Supplementary materials

Table S1 Upper and lower bounds of hydrological model parameters for GR6J and HBV

Model	Parameter	Lower bound	Upper bound
GR6J	X1 (Production store capacity)	0.05	4000
	X2 (Intercatchment exchange coefficient)	-35	35
	X3 (routing store capacity)	0.05	2000
	X4 (unit hydrograph time constant)	0.5	40
	X5 (intercatchment exchange threshold)	-35	35
	X6 (exponential store depletion coefficient)	0.05	2000
HBV	Max soil moisture storage	40	400
	Shape coefficient (soil moisture storage)	1	6
	Threshold for reduction of evaporation	0.3	1
	Snowfall correction factor	0.4	1.2
	Threshold temperature	-1.5	1.2
	Degree-day factor	1	8
	Recession coefficient (upper storage, near surface)	0.05	0.5
	Recession coefficient (upper storage)	0.01	0.3
	Recession coefficient (lower storage)	0.001	0.15
	Threshold for shallow storage	0	70
	Percolation	0	4
	Routing parameter	1	3

Table S2 Upper and lower bounds of hydrological model parameters for FUSE parent models (TOPMODEL, ARNO, PRMS and Sacramento) (Reproduced from Lane et al., 2019).

Parameter	Description	Units	Lower bound	Upper bound	Model(s) using parameter
MAXWATER1	Depth of upper soil layer	mm	25	500	TOPMODEL, ARNO, PRMS, SACRAMENTO
MAXWATER2	Depth of lower soil layer	mm	50	5000	TOPMODEL, ARNO, PRMS, SACRAMENTO
FRACTEN	Fraction total storage in tension storage	–	0.05	0.95	TOPMODEL, ARNO, PRMS, SACRAMENTO
FRCHZNE	Fraction tension storage in recharge zone	–	0.05	0.95	PRMS
FPRIMQB	Fraction storage in first baseflow reservoir	–	0.05	0.95	SACRAMENTO
RTFRAC1	Fraction of roots in the upper layer	–	0.05	0.95	ARNO
PERCRTE	Percolation rate	mm d−1	0.01	1000	TOPMODEL, ARNO, PRMS
PERCEXP	Percolation exponent	–	1	20	TOPMODEL, ARNO, PRMS
SACPMLT	SACRAMENTO model percolation multiplier for dry soil layer	–	1	250	SACRAMENTO
SACPEXP	SACRAMENTO model percolation exponent for dry soil layer	–	1	5	SACRAMENTO
PERCFRAC	Fraction of percolation to tension storage	–	0.5	0.95	SACRAMENTO
FRACLOWZ	Fraction of soil excess to lower zone	–	0.5	0.95	PRMS
IFLWRTE	Interflow rate	mm d−1	0.1	1000	PRMS, SACRAMENTO
BASERTE	Baseflow rate	mm d−1	0.001	1000	TOPMODEL, ARNO
QB_POWR	Baseflow exponent	–	1	10	TOPMODEL, ARNO
QB_PRMS	Baseflow depletion rate	d−1	0.001	0.25	PRMS
QBRATE_2A	Baseflow depletion rate first reservoir	d−1	0.001	0.25	SACRAMENTO
QBRATE_2B	Baseflow depletion rate second reservoir	d−1	0.001	0.25	SACRAMENTO
SAREAMAX	Maximum saturated area	–	0.05	0.95	PRMS, SACRAMENTO
AXV_BEXP	ARNO/VIC b exponent	–	0.001	3	ARNO
LOGLAMB	Mean value of the topographic index	m	5	10	TOPMODEL
TISHAPE	Shape parameter for the topographic index gamma distribution	–	2	5	TOPMODEL
TIMEDELAY	Time delay in runoff	d	0.01	7	TOPMODEL, ARNO, PRMS, SACRAMENTO

Table S3 Start and end years of 25-year time slice representing a 2°C GWL for each ensemble member of the CANARI-LE

Ensemble member	2°C GWL	4°C GWL	Ensemble member	2°C GWL	4°C GWL
1	2031-2055	2070-2094	21	2033-2057	2070-2094
2	2030-2054	2069-2093	22	2031-2055	2068-2092
3	2032-2056	2069-2093	23	2033-2057	2072-2096
4	2029-2053	2068-2092	24	2033-2057	2070-2094
5	2029-2053	2068-2092	25	2032-2056	2070-2094
6	2029-2053	2071-2095	26	2031-2055	2070-2094
7	2032-2056	2069-2093	27	2033-2057	2072-2096
8	2030-2054	2069-2093	28	2030-2054	2073-2097
9	2032-2056	2069-2093	29	2032-2056	2069-2093
10	2030-2054	2069-2093	30	2028-2052	2068-2092
11	2033-2057	2070-2094	31	2032-2056	2068-2092
12	2032-2056	2070-2094	32	2029-2053	2070-2094
13	2032-2056	2070-2094	33	2029-2053	2068-2092
14	2032-2056	2070-2094	34	2031-2055	2070-2094
15	2031-2055	2069-2093	35	2030-2054	2068-2092
16	2032-2056	2071-2095	36	2033-2057	2070-2094
17	2031-2055	2069-2093	37	2031-2055	2071-2095
18	2032-2056	2070-2094	38	2031-2055	2069-2093
19	2032-2056	2070-2094	39	2032-2056	2071-2095
20	2033-2057	2069-2093	40	2030-2054	2072-2096

