Editorial board,

Biogeosciences

We thank the reviewer 2 for these comments. We respond to all comments below in plain text, while *comments by the reviewer are reported in italic*.

This article aims to validate whether the research findings on the drivers of respiration pulses after soil drying and rewetting (DRW) in the laboratory can be applied to field measurements. By integrating laboratory and field datasets, it compares the effects of multiple factors on soil respiration, which is of great scientific significance. The overall logic of the article is clear, the methods are reasonable, but there are still some areas that can be improved.

We thank you for this positive feedback!

Among them, the biggest problem / limitation of the MS is the small amount of data, which leads to a mismatch between the data of laboratory experiments and field experiments. If the amount of data is large, the uncertainty / error in this regard can be reduced. Therefore, the author needs to be cautious when drawing conclusions and should discuss and explain in the discussion.

We fully agree that the discrepancy between laboratory and field data could be an issue. This issue has been acknowledged in the current manuscript. For example, when we reported the results, we did not make a quantitative comparison of the insights obtained from laboratory data and the field data, but rather a qualitative comparison. In addition, we have acknowledged this issue in the Discussion (line 240-244) and Uncertainties (line 249-351) sections.

To further clarify this, we will add more content to the Conclusion in line 358 if we get a chance to revise this manuscript. "In this study, we compared the respiration response to rewetting using both laboratory and field datasets, although the sample size of the data differs between laboratory and field datasets, and the overlap of the drivers we selected is not complete".

It is recommended to modify the title to: "Comparative Validation of Laboratory Insights on Soil Rewetting Respiration Pulse Drivers: Evidence from Field Measurements". Such a title emphasizes the process of comparative validation and highlights that the research results are based on evidence from field measurements, which can attract readers' attention to the core findings of the research more effectively.

Thank you! We can change the title to "Validating laboratory predictions of rewetting respiration pulses using field data" to achieve a balance of conciseness and information.

At the same time, it is recommended to add some content about the significance of this research in the writing process, such as the importance of this research for the model simulation and future prediction of the DRW process; in terms of practical applications, the research results can provide a scientific basis for soil management and climate change adaptation strategies.

Yes, we can add some content about the significance of this research by adding an Implication section.

The validation of laboratory findings on the drivers of the rewetting pulse with field measurements is necessary for the prediction of future soil carbon stocks, which would be a natural application of our results.

The results of this study also highlight the role of environmental conditions (i.e. SOC and climate background) on rewetting pulses, which are becoming more important contributors to the global carbon cycle under climate change. Incorporating these results into model simulations could help improve the accuracy of global carbon predictions, especially for models that neglect rewetting pulses. In fact, most models of soil carbon cycling assume that respiration is a function of soil moisture (Bauer et al. 2008), but not of moisture changes. Therefore, such models describe how respiration varies when gradual variations of soil moisture occur, such as during drying, while neglecting the large respiration pulses occurring at rewetting. To model rewetting pulses, models need to include processes causing accumulation of bioavailable carbon during drying or release of labile substrates at rewetting (e.g., Brangari et al. 2020), but these processes are not easy to represent in a mechanistic way. One could argue that an empirical approach based on data such as those analyzed here could offer an alternative to roughly estimate the amount of carbon emitted at rewetting as a function of SOC, temperature, or other drivers.

Therefore, our results can provide a scientific basis for quantifying changes in SOC and thus ultimately inform management and adaptation strategies to climate change. However, we prefer not to overstate the implications, as our work is designed to address the more basic question of what we can learn from laboratory studies about field responses of soils to drying and rewetting.

When dealing with respiration rate and soil moisture data in different units, although the author believes that it does not affect the results, this treatment method may conceal some potential information or affect the accuracy of the model. Therefore, it is recommended that the author unify the units before analysis.

Having unified units for soil moisture and respiration rate and would be the ideal case for this work, we agree.

To convert the field respiration rate unit (μmol C m^{-2} h^{-1}) to the laboratory respiration rate unit (μg C $g^{-1}h^{-1}$), we would need to know the soil depth contributing to respiration in the field and soil bulk density information. In fact, the CO_2 efflux at the surface is equal to the CO_2 production rate per unit soil mass multiplied by contributing soil depth and by the soil bulk density. To assess if the unit conversion for respiration affects the results, we tried to convert the field measured respiration to units used in the laboratory incubations. This required some assumptions.

Because soil volume contributing to the measured respiration fluxes in the field is unknown (an issue also raised by reviewer 3) we assumed that the exact soil depth contributing to respiration is the same across six field sites (equal to 10 cm). In addition, we collected the bulk density information of these six sites in the literature (three values were estimated based on soil texture information), in order to make this unit conversion possible.

The results showed that after unit conversion, the importance of temperature and climate background are still there, while SOC became a more important driver of field respiration rate (Fig. R2). This result indicates that, with our current assumption of contributing soil depth and bulk density information, different units may lead to slightly different conclusions. However, this assumption is uncertain and therefore the results obtained are not robust. In fact, the contributing soil depth may differ between sites. This could further affect the comparison of drivers between laboratory and field data, as soil properties typically show vertical variation, and soil drying and rewetting occur at different rates along the vertical soil profile. To assess the possible effects of our assumptions, we plan to perform a sensitivity test by extracting contributing depth and bulk density from distributions centered around the estimated values at the six sites. This will allow testing the robustness of the importance ranking of these drivers.

