

Reply to Anonymous Referee #3 for “Peat Oxic and Anoxic Controls of Sphagnum Decomposition Rates in the Holocene Peatland Model Decomposition Module Estimated from Litterbag Data”

Henning Teickner^{1,2,*}

Edzer Pebesma²

Klaus-Holger Knorr¹

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¹ ILÖK, Ecohydrology & Biogeochemistry Group, Institute of Landscape Ecology, University of Münster, 48149, Germany

² IfGI, Spatiotemporal Modelling Lab, Institute for Geoinformatics, University of Münster, 48149, Germany

* Correspondence: Henning Teickner <henning.teickner@uni-muenster.de>

Comments made by the reviewer start with a bold **Q** while our reply starts with a bold **A**. In section “Additional changes” we list additional changes we would like to incorporate in an updated version of the manuscript.

1 Reply to comments

1.1 General comments:

1. **Q:** The authors clearly took into consideration the comments from the previous round of evaluation of the manuscript and improved it accordingly. They changed the title which now better reflects the content and relevance of the study. They also modified the abstract which now gives a better overview of the work. Generally, the main text is highly improved compared to the first version, although it still needs some minor improvements listed below. In this new version, the originality and aims of this study are stated more clearly. Additionally, the connections and differences of this study with other studies by the same authors are better described. The methods section has been improved considerably, as well as the supplement material. Considering all this, I suggest the manuscript should be accepted subject to minor revisions.

A: We thank the reviewer for the useful suggestions and hope that we addressed all comments (see the following replies).

1.2 Specific comments:

1.2.1 Introduction:

2. **Q:** L41: can “the litter that does not decompose fast even under environmental conditions favorable for decomposition” be explained by litter traits that make litter less decomposable (e.g., high C:N or lignin:N ratios, high toughness, high concentration of tannins, etc.)? If so, I think you could replace that part of the sentence with a statement about peat litter chemical and physical quality and how that makes it less decomposable.

A: We changed the sentence to (new: ll. 29 to 32): “Compared to other ecosystems, northern peatlands usually have small decomposition rates because of cold temperatures, high water table levels, acidic pH value, and litter that does not decompose fast because of chemical and physical litter properties (van Breemen, 1995; Rydin et al., 2013).”

3. **Q:** L43: in “during the Holocene and...”, I suggest changing and for but. You’re making a contrast, so I think it’s more suitable.

A: We changed the text as suggested.

4. **Q:** L55: what are the “both sides of the test”?

A: This refers to the rest of the paragraph: the models (one side of the test) have large error sources (structure, parameter values) and the observed data (the other side of the test) have large measurement errors. We agree that this can be written more directly.

We suggest to change (old: ll. 42 to 43):

“Second, there often are large uncertainties on both sides of the test”

to:

“Second, there often are large uncertainties both in the model being tested and the data used to test the model”

5. **Q:** L64: I suggest rephrasing this as: “Estimating values and uncertainties of parameters that directly control decomposition rates could be used to test the decomposition module of a peatland model”.

A: We thank the reviewer for this suggestion and changed the sentence accordingly (new: l. 49).

6. **Q:** L70: Why is this test restricted to short time ranges?

A: Available *Sphagnum* litterbag data cover only short time periods (usually not more than 5 years) and therefore do not provide information on long-term decomposition, which also restricts the test to these short time periods. To briefly explain this, we suggest to change this sentence from (old: l. 55):

“Admittedly, such a test is restricted to short time ranges and not representative for long-term decomposition rates which may differ from that of fresh litter (e.g., Frolking et al., 2001), but future tests with different scope and applications of the model will benefit from the reduced parameter uncertainties and can consider where the model fails already on short time scales.”

to (new: ll. 56 to 59):

“Admittedly, such a test is restricted to the time ranges covered by available litterbag experiments and therefore not representative for long-term decomposition rates which may differ from that of fresh litter (e.g., Frolking et al., 2001), but future tests with different scope and applications of the model will benefit from the reduced parameter uncertainties and can consider where the model fails already on short time scales.”

1.2.2 Methods:

7. **Q:** L155: I think you should reference Fig. 1 in this section and try to follow the flow of that figure to help the reader follow the workflow.

