The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

**2138-14**

# Joint ICTP-IAEA Workshop on Vulnerability of Energy Systems to Climate Change and Extreme Events

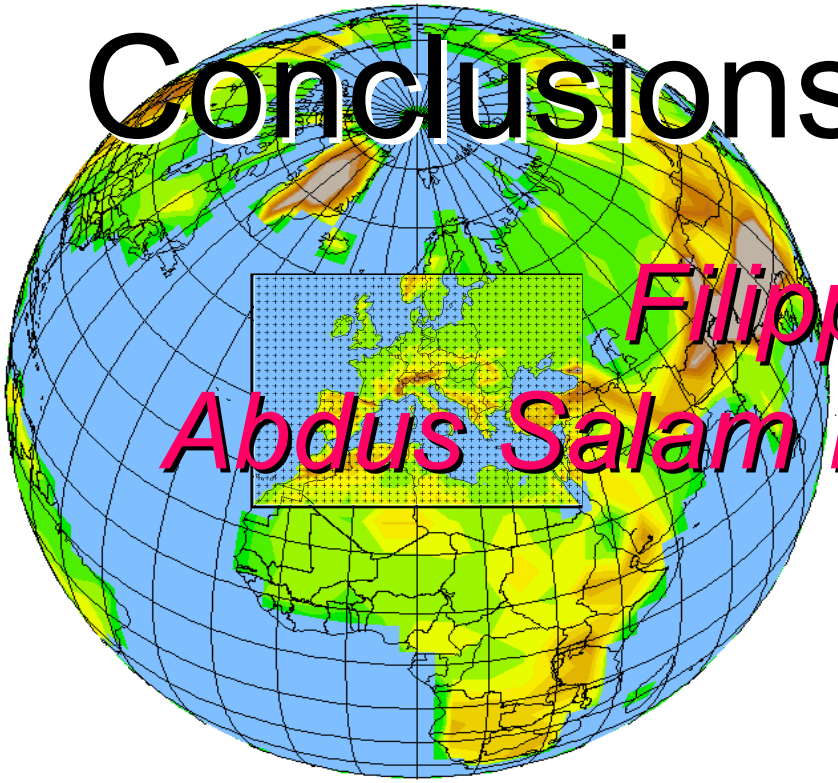
*19 - 23 April 2010*

## Climate change and extreme events: Conclusions from the IPCC

Filippo Giorgi
*ICTP*
*Trieste*
*Italy*

# Climate change and extreme events

## Conclusions from the IPCC

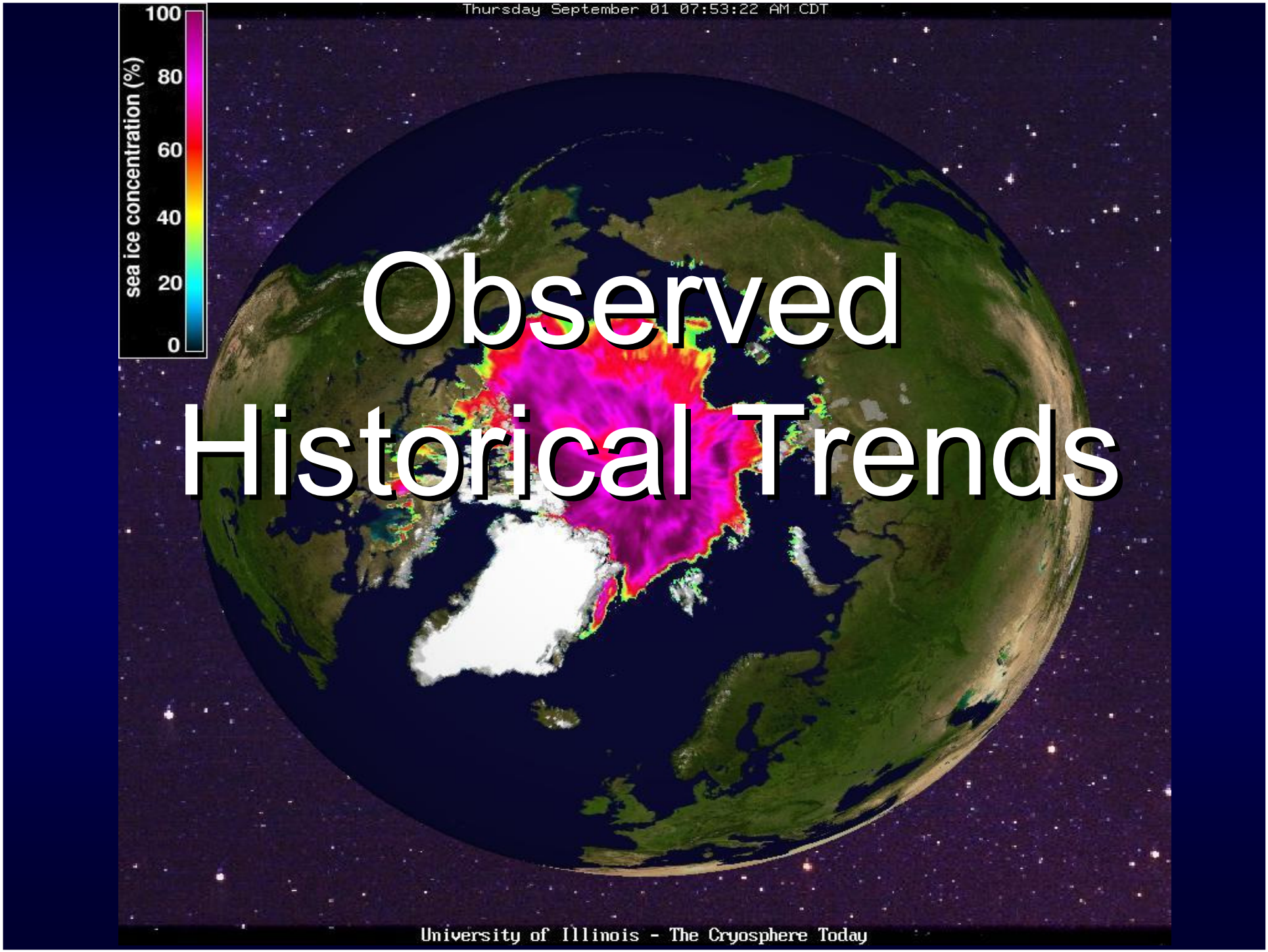


*Filippo Giorgi*
*Abdus Salam ICTP, Trieste, Italy*

**ICTP-IAEA Workshop 19-23 April 2010**

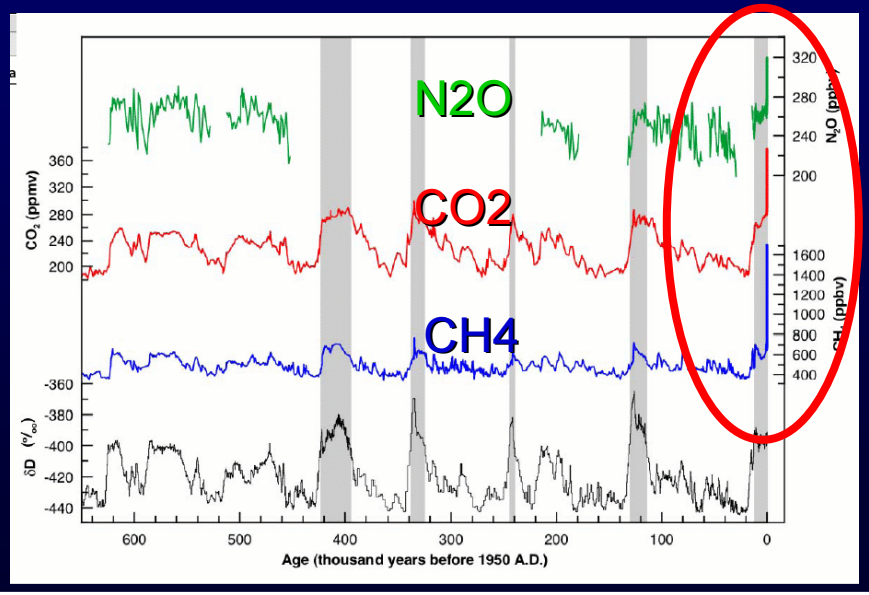
# Outline

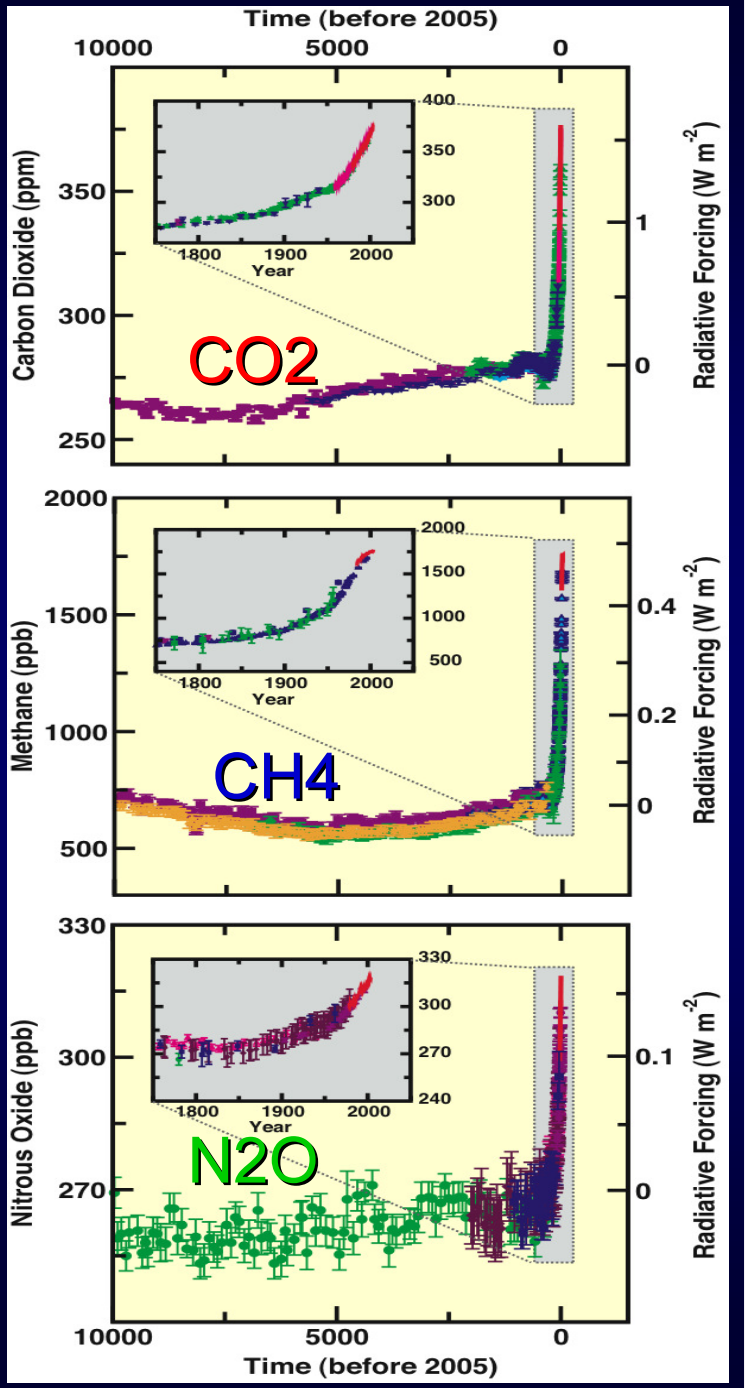
- Observed historical trends
- Climate projections
- Some considerations on implications for energy systems


