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Estimating out-of-bank discharge uncertainties using a hydrodynamic model and nationally available datasets

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Robust predictions and forecasts of flood risks and hazards are reliant on accurate estimates of stream flow data. However, the stage-discharge relationship is subject to substantial uncertainties from a range of error sources, particularly for out-of-bank flows where measurements are scarce and flows are often extrapolated. Hydraulic modelling can be used to produce more reliable stage–discharge relationships beyond the range of observed measurements, but, these methods are often data intensive requiring topographical, bathymetric, calibration data etc. restricting their use across large samples of gauges.

In this study, we present an automatable framework that can estimate out-of-bank discharge uncertainty using a hydrodynamic model and readily available national datasets. The framework utilises LiDAR data, in-bank stage-discharge measurements and gauged river flows to calibrate a 1D/2D hydrodynamic model (LISFLOOD-FP) of a river reach and make predictions of river flow and rating curve uncertainty beyond bankfull. A particularly novel aspect of this framework is the use of national LiDAR datasets of water surface elevation returns to estimate the bathymetry and friction in the channel using an inversion solver.

The framework was applied to produce models of two gauged river reaches in the UK, the River Severn at Montford in Shropshire, and the River Tweed at Norham in Northumberland. Bathymetry estimates were consistent with observations, considering that the channel was simplified to rectangular below the LiDAR water surface, while Manning's channel friction estimates were between 0.03 and 0.035. The model predictions showed a close fit to the official rating curve and out-of-bank stage-discharge measurements, with the model-predicted uncertainty bounds able to contain 89.5% and 100% of the out-of-bank flow measurements for Montford and Norham respectively. This holds promising results for quantifying out-of-bank discharge uncertainties across large samples of catchments to enable robust national flood risk assessment.