The conversion of soil moisture units between percent water holding capacity and volumetric water content is not a universal constant, but it depends on the soil water content at field capacity, which in turn varies with texture and organic matter content. Sand content at four of the field sites varied from 26% to 98% (we do not have information for the remaining 2 sites), so we expect large variations in the water content at field capacity. Since the soils change markedly between studies, the conversion will change the values of soil dryness and rewetting intensity in a way that could affect the results. However, without site-specific field capacity data, we are afraid that this unit conversion would introduce even more uncertainty than the unit conversion for respiration. Because of this, we would prefer not to unify the soil moisture units.

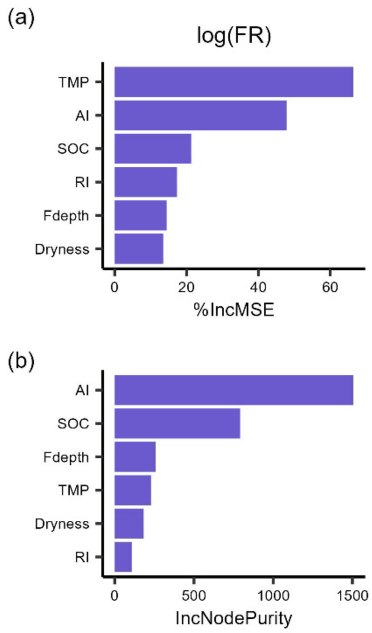

Figure R2: The importance ranking of predictors for mean respiration rates (μg C g $^{-1}$h^{-1}), during 48 hours after rewetting, from field (FR) measurements, based on random forest models using %IncMSE (a) and IncNodePurity (b). Predictors include soil organic content (SOC), aridity index (AI), soil dryness, rewetting intensity (RI), soil temperature for FR (TMP), and soil moisture sensor depth for FR (Fdepth). This ranking is slightly different from that obtained when considering a 48 hour time frame using original field respiration unit (μmol C m^{-2} h^{-1}).

In addition, for some potentially important driving factors (such as drought duration, the number of DRW cycles, etc.), although it was found in the test that adding these factors did not increase the explained variance, since these factors are of great significance in field conditions, future research can further explore how to better incorporate these factors to improve the comprehensiveness of data analysis.

Yes, we could explore these drivers in our future research. Once an objective method for defining drought duration and the number of DRW cycles for the field data is identified, we will be able to conduct this research. We interpreted this as a general remark, so we do not plan to make changes to address it.

The discussion part has a relatively in-depth analysis of the results, discussing the differences in respiration responses under laboratory and field conditions and their possible reasons, such as changes *in soil structure, microbial community changes, temperature and moisture changes, especially the plant carbon inputs. However, the discussion part can be further expanded to consider more factors that may affect soil respiration, such as soil texture, pH value, vegetation type, etc. In addition, a more in-depth discussion can also be carried out on the applicability and limitations of the research results in different ecosystems.*

We acknowledge that soil texture, soil pH, and other soil properties may be important drivers of respiration and help explain the variance in respiration responses after rewetting. However, whether or not the effects of soil texture and soil pH on respiration pulses are similar in the laboratory and in the field has not been tested. Testing this difference with our datasets is not feasible due to insufficient laboratory data on soil pH and soil texture. Therefore, for the sake of brevity, we prefer not to extend the discussion. It would be rather speculative.

Regarding vegetation type, it is definitely an important driver of respiration pulse because it affects labile carbon inputs to soils (as also noted by reviewer 1), so we will acknowledge the role of vegetation in the Introduction and Discussion.

Finally, it is recommended that the author add at least one field and laboratory DRW experiment at a sampling site, that is, to directly verify based on the same soil instead of being data-driven.

We agree that this could be a direct approach to validate laboratory results with field data. However, it may only allow us to validate the effects of "dryness" and "rewetting intensity" on the rewetting pulse (as these drivers can be manipulated in a given soil sample), but may be less applicable to other drivers that are site-specific (SOC, aridity index, soil temperature). For direct verification based on the same soils, laboratory experiments need to mimic different levels of DRW events at different incubation temperatures. Soils collected from six selected field sites (with different SOC content, climatic background) should all be used to conduct the above experiments. This would be a research project by itself and is outside the scope of this contribution. It remains a good idea for future research.

Overall, this is a valuable research paper. By comparing laboratory and field datasets, it provides important insights for validating the drivers of soil rewetting respiration pulses. Although there are some deficiencies, through appropriate improvements and further research, this research is expected to make greater contributions to the development of the soil carbon cycle field.

We thank you for this positive feedback!

References

Bauer, J., Herbst, M., Huisman, J. A., Weihermüller, L., and Vereecken, H.: Sensitivity of simulated soil heterotrophic respiration to temperature and moisture reduction functions, Geoderma, 145, 17–27, https://doi.org/10.1016/j.geoderma.2008.01.026, 2008.

Brangarí, A. C., Manzoni, S., and Rousk, J.: A soil microbial model to analyze decoupled microbial growth and respiration during soil drying and rewetting, Soil Biol. Biochem., 148, 107871, https://doi.org/10.1016/j.soilbio.2020.107871, 2020.