

Author reply to Referee comments from **Referee # 2**  
**Gerald Jurasinski** from 21 March 2021  
(<https://doi.org/10.5194/bg-2020-440-RC2>) on:

**Cushion bog plant community responses to passive warming in southern Patagonia**

Verónica Pancotto et al.

Reviewer comments (RC)

Author comments (AC)

Mentioned line numbers refer to the originally submitted manuscript

Manuscript changes (MC)

Dear Authors,

thank you very much for this well structured and well written manuscript. Please apologise my delayed review. I should have checked in early than I would have known, that this is an easy one. Along most of the manuscript it is a very interesting read that is strongly rooted in references and addresses an interesting and timely issue (change in C turnover in a warming world) with a comparably easy to implemented approach (open side chambers). In some parts of the methods and the results section it gets a bit lengthy but most of the provided information is interesting anyway (but sometimes maybe not necessary). The striving for providing the completest possible picture is also reflected in a huge number of supplemental materials and without suggesting explicitly to skip this or that I would suggest the authors discuss among themselves which of the materials are really worth reporting here.

We moved plots S9 to S32 from the supplements to this manuscript to the supplements of our data submission at Pangaea.

I made comments and suggestions on a pdf that you find attached. Apart from minor comments and/or suggestion regarding phrasing and wording or very few typos or grammar issues I suggest mainly slight edits or request some more information in the method section regarding the open side chamber approach and ask you to provide a little bit more information on the timing issue (e.g., not all measurements were carried out at the same time, why some measurements were spread across three months in the starting year but later not anymore, how do you think may the measuring on control and treatment plots in differently timed campaigns (at least partially) have influenced your findings). An illustration that explains the sampling design in a graphical manner, especially telling what was measured when would be great.

We added a chart to the supplementary material further illustrating the timing of our different field campaigns, see below. Basically, the treatment was installed in 2014; 2 years later, leaf lengths measurements and samples for lab analyses were collected and another two years later, samples were again collected and chamber measurements were performed. What we did when mostly had logistical reasons, gas analyzers or lab time are not always available, remote roads are not safe to drive on in winter etc.. We do discuss the bias of our flux measurements towards the growing season (line 259 and caption of Appendix Figure C1). Also see responses to line comments below.

Further, I am missing a subsection of the discussion section on "limitations" (although there are some aspects n this regard intermingled in the discussion) in which you could for instance discuss the last point mentioned in the parentheses above. Finally, I would

like to see a paragraph in the conclusion that discusses what your results mean for these peatlands, the world, future studies. Instead the conclusion is bloated with summary stuff that doesn't need to be there since its a conclusion not a summary.

We completely rewrote the conclusions, see below. The section now includes a further statement about the main limitation of our study with our measurements being biased towards the growing season. As mentioned by the referee, the discussion includes various aspects which potentially further limit the explanatory power of our study.

I do not address all single issues here since you can find them in the commented pdf.

After all, in my opinion, this is a very interesting and well developed contribution that only needs some editing before it can be finally published in Biogeosciences.

### **Line comments (extraced from pdf):**

Line 20: Move reference to the end of the sentence

Done

Line 20: increased. „Enhance“ carries with it the notion of „making it better“

Agreed. We replaced "enhanced" with "intensified" to avoid repetition of "increased".

Line 22: Isn't that true also in other ecosystems?

Added "Similar to other ecosystems, " to beginning of sentence

Line 26: „Increased compared to the soil matrix“

Changed to: "...increased compared to the surrounding soil matrix"

Line 28: Provide examples of species names please

Examples added in parenthesis.

Line 28: in

Done

Line 36: This start would profit from a linking word like „Additionally“ or something similar

Done

Line 39: on morphological and physiological traits of cushion plants

Done

Line 39: Because it is

Whole paragraph changed in response to comment from Referee #1

To partly simulate future conditions, warming studies have commonly been conducted. Passive methods to manipulate soil and air temperatures have been chosen in studies focusing on high latitude peatlands (Laine et al., 2019; Lyons et al., 2020; Mäkiranta et al., 2017; Munir et al., 2017; Strack et al., 2019; Zaller et al., 2009) as these methods are cost-effective and appropriate for remote sites with limited power supply. Passive warming devices like open top chambers (OTCs) act as "solar energy traps" (Marion et al., 1997) primarily by reducing radiative heat loss (Aronson and McNulty, 2009). We conducted a field experiment to determine how cushion- forming plants respond to moderate experimental warming. We manipulated the temperature conditions passively with open side chambers (OSCs) similar to the ITEX Corners presented by Marion et al. (1997).

Line 54: I know, it is probably correct but I have always a slight issue with below ground parts reaching „up to“.. Shouldn't it be „down to“

"Up to" refers to the range of values here. 2 m is the largest value. We think this sentence is unambiguous, no change made.

