

Dear Dr. Kuzyakov and two anonymous reviewers,

We thank you and the two anonymous reviewers for reviewing the manuscript entitled “The Use of Newly Assimilated Photosynthates by Soil Autotrophic and Heterotrophic Respiration on a Diurnal Scale” (egusphere-2025-2849) for publication in *Biogeosciences* and for providing helpful comments. Following these suggestions, we have revised the manuscript as outlined below.

Response to Reviewer #1

1. This study focuses on the diurnal coupling mechanism between soil autotrophic respiration (R_a), heterotrophic respiration (R_h), and photosynthetic carbon allocation in subtropical coniferous forests. It fills the gap in traditional soil respiration models that overlook the dynamic regulation of carbohydrates, and particularly reveals the rapid response of R_h to newly assimilated photosynthates (with a 2-4 hour lag), providing a new perspective for understanding the immediate driving mechanisms of soil carbon fluxes. However, there are still some uncertainties, as detailed below.

Response 1: We thank the reviewer for the positive and constructive comments.

2. It is necessary to clarify the criteria for determining the stable period (3-6 months) of R_h after the insertion of deep collars, supplement the correlation analysis between the vertical distribution of fine root biomass and collar depth, and explain whether the rhizosphere priming effect has been effectively excluded. The potential biases of the root exclusion method (such as interference of dead root decomposition on R_h) are only briefly mentioned in the "Limitations" section, without discussing whether the differences in the $R_h:SR$ ratio (59%-86%) in the supplementary materials compared with other studies stem from methodological factors.

Response 2: We have included two references that provide further evidence on the range of $R_h:SR$ in southern pines (McElligott et al., 2016) and more broadly (Bond-Lamberty et al., 2018), as well as a reference to our own earlier study from a similar nearby loblolly pine forest that experienced similar low-intensity fires with a return interval of 2–5 years (Ono et al., 2025) in lines 294-298. The ratio recorded with the study was the $R_h:SR$ ratio of 36–84% recorded using the root exclusion, which is similar to this study (59–86%). This earlier report (Ono et al., 2025) also includes supplementary material (Fig. S2) demonstrating how the stability of $R_h:SR$ ratio was assessed.

3. Description of wavelet analysis parameters: The basis for selecting the period parameters of the Morlet wavelet and the specific threshold for excluding data outside

the "cone of influence (COI)" should be supplemented to ensure the reproducibility of the results.

Response 3: We used the white noise for the significance analysis, and the cone of influence at a 5% significance level was checked with Monte Carlo methods (100 simulations). We have included the information in lines 157-158. Please also refer to Response #14 for Reviewer #1 on the selection of noise type.

4. Calculation of model residuals: The differences in the estimation of Q₁₀ parameters in Formula (1) between daily and weekly scales need to be quantified, and an explanation should be provided for the use of two time windows (day/week) and their impact on residual results.

Response 4: The Q₁₀ and R₂₀ parameter values are not central to our main analysis but were included only as a confirmatory analysis for the main cospectrum among the total respiration fluxes. We have expanded the discussion to clarify why two time windows (daily and weekly) were applied in lines 134-141.

While we would prefer to leave it out of the final publication, we have included a table of the different Q₁₀ estimates below. The Q₁₀ values vary widely between different campaigns and between Rh and Ra. They also have widely varying standard errors. Furthermore, the Q₁₀ of Ra during campaigns 3 and 4 is unreasonably large in both daily and weekly models, given the narrow temperature and wide Ra range. Reporting these necessitates an additional explanation that we have included in lines 225-226.

Although this further reinforces the main conclusion of our analysis, it is a divergence from the main analysis, and we would prefer to leave it out.

Table. Average apparent Q₁₀ (Mean ± standard deviation) estimated with a daily or weekly rolling window for soil heterotrophic (Rh) and autotrophic respiration for analyzing the cospectral dynamics of respective model residuals (r_{Ra_day}, r_{Ra_week}, r_{Rh_day}, and r_{Rh_week}). Campaigns conducted during active growing seasons are marked with an asterisk (*).

