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A space–time Bayesian hierarchical modeling framework for projection of seasonal maximum streamflow

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Table S1: DIC values for different candidate BHMs for a 1-month lead time. For each model, the same covariates are considered at all gauges for the location parameter. Candidate BHMs are sorted from the lowest to the highest DIC value. Scale and shape parameters are considered stationary. All candidate BHMs consider a Gaussian copula to model spatial dependence.

Model	Covariates	DIC
Nonstationary	SASWE, PDO	1065.2
Nonstationary	SASWE, ENSO	1067.3
Nonstationary	SASWE	1069.7
Nonstationary	SASWE, AMO	1071.9
Nonstationary	SASWE, ENSO, PDO	1077.4
Nonstationary	SASWE, PDO, AMO	1080.6
Nonstationary	SASWE, ENSO, AMO	1117.1
Stationary	–	1132.8

Table S2: DIC values for different candidate BHMs for a 2-month lead time. For each model, the same covariates are considered at all gauges for the location parameter. Candidate BHMs are sorted from the lowest to the highest DIC value. Scale and shape parameters are considered stationary. All candidate BHMs consider a Gaussian copula to model spatial dependence.

Model	Covariates	DIC
Nonstationary	SASWE, ENSO	1075.6
Nonstationary	SASWE	1078.6
Nonstationary	SASWE, PDO	1090.8
Nonstationary	SASWE, PDO, AMO	1097.6
Nonstationary	SASWE, ENSO, PDO	1099.1
Stationary	–	1132.8
Nonstationary	SASWE, AMO	1144.9
Nonstationary	SASWE, ENSO, AMO	1158.5

