Response to reviewer 2

We thank reviewer 2 for their evaluations and suggested improvements. We have addressed all the concerns and made the suggested revisions to the text and figures. Below we show the reviewer comments in black, and our response in red.

The manuscript by Thomas et al. presents a preliminary analysis of the potential of a number of ice cores from sub-Antarctic islands for short-term climate reconstructions. The data are novel and exciting, though this is somewhat undersold until the Conclusions.

The structure of the manuscript could be much improved; in particular, the Methods need to be complete (including uncertainties) and a separate Discussion section would allow for more detailed and clearer interpretations.

Thank you for your suggestions. We agree that the conclusions were a little undersold and that expanding on the methods and discussion sections will improve this.

I also wonder if the title best summarises the manuscript, as the ultimate goal is currently to calculate the bottom age of a longer core at each site (though no climate reconstruction is actually carried out) – certainly to keep the title, more description (and analysis) would be required.

We would prefer to keep the title for consistency. We hope that the expanding discussion section (see below) and enhanced description of the GPR reflections and how they relate to the ice core will allow this. At this stage we are not presenting any climate reconstructions.

There are a large number of minor technical inconsistencies that need correcting. Major comments

1. The manuscript would benefit from having a Discussion section. At present, the small amount of discussion is mixed in with the Results, and as such, is lacking in detail. I at least expected a discussion of the suitability of each of the sites (ice conditions and location as that was a primary focus in the Methods) – some of this is hidden in the Results and would be much clearer in the Discussion, perhaps organised with a subsection structure for this section that answers each of the aims.

Agreed. We have now separated the results and discussion section to include sub-heading addressing the main issues as expressed in the introduction. 1) evaluate the ice conditions and internal layering in the upper ice column, 2) determine the extent of surface melt and 3) estimate potential bottom ages of future deep drilling expeditions.

2. The structure of the Methods and Figures 2-5 could be improved. I would expect the field site/ice core descriptions to come first, followed by ice core analysis, GPR, then met data. This makes more sense with the order the aims are presented in the preceding paragraph (and would make more sense for the structure of the following sections as well).

Agreed. The methods sections have been restructured.

The Methods are incomplete in places and some important details are floating around in the Results/Discussion section rather than the Methods. In addition, I don't see the value in separating Figures 2-5 into sea sectors when this isn't referred to elsewhere and when the Methods describe each site in turn. I suggest either dividing the Method sub-sections by sea sector (if that makes sense with discussion later in the manuscript), or combining these figures into one – perhaps as subpanels on Figure 1, colour/shape-coded by site. It would also be useful to show the GPR lines on these figures as well as the ice core locations.

The intention was to avoid a large and over-crowded figure, hence separating into smaller sections. However, we can revise this and put all the location maps into one figure and remove the reference to sea sectors. In combining the figures in this way, it might be too small to see the GPR lines but we can add those too.

3. A large part of the Results focuses on the GPR results but is isn't clear what these data ultimately contribute to other than general characterisation and providing ice depth for one site – they are set up as if they will provide much more than this. It almost feels like the data analysis is not complete(ly presented). Layers are identified in the radargrams, but this seems a little haphazard and is not compared with the ice cores – why?

Our intention was never to directly compare the ice core observations with the layer detection of the GPR. The resolution of the two methods is very different. The ice core shows ice lenses in mm, while the GPR layers have a resolution of about 30 cm. Thus, a single thin layer (<30 cm) would not be seen in the radargram.

The value of the GPR measurements is that it helps to characterise the site over a larger area and investigate the spatial distribution eg stratigraphy, continuity and number of layers. It is also important to establish the likelihood that a melting event observed in the ice core is a well distributed layer or a localised event. We have now expanded the GPR description (see comments to reviewer 1) to include a detailed comparison of the GPR layers with the observed melt layers in the ice core.

4. Uncertainties for the measured densities and fitted density curve are not presented, and the calculations for the calculated depths are not explained?

Agreed. Additional descriptions of the depth uncertainties have been included and estimated uncertainties added.

Minor comments

L21 and throughout: Please be consistent with hyphenation; e.g. ground-penetrating radar, pore close-off

Revised.

L28: Units should be kg m-3?

Revised.

L33-53: These first four paragraphs are a little repetitive and double back on themselves. I think it could be condensed into two paragraphs, with, for example, the first explaining why climate records are important and missing in this region, and the second detailing the potential of SAIs. This would lead nicely into the few paleoclimate records that do exist.

The introduction has been re-structured and condensed.

L57 and throughout: Be consistent in use of comma to denote thousands in numbers

Revised.

L58: Remove comma after limitation

Revised.

L71: Terminus should be termini

Revised.

L74: How much retreat has occurred – how much of the record is lost?

The referenced paper describes 97% retreat of the island's glaciers. However, this occurs at the margins and it is difficult to determine how much of the paleoclimate record has been lost.

L83: Why the upper 40 m? The longest ice core was 24 m, and the GPR up to 51 m so this seems quite a strange depth to choose. Perhaps instead state the "upper ice column"?

We agree, upper ice column is more appropriate. The maximum expected ice depth was ~25 m, therefore we choose a frequency to best capture this.

