Earth Surface Dynamics Discussions

Earth Surf. Dynam. Discuss., referee comment RC2
https://doi.org/10.5194/esurf-2021-82-RC2, 2022

Comment on esurf-2021-82

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Referee comment on "The push and pull of abandoned channels: how floodplain processes and healing affect avulsion dynamics and alluvial landscape evolution in foreland basins" by Harrison K. Martin and Douglas A. Edmonds, Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-82-RC2, 2022

Review of "The push and pull of abandoned channels: How floodplain processes and healing affect avulsion dynamics and alluvial landscape evolution in foreland basins" by Martin and Edmonds

General Comments

The manuscript presents novel and interesting results from a new cellular model of river avulsions in a foreland basin setting that explicitly parameterizes the influence of abandoned channels in channel pathfinding. Although several models of river avulsion exist, there has been a lack of attention to floodplain topographic controls on flow routing, and this manuscript presents an interesting and logical new parameterization of the ways in which abandoned channels might control avulsion pathways. They treat abandoned channels in three ways: 1) their repulsion caused by the elevated topography of alluvial ridges; 2) their attraction because of channelized flow paths; 3) different modes of abandoned channel healing, depending on abandoned channel deposition and erosion. Model results show that all tested aspects of abandoned channels control avulsion location, especially whether avulsions are occurring in the proximal or distal reaches of the fan. They also show, most interestingly, that active lobes and lobe switching – that is, when avulsions occur in a clustered region of the fan before switching to a new, clustered region – only occurs under certain abandoned channel healing conditions. This suggests that abandoned channel topography exerts a strong control on the locus of avulsions and also the tendency for some fluvial fans to have active lobes. This is a valuable modeling contribution that sets the stage for field and remote sensing work to gather more real-world data about the role of abandoned channels to test some clearly defined model predictions. At the beginning of the manuscript, they also characterize the amount of abandoned channels on three fluvial megafans, to show that these are indeed prevalent features in modern environments. Overall, this is a well-written manuscript with exciting

findings; the comments below are mostly minor questions or suggested revisions to improve the clarity of the manuscript before publication, although there are a few more significant comments, especially about the default channel healing mode used in most of the model runs.

Specific Comments

Base run and validation

In section 4.1, the authors validate the model results by comparing a baseline run to 2 modern megafans. However, it is unclear why the strike and dip-section profiles are compared to two different megafans. Is the dip-section of the model inconsistent with the Taquari fan? Is it important to have reasonable consistency in both dimensions? A lot of the main conclusions of this paper are about the proximal-distal location of the avulsions, so the length-to-width ratio of the fan area does seem like an important property. Also, for the along-strike comparison with the Taquari fan, the Y-axis values are comparable but the x-axis values are very different; the plots make them look the same, but the axis values are different. How important is this difference? Additional text should be added to address this, and ideally the dip and strike profiles should be compared from the same fan system or systems.

Abandoned channel healing mode in the first 3 sets of model runs

Lines 374-387 describe four series of model runs that are then analyzed in the results section. If I understand this correctly, series 1-3 were all run in far-field directed healing mode, and thus the effects of the repulsion and attraction parameters were tested only with the far-field healing. However, in the fourth series of model runs, the authors show that the depositional and erosional healing modes cause major (and interesting!) changes in avulsion behavior. Do the impacts of the attraction and repulsion parameters still occur under the depositional/erosional channel healing modes, or are they only important variables under the far-field directed healing mode? It would be good to see some model runs added (perhaps just a limited subset of the model space) that address this question. Is the channel healing mode more important than the attraction/repulsion rules? Also, what is the justification for using the far-field directed mode as the default mode? Is there evidence to suggest that this is the most common/reasonable healing mode in modern floodplains? The authors mention that this is the least computationally intensive, but it would be good to see scientific justification for this as the default mode.

Model mass balance variations based on healing mode

Because of the way this model is set up, mass balance is not constrained between model runs, and that is not an impediment to the analysis. However, the different healing modes shown graphically in Figure 4 have very systematic differences in mass balance that might have big impacts on the model results. For example, the depositional only mode of healing would require a much larger sediment input to the floodplain than the far-field directed or erosion-only modes. There is no mention of this in section 4.5 or in the discussion, but I think this difference in mass balance between the model types warrants some analysis. If equivalent amounts of sediment were added into the proximal floodplain in the far-field directed healing model runs, even outside of the abandoned channels, wouldn't that also cause lobe switching? In other words, to what degree are these results caused by the abandoned channel healing versus just accumulation of more or less sediment in the floodplain around the active channel belt?

