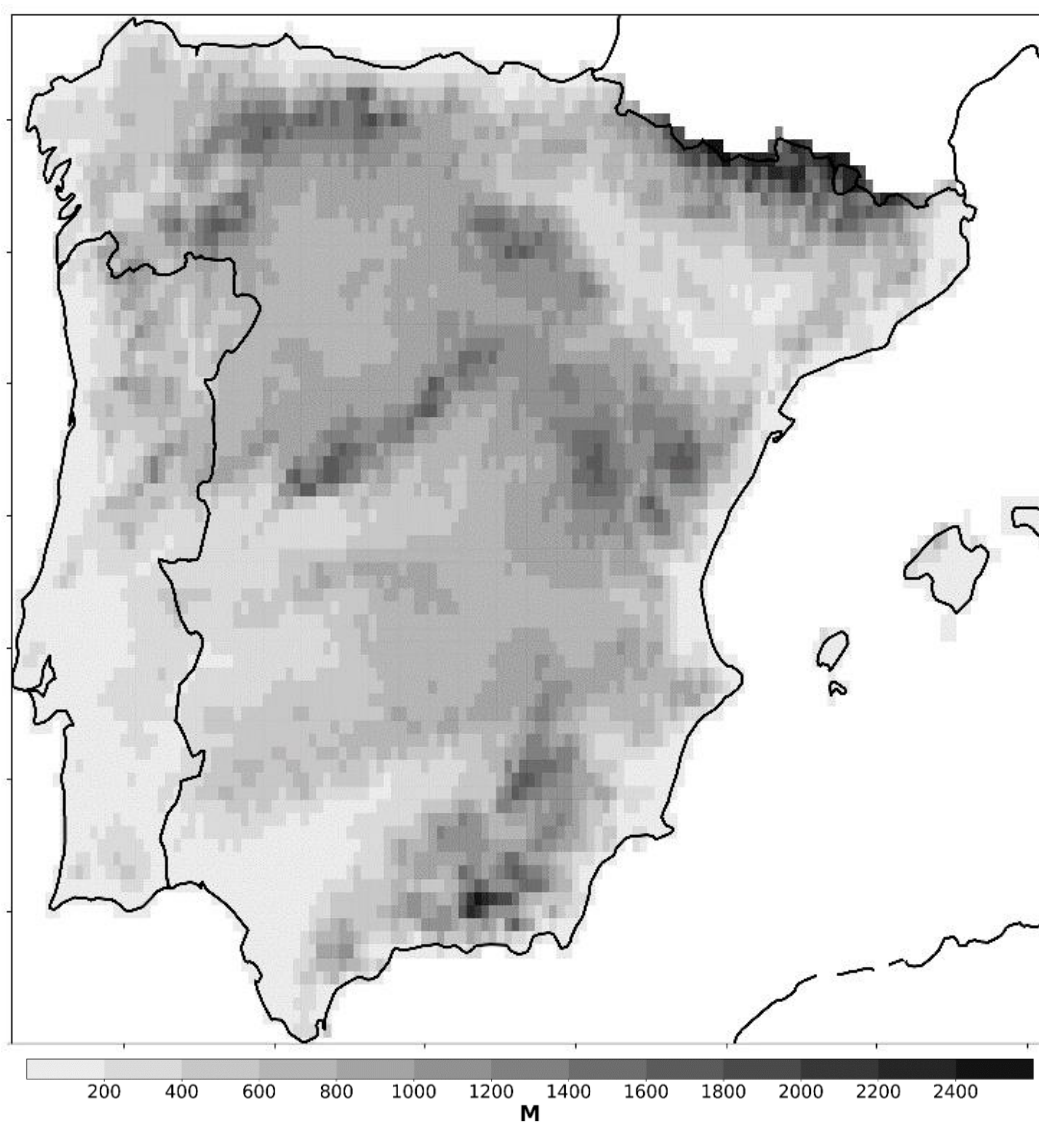Geoscientific
Model Development

Open Access

EGU

Supplement of

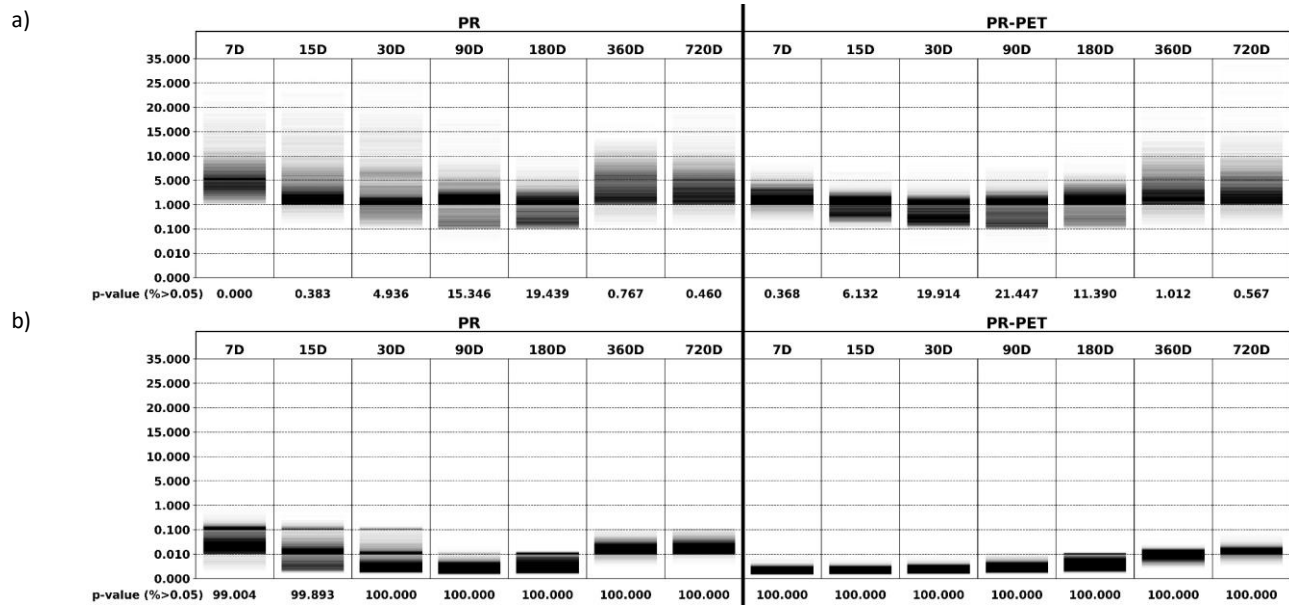# Generalised drought index: a novel multi-scale daily approach for drought assessment

João António Martins Careto et al.

