



Interactive comment on “A detailed radiostratigraphic data set for the central East Antarctic Plateau spanning the last half million years” by Marie G. P. Cavitte et al.

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Response to RC3 comments on the submitted paper *A detailed radiostratigraphic data set for the central East Antarctic Plateau spanning the last half million years*

We thank the reviewer for her detailed review and constructive comments that have helped to increase the impact of this manuscript. We have responded to all comments and modified the paper accordingly, our point-by-point answers follow.

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Please note that review comments are in bold italics while our answers are not.

C2

Answers to RC3

Overall questions

I am not very familiar with the standards for data release that may have been put out by the AntArchitecture program in order to facilitate bringing together different data sets in the future, but is the main piece that is new that these data are now available, or that they have been processed in a way that allows them to be used all together? Or, it seems likely both. Does the way that these data are archived follow a standard that was either established by previous data contributions, or does this set one that future archival efforts should follow? What are the ways that ensure that these data can be used together with other data sets in order to advance the goal of assembling a continent-scale radiostratigraphy? Perhaps this is not the paper to describe the protocols and how fields are archived, but given the focus on contributing to AntArchitecture, it would be interesting to mention.

Answer: No protocol was defined for archiving IRH data in a consistent way under the AntArchitecture program so far. It is an important task of the program, but until then, contributions to the AntArchitecture continent-wide data set require the IRH data to be open-access. However, we have followed the structure of other published IRH data sets so that there is some uniformity in the data structures across data releases. We have added the following sentence at the end of the introduction:

“We archive this data set based on the standards established by previous IRH data contributions (e.g Winter et al., 2019; Bodart et al., 2021; Beem et al., 2021), adapted to fit the information available for this specific data set.”

The point in the discussion about tracing the same IRH in radar data from different systems may be worth mentioning earlier. It could even be that this

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discussion and Fig 8 make sense to move up in the manuscript when the data are being discussed, since what is discussed strikes me as more of a statement of the reality of the problem. The discussion section also includes multiple different points and it could be worth using sub-sections or considering to restructure some of that text elsewhere in the manuscript.

Answer: We agree and have moved this discussion up to Sect. 3.3 Internal Reflecting Horizon, where tracing the IRHs across transects is being discussed. Fig 8 (now Fig. 4) has also been moved up). We find that the discussion section now reads more sequentially, after removing this point about tracing the same IRH in radar data from different systems. It now focuses on the geometry of the IRHs, how easy/complicated they are to trace in the region, discusses new model developments for which these IRHs would be interesting and ends with considerations for the AntArchitecture project.

Given it's prominence in the figures, how accurate are the Zwally et al. (2012) drainage divides? I assume these are from ICESat data, but one version used ERS, and regardless there would be higher resolution data products from which to designate the divide. Would this matter? Does the divide appear where it is expected from the LDC survey?

Answer: The Zwally et al (2012) divides used were indeed from ICESat data, from <https://earth.gsfc.nasa.gov/cryo/data/polar-altimetry/antarctic-and-greenland-drainage-systems>. The divide position is not discussed in this data release paper: it is only shown to impress upon the readers that the BE-OI search focused on the divide area. But we have now replaced the drainage divides with the Rignot et al (2019) more recent positions, which differ a little, but not significantly across the LDC region. Given that the overall slope is of the order of a meter or two across the DELORES LDC survey region, the divide line does not move in any discernible way in the small area of the DELORES survey region using the higher resolution DELORES radar data.

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The title mentions "last half million years" but the deepest layer is ~700 kyr. Is it preferred to exclude credit for these deepest layers in the compilation because they are dated only with the age model? In that case the title should reflect the past 350 ka - I didn't follow why half a million was referred to in the title.

Answer: Although the ages defined of the oldest IRHs are estimates, they are relatively robust. E.g. the 1D age model was updated recently to include a stagnant ice layer (unpublished) and ages predicted are still on the order of half a million years. Lillien et al (2021) used another 1D model over the LDC region and they agree that isochrones can be dated to at least half a million, (they have isochrones between the age of 71 and 565 ka), and their deepest continuous isochrone is dated at 465 ka. We can therefore reasonably assume that our IRH data set goes back half a million years. The choice of title is supported by the modelled deep isochrone ages. But since the deepest isochrone age is an estimate, we have chosen to modify the title to reflect this to: "A detailed radiostratigraphic data set for the central East Antarctic Plateau spanning from the Holocene to the mid-Pleistocene".

