Climate Change over the Mediterranean region

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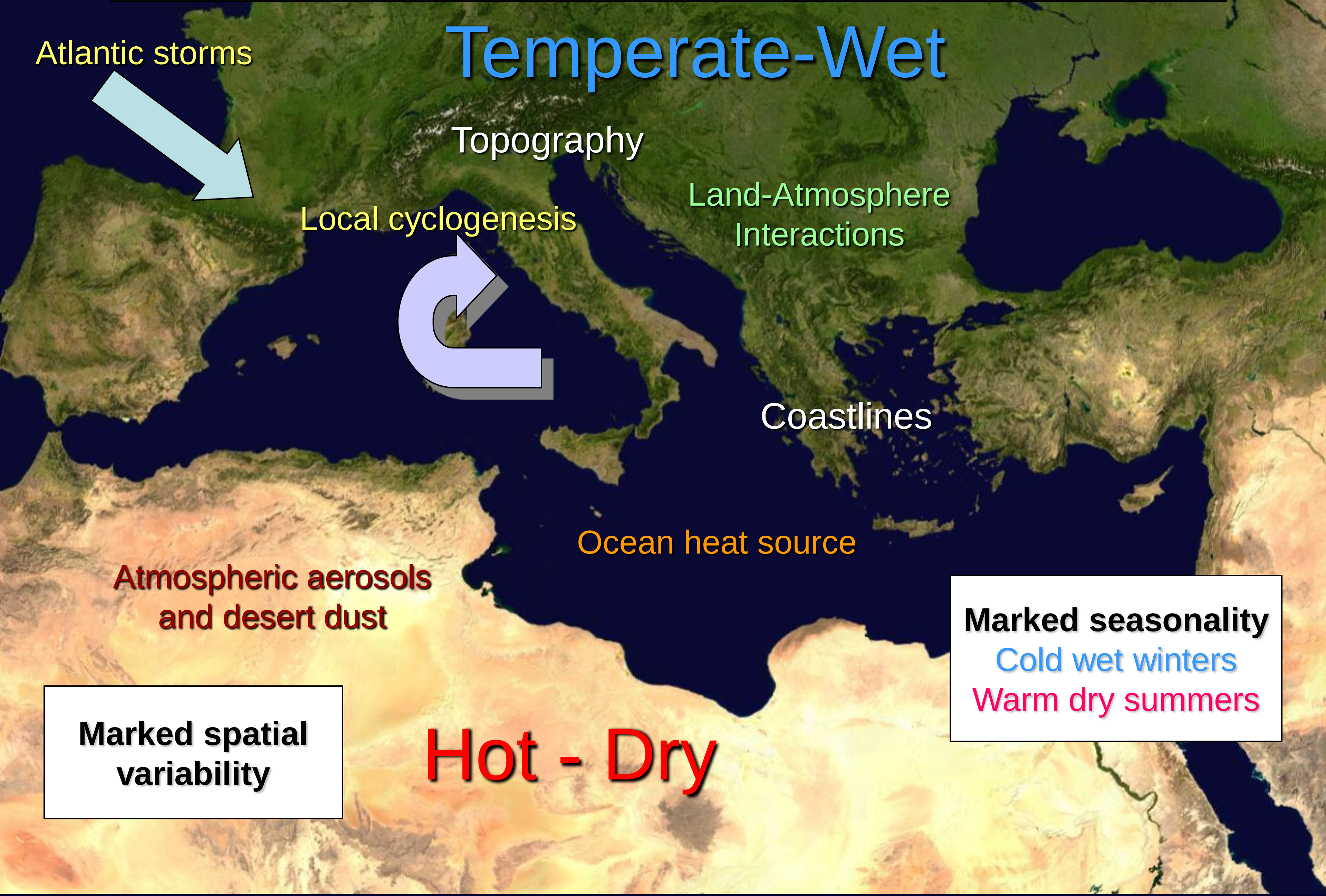
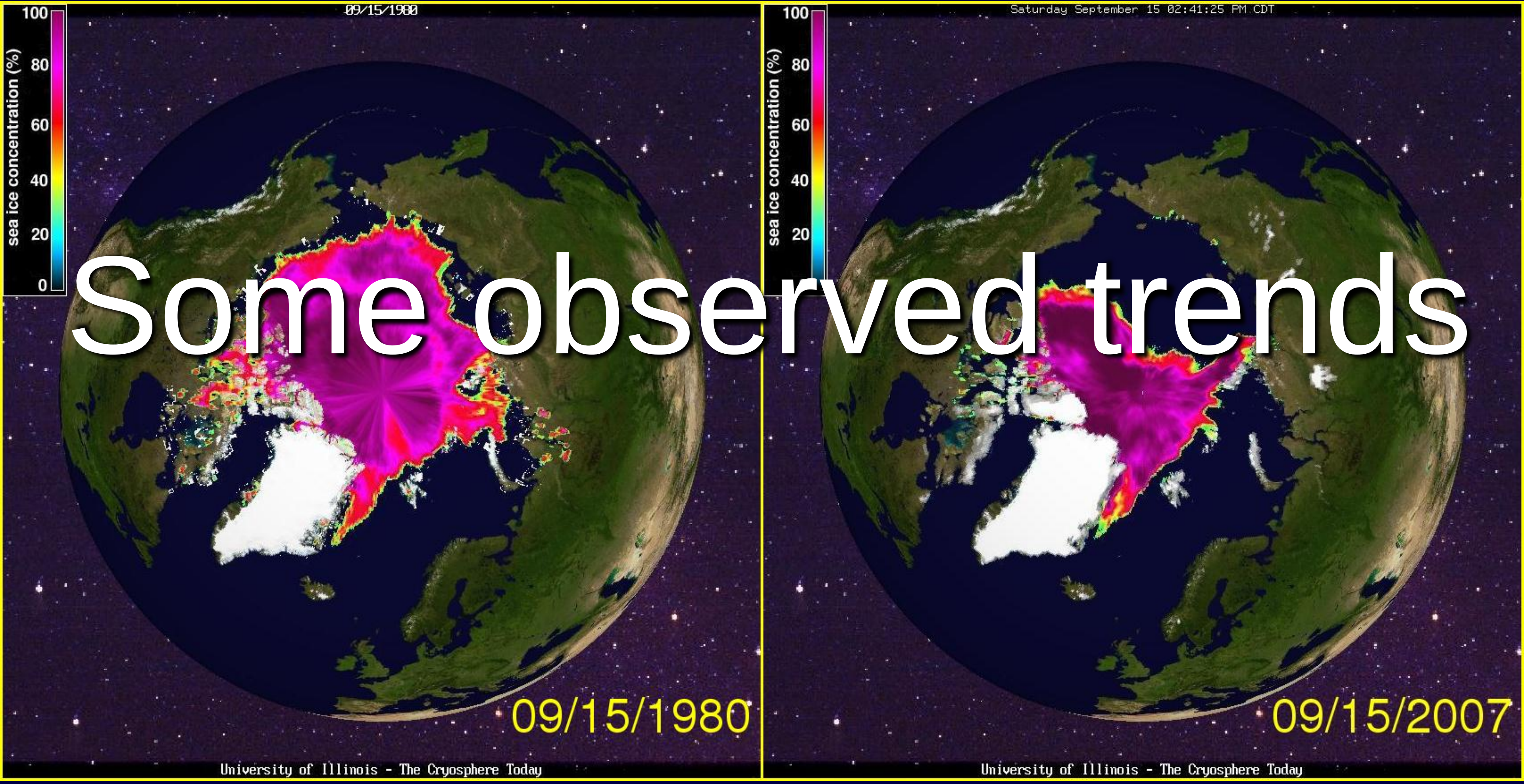
Abdus Salam ICTP, Trieste

ECSAC 2012, Losinj, Croatia

The climate of the Mediterranean

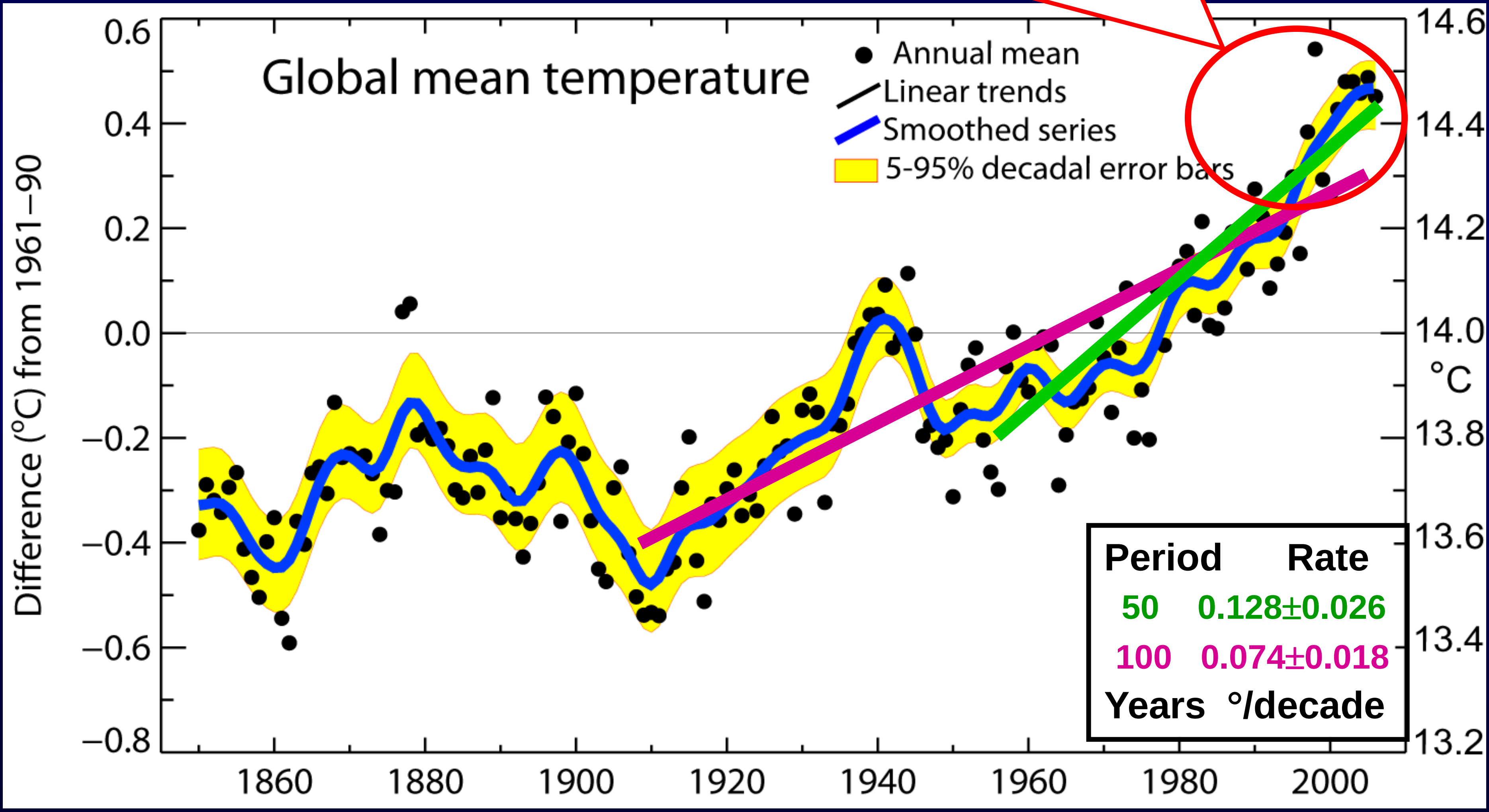


Some observed trends

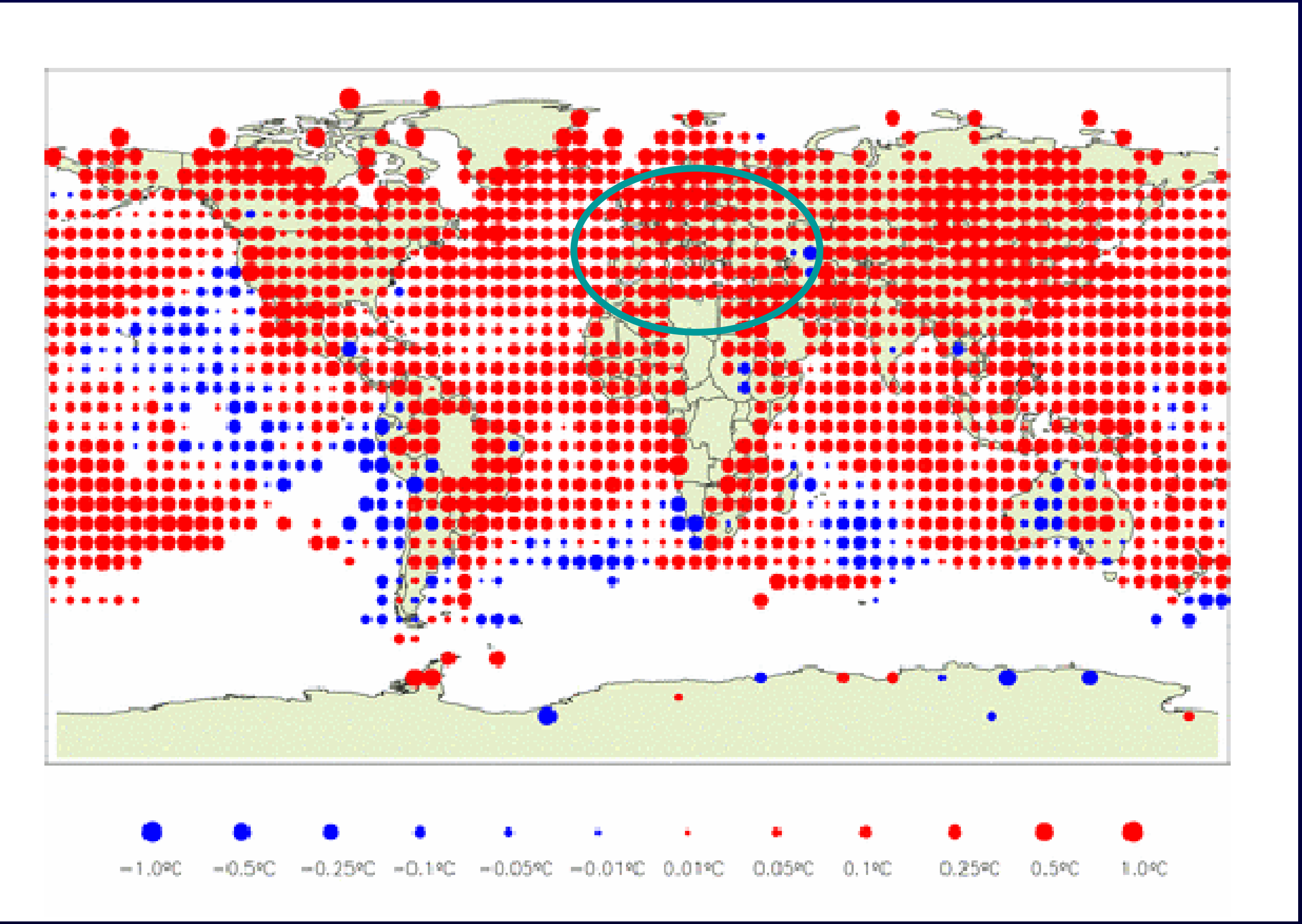


Observed change in global surface temperature

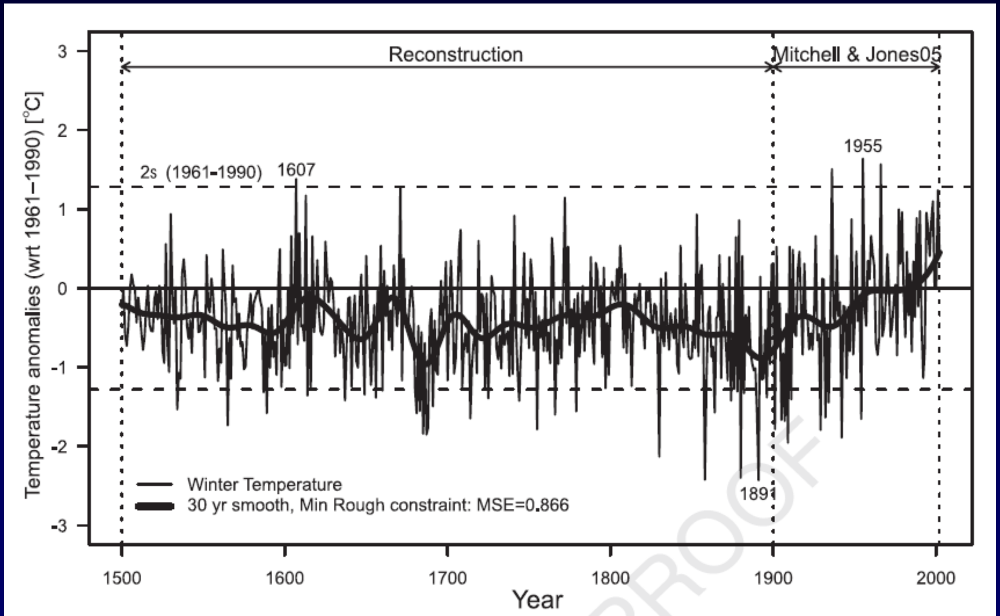
Warmest 12 years:
1998,2005,2003,2002,2004,2006, 2001,1997,1995,1999,1990,2000



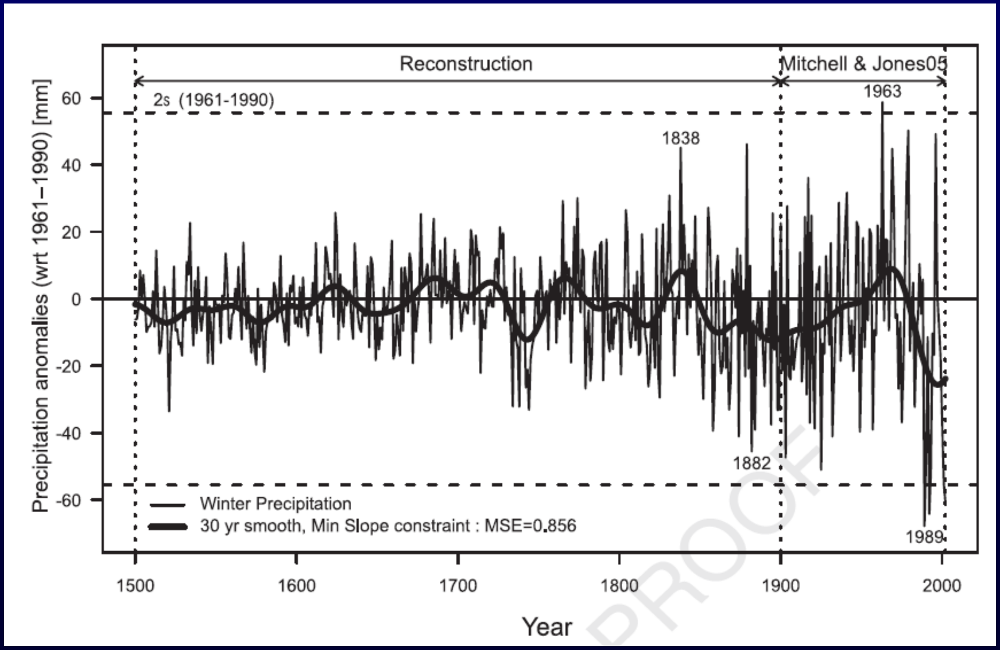
Temperature change 1979-2003



Reconstructed Mediterranean climate variability (last 500 years)



