Enhancing forecasting flood inundation mapping through data assimilation

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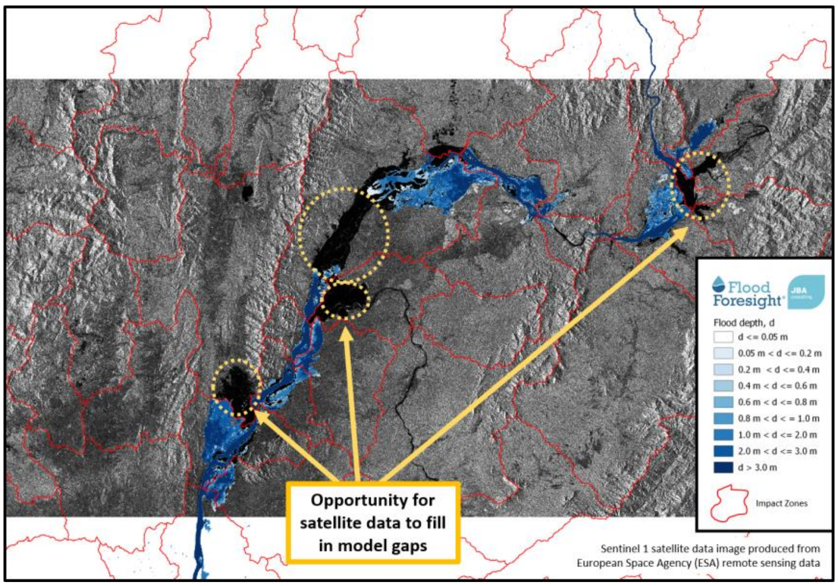

Satellite image with flood hazard forecast overlaid. Water appears dark in the satellite image.

Flooding is major risk for lives and livelihoods around the world. In Europe alone, the annual cost due to flood damage is expected to rise to 100 billion EUR by the year 2080, due to a combination of climate change and socio-economic growth. Timely flood inundation forecasts allow pro-active flood management, mitigating against loss of life and damage to key infrastructure. The goal of this PhD project is to investigate new mathematical methods using observations of floods to verify and improve flood inundation forecasts.

The state-of-the art in operational flood inundation forecasting at national and trans-national scale uses a simulation library, where rainfall data from numerical weather forecasts or observations drives a chain of computational models including physical process models and probabilistic analysis. The final flood forecasts are produced from a pre-computed library of flood hazard maps. This approach saves computation time, allowing near-real-time updating for large areas, which otherwise presents a significant challenge. However, this approach does not allow for incorporation of information from observations of the flood as it evolves.

Observations of floods are available from a range of instrument types and locations around the world. Satellite Synthetic Aperture Radar (SAR) instruments have the advantage that they can image areas during day or night, and can see through cloud. SAR images can be used to derive accurate flood maps under certain conditions, but the satellite orbit frequency means that this can only be done once or twice a day. On the other hand, local traffic

CCTV cameras can provide images every few minutes, but over a much smaller area.

In order to have the best flood forecasts, we need to combine both computational flood forecasts with observations, taking account of our confidence in each source of data as the flood evolves. This process is known as *data assimilation*. The sophisticated mathematical framework of data assimilation allows us to optimally combine heterogeneous data sources in a dynamical feedback loop, to keep forecast on track.

A key aspect of data assimilation is comparison of computational forecast data with observations. However, the spatial lengthscales resolved by computational model data may be very different to those observed (for example, consider the comparison between an average over a large area with a measurement at a point). For this reason, it is first important to understand the spatial scales of variability of the forecast model in order to make a fair comparison. The student will study an ensemble forecast (a large number of realisations of a forecast with slightly different driving data) and develop methods to assess lengthscales where we can reliably discriminate between forecasts. This is valuable for qualitative interpretation of forecasts for end users as well as for quantitative comparisons with observations. The student will go on to develop methods for comparing models with observations that take account of these scale differences, before building a full data assimilation system.

The student is expected to develop generic methods, but to explore them for a range of case study locations that may include river basins in Myanmar, India, Bangladesh, the Republic of Ireland and UK. They will primarily explore river floods triggered by heavy rainfall events.

The project is a collaboration of the University of Reading with JBA Trust, sponsored by JBA, an award-winning, international, multi-disciplinary consultancy delivering professional services across a wide range of water, environmental, engineering and risk management specialties. The researcher will be supported by advice from JBA experts and access to JBAs’ Flood Foresight forecasting system for case studies and is expected demonstrate how improvements to operational flood forecasts can be embedded in systems of this type through high quality academic research outputs.

Training opportunities:
The student will receive full technical training for the project through Masters level courses, short training courses and summer schools. The student will also have the opportunity to undertake a 3-month placement with JBA at their offices in Wallingford, Oxfordshire or Skipton, Yorkshire.

Student profile:

This project would be suitable for students with a degree in physics, mathematics or another scientific or engineering discipline with a high mathematical content. Previous computer programming experience is desirable but not essential, as training can be provided. Interest in flood prediction and/or Earth observation data, will be beneficial.

Funding particulars:
This project has CASE sponsorship from JBA.

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