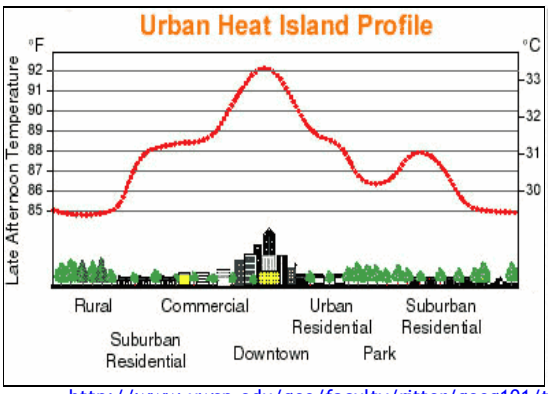
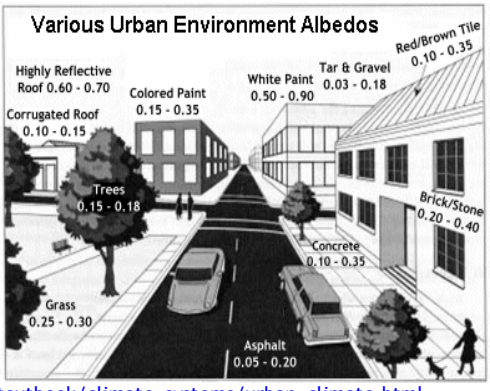
Urban Climates MICROCLIMATES

Microclimatology: study of climate over small area over 30 years. Includes changes resulting from construction of large urban centres & existing naturally between different land surfaces (forests, lakes)

- ✓ Urban climates:
  - More dust & condensation nuclei that natural environments
  - Create / trap more heat & affect albedo
  - Alter chemical composition & moisture content of air above & altering flow of air

Indicators	*Differences*
Temperature	✓ Dark-colored concrete / tarmac high thermal capacity which store heat in day and release slowly at night ✓ Temperatures highest in built-up city centre, decreasing towards suburbs & open countryside ✓ Daytime temperatures ~0.6°C higher; nighttime temperatures 3-4°C higher as dust & cloud blanket & trap heat and buildings radiate heat ✓ Mean winter temperatures 1-2°C higher; mean summer temperatures ~5°C higher
Sunlight	✓ Less sunshine & more cloud cover than rural areas ✓ Dust & other particles albedo effect: absorb & reflect ~50% insolation in winter (when sun lower & pass through thicker atmosphere) ✓ High-rise buildings block out light (shadow)
Winds	✓ Wind velocity reduced by buildings, creating friction & windbreaks, leading to turbulent winds ✓ High-rise buildings form canyons funneling winds like wind tunnel
Relative **H**umidity	✓ 6% lower in urban areas, as warm air holds more moisture & lack of vegetation and water surface limits evapotranspiration
Clouds / **F**og	✓ Thicker & 10% more frequent cloud cover, resultant from convection currents generated by higher temperatures & presence of larger number of condensation nuclei ✓ More radiation fog / smog in winter
Precipitation	✓ Mean annual precipitation total & number of days with <5mm rainfall 5-15% greater ✓ Strong thermals increase likelihood of thunder ✓ Frequency of hail increases 400% ✓ Higher urban temperatures turn snow into sleet
Atmospheric **C**omposition	✓ Burning of fossil fuels, industrial processes & car exhaust increase gaseous & solid impurities, leading to more cloud cover, precipitation & smog ✓ 200x more SO_2, 10x more hydrocarbons & 2x more CO_2 ✓ Pollution dome / plume can result





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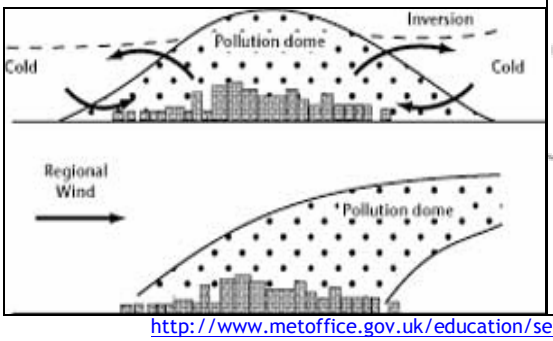
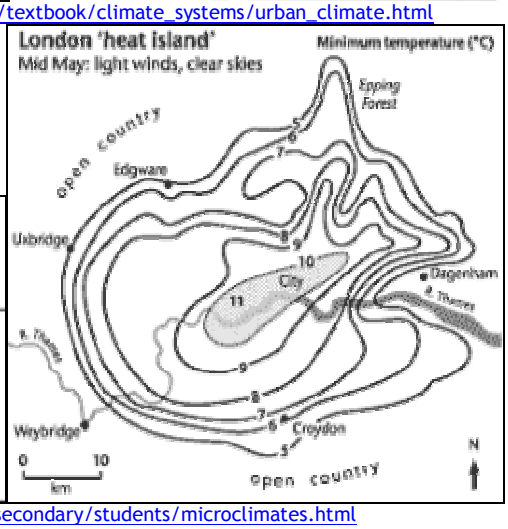