A: We added cross-references to Fig. 1 in section 2.1, 2.2, and 2.3 (see next sentence). In addition, we moved part of the former section 2.2.2 to a new section 2.2 (“Modeling remaining masses and decomposition rates with the litterbag decomposition model”) to better separate the description of the litterbag decomposition model from the HPM decomposition module. The new section 2.3 (former section 2.2) now has the title “Prediction of litterbag decomposition rates with the Holocene Peatland Model decomposition module”. We made some smaller adjustments to make the text fit the new section structure.

8. **Q:** L159 and L163: here you mentioned k_0 , but you have not defined it yet.

A: We thank the reviewer for pointing this out. We suggest to change the text from (old: ll. 131):

“... to estimate k_0 using the litterbag decomposition model.”

to:

“... to estimate decomposition rates (k_0) using the litterbag decomposition model.”

9. **Q:** L162: define WTD on the main text, please. You only defined it on the caption of Fig. 1.

A: We thank the reviewer for pointing this out. We suggest to change the text from (old: ll. 133 to 134):

“... reported WTD and therefore only these data were used to predict k_0 also with the HPM decomposition module.”

to (note: this sentence also includes changes due to comment 11 of referee 2):

“... include water table depths (WTD) and depths below the surface where litterbags were incubated, in addition to remaining masses and taxonomic information, and therefore only these datasets were used to predict k_0 also with the HPM decomposition module.”

10. **Q:** L201: it should be “consider it as an unknown parameter”.

A: We corrected the text as suggested.

11. **Q:** L285: It is not clear to me in this section if this refers to the estimation of mass lost before the collection of the samples and before the start of the experiment. Can you clarify this? Also, can you explain why samples from the surface are not expected to have lost any mass previously? And how did you estimate mass lost before the experiment for the samples in Prevost et al. (1997)?

A: We thank the reviewer for pointing out that this section is confusing. To answer the questions:

- “It is not clear to me in this section if this refers to the estimation of mass lost before the collection of the samples and before the start of the experiment.”: This section refers to mass lost before the collection of the samples and before the start of the experiment.
- “Also, can you explain why samples from the surface are not expected to have lost any mass previously?” It is generally difficult to separate living from dead *Sphagnum* material because a *Sphagnum* plant grows continuously at the top and dies off continuously at lower parts. This has difficulty is mentioned in several studies [e.g.; Breeuwer.2008], but the litterbag studies included here that use *Sphagnum* material from the surface tried to collect material that has not experienced decomposition yet. Thus, even though separating living from dead parts is poorly standardized, we here assume that experiments that report to have used undecomposed material indeed used undecomposed material.
- “And how did you estimate mass lost before the experiment for the samples in Prevost et al. (1997)?” This is a misunderstanding that may have been caused by the section title. Since the HPM decomposition module assumes that decomposition rates decrease as mass is lost, one has to know how much mass is lost prior to the start of a litterbag experiment to correctly predict its decomposition rate with the HPM decomposition module. Prevost et al. (1997) clearly used material that has experienced decomposition before the start of the litterbag experiment, but the amount of mass lost is unknown because of the nature of the sample (material from a peat core). To avoid this problem, we did not estimate mass lost before the experiment, but we defined a dummy *Sphagnum* species for the samples from the same depth layer and the HPM decomposition module is used to estimate an initial decomposition rate for these dummy species. This way, we account for the prior decomposition loss, making the data compatible with the HPM decomposition module, but do not need to estimate the fraction of initial mass already lost.

To avoid confusion, we suggest the following changes:

- We suggest to change the section title from “Fraction of mass lost during previous decomposition” to “Accounting for mass loss before the start of the litterbag experiments”.
- We suggest to re-write the section to provide more details that answer the questions of the reviewer:

“The HPM decomposition module assumes that decomposition rates decrease the more of the initial mass has already been decomposed (Frolking et al., 2001; Frolking et al., 2010). Thus, if litter lost some mass due to decomposition before the start of the litterbag experiment, one has to know the magnitude of this mass loss to correctly predict decomposition rates with the HPM decomposition module.

Because of the continuous growth of *Sphagnum* at the top and die-off below, it is difficult to separate living material, assumed to not have lost mass, from dead material, which may have already lost some mass. Based on a visual assessment, the studies that used *Sphagnum* material from the surface, assume that the material did not lose mass prior to the litterbag experiments and we follow this assumption ($m(t = 0) = 1$ in equation (2)).

