Response to review from Referee 2

On behalf of all authors, I would like to thank Referee 2 for the helpful comments and the review of our manuscript. The responses and planned changes are provided in italics and green.

The manuscript by Adolph et al. titled 'North Atlantic Oscillation polarity during the past 3 ka derived from lacustrine sediments of large lowland lake Schweriner See, NE Germany' presents a study of a lake sediment core integrating scanning techniques, sedimentological, bulk geochemical, pollen, diatom and leaf wax records. Aim of the study is to reconstruct the environmental factors modifying sediment deposition.

The efforts undertaken are methodologically state of the art and the results provide insights into the regional climate dynamics within the last 3000 years. Therefore, the study can be of interest for a broader geoscience community and would be suitable for publication in Climate of the Past. However, before publication the results/proxy interpretations should be discussed in a more rigorous way, some generalizing statements should be specified or revised and the manuscript would benefit from reorganization.

Main points:
I would prefer to read a more focussed, results-based and mechanistic discussion of the possible factors controlling organic matter accumulation, preservation and degradation in Schweriner See and, consequently, the relevance of the area600-700, LOI550, TOC, TN and inc/coh proxies. In this version of the manuscript area600-700 is defined as productivity indicator in the methods section based on one citation (lines 156-157) and LOI550, TOC, TN and inc/coh are defined as productivity proxies based on their correlation with area600-700 in the results section (lines 256-258). Therefore, the presented proxy interpretations and lenghty paleoclimate implications remain ta degree speculative. In addition, the reconstructed NAO polarity and precipitation records from Schweriner See do not match well (e.g. around 700 or 2500 a BP). Please discuss these discrepancies between both proxies, as both should be interconnected. In general, the manuscript would benefit from a clearer distinction between the methods, results and discussion sections.
As this was also noted by Reviewer 1, we will restructure the results and discussion section by combining "Results and Interpretation" to better explain the involved processes and improve the Discussion in a revised version of the manuscript. We will discuss the discrepancy, though, the addressed "precipitation record" is the minerogenic input, which was not addressed as precipitation but as shoreline distance record. As such it is stated in the manuscript that "the main driver for minerogenic input to the coring location of SAS21 at Schweriner See were lake-level variations with additional wind speed influences and direction amplifying wave action" (Line 520). Phases with additional wind speed influences and wave action were discussed in section 5.2.1 (Processes affecting minerogenic input). We agree with the reviewer that both processes should partly be related. NAO occurs predominantly during winter while lake-level variations may also be significantly influenced by summer droughts, which are not reflected in the NAO proxies. We will address this issue in detail in a revised version of the manuscript.

Specific comments:

Lines 39-40: Continentality is to my knowledge controlled by a place's distance from the ocean and not directly connected with the NAO.
The reviewer is right and we will rewrite these lines in a revised version of the manuscript to "Recent climate shows a spatial climatic gradient with increasing continentality from west to east and existing paleoenvironmental studies from North Germany point to considerable environmental variability during the Holocene (e.g. Dietze et al., 2016; Theuerkauf et al., 2022; Kaiser et al., 2012)."

In think the introduction can be streamlined and better organized.
We will try to reorganize the introduction in a revised version of the manuscript.

Lines 327-328: This statement is not true. Small lakes do not generally suffer from anthropogenic overprinting. For example, the sediment records from small Lakes Tiefer See, Belau and Woserin located in the Schweriner See region allowed to reconstruct changes in NAO polarity, humidity and wind speed.
The reviewer is right. We will remove this statement.

Is the construction work for the Paulsdamm AD 1848 visible in the investigated sediment core? This could be a nice time marker.
Generally, the decade around 1850 marks a distinct shift in the sedimentation from calcareous to organogenic sediment in Schweriner See, which was previously shown in Adolph et al. (2022). This distinct change was linked to an increase in population density leading to increases in sewage and, consequently, productivity. This distinct shift was observed in short sediment cores from three different locations and also in the record presented in this study. This distinct increase in productivity likely masked the signal of the Paulsdamm construction.

The lake sediment record investigated in Olsen et al. (2012) is located in Greenland which is not mentioned in the list.
Greenland will be added to the list in a revised version of the manuscript.

