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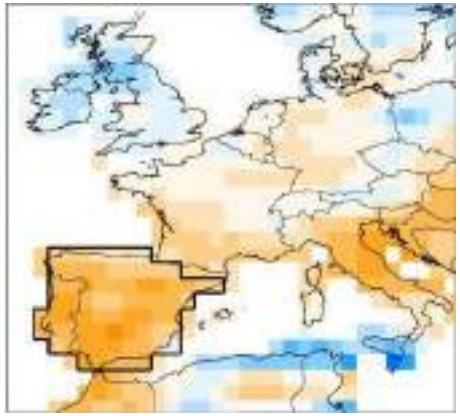
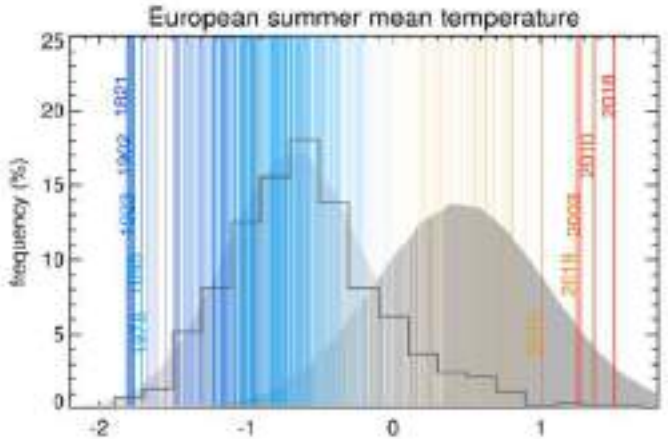
Alterações Climáticas: que perspectivas para os próximos anos



Ricardo M Trigo
(IDL, FCUL)



As Alterações Climáticas e a Cultura do Milho: Principais Desafios e Ferramentas de Apoio à Decisão

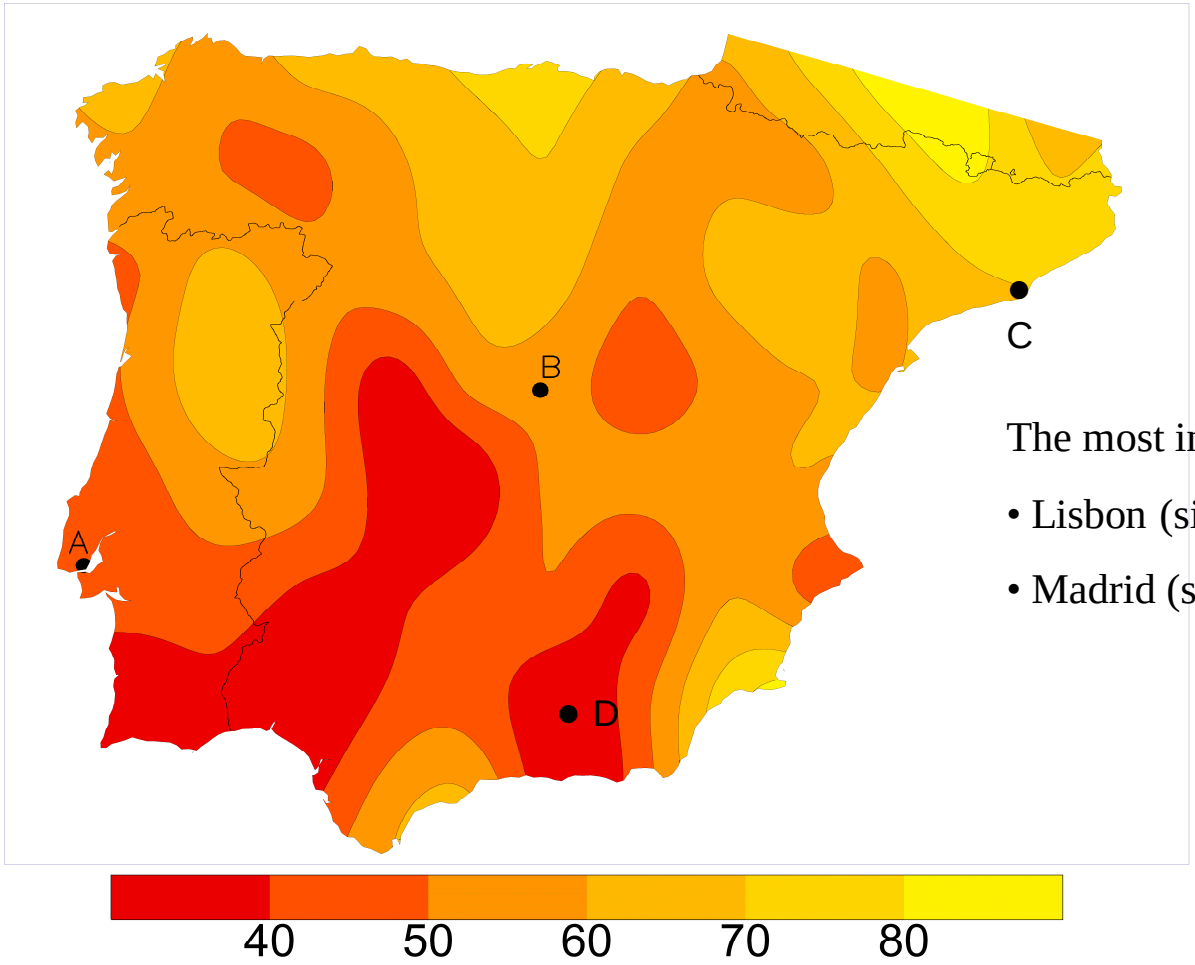
5 de Junho 2025

Eventos climáticos extremos no Mediterrâneo

1. Secas
2. Ondas de calor
3. Incêndios florestais
4. Extremos compostos (Secas-Ondas de calor)
5. Precipitação extrema

Accumulated precipitation in Iberia between Oct. 2004 and Sept 2005

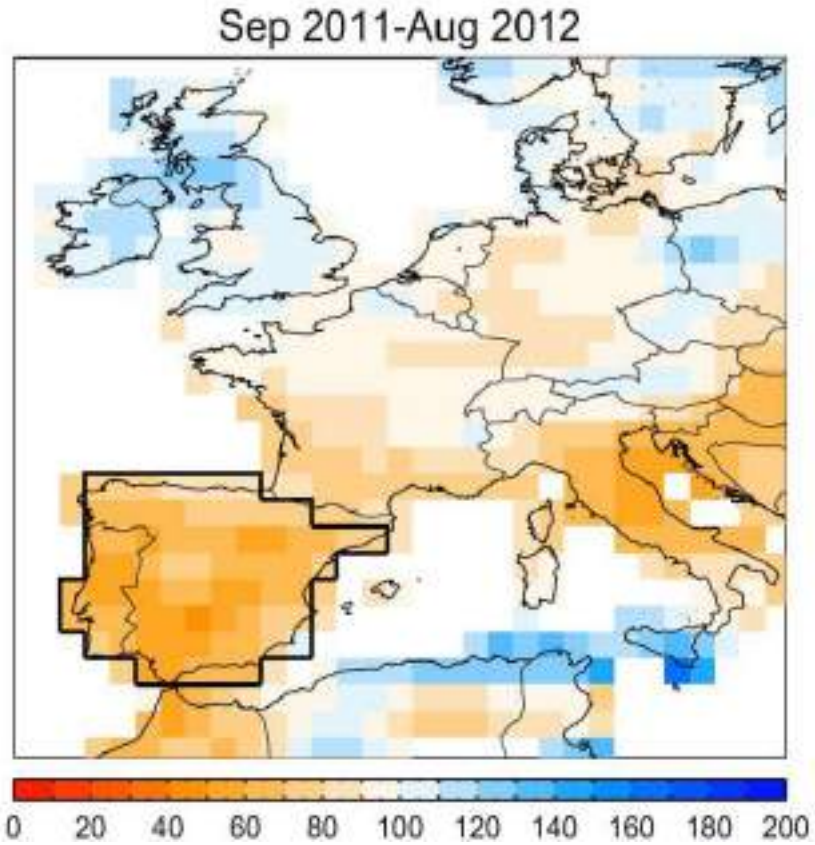
(% relative to the average for the period 1961-1990)