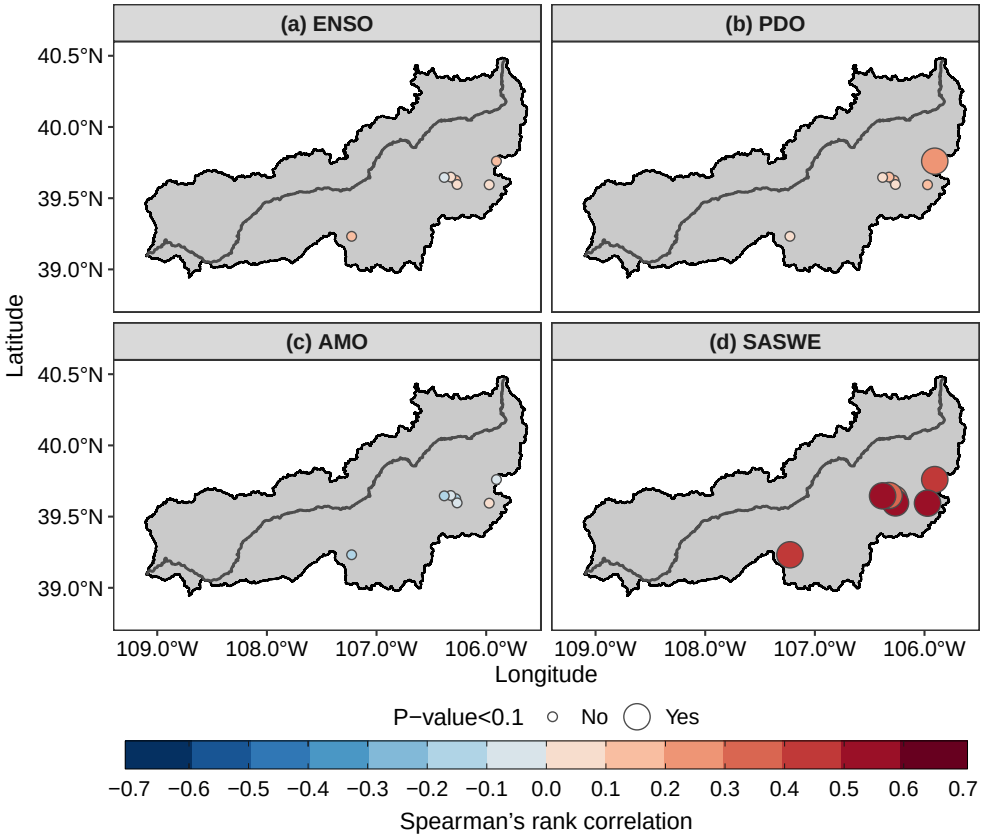

Figure S1: Spearman's rank correlation coefficient between spring 3-day maximum streamflow and potential covariates for a 1-month lead time. **(a)** Mean Nov-March ENSO. **(b)** Mean Nov-March PDO. **(c)** Mean Nov-March AMO. **(d)** The spatial average of Nov-March snow water equivalent (SASWE). Big circles indicate that Spearman's rank correlation is significant (p value$<$0.1).

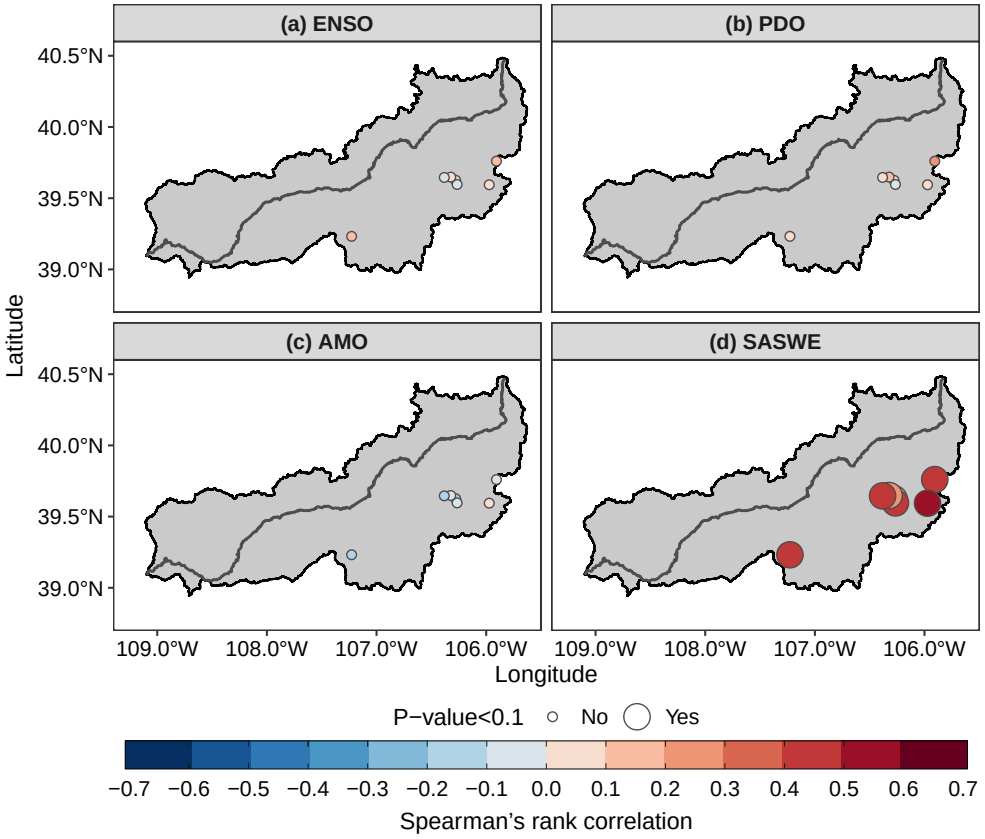

Figure S2: Spearman's rank correlation coefficient between spring 3-day maximum streamflow and potential covariates for a 2-month lead time. **(a)** Mean Nov-Feb ENSO. **(b)** Mean Nov- Feb PDO. **(c)** Mean Nov-Feb AMO. **(d)** The spatial average of Nov- Feb snow water equivalent (SASWE). Big circles indicate that Spearman's rank correlation is significant (p value$<$0.1).

