

## ***Interactive comment on “Methane Pathways in Winter Ice of Thermokarst Lakes, Lagoons and Coastal Waters in North Siberia” by Ines Spangenberg et al.***

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This paper describes ice on three distinct water bodies, in particular examining the methane within the ice and the physical properties associated with understanding the observed methane concentrations. I am expert in the growth of ice on water bodies, but not on the suite of chemical techniques involved in the study and my comments below need to be read with this in mind. I believe that the study is interesting and deserves publication but could be made easier for the reader to understand, especially those not already expert in every aspect of the work.

Comment 1: The paper deals with three distinct water bodies which are expected to

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show different characteristics. Yet there is nothing in their abbreviated names that helps the reader immediately recognize which water body is being described. Why not call the sites Bay, Lake, Lagoon, or some abbreviation that is easily recognizable, such as BY, LK, LG?

Comment 2: In addition a number of cores are taken at each site, and interesting behavior is shown in these data in Figures 3-5. However the naming of the cores could better reflect their position and make it easier for the reader to interpret this behavior—for example the TB cores could be labeled from N to S, while GL cores from E to W.

Comment 3: In my opinion there was too much description of the shape of graphs etc at the expense of what the reader might expect to learn from that particular type of behavior in the graph. I understand that the paper is the work of a thesis, but while such description is appropriate for a thesis it extends the length of a journal article unnecessarily. For example, sections 4.2.2, 4.2.3, 4.2.4, 4.3.1 and 4.4.1 give detailed description of what can be seen by looking at Figs 3, 4 and 5, and Table 2. What I wanted to know was what can be scientifically deduced from the observed values of parameters, or form of graphs. I suggest that the authors replace these detailed descriptions with the scientific evidence provided by the particular behaviors.

Comment 4: I felt that the authors tended to make rather grandiose statements that were not obviously dealt with in the paper e.g. statements regarding ice as a barrier to methane fluxes and the importance to warming in the Arctic. I suggest that authors carefully consider what can be deduced from their work and focus on the aims of their study. Comment 5: I do not have the expertise to critically review the chemical techniques used in this paper and whether they are appropriate and carefully carried out. I'm afraid that the editors must seek advice another reviewer for that expertise.

Technical Corrections

p. 1: Abstract: Please rewrite, taking into consideration the Comments above.

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p.1, line 3: “.. provide insights on methane pathways in winter ice cover.” But at the end of the paper I had not recognized what these insights were, nor could I find it in the Abstract.

p.1, line 10: “except for three”

p. 1, Line 14: Comment that “methane oxidation may decrease methane concentrations during winter” Where? In the ice? In the atmosphere? Both? Is this the evidence for the winter pathway but I have not recognized it?

p. 1, Line 14-16: I could not follow how methane pathways in freshwater systems led to the understanding of permafrost carbon feedbacks in global warming – this seemed to be a huge leap to me – but perhaps I show my lack of knowledge of permafrost.

p. 2, Line 27-28: This is not a sentence

p. 3, Line 20-23: Here the authors clearly outline the three aims of the paper. I am clear that they have achieved the first aim, but I am unclear regarding aims 2 and 3. I return to this comment in the Conclusions.

p. 3, Line 20-23: “The Bykovsky..”

p. 4, Line 3: please give approximate depths

p. 5, Table 1: The Table implies that PF had a temperature constant to 0.01 oC over its 4 m depth. I found this unlikely. Please justify.

p. 5, Lines 10-16: I don't see the point in telling us about data collected that is not analysed in the article.

p. 5, Lines 15: What does “res” mean?

p. 6, Sect 3.2: I think information about transport and storage of the cores is missing (e.g. temperature) and seems as important as other details that are provided.

p. 6, Line 11: Define EC first time used.

