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Flood frequency analysis – the challenge of using historical data

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Estimates of high flood quantiles are needed for many applications, .e.g. dam safety assessments are based on the 1000 years flood, whereas the dimensioning of important infrastructure requires estimates of the 200 year flood. The flood quantiles are estimated by fitting a parametric distribution to a dataset of high flows comprising either annual maximum values or peaks over a selected threshold. Since the record length of data is limited compared to the desired flood quantile, the estimated flood magnitudes are based on a high degree of extrapolation. E.g. the longest time series available in Norway are around 120 years, and as a result any estimation of a 1000 years flood will require extrapolation. One solution is to extend the temporal dimension of a data series by including information about historical floods before the stream flow was systematically gaugeded. Such information could be flood marks or written documentation about flood events. The aim of this study was to evaluate the added value of using historical flood data for at-site flood frequency estimation. The historical floods were included in two ways by assuming: (1) the size of (all) floods above a high threshold within a time interval is known; and (2) the number of floods above a high threshold for a time interval is known. We used a Bayesian model formulation, with MCMC used for model estimation. This estimation procedure allowed us to estimate the predictive uncertainty of flood quantiles (i.e. both sampling and parameter uncertainty is accounted for). We tested the methods using 123 years of systematic data from Bulken in western Norway. In 2014 the largest flood in the systematic record was observed. From written documentation and flood marks we had information from three severe floods in the 18th century and they were likely to exceed the 2014 flood. We evaluated the added value in two ways. First we used the 123 year long streamflow time series and investigated the effect of having several shorter series' which could be supplemented with a limited number of known large flood events. Then we used the three historical floods from the 18th century combined with the whole and subsets of the 123 years of systematic observations. In the latter case several challenges were identified: i) The possibility to transfer water levels to river streamflows due to man made changes in the river profile, (ii) The stationarity of the data might be questioned since the three largest historical floods occurred during the "little ice age" with different climatic conditions compared to today.