A review of climate change projections over the Mediterranean region

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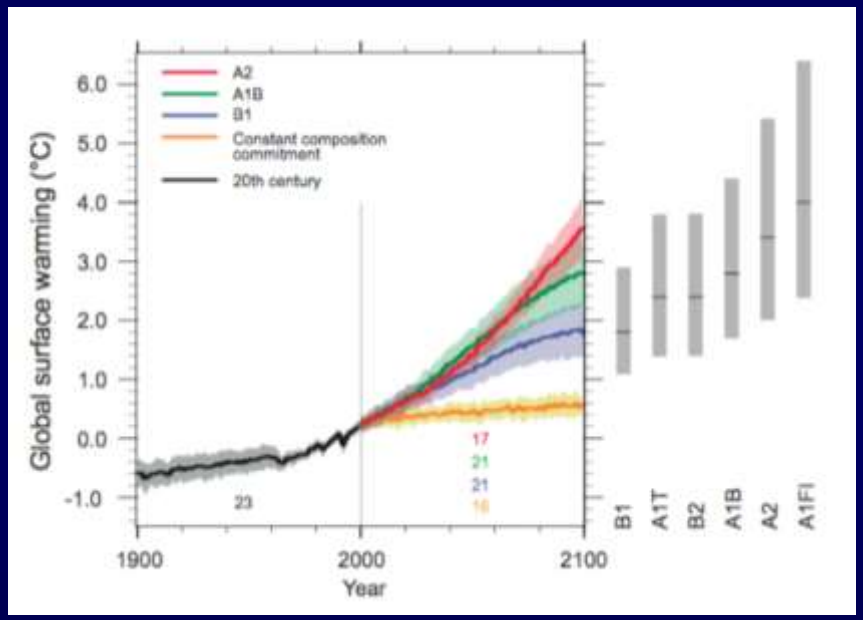
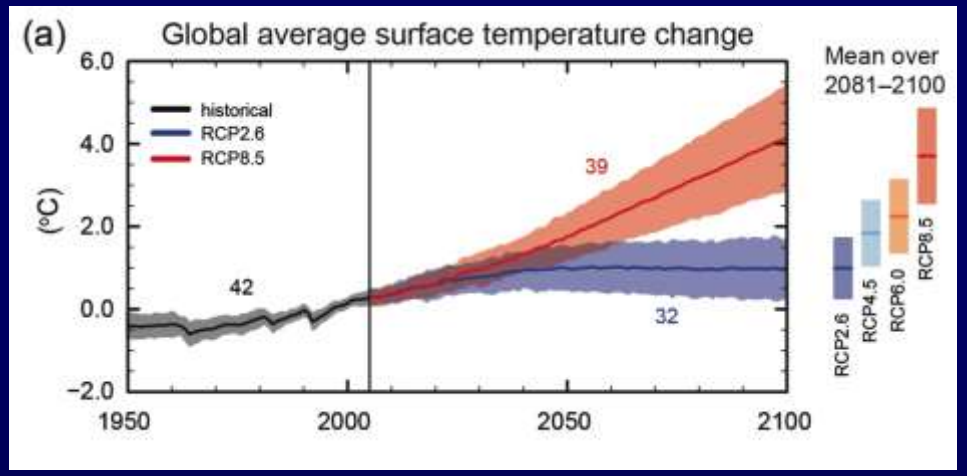
International Conference on Climate Change, Nicosia, May 2018

IPCC : Global temperature change projections for the 21st century

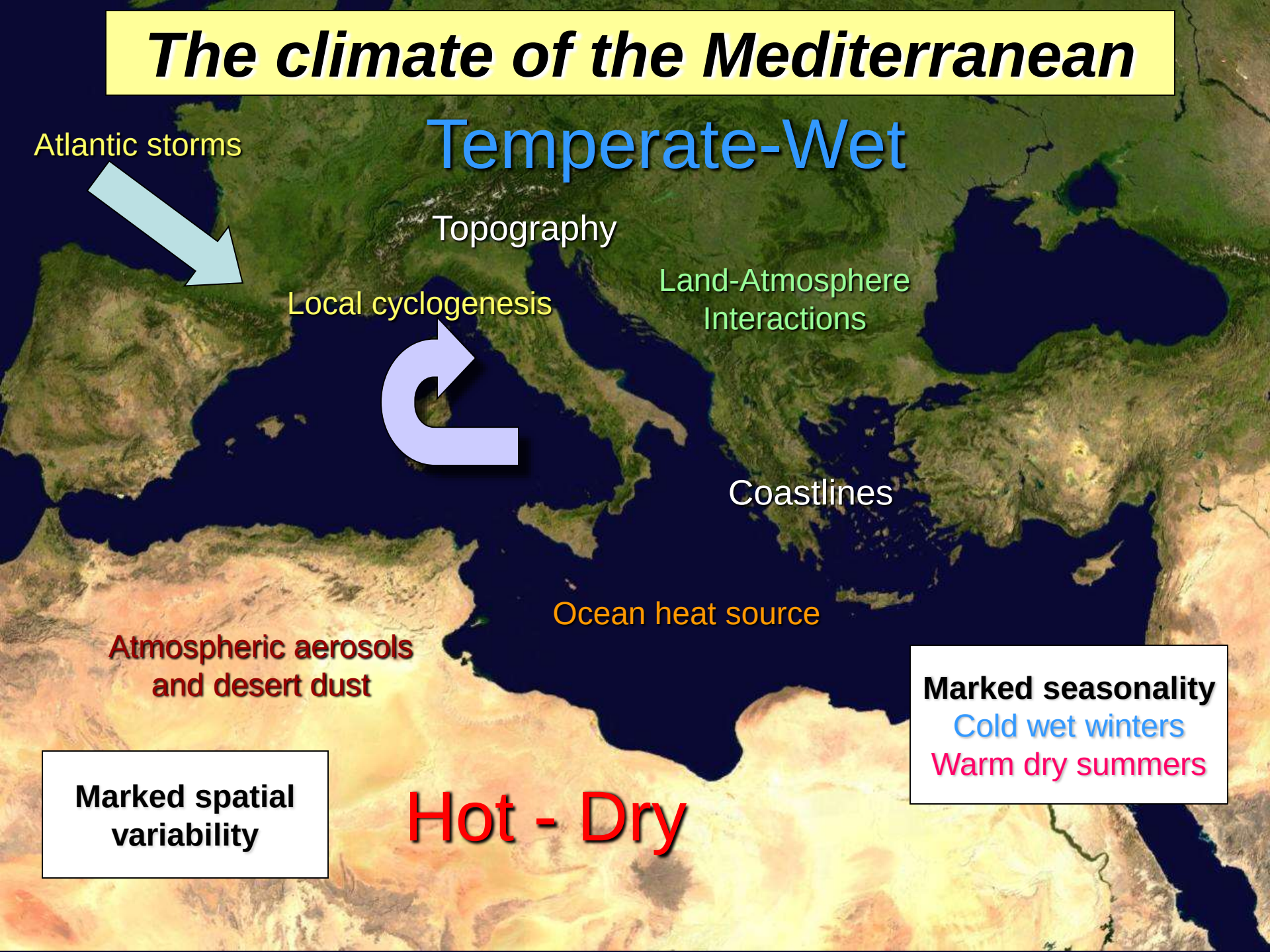
CMIP3, AR4 (2007)



CMIP5, AR5 (2013)

