Overview

This study makes use of a variety of datasets collected in the field and supplemented by satellite derived remote sensing data to investigate the role that landfast sea ice and melange may play in regulating iceberg calving at three outlet glaciers in Northwest Greenland.

Whilst the data collected and analysed in this study is novel and provides a fantastic opportunity to add nuance to the dynamic behaviour of the combined glacier, melange and fast ice regions over much shorter time intervals than is possible using satellite data, the evidence as currently presented is not a robust proof of the conclusions drawn from the study. Further use of remote sensing data could be used to investigate correlations between the extent and thickness of landfast sea ice and to gain further insight into the overall calving dynamics of the glaciers. The role of melange and fast ice in buttressing and suppression of calving is an important topic to address and with major revisions to the manuscript, this study could be very beneficial to furthering understanding in this area.

Major Comments

- It is not explicitly stated in the methods how the roles of landfast sea ice and melange are distinguished in modulating the calving behaviours. This appears to be given by the extent of the fast ice? Further clarification could be given on this i.e. how the spatial coverage of the fast ice within the fjord changes throughout the assessed time period and how this correlates to calving and velocity changes. Satellite imagery could be used to quantify this. Similarly, the thickness of the fast ice could be an important factor – are any measurements available (either from the field or from altimetry) to quantify how the thickness changes over the time period? Note that times of maximum and minimum sea ice thickness are mentioned in the manuscript but it is not clear how these thicknesses were measured. Again, it would be interesting to see how thickness correlates to the velocities and calving dynamics.
- The distinction between velocities at different points within the glacier compared to velocities within the fast ice may be misleading. We may expect the velocities to increase as the ice approaches the terminus (or flotation – are they grounded at the time of these measurements as they are mentioned to transiently float in the introduction?). A 2D velocity map would show the spatial change in velocity better and could still be used to illustrate the temporal changes in velocity as Figure 5b attempts.
- The differences in velocities as presented in Figure 5b are used to infer that the fast ice does not significantly buttress the glaciers (Section 4.2). The velocities can be used to calculate strain rates and with knowledge of the thickness of the fast ice the backstress can be quantified, so we don't need to speculate on this.
- The conclusions of the study are based on calving events identified through satellite imagery (shown in Figure 10). Whilst larger calving events may be discernible from satellite imagery, smaller events cannot be identified, as is discussed in the manuscript. Assessing calving through this methodology may therefore not tell the whole story. The 'overall' calving rate could be analysed from remote sensing data as the difference between the glacier's flow velocity and the change in the calving front position over time. Considering averaged calving rates in this way rather than as discreet events may shed more light, in particular if they can be plotted against changes in fast ice thickness / extent.
- It is difficult to conclude from the results as currently presented where correlation and causation between the factors discussed in the study lie. Restructuring the results could therefore be beneficial in comparing the relationship between all of the variables discussed. For example could a single plot show a time series of velocities, calving rates, sea/air temperatures, smb/melt rates etc. would make a nice visual comparison of correlated events.
- The glaciers assessed in this study are discussed as being widely representative of Greenland's outlet glaciers due to the different calving styles observed however further information on the flow speeds / widths / thicknesses etc of the glaciers may help the reader to determine how representative these glaciers are in the wider context. Adding this information in a table may help.

We also need to understand the thickness and the extent of the fast ice and melange regions as these may vary in different regions around Greenland. Similarly, the topography/confinement of the fjord may also impact how readily backstresses from fast ice may be transmitted to the glaciers. It is therefore not clear whether the results presented here can be considered representative across Greenland.

Specific Comments

Figure 2 – It is later discussed that the start points of the buoys were influenced by accessibility / patterns of melange then a basemap from around the time of deployment would be useful. Were certain spatial coverages of the buoys targeted?

Line 227 – 'the melange velocities when bounded by landfast sea ice' - when exactly were these not bound by the fast ice? Can a figure be referenced in relation to this statement?

Line 236 – 'a more spatially dispersed dataset is necessary to fully determine this' – can satellite data be used in this sense?

