Response to reviewer comments by Pierre Taillardat (received 23 May 2024)

Dear Pierre Taillardat,

Thank you very much for your second review of our manuscript. Your comments have greatly helped us to further improve the manuscript. Below, we copied your comments and questions in *italics* and address them point by point in bold text.

This is the second version of the manuscript "Shoulder season controls on methane emissions from a boreal peatland". Overall, I feel that the authors have nicely addressed my initial concerns, along with those of the author reviewer. The new version of the manuscript is much more coherent and conclusive. I only have a few minor comments for consideration. Please see below.

Line 337-341: Do the authors mean by 30 times and 2 times in this sentence? Otherwise, I don't think I understand this sentence. I also encourage the authors to refer to the figure and panel that illustrate these results (i.e., Figure 2a)

In this paragraph we are giving the range of values by which the presence of presence of *Sphagna* decreases and the presence of vascular plants increases the CH4 emissions, respectively. 30 mgCH_4m^{-2}d^{-1} and 2 mgCH_4m^{-2}d^{-1} are the minimum values of these ranges. We have added the units to both numbers for clarification.
As you suggested, we have added the reference to Figure 2a.

Line 375: why not stick to the "δ13C" nomenclature?

We have changed the title of section 3.3.2 from "Stable $^{13}C/^{12}C$ isotope values in pore water and emitted CH_4" to "$\delta^{13}C$ values of CH_4 emitted and dissolved in the pore water"

Line 393: A negative sign is missing.

We have added the negative sign.

Line 419 and 437: Could the titles for these two sections be more informative on the findings of this study? For example "Sphagnum moss layer decrease CH4 emissions" and "Vascular plant increase CH4 emissions" or something like that?

As suggested, we have changed the titles of the sections to "*Sphagnum* moss layer decreases CH_4 emissions" and "Vascular plants increase CH_4 emissions"

Line 410: Could the CH4 flux magnitude and dissolved CH4 concentrations measured in this study be compared with the literature?

We have added the following paragraph to the discussion to compare the CH4 fluxes found in our study to the literature:

The CH_4 emissions measured in this study were higher than most chamber measurements of CH_4 emissions reported for other non-permafrost bogs but similar to the emissions previously found at Siikaneva bog. According to our study, on average, 287 $mgCH_4m^{-2}d^{-1}$ were emitted from the control plots with intact vegetation in the hollows of Siikaneva bog between May and October in 2021 and 2022 while the mean emissions from non-permafrost bogs with sedges during the same time of year that are included in the BAWLD data set were 52±66 $mgCH_4m^{-2}d^{-1}$ (Kuhn et al., 2021). The mean CH_4 emissions in our study were however similar to the ones found for Siikaneva bog by Korrensalo et al. (2018) of 200, 250, and 300 $mgCH_4m^{-2}d^{-1}$ in 2012, 2013, and 2014. This indicates that CH_4 emissions from Siikaneva bog are high compared to the emissions from other boreal bogs. The emissions found in our study might also be higher than most mean emissions reported in the BAWLD data set because we focused on hollows which have been shown to be high-emitting features of patterned boreal bogs (Frenzel & Karofeld, 2000; Moore and Knowles, 1990; Waddington & Roulet, 1996; Laine et al., 2007).

To compare the concentrations of CH_4 dissolved in the pore water that we found in our study to the literature, we have added the following paragraph to discussion section 4.1.2 of the manuscript to further underline the effect of plant transport on the CH_4 concentrations in the pore water:

The pore water concentrations of 242 ± 118 $\mu molL^{-1}$ that we measured at 50 cm depth underneath the control plots in summer are lower than the concentrations of around 600 $\mu molL^{-1}$ reported for an unvegetated mud bottom hollow in an Estonian bog by Frenzel and Karofeld (2000), which are more similar to the concentrations of 350 ± 117 $\mu molL^{-1}$, reaching individual values of up to 541 $\mu molL^{-1}$, that we found underneath the plots where all vascular plants had been removed. Concentrations underneath the control plots were similar to the concentrations of 150 to 250 $\mu molL^{-1}$ found for the sedge-dominated hollows of a Finnish fen by Dorodnikov et al. (2013).

Line 546: Can the authors refer to a figure for this result?

We have added a reference to Figures 2b and 2e as well as to Table A5.

Consider adding more figures to the main text to make the reading experience more enjoyable. Figure A1 and A8 are potential candidates.

We have moved figure A1 to the main text since it is referred to several times in the text when describing the meteorological conditions, the timing of the field campaigns, and the definition of the seasons.

Figure A6: Can the authors remind in the caption how these ratios were calculated? What about ebullition and oxidation?

We added to the figure caption that we used the CH_4 emissions from the moss-only (PS) plots as diffusive CH_4 emissions and the emissions from the control (PSV) plots minus the emissions from the PS plots as the rate of vascular plant transport. To calculate the percentage of CH_4 emitted via diffusion and via

plant transport we related both values to the total CH_4 emissions from the PSV plots. All episodic ebullition events were excluded from the measurements prior to these calculations.

We have decided not to quantify the amount of CH_4 emitted via ebullition in this study and to instead only analyze the number of ebullition events observed from each vegetation treatment. This is because ebullition events in our study were probably mostly triggered by chamber placement and therefore likely not representative of ebullition occurring under natural, undisturbed conditions. While the number of ebullition events can therefore give us an indication which vegetation treatments are most prone to a buildup of gas bubbles in the peat in which seasons (Figure A8 in the manuscript), the absolute amount of CH_4 emitted during these events is probably more random and therefore not very meaningful. In order to more reliably quantify the share of CH_4 emitted via ebullition we would suggest to use bubble traps in addition to the chamber measurements to capture the gas bubbles over a longer time, as done by Männistö et al. (2019).

The percentage of CH_4 oxidized (in the *Sphagnum* layer) is given as the relative decrease in CH_4 emissions in the presence of *Sphagnum* moss in Figure A5. Unfortunately, we were not able to quantify the total oxidation rates, that is the oxidation in the *Sphagnum* layer plus the oxidation in the aerobic peat below the living moss with our study setup. One way to achieve this would probably be to remove the entire acrotelm instead of just the moss layer for a treatment, as done by Karofeld & Frenzel (2000). If isotopic fractionation factors for CH_4 transport and oxidation are determined, isotope modelling can also provide the share of produced CH_4 that is oxidized in the entire acrotelm.

References

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