Biogeosciences Discussions

Biogeosciences Discuss., author comment AC2
https://doi.org/10.5194/bg-2022-47-AC2, 2022

Reply on RC2

Romina Llanos et al.

Author comment on "Recent significant decline of strong carbon peat accumulation rates in tropical Andes related to climate change and glacier retreat" by Romina Llanos et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-47-AC2, 2022

In order to be able to respond to each of the referee's observations and comments, I will put all of them in "normal" font, and our responses to them in bold italics, to make sure we respond to everything.

Dear Editor,

Now I can inform you about the paper titled "Recent significant decline of strong carbon peat accumulation rates in the tropical Andes related to climate change and glacier retreat" by Romina Llanos et al.

In this work, four-peat cores from high-Andean Distichia cushion-plant peatlands close to tropical glacial were radiocarbon-dated to estimate the C accumulation rates. The paper would potentially contribute to paleoenvironmental data since they are scarce. However, the data interpretation is highly speculative. For this reason and those explained below, I suggest rejecting the manuscript.

This work does not present hypotheses: The authors state that the retreat of the glaciers could have affected the rate of C accumulation due to temperature change from the 1970s, but this effect could have impacted both sites where the carbon accumulate were lower in the southern sites than the northern ones (only 6 km away and similar elevation, nothing is said about how far or glacial description). As the authors state, the increase in temperature could have impacted the primary production rates and decomposition rates. However, neither of these were measured; therefore, it is difficult to sustain that the temperature change was the primary driver because both sites received a similar impact (Figure 8 shows a similar average), and other factors such as topography and drainage conditions, other potential factors mentioned were not measured either or described properly. In general, this paper is highly speculative, and it lacks rugosity with many imprecise sentences and often confusing ones (see below).

We thank the referee for their positive comments and suggestions.

There are two aspects to the referee's remarks: one is how to explain the differences between the two sites and the other is why there were changes over time.

As the other referees pointed out, the detailed description of the sites is

insufficient to understand their differences. We returned to the field to a better understanding of the relationship between the Apacheta River and our peatlands. The two peatlands have similar vegetation. APA2 is located at 4420m on a gentle slope of the valley, and APA1 is at 4200m and is located on a glacial terrace now incised by the Rio Apacheta which is a few meters lower. So, the river does not supply water to APA2 and it turns out that the drainage areas of the two peatlands are not as different as we thought.

The ratio of drainage area to peatland area explains well the difference in accumulation rate between the peatlands and in net primary production that has been estimated by MODIS as you suggested (please see Table RC2.1: Data comparison between both peatlands (APA1 and APA2), in SUPPLEMENT).

With respect to changes in accumulation over time, the observed trend is the same in all 4 cores with a reduction in peat growth rates and carbon accumulation starting in the 1980s (please see Figure RC2.1: Carbon Accumulation Rates for the 4 cores, in SUPPLEMENT). For such short time scales, it is not differences in topography **or drainage area that may have influenced the observed changes and no anthropogenic action on the drainage network was observed. The most likely hypothesis is that climate change has caused this reduction. It may have intervened directly, through changes in temperature or precipitation, or indirectly through reductions in snow, glaciers and permafrost. It is these hypotheses that we test here using the available data.**

OTHER IMPORTANT AND MINOR DETAILS

ABSTRACT

L.15-17 "…Here, we point out the important role of Andean peatlands on carbon accumulation rates (CAR), one of the highest in the world, and the impact of climate on carbon storage over the last 65 years, using four peat cores". From the sentence above it is not clear what is the highest in the world, the Andean peatlands in general, or your study using four-peat cores?

Both are very high. CAR for Andean peatlands in general are high (Benavides et al., 2013; Benavides, 2014; Cooper et al., 2015) and in our study CAR values are even higher.

1. L 19 "For both peatlands": Never mention before the two peatlands sites.

Thank you, we have took this into account to improve the manuscript.

2. L 25 Where did depth accumulation rates reach up to? What is CE?

Highest CARs are found at the base of the cores.

