Biogeosciences Discuss., 9, C6431–C6436, 2012
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Biogeosciences Discussions

Interactive comment on "Distribution of methane in the Lena Delta and Buor Khaya Bay, Russia" *by* I. Bussmann

Anonymous Referee #1

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General Comments: The data presented in the manuscript are important given the emerging role of inland waters and the global greenhouse gas balance. I think both the region of study and the data are important for understanding the response of northern ecosystems to climate change. I was surprised that many important papers regarding aquatic methane emissions were not included in this paper. I was also surprised that no data regarding CO2 concentrations were presented. In fact, CO2 was not even mentioned; the third sentence of the abstract reads "With this melting, large amounts of carbon – either organic or as methane – will reach the waters of the Lena and the adjacent Buor Khaya Bay (Laptev Sea)". Why would CO2 not reach the Lena? This is a fatal omission by the authors as there is a rapidly expanding literature regarding CO2 fluxes from northern aquatic ecosystems (some are just now going to press; i.e. doi:10.1029/2012GB004306, DOI: 10.1111/gcb.12083, doi: 10.1111/j.1365-

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Interactive Discussion

Discussion Paper

2486.2009.02092.x, doi:10.1029/2008GB003404) Aside from an incomplete framing of the topic, my main issues with the paper concern the estimates of evasion, an incomplete description of the redox conditions and no attempt to constrain the proportion of meltwater (a proposed source of methane) to the river and estuary methane balance. If waters are oxygenated, how is methane produced in situ? Can meltwater balance the CH4 in the river given the potentially enormous discharge of this river? I cannot support publication of this manuscript in its present form.

The figures could be more clear. For example, Figure 1 is rather difficult to interpret. Coloring or shading of water and terrestrial portions would help, labeling of important features might also be useful. Where are: Muostakh Island, Buor Khaya Bay, Lena Channels, Olenekskaya Channel on the map?

Comments directed to the prescribed questions: 1. Does the paper address relevant scientific questions within the scope of BG? Yes, I find that the paper addresses a relevant topic that is likely of interest to readers of BG. 2. Does the paper present novel concepts, ideas, tools, or data? I believe that the data is important. 3. Are substantial conclusions reached? I do not find that the conclusions are fully supported, and are thus not substantial in present form. 4. Are the scientific methods and assumptions valid and clearly outlined? I do not find that all of the methods are supported. Assumptions regarding water sources (especially the meltwater balance) are not supported in the text. 5. Are the results sufficient to support the interpretations and conclusions? I do not find the results to be sufficient. The interpretation of the mixing experiments is especially problematic. 6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? I find the methodology to be sound. 7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? The authors properly credit other works, however, there are significant omissions of relevant works regarding aquatic methane and CO2 fluxes. 8. Does the title clearly reflect the contents of the paper? Yes 9. Does the abstract provide a concise and complete summary? I

BGD

9, C6431–C6436, 2012

Interactive Comment

do not find that the abstract is supported by the data and the analysis described in the text. See detailed comments below. 10. Is the overall presentation well structured and clear? I do not think the organization of the paper is strong. The introduction requires more background and references to the literature. Certain components of the methods section are not placed properly (i.e. the study site) , and the section of the discussion regarding gas transfer velocities actually belongs in the methods section. 11. Is the language fluent and precise? The language is mostly precise, however, I would suggest a final review by a fluent speaker before resubmission. 12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? 13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? I think the figures could be reformulated. Figure 1 is specifically problematic (comments are provided above). 14. Are the number and quality of references appropriate? No, there are serious omissions of references regarding aquatic gas fluxes in northern regions. More background is especially required in the introduction. 15. Is the amount and quality of supplementary material appropriate? NA.

Detailed Comments: 16214.2: My understanding is that the permafrost community prefers the term "permafrost thaw" as opposed to "melt." The term melting implies water ice. I would recommend that melt be replaced with the thaw term. Alternatively, a description or discussion of ice content in the region is necessary to support the hypothesized meltwater methane source. 16214. 5: Will any of this carbon reach the Lena as CO2? 16214. 16: Where is the methane released? In the bay or in the river itself? 16214. 19: Unclear. Suggestion "10% of global runoff flows into areas of shallow shelf seas." 16215.2: I understand that runoff may change, but specify the likelihood of increase, and the expected magnitude. 16215.11: transition between paragraphs. Perhaps begin by stating the relevance of CH4 in regional budgets and the large uncertainty. 16216. 16: Sampling details should be included in the following section 16216.16: what gas was used to flush the serum bottles? 16218.4: Please explain the purpose of these mixing experiments initially. I am concerned that these experiments to determine aerobic methane oxidation actually experienced anoxic conditions. The oxy-

