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Title: Using hydrologic measurements to investigate free phase gas ebullition in a Maine Peatland, USA

Comments:

The manuscript focuses on the effect of atmospheric pressure changes and rising water tables on ebullition events, which are assumed to be important pathways for the emission of CH₄ from peat soil to the atmosphere. The analysis is based on a comprehensive data set including water level and pressure head dynamics measured in different well clusters, and dissolved CH₄ concentrations in the groundwater, among others. The analysed data set is comprehensive and promising. However, in my opinion the challenging aim and interesting scientific approach of the study is partly downgraded by a poor (at least in some parts) and improper description/discussion of the methodology used. Please refer to the specific comments below for further detail.

To sum up, I rather suggest to reject this paper in its present form. However, since the data is promising and unique I highly encourage the authors to resubmit the manuscript after a thorough and detailed review.

Specific comments:

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

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)?

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).

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

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.

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

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...".

- P 9724, I 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?
- I 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!
- P 9725, I 1 ... understanding the influence of CH₄ *production/storage* from...
- I 5 CH₄ is not only produced in peat but in soil in general under un-aerobic conditions.
- P 9727, I 7-11 This section is a summary of the key results of the present study. It should be shifted to the concluding section.
- I 26 It might be helpful to add the contour of the Caribou Bog (2200ha) to Figure 2.
- P 9728, I 9 I recommend to replace the phrase “interesting” by “diverse” (for example).
- I 21 It might be helpful if you provide the measured values for the hydraulic conductivity of the esker and the surrounding material.
- P 9729, I 3 How many wells per cluster? How did you choose the locations, randomly?
- I 7 Are the wells of each cluster spatially arranged as a raster? How did you install the wells?
- I 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?
- P 9730, I 11 What is the ground cover vegetation at this site?
- I 23 Please quantify the accuracy of this measurement (e.g. standard error)?
- P 9731, I 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?
- P 9732, I 11 How does over pressurizing preserve concentrations upon extraction? Please explain!
- I 13 Why did you not sample all three sites at both dates?
- I 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 degassing during transfer?

- P 9733, I 17 Please provide the limit of detection/quantification of the FID and TCD.
- I 26 ...the measurements (not the bottles) should no noticeable change.... What does noticeable mean? Statistically not significant?
- P 9734, I 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.
- I 4 What do “initial levels” refers to?
- I 11 Is the difference of the average concentration of day 1 and 2 statistically significant? If so, what might be the cause of this increase?
- I 22 I am wondering, Figure 5 indicates highest concentration at a depth of 3.3 m.
- P 9735, I 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!
- I 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?
- I 20-25 Are these information only related to figure 6 or is it now a more general summary of all results? Please clarify!
- P 9736, I 28 Please locate Pushaw lake in Figure 2.
- P 9740, I 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.
- 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 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 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?
- Figure 10: I recommend to delete the satellite image and to link the information in this figure with those of figure 2.

Figure 11: The readings given in figure 10 are not in line with those provided in figure 9. Please explain!