Minor Points

Line 40: Perhaps also indicate that accessibility is an issue to radar-data collection in Antarctica (not just size – though of course that is the major challenge)

Answer: We have now added this information at this line, which now begins with: "However, due to its sheer size and much lesser accessibility,...". Further changes have been made based on Reviewer 2's comments.

Line 43: It would be worth being consistent with how AntArchitecture is referred to, as the manuscript uses "AntArchitecture project", "program", "community", and "action group", yet I think nearly all of these uses refer to the same. Perhaps

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"action group" is best since that is how it is referred to on the SCAR page. Would it be appropriate to cite the white paper or link to AntArchitecture page?

Answer: We agree and "action group" has now been adopted throughout. The White paper is under way but not published yet, so instead, we include a link to the AntArchitecture report (AntArchitecture, 2017)

Line 45-48: "potentially reducing the lack of unique solutions, a persistent problem until now . . ., as well as solving the problem of modeling 3D data in simple 1-D or 2-D models. . ." – I would suggest revising this sentence as it isn't completely clear what is being stated. And, my read of this is to say that a continent-scale radar data set would in itself help to constrain parameter values and would facilitate solving 3-D problems that are better than 1-D or 2-D problems. I may not be understanding the point but I would caution that radar data are one part of the problem, and the ability to use them to solve an inverse problem or constrain a 3-D model and get a robust solution depends on the problem as it is set up (not only including the data). Unfortunately, a 3-D radiostratigraphy won't on it's own make all ice-sheet problems well posed.

Answer: We agree. Our wording was awkward and we only meant that a more extensive data coverage (spatially and temporally) can help reduce the uncertainties of modeling experiments that forward or inverse model IRH data by providing more tuning targets. We have reformulated this section as follows:

"The construction of a comprehensive Antarctic-wide IRH data set will both play a key role for projects such as the Beyond EPICA - Oldest Ice European search for million-year-old ice (Van Liefferinge and Pattyn, 2013; Parrenin et al., 2017) and provide valuable additional constraints for inverse models, potentially helping in cases where a unique solution could not be found due to a lack of data constraints (a persistent problem until now, e.g. Morse et al., 1998; Eisen et al., 2008; Koutnik et al., 2016; Parrenin et al., 2017; Muldoon, 2018), or providing large-scale constraints 1D, 2D and 3D ice flow models (e.g. Leysinger Vieli et al., 2007, 2011; Passalacqua et al.,

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2018; Muldoon, 2018; Sutter et al., 2020).”

Line 48: Perhaps indicate here that Cavitte et al. 2020 is the citation to the data set as it otherwise could read like part of this work was already published elsewhere in a manuscript

Answer: Now modified to read: (data set release: Cavitte et al., 2020, <https://doi.org/10.15784/601411>)

Line 50: I think “the umbrella” could be cut since these projects were not necessarily connected

Answer: Agreed, removed.

Line 55: This may just be American English usage, but I use “farther” when referring to physical distance (“further” for figurative distance)

Answer: Good to know! Changed

Page 5: I wasn’t sure why there was a footnote for Holschuh et al. (2014), seems like that goes more naturally with the table

Answer: There was a glitch with the LaTeX formatting, it has now been changed.

Figure 1: It took me a moment to see the black lines well outside of the grid indicating the locations of the HiCARS prior to 2016. Since the grid is on, perhaps make those a different color? Or, swap blue and black since those lines in a tight grid will stand out?

Answer: We have changed the colors around so that the HiCARS prior to 2016 are in magenta, i.e. colored like the other radar data sets.

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Figure 3: I wasn’t sure of the need for the Landmark software interface to be included in the figure, especially since the font is too small to read for the tracing settings. Given that this is proprietary software, what is the message to the reader about the value of this interface? Would it be just as informative to share the figure without the Landmark panel view?

Answer: We agree, and based on reviewer 2’s suggestions, we now show the figure without the Landmark panel view. Furthermore, we now display an OIA transect that cuts across the Concordia Subglacial Trench and therefore displays what is discussed later in the manuscript: that the deepest IRHs drop off due to basal process influence, in particular as we move away from LDC.

Line 173 and previous: May be better to write out two-way travel time in this case, or perhaps use “TWTT”? Or, “twtt”? Is there a convention?

Answer: We have changed it to TWTT everywhere (it is the most common usage).

Line 184: What does “applied equally” mean in this sentence?

Answer: We meant that it could also be used. The sentence has been changed to “could also be applied to...”.