Samples from Prevost et al. (1997) are *Sphagnum* peat collected from two different depth levels from the same location and these samples probably had already experienced some decomposition, however it is difficult to estimate how much. Apart from knowing the exact mass loss prior to the litterbag experiment, an alternative approach to allow predicting decomposition rates with the HPM with previous mass loss is to define a dummy species for a sample, such that the maximum possible decomposition rate for the sample ($k_{0,i}$) is estimated separately. We therefore estimated $k_{0,i}$ separately for each peat layer in Prevost et al. (1997), implicitly assuming that these are two different PFT with different maximum possible decomposition rates.”

12. **Q:** L290: it should be ‘rates’.

A: We corrected the text as suggested.

13. **Q:** L335: Can you please rewrite this sentence without the long dashes, using connectors instead?

A: We replaced each “—” by a “,”.

14. **Q:** L380: it should be ‘predictions’.

A: We thank the reviewer for reporting this typo. We corrected the text as suggested.

15. **Q:** L438: I suggest rewriting this as: ‘With these settings, we predicted five sets of average k_0 : (1) with HPM-leaching ($k_{0,modified(HPM-leaching)}$), and the remaining with (2) c1, (3) Wopt, (4) fmin, and (5) c2 set to their standard value ($k_{0,standard(HPM-leaching)}$).’

A: We thank the reviewer for this suggestion. We changed the text as suggested (new: ll. 378 to 380).

1.2.3 Results:

16. **Q:** L458: instead of ‘less well’ use ‘worse’.

A: We changed the text as suggested.

17. **Q:** L621: Where are the results to support this paragraph?

A: Unfortunately, it is not clear what the reviewer means. The paragraph is:

“In model HPM-leaching, we included a logistic regression model that estimates the relation between l_0 and the degree of saturation. The parameter estimates suggest that both positive and negative relations of l_0 to the degree of saturation are compatible with available litterbag data (95% confidence intervals for the slope (logit scale): (-0.28,0.15)). Thus, available litterbag data do not allow to conclude whether l_0 are positively related to the degree of saturation or not.”

The result that we report is that the 95% confidence interval clearly contains 0 and a range of negative and positive estimates for the relation between μ_l and the degree of saturation and we do not think the paragraph makes any statement that would not be supported by this result.

1.2.4 Discussion:

18. **Q:** L788: I suggest rewriting this as ‘Previous global and local sensitivity analyses, where HPM parameter values and environmental conditions were varied in broad ranges, ...’.

A: We thank the reviewer for this suggestion. We changed the text accordingly (new: ll. 596 to 597).

19. **Q:** L814: Is *Sphagna* correct or is this a typing error? I do not think you can make scientific genera plural.

A: We agree that it is more appropriate to write “*Sphagnum* species” instead. We changed the text accordingly.

20. **Q:** L839: I suggest rewriting this as ‘We suggest the following steps to improve accuracy when estimating peatland decomposition module parameters:’.

A: We thank the reviewer for this suggestion. We changed the text accordingly (new: l. 640).

21. **Q:** L879: I think this section needs at least a sentence that clearly states your suggestions on how to decrease errors in k_0 and l_0 .

A: This is the topic of Teickner et al. (2025). We agree that the sentence can be improved. We suggest to change (old: ll. 588 to 589):

“Future litterbag experiments that aim to improve peatland models should reduce errors of k_0 and l_0 estimates (e.g., Teickner et al., 2025)”

to:

“Future litterbag experiments that aim to improve peatland models should reduce errors of k_0 and l_0 estimates. A first step would for example be to modify litterbag experiments as described in Teickner et al. (2025).”

22. **Q:** L913: Can you explain what you mean by ‘Studies that systematically change litter chemistry within species’?

A: We mean studies that change in litter chemistry by changing growth conditions, for example different N supply, CO₂ concentration, or moisture conditions (e.g., Siegenthaler et al., 2010; Straková et al., 2010) or that observe systematic differences in litter chemistry under different environmental conditions [e.g.; Bengtsson et al. (2018)]. We suggest to include “(e.g., Siegenthaler et al., 2010; Straková et al., 2010)” in this sentence (new: l. 680).

1.2.5 Conclusions

23. **Q:** L930: I suggest rewriting this as ‘Based on the litterbag data, our estimates of the degree of saturation where decomposition is optimal (Wopt) and the anoxia scale length (c2) are significantly larger than the standard parameter values.’

A: We thank the reviewer for the suggestion and changed the text accordingly (new: ll. 696 to 697).

1.2.6 Supplement

24. **Q:** S3: The x axis label of Figures S1 and S2 should be ‘Remaining mass (%)’.

