We thank the editor and the reviewers for their helpful input, and we respond to their feedback below.

Sincerely,

Yavor Kostov, lead author

Responses to the editor

Justification (visible to authors and reviewers only):
Dear Dr Kostov and co-authors,

Thank you for your relevant, interesting and novel submission to TC / EGUsphere. I believe that it is suitable for further peer review. Below I have made note of some minor issues that I encourage you to address during the peer review process. They are mostly geared toward accessibility and clarity.

I will now send it for peer review.

Best regards,
Felicity McCormack

We thank the editor for allowing our manuscript to advance to the next stage of peer review. Our revisions have addressed both the editor's and the reviewers' feedback.

We enclose responses to each comment below, and we point to specific line-by-line changes in the manuscript.

Best regards,

Yavor Kostov, lead author

- I suspect that the developments presented in this manuscript should have substantial impact in terms of modelling icebergs. However, the significance could be described more clearly in the introduction, discussion, and conclusion. For example, the end of the first paragraph in the introduction notes that modelling the behaviour of the largest icebergs is particularly challenging. However, the introduction does not elaborate on what those challenges are, which may make it unclear to readers less (or not at all) familiar with iceberg modelling why the developments presented in this manuscript are important. A brief overview of the limitations of previous modelling approaches -- perhaps highlighting which factors (e.g. thermodynamics, biogeochemistry, interaction with underwater infrastructure, influence on polynya activity) are likely to have the largest impact -- would help clarify the motivation and significance of this work.

We are grateful to the editor for this recommendation. We have now explained in greater detail the modelling challenges in lines 28-32 of the introduction. We have cited an additional source, Duprat et al. (2016) regarding the role of icebergs as a source of iron (line 41). We have also pointed out the importance of properly representing iceberg grounding for the simulation and projections of sea-level rise (lines 71-73). In lines 911-914 of the Summary and Conclusion, we once again elaborate on the implications of iceberg grounding for the stability of the ice shelves and for the Antarctic contribution to global sea level rise in future climate projections.

- Line 15: should this be "iceberg acceleration"

We thank the editor, and we agree that we should specify we are referring to "iceberg acceleration" in Line 14.

- Section 3.4. In places it's difficult to follow what is new in the berg scheme and how it differs from the previous schemes or what is commonly done in other berg schemes. It could be helpful for readers to see the updates represented schematically (e.g. some kind of flowchart), including how the bergs interact with ice shelves, or at least an itemised summary of the new processes / parameterisations implemented

We appreciate the editor's comments about clarifying the novelty of the new grounding scheme in Section 3.4. In lines 440-444, we have now specifically listed the new processes that we have implemented, and which were missing from the previous grounding schemes in NEMO.

- There are some sentences that contain large whitespaces which makes me wonder whether some terms haven't rendered in the pdf? (e.g. 204, L454)

We thank the editor for pointing out that there are larger than usual whitespaces in the text (e.g., lines 219 and 471). We have fixed them.

- If you've not already done so, please check all colour maps in the coblis color blindness simulator (https://www.color-blindness.com/coblis-color-blindness-simulator/) and adapt the colour schemes as necessary

We thank the editor for reminding us to double check the figures in the colour blindness simulator one more time. Following up on that, we have made Figures 1, 8, 16, and C1 more accessible.

- The manuscript is quite long. Please consider whether you can reduce the text length for clarity and conciseness or combine some of the figures (e.g. figures 15 and 16)

We have reduced the text length in the new lines 12,110, 112, 114, 168-175, 198-194, 216, 311-333, 358, 428-430, 872-881, 895-897 and 904-905. We have also merged Figures 15 and 16 and their respective captions, as suggested. In the process, we noticed an issue with the new Figure 15a. In that figure, we show the net productive forces (except gravity) acting on icebergs that are statically grounded along the solid basement. Since the icebergs are static, we show cardinal geographical directions. However, previously this figure averaged over icebergs that ground along Bear Ridge and others that ground in sediment and along the bottom elsewhere. In order to keep a consistent focus on grounding on top of Bear Ridge, in the updated figure, we focus only on the subset of icebergs there.

We have shortened many parts of the previous text. However, we should point out that in response to Reviewer #2, we have added a new subsection 3.3 on iceberg melting and capsizing. We have also discussed capsizing once again in lines 846-858, while acting on feedback from Reviewer #2.

Reviewer #1

The authors have developed the modelled dynamics of drifting and grounding/grounded icebergs, with close attention to realism, in particular the evidence from scouring. In the former instance, the pressure gradient force for drifting bergs is more correctly separated into barotropic and baroclinic parts. In the latter case, with a focus on the topographic obstacle that is Bear Ridge in the Amundsen Sea, more extensive improvements to the NEMO-ICB model configuration are outlined. The attention to dynamical detail is impressive, most notably representation of the force balance for a grounded (and ungrounded) berg. The authors outline in considerable detail the additional forces and accelerations, based on clear fundamental physics, with just a degree of uncertainty in the coefficients of Coulomb friction.

