Lecture Notes for 1/6/04

<u>Current Weather Discussion</u>

- high winds coming through the passes near Enumclaw
- 18 hours ago, the prediction for 10 am was for 1 inch of snow/hour – this turns out to be approximately correct
- radar imagery shows Seattle in the region of heavy snowfall
- The snow is predicted to turn into rain later on – since the ground is frozen, the rain will form puddles instead of sinking in, leading to flooding

<u>History of the Atmosphere Continued</u>

composition of volcanic outgassing is:

water (H_2O):	85% (by mass)
carbon dioxide (CO_2):	15%
oxygen (O_2) and nitrogen (N_2):	tiny

composition of current atmosphere is:

nitrogen:	76% (by mass)
oxygen:	<u>23%</u>
	99%

How did we get from the volcanic composition to the current composition?

- Water condensed to form the oceans
- Carbon dioxide dissolved in water and then precipitated out to form rocks. Rocks and the ocean now store far more carbon dioxide than the atmosphere. In contrast, on Venus the carbon dioxide stayed in the atmosphere, creating a greatly different climate from the Earth's.
- Oxygen created by life
- Much of this transition occurred approximately 2 billion years ago when the first life appeared in the ocean. Life originated in the oceans because the ocean protects tissues from harmful rays from the sun. Once enough oxygen was produced to allow ozone (O_3) to form, the ozone protected the earth from these harmful sun rays, allowing life to develop on land.
- There is believed to be an upper limit on the amount of oxygen in the atmosphere. If oxygen levels become too high, the conditions become favorable to fire. Thus the oxygen level is self-regulating.

Today's Atmosphere

These gases, which constitute the majority of the atmosphere, have stable concentrations and do not contribute to the greenhouse effect:

nitrogen: 78.10% (by volume)
oxygen: 20.95%
argon (Ar): 0.93%
neon (Ne): 0.0018

The following gases, which have variable concentrations, are greenhouse gases:

water vapor: 0-4%
carbon dioxide: 0.37% = 370 ppm
methane (CH_4) : 1.7 ppm
nitrous oxide (N_2O): 0.3 ppm
ozone: 0.04 ppm

note: 1 ppm = 10^{-4} %
ppm stands for parts per million, so 1.7 ppm methane means there are 1.7 molecules of methane for a million molecules of air.

- Water vapor is the most important greenhouse gas.
- Carbon dioxide is the second most important greenhouse gas.
- Per molecule, methane has a stronger greenhouse effect than carbon dioxide, but since there is less methane, it's total effect is smaller.
- The greenhouse effect is big and has existed for millions of years
- Climate change is different from the greenhouse effect, and refers to what is happening currently.

2) Energy, Temperature, and Heat

The most important energy source to the earth is the sun. We can tell that the sun is more important than geothermal energy by observing that the earth cools substantially during the night.

2.1) energy – the ability to do work, i.e. to lift, push, etc.

forms of energy	*examples*
Potential	gravity (suspended mass, ball on a table)
	chemical (batteries, food)
Radiant	electromagnetic (EM) energy (light)

Kinetic	heat (molecules in motion) – internal wind, car moving – external

note: internal energy is stored energy

- Energy can be transferred between these different forms but it must be conserved

2.2) Kinetic, heat, and temperature

- All substances are made of atoms or molecules in rapid motion, and thus all substances have kinetic energy (KE).
- Kinetic energy is given as the product $KE=1/2\ mv^2$, where m is the mass and v is the speed.
- Example: From this equation we see that a man weighing 100 kg riding a bike at 10 m/s (22 mph) has the same kinetic energy as a car weighing 1600 kg travelling at 2.5 m/s
- Air molecules at room temeperature (20 degrees C) move at approximately 450 m/s, and collide with each other. In a room there are billions of collisions per second. All of these collisions together have a total kinetic energy, defined as *heat*.
- *Temperature* is a measure of the average kinetic energy of the ensemble of molecules.
- So, more kinetic energy means more heat, and less kinetic energy means less heat, but the same is not true for temperature. For example, imagine two glasses of water at 20 degrees C being combined into 1 glass. The resulting large glass has more heat than one small glass, but the temperature is still 20 degrees C.
- When KE=0, the temperature is “absolute zero”.

Temperature (heat) and evaporation

Liquid water at high temperatures has more kinetic energy than water at low temperatures. Thus, the molecules in the hot water will be moving faster on average. When a molecule moves fast enough, it can escape, a process called evaporation. Since the likelihood of a molecule travelling fast enough to escape increases with increasing temperature, molecules are more likely to escape from warmer liquid water.

2.3) Temperature Scales

- There are many, including 3 important ones.
- Farenheit (degrees F) was invented in 1715, and is still used in the U.S. We' ll be using it on surface charts.
- Farenheit is based on water, which freezes at 32 degrees F and boils at 212 degrees F