Response to reviewer 2

Reviewers' comments are marked in black, and the authors' responses are in blue.

This study used eddy covariance to assess the carbon balance of an unmanaged drained peatland in Iceland. The partitioned carbon fluxes (gross primary productivity and ecosystem respiration) were analyzed alongside environmental drivers to understand processes of carbon uptake and release in this system. The two-year sampling period allowed them to capture processes under both dry and warm conditions, and wet and cool conditions.

This research will have important impacts for both scientific inquiry and national reporting. This study adds to the literature on the influence of water level on NEE, and how changes in GPP can be compensated by changes in ecosystem respiration. It also highlighted the need for yearly emission monitoring, especially in regions with mild temperatures during the non-growing season. This study will also support updating emission factors for unmanaged drained peatlands in Iceland to better align with current research.

This paper was well prepared and clearly written. I propose minor revisions. Below I listed out potential areas for improvement.

We sincerely thank the reviewer for their positive assessment of our manuscript, as well as for their constructive suggestions. We appreciate the opportunity to address the specific points raised, which have helped us further refine the clarity and quality of our work. Please find our detailed, point-by-point responses to all comments below.

Line 118: How far away was the weather station from the study site?

The Hafnarfjall station is ~10km away and the Neðra-Skarð is ~5 km away and the data showed strong correlation with the measured data by the Eddy Covarinace system in our site. This information has been added to each station's information (Table 1).

Line 145: Was soil moisture assessed at 10 cm below the surface, or is this an average soil moisture across the top 10 cm? Additionally, were any calibrations performed on it for organic soil?

The soil moisture was measured at 10 cm depth, representing a localized measurement around the probe rods rather than an average across the top 10 cm. No site-specific calibration for organic soil was performed; and the factory calibration for organic soil was used. The text has been updated to include this information (Line 146)

Line 295: Can you add in a comment here about whether the dominant vegetation characteristics changed after raising the tower and increasing the footprint area?

The dominant vegetation characteristics did not change after increasing the footprint and the area is very homogeneous. This information has been added to the text (Line 303).

Line 302: Can you clarify this. You first say that there was no discernible spatial trend in depth variation, and then you say that deeper peat was found in certain sections, and shallower peat in other sections.

Thank you for highlighting this important point. The statement regarding "no discernible spatial trend" was intended to justify the choice of the interpolation method (IDW), which emphasizes local variation between measurement points rather than assuming a broad, systematic gradient across the site. The subsequent reference to deeper and shallower peat explains patterns observed in the interpolated surface.

We agree that this distinction was not clear in the original text and have revised the manuscript to make it more clear (Line 309).

Figure 4: Many of the black points are hidden behind the blue points. Is it possible to make the blue points slightly transparent, or some other modification to improve readability?

The figure has been updated to enhance the visibility of the black points. (Figure 4).

Table 3: Can you include how many days were in the growing and non-growing season for each year in the table caption? This will help readers better interpret the data presented.

The numbers of days have been included in the caption of the table (Table 3).

Figure 7: I suggested mentioning that your weekly aggregated fluxes were computed using non-gap filled data in the figure caption.

The caption of the figure has been updated to include this additional information (Figure 7).

Line 454: Do you mean exposure to aerobic microbial decomposition?

Yes, thank you for your suggestion, we have added this detail to the text (Line 450).

Figure 7: I think it is the same Reco vs WL plot in this figure, and in Appendix B2. But the R2 and p-values are slightly different in the main text versus appendix.

Thank you for your helpful comment. The plots in Appendix B2 were mistakenly generated using gap-filled data rather than observed data while the plot in the main text is correct. These have now been replaced with plots based on observed data, and the text has also been revised accordingly (Appendix B2).

Section 4.1: Can you include some discussion of how your GPP values compare to other unmanaged drained peatlands? Your work is contributing to EFs for unmanaged peatlands in Iceland. Is the vegetation at this site representative of conditions commonly found?

The discussion has been revised to include a comparison of GPP and R_{eco} between our site and other unmanaged drained peatlands in Iceland. Our results showed that the annual GPP (−7.85 to −8.8 t CO_2-C ha^{-1}) and R_{eco} (12.2 to 12.7 t CO_2-C ha^{-1}) observed here were somewhat higher than most chamber-based estimates from other Icelandic sites (GPP: −4.3 to −7.4 t CO_2-C ha^{-1} and R_{eco}: 7.19 to 12.3 t CO_2-C ha^{-1}) likely reflecting the broader spatial footprint and continuous temporal coverage of the EC method.

Additionally, we have clarified the representativeness of our study site within the regional context of unmanaged drained peatlands. These ecosystems are characterized by a shift toward graminoid-dominated communities and are classified as “Grassland on organic soil” in the Icelandic National Inventory Report (Lines 467 and 483).

Line 525: Have other studies also seen this compensation mechanism?

Some other studies have seen high covariance between R_{eco} and GPP which has led to small interannual difference in NEE such as Wohlfahrt et al. (2008). This reference has been added to the text (Line 533).

Line 537: Can you clarify if this statement is based on interpretation of the negative linear relationship between Reco and WL, or if you tested if fluxes were significantly higher in 2023 compared to 2024. “In fact, Reco showed a significantly enhanced response to lower WL.”

Thank you for requesting this clarification. Our statement was primarily based on the relationship observed between R_{eco} and WL. However, interannual comparisons also confirm that overall fluxes were significantly higher in 2023 compared to 2024. Specifically, the median R_{eco} in 2023 (4.087 µmol m^{-2} s^{-1}) was significantly greater than in 2024 (2.751µmol m^{-2} s^{-1}; Mann-Whitney U test, $p < 0.0001$). This information has been added to the text (Line 446).

Line 538: Can you justify this line a bit more. "The authors concluded that the mean annual effective water-table depth represents the overwhelmingly dominant control on CO2 fluxes in these ecosystems." By CO2 fluxes do you mean NEE, or GPP or Reco? Earlier you show the WL did not have a significant effect on Reco is 2024, but did in 2023. You also say that NEE is similar between years.

Thank you for pointing this out. That sentence was intended to reflect the findings of Evans et al. (2021), but we agree the phrasing was unclear. In our study, this effect appeared to be threshold-dependent, occurring only in 2023 when the WL dropped below a critical point. We observed a significant relationship between WL and R_{eco} during 2023, as higher temperatures and reduced precipitation led to deeper WL and greater exposure of the peat profile to aerobic conditions. While WL was not the primary driver of the overall higher R_{eco}, it had secondary influence. Furthermore, NEE remained generally similar between the two years, likely due to a compensatory mechanism where the conditions simultaneously enhanced GPP. The text has been revised to make the explanation clear (Line 545).