The manuscript is succinctly written throughout. The Introduction (Sect. 1) clearly motivates the model development presented here, with a view to the wider system ice-ocean-climate system. Sect. 2 provides thorough background information on the character of seafloor and sediments, or relevance to grounding. Sect. 3 provides a detailed outline of the existing model equations and developments thereof, model configuration and experimental design. In the Results (Sect. 4), well-crafted figures convey a rich level of information, in particular the wind roses that summarise the strength and relative orientation of accelerations and forces, and the summary force balances (given typically small net accelerations). Sect. 5 provides a brief summary and discussion, pointing towards new modelling possibilities now that the basis is provided for more realistic representation of tabular bergs near Antarctica, specifically the consequences of grounding for sea ice, hydrography and even feedback on the calving process. I close with the following technical comments:

Thank you carefully reviewing our manuscript and encouraging us! We have implemented your suggestions.

Technical Comments:

1. **'Equations' 9, 10, 12-16 are actually terms or relations; either refer to these as such in the main text, or formally make these equations; likewise (27) is a set of proportionalities, not equations**

   Thank you for this helpful suggestion! We have turned the aforementioned relations (now equations 9,10, 12, and 14) into equations and refer to (24) as a set of proportionalities.

2. **6 caption: typo - 'small' rather than 'smalls'**

   Thank you for pointing this out! We have corrected the Figure 6 caption.

3. **Line 797: typo – 'or' not 'of'?**

   Thank you for pointing this out! We have corrected the typo (now lines 814-815).

Reviewer #2

In this manuscript, Y Kostov and co-authors present an updated grounding representation for icebergs in the NEMO ocean model, as well as improvements to how iceberg drift is computed.

The paper is very well written and structured, clearly illustrated, and the subject matter is a natural fit for The Cryosphere. I believe this work presents substantive steps forward in the representation of icebergs in models and I am looking forward to seeing how these changes will improve future iceberg modeling efforts.

In light of this I recommend the paper for publication after revisions, with my comments detailed below. (Please note that some of these comments are musings rather than requests for edits, arising largely because I am fascinated by this topic. Relatedly, I am keenly aware that I refer to my own papers quite a lot in my comments - which is mostly just a consequence of being most familiar with those and not a request for citations).

Thank you for your detailed and constructive comments and recommendations! We are grateful for your feedback that we have acted upon. We have also cited the additional references to relevant papers that you have provided.

General Comments:

1) **My most substantial comment is that I do wonder whether the paper may benefit from being split into 2 separate articles: one on grounding and one on drift dynamics. My reasons for suggesting this are two-fold:**

   i) The paper is quite long and it is at points hard to keep track of all the different pieces (see also a similar comment by the editor).

   We thank you and the editor for this comment. We have shortened the paper and we are grateful that you have highlighted particular portions of the text that could be written more concisely.

We have reduced the text length in the new lines 12,110, 112, 114, 168-175, 198-194, 216, 311-333, 358, 428-430, 872-881, 895-897 and 904-905. We have also merged Figures 15 and 16 and their respective captions, as suggested. In the process, we noticed an issue with the new Figure 15a. In that figure, we show the net productive forces (except gravity) acting on icebergs that are statically grounded along the solid basement. Since the icebergs are static, we show cardinal geographical directions. However, previously this figure averaged over icebergs that ground along Bear Ridge and others that ground in sediment and along the bottom elsewhere. In order to keep a consistent focus on grounding on top of Bear Ridge, in the updated figure, we focus only on the subset of icebergs there.

We have shortened many parts of the previous text. However, we should point out that in response to your comments, we have added a new subsection 3.3 on iceberg melting and capsizing. We have also discussed capsizing once again in lines 846-858, while acting on your feedback.

ii) The paper consists of two fairly independent components: the grounding parameterization and the free drift analysis and improvements. While the grounding work

is more developed in the manuscript as it stands I would argue that there is plenty of material to expand the drift analysis into its own paper (without too much extra work). Such a split could streamline the presentation in a number of ways, for example, you wouldn't have to bring in the MEDIUM icebergs at all for the grounding work. I do think a split would also help the impact of the work - other modeling groups may be more likely to pick up on the improvements in grounding when this is presented in a more focused way.

We decided not to split the draft paper into two manuscripts. Here is once again our reasoning. In order to describe grounding behaviour, we have to understand the dynamics of freely floating icebergs as they approach topographic obstacles such as Bear Ridge. The contrast between the force balance of freely floating and grounded icebergs is itself very illuminating. Instead of splitting the paper, we have strengthened a few of the bridges in the text between passages focusing on freely floating icebergs and the ones that directly concern grounding (Lines 540-542 and 692).

Having made this case, I happily leave it to the authors and the editor what to do about it.

2) There are a few passages where I thought text could be shortened somewhat. I have highlighted those in the attached pdf.

We have gone through all passages that you have highlighted and rewritten them more concisely. For example, we have reduced the text length in the new lines 12,110, 112, 114, 168-175, 198-194, 216, 311-333, 358, 428-430, 872-881, 895-897 and 904-905.

3) It would be helpful to early on provide a short discussion of the types of icebergs that get stuck on Bear Ridge with typical sizes and approximate numbers. While reading the paper, I somehow assumed there would be only a handful of large tabular icebergs at a given time, until I got to Appendix A and realized you are mostly talking about ~hundreds of fairly small icebergs.

