ESCI 107/109 – The Atmosphere
Lesson 3 – Temperature

Reading: *Meteorology Today*, Chapters 2 and 3

**GENERAL**

- Temperature is a measure of the average kinetic energy of the molecules in the substance.
  - If you add energy to an object, its molecules will move faster, and have more kinetic energy...therefore, its temperature will go up.

- A temperature scale must have at least two fixed points, or reference points.
  - **Celsius**
    - 0°C chosen as the melting point of ice.
    - 100°C chosen as boiling point of water (at sea-level pressure)
  - **Kelvin**
    - 0 K chosen as coldest theoretical temperature possible, referred to as *absolute zero*. No object can be cooled below this temperature.
    - A change of 1 K is chosen to correspond to a change of 1°C. Therefore, the freezing point of pure water is 273 K.
  - **Fahrenheit**
    - 0°F chosen as lowest temperature that a mixture of ice, water, and ammonia salt (ammonium chloride) can reach in equilibrium.
    - 32°F is the freezing point of pure water.
    - 96°F was originally chosen as the blood temperature of a healthy person (now 98.6°F on the modern Fahrenheit scale).
  - Fahrenheit’s choices of his fixed points seems arbitrary, and his exact reasoning hasn’t been recorded.

- **Note:** If you are interested in historical accounts of thermometers and the creation of the various temperature scales you can try the following two books: *A History of the Thermometer and its use in Meteorology* by W.E.K. Middleton, Johns Hopkins Press, 1966; or *Inventing Temperature: Measurement and Scientific Progress* by H. Chang, Oxford University Press, 2004.
Temperature measurement
- Temperature should be measured in the shade, so that solar radiation does not heat thermometer and give exaggerated readings.
- Temperature should not be measured close to a building or hot pavement.
  - Ideally, a well ventilated, white instrument shelter should be used.
- Lines of constant temperature are called isotherms.

CONTROLS OF TEMPERATURE
- Latitude
- Differential heating of land and water
  - Difference in specific heat
  - Evaporation
- Ocean currents
  - East coast of continents have warm currents
  - West coast of continents have cold currents
- Altitude
  - Environmental lapse rate can’t explain all of the difference between a valley station and a mountain station.
  - Daily temperature range generally increases with altitude (because atmosphere is less dense, and solar radiation is more intense at higher altitudes).
- Geographic position
  - Windward vs. leeward coast
  - Mountains act as “rain shadow”
    - Urban vs. rural – The heat island
- Cloud cover and albedo
  - During day, clouds lead to cooler temperatures
  - At night, clouds lead to warmer temperatures
  - Snow absorbs less radiation than bare ground, and results in cooler temperatures. Dirty snow absorbs more radiation than fresh snow.
- **Humidity**
  - Since water vapor is a greenhouse gas, then in general, humid nights are warmer than dry nights.

- **Wind**
  - Wind mixes the air near the ground.
  - In the day time the warmest air is usually near the ground. Because of mixing, the wind will move cooler air toward the ground during the day.
  - At night the coolest air is usually near the ground. Because of mixing, the wind will move warmer air toward the ground at night.
  - So, in general
    - Windy nights are warmer than calm nights.
    - Windy days are cooler than warm days.

**GLOBAL TEMPERATURE DISTRIBUTION**

- Temperature decreases from the tropics to the poles
- Spacing of the isotherms (*temperature gradient*) is not uniform with longitude. This is due to:
  - Ocean currents
  - Land-sea contrasts
- Band of maximum temperature migrates with the seasons
- Hottest and coldest temperatures are over land

**TEMPERATURE CYCLES**

- Daily cycle
  - Time of daily temperature maximum does not coincide with time of maximum solar radiation.
  - Maximum temperature usually in afternoon
  - Minimum usually near sunrise
  - Daily temperature variation is smaller on a windward coast
  - Clouds and wind both decrease the daily temperature variation
● Annual cycle
  ○ Month of annual temperature maximum does not coincide with month of maximum solar radiation July and August are usually hottest months in U.S., but max solar radiation is in June).
  ○ Month of annual temperature minimum does not coincide with month of minimum solar radiation.

USEFUL TEMPERATURE INDICES

● Heating and cooling degree days
  ○ Used to estimate energy consumption for heating or cooling a building.
  ○ Assume no heating or cooling if temperature is 65 degrees F.
  ○ Find difference between daily mean temperature and 65 degrees. Every 1 degree difference is a heating degree day if positive, or a cooling degree day if negative.

● Wind chill
  ○ Factors in the effects of wind and evaporation on the human sensation of temperature to give an wind-chill equivalent temperature.
  ○ A thermometer reads air temperature, NOT the wind-chill equivalent temperature!

● Heat index factors in the effect of humidity on the human sensation of temperature.