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On the robustness of flood hazard assessment in a changing climate for Europe

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One of the expected effects of climate change is the modification of precipitation patterns, which will affect the frequency and severity of extreme events such as floods. Changes in flood hazard due to global warming are typically assessed by combining regional climate information with a hydrological model. Projections by climate models of changes in precipitation patterns, especially of extreme events, are still prone to large uncertainty. Hence, probabilistic scenarios that consist of multiple realizations of the current and future climate state are indispensable to better identify the climate signal amidst large variability.

In this work we used an ensemble of regional climate developments from the ENSEMBLES project with a spatial resolution of 25 km to drive the hydrological model LISFLOOD running at 5-km grid scale. For each regional climate model (RCM) we considered the simulation driven by ERA40 (a forty-year European re-analysis of the global atmosphere) and a transient simulation (1961-2099) driven by a given General Circulation Model (GCM) under the SRES A1B emission scenario defined by IPCC (Intergovernmental Panel on Climate Change). The probability of extreme discharge levels was estimated by fitting an extreme value distribution to the simulated river discharges in every river cell. For each RCM, the performance of the hydrological model was furthermore tested by comparing the ERA40 driven simulations with observation-based estimates of extreme discharge at over 600 gauging stations throughout Europe. Then, we compared the ERA40 results with the control period (1961-1990) of the transient simulation in order to highlight the effect of the driving GCM. Future changes in flood hazard were assessed in the short (2011-2040), medium (2041-2070) and long (2071-2100) term by comparison of simulated extreme discharges for these three time slices with the control period (1961-1990). In addition to the uncertainty derived from the RCMs and GCMs we assessed the uncertainty associated with the fitting of the extreme value distribution.

Results show a general reduction – more pronounced in time – in the hazard of extreme snowmelt floods in the scenario period in northeastern Europe. Elsewhere, we find a consistent tendency toward a higher flood hazard in the majority of the model experiments in several major European rivers. We find evidence for a considerable influence of especially the global model that is used to drive the regional climate model. At the scale of individual river basins, using a different combination of climate models sometimes may result in a very different or even opposite climate change signal in flood hazard. The uncertainty in the fitting of the extreme value distribution to estimate discharge extremes has a significant influence on the results, especially for events with return periods of 50 years and more.