Session #2, CLASS NOTES.

Relevant reading: Chap 1, p.1-10; Chap 4, p.69-72

Three major global problems. We discussed three major global problems due to the activities of humankind:

(1) Global warming
(2) Ozone depletion
(3) Biodiversity loss (primarily a result of deforestation)

#1 Global Warming and the Greenhouse Effect Notes:
The surface of the Earth is warmed by sunlight (also known as solar radiation). Certain gases in the atmosphere absorb heat radiation (infrared radiation) coming from the warm planetary surface and this causes the atmosphere itself to warm up to some finite temperature. The atmosphere then gives off infrared radiation because it is at a finite temperature. Some of the atmosphere's infrared radiation goes down back to the surface of the Earth and warms the surface. Consequently, the Earth's surface is warmer than it would be if there were no atmosphere because it is heated from two sources: (1) radiation from the Sun AND (2) radiation from the atmosphere. If there were no atmosphere, the Earth's surface would only be heated by the Sun, so the Earth would be much colder. The mechanism by which a planet's atmosphere heats a planet's surface is called the **greenhouse effect**. The greenhouse effect warms the Earth's surface by about 33°C. The current mean global temperature is 15°C, so if we did not have the greenhouse effect of the Earth's atmosphere, the mean global temperature would be –18°C, i.e. well below freezing.

Greenhouse gases are those gases in the atmosphere that absorb infrared radiation and radiate some of it back down to the surface, thereby warming the surface. **Global warming** is a warming of the Earth's atmosphere due to human-induced enhancement of the greenhouse effect.

Greenhouse gases include carbon dioxide, CO_2. Carbon dioxide is produced by humans, who burn fossils fuels (coal, oil, natural gas). Deforestation also contributes to CO_2 increases because dead trees decay and make CO_2 during decay. Other greenhouse gases include methane (CH_4), nitrous oxide (N_2O), and certain chlorofluorocarbons. Chloroflurocarbons (CFCs) are so called because they contain chlorine (Cl), fluorine (F) and carbon (C). CFCs are also known as freons. Examples of CFCs include CCl_3F and CCl_2F_2. Water vapor (H_2O) is also an important greenhouse gas, but the concentration of water vapor in air is variable and depends on the temperature of the atmosphere. For example, when it is cold, the atmosphere can contain little water vapor and water condenses out (witness your breath on a cold day). So water vapor levels are driven by an atmospheric temperature that is set, in turn, by the other main greenhouse gas, CO_2.

#2 Ozone depletion notes.
For now, note that ozone molecules are made up of three oxygen atoms (O_3), which is different from oxygen molecules made up of two oxygen atoms (O_2). The peak

concentration of ozone is about 25 km altitude above where we live.

#2 Biodiversity notes
We need to define biodiversity. We define it as the number of species in a given area. For example, it could be the total number of animal and plant species in a given area. Alternatively, we might just be considered with bird biodiversity, say – the total number of bird species in a given area.

What is "climate"? How does it differ from "weather"?
If we're to discuss "climate change" we need to understand what we mean by "climate". The difference between weather and climate is that between instantaneous conditions and averaged conditions. We define *climate* as "the characteristic pattern of weather over a region and over a period of time." For example, the average monthly temperature for January in western Washington indicates the climate during a particular period over a specific region. We could also average other weather elements, such as temperature, rainfall, humidity, sunshine, wind, etc., to get a broader sense of the climate conditions during a particular period. However, on any particular day, we might get a temperature (or rainfall, humidity, etc.) that is higher or lower than the historical average. Thus climate is "what you expect" and weather is "what you get".

In class, we compared Fig 4.18a,b & c that show temperatures across the world and indicate summer and winter climates. Primarily, the climate is driven by the latitudinal distribution of sunlight (see Fig. 4-15, p.67, and associated write-up). However, the world is complicated. Land/ocean contrasts, altitude/topography, and atmospheric and ocean currents all play a role in setting the climate in a particular region. Continents have a larger variation in temperature between summer and winter than oceans. Tropical oceans, for example, have little variation in temperature between summer and winter (see Fig 4.18). At altitude it is generally colder and wetter/snowier. Ocean currents can also modify temperatures, e.g. the Gulf Stream moderates the temperature in wintertime coastal western Europe.

The Earth System

A key theme is that the Earth system behaves as a "coupled system". This is a system of components that interact with each other and affect one another. The Earth system is not a single entity but made up of an ocean, atmosphere, biosphere and solid planet. Each of these, in turn, is made up of components, e.g. the atmosphere can be thought of as composed of a number of weather systems, a water cycle, and so on.

In discussing systems, we often talk of "forcings". In the textbook (p.3-4), it says: "One of our goals is to show how the different components of the Earth system interact in response to various internal and external influences, or *forcings*." What do we mean by the term "forcing"? **Forcing** is a persistent disturbance to a system. Forcing imposes a change on one or more components of the Earth system, e.g., the variation of sunlight over a year on the planet drives the climatic temperature, which in turn, affects the cycling of water. When we are dealing with systems as complicated as the Earth, it is not always simply a matter of cause and effect. Global warming might change ocean currents, for example, that could change the exchange of greenhouse gases between the atmosphere and ocean, and cause more global warming. This is an example of *feedback*. Also we often think of cause and effect as an immediate linear response. However, systems can also have delayed responses and abrupt changes (or nonlinear response). For example, when you boil some water, it takes time to reach a transition point where convection cells and bubbles appear abruptly. The climate system also appears to undergo abrupt changes. The historical record of climate change, such as the abrupt change of ice-age to interglacial periods (or the onset of "Snowball Earth" events) is evidence for the potential for sudden changes in the climate system.