


**ENVIRONMENT**  
*THE SCIENCE BEHIND THE STORIES*  
Jay Withgott • Scott Brennan

**Ch 18**  
**Global Climate Change**

Part 2: Environmental Issues  
and the Search for Solutions

PowerPoint® Slides prepared by  
Jay Withgott and Heidi Marcum



Third Edition

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**This lecture will help you understand:**

- The Earth's climate system
- Human influences on the atmosphere and climate
- Methods of climate research
- Impacts of global climate change
- Ways we can respond to climate change



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## Central Case: Rising seas may flood the Maldives

- Visiting tourists think of the Maldives Islands in the Indian Ocean as paradise
- The islands could be submerged by rising seas accompanying global climate change
- The government has already evacuated residents from of the lowest-lying islands



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## Our dynamic climate

- Climate influences everything around us
- The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) made it clear that:
  - Climate is changing, we are the cause, and this change is already exerting impacts that will become increasingly severe
- Al Gore's movie *An Inconvenient Truth* has been seen by millions
- Climate change is the fastest-moving area of environmental science today

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## What is climate change?

- **Climate** = an area's long-term atmospheric conditions
  - Temperature, moisture content, wind, precipitation, etc.
- **Weather** = conditions at localized sites over hours or days
- **Global climate change** = describes trends and variations in Earth's climate
  - Temperature, precipitation, storm frequency
- **Global warming** = an increase in Earth's average temperature
  - Earth's climate has varied naturally through time
  - The rapid climatic changes taking place now are due to human activity: fossil fuels, combustion, and deforestation

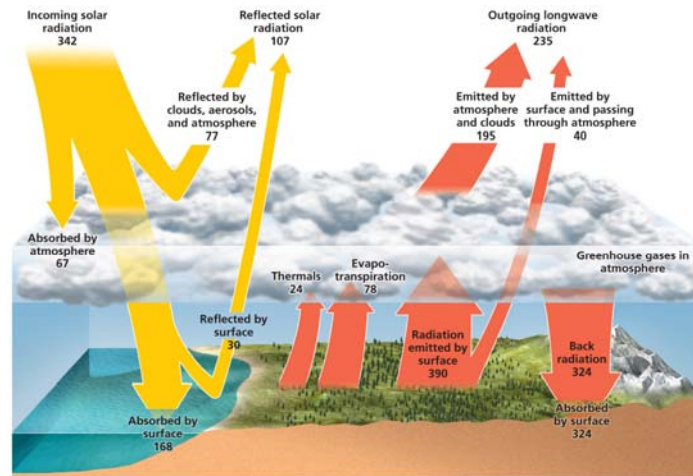
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## The Sun and atmosphere keep the Earth warm

- Three factors exert more influence on climate than all others
- The Sun = without it, the Earth would be dark and frozen
  - Also supplies most of our planet's energy
- The atmosphere = without it, the Earth's temperature would be much colder
  - Earth's atmosphere, clouds, land, ice, and water absorb 70% of incoming solar radiation
- The oceans = shape climate by storing and transporting heat and moisture

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## The fate of solar radiation



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## Greenhouse gases warm the lower atmosphere

- As Earth's surface absorbs solar radiation, the surface increases in temperature and emits infrared radiation
- **Greenhouse gases** = atmospheric gases that absorb infrared radiation
  - Water vapor, ozone, carbon dioxide, nitrous oxide, methane, chlorofluorocarbons (CFCs)
  - Greenhouse gases differ in their ability to warm the troposphere and surface

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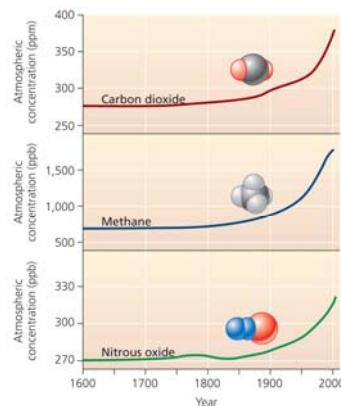
## The greenhouse effect

- After absorbing radiation, greenhouse gases re-emit infrared energy
  - Some energy is lost to space
  - **Greenhouse effect** = some energy travels back downward, warming the atmosphere and planet's surface
- **Global potential** = the relative ability of one molecule of a given greenhouse gas to contribute to warming
  - Expressed in relation to carbon dioxide (potential = 1)
  - Hydrochlorofluorocarbons are 12,000 times as potent as carbon dioxide

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## Carbon dioxide is of primary concern

- Not the most potent greenhouse gas, but it is extremely abundant
  - The major contributor to global warming
- Human activities have boosted atmospheric concentrations from 280 parts per million (ppm) to 383 ppm
  - To their highest levels in more than 650,000 years



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## What caused levels of CO<sub>2</sub> to increase?

