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Hydrological consistency between the upstream and downstream estimates of Q1000 flood on the upper Rhine River, using historical series in Basel (1808-2017) and Maxau (1815-2018)

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Estimation of extreme design floods with a short series of a few decades remains challenging because the statistical extrapolation of observed floods to extreme floods induces great uncertainties. Several alternative methods take advantage of the use of additional information: regional methods (e.g. the index flood method), Monte Carlo rainfall-runoff simulation methods, or specific statistical methods adapted to historical series. Here we present a flood frequency analysis on the upper Rhine River, using long historical series in Basel (1808-2017) and Maxau (1815-2018). We used a Bayesian framework to fit the parameters of the GEV distribution. Each value of the annual maximum discharge has uncertainties, which vary from ± 5-7% for the last decades to ± 22-42% for the oldest period depending on the station. At the local scale, without prior assumption on the three parameters of a GEV distribution, we found that the credibility intervals of the Basel and Maxau flood distributions are consistent. However, beyond a 1000-year return period, flood quantiles are incoherent with Q(Maxau) < Q(Basel) although Maxau (50 000 km^2) is located downstream of Basel (36 000 km^2). The floods at Basel are almost Gumbel distributed (shape parameter k = 0.066), whereas the floods at Maxau are Weibull distributed (shape parameter k = 0.219) with an asymptotic maximum value. Assuming that the shape parameter k has a certain regional consistency, we have performed a second iteration, with a prior interval [-0.1; +0.4] on k. The width of this interval corresponds to the union of the posterior distribution of k parameter of each local distribution: [-0.1; +0.2] at Basel and [0.0; +0.4] at Maxau. The second version of each distribution is almost the same up to a return period of 100 years, but there is no more crossing for extreme values. Using the predictive distribution with a regional prior on the shape parameter of the GEV distribution, the result is hydrologically consistent from upstream to downstream.