A: We changed the axis labels as suggested.

25. **Q:** S5 and S8: The captions in Figure S10, S11, and S16 are backwards, (a) and (b) should be interchanged.

A: We thank the reviewer for pointing out this mistake. We corrected the figure captions as suggested.

2 Additional changes

1. In Fig. S2 and S4, we changed the title of the first panel from “HPM-standard” to “LDM-standard”.
2. In l. 513 (old), we changed “... and in addition similar across these (independent) studies ...” to (new: l. 522) “... and in addition similar across independent studies ...”.
3. In l. 530 (old; new: l. 539), we added the panel label “(b)” to the figure cross-reference.
4. In l. 534 (old; new: l. 543), we corrected the figure cross-reference from “supporting Fig. S15” to “Fig. 7 (a)”.

References

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- van Breemen, N.: How *Sphagnum* bogs down other plants, 6, 1995.

Reply to Anonymous Referee #2 for “Peat Oxic and Anoxic Controls of Sphagnum Decomposition Rates in the Holocene Peatland Model Decomposition Module Estimated from Litterbag Data”

Henning Teickner^{1,2,*}

Edzer Pebesma²

Klaus-Holger Knorr¹

05 March, 2025

¹ ILÖK, Ecohydrology & Biogeochemistry Group, Institute of Landscape Ecology, University of Münster, 48149, Germany

² IfGI, Spatiotemporal Modelling Lab, Institute for Geoinformatics, University of Münster, 48149, Germany

* Correspondence: Henning Teickner <henning.teickner@uni-muenster.de>

Comments made by the reviewer start with a bold **Q** while our reply starts with a bold **A**. In section “Additional changes” we list additional changes we would like to incorporate in an updated version of the manuscript.

1 Reply to comments

1. **Q:** Dear Authors,

Thanks for your response and the modified manuscript. I think I now understand better what you did and what the litterbag model is, and therefore, also the text in general is clearer. However, I find especially the Method part of the text should still be clarified regarding different models. It was still difficult to follow which model you talk about and what are the differences between different models. Perhaps one of the reasons for the confusion was that you mention separately the HPM decomposition model and the litterbag decomposition model LDM, and in addition there are four different versions of models that combine those two - but their names only include ‘HPM’. I would understand this if you only used their HPM decomposition module, with the new parameters, to predict decomposition rates, but that’s not the case. For example, Fig.2a has titles HPM-peat, HPM-all and HPM-leaching, but the caption says the remaining masses are predicted by the litterbag decomposition model, not

HPM. I found this confusing. So, I hope you find a way to differentiate still more clearly the different models.

A: We thank the reviewer for this suggestion. We changed the names of the different model versions as suggested by referee 3 (from the first round of reviews). In the first version of the manuscript, we had model names that contained more information, but we agreed with referee 3 that it is better to use simple model names that are easier to parse and remember instead of trying to encode all the information about the models in these abbreviations. We therefore do not think that it makes sense to make the model abbreviations more complex again.

We hope that Tab. 3 provides a concise summary of what the different models contain and how they differ and we think that the Methods section now describes the different models in a comprehensive way. We think that this is a good compromise between the need for a more complex modeling strategy to test the HPM decomposition module against heterogeneous data and making our analysis as easy to follow as possible. For example, regarding the example of Fig. 2 (a), the models HPM-peat, HPM-all and HPM-leaching are described in Tab. 3 and there, it is clearly described that they contain the litterbag decomposition model as prior and also what the litterbag decomposition model is.

2. **Q:** I don't go through point-by-point my previous comments since you re-wrote many parts of the manuscript. But here are more specific comments for this version: Around line 54: Please describe briefly what is a litterbag experiment and what kind of data it produces (litter masses etc.), it's not necessarily a familiar concept for all readers.

A: We thank the reviewer for this suggestion. We suggest to change ll. 53 to 55 (old) from:

“The predictions can be compared to decomposition rates estimated from litterbag data and therefore future litterbag studies can directly test whether discrepancies identified in such a test are replicable.”

to (new: ll. 52 to 56):

“Decomposition rates can also be estimated from litterbag experiments, where a known initial mass of litter is filled into mesh bags, incubated in peat, excavated after some time, and re-weighed to estimate the mass loss due to decomposition. Therefore, predicted decomposition rates can be compared to decomposition rates estimated from litterbag experiments and replicability of any identified discrepancies can be directly tested in future litterbag studies.”