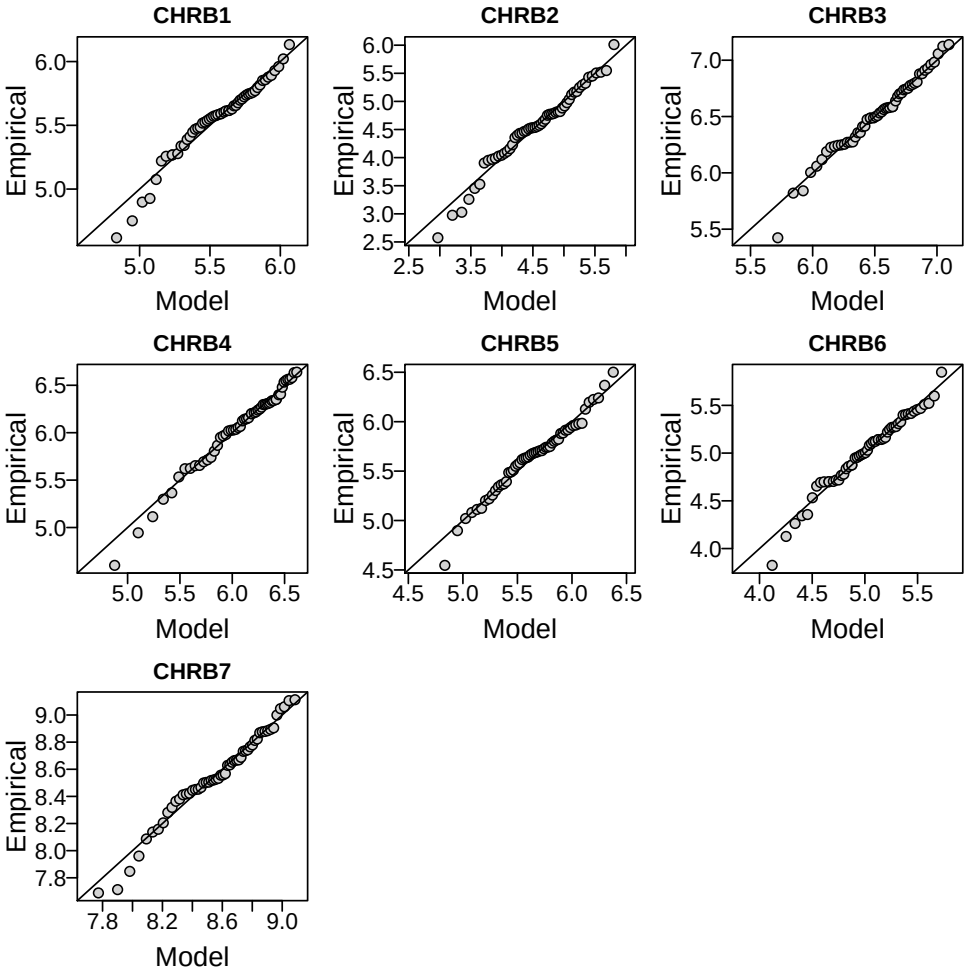

Figure S3: Q-Q plots of the stationary GEV distribution fitted for spring 3-day maximum streamflow for seven streamflow gauges of UCRB.