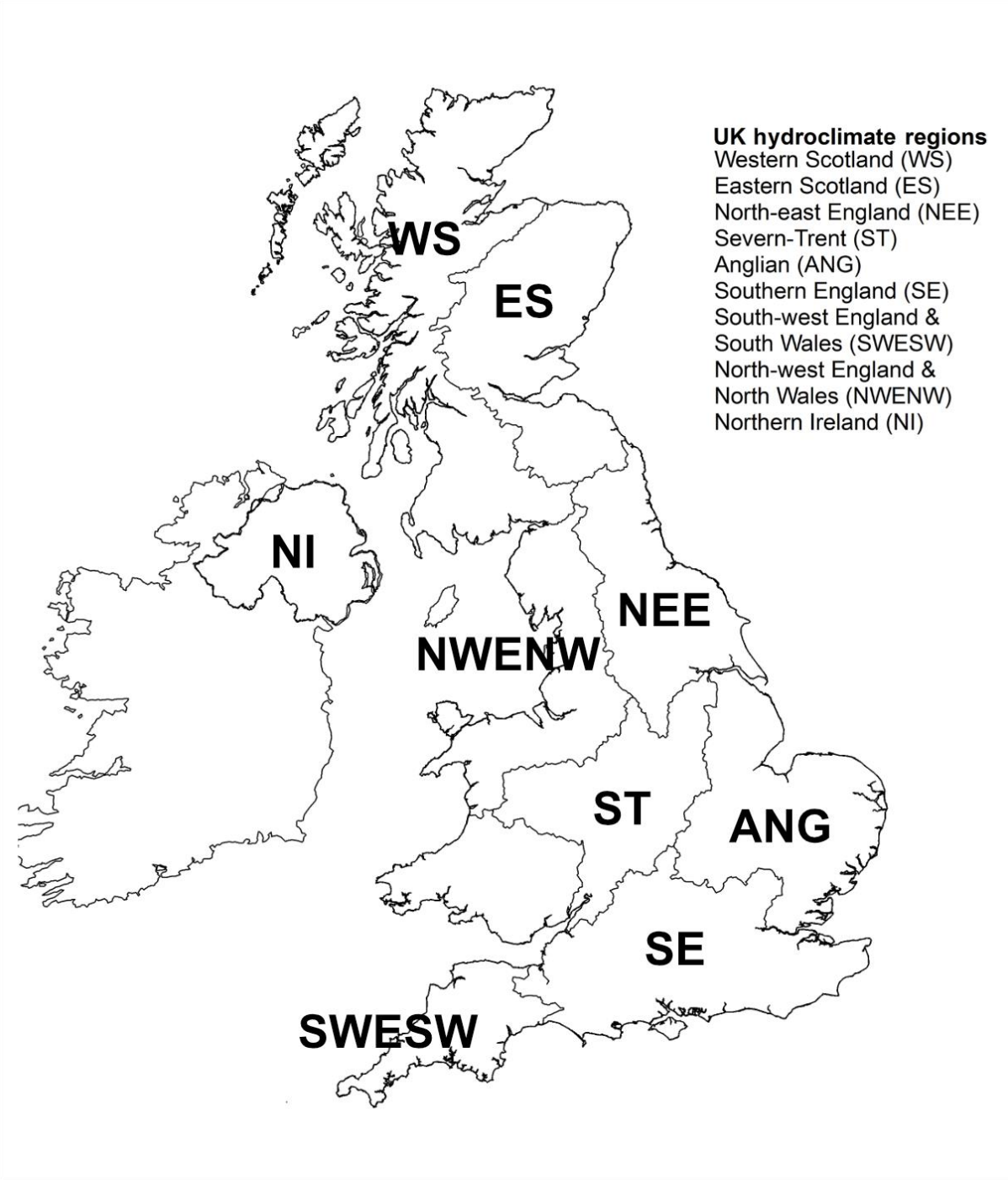


Figure S1 Hydroclimate regions across the UK.

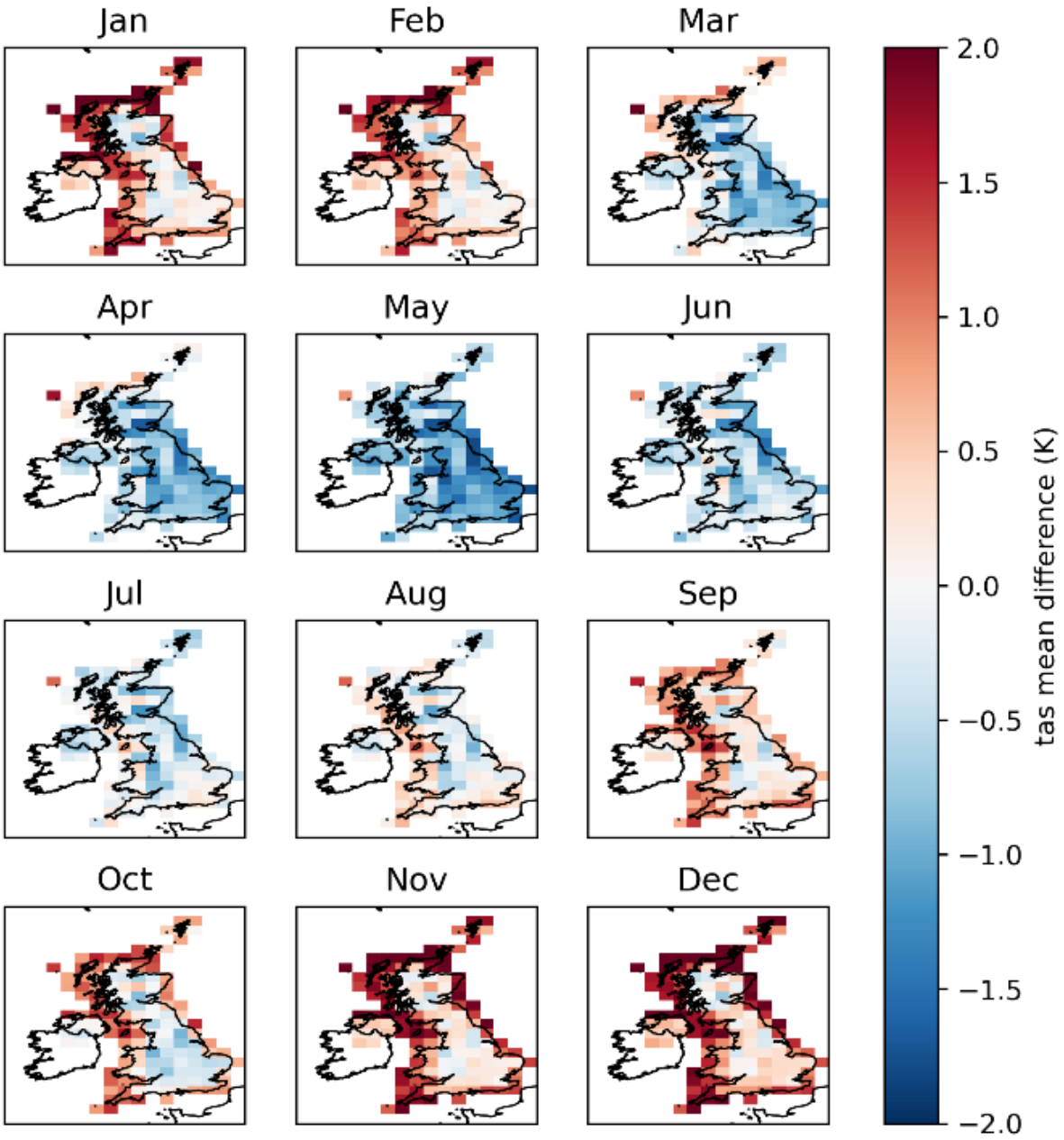


Figure S2: Ensemble median percentage bias in temporal mean of projected temperature compared to HadUK-grid gridded observations for 1950-2014, showing a cold bias in spring. Projected temperatures in coastal pixels represent averages over the entire pixel, while observed data represents only the land in that area, thus showing high temperature bias in comparison.

