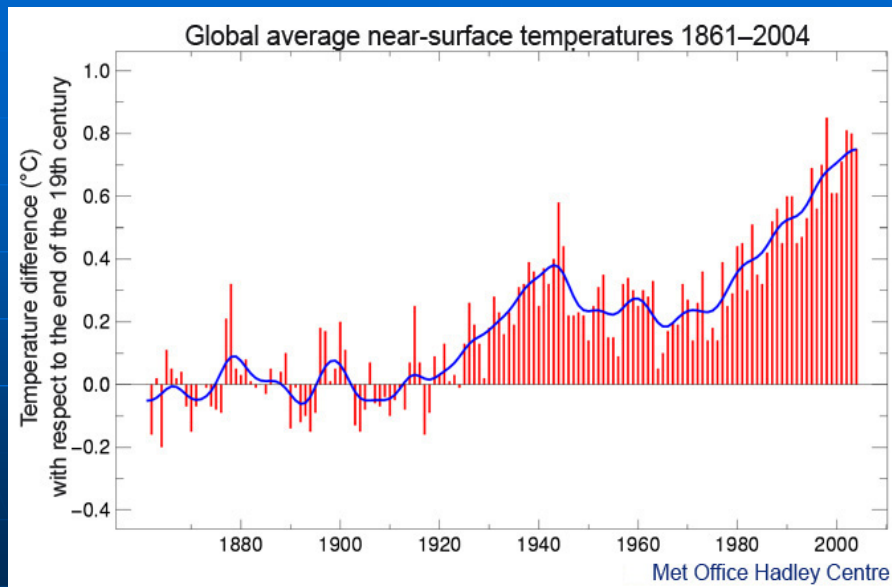


Observed warming

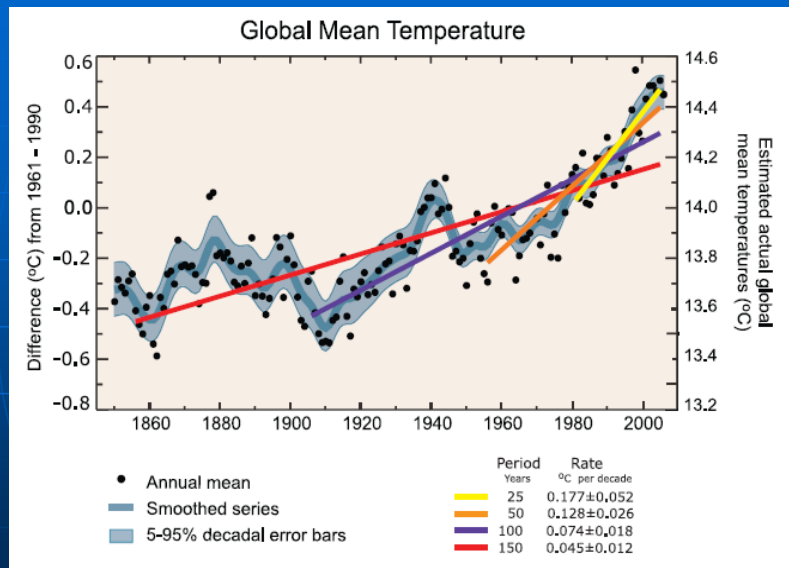
Helen Cox, 2007

Observed Global Warming



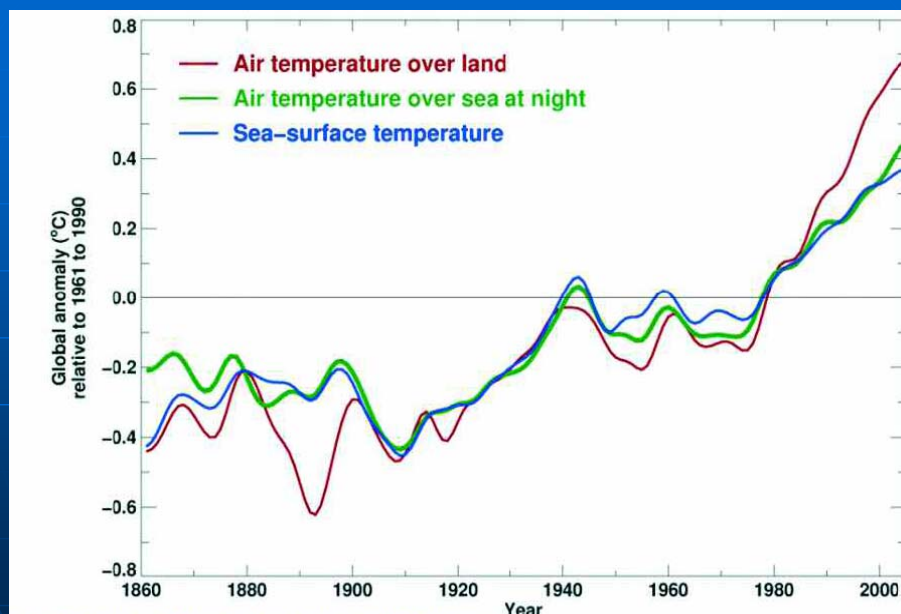
Hadley Centre for Climate Prediction and Research

