We thank the reviewers for their helpful comments. We used the opportunity to check the manuscript again for grammar, punctuation and spelling, and revised the document accordingly. We also altered the acknowledgements.

See below for our answers on the reviewers' comments. We altered the manuscript following the reviewers' suggestions and refer to changes by referring to lines in the revised manuscript where possible and useful.

Reply to reviewer #1

Reviewer comments are in bold.

The authors have made substantial improvements to the manuscript, and I appreciate the effort invested in the revision. The revised structure has significantly enhanced the clarity and accessibility of the article. I also welcome the addition of explicit hypotheses, which strengthens the scientific framing of the study.

We thank the referee for their observations and recommendations.

That said, I am not fully convinced that the current formulation of the hypotheses accurately reflects the scope of the study. As written, they appear to test whether root exudation increases, whereas my understanding is that the primary aim is to evaluate the implementation of root exudation into the model and assess whether this improves the representation of carbon fluxes and pools. I encourage the authors to revisit the hypotheses to ensure they are fully aligned with the study design and objectives.

We believe that this may be a misunderstanding. While we compare our results to other models and QUINCY-JSM without root exudation in the discussion, our primary focus was to use the model to investigate possible underlying mechanism in SOM cycling under increased root exudation in EucFACE. We believe that our results answer the questions raised in the introduction. We hope that renaming "research objectives" in "research questions" clarifies the scope of the study.

Minor Comments

• Terminology: Some terms still remain unclear or inconsistently used. For example, does "biomass production (BP)" correspond to net primary production (NPP)? Please clarify and use terminology consistently throughout the manuscript.

We agree that this term was not properly defined in the manuscript. We use biomass production (BP, to refer to growth and to differentiate from C allocation to root exudation and respiration:

$$GPP = Ra + BP + CEX$$

To clarify this, we now write (L 50):

"Observation and modeling studies suggest that CO_2 fertilization leads to higher leaf-level photosynthesis and biomass production (BP), defined as the use of photosynthates for plant growth, potentially increasing C sequestration in vegetation biomass […]"

We also altered Figure 1 to clarify the terminology used to describe C allocation to Ra, BP and root exudation.

In the previous version we wrote NPP when referring to measurements from Jiang et al. (2020) following the terminology used therein. However, with the consideration of root exudation flux, and to avoid confusion, we decided to refer to these measurements as BP, as they did not include root exudation.

• L61: The phrase "helped in maintaining BP response" is unclear. Do the authors mean that increased exudation under eCO_2 contributes to balancing the carbon budget? If so, please state this more explicitly. More generally, it would be helpful to clearly indicate the direction of responses in the entire text.

We agree that maintain is not the right word here. We now write (L61) :

"Free Air Carbon Enrichment (FACE) experiments in nitrogen (N) limited forests suggest increased root exudation and cycling of soil organic matter helped to sustain a positive BP response to eCO_2."

Instead of

"[…] helped in sustaining positive BP response […] "

We also clarified direction of responses where they are known and refer to a single flux/pool. For example L(64):

"[…] while in ORNL FACE progressive N limitation decreased the positive response of BP […]"

instead of

"[…] while in ORNL FACE progressive N limitation decreased the response of BP […]"

or L(92)

"[…] preventing a strong increase in BP in response to eCO_2 […]"

Instead of

"[…] preventing a strong response in BP in response to eCO_2 […]"

Or L(598)

"[…] the model explains weak increases in topsoil C to eCO_2 by […] "

Instead of

"[…] the model explains weak responses in topsoil C to eCO_2 by […] "

• L135 (Figure caption): It appears that the term "carbon" may be missing. The figure presents the conceptual framework well; however, including key fluxes such as GPP, BP (NPP), and autotrophic respiration could further improve clarity. It may also be useful to indicate the roles of nutrients and eCO_2 as drivers within the system.

Agreed. We revised figure 1, based on both referee comments. The figure now includes plant C allocation, and explicitly shows nutrient cycling. We decided to make processes, that are not directly related to the described mechanisms for microbial necromass cycling (processes (1)-(3)) slightly transparent.

• L141: Consider revising "objectives" to "research questions" or "testable hypotheses" for greater precision.

Revised, we now write (L143):

"We further aim to answer the following research questions:"

• Figure 5: The y-axes differ in scale across panels. If possible, using a consistent scale would improve comparability.

We revised the figure but disagree as a consistent scale would result in panels in which fluxes are too small to identify. To clarify the figure and improve comparability, we increased the distance between panel 1 and 2, and added a dotted line at 150 gC m-2 yr-1 in all panels.

Reply to reviewer #2

Reviewer comments are in bold.

Schufft and others model root exudation under elevated CO2 at EucFACE. The study is certainly rigorous and QUINCY-JSM is a good model for exploring the unique dynamics of this site, and the authors were forthcoming about its limitations. The presentation in some cases was lacking, and improvements would go a long way toward creating a more compelling study.