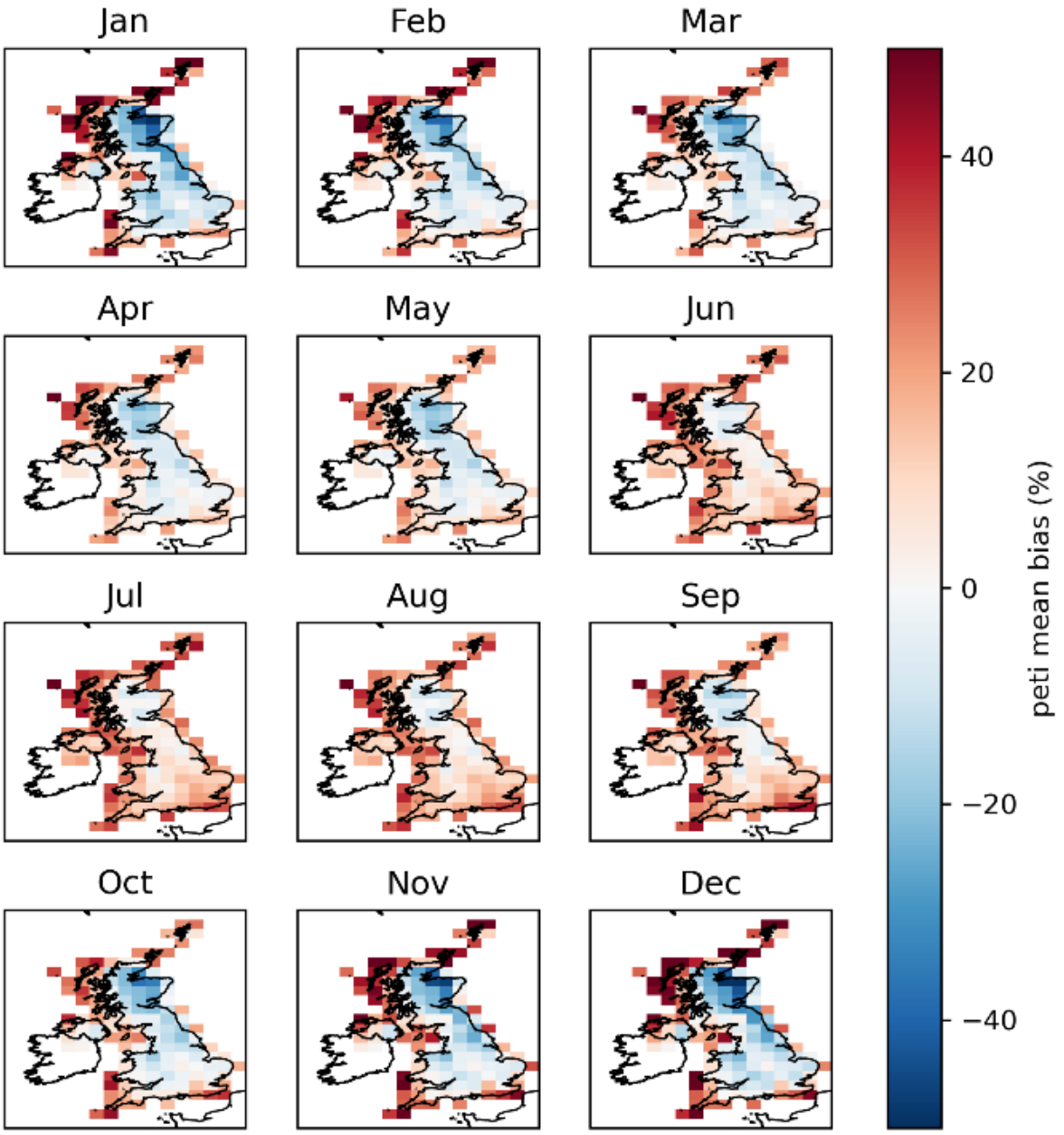


Figure S3: Ensemble median percentage bias in temporal mean of projected PET compared to HadUK-grid Hydro-PE gridded observations for 1969-2022. As PET is derived from temperature, the same land-bias is seen for coastal pixels.

