Dear reviewer,

We appreciate the supportive and constructive comments you provided for our manuscript. We will revise the manuscript based on your review, and are confident that our efforts, with the insight from your end, have improved the manuscript.

Below, you will find the original comments, followed by our response in red font and description of planned revisions to the manuscript, made in effort to address each comment. We include in the response the updated sections of the manuscript corresponding to each comment in italic.

Kind Regards,

Theresia Yazbeck, on behalf of all authors

The study by Theresia Yazbeck et al. investigates an innovative method for quantifying CO2 fluxes from heterogeneous land cover types, by combining Uncrewed Aerial Vehicle (UAV) measurements with large-eddy simulation (LES) modeling and eddy covariance tower data. It was conducted at Stordalen Mire in subarctic Sweden, a permafrost peatland with diverse patches of vegetation, including elevated palsa areas, wet bogs, fens, and open water. This method helps bridge the gap between small-scale chamber measurements and relatively large-scale tower data, providing a more accurate way to estimate carbon balance across heterogeneous land cover types. I found the paper interesting, useful, and worthy of publication in the journal Atmospheric Measurement Techniques after some minor revision, not so much in terms of redoing the analysis, but rather providing a perspective on important questions. In principle, it is a good contribution to address the carbon balance in the heterogeneous ecosystems. My specific comments are listed below.

Thank you for this positive review.

Page 4, line 112-113: please remove the sentence 'The tower location is shown on the map in Figure 1'. It is a repetition of tower position already mentioned in line 112.

This sentence will be removed.

Page 4, line 115-118: 'Chamber measurements of CO2 fluxes ....the daytime, mostly between 8:00 and 14:00 local time'. Based on results obtained during these timeslots, what could be the potential contribution of nighttime fluxes from individual landcover types?

Our method results in fluxes associated with different patches forming the mixed landscape. The flux values are related to the time of measurement and the meteorological conditions governing this timeframe, which makes it challenging to expand the flux values to nighttime conditions. However, the method is still valid for other time of the day noting though that running LES under stable conditions could be challenging due to weak turbulence and strong stratification. Thus, we are hoping to keep developing this method by applying it to different time of the day. We will emphasize this point in our discussion as follows:

"By applying this method during different periods over the course of the growing season, i.e., through flying the drone several times over the growing season, we could get a larger set of the patch-level fluxes that could be integrated over the whole growing season and result in season-long patch-level flux. In this study relying on just a couple of flights, we are able to estimate fluxes corresponding to the UAV flight time and/or any other time within similar meteorological and phenological conditions. Extending the results to represent patch-level carbon budgets for a full growing season is thus challenging; however, with further implementation of UAV flights within the EC tower footprint, patch-level carbon budgets could be possible. In this case getting UAV measurements over different time of day is important to get patch-level flux contributions across different daytime conditions, notably nighttime conditions, although running LES under stable conditions could be challenging."

Page 9, Line 213: What is the background concentration?

The background concentration is the ambient concentration during the time of measurement. Background concentration in LES domain is different than the background concentration in reality when drone was taking measurements. However, that would not affect the method, as this latter relies on the concentration variability. The concentration variability measured by the UAV should be comparable to the concentration variability modelled by EULAG at the same height as they are both driven by fluxes regardless of the difference in background concentration between EULAG and UAV. Therefore, we removed the mean concentration (or background concentration) from both concentrations values before applying our inversion. We will expand on this further in the text as follows:

"From the EULAG output, we get the time-averaged φ_i over 30 minutes of steady-state simulation time at the same height as the UAV concentrations are provided. UAV concentrations are then converted from ppm to kg/kg to be consistent with EULAG concentrations. EULAG domain has a different background concentration than ambient concentration during the UAV flight, however, that would not affect our method as this latter relies on the concentration variability driven by fluxes regardless of the difference in background concentration between EULAG and UAV. Therefore, we subtract the mean concentration from observed and modeled concentrations, respectively, in order to remove the effect of background concentration, which is different in both modeled and observed datasets."

Line 324: Check R2 value and correct it in the whole manuscript.

We will adjust the R^2 value in the abstract as follows (l. 17):

"Model evaluation showed an R^2 up to 0.70"

In addition, we will paraphrase the section explaining the R^2 corresponding to the 20 consecutive runs simulated to get the model's uncertainty which are different than the R^2 represented in Table 3 in order to avoid confusion (l. 299-300):

"Each of the 20 simulations shown in Figure 7(a) has an associated R^2 value, corresponding to the R^2 of the linear regression between modeled and observed concentrations."

Line 354: in the sentence 'Taking this range as a reference, our estimations appear to be slightly over-estimating lake emissions… bogs (Holmes et al., 2022)'. While authors largely discussed model uncertainty, the other sources, including chamber measurements and eddy covariance data (collected during neutral conditions where simulations were performed), were not discussed. This remains important to be discussed because the approach contributes to a better understanding of carbon dynamics in complex landscapes, which is crucial for accurate greenhouse gas accounting and climate modeling.

Thank you for pointing this out. We will add the following section to the discussion addressing EC and chamber measurements-related uncertainties:

"Other sources of uncertainty arise from the errors associated with the EC measurement of NEE and the footprint model, although these errors would not affect the inversion-derived fluxes, but the computation of the quantitative flux values. This comprises, for example, the errors associated with the EC instrument noise, calibration drift, and data processing methods, as well as from the footprint model, which introduces uncertainty through assumptions about

atmospheric stability, turbulence, and the spatial representation of flux contributions from heterogeneous surfaces. Uncertainty is also associated with chamber measurements used to compare the derived fluxes with, which can be affected by issues such as leakage, pressure effects, and alterations of the natural microclimate inside the chamber during sampling time."