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Biogeosciences Discussions

Interactive comment on "Greenhouse gas fluxes in a drained peatland forest during spring frost-thaw event" *by* M. K. Pihlatie et al.

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We would like to thank the reviewer for carefully reading and suggesting improvements to the manuscript. Our responses to the comments are written below.

The technical description of the chamber methods and analysis is absolute sufficient, but both for the details and for the analysis of eddy covariance methods they refer to other articles and manuscripts.

Response: Detailed description of the eddy covariance method and data analysis was added as follows.

The eddy covariance data acquisition above the forest canopy was carried out by a LabView-based program BARFLUX. Coordinate rotation and data detrending by an

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autoregressive running-mean filter with a 200-s time constant were performed according to McMillen (1988). The lag between the time series resulting from the transport through the inlet tube was taken into acÂňcount in the on-line calculation. An air density correction related to the sensible heat flux is not necessary, but the corresponding correction related to the latent heat flux was made (Webb et al. 1980). Corrections for the systematic high-frequency flux loss owing to the imperfect properties and setup of the sensors were carried out off-line using transfer functions with empirically-determined time constants. The data processing procedures have been presented in more detail by Lohila et al. (2007) and Aurela et al. (2009).

McMillen, R.T., An eddy correlation technique with extended applicability to non-simple terrain, Boundary Layer Meteorol. 43, 231-245, 1988.

Webb, E.K., G.I. Pearman, and R. Leuning, Correction of flux measurements for density effects due to heat and water vapour transfer, Q. J. R.. Meteorol. Soc. 106, 85-100, 1980.

Lohila A., Laurila T., Aro L., Aurela M., Tuovinen J.-P., Laine J., Kolari P. and Minkkinen K. 2007: Carbon dioxide exchange above a 30-year-old Scots pine plantation established on organic-soil cropland. Boreal Environment Research 12, 141–157.

Aurela M., Lohila A., Tuovinen J.-P., Hatakka J., Riutta T., Laurila T. 2009. Carbon dioxide exchange on a northern boreal fen. Boreal Environment Research 14, 699–710.

The sub-canopy EC data was processed using an EC software that has been developed by the Micrometeorology group at the University of Helsinki, Department of Physics, and it is routinely used for post-processing EC data measured in several permanent sites and field campaigns. It mainly contains all the update methods and corrections according to the Euroflux methodology (Aubinet et al., 2000, Lee et al., 2004). For the present study, the software has been slightly modified in order to handle with the laser data, as reported by Mammarella et al. (2010).

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Aubinet, M., Grelle, A., Ibrom, A., Rannik, Ü., Moncrieff, J., Foken, T., Kowalski, A. S., Martin, P. H., Berbigier, P., Bernhofer, C., Clement, R., Elbers, J., Granier, A., Grünvald, T., Morgenstern, K., Pilegaard, K., Rebmann, C., Snijders, W., Valentini, R., and Vesala, T.: Estimates of the annual net carbon and water exchange of European forests: the EUROFLUX methodology, Adv. Ecol. Res., 30, 113–175, 2000.

Lee, X. L., Massman, W., and Law, B.: Handbook of micrometeorology, Kluwer Academic Publisher, Dordrecht, The Netherlands, 2004.

I. Mammarella, P. Werle, M. Pihlatie, W. Eugster, S. Haapanala, R. Kiese, T. Markkanen, UÂÍ . Rannik, and T. Vesala: A case study of eddy covariance flux of N2O measured within forest ecosystems: quality control and flux error analysis. Biogeosciences, 7, 427–440, 2010

The manuscript presents the experimental setup. Results are described and presented in 5 figures. The figures are sufficient clear although some figures are rather small.

Response: we increased the size of the figures 3, 5 and 6 by removing soil temperature (fig 3 and 6) and water table depth (figure 5) from the figures as suggested by the referee 1.