We thank the anonymous referee for taking the time to read our manuscript and for their feedback. We revised our figures. We added some processes in Figure 1, improved readability, and changed colour palette of all figures

The abstract could perhaps have had more numerical values to help explain impact quickly.

Agreed. We added a few more numerical values in the abstract:

L(31)

"[…], the model predicted that eCO_2 increases belowground C allocation by 20% and microbial growth by 14%, […]"

L(35)

"Although increased C input through root exudation stimulated microbial growth, microbes partially met their higher nutrient demand through a 9% higher decomposition and increased mineralization of organic matter"

Model references in the paragraph beginning line 70 were lacking. What models found this and what did they do instead?

Agreed. We moved the reference from the following sentence to this sentence and write L(70):

"Model-data synthesis of observations from FACE experiments and terrestrial biosphere models (TBMs) highlighted the role of plant-soil interactions but also revealed model limitations (De Kauwe et al., 2014; Zaehle et al., 2014). These studies identified C allocation, N uptake and soil N cycling as key processes for CO_2 responses under N limitation."

The paragraph on line 100 is justified well; QUINCY-JSM is ideal to investigate here

We thank the referee for this observation.

On 119, will it be respired as 'waste' respiration or just not respired in the first place? (Or respired by microbes that don't contribute to tree growth processes…is this what is meant by 'waste'?)

We use this term based on the hypothesis of Schimel and Weintraub (2003). We refer to this paper in the text but to further clarify, we added quotation marks around waste L(118):

"If microbes are not able to fulfill their stoichiometric nutrient requirement for growth, excess C will be respired as "waste" respiration, leading to a decline in microbial growth CUE (Schimel and Weintraub, 2003)."

Figure 1 is somewhat uninspiring, doesn't make efficient use of space, [2] should have bidirectional arrows, P isn't even noted for [3]. Also, are these mechanisms mutually exclusive? I can't imagine they would be. Improving Fig. 1 would go a long way to helping explain the complex

mechanisms at hand.
We revised figure 1, see also reply to referee 1

Figure 2 is a bit better but biorender.com doesn't seem to be a very good way to make compelling figures.
We revised figure 2 in colour scheme and alignment. However, we think that the figure fully serves its intended purpose as overview of model processes and demonstrates what is needed.

242: not also root or soil moisture?

QUINCY-JSM calculates maintenance respiration based on soil temperature and tissue N content. The model does not directly account for dependence of root respiration on soil moisture.

Equations: use the multiplication sign rather than the star, it gets confusing with C^*_{lab} and more. Note that dots are used in Fig. 3.

Agreed. We replace * with multiplication signs (dots)

256: superscripting (there are a few usage errors throughout the manuscript)

Revised.

266: what is the justification for the 0.0125Bmin value?

As written in section 2.6 L(298):

"As no direct measurements of root exudation exist for this site, we calibrated s and β_{min} to reproduce GPP, biomass and soil respiration for ambient conditions from 2013–2016 (Jiang et al., 2020) (Table B1). This limits the size of the root exudation flux."

However, we choose the value 0.0125 as it translates in a minimal exudation rate equal to 5% of fine root respiration. We therefore added in line 268:

"We constrained β to values larger than 0.0125 (β_{min}), to ensure a minimal root exudation flux equal to 5% of fine root respiration, even at nutrient-saturated conditions. "

Figure 5 and elsewhere: does 'CO2 effect' mean elevated CO2? All ecosystems have a CO2 effect
We revised this figure and now write 'eCO2 effect' in figure and text.

I'd expect Figure 6 to be easier to read; black lines are used for both for no reason, font size is small.

We revised this figure.

Similar for Figure 7; this is an online-only journal so no harm in using some colour within reason to help the reader

We revised this figure.

468: how was it determined that simulated allocation of additional GPP was improved? Vs. what?

We clarified this sentence by writing L(472):

“We found that – in the model – increased root exudation links enhanced GPP and heterotrophic respiration under eCO_2 and improved simulated allocation of additional GPP to ecosystem fluxes, compared to simulations without root exudation (Fig. 4, Fig. B8, Fig. B9).”

We further picked up on this topic in section 4.5: Comparison to other models L(595).

“Implementing root exudation improved the allocation of additional GPP: Compared to other models in Jiang et al. (2024a) and to QUINCY-JSM without root exudation, and consistent with observations, QUINCY-JSM with root exudation allocates a substantial part of additional GPP to heterotrophic respiration instead of autotrophic respiration. Additionally, less C remains in the system in the form of increased vegetation pools (Fig. B8). With consideration of root exudation, the model explains weak increases in topsoil C under eCO_2 by respiration of root exudation and priming, rather than by low litter C input (Fig. B9). “