# Interactive comment on "Coarse bedload routing and dispersion through tributary confluences" by K. S. Imhoff and A. C. Wilcox

**Anonymous Referee #2**

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Summary - This article explores coarse sediment transport within mountain stream confluences through the use of RFID PIT tagged sediment tracers. Tracer particles were placed upstream of two confluences and in a single thread control and their resulting displacement is surveyed following a significant flood. Using various analysis the authors conclude that equilibrium confluences act to increase the dispersion of coarse sediment relative to the single thread control reach and propose that equilibrium confluences represent a potentially key node of increased transport within basin networks.

General notes -

In general, I am supportive of the approach that the authors have taken and believe that the community of researchers interested in sediment routing and bed load dynamics

will welcome the new results. To my knowledge routing RFID tagged sediment particles through confluences is novel, and the affirmation for gravel of previously examined particle trajectories through confluences for sandy streams is very interesting. That particles stick to their respective sides of the river is intriguing and should make for an interesting follow-up study as to how far downstream of the confluence particles start to mix again. I applaud the amount of field work and effort that went into the collection of this data. There are quite a few different methods or analysis in this article and it is not clear to me that all of them are necessary or that they all support the main conclusions of the work. In particular, the analysis of the transport distributions shows that gamma and exponential distributions fit the data fairly well (figures 7 & 9), but then some of the streams also seem to possess heavy tails (figure 10). It is this part of the article where I have some reservations as to if the distributions are actually heavy-tailed (they may be), as there is not enough shown in the figure or written in the text to describe how the character of the tail was assessed. I encourage the authors to revisit this aspect of the paper and in some ways I think the paper would be fine if discussion of the heavy or thin-tailed nature of the right tails were completely omitted as the significance of the analysis and physical reasoning is not discussed in terms of the control reach and confluences. It is interesting that in each set of streams meeting at the confluence seem to have very similar transport statistics and to my knowledge, the demonstration of confluences in near equilibrium from the particle scale hasn't been tested before (this should be emphasized). I encourage the authors to also discuss in more detail how the transport statistics within the confluences differ from the control reach, as it currently seems that they are more similar than different (at least in figures 6-10). Some of the differences may be obscured within the figures. There is a slight difference between the control reach and the confluences within figure 11, but it is not clear to me how significant that difference is given the general and expected messiness of field data, perhaps adding some error bars or ranges could help show that indeed the behavior is different.

I urge the authors to consider the physical reasons for the stochastic distributions that

they employ, and what that might tell us about how confluences alter or don't alter coarse particle transport. As an example I'll focus on the exponential in figure 10, an exponential or gamma-like distribution is an adequate description of particle step length in the lab under ideal conditions (see Roseberry et al., 2012 or Martin et al., 2012) or in the field for simple bed topography, but given that there are bars, scour holes and changing hydraulics within the confluences does the reasoning for the distribution remaining exponential still apply. My expectation given the complexity of the topography within the confluences is that the distribution would not be well defined, but that it is still decently well described by an exponential (relatively straight on a semi-log Y plot) is rather interesting.

Specific comments -

Pg.2 ln.5-9 : This sentence is rather long. Perhaps consider something along the lines of "We investigate sediment routing patterns in headwater confluences by comparing them to low gradient gravel bed river reaches to characterize how confluences alter the transport of coarse clasts."

Pg.2 ln.16 : Tail analysis? I imagine you mean of the distribution of particle transport lengths, but at this point in the paper it is not clear what tail analysis means. Please add a couple of extra words of description.

Pg.3 ln.9 : This probably needs another citation earlier than Phillips et al., (2013), I would suggest Einstein (1937), especially since the next three references directly build on his work. Phillips et al., 2013 could be placed after haschenburger, 2013 in line 14.

Pg.4 ln.9 : I suggest added additional references here such as Nikora et al., (2002) and Metzler and Klafter (2000) which is a good introduction and review into diffusive processes from the physics literature.

Pg.7 ln. 16 : You've already introduced PIT as the shorthand for the Passive-integrated transponder on pg. 5 ln. 16. It makes more sense to introduce it here where RFID is

mentioned. I think, you could easily remove the earlier occurence without any loss of clarity.

Pg. 7 ln. 26 : This line suggests that all of your particles are larger than the D50, suggest adding a percentage of particles greater than D50 or saying that most particles used were larger.

Figure 3. b, c, d seem to be missing. This suggesting would make the figure larger or require several figures but it would be conceptually useful to see the grain size distributions for each tracer set with their field site bed grain size. If the control reach is slightly coarser that would support the hypothesis that confluences result in enhanced transport.

Pg. 8 ln. 4 : I don't think you need to keep reminding people of what PIT means.

Pg. 8 ln. 4-14 : This paragraph could be omitted. It seems adequate to state the manufacturer, tag size, and the maximum read ranges and then refer to a citation where the reader if interested can find more information.

Pg. 9 ln. 10-23 : Please report the detection range of the loop antenna that you used and manufacturer if known.

