Earth Surf. Dynam. Discuss., 3, C733–C742, 2016
www.earth-surf-dynam-discuss.net/3/C733/2016/

ESURFD_Log

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

K. S. Imhoff and A. C. Wilcox

kurt.imhoff@umontana.edu

Received and published: 26 March 2016

(1). As discussed in the introduction (p 1512), in section 4 (p 1526) and exemplified by figure 1, the sudden increase of discharge at the confluence is likely to be a important control parameter of sediment dispersion and transport distances. It is therefore regrettable that the sites being ungauged, the entire analysis relies on water stage measurements. This weakens the conclusions of the paper.

We certainly agree that discharge measurements are valuable for this (or really any) type of fluvial process study, but we do not agree that stage measurements weaken our conclusions; we consider these a suitable substitute, complemented by topography measurements, for understanding differences in the hydrologic driving forces tempo-

rally (across the hydrograph) and spatially (among study sites), for our study purposes. Our use of stage data is supported by Phillips et al. (2013), who found that stage is an acceptable metric for calculating I*, which has been shown to be analogous to the time above the critical discharge threshold for motion. Direct measurement of discharge across the hydrograph at our five sites was also not feasible, and gauged headwater streams of the type we target here are not available in our region.

(2). Abstract, page 1520, line 14-15. The authors mention the existence of "finer grained experiments" in which efficient transport corridors are also observed. Unless I'm wrong, these "finer-grained experiments" are discussed nowhere in the manuscript.

We have changed "finer grained" to "prior"- our intention was to allude to prior studies involving finer-grained particles, but we agree that this was not clear.

Line 20 Within the confluence zone, transport occurs along scour hole margins in narrow, efficient transport corridors that mirror those observed in finer-grained prior experiments and field studies.

(3). page 1514, line 5. What exactly do you call a "disturbance"? Please be more explicit.

In this case, we are referring to physical disturbances that disrupt equilibria among transport capacity, sediment supply, and channel morphology, including the confluence morphology discussed (scour hole with flanking bars) via sediment evacuation or infilling. Such disturbances can include floods and debris flows; in our study system post-wildfire debris flows are a key disturbance.

Line 131 We selected a study area in the East Fork Bitterroot (EFB) River basin in western Montana, USA (Fig. 2) that is typical of semiarid, snowmelt-dominated, montane headwater systems. This location lacks lacking recent physical disturbances affecting the sediment equilibrium (i.e.,e.g., post-wildfire debris flows) and containsing confluences exhibiting characteristics of the equilibrium morphology described above.

(4). page 1515, lines 25-30. What is the bed D50? What is the D50 of the tracer particles?

Grain size information for the bed and tracers are provided in Tables 1 and 2, respectively. We have revised the text, including additional references here to Tables 1 and 2, to improve clarity.

Line 187 30mm long were drilled using a $\sim$ 0.8mm diamond-tipped drill bit.. . .. Tracer particles used were primarily larger than the bed D50 (Table 1), as particles with b axis below 45mm often fractured during drilling. We tagged cobbles with median axes mostly between 60 and 130mm (Fig. 34, Table 2). Many of the tracer particles were larger than the bed D50 (Table 1), because particles with b axis below 45mm often fractured during drilling. This represents the D37 to D70 size fraction, which wWe assumed our tracer particles, which fell within the D37 to D70 size fraction of bed materials, to be representative of the coarser fraction of mobile bedload particles. The D50 of our tagged tracers varied between 0.077m and 0.082m (Table 2). The results and interpretation of our sediment tracers thus do not apply for the entire mobile bedload population in this system.

(5). page 1516, lines 16-19. How exactly did you make sure that the tracer particles were deposited randomly? Why would randomly distributed particles be more likely to move to natural positions? How long does it take? And what do you mean by "natural position"? I understand that your objective is to minimize the possible influence of the initial condition. But your statements need to be supported by observations or reasoning. For my part, I would be inclined to believe that it is very difficult to ensure a random distribution on the field so that starting from a regular grid is the most reproducible initial condition even though it is not the most "natural" one (as in Phillips et al. 2013).

We have revised the text here to address these comments. We have deleted the word "random" to describe the grid and replaced it with reference to Figure 5, which shows

the initial layout of our tracer particles. We have also deleted the second part of the sentence (where we referred to "natural position"). We have added text recognizing the challenge of simulating natural particle arrangement in tracer deployment, per the reviewer's comment. The new text reads:

Line 209 Our seeding method emulated that employed by Ferguson and Wathen (1998): particles were seeded loosely on the bed surface near the channel thalweg in a random grid (Fig. 5)., an established and easily reproducible initial condition for coarse particle tracers. Mimicking the arrangement of fluvially deposited gravels and minimizing the influence of the initial condition of particle deployment is a challenge in tracer studies, but a regular grid such as ours provides a reproducible initial condition and is consistent with previous work (Ferguson and Wathen, 1998). so the tracers were most likely to move to natural positions from which further dispersion could be monitored.

