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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 Wolfgang,

thanks for your encouraging comments! Just about the three minor points you mentioned:

164: $S_i(t)$ is actually not used later, at least in the immediate context (Eqs. 20-25). You may, however, replace the second term in the right-hand side of Eq. 20 with $S_i(t)$.

It is in fact used exactly the way you suggest since the direct form of Eq. (20) is $Q_i(t) = KA_i^{m+1}S_i$. But this is just the intermediate step from Eq. (11) to Eq. (20). In order to proceed to Eq. (21), however, I need the form of Eq. (20) used here. So the form of Eq. (20) with S_i would be an intermediate step that might help the readers, but it cannot be used as a simplification.

What about upstream boundary conditions? I wrote the model in MATLAB as 1-D model and the uppermost node remains fixed (if no uplift is applied). I may have wrongly written the code, though.

The “natural” upstream boundary condition is no influx of sediment (homogeneous von-Neumann), which is implicitly defined by the condition that the direction of the sediment flux follows the flow direction of water. So grid cells that are not supplied with water from other cells also do not receive sediments. In the equations, this means that all sums over the donors (all $\sum_j$ terms) are empty. Then $\alpha_i = s_i = A_i$ and $\beta_i = s_i U_i = A_i U_i$ (Eq. 18),

$$Q_i(t) = \frac{A_i\left(H_i(t_0) - H_b(t)\right) + A_i U_i \delta t}{A_i \frac{d_i}{K A_i^{m+1}} + \delta t}$$

(Eq. 23), and then into Eq. (21):

$$H_i(t) = H_b(t) + \frac{H_i(t_0) - H_b(t) + U_i \delta t}{1 + \delta t \frac{K A_i^m}{d_i}}.$$

This expression is even the same as the fully implicit step for the detachment-limited model, and according the formulation in Sect. 2 detachment-limited erosion and transport-limited erosion must indeed be the same at those sites without donors. So I guess that it might be just a problem in your 1D implementation.

In the end, the model is not fully 2D, as the scheme is solved in 1D on a network. This may lead to weird aggradational forms (linear ridges on flat topography) if too long time steps are applied. Can you comment on this? What is an appropriate time step length?

Yes, this problem affects all models where the computation of the flow pattern is separated from the change in topography. Changes in topography are then partly computed with the wrong flow pattern at large time step lengths. In the detachment-limited model, it results in steep walls at drainage divides, and in the transport-limited model it generates these weird aggradational ridges. And as flow direction changes then, eroding them may even take much longer than generating them. However, it depends strongly on the considered situation. If a large river suddenly enters a completely flat area, it is definitely a problem, and it might even be necessary to use an adaptive scheme that also rejects time steps that resulted in a too large number of changes in flow direction. In turn, I am actually running large simulations of permanently changing rivers in a foreland with zero uplift, and there it seems not be a problem at all. So it is definitely an aspect that has to be taken into account, but I am actually not able to specify how strong it is under which conditions. Nevertheless it should be worth some words in the discussion part.

Best regards,
Stefan

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