- Burned fossil fuels in our homes, factories, and automobiles
  - Transferred large amounts of carbon dioxide from lithospheric reservoirs into the atmosphere
  - The main reason atmospheric carbon dioxide concentrations have increased so dramatically
- Deforestation has contributed to rising atmospheric CO<sub>2</sub> concentration
  - Forests serve as sinks for recently active carbon
  - Their removal reduces the biosphere's ability to absorb carbon dioxide from the atmosphere

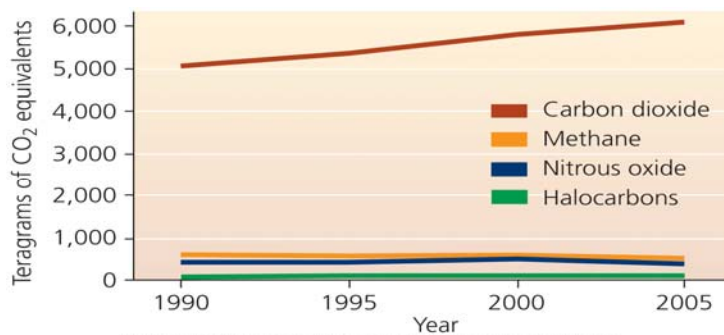
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## Other greenhouse gases add to warming

- Methane = fossil fuel deposits, livestock, landfills, and crops such as rice
- Nitrous oxide = feedlots, chemical manufacturing plants, auto emissions, and synthetic nitrogen fertilizers
- Ozone = risen due to photochemical smog
- Halocarbon gases (CFCs) = are declining due to the Montreal Protocol
- Water vapor = the most abundant greenhouse gas and contributes most to the greenhouse effect
  - Could increase cloudiness, which might slow global warming by reflecting more solar radiation back into space

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## U.S. emissions of major greenhouse gases

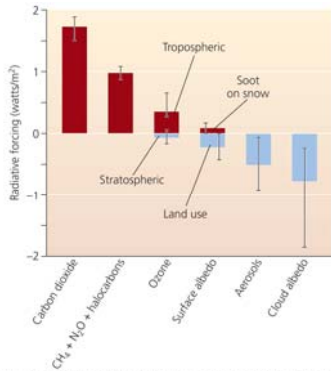


## Aerosols may exert a cooling effect

- **Aerosols** = microscopic droplets and particles that have either a warming or cooling effect
- Soot, or black carbon aerosols, cause warming by absorbing solar energy
  - But, most tropospheric aerosols cool the atmosphere by reflecting the Sun's rays
- Sulfate aerosols produced by fossil fuel combustion may slow global warming, at least in the short term
  - Volcanic eruptions reduce sunlight reaching the earth and cool the Earth

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## Radiative forcing expresses change in energy



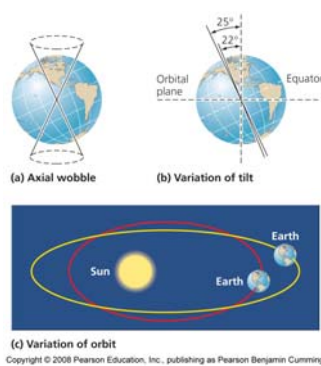
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- Scientists estimate the influence of factors over Earth's energy balance
- **Radiative forcing** = the amount of change in energy that a given factor causes
  - Positive forcing warms the surface; negative forcing cools it
- Compared with the pre-industrial Earth, Earth is experiencing radiative forcing of 1.6 watts/m<sup>2</sup>
  - Enough to alter the climate

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## Milankovitch cycles influence climate

- **Milankovitch cycles** = periodic changes in Earth's rotation and orbit around the Sun
  - Alter the way solar radiation is distributed over Earth's surface
  - By modifying patterns of atmospheric heating, these cycles trigger long-term climate variation such as periodic glaciation



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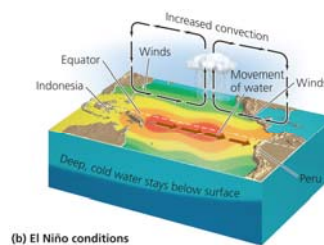
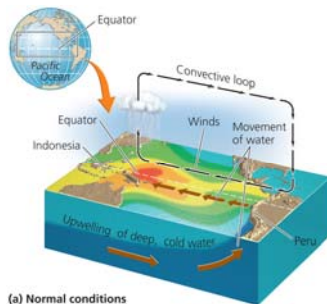
## Solar output and ocean absorption influence climate

- **Solar output** = drives temperature change on Earth's surface
  - The Sun varies in the radiation it emits
  - Variation in solar energy (i.e., solar flares) has not been great enough to change Earth's temperature
- **Ocean absorption** = the ocean holds 50 times more carbon than the atmosphere and absorbs it from the atmosphere
  - Carbon absorption by the oceans is slowing global warming but not preventing it
  - Warmer oceans absorb less CO<sub>2</sub> because gases are less soluble in warmer water – a positive feedback effect that accelerates warming

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## Ocean circulation and ENSO influence climate

- **Ocean circulation** = ocean water exchanges tremendous amounts of heat with the atmosphere, and ocean currents move energy from place to place
- **El Niño-southern oscillation (ENSO)** = a systematic shift in atmospheric pressure, sea surface temperature, and ocean circulation in the tropical Pacific



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## El Niño

- Normally, winds blow from east to west along the equator, from high to low pressure
- Westward-moving surface waters allow nutrient-rich upwelling along the coast of Peru
- ENSO occurs when air pressure increases in the western Pacific and decreases in the eastern Pacific, causing the equatorial winds to weaken
- Water flows eastward, suppressing upwellings, shutting down delivery of nutrients that support aquatic life
- Coastal industries are devastated, global weather is changed