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

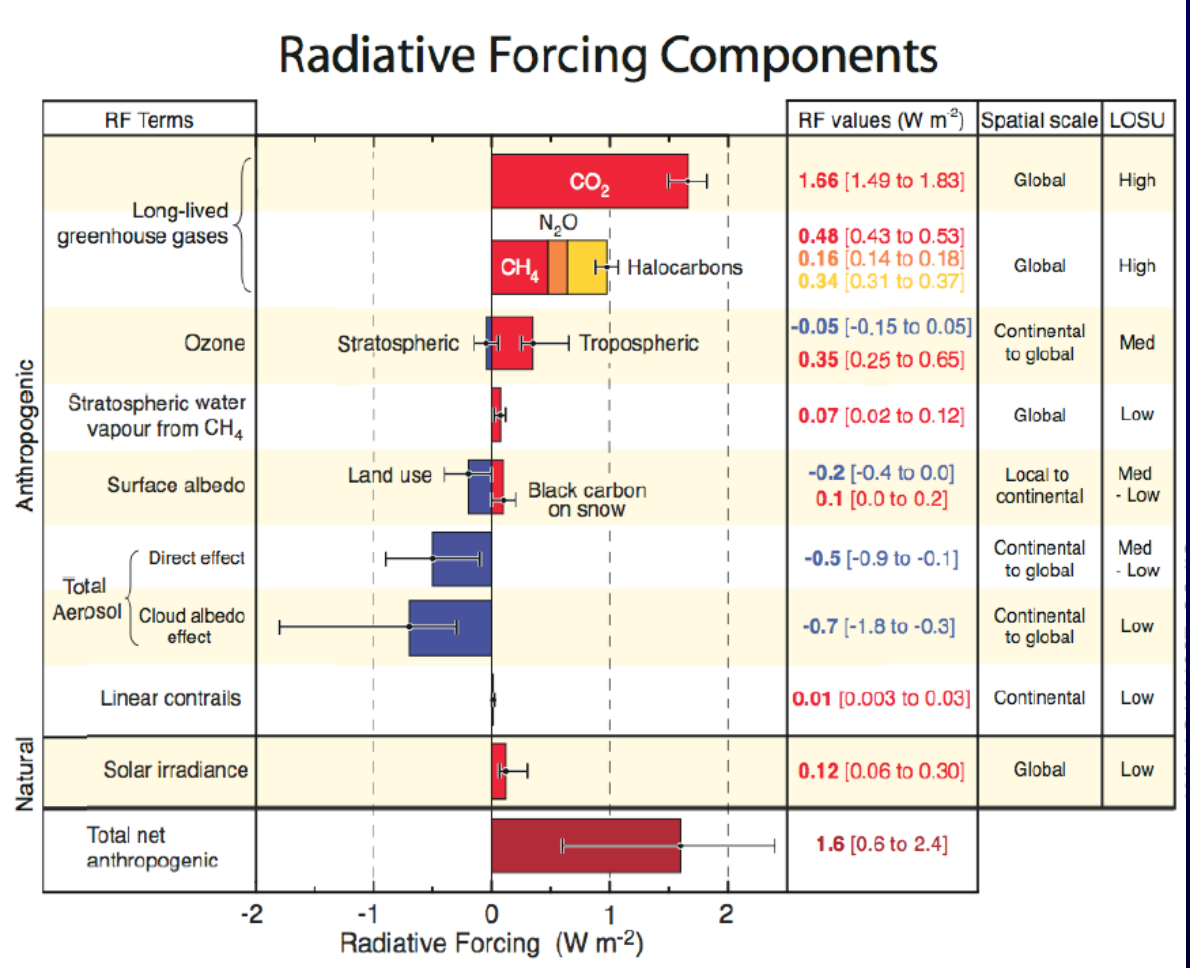
The greenhouse gas concentration is higher than in the last 650000 years and continues to increase mostly due to fossil fuel burning and agricultural activities.



# Anthropogenic and natural forcings from 1750 to 2005

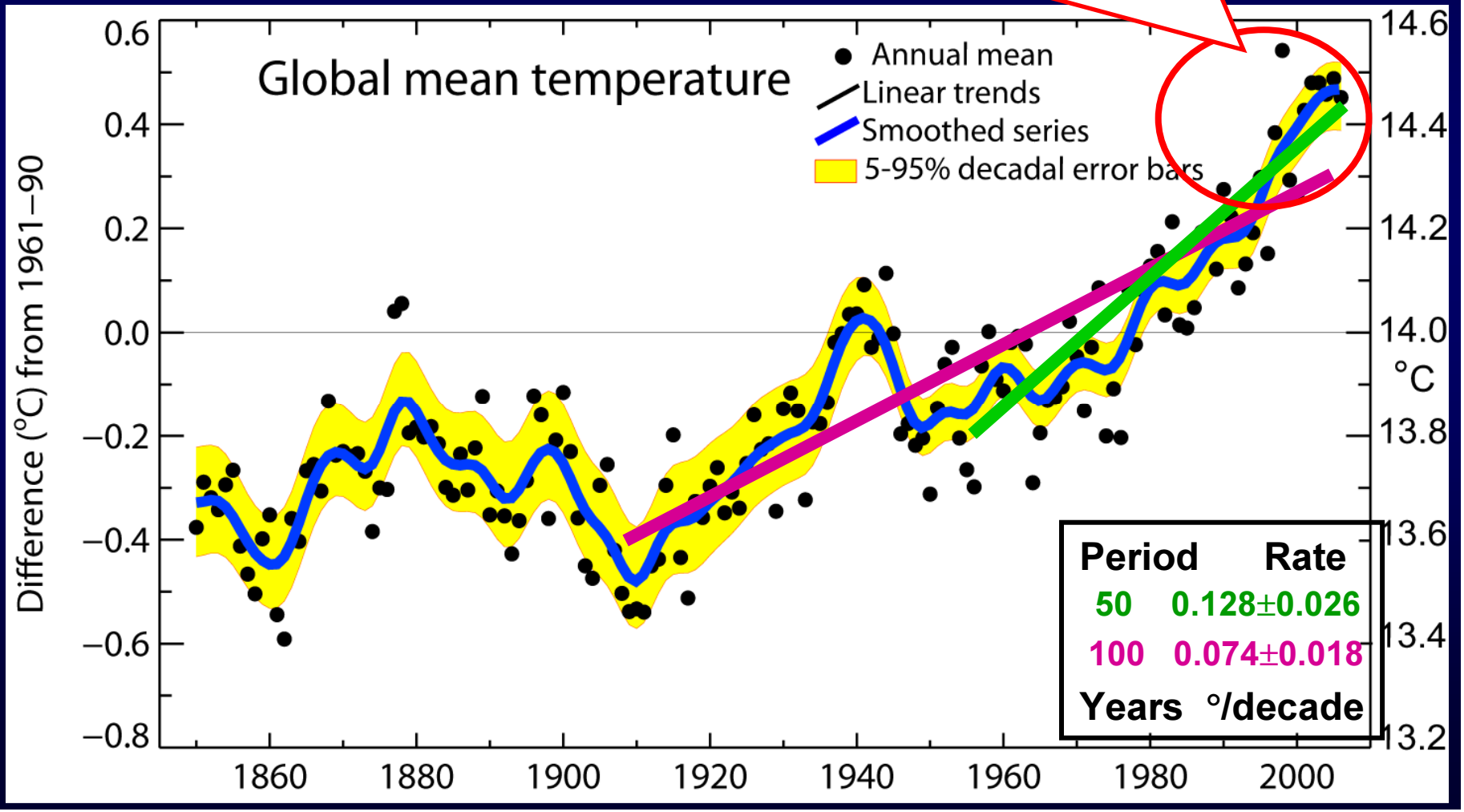
## Anthropogenic forcings are estimated to be much higher than natural forcings



# Observed global temperature change

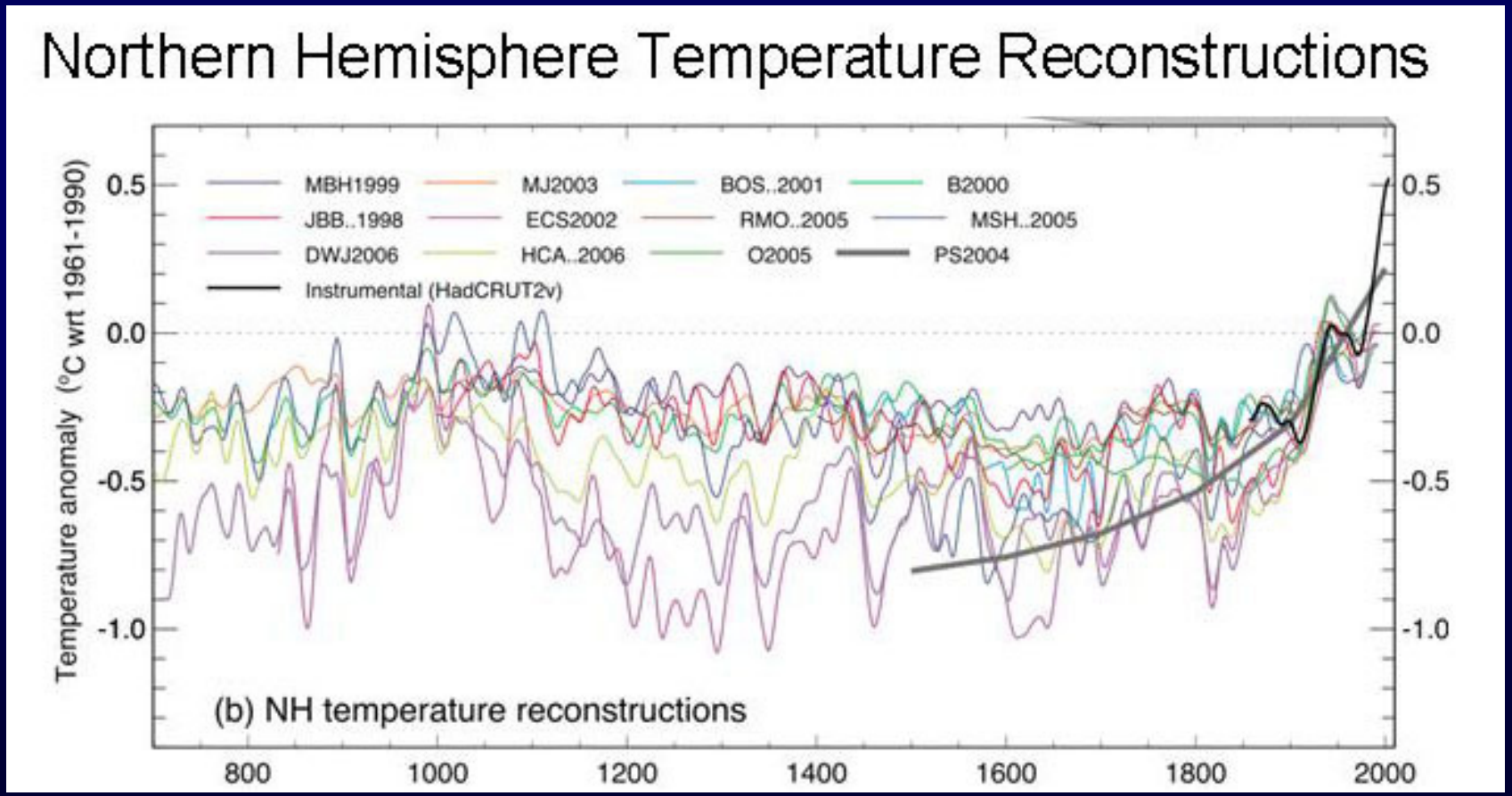
Last 50 years warmest during the last 1300 years

