The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2257-25

Joint ICTP-IAEA School of Nuclear Energy Management

8 - 26 August 2011

Climate Change: from observations of current trends to future climate projections

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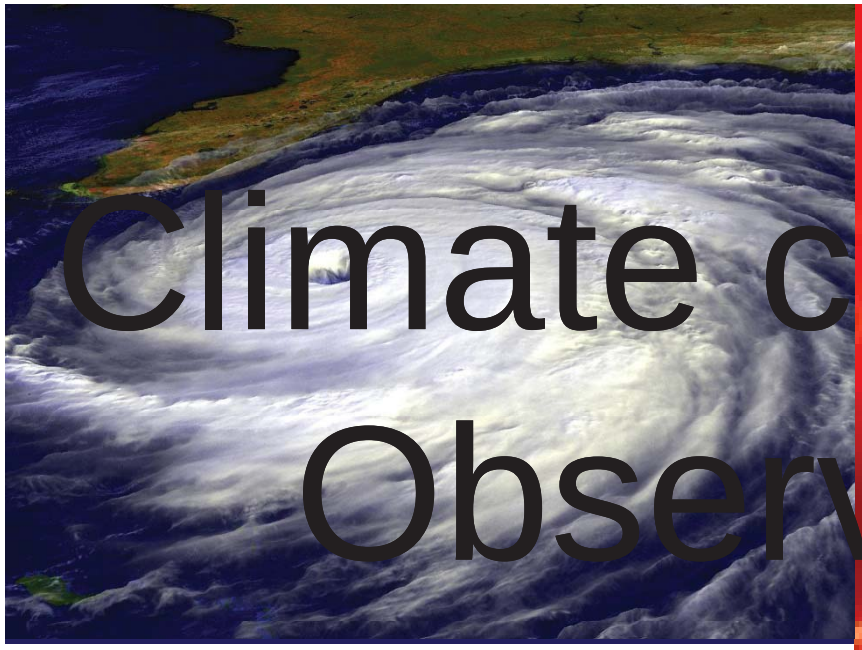
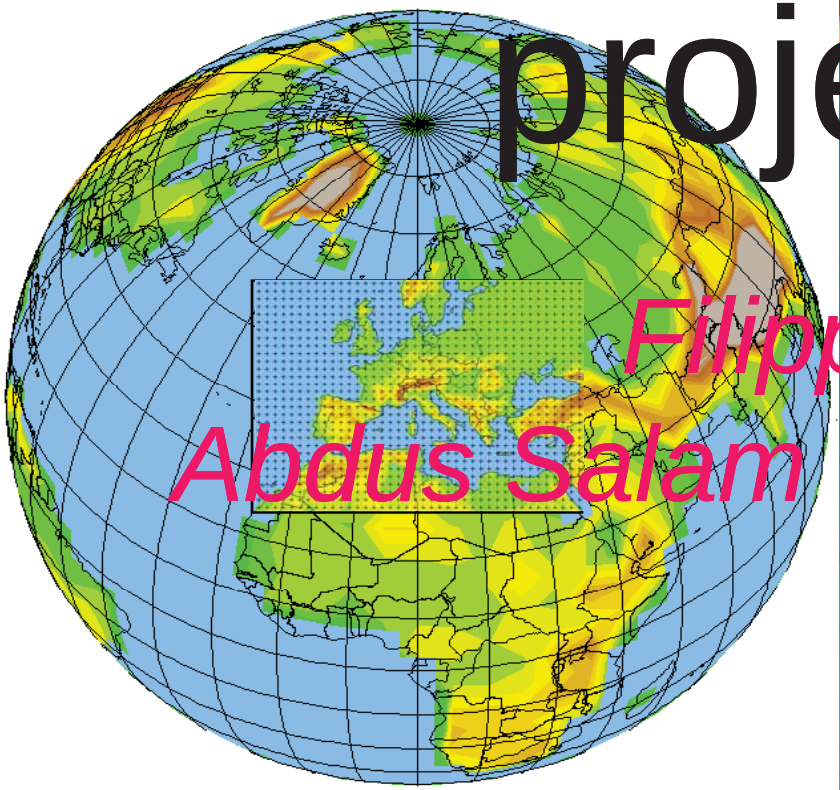


Climate change: from Observations to projections



Filippo Giorgi
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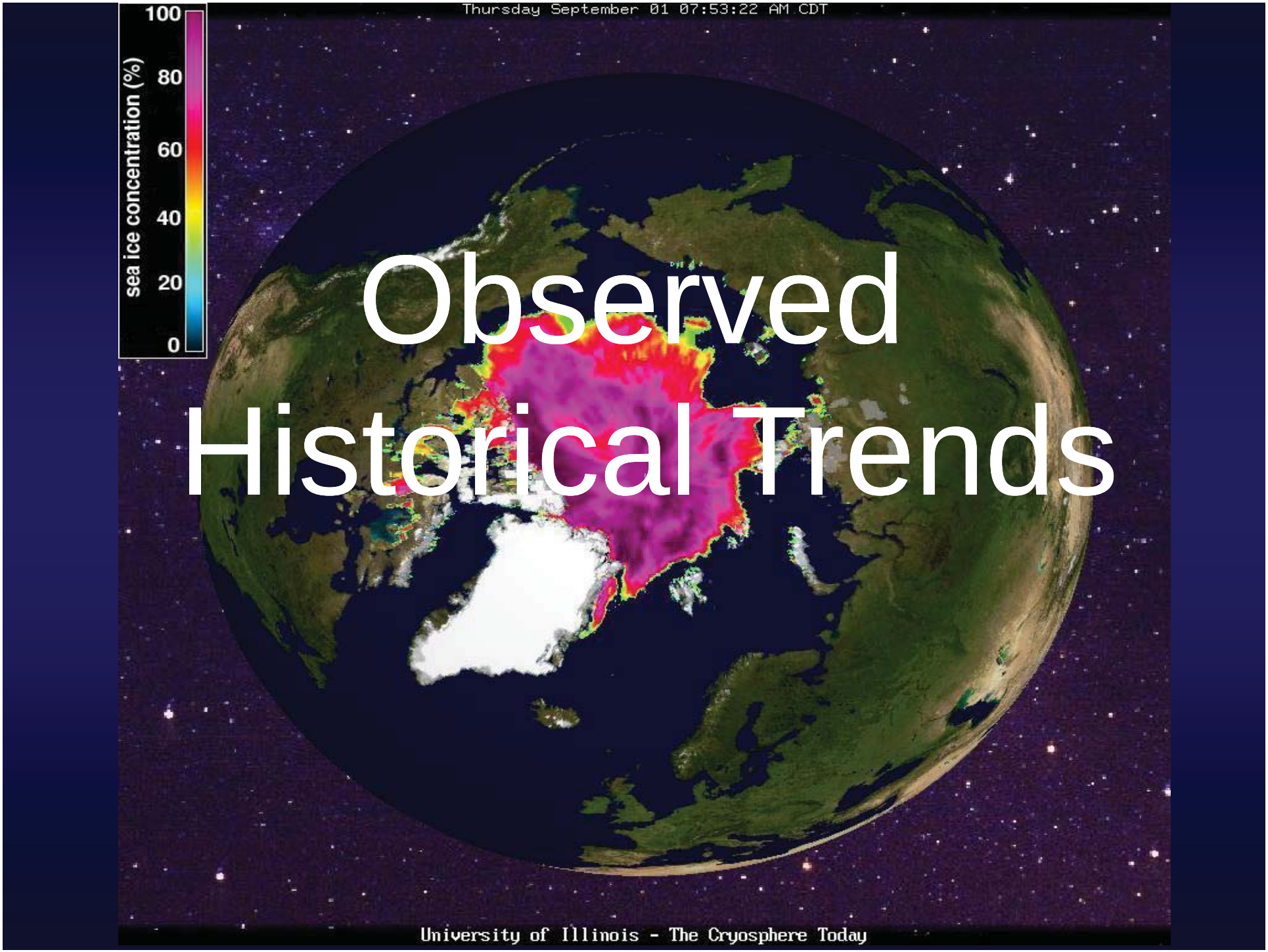
ICTP-IAEA Workshop 8-13 November 2010

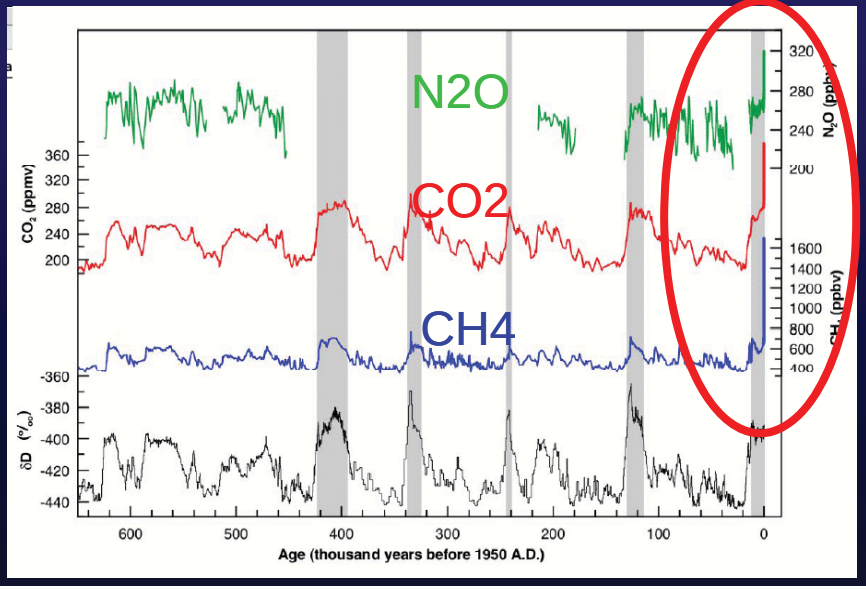
Outline

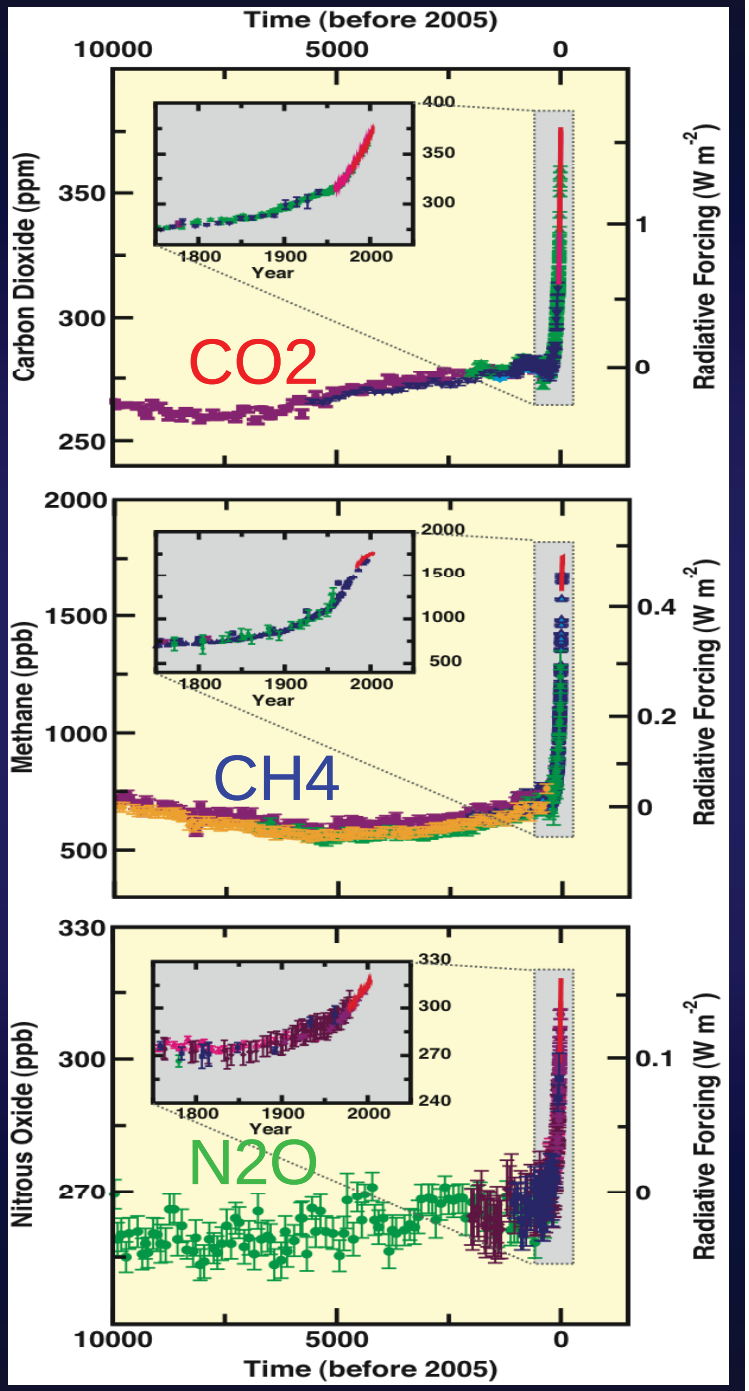
- Observed historical trends
- Attribution
- Climate projections
- Key uncertainties
- Next steps


Thursday September 01 07:53:22 AM CDT
sea ice concentration (%)
100
80
60
40
20
0
Observed
Historical Trends
University of Illinois - The Cryosphere Today

