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Reach-scale retrieval of alluvial bed roughness

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System-scale patterns of bed roughness exert a fundamental control on flow resistance, sediment transport and river ecological processes. While field techniques for the measurement of roughness are well established they are often invasive, labor intensive and difficult to generalize over space. Recent research has demonstrated that analysis of low-altitude imagery can be used to map grain-size over large spatial scales with tolerable precision. However, although this approach provides a route to the parameterization of particle roughness, such an implicitly 2D method provides little insight into the stage-dependence of particle and form resistance arising in mixed grain-size, water-worked contexts. By contrast patch-scale experiments with hand-held laser scanners, have indicated that an explicitly topographical approach to roughness, involving statistical analysis of elevations, may hold more potential to capture these complex effects (e.g., Aberle and Nikora, WRR, 42, W11414). Upscaling this approach to acquire system-scale data however remains unresolved.

In an attempt to address this, we outline a methodology to retrieve local patterning of topographical roughness from detailed 3D point cloud data, acquired using a terrestrial laser scanner (TLS) in a 1 km long study reach of the River Feshie. Unlike hand-held scanners, a ruggidized TLS can be tripod mounted and acquire data over ranges exceeding 100 m and with high angular resolution and temporal sampling rates, achieve data densities well above 1000 points/m2. Here, a Leica ScanStation was deployed to acquire a point cloud comprising over 200 million points, with RMS errors of 2-11 mm. An experimental design using a combination of grain-size counts, physical profiling, aerial photography and detailed patch-scanning, was developed to test a range of

algorithms designed to retrieve patch-scale (0.5-5 m) roughness metrics from the 3D point cloud. Results indicate that after local detrending using a low-frequency DTM, the local standard deviation of elevations can be successfully correlated to ground mapping and offer potential for improved parameterization of hydraulic models.