<u>Answer to Referee2: comment on EGUsphere-2024-2346</u>

*Forests are highly relevant to global greenhouse gas (GHG) budgets. The Congo equatorial forest is one of the forests with little knowledge of GHG fluxes. Daelman et al. presents a study on fluxes in the Congo Basin using dynamic chamber techniques. The flux numbers are robust, with results close to those obtained in other tropical forests.*

We thank the reviewer for this positive feedback.

*However, some points require further clarification or discussion:*

1. *What are the intervals between samples for both types of chambers, the average number of measurements for the daytime and nighttime periods?*

   Thank you for pointing out that this information was not clear in the manuscript. For the automated chambers, one out of nine chambers was closed every 17 minutes, resulting in one data point every 17 minutes, with almost the same number of day and night measurements due to the continued operation of the chambers. In lines 115-116, we have rephrased this information:

   > LINES 115-116: " The chambers were installed in May 2022 and were operated with a closure time of fifteen minutes per flux measurement, followed by two minutes of purging with ambient air, resulting in one datapoint every 17 minutes"

   For the fast box measurements we added that only daytime measurements were available and that there was an average of 5 minutes between consecutive measurements, which was the time that it took to walk from one chamber to the next one.

   > LINE 133: " During a period of three weeks from August 4 to August 28, 2023, flux measurements of $CO_2$, $CH_4$ and $N_2O$ were made during daytime (between 08:00 – 18:00) in these plots using two portable analysers …."
   >
   > LINE 136: ". Two plots were measured per day with an average of 5 minutes between consecutive chamber measurements."

2. *It is not clear in the text that the soil parameters shown in Table S2 were obtained only for the CongoFlux climate site and not for the other points of the experiment (CF1, CF2, Mi2 and Mi5). How representative are these measurements for the remaining points?*

   The article did not mentioned where the soil property data was measured. We have added to the caption of Table 2 that these measurements were made in the CF1 plot.
   We do not have information on nutrient availability or soil N for all chambers separately. The CF1, CF2 and Mi5 plots are all dominated by Haplic Ferralsols and have a clay content of around 30% to 40% , while the area of Mi2, which is the plot furthest away from the others, situated slightly lower, is dominated by both Haplic and Xanthic Ferralsols and has a slightly smaller clay content, between 20% and 30%. Mi2 is therefore slightly different from the other plots, but all soils are Ferralsols, kaolinitic, acidic with a pH in water less than 4.5, poor in organic carbon and in exchangeable cations. Therefore, only one set of soil parameters is included in the article. To give the reader more information about the

homogeneity of the soils, we have included the following soil map in the Supplementary Material (Figure S10) and added a reference to a soil map, i.e.: “Gilson, P., Van Wambeke, A. and Gutzweiler, R.: Carte des Sols et de la Végétation du Congo Belge et du Ruanda-Urundi, 6: Yangambi, planchette 2: Yangambi. Notice explicative. INEAC, Bruxelles, 1956”.