CE: Common Era.

Copernicus English Standard: "CE (common era) and BCE (before the common era) should be used instead of AD and BC since CE and BCE are more appropriate in interfaith dialogue and science".

3. L20 Annual mean temperature cannot be responsible; only humans are responsible for something.

We agree.

4. L25 The authors indicate a decrease in CAR during the study period may be due to a decrease in meltwater by the retreat of the glaciers and the increase in temperature (the last tested); however, an increase in temperature is not the only factor even when you do not mention if there was a type of control to confirm your findings. For comparison you have to be sure that the primary productivity was similar 50-60 years ago.

This is the characteristic of all paleo-environmental studies: we cannot be sure whether primary production has changed or not in the past, but if it has changed it is probably due to climate change. The MODIS satellite productivity data (figure below), while clearly showing the difference between the two peatlands, only shows a slight upward trend over the past 20 years. For precipitation no clear tendency appears, only a very recent increasing trend (Fig. 7). For this reason, we believe that temperature is the main driver of the observed changes, either directly or indirectly.

INTRODUCTION

L38 say: …researches, …must say: researches, however,..

We agree.

L.76-103 move this section to M&M.

OK.

The authors need to clearly describe the differences between APA-1 and APA-2 in the results section, as the calibrated age from APA-1 and APA-2 are compared.

According to the suggestions made by Referee 1, we recalibrated the age with the most recent curve published by Hua et al. (2021) using the mixed curve recommended for South American Monsoon region (Bomb21SH3). All other data as been recalculated in agreement.

The new age models are shown in Figure RC2.2 (in SUPPLEMENT) and are very similar to the old ones.

M&M

I generally miss the statistical analysis for setting the differences of CAR and depths.

Please see Figure RC2.3 (Statistics for the two periods, before and after the transition for the 4 cores, in SUPPLEMENT).

L.105 says: between 29 and 35 cm-long, it must say: intervals layers between 2 and 31 cm depth.

To clarify this point, we have changed the sentence to: "For this study, four peat cores were collected: APA1-C1(34 cm) and APA1-C5 (29 cm) from the site APA1 located at 4200 m, and APA2-C3 (35 cm) and APA2-C4 (34 cm) from the APA2 site at 4420 m."

L.105-107 The authors need to clarify how they named the samples in Table 1. In M&M, there is no clear description.

We have added more information about the two sites in M&M. And we have added an extra column in Table 1 to identify the differences between the two

sites (APA1 and APA2). The description of the two sites is now more detailed.

L.114 says: accelerator mass spectroscopy, it must say: accelerator mass spectrometry. This mistake comes from another article, Xing et al. (2015) that used the same terminology.

We agree with the referee. This was a mistake. It is now corrected.

L.127 says C stable isotope. It must say. The natural abundance of stable isotope…

We agree. It is now corrected: "The natural abundance of C stable isotope was determined using an isotope mass spectrometer … ".

L.131-132 Even though you are citing a source, please give the equation and units of each variable. How were C accumulation rates calculated? It is not straightforward and familiar for all readers. By the way, Lähteenoja et al., 2009 and Cooper et al., 2015 are not listed in the reference.

Sorry, we have added the two references in the list.

"Carbon accumulation rates (CAR in g C m^{-2} yr^{-1}) were determined using the mathematic equation (Eq. 2) (Lähteenoja et al., 2009; Cooper et al., 2015; Xing et al., 2015):

CAR = BD * GT * TOC (Eq. 2)

Where: CAR is the carbon accumulation rate (gC m^{-2} yr^{-1}); BD is the bulk density of the bulk peat samples (g cm^{-3}); GT is the growth rate (cm yr^{-1}); TOC is the total organic carbon content (%)."

We have changed the term accumulation rate to growth rate, which is more appropriate for peatlands.

L.133 says: strong. It must say: significant and positive (or negative)…

We agree with the referee. The term "strong" is too much. "We used new stable isotope paleoclimate proxy ($\delta^{13}C$) based on a positive significant relationship found between the C stable isotope composition of Distichia and air temperature (Skrzypek et al. 2011)."