http://www.metoffice.gov.uk/education/secondary/students/microclimates.html

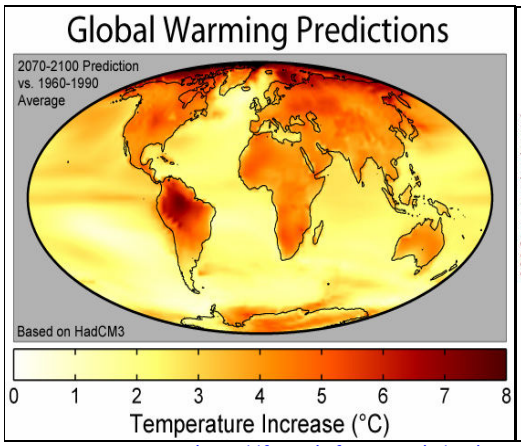
Case Studies

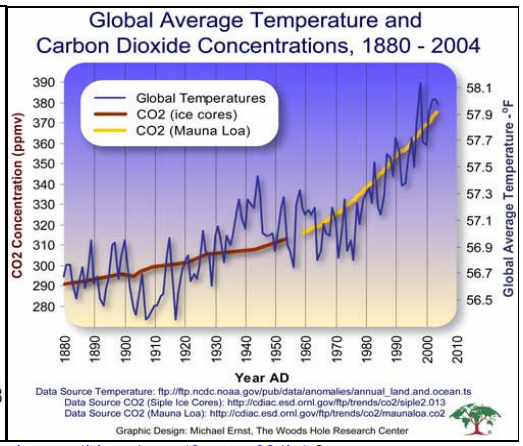
1. **Tokyo, Japan**
   - ✓ Population of 12m, with large road network, tall buildings, hot air from air-conditioning plants & lack of greenery creating heat trap
   - ✓ Summer temperatures can hit 35°C; average temperatures have risen by 3°C over last 100 years
   - ✓ If nothing is done to counter heat island, temperatures could hit 40°C within next two decades
   - ✓ Possible solution: building roof gardens to absorb heat
2. **Johannesburg, South Africa**
   - ✓ South Africa's largest city, located on Witwatersrand ridge at altitude of 1700m (Location on ridge intensifies local weather conditions)
   - ✓ Urban temperatures as much as 11°C higher than countryside
   - ✓ Rainfall 25% more than surrounding lowland areas, with intense summer convectional showers
3. **Shanghai, China**
   - ✓ China's largest city, with well developed heat island effects
   - ✓ Higher rainfall and lower relative humidity than surroundings

Intensified greenhouse effect: sustained increase in average temperatures of Earth's atmosphere. Is global temperature rises part of natural long-term patterns? (E.g. negative & positive feedback loops) Evidence of global warming can be monitored directly (CO_2 levels) or indirectly (e.g. sea levels)

- ✓ First evidence of global warming: University of East Anglia Climatic Research Unit (CRU) in UK recorded global mean temperatures in 1990 0.39°C above average from 1951-80 (Warmest year then)
- ✓ Intergovernmental Panel on Climate Change (IPCC)'s first report in 1990 estimated global warming of 3-5°C by 2100, forming basis for first debate of global warming at Earth Summit (1992 in Rio de Janeiro, Brazil)
- ✓ Mauna Loa weather station collecting data on CO_2 levels since 1960s
- ✓ IPCC main authority with global statistics on global warming

Indicators	*Statistics*
CO_2 levels	✓ 2007 CO_2 levels have increased by 20 ppm from 1997 to 383 ppm ✓ CO_2 levels 27% higher than in last 650k years! ✓ Dramatic rise in CO_2 levels since Industrial Revolution
Sea levels	✓ 10-20cm rise worldwide in 20th century ✓ Further sea level rise of 9-88cm by 2100
Ice cover / glaciers	✓ North Pole sea-ice thinned by 40% ✓ Global snow cover shrunk by 10% ✓ Ice fields around Mt Everest receded by 6km ✓ Parts of 182m-thick Larsen B ice shelf in Antarctica collapsed in 35 days
Temperatures	✓ Temperature over last century rose by 0.74°C ✓ Hottest years on record: 2005 & 2007 (14.7°C) ✓ Ten hottest years on record all occurred since 1990 ✓ Global temperatures predicted to rise 1.1-6.4°C over next century





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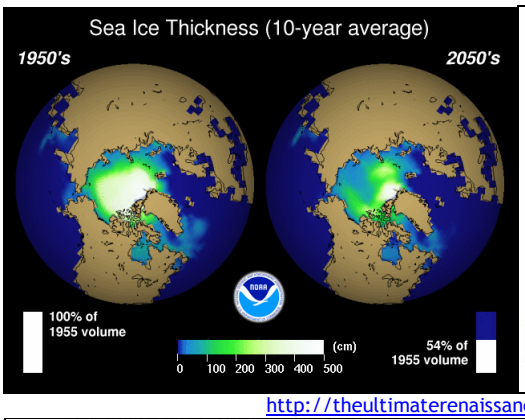

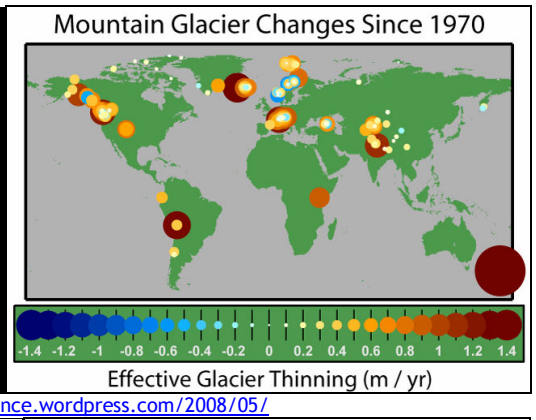

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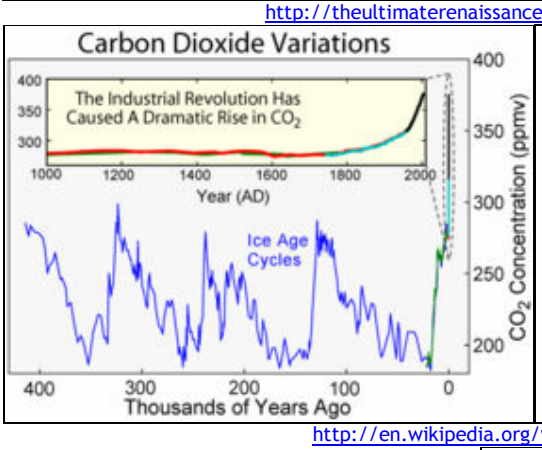

