Supplement 2. BN model's results for alternate climate models.

1 Introduction

In this document we present the validation of the BN model's results using two additional climate models, different than those used in the main paper. The models are:

- EURO-CORDEX climate simulation, combining global circulation model HadGEM2-ES from Met Office Hadley Centre (Jones et al. 2011) with KNMI's regional climate model RACMO22E (Van Meijgaard et al. 2008), realisation r1i1p1; downscaling realisation v2.
- ERA-Interim climate reanalysis (Dee et al. 2011). In this case, the BN model was quantified based on data from 1979–2013.

First, we present graphs of the standard normal transforms of variables discussed in Fig. 6 in the main paper. They show that even for specific discharges the model presents high correlation with observations. We also present graphs equivalent to Fig. 5 and 6 in the main paper with simulations using HadGEM2-ES-RACMO22E climate model. Then, a summarized comparison is given in Table S2, including comparison with the regional frequency analysis (using methodology from Smith et al. 2015). Finally, the equivalent to Fig. 7 shows the climate change predictions based on the HadGEM2-ES-RACMO22E model.

2 Semi-correlations for specific discharges

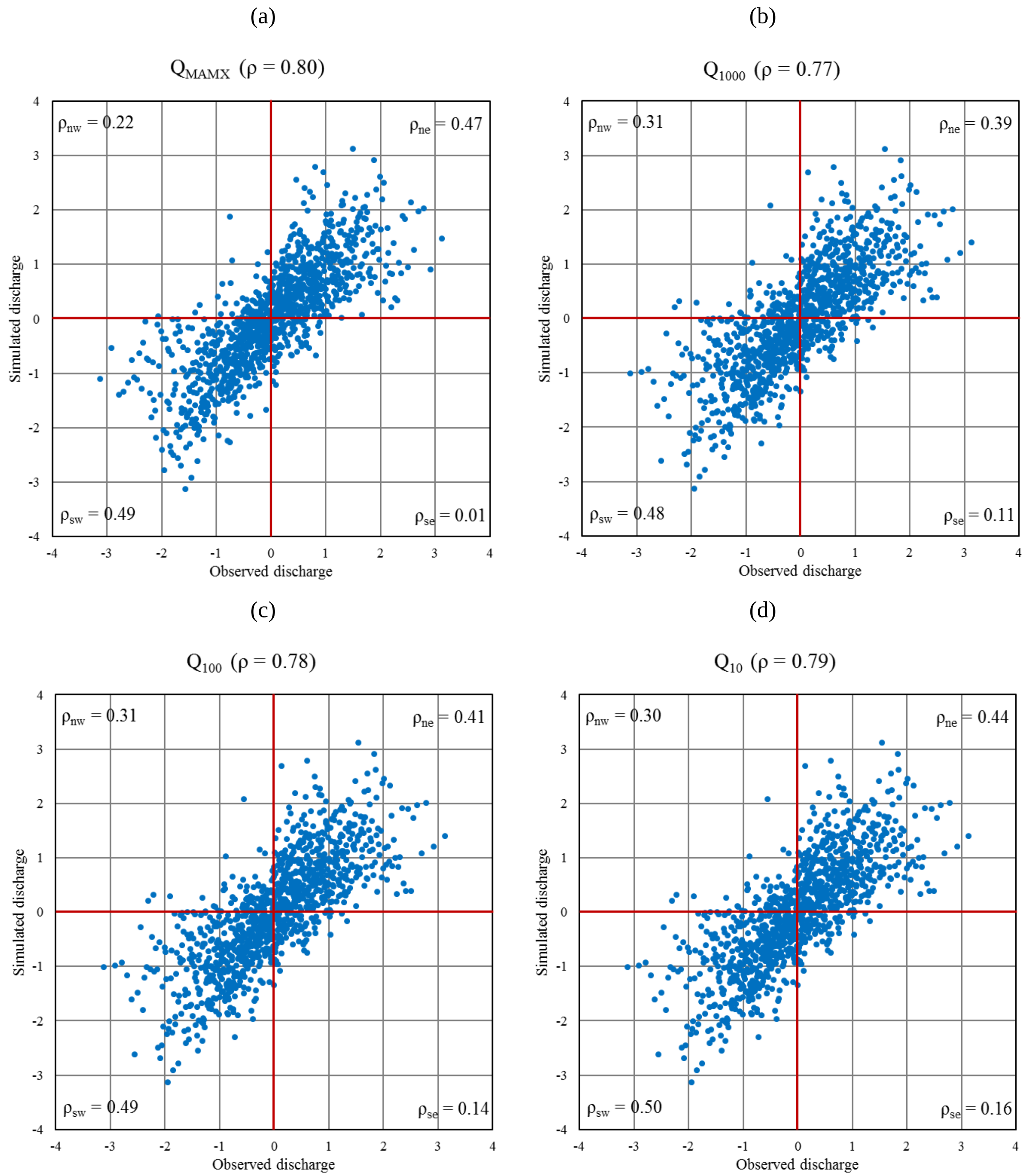

Figure S5. Simulated and observed average annual maxima of daily river specific discharges (as in Fig. 6 of the main text) transformed to standard normal.

