#egusphere-2024-1931

Documentation of changes and reply to the review comments

*[The original review comments are in **bold and italic**]*

REVIEWER COMMENTS:

Referee 3

1. **General comments to the manuscript.**
   The manuscript deals with paleogeography of the Baltic Sea during the Holocene by combining eustatic sea-level change, glacio-isostatic adjustment and sediment deposition.

   They present paleoreconstruction and map of Holocene sediment thickness based on different datasets and calculate total mass of Holocene sediment in the Baltic Sea and yearly sediment accumulation.

   Reading the manuscript there are terminological and methodological problems, which are described below.

   First there are some errors using terminology, like using plate (plate tectonics) instead plain and its not clear what is meant by platform (lines 64-68 see comments below). For some terms it's not clear the meaning, like inland ice (possibly glacier), gate and gate function or amphibious Digital Elevation Model.

Author response #1:

Thank you for the comment. We are aware of terminological discripancies in structure description Northeast and Southwest of the SST/TTZ suture zone. We will change the terminology according to definitions given by Uscinowicz (2014) and Maystrenko et al. (2008).

We deliberately chose the term "gate" to describe the hydrographic interaction of sea level rise and vertical coastal movement in opening and closing the connecting routes between the Baltic Sea basin and the Paleo-North Sea. This term is widely used in literature for such topographic features. As you point out below „gate function" sounds more like a technical term. This is why we put it in „quotation marks".

„Inland ice" stands here indeed for glacier. We will change the term accordingly. „Amphibiuous Digital Elevation Model" refers to a DEM that covers both subaquous and subaerial parts. We will add an explanation and remove the word „amphibiuous" to avoid confusion.

2. **Secondly there are some methodological problems like Baltic Ice Lake /Yoldia Sea transition (look details below Figure3) and creation of sediment thickness map.**
   Chapter 3.4 Sediment thickness does not have information about the uncertainties of the used data sources. Why only present-day sea area data were used? In central and northern areas, like Gulf of Botnia, coastline was several hundred meters higher, and sedimentation in the Baltic Sea occurred also in present day mainland. Moreover referred Winterhalter 1972 does not have any datapoints from north of Gulf of Botnia (yellow square in Figure 5) so its not clear how those data were manipulated.

Author response #2:

Information about uncertainties and input data resolution will be added to the manuscript (see also Author response #4). The idea of generation of „Baltic Holocene sediment thickness" map was to limit it to present-day Baltic Sea. Regarding sedimentation on present-day mainland (mainly the northern Baltic coast) after it was emerged, this part of sedimentation has been subjected to reworking by both water flow and wind, therefore any estimation of marine sediment thickness would be even more difficult to obtain and justify. Moreover, the Holocene sediment thickness of the northern Baltic Sea and its coast is generally very thin that any extrapolation to the mainland would have no visual impact on the paleo-DEM and very minor impact on the total estimated sediment budget of the Holocene. We will include discussion of this aspect in the revised manuscript.

Regarding Winterhalter 1972 dataset it was indeed limited to the southern Gulf of Bothnia. Unfortunately we could not find any literature providing sedimentation thickness in the northern Gulf of Bothnia. This is why we used co-kriging to extrapolate it to the north (explained in lines 256-262). A brief explanation will be added for clarification.

3. **According to line 231, Holocene sediments in the southern Baltic Sea are on top of the glacial till. Holocene started at ~11.7 ka BP but glacial till accumulated around 17-15 ka BP, so there was no sedimentation several thousand of years? According to line 241 glacial varved sediments of the Baltic Ice Lake are considered early Holocene age, what is not true as Baltic Ice Lake drainage (end) coincides more or less with the start of Holocene, so Baltic Ice Lake sediments are from Pleistocene, not from Holocene.**

Author response #3:

Top of glacial till is a well-visible seismic reflector, whereas border between Baltic Ice Lake (BIL) and Yoldia Sea is hard to determine from the seismic profiles. Due to fact that BIL sediment chronostratigraphically belongs to Late Pleistocene, the modelled thickness may be slightly overestimated. We will add an explanation to chapter 3.4.2 including an estimate of uncertainty related to this.

