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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Using hydrologic measurements to investigate free phase gas ebullition in a Maine Peatland, USA" *by* C. E. Bon et al.

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Please see attached .zip file containing supplemental material (text, figures, figure captions).

Referee #2

1. Please use units consistently throughout the manuscript. I recommend the use of SI units.

Units have been changed to SI units.

2. P 9723, l 5 You state that rates of net carbon accumulation are low (76 Tg C yr-1) and those of CH4 release are high (46 Tg C yr-1).What is the basis of this comparison (low and high rates compared to other regions or other peatlands or other soil)?

Statement has been changed to "Net carbon accumulation rates in northern peatlands have been modelled at 76 Tg C year-1 and rates of CH4 have been modelled at 46 Tg CH4-C year-1, contributing approximately 5-10% of total terrestrial CH4 flux to the atmosphere [Gorham, 1991]."

3. l 6 ": : :5-10% of total CH4 flux to the atmosphere". Do you mean total flux from peatlands or from soil in general or from terrestrial ecosystem? Please be more specific. It might be helpful to quantify the fraction of CH4 fluxes from northern peatlands in relation to the total terrestrial emissions (e.g. incl. livestock farming).

See #2

4. l 10-11 Is it really a contradiction? Please explain.

Statement was revised: "Results from climate models disagree on the response of peatlands to climate change; some models show increased CH4 emissions due to an increased breakdown of peat while others show an accelerated carbon storage in peatlands due to a warmer and wetter climate [Walter et al., 2001]."

5. l 15 FPG is not a source of CH4 (it is produced in the soil by microbiological processes) but an additional pathway or physical mechanism for the transport of CH4 from the soil to the atmosphere.

"Source" has been changed to "pathway".

6. l 19 The interconnection is rather due to groundwater dynamics than simply groundwater.

The statement has been changed to groundwater flow rather than simply stating groundwater.

7. l 24 Throughout the manuscript you are using the terms FPG and CH4 inconsistently. Here, for example, I recommend to restructure the sentence as follows ". . . storage, and emission of CH4 and other FPGs with respect. . .".

The statement now reads, "Two models have been proposed for the production, storage, and emission of CH4 and other FPGs with respect to the hydraulics of a peatland. The first has been called the "deep peat model" and was proposed based on field investigations of the Lake Agassiz Peatlands, MN [Glaser et al., 2004]."

8. P 9724, l 2-4 This sentence does not sound logical to me. What does "near the peat surface" mean? If there is production of CH4 in deeper soil layers, there might be diffusion from those deeper layers to near surface layers (assuming a concentration gradient) thus also contributing to the emissions. Is this process not considered in the model? From my understanding, the model only includes diffusion of gas that is produced near the peatland surface. I have changed the statement to "The deep production model includes diffusion of shallow peat CH4 to the atmosphere and production at depth due to a downward transport of labile carbon."

9. l 25-28 Here, you summarize the key mechanisms leading to ebullition events. These mechanisms, however, are the groundwork and motivation for your study. You should clarify in more detail (e.g. from a physical point of view), how these mechanisms generate or promote ebullition events!

There lines were changed to Reviewer #1's specifications: "Ebullition events have been known to occur in response to a rising water table as the buoyancy of formed bubbles causes them to propagate upwards with the rising water table [Coulthard et al., 2009]. Decreases in atmospheric pressure were thought to cause an increase in pressure difference between pore fluids and the atmosphere causing free phase gas bubbles to release to the atmosphere [Tokida et al., 2007b]. Ebullition events have also been known to occur as 4-12 hour events as peat depressuring cycles [Glaser et al., 2004]. Ebullition accounts for 50-60% of total CH4 flux from northern peatlands and is a major

mode of gas release from deeper peat [Tokida et al., 2007a] stressing the importance of understanding the influence of CH4 from greater depths."

10. P 9725, l 1 . . .understanding the influence of CH4 production/storage from. . .

The statement now reads ". . .stressing the importance of further understanding CH4 at greater depth."

11. P 9727, l 7-11 This section is a summary of the key results of the present study. It should be shifted to the concluding section.

These statement have been removed because they were restated in the results and conclusions.

12. l 26 It might be helpful to add the contour of the Caribou Bog (2200ha) to Figure 2.

The Caribou Bog has been delineated in improved Figure 2.

13. P 9728, l 9 I recommend to replace the phrase "interesting" by "diverse" (for example).

The word interesting has been replaced with diverse.

14. l 21 It might be helpful if you provide the measured values for the hydraulic conductivity of the esker and the surrounding material.