Campaign	Daily Q ₁₀ estimate		Weekly Q ₁₀ estimate	
	Rh	Ra	Rh	Ra
1*	1.70 ± 0.34	0.45 ± 0.17	1.88 ± 0.17	0.64 ± 0.14
2	2.67 ± 1.88	6.94 ± 18.4	1.51 ± 0.12	14.0 ± 18.0
3	3.58 ± 2.05	4×10 ⁹ ± 2×10 ¹⁰	1.88 ± 0.23	2×10 ⁸ ± 3×10 ⁹
4*	4.87 ± 3.55	1×10 ¹¹ ± 5×10 ¹¹	2.00 ± 0.14	2×10 ²⁷ ± 5×10 ²⁸
5*	1.16 ± 0.17	1.51 ± 0.30	2.13 ± 0.14	1.55 ± 0.30
6	1.03 ± 0.18	3.94 ± 6.84	1.74 ± 0.21	2.53 ± 1.01

5. Seasonal differences in lag time: The slight advance (+0.64 hours) of Rh relative to GPP in C2 (dormant season) in Figure 8 needs further explanation, whether it is related to microbial metabolic lag under low temperatures or the release of root carbon reserves.

Response 5: While the mean lag time was smallest during this campaign, it also had the

second largest standard deviation. We are unsure if the small difference in the mean lag time can be given much significance, much less attributed to a specific driver.

6. Fluctuation mechanism of Ra: Combined with the positive and negative alternation of Ra lags in Figures S10-S11, it is suggested to supplement the measured data of non-structural carbohydrates (such as starch) in different seasons to verify the "reserve buffer" hypothesis.

Response 6: Unfortunately, we do not have a matching dataset for non-structural carbohydrate concentrations. The non-structural carbon study cited in line 350 (i.e., Baniya et al., 2025) is a separate analysis with only a partly overlapping study period. Resolving the mechanistic controls of Ra is the focus of our ongoing studies.

7. Interaction of temperature and humidity: Did the high VWC values (42-43%) in C3-C4 inhibit the response of respiration to substrates? It is necessary to analyze the synergistic effect of VWC and GPP to avoid the limitation of single-factor interpretation.

Response 7: Water availability is expected to be a key regulator of carbon allocation in plants, as well as a modulator of plant and microbial respiration. However, the current analysis does not address sensitivity in the traditional sense (change in respiration per change in VWC), only the consistency of temporal cospectra.

8. Differences from early studies: A clearer comparison should be made between the results of this study (2-3 meters tree distance) and the "tree distance gradient method", attributing the differences to vegetation types (coniferous vs. deciduous) or methodologies (root exclusion vs. spatial substitution).

Response 8: Thank you for pointing out this connection. We have revised the paragraph and have added some discussion regarding the interpretation of results based on the distance to the tree in lines 371-380. However, it may be premature to make blanket interpretations about all reports of elevated soil CO₂ efflux in proximity to trees having been due to C transfer to heterotrophs. Until we understand this process more completely or test it explicitly, it may be possible that the C transfer to microbes could vary among different ecosystems or in different environmental settings.

9. It is recommended to discuss the stability of this mechanism under extreme climates (such as drought), and infer the impact of water stress on carbon allocation based on the data of C5 (VWC=10.4%).

Response 9: The sensitivity of phloem transport to water availability is unclear. We

noted, in lines 346-347, that the drought in 2024 (C5-C6) did not alter the time lag between Rh and GPP. Even the size of the cospectral peak did not clearly correlate with drought or active vs dormant season. A larger dataset is required for comprehensive resolving of both spectral and mechanistic patterns.

10. The differences in Rh:SR ratios (47%-86%) among various campaigns in Table 1 require ANOVA analysis to clarify seasonal significance.

Response 10: The mean and standard deviation of Rh:SR ratio between the growing season (0.63 ± 0.19 , $n = 3$) and the dormant season (0.79 ± 0.08 , $n = 3$) were not significantly different ($p = 0.26$) based on one-way ANOVA analysis. We have added this result in lines 180-182.

11. Soil temperature and humidity were only measured at a 5cm depth, while 84% of fine roots are distributed in the 0-30cm layer (Figure S1). The association between deep root activity and carbon allocation is ignored, which may underestimate the impact of vertical gradients on Ra/Rh.

Response 11: Yes, the increasing time lag of temperature with soil depth could affect spectral analysis. In the current study, we reasoned that processes in the surface soil with >50% of fine roots in the top 10 cm (Fig. S1) and the greatest heterotrophic activity would dominate the respiration signal and any cospectral pattern. We did measure soil temperature and moisture in multiple depths (the 20 cm depth has now been added to Fig. 2). For reference, we have included a supplementary figure (now as Fig. S2) of the cross-wavelet transformation of both Rh and Ra with Ts and VWC at 20 cm (Ts_{20} , VWC_{20}). The results show a consistent pattern with both depths, but the cospectral peaks are more pronounced with the Ts and VWC at 5 cm.

