Palaeoclimate evidence in the Mediterranean area; climate variability and extremes. Part II

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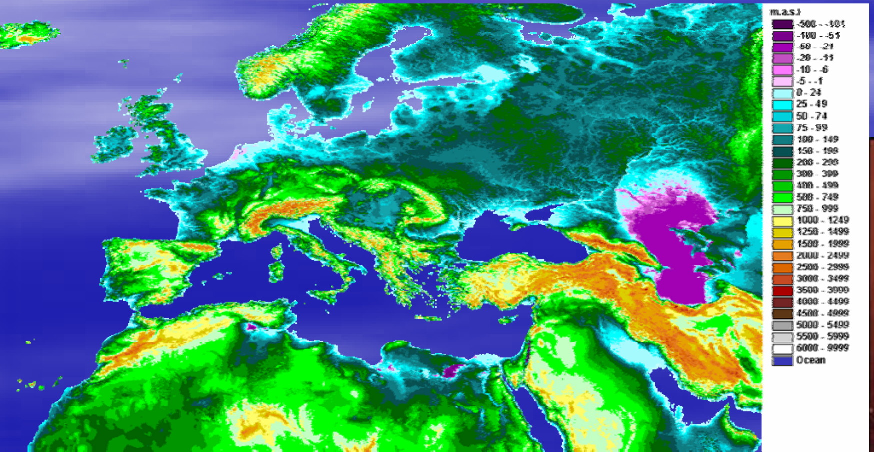
Outline

- Mediterranean climate & climate change
- Links between large scale atmospheric circulation and Mediterranean climate
- Extreme events in the Mediterranean
- Conclusions

Why is the Mediterranean of importance?

- A “hotspot” whose climate is especially responsive to global change and where potential climate change impacts are particularly strong
- Spatial distribution of temperature and precipitation
  - Large scale atmospheric circulation, latitude, orography, land-sea interactions, SSTs, other smaller scale processes



Vulnerability in the Mediterranean

- Hydrologic cycle – Rainy season
  - Water resources & water quality
  - Agriculture & environment
  - Economics & social development & behaviour
- Temperature extremes – Heat waves
  - Mortality & air pollution
  - Tourism

Vulnerability in the Mediterranean

Deforestation, afforestation, desertification
Land degradation
Food production, food security
Livelihood
Civil security, migration
Political conflicts
Health, vector borne and tick borne diseases
Energy demand, energy generation, solar, wind

Data and Methods

Independent climate data for the Mediterranean

- Gridded temperature 1750-2006
  Luterbacher et al. 2004 & Xoplaki et al. 2005, updated; Mitchell and Jones, 2005

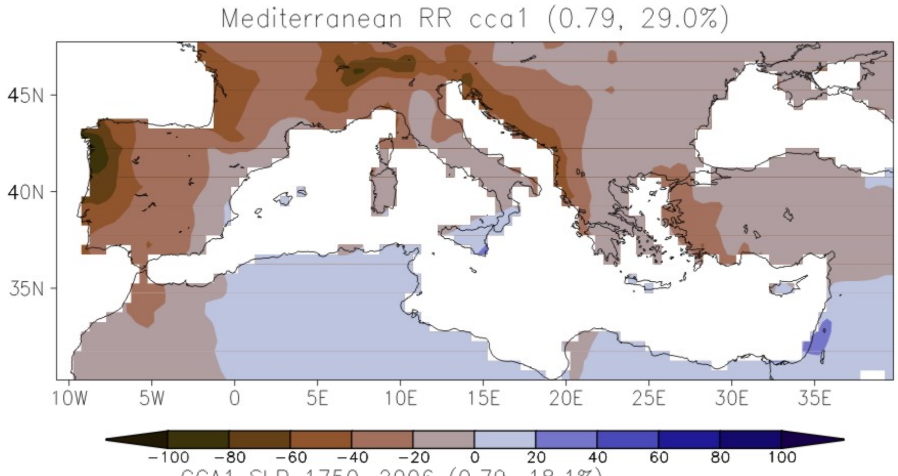
- Gridded precipitation 1750-2006
  Pauling et al. 2006; Brohan et al. 2006

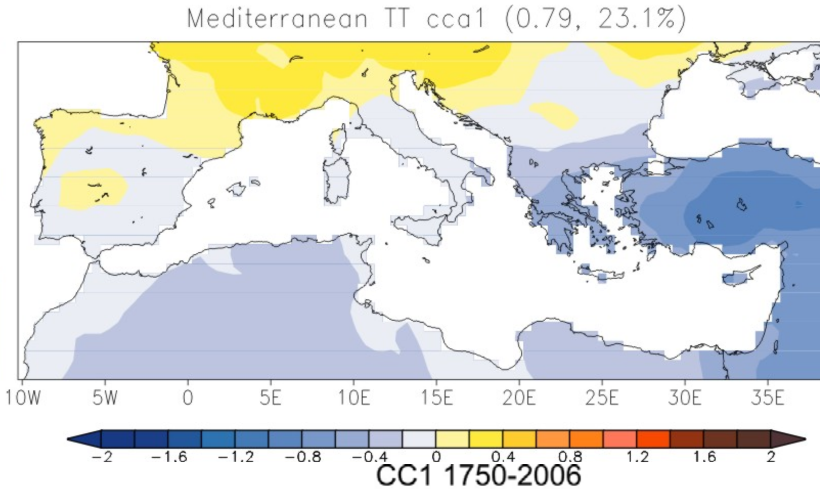
- Large-scale gridded sea level pressure 1750-2006, combined station pressure and CLIWOC/ICOADS data
  Küttel et al. 2010 & Allan and Ansell 2006

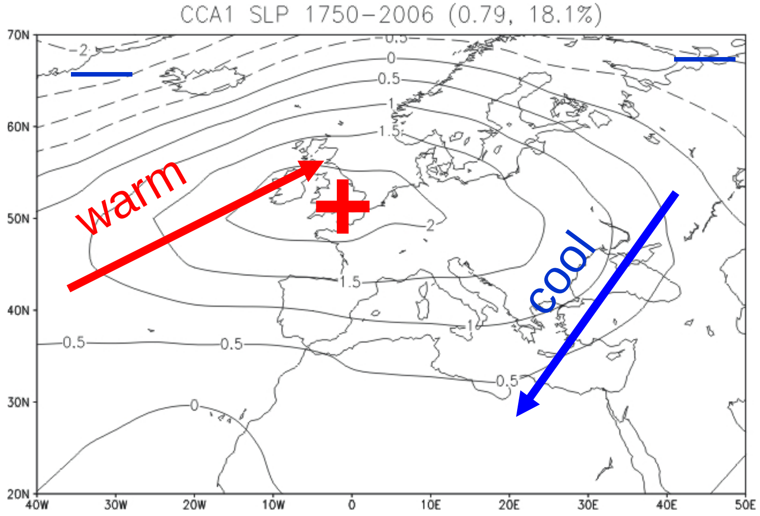
Method

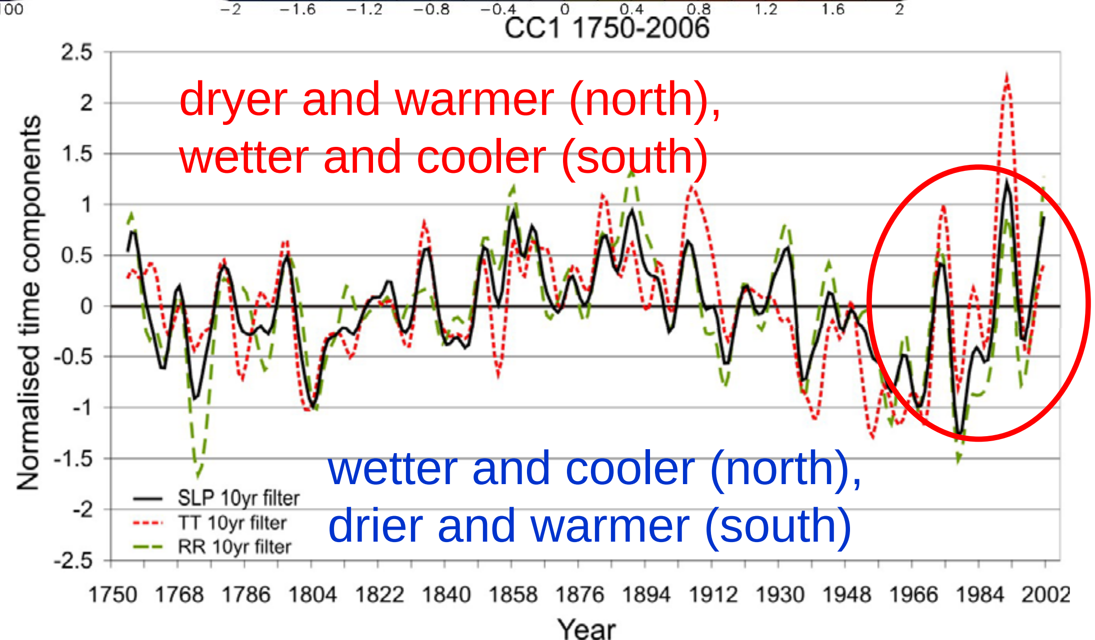
- Canonical Correlation Analysis in the EOF space
  → selection of optimally correlated patterns between SLP and Mediterranean temperature & precipitation

