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***Interactive comment on* "Methane distribution and oxidation around the Lena Delta in summer 2013" *by* Ingeborg Bussmann et al.**

Anonymous Referee #3

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GENERAL COMMENTS

Bussmann and colleagues report a valuable data-set of dissolved CH4 concentration in the Lena Delta.

It could be useful if authors compare in much more detail their new data-set with older data-sets obtained in the area (Bussmann et al. 2013). As it stands it's unclear what's the added value and novelty of the present ms compared to what was previously published by the authors on the same topic.

In the present study only transect 1 overlaps with the previous study, most of the present sites are more to the north. As a novelty of this study we also assessed the influence of methane oxidation on the methane distribution pattern. As specified at the end of the introdcution: "The aim of this study was to get an overview of the methane distribution in the near shore and northern parts of the Laptev Sea and to gain insight into the role of methane oxidizing bacteria in the methane cycle in this area. Furthermore we tried to assess which environmental factors determine the methane distribution and its oxidation".

The CH4 concentrations in the study area are extremely low compared to other estuarine environments (at lower latitudes), and the spatial gradients are also extremely low given the large salinity gradients. This fundamental difference contains some potentially important information on the functioning of estuaries in high latitudes and deserves to be discussed in light of published CH4 data in other estuaries. Is this due to a low CH4 concentrations in the Lena inner river itself? Any data on the CH4 concentration in the river itself ? If so does it differ from other rivers worldwide (e.g. Stanley et al. 2016) ? Or are these patterns related to removal of CH4 from river water by emission to the atmosphere and by MOX within the delta, since the measurements were made quite away from the coast ?

The following sentence is now added to the discussion 4.1: "Methane concentrations in the Lena River, Bykowski Channel are on average 58 ± 19 nM (Bussmann 2013 and unpublished data from 2012 and 2016). This is much lower than the average global riverine methane concentration of 1350 ± 5160 nM [Stanley, 2016 #2645]. However, for the esturies of the Ob and Yenisei similar low concentrations are reported; 18 ± 16 nM from [Savvichev, 2010 #2447] and approx. 30 nM from [Kodina, 2008 #2485]."

I suggest that the authors make their data-set publically available, either as a supple- ment of the paper, or in an international data-base (PANGEA, MEMENTO, . . .).

The methane related data set is already available at www.pangaea.de, doi:10.1594/PANGAEA.868494, 2016. This is now stated in Line 103 and L481

SPECIFIC COMMENTS

All of the abbreviations need to be defined, e.g. qPCR (L13), MISA (L14), OTUs (L21), etc. . .

We agree with the reviewer, however the whole definition of these methods would be rather long. Thus we suggest that the interested reader should refer to the M&M section and we would rather keep the abbreviations in the abstract.

L24-26: In estuaries there are typically differences in residence time in different regions (e.g. salinity ranges). Residence time will strongly affect the distribution of microbes that for some groups can have relatively long growth times.

We added the following sentence to the discuccion 4.4: "In estuaries the residence time of the water (as influenced by water discharge and tidal force) also influences the effidiency of the estuarine filter (Bauer et al., 2013)."

L33: Please add a reference to back this statement on latitudinal variations of CH4 source-sinks.

We refer now to Saunois et al., 2016.

L50: Conversely, the authors should also describe what goes on at depths <200 m since this corresponds to the regions covered by the paper.

The next sentence does refer to water < 200 m: "However, ebullition at shallow water depths represents a short cut as it will not dissolve into the water, and most of this methane will reach the atmosphere. For lakes, it has been estimated that ebullition contributed to 18-22% of the total emission (Del Sontro et al. 2016)"

L91: how was equilibration achieved ? Shaking ?

Yes, the following is added to the text now: "The samples were vigorously shaken and equilibrated for at least two hours".

L101: Please add the reproducibility of peak areas of the standards, and the repro- ducibility of sample duplicates.

The precision of the calibration line was r^2 = 0,99, the reproducibility of the samples 7%. This information is now added to the M&M section, 2.2

L 178: this equation was not given by Wanninkhof et 2009, it goes back at least to Liss

& Slater (1974).
Corrected accordingly

L226: Please add all of the station numbers to figure 1.
Changed accordingly

L232: I suggest that authors show the figures of the correlations as supplemental figures, in addition to the statistics in the Tables. The visual inspection of correlations can also be informative and useful.
Reviewer 2 "complained" about to much statistics, thus we think that showing only the tables is a good compromise giving all the essential informations.

L243: Please use nmol L-1 instead of nM throughout the text
Changed accordingly

L294: does the difference of 0.05 ppm in air CH4 have a significant incidence of the air-sea CH4 flux computation, given that the analytical uncertainty on the dissolved CH4 concentration is typically of +/- 3% ?
Well, the reviewer is right here, however these are the numbers as given in the data base.

