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

Anonymous Referee #1

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Overview

This paper reports an in situ-produced 14C chronology of past ice thickness change for several sites around the Weddell Sea Embayment. Reconstructions of Last Glacial Maximum (LGM) ice thicknesses and subsequent deglaciation have been complicated onshore by a lack of reliable constraints, primarily due to issues with the cosmogenic inheritance of 10Be. Here the authors attempt to improve on existing LGM constraints from the region, and present an approach to determine whether sites were covered at the LGM using the concentration saturation point of in-situ 14C. Evidence is found for LGM thickening at all sites, with an upper limit provided at one site. The new con-

straints help resolve apparent differences between marine and terrestrial records. They conclude by providing sea-level equivalent estimates of ice volume from their new ice thickness constraints.

Main comments

The paper presents novel data to address the important topic of LGM ice volume. Notably, the ice sheet was at least 310-800 m thicker in the Weddell Sea Embayment. The results are definitely within the scope of The Cryosphere, and will be of interest to those reconstructing past ice sheet change using empirical data, ice sheet modellers and glacial isostatic adjustment modellers. I enjoyed reading the paper, which is well-written with clear figures. The title is suitable and the abstract concisely summarises the paper. The methods are described in adequate detail (the schematic in Fig. 1 is very useful), the treatment of the data seems valid, and the limitations of the technique and data are well-discussed.

My main issue with the paper is how the data are discussed in relation to the maximum LGM ice thickness and the contribution to deglacial sea-level rise (primarily sections 4.2 and 4.4). Firstly, the highest sample at Mt Provender produces a 14C concentration that appears to have reached saturation, which would imply ice cover at 30-35 kyr. But, as the authors discuss in detail for Mt Skidmore and Schmidt Hills, bogus high 14C concentrations can result from analytical and geomorphic issues. I would therefore be justified to argue that the single sample at Mt Provender is not sufficient to provide an upper LGM thickness limit, and that all of the data presented in the paper only provide minimum LGM ice thickness estimates.

Secondly, without maximum constraints on LGM ice thickness, it is not possible to infer when the majority of post-LGM ice thickness occurred. Specifically, the exposure ages do not indicate that the Weddell Sea sector contributed to sea-level most significantly during the early-mid Holocene (section 4.4, line22), and the majority of exposure ages occurring post-MWP1a does not mean that this sector didn't contribute significantly to sea-level rise at this time as there is limited data constraining maximum ice thickness prior to MWP1a (4.4, lines 22-26). It also appears in Figures 5 (Mt Skidmore) and 7 (Schmidt Hills) that accelerated thinning may have occurred at about the time of MWP1a, but the logarithmic axis prevents the reader from assessing this.

Minor comments

Page 1, line 30: It is necessary to broadly define the time of the Last Glacial Maximum, and briefly discuss global vs regional differences, as this has implications for what you are trying to achieve.

Page 2, line 13: "Results from Schmidt Hills (Fig. 1)..." do you mean Fig. 2?

Page 3, line 17: You should state the half-lives of 10Be and 26Al.

Page 3, lines 19-20: Reduce concentrations to what level? To below analytical uncertainty?

Page 3, line 23: "before the LGM", as above, the time of the LGM has not been defined.

Page 3, lines 44-45: Erratics can be considered bedrock, but with the assumption that they have not been transported from upstream during periods of ice cover.

Page 4, lines 2-5: What about surface erosion? This should be acknowledged here.

Page 5, line 9: 320 m above the FIS ice margin, but are very close to ice at a much higher elevation on the other side of the range. Which ice surface likely covered the samples? Why?

Page 5, lines 34-35: How well known is it that the sampling location was not covered by ice at the LGM?

Page 6, lines 6-7: The "upper limit" is based on a single sample as discussed above. How reliable is this? This limitation should be acknowledged here and discussed in section 4.

Page 7, line 44: What is the statement that the entirety of Mt Skidmore was covered by ice at the LGM based on? How high is Mt Skidmore? Is there a post-LGM sample at the top?

Page 8, line 3: Again, only a single sample supports Mt Provender remaining exposed at the LGM.

Page 9, lines 1-4: It is probably overly precise to report estimates of modelled ice thickness to the nearest metre given the uncertainty in the modelling experiments.

Page 9, lines 16-17: "Using the average LGM thickness constraint" is a little misleading as it is the average of minimum ice thickness estimates, rather than an average of a suite of maximum and minimum estimates.

Page 9, lines 17-20: How would you expect these simple estimates to differ if you were to account for spatial variation in ice thickness, etc.? At the very least it is probably fair to say that there was less thickening inland relative to at the sample sites and the ice sheet margin.

Page 9, line 24: Unnecessary to abbreviate to MWP1A as only referred to one other time.

Page 9, line 35: Possibly "up to 655 m...".

In several places: Both ka and kyr is used. Pick one.

References: Fogwill et al. (2014), and maybe other papers, are missing.

Fig. 1: Should 2a, 2b, ... not be labelled 4a, 4b, ...?

Fig. 3: What is the error envelope based on? What uncertainty has been used for the hypothetical sample concentrations? Typical analytical uncertainty?

Supplementary material:

Would be useful if the study site figures had contours (e.g. from REMA).

Would be nice to see a figure with the 14C ages plotted on a linear axis, perhaps vs the relative elevation of the samples.

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