

Response to Referees

Reviewer 2

[**Comment 1**] Thank you very much to the authors for addressing our comments. I just have a few more minor questions.

Response: We thank the reviewer for the detailed comments and suggestions. We have carefully revised the manuscript accordingly. Please refer to the point-by-point responses below.

[**Comment 2**] L52: isn't the 'thermal and hydrological' part repeated L53?

Response: Thank the reviewer for the careful review. We have merged the two similar phrases into a single statement (see revised manuscript, lines 51–53), removing the repetition while preserving the meaning.

[**Comment 3**] L121: as I understand, you didn't incubate the three replicates here. Did you mix them to create the 300 g jar? Or did you choose one of the replicates to incubate?

Response: Thank the reviewer for pointing out this. Yes, the three field replicates were mixed to obtain one composite sample. This has been now clarified in lines 121–122.

[**Comment 4**] L142: why terminate on different cycles? (except for LFLT, as there are only 2) I mean, why not do it all along the experiment?

Response: We thank the reviewer for this question. Our experiments were designed to obtain same cumulative thawing duration (i.e., 12 days) under a common affordable and feasible total incubation length. The four freeze–thaw regimes reach 12 cumulative thaw days after different numbers of freeze-thaw cycles. We have now clarified this in lines 144–145.

[**Comment 5**] L171: you can add it is measured by absorbance (I guess?)

Response: Thank the reviewer for this suggestion. Yes, enzyme activities were measured by absorbance: BG and CBH at 405 nm, PPO and POD at 475 nm. We have now explicitly stated this in the revised manuscript. (please see lines 175–177).

[**Comment 6**] L280: this sentence could be moved one line above, right after 'Solid lines indicate significant linear regressions, whereas dashed lines indicate non-significant relationships.' (since you are giving information about the significance).

Response: Revised accordingly.

[**Comment 7**] L283: I now see the link with the first thawing day in Fig. 3, thanks for the clarification. However, I don't see it clearly for Fig. 4: do you mean you made Fig. 4 with the data of the first thawing days? If so, you could add it in the caption. Otherwise, you should probably remove 'Fig. 4' in L.283. Also, what I understand when you say 'first thawing day' is that it is the first thawing day of several cycles (one for LFLT and SFLT but three for SFLT and SFST). Is that right? If so, it may need a clarification.

Response: Thank the reviewer for the careful review. The reviewer's understanding of

“first thawing day” is correct: for the LFLT and SFLT treatments, it refers to the first thawing day of the first freeze–thaw cycle; for the LFST and SFST treatments, it refers to the first thawing day of the first, second, and third freeze–thaw cycles. We have now added a clarifying sentence to the caption (please see lines 283-286).

[**Comment 8**] L288: 'were not as significantly elevated as DOC', maybe? (missing word?)

Response: Corrected accordingly.

[**Comment 9**] L423: 'even in deep horizons with lower biomass and reduced enzyme pools': in the text and in your response to my first comments, you stated that enzyme activity was higher in subsoil to tackle the lack of resources. Do you mean that 'enzyme pools' are related to the quantity of enzymes rather than their efficiency?

Response: We thank the reviewer for this careful comment. The term "enzyme pools" was a mistake; we intended to convey that absolute enzyme activities were lower in subsoil, which is consistent with the reduced biomass. We have replaced "reduced enzyme pools" with "lower enzyme activities" in the revised manuscript to accurately reflect our measurements. The higher specific activities in subsoil, which we noted previously, reflect greater enzymatic efficiency per unit biomass, not larger enzyme pools (please see lines 429).

[**Comment 10**] L479: 'CO₂' needs subscript.

Response: Corrected.

[**Comment 11**] L526: 'greater FTC frequency may enhance cold– season carbon losses': this part of the sentence is repeated.

Response: Corrected.