Supplement of

Mitigating the impact of increased drought-flood abrupt alternation events under climate change: the role of reservoirs in the Lancang-Mekong River Basin

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Sect. S1 Argument for the simulated runoff conforming to a Gamma distribution

This study investigates the runoff distribution at principal mainstream hydrological stations in the Lancang-Mekong River (LMR) Basin using simulated outputs from the THREW (Tsinghua Representative Elementary Watershed) model over its calibration period (2000–2009). An evaluation of five common statistical distributions is conducted. The distributions under consideration are the Gamma, Log-Normal, Weibull, Generalized Extreme Value (GEV), and Log-logistic (see Fig. S1). The analysis demonstrates that the simulated runoff at the LMR Basin's four mainstream stations are most accurately represented by the Gamma distribution.
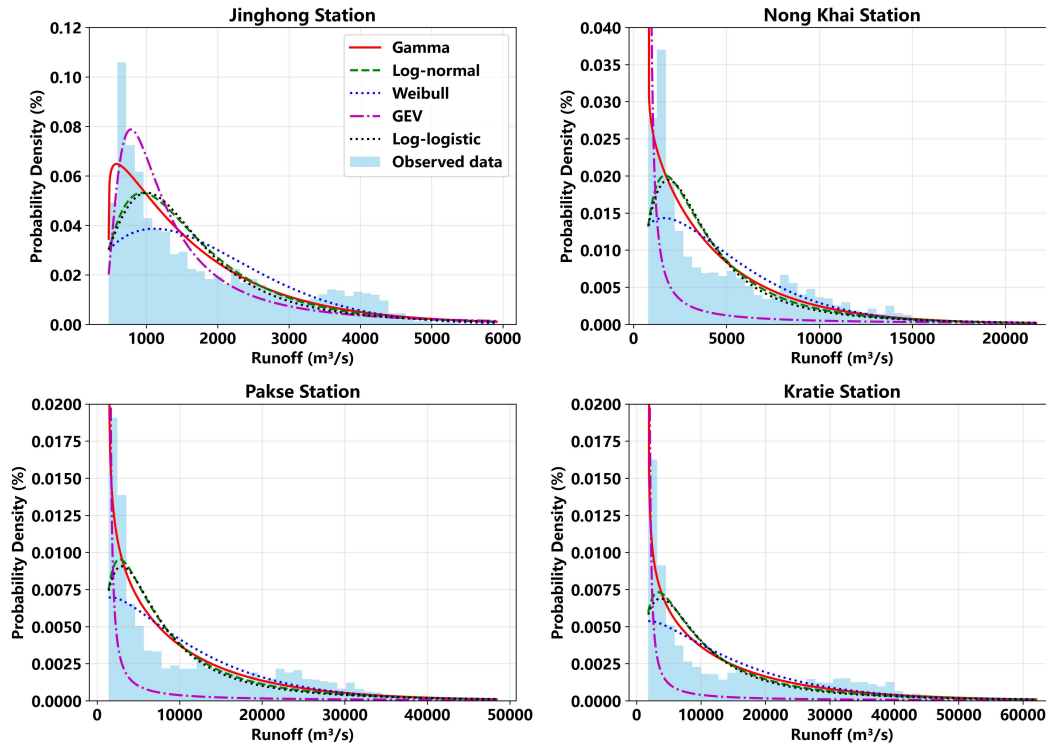
Figure S1: Distribution of simulated runoff at four major mainstream hydrological stations during the calibration period (2000-2009).

Furthermore, the Akaike Information Criterion (AIC) (Akaike, 1974) is employed in this study to identify the distribution that most accurately reflected simulated runoff in the calibration period. The AIC method is a widely utilized approach for conducting relative comparisons among multiple candidate distributions. The distribution that corresponds to the minimum AIC value is regarded as the optimal one. The calculation formula for AIC is provided in Eq. S1.

$$AIC=2k+nln(\frac{SSR}{n})\qquad\qquad\qquad\qquad\qquad\text{(S1)}$$

Where, k is the number of parameters n is the number of data sequences, and SSR denotes the sum of squared residuals.