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## La Niña events

- The opposite of El Niño events
  - Cold surface waters extend far westward in the equatorial Pacific and weather patterns are affected in opposite ways
- ENSO cycles are periodic, occurring every 2-8 years
  - Globally warming air and sea temperatures may be increasing their frequency and strength

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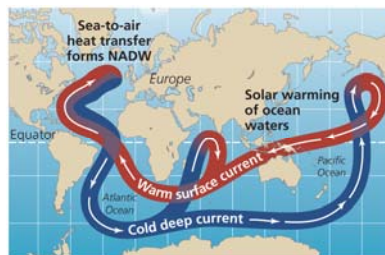
## Thermohaline circulation

- **Thermohaline circulation** = a worldwide current system in which warmer, fresher water moves along the surface; and colder, saltier water moves deep beneath the surface
  - Warm surface water carries heat to Europe
  - **North American Deep Water (NADW)** = the deep portion of the thermohaline circulation, consisting of dense, cool water that sinks
  - Interrupting the thermohaline circulation could trigger rapid climate change

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## NADW is vulnerable

- If Greenland's ice melts, freshwater runoff would dilute ocean waters, making them less dense, and stopping NADW
  - Some data suggest thermohaline circulation is slowing
- Europe would rapidly cool, as shown in *The Day After Tomorrow*, a movie which exaggerated the impacts



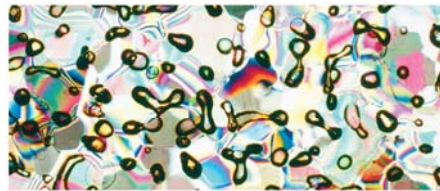
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## Proxy indicators tell us about the past

- **Proxy indicators** = types of indirect evidence that serve as substitutes for direct measurements
  - Shed light on past climate
  - Ice caps, ice sheets, and glaciers hold clues to Earth's climate
  - Trapped bubbles in ice cores show atmospheric composition, greenhouse gas concentration, temperature trends, snowfall, solar activity, and frequency of fires



(a) Ice core  
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(b) Micrograph of ice core  
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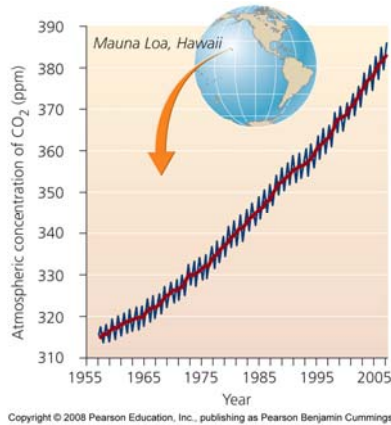
## More proxy indicators

- Cores in sediment beds preserve pollen grains and other plant remnants
- Tree rings indicate age, wetness of the season, droughts, and seasonal growth
- Researchers also gather data on past ocean conditions from coral reefs
- Scientists need to combine multiple records to get a global perspective

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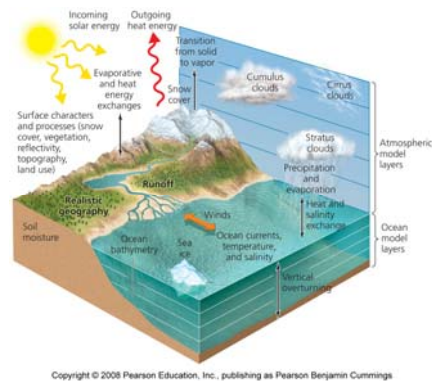
## Direct atmospheric sampling tells us about the present

*Trends in atmospheric concentrations of carbon dioxide show that concentrations have increased from 315 ppm to 383 ppm*



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## Models help us understand climate



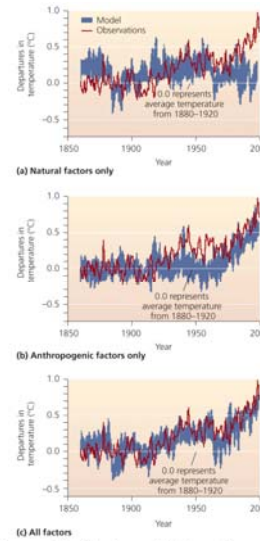
**Coupled general circulation model (climate models)** = programs that combine what is known about atmospheric circulation, ocean circulation, atmosphere-ocean interactions, and feedback mechanisms to simulate climate processes

- These models are becoming more reliable in predicting climate change

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## Results from three simulations

- Figure (a) shows natural climate factors only
  - Volcanoes
- Figure (b) shows only human factors
  - Emissions of greenhouse gases
- Figure (c) shows both factors



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## Current and future trends and impacts

Evidence that climate conditions have changed since industrialization has increased

- **Intergovernmental Panel on Climate Change (IPCC)**
  - An international panel of scientists and government officials established in 1988
  - Has presented a series of reports on the synthesis of scientific information concerning climate change

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## The fourth assessment report

- *Fourth Assessment Report (2007)*
  - Consensus of scientific climate research from around the world
  - Summarizes thousands of studies
  - It documents observed trends in surface temperature, precipitation patterns, snow and ice cover, sea levels, storm intensity, etc.
  - Predicts future changes, addressing impacts of current and future climate change on wildlife, ecosystems, and human societies
  - Discusses possible strategies to pursue in response to climate change

