“Quantifying the Buttressing Contribution of Sea Ice to Crane Glacier”, by Parsons et al. - egusphere-2024-1499

The manuscript quantifies the buttressing effect of land-fast sea ice on the Crane Glacier. The authors use the 2022 disintegration of the fast ice that occupied the Larsen B embayment as a reference to quantify the buttressing. The main findings showed that the land-fast sea ice provided significant buttressing to the glacier with a mean buttressing number of 0.68 and that the loss of this buttressing led to increased extensional stresses and rapid calving, triggering further acceleration of ice flow.

This study provides new insights into the significance of fast ice for the structural stability of ice shelves and how the resistant stresses of the floating ice respond to the absence of surrounding fast ice. It quantifies this effect for the first time using numerical modelling.

This work is an important addition to the current scientific debate about the importance of sea ice (in this article land-fast sea ice) in stabilising ice shelves. The novelty lies in using numerical modelling for the first time to quantify the buttressing effect of fast-ice/melange.

The manuscript is well written and gives a good picture of the current knowledge of sea ice - ice shelf interaction/ glacier interaction, with a specific review of the recent work on the 2022 disintegration event.

Comments regarding the overall text:

One of the main issues that needs to be addressed before publication is the use of the term "sea ice." This term encompasses various types of ice. This article focuses on sea ice that is connected to the land (known as land-fast sea ice or fast-ice), and contains calving debris of different sizes, forming a dense melange. It's important to note that this type of "sea ice" is not smooth, nor even in its thickness, and this distinction is crucial because a reader might assume that any sea ice type could generate buttressing.

The paper would benefit if it included a more in-depth discussion about the minimum expected thickness that would generate significant backstress. According to the sensitivity analysis, even a 40% reduction in this particular case won't make a significant change. This is important because it relates to the likely thickness that fast-ice might need to create buttressing, and this will depend on the age and genesis of the formation of the fast-ice/melange.

Please make sure to clarify the methodology used to define the grounding line. It was mentioned that the floating criteria is used in combination with the REMA DEM, but it's important to provide more details. Additionally, has this method been compared with other datasets, such as the one described in the study by Rott et al. (2018)? In the supplementary materials this is mentioned with more detail. Please add the references from where the grounding line was taken to the main text.

Is there space to create a map similar to the ones that Fürst et al. (2016) created for Antarctica, but for the entire boundary area? Additionally, it would be beneficial to include a

paragraph in the conclusions discussing how further research in other regions of Antarctica, which are not fjord-like embayments, will contribute to a comprehensive understanding of the significance of melange/land-fast sea ice in buttressing Antarctic glaciers/ice shelves.

If section 3.6 it's joined with 4.3 the sensitivity analysis reads better and it's easier to understand. As it is now it reads disjointed, with 3.6 finishing abruptly. Lastly, please ensure that all the supplementary materials are well formatted and the captions are correct.

Comments on figures:

For ALL figures, the size of ticks and axes labels must be larger. They should be easy to read on an A4 printed paper.

Figure 1: The colours selected for the model boundary, glacier and fast-ice extent (filled and dashed) lines are hard to see, especially the dashed ones; choose colours with better contrast over the underlying image, and consider that it might be printed in greyscale. Please add labels to the different panes (A and B) and refer to them in the text accordingly. Add the glacier terminus over the Dec-2021 image. Could it be possible to add a panel showing just the terminus of the glacier? In order to understand how fractured the glacier is and how the terminus was defined. Mention in the legend that the image is in polar stereographic projection.

Figure 2: Please add the dates of acquisition on the different panel titles and labels to each panel (a, b, c, d, and e) and use them when referencing in the text. If the projection is added, there is no need to add the x and y labels. I will leave the ticks labels in metres and less frequently, the same for Figures 1, 3e, 4, and 5. I would add the word “digitised” to: …the white line shows the digitised terminus position.

