Response to Anonymous Referee #1, 25 Oct 2024

We thank the reviewer for the evaluation of our manuscript. All comments are one-by-one addressed below and will help us greatly to further improve our study.

I don't think you can compare the sites; they are very different. If you compare different treatments like grass/cereal, it should be on the same field in a regular field trial. In this paper, you don't know how all other variables affect emissions and/or yield.

RESPONSE #1: *Thank you for the comment. However, we are not quite sure if we understand what is meant here. Our aim was not to compare specific cropland and grassland sites with each other. Instead, we aimed to produce the first estimates on annual net CO_2 fluxes from drained organic soils in two different types of agricultural land (cropland and grassland) typical of the region (the Baltic states), and to elaborate corresponding CO_2 emission factors for this region. For this purpose, we need sites that represent the variation in such sites in the region, not sites that are comparable concerning some specific characteristics. We believe that the number of studied sites and monitoring over a 2-year period is sufficient to characterize the variation in net CO_2 emission at regional level.*

The method to measure Reco is different from Rh. Reco is probably underestimated due to the long time the chamber is over the soils compared with the Rh measurement.

RESPONSE #2:

Yes, the method to measure R_{eco} was different from R_{het}. That is to be expected because the measurements cover different conditions, one with plants and the other just the soil. The chamber methods should be designed accordingly (e.g., Pavelka et al. 2018) so that they match with the conditions. Data from the two methods were handled separately. Also, specific data quality controls were applied in both methods before readout acceptance, as described in the methods section. Both methods have been widely used in flux data collection also in earlier research (e.g., Maier et al. 2022; Ryhti et al. 2021; Barbosa et al. 2024). The validity of these methods and the reporting based on their parallel use has, to our knowledge, not been generally challenged. We agree that static chamber methods used for R_{eco} require careful consideration of the concentration gradient over time. To avoid potential risks that a build-up of CO_2 in the sealed chamber space reduced diffusion-driven soil CO_2 efflux, we conducted a thorough validation of the method, including comprehensive comparability tests of the techniques employed, prior to field measurements. These tests included an evaluation of the linearity of CO_2 concentration increase within the chambers. Simultaneously, we measured CO_2 concentration continuously using an EGM (employed in heterotrophic respiration measurements) and collected manual gas samples for gas chromatography, following the study procedure. Our analysis did not reveal any evidence of disrupted linearity, leading us to conclude that pressure build-up did not introduce bias. Noteworthily, the size of the chambers used for our R_{eco} measurements was large (a volume of

0.0655 m³ and an area of 0.1995 m²), which evidently prevented the formation of nonlinearity. Our team includes scientists with thorough experience in measuring greenhouse gas fluxes using different chamber techniques. As part of our quality control procedures, we included steps such as examining the raw data for linear versus non-linear patterns over time. Thus, the potential risks mentioned (compatibility of methods, reduced diffusion-driven soil CO_2 efflux) were already initially assessed, and avoided.

Pavelka et al. 2018: https://doi.org/10.1515/intag-2017-0045
Maier et al. 2022: https://doi.org/10.1002/jpln.202200199
Ryhti et al. 2021: https://doi.org/10.1016/j.agrformet.2020.108266
Barbosa et al. 2024: https://doi.org/10.1016/j.geoderma.2024.116891

If there is no significant difference, there are no differences; remove the use of tendency...

RESPONSE #3: *We rephrased the text based on the results of the statistical analysis to avoid misleading the readers regarding tendencies.*

I think using one factor to convert to Rh for all different soils is problematic.

RESPONSE #4: *We agree, but could not find a better way to come around the fact that our R_{het} measurements yielded overestimates that we could not apply (see also RESPONSE #2). We are aware that the share of R_{het} in R_{eco} can vary not only between study sites, but also between different seasons and vegetation types. The assumption that the proportion of annual soil R_{het} from R_{eco} is 64%, is based on results of a large number of previous studies (n=61, Fig. S4) conducted in temperate and boreal regions (Jian et al., 2021). These assumptions were consistent with the most conservative approach and should clearly avoid underestimation of R_{het} since our R_{eco} values additionally included the dark respiration of the aboveground plant biomass, not included in the soil surface respiration (R_s). Although the use of static factor introduces some uncertainty (Figure S4), the used approach is based on the best available and most comprehensive data. This was the best option that we could think of, but if there are in fact better ways for estimating R_{het} based on R_{eco} in grassland and cropland, we would be delighted to learn and apply such. Also, the used approach and reporting the specifics provide the possibility to improve the estimation by applying condition-specific factors (that could be obtained in further studies). Thus, we trust that obtained results are valuable, serving as the first region-level study to estimate annual net soil CO_2 emissions from cropland and grassland on drained organic soils in the hemiboreal region.*

Jian et al., 2021: https://doi.org/doi.org/10.3334/ORNLDAAC/1827

Comments in the pdf file

Line 120-123: This will underestimate the emissions. too long time will reduce the gradient in the chamber. Thats why Rh is larger than Reco.

