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Bedload measurement with a set of vertical and horizontal pipe hydrophones in a mountainous stream

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The pipe hydrophone has been shown to be an effective means for monitoring bedload transport in mountainous streams. It is commonly installed perpendicular to the flow on a stable river bed such as a check dam. Acoustic pulses caused by bedload collisions on the pipe are detected by a microphone. However, bedload particles saltating over the pipe remain undetected. To overcome this disadvantage we have installed a horizontal as well as a vertical pipe hydrophone in the Ashiarai-dani supercritical flume located in the Hida mountain range, Japan. The vertical pipe was installed on the wall of the flume and the horizontal pipe was installed on the flume bed. The horizontal and vertical pipes respond acoustically; the acoustic energy derived from the horizontal pipe is larger than that for the vertical, but the number of pulses from the vertical pipe is more numerous than that monitored by the horizontal pipe at high amplitudes. We explain this as follows: the volumetric concentration of bedload decreases with increased height above the bed. Therefore, the acoustic response of the horizontal pipe is expected to be larger than that of the vertical pipe. However, at high amplitudes and high bedload discharges the pulses of the horizontal pipe are saturated but those of the vertical pipe are not saturated. We propose a ratio (Rhv) between pulses detected by these sensors, and applied this ratio in calibrating the contemporaneous pulses detected by a hydrophone located immediately upstream of a Reid-type bedload slot sampler. Indeed the Rhv-corrected pulses correlate well with the bedload discharge calculated from the sampler, thereby supporting our explanation. We conclude that bedload monitoring using concomitant vertical and horizontal pipe hydrophones can be used to calibrate centrally-located hydrophones, thereby representing bedload discharges more accurately than those based on a single pipe hydrophone.