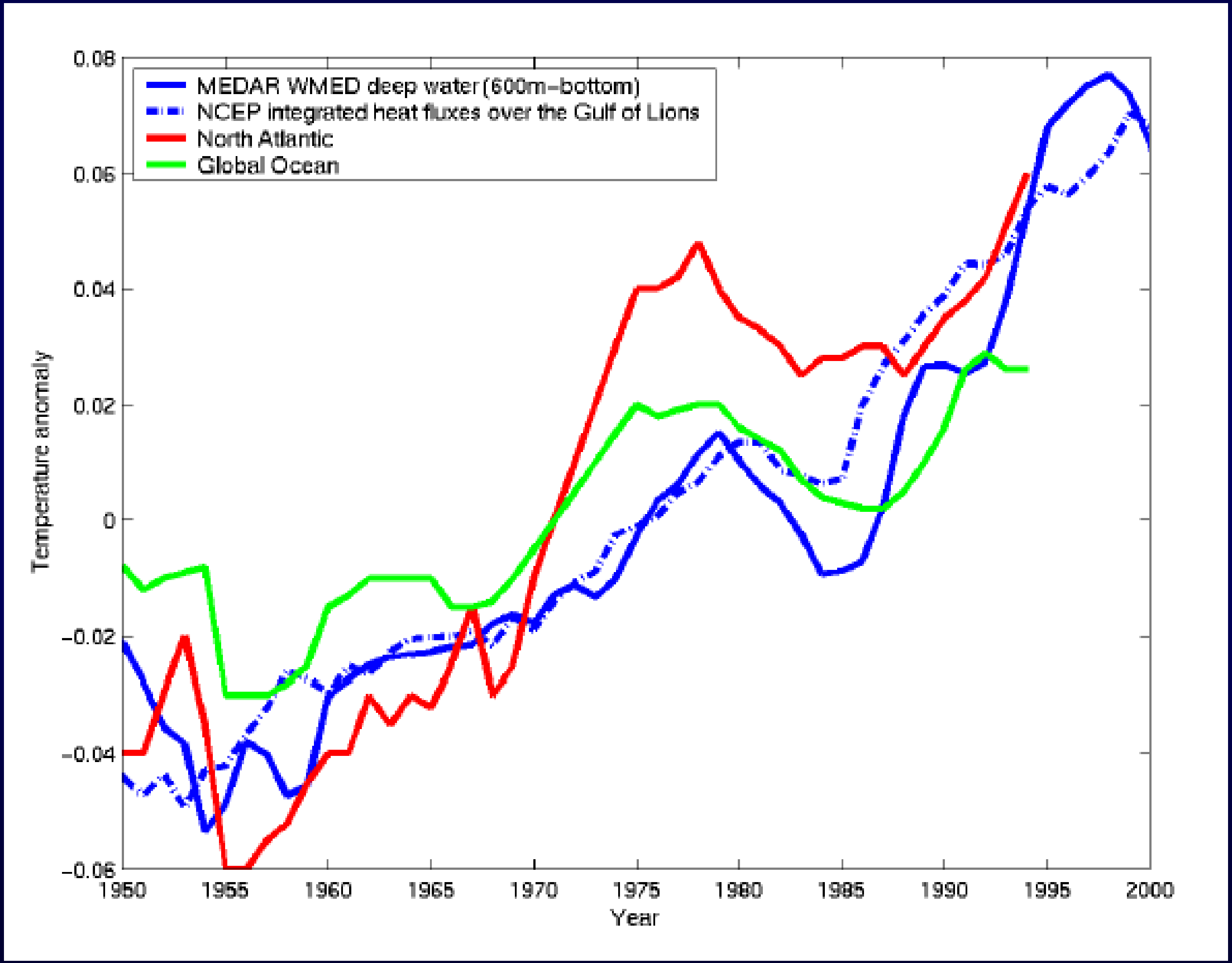
Winter Temperature



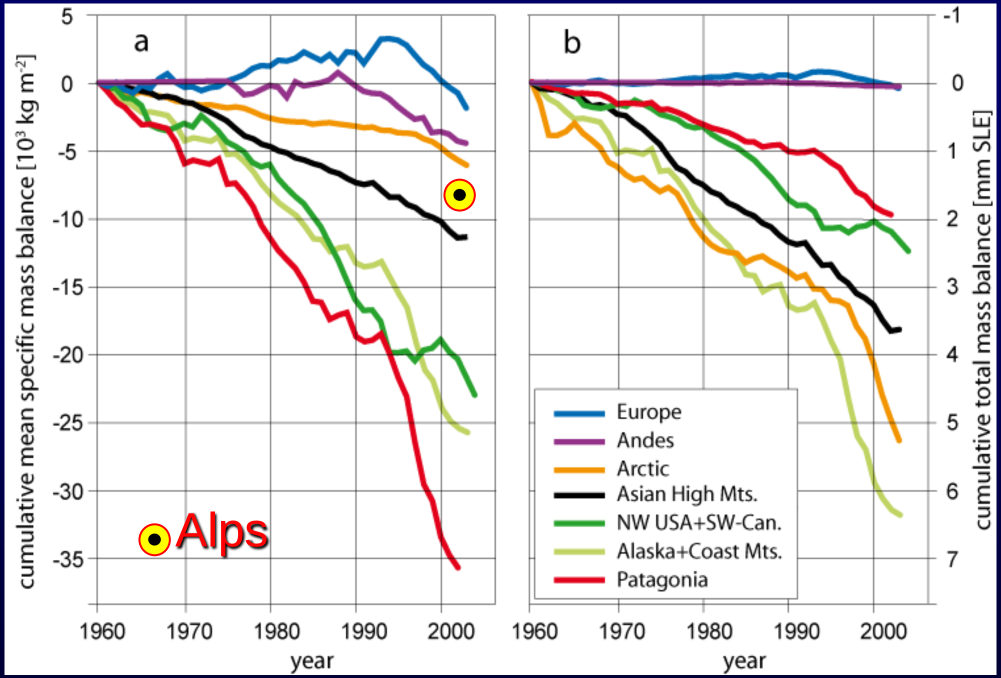
From
Lutherbacher et al. (2006)

Winter Precipitation

Change in Mediterranean water temperature



Melting of glaciers



Sea level rise

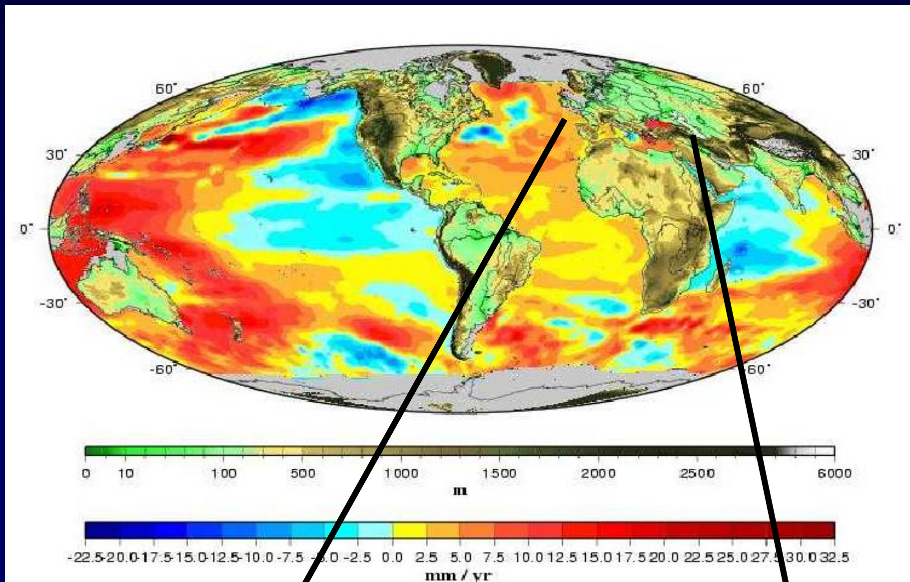
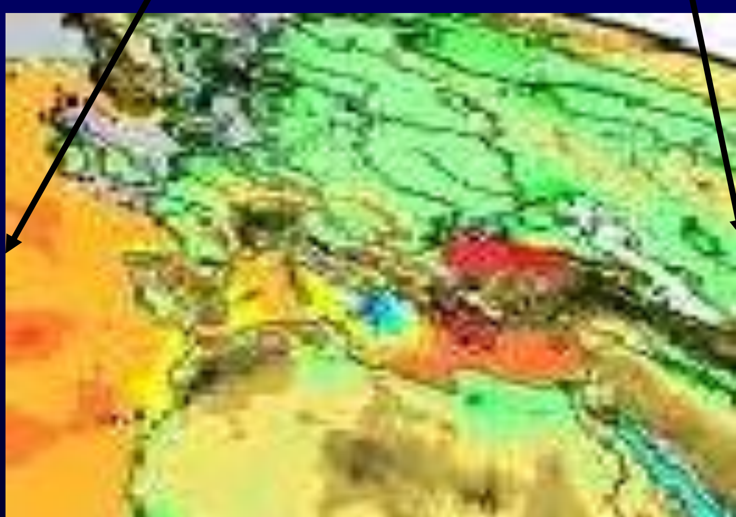
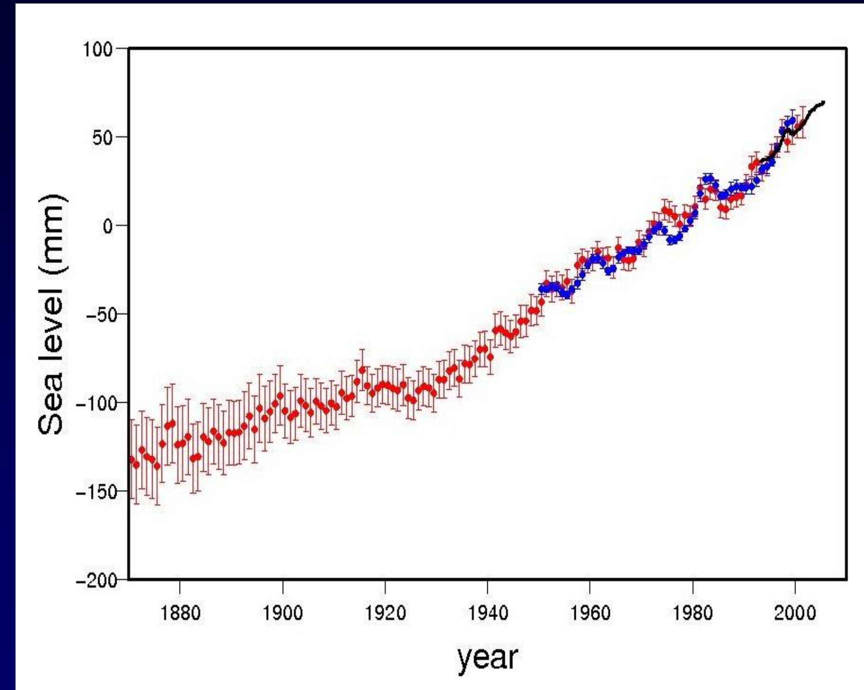


Figure 7. Sea level trends over 1993-2003 from the T/P mission.





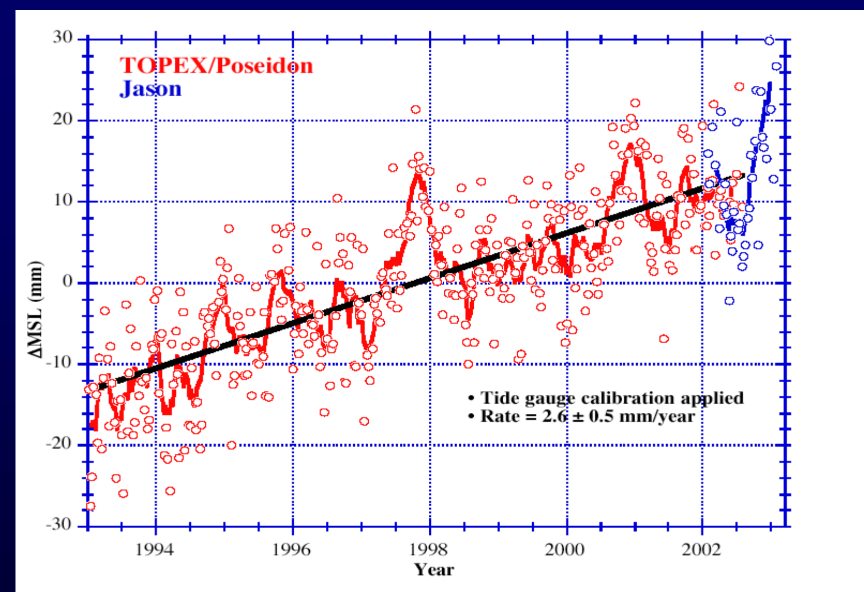


Figure 5. Global mean sea level variations from T/P and Jason.

Other observed changes

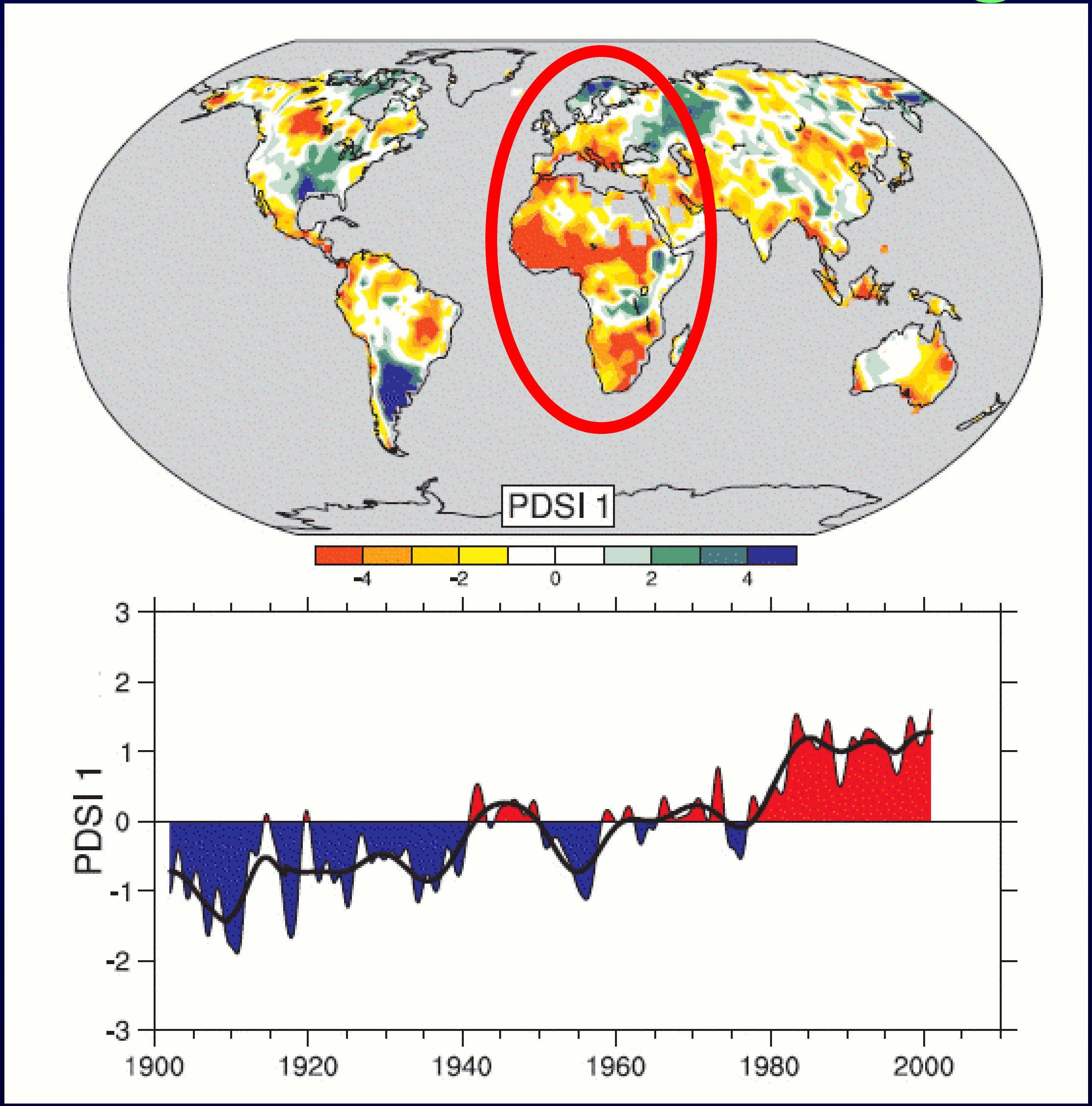
Temperature and precipitation extremes

Increased frequency
of heavy precipitation events

Warmer and more hot days,
warmer and fewer cold days

Increased frequency of
heat waves

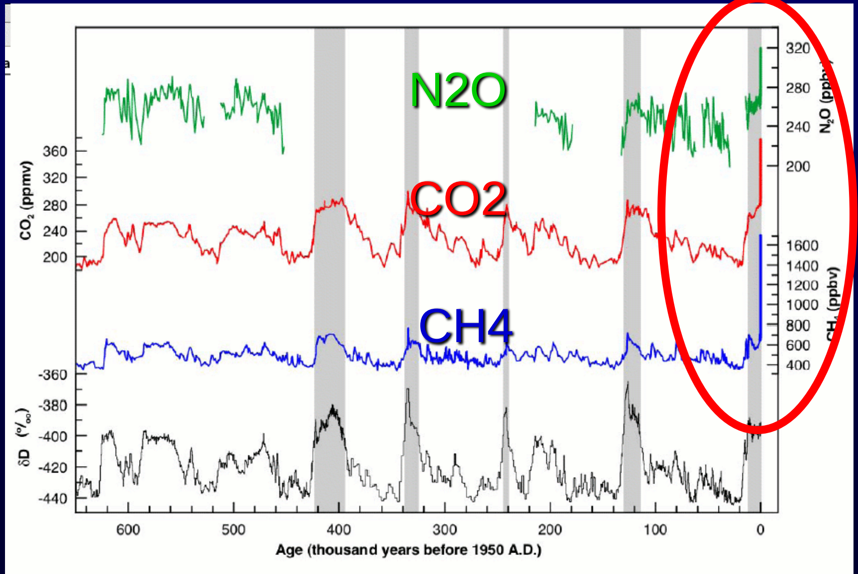
Other observed changes
Droughts

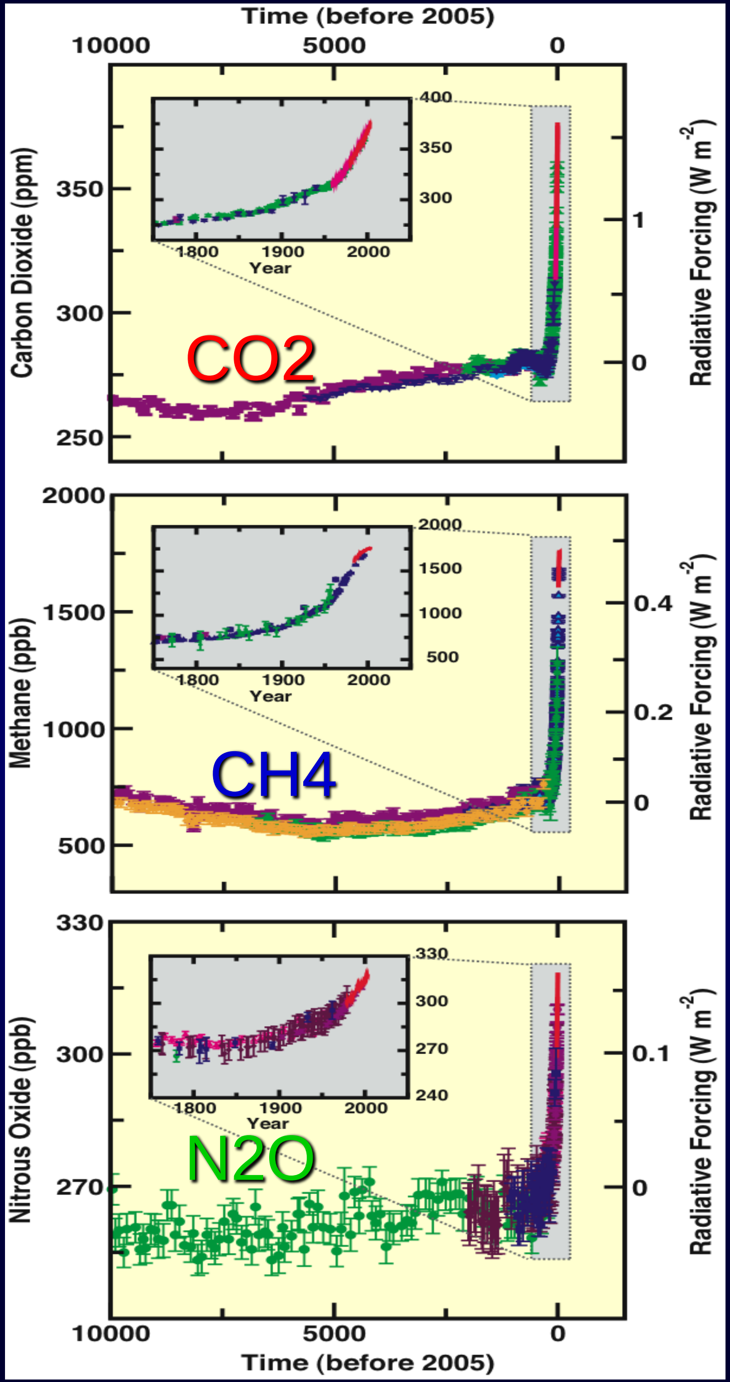


Increase in length and intensity of droughts as measured by the PDSI

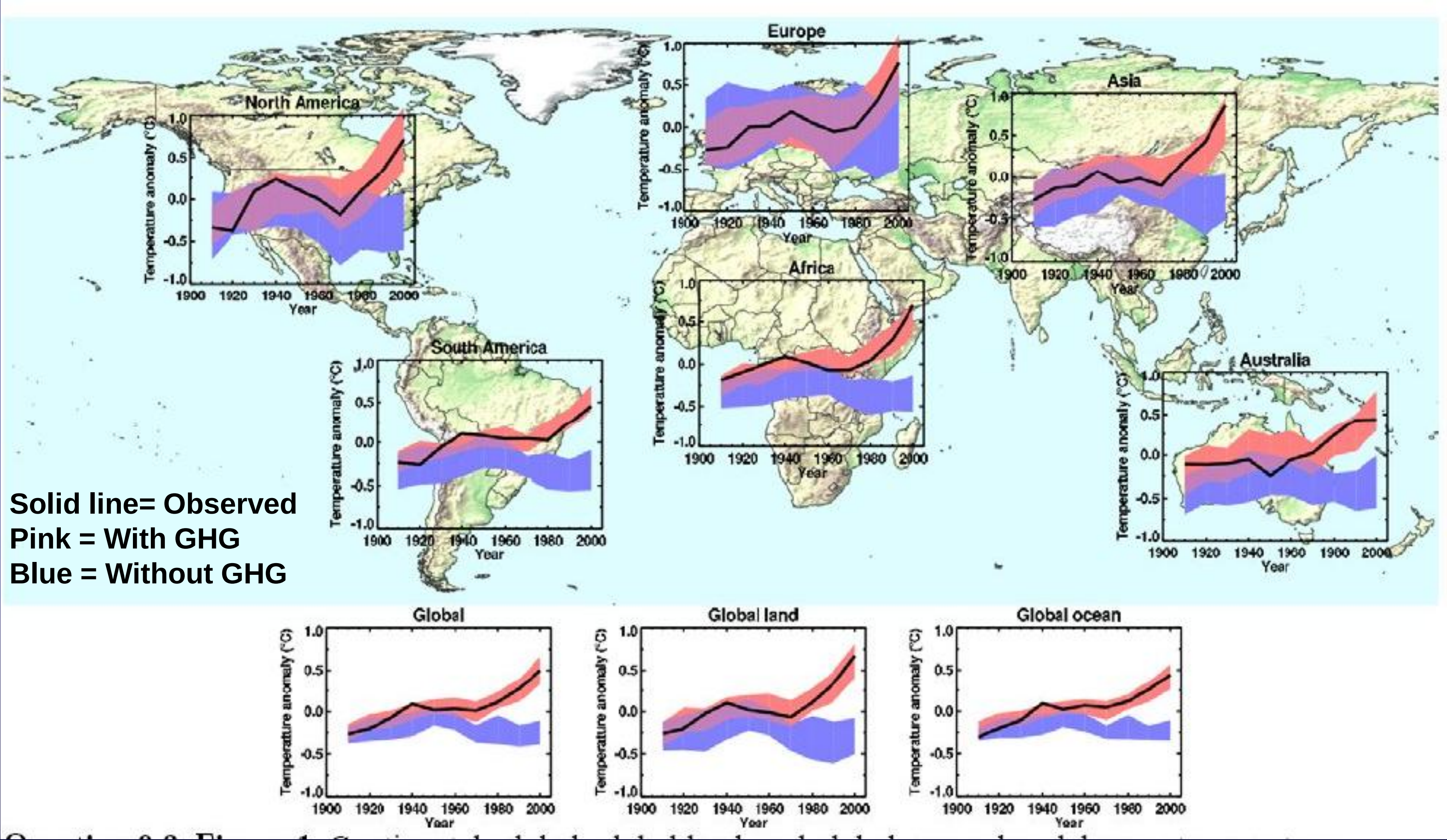
Variation of greenhouse gas concentration in the atmosphere

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.



