Review – Last Glacial Maximum extent and subsequent retreat of the East Antarctic Ice Sheet from the Mac. Robertson Shelf, Güntzel et al.

This manuscript presents valuable new data, arrives at potentially important conclusions regarding the timing of deglaciation of a very poorly known sector of the Antarctic continental shelf, and has important implications for deep water formation during the last glacial and deglacial periods. However, the manuscript structure, language, discussion and presentation need some attention before publication. Some method details are unclear or missing, as is some information that ought to be presented on figures.

In general:

Language: there are countless cases of ambiguous use of this, these, it, they, which, and other such pronouns – sentence by sentence needs attention to ensure that the meaning is always clear. There are several cases of poorly chosen or imprecise word choices, which I've tried to highlight in detailed comments below.

Structure: I strongly recommend revising sections 4 & 5 into a combined Results & Interpretations section, in which morphological observations are immediately followed by morphological interpretations, and then sediment core results are immediately followed by sediment interpretations. The current order, alternating between morphology and cores, produces a very disjointed narrative, and in fact I had to read 4.1 followed by 5.1 in order to follow the evidence and the story, before returning to do the same with the sediments.

Morphology results: in part reflecting the structural problems, I found 4.1 difficult to follow. The language is unclear (ambiguous pronouns) and the reader really needs close reference to both Figs 2 & 5 (all panels) in order to follow the geography and the different landform descriptions – Fig 5 should be brought forward in figure sequence. There are references to features previously reported in literature that are missing from the figures, and while most of 4.1 describes landforms in generic morphological terms, there are occasional interpretations of specific glacial landforms given. I suggest if this section is immediately followed by 5.1, both sections of text can be tightened and refined.

Sediment results & facies interpretation: in both of these sections, the descriptions of core stratigraphy are vague and difficult to follow. Phrases such as "towards the top" or "upward" are imprecise. Revise to refer to specific depth intervals, or specific units – all cores presented appear to have 3 units, and referring to these explicitly by number or letter would avoid confusion. Many of the interpretations of sediment units in 5.2 are vague, and don't draw on specific evidence – closer reference to Table 3 would help here, and/or a more full explanation of reasoning in the text.

Disjointed narrative in Introduction, Discussion & Abstract:

- the Introduction has 3 themes (GL importance for stability, LGM-to-Holocene retreat, ocean masses) but these could be better linked, and more clearly introduced as separate themes, noting the importance of each and/or connection between each theme. For example, paragraph 3 opens stating that GL retreat is investigated, then in the same sentence we start finding out about water mass movements, without an introduction as to why.

- 6.1 references figure 6 once, and in a sentence that doesn't really need fig 6 to support the statement it makes. Otherwise, fig 6 isn't referred to at all. Is Fig 6 important? If so, write about it.
- 6.2 mentions the ACR, MWP1a and MWP1b without developing any connections between these events and the reconstruction put forward here. These should be better developed. The role of CDW seems more assumed than motivated, and the final interpretation that AABW formation was shut-off is merely stated – arguments building up to this interpretation are missing. The 'future studies' paragraph is a bit scatter-gun and the points don't explicitly emerge from the rest of the discussion. Section 6.2 should be revised with a clearer structure and explicit build-up of arguments relating to the forcing of retreat (timing) and implications for water mass movements.
- Abstract – there are themes mentioned here that don't emerge from the discussion, such as slow or fast retreat, or the importance of the ACR. The reason you suddenly introduce dense shelf water should be made more clearly, and it would help to re-order some of the middle sentences so that themes follow on from each other and are finished before moving on.

Line by line:

15: that all modern observations are "of limited value" is a bit harsh! Reframe this.

47: ambiguous pronoun – what does "they" refer to? (However, they concluded)

51: ambiguous pronoun – what does "it" refer to? (From here, it)

(I note these two as examples of ambiguous pronouns. They occur throughout the manuscript and the authors should carefully check sentence by sentence.)

52: define CDW

59-64: these sentences are muddled and contain repetitive phrases

66-69: repeats previous sentences

70-1: revise to end with a more concrete statement – shut-off does mean absent or different.