Line 57: ...low cover, in total not more than about 20% areal cover

Done

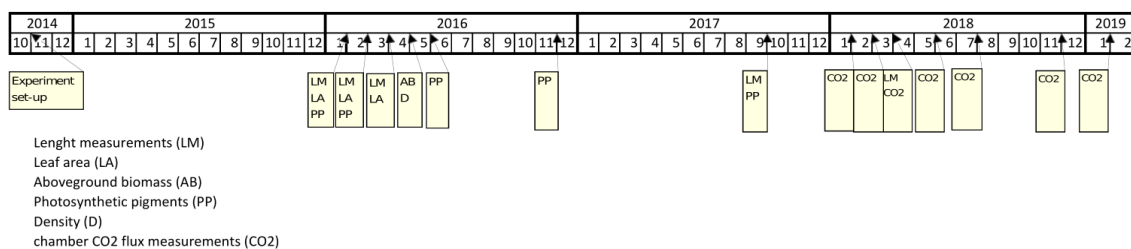
Line 74: But still the plants get 20 to 16% less radiation. Couldn't this influence your results?

Not that much due to the position of the chamber, see discussion, line 295.

Line 87: So the temperatures were measured later, right? After all, the temperature series and the leaf property measurements were not done at the same time. Would be good to discuss this directly in the methods and offer an explanation.

We added a chart to make the timing of the different measurements clearer. We refer to the figure after line 10:

See supplementary Figure S35 for an overview of the timing of our different sampling and measurement campaigns between 2014 and 2019.



Line 93: Why so many months for the start point?

We are not talking about start points here. In the season 2015/2016, we measured three times (beginning, middle and end of growing season). In the season 2017/2018, we measured two times (beginning and end of growing season).

Line 96: A figure, i.e. an illustration, how you did it, would be great

Gantt chart added to supplements, see above. Sampling described in more detail, see below.

Line 100: For this you have to take leafs home but I didn't see anything mentioning your field sampling for this. Please add

True, we made a mistake here. We changed the beginning of the paragraph starting in line 96 to:

All leaves we sampled for lab analysis were put in plastic ziplock bags, transported to the lab and stored in a refrigerator until the next day if they were not processed the same day. During 12 measurement days between 15 January 2016 and 04 March 2016 (see supplementary Table S2), we sampled in total 86 sun-exposed, fully expanded leaves. We took pictures of the leaves which included a ruler so we could estimate their area using the software ImageJ (Rueden et al., 2017).

Line 103: Maybe the same leaves were used for the above described analysis? Be it as it may, I would like to see some information on the sampling.

No, this was a different sampling campaign. Information on sampling added, see above.

Line 109: I have to do in keeping up with what was done when.. Here the above mentioned illustration to explain the sampling and analysis approach could help readers following

Gantt chart added, see above.

Line 112: So obviously together with the temperature measurements? This collars, don't they have a strong effect on the vegetation and C cycling when they are permanently installed?

Yes, temperature measurements were performed during the same timespan like the flux measurements.

We would argue the other way around: Because the collars were installed permanently four years (!) before measurements started the disturbance of soil and vegetation by collar installation was long enough ago to not affect carbon cycling decisively.

Line 124: Was it plugged immediately after placing or immediately after finishing the 3 minute measurement. That is not clear from the phrasing here.

Agreed, sentences were rearranged for clarification.

The opening was plugged immediately after the chamber was placed on the collar.

Line 138: I know that many people are doing this. But it introduces a subjective element in to this flux estimation...

We agree, it does add a subjective element. On the other hand, it is much harder to train an algorithm to identify perturbations than just to use human judgement/feature detection capabilities. From our point of view, the possibility of visual inspection is rather a feature than a shortcoming of this software/user interface. For us, this was also a way to use as many measurements as possible from this remote site from where it is not easy to get more data.

Line 143: Why so many more control than treatment fluxes?

We do not think that a large number of control fluxes affects data analysis negatively in any way. This imbalance in N between treatment and control fluxes is not the result of considerations with respect to experimental design. Rather, practical reasons are responsible, like the fact that not all flux measurements taken during this campaign are related to and part of this manuscript. Another practical reason could be that we tried to cover a large radiation range with our flux measurements. It possibly took us longer to get enough measurements for the control plots.

Line 189: Interesting. Do you have an explanation for this? Something to do with water in the ground?

Suspicion added:

We suspect that sensor placement might have been suboptimal, and the temperature probe was not installed as deep as at the other plots.

Line 191: Is this really enough to draw generalisable conclusions? I am not questioning this in general but would like some discussion on this in the methods section

No conclusion here, we merely report averages. Not entirely sure if we understand the comment and/or what it refers to.

Line 194: Clearly understandable because of the way you implemented the treatments  
Yes, we expected higher differences at midday.

Line 205: Is this really necessary for the research question to discuss this in this much detail?

