Project Title: Better understanding and handling of uncertainty in flood management

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Summary

Hydrology is inherently uncertain. Uncertainties include those associated with knowledge, models and data. Those uncertainties have important real-world implications because hydrology underpins many decisions relating to flooding, including flood defence design, flood mapping, real-time forecasting and long-term planning for climate change resilience.

The UK government spends around £1bn each year on flood protection; the decisions on where and how to spend this depend strongly on assessments which are highly uncertain: for example, the impact of climate change on future flood hazard, the effectiveness of proposed flood mitigation measures, and the costs of future flood damage.

More robust investment decisions can be made by considering these uncertainties, reducing them when possible, and acknowledging them when they are irreducible – for example by looking for investment options that achieve an acceptable performance across a wide range of future uncertain scenarios, rather than options that are optimal under any particular scenario.

This project will address the broad question of how to better quantify and use uncertain flood information when making investment decisions about hydrometeorological flood resilience. A key step in this will be identifying dominant sources of uncertainty, and in particular noting which characteristics of place determine the relative sizes of different sources of uncertainty.

Methods

In flood risk management, hydrological data and analysis typically takes place within a "chain" of models and analytical processes. Different modelling chains are relevant for different flood risk management applications, although most consider hydro/hydrometeorological hazard, hydraulic and/or infrastructure systems and flood impacts. Examples that the student may use include FEH, PDM, JFlow, HEC-RAS, MCM.

To analyse the propagation of uncertainties through such complex modelling chains, we can use statistical techniques such as uncertainty and global sensitivity analysis (Wagener and Pianosi, 2019) and address questions like: Which model inputs mostly contribute to the uncertainty in model predictions, and where should we focus efforts for uncertainty reduction? How robust are model predictions to modelling assumptions, and to what extent would model-informed decisions change if different assumptions were made? What are the tipping points that, if crossed, would enable reaching required performance targets, and what investment options are most likely to ensure reaching those targets against uncertainty?

Some initial investigation has been attempted in applied research (EA, 2022), revealing the practical relevance of understanding the relative importance of different uncertainties in the modelling chain, and highlighting the need for more general and advanced approaches, making this a suitable challenges for a PhD study.

Essential Skills

Some previous knowledge of hydrology and hydraulics processes and their modelling
Good analytical skills and some programming skills.

Background reading and references

Wagener, T., Pianosi, F. 2019 What has Global Sensitivity Analysis ever done for us? A systematic review to support scientific advancement and to inform policy-making in earth system modelling. Earth-science reviews. 194. 1-18.
https://doi.org/10.1016/j.earscirev.2019.04.006

Wilby, R.L. and Dessai, S., 2010 Robust adaptation to climate change, Weather, https://doi.org/10.1002/wea.543

Environment Agency, 2022. Relative importance of the hydrological uncertainties within the flood modelling chain: Technical Report.
https://engageenvironmentagency.uk.engagementhq.com/20280/widgets/57541/documents/33641

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/.

More information on how to apply can be found here