The study evaluates the potential of restored peatlands to function as CO_2 sinks under changing climate conditions with adapting the CoupModel considering the ecohydrological feedback – to simulate land-atmosphere exchanges, including CO_2 fluxes at a bog in eastern Canada. After being extracted for eight years, the site was restored by the MLTT (moss layer transfer technique). The model outputs were validated against three years of eddy covariance (EC) measurements of NEE, surface energy fluxes and associated environmental parameters (time since restoration: 14-16 years). The authors also assessed model sensitivity to climate variabilities and moss thickness and compared the emissions factors (EFs) resulted from this study with IPCC Tier-1 EFs. Results showed that the restored peatland has a similar mean CO_2 uptake rate to pristine sites, though with higher interannual variability. In an attempt of considering future climate change scenarios, they evaluate the potential CO_2 uptake function using the 28-year simulation as a longterm reference run and the possibility of a temporarily shift of the site back to a CO_2 source, during dry conditions. The model predicts a moderate reduction in CO_2 uptake with future climate change but maintains a CO_2 sink function if ecological and hydrological conditions are stable. They show that the CoupModel accurately represents CO_2 fluxes, hydrology, and heat exchanges in restored peatlands, based on the findings in this study. They also argue that earlier studies - based on modeling results and IPPC default EFs - might significantly underestimate the climate colling effects for Canadian bogs being restored by MLTT. The authors confirm that restored peatlands exhibit less resilience to climate variability compared to pristine peatlands. The model estimated an emission factor of -1.01 ± 0.64 t C ha^{-1} yr^{-1} for Canadian bogs restored via the MLTT, almost five times the IPCC Tier-1 default emission factor. To summarize, the authors demonstrate that CoupModel simulates the coupled Carbon-hydrological processes in a fine temporal resolution and is now capable of simulating all stages from pristine peatlands to drained for extraction and restoration.

Overall, the manuscript represents an important contribution to scientific progress within the scope of this journal, so the methods - while it has been previously used for different peatland categories - have a broad application and presents new concepts and ideas. The quality of the scientific approach, here in the study, is excellent and the applied methods are valid. The results are discussed in an appropriate and balanced way and related work, including appropriate references, are considered. The results and conclusions are presented in a clear, concise, and well-structured way. The visualization and the quality of figures and tables are good except for a couple of issues raised below.

Please see the comments below. I would like to receive the revised manuscript prior to acceptance.

General comments: While the manuscript provides valuable insights into peatland carbon dynamics by using site-specific EC measurements to validate the model, drawing broad conclusions across all restored peatland types based on data from a single site may not be an ideal scenario. Peatlands exhibit considerable spatial and temporal heterogeneity, with carbon fluxes influenced by factors like hydrology, vegetation composition, peat depth, climate, previous land use and land management history. Validating the model with data from additional sites representing a range of peatland categories and environmental conditions would enhance confidence in the model's applicability to different peatland types. The authors might consider discussing the limitations of single-site data and suggesting avenues for further validation across a broader dataset to be representative of different categories and to strengthen the robustness of their conclusions for various peatland ecosystems.

Title: To enhance clarity and avoid confusion between soil-atmosphere exchanges and ecosystem-atmosphere exchanges, I would suggest to revise the title. The title must cover the broader scale of exchanges that include the entire ecosystem or land surface and not only soil components. The key processes discussed in this manuscript include NEE, GPP, ER based on various meteorological data and vegetation types or i.e., the thickness of the of the newly grown mosses and not necessarily on soil processes. Therefore, to avoid confusion on presenting the dominant role of i.e., heterotrophic respiration mainly through microbial activities, a broader ecosystem level exchange encompassing the entire land surface (soil, vegetation, water bodies) is recommended for the title. Furthermore, "CO2 fluxes" is already a component of land-atmosphere exchange, I am not sure what the purpose of bringing "... **AND** CO2 fluxes" for a restored peatland is?

Another general comment is referring to “C fluxes” term throughout the manuscript. The authors need to clarify whether the C source-sink transition here means only C from CO2 or CH4 fluxes are also considered. If CO2 is only the focus of the study, then all the C sink strength or uptake function has to be reviewed and changed to C-CO2 or CO2 (for instance: line 30 & 32). Or in line 55-58: it is stated first about the CO2 status of the systems and then switch to C sinks and uptake rate. This has to be determined and specified throughout the manuscript.

L59: to a great extent and not fully.

L135-138: please indicate the peat depth as it can be an indicator of disruption component of the hydrological and temperature balance needed for moss survival and peat formation in such study sites.