Re-organization of introduction & background

The introduction section of this manuscript is very short (3 brief paragraphs!) and does not give enough background to set up the hypotheses or the model set-up. Other sections of the paper (specifically section 2.2.2 and Lines 611-625 of the discussion) would be better suited to this introduction, so that more specific background about abandoned channels and cellular modeling of avulsions was provided to the reader before they continue on in the paper. Also, the topic of avulsion reoccupation is not mentioned in the introduction, but the observations from the modern and the ancient that channels commonly reoccupy previous channel courses is critical to the motivation for this paper. There should be at least some description of the evidence for channel reoccupation of abandoned courses in the introduction here.

Discussion section revisions

As noted with detailed line numbers in the following section, a lot of the discussion reads more like background about avulsion models and justification of the model rules used in this paper, rather than contextualizing these novel results. I think the background information and justification of model parameters should be moved earlier in the manuscript, and a more detailed analysis of the results could be added to this discussion section – especially thinking about their broader implications. For example, based on the prevalence of lobe-switching in modern fans, does this suggest that the deposition/erosion-only healing rules are most consistent with modern observations? Additionally, what are

the implications for stratigraphic analysis of avulsion patterns? In systems with clearly clustered avulsions (such as the Ferris Formation; see Hajek et al. (2010)), does that suggest abandoned channels were attracting avulsing flow more than in randomly distributed systems (e.g., the Williams Fork Formation; see Chamberlin et al. (2017))?

Technical Comments

Section 2.2 - Megafan floodplain topography discussion: the organization/title of this section is odd, because this is really the background needed for the model set-up, not a discussion of the field results. I think almost all of the content in this section would be better in a background section about avulsion set-up, initiation and pathfinding that would come before the remote sensing section.

Figure 3: missing caption

Line 140-141: There is also good evidence from the rock record that avulsion reoccupation of previous channel courses is common – e.g., see references in Chamberlin and Hajek (2015).

Line 161: There are several studies that have observations of oxbow lake sedimentation rates, which is a type of abandoned channel sedimentation. These studies should be cited and discussed here. (for example, Wren et al., 2008, "The evolution of an oxbow lake in the Mississippi alluvial plain").

Line 163: The language "if one assumes that abandoned channels do heal" is confusing – what would another option be? Over geologic time, they must heal, right?

Line 168: The details in the discussion should be moved up front into a background section.

Table 1: Maybe "numerical" or "cellular" model is more clear than "non-experimental" in the table title?

Line 263: This is an interesting way to code channel healing! Can you add some more

explanation – maybe here, maybe in the justification for the model set-up – about the mechanistic justification for these different healing modes? In other words, for the depositional only healing, how would that actually work? Via overbank sedimentation? Via temporary reoccupation of the abandoned channels during floods? I know that this model is not attempting to resolve those processes, but some general outline of how each of these healing mechanisms could be possible would be helpful for thinking about the implications.

Line 333: I'm surprised by this decision to have floodplain aggradation independent of active channel position. Why are they decoupled? Additional justification of this choice would be helpful, because this would have a big influence on superelevation dynamics. This might be a point that would be good to add into the discussion and a direction for future modeling work.

Line 341: I think you mean equation 12, not 17

Line 347: Put the detailed explanation of other models in the background, not discussion, and then this line can be removed from this paragraph.

Figure 4: this is a very helpful figure that I referred to many times when reading this!

Table 3: I think presenting model run parameters based on figure # is confusing. It would be more straightforward to include a table that shows the parameter ranges for each of the four series of model runs.

Lines 472-474: Interesting! Is there any evidence for this in modern systems, that avulsion nodes cluster immediately downstream of previous avulsion nodes? This would be an interesting point to expand on in the discussion.

Figure 12: Make dashed lines have a bigger dash, they are hard to distinguish from solid lines. Also, typo in the first part of the caption – missing "on" before (a).

Line 592: Abandoned channels impact the compensation rule in the Chamberlin and Hajek models because they leave an elevated abandoned alluvial ridge, so they cause repulsion away from the abandoned channels in the compensational rules.

Lines 596-598: The clustered mode in the Chamberlin and Hajek (2015) model randomly selects a channel location within the clustering zone; it only selects the lowest location

when an elevation threshold above the far-field floodplain has been reached.

Paragraph beginning at line 611: I think this would be better suited as background material.

Lines 637-647: This material would be helpful for justifying the healing rules used, and thus could be presented earlier in the paper.

Section 5.3: These are interesting predictions focusing on the proximal-distal location of avulsion nodes! I think adding predictions about channel healing & lobe-switching behavior would be very helpful too. Are there characteristic types of fans that show lobe switching? Is there something about the floodplain aggradation style on those fans that influences abandoned channel healing? That would be really cool to explore.