Climate change and extremes events in the Mediterranean

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Acknowledgments:

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Celia Gouveia, Malik Amraoui, Pedro Sousa, Ana Bastos

2ND OTMED PROGRESS MEETING

Outline

1. Climate change scenarios (**average** vs **extremes**)
2. **Drought** case studies:

   Iberian Peninsula (2004/05 + 2011/12)

   Fertile crescent (2007-2009)

3. Is there an anthropogenic role in the Increasing drought frequency in the Mediterranean?
4. Heatwave case studies

   Western Europe (2003)

   Greece + Italy (2007)

   Russia (2010)

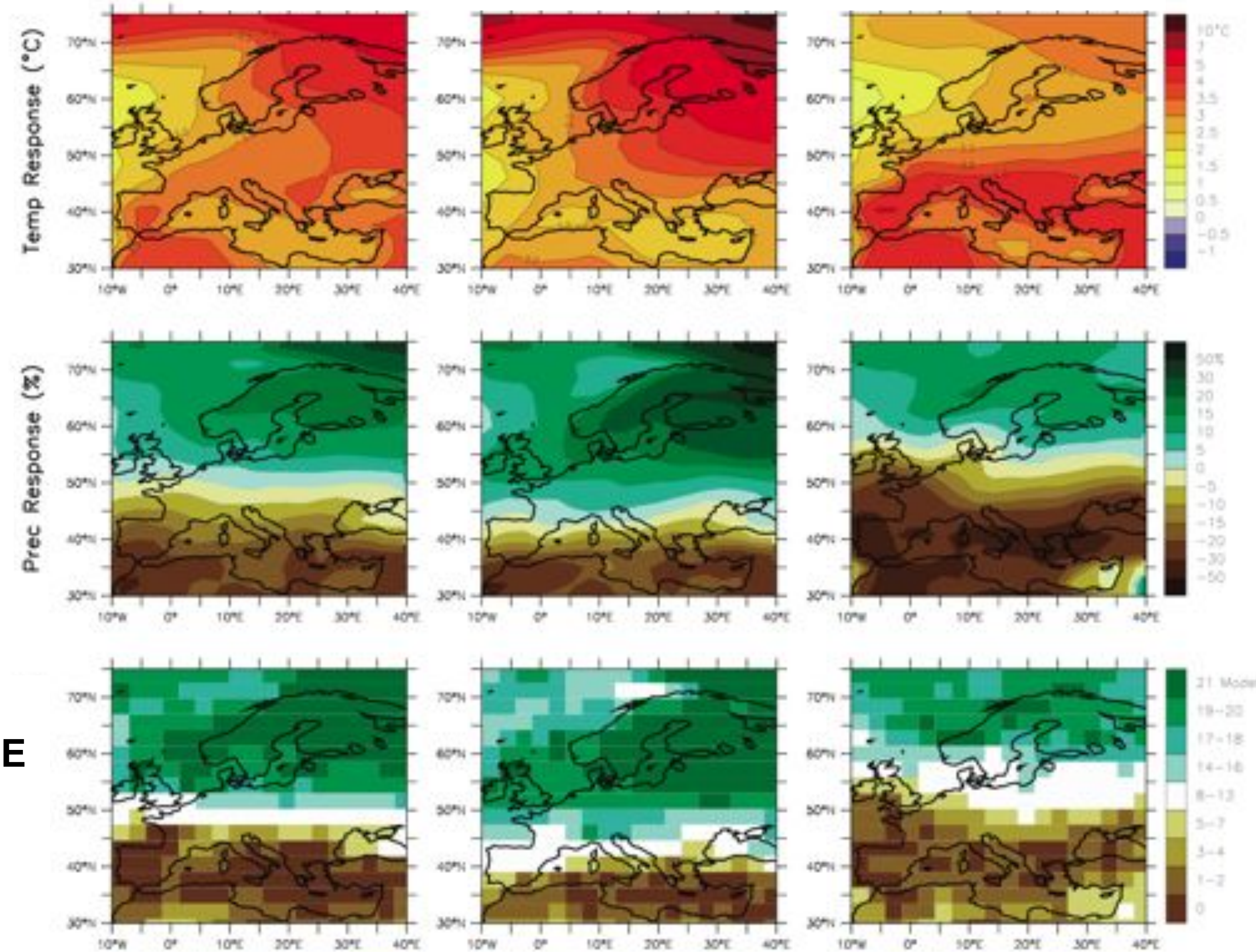
IPCC - Temperature and Precipitation changes over Europe

Annual | **Winter** | **Summer**

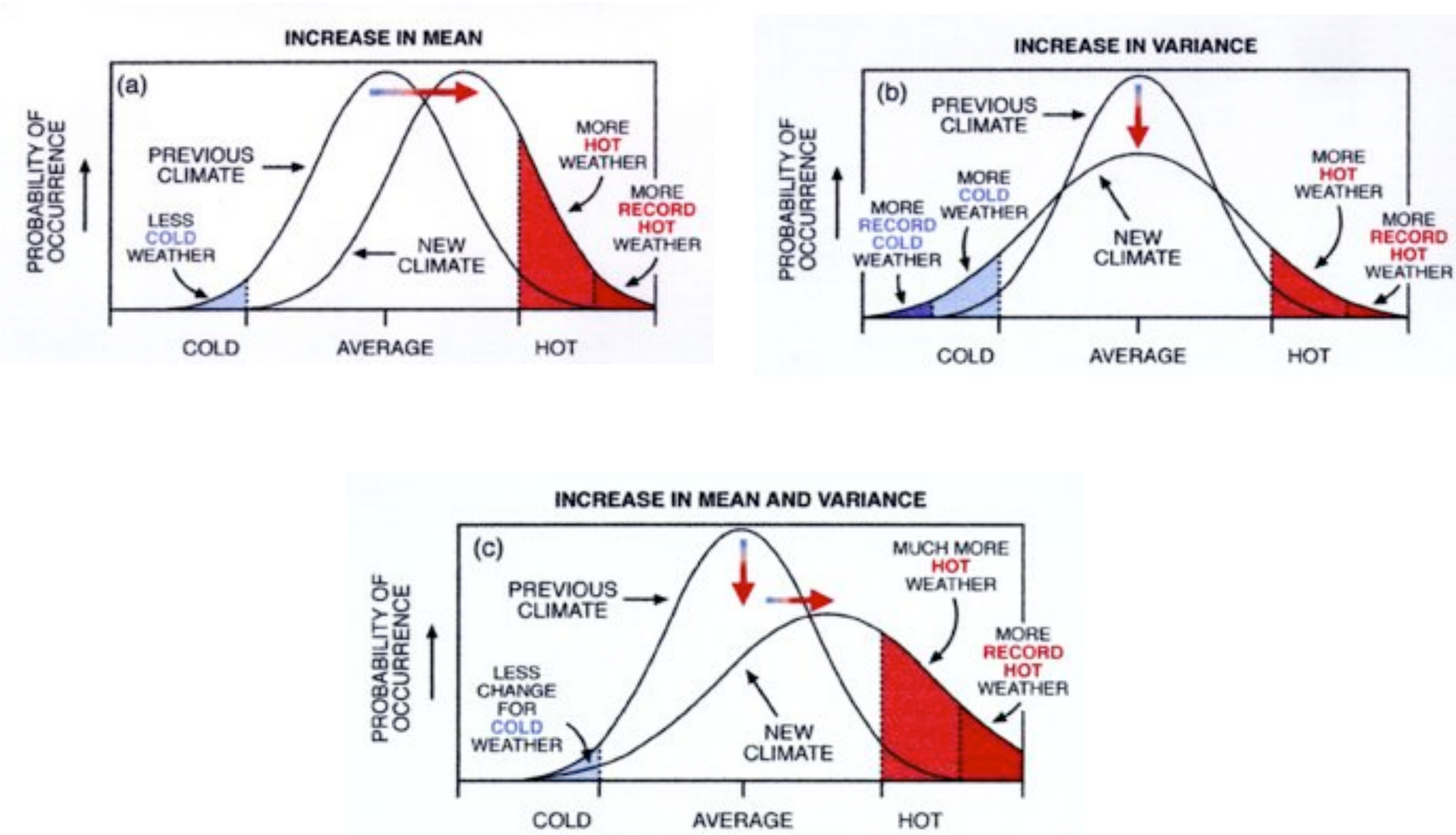
TEMP (ºC)

PRECIP. CHANGE (%)

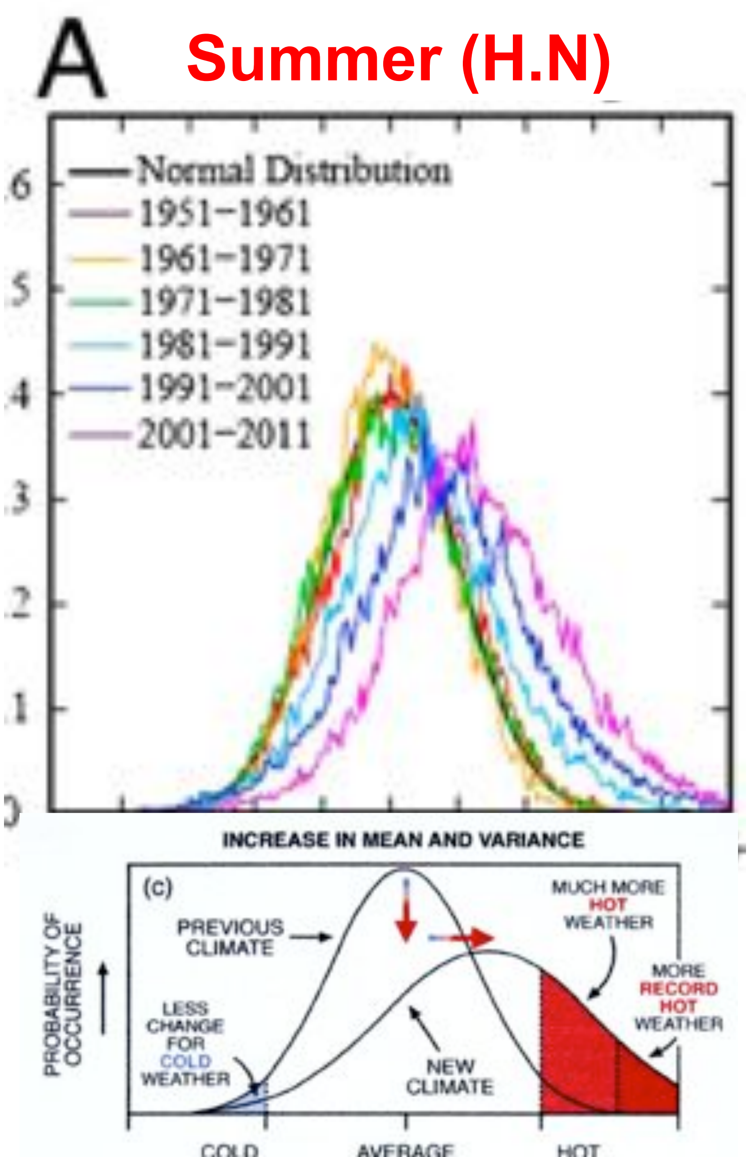
COHERENCE (Nº Models)

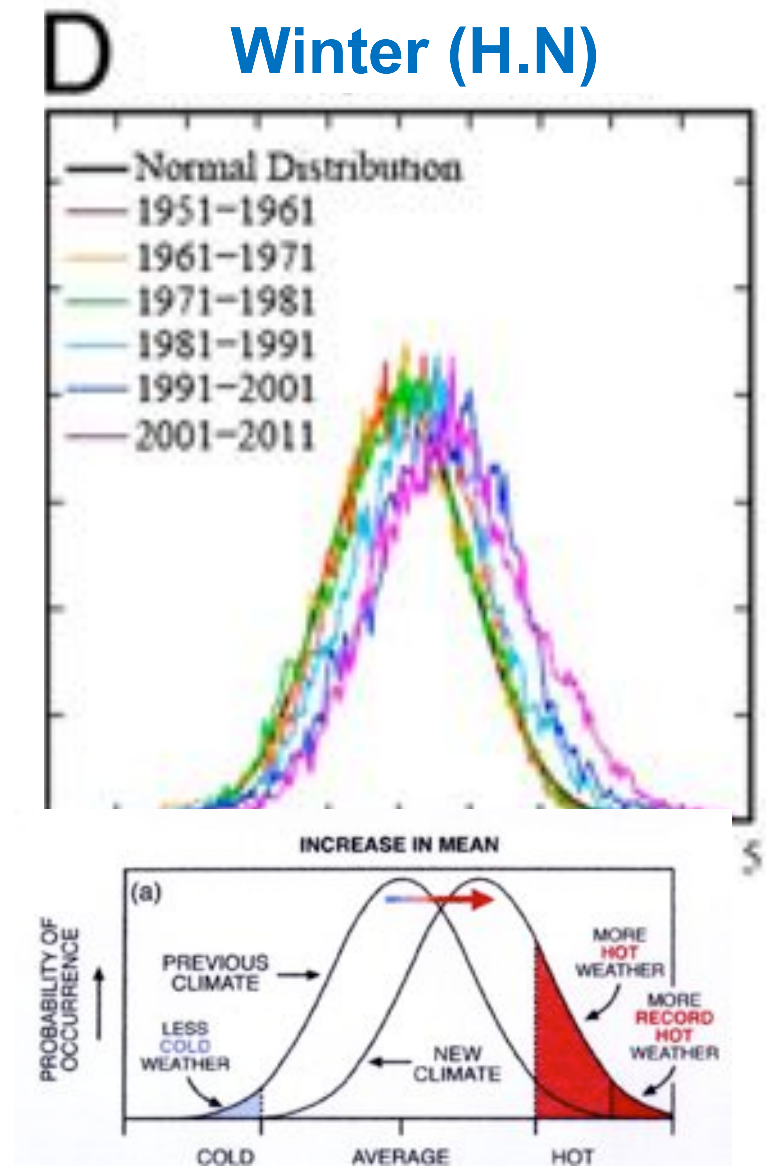


Different types of climate change and implications for climate extremes (IPCC)



Evolution of N.H daily temperature anomalies between 1951 and 2011 (Hansen 2012, PNAS)

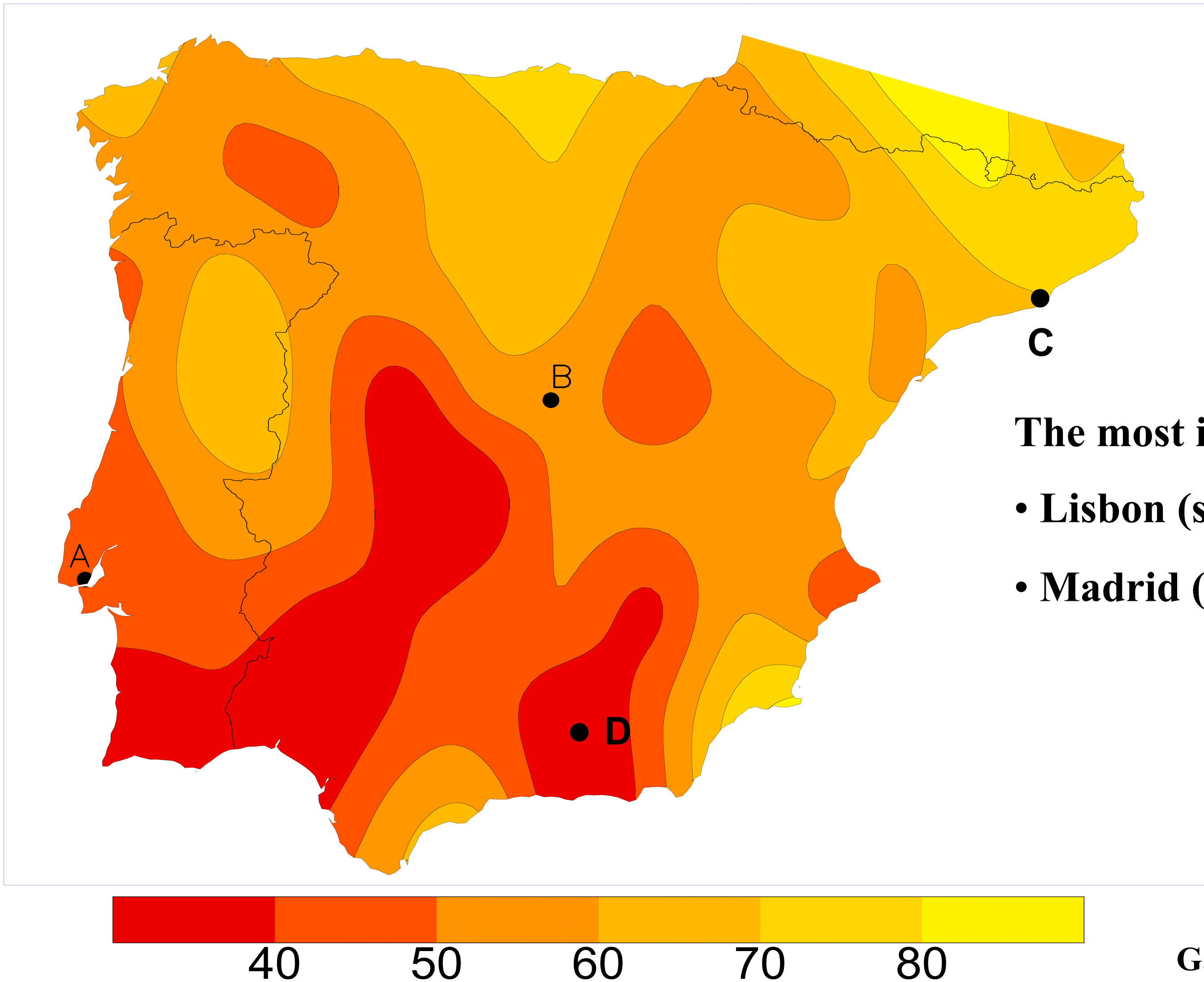




Drought
Case-studies

1. The outstanding **2004-2005** drought in **IBERIA**

Accumulated precipitation in Iberia between Oct. 2004 and Sept 2005 (% relative to the average for the period 1961-1990)



The most intense drought:

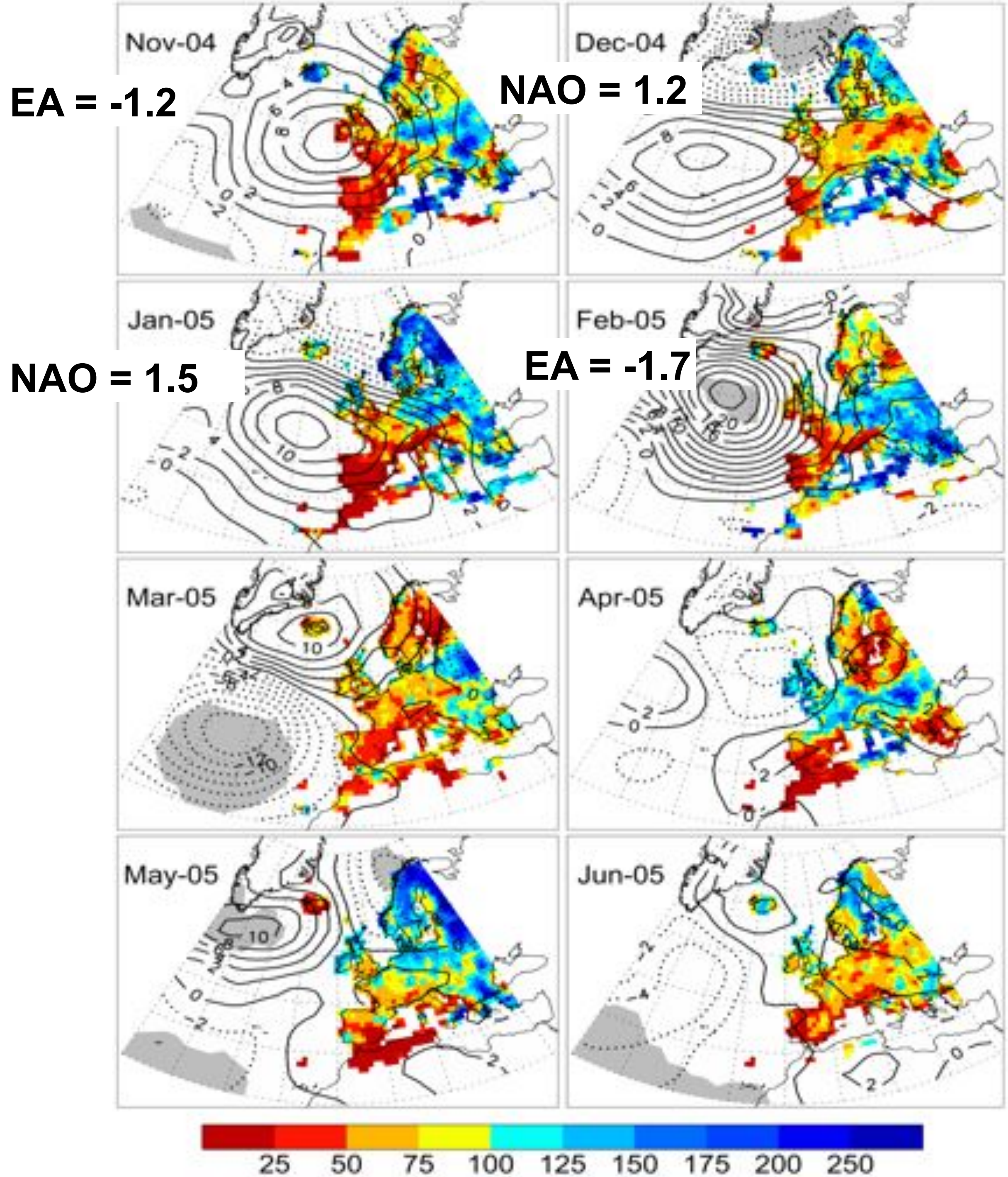
- **Lisbon (since 1865)**
- **Madrid (since 1859)**

