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High-end climate change impact on European runoff and low flows – exploring the effects of forcing biases

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Electronic Supplementary Material

Table S1. Results of linear regression applied to basin aggregated annual average runoff production for raw and bias adjusted Euro-CORDEX data.

	Basin's Annual Average Runoff Production [mm/year]													
	Raw							**Bias Corrected**						
Danube		Coeff.	St. Error	tStat	P-value	r	0.32		Coeff.	St. Error	tStat	P-value	r	0.19
	Interc.	829.12	127.91	6.48	1.82E-09	R^2	0.10	Interc.	451.47	104.08	4.34	2.91E-05	R^2	0.04
	X	-0.24	0.06	-3.77	2.45E-04	Adj. R^2	0.09	X	-0.11	0.05	-2.19	3.02E-02	Adj. R^2	0.03
Rhine		Coeff.	St. Error	tStat	P-value	r	0.10		Coeff.	St. Error	tStat	P-value	r	0.08
	Interc.	950.24	228.55	4.16	5.87E-05	R^2	0.01	Interc.	640.82	204.57	3.13	2.15E-03	R^2	0.01
	X	-0.13	0.11	-1.14	2.58E-01	Adj. R^2	0.00	X	-0.09	0.10	-0.93	3.56E-01	Adj. R^2	0.00
Elbe		Coeff.	St. Error	tStat	P-value	r	0.10		Coeff.	St. Error	tStat	P-value	r	0.26
	Interc.	112.23	155.05	0.72	4.70E-01	R^2	0.01	Interc.	-171.71	119.48	-1.44	1.53E-01	R^2	0.07
	X	0.09	0.08	1.18	2.39E-01	Adj. R^2	0.00	X	0.18	0.06	2.99	3.38E-03	Adj. R^2	0.06
Guadiana		Coeff.	St. Error	tStat	P-value	r	0.54		Coeff.	St. Error	tStat	P-value	r	0.49
	Interc.	794.88	98.58	8.06	4.76E-13	R^2	0.29	Interc.	713.59	100.97	7.07	9.31E-11	R^2	0.24
	X	-0.35	0.05	-7.21	4.46E-11	Adj. R^2	0.28	X	-0.31	0.05	-6.28	4.87E-09	Adj. R^2	0.23
Kemioki		Coeff.	St. Error	tStat	P-value	r	0.80		Coeff.	St. Error	tStat	P-value	r	0.86
	Interc.	-2257.94	186.45	-12.11	6.46E-23	R^2	0.63	Interc.	-2717.09	159.07	-17.08	1.06E-34	R^2	0.74
	X	1.36	0.09	14.83	1.72E-29	Adj. R^2	0.63	X	1.50	0.08	19.16	2.81E-39	Adj. R^2	0.74

Table S2. Results of linear regression applied to basin aggregated annual 10th percentile runoff production for raw and bias adjusted Euro-CORDEX data.

	Basin's Annual 10th percentile Runoff Production [mm/year]													
	Raw							**Bias Corrected**						
Danube		Coeff.	St. Error	tStat	P-value	r	0.78		Coeff.	St. Error	tStat	P-value	r	0.75
	Interc.	817.99	53.05	15.42	6.94E-31	R^2	0.61	Interc.	442.02	32.50	13.60	1.49E-26	R^2	0.56
	X	-0.36	0.03	-13.96	2.09E-27	Adj. R^2	0.60	X	-0.20	0.02	-12.80	1.29E-24	Adj. R^2	0.56
Rhine		Coeff.	St. Error	tStat	P-value	r	0.72		Coeff.	St. Error	tStat	P-value	r	0.69
	Interc.	1665.80	127.58	13.06	3.13E-25	R^2	0.52	Interc.	1102.30	94.45	11.67	7.82E-22	R^2	0.48
	X	-0.74	0.06	-11.76	4.59E-22	Adj. R^2	0.52	X	-0.50	0.05	-10.78	1.21E-19	Adj. R^2	0.47
Elbe		Coeff.	St. Error	tStat	P-value	r	0.46		Coeff.	St. Error	tStat	P-value	r	0.39
	Interc.	530.57	79.89	6.64	8.18E-10	R^2	0.21	Interc.	139.24	26.24	5.31	4.84E-07	R^2	0.15
	X	-0.23	0.04	-5.84	4.19E-08	Adj. R^2	0.21	X	-0.06	0.01	-4.75	5.40E-06	Adj. R^2	0.14
Guadiana		Coeff.	St. Error	tStat	P-value	r	0.60		Coeff.	St. Error	tStat	P-value	r	0.54
	Interc.	4.70	0.55	8.61	2.35E-14	R^2	0.36	Interc.	0.02	0.00	7.63	4.97E-12	R^2	0.29
	X	0.00	0.00	-8.47	5.23E-14	Adj. R^2	0.36	X	0.00	0.00	-7.15	6.16E-11	Adj. R^2	0.28
Kemijoki		Coeff.	St. Error	tStat	P-value	r	0.91		Coeff.	St. Error	tStat	P-value	r	0.80
	Interc.	-1048.22	43.96	-23.85	9.80E-49	R^2	0.82	Interc.	-247.59	16.93	-14.62	5.35E-29	R^2	0.64
	X	0.53	0.02	24.41	8.67E-50	Adj. R^2	0.82	X	0.13	0.01	15.18	2.62E-30	Adj. R^2	0.64

