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Calibration of a pipe hydrophone through bedload traps in a glacierized mountain basin (Saldur river, Eastern Italian Alps)

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The quantification of sediment transport in small mountain basins is of great relevance to assess the morphological and ecological dynamics of the entire channel network and as well as to predict flood hazards. Bedload transport in small mountain basins is highly variable in space and time due to the complexity of flow resistance sources, to the marked non-uniformity of bed sediments, to the relevance of bed armouring, as well as to varying activity and connectivity of the different sediment sources at the basin scale. In high-elevation, glaciarized basins, seasonal variability in sediment transport is known to be dramatic, but despite the relevance of such basins in many regions worldwide, very few investigations have tried to quantify it. Unfortunately, the measurement of bedload transport via direct methods is time-consuming and practically challenging at high flows. Therefore, indirect surrogate methods for bedload transport allowing its continuous measurements over time are highly desirable. Nonetheless these have to be calibrated to provide reliable estimations.

This study focuses on the calibration of a pipe hydrophone in the recently established (spring 2011) monitoring station in the Saldur basin, a high-elevation glacierized watershed in the Eastern Italian Alps (18.6 km^2 drainage area, about 3 km^2 covered by the glacier). The hydrophone is a 0.5 m-long steel pipe closed at both ends, air-filled, with one microphone at one end, and it was developed and built in Japan. Sediment particles hitting the pipe induce an acoustic wave which is registered by the microphone. The wave is then amplified and transmitted through 6 channels, each having a different sensitivity, so that small impacts due to little particles and bigger impacts generated by coarser material are both recorded. The hydrophone was installed at about 2100 m a.s.l. within a wood log spanning the 2.9 m wide channel, where a rounded slot had been previously carved to allow half of the pipe diameter protruding in the flow. The log was then stabilized by large rocks forming a sort of ramp. The number of impacts detected by each channel is registered at 1 min intervals in a datalogger powered by a solar panel. Flow stage is measured continuously by a pressure transducer at the same section.

The hydrophone signal was calibrated against 53 bedload measurements taken 12.4 m upstream using "Bunte" bedload traps, featuring a 4mm mesh. Bedload samples were measured from June to August 2011 during daily discharge fluctuations due to snow- and glaciermelt flows. Samples were taken at a wide range of discharges (from 1.44 to 3.95 m^3 s^{-1}, i.e up to almost bankfull flows and bedload rates (0.01 to 7350 g s^{-1} m^{-1}). The total number of impacts registered by the hydrophone for the duration of each bedload trap sampling was calculated, and subsequently bedload rates and number of impacts were expressed at 1 min intervals. As expected, the signals of the two most sensitive channels become dampened at lower discharges, and thus cannot be reliably used for bedload assessment. Instead, starting from channel 3 upward, power laws relating the number of impacts per minute to the unit bedload rate were obtained, with correlation coefficients R^2 ranging from 0.75 to 0.83, with higher correlations associated to the less sensitive channels.

Keywords: bedload monitoring, glacierized basins, indirect methods, calibration