BGD

9, C6431–C6436, 2012

Interactive Comment

gen environment must clearly be explained. If not, these results can not be interpreted as the authors present them. The issue of oxygen conditions and methanogenic potential is currently a major problem for the conclusions of this manuscript. 16219.3: what were the oxygen conditions of the sampling locations? The methane production potential (3.4 Mixing Experiments) is essentially irrelevant if the redox state will not support methane production. 16219.17: remove "in a first overview". What area are we talking about? The River, the estuary? State it clearly. I think it would be useful to separate Figure 3 into river and estuary samples. 16219. 23: Is there any explanation for the higher methane concentrations (∼100nM) at greater depths shown in the lower panel of Figure 4? 16219.25: The repeated reference to the "background" concentration of 20nM needs to be evaluated further. Is this concentration reflective of waters in equilibrium with respect to the atmosphere or is the water supersaturated/undersaturated? 16220.20: Omission of these data is surprising given the stated purpose of the paper. Could non-biogenic sources such as those referred to in the introduction be important? What processes could account for these signatures? Degassing, hydrates, something else? 16221.15: what sources do these 13C signatures reflect? I appreciate the comparison to literature values, but more complete interpretation is necessary. 16222.3: I liked seeing the downstream methane pattern in Figure 7. This result is rather interesting. This result could be extended by modeling gas residence time/distance. For example given the concentrations at 0km, what would the predicted concentration be at 2km downstream, or at further distances. The authors suggest that there are new sources but this statement must be proven more explicitly. This analysis should be extended further to the estuary data, assuming advective flows into the estuary, how far out would you expect to find a riverine methane signal before all the methane has been lost to the atmosphere? I suggest the equations reported by Baulch et al (2011) (and references therein) for 95% evasion length (ie. 3v/k), or a simple model of exponential decay would be a good starting point. 16222.12: Discussion of methane emission modeling belongs in the methods section. Furthermore, given that evasion is the main process described in this paper, a more detailed discussion and evaluation of

BGD

9, C6431–C6436, 2012

Interactive Comment

gas transfer is required. It is unclear why this particular model was chosen, or if it is even applicable in this environment. The physics of gas transfer are perhaps the most uncertain components of evasion estimates, and thus require much, careful attention. How do the estimates of k compare to other literature values? 16222.20: from where does this transfer velocity equation originate and why this particular equation? There is a large literature regarding transfer velocity modeling in rivers and it would be important to evaluate other potential equations and their application to the studied waterbody. 16223.6: This statement is important. The comparison between terrestrial and aquatic emissions is important for understanding the landscape greenhouse gas balance and for predicting future change. However, I do not believe that the data can support this conclusion. Seasonal variability could alter this conclusion and I do not believe that these data can support a direct comparison between the two ecosystems. How much variability was there in the eddy covariance data cited? 16223.14: The statement "we can only conclude that the observed methane concentrations of around 100 nM are the result of a strong meltwater input and a strong in situ production of Methane" is highly problematic and is not well supported. Most importantly, the redox status of the sampled waters are not presented. If oxygen is present, in situ methane production would not be probable. The suggested methane sources are not fully supported. Please include estimates of discharge from the Lena and provide at least some discussion of water sources. The meltwater source is not supported hydrologically in the text. Given the expected large flows in the river would there be enough meltwater input to detect new CH4 in the river? The author does not present any data regarding river discharge and it is difficult to judge whether small inputs could even be detected. Could groundwater or production in the river sediments be an important methane source? 16224.13: What might explain the outliers plotted in Figure 9? 16224.21: Is there any literature that describes controls on methane oxidation in other estuaries? 16225.10: Again, reference to high methane production are not supported by oxygen data. I assume that the river and the estuary are oxic, so how can methane be formed? 16225.15: The author does not adequately present conclusions regarding the mass of methane

BGD

9, C6431–C6436, 2012

Interactive Comment

which could reach the bay. What fraction of the methane is emitted before reaching the estuary?

Interactive comment on Biogeosciences Discuss., 9, 16213, 2012.