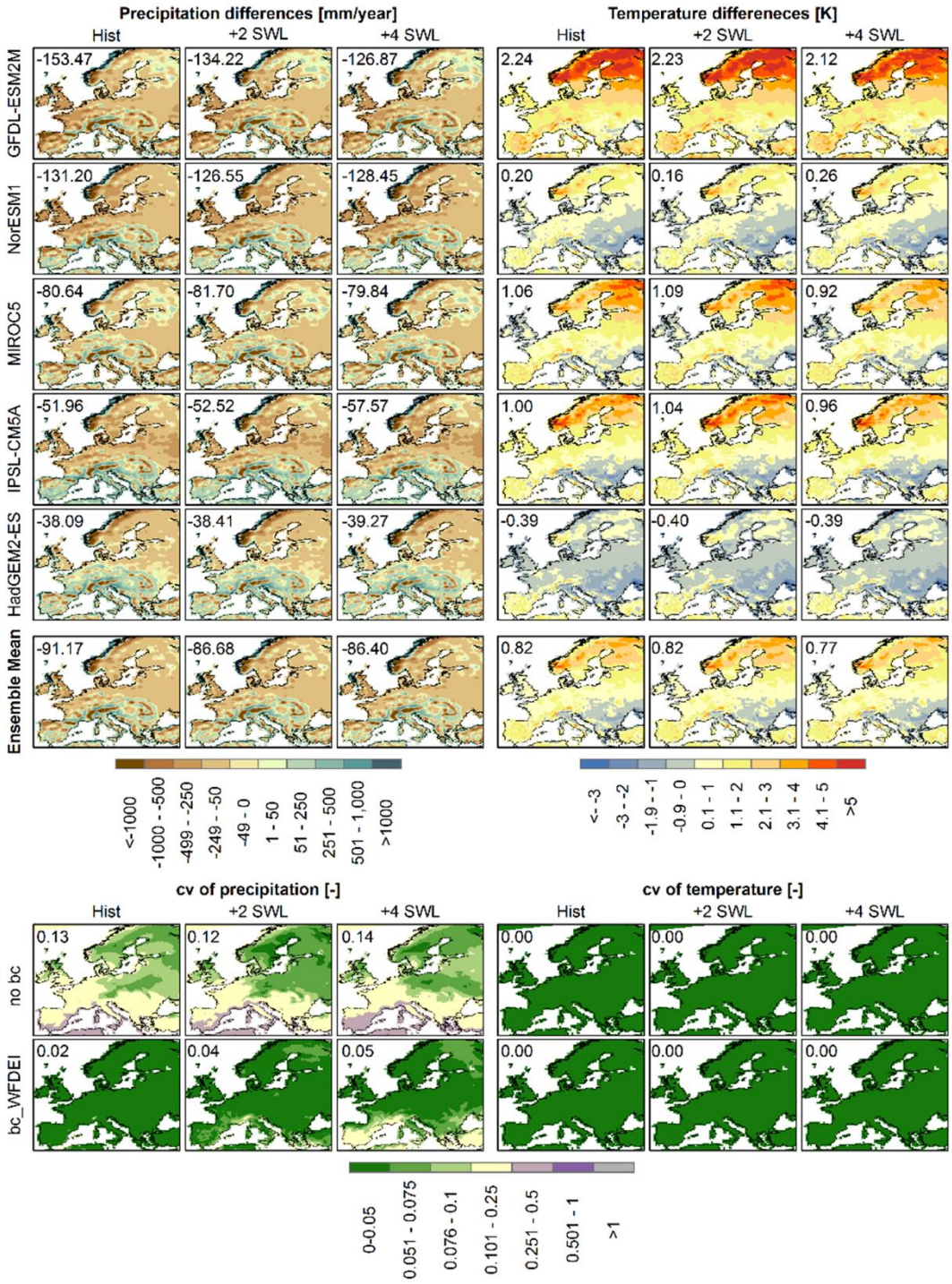


Figure S1. Absolute differences between Euro-CORDEX data bias adjusted against the WFDEI dataset and raw Euro-CORDEX data, for the variables of precipitation (right block) and temperature (left block). Differences are calculated from the historical (1976-2005), +2 SWL and +4 SWL time-slice averages, for all dynamical downscaled GCMs and their