Variation of greenhouse gas concentration in the atmosphere

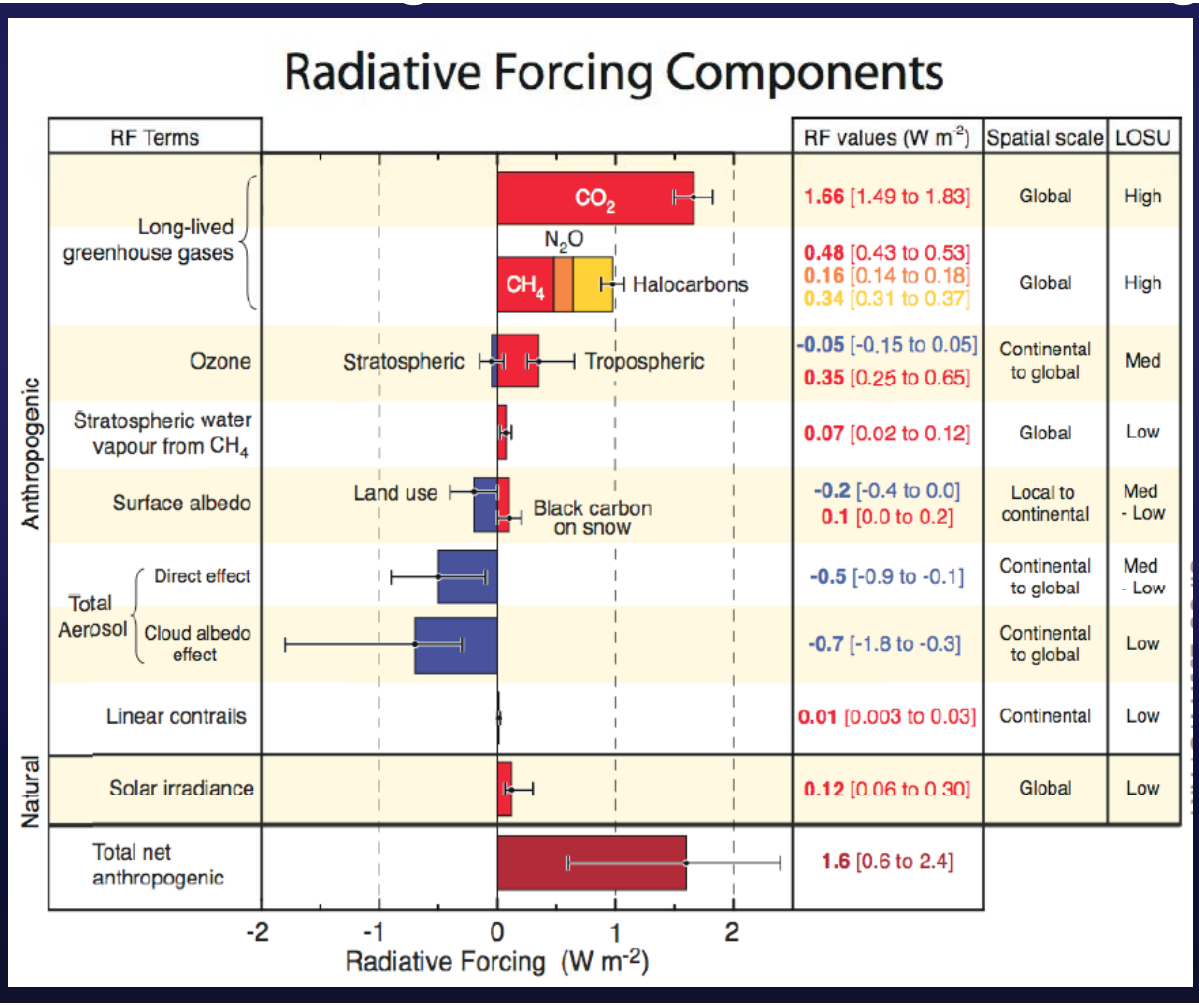
The greenhouse gas concentration is higher than in the last 650000 years and continues to increase mostly due to fossil fuel burning and agricultural activities.





Anthropogenic and natural forcings from 1750 to 2005

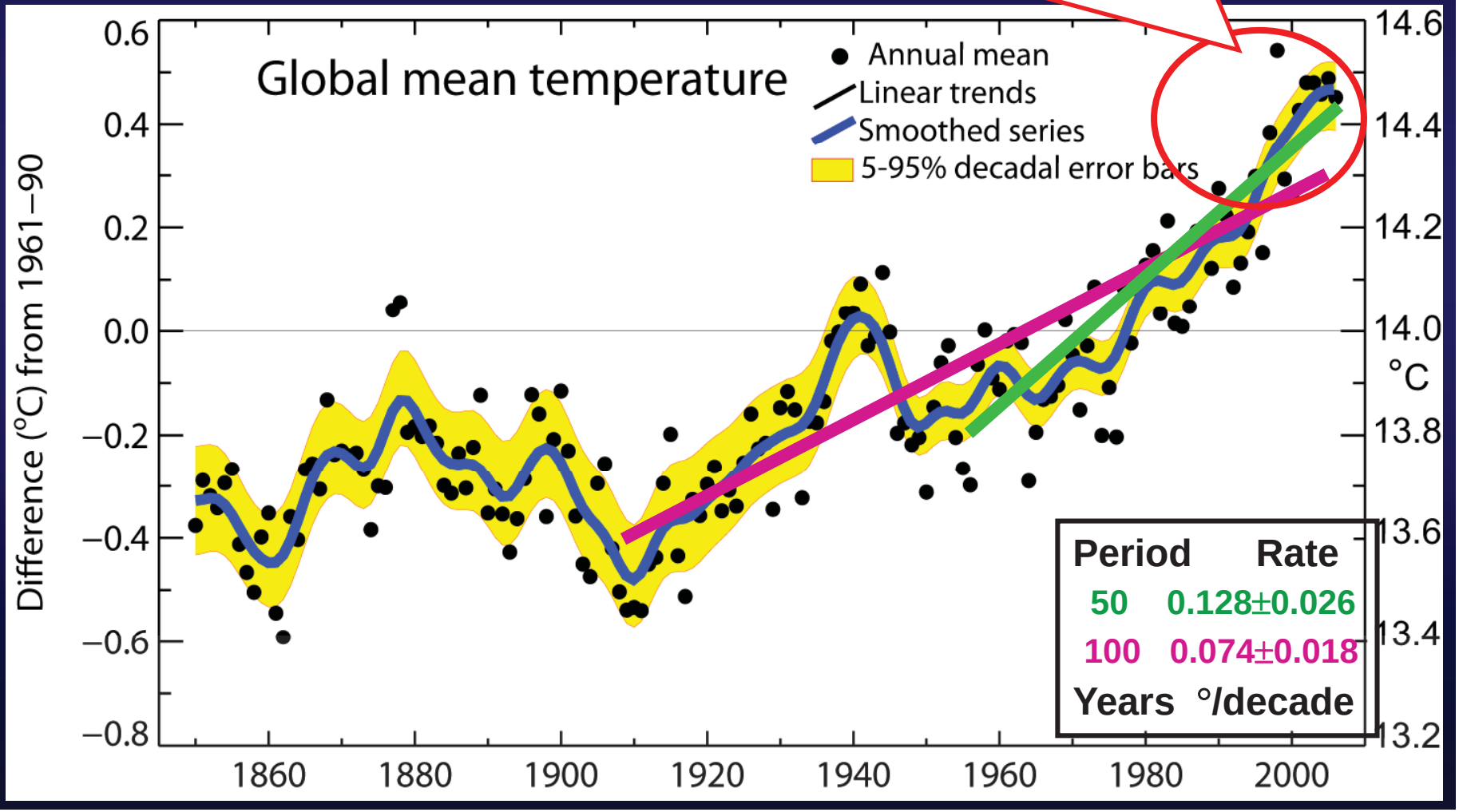
Anthropogenic forcings are estimated to be much higher than natural forcings



Observed global temperature change

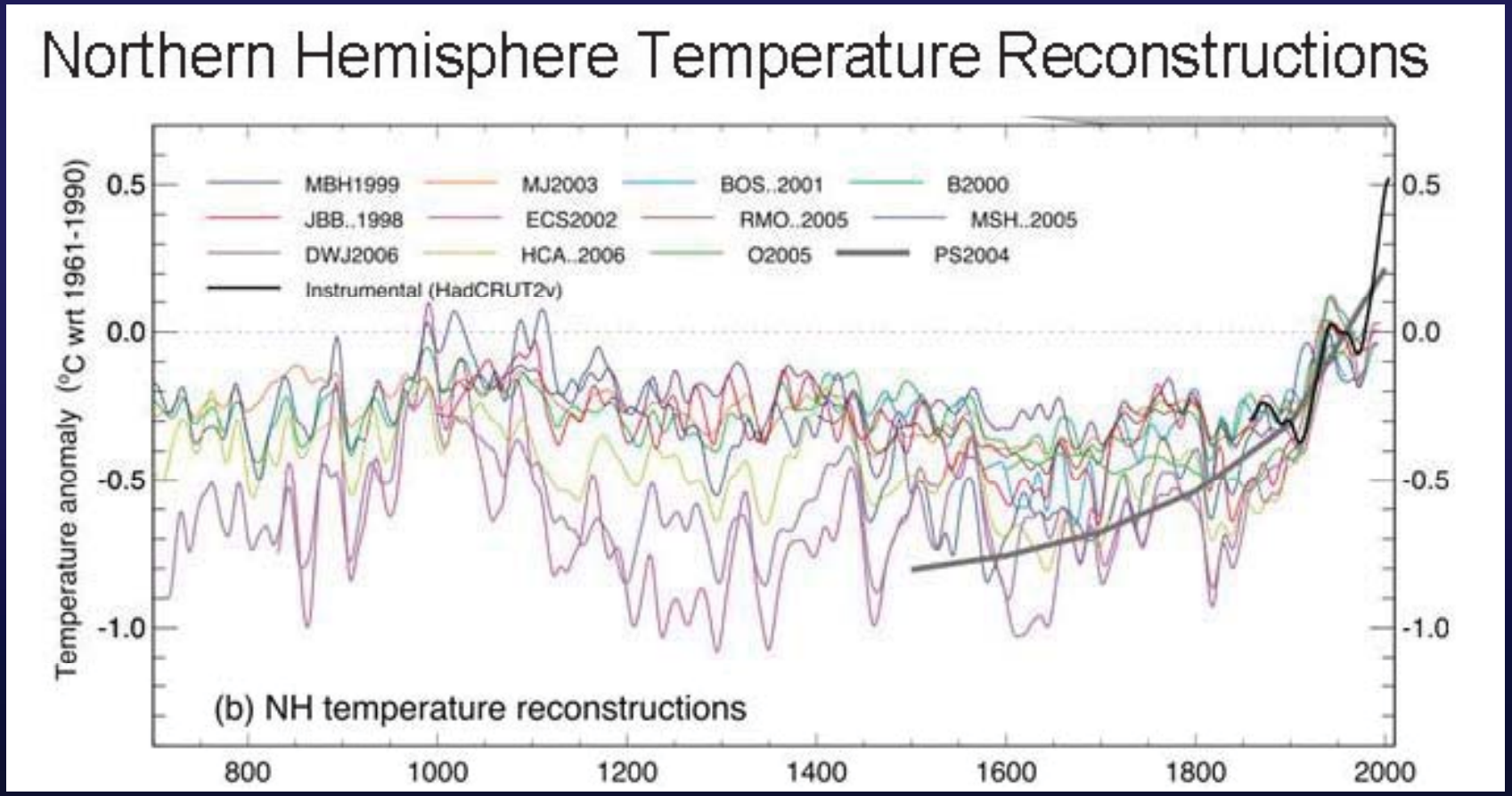
Last 50 years warmest during the last 1300 years

Warmest 12 years:
1998, 2005, 2003, 2002, 2004, 2006, 2001, 1997, 1995, 1999, 1990, 2000



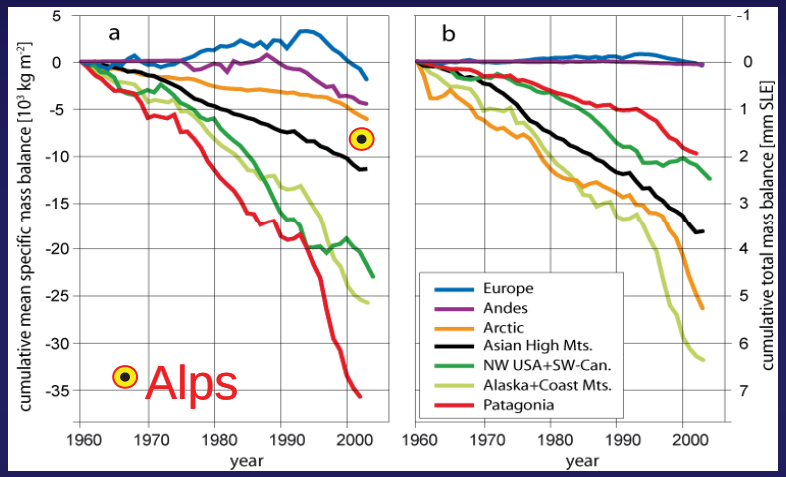
Temperature anomaly reconstructions for the last 1000 years

The last 50 years are warmest in the last millennium

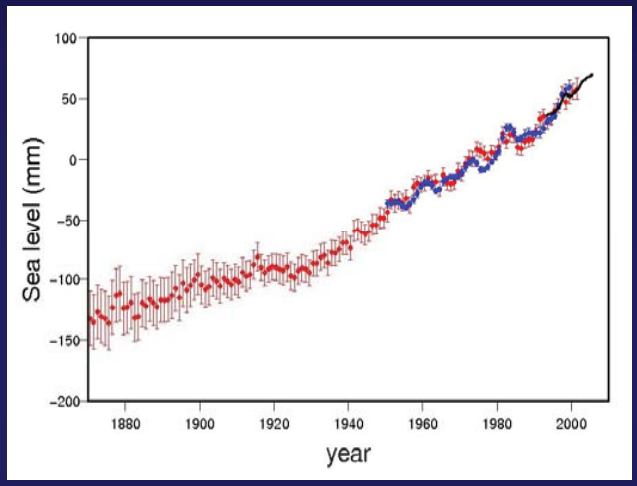


Other evidence of warming: Decrease of snow cover, sea ice and glaciers, sea level rise

