DROUGHTS FEEDBACK ON SUMMER HOT DAYS AND NIGHTS OVER THE MEDITERRANEAN

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1. Motivation

The Mediterranean is often affected by extreme weather (EW) events [1], such as droughts and heatwaves, which are two of the most frequent EW events in the Mediterranean [1], having negative impacts on different economic and social activities [1]. Several studies have stressed the role played by recent climate change in the increase likelihood of occurrence of some of these extremes [1,2], with emphasis on the fact that temperature extremes are expected to occur more frequently [3].

A number of studies have put into evidence the existence of several positive feedback mechanisms between droughts and heatwaves [4,5]. Here, we propose to analyze if the occurrence of summer extremely hot days and nights in the Mediterranean is preceded by the occurrence of drought events in spring and early summer.

2. Data and Method

- SPI and SPEI are multi-scalar drought indicators which allow for the assessment of drought's duration and severity, where SPEI relies on both precipitation and evapotranspiration [6].
- SPI and SPEI were calculated from the CRU TS 4.01 database (0.5° resolution) for the 1980-2014 period [7] for three timescales (3, 6, 9 months). SPI and SPEI were selected for the months preceding the hottest months of each year.
- SPI and SPEI were used as proxy for surface moisture deficits to assess the impact of these deficits on the occurrence of subsequent hot days in the respective hottest months of each particular year and at each location using correlation analysis.
- The number of hot days and nights per month (respectively NHD and NHN) was determined as the number of days with maximum or minimum temperature exceeding the 90th percentile. Both NHD and NHN were computed based on daily temperatures (0.5° resolution) for the 1980-2014 period from the ECAD-EOBS v14 daily dataset [8].
- To avoid time discontinuities, the NHD (NHN) were summed up at each grid point over the two months (Fig. 1).
- Results will be shown only for SPEI and focusing mainly on Iberia (IP) and the Balkans (BKS).

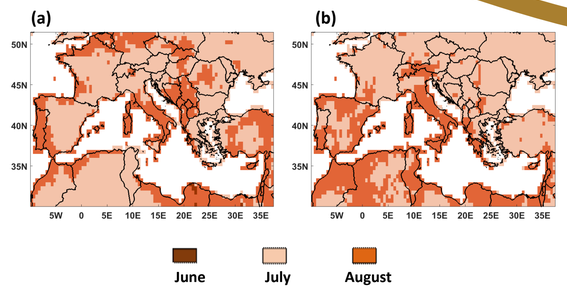

Fig. 1 *Geographical distribution of most frequent hottest month based on (a) the maximum temperature; (b) the minimum temperature.*

3. Results

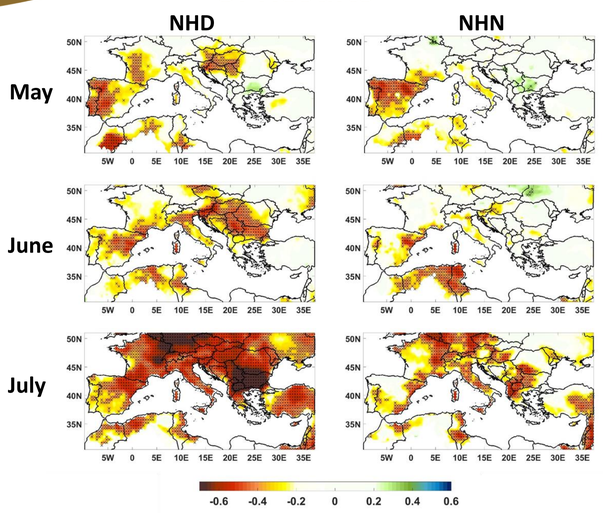

Fig. 2 *Correlation between SPEI at 3-months' time scale in May (top), June (middle) and July (bottom) and the sum of NHD (left) and NHN (right) in July and August for the 1980-2014 period. Correlation values significant at 95% (99%) are marked with a x (•).*

