egusphere-2026-605 "Temperature dependence of the contribution of soil moisture to soil respiration and the soil respiration temperature threshold in a temperate deciduous forest"

Dear Associate Editor and Reviewers,

We sincerely thank you for your careful review of our manuscript and for providing constructive and insightful comments. We have carefully considered all comments and revised the manuscript accordingly. Below, we provide our responses to each comment.

I believe this study offers a novel perspective on how soil temperature and moisture control soil respiration. Generally, soil temperature is identified as the primary controller of the temporal variability of soil respiration (SR), subsequently modulated by water availability, which limits both autotrophic and heterotrophic respiration when water is scarce. This study demonstrates that, in these temperate forest ecosystems, the opposite view holds true: temperature appears to control the SR response to moisture. This control occurs above a threshold of 15-17°C. In other words, above a certain temperature, the variability in Rs is mostly explained by fluctuations in soil moisture, but with the modulation of Ts. Below this threshold, soil metabolic activity appears to decrease and lose all relationship with moisture, with temperature being the sole factor controlling the temporal variability of Rs.

Response: We thank the reviewer for this thoughtful summary of our study and for recognizing the novelty of our perspective on the interactive roles of soil temperature and soil water content in regulating soil respiration. We agree that the main finding of this study is that the contribution of SWC to Rs changes across a temperature threshold of approximately 15–17°C. Specifically, the influence of SWC becomes more evident at higher temperatures, whereas below this threshold the relationship between SWC and Rs becomes weaker or differs in form. In the revised manuscript, we have further clarified this interpretation and its ecological context.

The result seems interesting to me, as I mentioned above, but some factors and limitations should be considered and discussed in the manuscript. First, the scope of this study needs to be better contextualized, since in this study system water availability is quite high throughout the year, and particularly during the warmer periods. In temperate systems outside the monsoon influence, this is not the case, and soil temperature and moisture tend to have a negative seasonal relationship. That is, in non-monsoon temperate systems, the relationship between soil moisture and Rs at high temperatures is very likely nonexistent because there is insufficient moisture for even minimal autotrophic or heterotrophic metabolism. In other words, in these systems it is humidity that limits the response to temperature, and not the other way around. This should be discussed and contextualized in the discussion.

Response: We appreciate the reviewer's valuable comment that the scope of our interpretation should be more clearly contextualized, and we agree with this point. In the revised Discussion, we now explicitly state that our findings are most applicable to monsoon influenced temperate forests, where SWC tends to remain relatively high during the warm season, and that this pattern may not be directly transferable to non-monsoon temperate systems, where SWC is more seasonally constrained. This revision has been added on Page 16, Lines 326–331.

4.5 Implications and considerations

"In particular, in temperate deciduous forests, monsoon climates tend to maintain relatively high soil water availability during the warm season because precipitation is concentrated in this period, whereas non monsoon climates tend to experience intensified seasonal drying with increasing temperature (Chae, 2011; Prigoliti et al., 2023). In this context, our findings should be interpreted within the hydroclimatic setting of monsoon influenced temperate forests where soil water availability remains relatively high during the warm season, and the same pattern may not occur in non-monsoon temperate forests where water availability is seasonally limited."

Another aspect that I believe the authors do not sufficiently discuss in this study are the results obtained in Figure 3. Particularly interesting are the "jumps" in basal respiration rates between the different temperature ranges above 15°C, and the difference in the shape of the relationship between soil moisture and Rs between these ranges. On the one hand, what do these jumps respond to? They aren't controlled by humidity or temperature. They may respond to changes in the biomass of microorganisms and fruit roots in different phenotypic phases during warmer periods. Regarding the form of the relationship, I partially disagree with the interpretation of Fig 3. Made in lines 260. If oxygen limits, should limit Rs either similarly for each Ts ranges or should be higher at the highest temperatures, when O2 demand peaks. Here does not seem consistent with neither of those cases. Again, I think that the phenophase might have played a role here, because in these Ts ranges data from spring and fall are mixed up, and things are generally very different phenologically speaking between spring and fall. Maybe to try to separate also this phenophases with the temperature ranges will help explaining the differences in the slope of the relation between temperature ranges.

Response: We sincerely thank the reviewer for this thoughtful and valuable comment regarding the interpretation of Figure 3. In the revised manuscript, we have further expanded the Discussion to clarify that the observed jumps in basal respiration around 15°C cannot be fully explained by Ts or SWC alone and may also reflect seasonal biological changes, including changes in fine root biomass and activity as well as enhanced microbial activity during warmer phenophases. In addition, we have refined our interpretation of the nonlinear response observed in some warm Ts bins. In the revised manuscript, we distinguish more clearly between the weakening of the Rs response at high SWC within warm Ts bins, which may reflect physical constraints under wet conditions such as limited oxygen diffusion, and the observed jumps in basal respiration around 15°C, which may also be associated with seasonal biological shifts. In this way, the revised text more clearly separates these two features in Figure 3: the nonlinear response of Rs to SWC within warm temperature ranges and the jumps in basal respiration across temperature ranges. These changes have been incorporated into the revised Discussion on Page 14, Lines 277–279.

