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The application of Global Sensitivity Analysis to quantify the dominant input factors for hydraulic model simulations

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Predicting flood inundation extents using hydraulic models is subject to a number of critical uncertainties. For a specific event, these uncertainties are known to have a large influence on model outputs and any subsequent analyses made by risk managers. Hydraulic modellers often approach such problems by applying uncertainty analysis techniques such as the Generalised Likelihood Uncertainty Estimation (GLUE) methodology. However, these methods do not allow one to attribute which source of uncertainty has the most influence on the various model outputs that inform flood risk decision making. Another issue facing modellers is the amount of computational resource that is available to spend on modelling flood inundations that are 'fit for purpose' to the modelling objectives. Therefore a balance needs to be struck between computation time, realism and spatial resolution, and effectively characterising the uncertainty spread of predictions (for example from boundary conditions and model parameterisations). However, it is not fully understood how much of an impact each factor has on model performance, for example how much influence changing the spatial resolution of a model has on inundation predictions in comparison to other uncertainties inherent in the modelling process. Furthermore, when resampling fine scale topographic data in the form of a Digital Elevation Model (DEM) to coarser resolutions, there are a number of possible coarser DEMs that can be produced. Deciding which DEM is then chosen to represent the surface elevations in the model could also influence model performance.

In this study we model a flood event using the hydraulic model LISFLOOD-FP and apply Sobol' Sensitivity Analysis to estimate which input factor, among the uncertainty in model boundary conditions, uncertain model parameters, the spatial resolution of the DEM and the choice of resampled DEM, have the most influence on a range of model outputs. These outputs include whole domain maximum inundation indicators and flood wave travel time in addition to temporally and spatially variable indicators. This enables us to assess whether the sensitivity of the model to various input factors is stationary in both time and space. Furthermore, competing models are assessed against observations of water depths from a historical flood event. Consequently we are able to determine which of the input factors has the most influence on model performance. Initial findings suggest the sensitivity of the model to different input factors varies depending on the type of model output assessed and at what stage during the flood hydrograph the model output is assessed. We have also found that initial decisions regarding the characterisation of the input factors, for example defining the upper and lower bounds of the parameter sample space, can be significant in influencing the implied sensitivities.