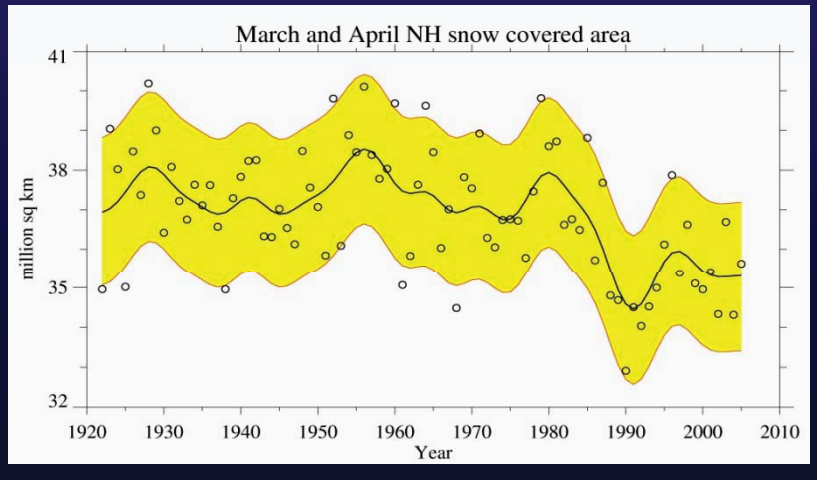
Melting of glaciers



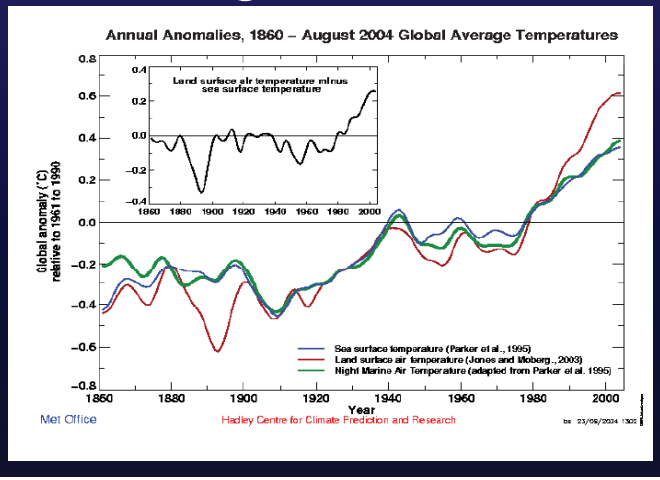
Sea level rise



Decrease of snow cover

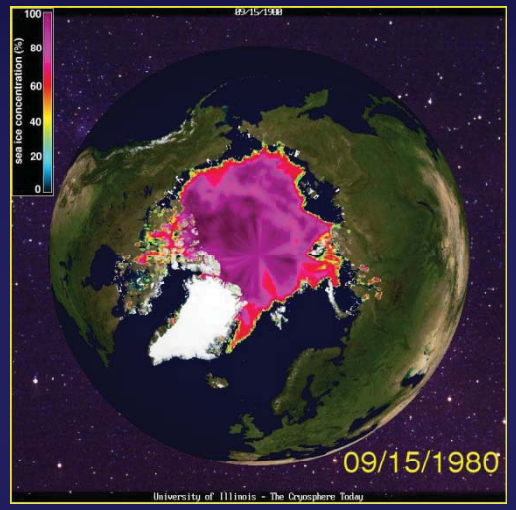


Warming of the oceans

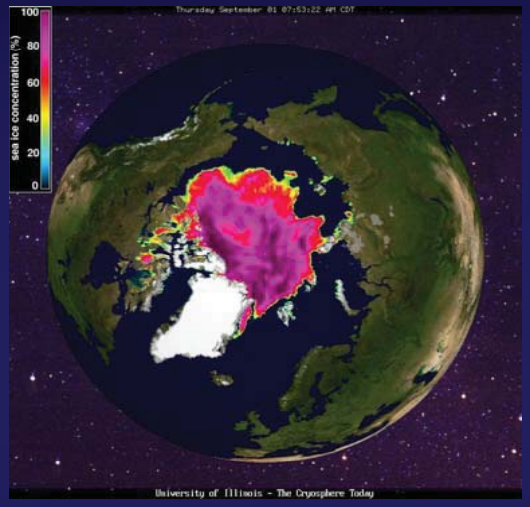


Melting of the Arctic cap

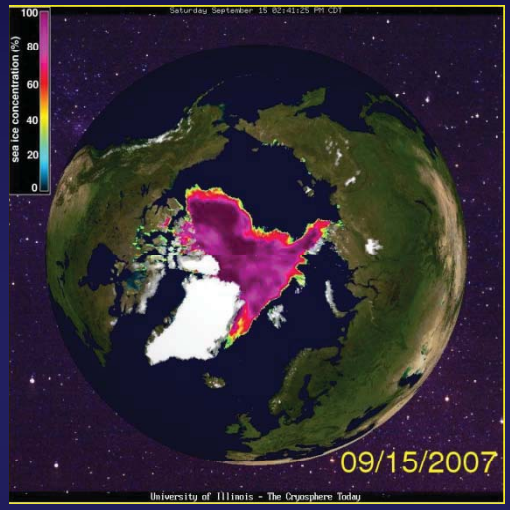
15 September 1980



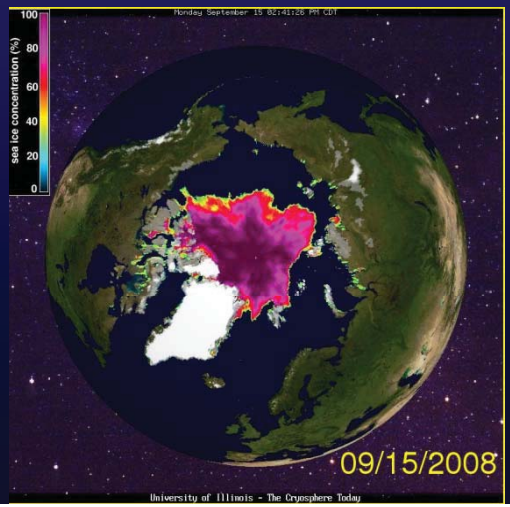
15 September 2005

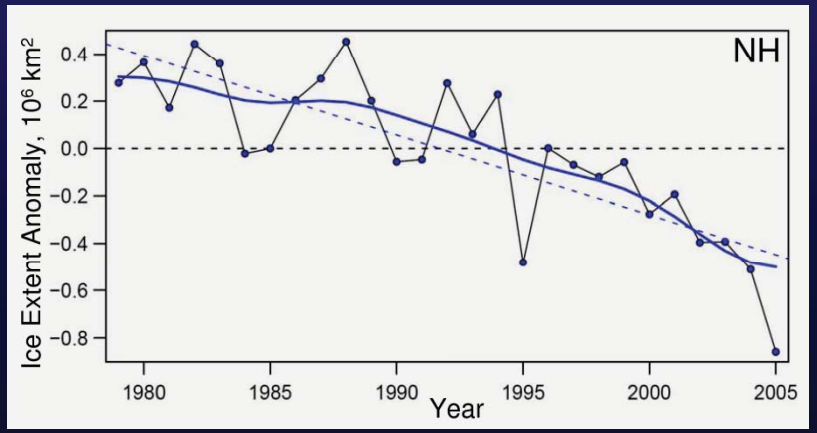


15 September 2007



15 September 2008





Other observed changes

Temperature extremes

Warmer and more hot days,
warmer and fewer cold days

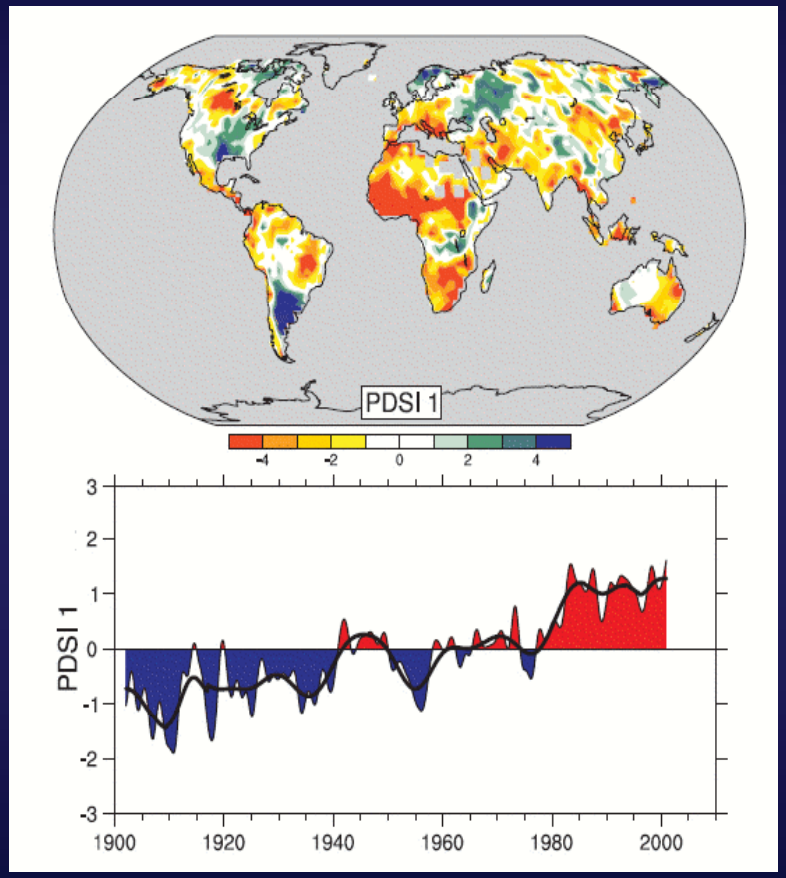
Increased frequency of
heat waves

Other observed changes

Intensification of the hydrologic cycle

Increase of precipitation intensity

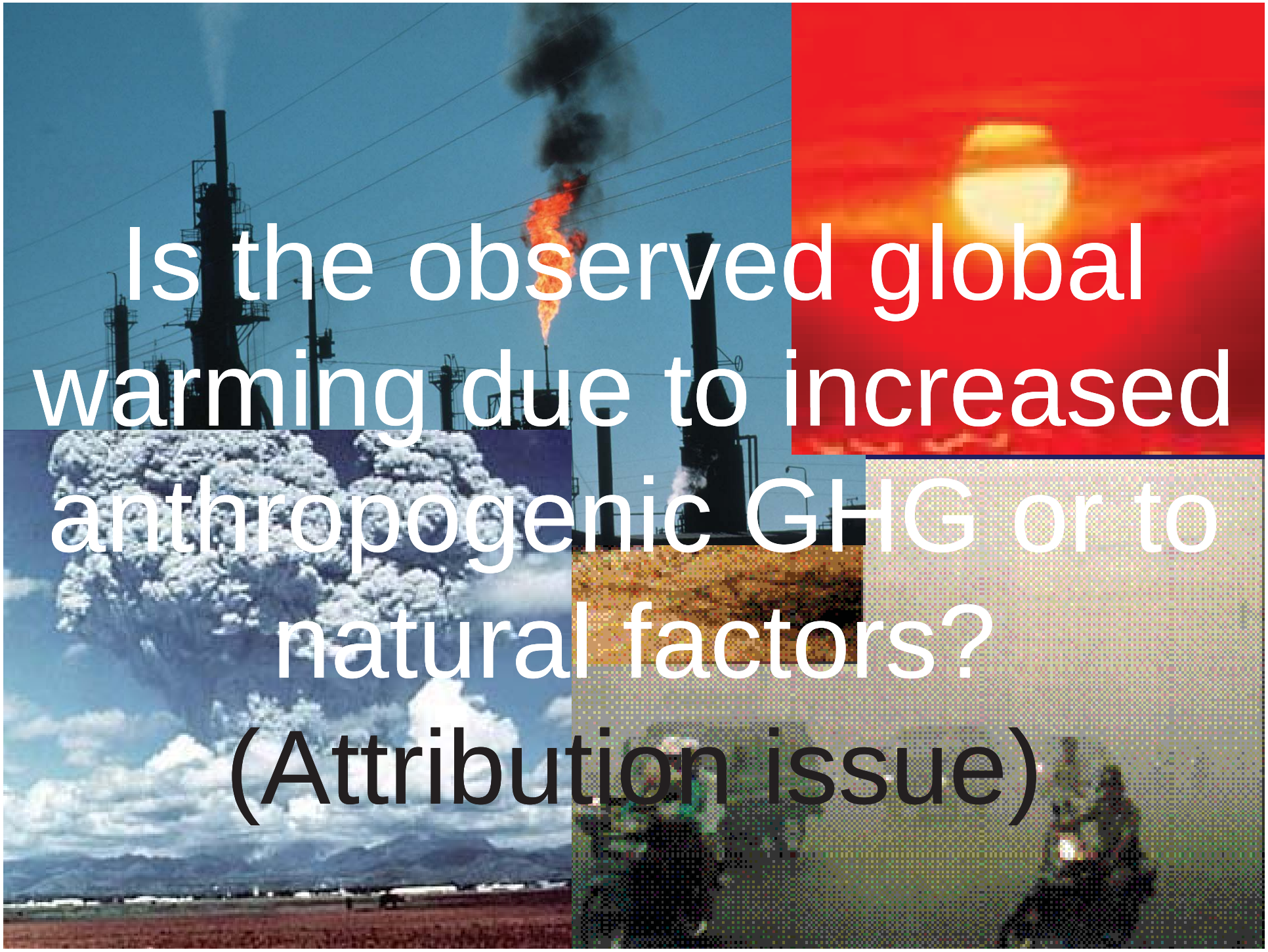
“It rains less often but more intensely”



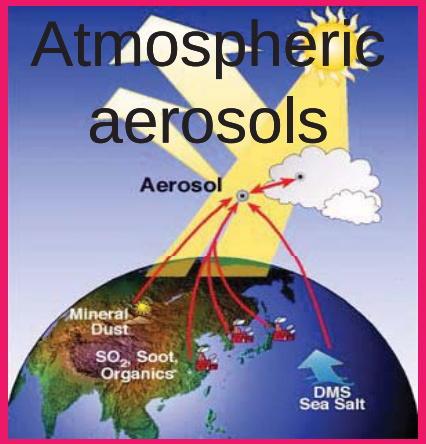
Increase of drought

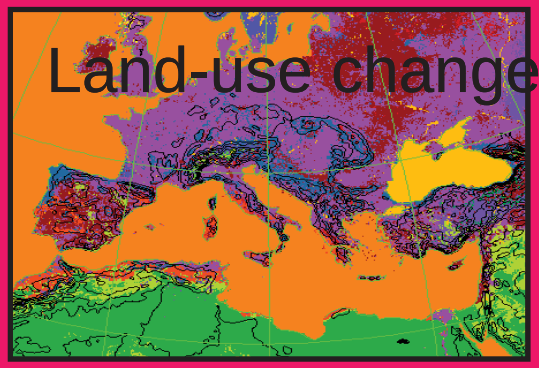
IPCC-2007

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.


