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The Cryosphere Discussions

Interactive comment on "New Last Glacial Maximum Ice Thickness constraints for the Weddell Sea sector, Antarctica" *by* Keir A. Nichols et al.

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General comments: This paper presents new in-situ 14C ages (+ replicate measurements) to constrain the glaciation history of the Antarctic ice sheets in the Weddell Sea sector. Such data are highly necessary in order to tease out non-erosive burial of bedrock and erratics, which due to the often cold-based nature of the ice sheet margins outside of major troughs, is a prevalent problem for the interpretation of existing cosmogenic records using longer-lived nuclides. This study thus provides an important contribution that I expect will draw great interest from the scientific community. The paper is well-written, figures are good, and the data presented clearly. My main concerns

are as follows:

1. The replicate measurements demonstrate that there are serious problems with the reproducibility of this dataset. In the current form, this comes as a complete surprise halfway through the manuscript, as it is not reported in the abstract, introduction or conclusion were the results are stated without mentioning this important issue. I think this issue should be made more transparent throughout the manuscript, and that the implications for the non-replicated data should be discussed in more detail. Given the authors' argument that the saturated samples are more prone to being erroneous due to contamination issues with modern carbon, I am specifically concerned with whether too much emphasis is put on the single saturated sample from Mount Provender. Is there any evidence that this sample should be more reliably saturated than the replicated ones? This is particularly important since this is the only data point within the dataset that could otherwise provide a maximum ice sheet thickness during LGM. Furthermore, since this issue challenges the premise of the paper - that the maximum LGM thickness can be detected by the limit between saturated and unsaturated samples in an in situ 14C-elevation profile - I would like to see a brief discussion on how this issue could be handled in the future. Since measurements have been done on samples collected by others with the aim of dating with long-lived nuclides, such a discussion could further include a description of a sampling strategy that could better test your basic premise, would you e.g. recommend sampling bedrock for future applications of this method?

2. I find the presentation and discussion of the implication of these data for the Weddell sea sector's contributions to LGM-present sea level somewhat misleading, and think the authors should give this subject some more consideration. Firstly, I think the estimated range of 2.2-5.8 m is somewhat deceiving as it gives the impression that this is a minimum-maximum envelope, while it is really based on minima estimates from two different locations. It should be clearly stated that these are both minimum estimates. Perhaps it would be more appropriate to make a single minimum estimate based on

e.g. a smoothed surface fit to the minima-elevations. Secondly, I don't see how the author's interpretation of a limited MWP-1A contribution from this sector of the AIS is based on the available cosmogenic data. In my opinion, the results provide robust minimum estimates of the maximum thickness during LGM, and Holocene thinning rates at sites where (sampled) nunatak elevations coincide with ice sheet surface lowering. Yet, given that the only maximum ice thickness estimate is based on a single saturated sample (which again is less certain owing to the replication issue mentioned above), nothing can be reliably said about thinning rates prior to the early Holocene.

Specific comments:

P1, L20-22: specify already here that you use a 'short-lived' cosmogenic nuclide, which is less susceptible to inheritance problems than 10Be and other long-live nuclides.

P2, L21: 'without erosion beneath cold-based ice' is confusing, perhaps 'when protected from erosion beneath cold-based ice'.

P2, L22: 'reduce concentrations' - concentrations will start to reduce immediately by decay when buried, specify 'to below measurable levels' or similar.

P2, L24-25: briefly specify somewhere around this transition in the paper that in-situ 14C is less sensitive to inheritance due to its short half-live, this is key to understand the difference between using one nuclide or another. Also state half-lives of 10Be (+ 26Al) here or elsewhere.

P2, L25&27: you are not really discussing and constraining 'LGM thickening', but the maximum thickness and subsequent thinning.

P3, L19: again, 'reduce' on its own is confusing, add 'to below analytical limit' or similar. Also specify what you mean by 'short' by stating the approximate burial time it would typically require.

P3, L21: 'surfaces not covered by ice during the LGM', this could be stated more generally, e.g. 'continuously-exposed, slow-eroding surfaces'

P3, L22: it would also require low erosion rates to reach such high apparent ages, specify this.

P3, L25: cold-based ice has been shown to sometimes erode (e.g. Atkins et al., 2002, Geology v30 p.659-662). Perhaps specify 'cold-based, non-erosive ice' or simply 'non-erosive ice'

P3, L38 – P4, L4: I think the discussion of whether the erratics record the history of their sampling location could be made more concise. It shouldn't matter for in-situ 14C whether the erratic has been 'covered and uncovered' in place or during transport, as long as it has been buried long enough and then deposited by the ice, with no subsequent movement? Also avoid moving back-and-forth between discussing bedrock and erratics. P3, L46: specify which assumption.

P4, L9-11: I don't think it is necessary to repeat this information here

P6, L. 43-46: At present this section has a bit of an 'ad-hoc argument' feel to it, I think it would be better to first provide an objective discussion on what criteria can be used to assess the validity of this method before you go through each site.

P6, L. 44: I don't think the Lassiter coast dataset can be strictly described as having a 'linear age-elevation relation', as it requires at least two lines two fit the data. Perhaps rephrase to 'ages continuously decrease towards the present ice sheet surface'.

P7, L7: 008-NNS doesn't seem to be replicated here? I don't find a saturated (replica-) measurement in the table or figure.

P7, L12-13: You don't present replicate measurements from elsewhere than the Schmidt hills, so this sentence reads a bit strange.

P7, L14: This transition was not obvious to me. This also goes for the next two paragraphs, I think you could link the various paragraphs discussing the poor replicability better. The 'Regardless,' makes it sounds like you are moving on to another subject. This paragraph is discussing whether there could be any geological reasons that the

in-situ 14C profiles are ‘inverted’?

P7, L22: specify ‘erratic’ samples

P7, L26-27: I couldn’t follow this argument.

P7, L37: I think you need to discuss here whether or not you expect the same issue for the saturated, but non-replicated sample from Mount Provender. Given only two data points from this site, the fact that the ‘profile’ isn’t inverted is not a very strong argument, or?

P8, L11: provide the in situ 14C ages with uncertainty here to make it easy for the reader to compare

P9, L23: You first state that your data ‘do not preclude a significant contribution earlier than (the early to mid-Holocene)’, yet move directly on to suggest that MWP1A was not significant in this region, thus contra-arguing yourself. I don’t think you can constrain MWP1A thinning on the basis of these data.

Fig. 1: boxes should refer to Fig 4a-d, not 2a-d.

Fig. 2: legend P13, L13: remove ‘constraints’ before ‘ice’

Fig. 3: specify that you used zero erosion (presumably) for these calculations. It looks strange to me that the saturated samples are labelled as ‘true’ exposure. The figure is a bit blurry compared to the others.

Fig. 4: green color of sample points in legend and on map does not appear to be the same

Fig. 5: add legend showing circle=erratic, triangle=bedrock.

Fig. 9+10: legend refers to maps on left, but they are on the right

Technical corrections:

P1, L32: Should Antarctic ice sheet(s) be in plural, west+east?

P2, L18: specify ‘non-erosive’ burial

P3, L22: ‘measured today’ seems unnecessary

P4, L31: remove ‘from’

P5, L13: ‘analysed’ and ‘analysis’ in same short sentence

P6, L18: perhaps ‘ice thinning’ rather than ‘deglaciation’?

P7, L17: fig 10 referred before fig. 9. Fontsize is odd

P10, L6-7: BG rather than BM?

Supplementary table S2: Spreadsheet tab is named ‘Table 3’ while table is ‘Table 2’.

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