The AIC values for five commonly used distributions and the empirical distribution (derived from the histogram in Fig. S1) are calculated based on the simulated runoff at four major hydrological stations during the calibration period. The results are presented in Fig. S2. It can be observed that for all four major hydrological stations, the Gamma distribution provides the closest match. Therefore, under the assumption that runoff conforms to a Gamma distribution, employing the Gamma-based R-SDFAI index to evaluate Drought-Flood Abrupt Alternation (DFAA) events in the LMR Basin is a justifiable undertaking.
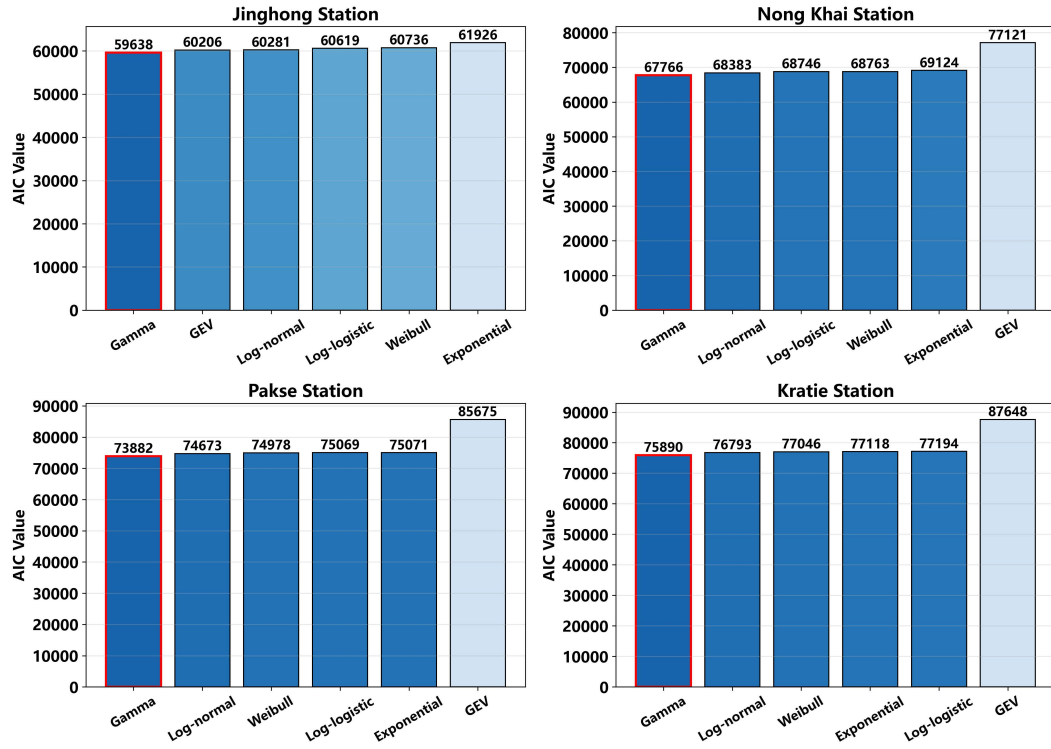

Figure S2: AIC values of five common distributions and the empirical distribution at four mainsrteam hydrological stations.

Reference

Akaike, H.: A new look at the statistical model identification. IEEE Transactions on Automatic Control, https://doi.org/10.1109/TAC.1974.1100705, 1974.

Sect. S2 DFAA event probability in the LMR Basin under multiple scenarios

This section presents the raw data on the probabilities of DFAA events occurring during each study period. The data are organized by scenario (natural or dammed), season (wet or dry), and intensity level (mild, moderate, or severe), as illustrated in Tables S1 to S4.

Table S1: The seasonal probability of DFAA under the natural scenario, averaged across five GCMs, during the history period (1980-2014), the near future (2021-2060), and the far future (2061-2100), as well as under three SSPs.