3 Simulation using HadGEM2-ES-RACMO22E climate model

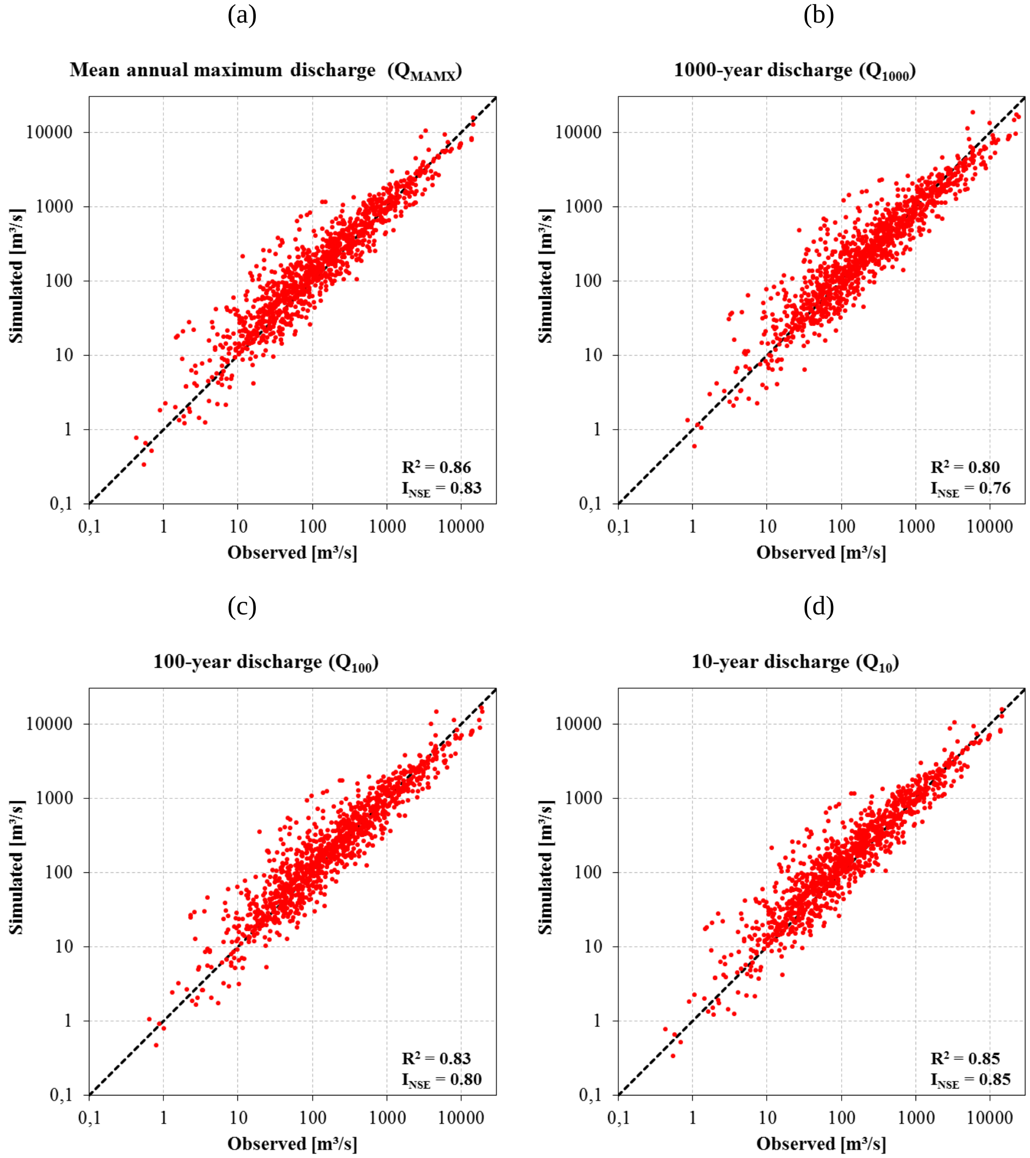

Figure S6. Simulated and observed average annual maxima of daily river discharges (a) and annual maxima fitted to Gumbel distribution to calculate 1000-, 100- and 10-year return periods (b–d), for 1125 stations. 30-year periods of annual maxima were used (the most recent available out of 1971–2000, 1961–1990 or 1951–1980). Data based on the HadGEM2-ES-RACMO22E climate model.

