A review of:
The push and pull of abandoned channels: How floodplain processes and healing affect avulsion dynamics and alluvial landscape evolution in foreland basins

Eric A. Barefoot

January 31, 2022

Synopsis

In this manuscript, Martin and Edmonds present a numerical approach to studying how abandoned channels affect flow routing and channel stacking patterns in alluvial fans. The authors formulate a random-walk model that finds a route for water and sediment on a fan surface, thereafter evolves the channel bed in one dimension along this path until an avulsion criterion is met, and then re-routes the flow according to a random walk until a new path is forged. This relatively simple algorithm is decorated with a few extra rules, which turn out to make a great deal of difference in the outcomes.

The first, and most important rule, is that previous channels in the landscape can either be a preferred path for the random walk, or an unpreferred path for the random walk when the algorithm is in the route-finding phase. This attractive or repulsive quality of the abandoned channels is a continuous variable for each that modifies the probability of a given random walk cell. The second rule is that channels do not persist on the landscape forever, and are "healed" according to one of three procedures: (1) eroding high elevations until only swales remain, (2) filling depressions until only ridges remain, or (3) the topography both raises and lowers until no topographic features remain.

Their model design is motivated by observations from large alluvial fans, where the authors see a large density of relict alluvial ridges, as well as a lower density of channels beyond some critical distance from the mountain front. The authors find that with these two continuous variables, and three mechanisms for abandoned channel modification, they can produce a rich diversity of outcomes in the model. In particular, they find that only the third (3) mode of channel healing is capable for achieving a steady-state fan, and that the degree that channels either repulse or attract reoccupation fundamentally shifts where avulsions occur in a strike-average sense. Moreover, their model results broadly mimic the general topographic features of the fans they drew inspiration from, lending some credence to the approach.

Overall Comments

I found this manuscript to be clear, well-structured, and very detailed. The model design makes a lot of sense, and I think the authors have shown a few very intuitive outcomes while also demonstrating a few less intuitive ones that spark interest. In particular, I thought the outcome where avulsion locations shift basinward when abandoned channels are barriers to flow was very intuitive, and makes for a satisfying result. In contrast, I found it surprising that imposing a rule that only negative or positive relief can be erased can drive the model to never achieve steady-state. These outcomes are presented and framed well, the conclusions are well-supported and impactful. My constructive comments are limited to a few minor comments on the visual presentation of the figures, and a few clarification questions on a few modeling choices. Other than these, I recommend the article be published. I look forward to citing this paper when my future work involves the stratigraphic architecture of fans.

Minor Comments

1. I have a question about this modeling choice. I am not sure if I understand why the simulation has to abort if a timestep results in a failed routing. If this were a real fan, the avulsion does not get a do-over, it has to fill the pond until it overflows, and then carries on its way. I wonder if by imposing this rule, you've introduced an artificial artifact of channel choice, where avulsions from the far-distant past can prohibit the present channel from traversing an entire sector of the fan. What if you adopted a really simple flooding algorithm instead? If while doing the random walk, the river encounters a dead end, it floods the area until it finds the nearest low point, and then starts routing from there. line 325
2. I think you mean Equation 12 instead of 17? line 341

Figures

- Throughout, I found myself struggling with the choices of colorbar used here. The authors are using `parula`, I think, which is a marked improvement in Matlab to the previous default colorbar, `jet`. However, `parula` is still not perceptually uniform. If a sequence of numbers that was strictly linear was plotted in `parula`, a viewer would perceive nonlinear jumps in intensity along the gradient. Put another way, there are features in the colormap that show up in plots that are not features of the dataset. To plot elevations, maybe try a single-hue colormap, or `winter` which I *think* is perceptually uniform.

- In general, I have one piece of feedback that applies to all your figures. As a point of style, you seem to have opted to putting a heavy black frame around every plot. While in the design phase, I can imagine it is helpful to have such a frame to see spacing between elements. For a finished product though, it intrudes on the visual space and commands attention, subconciously distracting the reader from the contents of the figure. Rules, used judiciously, can establish visual hierarchy (Figure 1 is a good example), but in a lot of cases here it is just too much. For all of your figures, I recommend getting rid of the bounding boxes.

- For example, here in Figure 2, the boxes around the annotations are essential, because otherwise the reader will never see them. However, I would remove the box around the figure, and take away the boxes around each of your colorbars. For these elements, proximity is all you need to establish a connection. On the subject of color, I would recommend a different colormap. The one here is distorting the visual presentation of the data. This colormap is really good at highlighting contrast in certain parts of its spectrum (e.g. yellow-to-red), and so the nice contrast showing the ridges that you want to see is limited to an arcuate band halfway through each map. I might instead recommend making four maps. In one pair, show just elevation in a single-hue colormap from light to dark so that the reader can see the conical shape. In the other pair, compute the slope map and plot that in a different single-hue colorbar. That way we can see both the ridges and the overall shape, but separated into two panels.

- Figure 3 is very nice, and seems intuitive and helpful, but it appears to have lost its caption.

- I like Figure 4 a lot. It's very helpful.

- In Figure 7, why do you think there is this odd, smoothly-sinusoidal lobe-switching? I didn't see it discussed in detail, but this is shockingly regular, and only seems to occur in the deposition-only or erosion-only healing modes

Tables

Usually for a manuscript, table design is not super important, but for ESurfD, it seems that they simply publish tables as-is, instead of reformatting them. Since this is the case, I have a few constructive comments that will make your tables much more legible.

– Vertical rules are not a great way of guiding a reader's eye. Alignment is a much better tool in the vertical direction.

– Horizontal rules are great for breaking up your tables visually into topical or related sections and for connecting items across rows, which is much harder for human eyes on the written page.

– So for Table 1, remove the box around the outside, and leave just the horizontal rule separating the heading from the table elements. See if you can make the individual cells single-spaced, while leaving some breathing room between cells. All the same for Table 2.

– For Table 3, do the same things like tightening the spacing within cells while leaving space between cells, also consider making the headings for each column bold. I would put the first column for figure references at the end. Also, the bit about having a parameter marked as "variable, see figure X" is very confusing, and forces your reader to flip back and forth. Instead, I would have groups of rows (set apart with horizontal rules) where you show every model run with every parameter combination. I know its a lot, but this table is already almost a page, so why not just make it a well-designed full-page table and go for it?