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# Coupled effect of river bed and wall roughness on flow resistance

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Understanding flow resistance in rivers with rough beds and banks is critical in predicting flow velocities and depths for a given discharge; this has important applications in improving estimates of sediment fluxes, flood risk, and the identification of hotspots of geomorphic adjustment in rivers. Previous flume experiments have identified the usefulness of topographically derived bed roughness metrics in evaluating the effect of roughness on flow resistance: (1) standard deviation and (2) skewness of bed elevation distributions, as well as (3) frontal area of in-channel obstacles ($\sigma_z$, $\gamma$ and $\lambda_f$respectively). In reality, flow resistance is also provided by channel wall roughness, for example, metre scale fluctuations in bank protrusion, riparian vegetation, or the presence of rough bedrock banks in upland reaches. Here, we extend our physical experiments to include sidewall roughness in addition to bed roughness, to quantify the combined influence of bed and bank roughness on flow hydraulics.

Our experimental arrangement uses varying combinations of both bed and bank roughness, both at 1:10 scale. We used two different rough-bed configurations, which comprised a 3D mould of a bedrock riverbed (River Greta, UK), with added scaled boulders at 10% and 40% cover. For the banks we added vertical battens running at regular spacing down the length of the flume walls. Seven sidewall configurations were used (as well as a smooth-walled configuration), with battens varying in protrusion and spacing, to achieve configurations with different combinations of sidewall versus bed roughness. Depth-averaged roughness metrics, $\langle\sigma_z\rangle$, $\langle\gamma\rangle$ and $\langle\lambda_f\rangle$ describe the combined roughness of the wetted channel. For each configuration, average water depths were measured for five discharges. Water depths were used to evaluate the Darcy-Weisbach friction factor, f, for each experimental run. We present initial results for the rough-wall experiments, evaluating the combined influence of bed and bank roughness on bulk flow resistance, as well as the relative influences of bed versus bank roughness in each configuration.