UKCP Case Study: Climate Change Impacts on Peak River Flows

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Target Audience: A range of infrastructure planners

Executive Summary

- Potential future increases in floods due to climate change need to be accounted for in the design of new housing developments, infrastructure projects and new or updated flood defences.
- To provide a nationally consistent analysis, a national-scale grid-based hydrological model was used to produce a 1 km resolution assessment of the sensitivity of flood peaks across Britain to climatic changes.
- The flood modelling was then combined with UKCP data to produce location-specific information for three flood return periods, for three future time-slices using four different emissions scenarios.
- Future developments will include ensuring this information is easily available to the target audience.

Climate Change Impacts on Flood Peaks

There is some evidence that flood events in Great Britain have already been influenced by climate change, and the general conclusion is that flooding will become a more serious problem in the future due to climate change. As such, guidance exists for local planners and flood management authorities to support them in understanding the potential impacts of climate change when managing flood risk. But the current guidance needs updating to use the latest climate projections, and to take advantage of developments in hydrological modelling and computing. Here, rather than driving a hydrological model directly with the output from climate models to assess potential changes in flood hazard, a sensitivity-based approach is used. The approach creates a flood response surface for each location in the domain (here at a 1 km resolution for Great Britain), which can then be combined with climate model data to produce an analysis of possible changes in flood peaks . While the central estimate for all time-slices and regions shows an increase in the flood peaks through the 21st Century (under RCP 8.5 forcing, Fig. 1), regional mean changes are greater in western regions, with the eastern regions of Great Britain likely to experience smaller changes in peak river flows.

When the four emissions scenarios are considered, then there is a greater spread in the future response, particularly for the 2080s time-slice, due to the role of emissions uncertainty on the future projections.

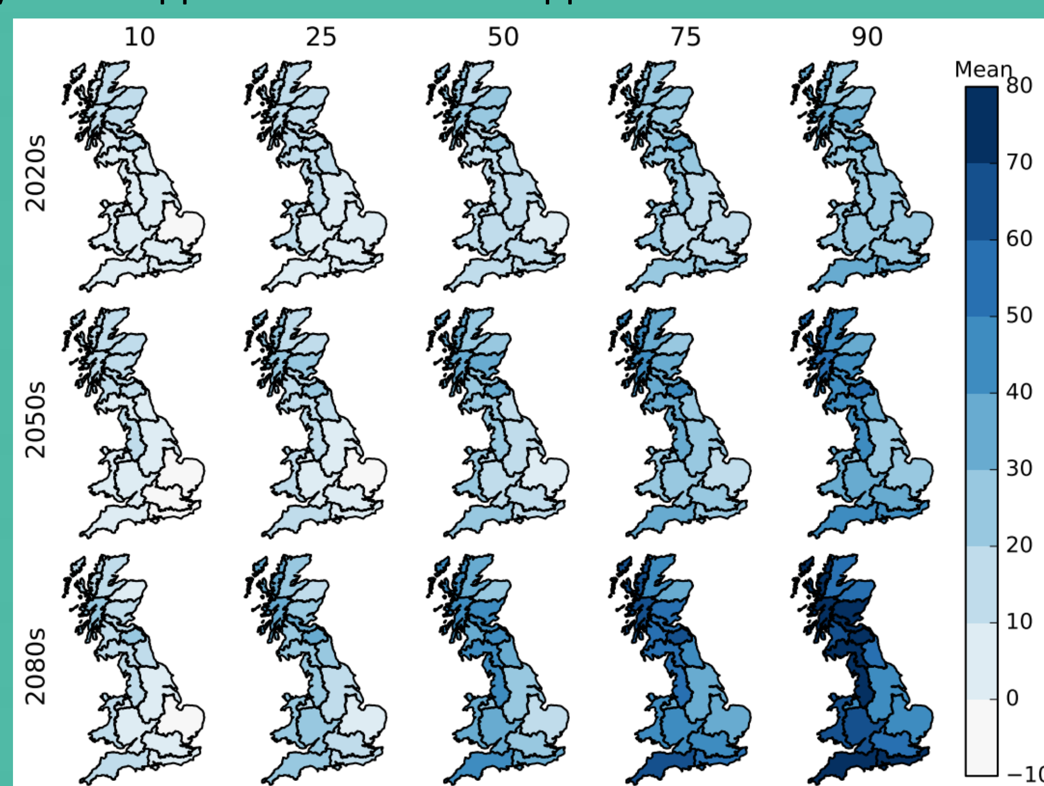

Figure 1: Maps showing regional means of five percentiles of percentage change in 20-year return period flood peaks for three time-slices under RCP 8.5 forcing. Figure from Kay et al. (2021)

Summary

The application of the sensitivity-based approach with a national-scale grid-based hydrological model and the UKCP Projections provides a nationally consistent method for producing an up-to-date assessment of potential future changes in flood peaks across Great Britain, under different climate change scenarios.