CCA1, 1750-2006
The EA/WRUS-like pattern

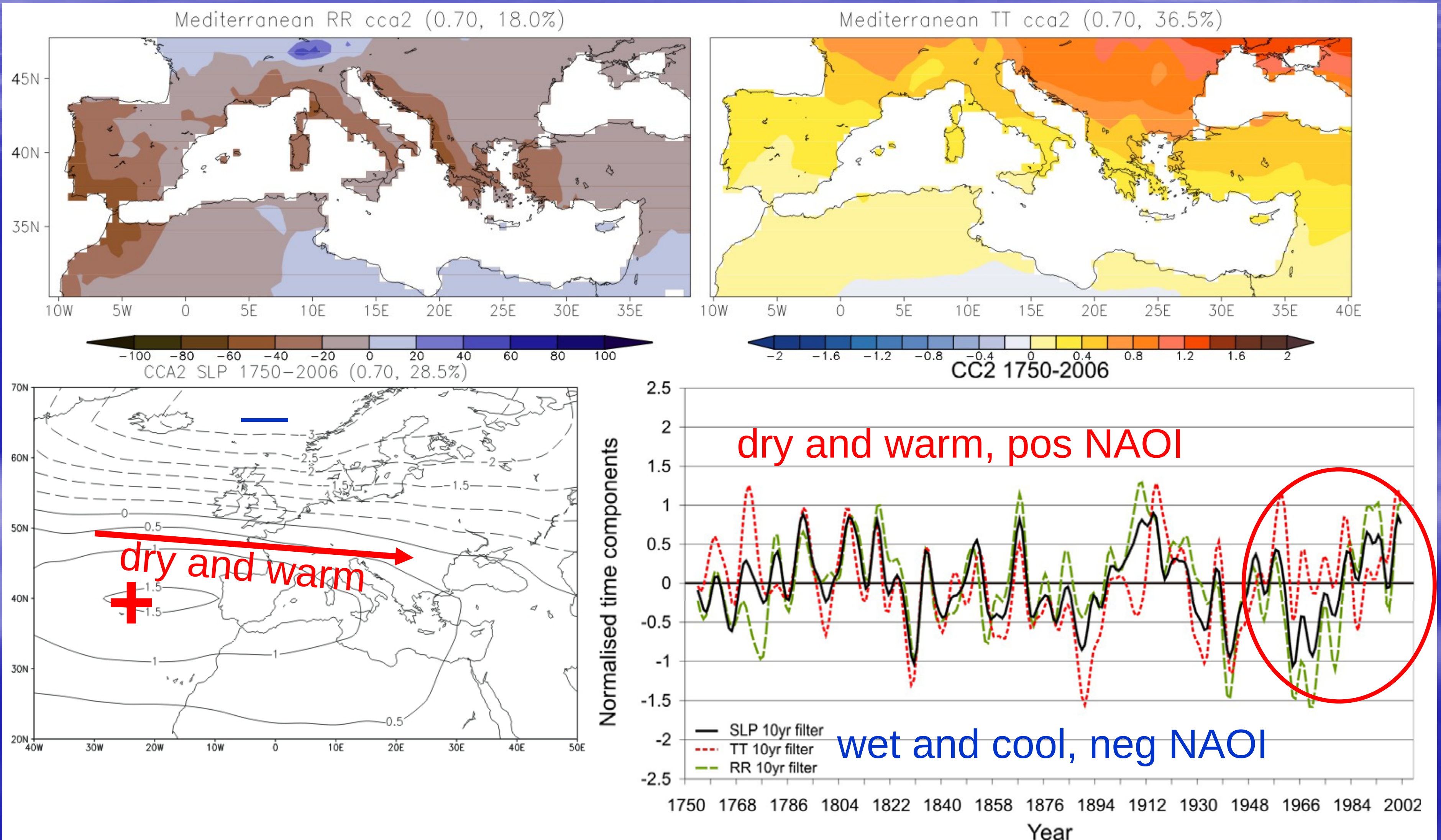




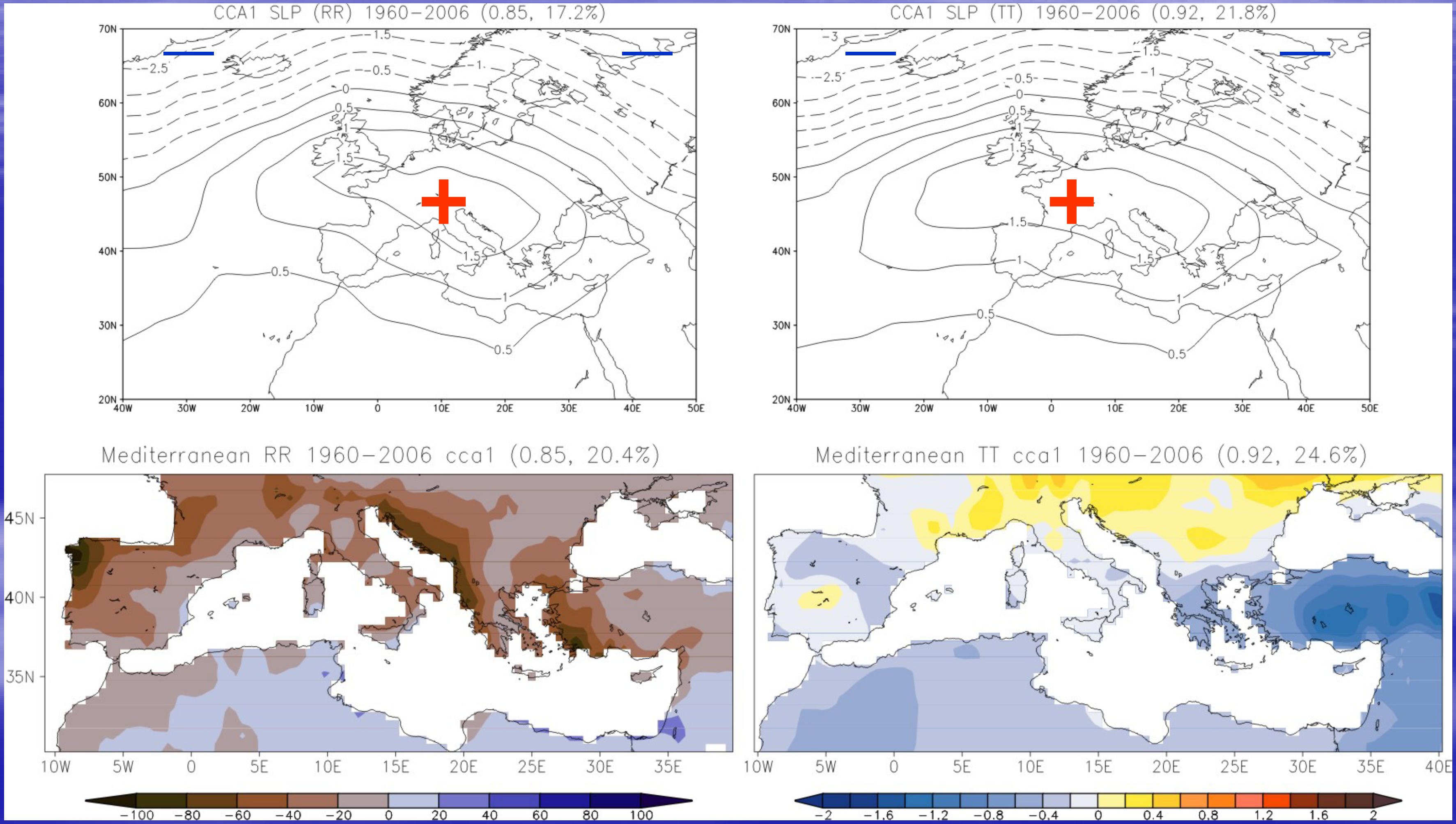




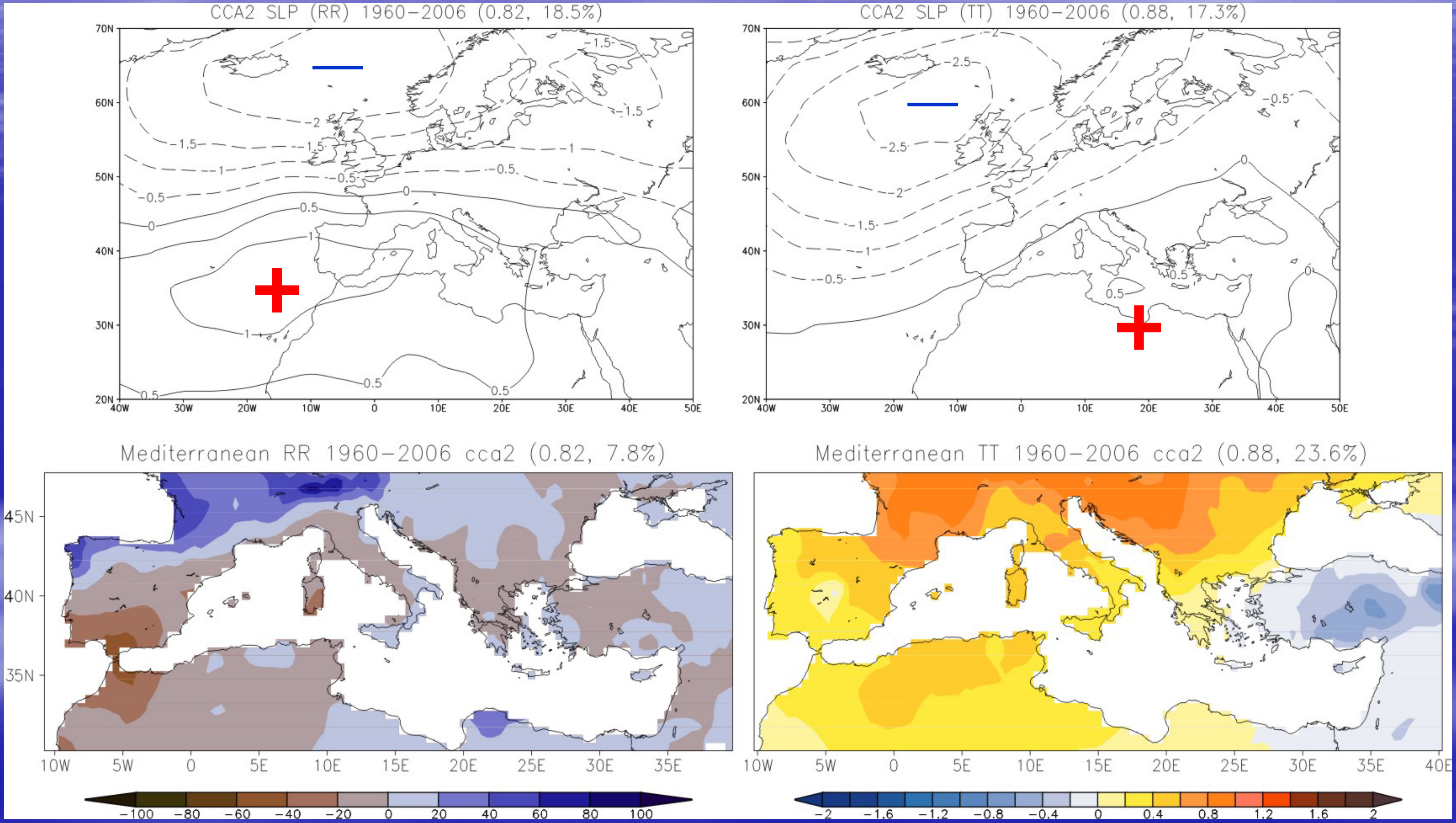
CCA2, 1750-2006
The NAO-like pattern



CCA1, 1960-2006
The EA/WRUS-like pattern

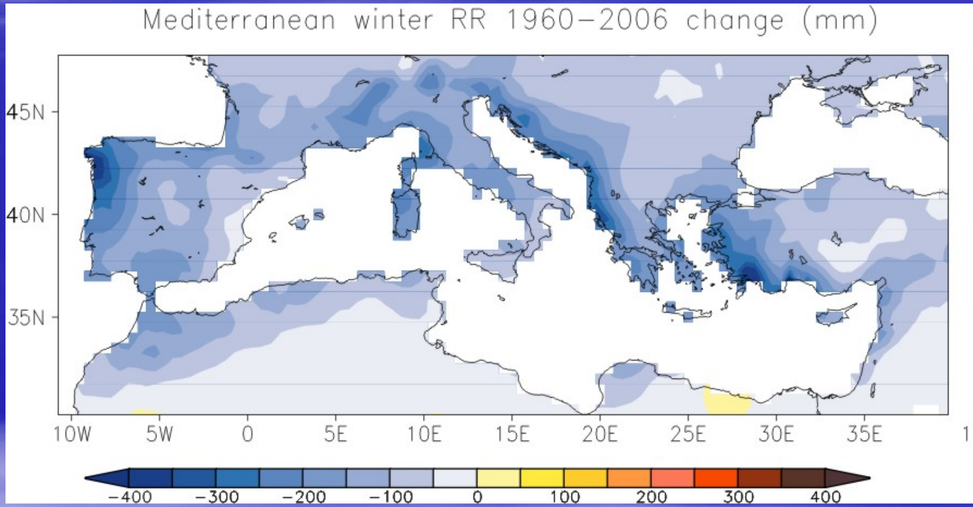


CCA2, 1960-2006
The partially NAO-like pattern

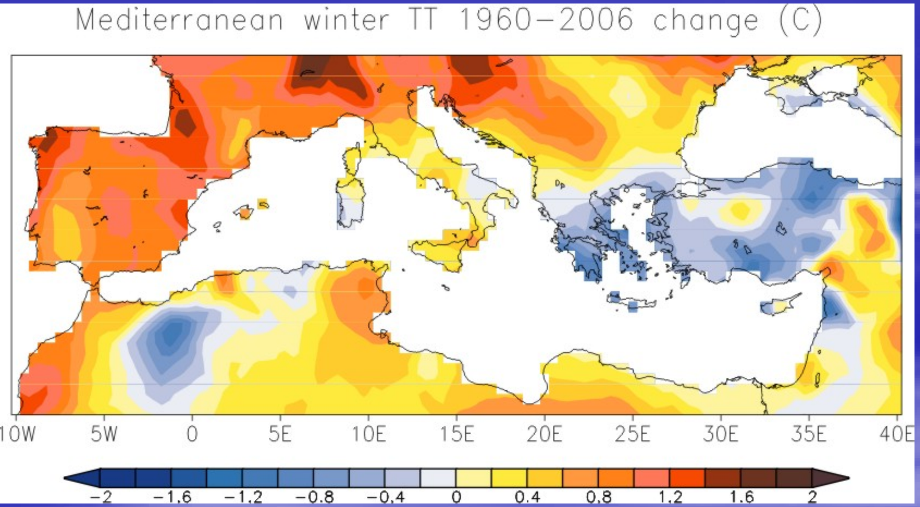


Winter precipitation and temperature trends 1960-2006

Winter RR

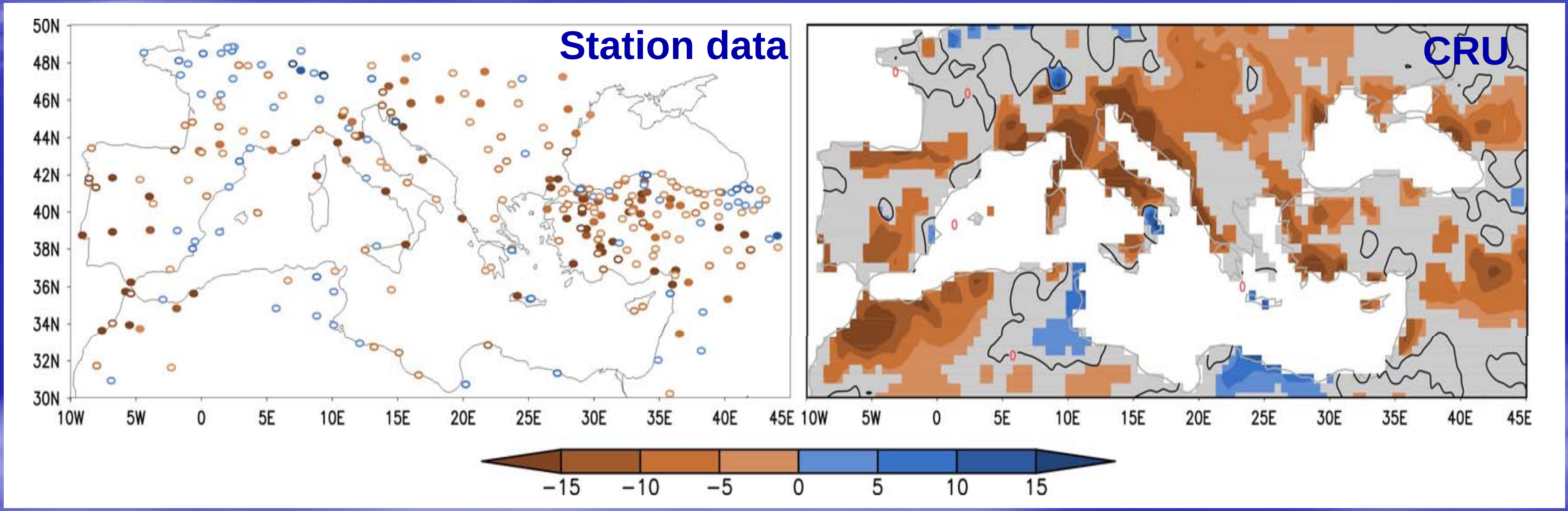


Winter TT



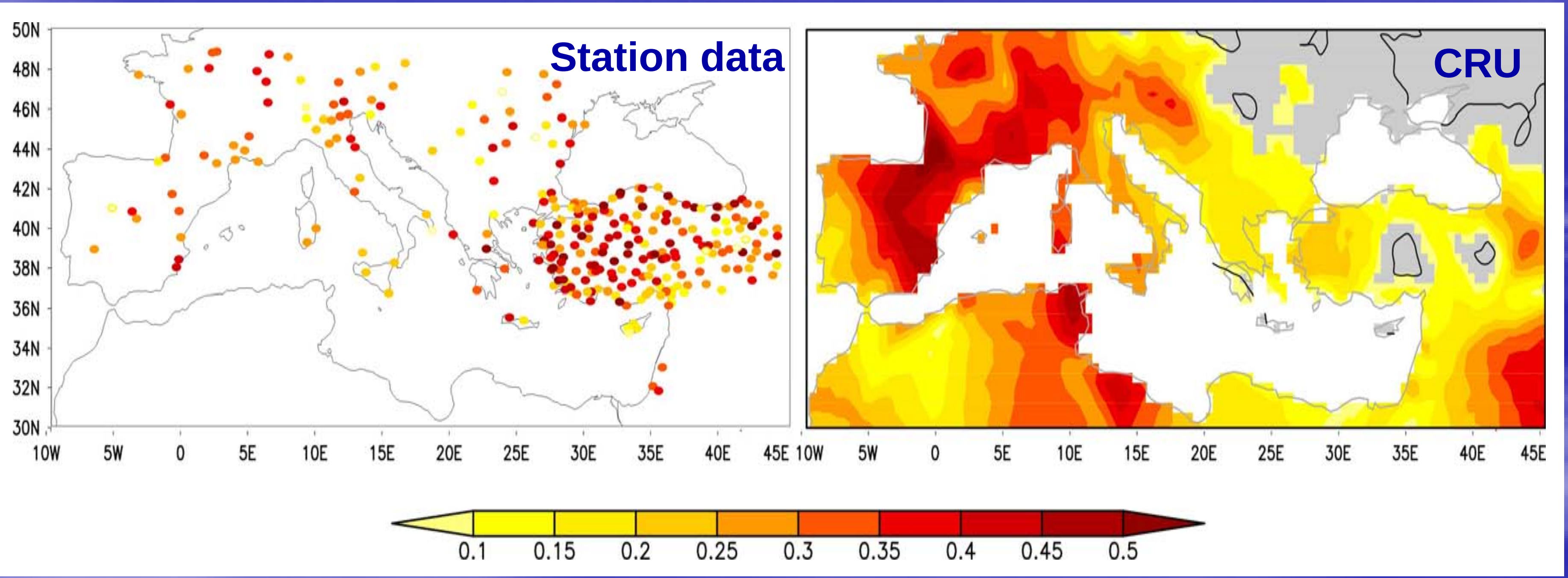
Data: CRU TS3.0
Mitchell and Jones 2005

Mediterranean Climate Change
Winter precipitation, 1951-2005