RESPONSE #5: *Please see RESPONSE #2. We understand that the concern is likely related to potential CO_2 saturation during longish closed chamber incubation on the vegetation covered plots. As described above, we applied rigorous quality control on the data. As part of the quality control, linear increase of the CO_2 concentration over time was checked and there were only a few events where linearity was not optimal, leading to discarded readout. The potential risks of reduced diffusion-driven soil CO_2 efflux were already initially assessed and avoided.*

Line 153-155: The different methods measuring heterotrophic and ecosystem respiration is a big problem.

RESPONSE #6: *Please see RESPONSE #2. We do not see how it would be beneficial, or even feasible, to use the exact same method under clearly different conditions. The key point should be whether the different methods yield reliable estimates for the conditions for which they were designed and under which they were applied. As far as we know, the applicability of either method as such has not been challenged generally.*

Line 166: This is very shallow, surely the roots will go much beyon that?

RESPONSE #7: *We agree that the maximum rooting depth in grasslands and croplands can extend well beyond the top 20–30 cm. However, we focused on the top 30-cm soil layer to capture the most densely rooted zone and its microbially active rhizosphere, the processes of which are driving the CO_2 emissions. Designing the study, we also considered the fluctuations of the water table, and although it varied widely, being lower than 1 m in some sites and time periods, we had to consider a comparable rooting depth. However, we fully agree that deeper layers or rooting depth per site should be studied in the future.*

Line: 197: But you dont really know. This can be very differente between sites.

RESPONSE #8: *Please see RESPONSE #4. We agree, and regret that this could not be considered. This is also clearly acknowledged in the Discussion. We still think that our results are better representative of the conditions in the region considered than the existing data that are still overall rather scarce and not including any sites from the region considered. Future research can build on our findings and yield more accurate estimates, if and when resources allow the work to be continued. Probably no scientific paper so far has yielded an absolute truth concerning emissions from drained organic soils, which are an outcome of several contributing and constraining factors, but they may all be considered as necessary steps towards reliable generalizations.*

Line 202: Probably over estimation since you measure during peak temperature.

RESPONSE #9: *We fully agree. To avoid misleading readers, we have emphasized this several times in the article (in both the discussion and conclusions section): "In general, estimation of mean CO_2 flux within our study could be slightly overestimated as all CO_2 flux measurements were*

conducted during the daytime, and previous studies have concluded that mean CO_2 production occurring during the daytime is 14–23 % higher than the mean daily fluxes (Maljanen et al., 2002). This is largely caused by diurnal variation in air temperature and consequently soil temperature which are intercorrelated parameters. Thus, for further evaluations, regression describing variation in R_{eco} depending on soil temperature could be used to avoid overestimation of R_{eco} due to lack of measurements during night. ".

Line 265: You must describe what is measured in the figure text

RESPONSE #10: *Thank you for noting the lack of some necessary information. While we think that generally, "topsoil characteristics" can be used, explanations of the abbreviated variables OC and TN were lacking, and we have added the corresponding description: "Variation in topsoil (0–20 cm soil layer) characteristics (organic carbon (OC), total nitrogen (TN), organic carbon/total nitrogen (C/N) ratio, HNO_3-extractable potassium (K), calcium (Ca), magnesium (Mg) and phosphorus (P) concentration, soil bulk density, soil pH) in the cropland and grassland sites, separately for the two soil types (deep organic soil and shallow highly decomposed organic soil).".*

Line 284: No, not different

RESPONSE #11: *We agree. The text is reworded to avoid misleading.*

Line 320: The applied funktions does not seem to fit the data.

RESPONSE #12: *We tested different types of regression curves and found that polynomial regression provided the best fit of all options evaluated.*

Line 409: cant do. the soils will be too different.

RESPONSE #13: *Please see RESPONSE #1. The soils with all their variability represent the conditions in croplands and grasslands on current or former peatlands in the region, and thus form a good, and the only feasible, basis for estimating emission factors for them. To avoid confusion, we replaced the words "with similar characteristics" with "(study sites) on current or former peat soils (in the Baltic states)".*

Line 500: probably due to the different gas measurements methods

RESPONSE #14: *Initial testing and validation of the methods were performed in order to avoid risks of method incompatibility (please see RESPONSE #2). The observed inconsistency that the magnitude of instantaneous R_{het} tended to exceed the R_{eco} is most likely explained by other methodological challenges, as described in Discussion. Measurement points established for R_{het} involved trenching, vegetation removal, and keeping the soil surface bare. This may elevate the R_{het} as compared to vegetated surface firstly by higher temperature in bare soil than under*

vegetation. Second, soil moisture conditions may differ from vegetated soil. Third, CO_2 from the decomposition of roots killed by the trenching is likely to further add to R_{het}. These challenges have been encountered in earlier studies as well, but their net effect was higher in our study than what we expected. We think that it is worthwhile to fully address this to inform future research so that a similar outcome can be avoided. If only nice success stories are reported in scientific papers, we learn much less than what we could, to the disadvantage of the whole scientific community.