

Discussion of “Seasonal dynamics of vegetation effect on peatland surface energy balance”

By Flemming et al.

Author Response to Review #1

(Reviewer’s comments are marked in black and author’s responses are marked in blue.)

The manuscript “Seasonal dynamics of vegetation effect on peatland surface energy balance” by Flemming et al. report energy fluxes and look into their drivers at a restored peatland using 1 year of eddy covariance data. Despite the topic is interesting, the manuscript is very poorly written with confusing justification on hypotheses, weak analyses to support tests of hypotheses, and messy abstract, introduction, and discussion. Additionally, the results are quite trivial that radiation is the most important driver of LE and VPD can additionally exert impacts on LE via biotic controls are very well known. Furthermore, there’s no discussions on limitations of analyses while the authors only used 1 year of data and didn’t consider lagging effects. I am afraid to say the manuscript has many fundamental issues that the authors have to address. I was not able to finish reading the entire manuscript because all the confusions from the fundamental parts. I strongly encourage the authors to put substantial efforts into refining the manuscript to make it matching the quality of *Biogeosciences*. Here are my major comments:

Response: We thank the reviewer for their constructive feedback. We will carefully consider all comments and substantially revise the manuscript to improve clarity, analytical rigor, and the positioning of the study. While radiation is an important control, evapotranspiration (ET), or latent energy (LE) in energy units, exhibits complex responses to environmental conditions, particularly through the physiological regulation of vegetation under interacting humidity and temperature constraints. Investigating these biotic and abiotic controls was a central objective of our study, especially given the limited number of studies that have explicitly examined the drivers of LE in peatland ecosystems. We acknowledge that this objective was not sufficiently articulated in the original submission. Guided by the reviewer’s comments, we will substantially revise the manuscript to clarify our research questions, hypotheses, and conceptual framing.

In addition, we will extend the analysis from one year to three years, using the most recent observations from the study site. This expanded dataset should strengthen the robustness of our results and broaden the scope of the study.

We appreciate the reviewer’s encouragement to improve the manuscript and will implement substantial revisions to ensure that it meets the quality standards of *Biogeosciences*. We consider all comments feasible and would like to provide a detailed, point-by-point response outlining how we will revise the manuscript according to the reviewer’s comments.

[Major comments]

1. Abstract is not well written

As the first piece to be seen for a manuscript, a nicely constructed abstract is critical. However, the current iteration has many errors and confusing spots that make it difficult for readers to get the importance of this study.

Response: We will rewrite the abstract to improve the clarity and sharpen the focus on the key findings of the study. We will reflect the changes we make in the text, in response to the following comments, also in the abstract.

- The goal of this study is not clear. The authors said “energy fluxes in these ecosystems are strongly influenced by climate conditions” but wanted to “separate the influence of climate and vegetation remains challenging”. If it’s strongly influenced by climate conditions, why is it necessary to separate vegetation effects?

Response: The primary focus of this manuscript is on LE fluxes, which represent ET, and on disentangling how these fluxes are regulated by both biotic and abiotic drivers, particularly through vegetation physiological responses. We acknowledge that this focus was not sufficiently articulated in the original version. We will revise the manuscript to clearly state this objective and ensure that the scope and intent of the study are unambiguous.

- Linked to the previous point, by saying only GLSAR, it’s unclear how it can do the separation.

Response: The generalized least squares models with autoregressive error (GLSAR) model enables us to deal with temporal autocorrelation, which arises, for example, from energy storage in soil. We will make sure this point is clarified.

- I can’t follow the justification of jumping from surface energy fluxes to LE, how about sensible heat flux (H)? Isn’t vegetation also affecting H, e.g., leaf wetness, structure (subjecting to what species), etc? And how can you claim both GPP and VPD must be jointly considered in analyses of “turbulent energy fluxes” in the end?

Response: We agree with the reviewer that the previous phrasing was unclear. We will revise the text to clearly state that the focus of the study is on LE fluxes and on disentangling plant physiological controls from their climate drivers – an approach that remains largely unexplored in peatland ecosystems. To avoid ambiguity, we will remove confusing wording throughout the manuscript. In addition, we will revise the title to “Disentangling biotic and abiotic drivers of evaporative cooling in drained bogs” to ensure that the central objective of the study is clearly communicated from the outset.

- The authors specifically mentioned that abiotic drivers were evaluated using daily and seasonal patterns; however, not for biotic ones but only saying “continuous time series”.

Response: To assess vegetation physiological responses of LE and disentangle biotic from abiotic controls of LE, we derived a continuous time series of canopy conductance (g_c) by inverting the Penman-Monteith equation using 30-minute LE fluxes measured with the eddy covariance, which have been averaged to daily values. This approach enabled us to estimate daily g_c alongside gross primary production (GPP) and continuous daily meteorological variables, including net radiation (R_n), air temperature (T_a), vapor pressure deficit (VPD, i.e., atmospheric dryness), and water table depth

(WTD), at a daily temporal resolution. Averaging to daily values is used to remove daily fluctuations and the associated autocorrelation. We then quantified the relative effect sizes of biotic and abiotic drivers using GLSAR structures to account for remaining temporal autocorrelation.