4. **There has been earlier attempt to create Holocene sediment thickness by Jakobson et al 2007 https://doi.org/10.1016/j.gloplacha.2007.01.006, which differs from results here. So the map presented here seems to include not only Holocene sediments but some Pleistocene sediments also.**

Author response #4:

According to the information from Jakobson et al. (2007), the Holocene sediment thickness map for the Baltic Basins shown in their Figure 3d was compiled through assembling information from available sediment distribution maps and information retrieved from the Swedish Geological Survey's mapping archives which unfortunately do not provide an open access. A comparison between our map (Figure 5) and the map from Jakobson et al (2007) shows a general agreement in the Borholm basin and along the Swedish coast near the Gotland. However, there exists a large descrepency in the thickness value in other basins (e.g. Arkona basin, Gotland basin) between the two maps. The thickness values in Jakobson et al. (2007) for these basins are much smaller than previous published values from Lemke (1998) and Uścinowicz (1998) focusing on these local areas. The compiled thickness data from the difference sources we have collected show more consistent patterns covering both deep basins and shallow coastal areas and therefore we argue that our map provides a more accurate distribution of Holocene sediment thickness compared to earlier publications. We will add discussion on this aspect in the revised version.

5. **There are some issues with Figures:**

Figure 1 longitude values starting from 15° and specially 20°-40° are almost 5° wrong. Glacier extent specially for 10.5 ka BP is not the same as in Andren et al 2011. It seems that there is problem with georeferencing.

Author response #5:

Thanks for pointing this out. We admit that it is a mistake in our georeferencing. We will provide updated figure to correct this problem.

6. **Figure 2 according to figure Peltier 1999 ice thickness model was used (ICE-4G), but in text Peltier 2004 (ICE-5G)**

Author response #6:

It will be corrected to Peltier (2004) in Fig. 2.

7. **Figure 3 explains that authors have wrongly modelled Baltic Ice Lake at 11.7 ka BP or they don'tunderstand how Yoldia Sea Stage started. According to that figure the highest BIL water level occurred 12 ka cal BP and not at 11.7 ka BP as suggested by Andren et al 2011. At 11.7 ka BP water level in BIL dropped during ca 1-2 years 25 meters and Yoldia Sea started. So modelled BIL at 11.7 ka BP (Fig 7) is actually Yoldia Sea first stage after BIL drainage not BIL prior the drainage. In the 11.7 kyr BP map by Andren (2011), the hydrographic connection between the Baltic Sea basin and the Kattegat indicates communicating systems. This makes Andren's caption "(...) BIL prior to final drainage" questionable.**

Author response #7:

Please note that the red line on Fig 3. stands for the Uścinowicz (2006) RSL curve that we used only for the Ancylus lake phase. Our reconstruction started exactly at 11.7 kyr BP when the water level of the Baltic region was dropped to the level of the open North Sea. You are right that modelled BIL at 11.7 kyr BP is actually Yoldia Sea first stage after BIL drainage but not BIL prior the drainage. We will correct „BIL prior to drainage" to „Baltic Ice Lake/Yoldia Sea transition" in all relevant texts including captions of Figure 1 and 7.

8. **Figure 7 reconstruction for 11.7 kyr BP and 11.0 kyr BP look in the southern part near Bornholm exactly same**

Author response #8:

They are similar but not the same. The RSL on the map 7b is higher than that on map 7a what makes the land bridge connecting Bornholm with mainland narrower. We will add a brief explanation on this in the text.

9. **Figure 8 the caption is not correct. Both curves red (results in manuscript)and black (Rosentau et 2021) are modelled RSL curves according to ICE-5G model. Rosentau et al 2021 has on Figures 7,8,9 shown results with ICE-5G model with three different lithosphere thicknesses and also ICE-6G, which one is used here is not clear. Black curve is not field data (or proxy data). Only RSL for Finland N looks similar to Rosentau et al 2021 results.**

Author response #9:

Thank you for pointing it out. We will correct Fig. 8 caption and remove the word „field data".

Regarding the model, we digitized ICE-5G model with 120km lithosphere thickness curves. We will add this information to the caption. Putting all four curves overlaid with ours would have been too much information on one graph. We agree that the RSL of Rosentau et al (2021) show differences with our results mainly for the initial stage between 11.7- 10 kyr BP and afterward a general agreement is reached. We will add some descriptions and discussion on this aspect in the revised version.

10. **Figure 9 Comparison in present form is not convincing as shorelines from Andren et al 2011 seems to like freehand drawings and differ from original. Moreover, on Figure9 a) You compare results here with BIL prior final drainage (Andren et al 2011) but its water level was about 25 meter higher than in present reconstruction. That also explains why Figure 9a and 9b coastlines are so similar.**

Author response #10:

Paleo-coastlines from Andren et al. 2011 were digitized and overlaid with our reconstructions. Since Andren's original maps do not contain exact coordinates, the digitization was done in a imprecise manner by roughly matching the geographic features.
We agree that the comparison is rather qualitative than quantitative due to georeferencing difficulty and mismatch in the data resolution between Andren et al 2011 and our study. Therefore we will remove this figure and replace by text descriptions. Further, we will also add comparison with other reconstructions such as Jakobson et al. (2007).

11. **There are some spelling errors in references and reference list and not all reference are on the list. In reference list sometimes only first author is shown are not.**

Author response #11:

We will double-check all the citations and reference list.