73: "cross-cutting" implies two features are superimposed but with different orientations, i.e. one cuts across another. Troughs are not typically cross-cutting. "cross-shelf troughs" would be a better way to phrase what I think you mean.

77-8: missing/incorrect word – prominent what? The main rock types, or lithologies? (And perhaps you mean predominant?) Sentence should end "formed ~3100-2800 Ma ago".

79: since you refer to both continental shelves and ice shelves, clarify which you mean: "The continental shelf area is bounded by"

89-90: ambiguous "which". Suggest break into two sentences, with the second: "These GZWs, which are at equal water depths in both troughs, are thought to mark the most recent expansion of the ice sheet onto the continental shelf." Suggest also "limits" or "limits of expansion" instead of "most recent expansion".

92-6: this paragraph doesn't follow from the previous – it would benefit from an opening sentence that lets us know the relevance. Locations of the Cape Darnley polynya and Wild Canyon ought to be shown on a figure. Who has "newly described" CDBW? Provide a reference or otherwise clarify or

delete. Also clarify “grounded iceberg tongue” – an ice tongue is usually considered an elongate ice shelf, i.e. floating, so what do you mean by iceberg tongue? The text doesn’t explain the formation of CDBW – are we to assume it’s equivalent to ISW? Or DSW? I suggest reducing the acronyms and names for each state, and focus on describing the process.

105: this section launches into data collection specifics without any introduction. What is PS128? It would be helpful for part of lines 125-6 to be moved here (did you originally have the sediment coring section first, or even didn’t originally include any geophysical data in the manuscript?).

106-8: awkward wording, and it’s not clear what your set up choices were – are the opening angle settings yours? Suggested edits: “The frequency of the MBES system… and transducers are arranged in a Mills cross…” (?). “In water depths <2000m, the opening angle was set to 70°, while in greater depths the angle was reduced to 50° either side of nadir.

109-110: “Afterward, the data” – which data – new and legacy data were processed together? 50m x 50m seems rather coarse resolution for modern multibeam systems in these water depths – did you try gridding at higher resolution? Or was data too noisy or sparse for that?

111: Redundant wording. Suggest “Sub-bottom profiles were acquired with a Teledyne…”

112-123: the rest of this paragraph is muddled, and should be revised to clarify settings that contribute to penetration, vertical resolution, lateral resolution, and footprint.

130: Results refer to CT-scans (images in Figs 3 & 4?) – include these in the Methods

134-165: These methods need a clearer narrative – it is unclear what samples have been taken, from where, how, for what purpose. In this section, first describe the sampling scheme and purpose, before describing how samples were then handled. E.g. line 134 – which samples? Line 141 – what spatula samples? Are these the same as the ones just described, or a new set? Was datable material (line 145) picked from samples – which samples (in relation to those you’ve just been describing)? Does microfossil extraction (line 162) also relate to picks for dating – mention this first.

136: how were inorganic carbon + carbonates removed?; line 138 – clarify bulk sediment organic C.

152: Edit to something like - The maximum reliable age limit… was estimated to be, or determined to be… A limit of 42 radiocarbon ka is something that arises from the method, not a parameter or setting you arbitrarily decide on?

164: revise “carefully considering” – having considered, what deltaR values did you use?

168-70: inner, mid and outer are geographic descriptors – they don’t need referencing to other studies, or to particular landform assemblages. If you find that the landform assemblages that occur in different zones match the distribution of landforms observed elsewhere, then state this as a result.

170: why start on the mid-shelf, not inner (or outer)? Consider the order of presentation, and try to be systematic.

171: “subparallel features” and “wedge-like structures” should be followed by semi-colons, and/or the 3 separate groups of features should be numbered, otherwise the list of terms that are supposed to represent 3 groups is confusing.

181: delete “Based on this morphology” – the internal composition is its own result, not based on shape.

179-189: clarify what direction the “length” of a wedge means – in the along-flow direction, i.e. cross-wedge direction?