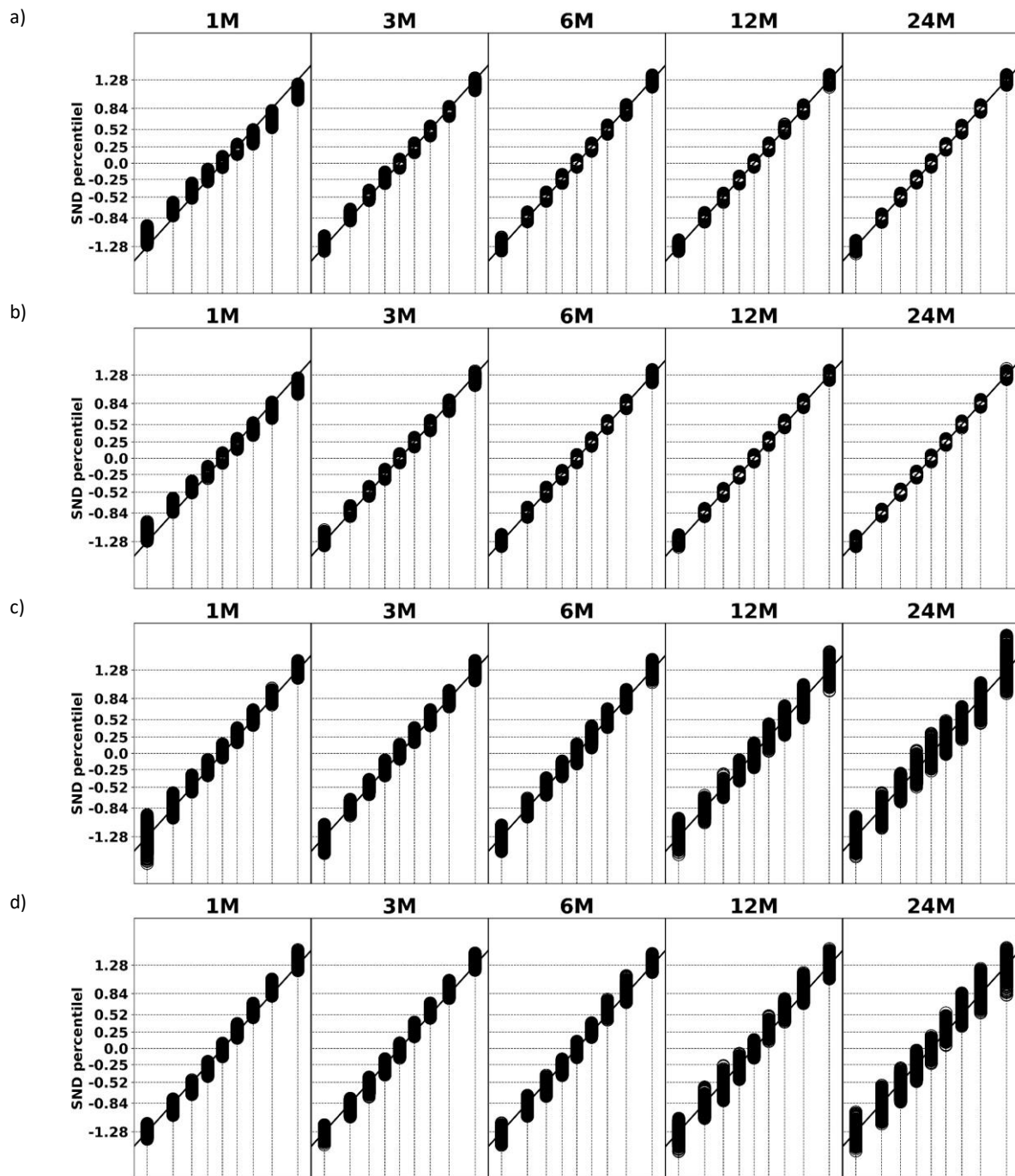*Correspondence to:* João António Martins Careto (jacareto@ciencias.ulisboa.pt)

Figure S1. Orography for IB01 dataset at 0.1º resolution

a)

	PR							PR-PET						
	7D	15D	30D	90D	180D	360D	720D	7D	15D	30D	90D	180D	360D	720D
p-value (%>0.05)	0.000	0.383	4.936	15.346	19.439	0.767	0.460	0.368	6.132	19.914	21.447	11.390	1.012	0.567

b)

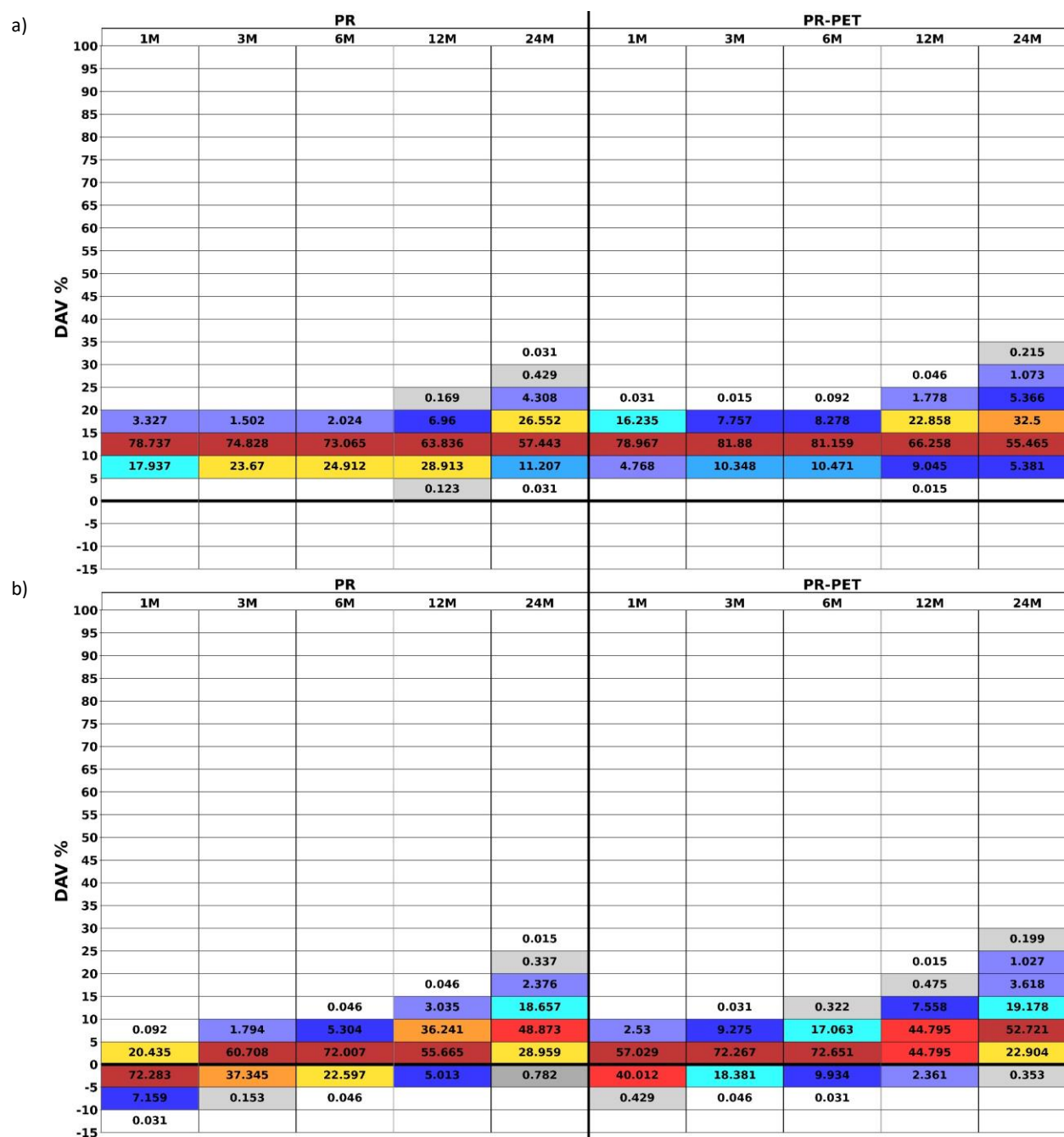|	PR							PR-PET						
	7D	15D	30D	90D	180D	360D	720D	7D	15D	30D	90D	180D	360D	720D
p-value (%>0.05)	99.004	99.893	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

