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Surface roughness: capturing rough-bed river diversity

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Channel geometry and bed surface roughness modulate the flow resistance of river channels, which is fundamental to the conveyance of water and sediment. In rough-bed rivers, where the flow is shallow relative to roughness height, there is notable uncertainty in flow resistance calculations based on sediment percentiles (D50 or D84) or the standard deviation of bed elevations. A new approach based on alternative surface roughness metrics is required to encompass the diversity of rough-bed rivers and to identify alternative metrics capable of characterising their complex topography and elements including boulders and bedrock.

Here, geostatistical analysis is conducted for 20 rough-bed river reaches with varying channel characteristics (channel geometry, bedrock exposure, sediment grainsize, boulder density, and lithology). Multi-scale elevation- and gradient-based surface roughness metrics are extracted from high-resolution digital elevation modes and analysed to determine the most applicable metrics to fully define rough-bed rivers. Statistical analysis includes application of correlation analysis, Principal Component Analysis (PCA), and Hierarchical clustering. The results reveal that a complete description of the topographic properties of rough-bed rivers requires the use of multiple roughness metrics. Research outside Geomorphology has found that *elevation skewness* and *frontal solidity* are two metrics that can comprehensively define surface roughness. We find these metrics are capable of distinguishing between channels with differing characteristics, including bedrock or boulders, across multiple scales. The results provide a framework to support further research on the topographic controls on flow resistance and offer insights that advance topographic analysis across geomorphology.

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