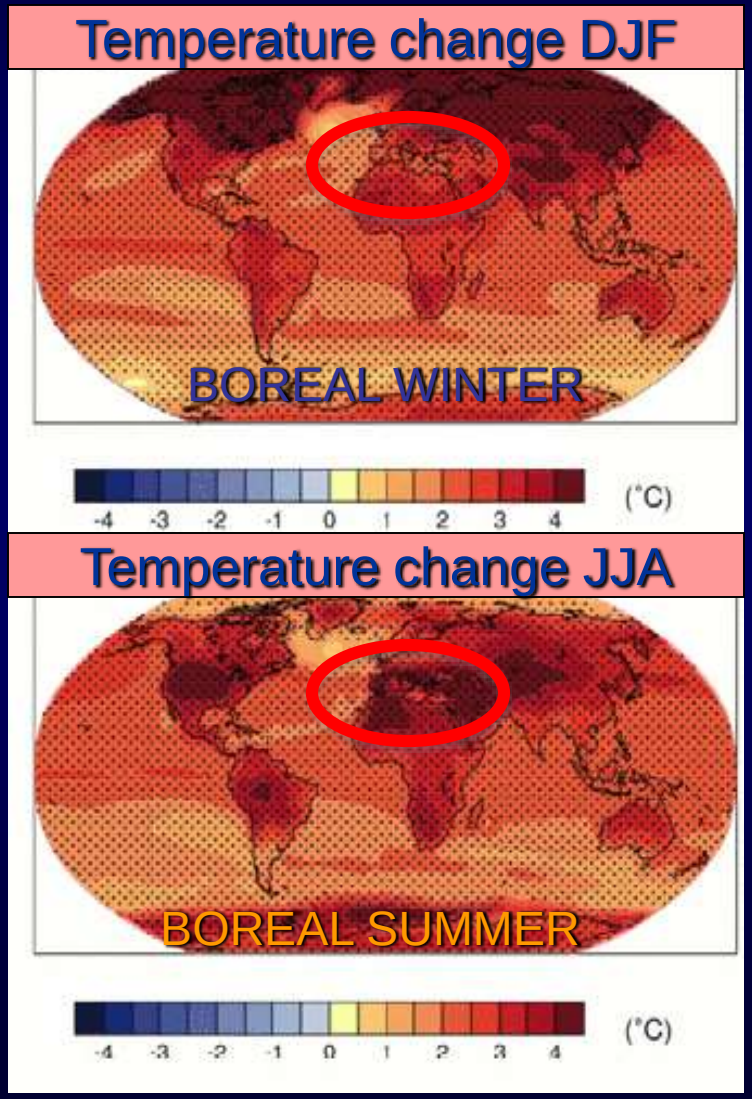


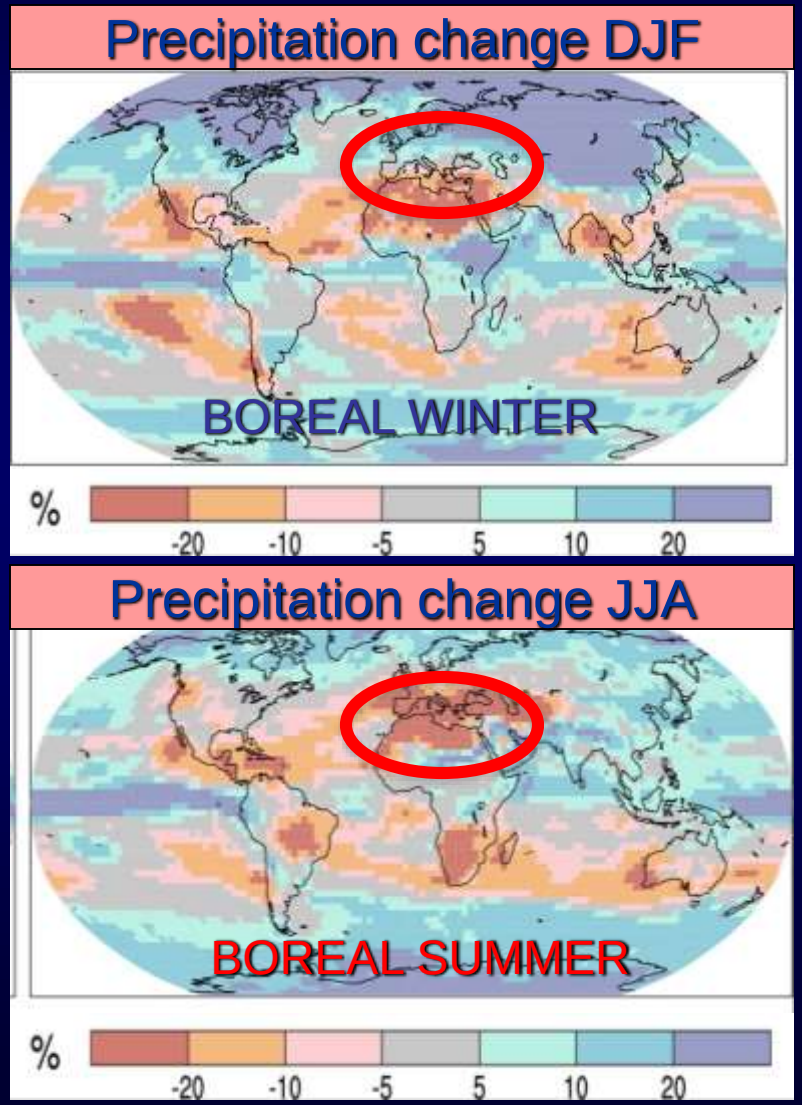
The climate of the Mediterranean

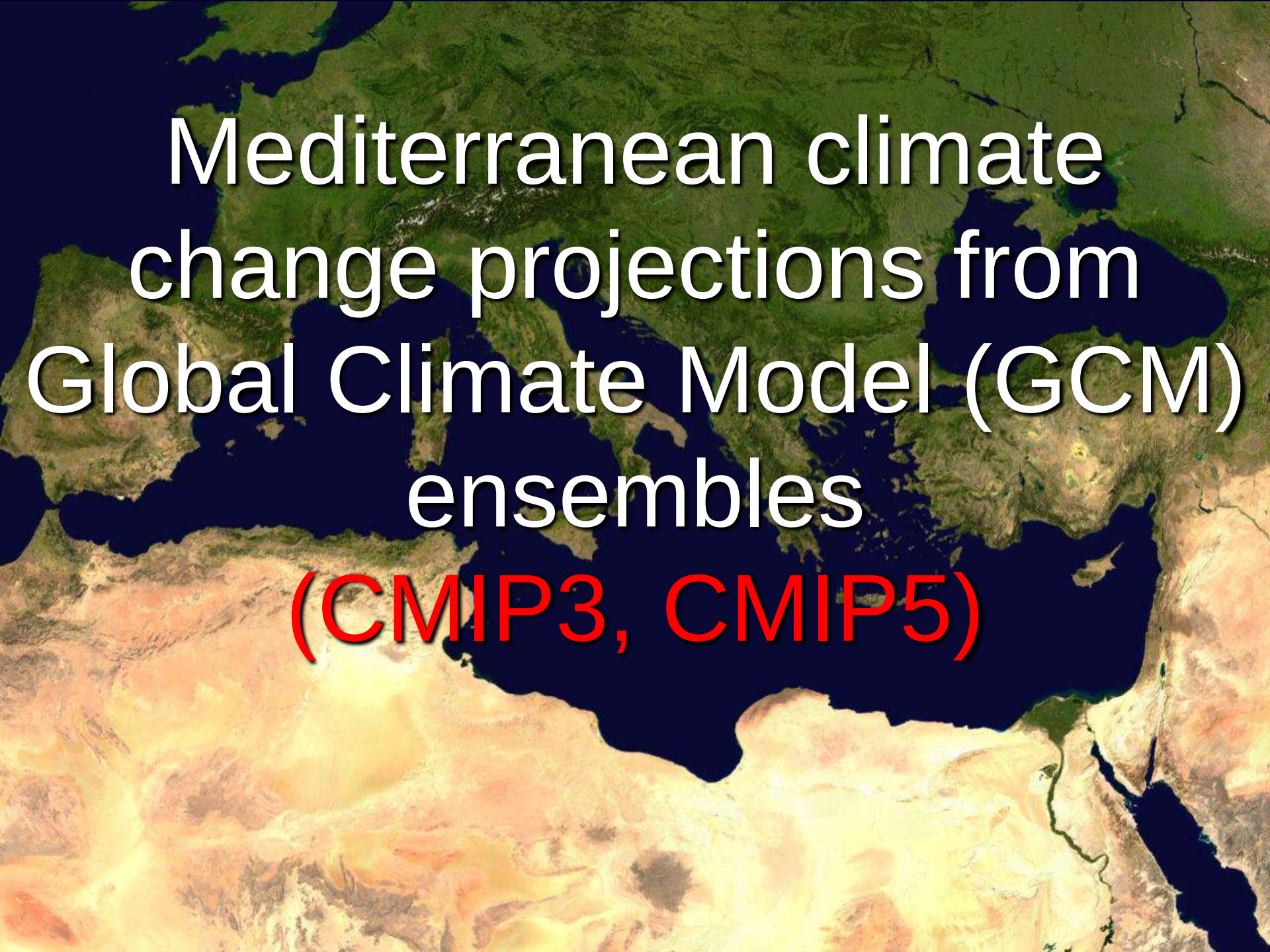


Regional distribution of projected temperature and precipitation change

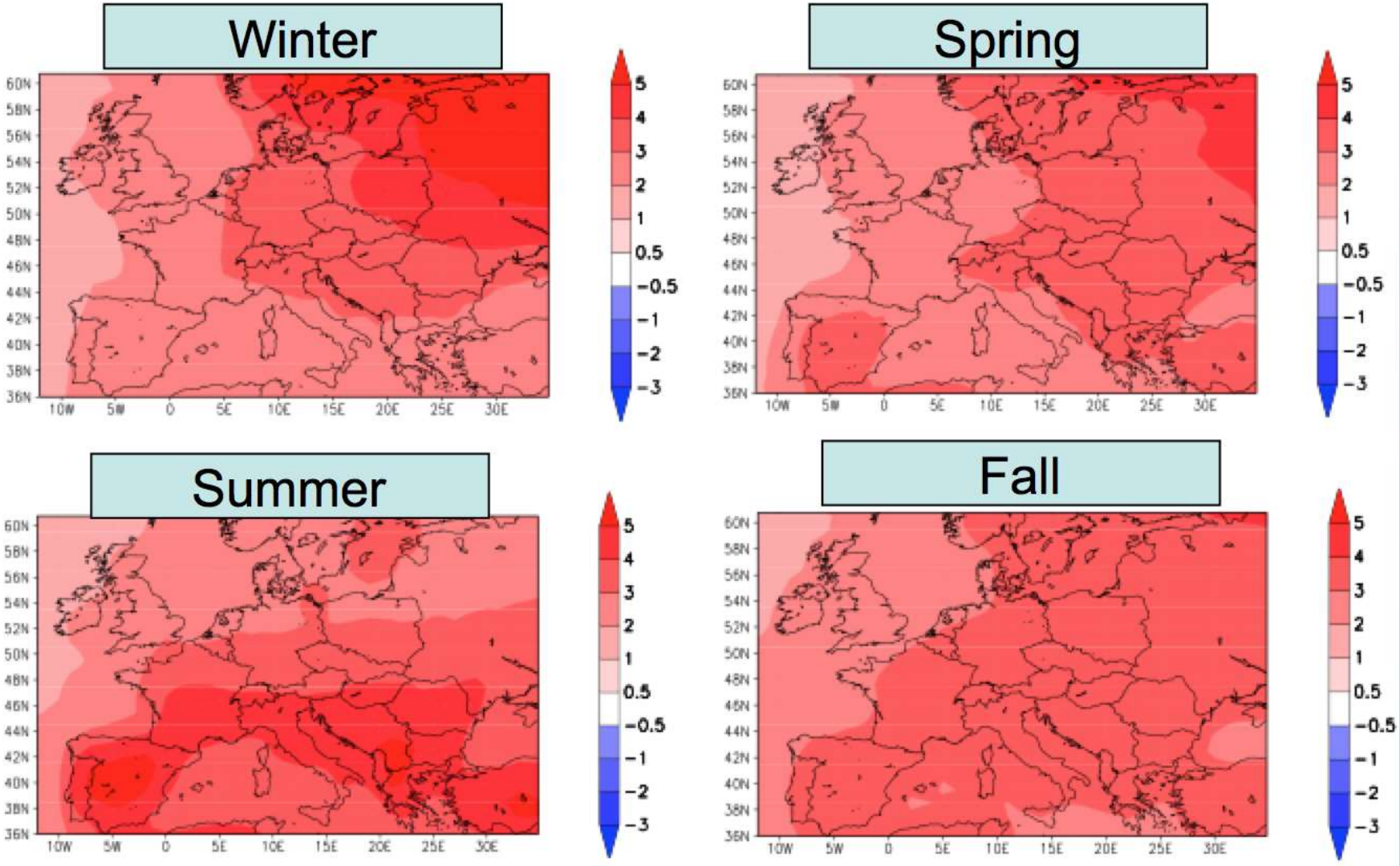
(A1B scenario, 2090-2100)





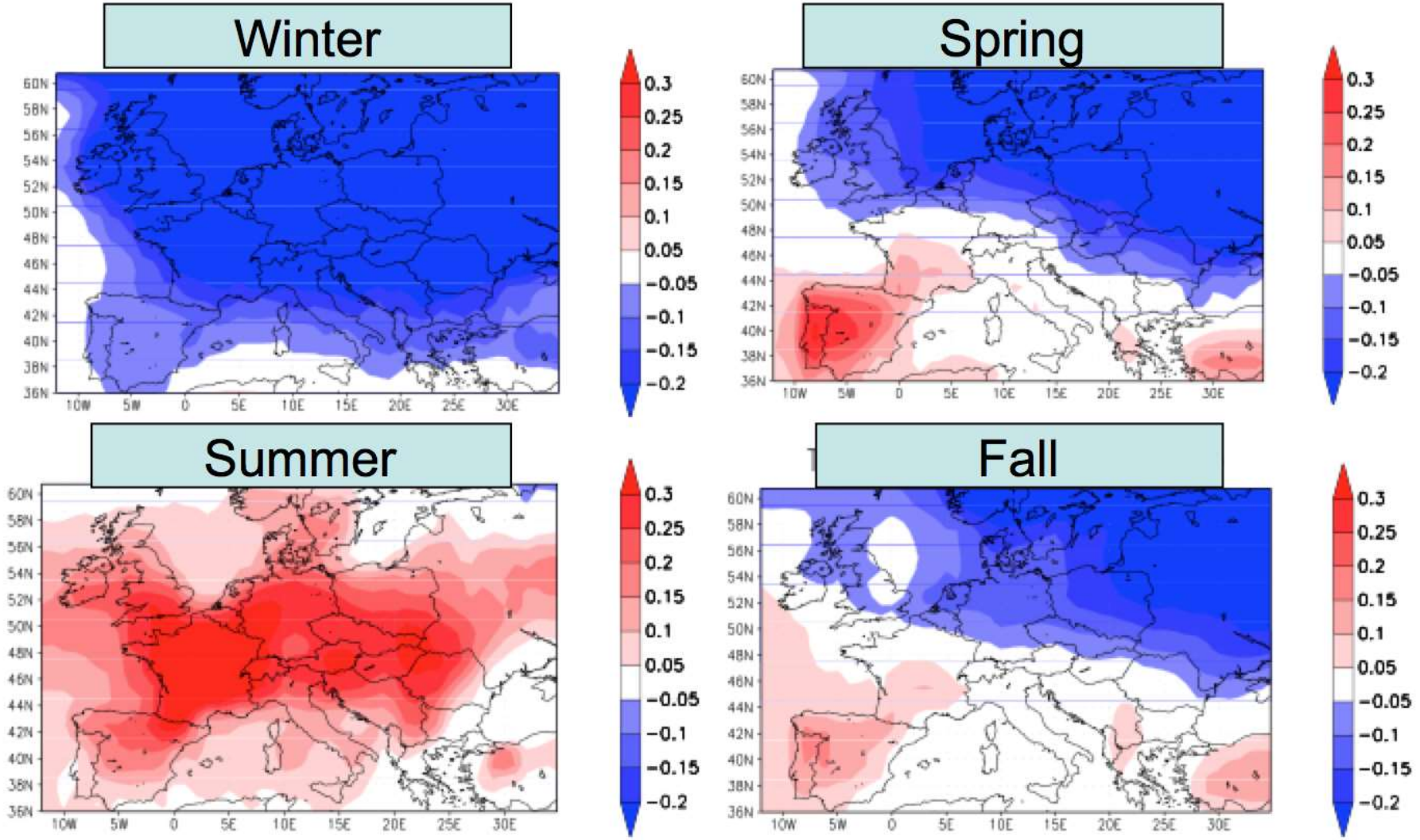

Mediterranean climate change projections from Global Climate Model (GCM) ensembles
(CMIP3, CMIP5)

