

Interactive comment on “Impact of millennial-scale oceanic variability on the Greenland ice sheet evolution throughout the Last Glacial Period” by Ilaria Tabone et al.

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The manuscript (MS) aims at estimating the Greenland contribution to sea level variability during the last glacial period in relation to D-O and Heinrich events. The authors apply an approach similar to that used in an already published paper concerned with glacial-interglacial cycles.

Overall, I think the exercise is very useful to give a first order estimate for the Greenland contribution to sea level variability during glacial times, and I think the approach of implementing ice-shelf ocean interaction is new and very relevant. I have one major point of concern, however, that I think needs consideration in order for the MS to make

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a good case.

It is very well established in the literature that during the last glacial period, the Heinrich events and the major ice rafting events in the North Atlantic are associated with the Greenland cold phases, the stadials. In contrast, during the mild Greenland periods, the interstadials, ice rafting and transport of continental material to the North Atlantic is much more limited. This is clearly illustrated in Figure 11 in the cited Hodall et al., QSR, 2010 paper, but also in many other studies where record resolution allows for a detailed comparison of marine records to the Greenland temperature record.

If I understand the model of the manuscript correctly, the ocean-terminating melt of GRiS is forced by the Greenland derived surface temperature, and the ocean temperature variability is assumed to be in phase with the (Greenland) atmosphere. Therefore, most of the marine-induced/basal melt from GRiS occurs during the interstadials. I see this as a highly unrealistic approach. Whereas the Greenland surface temperature is quite likely to give a good estimate for the Greenland surface melt during D-O events, I think this approach leads to a very unrealistic scenario for the basal melt that is mainly caused by interaction between the ice sheet and the subsurface ocean.

As seen in the MS figure 11, the modelled basal melt is completely out of phase with the melt events observed in the marine record. All the major modelled melt events occur during the Greenland interstadials, whereas all of the observed melt events occur during stadials. It is argued in the MS that the reason for this discrepancy could be that the source area for the marine IRD in this specific core could be different from Greenland. However, the timing of other IRD sources are also consistently occurring in the stadials. I think that the reason for this significant model-data disagreement is that the model approach of forcing the basal melt by Greenland surface temperatures is fundamentally wrong.

One could argue that it may not matter so much exactly when the ice sheet is losing or gaining mass as long as the inferred change in sea level variability is of the right

order of magnitude. In this case, however, I think it is quite clear that the GRiS mass changes observed in the model are caused by an entirely wrong mechanism, and therefore are likely to be misleading and possibly of the wrong magnitude, also when it comes to sea level variability. Therefore, I think it is very important that a more realistic approach is applied for the basal melt/marine-terminating ice melt. It can possibly still be a simple approach, but it needs to include some estimated extent of sea ice in the North Atlantic, and some marine-based estimate of sub-surface ocean temperatures. The inclusion of sea ice is essential, because the sea ice partly seals off the ocean from direct heat exchange with the atmosphere, and thereby hampers the assumption of an in-phase temperature variability of ocean and atmospheric temperatures on the time scales relevant for D-O events.

Possibly, the authors can seek inspiration for a more realistic basal melt timing in those papers:

Dokken et al., *Paleoceanography*, 2013: Dansgaard-Oeschger cycles: Interactions between ocean and sea ice intrinsic to the Nordic seas

Bassis et al., *Nature*, 2017: Heinrich events triggered by ocean forcing and modulated by isostatic adjustment.

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