

# Response to reviewers

**Manuscript:** Destabilization of buried carbon under changing moisture regimes

## Response to Reviewer 1

### Point-by point responses

1. *Reviewer Comment: Line 254-255= there's an upside down exclamation mark in the parenthesis for I dont know what reason. Believe it's a typo*

#### Response & revision:

Good catch! We have corrected the upside-down exclamation point, which was meant to be a “<” symbol.

2. *Reviewer Comment: Milli-Q is a company name, I'd refer to this as just ultrapure water or 18.2 MΩ·cm*

#### Response & revision:

We agree that using the technical specification is more appropriate. We have removed references to Milli-Q and replaced this with ultrapure water (18.2 MΩ·cm).

3. *Reviewer comment: Nice job!*

#### Response

Thank you for your encouraging feedback. We are glad that you enjoyed the paper. We have addressed your specific suggestions to ensure the technical terminology and notation are precise.

## Response to Reviewer 2

### General comments

First, I will note that I was not an initial reviewer for this manuscript. Therefore, I saw it after the first round of revisions and author responses. After my initial review, I did read through the previous reviewer comments and author responses. There is a chance I missed something, so I apologize if anything below was already commented on by reviewers and addressed/justified by the authors.

Overall, I found the topic of this manuscript very interesting and have a greater appreciation for the effects of how variable moisture regimes may influence soil organic

carbon (SOC) stability by reading this work. In particular, I think the proposed question below is intriguing.

*“Will millennia-old SOC decompose rapidly once oxygen and moisture access is restored, or do the same properties that enabled its long-term preservation – fine texture, mineral associations, chemical recalcitrance – confer lasting resistance?”*

I think overall the paper is well written and addresses a complex and scientifically relevant topic and the authors revised much of the text in response to other reviewer comments and have improved the manuscript. However, I found some aspects confusing and believe that there are opportunities for improvement in clarity. I address those below in my general and line by line comments.

One particular aspect that I think needs clarity to improve the manuscript is for the authors to be very specific about what they mean by erosional, depositional, and burial zones/transects. For instance, clarifying that the burial transect is not equivalent to a modern depositional zone would be helpful. There is some discussion of this in the introduction, stating that it is historical geological events that caused the burial/deposition. However, when contrasting the geomorphic contexts as depositional vs erosional, that feels not quite accurate. Although the erosional transect is actively undergoing erosion, the depositional zone appears to be a “stable” rather than a “dynamic” landscape.

Thus, in a geomorphic framework, I think saying “depositional” transect may not be the best word choice. I think that “burial” or “buried” zone (used in many locations throughout the text) may be more appropriate since the zone is not actively undergoing deposition now - unless I have misinterpreted the background. In lines 223 - 226, the authors state the following - and I think this is the language they should be consistent with throughout the entirety of the paper to avoid confusion.

*“Sampling was conducted in 2016 and 2017 across two geomorphic settings: burial transects (where the Brady Soil is deeply buried beneath Holocene loess) and erosional transects (where the Brady Soil is exposed or shallowly buried due to hillslope erosion).”*

Additionally, I found the use of shallow, intermediate, and deep to describe “Depth” or “Soil Depth” in a few of the figures slightly confusing. If I am interpreting it right, this is the depth to the Brady Soil? In much of the text and captions this is referred to as “degree of exposure/burial” and relates to the Roman Numerals used in figure 1 and table A1. I think it would be very helpful to call this variable “Depth to Brady Soil” or perhaps even say “Degree of exposure/burial” in the legends so that it matches the text and schematic for the field sampling.

I want to reiterate that I find this topic interesting and overall a well written manuscript. I understand the difficulties of sample collection and logistical limitations in the field. So with the samples available, I think the study design is appropriate. I do believe the

manuscript could be improved from further clarity that might help it reach and be incorporated by a broader audience. I enjoyed reading this!

### **General Response**

We are grateful for your insightful and thorough review, especially coming to the manuscript at this stage. We have replaced the words ‘depositional’ with ‘burial’ throughout. We truly appreciate your kind words regarding the interest and relevance of our study. Your suggestions regarding geomorphic terminology and depth descriptions were incredibly helpful for improving the manuscript’s clarity. We have implemented several changes to ensure that our terminology is consistent and that our experimental design is easily understood by a broader audience.

Specifically:

- We replaced “depositional” with “burial” throughout to more accurately reflect the geomorphic context.
- We clarified the nomenclature for sampling depths and degrees of exposure/burial in both the text and figure captions.
- We integrated the recent literature you suggested to provide a more robust context for our findings.

