Response to Associate Editor

We've received two reviews of the manuscript. One suggests major revisions and the other recommends rejection. Upon reviewing the manuscript myself, I find the objectives to be interesting and the analysis to be expansive for validating and intercomparing several model types. Nevertheless, the reviewers raised some constructive points about the novelty and presentation of results that I agreed with nearly all. Therefore, we request substantial revisions addressing all comments. I've added a few overarching points to address giving context to the referee points.

We sincerely appreciate the opportunity to improve our paper. Thanks to the insightful comments from the reviewers and yourself, we have significantly strengthened the study by incorporating all available ENF and DBF sites in Europe with at least five years of data, integrating additional data-driven and process-based models, and refining our objectives. The paper now focuses on the space-time variability of CO_2 fluxes across European forests and investigates how climate influences both their annual cycle and interannual variability.

1) The site selection needs more motivation than lines 154-156. The introduction motivates the number of FLUXNET and ICOS sites around line 80, but then only uses a few specific sites.

We no longer provide the total number of sites available in the FLUXNET database, as this global-scale information was misleading. Instead, we now report the number of flux towers located in Europe, which is 98 across all ecosystem types (see l122-124). This number decreases significantly when focusing on the ENF and DBF land cover classes, with only 24 sites. Among these, we selected 19 ENF sites, all of which have at least five years of data.

The site selection and characteristics are now fully justified in section 2.1. It now reads (l163-173): "Out of the 24 ENF and DBF sites from the ICOS network, we selected the 19 sites (Fig. 1), 13 classified as ENF and 6 as DBF, for which observed CO_2 fluxes are available for at least 5 years (Table 1). These sites allow to sample the different climatic zones of Europe. Three ENF sites (FR-Bil, FR-FBn and IT-SR2) are located in the northern region of southern Europe, close to 45°N, and ranging from sea level to 400 m in elevation. They are characterized by mild, wet winters and hot dry summers, with annual mean temperature and precipitation of 12.9–13.90 °C and 700–960 mm, respectively. Four ENF sites (FI-Hyy, FI-Let, SE-Nor and SE-Svb) are located in northern Europe (60-65°N) at an elevation below 270 m. They are characterized by subarctic climate with annual mean temperature and precipitation of 1.8–6.5 °C and 586–711 mm, respectively. The remaining twelve sites (6 DBFs and 6 ENFs) are situated in central Europe within the 45–60°N, 2.5–20°E domain, encompassing a wide range of elevations (40–1730 m) and spanning temperate to continental climates. As a result, they exhibit substantial variability in annual mean temperature (4.3–11.4 °C) and precipitation (563–1338 mm)".

2) Both referees found the presentation of results to be fair or poor and I agree there are likely better methods to plot the data. For example, it would be nice to call out more clearly the FLUXNET data in the results figures. The color is similar to the others and not easy to quickly

find. Please prioritize means to improve the readability of the figures such as increasing font size, or reducing panels if possible.

The results are now presented much more clearly in the revised manuscript. We first describe the mean annual cycle and interannual variability of observed CO_2 fluxes (Section 3.1), followed by an evaluation of the models' ability to capture these observed patterns (Section 3.2). Finally, we examine the impact of climate on both the annual cycle and month-by-month interannual variability of CO_2 fluxes (Section 3.3).

The figures have also been improved. While the inclusion of additional sites and datasets means that some figures are not necessarily simpler than before and require a full-page width for readability (Figs. 5 and 9), they provide a more comprehensive synthesis of the space-time variation in CO_2 fluxes and the influence of climate on these dynamics.

3) I agree with referee 1 that the introduction could go a bit further to be more specific about the knowledge gaps being addressed.