12. Root exudate concentration or isotope labeling data were not measured, so it is impossible to directly prove that the "2-4 hour lag" is caused by carbon input, and the evidence chain is incomplete only through indirect correlation inference.

Response 12: Yes, we do lack this data. The only evidence for the relationship between photosynthesis and CO_2 efflux from the root-excluded soil columns is the consistent cospectral behavior reported in this paper and parallel studies (Yang et al., 2022). As described in the Introduction (lines 58-61), given the temporal lag of pressure-concentration waves and mass flow in the phloem, the flux-based method is considered more powerful than pulse labeling for the interpretation of short-term coupling between photosynthesis and soil processes (Gunina & Kuzyakov, 2022; Mencuccini & Hölttä, 2010). (Admittedly, the exact pathway and regulation of C transfer from leaves to roots and the soil remains to be elucidated.) We have also added a paragraph in lines 310-313.

13. When using the Q10 model to isolate temperature effects, the differences in parameter estimation between daily-scale (rRh_day) and weekly-scale (rRh_week) were not quantified. If the weekly-scale parameters smooth out short-term fluctuations, it may artificially amplify the correlation between residuals and GPP, leading to an overestimation of the "substrate-driven" conclusion. However, the actual situation is that I am not familiar with this content, and I would ask other reviewers to comment on it.

Response 13: This question overlaps partly with question #3 from Reviewer #1 and was addressed above. We have added the Q_{10} values of both daily and weekly scales, and the results show that Q_{10} for Rh did not differ substantially between the two. We applied both methods to account for diurnal and synoptic temperature responses. While the weekly scale may smooth short-term fluctuations, these effects should be captured by the daily-scale analysis, which yielded comparable Q_{10} values. Therefore, we believe that the use of weekly-scale windows did not artificially inflate the correlation between residuals and GPP.

14. In cross-wavelet transformation (XWT), the determination of the "5% significance level" is based on the white noise assumption, but the relationship between soil respiration and environmental factors may have red noise characteristics, leading to misjudgment of significantly correlated regions.

Response 14: The choice of white noise as a background spectrum was consistent with previous work on the spectral analysis of soil respiration, such as Vargas et al. (2010) and Mitra et al. (2019). Additionally, it has been shown that the color of the noise, including red noise, has little impact on the results of spectral analysis (Grinsted et al., 2004; Vargas et al., 2010). We have expanded the explanation in lines 157-158.

15. The statement that "the coupling strength between Rh and GPP is 1.2-2.6 times that of R_a " lacks statistical significance testing.

Response 15: It was statistically significant by one-way ANOVA ($p = 0.047$). We have added this result in line 210.

16. In the seasonal difference analysis, what are the sample sizes of the growing season and dormant season groups respectively?

Response 16: Growing season campaigns were during C1, C4, and C5 ($n=3$) and dormant season campaigns were during C2, C3, and C6 ($n=3$). Please refer to Table 1.

17. The observed lagged association between Rh and GPP may be driven by third-party factors (such as Ts) (Figure S12 shows that GPP lags behind Ts by 3.5 hours), and confounding effects have not been excluded through methods such as structural equation modeling.

Response 17: Thank you for pointing this out. The labels on this graph were plotted in the wrong order. We have now corrected the figure and the caption (now Fig. S13), and it now shows that Ts lags behind GPP and PAR.

18. If Rh depends on root exudates and Ra originates from immediate carbon allocation, Ra should respond to GPP more rapidly than Rh, but the results show the opposite. This contradiction has not been reasonably explained, which may be due to methodological biases.

Response 18: This is, indeed, unexpected. We hypothesized that the coupling of SR with GPP would be caused by Ra. As to why Ra would not be as tightly coupled, we have offered a hypothesis in lines 323-325. Root cells hold carbohydrate reserves (starch and lipids) that can be hydrolyzed based on local metabolic needs, and the soluble sugars so produced may be consumed before any excess can be exported into phloem and released into soil. Thus, the inconsistent cospectral lag does not necessarily indicate a lack of respiratory demand, but rather a local buffer that can more precisely respond to cellular metabolic state. Clearly, the exact mechanism is yet to be elucidated.

