Clouds
    - Cloud Classification
      - Form:
        - Cirrus
        - Cumulous
        - Stratus
      - Height
        - High
        - Middle
        - Low
    - Nimbus Clouds = rain
    - Cloud Descriptions
  - Types of Fog
    - Formed by cooling
      - Radiation
      - Advection
      - Upslope
    - Formed by evaporation
      - Steam Fog
      - Frontal
  - Dew and Frost
    - Frost is NOT frozen Dew!
  - Precipitation Formation
    - Condensation does NOT produce rain!
    - Condensation produces CLOUDS!
    - Precipitation forms within clouds in two ways...
      - In Warm Clouds: Collison / Coalescence

- In Cold Clouds: The Bergeron Process
  - Collision / Coalescence ← UNDERSTAND THESE!
  - The Bergeron Process ← UNDERSTAND THESE!
    - Freezing Nuclei
- Forms of Precipitation
  - Rain
  - Snow
  - Hail
  - Sleet
  - Glaze
  - Rime
- Weather Modification
  - Cloud Seeding:
  - Fog and Cloud Dispersal:
  - Hail Suppression:
  - Frost Prevention

## Chapter 8: Air Masses

- **What is an Air Mass?**
  - An extensive body of air that has relatively uniform temperature and humidity derived from a source region
- **Source Region**
  - The place where an air mass “gets” its temperature and humidity characteristics
  - Air needs to “sit” over this area to “get” humidity & temp (air stagnates over this area and acquires characteristics)
  - **Moisture:** Large uniform areas:
    - **m = Maritime (Humid)**
    - **c = Continental (Dry)**
  - **Temperature:** Latitude
    - **A = Arctic (Very Cold)**
    - **P = Polar (Cold)**
    - **T = Tropical (Warm)**
    - **E = Equatorial (Hot)**



### Air Masses Affecting North America

- **Continental Arctic (cA)**
  - Arctic Basin & Greenland
  - Bitterly cold, very dry (winter)
- **Continental Polar (cP)**
  - Interior Canada & Alaska
  - Very cold, dry (winter)
- **Maritime Polar (mP)**
  - North Pacific – Cool, humid (all year)
  - Northwestern Atlantic
    - Cold, humid (winter)
    - Cool, humid (summer)
- **Continental Tropical (cT)**
  - North Mexico & Southwestern US
  - Hot, dry
- **Maritime Tropical (mT)**
  - Gulf of Mexico, Caribbean, Western Atlantic

- Warm, humid (all year)

### Lake Effect Snow

- **Heavy snow that falls on the leeward side of lakes**
- Process
  - Cold, dry air masses move over warmer lakes
  - Air is warmed  $\diamond$  can hold more water vapor
  - Evaporation from lakes fills air with water vapor
  - Clouds move off of lakes over colder land
  - Air is cooled  $\diamond$  can hold less water vapor
  - Air becomes saturated  $\diamond$  precipitation begins (snow)
  - Usually occurs within 50 miles of the lakes