Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2017-530-AC2, 2018


Biogeosciences Discussions
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# *Interactive comment on* "Carbon accumulation in a drained boreal bog was decreased but not stopped by seasonal drought" *by* Kari Minkkinen et al.

**Kari Minkkinen et al.**

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Received and published: 14 March 2018

Anonymous Referee #2 Received and published: 4 February 2018

"GENERAL COMMENTS This is a well written, clear paper that tackles the important yet controversial topic of peat accumulation of peatlands drained for silviculture. The results of the experiments presented in the manuscript are interesting in that they highlight that the ecosystem is still a sink, in spite of having been drained. The authors approach the problem with rigour, and measure gas exchange via two means, eddy covariance and chambers. They report the results of their experiments in a clear manner and discuss possible implications. I especially thought the last section in the discus-



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sion “Can the carbon sink last?” was valuable. In this section they discuss the ultimate fate of the carbon and how important the carbon accumulation in the soil (rather than in the forest biomass) is for sustainable practices. The authors present an important topic at a time where peatland ecosystem services are being valued more than ever before and management practices need to be evidence-driven. "

"SPECIFIC COMMENTS My main criticism of the manuscript is the issue of DOC losses and actual long-term carbon accumulation (as measured in the peat profile using dating and carbon measurements). "

"Is DOC loss really a minor component – due to ineffective ditching and high transpiration? All peatlands lose some carbon via DOC, the losses in pristine peatlands are often non-negligible. Drained peatlands may experience even larger (or sometimes smaller) DOC losses. Are the authors suggesting there is no water that comes off their site due to evapotranspiration? Can the authors show evidence of studies on forested drained peatlands that have measured DOC losses during high precipitation events after a dry period, for example? Evidence from non-forested drained peatlands suggests losses are substantial (see for example papers from Strack et al., 2008 and others). "

–The same answer as for referee #1: Leaching of DOC, i.e. the output of dissolved C from Finnish drained peatlands varies between 10 to 15 g C $m^{-2}$ $a^{-1}$ (Sallantaus and Kaipainen, 1996; Kortelainen et al., 1997; Sarkkola et al., 2009; Rantakari et al., 2010). This is 4–7% of the estimated NEE and 17–25% of soil C balance in Kalevansuo. The smaller the soil C balance the higher the share of DOC export naturally becomes. However, the input of DOC into the forest soils is of the same magnitude as the output. According to Lindroos et al. (2008) Finnish forest soils receive 2–6 g C $m^{-2}$ $a^{-1}$ dissolved C as deposition in stand throughfall and in 2–10 g C $m^{-2}$ $a^{-1}$ percolation water. Kalevansuo is mainly ombrotrophic, so that DOC in percolation water is insignificant. However, as mentioned earlier, ditches in Kalevansuo are ineffective and transpiration of the tree stand is likely an important pathway for water output in such a case like Kalevansuo (Sarkkola et al. 2010) decreasing the possibility for big DOC





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losses. It is thus likely that net export of DOC does not have a major significance for the C balance at Kalevansuo peatland.

"Page 10 Line 24: Again, this issue is related to DOC loss. A large Rhet is originated in the top part of peatlands when these are pristine (as was the case for the study site in the reference the authors cite, Chimner and Cooper, 2003). Once a peatland has been drained for a long time, I am not sure this necessarily holds true for every peatland. Of course, labile carbon from the top of the peat is preferentially decomposed always, but the older peat might also get decomposed if exposed for a peat along time and this may be lost via DOC preferentially (not completely oxidised as CO2 and therefore not detected by any of the means the authors deployed). See for example Evans, C. D., et al. (2014), Contrasting vulnerability of drained tropical and high-latitude nds to fluvial loss of stored carbon, Global Biogeochem. Cycles, 28, doi:10.1002/2013GB004782. "

–We understand this possibility. We added discussion about DOC (see above).

"2. An important methodological question is, considering the uncertainty in the measurements (NEE has an error between 35-114 g CO2 m-2 yr-1) and the fact that the authors did not measure DOC losses, I wonder if coring the peat, and measuring recent accumulation of peat directly by dating the peat would have been a good way of validating the idea of the carbon sink. It is a shame that this has not been done, since the authors even cored the peat at the site. Have any of those cores been analysed for carbon and dated? Is peat actually accumulating (and shrinking) at the same time? The authors present a very interesting result, but with the uncertainty in NEE and the possibility of DOC losses, one cannot be absolutely certain that this site is actually accumulating peat in the long term. Additionally, the authors need to be careful of estimating actual peat accumulation via modern fluxes alone. Experiments in which both a) fluxes and b) peat C accumulation measured via dating of the peat profile have been carried out, have found a large disparity between the two measurements. In fact, experiments demonstrate long term peat accumulation is much smaller than contemporary fluxes suggest, see: “Contemporary carbon fluxes do not reflect the long-term carbon balance

for an Atlantic blanket bog", Joshua Ratcliffe, Roxane Andersen, Russell Anderson, Anthony Newton, David Campbell, Dmitri Mauquoy,Holocene Vol 28, Issue 1, pp. 140 – 149, First Published June 30, 2017, https://doi.org/10.1177/0959683617715689 I'd be really interested in seeing some of those collected cores dated from Kalevansuo. "

