Review of The impact of landfast sea ice buttressing on ice dynamic speedup in the Larsen-B Embayment, Antarctica, Surawy-Stepney et al., 2023

This study focusses on the disappearance of the landfast sea ice from the Larsen B embayment in Jan 2022, and the impact this had on the glaciers that terminated in the region. The paper starts with an extensive summary of observations extracted from satellite data for the region, homing in on the Hektoria, Green and Crane glaciers that experienced the biggest speed up following the disappearance of the landfast sea ice.

Give the timing, it is most likely that the disappearance of the landfast sea ice caused the speed up of the glaciers in the region. However, the exact mechanism by which this occurred is uncertain. In this study, the authors are answering the valuable question of whether the sea ice conferred stability on the glaciers directly through a buttressing mechanism akin to the buttressing effect of confined ice shelves on upstream grounded ice.

They investigate both the direct buttressing of the grounded portion of the glaciers, and the buttressing of the floating ice tongues. The study uses a diagnostic numerical model to look at the flow speeds and stresses within the glacier, with and without an "ice shelf" of fixed thickness ranging from 1m to 50m, that represents the sea ice.

The conclusion of the paper is that the direct buttressing effect is too small to explain the observed disintegration of the ice tongues and so other mechanisms must be at play through which the sea ice conferred stability on the glaciers in the region. The authors provide many caveats on the limitation of the study such as the unknowns in the geometry.

I enjoyed reading the paper. The manuscript was well written, with a clear narrative that leads you through the paper, but I felt there were a few places where some more explanation is needed. Details below. I would fully recommend publication with these changes.

Specific Comments (in chronological order, not necessarily importance):

1. L4: "satellite measurements show that Hektoria, Green and Crane Glaciers have sped up by… more than 100 m a^{-1}." As it stands, it is not clear that these observations constitute part of the novel contribution of this paper, and yet Section 2 is devoted to the processing of the satellite data to arrive at these values. Perhaps add something like "*we show from* satellite measurements that Hektoria, …"

2. L79: "Speed changes extend up to 10 km upstream of the 2021 grounding line on Hektoria, Green and Crane Glaciers, where the speed up is most pronounced." Does this refer to the speed up being most pronounced on Crane glacier, or the 10km

upstream, or indeed on all three glaciers relative to the rest of the region? Consider rewording.

3. There are two places where the paper refers to “mean” ice speed, but it isn’t clear whether that is data averaged over time, or a spatial average. It would be helpful for that to be made explicit.
    a. The first is the grey-scale plot in Fig 1.a “Inverse-error-weighted mean ice speed of glaciers… between October 2014 and April 2023”. Is this the average over that entire time period? I found it surprising to have the average over such a long time, spanning the entire period that changes are being investigated in the study, if that is indeed what is plotted.
    b. The second is on L123: “mean observed ice speed across…in 2021”. Is this what was plotted in greyscale in Fig 1a? Or is this an average over data gathered in 2021? Or in this case is it a spatial average?

4. L123. Add an explanation of what the enhancement factor \phi is in Biscicles. I don’t think the authors define \bar{\mu} at any point in the paper (introduced on L502); presumably the viscosity? But the relationship to the enhancement factor is unclear. It would be helpful to explain how the rheology is set in the simulation.

5. L151-153. It wasn’t immediately clear to me why this choice of Coulomb sliding law would ensure that “basal stresses on much of the grounded ice remain relatively unchanged”. Could the authors elaborate?

6. L175-183, Fig 3 and Appendix A2. This section about the sensitivity to the ice thickness is quite difficult to make sense of and I think generally needs more explanation. It can feel a bit vague and confusing at points as it stands. I’ve added some specific points below:
    a. The label on Fig 3.a is “ln(Du/D\phi)”. The caption says that (a) is log and (b) is linear. Does that mean the y-axis in Fig 3.b is “Du/D\phi”? It would be clearer to label the y-axis that way rather than simply “sensitivity”, or define “sensitivity” in the caption.
    b. Could the authors expand on the derivation of Eqs (A3) and (A4) in the appendix? The reference to Goldberg & Sergienko 2011 is sufficiently different to the problem set up that it would be helpful to provide the full derivation here, and lay out the assumptions more clearly.
    c. Is the exact location of the coloured circles in Fig 3.a significant? My understanding from the text in the Appendix is that they mark the model domain \Omega_{HC} and represent the catchment area of the two glaciers, but reading the caption for Fig 3a it was quite confusing. “Magnitudes of different sensitivities of ice speed in the locations marked by the coloured circles…” It sounds as if those are two singular points. I would suggest either representing the domain \Omega_{HC} by an outline in the figure, or at least refer to “*regions* marked” not “*locations* marked” in the caption.

7. L192 – 199 and Fig 4. Could the authors elaborate on how they extracted the principal strain and stress components across the region? Is the direction for \epsilon_1 and \sigma_1 determined for each parcel of ice, or is it taken as the average for the domain?

8. The paper is well written overall, but Section 4 (Discussion) was generally a bit weaker than the rest of the paper, and lets it down. A few specific notes:
    a. Section 4.2 presents new data and comes as a bit of a surprise when reading the discussion section. Perhaps a more natural home for this section is under "Section 2. Observations"?
    b. L300: "Several studies have indicated the importance of sea ice…and the results of this study do little to suggest otherwise." The modelling results of this paper generally show that the buttressing action of the sea ice is not significant, so shouldn't this be "despite the results of this paper"?
    c. L302: "However, to more accurately judge the extent to which sea ice stabilises ice shelves… measurements at the critical zone near glacier calving fronts." This statement would be more meaningful if the authors gave specific detail about how access to these measurements would have helped their modelling study. What would different measurements enable you to do differently/more accurately in the study?
    d. L308: "We argue that the results represent an upper bound…. assuming viscous rheology, however, this may not be the case". I think given what follows, the authors mean that the results may not be restricted to *viscous* rheology, but it reads as if it may not be any kind of upper bound. Consider rewording that sentence.
    e. L310: "the specification of a particular constitutive relation has no impact on the stress distribution". I'm not sure what the authors are saying here; a different value for viscosity would certainly change the equilibrium profile of an ice shelf. Could this point be explained more?
    f. L311: "Fig. 3 a suggests that the sea ice in front of the centre of the ice shelf…has greatest impact on upstream flow." I assume this is referring to the magnitude of "ln(Du/D\phi)" in the plot, and yet by eye the values seem rather similar for all the sea ice in front of the ice shelf not just along the centre line. Could this be clarified?

Technical Corrections:

1. Fig 1(f). There is a mismatch between the figure legend and the caption, one has "HGE" and the other "Hektoria Glacier". I think in this case the time series does relate to Hektoria Glacier specifically so the legend on the plot should be updated?
2. Fig 3.b.1. The y-axis ticks are obscured by the label.
3. L136. "thin-ice-covered *leads*". I'd never heard this term before, is it a typo?

4. Fig 4a. The grey dashed line for the floating ice region of HGE does not line up with the edge of the reddish coloured domain. Is this just a plotting problem or is there something else going on here?
5. L216. “geomeotry” typo
6. L225. “to” missing
7. L316 “chocking” I’m not sure what that means in this context. Could it be a typo?
8. L538. “between” repeated.