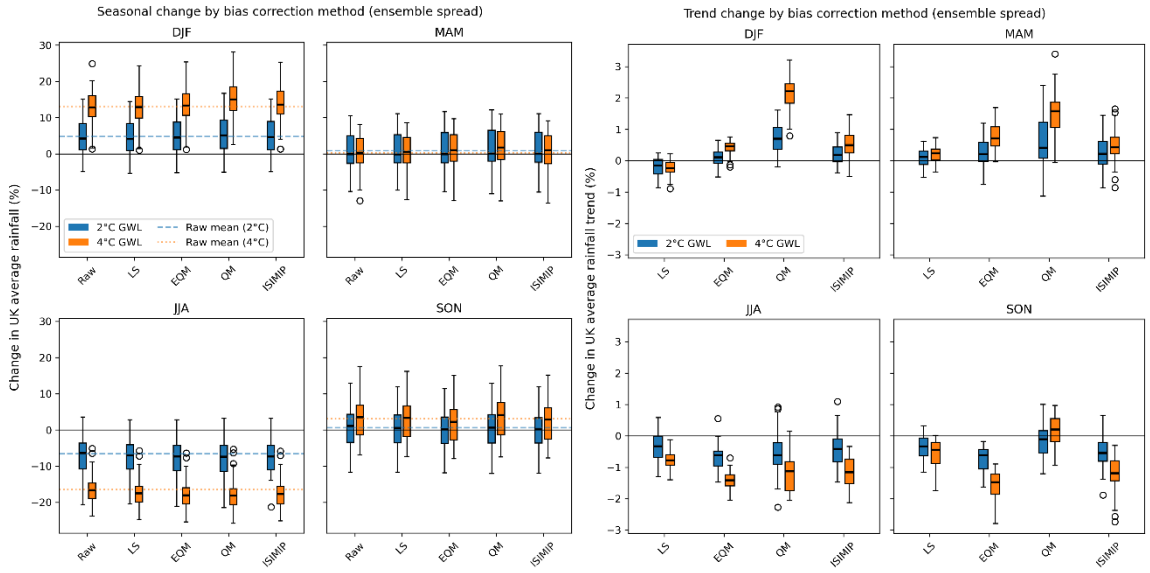


Figure S4: Projected change in average seasonal precipitation across the CANARI-LE for 2°C and 4°C GWL with respect to 1991-2020 (left) and change in trend for different bias correction methods for both GWL periods (right).

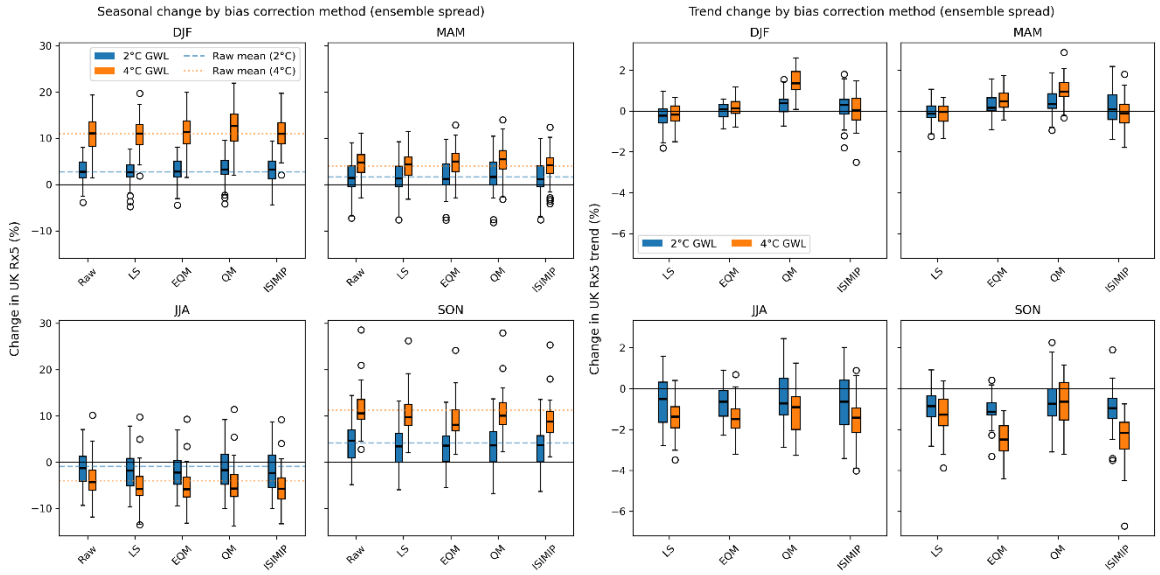


Figure S5: Projected change in seasonal precipitation extremes (Rx5) across the CANARI-LE for 2°C and 4°C GWL with respect to 1991-2020 (left) and change in trend for different bias correction methods for both GWL periods (right).

