

Supplementary Notes (PJ Shlachtman) – Miller book - Global Warming and Ozone Loss

The Greenhouse Effect and Global Warming

About the Greenhouse

Greenhouse effect - certain gases in the atmosphere trap heat in the lower atmosphere (troposphere).

- most widely accepted theory is by Svante Arrhenius in 1896
- without it life would not exist as it does (covered by water)
- the amount of trapped heat in the troposphere depends on the concentration of greenhouse gases and how long they stay.
- Gases- water, carbon dioxide, ozone, methane, nitrous oxide, CFC's and PFC's.
- Carbon dioxide has a big effect on the amount of heat trapped

Global Warming

- an enhancement in the Earth's natural greenhouse effect.
- caused by burning fossil fuels, agriculture, deforestation and use of CFC's.
- developed countries-60% of CO₂ emissions:
 US-23% ; China-14% ; Russia-7% ; Japan-5%
- altered gases will affect climate for centuries

Consensus About the Past Temperatures

- to tell about past temperatures - study glaciers
- Holocene - after each ice age the period of warmth
- small temp changes during this time have led to hardships
- Water vapor levels have remained consistent- shown through bubbling gases

Computer Models

General circulation models (GCM) - most sophisticated of computer models

there are 7 computer models:

1. Level of greenhouse gases
2. Average global temp
3. Changes in regional climate
4. Droughts
5. Increased rainfall and storms
6. Rising sea levels
7. Loss of Biodiversity

Many models disagree on how projected rises in average global temps may affect the climate in different areas.

About Future Global Warming and Effects

- IPCC projects that the Earth's temp will rise to 1-3.5°C if the carbon dioxide doubles it will continue for hundreds of years.
- Northern Hemisphere - warm faster because of heat-absorbing ocean and that water cools more slowly
- More warming at the poles
- 5 of 9 ice shelves have broken up since 1950
- Global warming may thicken the region's two largest ice shelves
- Climate models project as the earth's atmosphere warms

The rate of water evaporation will rise; Global average precipitation will rise at mid-high latitude.

Possible signs of global warming

- Increased retreat of glaciers on mountains tops (such as The Alps, Andes, Himalayas).
- some warm-climate fish and trees will migrate Northward
- warmer water may bleach coral reefs in tropical areas
- Sea levels rise - 48 centimeters (19 inches) - due to global warming and deforestation.
- Warming or cooling by more than 1°C has caused serious disruptions of the current structure and functioning of Earth's ecosystems

Global Warming or A Lot of Hot Air? ; How serious is the threat?

Will Earth Really Get warmer?

- There is controversy over whether we are already experiencing global warming
- Since we only have 100 years of accurate data it is difficult to distinguish between climate noise and rise in global temperature.

How do Changes in Solar Output Affect Earth's Temperature?

- Solar output varies according to 11 and 22 year sunspots
- Sunspots - when strong solar magnetic fields periodically protrude through the sun's surface and slightly increase the sun's energy output, temporarily warming or cooling the Earth.
- Sunspots account for only 10-30% of the warming during the past century.
- If the sun continues to warm and our human activities don't change there will be even more greenhouse gases in the troposphere.

How do the Oceans affect Climate?

- The world's oceans amplify global warming by releasing carbon dioxide into atmosphere or the world's oceans can dampen global warming by absorbing more heat.
- 29% of excess carbon dioxide is removed by oceans which decreases global warming.
- It takes hundreds of years for deep vertical mixing to take place
- Deep ocean currents may be disrupted
- Currents act as a giant conveyor belt which transfers heat and stores carbon dioxide in the deep sea heat, from tropical waters to Europe.
- Global warming will reduce density and salinity of water.
- If heat transfer loops stop it could cause an atmosphere change more than 5°C.

Water Vapor Content and Clouds Affect Climate

- Warmer temps will increase evaporation and create more clouds.
- Increase in water vapor may cause warming
- Increase in production of clouds
- By trapping heat it could have a warming effect or a cooling effect caused by reflecting sunlight back into space.

