

Supplementary Figures

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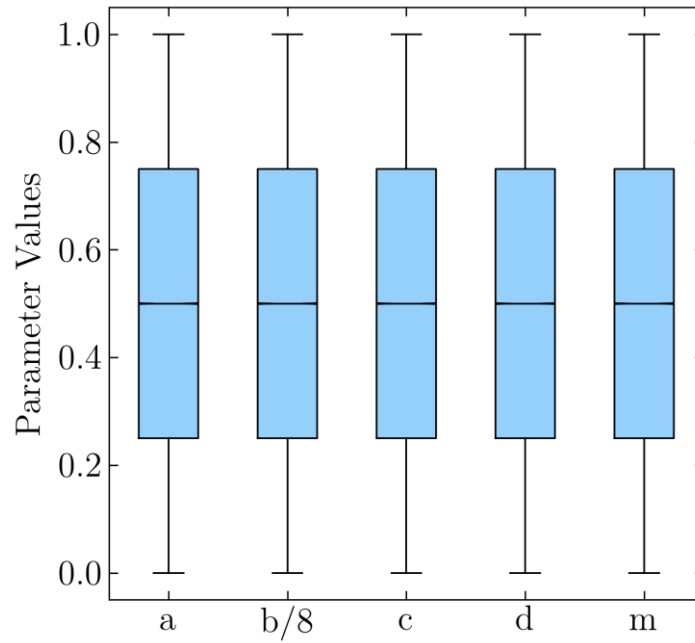
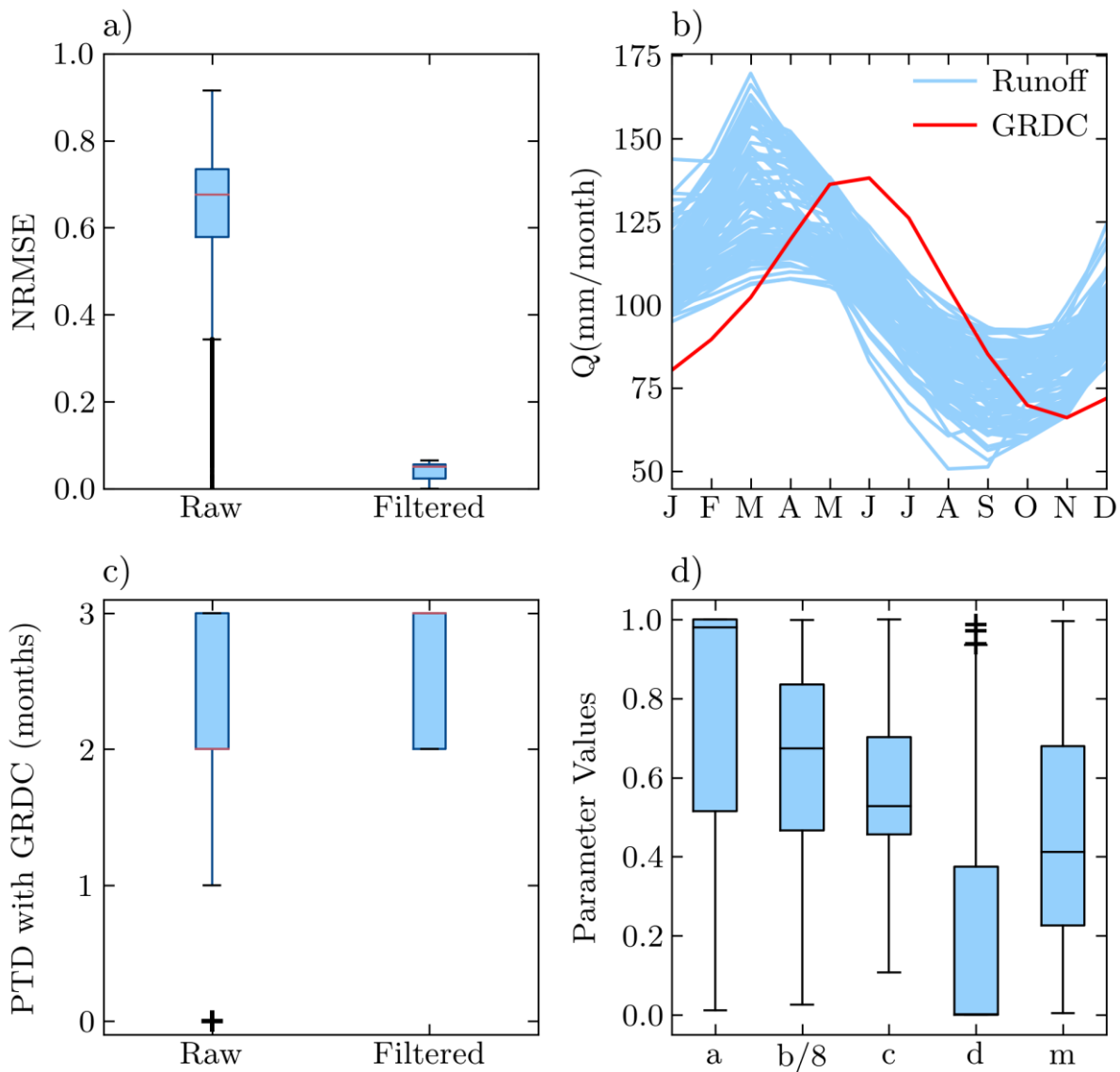
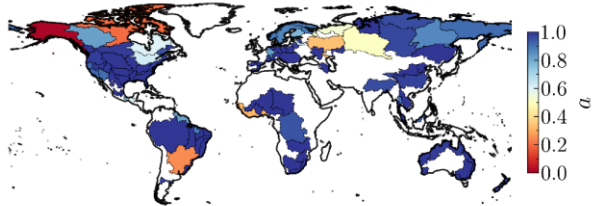