206: refer to Fig 2, not Fig 1

209: “shelf break of Nielsen Basin”

213: “in front of” -> seaward ?

219 + 223: does “poorly rounded” mean angular, and “poor angularity” mean rounded? If so, say so more simply!

219: ambiguous reference to “previous cores” -> Unlike the lowermost unit from the other outer shelf cores, it has…

222 onward: “some layers”, “distinct sequences” – it is not clear where in the stratigraphy these layers are found. In the mid-core? At the core top? Where are the fining upwards and coarsening upwards trends, in the stratigraphy? The sentences in lines 227-231 ought to be incorporated into the previous paragraph with a more clear, explicit description of core stratigraphy. Refer to depth intervals, if that helps.

236: “boundary” and “mid-shelf cores” are confusing here – I think you mean an up-core boundary, rather than referring to spatial core site boundaries? Instead: “Above the diamicton unit, the shear strength drops.” ?

256: why are 14C ages plotted on the figures, and not calibrated ages?

Here, or in the Methods earlier, you should also mention that other published ages are re-calibrated and included in your study. The core sites for these published ages should also be plotted on at least one of your figures. The caption for Table 2 is confusing – you refer to Heaton et al. 2024 for two other cores, yet in the table itself you list Leventer et al. 2006 for these cores, and you add another core/reference from Borchers et al. 2016. Please explain clearly what you’ve included, from where, and whose re-calibration you use.

265-275: this paragraph has limited referencing to substrate (or other) controls on ice streaming and lineation morphology. Consider also Livingstone et al 2016 (J. Glac.), Jamieson et al 2016 (J. Glac.), Halberstadt et al. 2016 (Cryosphere), Ó Cofaigh et al. 2007 (JGR), Greenwood et al 2021 (Sci Adv)

266: inappropriate reference – King et al. 2009 was a sub-ice sheet study (imaging the active bed), not a continental shelf study of relict landforms.

273: relate landform types to your subbottom profiler data? Roches moutonnées and whalebacks are bedrock landforms…

280: see also Simkins et al 2018 (Cryosphere)

286-8: I don’t follow these two sentences. Which previously described GZW, and what interpretation do you make about shelf transitions or cavities that relate to multi-directional iceberg scouring?

293: what differences in substrate? Please be specific in your interpretations.

296-7: GZW superimposition on MSGLs has not been presented in the results section or figure – this seems important and you return to it in the Discussion, so please address specifically.

320 + 335: “towards the top” seems inappropriate in both cases – these units are lower-mid-core

322: what tells you sub-ice shelf, and not due to freely moving icebergs?

324: what proxy signatures do you find that are indicative of ice shelf break-up and turbation of sediments?

327: meltwater plumes should also leave a distinct sedimentological/physical record, e.g. well-sorted silt fraction, rounding, lamination. E.g. Witus et al 2014 (QSR), Lepp et al 2023 (Cryosphere). What evidence of these do you find, in addition to particular microfossils? The microfossil reasoning should also be more specific – are there particular species that favour fresh or nutrient-rich waters?

333: higher variability of what?

338: why grounding line proximal?

340: advanced GL retreat is ambiguous! -> "suggest that the GL had already retreated towards the inner shelf"

349: do the sediments/proxies tell you about GL oscillation? An oscillating GL should have already been clearly argued from the landform and sediment evidence

350-5: these arguments are unclear

361: only a few studies of Mac. Roberson land? Otherwise, this statement is incorrect!

363: "varves" is widely used in the context of annual laminations -> replace with "layers" or "laminations"

368-9: delete "a minimum", delete "further"

370: if the outer shelf GZW was vacated at 12.5, that doesn't mean that it couldn't have formed during the LGM – just that the limit was stable for a long time. What is the argument for GZW formation at, or "during" the period around 12.5? Are you referring to a single outer GZW or a sequence of GZWs?

383: what is the evidence for GL retreat accelerating? Why should that be due to CDW? And what does freshwater have to do with enhanced CDW?