Observed Global Warming



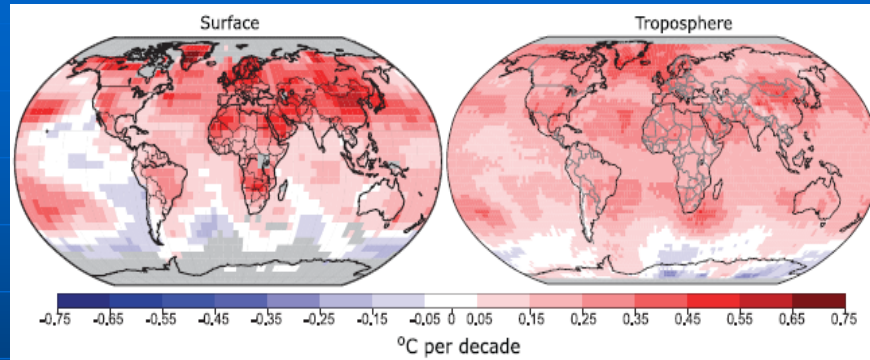
Trenberth et al., 2007

Observed Global Warming



Hadley Centre for Climate Prediction and Research

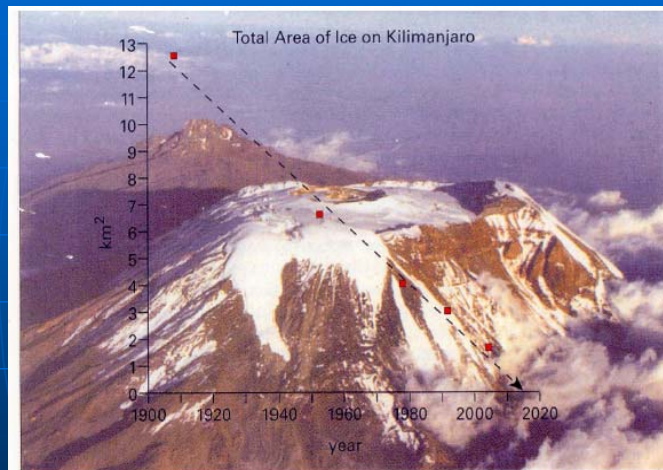
Observed Global Warming



Patterns of linear global temperature trends from 1979 to 2005 estimated at the surface, and for the troposphere from the surface to about 10 km altitude, from satellite records. Grey areas indicate incomplete data.

Trenberth et al., 2007

Evidence for global warming?



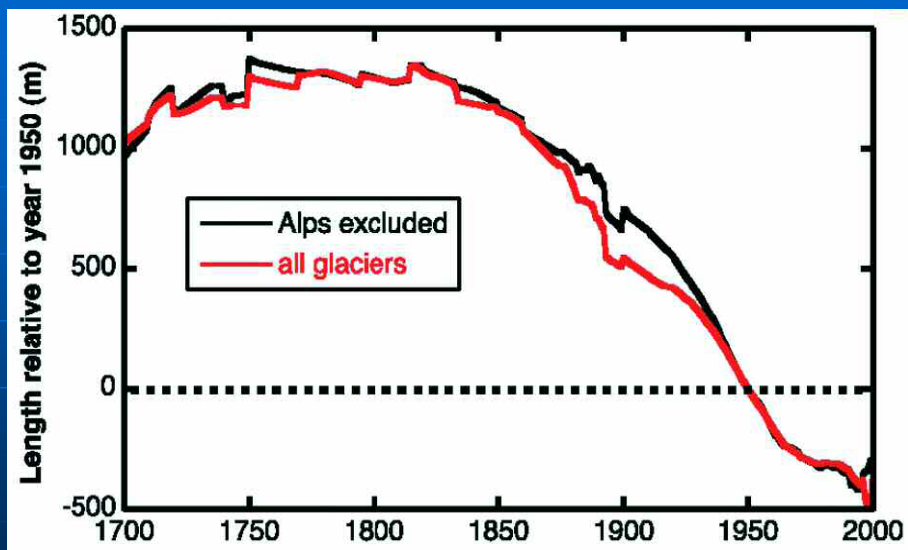
The extent of the ice cover on Mt. Kilimanjaro decreased by 81% between 1912 and 2000.

Schneider, Stephen, *Overview of "Dangerous" Climate Change*, Scientific Symposium on Stabilization of Greenhouse Gases, U.K. Met. Office, Feb. 2005.

Evidence for global warming?



Retreat of glaciers



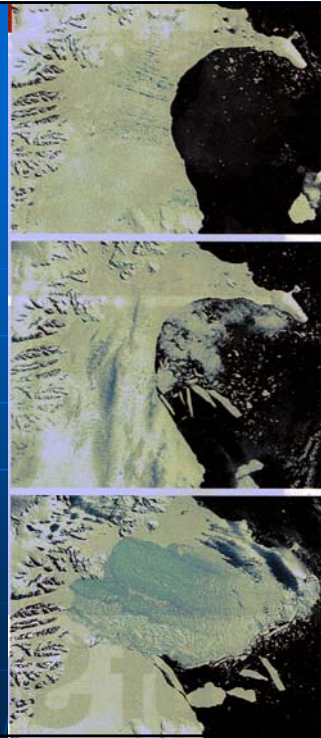
Oerlemans, 2005.

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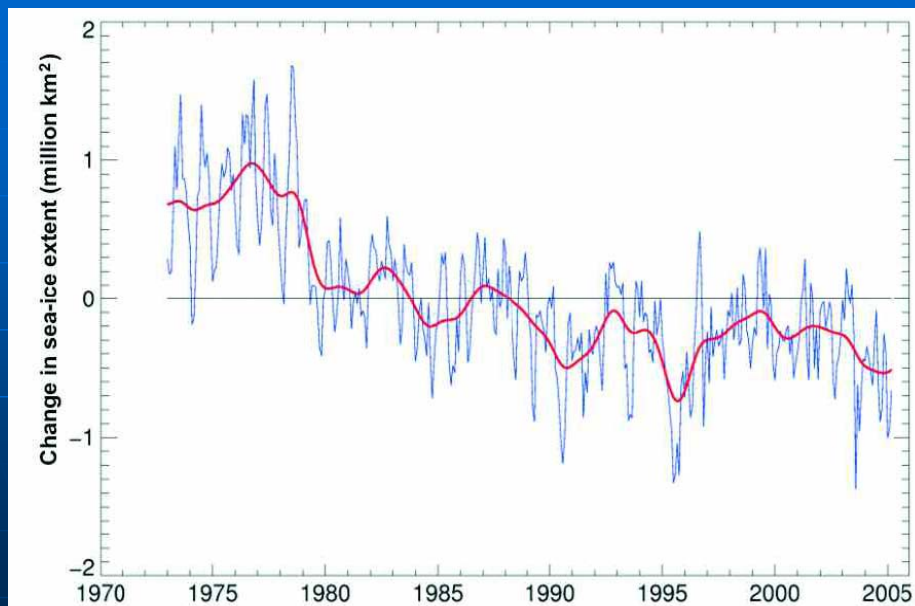
Evidence for global warming?

The Larsen B ice shelf disintegrates, setting thousands of ice bergs adrift in the Weddell Sea in 2002.

