Chapter 23 - The Atmosphere, Climate, and Global Warming

Case Study: Global Warming and the bears of Hudson Bay
This case study how global warming has had an impact on polar bears by causing a thinning of the sea ice in Hudson bay. Since Polar bears have to move around on the ice to hunt. the bears weigh less on average and have fewer pups.

The Atmosphere

90% of the weight of the atmosphere is in the lowest layer, or *troposphere*, of the atmosphere. Air in this layer is78% nitrogen, 12% oxygen, 0.9%argon, and 0.04% carbon dioxide.

The atmosphere is structured in layers [figure 23.1]. The lowest is the troposphere, where the temperature decreases with height. Above it is the *Stratosphere*, where the temperature increases with height as a result of the interaction of uv light with the ozone layer found here.

Air rises and sinks above the surface of the earth as a results of the changing angle of sunlight incident on earth. It rises above the warm equatorial region and sinks at the poles. This results in several atmospheric convection cells. Air tends to sink at about 30 degrees north and south where deserts are found since this sinking air is dry, having lost its moisture as it rose above the equator. This motion of the air, along with the coriolis effect, account for global scale winds patterns.

Climate Change

Climate means the average weather conditions over a long period of time, usually 30 years.

the temperature of earth has fluctuated up and down by several degrees centigrade over the past several million years [figure 23.4]. There is a cyclical pattern of about 120,000 years cause by the Milankovitch cycles, which have to do with periodic variation in the earth's orbit around the sun.

A warming trend clearly began around 1850. Most of hte hottest years on record have been in the last decade. AS global temperatures continue to affect ocean temperatures, interest in teh ocean conveyor increase [fig 23.5], this current distributes equatorial heat to the north regions. As it warms it brings more heat there. However, as glacial ice cools it may interfere with the current's ability to lose it's heat, causeing local cooling.

Earth system Science and Global Change

Studying global climae change requires both our best methods of current measurement as well as ways to make measurements of conditions from teh past. Scientists get information fromteh past, or "proxydata"," from several sources, including ocean sediments and ice cores. Ice cores, in particular, have allowee us to gather information about historical CO2 levels because they have trapped bubbles of gas representative of hte atmosphere at that time [fig 23.7]. Modern measurements of CO2 have been taken at Mauna Loa observatory since the late 1950s [fig 23.8]. During that time the concentration of CO2 in the atmosphere has increased from about 315 ppm to 400 ppm.

Electromagnetic Radiation and and Earth's Energy Balance

Earth Receives energy from teh sun in the form of electromagneti radiation [fig23.11]. The light received from the sun is 30% reflected (25% by hte atmosphere, 5% by the surface of the earth) and 25% absorbed by hte atmosphere (especially the harmful shorter wavelengths). about 45% of the Energy is absorbed by the earth [fig 23.10].

The Greenhouse Effect

The sunlight absorbed by the earth is turned to longer infrared (heat)wavelength and re-radiated by the Earth. Certain gases in the atmosphere absorb and reradiate this heat. This trapping of heat is called the greenhouse effect [fig23.13].

About 97% of the absorption of heat in the atmosphere is done by water as either vapor or int eh form of tiny droplets. The concern is about anthropogenic (human caused) warming. The main anthropogenic greenhouse gases are CO2 (50%), Methane, CH4 (20%), CFC (20%), tropospheric ozone O3, 8%, and N2O 3%. [table 23.1].

The Earth emits infrared in teh 4 to 20 micron range. CO2 and H2O absorb in the 8 and 14 micron ranges, leaving a large "atmospheric window." One issue with the increased emission of CFC and Ozone is that they absorb in this wavelength [fig 23.14].

Sources of CO2 are primarily from the burning of fossil fuels and burning trees during deforestation. CO2 had been at a concentration of about 280ppm for 700 years prior to the industrial revolution in 1860. It is now at 400ppm.

Methane has doubled over the last 100 years. Methane is emitted naturally by wetlands and seepage from oil fields. Anthropogenic sources include landfills, oil and gas produciton and agriculture - especilly from livestock.

Chlorofluorocarbons are used as refrigerants and were formerly used as a propellant in spray cans. They have a residence time of 100 years.

Science of Global Warming

Over 160,000 years there is a strong correlation between CO2 concentrations and atmospheric temperature [fig 23.16]. Recent science stringly indicates that current increases in CO2 will cause future warming sonsistent with that correlation. The most optimistic projections are for a 1 degree increase by 2100.

Negative and Poitive feedbacks [fig 23.17]

Negative feedbacks

- warming increases algae populations, this absorbs CO2, resulting in cooloing
- Increased CO2 prompts terrestrial plant growth, decreasing CO2 and therefore decreasing global temp
- increased temp leads to increased evaporation, leading to more polar precipitation. this increases albedo. Less solar radiation is absorbed and turned to heat, leading to cooling
- increased temp leads to increased evaporation, leading to more cloud cover. this increases albedo. Less solar radiation is absorbed and turned to heat, leading to cooling

Positive Feedback

- Increased warmth leads to increased water vapor, water vapor is a greenhouse gas, this leads to warming (and more evaporation…)
- Increased temp. leads to melting of permafrost, this releases methane which is a greenhouse gas, therefore, more warming (and more melting of permafrost…)
- increased temp leads to increased evaporation, leading to more cloud cover. clouds keep infrared in, causing warming (and more evaporation…)

A lot of research is focussed on these feedbacks, since their relative balances will determine the future of warming.

Forcings

Any phenomenon that can affect global temperature is called a "forcing."

Solar Forcing - the sun's output is not constant, and its variability may have some influence on changing climate. there is a well known 11 year sun slot cycle

Aerosols and volcanic forcing - particles of solid and liquid suspended in the atmosphere are called aerosols. They reflect sunlight, causing cooling. One source of large amounts of these aerosols is volcanoes - so paradoxically they tend to result in global cooling.