This has not been measured.

15. P 9729, l 3 How many wells per cluster? How did you choose the locations, randomly?

I have added that the well sites were chosen to create an array of wells around the pool system and by accessibility. Other changes were made according to Review #1's specifications: "Clusters of PVC monitoring wells (2.54 cm diameter flush threaded PVC, 30 cm machine slotted screen) were manually installed in 9 locations of Caribou Bog with a horizontal spacing of $\sim$100 m (Fig. 2). Well sites were chosen to create an

array of wells to easily calculate flow directions in the central unit and by accessibility. Each well was inserted into the peat manually with a slide hammer and hit until the desired peat depth was reached. The first well was installed down to the mineral soil with the following monitoring wells installed at 1 to 2 m intervals from the first to create clusters of 6 to 8 wells. Two wood boards (3.81 cm x 6.35 cm x 121.92 cm) were clamped together and eight 2.54 cm diameter holes were drilled through the boards with the hole centered along the surface of the intersecting boards. The boards were then clamped around up to eight wells using 9 bolts to tightly clamp the wooden boards around the wells. The deepest wells were positioned at the ends of each well cluster and typically extended into the mineral soil."

16. l 7 Are the wells of each cluster spatially arranged as a raster? How did you install the wells?

Referring back to #15, we believe the well clusters are now more thoroughly described.

17. l 17 Please provide the company's name and the trade name of the used dual frequency GPS. What is the general accuracy of the used GPS?

"Well clusters were surveyed using a Trimble netR9 GPS dual frequency receiver with zephyr antenna that recorded data at 10 second intervals." We have also added that the accuracy is +/- 5 cm.

18. P 9730, l 11 What is the ground cover vegetation at this site?

We have added, "Vegetation is a mix of shrubs and evergreen trees."

19. 23 Please quantify the accuracy of this measurement (e.g. standard error)?

Accuracy of the instrument has been added (+/- 0.1 cm)

20. P 9731, l 2 Please provide the company's name as well as the trade name of the used pressure transducers. Are the transducers vented or non-vented? If non-vented, did you compensate your data for barometric pressure changes?

In methods, at the first mention of the loggers, we have added, "Solinst Junior, non-vented, data logging pressure transducers were used. . . Also, after the site descriptions, we added "The logger data were compensated for atmospheric pressure with a barometric data logging pressure transducer located at well site [ii].

21. P 9732, l 11 How does over pressurizing preserve concentrations upon extraction? Please explain!

We have added, "Over pressurization of vials ensured that air that could oxidize methane would not be pulled into the vial." High pressure in the vial prevents atmospheric gas from flowing into the vial.

22. l 13 Why did you not sample all three sites at both dates?

We did not sample at all 3 sites on both days due to time restrictions associated with walking in and out of the study area. There was also limited access to a gas chromatograph. No changes were made here.

23. l 18 Did you use a vacuum pump? Can you exclude any degassing during sampling? How long did the recovering of the well take? How did you transfer the water samples from the flask to the glass vials? Can you exclude any exposition of the sample to the atmosphere during the transfer? If not, did it produce any degasing during transfer?

We have added: "Wells were purged via a vacuum hand pump until the well went dry. The well was allowed to partially or fully recover over a 60 minute period. The well was then pumped again into an Erlenmeyer flask and then transferred carefully by pouring to a 10 ml glass vial so as not to agitate or create bubbles.

In the discussion of Gas and Water Samples (5.1), Since degassing cannot be excluded,I have added that "Although none of our tested water samples showed concentrations that were supersaturated with respect to CH4 or CO2, bubbles were seen forming in the capped 10 ml glass vials soon after collection. Some degassing of sam-

ples may have been possible upon collection when samples were transferred from the Erlenmeyer flask to the 10 ml glass vials, although samples were carefully transferred. The shallow peat model would suggest. . .”

24. P 9733, l 17 Please provide the limit of detection/quantification of the FID and TCD.

Detection limit is now included: “The SRI 8610C Gas Chromatograph (GC), with conductivity detector (TCD) and flame ionization detector (FID), has detection limits at 1 ppm. The GC was calibrated by injecting a 1% gas standard of CH4, CO2, and nitrogen into the direct injection valve.”

25. l 26 . . .the measurements (not the bottles) should no noticeable change... What does noticeable mean? Statistically not significant?

“Noticeable” has been changed to “measurable”.

26. P 9734, l 1-5 Please delete the phrases “GC analysis of. . .”. We have learnt already in the material and methods part, how you measured the concentrations. Sharpen your statements.

