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Reply on CC1

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Author comment on "Linking levee-building processes with channel avulsion: geomorphic analysis for assessing avulsion frequency and channel reoccupation" by Jeongyeon Han and Wonsuck Kim, Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2021-92-AC1, 2022

Response to Harm Jan Pierik's comments on

"Linking levee-building processes with channel avulsion: Geomorphic analysis for assessing avulsion frequency and style"

In the submitted preprint 'Linking levee-building processes with channel avulsion: Geomorphic analysis for assessing avulsion frequency and style' Han and Kim describe the relation between avulsion frequency and style and levee geometry. For this a numerical model is used, and the results are tested using two field cases. They explore the interesting hypothesis that levee slope on one had is a function of avulsion frequency, and on the other hand can also be an important agent in avulsion style. For the latter mechanism they find an interesting relation with morphology of abandoned channels. We think this paper is relevant to better understand fluvial sections and modern delta landscapes and will be worth publishing. We also see opportunities to clarify statements made and to make a wider comparison with existing studies. This includes adding more cases for validation, but also discussing other important factors in levee and avulsion that known to be important from literature.

Thank you for taking the time to read and provide constructive comments on our manuscript. We really appreciate the suggestions and many interesting references you provided, which are very helpful for us to improve and clarify our manuscript. We tried to respond to each comment below in italic.

- The cause and effect of levee geometry and avulsion frequency is not always clear: do avulsions force levee topography or the other way round, or both?

  It is generally accepted that the initial levee geometry can be modified by more deposition in the distal parts of the levee as "backloading". The impact of backloading may vary depending on the avulsion frequency (mentioned in the original version at *lines 363-365). We believe that this would be one of many processes that avulsions influence on levee topography. However, the main goal of this study is to reveal the first-order correlation between the levee geometry and avulsion frequency using the advection settling that builds a simple levee geometry over a uniform initial channel and floodplain configuration. We think that levee geometry is primarily controlled by overflow properties and is strongly correlated with avulsion frequency, even considering the bi-directional influences between avulsion frequency and levee topography. These bi-directional influences can form an exciting future topic but are beyond what we can thoroughly investigate using the current model.*

- Some confusion raises regarding the term levee slope and how this is controlled. E.g. in L 384 isn't levee height meant here instead of slope? Boechat Albernaz et al. (2020) (https://doi.org/10.1002/esp.5003) find fast initial heightening and then widening of levees (decreasing the slope over time), could slope simply be a function of time?

  Thank you for this comment. As we discussed above, we understand that the levee slope can change as it evolves over time. What we use in the current are the relative levee slopes where all their crests are superelevated up to the same height. This slope at the superelevation is still controlled by the flood discharge and grain size. We think that there are relatively "steeper" and "gentler" levee slopes at the superelevation stage associated with the boundary conditions. However, we have clarified the underlying assumptions of the relative levee slopes to avoid a potential misunderstanding.

- The authors state that topographical leveling/smoothing after channel abandonment is important for avulsion potential, this mechanism could be explained more: is floodplain deposition meant here, and where in the system exactly? We can indeed imagine that this makes topography more gentle, and less avulsions help in that sense, because large areas of inactive delta plain only experience modest floodplain deposition, smoothing out topography.

  We agree with the review that topographic smoothing is important for avulsion potential. We now elaborate more on a smoothing mechanism in the discussion section of our revised manuscript.

- Important in this hypothesis is the proposed mechanism of abandonment of the river, which is currently not fully explained. There are more phases of infilling of abandoned channel, that even occur before the end of avulsion. The statement in L 382 is not correct; topographic lows, in particular residual channels have finer infillings than the channel belts they are in. The paper by Toonen et al. 2012 (https://doi.org/10.1002/esp.3189), a review on sedimentology of residual channels, may be of interest.

  We see the reviewers' point. We thus have rephrased our initial statement as:
  "As maintaining topographic lows and filled with less overbank deposits…"

- We think the smoothing hypothesis is interesting to explore, but now a discussion misses on how important this is compared to other factors that have been discussed in avulsion and levee literature before. For example, vegetation and even tides (in some cases present up to a delta apex) are also relevant to mention, even though these were not a central topic in the study. A link between vegetation density and levee width (hence slope) was found. For more on this, we recommend Kleinhans et al. 2018 https://onlinelibrary.wiley.com/doi/10.1002/esp.4437 and Boechat Albernaz et al. (2020) who use numerical models to build levees.

This is a good point. Other factors, e.g., vegetation change the hydrodynamics during floods to vary sedimentation in the floodplain and thus influence the smoothing effect. We incorporate this in a discussion but briefly since this is not the main focus of the current study. We also try to clarify this limitation in Sect. 4.6.

- Important are the timescales at which mechanisms take place: how fast do levees grow compare to avulsion duration? Filgueira-Rivera et al. (2007) and Boechat Albernaz et al. (2020) for example, find that levee crest height is reached relatively fast and that it is a function of flood level height, while avulsions generally take much longer to complete (e.g. Stouthamer & Berendsen 2001: https://doi.org/10.1306/112100710589). L 388: if this is correct, how can this be seen in the geological record? A hiatus with small time, this is very hard to see, and therefore the relevance for geology may be relatively small.

  We thank the reviewers for this interesting comment. We agree that the timescale difference between levee growth and the avulsion event would be important in the geological record. As the reviewers described, levee growth would be relatively faster compared to the avulsion process until it is completed. This might be a reason that levee has relatively low preservation potential due to reworking over a long avulsion process. The long avulsion process, therefore, can generate significant variability in preserved levee geometry in the sedimentary record. We think it is still important to know what the upper end member that represents minor reworking could be, which potentially provides a useful hint for the boundary conditions. This is an exciting new topic but beyond our scope of the current study.

- The authors use two geological cases to validate the outcomes of the study. To fully understand them and relate them to the model outcomes, more introduction of these cases as well as some figures would be helpful. The authors may also consider adding more cases datasets from literature, e.g. in Boechat Albernaz et al. 2020 (fig 10, data in their supplements) and in the work of Stouthamer (2005) on reoccupation (involving also timescales) https://achives.datapages.com/data/sepm_sp/SP83/Reoccupation_of_Channel_Belts_and_Its_Influence.htm)

  Thank you for the suggestions and potential field datasets for further validating the current modeling results. Considering the limited time for the revision this round, we have decided to enhance the applications to the two current field cases instead. We added a schematic of infilling processes of abandoned channels concerning levee geometry and two avulsion styles, which now provides a better guide to understand the implications of the insight we gained through the modeling work to field cases. Again, we appreciate the reviewers for suggesting such interesting references that encourage us to further refine our numerical model.