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Biogeosciences Discussions

Interactive comment on "Climate-related changes in peatland carbon accumulation during the last millennium" *by* D. J. Charman et al.

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I found the paper very interesting, well-written and for the most part well justified. The main shortcomings arise from: the reconciliation between what is estimated by the analyses here and what has been reported in many "contemporary" studies on the effect of warming on the GHG emission in high latitudes ecosystems (most of them showed increase in C loss with warming and permafrost degradation, etc.); also the r2 reported here are generally fairly low so the authors should be careful in over interpreting their results.

Specific comments: Line 28 Page 14331: is there a more recent estimate than Gorham,

1991? This reference is quite old, I would think there should be some more update studies reporting on C accumulation rates

RESPONSE: Gorham (1991) was the first to make this type of estimate and most subsequent estimates are based on very similar assumptions. However, we have now inserted reference to Yu (2011) as an update on this figure but note this recent reference for average long term C sequestration at 0.088 GtC yr-1 is very similar to that of Gorham (1991) at 0.076 GtC yr-1.

Line 3-5 Page 14332: what would drive the occurrence of the ocean outgassing of the increase C uptake from peatlands? Is it temperature? It would be helpful if this is clarified here.

RESPONSE: The elevated ocean outgassing is caused by reduced pCO2 in the atmosphere (the 36 ppm equivalent in C uptake by peatlands over 1000 years) and reduction in air-sea CO2 partial pressure. This explanation is now included in the text.

Page 14332-14333: The numbering of the criteria used for the selections of the studies in the Methods section are at bit confusing, The paragraph is numbered as 2.1 then selection criteria are numbered as 1 and 2, then again 1 and 2 for a set of different criteria, I would suggest a clearer subdivision: 1.1 and 1.2 for the first two selections and then 2.1 and 2.2 for the last two? Or if the last two criteria are derived from a subsampled of the first two this should be clear from the numbering.

RESPONSE: We have changed the numbering of the criteria to a), b) etc. for clarity and the text has been amended to make the difference between the data sets clearer.

Page 14334 Lines11-12 Why this difference in the dating methods? Specify

RESPONSE: We have not re-dated the cores for this study but have recalibrated the dates given in the original studies. In the case of Site 68, the original dates were conventional dates on bulk samples rather than AMS dates and we wanted to make this clear in case this affected the results or interpretation. In the case of the other

sites, the dates available were all AMS dates on small amounts of above-ground plant material, which is the approach now routinely adopted in dating peat sequences. We have clarified the fact that we made use of published dates in the text.

Page 14335 Lines 22-23 It would be interesting mentioning and comparing decomposition rates in anaerobic vs aerobic peat

RESPONSE: A typical estimate of acrotelm decay loss is around 90% of dry mass over the period spent in the aerobic decay zone (the acrotelm). This would represent an annual proportional loss of around 0.01. Typical decay rates in the lower anaerobic peat (catotelm) are perhaps 10-4 to 10-5, several orders of magnitude lower than in the acrotelm. However, this is partly because as the organic matter decays in the acrotelm, it becomes more recalcitrant, so that the observed decay rates are partly a function of changing substrate quality as well as the switch from aerobic to anaerobic conditions.

Figure 4 is hard to read, please use larger font size

RESPONSE: In the final version of the ms we have redrawn these figures with larger font sizes to make them easily legible.

Page 14335 Line 4: PAR is defined here no need to define it again in page 14338 Lines 3-4

RESPONSE: We have removed the second definition of PAR. Defined only at first mention.

Page 14338: This is not completely true, several studies indicated that warming increase C loss from high latitudes ecosystems (including some arctic and boreal forest studies). Please discuss and include references here.

RESPONSE: This was not clear in the ms and we have modified the text to say that it is NPP, not necessarily carbon accumulation, that is expected to increase with warming in high latitudes due to increased growing season length.

Page 14338 Define C (formula 3). It is carbon accumulation? What is the difference between C and M (formula 2)? Why using different terms for the same thing? If there is a difference between them explain also in the methods not inly in the results, otherwise be consistent in the use of symbols

RESPONSE: C is now defined in text as total carbon accumulated over the last 1000 years as estimated from the radiocarbon dated profiles. M is the mass of carbon accumulated, but is estimated from the curve fitting process and is variable over time.

