Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., referee comment RC1
https://doi.org/10.5194/esurf-2022-50-RC1, 2022

Comment on esurf-2022-50

Anonymous Referee #1

Referee comment on "Phenomenological model of suspended sediment transport in a small catchment" by Amande Roque-Bernard et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2022-50-RC1, 2022

Review of "Phenomenological model of suspended sediment transport in a small tropical catchment" by Roque-Bernard et al. for *Earth Surface Dynamics*

This study provides an elegant semi-empirical model based on sediment entrainment and settling to explain certain suspended-sediment hysteresis loops in rivers. One of the ways this study is most useful is in providing a null model for understanding sediment hysteresis. It also generates testable predictions about the dominant grain size during floods and the role of sediment armoring. This is a clever study which I believe will be a significant contribution to the study of sediment hysteresis loops in rivers and fluvial sediment transport more generally.

My only major comment on the paper is that I felt that it needed a more thorough discussion. The way the paper is currently structured, small bits of discussion are sprinkled throughout and in particular the "conclusion" section, but a more thorough discussion of how this work fits within the broader context of the scientific field is warranted. Some questions I believe would be pertinent in a broader discussion include:

- (How) does this work alter the interpretations of previous studies? A better sense of how this work fits within the scientific literature would be useful.
- What are other mechanisms for generating counterclockwise hysteresis loops? Would this be reflected in a poor model fit, or might the model fit the loop well but for the wrong reasons? How might one check for the latter?
- What are some ways that this model could be tested? E.g. grain size measurements, bed characterization, etc.
- Are there certain types of river systems where this model can be expected to perform poorly?
- How might this model be used in the future to improve studies of hysteresis and better understand sediment transport dynamics? In other words, an explanation of why/how this is a significant scientific contribution.

- Could this model be used to improve predictions of sediment yield, e.g. by going beyond a simple sediment rating curve?
- Why do best-fit parameters (such as grain size) change flood to flood? Is the amount of change between sequential floods predicted by the model realistic? Given L152-156, do these changes reflect basin-wide changes? What are some mechanisms that could be driving this change?

Comments:

Would it be possible to show either on existing plots or as a new plot how this model performs compared to regressing the concentration as a function of discharge, i.e. a simple sediment rating curve? Would be useful to compare the two in the time series plots to highlight the improvement provided by this work.

All figures: I find the upside down hydrographs a bit hard to read. Not sure if this was to help show the offset between peaks (which is still hard to see), but perhaps a better way to do that is to add a vertical dashed line corresponding to the peak discharge.

L119 – Should the denominator be $h_{max}-h_{min}$ (and similarly for c)? Otherwise L123 is in error.

L151 – I think this is a fine assumption to make but worth discussing more. If there is in reality a vertical concentration gradient, then essentially the parameter inversion will overestimate the settling velocity by a factor equal to the ratio of near-bed to flux-averaged SSC, correct? Grams and Wilcock (2007) is relevant in discussing vertical concentration profiles in rivers with macro-roughness.

Table 1: Could a column for grain size (inferred from V_s) be added?

Table 1: should be Fig. 5, not Fig. 4.

L256: "In this dilute regime, sediments settle at a velocity equal to the settling velocity of a single particle" – I'm not sure that I understand this sentence. I agree with interparticle interactions being negligible, but it does not follow that sediment settling can be represented by a single settling velocity. E.g., considering the case of particles settling out of suspension without re-entrainment, the concentration of each settling-velocity class of particle declines exponentially with a rate constant proportional to the settling velocity, but the decline in total sediment concentration (i.e. all settling velocity classes summed) is not itself exponential and therefore cannot be represented with a single settling velocity.

L283 – typo, “not” is missing

L283 – Worth mentioning that this is not an abrupt transition: between 5 and 10 microns there is a clear decline in SSC, it’s just slower.

L284: “which do not settle on the bed” – clarify that this is an interpretation based on the data. There is a growing body of work suggesting that this conceptualization of washload is perhaps over-simplified (e.g. Ren and Packman 2007, Dallman et al. 2020). Also, does the wash load pick up at the same threshold water level as the rest of the sediment?

L287-288: I think this is overstated; it shows that the inferred grain sizes are within the range observed in the field but not necessarily that the model can be used to accurately infer a characteristic size of suspended sediment. That said, the possibility of using the model to infer grain size would be an excellent discussion point.

A broader discussion of how the model represents a grain size distribution as a single characteristic grain size and why this seems to work would be warranted. Where does “washload” fit in – does the washload component need to be subtracted out, or does the model work well despite it? What kinds of grain size distributions might “break” the model? Does flocculation matter (Lamb et al. 2020)?

L362-363: In other words, supply limitation? This sentence would be worth expanding into a short paragraph of discussion.

References:

Dallmann, J., Phillips, C. B., Teitelbaum, Y., Sund, N., Schumer, R., Arnon, S., & Packman, A. I. (2020). Impacts of suspended clay particle deposition on sand-bed morphodynamics. *Water Resources Research*, 56, e2019WR027010. https://doi.org/10.1029/2019WR027010

Grams, P. E., and Wilcock, P. R. (2007), Equilibrium entrainment of fine sediment over a coarse immobile bed, *Water Resour. Res.*, 43, W10420, doi:10.1029/2006WR005129.

Lamb, M. P., de Leeuw, J., Fischer, W. W., Moodie, A. J., Venditti, J. G., Nittrouer, J. A., Haught, D., & Parker, G. (2020). Mud in rivers transported as flocculated and suspended bed material. *Nature Geoscience*, *13*(8), 566–570. https://doi.org/10.1038/s41561-020-0602-5

Ren, J., & Packman, A. I. (2007). Changes in fine sediment size distributions due to interactions with streambed sediments. *Sedimentary Geology*, *202*(3), 529–537. https://doi.org/10.1016/j.sedgeo.2007.03.021