Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-230-RC1, 2020

Interactive comment on "Sub-soil irrigation does not lower greenhouse gas emission from drained peat meadows" *by* Stefan Theodorus Johannes Weideveld et al.

Anonymous Referee #1

Received and published: 1 August 2020

General comments:

The authors investigate the GHG reduction potential of drained peatlands by using sub-soil irrigation. The topic of the paper is of relevance to Biogeosciences and will be of interest to an audience interested in mitigating greenhouse gas emissions from agriculturally used peatland. It is a novel approach, which needs further research. For the evaluation of the effect of sub soil irrigation on GHG emissions, a paired design of a control site and a sub-soil-irrigated site is used. Four different sites were investigated. CO2, CH4 and N2O fluxes were measured with chambers over a two 2 years period. Carbon and greenhouse gas budgets are determined and compared for the paired sites.

I do not understand the experimental setup: The basic hypotheses of the manuscript that main GHG emissions comes from soil layers deeper than 70 cm is not well explained. Moreover, no information about soil properties and soil moisture of this relevant depth are given in the manuscript. As these soil data are missing, it is not clear, which amount of soil organic carbon is exposed to oxygen due to the alterated groundwater level. Often the bulk density is low in deeper peat layers. It would be interesting to calculate the additional % of aerated carbon due to the alteration of the groundwater level and to compare it to GHG emissions. Moreover, the authors should estimate if the small differences in groundwater level (<20 cm) can lead to a theoretical GHG reduction, which can be measured with this method (and associated uncertainties) and experimental set up. Unfortunately, soil moisture was only measured to soil depth of 20cm. (At site A, C, D, soil moisture and temperature is measured only in the mineral soil cover). Moreover, these data are not presented in the paper, although the importance of soil moisture is discussed in the discussion section. The main conclusion that SSI does not lower GHG emissions cannot be drawn from the presented data as most of time the difference in ground water level between the treatments was relatively small. However, when the differences in ground water level were > 20 cm a reduction of GHG emissions was observed. In my view, the conclusion from this paper would be that a substantial increase in groundwater level is needed to allow large enough effects in the emissions to be measured.

For two sites, the comparability of control and SSI treatments is not given. This may influence the mineralization processes and thus the results. In particular, Site A: SSI has considerably higher organic matter content (39 vs 27%) as the control, and C/N ratios (29 vs 20) indicate different organic matter quality. Moreover, Site D: Control site has nearly the double amount of organic matter than SSI (38 vs 61%). This aspect is not discussed in the manuscript and might bias the results.

In particular, the methods used to measure the carbon and greenhouse gas fluxes and management are not described in sufficient detail.

The annual N2O budget was calculated based on only few measurement campaigns. In my opinion, it is not possible to calculate annual N2O budgets from 6-9 daily values, which were measured within 6 month in 2017. This is most evident at Site B Control: Linear interpolation of the high N2O emission in March probably overestimate the N2O emissions for the whole winter time. Moreover the material and methods section is misleadingly stating that N2O was measured for each measuring camping, but at Site B 38 campaigns were made, whereas I counted only 17 data points in Figure C1. Researchers reading the manuscript without looking at the supplementary data could extract the N2O data for annual budgets. Due to the low temporal resolution of the N2O data, it is not possible to distinguish between background N2O emissions and fertilizer-induced N2O emissions. As no daily data are presented for the CH4 budget, the data coverage and thus quality of annual budget cannot be evaluated.

The description of management is very short and important information about cutting days, fertilization events, and amount of applied fertilizer are missing, which makes it difficult to understand N2O and NEE data. E.g. Why are the cutting days not visible in the GPP data? In other studies, the decrease in GPP after management events can be nicely seen (Poyda et al. 2016 or Beetz et al 2013,). In comparison to their data, the GPP stayed rather constant and relatively high (-10 g CO2 m-2 d-1) throughout the year. Accordingly, it is difficult to evaluate the quality of GPP modeling.

The uncertainty assessment is nicely done for the gap filling method of NEE, but the uncertainty estimates are not integrated in the results and transferred to GPP and Reco. For NEE, Reco, and GPP an uncertainty is indicated, but it is not stated what it is (error of SD or 95% confidence interval . . .). The uncertainty range is given for NEE as 3-16 t CO2 ha-1 yr-1, (L 370), but NEE uncertainty from NEE gap filling is given as 14-25 t CO2 ha-1 yr-1). For N2O and CH4 the uncertainty assessment is missing. Other sources of uncertainty (systematic errors of the use of chamber methods or random errors) are not discussed. Please provide a more thorough uncertainty estimation of all component of the net ecosystem carbon balance and included this values in Table 2 and 3.

Specific comments:

Experimental set up and management Table 1: please provide more information about soil properties of the mineral soil cover, and underlying peat layers (carbon content, bulk density, C/N and carbon stock) in a higher resolution for the entire aerated soil depth. Please state how many soil samples were taken per depth and where. Please also add the information of the depth location of the schalter. Figure 2: please provide information about the location of the chambers of the control site relative to the main ditch. Please provide data of cuttings days, fertilization events and measurement campaigns for CO_2, N_2O and CH_4 as the growth of the grass and thus GPP strongly depend on time of measurement (days after cutting). Information can be added in Figure 7, Appendix B1, C1. Please add information about amount and determination of N und C input through slurry application. Please add information about the determination of the yield (dry mass of the grass). According to Table 1 Site A und B were grazed. How was carbon import through cattle manure determined? How was the carbon export through grazing determined? Was the yield only determined within the chambers or for the entire grassland? How was the grass height determined?

Gas fluxes Chambers: Was the location of the frames fixed over the two years? Did the vegetation change within the chambers during the experiment? Please add the transparency of the chambers? Was a correction term introduced due to a reduced transparency? Please add information about the used sign convention, positive fluxes = loss of carbon? Please add information about the used equation for the calculation of GHG balances and assumptions (harvest is assumed to be released as CO_2?, loss of dissolved organic carbon?)

L242ff: what is the accuracy of precipitation data derived from satellite images?

L243: June 2017 seemed to have received more than the average precipitation, but

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Discussion paper

June is included in the drought period?

Figure 4: As there were 3 groundwater measurements per site, it is not clear which groundwater table is presented, average of all 3?, what is the SD of the three wells? How is the variability of groundwater level of the control site? Please explain DRN

L276: I do not understand the sentence "There is variation.." please clarify.

L327-330: What is meant by uncertainty of 3-16 t CO2 ha-1 yr-1. What is represented by 1.6 t CO2 ha-1 yr-1 I for NEE in 2017?

L326-332: What is the difference between annual NEE of 47 t CO2 eq. ha-1 yr-1 (L327) and emissions of 62 t CO2 eq. ha-1 yr-1 (L313)

L 334-338: Please provide daily CH4 data.

Table 2 and Table 3: Please add uncertainty estimates for all components of GHG balance

L. 380: Reco was lower when the differences of groundwater level was >20 cm

L. 420: N2O emissions are not only driven by fertilization events, but also by soil moisture, which should be differ by the treatment. Thus, the comparison can be biased by missing peak events.

L428: please use the same sign convention for all cited references.

Technical comments: L310: Please state was the 4 t are, SD?, . . .,

Please indicate A und B in Figure 6

Figure 7: please use colors, which can be clearly distinguished

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