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Climate of the Past Discussions

Interactive comment on "The Holocene thermal maximum in the Nordic Seas: the impact of Greenland Ice Sheet melt and other forcings in a coupled atmosphere-sea ice-ocean model" *by* M. Blaschek and H. Renssen

R. F. Spielhagen (Referee)

rspielhagen@geomar.de

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General comments

I must admit that I am not a model specialist and can therefore not comment on the details of the model design etc. From my view as a paleoceanographer this paper is a valuable contribution which will strongly improve our understanding of the impact of the Greenland ice sheet on the Holocene Nordic Seas. In particular, it helps to identify some important actors in the game of Holocene Nordic Seas paleoceanography

regarding the temporal and spatial variability. In general the paper is well written (except the last subchapter of the discussion which looks like it was written in a hurry), properly organized, of adequate length and supplied with good illustrations and figures. The English is mostly fine but should be improved by a native speaker. A list of language corrections is found further below but there may be more corrections necessary. Despite my overall good impression of the paper I have a number of comments and questions to the authors which may help to improve the paper in the course of a minor revision. Some of these comments and questions may arise from my lack of knowledge of paleoceanographic models. However, since the paper is apparently directed to the general paleoceanographic-paleoclimatic community, they may be still be valuable for the authors.

Specific comments and questions sorted by page and line numbers (page*line(s))

5265*12 "down-wind continents" Which are these? Are there several affected?

5265*15-16 "in the Labrador Sea, causing expanded sea-ice cover and cool surface conditions compared to today" The Labrador Sea is rather cool already today. Do you mean "cooler" or "colder"?

5265*16-17 "An important part of this spatio-temporal complexity can be explained by the impact of the remnant LIS in North America" This restrictive statement is somewhat surprising since the reader got the impression from lines 11-16 that the LIS is the only factor.

5265*3-5 This is more or less a repetition of what was said in the sentence before.

5266*5-7 "It has been suggested that the eastern side has a stronger response to orbital forcing in the early Holocene compared to the western side (Andersen et al., 2004)." The reader will be interested to know the reason for this variability without looking it up in the Andersen et al. paper.

5266*27-28 "although eastern SST reconstructions might be not as well known as

previously anticipated" What do you mean here? The reconstructions are published and therefore quite well known!

5267*12-13 "It is likely that in the early Holocene the GIS was bigger than at present-day." There is a reletive new review on the GIS history which may useful here: Funder et al., The Greenland Ice Sheet During the Past 300,000 Years: A Review. In J. Ehlers, P.L. Gibbard and P.D. Hughes, editors: Developments in Quaternary Science, Vol. 15, Amsterdam, The Netherlands, 2011, pp. 699-713. ISBN: 978-0-444-53447-7.

5267*16-17 "Vinther et al. (2009) suggest changes in the range of 100–300m higher for 9 ka BP compared to today." What do you mean here? Were the changes higher? Or was the site higher? Or what?

5267*21-23 "No quantified estimates of this early Holocene melt flux have yet been published, but based on Peltier (2004) we could infer a best guess additional flux of 13 mSv (1 Sv=1°âĂŤ106 m3 s−1) for 9 kaBP." What is this flux additional to? It may be interesting for the reader to have some published estimates of modern fluxes here, just for comparison.

5267*24-25 "How does this early Holocene GIS melt flux compare to projections of GIS melt for the present and the near future?" Are projections of present flux interesting? I guess more interesting would be estimates/measurements of modern fluxes. Although this is a modelling study, it should use modern values wherever possible.

5268*25-26 "We have not activated the components for dynamical ice sheets" At this point the reader will wonder why you did not do this. Later (5269*12) you give the reason. Why not right here?

5270*9 "PI" was not introduced before.

5270*20-22 "We have added this melt water to the top layer of the ocean corresponding to the surface runoff outlets of the Greenland landmass." Where was it added? At one single point? At several points? How were these selected and how was the discharge

calculated? Or was the discharge distributed homogenously around Greenland?This is a crucial point because later (5274*18ff) you discuss regional differences of the impact of this meltwater (Nordic Seas vs. Arctic). Most likely sea-ice formation etc. will depend on the distribution of freshwater outlet points.

5270*10-16 Does the model take into account the strong meltwater influx from the LIS at the onset of the 8.2 ka event? Should we (do we) see an effect of this event in the model results? Not every paleoceanographer working in the area will be acquainted with the details of the Renssen et al. (2009) model but all of them know about the 8.2 ka event...

5272*22 add "in 9kOGMELT" at the end of this sentence to clarify what you are referring to.

5273*4ff You are discussing "gradients" a lot in this paper but you do not use this term correctly. By definition, a gradient is a quotient of two differences, in your case usually dT/dL (where T is temperature and L is degree longitude). Accordingly, a gradient cannot have just a temperature value. In most cases you should replace "gradient" by "difference" in your paper.

5273*7 I have problems to understand what a "yearly gradient" is.

5273*16-17 "Along with this gradient reduction, a reduction in variability can be noted by smaller standard deviations." The differences in standard deviations do not seem large to me. Are the differencdes statistically significant so that you can make an argument out of that?

5273*20-24 These comparisons to published proxy data sound a bit like cherry picking. As long as you do not discuss the pros and cons of the different proxies and what they may or may not reflect, the reader remains puzzled and has no idea as to what may more trustworthy: Proxy data (which?) or model results. I suggest that you elaborate somewhat more on this issue in the paper - it's a crucial thing...