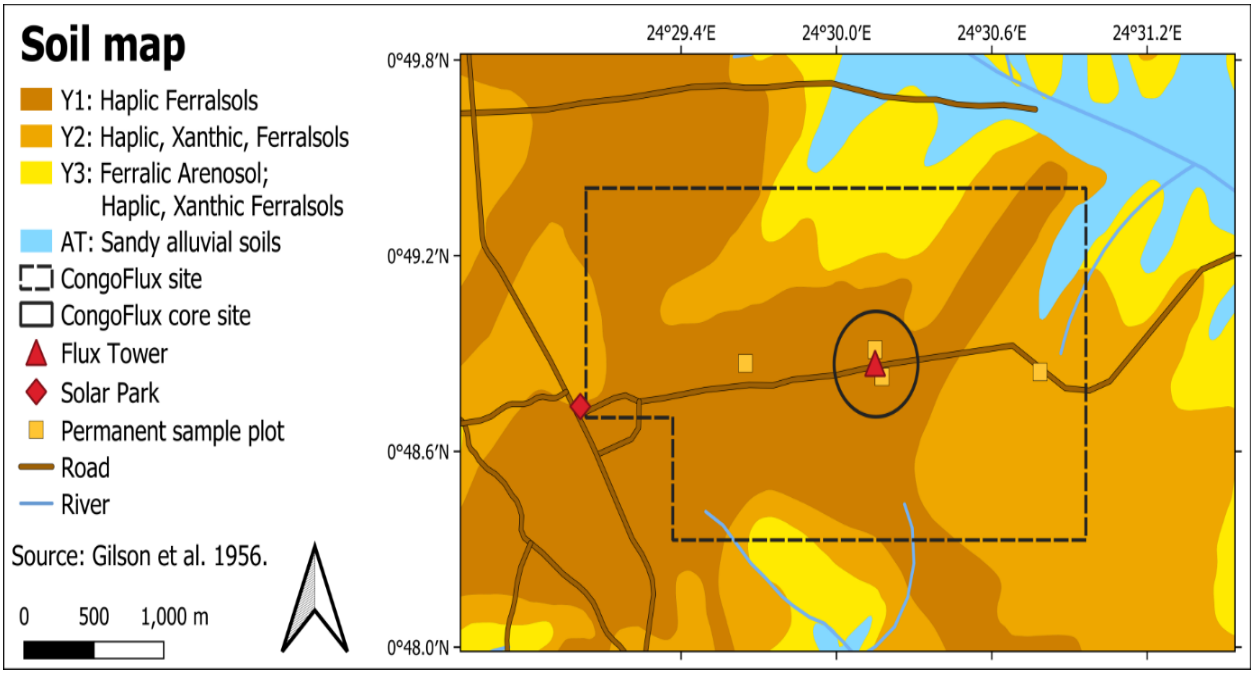


*Figure S10: Soil map of Yangambi with the CongoFlux climate site (0°48’52.0” N 24°30’08.9” E) in the black dotted line tower and the squares indication the locations of the 4 sampling plots (CF1, CF2, Mi2 and Mi5). Source for the map is: Gibson et al., 1956*

3. *Regarding fast boxes, is there any reference to their use in an experiment like the one presented or were they designed by the authors?*

The previous use of this method was not yet mentioned in the article. Thank you for pointing this out. The fast measurements with the portable analyzer is briefly described in Hensen et al., (2013) and used in Bureau et al., (2017) and Wangari et al., (2022). We have added two references in the article.

> LINE 128: The four GEM plots on the CongoFlux site were divided into twenty-five subplots of 20 m by 20 m and in each subplot, one soil chamber was installed in March 2023 to be measured using the fast box method (Hensen et al., 2013; Wangari et al., 2022).

4. *Was there any place where the automatic chambers and fast box were placed close together in the same sampling location to evaluate the performances?*

Thank you for bringing this to our attention. The automated chambers were located to the west, just outside the CF1 plot, so the fast box chambers of the CF1 plot were closest to the automated chambers. However, even the closest fast box chambers were already between 10 and 60 meters away from the automated set up. It is expected that $CH_4$ and $N_2O$ can already vary a lot between sites within only several meters. Selecting the fast box chambers located at the CF1 plot, closest to the automated chambers, we can make the following comparison for $CO_2$, $CH_4$ and $N_2O$. The fast box measurements from the CF1 plot for $CO_2$ are quite comparable with those of the automated chambers over the same time period. The spread for the fast box method is a bit larger, which is to be expected since we have more locations and smaller chambers. In both the automated and the fast box measurements, positive fluxes for $CH_4$ are present, but the measurements are dominated by negative fluxes. Especially in the second half of august the fast box fluxes tend to be more negative than the fluxes measured with the automated chambers. For $N_2O$ no real comparison can be made due to the malfunction of the $N_2O$ analyzer of the automated soil chamber set-up. Therefore the measurements of July and September from the automated chambers are compared to the measurements of August of the fast box chambers. Our results show that the fast box measurements are generally higher than the automated measurements. The mismatch of dates could lead to a discrepancy in the averages, especially because we see a slight increase in flux for some automated chambers in early August and then a decrease again at the end of August, which could indicate a period of higher fluxes that is missed here. Line 376 notes that this discrepancy could also be due to altered soil conditions at the automated chamber locations due to the long term deployment on the same location.
We will add figures to the supplementary material which illustrate the above points with a small explanatory text to give the reader insight into the performance of the two methods.