Toreti 2010

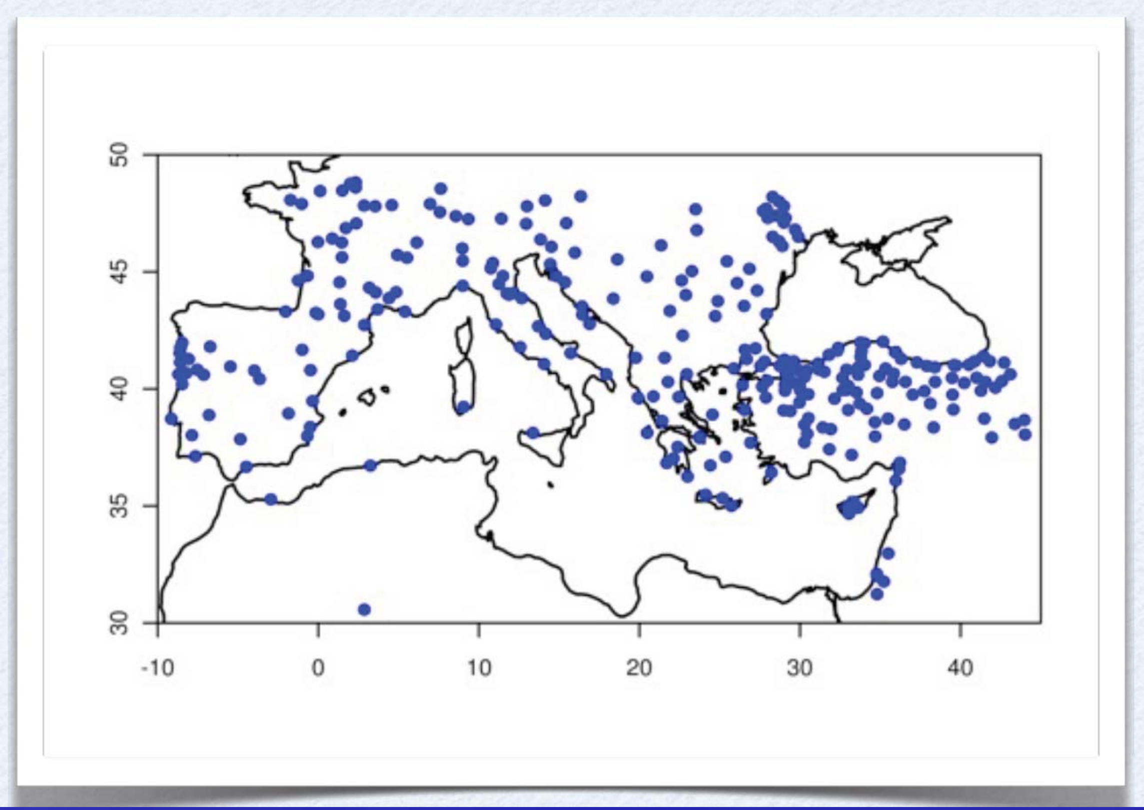
Mediterranean Climate Change
Summer temperature, 1951-2006



Toreti 2010

Extreme events in the Mediterranean
Winter precipitation
Summer temperature

Extreme precipitation Data



400 series

Quality control
break point detection

286 series
1950-2006

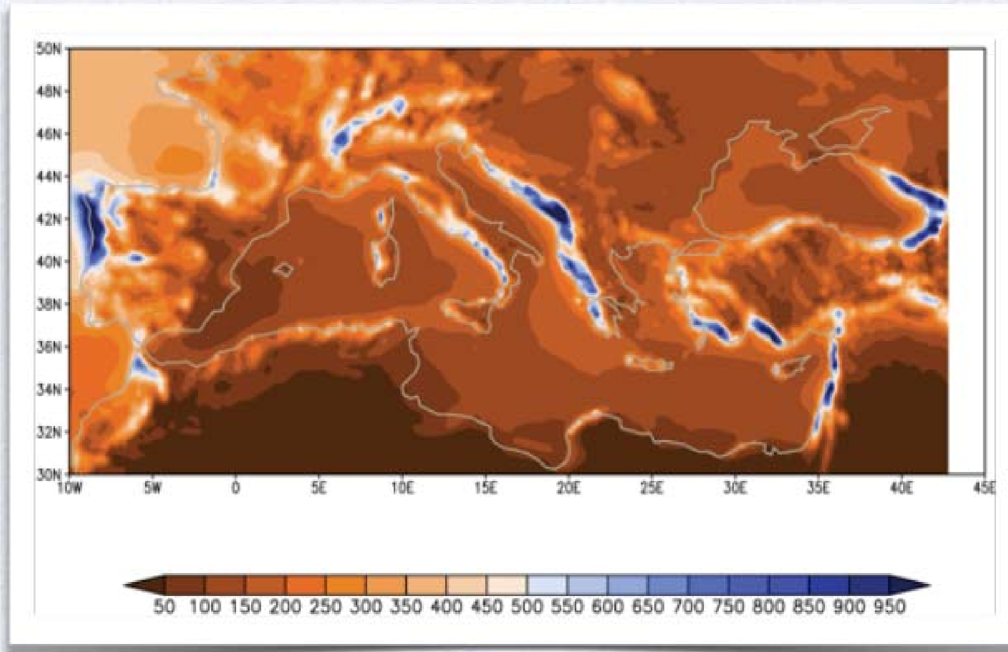
Toreti 2010

CLIMATE CHANGE AND IMPACT RESEARCH:
THE MEDITERRANEAN ENVIRONMENT

Circe

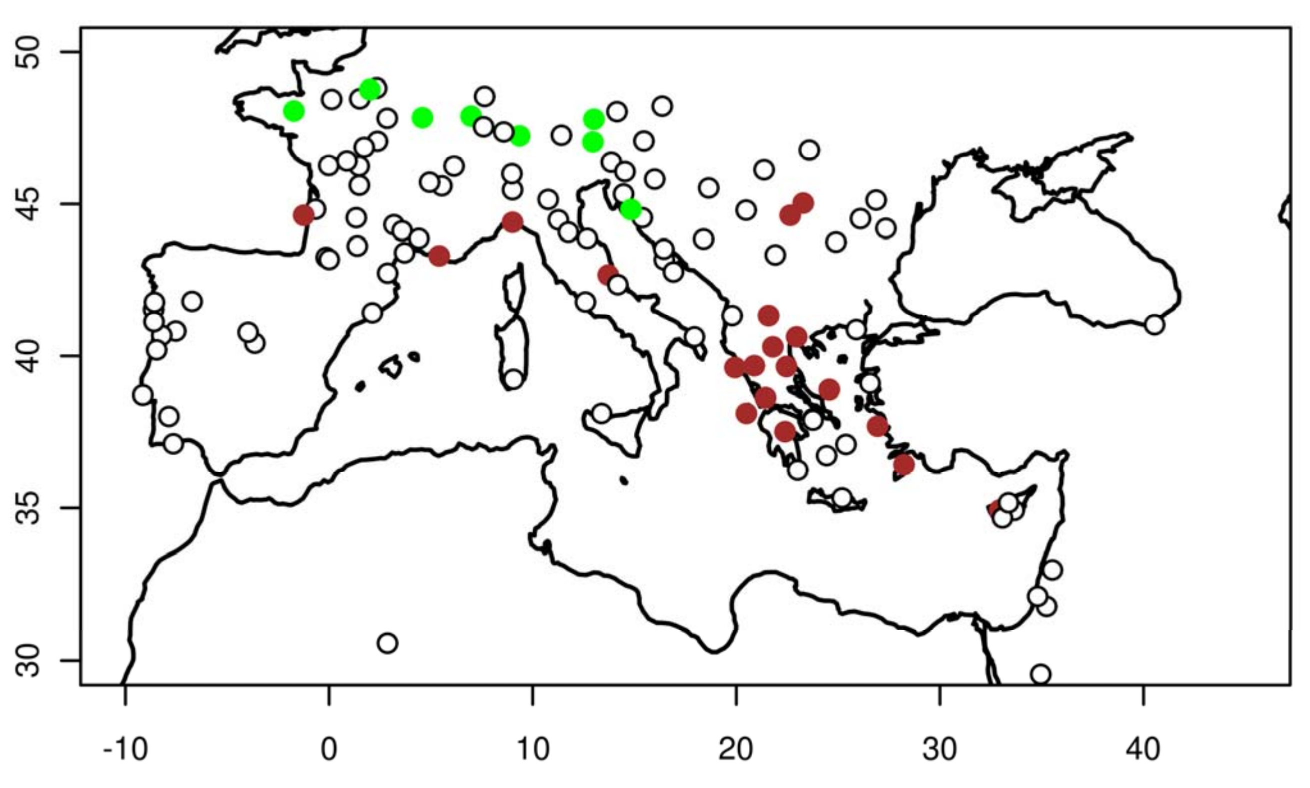
5 runs from 1950 to 2050 (A1B). 2 GCMs and 3 RCMs

- CMCC - Med
- CNRM - MM
- IPSL-Reg
- ENEA - Protheus
- MPI - Med



MPI-Med. Winter total precipitation, 1961-1990.

