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Robust Adaptation? Assessing the sensitivity of safety margins in flood defences to uncertainty in future simulations - a case study from Ireland.

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Climate change impact and adaptation assessments have traditionally adopted a 'top-down' scenario based approach, where information from different Global Climate Models (GCMs) and emission scenarios are employed to develop impacts led adaptation strategies. Due to the tradeoffs in the computational cost and need to include a wide range of GCMs for fuller characterization of uncertainties, scenarios are better used for sensitivity testing and adaptation options appraisal. One common approach to adaptation that has been defined as robust is the use of safety margins. In this work the sensitivity of safety margins that have been adopted by the agency responsible for flood risk management in Ireland, to the uncertainty in future projections are examined.

The sensitivity of fluvial flood risk to climate change is assessed for four Irish catchments using a large number of GCMs (17) forced with three emissions scenarios (SRES A1B, A2, B1) as input to four hydrological models. Both uncertainty within and between hydrological models is assessed using the GLUE framework. Regionalisation is achieved using a change factor method to infer changes in the parameters of a weather generator using monthly output from the GCMs, while flood frequency analysis is conducted using the method of probability weighted moments to fit the Generalised Extreme Value distribution to $\sim$20,000 annual maxima series. The sensitivity of design margins to the uncertainty space considered is visualised using risk response surfaces. The hydrological sensitivity is measured as the percentage change in flood peak for specified recurrence intervals.

Results indicate that there is a considerable residual risk associated with allowances of +20% when uncertainties are accounted for and that the risk of exceedence of design allowances is greatest for more extreme, low frequency events with considerable implication for critical infrastructure, e.g., culverts, bridges, flood defences whose designs are normally associated with such return periods. Sensitivity results show that the impact of climate change is not as great for flood peaks with higher return periods. The average width of the uncertainty range and the size of the range for each catchment reveals that the uncertainties in low frequency events are greater than high frequency events. In addition, the uncertainty interval, estimated as the average width of the uncertainty range of flow for the five return periods, grows wider with a decrease in the runoff coefficient and wetness index of each catchment, both of which tend to increase the nonlinearity in the rainfall response. A key management question that emerges is the acceptability of residual risk where high exposure of vulnerable populations and/or critical infrastructure coincide with high costs of additional capacity in safety margins.