Thank you for this comment! Yes, indeed, we have now pointed out that these are hundreds of fairly small icebergs in the Amundsen Sea Embayment (Lines 50-52): "in shelf seas such as the Amundsen Sea Embayment, where there are hundreds of icebergs at any time and almost 90% of them are smaller than 2 km^2 (Mazur et al., 2019)."

Relatedly, I would recommend picking one of the images from the timelapse movie (ideally one with very clear sea ice differences on the two sides of the "wall of icebergs", e.g., timestamp 2:15 of the movie), annotate this, and combine it with figure 1, to provide the reader early on with a sense of the general setup. These images are rather striking.

We have combined still frame ~2:15 of the movie with Figure 1 as a new panel. Thank you for this suggestion!

4) The manuscript is largely focused on grounding, however, I'd argue that the subsequent ungrounding is also important. [As a side note: Reading the paper I was wondering whether ungrounding is primarily the result of melting (and potentially capsizing), or rather changes in ocean current/wind direction? This is not a focus of this work, but if you have any insight I'd be interested to hear it.]

Winds seem to be the main driver of motion for kinetically grounded icebergs that remain embedded in the sediment (Figure 12).

We have added a new subsection 3.3 on iceberg melting and capsizing. We have also discussed capsizing once again in lines 846-858, while acting on your feedback.

In our study we have kept the old NEMO iceberg capsizing criterion based on the ratio between horizontal length and keel depth. Our companion manuscript, Olive Abello et al. (2025) use an updated capsizing criterion that compares width and thickness, and is consistent with the careful mathematical arguments laid out in Wagner et al. (2017 OM).

Simulated icebergs grounded on Bear Ridge experience faster lateral than basal melting. However, when the old capsizing criterion is active, the icebergs' width decreases to zero before its length can cross the critical threshold based on the *keel* thickness (Figure R1 in this response). In contrast, when the criterion in Olive Abello et al. (2025) is used, grounded icebergs do capsize (Figure R2, top). In that case, they unground (Figure R2, bottom) and resume flotation, only to become marginally grounded once again (Figure R2, bottom).

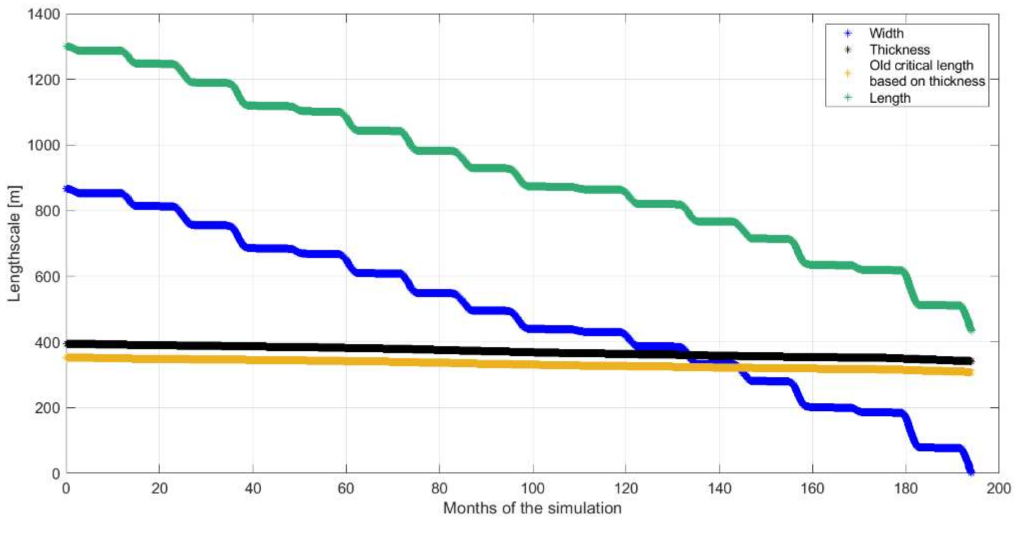

Figure R1. Example of a simulated iceberg that is grounded along Bear Ridge a month into the simulation and remains grounded. Using the old capsizing criterion comparing length and keel thickness, the iceberg melts away before it can capsize.