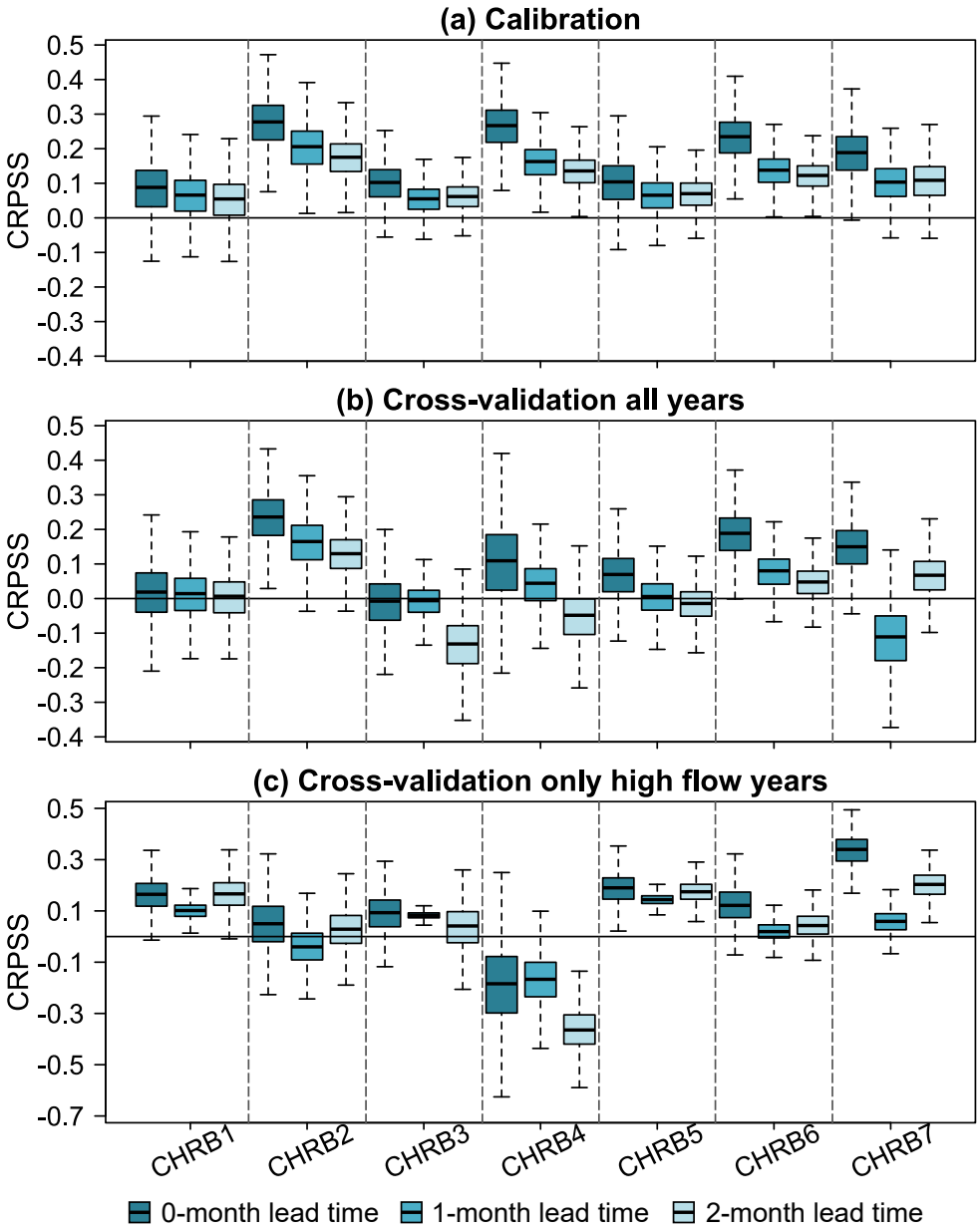

Figure S4: Continuous rank probability skill score (CRPSS) distribution for different lead times from the **(a)** calibration, **(b)** leave-1-year-out cross-validation, and **(c)** leave-1-year-out for extremes (60th percentile) cross-validation. Dark turquoise box plots denote a 0-month lead time, turquoise box plots a 1-month lead time, and light turquoise box plots a 2-month lead time. Higher values of the CRPSS indicate better model performance. The whiskers show the 95 % credible intervals, boxes the show interquartile range, and the horizontal lines inside the boxes show the median. Outliers are not displayed. All the lead time models consider a Gaussian copula. As for the ESS, the CRPSS ranges from $-\infty$ to 1, and its values have the same meaning.