Figure S2. Two-sample Cramér-von Mises for the (a) SPI and SPEI index and (b) GDI index. The plotted values show the Cramér-von Mises statistics and the values on the x-axis correspond to the percentage of points with a p-value above the 5% significance level. The two samples correspond to the empirical distribution of the data and the fitted cumulative distribution obtained from each index. If for a certain point, the p-value is above the significance level, then the hypothesis where both samples came from the same distribution cannot be rejected. The empirical CDF for each location is given by normalising the rank of the data between 0 and 1, where the first value is close to 1/n and the last value is 1-1/n, where n corresponds to the length of data at each location. The factor used in eq. 17 is also considered here. Each column denotes the accumulation periods, where PR stands for accumulated precipitation (left) and PR-PET stands for accumulated precipitation minus potential evapotranspiration (right). The lines represent each land point for the IB01 observations.
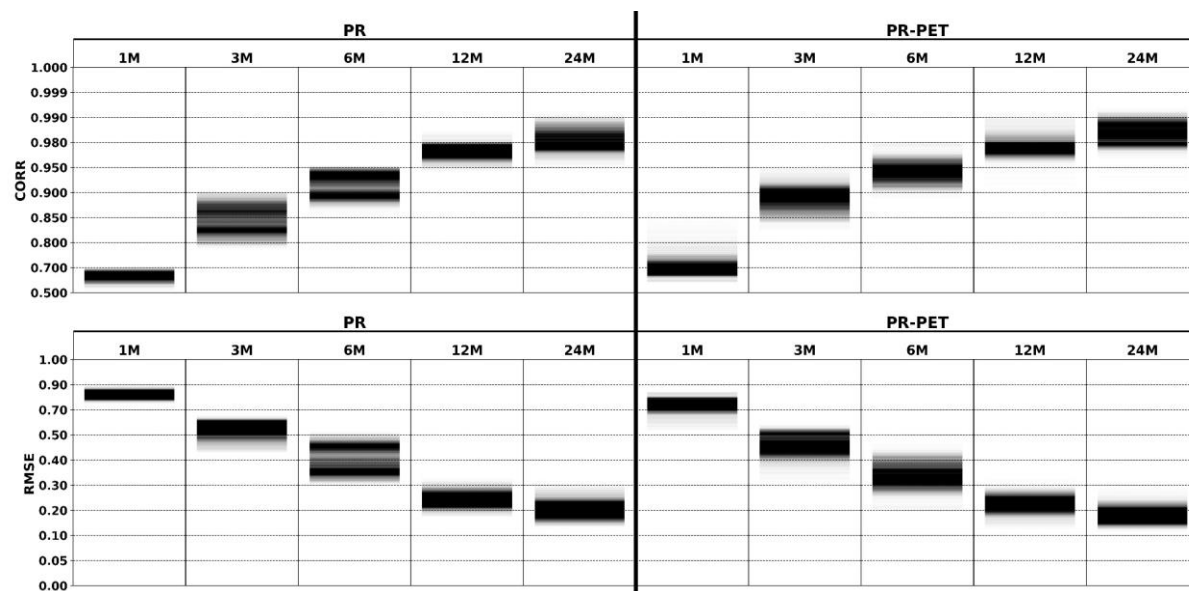
Figure S3. Quantile-Quantile plot against the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th and 90th percentile from the standard normal distribution for all grid points of IB01 dataset for (a) GDI (PR), (b) GDI (PR-PET), (c) SPI, (d) SPEI for the monthly indices. A smaller vertical spread indicates a better agreement with the standard normal distribution from all locations. The numbers of the y-axis, the horizontal and vertical lines correspond to the percentiles of the standard normal distribution (SND percentile).