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



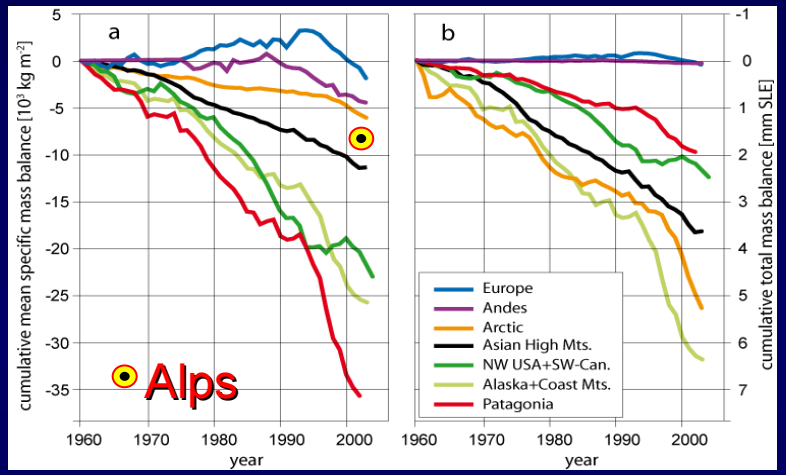
# Temperature anomaly reconstructions for the last 1000 years

