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Interactive comment on "Short communication: Rivers as lines within the landscape" *by* John J. Armitage

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This short communication presents landscape evolution simulations conducted with different flow routing algorithms. It compares and contrasts the simulation results and finds that a distributed flow routing algorithm produces resolution-independent topography and sediment flux evolution, and that it better resolves a natural example. The short communication also describes a theoretical argument in support of the use of node-to-node rather than cell-to-cell routing scheme.

Overall, the motivation behind this work is justified. The use of Landscape Evolution Models (LEMs) is growing, and the community needs tools for evaluating the deficiencies and advantages of different numerical implementations. The approach of comparing various implementations and testing their influence on resolution dependency is also promising, since generally, modelers would like to reduce computation time, and one way to achieve it is by decreasing the model resolution.

The manuscript is well-written.

Despite these advantages, I identify several, possibly significant shortcomings that relate to the three major themes of the manuscript: Representing rivers as lines, grid resolution dependency, and topographic unsteadiness.

First, given the fixed cell size, the differences between the cell-to-cell steepest descent routing algorithms and the node- to-node steepest descent routing algorithms might not be accurately presented. Isn't it possible to cast the cell-to-cell as a node-to-node over the complementary hexagonal graph, whose edges connect the centers of the triangles of the original grid? In this case, the differences between the two implementations lie in the grid spacing, l vs. l_s, and in the possibility to route water in 6 directions over the triangular grid with respect to 3 directions in the complementary hexagonal grid. If the number of routing directions is the critical issue, then the difference between the simulations is not the outcome of river representation (i.e., rivers with finite width with respect to rivers as lines), but of the grid shape. Specifically, using cell-to-cell hexagonal grid should be similar to node-to-node triangular grid.

If this claim is true, then the comparison between these two implementations could be invalid, and as a consequence, it cannot be used to test the theoretical claim for the advantage of representing rivers as lines, which is central to the manuscript.

On a side note, other LEMs such as CASCADE and DAC use line representation of rivers as well.

Another issue is the observed unsteadiness of the topography only with the distributed flow routing algorithm. Goren et al., 2014 (Earth Surf. Process. Landforms) showed that a similar unsteadiness emerges in the DAC LEM that uses the steepest descent algorithm, but importantly, allows for the drainage area and the discharge in each grid node to vary continuously though time due to shifting water divides. The possibility for a continuous change in the drainage area leads to the emergence of the drainage area feedback, by which an increase in the drainage area, leads to faster channel downcutting that propagates downstream and then upstream back to the original node, promoting further drainage area increase. Since the downcutting signal propagates throughout all the tributaries, it affects all the neighboring basins, leading to ongoing “ringing” in the landscape elevation and erosion rate, namely, to unsteadiness. Goren et al., 2014 further developed the argument that this behavior is similar to the one observed in the distributed flow routing algorithm of Pelletier 2004, whereby small changes in elevation affect the local discharge (equivalent to area), which leads to further changes in elevation. This means that distributed flow routing is just one possible implementation for representing the ‘area feedback’ that is responsible for unsteadiness in numerical, experimental, and possibly natural landscapes.

A third issue is the observation of resolution independency with the distributed flow algorithm. This, as well, has been documented in Goren et al. 2014 (e.g., fig 10) for the DAC LEM that implements the steepest descent algorithm. It is therefore possible that the resolution independency is the outcome of the LEM ability to represent the area feedback, while the distributed flow algorithm is just one possible implementation for it.

Finally, the use of a diffusion equation (eq. 1) rather than an advection equation to represent incision along fluvial channels at the scale of a mountain range needs to be justified, since such an equation cannot produce knickpoints, which are a dominant feature in mountainous rivers.

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