Since ice cover duration is interpreted to play an important role for productivity changes in Lake Schwerin, it would be interesting to read a sentence about varying ice cover durations during the instrumental period.
Unfortunately, we do not have any data about the ice cover duration during the instrumental period. However, we would likely not see any interplays between ice cover duration and productivity changes because since 1850 CE productivity is not driven by winter temperature changes but by nutrient availability, which masks the temperature signal. This is shown in this manuscript by the distinct increase in eutraphentic diatoms after 1850 CE as well as in Adolph et al. (2022), which links productivity to sewage disposal and population dynamics within the catchment.

Lake level reconstruction: Please discuss the role of the Stör river draining Schweriner See for the presented lake level reconstruction. Is the river too small to level out lake level changes?
We will discuss this in a revised version of the manuscript. But generally, yes, Stör river is a relatively small, shallow river with only a slight gradient. Indeed the river was so shallow that until 1830, Stör river was difficult to navigate by boat, which is why we assume that the river is too small/shallow to level out lake-level changes.

Lines 403-405. Different moisture sources do not influence the amount of precipitation.
We will rewrite this section as "As expected under a positive NAO influence, a southern moisture source region is linked to wetter conditions. In comparison, a northern moisture source region under negative NAO conditions causes drier conditions (Fig. 5) due to shifts in the westerly pathway."

Lines 429-431. This sentence connects a positive NAO polarity with a coinciding period of dryness in Europe. This contradicts with the statement in lines 64-65, associating a positive NAO with more humid conditions.
We will address this in the revised version of the manuscript.

Please provide a definition on how you distinguish NAO+ and NAO- time slices based on the Schweriner See data.
In the revised version of the manuscript, the following section will be added: "NAO time slices are defined by distinct changes in productivity, the occurrence or disappearance of the diatom species S. chantaicus and changes in the compound-specific hydrogen isotopes. Phases with

low productivity, which co-occur with the occurrence of S. chantaicus and a shift to depleted δ^2H_{C25} values, are defined as negative NAO phases. In contrast, phases with high productivity, which co-occur with the disappearance of S. chantaicus and a shift to enriched δ^2H_{C25} values, are defined as positive NAO phases."

Detailed comments:

Line 52: Delete 's' in 'circulations'.
We will delete this in a revised version.

Lines 244-245: Shortly mention why 897.5 cm core depth is the lower limit.
In the revised version of the manuscript, we will add that 897.5 cm core depth is the lower limit because this is the depth of the lowermost ^{14}C age. We refrain from extrapolating the age-depth model.

Lines 372-375: Does a distance of 120 km substantially change the degree of continentality and evaporative enrichment?
Northern Germany has a distinct climatic gradient, which can be observed, i.e., in the water balance. Areas west of Schweriner See have a positive water balance, while areas east of Schweriner See, where the mentioned study was conducted, have a negative water balance (Figure 1) indicating that potential evapotranspiration is higher than precipitation. Therefore, we expect that even these 120 km may have an impact on the degree of continentality and, consequently, the evaporative enrichment.

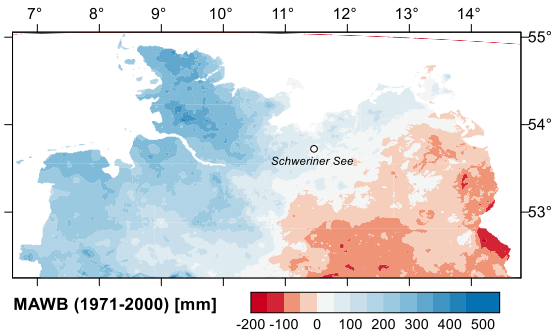

Figure 1: Mean Annual Water Balance (MAWB) of North Germany for 1971-2000 in mm. Areas in red have a negative water balance, and areas in blue have a positive water balance. – Data source: DWD

Lines 376-386: This part can be shortened, as a detailed description of the NAO is already given in the introduction.
As suggested, this part will be shortened in a revised version of the manuscript.