Is the observed global warming due to increased anthropogenic GHG or to natural factors?
(Attribution issue)

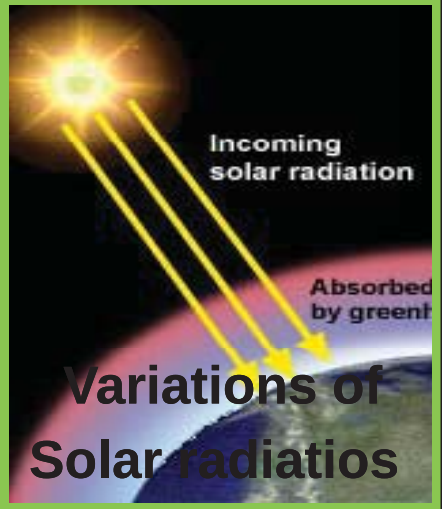
Human factors

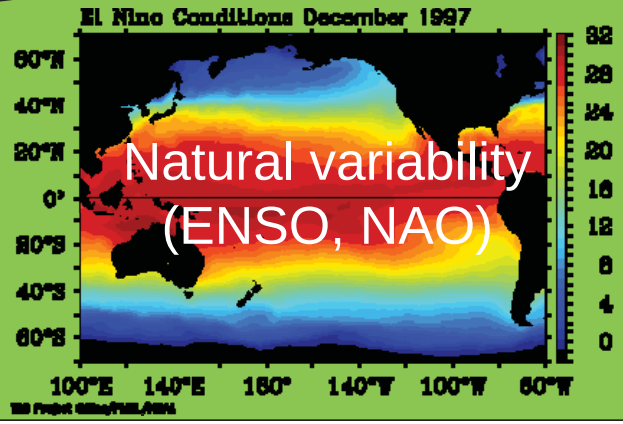




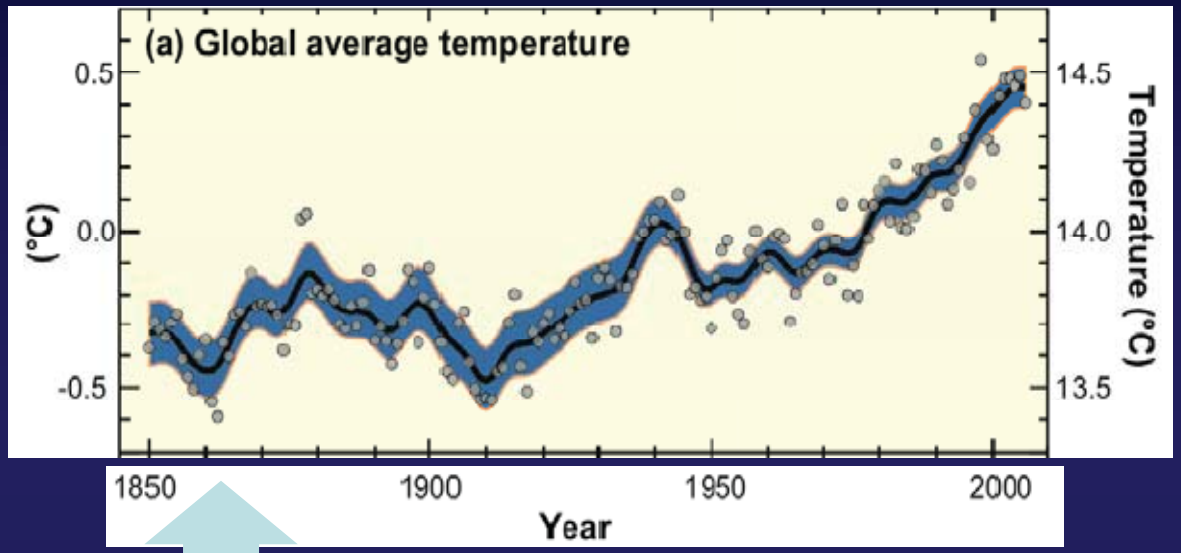
The earth's climate can change because of anthropogenic or natural factors

Natural factors





“Fingerprinting” of the anthropogenic effects



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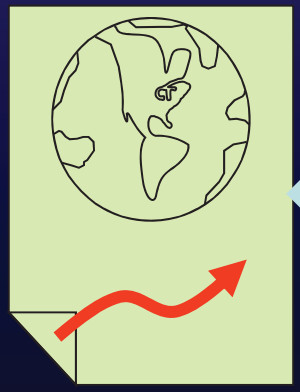
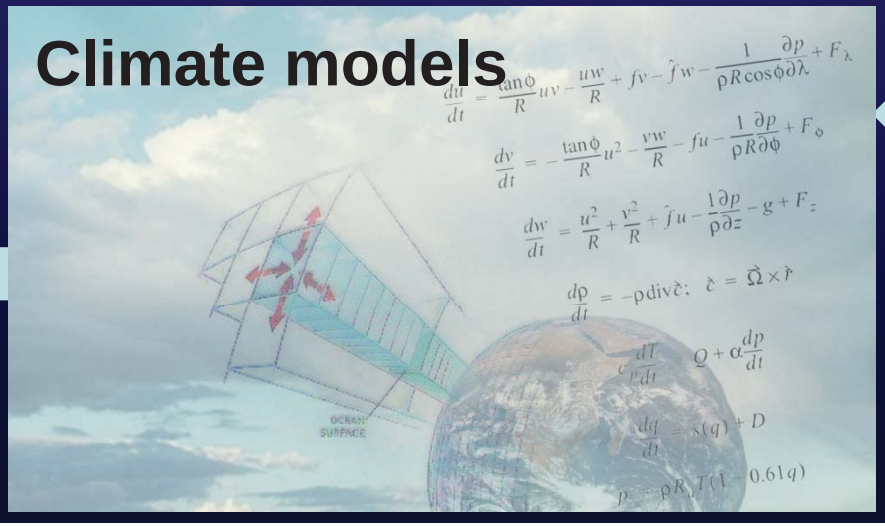
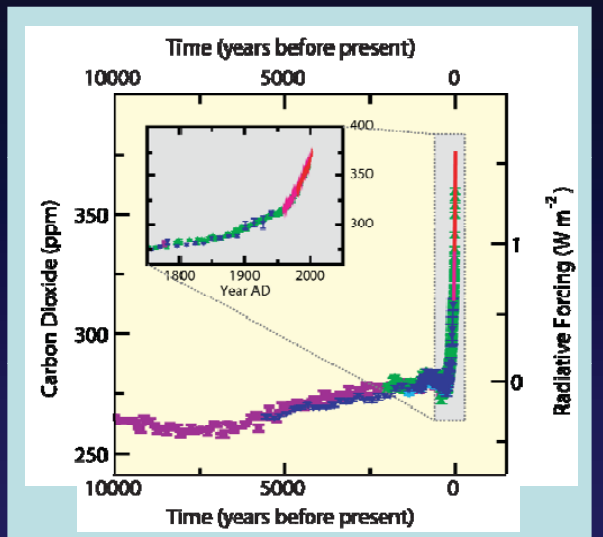
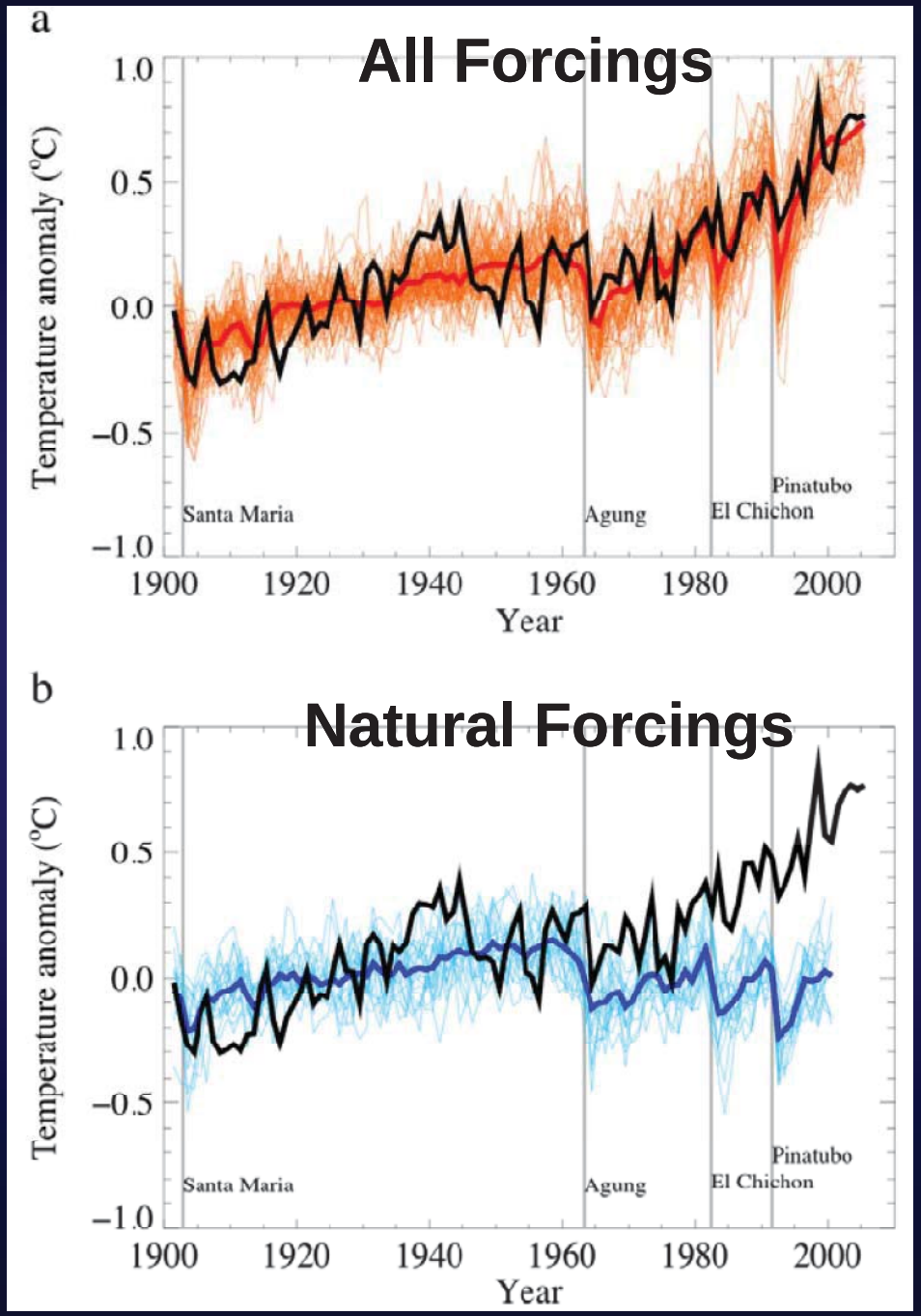






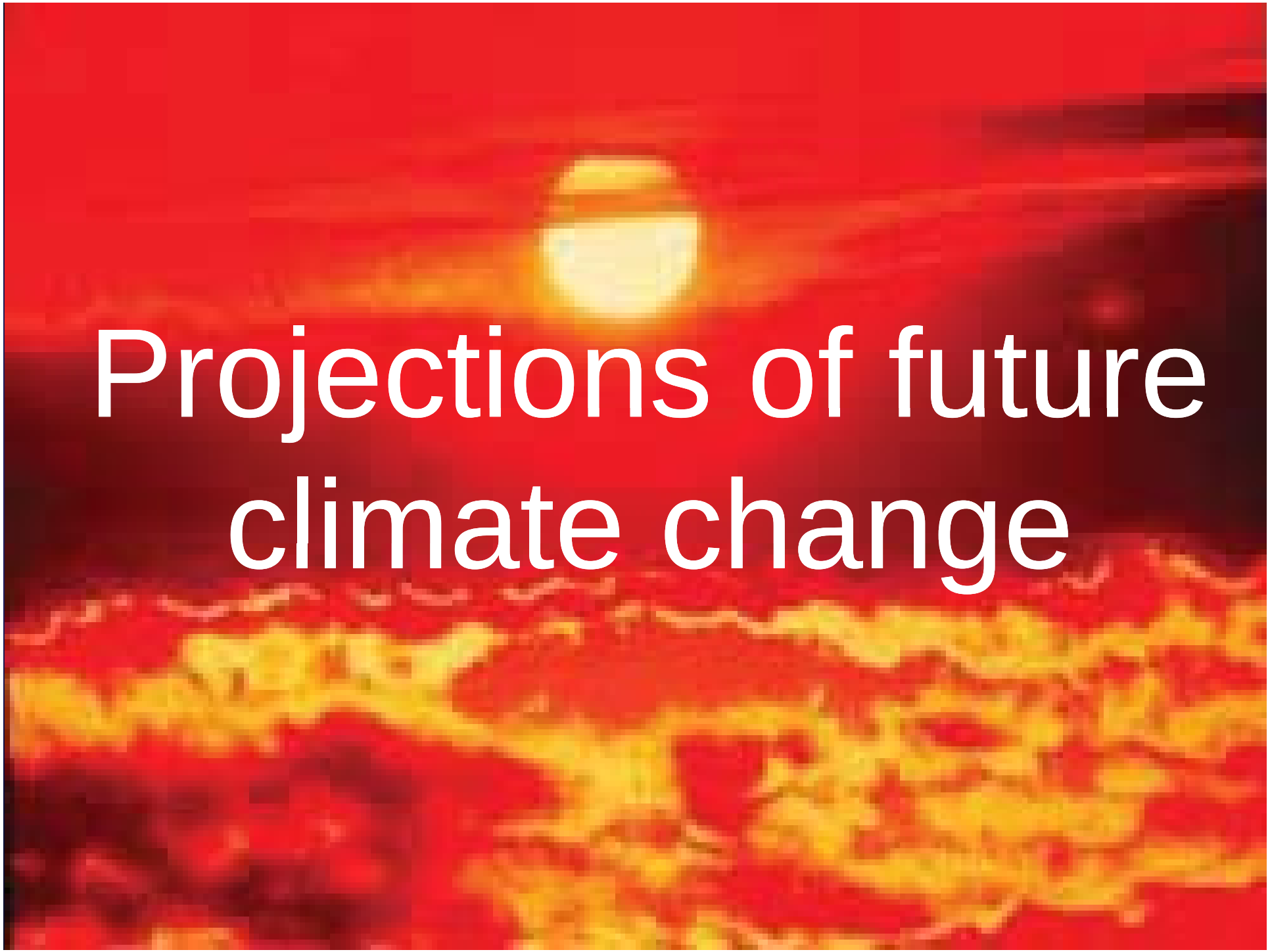
- other GHGs
- aerosols
- volcanic
- solar
- natural internal