Garcia-Herrera et al. (2007)

Monthly Analysis

SLP and Precip

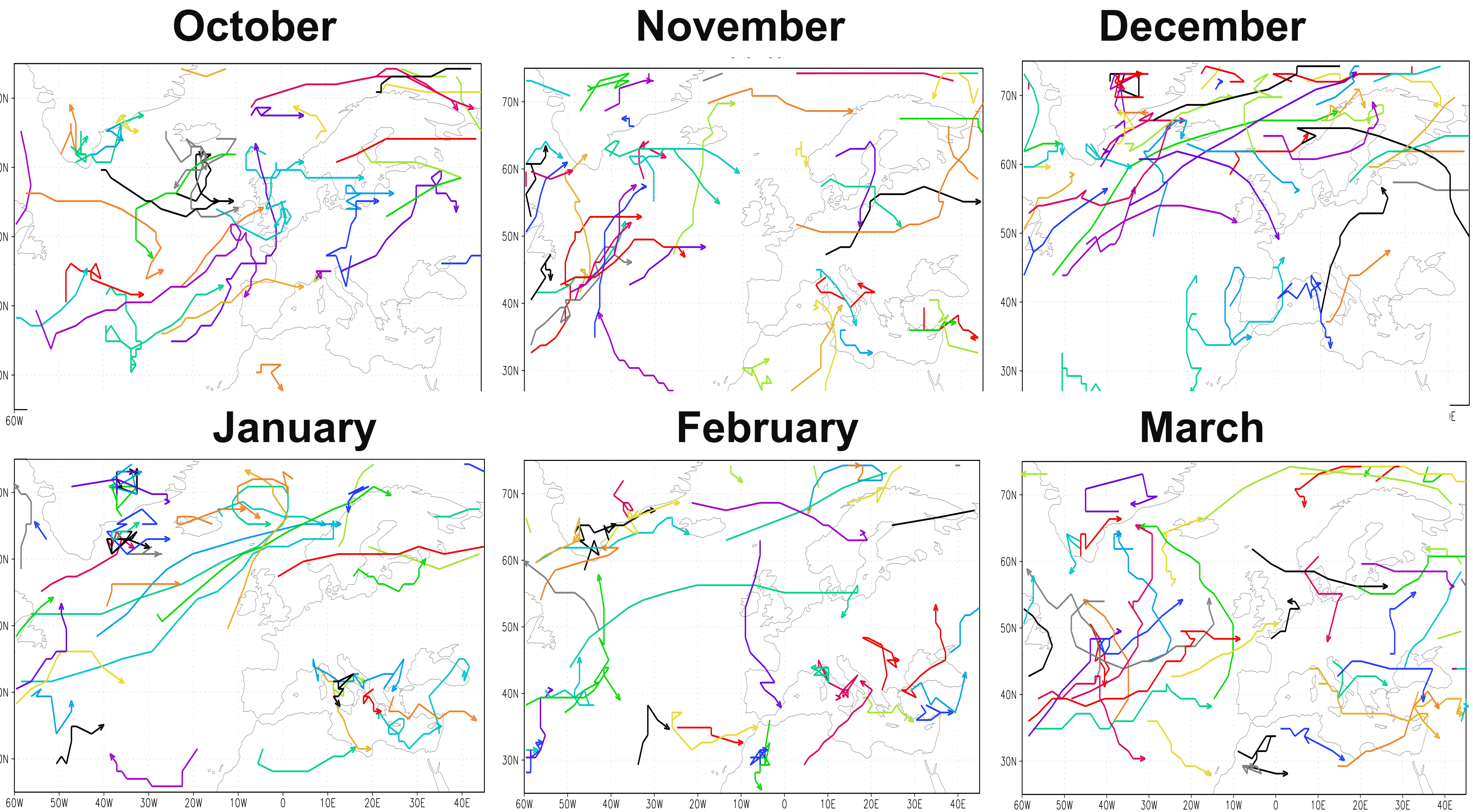
The role of NAO and EA!!



Garcia-Herrera et al (2007)

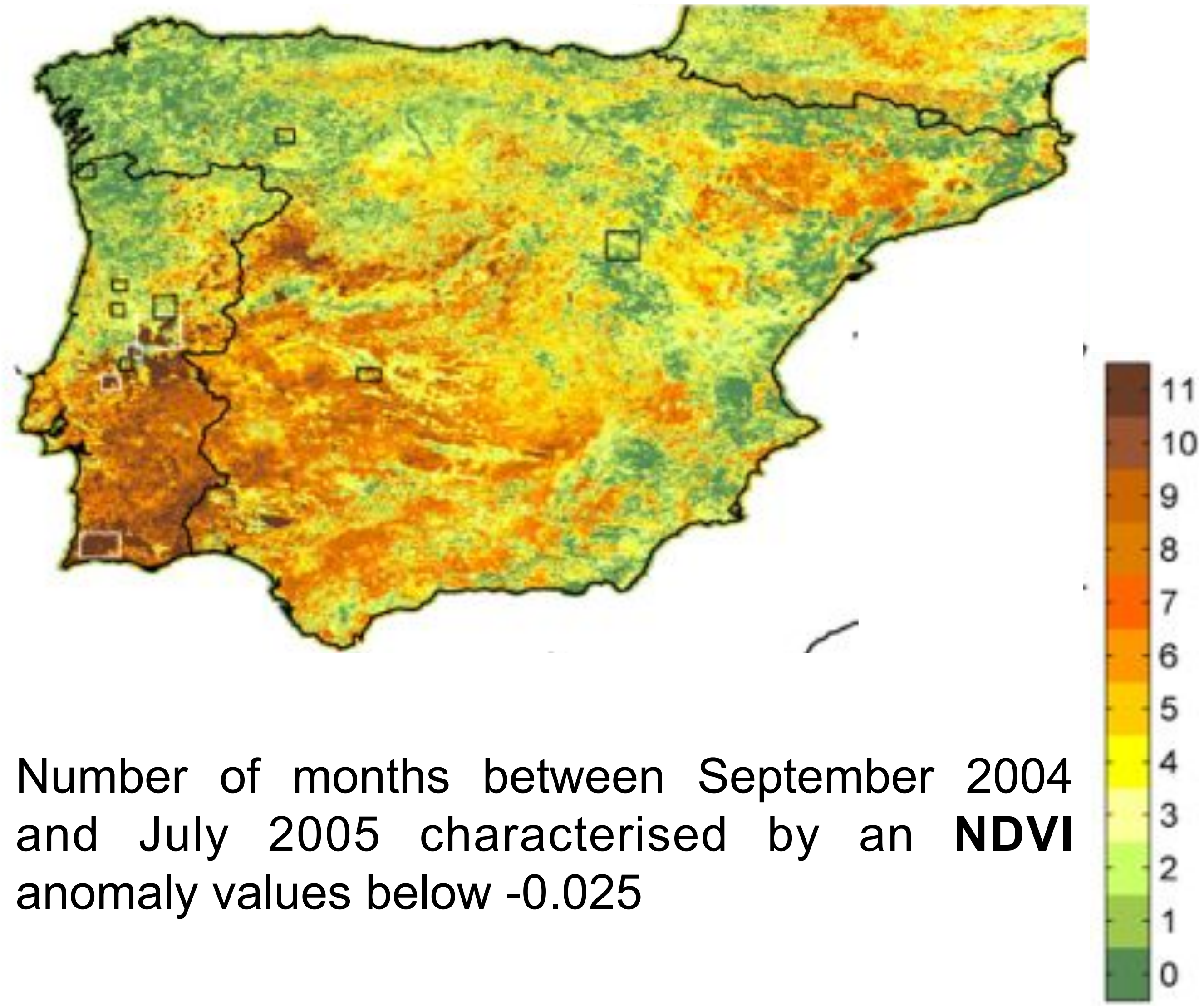
J.Hydrometeorology

Trajectories of all Storm Tracks longer than 48h



Garcia-Herrera et al (2007)

Impact on vegetation

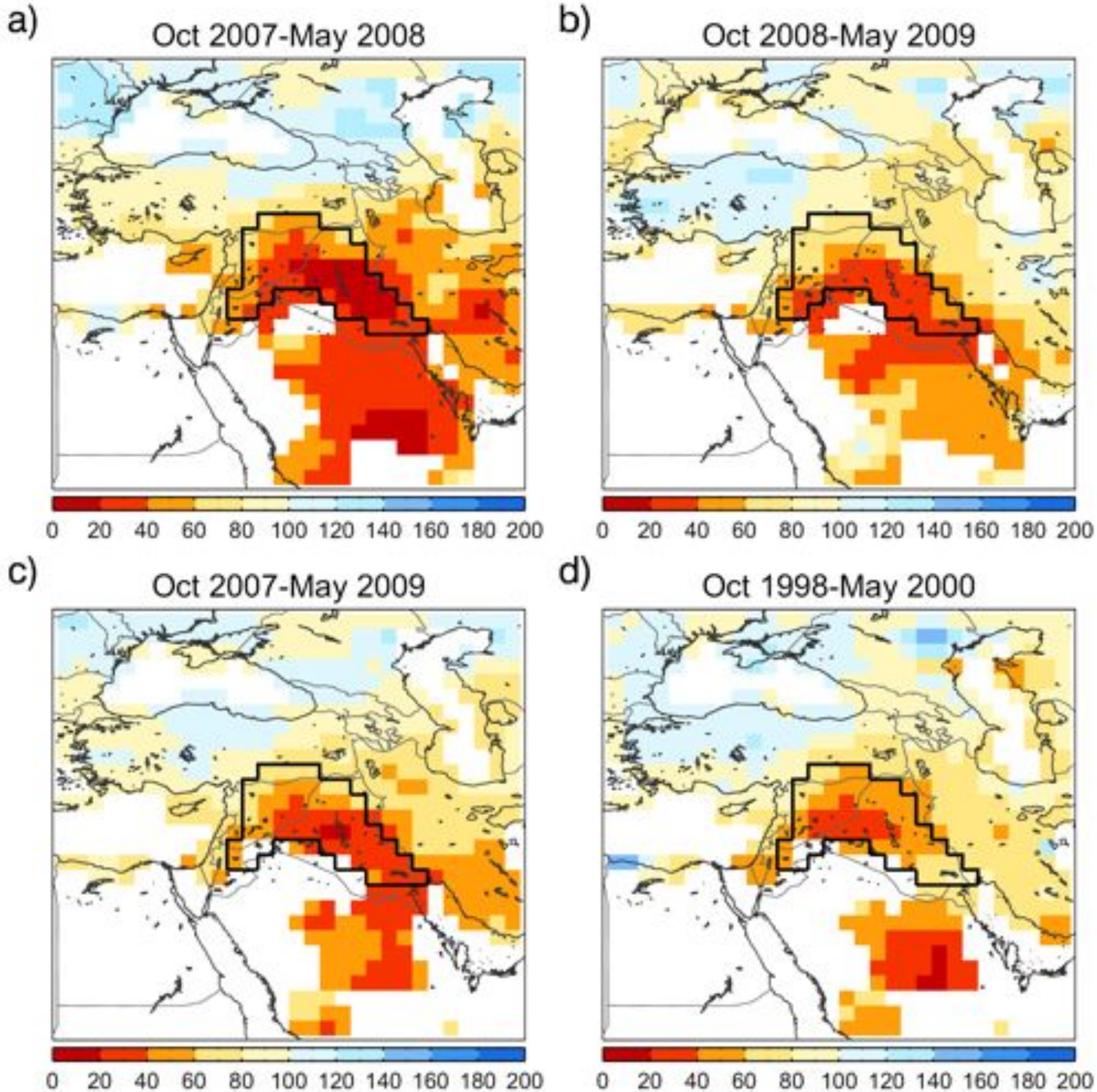


Number of months between September 2004 and July 2005 characterised by an **NDVI** anomaly values below -0.025

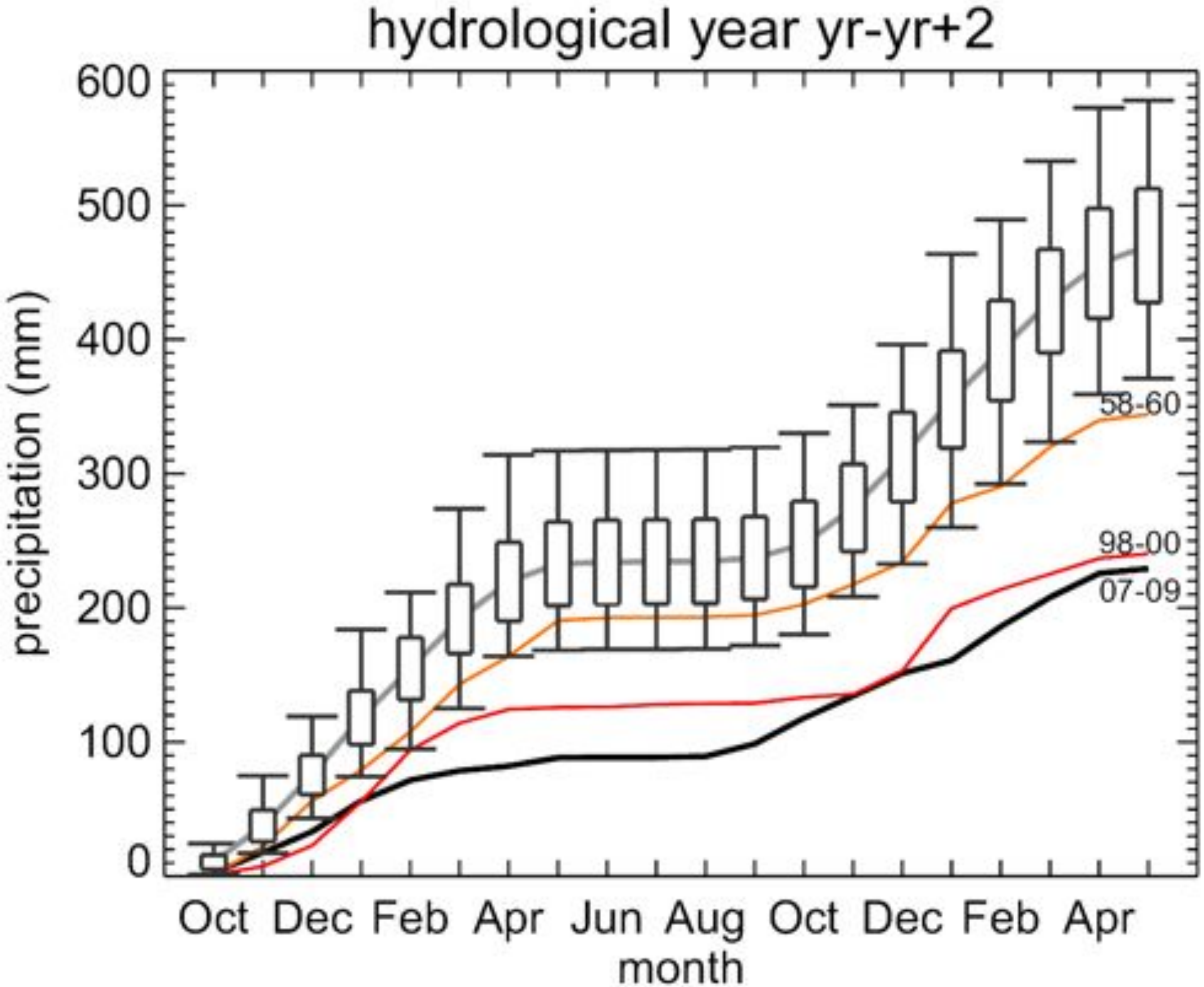
Gouveia et al (2012)

Drought
Case-studies

2. The intense **2007-2009** drought in the Fertile Crescent

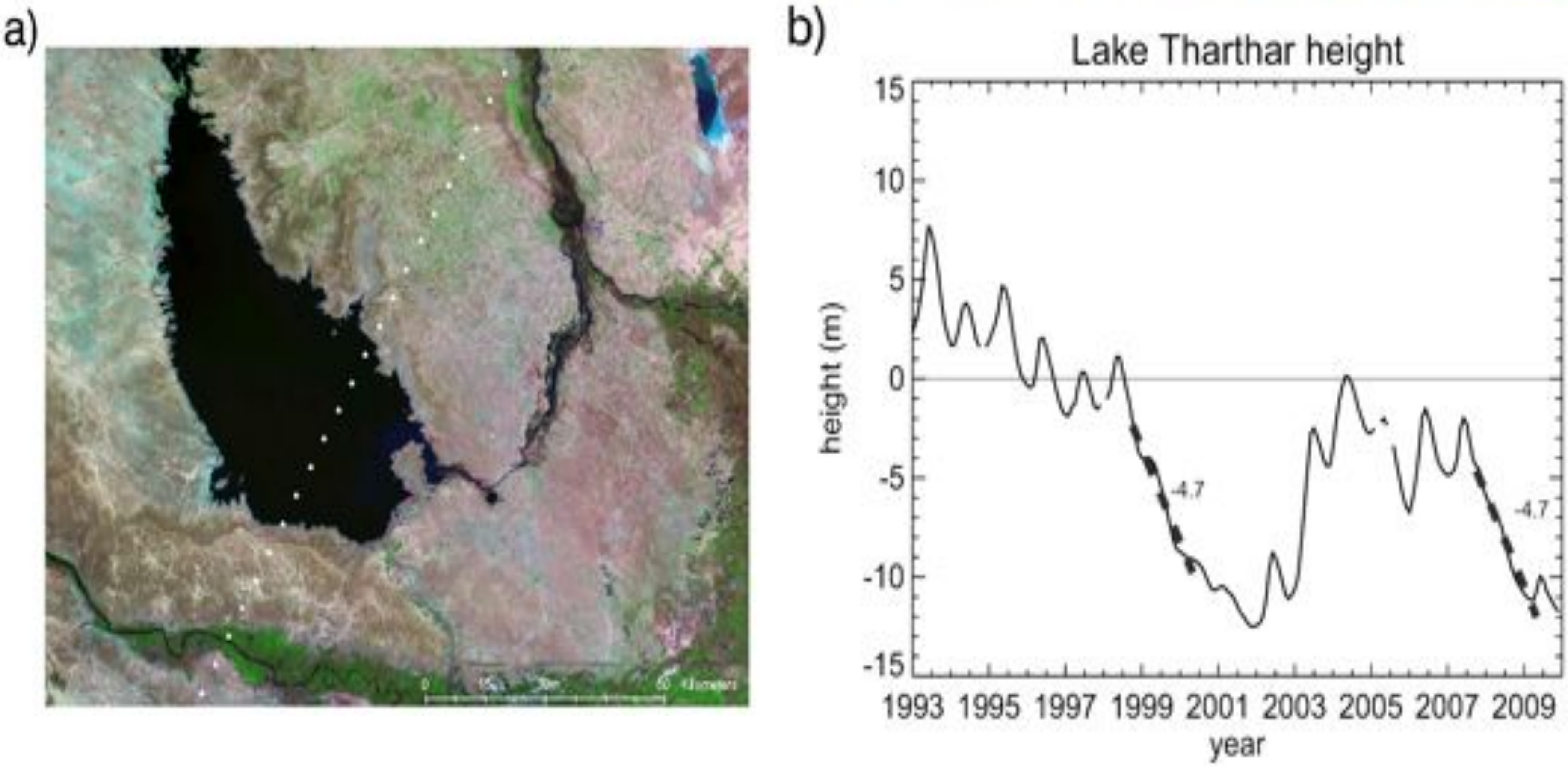


(Trigo et al., 2010)



Accumulated monthly precipitation averaged over the FC during two consecutive hydrological years.