19. The study only infers that root exudates drive Rh through the "2-4 hour lag consistent with the propagation rate of phloem pressure-concentration waves", but fails to explain in depth. For example, how do microorganisms quickly utilize newly input carbon sources (such as whether specific functional flora are involved in activation)? Do the chemical compositions of root exudates (such as the proportion of sugars and amino acids) change with photosynthetic dynamics, and what are their differential impacts on Rh?

Response 19: These are details that our study cannot answer. We hypothesize that the rapid up- and down-regulation may indicate bacterial rather than fungal metabolism. We do not have any data to support this, but Kuzyakov and Gavrichkova (2010) showed that labile compounds can activate soil microbes and that they can metabolize the compounds within hours. Furthermore, Canarini et al. (2019) and Yang et al. (2022) have shown, similarly to our current report, that microbial activity is tightly coupled to photosynthesis. We also do not have data about the chemical composition of root exudates, although we have detected diurnal fluctuation in the soluble sugar concentrations in the soil (a separate study).

20. Why does the significant correlation between rRh_{day} and GPP in the supplementary materials (Figures S2 and S6) still exist in the dormant season (such as C2), which contradicts the common sense that "carbon input is more active in the growing season", and this abnormal phenomenon has not been discussed.

Response 20: The term "dormant" is misleading, and we have explained it better in 107-110. Given the subtropical climate and evergreen canopy, the active and less active periods are defined based on canopy leaf area, soil CO_2 efflux, gross photosynthesis, soil temperature, and moisture. Even though the irradiance and LAI are lower during winter months, photosynthesis continues, nevertheless.

21. The high variability in the lag time between R_a and GPP (-1.8 to +4.8 hours) is only attributed to "starch reserves", but without data support.

Response 21: Yes, this is a hypothesis, which remains to be tested.

22. The differences in carbon reserve strategies between coniferous and broad-leaved trees have not been discussed. For example, coniferous trees retain leaves throughout the year, which may have a more stable R_a regulation mechanism.

Response 22: We have added the discussion on the seasonal and vegetation type differences in lines 346-349.

23. The study mentions that the coupling between R_h and GPP in this research is stronger than that of R_a , which is opposite to the results of temperate forest studies by Savage et al. (2013), but only attributes it to "vegetation type differences" without in-depth analysis.

Response 23: We have added Yang et al. (2022) to interpret these results. Regarding vegetation type, we included a paragraph discussing that differences between evergreen and deciduous species are likely due to year-round photosynthetic capacity, in lines 346-349. Please also see response #8, which compares with early studies.

24. In Table 1, the proportion of R_a in C1 (growing season) reaches 53%, while that in C6 (dormant season) is only 15%. Why is R_h still significantly coherent with GPP in the dormant season (Figure S4)? The "source of surplus carbon in non-growing seasons" has not been explained; moreover, the proportion of "surplus carbon" has not been quantified (such as estimated through the flux balance of GPP and R_a/R_h), and only qualitative descriptions are provided, lacking data support.

Response 24: The consistency of the R_h -GPP cospectra across seasons is the main result of the current study. Its independence of the actual flux magnitude and the $R_h:R_a$ ratio

underlines the plausibility of the mechanisms proposed. As noted in response #22-23, the year-round photosynthetic activity (Fig. 2A) provides the C supply. Closing the C budget quantitatively between the non-structural pool and that exuded into the soil, particularly on a diurnal scale, is currently not possible. The closest support we currently have is that NSC flux was estimated to be positive during campaigns C5 and C6, while new biomass growth had ceased due to drought. We have added the discussion in lines 349-352.

25. The reason why the correlation between VWC and respiration in wavelet analysis is extremely weak (VWC-related subgraphs in Figures S2 and S6) has not been explained, which contradicts the general cognition that "soil moisture affects microbial activity", and it is only mentioned in passing as "weak and unstable".

Response 25: We did not find a strong diel correlation between Rh and VWC, but detected a synoptic (weeks to months) relationship across campaigns, which is consistent with the past study (Mitra et al., 2019). However, we did not emphasize this point in this manuscript because (1) we detected the signals on the synoptic relationship, but this is largely outside the cone of influence (COI), and (2) our focus in this manuscript is on the short-time scale (i.e., the diel relationship).