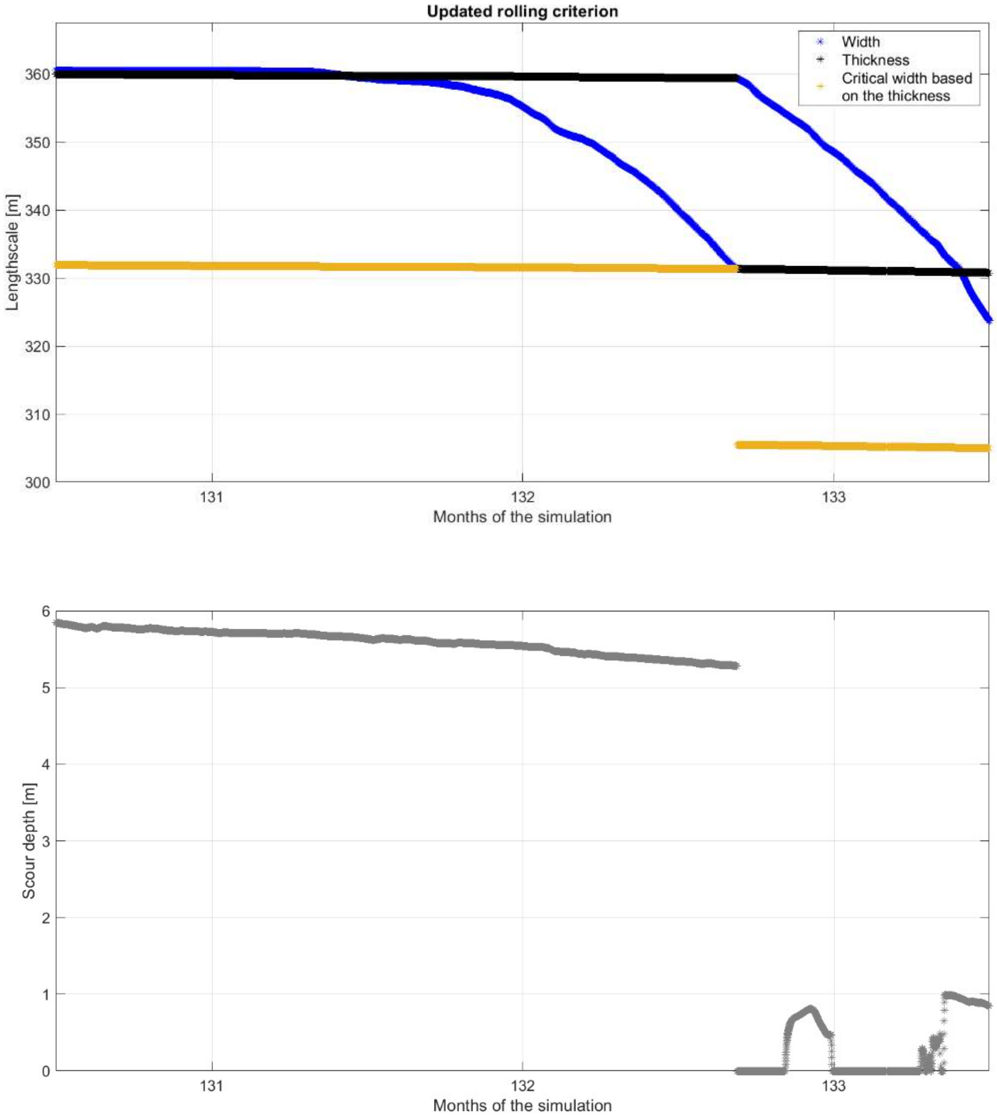

Figure R2. Example of a simulated iceberg that is grounded along Bear Ridge a month into the simulation. We have zoomed on particular months of the simulation. Top: using the Olive Abello (2025) capsizing criterion, the iceberg capsizes. Bottom: the scour depth reached by the iceberg keel at any point in time. After capsizing, the iceberg briefly resumes free flotation. However, its shallower keel quickly becomes marginally grounded.

While I agree with the authors' choice to focus on the novel representation of the grounding process, I do think it would be helpful to also discuss ungrounding and the role of melting. Two things came to mind:

We have added a new subsection 3.3 on iceberg melting and capsizing. We have also discussed capsizing once again in lines 846-858, while acting on your feedback.

- First, as far as I know the melt model in NEMO-ICB contains a dependence of basal melt

on the relative velocity between the iceberg and the ocean current at the height of the iceberg base (Merino et al, 2016, eq 2). I wonder how this plays out for grounded icebergs in the latest version?

Thank you for raising this question. We have added a clarification that in the new grounding formulation, the relative basal velocity is computed at "the deepest ocean level above the sediment" (line 373-374). This formulation may not be perfect, but it allows even the statically grounded icebergs which have no velocity of their own to melt at the base.

Lines 871/872 make it sounds like this is not the case in the current model formulation?

We have clarified in lines 890-894 that "the formulas in NEMO explicitly represent the direct effect of iceberg lengthscale on basal melting through a -0.2 power law, while the potentially large impact of horizontal size via changes in relative velocity is an emergent phenomenon."

The dependence on the size of the iceberg is evident as well in the Merino et al. formulation. I'm likely missing something, but maybe this paragraph could be reworded and/or clarified?

We have clarified in lines 890-894 that "the formulas in NEMO explicitly represent the direct effect of iceberg lengthscale on basal melting through a -0.2 power law, while the potentially large impact of horizontal size via changes in relative velocity is an emergent phenomenon."

Hence, we expect the inverse length scale to have a much stronger net impact on the melting rate than an estimate based solely on the -0.2 power law.

- Second, freely floating icebergs typically erode much faster on the side walls due to wave erosion (~1 m/d) than the base (~0.1 m/d) - see, e.g., Wagner & Eisenman (GRL, 2017, https://doi.org/10.1002/2016GL071645). In that case you might expect that icebergs shrink laterally until the aspect ratio becomes unstable and they become ungrounded by capsizing (as the authors mention). This may be particularly relevant for the smaller icebergs found all over Bear Ridge. However, since for grounded icebergs the relative basal velocity is higher, maybe the thinning is substantially faster than for freely floating ones, which might entail that capsizing isn't that important after all. Would it be easy to check how often ungrounding in the model coincides with capsizing? I appreciate that a detailed analysis of these processes is beyond the scope of this study, but I do think it would be helpful to comment on how melt is represented in the model, and to at least mention some of the considerations above.

