Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., author comment AC2
https://doi.org/10.5194/esurf-2021-35-AC2, 2021

Reply on RC2

Philippe Steer

Author comment on "Short communication: Analytical models for 2D landscape evolution" by Philippe Steer, Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-35-AC2, 2021

Reply to review by Sébastien Carretier (Reviewer comments are in bold)

Philippe Steer presents a numerical solution scheme for the stream power incision model (SPIM) based on analytical solutions. This solution allows to reduce the computation time, and to preserve the shape of the knick-points, which are the two main advantages of this new model called Salève. The numerical solution proposed here does indeed offer perspectives for the inversion of topographies that would be demonstrably controlled by SPIM. Despite these interesting perspectives, I have several questions and remarks whose consideration could improve the clarity of this manuscript.

I am very grateful to Sébastien Carretier for his comments.

The first one concerns the evolution of the drainage network. In the simplest scenario with constant uplift, it is indicated that the rivers develop according to the same network as in the initial stage (p5 line3). I confess that I do not understand this, neither in the text nor in figure 1 which shows that the network varies during the iterations. It is also obvious that the network must adapt dynamically since the initial topography is noisy and without any connected network. So I probably missed something here.

I agree with Sébastien. The misunderstanding comes from the unclear explanation given in my manuscript. During the first iteration, the algorithm indeed uses the flow network of the initial iteration, as correctly pointed out by Sébastien Carretier (that is what line 3 of page 5 was meant to explain). However, the flow network is then updated during each iteration, so that the flow network at steady state is not similar to the initial flow network.

- I have clarified the explanation about the flow network in section 3 and added a figure (Fig. 2a) to explain the main stages of the algorithm.

I have the same question about the transient simulations where it is said that the horizontal reorganization of the network is instantly accompanied by a topographic adaptation. How and why does this reorganization of the drainage network in Salève take place? I think that further explanation of the procedure by which the drainage network is established at a given iteration, or a given time, is strongly required.

Indeed, compared to classical LEMs which compute erosion to update topography, Saleve directly computes a topographic state at a time t based on the current flow network. In turn, any change to the flow network, between two time-steps, will directly lead to an instantaneous change of the topography. This is already largely mentioned in the manuscript (in section 4).

The flow network is computed as in most LEMs based on the topography at the previous time step, which defines the steepest slope and the flow network. The flow network can change significantly in between successive iterations due to river capture.

- I believe the existing explanations as well as the new figure (Fig. 2b) clarify this point.

Concerning the scope of this numerical solution, it is well specified that it is limited by the value of n=1, which could be different in natural cases. It would also be good to add that this model is a pure erosional model, without deposition and therefore a pure detachment limited model. The absence of sedimentation, which controls the degree of limitation by transport or detachment (Davy and Lague, 2009), could be discussed as one of the strong limitations.

I agree, even if the detachment-limited nature of this model was already mentioned in section 2.

- I have therefore clarified these limitations in the Discussion and conclusion section. "Moreover, Salève is a purely detachment-limited model which does not consider the role of sediment transport and deposition in landscape dynamics. Only the linear SPIM with n=1 has been considered in this study, while some observations support non-linear models with greater values for n (e.g. Lague, 2014)."

The treatment of colluvium erosion is treated here using a different value of m, referring to Lague and Davy (2003), but in that paper the erosion law includes a large erosion threshold, which results in an n>1 in the SPIM, whereas the law used in the Salève uses n=1. It is therefore questionable to argue that slope erosion is taken into account by changing only m.

I agree with this comment. Indeed, I took a "shortcut" by neglecting the threshold in Lague & Davy (2003) colluvial erosion law. Using their parametrization, this threshold is of prime importance for low to intermediate value of uplift rates (up to a few cm/yr) and become less and less important for greater uplift rates.

- As the objective is to illustrate that the model can be extended to domain other than the fluvial one, I have decided to keep this part. I however now clearly mention in section 6 that the model I use is inspired by the colluvial law of Lague & Davy (2003) but does not integrate the threshold effect.

Specific comments

Page 7 line 7. Could you explain what do you mean by "non-optimality of the planar organization of the river network" ?

I mean that the flow network is not already in its steady-configuration starting from the first time-steps. This is important as once again, the only limitation in terms of time step for this analytical model, is the need to update the flow network "frequently". Otherwise, the topography can exhibit sharp height differences at the crest between successive catchments.

Page 7 line 18 "than" -> as?

Done

Page 9 line 27. Could you explain what do you mean by "slope patches"?

Slope patches is a term that was coined by Royden & Perron (2013): "A river longitudinal profile evolving according to the stream power law consists of a series of contiguous segments, or "patches," of slope." (section 5). We already refer to this explanation in section 2 of the paper.

Page 11 I suppose you specify l1, l2 and l3?

Yes, l1 and l2 are parameters that need to be specified. It is now mentioned that these are model parameters.

Page 13 line 14 Carretier et al. 2016 (not 2015)-> the same in the biblio list

Done