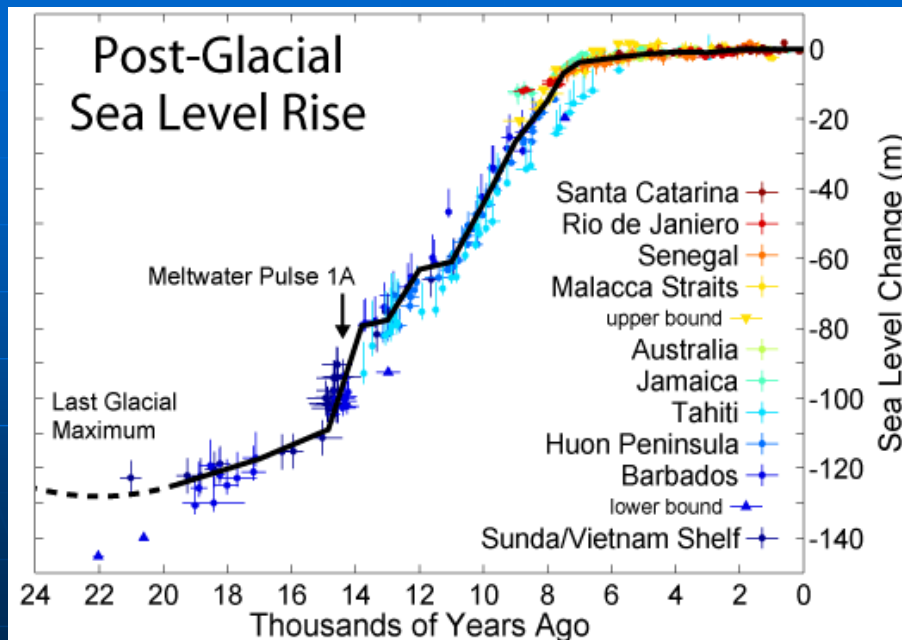
720 billion tons of ice!



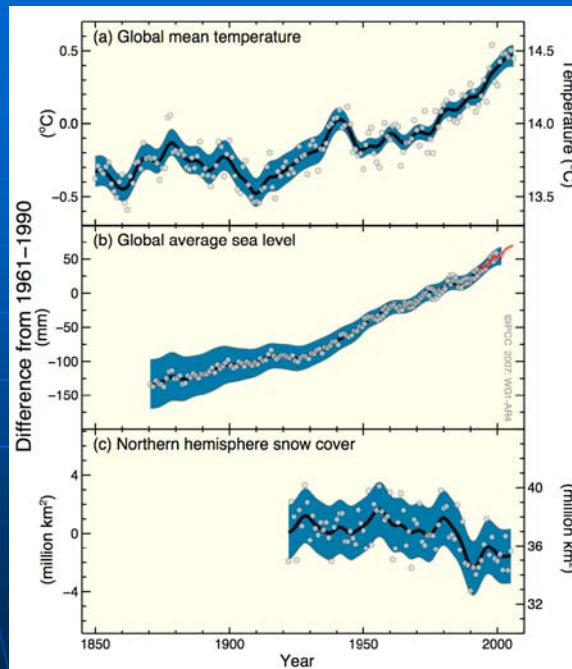
Decrease in Arctic Sea-Ice



Hadley Centre for Climate Prediction and Research

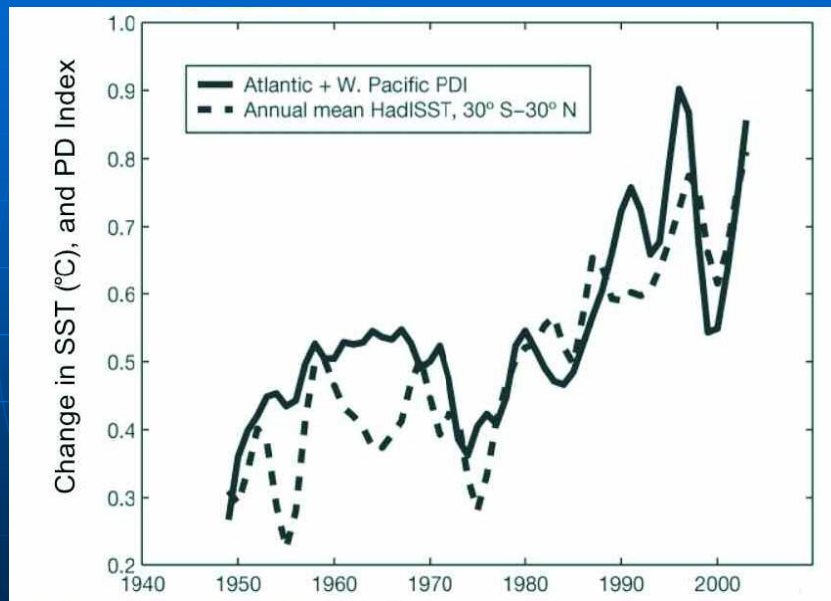


Observed Changes in Sea Level, Temperature and N.H. Snow Cover



Intergovernmental Panel on Climate Change (IPCC), WG1 Fourth Assessment Report 2007: *Summary for Policymakers*, Cambridge University press, 2007).
<http://www.ipcc.ch>

