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Testing seismic noise caused by highly concentrated sediment flows in laboratory experiments

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Sediment transport processes and fluxes play a key role in fluvial geomorphology and hazard triggering. In particular, extreme floods characterized by highly concentrated flows set the pace of mountain landscape evolution, where the linkage between streams and sediment sources leads to strong solid inputs characterized by significant grain sorting processes. The main observation that river processes generate ground vibrations has led to the application of seismic methods for monitoring purposes, which provides an innovative system that overcomes traditional monitoring difficulties especially during floods. Mechanistic models have been proposed in the attempt to invert river flow properties such as sediment fluxes from seismic measurements. Although those models have recently been validated in the laboratory and in the field for low transport rates, it remains unknown whether they are applicable to extreme floods.

Here we carry a set of laboratory experiments in a steep (18% slope) channel in order to investigate the link between seismic noise and sediment transport under extreme flow conditions with highly concentrated sediment flows. The originality of this set-up is that instead of feeding the flume section directly as usually done, we feed with liquid and solid discharge a low slope storage zone connected to the upstream part of the steep channel. This allows us to produce sediment pulses of varying magnitude (up to the transport capacity) and granulometric composition, traveling downstream as a result of alternate phases of deposition and erosion occurring in the storage area. We measure flow stage, seismic noise, sediment flux and grain size distribution. We find that the previously proposed relationships between seismic power, sediment flux and grain diameter often do not hold in such sediment transport situations. We support that this is due to granular interactions occurring between grains of different sizes within the sediment mixture and leading to complex grain sorting processes. In particular, we observe that bigger grains do not directly impact the bed but rather roll over fines or smaller grains, such that observed seismic power is much lower than expected. These results constitute a starting point for the development of a new mechanistic model for seismic power generated by highly concentrated bedload sediment flows.