

The Cryosphere Discuss., author comment AC1
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Reply on RC1

Astrid Oetting et al.

Author comment on "Geomorphology and shallow sub-sea-floor structures underneath the Ekström Ice Shelf, Antarctica" by Astrid Oetting et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-305-AC1>, 2022

Section 3.1: Worth mentioning broad survey layout in respect of total line length and an indication of spacing etc.

In case for the multibeam echosounder, the tracks are irregularly spaced, their width are variable (depending on the number of beams (see supplement)) and some of them lie on top of each other. Therefore, an indication of the total length is of limited informative value. Here, the important information is gridding, which is mentioned with 25 m resolution. The course of the cruises is shown in Fig. 1b.

Sentence in line 84 will be changed to: "The master tracks of these RV Polarstern expeditions, which have a total track length of ~ 400 km in the considered area, are shown in Figure 1b."

L90: Worth summarising the broad survey layout.

Sentence will be changed to: "The seismic profiles are orientated across or along the predominant ice-flow direction and shown in Figure 1b."

A more detailed survey layout was considered, but to avoid several repetitions (details of acquisition on the Ekström Ice Shelf are given in Smith et al. (2020), Fig 1b, Section 5.2 and "Assessment of sub-ice shelf seismic data for the interpretation of glacial landforms" (Line 305)), we decided to keep it short and refer to the named sections.

L110: you say they are randomly oriented, but you don't mention that they have variable orientations along their length too. Their along-length geometry is also an indicator that they are ploughmarks.

True. Sentence will be changed to: "These furrows are randomly oriented, changing orientation within their tracks and occasionally cross-cutting."

Section 4.1.2 Can the statistics (e.g. lengths, widths, orientations, elongation ratios) be shown graphically (e.g. distribution histograms etc.).

A statistical analysis of the measured MSGs would be possible in principle, but it is evident (especially in the west of the study area) that the lengths of the MSGs were not fully recorded with the multibeam echosounder (Figs. 3a and c). Overall, only a few MSGs were imaged in their entire length. Less wide MSGs can only be resolved with the sub-bottom profiler, which also imaged a very limited area of the overall study area (Figs. 1 and 3e). There, it can also be seen that the MSGs partially overlap, which makes an exact determination of the widths difficult. Therefore, a statistical evaluation of the

lengths, widths and elongation ratios would not be meaningful. Therefore, we limit ourselves only to the indication of the predominant orientations.

L206: what it meant by short lived? And how is it known that they represent a short period?

Longer grounding line stillstands are associated with the formation of GZWs. Since there are no indications for a longer grounding line halt, we assume the stillstand to be relatively short, at least too short for a formation of GZWs.

L211: different origins? Could the ice origin actually be the same glacier but that the extent of that glacier may have been different (e.g. shorter and thus calving front was thicker) when the large icebergs were discharged. Feels too speculative that the origin was different. Or maybe not if the two sets are being created at the same time.

A bit more of an explanation is given in Line 214-219.

There is a bathymetric sill (with ~ 390 m water depth at its deepest point) at the continental shelf break, which separates the open ocean from the over-deepened incised trough. It acts as a barrier that prevents thicker icebergs coming from the ocean from entering the inner trough and vice versa. Thus, even if a thicker calving front had been present, icebergs from the Ekström Ice Shelf could hardly have crossed the bathymetric sill to leave ploughmarks seaward of the sill at water depths of ~535 m.

L232: How would it effect the basal thermal regime?

At the transition zone, there is a change between rough, crystalline bedrock and probably soft sediment. The smooth seafloor present downstream of the Explora wedge is assumed to reduce basal friction, favoring fast ice flow velocities and a warm-based thermal regime (e.g. Wellner et al., 2001; Ó Cofaigh et al., 2002; Lowe and Anderson, 2003; Siegert et al., 2005; Benn and Evans, 2010). More details on the respective paleo-thermal regime and ice flow regime is provided in the interpretation of the individual lanforms. A brief summary sentence is provided in line 368.