Tropical Storm Indicators

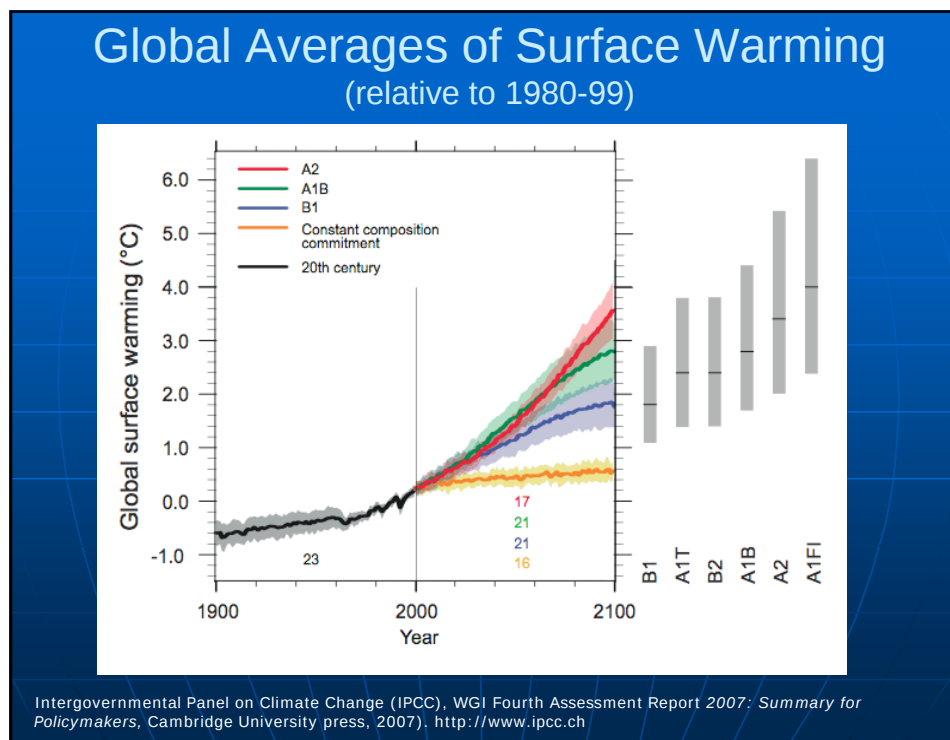
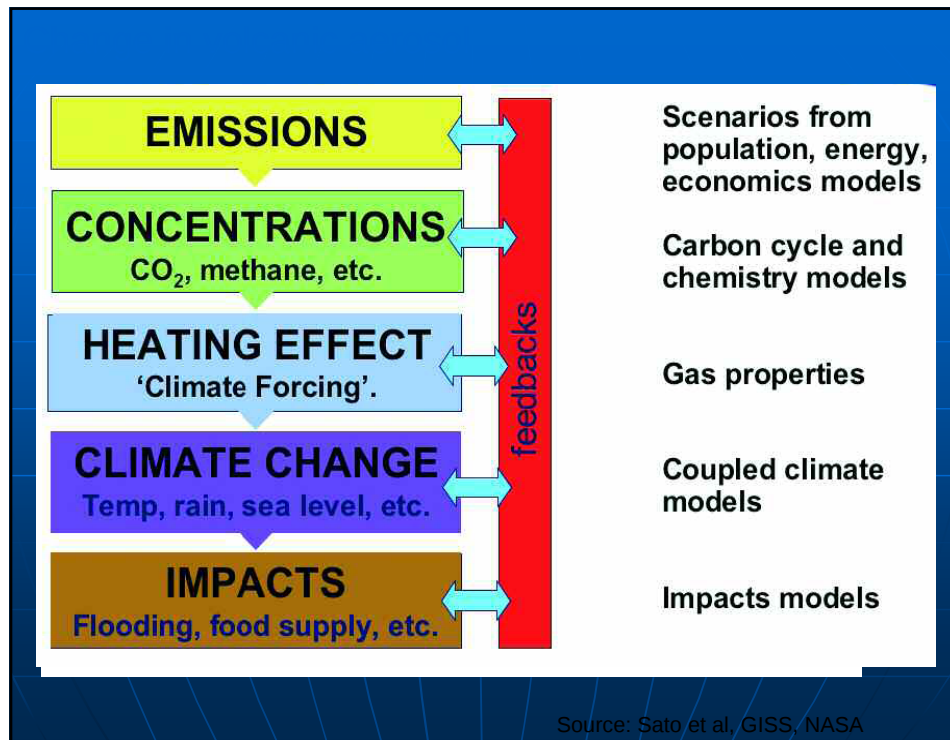


SST = Sea Surface Temperature.

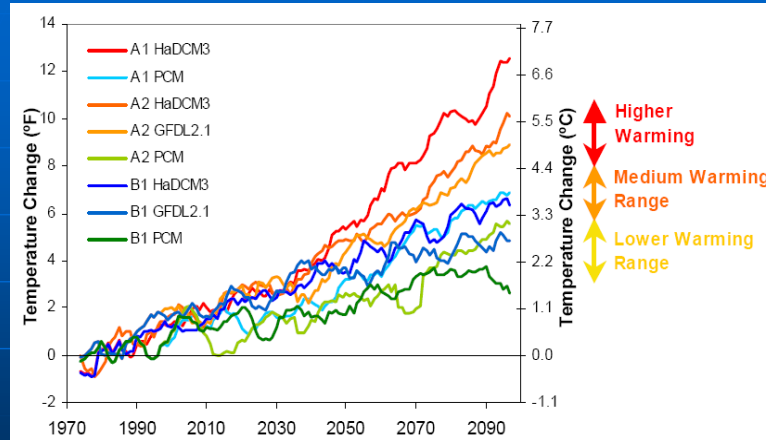
PDI = (Hurricane) Power Dissipation Index

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The future



Predicted Climate Changes in California: Temperature

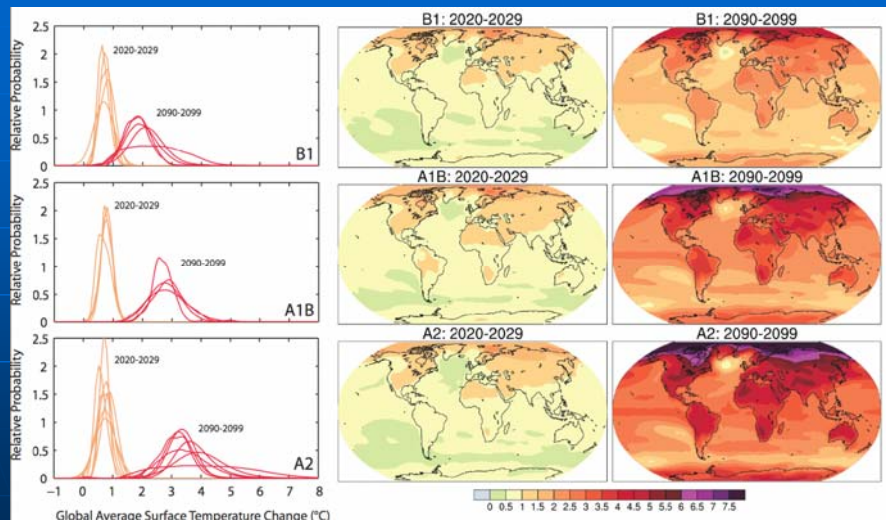


Low range: 3.0°F – 5.4°F
 Medium range: 5.5°F – 7.8°F
 High range: 8.0°F – 10.4°F

Greater warming in summer than winter

Cayan et al., 2006:CEC-500-2005-186-SF

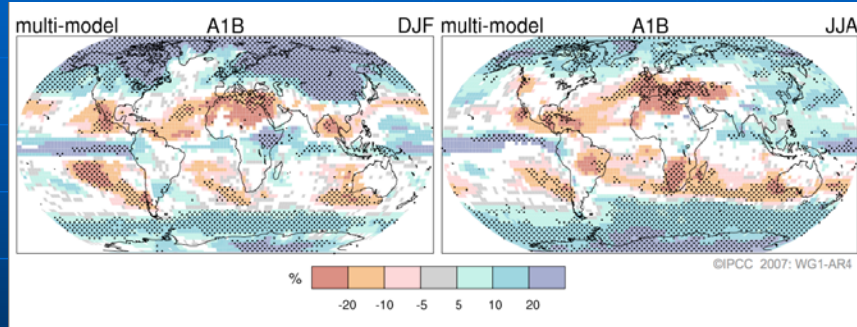
Projected Changes in Temperature



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report 2007: *Summary for Policymakers*, Cambridge University press, 2007). <http://www.ipcc.ch>

