

CO₂ and CH₄ budgets and global warming potential modifications in *Sphagnum*-dominated peat mesocosms invaded by *Molinia caerulea*

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Leroy and co-authors present a re-analysis of previously published greenhouse gas flux data to model and estimate greenhouse gas budget (for CO₂ and CH₄) of mesocosms derived from a *Sphagnum* bog in France subject to invasion by a vascular plant in the genus *Molinia*. The experimental design and gas flux data are shared with two previous publications with the same first author and many of the co-authors. The novelty presented in this study is the modelling of temperature and water and the addition of the vascular plant to produce estimates of net greenhouse gas contributions. Both *Sphagnum*-only and *Sphagnum* + *Molinia* mesocosms were net sources of greenhouse gases, largely due to large CH₄ emissions and the large CO₂-equivalency of CH₄.

Because of the shared underlying dataset, great care needs to be taken in describing exactly how this paper differs from the two previous publications. The question is: does this paper apply something really new to a now twice-investigated year-long series of observations of greenhouse gas flux in mesocosms?

Introduction

The final part of the Introduction makes it clear where the data and analyses of this paper originated and how it differs from previous publications based (at least in part) on the same data set and experiments. However, a GHG budget is potentially a simple calculation based on values of gas flux already reported in the previous publications, particularly Leroy et al. (2017). It could also be a more sophisticated calculation that takes other parameters into account, which might make the publication of those estimates in a separate, stand-alone paper worthwhile. This paper, as stated in the Introduction, appears to take a rather sophisticated approach to estimating GHG budgets from mesocosm data.

I could not find the reference (Leroy et al. 2019) in the References, a critical omission when that paper apparently shares a considerable amount of raw data with the current study. I was able to find a likely candidate through Web of Science. Please include the full citation in the References, and confirm that the paper from Journal of Environmental Sciences is the intended reference.

Materials and methods

Throughout this manuscript, the full name of the studied vascular plant species always given, *Molinia caerulea*. Because no other species in this genus are discussed, the use of the genus name alone would be suitable for every use after the first, with a comment to the effect of "referred to as *Molinia* for the rest of this study". This would make the paper a bit easier to read.

The sentence on page 3, lines 18-20 is incomprehensible. Please re-write.
Please quantify what is meant by "several to twenty minutes" on page 3, lines 29-30.

Why were chamber measurements so variable in their time closed? Most users of chamber-based methods standardize the length of time a chamber is closed for measurement. Were the chambers removed when a pre-determined gas concentration value was recorded?

The model based on Bortoluzzi et al. (2016) and Kandel et al. (2013) presented on page 4 (Eq 2) is exactly the same as Eq 2 of Leroy et al. (2019). Table 1 of Leroy et al. (2019) contains many of the same parameters as appear in Table 1 of the current manuscript, yet the values are slightly different. A very similar Table 1 also appears in Leroy et al. (2017), yet again the exact values are different.

Please explicitly describe how these three separate papers using a common (or mostly common?) data set and a single experimental design (slightly modified?) arrived at different values for the components of greenhouse gas fluxes. If the values from previous publications are used in the GGCB calculation of the current manuscript, do the conclusions change at all? Which values are the most accurate - if you were to conduct a meta-analysis of the GHG budget effects of vascular plant invasion of Sphagnum peatlands, which of these three sets of values would you include?

In the description of how the greenhouse gas budget is calculated (Eq. 8), please specify what positive and negative values indicate. Some studies declare negative values to indicate net movement of C into the ground or terrestrial ecosystem (e.g. strong photosynthesis, a net sink), others declare negative values to indicate net movement of C into the atmosphere (e.g. strong respiration, a net source).

Results

Pg 7, LN 3: what do you mean by "linked"? Was GPP significantly correlated with the number of *Molinia* leaves? Was number of *Molinia* leaves an important parameter in your GPP model? How was this tested?

Figure 1 has a confusing use of parentheses in the legend. Please change from "(ER; a)" to "(ER; a)" or a similar separation of clauses.

In Figure 1d, it is clear that CH₄ emissions from *Molinia* + Sphagnum plots peaked in summer, as described (Pg 7, LN 7-8). It also appears the Sphagnum plots also had a CH₄ emission peak at around the same time. Were the changes in CH₄ emissions through the seasons not significant differences in the Sphagnum plots?