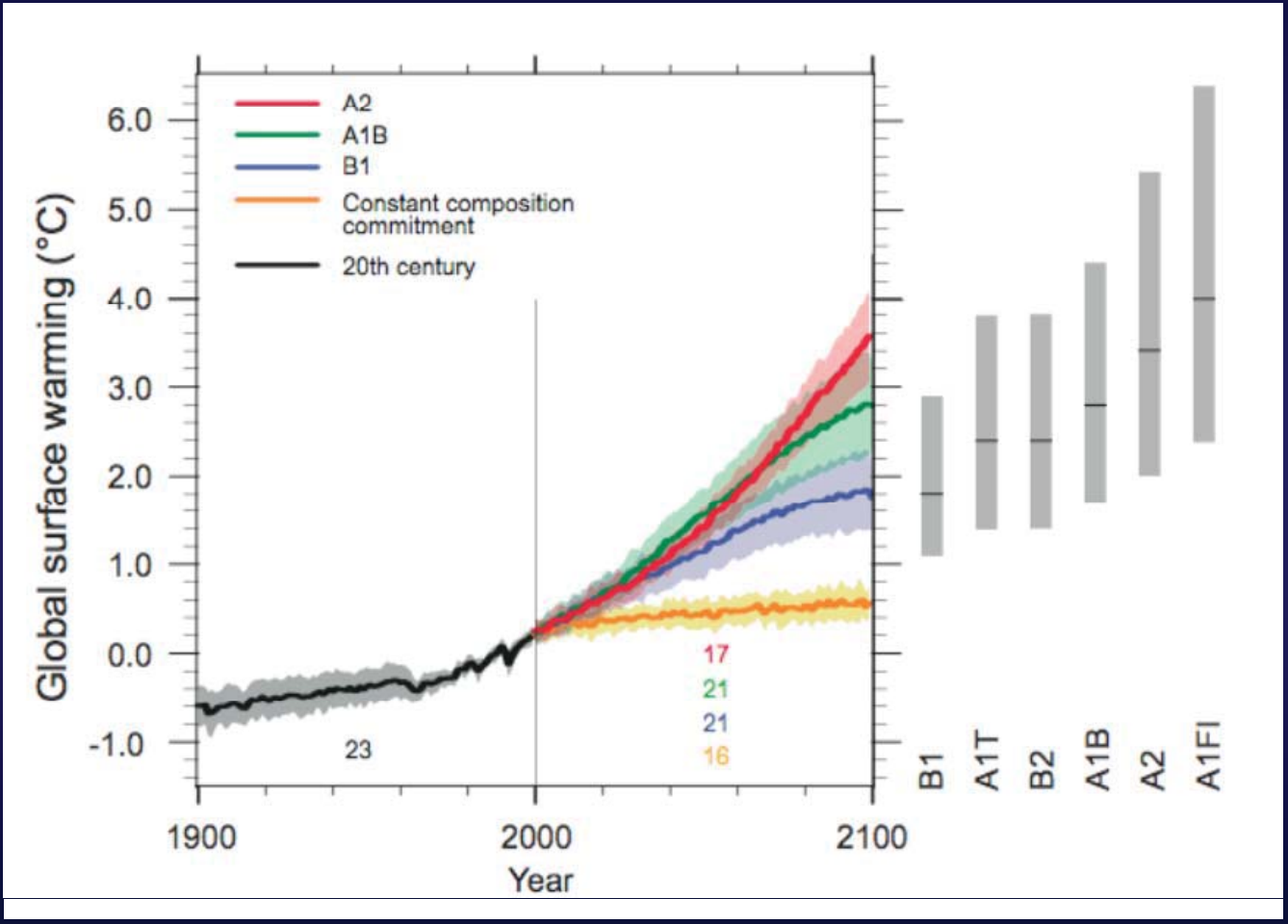
Identification of the anthropogenic effects on global warming

IPCC-2007

Most of the observed increase in globally averaged temperature since the mid-20th century is very likely (90-95%) due to the observed increase in anthropogenic greenhouse gas concentrations. Discernible human influences now extend to other aspects of climate, including ocean warming, continental average temperatures, temperature extremes and wind patterns.


Projections of future
climate change

IPCC – 2007: Global temperature change projections for the 21st century

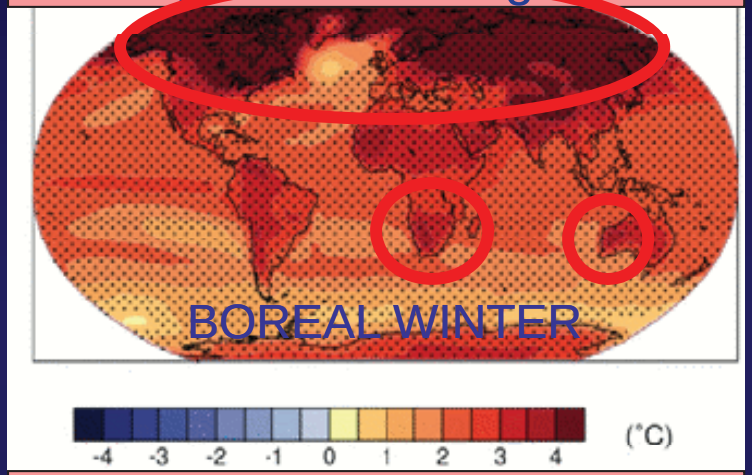


Corresponding changes in sea level rise are 19-58 cm

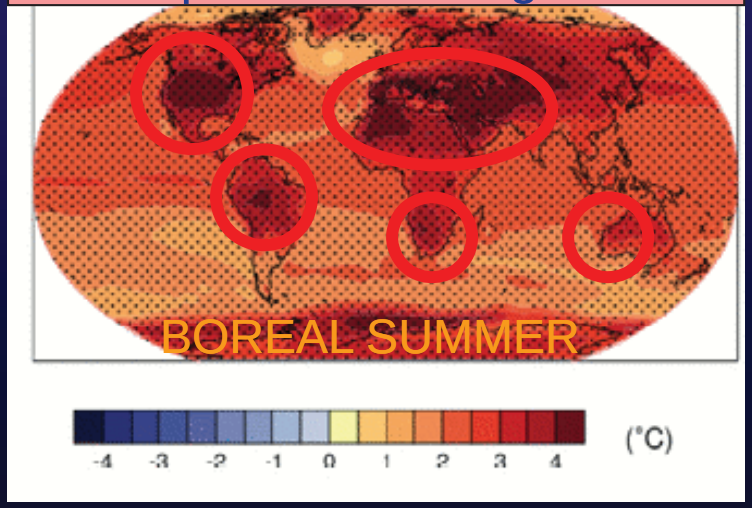
Regional distribution of projected temperature and precipitation change

(A1B scenario, 2090-2100)

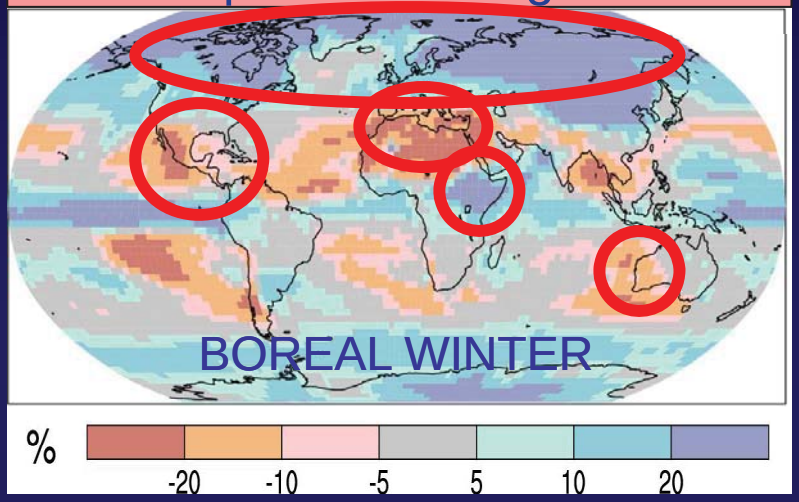
Temperature change DJF



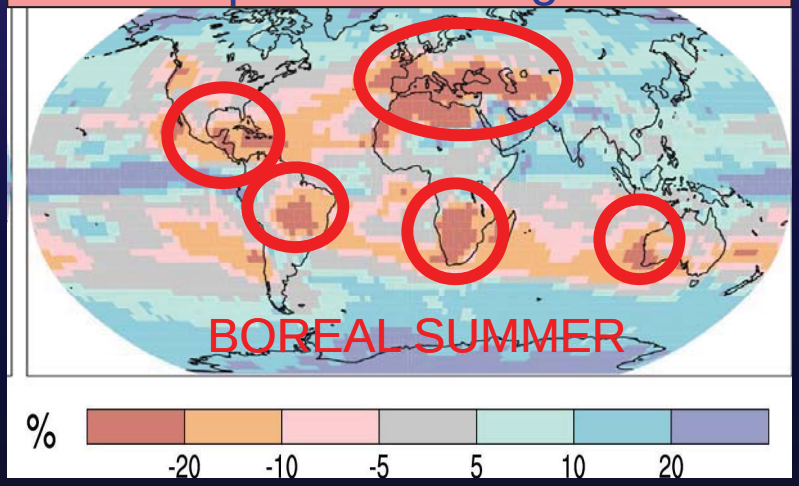
Temperature change JJA



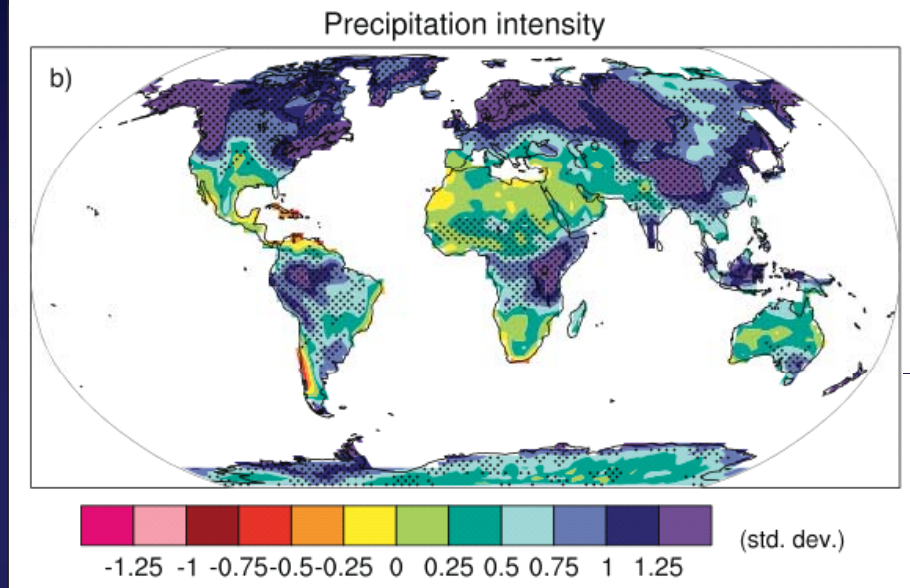
Precipitation change DJF

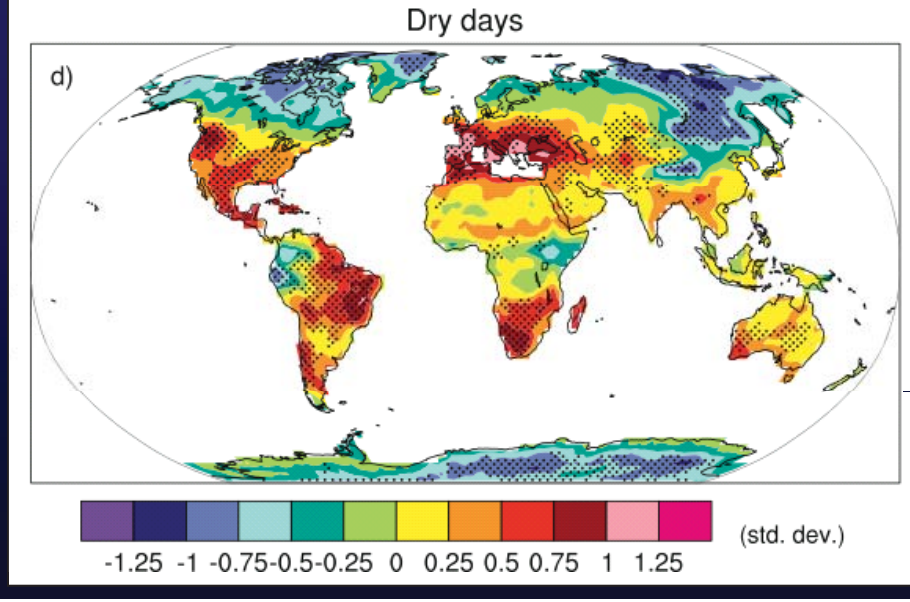


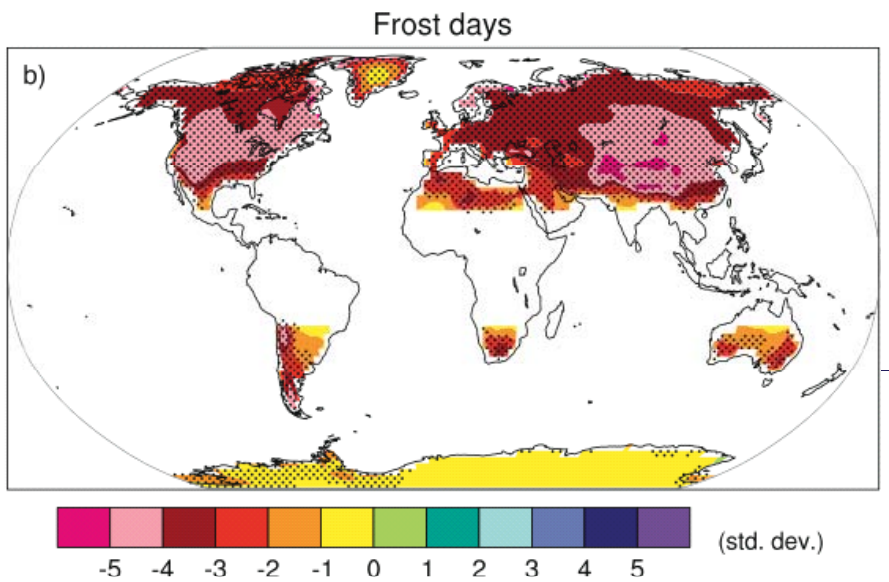
Precipitation change JJA

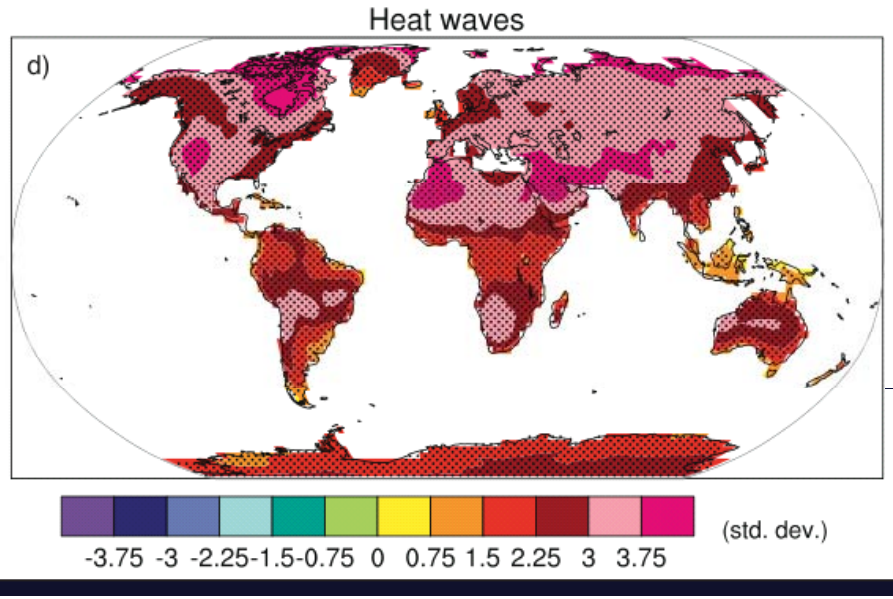


Changes in precipitation and temperature characteristics









August 2010:
A “climate change” August

Other projected changes for the 21st Century

-> Poleward shift of mid-latitude storm tracks

-> Greater intensity of tropical and extratropical cyclones

-> Increase of heat-waves and droughts

-> Greater intensity of precipitation

-> Increased warm season interannual variability

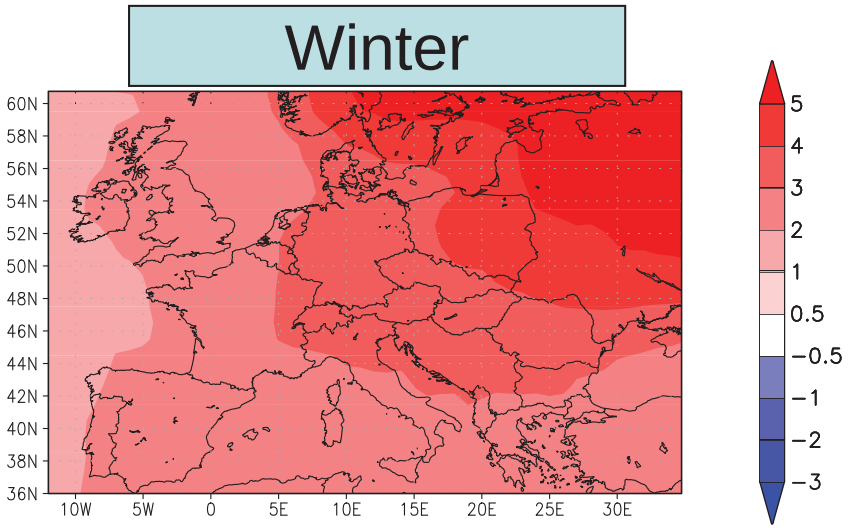
-> Further widespread melting of glaciers and sea ice

