Response to the comments made by Anonymous Referee #2

Dear Referee #2,

I thank you for your critical assessment of the manuscript. I appreciate your valuable comments that have helped to improve the manuscript. I agree with most of your suggestions, and I have revised the manuscript accordingly. Below, the reviewer comments are reported in italics, and my responses in normal font (blue colour).

This work presents an analysis of an extensive set of geophone and piezoelectric sensor data that are used to infer bed sediment transport in an Alpine stream. The primary focus of the paper the collection and processing of these particular data, and correlations in the results.

The paper is closely related to the work of Rickenmann (2020), which presented an analysis of the same data, but based on events rather than per-minute observations. Although it is reassuring to see that the change in methodology does not significantly change the results, in my view a shortcoming of the paper is the similarity to this previous work.

My main comment is therefore to suggest that a more direct comparison of the strengths and weaknesses of the two approaches is made, in order to demonstrate that the method presented here is indeed a substantial advance. In particular, the scientific benefit would be demonstrated by showing that the new methodology has the ability to test specific scientific hypotheses that could [NOT] be tested with the previous approach.

Response: I assume that the last statement in the third paragraph should rather read: "that could NOT be tested with the previous approach." I would like to mention here first that the similarity of the analyses only concerns a part of this study, i.e. mainly the results presented in Figures 6 to 10. However, in the earlier study (Rickenmann, 2020) all flood events had the same weight in the analysis (independent of the event duration), whereas in this study each single observation on bedload transport (i.e., 1 min value) had the same weight. All the other results, presented in Figure 4 and Figures 11 to 15, are completely new and could not have been obtained using the event-based analysis presented in Rickenmann (2020). Regarding the first part of the analysis in this study (i.e. the results related to Figures 6 to 10), I will use the expression “minute-based” analysis in the following, to distinguish it from the earlier event-based analysis. In fact, in the first part of this study, the minute-based analysis examined longer time intervals than the event-based analysis, whereas in the second part of this study, the minute-based analysis considered shorter time intervals than the event-based analysis, and also examined variations in the coefficient of variation of the transport rate and hysteresis effects. To make these differences clearer, I have introduced a short paragraph at the beginning of the discussion section.

I would also like to mention two important elements that may have influenced the results of the two types of analysis in different ways: (i) Between the sediment-transporting flood events in the Erlenbach, streambed characteristics may change due to sediment supply from the hillslopes, as discussed in Turowski et al. (2011). They showed that Q_s of a given event can be different from Q_e of the previous event, partly due to this phenomenon; (ii) between the

sediment-transporting flood events in the Erlenbach, an armouring effect on the streambed can also occur due to below-threshold flows (with no bedload transport according to the SPG measurements). Such flows are still sufficiently high to cause a rearrangement of the particles on the bed, as discussed in Masteller et al. (2019). Now, in general it may be concluded that the results of the minute-based analysis confirmed the results of the event-based analysis.

In both types of analysis, the effects of the elements (i) and (ii) were not considered explicitly. If they had been (very) important, they might have affected the results of the minute-based analysis more strongly, because in this analysis time intervals were used (i.e. periods p1 through p13) that each contained several events. From this assessment and given the general similarity of the results from the two types of analyses, it may be hypothesized that the effect of (variable) sediment availability on the streambed was more important than an effect of elements (i) and (ii) on the results. This concerns the results regarding the autocorrelation of bedload transport rates and disequilibrium ratio (Figure 6, 7) and the correlations between threshold discharges (Q_s, Q_e) and either disequilibrium ratio (E_{dM}, Figure 8) or hydraulic forcing (Q_{btot}, Figure 9).

I concur with anonymous referee #1's list of comments, and suggest a few more minor clarifications:

***Abstract**: a certain amount of jargon is used here (disequilibrium ratio, lag time, critical discharge, coefficient of variation, clockwise/anticlockwise transport behaviour) much of which is likely to be unclear to people who have not already read the paper.*

Response: I have changed some expressions in the abstract to make it easier to read. However, the use of some technical terms has been retained in favour of a more direct connection with the main text.

***line 78**: define coefficient of variation*

Response: An explanation has been added to the revised manuscript.

***line 219**: "xx% of the particles are finer" presumably refers to particle mass, rather than particle number?*

Response: This has been specified in the revised manuscript.

***line 262**: Clarify exactly what the 'kernel smoothing' does (presumably a type of low-pass filter?) and what the unit of bandwidth is? (I'd usually understand bandwidth to be measured in Hz).*

Response: Yes, the kernel smoothing is used here as a type of low-pass filter. The bandwidth defines the number of neighbouring points that are included in the smoothing window. The selected bandwidth of 30 with a Gaussian kernel (used here) smoothens over a window of roughly 60 minute-values. This number was selected because it resulted in a smoothing of the short-time fluctuations of bedload transport (with an associated increase in the correlation between Q_b and Q, Figure 4) and because the majority of the events have longer durations. This information has been added at the end of section 2.6.

Further changes

I have also made some further minor changes to the original manuscript. These are mainly typos. All changes can be found in the “tracked-changes” version of the revised manuscript.