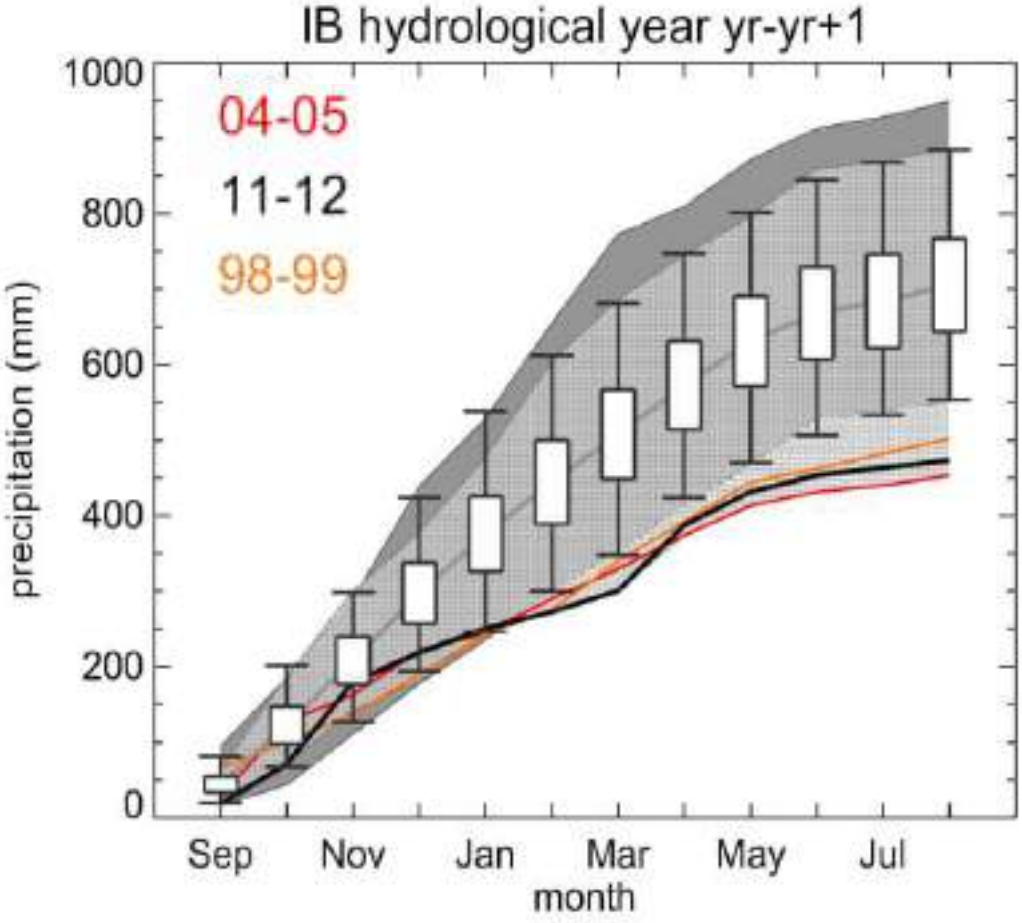


The most intense drought:

- Lisbon (since 1865) A
- Madrid (since 1859) B

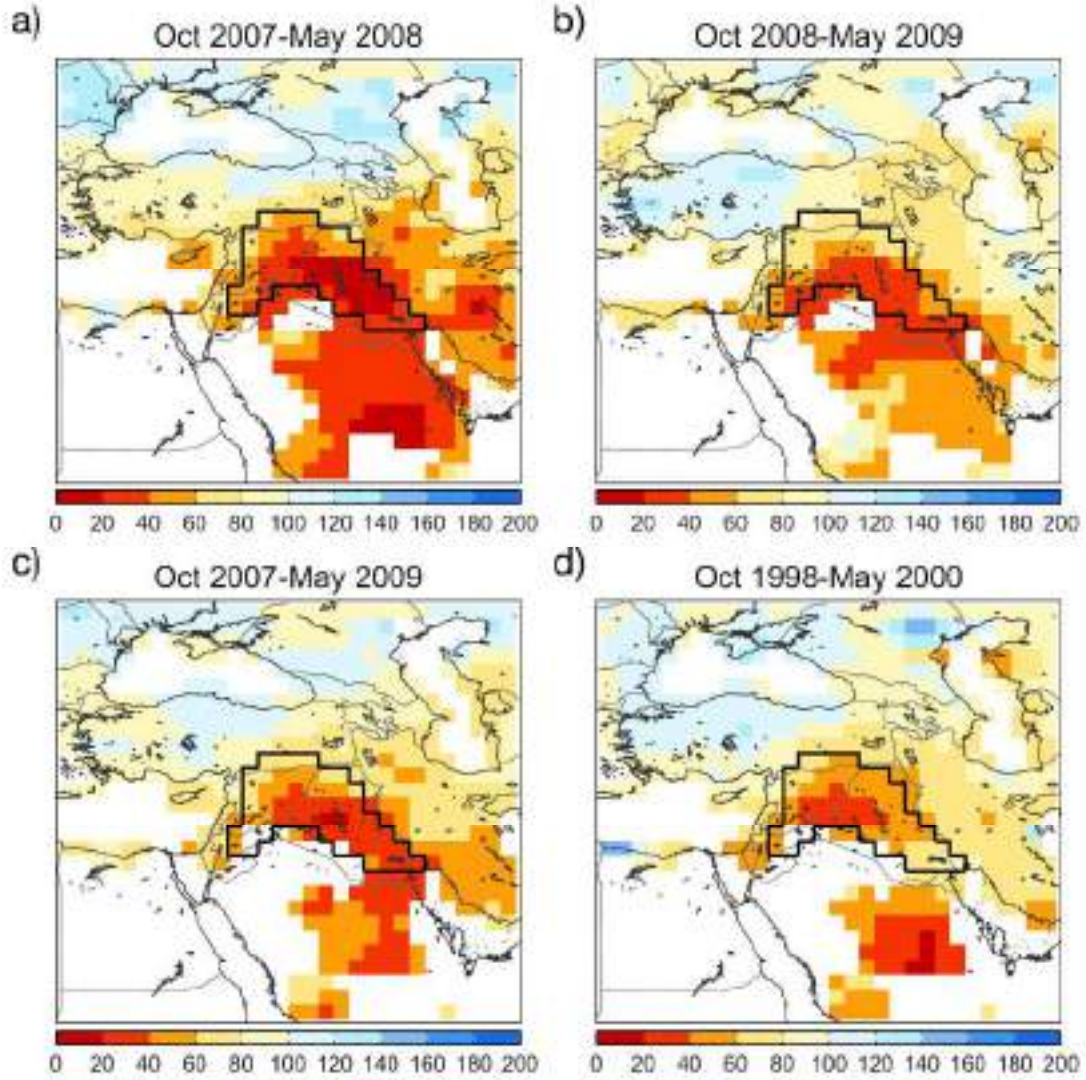
Garcia-Herrera et al. (2007)





Trigo et al. (2013)

The intense 2007-2009 drought in the Fertile Crescent



(Trigo et al., 2010)

nature
International weekly journal of science

Article

High temporal variability not trend dominates Mediterranean precipitation

https://doi.org/10.1038/s41586-024-08576-6

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Sergio M. Vicente-Serrano[1,2], Yves Tramblay[3], Fergus Reig[1,2], José C. González-Hidalgo[2,4,5], Santiago Begueria[2,6], Michele Brunetti[7], Ksenija Cindrić Kalin[8], Leonardo Patalen[8], Aleksandra Kržič[9], Piero Lionello[10], Miguel M. Lima[11], Ricardo M. Trigo[11], Ahmed M. El-Kenawy[1,2,12], Ali Eddenjal[13], Murat Türkes[14], Aristeidis Koutroulis[15], Veronica Manara[16], Maurizio Maugeri[16], Wafae Badi[17], Shifa Mathbout[18,19], Renato Bertalanič[20], Lilia Bocheva[21], Ismail Dabanli[22], Alexandru Dumitrescu[23], Brigitte Dubuisson[24], Salah Sahabi-Abed[25], Fayez Abdulla[26], Abbas Fayad[27], Sabina Hodzic[28], Mirjana Ivanov[29], Ivan Radevski[30], Dhais Peña-Angulo[2,4,5], Jorge Lorenzo-Lacruz[31], Fernando Domínguez-Castro[1,2], Luis Gimeno-Sotelo[32,33,34], Ricardo García-Herrera[35,36], Magi Franquesa[1,2], Amar Halifa-Marín[1,2], Maria Adell-Michavila[1,2], Ivan Noguera[37], David Barriopedro[36], Jose M. Garrido-Perez[35], Cesar Azorin-Molina[38], Miguel Andres-Martin[38], Luis Gimeno[34,39,40], Raquel Nieto[34,39,40], Maria Carmen Llasat[41], Yannis Markonis[42], Rabeb Selmi[43], Soumaya Ben Rached[43], Slavica Radovanović[9], Jean-Michel Soubeyroux[24], Aurélien Ribes[44], Mohamed Elmehdi Saidi[45], Siham Bataineh[26], El Mahdi El Khalki[46], Sayed Robaa[47], Amina Boucetta[25], Karam Alsafadi[48], Nikos Mamassis[49], Safwan Mohammed[50], Beatriz Fernández-Duque[1,2], Sorin Cheval[23], Sara Moutia[17,51], Aleksandra Stevkov[52], Silvana Stevkova[52], M. Yolanda Luna[53] & Vera Potopová[54,55]

