

Clim. Past Discuss., referee comment RC1
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Comment on cp-2020-163

Anonymous Referee #1

Referee comment on "Co-evolution of the terrestrial and aquatic ecosystem in the Holocene Baltic Sea" by Gabriella M. Weiss et al., Clim. Past Discuss.,
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Comments to manuscript: Co-evolution of terrestrial and aquatic ecosystem structure with hydrological change in the Holocene Baltic Sea

This is a well-written manuscript that presents analyses of biomarkers and stable isotopes of specific compounds. The analyses are state of the art and have not previously been used in the south-western Baltic. It is important to use new methods to improve our understanding of past environmental changes. However, the interpretations of the data are not straightforward and after reading the manuscript I did not feel that I learned much new about the history of the Baltic Sea. I am sorry but I don't feel that the study "provided new insights into changes ... in the vegetation in the western Baltic region throughout the Holocene" (line 210).

The interpretations are hampered by the fact that the geography of the Arkona Basin changed over time. During the Yoldia Sea stage it was a bay of the Baltic Basin, which was connected to the Kattegat via straits in south-central Sweden. During the early part of the Ancylus Lake stage the outflow shifted from south-central Sweden to what became the Danish straits. During the Littorina Sea stage it was part of the Baltic Sea, with outflowing and inflowing water masses. Water level varied a lot over time due to glacioisostatic rebound and global eustatic sea level rise.

Another issue concerns erosion, reworking and redeposition. Erosion is particularly important at the transition from the Ancylus Lake to the Littorina Sea. Could it be that reworking explains the low $\delta^{13}\text{C}$ values of bulk sediment samples from the Transgression phase?

It is mentioned that some of the molecules analyzed in the study can be wind transported (line 69). I wonder if the molecules in the sediment formed in the Arkona Basin and the surrounding land area? Or could it be that the molecules come from the Kattegat and were transported by inflowing water to the Arkona Basin? Or did they come from northern parts of the Baltic Sea or from the whole drainage area of the Baltic Sea?

The authors discuss the results "by Baltic Sea phase"(s) (line 212). The phases are Yoldia Sea, Ancylus Lake and Littorina Sea. However, the discussion is divided into: Yoldia Sea, Ancylus Lake, Ancylus Regression, Ancylus Lake vegetation and hydrological change, Marine transgression and finally Littorina Sea and Modern Baltic phases. I suggest that the authors use only three headings. What they term Marine Transgression is part of the Littorina Sea stage.

Modern palaeostudies relies on well-dated records and high temporal resolution. However, I get the feeling that the chronology of the studied record is poorly constrained. The age-depth model needs to be described in detail in the paper. It is mentioned that the age-depth model is described in detail in Weiss et al. (2020) and that it was created by combining ^{14}C -ages of mollusk shells and ... (line 99). According to Weiss et al. (2020) three radiocarbon ages were obtained. I could find no information on the ages or which species was used for dating in the 2020 paper or in the supplementary material. Also, I saw no information about which calibration curve was used. It should also be explained in the paper that only calibrated ages are discussed. In particular, I wonder how the older non-marine part of the core was dated.

With respect to resolution, I note that four samples were analysed for the time period from 6 ka to the present. The resolution is higher in the older part of the record.

The paper must also provide information about the sediments in the core, based on a visual core description.

One of the main scientific questions in the development of the Arkona Basin and the Baltic Basin is the dating of the transition from the Ancylus Lake to the Littorina Sea. Andrén et al. (2000) dated it to ca. 10.1 cal. ka BP and Berglund et al. (2005) dated it to ca. 9.8 cal. ka BP, whereas other studies have dated it to 7-8 cal. ka BP. I am surprised to see that this question is not mentioned in the manuscript. Did the study provide any information on this issue?

I think one of the most interesting outcomes of the study is that the Ancylus Lake stage was highly dynamic with large isotopic shifts. But the interpretation is difficult. It was partly caused by decreasing influence of melt water. But I suggest that the shift in drainage may also play a role. I am not sure about the importance of the short-lived cold events during this time.

Other comments

Line 15. According to the first sentence in the abstract: "The Baltic Sea experienced a

number of marine transgressions and regressions throughout the Holocene". However, only one marine transgression is discussed in the manuscript. The northern part of the Baltic Sea experienced regression throughout the Holocene, whereas the southern part experienced one marine transgression during the Holocene.

Line 16. According to the next sentence: "These fluctuations in sea level coupled with substantial regional ice melt led to isostatic adjustment and periodic isolation from the North Sea". Isostatic adjustment was caused by ice retreat, not by the "fluctuations in sea level".

Line 28-29. "that promote ... diverse phytoplankton communities". A reference is needed. Is the diversity larger than in other areas?

Line 31, 33. Retreat was caused by melting and calving.

Line 33. "the Scandinavian Ice Sheet covered large swaths of Europe". Change to: the Scandinavian Ice Sheet covered large parts of northern Europe.

Line 35. The Yoldia Sea stage began in the earliest part of the Holocene. Therefore it was not caused by global and regional temperatures that continued to rise during the Holocene.

Line 38. Sea level fluctuations. It should be water level fluctuations, because lake stages are also involved.

Line 38. The Ancylus Lake was a freshwater lake - I find it a bit strange to call it a low salinity phase.

Line 41. The freshening was probably caused by land uplift, increased precipitation and decreased evaporation, not by lack of large marine transgressions.

