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Bedload transport rates in a gravel bedded-river derived from high-resolution monitoring using seismic impact plates

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Accurate characterisation of bedload transport rates is critical for a better understanding of geomorphological process dynamics, aquatic habitats, sediment budgets and strategies for catchment-scale initiatives in sediment management under conditions of climate change. However, rate estimation is challenging in practice: direct measurements are costly and logistically difficult to achieve with acceptable accuracy over geomorphologically-relevant time periods, and the uncertainty in transport rates predicted from empirical formulae and numerical simulation is rarely below 50 per cent. Partly reflecting these issues, passive technologies for continuous bedload monitoring are becoming increasingly popular. Sensors such as seismic impact plates offer the opportunity to characterise bedload activity at exceptionally high resolution – monitoring from the River Avon, (Devon, UK) indicated that despite significant intra-event and between-plate differences in apparent bedload transport aggregated over 5-minute periods, the magnitude-frequency product of discharge and impact frequency result in a highly plausible effective discharge, supporting the potential value of impact plates as indicators of relative sediment transport loads over annual timescales.

Whereas the focus in bedload rate estimation to date has been on developing satisfactory sediment rating curves from detection signals, we instead develop a method for directly estimating bedload transport rates from impact plate data as a function of intensity of transport (count, n, per second), bed material mass (kg) and cross-stream transport variability. Bulk sediment samples are converted to a mass in transit for each instantaneous discharge according to the intensity of transport and a Monte Carlo simulation of the load in transit determined at random from the bed material particle size distribution. The lower detection threshold is determined using experimental calibration and the upper size limit is determined from incipient motion estimates thereby establishing the fraction of transported material sensed by the plates. The lateral variability in transport rates across the cross-section is estimated empirically using multiple plates or by interpolation. This procedure provides a potentially affordable and robust method of achieving uncertainty-bound indicative measures of bedload transport with the potential for wide-ranging practical applications.