1951-2020

1981-2020

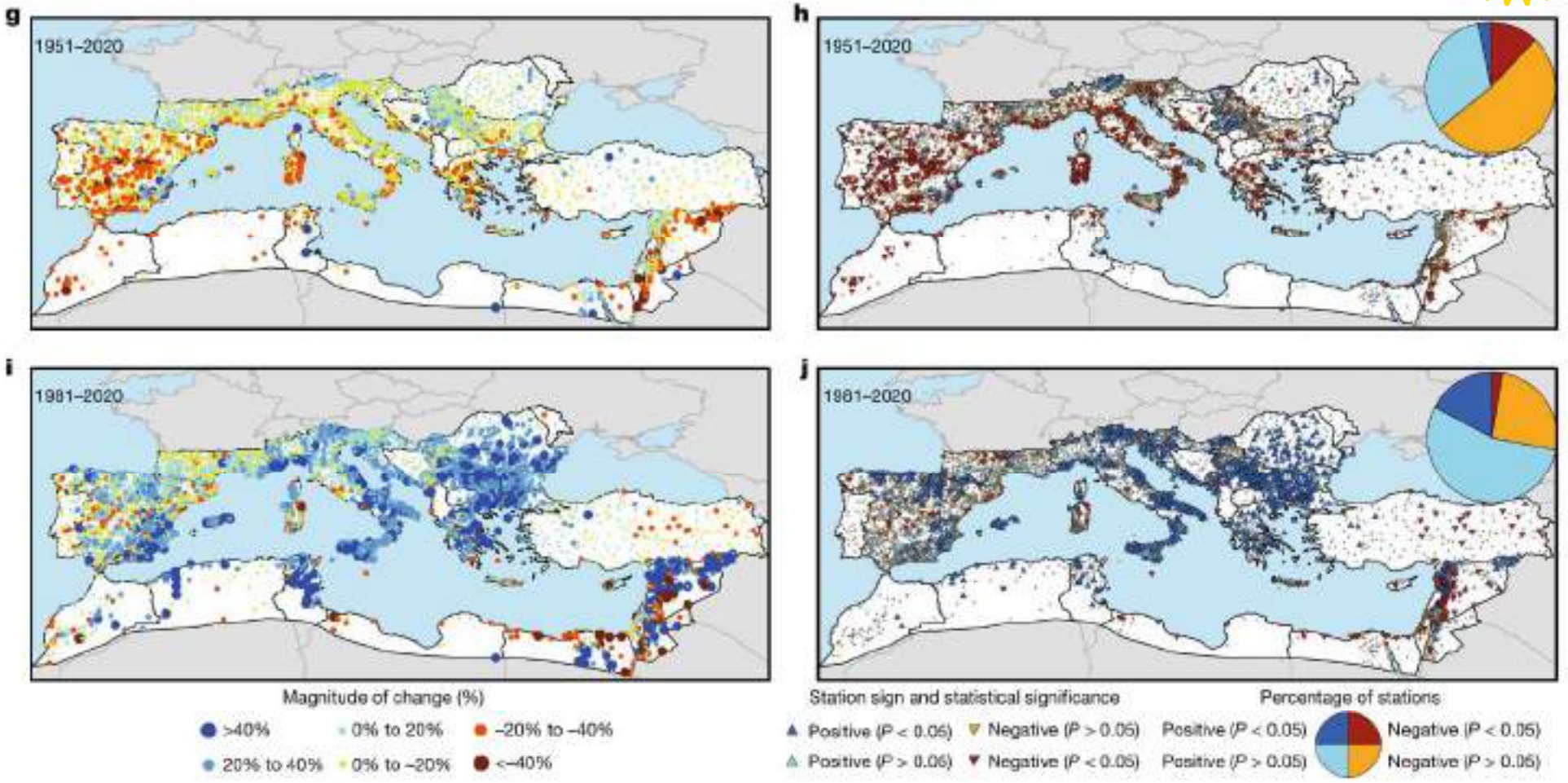
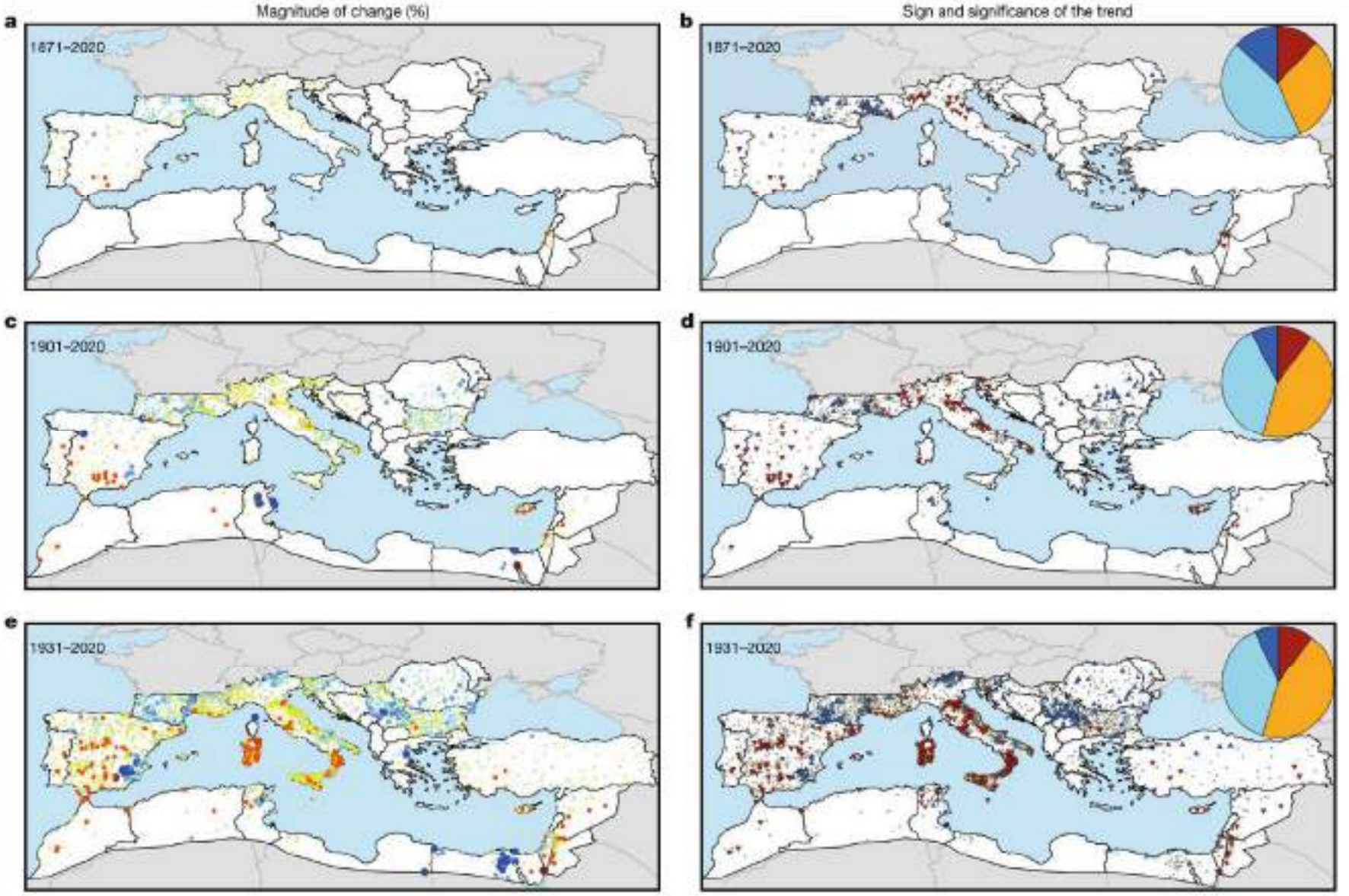


Fig. 1 | Spatial distribution of annual precipitation trend in different analysed periods. a,**c**,**e**,**g**,**i**, Magnitude of the change (in per cent) at each station. **a**, 1871–2020; **c**, 1901–2020; **e**, 1931–2020; **g**, 1951–2020; **i**, 1981–2020. **b**,**d**,**f**,**h**,**j**, Sign and statistical significance of the change at each station. **b**, 1871–2020; **d**, 1901–2020; **f**, 1931–2020; **h**, 1951–2020; **j**, 1981–2020. The circles contain the percentage of stations showing positive and negative significant (and nonsignificant) changes.