Lake Tharthar height (1992-2009)

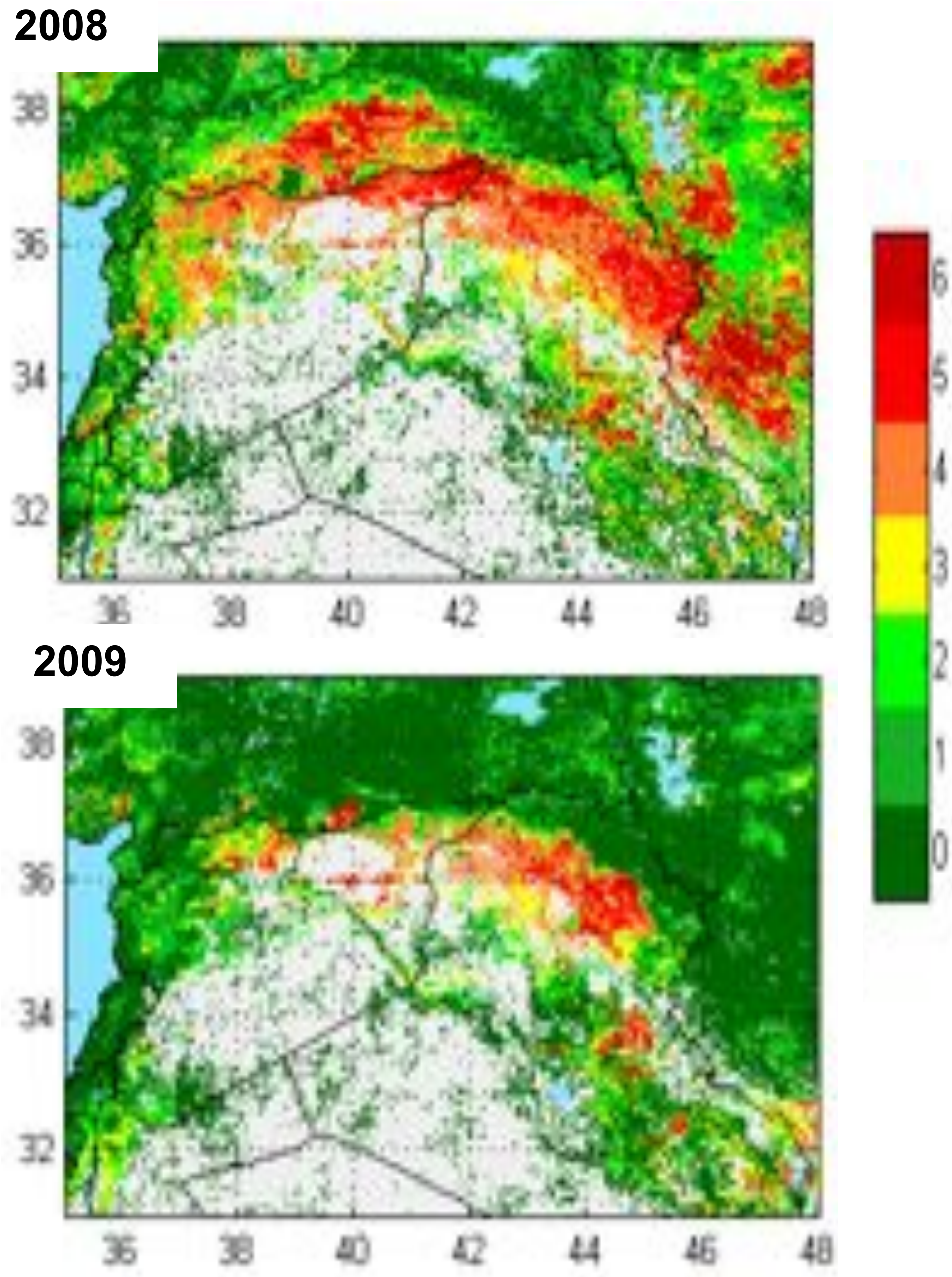


Lake Tharthar level based on TOPEX/ Poseidon – Jason satellites

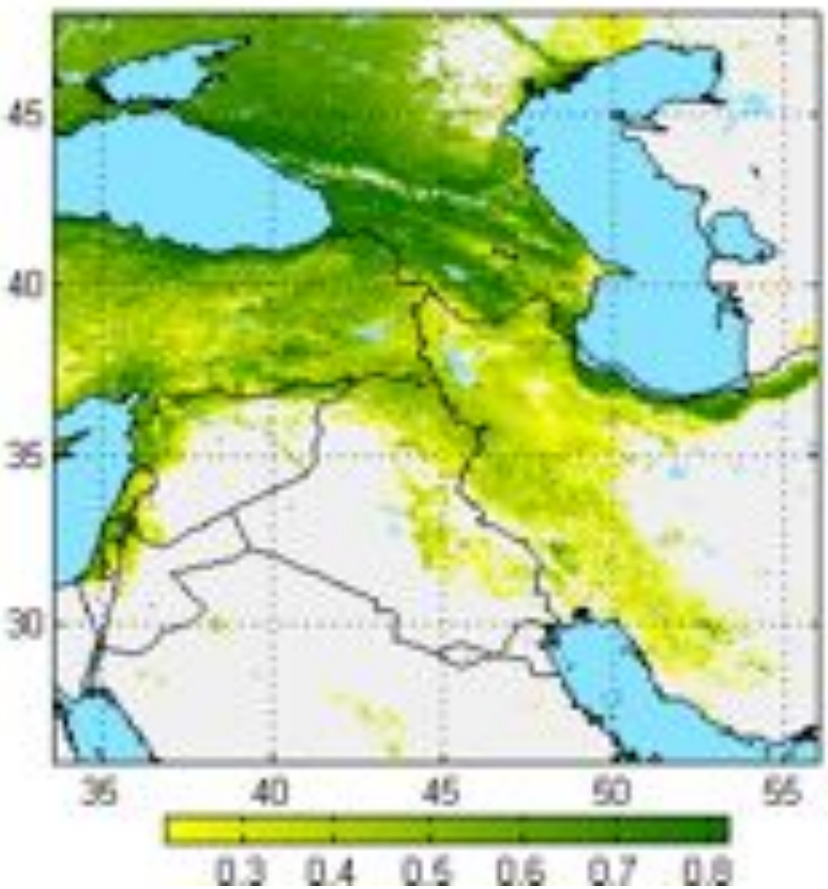
(Trigo et al., 2010)

In 2007-08 drought year, pixels located over south-eastern Turkey, eastern Syria, northern and western Iran reveal **up to 6 months of persistently stressed vegetation**.

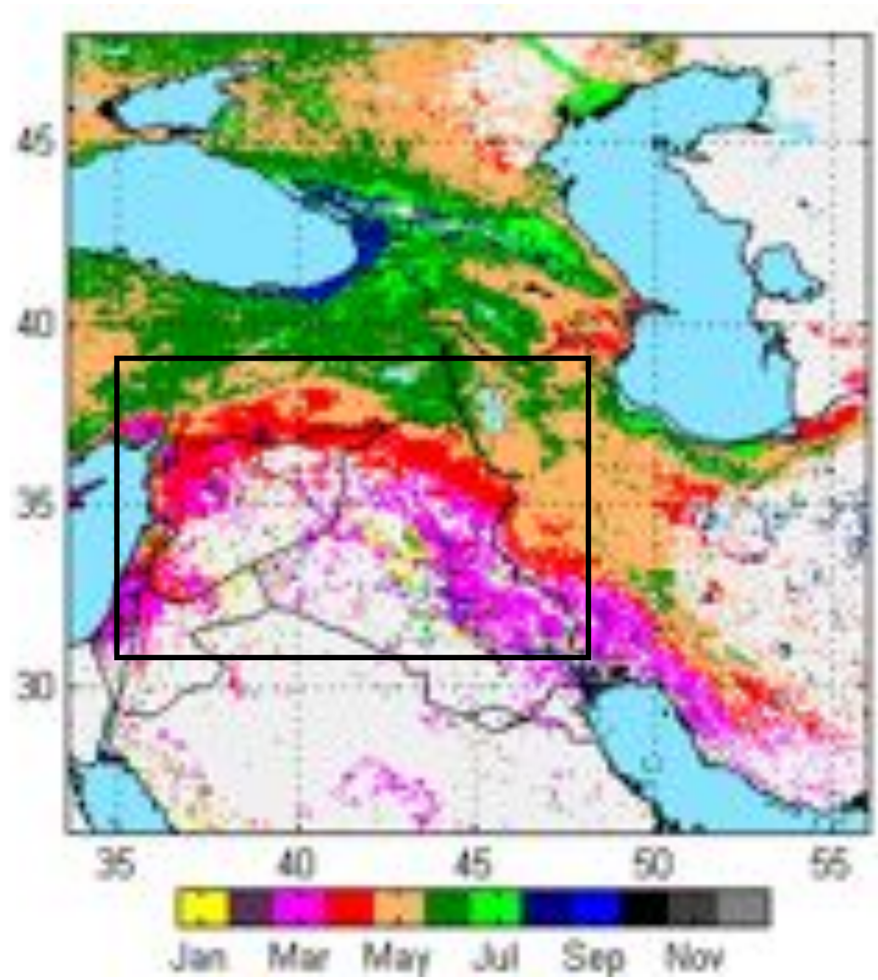
(Trigo et al., 2010)



Maximum vegetation greenness, as represented by the NDVI value for the monthly maximum obtained



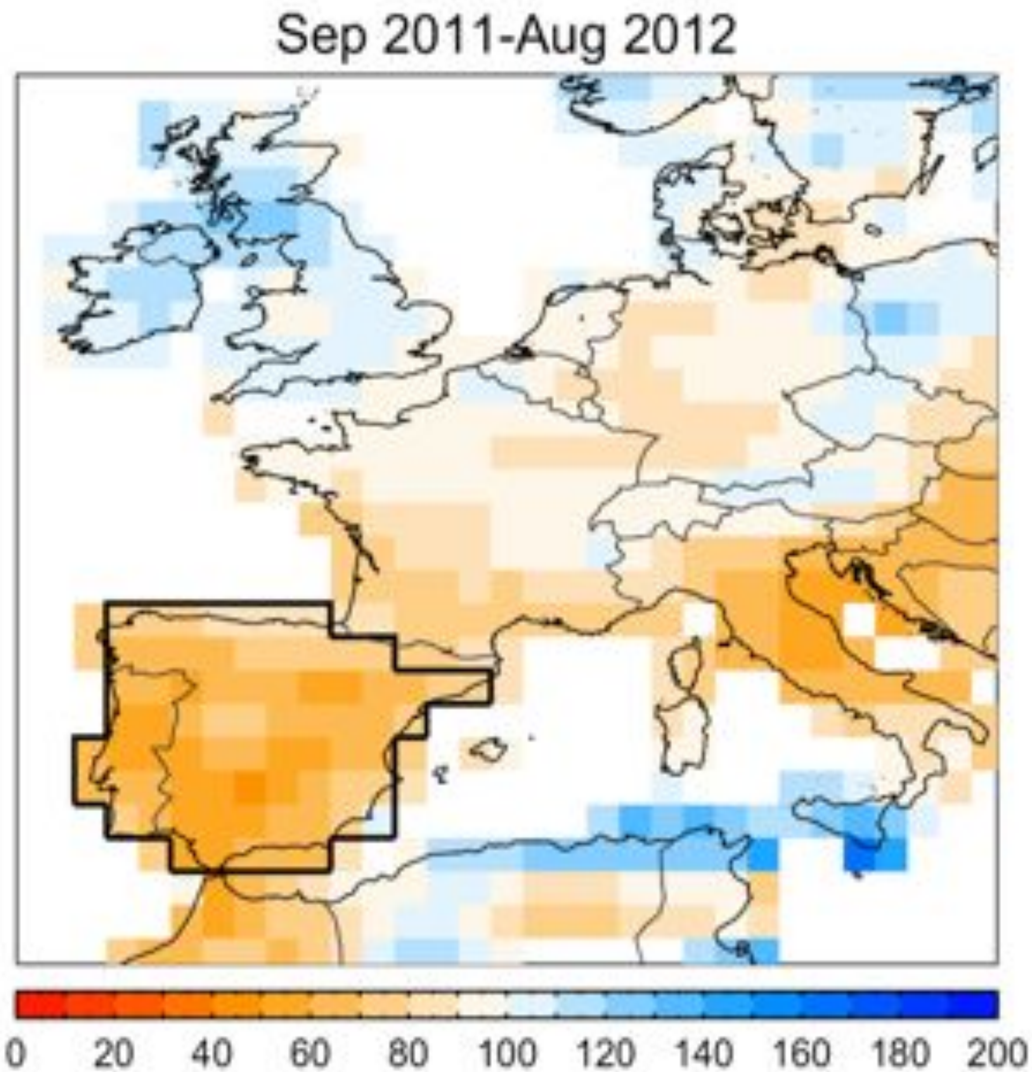
Spatial distribution of the month with maximum annual mean NDVI



(Trigo et al., 2010)

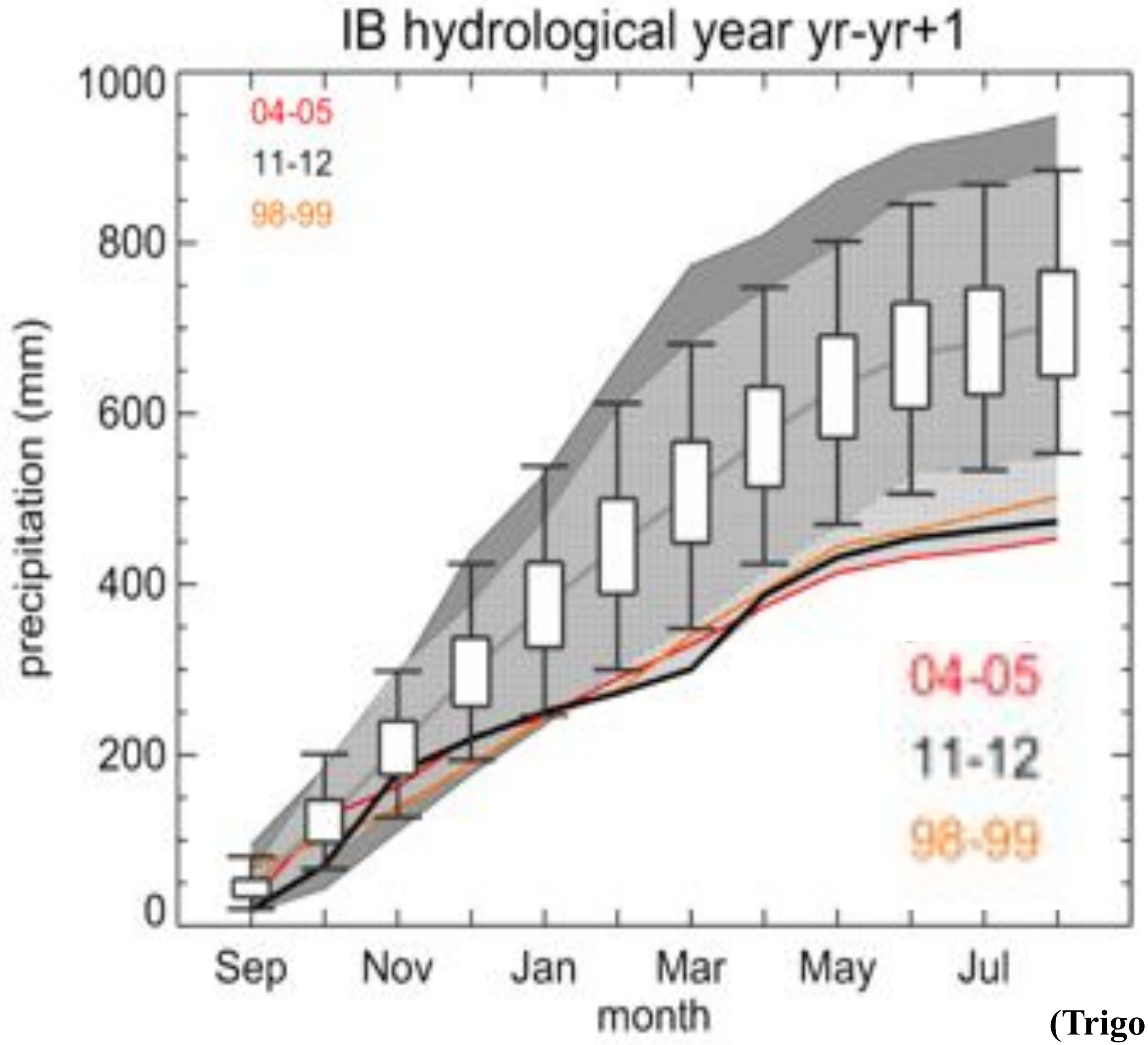
Drought
Case-studies

3. Another major **2011-2012** drought in **IBERIA?**



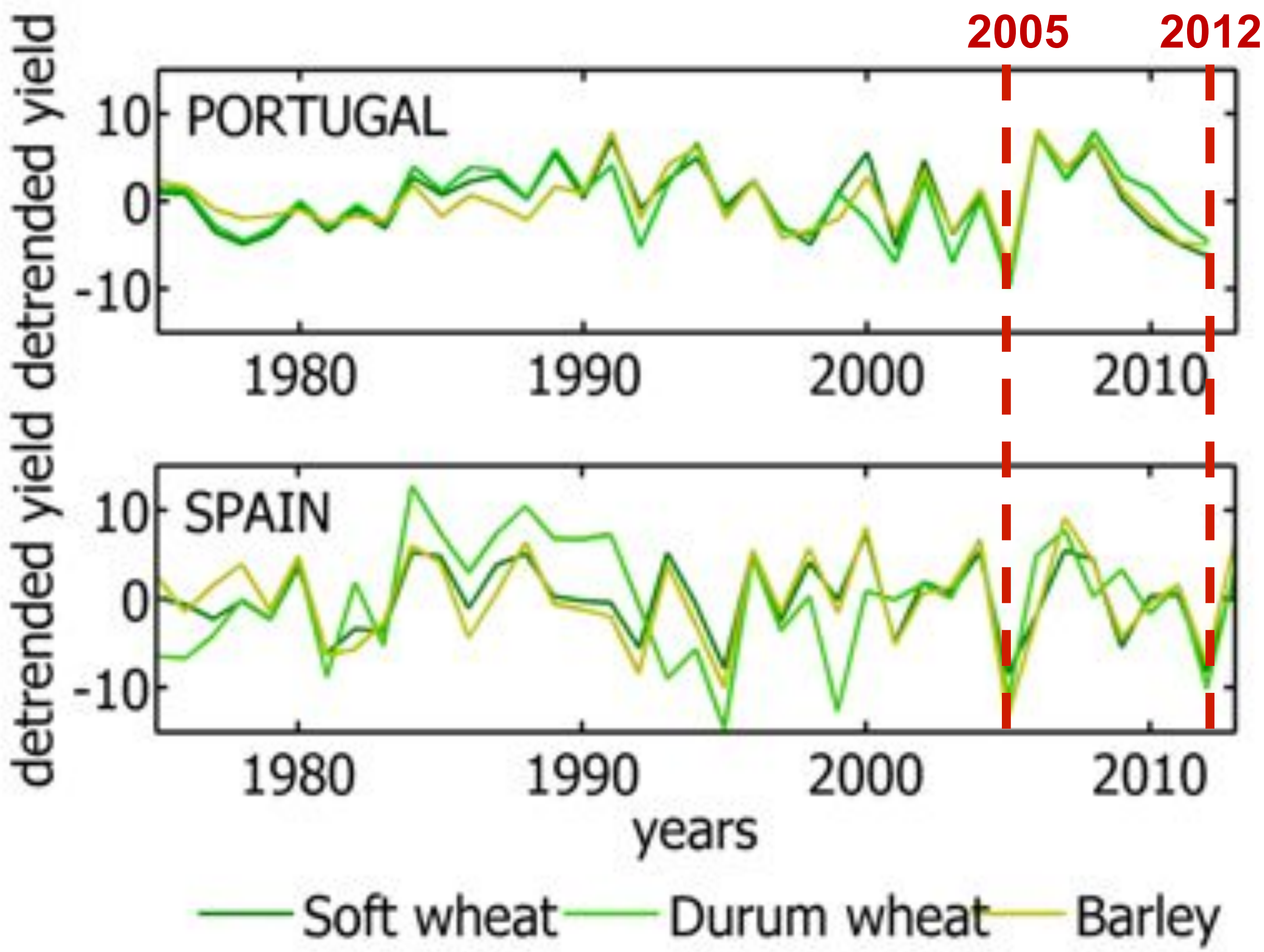
(Trigo et al. 2013, BAMS)