> "To evaluate the two methods used in this study, i.e. fast box and automated chamber method, a comparison can be made between the measurements of the automated chambers and the measurements of the fast box chambers closest located to the automated chambers (plot CF1), during the overlapping time period. The fast box measurements from the CF1 plot for $CO_2$ are quite comparable with those of the automated chambers over the same time period. The spread for the fast box method is larger, which is to be expected since there are more locations of the fast box chambers and the chambers are smaller in size. In both the automated and the fast box measurements, positive fluxes for $CH_4$ are present, but the measurements are dominated by negative fluxes. Especially in the second half of august the fast box fluxes tend to be more negative than the fluxes measured with the automated chambers. For $N_2O$ no real comparison can be made due to the malfunction of the $N_2O$ analyzer of the automated soil chamber set-up. Therefore the measurements of July and September from the automated chambers are compared to the measurements of August of the fast box chambers. Our results

show that the fast box measurements are generally higher than the automated measurements. The mismatch of dates could lead to a discrepancy in the averages, especially because we see a slight increase in flux for some automated chambers in early August and then a decrease again at the end of August, which could indicate a period of higher fluxes that is missed here. This discrepancy could also be due to altered soil conditions  at the automated chamber locations due to the long term deployment on the same location."

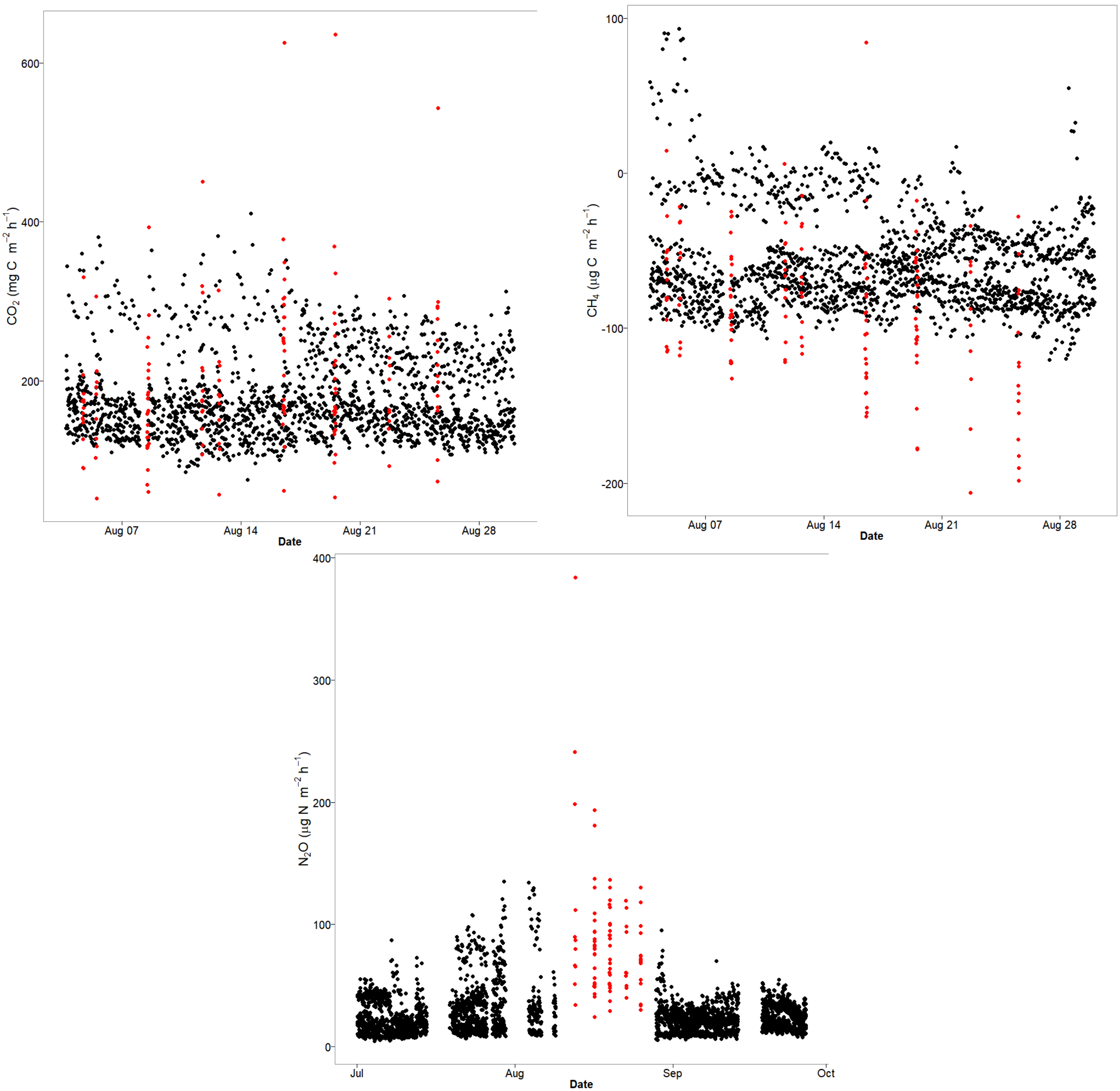


*Figure 1: Flux measurements for $CO_2$, $CH_4$ and $N_2O$, with in red the measurements from the fast box chambers in plot CF1 and in black the measurements from all automated chambers.*

5. *Considering the occurrence of precipitation almost every day (Fig. S3), what is the strategy for measurements with these events?*

