Project Title: Climate drivers of future extreme UK flood risk

Lead Institution/Department: University of Bristol School of Geographical Sciences
Primary Supervisor: Dr Peter Watson
Co-Supervisor: Professor Paul Bates, Dr Sally Brown (EA), Dr James Pope (Met Office), Dr Oliver Wing (Fathom)

Summary

The main aim is to apply core understanding of future changes in major modes of climate variability that affect the UK (e.g. the NAO, jet stream latitude) to understand how these each impact projections of changes in extreme UK pluvial and fluvial flood risk and translate these into better understanding of how these drivers could combine to affect future risk. This will include studying potential extreme outcomes e.g. what will be the impact on future flood risk if multiple drivers are at the high end of projections? We will do this for policy-relevant ~100–1000 year return period events, applying our expertise in studying extreme weather. It is only the combination of interdisciplinary techniques from climate science and hydrology used in this project that will make this possible for the first time.

The project will combine state-of-the-art methods from both fields. This will include national-scale high-resolution hydrological and flood modelling (Bates et al., 2023), the latest generative machine learning rainfall downscaling methods to produce realistic km-scale resolution rainfall samples for use as input for hydrological modelling (e.g. Addison et al., 2023), and large ensembles of high-resolution climate model simulations to sample the full range of plausible weather states (e.g. Leach et al., 2022).

Methods

We will:

- Produce large samples of extreme rainfall events using large ensemble climate simulation data (such as from recent high-resolution climateprediction.net experiments [e.g. Leach et al., 2022], the CANARI project).
- Downscale these rainfall simulations to km-scale resolution by applying new machine learning-based downscaling methods (e.g. Addison et al., 2023).
- Produce large samples of extreme flood events by applying state-of-the-art hydrological models to these simulated events (e.g. DECIPHeR, LISFLOOD) and combine with vulnerability and exposure to predict associated flood risk (Bates et al., 2023).
- Analyse how risks of extreme flooding vary with major climate modes (e.g. the jet stream latitude, the North Atlantic Oscillation), using the unprecedented size of these datasets.
- Produce a clear analysis of how flood risk would be expected to change given different possible future evolutions of climate drivers, including combinations of drivers that are plausible but are not seen in climate model simulations, to show the full range of possibilities (e.g. a particularly high jet stream intensification combining with an especially large increase in atmospheric water loading). This will be achieved through statistical analysis and production of storylines covering the breadth of possibilities of future climate changes, informed by multi-model

climate simulations.
- Performance of the modelling framework in forecasting groundwater flooding will be quantified. This will make use of historical observations of groundwater floods, such as groundwater level time-series, and field observations and aerial imagery (e.g. as collected by the EA) of flood extents.

Background reading and references

- On present state-of-the-art UK flood risk modelling by our group:
  Bates et al., 2023, "A climate-conditioned catastrophe risk model for UK flooding", NHESS, 23, 891–908, https://nhess.copernicus.org/articles/23/891/2023/
- On new multi-thousand-year climate simulations that we co-developed to study extreme rainfall and temperatures:
  Leach et al., 2022. "Generating samples of extreme winters to support climate adaptation". *Weather and Climate Extremes*, 36, 100419. https://doi.org/10.1016/j.wace.2022.100419
- A presentation on application of state-of-the-art machine learning methods to predict high-resolution UK rainfall from our group:
  Addison et al., 2023. "Downscaling with a machine learning-based emulator of a local-scale UK climate model". *EGU General Assembly 2023*. https://doi.org/10.5194/egusphere-egu23-14253

How to Apply: The deadline for this position is 8th April 2024. The studentship will begin in September 2024. Please apply to the "PhD in Geographical Sciences (Physical Geography)" at https://www.bristol.ac.uk/study/postgraduate/apply/