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SUPPLEMENTARY INFORMATION

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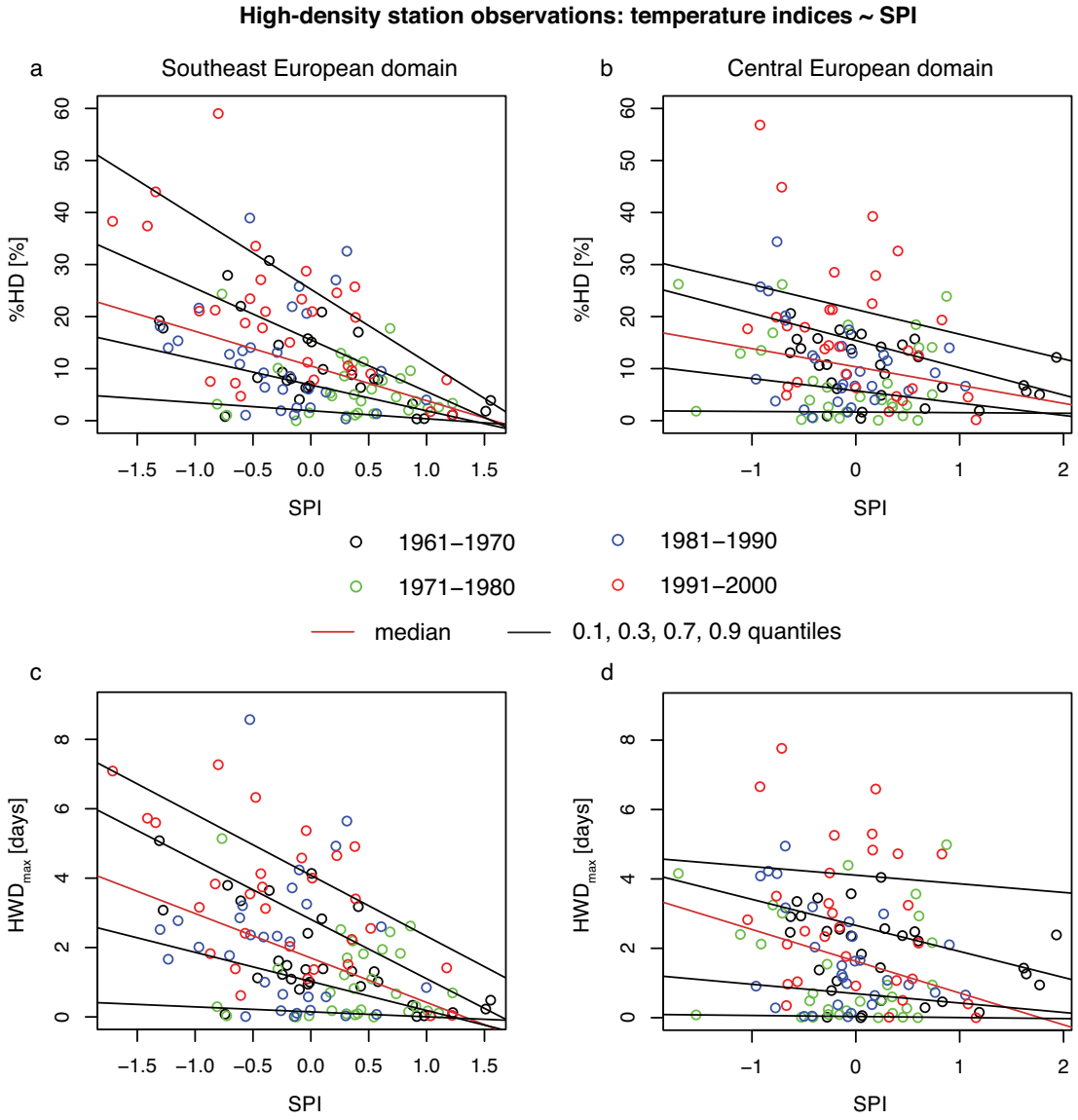

Supplementary Figure 1: Hot extremes vs. SPI (station observations). Scatter plots of monthly JJA %HD and HWD_{max} vs. SPI from the high-density station observations, domain-averaged values for the Southeast (a,c) and Central (b,d) European domains (1961–2000 period, data points coloured according to four 10-year time periods). Also shown are the regression lines for a selection of distinct quantiles (i.e., median, 0.1, 0.3, 0.7, 0.9). For 95% confidence intervals of the slopes of the quantile regression lines, see Figure 3 of the main article.