The authors should present more about the soil temperatures regarding the title of the manuscript. They describe that soil temperatures were measured and different depths and locations, but present only one soil temperature curve. It is unclear if this an average of all soil temperature measurements. The presented soil temperature in figures 2A and 3C are actually never below zero, so my main comment is if you can actually consider the soil frozen during the measurements. Air temperature is below zero during the nights, which implicates frost-thaw events in the very top of the litter layer. It should already be mentioned in the abstract as well as in the introduction that the frost-thaw events are short events on daily scale and not longer periods with deep soil. This might also be the reason why actually no real effect of frost-thaw was detected and I suggest reconsidering the title of the manuscript.

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Response: We modified the figure 2 to include both litter layer temperature and soil temperature at 5 cm below the litter layer. The litter layer data shows that temperatures in the litter layer occasionally were below zero degrees Celsius. Due to breaks in the temperature measurements at several locations, we present soil and litter layer temperatures measured at one location only. We modified the description of the soil measurements accordingly.

At the start of the measurement campaign, we observed that the top-soil (mainly litter layer) was partly frozen, and the freezing-thawing of the soil occurred in the litter layer following changes in the air temperature. We show this in the updated figure 2. We agree that the freezing-thawing cycles are short events occurring in daily scales, and only in the litter layer. We modified the abstract and introduction so that it underlines the nature of the freezing-thawing cycles at this site. However, as we consider that we were able to measure real freezing-thawing effects, we are not willing to change the title of the manuscript.

Further comments: Introducton Line 17-19 Drained peatlands: : :.soils : please clarify! Do you want to say that drained peatlands which have been used for agriculture first and then planted with trees have emissions in the same order of magnitude as drained peatlands which are still used for agriculture. Is a drained peatland with forest not cultivated?

Response: Yes, you are correct. We clarified this in the text.

Material and Methods 2.1 Site description: Please give the tree density and/or the leaf area index of the forest. This will give the reading an idea how dense is the forest.

Response: we added the density information and LAI.

“Currently the height of the tree stand is 15–18 m, average basal area is 18 m2 ha-1, and average stem densities are 900, 750, and 40 stems per ha for the dominant pine trees and the smaller understorey birch and spruce trees, respectively.”

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Page 6115 line 6: The site was drained for the first time in 1971. This implies that the site was drained more often. Please specify if the drainage ditches were deepened or maintained.

Response: we corrected the sentence to “The bog was drained for forestry in 1971...". There was no management of the ditches thereafter.

In the final section of this page the well-decomposed peat is up to 2.5 m deep although the average (?) water tables was lowered to 40 cm depth. Any indication how deep the average water table was before drainage. Can you say anything about fluctuations in the water table during the season and year?

Response: We have no data of the water table depth before the drainage. In natural peatlands the water table depth can vary greatly due to changing weather conditions, however, numbers between 10 and 20 cm below the surface seem normal during growing season.

We show the variation of the water table depth during April –September in the figures 2b and 5c. Variation in the water table depth during April-September 2004-2005 was similar.

2.2 Flux measurements Page 6117 line 11: change ‘enclosure’ to ‘closure’. Is 48 min per chamber the time for one measurement or is it really the time that a chamber was closed? In that case it is important to mention when the readings of concentrations were taken during those 48 minutes.

Response: The information of the sampling intervals was added to the text. Each chamber was closed for 48 minutes, and the mean sampling intervals were 6, 18, 30, and 42 minutes after the closure.

Page 6117 line: what was the volume of the manual chamber.

Response: Volume (approx. 27 L) of the manual chambers was added to the text.

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2.3 Soil measurements Page 6118 line 20-26: Please specify if soil water content and soil temperatures were also measured at depths given below the litter-layer or below the surface.

Response: The soil temperature and water content depths were given as cm below the litter layer. We corrected this. Also, we removed description of those temperature and water content sensors from which no data was used due to breaks in the measurement series.

2.4 Data analysis Page 6119 line 16: Which pressure and temperature data were used to correct the flux rates.

Response: Chamber headspace temperature was used to correct the concentration of the target gas (CO2, CH4 or N2O) at standard pressure (101325 Pa). These temperature corrected concentrations were used in the flux calculations.

