

REVIEWER 2

The Cryosphere Discuss.,

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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 study attempts to improve our understanding of CH₄ pathways in ice covered water bodies by focusing on ice and inland water continuum from lake to coast, both seldom included in the limited winter CH₄ inland water studies. In doing so, the study highlights varying CH₄ concentrations explained by the geomorphological differences between the aquatic systems. This is an interesting study with a unique data set and with revisions could be a nice addition to the scientific community.

General Comments:

1) The studies focus is on Arctic waterbodies underlain by permafrost. However, the introduction covers a broader range, i.e. when referring to Arctic and Northern lakes not all are in continuous permafrost zones. I think this broad perspective of northern lakes is appropriate but think the introduction could be better structured to go from a broad approach (Northern ice-covered lakes) to lakes in a continuous permafrost landscape. In particular Paragraph 2 of the introduction would benefit from this restructuring.

We have substantially re-written the introduction, slimming it down, and removing the tacit differentiation between ebullition and diffusive fluxes of methane.

2) Additional details needed to be clarified in the methods, particularly on CH₄ lab sampling. See specific comments below.

Answered below.

3) The discussion is sorted into the three different water bodies, which works but it would be helpful to also have an overview of how the values calculated for these water bodies compare with values in the same system (lakes/coastal permafrost areas). Perhaps reporting a range for all 11 ice cores and discussing how it compares to other ice-covered inland water values. This could be done in the initial discussion paragraph before diving into the specifics of the three water body types.

We compare ranges in the results table but have not added comparisons to other values.

These are simply not available for all three water body types covered in this paper, nor are their seasonal variabilities characterized. This is part of what makes our paper unique.

4) In the conclusion, in addition to returning to the aims of the study it would be nice to know how these findings fit into understanding the lake-lagoon-coast transition in the arctic region. Although I appreciate that caution should be taken in making large upscaling statements given the limited sample size and snapshot in time.

We are trying to strike a balance between restricting ourselves to the conclusions permitted by our results, and explicit statements of what we feel are the implications of these findings.

5) Much of cited literature focuses on findings from lakes. Are there any studies that have looked at CH₄ concentrations below ice in coastal areas? If so, it would strength the paper to include them in the introduction and discussion (see general point 3).

We agree, but are not aware of any additional studies from coastal ice.

Specific Comments:

Title: Since the study only investigates one lake, lagoon and bay perhaps the title would better represent the actually study as, “Methane Pathways in Winter Ice of Thermokarst Lake-Lagoon-Coastal Water Transect in North Siberia”

Yes, corrected.

P1, L 7-9: Could use a tie in sentence and possible move this information after L 5-6 as it is continuing to point out differences between the system, e.g. "In addition the three water bodies had different freezing systems. In TB. . ."

We have moved the sentence.

P1, L 12: is "above the ice-water interface" referring to in the ice? If so please clarify.

Clarified by including "in the ice".

P 2, L 7-9: This sentence should be rewritten. Is the idea that CH₄ can continue to accumulate in lakes over the ice-covered period whereas in soils the active layer freezes during winter and CH₄ is not produced? A reference showing that CH₄ production in the active layer of permafrost is mainly during summer would help support this statement. CH₄ has been found to accumulate in shallow lakes over winter, so the authors may need to think about the definition of "certain circumstances".

As part of revision of the introduction, these sentences have been removed. We do not seek to compare aquatic and soil environments.

P2, L 23-25: I assume these two sentences are referring to lake sediments? Please clarify.

This sentence has also been deleted.

P2, L 25: a third pathway, plant mediation, should be included.

This sentence has also been deleted.

P3, L 1-4: Are these the only two studies looking at CO₂ and CH₄ in ice? Perhaps these sentences could be simplified as one, "Of the limited studies, accumulation of CH₄ in and under the ice during winter were realized for shallow ice-covered lakes in Alaska (Phelps et al. 1998) and four lakes in discontinuous permafrost area (Boereboom et al. 2012)." Or something like that.

Adopted.

Pg 3, L6, "However, methane oxidation. . ."

Adopted.

P3, L10: change to, "methane has been found to oxidize at temperatures as low as "C."

Adopted.

Material and Methods:

P5, L 15: typo "res"

Corrected.

P6, L 1-9: How were the ice samples stored, in -15C? Could there have been CH₄ oxidation? How effective was the vacuum pump at removing O₂?

We describe that the ice cores were stored in sealed plastic tubes and in thermally insulated boxes for transport. We have added: "..., which effectively sealed the inner bag surface to the ice." We did look at our data critically and consider potential or plausible roles played by oxidation after sampling. The observed methane concentrations and isotope concentrations are not consistent with oxidation during transport.

Pg 6, L 22-25: How many samples were considered high salinity and low salinity?

Now specified in text (7 were "high").

Pg 7, L 14: Remove Global Meteoric Water Line, already abbreviated above.

Adopted.

Pg 7, L 19-20: More details needed here. When the N₂ was added did it create an overpressure in the vial or was 5 mL of water removed? How was the water sample equilibrated with the N₂, shaken?

Was the equilibrated air then removed from the vial and injected into the GC?

Added: "For methane concentration, 5 ml N₂ was added and 5 ml of water simultaneously removed from the vials. Afterwards, the water sample was equilibrated with the N₂ by being shaken for 1 hour at room temperature. Then, 1.5 ml of the equilibrated air was removed from the vial and injected into a gas chromatograph (GC; Agilent 8900) with a flame ionization detector (FID)."

Pg 8, 10-19: Was the bubble transect done before or after the ice coring, i.e. were the ice core samples taken from the targeted plot area or were they randomly selected?

The bubble transect and coring happened during the same time period but were independent of each other, i.e. cores were not taken from the bubble transect.

P 18, L 9: typo, "(Tab. ??)"

Corrected.

P 18, L 10: typo, "admixture"

Corrected.

P 19, L 12-16: Could it also be because less is being produced?

This would not explain the shift in isotope composition.

P 20, L 29: typo, "lwas"

Corrected.

Table 1: In the legend add "Water" at the start of the second sentence. For the electrical conductivity column could you report Salinity [PSU] /EC [mS/cm] since salinity is known for all three water bodies. Or have two sperate columns for salinity and EC.

We have created two columns with a conversion to salinity.

Table 2: For PF replace Lake with Lagoon in the Sampling Site header.

Corrected.

Figure 4: GL has different scales for the first two rows

This is necessary, since the values for one core (LK-5) are so extreme and using the same scale would mask any variation at the other 2 sites. We have added to caption: "Note that the isotope concentration scales for Goltsovoye Lake (LK, at right) differ from the other 2 sites to accommodate the values observed in core LK-5."

Technical Comments:

1) There are many places where Methane is written out, since it is abbreviated to CH₄ on P1 L19 it should be changed to CH₄ thereafter.

Corrected, also in figure captions.

2) Keywords: remove . . . at end of list

Corrected.

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