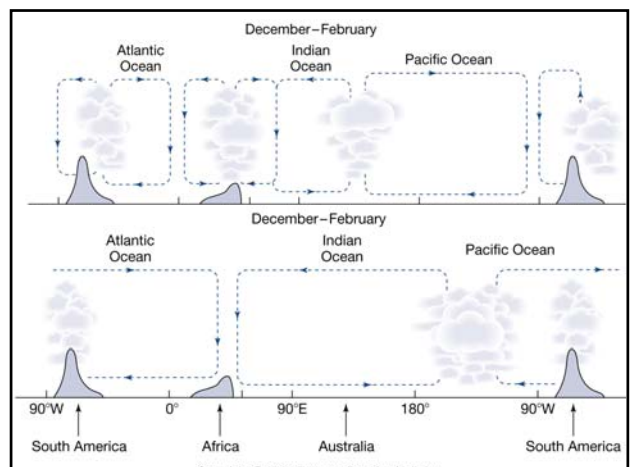
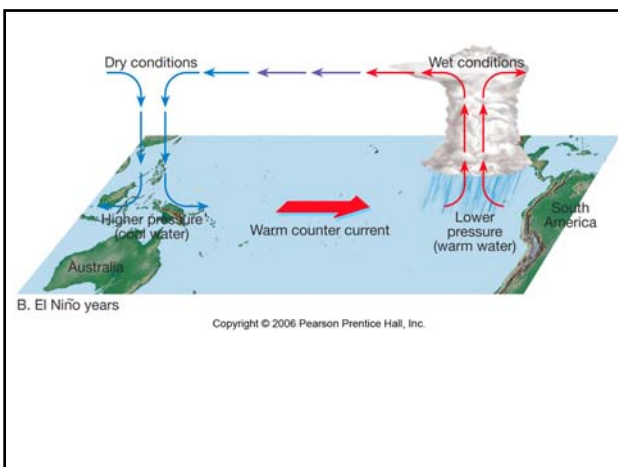
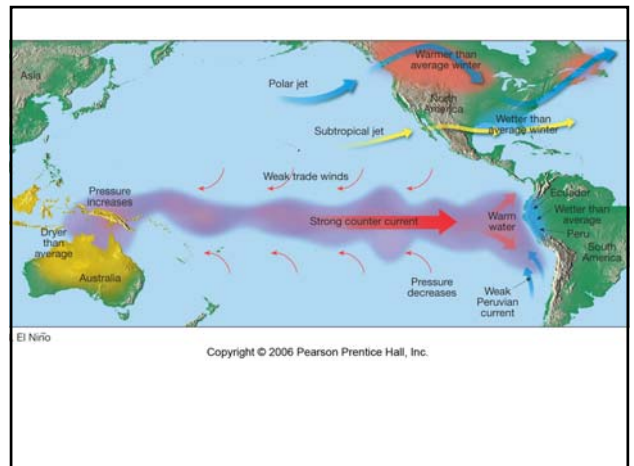
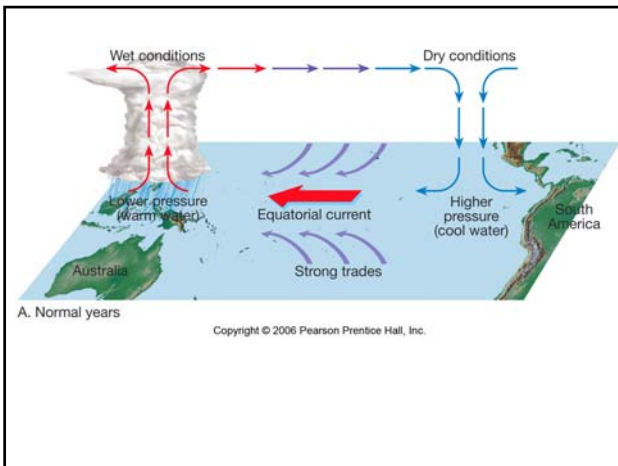
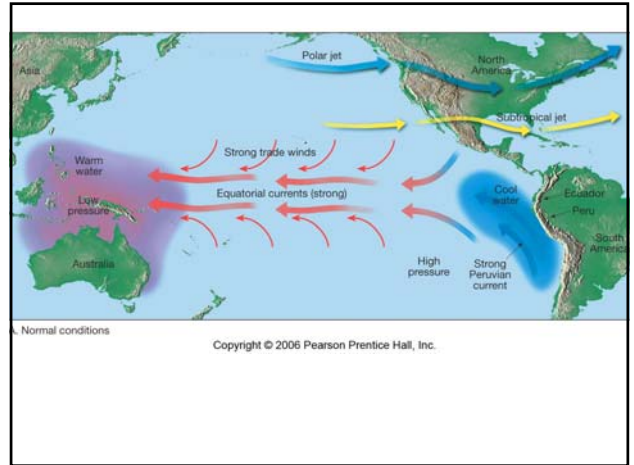
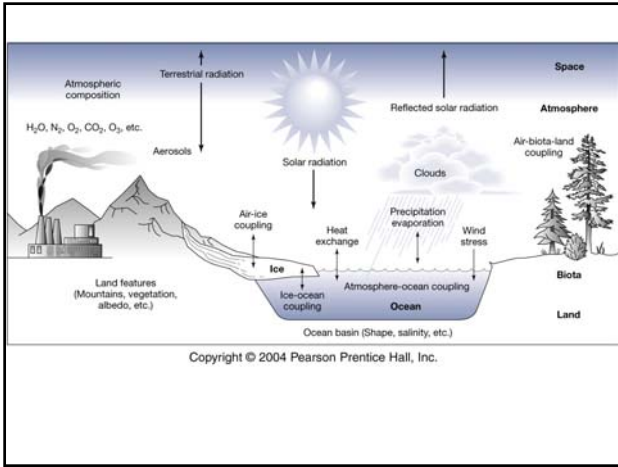