L.136-137 says: …can be used to estimate relative paleotemperature changes recorded in Andean Distichia peat, as they mentioned. It must say: can be used to estimate relative paleotemperature changes recorded in Andean Distichia peat during the growth season (See Skrzypek et al. 2011).

We agree.

L.138-139 Please expand the explanation about the resolution used because I understand that NCP-NCAR uses 5ºx5º pixel. I know you cite Kalnay et al., 1996; however, the last reference is not in the list of references.

We are sorry for this oversight. The NCEP/NCAR reanalyses data have a latitude-longitude 2.5° grid spatial resolution (Kalnay et al., 1996).

The reference is below.

Kalnay, E., Kanamitsu, M., Kistler, R., Collins, W., Deaven, D., Gandin, L., Iredell, M., Saha, S., White, G., Woollen, J., Zhu, Y., Chelliah, M., Ebisuzaki, W., Higgins, W., Janowiak, J., Mo, K. C., Ropelewski, C., Wang, J., Leetmaa, A., Reynolds, R., Jenne, R., and Joseph, D.: The NCEP/NCAR 40-Year Reanalysis Project. Bull. Amer. Meteor. Soc., 77, 437–472, doi:10.1175/1520-0477(1996)077<0437:TNYRP>2.0.CO;2, 1996.

RESULTS

L 146-147 The authors say "…an abrupt change occurred at the end of the 1970s when the rates visibly decreased"… Compared with? APA-2 ? I see such abrupt change from Fig 2 if I only compare APA-2 with APA-1.

The four cores show a marked decrease in carbon accumulation rates from the early 1980s. We interpret this decrease as being the consequence of a decrease in nutrient input from the melting and retreat of the glaciers over tiem which has caused a decrease in productivity. And this is originally related to a rise in temperature in the Andes.

L161. "Mean TOC content…" Figure 3: Neither the text tells us if these results average the three depths or only the upper part? The authors refer to supplementary information to prompt the reader to seek information, but this must be carried over to the main text.

We will transfer the Figure 1 from the Supplementary Material to the main text.

L.174 The authors say, "…CAR varied depending on age and elevation" however, the elevation of these sites is similar (see sites description).

Although the difference between the altitudes of APA1 and APA2 are only 220 m, for the Andes this difference is important for temperature and productivity.

L.184. It is hard to see differences without statistical analysis. The variability is so high.

We thought that the variability between the two sites was visible from the graphs, but at the request of the referee we present the table below with the mean and standard deviation of the CARs before and after the transition year. We hope this data is enough to present this transition (please see Table RC2.2: Statistics for the two periods, before and after the transition for the 4 cores). We think that the data in the table highlights this transition.

L193. I do not see the difference for APA-2, even when it was the site that present lower CAR.

We believe that the table mentioned above (Table RC2.2: Statistics for the two periods, before and after the transition for the 4 cores) highlights these differences.

DISCUSSION

L.197 The authors introduce Fig 6 for tropical versus boreal and temperate climate; however tropical high latitude presents an enormous error bar, invalidating the comparison. Please remove this Figure from the Discussion.

These are not error bars, but extreme values. We will remove and modify this figure.

L.234-235 "…The author says: ...differences found in CAR (Fig. 4) ...were related to the different drainage area surfaces, much more prominent for APA-1 than for APA-2. These differences must be described in the site descriptions first and later discussed.

We thank the referee for this comment and in the new version we have included these data in the text. Now the sub-catchment areas have been recalculated after a supplementary field work (March and April 2022), indeed APA1 is much smaller since it is not drained by Apacheta River which is located several meters below the peatland. The sub-catchment area of APA1 is only 3.3 Km^2 while for APA2, the sub-catchment area, inserted in APA2 one, is 2.14 km^2. Plear see Figure RC2.3: The sub-catchment area of APA1, and Figure RC2.4: The sub-catchment area of APA2, in SUPPLEMENT.