**The last 50 years are warmest in the last millennium**

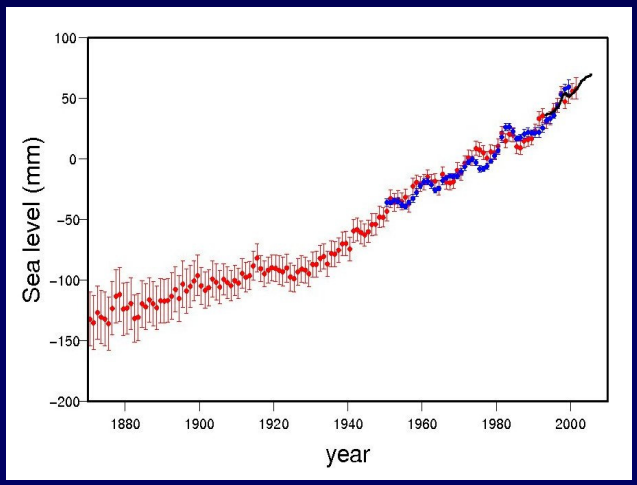


# Decrease of snow cover, sea ice and glaciers, sea level rise

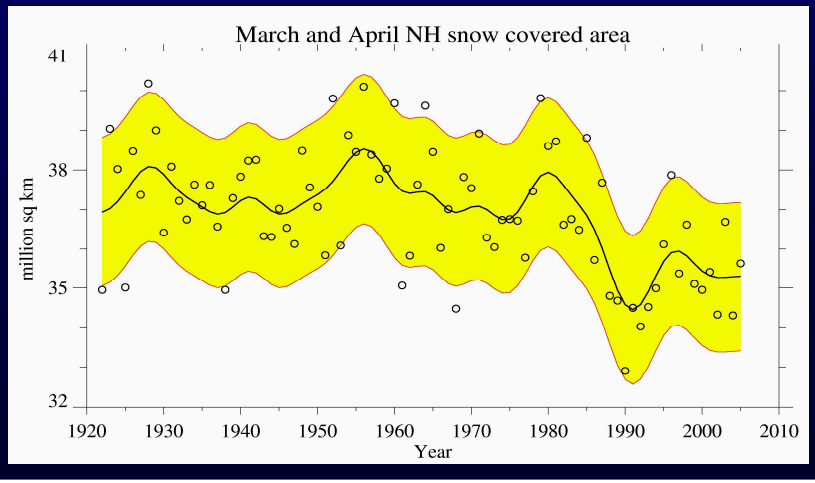
## Melting of glaciers



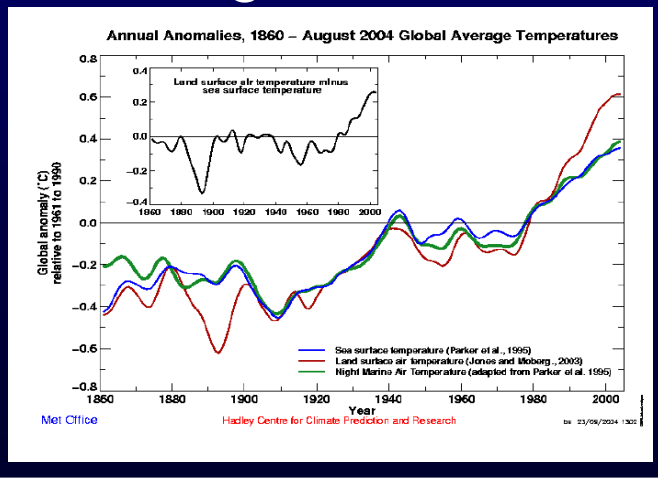

## Sea level rise




## Decrease of snow cover

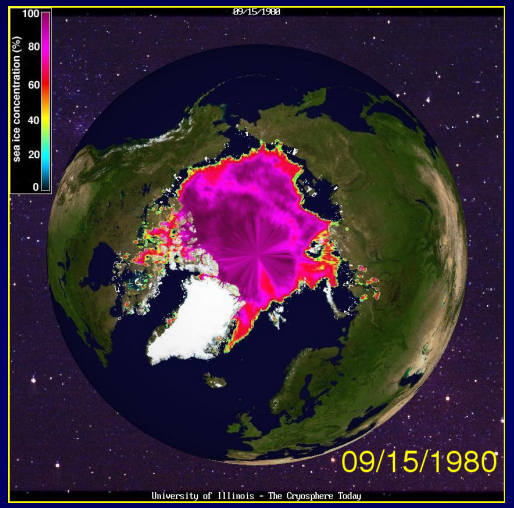



## Warming of the oceans

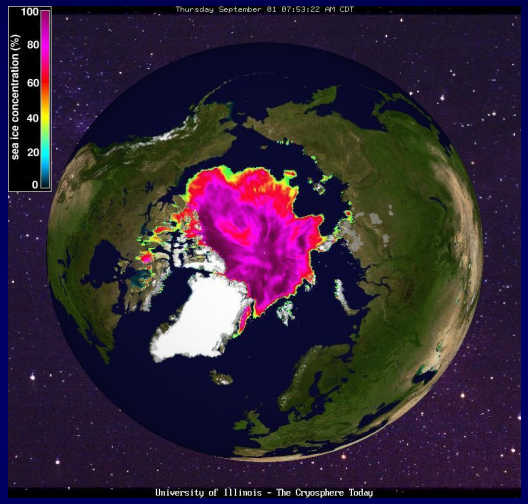


# Melting of the Arctic cap

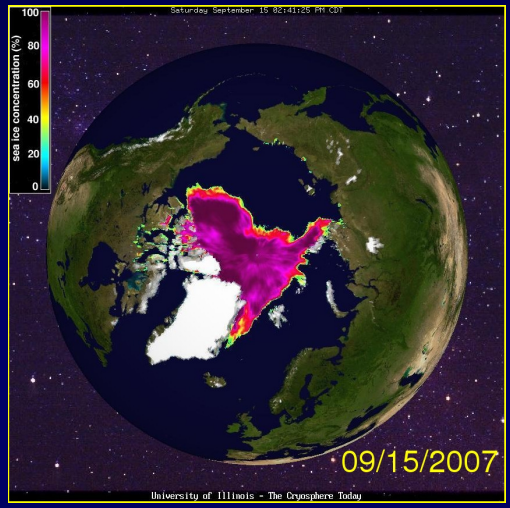
15 September 1980



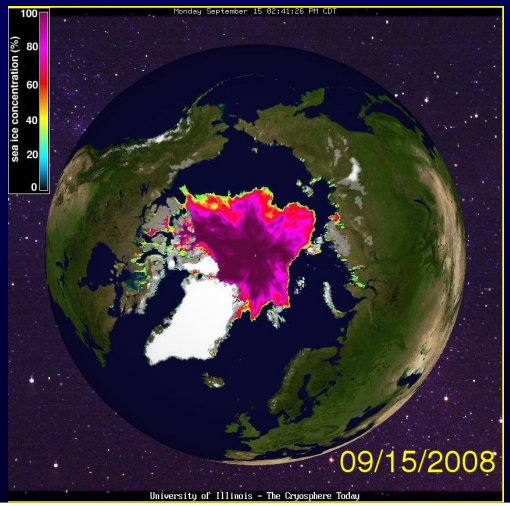

15 September 2005

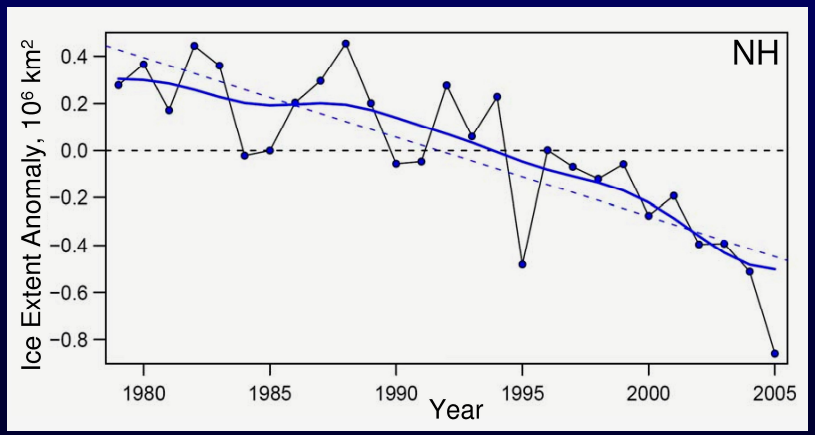



15 September 2007

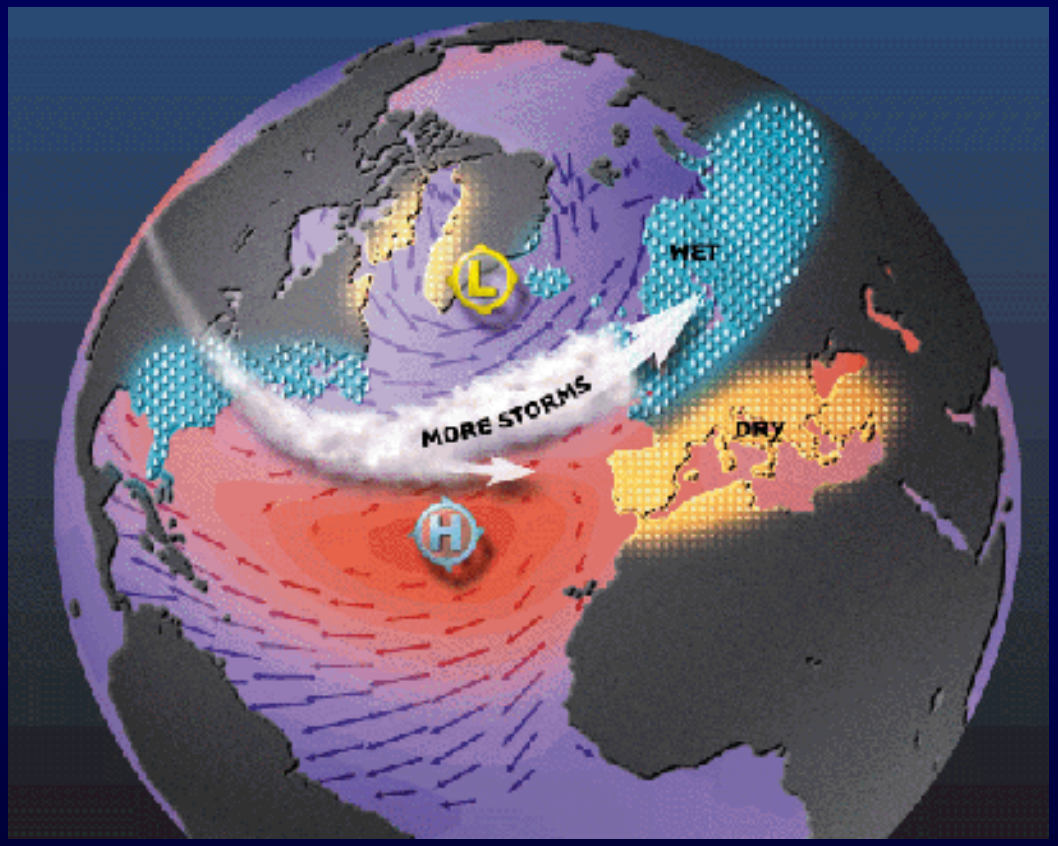



15 September 2008



# Other observed changes
## Circulation




Poleward shift of mid-latitude storm tracks

More intense westerlies

# Other observed changes

## Temperature and precipitation extremes

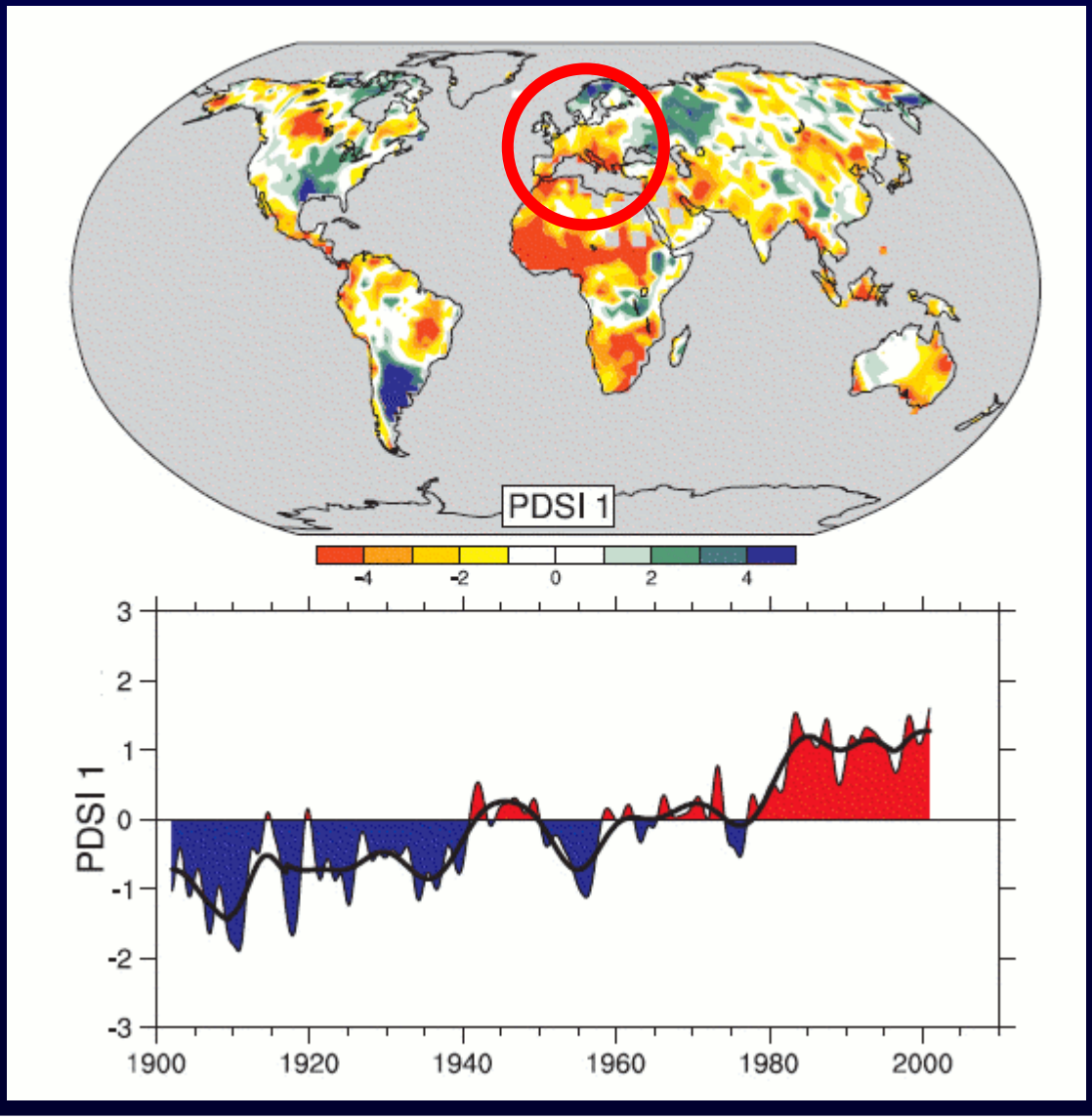
Increased frequency
of heavy precipitation events

Warmer and more hot days,
warmer and fewer cold days

Increased frequency of
heat waves

# Other observed changes

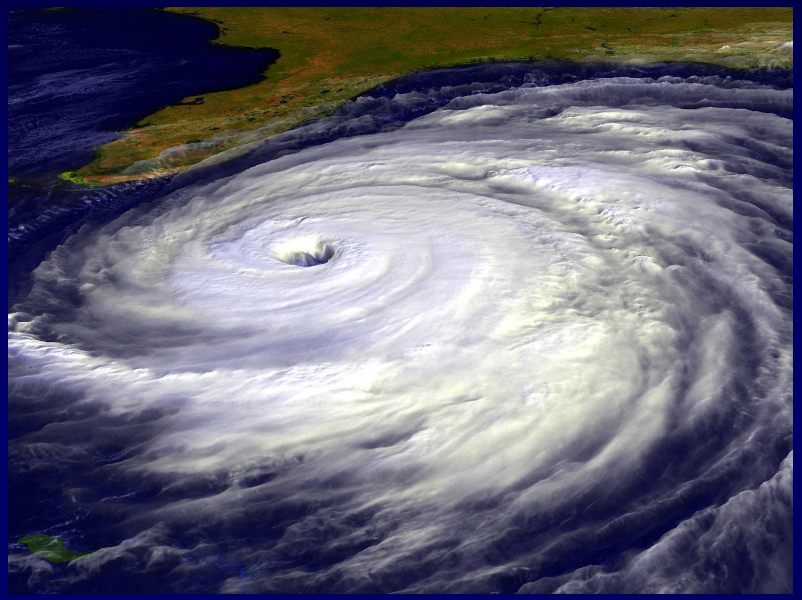
## Droughts




Increase in length and intensity of droughts as measured by the PDSI

# Other observed changes

## Storms



Increase in intense tropical cyclone activity in the North Atlantic since ~ 1970 correlated with increases in tropical SSTs

Insufficient evidence to determine whether trends exist in small scale phenomena such as tornadoes hail, lighting and dust storms

# IPCC-2007

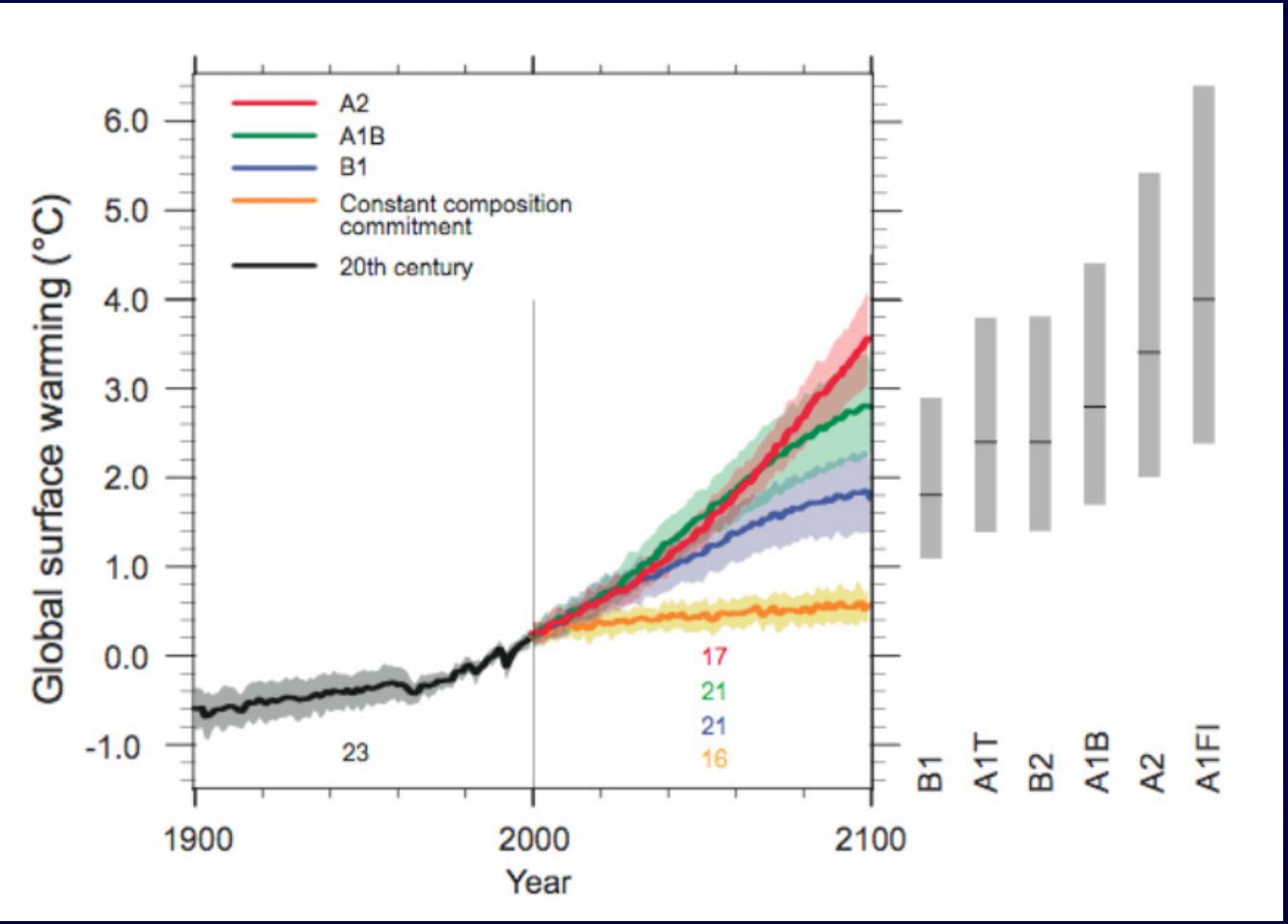
Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.