Figure S1: Sampling runoff generation parameters using the Latin Hypercube Sampling (LHS) method. Parameter b ranges between 0-8 meters, and it is scaled by 8 (b/8) for plotting purposes

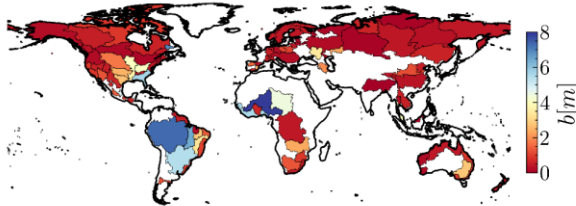


10 **Figure S2: First-stage parameter determination over the Amazon River basin: (a) NRMSE between simulated annual runoff and**
observed annual streamflow time series for original one million parameter sets (raw) and the selected subset of one hundred
parameter sets (filtered), (b) Mean monthly runoff corresponding to the selected top 100 (filtered) parameters and observed mean
monthly streamflow from the GRDC station, (c) Peak Time Difference (PTD), the difference between the average peak runoff time
(month) and peak flow time for the raw and filtered parameter sets, and (d) distribution of the parameter values from the 100
15 **selected parameter combinations after filtering. Parameter b is normalized by 8 for plotting along with the other parameters.**

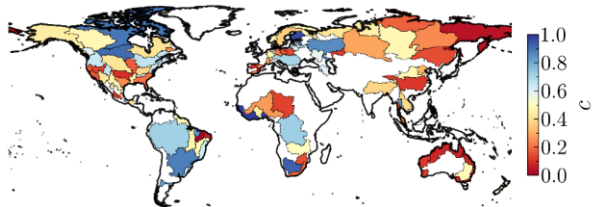
a) Optimal value for parameter a



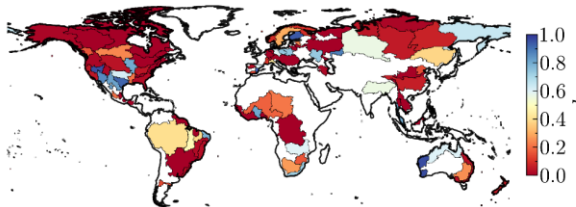
