

## **Supplementary Material - Daily identification of compound drought and heatwave across four seasons**

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This supplementary material includes:

Table S1: The days per year and events number per year compared before after removing and merging

Table S2: Trend test of annual days for drought, heatwave, and CDHW events based on Mann Kendall statistic test for different cumulation periods and pre-identification thresholds.

Fig. S1: Mann Kendall statistic test at 0.05 level for daily mean temperature over 1901-2020 and 30-years moving window.

Fig. S2: Distribution of duration of droughts and heatwaves without removing and merging.

Fig. S3: Identification of drought, heatwave, and CDHW events (union, conditioned on drought, conditioned on heatwave, and intersection).

Table S1: The days per year and events number per year compared before after removing and merging

		Without removing and merging			After removing and merging		
Drought	Scales	SPI <sub>T</sub> =-0.5	SPI <sub>T</sub> =-1	SPI <sub>T</sub> =-1.5	SPI <sub>T</sub> =-0.5	SPI <sub>T</sub> =-1	SPI <sub>T</sub> =-1.5
	15	103.6, 11.0	56.8, 7.8	38.4, 5.9	37.8, 1.12	28.3, 1.13	21.2, 1.18
	30	111.6, 7.2	58.8, 5.2	36.9, 3.8	45.7, 0.65	33.6, 0.68	17.9, 0.55
	45	112.4, 6.1	57.8, 4.0	36.4, 2.9	59.8, 0.78	30.8, 0.60	18.7, 0.43
	60	114.7, 5.0	58.4, 3.3	35, 2.4	62.1, 0.58	28.9, 0.43	24.9, 0.39
	90	115.6, 3.8	60.6, 2.9	36.3, 2.1	67.2, 0.43	30.2, 0.25	23.6, 0.28
Heatwave	Scales	SHI <sub>T</sub> =-0.5	SHI <sub>T</sub> =1	SHI <sub>T</sub> =1.5	SHI <sub>T</sub> =-0.5	SHI <sub>T</sub> =1	SHI <sub>T</sub> =1.5
	3	123.1, 21.9	68.8, 16.4	42.9, 12.6	34.9, 1.83	19.2, 1.56	16.4, 1.88
	5	124.9, 16.5	68.3, 12.0	42.8, 9.0	40.6, 1.73	25.5, 1.83	16.4, 1.47
	7	125.1, 13.6	68.3, 9.8	43.4, 7.5	23.5, 0.49	29.9, 1.90	16.5, 1.09
	10	126, 11.1	68.6, 7.8	44.5, 6.1	41.12, 1.23	33.6, 1.76	18.6, 1.08
	15	127.6, 8.5	69.6, 6.2	44.8, 4.6	49.1, 1.03	33.6, 1.30	15.4, 0.58

Table S2: Trend test of annual days for drought, heatwave, and CDHW events based on Mann Kendall statistic test for different cumulation periods and pre-identification thresholds. Values larger than 1.96 mean significant positive trends at 0.05 level while values less than -1.96 means significant negative trends.

Start and end thresholds	Scales of drought	Scales of heatwave	Trend for drought	Trend for heatwave	Union	H D	D H	Intersection
SPI=-1(or SHI=1)	15	3	0.22	3.67	1.47	1.46	1.52	1.53
	30	5	1.33	3.59	1.70	1.67	1.55	1.50
	45	7	0.64	2.54	0.43	0.44	0.30	0.37
	60	10	-0.03	2.57	0.60	0.53	0.64	0.54
	90	15	0.02	2.74	0.33	0.33	0.31	0.28
SPI=-1.3(or SHI=1.3)	15	3	0.42	4.10	1.68	1.70	1.74	1.78
	30	5	0.56	3.88	0.47	0.47	0.44	0.42
	45	7	0.88	2.76	0.51	0.51	0.53	0.49
	60	10	0.30	3.31	0.74	0.76	0.62	0.66
	90	15	0.21	2.30	0.38	0.39	0.40	0.39