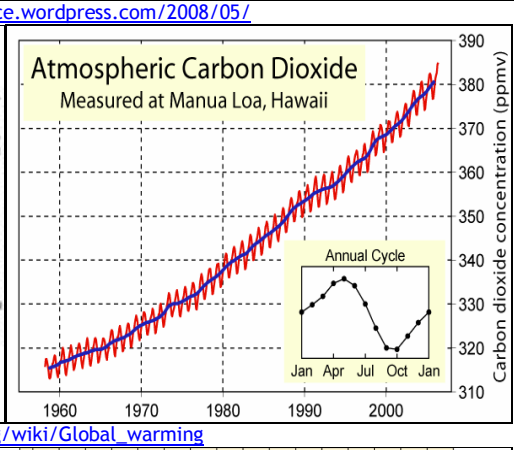

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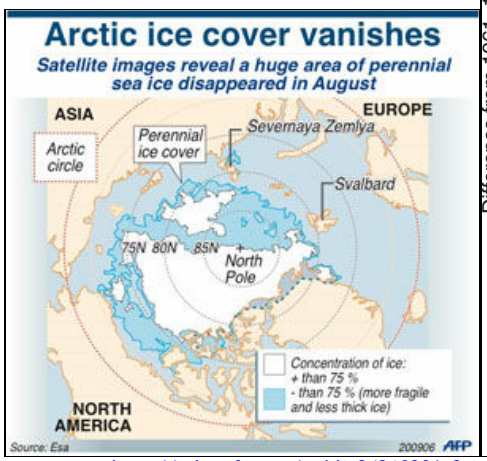
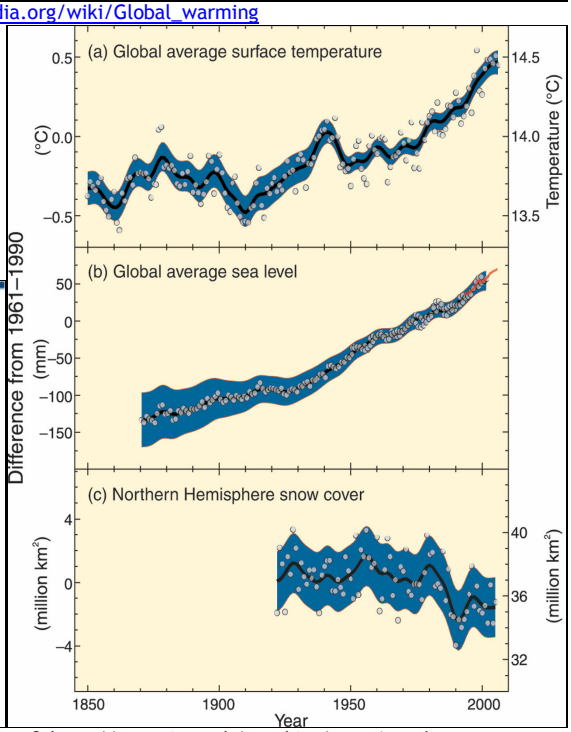


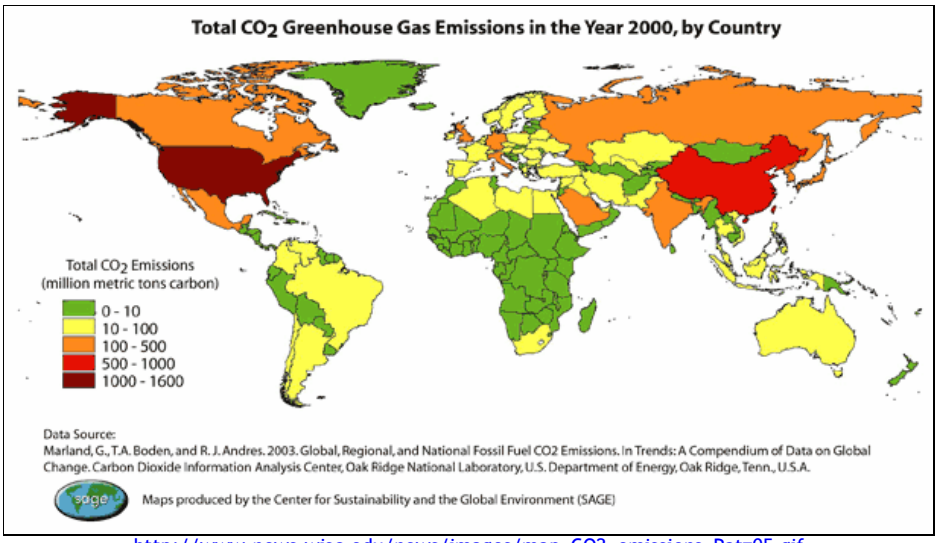


http://mb-soft.com/public3/210906a3.jpg & http://www.ipcc.ch/graphics/gr-ar4-syr.htm