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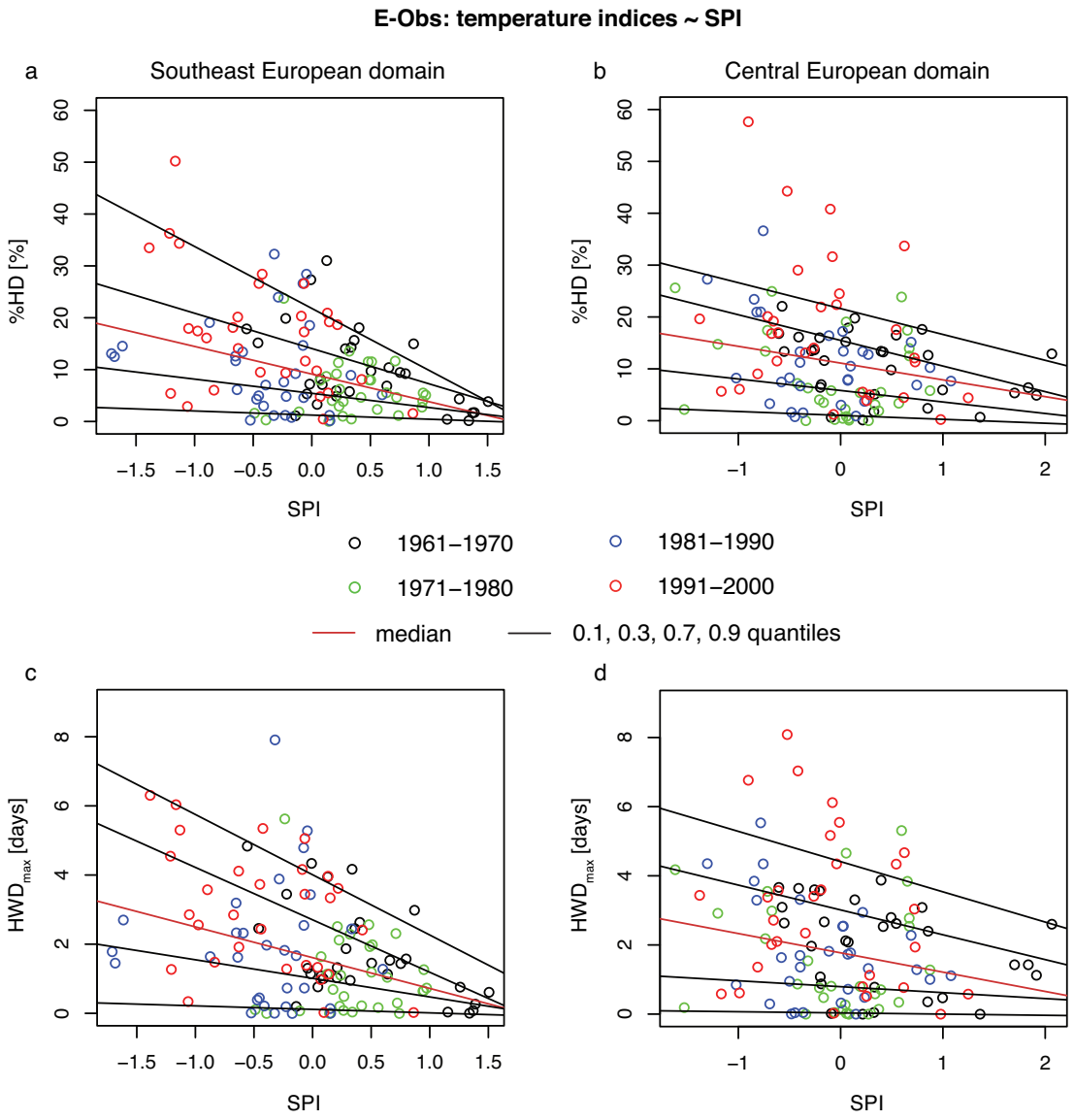
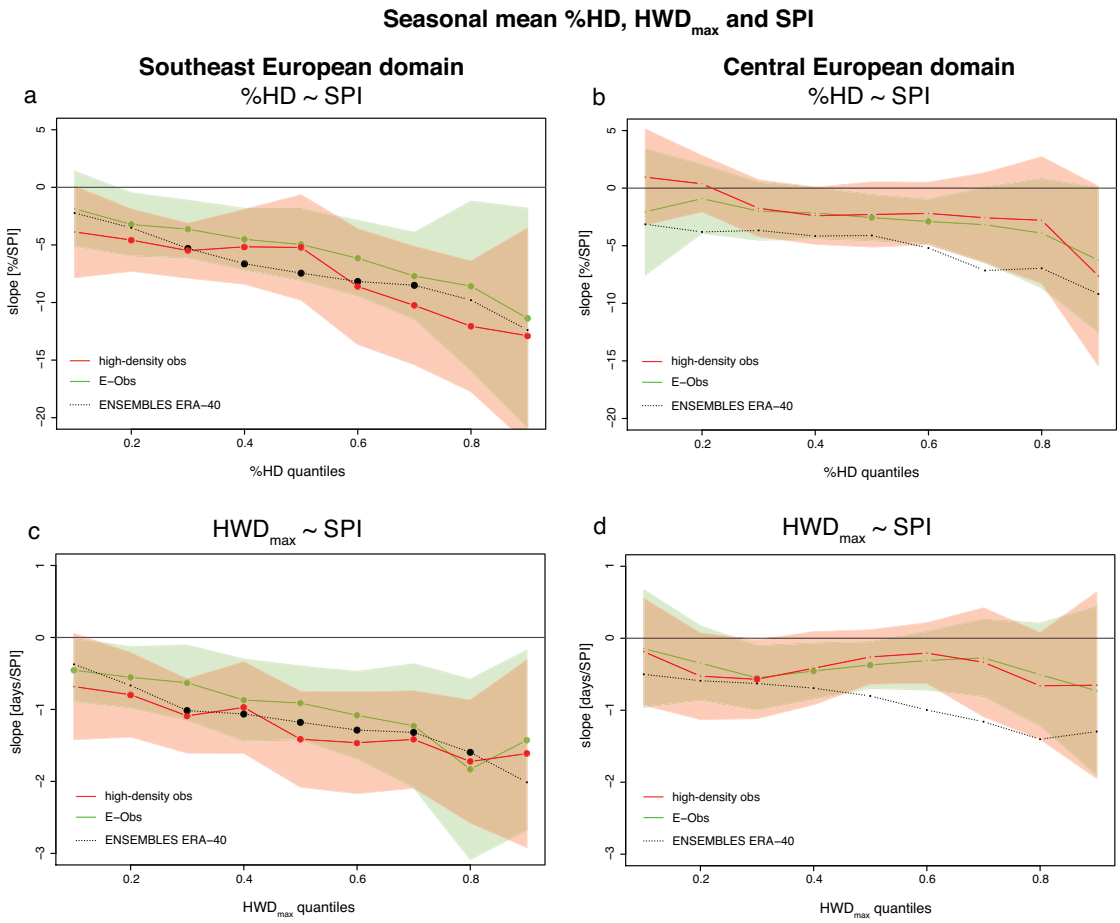