### **Point-by point responses**

1. *Reviewer comment: Lines 93 - 104: This is a good addition and addresses some of the past reviewer concerns. I think it could be strengthened by additional references to recent work. One research paper that comes to mind is Thaler et al (2021) - The extent of soil loss across the US Corn Belt. Although it is not addressing paleosols, they are assessing the effects of soil loss/erosion on soil fertility and carbon that feels relevant to your motivation.*

Author response: That is an excellent suggestion. We have added the citation of Thaler et al. 2021 to strengthen the motivation regarding the effects of soil loss and erosion.

2. *Reviewer comment: Lines 112 - 114: This is a very cool process! Just to clarify, is the rejuvenation of rock-derived nutrients here coming from new soil production via exposure of unweathered parent material (thus likely containing more rock-derived nutrients)? I think this sentence could benefit from a little more specificity. A suggestion may be “While erosion may remove C, the exposure of fresh relatively unweathered parent material can increase photosynthate additions due to the rejuvenation of rock-derived nutrients”. That change is up to the authors though.*

Author response: We completely agree that more specificity helps here. We have revised the sentence to “While erosion may remove C, the exposure of fresh relatively

unweathered parent material can increase photosynthate additions due to the rejuvenation of rock-derived nutrients.”

3. *Reviewer comment: Lines 118-127: I think this is a really interesting section. I think the discussion of soil properties (physical and chemical) and soil depth controls on SOC dynamics could be strengthened by recognition of some additional work. Maybe here in the introduction or later in the discussion. In particular the following papers may be worth considering. However, I understand if the authors believe they are out of the scope of the paper or are limited by the number of citations in the journal allows for.*
- *Lawrence et al (2015) - Long-term controls on soil organic carbon with depth and time: A case study from the Cowlitz River Chronosequence, WA USA*
  - *Lawrence et al (2021) - The trajectory of soil development and its relationship to soil carbon dynamics feel like they could be relevant.*
  - *Slessarev et al (2022) - Rock weathering controls the potential for soil carbon storage at a continental scale*

Author response: Thank you for pointing us toward these relevant papers. We have revised the paragraph to include these citations, clarifying how mineral surfaces and geomorphic history dictate SOM persistence and vulnerability.

4. *Reviewer comment: Line 122: Is this reference to “Dolui et al. (in press)” different from the Dolui et al. (2026) paper? If not, the “Dolui et al. (in press)” needs to be corrected in many locations throughout the manuscript. If this is referring to an additional paper, it should be listed in the references list. Additionally, both initial reviewers pointed out that a typo of “(cite Dolui et al. i.e., paper 1)” existed. This is still present in section 3.1 and will need to be fixed (lines 406-412)*

Author response: We apologize for the confusion caused by these placeholder citations. Since both papers have now been officially published, we have updated all instances to the final 2026 citation and removed the editorial note.

5. *Reviewer comment: Lines 145 - 168: This section was easy to follow and a good review of these topics!*

Author response: We are very pleased to hear that this section provided a clear and helpful overview. Thank you for the positive feedback!

6. *Reviewer comment: Lines 170-172: “This study investigates the sensitivity of modern and buried SOM to moisture inputs under erosional and depositional geomorphic conditions in the Brady Soil”. I am not sure that the term depositional here is totally accurate. I understand that different subfields may use this term variably, however is this an active depositional zone? I think the term burial (used in some spots) or maybe “past burial” or “buried” may be better to use. Mostly, I am not convinced (based on the background information provided) that this area*

*is under a depositional geomorphic condition. It was a depositional zone in the past (just like the modern erosional setting). I am convinced that the erosional transect is undergoing erosional geomorphic conditions currently though!*

*Lines 223 - 226: Relates to comment above - I think this is a better way to say it and the authors should try to stay consistent throughout the paper.*

*“Sampling was conducted in 2016 and 2017 across two geomorphic settings: burial transects (where the Brady Soil is deeply buried beneath Holocene loess) and erosional transects (where the Brady Soil is exposed or shallowly buried due to hillslope erosion).”*

Author response: You are correct that the area is not currently an active depositional zone in the same way the erosional transect is currently active. To avoid any technical ambiguity, we have replaced the word “depositional” with “burial” throughout the manuscript.

*7. Reviewer comment: Line 235: 0-30cm for both modern and Brady Soils?*

Author response: To clarify, the 0–30 cm interval refers specifically to the upper portion of the Brady Soil horizon itself, rather than an absolute depth from the modern surface. We have added a phrase to the text to ensure readers understand this refers to horizon-specific depths.

*8. Reviewer comment: Line 254: Again, is “(Dolui et al., in press).” a different paper from the 2026 one referenced in line 263?*

Author response: We have updated all Dolui et al. references.