ensemble mean. Bottom block: Coefficient of variation between the ensemble members, for raw and bias corrected against the WFDEI dataset precipitation and temperature forcing variables, for the historical, +2 SWL and +4 SWL time-slices. The average value for the pan-European area is shown in each sub-figure.

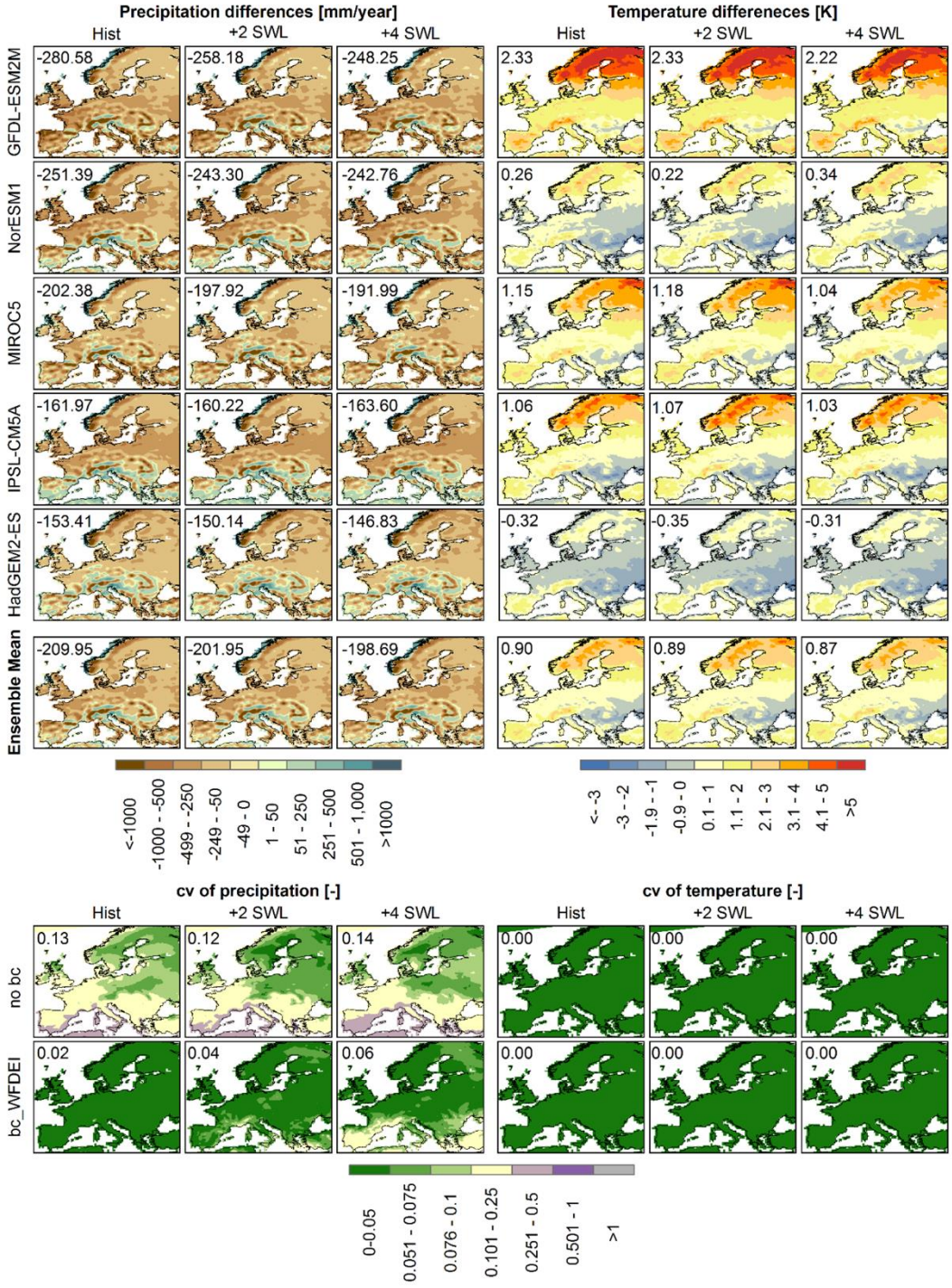
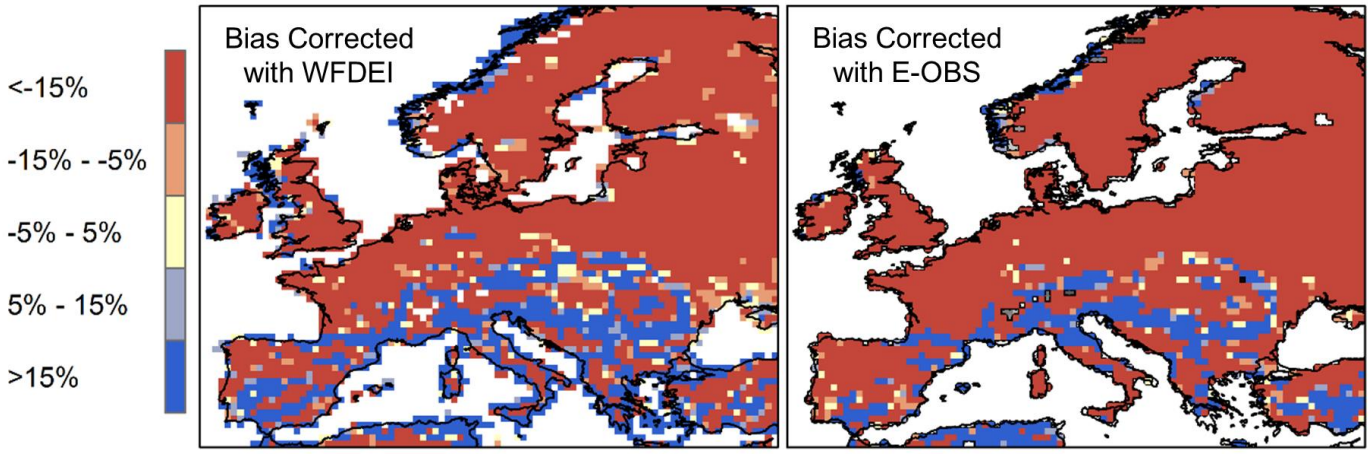


