Response to Referee #2 (Alan Aitken) comments on:

EGUSPHERE-2024-2593 Review Article: Antarctica's internal architecture: Towards a radiostratigraphically-informed age–depth model of the Antarctic ice sheets

(paper title may alter slightly as per the discussion below)

14 February 2025

Referee #2 (Alan Aitken)

I review this review article from the viewpoint of a likely user of the product rather than a technical expert in RES or radiostratigraphy. Therefore my comments focus on the accessibility of the article to support a broad user-base for the AntArchitecture data products, rather than precision in the more technical aspects of the work, that may be better assessed by others.

First of all I enjoyed reading this paper and learned a fair amount. The paper tackles an important topic and has an important message, this being that the development of a knowledge of the internal structure of Antarctica's ice is important for a better-constrained knowledge of ice dynamics and ice histories, with consequent impacts from that. I have no criticisms with respect to the content, but I think that the message might benefit from some changes to the presentation of the work to have more meaning to a broader audience

We are grateful to Alan Aitken for this overall assessment and the approach taken to reviewing the manuscript. We are aiming for broad accessibility and so are pleased to act upon many of the suggestions.

Main comments

1) The value of the work outside the immediate community was not always well expressed, and I think it might be good in general to seek to define this further and keep it in focus.

Through the text there tends to be a focus on work done and work to do. For me at least there was a less clear thread on the summative value of all this work. This begins with the title, which is focused on the technical outcome, but not so much its value

Perhaps a change of title might help focus the work. I leave this to the authors but my suggestion would be something like:

Building a radiostratigraphically-informed age–depth model of Antarctica's ice architecture to resolve cryosphere change.

We are grateful for the suggestion and will now work with the revised title:

AntArchitecture: Building an age-depth model from Antarctica's radiostratigraphy to explore ice-sheet evolution

Also, the first point of confusion comes in the title...Antarctica's ice sheets are mentioned in plural in the title and early in the abstract but there is no definition of what these ice sheets are. The reader must presume this refers to mean East and West Antarctic Ice sheets but this is not made explicit until much later on in the text.

This could be made explicit, or perhaps in the early text either the singular Antarctic Ice Sheet might be better, or perhaps just 'Antarctic ice' with the sheets to be defined later as the distinction becomes important.

We will clarify that we have used the plural to recognise that there are some glaciological distinctions between the West and East Antarctic ice sheets (and we could also have included the Antarctic Peninsula Ice Sheet).

2) Elements of the article read like a list of achievements completed and key findings, but the synthesis of these into a broader understanding sometimes is lacking.

In particular, for section 3 I saw the value its structure with respect to historical perspective, covering differing (yet co-evolving) equipment and data processing etc, it seems a little writer-focused, rather than reader focused. Instead of going through by data providers, I think this section might be rewritten focusing on the main 'eras' of airborne RES surveying, each with different value to resolving architecture.

With some transitional work, the main 'eras' seem to be 1) non-GNSS, analogue, incoherent; 2) GNSS, digital, incoherent; 3) GNSS, digital, coherent....so this would be my suggestion for section 3.1, 3.2, 3.3, with 3.4 for ground surveys

Referee #1 also suggested a revision of Section 3 and we will work through this accordingly. We think your suggestion sounds good, and we will aim to implement it, although reserving the right to maintain some elements of the original structure, simply through the logistics of coordinating a large and international overall writing team.

In section 5, to connect the applications to the data better, I would recommend at the beginning of each subsection to include a short introduction to the physical premise of the application...that is, how is the phenomenon expected to be observed in RES data....for example in section 5.4 ice flow dynamics, you might say "Moving ice causes originally flat layers to deform through folding, tilting and disruption. Therefore, deformed isochrons may be analysed to interpret past ice motions"

We will reflect on Section 5 and modify the writing as fit.

3) Section ordering was not ideal for me to follow the concepts

For me, section 4 I think is logically precedent to section 3 if we consider the need of the reader to understand the means of measuring and defining ice architecture, before we can meaningfully consider the value of surveys done. At least, before section 3, where we learn a lot of details about different radar systems of different providers, we need some brief introduction to the main factors that impact on data quality...this is all made quite clear in section 4.1 to 4.4 though so they could be moved en-bloc. Section 4.5 could be part of section 5

Referee #1 has also made a similar point, and in response we propose to rework the previous Section 4.1 into a revised and shortened Section 3. We propose to maintain Sections 4.2-4.5 as Section 4 (the same order) but will also work on streamlining Sections 3 and 4 for the revision.

4) The discussion needs a more rigorous defense

Section 6 outlines the importance of the work to develop deeper and broader knowledge of Antarctica's ice. I felt for this section that while it is a good identification of future directions within the scope of the review, it lacked a framing in the context of targeted decisions for the optimal outcome.

For section 6.1 My key question is what is the (relative) cost vs value vs risk proposition for each of these given technological, logistical and financial constraints? What is the low-hanging fruit and what are the grand challenges? I would appreciate here a table with some information on what

resources each is expected to require (e.g. IP, funding, technology, logistics, infrastructure) to achieve a significant improvement, and perhaps some indication of if these requirements can be met in the next decade or so.

We feel that the exercise of engaging in the language suggested here is beyond the scope of this review paper, but is certainly a logical extension in the forum of SCAR, science programmes and future grant applications. We think the exercise would be appropriate for a "white paper" building on this science review article.

For section 6.2 Deliverable is not the right word for this section. For me, a deliverable is a finite and defined outcome with a specific timeframe. Perhaps outcomes?