Thank you for this comment. We have added a description of melting and capsizing in our new subsection 3.3 Representation of iceberg melting and capsizing in NEMO and their role in ungrounding. In addition, we have discussed results from Amundsen Sea simulations in the context of melting, capsizing, and grounding in lines 846-858:

"In order to explore the potential for capsizing, we have extended our four-year LONG simulation with THICK icebergs up to 20 years by applying a repeat cycle of the same four-year surface boundary conditions. We see that in our extended LONG simulation, the rate of lateral melting indeed exceeds the rate of basal melting, with a potentially unrealistically large contribution of wave erosion to the former. One may expect that this causes widespread capsizing of grounded icebergs. However, the pre-existing NEMO capsizing criterion incorrectly compares horizontal length rather than horizontal width against vertical thickness. As a result, the excessive lateral melting of individual grounded icebergs eventually reduces the horizontal width to zero within 17 years and completely destroys the iceberg before the horizontal length decreases enough for the iceberg to capsize (not shown). Abello et al. (2025) correct the unphysical capsizing criterion in NEMO, a change that will be implemented in new model configurations. On the other hand, eliminating the relevant bias in the horizontal wave erosion remains an important outstanding issue left to future studies."

5) It was my understanding that the original NEMO-ICB used the erroneous capsizing criterion of Bigg et al (2017). We published a correction to this in Wagner et al (Ocean Modeling, 2017, https://doi.org/10.1016/j.ocemod.2017.07.003) and I discussed this briefly with Bob Marsh back then but never followed up. I just want to make sure the capsizing errors have been fixed, if there ever were any.

Compared to Wagner et al. (OM, 2017) and Bigg et al. (2017), the present capsizing criterion uses a different power law, namely:

SQRT(0.92*(KeelDepth**2) + 58.32*KeelDepth))

This makes a direct comparison with Wagner et al. (OM, 2017) formulation more difficult.

However, it stands out that in the present NEMO-ICB version, the criterion is applied as a comparison between the iceberg horizontal length and keel depth. Wagner et al. (OM, 2017) suggests that the appropriate comparison should be between the horizontal width and the full thickness rather than the horizontal length and the keel depth. The full thickness swaps with the horizontal width when the iceberg rotates. Analysing and improving the capsizing is beyond the scope of our current manuscript. However, our companion manuscript Abello et al. (2025) introduces an updated rolling criterion in NEMO that is based on the ratio between horizontal width and the full thickness while taking into account the exact issues highlighted in Wagner et al. (OM, 2017).

As we say above, lines 846-858 now state:

"In order to explore the potential for capsizing, we have extended our four-year LONG simulation with THICK icebergs up to 20 years by applying a repeat cycle of the same four-year surface boundary conditions. We see that in our extended LONG simulation, the rate of lateral melting indeed exceeds the rate of basal melting, with a potentially unrealistically large contribution of wave erosion to the former. One may expect that this causes widespread capsizing of grounded icebergs. However, the pre-existing NEMO capsizing criterion incorrectly compares horizontal length rather than horizontal width against vertical thickness. As a result, the excessive lateral melting of individual grounded icebergs eventually reduces the horizontal width to zero within 17 years and completely destroys the iceberg before the horizontal length decreases enough for the iceberg to capsize (not shown). Abello et al. (2025) correct the unphysical capsizing criterion in NEMO, a change that will be implemented in new model configurations. On the other hand, eliminating the relevant bias in the horizontal wave erosion remains an important outstanding issue left to future studies."

Specific comments:

A number of mostly minor and technical comments are provided as annotations to the attached pdf.

Thank you for your detailed feedback. We have responded to these comments line by line below and implemented your suggestions in the text.

Dear authors - I am often wrong, and if you think that any of my comments are misguided please reach out to me and I'll be eager to amend my review.

Till Wagner

Line 10: not sure I'd call it ubiquitious - maybe "commonly observed"?

Thank you, we have replaced it with "commonly observed" (Line 10).

Lines 12-13, remove text: Strikethrough text

Thank you, we have shortened the text as suggested (Lines 12-13).

Line 27: just note that this is given as "2025" elsewhere.

Thank you, we have changed "in prep." to 2025 (Line 26).

Lines 30-39: This paragraph could be shortened to 1 or 2 sentences?

Lines 33-42: Thank you for this suggestion, but we think that it is important to refer the reader to broadly relevant previous literature on icebergs. This entire paragraph is composed of citations of previous publications that we prefer not to remove from our reference list.

Lines 31-32: see also: Duprat, L., Bigg, G. & Wilton, D. Enhanced Southern Ocean marine productivity due to fertilization by giant icebergs. Nature Geosci 9, 219–221 (2016). https://doi.org/10.1038/ngeo2633

Thank you, we have cited Duprat et al. (2016) here (Line 41).

Line 43: there is also a body of literature that looks at iceberg scouring to shed light on paleo processes. 2 examples: Hill, J., Condron, A. Subtropical iceberg scours and meltwater routing in the deglacial western North Atlantic. Nature Geosci 7, 806–810 (2014). https://doi.org/10.1038/ngeo2267 and Starr, A., Hall, I.R., Barker, S. et al. Antarctic icebergs reorganize ocean circulation during Pleistocene glacials. Nature 589, 236–241 (2021). https://doi.org/10.1038/s41586-020-03094-7

Thank you, we have cited the suggested literature on iceberg scours in a paleoclimate context (Lines 46-48).