3. **Q:** Line 60-62: I find it slightly inaccurate to write that a parameter can result in a doubling of accumulated C. Do you mean that a minor change in the parameter value can result in the doubling of accumulated C?

A: We agree that it is more correct to state that a change in a parameter value causes changes in some target quantity. We suggest to change the text from (old: ll. 60 to 63):

“Previous sensitivity analyses of the HPM and applications to peat cores suggest that the anoxia scale length (c_2), the parameter controlling how anaerobic decomposition rates are limited by electron acceptor depletion and accumulation of decomposition products, can result in a doubling of accumulated C, depending on climate conditions (Frolking et al., 2010; Quillet et al., 2013; Kurnianto et al., 2015).”

to (new: ll. 61 to 64):

“Previous sensitivity analyses of the HPM and applications to peat cores suggest that relative small changes to the anoxia scale length (c_2), the parameter controlling how anaerobic decomposition rates are limited by electron acceptor depletion and accumulation of decomposition products, can result in a doubling of accumulated C, depending on climate conditions (Frolking et al., 2010; Quillet et al., 2013; Kurnianto et al., 2015).”

4. **Q:** Line 76: Please define here briefly what a litterbag decomposition model is. Is it e.g. any model that takes as input data from a litterbag experiment and outputs the mass loss of the litter as function of time? Can you add a reference/references to model(s) other than yours?

A: We suggest to change the sentence from (old: ll. 75 to 76):

“Since decomposition rates have been estimated with different litterbag decomposition models in previous studies, their values are not directly comparable.”

to (new: ll. 76 to 77):

“Since decomposition rates in litterbag experiments have been estimated with different litterbag decomposition models in previous studies, their values are not directly comparable.”

We do not cite our litterbag decomposition model in the referenced sentence and we do not think that specific references are required here.

5. **Q:** Point 7. of my first review (and here line 83 onwards): The problem with the sentence maybe is that the text above seems to talk about peatland models in general, but here you refer specifically to “model compatible with the HPM”. So I get confused about why in general, for all models, compatibility with the HPM is relevant. In addition, I think it would be good to shortly write here what it means that a litterbag decomposition model is compatible with HPM, like you explained in your response letter.

I mean, would e.g. something like this be correct, line 83-: “Even though tests of only a part of the HPM are less uncertain than tests of the whole model, there still is a risk that they are dominated by uncertainties. Remaining masses in litterbag experiments are often very variable, even under controlled environmental conditions (e.g., Bengtsson et al., 2018). In addition, for many litterbag experiments, a range of decomposition rates may produce similar predictions for remaining masses (e.g., Yu et al., 2001), also when the litterbag decomposition model is compatible with HPM, i.e., uses the same equation as HPM to describe mass losses (Teckner et al., 2025a).”

A: We thank the reviewer for the clarification. We suggest to change the sentence from (old: ll. 84 to 87):

“Remaining masses in litterbag experiments are often very variable, even under controlled environmental conditions (e.g., Bengtsson et al., 2018), and for many litterbag experiments, a range of decomposition rates may produce similar predictions for remaining masses (e.g., Yu et al., 2001), also if a litterbag decomposition model compatible with the HPM is used (Teickner et al., 2025).”

to something similar as suggested by the reviewer (new: ll. 85 to 89):

“Remaining masses in litterbag experiments are often very variable, even under controlled environmental conditions (e.g., Bengtsson et al., 2018), and for many litterbag experiments, a range of decomposition rates may produce similar predictions for remaining masses (e.g., Yu et al., 2001), also if a litterbag decomposition model compatible with the HPM, i.e. that uses equation (7) in Frolking et al. (2010) to describe decomposition mass losses, is used (Teickner et al., 2025).”

6. **Q:** Line 91: Is it only to estimate uncertainties or also parameter values?

A: We think that the reader knows that Bayesian methods can be used to estimate parameters. The referenced sentence and the previous sentence explicitly refer to parameter uncertainty (parameter errors) and therefore, we only mention parameter uncertainty here.

7. **Q:** Line 96: Larger than what?

A: We suggest to change “larger” to “large”. We did not want to make a comparison, but give a statement that the discrepancies exceed a threshold considered as ecologically significant.

8. **Q:** Line 112: Please specify what “these studies” are.

A: We mean “the litterbag studies” and suggest to change the text accordingly.

9. **Q:** Lines 119-124: I’d rather put this into conclusions.