Scientists don't know what factors of clouds will be predominate

- **day:** clouds are reflective and have a cooling effect
- **night:** insulate and lead to warmer temps
- **thin and high:** warming effect
- **low and thick:** cooling effect

Changes in Polar Ice Affect Climate

Albedo: ability of the earth's surface to reflect light

- Greenland and Antarctic-high albedo - light colored ice sheets reflect sunlight back into space - if they melt more sunlight would be absorbed and warming would be accelerated.

- Global warming increase earth's water stored as ice
- Warmer air carries more water vapor that drops snow on polar glaciers, which will effect more ice - perhaps leading to a new ice age.

Air Pollution Affects Climate

- Affected by air pollution- offset by aerosols
- Sulfur dioxide and tiny particles attract enough water molecules to increase cloud formation- has a high albedo – reflecting more sunlight.
- Clouds at night will cause heat to be stored in earth's surface.
- Northern Hemisphere - 90% of sulfur dioxide emissions which may offset global warming.
- Southern Hemisphere - form particles in smoke emitted by burning biomass.
- It is known that aerosols will have little effect on global warming.
- Aerosols only stay in atmosphere for a few weeks
- Component of acid rain that weakens trees, which creates more CO₂ in the atmosphere.
- Increasing amount of aerosols in the world will kill people and crops.

Increased Levels of CO₂: Does It Affect Photosynthesis and Methane Emissions

- Remove carbon dioxide from atmosphere and help slow global warming.
- Increase carbon dioxide rate may increase photosynthesis
- It will depend on different types of plants in different climate zones.
- High plant growth can be offset by plant-eating insects
- CO₂ increase will worsen global warming because the stomata will remain closed for longer periods of time- water can't get out and the plant and its surroundings get warmer.
- Forest turnover: how fast trees grow and die in a forest
- Reduces the biodiversity because of the reducing removal of carbon dioxide.
- Global warming accelerated by increased release of methane.
- Increase in carbon dioxide = an increase in methane
- If arctic tundras melt, huge amounts of methane are released

Rapid Climate Shift

- If global temps change over the next decades we will not be able to switch food-growing regions and relocate the world's population near the coast.
- Lead to deaths, chaos and reduction in biodiversity.
- Temperatures have shifted as much as 10`F in past decades that lasted 1000+ years
- The shifts are disastrous for humans

Human Responses Accelerate Global Warming

- As temperatures increase people will use more air conditioning which requires more burning of fossil fuels which releases more carbon dioxide causing additional warming and more of a need for air conditioning.
- Aerosols may offset warming but pollution will have serious health impact
- Global warming and rises in average sea levels could either be half of current projections or double

Affected Food Production

Climate belts will shift northward - rise in global temperature cause a rise in food production

Depends on:

- fertility of the soil
- amount of money
- Asia productivity will increase while US and Canada will decrease.

- Will cause increase in hunger and starvation
- Increase in temps will allow insects and pests to live through the winter destroying crops
- Seafood supplies decrease due to flooding of coastal wetlands.
- Reduce biodiversity because of the average temp and depth of tropical ocean waters
- Coral reefs – become bleached & animals will die

Global Warming's Effects on Forests and Biodiversity

- The makeup and location of world's forests will change
- Due to seed movement by animals forests will move further North
- Mountaintops that are far North will become extinct - no where to go - causing release of carbon
- Wildfires will happen in up to 90% of forests
- Huge amounts of carbon dioxide will then accelerate global warming
- Reductions in biodiversity due to mass extinction of animals that can't migrate
- Fish would die because the temp would rise

What could Happen to Sea Levels?