# Climate Variability

El Niño-Southern Oscillation  
 Human-caused climate change  
 Alternative Energy sources





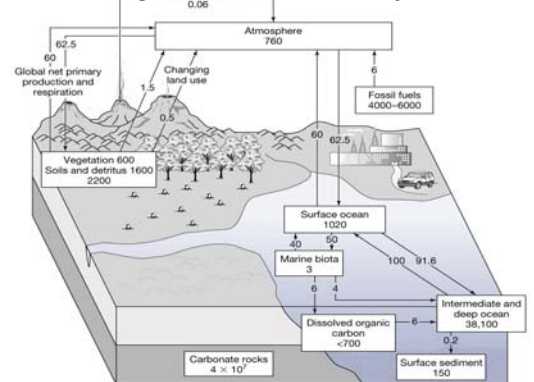
## Human contributions to climate change

- Fire
- Deforestation
  - Agriculture
  - Overgrazing
- Cities
  - Heat island
  - Particulates
- Carbon dioxide

## Carbon dioxide

- Sources
  - Volcanic gases
  - Respiration
  - Decay
  - Combustion of carbon compounds
- Removing fixation organisms decreases removal from atmosphere
  - Forests: tropical and temperate

## Carbon cycle—gigatons and exchange of carbon per year

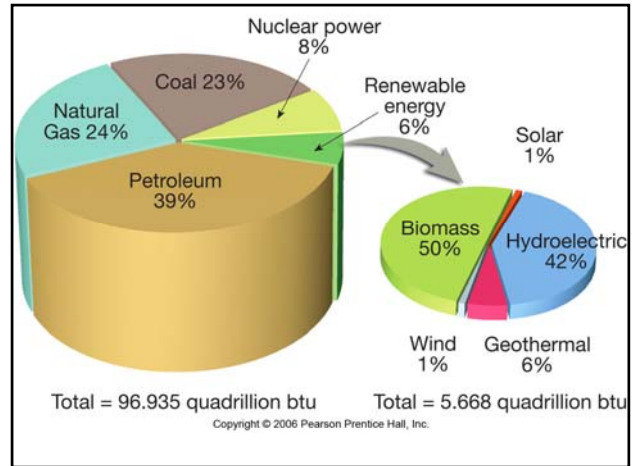
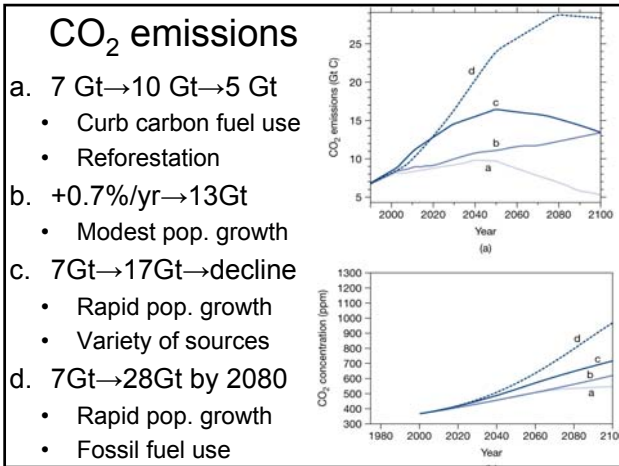
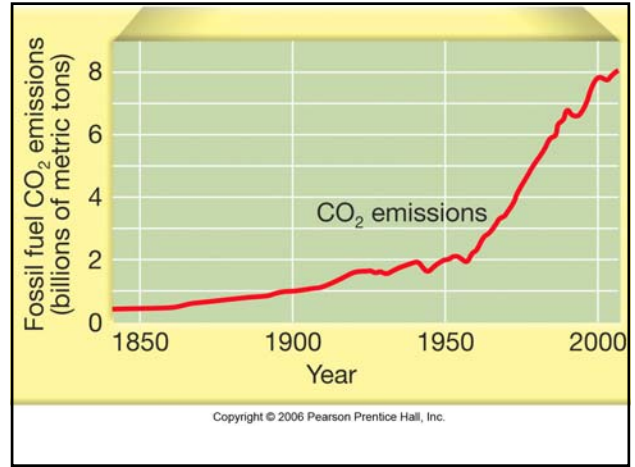
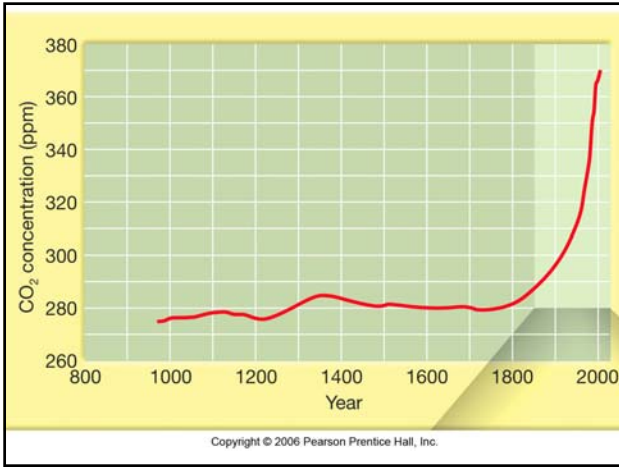


## Greenhouse gases

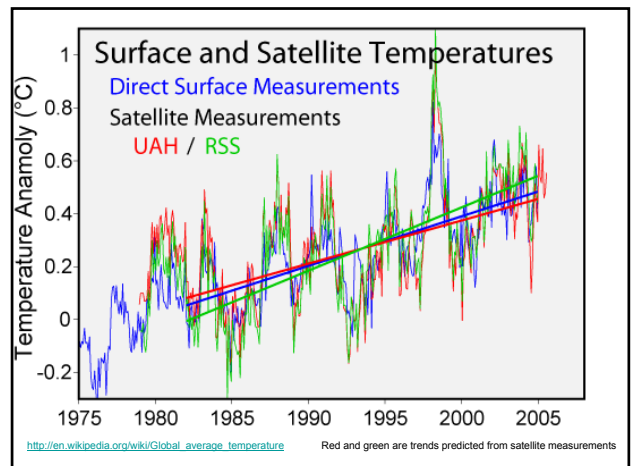
- Transparent to visible light
- Opaque to re-emitted heat energy
- Carbon dioxide is powerful greenhouse gas