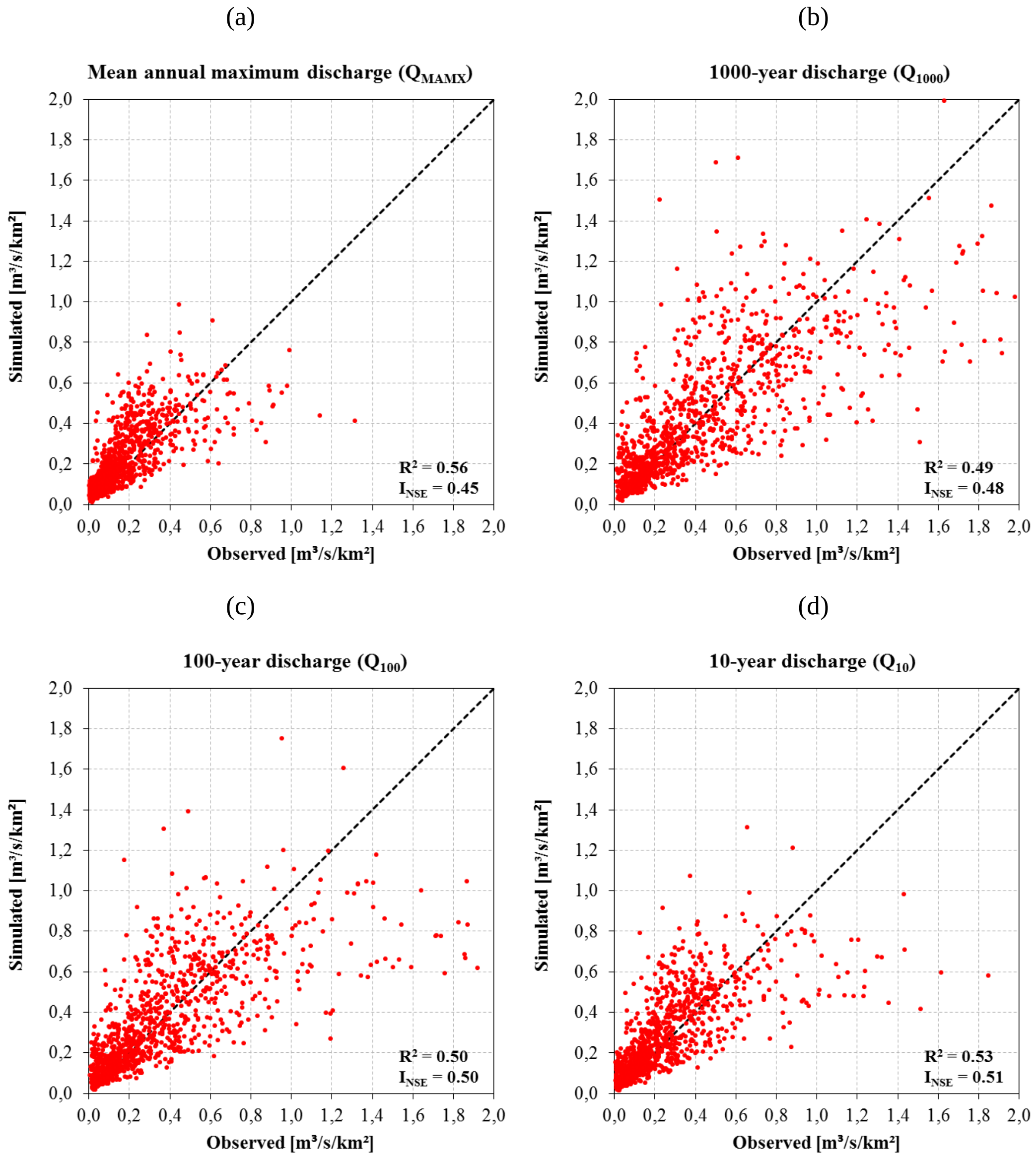

Figure S7. The same as Fig. S6, but for specific discharge, i.e. divided by catchment area.

