Response to Referee #2's Comments

We quote the original comments in ***bold-italics*** typeface, and give our responses in light typeface below each section.

The authors have made significant revisions and improvements to this paper. I appreciate their attention to the reviewer comments, but still have the following concerns/suggestions, warranting minor revision:

We thank the referee for the positive assessment of our manuscript and the affirmative view of our first revision. We describe our responses and the associated efforts below.

The authors still do not provide any results showing what areas are frozen/unfrozen. It would be helpful to include, at least in supplemental, some information to help the reader visualize freezing and thawing patterns on the deltas and how this is or is not related to ramp development.

We have added the thaw-depth plots of two simulations (corresponding to those shown in Figures 4b and 4f) at time steps 4970 to 4973 (out of 5000, not counting the 300-step ramp-up phase). These time steps correspond to the step before the final maximum winter ice cover, through to two time steps afterwards. Due to the lack of "permafrost" labels in the sediment pixels in ArcDelRCM.jl (as described in Sect. 2.2.2 and 2.2.3 of the manuscript), thaw-depth values are the closest way to display the frozen/thawed pattern of the delta bed. The new figure (C1) is included in a new Appendix C, which also includes a short text description of what is shown and its purpose.

References to the new Appendix C and its figure (C1) are added in the main text on lines 546-548:

> "As a pair of examples, Figure C1 shows the spatial views of the thaw-depth pattern corresponding to simulations shown in Figures 4b and 4f. These thaw-depth

> patterns provide an indication on where the aforementioned processes and balances are active."

And line 389:

> "A visual representation of the thaw-depth patterns corresponding to Figures 4b and 4f is shown in Appendix C."

I appreciate the explanation of how bank erosion is treated, showing that their model requires sediment to be thawed in order to be mechanically eroded and that thaw proceeds in the next time step, allowing more cells to be eroded. The modifications to the text in this regard are adequate. Related, however, the reviewers in their response file suggest there is some 'alternate' definition of permafrost they intended (e.g., seasonally frozen ground). Permafrost, by definition, is at a temperature of <= 0C for at least two years. If the authors do not intend to model or describe permafrost but only frozen vs. unfrozen, then the authors should refer only to frozen ground rather than permafrost to avoid confusion.

Nearly all of the usage of the term "permafrost" in the manuscript refers to general descriptions of the landscapes or settings of Arctic deltas, or the "permafrost" label and its associated erosional rules in the DeltaRCM-Arctic model. We have already been using the "frozen"/"thawed" terminology when discussing the simulation rules used in ArcDelRCM.jl. Nevertheless, we have identified a few remaining places where the referee's suggestion is applicable, and made the changes described below.

We have added the following sentence to the end of Sect. 2.2.2:

> 'To avoid confusion, we will use the terms "frozen" or "thawed" (as opposed to "permafrost") in the context of the erosional rules in ArcDelRCM.jl.'

The title of Sect. 2.2.3 has also been changed from "Permafrost Erosion" to "Erosion of Frozen Ground". To the last sentence of the first paragraph of Sect. 2.2.3, we added the following clarifying sub-clause:

> "[...], and consider only the depth of the boundary between frozen and thawed grounds."

The authors did not actually address my comment regarding how channel networks were extracted. They simply state that graphs were extracted based on the locations of the channels, but determining the locations of the channels was my actual concern, as this is also somewhat subjective and rather difficult! Did you use a velocity threshold? The topography? A wet-dry map? Some combination? Based on Figure 3, it looks like you used bed elevation. Was it a simple threshold? How was the threshold selected?

We have added clarifying sentences to where we describe the graph-extraction process in Sect. 2.3, on lines 336-339:

> 'In this context, channel pixels are defined as those having a water depth of 0.1 m or over, which is the threshold value for "dry"/"wet" pixel labels used in DeltaRCM (Liang et al., 2015b) and inherited by both DeltaRCM-Arcticand ArcDelRCM.jl. "Open-ocean" pixels without any depositions (i.e., with depth equalling the ocean-basin depth, h_B) are excluded.'

I appreciate the authors' attempt to include more justification on the Lena delta modeling, but more information would be appreciated in the manuscript text. Even including the information written in the response to reviewer file (the non-quoted part) would help. This would also allow you to elaborate in the text on whether you think these results, in terms of the processes, are applicable to other Arctic deltas or not, which I suggest you include.

As the referee suggested, we have added the following elaboration (based on the non-quoted part of the previous response to reviewer) to lines 82-87 in the Introduction:

> "Aside from being the largest Arctic delta, Lena Delta is chosen for the real-world example because of its fit to the modelled geometry. Many of the other Arctic river mouths (e.g., Ob, Yenisei, Mackenzie) are estuarine or geologically confined, and thus match the modelled geometry poorly, which may confound the analyses herein. Other Arctic deltas such as Olenyok and Colville are much smaller, and therefore more likely to be influenced in their growth by processes other than those modelled here (we discuss some of these processes at the end of Sect. 4). Through the exemplary case of the Lena Delta, [...]"

This, in combination with the existing discussion on the model limitations at the end of Sect. 4, should provide readers with a sense on the extent of extrapolation that can be safely applied to our results.

Re: ice remaining on the ramp longer - My suggestion was not that the ice remaining there was contrived, but rather that if you force the ice to stay on the ramp longer, and then claim that the fact that the ice stays there longer is responsible for preserving/forming the ramp, then this seems contrived because you created a rule that causes the ice to stay there and a rule that causes the ice to shield the ramp. Nonetheless, I think the modifications to the text sufficiently address this issue and we can consider it resolved.

Figure 6-7, I appreciate having this in the manuscript but the box and whisker plots are not visible at this scale. Removing the points for individual runs may help, or rearrange the figure/make it larger.

The size of the black dots, representing the individual realisations of the simulations, have been reduced in Figures 6 and 7. The box and whisker plots should now be visible despite the black dots.

We thank the referee again for the affirmative assessment, the time and effort spent on twice-reviewing our manuscript, and the constructive suggestions.

Other Changes

Aside from the changes responding to Referee #2's comments, we have also made the following pair of minor changes:

- We have added one recent reference, Rantanen et al. (2022) to the sentence about amplified warming in the Arctic (on line 29).
- We have also modified the capitalisation of the title of Appendix B to "title case".
- We have moved the hosting location of the ArcDelRCM.jl source code from the first author's personal GitLab instance to an institutional instance hosted at the GeoForschungsZentrum German Research Centre for Geosciences (GFZ). The web link has been modified accordingly.