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Probabilistic flood warning using grand ensemble weather forecasts

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As the severity of floods increases, possibly due to climate and landuse change, there is urgent need for more effective and reliable warning systems. The incorporation of numerical weather predictions (NWP) into a flood warning system can increase forecast lead times from a few hours to a few days. A single NWP forecast from a single forecast centre, however, is insufficient as it involves considerable non-predictable uncertainties and can lead to a high number of false or missed warnings. An ensemble of weather forecasts from one Ensemble Prediction System (EPS), when used on catchment hydrology, can provide improved early flood warning as some of the uncertainties can be quantified. EPS forecasts from a single weather centre only account for part of the uncertainties originating from initial conditions and stochastic physics. Other sources of uncertainties, including numerical implementations and/or data assimilation, can only be assessed if a grand ensemble of EPSs from different weather centres is used. When various models that produce EPS from different weather centres are aggregated, the probabilistic nature of the ensemble precipitation forecasts can be better retained and accounted for. The availability of twelve global EPSs through the 'THORPEX Interactive Grand Global Ensemble' (TIGGE) offers a new opportunity for the design of an improved probabilistic flood forecasting framework.

This work presents a case study using the TIGGE database for flood warning on a meso-scale catchment. The upper reach of the River Severn catchment located in the Midlands Region of England is selected due to its abundant data for investigation and its relatively small size (4062 km2) (compared to the resolution of the NWPs). This choice was deliberate as we hypothesize that the uncertainty in the forcing of smaller catchments cannot be represented by a single EPS with a very limited number of ensemble members, but only through the variance given by a large number ensembles and ensemble system. A coupled atmospheric-hydrologic-hydraulic cascade system driven by the TIGGE ensemble forecasts is set up to study the potential benefits of using the TIGGE database in early flood warning. Physically based and fully distributed LISFLOOD suite of models is selected to simulate discharge and flood inundation consecutively.

The results show the TIGGE database is a promising tool to produce forecasts of discharge and flood inundation comparable with the observed discharge and simulated inundation driven by the observed discharge. The spread of discharge forecasts varies from centre to centre, but it is generally large, implying a significant level of uncertainties. Precipitation input uncertainties dominate and propagate through the cascade chain. The current NWPs fall short of representing the spatial variability of precipitation on a comparatively small catchment. This perhaps indicates the need to improve NWPs resolution and/or disaggregation techniques to narrow down the spatial gap between meteorology and hydrology. It is not necessarily true that early flood warning becomes more reliable when more ensemble forecasts are employed. It is difficult to identify the best forecast centre(s), but in general the chance of detecting floods is increased by using the TIGGE database. Only one flood event was studied because most of the TIGGE data became available after October 2007. It is necessary to test the TIGGE ensemble forecasts with other flood events in other catchments with different hydrological and climatic regimes before general conclusions can be made on its robustness and applicability.