Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2019-487-AC1, 2020

Biogeosciences Discussions

Interactive comment on "Modern calibration of *Poa flabellata* (Tussac grass) as a new paleoclimate proxy in the South Atlantic" *by* Dulcinea V. Groff et al.

Dulcinea V. Groff et al.

dulcineavgroff@gmail.com

Received and published: 13 April 2020

Dear Anonymous Reviewer,

We are grateful for your helpful comments, which have improved this manuscript. We have responded to your comments below. We also provide an explanation of the changes we intend to make in the manuscript.

Best wishes, Dulcinea Groff

* There is a lot of analysis into explaining the variation in the isotopes, how that's controlled by plant physiology, but not much discussion and explanation of how these

isotope signals will be used to reconstruct paleoclimate especially in context of applying this to a peat core (through time). Providing a roadmap for how changes in d13C and d18O will be interpreted would be useful and weather this is qualitative or can it be pushed further to be quantitative?*

Peat-based reconstructions may be limited to identifying periods of warm/dry or cold/wet conditions that are more extreme than our observed seasonal variations (or more similar to them). For now, this proxy remains qualitative, but more work could be done to evaluate this proxy to assess its suitability for quantitative reconstructions (perhaps with leaf wax or alkenone biomarkers, though our preliminary data on hydrogen isotopes in precipitation suggests this may not be feasible). Resolving temperature and moisture signals independently would likely require growth chamber experiments.

Solution: We agree that an expanded discussion on paleoclimate reconstructions would be helpful. We intend to add a flow-chart and/or conceptual figure that outlines exactly what we think this proxy could reconstruct, including time averaging, and what the methods should look like i.e. bulk, individual leaves, different processing needed.

There is the suggestion that this is going to really help us understand climate dynamics, but then there is not discussion of how. Is this going to provide temperature or relative humidity or both (there is not clear indication of which and both are correlated with the isotopes) and how to you disentangle any changes in source water d18O through time?

Thank you for pointing out that this is unclear in the manuscript. The oxygen and carbon isotopic signatures are positively correlated in our study, which represents a modern snapshot of conditions Fig. 2B). Based on this modern calibration work, we recommend measuring C and O values together, and that these values would identify the timing of transitions between warmer and drier to colder and wetter conditions that correlate with major hemispheric drivers in climate.

Solution: We intend to add a section to the Discussion that more clearly outlines how

this proxy would work in practice, including the conceptual figure/flowchart mentioned above.

We didn't find a relationship between d18O in precipitation and the d18O of leaf cellulose in our 1-year study. It is possible that because the d18O in leaf water is controlled by source water and humidity, any changes in humidity confound a direct relationship between source water d18O values and leaf water/cellulose d18O. It may also be possible that the variation in source area did not affect the d18O enough for us to detect a significant impact on the d18O of the leaf cellulose. Based on this work, the source area could influence leaf cellulose d18O value in peat records if source area changes were greater than what we observed. That's true of all oxygen isotope reconstructions, though, and is not a unique consideration for the Southern Ocean.

Solution: We intend to make this clearer in the text.

* Some discussion of how to do this for paleoclimate also needs to focus on how this study shows nicely that the leaves are recording a seasonal signal. So, when you go down core, how are you going to deal with this? Are you going to focus on a large sampling of leaves from each horizon (age?) with the expectation that you are sampling both seasons or is it going to be a single multiple leaf measurement to approximate an annual signal? Some thought into this is needed as the data analysis and presentation may need to be added to or adapted for paleo work. I'd like to see a clearer connection between this nice modern calibration data and how to use it for the past.*

We recommend incorporating a large sampling of leaves from a horizon (1 cm), and expect that to be a sampling of both seasons, incorporating several years. These peat records are highly productive, but even so, time averaging within a given 1-cm level should be greater than than the age of a leaf. In the peat records we've analyzed, we've commonly found sedimentation rates to be $\sim$20-30 years/cm, with most records extending at least 13,000-15,000 years old. As with any prehistoric reconstruction, it is important to consider temporal grain and resolution, which is going to constrain the

inferences you can make.

