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Future flood risk in Europe under high-end climate projections

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Every year, new record-breaking hydrological extremes affect our society, fueling the debate between climate change and natural climate variability. A new generation of climate projections for the present century has recently become available, based on the Representative Concentration Pathways (RCP) adopted by the IPCC Fifth Assessment Report. A number of COordinated Regional climate Downscaling EXperiments (CORDEX) were set up to provide high-resolution climatic scenarios over different areas of the world, where the European branch is referred to as EURO-CORDEX. In this work, an ensemble of EURO-CORDEX RCP 8.5 scenarios is used as input to a distributed hydrological model to assess the projected changes in flood hazard and flood risk in Europe through the current century. Statistical robustness is sought with the use of ensemble projections, through data aggregation over time (i.e., 30-year time slices) and space (i.e., country and river basin level), with the goal of detecting statistically significant trends over time and with regard to extreme events. A consistent method is proposed to evaluate the agreement of ensemble projections. Changes in the magnitude of average and extreme precipitation and streamflow are investigated through statistical tools and extreme value distribution fitting. A dedicated analysis on peaks over threshold is performed to evaluate changes in the frequency of extreme discharge peaks. The hazard component driven by the climate scenarios is then combined with exposure maps obtained from high resolution flood hazard maps and with vulnerability information, to estimate the overall flood risk in Europe under high-end climate projections. This work brings a number of novelties to address issues pointed out in previous flood risk assessments at continental scale: 1) flood hazard maps are derived by a 2D hydraulic model rather than through simplified approaches; 2) the frequency of extreme peak discharges is assessed more consistently through a peak over threshold approach; 3) a new methodology is proposed to bias correct the climate projections used, which is performed in the evaluation of the flood risk and therefore does not modify atmospheric variables nor the energy balance; 4) a coherent estimate of vulnerability information is included.
Results indicate that the change in frequency of discharge extremes is likely to have a larger impact on the overall flood hazard as compared to the change in their magnitude. This underlines some limitations embedded in the commonly used block-maxima analysis on annual peak discharges. On a continental average, flood peaks with return period above 100 years are projected to double in frequency within the next few decades. This is reflected into an average 200 percent climate-related increase in the future expected damage and population affected by the end of the century in Europe.