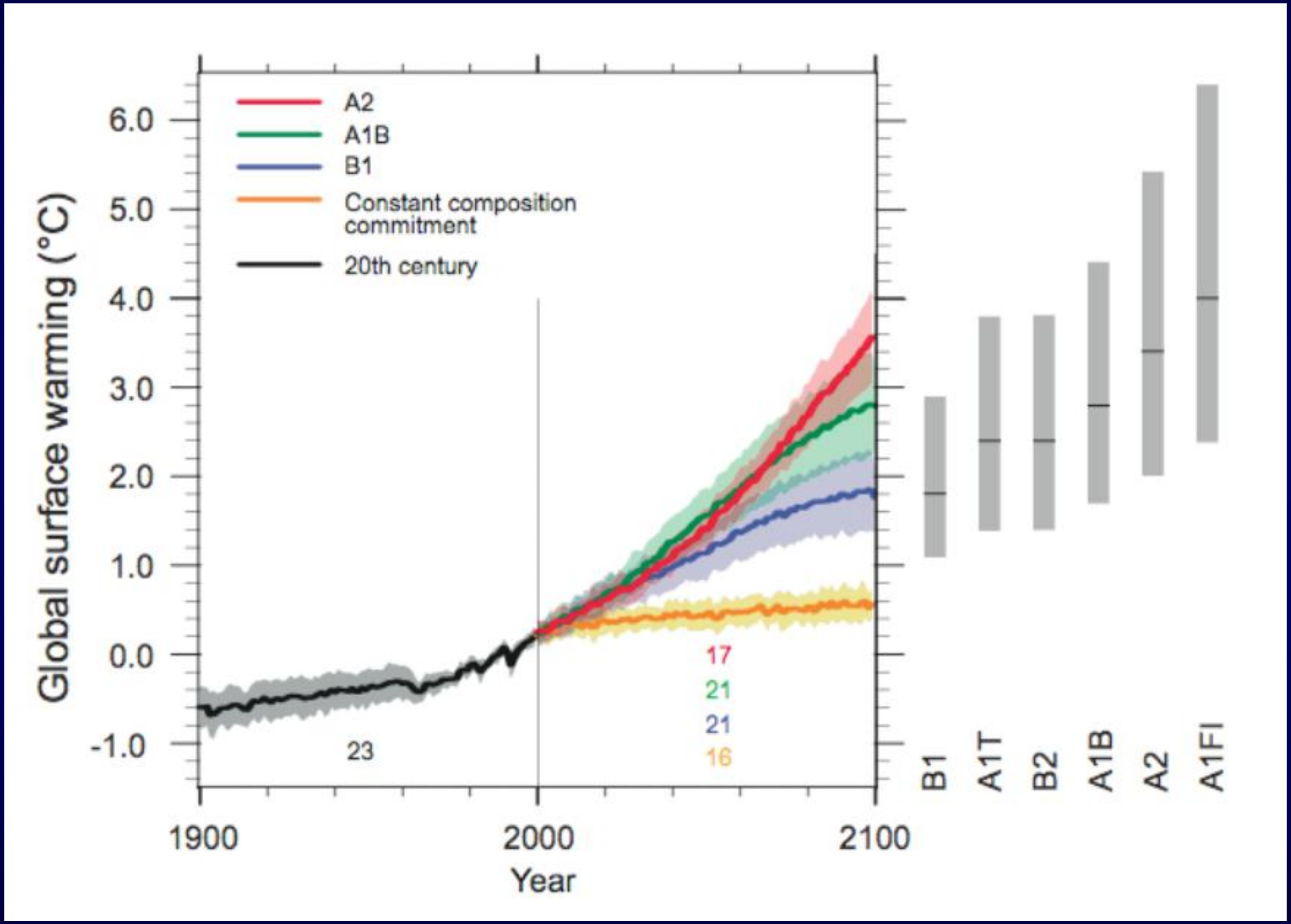


Identificaton of the anthropogenic effect on regional and ocean warming



Projections of future climate change

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

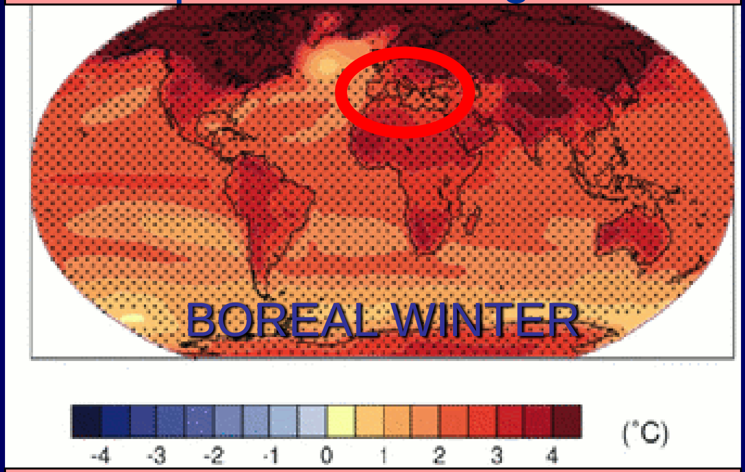


Corresponding changes in sea level rise are 19-58 cm

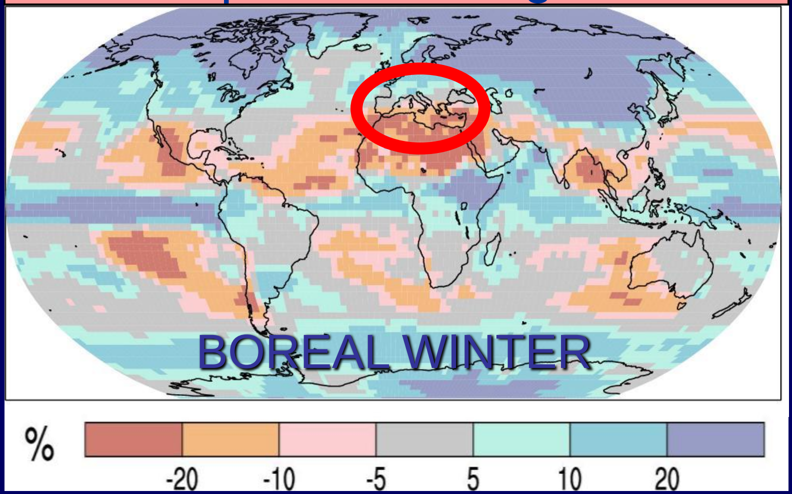
Regional distribution of projected temperature and precipitation change

(A1B scenario, 2090-2100)

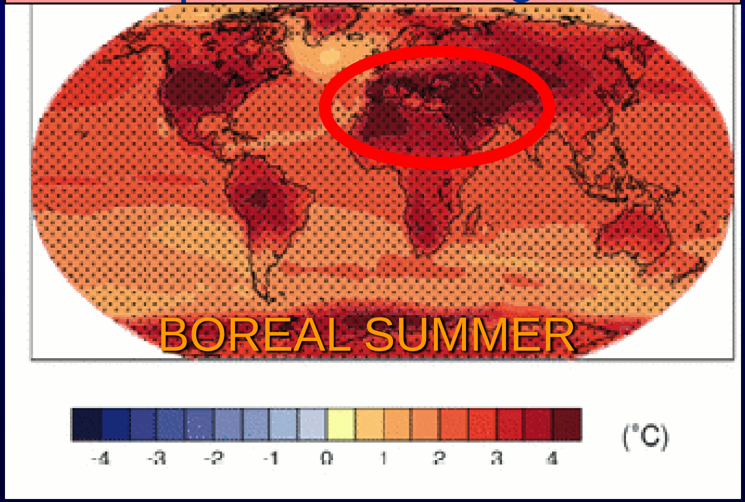
Temperature change DJF



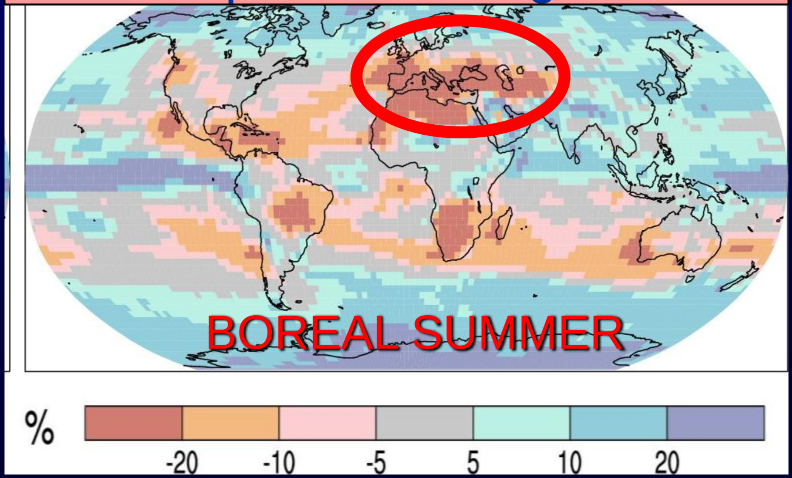
Precipitation change DJF



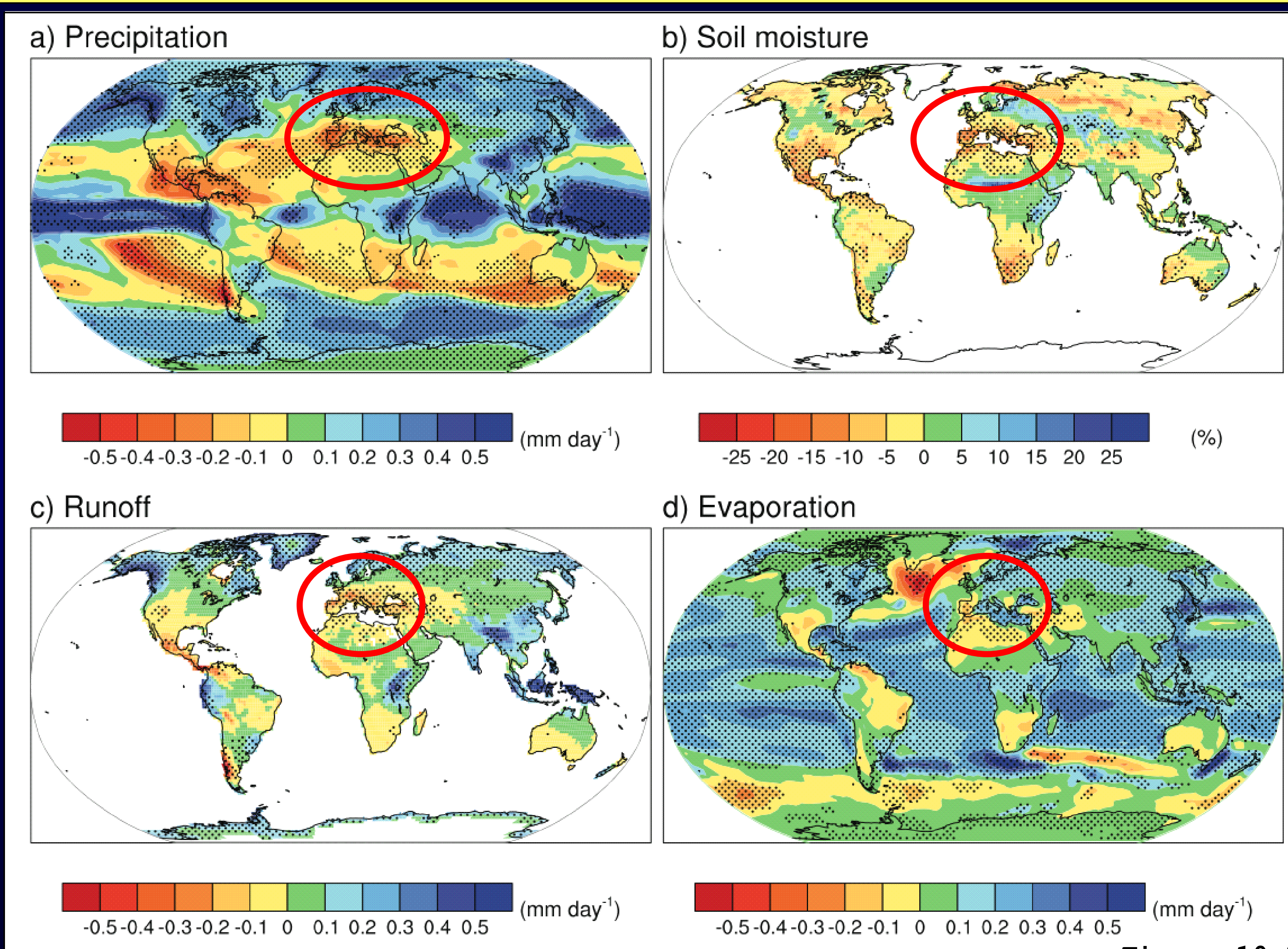
Temperature change JJA



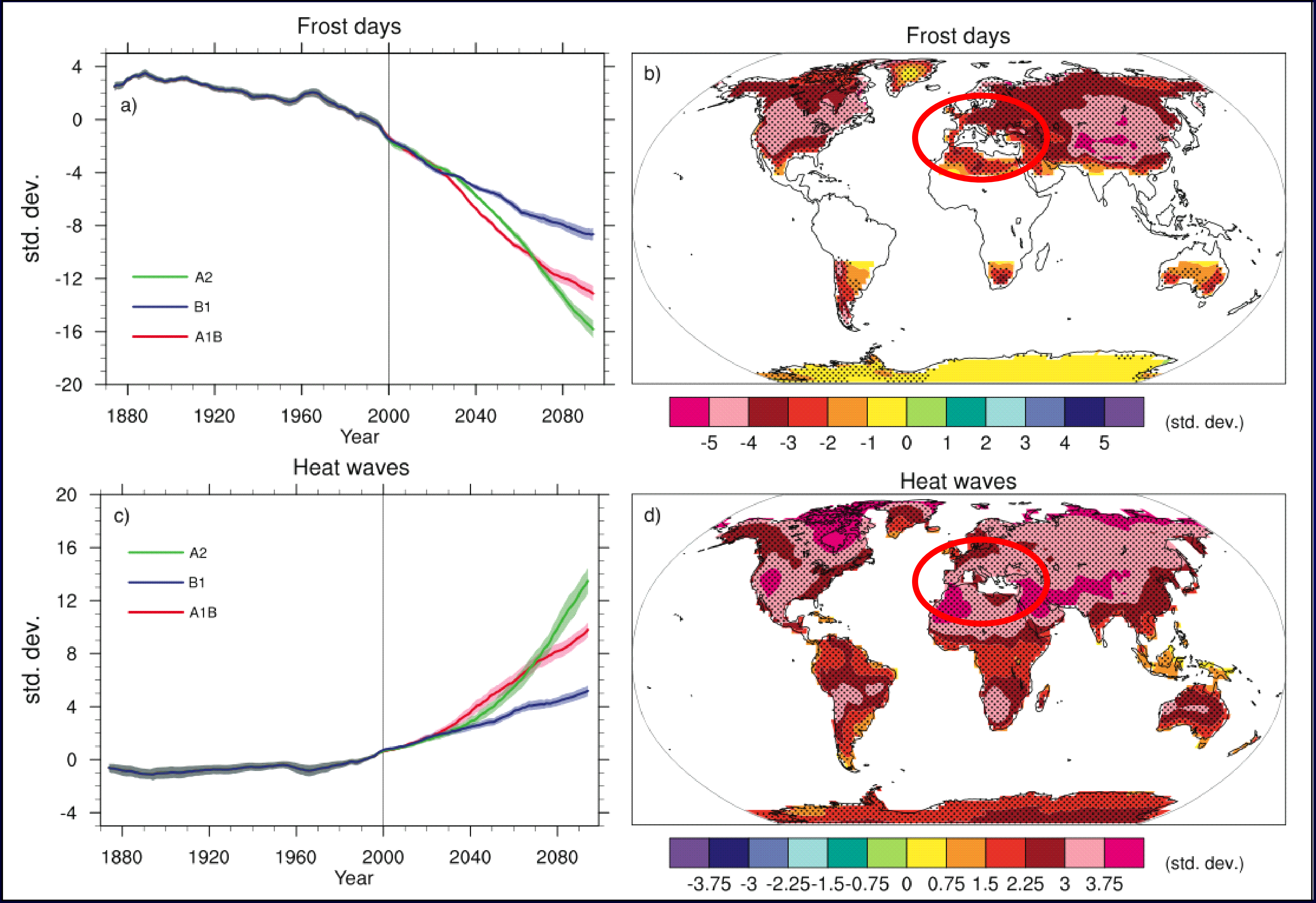
Precipitation change JJA



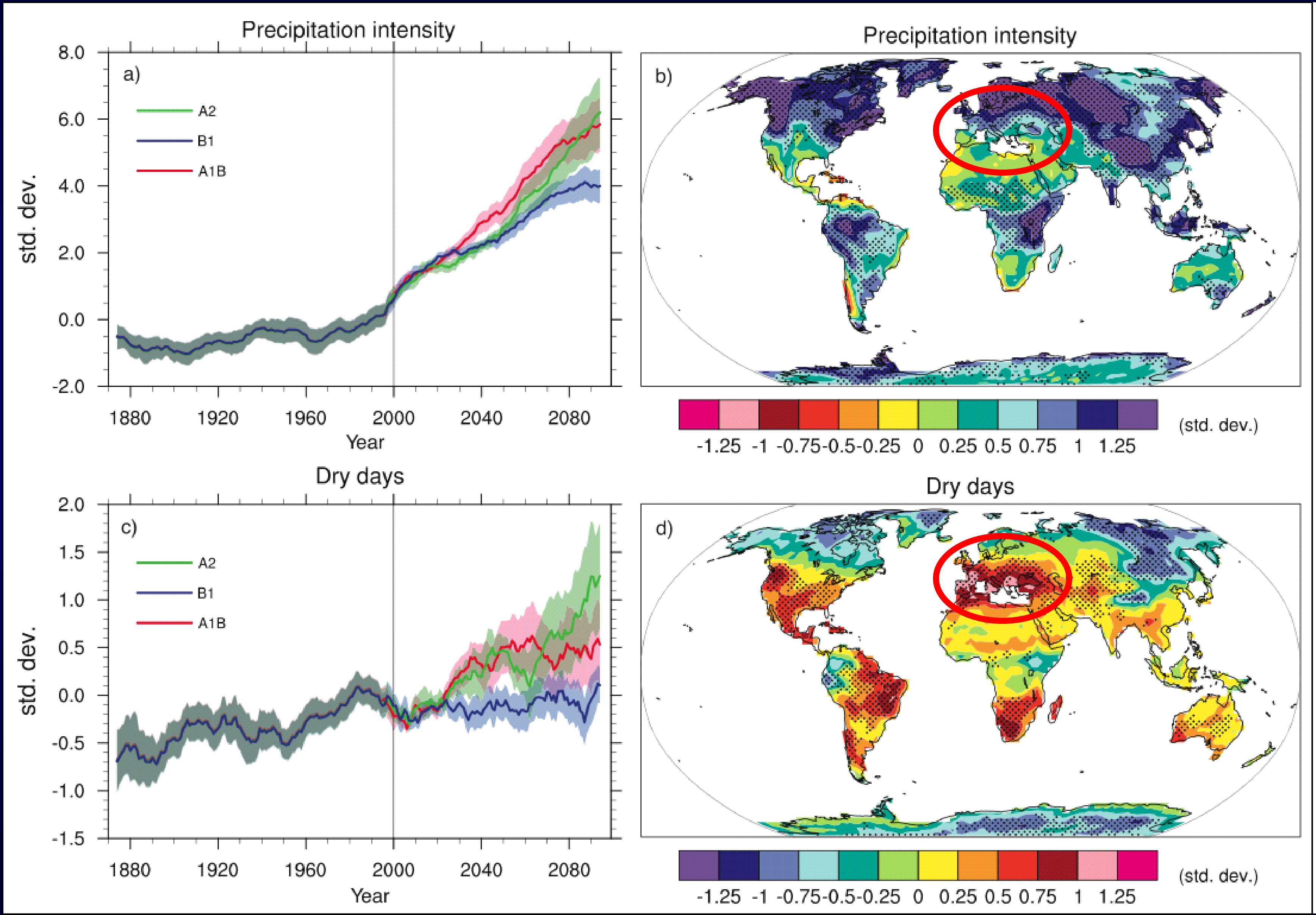
Projected changes in the hydrologic cycle