A: The referenced paragraph is: “We only test the decomposition module of the HPM, but the decomposition modules of many other peatland models are also parameterized based on litterbag experiments and our modeling approach is flexible enough to be combined with other decomposition modules. Therefore, our test could serve as a blueprint for similar tests of other peatland model decomposition modules. Similarly, the parameter discrepancies identified here suggest future litterbag experiments that would provide novel insights into oxic and anoxic controls of *Sphagnum* decomposition rates and our study therefore suggests a strategy to improve decomposition modules in general.”

We think that it is useful to use the last paragraph in the Introduction to circle back to the broad topic or problem a paper tries to address in order to describe what the study contributed to this broad topic or problem.

10. **Q:** Figure 1 caption: Please move the (μ_k) after “average decomposition rates”, and explain why there are the arrows from the bottom (from $\mu_m(t)$) back to the top.

A: We changed the position of “ (μ_k) ” as suggested. We changed “The equation at the bottom uses these to estimate remaining masses in the litterbag experiments.” to “The equation at the bottom uses these to estimate remaining masses as reported in the litterbag experiments.” to clarify that the arrows indicate that estimates are conditional on observations.

11. **Q:** Line 133: Is it so that “these data” means *Sphagnum* PFT, WTD and depth of litter sample below water table from these studies? No litter masses? I suggest this is mentioned clearly here, because it helps to understand the difference between HPM and litterbag decomposition model.

A: The referenced sentence is: “Data from Johnson and Damman (1991), Szumigalski and Bayley (1996), Prevost et al. (1997), Straková et al. (2010), Golovatskaya and Nikonova (2017), and Mäkilä et al. (2018) reported water table depths (WTD) and therefore only these datasets were used to predict k_0 also with the HPM decomposition module.”

As illustrated in Fig. 1, we used only data from litterbag studies where at least remaining masses and *Sphagnum* PFT were reported. These data were used to estimate the litterbag decomposition model. If a study in addition reported WTD and the depth of the litter sample below the peat surface, it was used to estimate μ_k with the HPM decomposition module (and hence parameters of the HPM decomposition module).

To avoid confusions, we suggest to change the sentence to (new: ll. 133 to 137):

“Data from Johnson and Damman (1991), Szumigalski and Bayley (1996), Prevost et al. (1997), Straková et al. (2010), Golovatskaya and Nikonova (2017), and Mäkilä et al. (2018) include water table depths (WTD) and depths below the surface where litterbags were incubated, in addition to remaining masses and taxonomic information, and therefore only these datasets were used to predict k_0 also with the HPM decomposition module ...”

12. **Q:** Title of 2.2: It seems you also describe the litterbag decomposition model under this title, so perhaps remove “with the Holocene Peatland Model” or add “and the litterbag decomposition model”?

A: We thank the reviewer for this suggestion. We moved part of the former section 2.2.2 to a new section 2.2 (“Modeling remaining masses and decomposition rates with the litterbag decomposition model”) to better separate the description of the litterbag decomposition model from the HPM decomposition module. The new section 2.3 (former section 2.2) now has the title “Prediction of litterbag decomposition rates with the Holocene Peatland Model decomposition module”. We made some smaller adjustments to make the text fit the new section structure.

13. **Q:** Lines 153-179: If this is now description of your litterbag decomposition model, please mention it clearly here. It seems that from line 180 onwards you describe the HPM decomposition module.

A: We thank the reviewer for this suggestion. We hope that our reply to the previous comment addresses this issue.

14. **Q:** Line 193: Please write what model is “our model” in this case, whether it is the litterbag decomposition model or HPM decomposition module.

A: It is neither the litterbag decomposition model nor HPM decomposition module, but the combination of both, as illustrated in Fig. 1.

To clarify this, we suggest to change (old: l. 193):

“In our model, k_0 estimated from the litterbag data for each litterbag experiment ...”
to (new: l. 197):

“In our model that combines the HPM decomposition module and the litterbag decomposition model, k_0 estimated from the litterbag data for each litterbag experiment ...”

15. **Q:** Line 204: I don’t understand what you mean. What is the difference between estimating HPM decomposition module parameters and adjusting decomposition rates to the HPM decomposition module?