Accumulated monthly precipitation (expressed in percentage relative to the 1940-2010 normals) during the hydrological year



(Trigo et al. 2013, BAMS)

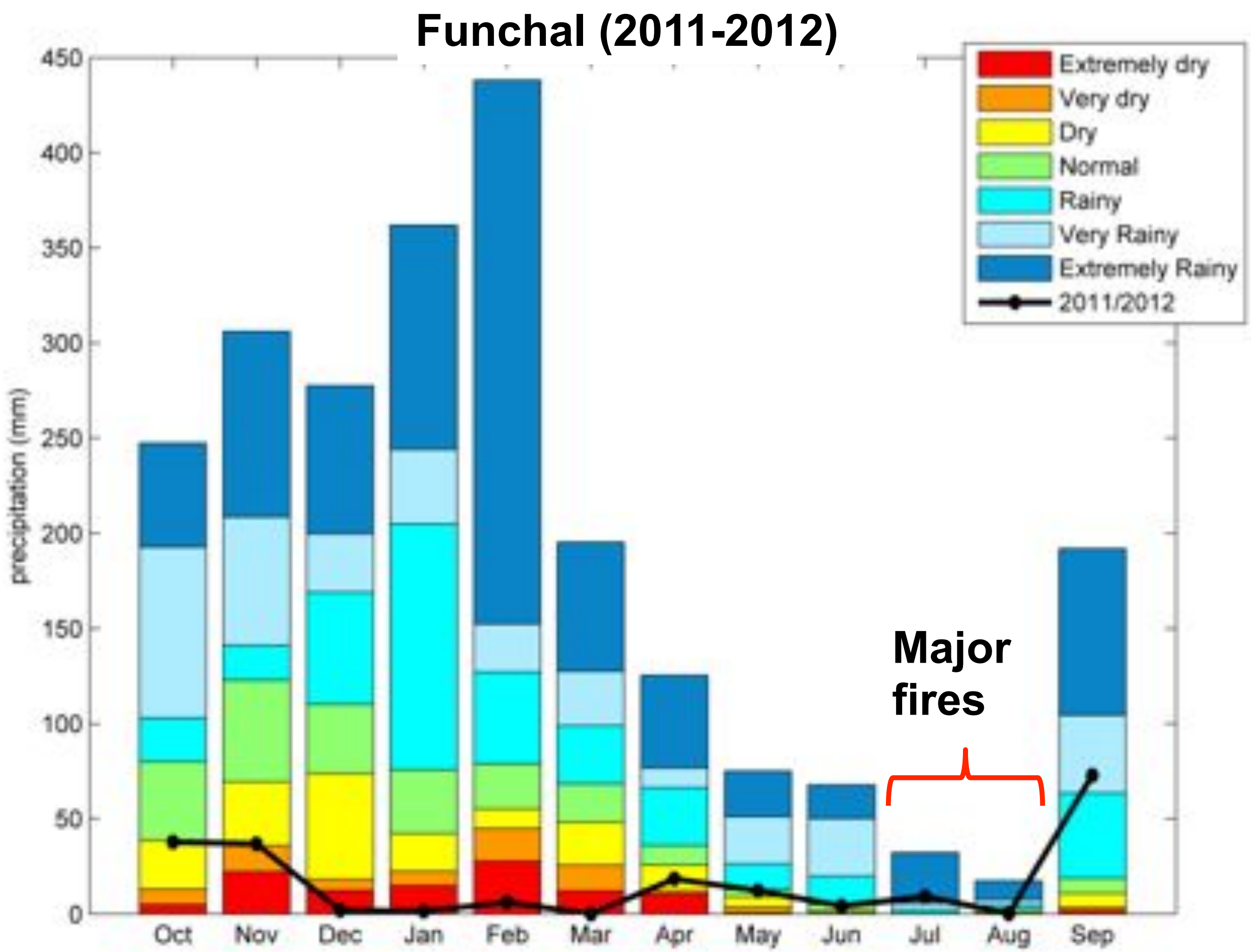
Detrended time series of **wheat** and **barley** yields for Portugal and Spain



(Gouveia et al. 2015)

Drought in Madeira

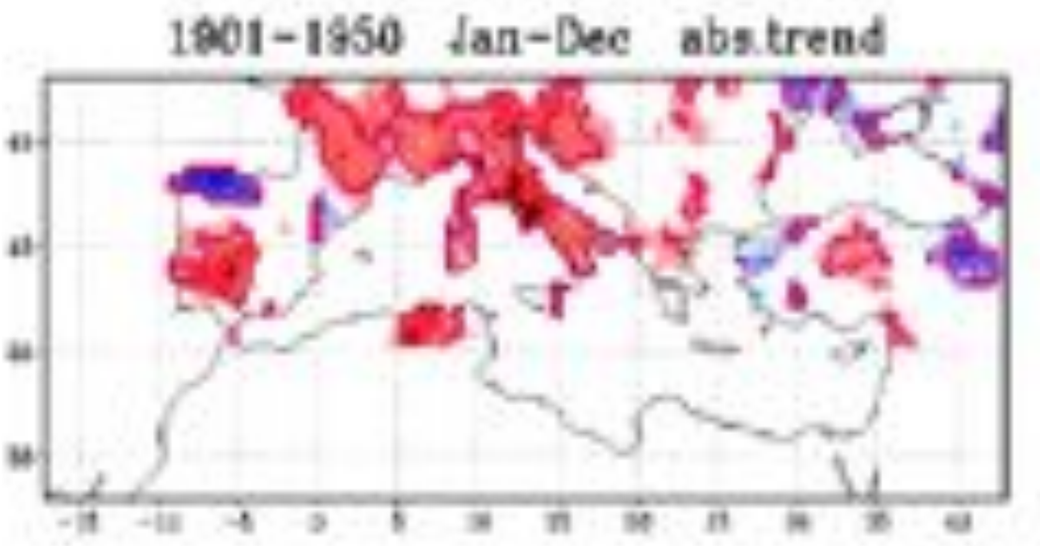
IPMA (2012)



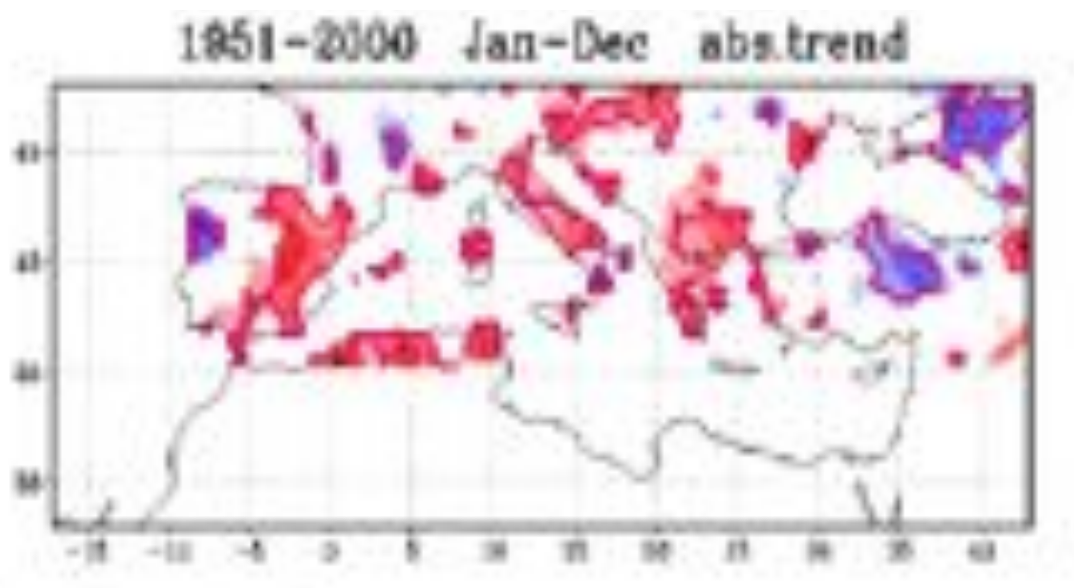

Porto Moniz
Ponta do Pargo
São Vicente
Santana
Ilha da Madeira
Madeira
Calheta
Curral das Freiras
Ribeira Brava
Câmara de Lobos
Funchal


19Jul2012

Evolution of drought in the Mediterranean

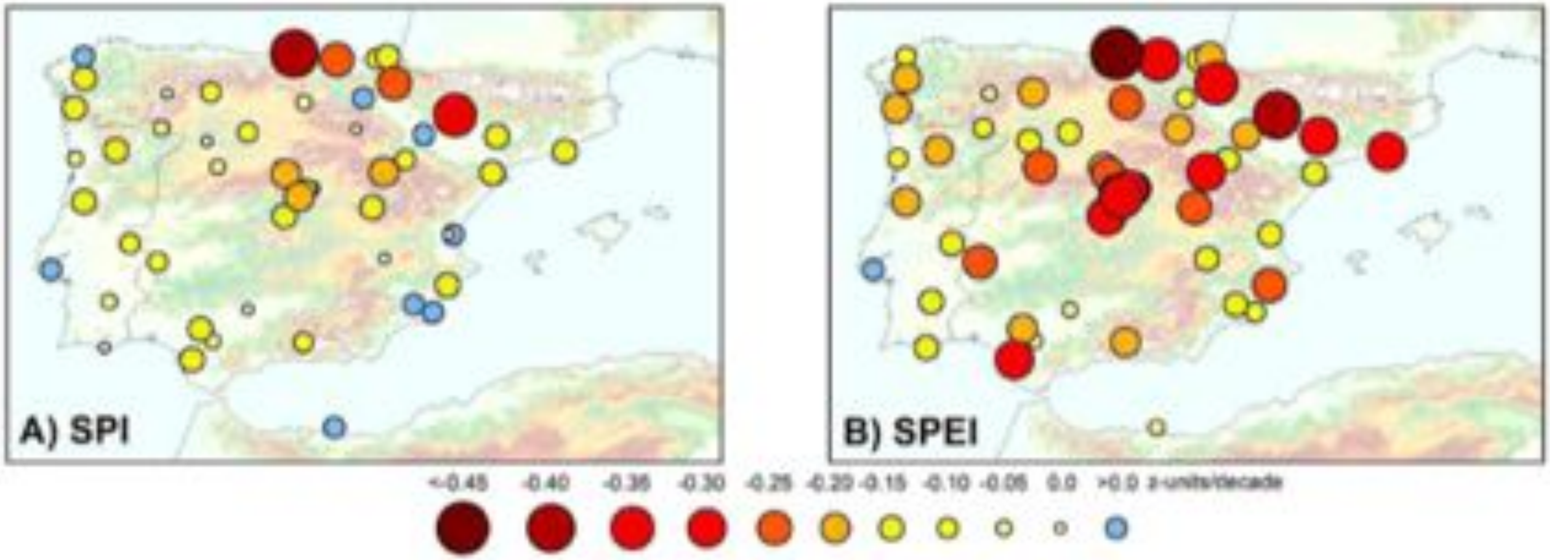


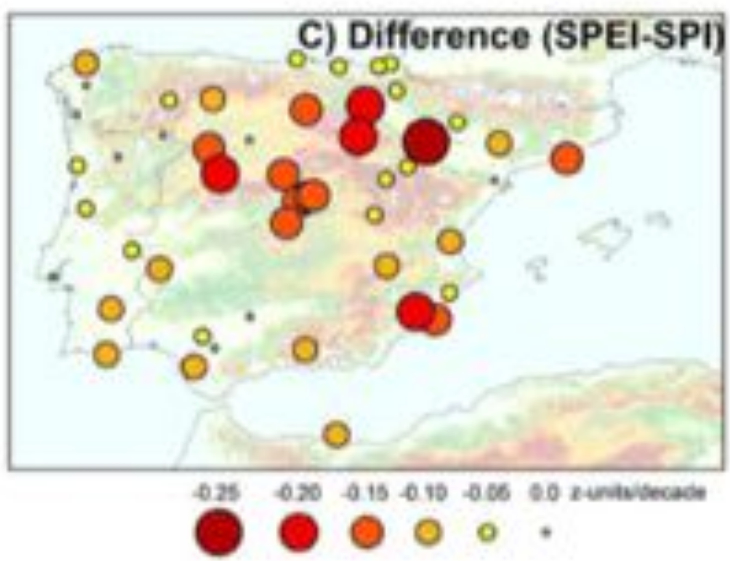
scPDSI trends



(Sousa et al., 2010 NHESS)

Evidence of increasing drought severity caused by temperature rise in southern Europe



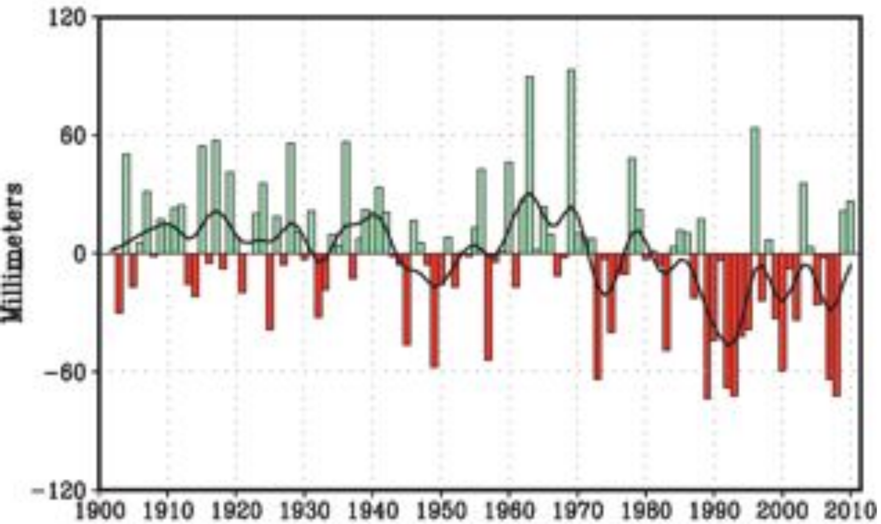


(Vicente-Serrano et al., 2014)

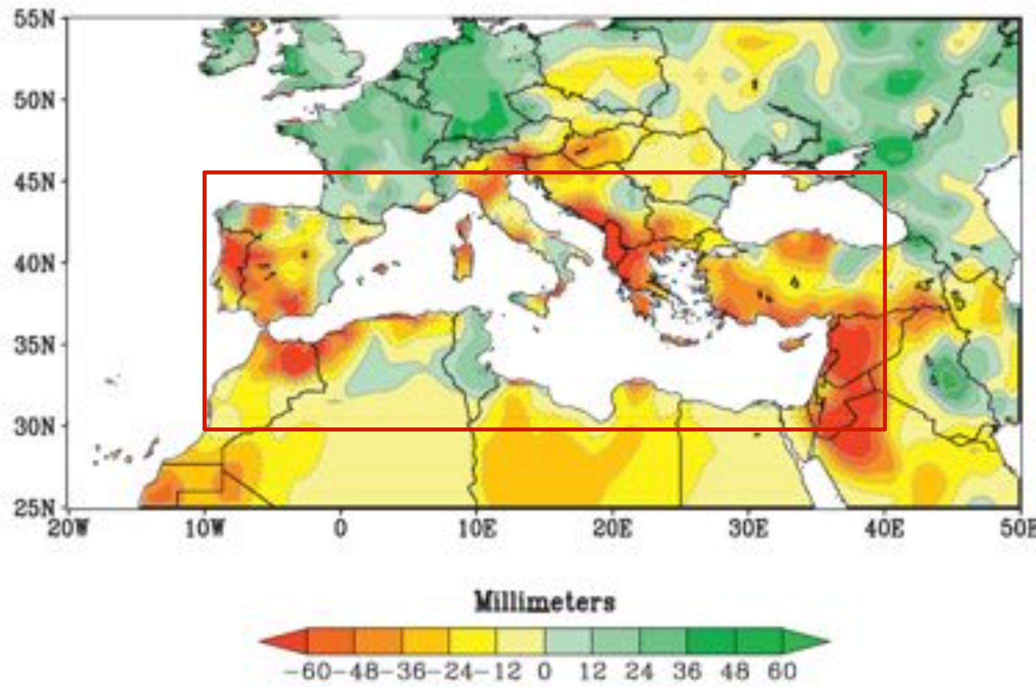
The **SPEI** indicates increased drought severity relative to the **SPI**

Observed precipitation changes in the Mediterranean (1902-2010)

Winter (NDJFMA) Precipitation variability for the Mediterranean area (red line)

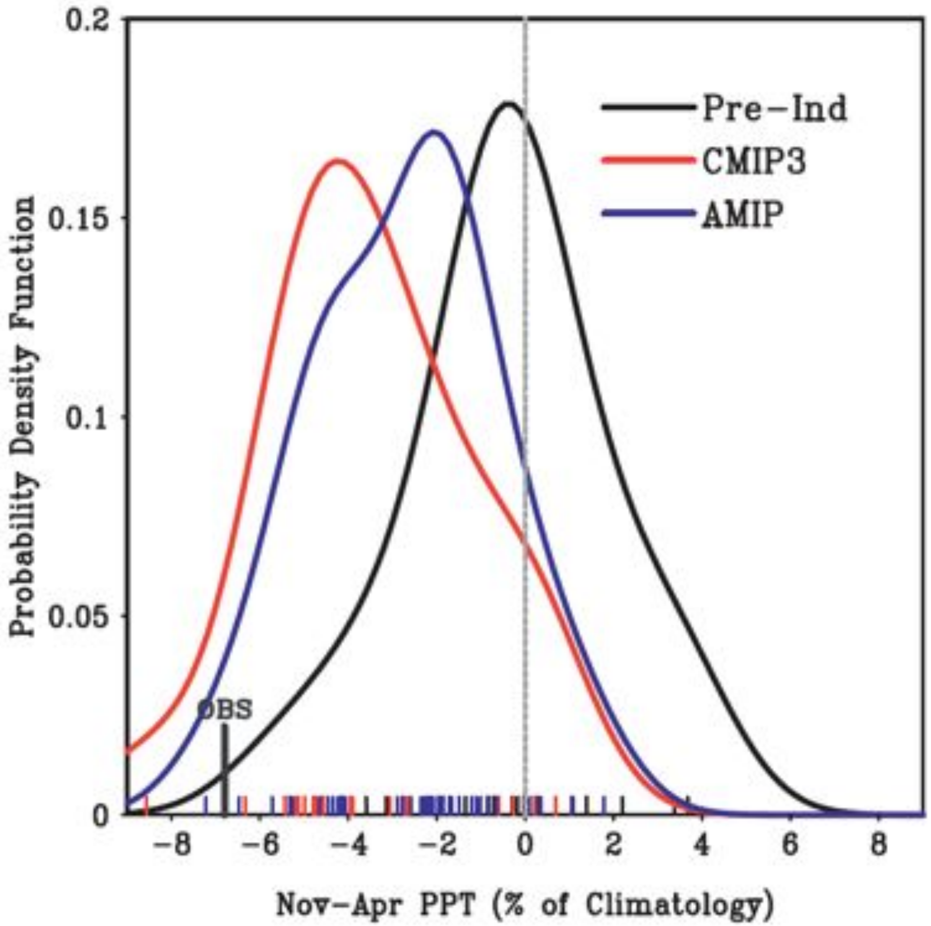


Observed change of winter Precipitation (1971:2010) – (1902:1970)

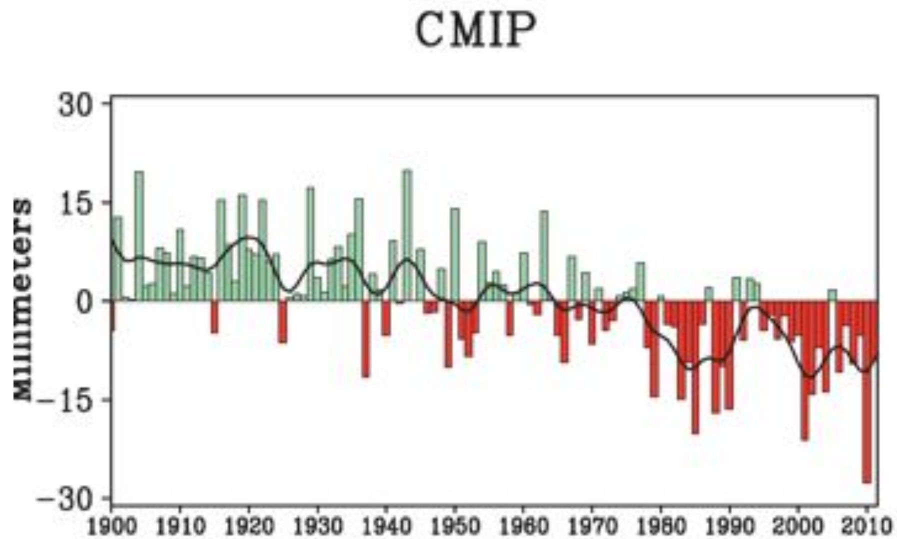


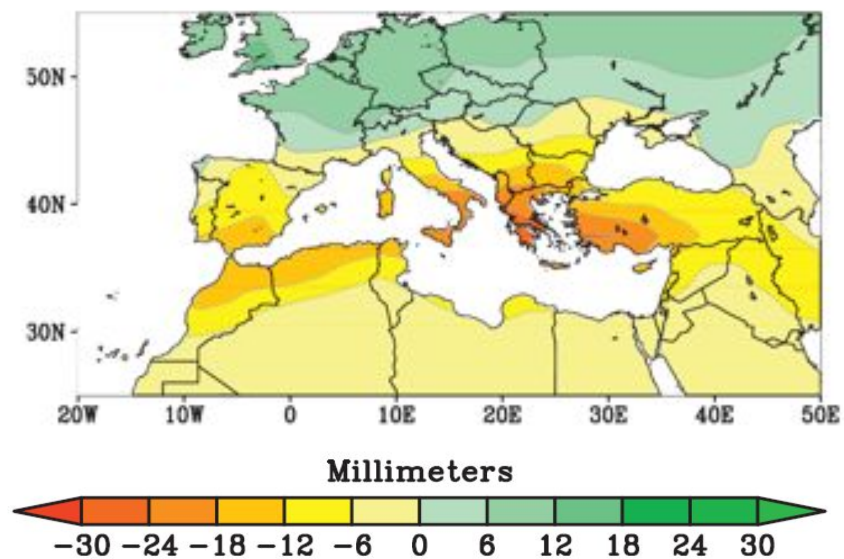
Hoerling et al. (2012)

Modeled precipitation changes in the Mediterranean (1902-2010)



Probability distribution functions for the 1971-2010 minus 1902-1970 period anomalies of winter precipitation.





