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Earth Surface Dynamics Discussions

Interactive comment on "Tracing bedload transport in a high-elevation, formerly-glaciated mountain basin" *by* A. Dell'Agnese et al.

Anonymous Referee #2

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1 General Comments

This paper evaluates coarse sediment transfer in the Strimm creek, Eastern Italian Alps, using a large number of PIT-tagged particles. The results of the measurements are used to estimate, via the virtual velocity approach, the total and annual volume of bedload transfer. The 3-year measurements include snow-melt-dominated periods, events of (heavy) precipitation in summer, and mixed periods; hence, they are analysed with respect to the hydrogeomorphic regime between the surveys (in total 8 and 10 in the two sections, respectively). Another focus of the paper lies in comparing the bedload transfer in the Upper vs. Lower section of the Strimm creek (termed US and LS, respectively) that are separated by a bedrock step and differ with respect to their

morphology and lateral sediment connectivity.

The paper presents an original study that I consider very relevant for the scope of ESurf. It is generally very well written and contains an appropriate number of tables and figures of good quality. The conclusions are well supported by the results. I suggest that the manuscript be accepted for publication in ESurf after moderate revisions. My biggest concern is that the step from weight-classed Q thresholds and virtual velocities to "overall" volumetric transport rates is poorly described.

2 Specific Comments

The introduction contains a more technical part related to bedload transport estimation and measurement, and a part that refers to the application to landscape evolution, specifically with respect to the issue of glacial inheritance.

- p419 l26 pls define "relative sediment transport rates"

Study area section

- p422 l10: pls explain on what basis (single-year or short period measurements ? annual precipitation regressed on elevation ?
- p422 l22,26: you give the slope range for the "valley floor" - the definition and delineation of the valley floor influences the slope values found within this area. Was it delineated using a geomorphological map ? Is there always a conspicuous breakline between the valley floor and the hillslopes ? Moreover: In l22, you write "the large hummocky moraine" without having introduced this landform and its position in the landscape. I'd suggest that you either do so, or write "a large...".

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- p423 l7,9: do the slope values refer to the channel gradient (i.e. to the longitudinal profile) or to the valley bottom (i.e. to an area) ? Pls clarify
- Can you offer any evidence that the two sections are reasonably homogeneous and representative ?

Methods section

- p423 l23 consider re-wording "flows in WS1 are on average 60% higher"
- p423 l5ff: you indicate the range and the SD (please introduce this abbreviation; I assumed it is "standard deviation") of grain sizes. I think that you should give the mean also, because the SD directly relates to it. Moreover, the SD has the same units as the range (and the mean). The value of SD (2.1 mm) sounds very low to me for a total of 34 sediment samples with a range across three orders of magnitude. Is it correct ?
- p425 l23: pls indicate how the relative position was measured (tape measure ? laser distancer ?
- p426 l2-4: consider re-wording; what are "statistical relations within site" ? Can statistical relations exhibit scatter ?
- p426 l7: how do the (arbitrary ?) classes compare to the empirical distribution of grainsizes (weights) of the natural sediment ?
- p426 l15-21: I'd suggest that you add the Q_t values for each weight class as a new row in table 2. You could then discuss the consistency of the so derived thresholds in addition to fig. 6ff
- p426 l28ff: If G = d*w*v(1-p), the dimension is L*L*L/T = L^3/T, so the unit must be m^3/Time, not m^3, and G must be termed a bedload transport rate, not a bedload

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transport volumme (also to avoid duplication of volume/volumetric). Moreover, it is not clear to me if G refers to a weight class and should hence read G_i, or if it refers to the total quantity of sediment. This is important because it is needed to reproduce the estimation of total sediment flux rates. If the latter is true (i.e. G refers to total sediment flux), I'd suggest that you change the notation of v, because it would then refer to the mean virtual velocity computed across all grain sizes; should this mean be weighted with the proportion of the respective weight classes ?
Can you give a reference for the assumption that p=0.3 ?

- p427 l11: Pls report a last a short summary of depth of burial to make your assumption more reproducible. The cited literature suggests it is reasonable, though.

Results section

- p429 l1 and anywhere you use "intra-survey" throughout the paper: If a survey is defined as the act of measuring the relative position of the tracer particles, then Qmax during the time between two surveys is relevant. This period should be termed "inter-survey" rather than "intra-survey" in my opinion. In the caption of Fig 7, the term "inter-survey" is used correctly.
- p430 l4 and Fig. 6: the naming of the small figures is inconsistent as the letters j and k are left out. I'd suggest that you use the letters a-h for the US diagrams in the left columns and the letters i-q for the LS diagrams in the right column. Moreover, 10 surveys can be counted for LS in Fig 4 (however the first two are very close to one another). If there are 10 surveys, then mention that and why one of these was left out. If there are nine, pls correct Fig 4.
- p430 l6: which of the plots are meant by "selected plots" ? Please be more specific by explaining your point by example of a specific diagram

