Reply to editor:

The manuscript improved after the review, still there are many issues with language, abbreviation, and inconsistencies in units.
Please carefully revise the manuscript.

In response to reviewer 1 about the real-world application of the authors added the following sentence (lines 676-683):

"Nature-based approaches represent the most common real-world rewetting strategies, aiming to restore peatlands towards their natural hydrological regime. At a minimum, such rewetting requires terminating tillage activities and eliminating artificial drainage for instance by blocking of drainpipes and ditches. The rewetting scenarios implemented in this study, represented as simple modifications to WTD, are not reflective of practical management interventions - except perhaps in a few rare and costly restoration projects that involve installing artificial impermeable membranes along peatlands edges (Naturstyrelsen, 2022). However, the outcome of this study can serve as a reference for discussions on realistic expectations on CO2 emission reductions from rewetted peatlands."

Although the sentence clarifies some aspects, such as the fact that the tested rewetting solution is only partly applicable in the real world due to the high costs, I think the authors should explain more clearly how the study can serve as a reference. How can the study serve as a benchmark? How can other solutions be implemented, and what would the expected results be compared to the benchmark? Is the selected strategy the one that can achieve the greatest emission reduction potential? Can you compare it with other studies and provide more context on this aspect?

What we mean by serving as a reference is that this study illustrates that the WTD dynamics after rewetting are very important for the impact on CO_2 emission reductions. So irrespective of the exact rewetting practice, this study introduces the consideration to post-restoration WTD dynamics and its influence on emission reductions. If rewetting mainly impacts winter WTD and the farmer still requires e.g. the area to be dry for cattle grazing in summer, and the rewetting supports that, then the CO_2 emission reduction is much lower that if the area is wet during summer. Commonly, within rewetting in Denmark, there is a perception that, when abandoning intensive farming on a peatland area and seizing drainage, the natural hydrology will return it to a wet state where CO_2 emissions go to zero. Our hope is that our study can facilitate discussions of rewetting impacts and the need to monitor rewetting impacts on WTD dynamics and designing rewetting to increase WTD also during summer and drought periods where emissions are large.

We suggest reformulating the revised session above to illustrate this instead of merely state that it can “serve as a reference”.

“However, the outcome of this study can inform discussions on requirements and best practices for rewetting and peatland restoration. The study also highlights the need to monitor or model pre- and post-restoration WTD dynamics in order to develop realistic expectations regarding CO_2 emission reductions from rewetted peatlands.

We are not aware of other studies in a Danish context that addresses the temporal aspect of CO_2 emission reductions, those are typically estimates by fixed emission factors for soil and land cover or by the annual WTD emission model described in the paper.

On line 57, there is something wrong with the parentheses.

Corrected

Line 88: 'most LSM's' should be 'most LSMs'.

Corrected

On line 170, 'LAI' please define LAI.

Corrected

I have noticed that units are sometimes reported as kg/m^3 or kg m^{-3}. Please use only the second throughout the manuscript.

Corrected.

Define KGE before line 202.

Between lines 202 and 230, the description is a mixture of equations and undefined terms. Please rewrite it, making sure that all the symbols and acronyms are defined, and that this part of the text is written as an equation (for example, the beta equation at line 207).

We agree lines 202-230 are a bit unorganized. However, the equations are all defined and described and written in equation form in Table 1. We suggest adding the definition of all variables in the equation inside Table 1 instead of writing all 5 equations in full inside the main text. These statistics are very common, they are KGE, ME and correlation coefficients, so we feel it is a bit too much to take up a large part of the text with five inserted equations and the associated definitions of variables. We prefer spending time explaining how and why we

combined the objective functions in the way we did for this calibration exercise. We have edited the section a bit to avoid the intext equation and introduced table 1 earlier which we believe will also guide the reader better.

Figure S1: Clarify what Kristensen and Jensen mean.

The reference to Kristensen and Jensen (1975) is included in the caption

The units are missing from Figure S3. Please ensure that you add them to the axes.

Now in caption

Line 263: Please clarify what MgCO2-C refers to. I believe it is cumulative, but it should be defined.

It is the annual CO_2 emission (Mg CO_2-C ha^{-1} yr^{-1}). See figure 5.

Line 324: I suggest changing the title to 'Uncertainty of future climate CO_2 emissions'.

We agree, but prefer 'Uncertainty of future CO_2 emission estimates', to not confuse it with the uncertainty of the climate model global emission scenarios.

Line 451: This is the third time that the NECB has been introduced.

Corrected.

