

Interactive comment on “Water mass evolution of the Greenland Sea since lateglacial times” by M. M. Telesiński et al.

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Received and published: 21 November 2013

The authors would like to thank reviewers Juliane Müller and Thomas Cronin for their constructive criticism and suggestions which helped to improve the manuscript. We took all of the comments into consideration. We attempted to make the discussion more decisive. Our answers can be found below.

Thomas Cronin General: Important paper dealing with key issues: the ID of Heinrich Events in this region, the hyperpycnal hypothesis of Stanford, the identification of YD being difficult due to effects of fresh Polar water, as opposed to glacial lake meltwater; the important role of Atlantic warm water under sea ice. I would like to see more definitive discussion of all these topics, as the authors are somewhat inconclusive. Especially, the Arctic – Mackenzie origin of Agassiz lake freshwater, because the current

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study region is right in the path. However, is the temporal resolution of these cores too low, like central Arctic sites, to pick up a very short glacial lake water signal?? If so please say so.

AUTHORS: We claim that our data indicate the Arctic origin of the YD and support the modeling results (Condrón and Winsor, 2012) that indicate the Mackenzie River as the source (the paragraph rephrased).

The Holocene discussion is quite long and will confuse those not familiar with the regional oceanography. Can the authors condense or synthesis major steps in Hol. Climate, notably whether they think the 3ka “event” is of broader significance?

AUTHORS: We have condensed the Holocene section from 147 to 139 lines. Nevertheless, we consider the Holocene section an integral part of the manuscript because only for this time interval we have a full set of proxy records. These allow a more detailed reconstruction of both near-surface and deepwater environments, something that is not possible for the older part because of the lack of suitable benthic foraminifers. Regarding the youngest interval, we state that the 3ka “event” appears to be a sound stratigraphic time marker of a supraregional implication.

Line 6 abstract “ice-bearing” what kind of ice? Sea ice, icebergs, ice shelves?

AUTHORS: Changed to “sea-ice bearing”.

Line 8. The YD was a freshwater event. OK, but do you mean freshwater entered the study area? A freshwater lid? Or are you referring to Mackenzie or St Lawrence YD lake water discharge? Or Greenland glacial ice melt?

AUTHORS: Freshwater certainly affected at least part of the area during the YD, as indicated by the oxygen isotope records. We are unable to distinguish whether it came from Mackenzie, St. Lawrence or Greenland but we discuss the potential sources for freshwater during the two major events recorded in our cores (18-15 ka and YD). For the YD, we demonstrate that our data fit with the modeling results of Condrón and

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Winsor (2012) indicating that only a freshwater discharge to the Arctic (probably via the Mackenzie Valley) was able to reach the deepwater formation regions in the North Atlantic (including our study area).

Line 9, replace "improvement" it was not so, if you are a member of a sea ice dwelling community, a cryophilic species or *N. pachyderma* left.

AUTHORS: Sentence rephrased to "The onset of the Holocene interglacial was marked by an increase in the advection of Atlantic Water and a rise in sea surface temperatures (SST)."

Page 5039, lines 5-10. Reword the sentence.

AUTHORS: Sentence rephrased.

The next paragraph, tell the reader what age period you cover, since the term "lateglacial" is not clear to everyone

AUTHORS: We now mention that we mean the last 22.3 kyr.

p. 5043 line 11. "In addition to our own data,..."

AUTHORS: Corrected.

Also, why no discussion of C14 reservoir effects in this basin?

AUTHORS: Uncertain reservoir ages are mentioned in this section and discussed in the "Discussion" section.

p. 5046, line 4. Do you mean Last GM? Not "late" GM ?

AUTHORS: Changed to "late LGM".

p. 5048, line 10. Cite Hanslik 2010 reservoir paper for the Arctic

AUTHORS: Done.

General – the text seems to rely on Telesinski 2013. I hope there is not too much
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overlap, but that is why comments above, asking for more definitive conclusions on a number of topics would distinguish the two papers.

AUTHORS: We now try to explain in more detail which additional data are presented in this manuscript (3 additional cores, additional benthic isotope records) and why this should warrant an additional publication (regional reconstruction for the entire Greenland Sea, reconstruction of variable deepwater renewal).

Juliane Müller This paper by Telesinski et al. provides valuable information on late glacial to Holocene water mass characteristics in the Greenland Sea - a crucial though only poorly studied area in the subpolar North Atlantic. The authors present foraminifer, stable isotope, subsurface temperature, and IRD records of four sediment cores from the Greenland Sea and compare and discuss their results with published data sets in an adequate manner. The reconstructions mainly support existing assumptions about the deglacial (freshwater driven) and Holocene (insolation driven) palaeoceanographic evolution in the study area and the authors identify solar forcing and Atlantic Water advection as the main drivers for the temporal and spatial development. Some more decisive interpretations of the data, however, would certainly improve the paper. Further, the discussion of the deglacial development could benefit from the consideration of the role that sea ice plays in the Greenland Sea - in particular since the impact of sea ice is already highlighted in the introductory part of the paper. The authors, for example, relate the deglacial (HS1) $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ minima to enormous freshwater discharge events (i.e. glacial lake outbursts). In this context, the role of sea ice (as a further freshwater supplier) should be addressed, which could also help with the interpretation of the duration of light $\delta^{18}\text{O}$ intervals.