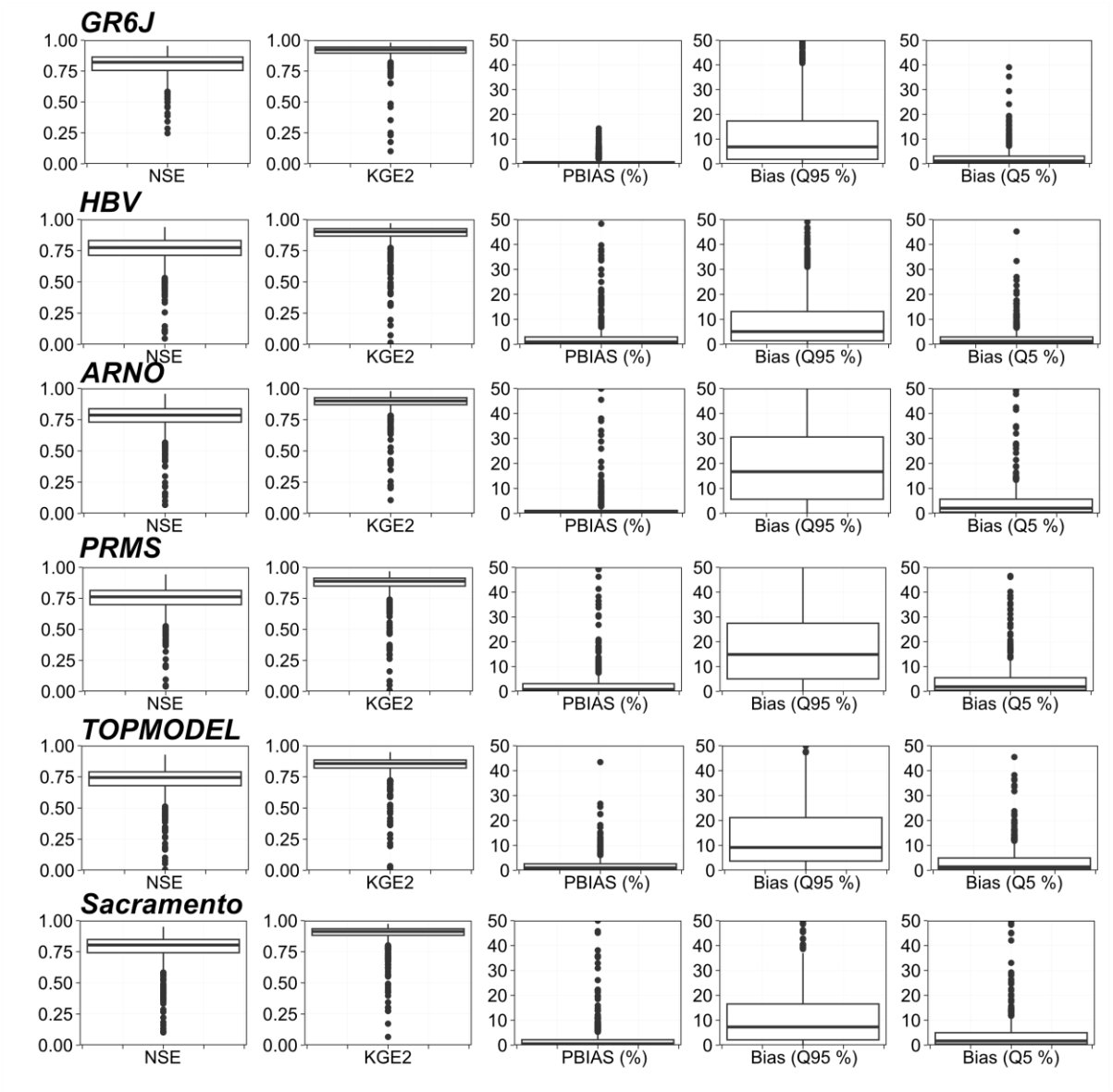


Figure S6 Evaluation of simulated river flow for the six catchment hydrological models (rows) across the selected model performance metrics (columns). Metrics are plotted as boxplots ranging across all 680 modelled catchments. Note G2G is not included as it was not calibrated to individual catchments and simulates natural flows.

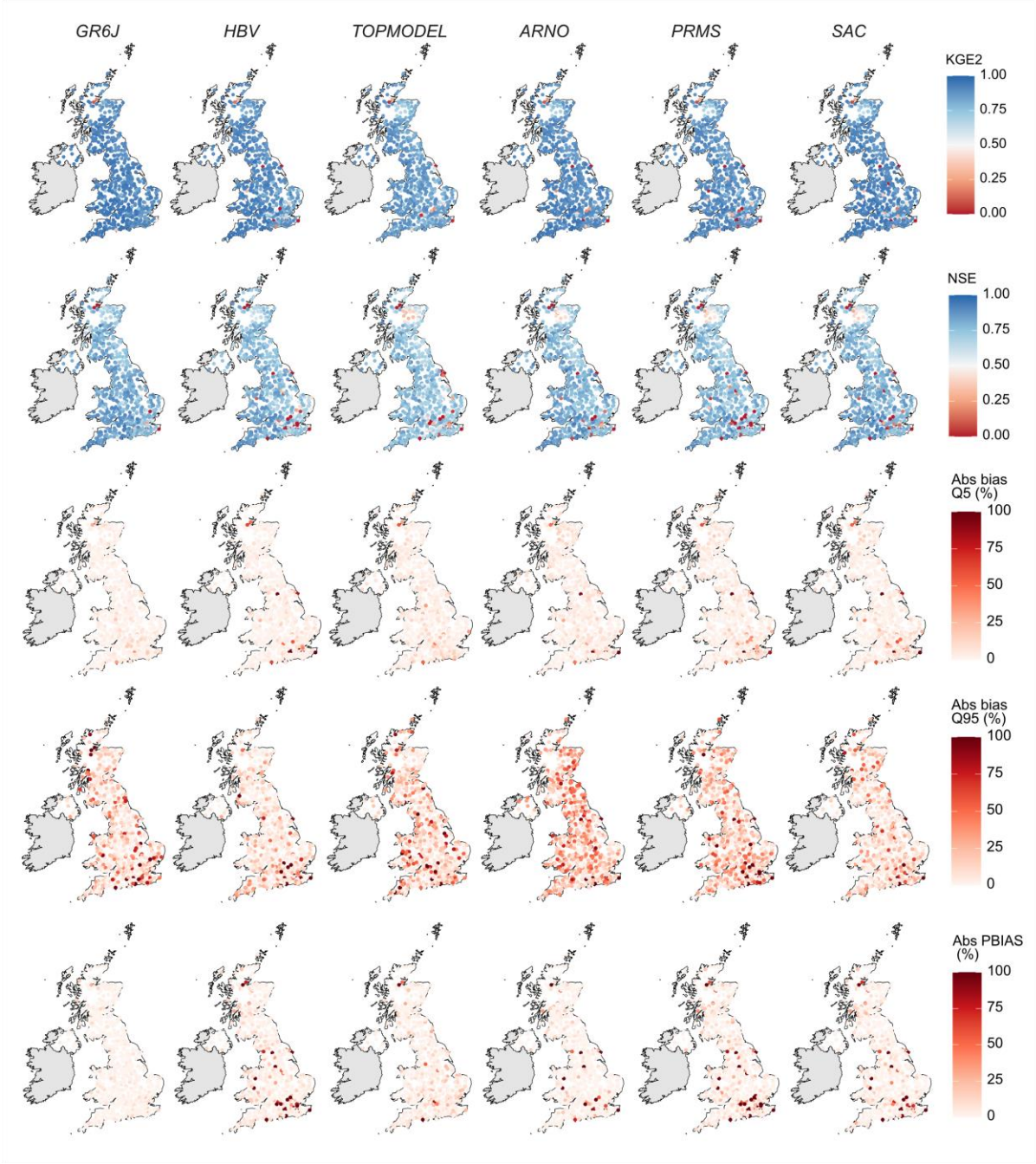


Figure S7 Spatial distribution of model performance metrics (rows) across the UK for all catchments and hydrological models (columns). Note G2G is not included as it was not calibrated to individual catchments and simulates natural flows.