Supplementary Figure 2: Hot extremes vs. SPI (E-Obs). As Supplementary Figure 1, but for the gridded E-Obs dataset.



Supplementary Figure 3: Quantile regression analysis (seasonal mean JJA data). Quantile regression slopes of the 0.1–0.9 quantiles of seasonal mean %HD and HWD_{max} in relation to SPI for the two observational data sets and for the reanalysis-driven regional climate model simulations (1961–2000 period, Southeast (a,c) and Central (b,d) European domains). The 95% confidence intervals (from a pairwise bootstrap) of the estimated slopes are displayed as shadings for the observational datasets, with significant slopes denoted with a bold dot (5% significance level, two-tailed test). In the case of the model simulations, the ensemble median slopes are shown, and dots are displayed as bold when at least 75% of the simulations present significant slopes.

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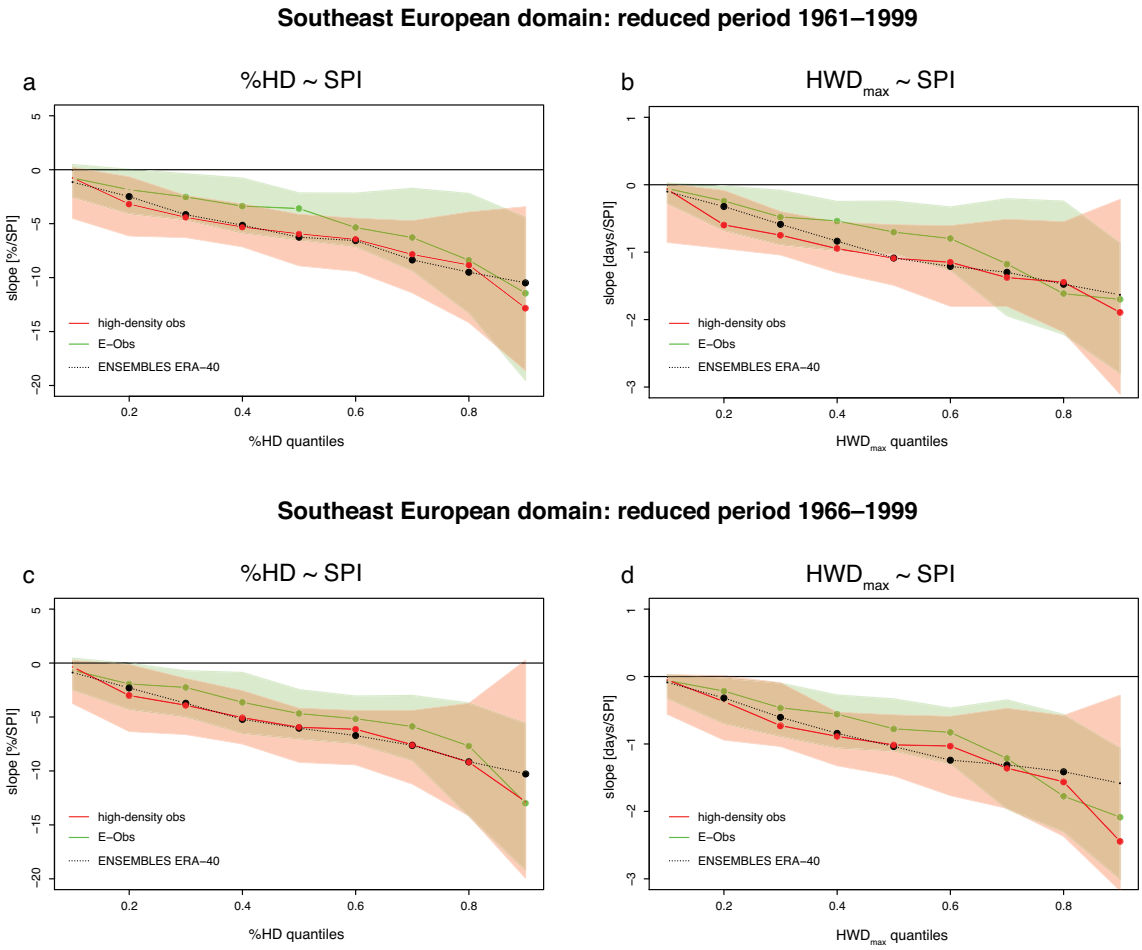
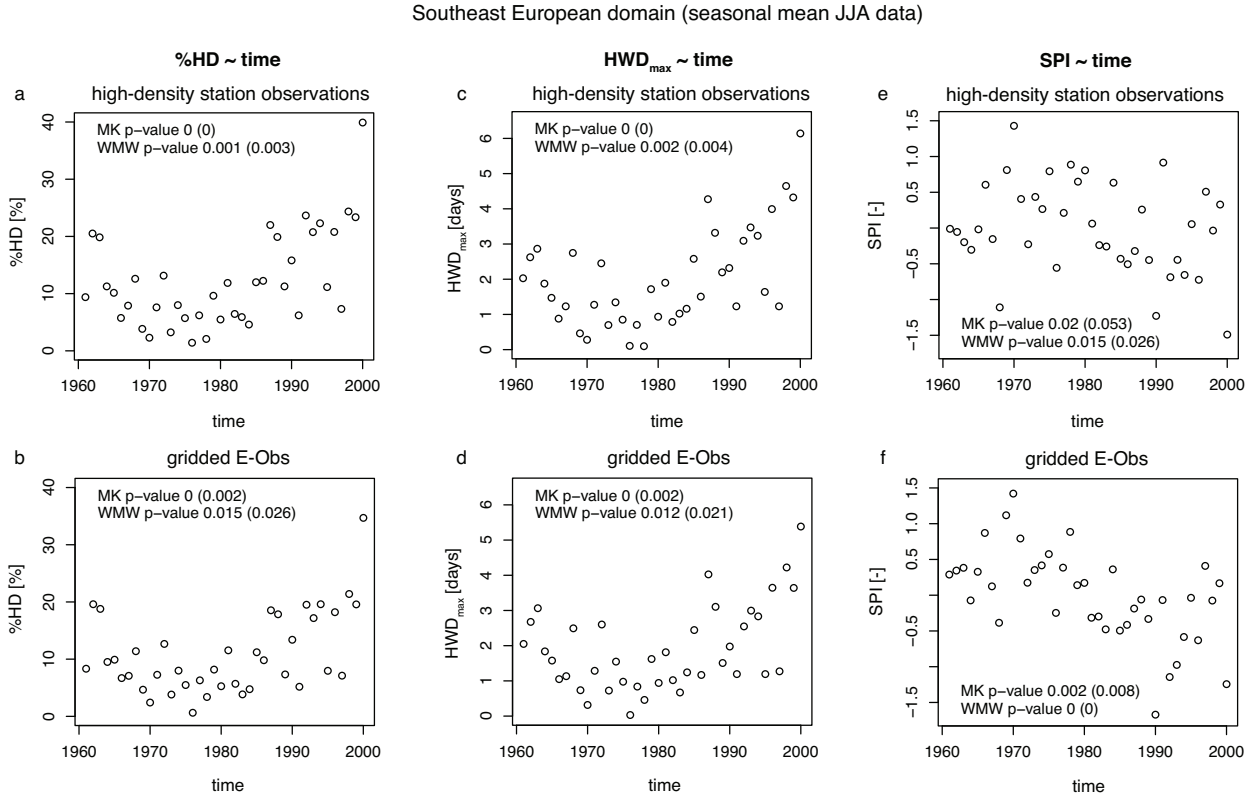