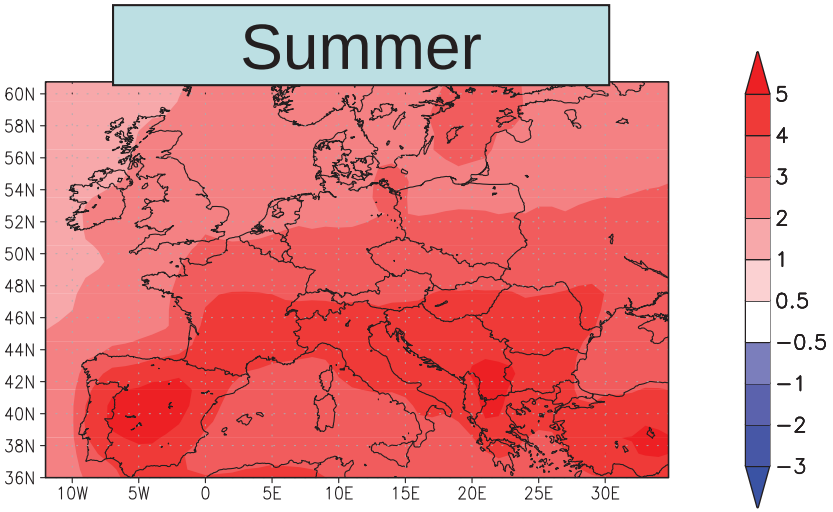
-> Slow down (but not collapse) of the MOC


Focusing on the
european region

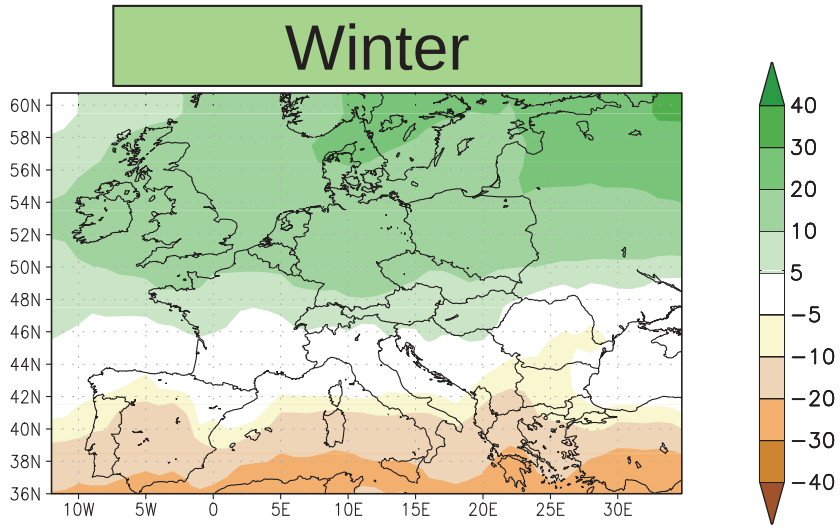
A1B Scenario, 20 AOGCMs

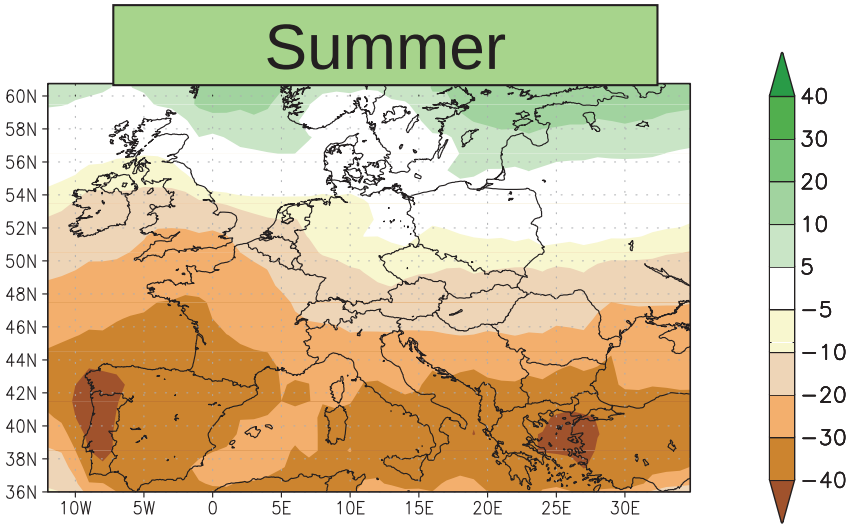
Temperature Change





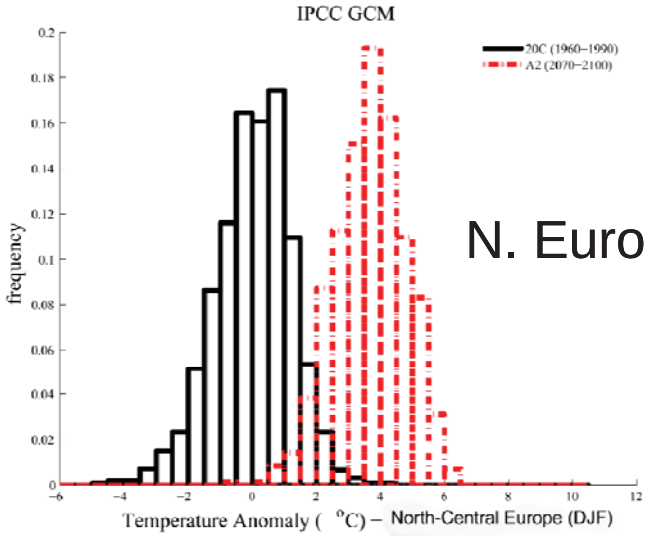
Precipitation Change



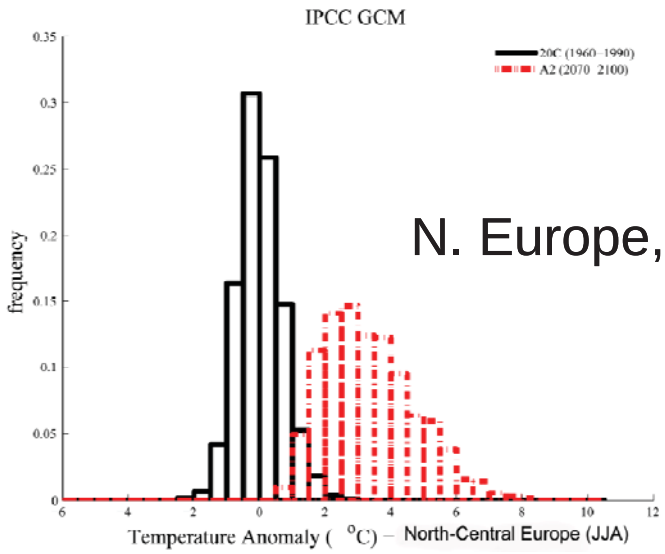


Change in seasonal temperature distribution

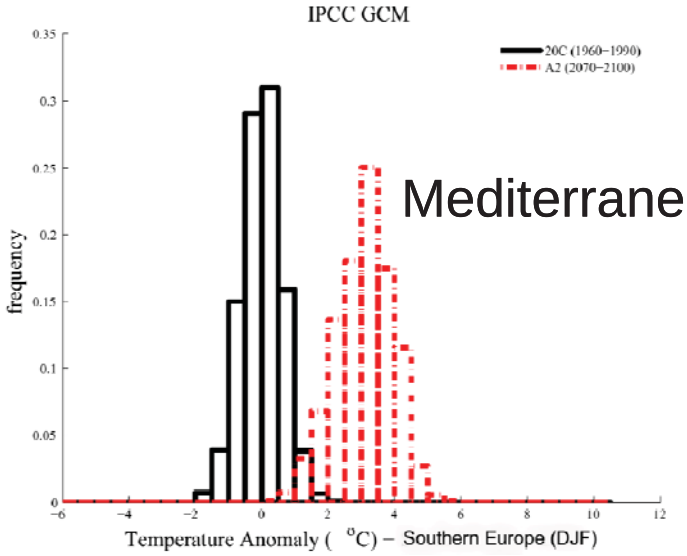
CMIP3 Ensemble (%, 2071-2100 minus 1961-1990),



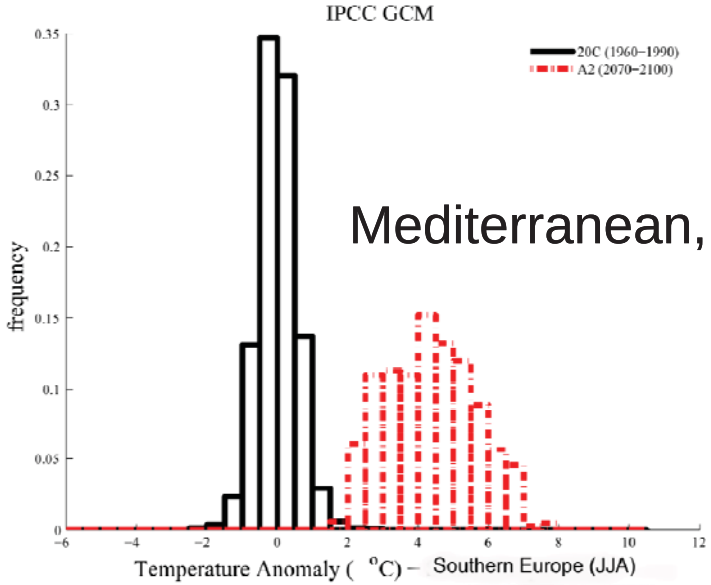
N. Europe, DJF



N. Europe, JJA



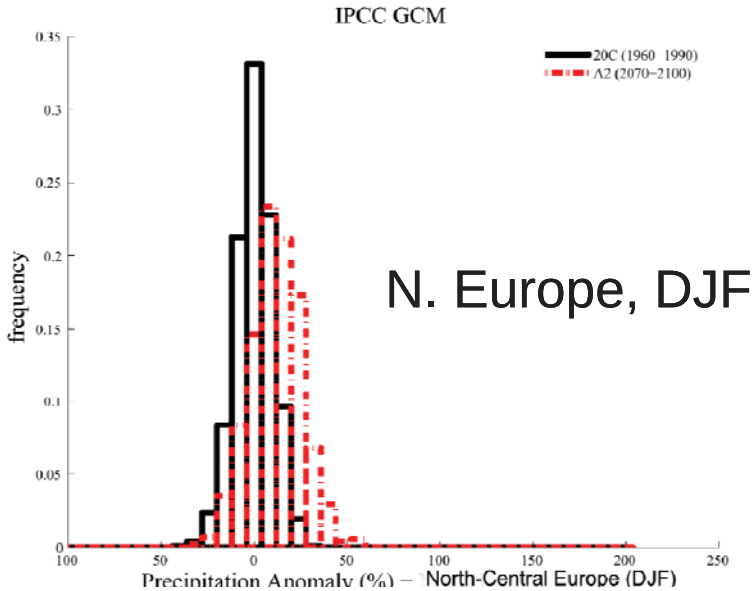
Mediterranean, DJF



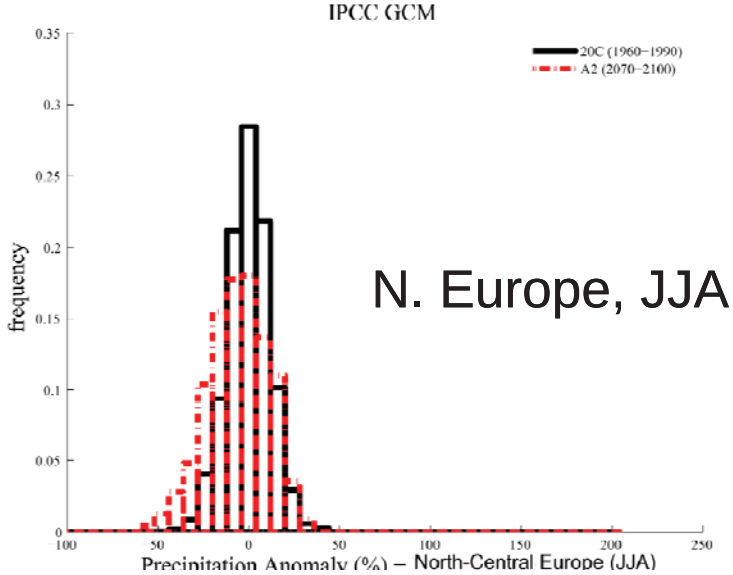
Mediterranean, JJA

Change in seasonal precipitation distribution

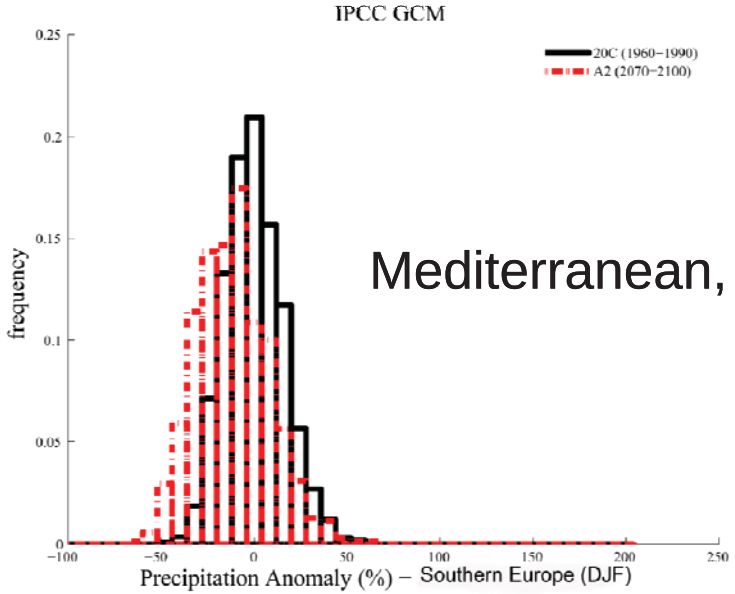
CMIP3 Ensemble (%, 2071-2100 minus 1961-1990),