Line 44: just a note that, relatedly, Stern et al (2015) https://doi.org/10.1002/2015JC010805 found that grounded icebergs can act much like islands, in the sense that they can cause upwelling on the downwind side and increased stratification on the upwind side. Which made me wonder - how much of the differences in sea ice cover between east and west of Bear Ridge is due to icebergs mechanically blocking the sea ice advection and how much is due to the icebergs causing different ocean conditions on the two sides? Also, I found it interesting that these differences in turn impact the melt process of the iceberg itself (disclaimer - I'm an n-th author of that paper).

Thank you for pointing us to this reference. We have cited it here (Line 50) in the context of modified ocean conditions sustained by grounded icebergs. We avoid speculating whether such a downwelling effect on the eastern side of Bear Ridge contributes significantly to the sea-ice dipole. Bett et al. (2020) found that representing the grounded bergs as a thin ice shelf had the same effect on sea-ice as representing them as land. This may suggest that the impact of the altered ocean conditions on sea-ice is small compared to the direct blocking of sea-ice advection. We now point this out more clearly in Lines 53-55.

Line 62: maybe better in quotation marks? "wall of icebergs"

Lines 36, 69, 451: Yes, we have added quotation marks, as you suggest.

Lines 65-67: I would argue that there were important efforts quite a bit earlier - e.g., Mountain (1980) https://doi.org/10.1016/0165-232X(80)90055-5 and Smith and Banke (1983) https://doi.org/10.1016/0165-232X(83)90045-9

Maybe it would be more accurate to say that most currently used iceberg models can be traced back to Bigg et al (1997) and Gladstone et al (2001).

Thank you for pointing us to these references. We have cited them here (lines 74-76) and rephrased the statement about Bigg et al. (1997) and Gladstone et al. (2001) in lines 74-76.

Interestingly, Mountain (1980) actually assumes that Ekman currents play an important role in driving iceberg motion. So we have also cited this in our Section 4.1 (line 555-556) when discussing the ageostrophic contribution to the ocean dynamics around icebergs.

Lines 99-106: paragraph could maybe be shortened

Lines 109-116: Yes, we have made this paragraph more concise, as you suggested.

Line 112: Shoal

Line 123: Thank you. We have replaced "shallow" with "shoal," as you suggest.

Line 132: in my experience "capsizing" is used more typically in the literature

Lines 144, 157: Thank you. We have replaced "toppled" with "capsized," as you suggest.

Line 132: note that the standard capsizing criterion that was used by Bigg et al (1997) and most subsequent iceberg modeling studies dated back to Weeks and Mellor (1978) https://doi.org/10.1016/B978-0-08-022916-4.50015-7 and featured some errors that led to icebergs continually capsizing among other things (see also my general comment 5).

A direct comparison between the existing NEMO capsizing criteria and the Wagner et al. (OM, 2017) formulation is difficult because they follow different power laws. However, it stands out that in the present NEMO-ICB version, the criterion is applied as a comparison between the iceberg horizontal length and keel depth. Wagner et al. (OM, 2017) suggests that the appropriate comparison should be between the width and the full thickness rather than the length and the keel depth. The full thickness swaps with the horizontal width when the iceberg rotates. Analysing and improving the capsizing is beyond the scope of our current manuscript. However, our companion manuscript Olive Abello et al. (2025) introduce an updated rolling criterion in NEMO that is based on the ratio between horizontal width and the full thickness while taking into account the exact issues highlighted in Wagner et al. (OM, 2017). We have already cited Olive Abello et al. (2025), but we also refer to it when discussing the capsizing criterion and its update in NEMO (Lines 362-382 and 846-858).

Figure 2: Instead of using a schematic for panel (c), could you take an actual representative cross-section example - and you could mark that cross-section on the map of panel a or b?

Figure 2: Thank you for this suggestion, which we have carefully considered. However, individual sections do not necessarily provide a clearer picture compared to this schematic, which is very representative of typical scour shapes.

Line 155: could you mention in this paragraph briefly why you're interested in WBD and shear strength - I was wondering about it until I got quite a bit further down.

Thank you, yes, we now mention that WBD and shear strength determine the sediment resistance forces acting on grounded icebergs (Line 168).

Line 168: Strikethrough text

Thank you for suggesting this correction. We have removed the "s." (Line 184).

Figure 3: It's not clear to me exactly how the partition of the 3 layers plays out in this plot - maybe you could color the markers accordingly or draw approximate boxes around them.

I was also wondering whether different colors (or using different markers) for different cores may be insightful?

Figure 3: Yes, we have made sure that the three layers are differentiated in this figure by drawing boxes around the data markers while using distinct color and line types for the box contours.

Lines 200-201: are these two sentences needed?

In order to make the text more concise, we have removed these sentences (Line 216).

Line 204: Strikethrough text

Line 219 Thank you for pointing out this typo. We have corrected it.

Line 204: And

Line 219: Thank you for pointing out this typo. We have corrected it.