# IPCC-2007

Most of the observed increase in globally averaged temperature since the mid-20$^{th}$ 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

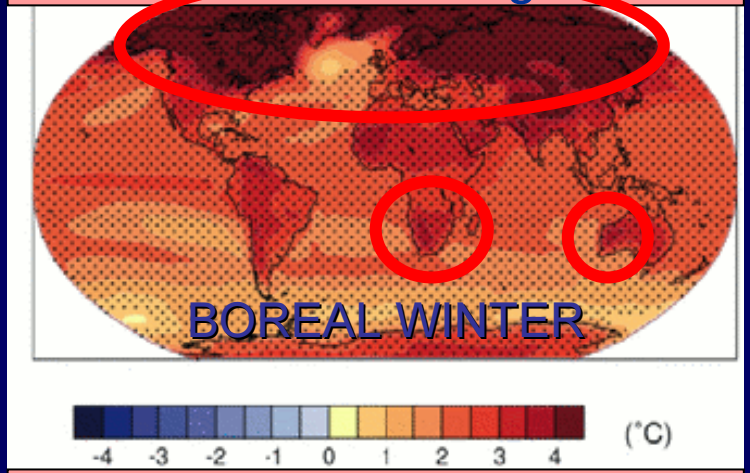



Corresponding changes in sea level rise are 19-58 cm

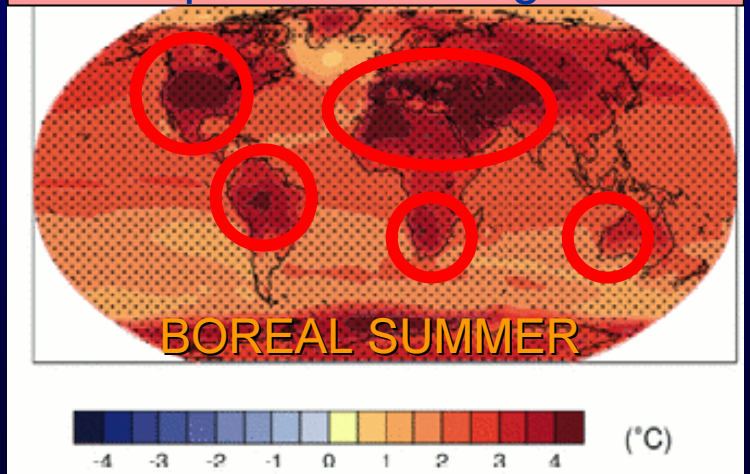
# Regional distribution of projected temperature and precipitation change