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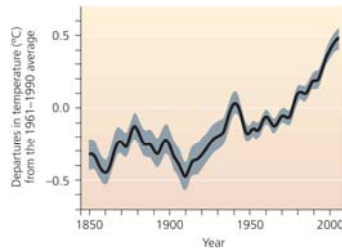
Major Trends and Impacts of Climate Change, from IPCC Fourth Assessment Report, 2007	
Global physical indicators	Regional physical indicators
Earth's average surface temperature increased 0.74° C (1.33 °F) in the past 100 years, and will rise 1.8–4.0° C (3.2–7.2° F) in the 21 <sup>st</sup> century.	Arctic areas warmed fastest. Future warming will be greatest in the Arctic and greater over land than over water.
Eleven of the years from 1995 to 2006 were among the 12 warmest on record.	Summer Arctic sea ice thinned by 7.4% per decade since 1978.
Atmospheric water vapor increased since at least the 1980s.	Average Northern Hemisphere temperatures of the past 50 years were the highest in at least 1,300 years. <sup>1</sup>
Oceans absorbed >80% of heat added to the climate system, and warmed to depths of at least 3,000 m (9,800 ft).	Thawing decreased area of Arctic permafrost in spring by 15% since 1980.
Glaciers, snow cover, ice caps, ice sheets, and sea ice will continue melting, contributing to sea-level rise.	Precipitation increased in e. North America, e. South America, n. Europe, and n. and c. Asia since 1900.
Sea level rose by an average of 17 cm (7 in.) in the 20 <sup>th</sup> century, and will rise 18–59 cm (7–23 in.) in the 21 <sup>st</sup> century.	Precipitation decreased in the Sahel, the Mediterranean, s. Africa, and parts of s. Asia since 1900.
Ocean water became more acidic by about 0.1 pH unit, and will decrease in pH by 0.14–0.35 units more by century's end.	Precipitation will generally increase at high latitudes and decrease at subtropical latitudes, often making wet areas wetter and dry ones drier. <sup>1</sup>
Storm surges increased, and will increase further. <sup>1</sup>	Heavy precipitation events increased over most land areas. <sup>1</sup>
Sea level rise will worsen coastal erosion and degrade wetlands.	Droughts became longer, more intense, and more widespread since the 1970s, especially in the tropics and subtropics. <sup>1</sup>
Carbon uptake by terrestrial ecosystems will likely peak by the mid-21 <sup>st</sup> century and then weaken or reverse, amplifying climate change. <sup>2</sup>	Droughts and flooding will increase, leading to agricultural losses. <sup>2</sup>
<b>Social indicators</b>	Over most land areas, cold and frost days decreased <sup>3</sup> and will continue to decrease <sup>3</sup> while hot days and heat waves increased <sup>3</sup> and will continue to increase. <sup>3</sup>
Farmers and foresters have had to adapt to altered growing seasons and disturbance regimes.	Hurricanes intensified in the North Atlantic since 1970 <sup>4</sup> , and will continue to intensify. <sup>4</sup>
Temperate-zone crop yields will rise until temperature warms beyond 2° C (3.4° F), but in the dry tropics and subtropics, crop productivity will fall and lead to hunger. <sup>5</sup>	The thermohaline circulation will slow, but will not shut down and chill Europe in the 21 <sup>st</sup> century. <sup>1</sup>
Timber production may rise slightly in the near-term, but will vary by region. <sup>5</sup>	Antarctica will continue accumulating snow, but may also continue losing ice around its edges.
Impacts on biodiversity will cause losses of food, water, and other ecosystem goods and services. <sup>7</sup>	<b>Biological indicators</b>
Sea-level rise will displace people from islands and coastal regions. <sup>8</sup>	Species ranges are shifting toward the poles and upward in elevation, and will continue to shift.
Melting of mountain glaciers will reduce water supplies to millions of people. <sup>9</sup>	The timing of seasonal phenomena (such as migration and breeding) is shifting, and will continue to shift.
Economic costs will outweigh benefits as climate change worsens; costs could average 1–5% of GDP globally for 4° C (7.2° F) of warming.	About 20–30% of species studied so far will face extinction risk if temperature rises more than 1.5–2.5° C (2.7–4.5° F). <sup>5</sup>
Poorer nations and communities suffer more from climate change, because they rely more on climate-sensitive resources and have less capacity to adapt. <sup>7</sup>	Species interactions and ecosystem structure and function could change greatly, resulting in biodiversity loss.
Human health will suffer as increased warm-weather health hazards outweigh decreased cold-weather health hazards. <sup>7</sup>	Corals will experience further mortality from bleaching and ocean acidification. <sup>1,4</sup>

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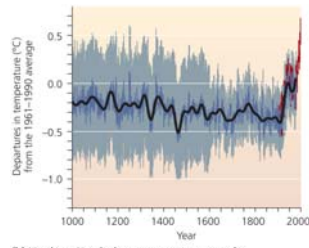
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## Temperature increases will continue

- The IPCC report concludes that average surface temperatures on earth have been rising since 1906, with most of the increase occurring in the last few decades



(a) Global temperature measured since 1850  
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(b) Northern Hemisphere temperature over the past 1,000 years  
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## Temperature changes are greatest in the Arctic