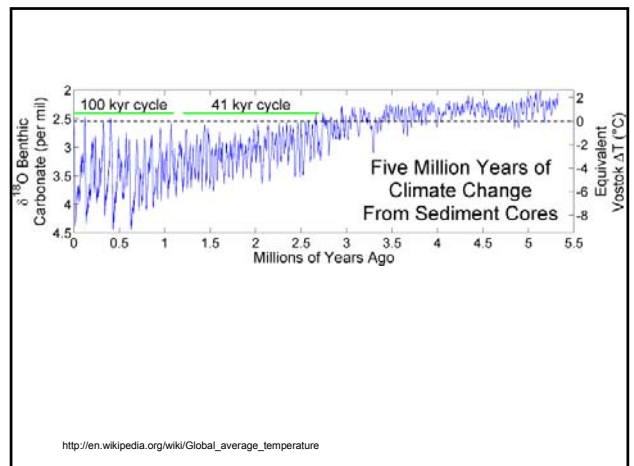
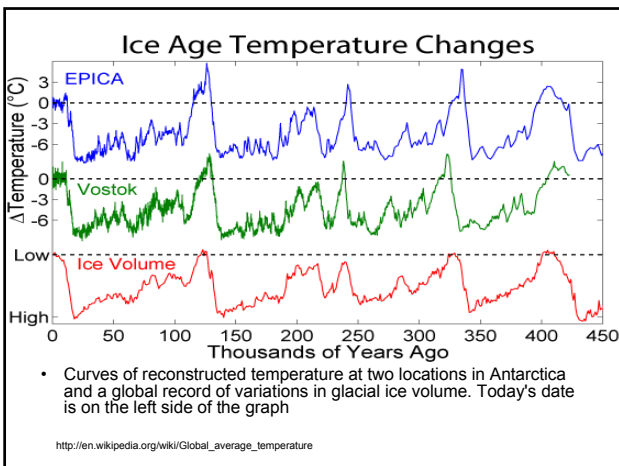
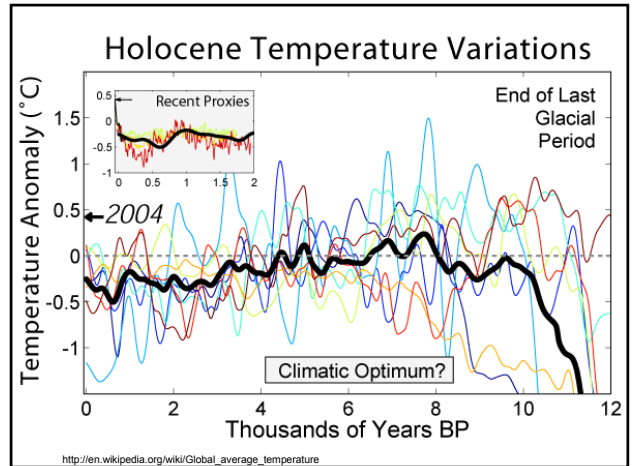
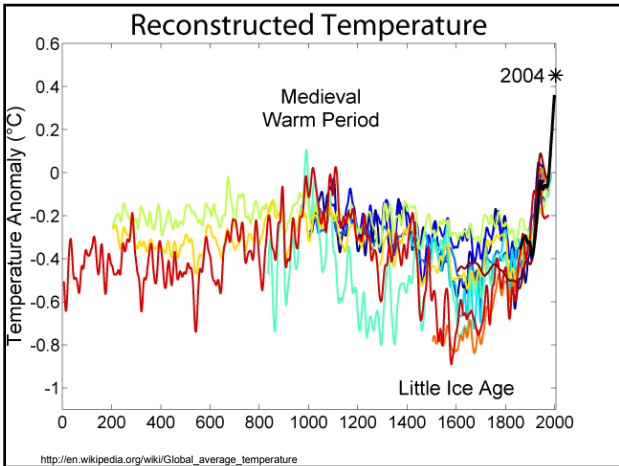
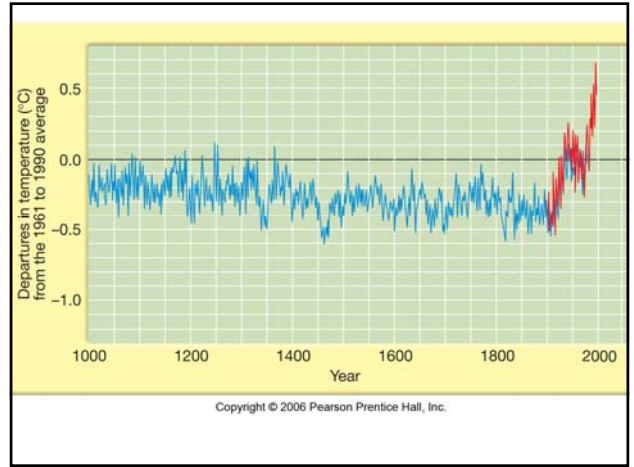
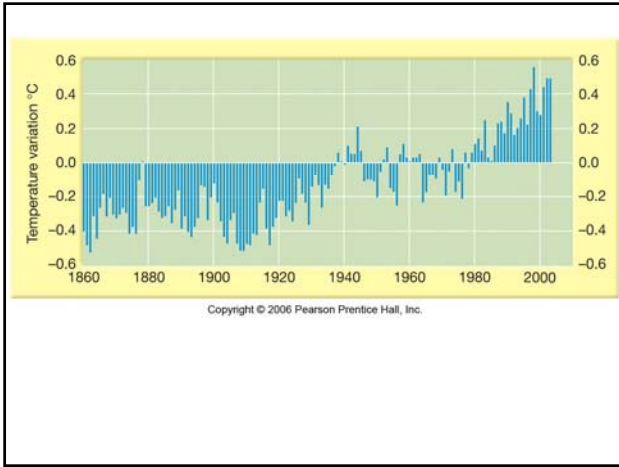
## Carbon Dioxide