Figure 3: Even though "dotted line" is correct when referring to a dotted or dashed line, I would specifically write “dashed line” for the different examples shown here. Increase the size of the month-year labels in panel e.

Figure 4: An inset zooming into the edge of the terminus on panel b would help to better visualize the exchange in stress distribution at the terminus. The blue arrows are barely visible; the inset would also help with this. The last sentence can be removed as is also in the text.

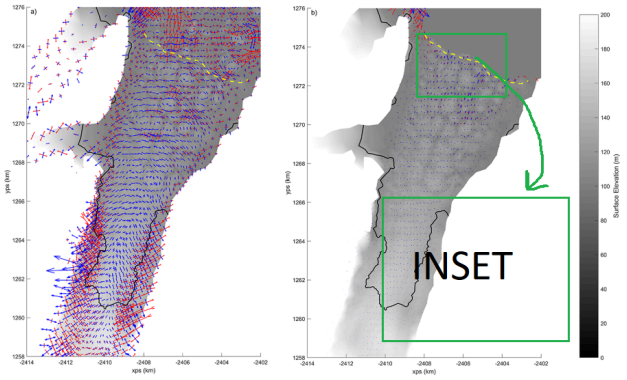

Figure 5: This figure is important for understanding the thickness distribution along the glacier margins and its relationship to the buttressing number.However, it's quite challenging to comprehend this from the surface models. To help with this, it would be beneficial to have a graph showing the thickness distribution and another graph displaying the variability of the buttressing number along the sampled line. Furthermore, including only two end members and the original DEM, in addition to the graphs, will help focus on highlighting the low significance of the thickness reduction on the buttressing number.

In-text comments:

Line 14 to 20 - Introduce Fraser, et al 2021 and/or Fraser et al 2023, to present changes in fast ice that are more relatable to this paper than changes in broader sea ice.

Line 25 - It says … of sea ice … it should say … of land-fast sea ice …, or fast -ice if it was defined before.

Line 65 - add Gudmundsson, 2013 alongside Schoof, 2007.

Line 85 - Floatation Criterion should be Flotation Criterion.

Line 85 - Citations are needed for the grounding line and floatation criterion.

Line 100 to 104 - Could this long sentence be divided in two? It's very hard to comprehend what the authors are trying to say.

Line 220 - It says … the sea ice … it should say … the fast-ice …, or melange.

Line 265 - Please add more statistics, standard deviation, min, max of the ice/melange thickness.

Line 275 - Again not sea ice, either fast-ice or melange, please change in other places throughout the text.

References

Fraser, A. D., Wongpan, P., Langhorne, P. J., Klekociuk, A. R., Kusahara, K., Lannuzel, D., ... & Wienecke, B. (2023). Antarctic landfast sea ice: A review of its physics, biogeochemistry and ecology. Reviews of Geophysics, 61(2), e2022RG000770.

Fraser, A. D., Massom, R. A., Handcock, M. S., Reid, P., Ohshima, K. I., Raphael, M. N., ... & Porter-Smith, R. (2021). Eighteen-year record of circum-Antarctic landfast-sea-ice distribution allows detailed baseline characterisation and reveals trends and variability. The Cryosphere, 15(11), 5061-5077.

Fürst, J. J., Durand, G., Gillet-Chaulet, F., Tavard, L., Rankl, M., Braun, M., & Gagliardini, O. (2016). The safety band of Antarctic ice shelves. Nature Climate Change, 6(5), 479-482.

Gudmundsson, G.: Ice-shelf buttressing and the stability of marine ice sheets, The Cryosphere, 7, 647–655, 2013

Rott, H., Abdel Jaber, W., Wuite, J., Scheiblauer, S., Floricioiu, D., Van Wessem, J. M., ... & Van Den Broeke, M. R. (2018). Changing pattern of ice flow and mass balance for glaciers discharging into the Larsen A and B embayments, Antarctic Peninsula, 2011 to 2016. The Cryosphere, 12(4), 1273-1291.