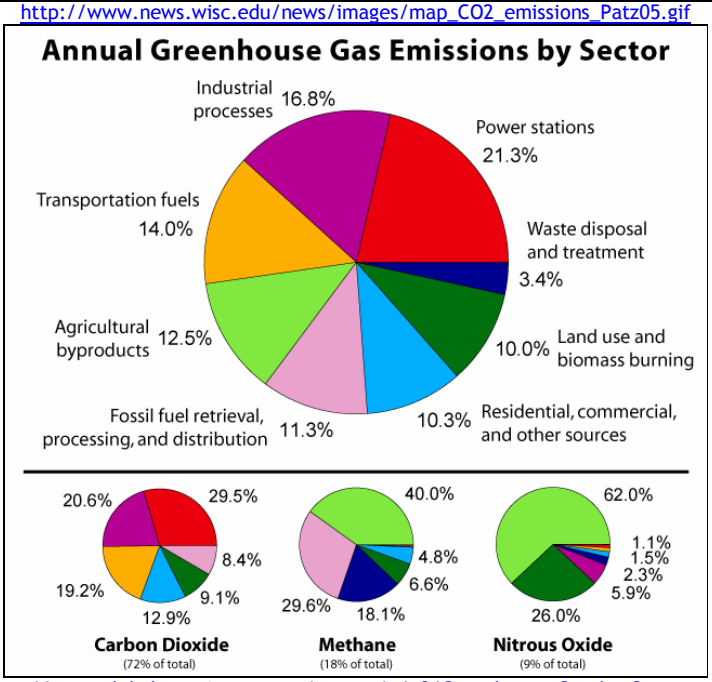
Global Warming: Causes GLOBAL CLIMATE

Global warming acknowledged as highly probably anthropogenic, with increase in greenhouse gas (GHG) emissions direct cause of global warming, with Man's activities contributing to this increase in GHG emissions

GHG	*Main sources*	*Contribution to Global Warming*
Water vapour	Surface water, not significantly affected by human activity	97% of natural greenhouse effect
Carbon dioxide	Burning of fossil fuels & vegetation	50%
Methane	Wetlands & ruminating animals	18%
CFCs	Aerosol sprays & refrigeration	24% (33% by 2030 as CFCs survive 100 years in atmosphere)
Ozone	Nitrogen oxides from power stations, hydrocarbons from transportation	Difficult to estimate as concentration varies spatially



http://www.news.wisc.edu/news/images/map_CO2_emissions_Patz05.gif



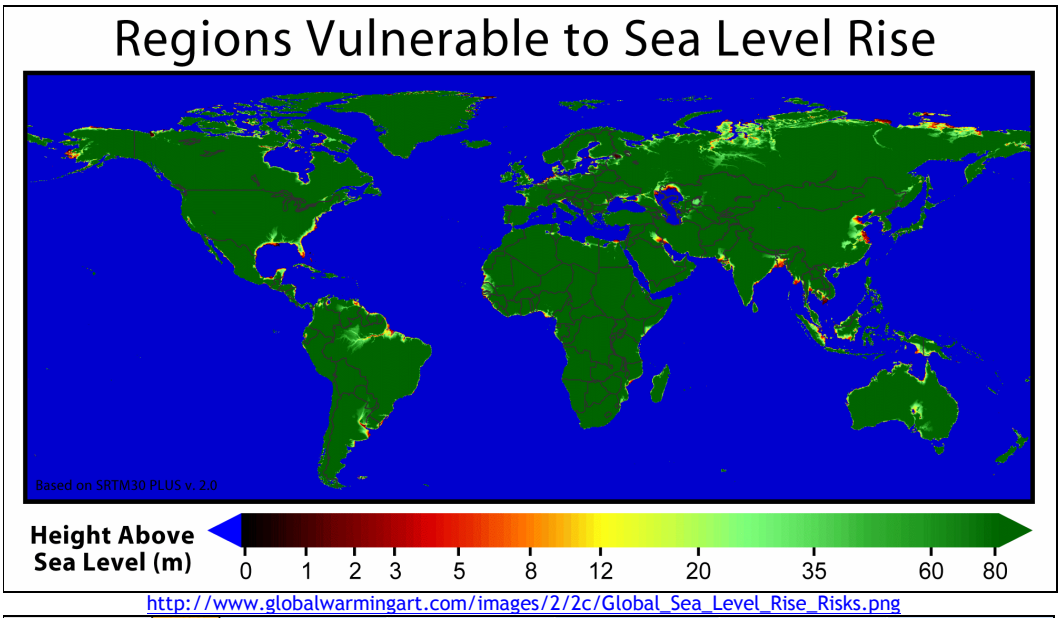
http://www.globalwarmingart.com/images/e/e0/Greenhouse_Gas_by_Sector.png

- ✓ Source of CO_2: burning fossil fuels & burning forests (deforestation)
- ✓ Carbon cycle broadly in balance for centuries, as output from respiration compensated by photosynthesis, corals & oceans that act as natural carbon sinks
- ✓ But global warming will create positive feedback loop in oceans: warm water absorbs less CO_2 than cold water, hence more CO_2 will be left in the atmosphere to encourage warming
- ✓ Destruction of coral reefs release CO_2 and also reduce role of reefs as carbon sinks
- ✓ Similarly, destroying trees release CO_2 into atmosphere as well as reduce photosynthetic effect of trees