Line 230: Perhaps use “and” instead of “;” between references

Answer: Changed.

Line 267: Are the ages archived with the radar data set? Is there a way to update the data archive in the future if different ages are considered more realistic)?

Answer: The ages are archived with the radar data set. This data set can be updated easily or additional files can be added easily: the USAP data center simply needs to be contacted to make changes/additions.

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Figure 4: Is this figure here just to show where the IRHs fall with respect to climate cycles, or is there any information about the distribution over time and why these layers can be detected by the radars that relates to climate? I wasn't quite sure why this figure was included (though it is interesting to see)

Answer: We thought it was interesting to show the temporal spread of the IRHs of this data set with respect to the glacial-interglacial cycles. We have slightly reformulated the sentence that refers to this figure under the Results section to this effect. "The depths and ages, as well as the uncertainties associated, of the dated IRHs are summarized in Table 3, and their temporal spread is displayed in Fig. 4."

Line 281: "Leysinger" was dropped from "Leysinger Vieli" for 2018 reference, and same issue in the reference list

Answer: Corrected.

And, on this line I did not find that "This effect is obvious, even visually. . ." – I don't see the influence of basal processes here (?)

Answer: (see response to earlier comment) As we now show a transect going across areas with ongoing basal processes e.g. the Concordia Subglacial Trench, this sentence is still relevant.

Line 284: "fall into nulls" seemed like awkward phrasing, but perhaps I am not familiar with this language. In either case, if there is a way reword that could help make the point more clear

Answer: We have changed this to: "...similarly, reflections from surfaces dipping across track can be nulled by the across track antenna beam pattern structure. "

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Lines 301-309: I think there may be an unintended simplification of the goals for Antarctica in relation to what has been achieved for Greenland. For Greenland, it is a huge advantage to have significant coverage from the same system. Antarctica has the challenge of being bigger, more remote, and the existing data sets have been collected for decades using many different systems. I didn't think that came across in this paragraph so would suggest revising to make it more clear how radiostratigraphy generation for Greenland and Antarctica compare.

Answer: We have added the details that you mentioned, and these lines have been changed to the following:

"The formulated goal of the AntArchitecture action group is to have a joint community effort to build an Antarctic-wide IRH data set to check the match between all previously traced and published IRH data sets that can be directly connected for the East Antarctic Plateau region (to name a few, Siegert et al., 1998a; Winter et al., 2019). Eventually, the aim is that IRHs from currently disconnected surveys (e.g. Steinhage et al., 2001; Leysinger Vieli et al., 2011; Steinhage et al., 2013) are also connected after the collection of additional radar campaigns in the gap areas. The Greenland Ice Sheet already benefits from an325ice sheet-wide IRH data set (MacGregor et al., 2015). For Greenland, it is a huge advantage to have significant coverage from the same system. Antarctica has the challenge of being bigger, more remote, and the existing data sets have been collected for decades using many different systems. However, several studies have already demonstrated this is achievable at the scale of the West Antarctic Ice Sheet (Muldoon, 2018; Ashmore et al., 2020; Bodart et al., 2021)."

Line 307: When "previously rare" is mentioned, I wasn't sure if it was meant for 3-D cases or for continent-scale cases? The citations refer to very different types of work (and many other examples could fit into this by my read, so perhaps use "e.g.") and the statement isn't correct that radar data themselves

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are rarely available for modeling efforts, but of course most of the surveys are local – but models have been integrating these data for decades, and different problems can be tackled as the radar data sets become more spatially extensive. It may be worth elaborating slightly here, or possibly deleting this point as I don't find that it adds much as a single sentence. The authors can decide what is best.

Answer: We liked the wording that you used and have elaborated this section slightly as follows: “Models have been integrating IRH data for decades, but until now, most of the surveys used had been local (a few square kilometers to a few ice catchments in size) (e.g. Koutnik et al., 2016; Beem et al., 2018; Drews et al., 2015). As the radar data sets become more spatially extensive, different problems can be tackled (e.g. Medley et al., 2013; Muldoon, 2018; Sutter et al., 2020).”

Line 318: Should be “confirm”, but I would suggest “corroborate” – there is still dependence on age models

Answer: We changed this to “corroborate”. The sentence has been further changed to:

“This data set was used to corroborate suspicions of 1.5 million-year-old ice in the Little Dome C region (Van Liefferinge and Pattyn, 2013; Parrenin et al., 2017), and will also provide the basis for a regional assessment of age at depth for other planned deep drillings in this region (e.g. Australia)”