## (A1B scenario, 2090-2100)

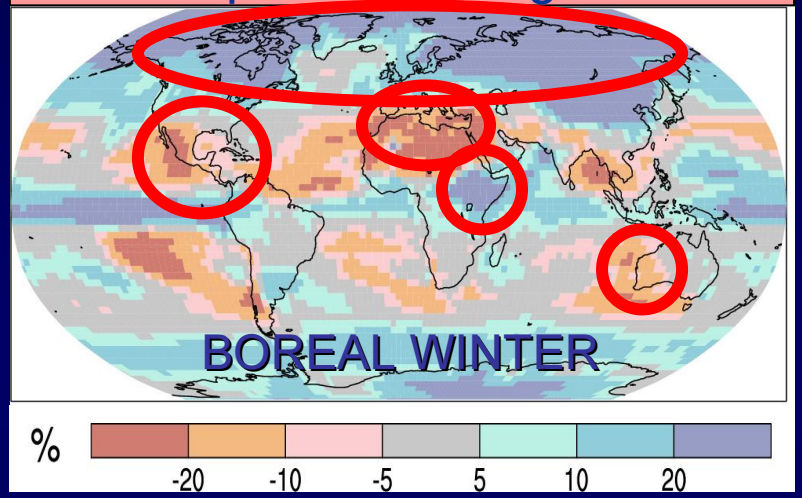
### Temperature change DJF



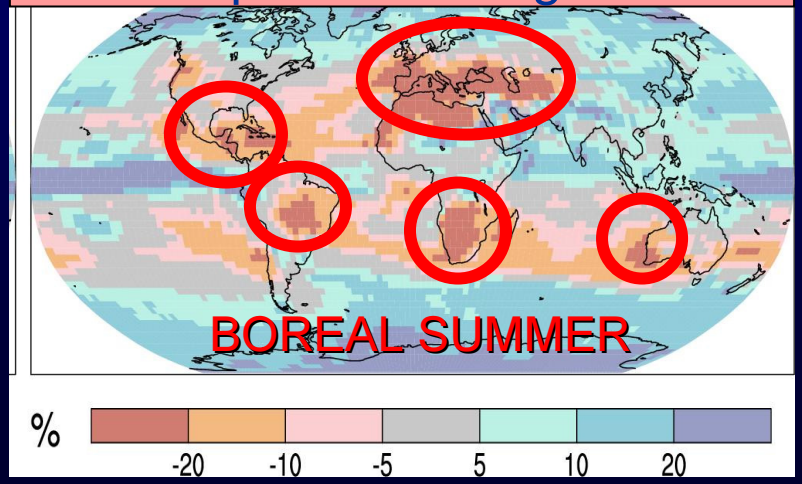

### Temperature change JJA



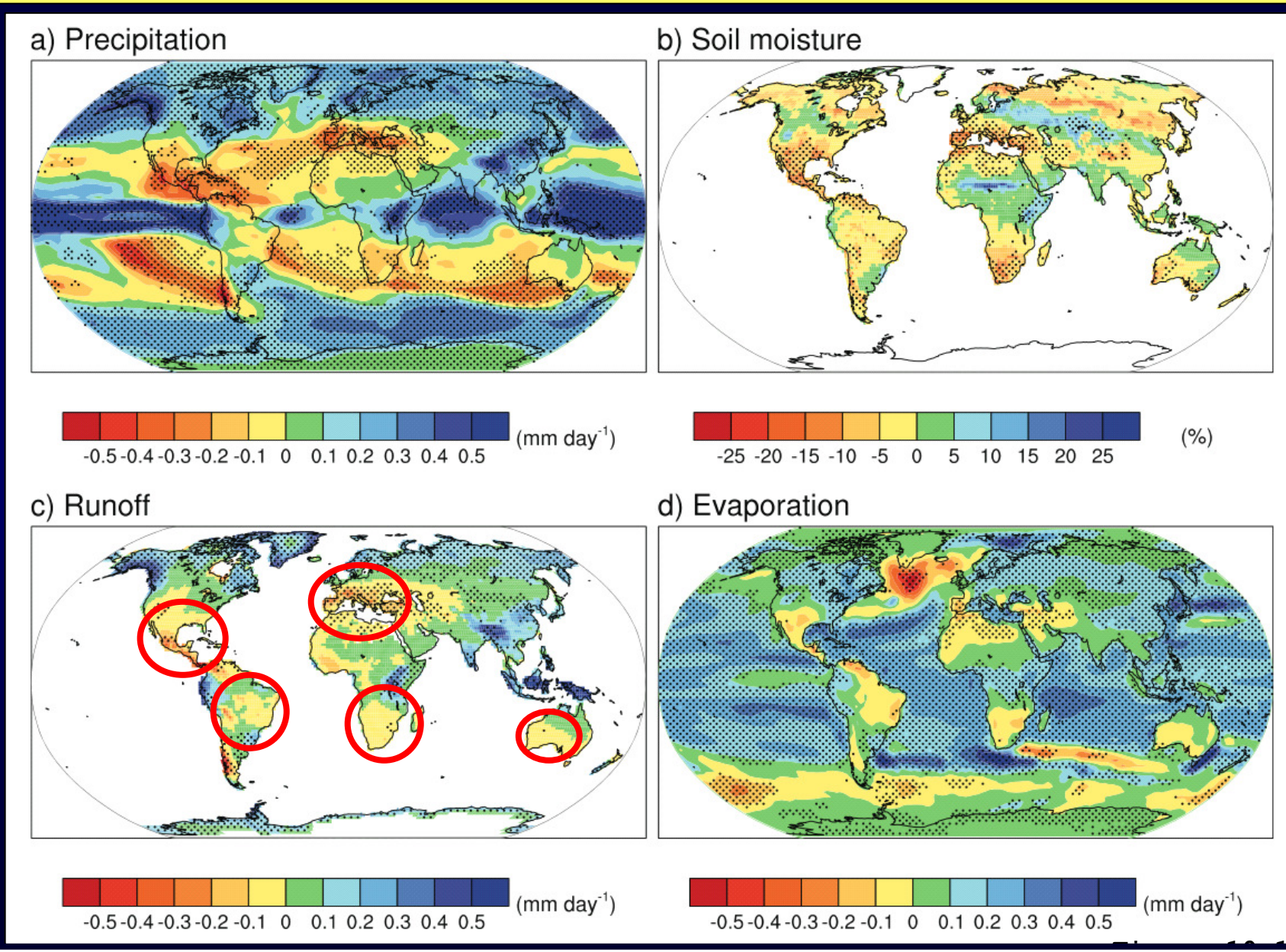

### Precipitation change DJF



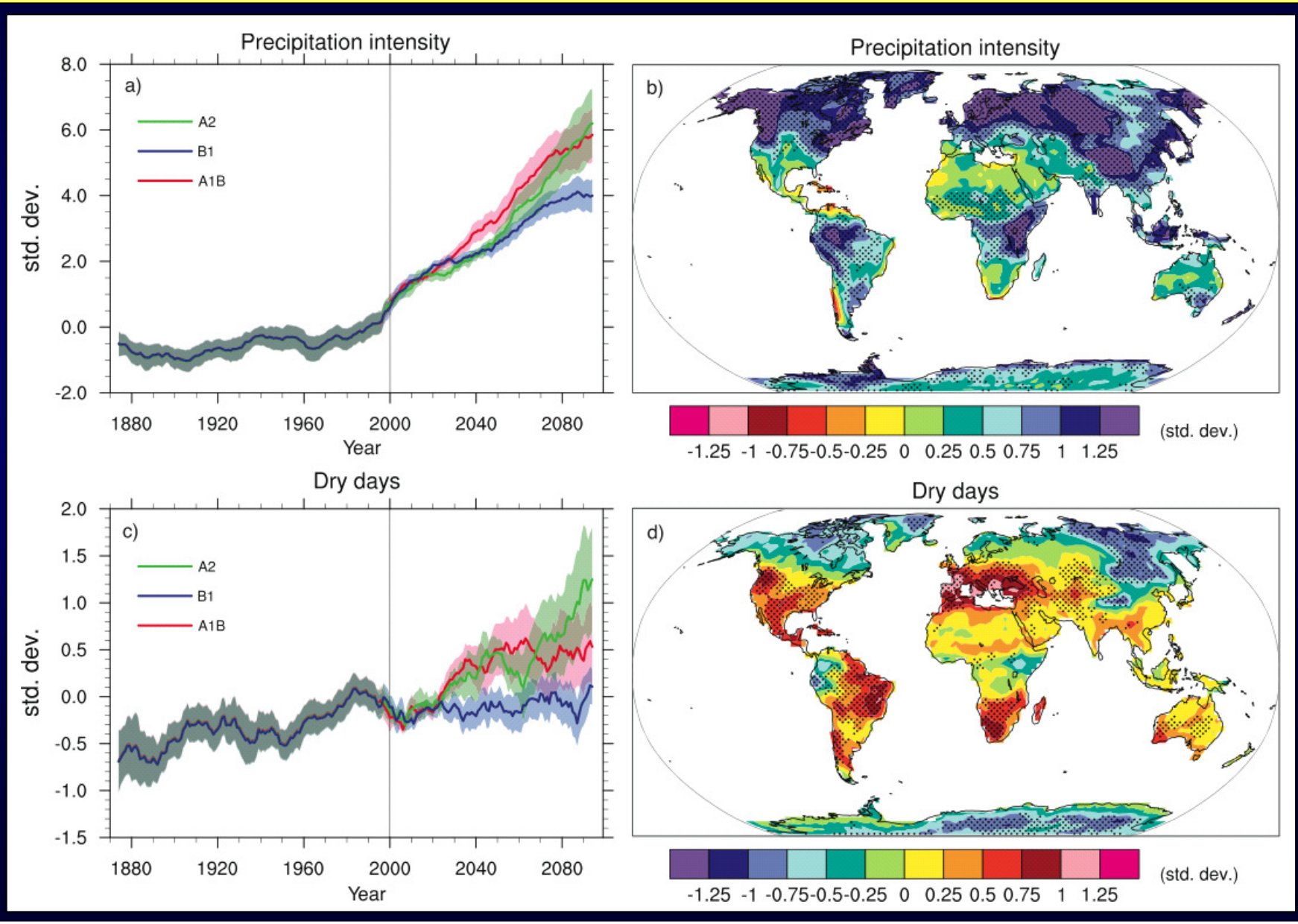

### Precipitation change JJA



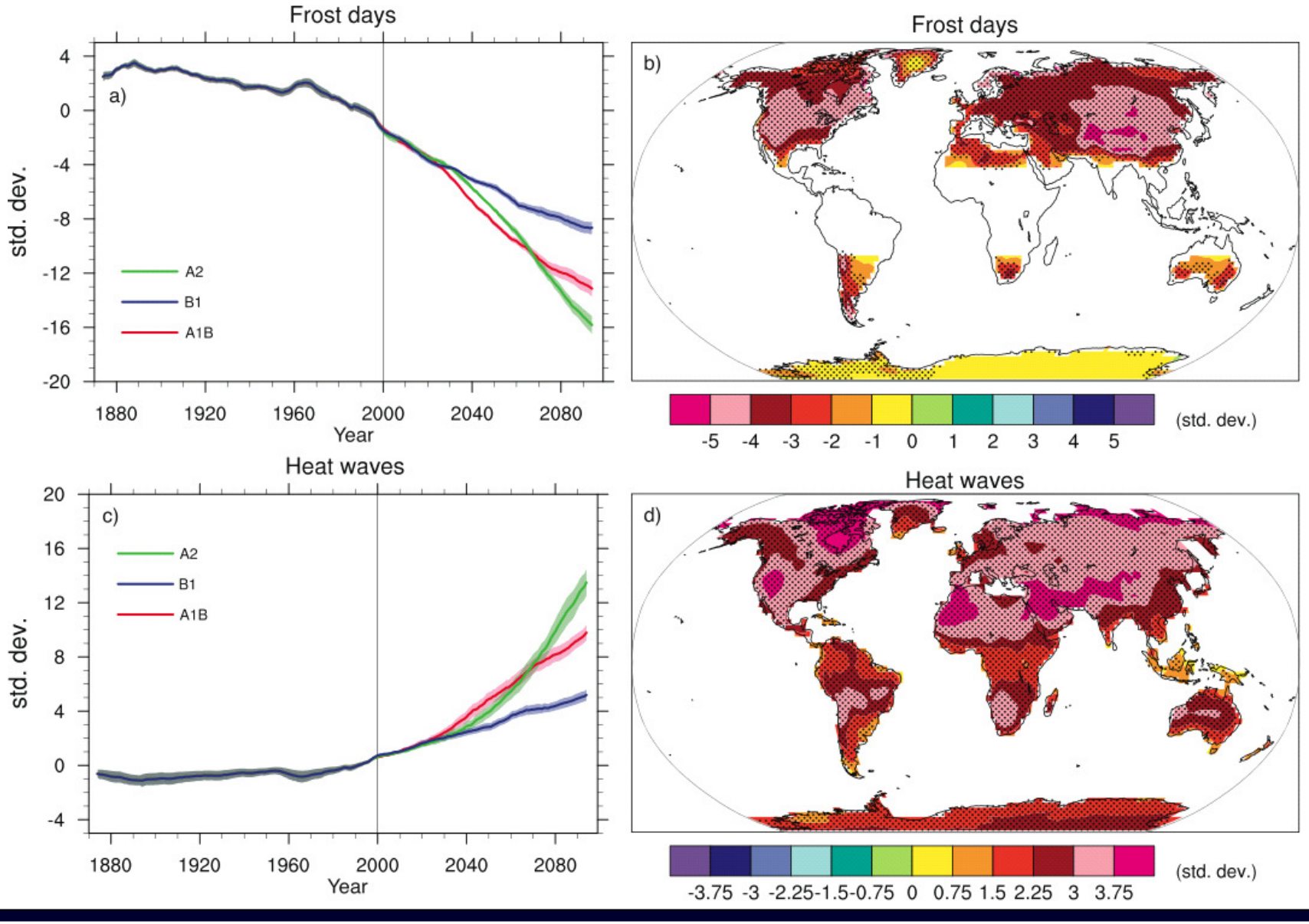
# Projected changes in the hydrologic cycle



# Changes in precipitation characteristics



# Projected changes in extremes



# 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

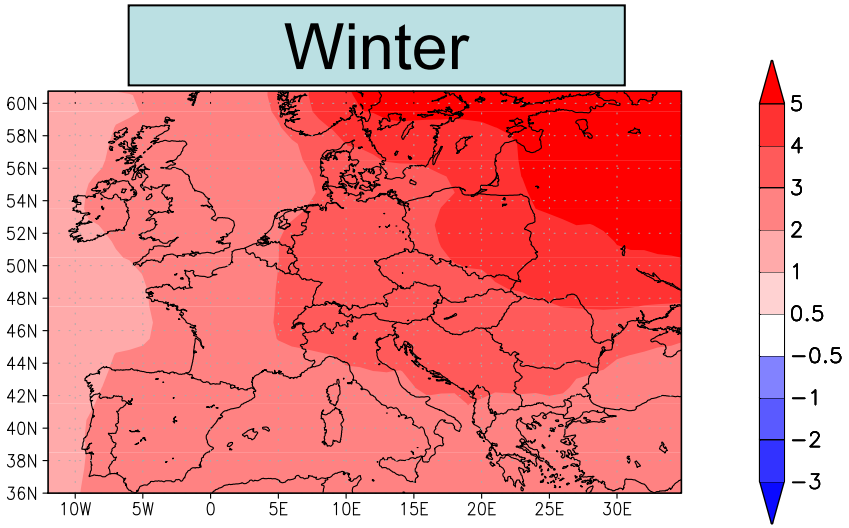
-> Further widespread melting of glaciers and sea ice

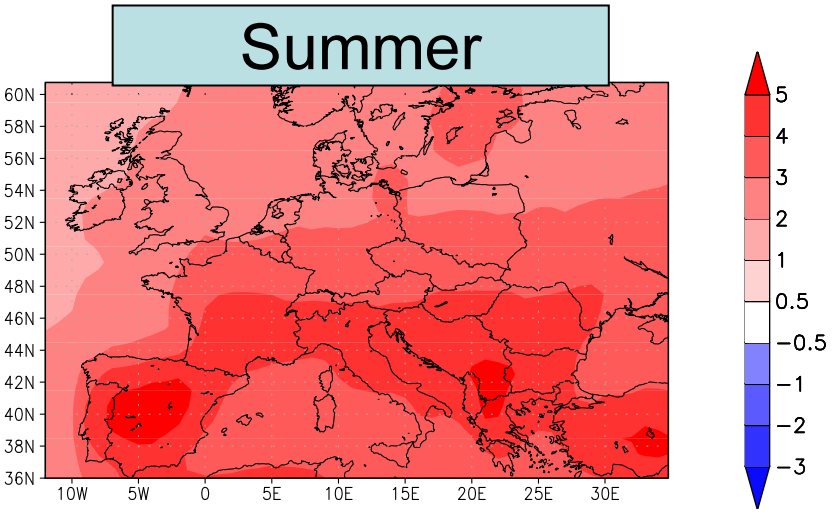
-> Slow down (but not collapse) of the MOC