Hoerling et al. (2012)

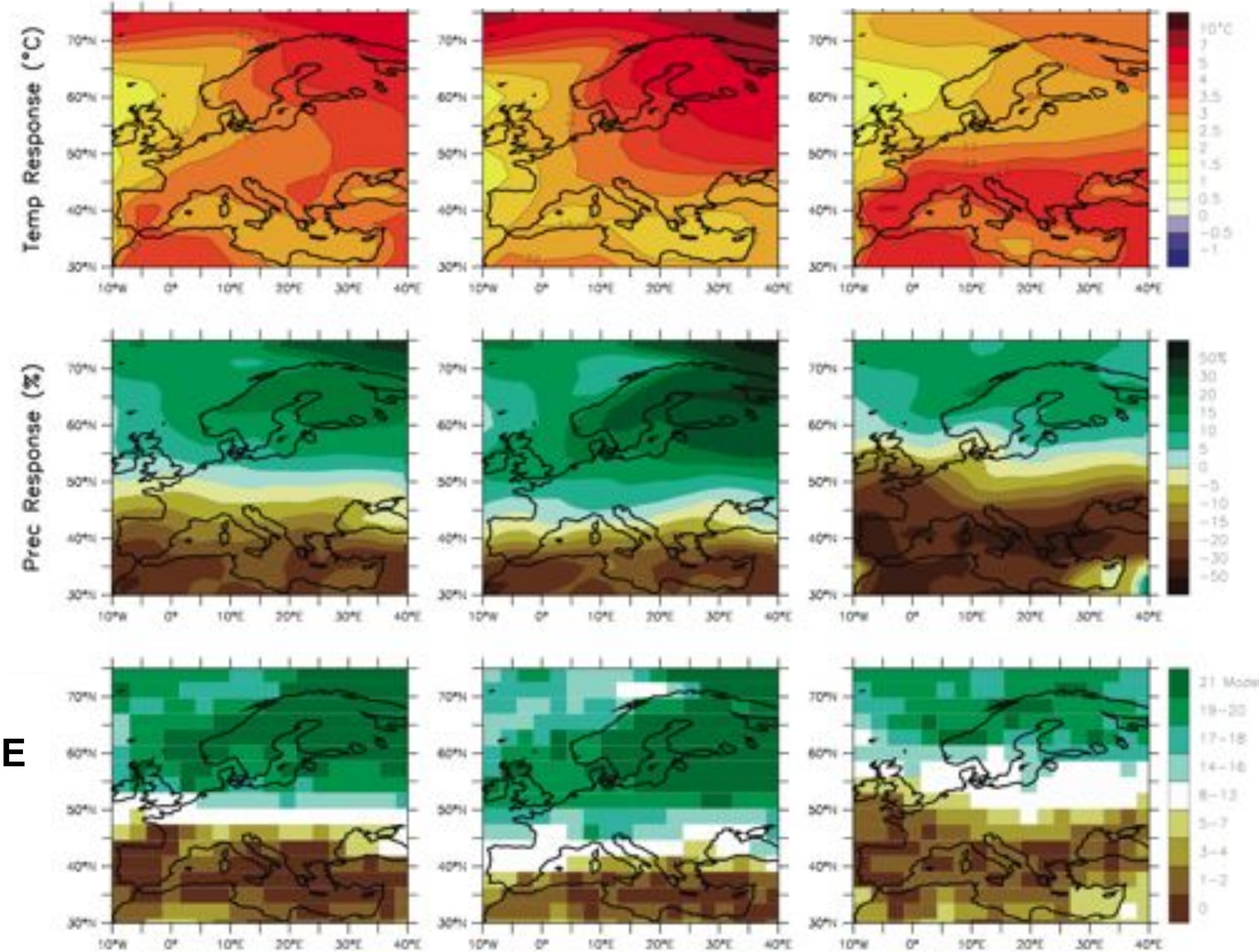
IPCC - Temperature and Precipitation changes over Europe (A1)

Annual | **Winter** | **Summer**

TEMP (ºC)

PRECIP. CHANGE (%)

COHERENCE (Nº Models)



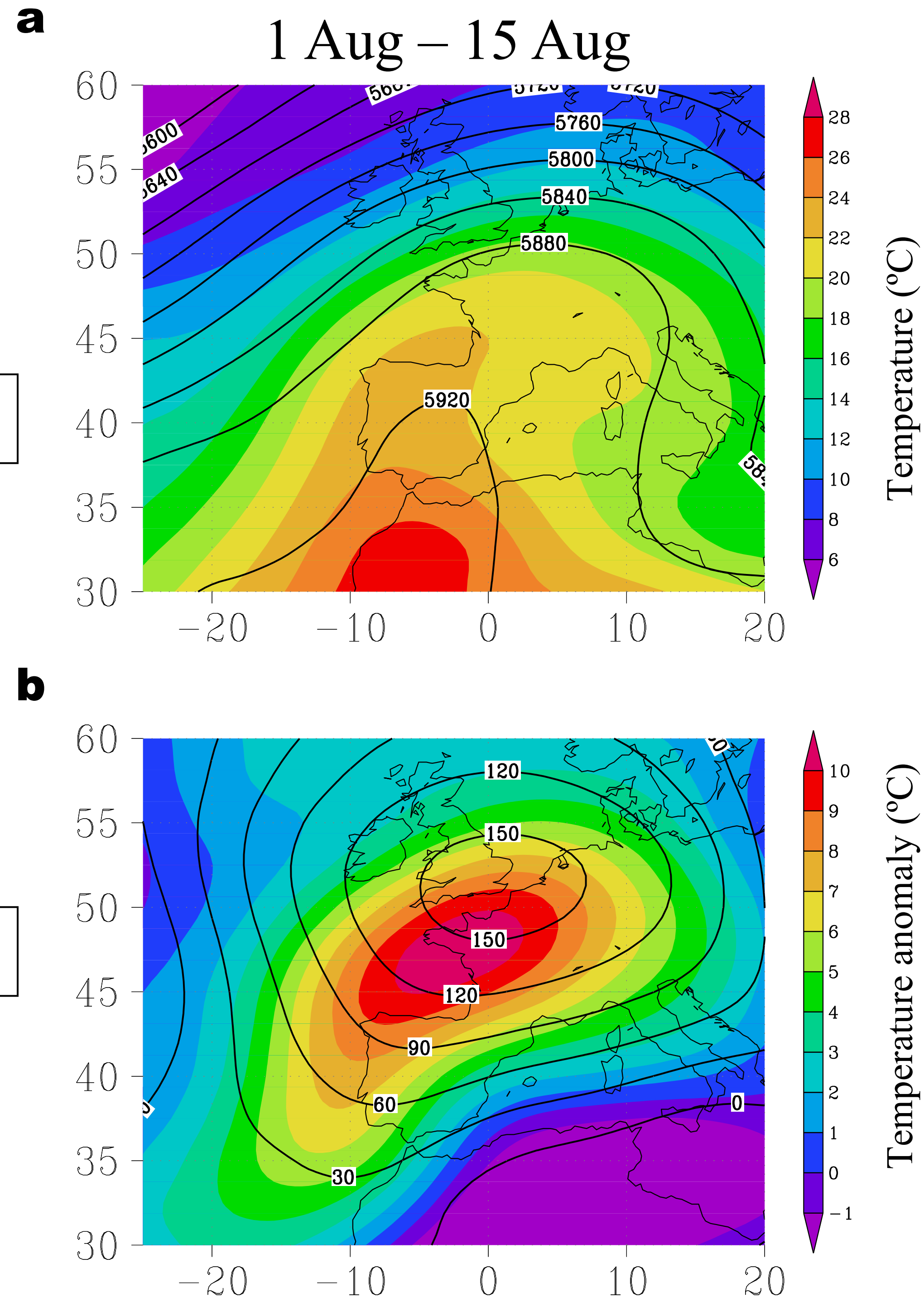
Heatwave
Case-studies

1- The summer **2003** heatwave in **Iberia/western Europe**

500 hPa geopotential height

and

850 hPa Temperature

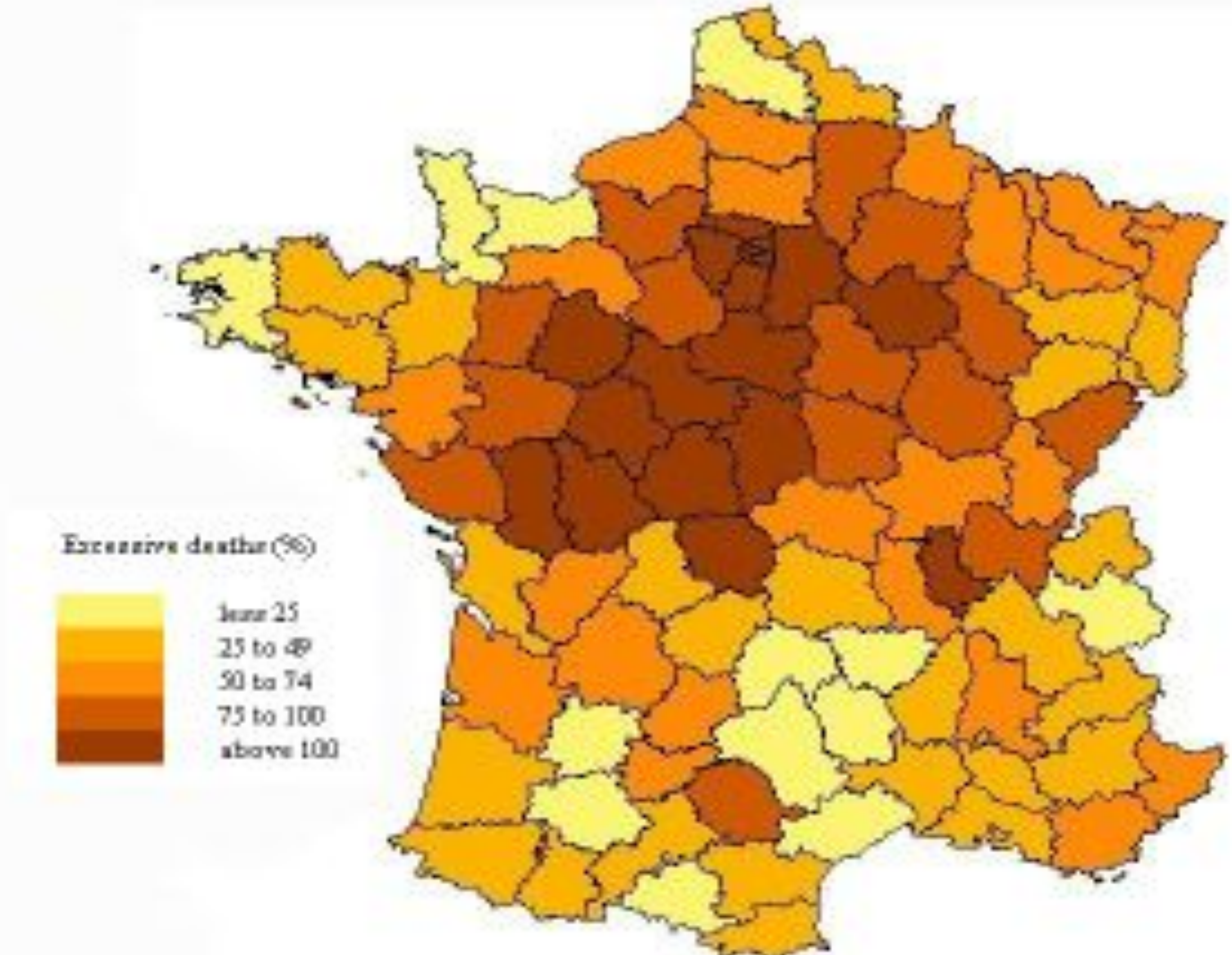


Average

Anomaly

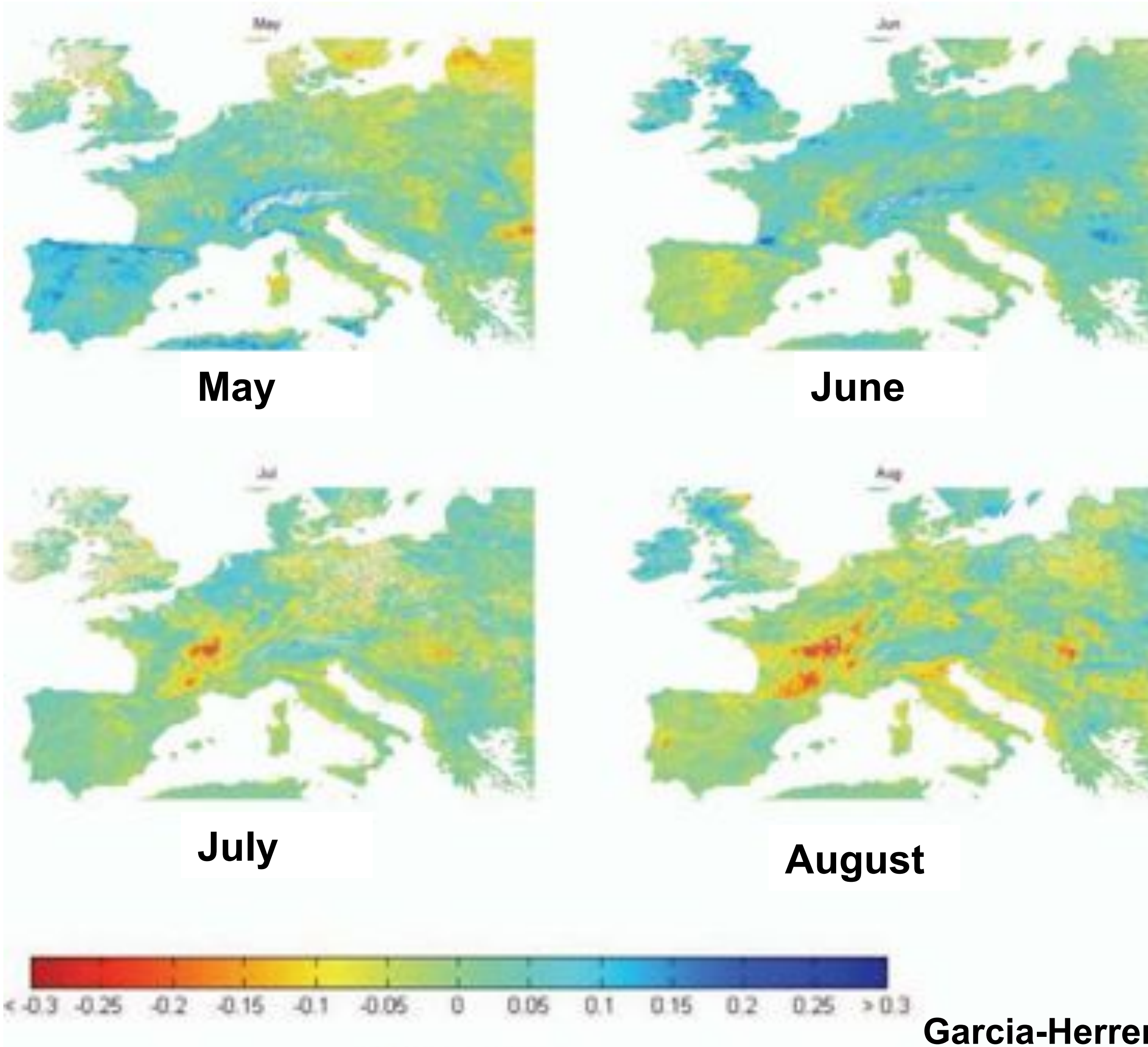
(Trigo et al., 2005, GRL)

Excessive mortality 1-15 August (vs 2000-2002 average)



(Trigo et al., 2005, GRL)

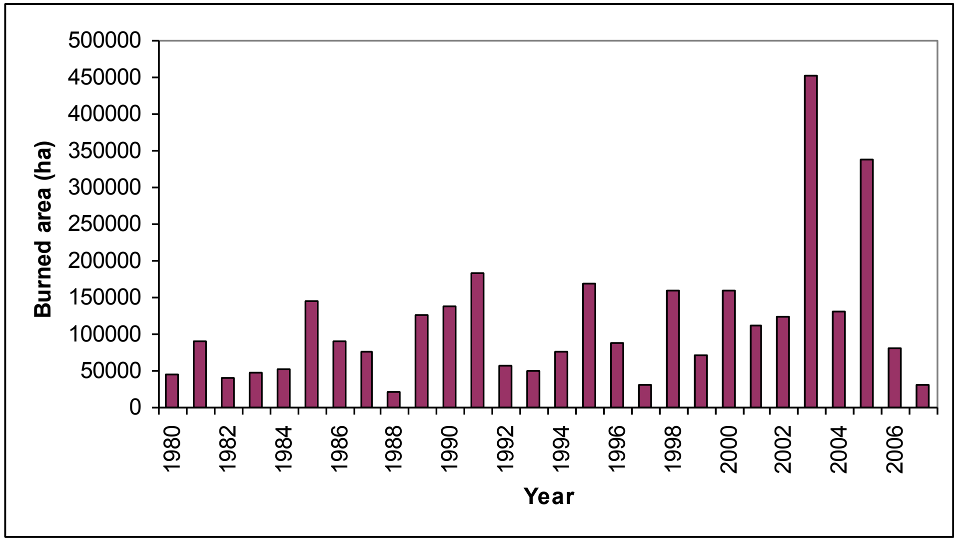
NDVI anomalies (Vegetation)



Garcia-Herrera et al. (2010)