- Human-caused increase in CO<sub>2</sub>
  - From 280 ppm to 380 ppm in 200 years
  - Increases plant vigor—negative feedback
- Carbon 'reservoirs'
  - Dissolve in ocean
  - Dissolution of carbonate minerals
  - Sinking of carbonate skeletons, tests

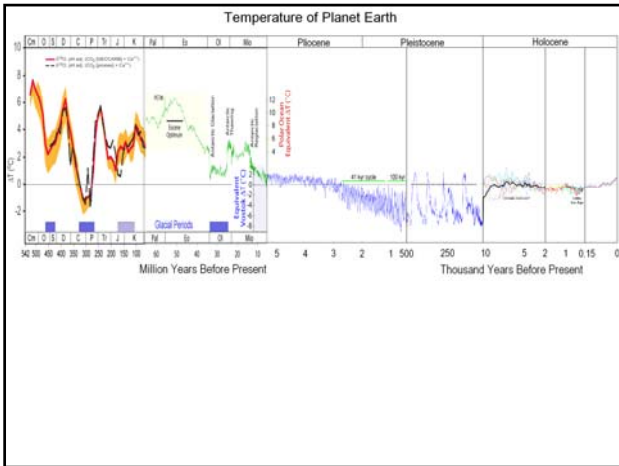
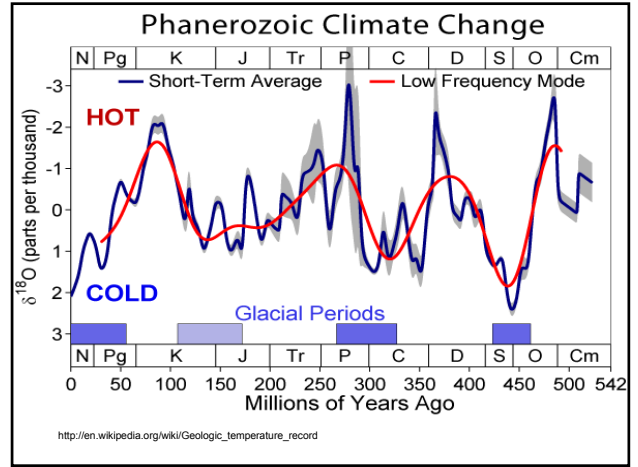
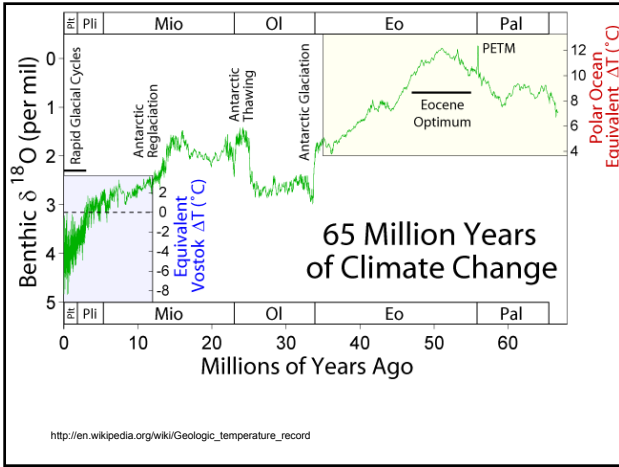


- ### Increase in surface temperature
- Methane increase
    - From agriculture
    - From warming of permafrost (but more formed on sea floor, causing reduction?)
  - Ozone depletion allowing more energy to reach Earth's surface
  - Variance in solar intensity
  - Positive feedback mechanisms
    - Albedo decline results in warming
    - Increased temperature causes more rainfall and reduces iron fertilization of sea









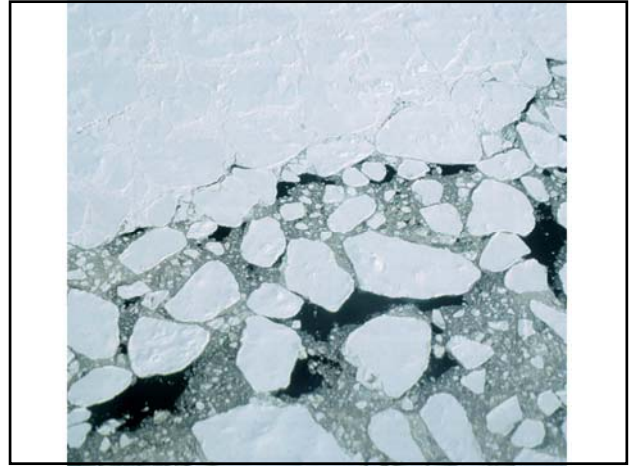
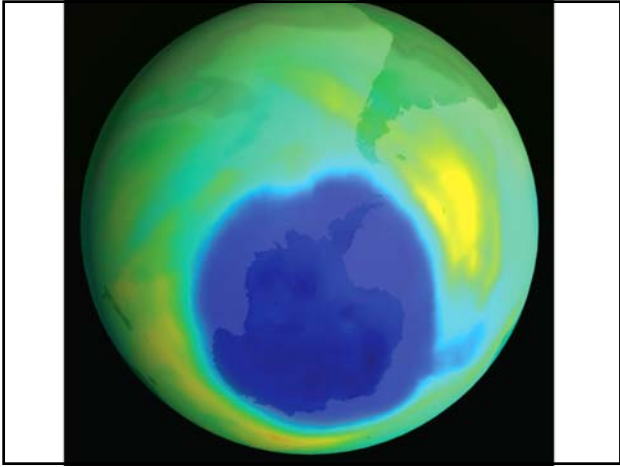
### Other greenhouse gases

