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Calibration of an Acoustic Sensor (Geophone) for Continuous Bedload Monitoring in Mountainous Streams

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Measurement of bedload rates is a crucial component in the study of alluvial processes in mountainous streams. Stream restoration efforts, the validation of morphodynamic models and the calibration empirical transport formulae rely on accurate bedload transport measurements. Bedload measurements using traditional methods (e.g. samplers, traps) are time consuming, resource intensive and not always feasible, especially at higher flow conditions. These limitations could potentially be addressed by acoustic instruments, which may provide unattended, continuous bedload measurements even at higher flow conditions, provided that these instruments are properly calibrated. The objective of this study is to calibrate an acoustic instrument (geophone) for performing bedload measurements in a well-monitored laboratory environment at conditions corresponding to low flow regime in mountainous streams. The geophone was manufactured by ClampOn® and was attached to the bottom of a steel plate with dimensions 0.15x0.15 m. The geophone registers the energy of the acoustic signal produced by the movement of the bedload particles over the steel plate with time resolution of one second. The plate-sensor system was installed in an acrylic housing such that the steel plate top surface was at the same level with the surface of a flat porous bed consisting of unisize spheres with diameter 19.1 mm. Unisize spherical glass particles, 15.9 mm in diameter, were preplaced along a 2 m long section upstream of the sensor, and were entrained over the steel plate. In these experiments, the geophone records spanned the complete experiment duratio. Plan view video of the particle movement over the steel plate was recorded via an overhead camera, and was used to calculate the actual bedload rate over the steel plate. Synchronized analysis of this plan view video and the geophone time series revealed that the geophone detected 62% of the bedload particles passing over the steel plate, which triggered discernable peaks in the time series. The bedload rate over the plate correlated as a power law relation with the magnitude of the registered peaks. This relation can be used for estimating the temporal variations of bedload from the record of the geophones records, which can produce continuous records and thus bedload measurements over extended time periods. Future research on the geophones is guaranteed and will aim on calibrating the geophones for particle movement at higher flow conditions where general sediment movement and possibly particle saltation occur.