L88: ECMWF acronym needed after this first use L90 and throughout: Either use "degree" or the symbol, unless there is a reason for swapping between these?

Revised.

L91: Comma needed before "however"

Revised.

L95-100: Links and DOIs might be better provided in the reference list rather than intext. This would allow a clearer description of the Bouvet station, for example (what does WMO stand for?). You state in this paragraph what data is available, but what is actually used for this study?

The text has been condensed and DOIs added to reference list. The data provide estimates of site temperatures, which is used in the discussion regarding surface melt.

L97: Unnecessary comma and missing space after "Island"

Revised.

L107: Use defined SAI acronym

Revised.

L108-109: This sentence belongs in the Results

Revised.

L150: Missing space between 3,110 and m

Revised.

L152 and throughout: "average annual temperatures" should be singular

Revised.

L153: You haven't defined or used a.s.l. as an abbreviation prior to now – either use throughout or don't

Revised.

L173-174: The phrasing of this sentence is confusing – if the cores aren't used, then how are the bottom ages obtained? If they aren't used, I simply wouldn't mention them at all (save for your

future study), but if they are, perhaps present this site at the end of this sub-section and describe what you do do with the core (differently to the others)

Agreed. Reference to these sites should be removed.

L174: Elevation, not altitude

Revised.

L178 and throughout: “islands” should be “island’s”

Revised.

L188: I think “extent” should be “extend”

Revised.

L198: GPR has been used prior to this (without the acronym...)

Revised.

L226: How much correction was applied for ice thinning – is it possible to give an idea with a mean and range?

We have decided to remove the correction for thinning in the paper because the estimation that thinning is proportional to burial may not be appropriate. More information is needed to establish the rate of thinning in the firn column at sites susceptible to melt and thus we think it better to present the raw (un-corrected) thicknesses in the revised text.

L226: “that” should be “which”

Revised.

L228: Where are the methods for estimating the bottom depth of each site? Found – Sections 3.3 and 3.4; I think these would make more sense here at the end of the Methods, with more detail than currently provided (how are uncertainties calculated?)

Agreed, we will move to methods and expand.

L236-238: The number of clauses in this sentence makes it hard to follow. Perhaps rewrite to something like: “Layers could not be distinguished in the upper~7m of snow and only reflected weakly beneath this depth; 11 distinct, but discontinuous, layers were identified down to a depth of 62 m. We estimate this to be the...”

Sentence updated.

L245: Typical of what?

Added – “typical of surface snow”.

L268-269: I don’t see the multiple layers you interpret in the radargram. Perhaps they would be clearer if you made the radargrams larger or only showed a section of the image currently presented?

This is because of the resolution of the image. We wanted to show that the layers follow the surface slope, but it will be best to change the figure to show a small section. The figure will be expanded, and a small section will be shown.

L275: Have you only shown some of the layers in Figure 9 – there appear to be many more?

Yes, we have only selected the strongest for this section and those that are the most continuous through the full profile.

L281: I see the horizontal layers discussed here, but not the nearer-vertical layers that are shown in Figure 10? Is this again a size-resolution issue with the figure?

We believe this may be a resolution issue. We are showing the full profile but will update the figure with just the section of the profile to improve this.

L303: "effected" should be "affected"

Revised.

L309: Thus far, the project has been subICE not SUBICE

Revised.

L317: AWS has already been used so doesn't need defining here

Revised.

L320: What could have caused the large number of melt layers at Young Island if not surface temperature? Is it possible to plot the number of positive degree days from the AWS (admittedly over a short period)? A discussion of the depth distribution of these layers might be interesting and help to suggest other causes

This section has been expanded to address this question. Reflecting on the observed increased melt layer thickness with depth, however we include the caveat that the current method of visual layer counting is not sufficient to determine if the layers are a result of an individual melt event or formed from a sequence of smaller events. The aim of this study was to establish if melt was evident at the sites, as a first approach to establishing the islands suitability for deeper drilling. A detailed evaluation of the ice microstructure is currently being conducted as part of a PhD project and we hope to be able to address this issue more thoroughly in future publications.

We evaluate the positive degree days from the AWS. This reveals exceptionally large variability in the 3-hourly data, especially during the winter. We will include more detailed explanation of the AWS data in the revised discussion section.

L356: This sentence is incomplete

Revised.

L365: If the annual layer counting was done in this study please describe in Methods, or if another please provide a reference

Annual layer counting has not been completed for this study. The Bouvet record has been dated and the methods and figures are presented in King et al., 2019.

L371: Table 5 should be Table 3?

Updated.

L412: Estimate should be plural. Is this sentence stating that only Bouvet provided an ice thickness estimate?

Updated and yes, only Bouvet has a clear bed reflection.

L414: I think core should be plural Figures 5-10 - Revised.

It would make more sense to me to have the reference map first, then the uninterpreted radargram, then the interpreted radargram on the far right. All these figures need panel labels for consistency with other figures, and the captions can be shortened(e.g. axes do not need to be described). Font size could be larger and some of the radargrams, as previously mentioned.

Figures update and font increased.

The figures would also be neater if the reference map panel was the same height as the other panels and all the of the tracks filled each box. The mid-panel y-axis on Figure 7 is obscured.

Agreed and revised.