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Hydrology and Earth System Sciences Discussions

Interactive comment on "Technical Note: Automatic river network generation for a physically-based river catchment model" *by* S. J. Birkinshaw

Anonymous Referee #2

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SUMMARY AND RECOMMENDATION:

The problem presented in the technical note is trivial to solve, as described below. The comparatively involved solution that is presented in the technical note is also flawed, as reviewed below. Therefore, I do not recommend publication.

COMMENTS:

1. A TRIVIAL PROBLEM

The problem presented is that of automatically generating a river channel network from

a DEM (digital elevation model), where the channels run along the edges of grid cells. I will call the desired networks "edge networks".

Previously published algorithms have not restricted channels to edges. Instead, algorithms have either allowed linear channels to run freely across the grid cell surface (Lea, 1992; Costa-Cabral and Burges, 1994) or, in the overwhelming majority of cases, they have simply identified those grid cells within which the channels run. I will call these "grid networks". The results of Lea and Cabral/Burges algorithms are also presented as grid networks, even though calculations are based on pathways that are not grid-bound.

Given a "grid network", it is trivial to obtain an "edge network". Let us imagine, strictly for computational purposes, that the grid network is a river. This "river" is as wide as a grid box at most locations, but here and there it squeezes through a point (a grid corner). If we can indeed visualize a grid network as a river, then we can borrow the terms "right bank" and "left bank" to refer to the two lines that delimite this river. These are polygonal lines composed of grid box edges.

Very well, then: What happens if we take a marker and trace the "right bank" of the grid network? Voila, we have an "edge network". If instead of the "right bank" we trace the "left bank" we obtain an "edge network" which is only slightly different from the first. These two edge networks never part from eachother by more than a grid cell's width.

In either case (right bank or left bank), the distance between an edge network thus obtained from the original grid network is the minimum possible distance given the definition of edge network.

In terms of algorithm to convert from a "grid network" to the desired "edge network":

Let's say we go for a "right bank" edge network (for example, though we can equally pick a "left bank" edge network).

a) Assuming each cell has been assigned one of 8 directions, and we have the matrix of flow directions. For each grid cell with a value of accumulation area larger than the pre-specified channelization threshold, we look at its flow direction. If the flow direction is to the north, then the eastern edge of that cell is added to the "edge network". If the flow direction is to the northwest (i.e., the cell discharges to its northwest neighbor), then both the eastern and norther edges of the cell are added to the "edge network". And so on.

b) Assuming that we do not have the flow directions (perhaps because the "grid network" was obtained by some algorithm which does not have just 8 directions, such as Tarboton's D_inf, e.g.). In this case, we only have the matrix of accumulated area values. Then we assume that each cell discharges into the neighbor cell with the highest value of accumulated area. This is generally not true for algorithms such as D_inf because they are not constructed that way; but nevertheless the assumption is used only to determine the general direction of flow for the purpose of finding which of the 4 grid cell edges belong to the "edge network" – and for that purpose the assumption works well.

The major point here is that any of the already published algorithms for automatic network generation can be used in conjunction with SHETRAN (and other such models) as long as the relatively trivial step of converting a grid network into an edge network is followed. The trivial step consists on tracing either the right bank or the left bank (take a pick) of every channel.

2. THE SOLUTION PRESENTED IS FLAWED

There are several flaws. First, step 3 is a serious hazard. Restricting flow directions to the four orthogonal directions along which the grid happens to be aligned, will make the results very grid dependent and subject to distortion. Distortion will occur whenever the grid is oriented unfavorably relatively to terrain aspect. Such distortion is commonly seen when DEMs are processed with 8 directions; let alone just four!

In any case, step 3 is unnecessary, as reviewer S. Grimaldi has already pointed out.

In point 5(a), there is an attempt to pick the grid cell's edge with the lowest-elevation neighbor. This attempt lasts successfully for exactly one grid cell. For one grid cell downstream, when we pick the connected corner with the highest area accumulation (5,4), we are now following the edge with the highest-elevation neighbor (the eastern neighbor, with elevation 120, rather than the western neighbor, with elevation 118). From there to the outlet we maintain this situation in which the edge picked is the higher-elevation edge.

If when above I suggested choosing between a "left bank" and a "right bank" seemed unacceptably arbitrary, well, we now find out that picking the edge at lowest elevation doesn't work at all, because the lowest elevation edges will not all connect, and we have no choice but to switch between higher-elevation and lower-elevation edges anyway.

The process of assigning accumulation area values to corner points, equal to the maximum of the four grid cells that meet at that corner (step 4) and then always connecting to the corner of highest accumulation area (step 5) will easily produce parallel channels. This is because the path of grid cells with high area accumulation (i.e., the "grid network" cells) will establish the accumulation values assigned to 2 different grid corners (sometimes three). We see such parallel channels in the area towards the bottom of Figure 2f. What we see there is two channels running west to east in parallel – in a direction defined by the grid orientation. Examining the terrain elevations (Figure 2a) we would expect to see a shorter channel connecting more directly to the outlet by zig-zagging from northwest to southeast. In any case, the example given (Figures 1 and 2) are really too small to demonstrate the widespread effect that is probably visible in much larger examples.

I do recognize that the small scale of the examples (Figures 1 and 2) was chosen for the purpose of clear illustration. However, a much larger example would, I believe, reveal the biases that result from steps 4-5.

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