Focusing on the
european region

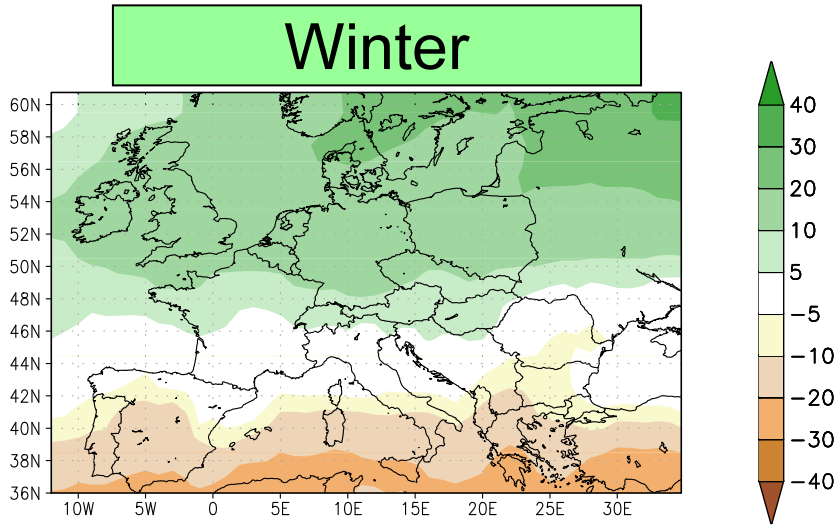
# A1B Scenario, 20 AOGCMs

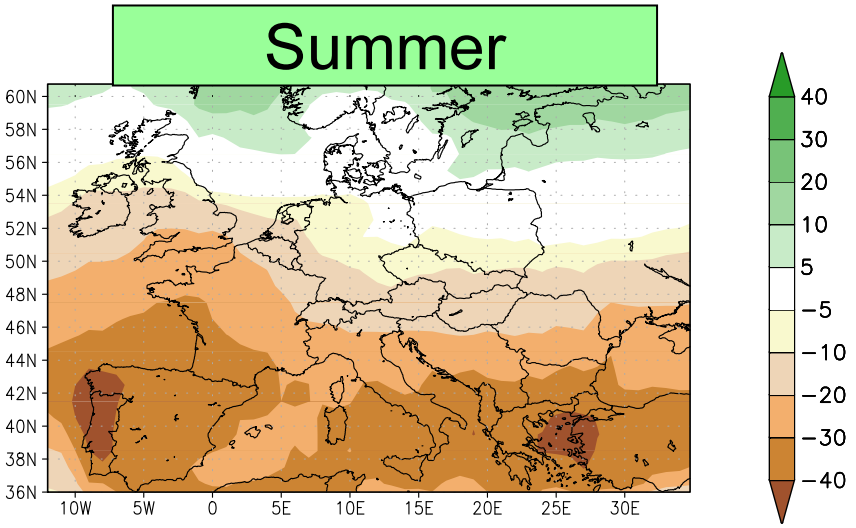
## Temperature Change



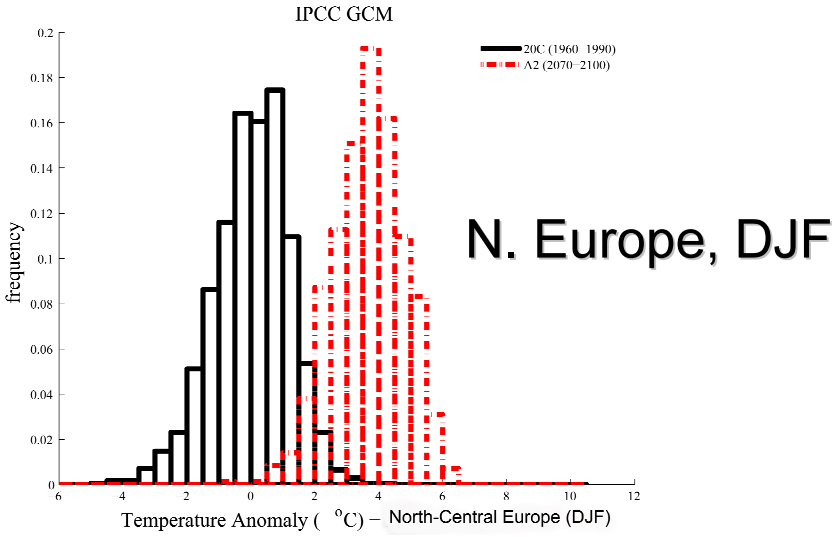

## Precipitation Change



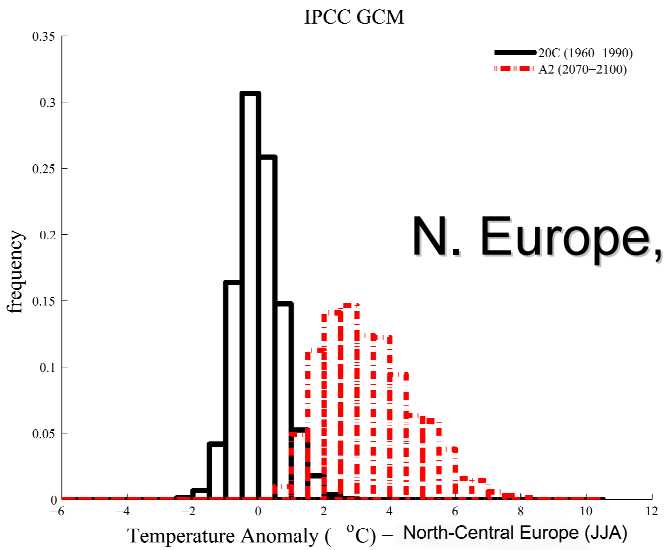



# Change in seasonal temperature distribution

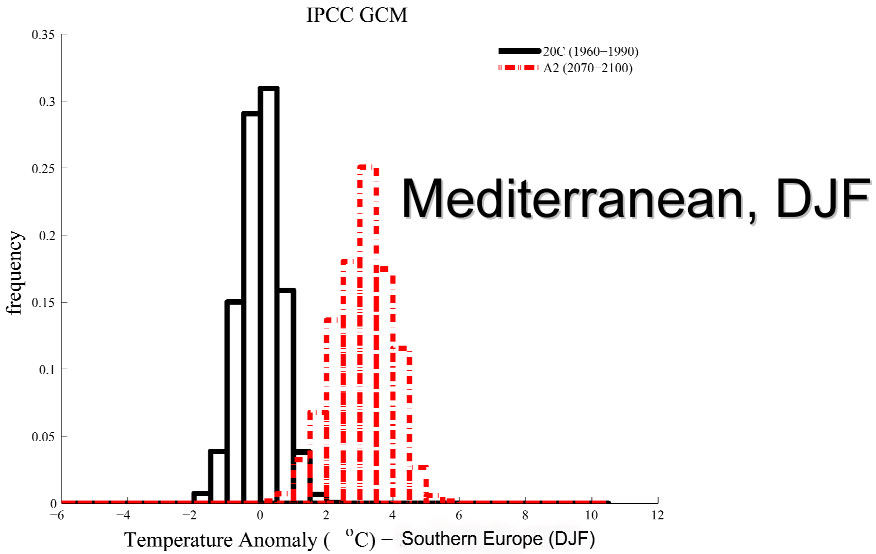
## CMIP3 Ensemble (%, 2071-2100 minus 1961-1990),



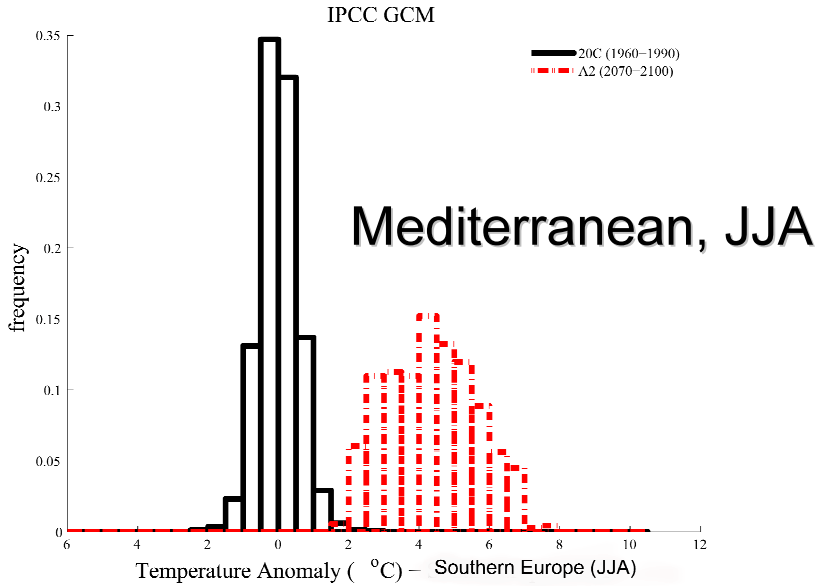

N. Europe, DJF




N. Europe, JJA



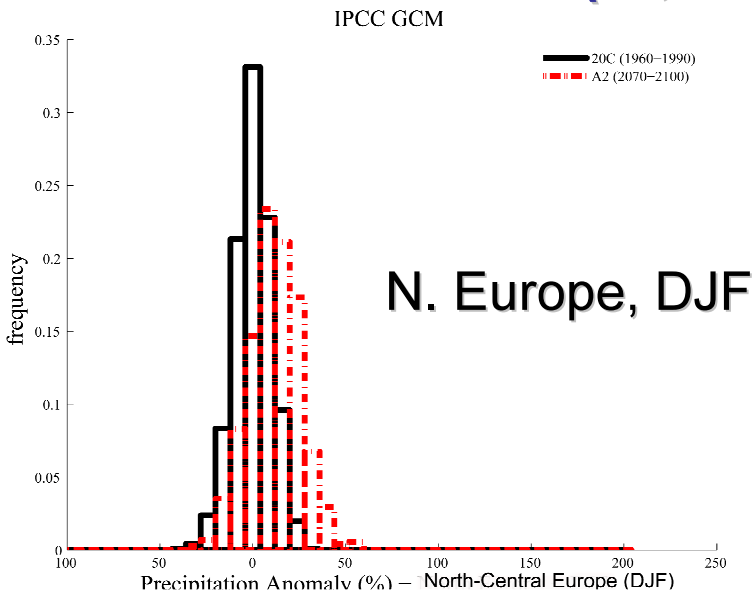

Mediterranean, DJF



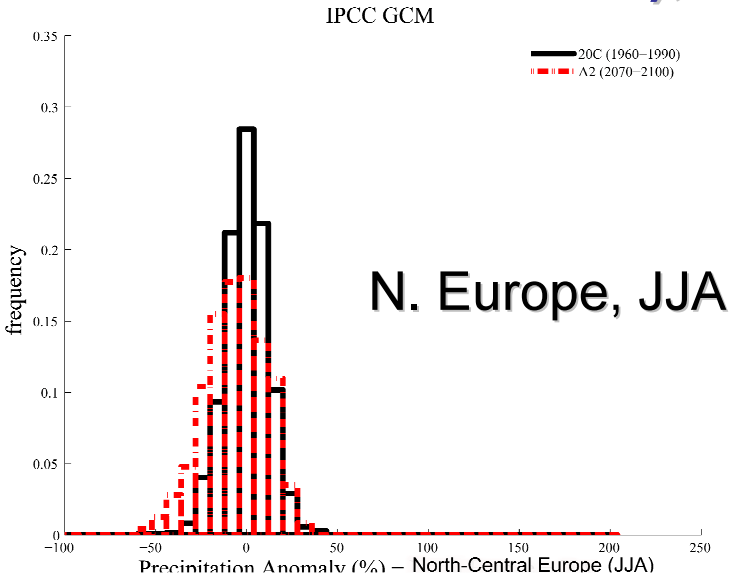

Mediterranean, JJA

# Change in seasonal precipitation distribution

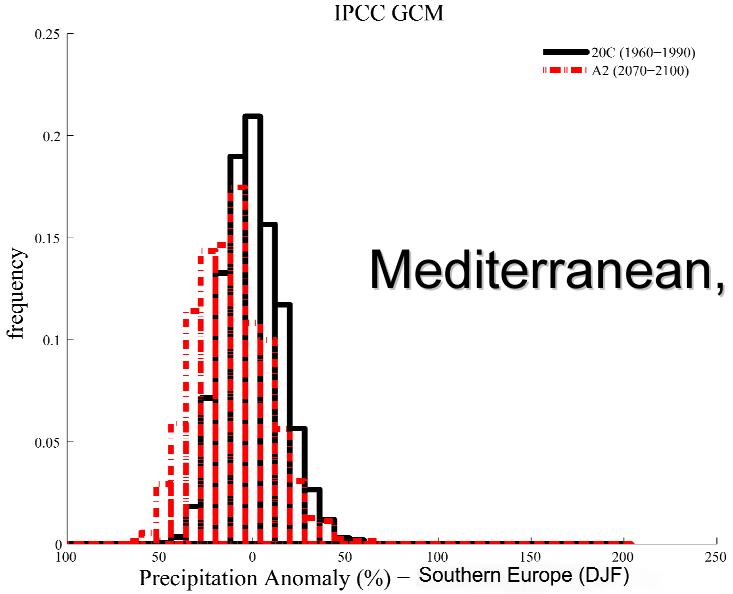
## CMIP3 Ensemble (%, 2071-2100 minus 1961-1990),