26. The study indirectly infers photosynthetic carbon input through GPP and PAR, but key indicators such as the concentration, flux, and chemical composition of root exudates, the content of non-structural carbohydrates in leaves and roots, and the allocation path of newly assimilated carbon to Ra and Rh have not been directly measured, resulting in a lack of direct evidence for relevant conclusions.

Response 26: Quantifying all these components and closing the C allocation budget at different time scales is the ideal, but it would entail methodological, labor, and monetary costs well beyond the scope of the current analysis. We do cite a follow-up study (Baniya et al., 2025) that provides independent lines of evidence and supports the interpretation of the cospectral analysis. Still, we do not have tracing and concentration data at the same resolution as the flux data on which the current work is based.

Response to Reviewer #2

1. This manuscript presents an investigation into the diurnal coupling between photosynthesis and soil respiration components (autotrophic - R_a , heterotrophic - R_h) in a pine forest. The use of cospectral analysis to explore time lags is a relevant approach. The authors found a strong diurnal link between R_h and GPP/PAR with a consistent 2-4 hour lag, contrasted with weaker/more variable links for R_a , which is potentially significant for understanding rapid C cycling. However, the manuscript in its current form has substantial weaknesses in clarity, methodology description, figure interpretation, and discussion depth that prevent publication.

Major revisions are required.

Response 1: We thank the reviewer for the constructive comments.

Major comments:

2. The separation standards regarding campaigns (especially C3, C4, and C5, C6) is valid and severe. The manuscript fails to adequately define what these campaigns represent (e.g., different seasons? specific meteorological conditions?), and why they were chosen? The method for partitioning soil CO₂ efflux is fundamental to the entire study's conclusions but is either missing or described insufficiently. Without this, the validity of the R_a and R_h data, and thus the core findings, is questionable.

Response 2: We have expanded the description of measurement protocols and data classification to address these points.

- First, we partitioned soil CO₂ efflux into component fluxes, autotrophic (R_a) and heterotrophic respiration (R_h), using the root exclusion method. A deep PVC collar (35 cm depth) was inserted to sever roots, and the efflux 3-6 months following root severing was considered as R_h . The R_a was estimated by the difference between total soil CO₂ efflux and R_h . This explanation is provided in lines 85-102.
- Second, the available data of high-quality GPP, SR, R_h , PAR, T_s , and VWC data were divided into “campaigns” and “active” and “dormant” seasons based on GPP and SR flux magnitudes and temperature (as explained in lines 103-107 and expanded lines 107-110). Specifically, the transition between C3 and C4 was based on a change in GPP (Fig. 2A) and between C5 and C6 based on SR. These transitions were also marked by temperature dynamics, in the case of C5 and C6 by deepening drought.
- Aware that the data aggregation period may affect the results of the spectral analysis, we also analyzed the data without separating these periods (e.g., combining C3+C4 and C5+C6). The results showed similar cospectral peaks and similar patterns in lag times between respiration components (R_a and R_h) with potential drivers (GPP, PAR, T_s , and

VWC). Only the standard deviations were larger with the longer averaging periods. Therefore, we chose to subdivide the data into 6 instead of 4 campaigns, as the differences in flux magnitudes may also signify changes in underlying physiology. We have added the explanation in lines 141-145.

3. Figures 3-7 are currently incomprehensible to the reader, as noted. The primary issue is the lack of explanation for the "Period" axis. This presumably represents the period of the cyclic components identified by the cospectral analysis (e.g., Wavelet Coherence? Cross-Wavelet Transform? Other?). How were the parameters chosen (e.g., wavelet type, wavelet power) in the cospectral analysis. Without this fundamental explanation in the caption, methodology, or axis label, the figures convey no meaningful information for general readers. The x-axis labels in Figs 6 & 7 are absent. Furthermore, the meaning of "cospectral peak" and "lag" in the context of these figures needs clearer explanation.