A: We tried to express the difference between how parameters are constrained by data (estimated) and by a prior (adjusted). Since we use the HPM decomposition module as hyper-prior (a prior that is estimated from data), both the HPM decomposition module parameters are constrained by the remaining masses of the litterbag experiments and the decomposition rates estimated with the litterbag decomposition module are constrained by the HPM decomposition module prior. We hope to clarify the sentence by changing it from:

“Moreover, combining the litterbag decomposition model and the HPM decomposition module into one Bayesian model does not only estimate HPM decomposition module parameters from the litterbag data, but it also adjusts the decomposition rates estimated from litterbag data to the HPM decomposition module because the HPM decomposition module serves as prior in the combined model which therefore estimates what parameter values are compatible with the data and the combined model.”

to (new: ll. 206 to 210) (changing the word “adjusts” to “constrains”):

“Moreover, combining the litterbag decomposition model and the HPM decomposition module into one Bayesian model does not only estimate HPM decomposition module parameters from the litterbag data, but it also constrains the decomposition rates estimated from litterbag data by the HPM decomposition module because the HPM decomposition module serves as prior in the combined model which therefore estimates what parameter values are compatible with the data and the combined model.”

We made similar changes in l. 353 (new: l. 363).

16. **Q:** Line 262: Can you say - for clarity - shortly that HPM-standard is the HPM with standard values, instead of that it corresponds to it?

A: We thank the reviewer for this suggestion and changed the text accordingly.

17. **Q:** Line 264-265: I don't quite understand the logic of this sentence. Even though the parameters of HPM-standard were used as priors for the litterbag decomposition model, wouldn't it itself remain independent of litterbag data?

A: For all model versions except HPM-standard, the HPM decomposition module is a prior for the litterbag decomposition rates which has parameters that are estimated from litterbag data. Therefore, the HPM decomposition module depends on the litterbag data when it is used as prior.

18. **Q:** Lines 282-285: Please re-formulate this sentence, it is too long.

A: As suggested by referee 3, we replaced each “—” by a “,”, and hope that the sentence is now better to understand.

19. **Q:** Line 285: Please define briefly, what tea bags.

A: We do not think that “tea bag” needs to be defined. For details on the experiments, we refer to Lind et al. (2022).

20. **Q:** Line 329: I don't understand why HPM-standard can't predict remaining masses. Why do you need the litterbag decomposition model to get the prediction?

A: The referenced sentence is: “To analyze how well the models fit remaining masses observed in the litterbag experiments, we plotted reported remaining masses versus remaining masses estimated by the litterbag decomposition model in HPM-peat, HPM-all, and HPM-leaching. HPM-standard is not linked to the litterbag decomposition model and therefore does not predict remaining masses.”

HPM-standard is the HPM decomposition module (without litterbag decomposition model). The HPM decomposition module as defined in our study does not predict remaining masses (see the new section 2.2.2). As described in section 2.2.1, the HPM (note: this is more than the HPM *decomposition module*) has an equation to predict remaining masses, but as also described there, this equation does not account for initial leaching losses which need to be considered in order to get unbiased decomposition rate estimates, and it does not account for remaining variations in remaining masses observed in litterbag experiments. Therefore, HPM-standard cannot predict remaining masses because it needs to be linked to a litterbag decomposition model, which is the purpose of HPM-peat (see Tab. 3).

21. **Q:** Line 331: Plot similar to what?

A: The referenced sentence is: “To analyze how well all HPM decomposition module versions fit k_0 estimated by the respective litterbag decomposition model, we created a similar plot for k_0 .”

“similar plot” refers to the plot mentioned directly above in:

“To analyze how well the models fit remaining masses observed in the litterbag experiments, we plotted reported remaining masses versus remaining masses estimated by the litterbag decomposition model in HPM-peat, HPM-all, and HPM-leaching. HPM-standard is not linked to the litterbag decomposition model and therefore does not predict remaining masses.”

22. **Q:** Lines 378-381: I think here is a contradiction. You seem to refer to all litterbag decomposition models, also LDM-standard, because according to Table 3, it was the only one that did not use HPM parameters as priors. However, LDM-standard is not in Fig. 2a.

A: It is true that we refer to all litterbag decomposition models, also LDM-standard, and it is also true that predictions of LDM-standard are not shown in Fig. 2 (a). However, results for LDM-standard are shown in Fig. S2 which is also cross-referenced in the same sentence. We could have included a plot for LDM-standard in Fig. 2 (a), but we did not do so to avoid confusions with Fig. 2 (b), where estimates of LDM-standard are the x-axis value of the first panel. We therefore decided to refer to the supporting information here. If the editor thinks that it would be better to also include a panel for LDM-standard in Fig. 2 (a), we will do so.

