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Supplement of

Changes in groundwater drought associated with anthropogenic warming

John P. Bloomfield et al.

Correspondence to: John P. Bloomfield (jpb@bgs.ac.uk)

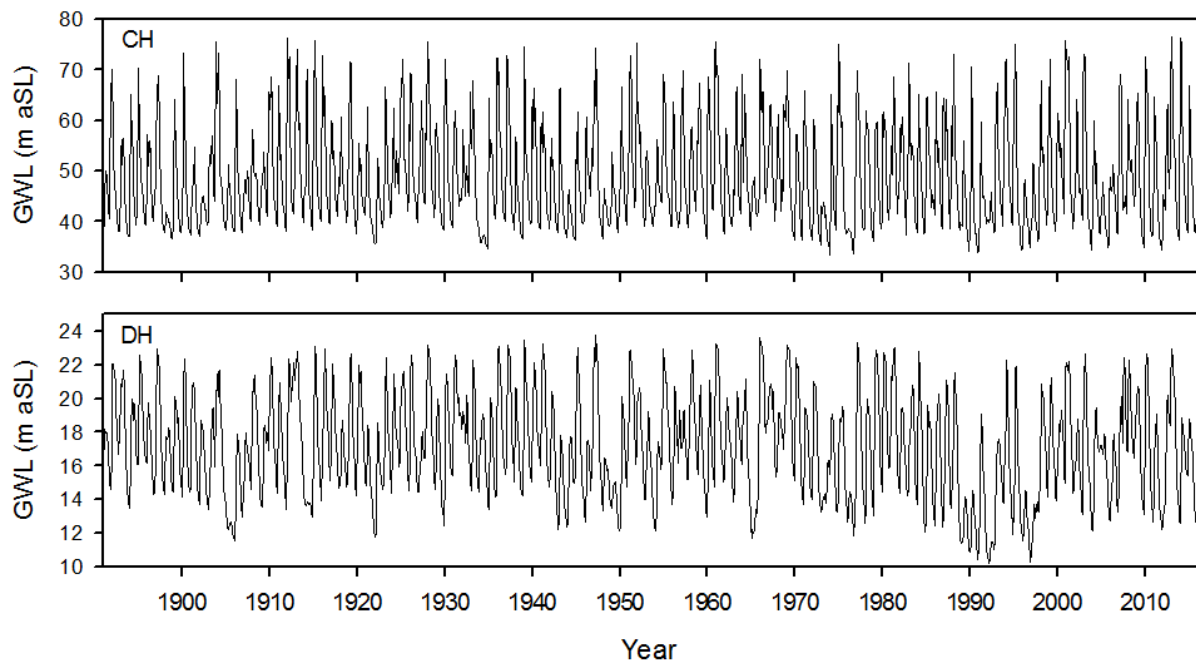# Supplementary information

Figures

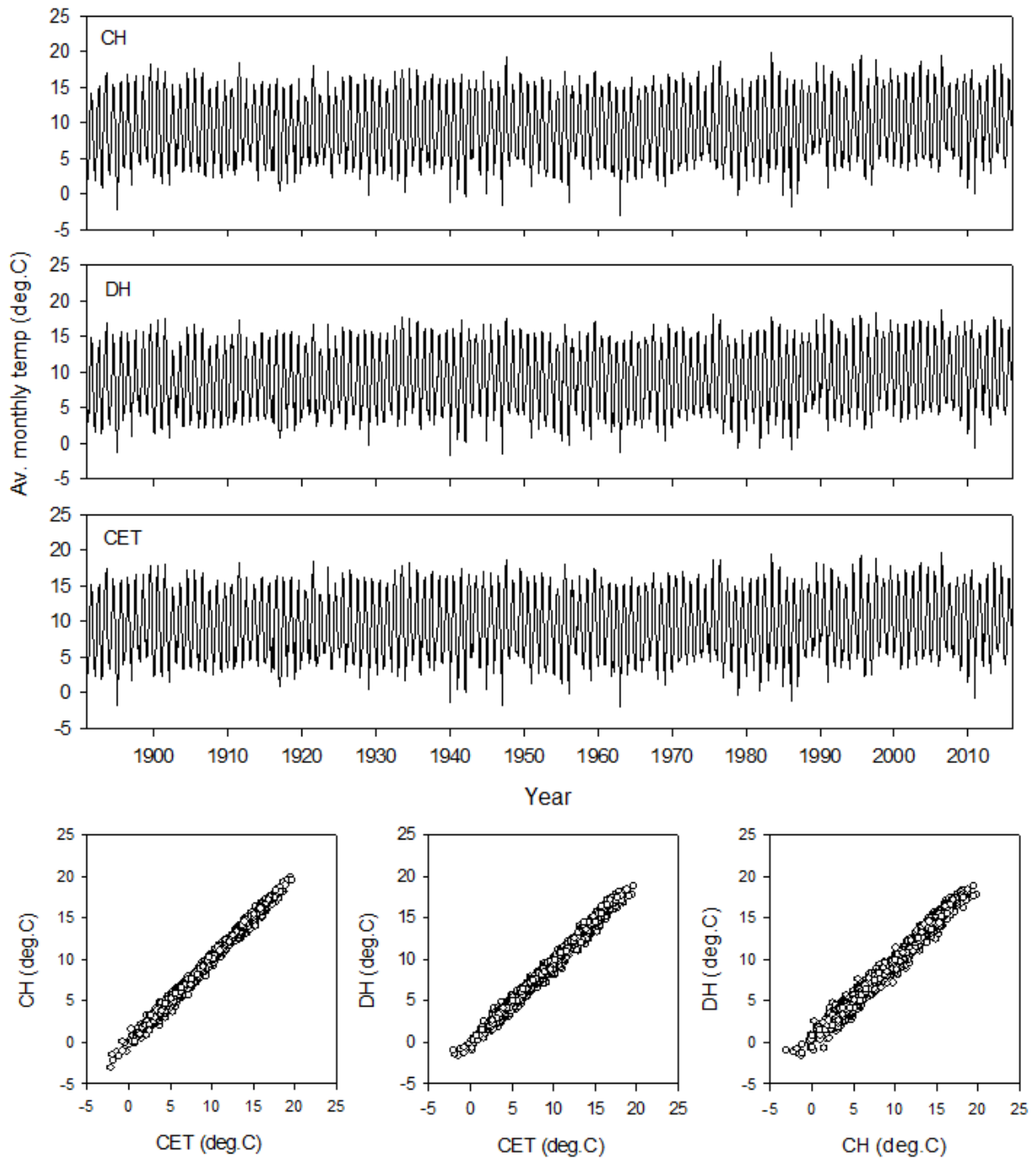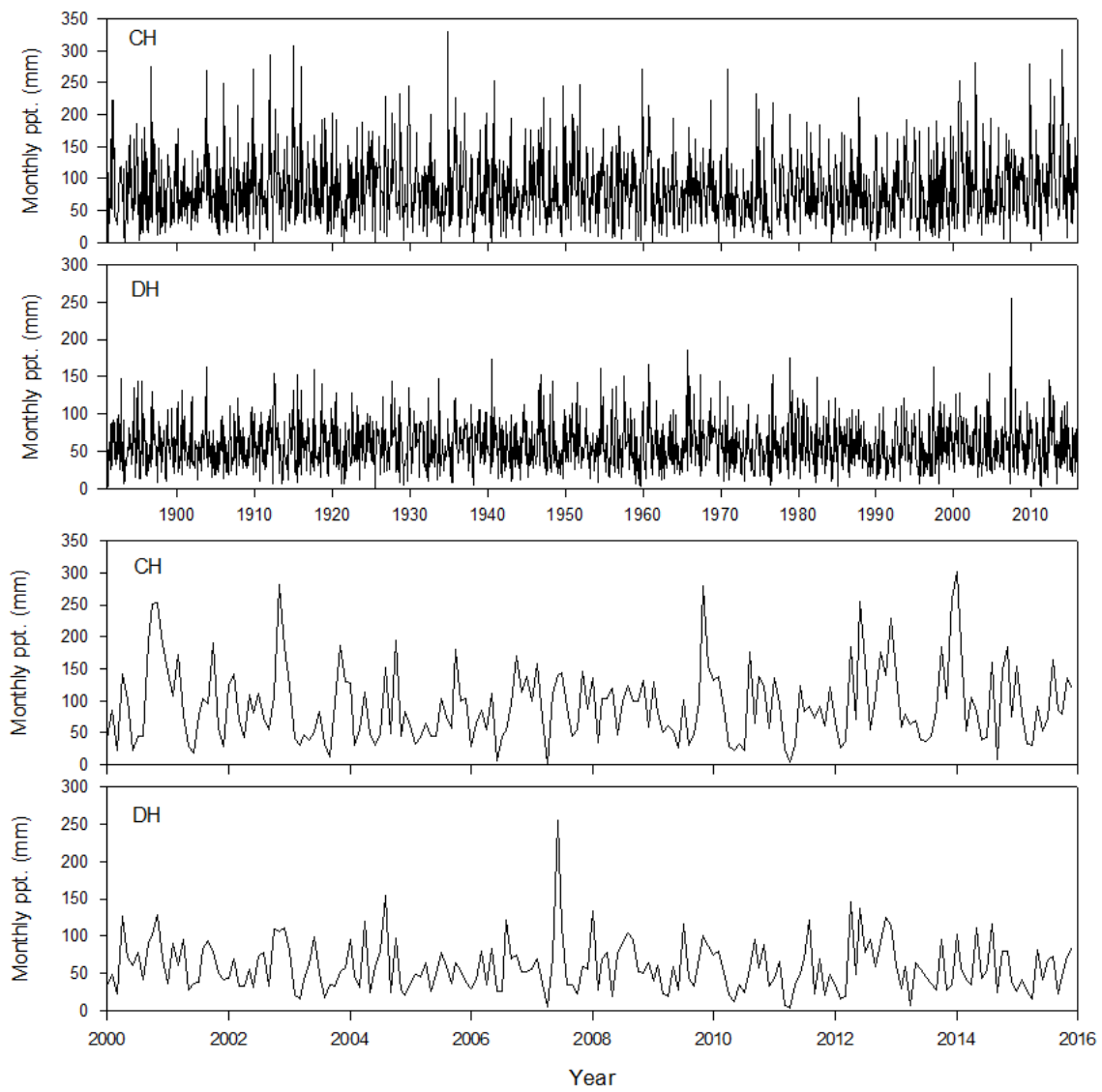**Figure S1. Monthly groundwater levels at CH and DH.**