L 237. Again other differences that were not described "…specific topographic factors,..."

We have included information about the topography and soils of the study area:

"The Apacheta region is characterized by being a mountainous area, with peatlands located in the valleys and sections with gentle slope, at altitudes above 4100 m asl. Edaphologically, the study areas are mainly composed of relatively medium texture deep soils developed upon volcanic rocks (porphyritic andesite) from Apacheta formation (Nm-ap_s) (INGEMMET, 2002). In this area, the main economic activities of the local population are agriculture and livestock. Agriculture takes place at lower altitudes than peatlands and grazing of livestock occurs in the peatland zone, because peatlands provide year-round forage production for grazing native domestic camelids (llama and alpaca) and for livestock species (particularly sheep). Evidence of grazing activity has been observed in the study area although with little visible impact on peatlands."

L.239-240 "…Although there is a similar downward trend in the CAR at both sites after the early 1980s,.." I do not see the difference in APA-1 in Fig. 2.

Statistics are in the table RC2.2 (Statistics for the two periods, before and after the transition for the 4 cores, in SUPPLEMENT).

L.256. Move Fig. 7 to the results section.

We agree.

L.255-260 What about photosynthesis. The increase in CO_2 must have a consequence?

L.280-285. Ok, here photosynthesis is discussed.

Ok.

L.283 "…The strong gradients in $\delta^{13}C$…" Insist I do not see this gradient in APA-2 having a similar temperature.

The gradient we are talking about is the one established by Skrzypek et al. (2011).

L286 Figure 8 should be the first figure that the authors must show in the result section.

The main objective of our study is to estimate the rates of recent carbon accumulation in these peatlands. It is only in a second step that we formulate hypotheses as to the cause of the decrease of these rates after 1980.

L.292 Say: "showed a good relationship especially in trends". It must say: showed a good relationship"

We agree.

L.291-294 "…this comparison is difficult because the NCEP data … because we do not know precisely what time period each peat sample corresponds to", this sentence is not clear.

The problem is that the $\partial^{13}C$ and thus temperature values are obtained for different dates on the different cores. Another point is that the growth rates are different in the two cores, meaning that each sample do not correspond to the same interval of time.

L.296 "between 1.9 and 2ºC" is different than "from 1.9 and 2ºC" what do you mean?

Sorry for the English redaction. We observed an increase of 1.9 °C for a core and 2°C for the other.

CONCLUSIONS

L 307-311 Sentences are more summary than conclusions.

We will reformulate those sentences.

L.314-316. "…This decline in C accumulation was mainly related to the temperature rise which increases the organic matter degradation rate…" The lower CAR probably comes from a lower primary biomass production in APA-2, which was not measured neither discussed. This may have shed light on the input, prevented speculation such as high decomposition rate, and reduced water supply from glacier retreats. The hypothesis that the temp We have estimated the primary production from MODIS satellite data (2000-2021) and can observe the variations between the two sites (see results in graph below) erature causes the differences been CARs in my view has not been demonstrated.

We appreciate the suggestion.

We have estimated the primary production from MODIS satellite data (2000-2021) and can observe the variations between the two sites (please see Figure RC2.5: Primary production from MODIS satellite data (2000-2021) for the study area, in SUPPLEMENT). APA1 has an average net primary production (NPP) for the period of 0.37 kg C m^{-2} and APA2 of 0.27 kg C m^{-2}.

The two peatlands have similar vegetation, APA2 is located at 4420m on a gentle slope of the valley, and APA1 is at 4200m and is located on a glacial terrace now incised by the Rio Apacheta which is a few meters lower. So the river does not supply water to APA2 and it turns out that the drainage areas of the two peatlands are not as different as we thought and that the ratio of drainage area to peatland area explains well the difference in accumulation rate between the peatlands.

Please also note the supplement to this comment:
https://bg.copernicus.org/preprints/bg-2022-47/bg-2022-47-AC2-supplement.pdf