23. **Q:** Line 382: You write that “when the HPM decomposition module is not used as prior”. Again I’m slightly confused: I would have thought it’s not relevant whether it was used as prior or not, but the relevant factor is that it used the default parameters. But perhaps I misunderstood this.

A: We hope that our reply to comment 17 above addresses this issue. As stressed in sections 3.1 and 3.2, the worse fit of HPM-standard mentioned in the sentence referenced by the reviewer is not necessarily a cause of using HPM decomposition module standard parameters. Indeed, HPM-peat, better fits k_0 estimated with the litterbag decomposition module included in HPM-peat, but still sets HPM decomposition module parameters to their standard values and does not estimate them from data. Therefore, what is relevant here, is whether the HPM decomposition module is used to constrain estimates from the litterbag decomposition model (= is used as prior for the litterbag decomposition module) or not.

24. **Q:** Section 3.3: You don’t explain results related to c_1 .

A: It is true that we only mention that estimates for c_1 in either model version are compatible with the standard parameter values (section 3.3) and that this parameter does not cause qualitative differences in how k_0 change in dependency of the WTD (section 3.5). For this reason, we decided not to discuss these results in more detail.

25. **Q:** Lines 483-487: I was wondering whether observational data about the initial leaching losses could be compared with your results or whether they could be used as a constraint for the l_0 results. Did you consider that?

A: We thank the reviewer for this suggestion. If data on initial leaching losses were available, we would have used them to constrain l_0 estimates and this would have solved a lot of problems (in particular this would have made k_0 estimates by the litterbag decomposition model more accurate and therefore HPM decomposition module parameters would have been estimated more accurately, too). However, it would have been necessary to have precise l_0 estimates for the litterbag experiments since the magnitude of l_0 probably depends a lot on properties of the litter samples used in the experiment and how they were preprocessed (Teickner et al., 2025). This is mentioned in point 4 of section 4.4 of our manuscript here.

26. **Q:** Line 528 and 532: ModGberg

A: This abbreviation for the modified Granberg model was introduced in l. 234 (old; new: l. 238).

27. **Q:** Line 660 onwards: I think that yes, it would be good to have litterbags in constant anoxia, but deep depths as such are perhaps not so relevant for fresh *Sphagnum* litter since peat deep in the soil is probably quite old.

A: As shown in Fig. 7 and described in Tab. 1, the HPM decomposition module implies that there is a gradual change in anaerobic decomposition rates with distance below the average annual WTD due to a gradual change in availability of terminal electron acceptors and concentration of decomposition end products and it implies that this change is independent of the litter quality.

As stated in ll. 660 to 668, our suggestion does not aim to provide decomposition rate estimates that are representative for natural conditions (as the reviewer seems to suggest), but it describes how one can estimate the hypothesized gradient in anaerobic decomposition rates with distance below the average annual WTD as accurately as possible; a necessary condition for this is that the same litter type is used across the entire depth gradient, since different litter types may have different decomposition rates under the same environmental conditions.

Of course, one could use already decomposed peat (*Sphagnum* litter) for this, but because this material has smaller decomposition rates even under aerobic conditions (due to a decreased litter quality due to previous decomposition), it would result in smaller mass losses and therefore differences in decomposition rates across the gradient cannot be detected as accurately as would be the case with litter with larger decomposition rate. Moreover, *Sphagnum* litter is much easier to standardize than already decomposed peat and therefore experiments with already decomposed peat are less replicable. Therefore, it makes more sense to use fresh *Sphagnum* material or any other litter with not too small decomposition rate (assuming the HPM decomposition module assumption that the gradient is independent of the litter type is true). Only then, when the gradient has been estimated more accurately, the gradient of anaerobic decomposition rates for older peat can be estimated by using $k_{0,i}$ estimates for older peat samples (see also equation (5)).

2 Additional changes

1. In Fig. S2 and S4, we changed the title of the first panel from “HPM-standard” to “LDM-standard”.
2. In l. 513 (old), we changed “... and in addition similar across these (independent) studies ...” to (new: l. 522) “... and in addition similar across independent studies ...”.
3. In l. 530 (old; new: l. 539), we added the panel label “(b)” to the figure cross-reference.
4. In l. 534 (old; new: l. 543), we corrected the figure cross-reference from “supporting Fig. S15” to “Fig. 7 (a)”.

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