

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-360

Anonymous Referee #2

Referee comment on "Review article: Existing and potential evidence for Holocene grounding line retreat and readvance in Antarctica" by Joanne S. Johnson et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-360-RC2>, 2022

General comments

This review article provides an extremely useful overview of the different geological, geophysical, and glaciological datasets that can be used to demonstrate Holocene readvance of portions of the Antarctic Ice Sheet. The paper was written very clearly, which was particularly impressive given the breadth of scientific fields represented in the paper. The figures were in general clear and easy to follow. This paper will be helpful for the scientific community investigate past changes in the AIS and I think will be a particularly useful resource for teaching undergraduates and early graduate students about Antarctica's Holocene history. I look forward to seeing how this paper guides future research in Antarctica.

Most of my comments are minor and I hope they will improve the clarity of the paper and some figures. Figure 2 needs to be revised to better communicate its significance, but the other figures are excellent.

Specific Comments

Abstract: very well written and clear. This is an exciting topic!

Introduction:

I think within the first paragraph you should be clear that, for this paper, the AIS consists of the WAIS, EAIS, *and* APIS. The AP is not always considered part of the wider AIS given

its small size and different behavior, so it should be made clear early on in the paper which component glacial systems are considered part of the AIS.

Line: 90-91 This sentence is a bit difficult to follow. I suggest breaking up direct vs circumstantial evidence into two different sentences.

Lines 100-116: What about nuclide inheritance from incomplete erosion or glacier transport from cold-based ice that yield older-than-expected exposure ages? This can be particularly problematic for LGM and younger deposits for nuclides other than ^{14}C . I think it is important to point out this complication and how it limits interpretations of Holocene ice sheet configurations. I recognize that you discuss this later in the article, but this problem is non-trivial.

Line 165: There's also a good body of evidence in tidewater glacier systems from the west Antarctic Peninsula displaying this pattern of ice shelf collapse following Late Holocene readvance linked to the Little Ice Age . Simkins et al. (2021, QSR) recently wrote a good summary in the background section. West Antarctic Peninsula tidewater glaciers may be smaller and respond to different forcing mechanisms than WAIS or EAIS, but the same sedimentary facies of subglacial, ice-proximal, and open marine are present. This comment is related to my suggestion that you need to be clear about what component glacial systems are considered part of the AIS. Understanding what drove Late Holocene glacial advance in the AP (and how/why it is similar and/or different from WAIS or EAIS) is important in the near term since this area is warming more rapidly than the rest of the continent.

I do agree with you that in general marine records alone cannot be used to prove Holocene readvance, but in some specific and rare circumstances where dateable material can be found in subglacial sediment, it is possible to directly demonstrate that ice readvance has occurred. For example, in Barilari Bay in the west Antarctic Peninsula there are bivalve shell fragments with Early Holocene radiocarbon ages that were recovered from subglacial diamicton on a former grounding zone wedge. Those radiocarbon ages were used to demonstrate that the tidewater glaciers must have been less extensive during the Early Holocene in order for the shells to be incorporated into the diamicton by a Late Holocene readvance (Christ et al., 2015, GSA Bulletin). Prothro et al. (2018, Marine Geology and 2020, QSR) also discuss specific sediment coring strategies on grounding zone wedges to try to recover dateable material in the Ross Sea.

Line 201: check if "in review" references are allowed for this journal

Line 229: I may have missed earlier in the paper but spell out what Ramped PyRox stands for if it's the first use of this term.

Line 234. End this line with a period and begin a new sentence.

Line 235: remove "would exist" to make sentence clearer.

Line 280: While it seems obvious, I think you need to explain that luminescence ages of subglacial materials can only record when a land surface has been exposed to sunlight and is therefore records sub-aerial exposure of a landscape. Similar to cosmogenic nuclides, this dating method limits our ability to only date deglaciated landscapes that were ABOVE local sea level. Luminescence dating of raised beach deposits is dating a different process than luminescence dating of subglacial materials. This limits the use of luminescence dating to mountainous areas or land-based portions of the ice sheet and cannot be used in more marine-based ice sheet areas.

Line 295-299: can you include references that show this? I agree with this in theory but as this is a review paper, it would be helpful to direct readers to those papers where *in situ* ^{14}C has been used to demonstrate Holocene readvance. Other sections include a greater number of references to existing work.

Line 360: Great point! The geologic community has not integrated radar studies of the ice to understand changes in ice extent.

Line 392: Which ice cores have only captured partial Holocene records? Do those ice cores only contain ice from later parts of the Holocene? Is that time limitation another possible indicator of readvance or a major change in accumulation/ablation? Or is this a limit of high accumulation rates at coastal sites that is mentioned in line 424? Perhaps figure 3 could include the locations of partial Holocene ice core records.

I did not comment as much in the radar and ice core sections because this is outside my expertise to provide critical commentary.

Line 448: subglacial ^{14}C refers to organic radiocarbon right? Now that I think about it, any mention of ^{14}C needs to be specified whether it is organic ^{14}C or cosmogenic *in situ* ^{14}C to avoid confusion.

Line 450: add citations here to direct readers to these inconsistent data sets.

Line 453: Yes – filling in exposure age datagaps in East Antarctica is quite important.

Figures:

In general, some of the most clear and well-made figures I have seen in a scientific article. This is impressive given that each figure comes from a different field of Antarctic science. I like the small and consistently formatted inset maps showing field locations.

Figure 1: this is a fantastic visual that communicates each of the archives you will discuss.

Figure 2: I stared at this figure for a long time and could not understand what it is trying to communicate. I think it needs more labeling, at least on two of the individual elevation vs exposure age plots so that the reader can understand better what you are trying to show. For example, It would be helpful to have the Late Holocene gap labeled on at least one of the gray axis graphs because I am not able to see that pattern. The radial design of the individual exposure vs elevation plots makes it difficult to see the patterns you are trying to point out. Could those graphs be plotted below the map and organized by sites that do and do not permit readvance?

Figure 3: Another excellent figure. In panel b it would be very helpful to place facies labels next to the core photograph.

Figure 4: in panel b you might consider adding a label on the RSL curve denoting when the ice re-advance appears.

Figure 5: No comments

Figure 6: The inset map is missing its accompanying location name like the other figures. Add "Patriot Hills" somewhere in the figure.

Figure 7: consider adding opaque symbols marking ice cores that recovered only partial Holocene records. I know that there was an ice core on the saddle of Ross Island as well as the Bruce Plateau in the AP that had partial Holocene records.