1871-2020

1901-2020

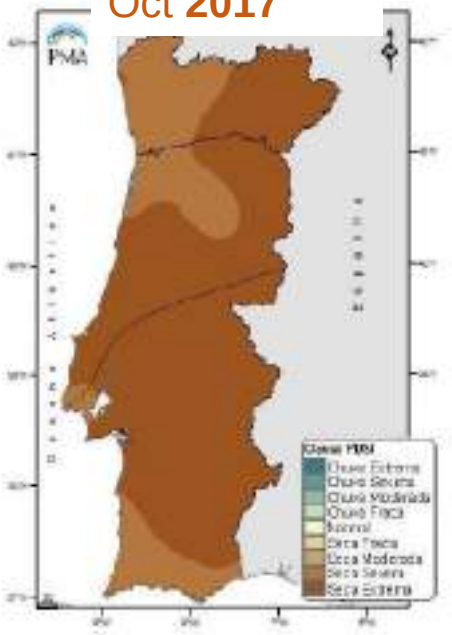
1931-2020



Sep **2005**

Feb **2012**

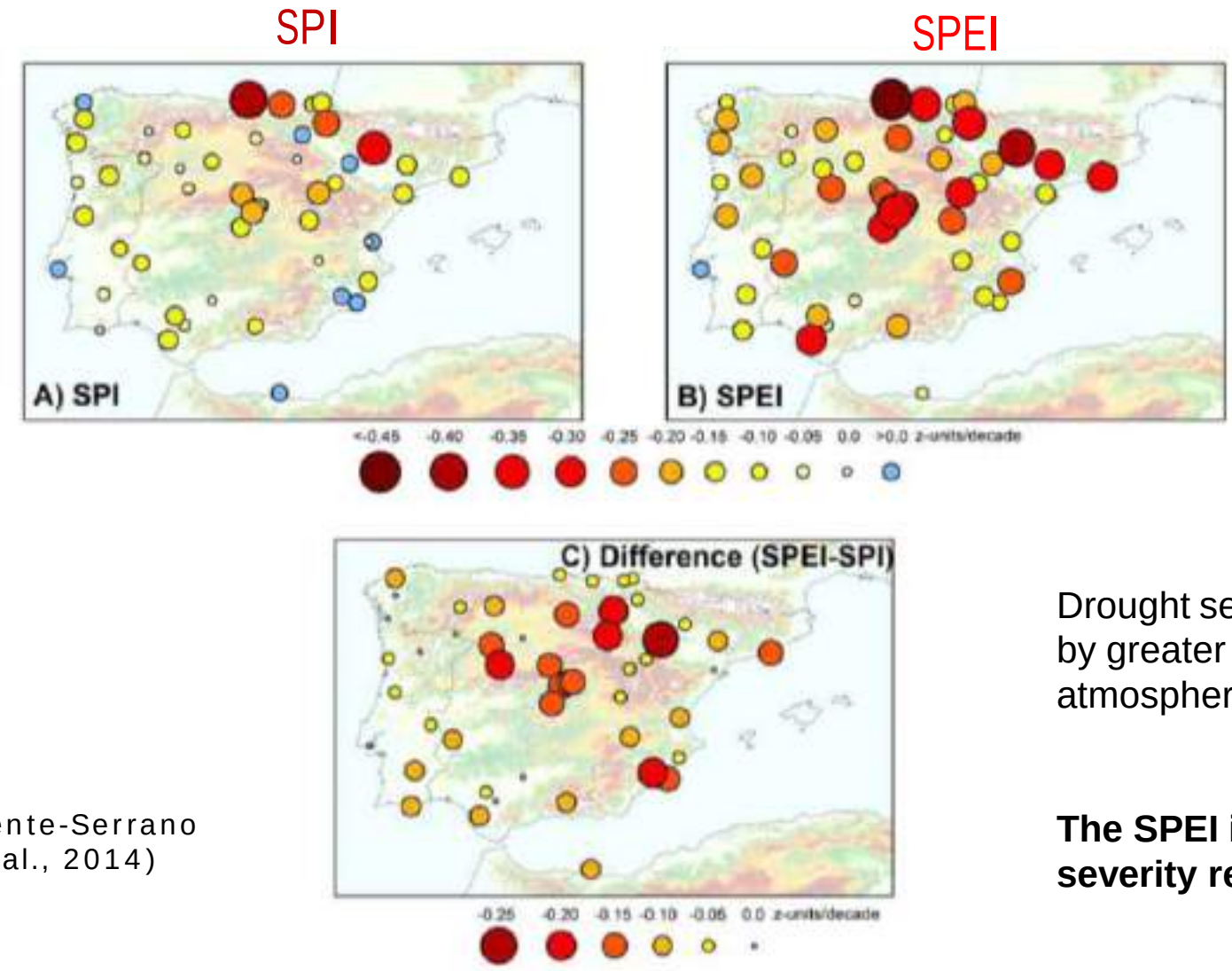
Oct **2017**



Feb **2022**

Percentage of territory under the **two most severe PDSI** classes

Evidence of increasing drought severity in Iberia between 1960 and 2010



(Vicente-Serrano et al., 2014)

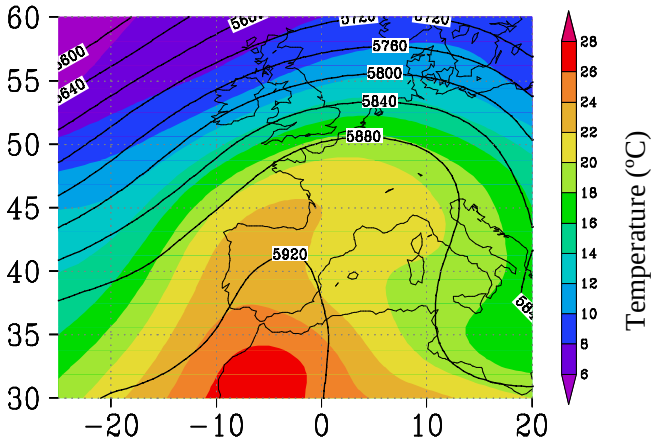
Drought severity has been aggravated by greater evaporative demand by the atmosphere since 1960s.

The SPEI indicates increased drought severity relative to the SPI

The 2003 heatwave over western Europe

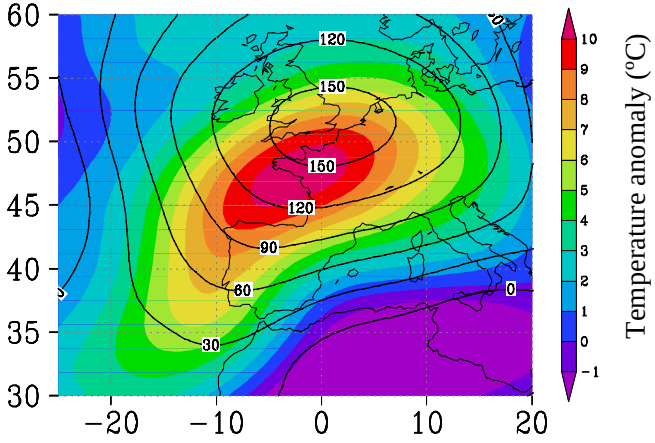
a 1 Aug – 15 Aug

Average →

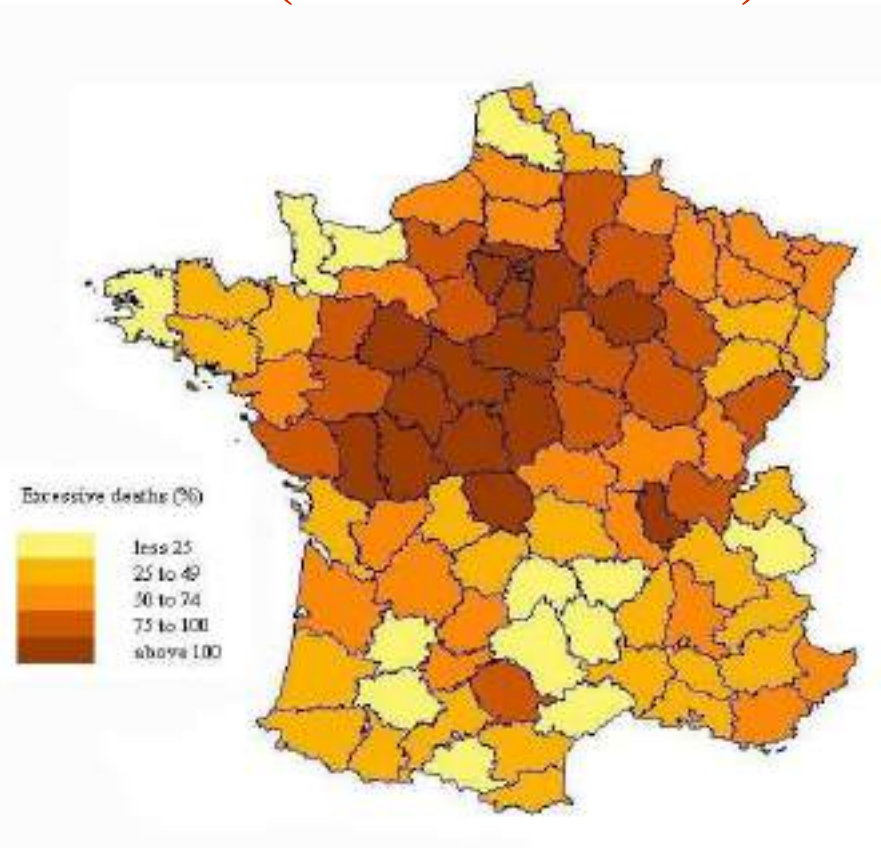


b

Anomaly →

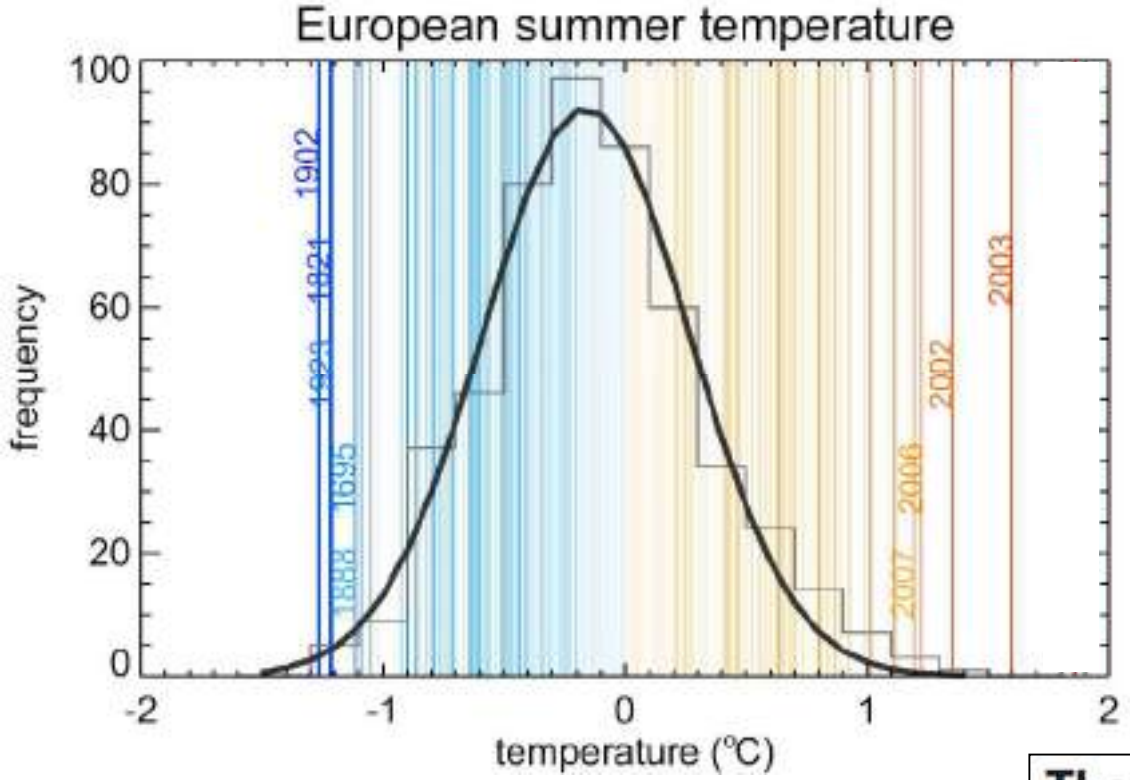


Excessive mortality 1-15 August
(circa 15000 in France)