We will revise the manuscript to ensure that this methodological framework and its rationale are clearly described.

- How did seasonal variations in vegetation productivity exert a strong influence on mean daily LE (Line 18-19)? And is vegetation productivity here GPP? And what's the temporal scale of LE dynamics (the end of Line 19) then?

Response: Yes, GPP represents vegetation productivity at the canopy scale. Both LE and GPP fluxes were measured at a 30-minute temporal resolution. We will clarify these points explicitly in the methods section. Additionally, we will clarify that seasonal variations in vegetation productivity exerted a strong influence on mean daily LE. GPP was the primary driver during the growing season (effect size = 8.7), whereas its influence was minimal during the non-growing season (effect size = 0.5). This linkage will be more clearly described in the revised manuscript.

- How did the “nonlinear” effect determine (Line 21)?

Response: Generally, the effect of VPD on g_c is not linear e.g., as observed in forests Gharun et al. (2015), in peatlands Speranskaya et al. (2024), and specifically for the main vegetation species found in our study site (Gobin et al., 2015)). While the correlation is positive at first, above a certain threshold (around 7 hPa in this study), g_c declines with rising VPD. This non-linear response of g_c (and consequently LE) to VPD which is governed by plant physiological response to immediate changes in atmospheric dryness, makes the understanding LE response to changes in the environment, a challenging task. Our objective in this study was to find the nature of this relationship and find the limiting threshold for drained bogs. We will make sure this point is clarified throughout the text.

- Mix used of present and past tense

Response: We will revise the manuscript to ensure consistent and appropriate tense usage throughout the text.

2. Similarly, the introduction was not well structured and does not solve issues in the abstract

- The author spent more than 50% of the introduction stressing the importance and drivers of LE, but suddenly said they would investigate energy flux partitioning (Line 53)?

Response: We agree with the reviewer that the structure of the introduction and the transition in focus were not sufficiently clear. The manuscript is centered on LE fluxes rather than on the partitioning of turbulent energy fluxes. The reference to energy flux partitioning was therefore misleading and will be removed in the revised version.

In the revised version, we will restructure the introduction to maintain a clear and consistent focus on LE throughout. We will also refine the research questions to explicitly state that the objective is to disentangle biotic and abiotic controls on LE. These revisions will ensure better alignment between the introduction, the abstract, and the overall scope of the study.

- The entire second paragraph (Line 40-49) contains many pieces of information but no convergence. What is the purpose of saying knowledge gap in Central European then importance of WTD, Rn, VPD, and vegetation?

Response: We will streamline this paragraph to clarify the knowledge gap that currently exists in our understanding of the importance of climatic versus vegetation physiological effect on peatland latent heat fluxes. We will make sure the text reads coherent.

- Hypotheses (b) and (c) are very confusing. So, if Rn is the most important driver, why is it even necessary to know canopy conductance can have the greatest influence on LE in spring? Readers can get confused, why did you focus on unimportant drivers?

Response: We agree that the wording here was confusing. The comparison of biotic versus abiotic controls of LE in peatland ecosystems is not clear, which creates a knowledge gap particularly in the face of climate change and rising drought conditions. We will address this by rewriting the text.

- Where's the elaboration on importance of separating climate and vegetation control on LE? This is your first sentence in the abstract.

Response: We will revise the introduction and add a paragraph on the importance of disentangling the biotic from abiotic drivers of LE in peatland ecosystems.

- Gerling et al., (2019) looked into soil moisture and ET but not WTD

Response: Thanks for pointing that out. We will remove Gerling et al. 2019 as a reference.

3. Weakly linked hypotheses and tests

Ignoring the confusing hypotheses mentioned above, it's very difficult to find justification of how those analyses in the methods test the hypotheses. Here I put the hypotheses:

(a) LE exceeds H in summer, while the opposite holds in winter, due to higher VPD and active vegetation during the growing season

(b) Rn is the primary driver of LE, as global radiation is the main energy source for the ecosystem

(c) canopy conductance (g_c) – and its influence on LE – is greatest in spring, when leaves are fully developed but stomatal regulation is still weak under low VPD conditions.

Response: Thank you for this comment. We understand how the wording has been confusing. We will streamline the research questions and clarify that our objectives are to: 1) explore the daily and seasonal dynamics of LE, 2) quantify the influence of biotic drivers (GPP, g_c) and abiotic drivers (R_n , VPD, T_a , WTD) to LE, and 3) find physiological thresholds at which g_c limits LE due to increase in atmospheric dryness (VPD).

- The authors first surprisingly added 2 sentences (Line 131-132) on testing VPD control on g_c . What's the purpose? Influence of g_c on LE is not confirmed at all.