Yes, we think a thorough description of the effects of the warming treatment belongs to the clarification of the research question.

Line 207: Avoid such judgemental statements in general and especially in the results section.

Ok, "clearly" removed.

Line 231: Couldn't this also feed back on the leaf lengths (shorter lengths with denser growth)?

Exactly, that is what we are saying in the summary of this section, see line 242.

Line 244: was

Ok, both occurrences of "is" changed to "was".

Line 246: Not necessary

Ok, removed

Caption of Figure 6: Not entirely clear what is shown in the different panels. Further: Delete the title of the plot. You tell readers what they see in the figure caption

Ok, caption changed to:

Change of chlorophyll contents from February to May 2016 in *A. pumila* leaves from treatment and control plots. During this growing season, control plants appear to have increased their chlorophyll a content (panel (a)) to a significantly ( $p < 0.05$ ) greater extent than treatment leaves. Differences in the contents of chlorophyll b (panel (b)) and total chlorophyll (panel (c)) did not change significantly. Sample size is, however, not large enough to firmly make these assertions.

Caption of Figure 8: I really like this figure although the 18°C isoline is really weakly determined in the treatment

Yes, we agree the 18 °C isolines are quite weakly determined at the treatment and control plots.

Line 274: If something suggests something it is a good indication that the statement should rather be placed in the discussion section

This is clearly a result. We removed the beginning of the sentence ("Model results suggest that").

Line 314: However

Done

Line 339: „would differ“?

Done

Line 379: Very likely this strongly depends on the morphologies of the plants under study  
Exactly, as stated in following sentence.

Line 382: The question is whether over a bit longer periods this would just lead to changes in density and/or abundance??

Yes, we agree. We are, however, not able to answer this question. We are merely reporting results from other studies here.

Line 386: From an Eriophorum...

Done

Line 397: Try to shorten and put as start of next sentence, like „In our warming experiment...“ Because it is not a summary, its a conclusion

We agree that there are too many summary elements in the conclusions in general. However, we think one introductory sentence summarizing the research question at the beginning of the conclusions is appropriate and serves as a reminder for the reader. We therefore left this sentence unchanged while we completely rewrote the rest of the conclusions.

We conducted a warming experiment in a southern hemisphere cushion bog to investigate responses of the cushion-forming plant *Astelia pumila* to elevated temperatures as they are projected to occur on the southern hemisphere in a future climate. At warmed plots, *A. pumila* grew in denser cushions and had shorter leaves leading to unchanged aboveground biomass per area. Furthermore, *A. pumila* physiology was altered so that at warmed plots, photosynthesis was less efficient while respiration was intensified. We propose an increase in photorespiration as a response to warming as one likely underlying mechanism since it could explain the diminished gross primary production and enhanced respiration simultaneously. Apart from alterations of the photosynthetic apparatus, differences in leaf morphology and chlorophyll contents between treatment and control plants most likely additionally, or even decisively, contributed to the observed GPP variability. Respiration variability could additionally have been impacted by changes in root respiration and stress-induced enhanced photooxidation.

Over the main growing season of two exemplary years, warmed *A. pumila* cushions cumulatively took up 55 % and 85 % less CO<sub>2</sub>-C than the cushions of unaltered control plots. This change in net C uptake is considerable, especially when comparing the amount of artificial warming achieved in our experiment (annual average between 0.4 °C and 0.7 °C at the three of ten replicates which were equipped with temperature sensors) with temperature projections for the region from the Coupled Model Intercomparison Project Phase 6 (CMIP6). Estimates for contrasting Shared Socioeconomic Pathways (SSPs) show increases in mean annual 2 m air temperature of 1 °C (SSP1-2.6) and 2 °C (SSP5-8.5) from 2014 to 2100 (Wieners et al. 2019a, b). In conjunction with our findings, a considerable weakening of the long-term C sink strength of austral cushion bogs in a future climate seems likely. However, the temporal cover of flux measurements in our study was biased towards the growing season and more data from the shoulder seasons and winter, when temperatures are lower but photosynthesis of the evergreen *A. pumila* is ongoing, would be desirable and should be collected in future studies.

Line 401: Again summary elements. Keep statements to what you conclude from your findings.

Agreed, see comment above

Line 417: Add one paragraph on what this means for this kind of ecosystems under future expected warming

See restructured conclusions above

Caption of Table A1: Could this measuring differently in control and treatment plots have an influence on your findings regarding the differences in CO<sub>2</sub> fluxes? Please discuss in the discussion section.

We do not think that the timing of flux measurements or the greater number of control fluxes affected data quality negatively. In our sampling design and due to the high temporal variability of CO<sub>2</sub> fluxes, measuring fluxes over a wide range of light and temperature conditions was prioritized over measuring at control and treatment plots on the same day or equally often. Also see our response to the comment to line 143.