The introduction has been completely rewritten to better reflect current understanding of how climate influences the temporal variability of CO_2 fluxes. We have also expanded our discussion of the knowledge gaps addressed by our study. It now reads (l142-148): "Most recent studies examining the influence of climate on the temporal dynamics of European forest CO_2 fluxes rely on case studies and primarily focus on spring and summer conditions (Smith et al., 2020; Thompson et al., 2020; van der Woude et al., 2023). However, a more comprehensive assessment is needed across the entire annual cycle, as CO_2 release during fall and winter is expected to increase under climate change. Additionally, climate conditions vary significantly between northern and southern Europe, necessitating a broader spatial perspective. These objectives are addressed at the monthly timescale, which is considered sufficiently fine to capture both the CO_2 flux annual cycle and its interannual variability".

4) There are some limitation points that do need mention here. First, the spatial scale difference between the flux tower and model resolution as mentioned by a referee. Second, we need to acknowledge the data driven approaches may be trained partly on these flux towers and there may then be concern about out-of-sample testing (or performance on a new site it wasn't trained on).

The first limitation (spatial mismatch) is now fully discussed. It now reads (l625-631): "As a first step, we assess the model abilities to reproduce the observed mean annual cycle and interannual variability of CO_2 fluxes. This evaluation presents two key challenges. First, the temporal coverage of observations in the FLUXNET database is often limited, making it difficult to extract robust signals, particularly for interannual variability. Second, there is a spatial scale mismatch between site-level observations, representing fluxes from the tower footprint to several square kilometers (Göckede et al., 2008), and most models used in this study, which simulate fluxes at regional to large scales, except for the hectometric-scale CarbonSpace model. Given these constraints, our evaluation should be considered qualitative rather than strictly quantitative".

The objective of the revised manuscript is no longer solely to evaluate the models but rather to use them as complementary tools for gaining deeper insights into the impact of climate on the temporal dynamics of CO_2 fluxes, particularly in terms of interannual variability. The superior performance of data-driven models compared to process-based models is no longer a concern, as our focus is not on determining which model performs better. Instead, data-driven models provide a unique opportunity to investigate climate impacts on CO_2 flux dynamics, as they incorporate most, if not all, ICOS sites.

We have added a few sentences to acknowledge that data-driven models are expected to outperform process-based models. It now reads:

- l249-255: "The four data-driven models include most, if not all, ICOS sites mobilised in this study. They accurately capture the mean annual and seasonal cycles of CO_2 fluxes (Tramontana et al., 2016; Jung et al., 2020; He et al., 2022; Zhuravlev et al., 2022) and are expected to outperform process-based models since the latter do not assimilate observed CO_2 fluxes. The methodological framework (e.g., machine learning model, forcing data and horizontal resolution) remains different between the data-driven models. An inter-model convergence will be interpreted as a forced response imposed by the observations. A divergence will be interpreted as uncertainties induced by the methodological framework";
- l640-647: "The interannual variability in the models is weaker than in the observations, consistent with previous studies (e.g., Nelson et al., 2024). Yet, the co-variability between observed and simulated CO_2 fluxes remains correct despite the aforementioned constraints. This agreement was expected for data-driven models, as they incorporate FLUXNET observations in their development. However, it was less anticipated for process-based models, which do not assimilate direct CO_2 flux measurements. Their ability to capture observed interannual variability likely stems from the fact that TRENDY models are driven by observed CO_2 concentrations, land-use changes, and climate data, while the SMAP-L4C model benefits from the assimilation of satellite-derived soil moisture observations".

5) I think the use of monthly data to look at the "annual cycle" is acceptable. However, since the reviewer questioned this point, it might be good to reiterate in the results/discussion that the monthly results are focused on the annual cycle.