*9. Reviewer comment: Lines 286-287: Perhaps this is described in references to the model, but it could be helpful to state generally what the timescales of “slow” and “fast” cycling are for this study.*

Author response: We agree that defining these scales adds valuable context. We have added parentheses to specify the turnover times: “...fast- and slow-cycling fractions (turnover times on the scale of days and centuries, respectively).”

*10. Reviewer comment: Line 292: biological replicates? Since there are multiple types of replicates it may be helpful to be overly explicit when referring to them.*

Author response: We confirm this to be biological replicates and explicitly state so in the text.

*11. Reviewer comment: Lines 307 -309: How quickly did you dry the soils/how fast did this process take place?*

Author response: The drying process took approximately 2–3 days within the overall seven-day period. We have added this detail to the text for better reproducibility.

12. *Reviewer comment: Lines 347-349: Did you measure respiration during the drying phase?*

Author response: No, as the jars were open during the drying phase, we did not measure respiration during drying and only after re-wetting. We have clarified this in the methods section.

13. *Reviewer comment: Line 371: Small note - Paleostatus is capitalized in some locations and not others. Is there a format the journal suggests?*

Author response: Thank you for noticing that inconsistency. We have decided to use lowercase “paleostatus” throughout, as the previous capitalization was only intended to highlight it as a statistical factor.

14. *Reviewer comment: Line 371-374: “Depth” here refers to the degree of burial or exposure right? I think the authors should try to be consistent with terms. Or be explicit and call this “depth to Brady Soil”.*

Author response: We have changed the wording to refer to the degree of burial/exposure.

15. *Reviewer comment: Line 401-402: Would it be useful to explicitly state the pH ranges for the modern vs Brady Soil if the authors say “especially the Brady Soil”?*

Author response: That is a helpful addition. We added “(pH >7.6)” to the statement to provide immediate context for the Brady Soil’s alkaline nature.

16. *Reviewer comment: Line 406 and 411: “(cite Dolui et al i.e. paper 1)” seems out of place...*

Author response: We have corrected all Dolui et al. citations.

17. *Reviewer comment: Lines 407-408: Units for the CEC should likely be included.*

Author response: Thank you for noting this omission. We have added the units  $\text{cmol}_c \text{kg}^{-1}$

18. *Reviewer comment: Line 426: Just to clarify, I am interpreting “greatest depth” here to mean largest burial (roman numeral III in that transect) and least erosion (roman numeral I in that transect). If that is not correct, I am misinterpreting something somewhere and more clarity may be useful.*

Author response: Your interpretation is almost correct. To make this less confusing for all readers, we have moved away from using the word “depth” in this context and now refer specifically to the “degrees of burial or exposure.”

19. *Reviewer comment: Line 485: Not to hyperfixate on this, but the “deepest layer” here is slightly confusing. Again, it might be more clear to say “greatest depth to Brady Soil” if that is what the authors mean. I could see there being confusion*

*with the measured soil depth/layer. However, the authors explicitly state that all are from 0-30cm (of the modern and the buried Brady soil). So it shouldn't get misinterpreted. However, I had to remind myself of that throughout this section.*

Author response: We now refer to the degrees of burial/ erosion instead of depth.

20. *Reviewer comment: Lines 574-597: I maybe missed something (reference to a specific pool or control) between these two statements or got a little lost in the results here. Both of the statements address the decay rate of fast cycling modern soil in the continuously wet vs wet-dry cycling, correct? But have different statements.*

- *Line 574: The decay rate of the fast-cycling SOM pool in modern soil was significantly higher in the wet-dry cycling experiment (8.11 day<sup>-1</sup> i.e., 0.123 days TOT) compared to the continuously wet experiment (0.127 day<sup>-1</sup> i.e., 7.89 days TOT,  $p < 0.001$ ), indicating a much faster turnover response to rewetting.*
- *Line 594: In modern soils, however, there was no significant difference between decay rates of fast-cycling SOM in continuously wet versus wet-dry cycling experiments.*

Author response: We appreciate you spotting this discrepancy. We neglected to specify that the second statement referred specifically to the control modern soils. We have corrected the text to distinguish between treatment and control groups.

21. *Reviewer comment: Lines 672-673: May consider providing a citation for this "Reduced decay could arise from physical protection within aggregates, reduced microbial access to substrates, or changes in solute diffusivity."*

Author response: We agree that a supporting citation is appropriate here and we have added one accordingly.