Page 14338 Sometime R2 and sometimes r2 is used, be consistent

RESPONSE: We have changed all these to R2

Page 14339 Lines 3-10 These are certainly important and interesting interpretation. But the authors should not forget that their model C/PAR0 only explained a minor % of the variability in C accumulation (about 30%), this means that almost 70% of the controls on C accumulation are unexplained. I realize the difficulties of modeling C accumulation, but it would be worth mentioning the limitation of the results and be cautious in drawing conclusions

RESPONSE: We acknowledge that the r2 value for this relationship between PAR and total carbon accumulation leaves a lot of variation unexplained but it is not surprising that this data set is noisy given the different foci of the original studies and the different research methodologies used in these studies. We also mention the effect of local hydrology as an additional factor on p 14339 for example. We have now added a further comment referring to the other residual sources of variation in the conclusions.

Page 14339 Line 10: which threshold? Specify

RESPONSE: We have clarified this to refer specifically to the threshold of moisture availability that we hypothesise is a limit for peat growth.

Page 14339 Lines 20-22 This contradicts what stated in the previous paragraph: if the importance of the moisture cannot be quantified with more certainty, how can it be

clear that it was not important? Be more careful in drawing conclusions. Also, there should be some explanation on how this is the case: similar decomposition under aerobic/anaerobic environment, etc: : :

RESPONSE: The paragraph makes the point that moisture levels are likely to vary with local factors, especially topography, that we cannot quantify in our analysis. However, we would still expect to see some relationship with macro-scale hydroclimate even with this local variability, but this is not observed in our data set. We have added a section of text at the end of this paragraph to make this point and to explain the lack of influence of moisture by the balance between decay and NPP under different hydrological conditions.

Line 5-6 Page 14340: Isn't PAR0 also linked to the growing season length? Also in Line 4 Page 14341, you said that growing season length is important? Be consistent and discuss this more clearly

RESPONSE: We do point out (page 11, lines 13-14) that PAR is also influenced by growing season length ('Taken together, these results support our hypothesis that peatland carbon accumulation is driven by PAR over the growing season.'). PAR0 is greater when the growing season is longer, even without any change in sunshine. What we demonstrate through these analyses, however, is that growing season length alone does not explain the patterns of carbon accumulation. Growing season length is more important for the additional PAR0 it drives rather than simply because it provides a longer period of time for growth.

Lines 1-4 Page 14340, "subsidiary importance" might be a bit too much for an explanatory power lower than 1%...use more appropriate term

RESPONSE: The explanatory power is 8% ($R2 = 0.08$, $p<0.01$ and therefore statistically significant), not <1%. We would therefore not want to say that the independent effect of GDD0 is insignificant and we therefore feel that the phrase 'subsidiary importance' is appropriate to use here.

Line 10 Page 1430: This is confusing: if there is a decrease in C accumulation in the LIA, how do you explain the decrease in [CO2]? Also you stated that there was a decrease in heterotrophic respiration, therefore also autotrophic respiration likely decreased, so the accumulation rates shouldn't increase? This is a critical point and should be better explained, and these two observations should be reconciled.

RESPONSE: The starting point for our paper was the idea that the decrease in [CO2] during the LIA might be associated with an increase in peatland carbon accumulation. Contrary to expectations, we found that the impact of peatlands on the LIA carbon cycle was in the opposite direction because the rate of peatland sequestration was reduced at this time. We explain this and reconcile the observations with reference to Figure 6 on p14345 lines 9-14. Our findings suggest that because of reduced C sequestration in peatlands, there has to be an even bigger increase in other terrestrial C sinks than was previously thought.

Line 3-4 Page 14345: How much are peatland and how much other ecosystems responsible for this change? What is the percent land cover of peatland?

RESPONSE: Peatland sequestration declined during the LIA, so other land areas must have increased their C sinks by an even greater proportion. We suggest this is may be because of reduced decay rates in other soil C during the colder climate of the LIA. The area of coverage of the different systems is less relevant, although because peatlands are a relatively small proportion of the total land surface (perhaps 3%), a small change in rates of decay in other soils could have caused a significant increase in global soil C sequestration rates.

Lines 21-22Page 14345: does this mean that warming will increase C accumulation in peatlands? What are the results drown by contemporary studies? Worth mentioning that most of them actually conclude the opposite, and discuss the possible reasons behind this discrepancy.

RESPONSE: Yes – this is what we conclude on Page 14346 Line 23-26. We refer to the

soil decay studies in the introduction but have now mentioned this contrast in findings in the conclusion as well. It seems likely that peatlands act differently to mineral soils in their response to warming and that NPP is equally or more important than changes in decay rates.

Use larger fonts for the some of the figures, they are hard to read

RESPONSE: We have redrawn figures with larger fonts for the revised version of the ms.

Interactive comment on Biogeosciences Discuss., 9, 14327, 2012.