Reviewed Manuscript: Effect of grain-sorting waves on alternate bar dynamics: Implications of the breakdown of the hydrograph boundary layer

Authors: Soichi Tanabe, Toshiki Iwasaki

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Referee: Chenge An (anchenge08@163.com)

It has been known that with cycled hydrographs, the alluvial river can reach a dynamic equilibrium under which only a limited distance from the inlet is influenced by the varying inflow discharge. This region is called a hydrograph boundary layer (HBL), and can be break down by advective bedload sheets when sediment is poorly sorted. However, previous studies only apply a 1D analysis, and cannot consider the alternate bars that are commonly observed in natural river. In this study, the authors extend previous studies to a 2D framework, and can therefore study the interaction of bedload sheets and alternate bars with the breakdown of HBL. That said, I regard this manuscript as a big progress on the knowledge of the HBL as well as the dynamic equilibrium of alluvial rivers. The topic is suitable for Esurf. Generally, the manuscript is well organized and easy to read. However, I still find a few issues that need to be addressed, with the major issue being about the governing equation. I list my detailed comments below.

<u>Main comments:</u>

1. Equation (7) seems to be incorrect to me. Following is the equation from Chapter 4 of Parker's e-book (Parker, 2004). A major difference between your Eq. (7) and the following equation from Parker's e-book is that, Eq. (7) does not have f_{li} which represent the grain size distribution of the sediment exchanging between the active layer and the substrate material. Besides, I am also confused with the L167-168 of Page 6. Doesn't F_{ai} denote the grain size distribution of the active layer by definition?

$$(1-\lambda_p)\left\{ f_{li}\left(\frac{\partial}{\partial t}(\eta - L_a) + \sigma \right) + \frac{\partial}{\partial t}(F_i L_a) \right\} = -\vec{\nabla} \cdot \vec{q}_{ti}$$

Parker, G. (2004). *1D sediment transport morphodynamics with applications to rivers and turbidity currents.* Retrieved from http://hydrolab.illinois.edu/people/parkerg//morphodynamics_e-book.htm

<u>Specific comments:</u>

1. L20-24 P1: In the last two sentences of the abstract, you stated that:

"…upstream non-equilibrium sediment supply condition in poorly sorted sediment has a non-negligible role in downstream alternate bar dynamics **EVEN FAR FROM** the sediment point. However, this effect becomes negligible in the **FURTHER DOWNSTREAM REACHES**…". The terms "even far from" and "further downstream" are rather ambiguous to me.

2. In L174 of P6 you said that the model applied an active layer, a deposition layer, and a transition layer. In L175 of P6 you said that there are several deposition layers. Whether you applied one or multiple deposition layers? Please keep consistent in the text.

3. L200-201 P7: How do you calculate the flow velocity near the riverbed? What values do you specify for μ_s and μ_k?

4. Fig. 2: Does the figure show water depth and bed elevation (as written in the caption), or the change in water depth and bed elevation from the initial bed to the end of the simulation (as written in L230 P8)?

5. L283-284 P12: If I understand correctly, do you apply a longer computational length for the wide channel cases than the narrow channel cases? The wide channel has 600 cells in the longitudinal direction while the narrow channel has 200 cells.

6. Fig. 7: Is this longitudinal riverbed averaged over the cross section?

7. Caption of Fig. 8: What do you mean by "upper low" and "lower low"?

8. Around L330 P15: In Fig. 8 you use the terms "upstream reach" and "downstream reach", but in the text you also use the term "middle reach". I think it would be good to keep consistent in the text.

9. L343 P17: A verb seems to be missing between "which" and "a".

10. L355 P18: How do you determine whether bedload sheets exist of dissipate from the plot? To me, the sediment transport rate still shows spatial variation at 0.5 T_h in the grey area.

11. L369 P19: Why does the disappearance of bedload sheets leads to a counterclockwise hysteresis?

12. L392 P19: What distribution? Grain size distribution?

13. Fig. 13: All the three locations shown in the figure are beyond HBL. I am quite interested about the hysteresis pattern within the HBL.

14. L414-422 P21: If I understand correctly, previous papers cited here studied transient process due to the long scale change in sediment supply, whereas your research focuses on the dynamic equilibrium under time varying cyclic sediment supply.

15. L452-454 P22: Another mechanism recently found to be important for magic sand effect is the change of flow regime in the viscous sublayer. The authors might be interested to read the following two papers:

Parker G., An C., Lamb M. P., Garcia M. H., Dingle E. H., Venditti J. G. 2024. Dimensionless argument: a narrow grain size range near 2 mm plays a special role in river sediment transport and morphodynamics. Earth Surface Dynamics, 12, 367–380.

Hassan M. A., Parker G., Hassan Y., An C., Fu X., Venditti J. G. 2024. The roles of geometry and viscosity in the mobilization of coarse sediment by finer sediment. Proceedings of the National Academy of Sciences of the United States of America, 121(38): e2409436121.

16. L483-484 P23: Do you mean that a narrow grain size distribution causes the migration of bedload sheets?