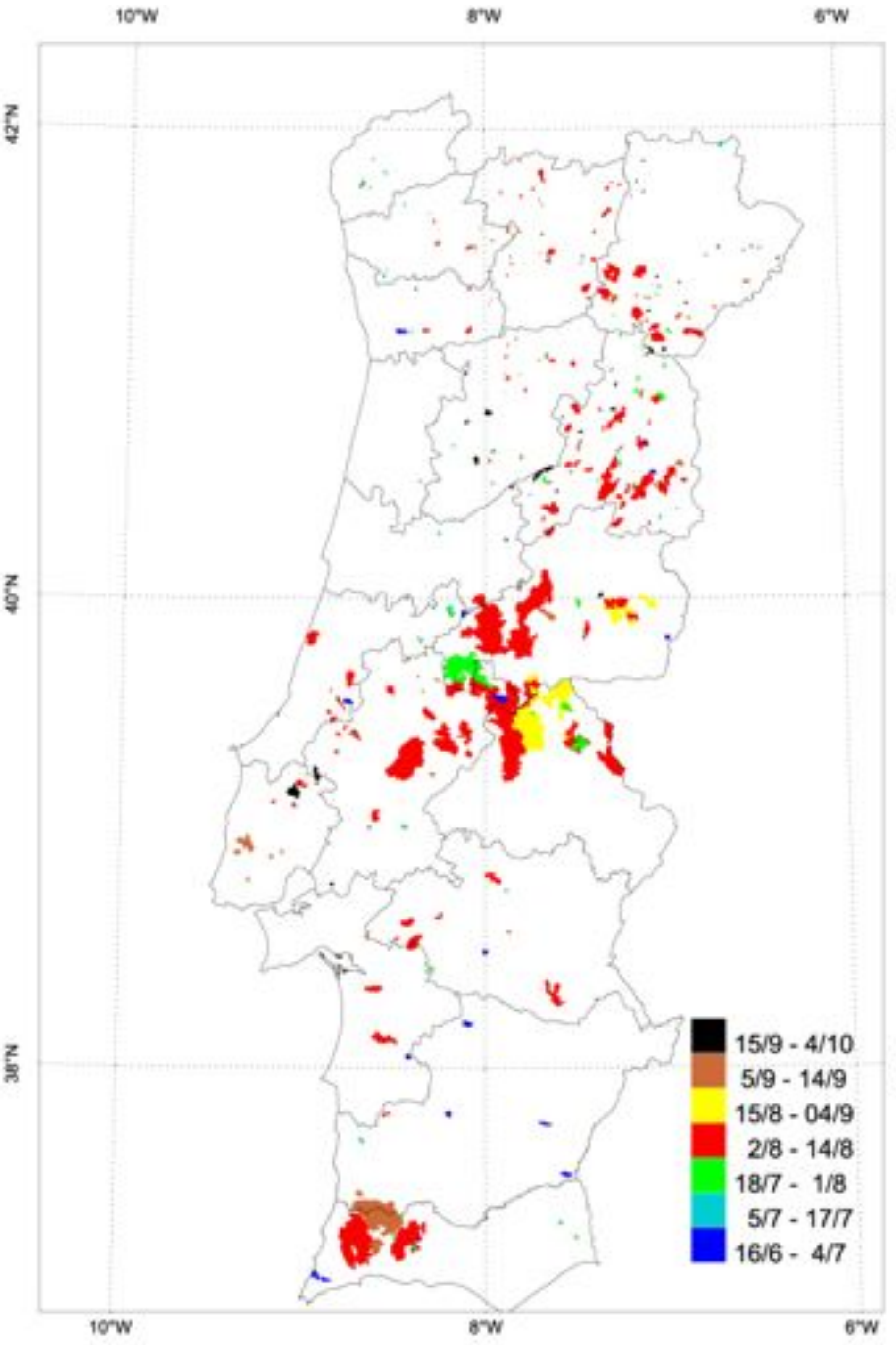
Record burned area in Portugal

Total burnt area**: 450.000 ha**

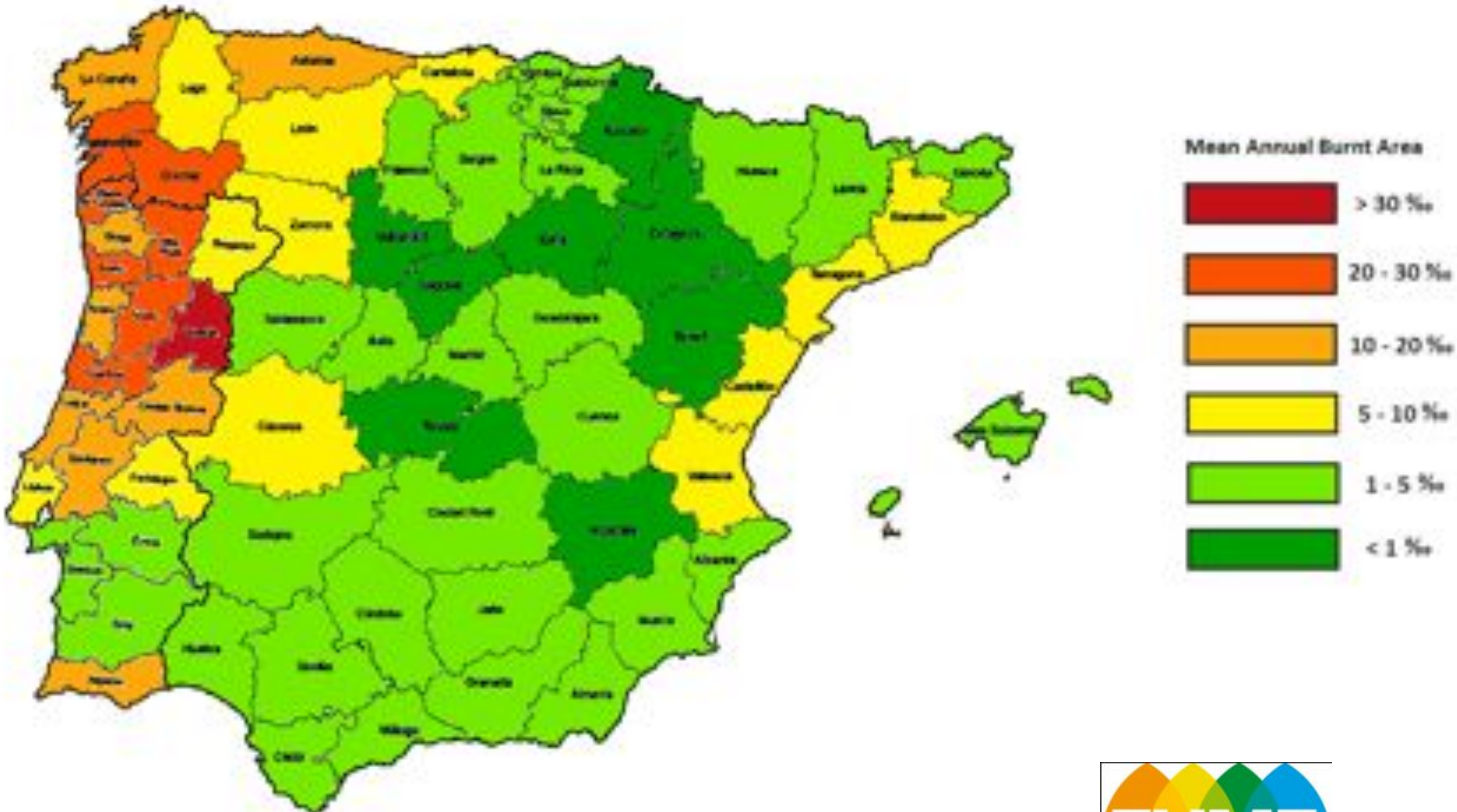


Mostly during the **first 2 weeks of August** (red **colour)**

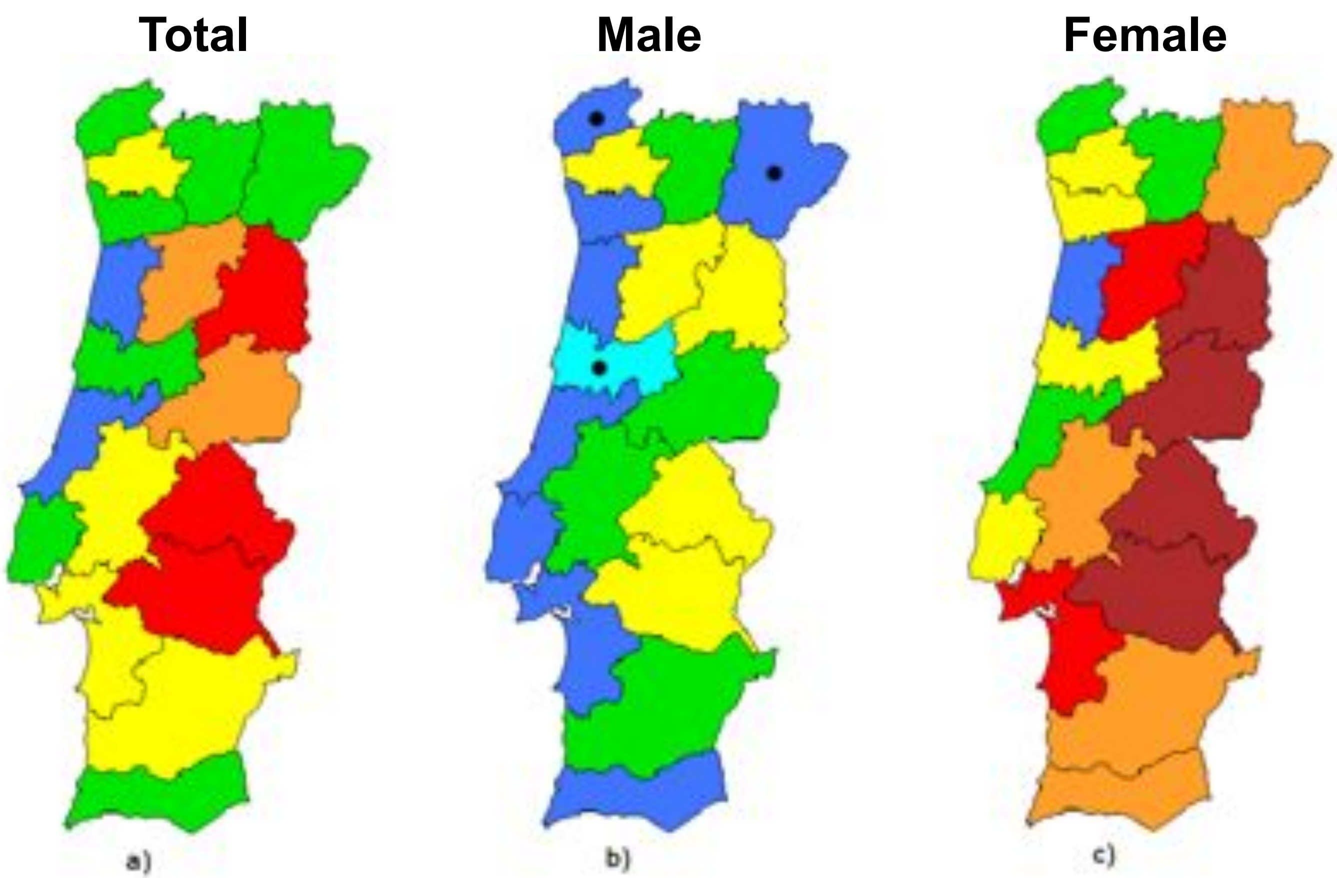
Garcia-Herrera et al. (2010)

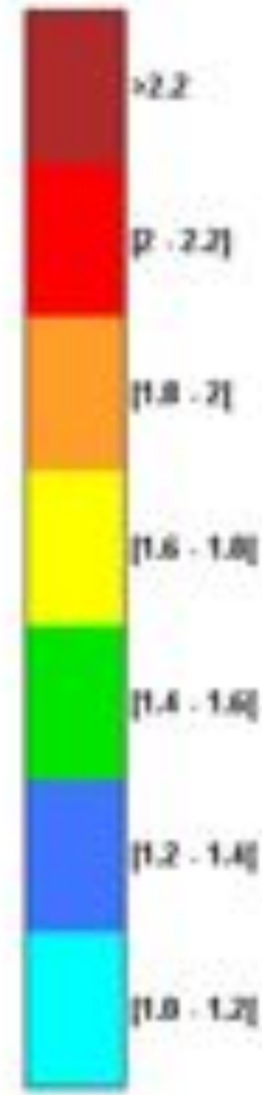


Mean annual burnt area (1980-2005)



Mortality per District and Gender





Spatial variability of the Observed/Expected (O/E) ratio per district.

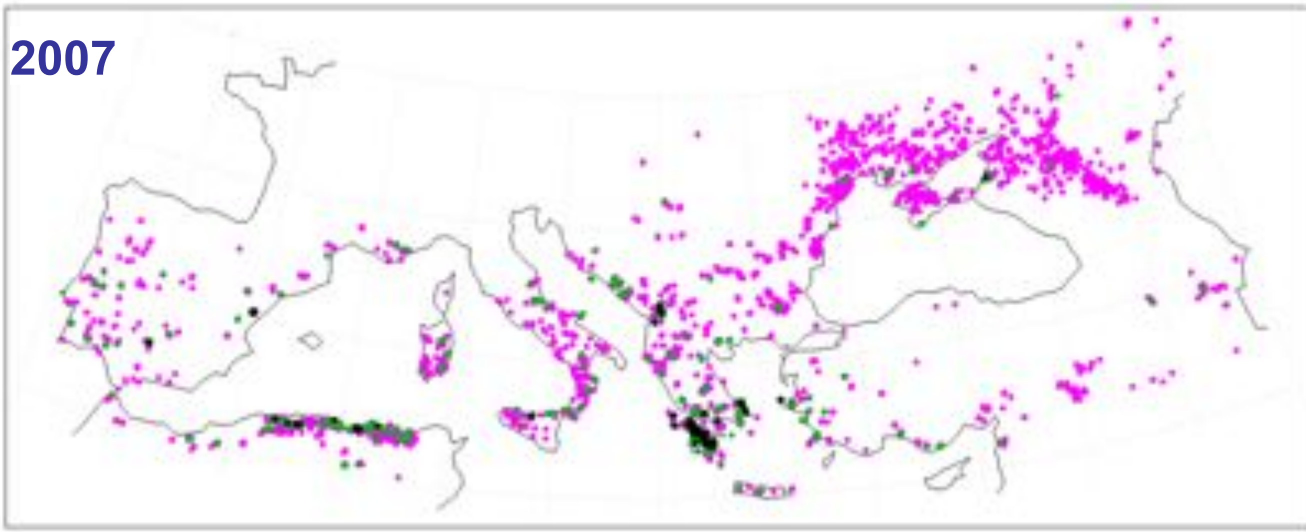
Additonal 2500 deaths in 1 month!

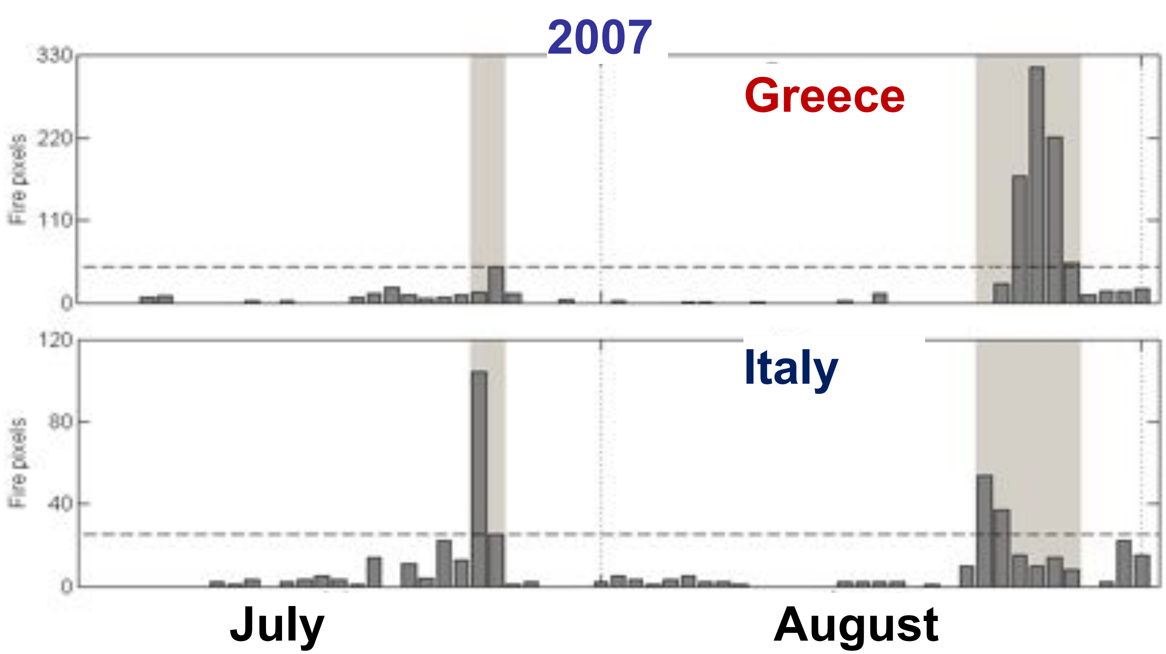
Trigo et al. (2010)

Heatwave
Case-studies

2)The summer **2007** heatwave in **central Mediterranean**

Fire pixels over Southern Europe during **July-August of 2007**.
Less than 2 hours (magenta), 2-10 hours (green), above 10 h (**black**)





Amraoui et al. (2013)