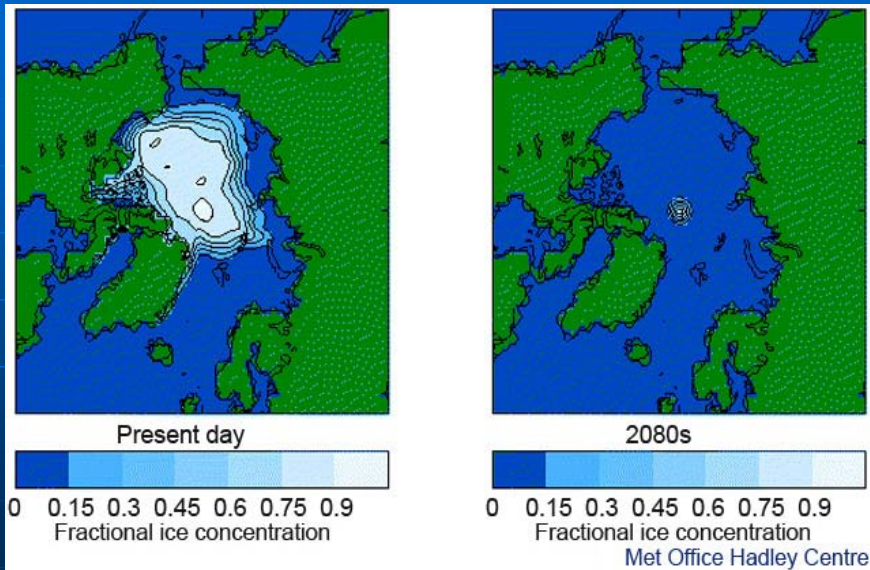
Projected Changes in Precipitation

(for 2090-2099 relative to 1980-1999)



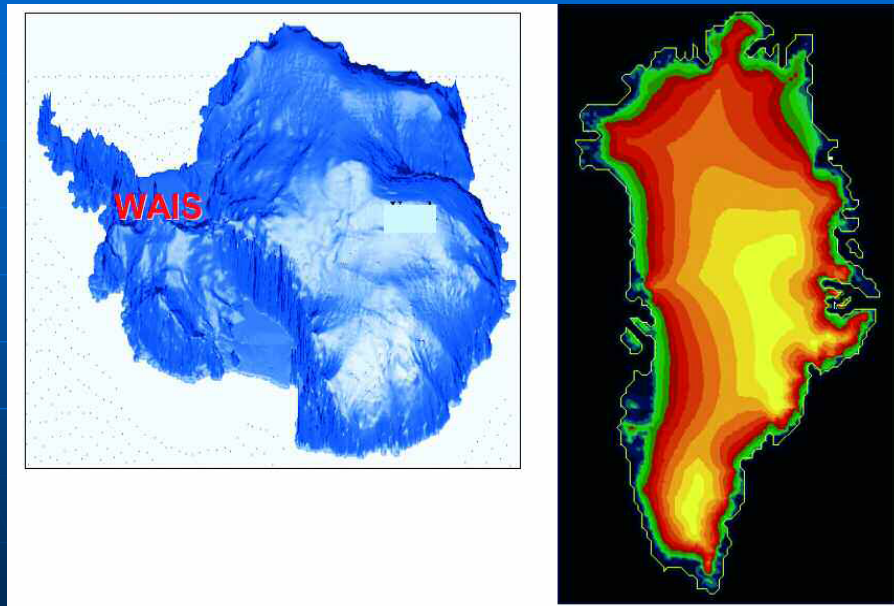
Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report 2007: *Summary for Policymakers*, Cambridge University press, 2007). <http://www.ipcc.ch>

Arctic summer sea-ice could disappear by 2080s under IPCC High Emissions scenario



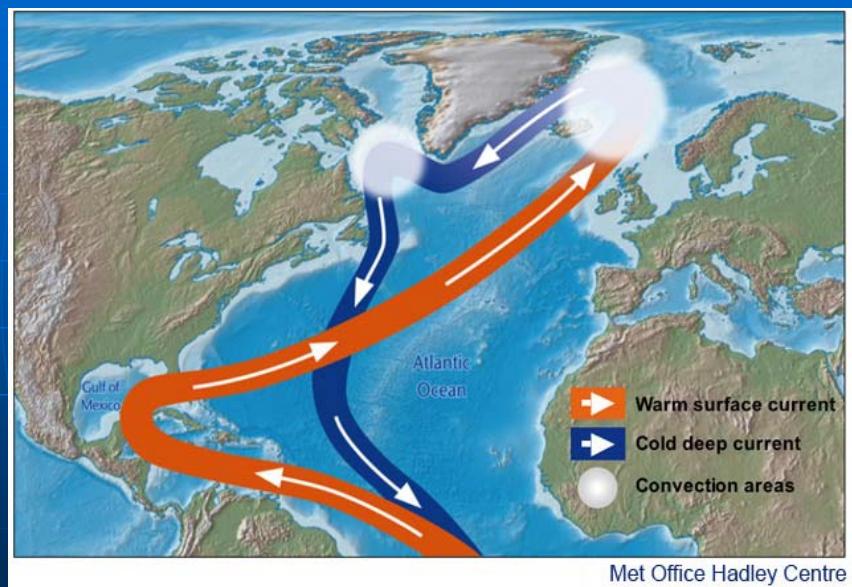
Hadley Centre for Climate Prediction and Research