4 Simulation using ERA-Interim climate model (reanalysis)

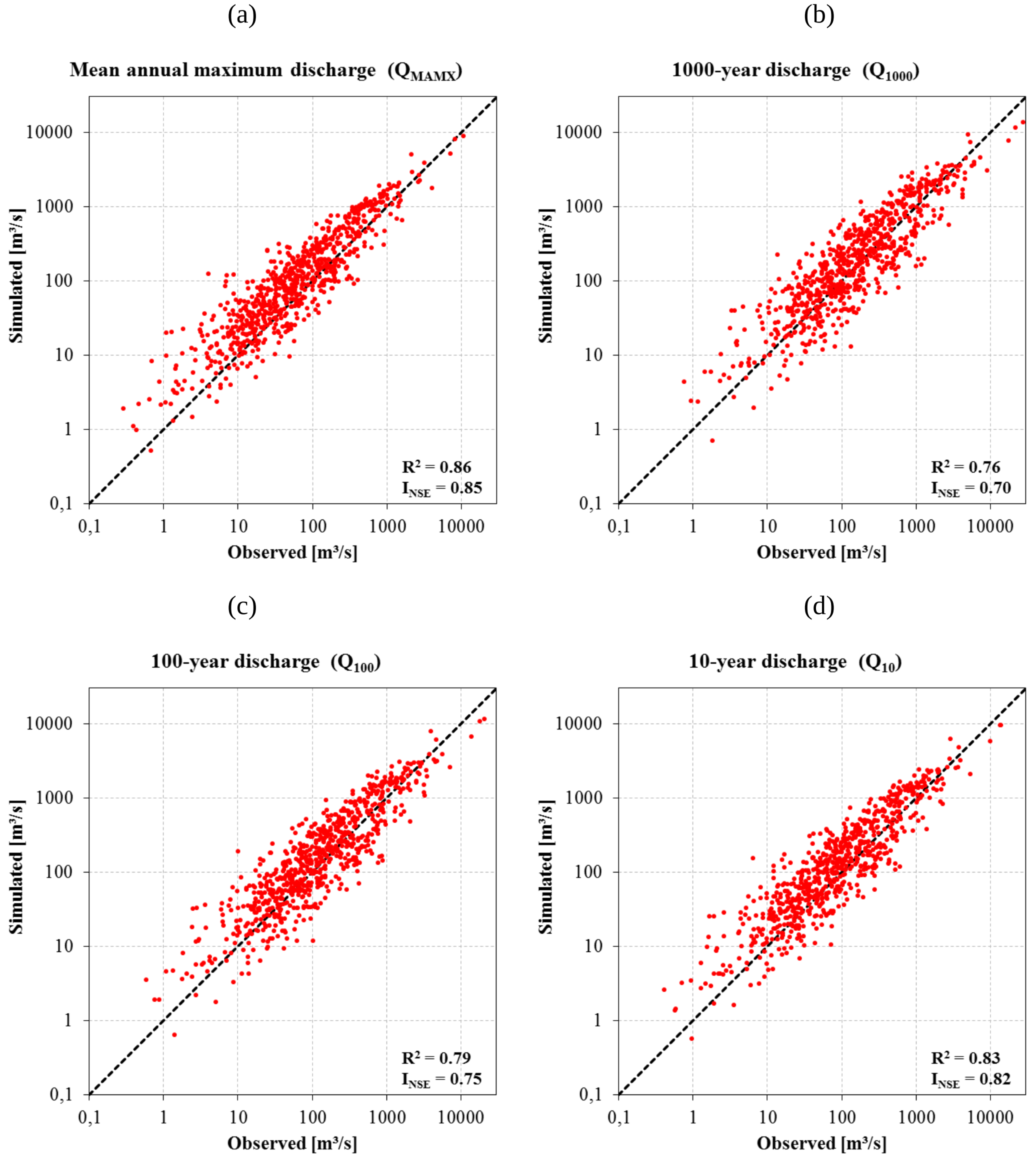

Figure S8. Simulated and observed average annual maxima of daily river discharges (a) and annual maxima fitted to Gumbel distribution to calculate 1000-, 100- and 10-year return periods (b–d), for 764 stations (1981–2010). Data based on the ERA-Interim climate model

(a) (b)