- Ice caps are melting
- Polar bears are starving
- Storms are increasing
- Sea ice is thinning



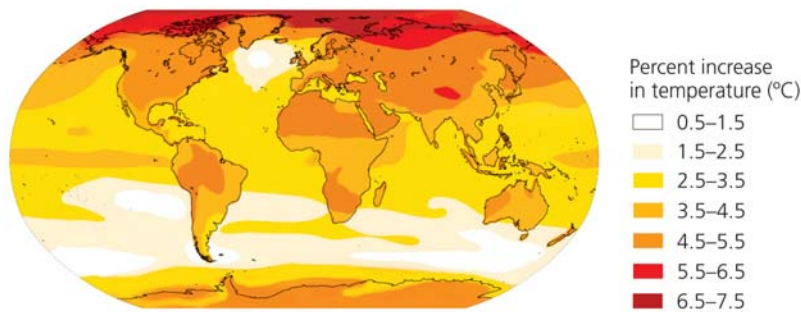
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## Temperatures will rise 0.2 degree Celsius per decade

- More frequent heat waves
- Temperature change will vary by region
- Stronger storms



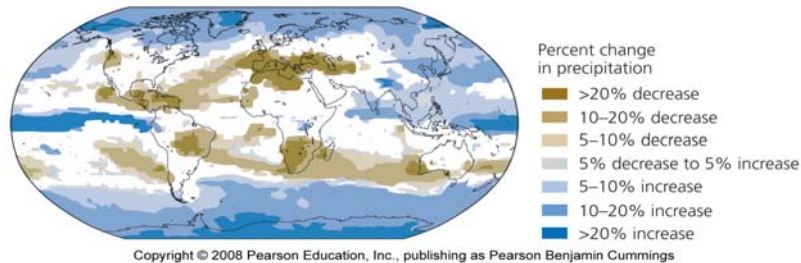
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## Changes in precipitation vary by region

- Some regions are receiving more precipitation than usual, and others are receiving less
- Droughts have become more frequent and severe
  - Harming agriculture, promoting soil erosion, reducing drinking water supplies, and encouraging forest fires
- Heavy rains have contributed to flooding
  - Killing people, destroying homes, and inflicting billions of dollars in damage

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## Projected changes in precipitation



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## Melting snow and ice

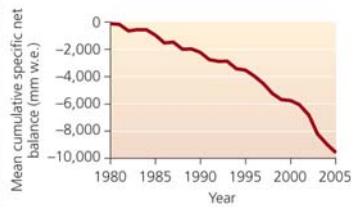
- Mountaintop glaciers are disappearing
  - In Glacier National Park, only 27 of 150 glaciers remain
  - Risks of sudden floods as ice dams burst
  - Reducing summertime water supplies
- Melting of the Greenland ice sheet is accelerating
- As ice melts, darker, less-reflective surfaces are exposed and absorb more sunlight, causing more melting

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## Worldwide, glaciers are melting rapidly



(a) Grinnell Glacier in 1938



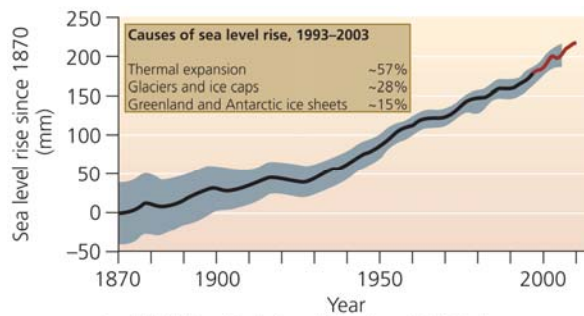
(b) Grinnell Glacier in 2005

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## Rising sea levels

- As glaciers and ice melt, increased water will flow into the oceans
- As oceans warm, they expand
- Leads to beach erosion, coastal floods, and intrusion of salt water into aquifers



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## Coastal areas will flood



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- **Storm surge** = temporary and localized rise in sea level brought on by the high tides and winds associated with storms
- Cities will be flooded
- Millions of people will be displaced from coastal areas
- IPCC predicts mean sea level to be 18-59 cm (7-23 in) higher than today's at the end of the 21st century

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## Climate change affects organisms and ecosystems

- Organisms are adapted to their environments, so they are affected when those environments change
- Global warming modifies temperature-dependent phenomena
  - Timing of migration, breeding
- Spatial shifts in the range of organisms
  - Animals and plants will move towards the poles or upward in elevation
  - 20-30% of all species will be threatened with extinction
- Plants act as carbon sinks; fewer plants means more CO<sub>2</sub> in the atmosphere

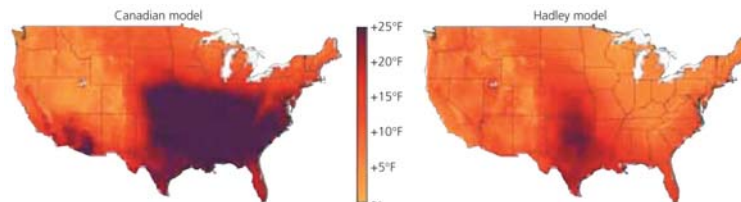
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## Climate change exerts societal impacts

