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Uncertainty introduced by flood frequency analysis in the estimation of climate change impacts on flooding

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Potential changes in extreme flooding under a future climate are of much interest in climate change adaptation work, and estimates for high flows with long return periods are often based on an application of flood frequency analysis methods. The uncertainty introduced by this estimation is, however, only rarely considered when assessing changes in flood magnitude. In this study, an ensemble of hydrological projections for each of 115 catchments distributed across Norway is analysed to derive an estimate for the percentage change in the magnitude of the 200-year flood under a future climate. This is the return level used for flood hazard mapping in Norway. The ensemble of projections is based on climate data from 10 EUROCORDEX GCM/RCM combinations, two bias correction methods (empirical quantile mapping and double gamma function), and 25 alternative parameterisations of the HBV hydrological model. For each hydrological simulation, the annual maximum series is used to estimate the 200-year flood for the reference period, 1971-2000 and a future period, 2071-2100, based on two and three-parameter GEV distributions. In addition, bootstrap resampling is used to estimate the 95% confidence levels for the extreme value estimates, and this range is incorporated into the ensemble estimates for each catchment. As has been shown in previous work based on earlier climate projections, there are large regional differences in the projected changes in the 200-year flood across Norway, with median ensemble projections ranging from 44% to +56% for the daily-averaged flood magnitude. These differences reflect the relative importance of rainfall vs. snowmelt as the dominant flood generating process in different regions, at differing altitudes and as a function of catchment area, in addition to dominant storm tracks.

Variance decomposition is used to assess the relative contributions of the following components to the total spread (given by the 5 to 95% range) in the ensemble for each catchment: differences between climate model input time series, differences between hydrological parameterisations, the distribution of flood frequency estimates for each time series, and the interaction terms for these factors. The results indicate that, on average, the climate model input data contributes slightly more than half the total variance in the hydrological projections when a 2-parameter Gumbel distribution is used for the flood frequency estimation. This is a commonly applied distribution due, in part, to the robustness of the estimates. In catchments where a change in the dominant flood season occurs under a future climate, the uncertainty introduced by hydrological parameterisation is more pronounced, in agreement with other published studies. The use of a 3-parameter GEV distribution, which can often be justified due to its ability to better capture changes in the tail of the distribution, introduces a large degree of uncertainty in the ensemble estimates, and in many catchments, is the dominant contribution to the total variance. This is, thus, an important factor to consider when presenting estimates for changes in extreme floods under a future climate and points toward the benefits of also considering alternative approaches for deriving such estimates.