Global Warming: Effects — GLOBAL CLIMATE

Complexity of consequences as temperature rises will not be uniform throughout the world and the impact of climate change is also not uniform. In addition the lack of understanding of climatic feedback mechanisms complicates matters further. In essence, a mixture of opportunities & problems in the effects of global warming

- ✓ A possible negative feedback loop:
  - Increasing temperatures encourage evapotranspiration, releasing latent heat into the atmosphere, forming clouds that reflect insolation & have shading & cooling effect
  - Counter-negative feedback: water vapour is a GHG!
- ✓ Precipitation & soil moisture changes will affect agriculture severely
  - Productive agriculture will shift to higher latitudes
  - Droughts intensify in tropics
  - Water supply reduced, especially for rivers supplied by glaciers and support huge populations (e.g. Ganges River)
- ✓ Sea level rise, of which half is brought about by melting glaciers & ice
  - IPCC predicts further rise of 18cm by 2030 & 44cm by 2070
  - Polar ice caps will contribute to most of sea level rise (especially Greenland & Antarctica, of which ice shelves are located on land unlike Arctic ice floating on water)
  - Flooding of low-lying areas & islands (even with just 1m rise) like Netherlands, Bangladesh, Maldives, many Pacific islands
- ✓ Famine could intensify
  - Even though crop yields in wealthy high-latitude countries like Canada will increase, this is more than offset by declining yields in poorer low-latitude countries
  - World cereal production will decrease 1-7% in 2060
- ✓ Other impact & consequences:
  - More intense hurricanes & tropical storms
  - More extreme climates (hotter summers colder winters)
  - Flora & fauna distribution shift; extinction of species
  - Distribution of tropical diseases across the world increase (e.g. malaria, cholera)



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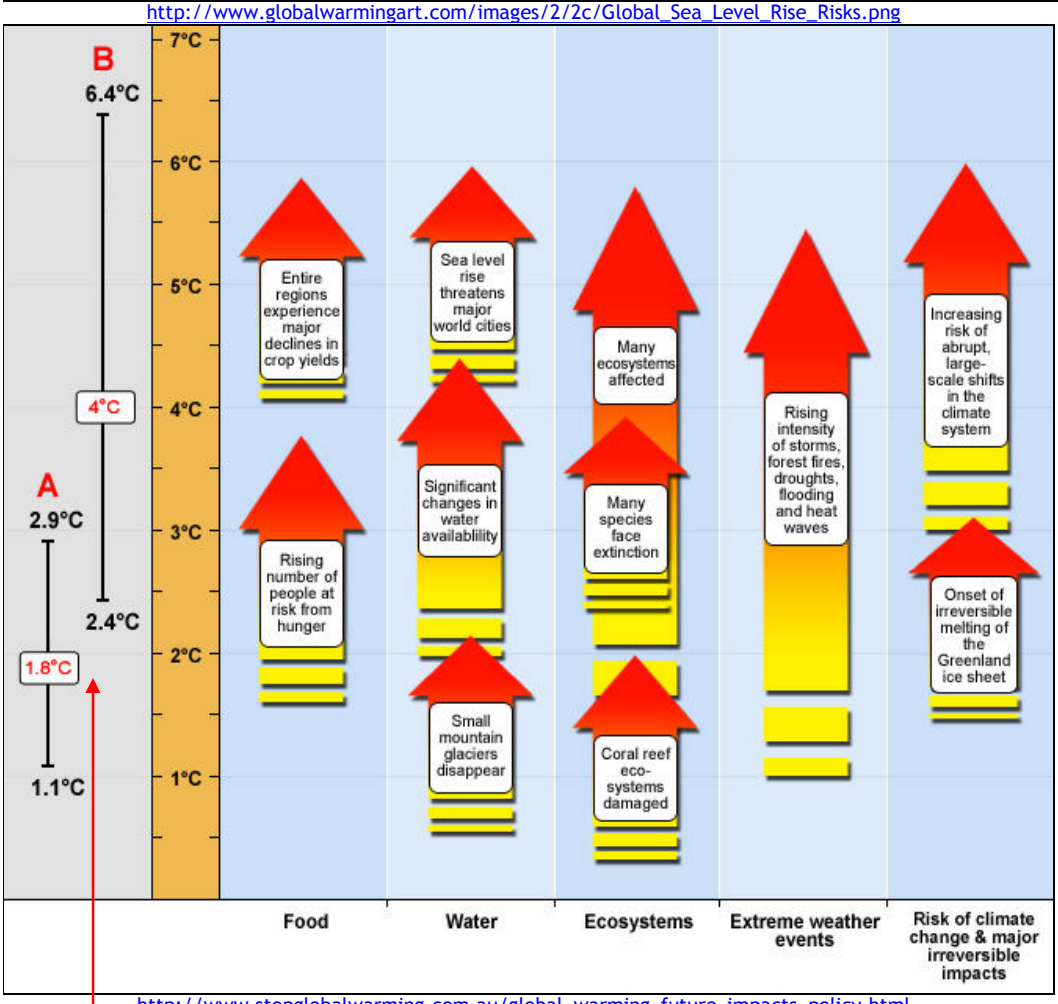
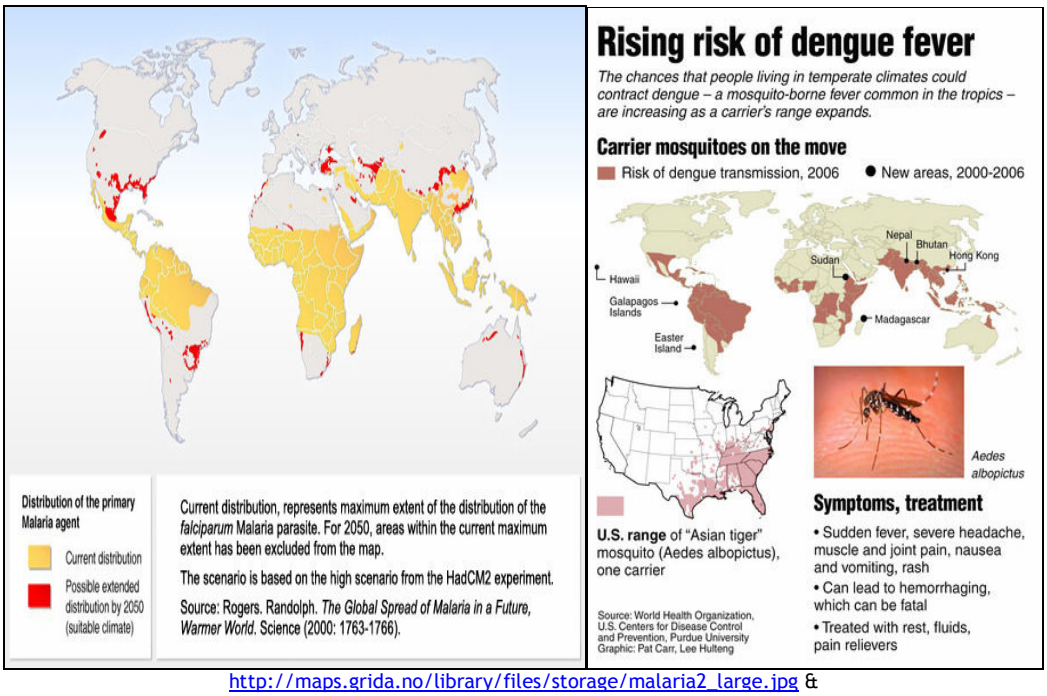