Response: In the context of climate change and rapid increase in frequency and intensity of drought events, the response of ecosystem LE depends strongly on reaction of vegetation to drier air (i.e., increased VPD). We will add a paragraph in the introduction section where we will introduce potential transpiration strategies of the main species found in the peatland of study with relevant references to support the text.

- In Section 2.6, the final analysis, the authors said they examined the biotic and abiotic variables influencing LE by including R_n , GPP, VPD, T_a and WTD. Then where to test the link of g_c to LE? And GPP is the only biotic factor, why spending that many efforts to obtain g_c ?

Response: We agree that the previous wording was unclear. In the revised manuscript, we will explicitly state that g_c was estimated as key biotic regulator of LE, alongside GPP. We will also clarify the rationale and implications of deriving g_c in the preceding sections (see our responses above), so that its role in the overall framework is clearly motivated.

Importantly, we will explain that the effect of g_c on LE is analyzed separately and not included in the GLSAR models. Because g_c is derived by inverting the Penman-Monteith equation and therefore already incorporates R_n . Including both, R_n and g_c within the same GLSAR framework would introduce statistical circularity and violate model assumptions. This methodological reasoning will be clearly described in the revised methods section.

4. Messy uses of abbreviations

The authors either defined an abbreviation but not using it consistently or randomly use abbreviations without definitions. Here are some examples, and I don't think it's reviewer's task to do this typesetting, and it's greatly disrupting my reading.

Line 33: You just acronymized transpiration

Line 56: You've defined EC. Check all the following lines (e.g., 74, 76, ...)

Line 85: Subscript 2 and what's GPP?

Table 1: What's PAR?

Line 98: You've defined P

Line 117: You've defined evaporation

Line 119: You've defined precipitation

....

Response: Thanks for pointing us to this oversight. We will check all abbreviations and make sure naming and descriptions are consistent throughout the text.

5. The manuscript was not even finished properly

Why is there only one subsection (4.1) and why aren't discussions on other hypotheses in independent subsections? Why is the overall conclusion (Line 358-361) ended so casually? And why is it included in subsection 4.1 (Drivers of latent energy)?

Response: We thank the reviewer for pointing this out. It appears that due to multiple versions, individual parts of the discussion have been lost in the submitted version. In the revised manuscript, we will ensure that the discussion is fully restored and properly structured. Each research objective will be addressed in clearly defined and logically ordered subsections, with appropriate headings that reflect their content. We will also separate the overall conclusion from subsection 4.1 ("Drivers of latent energy") and present it as a distinct concluding section that synthesizes the main findings and their broader implications. This restructuring will improve clarity and coherence of the manuscript.

6. Missed mentioned limitations

Do you think your findings will stand when another year of data is included? Where could be the limitations? Do you think lagging effects can be significant, why and why not?

Response: Since the initial analysis, we have obtained two additional years of energy flux measurements at the study site. We will incorporate this latest data (until 31.12.2025) to extend the study from a single year to three consecutive years of continuous observations. All relevant sections of the manuscript will be updated accordingly, including a discussion of the limitations and the scope of our findings. We expect that the additional data will strengthen the robustness of our results.

[Minor comments]

Line 11: What does d mean here? ... the periods "d" when ...

Response: " d" was a typo and will be removed.

Line 24: SOC is not needed, only used once

Response: The abbreviation will be removed.

Line 29-30: This should go with Line 25-26

Response: We will move the text in line 29-30 to before text in line 25-26.

Line 33: italicize “Betula spp.”

Response: Font will be corrected.

Line 41: What’s LE? Not defined yet in the main text.

Response: Abbreviation will be defined in the text.

Line 144: “two separating the growing season (March 15 to October 15) from the non-growing season” reads very awkwardly. So it’s “2 growing seasons” or “2 seasons with 1 growing season and 1 non-growing season”?

Response: We will re-write the sentence to: “Three models were fitted: one covering the entire year 2023, a second model covering the growing season (March 15 to October 15), and a third model covering the non-growing season (January 1 to March 14 and October 16 to December 31).”

References

Gerling, L., Weber, T.K., Reineke, D., Durner, W., Martin, S., Weber, S., 2019. Eddy covariance based surface-atmosphere exchange and crop coefficient determination in a mountainous peatland. *Ecohydrology* 12 (1), doi: 10.1002/eco.2047

Gharun, M., Turnbull, T.L., Pfautsch, S., Adams, M.A., 2015. Stomatal structure and physiology does not explain differences in water use among montane eucalypts. *Oecologia* 177, 1171-1181, doi: 10.1007/s00442-015-3252-3

Gobin, R., Korboulewsky, N., Dumas, Y., Balandier, P., 2015. Transpiration of four common understorey plant species according to drought intensity in temperate forests. *Annals of Forest Science* 72 (8), 1053-1064, doi: 10.1007/s13595-015-0510-9

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