Reply to Leonid Polyak (Referee #1), interactive discussion on

"*The impact of early Holocene Arctic Shelf flooding on climate in an atmosphere–ocean–sea–ice model* "

by M. Blaschek and H. Renssen

Thank you very much for your review. We have gratefully incorporated your helpful suggestions in the revised version of our manuscript. It is important for us that our study is of value to the whole scientific community, not only to palaeoclimate modellers. Therefore we appreciate your view of our results and conclusions.

Individual Comments:

P.4192 L.16 the wording needs to be changed for clarity, e.g.: "but sea-ice export decreases (-15%) contrary to our hypothesis":

> We rewrite to: Our **experiment on** early Holocene Siberian Shelf flooding shows that in our model the Northern Hemisphere sea–ice production is increased (15 %) and that the Northern Hemisphere sea–ice extent increases (14%) **but sea-ice export decreases (-15%) contrary to our hypothesis.**

P.4192 L.26 Consider streamlining this sentence, e.g.: "the flooding of the Siberian shelf resulting from an orbitally induced warming and related glacioeustatic sea-level rise causes …"

> We rewrite to: We find that the flooding of the Siberian shelf **resulting from an orbitally-induced warming and related glacioeustatic sea level rise causes** a Nordic Seas cooling feedback opposed to this warming.

P.4200 L.24 different from what?

> We meant the differences of the early Holocene insolation curve compared to present-day.
>
> We rewrite to : This counter-intuitive result can be explained by the **insolation differences of the early Holocene compared to present-day.**

P.4203 L.4 "rather than a direct consequence of an increase in sea-ice export"

> Changed accordingly.

P.4204 L.7 not sure this is a proper wording

> We rewrite to: The flooding of the Siberian shelf alters the sea–ice transport in the Arctic (compare 9kOG with 9kOGSIB, Fig. 8) in a way that more sea ice is transported away from the production centres on the western side towards the eastern Arctic (Fig. 8)**,** thus

leading to reduced export through Fram Strait (Fig. 3).

P.4204 L.18 this is an awkward wording

We agree rephrasing would clarify the text here.

We rewrite to: An increase of Arctic sea–ice production and a decrease of Fram Strait export **represents a unique combination of cause and effect in our model that is connected to the flooding of Siberian shelf.**

P.4204 L.20 the 2nd related is changed to caused by

P.4204 L.25 "Feedbacks from the Siberian shelf flooding as revealed in our model"

We rewrite to: **Feedbacks from the Siberian shelf flooding as revealed in our model** are illustrated in Fig. 9 and relate our findings to the bigger picture.

P.4204 L.26 changed to "10-step"

P.4205 L.4 changed to "...and thus changes land into ocean (4)**, which impacts** both ocean and atmosphere."

P.4205 L.9 changed to "... resolution, **potentially** leading to a bias ..."

P.4206 L.21 changed to "...should have been relatively **small** until 7 ka BP, ..."

P.4206 L.26-27 reduce repetition in "... followed by an increase, if the given increase in drift ice was related to the shelf flooding. As the drift ice increase reconstructed ..."

We rewrite into "...followed by an increase, **assuming that this** was related to the shelf flooding. As **reconstructed drift ice values** by Andrews et al. (2009)..."

P.4207 L.16-19 We applied suggested changes and rewrite to: They find that **IP25 was higher** from 11.5 to 8.4 ka BP and **strong fluctuations in the IP25 flux occurred** from 8.4 to 8.2 ka BP, followed by a period of relatively low IP25 from 8 to 5 ka BP. **Higher IP25 values indicate less persistent sea-ice cover in spring, while lower values refer to more persistent sea–ice cover in spring.**

P.4207 L.20-24 Comments: What is difficult to compare? Sentence is very difficult to read.

To answer your question: We find it difficult to compare a proxy that indicates more or less persistent sea-ice cover to our model results. Thus we agree that the wording does not indicate this. We rewrite in line with previous comment to: **Although it is difficult to find a model variable that is comparable to these reconstructed values, we** find that the seasonal sea–ice cover over the north-western Nordic Seas (Fig. 5a) in response to the Siberian shelf flooding in simulation 9kOGGIS as compared to 9kOGSIBGIS **increased**. **This equilibrium response of sea–ice cover** near Fram Strait and the northern EGC **can**

be seen as a temporal evolution of sea-ice cover from 9 to 7.5 ka BP **from reduced (9kOGSIBGIS) to increased sea-ice cover after the flooding (9kOGGIS).**

P.4207 L.27 We have removed the second "during summer", resulting in : From our early Holocene simulations we can see that ~~during summer~~ the Northern Hemisphere becomes almost sea ice free (Figs. 2, 5a, d), allowing insolation to warm surface waters, **thus** delaying the subsequent winter cooling and sea–ice production.

P.4208 L.10 Wording. We rewrite to: **The opposite response could be proposed during** times of **relatively low** sea levels **when** a warming of the Nordic Seas **could increase moisture transport to adjacent ice sheets.**

P.4209 L.9 We rewrite to: "...yielding stronger southward winds along the EGC, bringing relatively cold air, and **stronger northward winds** along the NwAC."

P.4209 L.16 Break sentence into two parts.

We rewrite to: In a simulation with **only** a flooded shelf the Nordic Seas region is cooled up to −4°C**. In** a simulation with a **more** complete set of forcings (**i.e. also including** Laurentide ice sheet topography and melt water and Greenland ice sheet melt water) in the early Holocene **the flooding of the shelf results in a similar cooling.**

P.4209 L.20 We rewrite to improve the wording: "The atmosphere-ocean interaction shows clearly that changes in land–sea distribution are able to force changes in sea–ice production **and affect** sea surface conditions in the Nordic Seas, **which is** the major pathway of Arctic sea–ice export**. Changes in Nordic Seas sea–ice extent affect** local convection and **alter** ocean–atmosphere heat exchange, **modifying** seasonal atmospheric circulation. This **finding** underlines the importance ..."