Supplementary Figure 4: Quantile regression analysis (reduced analysis periods). Quantile regression slopes of the 0.1–0.9 quantiles of monthly JJA %HD and HWD_{max} in relation to SPI for the two observational data sets and for the reanalysis-driven regional climate model simulations (reduced 1961–1999 (a,b) and 1966–1999 (c,d) analysis periods, Southeast European domain). The 95% confidence intervals of the estimated slopes are displayed as shadings for the observational datasets, with significant slopes denoted with a bold dot (5% significance level, two-tailed test). In the case of the model simulations, the ensemble median slopes are shown, and dots are displayed as bold when at least 75% of the simulations present significant slopes.



Supplementary Figure 5: Temporal evolution of hot extremes and SPI. (a,b) %HD vs. time, (c,d) HWD_{max} vs. time and (e,f) SPI vs. time for the high-density station observations (a,c,e) and the gridded E-Obs dataset (b,d,f). Also shown are the p-values for the Wilcoxon-Mann-Whitney test for a shift in location (1981–2000 vs. 1961–1980, WMW p-value) and for the Mann-Kendall trend test for the period after 1970 (MK p-value). Values in brackets denote the p-values for the tests without the last year of the record (2000), which was particularly extreme in terms of temperature.

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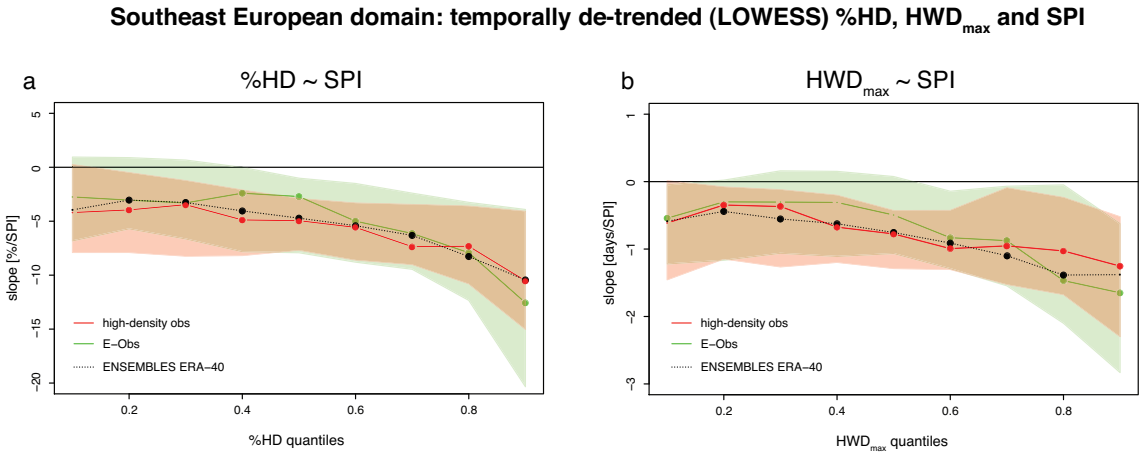

Supplementary Figure 6: Quantile regression analysis (LOWESS de-trended monthly JJA data). Quantile regression slopes of the 0.1–0.9 quantiles of LOWESS de-trended monthly JJA (a) %HD and (b) HWD_{max} in relation to SPI (i.e., subtraction of the LOWESS mean trend from the original monthly data) for the two observational data sets and for the reanalysis-driven regional climate model simulations (1961–2000 period, Southeast European domain). The 95% confidence intervals of the estimated slopes are displayed as shadings for the observational datasets, with significant slopes denoted with a bold dot (5% significance level, two-tailed test). In the case of the model simulations, the ensemble median slopes are shown, and dots are displayed as bold when at least 75% of the simulations present significant slopes.

Supplementary Methods: Spatial aggregation of the high-density station data The temperature indices and SPI from the station observations are simply averaged over the domains for the analyses. In order to test the robustness of the results, in particular linked with the reduced station density in Bulgaria (Figure 1 of the main article), various sensitivity tests have been performed for the Southeast European domain:

1. A principal component analysis (PCA) was applied to the station data (seasonal mean JJA values) of the Southeast European domain. The scores of the 1st PCA component can be interpreted as a weighted average of the stations that reflects the main temporal variability of SPI and the temperature indices in the domain. Applying the quantile regression to the time series of the scores leads to similar results as for the domain-averaged data (Supplementary Figure 7).
2. The analysis also leads to similar results when the stations are averaged on a country basis (Romania and Bulgaria) and the resulting values are combined using an area-weighted average (Supplementary Figure 8).
3. Maps of the quantile regression slopes for the median, 0.8 and 0.9 quantiles at the individual stations (seasonal mean JJA data) further confirm that the inferred relationship between SPI and the hot extremes is spatially robust in the Southeast European domain (Supplementary Figure 9).

From these analyses, we conclude that the identified relationship between SPI and the hot extremes in the Southeast European domain is a spatially robust feature, which is independent of the spatial aggregation, and that the use of a simple domain average for the station observations is appropriate.