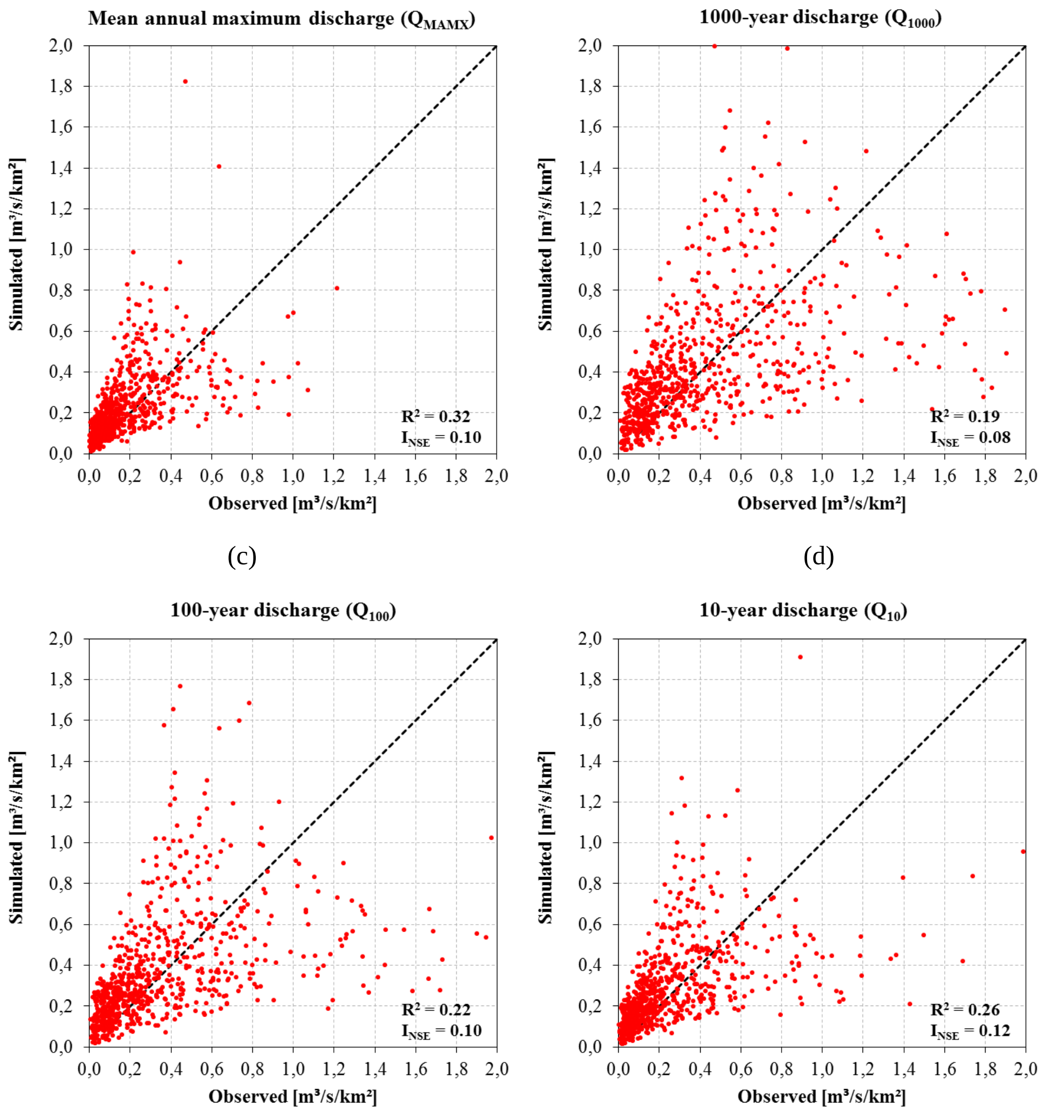

Figure S9. The same as Fig. S7, but for specific discharge, i.e. divided by catchment area.

5 Comparison of model's results

The comparison of the models show that with the climate model used in the main text, EC-EARTH-COSMO_4.8_clm17, the BN had the best performance in estimating extreme river discharge. However, when considering specific discharge, slightly better results were achieved with the alternative EURO-CORDEX model, HadGEM2-ES-RACMO22E. The performance of the model using ERA-Interim is the worst among the three models analysed. We may suppose that it is likely due to the coarse resolution of the model (0.75° compared to 0.11° in EURO-CORDEX). Yet, all models were better according to our measures of model performance than a regional frequency analysis.

Table S2. Comparison of results for 3 climate models in the quantification of the BN for extreme river discharges, together with regional frequency analysis.

Model Variable		EC-EARTH-COSMO_4.8_clm17		HadGEM2-ES-RACMO22E		ERA-Interim		Regional frequency analysis	
		R^2	NSE	R^2	NSE	R^2	NSE	R^2	NSE
Discharge	Q_{MAMX}	0.92	0.92	0.86	0.83	0.86	0.85	0.78	0.71
	Q_{1000}	0.87	0.74	0.80	0.76	0.76	0.70	0.65	0.27
	Q_{100}	0.89	0.80	0.83	0.80	0.79	0.75	0.70	0.44
	Q_{10}	0.91	0.88	0.85	0.85	0.83	0.82	0.75	0.58
Specific discharge	Q_{MAMX}	0.52	0.41	0.56	0.45	0.32	0.10	0.28	-0.02
	Q_{1000}	0.43	0.41	0.49	0.48	0.19	0.08	0.15	-2.94
	Q_{100}	0.44	0.43	0.50	0.50	0.22	0.10	0.17	-1.35
	Q_{10}	0.48	0.43	0.53	0.51	0.26	0.12	0.22	-0.45