Figure 4 appears before it is mentioned in the text. Table 3 appears directly above the block of text mentioning it. Figure and Table position is largely up to the final typesetting, but it was distracting to have these parts of the manuscript appear out of order.

Discussion

Molinia caerulea have aerenchymous tissues, as described by Lloyd et al. (1998). This could be a useful citation to include in the first paragraph of the Discussion on page 11.

Pg 11, LN 26: what is meant by "efficient" here? Did you compare your models to a standard and calculate the proportion of times your models matched the standard?

On page 11, CH₄ emissions via aerenchyma is described. On page 12, CH₄ emissions via stimulation of methanogenic organisms by root exudates from vascular plants is described. On page 13, the increased temperature sensitivity of CH₄ emissions under Sphagnum + *Molinia* is described. Your results show increased CH₄ emissions associated with *Molinia*.

How do these factors fit together?

Kao-Knifflin et al. (2010) appears in the Reference list but nowhere in the text. I suspect it would be a useful place to start in considering how various factors interact to increase CH₄ emissions when graminoid plants are added to a Sphagnum bog.

The value of 34 is used here for the GWP100 of CH₄. This is apparently from the 2013 IPCC report. Other values of CH₄'s GWP have been used in various studies, some as low as 25. Do your conclusions - that these wetlands are net contributors to climate warming, and not C-sinks - change with different values of CH₄ GWP?

The final sentence on page 13, lines 7-8 is almost word-for-word identical to the final sentence of the immediately preceding paragraph, same page, lines 3-4.

Please write a concluding paragraph that is more than a series of copy-paste from previous parts of the Discussion.

Typos and other minor writing points

Overall, there are more than a few problems with plurals, with missing or added 's' at the ends of many words. This is a most often trivial problem that does not seriously distract from the manuscript and can be fixed with rigorous proof-reading. Careful attention to verb tense is also necessary. The final sentence of the Introduction, on page 2 lines 26 to 28, is a useful example. "Such C budget calculation allowed the estimation of the global warming potential, a key feature of the paper submitted to Biogeosciences, which was not studied in the previous papers and deserve a communication on its own."

change to

"Such a C-budget calculation has allowed the estimation of the global warming potential, a key feature of the current paper, which has not been studied in the previous papers (i.e. Leroy et al., 2017; 2019) and deserves specific consideration."

Similarly, the sentence on page 4, lines 4-5 can be corrected by swapping the verb tenses of "established" and "derive" - to "and establish a" and "was derived for"

Pg 2, LN 1: conditions should be plural

Pg 2, LN 17: "encroachment is a well known"

Pg 2, LN 19: "ecosystems"

Pg 2, LN 22: change "Leroy et al. 2017 and Leroy et al. 2019" to "Leroy et al. (2017; 2019)"

Pg 2, LN 24: change "in the paper submitted to Biogeosciences" to "in the current paper" and similarly in the sentence on LN 27

Pg 3, LN 6: "chosen"; "were"; "covered"

Pg 3, LN 7-10: repeated sentence

Pg 6, LN 7: the usual term for comparing different greenhouse gases to the effects of carbon dioxide is "global warming potential", or GWP, and usually with a subscript or comment describing the time range (in years) for the comparison.

Pg 11, LN 16: re-arrange some words: "that are not taken into account in our models"

Literature cited

Kao-Kniffin, J., Freyre, D.S., Balser, T.C., 2010. Methane dynamics across wetland plant species. *Aquatic Botany* 93, 107–113. doi:10.1016/j.aquabot.2010.03.009

Leroy, F., Gogo, S., Guimbaud, C., Francez, A.J., Zocatelli, R., Défarge, C., Bernard-Jannin, L., Hu, Z., Laggoun-Défarge, F., 2019. Response of C and N cycles to N fertilization in Sphagnum and Molinia-dominated peat mesocosms. *Journal of Environmental Sciences (China)* 77, 264–272. doi:10.1016/j.jes.2018.08.003

Lloyd, D., Thomas, K.L., Benstead, J., Davies, K.L., Lloyd, S.H., Arah, J.R.M., Stephen, K.D., 1998. Methanogenesis and CO₂ exchange in an ombrotrophic peat bog. *Atmospheric Environment* 32, 3229–3238. doi:10.1016/S1352-2310(97)00481-0