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Propagation of radar rainfall uncertainty in urban flood simulations

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This work discusses the results of the implementation of a novel probabilistic system designed to improve ensemble sewer flow predictions for the drainage network of a small urban area in the North of England. The probabilistic system has been developed to model the uncertainty associated to radar rainfall estimates and propagate it through radar-based ensemble sewer flow predictions. The assessment of this system aims at outlining the benefits of addressing the uncertainty associated to radar rainfall estimates in a probabilistic framework, to be potentially implemented in the real-time management of the sewer network in the study area.

Radar rainfall estimates are affected by uncertainty due to various factors [1-3] and quality control and correction techniques have been developed in order to improve their accuracy. However, the hydrological use of radar rainfall estimates and forecasts remains challenging. A significant effort has been devoted by the international research community to the assessment of the uncertainty propagation through probabilistic hydro-meteorological forecast systems [4-5], and various approaches have been implemented for the purpose of characterizing the uncertainty in radar rainfall estimates and forecasts [6-11].

A radar-based ensemble stochastic approach, similar to the one implemented for use in the Southern-Alps by the REAL system [6], has been developed for the purpose of this work. An ensemble generator has been calibrated on the basis of the spatial-temporal characteristics of the residual error in radar estimates assessed with reference to rainfall records from around 200 rain gauges available for the year 2007, previously post-processed and corrected by the UK Met Office [12-13]. Each ensemble member is determined by summing a perturbation field to the unperturbed radar rainfall field. The perturbations are generated by imposing the radar error spatial and temporal correlation structure to purely stochastic fields.

A hydrodynamic sewer network model implemented in the Infoworks software was used to model the rainfall-runoff process in the urban area. The software calculates the flow through the sewer conduits of the urban model using rainfall as the primary input. The sewer network is covered by 25 radar pixels with a spatial resolution of 1 km2. The majority of the sewer system is combined, carrying both urban rainfall runoff as well as domestic and trade waste water [11]. The urban model was configured to receive the probabilistic radar rainfall fields. The results showed that the radar rainfall ensembles provide additional information about the uncertainty in the radar rainfall measurements that can be propagated in urban flood modelling. The peaks of the measured flow hydrographs are often bounded within the uncertainty area produced by using the radar rainfall ensembles. This is in fact one of the benefits of using radar rainfall ensembles in urban flood modelling. More work needs to be done in improving the urban models, but this is out of the scope of this research. The rainfall uncertainty cannot explain the whole uncertainty shown in the flow simulations, and additional sources of uncertainty will come from the structure of the urban models as well as the large number of parameters required by these models.

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