Natural	Station	History	Near Future			Far Future		
			SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Wet season								
DTF	JingHong	2.10%	2.50%	1.92%	1.83%	1.92%	2.17%	1.17%
	Nong Khai	2.00%	2.25%	2.83%	1.75%	3.00%	3.00%	2.33%
	Pakse	3.81%	3.42%	4.58%	2.58%	4.50%	3.75%	3.00%
	Kratie	3.71%	4.83%	4.50%	3.08%	5.25%	4.25%	4.08%
FTD	JingHong	0.95%	1.08%	1.50%	0.67%	1.33%	2.17%	0.83%
	Nong Khai	1.62%	1.92%	1.92%	1.25%	1.92%	2.08%	1.25%
	Pakse	3.52%	2.25%	3.17%	3.00%	2.92%	3.08%	2.25%
	Kratie	3.14%	3.25%	3.17%	2.50%	3.67%	3.33%	3.42%
Dry season								
DTF	JingHong	1.24%	1.58%	1.50%	1.42%	1.42%	1.33%	1.25%
	Nong Khai	1.05%	1.17%	1.33%	0.58%	0.92%	1.50%	1.08%
	Pakse	0.67%	1.33%	1.67%	1.08%	0.83%	1.75%	1.08%
	Kratie	0.96%	1.50%	1.17%	1.08%	0.83%	1.58%	1.00%
FTD	JingHong	0.48%	0.58%	0.83%	0.58%	0.25%	0.33%	0.25%
	Nong Khai	0.57%	0.58%	0.92%	0.17%	0.33%	0.17%	0.08%
	Pakse	0.67%	0.42%	0.92%	0.08%	0.25%	0.33%	0.08%
	Kratie	0.57%	0.17%	0.67%	0.17%	0.42%	0.42%	0.08%

Table S2: The DFAA probability at different intensities under the natural scenario, averaged across five GCMs, during the history period (1980-2014), the near future (2021-2060), and the far future (2061-2100), as well as under three SSPs.

Natural	Station	History	Near Future			Far Future		
			SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Mild events								
DTF	JingHong	1.39%	1.63%	1.29%	1.38%	1.38%	1.46%	1.08%
	Nong Khai	1.29%	1.29%	1.21%	0.71%	1.67%	1.75%	1.38%
	Pakse	1.71%	1.67%	2.29%	1.33%	2.13%	2.00%	1.46%
	Kratie	1.39%	2.21%	1.88%	1.46%	2.38%	2.04%	1.79%
FTD	JingHong	0.52%	0.75%	1.00%	0.63%	0.75%	1.08%	0.54%
	Nong Khai	1.00%	1.08%	1.25%	0.67%	1.00%	1.00%	0.54%
	Pakse	1.90%	1.00%	1.67%	1.21%	1.42%	1.50%	1.00%
	Kratie	1.53%	1.46%	1.67%	1.29%	1.83%	1.46%	1.46%
Moderate events								
DTF	JingHong	0.19%	0.33%	0.42%	0.13%	0.21%	0.25%	0.08%
	Nong Khai	0.19%	0.29%	0.67%	0.33%	0.29%	0.42%	0.29%
	Pakse	0.38%	0.42%	0.46%	0.29%	0.42%	0.46%	0.42%
	Kratie	0.76%	0.67%	0.58%	0.50%	0.50%	0.75%	0.42%
FTD	JingHong	0.05%	0.08%	0.17%	0.00%	0.04%	0.17%	0.00%
	Nong Khai	0.14%	0.17%	0.17%	0.04%	0.13%	0.13%	0.13%
	Pakse	0.10%	0.33%	0.29%	0.33%	0.17%	0.21%	0.13%
	Kratie	0.33%	0.21%	0.21%	0.04%	0.21%	0.42%	0.29%
Severe events								
DTF	JingHong	0.08%	0.08%	0.00%	0.13%	0.08%	0.04%	0.04%
	Nong Khai	0.33%	0.13%	0.21%	0.13%	0.00%	0.08%	0.04%
	Pakse	0.67%	0.29%	0.38%	0.21%	0.13%	0.29%	0.17%
	Kratie	0.67%	0.29%	0.38%	0.13%	0.17%	0.13%	0.33%
FTD	JingHong	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Nong Khai	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Pakse	0.10%	0.00%	0.08%	0.00%	0.00%	0.00%	0.04%
	Kratie	0.10%	0.04%	0.04%	0.00%	0.00%	0.00%	0.00%

Table S3: The year-round and seasonal probability of DFAA under the dammed scenario, averaged across five GCMs, during the near future (2021-2060) and the far future (2061-2100), as well as under three SSPs.

