Comment on esurf-2021-82
Anonymous Referee #1

The manuscript submitted by Martin and Edmonds investigates the planform differences in megafans in foreland basins as a result of abandoned channels topography on avulsion pathfinding and their healing mechanisms. The study is motivated by three megafans and their channel locations and topographic features, including abandoned channels, alluvial ridges, and internal basins. A coupled 1D diffusive channel bed elevation model and 2D cell model is used to investigate both the effects of abandoned channels as attractors or repellents for avulsion pathfinding and the effects of different topographic annealing styles on modifying abandoned channel topography. Martin and Edmonds’ results are very exciting and show that abandoned channels when acting as both attractors and repellents, create the characteristics topography of foreland basin megafans. Planform characteristics are also distinct between the proximal (near apex) and distal fan, which are directly related to avulsion potential and abandoned channel spacing. In their model, this spatial change in planform characteristics is only achieved if abandoned channel topography is transiently preserved and both high and low topography is diffused away over time. The megafan indefinitely progrades downstream if only the high or low topography of the abandoned channel is removed. These results provide a new and remarkable context to study the annealing of abandoned channel topography.

Below are major and minor comments and questions for the authors to consider.

**Major Comments**

The introduction is a great summary of the motivation for this study. There is an opportunity to put the subsequent modeling efforts in context to other avulsion modeling...
frameworks, including those mentioned in the discussion and avulsion models related to deltas.

Besides avulsion processes, floodplain processes are the other addition to the modeling. The introduction glances over floodplain processes because not as much is known. Even with the limited knowledge about aggradation rates and their spatial trends on floodplains, the choice of spatially varying floodplain aggradation rates away from the fan apex and not away from the active channel needs to be better supported.

Lines 81-82: How does this result compare to simulations?

Lines 138-139: Currently, only the avulsion location variation is plotted. What are the implications for timing?

Lines 213-214: Please clarify why only non-active channel cells have subsidence, especially since subsidence is accounted for in the equations of both the aggradation rates and 1D diffusive channel bed elevation model.

Lines 214-215: Please describe the motivation for varying floodplain aggradation away from the mountain front but not the active channel. Does this affect the planform result and avulsion patterns? What are the processes that distribute sediment across the floodplain in this system, especially with only one active channel (Line 84-85)?

Lines 331-332: See previous comments. The motivation for floodplain aggradation changing downstream but not with distance to active channel seems counter-intuitive. Please explain how results would be affected if floodplain aggradation rates varied with distance to channel.

Line 335: A_{fp,f} is listed in Table 2 as having two different rates for proximal and distal. Please describe this variation here and share how the boundary between proximal and distal is found. Does the boundary location change for each timestep? And how would these results differ if only one fix rate existed?

Lines 335-336: Please consider presenting the formula for A_{fp,v} here. Based on the description given, it's not clear if this is a positive or negative linear relationship with height difference.

337-338: Does channel depth also change downstream? What are the motivations for
normalizing the floodplain aggradation based on channel depth?

Equation 12: See previous notes (and please feel free to refer to your answers there). The model presented here is a physical-based cellular model (line 13). Please describe how this formula is inspired by our communities’ understanding of floodplain aggradation processes.

Figure 4: In the physical-based model, how would the deposition only or erosion only healing modes affect the sediment availability in the surrounding fields since either sediment is needed or transported away in these modes. Would adding a component accounting for this in the floodplain aggradation affect the potential for equilibrium to be reached (lines 20-22)?

Line 357: Please be more specific of the location in the discussion, where the choice of 55,000yrs as a healing timescale is explained. How does the healing rate compare to floodplain deposition rates described previously?

Section 4.1. The planform topography and feature similarity between observations and the model are striking. A short discussion on how channels bounding some of the observational fan (Fig 1 E, F) could be affecting the along-strike comparison would be helpful for context. Additionally, a short description of the 1D model validation, including the water depth of the channel, where available, would be a powerful addition to this section, especially since mean water depth dictates the healing rates (Eq 13).

Line 411: I would encourage acknowledging that some parameters were varied between the proximal and distal zone (Table 1). Therefore, it’s unclear if the results are affected by the choices in parameter variations.

Figure 6: Accounting for surrounding topography in T_a (Eq 1 and 2) shows a striking increase in avulsion location, especially in the proximal part of the fan. How different are the corresponding T_a distribution (Eq 1 and 2) between the red and blue line model runs?

Figure 7: Are the striking differences between distal and proximal related to slower healing rates and different water depth (h_avuls etc) for avulsion pathfinding?

Before describing the main discussion points, a short overview of the sensitivity of the results to slight variations in floodplain aggradation and subsidence rate (Table 1) and the ratio between them would be beneficial in a section.
One set of studies that have been conducted related to channel beds and levees during and after avulsions has been led by Dr. Brandee Carlson on the Huanghe River, China. Please consider including the findings of the studies here.

**Minor**

Line 10: Previous modeling work is portrayed as if they are vastly different from this study. I am not sure that’s representative.

Figure 3 is missing its caption.

Section 3.2: Does the choice of the 1D long profile elevation model affect the profile, water depths, and sediment transport rates?

It’s unclear how the 1D model is used to initiate the 2D model. I would suggest including a plot of the initial 2D domain.

Line 148-150: This information would be extremely helpful in the introduction.

Table 1: Please add notes to the caption that describe the motivation for the choice of parameters value. Apex elevation is missing in table 3.

Line 201: Will subsidence affect surface slope in the model?

Table 2: Please add notes to the caption for the motivation of the parameters. Especially sediment discharge, incoming sediment supply, and basin width.

Line 232: It’s not clear how Table 2 relates to solving h_chan. It would be interesting to include a description of how h_chan is found.

Line 262: Please include where the formula for healing rate is found in the manuscript here.
Lines 268-270: I am confused by this statement. Could floodplain aggradation allow for the elevations of these cells to increase?

Lines 289-290: Please clarify to which cells this applies. Are floodplain and abandoned channel cells equally likely to be a site for avulsion triggers?

298-299: Please specify why 30 years was selected here. How does this compare to results from equation 2 for model runs?

Line 310: Please describe how is h_avul is calculated.

Line 341: I think this should read equation 12.

Figure 5, 6, 10, etc. A more complete description in the caption of the planform elevation model results would be useful, including a color bar scale and a description of what is plotted – I am assuming it's all cells that have been channels at one point in the modeling.

Lines 433-434: Please clarify this statement. Currently, (b) doesn't appear to have a vertical scale.

Lines 507-510: This downstream shift in sediment conveyance because of internally drained floodplains is an exciting result and makes a lot of sense physically.

Lines 535-537: I wonder if one of the implications for this result is that more sediment will exit the domain at the downstream extent. Does this make sense with the physical-based framework set up here?

Lines 581-592: This paragraph would be a great context for the introduction.

Lines 596-597: This is super interesting, especially since it's in agreement with previous findings.

Lines 611-625: This paragraph would be a great context to motivate the study and results.
Lines 649-650: The sentence is currently not complete.