

## ***Interactive comment on “Seasonal methane dynamics in three different Siberian water bodies” by Ingeborg Bussmann et al.***

**Ingeborg Bussmann et al.**

ingeborg.bussmann@awi.de

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The manuscript "Seasonal methane dynamics in three different Siberian water bodies" by Bussmann et al. presents measurements of methane concentrations and oxidation rates (MOX) from different samplings in an Arctic river delta, in the adjacent coastal waters and in a nearby small Arctic lake from sampling campaigns carried out during ice-free summer conditions and under ice cover in late winter. The presented data close knowledge gaps on winter time methane dynamics in Arctic waters. The authors find that CH<sub>4</sub> accumulation under ice is governed by the exchange of waters under the ice, with insignificant accumulation in the river and strong accumulation in the stagnant lake waters. Additional measurements from ice cores did not show large CH<sub>4</sub> accumulation and no CH<sub>4</sub> gradients, and confirmed that the ice cover is an effective barrier for

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the CH<sub>4</sub> flux to the atmosphere.

The manuscript is generally well written, and the presentation of the CH<sub>4</sub> concentration and ice core data is clear and comprehensive.

I have some issues with the part on the MOX rates, however, which need to be resolved by the authors: in addition to the methane concentrations from the different water bodies, MOX rates were determined in winter time in the Lena river. The authors use these MOX rates to determine the potential of MOX for reducing the CH<sub>4</sub> accumulation under ice. Based on their assumptions, they conclude that the measured low MOX would lead to a rather small reduction of the CH<sub>4</sub> inventory, and strong CH<sub>4</sub> accumulation under ice is likely. However, this estimate is based on a number of assumptions the authors make, and I am missing a detailed chain of arguments that justifies these assumptions:

- the authors transfer the fractional MOX rate determined from the Lena river sampling to the coastal and lake waters (lines 318-320), but they miss a convincing argumentation if this is justified. In lines 460 to 470, they discuss the influence of different environmental factors such as oxygen and phosphate concentration and temperature (lines 460-470), but these factors are not taken into account or even discussed when the MOX rates from the coastal and lake waters are calculated. Instead, the authors present the MOX rates from these two water bodies as if these were independently determined (lines 320-325, Fig.5), and not calculated from the CH<sub>4</sub> concentrations.

Yes, the referee is right here, we determined  $k'$  for river water and for the ice cores from the Lake and Tiksi Bay, but  $k'$  was not determined for each single sample. This is a major drawback, but the best we could do at these difficult locations. We also removed the term “in situ MOX” and name it only MOX. This fact is stressed more now in the abstract, the result section, as well as in the discussion: “The fractional turnover rate  $k'$  was determined in ice cores from the lake and Tiksi Bay, and in river water. Within these locations  $k'$  was evenly distributed. However,  $k'$  may vary between different environments (river, lake and brackish water) as well as between ice cores and

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underlying water. The fractional turnover rate is influenced by temperature, methane and oxygen concentrations [Steinle, 2017 #2755]. Thus, in our calculations an error is embedded. However, as temperature was low at all locations, and the methanotrophic population of the ice cores is similar to the ones in the water below, we assume that the application of one  $k'$  to all samples is a good assumption.”

- the authors conclude that the accumulation of CH<sub>4</sub> under ice will lead to a pulse release of CH<sub>4</sub> when the ice melts, and the low MOX in winter compared to summer conditions induce larger overall emissions from winter than from summer conditions. I think this argumentation is a bit too superficial

We agree that the line of discussion was too simplified. We added now a more detailed discussion on the sources and sinks of methane in an aquatic system. As can be seen in the last part of the new discussion

– summer and winter conditions not only differ in the effectiveness of CH<sub>4</sub> oxidation, but also in the fact that during summer, gas exchange is an additional sink for CH<sub>4</sub>, and that CH<sub>4</sub> emissions are determined by the effectiveness of CH<sub>4</sub> oxidation vs. gas exchange. To fully assess the potential of CH<sub>4</sub> emissions from pulse release during ice-off or from continuous emissions under ice-free conditions, all sink terms would need to be carefully taken into account.

We agree that the line of discussion was too simplified. We added now a more detailed discussion on the sources and sinks of methane in an aquatic system. As can be seen in the last part of the new discussion.

Specific comments: Line 20: "Arctic regions and their water bodies are affected..." Changed accordingly

Line 134: "the Bykovskaya Bay" No, Buor-Kaya Bay is correct

Line 467: "But temperature is also : :": remove "but" Changed accordingly

Lines 504-505: A 60% reduction of the methane inventory by MOX does not seem like

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an insignificant reduction of the CH<sub>4</sub> inventory to me. This part has been removed and rewritten.

Lines 508-509: "we assume, that after ice-on, both parameters increase/decrease in a linear way" Could you explain this assumption? Why would this be justified? This part has been removed and rewritten.

Lines 546-550: I think this statement is somewhat speculative- I doubt that the increased MOX rates in summer than in winter is the only factor that determines CH<sub>4</sub> emissions from the Arctic water bodies. The authors should at least mention which additional factors could influence CH<sub>4</sub> emissions. This part has been removed and rewritten.

Line 554: The data should be submitted to PANGAEA and the data availability statement updated. The data are submitted in Pangaea and details are given in the revised version.

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