HWC 201 -- UNIT 4 -- THE ENVIRONMENT --

Human Impact on the Atmosphere--Ozone Depletion and Global Climate Change

The global climate is an essential foundation of natural ecosystems and the entire human economy. If we are entering a new period of climate instability, the consequences could be serious indeed, affecting virtually all of Earth's ecosystems, accelerating the pace of extinction, and leaving few areas of economic life untouched.—The Worldwatch Institute

I. Introduction – focus on concepts: unanticipated consequences; uncertainty; non-linear effects; lag time; long-term effects (e.g., cancer); complexity of global phenomena; multiple causation; when science is politicized–e.g., brownlash; tragedy of the commons

II. "Regional" Climate Change – e.g., city "heat island" effect; Amazon

III. Stratospheric Ozone Depletion

A. What is ozone and the ozone layer? – O_3 (a blue-tinted, toxic gas)

– Natural ozone production from oxygen (O_2) in the stratosphere 17-26 km (11-16 miles) above the earth's surface (actually a series of reversible reactions) with the result being a thin veil of ozone that blocks about 99% of harmful ultraviolet radiation (UV radiation) from the sun (providing an **ozone "shield"**)

B. Cause & mechanism of ozone depletion (reduction in ozone shield)

– CFC's (**chloroflurocarbons**)—freons—and related compounds – stable, odorless, non-toxic, non-reactive and non-corrosive "dream" compounds; therefore they had many uses—propellants, refrigerants; but also "nightmare" compounds—these compounds rise to the stratosphere over many years; they break down releasing highly reactive **chlorine** atoms—these chlorine atoms are involved in reactions which break down ozone (each chlorine atom can destroy 100,000 ozone molecules); also bromine compounds—e.g., halons used in fire extinguishers; ozone hole (better called **ozone thinning**) over Antarctica (in 2000 an area 3 times as large as the continental U.S.)—**polar vortex**—isolated mass of swirling air; with ice crystals—typically loss of about 40-50% of ozone, but up to 100%; global reduction of ca. 4%;

C. Consequences of O_3 depletion — Australia—3 out of 4 people predicted to get skin cancer in Queensland; emergency in Punta Arenas in Chile; also happening over the northern hemisphere—United States and Eastern Europe—reduction in ozone layer of ca. 10% in winter and spring and 5% in summer and autumn—serious implications for skin cancer, eye damage, immune system suppression, lowered crop yields, ecosystem problems; # of skin cancers has quadrupled in the U.S. in last 20 years (ca. 10,000 deaths/year); excellent example of *unanticipated consequences; lag time; complexity of global phenomena; science being politicized*

Brownlash (purposeful distortion of scientific information about the environment in the service of ideology and self-interest—very different from honest scientific disagreement; need to distinguish); Brownlash quote: "*Similarly, if there were in fact to be some reduction in the ozone layer, the appropriate response, to avoid the additional cases of skin cancer that would allegedly occur from exposure, to more intense sunlight, would be to be sure that there were more sunglasses, hats, and sun-tan lotion available*" –George Reisman

D. What are we doing? – If production of all **ozone depleting chemicals** (ODCs) was stopped, estimated it would take about 50 years to reach 1980 ozone levels and about 100 years or more for full recovery (reasons: many sources still in existence (various ODCs; old sources of CFCs); 10-20 years for CFCs to reach stratosphere; long-lived molecules—some a hundred year or more; many years needed for regeneration)

1987—Montreal Protocol—treaty among 36 nations to reduce emissions of CFC's; subsequently Copenhagen Treaty; now more than 150 countries; CFC production fell by more than 77% between 1988 and 1995; though reduced, some types of ODCs still being made—ozone loss will be at its worst between 2010 & 2019 (**lag time**)

But, ***good news*!**—a lot better than it could have been—environmentalists averted a potential worldwide catastrophe

Sherwood Rowland and Mario Molina—realized in the 1970s there was a problem—were awarded Nobel Prize in 1995 for their contribution; Why a success story?: clear evidence (despite brownlash); only a few companies making CFCs (economics); substitutes; global cooperation—in everybody's best interest (without major cost)

IV. Global Climate Change; Greenhouse effect; Global Warming

A. Explanation of the greenhouse effect

Greenhouse effect—certain gases in the atmosphere trap heat in the lower atmosphere and raise the average global temperature (by absorbing IR or infrared radiation = heat)—no controversy about the scientific basis; atmosphere acts like a blanket

--analogy of your car on a summer day in Texas

--greenhouse gas—one that absorbs infrared radiation and thus warms the atmosphere

--examples: carbon dioxide, methane, chloroflorocarbons (CFCs), nitrous oxide [Note: CO_2 responsible for 50-60 % of global warming]; greenhouse effect very important to maintenance of life on earth as we know it—without it the earth would be covered by ice!

