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Interactive comment on "Cosmogenic isotope measurements from recently deglaciated bedrock as a new tool to decipher changes in Greenland Ice Sheet size" *by* Nicolás E. Young et al.

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General Comments

This manuscript presents a new cosmogenic isotope chronology to help constrain retreat of the western Greenland Ice Sheet (GrIS) during the earlier Holocene. It has long been surmised that the GrIS was smaller than present during parts of early Holocene, but constraining the magnitude of margin retreat and its timing has been difficult due to the late-Holocene ("Historical") readvance covering much of the previously exposed surfaces. By utilizing 3 different cosmogenic nuclides (10Be, 14C, and 26Al) on sampling locations, the authors provide a clear picture of the complexity of nuclide inheri-

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tance, erosion, and exhumation that can sometimes confound cosmogenic nuclide interpretations. This is especially true in regions with a complex ice retreat history, such as that of the southwestern GrIS during the Holocene. This new dataset is compared with a robust compilation of existing exposure and lake chronologies from all along the historical extent of the southwestern GrIS that broadens the scope and significance into that of a larger regional signal. In addition to the chronological constraints provided in this manuscript, the authors also present new results from a high-resolution ice sheet model for the southwestern GrIS to help constrain the magnitude of retreat past the modern margin extent. These simulations are forced with temperature and precipitation from recent data assimilation efforts for Greenland. These model experiments explore a range of climate space, thus incorporating some parametric uncertainty in the results. Such a robust set of experiments allows for the exploration of a variety of possible solutions for Holocene margin retreat, a comparison with chronological constraints to constrain the model, and an assessment of model limitations (e.g. lack of iceberg calving). Generally, the manuscript provides a set of results that are consistent with improving our understanding of GrIS retreat during the Holocene. It is clear and well structured. I have a few concerns related to statistical significance and a need for a little more description about the modelling approach. After addressing these comments (mostly technical), I believe this manuscript is worthy of publication.

Specific Comments

Separate retreat timing from Kapisigdlit moraines? - One of the main conclusions is that the Kapisigdlit moraine deposition occurred with different timing for KNS (10.24 $\pm$ 0.36 ka) and Qamanaarsuup Sermia (9.57 $\pm$ 0.38 ka), thus suggesting a new mode of GrIS moraine deposition during the Holocene. However, don't these two mean ages overlap at 1σ? The overlap is small, but an overlap nonetheless. It seems statistically possible that these two ages are equivalent. At the very least, it would be good to show t-test statistics to help show the level of statistical difference between these ages. If the difference between these ages is not significant, then some of the wording of the paper

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may need to be modified to indicate the possibility of synchronous moraine deposition.

Ice Sheet Model Methods (section 2.7) – I think it would be good to offer a little more description on the nature of the model setup and experiment design. I realize this model is extensively described in Cuzzone et al (2019) and Briner et al. (2020), but there are some crucial distinctions that could be added here that would help in understanding the results. For example: -What is the nature of the surface mass balance calculations? PDD? -Provide a general description of the flow dynamics. -mention the lack of calving in the methods (it gets brought up later, but it would be good to mention such model limitations in the methods -More description of the 9 model combinations/experiments (line 238-239). How were these 9 permutations selected? How do they differ?

Discussion of marine Terminating Dynamics (lines 748-764) – How much of the full model domain is influenced by marine dynamics and iceberg calving? Since these regions minimize retreat in the model, is there a way to show or discuss how much of the model domain would be influenced by this model limitation. Are any of the margins still marine-terminating at the minimum Holocene extent?

Technical Comments

Lines 38-40 – This compound sentence is confusing. Consider breaking up into 2 sentences

Line 201 – Specifically, what is the production rate uncertainty that was used in quadrature? Is it a constant percentage? Or is it spatially varying?

Line 365 – "mean age of 10.20 $\pm$ 0.14 ka (10.27 $\pm$ 0.23 ka with production-rate uncertainty)." Why are the mean ages (10.20 and 10.27) different? Shouldn't the production rate uncertainty added in quadrature only effect the uncertainty value? Also, double check on these values are appropriately displayed in Figure 2.

Lines 373-377 – Would it be possible to include this early photograph with permission? It would be nice to see this photograph annotated to show the ice extent and trim-line

as described in the text.

Line 437 – I think the use of the phrase “more proximal” is confusing here. These high elevation sites are less proximal from the historical limit, when considering ice position. I would say that the recently deglaciated sites are “more proximal” than the historical limit. Do you mean that the high elevation sites are closer to the historical maximum limit?

Lines 508-509 – “we favor an interpretation that couples less site exposure over significant amounts of subglacial abrasion” – I think the use of the word “couples” is confusing here. What is being coupled to what?

Figure 1 – The orange diamond of Weidick et al (2012) is very hard to distinguish from other yellow circles. Consider using an alternative symbol.

Figure 2 & Figure 3 – In general it can be difficult to distinguish between italicized outliers and non-outliers. Is there a different way to distinguish outliers other than italics?

Figure 17c and 17d – What does this distance axis mean? Is it distance from the coast, or some other arbitrary point? Would be good to clarify in the caption.

Figure 17c and 17d – Is there a way to better display the present day location? The yellow dots are hard to see on the first pass

Figure 17c-17f – On each of the model result figures, it is hard to distinguish between the green lines and the blue lines. Would it be possible to use a more distinct color gradient for these groupings of simulations?

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