L240: What is meant by basal moraines?

Sentence will be changed to: "Basal tills may show MSGs (e.g. Ó Cofaigh et al. (2002); Dowdeswell et al. (2004)), however, ..."

L240-243 – this is speculation and I would remove it.

Sentence will be changed to: "Basal tills may show MSGs (e.g., Ó Cofaigh et al. (2002); Dowdeswell et al. (2004)), but since the resolution and line spacing of the used seismic data are not sufficient to image MSGs of the dimensions seen in front of the ice shelf, a presence of MSGs below the shelf ice cannot be detected."

L250-253: retreat and readvance are proposed, but no age determination is possible. I think it ought to be made clear that there is no information about the length of time between retreat and readvance. This is explored in the following paragraph a little and on

Sentence in L254 will be changed to: "An indication that periods of retreat and re-advance are possible in the EIS embayment is given by Schannwell et al. (2020), who simulated an idealised advance and retreat history of the grounding line of the EIS embayment over the past 40,000 years, however, there is no evidence to narrow down the timing between retreat and re-advance."

line 260 it needs to be made clear why this is 'less likely'. It also needs to be made clear that the Schannwell model does not simulate any readvance (yes a stillstand, but nothing more, despite the forcing). Indeed, I am not clear how changing the bed conditions would force a readvance. Could the authors reduce the speculation in this paragraph?

Paragraph will be changed to: "Schannwell et al. (2020) simulated an idealised advance and retreat history of the grounding line of the EIS embayment over the past 40,000 years in the EIS embayment. The simulations used a variety of bed conditions and showed that with both hard and soft beds, there were three periods of grounding line stillstand during advance and one in the retreat phase. However, the situation is likely more complex than that simulated by Schannwell et al. (2020), as our investigations have revealed a change in bed conditions 150 km from the grounding line, rather than a purely hard or soft bed, which has not been considered in the simulations so far. In general, short periods of re-advance after grounding line stillstand are conceivable at the EIS embayment, as ice sheets in the Weddell Sea are discussed to have undergone several re-advances (Davies et al. 2011 and references therein). An alternative scenario is that the lower layer originates from an earlier glaciation. However, this interpretation will remain ambiguous without age estimates from cores."

L270: compare also to the work of Ely et al 2016 – Geomorphology: Do subglacial bedforms comprise a size and shape continuum? - ScienceDirect) who explores geometries in detail including the transition from various elongated landform types.

Paragraph between L 267-271 will be changed to: "The more symmetrical shape of the bumps revealed by the across-flow profiles (Fig. 4d, f) may support an interpretation as drumlins. If we assume the along-flow and across-flow lines are cutting a family of such features orthogonally, then the heights and lengths of these features are within typical ranges for drumlinoids (Clark et al., 2009). Compared to Clark et al. (2009), the feature in Figure 4f is within the range for the typical width of a drumlinoid, however the landform in Figure 4d is wider than an expected width of 1500 m. However, compared to the work of Ely et al. (2006), who investigated the shape and size of subglacial bedforms in some locations of the northern hemisphere, the width of the feature in 4d fits to their reported width-range of 1510 m for drumlins. "

L340-343: The comment about expectations for similar behaviour in other troughs – I think that if we have learned anything from other regions it is that behaviour can vary significantly even between neighbouring troughs. This point therefore does not seem to be a safe one to make.

Generally yes, but we assume that the neighboring ice shelves do not behave fundamentally differently to the EIS. The paragraph will be changed to: "The EIS is a typical ice shelf of the wDML region (Neckel et al., 2012). Although it appears that adjacent ice shelves within Antarctica behave differently, the neighboring ice shelves of EIS have a similar narrow continental shelf and are as well underlain by incised troughs (Eisermann et al., 2020; Nøst, 2004; Favier et al., 2016), which may result in similar palaeo-ice thickness, retreat and advance styles. Relatively warm Circumpolar Deep Water masses have a significant influence on ice shelf variability (e.g. Jacobs et al., 1996, 2011; Hillenbrand et al., 2017; Paolo et al., 2015; Hattermann, 2018). However, as assumed for the neighbouring Fimbul Ice Shelf (Hattermann et al., 2014) as well as for the EIS (Smith et al., 2020), these warm water masses enter the cavity below the ice shelf only in relatively small amounts."