Dammed	Station	Near Future			Far Future		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Year-round							
DTF	JingHong	1.17%	1.00%	0.63%	1.13%	1.33%	0.83%
	Nong Khai	1.83%	2.04%	0.92%	1.83%	1.63%	1.58%
	Pakse	2.08%	2.83%	1.54%	2.29%	2.04%	1.83%
	Kratie	2.50%	2.33%	1.58%	2.50%	2.04%	2.25%
FTD	JingHong	0.46%	0.67%	0.21%	0.42%	0.33%	0.17%
	Nong Khai	1.46%	1.46%	0.58%	1.46%	1.17%	0.46%
	Pakse	1.38%	2.13%	1.37%	1.67%	1.33%	1.00%
	Kratie	1.58%	1.75%	1.17%	1.58%	1.83%	1.54%
Wet season							
DTF	JingHong	1.92%	1.75%	1.00%	1.83%	1.75%	0.83%
	Nong Khai	2.67%	2.75%	1.25%	2.58%	2.33%	2.08%
	Pakse	3.17%	4.33%	2.58%	4.08%	3.33%	2.83%
	Kratie	4.08%	4.17%	2.67%	4.75%	3.67%	3.92%
FTD	JingHong	0.75%	1.17%	0.42%	0.75%	0.67%	0.33%
	Nong Khai	1.83%	1.58%	0.58%	2.08%	1.17%	0.83%
	Pakse	2.42%	3.25%	2.25%	2.67%	2.42%	1.83%
	Kratie	2.83%	3.17%	2.08%	2.92%	3.17%	2.83%
Dry season							
DTF	JingHong	0.42%	0.25%	0.25%	0.42%	0.92%	0.83%
	Nong Khai	1.00%	1.33%	0.58%	1.08%	0.92%	1.08%
	Pakse	1.00%	1.33%	0.50%	0.50%	0.75%	0.83%
	Kratie	0.92%	0.50%	0.50%	0.25%	0.42%	0.58%
FTD	JingHong	0.17%	0.17%	0.00%	0.08%	0.00%	0.00%
	Nong Khai	1.08%	1.33%	0.58%	0.83%	1.17%	0.08%
	Pakse	0.33%	1.00%	0.50%	0.67%	0.25%	0.17%
	Kratie	0.33%	0.33%	0.25%	0.25%	0.50%	0.25%

Table S4: The DFAA probability at different intensities under the dammed scenario, averaged across five GCMs, during the near future (2021-2060) and the far future (2061-2100), as well as under three SSPs.

Dammed	Station	Near Future			Far Future		
		SSP1-2.6	SSP2-4.5	SSP5-8.5	SSP1-2.6	SSP2-4.5	SSP5-8.5
Mild events							
DTF	JingHong	0.88%	0.67%	0.50%	0.96%	1.25%	0.83%
	Nong Khai	1.42%	1.33%	0.79%	1.42%	1.21%	1.25%
	Pakse	1.29%	1.83%	1.33%	1.79%	1.42%	1.29%
	Kratie	1.42%	1.54%	1.21%	1.67%	1.50%	1.29%
FTD	JingHong	0.46%	0.63%	0.21%	0.42%	0.33%	0.17%
	Nong Khai	1.29%	1.46%	0.54%	1.38%	1.00%	0.38%
	Pakse	1.13%	1.79%	1.12%	1.50%	1.04%	0.83%
	Kratie	1.42%	1.54%	1.17%	1.37%	1.54%	1.42%
Moderate events							
DTF	JingHong	0.21%	0.33%	0.13%	0.08%	0.04%	0.00%
	Nong Khai	0.29%	0.58%	0.04%	0.42%	0.38%	0.29%
	Pakse	0.54%	0.67%	0.08%	0.42%	0.42%	0.33%
	Kratie	0.71%	0.42%	0.25%	0.75%	0.54%	0.71%
FTD	JingHong	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%
	Nong Khai	0.17%	0.00%	0.04%	0.08%	0.17%	0.08%
	Pakse	0.21%	0.25%	0.25%	0.17%	0.29%	0.13%
	Kratie	0.17%	0.17%	0.00%	0.21%	0.29%	0.13%
Severe events							
DTF	JingHong	0.08%	0.00%	0.00%	0.08%	0.04%	0.00%
	Nong Khai	0.13%	0.12%	0.08%	0.00%	0.04%	0.04%
	Pakse	0.25%	0.33%	0.12%	0.08%	0.21%	0.21%
	Kratie	0.38%	0.38%	0.13%	0.08%	0.00%	0.25%
FTD	JingHong	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Nong Khai	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Pakse	0.04%	0.08%	0.00%	0.00%	0.00%	0.04%
	Kratie	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%