Reviewed Manuscript: The transport of sediment mixtures examined with a birth-death model for grain-size fractions

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In this paper, the authors study the bedload transport of sediment mixtures in gravel-bed rivers, with a focus on the contribution of collective particle entrainment. A Fourier analysis is implemented on several series of experimental sediment flux, together with the application of an expanded birth-death Markov model. Results show that the effect of collective entrainment on bedload transport is size-dependent, with larger influence on smaller grain sizes, and this could explain the different transport behaviors among different grain sizes as observed in the experiments. The topic is interesting and the authors present good analysis. The contents are generally well organized. Therefore, I think that this paper could be published on Esurf after moderate revision. I list my comments below.

1. Explanation of the results from birth-death model

(1) Lines 18-19 of Page 11: Compared with Run b, Run c (in Figure 4) has much larger values of μ_{22} and μ_{33} (the values of other μ are also different, but not as significant as μ_{22} and μ_{33}). I do not quite understand how the conclusion here is reached, especially how it is linked with the values of μ.

(2) Lines 19-21 of Page 11: Does larger AR(2) weight parameters mean an enhanced collective entrainment? How?

2. Explanation of the experimental results

Figure 7 shows the temporal variation of sediment flux and bed elevation at fixed locations, which is very informative. Have you recorded the longitudinal profile/slope and the bed surface texture during the experiment? It would be interesting to see how the bed profile and texture respond to the change of water and sediment supply from the inlet.

3. Comparison between experiment and theory

According to the experiment, fall of NPSD with frequency occurs at lower frequency of about 10^{-3} ~ $10^{-1.8}$, and the NPSD at higher frequency shows the character of white noise (Figures 12 and 13). Whereas according to the theory, the NPSD falls at relatively high frequency but keeps about constant at relatively low frequency. Could you explain or discuss such difference?

4. Expression of grain size fractions

In the paper, the authors describe the sediment groups with two different expressions: (1) the retaining particle sieve size; and (2) the actual grain size. In many places, the authors do not explain clearly which expression they are using, which makes me confused. For example, in Section 4 the authors define the finer grain size fractions as 4-11.3 mm. I

do not know whether this is the retaining particle sieve size, or the actual grain size. If it is the former case, then the finer fractions should include the finest four groups in Table 3 (with the regard that grain size in Table 3 denoting the retaining particle sieve size, which is also not explained in the paper); if it is the latter case, then the finer fractions should include the finest 3 groups in Table 3. Also, the authors define the coarser grain size fractions as 16-32 mm. Again, I do not know whether this is the retaining particle sieve size, or the actual grain size. If it is the former case, but there should be no sediment coarser than 32 mm according to Figure 6 and Tables 2-3; if it the latter case, then which category should sediment in 11.3-16 mm belong to, finer fractions or coarser fractions?

To avoid such misunderstandings, I suggest the authors to use the same expression for the grain size throughout the paper. For example, the authors could use the actual sediment grain size via replacing “4 mm” by “4-5.6 mm”, “5.6 mm” by “5.6-8 mm”, etc. in the tables and figures.

5. Line 4 of Page 15: What do you mean by a “ramping up and down period”? What is it for?

6. Section 4.3: I think it would be better to state clearly at the beginning that results in this section are particle count based. Since in the appendix, there are also results which are particle mass based. The same is for Section 4.4.

7. The order of the appendices as listed at the end of the paper is not the same as they are referenced in the main text. Appendix D is referenced first in the main text, and then Appendices A-C.

8. Appendix C: What is the difference between the particle-based flux discussed here and the count-based flux presented in Section 4 of the main text? My understanding is that they are basically the same, except that in Section 4 you present fractional flux, whereas in Appendix C you present composite flux. If this is true, then please use the same name (either particle-based or count-based) for both the main text and the appendix.

9. Notation

(1) Line 12 of Page 4: What does f denote? Please define the parameter the first time it appears in the manuscript.

(2) In Section 2.1, N denotes moving particles within Area A, n denotes the number of particles that exits the right boundary from starting time. However, in Section 2.2, n_j denotes the number of active particles within area of A for the j-th size. Please keep consistent.

(3) Does the superscript * in Section 2.1 denote the characteristic parameters for the light table? Please clarify.

(4) Line 18 of Page 6: Shouldn’t it be A^* rather than A?

(5) Line 3 of Figure 3’s caption: $\lambda_3 \rightarrow \hat{\lambda}_3$?

(6) Upper part of Figure 4, what do ϕ_{11}, ϕ_{12}, ϕ_{21}, … denote? Do you mean ϕ_{a1}, ϕ_{b1}, ϕ_{a2}, …?

(7) Line 8 of Page 10: What does AR(2) stand for? Please write the full name of the

abbreviation the first time it appears in the paper.

(8) Equations 24 and 25a: The parameter *A* is used as area in the previous sections of the paper.

(9) Line 31 of Page 16: The parameter *N* is used for moving particle numbers in Section 2.1.

(10) Line 2 of Page 17: Please explain the meaning of E[X] and V[X].

(11) Line 14 of Page 22: The abbreviation “pmf” should be defined at the first time it appears in the paper. Also, I am wondering if capital letters should be used for an abbreviation.

(13) Considering that the paper includes so many parameters, I think a Notation Part at the end of the paper would be beneficial for the readers.

10. Equations

(1) Equations 21-23: I could be wrong, but it seems that the right hand side of these equations denotes the magnitude of $F_j(\omega)$, rather than the real part.

(2) Equations D2-D4: I could be wrong, but it is more common to me to use $d\omega$ in the integration, rather than $\partial\omega$.

(3) Equations D9-D10, and Line 7 of Page 36: Is *A* the same for different size ranges? If not, maybe use A_j?

(4) Cannot understand how you get Equation D11 from Equation D10c.

11. Figures

(1) Figure 3: The bottom of Figure 3 shows the sketch of particle entrainment and transport. In the sketch, is there difference between the dark gray circles and light gray circles? (Dark gray circles for collective entrainment, and light gray circles for entrainment due to fluid force? If so, please state in the caption.) Also, I do not see different behaviors of collective entrainment from the sketches of Panels b, c, and d. I cannot link the sketches with the corresponding text above. Please clarify.

(2) Figure 4: The figure shows the ranges for the input parameters of the Markov model. I am wondering is there references (or physical constraints) for these ranges?

(3) Figure 7: In the color bar, I do not understand the meaning of “f_r<<1.0>>f_r”. Also, the color bar lacks a scale. In Panel b, I suggest to add some text to explain what is the blue thick line (I guess it is the sediment flux measured by light table). Also in Panel b, the line of sediment supply is beneath the blue thick line, and therefore is not readable. In Panel c, what is the difference between the different lines? Also, how is the elevation averaged and normalized?

12. Table

(1) Table 1: I do not see "L.T." in Table 1. What is the footnote for?

(2) Table 2: Are the Light table total mass for sediment of all sizes, or only sediment with grain size larger than 4 mm?

(3) Table 3: What do minimum, maximum, mode, median, 90th percentile, mean, and variance particle count mean? Do you mean particle count per second? The same is for the vertical axis of Figures 8 and 10.

13. Typo

(1) Line 3 of Figure 8’s caption: two “reported”.

(2) Line 32 of Page 30: affect $\rightarrow$ effect.