Projected changes in extremes

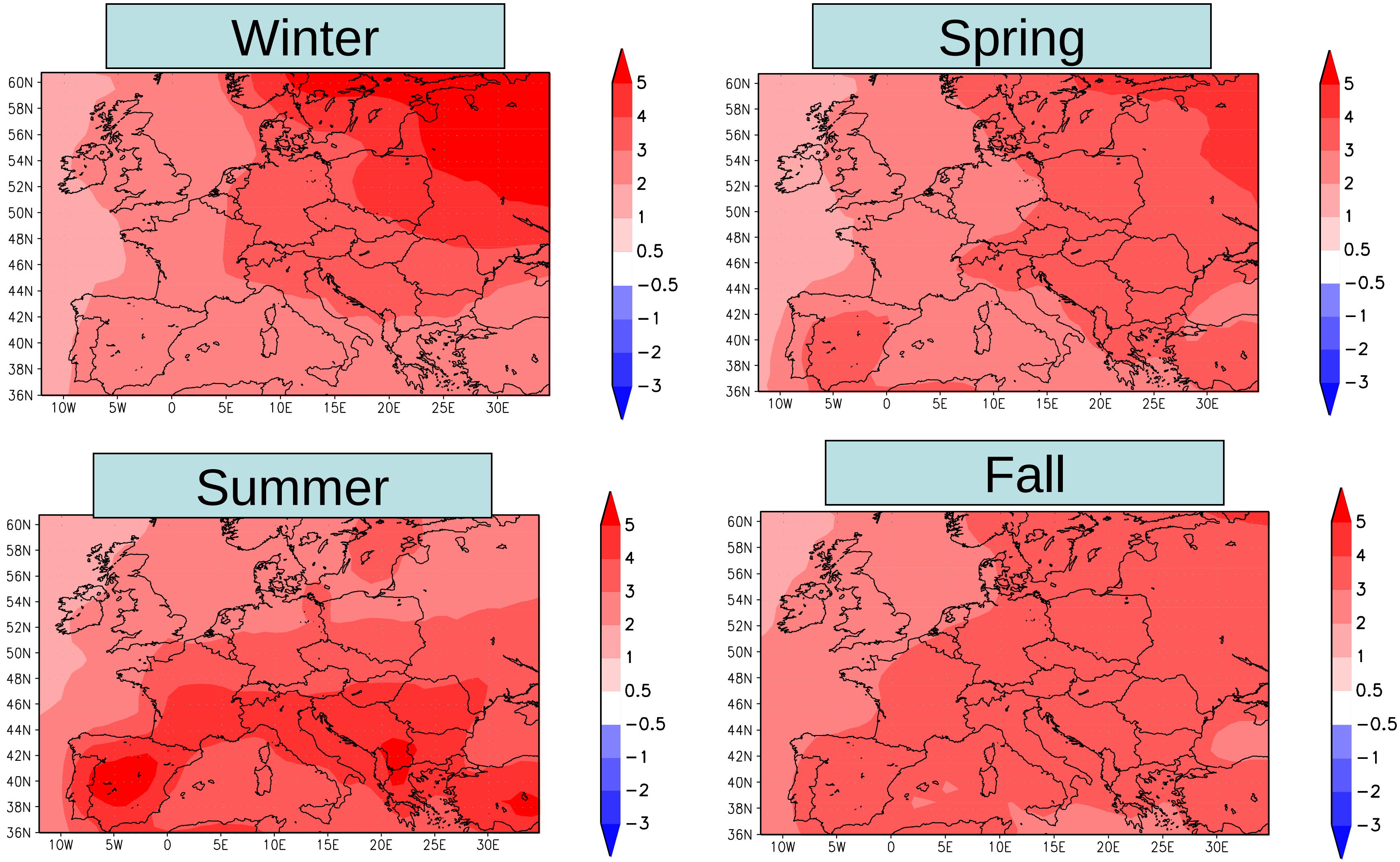


Changes in precipitation characteristics

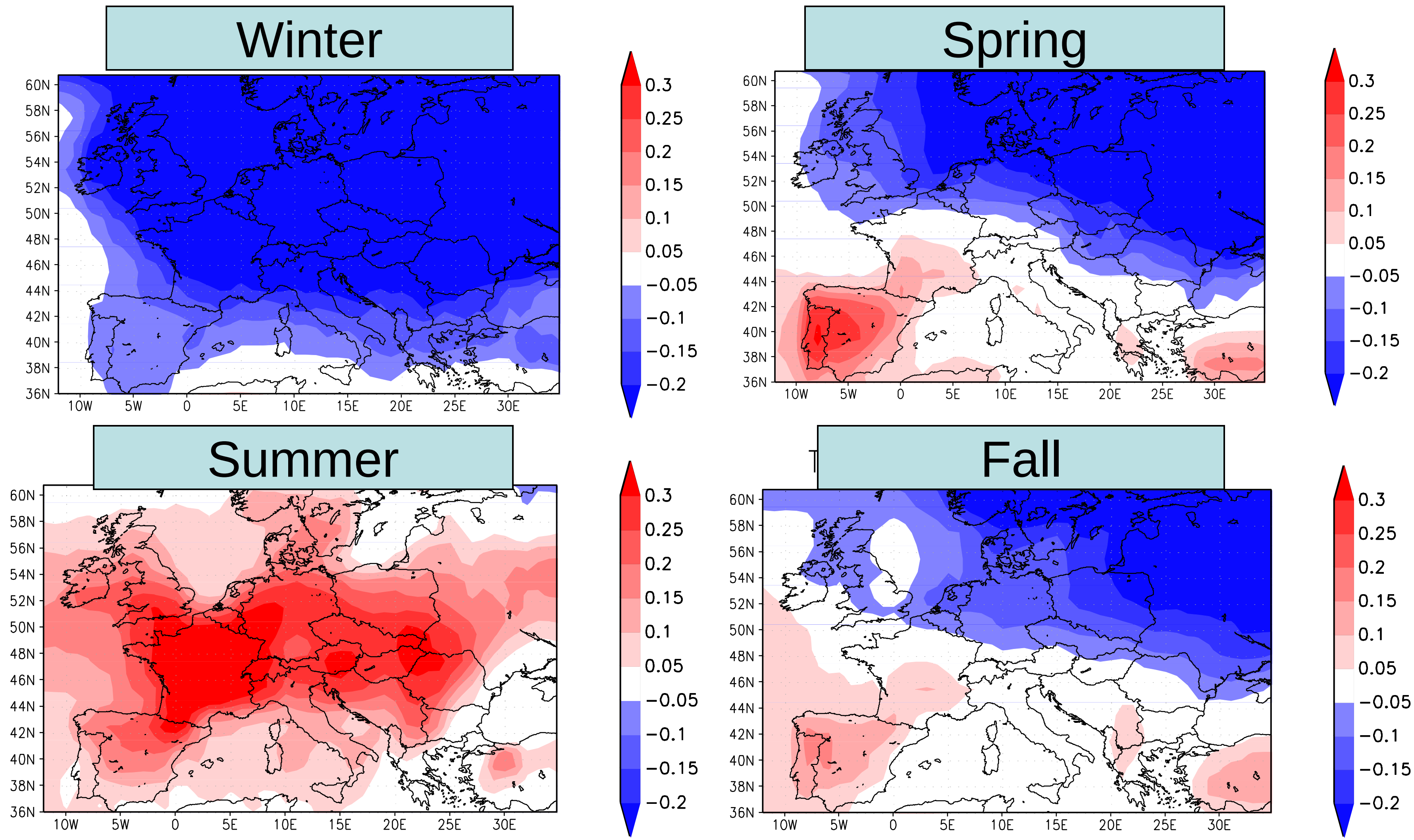



Focusing more on the Mediterranean

Temperature change, CMIP3
A1B Scenario, 20 AOGCMs

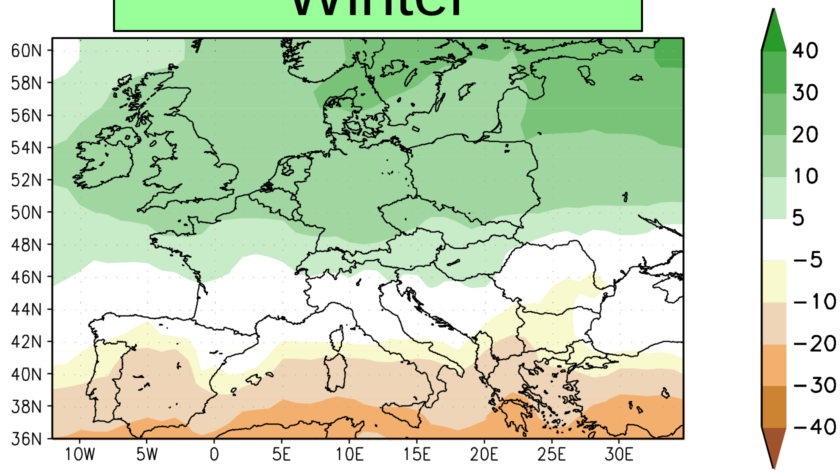


Temperature variability change, CMIP3 A1B Scenario, 20 AOGCMs

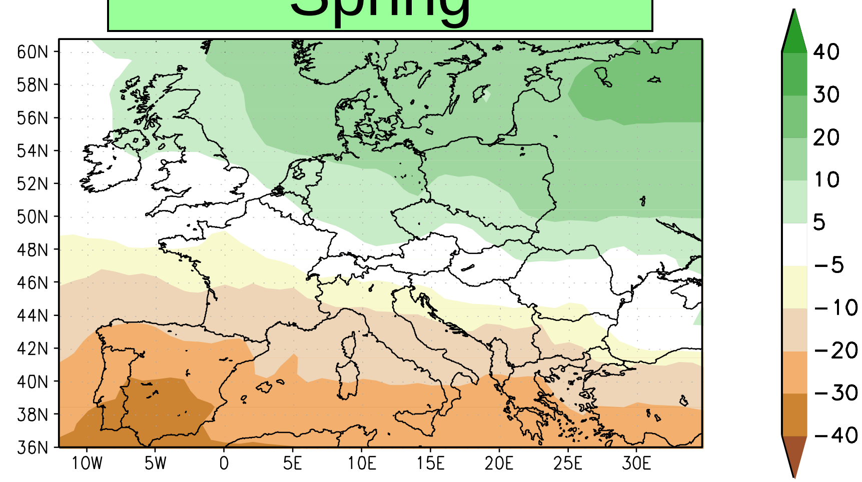


Precipitation change, CMIP3
A1B Scenario, 20 AOGCMs

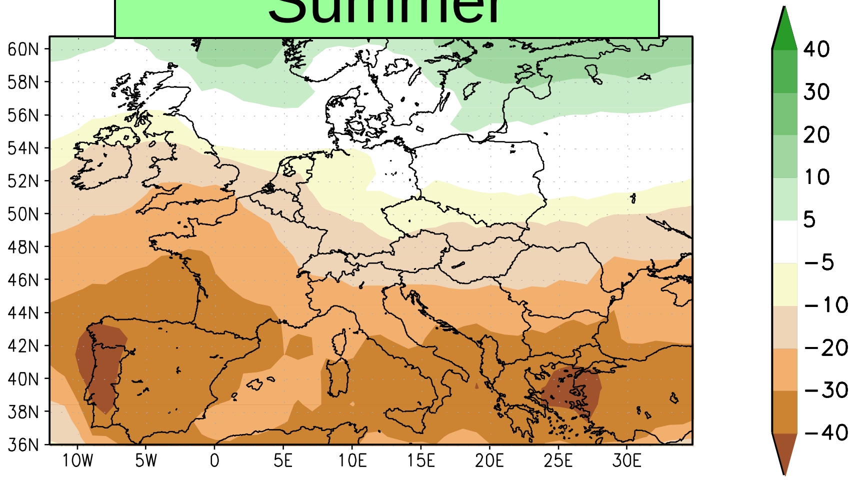
Winter



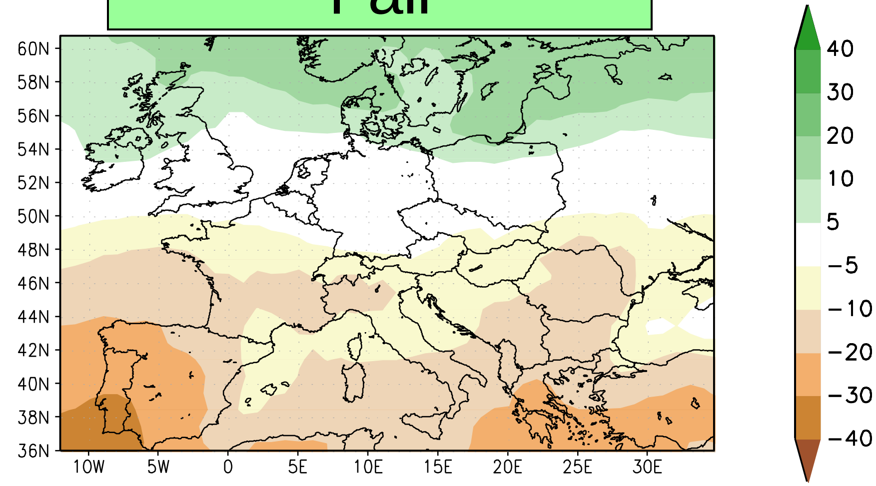
Spring



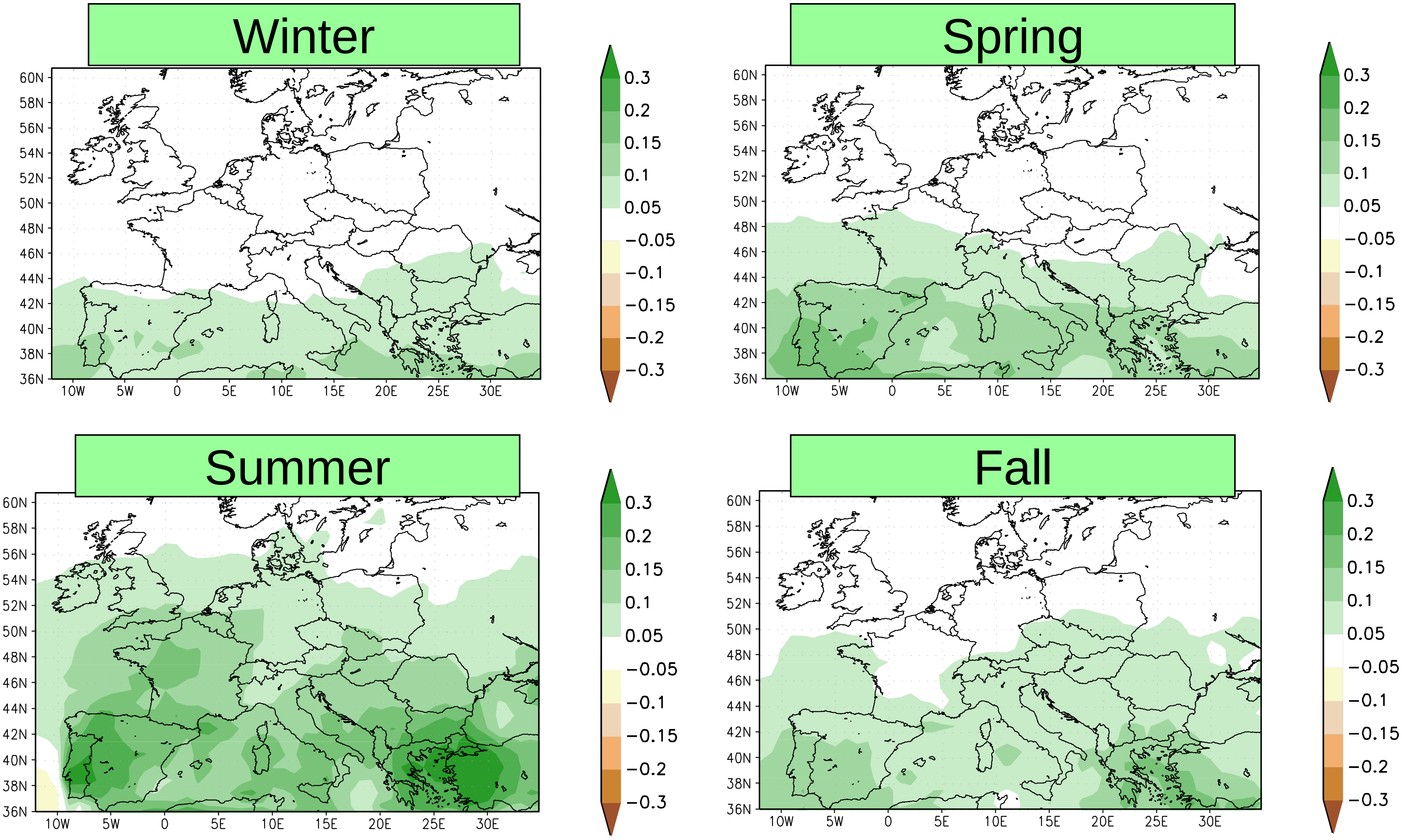
Summer



Fall



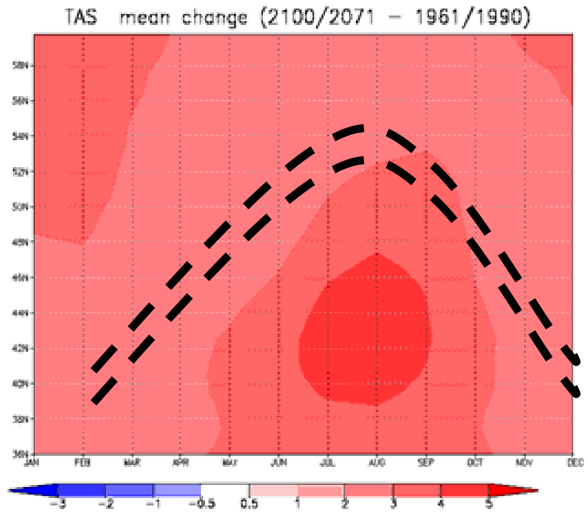
Precipitation variability change, CMIP3 A1B Scenario, 20 AOGCMs

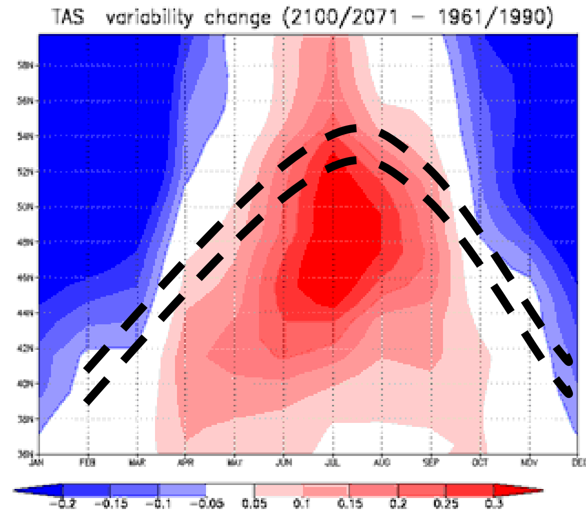


The European Climate Change Oscillation (ECO)

