ESCI 107/109 – The Atmosphere
Lesson 1 – Origin, Composition, and Structure of the Atmosphere

Reading: ***Meteorology Today*****, Chapter 1**

GENERAL

- **Earth system consists of four spheres**
  - **Lithosphere – rigid, outer layer of earth that includes the crust and the upper part of the mantle**
  - **Hydrosphere**
    - **97% of the earth's water is in the oceans**
  - **Biosphere**
  - **Atmosphere**
- **The four spheres interact**
  - **Example: The water cycle involves all four spheres.**
- **Energy sources for the Earth system are**
  - **Sun –** ***Very important for atmosphere!***
  - **Residual heat in the interior of the Earth –** ***<u>Not</u> important for the atmosphere!***

COMPOSITION OF THE ATMOSPHERE

- **Fixed gases**
  - **Nitrogen (N_2) 78%**
  - **Oxygen (O_2) 21%**
  - **Argon (Ar) 0.9%**
  - **Carbon dioxide (CO_2) ~400 ppm**
  - **Neon (Ne)**
  - **Helium (He)**
  - **Methane (CH_4)**
  - **Krypton (Kr)**
  - **Hydrogen (H_2)**

- **Variable gases**
  - **Water vapor (H_2O)**
  - **Ozone (O_3)**
    - **90% of ozone is in the stratosphere**
    - **Has several important roles**
    - **Absorbs harmful ultra-violet (UV) radiation**
    - **Plays an important role in the atmosphere's ability to cleanse itself of pollutants**
    - **Is itself a pollutant when in high concentration near the ground**
- **Aerosols**

EVOLUTION OF ATMOSPHERIC OXYGEN

- **The Earth was formed around 4.5 billion years ago.**
- **The very first atmosphere likely consisted of**
  - **Hydrogen (H)**
  - **Helium (He)**
  - **Methane (CH_4)**
  - **Ammonia (NH_3)**
- **This first atmosphere was lost to space during the bombardment by meteorites and the intense solar wind shortly after the Earth was formed.**
- **A new atmosphere eventually formed from outgassing from volcanoes and other venting activity.**
  - **This second atmosphere was composed primarily of**
    - **Water Vapor (H_2O)**
    - **carbon dioxide (CO_2)**
    - **nitrogen (N_2)**
  - **There were only trace amounts of oxygen in this first atmosphere.**
    - **This oxygen likely came from the reaction of ultraviolet radiation with water, which splits the water into hydrogen and oxygen.**
  - **O_2 was less than 2 ppmv (parts per million by volume), or about 100,000 times less than today.**
- **Photosynthesis evolved sometime between 3.5 and 2.7 billion years ago.**
  - **Photosynthesis evolved first in bacteria, called cyanobacteria.**

- **Photosynthesis takes in carbon dioxide (CO_2) and gives off oxygen (O_2).**

- **Rather than build up in the atmosphere, the oxygen formed from photosynthesis would have instead reacted with other substances such as iron (Fe) to form iron oxides in the rocks and soils.**
- **Eventually though, all the oxidation was essentially complete, and then oxygen could build up in the atmosphere.**
- **Between 2.4 and 2.0 billion years ago oxygen levels rose to somewhere between 1/10 or more of their present value, and then remained constant until around 850 million years ago.**
- **Oxygen levels began to rise around 850 million years ago, and 300 million years or so ago they were actually higher than today (perhaps as high as 35% of air molecules were oxygen).**
  - **This oxygen spike during the Carboniferous period is correlated to the finding of fossils of giant insects and amphibians.**
    - **Certain insects and amphibians rely on diffusion of oxygen for respiration, and oxygen can diffuse farther at higher concentrations.**
    - **Some dragonflies had 30 inch wingspans, and had bodies over 1 inch in diameter!**
- **Oxygen levels fell to present levels (21%) by about 200 million years or so ago, which ended the era of giant insects and amphibians.**
- **During the evolution of the atmosphere, the amount of nitrogen, N_2, remained relatively constant.**

HEIGHT AND STRUCTURE OF THE ATMOSPHERE

- **Pressure**
  - **Decreases rapidly with height.**
  - **If atmosphere were incompressible, pressure would change linearly with height. Instead, it changes nearly exponentially.**
  - **There is no "lid" on the atmosphere. The edge of the atmosphere is rather arbitrary.**
- **Temperature**
  - **The atmosphere is divided into four regions based on temperature.**

- **Troposphere – the lowest layer, characterized by decreasing temperature with height.**
  - **Average lapse rate ~ 6.5°C km^{-1} (3.5°F 1000 ft^{-1})**
- **Stratosphere – characterized by increase in temperature with height (due to absorption of UV radiation by ozone).**
- **Mesosphere – temperature again decreases with height.**
- **Thermosphere – temperature rises with height (due to absorption of UV radiation by oxygen and nitrogen atoms).**

- **The atmosphere can also be divided into two separate regions based on composition**
  - **homosphere**
    - **below about 80 km**
    - **well-mixed**
  - **heterosphere**
    - **above about 80 km**
    - **stratified by weight**
  - **the separation between the homosphere and the heterosphere is called the *turbopause*.**
- **Another special region – the *ionosphere***
  - **80 – 400 km (50 – 250 mi)**
  - **characterized by ions and free electrons**
  - **affects propagation of radio waves**