This has been changed.

27. l 4 What do “initial levels” refers to?

The initial level indicates the May 22nd level. This has been cleared up in this sentence: “Samples collected on May 24, 2012 were at roughly half the CH4 concentrations seen on May 22, 2012 for all wells.” 28. l 22 I am wondering, Figure 5 indicates highest concentration at a depth of 3.3 m.

This should have been the word “greater” instead of “less”. This has been changed.

29. P 9735, l 6-8 Can you really proof that daily fluctuations are due to evapotranspiration? Can you provide any values of typical evapotranspiration rates (radiation) in this area in October? I think that you should discuss your statement more carefully and detailed!

We have added, “Daily fluctuations in hydraulic head data match the patterns attributed to evapotranspiration in wetland systems (Mitsch and Gosselink, 2007) due the nighttime recovery of water levels and because fluctuations only occurred during the growing season. Data also showed unusual fluctuations lasting. . .” 30. l 10-14 You should provide much more additional information and analysis on this statement. Can you, for example, detect a certain temporal pattern or frequency? Can you calculate the average time duration of such events? Did you measure these events at all wells of each cluster?

The sentence has been revised: “Fluctuations are spikes of 2 to 5 cm in hydraulic head data that occur during decreasing atmospheric pressure are accompanied by a rising water level due to precipitation (Fig. 7).” The prior paragraph has also been changed: “Unusual fluctuations in hydraulic head were interpreted as FPG movement and release within the peat column (Fig 6). Hydraulic head typically increases rapidly with increased hydraulic heads lasting a few hours, followed by a sharp decrease in hydraulic head, and finally a recovery of hydraulic head back to levels consistent with long term data. This pattern may occur several times over longer duration events and these events end when lowest atmospheric pressure is reached and precipitation ends. These events are recorded more frequently by wells screened more than 3 m below the peat surface.” Temporal patterns and frequencies are being still being looked at. I did address that events occurred at all wells and the number of events at each location in lines 14-19.

31. 20-25 Are these information only related to figure 6 or is it now a more general summary of all results? Please clarify!

We have added a reference to figure 6 and changed the paragraph as described in #30.

32. P 9736, l 28 Please locate Pushaw lake in Figure 2.

Pushaw Lake is now labelled in Figure 2.

33. P 9740, l 13-15 This is not in line with figure 7. From figure 7 it can be concluded, that fluctuation in well 7.5 ft starts before those in wells 15 and 17.5ft.

We believe that the orange well (now the 5.2 m well) is the first well to fluctuate slightly at 03:00:00. No changes were made. 34. Figure 2: In my opinion, figure 2 is overloaded. There is hardly any knowledge gain obtained from the satellite (aerial) image. I am wondering if the information given in Figure 10 can be linked to Figure 2.

Figure 2 was updated: Labeled Pushaw Lake and outlined the approximate edges of the peatland. I have also changed the figure to include only a map of the study area. Some information, such as the esker and the well sites, overlapped with Figure 10 and are now included in Figure 10. The GPR image of the esker has been deleted because it was difficult to read and can be found by looking up the corresponding reference.

35. Figure 4: You can delete the headings of the figures because the required information is comprehensively provided in the figure caption. If I understood it correctly, data from both sampling dates are plotted. It might increase the information content of this figure if you use different symbols for each sampling day.

Figure 4 has been changed to use different symbols for the two sampling days. I have also deleted the headers. The header was also deleted for Figure 5.

36. Figure 6: Please delete the header! Please add a more meaningful time axis with information about the hour of day. That makes it easier to identify, for example, noon of each day. Which plot do the data represent? Is it the average of all wells?

The header has been deleted. The caption has been changed to “Figure 6: Plot zoomed in on fluctuations in hydraulic head from the 6.85 m well at the shrub site [i]. Fluctuations believed to be pressure release events are outlined by the box. Daily fluctuations in hydraulic head are believed to be caused by evapotranspiration. Each x-axis label represents the zero hour of the day.”

37. Figure 10: I recommend to delete the satellite image and to link the information in

this figure with those of figure 2.

The satellite image was kept because it was deleted in Figure 2. Figure 10 has been updated so that there is no overlapping information between the two figures.

38. Figure 11: The readings given in figure 10 are not in line with those provided in figure 9. Please explain! Figure 11 has been corrected to have consistent data with Figure 10. The water level measurements for Figure 11 had been subtracted from the top of the GPS antenna instead of from the top of the board holding the wells in place.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C7125/2014/hessd-10-C7125-2014-supplement.zip

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