Title: Change '3 ka' to '3000 years' in the title, as ka is not used within the text. Delete 'lacustrine' as lake is mentioned too.
As suggested, we will change the title to "North Atlantic Oscillation polarity during the past 3000 years derived from sediments of large lowland lake Schweriner See, NE-Germany"

Fig.1. Except for the coring location is Fig. 1b already included in Fig. 1a. Add the coring location to Fig 1a and delete Fig. 1b?
We would like to show the bathymetry again separately to highlight the distinct morphometry. In particular, the widespread shallow water area is essential for the discussion of the shoreline distance.

Fig. 6. Add 'Grand' to 'Solar Minima'.
As suggested, Grand will be added to the figure.

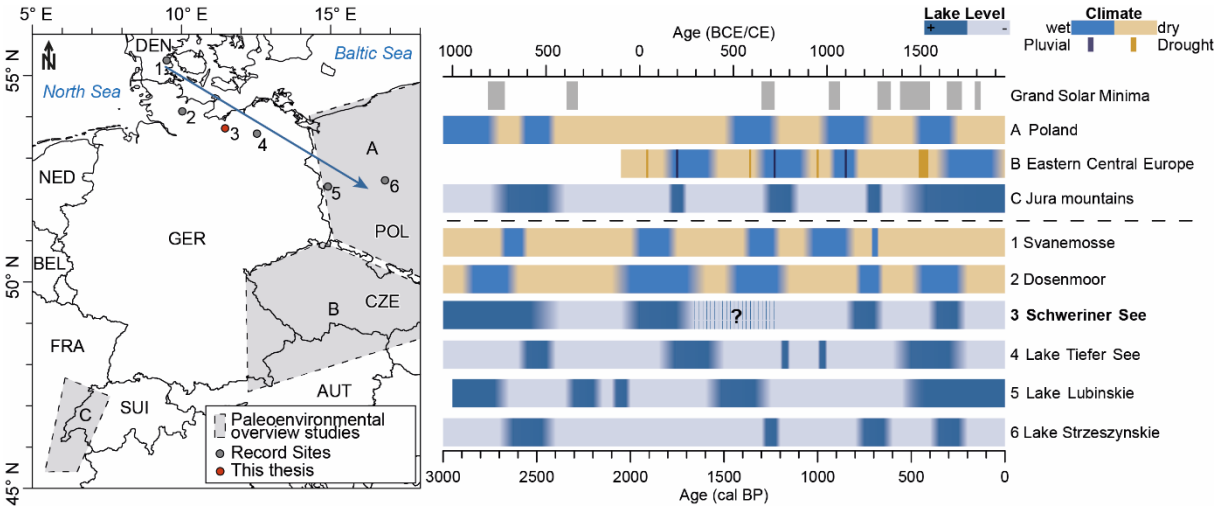

Fig. 1: Comparison of hydroclimate records covering the past 3000 years. Left: Map of the location of the records. Grey areas indicate the spatial extent of paleoenvironmental overview studies. The blue arrow indicates the NW-SE direction where the compared records are located. DEN: Denmark, POL: Poland, CZE: Czechia, AUT: Austria, SUI: Switzerland, FRA: France, BEL: Belgium, NED: Netherlands, GER: Germany. Right: Grouped hydroclimatic records and individual records below the dashed line are shown above. Summarized records are from A) Poland (Starkel et al., 2013), B) Eastern Central Europe (Büntgen et al., 2021) and C) the Jura mountains (Magny, 2004). Hydroclimate reconstructions, which show wetter (blue bar) and drier (beige bar) conditions, are compared to lake-level variations and bog surface wetness reflecting hydroclimatic conditions differentiating between lower (light blue bars) and higher (dark blue bars) lake levels from 1) Svanemosse (Barber et al., 2004), 2) Dosenmoor (Daley and Barber, 2012; Barber et al., 2004), 3) Schweriner See (this study), 4) Tiefer See (Theuerkauf et al., 2022), 5) Lake Lubińskie (Bonk et al., 2023) and 6) Lake Strzeszyńskie (Pleskot et al., 2018). Grand solar minima are shown as suggested by Usoskin et al. (2007). The question marks and shaded area in the Schweriner See lake-level variations mark the period, masked by increased storminess. The lake level during the period was most likely higher.