b) Optimal values for parameter b



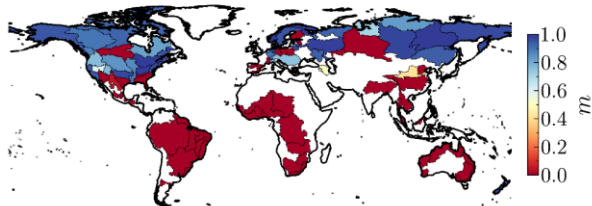
c) Optimal values for parameter c



d) Optimal values for parameter d



e) Optimal values for parameter m



f) Optimal values for parameter β

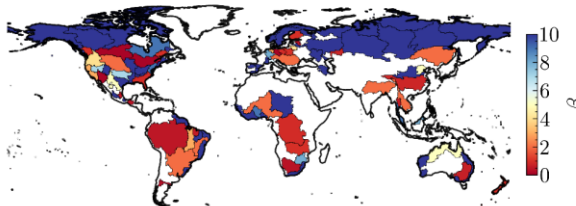
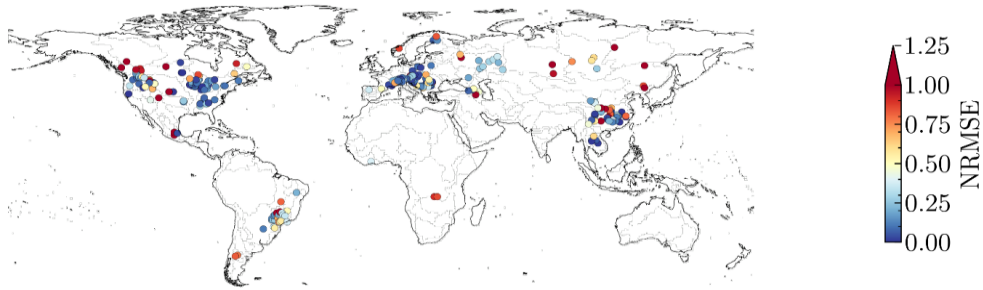


Figure S3: Spatial maps of the final parameter values after the 2nd-stage parameter determination. See Table 2 for a description of the parameter values.

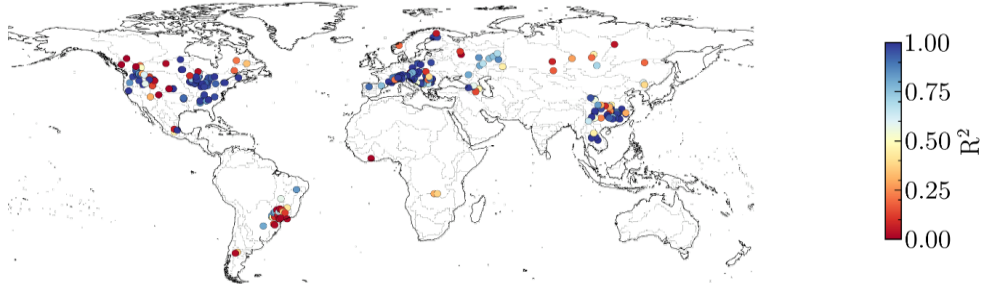
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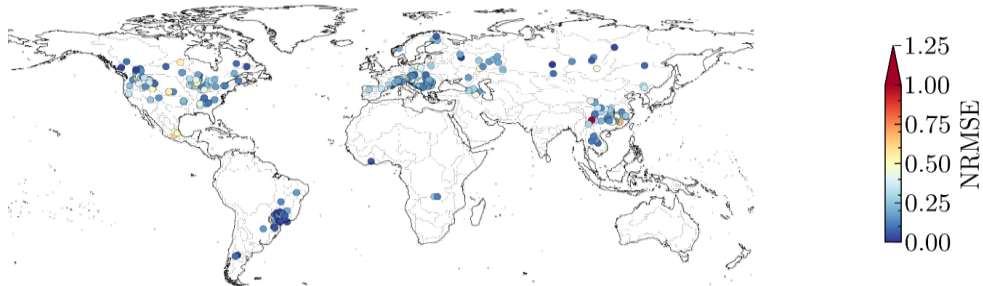
a) Reservoir Release: NRMSE



b) Reservoir Release : R^2



c) Reservoir Storage : NRMSE



d) Reservoir Storage : R^2

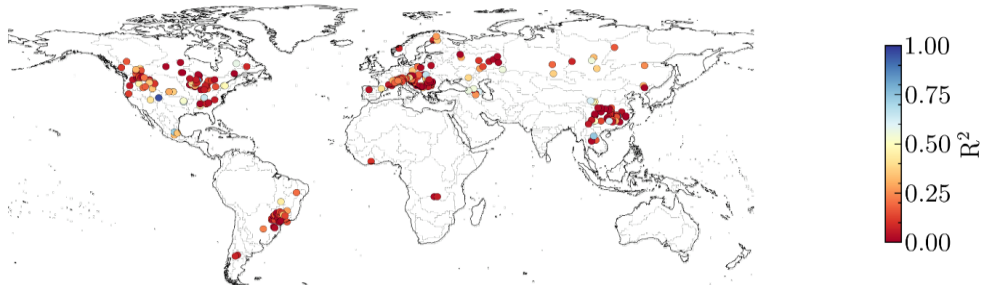


Figure S4: The difference between reservoir storage and release time series between Xanthos-enhanced-sim and Xanthos-enhanced-sim2 simulations at hydropower reservoirs demonstrates the value-added by accounting explicitly for hydropower reservoir functionality in *Xanthos-enhanced-sim*. A higher R^2 of 1.0 and NRMSE of 0.0 indicate a perfect agreement between the two.