Extreme precipitation

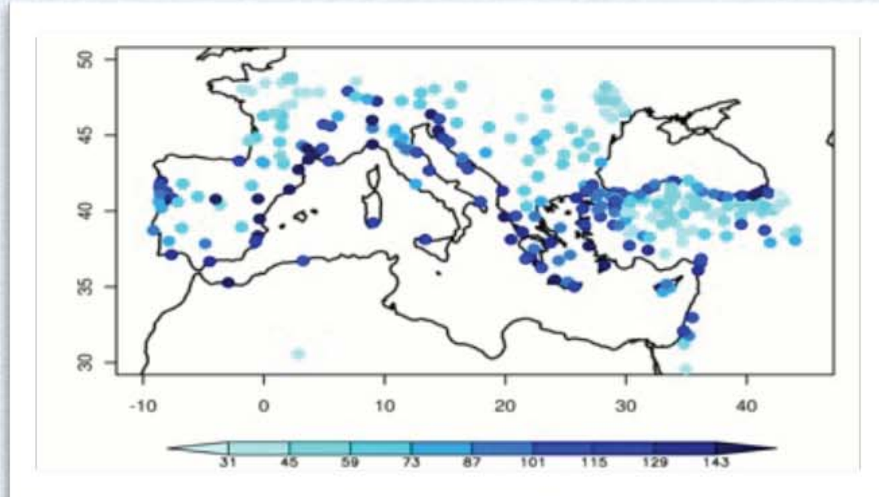


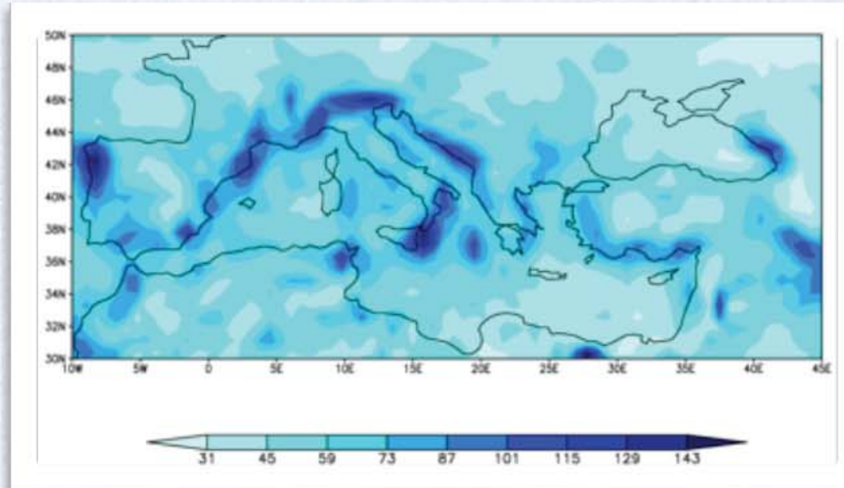
Probability of occurrence of extreme events. Estimated tendency