- They will rise because ocean expands when heated
- Will not rise because of melting glaciers and ice sliding into the sea
- Sea levels will rise by 48 centimeters
- Will effect cities near sea level (about 1/3 of world's people) would be flooded
- Some islands would completely disappear
- Beaches on East Coast might disappear within 25-50 years
- Move barrier islands further inland, accelerate coastal erosion, contaminate coastal aquifers with salt water

How Might Weather Extremes Change Our Life

- More air will move across the surface because more heat is retained in climate system
- There may be higher wind speeds, clashing fronts and more violent weather
- Increased intensity of hurricanes, typhoons and tornadoes
- Financial challenges for insurance companies who have to pay billions of dollars to flood victims
- Some companies are dropping their coverage or raising prices to be prepared and working with the government to decrease possible global warming

How Might Human Health Be Affected

- Global warming will bring more heat waves (double number of deaths) increase asthma and bronchitis
- Disrupt supplies of food and fresh water
- Alter disease patterns
- Insect diseases from tropical areas
- Higher humidity levels
- Rise in fungal skin diseases
- Speed up bacterial growth
- Climate change would lead to a large number of environmental refugees
- Illegal migration would increase
- Serious problems for foreign military and economic security policies of nations could occur

Solutions: Dealing with the Threat of Global Warming – Do More Research or Act Now?

3 schools of thought:

1. No-problem is a minority view - global warming is not a threat but a hoax.

2. Waiting strategy- Wait until more info is available about the global climate system. Why spend hundreds of billions of dollars phasing out fossil fuels and replacing deforestation with reforestation to help ward off something that might not happen.
3. Precautionary strategy- take action instead of doing research

1997-American Economics Association

- Oil & Insurance companies showed evidence that Human activities were contributing to Global Warming and they need to begin taking precautionary action.
- Boiled Frog System-

How can we slow Possible Global Warming?

We must reduce current global CO₂ emissions by 66-83%

Solutions:

- quickest and cheapest way is to use energy more efficiently
- increased use of nuclear power
- using natural gas- help to make the 40-50 year transition to an age of energy efficiency and renewable energy
- phase out gov't subsidies for fossil fuels over a decade/gradually phase in carbon taxes on fossil fuels

1997- ECONOMISTS & Nobel laureates signed statement:

- sound economic analysis shows that greenhouse emissions can be cut without harming American living standards
- calling for **carbon taxes**
 - as part of an international system of tradable permits for greenhouse gas emissions
 - Carbon tax based on
 - polluter - pays principle
 - requires industries & consumers to pay directly for the full environmental costs of the fuels they use
 - agree to global & national limits on greenhouse gas emissions

Can Technofixes save us?

- Technofixes - technological solutions for dealing with possible global warming
- Adding iron to oceans-would remove more CO₂ through photosynthesis
- Unfurling gigantic foil-surfaced sun mirrors in space to reduce solar input.
- Injecting sunlight - reflecting sulfate particulates into the stratosphere - mimics cooling effects of giant volcanic eruptions

What has been done to reduce Greenhouse Gas emissions?

2,200 delegates -161 nations met in **Kyoto, Japan** negotiated treaty to help slow global warming

The goal:

- between 2008 & 2012: 12-38 developed countries should have cut greenhouse emissions to an average of 5.2% below 1990 levels
- developing countries won't be required to cut
- there would be penalties for countries that violate treaty laws
- forested countries get a break in their quotas
- since the treaty was made, US cut greenhouse emissions by 7%, Japan by 6% and European countries by 8%

How can we prepare for possible global warming?

- waste less water
- develop crops that need less water
- move hazardous materials (storage tanks) away from the coast
- prohibit new construction or remodeling on low-lying coastal areas
- stockpile 1-5 years supply of key foods
- expand existing wild life reserves with corridors

Ozone Depletion: is it a serious threat?

What is the Threat from Ozone Depletion?