(A1B, 2071-2100 minus 1961-1990, Giorgi and Coppola, GRL 2007)

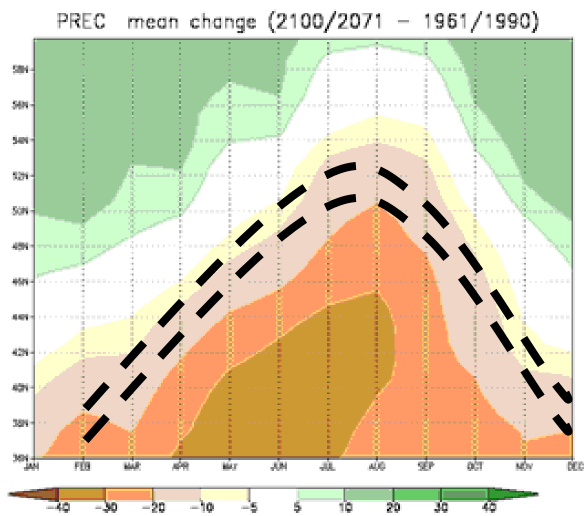
T-Mean

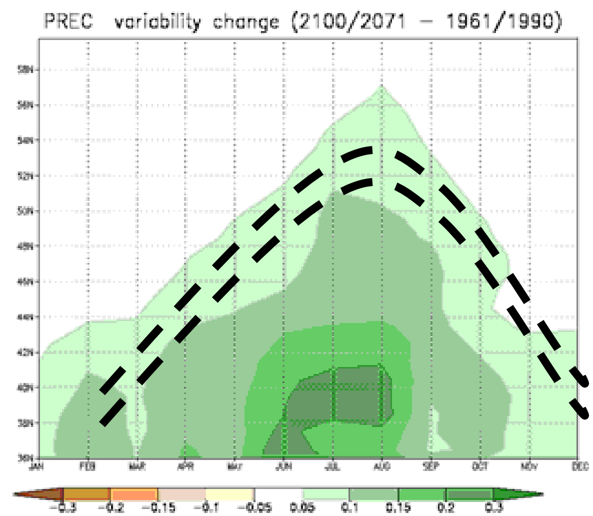




T-Var

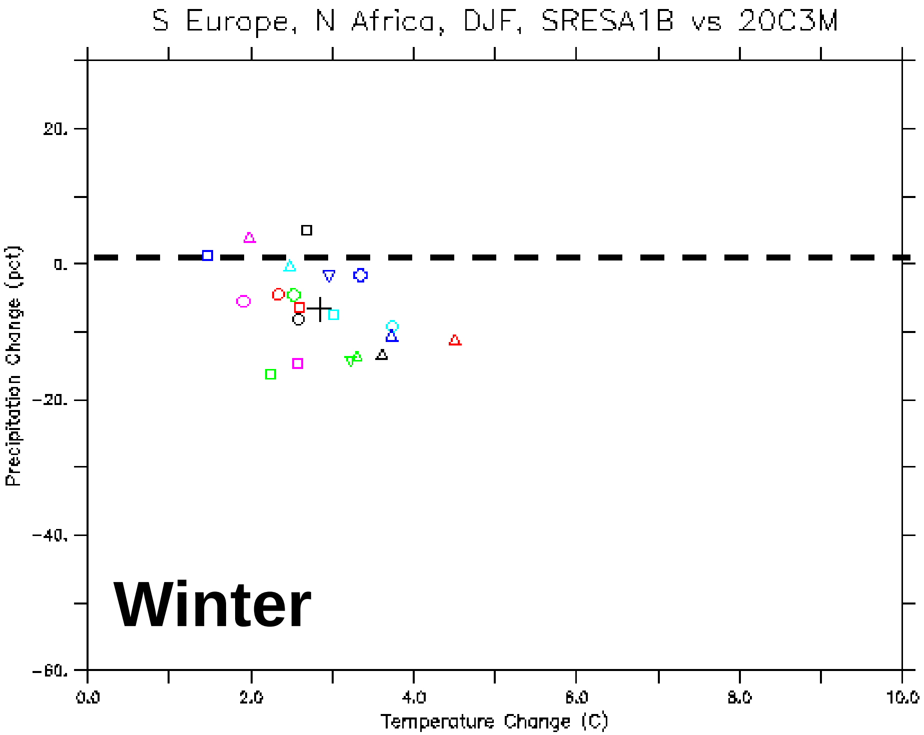
P-Mean

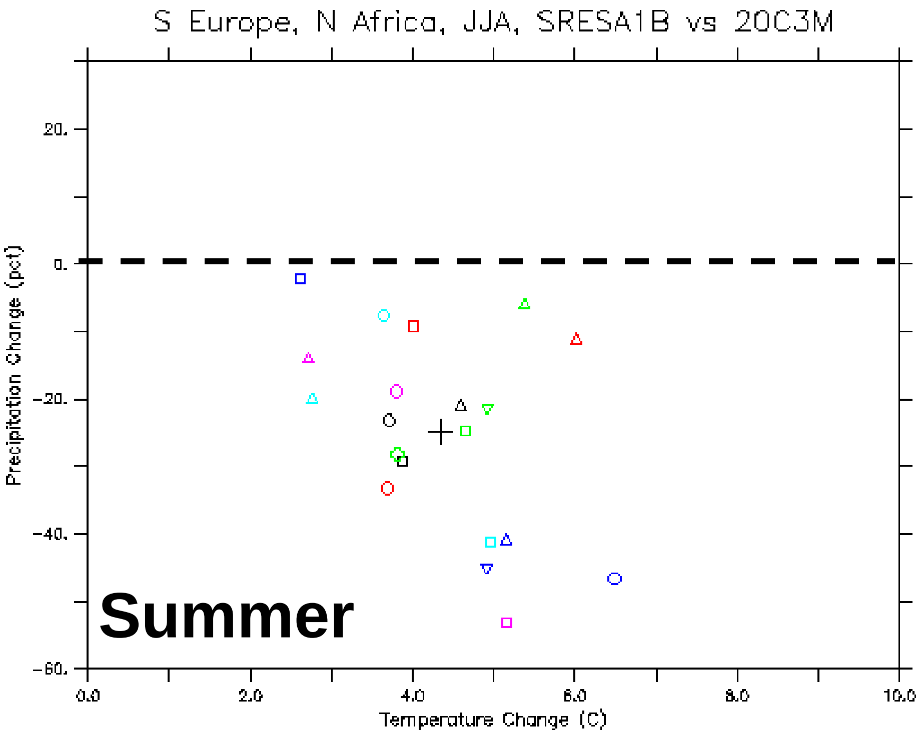




P-Var

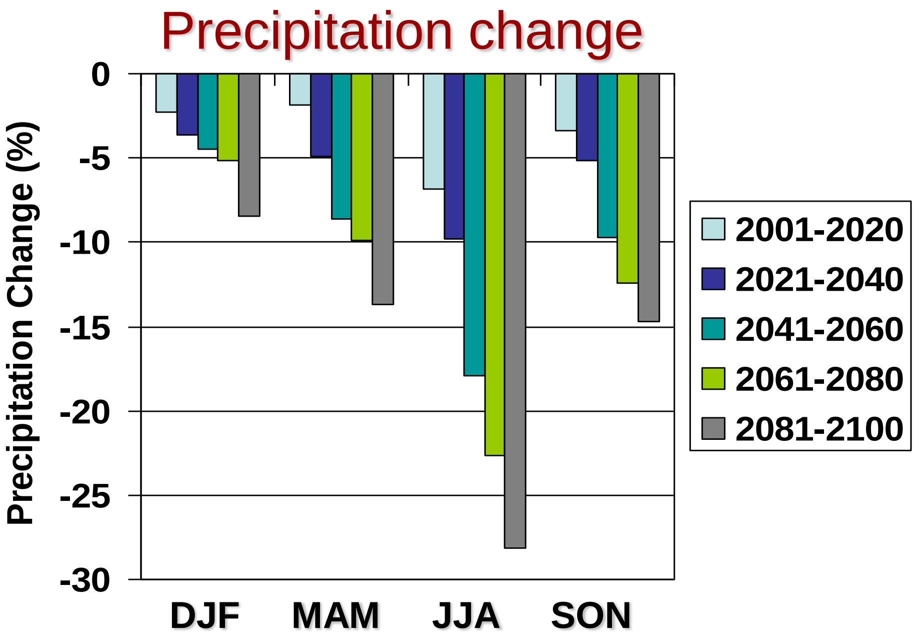
Projections of temperature and precipitation change over the Mediterranean in 21 AOGCMs
Scenario A1B, 2090-2100

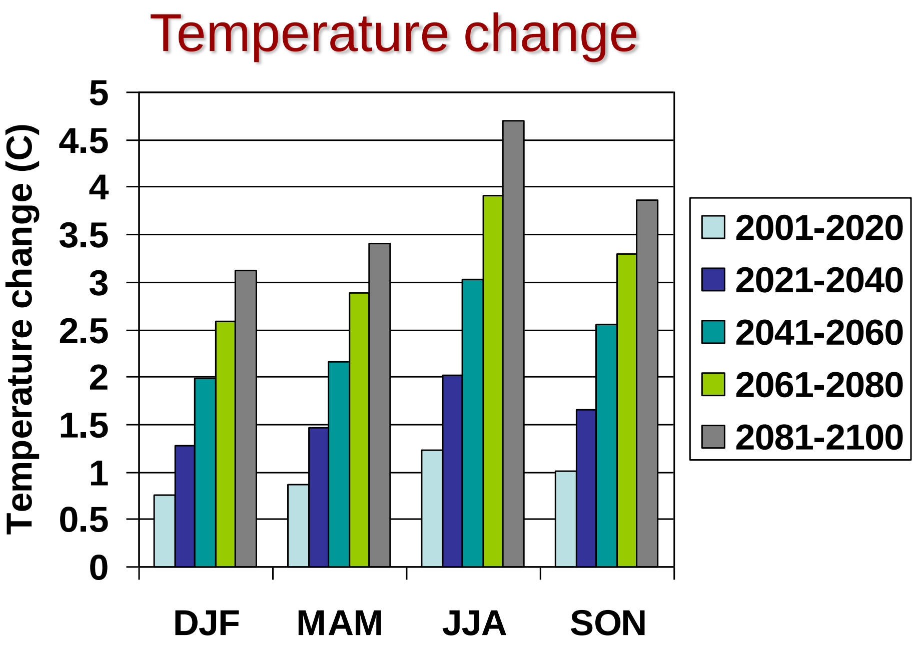




CMIP3 ensemble average change as as a function of time

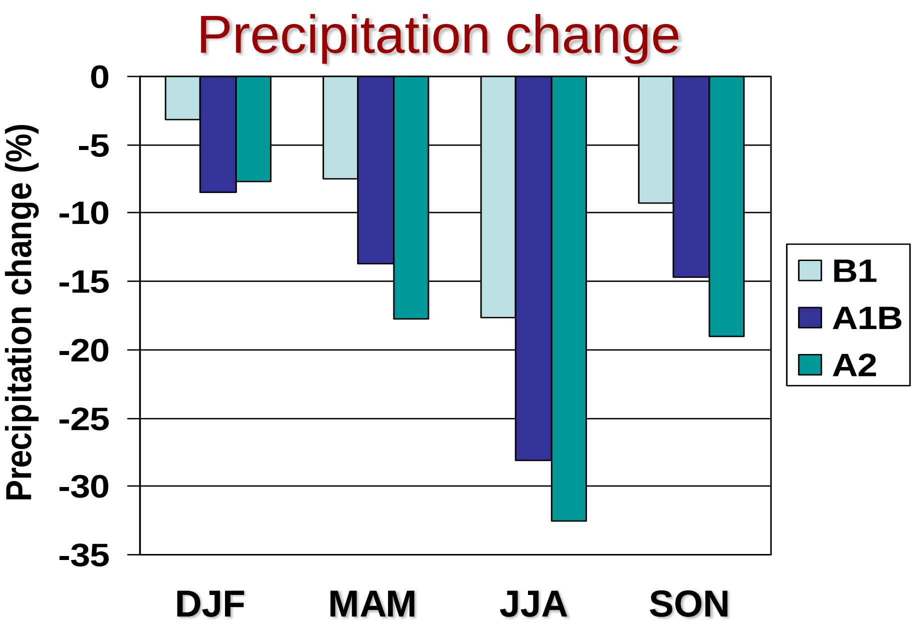
Full Mediterranean, A1B scenario

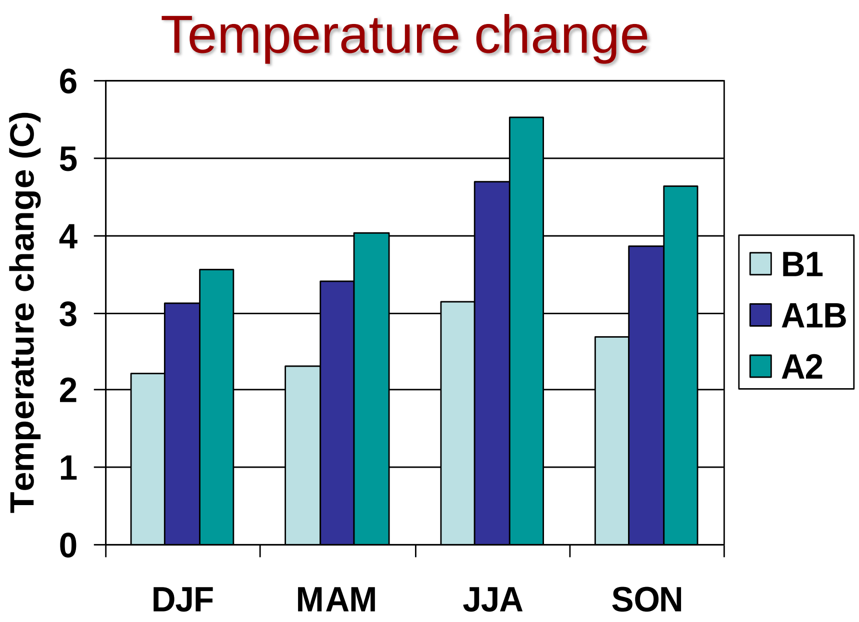




CMIP3 ensemble average change as as a function of emission scenario

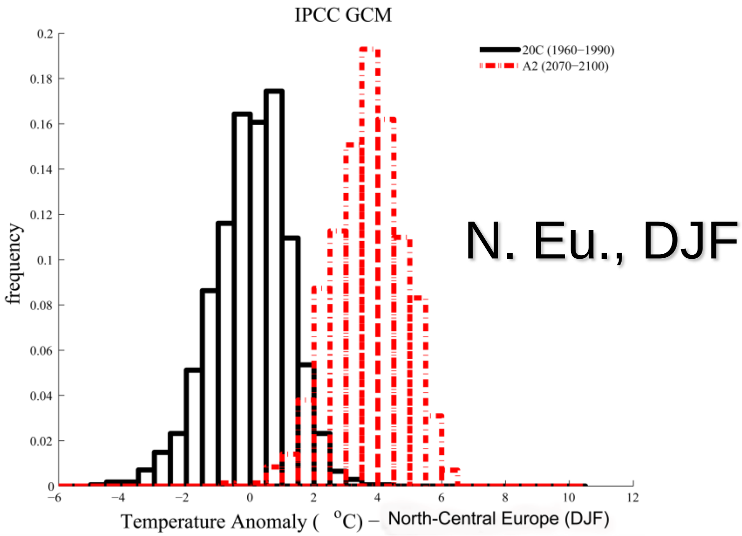
Full Mediterranean, (2081-2100) – (1961-1980)

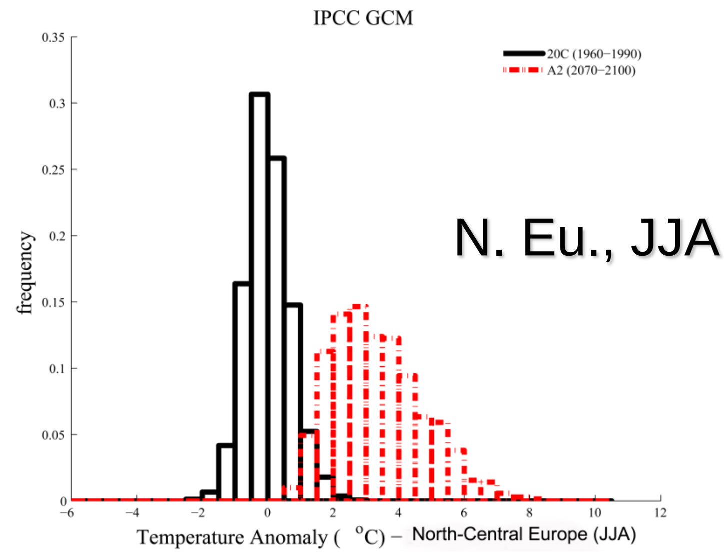


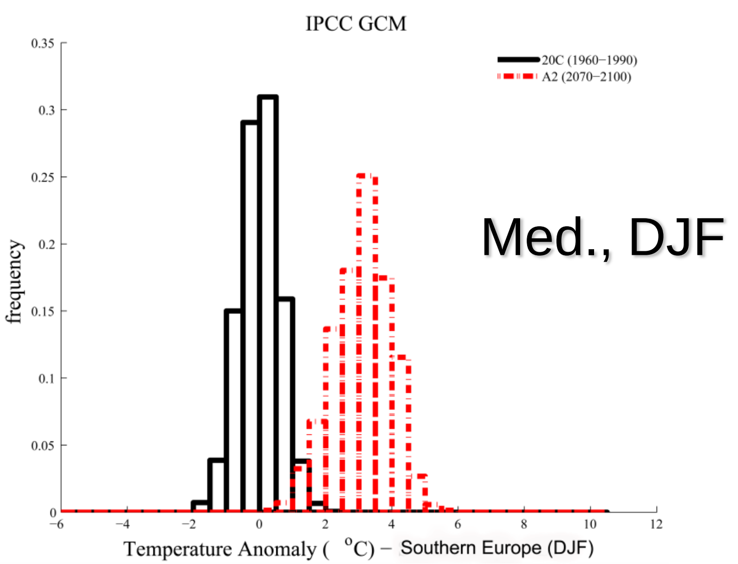


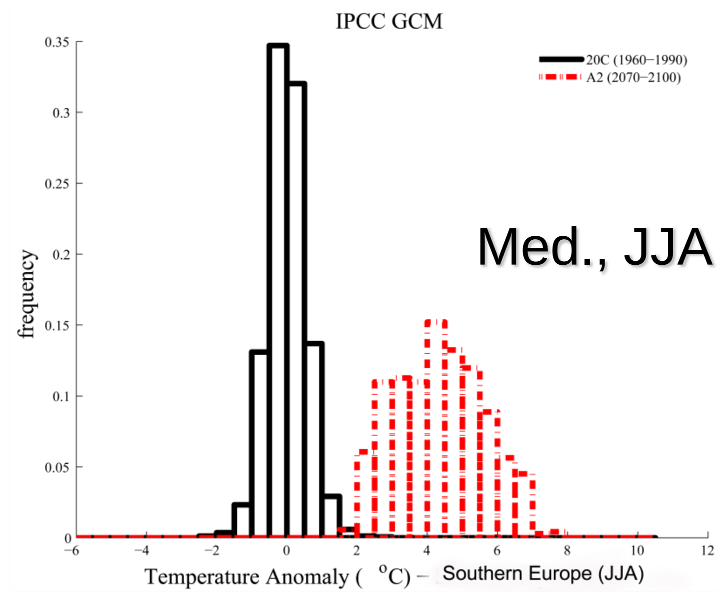
Change in seasonal temperature distribution