389: I think the previous AIO ages need drawing into the narrative better, e.g. Previously only bulk/AIO dates were available, and carbonate is a big improvement on those for … reasons. Published AIO ages from Leventer indicate…

393-5: you contradict yourself here in a confusing passage: RPO ages help better constrain… reworking complicates efforts to constrain… Does the bioturbation sentence link to the RPO ages sentences? Make these elements of the narrative clearer.

401: awkward wording -> "for the mid-shelf of Burton Basin, east of Nielsen Basin". You could also note that "These ages are almost identical to ours, and this strengthens…"

414: spell out ACR, MWP1a, MWP1b. And discuss these forcing mechanisms clearly. How would each drive retreat? Do you conclude that the ACR or MWP1b was important, and why? You consider the ACR important enough to mention in the abstract, but don't discuss it here beyond the first sentence.

421 onward: you mention various retreat timings from around Antarctica, but these come a little out of the blue – we are expecting discussion of East Antarctic timings, then suddenly and without

signalling, we're on the Antarctic Peninsula. Try to build this story more clearly, and then the argument that these different timings might be something to do with the accessibility or intensity of CDW water. CDW as a theme also appears in this paragraph very suddenly. Introduce us to why it's relevant, and then present the evidence and arguments for how it might vary.

440: this key point about AABW – included in the sub-header – comes without clear connection to the previous discussion.

450-1: and Iceberg Alley? Your Conclusions opening statement should reflect your whole study.

456-7: how does an age that contradicts LGM formation of an outermost shelf GZW also support grounded ice at the shelf break? Do you mean that the GZW is actually a bit retracted from the shelf break, and that ice sat beyond the GZW at maximum? That hasn't been clear from the earlier presentation.

Suggest also mention your radiocarbon timings in the Conclusions?

460-2: I would delete these last sentences – they repeat the end of your Discussion, and are a weak way to end the paper.

Fig 1.

- Consider using a more limited colour ramp range, to better bring out differences in water depth on the continental shelf
- Inset – Pacific Ocean label is much smaller than the others
- Caption – refer to the variable first, then colour code, i.e. Polar front (orange), southern ACCF green) and ACC (white) are indicated in… Define ACCF and ACC. Suggest also "The investigated data" rather than only mentioning cores.

Fig 3 & 4

- Consider swapping 39-1 and 45-1 around within Fig 3, so core 45-1 is on the left. It is introduced first in the text, so we expect to consult the left side of the diagram first.
- Increase in the contrast in all CT/x-ray images?
- Suggest colouring the axis values according to the variable presented, e.g. MS values in red, as well as the MS label. This reinforces which lines relate to which axes, and you could then delete the dotted line legends under shear strength and C-N (which took me a while to recognise for what they are).
- Comment in the Methods why different cores appear to have different resolution data, in both the sampled variables and the MSCL logged variables. E.g. 45-1 seems to have lower resolution results than 39-1.

Fig 5

- The grey hillshaded (? – or are they slope visualisations?) multibeam images are too pale or bright to see anything. Apparent GZWs (labelled) are completely invisible, scours and gullies in (c) are indistinguishable from each other, and scours in (a) are invisible. I suggest using a conventional hillshade with illumination from either NW or NE, depending on the orientation of relevant landforms, and make sure the greyscale ramp is extensive enough to clearly see landform morphology.
- Identify and label GZWs that you refer to in the text, whether your own interpretation or those that have been previously identified.
- I don't see any GZW morphology in the lower left inset of (b) or in (c)

- Consider a less diffuse background bathymetry colour ramp – it is also not bright or varied enough to be meaningful, we can't see any bathymetric variation in it. There should also be a colour ramp legend for the background.
- Is the placement of core sites in (c) correct? Or the colour ramp? The subbottom profile Y-Y' places core sites in topographic lows, but on the map view at least 46_1 looks to be on a topographic high.

Fig 6

- This figure ought to be more tightly integrated with the Discussion, including all the processes, environments and features labelled. What is the significance of katabatic winds? What is the significance of polynya formation? The sea ice zones labelled look more like iceberg zones in your sketches.