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Real-time flood forecasting with high-resolution NWP rainfall and dual data assimilation

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Mesoscale Numerical Weather Prediction (NWP) models are nowadays gaining more and more attention in providing high-resolution rainfall forecasts for real-time flood forecasting. In this study, the newest generation NWP model, Weather Research & Forecasting (WRF) model, is integrated with the rainfall-runoff model in real-time to generate accurate flow forecasts at the catchment scale. The rainfall-runoff model is chosen as the Probability Distribution Model (PDM), which has widely been used for flood forecasting. Dual data assimilation is carried out for real-time updating of the flood forecasting system. The 3-Dimensional Variational (3DVar) data assimilation scheme is incorporated with WRF to assimilate meteorological observations and weather radar reflectivity data in order to improve the WRF rainfall forecasts; meanwhile real-time flow observations are assimilated by the Auto-Regressive Moving Average (ARMA) model to update the forecasted flow transformed by PDM.

The Brue catchment located in Southwest England with a drainage area of 135.2 km2 is chosen to be the study area. A dense rain gauge network was set up during a project named HYREX (Hydrological radar experiment), which contains 49 rain gauges and a C-band weather radar, providing with sufficient hydrological and radar data for WRF model verification and data assimilation. Besides the radar reflectivity data, two types of NCAR archived data (SYNOP and SOUND, http://dss.ucar.edu) are also assimilated by 3DVar, which provide real-time surface and upper-level observations of pressure, temperature, humidity and wind from fixed and mobile stations. Four 24 hour storm events are selected from the HYREX project with different characteristics regarding storm formation and rainfall-runoff responses. Real-time flood forecasting is then carried out by the constructed forecasting system for the four storm events with a forecast lead time of 12 hours. The forecasting accuracy of the whole system is found to be largely improved by incorporating the WRF forecasted rainfall when the forecast lead time is beyond the catchment concentration time. The assimilation of real-time meteorological and radar data also show great advantage in improving the performance of the flood forecasting system.

Key words: real-time flood forecasting; Weather Research & Forecasting (WRF) model; high-resolution rainfall forecasts; dual data assimilation.