Figure S2. Absolute differences between Euro-CORDEX data bias adjusted against the E-OBS dataset and raw Euro-CORDEX data, for the variables of precipitation (right block) and temperature (left block). Differences are calculated from the historical (1976-2005), +2 SWL and +4 SWL time-slice averages, for all dynamical downscaled GCMs and their ensemble mean. Bottom block: Coefficient of variation between the ensemble members, for raw and bias corrected against the E-OBS dataset precipitation and temperature forcing variables, for the historical, +2 SWL and +4 SWL time-slices. The average value for the pan-European area is shown in each sub-figure.



	Bias Corrected with WFDEI			Bias Corrected with E-OBS		
	Drier output	Wetter output	Insignificant change	Drier output	Wetter output	Insignificant change
Percent of pan-European land area	70.40%	26.01%	3.59%	83.62%	14.67%	1.70%
Average percent change	-44.15%	148.77%	-0.53%	-56.10%	215.33%	-0.87%
Average absolute change [mm/year]	-231.44	159.37	-2.96	-285.70	131.97	1.49

Figure S3. The effect of bias correction on the ensemble mean of average runoff production for the baseline period (1976-2005). Figures: Relative difference between the ensemble means of bias corrected (left:with WFDEI, right:with E-OBS) and raw forcing data. Differences between -5% and 5% are classified as insignificant, differences <-5% as drier output and differences >5% as wetter output after bias correction. Table: percent of land area that falls into each category of change and average of the changes.