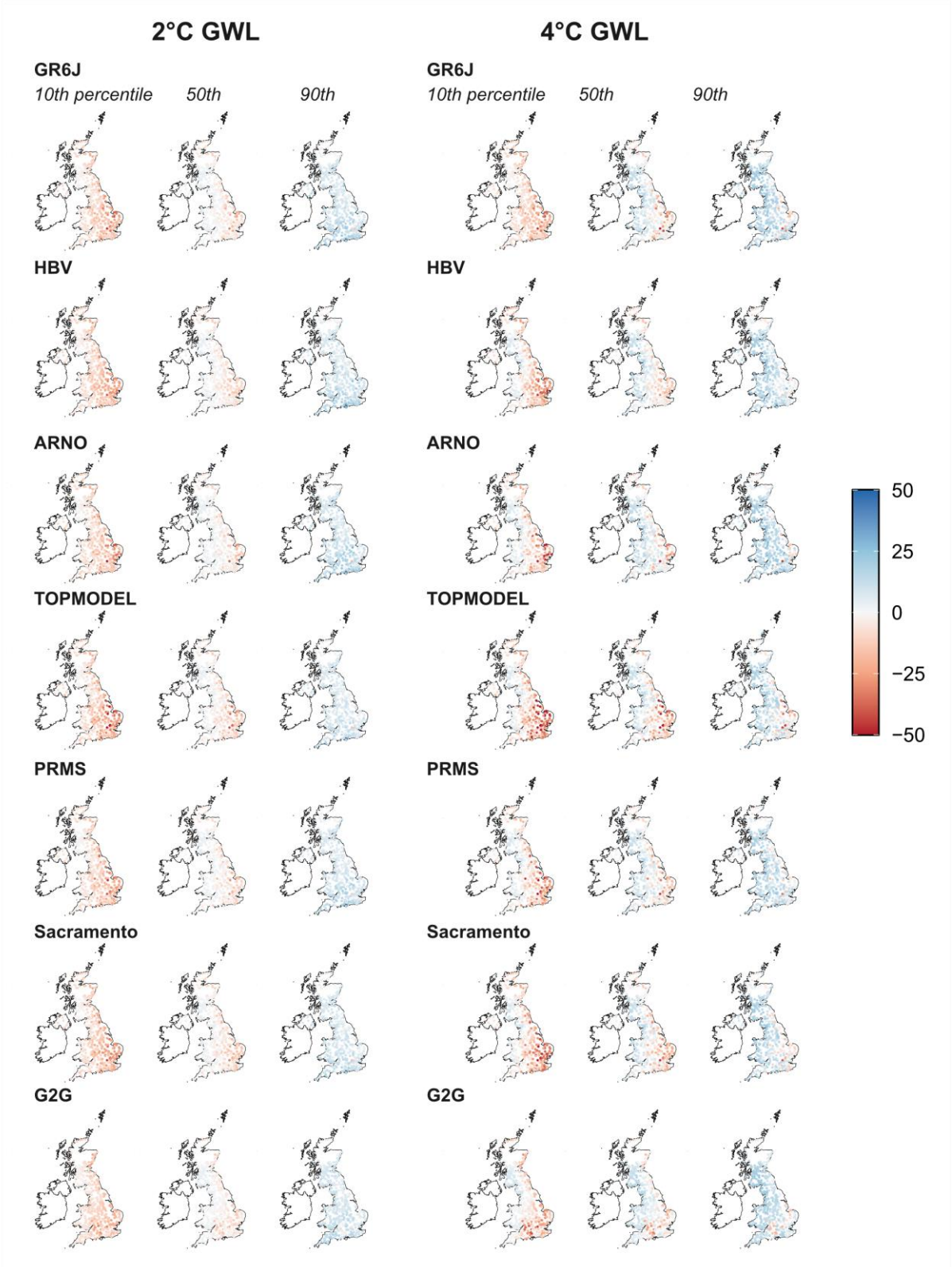


Figure S8 Change in high flows (Q5) (%) for all seven hydrological models at 2°C and 4°C GWLs relative to 1991-2020. The 10th, 50th and 90th percentile across the 40-member ensemble is shown.

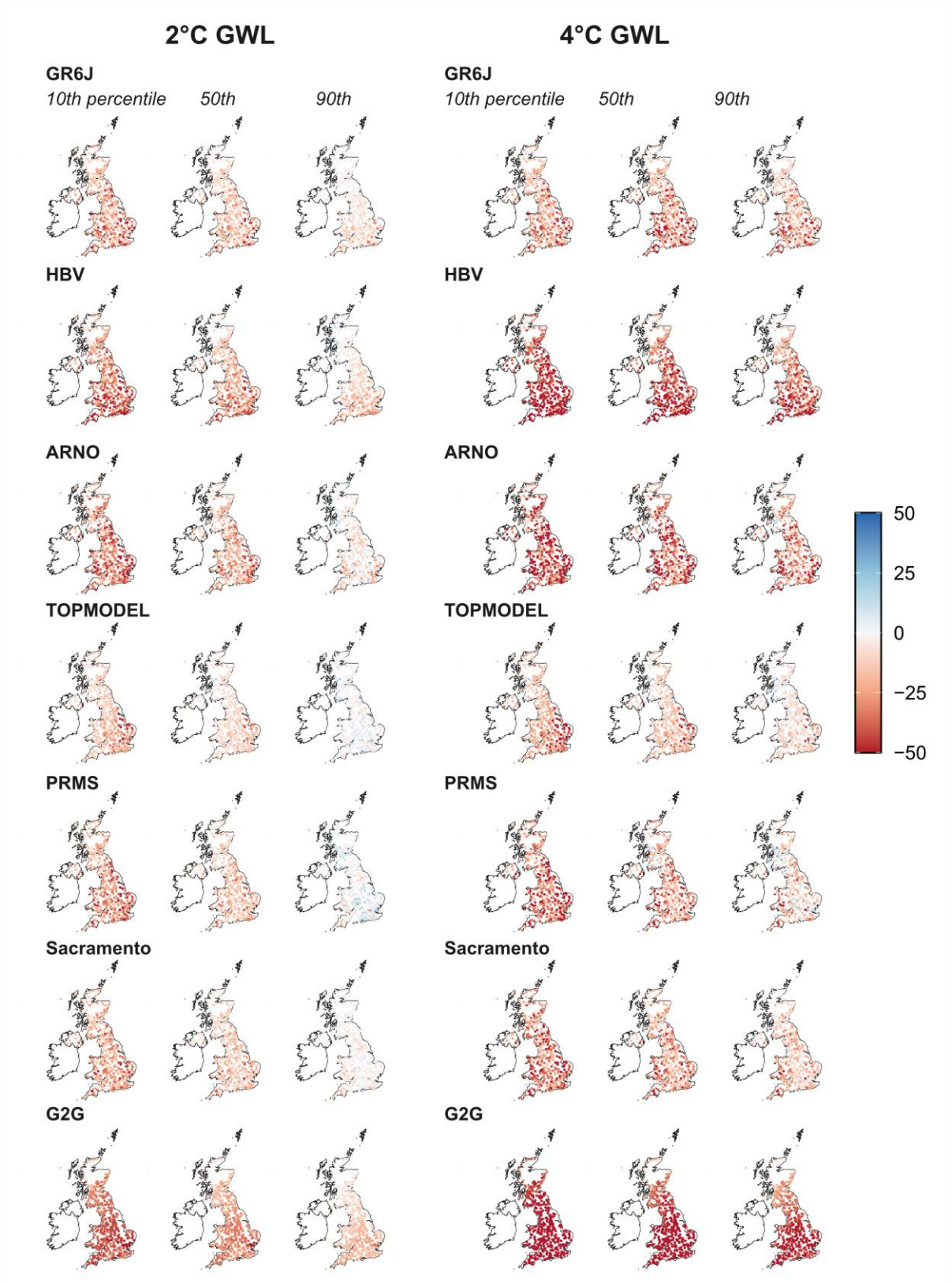


Figure S9 Change in low flows (Q95) (%) for all seven hydrological models at 2°C and 4°C GWLs relative to 1991-2020. The 10th, 50th and 90th percentile across the 40-member ensemble is shown.

