Review of “Advection and dispersion of bedload tracers” by Eric Lajeunesse, Olivier Devauchelle, and François James

This paper expands on a previously published model for describing fluvial bedload tracer transport. The model is derived from a mass balance based primarily on the erosion and deposition rates and the fractions of tracer in the mobile and immobile parts of the bed. The model assumes a homogenous bed grain size and steady and uniform transport. From the model, the authors derive analytic expression for the velocity and dispersion of a tracer plume. The paper is well organized and the derivations are mostly clear, with the exception of the derivation of the scaling of the mean and variance of the tracer plume with time. My difficulty following this derivation is perhaps the origin of my most serious concern, discussed below.

My most serious concern is the prediction of how the mean and variance scale with time t during the entrainment regime, specifically that the mean increases as t^2 and the variance as t^3 (page 6, figure 3, and equations 37-39).

I am not familiar with any literature that describes variance scaling greater than the ballistic regime, variance ~ t^2. The *Zhang et al.* [2012] and *Nikora et al.* [2002] references cited on page 6, line 15 do not support this variance scaling. *Weeks and Swinney* [1998] Figure 1 shows an upper limit to the variance scaling of t^2 and Table 1 limits the scaling of the mean to t^x, x<2. All the observations of anomalous super-diffusion with which I am familiar [e.g. *Bradley*, 2017; *Phillips et al.*, 2013] show a variance scaling of t^x with $1 < x < 2$. The paper needs more discussion of how these predictions are consistent with previous theoretical work and observations of tracer dispersion.

A secondary concern is the connection of the model to the classical advection diffusion equation.

First, it is unsurprising that the model is equivalent to the ADE because the assumptions in the model do not allow for anomalous dispersion that arises from heavy-tailed step lengths or resting times. For example, the assumption of steady and uniform transport without storage in the bed or bars pre-supposes this outcome and limits the model’s applicability to real rivers.

Second, I don’t see how the advection velocity U and the diffusion coefficient D are related to alpha. Alpha is the ratio of mobile concentration to stationary concentration and it is dimensionless. It’s not clear how the authors get from a dimensionless quantity to U with dimensions of L/T and D with L^2/T.

My final concern is the use of the mean travel distance as a proxy for transport time as a way to account for the intermittency of transport. While this somehow reduces the variance scaling during the entrainment regime to what *Weeks and Swinney* [1998] define as the allowable range, equating travel distance with time implies a steady tracer virtual velocity and therefore a linear increase of mean tracer position with time. This appears to be inconsistent with the predicted increase in mean position with time (eq. 37) during the entrainment regime. Further discussion of this apparent inconsistency and justification of travel distance as proxy for time is warranted.

Specific Comments

The author states on page 2, line 14 that at long times, tracer dispersion is normal, with linearly increasing variance as if it were settled science. In my opinion, this is not a settled issue. Recently published work [*Bradley*] presents evidence of anomalous super-diffusion over 9 years of observation.

Page 4, line 11. The connection between surface grain size concentration and grain size needs clarification. This seems to imply exactly 1 tracer per unit area, an unrealistic assumption.

Page 5, line 15. Phi = 0 is not the same as phi is null. I assume that the authors meant "nil." Null means undefined and not equal to anything. You can never state x = null.

Page 5, line 28-29. The statement that tracers rarely move during the first flood is incorrect and is inconsistent with the statement about tracer installation on the bed surface at the beginning of this paragraph. Nearly all tracer studies neglect the first episode of transport precisely because tracers placed on the bed surface are unnaturally mobile until they are thoroughly mixed into the bed. Similarly, the statement on line 33 that only a small proportion of tracers move during the entrainment regime needs justification. See *Bradley and Tucker* [2012] for example. In the first flood of that study, the proportion of mobile tracers was higher than in a subsequent, nearly identical flood.

Page 7, line 24. It is misleading to say that most tracer studies are limited to a few hundred particles. *Bradley and Tucker* [2012] used nearly 900 tracers.

Page 7. Line 25. The only way that statement that tracer concentration rapidly decreases to immeasurable levels could be correct is if no tracers were recovered. By definition, the recovery of even a single tracer particle is a measurable concentration.

Technical Corrections

The word "pebbles" is misspelled as "peebles" in several locations (e.g. page 7, line 24)

Page 2, Line 10 should read "propagate downstream"

Page 2, Line 11: The [*Bradley and Tucker*, 2012] reference is incorrectly cited as Nathan Bradley and Tucker.

Page 9, line 22, should read "expand equations" and the reference to equation 31 is probably intended to be eq. 30.

Page 15, line 20. This reference is incorrectly formatted.

References

Bradley, D. N. (2017), Direct observation of heavy-tailed storage times of bedload tracer particles causing anomalous super-diffusion, Geophysical Research Letters, doi: 10.1002/2017GL075045.

Bradley, D. N., and G. E. Tucker (2012), Measuring gravel transport and dispersion in a mountain river using passive radio tracers, Earth Surface Processes and Landforms, 37(10), 1034-1045, doi: 10.1002/esp.3223.

Nikora, V., H. Habersack, T. Huber, and I. McEwan (2002), On bed particle diffusion in gravel bed flows under weak bed load transport, Water Resour. Res., 38(6), 17.11-19.

Phillips, C. B., R. L. Martin, and D. J. Jerolmack (2013), Impulse framework for unsteady flows reveals superdiffusive bed load transport, Geophysical Research Letters, 40(7), 1328-1333, doi: 10.1002/grl.50323.

Weeks, E., and H. Swinney (1998), Anomalous diffusion resulting from strongly asymmetric random walks, Physical Review E, 57(5), 4915-4920.

Zhang, Y., M. M. Meerschaert, and A. I. Packman (2012), Linking fluvial bed sediment transport across scales, Geophysical Research Letters, 39(20).