http://www.stopglobalwarming.com.au/global_warming_future_impacts_policy.html

Where **A** represents best-case scenario if action is taken right now, and **B** represents worst-case scenario (business as usual).



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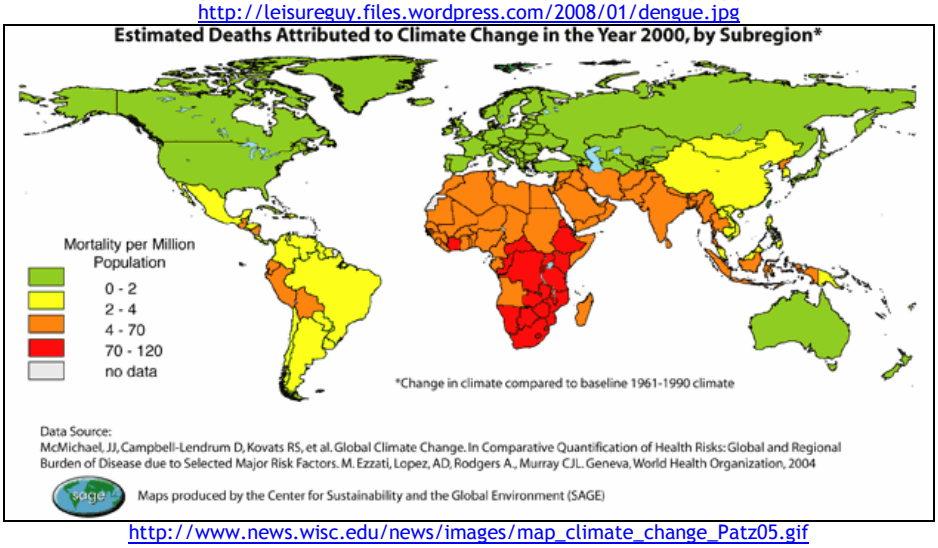


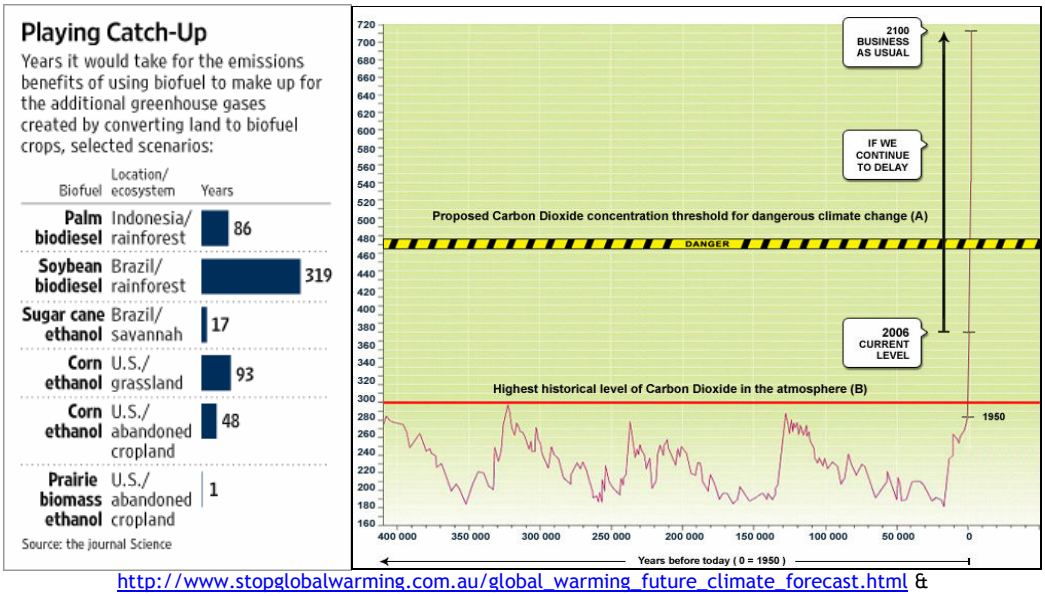
http://www.news.wisc.edu/news/images/map_climate_change_Patz05.gif

Global Warming: Mitigation GLOBAL CLIMATE

If action is taken as soon as possible locally & globally, temperatures will be raised by 1.1-2.9°C. Otherwise, it will increase 2.4-6.4°C!