12. **In the following are some comments by line numbers.**

Chapter 1. Introduction

45 climatically controlled eustatic sea level changes

Author response #12:

Thank you. This will be corrected.

46 Lambeck 2010 not in reference list

Author response #13:

The reference will be added, thank you for spotting that.

Chapter Geological setting some terminology is not clear/correct

62-63 Danish Straits and Swedish Sound?? First term is enough as it includes all straits,

second is The Sound or Öresund

Author response #14:

Thank you for pointing this out. We will use „Danish Straits" to descibe all straits.

64,68 Russian Plate - there is no such plate, do You mean East European (Russian) Plain?

Author response #15:

Terminology will be corrected according to definitions given by Uscinowicz (2014) and Maystrenko et al. (2008).

65 what are Western and Eastern European Platform?

Author response #16:

We are aware of terminological discripancies in structure description Northeast and Southwest of the SST/TTZ suture zone. We will change the terminology according to definitions given by Uscinowicz (2014) and Maystrenko et al. (2008).

78, 85, 99, 143 the term inland ice should be replaced by glacier/icesheet

Author response #17:

It will be replaced following your suggestion.

82. sea-level drop What about if land uplift is smaller than sea level rise?

Author response #18:

This sentence describes the interplay between two driving forcing: eustacy and isostasy. We used two examples to explain their relative importance in driving the connection/disconnection between the Baltic and the open North Sea. The case Reviewer #3 mentioned may lead to a connection between the basin and the open sea. We will rephrase these descriptions to increase their comprehensibility.

83,84 not clear what is meant by gate and gate function its more like technical term used in artificial reservoirs not for natural waterbodies

Author response #19:

We will rephrase the wording to avoid such confusion.

85 That sentence is not clear and not correct as there are surely sediments and proxy data older than post-glacial period (=last 11700 cal yr BP)

Author response #20:

There are indeed older data. However, due to several glacier advances much of this sediment was partly or completely eroded. Therefore, sediment and proxy data older than post-glacial period is

incomplete and much more scarce than the post-glacial period. We will rephrase this sentence for clarification.

89 There is no LGM on Fig. 1

Author response #21:

The description will be corrected to „The evolution of the Baltic Sea since the first stage of the Yoldia Sea at 11.7 kyr BP (Fig.1) is…"

100 Heinsalu and Veski were using brackish-water Yoldia Sea

Author response #22:

Thank you for correcting this. This will be corrected in the revised version.

102 why so-called?

Author response #23:

We will remove the word „so called".

110. Figure 1 longitude values are wrong. Maps are difficult to read, because its not clear what is light blue and what is blue in Gulf of Botnia and near Oslo fjord. Baltic Ice Lake existed in Pleistocene

Author response #24:

Thank you for pointing this out. We will improve the plots in a revised version accordingly.

Chapter 3. Data and methods

144 the sentence meaning not clear

Author response #25:

We agree that it is unclear. We will remove this sentence since it does not contain meaningful information related to our study.

150 Figure 2 What ice model was used?

Author response #26:

It was ICE-5G. We will add this information.

Chapter 3.2. Eustatic data (EC)

166 Waelbroeck et al 2002 not in reference list

Author response #27:

The missing reference will be added.

168 global ocean? what in none global ocean?

Author response #28:

You are right. We will replace the word „global" with „open".

Chapter 3.3. Vertical crustal movements…

191-195 add here some references

Author response #29:
References will be added.

205 explain how You get 500 years timeslices for reconstructions if GIA resolution is 1000 years

Author response #30:

It was achieved by assuming a linear trend between millenial-step reconstructions. It will be explained in the revised text.

Chapter 3.4 Sediment thickness
That full section needs more explanation and some information about reliability and resolution of used data sources.

Author response #31:

Information about resolution of input datasets as well as their associated uncertainty will be added as a new table in the revised version for clarification.

Chapter Discussion

399 Rosentau et al 2021 black curves are not proxy-based but modelled by ICE-6G_C(VM5a)

Author response #32:

Thank you for pointing this out. This will be corrected.

435 Figure 9 Andren et al 2011 coastlines are not similar to published maps.

Author response #33:

Pelease see our response #10.
We agree that the comparison is rather qualitative than quantitative due to georeferencing difficulty and mismatch in the data resolution between Andren et al 2011 and our study. Therefore we will remove this figure and replace by text descriptions. Further, we will also add comparison with other reconstructions such as Jakobson et al. (2007).

439-440 that was already in chapter 4.2

Author response #34:

Indeed. The purpose of repeating these numbers here is for comprehensibility of the narrative of the entire subchapter, so that readers do not need to go back to chapter 4.2 for the exact numbers.