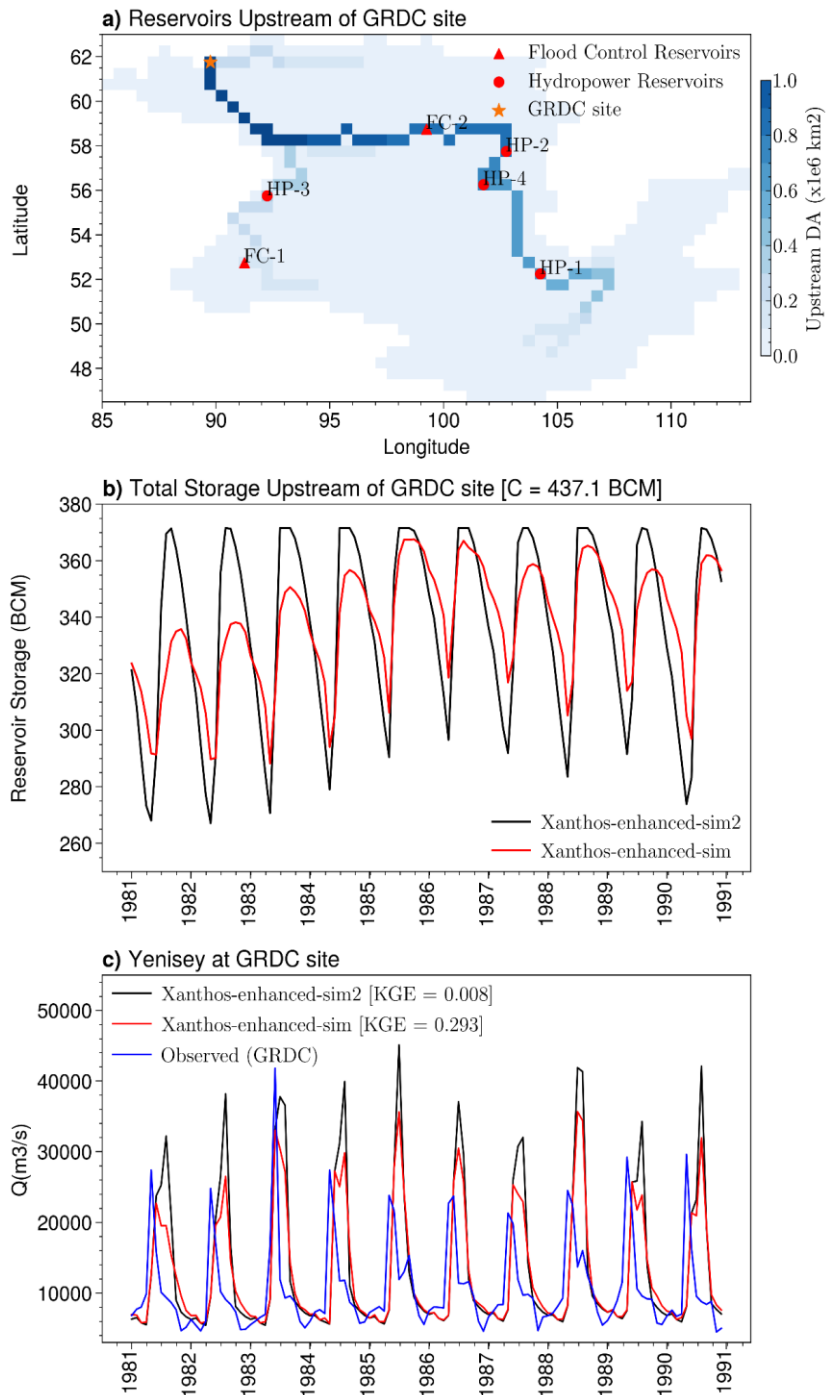
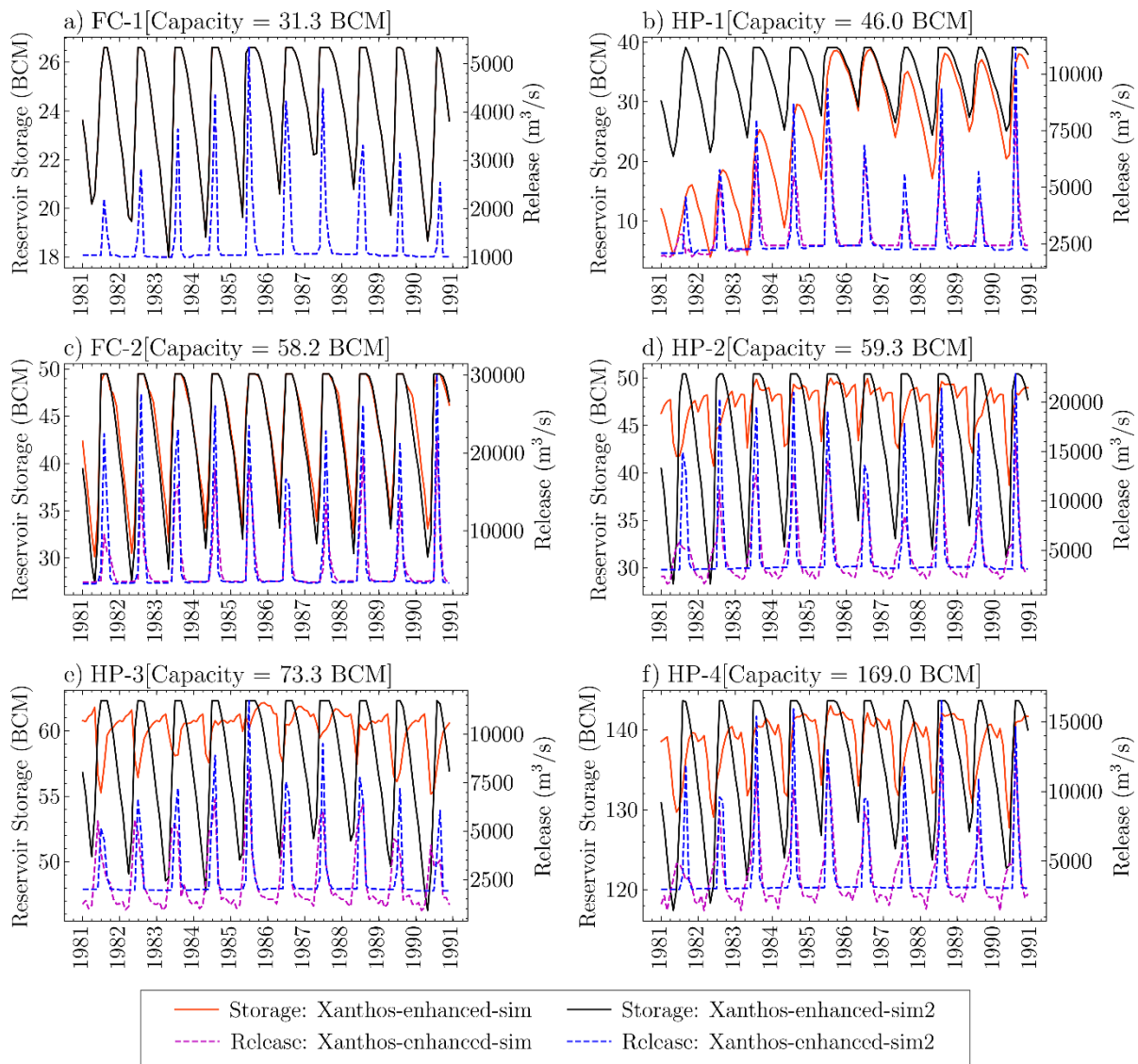


Figure S5: Yenisey basin: (a) reservoir distributions upstream of the GRDC site, (b) total reservoir storage upstream of the GRDC site, and (c) streamflow at the GRDC site. Upstream DA is the upstream drainage area, and C is the total capacity of reservoirs upstream of the GRDC site.



35 **Figure S6: Simulated storage and release characteristics for reservoirs located upstream of Yenisey basin GRDC station for the last ten years of our simulation. Four are hydropower (a, d, e, and f), and two are flood control (b and c) reservoirs. The reservoirs are arranged from (a) – (f) in order of increasing storage capacity.**