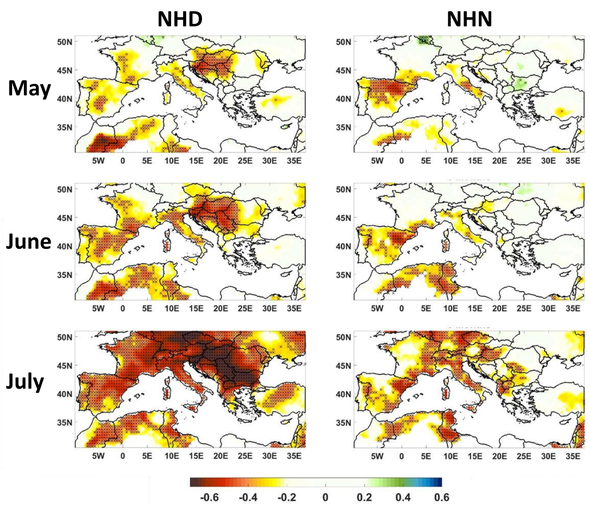

Fig. 3 *As Fig. 2 but for SPEI at 6-months' time scale .*

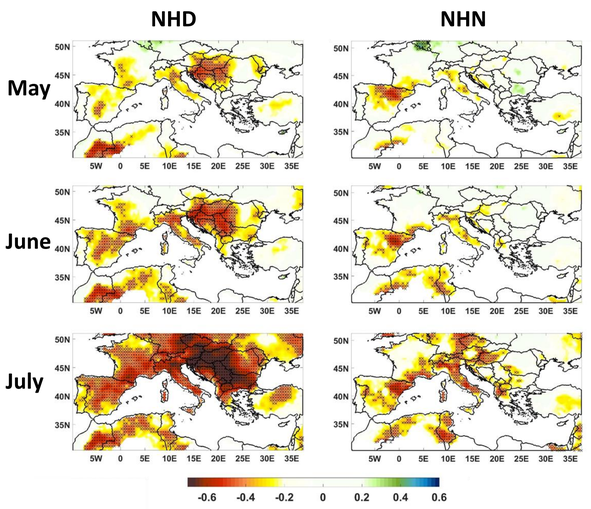

Fig. 4 *As Fig. 2 but for SPEI at 9-months' time scale.*

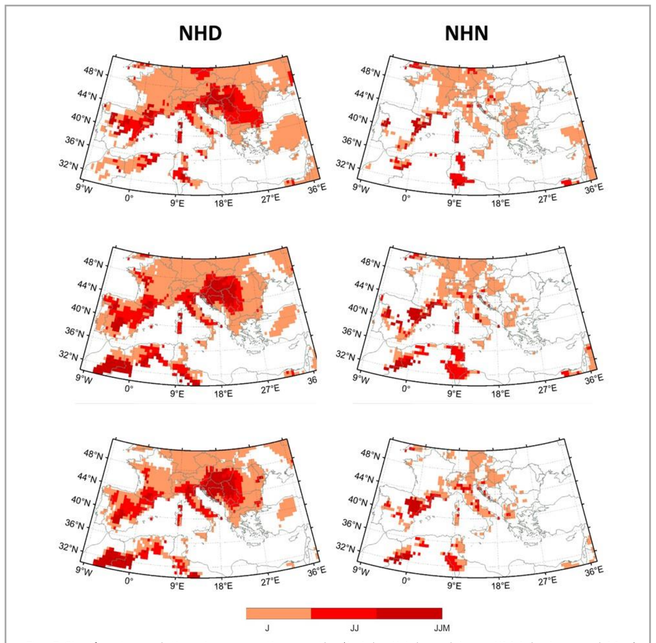

Fig. 5 *Significant correlations in consecutive months (J- July; JJ-July and June; JJM-July, June and May) between NHD (left) and NHN (right) and SPEI for the 3- (top panel), 6- (middle panel) and 9-months (lower panel) timescales.*