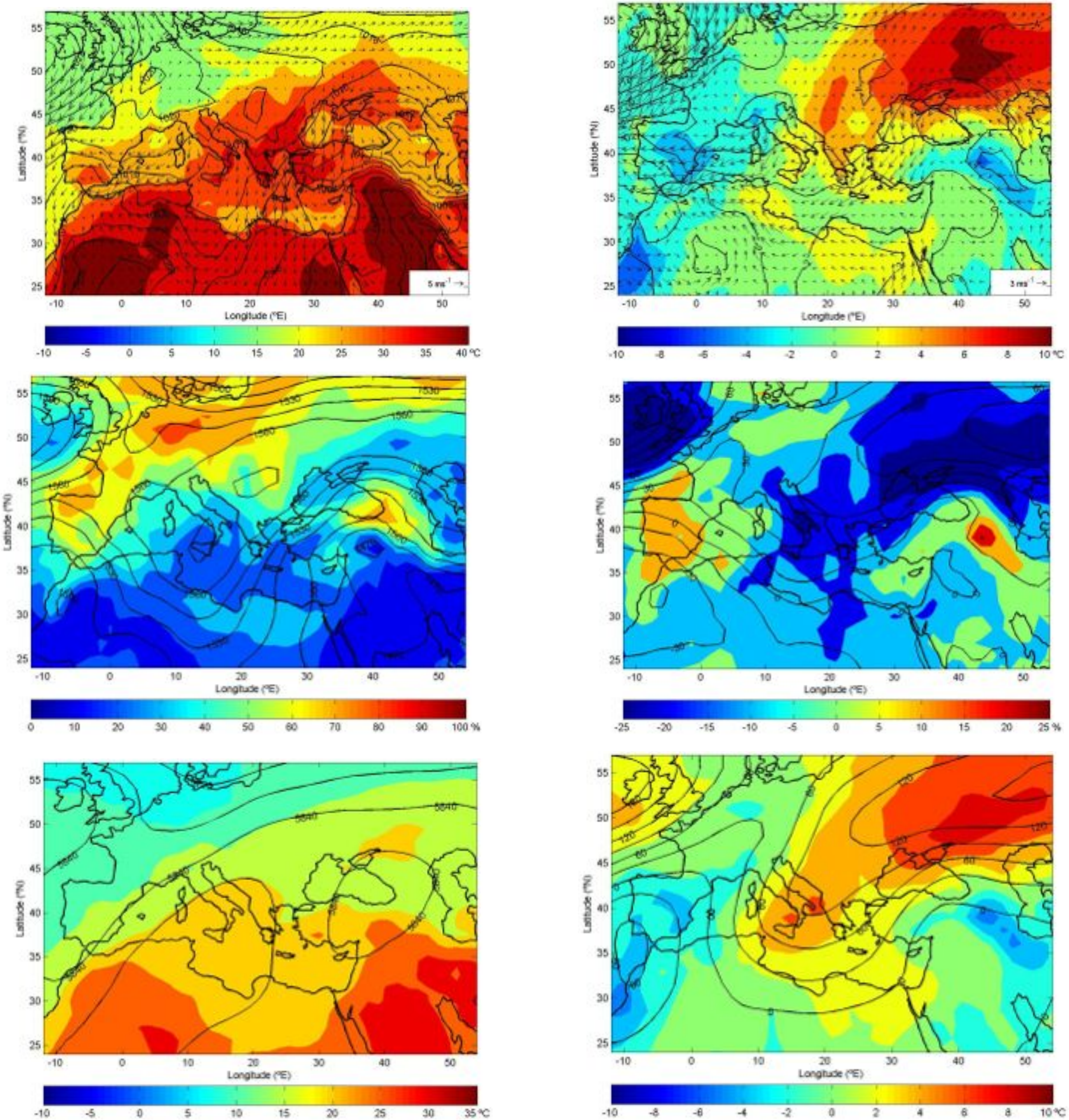
16 – 30 AUG 2007

Composite | Anomaly

SLP
T 2m
Wind

Z850
RH850

Z500
T850

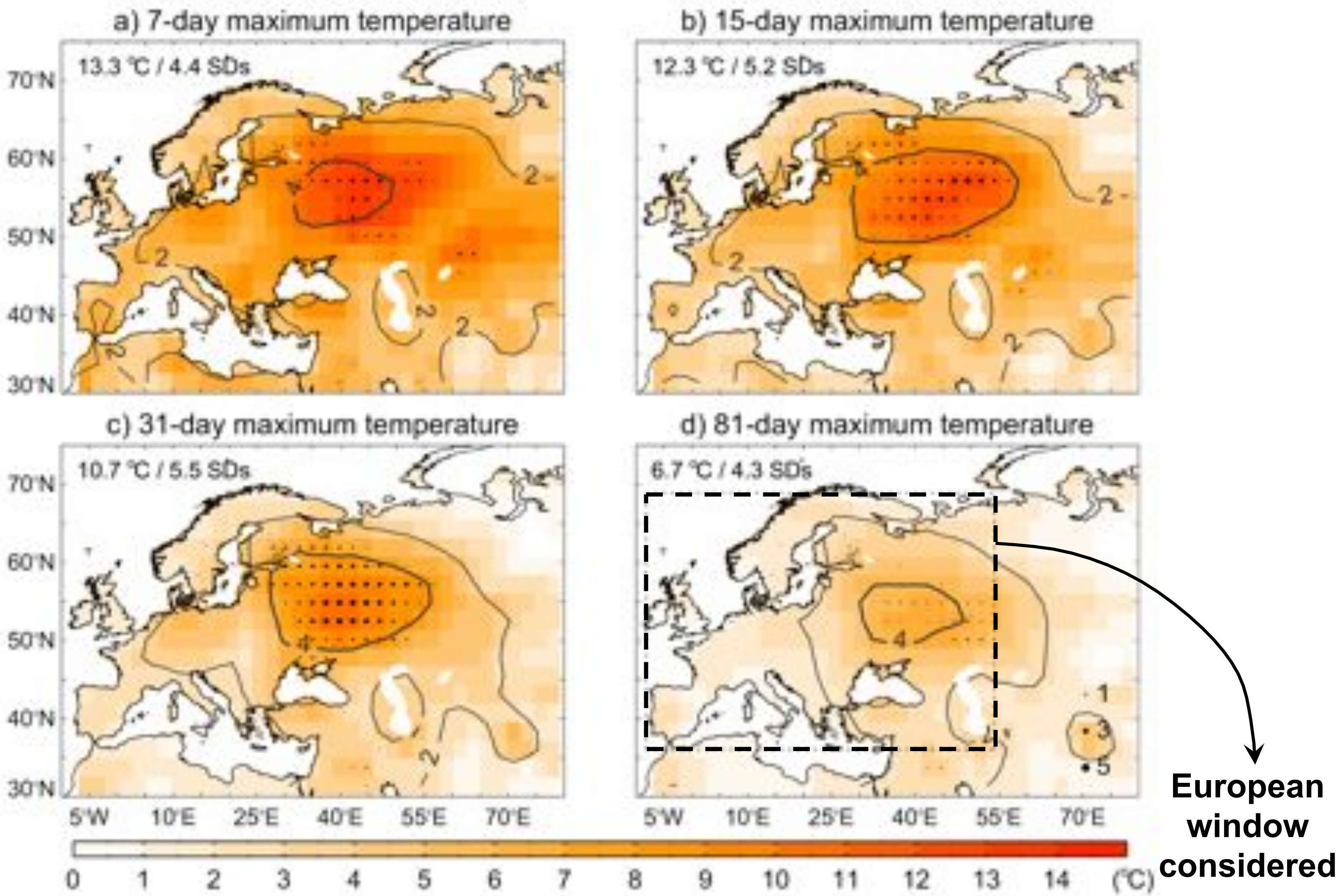


Amraoui et al. (2013)

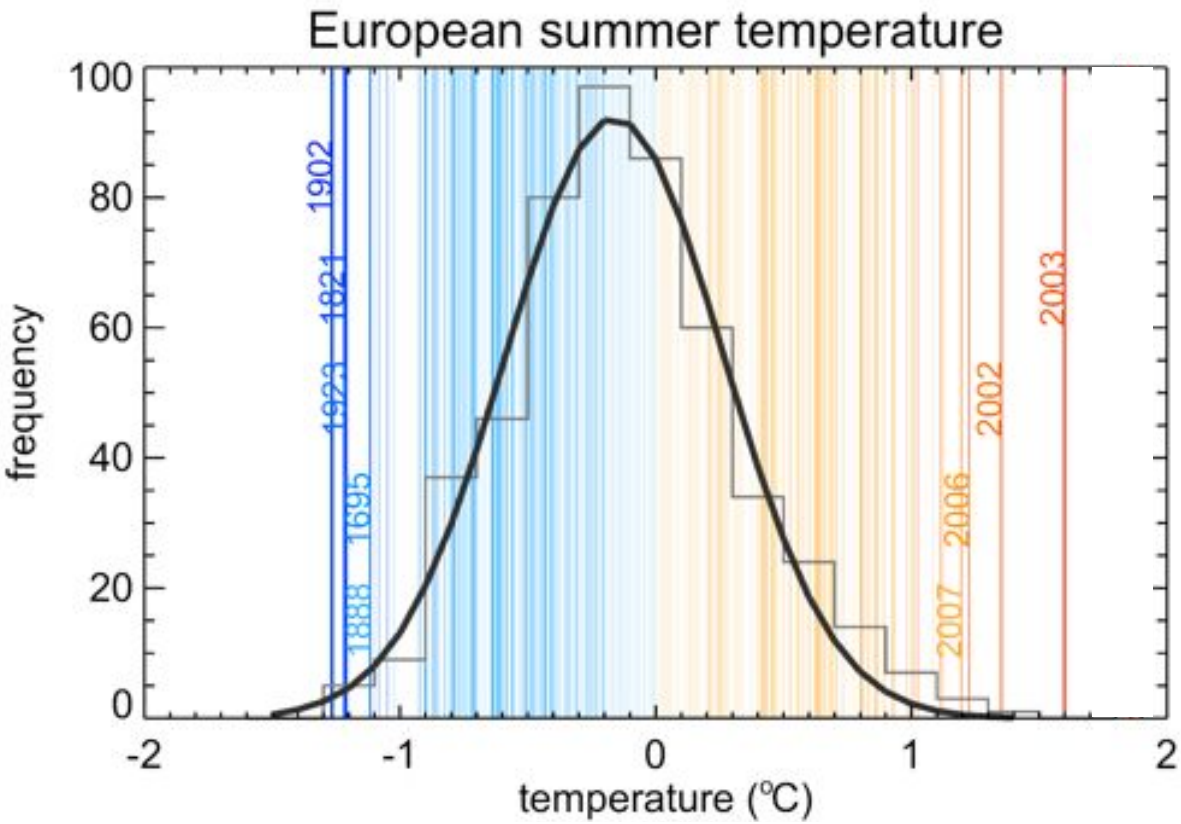
Heatwave Case-studies

3) The summer **2010** heatwave in **Russia / Black sea**

The 2010 heatwave at different temporal scales



The impact of summer 2010 heatwave in Europe



Frequency distribution of European summer land temp. anomaly (ºC) for the 1500-2010 period (vertical lines).

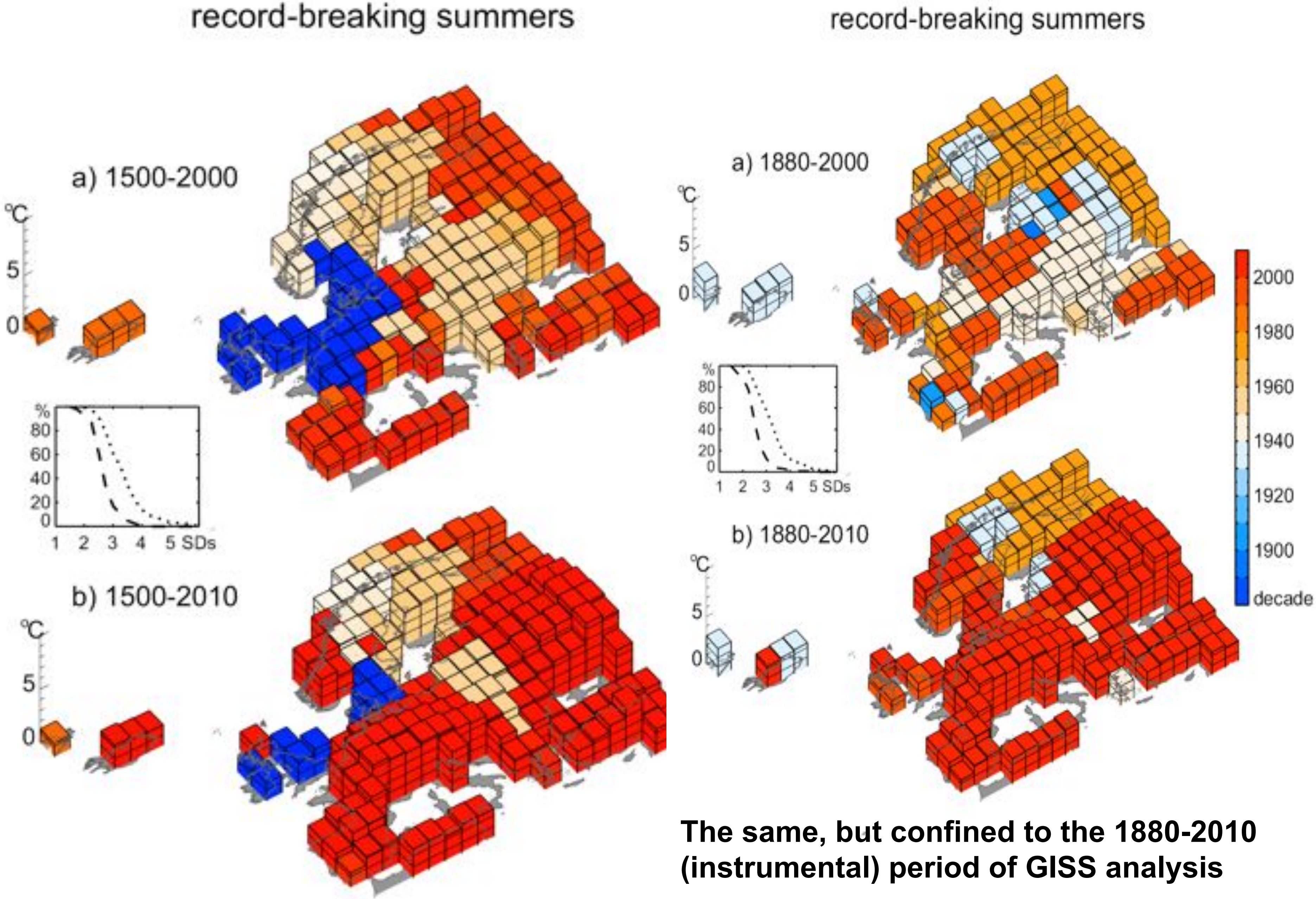
Grey bars represent the distribution for the 1500-2002 period with a Gaussian fit in solid line.

Multiproxy temp [Luterb. (2004)] 1500-2002

Temperature [GISS NASA] 2003-2010

Barriopedro et al. (2011, SCIENCE)

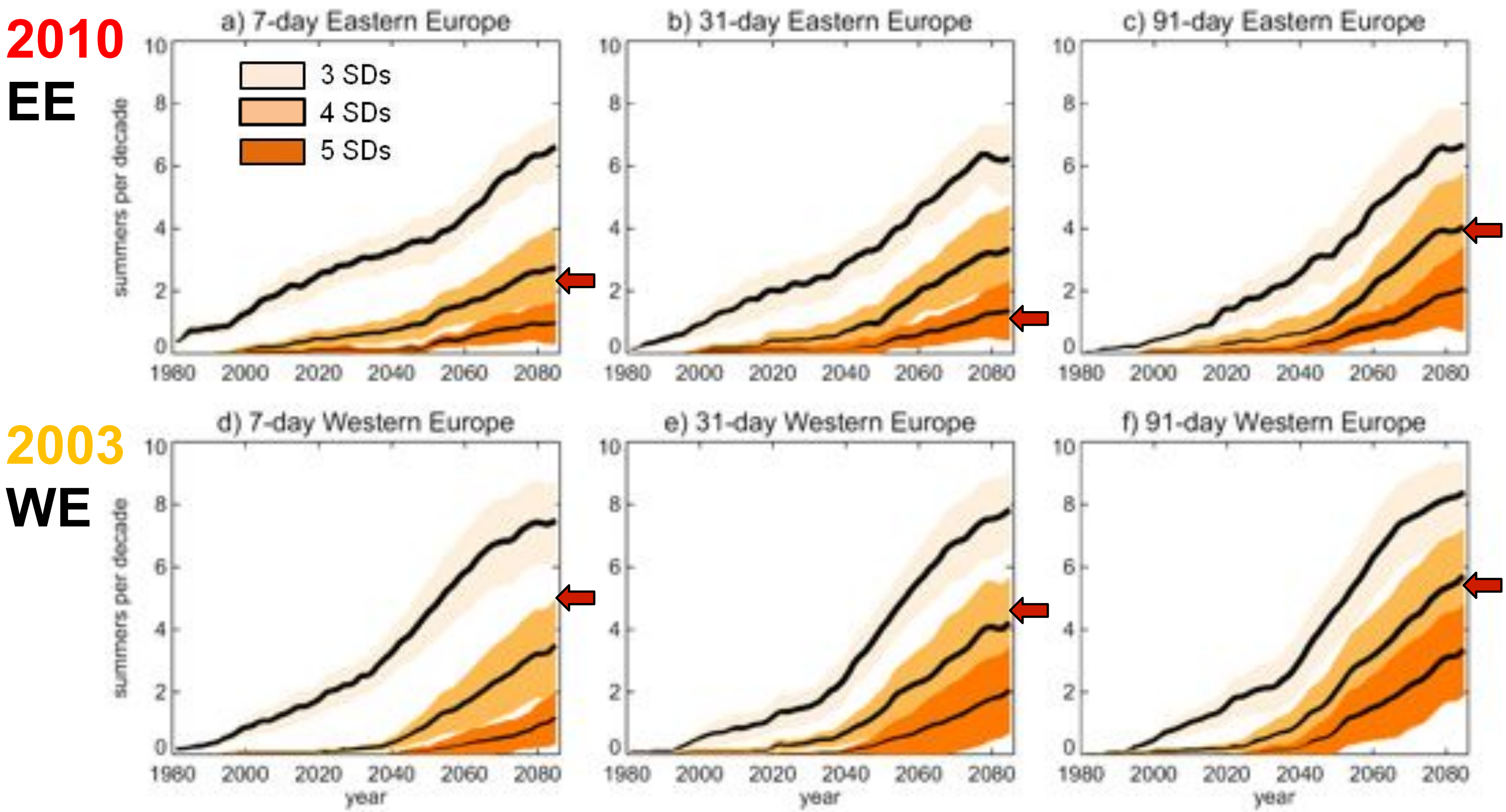
Spatial distribution of the hottest European summers since 1500



The same, but confined to the 1880-2010 (instrumental) period of GISS analysis

Changes in decadal frequency of summers with extreme episodes over EE and WE

(11 high-resolution RCMs (ENSEMBLES) under the SRES A1)



(Barriopedro et al. 2011, Science)

The Hot Summer of 2010: Redrawing the Temperature Record Map of Europe

David Barriopedro,[1*] Erich M. Fischer,[2] Jürg Luterbacher,[3] Ricardo M. Trigo,[1] Ricardo García-Herrera[4]

online material (SOM) text].

in July and ended abruptly by mid-August. Be-

S6). High-pressure systems are well-known to produce warm conditions at surface by enhancing subsidence, solar heating, and warm-air advection (19–21). The lack of water availability results in a continuous reduction of soil moisture and enhanced sensible heat fluxes that exacerbate the strength of summer heatwaves (20–22).

Unlike 2010, the summer of 2003 was characterized by two extreme periods (centered on 15 June and the first fortnight of August) (12) that contributed to the rise of the number of locations with temperatures beyond their historical maxima at seasonal time scales. However, the 2010 event exceeded the 2003 episode in terms of amplitude and spatial extent. Thus, the maximum extension of areas experiencing record-breaking temperatures in 2003 was ~1 million km^2, which is considerably lower than that of 2010. The intensity of the 2003 event was also ~1 to 2 SDs weaker for most of the subseasonal time scales (fig. S7).

Despite the distinctive spatio-temporal evolution of the 2003 and 2010 events, their record-breaking anomalies reached comparable amplitude and extension at seasonal scales. Therefore, from a seasonal perspective it is interesting to compare these events at continental scales. Herein, surface temperature analysis data (23) and multiproxy surface air temperature reconstructions since 1500 (11) are used to place these recent extreme European summers in a paleoclimatic context (15). Figure 2 displays the European mean summer land surface air temperature distribution for the 1500–2010 period. The European mean 2010 summer [temperature anomaly (ΔT) = +1.8°C, 3.5 SDs relative to 1970–1999] was ~0.2°C warmer than the previous warmest summer of 2003 (11). This number is even more noticeable if we consider that the European average temperature is defined for the land area [35°N, 70°N] and [25°W, 40°E], thus excluding many regions affected by outstanding temperatures in 2010. Further, the historical evolution of the hottest summers in Europe (Fig. 2, bottom) suggests that the last decade stands substantially above any other 10-year period since 1500. Taking into account the uncertainties in the reconstruction (11, 15), we found that at least two summers in this decade have most likely been the warmest of the last 510 years in Europe.