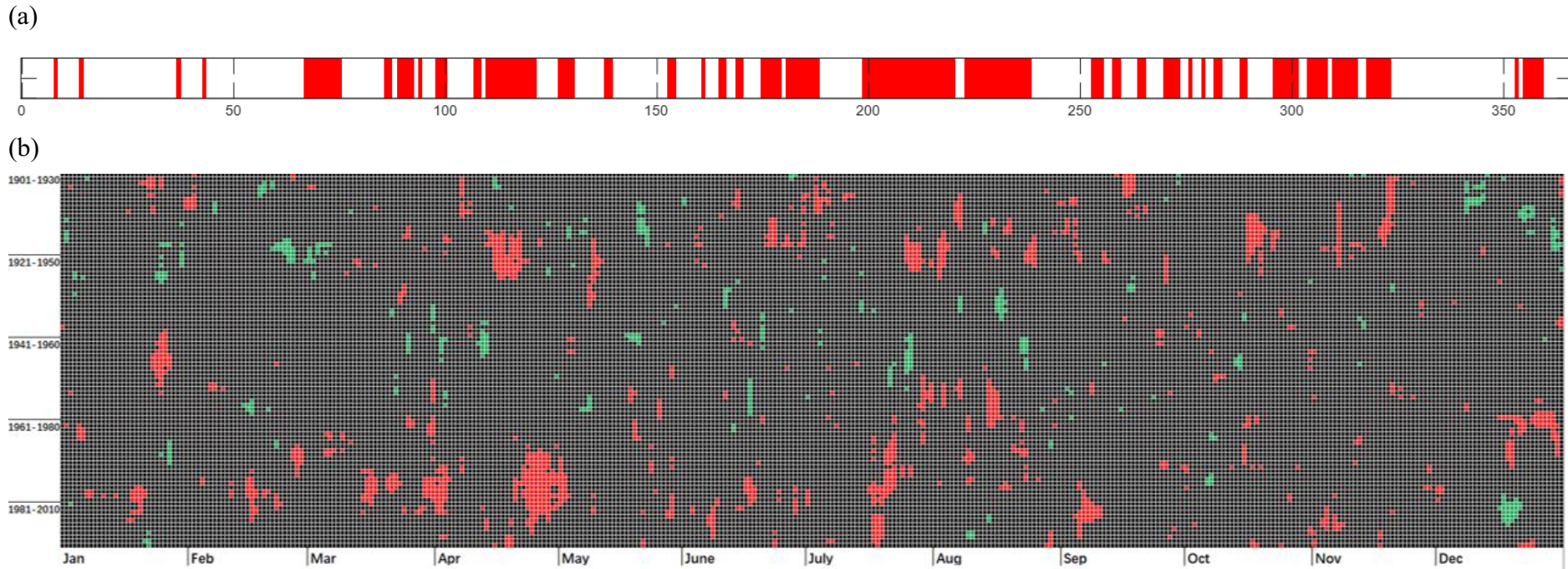
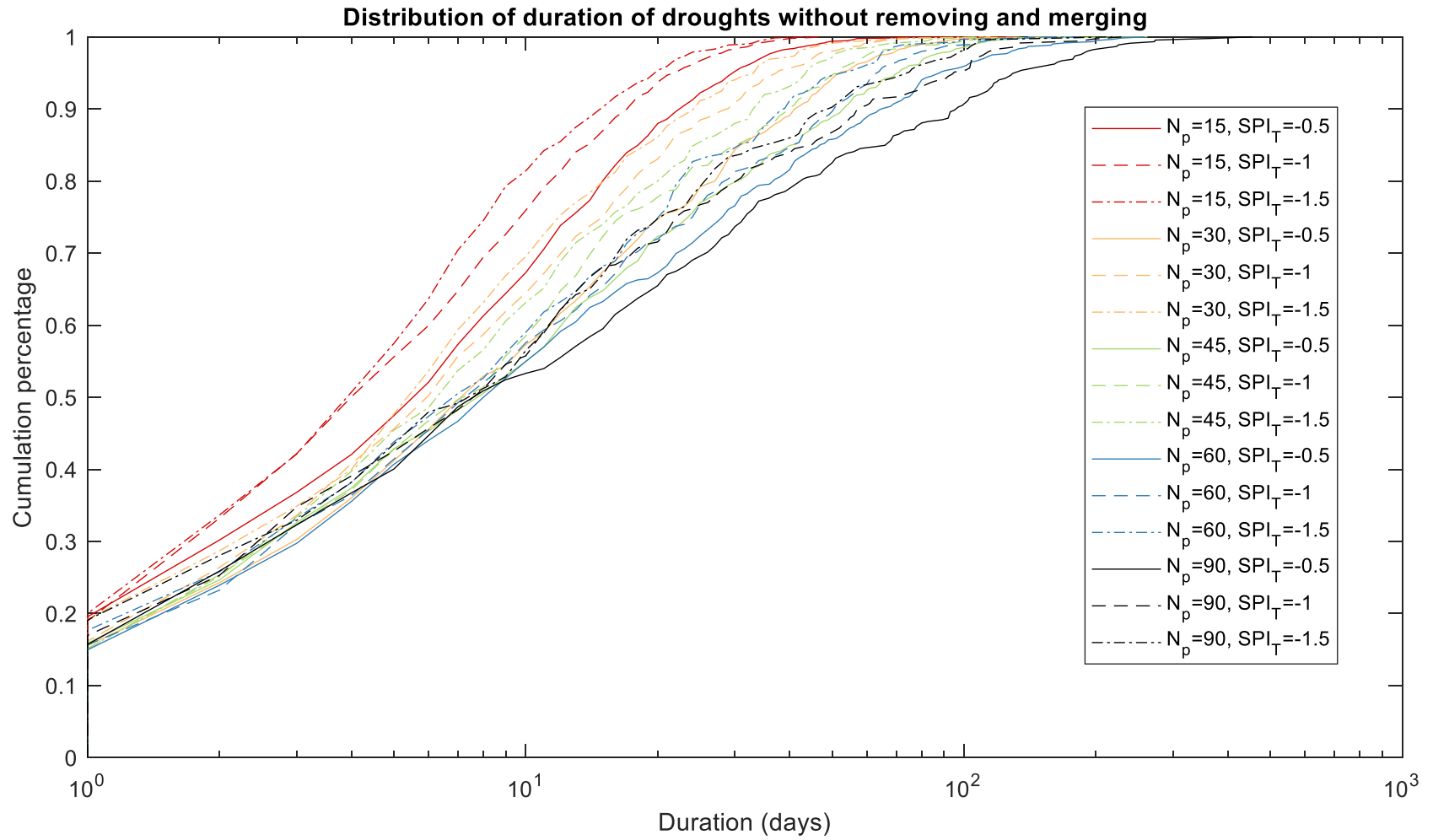