L149-50: While it has been referred to the original reference, it is important to provide more details in this section regarding the adapted model parameters, forcing components, etc. and refer to the supplementary table S1.

L165-178: Please consider a review of the vegetation composition listed here and the three PFT groups and confirm whether the vegetation coverage percentage associated with the predominant wind direction matches with Nugent et al. 2018 survey or not.

L185: I would suggest "aerodynamic conductance for both heat and momentum transfer".

L276-278: This statement needs to be elaborated better and mentioned earlier in the text as one of the MLTT issues to be considered.

L280: Maybe better with "Impact of interannual climate variability on CO_2 uptake in restored peatlands"?

L287: Shown in any figures or tables?

L295: Unfortunately, this figure is not informative as the years are not separated.

L295-299: Does this mean the CO_2 sink strength was mainly correlated with precipitation and Tair shows a non-significant correlation with CO_2 uptake? Any other correlation analysis done?

L315: Maybe better with "Impact of future climate change on CO_2 uptake in restored peatlands"?

L324-327: This should be elaborated in the discussion and compared better with an earlier correlation analysis where the Tair shows a non-significant correlation with CO_2 uptake.

L327: Decrease of what? Please be clear on CO_2 uptake decrease or something else?

L336-338: This is a strong statement which is not supported by previous studies. This study in only based on a model validated against 3 years of in-situ measurements. The statement cannot apply to all restored peatlands (even though restored and rewetted must be interpreted differently) with different vegetation composition, previous land use, water table dynamics or altered hydrology. Therefore, I would recommend to rephrase this sentence and make it specific for this type of peatlands i.e., bogs and not applicable to all peatland types. Since no site-specific response is considered here, different peatland types (e.g., bogs vs. fens) and stages of restoration might respond differently to these changes. The statement implies a uniform response, which may not be accurate. Also, you are discussing "extreme" scenarios earlier in this paragraph; do you mean future climate change? Climate extreme events could potentially lead into the vegetation die-off if the extremes, such as drought, are persistent (long-enough) and severe. The statement also implies that restored peatlands will remain unaffected by climate change, which is unlikely. A better term might be "may retain some capacity for CO_2 uptake," reflecting that while uptake might continue, it could be reduced or fluctuate significantly.

L367-368: This might vary across sites and not necessarily reach a stage of fully recovered vegetation after 14-16 years, depending on site-specific characteristics. The analyses here and earlier are based on the system behavior 14-15 years after restoration. Could you provide some data for the earlier years after restoration (year 1 to year 14) to compare the CO2 trajectories immediately after restoration and one decade later? I was curious whether there were any other measurements than EC data from that specific area (within the footprint of the tower); i.e., I guess chamber measurements were conducted there? Any comparisons done?

L377-387: While this is relevant information, it is difficult to make the link and visualize them. Please elaborate further on this or add data to support this discussion. Also, another general comment: perhaps including a high-resolution map/image of the site, with footprint isolines, could greatly enhance readers' understanding by linking land cover types with the associated fluxes. This visual context would allow readers to better interpret the spatial relationship between the site's land surface characteristics and flux measurements.

L396: t C-CO2 ha^{-1} yr^{-1} should be mentioned.

L404-405: While MLTT seems to be beneficial for the recovery of peatland C uptake, we would need to always consider that mosses need consistently high water levels to thrive after MLTT restoration. Therefore, an altered natural hydrological condition of such systems requires to maintain a stable WTD and that can be challenging, especially in areas where drainage has lowered groundwater levels and led to a less resilient system. Also, if water level drops even temporarily, especially during dry periods or in warmer climates, this can lead to poor establishment and even die-off of mosses, reducing restoration success. So, impact of future climate extremes has to be mentioned here. Furthermore, the influence of nutrient and altered pH levels - that can encourage invasive species outcompeting mosses - were not considered. I noticed that you've touched this issue earlier indicating "Since these are oligotrophic ecosystems, the influence of nutrients on C was not considered in this study".

L407-408: Is this the main driver?

L455: Is there any indication of the trends in NPP mosses throughout the manuscript text?

L465: The figures here are not informative as the years and interannual variability are not well-visualized.

L477-480: This concerns the code only and not data availability.

L491 & 493: NTR, the same as NR, I assume?

Supplementary:

L29: A figure showing the climatic water balance (CWB) – the difference between precipitation and evapotranspiration (ET) or potential ET (ET0) – and water table depth would be useful for readers' interpretation.