sign increase ***sign decrease*** ***no significance***

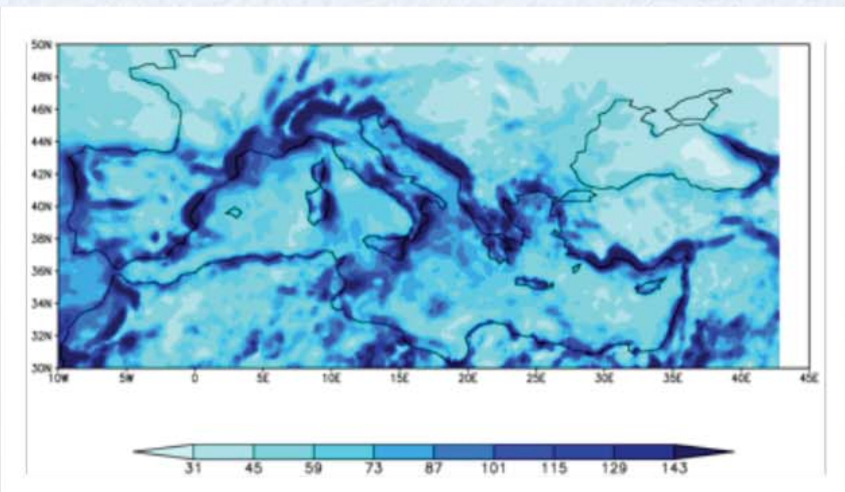
Toreti 2010

Extreme precipitation, 50-year return level

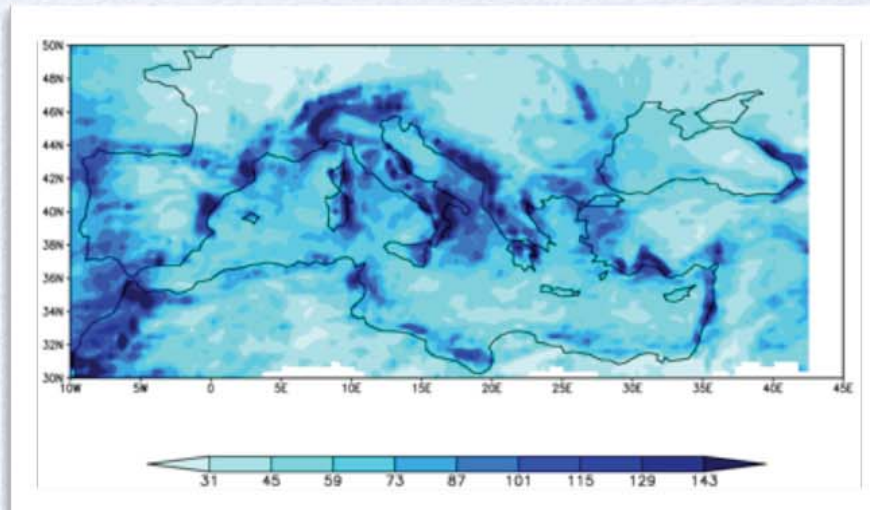




CMCC-Med



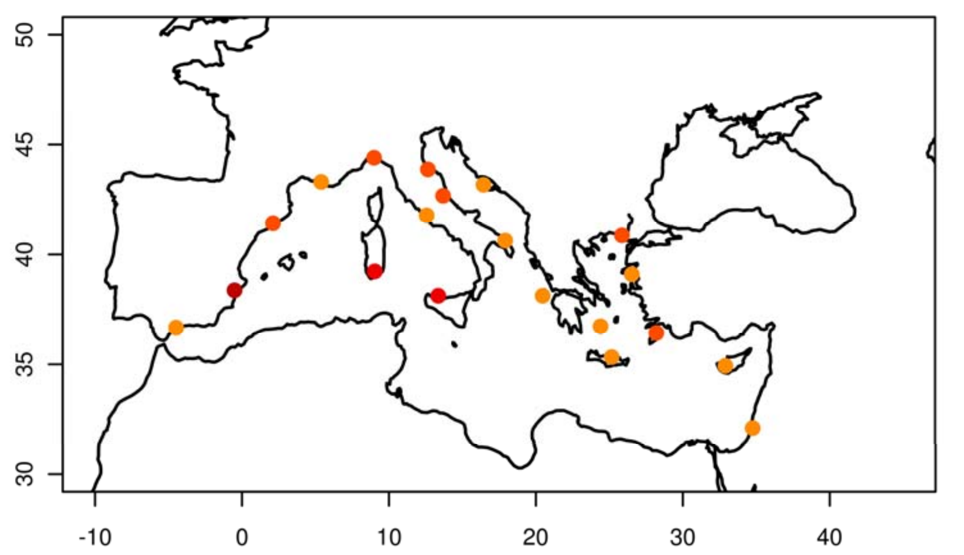
MPI-Med



IPSL-Reg

Toreti et al. 2010

Extreme precipitation and atmospheric circulation



20 coastal series

↓

500 hPa, SLP

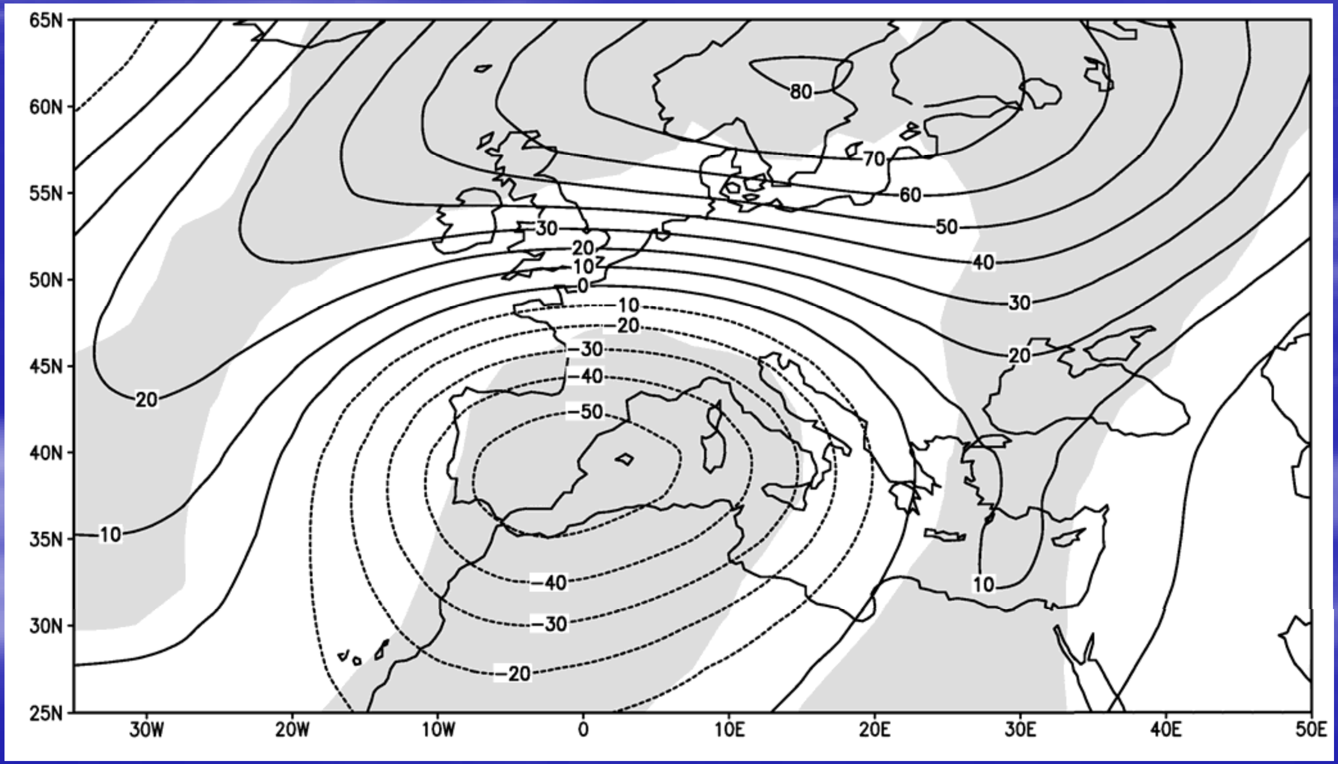
↓

Daily anomaly fields associated with extreme precipitation days

Toreti et al. 2010

Extreme precipitation and atmospheric circulation

500 hPa Western Mediterranean



Dipole structure

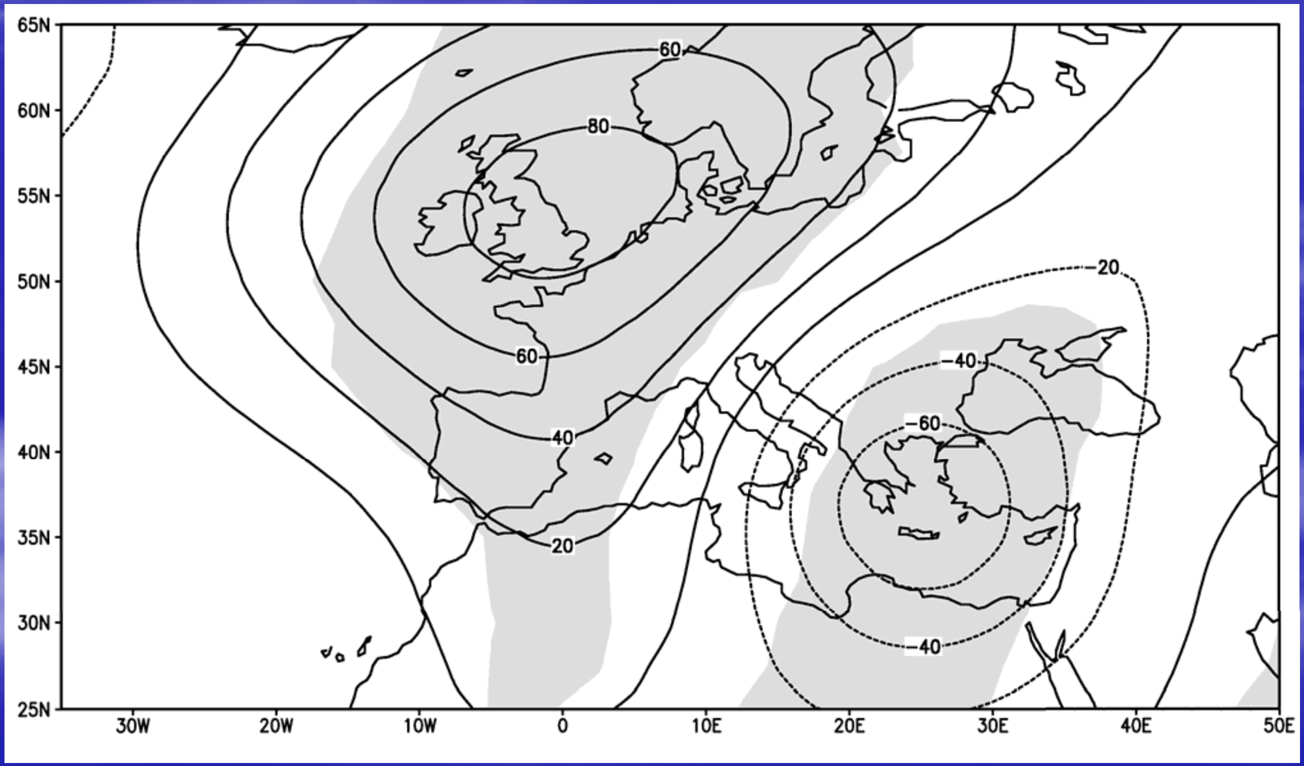
southwesterly flow

moisture transport from the Atlantic

Toreti et al. 2010

Extreme precipitation and atmospheric circulation

500 hPa Eastern Mediterranean



Warm air advection & anomalous vertical motion

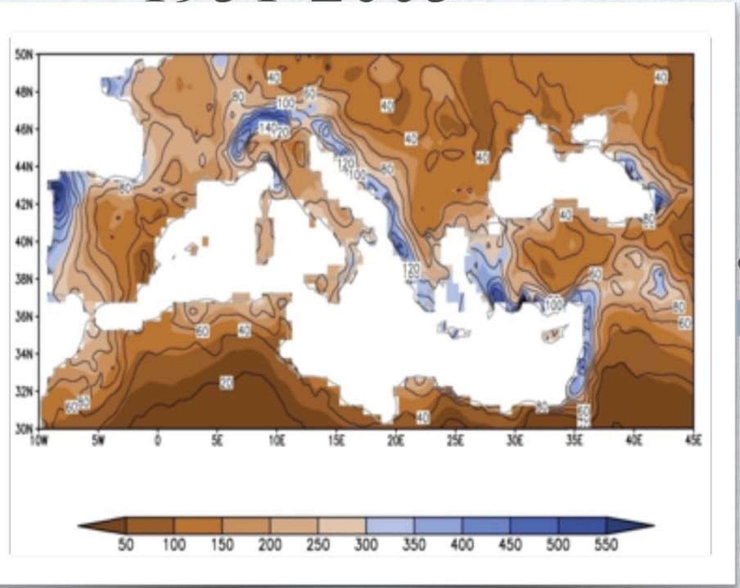
instability

moisture transport from western basin

Toreti et al. 2010

Winter Precipitation

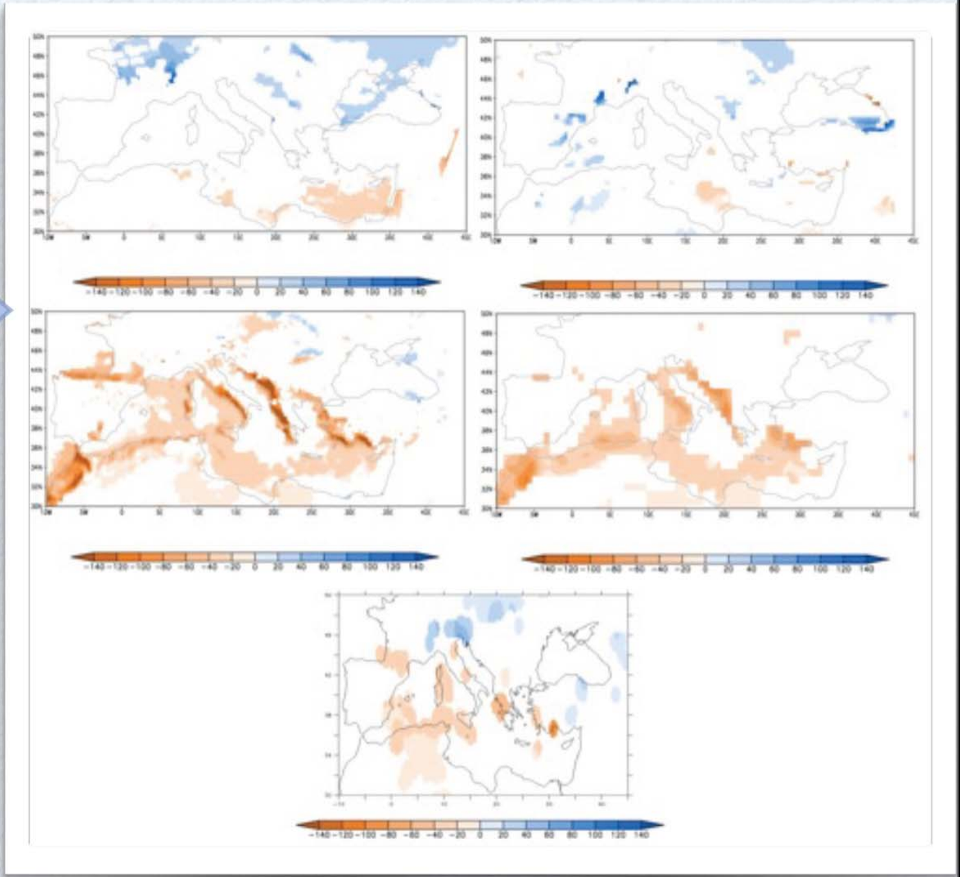
1951-2005



CRU TS 3.0[1]