Ice Sheets



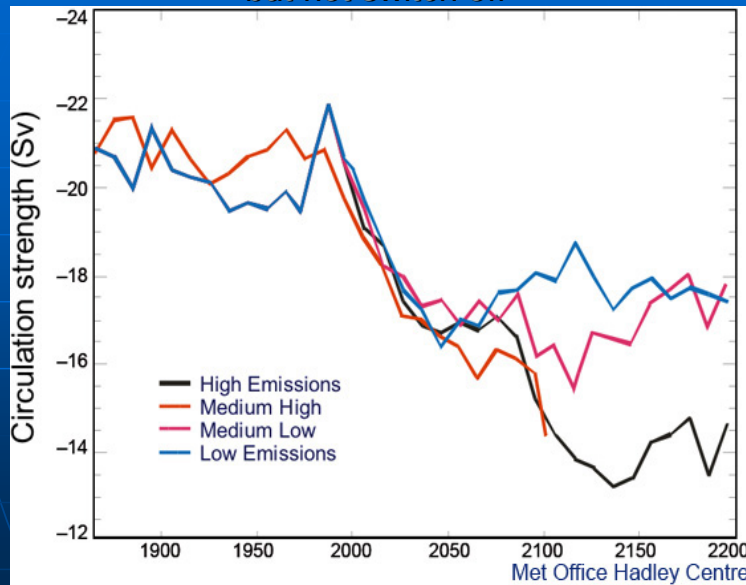
Hadley Centre for Climate Prediction and Research

Ocean circulation in the North Atlantic



Hadley Centre for Climate Prediction and Research

Atlantic ocean circulation is predicted to decline but not switch off



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Predicted Climate Changes in California: Impacts on Agriculture

Temperature – heat stress, number of chill hours, milk production

Pests and weeds – warmer winters lead to increase

Spring snowpack may be reduced by as much as 70 – 90% by the end of the century.

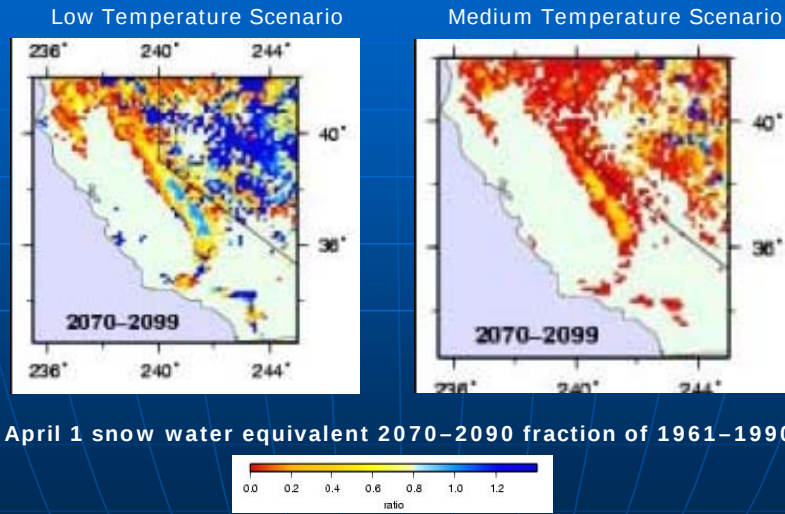
Need to build more storage capacity (maximum runoff will occur earlier – snowpack currently stores half the amount of the man-made reservoirs in California).

More demand for water from agriculture due to higher evaporation rates.

Economic consequences for ski resorts.

Cayan et al., 2006; CEC-500-2005-186-SF

Predicted Climate Changes in California: Snowpack and Water Supply

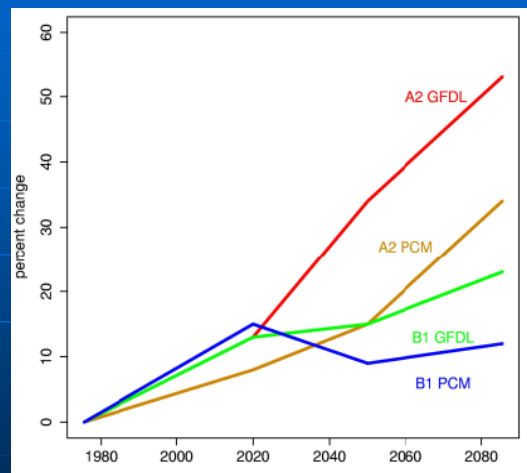


Cayan et al., 2006; CEC-500-2005-186-SF

Predicted Climate Changes in California: Fires

The risk of large fires could rise by as much as 55% by the end of the century and increase associated damage costs by as much as 30% (Westerling and Bryant, 2006).

In addition, wildfires add significantly to atmospheric carbon dioxide emissions, so that the expected increase in their frequency will further accelerate global warming (Running, 2006).

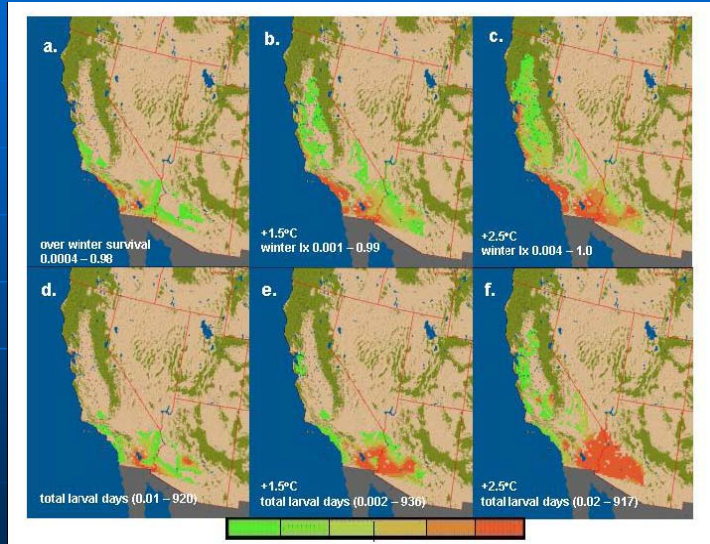


Cayan et al., 2006; CEC-500-2005-186-SF

Predicted Climate Changes in California: Impacts on Agriculture

PESTS:

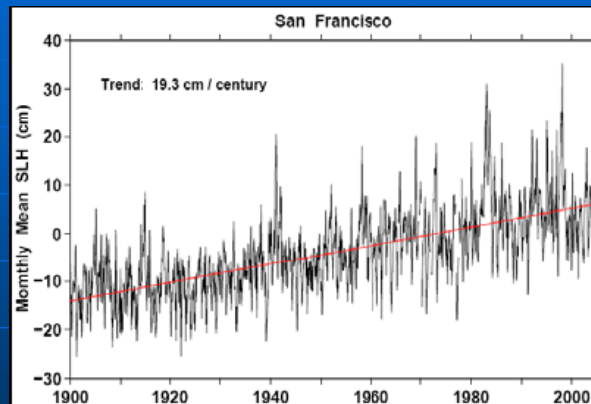
The effect of an increased temperature on the winter survival and larval densities of pink bollworm