Fig. S1: Mann Kendall statistic test at 0.05 level for daily mean temperature over 1901-1920 (a) and 30-years moving window(b). Red is for significant increasing trends; Green is for significant negative trends; White in (a) and black in (b) mean there is no clear trend. Over the whole time series, test results show 147 days over 365 days have a significant increasing trend and no day has a decreasing trend. For 30-years moving window, on average, only 5.59% periods have a clear trend: 4.38% is increasing and 1.22% is decreasing. Results indicate it is easy and effective to handle nonstationary by regarding the "normal" condition as the past 30-years, instead of the whole period.

(a) Distribution of duration of droughts without removing and merging



(b) Distribution of duration of heatwaves without removing and merging

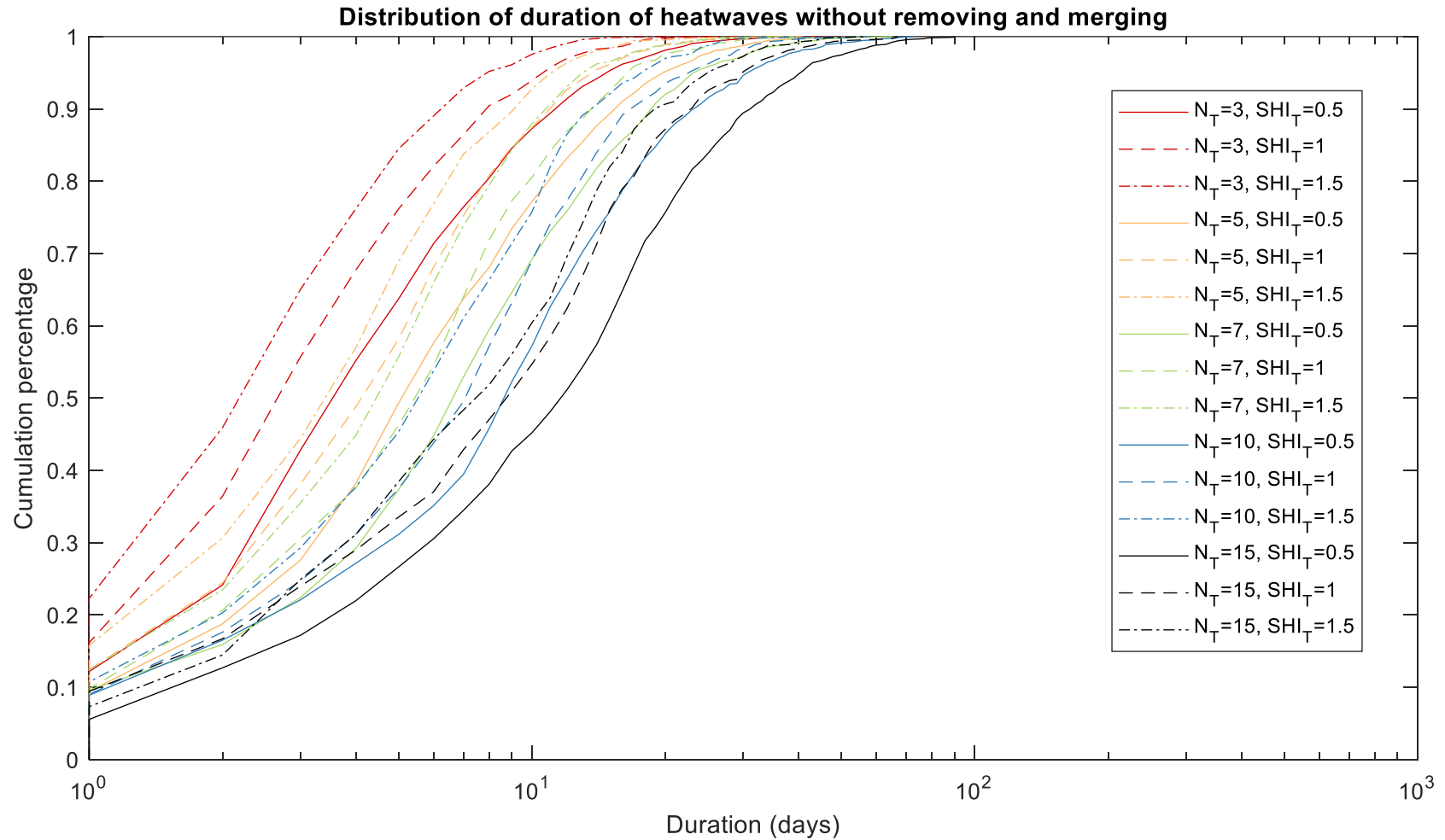
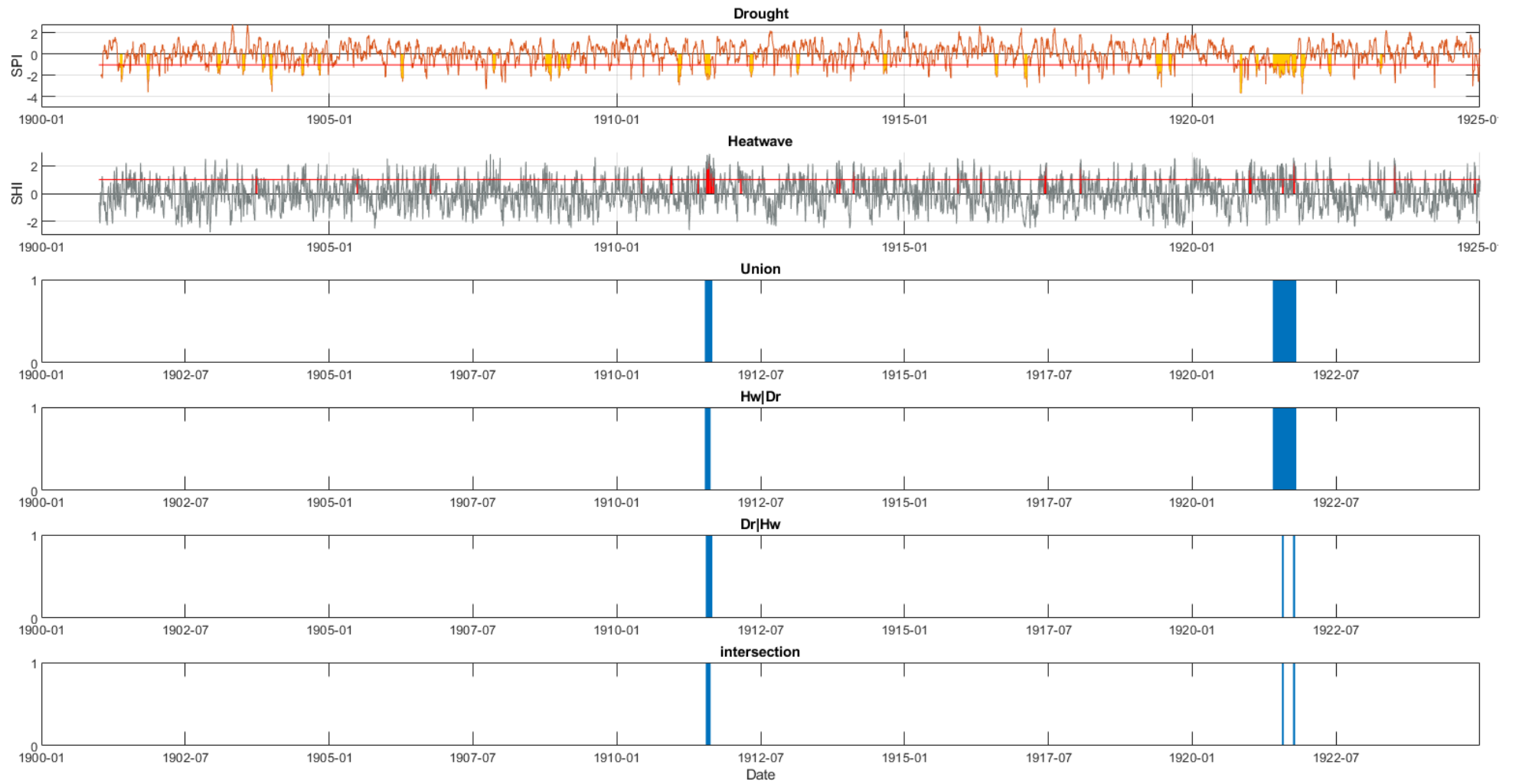
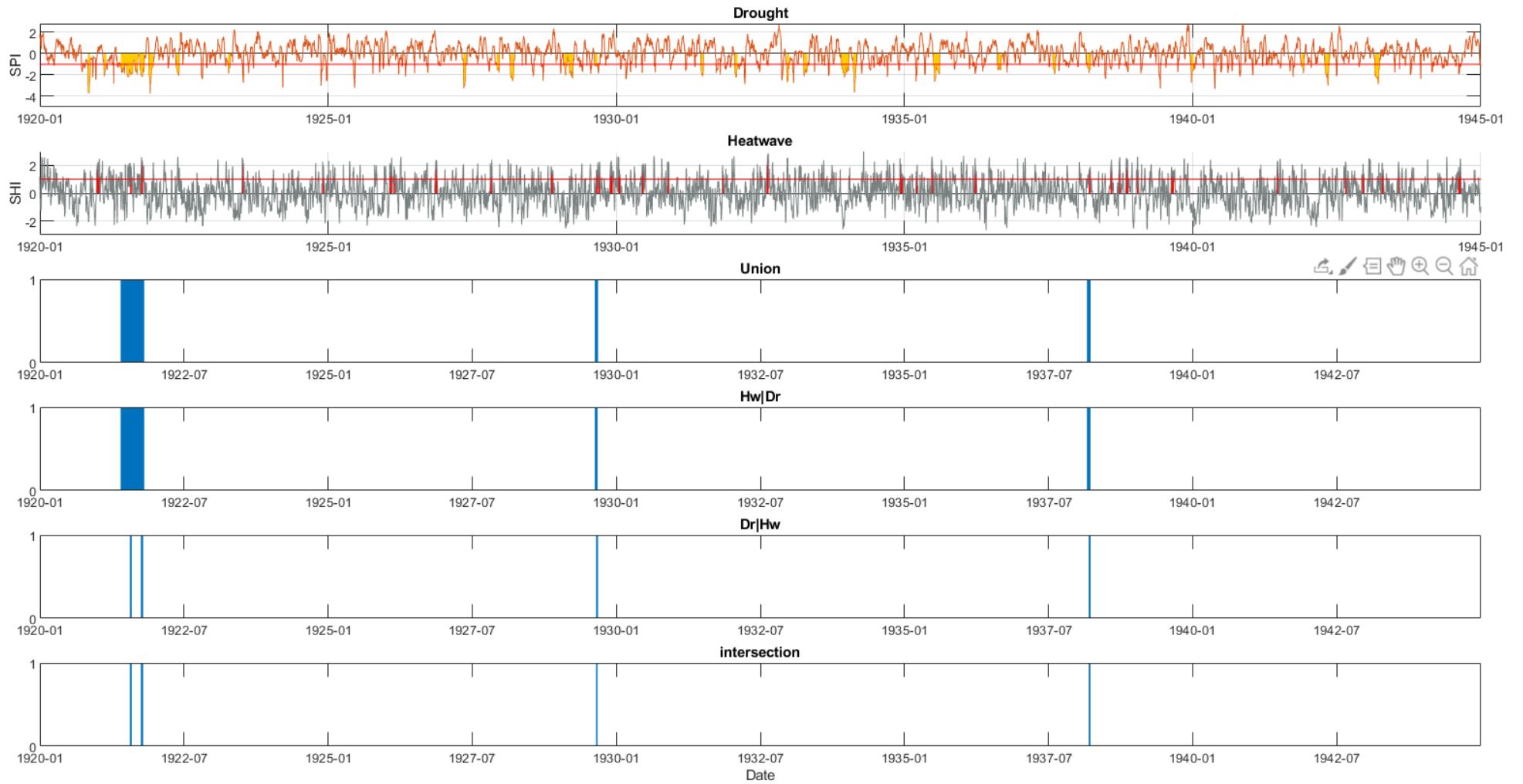


