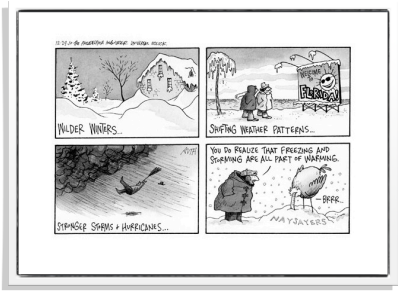


Chapter 19: Climate Change and Ozone Depletion

APES 2013

Climate Change not New

- Altered by volcanic emissions, changes in solar input, meteor impacts
- Relatively stable over the last thousand years, but has altered significantly in the last 100 years

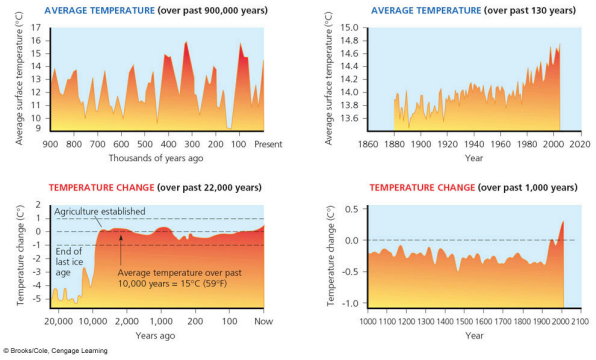


Fig. 19-2

Natural Greenhouse Effect

- We could not exist without it
- Warms the earth's lower atmosphere
  - Greenhouse gasses: water vapor, carbon dioxide, methane, and nitrous oxide
  - Heat (infrared radiation) radiated back from the earth causes greenhouse gas molecules to vibrate and release infrared rays (longer wavelength).
  - This increases the molecules kinetic energy.

Human Greenhouse Gas Emissions

- Carbon dioxide
  - From industrial revolution to today increased from 280 ppm to 384 ppm
  - If current figures continue: 560 ppm by 2050; 1,390 by 2100
  - Scientific studies consider 450 ppm to be a threshold or tipping point
  - Largest CO_2 emitters: United States, China, European Union (combination of 27 countries), Indonesia, Russia, Japan, and India (US emits 25% compared to China's 5%)

4

Human Greenhouse Gas Emissions

- Methane
  - 60% of emissions are from human activities (raising cattle, burning fossil fuels, landfills)
- Nitrous oxide
  - Risen 20% since industrial revolution (mainly because of nitrogen fertilizers)
  - Nitrous oxide traps 3-10 times more heat than carbon dioxide

5

2007 IPCC Report

- IPCC - International Panel on Climate Change
  - Contains more than 2,500 climate experts from over 130 countries
  - Report based on 29,000 sets of data
- Concluded that it is very likely (90-99% chance) that the lower atmosphere climate is changing because of human activities
- Evidence:
  - Between 1906 and 2005 average surface temperature has risen about 0.74 degrees Celsius (1.3 degrees F) (most of increase has happened since 1980)
  - Greenhouse gas emissions rose 70% between 1970 and 2005 and CO concentrations are higher than they have been in 650,000 years
  - Arctic temps have raised twice as much as the rest of the world
  - Glaciers and sea ice are melting, rainfall patterns have changed, drought is increasing
  - Sea level has risen by 10-20cm

6

Major Processes That Determine Climate Change

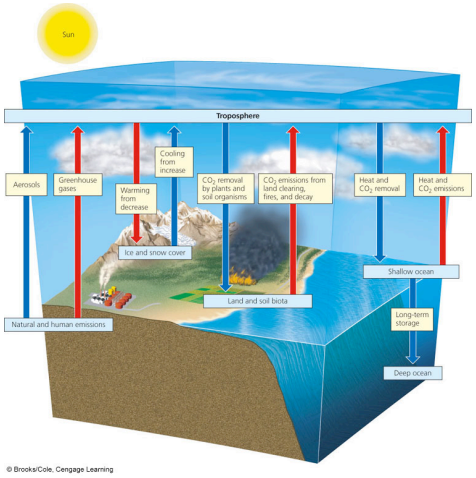


Fig. 19-A

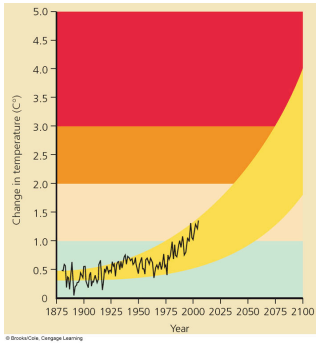


Fig. 19-B

7

Oceans and CO_2

- Oceans absorb half of the world's CO_2
- Some is converted into insoluble carbonate salts that stay in the sediment for millions of years
- Solubility of CO_2 in the oceans decreases as temperature increases. Therefore, as the earth heats up, more CO_2 is released from the oceans heating the earth up even more. (**positive feedback loop**)
- Added CO_2 also makes the the oceans more acidic, making it more difficult for some plants and animals to survive (especially plankton).

