

Operational flash flood forecasting in England: quantifying flood risk using radar-based nowcasts and high resolution NWP forecasts

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Intense rain falling on rapidly responding catchments has been responsible for some notable flooding across England, with examples including Boscastle in 2004 and Ottery St Mary in 2008. Flash floods pose a significant risk to lives and livelihoods. In 2008 the need for significant improvements to the detection and forecasting of flash floods was highlighted in a comprehensive review into the major flooding that affected large swathes of England and Wales in 2007. Aspirations were further raised after the flash flooding affecting Devon and Cornwall in December 2010, and many locations during 2012.

The Flood Forecasting Centre (FFC) and the Environment Agency (EA) are working with the Met Office (MO) and the Centre for Ecology & Hydrology (CEH) to develop new operational techniques to forecast flash floods using radar-based ensemble nowcasts and short-range numerical weather prediction (NWP) based ensemble forecasts of rainfall. During these times of austerity a phased approach has been adopted which delivers a service to all locations vulnerable to flash flooding in the first instance and which then enables the latest advances in rainfall forecasting and hydrological modelling to be exploited to improve that service as resources allow.

Recent advances in both rainfall forecasting and hydrological modelling are now providing the tools to begin to address some of the challenges which have, until very recently, frustrated the development of consistent and reliable methods for forecasting flash floods. The operational implementation of high-resolution (~2 km grid length) NWP models that partially resolve convective-scale processes explicitly has improved the realism, and to a modest extent, the deterministic predictive skill of precipitation forecasts. These data, when used in conjunction with rainfall observations, are proving more suitable as inputs to forecasting tools for rapid response catchments. Furthermore, ensemble formulations of these high-resolution NWP models now offer the prospect of a rigorous treatment of associated forecast uncertainties and of propagating these uncertainties through hydrological models. Recent application in the FFC of a high-resolution distributed grid-based rainfall-runoff-routing model - the Grid-to-Grid or G2G - has provided the opportunity to translate rainfall to streamflow for ungauged catchments, of particular relevance to the UK situation where rapidly responding catchments are typically small (i.e. less than 100km²) and ungauged.

The first phase in the provision of a flash flood forecasting service for England has been delivered at a relatively simple level. Lack of skill in deterministic rainfall forecasts is accommodated by applying a buffer to each catchment, generating a pseudo-probabilistic forecast using the so-called 'neighbourhood' approach. An alarm is triggered when nowcast rainfalls exceed pre-set extreme rainfall thresholds. This technique has been shown to be sufficiently effective to be applied across England with careful setting of the parameters to minimise false alarms.

The second phase, which builds on the first, exploits the availability of high-resolution rainfall ensembles to provide a more rigorous probabilistic approach to forecasting catchment maximum (CatMax) rainfall values across rapid response catchments. As with the method above, CatMax values are compared to pre-set depth-duration thresholds, and a probability of exceedance is calculated (percentage of ensembles that exceeded the pre-defined threshold at some point during the forecast). This methodology has been developed as a 'proof of concept' and has been trialled operationally across the rapid response catchments in the southwest of England. It has successfully demonstrated a more robust probabilistic approach that could be implemented operationally more widely across England.

The third phase, building on developments in the second, exploits the functionality of the high-resolution G2G hydrological model. This phase links high-resolution convective-scale ensemble rainfall forecasts with the G2G model configured to run at spatial and temporal resolutions of 1km² and 15 minutes respectively. G2G is able to respond to variations in rainfall distribution across catchments: a key factor when forecasting the flash flood response to the typically small-scale nature of convective storms. Although not yet operational, case studies using ensemble rainfall forecasts have shown great promise and potential in giving advanced warning of flooding.

The intended outcome of this phased approach is the delivery of a consistent and robust approach for forecasting flash floods across England to mitigate against flood risk, thereby reducing the risk to lives and livelihoods.