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



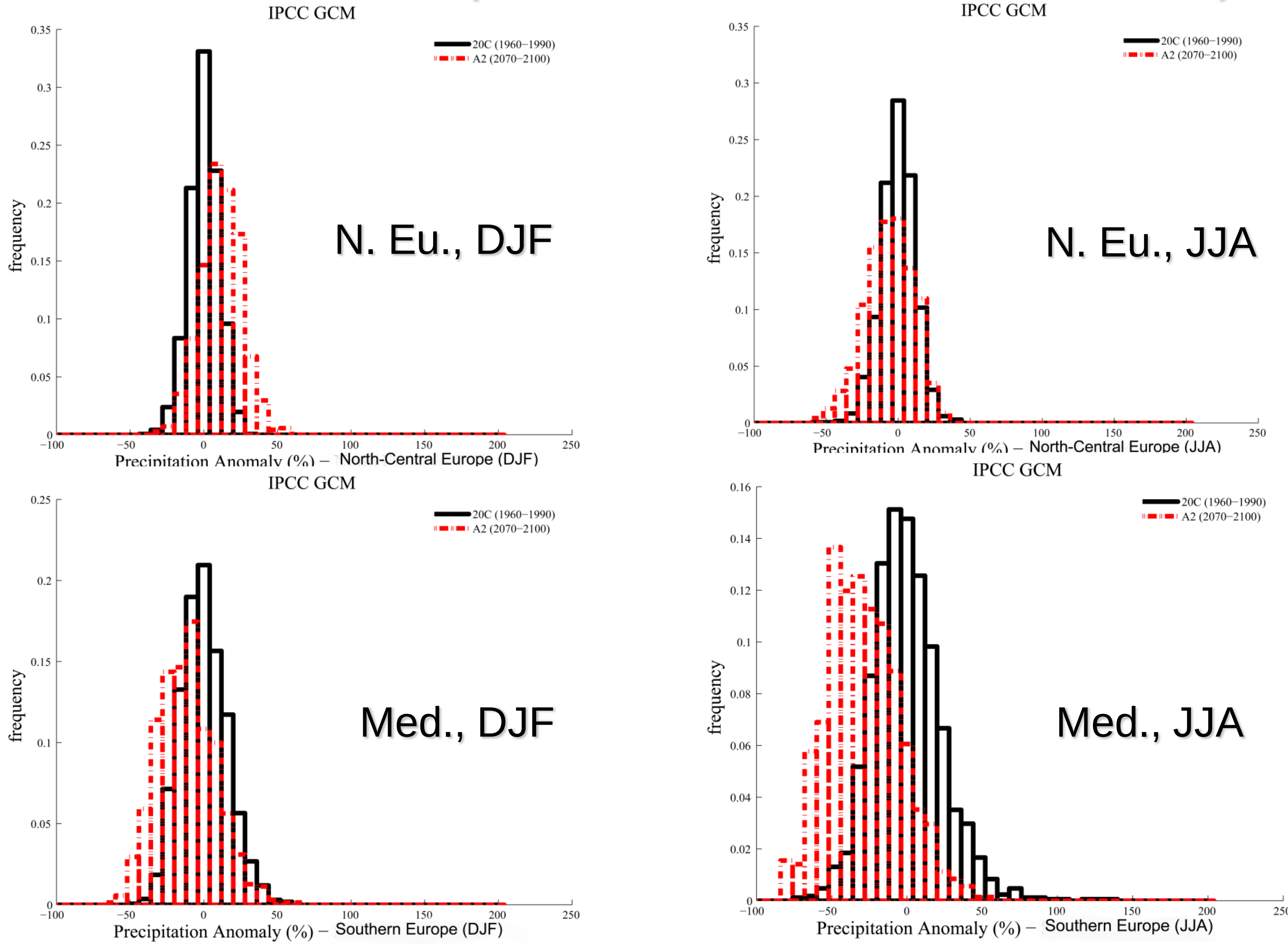




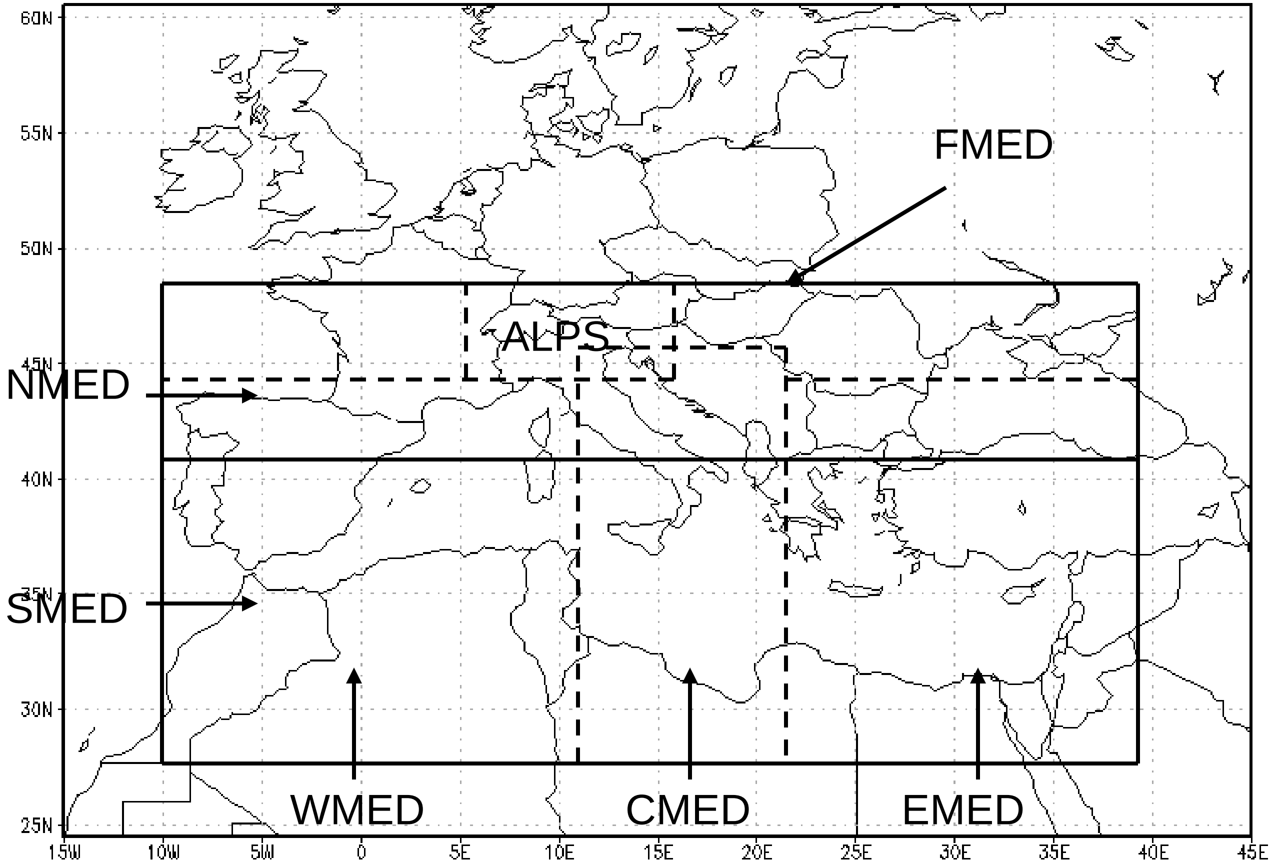


Change in seasonal precipitation distribution

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

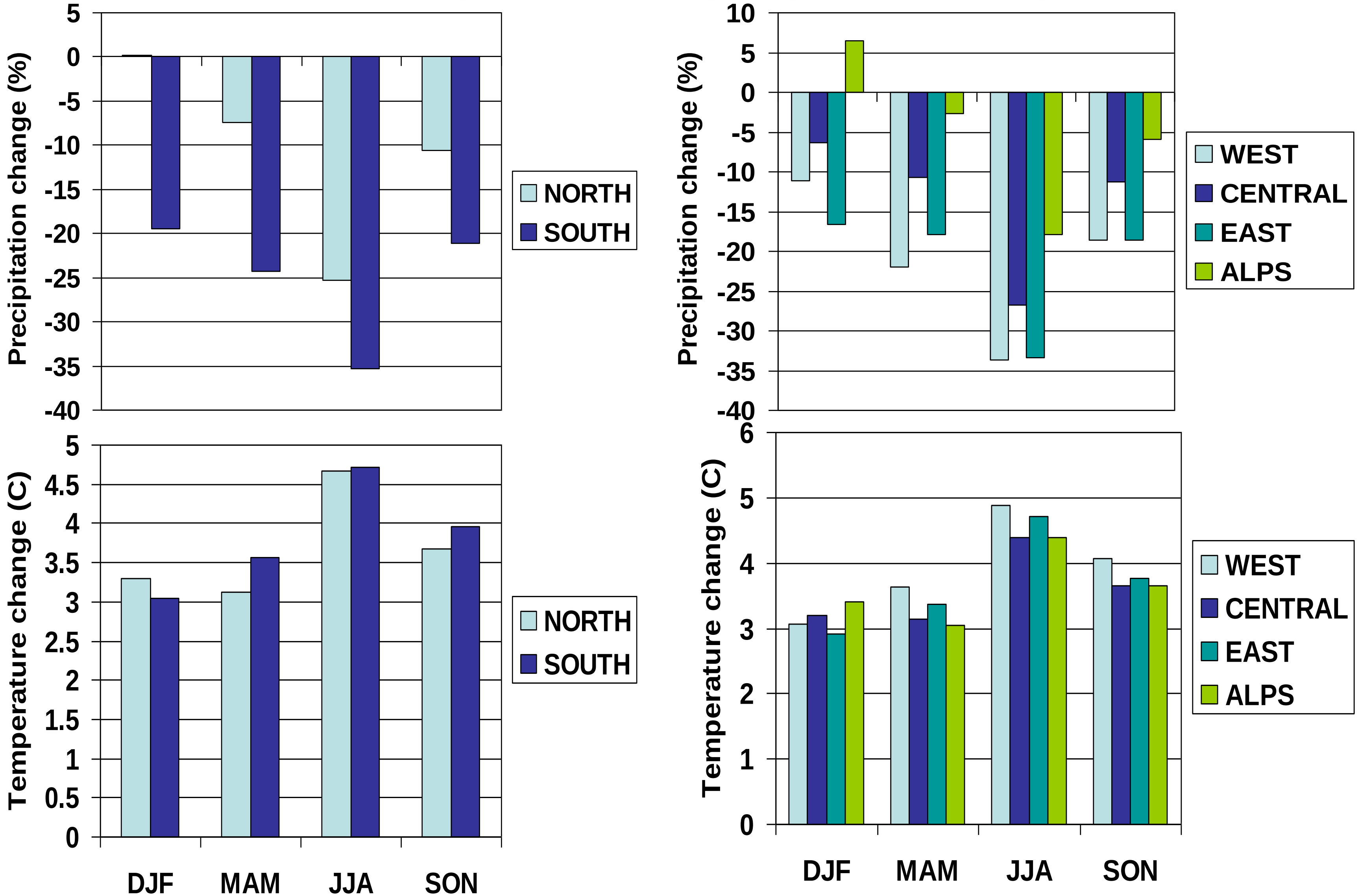


Mediterranean sub-regions



CMIP3 average change for different sub-regions

A1B, (2081-2100) – (1961-1980)



The special case of the change in summer climate over Europe

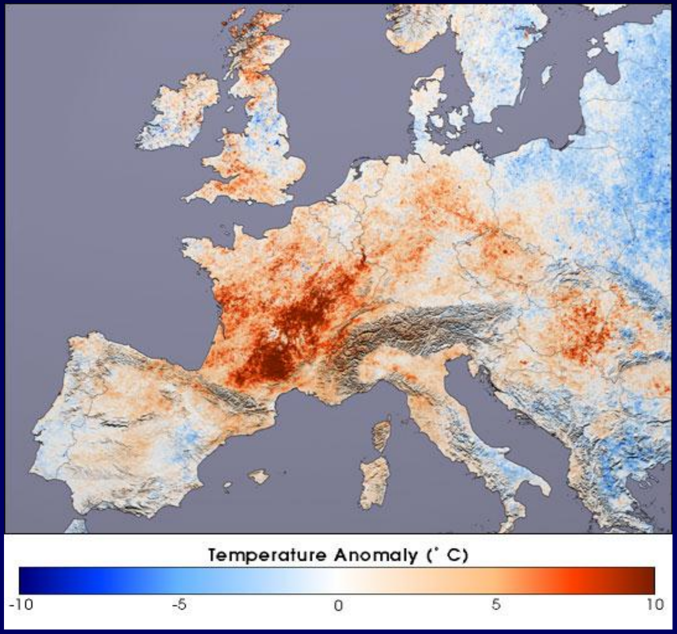
(J. Pal, F. Giorgi, X.Bi, 2004)

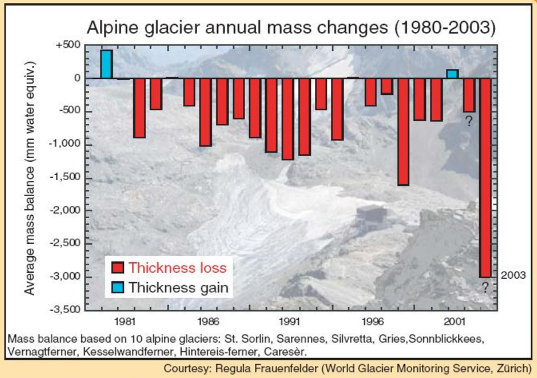
Recent European Summer Climate Trends and Extremes

- Summer precipitation over much of Europe and the Mediterranean Basin has shown a decreasing trend in recent decades
- The intensity of summer precipitation events has shown predominant increases throughout Europe
- The western European summer drought of 2003 is considered one of the severest on record.
  - Heat related casualties in France, Italy, the Netherlands, Portugal, the United Kingdom, and Spain reached nearly 20,000.
  - Many countries are experiencing their worst harvest since World War II.
- In contrast, during 2002, many European countries experienced one of their wettest summers on record.
  - Weather systems brought widespread heavy rainfall to central Europe, causing severe flooding along all the major rivers.
  - The Elbe River reached its highest level in over 500 years of record

The summers we can expect in Europe?

Summer of 2003

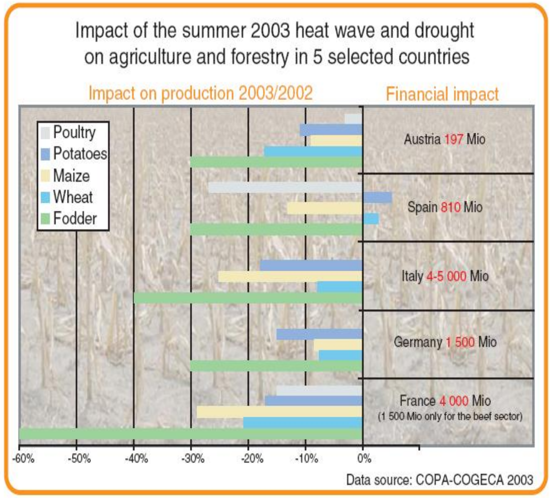




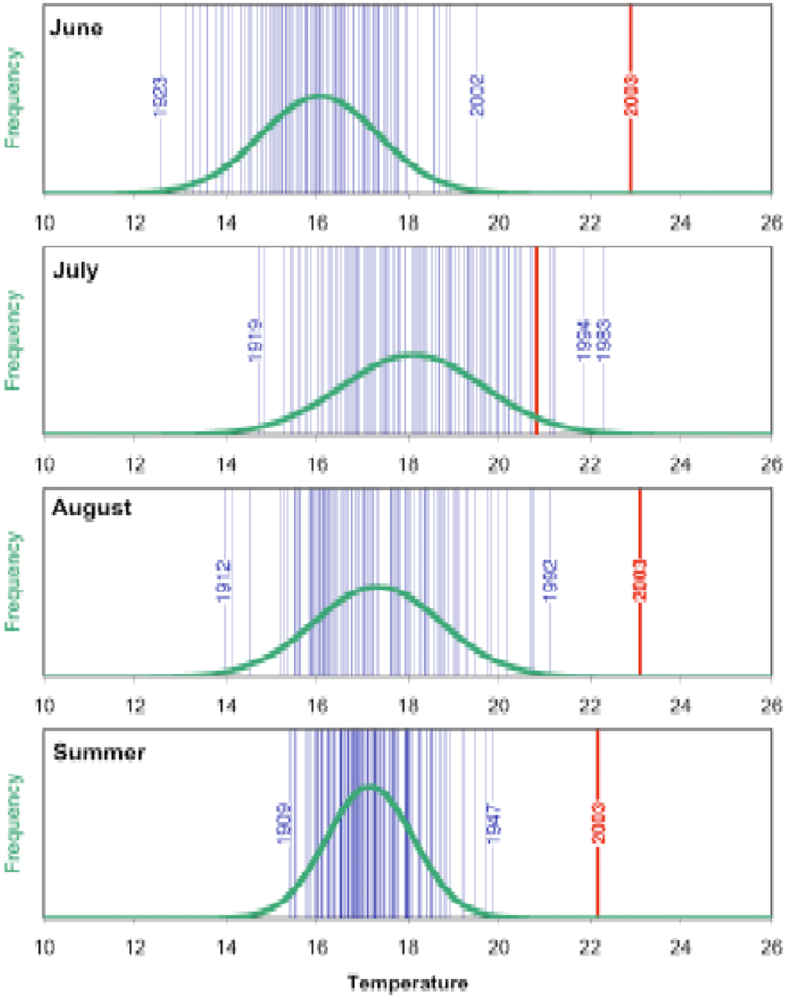
glaciers in the Alps. In 2003 alone, the total glacier volume loss in the Alps corresponds to 5-10% (probably closer to 10%) of the remaining ice volume. Alpine glaciers had already lost more than 25% of their volume in the 25 years before 2003, and roughly two-thirds of their original volume since 1850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



Summer Temperatures 1864-2003



Schär *et al.* (2004)

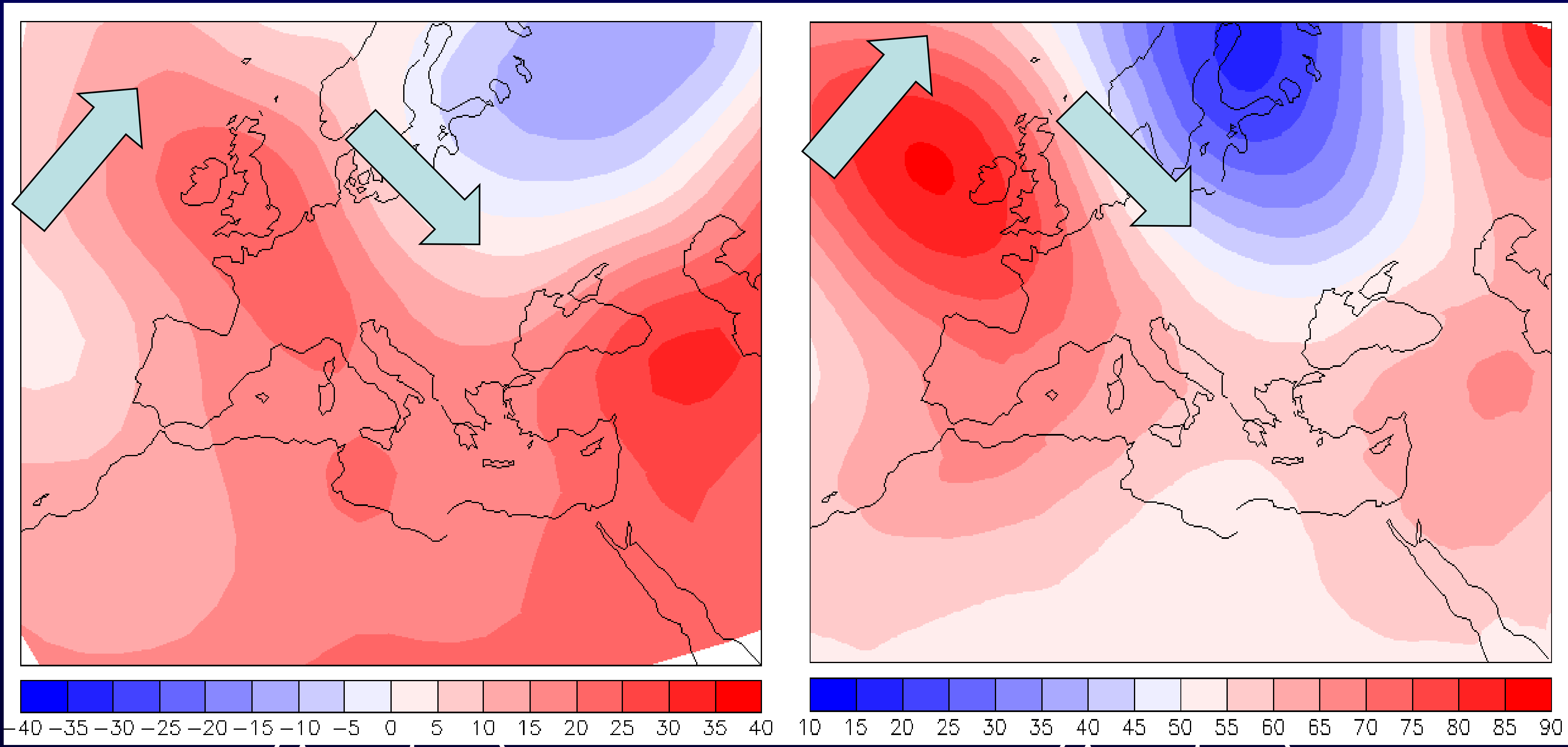
- June, August, and JJA have the characteristics of outliers
- There is no other event (other months, cold and warm events) of this kind in the whole data series

Schär, ETH Zürich

Change in Summer 500 hPa Geopotential height

Observations (NCEP)
(1976-2000) minus (1951-1975)

B2 Scenario
(2071-2100) minus (1961-1990)