We have clarified throughout the revised manuscript (and the figure captions) that the study aims to assess the impact of climate on the annual cycle and interannual variability of monthly CO_2 fluxes in European DBFs and ENFs:

- l147-148: "These objectives are addressed at the monthly timescale, which is considered sufficiently fine to capture both the CO_2 flux annual cycle and its interannual variability";
- l316-317: "Since these datasets have varying temporal resolutions (Tables 1 and 2), all were aggregated to a monthly timescale";
- l378-379: "Figure 4a displays the mean annual cycle of monthly NEE, GPP and RECO as provided by FLUXNET observations";
- l485: "Figure 7 shows the correlations between the modelled and observed interannual variability in monthly NEE";

- l621-623: “This study aims at assessing the impact of climate on annual cycle and interannual variability of monthly CO_2 fluxes in European DBFs and ENFs through conjointly analysing observations from the FLUXNET network and state-of-the-art data-driven and process-based models”.
- l695-697: “This study makes use of state-of-the-art data-driven and process-based models to complement observations for assessing the impact of climate on the annual cycle and interannual variability of monthly CO_2 fluxes in European DBFs and ENFs”.

Response to Reviewer #1

The study evaluated CO_2 flux outputs from models at six sites and their relationship with climate in temperate forests of Western Europe. Overall, this manuscript addresses an important topic and presents some interesting findings. However, I am not entirely convinced that the results significantly advance our understanding of CO_2 fluxes at forest sites across different temporal resolutions (such as monthly and annual, as analyzed in this study).

We would like to thanks Reviewer 1 for their constructive feedback, which will greatly contributed to the improvement of the manuscript. In response to both reviewers' comments, we have enhanced the study by focusing on 19 ICOS sites (instead of the 4 initial ICOS sites), incorporating more models (specifically the TRENDY, FLUXCOM-ERA5 and FLUXCOM-MODIS ensembles together with the newly released FLUXCOM-X), and focusing exclusively on the monthly timescale. This adjustment enables a more detailed exploration of the influence of climate on the temporal variability of CO_2 fluxes.

In the initial version of the manuscript, this influence was analyzed by considering all months together, which yielded results that closely resembled those at the annual timescale (e.g., see old Figs. 6 and 8). In the revised version, we examine the influence of climate on CO_2 fluxes for each month individually and show that this influence varies throughout the annual cycle and across Europe.

Based on Reviewer 1's comments, we have revised the study's objective to focus on assessing how climate influences the annual cycle and interannual variability of CO_2 fluxes, while examining how this relationship varies throughout the year and across Europe. To achieve this, we jointly analyse observations, whose temporal coverage remains limited, alongside state-of-the-art data-driven and process-based models, after ensuring that these models adequately capture the observed patterns. Additionally, we have updated the title to better reflect the revised objective. The paper is now entitled "Climate impact on mean annual cycle and interannual variability of CO2 fluxes in European DBF and ENF forests: insights from observations and state-of-the-art data-driven and process-based models".

General comments

1. The temporal variability in this study is not adequately addressed and may need reorganization. For example, there are ten figures illustrating monthly timescale results. However, these findings are neither included nor highlighted in the abstract or conclusion. Although there are similar patterns between the monthly and annual results, as shown in Figures 6 and 8, the monthly findings should be incorporated. Alternatively, I suggest removing or reducing the figures or text about the monthly results and focusing on annual and interannual scales.

The revised manuscript focuses exclusively on the monthly timescale. First, we evaluate the models' ability to reproduce the mean annual cycle and interannual variability of observed CO_2 fluxes, considering the overlapping periods between each model–observation pair. Next, we analyse the impact of climate on both the annual cycle and interannual variability of CO_2 fluxes. For interannual variability, we extend the analysis beyond the first version of the manuscript by assessing climate influences for each month of the year. Additionally, we have revised the abstract to ensure all key findings are well highlighted and have improved the balance between sections.

2. While I am not an expert in statistics, the R and R^2 results in this study (such as those in Figures 6 and 7) seem very close. Is it necessary to present Figure 7 in the main text? Regarding the long-term evolution, which method was used? Why do the authors state that it 'does not depict any trend'? Please provide this information in the Methods section.

R and R^2 provide complementary insights. R indicates the sign and strength of the relationship, while R^2 represents the proportion of variance in a given variable (e.g., NEE) that can be explained by another variable (e.g., 2 m temperature).