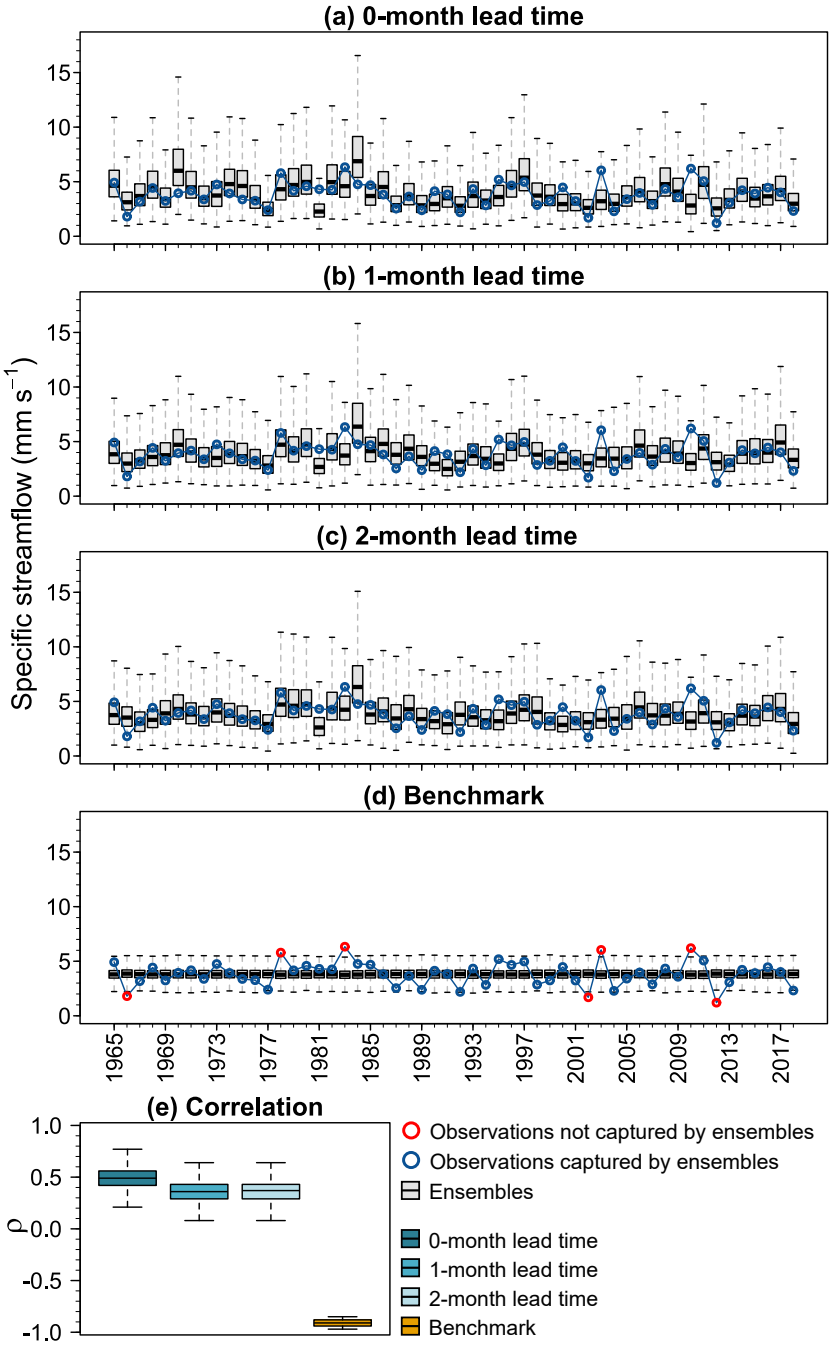

Figure S5: Time series of average projected spring maximum specific streamflow, (millimeters per day; hereafter $mm\,d^{-1}$), from the calibration for a **(a)** 0-month lead time, **(b)** 1-month lead time, **(c)** 2-months lead time, **(d)** benchmark, and **(e)** distributions of the Pearson correlation coefficient between observed and ensembles of average projection spring maximum specific streamflow over all seven gauges for the different models. Blue and red points in panels **(a) – (d)** indicate when observations are captured (or not) by the ensemble's variability, respectively. Whiskers show the 95% credible intervals, boxes show interquartile range, and horizontal lines inside the boxes show the median. Outliers are not displayed. All lead time models consider a Gaussian copula.