8

Ice and Snow Melting

- Ice and snow help to cool the earth by reflecting solar energy
- Glaciers melting play major role in water cycle as they melt in the summer (possible that Glacier National Park will not have glaciers by 2070)

Fig. 19-C

9

Rising Sea Levels

- Irreversible Effects:
  - Destruction and degradation of one third of coastal estuaries, wetlands, and coral reefs
  - Disruption of coastal fisheries
  - Flooding of barrier islands, erosion of coastline
  - Flooding of agricultural lowlands (where most of world's rice is grown)
  - Contamination of freshwater coastal aquifers with saltwater
  - Submergence of low-lying islands (home to 1 out of every 20 people on earth)
  - Flooding of coastal areas (including some of the world's largest cities)

10

Melting Permafrost

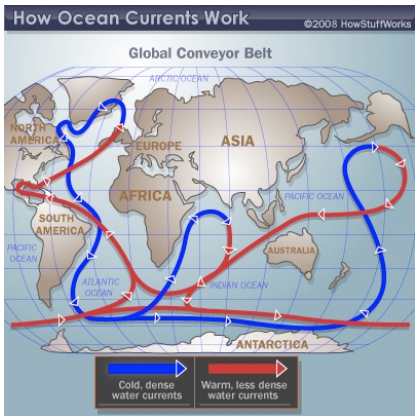
- Locked up methane in permafrost is 50-60 times as much emitted as carbon dioxide from burning fossil fuels

Fig. 19-10

11

Changing Ocean Currents

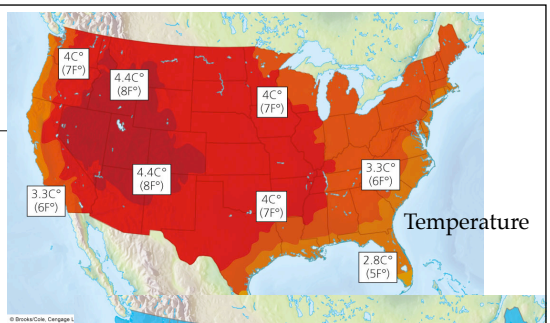
- Transport water between deep and shallow and between equator and poles
- Not clear what the impact of this will be

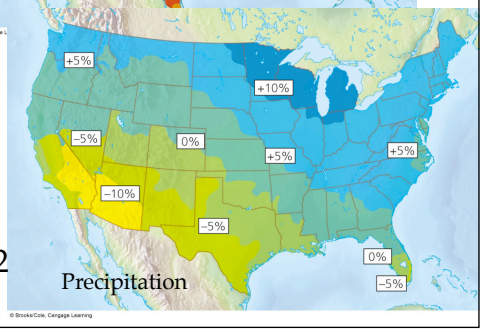


12

Extreme Weather

- Heat waves, droughts, and expanding deserts
- Warmer air can hold more moisture so some places will have more flooding





Pg. S72 & S73

13

Storm Severity Will Increase

- Hurricane Katrina
  - 8.5m storm surge
  - Killed more than 1,500 people
  - Loss of 320 million big trees
    - Significant reduction of amount of CO_2 taken out of the atmosphere
    - As trees decay, emitted CO_2 equal to what all other U.S. trees absorb in a year

14

Global Warming Threat to Biodiversity

Fig. 19-12

- More territory for species adapted to warmer climates while others die off
- Death of many specialist species that can not handle climate changes
- Coral bleaching
- Mountain pine beetles

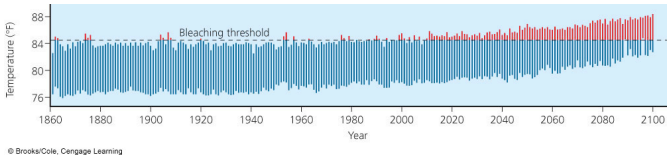


Fig. 19-11

15

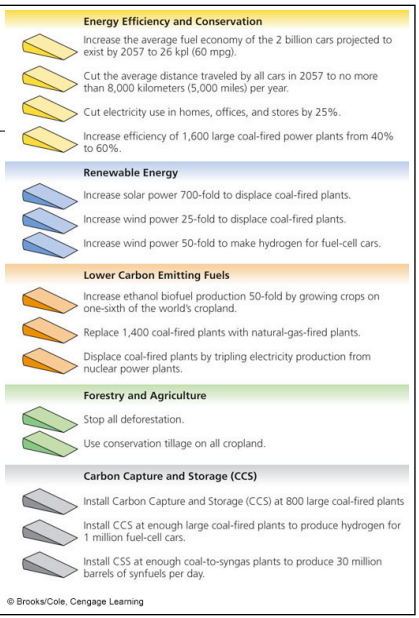
Why is Climate Change such a difficult problem?