5274*12-14 "In our simulations we find the impacts of the following forcings on August SSTs: (1) GIS melt near Greenland, (2) LIS melt water in the Labrador Sea, (3) the remnant LIS, (4) the combined effect of LIS and GIS". Point (4) sounds like as if the other effects were acting single. In fact you will always have combined effects! Or do you want to sum up the factors in the different experiments here? Then I must say that this was done already in chapter 2.

5274*15 "...mechanisms like (1) reduced vertical heat transfer,..." Do you mean atmospheric or oceanic vertical heat transfer?

5274*24-25 "In the Arctic Ocean, however, surface waters are already quite fresh and stratified, minimizing the effect of additional melt water." The differences in terms of salinity and stratification are certainly depending on the input localities for the meltwater. See my comment above.

5274*25-26 "As a consequence of cooler and fresher surface waters, sea-ice growth is facilitated here".... Sea ice growth will also be facilitated almost anywhere around Greenland by meltwater input because we must assume that winter air temperatures were low enough.

5275*10-25 For the interested reader a comparison of actual modern overturning values (from oceanographic dara) will be extremely helpful here to understand the significance of the reductions you discuss here. Furthermore, there is ample evidence for a strong Atlantic Water advection to the Arctic at ca. 11-8 ka (e.g., Rasmussen et al., 2007; Risebrobakken et al., 2011). Isn't that contradictory to the model results which seem to indicate a reduction in the AMOC? Discuss!

5275*21 Look up in a map where 30°S is!

5275*29 "NAC" has not been introduced before.

5276*1-8 Is the effect of brine rejection (i.e., salinity and density increase of subsurface waters) from sea-ice formation taken into account in the model? This may be important

for the salinity...

5276*3-4 Is the main deep convection site in the Nordic Seas really south of Svalbard? In the Barents Sea????

5277*4-14 Each of these three sentences is too long, sounds weird, and is difficult to understand. Make short sentences here and explain your thoughts in a logical line of arguments.

5277*11 "...another yet unknown forcing..." Oooops, here comes the joker? What could be such a "yet unknown forcing"? Discuss it or leave it out!

5277*19ff Figure 5 shows ages of the HTM while in the text you discuss delays with reference to 9 ka. This is confusing!

5277*26-28 The first part of this sentence is confusing. What ranges "by 500 to 2500 yr"?

5278*9-10 What is "more continuously"? Can you augment the word "continuously"?

5278*11-12 Here with "trend" a similar terminology problem comes up as with "gradient". A trend is from A to B and thus cannot be just a temperature value.

5278*13-14 "Slightly better are SST trends from Calvo et al. (2002)" Who is to decide which trend is better or worse? And what is a "good" trend?

5278*15-16 "Marine sites from Kaufman et al. (2004) in the Nordic Seas give SST trends between 2.5 and 6.6 K, mostly being diatoms" This a weird sentence. What are the diatoms? The temperature? The sites? The SSTs? Or what? I can guess what you mean but this should be intelligible also for people who have less time to read this article... :-)

5278*19-20 "...but leave some similarities." This is rather vague. What do you mean? The comparison of timing in models and proxy records is very interesting and should be discussed properly.

5278*25 "whereas the North Iceland shelf is between 9 and 6 ka BP" I do not understand. What happened to the shelf between 9 and 6 ka?

5278*26 What is a "spatial timing gradient"? I have problems to imagine...

5278*27-28 "the Norwegian site" Which site? This was not mentioned before.

5278*28 "the timing delay is $\sim$1 kaBP." Is that really what you mean? "1 ka BP" means 1000 years before present.

5279*10-12 You should mention what the reference is for the differences in temperature and overturning that you are mentioning.

5279*14-15 "Although absolute model temperatures do not compare well with exact core locations" No wonder! Temperatures and core locations are apples and oranges...

5279*20-22 Be specific: It is better reproduced than what?

5279*25-5280*7 This is all new to the reader. In my mind, conclusions should not come up with issues that have not been discussed properly in the chapters before. They should give the essentials from the discussion, not some brandnew ideas.

Technical comments, language corrections (proposed rewording) sorted by page and line numbers:

5264*5 reveals

5264*12 an ocean

5264*14 the early

5265*20 delete comma

5266*7 discussion on whether

5266*9-10 SSTs reconstructed from alkenones

5267*9-10 experi-ments

5267*12-13 suggest a ... BP that ...

5268*8 I propose not to begin a new paragraph with "therefore" or similar. If you are referring directly to the previous sentence, a break (i.e., a new paragraph) is not justified anyway.

5268*16 evaluate which expression

5269*5 to a sea-ice

5274*7 species were less affected

5274*27 second paranthesis is missing!

5274*28 9kOG, assisting

5275*3 in the Labrador Sea

5275*4 Labrador Sea is

5275*5-6 sea-ice cover from strong surface freshening

5276*3 convection site south of Svalbard

5276*5 reduction in surface density

5276*10-11 GIS melt that seems

5276*15 The modelled Nordic Seass SST

5276*18 OGMELT affects

5276*19-20 In contrast, in OGMELTICE the additional

5276*24 melt is at its peak

5277*3 is stronger influenced

5278*22-23 According to Kaufman et al. (2004) the timing of the HTM at the eastern

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