Line 208: Martin and Adcroft (2010) distinguished between form drag and skin drag. How does NEMO-ICB deal with this?

[As a sidenote: we looked in some detail at the relative importance of form vs skin drag and found that this varies substantially depending on whether you have a high length-to-height ratio or one that is O(1) - take a look if you're interested: https://doi.org/10.1175/JPO-D-20-0275.1

See also a further comment on C_drag below.

Lines 223 and 543-544: Here we have clarified that NEMO-ICB assumes form drag, and we have cited Martin and Adcroft (2010), as well as Wagner et al. (2022).

Line 239: Maybe a short paragraph on the melt representation in NEMO-ICB following here?

Line 362: You suggest adding a short paragraph on the melt representation here. We think this might be more appropriate after Line 362, and we have added it there, as a new subsection 3.3.

Lines 241-243: Maybe it's worth mentioning that you envisage the icebergs to plough a triangular (v-shaped) trench into the sediment, however, the motion of the iceberg is computed using a perfectly rectangular iceberg. (I've always assumed that these

icebergs are approximately flat at the bottom, which makes me think: how do they leave v-shaped scours? Am I missing something obvious?)

Thank you! Yes, we have mentioned that guided by observations, we assume that iceberg keels plough v-shaped trenches into the sediment (Lines 260-262). Even tabular icebergs are not flat at the bottom but rough (Lines 139-140), typically with a v-shaped protrusion. We state that our assumption about the keel shape is based on the indirect evidence provided by iceberg scours (Lines 260-262). In addition, in line 871 we explain that future radar sounding observations may reveal the distribution of iceberg keel shapes.

Line 256 and Section 2.2: is this the same as WBD ? maybe clarify ?

Lines 168, 170, 188, 292 in Sections 2.2 and 3.2: Yes, thank you for pointing out the inconsistent use of terminology which we have fixed. We assume fully saturated sediment, so in our case WBD is the same as saturated density. We now use consistent terminology in these lines.

Line 267, Eq. 11: could move this term in front of the curly bracket, since it's the same for the two cases?

Line 283, Eq. 11: We have moved the common factor outside the curly brackets, as you suggest.

Lines 274-277: maybe this should be moved to near line 170 ?

Yes, as you suggest, we have moved these sentences to lines 173-175.

Line 299: you provide a reference and more discussion for this later- I would move it up here and shorten

Thank you! We have moved the sentences and the Veldhuijsen et al. reference to Lines 313-315 of the new text.

Line 321: Strikethrough text

We have fixed the mistyped sentence, as you suggest (Line 331).

Line 321: of motion

We have fixed the mistyped sentence, as you suggest (Line 331).

Line 321: Strikethrough text

We have fixed the mistyped sentence, as you suggest (Line 331).

Line 321: capped?

Line 334: Yes, we have rephrased "limited" to "capped."

Lines 329-330: maybe discuss briefly here what range you tested and that the results are fairly insensitive to this exact value. Looking at Appendix B it seems to me that the effect of mu is saturated once you exceed 0.002, and the main differences arise somewhere in the range mu = [0,0.002]. Did you look at smaller values as well?

Lines 336-342: We have referred to the Appendix B results here in more detail. We state that we have done tests with values higher and lower than 0.002, including a case with no Coulomb friction that still includes sediment resistance and gravity. We point the reader to Appendix B.

Line 339 and equation 18: d

Line 333 and equation 15: Thank you! We have fixed the typo.

Line 341: force

Line 353: Thank you! We have added the missing word "force," as you point out.

Lines 344-361: I wonder whether this paragraph could be cut/shortened/moved to the appendix?

Lines 356-361: Thank you for this suggestion, we now briefly mention the curvature term here and elaborate only in the Appendix B.

Lines 407-419: This paragraph could maybe be summarized in a sentence or two?

Lines 423-431: Thank you for this suggestion. We have shortened this paragraph.

Lines 449-451: move this density discussion up (see earlier comment).

Yes, we have moved this discussion and the Veldhuijsen et al. reference to Lines 313-315 of the new text.

Line 471: maybe mention here somewhere how melt and ungrounding happens (+capsizing?) - see my general comment 4.

Lines 488-489: Thank you for this suggestion. Here we point out that complete un-grounding and the resumption of free flotation can be due to the melting process and compare the relative roles of basal melting versus lateral melting and capsizing.

Section 4.1: The following analysis is a really interesting step forward! I've always felt a little uneasy about our approximation ignoring the ageostrophic currents.

I will say that I struggled a bit to follow the argument of the next few pages in detail, I guess at least in part because I'm used to thinking of it in terms of the force balance equations, rather than just the accelerations. And since I think of the drags, for example, as "surface forces" acting on cross-sectional areas and Coriolis and gravity as "body forces" acting on the mass of the iceberg, I found myself doing some cognitive aerobics reconciling the two frameworks. I am not suggesting you recast the whole argument in terms of forces, but maybe you can go over the text once more with a critical eye to make it as clear as possible?