AUTHORS: In the revised manuscript we consider more thoroughly the role of sea-ice which may act as a supplier of freshwater but is also important because it reduces the atmosphere-ocean gas exchange. The latter case may be involved in particular when low planktic carbon isotope values indicate a diminished ventilation of near-surface waters.

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Considering the HS1 AMOC slow-down, McManus et al. 2004 (Nature) or Ritz et al. 2013 (Nat. Geoscience) could be cited.

AUTHORS: McManus et al. 2004 cited.

Though the authors acknowledge the dating problem it would be helpful for the reader if, for example, the LGM time/depth interval is defined more clearly (e.g. by the use of colour bars in the figures).

AUTHORS: We find it difficult to add such color bars to the figures because the LGM interval cannot be clearly defined in all of our cores. As discussed in the stratigraphy chapter, variable and often very low sedimentation rates in combination with bioturbational mixing likely resulted in ages from radiocarbon datings which are less reliable than in areas with higher sedimentation rates. In our mind, showing "LGM bars" would indicate an age precision that cannot be provided for this time interval on the basis of the available data. To give the reader a guiding line, we show grey-shaded bars which mark the onset of the deglaciation.

Finally, I recommend that the data is made available e.g. by providing a link to the PANGAEA data repository.

AUTHORS: All data will be made available on PANGAEA.

Minor issues: - correction of typos and re-phrasing of sometimes too colloquial wording (e.g. page 5051, line 20)

AUTHORS: Manuscript checked for typos, fragment rephrased.

- studies by Bert Rudels should be acknowledged in the description of the oceanographic setting in the study area

AUTHORS: Rudels and Quadfasel, 1991 and Rudels et al., 1999 cited.

- the so-called 'Odden ice tongue' could be considered as this phenomenon probably impacted on core site PS1878 palaeoceanography

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AUTHORS: Is Odden mentioned in the Study area section.

- consistent use of either ka or kyr

AUTHORS: We consistently use ka for 'thousand calendar years before 1950 CE' (points in time) and kyr for 'thousand years' (time periods).

- Page 5040, line 3: Denmark Strait not Danish Strait

AUTHORS: Changed to Denmark Strait.

- Page 5046, line 16: if these low d13C values are not related to sea ice/stratification provide other possibilities

AUTHORS: When discussing the low d13C values during the LGM we explicitly mention the possibility of changes in the carbon cycle, in addition to changes in sea ice coverage and stratification. Such carbon cycle changes and their influence on our records are difficult to quantify from our data and thus we refrain from a lengthy discussion which, in the end, would not be able to provide a definite answer to the question which of the factors may be most important.

- Page 5046, line 23: IRD and foraminifer peaks in core PS1906 seem to be a bit out of phase

AUTHORS: 'In cores PS1906, PS1894 and PS1878 they clearly coincide with foraminiferal abundance peaks.' rephrased to 'These peaks clearly coincide with foraminiferal abundance peaks in cores PS1894, PS1878 and partly in core PS1906.'

- Page 5047, lines 13-17: how about an enhanced sea ice export from the Arctic?

AUTHORS: We find it rather unlikely that an enhanced sea-ice export from the Arctic could result in $\delta^{18}\text{O}$ peaks of such high amplitude. The $\delta^{18}\text{O}$ signature of sea ice is not much different from that of the water in which it was formed. Even though one may expect that the $\delta^{18}\text{O}$ signature of sea ice which formed from low-saline (freshwater-rich) sea water had a larger difference to that of "normal" sea water, one would need

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to melt unrealistically large amounts of rather thick sea ice to produce the effect we see in our records. A discussion of the effects of freshwater additions and sea ice formation/melting on the isotopic composition of sea water can be found in Spielhagen and Erlenkeuser (1994).

- Page 5051, line 19 and below: here, the papers by Fahl & Stein, 2012 (EPSL) and Not & Hillaire-Marcel, 2012 (Nat. Communications) linking Younger Dryas freshwater forcing and enhanced formation of sea ice in the Arctic (and export through Fram Strait) should be cited

AUTHORS: Both papers cited.

- Page 5055, line 7-8: provide explanation/reference for enhanced inflow of polar water into the Greenland Sea during AMOC intensification

AUTHORS: Explanation given in the revised text: "An AMOC intensification after 7 ka would also imply enhanced inflow of AW and PW into the Greenland Sea since the increased convection rate must be compensated by an increased inflow of both saline AW from the south and cold PW from the north."

- Figs 2-4: I assume that the light grey shadings indicate HS1? explain in figure captions.

AUTHORS: Explanation given in figure caption.

Interactive comment on Clim. Past Discuss., 9, 5037, 2013.