Although Figure 7 offers valuable information on temperature-induced threshold effects, it would have occupying too much space with the inclusion of new sites and models. Therefore, we removed Figure 7 in the revised manuscript.

Trends are no more examined based on Reviewer 1’s comments.

3. The introduction of this study is not well-articulated. The discussion of the knowledge gap lacks a solid basis. Why is a finer spatial scale important? Why did the authors focus on monthly and annual timescales? The second objective, which involves the climate relationship, lacks motivation regarding the choice of variables in this study. Why were radiation or PPFD not considered?

The introduction has been entirely rewritten to address the knowledge gap concerning the influence of climate on the interannual variability of CO_2 fluxes in European forests, as well as the need to use models to complement the observational data.

In particular, the introduction now lists the main impacting climate variables. Note that preliminary analyses show that the impact of incident shortwave radiation on CO_2 flux annual cycle and interannual variability is similar to that of 2 m temperature. We thus consider only 2 m temperature in this study, which affects both GPP and RECO and NEE. This is now stated in section 2.2.4.

Finally, note that we did not use PPFD, as this variable is unavailable in the ERA5-Land product, which replaces the France-centered SAFRAN-SIM2 reanalysis in the revised manuscript.

4. It is not appropriate to assess flux trends using the FLUXCOM dataset, as FLUXCOM does not account for CO_2fertilization effects. Please refer to the following paper: *Jung, M., Schwalm, C., Migliavacca, M., Walther, S., Camps-Valls, G., Koirala, S., ... & Reichstein, M. (2020). Scaling carbon fluxes from eddy covariance sites to globe: synthesis and evaluation of the FLUXCOM approach. Biogeosciences, 17(5), 1343-1365.*

Thank you for this remark. We believe that CO_2 fertilization effects are just one of many factors influencing long-term trends in the CO_2 flux budget (e.g., fire, timber extraction). However, we no longer analyse long-term trends in this study.

Line-by-line comments:

Please note that most of the line-by-line comments are no longer applicable, as the revised manuscript has been almost entirely rewritten.

Line 42: "..the best models…" sounds inaccurate. Perhaps "better models" would be more appropriate, as the comparison is only made with process-based models.

No more applies.

LL 45-48: could you please explain why?

This points is now addressed in the discussion section. It now reads (l665-671): "Regarding interannual variability, the climate impact on CO2 fluxes can be summarized in three points. First, climate impacts more strongly GPP and RECO than NEE, regardless of the site and dataset. Since NEE is the difference between GPP and RECO, its interannual variability arises from various combinations of these two components. For instance, reduced CO2 sequestration can results from a greater increase in RECO compared to GPP, a larger decrease in GPP than in RECO, a decrease in GPP with no change in RECO, or an increase in RECO without any change in GPP. Such as complexity implies that the influence of climate on NEE is less direct and likely more intricate than its effects on GPP and RECO".

LL 45-47: The sentence contains a lot of information and lacks clarity. I suggest revising it for better readability.

The abstract has been completely rewritten and is hopefully clearer in the revised manuscript.

Line 49: How long is the 'long-term'?

The term "long-term" is contingent on the length of data availability, which does not exceed 20 years. This is why we have placed the term in quotation marks. However, this remark does no longer apply in the revised manuscript, as analyses conducted at the annual timescale have been removed.

LL 50-53: The statement is too general and does not seem related to the main point of the study.

Thank you for this remark. This statement has been removed in the revised manuscript.

Line 61: 'At the global scale, forest ecosystems cover about 30% of landmasses' suggest adding a reference.

This sentence has been simplified. It now reads (l85-87): "Forest ecosystems are the largest part of the land CO2 sink (Lindeskog et al., 2021), with up to 20-50% of anthropogenic CO2 emissions (land-use changes excluded) sequestered for the 2000-2010 period (Le Quéré et al., 2018; Pugh et al., 2019; Pan et al., 2024)".

LL 71-72: What is the meaning of this number here?