Methodology

The following outlines the datasets from the UKCP project that were used. The UKCP data used is available from the Centre for Environmental Data Analysis (CEDA) here: UKCP Data and on the UKCP User Interface.

Climate Data Used

The **UKCP Probabilistic Projections** are used, with the precipitation data extracted using the 'river basin regions' selection. The precipitation data were extracted for three non-overlapping time periods: 2010-2039, 2040-2069 and 2070-2099; for all time periods a baseline period of 1961-1990 was used. The precipitation data were available for four Representative Concentration Pathways: RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5.

Response Surface Creation

Sensitivity-based methods can be used to generate 'response surfaces', which illustrate changes in a variable of interest under a set of plausible climatic changes. A sensitivity-based approach was applied with a national-scale grid-based hydrological model (Grid-to-Grid; Bell et al. 2009), to create 2-d flood response surfaces for each 1 km river cell across GB (excluding 1 km cells with a drainage area less than 100 km^2, and tidal river cells). Separate response surfaces were created for changes in 10-, 20- and 50-year return period flood peaks.

The two axes of the flood response surface represent the assumed percentage change in precipitation, as the annual mean change (X_0) and the seasonal amplitude of the change (A) (Prudhomme et al., 2010). The mean change X_0 varies in 5% increments from -40% to +60%, and amplitude A varies in 5% increments from 0% to 120% (Fig. 2). A small set of assumed changes in temperature and potential evaporation was also applied, producing alternative response surfaces for each.

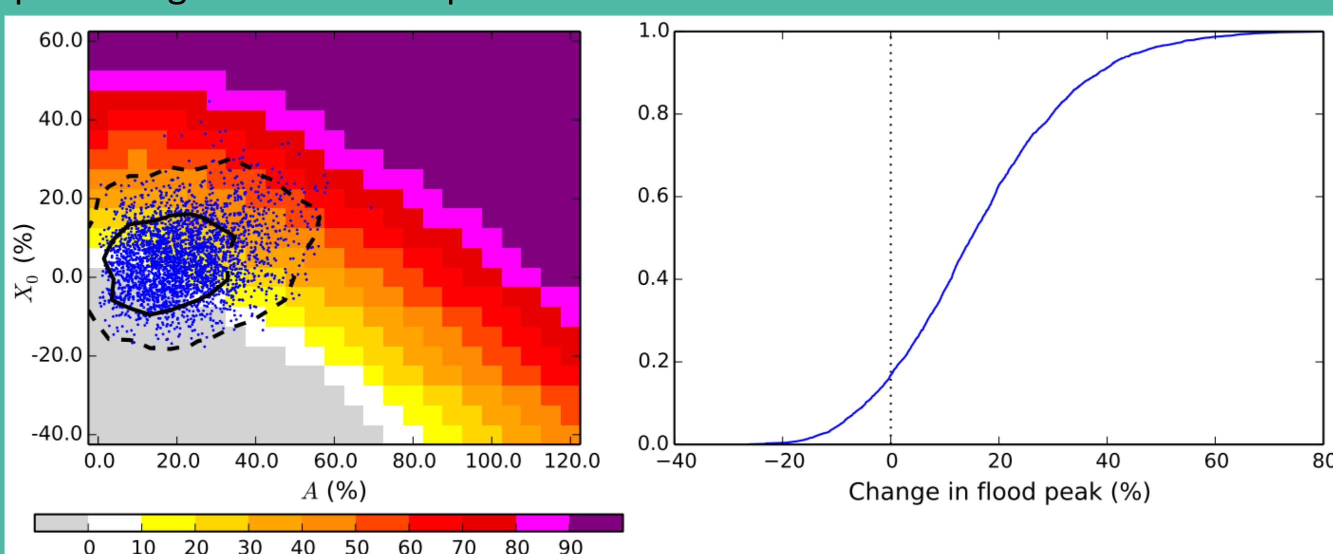

Figure 2: Example of overlaying UKCP18 climate change projections on a modelled response surface (left). Blue dots show each of the 3000 projections for the North Highland river-basin region under RCP8.5 for the 2070-2099 horizon. Also shown is the cdf of the percentage changes in flood peaks for a location in north-west Scotland. Figure from Kay et al. (2021)

Combining UKCP Projections with Modelled Flood Surfaces

The projected changes in precipitation from the UKCP Probabilistic projections can then be overlaid onto the modelled flood response surfaces. The impacts for each climate change projection are then extracted and the cumulative distribution function (CDF) plotted; changes in the flood peaks can be read from the CDF for any percentile of interest.

Note, only the precipitation projections were used in this work, as the temperature changes were shown to be much less important for the changes in flood peaks.

References

Bell, V.A., Kay, A.L., Jones, R.G., Moore, R.J. & Reynard, N.S. (2009). Use of soil data in a grid-based hydrological model to estimate spatial variation in changing flood risk across the UK. Journal of Hydrology. 377(3–4). 335–350. doi: 10.1016/j.jhydrol.2009.08.031.

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