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comment

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

J. Armitage

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I would like to thank Andrew Wickert for taking the time to review my submission. After much consideration I think Andrew Wickerts counter-hypothesis that " the most critical piece (and perhaps only critical piece) to grid-scale-independence is multiple-direction flow routing because this parameterizes sub-grid topography and drainage systems" is correct.

I have run the model using a distributed cell-to-cell algorithm. I distribute flow across the edges of the triangular elements weighting the flow by the slope. In this case there are typically two down-slope directions. In this case the time evolution of the sediment flux out of the model remains resolution dependent (see attached plot). However, the

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statistics of the wavelength of valleys remains much more similar when compared to the steepest slope of descent. I had not "dreaded" the suggestion of making this comparison. I was already aware that the cell-to-cell distributed algorithm did not improve the sediment flux against time comparison, but had overlooked the valley wavelength.

Overall these new model runs would put weight to the inference that it is the choice to distribute flow down multiple routes that removes the resolution dependence within my model. By treating surface flow as lines I achieve more flow directions, and this ultimately removes the resolution dependence. Modifying the manuscript to would be a significant undertaking, as some of the rational for the model will have to be changed. This I am willing to do if the editor agrees.

Below I respond to the general comments of Andrew Wickert:

General comment 1) *The idea that rivers can be approximated as lines is only appropriate for landscapes where the significant lateral scales are $>>$ river widths . . .*

I feel we come at the question of scale from very different angles. In the geodynamic community, from where I come, we are interested in understanding the feedback between landscape evolution, tectonics and mantle flow. In geodynamic models a single cell is typically tens of kilometers in size, but of course if adaptive meshing is used can become a kilometer or less. If surface processes are applied to the surface of such a model, that is looking at the evolution of continent, then the routing of surface flow needs to approximated. In this case the width of that flow routing is either a cell wide or more. However, at the scale of a continent, most rivers are less than 1 km wide. Therefore they operate on a sub-grid scale. This motivated the choice to route flow along the edges.

From reading the study "Global extent of rivers and streams" by Allen & Pavelsky, Science, (2018), I see that river width varies from 30 m to > 5 km. It would be interesting if this dataset can be used to get statistics on the distribution of river width globally to understand if the wide rivers are significant or outliers. From their validation exercise

in their Fig. 2 it looks like river width clusters at between 30 and 300 m. At this width I think most numerical models would need to find a method to capture a river width that is narrower than a single cell.

However, I have started to stray into dangerous territory as apparently "flow routing and river width are two processes that are about as separate as any become in Earth-surface processes". My understanding is that water flows over the surface of the Earth predominantly along rivers. In my LEM I want to capture the flow of water across the surface of the Earth. Do I not then need to approximate the river network? Which subsequently becomes difficult if most of it is narrower than a cell within my model domain.

General comment 2) *The appropriateness of the governing equations:* The governing equations for the landscape model are of course heuristic, and are based in the work of Smith & Bretherton (1972). They are transport-limited and therefore assume a constant supply of sediment. In a previous study (Armitage et al., Esurf, 2018) I explored how well this equation represents reality, so I chose not to dwell on that point here.

General comment 3) *Is it not multiple-flow-direction routing that creates resolution in-dependence?* Yes. It probably is. I think that this result is still novel, and would like to rework this manuscript to discus this important point. As responding in particular to this last comment would require significant rewriting, which is dependent on the decision of the editor I do not wish to respond to the all the subsequent minor comments.

Interactive comment on Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2018-50, 2018.
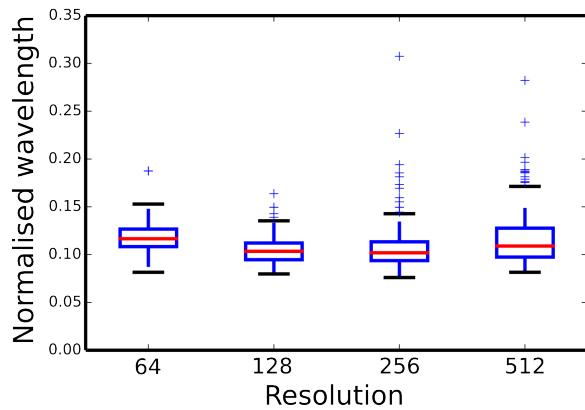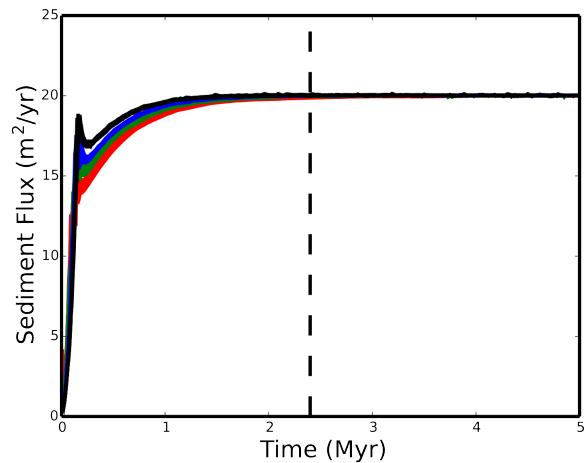
Fig. 1. Plot of sediment flux against time for a cell-to-cell distributed flow routing algorithm, and below the valley to valley wavelength.