Author comments for manuscript bg-2022-135

„The highest methane concentrations in an Arctic river are linked to local terrestrial inputs“
Karel Castro-Morales, Anna Canning, Sophie Arzberger, Will A. Overholt, Kirsten Küsel, Olaf Kolle, Mathias Göckede, Nikita Zimov, and Arne Körtzinger

On behalf of all co-authors, we thank the support from the associate editor Alexey V. Eliseev and the useful comments from two anonymous reviewers for the improvement of our work. The answers to each of the referees' comments are provided below in blue font color.

Referee #1

The article considers an extremely important phenomenon – the entry of methane into the water mass of the Arctic river from its catchment area. It is shown that methane is distributed inhomogeneously in the transverse direction, its highest content is characteristic of coastal areas. This work opens up the direction of research necessary to assess the flow of methane into the coastal zone of water bodies during the melting of permafrost. A large number of studied indicators gives grounds to confirm the results obtained. The conclusion seems to be important that a considered fraction of CH4 is already oxidized within the recently thawed active layer.

We thank the reviewer for highlighting the scientific contribution of our manuscript.

From the comments on the work, the following should be mentioned. Dissolved organic carbon is among the studied indicators. Why do the authors use this indicator, and not the total organic carbon, which seems more correct, since organic suspension can be a carbon source for methanogens?

The reviewer is correct that TOC should have been included for this analysis, and this is also mentioned by referee #2. We measured total organic carbon, TOC, in unfiltered water samples. Unfortunately, the TOC data is incomplete due to loss of samples. Results are only available for 8 out 21 stations (40 %). Still, we will provide the results of the correlation analysis to integrate TOC as indicator.

The trend of TOC for the available samples is similar to that of DOC along the river section, thus we do not foresee any major change in terms of the interpretation as an indicator for methane distribution. As stated in the original manuscript, the correlation between pCH_4 and DOC was positive, but weak and not statistically significant ($r^2=0.005$, $p<0.1$). A correlation between TOC and pCH_4 (for the available results) is negative and higher ($r^2=0.41$), but it is also not statistically significant at $p<0.1$.

Due to the lack of correlation between TOC and pCH_4, there is no further use of these data throughout the manuscript (as was also the case for DOC). Hence, in the revised manuscript section 3.3. of results we will substitute the mentions of DOC by TOC, and present the correlation results of TOC vs. pCH_4 (instead of DOC vs. pCH_4). The supplementary figure S10 presenting the distribution of DOC along the stations will also be removed.

The second remark concerns the authors' conclusion that the upstream river sections are not a source of CH4 entering the Arctic Ocean by transferring downstream with river runoff. It is possible that this is the case in low-water phases, and during the period of maximum flood flow, the time of water reaching can be significantly reduced. The study of the length of the river section from which methane enters the mouth in various phases of the water regime was not included in the list of research tasks, but this idea seems very relevant for further work.

We thank the reviewer for this remark. In our view, some of the riverine CH_4 could be transported to the Arctic Ocean predominantly in downstream waters under high flow regimes, and in combination with periods when high gas transfer from land to the river takes place. This is assuming that most of the CH_4 that is present in the river is of terrestrial origin and not produced via oxic methanogenesis in the river water.

Considering a distance of ca. 100 Km between the study section and the Arctic Ocean, and our measurements being done only during the late freshet period, it is not possible to assess if some of the CH_4 can reach the Arctic Ocean without being oxidized in the river course, or emitted to the atmosphere. Our results do not allow estimating a reach length to the Arctic Ocean. For future work, we would recommend to include a tracer study with isotopically marked CH_4 (e.g., $\delta^{13}CH_4$, as in Faber et al., 1996), and follow it from the source along the river. Additionally, vertical contributions of CH_4 such as those from anoxic bottom soils should be taken into account. In the revised manuscript, we will add a brief paragraph discussing this point.

Another remark concerns the reference to Figure 7. The authors write: statistically significant correlation between methanogen abundance and methane concentration (Fig. 7). Figure 7 in the appendix shows other data.

Thanks for your remark. As indicated in the manuscript, we referred in the mentioned paragraph (L587-588 of the original manuscript) to Figure 7 of the main text and not in the appendix. Perhaps this was overlooked by the referee. We will clarify this statement.

In addition, there will be a correction because the correlation between pCH_4 and methano-/methylotrophs is statistically significant (r^2=0.22, p=0.04), but the correlation between methanogens and pCH_4 is not statistically significant (r^2=0.11, p=0.15) at p<0.05. This will be also corrected in the corresponding section of results (L452-458, section 3.3 in original manuscript).

Despite the above comments, the work seems to be very important and should certainly be published.

Thank you to the referee for the support for the publication of our manuscript.