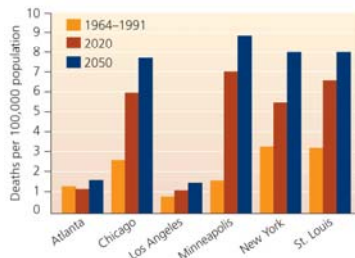
- Human society is beginning to feel the impacts of climate change
- Agriculture: growing seasons shortened, crops more susceptible to droughts and failure; crop production will decrease, worsening hunger
- Forestry: increased insect and disease outbreaks, increased chance of forest fires (especially in rainforests)
- Health: heat waves and stress can cause death, respiratory ailments, expansion of tropical diseases, increased chance of drowning if storms become intense, hunger-related ailments

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## Heat waves will increase



(a) Change in July heat index over the next century



(b) Average summer mortality rates attributed to hot weather episodes

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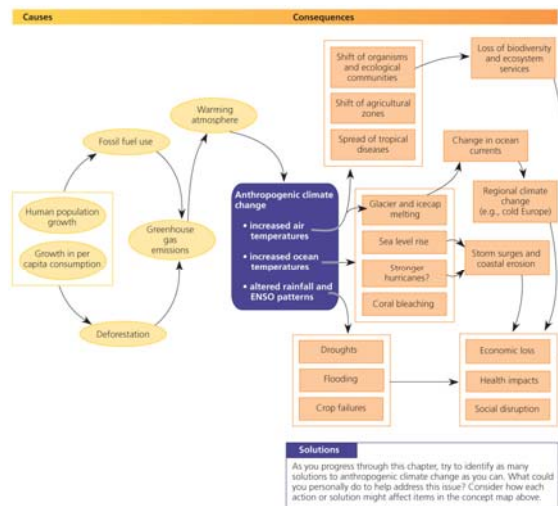
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## Climate change affects economics

- Costs will outweigh benefits
- Widen the gap between rich and poor
- Will cost 1-5% GDP on average globally
  - Poor nations will lose more than rich ones
  - Climate change could cost 5-20% of GDP by 2200

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## Causes and consequences of climate change



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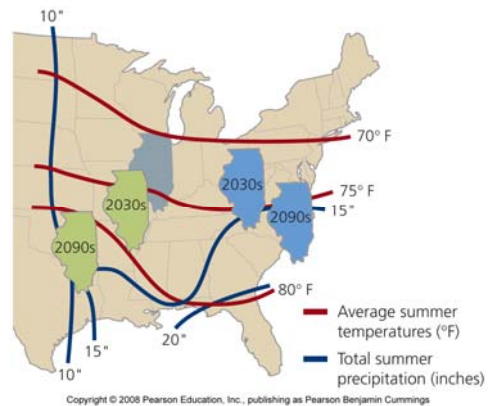
## U.S. Global Change Research Program (1990)

- Predicted:
  - Temperature increases
  - Worse droughts and flooding
  - Decreased crop yields and water shortages
  - Health problems and mortality
  - Altered forest ecosystems
  - Lost coastal areas
  - Undermined Alaskan buildings and roads

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## Predictions from two models

*By 2030, Illinois will have a climate like Missouri's.  
By 2090, it will have a climate like Oklahoma's.*



Green = Canadian model  
Blue = Hadley model

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## The USGCRP was suppressed

- Once President G.W. Bush came to power
- Climate change is politically divisive:
  - It challenges entrenched and powerful interests



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## Are we responsible for climate change?

- The IPCC concluded that it is more than 90% likely that most global warming is due to humans
- At the “G8” summit in 2005, national academies of 11 nations issued a joint statement urging political leaders to take action
- Despite broad scientific consensus that climate change is a pressing issue, it remains mired in an outdated debate
  - Is global warming real? Are humans to blame?
- The debate was fanned by skeptics-funded industry
  - Aimed to cast doubt on the scientific consensus
  - Today, the debate is largely over

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## The debate over climate change is over

- Most Americans accept that fossil fuel consumption is changing the planet
- *An Inconvenient Truth* helped turn the tide
  - 84% of people surveyed thought that humans contribute to global warming
  - Many corporations offer support for greenhouse gas reductions



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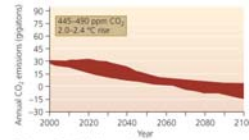
## Shall we pursue mitigation or adaptation?

- **Mitigation** = pursue actions that reduce greenhouse gas emissions, in order to lessen severity of future climate change
  - Renewable energy sources, farm practices to protect soil integrity, preventing deforestation
- **Adaptation** = accept climate change is happening and pursue strategies to minimize its impacts on us
  - Criticized as sidestepping
- Both are necessary

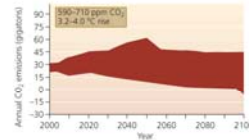
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## We need to act fast

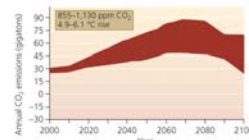
*The faster we reduce our emissions, the less we will alter climate*



(a) Scenario 1: Emissions peak soon



(b) Scenario 2: Emissions peak in 2020-2060



(c) Scenario 3: Emissions peak in 2060-2090

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## Electricity generation



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*A coal-fired, electricity-generating power plant*

- Largest source of U.S. CO<sub>2</sub> emissions
- Two ways to reduce fossil fuel use: conservation and efficiency
  - Arise from technology and individual choices
  - Replacing worn-down appliances with newer models, lifestyle choices
  - Use fewer greenhouse-gas-producing products

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## Sources of electricity

- We can change the energy we use
  - Natural gas
  - Carbon-capture = technologies or approaches that remove CO<sub>2</sub> from power plant emissions
  - Carbon sequestration (storage) = storing carbon somewhere (underground?) where it will not seep out
  - Use technologies and energy sources without using fossil fuels (nuclear, hydroelectric, solar power, etc.)