We will change the wording as suggested.

In this section it is not very clear to me the mechanisms by which these might be achieved . I think to identify the scale of the collaboration needed (i.e. is it needing a few research groups or a major multinational program), and also look at these through existing collaborative frameworks (are they sufficient?), and also to look at opportunities/needs for broad new collaboration.

Similarly to two suggestions above, we think this is more the job of a "white paper" (probably coordinated through SCAR) that can be underpinned by the science objectives set out in this paper.

Given the length of the manuscript, to close out , I think we could do with a distinct conclusion, even just 2 paragraphs, to reaffirm the main points of the text.

We will add this.

Minor comments

line 72: what is the basis of these proxy records?

These are all namechecked in Paragraph 1 so were not expanded upon here in the abstract. If we have space to expand the abstract we will consider adding some examples, e.g. cosmogenically-sampled former ice limits, offshore sediment sequences, etc.

line 104: also sediments are often very limited on the timescales of observation, and further are quite indirect with respect to ice conditions

We will add this nuance.

line 106: which ice sheets East and West? Here is a good place to introduce the challenge of a composite ice sheet with several distinct parts.

We will introduce this concept somewhere in the early part of the paper.

line 107-108 - can you be more specific here?

We are not sure what is being requested here so will take no action unless required further into review/revision.

line 115 - a point to consider here is the extent to which RES-derived architecture can be considered total architecture...perhaps a brief comment that RES can't resolve everything

Although we take the point, we prefer to discuss it later in the manuscript. Here we want to keep the focus on introducing the term as specifically what RES sees.

Figure 1: Axes need to be 3D to match the figure.

We will amend this.

line 124 - here again is the plural necessary?..if so we need some definition.

Addressed above.

line 160: complex as in complicated or complex as in real and imaginary numbers? perhaps avoid complex

We meant as in real and imaginary numbers but you are correct that the technicality is not needed here and we will remove it.

line 194: this active field of research presumably has at least one paper to cite

We will add some.

line 207: instead of for over, perhaps spanning

We will adopt this suggestion.

line 218: 'now commonly employ state of the art' is redundant. In the absence of specifics, I think improved would do

We will adopt this suggestion.

line 225: 'shallow' RES here refers to 100s m where before and in Fig 2 the 'shallow' sounding reached 2 km. Perhaps a different temrinology could be used to differentiate - perhaps shallow vs intermediate vs deep-penetrating RES

We will amend this in the revised paper.

line 249-250 - I think the brackets can go as they include a full sentence

We will consider this.

line 251 - 'from before' replace with preceding

We will adopt this suggestion.

line 252 - 'were' needs replaced with a verb - perhaps 'being' or 'becoming'

We will adopt this suggestion.

line 254 - 'acquiring data digitally' > 'digital data acquisition'

We will adopt this suggestion.

line 280 'positional uncertainty' can be singular I think?

We will adopt this suggestion.

line 321 - delete shallow as the depth is defined numerically

We will adopt this suggestion.

line 323 - 'across both west and Eat Antarctica'. I find this confusing. Are some radar setups east and west specific but PASIN is not? Is there a important difference in acquisition for East vs West Antarctica ... if it is just that surveys have been done in multiple places then I would omit this point

We recognise the unintended obfuscation in the original phrasing and we will rephrase within the wider revision of Section 3.

line 532 - 'density value ... of the order of several meters'. Unless I misunderstand the use of density this does not make sense

We agree this is unclearly phrased and will amend it.

line 549 - Here it might be useful to distinguish semi-automated and fully-automated...if that is the intent

We will clarify automated means fully automated.

line 560 - My question here is whether IRH brightness necessarily translates to significance for ice conditions. This is addressed later, but perhaps a brief comment here on this link between data and reality is warranted.

We will consider this.

Figure 8: I found this figure, while quite nice, but very complex and hard to glean any information from. Apart from the impression that work has been done i didn't learn so much. Perhaps fewer sub-figures and more annotations would be better?

We take the point but the figure has already been through multiple iterations through the authorship team so we prefer not to implement further substantive changes.

line 813 - drawing parallels with structural geology, a technical question is whether the details of the fold geometry can indicate the deformation mechanism, or if it is ambiguous.

Unfortunately with present understanding it is challenging to deconvolve which mechanisms discussed in the preceding paragraph predominate to cause the folding observed at any given location. We will add an additional sentence or phrase to clarify this.

Our understanding of this could improve significantly with a greatly enhanced database of Antarctica's internal architecture against which to assess models!

line 851 - winnowed is not I think the right word...perhaps pinched out or truncated?

We will change this.

line 943 - I don't get the sense here of whether you mean any model might do OK or more that for each circumstance there is an optimal model...this needs rewritten to be clear

We will revise this to be clearer.

line 1158 - this strikes me that the outcome of this approach would more be an upper limit on heat flux but this does not negate the value

Agreed but this does not require revised wording.

line 1226 - This is a key step. The need also for a standardised and automated processing (as far as it possible) is also important so might be added here if relevant. A key goal I think should be to move away from 'decadal' compilations and more towards and ongoing resource...this needs automation

We feel that the need for standardised, ideally automated, processing is already encompassed in Lines 1220-1226 so that no further additions to the manuscript are needed here. We are also on board with the vision that the database should grow in an ongoing and accessible manner rather than in decadal compilations. Our challenge is that even before then the standards for lodging data need to be agreed upon.

We are grateful to Dr. Alan Aitken for his time spent reading the manuscript and formulating this considered advice.