# Supplementary Material

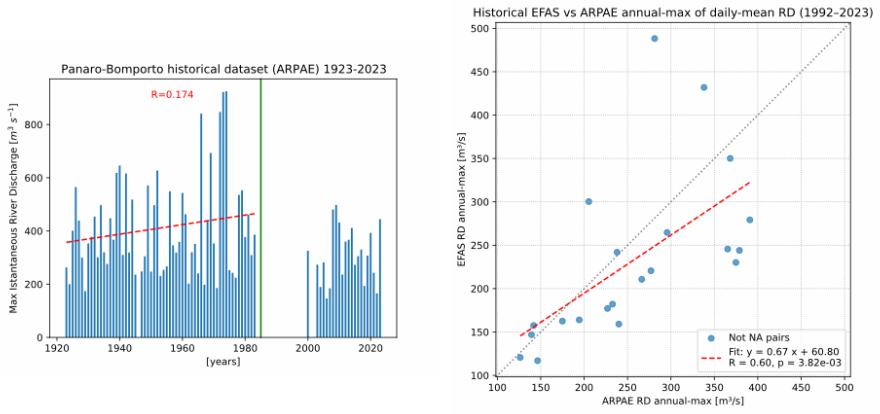


**Figure S1:** (a) Timeseries of maximum instananeous river discharge observations from gauge measurements at Bomporto station (source: ARPA Emilia Romagna, data accessible at www.arpae.it). The green line indicates the introduction of detention basins in 1985. (b) scatter plot of annual maxima of daily mean river discharge at Bomporto in EFAS historical data and ARPAE station measurements. The relatively poor coupling between the two series ($r = 0.6$) is attributable to the introduction of detention basins.

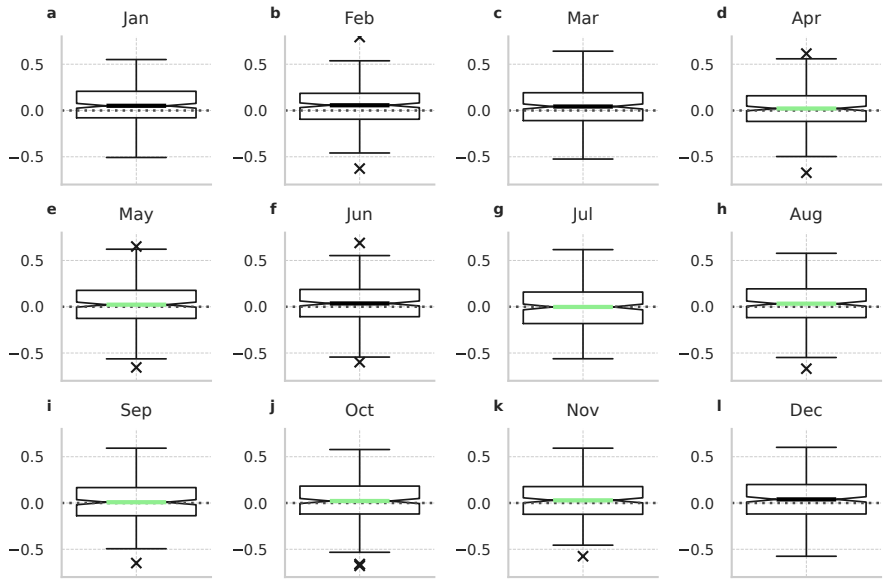


**Figure S2:** Ensemble independence scores of river discharge in EFAS5 seasonal reforecasts after removing the first 90 lead days. For each initialization month, the pairwise Spearman correlation is calculated between all combinations of the 25 ensemble members (box-and-whisker plots). The mean correlation is marked in green when it is not significantly different from zero according to a t-test at 1% confidence level. The test is performed on the grid point that best approximates the location of Bomporto station. A detailed description of the independence score test is provided in Sect. 2.3.1.