3 Results; environmental conditions Page 6120 line 26 Is the line for air temperature in figure 2A an average? 27ËŽC is not shown in figure 2. Please clarify.

Response: The data was checked and the figure 2 corrected. The figure 2 was originally plotted using non-processed data with few data gaps including the maximum value of 27 C.

Page 6121 lines 4-6: I cannot see clearly from figure 2A that the soil temperature becomes below zero. If you have measurements of the temperature in the litter layer please show them.

Response: We added the litter layer temperature data to the figure 2. This data shows that the litter layer temperature occasionally was below zero, whereas the temperature at 5 cm below the litter layer never reached minus degrees.

3.3 Fluxes Page 6122 line 24-28: what do you mean exactly? The negative correlation between flux with soil moisture and water table depth was not significant for EC-based sub canopy measurements. But was it not significant due to the negative correlation

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between soil moisture and water table with soil and air temperature or was the negative correlation of the flux with soil water and water table due to the negative correlation between soil moisture and water table with soil and air temperature. In other words; where is 'this' in line 27 referring to?

Response: We clarified this in the text. The word "this" referred to the negative correlation of the flux between soil moisture and water table depth.

Discussion 4.1 CO2 fluxes Page 6125 lines 17-24. This is why I consider change of the title: here you are actually suggesting that the freezing-thawing is only in the air and the very top of the litter layer and soil temperatures are not below zero.

Response: Assume that referee is referring to page 6126. We clearly show in the new figure 2 that we measured GHG fluxes during several days of freezing and thawing of the litter layer. We also show a clear frost-thaw peak in N2O emissions, whereas there were no peaks in CO2 or CH4 fluxes. Due to the late start of the measurement campaign, we may have missed several earlier frost-thaw peaks in N2O, CO2 or CH4. However, here we demonstrate that at least N2O emissions peaked after the observed frost-thaw cycles.

4.2 CH4 fluxes Page 6127 line 14 and Page 6128 line 25. Here I get confused regarding the different figures, please see over them again and use the same unit. For the site Kalevansuo you take 34 _g CH4-C m-2h-1 from Minkkinen et al, which is extrapolated to a year 3.2 kg CH4-C ha-1. In the next line you write 1.95 kg CH4 as average. I assume here CH4-C. However, on line 25, page 6128 you give an uptake of 0.9 kg CH4-C ha-1yr-1 for the site with a comparison to Minkkinen again with 2 kg CH4-C ha-1yr-1. Is the 3.2 kg for the year 2007 and 2 kg for 2004-2005? Could you also describe briefly how the extrapolation was done in case the measurements did not cover the full year? What did you use to extrapolate?

Response: We clarified the text so that it is clear where the numbers originate (from this study or other studies) and how the extrapolation was done. Also, we unified the

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units in the text and figures.

General comments Page 6115 line 4: change ‘was’ to ‘is’. Page 6115 line 10: consider to take away – before the 40 cm, as you write already that it is ‘down to’ ‘from the surface’ Page 6116 line 2: remove comma in 27 June, 2007 Page 6116 line 13: suggest changing ‘which has’to ‘with’ Page 6116 Line 17: explain ‘NEE’. You are introducing all abbreviations except this one Page 6116 Line 18: ‘at the centre’ to ‘in the centre’ Page 6120 line 22: give company for the SPSS program. Page 6122 line: 7: Suggest removal of sentence between brackets: (automatic chambers and sub-canopy eddy covariance) Page 6127 line 3: suggest removing ‘many’ Figure 2a: it is difficult to see the difference between soil and air temperature. Please use lines that are also clear in black and white.

Response: We corrected the text as suggested above.

Missing in references but given in the text: -Dutaur and Verchot 2007 -Wagner-Riddle et al 1997 -Scanlon and Kiely 2003 Page 6136: Move up Mäkiränta et al 2007 in correct alphabetic order: in english ä is considered as a.

Response: The reference list was updated.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/6/C4563/2010/bgd-6-C4563-2010-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 6, 6111, 2009.