6 Climate change predictions with HadGEM2-ES-RACMO22E

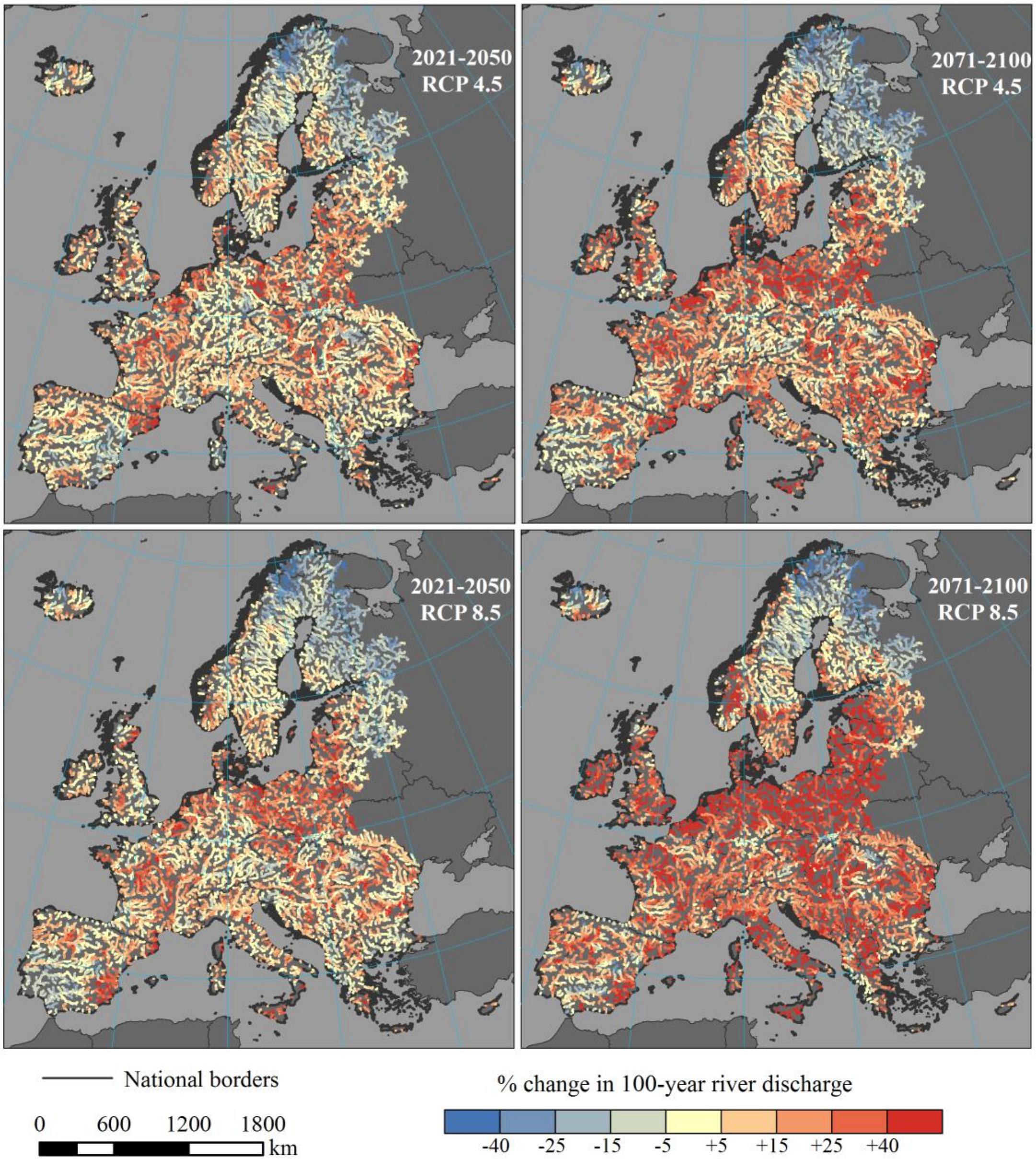

Figure S10. Predicted trends in daily river discharge with a 100-year return period (Gumbel distribution) under climate change scenarios (rivers with catchment area above 500 km2 only). Predictions based on EC- HadGEM2-ES-RACMO22E climate model run.

References

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Jones, C. D., Hughes, J. K., Bellouin, N., Hardiman, S. C., Jones, G. S., Knight, J., …, and Zerroukat, M.: The HadGEM2-ES implementation of CMIP5 centennial simulations, Geosci. Model Dev., 4, 543-570, doi:10.5194/gmd-4-543-2011, 2011.

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