Figure S4. Statistics for the SPI or SPEI (red), Z-Score standardisation (blue) and GDI (green) indices. From top to bottom, the rows are Mean, Median, Standard Deviation minus 1, Interquartile range minus the difference between the 75th and the 25th percentile from the standard normal distribution, third-moment Skewness, Yule-Kendall Skewness, and the fourth-moment Fisher definition of Kurtosis. Each column denotes the accumulation periods, where PR stands for accumulated precipitation indices while PR-PET stands for accumulated precipitation minus potential evapotranspiration indices.
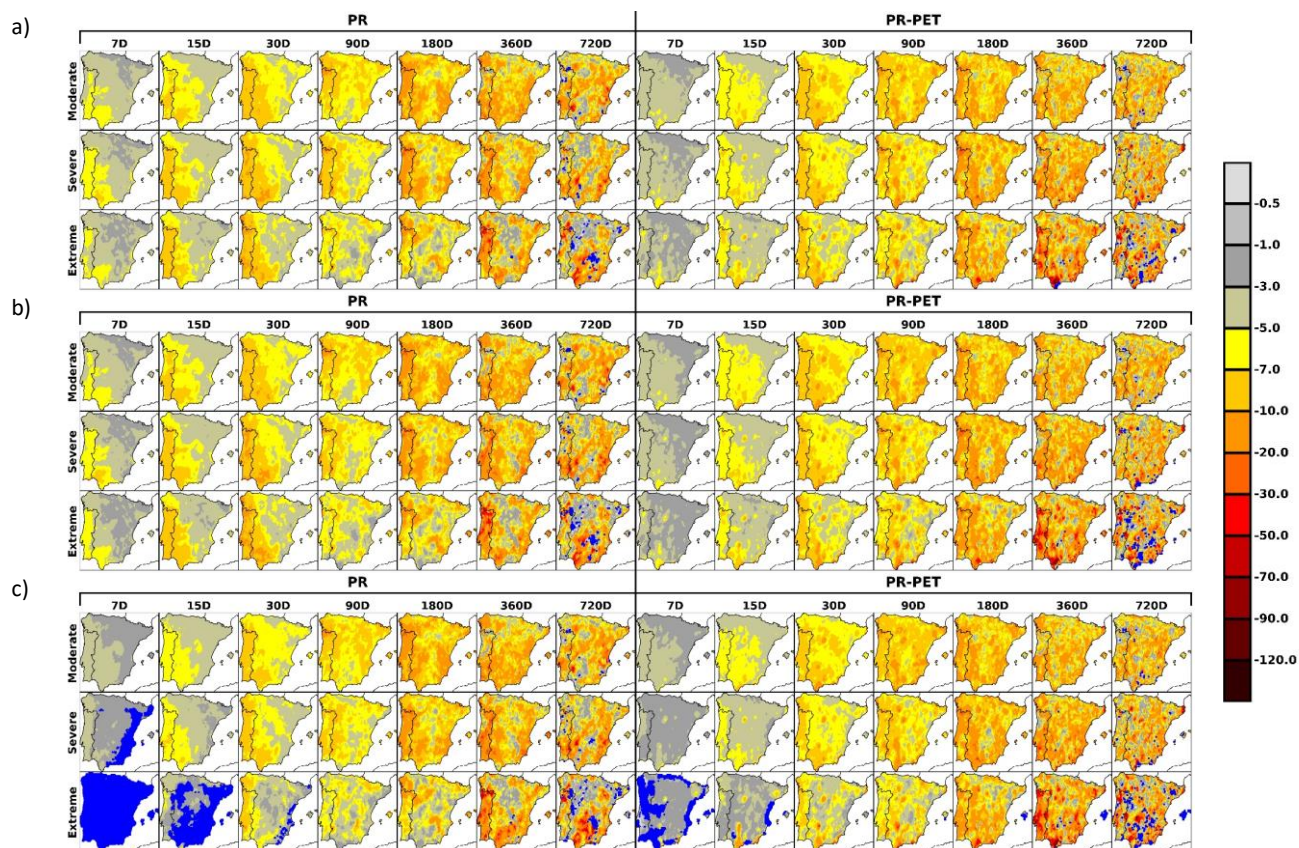
Table S1. Distribution Added Value for (a) daily GDI against the monthly SPI or SPEI, (b) monthly GDI against the monthly SPI or SPEI. Each column denotes the accumulation periods, where PR stands for accumulated precipitation (left) and PR-PET stands for accumulated precipitation minus potential evapotranspiration (right). The colours and values in each cell correspond to the percentage of land points within the respective DAV category. The Perkins Skill Score is built by confronting each index histogram against the normal distribution histogram. The DAV is then computed as the relative difference between each index Perkins Skill Score, and for each location individually. The table shows the percentage of land points falling within each DAV category. In table S1a, 1M corresponds to 30D, 3M to 90D, 6M to 180D, 12M to 360M and 24M to 720D.

a)

DAV % band	PR 1M	PR 3M	PR 6M	PR 12M	PR 24M	PR-PET 1M	PR-PET 3M	PR-PET 6M	PR-PET 12M	PR-PET 24M
~31				0.031						0.215
~28					0.429				0.046	1.073
~23				0.169	4.308	0.031	0.015	0.092	1.778	5.366
~18	3.327	1.502	2.024	6.96	26.552	16.235	7.757	8.278	22.858	32.5
~13	78.737	74.828	73.065	63.836	57.443	78.967	81.88	81.159	66.258	55.465
~9	17.937	23.67	24.912	28.913	11.207	4.768	10.348	10.471	9.045	5.381
~6				0.123	0.031				0.015	

b)

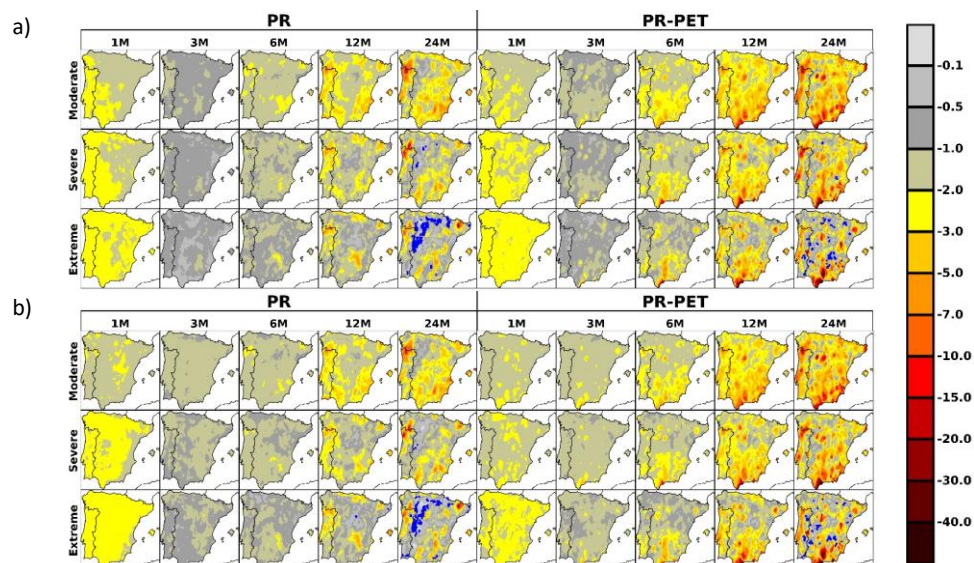| DAV % band	PR 1M	PR 3M	PR 6M	PR 12M	PR 24M	PR-PET 1M	PR-PET 3M	PR-PET 6M	PR-PET 12M	PR-PET 24M
~29					0.015					0.199
~24					0.337				0.015	1.027
~20				0.046	2.376				0.475	3.618
~15			0.046	3.035	18.657		0.031	0.322	7.558	19.178
~10	0.092	1.794	5.304	36.241	48.873	2.53	9.275	17.063	44.795	52.721
~5	20.435	60.708	72.007	55.665	28.959	57.029	72.267	72.651	44.795	22.904
~0	72.283	37.345	22.597	5.013	0.782	40.012	18.381	9.934	2.361	0.353
~-5	7.159	0.153	0.046			0.429	0.046	0.031		
~-10	0.031									

