

## ***Interactive comment on “Drivers of diffusive lake CH<sub>4</sub> emissions on daily to multi-year time scales” by Joachim Jansen et al.***

### **Anonymous Referee #2**

Received and published: 22 October 2019

This manuscript documents almost a decade of weekly-monthly resolution methane concentration and flux data from 3 sub-Arctic lakes. They found Arrhenius-type temperature relationships with flux and concentration, which has been found before and suggests a strong coupling to methane production rates. They also found that wind shear drove the gas transfer velocity, but on timescales of less than a month while temperature was a driver on timescales longer than a month. They also found that stratification only played a small role in storage/accumulation and emissions in general from their systems. The methods are sound and the results are well-detailed, perhaps a bit on the long side. The dataset is quite unique as it is so long. The authors need to use the length of their dataset to substantiate their results more. They find a temperature relationship that has been shown before in quite a few other datasets, but perhaps

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ones not as long as theirs. Also, they find that convection does not play as large of a role in surface turbulence as has been found in other lakes. How do those datasets compare to theirs? I also strongly suggest the authors structure the discussion to highlight the main takeaway messages from this work.

General comments: 1. The title seems broad as if you are referring to all lakes, but you actually point out in the manuscript many differences between your findings and those of other lakes, for example, in terms of convection contribution to  $k$ . I suggest you narrow down your title slightly. You could even highlight more in the title the amount of data that you have. This multi-year dataset is quite unique. 2. I think the discussion could do with some restructuring and more concisely define the main points of your findings. The subheadings closely follow the results structure, but this doesn't help the reader easily identify your main points. I like the way you summarized your findings in the first paragraph of the last section (summary and conclusions). I would suggest laying out the discussion with subheadings similar to the structure in that paragraph, at least to start and then edit from there. You also may not need all the information in the discussion if you find it does not highlight one of your main points.

Specific comments: Line 50- should read ‘, of which the upper boundary.’

Line 72 – did you not include Aben et al. 2017 because it is about ebullition? You don't specifically mention diffusive only in this sentence.

Line 101 – ‘stochastic tools’ sounds too vague here

Line 129 – I would say ‘During the 24 hr period. . .’ to avoid confusion. But why 2-4 samplings? What resolution and why?

Line 135-136 – you need to define  $F_{ch,unsh}$  and  $F_{ch,sh}$  here in this sentence (i.e., place the variables after ‘shielded’ and ‘unshielded’)

Section 2.3 – Do you flush the chambers between samplings or leave them the entire 24 hrs? Do you flush or mix the 4m long tube before sampling?

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Line 196 – do you mean ‘offshore’ instead of ‘nearshore’ here since you are differentiating between the littoral zone and another zone?

Line 198 – make sure the year is correct on the reference

Line 205 – define and give units for ‘kch’

Line 211-212 – why were there some water measurements not taken and which ones and how many?

Line 239 – should be ‘kmod’ specifically in this sentence, no?

Line 245 – why do you need to do this qualitative comparison? Why is it important?

Line 338 – definite ‘ $\sigma_{init}$ ’

Line 420 – include in the caption the panel letters for the histograms in parentheses too

Figure 4 caption – you need to describe the squares, triangles, and diamonds in the caption itself – all the variables that you are presenting here.

Figure 5 caption – what are the curves you speak of in line 500? Are you sure that e and f are the right panels when you discuss the white lines on line 499? What is the resolution in panels c and d?

Table 3 title – need to describe N here

Figure 6 caption – add ‘(a-c)’ after ‘residence time’ and ‘(d-f)’ after ‘storage’. You mention the regressions for residence time but not for storage. Also, it looks as if there could be a trend between temperature and storage (panel e) for at least 2 of the lakes. Was there not?

Line 560-561 – the sentence starting with ‘On diel timescales.’ needs rewording. I don’t understand it.

Figure 7 – put a complete legend in panels a and c and state that they apply to panels

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b and d.

Line 612 – what is ‘Twater/ice’?

Section 4.1 – The subheading ‘Magnitude’ doesn’t explain much. Magnitude of what?

Line 632 – you obtained lower k-values by nearly a factor of 2 compared to what?

Line 636 – who had the offset at 0 wind speed? You or the literature? Be specific as this sentence is a bit confusing.

Line 637 – ‘Another explanation’ for what?

Line 639-640 – how was the atmosphere stable?

Line 644-645 – I am confused because you have an equation in Figure 9 caption that has an exponent for  $u_{10}$  with 95% CIs.

Section 4.2 – delete ‘the’ in the subheading

Section 4.2 – this is a very important part of the discussion but I feel it needs a little more work to really bring out your main points. It reads a bit like a bunch of ideas thrown into a paragraph but without linking them all together nor highlighting why these ideas matter. For example, the first sentence states that the temperature relationship with flux and concentration suggests a strong coupling to sediment [methane] production (need that word ‘methane’ in there). I agree with this statement and it’s an important one because you did find some nice relationships there. But the next sentence talks about stream inputs (from your own data, correct?) and then the following sentence is back to how sediment methane production could be enhanced. They seem out of order. Then the last thought about the decrease in CH<sub>4</sub> after cold rain events is actually still in line with the temperature relationship you saw but you start this sentence off attempting to state that that shouldn’t be the case if there was runoff from fens. This fens part goes more along with the streams sentence from above. I feel the same for the second paragraph of the section. I think you clarify your point about the difference

between your results and those of Read et al. I am actually not sure who had lake in the warmer, lower humidity regions – you or them? Also need to put the 50 w/m<sup>2</sup> value in context. At the end, I wouldn't use the word 'expect' because I think you showed this. And I believe in this whole section you should already elude to the fact that these drivers work on different timescales.

Line 716-728 – The first sentence of this paragraph reads more like a summary sentence. It's confusing to hear about the feedback before you describe how you got to that point. I would try restructuring this paragraph a bit. I would start with the second sentence and state it like so: 'Higher temperatures led to elevated CH<sub>4</sub> concentrations, which in turn increased emission rates, but high wind speed was correlated with high emission rates and low concentrations. In this way,...

Line 744 – add the range of binned means in those parentheses of ~0 – 10

Line 784-791 – This is actually one very long sentence. Consider splitting it.

Line 798-799 – missing a word or something here '...but can limit surface exchange could be responsible...'

Line 834-837 – So you don't completely degas the lake, despite shallowness and frequent mixing, but you also don't have storage/accumulation of methane. I am finding a hard time reconciling those two results. I feel this needs more explanation here but also in the discussion where you mention it.

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