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Measuring flow resistance in rough-bed rivers using flume and CFD approaches

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Accurate predictions of river channel flow resistance are necessary for estimating flow depth and/or velocity, and so are needed for predicting sediment transport and flood risk, river restoration and in-channel engineering. Standard approaches typically predict resistance as a function of the channel bed grain size distribution (GSD). However, in rough-bed rivers that comprise much of the river network (i.e. rivers where flow depth is not much greater than channel roughness elements), the sediment GSD is not the main factor that controls the channel shape, and so GSD does not provide a good predictor of flow resistance. In these channels, predictions need to instead account for the influence of multiple scales and shapes of roughness, including boulders, sediment patches, exposed bedrock and irregular banks, but we do not yet have suitable methods for making these predictions.

We present initial results from flume and CFD modelling experiments that have been designed to identify how irregular river-beds affects the spatial pattern of form drag and determine overall flow resistance. Both experiments take advantage of high-resolution topographic data that has been collected from field locations using new survey techniques (terrestrial laser scanning and structure from motion photogrammetry). In the flume experiments, we used the data to create 1:10 scale 3D reproductions of three different river beds. For each bed we incrementally add sediment cover, boulders, and rough walls, and measured changes in channel topography. For each configuration we then measure how water depth varied across a range of discharges to evaluate bulk flow resistance. In the CFD experiments, we simulate a range of flows over the field topography to evaluate the spatial pattern of form drag across the bed. In subsequent experiments the topography will be manipulated to retain specific topographic scales, in order to assess how form drag changes. From both sets of experiments, we will identify which topographic (surface roughness) metrics best represent the effect of the differing river bed properties on bulk flow resistance, and hence offer most promise for improved predictive equations.

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