Figure S5. Pearson correlation (top) and Root Mean Squared Error (bottom) between the monthly GDI index against the monthly SPI or SPEI. Each column denotes the accumulation periods, where PR stands for accumulated precipitation (left) and PR-PET stands for accumulated precipitation minus potential evapotranspiration (right). The lines depict individual land points for the IB01 observations, with darker shading indicating a higher density of closely spaced lines.
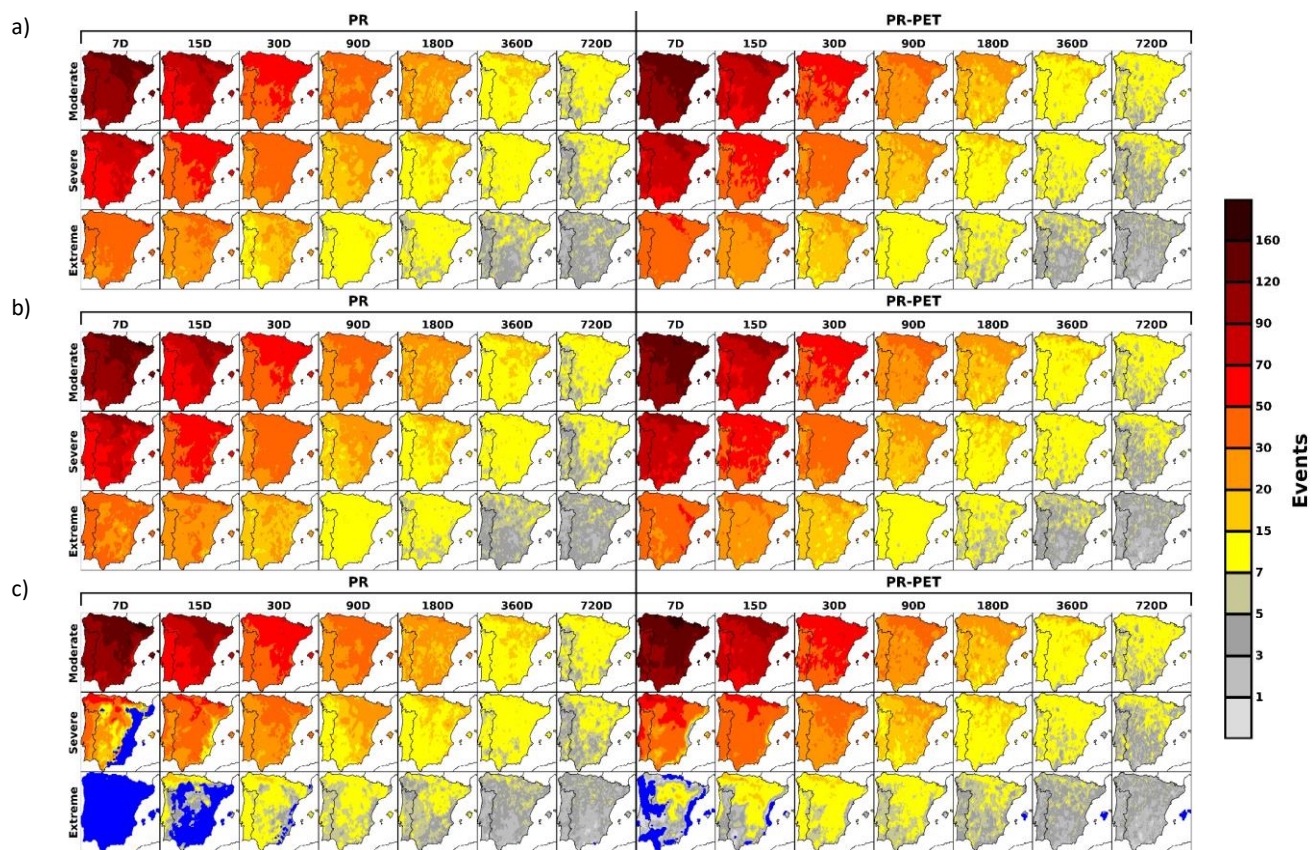
Figure S6. Mean Event Severity for (a) GDI index, (b) SPI or SPEI and (c) Z-Score index. Within each panel, the results are shown for moderate, severe and extreme drought. Each column denotes the accumulation periods, where PR stands for accumulated precipitation indices while PR-PET stands for accumulated precipitation minus potential evapotranspiration indices. The land locations which do not display values are marked in blue.
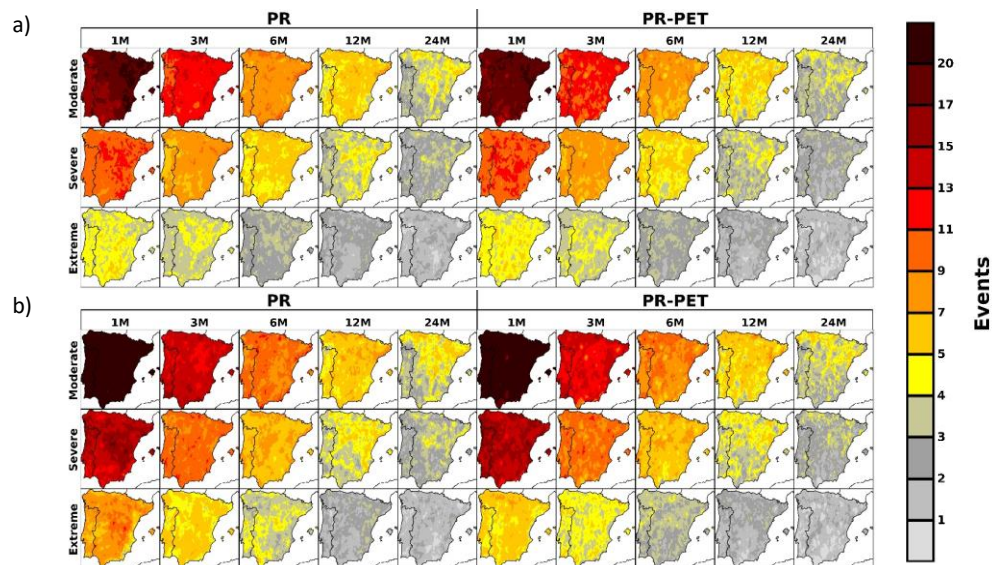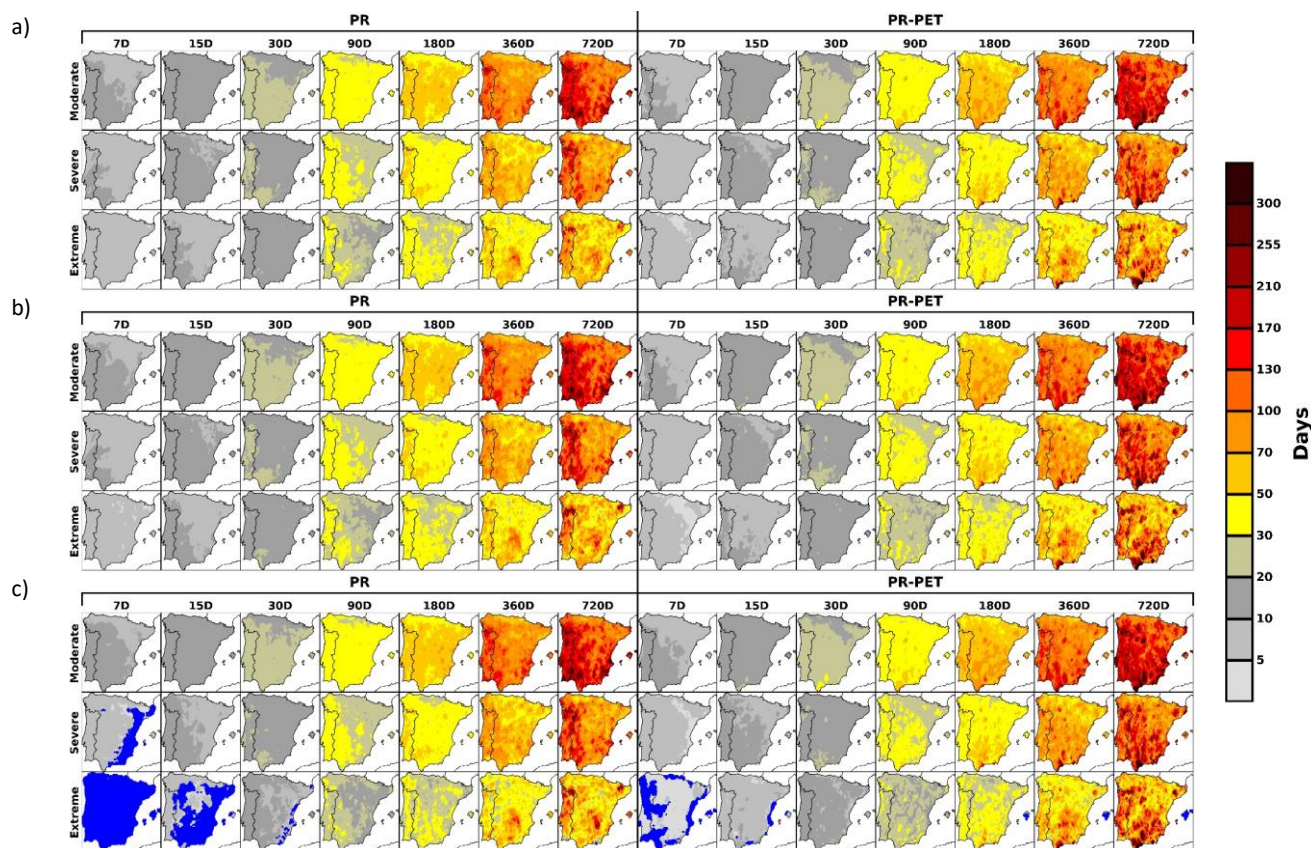