Figure S2. Monthly average air temperature at CH and DH and monthly CET. Cross plots of monthly average air temperature at CH and DH and monthly CET.

Figure S3. Monthly total precipitation at CH and DH (for the full observation record from 1891 to 2015 and for the last 15 years of the record).
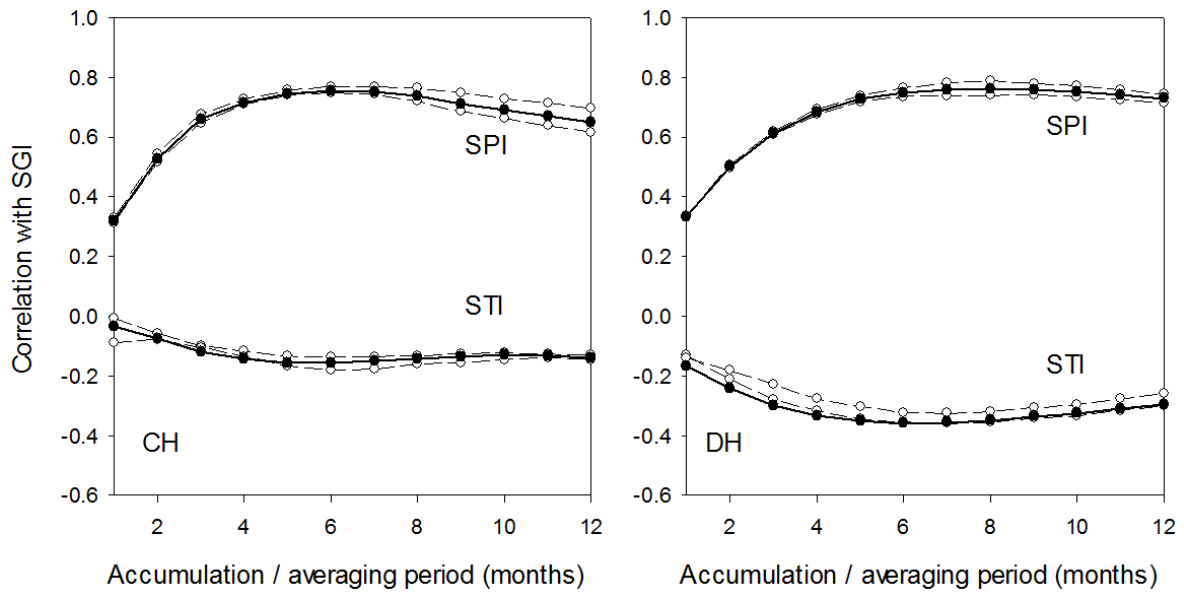
Figure S4. Variation in Pearson correlation coefficient between SGI and SPI for a range of SPI accumulation periods and between SGI and STI for a range of STI averaging periods. Solid lines show the correlation for the entire time series, the dashed lines indicate correlations for first and last third of the record.

Figure S5. Illustration of variation in SPI and STI during the episode of groundwater drought at CH between September 1933 and November 1934.

Tables

Table S1. Percentage of months of SGI, SPI and STI in a given standardised range for the whole record and for each third of the observational record