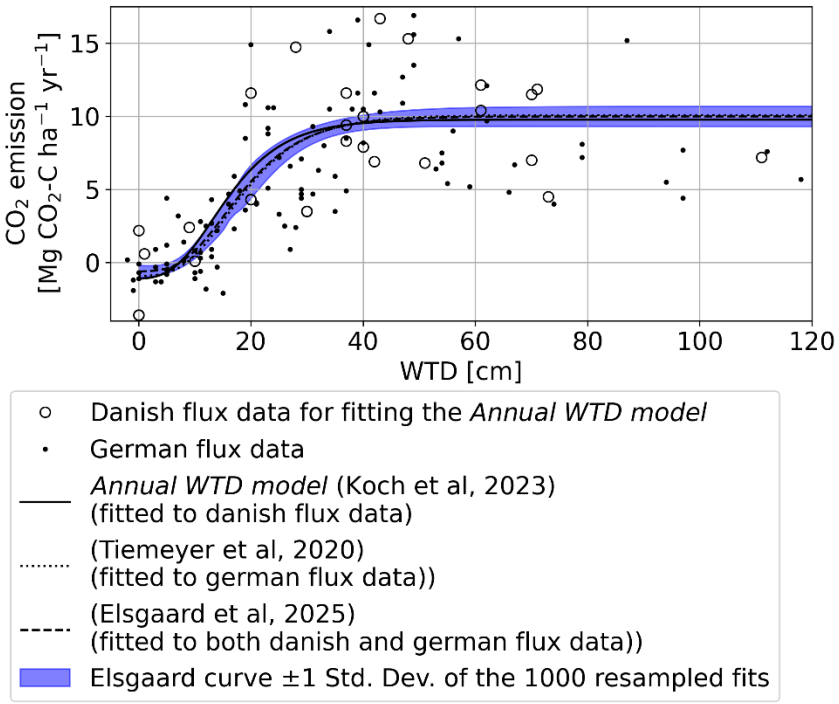
Figure 5: Please add the uncertainty of the fitting to the figure.
Expect for the green and yellow dots figure 5 is based solely on work by (Koch et al., 2023) and (Tiemeyer et al., 2020). We consider it outside the scope of this manuscript to evaluate the uncertainty of the models that originates from separate studies.

However, we have proceeded to calculate the uncertainty for this reply.

Below we show a version of figure 5 where the uncertainty is included. At the figure three different fits of the Annual WTD model are shown; (Elsgaard, 2024; Koch et al., 2023; Tiemeyer et al., 2020). In the manuscript we chose to use the (Koch et al., 2023) curve , as it appears in a peer-reviewed scientific journal (which (Elsgaard, 2024) doesn't) and is derived from Danish flux data. The figure below shows that the three Annual WTD models are very similar.

Uncertainty is estimated by performing 1000 bootstrap resamples (with replacement) of the Danish and German flux dataset (n=145). A Gompertz function is then fitted to each of the

1000 resampled flux datasets, and the uncertainty is expressed as ±1 std.dev of the (Elsgaard, 2024) curve. As mentioned above, it is important to note that the *Annual WTD model* used in this manuscript is based solely on the Danish flux data (Koch et al., 2023), which is why it is not centered within the blue band.



Line 709: RCP has already been defined above.

Corrected.

Reference:

Elsgaard, L.: Dokumentations notat vedr. forskningsprojekter om analyse af danske emissionsdata (> 12 pct . OC) samt relation mellem emission fra jorder med 6-12 pct . OC og > 12 pct . OC, Rådgivningsnotat fra DCA - Nationalt center for fødevarer og jordbrug, Århus University, 2024.

Koch, J., Elsgaard, L., Greve, M. H., Gyldenkærne, S., Hermansen, C., Levin, G., Wu, S., and Stisen, S.: Water-table-driven greenhouse gas emission estimates guide peatland restoration at national scale, Biogeosciences, 20, 2387–2403, https://doi.org/https://doi.org/10.5194/bg-20-2387-2023, 2023.

Kristensen, K. J. and Jensen, S. E.: A model for estimating actual evapotranspiration from potential evapotranspiration, Nordic Hydrology, 170–188, 1975.

Tiemeyer, B., Freibauer, A., Borraz, E. A., Augustin, J., Bechtold, M., Beetz, S., Beyer, C., Ebli, M., Eickenscheidt, T., Fiedler, S., Förster, C., Gensior, A., Giebels, M., Glatzel, S., Heinichen, J., Hoffmann, M., Höper, H., Jurasinski, G., Laggner, A., Leiber-Sauheitl, K., Peichl-Brak, M., and Drösler, M.: A new methodology for organic soils in national greenhouse gas inventories: Data synthesis, derivation and application, Ecol Indic, 109, 105838, https://doi.org/10.1016/j.ecolind.2019.105838, 2020.