Pg. 10 ln. 21 : Here <X/D> is the mean displacement length, which may not necessarily be the step length. Thinking about transport as steps and rests the step length represents (statistically) the average single displacement length from start to stop. A particle may move multiple times during a flood and thus, the resulting displacement length is a sum of an unknown (usually) number of steps.

Pg. 11 ln. 20 : Metzler and Klafter would be a good reference here. It is also important to consider that if your displacement data were heavy-tailed then rescaling it by the mean (<X/D>) wouldn't be correct because the longer you waited for the variance or mean of the data wouldn't converge. You might mention that you have tested the distributions to make sure that the mean is a meaningful parameter.

Pg. 12 ln. 1 : cumulative excess shear velocity rather than shear stress.

Pg. 13 ln. 3 : There are many rivers in Mueller et al. (2005), suggest rephrasing to say, Halfmoon Creek, a river in Mueller et al. (2005), is similar to...

Pg. 14 ln. 8-9 : It would help if you could describe what Parrett and Johnson (2004) is and then cite it rather than just referring to it without context.

Pg. 14 ln. 12 : Rather than list the average recovery percentage just give the range reported in table 2.

Figure 9 : The dashed line should be labeled as an exponential in the legend. It would also help to add color or make the points larger in size, as it is I am having a difficult time distinguishing between Martin creek lower and upper. While, the best fit exponential might not fit (in a least-squares sense) the cloud of data well, the data seem to be straight enough on a semi-log plot that an exponential doesn't look bad at all for describing the overall trend (perhaps because I am having trouble discerning the trend for each reach with the current symbols). This plot does tell us that the data seem to collapse fairly well after normalizing by a single parameter (this provides quite a bit of support for a thin-tailed tracer displacement model, and even the exponential distribution which has a single parameter, except for the single point at the far right). It doesn't look like there is any data below $10^{-2}$, you might as make that the lower bound which will make the other points easier to see.

Figure 10. It is not clear to me why starting the tail at 80% ($8*10^{-1}$) is correct. Given that each distribution has a substantial break in slope after this point, in the case of the lower martin creek it is close to the 20% mark ($2*10^{-1}$). In terms of exceedence probability the first 10-20% is the left tail (low transport distances) and 20-80% represents the middle of the distribution. Still some of the data may have lower slope than -2 (for reference it would help if a -2 slopes were added to the plot), but only barely. This interpretation also seems to conflict with figure 8 in which the data seems to be relatively straight on a semi-log plot, which does not support a heavy-tailed power law

distribution. It would also help to have the power-law fits to the tail region where you determine which ones are heavy-tailed or not. This could be done in the same way that Hassan et al. (2013) do their analysis. Something should also be mentioned about how tracer recovery percentage affects the scaling of the tail parameter (see Hassan et al., 2013). If you decide to assess the tail parameter though please describe the method that was used. At the moment it is not clear if the data were fit by a power law or a more rigorous approach like the Hill estimator was used.

Figure 11. Other figures would benefit from a similar color and symbol scheme as used in this figure.

Figure 12. Could you label which reaches the points are from? In the text (pg17 ln24) it states that the variance follows a power-law relation, but it seems that a linear line is plotted. Unless the exponent was left off of the equation given. Could you comment on why the relationship for the different populations of tracer particles should fall on the same linear line or why they are related linearly? In phillips and jerolmack (2014) tracer particles for their two field sites fell on two different linear relationships and in order to fit them onto a single curve the frictional resistance of the stream bed needed to be accounted for. Does normalizing I* by frictional resistance provide a better collapse of the data?

Pg. 17 ln. 25 : the linear relationship in Lajeunesse et al. (2010) is for average step length against shields stress for constant flow, whereas the results given and those of Phillips and colleagues are for total displacement in unsteady flow. These are likely related, but it has not been shown nor is it obvious to me how they are related. Perhaps leave the Lajeunesse citation out of this line.

Pg. 18 ln. 12-15 : It is not clear if these lines are suggesting that upstream geometry and bed discordance are minimal for morphodynamics in general or just for this river (because they are simple and minimal).

Pg. 20 ln. 9-12 and parts of the conclusion: If confluences enhance coarse particle

transport more than the standard plane bed reach then shouldn't there be enhanced deposition between the upper and lower confluences or is the conceptual model hypothesizing that coarse particle transport continues to increase with additional equilibrium confluences? Did you observe enhanced deposition or a coarser bed between the upper and lower confluence sites? The conclusions suggest that the interpretation of the confluences is that they locally enhance transport of coarse material, so in order for mass to balance there should be a noticeably (if the effect is strong) coarser bed between the confluences. If you have the particle size data, it would be interesting to look at this.

It is nice to see the tracer displacement data published with the paper and in general, the supplementary data and explanations are well done. Figure S5 should probably be shown with straight lines rather than curved lines. I encourage the authors to upload their tracer data to a digital repository as well (Figshare comes to mind because it is free and provides a citable DOI).

References cited in comments

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