Solution: We intend to include a section with a recommended workflow and considerations for applying to peat records, including our recommendations for methods (e.g., including that multiple whole leaf fragments should be used from each level, and methods for cellulose extraction and purification).

Line 28: "trends in southern hemisphere climate dynamics" – is that consistent with what you can actually do with this proxy? Or is it something more specific?

Based on what we have established with this study, this proxy can indicate trends in conditions similar to what we observed seasonally: warm/dry, cool/wet, which is more specific than our generalized statement. Multiple paleo-records could point to changes in Southern Hemisphere climate dynamics, but can not necessarily resolve the drivers of those dynamics.

Lines 43-46: Awkward sentence with semicolon connecting two separate statements.

Thanks for pointing this out. Solution: We will edit for clarity.

Line 56: Is it really called a "bog"? That's not confusing... It's hard to reconcile this description with the one line 70 and "pedestal" which is in the caption for Figure 2. Maybe some annotation on the figure or more description would be useful. I'd like to have a clear idea how this is going to develop over time in a peatland and how this plants growth habit is going to translate into a vertical succession (or some crazy patchwork of different ages in a peat core).

Yes, colloquially each pedestal is called a "bog," and we will remove this from the manuscript to avoid confusion – especially because the tussac peat that forms the soils in these stands is not a bog, either. We will call it a "pedestal" throughout. ("Tussac/tussock" is already confusing enough.)

The taphonomy of these pedestals is poorly understood. We intend to incorporate this in our conceptual figure of tussac pedestals and peat. There could be a patchwork of

ages within a peatland, but as of yet we have not found any evidence of age reversals or other chronology problems in our cores.

Line 57: Something wrong with new sentence that starts here and sentence seems incomplete too.

Thank you for pointing this out. Solution: This should read: Smith and Prince (1985) previously established radiocarbon (14C) dates for a P. flabellata pedestal and estimated an age of 250 to 330 years.

Line 56-57: Either they use precip or the precip wets all that organic matter and then there is evaporative enrichment b/c it is exposed to wind/sun.

Fair point. Solution: We will edit the text to indicate this.

Line 70: Maybe start a new paragraph here or have a better transition?

Will do, thanks.

Line 71 and below: check the order in which isotopes are first described. Here delta symbols are used first but aren't defined, next sentence doesn't use delta symbols (carbon isotopes), and then defined on line 90-91. I think this comes up a few other places and would be worth cleaning up.

Thanks for noting this. We will make this fix for consistency.

Lines 92-93: Improving "westerly wind dynamics" is different than what's mentioned elsewhere. What is it that this new proxy can solve and make it consistent throughout.

Great point. Solution: We intend to make the text clearer about exactly what climate conditions and questions this proxy can inform, while still placing it within the broader discussion of Southern Hemisphere climate dynamics.

Line 100: Could the km hr-1 also be reported here and later for reference? Not to many readers will think about wind speed in m/s.

The International System of Units recommends m/s, so we will retain use of this standard for consistency with them, and with other studies. (https://physics.nist.gov/cuu/Units/units.html)

Line 170-172: How are temperature and humidity related? Based on the figure, they look highly correlated. If they are, then how do you disentangle their effects from the cellulose d13C and d18O as they are both strongly related? I didn't see any multiple regression analysis reported below either.

As discussed above, we intend to make this clearer – these variables are definitely correlated, and we do not think they can be disentangled further without additional measurements (if at all).

Line 186: is west, NW, and SW 79%? That's missing from the sentence. Reporting 21% for the last source and not saying anything about the other 3 directions is reads strangely and compared to the prior sentence.

Thank you for pointing out this. We will clarify. Solution: This should read: In winter, 79% of the air mass back trajectories (n = 332) were from the west, NW, and SW, while 21% of air masses had backward trajectories south of the Falklands near the Antarctic Peninsula (Fig. S4).

Line 206-207: I think you need to be really careful presenting this here and then in the discussion below. With this data, maybe the other factors have a stronger control than precipitation d18O, but at least at some level, precip d18O must be important. So, when applying this down core (through Holocene), if there are changes in d18O, they must change the cellulose d18O (and then it's probably modified by the other factors you report here). I think this is critical to point out for those who will use this in paleo applications. More on this below.