22. *Reviewer comment: Lines 693-694: Could the authors reference a table where the data shows the 2000 times slower decay rates for slow vs fast cycling pools?*

Author response: To provide a clear visual comparison of these rates, we now refer the reader to Appendix Figure A2, which illustrates the ranges for both the slow- and fast-cycling pools.

23. *Reviewer comment: Lines 694-695: Are these turnover times (TOT) for the total bulk soil? Or a specific pool? I assumed at first one of the pools because of the sentence before, but I think it is for the bulk soil.*

Author response: We apologize for the confusion. This was in reference to the slow-cycling pool and we have clarified the sentence.

24. *Reviewer comment: Lines 702-708: I think the discussion section is much improved from the initial submission. I wonder if at the end of this paragraph it would be useful to cite Rasmussen et al (2018) - Beyond clay: towards an improved set of variables for predicting soil organic matter content or another research article. The authors mention their inability to resolve chemistry to it may be useful to cite something referring to the complexity of detangling texture and mineralogical controls? Just a suggestion!*

Author response: Thank you for the excellent literature suggestion. We have integrated the Rasmussen et al. (2018) citation to acknowledge the complexity of using texture as a proxy for stabilization mechanism.

25. *Reviewer comment: Lines 743-745: I think this is a great idea for future work!*

Author response: We are glad to know that the reviewer finds this a promising avenue of future research.

26. *Reviewer comment: Lines 777-791: The topic of this paragraph is a great addition to the discussion section. I think it could be strengthened by referencing past work addressing geomorphic and topographic controls on soil properties and organic carbon dynamics. These are a few suggestions that may be relevant. Perhaps they are addressing a different timescale than you are interested in, but I believe the discussion could be improved by including a wider perspective on these controls.*

- *Yoo et al (2006) - Spatial patterns of soil organic carbon on hillslopes: Integrating geomorphic processes and the biological C cycle*
- *Patton et al (2019) - Topographic controls of soil organic carbon on soil-mantled landscapes*
- *Hunter et al (2024) - Geomorphic controls on the abundance and persistence of soil organic carbon pools in erosional landscapes*

Author response: We have incorporated these papers as follows: This aligns with conceptual frameworks suggesting that spatial patterns of soil organic carbon (SOC) are fundamentally shaped by the interplay between biological cycling and geomorphic processes like erosion and deposition (Yoo et al., 2006). Furthermore, topography acts as a primary control on SOC distribution by mediating local microclimates and the lateral transport of soil material across mantled landscapes (Patton et al., 2019). ... Recent evidence underscores that geomorphic settings not only dictate the abundance of SOC but also the persistence of specific carbon pools, particularly in erosional landscapes where geomorphic "history" defines the vulnerability of buried carbon (Hunter et al., 2024).

27. *Reviewer comment: Figure 1a: I think this schematic helps a lot with visualizing the field sampling scheme and is very clean! I have some suggestions for clarity. The lidar in 1a is very intriguing and really demonstrates what the landscape looks like.*

- *Because the distance along the x axis in 1b appears to be relative to a reference point, is it possible to flip it so the direction of the burial and erosional surfaces matches the photograph below? I understand if that doesn't make sense though.*

Author response: We appreciate the aesthetic suggestion. However, since the photograph is just one representative example and transects can face various directions in the field, we believe maintaining the current orientation is more representative of the generalized landscape model.

28. *Reviewer comment: Figures 2 and 3: If these terms are referencing the “degree of burial/erosion” it may be useful to say that and reference the Roman Numeral scheme the authors included. Or call it “Depth to Brady Soil” explicitly.*

Author response: We have added a detailed explanation of depths to the figure caption.

29. *Reviewer comment: Figure 4 and 5: Are these field depths? 6 cm is quite shallow compared to the depth at which samples were collected. I think maybe it is supposed to be meters?*

Author response: Thank you for noting this labelling error. We have updated the figures to accurately reflect the field depths.

30. *Reviewer comment: Figure 5: Small note, I think the formatting got messed up somewhere, the p value is off of the figure in the PDF I am looking at.*

*Again, I thought this was overall very interesting work! I found it interesting to read and address a societally and scientifically relevant question. I think some clarification will greatly improve the manuscript's reach.*

Author response: The p is in the bottom right corner of the figure. We greatly appreciate the encouragement and interest in our work!

## **Conclusion**

We would like to thank both reviewers for their constructive and detailed feedback. The manuscript has been significantly strengthened by the clarification of our geomorphic terminology, the correction of technical typos, and the inclusion of contemporary literature that places our work in a broader context. We believe these revisions address all concerns raised and hope the manuscript is now suitable for publication in *Journal of Geophysical Research: Biogeosciences*.