According to Chuine et al. (2023) timber-extraction and climate-related mortality have increased by 20% and 54% between 2005-2013 and 2012-2020, respectively. This sentence has been removed since we no longer focus on CO_2 flux trends.

Line 101: Suggest deleting 'when available'

Done as suggested.

LL 101-113: Suggest moving these sentences to another paragraph or placing them above the objectives.

Thank you for the suggestion. These sentences have been placed above the objectives.

LL127-128: Redundace, and which varaible? all fluxes?

This sentence has been removed. We now clearly identify which variable impacts on each CO_2 flux. It now reads (l95-105): "Numerous studies have demonstrated the strong influence of climate on CO_2 exchanges between the atmosphere and forest ecosystems. The annual cycle, and to a lesser extent, interannual variability of these fluxes, are driven by factors such as incident shortwave radiation, temperature, atmospheric evaporative demand, and the water cycle, including soil moisture dynamics (Haszpra et al., 2005; Tang et al., 2014; von Buttlar et al., 2018; Kong et al., 2022; Sharma et al., 2022; Li et al., 2023; Xu et al., 2023). The dominant climate factor influencing CO_2 fluxes depends on the specific component considered. The variability in net ecosystem exchanges (NEE) is a mixed response of its two components: gross primary production (GPP), which sequesters CO_2 into the ecosystem through photosynthesis, and ecosystem respiration (RECO), which releases CO_2 into the atmosphere from forest metabolism (autotroph respiration) and the decomposition of organic matter by fungi and bacteria (heterotrophic respiration). GPP is primarily driven by vapour pressure deficit (VPD), shortwave radiation, temperature, and soil moisture, while RECO is mainly influenced by precipitation, soil moisture, and temperature (Messori et al., 2019)".

Line 132: "Extreme" can refer to both high and low conditions. To specify, consider using "extreme high" or "extreme hot" for clarity.

Thank you for your remark. We no longer refer to extreme events, as the revised manuscript no longer includes results from the composite analysis.

LL 132-133: Suggest revising the sentence.

The sentence has been removed.

LL147-149: Suggest deleting these sentences.

Done.

Figure 1: If the reader is not familiar with Europe, it may not be clear. Consider adding specific locations, such as "France".

Figure 1 now displays the locations of all 19 ICOS sites included in this study, along with their IGBP classification and temporal coverage.

Table 1: The table format needs adjustment. Please refer to the journal's guidelines, which typically suggest using horizontal lines only above and below the table, and as a separator between the table header and the main body.

All Tables (1, 2 and A1) have been adjusted to follow the journal’s guidelines.

Figure 9-11: Perhaps move to supplement.

We no longer show results from composite analyses. Figures 9 to 11 have been removed.

LL555-556: Suggest deleting the sentence.

Figure 12 has been removed since we no longer show annual budgets.

Line 603: “qualitatively similar” might sound speculative?

This has been removed. However, we still use the term “qualitative” in the context of model evaluation, as the limited temporal coverage of observational data prevents a robust quantitative assessment of model skill.

Line 724: Replace ‘best’ to ‘better’.

No more applies.

Line 772: Should be ‘Fig. 7’ not ‘Fig, 5’

No more applies.

Line 776: ‘Fig. 7’

No more applies.

Response to Reviewer #2

This study evaluates the performance of various carbon flux products against eddy covariance measurements at three forest sites in France. The authors investigate the monthly, seasonal, and inter-annual variability of NEE, GPP, and RECO to assess different global products and explore their relationships with meteorological variables. While the manuscript is generally written clearly, the analysis lacks sufficient depth and significance for the scientific community. This isn't to say that evaluating existing products isn't valuable, but the limited number of eddy covariance sites and the selection of only four global products raise concerns about the comprehensiveness of the study.