–Kalevansuo has been cored extensively and historical C accumulation has been determined using radiocarbon dating (Mathijssen et al. 2017). However, drainage is such a recent happening (35 yrs before our study) that 14C dating is not a reliable method to determine post-drainage C accumulation in peat. Even if the surface peat could be dated accurately, root growth into deeper layers would mess up the results. Many different peat-coring-dating-pollen-bulk density-based methods have been tried (e.g. Kruger et al. 2016, Minkkinen and Laine 1998, Minkkinen et al. 1999, Simola et al. 2012, Turetsky et al. 2004) but they have large uncertainties. Eddy covariance combined with biomass growth measurements is the most accurate method for this purpose.

–We know that long-term peat accumulation rates may be very different from current ones, although sometimes they may be quite similar, if the measurement span is long enough (e.g. Aurela et al. 2004, Roulet et al. 2007, Nilsson et al. 2008). It is also well-known that long-term average rates, determined by peat coring and radiocarbon dating, are not the same as the actual, current (or decadal average) rates. Modelling is needed to estimate that (e.g. Clymo et al. 1998, Frolking et al. 2014). However, as we have discussed, we are not trying to estimate long-term peat accumulation, only the current one.

"I am not expecting the authors to expand their methodology to measure DOC or C accumulation in the peat profile, but I perhaps expect them to discuss these two main issues a little more in their manuscript. This is important since the title suggests that C accumulation is the main topic of the article, but actually peat C accumulation has not been directly measured. "





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"Additionally. I have some suggestions for clarifying the methodology used: How long before the measurements were the chambers installed? I suggest this is included in the methods. "

–Collars were installed in June 2004, half a year before the respiration data was used here.

"Why are the chambers 30 cm deep? Did the authors know roots were not significant lower down? Other studies have used 50 or 60 cm deep chambers. "

–In this site average WT is so high that we estimated that 30 cm deep collars are deep enough. It is however possible that roots have grown under the collars, and thus Rpeat would be overestimated.

"Repeated clipping – did you clip before every measurement? Or if not, then how often? Please consider including this in the methods. "

–Plants were clipped every time before measurements if new plants had emerged.

"Was the biomass of the understorey measured? I thought it was according to the methods, but then in Page 11 line 11 the authors write that they assume biomass to not be increasing. Was the biomass only measured once? If so, this needs to be made explicit in the methods section. "

–Biomass of ground vegetation was measured once (p. 5, r. 3) only.

"11,14 “Thus the method should not be overestimating soil C pool increase, more likely underestimating it. “ It is unclear to the reader why this should be so, could the authors explain more explicitly in the text? "

–The correlation between tree stand and ground vegetation biomass is negative (Reinikainen et al. 1984): as the tree stand grows bigger, the available resources (light, nutrients) for ground vegetation decrease, leading, in theory, to decreased growth and biomass. If this is correct for Kalevansuo, C pool in ground vegetation would have de-





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creased, since tree stand C has increased. As dCsoil = NEE - dC biomass (all marked positive here), decrease in biomass C would lead to increase in soil C. However, we now think that this sentence is overinterpretation, and will delete the "more likely underestimating it".

"Why are the errors estimated (a very nice treatment of uncertainty in Appendix 2) but not reported in the main text? (What figure is (Fig. xx in chapter 3.2) in Appendix 2?)"

–Fig. xx on page 33, line 31 should refer to Fig. 5

–We will add the following text about the errors to the results section:

–p.7, line 11: ". . .the annual NEE was surprisingly similar in other years, varying from –950 to –990 g CO2 m–2 a–1. The estimated uncertainty in the annual budget, including the random error in measurements and gap-filling, the uncertainty in the correction for high-frequency loss and the uncertainty related to gap-filling of the longer than 2-day gaps, varied from 35 to 114 g m–2 a–1, corresponding to 3.6 to 22% of the respective annual balance.

–Fig. 5c, d.