Figure S7. Mean Event Severity for monthly (a) GDI index and (b) SPI or SPEI indices. Within each panel, the results are shown for moderate, severe and extreme drought. Each column denotes the accumulation periods, where PR stands for accumulated precipitation indices while PR-PET stands for accumulated precipitation minus potential evapotranspiration indices. The land locations which do not display values are marked in blue.
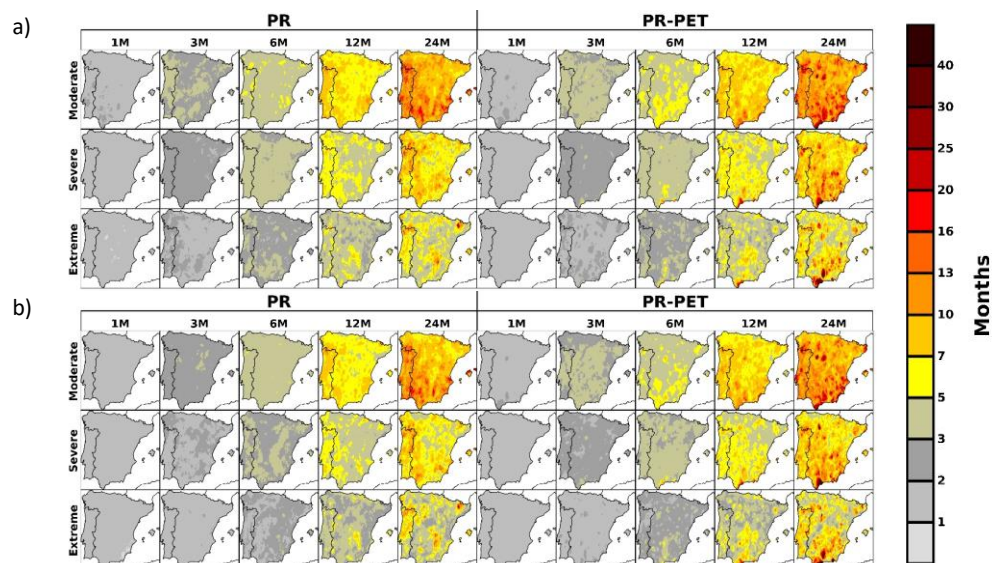
Figure S8: Decadal Event Frequency for (a) GDI index, (b) SPI or SPEI and (c) Z-Score index. Within each panel, the results are shown for moderate, severe and extreme drought. Each column denotes the accumulation periods, where PR stands for accumulated precipitation indices while PR-PET stands for accumulated precipitation minus potential evapotranspiration indices. The land locations which do not display values are marked in blue.

Figure S9. Decadal Event Frequency for monthly (a) GDI index and (b) SPI or SPEI indices. Within each panel, the results are shown for moderate, severe and extreme drought. Each column denotes the accumulation periods, where PR stands for accumulated precipitation indices while PR-PET stands for accumulated precipitation minus potential evapotranspiration indices. The land locations which do not display values are marked in blue.

Figure S10. Mean Event Duration for (a) GDI index, (b) SPI or SPEI and (c) Z-Score index. Within each panel, the results are shown for moderate, severe and extreme drought. Each column denotes the accumulation periods, where PR stands for accumulated precipitation indices while PR-PET stands for accumulated precipitation minus potential evapotranspiration indices. The land locations which do not display values are marked in blue.

Figure S11. Mean Event Duration for monthly (a) GDI index and (b) SPI or SPEI indices. Within each panel, the results are shown for moderate, severe and extreme drought. Each column denotes the accumulation periods, where PR stands for accumulated precipitation indices while PR-PET stands for accumulated precipitation minus potential evapotranspiration indices. The land locations which do not display values are marked in blue.