Gutierrez et al. (2006), Cayan et al., 2006:CEC-500-2005-186-SF

Predicted Climate Changes in California: Coastal Sea Level

Historical tide gauge data



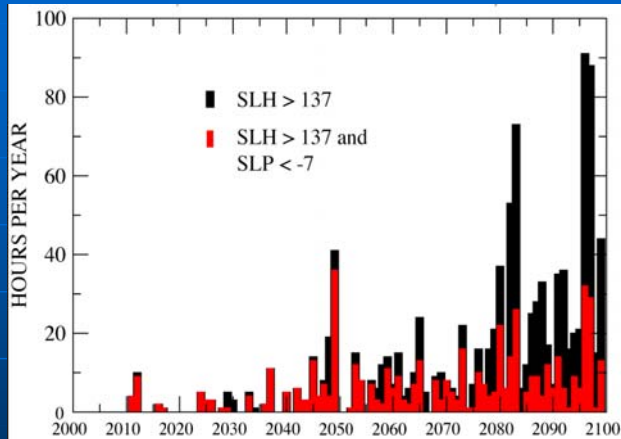
Sea level along CA coast has risen by about 20 cm (8 in)/century.

Rate is similar to global rate.

Cayan et al., 2006:CEC-500-2005-202-SF

Predicted Climate Changes in California: Coastal Sea Level

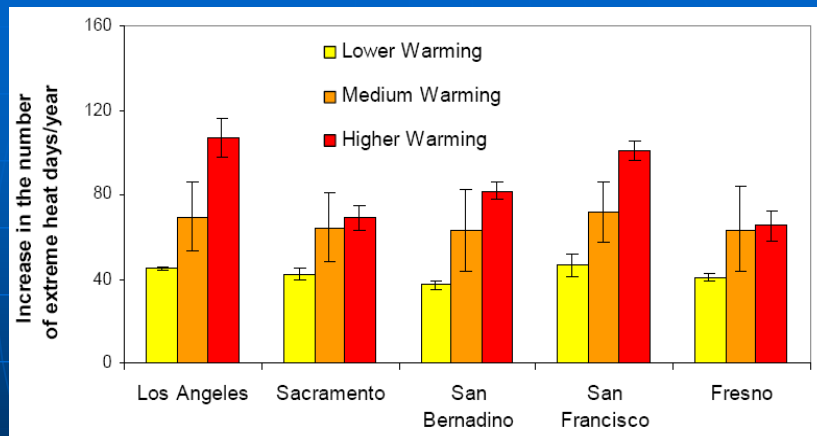
Projected exceedences of SF hourly sea level height above historical 99.99 percentile (black). Coincidences with storms (red)



Biggest impacts will be the result of the combined higher sea level with high tides and winter storm surges which bring heavy surf and wind-driven waves with them.
The frequency of these extreme events is expected to escalate.

Cayan et al., 2006; CEC-500-2005-202-SF

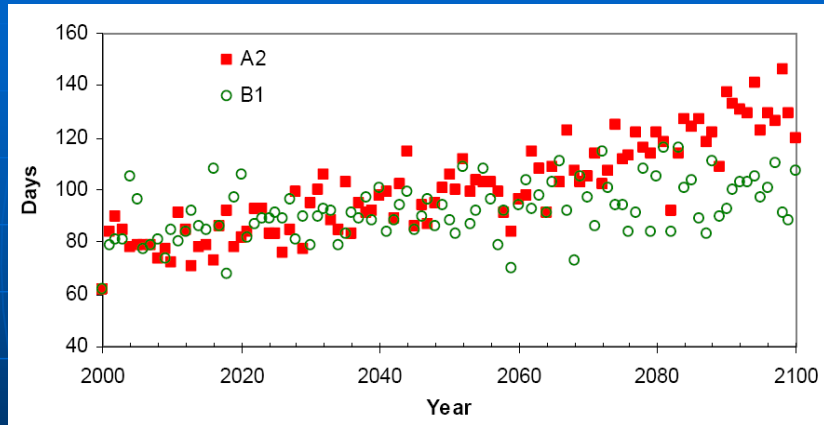
Predicted Climate Changes in California: Public Health



Most serious health consequences are a result of extreme conditions. Figure shows the projected increase in the number of extreme heat days relative to 1961 – 1990. Extreme heat days are defined as the hottest 10% of days in the year (90°F in Los Angeles, 95°F in Sacramento).

Drechsler et al. 2006, Cayan et al., 2006; CEC-500-2005-186-SF

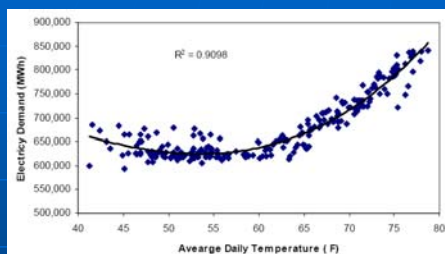
Predicted Climate Changes in California: Public Health



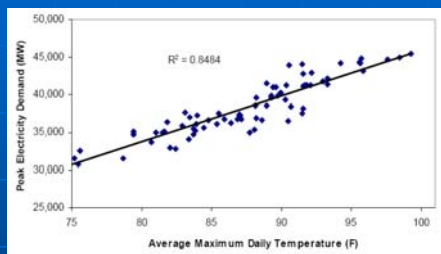
Increased temperatures favor the formation of ozone.
Figure shows number of days (Riverside) conducive to exceeding the California one-hour ozone standard (0.09 ppm).

Kleeman and Cayan 2006, Cayan et al., 2006:CEC-500-2005-186-SF

Predicted Climate Changes in California: Electricity Demand



Daily electricity demand in 2004 as a function of average daily temperature in San Jose, Sacramento, Fresno, and Los Angeles.



Daily peak electricity demand in 2004 as a function of maximum daily temperature in San Jose, Sacramento, Fresno, and Los Angeles.