Fig. S2: Distribution of duration of droughts(a) and heatwaves(b) without removing and merging.  $N_P$  and  $N_T$  are cumulation periods of droughts and heatwaves, respectively.  $SPI_T$  and  $SHI_T$  are pre-identification thresholds of droughts and heatwaves, respectively. We can find that the too short durations occupy a large percentile without removing and merging, which could disturb the extreme analysis.

(a) Identification results over the period 1901-1920

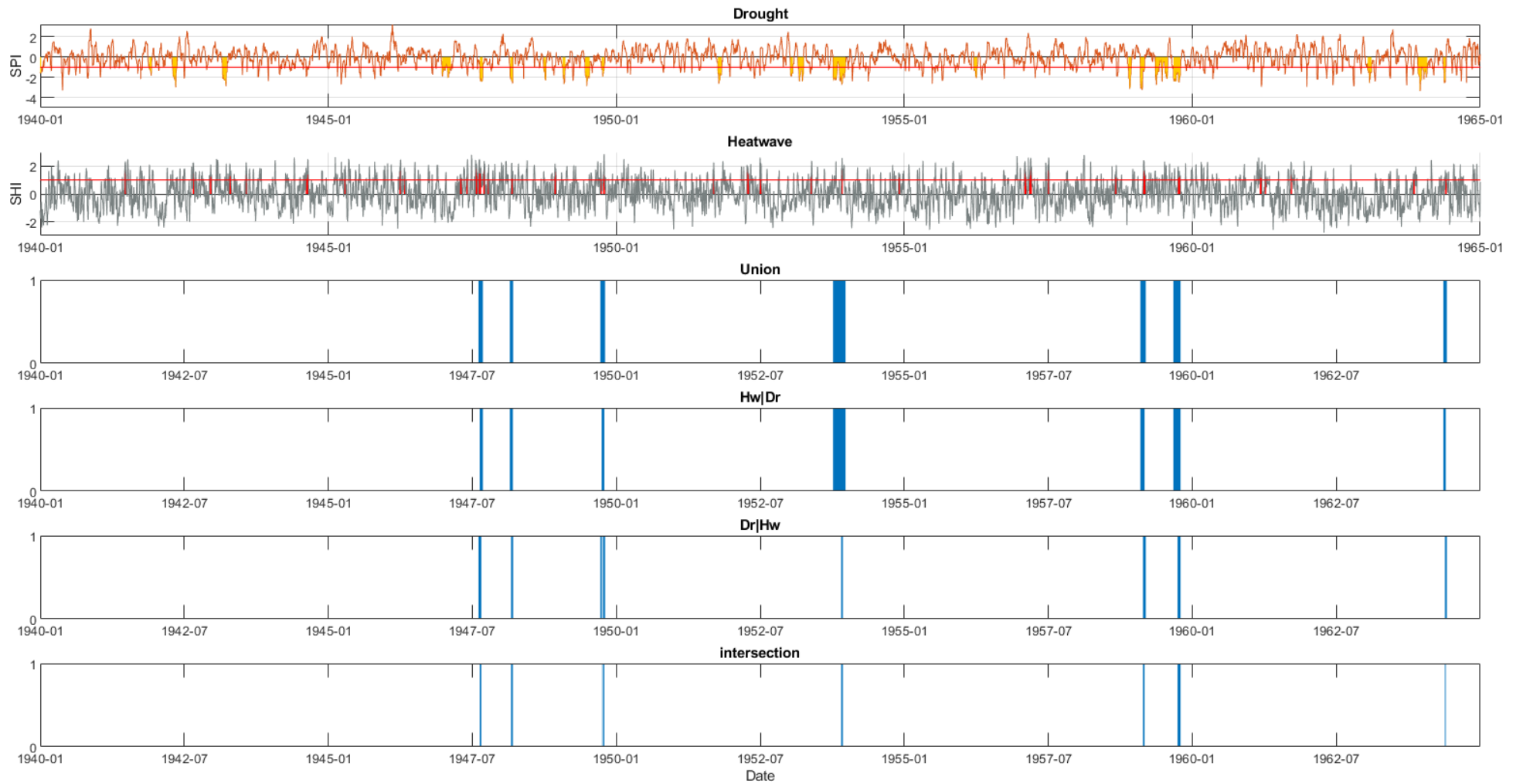


(b) Identification results over the period 1921-1940

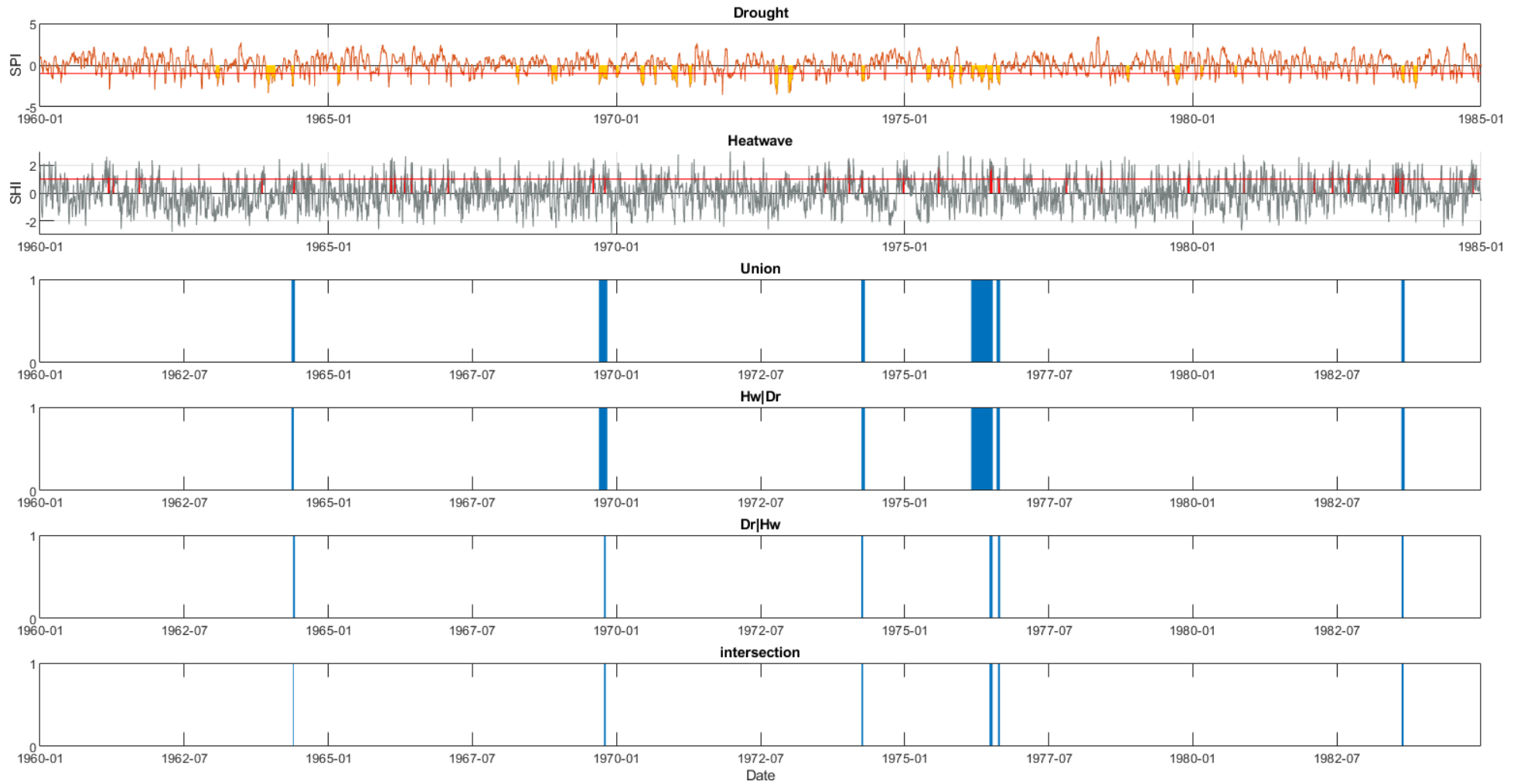




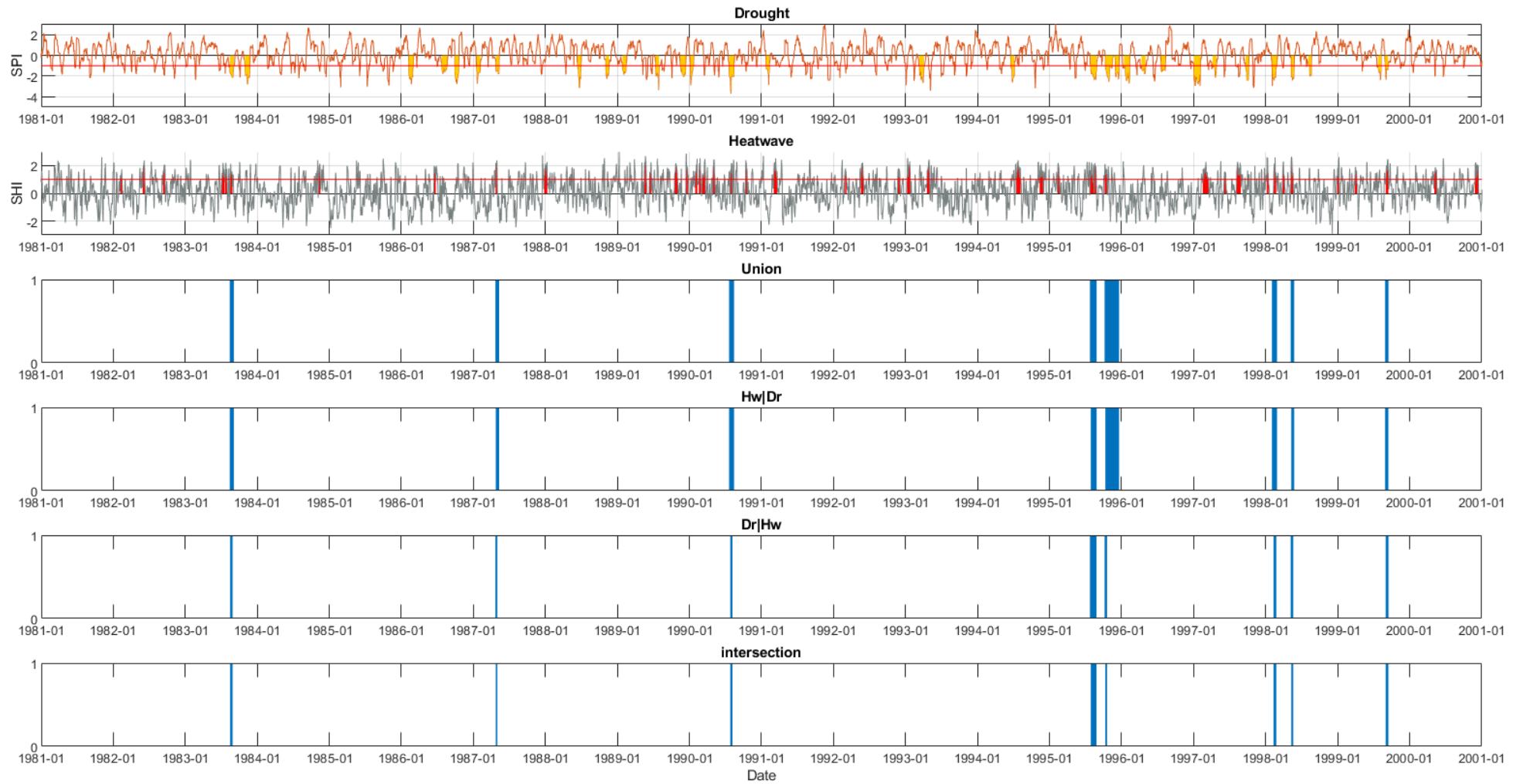
(c) Identification results over the period 1941-1960



