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Real-time flood impacts mapping: Appendix 3: Long-term options

SC120023/A3

Flood and Coastal Erosion Risk Management Research and Development Programme

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Director, Research, Analysis and Evaluation

Contents

1 Introduction

This appendix describes future possible approaches to providing real-time flood impacts information.

In the longer term, alternative methods to flood impact mapping in real time may become viable. They include different means of generating forecast inundation maps prior to an event, as well as flood detection and monitoring during or after an event.

Although these options were considered, they were not pursued further in this project due to current challenges in implementing them on a large scale, limitations in data or because they do not directly address current user needs. However, for completeness, this appendix provides an overview of different approaches that are not addressed elsewhere in the final project report and which may be considered in future research.

2 Flood forecasting

2.1 Forecasting models

Artificial neural networks are models composed of interconnected neurons, which simulate complex nonlinear relationships between inputs and outputs (Bishop 1995). They are suitable tools for run-off estimation or forecasting (see, for example, Hung et al. 2009, Jeevaragagam and Simonovic 2012), but their lack of physical basis means that they usually require long historical records. Their accuracy is therefore heavily dependent on data quality and quantity.

Many case studies have applied artificial neural networks in hydrology to reproduce flood flows, with a range of results; for a review, see Maier and Dandy (2000). However, their implementation in real-time forecasting on a large scale is not yet widespread. This is partly due to unresolved issues over uncertainties, their ability to extrapolate beyond the observed range and the interpretation of their 'black box' structure (Han et al. 2007, Prieto et al. 2016).

2.2 Data assimilation

Assimilation of observed data in real time enables flood forecasts to be adjusted to correct for model errors. Error correction is routinely used in the National Flood Forecasting System. In recent years, however, there has been progressive testing of different approaches to assimilating data. These include:

- state variables such as streamflow (Rafieeinasab et al. 2014, Randrianasolo et al. 2014, Sun et al. 2015)
- remotely sensed soil moisture (for a review, see Kornelsen and Coulibaly 2013, Ni-Meister 2008)
- snow products (Franz et al., 2014; Slater and Clark, 2006; Thirel et al., 2013)

However, there is still much research left to do on evaluating the impact of assimilating hydraulic information such as remotely sensed surface water extent data. See, for example, García-Pintado et al. (2013) and Mason et al. (2012) for examples on the Lower Severn and Avon rivers in the UK.

3 Flood detection and monitoring

3.1 Hydrometric networks

In the UK, several initiatives aim to enhance the capabilities of telemetered river gauge networks by integrating existing telemetry into mapping products or by using data from other sources:

The **GridStix project** supports flood prediction using depth sensors equipped with wireless networking. These depth sensors can be used to improve predictions of flood inundation and water level elevation with a view to improving flood warning capabilities at key locations. They can compute 'onsite' automated warnings and can make local forecasts using parsimonious time series models.

Flood Network (http://flood.network), which was launched in 2014, maps water levels in river networks from multiple data sources. The main aim is to encourage members of the public to install low-cost water level sensors which feed information to the Flood Network website via wireless feeds. Geographical coverage currently appears to be limited, but Flood Network has the potential to make use of feeds from Environment Agency telemetry.

3.2 Remote sensing

The scientific community has been exploring other potential solutions to deriving river level and flood extent information. A large part of this effort focuses on remotely sensed data (Bates et al. 2014).

Recent and future satellite missions have been specifically designed for measuring water levels or river widths from satellite imagery (Schumann et al. 2012, Westerhoff et al. 2013, Pavelsky et al. 2014), which can be used to derive river flows. Improvements in optical and radar imagery have assisted flood extent mapping. Optical flood extent maps are easier to process and have a shorter revisit time, but they are often affected by cloud cover and typically have a lower resolution. To overcome some of these issues, the European Commission's Copernicus rapid mapping service[1] uses radar imagery. Most maps use the European Space Agency's Sentinel-1 SAR mission outputs at a resolution of 10m. During December 2015, for example, Copernicus rapid mapping was activated for Cumbria, Yorkshire and Ireland to capture and process flood extent images.

Other high resolution satellites can be used to derive flood extents and are commercially available (for example, RADARSAT, COSMO-SkyMed, TerraSAR-X and TanDEM-X). In addition, the Landsat-8 products can be used but with a revisit time every 16 days; although not appropriate for monitoring of shorter flood events, they can be used in this context to map the pre-flood or post-flood extent of water bodies for comparison. In the future, the Surface Water and Ocean Topography (SWOT) mission, with a launch planned for late 2020, will provide high resolution surface water height and inundation extent data but at long revisit times.

One of the challenges of remote sensing is to task the satellites at appropriate times to capture the maximum extent of flooding. This can otherwise lead to underestimation of flood extents (and subsequently flood impacts). An alternative approach to overcome this limitation is the use of unmanned aerial vehicles and aerial survey aircraft. These can often

[1] http://emergency.copernicus.eu/mapping/ems/ems-rapid-mapping-products

be deployed rapidly and therefore may be able to better capture the progression of flooding, including the maximum flood extent.

Unmanned aerial vehicles and aircraft have the added benefit of being able to produce high resolution imagery and topography, typically with accuracy of a few centimetres. However, they can be affected by poor weather conditions and need to fly during daylight hours. Drones are also only able to capture relatively small areas (up to a maximum of 1km from the pilot) and have restrictions on where and how high they can operate (up to about 120m altitude).

Aerial survey can cover larger areas, but is typically more expensive to commission, although the Environment Agency remote sensing team already has 2 aircraft which can be deployed for emergency response work.

Integration of remotely sensed observations in near real time at an appropriate spatial and temporal scale has the potential to significantly increase operational awareness for flood forecasting and warning, and will allow estimates of flood impact mapping to be validated with observed data. Methods should be developed so to exploit the benefits of data from a range of sources simultaneously.

3.3 Social media data mining

Social media mining is the process of representing, analysing and extracting actionable patterns or trends from raw social media data. In recent years, it has increasingly been used for identifying and analysing areas affected by a range of emergencies, including flood events. Two initiatives are described below.

FloodTags (www.floodtags.com) is a social enterprise that uses data mining scripts to map social media posts about flood incidents. The technology has been successfully used in conjunction with the flood forecasting platform Delft-FEWS in Indonesia. Several other initiatives have also made use of the Twitter Firehose application programming interface to filter for various keywords associated with a specific geographic location (for example, www.petajakarta.org/banjir/en/index.html). One practical issue is the choice of hashtag or keyword as, in the English language, the word ‘flood’ can be used in various contexts. This method also cannot really provide a flood extent, but may provide some indication of the level of disruption caused in a particular area.

Flood Crowd (www.floodcrowd.co.uk) provides an alternative to capturing social media information by establishing networks where people can contribute information for a specific purpose (that is, flooding). There are successful examples of this such as the Met Office Weather Observations website (https://wow.metoffice.gov.uk). However, the episodic nature of flooding means that contributions are more likely in locations that flood on a regular basis.

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