Review
Morphodynamics of river bed variation with variable bedload step length
Earth surface dynamics

by A. Pelosi and G. Parker

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This paper compares a non-local bedload transport model to a classical model where the sediment flux is dictated by the local flow conditions. The non-local model is then associated with simplified shallow-water equations to model the evolution of a sediment bed in one dimension. The resulting set of equations is solved numerically for different values of the parameter controlling the non-locality.

The paper is clearly written, and its subject deserves interest. The results presented are sound, at least within the theoretical framework proposed by the authors. I am therefore supportive of publication.

However, I believe the manuscript could still be improved, and although none of the points below should be a basis for rejection, I hope that the authors will address them in a new version.

I am concerned mainly with relating better the theoretical analysis proposed here to the physics of bedload transport.

1. Equation (3) introduces non-locality into the model. Yet it is barely justified in the paper, although it has many physical implications.
   Assuming that deposition results from this upstream integral is equivalent to assuming that the trajectory of the transported particles is entirely determined by the conditions of their ejection from the bed. This is reasonable if their trajectory is purely ballistic. It is likely to be true in air, probably less so in water, where the flow conditions influence the particle during its flight. It is certainly wrong in viscous flows, and when the particle travels over very long distances.
   This should probably be discussed briefly in the paper.

2. The first point brings us to this: other “non-local” models have been developed, which in a sense represent the end-member opposite to the present model. Namely, the “erosion-deposion” model assumes that the flow sets particles into motion according to the local shear stress, and deposits them in proportion of the density of moving particles [2, 4]. In other words, it assumes that a particle forgets about the initial conditions quickly after it is set into motion.
   In the erosion-deposition model, non-locality is embedded into a physical variable which keeps the memory of past events: the concentration of travelling particles. The exchange between the bed and the reservoir of moving particles introduces a typical length l_{sat}, often called the “saturation length” [1, 3].
   In a way very similar to the model presented here, bedload is in phase with the flow conditions if the ratio of saturation length to domain length l_{sat}/L_d vanishes. When this is not the case, however, the Exner equation and the bedload transport equation must be solved jointly.
   I believe the erosion-deposion model is a better candidate for comparison with the authors's model than the naive model in which bedload adjusts instantly to the local flow conditions.

3. The condition in which the comparison is made might be mathematically simple, but they are rather unrealistic. I cannot imagine a laboratory experiment where condition (23) would be satisfied at the inlet. In my view, the authors would significantly improve the paper if they could provide theoretical results for a realistic experimental configuration, which would separate unambiguously the non-local model proposed by the authors from prior models.

Minor comments

- Line 28, “the pdf of step length”
- To me, figures 2-8 show too many curves together. They would be clearer with fewer time steps. In figures 2, 5 and 8, showing the difference between the data and the final state, instead of showing directly the data, might further improve clarity.

References

[1] François Charru. Selection of the ripple length on a granular bed sheared by a liquid flow. *Physics of Fluids*, 18:121508, 2006.

[2] François Charru, H Mouilleron, and Olivier Eiff. Erosion and deposition of particles on a bed sheared by a viscous flow. *Journal of Fluid Mechanics*, 519:55–80, 2004.

[3] Philippe Claudin, François Charru, Bruno Andreotti, et al. Transport relaxation time and length scales in turbulent suspensions. *Journal of Fluid Mechanics*, 671:491–506, 2011.

[4] E Lajeunesse, L Malverti, and F Charru. Bed load transport in turbulent flow at the grain scale: Experiments and modeling. *Journal of Geophysical Research: Earth Surface (2003–2012)*, 115(F4), 2010.