Rainfall was indeed a frequent event. During rain events, the automated chambers continued to measure as normal, without interruption. Originally, a longer chamber closure time was planned (45 minutes), with several chambers closing at the same time. A tipping bucket was installed in order to open all chambers during heavy rain events to ensure that the soil in the closed chambers did not miss out on an entire rain event and receive as much precipitation as the surrounding soil. However, we quickly shortened the closure time to 15 minutes, which reduced the chance of missing out on the whole rain event and only one chamber was closed at a time, which meant that only one chamber missed out on a part of the rain events. Therefore, we can assume that continuing the measurements during the rain events would not bias the data.

Manual measurements were continued during drizzle and light rain events, but were interrupted during two heavy rain events. Measurements were resumed as soon as possible after the rain event.

6. *In tab. 1, inform that the data refers to fast boxes.*

Thank you for reading the captions thoroughly. We have added in each caption if the metrics/measurements are from either the automated or the fast box chambers.

7. *Check if the $CH_4$ fluxes reported in lines 201 and 316 are correct, with the aforementioned tables.*

Thank you for checking the values in detail. The values on line 201 are correct. The range -133.1 to 1209.0 µg C $m^{-2}$ $h^{-1}$ can be found in Table S6, with chamber 4, collar 2 having the maximum value and chamber 5 collar one having the minimum value. The arithmetic mean in Line 201( -44.6 ± 59.1 µg C $m^{-2}$ $h^{-1}$ ) is the mean of all measurements over all chambers and all collars. This mean value is not the same as the mean mentioned in the last row of Table S6 (-45.2 ± 21.8 µg C $m^{-2}$ $h^{-1}$). This last value is the mean and standard deviation of all collar means.
The mean value of the fast box measurements in line 315 (-89.4 µg C $m^{-2}$ $h^{-1}$ ) is correct and can be found in Table 1. The range -230.8 to 256.99 µg C $m^{-2}$ $h^{-1}$ is the range of all measurements and not the average of the measurements per chambers, which are shown in Table 1.

The mean and range values of the automated chambers in line 316 (-66.8 µg C $m^{-2}$ $h^{-1}$ with a range of -162.8 to 272.2 µg C $m^{-2}$ $h^{-1}$) are calculated using the same time period as the fast box measurements are carried out and are therefore not the same as mentioned in line 201.

