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Interactive comment on "Holocene phototrophic community and anoxia dynamics in meromictic Lake Jaczno (NE Poland) using high-resolution hyperspectral imaging and HPLC data" *by* Stamatina Makri et al.

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Anonymous Referee #1

Makri et al present a very detailed record of variations in phytoplankton community composition and associated changes in redox conditions of a Polish lake. This lake has already been studied thoroughly in previous publications. However, the authors present new data together with these published records to make a very nice comparison of pigments and trace element records. Very elegant is the combination of high

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Discussion paper

resolution techniques to reconstruct short fluctuations in environmental conditions that the lake experienced with traditional techniques that provide high compound specificity, though at the expense of the high temporal resolution. The combination of these techniques provides large insight into the changes in water column conditions and species composition during the lake's history. This manuscript is suitable for Biogeosciences after consideration of mostly minor comments as outlined below.

General response: We greatly appreciate the feedback and constructive comments provided by the Anonymous Referee #1. We have addressed the comments point by point below (comments and our response right below). We agree with all the comments and we will implement all corresponding modifications in a revised version of the manuscript.

Title: redox dynamics

Line 15: altered mixing regimes – what does that mean? Is this aspect related to hypoxia or any other reasons? I guess the main problem with changed mixing regime is the change from a well-mixed system to meromixis? Please clarify.

Response: Yes, here we refer to changes pointing towards less frequent mixing in lakes. This was not clear enough. We have changed the sentence that now reads "Global spread of hypoxia and less frequent mixing in lakes is a growing major environmental concern".

Line 19: change sentence so that you state pigment analysis using two different techniques. While one method enables high spatial resolution pigment analysis (though only raw data), the HPLC data allow high compound specificity. This should be better explained here.

Response: Following the suggestion of the reviewer, we have modified the sentence so that the use of the different methods and measurement of bulk or specific compounds is clearly stated. The sentence now reads "We used a multi-proxy approach combin-

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Discussion paper

ing high-resolution bulk pigment data measured by Hyperspectral Imaging (HSI), with lower resolution specific chlorophylls and carotenoids measured by HPLC to examine Holocene trophic state changes. . .".

Line 43: The Diaz and Rosenberg papers about Hypoxia would be important references to cite here.

Response: Yes, we have added the citation here.

Line 73: Total chlorophylls or only Chlorophyll-a and derivatives considered here? Including Chlorophyll-b and c? Please clarify.

Response: Yes, thank you for this remark. We have added here more details. TChl refers mainly to Chl a and b, and their derivatives. We have also added this information in the Methods section (ref. 1st ms: p. 4, line 155).

Line 84: Related to my comment above. Please reformulate to low-resolution pigment record using HPLC analysis with high compound specificity, which cannot be achieved by the hyperspectral record.

Response: Following the suggestion of the reviewer the sentence now reads "we combined a high-resolution HSI-inferred record of TChl and Bphe, X-ray fluorescence (XRF) elemental data, and a low-resolution pigment record using HPLC analysis with high compound specificity, which cannot be achieved by the HSI record".

Line 90: Remove sentence 'This is rare in Europe.' This sentence is not useful.

Response: The sentence is removed.

Line 99: Remove Butz et al. in brackets, because it is noted twice.

Response: Corrected.

Line 157: Are bacteriopheophytin a and b both detected and distinguished by hyperspectral and HPLC techniques? It would be better to separate the records of both

compounds to establish if species-composition changes in the sedimentary record of the lake need to be considered for the reconstructions, because both compounds are not necessarily produced in the same quantities from the same species.

Response: Here we refer to total Bphe a and b. The two compounds cannot be separated using absorption spectra because their absorption almost overlaps. We have added here the word “total” so it is clear we refer to the sum of Bphe a and b and not to each compound separately.

Line 160: Are bacteriochlorophyll c, d and e present as well? If so, are they reconstructed by the HPLC technique? This also shows that the different bacteriochlorophylls and their pheophytins should be distinguished throughout the manuscript instead of using Bphe as abbreviation for the sum of these compounds.