Table S2. Spatial Pearson Correlation (blue) and spatial Root Mean Squared Error (red) between the monthly GDI against the monthly SPI or SPEI. Each row, for both panels and from top to bottom, represents the drought intensity, drought mean decadal frequency, and drought mean duration. The last row displays a time Pearson Correlation and Root Mean Squared Error for the drought spatial extent. These results are presented only for moderate drought (index< -0.5). Each column denotes the accumulation periods, where PR stands for accumulated precipitation (left) and PR-PET stands for accumulated precipitation minus potential evapotranspiration (right). The colours denote extremes of either correlation or RMSE.
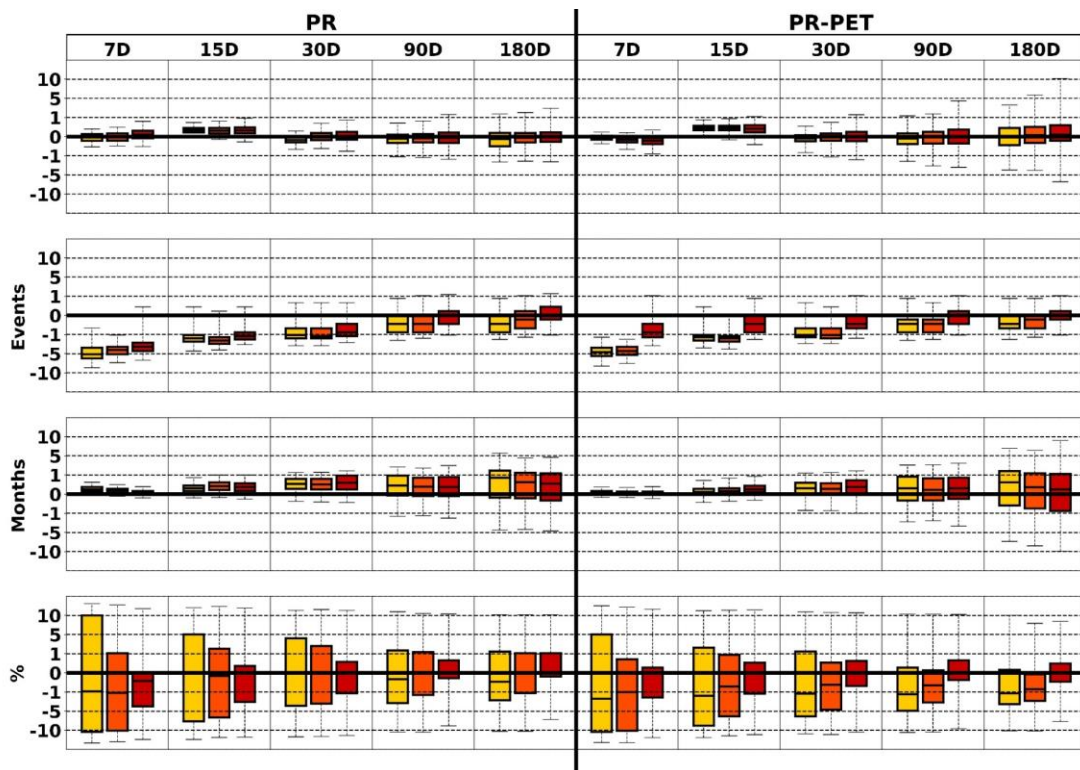
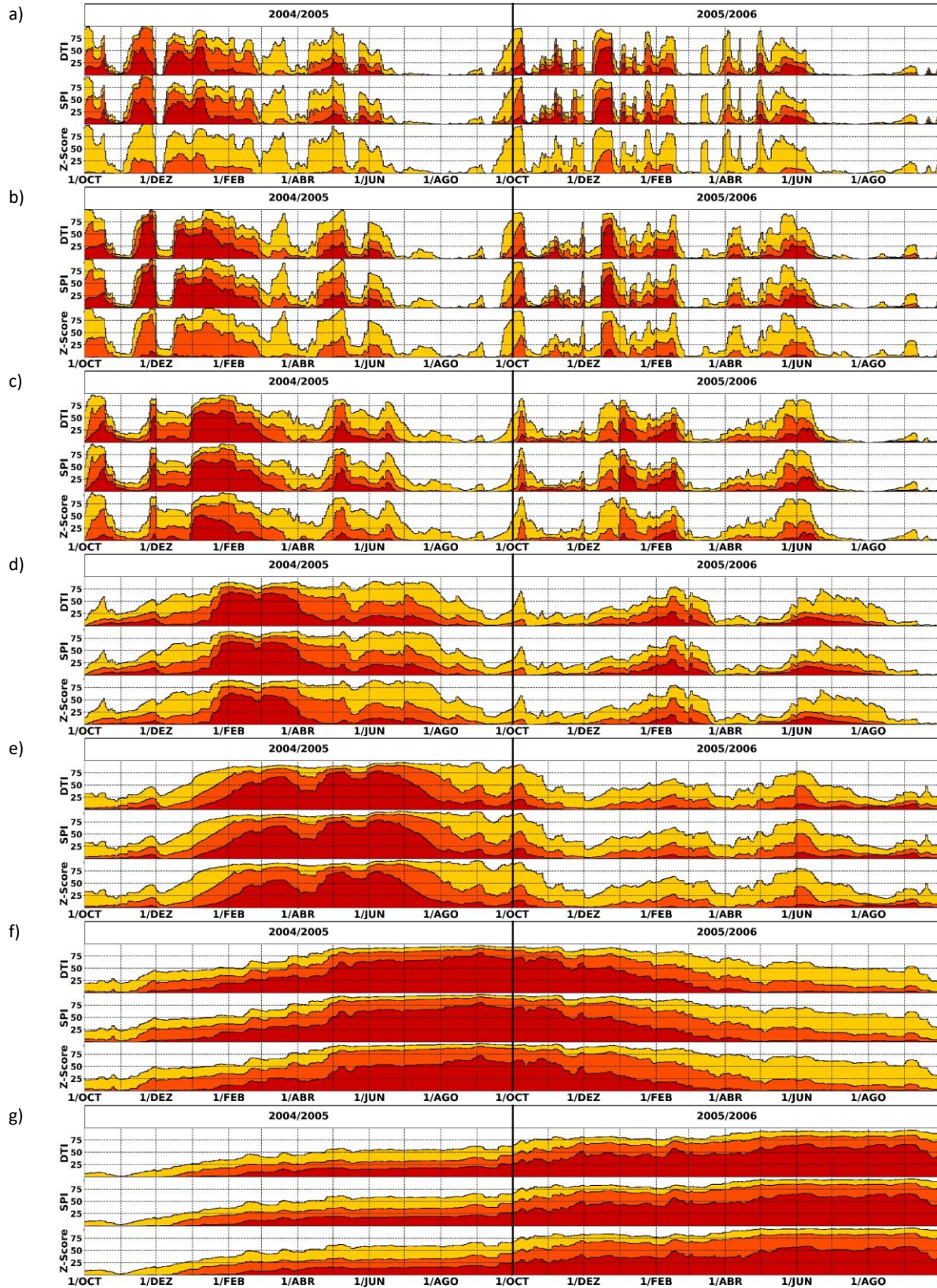|		PR					PR-PET			
	7D	15D	30D	90D	180D	7D	15D	30D	90D	180D
MES	0.147 / 0.231	0.463 / 0.381	0.864 / 0.255	0.919 / 0.387	0.911 / 0.751	0.711 / 0.145	0.882 / 0.488	0.938 / 0.292	0.934 / 0.648	0.909 / 1.457
MDF	0.276 / 5.267	0.228 / 2.103	0.482 / 1.481	0.773 / 0.837	0.818 / 0.776	0.523 / 4.920	0.627 / 1.856	0.741 / 1.350	0.808 / 0.839	0.800 / 0.714
MED	0.026 / 0.305	0.349 / 0.381	0.506 / 0.669	0.763 / 0.977	0.775 / 2.083	0.713 / 0.142	0.709 / 0.271	0.793 / 0.555	0.796 / 1.167	0.784 / 2.650
SPA	0.583 / 25.553	0.821 / 16.849	0.905 / 12.151	0.963 / 7.141	0.982 / 4.803	0.670 / 23.575	0.880 / 14.080	0.940 / 9.713	0.971 / 6.397	0.986 / 4.120