- Problem is global (requires international cooperation)
- Effects will last a long time (CO_2 can stay in atmosphere for 120 years)
- Long-term political issue (most people who will be impacted are not born)
- Impacts are not spread evenly
- Solutions disrupt economies and lifestyles

16

15 Ways to Cut CO_2 Emissions

- Climate stabilization wedges
- Each wedge would reduce emissions by roughly the same amount



17

Carbon Capture and Storage

- Removing CO_2 from smokestacks and storing it.
- Many problems with this
  - Only partially addresses the problem, requires large inputs of energy, huge government subsidies, does not reduce dependence on coal, possibility of leaks

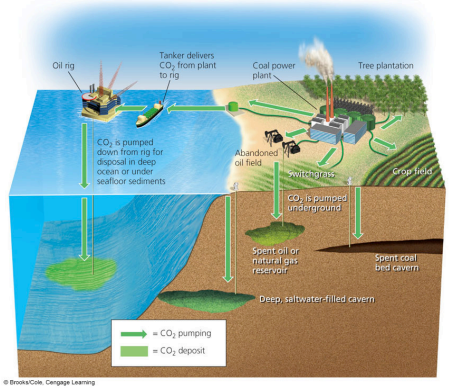


Fig. 19-15

18

How Can Governments Help?

- Regulate carbon dioxide and methane as pollutants (tax their emissions rather than profits)
- Cap-and-trade (difficult to manage)
- Provide tax breaks and subsidies for energy efficiency and sustainable agriculture while decreasing those for use of fossil fuels and unsustainable agriculture
- Technology transfer to developing countries
- International climate negotiations (Kyoto Protocol)

19

Kyoto Protocol

- December 1997, more than 2,200 delegates from 161 nations met in Kyoto, Japan
- First phase went into effect in February 2005 with 174 of the world's 194 countries ratifying (not United States)
- Requires developed countries to cut emissions of CO_2, CH_4, and N_2O to an average of at least 5.2% lower than 1990 levels by 2012 (Developing countries will be required to reduce emissions in phase two)
- Established a global cap-and-trade system
- U.S. started the push, but in 2001, George W. Bush withdrew the United States arguing that it would hurt the U.S. economy

20

Some Countries and Cities Leading the Charge

- Costa Rica aims to be carbon neutral by 2030
  - Generates 78% of electricity with hydroelectricity and 18% from wind and geothermal
- Norway aims to be carbon neutral by 2050
- China and India are developing countries that are seriously trying to cap carbon emissions
- Since the U.S. government is doing little, many U.S. cities and states are taking the lead
  - Portland, Oregon reduced greenhouse gas emission back to 1990 levels by 2005 (national average increased by 16%)
  - Other U.S. cites: Seattle, WA; San Francisco, CA; New York, NY; Chattanooga, TN; Boulder, CO; Chicago, IL; Minneapolis, MN; and Salt Lake City, UT

21

Ozone Depletion

- Ozone in lower stratosphere keeps out about 95% of UV rays
- CFCs - Chlorofluorocarbons (trade name Freon) discovered in 1930s
  - unreactive, odorless, nonflammable, nontoxic, noncorrosive
  - Used as coolants, propellants in aerosol spray cans, cleaners for electronics, fumigants, gasses used to fill bubbles in plastic foam packaging and insulation
- Eventually, Sherwood Rowland and Mario Molina demonstrated that CFCs destroy ozone

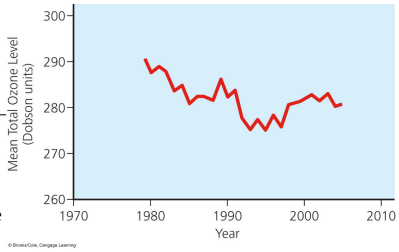


Fig. 19-18

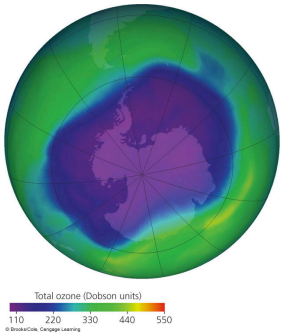


Fig. 19-19