Technical corrections:

L37: Tending towards methodology – save for later. Also, what is meant by 'bottom' of the ice shelf? Underside?

We want to briefly touch on the possibility of investigating sub-ice shelf cavities with AUVs, but want to focus only on the methods actually used in the method section.

Yes, the 'bottom' of the ice shelf is the underside.

Sentence will be changed to: "However, no high resolution sea floor bathymetry data was collected since it was aimed to survey the ice shelf base."

L39-41: Not sure this is particularly useful to the science being presented here.

It explains why we focus on the approach of combining reflection seismic data with marine geophysical methods as an alternative (in a broad sense) to expensive AUVs to image areas below ice shelves.

L60: semi colon between Smith and Eisermann references – should be an ‘and’?

Sentence will be changed to: “Schannwell et al. (2020), using the bathymetry of Smith et al. (2020) and Eisermann et al. (2020), modelled the evolution...”

L205: ‘fare’ – doesn’t seem right word. Provide?

Sentence will be changed to: “...fresh appearance of MSGs and recessional moraines in the multibeam data, provide evidence that these features are relatively young...”

L278: ‘preferably’ should be preferentially.

Sentence will be changed to: “...were found to be preferentially formed at the transition...”

L330: ‘worth to be’ should be ‘worth applying’.

Sentence will be changed to: “...this methodology is worth applying and developed...”

L338: provide a reference or weblink to instant or don’t mention. It’s arguable that the instant programme itself need not be mentioned because that’s not so relevant to the finding of the paper. The general point of this approach and work being useful can be made without the need to link to particular programmes.

Sentence will be changed to: “Our findings here can be used to determine and evaluate boundary conditions for palaeo-ice flow models of this wider region in this relatively poorly-investigated sector of East Antarctica, allowing us to understand and simulate future behaviour of the ice shelves more reliably.”

Sentence will be added to the acknowledgements: "This research is a contribution to the SCAR program Instabilities and Thresholds in Antarctica: The Antarctic contribution to Sea Level Change".

L345-346: reference to the cruise next year. Be specific about the year. Also ‘aimed to be’ should be ‘will be’.

Sentence will be changed to: “...will be collected during the Polarstern expedition EASI-1 in 2022 (Tiedemann and Müller, 2021).”

The cruise will be cited as: Tiedemann, R. and Müller, J. (2021). Expedition Programme PS128, Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, 34 p. [hdl:10013/epic.5f6c7ebb-86be-4277-a757-175baf6d916c](https://hdl.handle.net/10013/epic.5f6c7ebb-86be-4277-a757-175baf6d916c)

L351: Year for Patterson et al reference?

For Patterson et al. “under review” will be added.

L370: ‘suggesting’ should be ‘suggest’.

Sentence will be changed to: “...which potentially suggest more intense meltwater flow...”

L380: ‘to provide’ should be ‘for providing’.

Sentence will be changed to: “Hence, these methods are suitable for providing crucial constraints for palaeo-ice flow models...”

Figure 1: Why not write the PS1385 label onto the map? The grey contour line is not obviously grey – perhaps symbolise as a black dashed line?

‘PS1385’ will be added in Figure 1. The grey line will not necessarily be replaced by a black dashed line, as it could be confusing with the black dotted coordinate system, but it will be improved.

Figure 3: This figure needs to be full page width to enable clarity. Iceberg ploughmarks dash in the legend is difficult to see (yellow on white).

Figure will be changed to full page width. A contour line will be added in the legend.

Figures 4-7: these figures need to be full page width for clarity.

Figures will be changed to full page width.