Response 3:

- We have clarified the "Period" axis by adding more explanation in the figure caption. Specifically, the "Period" axis represents the time frequency domain corresponding to time intervals from 6 hours to 64 days for this analysis. Also, we have added more detailed explanations in the Methods and figure legends on which transformation type was used: wavelet transformation was applied for a single time series (e.g., Rh, Ra), whereas cross-wavelet transformation was applied for the relationship between two time series (e.g., Rh vs GPP).
 - Regarding the parameters, we have added the information in lines 156-158. Please also refer to response #3 to reviewer #1.
 - Thank you for pointing that out. We have added the x-axis title to Figs. 6 and 7, as well as all heatmaps in the supplement.
 - "Lag" refers to the time lag between the two time series, and we explain how it was derived in lines 154-155. A "spectral" or "cospectral peak" refers to the maximum wavelet power identified in the spectral or cospectral analysis.
4. The concluding statement ("These findings highlight the tight coupling between plant carbon status and soil microbial activity...") is not directly supported by the data presented. The study measures Rh, which includes microbial respiration, but it does not measure any specific microbial activity parameters (e.g., biomass, composition, enzyme activity, substrate use efficiency). Attributing the Rh signal directly to "soil microbial activity" without this link is speculative. The mechanism proposed (direct exudation of

recent assimilates) is plausible but remains inferred, not proven, by the Rh-GPP lag correlation.

Response 4: We define in the Introduction that, following earlier similar interpretations (e.g., Jilling et al., 2025; Meier et al., 2017; Mencuccini & Hölttä, 2010; Yang et al., 2022), we will consider Rh as an indicator of microbial activity. It could be argued that it is a better integrator of metabolic activity than the metrics listed by the reviewer above, although they, too, have been used for this purpose. While Rh does not tell whether the respiration was associated with growth or maintenance, much less with any specific metabolic step, it is well-suited for the current analysis. Our findings of (1) consistently strong cospectral peaks of Rh and GPP (or PAR), and (2) a consistent lag-lead relationship between Rh and GPP (or PAR), suggest consistent coupling between fresh carbon inputs and microbial activity on a diurnal scale. We have expanded a paragraph to explain the logic of this argument in lines 337-342, and also added a new citation (i.e., Liesche et al., 2015) in line 344.

5. The Discussion primarily restates results without sufficient context or mechanistic depth. Crucially, it lacks comparison with previous studies. How do the observed lags (2-4 hours for Rh-GPP) compare to other forest ecosystems? Are they faster/slower? How do they align with known phloem transport speeds or exudation dynamics reported elsewhere? The discussion of Ra's inconsistency is underdeveloped. What does "carbon availability from local starch reserves" mean mechanistically? Why would this buffer Ra differently than Rh? The dismissal of temperature needs more nuance – why might the lag vary? Could other factors (e.g., moisture, labile C pulses) interact with temperature differently at different times?

Response 5:

- Phloem mass flow occurs on the scale of 0.2 m/hr for gymnosperms (Liesche et al., 2015), whereas pressure concentration waves travel orders of magnitude faster. Moreover, the pressure concentration wave travel speed seems to increase with path length (lag time is almost independent of path length; Mencuccini and Hölttä (2010)).
- To our knowledge, the study by Yang et al. (2022) is the only one that has analyzed the response signatures separately for Ra and Rh. As noted in the paper, they observed a consistent lag of Rh relative to PAR by 2-6.5 hours across a year in a subtropical evergreen forest, which is similar to our results. Like our current report, Yang et al. (2022) was also based on flux measurements and did not include direct measurements of root exudation, microbial biomass, or enzyme activity.
- We have revised the explanation on “carbon availability from local starch reserves” in lines 323-325.

- Current results do not tell us why R_a is not tightly coupled to GPP. There could be several regulatory mechanisms, but as described above (lines 323-325), we hypothesize that the starch reserves in the roots (both coarse and fine) act as a local buffer regulating cellular homeostasis and their metabolic needs. Given that the signaling of the metabolic state and energy needs occurs within individual cells, starch hydrolysis may be controlled at a rate that does not result in phloem loading, and thus does not contribute to exudation. Temperature and moisture may well modulate the different physiological processes, as also indicated by the slight variations in the mean lag times between R_h and GPP (point #3 in response to Review #2's question #2). However, the current dataset is insufficient to quantitatively resolve such interactions.