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p. 6, Line 12: “as soon as possible” is not very specific

p. 7, Line 2: “Slope”

p. 7, Line 23: “100 ppm that were”

p. 7, Line 27: “from the same bottle”

p. 8, Line 14: What is the “ice-free transect area” and why was it needed as scale in the photos?

p. 8, Line 22: What are “the cores of the water bodies”?

p. 8, Line 27: “identified”

p. 8, Line 27: How is regelation ice from snow melt identified?

p. 8, Sect 4.1: Difficult to follow as the reader needs to keep referring to which core numbers are from which site. A sketch of the ice types would reduce the need for detailed description and give a better overall view of the structure of the ice covers.

p. 9, Figure 2: Why does PF look so small on this figure? On Figure 1 no dimension of PH seems to be less than GL? In addition it would be good to label geographic location on the transects, i.e. N, S, NW etc

p. 9, Line 2: remove “on”

p. 10, section 4.2.4 & p. 15, 4.4.1: I suggest replacing “stable” with “constant”. “Stable” implies “firmly fixed” and I am not sure that this is what you wish to imply. If you do mean “stable” then I think you need to justify why you expect no change under any change in circumstances.

p. 10, Line 12: spelling “composition”

p. 12, Fig 3: It is very interesting that PF is colder than GL. Is this because it is shallower?

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- p. 15, Fig 6 caption: “free”. Has the ice free area been marked on Fig 1?
- p. 15, Line 13-14: Is this statement tested in the present article, or is this speculation to introduce the Discussion?
- p. 16, Line 10-11: It was not at all obvious to me how the data presented showed that the type of water body determines the circulation of methane. Please explain.
- p. 16, Line 15: Suggest replacing “impact” with “setting”
- p. 16, Line 18: “. . .(2018), while in winter, when the connection..”
- p. 16, Line 26: Why would the freezing velocity be approximately constant? It is likely to decrease as  $1/(\text{ice thickness})$ .
- p. 16, Line 24-29: The authors note that they have not taken into account the freeze fractionation influences (e.g. see Toyota et al., 2013), based on the assumption that the freezing velocity is roughly constant. If this is not necessary please provide an order of magnitude calculation to convince the reader that this is a small effect.
- Toyota, T., I.J. Smith, A.J. Gough, P.J. Langhorne, G.H. Leonard, R.J. Van Hale, A.R. Mahoney, and T.G. Haskell. (2013) Oxygen-isotope fractionation during the freezing of seawater. *Journal of Glaciology*. Vol. 59, No. 216, 2013 doi:10.3189/2013JoG12J163
- p. 17, Fig 7: Very nice helpful sketches. They might be useful earlier in the manuscript.
- p. 18, Line 2: “alone”
- p. 18, Line 5: “may capture”
- p. 18, Line 5-7: Interesting observation that may be compared with the results of Smith et al., (2016).
- Smith, I.J., Eicken, H., Mahoney, A.R., Van Hale, R., Gough, A.J., Fukamachi, Y., Jones, J. (2016). Surface water mass composition changes captured by cores of Arctic land-fast sea ice. *Continental Shelf Research*, 118:154-164, doi:

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10.1016/j.csr.2016.02.008.

- p. 18, Line 7: “indicative for the preceding freezing process (Souchez and Jouzel, 1984).” I’m not sure what this means? Does this mean that freeze fractionation should be taken into account?
- p. 18, Line 9: “Tab ??”. This is not at all obvious from Fig 8.
- p. 18, Line 18: “but with the carbon isotope signature”. I could not see much change in the carbon isotope?
- p. 18, Line 29: “(Lacelle, 2011)”
- p. 18, Line 29: Again, this is not at all obvious from Fig 8.
- p. 20, Line 29: “was”
- p. 21, Fig 8: The changes in slope appear to be important but cannot be seen on the plots as currently displayed. Please consider how to display this information to match the Discussion. Why is global rather than local meteoric line used?
- p. 22, Fig 9: Is it not possible to write down the equation of the model displayed?
- p. 22, Conclusions: Please return to the aims of the study here, and show how they have been moved forward.
- p. 23, Line 8: It is not obvious to me how the data provided has shown that the ice examined “acts primarily as a barrier to methane fluxes to the atmosphere, a barrier that is effective for most of the year but also will be effected by rapid changes due to Arctic warming and associated ice thinning.” Please make this clearer in the Discussion and/or Conclusion.
- p. 23, Line 8: What does “providing a habitat for methane oxidation” mean? Again this needs to have been explained earlier in the paper.