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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

Anonymous Referee #3

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The study of Blaschek and Renssen investigates the impact of including runoff from a melting Greenland ice sheet in coupled simulations of the period following the Holocene thermal maximum (∼10ka BP). Imposing best-guess estimates of early Holocene Greenland melt flux from the ICE-5G model (Peltier, 2004), the authors find an ocean surface cooling of ∼2K southeast of Greenland in their model. Imposing a stronger Greenland melt flux, or including a relatively small input of meltwater from the Laurentide ice sheet, gives a significantly larger cooling, focused to the southwest of Greenland. These results are further analyzed in terms of the simulated east-west SST

gradient across the Nordic Seas and the timing of the Holocene Thermal Maximum as seen in the model SST.

One of the main points discussed is the agreement of the model results with diatom-based reconstructions indicating a strong early warming (∼10-9ka BP) in the eastern part of the Nordic Seas, versus a relatively weak late warming (∼8.5-6.5ka BP) in the western Nordic Seas. I.e. the authors test the models ability to reproduce a delayed Holocene Thermal Maximum (HTM) in the western Nordic Seas and a highlight of the manuscript is the final figure showing the local timing of Holocene SST temperature maxima.

The manuscript is well written and contributes to our understanding of Holocene climate of the Nordic Seas. However, there is a general lack of discussion on the underlying mechanisms behind the simulated changes in ocean temperature, convection and circulation and the manuscript would benefit from including further comparisons with proxy data, preferentially plotted together with the model data. Another concern is that, by the end of the manuscript, it is still unclear that the Greenland ice sheet contributes significantly to the cooling of the western Nordic Seas when compared to the impact of the remanent Laurentide ice sheet. This is true both for the snap-shot experiments at 9ka BP and the transient Holocene experiments.

Pending publication, these general comments, as well as the following issues and specific comments should be addressed:

Is it possible to explain the reconstructed east-west gradients with the impact of a remanent LIS alone, excluding contributions from the GIS?

The impact of Greenland melt water cannot be isolated from that of the Laurentide ice sheet. This makes it hard to conclude on the relative importance of the two ice sheets. To clarify the relative roles of Greenland and Laurentide and their meltwater input, an additional transient experiment is required (equivalent to 9kOGx e.g.) where the model is only forced with GIS melt water (not including LIS albedo, topo and melt

as in experiment OGGIS).

To what degree is the simulated east-west SST gradient dependent on the anomalous warmth to the east of Greenland in experiment 9kOGMELTICE? Also, what is the cause of this warm anomaly and is it likely to be model dependent?

Much of the simulated SST response is shown to be caused by including the forcing by a remanent LIS. It is therefore crucial to assess the dependency of the simulated SST on the response of the models atmospheric circulation to the topography and albedo of the LIS. As ECBILT is a highly idealized atmospheric model, what are the uncertainties in the simulated response in experiments 9kOGMELTICE and OGICE?

SPECIFIC COMMENTS

5269.22: in what state is the model at quasi-equilibrium? Please document the model drift at this state (e.g. in deep sea temperature, or global ocean T), preferentially with a timeline plot.

5270.21: it is stated that the meltwater is added to the surface runoff outlets of GIS. What are these? Are these the modern runoff sites. This is crucial for the model results and should be described in detail, as well as shown in one of the figures. Same applies to LIS meltwater.

5272.6: add amount of meltwater used (13 mSv) in 9kOGx1 to the text.

5273.22: gradients in SST should not be based on different types of proxies. Make clear why this is done, and why it is preferential to comparing gradients in the same proxies (e.g. alkenones, radolaria, foraminifera etc).

5273.23: clarify what is meant by this statement: “Alternatively we could argue for the just diatom gradient, but as eastern SSTs are not as high in the model as the reconstructed ones, we see the other possibility more likely.“

5274.1: why is 9kOGGIS better than 9kOGx?

5274.5: it is stated in Andersson et al. (2010) that winter SSTs are well represented by the deeper dwelling foraminifera due to the influence of the winter mixed layer. In the model, the largest changes in zonal SST gradients are found in February. Therefore, more emphasis should be put on discussing the model data in light of available planktonic foraminfera data, not solely relying on surface dwelling diatoms (and alkenones).

5275.20: it is stated that the northward heat transport (PHT) by the North Atlantic is reduced by 68% in 9kOGGIS as a result of reduced meridional overturning circulation (AMOC). Note, however, that there is not necessarily a direct link between AMOC strength and PHT. If this is to be stated here, an analysis of the different components of the PHT must be included. I.e. what is the change in the PHT due to the barotropic (gyre) circulation?

5274.25: which convection site(s) is referred to here? Please specify.

5277.11: this statement needs clarification: “Alternatively, another yet unknown forcing might have caused the prolonged cooling of the Western Nordic Seas, as in any case it seems to be clear that the impact has to be on the western side, rather than on the eastern side.“ Why is this impact clear and what are alternative forcing mechanisms?@

5277.27: this statement needs clarification: “suggesting a west-east spatial timing gradient, rather than a east–west gradient.”

Table 2: in the manuscript convection in the Labrador Sea is given much attention as it responds to the input of meltwater from GIS and LIS. However, this component of convection is not specified in the table. This should be added, and “North Atlantic”, “Nordic Seas” convection should be defined.

TECHNICAL COMMENTS

5271.4: from the text (and acronym) it is not clear that 9kOGGIS includes all LIS forcing. Should be clarified event if it is clear in the table.

Fig 1: for clarity, insolation and GHG should be added to the figure legend (in addition

to LIS and GIS melt water)

Interactive comment on Clim. Past Discuss., 8, 5263, 2012.