

## Climate Change and Ozone Depletion

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### Troposphere

- 78% N<sub>2</sub>, 21% O<sub>2</sub>, 0.09% Ar, 0.035% CO<sub>2</sub>
- Global warming occurs here

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### Stratosphere

- “global sunscreen” (ozone layer)
- Keeps 95% of the sun’s harmful UV radiation from reaching the earth’s surface.
- Helps protect humans from sunburn, skin & eye cancer, cataracts, etc.

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## Global Warming

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## Question

- Explain the relationship between global warming and the greenhouse effect.

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## Global Warming

- Warming of earth's troposphere by the greenhouse effect.

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## Greenhouse Effect

- The warming of the troposphere caused by greenhouse gases that absorb heat.

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## Quote...

- "More people enjoy health and prosperity now than ever, and a warmer environment...should sustain life better than the current one does."  
- February 2001, *Oil and Gas Journal*

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## Question

- What are the greenhouse gases?
- What are the primary sources for each of these gases?

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## Greenhouse Gases

- Water vapor
- Carbon dioxide
- Methane
- Nitrous oxide
- Synthetic HFC's, PFC's, and SF<sub>6</sub>

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## 1. Water Vapor

- Naturally occurring due to hydrologic cycle.
- Necessary to sustain life as is (keeps earth warm - average global surface temperature = 59 F).
- Man not proven to affect the amount of water vapor in troposphere - yet.

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## 2. Carbon Dioxide

- Occurs naturally (carbon cycle) and by human activities (use of fossil fuels).
- Emissions is 30-35% higher today than before the industrial revolution (280 ppm to 375 ppm).
- Residence time in troposphere ~ 50 - 200 years.

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### Share of Global Total CO<sub>2</sub> Emissions

- United States – 23.4%
- China – 13.6%
- Russia – 6.2%
- Japan – 4.8%
- India – 4.2%
- Germany – 3.4%
- Canada – 2.4%
- UK – 2.3%

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### Question

- What is the latest technology in removing CO<sub>2</sub> from the troposphere?

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### Sequestering CO<sub>2</sub>

- Injecting gaseous or liquefied CO<sub>2</sub> deep in the Earth. Possible locations include:
- Empty oil and gas reservoirs
- Deep saline aquifer
- Deep sea

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### 3. Methane

- Sources include: livestock, landfills, natural gas production, manure, and rice fields.
- Residence time in troposphere ~ 12 yrs
- Concentration has doubled since Industrial Revolution.
- Current annual increase is 0.6%

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### 4. Nitrous Oxide (N<sub>2</sub>O)

- Sources include: burning fossil fuels, inorganic fertilizers, & biomass burning, decomposition of wastes and sewage.
- Residence time in troposphere ~114 years.
- Increased about 17% since 1750.

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### Synthetic HFC's, PFC's, and SF<sub>6</sub>

- HFC = Hydrofluorocarbons: primarily used as replacements for ozone depleting substances. Have small impact, still unknown.

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- PFC = perfluorocarbons
- SF<sub>6</sub> = sulfurhexafluoride.
- These two are predominately emitted from various industrial processes (aluminum smelting, semiconductor mfg, electric power transmission and distribution, etc.)
- Impact is also small, but significant growth, long atmospheric lifetime, and are strong absorbers, could influence in the future.

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What is being done to reduce global warming?

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### Kyoto Protocol

- Dec. 1997
- 171 nations
- Developed treaty requiring 38 developed nations to cut GHG 5.2% below 1990 levels by 2012.
- GHG includes: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFC, SF<sub>6</sub>
- Developing countries not required to participate.
- Allowed emission trading.

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## Kyoto Protocol

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## Kyoto Protocol

- Computer models predict with this reduction would only reduce the projected 2060 temp. rise of 1-3°F by 0.1°F.

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## Kyoto Protocol

- 2001 – US Congress pulled out.
- Thought treaty was unfair as India and China did not have to meet these requirements.
- Intensive lobbying by coal, oil, steel, & auto companies claimed that it would impact the US economy.

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## Kyoto Protocol

- 111 nations have ratified by late 2003. Waiting for Russia so treaty can take effect.
- Other countries are not waiting – going ahead as planned for their country.
- Russia finally signs and treaty officially in place as of Feb. 2005

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## Impacts of Global Warming

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## Impacts of Global Warming

- Weather
- Diminishing crop yields
- Loss of biodiversity
- Rising Sea Levels
- Human Illness

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## Ozone Depletion

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### Question

- What is the difference between the greenhouse effect and ozone depletion?

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### What is O<sub>3</sub> Depletion?

- Thinning concentrations in stratosphere above Antarctica and Arctic
- <http://www.epa.gov/ozone/science/movies/index.html>
- <http://www.epa.gov/ozone/science/unepSciQandA.pdf>

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### Question

What causes ozone depletion?

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### CFC's

- Chemically stable, non-reactive
- Odorless
- Nonflammable
- Non-toxic
- Non-corrosive
- Cheap to make

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### CFC products include:

- Coolants in Air Conditioners & refrigerants (Freon)
- Propellants in aerosol spray cans
- Cleaners for electric parts
- Sterilizing hospital instruments
- Bubbles in plastic foam

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### Key problem

- This cycle depletes  $O_3$  in stratosphere faster than formed
- Each CFC molecule can last in stratosphere for 75 – 111 years

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### Montreal Protocol

- 1987 – Canada
- 36 nations met. Treaty to reduce CFC's by 35% between 1989-2000.
- Due to 1989 news, nations met again in 1990 & 1992 to phase out key ozone depleting chemicals immediately.

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### Thinning of $O_3$ over South Pole

- Layer thins during the Antarctic spring and early summer (Sept – Dec), when sunlight penetrates stored up chlorine molecules, releasing them to attack  $O_3$

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## Current Ozone

[http://toms.gsfc.nasa.gov/teacher/ozone\\_overhead\\_v8.html](http://toms.gsfc.nasa.gov/teacher/ozone_overhead_v8.html)

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