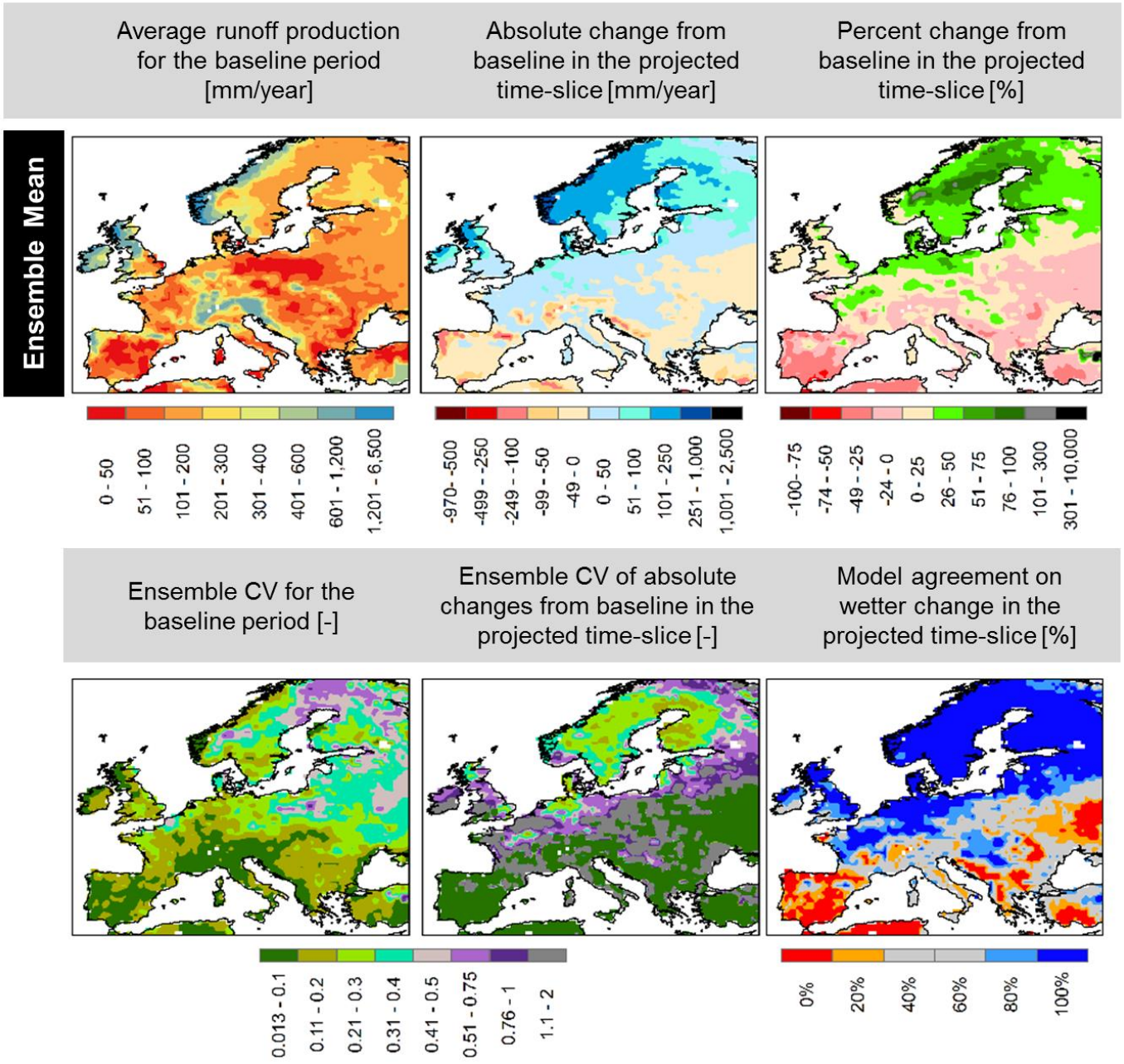


Figure S4. Ensemble mean of average runoff production from Euro-CORDEX data bias adjusted against the E-OBS dataset. Top row: Runoff production averaged over the baseline period (1976-2005) (top row), absolute (middle row) and percent change (bottom row) in ensemble mean runoff in the +4 SWL projected time-slice. Bottom row: coefficient of variation of the ensemble members for the baseline period (left column), coefficient of variation of the projected absolute changes in the +4 SWL projected time-slice (middle column) and model agreement towards a wetter change in the +4 SWL projected time-slice