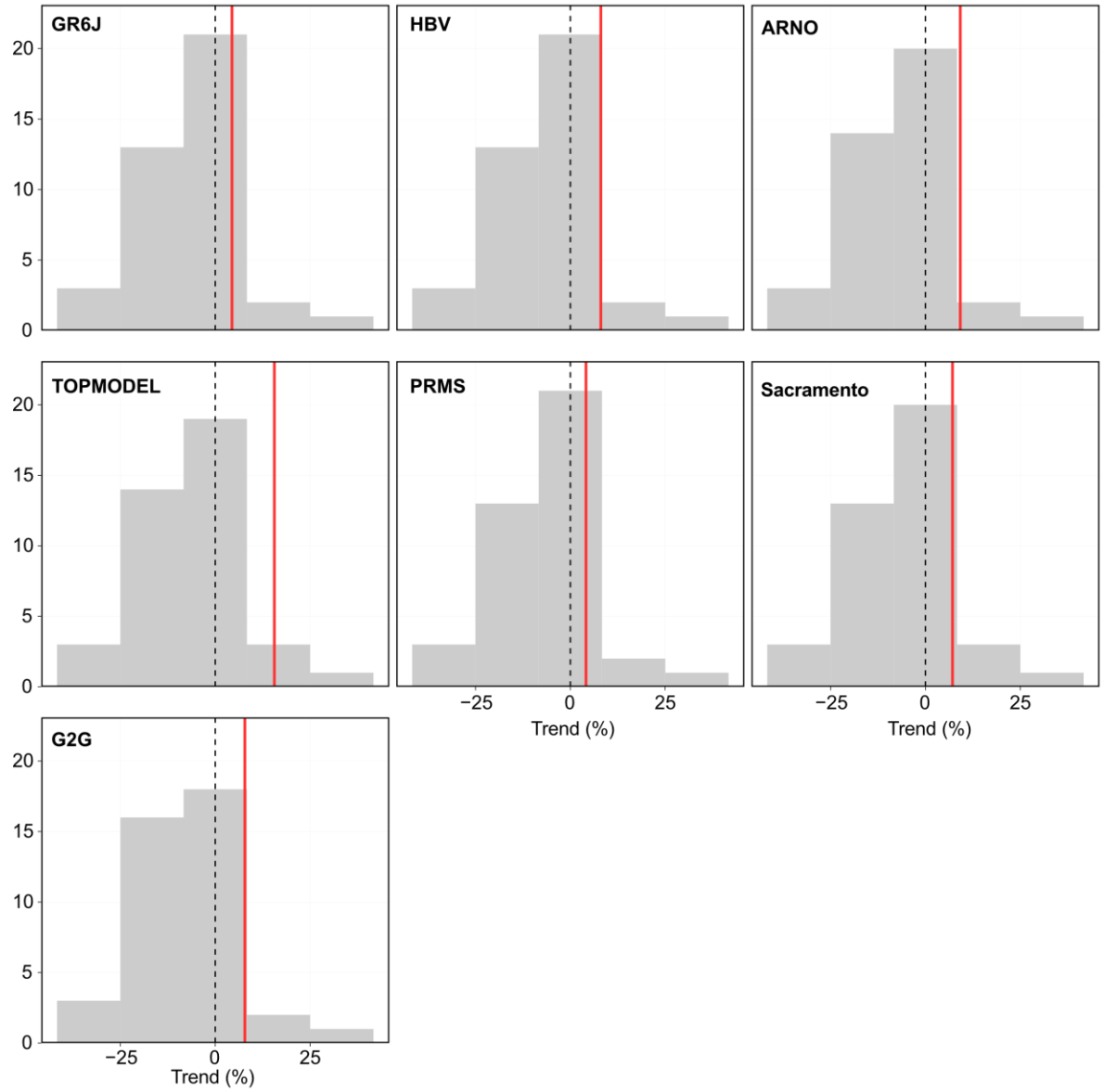


Figure S10 Distribution of trend (% over 45-year) in UK-averaged annual mean simulated river flows across the 40-member CANARI-LE for the historical period (1970-2014) (Grey distribution). The red line shows the simulated observed (SimObs) trend over the same period (i.e. simulated river flows driven by observed meteorological input data) for each hydrological model.