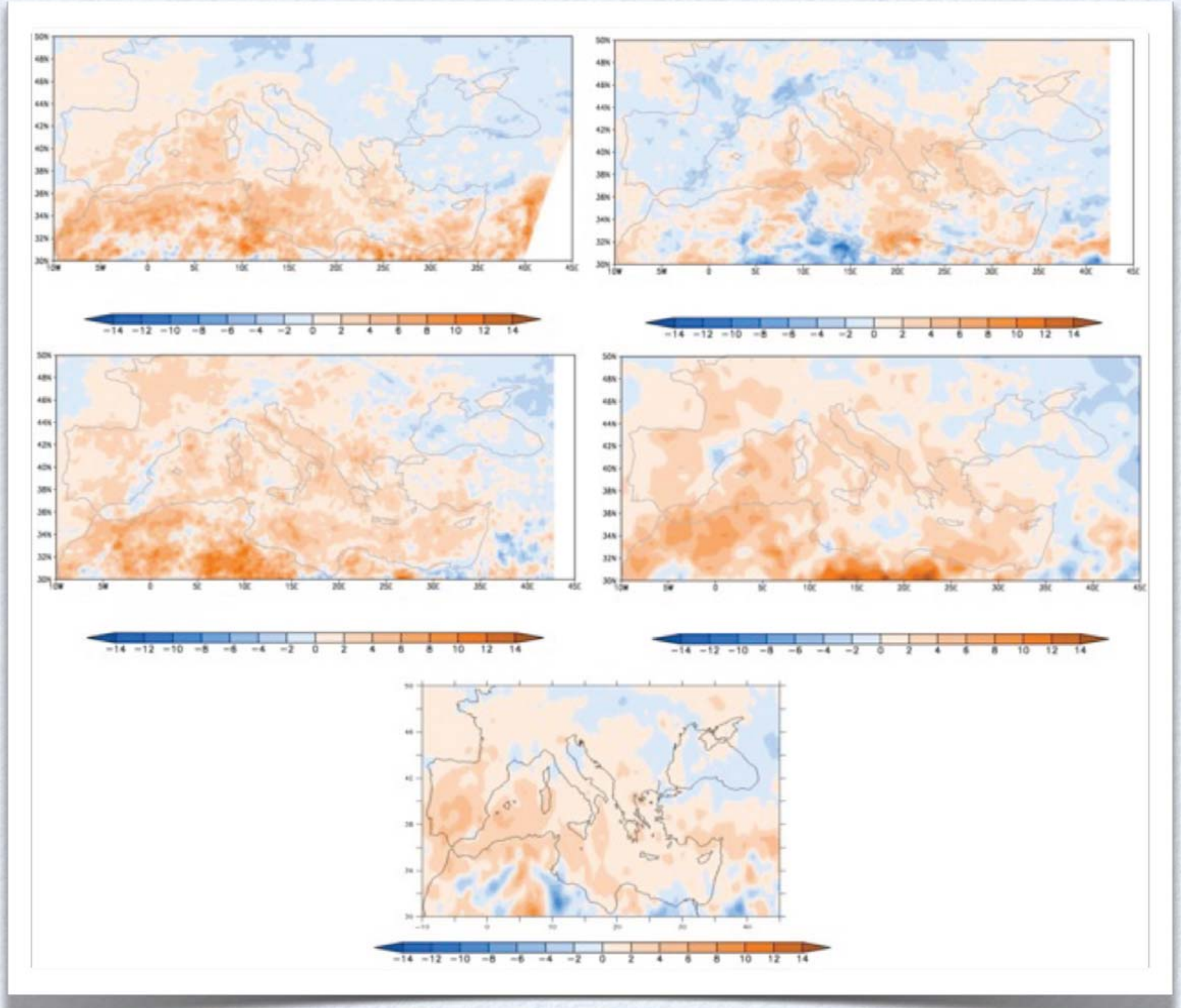
2012 2014 2016

2021-2050 wrt 1961-1990

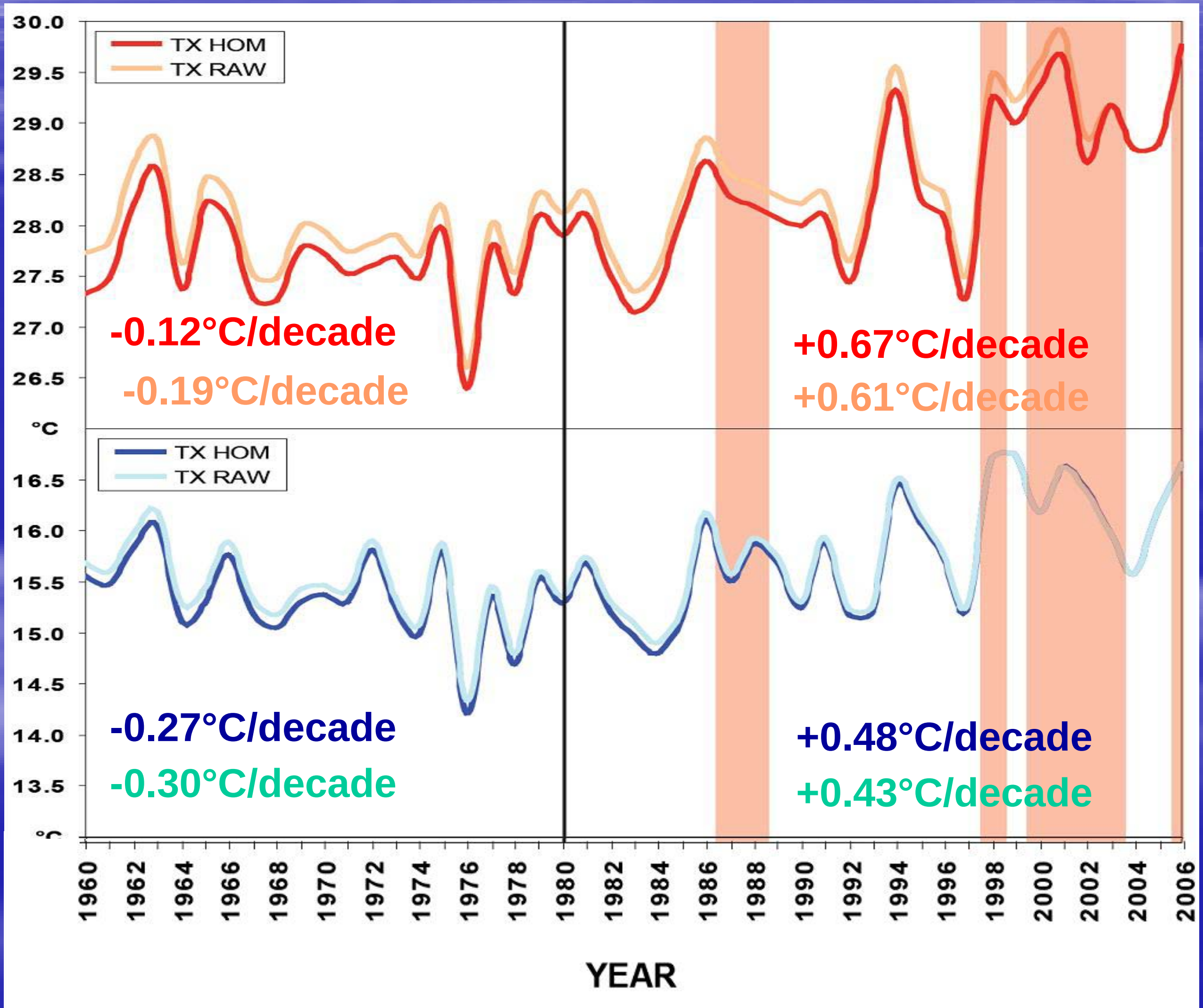


Significant changes (90%) in winter total precipitation (mm).
5 runs performed within the CIRCE project

Winter CDD 2021-2050 wrt 1961-1990

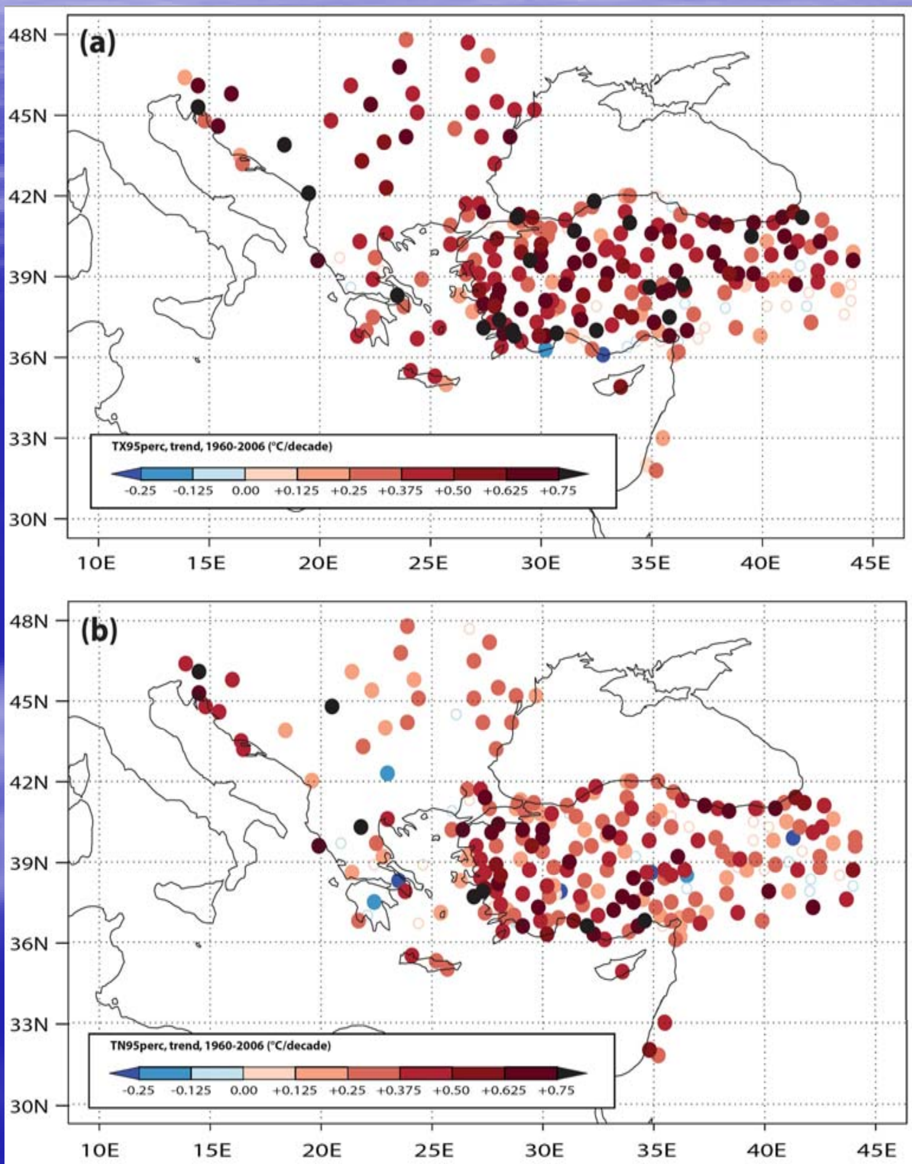


Mediterranean summer Tmax & Tmin



Kuglitsch 2010
Xoplaki et al. 2011

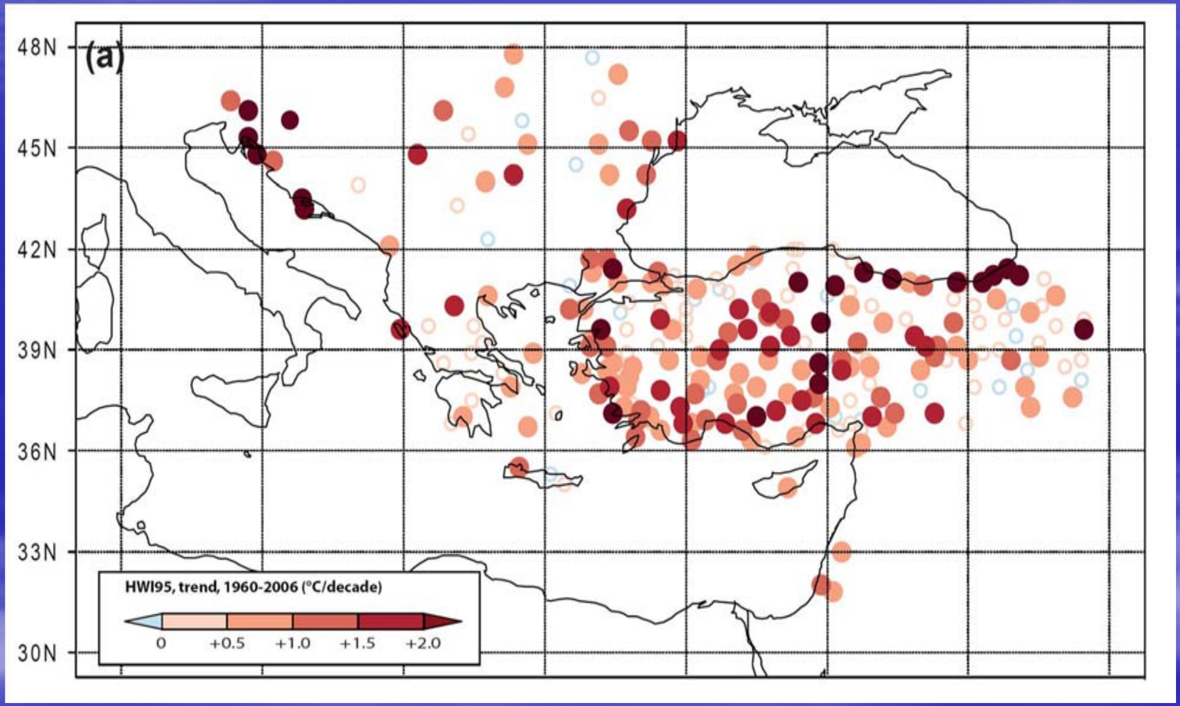
Summer trend TX/TN 95th percentile



- TX: +0.38 ± 0.04°C/decade
  - Max. increase in continental areas
- TN: +0.30 ± 0.02°C/decade
  - Max. increase in coastal areas