Figure 3 further stresses the exceptional magnitude of the 2010 summer, displaying the amplitude

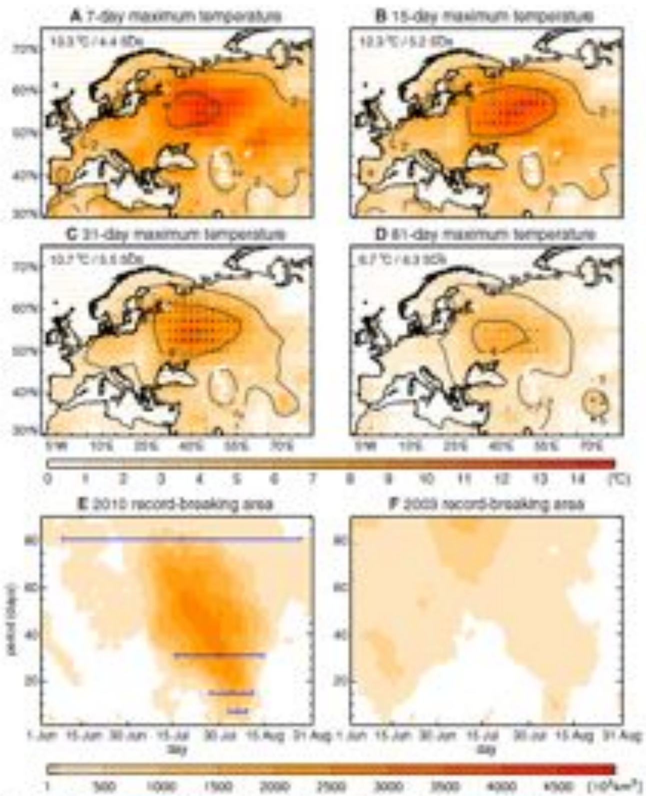
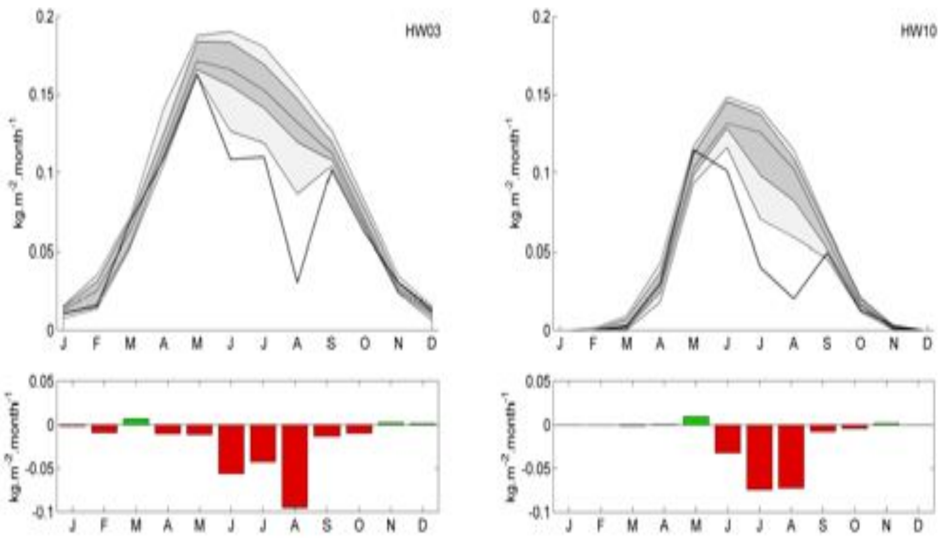
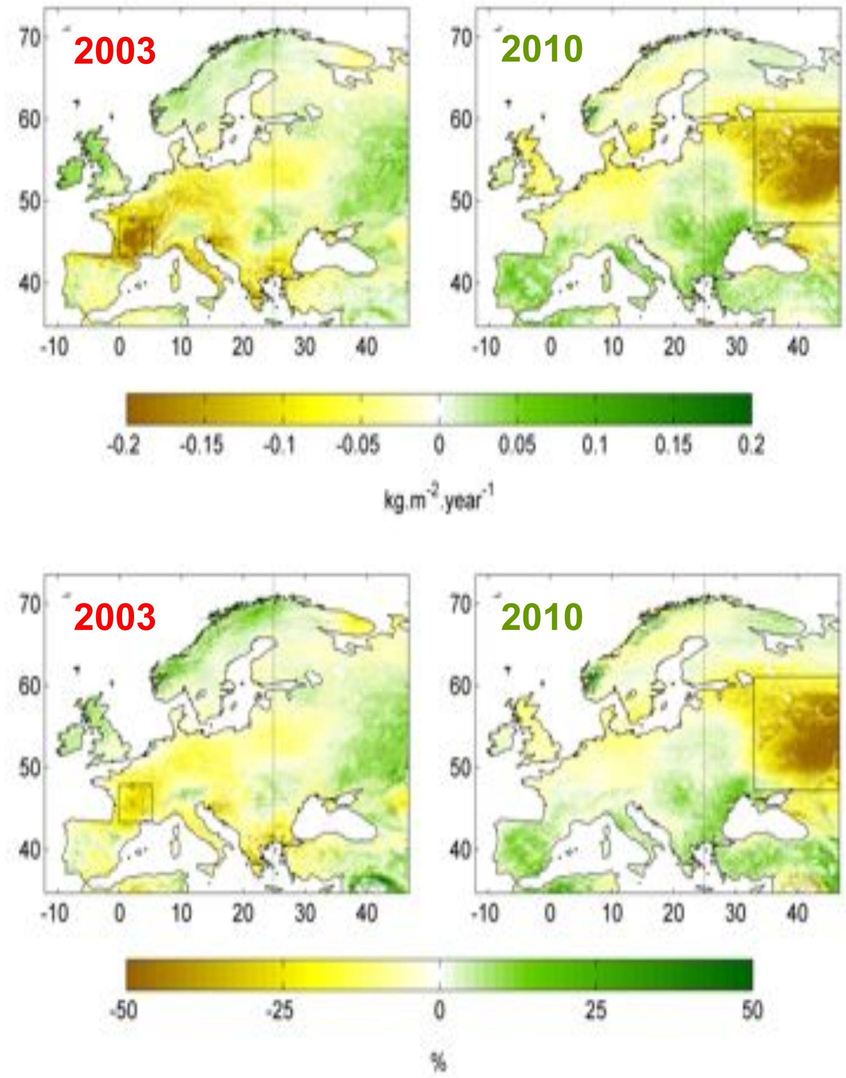


Fig. 1. Spatio-temporal evolution of the 2010 summer. Shown are maximum temperature anomalies (degrees Celsius, relative to 1970–1999) in summer 2010 for (A) 7-day, (B) 15-day, (C) 31-day, and (D) 81-day average periods. Contour lines indicate the anomaly divided by the corresponding SD of all summer days of the reference period. Black points highlight record-breaking values, the size being proportional to exceedance over the previous maximum. The maximum record-breaking temperature anomaly is shown in the top left corner. (E and F) Temporal evolution of the spatial extent (in 10^3 km^2) of areas experiencing record-breaking temperatures at different time scales during summer 2010. Only those land regions within the box of (D) are considered. Blue bars indicate the period of maximum extension for the time scales represented in (A) to (D). Data are from (27) (1871–1947) and (16) (1948–2010).

Impact of 2003 and 2010 heatwaves on NPP

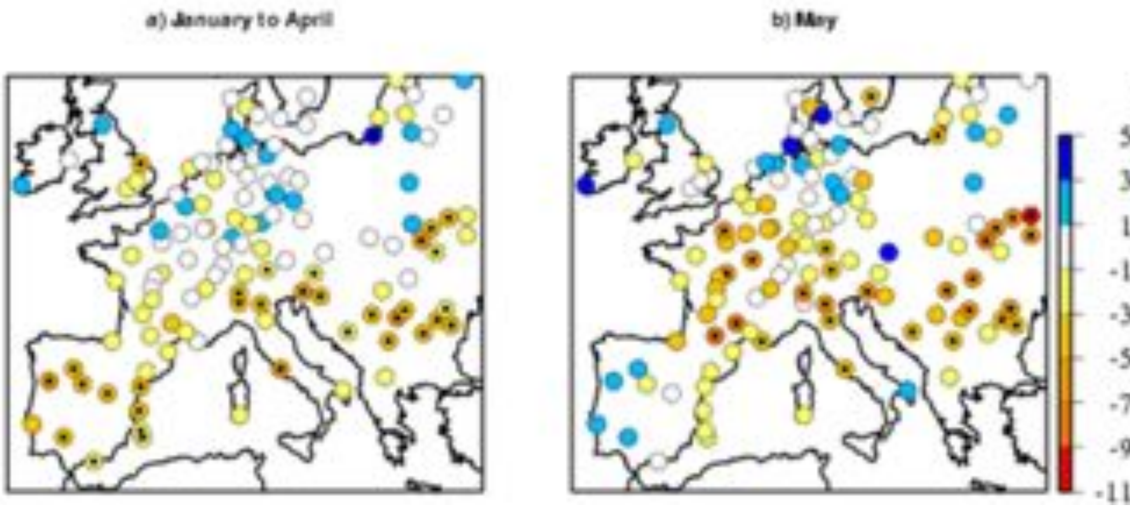
2003 2010



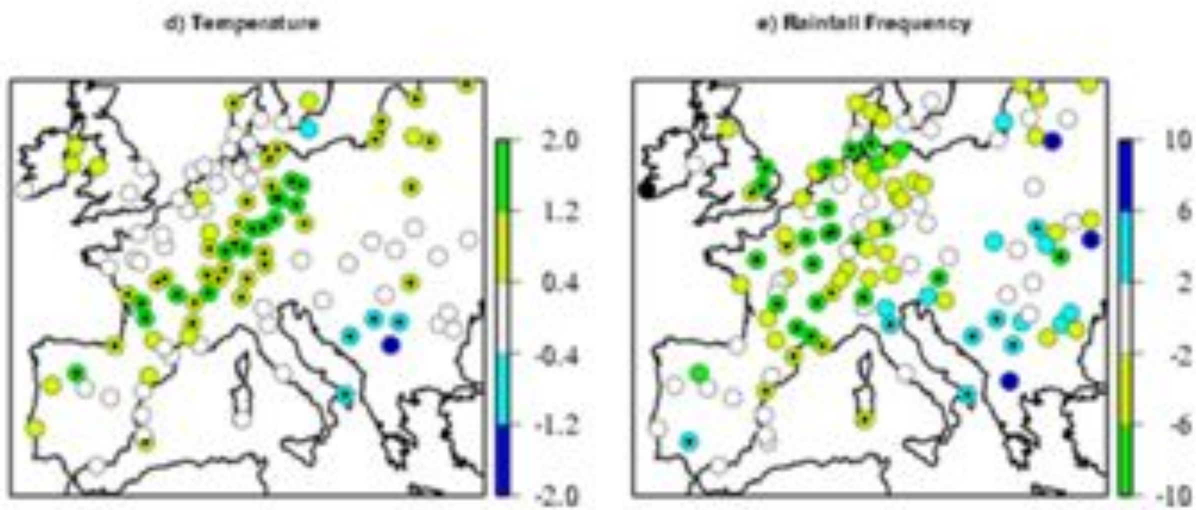


Bastos et al. 2014, Biogeoscience)

Precipitation anomalies during the 10 strongest heatwave years

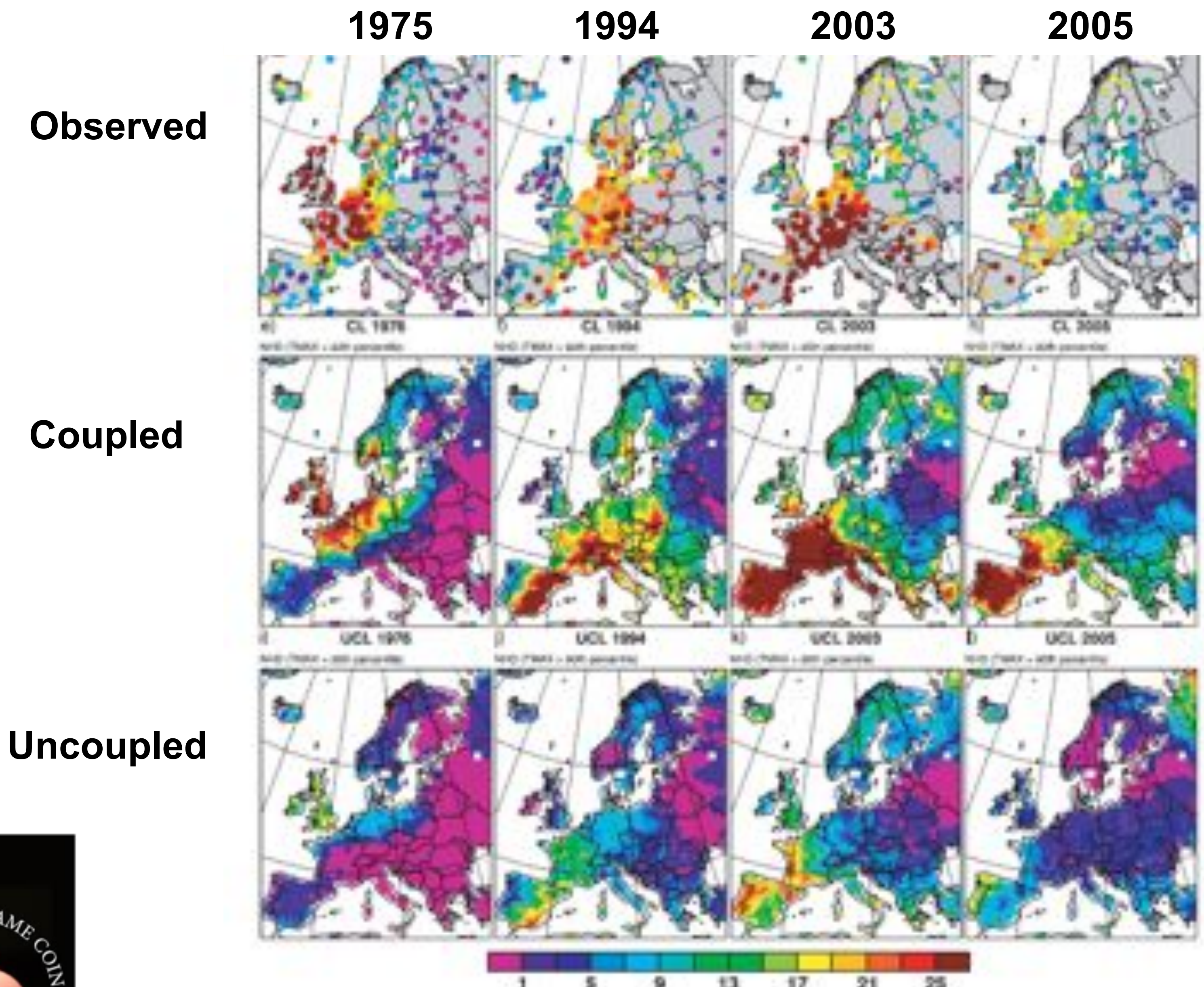


Maximum temperature and rainfall difference between southerly and northerly winds



(Vautard et al. 2007)

Spring droughts: Land-Atmosphere coupling



(Fischer et al, 2007, GRL)

nature
geoscienc

Mega-heat
combined
heat accun

Diego G. Miralles[1,2*],
and Jordi Vilà-Guerau

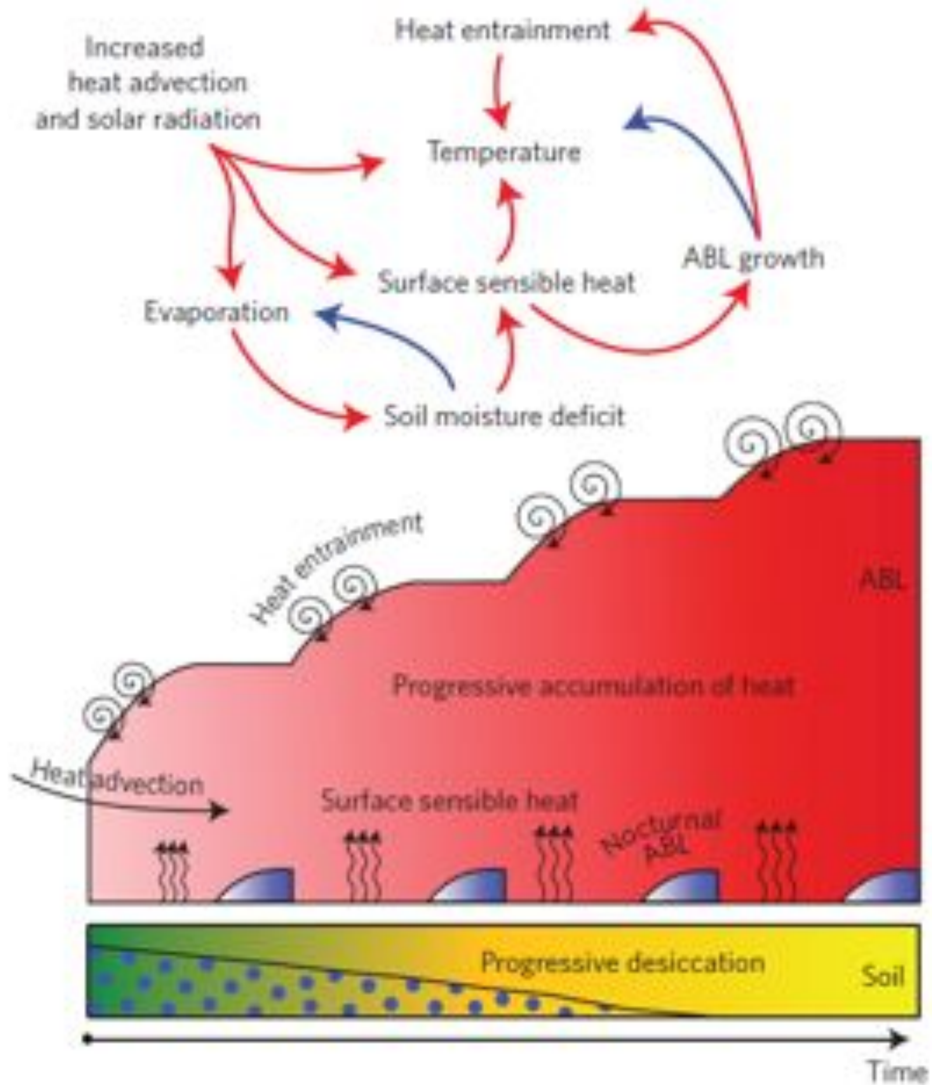
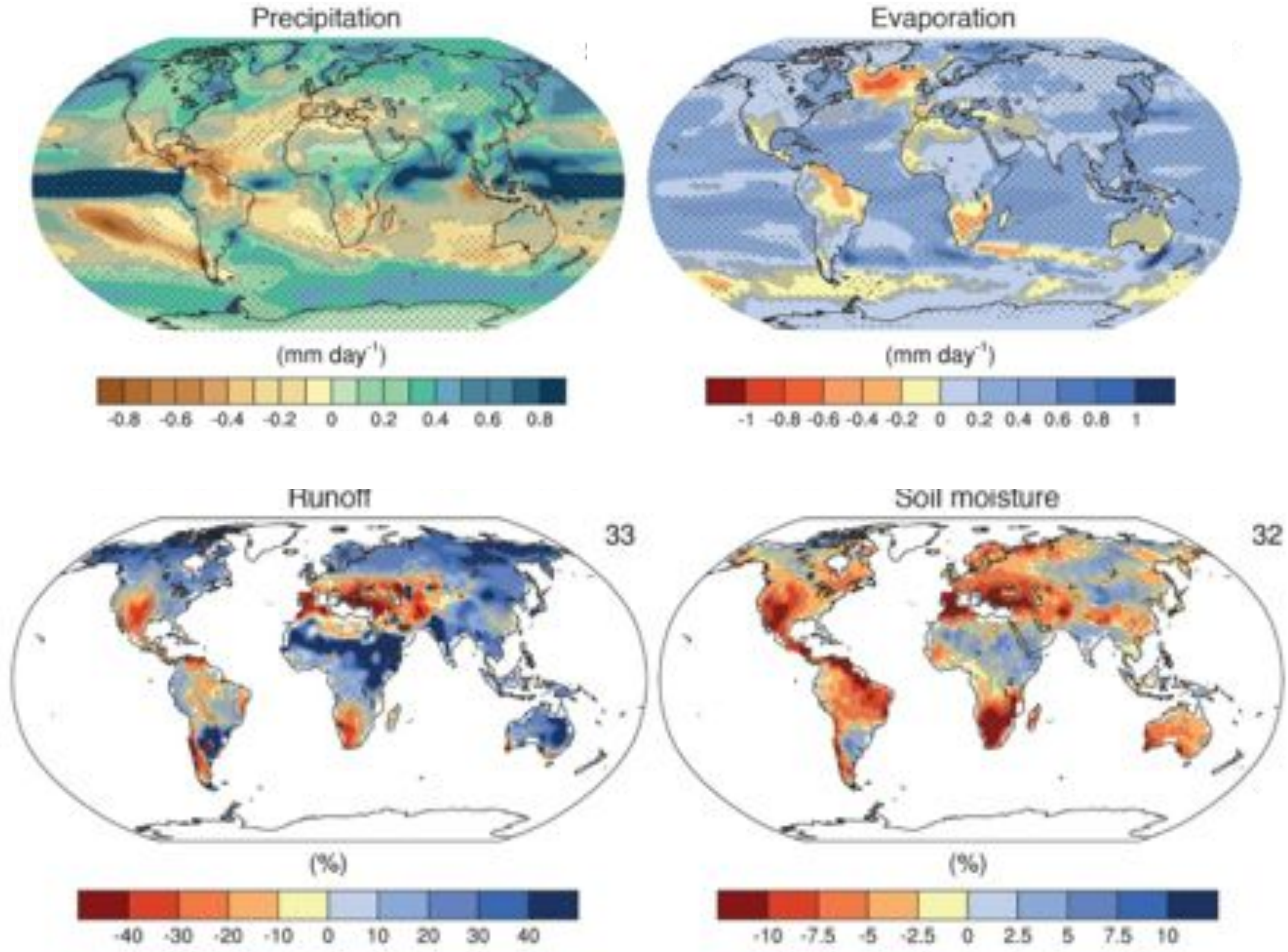


Figure 4 | Land-atmosphere interactions during mega-heatwaves revisited. Representation of the main soil moisture–air temperature interactions in the development of a mega-heatwave. Red and blue arrows represent positive and negative correlations, respectively.

IPCC 2014

The Mediterranean will maintain its **hotspot** status in the coming decades



Summary

1. The Western (Eastern) Europe **heatwave** of summer of 2003 (2007) was **exceptional at the monthly/seasonal**, but also at the **weekly and daily scales.**

2. The **Eastern Europe heatwave** of summer of **2010** was even more outstanding than 2003/2007 at the weekly-monthly-seasonal scales**.**

3. Usually heatwaves are associated to intense **blocking circulation** pattern. However, **Winter/Spring drought conditions** have exacerbated the strength of both summer heatwaves**.**

4. The **Mediterranean basin is getting drier** and **drought frequency is bound to increase during the 21st Century**.

5. A large number of Regional Climate Models predict **more intense heatwaves** and **drought episodes** for the Mediterranean.

Merci

Obrigado Thanks