Temperature change, CMIP3 A1B Scenario, 20 AOGCMs



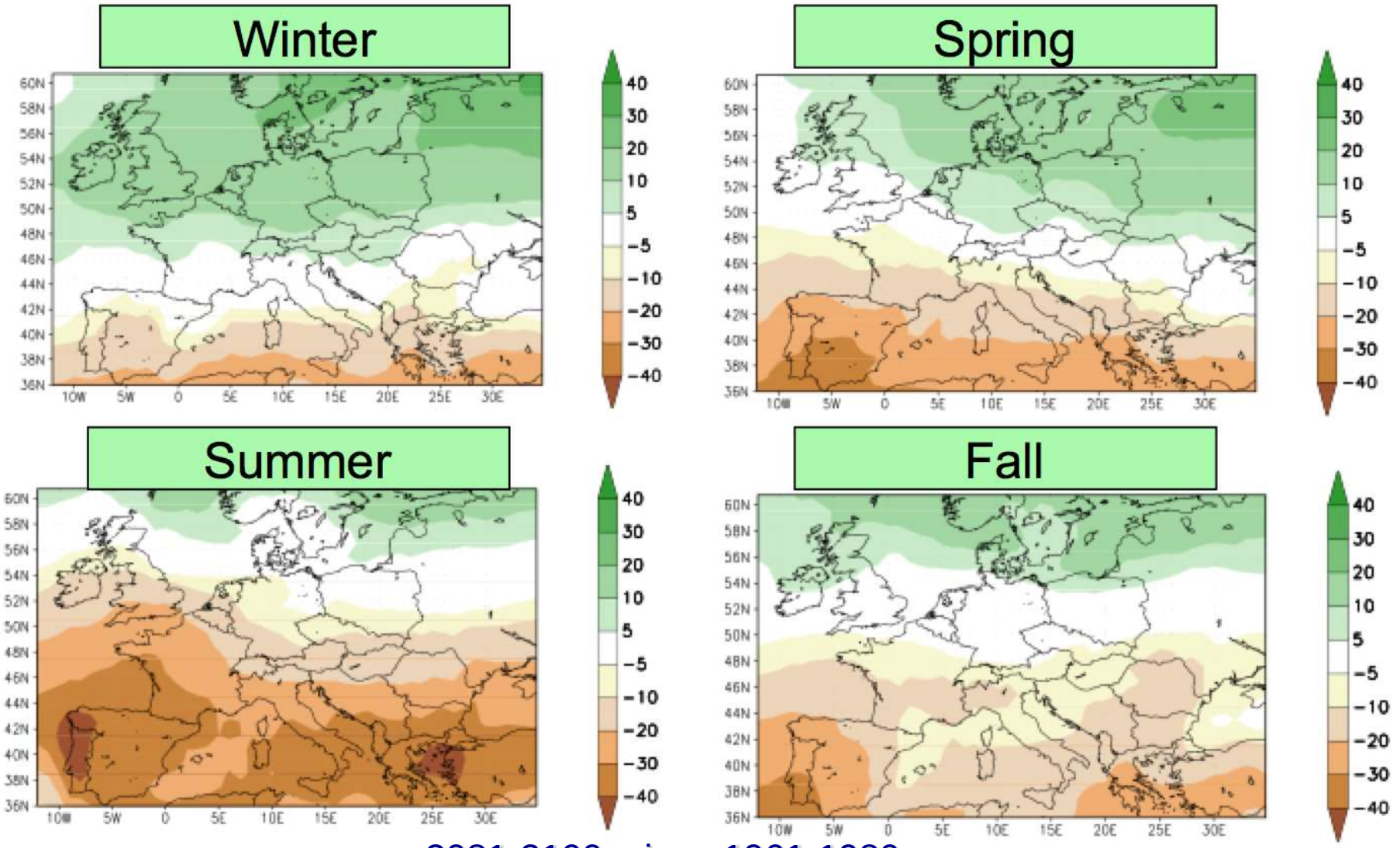
2081-2100 minus 1961-1980

Temperature variability change, CMIP3 A1B Scenario, 20 AOGCMs

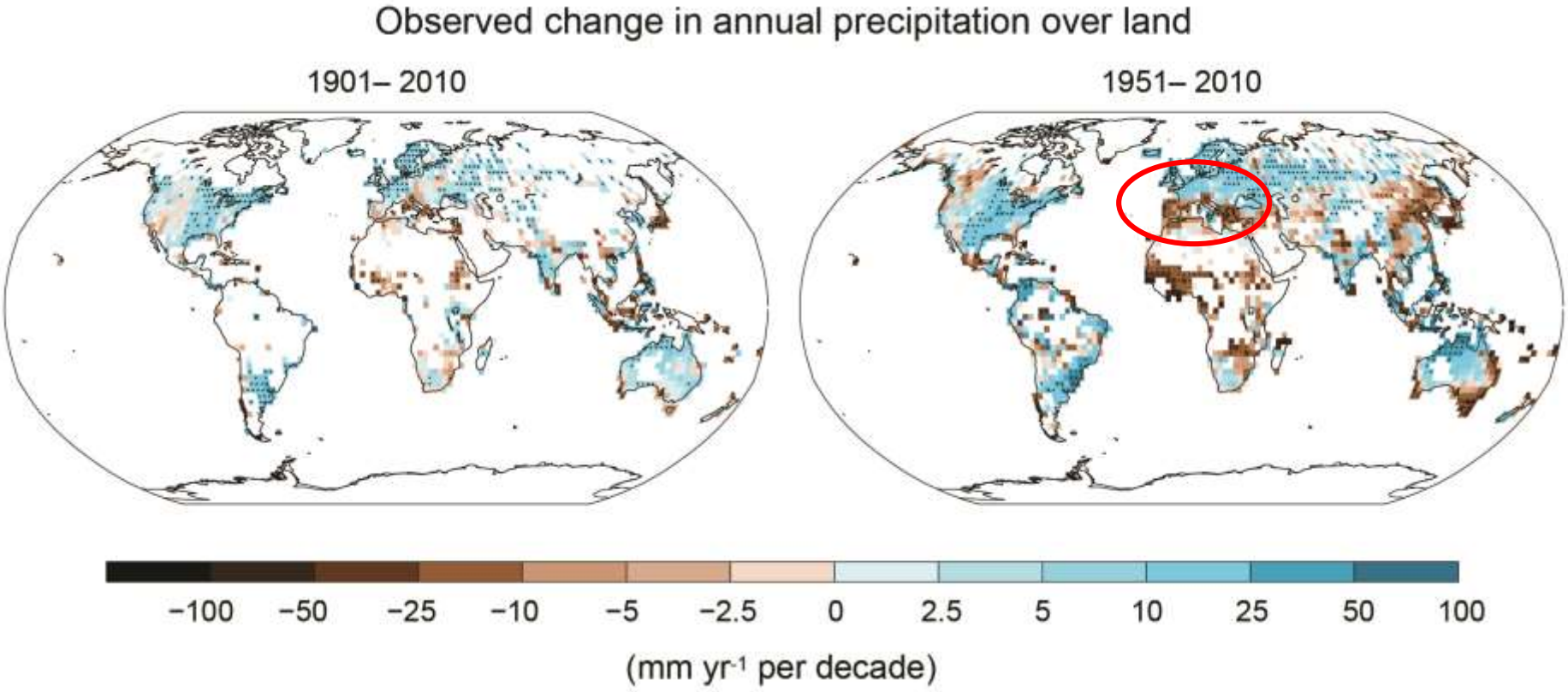


2081-2100 minus 1961-1980

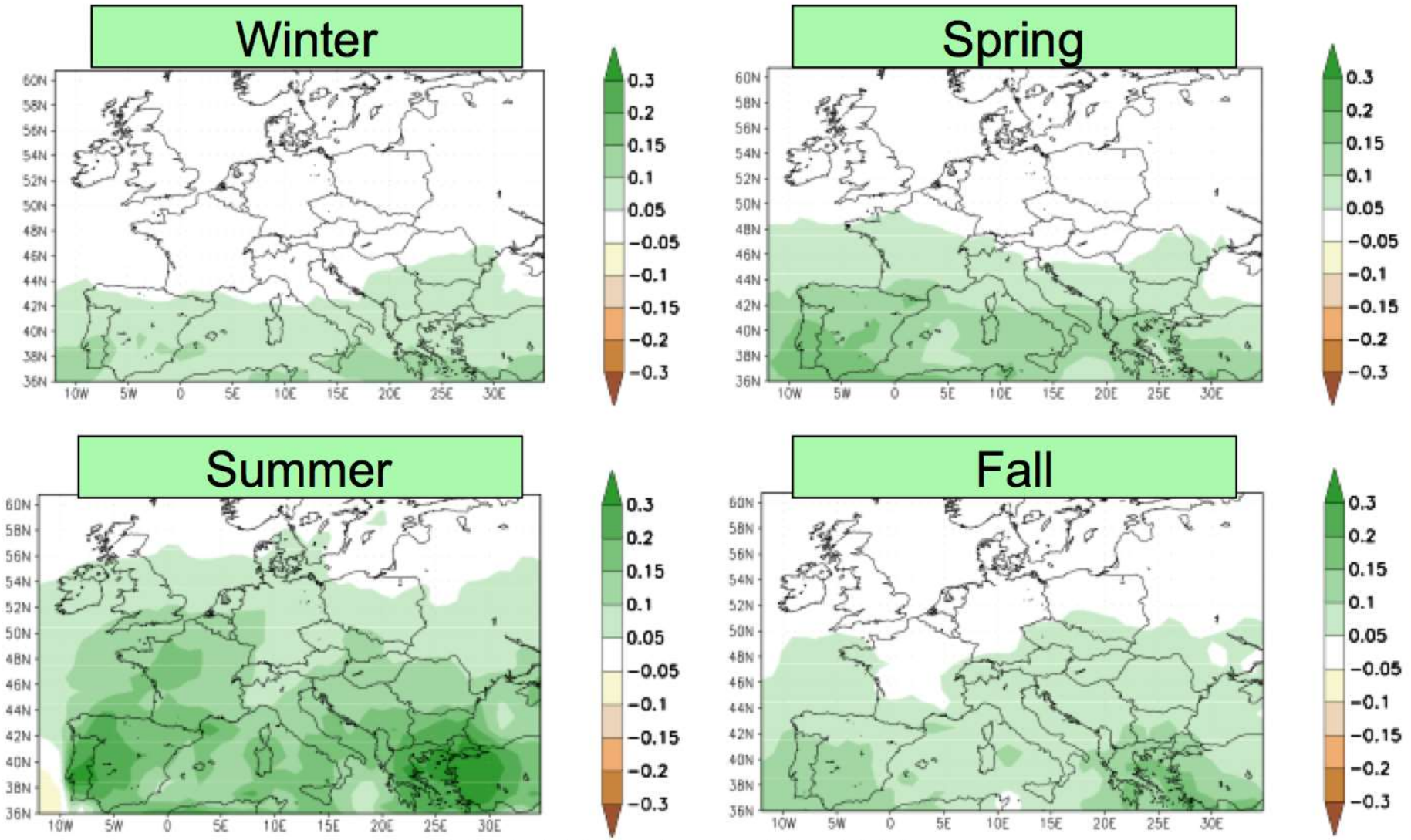
Precipitation change, CMIP3
A1B Scenario, 20 AOGCMs



2081-2100 minus 1961-1980


Observed change in annual precipitation over land
1901– 2010
1951– 2010
−100
−50
−25
−10
−5
−2.5
0
2.5
5
10
25
50
100
(mm yr-1 per decade)

Precipitation variability change, CMIP3 A1B Scenario, 20 AOGCMs

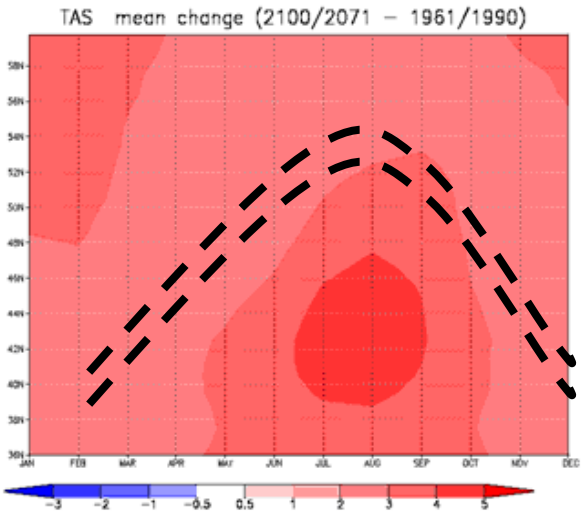


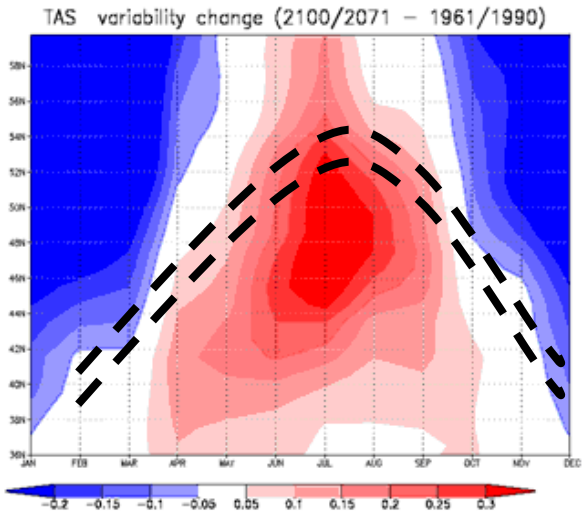
2081-2100 minus 1961-1980

The European Climate Change Oscillation (ECO)

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

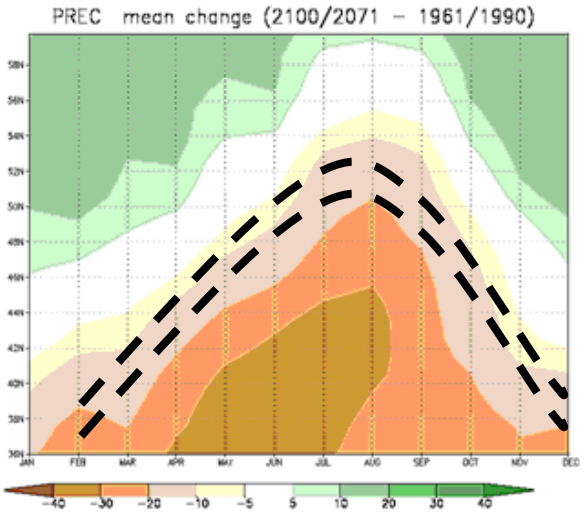
T-Mean

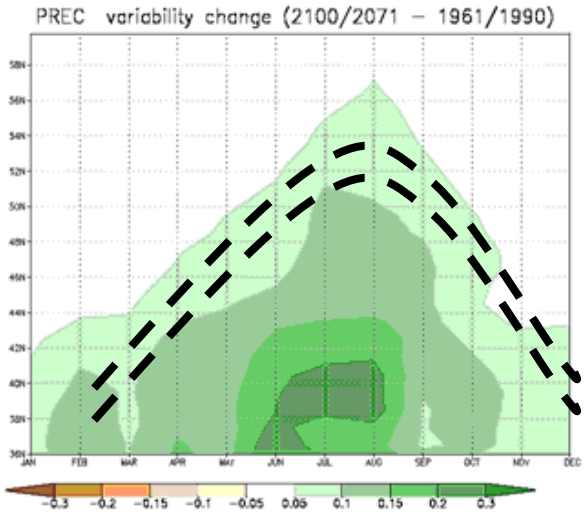




T-Var

P-Mean

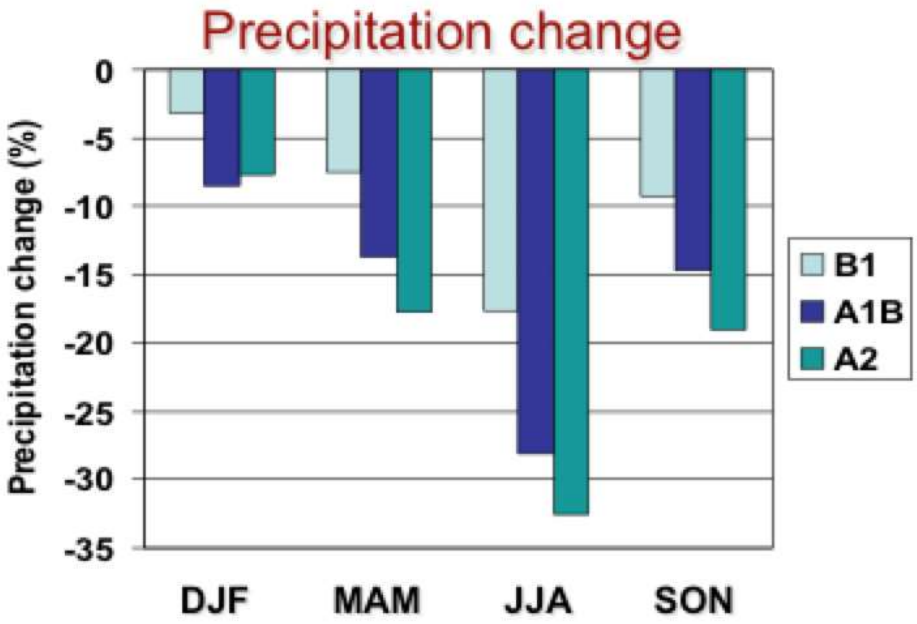


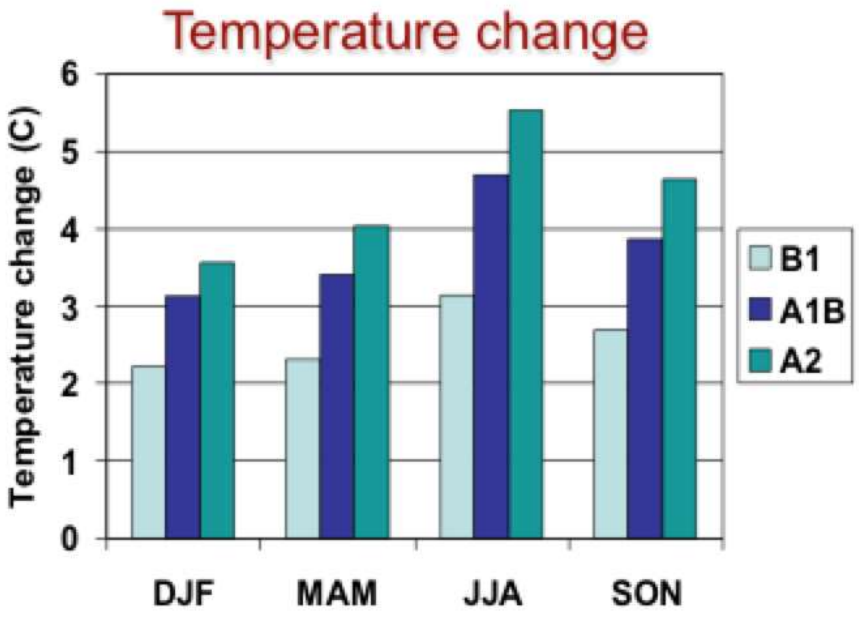


P-Var

CMIP3 ensemble average change as as a function of emission scenario

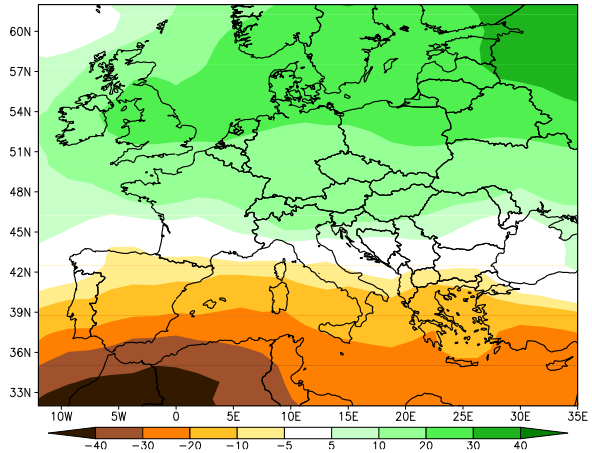
Full Mediterranean, (2081-2100) – (1961-1980)