"In addition, the shift in Rs response around 15°C cannot be fully explained by Ts or SWC alone and may also reflect seasonal biological changes, including increases in fine root biomass and activity and enhanced microbial activity during warmer phenophases (Schindlbacher et al., 2015; Heinzle et al., 2023)."

Finally, I understand that Figure 5 confirms what we see in Figures 3 and 4. What the authors mean is that below this threshold (which largely coincides with the 15°C shown in Figure 3), the variation in Rs is entirely explained by temperature, while above it, Rs is controlled by the interaction of Ts and SWC. However, the correlation coefficients and the slope that would confirm that Ts's control is more important below the threshold are not shown. It is also possible that below the threshold the roles of Ts and SWC have reversed: Ts is the primary control, modulated by SWC.

Response: We sincerely thank the reviewer for this careful and important comment regarding the interpretation of Figure 5. We recognize that the original wording could be read too strongly, particularly in suggesting that Rs variability below the threshold is explained entirely by temperature. In the revised manuscript, we therefore modified the text to clarify that our results support a change in the relative contribution of soil water content (SWC) across the breakpoint, rather than indicating that temperature alone explains the pattern below the threshold. More specifically, we revised the relevant text to emphasize that the relative contribution of SWC becomes more evident above the breakpoint, whereas below the breakpoint the contribution of SWC appears limited or less evident under the conditions of this study. Accordingly, we no longer describe the pattern below the breakpoint as entirely temperature controlled. This revision is consistent with the results presented in Figures 3–5, which together show that the contribution of SWC differs across temperature conditions and becomes more pronounced above the breakpoint. We appreciate the reviewer's suggestion that, below the threshold, Ts may act as the primary control while SWC plays a secondary or modulating role. In response, we revised the manuscript to present a more cautious interpretation and to avoid stronger claims than those directly supported by our analyses. These changes have been incorporated into the revised manuscript on Pages 15–16, Lines 309–311, and Page 17, Lines 344–345.

"Across this breakpoint, the relative contribution of SWC to Rs variability changed, suggesting that the dominant controls on Rs differ between cooler and warmer temperature conditions, with the influence of SWC becoming more evident above the breakpoint (Johnston et al., 2021)."

"Together, these results indicate that the control structure of Rs may differ across the breakpoint, with a greater relative contribution of SWC above the breakpoint, while below the breakpoint the contribution of SWC appears limited or less evident."

Minor comments:

Title: looks like a riddle. Please rephrase

Response: We sincerely thank the reviewer for this helpful comment. We agree that the original title could be made clearer and more direct. In the revised manuscript, we have rephrased the title to better reflect the main finding and contextual scope of the study.

The revised title is:

"Temperature dependent changes in the contribution of soil water content to soil respiration across a temperature threshold in a monsoon influenced temperate deciduous forest"

References: Most references are from the last 5 years. Most important references in the study of the role of soil temperature and soil moisture in soil respiration are before 2020. Please make a better bibliographic search and cite other key papers

Response: Thank you for this helpful comment. We agree that earlier foundational studies are important for properly contextualizing the roles of soil temperature and soil water content in soil respiration. In the revised manuscript, we strengthened the background and Discussion by incorporating additional key references from the earlier literature. Several foundational studies were already included in the original manuscript, and these have now been complemented by a broader set of classic references to improve the historical and conceptual context of the study.

Methodology: method section could be substantially improved. You learn at the end of the methods section that there were 5 automated chambers installed (what was the criteria where to install them, for instance?) but no information about where the sensor of SWC and Tz where installed with respect to the Rs measures. Were SWC and Ts measured near each automated chamber? Or there were only one measurement point? By the way, why the authors use the acronym SMC instead of the more commonly used in literature SWC (soil water content) to refer to soil moisture? It is just a matter of consistency and reproducibility of results.

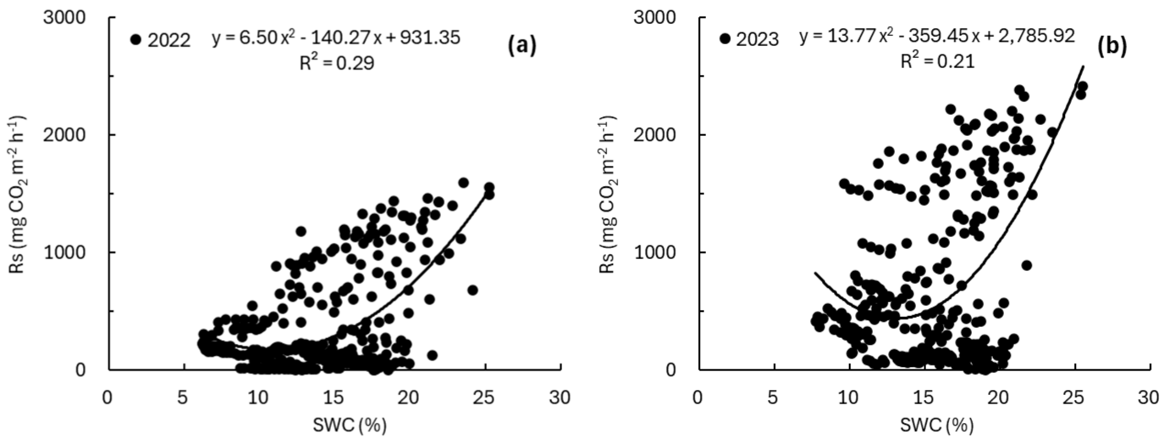
Response: Thank you for this helpful comment. In the revised manuscript, we substantially clarified the Methods section to improve transparency, consistency, and reproducibility. Specifically, we now state more clearly that soil respiration was measured using five automated chambers, and we added a more detailed description of the chamber installation criteria. The chambers were installed at least 1 m apart and were arranged to reflect the spatial heterogeneity of soil and surface environmental conditions within the study plot. To avoid spatial bias in chamber placement, the characteristics of each location were carefully assessed and the five chambers were arranged in a pentagonal configuration within the plot. Locations with substantial surface disturbance or conditions that could reduce measurement stability were excluded. In addition, the chambers were installed at least 50 cm away from tree stems to minimize the potential overestimation of root respiration associated with dense root distribution near the stems.