Kuglitsch et al. 2010

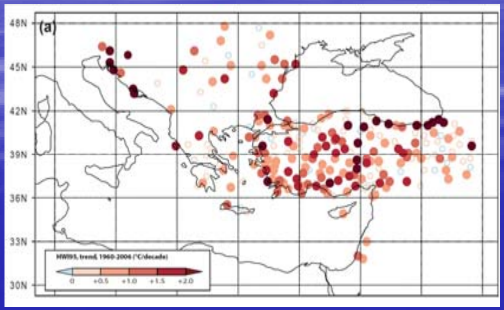
Heat wave intensity trend

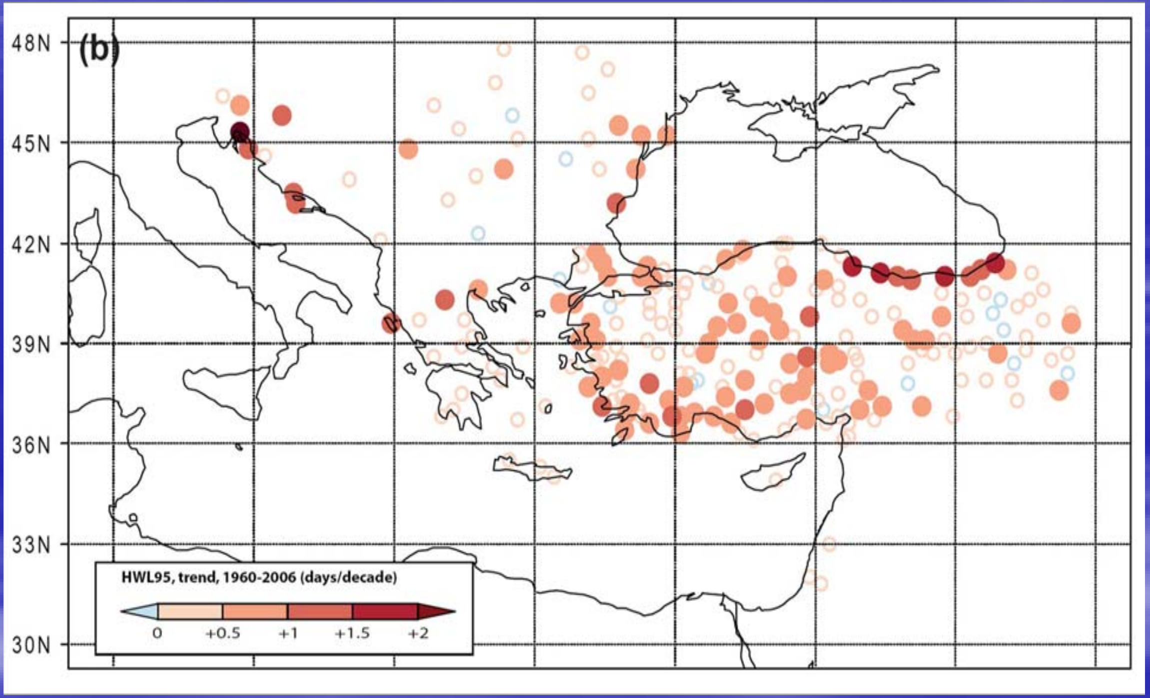


- **HWI95: +1.33 ± 0.06°C/decade**
  - 56% significant

Kuglitsch et al. 2010

Heat wave duration trend

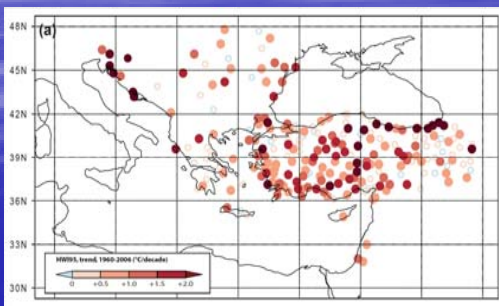


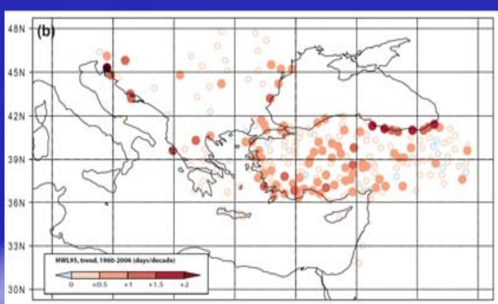


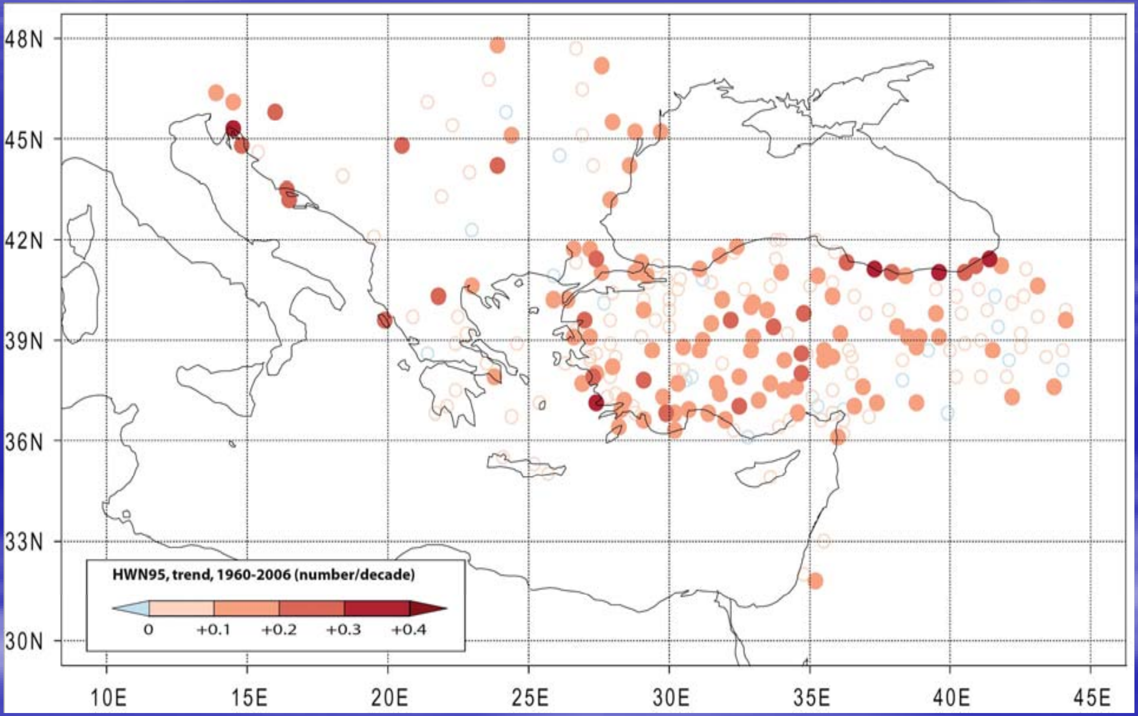
- **HWL95: +0.85 ± 0.02 days/decade**
  - 37% significant

Kuglitsch et al. 2010

Heat wave number trend

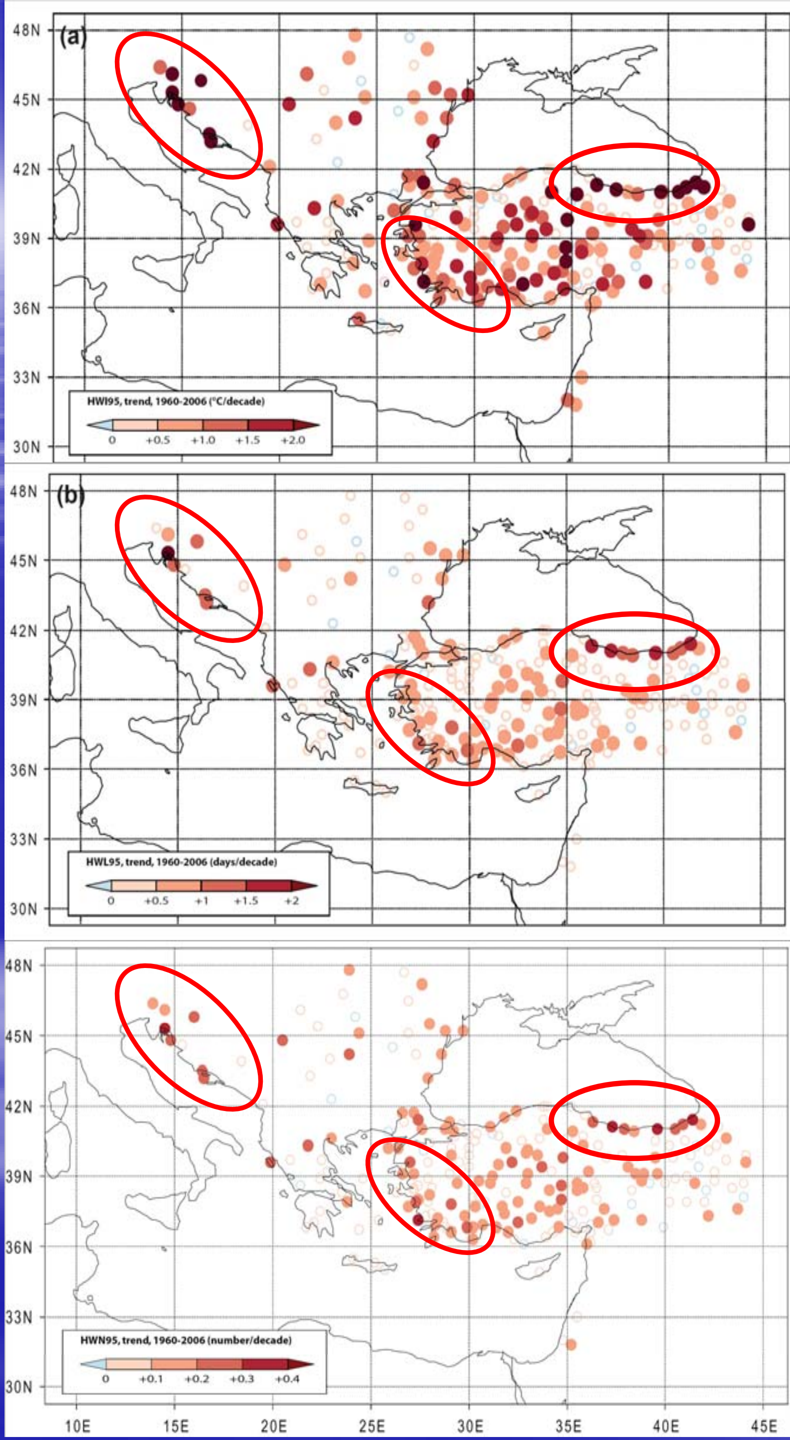






- **HWN95: +0.17 ± 0.01/decade**
  - 47% significant

Kuglitsch et al. 2010



Heat waves trends

- **Heat waves "hotspot"?**
  - Western Balkans
  - Western Turkey
  - Black Sea Coast

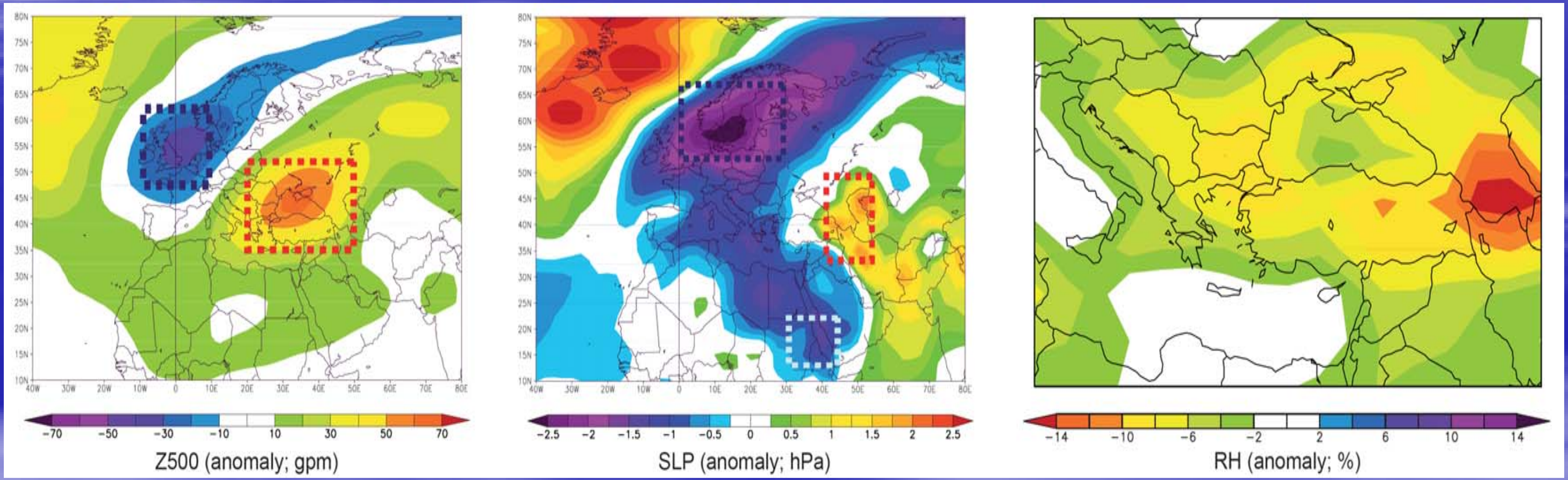
Kuglitsch et al. 2010

Eastern Mediterranean heat waves

COUNTRY	1987	1988	1998	1999	2000	2001	2002	2003	2005	2006	ALL YEARS
Albania	NA	NA	8	6	0	0	NA	NA	NA	NA	**14**
Bulgaria	NA	NA	54	35	56	27	90	NA	NA	NA	**262**
Croatia	NA	NA	15	0	40	0	0	788	22	69	**934**
Cyprus	NA	NA	52	NA	5	NA	NA	NA	NA	0	**57**
FYROM	NA	NA	0	0	0	NA	NA	NA	NA	NA	**0**
Greece	$> 2,000$	56	1,976	378	27	0	NA	NA	NA	NA	$> 4,437$
Israel	NA	NA	160	33	0	0	0	37	0	NA	**230**
Romania	NA	38	20	280	123	84	129	220	368	611	**1,873**
Serbia	NA	NA	50	0	3	0	0	55	0	116	**224**
Slovenia	NA	NA	0	0	0	0	0	289	0	12	**301**
Turkey	NA	NA	NA	NA	11	NA	NA	NA	NA	NA	**11**
ALL COUNTRIES	$> 2,000$	**94**	**2,335**	**732**	**265**	**111**	**219**	**1,389**	**390**	**808**	$> 8,343$