References

- Baniya, B., Kim, D., Nkrumah, M., Ono, M., Miao, G., & Noormets, A. (2025). Carbon Dynamics in a Shortleaf Pine Forest Amidst a Two-Year Drought. *ESS Open Archive*.
<https://doi.org/10.22541/essoar.175611350.04251050/v1>
- Bond-Lamberty, B., Bailey, V. L., Chen, M., Gough, C. M., & Vargas, R. (2018). Globally rising soil heterotrophic respiration over recent decades. *Nature*, 560(7716), 80-83.
<https://doi.org/10.1038/s41586-018-0358-x>
- Canarini, A., Kaiser, C., Merchant, A., Richter, A., & Wanek, W. (2019). Root Exudation of Primary Metabolites: Mechanisms and Their Roles in Plant Responses to Environmental Stimuli [Review]. *Frontiers in plant science*, 10. <https://doi.org/10.3389/fpls.2019.00157>
- Grinsted, A., Moore, J. C., & Jevrejeva, S. (2004). Application of the cross wavelet transform and wavelet coherence to geophysical time series. *Nonlinear Processes in Geophysics*, 11(5/6), 561-566. <https://doi.org/10.5194/npg-11-561-2004>
- Gunina, A., & Kuzyakov, Y. (2022). From energy to (soil organic) matter. *Global Change Biology*, 28(7), 2169-2182. <https://doi.org/10.1111/gcb.16071>
- Jilling, A., Grandy, A. S., Daly, A. B., Hestrin, R., Possinger, A., Abramoff, R., Annis, M., Cates, A. M., Dynarski, K., Georgiou, K., Heckman, K., Keiluweit, M., Lang, A. K., Phillips, R. P., Rocci, K., Shabtai, I. A., Sokol, N. W., & Whalen, E. D. (2025). Evidence for the existence and ecological relevance of fast-cycling mineral-associated organic matter. *Communications Earth & Environment*, 6(1), 690. <https://doi.org/10.1038/s43247-025-02681-8>
- Kuzyakov, Y., & Gavrichkova, O. (2010). REVIEW: Time lag between photosynthesis and carbon dioxide efflux from soil: a review of mechanisms and controls. *Global Change Biology*, 16(12), 3386-3406. <https://doi.org/10.1111/j.1365-2486.2010.02179.x>
- Liesche, J., Windt, C., Bohr, T., Schulz, A., & Jensen, K. H. (2015). Slower phloem transport in gymnosperm trees can be attributed to higher sieve element resistance. *Tree Physiology*, 35(4), 376-386. <https://doi.org/10.1093/treephys/tpv020>
- McElligott, K. M., Seiler, J. R., & Strahm, B. D. (2016). Partitioning soil respiration across four age classes of loblolly pine (*Pinus taeda* L.) on the Virginia Piedmont. *Forest Ecology and Management*, 378, 173-180. <https://doi.org/10.1016/j.foreco.2016.07.026>
- Meier, I. C., Finzi, A. C., & Phillips, R. P. (2017). Root exudates increase N availability by stimulating microbial turnover of fast-cycling N pools. *Soil Biology and Biochemistry*, 106, 119-128. <https://doi.org/10.1016/j.soilbio.2016.12.004>
- Mencuccini, M., & Hölttä, T. (2010). The significance of phloem transport for the speed with which canopy photosynthesis and belowground respiration are linked. *New Phytologist*, 185(1), 189-203. <https://doi.org/10.1111/j.1469-8137.2009.03050.x>
- Mitra, B., Miao, G., Minick, K., McNulty, S. G., Sun, G., Gavazzi, M., King, J. S., & Noormets, A. (2019). Disentangling the Effects of Temperature, Moisture, and Substrate Availability on Soil CO₂ Efflux. *Journal of Geophysical Research: Biogeosciences*, 124(7), 2060-2075. <https://doi.org/10.1029/2019jg005148>
- Ono, M., Noormets, A., & Mitchell, S. (2025). The effect of the frequency of prescribed burning on annual soil carbon balance in a loblolly-shortleaf pine forest in East Texas. *Frontiers in Forests and Global Change*, 8. <https://doi.org/10.3389/ffgc.2025.1602557>

- Vargas, R., Detto, M., Baldocchi, D. D., & Allen, M. F. (2010). Multiscale analysis of temporal variability of soil CO₂ production as influenced by weather and vegetation. *Global Change Biology*, 16(5), 1589-1605. <https://doi.org/10.1111/j.1365-2486.2009.02111.x>
- Yang, Z. J., Lin, T. C., Wang, L. X., Chen, S. D., Liu, X. F., Xiong, D. C., Xu, C., Arthur, M., McCulley, R., Shi, S. H., & Yang, Y. S. (2022). Recent Photosynthates Are the Primary Carbon Source for Soil Microbial Respiration in Subtropical Forests. *Geophysical Research Letters*, 49(22), Article e2022GL101147. <https://doi.org/10.1029/2022gl101147>