Some things also cool earth: reflection of sunlight (planetary albedo) by clouds, dust from volcanoes, aerosols (micron-size particles--e.g. sulfates). Thus global temperature is a balance of warming & cooling.

However, recently we have been increasing the quantity of greenhouse gases in the atmosphere: U.S. producing between 1/5 and 1/4 of total anthropogenic (=human-caused) CO_2; global climate models--predictions; effects of volcanoes on climate—Pinatubo-1991--1˚ C drop in global temperature due to material injected into atmosphere (ash and sulfate particles); early 1800's "year without a summer" due to eruption of Tambora

Best called **global climate change** because not just temperature but many aspects of global climate, including precipitation patterns and the occurrence and severity of storms, are affected (also local cooling)

B. Evidence – recent data on CO_2

—steady increase due mainly to ***burning of fossil fuels & deforestation*–multiple causation**

30 % increase in global atmospheric CO_2 from 1860 to 1998; highest in past 420,000 years, > 0.5%/year

0.6˚–0.7˚ C (1.1˚–1.3˚ F) increase over the past approx. 100 years

globally the 20th century was the warmest in the last 1,000 years

the last decade of soaring temperatures represents the warmest seen globally during the past 600 years; since record-keeping began in 1866, the warmest 15 years have all occurred since 1980

spring about a week earlier than normal across much of the U.S. and Canada

extreme weather events more common (heavy rains, droughts, record temperatures, severe storms)—ice storm U.S. & Canada, drought in parts of U.S.; fires in tropics—Indonesia, Mexico; flooding in China

Glacial recession in many parts of world—**What is the cause?** Natural climate cycle? Human activities? Some combination? **Simple answer to human activities as the cause: Maybe to probably**

Intergovernmental Panel on Climate Change (IPCC) – 1995 – through United Nations – 100's of scientists

Report on **anthropogenic** impacts on global climate concluded:

1) world climate has changed significantly over the past century
2) the balance of evidence suggests a discernible human influence on climate change
3) climate models (computer) suggest that –if current trends continue—global mean surface air temperatures will likely increase between 1.4˚ C and 5.8˚ C (2.5˚ and 10.4˚ F) by A.D. 2100 (compared to 5˚ C (10˚ F) difference during last glaciation

—2001 IPCC update--2,500 experts in 70 countries; more confidence in humans as at least part of the cause

A number of **uncertainties**–global climate models (complexity); confidence but effects of aerosols, ocean currents? Critics(many, *but not all*, with an interest in maintaining current energy use patterns) say we don't have scientific proof—therefore lack of absolute certainty (What is "proof" scientists?) & should do nothing (skepticism; look at who benefits; follow the money)

Three schools of thought: 1) *no problem* (small minority); 2) waiting strategy; 3) precautionary strategy; Thomas Lovejoy argues against doing "*total planet experiments that bet the biosphere, if there is even a small chance we may regret the result. After all, there is not even an experimental control planet to colonize if we lose at biosphere roulette*." Lag time; thresholds; point of "no return"; reasoned judgment (national defense); Do we know for sure temp. will rise? Do we need climatic insurance policy?

C. Possible consequences – could have a greater potential to change life on the planet than anything else humans can do outside of nuclear war; "boiled frog syndrome"

– mid-latitudes most affected(Dallas predicted to go from 100 to 162 days over 90˚F); who pays?

– specific consequences: rainfall patterns; arable lands; rise in sea level–thermal expansion and melting of glacial ice and Antarctic ice sheets—millions of people could be displaced; half of world's megacities would need massive dikes; half of Florida would be lost by a 1 meter rise in sea level; loss of island nations; increase in catastrophic storms and weather extremes; spread of infectious disease—e.g., malaria and yellow fever; decreased water supplies; wild plants and animals forced out of their habitats--*no migration corridors and not enough time*

– non-linear effects (tipping point): e.g., release of methane hydrate now locked under arctic permafrost; 1998 was the largest increase in atmospheric CO_2 ever recorded—due to extensive burning of tropical forests associated with strong 1997-98 El Niño—risk of **positive feedback loop**; albedo effects; change in ocean currents—thermal conveyor belt; maybe already too late?

D. Solutions – much more difficult problem to solve than ozone depletion – billions of CO_2 sources and more economic impact—Kyoto Protocol—1997—U.S. Senate has not ratified (serious problems)—developed vs. developing countries; China plans to **quadruple** its coal consumption over the next decade—if that happens it will replace the U.S. as the largest emitter of CO_2 (but still less per capita); **have to reduce CO_2 emissions on worldwide basis**

SOLUTIONS: things we should be doing anyway—use energy more efficiently; use less fossil fuel (carbon taxes; polluter pays; switch to renewable energy); eliminate CFCs; switch from deforestation to reforestation (use forests sustainably); slow world population growth (per capita)

V. Tragedy of the Commons – Earth's atmosphere is an example – a common global resource