(Trigo et al., 2005, GRL)

The impact of summer 2003 and 2010 mega-heatwaves in Europe



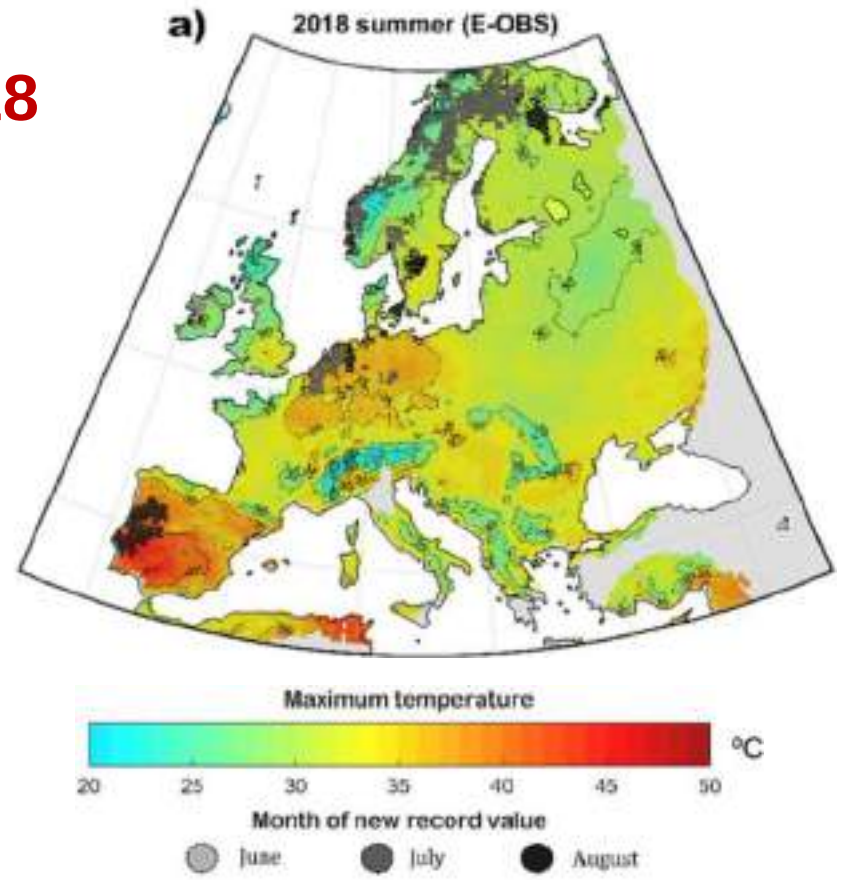
Barriopedro et al. (2011, SCIENCE)

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

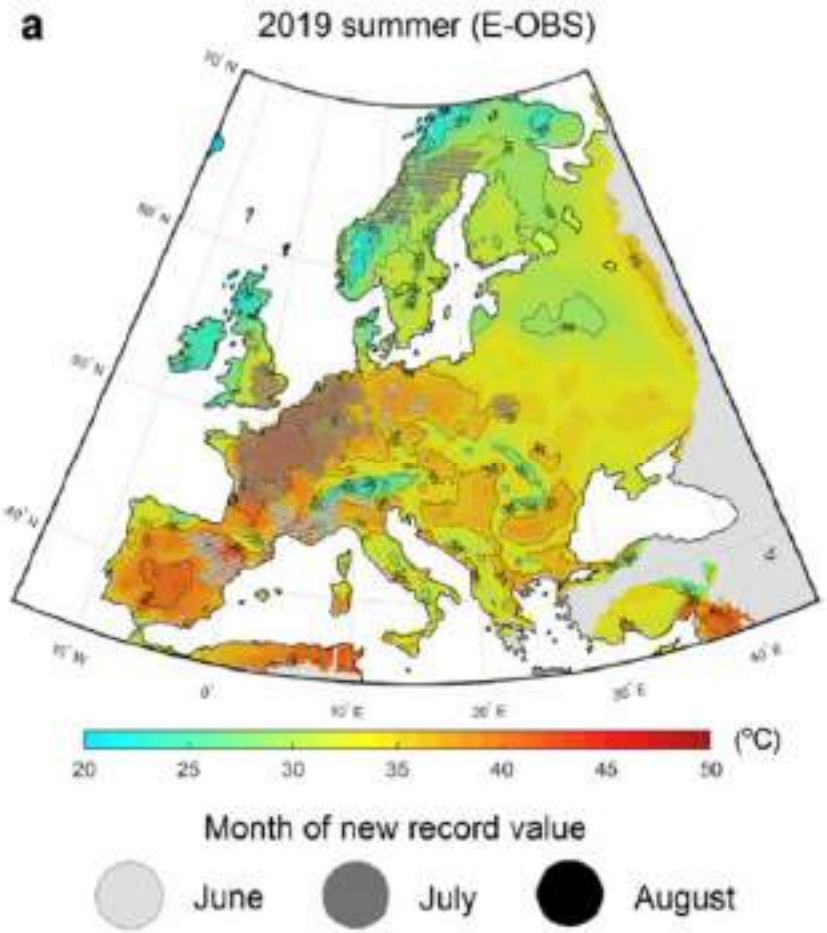
David Barriopedro,[1]* Erich M. Fischer,[2] Jürg Luterbacher,[3] Ricardo M. Trigo,[1] Ricardo García-Herrera[4]

The impact of summer **2018** and **2019** heatwaves in Europe

2018



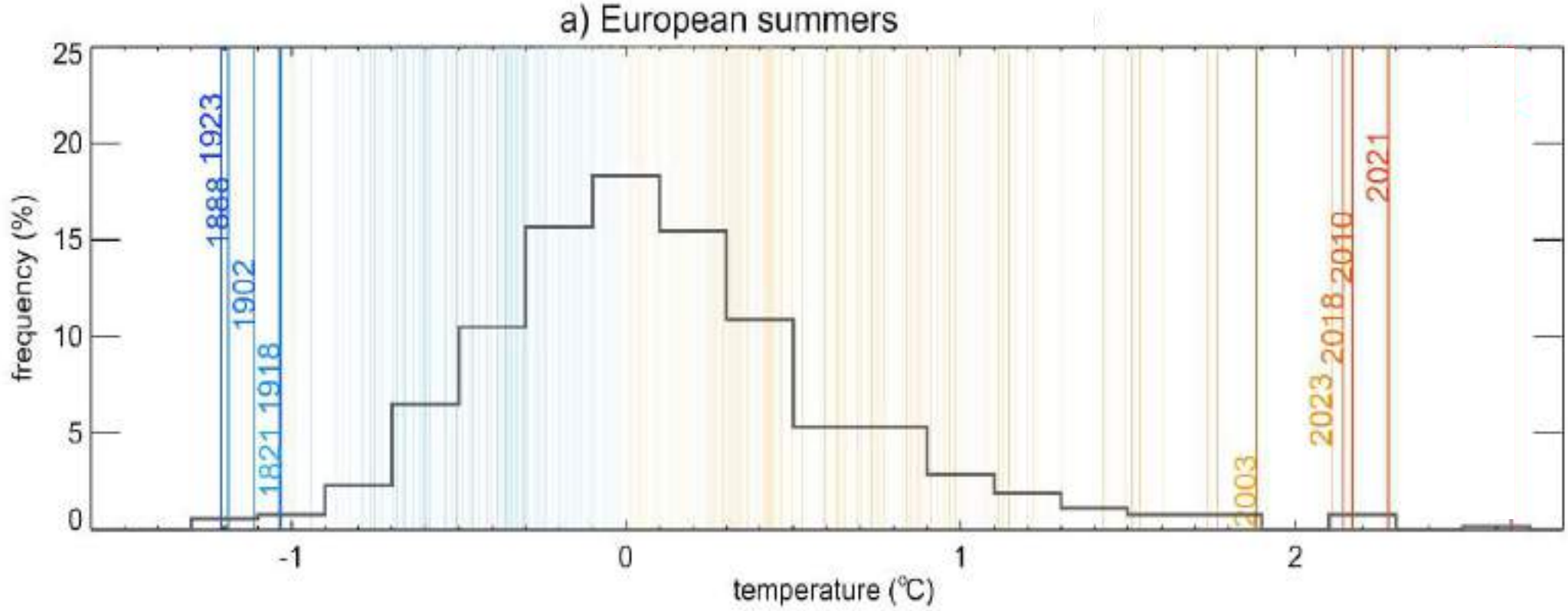
2019



(Sousa et al, 2019)

(New French Record) 44,1ºC (2003) ⟶ 46ºC (2019)

What about the recent summers **2021 - 2023** in Europe ?