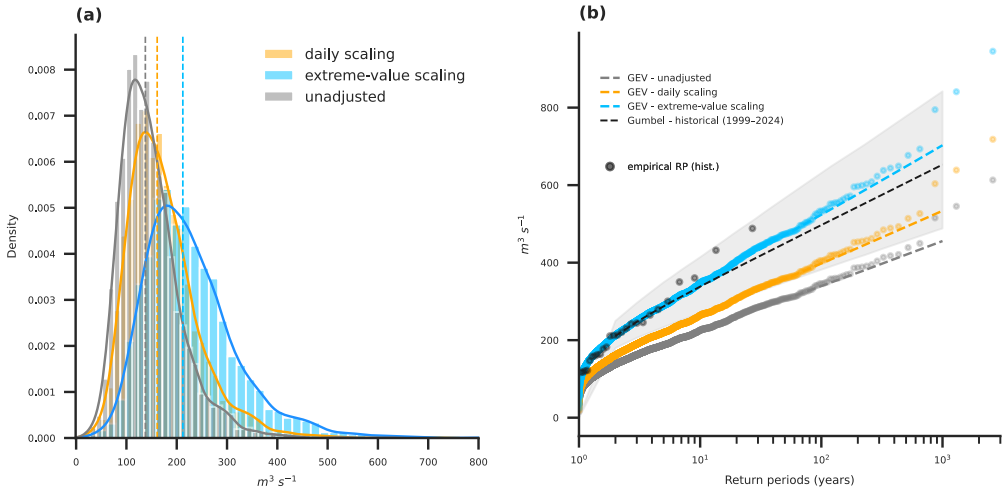


**Figure S3:** Distributions (**a**) and extreme-value fits (**b**) of annual maxima of daily discharge sampled from EFAS surrogate series and processed with different bias correction methods (no bias correction - grey; daily scaling - orange; extreme-value scaling - blue). The black dashed line in panel (**b**) shows a Gumbel fit applied to historical annual maxima, with light grey shading indicating 95% confidence intervals; all other fits are estimated with a Generalized Extreme Value (GEV) distribution. Dots mark empirical return periods estimated with the Weibull plotting position formula.

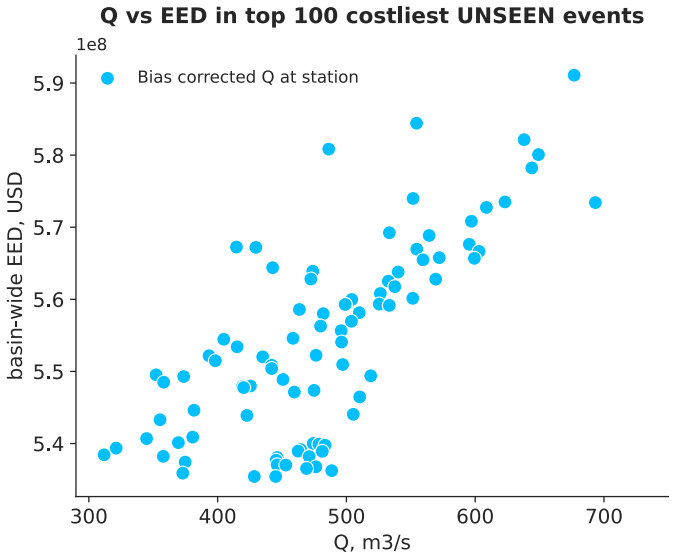


**Figure S4:** River discharge at Bomporto vs basin-wide estimated economic damage (EED, USD) for the 100 top-ranking UNSEEN events by EED. Note that river discharge is bias corrected using extreme-value scaling relative to EFAS historical daily mean discharge.

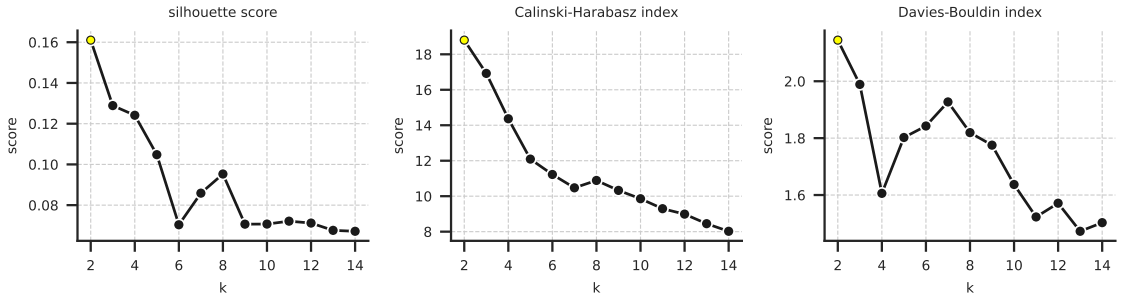


**Figure S5:** Metrics for identifying the optimal number of k-means clusters for the MSLP and Z500 detrended anomaly fields (ECMWF SEAS5) associated with the 100 UNSEEN events with the highest EED. The chosen regional domain of MSLP/Z500 fields extends from 30°N - 70°N and from 20°W - 20°E. The optimal $k$ for each metric is highlighted in yellow.