Dear editor, dear reviewer,

We thank you for your thoughtful comments and the constructive suggestions which will be helpful to further improve the manuscript. Attached you can find our comments to those points that require a response as well as the suggested changes for the revised manuscript in bold print. We hope that we successfully addressed each point raised.

All the best

Franziska Koebsch

Anonymous Referee #1

In the paper the effect of rewetting of agricultural peat field on methane formation has been studied by way of pore water and sediment chemistry, isotopic analysis as well as by studying the prevailing microbial community. The authors found evidence that rewetting by fresh water may increase methane emissions due to lack of sulfate and its reduction. In conclusion they suggested using marine water instead of fresh water in waterlogging.

1. The paper is in the scope of BG while it deals with interactions between biological and chemical processes in former cultivated field being subsequently wetland.

2. The authors have used versatile and state-of-art methods and the results are novel.

3. Substantial conclusions have been made. The supression of methanogenesis by sulfate reduction has been known for a long time. However, in this kind of practical context such substantial conclusions have not been made earlier.

4. The scientific methods are mainly clearly presented, with the exception of pH. Line 123: It was not stated that pH was measured even though the pH device was presented in the same sentence. In addition, the pH was presented in the principal analysis but not discussed. It is suggested that pH will be discussed.

Author's response

- **You are correct, the pH measurements were not mentioned in the method section. Further, the patterns found in pH deserve to be discussed at least briefly.**

Suggested change in the manuscript

- **Information about pH measurements will be added in the methods section, further we will briefly discuss the observed patterns in pH with respect to its indicative value for peat degradation**

5. The results are clearly presented and mainly in line with the text and the figures. However, there are discrepancies between the results in Table A1 and Figure 4. Line 268: The authors write that "H2S concentrations were below detection limit (∼1 µM, Fig. 4)". However, according to Table A1 there are higher concentrations (at 10 cm 3 µM, and at 40 cm 2 µm). In addition, the sulfate concentration is suggested to be reported with the same accuracy in Table A1 and Fig. 4. Otherwise the readers of

the journal might get confused. Line 274: The same comment as above regarding AVS, and similarly with the other spots.

Author's response

- **We agree, that the description of the H2S and AVS concentration were not very accurate and that the unit notations presented in Fig 4 (and Fig. 7a and 7c), and Table A1 require harmonization.**

Suggested change in the manuscript

- **We will change line 268 to "H2S concentrations hardly exceeded the detection limit (∼1µM, Fig. 4)". Also inaccurate H2S and AVS quantity descriptions of other spots will be checked thoroughly.**
- **We will change the unit notation of Fig. 4a into 'mM dissolved S', the unit notation will then correspond with Table A1 and Fig. 7a and 7c**

6. The results support the interpretations and conclusions partly but I feel that the equivocal vertical methane concentrations do not clearly support the interpretations and conclusions. For example, along the studied transect the sum of methane concentration till the depth of 40 cm is the highest in spot 2 and the lowest in spot 1. I feel that the topsoil of spot 1 might be aerated occasionally and therefore methanogen formation was the lowest there. The authors do not present any data for water levels in the spots although water saturation is crucial in determining whether the soil is aerobic or anaerobic. In addition, in spot 2 the highest methane concentration is at the depth of 30 cm and there is still some sulfate left in pore water but not any methanogens. On the contrary, at the depth of 30 cm and 20 cm methane concentrations are the lowest in the profile but in these layers there is not any sulfate left. This is contrary to the hypothesis and should be discussed in the text.

Author's response

- **We agree that patterns in methane concentrations are equivocal. In general, methane concentration pattern should be Interpreted with care as methane is a highly volatile gas. Especially at high methane production rates, the indicative value of methane concentration profiles can be easily impaired by erratic ebullitive release. Hence, the observed methane concentration patterns are likely to present a snapshot resulting from the combination of methane production and erratic methane loss but may not be well suited to represent overall patterns in methane production. Therefore, we are very careful concerning the indicative value of single methane concentration data points. Still, we decided to show the methane concentration profiles for the sake of completeness.**
- **Since methanogenesis exerts a strong fractionating effect on CO_2 and DIC is less volatile than methane, we use the $\delta^{13}C$ values of DIC as indicator for methane production. In concert, with the isotopic composition of methane and the microbial structure, these can provide a comprehensive picture on methane cycling in our study site.**
- **In the current manuscript, we have explicitly qualified the indicative value of methane concentrations and explained why we focus on the isotope composition of methane and DIC instead in line 116f: "Measured pore water CH_4 concentrations were up to 0.7 mM with equivocal vertical patterns across spots (Fig. 7a), reflecting the methane-specific spatial variability that evolves from small-scale heterogeneity in production and consumption processes and from ebullitive release events (Chanton et al., 1989; Whalen, 2005). The isotope composition of CH_4 (Fig. 7b) and DIC (Fig. 7c) provided a clearer (and probably more robust) indication for patterns of methanogenesis and methanotrophy".**

- **Referee 1 is right in his suggestion that spot 1 is located on slightly higher grounds. Indeed, since the rewetting of the wetland, all spots have been flooded throughout the year, so contemporary water levels should not restrict methane production. In the current manuscript, we have mentioned the hydrological state in line 116f: "At the time of sampling, water depth above peat surface spanned from 15 to 25 cm, which presented the lowest range within the seasonal water level fluctuation". In fact, lower water levels in the past have, in combination with groundwater flow from the nearby forest catchment, certainly affected peat formation and soil geochemistry at spot 1.**

Suggested change in the manuscript

- **We will add measured water tables in table A1 and remind the reader about permanently inundated conditions in the results and discussion section. Further, we will discuss lower water levels in the past, in combination with groundwater flow from the nearby forest catchment, as possible reasons for the specific geochemistry and microbial community at spot 1.**

7. The description of experiments, the result table and calculations are sufficiently complete and precise to allow their reproduction by fellow scientists.

8. The authors refer to related work and clearly indicate their own new contribution. The title is clear and reflects the contents of the paper.

9. The abstract provides a concise and complete summary.

10. The overall presentation is well structured and clear.

11. The language is fluent and precise.

12. Mathematical formulae, symbols, abbreviations, and units are correctly defined and used.

13. The number and quality of references are appropriate.

14. The quality of supplementary material is appropriate, but the water table depths in the spots should be presented in a cross-section or in a table.

Suggested change in the manuscript

- **We will add measured water tables in table A1.**