- Water vapor
- Methane
- Chlorofluorocarbons (CFCs)
- Nitrogen oxides

### Carbon Dioxide-Water system

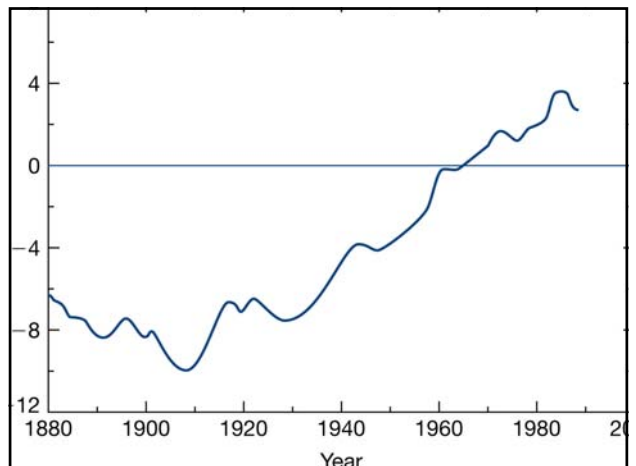
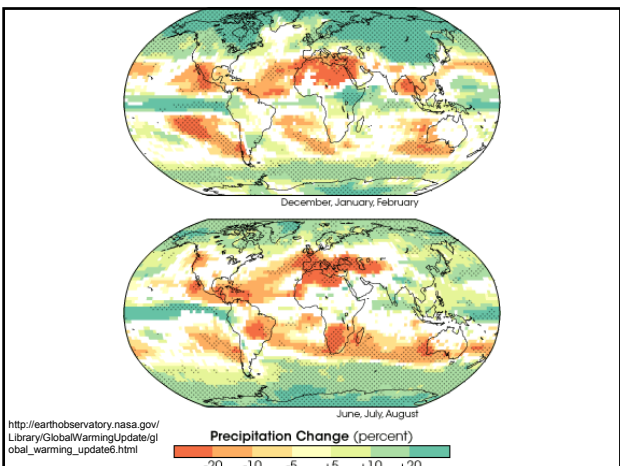
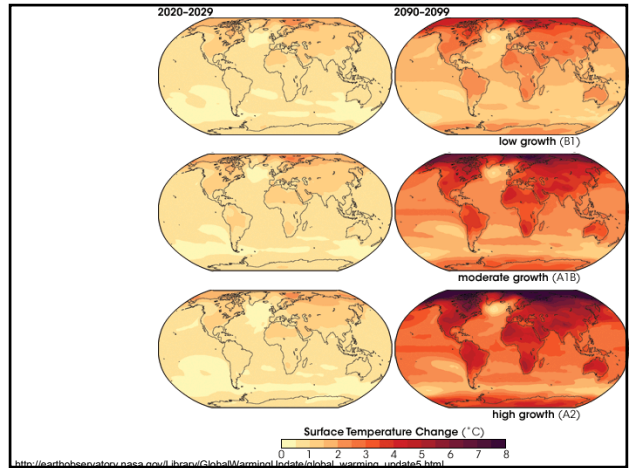
- $\uparrow \text{CO}_2 \rightarrow \uparrow T \rightarrow \uparrow \text{evaporation} \rightarrow \uparrow T$
- $\uparrow \text{evaporation} \rightarrow \uparrow \text{cloud cover, albedo} \rightarrow \downarrow T$
- Positive outweighs negative feed back

