Earth Surf. Dynam. Discuss.,
https://doi.org/10.5194/esurf-2019-34-AC1, 2019

ESurfD

Interactive comment

Interactive comment on "Computing water flow through complex landscapes, Part 2: Finding hierarchies in depressions and morphological segmentations" *by* Richard Barnes et al.

Richard Barnes et al.

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Received and published: 10 October 2019

I think this draft only presents the method part of this study without adequate support from real-world hydrological applications. Although in the Application section, the authors list several potential terrain analyzing processes that this new data structure can be beneficial to, there is no concrete evidence to demonstrate the improvement brought by this new data structure. The only result presented with quantified information is Table 1, which only shows the time requirement of implementing this algorithm on data sets in different sizes. To make this paper complete as an individual journal article itself, the authors need to compare the efficiency of running differ-

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ent applications (such as pit filling) without introducing this new depression hierarchy structure. Even with another paper submitted, it only focuses on 6.5 Flow Modelling, but evidence for application in section 6.1-6.4 is still missing.

We will be happy to include some time comparisons for pit filling with and without the depression hierarchy structure in the updated paper (i.e. application 6.1). However, the algorithm does considerably more work than simple pit filling: it produces a data structure that can be used to analyze and operate on nested depressions. Therefore, a direct comparison of the wall-time of the new algorithm versus simple pit filling is not really appropriate: these are separate operations for separate things. This is also true of depression carving.

We will also include a table with more information about the depression statistics (application 6.4) for the examples processed. These data are retained within the depression hierarchy and would not be available when performing simple pit filling. We will also include an example of depression filtering (6.3) to selectively remove depressions below a certain threshold, and an example of depression carving (6.2).

If it is possible, try to reconcile the 1-d topographic profiles used in Figure 1 & 2 and Figure 3 & 4 as a single dataset/profile. Illustrating the points in the context by jumping back and forth between two examples is confusing. For example, the majority of Section 3.4 Hierarchy Construction is explained with the case presented within Figure 3 and 4. Then in line 12-13 of Page 10, the authors suddenly refer to Figure 1 to illustrate some point. The thing is that the outlet key assignment is only given in Figure 3 and 4. Then the point the authors make ("As an example, in Figure 1, 5 drains into 8, but the cells that actually constitute the outlet will be labeled 2 and 6") is not that obvious to readers.

It was impractical to use the exact same topography (and hence, topology) for all four of these figures, since it was necessary to show several different possible cases in the depression tree in Figure 1. Using this full topography would have made figures 3 and 4 unwieldy. However, we will experiment with remaking figures 3 and 4 so that they represent the same topography as seen on the right-hand side of Figures 1 and 2, i.e. the depressions labelled 9-15 in the first two figures. This may make it easier for a reader to follow the changes through these four figures.

We will update the references to Figure 1 in these later parts of the text to refer to a similar case in Figure 4, so that the reader does not have to jump back as far. We hope that the point made here will be clearer to a reader when viewing Figure 4, which depicts the colours associated with each depression label.

> Figure 3(f) "an outlet of elevation 3" A specific elevation number ("3") suddenly appears without any indication in the context. If these numbers need to be maintained, please add a y-axis with labels to the subplot. Also, try to use different number formats (like with circles) to differentiate those representing the PQ popup order from those representing the spilling elevations of the outlets.

We have added elevations along the y-axis of the plots in Figures 3 and 4.

> Page 7 Line 29–30 "Figure 3h-i depicts the front of a traversal, in this case, expanding the area that is defined as OCEAN. We discuss both possibilities below." The placement of this sentence seems odd. It is not closely connected to previous statements in this paragraph, which explains cells assigned with given depression labels.

This sentence was referring to a specific case in which cells are assigned the depression label associated with the OCEAN depression. It is one of the possible cases for depression label assignment. Nonetheless, this sentence has now been changed to reflect the changed topography seen in figure 3.

> Page 8 Line 23-24 “If any entry for an outlet is already present, only the outlet of lower elevation is retained; this is important, as it allows for the realistic case of multiple spillways that exist between two depressions." This statement seems contradictory. The former part states that the value of the lowest joining cell will overwrite the value in the hash map as the outlet value. Since the value of this hash map is a single value instead of an array. How can it keep track of the multiple-spillway case the authors discuss in the later part?

We have added a sentence to the text clarifying what was meant here. To clarify here, we are referring to cases that would be common in the real world, in which two depressions meet one another at multiple cells. In other words, there is a ridge between two depressions, and each time that a cell along this ridge is processed in the depression hierarchy, it will detect that it is a potential link between the two depressions. Once a potential link has been detected, it will check to see whether an outlet has already been recorded in the hash map. If so, it will replace the recorded value only if the new cell has a lower elevation. In this way, only the true outlet, which has the lowest elevation, is recorded between these two depressions.

> Page 8 Line 24–25 “but the one-dimensional elevation profile in Figure 3 can-not depict the case of multiple outlets of different elevation." Then can you add a figure of a two-dimensional domain to clarify the multiple outlets case?

We are not sure that a figure is needed for this concept, which is a relatively small part of the overall algorithm, now that it has been further clarified. The multiple outlets case is simply any case in which depression 1 and depression 2 (for example) border one another at more than one single cell, which will often be the case. Any location at which a cell from depression 1 and depression 2 are adjacent to one another is a potential outlet. Each of these potential outlets may have a different elevation. Only the outlet with the lowest elevation is recorded.

> Page 8 Line 28 “assigned each of them a flow direction" As a byproduct, the flow directions are rarely discussed during the depression assignment process, which is understandable. The only place I saw that flow directions were mentioned is in Line 10 (P8): “Flowdir(n) is set to point to c". If I understand it correctly, in this way, the flow directions are assigned locally, which means each cell will drain to the lowest local pit following the assigned directions. This point needs to be emphasized here because they are different from the typical flow directions we have seen draining water to the ocean.

It is correct that flow directions are assigned such that each cell drains to the lowest local pit following the assigned directions. However, this method of flow direction assignment is not vastly different from other typical flow directions used in other algorithms. While there are some algorithms that always route water to the ocean, for example, those that use a least-cost path to the ocean, ‘typical’ flow direction algorithms simply assign flow direction in the local downslope direction. These algorithms rely on a user having already filled depressions prior to calculating flow directions and performing flow routing. This is the key difference in our method: we are not simply filling all depressions prior to calculating flow across the landscape. Instead, we are particularly interested in what happens within the depressions. In the revised paper we will clarify this point.

> Page 9 Figure 4(d) “Were M part of another depression (call it 6) that had

previously found an outlet to the ocean, then 5's parent would be the depression identified by the label of M, which would be a leaf of the tree rooted by 6. This would ensure that 5 would drain into the bottom of 6 before overflowing out of it." An actual figure could be helpful to illustrate this hypothetical scenario. If the authors think it's not necessary, remove this statement should be fine.

This refers to the 'ocean-linked' case and is shown in Figure 1, where depression 5 is linked to the ocean via depression 6. However, this caption has now changed due to the changes to Figure 4.

Adding a reference to a draft in preparation is not acceptable. Please remove the reference to "Barnes, R., Callaghan, K., and Wickert, A.: Computing water flow through complex landscapes, part 3: Fill-Merge-Spill: Flow routing in depression hierarchies, In preparation, 2019."

We have removed reference to this in-preparation paper. We will restore these references if the in-preparation paper is submitted before we submit our revised draft.

We thank the reviewer for their diligence and detailed comments.

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