Comments *Peatland Research* on manuscript 'Cutting peatland CO_2 emissions with rewetting measures (Biogeosciences discussions BG-2021-276)'

Carbon fluxes from drained peatlands receive increasingly attention within various scientific disciplines. This paper follows this trend promoting an interdisciplinary approach. The authors have provided a valuable theoretical attempt to improve the community's understanding of soil moisture and carbon fluxes interactions. At the first sight the modelling work focuses on combining soil moisture, temperature and potential carbon mineralization rates for an improved quantification of hydrological variables steering seasonal peat losses.

However, after a second read through there is more to the paper. The authors incorporate a new method to approximate carbon fluxes from drained grasslands on peat quantitively. The new method relies on closed chamber technique. Chambers were supposed to close automatically 2-3 times per hour. The static chambers are reported to be surprisingly high (full 20 inches).

To compare the new chamber method with published data the authoring team builds a soil-water-carbon model. The 3.5 model exploration (Figure 1) helps to quantify how well the flux method can approximate existing carbon flux data at an annual resolution. Figure 11 highlights that the gas flux method deployed for model calibration in this study may systematically underestimate carbon fluxes from drained peatlands. The comparison with Evans et al. 2021 seems vulnerable given the almost absent overlap in grazing intensity and primary production of the sites included in both data sets.

The paper's modelling approach would need a proper cross validation with more established gas flux methods on the one hand and multi-year data sets for calibration and validation on the other hand. Multi-year carbon flux data sets are essential for quantifying main drivers of soil carbon, climate and water interactions in peatlands (e.g., https://doi.org/10.1111/j.1365-2486.2006.01292.x https://doi.org/10.1111/j.1365-2486.2009.02104.x). More so where soil temperatures are likely to change methodically by static chambers that are commonly deployed for experimental warming at higher latitudes.

The title seems misleading. All 4 paddocks remained drained during the course of the experiment. 'Cutting peatland CO2 emissions with irrigation measures' would fit the content of the paper.

I enjoyed reading this version of the manuscript. Looking forward to updates of the model supported by cross-validation of carbon fluxes.

Reply on RC8:

We thank you for your critical reflection and the discussion points you brought up and are content to read that you evaluate the research as a valuable approach. We discussed your concerns with the team and are motivated to improve the manuscript as explained in the answer formulated below.

You mention that our method to estimate peatland carbon fluxes relies on the closed chamber technique. Our aim was to measure CO_2 fluxes with the least amount of soil and vegetation disturbance as possible. The height of the chambers is above the maximum vegetation height. Smaller chambers would not support the conditions that we find at the farmland. Furthermore, we are aware of affecting the microclimate of the soil and vegetation, with possible changes in air temperature, amount of wind, radiation, precipitation and air moisture content. Therefore, we chose not to compare model outcomes with the absolute observed CO_2 fluxes, but we chose to compare CO_2 flux-differences between different management regimes. Furthermore, we compared our measured chamber ecosystem respiration dynamics with potential aerobic respiration rate dynamics that we calculated with a variety of WFPS-activity curves. We chose the WFPS-respiration activity curve that matched the dynamics the closest. An under or overestimation in chamber ecosystem respiration would not have any consequences for this comparison, as we solely rely on the daily and seasonal dynamics. We stimulate air mixing by using ventilators and change the location of the chambers every two weeks to limit the development of a micro-ecosystem and to achieve proper field representation. Our equipment has been tested in the lab and is calibrated each year.

We think that the chamber flux data that we used in our yearly carbon budgets give reliable estimates of the effects of different peatland management practices. Firstly, we found that our model supports our measured differences, as we found a similar reductions in yearly carbon budgets -that were constructed using the chamber measurements- as our model simulated for both our measuring locations. We did not calibrate our model on these differences but used literature and measured properties to describe soil water and temperature. Secondly, the research application of static automatic transparent chambers to measure greenhouse gas fluxes knows a long history and has been evaluated successfully frequently (Huth et al., 2017). Many published research articles are based on chamber datasets with highly limited measuring intervals and continuity (for example Görres et al., 2014; Tiemeyer et al., 2020). Interpolation is done with relatively simple light and temperature response curves, resulting in large uncertainties in the yearly carbon budget. In contrast, our temporal data coverage is very high (>90%) and interpolation is hardly needed. Following your comment, we stress reliability of transparent chamber measurements by referring to research articles in which comparable chamber methodologies were used to quantify CO_2 fluxes with similar vegetation settings within our revised manuscript.

Indeed, it would be great to be able to present a multiyear cross-validation between chamber and eddy-covariance measurements. However, it has been already been proven that eddy-covariance and chamber measurements yield comparable results (Frolking et al., 1998; Laine et al., 2006; Stoy et al., 2013). Besides this and the arguments that we provided earlier -to explain why we can rely on the chamber measurements- the peatland community is in need of knowledge on how to prevent greenhouse gas emissions from managed peatlands. We are currently processing eddy covariance and chamber data of 2021, and plan to publish the outcomes of the comparison. Nevertheless, this should not constrain the publication of this research article. As a matter of fact, eddy covariance also induces many uncertainties (affected by choices in measurement set-up and methodologies for analysis).

We regret to read that our title could be misleading and will consider alternative options for the term *rewetting*. However, only referring to *irrigation* measures in the title as you suggest would miss the ditch water level elevation measure to reduce peat respiration.

We agree upon the fact that extensively used grasslands are underrepresented in the research of Evans et al. (2021). However, the authors state that annual groundwater levels "override other ecosystem- and management-related controls on greenhouse gas fluxes". Therefore, we think that the comparison with Evans et al. (2021) within our research is appropriate. Nevertheless, we included other important relations between annual water table depth and CO_2 emissions. Within our revised manuscript, Figure 11 will be updated with the relation from Couwenberg et al. (2011). Following your comment we will consider in text comparisons featuring the other relations plotted in Fig. 11 instead of highlighting the comparison with Evans et al. (2021).

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