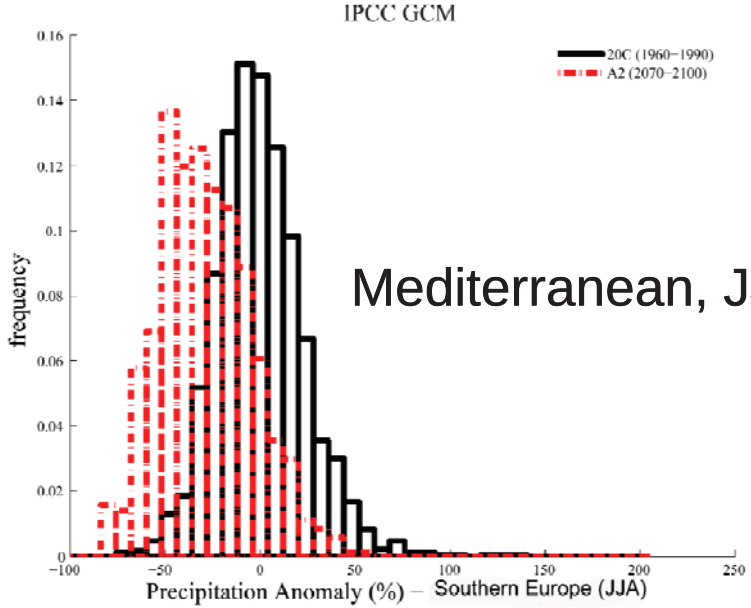
N. Europe, DJF



N. Europe, JJA

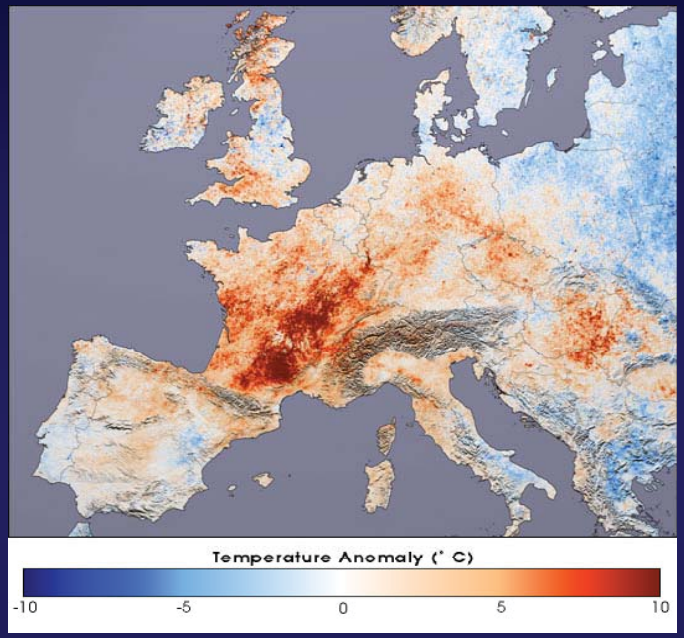


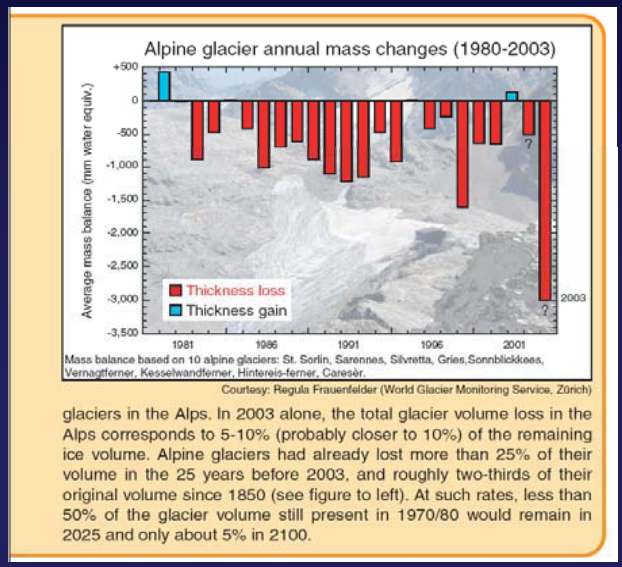
Mediterranean, DJF



Mediterranean, JJA

The summers we can expect in Europe?
Summer of 2003

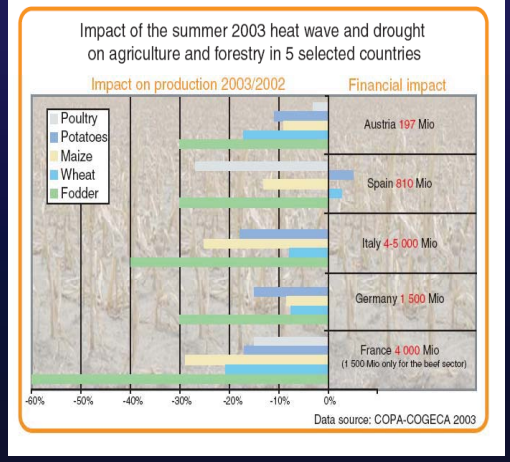




glaciers in the Alps. In 2003 alone, the total glacier volume loss in the Alps corresponds to 5-10% (probably closer to 10%) of the remaining ice volume. Alpine glaciers had already lost more than 25% of their volume in the 25 years before 2003, and roughly two-thirds of their original volume since 1850 (see figure to left). At such rates, less than 50% of the glacier volume still present in 1970/80 would remain in 2025 and only about 5% in 2100.

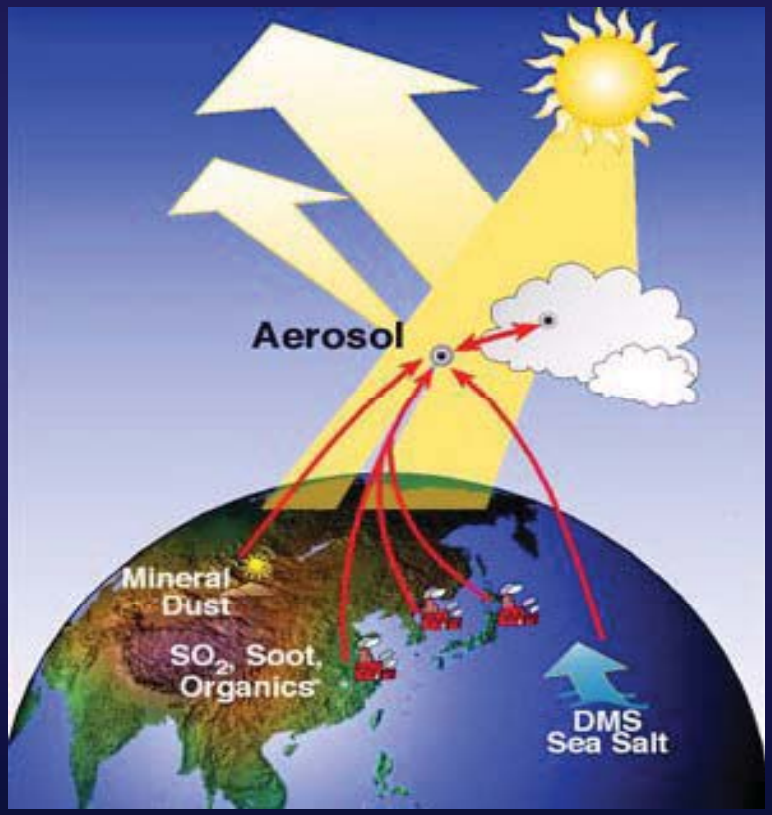
Country	Casualties
France	14 082
Germany	7 000
Spain	4 200
Italy	4 000
UK	2 045
Netherlands	1 400
Portugal	1 300
Belgium	150

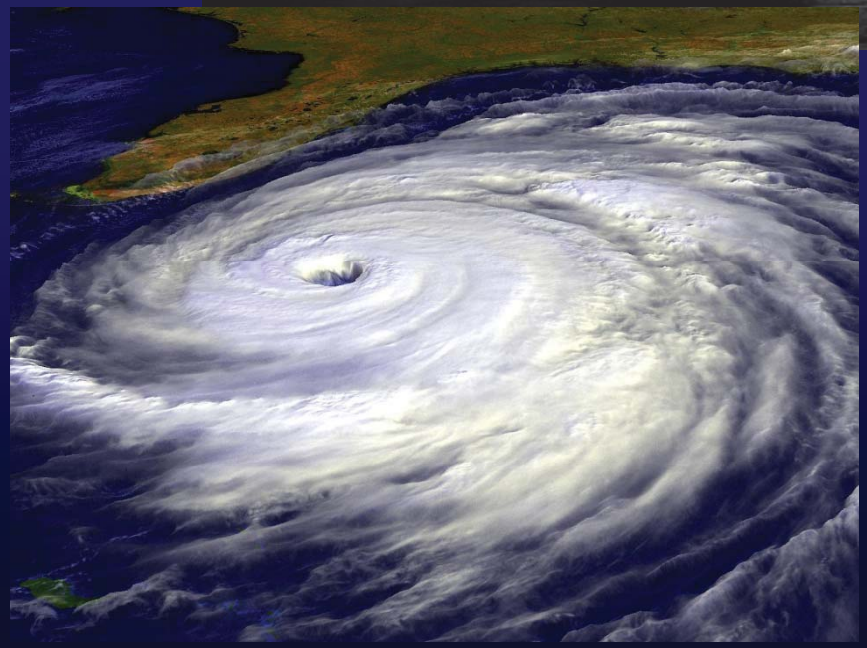
INSERM: "Surmortalité liée à la canicule de l'été 2003", AP September 25, 2003