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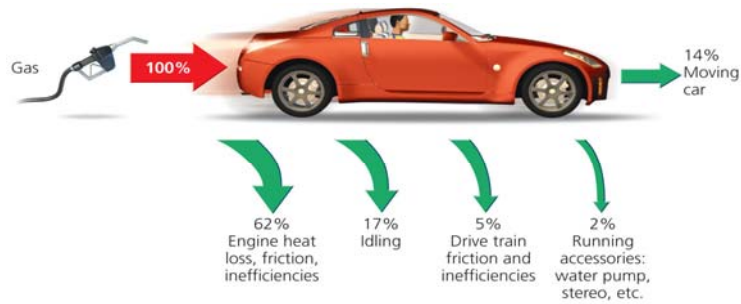
## Transportation

- 2nd largest U.S. greenhouse gas
- The typical automobile is highly inefficient
- Ways to help:
  - Technology: make vehicles more fuel-efficient, hybrid cars
  - Drive less and use public transportation
  - Public transportation is the most effective way to conserve energy, reduce pollution
  - Live nearer your workplace, so you can bike or walk



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## Conventional cars are inefficient



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## We can reduce emissions in other ways, too

- Use advances in agriculture, forestry, and waste management
  - Grow renewable biofuels
  - Rapid reforestation of deforested areas
  - Recovering methane from landfills
  - Recycling, composting, and reduction or reuse of materials

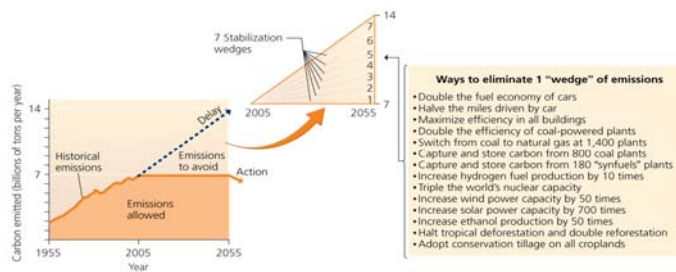
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## We need to follow multiple strategies

- There is no single magic bullet for mitigating climate change
- Most reductions can be achieved using current technology
- **Stabilization triangle** = a portfolio of strategies, each one feasible in itself, that could stabilize CO<sub>2</sub> emissions
  - Not enough, we need to reduce, not merely stabilize, emissions

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## Halting emissions



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## Government mandates or market incentives?

- Governmental command-and-control policy has been vital in safeguarding environmental quality and promoting human well-being
  - However, mandates are resisted by industry
  - Market incentives can sometimes be more effective in driving change
- Policymakers, industry, commerce, and citizens are searching for ways to employ government and the market to reduce emissions in ways that are fair, economically palatable, effective, and enforceable

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## The FCCC

- **UN Framework Convention on Climate Change (FCCC)** = outlines a plan for reducing greenhouse gas emissions to 1990 levels by the year 2000 through a voluntary, nation-by-nation approach
  - By the late 1990s, it was clear that the voluntary approach would not succeed
  - U.S. emissions increased by 17.9% from 1990 to 2006
  - Germany, with the third most technologically advanced economy in the world, reduced emissions by 17.2% between 1990 and 2004
- Developing nations created a binding international treaty that would require all signatory nations to reduce their emissions

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## The Kyoto Protocol seeks to limit emissions

- The Kyoto Protocol mandates that, between 2008-2012, signatory nations must reduce emissions of six greenhouse gases to levels below those of 1990
  - This treaty took effect in 2005, after Russia became the 127th nation to ratify it
- The United States will not ratify the Kyoto Protocol because it requires industrialized nations to reduce emissions, but it does not require the same of rapidly industrializing nations such as China and India
- Businesses in industrialized nations feel they have more to lose economically from restrictions

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## Advancing climate change policy

- George W. Bush and Congress will not address climate change
  - State and local governments across the U.S. are responding and advancing policies to limit greenhouse emissions
  - Mayors from all 50 states signed the U.S. Mayors Climate Protection Agreement, where the mayors commit their cities to pursue policies to “meet or beat” Kyoto Protocol guidelines
- California’s legislature passed the Global Warming Solutions Act, which aims to cut the state’s greenhouse gas emissions 25% by the year 2020
- 10 northeastern states launched the Regional Greenhouse Gas Initiative (RGGI) in 2007, which set up a cap-and-trade program for carbon emissions from power plants

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## Market mechanisms address climate change

- Permit trading programs can harness the economic efficiency of the free market to achieve policy goals while allowing business
- The price of a permit fluctuates freely in the market, creating the same kinds of financial incentives as any other commodity that is bought and sold in our capitalist system
- The Chicago Climate Change is the world's first emissions trading program for greenhouse gas reduction
- The world's largest cap-and-trade program is the European Union Emission Trading Scheme