(6). The authors chose to organize the discussion of the results in three separate sections: 1) short presentation of a few sediment dispersion models in section 2.3, 2) test of these different models against the field data in section 3, 3) discussion in section 4. I don't like this organization which prevents from conveying a clear message.

First of all, the reader loses track of the central idea of the manuscript. The accumulation of sentences starting with "We also ..." (at least 3 or 4 in sections 2.3.2 and 2.3.3) participates to this feeling and leaves the reader under the (false) impression that the authors are randomly testing theoretical models. Secondly, many notions are defined long before being actually used. E.g. the normalized transport distance defined page 1518 is plotted and discussed page 1524. Similarly, equation (2) or the dimensionless impulse are introduced page 1519 and used page 1525. Again, this does not facilitate the reading of the manuscript.

The authors should therefore reorganize the manuscript. It is particularly important to explain 1) what motivates the choice of a given model instead of another, 2) what are the differences between the different models (assumptions, physical mechanisms...).

We have reorganized several elements of the manuscript in response to these comments. We revised subheadings in the methods and results so that the reader can easily track which methods lead to which results (e.g., where appropriate, we use the same subheads in each section) and eliminated some subheads. To more clearly convey the key elements of our analysis and to avoid the impression of randomly testing models, we eliminated one line of analysis (size-selective transport and comparison to Church and Hassan 1992), which we decided muddied, rather than clarified, our results. This resulted in elimination of sections of methods, results, and a figure. We attempted to more clearly explain choices of given models and differences among them. We attempted to define terms closer to where they were mentioned.

See revised manuscript.

(7). page 1519, L1. D50 instead of L50

We have retained the original text; our scaled travel distance (using L50, as defined in the text) follows the convention of Milan (2013) and Church and Hassan (1992).

(8). page 1519, equation (2). I imagine that the coefficients involved in equation (2) (0.232, 1.35) are empirically fitted coefficients and not fundamental constants. If so, these coefficients probably depend on the field site where equation (2) is applied. The authors should comment on this.

Per our response to comment 6 above, we decided to eliminate the comparison of our results to the Church and Hassan (1992) size-selective transport equation (formerly Eq. 2). Some of the sites used in that equation were indeed quite different than our site.

(9). Page 1521. What motivates the choice of equations (5) and (6) to compute the critical Shields stress? To what extent do the values calculated from equations (5) and (6) differ from each other? From the empirical shields curve?

We selected these equations after literature review of approaches to calculating critical Shields stress in rivers that are comparable to our field site. We used the Mueller et al. approach (equation 5) because of the similarities between one of the streams from which their relation was developed (Halfmoon Creek) and the EFB in terms of morphology and hydroclimatic setting. To provide insight to the sensitivity of impulse to estimated critical Shields stress values, we chose to complement this with Recking's (2013; equation 6) approach, which is based on data from a large series of coarse-bedded rivers, including Halfmoon Creek, similar to Mueller et al (2005).

Differences in the Shields number are reflected in the I* values (Table 4). Table 4 also has the Shields number approximations obtained using the equation – the Recking approach always provides larger Shields numbers than the Mueller approach. Our Shields number values correspond to the area of the Shields diagram where bedload transport would be expected.

Line 297 Because our tracer equipment could not directly detect initial motionthe conditions under which particles were mobilized, we instead estimated a range of τ_cˆ* using two different empirical approaches,equations derived from similar which we selected based on their derivation in gravel-bed systems similar to our study sites and our ability to measure required inputs. For the first estimate, we used Mueller et al.'s (2005) reference dimensionless shear stress relation for steep gravel and cobble-bed rivers:

τ_(c,Mueller)ˆ*≈τ_rˆ* = 2.18S+0.021 (5) where τ_rˆ* is a reference shear stress, which we assume is similar to τ_cˆ* (after Mueller et al., 2005). The river in Mueller et al.'s studyOne of the study rivers in Mueller et al. (2005), Halfmoon Creek, is similar to our study site, as described above with respect to channel dimensions, critical discharge, hydrology, elevation, and bed sediment characteristics. For the second estimate of τ_cˆ*, we used Recking's (2013) mobility shear stress (τ_mˆ*) equation, which was empirically developed using bedload transport data from gravel-bed transport studies in mountainous streams:

τ_(c,Recking)ˆ*≈τ_mˆ* =(5S+0.06)ãĂŰ(D_84/D_50)ãĂŮˆ(4.4√S-1.5). (6)

See revised manuscript.

(10). Many paragraphs address several different ideas and should therefore be split. See, for example, the very long paragraph of the introduction extending from page 1511, line 7 to page 1512, line 5. The paragraph starting p 1524, line 16 and ending page 1515, line 4 is another example.

We have edited the manuscript throughout in an effort to improve the writing, including spliting numerous paragraphs in the revised manuscript to better convey each idea separately and clearly.

