Geophysical Research Abstracts
Vol. 16, EGU2014-15476-1, 2014
EGU General Assembly 2014

Probabilistic flood forecasting for Rapid Response Catchments using a countrywide distributed hydrological model: experience from the UK

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Across Britain, floods in rapidly responding catchments are a major concern and regularly cause significant damage (e.g. Boscastle 2004, Morpeth 2008, Cornwall 2010 and Comrie 2012). Typically these catchments have a small area and are characterised by steep slopes and/or significant suburban/urban land-cover. The meteorological drivers can be of convective origin or frontal with locally intense features (e.g. embedded convection or orographic enhancement); saturated catchments can amplify the flood response. Both rainfall and flood forecasting for Rapid Response Catchments (RRCs)are very challenging due to the often small-scale nature of the intense rainfall which is of most concern, the small catchment areas, and the short catchment response times.

Over the last 3 to 4 years, new countrywide Flood Forecasting Systems based on the Grid-to-Grid (G2G) distributed hydrological (rainfall-runoff and routing) model have been implemented across Britain for use by the Flood Forecasting Centre and Scottish Flood Forecasting Service. This has achieved a step-change in operational capability with forecasts of flooding several days ahead "everywhere" on a 1 km grid now possible. The modelling and forecasting approach underpins countrywide Flood Guidance Statements out to 5 days which are used by emergency response organisations for planning and preparedness.

The initial focus of these systems has been to provide a countrywide overview of flood risk. However, recent research has explored the potential of the G2G approach to support more frequent and detailed alerts relevant to flood warning in RRCs. Integral to this activity is the use of emerging high-resolution ($\sim$1.5km) rainfall forecast products, in deterministic and ensemble form. High spatial resolutions are required to capture some of the small-scale processes and intense rainfall features such as orographic enhancement and convective storm evolution. Even though a deterministic high-resolution numerical weather prediction (NWP) model can provide realistic looking rainfall forecasts, significant uncertainties remain in timing, location and whether a particular feature develops or not. Generally the smaller the scale of the rainfall feature, the shorter the lead-time at which these uncertainties become important. Therefore ensembles are needed to provide uncertainty context for longer lead-time G2G flow forecasts, particularly for small-scale RRCs.

A systematic assessment framework has been developed for exploring and understanding the utility of G2G flood forecasts for RRCs. Firstly perfect knowledge of rainfall observations is assumed for past and future times, so as not to confound the hydrological model analysis with errors from rainfall forecasts. Secondly an assessment is made of using deterministic rainfall forecasts (from NWP UKV) in a full emulation of real-time G2G forecasts, and using foreknowledge of rainfall observations as a reference baseline. Finally use of rainfall forecast ensembles with G2G to produce probabilistic flood forecasts is considered, empploying a combination of case-study and longer-term analyses. Blended Ensemble rainfall forecasts (combining radar ensemble nowcast and NWP rainfalls) are assessed in two forms: forecasts out to 24 hours updated 4 times a day, and nowcasts out to 7 hours updated every 15 minutes. Results from the assessment will be presented along with candidates for new operational products and tools that can support flood warning for RRCs, taking account of the inherent uncertainty in the forecasts.