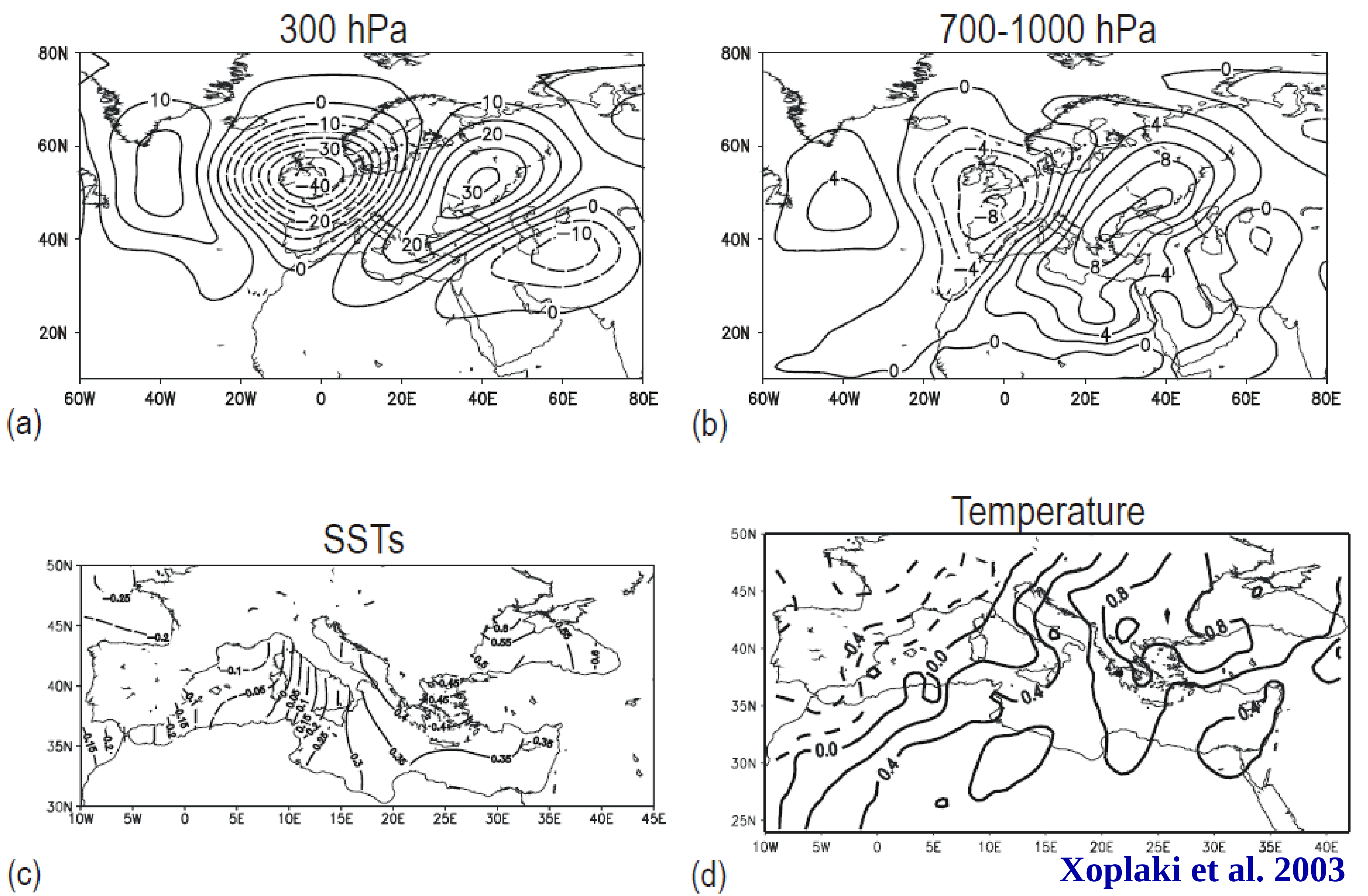
from The International Disaster Database; Kuglitsch 2010

Eastern Mediterranean heat waves
Atmospheric circulation



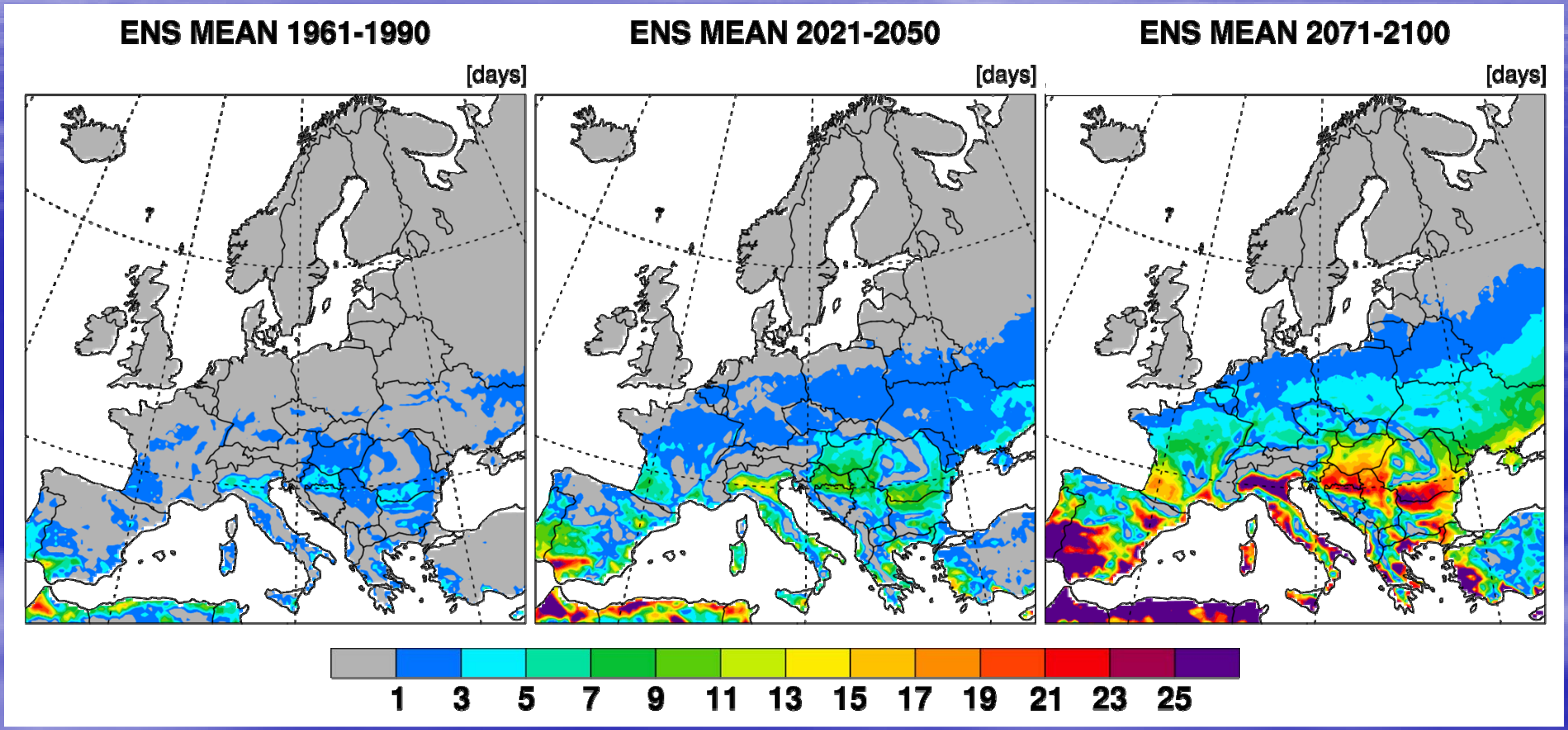
Xoplaki et al. 2011

Eastern Mediterranean heat waves
Atmospheric circulation



Xoplaki et al. 2003

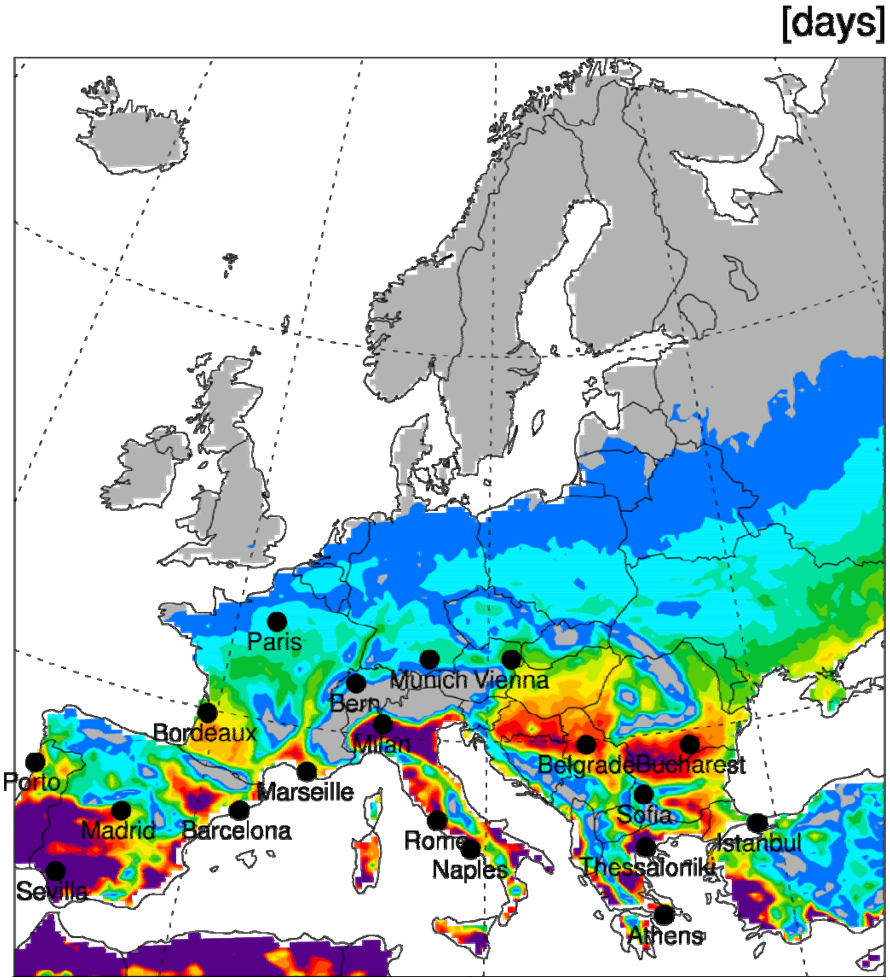
Apparent temperature > 105°F/40.6°C

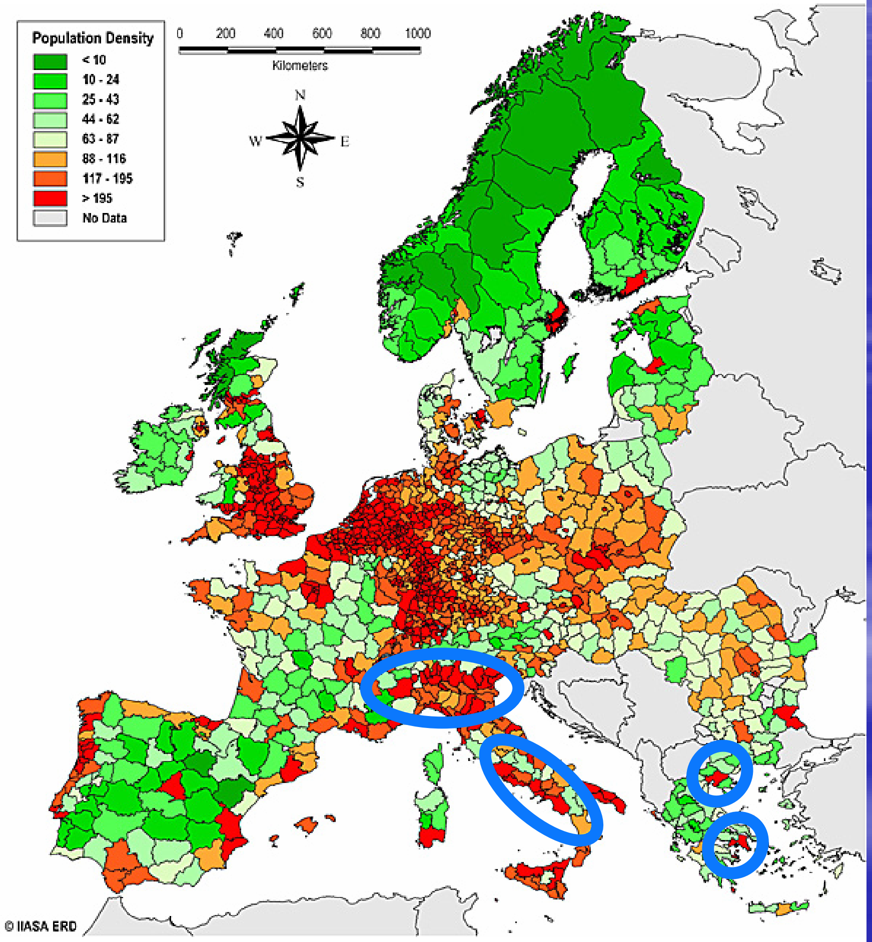


Fischer and Schär 2010

- *Higher apparent temperature despite lower relative humidity*
- *Changes are strongest over humid and warm regions (coasts & river basins)*

Health risk and population density





Fischer and Schär 2010

Source IIASA

Conclusions

- The most important atmospheric modes to account for Mediterranean winter climate variability are the NAO and EA/WRUS with changing influence over time and different impacts at regional scales
- Positive NAO and EA/WRUS strongly contributed to the recent overall winter dryness
- Lesser warming to the west and cooling to the east can be partly attributed to the different impact of the NAO and EA/WRUS patterns in these regions
- Increased occurrence probability of extreme precipitation events
- West Mediterranean extreme precipitation events are connected with intensified moisture transport of Atlantic origin

Conclusions

- East Mediterranean extreme precipitation events are connected with warm air advection, instability
- Upward trends of Eastern Mediterranean heat wave intensity, number and duration
- 10 most severe Eastern Mediterranean heat waves are connected with increased atmospheric stability resulting in clear skies, maximum insolation, reduced relative air humidity
- Strongest apparent temperature increase over humid and warm regions and densely populated areas and cities


Thank you very much
for your attention!