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Interactive comment

Interactive comment on "Transport-limited fluvial erosion – simple formulation and efficient numerical treatment" *by* Stefan Hergarten

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Dear Xiaoping Yuan,

thanks for your constructive and encouraging comments! Although I have to argue against some of them, they will be very helpful for the revision.

First, however, I would like to point out that we apparently use slightly different terminologies concerning detachment-limited and transport-limited erosion. In my manuscript, I refer to the classical concept with detachment-limited and transport-limited erosion as end members that do, however, not occur in nature in this strict form. Anything in between would be called mixed channels then. In turn, you rather start from the approach suggested by Davy & Lague (2009) that is the basis of your

2019 paper. This approach already uses a quite specific (but probably very good) concept for the transition between the two end members, and then you distinguish the two regimes by a threshold parameter value (sediment deposition parameter $G = 0.4$). So you classify each scenario either as detachment-limited or transport-limited, while both are only the end members in my manuscript. The obviously led to some confusion.

As a main point of your review, you mention the difference in transient behavior between the detachment-limited and transport-limited models. “However, the author needs to show several transient-state comparisons between these two models before reaching steady state, and may test the sediment flux out of the domain to explore the differences between these two models (e.g., Armitage et al., 2018, ESurf). I have the feeling that they are different even they have the same final landscape.” Yes, of course! Both end members have not much in common concerning their transient behavior. It is a second-order diffusion equation vs. a first-order advection equation. Transport-limited erosion in principle even supports no distinct transient knickpoints. I thought the difference in transient behavior was clear, and I just wanted to point out with the numerical example that they also differ under non-uniform steady-state conditions. The key point of Sect. 2 is just that the old findings of Hack (1957) could be alternatively be interpreted as transport-limited erosion in a uniform steady state.

Your second point refers to the suitability of the transport-limited model under inhomogeneous or under transient conditions. “The proposed transport-limit model, assumed a uniform erosion, is unlikely suitable to study a non-steady-state (transient) landscape evolution or a non-uniform uplift scenario. Please argue against me if I am wrong.” Of course, the transport-limited end member is not suitable in bedrock mountain streams, and the detachment-limited end member not suitable for large parts of Earth’s surface outside the mountain belts. We can conclude that we need combined models such as the one proposed by Davy & Lague (2009) in order to capture the majority of the rivers in the real world, but nothing more.

The third point addressing the convergence of your iterative scheme is just due to the different terminology. “The author mentioned that Yuan et al. (2019, JGR)’s erosion-deposition model/method breaks down if the model approaches the transport-limited regime, which is not true.” I referred to the transport-limited regime as an end member and not to $G > 1$. This end member is $G \to \infty$. The rate of convergence decreases with increasing G and convergence indeed breaks down if we approach $G \to \infty$ according to my experience with the model. Mathematically, it is a singularly disturbed problem where the type of differential equation changes from hyperbolic to parabolic, and solving a parabolic equation iteratively with a scheme for a hyperbolic equation does not work well. This can of course be clarified in the revised version, but even the arguments in your own paper point towards avoiding too large values of G.

The specific point at the end of your reviews can be easily addressed in the revised version. Thanks for finding some mistakes!

Best regards,
Stefan Hergarten

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