- Ozone layer - 450 million years old
- It allowed life to develop and expand on land and in the surface layers of aquatic systems
- oxygen- converted to ozone and back to oxygen by sequence of reactions initiated by ultraviolet radiation from the sun.
$$3 \text{ O}_2 + \text{UV} \rightarrow 2 \text{ O}_3$$
- result: a thin veil of renewable ozone at very low concentrations; absorbs ~99% of harmful incoming ultraviolet radiation from sun & prevents it from reaching the earth's surface
- UV radiation reaching the stratosphere consists of 3 bands: A, B, C
 - **UV-C** ; highest energy, shortest wavelength, most hazardous
 - **UV-B** ; next highest and biologically damaging
 - **UV-A** ; lowest energy- can also damage living cells

What Causes Ozone Depletion? From Dream Chemicals to Nightmare Chemicals

1930: Thomas Midgely, Jr. (a GM chemist) discovered the first **chlorofluorocarbon (CFC)**

2 most widely used: known as freons

- CFC-11 (trichlorofluoromethane)
- CFC-12 (dichlorofluoromethane)
 - seemed like dream chemicals
 - cheap to make, stable, odorless, nonflammable, nontoxic & noncorrosive
 - began to be used:
 - as coolants in air conditioners & refrigerators
 - propellants in aerosol spray cans
 - cleaners for electronic parts
 - sterilants for hospital instruments

1974: chemists Sherwood Rowland & Mario Molina indicated that CFC's creating a global chemical time bomb by lowering the average concentration of ozone in the stratosphere

- spray cans, discarded or leaky refrigeration & air conditioning equipment, and the production & burning of plastic foam products release CFC's into the atmosphere.
- They rise slowly into the atmosphere (10-20 yrs)
- A CFC molecule can last in the stratosphere for 65-110 yrs.
- Turned into a nightmare of global ozone destroyers
- What other chemicals Deplete Stratospheric Ozone?

ODC's- ozone depleting compounds

- Halons & HBFC's - long-lived bromine-containing compounds
- Methyl bromide
- Carbon tetrachloride - cheap/highly toxic solvent
- Methyl chloroform - toxic
- 1,1,1-trichloroethane - cleaning solvent in more than 160 consumer products

Why is There Seasonal Thinning of Ozone over the poles?

- 1984 - researchers discovered 40-50% of ozone in upper stratosphere over Antarctica was being destroyed
- 1987 - “smoking gun”
 - CFC’s primarily cause of ozone thinning
 - **Polar vortex** - huge swirling mass of very cold air that is isolated from the rest of the atmosphere until the sun returns a month later

Is Ozone Depletion Really a Serious Problem?

- some say ozone depletion is a hoax & exaggerated problem
- others believe it is a problem

Why Should We Be Worried about ozone Depletion? Life in the UV Zone

- less ozone causes:
 - worse sunburns
 - more cataracts
 - more skin cancer
- skin cancer & cataracts - increasing in Australia, New Zealand, South Africa, Argentina & Chile because the ozone layer is thin got several months a year there

Solutions: Protecting the Ozone Layer

- How can we protect the ozone layer?
 - researchers say stop producing all ozone-depleting chemicals
 - substitutes are available for CFC’s:
 - HCFC’s- contain fewer chlorine atoms per molecule than CFC’s
 - HFC’s- contain Fluorine but no chlorine
 - HC’s- hydrocarbons - useful as coolants & insulating foam in refrigerators

Can TechnoFixes Save us?

- Physicist Alfred Wong - each year wants to launch blimps 20-30 football-fields long.
- Blimps are radio-controlled and would contain electrical wires that would inject negatively charged electrons to the stratosphere when exposed to high voltages
- Others suggest using lasers to blast CFC’s out/ but no one knows how it will affect climate, birds, or planes

What is being done to reduce ozone Depletion? Some helpful progress

- Montreal Protocol - treaty created in 1987 by 36 nations
- Says: cut emissions of CFC’s into the atmosphere by about 35% between 1989 & 2000
- Met 3 more times
- Met in 1997 in Montreal
 - adopted a protocol accelerating the phase out of key ozone depleting chemicals
 - CFC production fell by 85%

Will the International Treaty to Slow Ozone Depletion Work?

- still a black-market of CFC’s
- some countries cheating
- prevention is the best way to deal with global environmental problems