Pearson Correlation: <0.7   >0.9
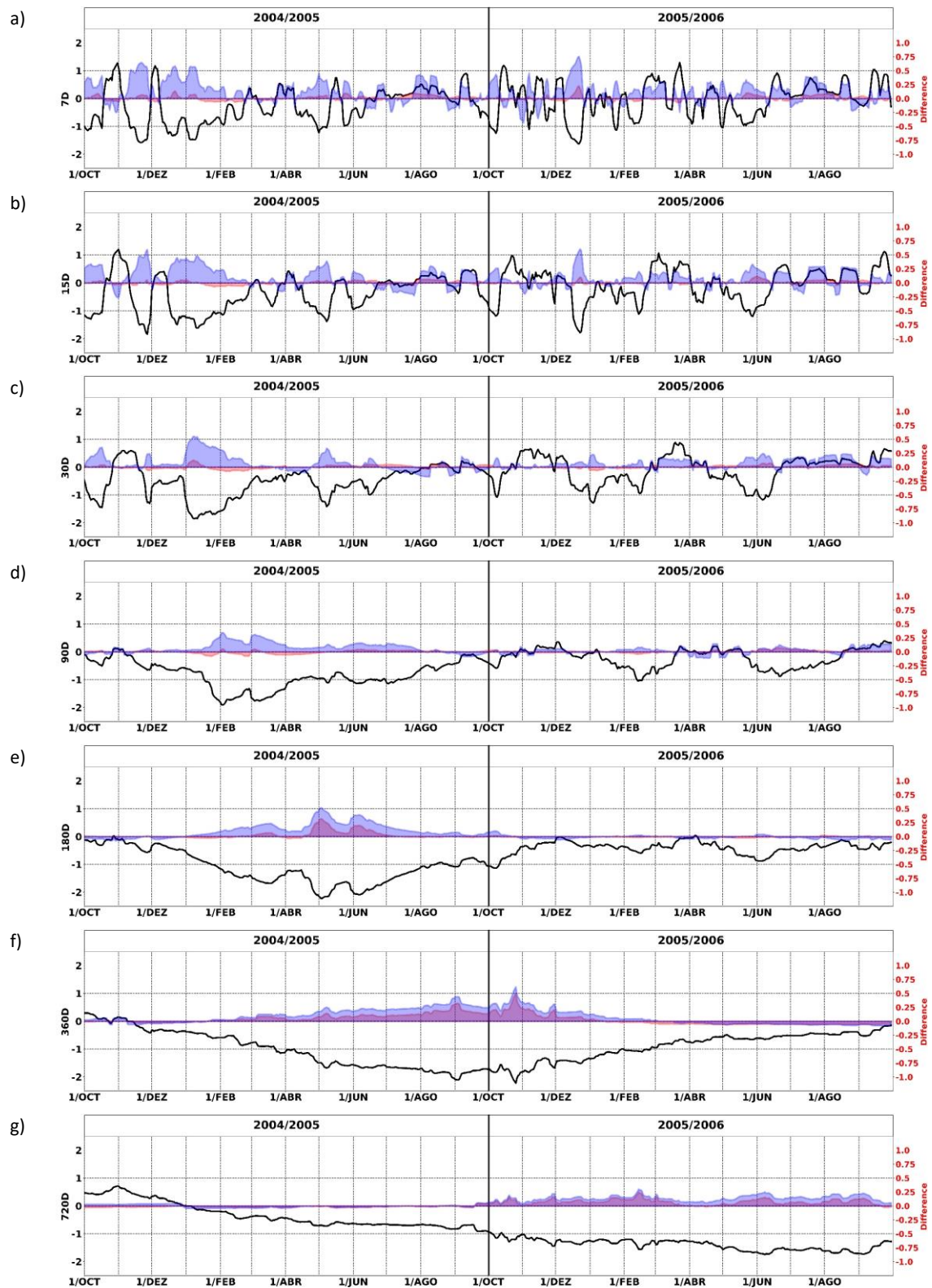
Root Mean Squared Error: <1   >10

Figure S12. Boxplot of all land points featuring the difference in drought characteristics between the monthly GDI index and the monthly SPI or SPEI. The monthly GDI index was obtained by aggregating the results of the daily index for each month. In each sub-figure, from top to bottom: the mean event severity, decadal frequency, mean event duration and spatial extent of droughts. For the case of drought spatial extent, the differences are made for each time step. Each column denotes the accumulation periods, where PR stands for accumulated precipitation (left) and PR-PET stands for accumulated precipitation minus potential evapotranspiration (right). The different boxplot denotes the results for moderate drought for index <-0.5 (yellow), severe drought for index <-1 (orange) and extreme drought for index <-1.5 (red). For each boxplot, the low (high) whisker denotes the 1st (99th) percentile, while the three horizontal lines within the box correspond, from bottom to top to the 25th, 50th and 75th percentiles.

Figure S13. Time series of the daily drought spatial extent of the period from 1 October 2004 until 30 September 2006 for the IB01 with aggregations of (a) 7-, (b) 15-, (c) 30-, (d) 90-, (e) 180-, (f) 360- and (g) 720-days. In each panel the top row displays the results for the GDI index, the middle row for the SPI index and the bottom row for the Z-Score standardization. All indices consider only the precipitation. The yellow colour denotes the results for moderate drought for index <-0.5, light orange for severe drought for index <-1 and dark orange for extreme drought for index <-1.5.

Figure S14. Area average time series of the daily drought indices for the period from 1 October 2004 until 30 September 2006 for the IB01 dataset with aggregations of (a) 7-, (b) 15-, (c) 30-, (d) 90-, (e) 180-, (f) 360- and (g) 720-days. The black line represents the GDI index, while the red and blue shadings denote, respectively, the absolute differences between the GDI and SPI and between GDI and the Z-Score index. All indices only consider the precipitation a input.