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- p430 l9: I suppose that the box plot contains data from all tracer particles and all surveys; hence, there must be data with zero movement; I understand that these cannot be shown on a logarithmic y axis. Please make clear (both in the text and in the caption of Fig 7b,8b) if you only evaluated particles that moved, or if you set the tracer travel distance to a minimum (20 cm according to your error estimation) even if the respective particle has not moved at all between two surveys. I think that both possibilities imply potential problems with the visual interpretation of the boxplots that you should discuss briefly.
- p430 l11: Do you have any idea why W5 forms an exception here ? Is it a random effect ?
- p430 l12: Why "interestingly" ? The upper whisker of the boxplots in Figs B should exactly reproduce the highest data points of Figs A, so that the correspondence of Figs A and B is not surprising. And the intepretation that there is a decline in maximum travel distances with increasing weight is not counter-intuitive I think. Probably just delete "interestingly" ?
- p430 l18: "no motion recorded in W1", similarly to US (p429 l5). Is it considered a random effect, or could it be that the smallest particles may be caught between larger particles and therefore may be immobile ?
- p431 l2f: "only 9 clasts (in W1 and W4) moved further than 10 m" - the maximum travel distance in W3 was larger, too (as mentioned in the same line)
- I was asking myself if it was really necessary to report in the text with so much detail on the movement of selected W classes between each survey. I think that the sections 4.2 and 4.3 could be shortened to highlight only the most important findings together with the relevant characteristics of Q in the respective inter-survey period.

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- p432 l 14-19: This paragraph suggests that one single Qt was sought for which all W classes were mobilised. However, the formula refers to each W class. Please consider my comment referring to naming Qt for each W class in Table 2. I think that the reader can also better assess the consistency of the different Qt's (Qt should at least not decrease for increasing particle weight), and the significance of the difference between the two "overall" thresholds for US and LS named here. In l20ff, you refer to the different W classes again.

- p432 l25f: while the Fig shows virtual velocities in cm/min, you use cm/s here. Please stick to the same units in the text and in the table. In l25, Qmax $<$ 0.36 m^3/s should read "Qmax $<=$ 0.36 m^3/s".

- p432 l28f: I would write "may include" instead of "includes", because you simply do not know to what extent this is the case, even if you constrain the inter-survey time to the time where $Q > Q_t$, your data shows that particles may rest even if $Q > Q_t$.

- One of my biggest concerns is that you do not clearly state, in my opinion, where/whether you use Qt for single W classes or for the whole bedload. This needs to be clarified anywhere you refer to bedload rates and transport velocities. As you later refer to the "bedload transport volume", I think that you refer to the total sediment. Then, you have to describe and explain how you come from the different virtual velocities of the single W classes to the overall transport rate.

- p433 l17: the progressive increase is only visible for the last three boxes (and strictly, not for the median) in Fig 9B, the first snowmelt-related box in Fig 9B "destroys" this "progressive increase"

- p433 l28f: Please specifiy for which event you see this "direct correlation". I spotted a slight positive (please add direction of the assumed correlation) one only for the red triangles in Fig 10A. And it would be interesting to discuss this

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counterintuitive behaviour (heavier clasts moving faster than small ones). I also think that the smaller velocity of the smallest particles could be due to shielding by larger particles, right ?

- p434 l9: Please be consistent with "transport volume" vs. "transport rates"; here, you convert a volume (m^3/3 years) to a mean annual mass flux (t/yr), which might be fully correct, but is a bit confusing.
- p343 l13f: This seems to anticipate the discussion; the rates are not only controlled by the event dynamics, but also by sediment availability and morphology, right ? This is discussed in the next chapter. Concerning the term "higher efficiency" in l13: Spontaneously, I would say that "long distance transport in short time" is efficient; here, you use "high efficiency" for snow melt periods for which you have already stated that they span a long time, and virtual velocities are (well, perhaps spuriously) low. Are snow-melt periods perhaps "effective" by contributing most of the annual budget ?

Discussion chapter

- p434 l27f: "decoupled conditions" refers to within-channel connectivity, right ? Later, you address lateral sediment connectivity; please refer to sediment availability (which is partly a consequence of lateral connectivity) also.
- p435 l27 compare annual rates of sediment, $200m^3year^{-1}$ and $1m^3year^{-1}$, not

$$1m^3$$

- p436 l24f: I do not understand the conclusion that Strimm Creek is a bedload-dominated system because, remarkably, the single debris flow accounts for 20-25 years of "ordinary" bedload transport. Please explain

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Interactive Comment

Conclusions

- p437 l19ff: I think that the conclusion reported here has not been developed in the results and/or discussion chapter. In order to appear in the conclusions, it should be in the discussion chapter.

Figures and captions

- Fig 1: Add legend symbol for lakes; is it correct that the ephemeral section of the US creek is discontinuous - if so, what is the reason ?
- Fig 7: Weight classes W7 and W8 are not part of 7a - not represented in US area ? If so, please mention in caption and text. The X axis is not to scale, i.e. you use a seemingly metric axis for a categorial variable (in turn, the lines connecting the dots are misleading to some degree). Either use a metric axis and the mean of each category, or remove the lines to make clear(er) that a categorial variable is displayed on the x axis.
- Fig 8A: The data for Qmax=0.41 m^3/s displays a non-consistent relationship, i.e. the maximum displacement is very low for the smallest class and appears to slowly decline for the heavier ones. This could/should be addressed in the text. Do you think that is due to random effects, or is it a systematic observation because the smallest particles are shielded by larger ones, at least for comparatively low Q ? - similar in Fig 7A

3 Technical Corrections

- p422 l4 write "Ötztal" or "Oetztal" instead of "Otztal"

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- p422 l28 duplication of "colluvial", I'd suggest you write "convey colluvial material from hillslope tributaries"
- p423 l2 insert comma between "Here" and "open-slope"
- p425 l16 consider re-wording "foregoing" to "aforementioned"

Interactive comment on Earth Surf. Dynam. Discuss., 3, 417, 2015.