- The most frequent hottest months in the Mediterranean are July and August (Fig. 1).
- The spatial patterns of the correlations between NHD or NHN with SPI or SPEI are generally similar.
- Positive correlations are usually located in northern France, Germany, Albania, Romania, Bulgaria or Ukraine, and mostly not statistically significant; and negative significant correlations are mostly located in the Iberian Peninsula (IP), Balkans (BKS) and on northern Africa (Figs. 2-4):

IP: The most negative correlations are reached when SPI/SPEI at 3-months' time scale in May, or SPEI at 6-months' time-scale in June, are correlated to the NHD/NHN. When concurrent SPI/SPEI in July is correlated to the NHD/NHN in July and August, the most negative correlations are reached for the 9-months time scale, reflecting that the winter and spring water balance (precipitation-evaporation) have a major importance on the occurrence of NHD and NHN in the summer.

BKS: The most negative correlations identified in May or in June are mostly reached when SPI/SPEI at 6- and 9-months' time scales are correlated to the NHD/NHN. In July, a dichotomic behavior appears when using SPI or SPEI. SPEI is better correlated for the 3-months' time scale and SPI for the 9-months, possibly reflecting the capacity of SPEI capturing earlier the balance between precipitation and evapotranspiration.

The results reinforce the robust link between heatwaves occurrence preceded by drought conditions.

	Index	May			June			July		
		Corr	IP	BKS	Corr	IP	BKS	Corr	IP	BKS
NHD	SPEI_3	-0.60	-0.55	-0.51	-0.60	-0.59	-0.60	-0.79	-0.62	-0.79
	SPEI_6	-0.70	-0.49	-0.56	-0.66	-0.59	-0.59	-0.76	-0.68	-0.76
	SPEI_9	-0.66	-0.46	-0.52	-0.66	-0.52	-0.58	-0.77	-0.65	-0.77
	SPI_3	-0.65	-0.56	-0.57	-0.58	-0.57	-0.58	-0.74	-0.62	-0.73
	SPI_6	-0.69	-0.53	-0.60	-0.72	-0.60	-0.66	-0.76	-0.64	-0.76
	SPI_9	-0.63	-0.51	-0.55	-0.69	-0.51	-0.67	-0.81	-0.65	-0.78
NHN	SPEI_3	-0.63	-0.63	-0.30	-0.60	-0.55	-0.38	-0.65	-0.60	-0.59
	SPEI_6	-0.61	-0.61	-0.38	-0.66	-0.66	-0.38	-0.65	-0.64	-0.57
	SPEI_9	-0.57	-0.57	-0.38	-0.66	-0.66	-0.41	-0.64	-0.64	-0.56
	SPI_3	-0.63	-0.63	-0.30	-0.58	-0.58	-0.37	-0.57	-0.43	-0.57
	SPI_6	-0.62	-0.62	-0.44	-0.67	-0.67	-0.42	-0.64	-0.58	-0.55
	SPI_9	-0.57	-0.57	-0.39	-0.66	-0.66	-0.46	-0.66	-0.63	-0.57

Tab. 1 *Correlations for the study area (Corr) and for the Iberian Peninsula (IP) and Balkans (BKS) between SPI and SPEI at 3-, 6- and 9-months' (SPI_9 and SPEI_9) time scales in May, June and July and the sum of NHD in July and August for the 1980-2014 period.*

4. Conclusion

- Results show that the **most frequent hottest months** for the Mediterranean region occur in ***July and August***.
- Most regions exhibit ***statistically significant negative correlations***, i.e. **high NHD/NHN following negative SPEI/SPI values**, and thus a potential for NHD/NHN early warning.
- This analysis allowed to **identify** the Iberian Peninsula, northern Italy, northern Africa and the Balkans as the main ***hotspots of predictability of extreme hot temperatures in the summer*** precedded by the occurrence of drought events in the spring or early summer (Fig. 5).

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