(Trigo et al, 2025)

Environmental Research Letters

LETTER

The synergy between drought and extremely h in the Mediterranean

A Russo [1], C M Gouveia [1,2], E Dutra [3], P M M Soares [1] and R M Trig
[1] Instituto Dom Luiz (IDL), Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa
[2] Instituto Português do Mar e da Atmosfera, Lisboa, Portugal

NHD is the number of days with Tmax above the 90th percentile

NHN is the number of nights with Tmin above the 90th percentile

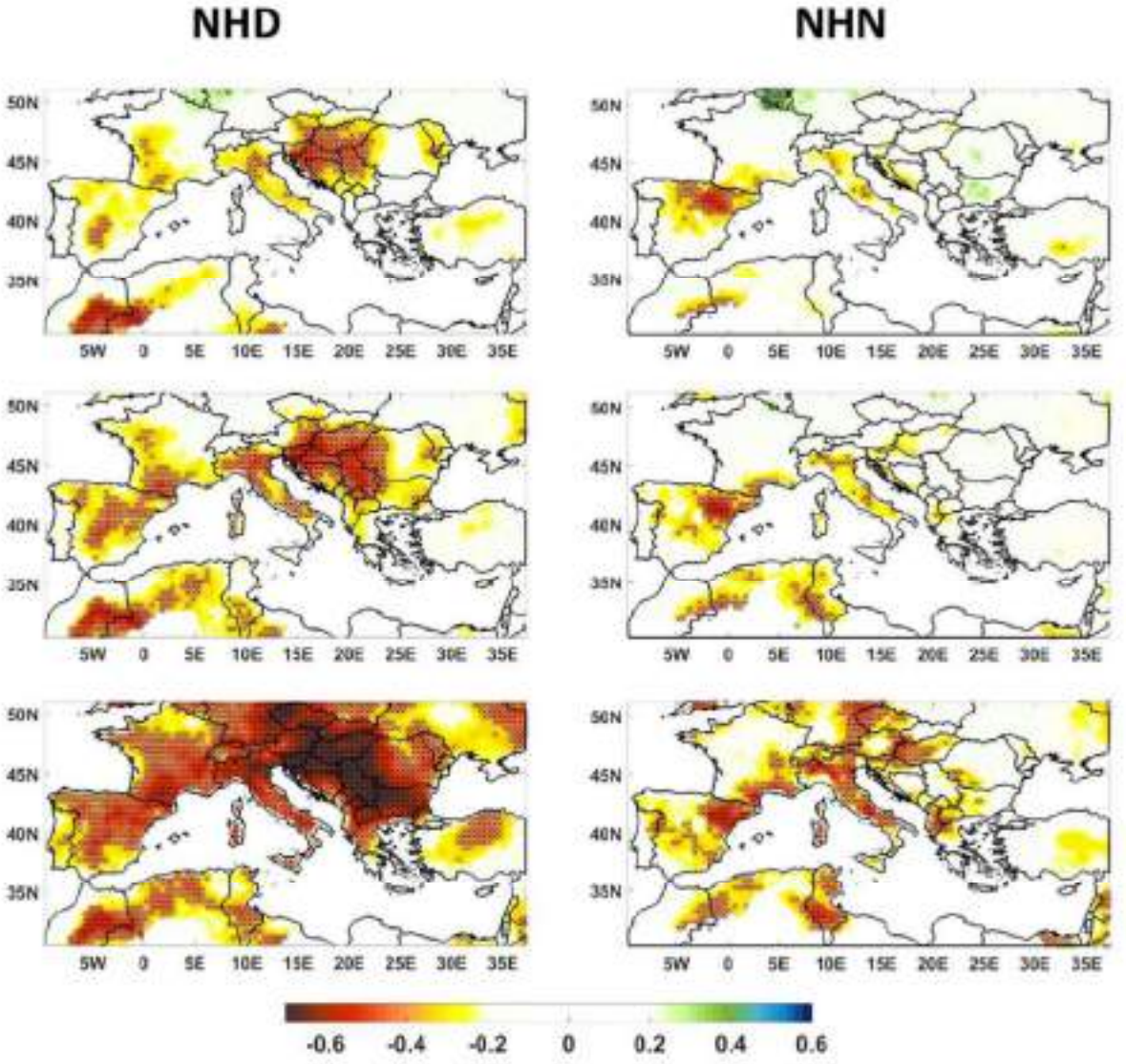
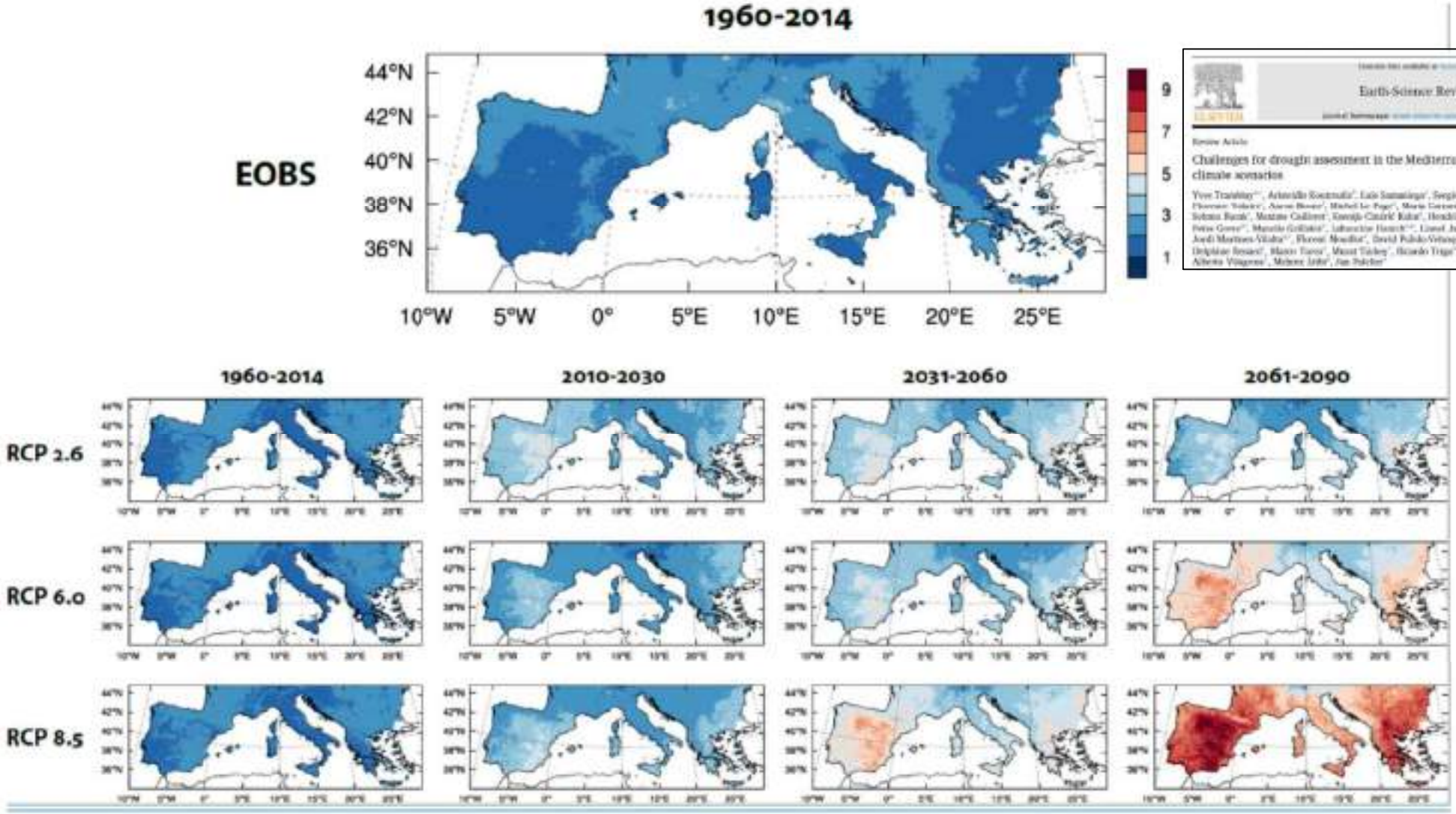


Figure 3. Correlation between SPEI at 9 months time scale in May (top), June (middle) and July (bottom) and the sum of NHD (left) and NHN (right) in July and August for the 1980–2014 period. Correlation values significant at 95% (99%) are marked with a x(•).