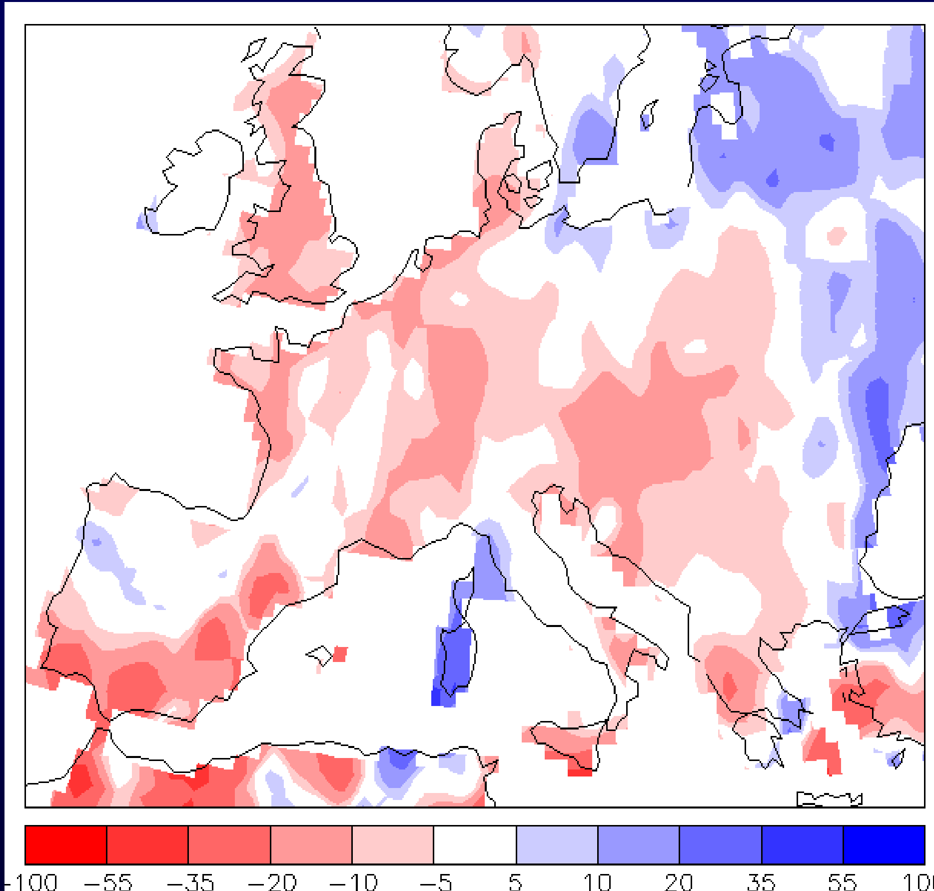
(Δ meters)

(Δ meters)

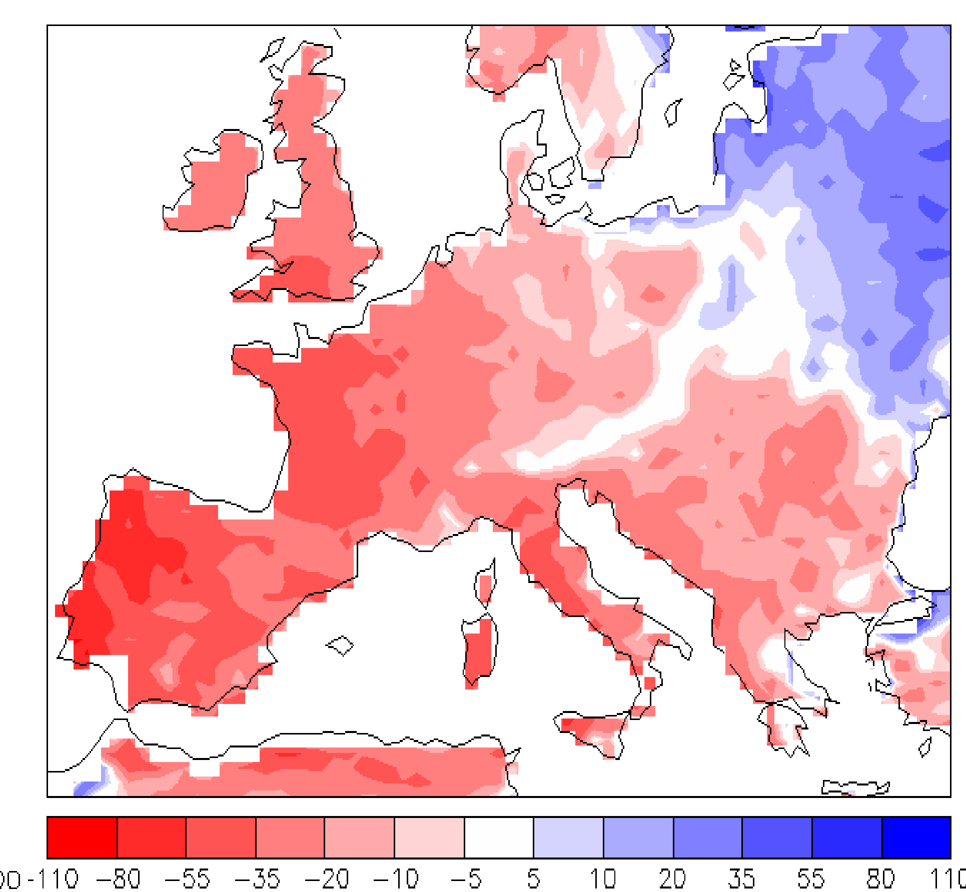
Change in Summer Precipitation

CRU Observations
(1976-2000) minus (1951-1975)

B2 Scenario
(2071-2100) minus (1961-1990)



(% change)

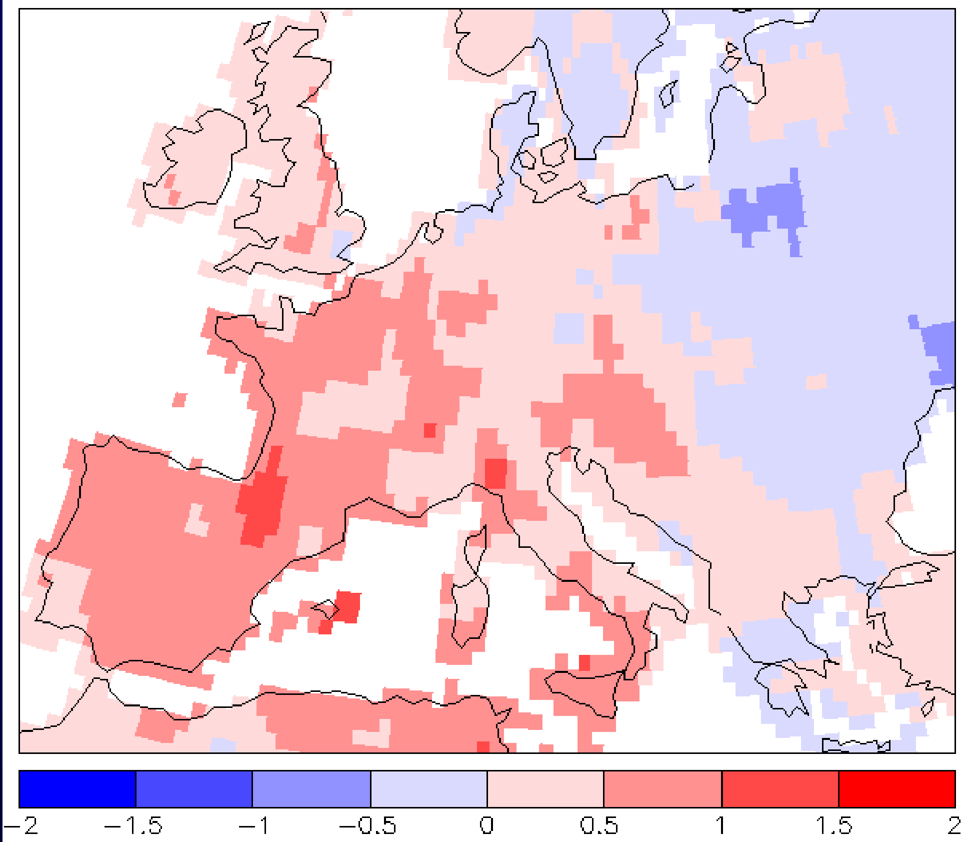


(% change)

Change in Summer Temperature

Observations

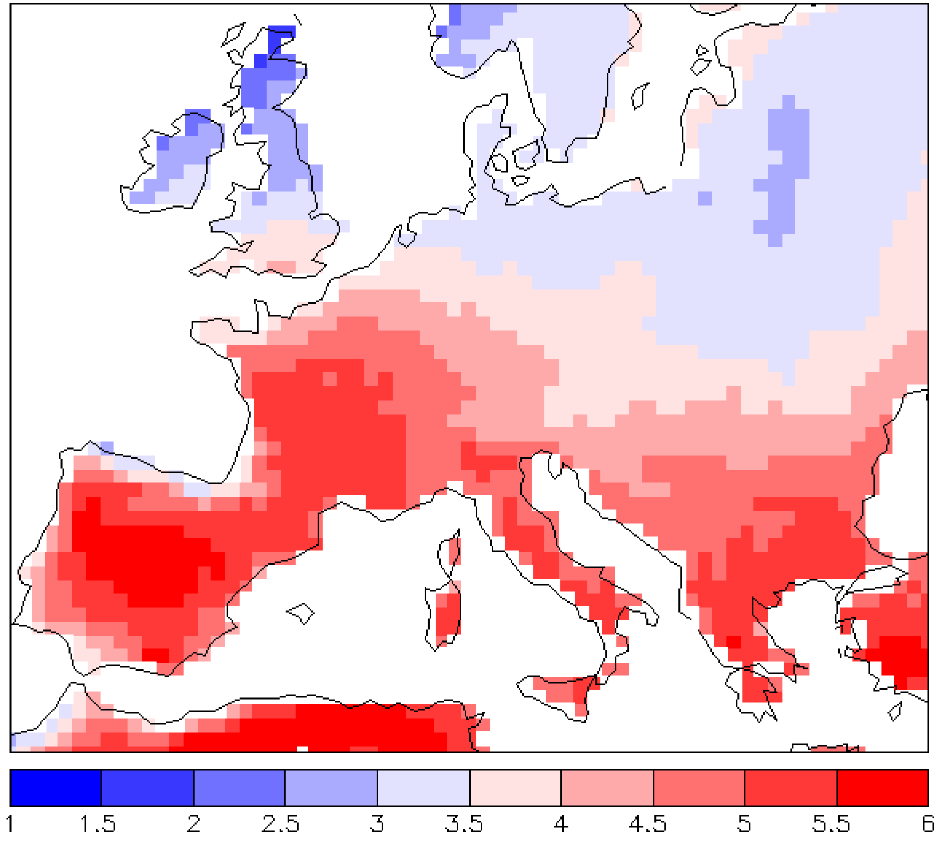
(1976-2000) minus (1951-1975)



(C)

B2 Scenario

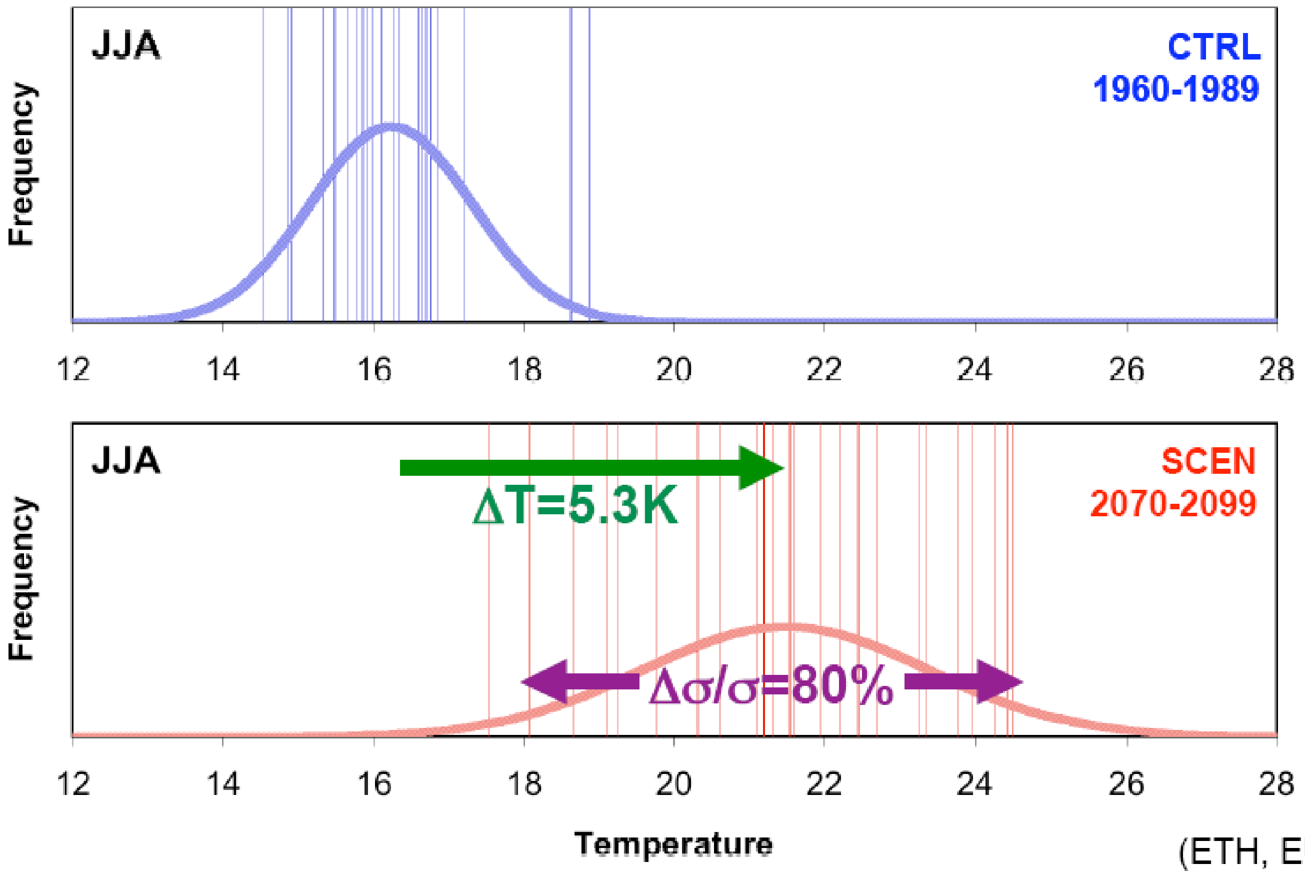
(2071-2100) minus (1961-1990)



(C)

Summer Temperatures

Domain Mean (F, parts of D and CH)



Gridpoint near Zurich

Simulated:
T = 15.8 °C
σ = 0.97 °C

Observed:
T = 17.2 °C
σ = 0.94 °C

Dramatic increase in variability

(ETH, EU-Project PRUDENCE)

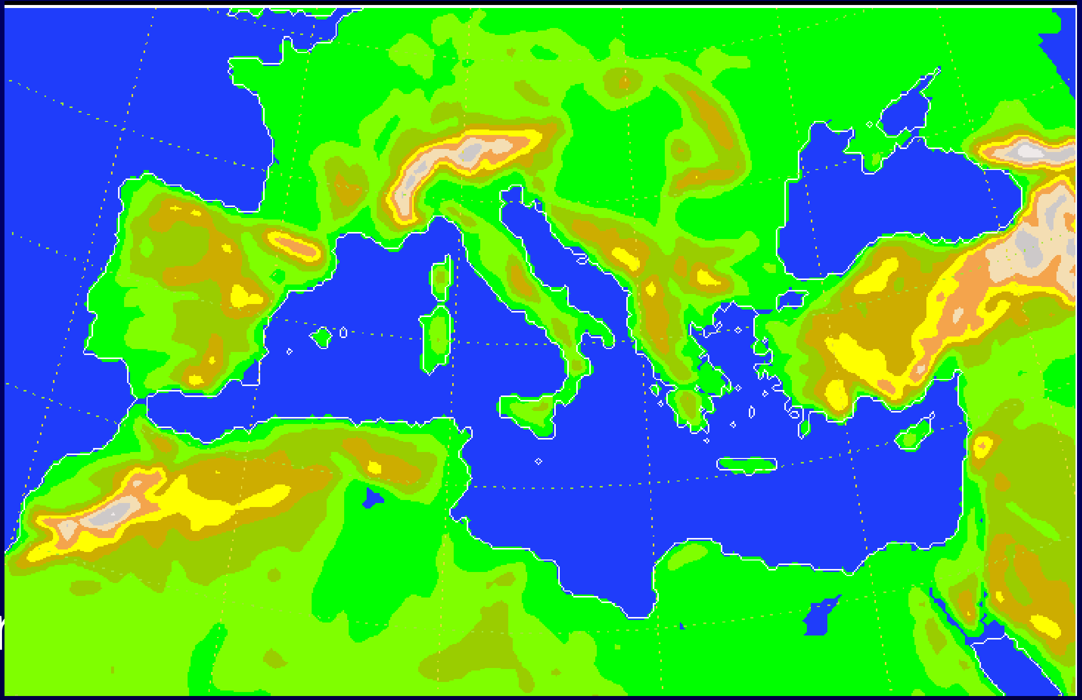
Schär *et al.* (2004)

HIGH RESOLUTION EXPERIMENTS

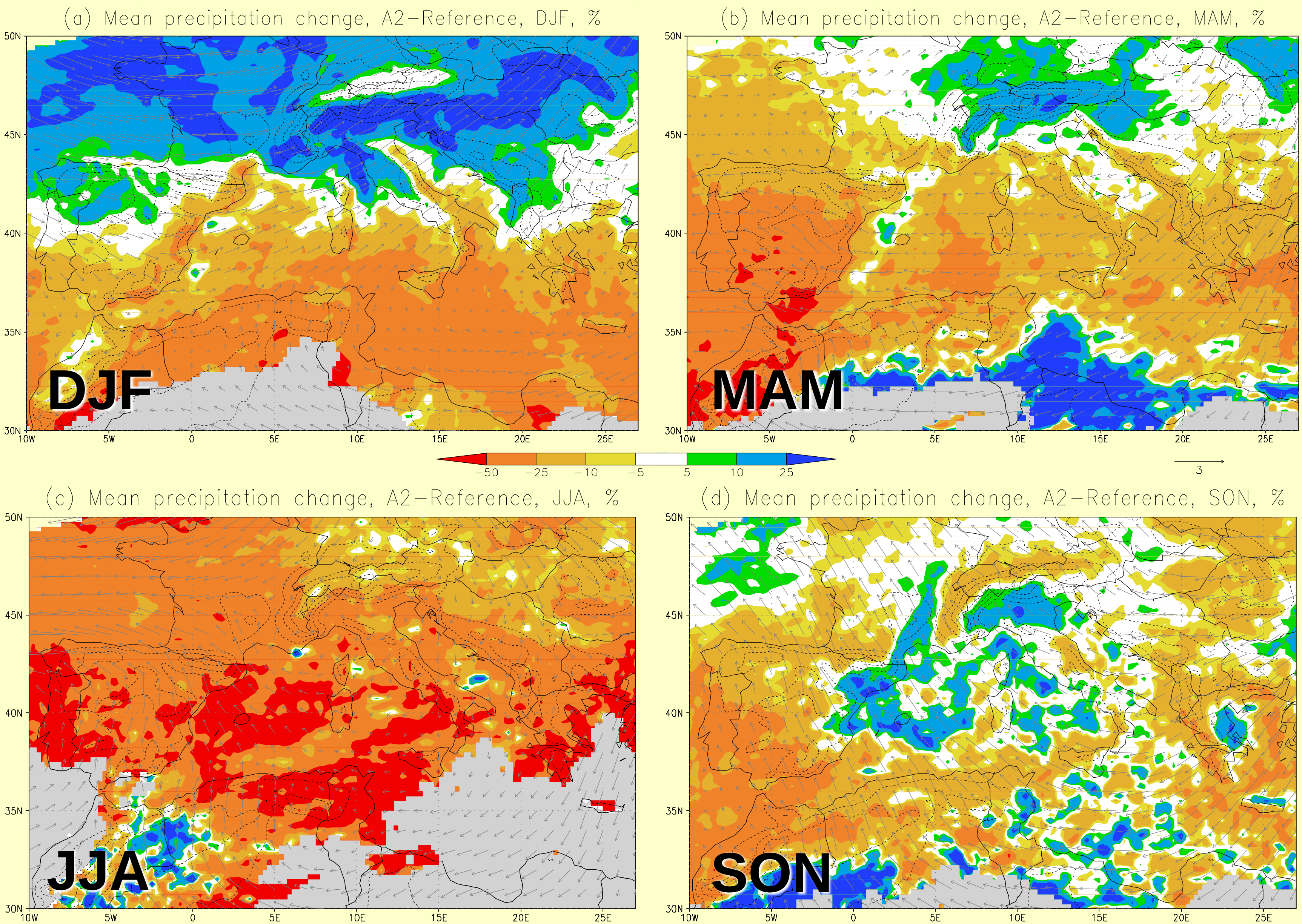
Gao et al (2006)

