Response to Reviewer #2

General remarks on the revision and the reviewer's comments:

Dear reviewer,

Thank you very much for all your constructive comments. We have addressed all of them and provide a point-by-point response below (our responses are in italics).

Based on your comments and suggestions, we have addressed the main issue you raised in the following way:

Main point raised:

i) Figure 2 needs to be clearer.

This figure was designed to communicate a large amount of existing data from multiple sectors of Antarctica, in a way that is accessible for colour-blind readers. We have tried various schemes and layouts to make this as clear as possible. As explained below, the radial layout seems to us to work best, and indeed Reviewer 1 did not find any problem with the figure. We have therefore decided to keep the figure layout the same, but to improve its clarity by adding shaded bars to highlight the gaps in exposure age data arrays. This should make it easier to link with our discussion in the text.

Point-by-point responses:

Abstract: very well written and clear. This is an exciting topic!
No response needed.

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.
We have added a sentence to the introduction of the revised manuscript to address this comment.

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

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.
We agree with the reviewer and, as noted, we do discuss this later in the article. Our main point in this section of the paper is just that exposure dating is commonly used to reconstruct ice thickness changes. A challenge with a paper of this sort is that there is not enough space to discuss all the technical details, assumptions, and potential challenges of each approach - a number of review comments point out that we have passed over technical aspects or assumptions in several methods that we cover in the paper. In the revised manuscript, we have revisited this and tried to either address these concerns in a concise way in the text, or include additional citations that cover them in more depth.

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 re-advance 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.
We have added references to the Christ and Simkins papers to satisfy this comment. We have chosen to exclude an in-depth review of sediment coring strategies on grounding zone wedges by Prothro, as we feel this is outside the scope of our paper.

Line 201: check if "in review" references are allowed for this journal
Our understanding is that "in review" references are allowed. In any case, this paper is now provisionally accepted, so we will update the reference and citations accordingly.

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.

Thanks for pointing this out. In the revised text we have changed the shorthand "Ramped PyrOx" to the full name "Ramped pyrolysis".

Line 234. End this line with a period and begin a new sentence.
This has been corrected in the revised manuscript.

Line 235: remove "would exist" to make sentence clearer.
This has been resolved in the revised manuscript.

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 mateirals. 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.
We agree. We have clarified this by adding some extra sentences to the third paragraph of Section 3.2.2 in the revised manuscript.

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.
The reason that this section of the text does not indicate that there are any sites where this approach has been implemented is because, so far, there are none! Hopefully, ongoing subglacial bedrock recovery drilling projects will provide some examples. We have clarified this in the revised text.

Line 360: Great point! The geologic community has not integrated radar studies of the ice to understand changes in ice extent.
No response required.

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.
Line 392 was referring to sites with full snow accumulation records presented in Buizert et al., 2021 (i.e. WAIS Divide, EDML, Dome C, Talos Dome, Siple Dome, South Pole and Dome F). There are no deep ice core sites with only partial Holocene records. Only shallower ice cores would have only a partial Holocene record, either because it was not fully recovered by the drilling or because the ice thickness is too thin to record the full 11,700 years of the Holocene.

We chose not to include the locations of partial Holocene records in Fig. 7 because we think they would unnecessarily complicate the figure.

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.
In the revised manuscript, we use "radiocarbon" and "radiocarbon dating" when discussing atmospherically produced ^{14}C and "in-situ-produced" to specify cosmogenic ^{14}C. We have added additional text to the revised manuscript summary (Section 4) to clarify that we are talking about radiocarbon in subglacial sediment.

Line 450: add citations here to direct readers to these inconsistent data sets.
We have added these in the revised manuscript.

Line 453: Yes – filling in exposure age datagaps in East Antarctica is quite important.
No response needed.

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.
Thank you!

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?
We tried several schemes for organising this figure and settled on the radial layout as most clearly communicating both the data themselves and the geographic pattern of sites that do and do not display late Holocene exposure-age gaps. However, we have revised the figure to highlight the late Holocene gaps on each of the relevant (age, elevation) plots, which should make it easier for readers to see the patterns we point out in the text.

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

We have added these in the revised version.

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

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.
We have added this in the revised version.

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.
The purpose of Figure 7 is to show ice cores that have the potential to provide full Holocene records. The ice cores highlighted in the figure all contain ice that spans the Holocene, although not all of those ice cores have full Holocene records published yet (due to differences in analytical capabilities and time since drilling). A number of ice cores also exist that span much shorter timescales. These sites reflect the length of the record rather than any loss of indicator of change. For example, there are multiple cores drilled along the Antarctic Peninsula, however, the cores are all ~150m deep (maximum drilling depth without the need for drilling fluid), which captures just 200-400 years of snowfall. We feel that adding all these shorter records (>200) would make the plot messy and not provide much benefit for this study. In summary, we think it is preferable to show ice cores where the full Holocene was recovered, and therefore that have the potential to provide full Holocene records, rather than only partial ones.