We would like to thanks Reviewer 2 for their constructive feedback, which will greatly contributed to the improvement of the manuscript. In response to both reviewers' comments, we have enhanced the study by focusing on 19 ICOS sites (instead of the 4 initial ICOS sites), incorporating more models (specifically the TRENDY, FLUXCOM-ERA5 and FLUXCOM-MODIS ensembles together with the newly released FLUXCOM-X), and focusing exclusively on the monthly timescale. This adjustment enables a more detailed exploration of the influence of climate on the temporal variability of CO_2 fluxes.

In the initial version of the manuscript, this influence was analyzed by considering all months together, which yielded results that closely resembled those at the annual timescale (e.g., see old Figs. 6 and 8). In the revised version, we examine the influence of climate on CO_2 fluxes for each month individually and show that this influence varies throughout the annual cycle and across Europe.

Based on Reviewer 1's comments, we have revised the study's objective to focus on assessing how climate influences the annual cycle and interannual variability of CO_2 fluxes, while examining how this relationship varies throughout the year and across Europe. To achieve this, we jointly analyse observations, whose temporal coverage remains limited, alongside state-of-the-art data-driven and process-based models, after ensuring that these models adequately capture the observed patterns. Additionally, we have updated the title to better reflect the revised objective. The paper is now entitled "Climate impact on mean annual cycle and interannual variability of CO2 fluxes in European DBF and ENF forests: insights from observations and state-of-the-art data-driven and process-based models".

1.Choice of Models (LPJ-GUESS and FLUXCOM v1): Why were LPJ-GUESS and FLUXCOM v1 selected when many other land surface models or upscaled products are available for evaluation? Including more models and products could improve relevance, especially since ensemble models are commonly used in land carbon sink studies.

Thank you for your remark. The revised manuscript now incorporates 15 DVGMs from the TRENDY project (S3 simulations, which include time-varying CO_2, climate, and land use) instead of relying solely on LPJ-GUESS. This broader selection provides a more comprehensive representation of the uncertainties associated with process-based models.

Additionally, we have included:

- the FLUXCOM-MODIS ensemble, which consists of data-driven models using different machine learning methods and relying only on satellite-derived vegetation data, unlike FLUXCOM-ERA5, which includes both climate and vegetation variables as predictors ;

- the FLUXCOM-X model, a newly released and high spatial resolution (0.05°) product that improves coverage, training quality, and satellite data processing and incorporates additional sites compared to previous FLUXCOM versions.

Please note that the goal of this study is not to include all existing CO_2 flux models. Instead, by jointly analysing observations alongside a large ensemble of DVGMs, a reanalysis process-based model (SMAP), various FLUXCOM models, and a site-scale data-driven model (CarbonSpace), we provide a comprehensive assessment of how climate influences the annual cycle and interannual variability of European forest CO_2 fluxes, while also addressing the associated uncertainties.

2.Spatial Resolution Mismatch: The 50 km spatial resolution of LPJ-GUESS and FLUXCOM products may not align with the footprint of the eddy covariance sites, and this mismatch is not addressed in the manuscript.

Comparing coarse-resolution models with local measurements can indeed result in significant discrepancies that may not necessarily reflect model errors. While we do not anticipate a one-to-one match, we expect that the main observed patterns to be captured by both data-driven and process-based models. It is also important to note that all the data-driven models used in this study are trained using FLUXNET2015 local measurements, making comparisons between CarbonSpace/FLUXCOM estimates and local measurements meaningful. We now discuss the spatial resolution mismatch in section 4. It now reads (l625-631): "As a first step, we assess the model abilities to reproduce the observed mean annual cycle and interannual variability of CO_2 fluxes. This evaluation presents two key challenges. First, the temporal coverage of observations in the FLUXNET database is often limited, making it difficult to extract robust signals, particularly for interannual variability. Second, there is a spatial scale mismatch between site-level observations, representing fluxes from the tower footprint to several square kilometers (Göckede et al., 2008), and most models used in this study, which simulate fluxes at regional to large scales, except for the hectometric-scale CarbonSpace model. Given these constraints, our evaluation should be considered qualitative rather than strictly quantitative".