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## Carbon offsets are in vogue

- Emissions trading programs allow participants who cannot or will not reduce their emissions to use carbon offsets instead
- **Carbon offset** = a voluntary payment to another entity intended to enable that entity to reduce the greenhouse emissions that one is unable or unwilling to reduce oneself
  - Becoming popular among utilities, businesses, universities, governments, and individuals trying to achieve **carbon-neutrality**, where no net carbon is emitted
- Carbon offsets fall short
  - A lack of oversight to make sure that the offset money accomplishes what it is intended for

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## You can reduce your own footprint

- Our **carbon footprint** expresses the amount of carbon we are responsible for emitting
  - You may apply many strategies such as deciding where to live, how to get to work, and what appliances to buy to decrease your footprint
- Global climate change may be the biggest challenge facing us and our children
  - Taking immediate action is the most important thing we can do

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## Conclusion

- Many factors influence Earth's climate
  - Human activities play a major role
- Climate change is well underway
  - Further emissions will cause severe impacts
- More and more scientists are urging immediate action
  - Reducing emissions, and mitigating and adapting to a changing climate, represents the foremost challenge for our society

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### **QUESTION: Review**



The Fourth Assessment Report of the Intergovernmental Panel on Climate Change made it clear that:

- a) Climate is changing
- b) Humans are the cause
- c) This change is already exerting impacts
- d) All of the above are included in this report

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### **QUESTION: Review**



“Climate” is defined as....

- a) Conditions at localized sites
- b) Conditions over hours or days
- c) An area’s long-term atmospheric conditions
- d) Variations in Earth’s temperature

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### **QUESTION: Review**



“Global potential,” when referring to greenhouse gases, means....

- a) The ability of a molecule to contribute to global warming
- b) The ability of a molecule to prevent global warming
- c) Carbon dioxide is the most potent greenhouse gas
- d) Energy travels back to the Earth, after being emitted

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### **QUESTION: Review**



Which of the following are major contributors of global warming?

- a) Burning fossil fuels and recycling
- b) Burning fossil fuels and deforestation
- c) Deforestation and nuclear energy
- d) Fossil fuels and nuclear energy

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**QUESTION: Review**



U.S. emissions of greenhouse gases have....

- a) Decreased
- b) Stabilized
- c) Increased
- d) Gone away

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**QUESTION: Review**



A “proxy indicator” is ....

- a) Indirect evidence
- b) Indirect evidence that substitutes for direct evidence
- c) Direct evidence
- d) Direct evidence that substitutes for indirect evidence

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### **QUESTION: Review**



What happens as ice melts in polar regions?

- a) More heat is reflected into space
- b) Glaciers re-freeze at night
- c) Exposed soils absorb heat and make melting worse
- d) Polar bears learn to like the Sun

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### **QUESTION: Weighing the Issues**



Do you think Arctic-living people deserve some sort of compensation from developed nations whose emissions have caused climate change and negatively affected Arctic-living people?

- a) Yes, because their way of life is being destroyed
- b) Yes, but compensation should be in the form of helping them move to another area
- c) No; they need to change their lifestyles to adapt
- d) No; people have always had to adapt to new conditions

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## QUESTION: Weighing the Issues



If people are displaced from their homeland due to climate change, should industrialized nations have to take them in, since fossil fuel burning is responsible for their loss of homes?

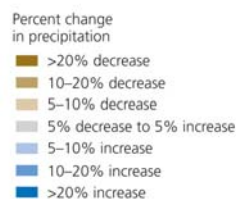
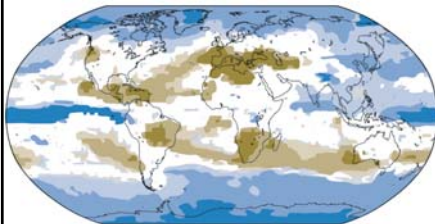
- a) Yes; if we deprive them of their homes, we owe them new ones
- b) Yes, but they should have to pay to enter this country
- c) No; it's their tough luck
- d) Definitely not; it's not my problem

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## QUESTION: Interpreting Graphs and Data



According to this model, which area will have increased droughts and starvation?



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- a) The U.S.
- b) The tip of South America
- c) North Africa
- d) Greenland

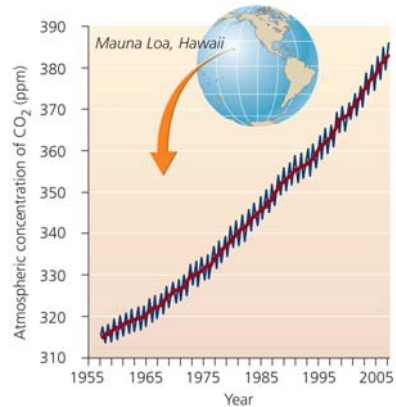
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## QUESTION: Interpreting Graphs and Data



Which statement is supported by this figure?

- a) CO<sub>2</sub> emissions have stabilized recently
- b) CO<sub>2</sub> emissions fluctuate only in Hawaii
- c) CO<sub>2</sub> emissions have increased drastically
- d) CO<sub>2</sub> emissions average 320 ppm



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