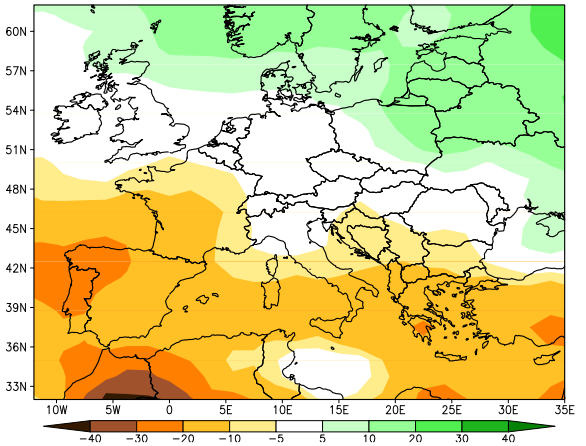


Precipitation change (2071-2100), CMIP5 RCP8.5 Scenario, 21 AOGCMs

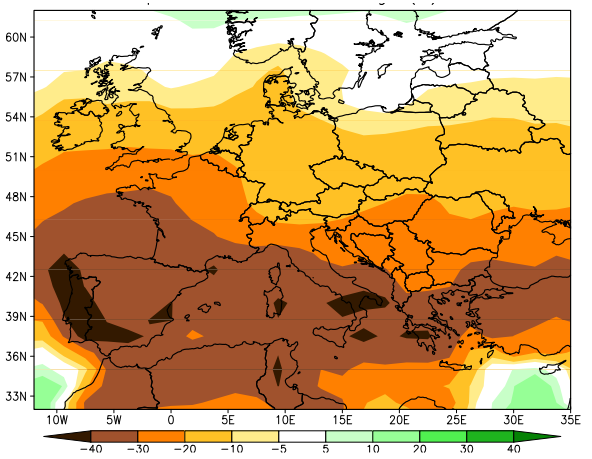
Winter



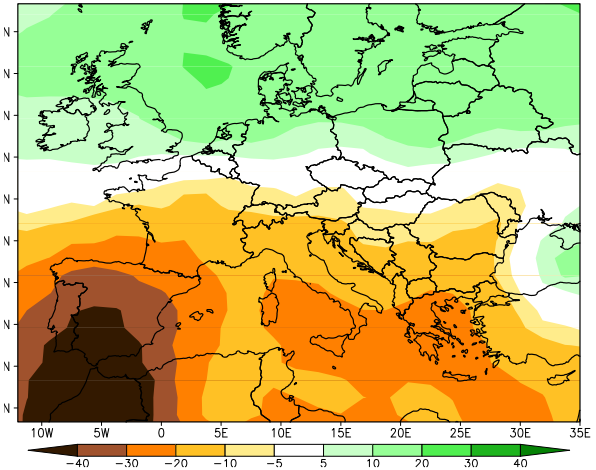
Spring



Summer

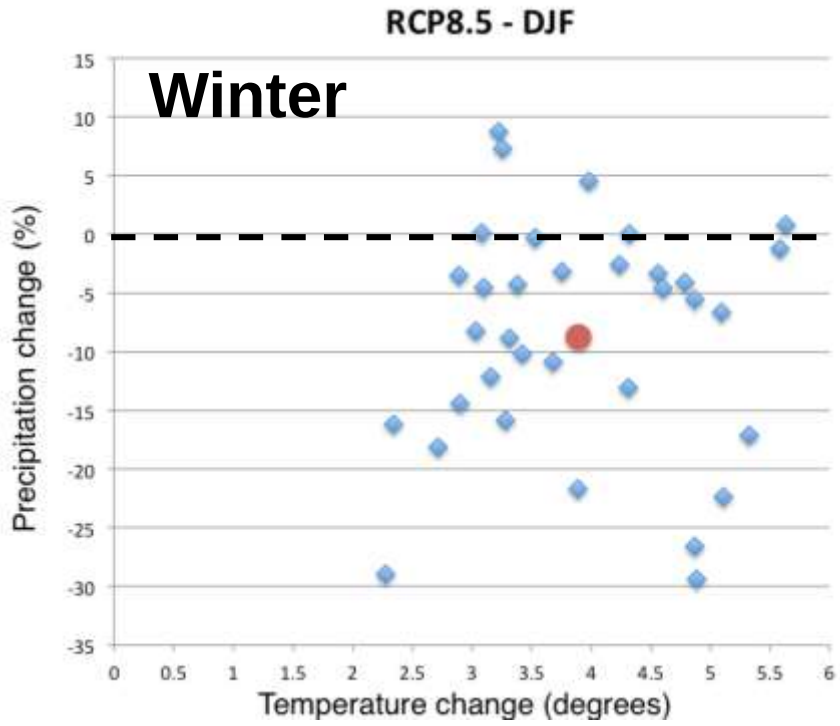


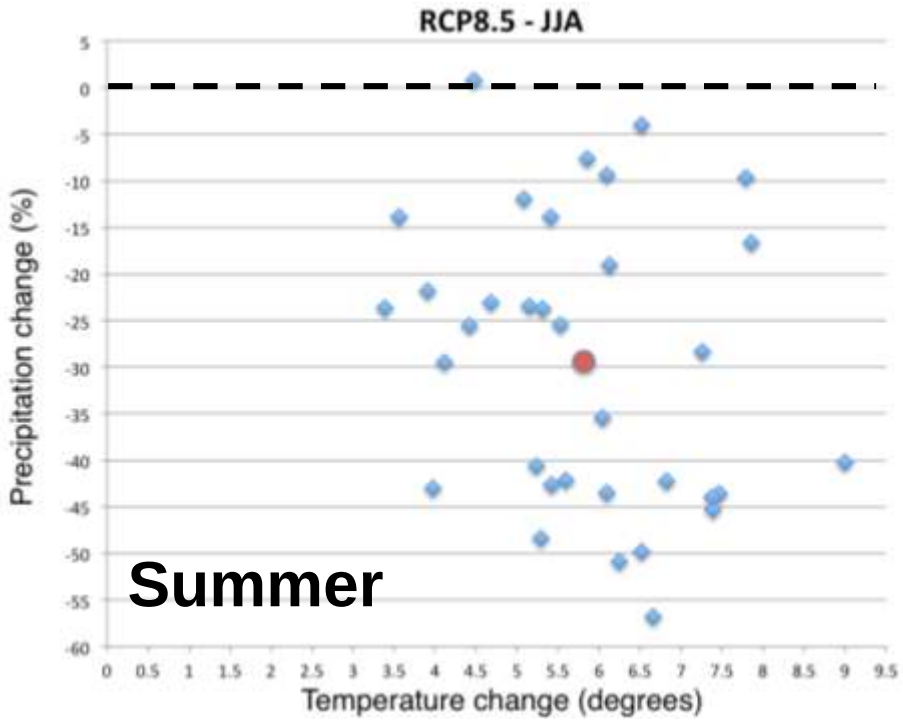
Fall



Projections of temperature and precipitation change over the Mediterranean in 32 CMIP5 AOGCMs

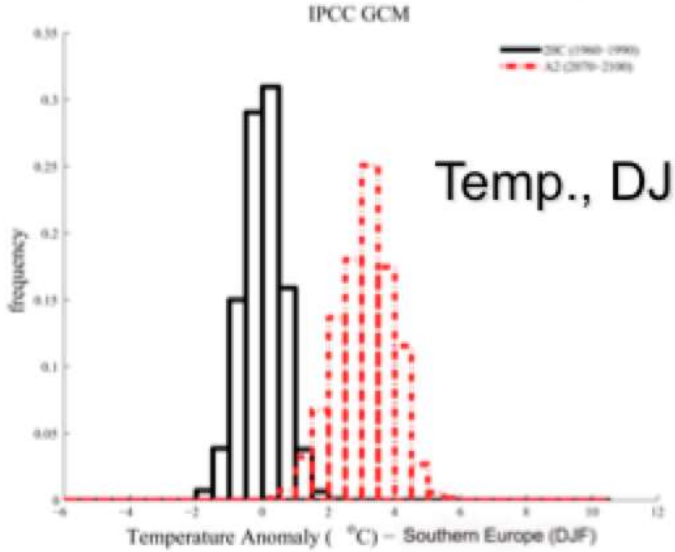
Scenario RCP8.5, 2071-2100

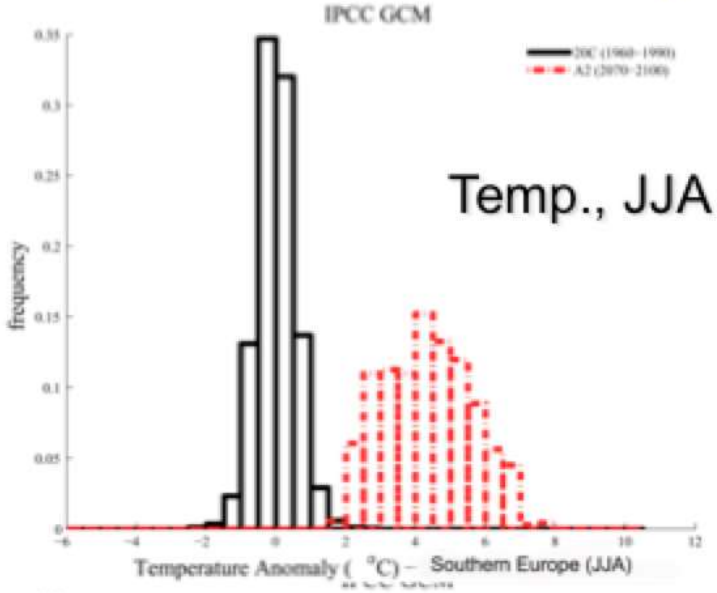


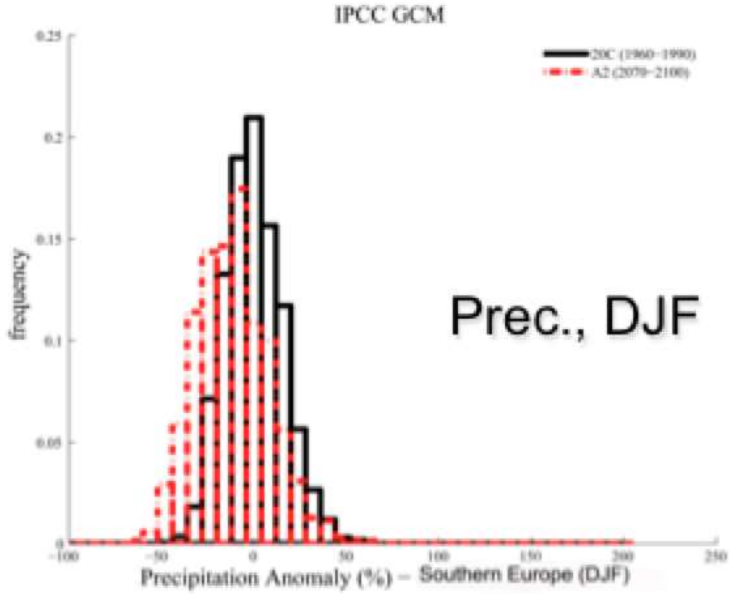


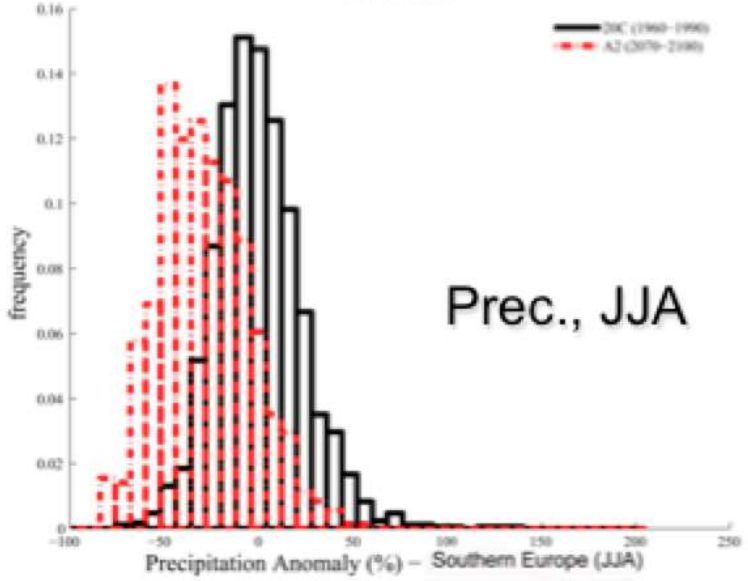
Change in seasonal precipitation distribution

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



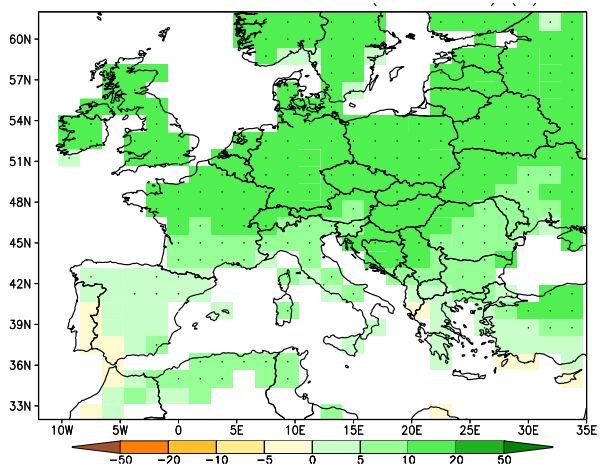




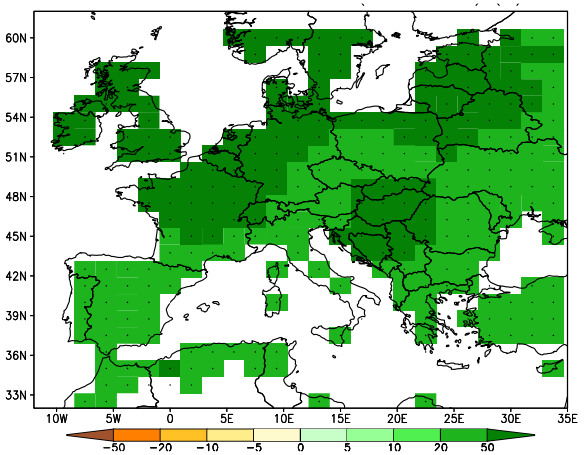


Trends in hydroclimatic indices (2006-2100) RCP8.5, 9 CMIP5 AOGCMs (Giorgi et al, 2014)

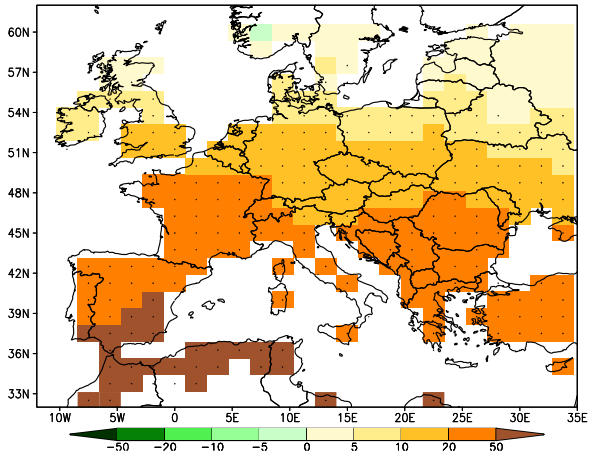
Mean Prec. Int.