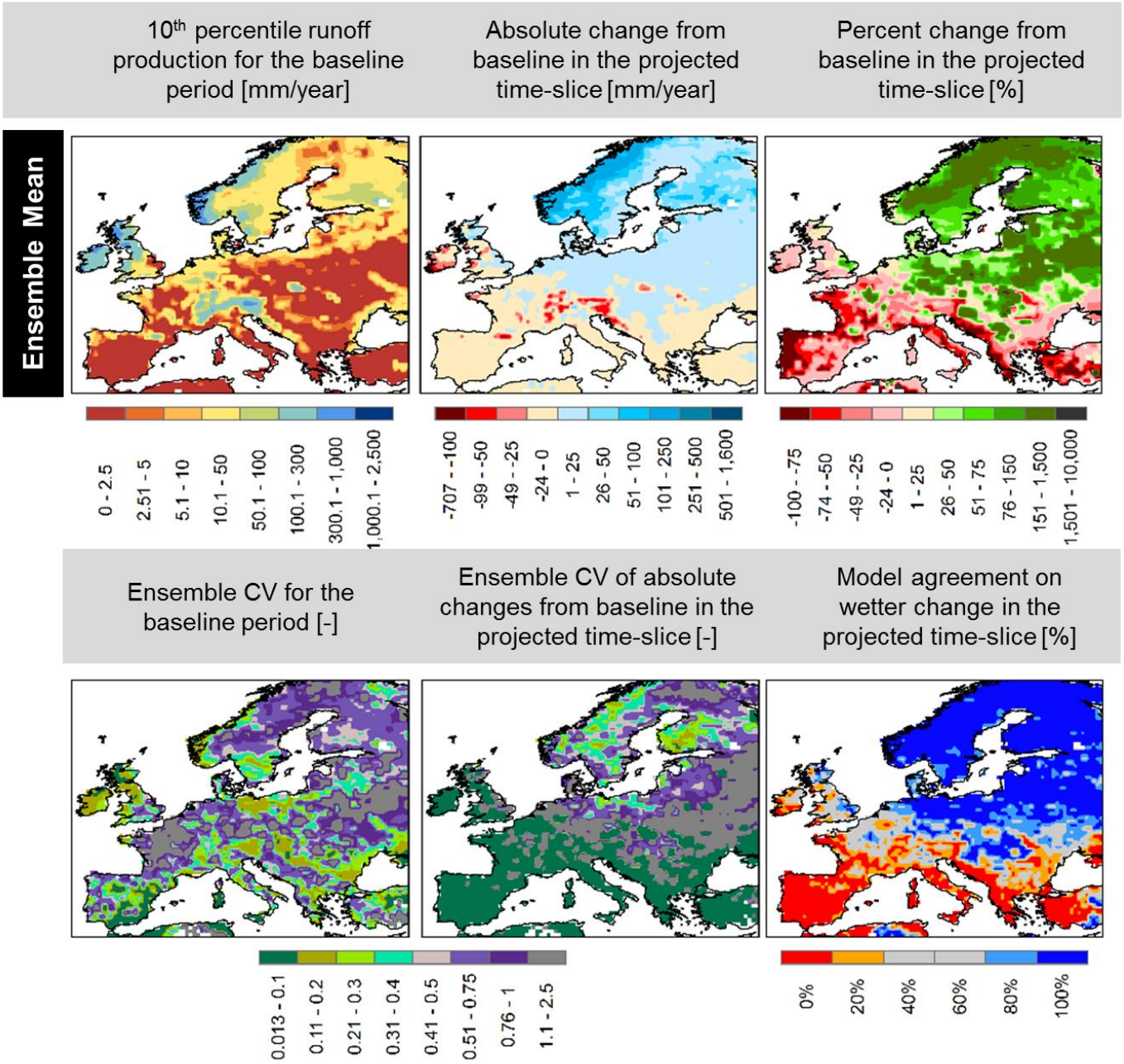


Figure S5. Ensemble mean of 10th percentile runoff production from Euro-CORDEX data bias adjusted against the WFDEI dataset. Top row: 10th percentile runoff production derived on an annual basis averaged over the baseline period (1976-2005) (top row), absolute (middle row) and percent change (bottom row) in ensemble mean runoff in the +4 SWL projected time-slice. Bottom row: coefficient of variation of the ensemble members for the baseline period (left column), coefficient of variation of the projected absolute changes in the +4 SWL projected time-slice (middle column) and model agreement towards a wetter change in the +4 SWL projected time-slice.

