Chapter 5.
Atmospheric Moisture

- Movement of water between and within the atmosphere and Earth
  - Water covers over 70% of the planet
  - Cycle is in balance (~41 in. yearly average)
  - Easily changes state on Earth
  - Water cycles with different processes
    - Evaporation/transpiration
    - Infiltration
    - Condensation

- Phase changes of water
  - Evaporation – liquid to gas
  - __________ – gas to liquid
  - Melting – solid to liquid
  - __________ – liquid to solid
  - Sublimation –
    - __________ – gas to solid

- During phase changes heat is absorbed or released (latent heat)

- Measures of Water Vapor Content
  - Vapor pressure -
    - Units (mb, kPa, Pa)
    - Affected by temperature and density
      - Higher temperature or density results in higher pressure
      - Density is the larger factor
  - Saturation vapor pressure - maximum water vapor pressure possible
    - Solely dependent on temperature
    - Exponentially increases with temperature
  - Absolute Humidity - Density of water vapor in g/m³
    - Changes as air volume changes
    - Not readily used in meteorology
  - Specific Humidity - mass of water vapor per mass of air in g/kg
    - Does not vary with air volume changes
  - Not widely recognized by public
    - Saturation specific humidity – maximum mass of water vapor for a given temperature
  - __________ – mass of water vapor relative to mass of dry air
    - Does not vary with air volume changes
    - Does not change with temperature
    - Saturation mixing ratio
  - __________ – amount of water vapor present related to the amount air can hold
– Given as a percentage
– RH = SH / C

• Highest RH occurs during the coolest times
• Lowest RH occurs during time of greatest air temperature
• A hot humid day results in a low relative humidity value, making this a poor indicator of actual humidity
– Cannot be used to compare moisture content at different locations with different temperatures

• **Dew Point** -
  
  • **Dew point depression** – difference between temperature and dew point
    – Smaller difference equals more saturated air therefore more likely clouds and precipitation are occurring

• Used to forecast the minimum temperature

• **Frost Point** – temperature where saturation point is below freezing

• Distribution of Water Vapor
  – Moisture in increased by
    • Evaporation
    • Advection
  – __________________ = major source of precipitation for the eastern half of the United States

• **Effect of Curvature on moisture**
  – Small drops exhibit greater curvature than larger drops
    • Influences saturation vapor pressure
    • Small droplets require higher RH’s to remain liquid
    • *Supersaturation* may occur

• **Effect of Solution on moisture**
  – Aerosols dissolve in water creating solutions
    • Opposes curvature and lowers the RH needed to remain liquid
    • __________________ – condensation nuclei that readily attract water (salt)

  • Natural (salt, dust, ash, etc.) and anthropogenic (combustion derivative) sources

• **Ice Nuclei**
  – Atmospheric water does not freeze at 0°C (32°F)
  – Leads to *supercooled* water (0°C and -4°C)
  – Between -10°C and -40°C contains a mixture of liquid drops and ice nuclei
  – At or below -40°C (-40°F) = *spontaneous nucleation*

• **Measuring Humidity**
  
  • Two thermometers to measure wet and dry bulb temperatures
  • Wet bulb depression – difference between dry and wet bulb
– *Aspirated psychrometer*
  • Uses a fan for air flow instead of slinging the instrument

– Uses hair expansion and contraction to measure humidity
  • Hygrothermograph produces a continuous record of humidity

• Human Discomfort Index
  – *Heat index* - Combines heat and humidity factors to determine an apparent temperature
  – High humidity reduces evaporation reducing the cooling power of perspiration

• Cooling Air to the Dew or Frost Point
  – *Diabatic processes*
    • The direct addition or removal of heat energy
    • The *Second Law of Thermodynamics*
      – Energy transfers from areas of high temperature to areas of lower temperature
    • Usually only produces fog

• Adiabatic Processes
  –
    • Rising air will expand and cool adiabatically
    • Sinking air will compress and warm adiabatically
  – *Dry adiabatic lapse rate* (-5.5°F/1000ft)
    • Lapse rate in dry air
  – *Saturated adiabatic lapse rate* (-3.3°F/1000ft)

• Overall decrease in air temperature with height
  – Changes diurnally from place to place
  – When temperatures decrease rapidly with height this establishes a steep ELR
    • Creates unstable air and can assist with storm development

*Forms of Condensation*

• *Dew*
  – Liquid condensation on surface objects
  – Occurs on clear windless nights

• *Frost*
  –
    • Directly from gaseous water vapor to solid ice crystals

• *Frozen Dew*
  – Dew formation followed by a temperature drop
  – Creates a tight surface bond making it difficult to remove

• *Fog* –
– *Precipitation fog*
  - Evaporation of falling rain drops
  - Water evaporates off a hot road
– *Steam fog*
  - Warm and cold air mixing
  - Cold air over warmer water
  - Your breath on a cold day
– *Radiation Fog*
  - At night, ground cools radiatively and cold air sinks to the lowest levels (“valley fog”)
  - Clear cool nights with light winds
– *Advection Fog*
  - Warm, moist air moving over cool surface
  - Warm spring air over cold snow surface
– *Upslope Fog*
  - Adiabatic process from upslope advection

*Formation and Dissipation of Cloud Droplets*
– Clouds formed through adiabatic cooling of rising air
– 50 m above the LCL all condensation nuclei are used
– Additional growth occurs instead of new drop formation

**End of Chapter 5**