We also clarified the spatial relationship between the Rs measurements and the environmental sensors. In the revised Methods, we now explicitly state that soil temperature and soil water content were measured for each chamber, with the Ts and SWC sensors installed within 5 cm of each chamber so that they represented the same local environmental conditions. We further clarified that the Ts sensor was positioned adjacent to the SWC sensor while avoiding direct physical contact or interference that could affect SWC measurements. These revisions have been incorporated into the revised manuscript on Pages 5–6, Lines 110–138.

Regarding terminology, we agree that SWC is the more commonly used and reproducible term in the literature. To improve clarity, consistency, and accessibility for readers, we revised the terminology throughout the manuscript and now use SWC consistently.

Figure 2. Why different symbols if they are presented in two different panels?

Response: Thank you for this helpful suggestion. We agree that using different symbols was unnecessary because the two years were already separated into different panels. In the revised figure, we therefore unified the symbols across both panels to improve visual consistency and avoid redundancy.



Discussion: throughout the discussion I see many paragraphs that looks more results than discussion (e.g. paragraphs 250, 275, 280…). The discussion should be used to discuss

results rather than to reporte them again. Please try to improve this too.

Response: Thank you for this helpful comment. In response, we substantially revised the Discussion to ensure that it functions primarily as an interpretation of the results rather than a repetition of them. Repetitive descriptions of numerical values, statistical significance, and figure based patterns were reduced throughout the revised manuscript. We also rewrote the relevant paragraphs to highlight the ecological meaning of the observed patterns and to clarify the mechanisms underlying the temperature dependent contribution of soil moisture to soil respiration. In particular, the revised Discussion now places greater emphasis on why the contribution of SWC became more evident under warm conditions and how the breakpoint can be interpreted in relation to shifts in the dominant controls of soil respiration.

Figure 5. Which is the fit for each part of the threshold? It would be nice to see the slope and R^2 for the two different sections at both sides of the threshold. Does temperature fit better Rs at colder periods? Below the threshold there is also some variability around the model. Could this be done to fluctuations in SWC?

Response: Thank you for this important comment. In Figure 5, separate linear fits were applied to the two segments on either side of the breakpoint, and we agreed that it was necessary to present the slope and R^2 values for each segment more clearly. Accordingly, we added Table S2, which summarizes the Ts range, slope, R^2, *p*-value, and mean SWC for the segments below and above the breakpoint in both years.

However, the fact that the relationship between Ts and Rs was also evident below the breakpoint does not necessarily mean that temperature explains Rs better under colder conditions. Rather, our results suggest that the overall contribution of SWC below the breakpoint was limited or less evident, which may reflect possible differences in the regulatory mechanisms controlling soil respiration across the breakpoint. This does not mean that SWC had no effect at all, and although the relative importance of Ts may have increased under colder conditions, the present data do not allow us to determine the extent of this clearly.

In addition, some of the variability remaining around the fitted relationship below the breakpoint may have been associated with fluctuations in SWC. However, this variability may reflect not only short term changes in SWC following rainfall events, but also other environmental changes associated with rainfall. Therefore, additional analyses or experiments that separate the effects of temperature from those of various environmental drivers, including extreme dry and wet conditions, would be needed to more clearly distinguish the relative roles of temperature and SWC under colder conditions.

Table S2: Segment specific regression statistics for the relationship between soil temperature and soil respiration below and above the breakpoint in 2022 and 2023. Ts range, slope of the Ts–Rs fit, R^2, *p*-value, and mean SWC are shown for each segment.

Year	Section	**Ts range**	**Slope of Ts–Rs fit**	R^2	***p*-value**	**Mean SWC (%)**
2022	Below breakpoint	Ts < 16.94	10.88	0.65	< 0.0001	13.58
2023	Below breakpoint	Ts < 16.77	30.27	0.77	< 0.0001	15.27
2022	Above breakpoint	Ts ≥ 16.94	127.91	0.66	< 0.0001	15.22
2023	Above breakpoint	Ts ≥ 16.77	190.00	0.68	< 0.0001	16.18