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

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General comments

This study proposes a simple formulation of transport-limited fluvial erosion. In particular, a new numerical scheme for treating transport-limited erosion with an implicit discretization in time was presented. It is also of linear time complexity (O(n)), similar to the scheme to solve the detachment-limited erosion model (Braun and Willett, 2013, Geomorphology). The scheme does not require iteration and is numberically stable for large time increments. This work also uses two landscape evolution simulations subjected to the uniform uplift and non-uniform uplift scenarios to show the model behaviours between the proposed transport-limited model and detachment-limited model.

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Interestingly, the scheme can also be applied to the model of fluvial erosion and sediment deposition proposed by Davy and Lague (2019, JGR-ES). The direct scheme is at least 30% faster than the iterative scheme proposed by Yuan et al. (2019, JGR-ES), and even faster if the iterative scheme needs >=3 iterations. From these new aspects, the manuscript is suitable for publishing in Earth Surface Dynamics. However, the manuscript has some shortcomings on methods that need to be addressed and which may require minor-substantial revision.

Assumption in the transport-limit erosion: The author has an assumption to obtain the sediment flux in equations (10) and (11), which are important for the later derivation of implicit and O(n) scheme of the transport-limit erosion model. Erosion rate KAmSn in equation (6) is the rate at the outlet of drainage area A. The equation (11) assumes that the sediment flux of the drainage area equals to KAmSn × A = KAm+1Sn, which implies that the erosion rate is same everywhere in the drainage area A, which is true at the steady state subjected to a uniform uplift rate. Because at steady state, erosion everywhere balances rock uplift rate such that under conditions of spatially uniform uplift the total sediment flux at a given point along a river equals the product of upstream drainage area (A) and the rock uplift rate or the uniform erosion rate. This has been proved by the author using the uniform uplift rate (Figure 1, left panel) that transport-limited model produces the same, final steady-state landscape as the detachment-limited model. 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.

Because of the above assumption (uniform erosion rate), in the case of non-uniform uplift rate (and thus non-uniform erosion rate at steady state), the transported-limited model produces different final landscape compared to the detachment-limited model (Figure 1, middle and right panels). 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.

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. Yuan et al. (2019) mentioned in their article that "…, the iterative method is proven to converge unconditionally at least when G $\leq$ 1, but we show experimentally that this method can also converge even if this condition is not satisfied", e.g., at G=10 (their Figure 3a), which is in transport-limited regime for G>1, a criteria estimated from various experimental and natural landscapes (Guerit et al., 2019, Geology).

I hope that these comments are helpful for the revision.

Xiaoping Yuan

Common and specific comments (by line)

L5: "as the stream-power law is" change to "of the stream-power law".

L7: "as the established implicit solver for transport-limited erosion", should be detachment-limited erosion?

L23 and L25: "sediment flux density" change to "sediment flux per unit width".

L67: A reference is needed for the upstream propagating velocity of erosion.

L72: "but despite increasing computing capacities still important point" change to "because increasing computing capacities is an important aspect in the landscape evolution modelling".

L78: Two 'n' in O(n) and Sˆn are confusing. Suggest to use 'O(N)' and N is the number of nodes discretizing the landscape. Suggest to change throughout the manuscript.

L134: Not easy to understand how to derive this equation (12) based on the above equations. Before the sentence, please write "Combine equations (1) and (12)", ….

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L288-L291: It is better to list this computational time in Table 1.

References:

Armitage, J.J., Whittaker, A.C., Zakari, M. and Campforts, B., 2018. Numerical modelling of landscape and sediment flux response to precipitation rate change. Earth Surface Dynamics, 6(1), p.77.

Guerit, L., Yuan, X.P., Carretier, S., Bonnet, S., Rohais, S., Braun, J. and Rouby, D., 2019. Fluvial landscape evolution controlled by the sediment deposition coefficient: Estimation from experimental and natural landscapes. Geology, 47(9), 853-856.

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