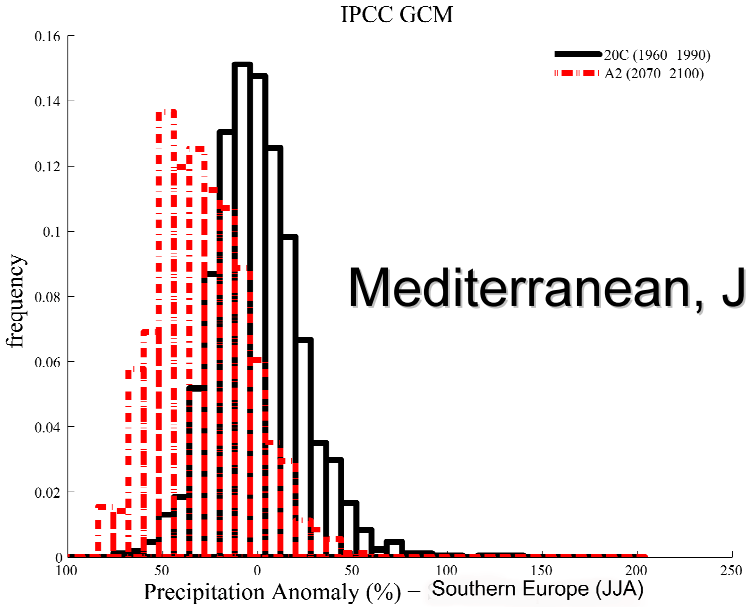

N. Europe, DJF




N. Europe, JJA



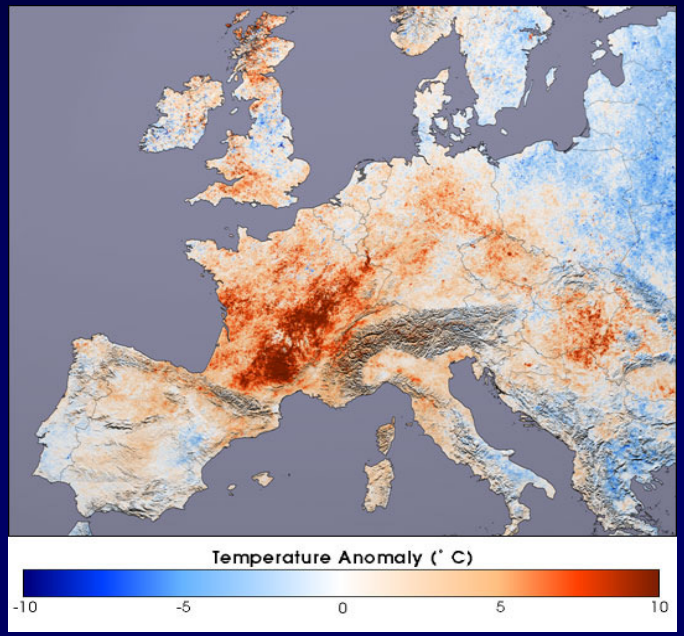

Mediterranean, DJF

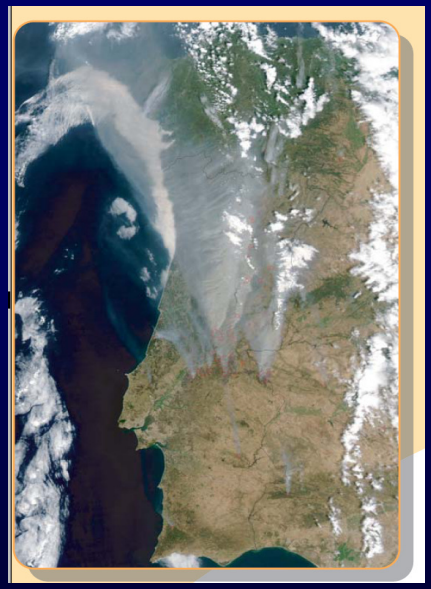


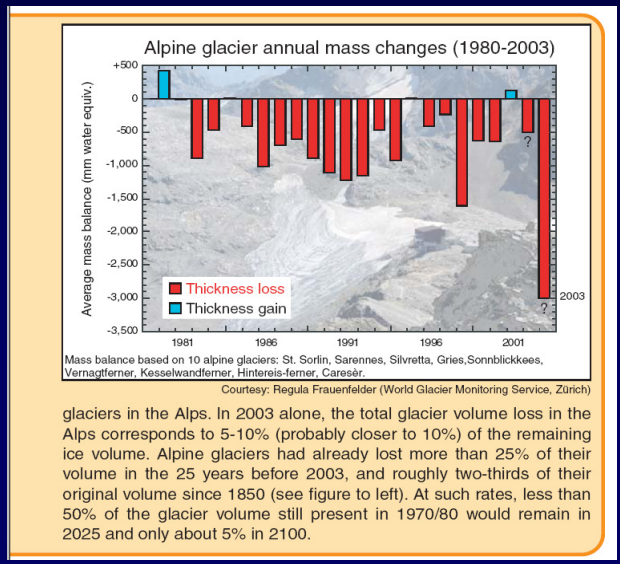

Mediterranean, JJA

# The summers we can expect in Europe?

## Summer of 2003



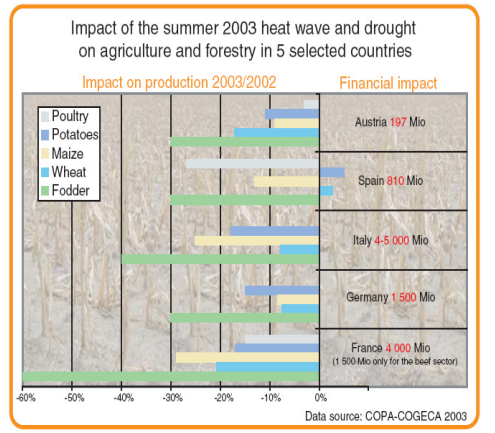






glaciers in the Alps. In 2003 alone, the total glacier volume loss in the Alps corresponds to 5-10% (probably closer to 10%) of the remaining ice volume. Alpine glaciers had already lost more than 25% of their volume in the 25 years before 2003, and roughly two-thirds of their original volume since 1850 (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 |

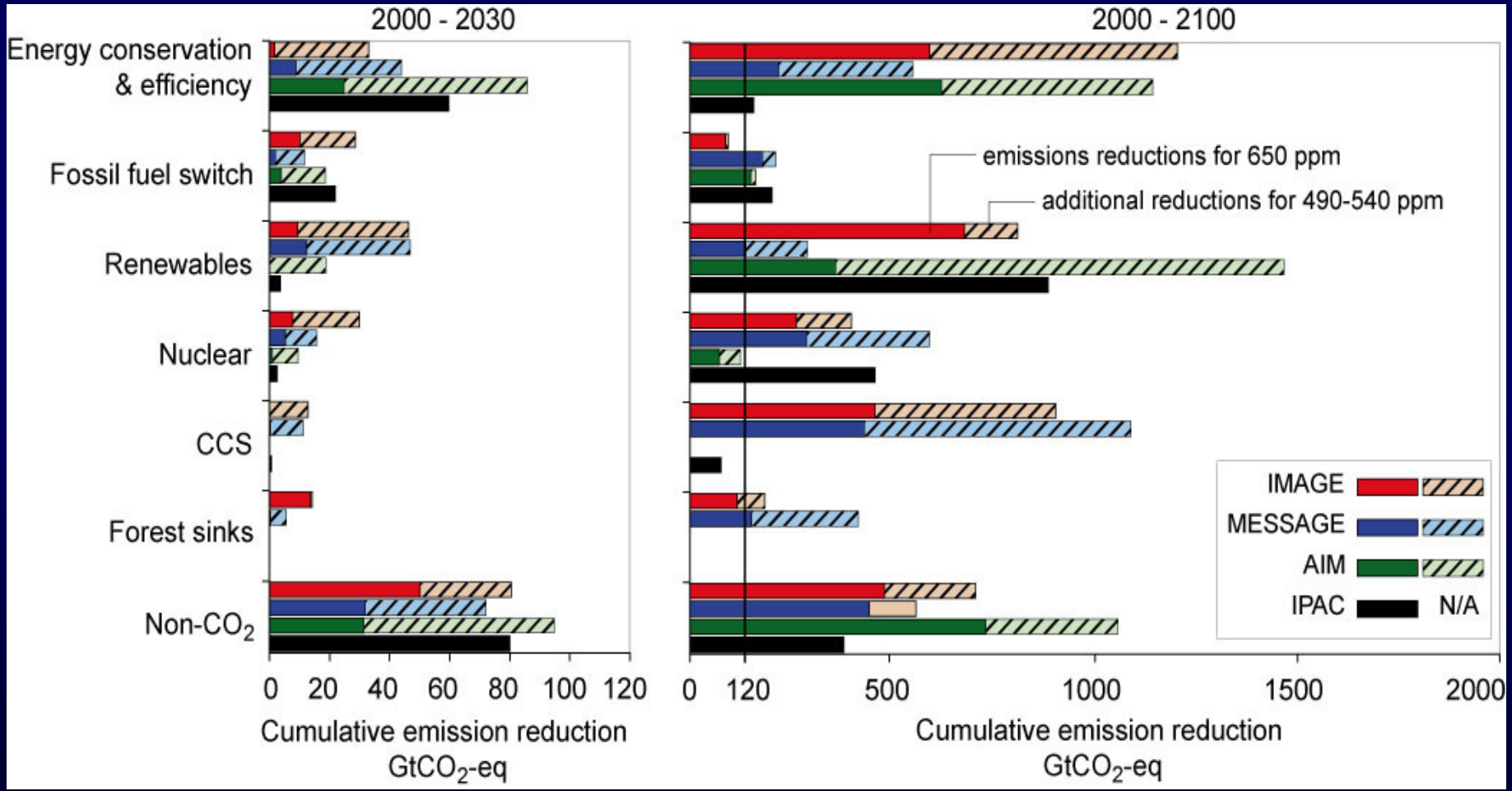
INSERM: "Surmortalité liée à la canicule de l'été 2003", AP September 25, 2003



# Summary of changes relevant for energy policies

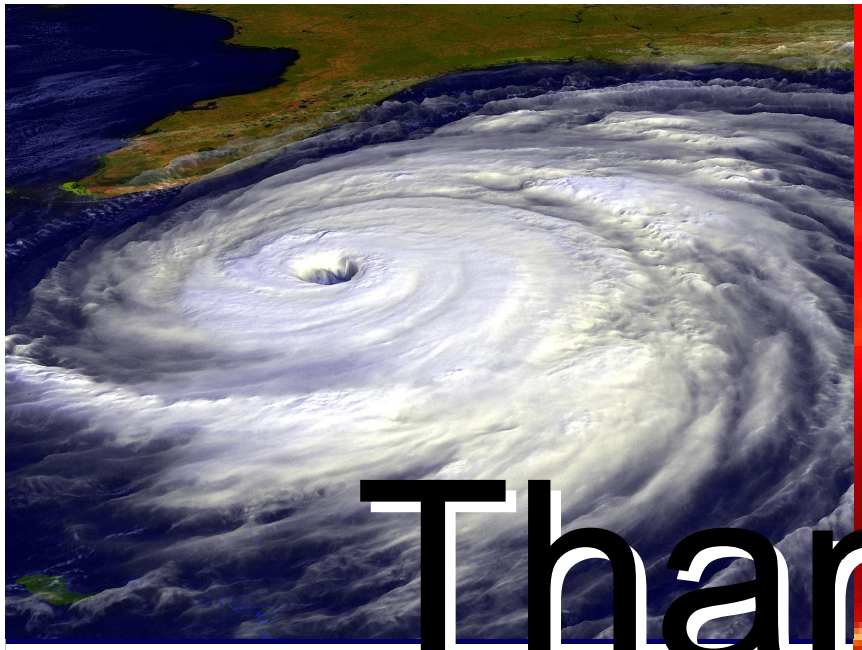
- Increase in intensity of storms and winds
- Increase in dry and wet extremes
- Increase in interannual variability
- Increase in heat waves
- Large regional variability of changes

# 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)



# Thank You