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, $T_{mean} - 65^{o}F$. Every 1 degree difference is a heating degree day if negative, or a cooling degree day if positive.**
- **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.**