Franco and Sanstad 2006, Cayan et al., 2006:CEC-500-2005-186-SF

Predicted Climate Changes in California: Electricity Demand

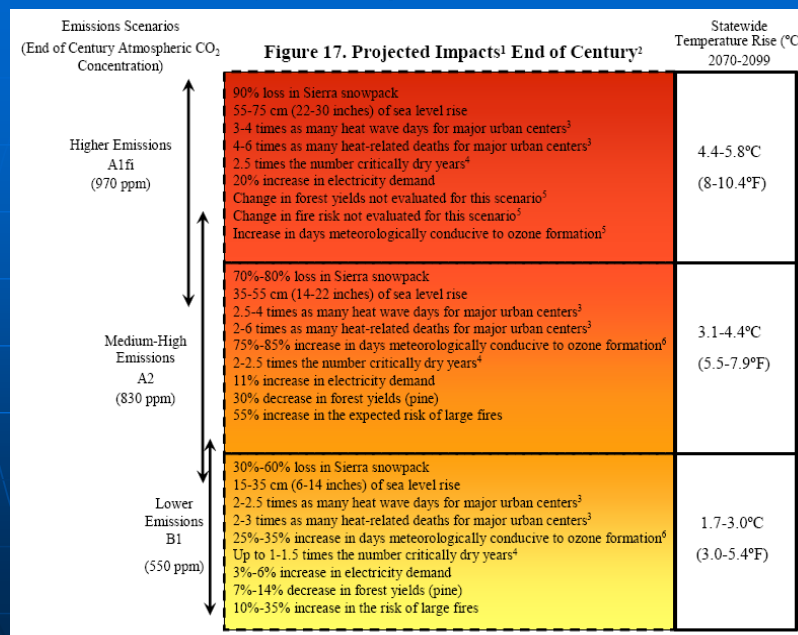
Estimated changes in annual and peak demand for electricity for multiple temperature projections.

Time Period	Projected Warming Range	Change in Annual Electricity Demand (%)	Change in Peak Demand (%)
2005-2034	Low	0.9	1.4
		2.5	1.5
		1.2	1.0
	Medium	2.9	3.6
		3.4	4.8
		3.1	4.1
2070-2099	Low	5.8	7.3
		5.3	5.6
		11.0	12.1
	Medium	20.3	19.3

Annual expenditures of electricity demand in California represent about \$28 billion (U.S.EIA 2005), so a 3% increase in electricity demand by 2020 would translate to about \$1.2 billion nominal dollars a year in additional electricity expenditures.

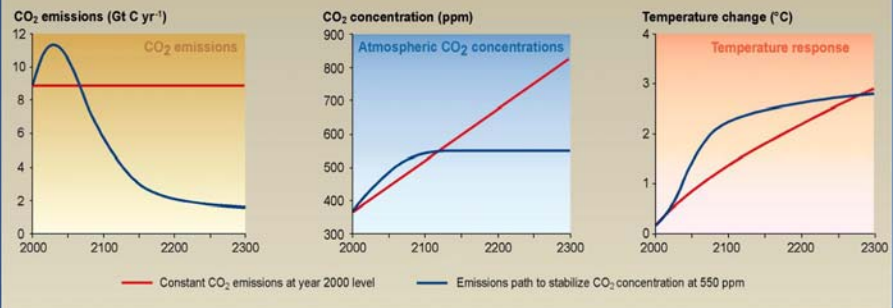
Franco and Sanstad 2006, Cayan et al., 2006:CEC-500-2005-186-SF

Summary of Impacts in California



Cayan et al., 2006:CEC-500-2005-186-SF

Impact of stabilizing emissions versus stabilizing concentrations of CO₂

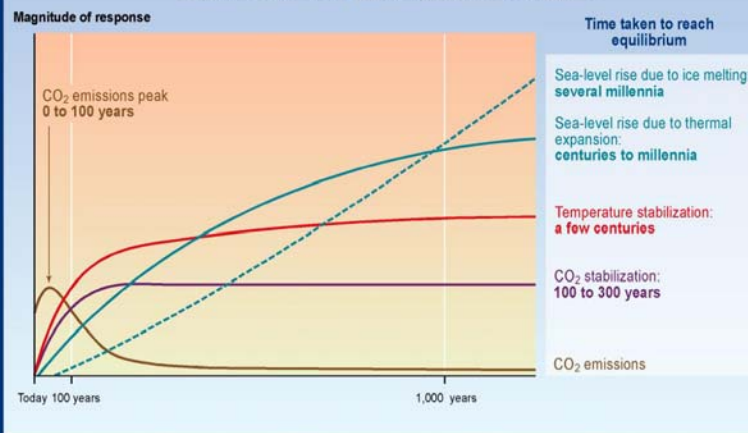


SYR - FIGURE 5-2

IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



CO₂ concentration, temperature, and sea level continue to rise long after emissions are reduced

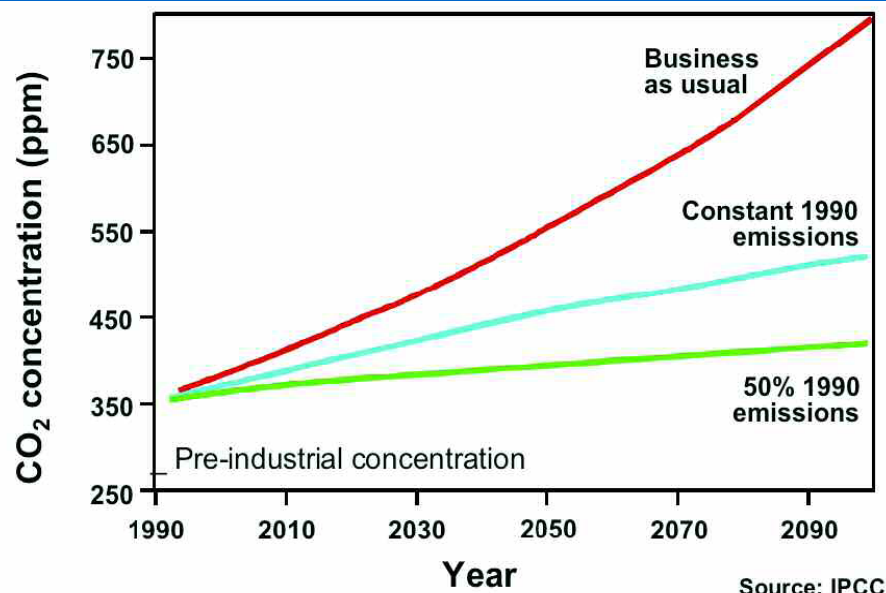


SYR - FIGURE 5-2

IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



Required reductions in CO₂ concentrations



Hadley Centre for Climate Prediction and Research