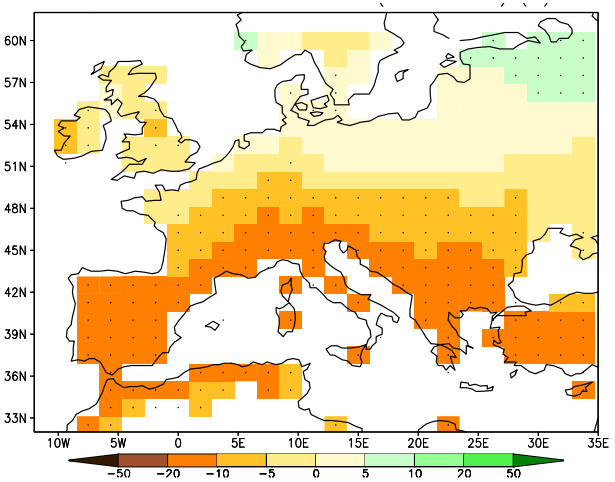
R95Tot



Dry Spell Length

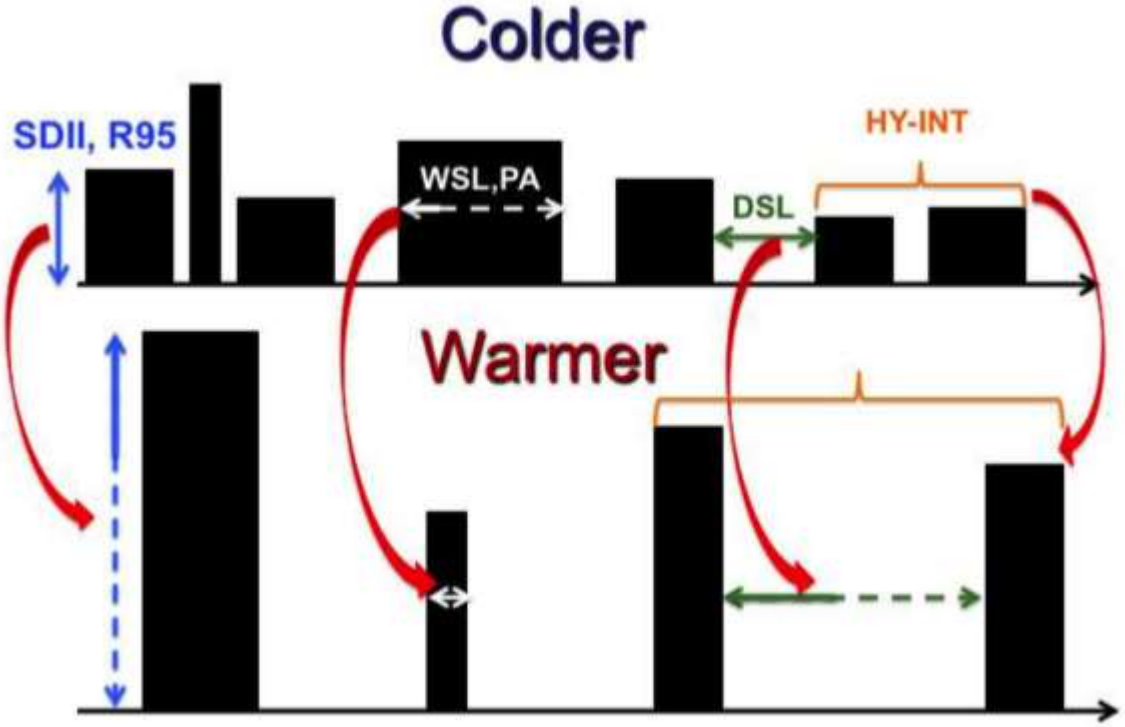


Wet Spell Length

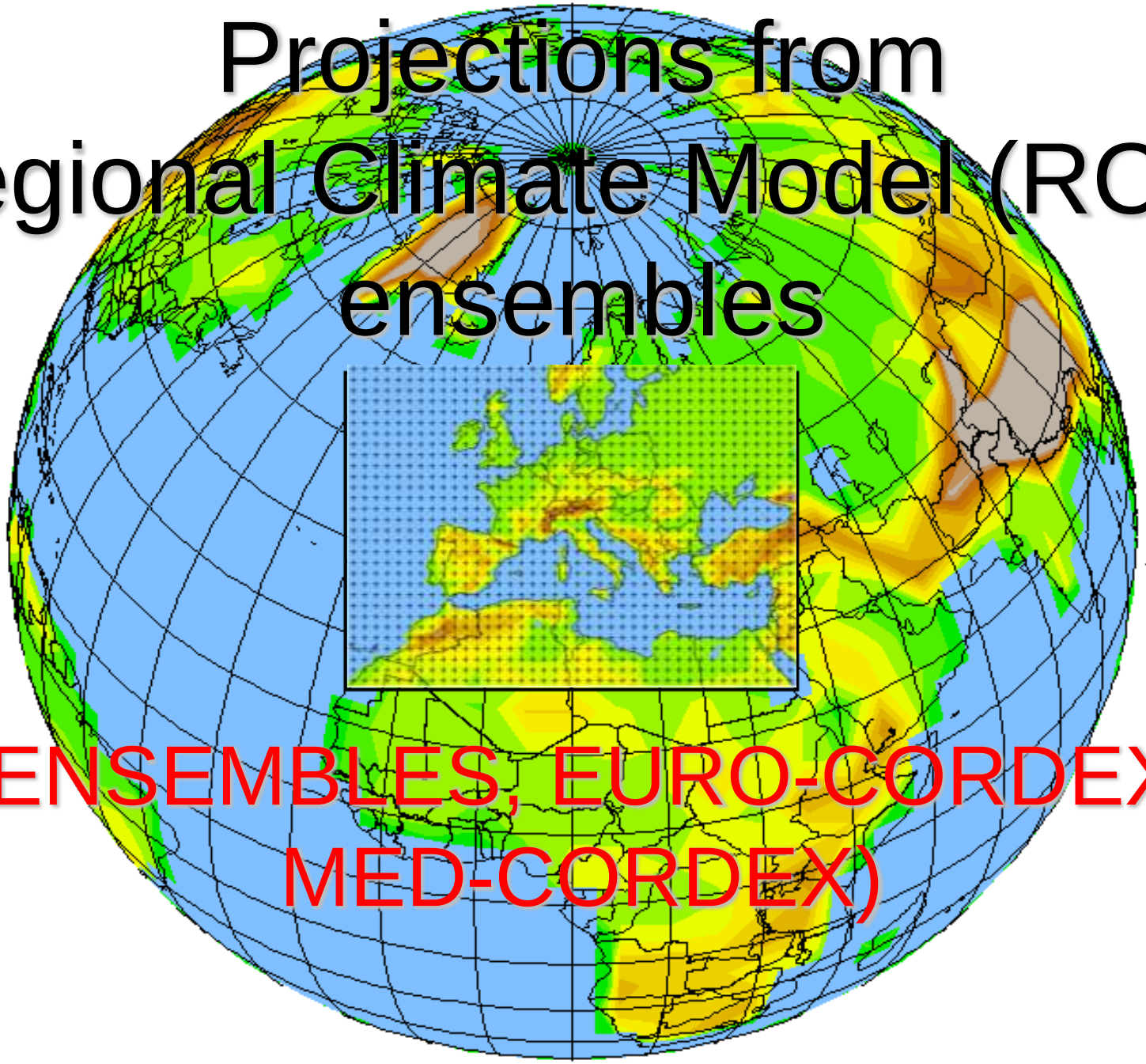


Hydroclimatic response to global warming emerging from the analysis of multiple interconnected indices (Giorgi et al. 2011, 2014)

Global warming should lead to more intense and extreme, more concentrated and less frequent precipitation events

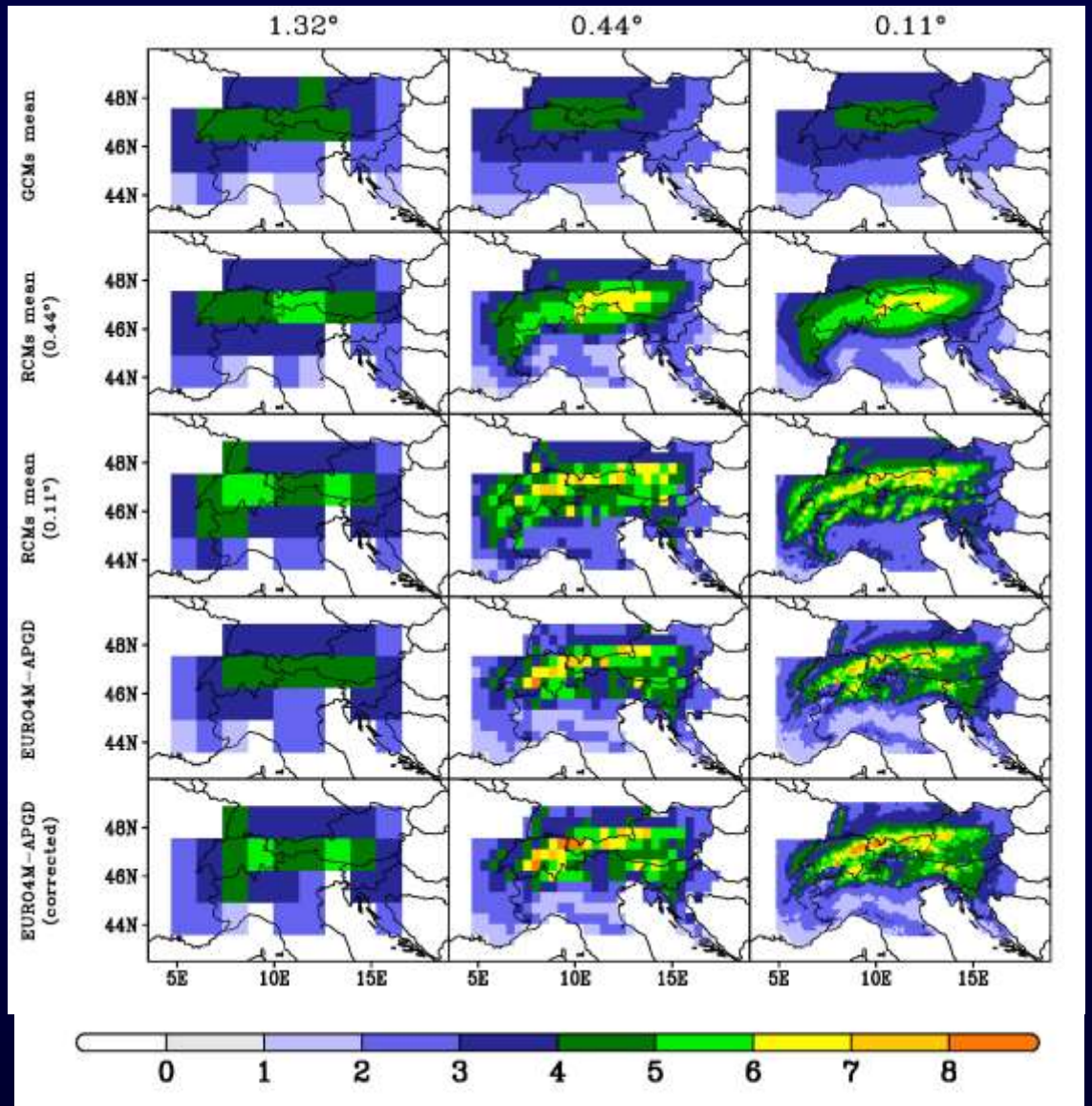


Projections from Regional Climate Model (RCM) ensembles



(ENSEMBLES, EURO-CORDEX, MED-CORDEX)