Earth-Science Reviews

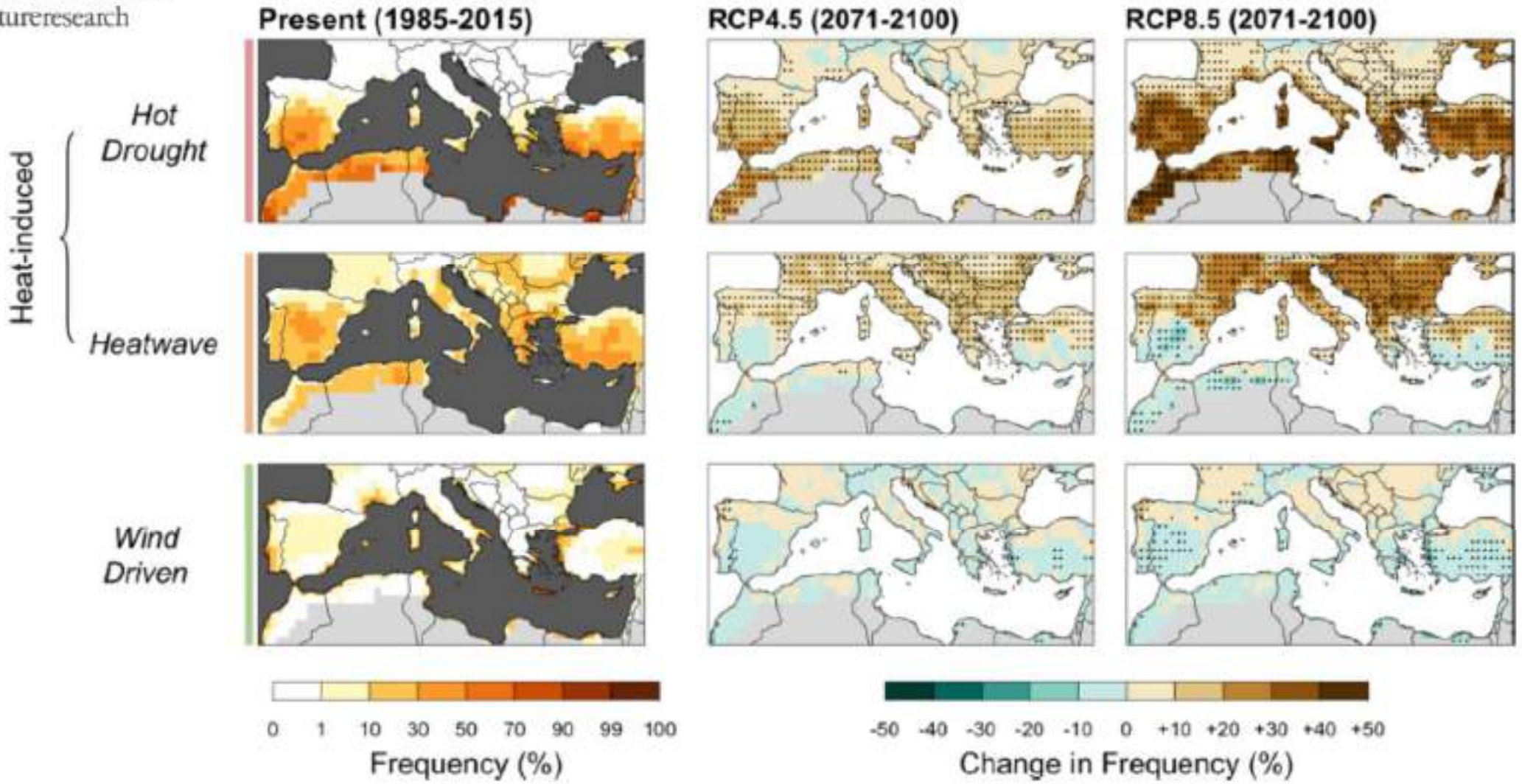
Review Article

Challenges for drought assessment in the Mediterranean region under future climate scenarios

Fig. 2. Multi-model ensemble mean drought duration (months/year) obtained with historical observations (*E*-OBS) during the period 1960–2014 and with for RCP 2.6, 6.0, and 8.5 for three periods: near future (2010 − 2030), mid-century (2031–2060) and end of century (2061–2090) for the northwestern Mediterranean region.

SCIENTIFIC REPORTS
nature research

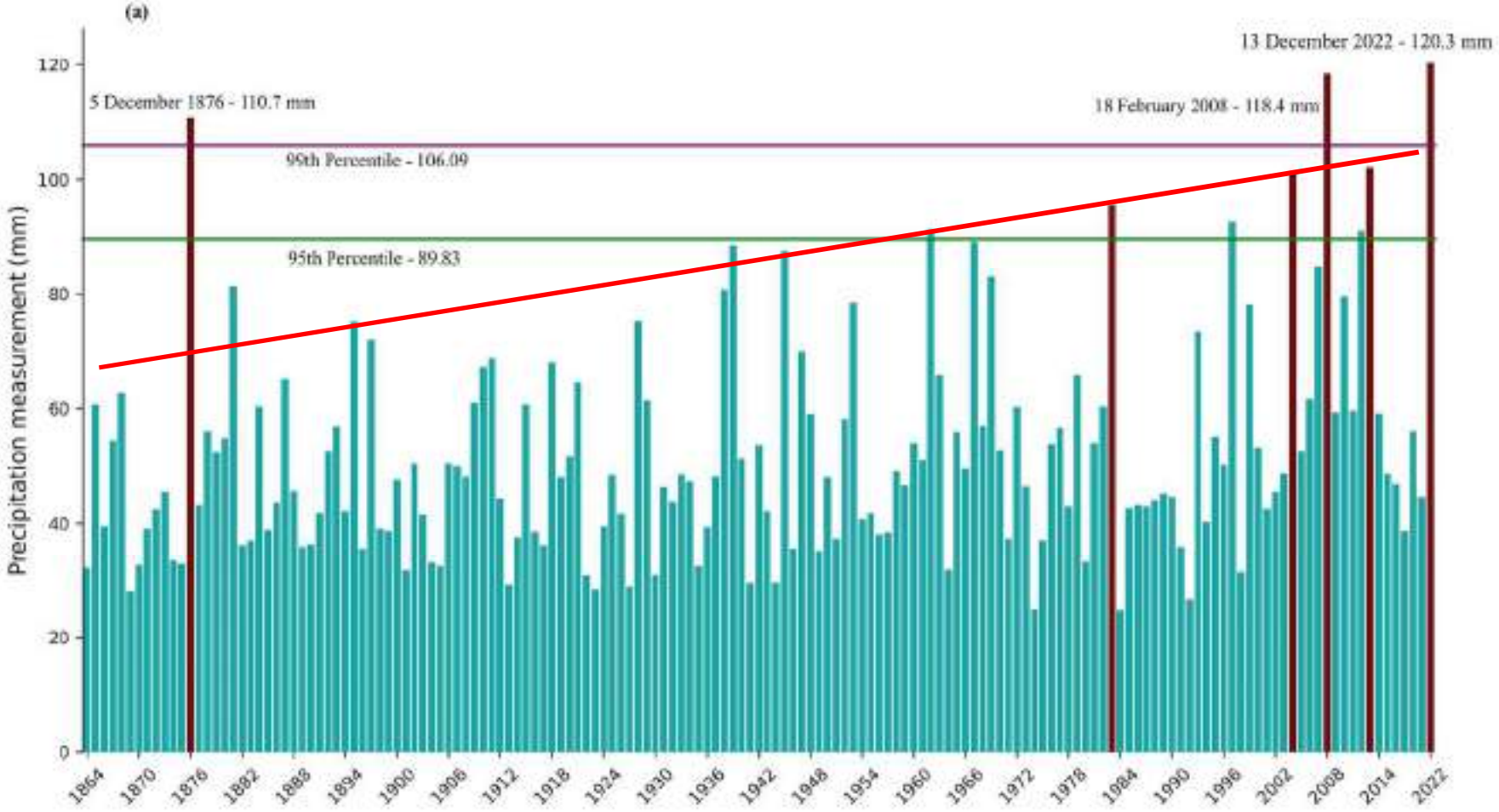
(Ruffault et al, 2020)



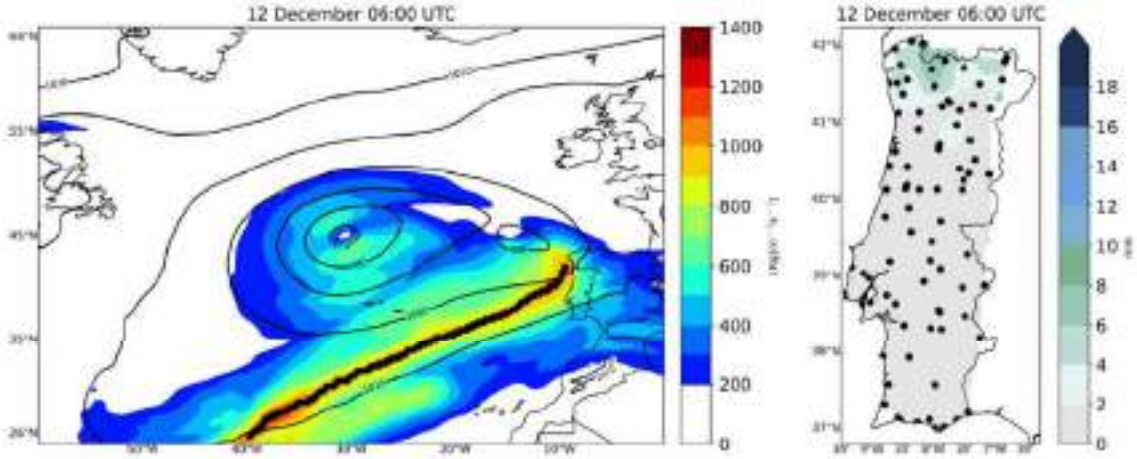
The record-breaking precipitation event of December 2022 in Portugal

Tiago M. Ferreira[1,2], Ricardo M. Trigo[1], Tomás H. Gaspar[1], Joaquim G. Pinto[2], and Alexandre M. Ramos[2]

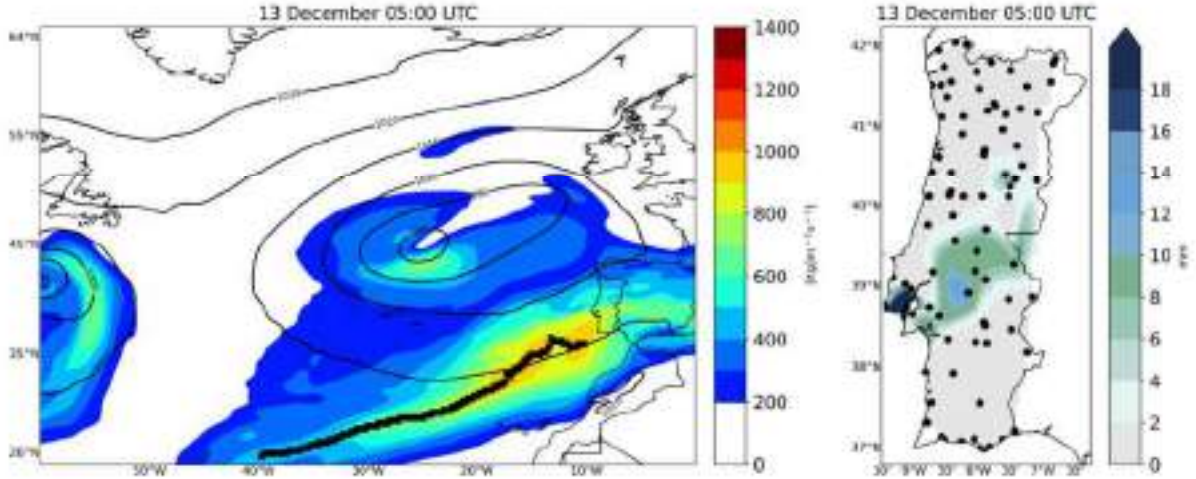
[1]Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa, Lisbon, Portugal



Floods on 12 and 13 December 2022 associated with an intense Atmospheric River that transported enormous amounts of water vapor from the tropics to Portugal.