Line 42. until now the authors have discussed salinity changes, but now they state that "The complex climate dynamics caused substantial shifts in the salinity of the Baltic Sea during the Holocene, indicated by changes in the phytoplankton population". However, the main salinity changes were not caused by climatic changes.

Line 57. recalcitrant – is that the same as resistant?

Line 60, 61. Are there any relevant C4 and CAM plants in the region?

Line 71. It is mentioned that wind-transported *n*-alkanes are generally deposited within weeks. Does this mean that part of the *n*-alkanes could have their origin in North

America?

Line 74. preserve information – change to can provide information.

Line 77. convolutes – is this the correct word?

Line 96. what was the diameter of the piston core?

Line 97. what was the water depth at the core site?

Line 98. Arkona Basin not Arkona basin.

Line 110. I don't think the authors extracted sediment samples, it should be lipids.

Line 161. The authors note large difference between the piston core described in the manuscript and nearby cores. I wonder if these differences could be explained if the other cores are gravity cores?

Line 199. The temperature reconstructions for the early part of the record is not similar to those of Kotthoff et al. (2017). The record by Kotthoff only went back to ca. 7.4 ka. I don't think that 18.5°C for the Yoldia Sea phase, 11.5°C for the Ancylus Lake phase and 24° fit with other temperature reconstructions from the region.

Line 212. change Baltic Sea phase to Baltic Sea phases.

Line 215. The salinity of the Yoldia Sea phase was first discussed from the presence of *Yoldia arctica* (now *Portlandia arctica*, a marine bivalve). However, marine species are only recorded from the Baltic proper (including the Gotland Deep discussed by Sohlenius et al.). Not sure if any marine species have been recorded from the southern part of the Baltic Basin.

Line 218. Yoldia Sea sediments in the Arkona Basin are usually considered to be barren of fossils (except for reworked pollen and spores). It is interesting to see that the authors found diols that are produced by freshwater eustigmatophytes. However, I wonder if these algae lived in the Arkona Basin, or in rivers and pools in the catchment?

Line 234. The pollen records referred to are not nearby.

Line 235. Strictly speaking, temperatures can be low or high, not cold.

Line 241. Moros et al. (2002) did not suggest that the Baltic Sea experienced "a large regression" at 10.2 ka – they only suggested a regression. The evidence for this regression was weak. It is currently debated if the Ancylus Lake stage ended with a large regression, a small regression or no regression. If there was a indeed a regression in the Arkona Basin, it was definitely not caused by "a continental uplift".

Line 247. The authors suggest that a meltwater pulse occurred at 10.2 ka. However, some studies indicate that the Scandinavian Ice Sheet expanded at ca. 10.2 ka (the Erdalen event).

Lines 258-259. did you observe a thin layer rich in remains of terrestrial plants at the same level? Such a layer is seen in many cores from the Arkona Basin.

Line 266 Pinaceae is a family name, it should not be in italics

Line 267 "can be tentatively attributed to *Juniperus* shrub extension" (should be expansion?). To my knowledge, no pollen records from the region show a *Juniperus* peak at ca. 9.2 ka. However, the 9.2 event was short-lived and you need extremely high-resolution pollen analyses and high sedimentation rates or varves) to be able to detect possible influence on the vegetation.

Line 268. I don't understand why the authors chose to compare their record with pollen records from far away (northernmost Finland and Bohuslän in south-central Sweden). Why not compare with nearby pollen records? Anyway, to my knowledge no maximum occurrence of *Pinus* and *Juniperus* at 9.2 ka have been reported in pollen diagrams from the Arkona Basin region. See for example the detailed and well dated pollen diagram from Krageholmssjön in Scania in southernmost Sweden (Berglund et al. 2008, Veget Hist Archaeobot).

Line 269. what is a regional lake?

Line 289. Not sure what you mean by this: "The global transition from a glacial to an interglacial climate state across the Holocene, was punctuated by a few abrupt cold events". The cold events mentioned in the following happened long after the glacial-interglacial transition.

Line 293. It is unclear to me whether the authors see evidence of the 9.2 ka event in their data.

Line 297. Moros et al. did not give an age of 7.7 ka for the re-establishment of the connection between the Baltic Sea and the North Sea. From where did you get this age?

Line 298. Do you mean that the onset of the transgression lasted from 7.7 to 7.2 ka. Or do you mean that the transgression lasted from 7.7 to 7.2 ka? I believe that the marine transgression of the Arkona Basin began somewhere between 7 and 8 ka and continued for the rest of the Holocene, although the transgression rate slowed down after ca. 6 ka.

Line 300. regional warming began already in the earliest part of the Holocene, although interrupted by some short-lasting cold events.

Line 304. change *n*-alkanes were to *n*-alkane values were.

Line 341. Again, to my knowledge, no "large fluctuations in the extent of gymnosperm cover" have been reported by pollen studies from the region.

Line 345. "lack of diversification of terrestrial vegetation noted for this period". Which period? The Ancylus Lake stage? The pollen records from the region show that many species arrived during this period.

Line 347. "regional warming which continued into the Late Holocene". Warming certainly did not continue into the Late Holocene.

Line 351. I don't think that we can ever "fully understand the complexity of paleoenvironments" as stated by the authors – not even if we use multiple proxies.

Figures and tables

The authors have Age (ka), Age (Ka) and Age (kyr). I am not sure if the journal has a style to follow, but it should be consistent.

Table 2 and 3 can go to supplementary.