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Cascading rainfall uncertainty into flood inundation impact models

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Observed and numerical weather prediction (NWP) simulated precipitation products typically show differences in their spatial and temporal distribution. These differences can considerably influence the ability to predict hydrological responses. For flood inundation impact studies, as in forecast situations, an atmospheric-hydrologic-hydraulic model chain is needed to quantify the extent of flood risk. Uncertainties cascaded through the model chain are seldom explored, and more importantly, how potential input uncertainties propagate through this cascade, and how best to approach this, is still poorly understood. This requires a combination of modelling capabilities, the non-linear transformation of rainfall to river flow using rainfall-runoff models, and finally the hydraulic flood wave propagation based on the runoff predictions. Improving the characterisation of uncertainty, and what is important to include, in each component is important for quantifying impacts and understanding flood risk for different return periods.

In this paper, we propose to address this issue by i) exploring the effects of errors in rainfall on inundation predictive capacity within an uncertainty framework by testing inundation uncertainty against different comparable meteorological conditions (i.e. using different rainfall products) and ii) testing different techniques to cascade uncertainties (e.g. bootstrapping, PPU envelope) within the GLUE (generalised likelihood uncertainty estimation) framework.

Our method cascades rainfall uncertainties into multiple rainfall-runoff model structures using the Framework for Understanding Structural Errors (FUSE). The resultant prediction uncertainties in upstream discharge provide uncertain boundary conditions that are cascaded into a simplified shallow water hydraulic model (LISFLOOD-FP). Rainfall data captured by three different measurement techniques - rain gauges, gridded radar data and numerical weather predictions (NWP) models are evaluated. The study is performed in the Severn catchment over summer 2007, where a series of large rainfall events (over 100mm between the 20th and 21rst of July in certain sub-catchments) caused record floods in the study area.

Differences in water level at benchmark stations are compared and the resulting prediction uncertainties are analysed for the different rainfall products. These results quantify how different cascading techniques and rainfall input uncertainty affects the resultant set of behavioural simulations. This allows us to compare the performance of different rainfall products used for real forecasting situations.