3.Insufficient Number of Sites: Only three forest sites are used in the analysis, despite the availability of hundreds of FLUXNET sites globally. Using only these sites may not provide a robust basis for summarizing product performance.

Thank you for this remark. We have significantly increased the number of sites considered in this study by expanding the study domain to Europe. Across Europe, the FLUXNET database includes 24 ENF and DBF sites, from which we selected all sites with at least five years of CO_2 flux data. The final selection includes 19 sites, shown in Fig. 1 and detailed in Table 1 of the revised manuscript. This expanded dataset enables us to assess the extent to which CO_2 flux temporal dynamics and the influence of climate change across Europe.

4.Correlation Analysis: The correlation analysis in Figure 6 lacks a logical basis, as some variables (e.g., VPD and RECO) do not have clear biogeochemical or biophysical relationships. Also, the analysis does not account for multicollinearity among variables, which affects the validity of the results.

We recognize that the physical influence of VPD on GPP and NEE is more evident than on RECO. However, it is important to note that respiration is closely correlated with GPP. As a result, VPD indirectly influences RECO through its impact on GPP. The fact that the impact of VPD on the interannual variability of RECO is just as significant as on GPP supports this idea (see Figs. A6c and A7c).

Note that we restrained the number of climate variables in the revised manuscript for conciseness purpose. We now examine the climate impact using 3 variables: 2 m temperature, soil moisture and VPD. These variables exert a significant, physically grounded influence on NEE, GPP and RECO, justifying their inclusion in the analysis.

While multicollinearity poses a strong issue when analysing the combined influence of climate variables on CO_2 fluxes (e.g., in multiple linear regression), this study computes correlations variable by variable, which is methodologically sound and unaffected by multicollinearity.

5.Focus on Temperature: The authors only consider temperature when analyzing carbon fluxes in Figure 6 and do not include other important variables, such as soil moisture, which were emphasized in the introduction. Given this, the use of polynomial regressions without considering other factors raises questions about interactive effects of multivariate factors of the carbon fluxes.

The polynomial regressions presented in Figure 7 of the initial manuscript were useful for discussing temperature-induced threshold effects, which are known to influence both GPP and RECO. However, with the addition of new models and sites, retaining Figure 7 would have taken up too much space. Therefore, it has been removed in the revised manuscript.

Specific Points:

Please note that most of Reviewer 2's specific comments are no longer applicable, as the revised manuscript has been extensively rewritten.

Inconsistent Visualization (Figures 5 and 13): Figures 5 and 13 present similar data for annual and monthly scales, but the visualizations need to be consistent to enable direct comparison.

Figure 13 has been removed in the revised manuscript to maintain a strict focus on the monthly timescale and to further explore the climate–CO_2 flux relationship throughout the annual cycle. Additionally, Figure 5 has been significantly revised to incorporate the 19 sites and the additional data included in the updated manuscript.

Climate Anomalies Definition: The authors should clarify how climate anomalies are defined, as the methods section only explains CO_2 flux anomalies. Also, the choice of the -0.5/+0.5 thresholds for carbon flux anomalies seems arbitrary and needs further justification.

This remark is no longer applicable, as the revised manuscript no longer includes results from composite analyses.

Response to Community reader #1

Section 1 Introduction:
Many of your references seem to be missing from this preprint or are cited incorrectly, e.g. Smith et al., 2020; Thompson et al., 2020; Yuan et al., 2009

Thank you for your remark. Many references were missing from the reference list due to a bug. We have carefully reviewed and updated the list to include all missing references.

Section 2.1 Site description:
It would be useful to know when each forest was established (e.g. 10s,100s or 1000s of year ago.)

We completely agree that this information is valuable. However, we were unable to find it in the FLUXNET database or website. That said, this omission does not significantly impact our study, as (1) we do not analyze the effect of forest age, and (2) neither the data-driven nor process-based models explicitly account for forest age.