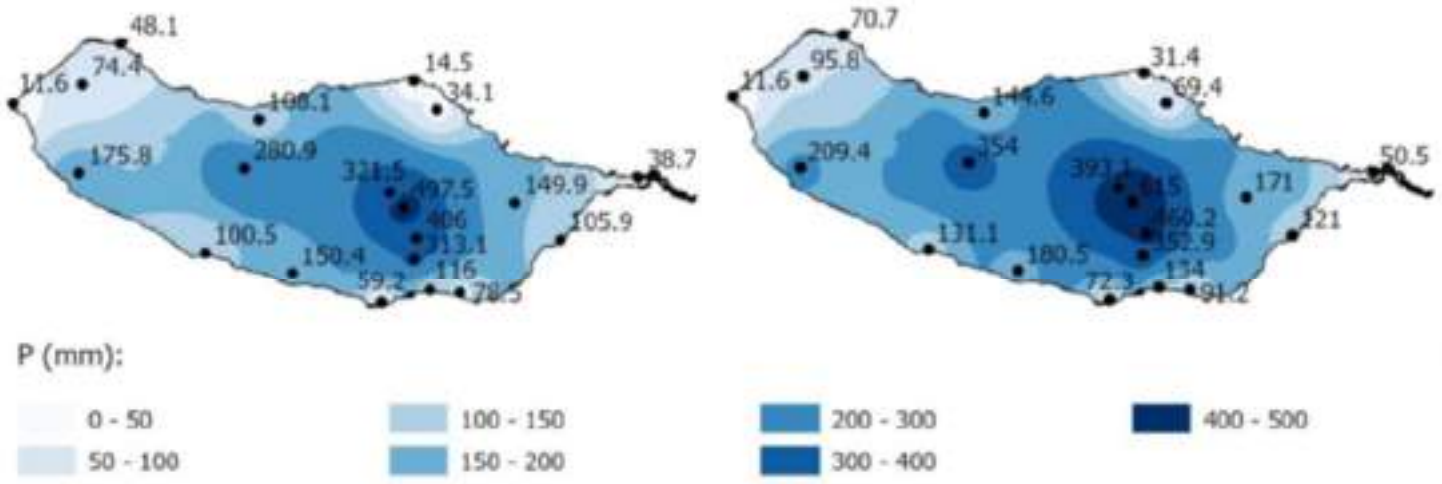
6 UTC de 12 Dezembro 2022

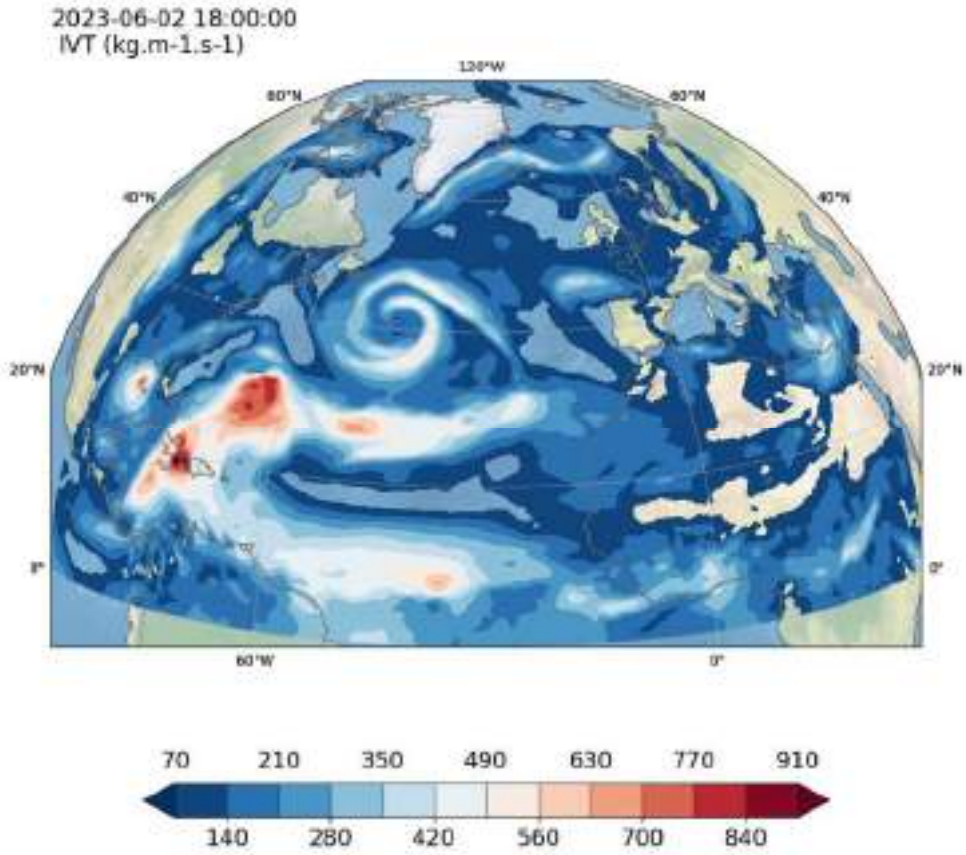


5 UTC de 13 Dezembro 2022

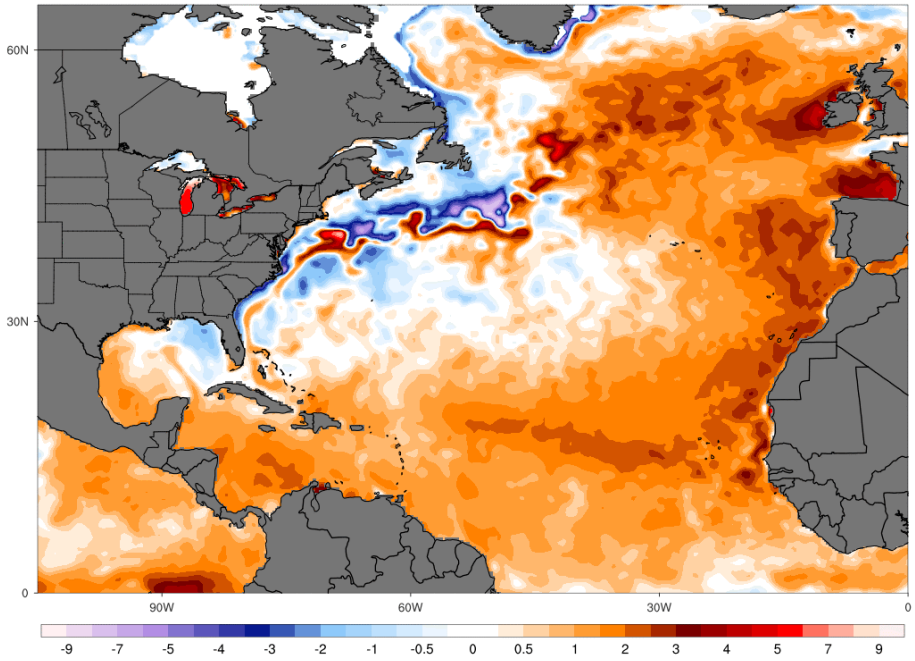
Extreme Rainfall in Madeira: The June 2023 Weather Phenomenon

Station	Daily Max.	24h Max.	Climatological June	Climatological Annual	Previous June Extreme		Extreme Absolute		Since
	(mm)	(mm)	(71-00)	(71-00)	(mm)	Date (day-year)	(mm)	Date	Date
Santana	34.1	69.4	44.5	1399.6	134.0	06/1966	217.0	06/03/2001	01/01/1942
Bica da Cana	280.9	354.0	66.0.	2635.4	212.0	21/1964	327.2	26/01/2011	01/01/1961
Chão do Areeiro	**497.5**	**615.0**	48.2	2620.0	282.3	01/1965	**497.5**	06/06/2023	01/01/1961
Lugar de Baixo	100.5	131.1	8.9	600.2	68.8	21/1964	111.9	26/11/2010	01/01/1961
Santa Catarina/Aeroporto	105.9	121.0	9.0	693.6	67.9	06/2020	147.4	21/02/2010	01/01/1961
Funchal Obs.	116.0	134.0	6.4	596.4	57.8	21/1964	292.7	28/03/2021	01/01/1949





Anomalias das temperaturas do mar em Junho de 2023



Conclusões

1. O mediterrâneo está a ficar mais seco e a frequência das secas aumentou nos últimos 40 anos. No entanto o papel dos GEE não é claro (Precip vs Temp).

2. A Europa está a aquecer mais rapidamente que o resto do Mundo. As mega-Ondas de calor dos verões de 2003 e 2010 passaram a ser recorrentes (2018, 2019, 2021, 2023) e claramente superadas em 2022.

3. Nos climas do tipo Mediterrânico a frequência e amplitude dos Compound Extremes (Secas – Ondas de Calor – Fogos) está a aumentar de forma significantiva e cada vez mais como resultado das Alterações Climáticas.

4. Os eventos de precipitação extrema diária estão a aumentar em toda a Europa incluindo Portugal (frequentmente associados a Rios Atmosféricos).