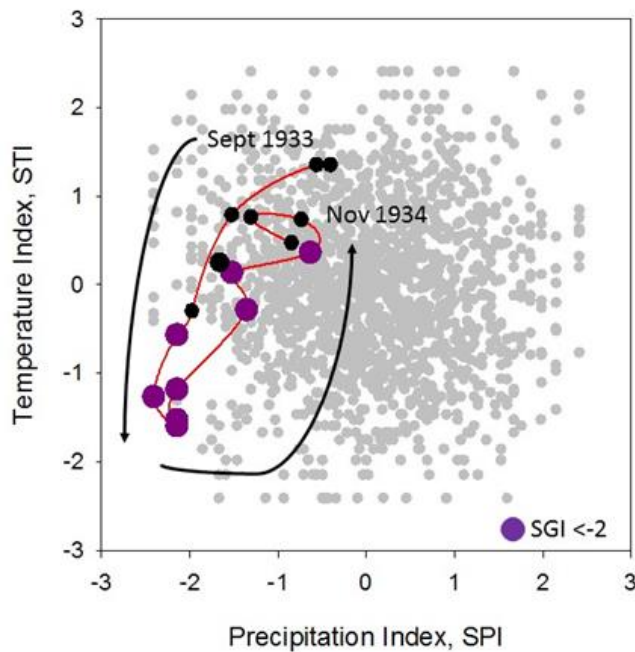| Period	CH SGI						DH SGI					
	<=-2	<=-1 & >-2	<=-0 & >-1	>0 & <1	>=1 & <2	>=2	<=-2	<=-1 & >-2	<=-0 & >-1	l>0 & <1	>=1 & <2	>=2
1890-2015	1.6	14.3	33.7	34.4	14.3	1.6	1.6	14.3	33.7	34.4	14.3	1.6
1890-1932	0.2	10.1	36.5	37.5	13.9	1.8	0.4	9.5	31.7	42.1	15.3	1
1933-1973	1.8	14.6	34.3	34.3	13.6	1.2	0.2	11.8	32.7	34.3	18.3	2.6
1974-2015	2.8	18.3	30.2	31.4	15.5	1.8	4.2	21.7	36.6	26.8	9.5	1.2

Period	CH SPI$_6$						DH SPI$_6$					
	<=-2	<=-1 & >-2	<=-0 & >-1	>0 & <1	>=1 & <2	>=2	<=-2	<=-1 & >-2	<=-0 & >-1	>0 & <1	>=1 & <2	>=2
1890-2015	1.6	14.3	33.7	34.4	14.3	1.6	1.6	14.3	33.7	34.4	14.3	1.6
1890-1932	1.6	13.7	35.3	32.3	16.7	0.4	1.4	12.7	31.9	39.7	13.3	1.0
1933-1973	1.2	17.9	33.5	33.7	12.6	1.0	1.4	13.4	33.5	31.7	17.3	2.6
1974-2015	2.0	11.5	32.2	37.2	13.7	3.4	2.0	16.9	35.6	31.8	12.5	1.2

Period	CH STI$_6$						DH STI$_6$					
	<=-2	<=-1 & >-2	<=-0 & >-1	>0 & <1	>=1 & <2	>=2	<=-2	<=-1 & >-2	<=-0 & >-1	l>0 & <1	>=1 & <2	>=2
1890-2015	1.6	14.3	33.7	34.4	14.3	1.6	1.6	14.3	33.7	34.4	14.3	1.6
1890-1932	0	4.8	29	42.1	21.8	2.4	0	2.4	22.0	46.2	26.0	3.4
1933-1973	0	8.5	38.4	34.8	16.5	1.8	0.6	10.4	42.7	31.5	13.4	1.4
1974-2015	4.6	29.6	36.0	24.3	4.8	0.6	4.2	30.2	38.8	23.3	3.6	0

Table S2. Percentage of groundwater drought months associated with SPI<=-1, STI>=1, and SPI<=-1 and STI>=1 for three time periods and for CH and DH.

Period	CH			DH		
	SPI<=-1	STI>=1	SPI<=-1 & STI >=1	SPI<=-1	STI>=1	SPI<=-1 & STI >=1
1890-1932	67.3%	7.7%	7.7%	66.0%	10.0%	10.0%
1933-1973	69.1%	11.1%	6.2%	49.2.0%	26.4%	6.8%
1974-2015	48.1%	48.1%	34.0%	51.5%	43.1%	34.6%

Table S3. Summary statistics for episodes of groundwater drought at CH and DH

Site & period	Total no. drought episodes	No. episodes where SGI intensity <-1	Average duration of all episodes (months)	Average SGI magnitude of all episodes	Average SGI intensity of all episodes	Average SPI of all episodes	Average STI of all episodes
CH							
1891-2015	45	16	10.7	-10.6	-0.89	-0.73	0.10
1891-1932	12	2	10.8	-9.8	-0.81	-0.88	-0.44
1933-1973	14	5	11.9	-11.5	-0.77	-0.70	-0.24
1974-2015	19	9	9.7	-10.9	-1.02	-0.65	0.68
DH							
1891-2015	33	9	16.2	-15.6	-0.84	-0.70	0.24
1891-1932	9	2	14.0	-12.3	-0.79	-0.93	-0.21
1933-1973	8	3	17.2	-15.3	-0.88	-0.88	0.03
1974-2015	16	4	17.0	-17.6	-0.85	-0.55	0.60