We added now small indications in the article to make these differences more clear. We added the reference to the table for the ranges and added the words ‘calculated with all measurements’ in the text to make clear that this is a different value from the means in Table S6, .

In the caption of Table S6, it is written that the "all chambers" row is calculated with the mean values per chamber, and not with all measurements combined.

> LINE 194-195: $CO_2$ emissions from all chambers during the measurement period ranged from 37.2 to 463.1 mg C $m^{-2}$ $h^{-1}$ (Table S6) with an arithmetic mean, calculated with all measurements, of 174.5 ± 50.1 mg C $m^{-2}$ $h^{-1}$ and a median of 64.1 mg C $m^{-2}$ $h^{-1}$ (Fig. S6 a).

> LINE 2021-202: The $CH_4$ flux during the measurement period ranged from -133.1 to 1209.0 µg C $m^{-2}$ $h^{-1}$ (Table S6) with an arithmetic mean, calculated with all measurements, of -44.6 ± 59.1 µg C $m^{-2}$ $h^{-1}$ and a median of -54. µg C $m^{-2}$ $h^{-1}$ (Fig. S6 b).

> LINE 210-211: The $N_2O$ emissions during the measurement period ranged from 2.8 to 841.5 µg N $m^{-2}$ $h^{-1}$ (Table S6) with an arithmetic mean, calculated with all measurements, of 40.9 ± 46.4 µg N $m^{-2}$ $h^{-1}$ and a median of 25.4 µg N $m^{-2}$ $h^{-1}$ (Fig. S6 c).

> LINE 315-316: The average uptake measured with the fast box method was -89.4 µg C $m^{-2}$ $h^{-1}$ with a range of all measurements separately of -230.8 to 256.99 µg C $m^{-2}$ $h^{-1}$, while during the same period, the automated chambers measured an average …

8. *Still in relation to the fast boxes, when evaluating the performance of the chambers, it should be taken into account that with their small area, an increase in the variability of the fluxes was expected due to edge effects, while a larger area of the automatic chamber would reduce this influence on the fluxes.*

Thank you for bringing this up. The larger number of smaller chambers would indeed lead to an increase in variability compared to a smaller amount of larger chambers. In this study we had to take the practicality and the feasibility of the method into account. We chose for the small and easy to handle chambers because the vegetation in the plots was dense, the trails were not easy to walk and the distances between plots were sometimes long. Larger chambers, to match the size of the automated chambers would have been very difficult to manage with the small field team we had.

However the effect of installing the edges into the soil, can be ignored in this study. The manual chambers were installed in March 2023. The chamber measurements used in this study were taken in August 2023 and so the effects of installation can be discarded. This information was not previously included in the article, we have now added this information in Line 128-129:

> LINE 128: "The four GEM plots on the CongoFlux site were divided into twenty-five 20 m by 20 m subplots and in each subplot, one soil chamber was installed in March 2023 to be measured using the fast box method."

**References**

Bureau, J., Grossel, A., Loubet, B., Laville, P., Massad, R., Haas, E., Butterbach-Bahl, K., Guimbaud, C., and Hénault, C.: Evaluation of new flux attribution methods for mapping N2O emissions at the landscape scale, Agriculture, Ecosystems & Environment, 247, 9–22, https://doi.org/10.1016/j.agee.2017.06.012, 2017.

Hensen, A., Skiba, U., and Famulari, D.: Low cost and state of the art methods to measure nitrous oxide emissions, Environ. Res. Lett., 8, 025022, https://doi.org/10.1088/1748-9326/8/2/025022, 2013.

Wangari, E. G., Mwanake, R. M., Kraus, D., Werner, C., Gettel, G. M., Kiese, R., Breuer, L., Butterbach-Bahl, K., and Houska, T.: Number of Chamber Measurement Locations for Accurate Quantification of Landscape-Scale Greenhouse Gas Fluxes: Importance of Land Use, Seasonality, and Greenhouse Gas Type, Journal of Geophysical Research: Biogeosciences, 127, e2022JG006901, https://doi.org/10.1029/2022JG006901, 2022.