Simulation of summer precipitation patterns by the EURO/MED CORDEX RCMs



GCMs

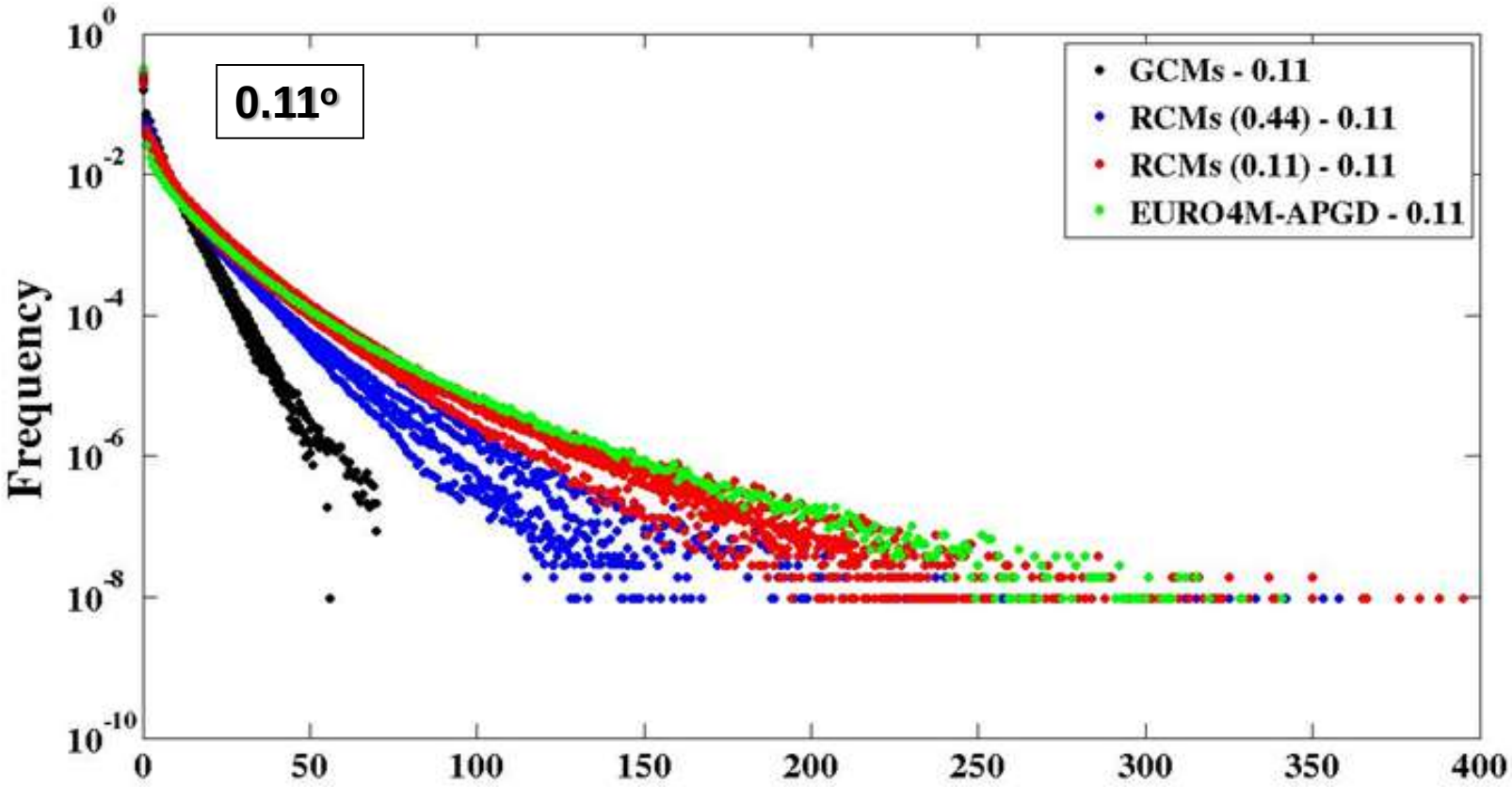
RCMs
dx=50 km

RCMs
dx=12 km

OBS

OBS
Corr.

Simulation of daily precipitation intensity PDFs by GCMs and RCMs

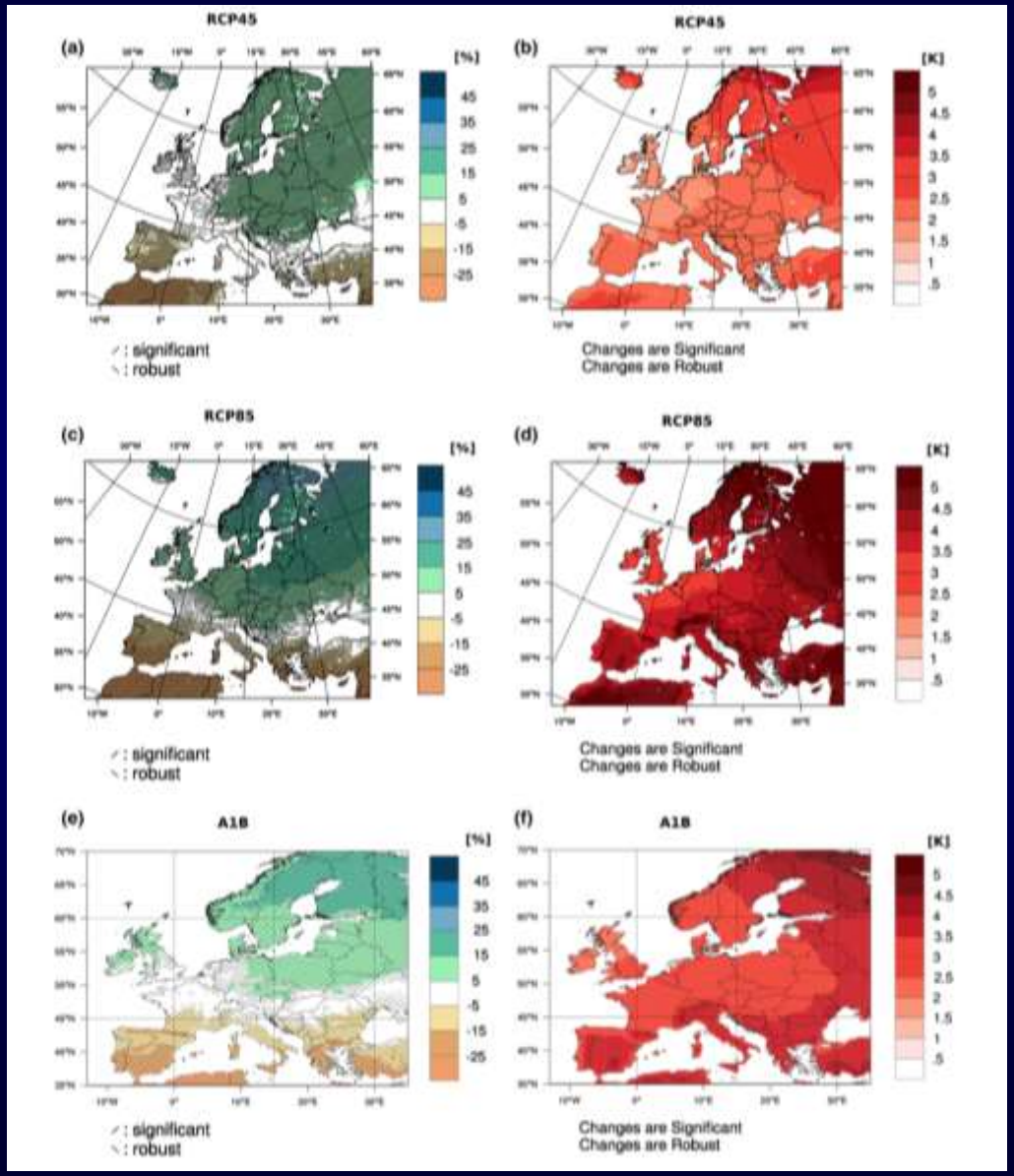


RCMs are always closer to OBS (also when upscaled)

Change in mean annual precipitation (left column) and temperature (right column) in different RCM ensembles

2071-2100
minus
1971-2000

Jacob et al.
2014

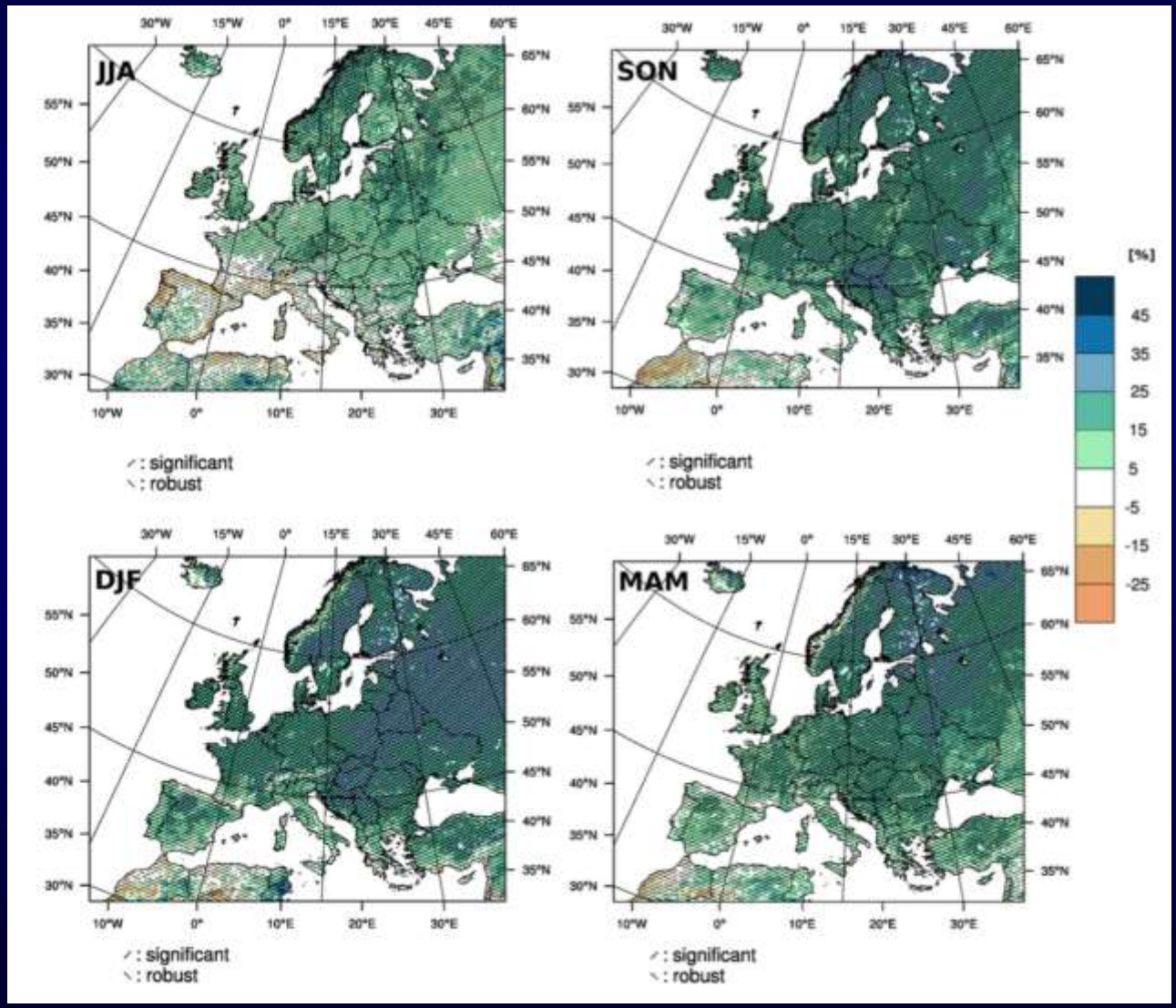


EURO
CORDEX
Ds=12 km
RCP4.5

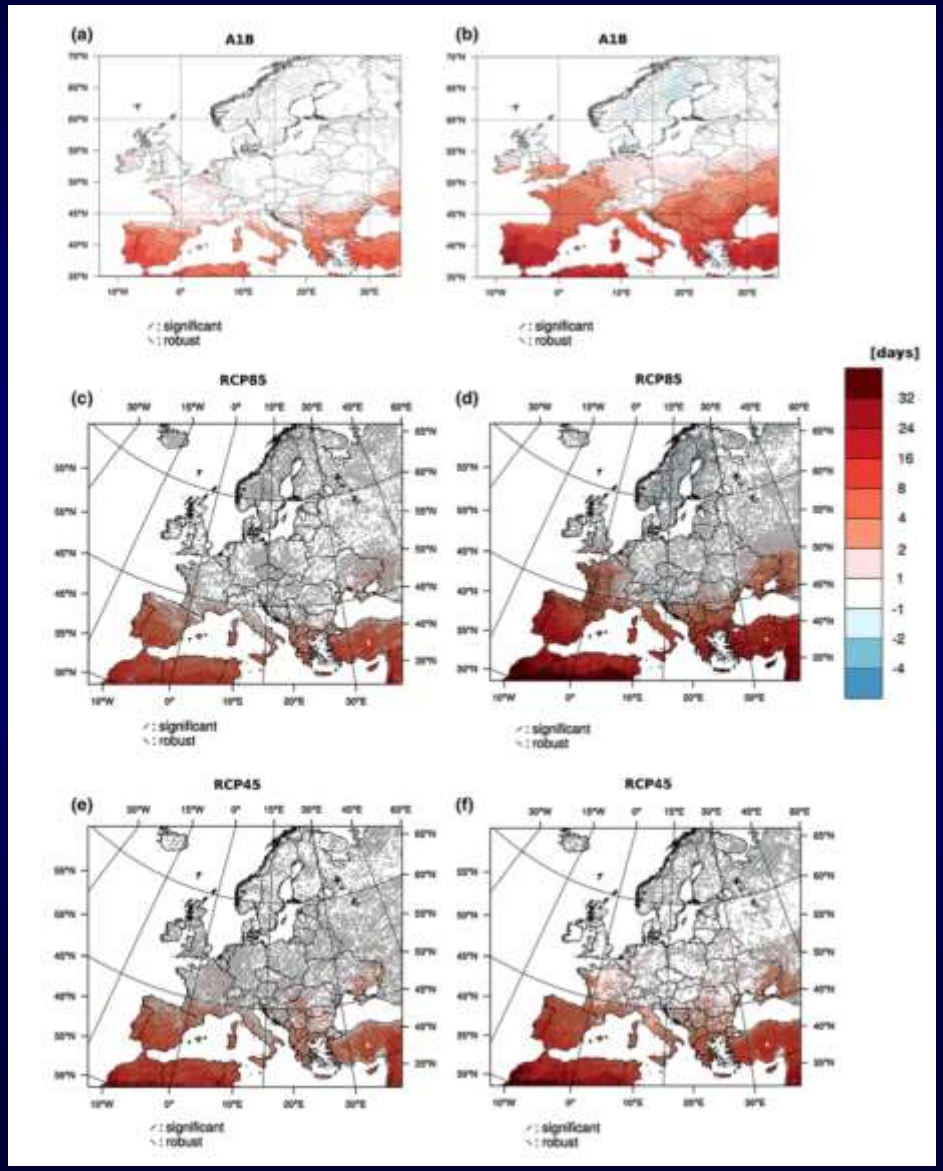
EURO
CORDEX
Ds=12 km
RCP8.5

ENSEMBLES
Ds=25 km
A1B

Change in heavy precipitation (95%) in the EURO-CORDEX ensemble (RCP8.5, 2071-2100 minus 1971-2000)



Change in mean annual “long” dry spell (95%) in different RCM ensembles (2071-2100 minus 1971-2000)