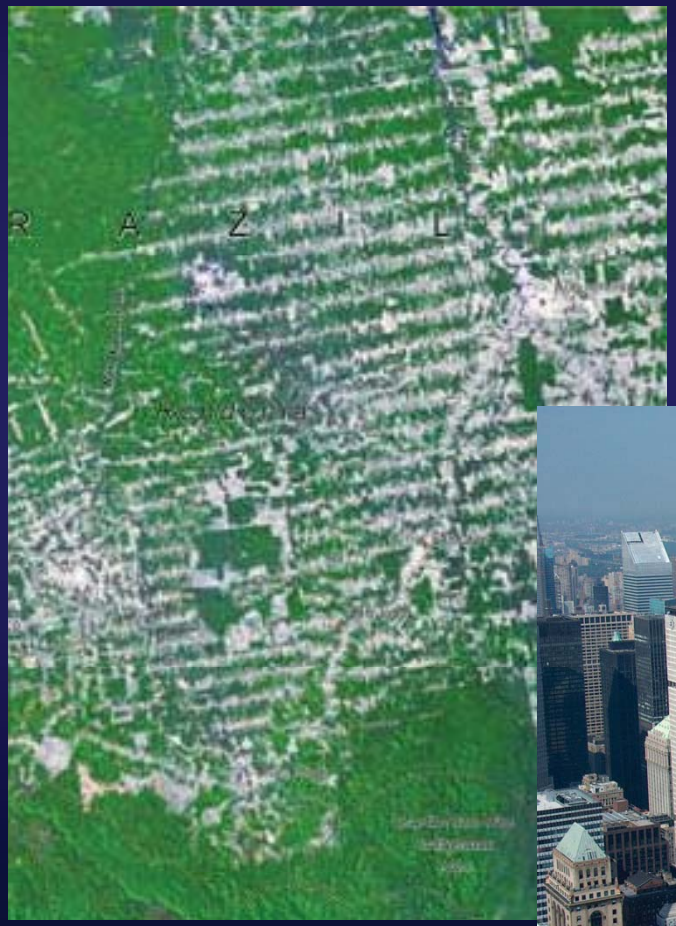
Some key uncertainties

Effects of clouds, aerosols and tropical convection

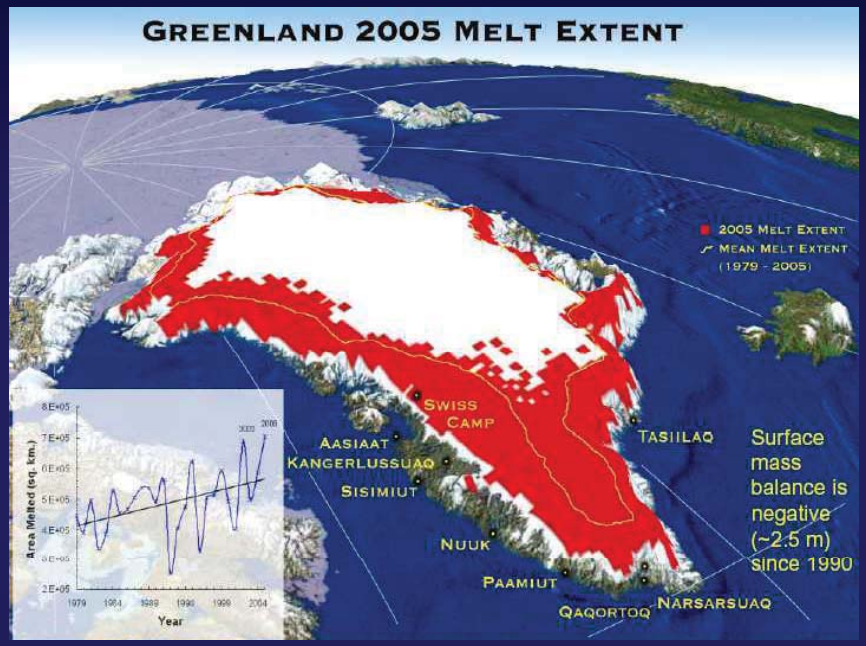


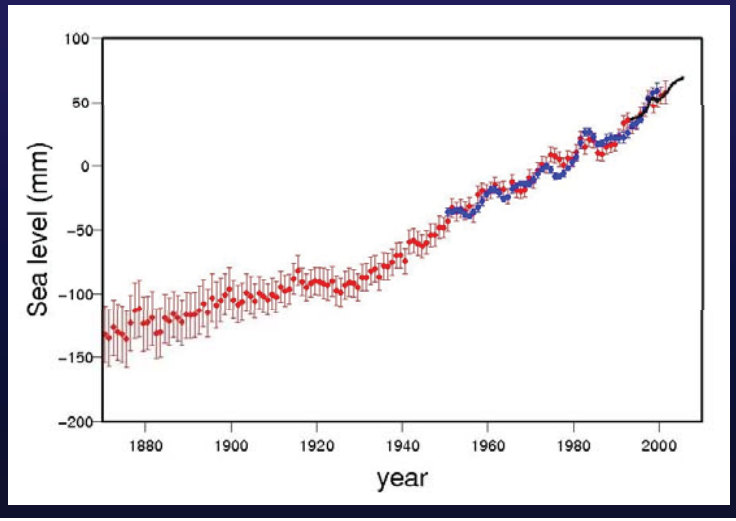


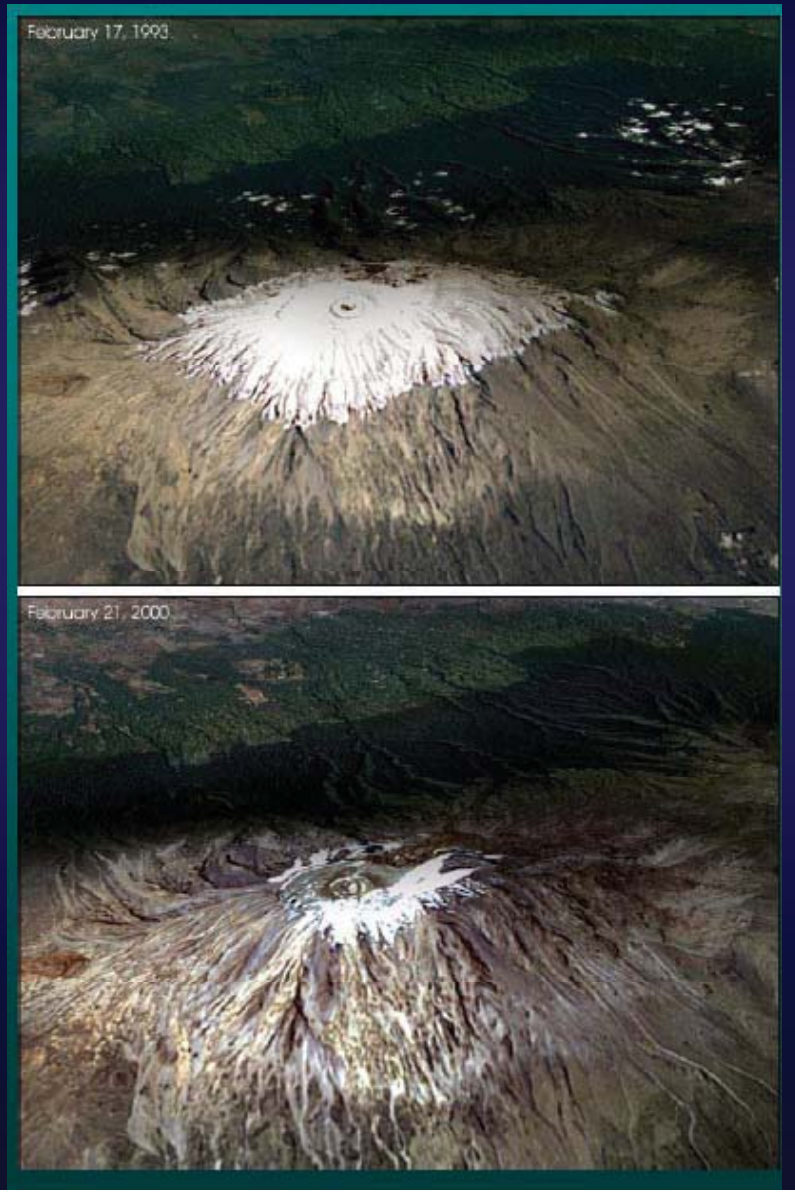
Land use change and carbon cycle



Sea level rise



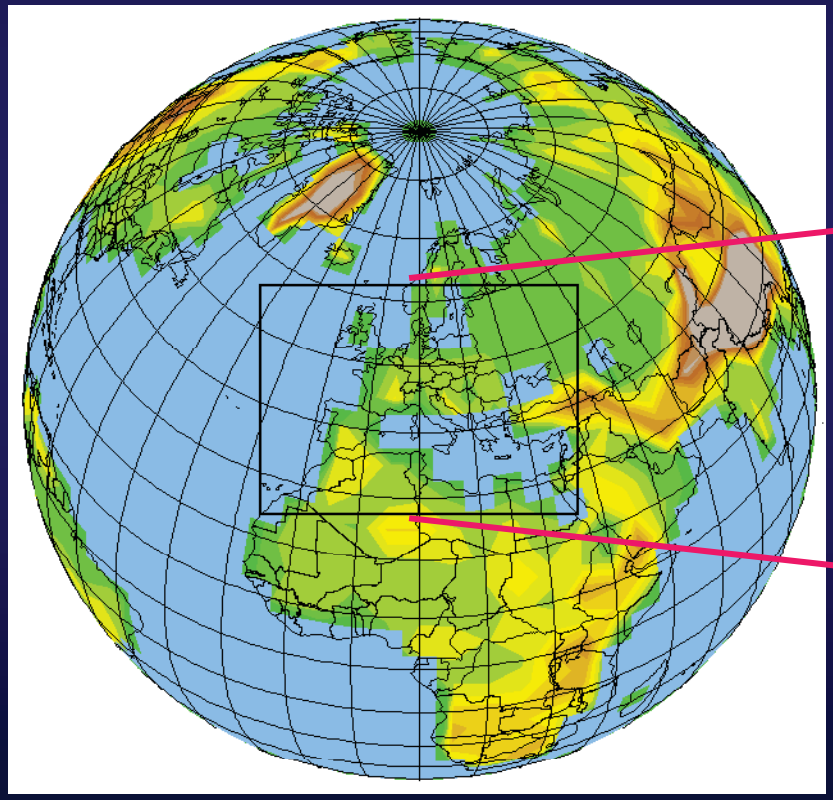




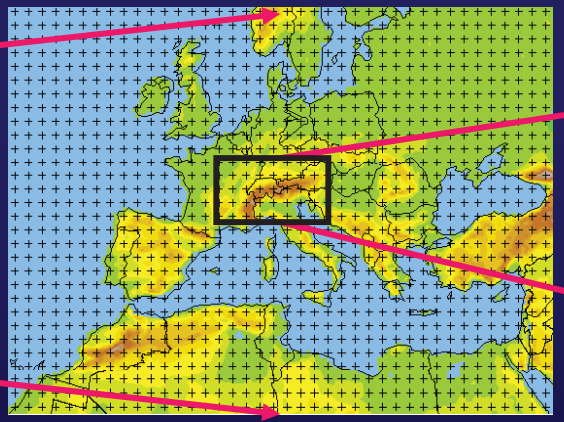
Greenhouse gas emission scenarios

Projections at regional to local scales

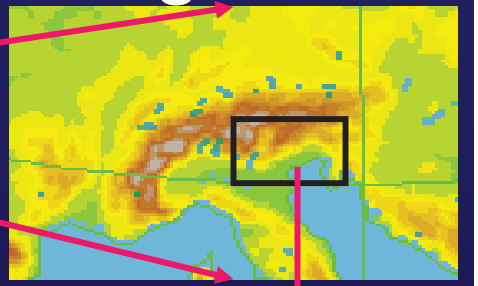
Globale



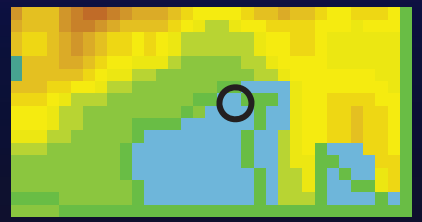
Continentale



Regionale



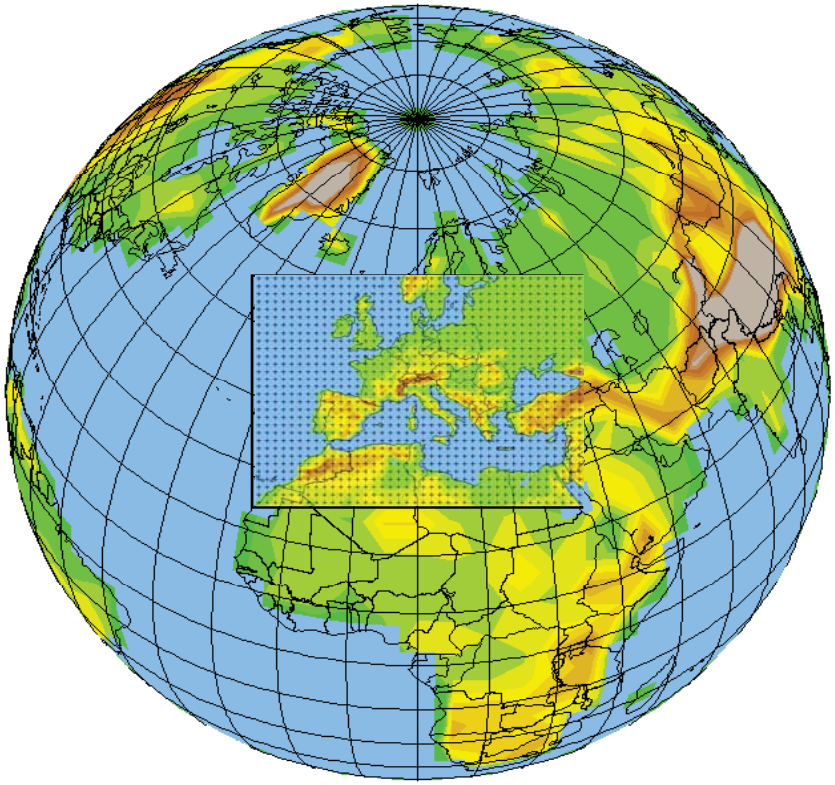
Locale



Next steps

- Work for the IPCC AR5 just under way, reports to be released in 2013/14
- Large coordinated modeling efforts to support the IPCC process
  - CMIP5
  - CORDEX
- Some new areas of emphasis
  - Decadal climate prediction
  - Geoengineering options

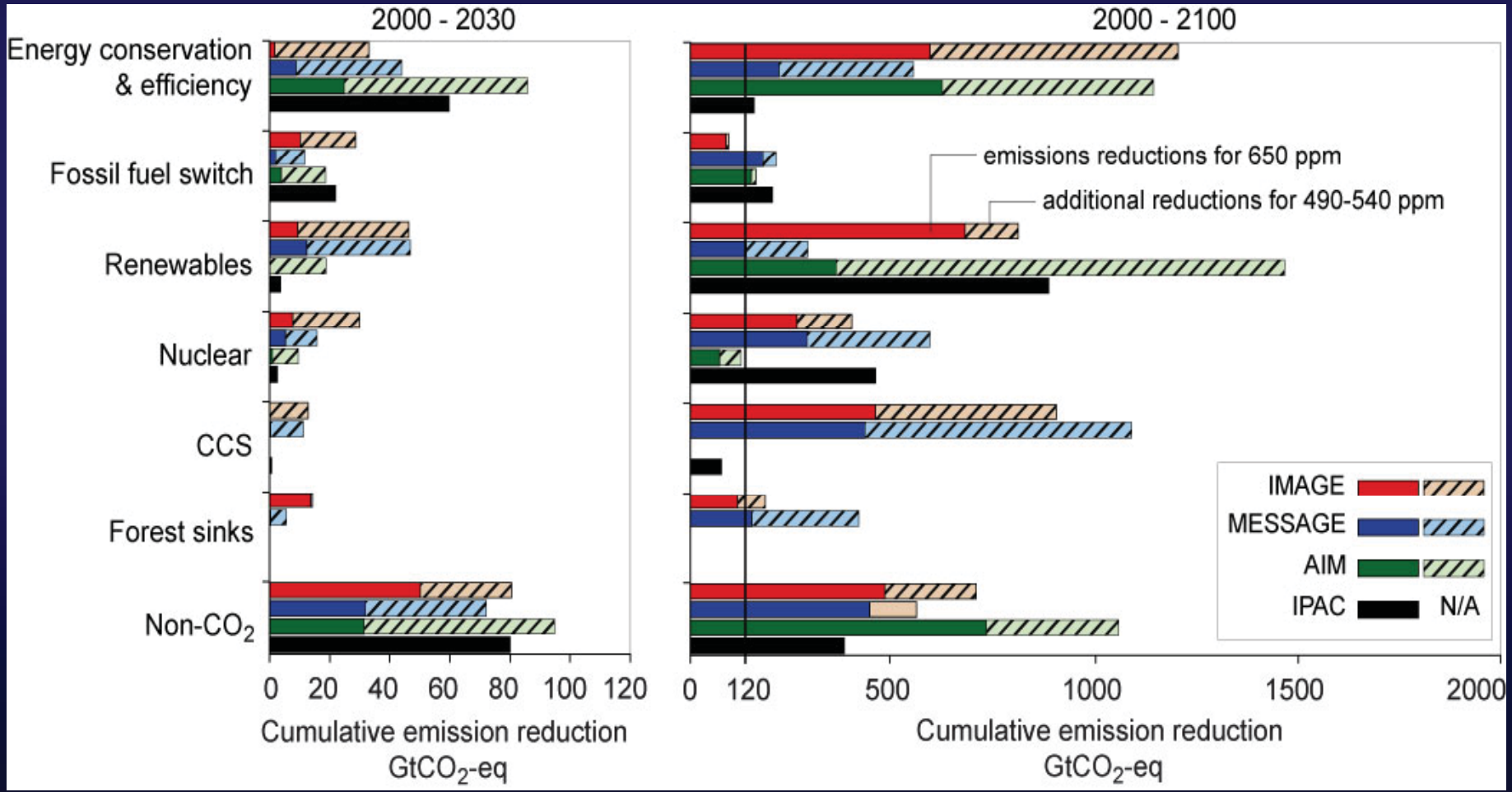
Thank You



Summary of changes relevant for energy policies

- Increase in intensity of storms and winds
- Increase in dry and wet extremes
- Increase in interannual variability
- Increase in heat waves
- Large regional variability of changes

Mitigation potential of different alternative energy sources



Some consequences for the energy systems

- Demand side
  - Greater demand in summer, decreased demand in winter
  - Greater peak demand during summer heat waves
  - More spatially and temporally “variable” demand
- Supply side
  - Adaptation to more intense extremes
  - Safety of plants
  - Adaptation to higher temperatures (e.g. for reactors cooling)
  - Adaptation to more temporally variable supply of renewable energy sources (hydropower, wind)
  - Regional changes of power sources (renewables)

Projected changes in the hydrologic cycle