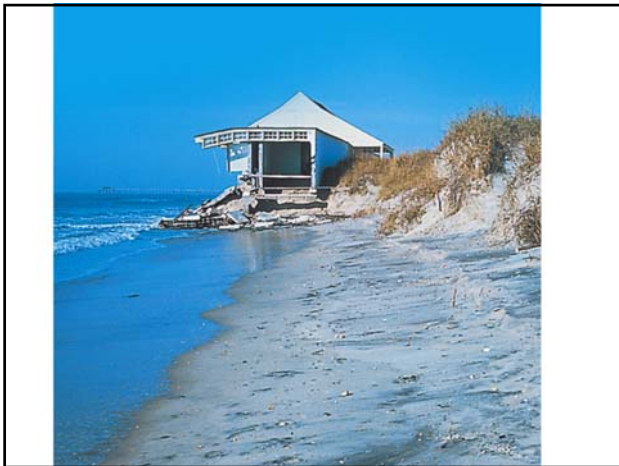
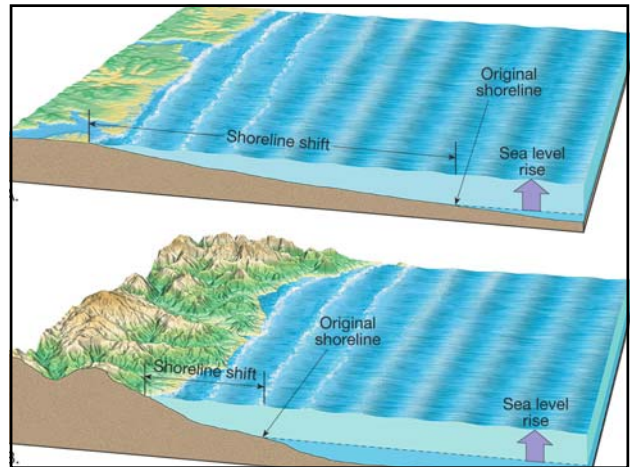
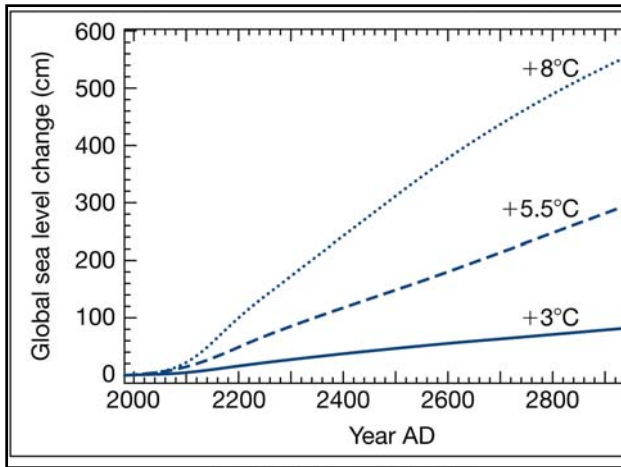




## Increase in surface temperature

- Sea level rise
- Shift in climate zones
- Increased intensity of cyclones: both tropical and midlatitude





## Mitigation

- Reduce fossil fuel use
- Alternative fuels
  - Nuclear power
  - Renewable sources
  - Geothermal
  - Water power
- Plants
  - Forests: reduce logging, plant trees
  - Algae: fertilize sea removes CO<sub>2</sub>
  - Biomass energy sources

## Current nuclear plant capabilities by country

- 437 nuclear power reactors in operation in 30 countries. These reactors supply about 15.2% of the world's electricity
- France depends on nuclear power for 78% of its electricity supply. In Japan the figure is 30%.
- Emits only 1–6 grams of carbon equivalent per kilowatt-hour. This is about the same negligible emission rate as wind and hydropower

<http://www.iaea.org/NewsCenter/Statements/2007/ebsp2007n011.html>

## Nuclear power

- Safety utmost concern
  - Well designed plants with redundant safety mechanisms installed
  - Well constructed and continual inspection
- Determine method of dealing with waste
  - Deep burial popular but short-sighted
  - recycle or breed to short-half-life substances more reasonable
  - Rockets to space seems dangerous