ENSEMBLES
Ds=25 km
A1B

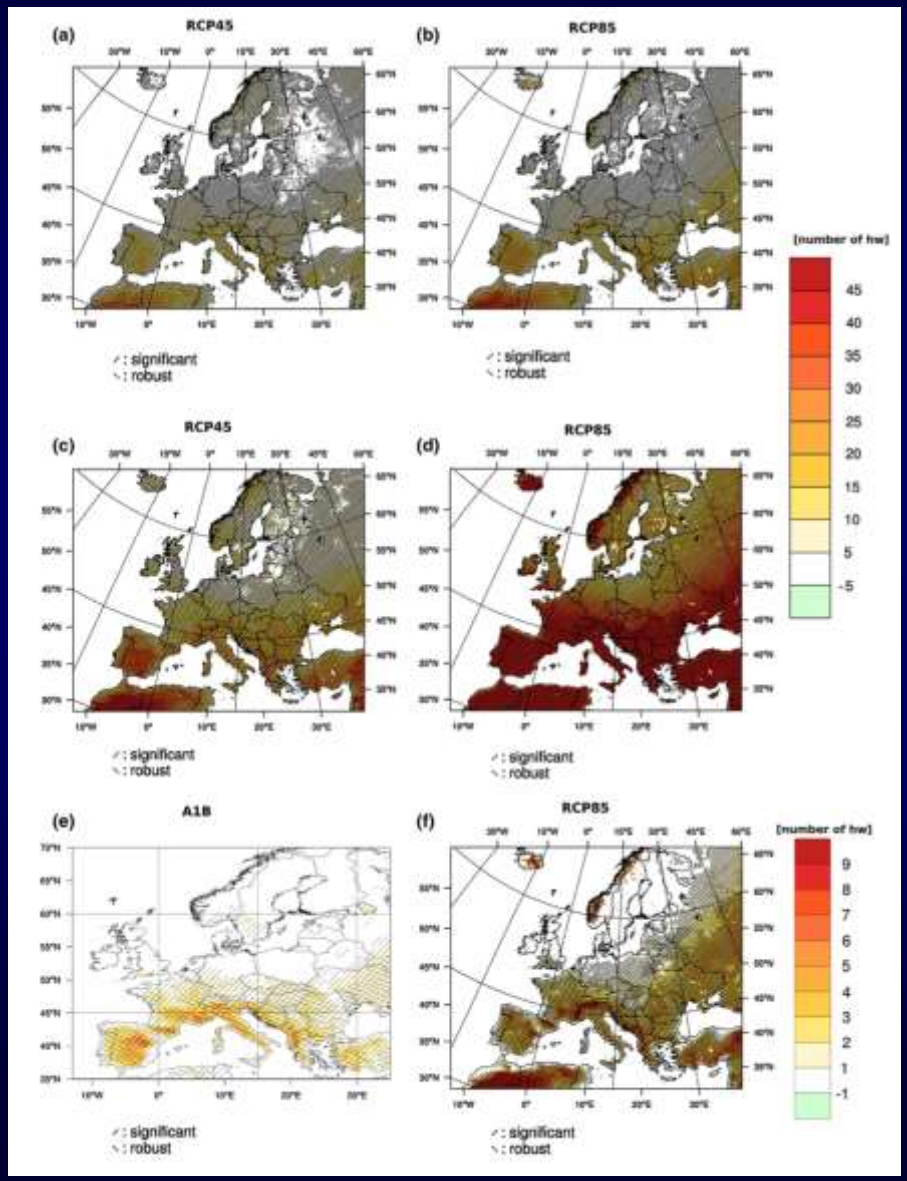
EURO
CORDEX
Ds=12 km
RCP8.5

EURO
CORDEX
Ds=12 km
RCP4.5

Change in warm season heat waves in different RCM ensembles

2021-2050
minus
1971-2000

3cd > 99%

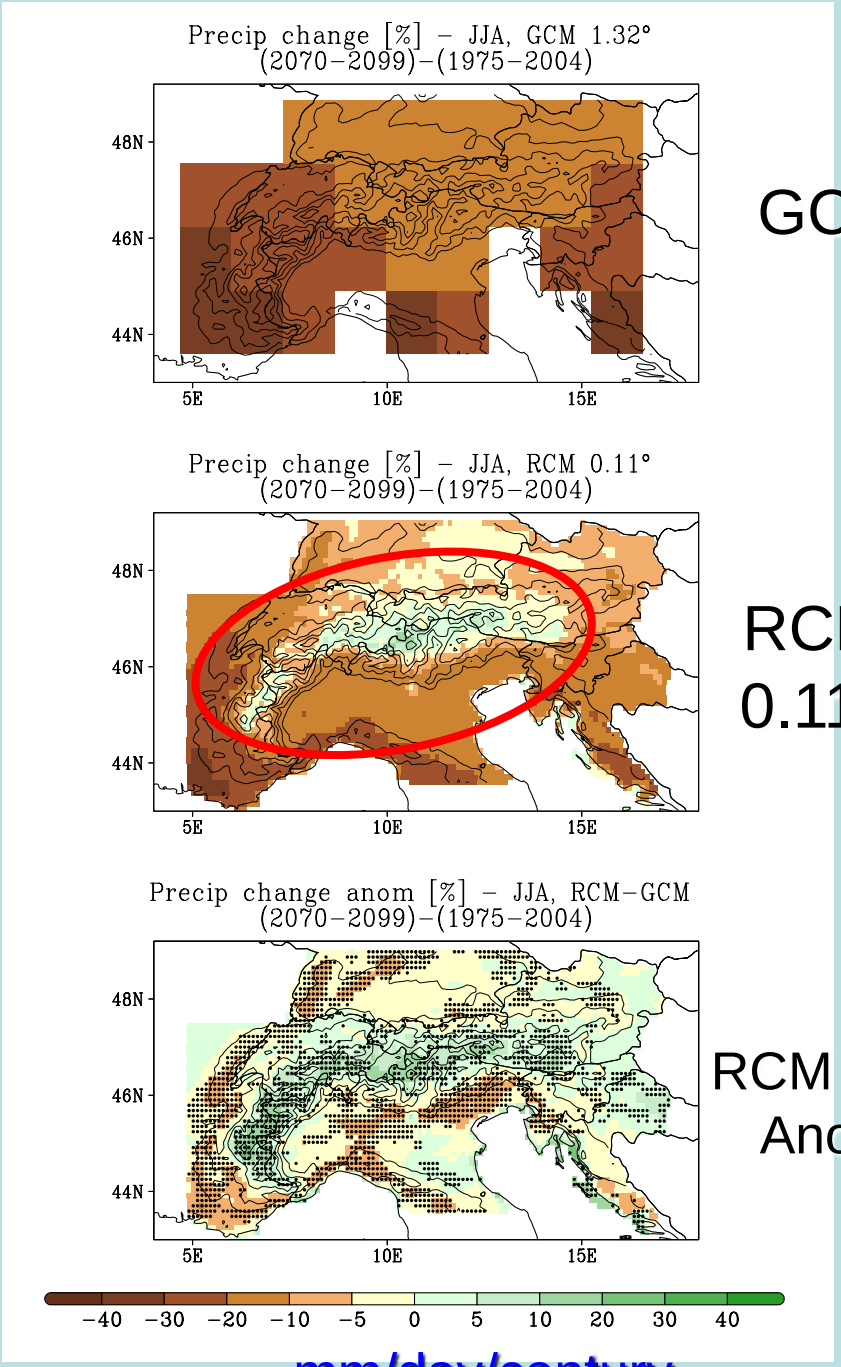


2071-2100
minus
1971-2000

3cd > 99%

2071-2100
minus
1971-2000

5cd > 5C



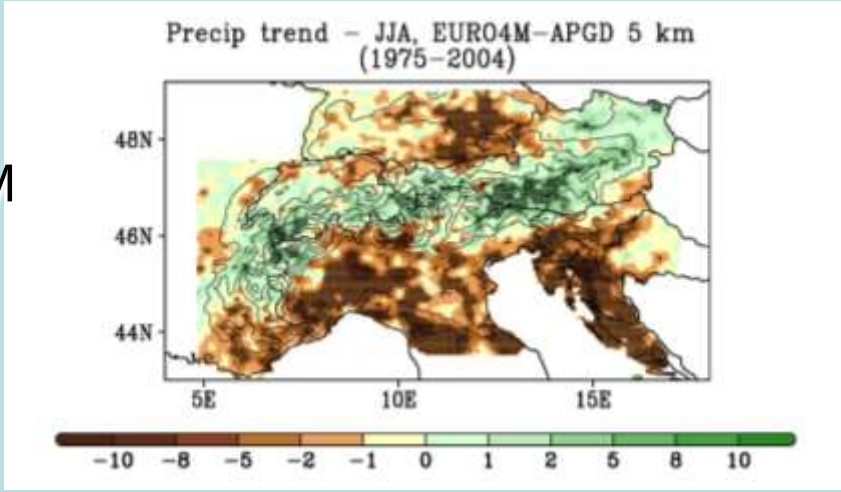
GCMs

RCMs
0.11°

RCM – GCM
Anomaly

High resolution can lead to some surprises: Summer precipitation change over the Alps. (Giorgi et al. 2015)

Observed summer precipitation change (1975-2004)



Summary of current projections

Model projections indicate some robust signals over the Mediterranean region

- Maximum warming an drying in the warm season for mid to long range time horizons throughout the Mediterranean basin. Wetting over the Alps in winter.
- Increase of interannual variability of temperature and precipitation in the warm season
- Increase in heat waves, temperature extremes and dry spells
- Change of the hydrologic regime to less frequent but more intense, extreme and concentrated events.
- Fine scale modulation of changes by topography and coastlines
- **Overall much drier and warmer conditions, decreasing in severity for lower global warming conditions.**

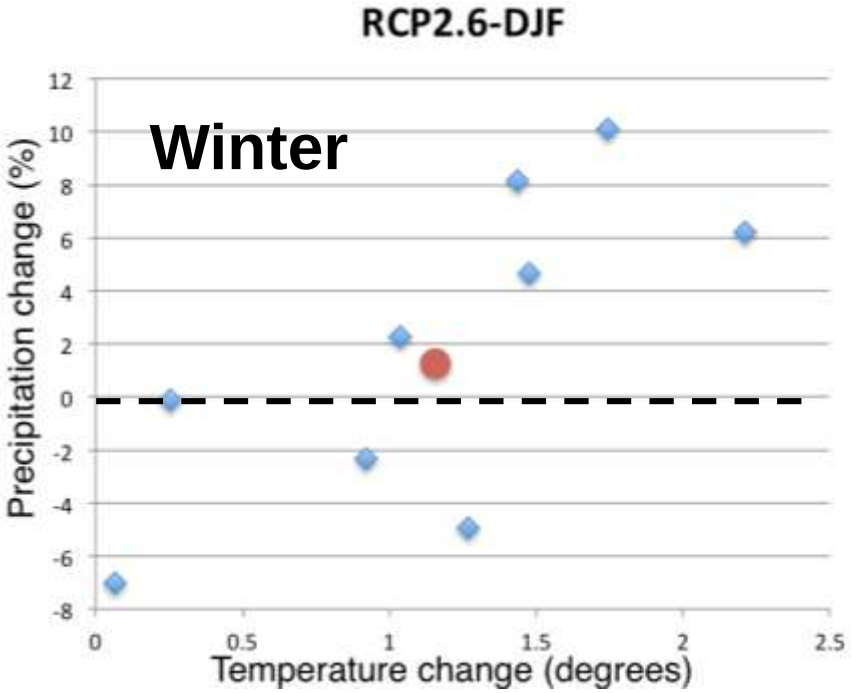
Future challenges in Mediterranean climate change projections

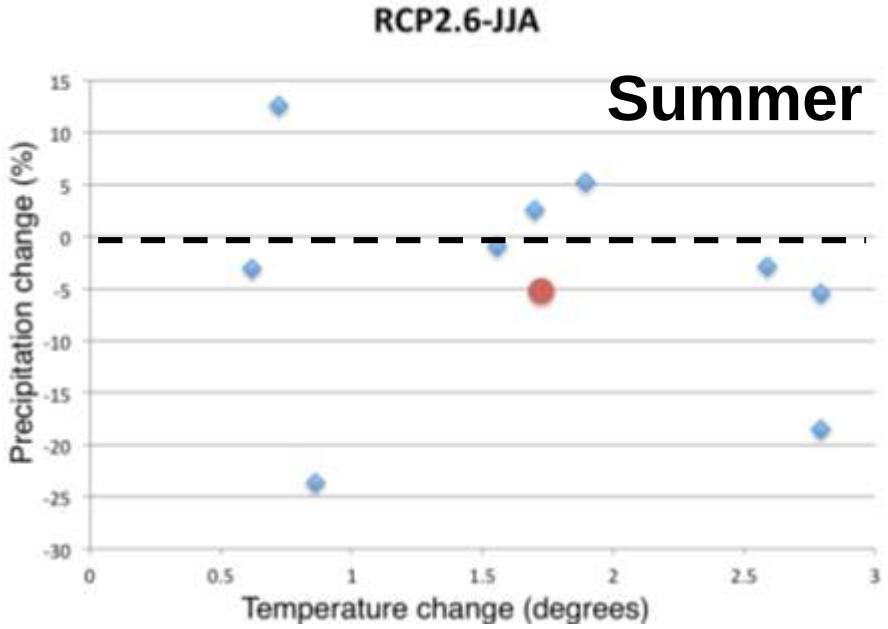
- Larger GCM and RCM ensembles of projections
  - Better characterization of uncertainty
  - CMIP6 (IPCC AR6), COPERNICUS, CORDEX
- Higher model resolutions
  - Down to 1-3- km scale with convection permitting RCMs
  - EUCP, CORDEX FPS
- Development of coupled models for the Mediterranean
  - Air-sea interactions, aerosols
- Inclusion of the human component
  - Land-use change, urbanization


THANK YOU

Projections of temperature and precipitation change over the Mediterranean in 9 CMIP5 AOGCMs