Section 4.1: Thank you for your feedback! We have rephrased this part of the text to make it clearer. For example, when we discuss the atmospheric terms in the momentum budget, we point out that they are an external source of iceberg acceleration (Lines 586-587). The question then becomes what balances these external forces (Lines 586-587). When discussing the drag terms, we specify that they are form drag (lines 543-544, 599, 610). When discussing actual values of the drag terms, we point out that they are direct output from the model (Line 613). When referring to the geostrophic component of ambient ocean flow, we suggest that it is indeed a “dominant” component (Line 664) without implying that Ekman transport is negligible.

Line 542, Eq. 22: this reminds me of the discussion in Bigg et al (1996) - see their eq (4)

Line 563, Eq. 19: Thank you for pointing this out. We have cited Bigg et al. (1996) elsewhere, and we also cite that reference here. We point the reader to eq (4) in Bigg et al. (1996).

Lines 590-599: this may speak to my confusio (see comment above) - how exactly is C_drag obtained here?

Lines 598-600: Thank you for pointing out the need for greater clarity! We now specify that this is form drag (reiterating this in lines 543-544), which is calculated as a function of the fluid density and iceberg geometry. And in lines 613-614, we specify that the values cited here are output directly by the model during the respective simulations.

Lines 590-599: following up on an earlier comment, it appears that C_drag represents the form drag only? (For skin drag in the limit of thin icebergs the atmospheric and oceanic drag coefficients are comparable - see Wagner et al (2022)). Might be helpful to clarify what C_drag represents.

Lines 598-600: Thank you once again for your feedback! We have clarified that this is form drag (reiterating this in lines 543-544), which is calculated as a function of the fluid density and iceberg geometry. We cite Wagner et al (2022). We specify that the values cited here are output directly by the model during the respective simulations.

Lines 710-711: this is largely a repeat of l 696/697. Also, maybe make it clear when you first introduce MEDIUM icebergs that these do not feature in the grounding discussion?

Line 731: We agree and remove these lines because re-stating this information here is redundant to previous lines. Moreover, as you suggest, we point out earlier, in Lines 467-469, that MEDIUM icebergs do not feature in the grounding analysis.

Line 754: Strikethrough text

Line 773: Thank you! We have moved the quotation mark outside the word "kinetic".

Line 754: "

Line 773: Thank you! We have moved the quotation mark outside the word "kinetic".

Line 766: Strikethrough text

Line 785: We have moved the word "only," as you suggest and deleted the phrase "the course of."

Line 766: Strikethrough text

Line 785: We have moved the word "only," as you suggest and deleted the phrase "the course of."

Line 766: only

Line 785: We have moved the word "only," as you suggest and deleted the phrase "the course of."

Line 785, Figure 13 caption: cut?

Figure 13 caption: We deleted the mistyped word "and," as you suggest.

Lines 797-798: something went wrong here - revise?

Lines 813-815: Yes, we apologize for accidentally pasting the unnecessary words at the end of the sentence. We have deleted them.

Lines 797-798: Strikethrough text

Lines 814-815: Yes, we apologize for accidentally pasting the unnecessary words at the end of the sentence. We have deleted them.

Lines 812-813: Maybe this can be combined with the first discussion of mu on l 329? See also my comment there.

Thank you, we have indeed moved that to the earlier discussion of mu in Lines 338-342.

Figure 15: I'm missing something here, sorry - how do you have acceleration in the case of "statically grounded" ? Could this be rephrased?

Figure 15 and Lines 831-836: We accept your suggestion. In the case of statically grounded icebergs, we rephrase "acceleration" to "force per unit mass."

Lines 854-896 on page 32: I feel like this page could be shortened?

We have now made the whole Summary and Conclusions section more concise. At the same time, on your request (Revewer #2), we had to expand the discussion of melting in NEMO and its dependence on iceberg lengthscale.

Lines 867-869: note that this was studied (and indeed found to be the case) in England et al (2022) https://doi.org/10.1126/sciadv.abd1273 (disclaimer: I'm a co-author) and breakup was implemented in the GFDL model in Huth et al (2023) https://doi.org/10.1029/2021MS002869

In my experience, breakup is a first-order process for large icebergs. I'd be excited to talk more if you're interested in adding something like this to NEMO ?

Lines 885-886: Thank you for pointing us to these references, which we cite here. It is noteworthy that England et al (2022) demonstrate the potential for iceberg fragments to move at a different angle relative to parent icebergs. In England et al. (2022) the Wagner et al. (2017) analytical model is directly imposed on icebergs. At the same time, it would be interesting if a future study explores whether this motion of iceberg fragments appears as an emergent phenomenon when all model forces are applied to the iceberg momentum budget. There is also indeed potential room to improve the iceberg representation in NEMO by introducing fragmentation. WE have cited Huth et al. (2022) in lines 892-894.

Lines 872-873: I think it does, and I think the NEMO model accounts for that (?) see my comment earlier.

Lines 890-892: Yes, we include a clarification that the melting in NEMO is indeed a function of the relative velocity and the geometry. Our results imply that the iceberg lengthscale impacts the rate of melting not only by changing the geometry of the icebergs but via an impact on the relative velocity. This impact on melting via the relative velocity is an interesting new avenue for exploration in a future study, especially if it naturally emerges from the full set of dynamical and thermodynamical forcing factors applied to simulated icebergs.

Line 1134: Strikethrough text

Line 934: Thank you. We have deleted the typo.