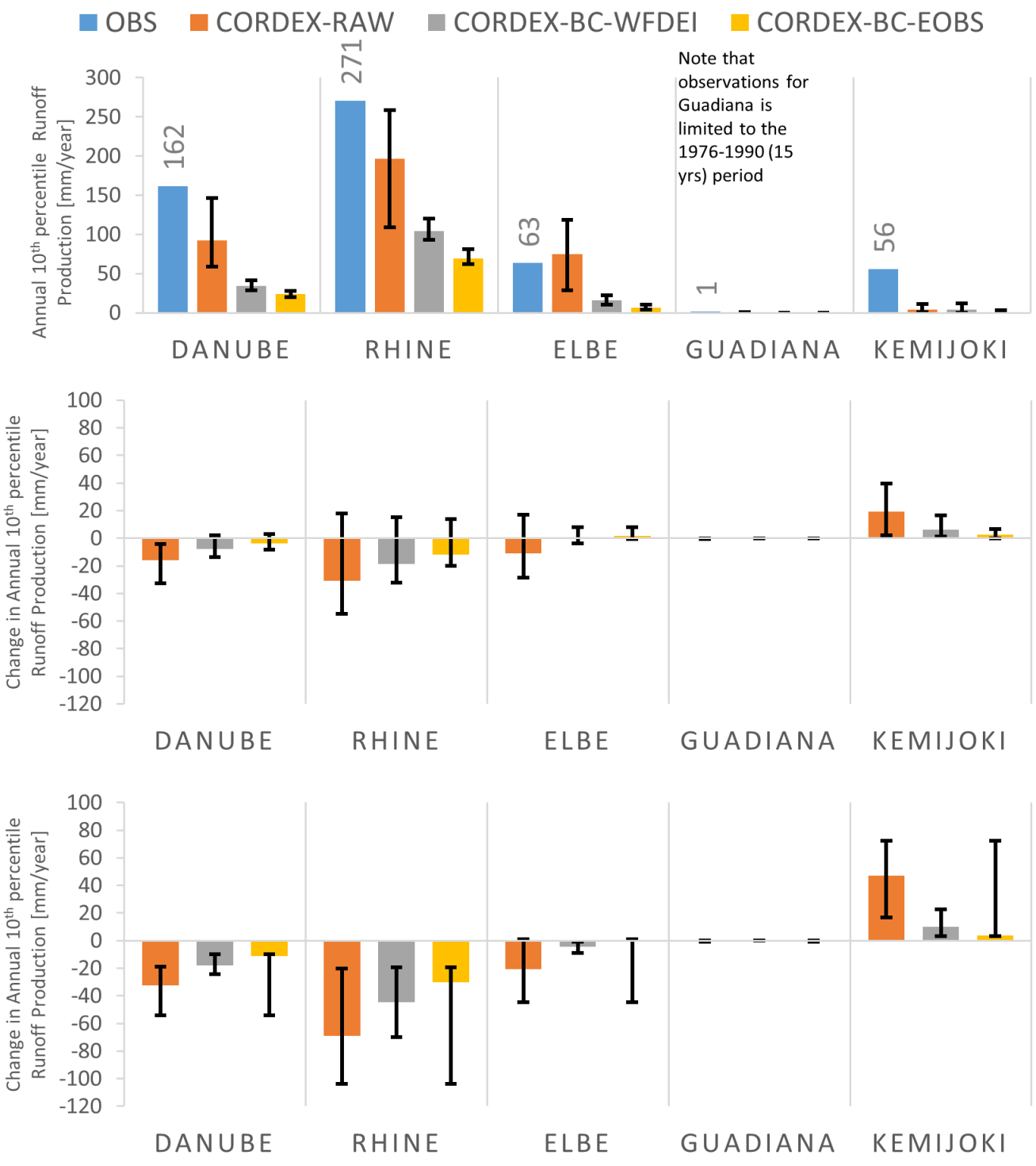


Figure S6. Comparison between the simulations of raw Euro-CORDEX data and bias adjusted against two different datasets (WFDEI and E-OBS) for five study basins. Bars show the ensemble means and error bars the minimum and maximum ensemble member values. (Top row) Annual 10th percentile runoff production for the period 1976 to 2005.OBS values are derived from GRDC discharge measurements converted to basin averages at the annual time-scale. (Middle row) Percent change in annual 10th percentile runoff production at the +2 SWL and (bottom row) at the +4 SWL.