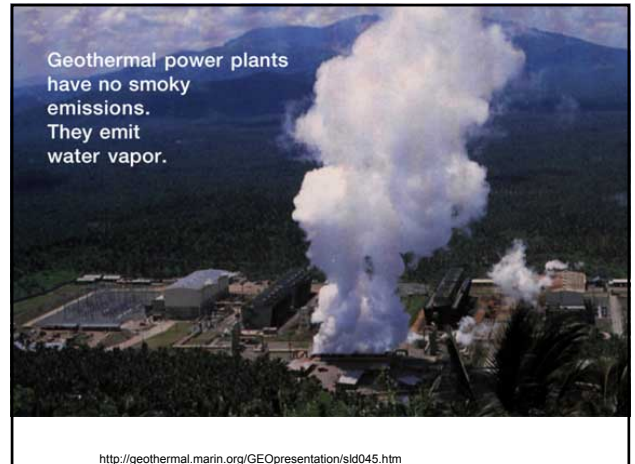
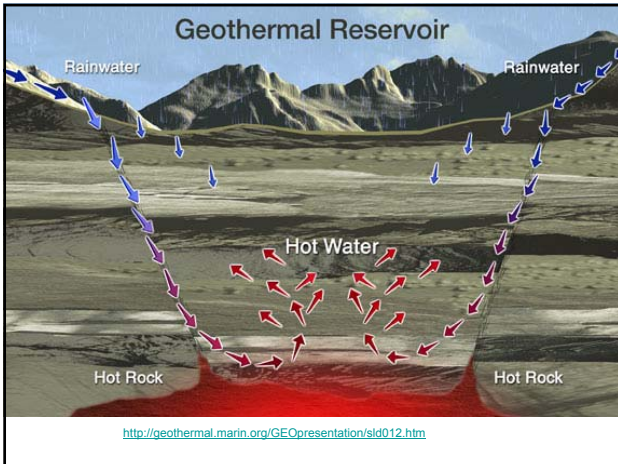
• <http://www.earthship.com/staticpages/index.php?page=sale&osCsid=e2e983564ec7a5b9921a71236bed60c8>

- Building for passive Sun heating
- Photovoltaic and Water heating also incorporated
- Note operable skylight for cooling

## Wind Power



• <http://www.bergey.com/>



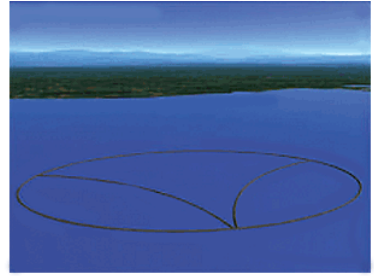




Reykjavik today

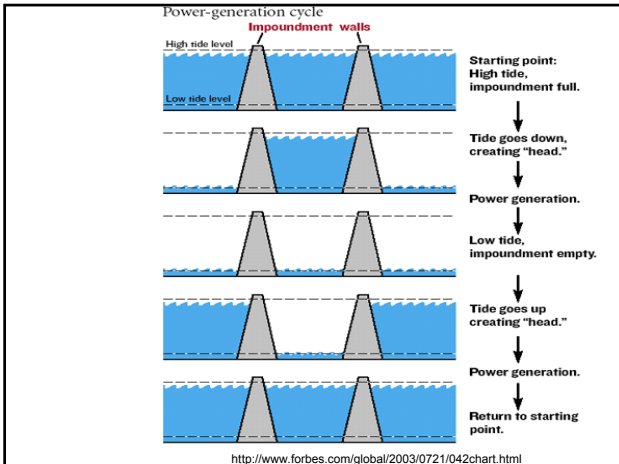
<http://geothermal.marin.org/GEOpresentation/sld095.htm>

## Tidal Lagoon



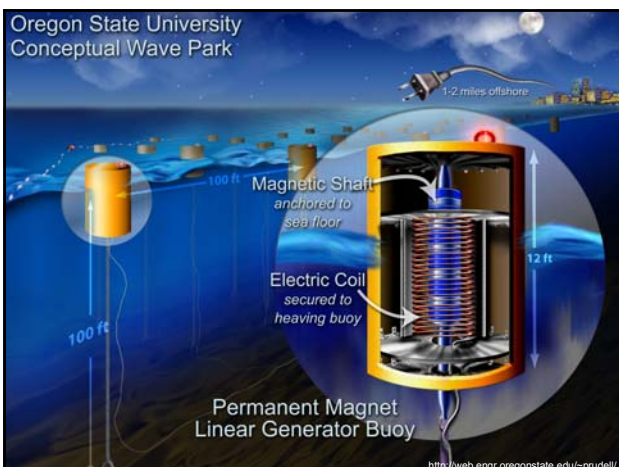
Artist's impression of a tidal lagoon 2 kilometers offshore.

• <http://www.forbes.com/global/2003/0721/042chart.html>



## Grand Coulee Dam

- Hydroelectric power
- North America's largest concrete structure
- Located on the Columbia River in Central Washington



## Biomass

- Direct burning of plant material
- Oil harvested from seeds
- Plant material converted to
  - Alcohol: methanol and ethanol
  - Converted to methane