General – the results sections tend to contain some interpretation which may be better placed in the discussion sections - and in some cases is repeated/contradicted later in the discussion. For example line 241 – 'these large abrupt movements likely represent large calving events' and line 408/409 'it is difficult to judge therefore if the abrupt movements reflect stress relief in the melange that then leads to calving, or if the iceberg calving leads to the abrupt jump..'

Figure 3 – the plot scale on panel b) could be changed so we can better see the velocities for the majority of the data – which are mostly <50 m d^{-1} (note units don't need the 'x' in m x d^{-1}). In panel a) it is not clear why a base map from 2024 is used? Could large iceberg fragments influence the lateral deviation in movement (particularly seen in red / blue / orange / yellow buoys? There may be a better visual representation of this. The grey outline of the start point is not clear. Same comments apply to Figure 4.

Line 263/264 – 'The Sentinel-1 data has a 12 day repeat orbit which means it cannot be used to assess the abrupt events identified in the GNSS buoy data' . Do the calving front time series in Figure 9 not correlate? Plotting the calving front time series under fig 3b / 4b may allow correlation to be identified?

Line 268/269 – the melange zone and outer fast ice zones are mentioned a few times – can you mark on a figure what you mean by these zones?

Figure 5 – Flow speeds are shown, not velocities. Can 2D velocity maps be used to better illustrate the spatial changes in velocity?

Figure 6 / 7/ 8 – The colour scheme makes it quite difficult to follow the difference between sequential months. Are the spatial scales different? If so why?

Figure 7 /8 – is it necessary to plot the calving fronts which are clearly wrong and can be discounted from the datasets? Are any higher resolution basemaps available?

Figure 9 – can the central flow lines that these refer to be marked on Figures 6 -8 for reference? More subdivisions on the x axis would make it easier to see how this correlates to the displacements shown in figs 3 and 4. Even better to combine with figs 3 and 4.

Figure 10 – title not required – this is covered in the caption.

Figure 12 – Refer to panels a and b (rather than left and right) for consistency. Titles are not needed and they reference Qaanaaq – should this be a specific outlet glacier? Can a colour scale or legend be added to show what times the dots refer to?

Figure 13 - What are the intervals that are referred to in the caption? The caption could be a bit more detailed to ensure that the figure can be interpreted without needing to refer back to the main text. Refer to panels a and b (rather than top and bottom) for consistency.

Line 439 – 'given the importance of melt and glacier sliding on velocities, it is likely that these processes are also moderating calving activity'. It was discussed in Section 3.3.4 that a significant increase in glacier / melange velocities were not observed in correlation with runoff, please can you clarify this? Plotting the panels in Fig 15 against velocities and calving rates could better display correlation or lack of.

Line 449/450 – 'we do detect a small increase in the glacier velocity in 4 out ***of*** 10 ***calving*** events detected in 2022' – can this be shown by plotting calving vs velocity? Line 450/451 goes on to say 'we can conclude that the presence or absence of melange … seems rather unimportant for calving dynamics'. This conclusion does not seem robust to me. It could be that these are large tabular style caving events in which a large amount of energy is released – in which case we may not expect backstresses from fast ice / melange to be of a magnitude large enough to suppress this. The melange may have more impact on suppressing smaller calving events (which could be analysed by assessing overall averaged calving rates), which in turn could moderate the glacier velocities – in which case it could be argued that the melange does play an important role. Neither conclusion is clear to me on the evidence provided so far, but a plot of melange / fast ice thickness and extent against velocities and calving rates could go a long way to showing this. I wonder also if discreet calving events could be looked at separately to overall calving rates – i.e. does the calving type matter and does melange / fast ice inhibit the smaller calving events but have little impact on the larger scale events?

Typos

Line 44 – 'spring an***d*** early summer' ?

Line 99 – '… all outlet glaciers i***n***s not well constrained'

Line 312 – 'observations ***of*** ocean processes'

Figure 12 caption – 'dispersions***m***'