Scenario RCP2.6, 2071-2100



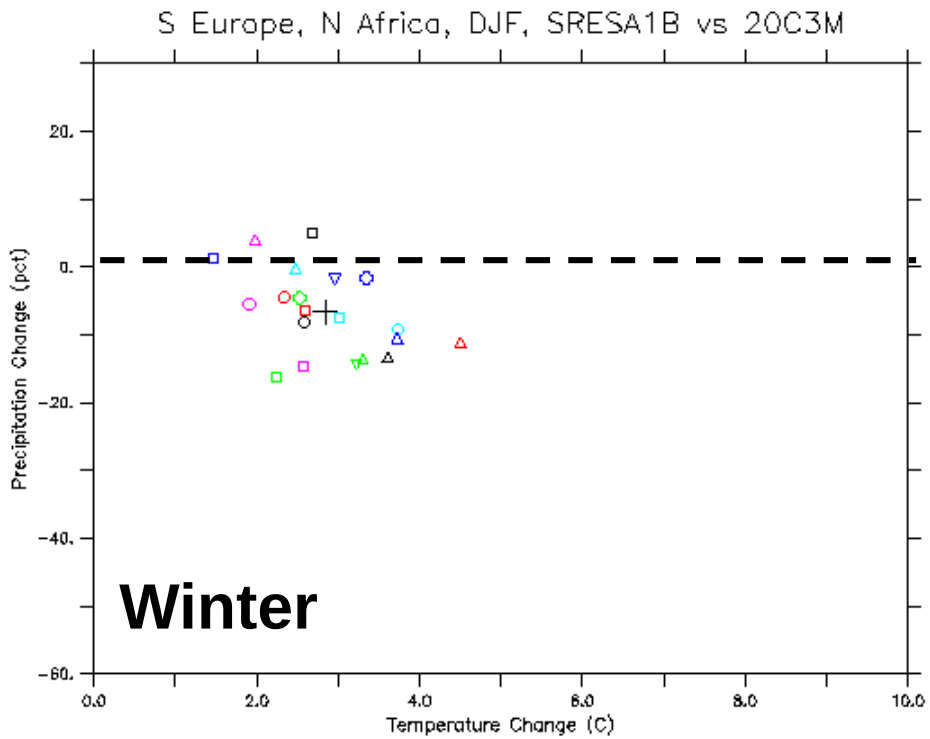


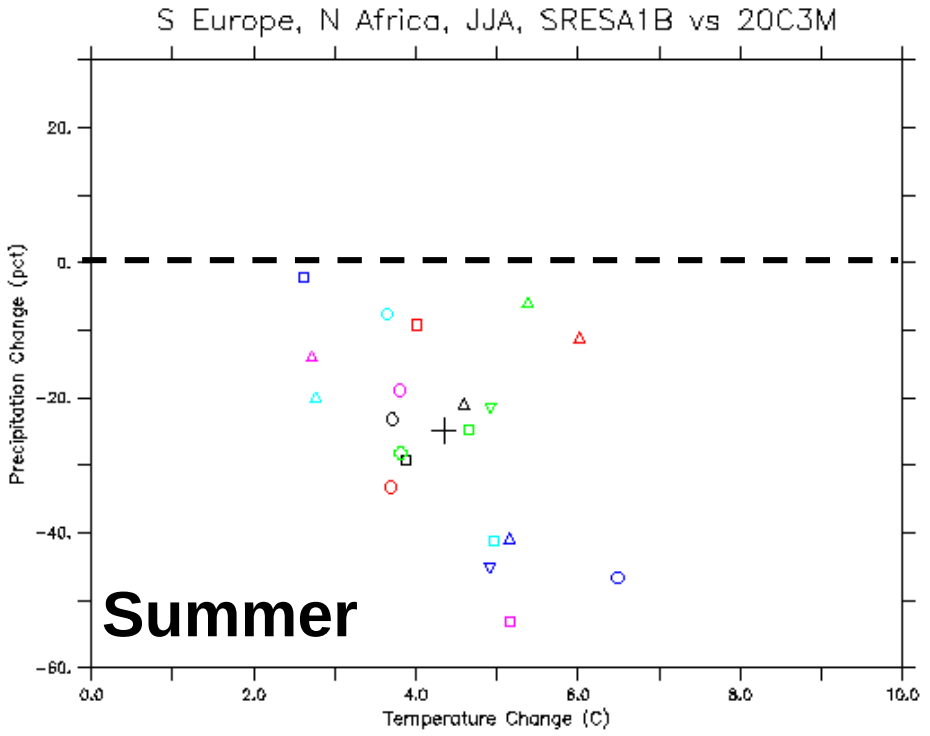
Causes of concern?

- 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
- Increased risk of fire
- Health issues related to coping with summer heat
- Increased pollution related to higher temperatures and reduced precipitation
- Large decrease of glaciers and snow
- Problems with the tourism industry
- Problems with coastal areas (heat, sea level rise)
- Adaptation of ecosystems (land and marine)

Projections of temperature and precipitation change over the Mediterranean in 21 CMIP3 AOGCMs

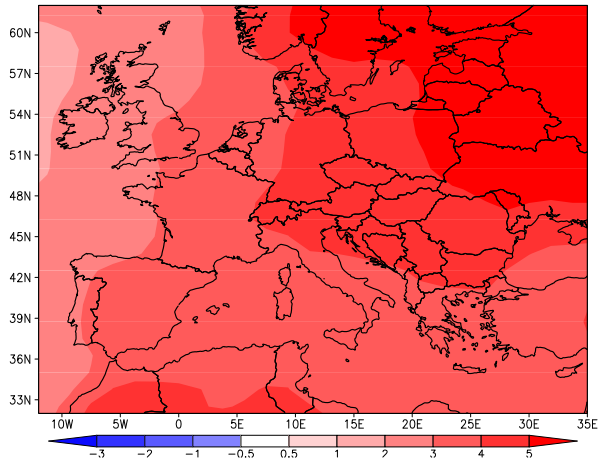
Scenario A1B, 2090-2100



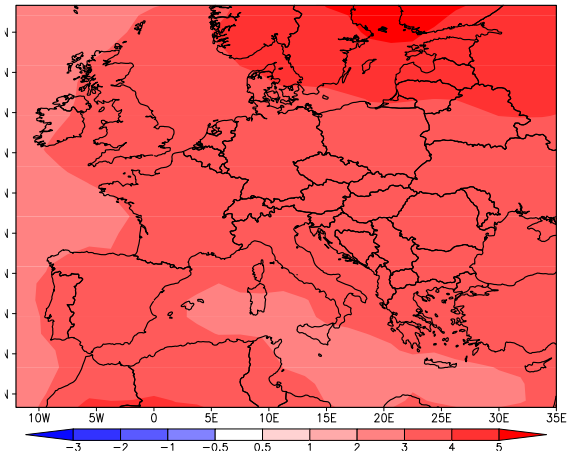


Temperature change (2071-2100), CMIP5 RCP8.5 Scenario, 21 AOGCMs

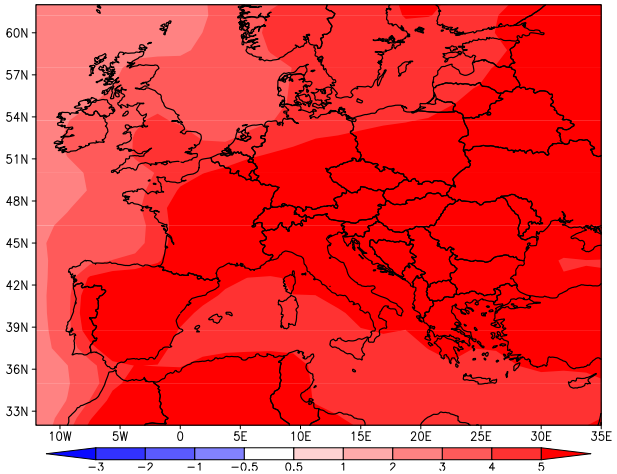
Winter



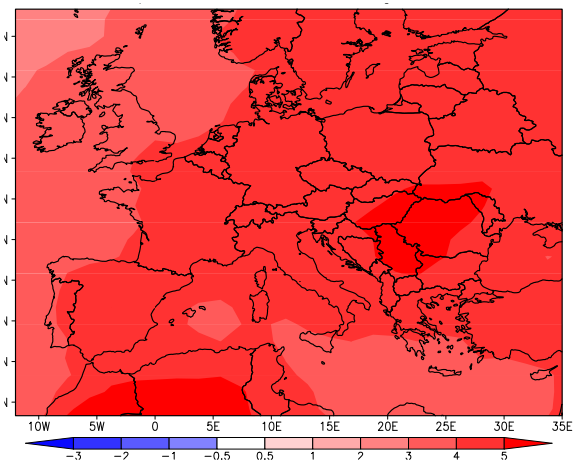
Spring



Summer

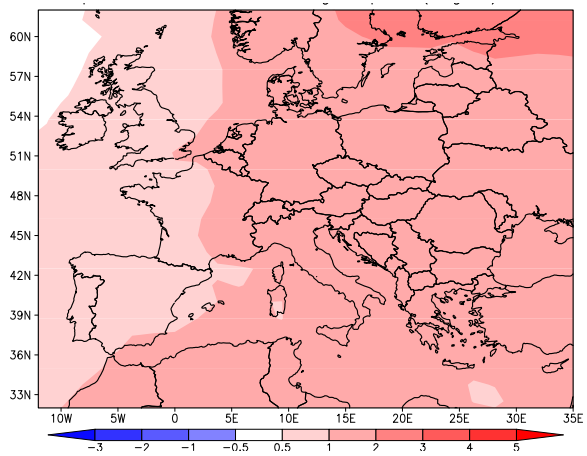


Fall

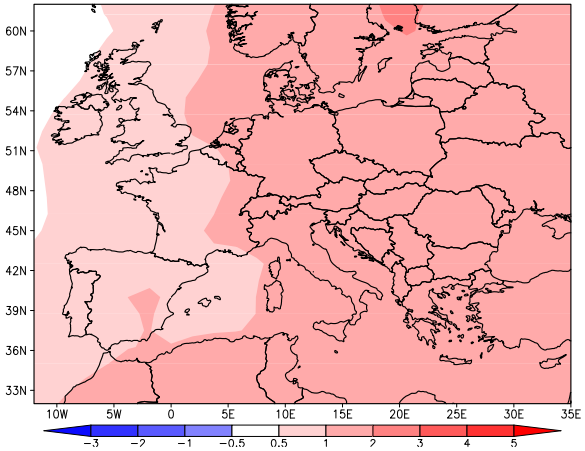


Temperature change (2071-2100), CMIP5 RCP2.6 Scenario, 9 AOGCMs

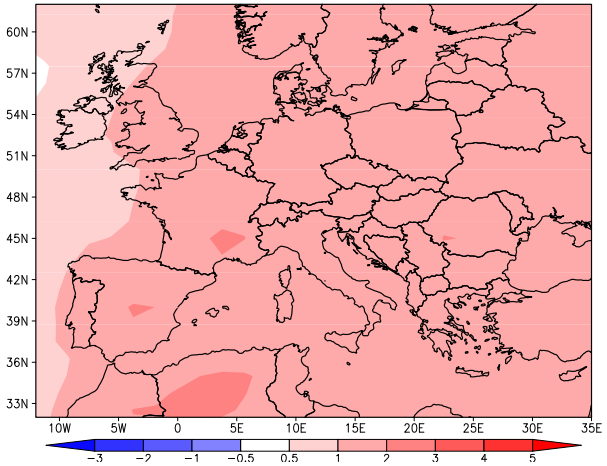
Winter



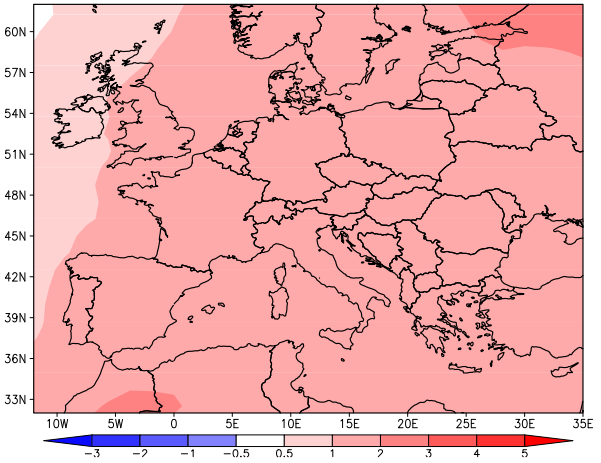
Spring



Summer

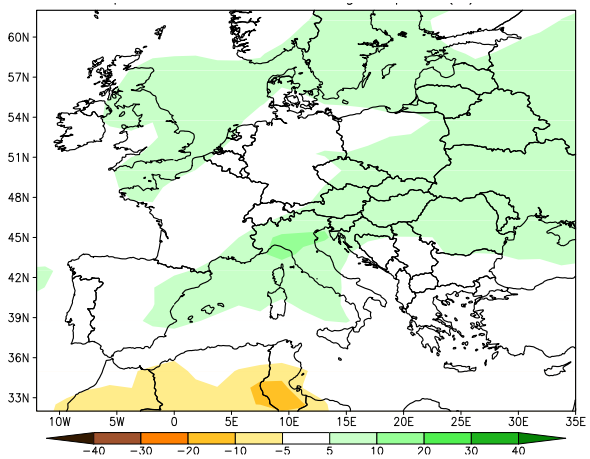


Fall

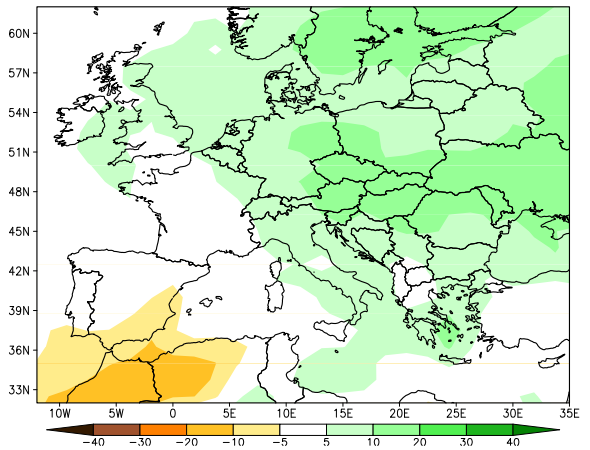


Precipitation change (2071-2100), CMIP5 RCP2.6 Scenario, 9 AOGCMs

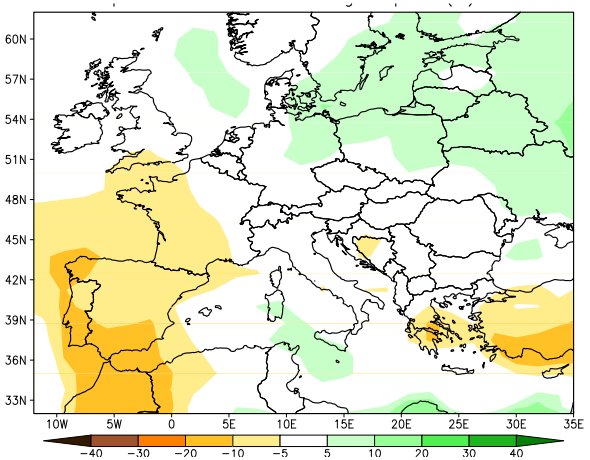
Winter



Spring



Summer



Fall