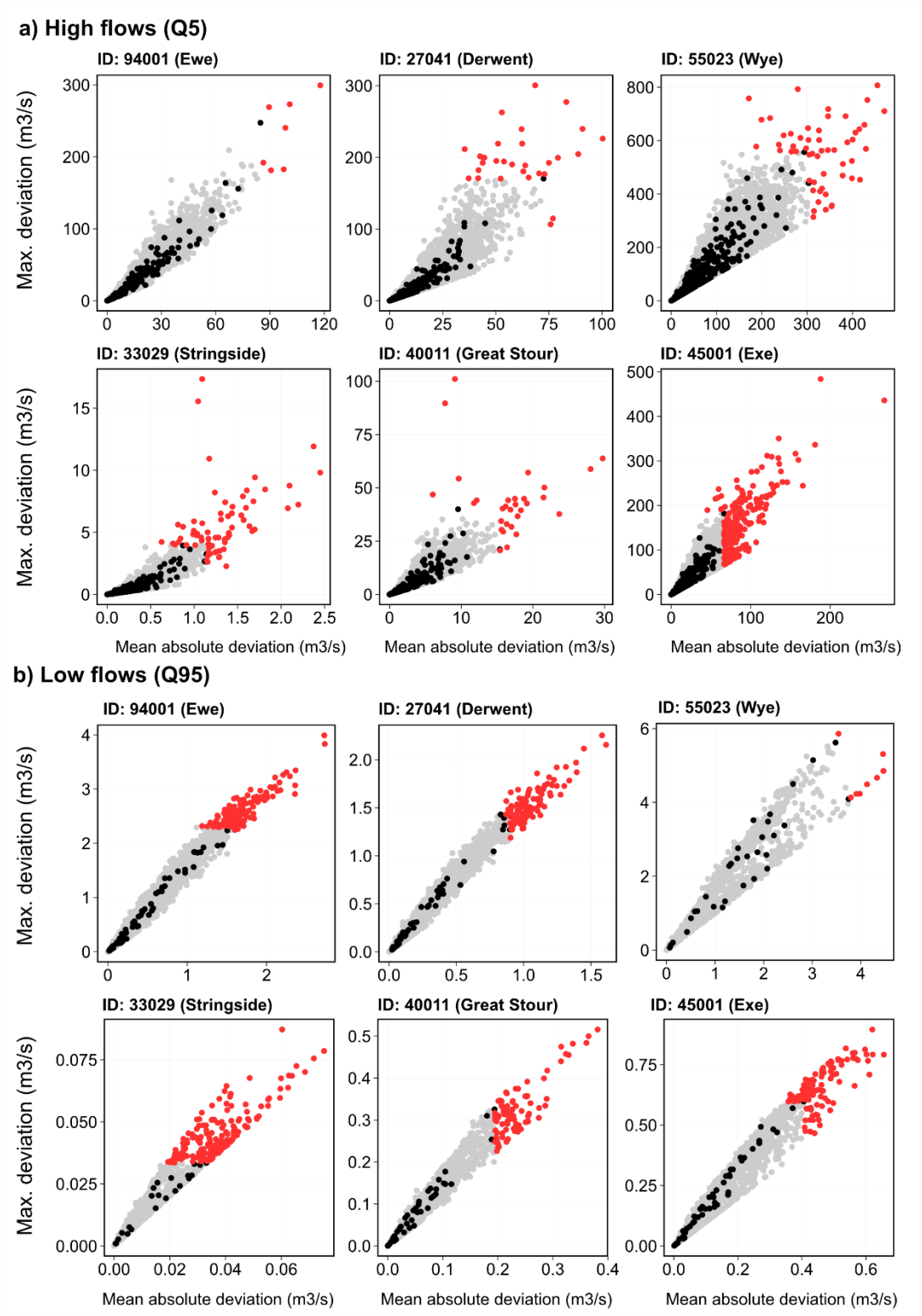


Figure S11 Extreme high and low flow events extracted for six example catchments across the UK for the GR6J hydrological model. Black dots are events within the SimObs simulations while the grey dots are events within the historical period (1955-2014) of the pooled CANARI-LE hydro-SMILE. Red dots are those events within the CANARI-LE hydro-SMILE which are unprecedented compared to the worst SimObs event for either mean deviation or maximum deviation from high (Q5) and low (Q95) flows.

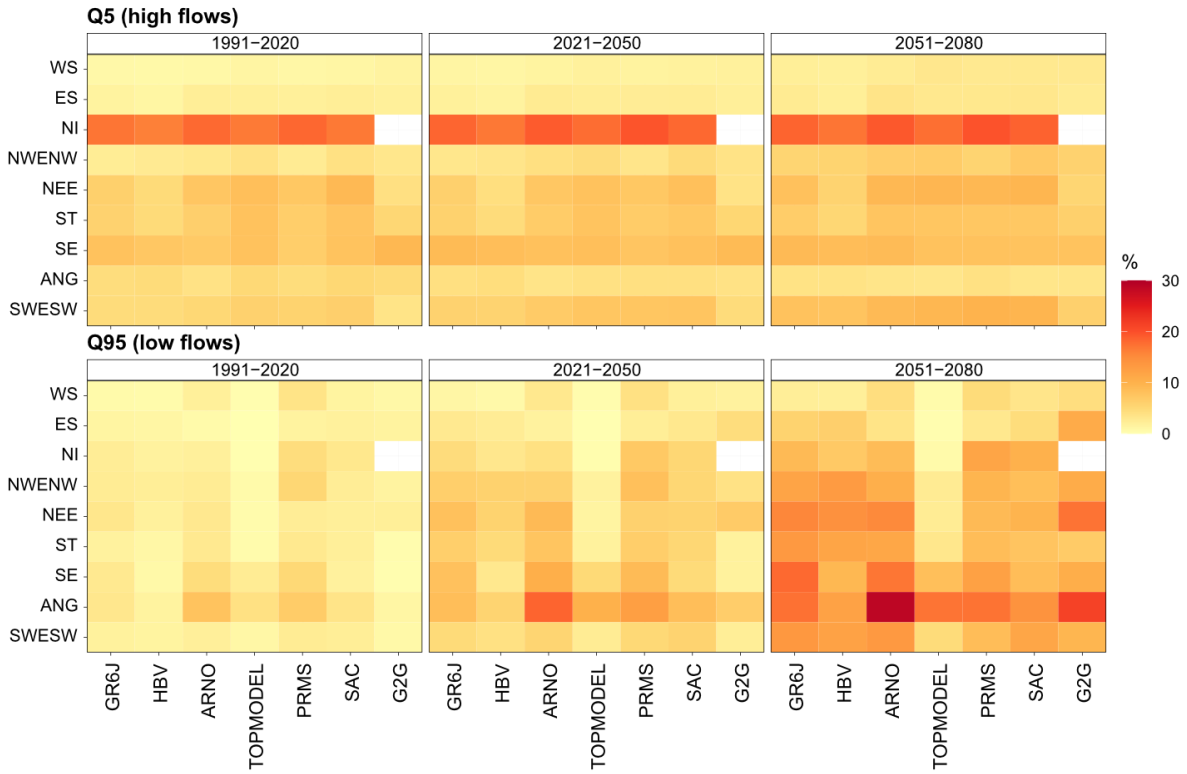


Figure S12 Mean chance of record-breaking high and low flows across hydroclimate regions for each hydrological model for three time slices. Record-breaking annual Q5 and Q95 is assessed against the highest Q5 and lowest Q95 value in the SimObs period. Note that Northern Ireland is not included in G2G.