L 311: Can you provide a statistical test ?
Has been changed to: "Overall, there was no significant difference (Wilcoxon Rank Sign Test for paired data, n = 18, p = 0.84)".

L311: "a bit more north", can you quantify this in km ?
No, the figure in this publication does not give enough details, thus it is changed to "In the same study area and in summer 2014"

L318: I suggest to remove "unfortunately" this is a self-evaluation, let the reader decide what's unfortunate or not.
Well, I think most readers will agree that missing data are "unfortunate", thus we would prefer not to change our statement here.

L335: "In contrast to sea-ice, the freezing and melting of freshwater-ice does not alter the salinity pattern": Please develop and clarify this statement, as I do not understand it. Melting of fresh-water ice and mixing with sea-water leads to a decrease of the initial salinity.
We modified the paragraph to:
"One reason could be another source of freshwater, but with low methane concentrations. In contrast to other estuaries, arctic estuaries are ice covered about 2/3 of the year and the seasonal freezing and melting of ice has a strong impact on the water budget. The freezing of sea water results in brine formation with strongly increased salinity, while its melting results in a freshwater input (Eicken et al., 2005). In contrast to sea-ice, the freezing and melting of freshwater-ice does not alter the salinity pattern. In 1999, the river water fraction in ice-cores near our study area ranged from 57% - 88% (Eicken et al., 2005), thus at least some additional non-river-freshwater input is possible. Even though not much is known about methane concentrations in ice, based on a recent study on sea-ice in the East Siberian Sea (Damm et al., 2015), we assume that this melt water probably has lower methane concentrations than the river-freshwater. This additional aspect of the water budget in ice covered eaturies might

explain the missing relation between salinity and methane concentration. "

L340: then
Changed accordingly

L344: same as L318
Well, I think most readers will agree that missing data are "unfortunate", thus we would prefer not to change our statement here.

Figure 2: please add a legend for the variable (and units) in the plot.
Changed accordingly

Figure 3: please add a legend for the variable (and units) in the plot. Add units in the text of the legend of the figure. It could be useful to add a plot with the horizontal distribution of salinity.
The units are now added. The salinity is shown in a supplementary Figure A2

Figure 4: please add a legend for the variable (and units) in the plot. Add units in the text of the legend of the figure. This figure could be merged with Figure 2. It could also be useful to add the O2 vertical distribution along this transect.
The units are now added to the figure and the legend. Figure 2 and 4 are now merged to figure 2a and 2b. We checked on the O2 distribution, but it was rather uniform and we think it would not give additional insights.

Figure 5: legend of the figure is incomplete. Add the spatial (where) and temporal (when) info. The sediment data should also be in nmol/L. Add statistics of the regression. Please specify that the two crossed dots were excluded (I assume). Do you have an explanation why those two points are outliers ?
The sediment methane concentrations have been modified and the legend modified to: "Correlation between the methane concentration in bottom water and the concentration in the underlying sediment for all stations ($r2 = 0.62$, $p < 0.001$, $n= 33$) . Two very high values from station TIII-1304 were excluded from the analysis. "
The high concentrations at station TIII-1304 are discussed in paragraph 4.1

Figure 6: please add a legend for the variable (and units) in the plot. Add units in the text of the legend of the figure.
The legend is the plot is now modified and the units are explained in the figure legend.

Figure 7: please add a legend for the variable (and units) in the plot. Add units in the text of the legend of the figure
The legend is the plot is now modified and the units are explained in the figure legend.

Table 2: How can r2 be negative ? Is this r ?
Ok, the negative sign should indicate a negative correlation, thus we put the "-" in brackets.

Table 2: what do the empty cases in the Table mean ? statistics not significant ? Please provide all of the stats and put in bold those that are significant.
All statistics are now provided, however in response to reviewer 2 we have moved the tables to the supplementary material.

Table 5: Specify this is for high latitude shelf seas.

As referee requested a reference from a boreal bay, we do not think this addition is justified.

REFERENCES

Fenwick, L., D. Capelle, E. Damm, S. Zimmermann, W. J. Williams, S. Vagle, and P. D. Tortell (2017), Methane and nitrous oxide distributions across the North American Arctic Ocean during summer, 2015, J. Geophys. Res. Oceans, 122, doi:10.1002/2016JC012493.

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Stanley EH, Casson NJ, Christel ST, Crawford JT, Loken LC, Oliver SK. 2016. The ecology of methane in streams and rivers: Patterns, controls, and global significance. Ecological Monographs 86: 146–171.

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