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Exploring the use of Artificial Intelligence for flood forecasting in Scotland

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Aim of the project

Flooding presents a significant threat in Scotland, which is expected to become more frequent and severe with climate change. The Scottish Environment Protection Agency (SEPA) is responsible for forecasting floods and helping communities prepare and respond. This *DelugeAI* project, funded by Scotland's Centre of Expertise for Waters (CREW), and led by the University of Strathclyde, explored how Artificial Intelligence (AI) and Machine Learning (ML) could help improve flood forecasting in Scotland by addressing the following questions:

1. What evidence is in the academic and grey literature regarding the application of AI/ML in flood forecasting?
2. What do AI/ML and hydrological flood forecasting experts see as key challenges, opportunities, and future directions?
3. How practical is the integration of AI/ML into SEPA's existing Flood Warning Development Framework?
4. Can a set of recommendations be developed outlining the priorities and implementation pathways for SEPA?

Background

Flood forecasting is not just about predicting when rivers might flood, it involves a whole chain of activities. In this project, the research team framed the review around seven key stages where AI/ML could play a role. These include: monitoring (gathering data from sensors, satellites or even citizen reports); calibrating models (fine-tuning how forecasts are made); improving weather inputs (like rainfall forecasts); supporting and complementing traditional models; fully replacing the numerical models; helping with decision support and evaluating impacts; and issuing timely warnings to the public. Looking at the full forecasting process in this way helped the team explore where AI/ML can have the greatest impact and what challenges might arise.

Artificial Intelligence (AI) refers to computer systems that can perform tasks that normally require human intelligence, like recognising patterns, making decisions, or learning from data.

Machine Learning (ML) is a subset of AI where computers are trained to recognise patterns in large amounts of data and make predictions based on that. For example, ML models can learn to predict when and where flooding might happen based on past events.

The project reviewed the latest scientific research, looked at real-world examples, and brought together international experts in an online workshop. It also assessed how practical it would be for SEPA to adopt AI/ML tools in its current forecasting work.

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To access the outputs for this project, please visit: www.crew.ac.uk/publication/artificial-intelligence-for-flood-forecasting-in-Scotland

Key findings

While AI has advanced quickly in recent years, most real-world applications still use it to support rather than replace traditional flood forecasting methods. Research has often focused on highly complex models, but operational systems favour simpler, blended approaches that combine ML with existing tools.

One of the most feasible uses of AI is in improving how early warnings are delivered and how flood forecasts are communicated. These applications are relatively straightforward and could be introduced quickly to help people respond faster and more effectively.

The study also found that AI/ML can support tasks like improving the integration of weather inputs, updating existing models, and monitoring local flood risks, especially in areas with limited data. However, these more technical applications are harder to set up and would take longer to implement.

Experts agreed that human judgement should always remain central. AI tools can enhance forecasting, but they cannot replace the experience and understanding of trained forecasters. Trust, transparency, and good quality data are also essential if AI/ML is to be used responsibly and effectively.

Recommendations

The *DelugeAI* project recommends that SEPA take a phased approach to using AI and ML. Starting with simpler tools in the next 1–2 years that deliver quick, visible benefits, such as improving early warnings and decision support. These can help build skills and confidence and demonstrate potential.

In a longer 3–5 year horizon, SEPA could begin to explore more advanced uses of AI, such as integrating enhanced weather inputs, local monitoring, and model calibration. These tools could increase accuracy and efficiency, especially when used alongside traditional forecasting methods.

The *DelugeAI* project team also recommend investing in training and upskilling the worksforce. This would allow SEPA staff to understand how AI works, use it safely, and explain it to others, ensuring human expertise remains central.

Finally, AI/ML systems should always be chosen based on the specific problem they are meant to solve, the type of data available, the resources required and how easy they are to understand and trust.