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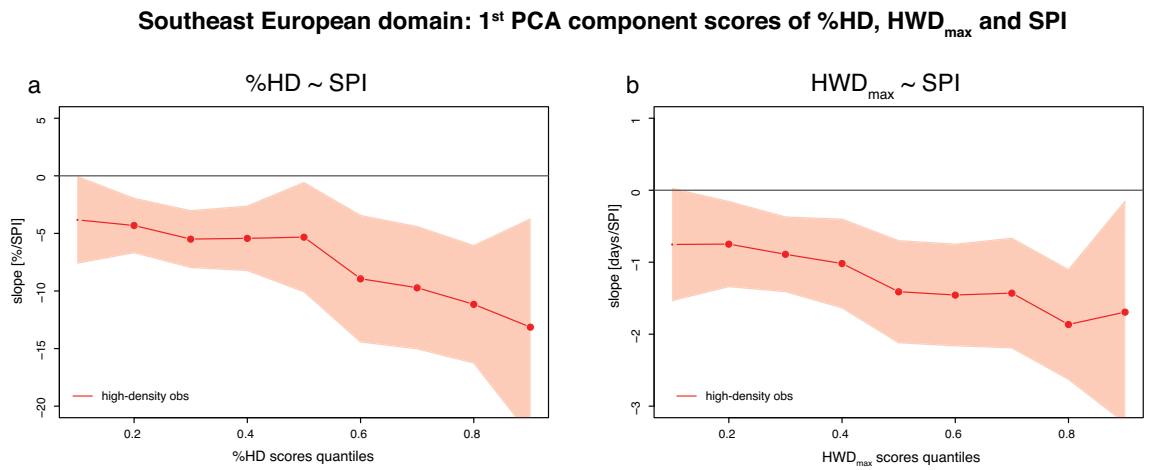
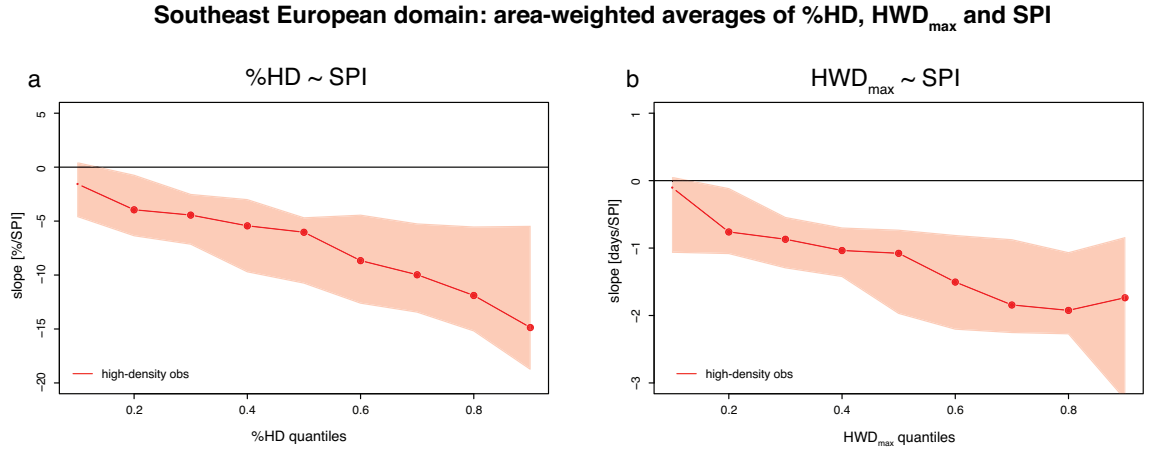
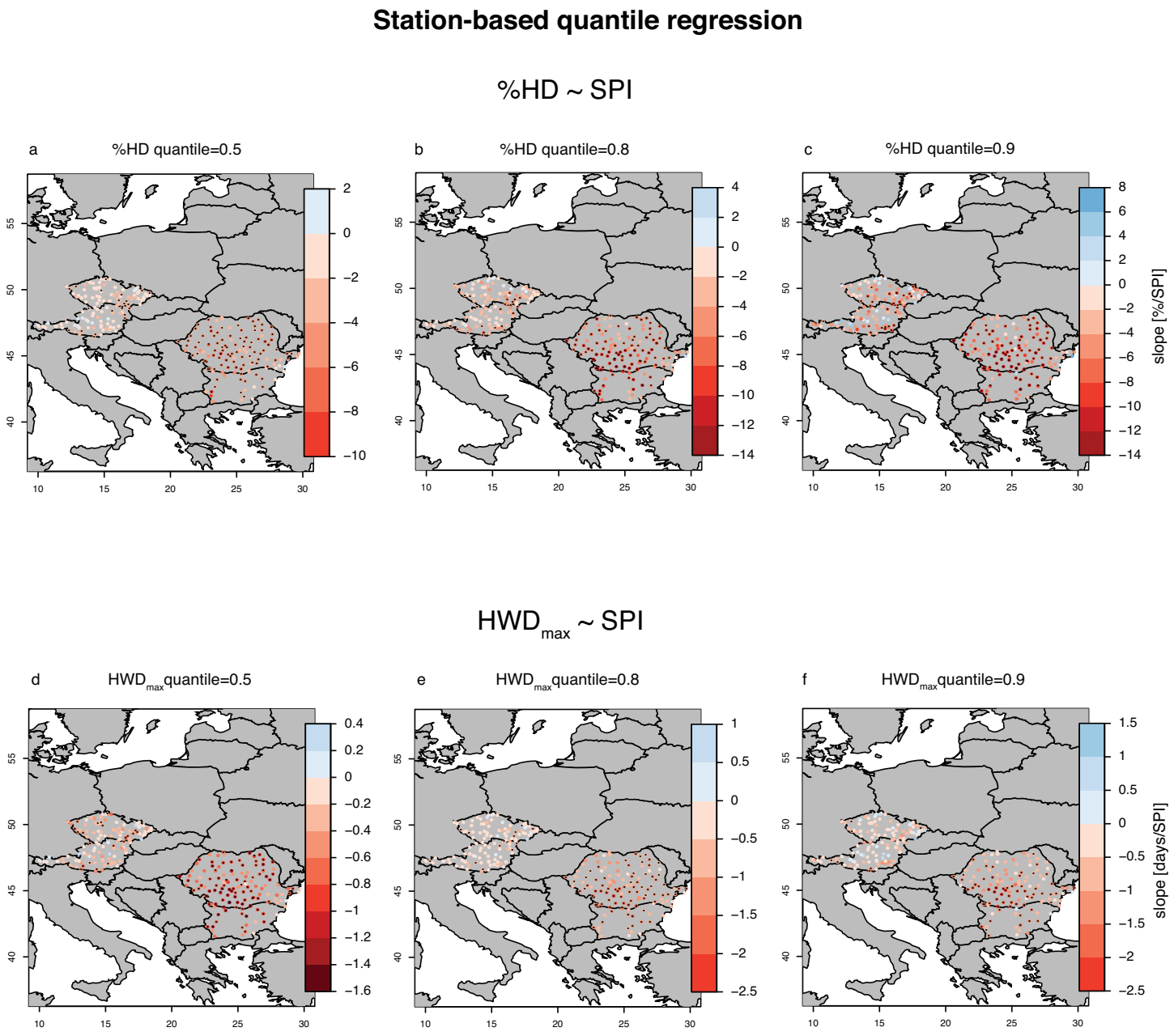


Supplementary Figure 7: Quantile regression analysis (1st PCA component scores). Quantile regression slopes of the 0.1–0.9 quantiles of (a) %HD and (b) HWD_{max} in relation to SPI for the 1st PCA component scores of the variables from the high-density station observations (seasonal mean JJA values) in the Southeast European domain. The 95% confidence intervals (from a pairwise bootstrap) of the estimated slopes are displayed as shadings, with significant slopes denoted with a bold dot (5% significance level, two-tailed test).



Supplementary Figure 8: Quantile regression analysis (area-weighted averages). Quantile regression slopes of the 0.1–0.9 quantiles of (a) %HD and (b) HWD_{max} in relation to SPI for the area-weighted domain averages of the variables from the high-density station observations in the Southeast European domain. The 95% confidence intervals of the estimated slopes are displayed as shadings, with significant slopes denoted with a bold dot (5% significance level, two-tailed test).



Supplementary Figure 9: Station-based quantile regression analysis. Quantile regression slopes of the 0.5, 0.8 and 0.9 quantiles of (a,b,c) %HD and (d,e,f) HWD_{max} in relation to SPI for the seasonal mean JJA high-density station data. Significant slopes are denoted with a black dot inside the coloured dot (5% significance level, two-tailed test).