Local measures	*Examples*	*Pros & Cons*
Change use of fossil fuels	Use of less-polluting natural gas (generates 50% less CO_2 & more energy efficient than coal-fired station)	✓ (+) Temporary measure to slowly reduce burning of coal & oil for energy ✓ (+) More natural gas available for burning compared to oil & coal
	Increasing efficiency of current power stations	✓ (+) Older power plants tend to be less efficient and hence waste more

Alternative energy sources	Renewable energy sources (e.g. hydroelectric, tidal, solar & wind power)	✓ (-) Lower efficiency & usable only on small-scale
	Use of biofuels / methane	✓ (-) Use of food-based biofuels cause of huge food prices increase ✓ (-) Low efficiency of biofuels
	Use of nuclear power	✓ (+) Crucial to & efficient in reducing CO_2 output ✓ (-) High costs of building nuclear power plant ✓ (-) Safety issues ✓ (-) Increase in nuclear waste with no effective means of disposal
Energy pricing & efficiency	Increase fuel efficiency of buildings & transport	✓ (+) Also cost-efficient
	Pricing fuels to reflect environmental costs	✓ (+) Encourage conservation, deter waste
Deforestation control / Afforestation	Limit deforestation & manage forests better	✓ (+) Stops emitting CO_2 and maintains carbon sink
	Carbon offsetting by planting trees according to CO_2 emitted	✓ (-) Does not encourage conservation ✓ (-) Buying a conscience



http://www.stopglobalwarming.com.au/global_warming_future_climate_forecast.html &
http://media.artdiamondblog.com/images2/BiofuelGraph.gif

International measures

- ✓ Dilemma: should DCs, who have contributed to most of past CO_2 emissions, be more responsible than LDCs, who will contribute to most of CO_2 emissions in future?
  - LDCs need to consume more energy to develop economies & improve living standards

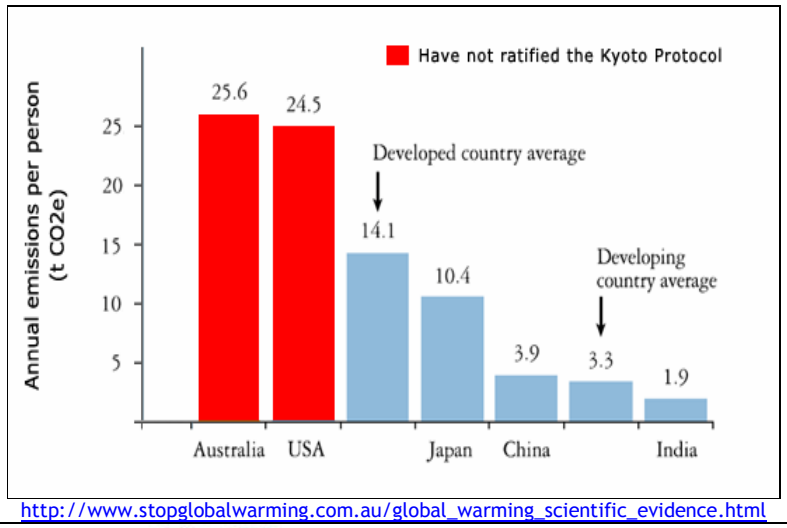
- DCs do not wish to compromise current living standards

✓ Transfer of environment-friendly technology from DCs to LDCs important (since LDCs cannot afford such technology)

✓ Carbon trading uses economic incentives to control emission of pollutants, by allowing trade of carbon credits / permits to pollute
- Amount of carbon credits pre-determined and lowered with time (to reduce CO_2 emissions)
- Firms that cut CO_2 emissions can trade their credits on the market for money, firms that are more polluting can buy credits from the market (incentivize reducing CO_2 emissions)
- (+) More free-market approach than carbon tax or banning
- (-) Little incentive to reduce emissions if can afford permits
- (-) Avenues for abuse of system

✓ 1989 Montreal Protocol to control reduction in CFC emissions motivated by concern to damage for ozone layer, but helpful in curbing global warming as CFC is also a GHG
- (+) Single most successful international agreement with the most international cooperation and implemented swiftly