"TECHNICAL CORRECTIONS Page 1: Line 10: turn into (instead of turn to) "

–corrected

"Line 11: We measured the carbon ("the" is missing) "

–added

"Line 11: NEE of CO2 was measured with an eddy covariance method. . . "

–"the" added

"Line 14: Biomass (in singular, not plural) and litter production. . .. "

–ok





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"Line 14-16: Consider changing to: Soil balance was estimated. . .from NEE, and this showed that the soil itself was a carbon sink as well. "

–ok, changed

"Page 6: Line 34: Consider changing to: WT varied also spatially ("quite much" should be deleted). "

–ok, deleted

". ... Page 10: Line 33: Consider changing to: “The value is considerably smaller than that reported for agricultural fields.” "

–ok, changed

References:

Aurela et al. 2004. The timing of snow melt controls the annual CO2 balance in a subarctic fen Geophysical Research Letters, Vol. 31, L16119, doi:10.1029/2004GL020315, 2004

Clymo, R.S., Turunen, J., Tolonen, K. 1998. Carbon accumulation in peatland, Oikos, 81, 368-388.

Frolking et al. 2014. Exploring the relationship between peatland net carbon balance and apparent carbon accumulation rate at century to millennial time scales. The Holocene 2014, Vol. 24(9) 1167–1173. DOI: 10.1177/0959683614538078

Kortelainen, P., Saukkonen, S., and Mattsson, T.: Leaching of nitrogen from forested catchments in Finland, Global Biogeochem. Cy., 11, 627–638, 1997.

Krüger, J.P., Alewell, C., Minkkinen, K., Szidat, S. and Leifeld, J. 2016. Calculating carbon changes in peat soils drained for forestry with four different profile-based methods. Forest Ecology and Management 381: 29–36. http://dx.doi.org/10.1016/j.foreco.2016.09.006

Lindroos, A.-J., Derome, J., MustajÂÍarvi, K., NÂÍojd, P., Beuker, E., and Helmisaari, H.-S.: Fluxes of dissolved organic carbon in stand throughfall and percolation water in 12 boreal coniferous stands on mineral soils in Finland, Boreal Environ. Res., 13B, 22–34, 2008.

Mathijssen, P. J. H., Kähkölä, N., Tuovinen, J.-P., Lohila, A., Minkkinen, K., Laurila T. and Väliranta, M. 2017. Lateral expansion and carbon exchange of a boreal peatland in Finland resulting in 7000 years of positive radiative forcing, Journal of Geophysical Research: Biogeosciences 122. http://dx.doi.org/10.1002/2016JG003749.

Minkkinen, K. and Laine, J. 1998. Long term effect of forest drainage on the peat carbon stores of pine mires in Finland. Can. J. For. Res: 28: 1267–1275.

Minkkinen, K., Vasander, H., Jauhiainen, S., Karsisto, M. and Laine, J. 1999. Post-drainage changes in vegetation composition and carbon balance in Lakkasuo mire, Central Finland. Plant and Soil 207:107–120.

Nilsson et al. 2008. Contemporary carbon accumulation in a boreal oligotrophic minerogenic mire – a significant sink after accounting for all C-fluxes. Global Change Biology (2008) 14, 1–16, doi: 10.1111/j.1365-2486.2008.01654.x

Rantakari, M., Mattsson, T., Kortelainen, P., Piirainen, S., Fin′er, L., and Ahtiainen, M.: Organic and inorganic carbon concentrations and fluxes from managed and unmanaged boreal first-order catchments, Sci. Total Environ., 408, 1649–1658, 2010.

Reinikainen, A., Vasander, H. and Lindholm, T. 1984. Plant biomass and primary production of southern boreal mire-ecosystems in Finland. In: Proceedings of the 7th International Peat Congress, Dublin,Ireland, 18-23 June, 1984, vol. 4. The Irish National Peat Committee, Dublin. pp. 1-20

Roulet et al. 2007. Contemporary carbon balance and late Holocene carbon accumulation in a northern peatlandGlobal Change Biology (2007) 13, 397–411, doi: 10.1111/j.1365-2486.2006.01292.x

Sallantaus, T. and Kaipainen, H.: Water-carried element balances of peatlands, in: Northern peatlands in global climatic change, edited by: Laiho, R., Laine, J., and Vasander, H., Publications of the Academy of Finland, Edita, Helsinki, 197–203, 1996.

Sarkkola et al. 2010. Role of tree stand evapotranspiration in maintaining satisfactory drainage conditions in drained peatlandsCan. J. For. Res. 40: 1485–1496 (2010) doi:10.1139/X10-084

Sarkkola, S., Koivusalo, H., Laur′en, A., Kortelainen, P., Mattsson, T., Palviainen, M., Piirainen, S., Starr, M., and Fin′er, L.: Trends in hydrometeorological conditions and stream water organic carbon in boreal forested catchments, Sci. Total Environ., 408, 92–101, 2009.

Simola, H., Pitkänen, A. & Turunen, J. (2012) Carbon loss in drained forestry peatlands in Finland, estimated by re-sampling peatlands surveyed in the 1980s. European Journal of Soil Science 63: 798–807.

Turetsky et al. 2004. Dating recent peat deposits. Wetlands, 24(2): 324–356.

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