Response: Bacteriochlorophyll c, d and e cannot be measured by HSI because their absorption overlaps with Chl a, b and their derivatives. Additionally, the extinction coefficients of these compounds are poorly constrained (or even unknown in the literature). Bphe c, d, e were absent in the HPLC record. Most probably, their concentration was very low to be detected since these compounds are very labile. We have added the wording “total Bphe a and b” for the definition and use of the word Bphe, and we trust that it is now clear that we refer to bulk Bphe a Âň+ b and not the specific compounds. We avoided using TBphe because as we explain in the text not all Bphes can be measured using the HSI RABD we refer to (ref. 1st ms: p. 4-5, lines 156-161).

Line 183: blue–green algae are also cyanobacteria. Please distinguish which forms of cyanobacteria can be reconstructed by these two pigments or are these indicators widespread in all cyanobacteria?

Response: Yes, according to Jeffrey et al. (2011) and Guilizzoni and Lami (2002), echinenone and zeaxanthin are common and most abundant in all cyanobacteria or blue-green algae. Other pigments such as myxoxanthophyll and canthaxanthin can be used to distinguish colonial and filamentous cyanobacteria since these pigments are

more abundant in these taxa. To make these more clear we have added the information in the text stating that “Echinenone and zeaxanthin are associated to most taxa of blue–green algae. . ..” .

Line 186: Pheophorbide a is considered as indicator of grazing – Please add reference to support this. It is a derivative of chlorophyll like other derivatives and can also simply form by degradation/structural alteration, which is not limited to grazing.

Response: Several authors have reported pheophorbides a to be a degradation product of Chl a transformed by microbial processes, and a useful biomarker of the effects of grazing (Bianchi and Findlay, 1991; Cartaxana et al., 2003). We have added this information and relevant references in the manuscript. The text now reads “Pheophorbide a is a degradation product of Chl a transformed by microbial processes and used as an indicator of grazing (Bianchi and Findlay, 1991; Cartaxana et al., 2003)”.

Line 233: Unclear why the age uncertainty is high in the varved part of the sedimentary record. These are annual layers, so age determination should be up to a few years only? How to explain this?

Response: Thank you for this comment. As stated in the Methods section the Age-Depth model was based on 18 radiocarbon AMS dates on taxonomically identified terrestrial plant macrofossils hence the ranges of uncertainty. Establishing a varve chronology was beyond the scope of our study but is planned for the future.

Line 331: The chronology is robust and exclusively based on terrestrial macrofossils – Related comment to the previous comment. Why is there no higher precision in the age record of the upper part of the record as it is varved? Other radiometric dating techniques that are useful, such as 210Pb dating? The high uncertainty of about 140 years indicates that the age model appears less robust than it is expected to be due to the presence of varves?

Response: As mentioned above, establishing a varve chronology was beyond the

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Discussion paper

scope of our study, but this is planned in a future PhD project. The density and quality (identified terrestrial macrofossils) of our 14C ages can be considered very good, and certainly adequate for the purpose of our study covering a period of 9500 years. In several sections of the sediment core, varves are extremely thin; thin sections and microscopic analysis would be required for varve counting. We do agree that varves counting or 210Pb dating for the top part would reduce the uncertainty significantly. Nonetheless, for the top 10 cm of the core (data shown in Fig. 4b), where HSI indices variability was high, we used the HSI data of our core for stratigraphic correlation with the 210Pb-dated core of Butz et al. (2016) which shows typical age errors of 3-5 years for this part of the core (Section 4.1 in the ms).

Line 481: The data should be uploaded to PANGAEA now so the link to the datasets can be included into the final version of the paper.

Response: The PANGAEA platform informed us that due to maintenance our data will be uploaded with delay. Hence, we have uploaded the data to BORIS and the link is now added in the manuscript.

References

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