High resolution simulations

- Model configuration
  - 20-km grid point spacing
  - Full Mediterranean domain
- Experiment design
  - Forcing fields from PRUDENCE RegCM simulations
  - Reference simulation (1961-1990)
  - A2, B2 scenario simulations (2071-2100)



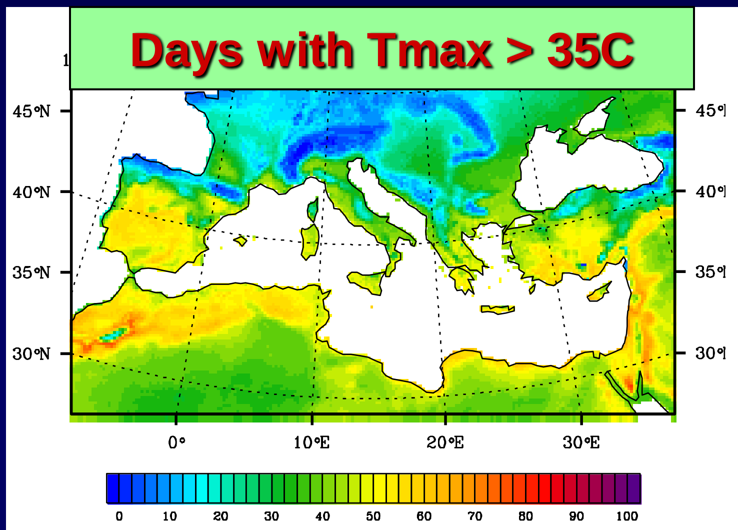
Precipitation change (%)- dx=20 km
A2 (2071-2100) – Control (1961-1990) (Gao et al. 2005)



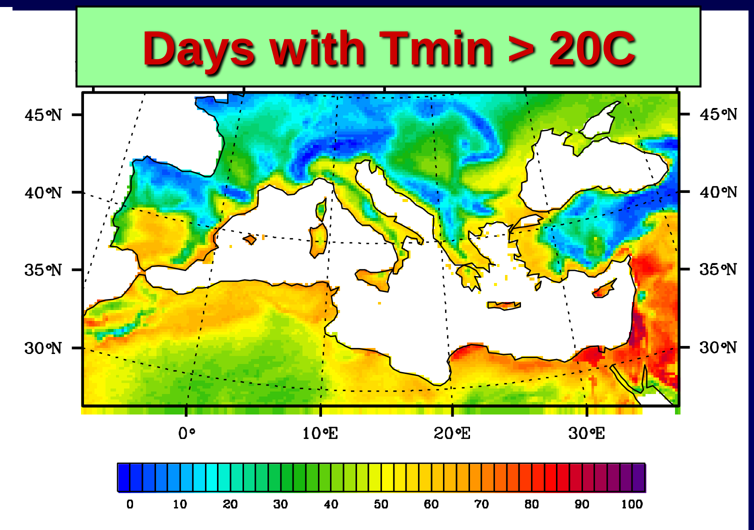
Effects of climate change over the Mediterranean on human health, A2 scenario

Increase of pathologies related to heat stress

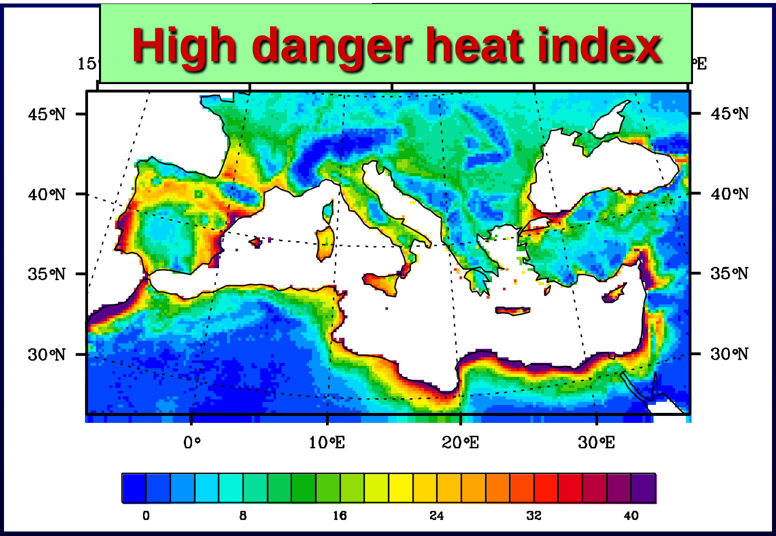
Days with Tmax > 35C



Days with Tmin > 20C



High danger heat index

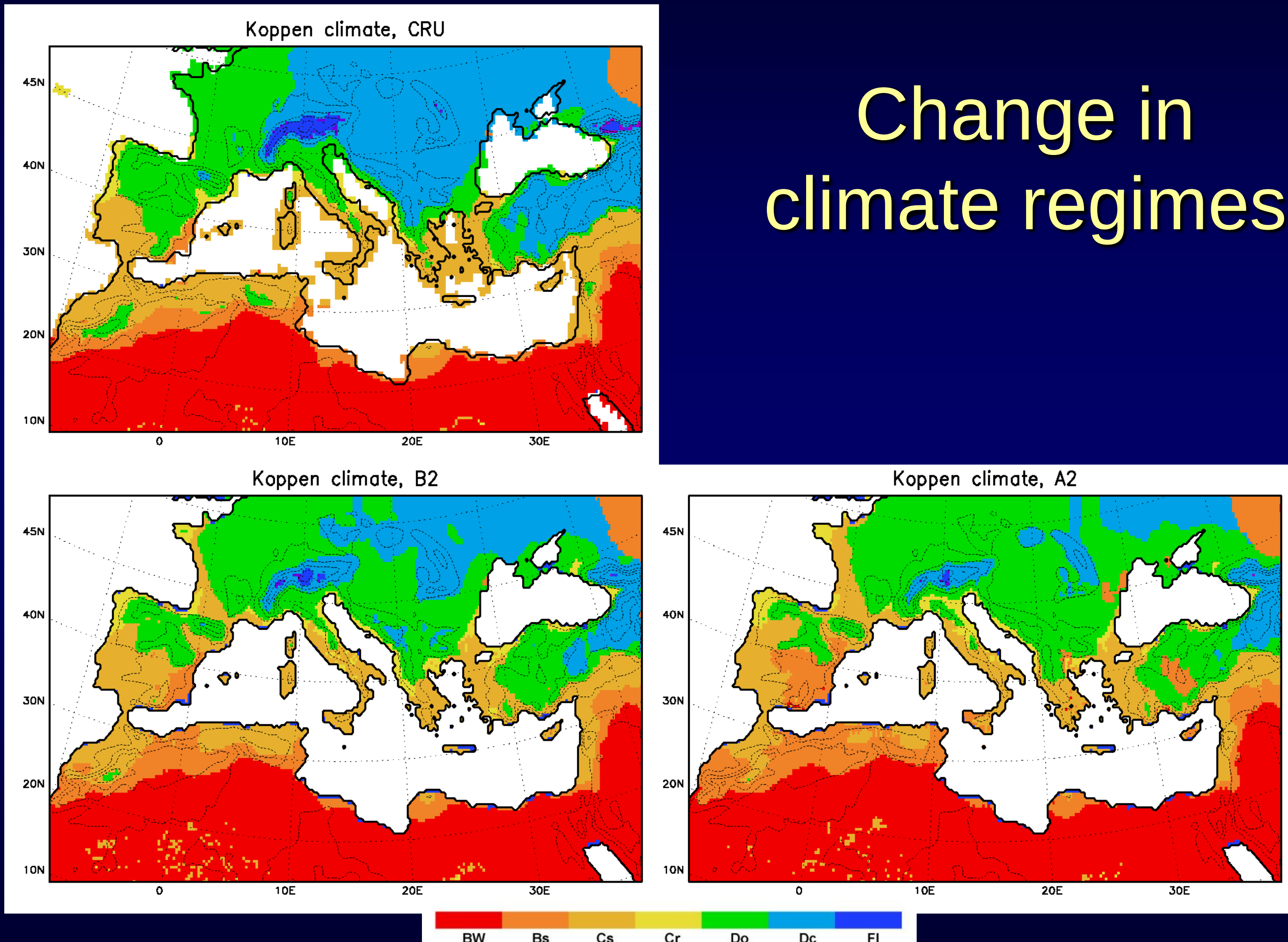


Pronounced Coastal effect

The heat index is obtained from a polynomial regression formula based on temperature and relative humidity

From Diffenbaugh et al. GRL, 2007

Change in climate regimes



From Gao and Giorgi (2007)

Summary

Model simulations indicate some robust signals over the Mediterranean region

Winter climate

- Warming greater than the global average
- Decrease in precipitation except over the Alpine region
- Increase in the positive phase of the NAO (Terray et al. 2004; Coppola et al. 2005)
- Increase in interannual variability, especially in the warm season

Summary

Model simulations indicate some robust signals over the Mediterranean region

Summer Climate

- Maximum warming over the Mediterranean region, much greater than the global average
- Large decrease in precipitation
- Increased temperature and precipitation interannual variability
- Increase in dry spell length and maximum intensity of precipitation
- Consistency with trends observed in recent decades (Pal et al. 2004)

Causes of concern?

- Water availability and water management to become a much bigger issue
- Large effects on agriculture
- Increased aridity and risk of desertification, especially in the southern Mediterranean
- Issues related to coping with summer heat
- Increased pollution related to higher temperatures and reduced precipitation
- Large decrease of glaciers and snow
- Changes in Mediterranean circulations
- Problems with the tourism industry
- Problems with coastal areas (heat, sea level rise)
- Adaptation of ecosystems (land and marine)

Regional Climate Change Index (RCCI)

$$RCCI = [n(\Delta P) + n(\Delta\sigma_P) + n(RWAF) + n(\Delta\sigma_T)]_{WS} +$$

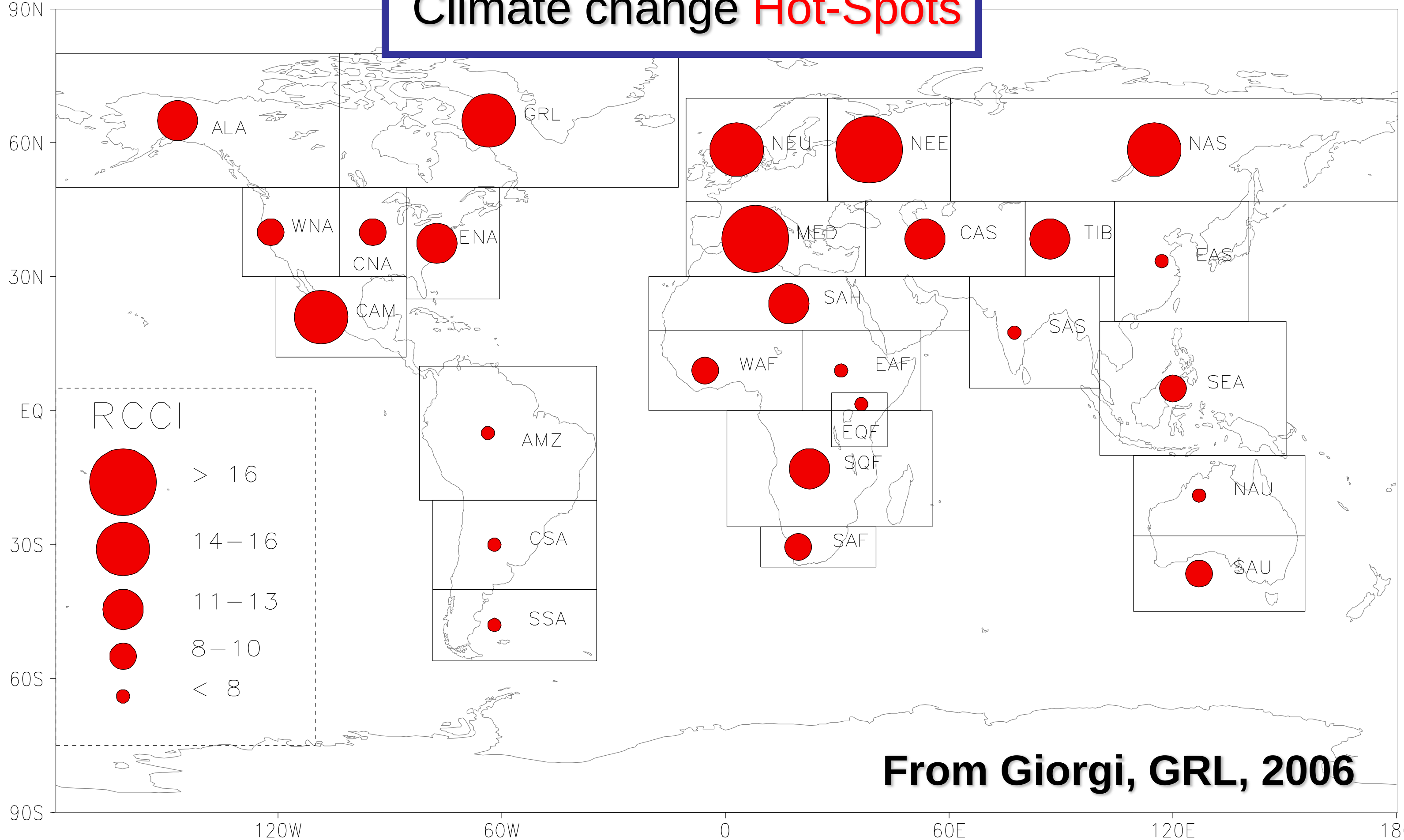
$$[n(\Delta P) + n(\Delta\sigma_P) + n(RWAF) + n(\Delta\sigma_T)]_{DS}$$

n	ΔP	$\Delta\sigma_P$	RWAF	$\Delta\sigma_T$
0	$< 5\%$	$< 5\%$	< 1.1	$< 5\%$
1	$5 - 10\%$	$5 - 10\%$	$1.1 - 1.3$	$5 - 10\%$
2	$10 - 15\%$	$10 - 20\%$	$1.3 - 1.5$	$10 - 15\%$
4	$> 15\%$	$> 20\%$	> 1.5	$> 15\%$

The Mediterranean appears to be particularly responsive to global change

We cannot ignore this problem

Climate change Hot-Spots



From Giorgi, GRL, 2006


THANK YOU

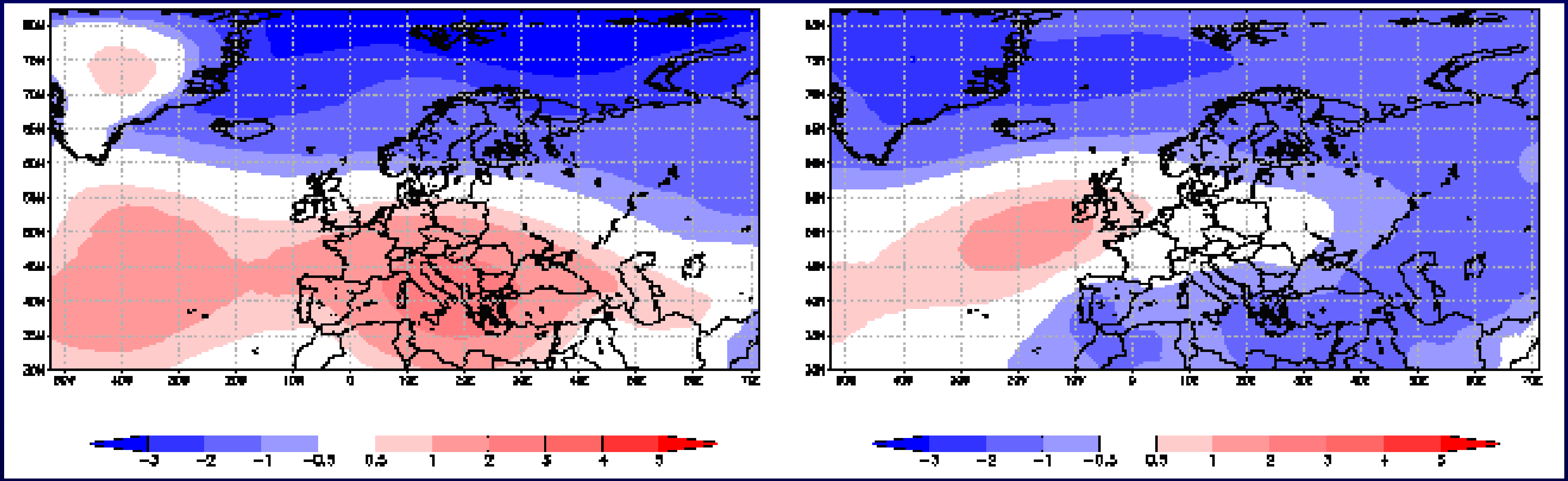
Hypotheses for the projected summer drying over Europe (Rowell and Jones 2006)

- Low Spring soil moisture leading to reduced convection
- Large land-sea contrast in warming leading to reduced relative humidity over the continent and reduced precipitation
- Remotely forced circulation changes (Asian monsoon effect)
- Positive summer soil moisture-precipitation feedback

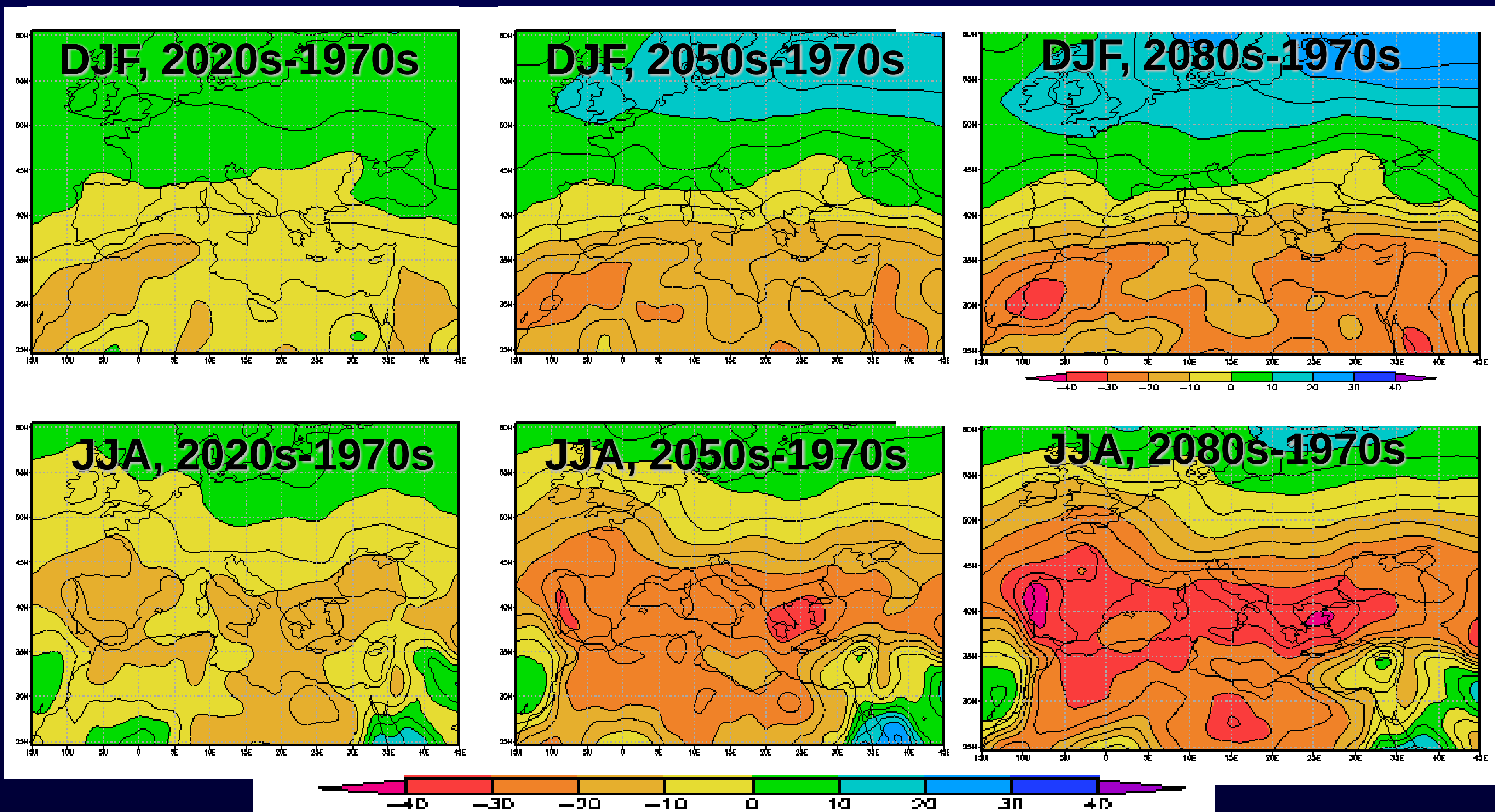
SLP change (mb, 2071-2100 minus 1961-1990), CMIP3 ensemble average, A1B scenario

DJF

JJA



Precipitation change (%) as a function of time, CMIP3 ensemble average, A1B scenario



Precipitation change (%, 2071-2100 minus 1961-1990), as a function of scenario, CMIP3 ensemble