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Can high resolution topographic surveys provide reliable grain size estimates?

Eleanor Pearson, Mark Smith, Megan Klaar, and Lee Brown
School of Geography and water@leeds, University of Leeds, Leeds, United Kingdom (gy12e2p@leeds.ac.uk)

High resolution topographic surveys contain a wealth of information that is not always exploited in the generation of Digital Elevation Models (DEMs). In particular, several authors have related sub-grid scale topographic variability (or 'surface roughness') to particle grain size by deriving empirical relationships between the two. Such relationships would permit rapid analysis of the spatial distribution of grain size over entire river reaches, providing data to drive distributed hydraulic models and revolutionising monitoring of river restoration projects. However, comparison of previous roughness-grain-size relationships shows substantial variability between field sites and do not take into account differences in patch-scale facies. This study explains this variability by identifying the factors that influence roughness-grain-size relationships. Using 275 laboratory and field-based Structure-from-Motion (SfM) surveys, we investigate the influence of: inherent survey error; irregularity of natural gravels; particle shape; grain packing structure; sorting; and form roughness on roughness-grain-size relationships. A suite of empirical relationships is presented in the form of a decision tree which improves estimations of grain size. Results indicate that the survey technique itself is capable of providing accurate grain size estimates. By accounting for differences in patch facies, R2 was seen to improve from 0.769 to R2 > 0.9 for certain facies. However, at present, the method is unsuitable for poorly sorted gravel patches. In future, a combination of a surface roughness proxy with photosieving techniques using SfM-derived orthophotos may offer improvements on using either technique individually.