We agree. Solution: We will address this more clearly and consistently in the text, but also in a new section we propose on paleo applications (see comments above) to make

this clear.

Section 3.4: there's no mention here of the relationships between the isotopes and temp and humidity but these are in the discussion, figures and tables. This would be a good place to describe the relationships of to both environmental factors.

This is addressed in section 3.5.

Line 237: What negative correlation? Not in the results or the figures. VPD is not discussed prior to this.

Thank you for the suggested change. It should read "positive". Solution: We will make the following changes: "Ferrio and Foltas (2005) established a positive correlation between δ13Cleaf and vapor pressure deficit, suggesting stomatal conductance is sensitive to atmospheric moisture conditions."

Line 242-244: Is this consistent with the "low" humidity of the Falklands of >70%?

Yes, we will change this sentence to explain. Solution: "As plant stomata close in response to low humidity and/or high evaporative conditions like high wind speeds in the Falklands, the internal partial pressure of CO2 decreases and the δ13Cleaf increases (Farquhar et al., 1982, p.198)."

Lines 283-288: Relating plant tissue d18O (or dD) to precipitation is always a challenge. Even if you had leaf water or soil (pedestal?) water, it would still be complicated, but maybe give some insight. Many studies try to relate d18O of the plant back to precipitation, but here, it's clear that other factors modify this. But, at the most basic level, d18O precip is setting source water and then maybe there is mixing with other sources (ground water, dew, etc), but that is then modified by temp/humidity, etc. I think some discussion here is needed to highlight that this is much more complicated than indicated for the reader. If one tries to do this down core, changes in d18Oprecip must at some level matter for the d18O of plant source water and ultimately the d18O cellulose.

We agree. Thank you for pointing this out. Solution: We intend to address this in the Discussion by adding some sentences here to signal that this is not straightforward e.g., "Interpretations of d18O of leaf cellulose from downcore peat records would need to consider that the relationship with d18O in source water is confounded by relative humidity. Still, the d18O in plant water pools and d18O in leaf cellulose are primarily influenced by d18O in precipitation."

Also, getting into event precip (as mentioned) could be interesting, but it might be more informative to pull into this discussion when the leaves/cellulose are being made. Can you say anything about this with the data in hand?

No, we can not because we collected samples monthly. In the manuscript we described in our methods section that the youngest leaves of a new plant were collected each month. We assume leaves/cellulose are being made at this time (1 month) because Poa flabellata continuously grows. We will add that we assume the leaf cellulose is being made during the past 1 month of growth to the manuscript (line 128-129).

Solution: rewrite as "For leaf material, the inner developing (youngest) leaves were collected and assumed to represent the past month of growth."

Overall, the discussion is lacking a clear description of how the d13C and d18O would be used to interpret paleoclimate. Is it a temperature signal, a humidity signal, a source of precipitation signal? Or is it all of the above? How will a down core record be interpreted? Is there any way to put some uncertainty into this? How are you going to disentangle the multiple correlations between the isotopes themselves and the relationships with temp and humidity?

Without experimentation we can not disentangle temperature and humidity using d13C and d18O. We suggest in the manuscript that stomatal conductance is likely driving the changes in d13c and d18O because of relative humidity (Line 270-274). The precipitation signal can not be separated using these data.

Solution: We propose a new section paleoclimate interpretations where we address these peat core questions, as indicated above.

Figure 1: It would be nice here or elsewhere to have the wind diagrams and the precip source isotopes provided. I don't know what the figure limitations are for this journal, so maybe that's not possible. But, it sure would be nice to have a bit more of the great data collected here summarized in the main article figures.

Both of these are in the Supplemental Information (S2 and S4), will be moved to the main text if that would be helpful.

Figure 2: It would be nice if the interpretive strategy figure here was where that data is reported. The peat core is interesting, but not really discussed. It would be nice if it was to put into an interpretive strategy that could be used for downcore paleo Reconstructions.

We agree and would include this in the new proposed section (as commented above).

Figure 3: VSMOW on 3a, but VSMOW and VPDB missing on 3b. For the LMWL reported here, can you report the r or R2, p-value, and n? Figure 4, VSMOW and VPDB needed

These are all easy fixes, thank you.

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2019-487, 2020.