(11). The phrasing of some sentences is rather unclear. I have listed some of them below. This list is not exhaustive and the authors might want to check the whole manuscript:

(a). page 1510, Line 18-19 : “We suggest that confluences absent of disturbances enhance sediment transport...”

(b). page 1513, Line 7-9 : “Sediment transport through equilibrium confluences, however, is poorly understood (Best and Rhoads, 2008), in turn constraining understanding of confluence influences on local and network-scale patterns of sediment routing.”

(c). p. 1514, l. 21-22 “Between the study confluences is a plane-bed morphology control reach.”

(d). p 1528, l. 6-7 “Despite this, observed tracer transport suggests that confluences enact an enhanced dispersive regime through increased travel distances and reduced depositional probabilities.”

We have revised the phrasing of sentences in question (as well as other sentences throughout the manuscript) to improve clarity.

(12). Figure 3. The caption mentions “photographs of the (b) upper confluence, (c)

control reach, and (d) lower confluence” which are not on the figure.

This was an error left over from a prior version of Figure 3 that included photos and has been corrected.

(13). Figure 5. Describe a, b, and c in caption.

Caption has been revised as suggested.

(14). The aspect ratio of figures 9, 10, and 11 should be increased so as to make them more readable.

Figures 9-10 have been revised as suggested, along with Figure 8.

(15). Figure 11. Modify axis limits to zoom in on the data.

Figure 11 has been removed from this manuscript, as described above.

Interactive comment on Earth Surf. Dynam. Discuss., 3, 1509, 2015.

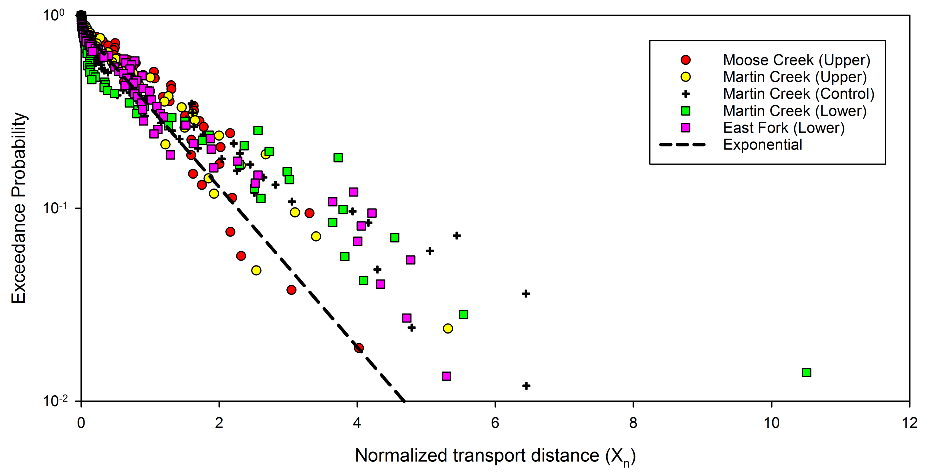
Exceedance Probability
Normalized transport distance (X_n)
Moose Creek (Upper)
Martin Creek (Upper)
Martin Creek (Control)
Martin Creek (Lower)
East Fork (Lower)
Exponential

Fig. 1.

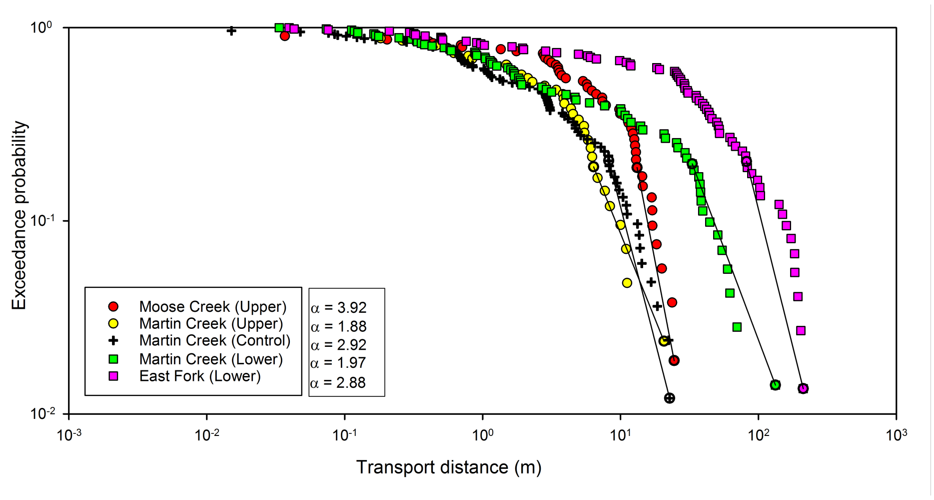
Exceedance probability
Transport distance (m)
Moose Creek (Upper)
Martin Creek (Upper)
Martin Creek (Control)
Martin Creek (Lower)
East Fork (Lower)
α = 3.92
α = 1.88
α = 2.92
α = 1.97
α = 2.88

Fig. 2.