(d) Identification results over the period 1961-1980



(e) Identification results over the period 1981-2000



(f) Identification results over the period 2001-2020

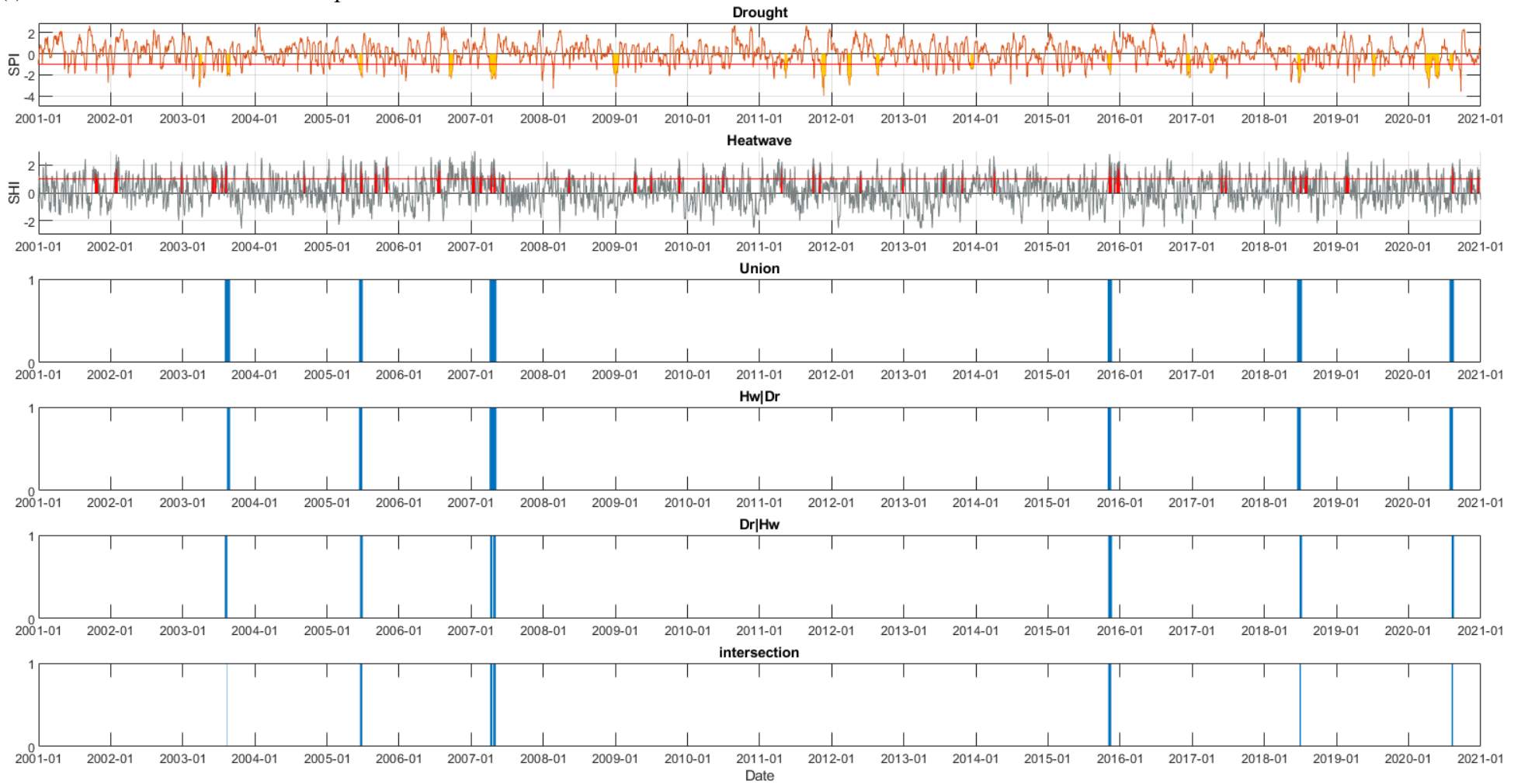


Fig. S3: Identification of drought, heatwave, and CDHW events (union, conditioned on drought, conditioned on heatwave, and intersection). SPI is with 15-days scale and pre identification threshold equals -1; SHI is with 3-days scale and pre identification threshold equals 1.