✓ 1997-2005 Kyoto Protocol to stabilize GHG concentrations in atmosphere to reduce impact of further global warming
- Comprehensive inclusion of mechanisms that allow countries to participate on different levels (Annex 1 economies with stricter regulation being DCs and non-Annex 1 economies with non-binding targets being LDCs)
- Involves imposition of GHG emission reductions by 5% to 35 DCs, and transfer of technology from DCs to LDCs
- Singapore has set target to reduce CO_2 emissions per GDP dollar by 25% by 2012 compared to 1990
- Carbon trading under Kyoto Protocol framework expected to be rolled out by 2009
- Successor to Kyoto Protocol being discussed and gradually rolled out following 2007 Washington Declaration, with conferences on this to be held in 2008 in Poland & 2009 in Copenhagen, Denmark
- Denmark seeks new climate treaty during 2009's conference
- (-) Symbolism of treaty as countries can be signatories but not ratify the treaty (which means targets are non-binding)
- (-) Inefficient & slow action unsuitable for urgency of issue
- (-) USA, as largest polluter, has not ratified treaty (it is a signatory though) because it believes LDCs need to be more involved and regulated more strictly and believes that the regulations will be detrimental to the economic growth of USA
- (-) LDCs do not need to meet targets, allowing them to continue polluting, though they do benefit from transfer of technology and assistance on reducing GHG emissions
- (-) Only Germany, France, UK, Norway & Australia have reduced GHG emissions significantly; most other DCs under the treaty have in fact increased GHG emissions! (E.g. Spain, Portugal & Canada)



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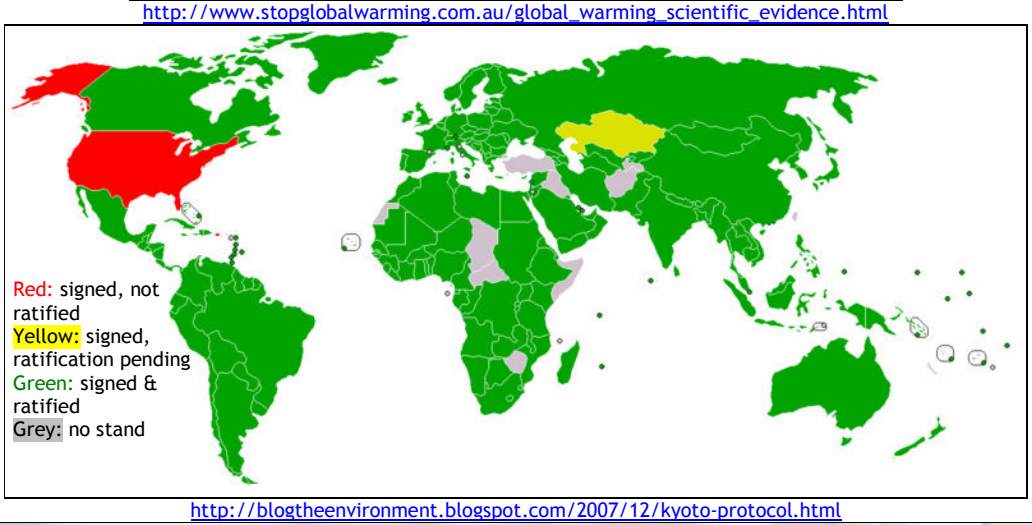

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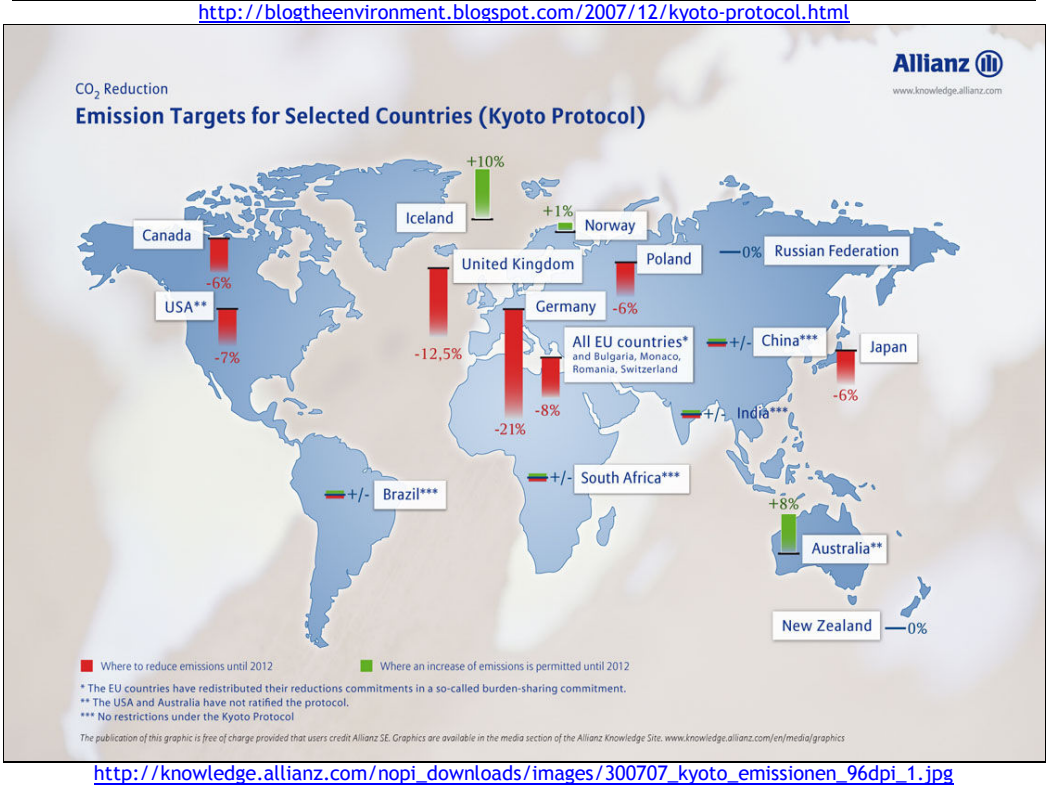

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