

Biogeosciences Discuss., referee comment RC1  
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## Comment on bg-2022-122

Anonymous Referee #1

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Referee comment on "Relationships between greenhouse gas production and landscape position during short-term permafrost thaw under anaerobic conditions in the Lena Delta" by Mélissa Laurent et al., Biogeosciences Discuss.,  
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The manuscript of Laurent and co-workers present data from an anaerobic short term incubation study of six samples from three different permafrost affected soils in a transect from ice-complex deposits into a floodplain in the Lena Delta, Russia. The authors incubated the samples at 4°C and 20°C, and measured for 60 days CH<sub>4</sub> and CO<sub>2</sub> concentrations. At the end of this incubation, they added glucose and measured for another week. Furthermore, they measured the abundance of *mcrA* genes (methanogenes) and *pmoA* genes (aerobic methane oxidizers).

We urgently need to better understand the consequences of thawing permafrost in the northern hemisphere on the global carbon cycle. In this respect, the study is concerned with an unquestionable important topic.

However, the main result of the study is that except for one sample, no consistent methane production was observed and that methanogens were still in the lag-phase during the short-term incubation experiment. This means that the experiment was too short to gain information about methanogenesis in most of the samples. Consequently, there is only limited information in the presented Q<sub>10</sub> values for methanogenesis or the calculated CO<sub>2</sub>:CH<sub>4</sub> ratios. The remaining results are mainly a confirmation of established knowledge. I suggest that the authors better elaborate, which new information or insights the reader gets from this study.

Furthermore, the description of methods is in part insufficient to evaluate their suitability and the references repeatedly do not support the statement in the text (see detailed comments). The discussion should substantially be shortened. In its current form its very lengthy, extensively repeats results and itself.

The microbial data on methanogenesis are interesting but the importance of the microbial data about aerobic CH<sub>4</sub> oxidation remains obscure, since the experiments were done under anoxic conditions.

Finally, I suggest clearly differentiating between production and emission. The data presented here are data on CH<sub>4</sub> and CO<sub>2</sub> production. There are no data on in situ CH<sub>4</sub> and CO<sub>2</sub> emissions. Particularly in the discussion, 'emission' is used for both the production in highly artificial laboratory incubations and in situ CH<sub>4</sub> and CO<sub>2</sub> fluxes. But incubations give only very limited information, if any, about in situ fluxes.

Specific comments:

L33: 822 Pg is the C in permafrost, not in permafrost soils. Please clearly differentiate between permafrost (permanently frozen) and permafrost soils (soils containing permafrost).

L34: Obu et al. 2019 reports that permafrost affected soils cover 14.6% of the northern hemisphere. 21.8% of the northern hemisphere is the permafrost region, i.e. the region where permafrost might be found (but not necessarily underlying 100% of the soils). Please clarify.

L38: Here is a misunderstanding of permafrost. The upper part of permafrost does not thaw in summer, in this case it would not be permafrost (see the definition given in line 34-35).

L44: This sentence is unclear. Who is "providing decomposable C"?

L50: The review of Schuur et al., 2015 does not present data on aerobic CH<sub>4</sub> production. Better cite original data.

L79: The studies cited here report GHG production rates from incubation studies, which do not give much information about 'C emissions released from different landscape forms'. Please clarify.

L81: The meaning of this sentence is unclear. Do you mean that microbes with a certain function may be active even if the redox conditions are not suitable for the respective process? Please clarify.

L85: This is a bit strange question in the context of this study. There are numerous studies on the importance of microbes and redox conditions on e.g. methane production and oxidation, but this study is not addressing redox conditions. Furthermore, in situ C emissions are strongly affected by vegetation, which is not mentioned at all. Please clarify.

L90: To prevent confusion, I recommend to replace 'emission' by 'production'. In that case, the reader does not expect data on in situ GHG fluxes.

L133: Fuchs et al., 2018 determined the bulk density 'by dividing the dry weight of a sample by its original volume'. How may the bulk density be determined by the water content of the soil without knowing the volume of the sample? Particularly when the samples are not water saturated. Please explain.

L162: Please explain in more detail how the CO<sub>2</sub> and CH<sub>4</sub> production rates were determined. Did you consider DIC in the soil water? At pH > 7 this might be more than in the headspace. How did you calculate rates from single concentration measurements? I could not find a method in the cited reference (Robertson et al., 1999) that enables the determination of production rates from single gas concentration measurements.

L164: As the equation is written G<sub>f</sub> gives the factor by which glucose addition increases gas production, the unit is not %.

L205: P16-F has a EC of 479 μS cm<sup>-1</sup>.

L215: <0.3%

L219: ... P17-A .... P17-F

L301: Could you give the detection limit of your mcrA quantification? Can you measure 76 gene copies per gram?

L329: Is there a concentration of carbon below which it may not be decomposed? Please explain.

L332ff: This is correct as long as sufficient sulphate or nitrate is available, which is generally not the case in terrestrial soils. The reason for low methanogen abundance is

probably rather the high redox potential in these soils.

L385: Please explain what you mean by 'favourable to C mineralization'.

L417: Which discrepancies do you mean? 'Cumulative emissions' (production) are the consequence of the observed production rates. Please explain.

L419: What do you mean by 'methane conditions'. Please explain.

L448f: In a completely anaerobic incubation experiment, landscape position might not be relevant since CO<sub>2</sub> production depends on C and N availability. However, at in situ conditions the redox potential differs and hence likely also CO<sub>2</sub> production. Please clarify.

Fig 5: This figure gives no new information or concept. It is quite similar to several figures that have been published previously, even from the same region. Furthermore, the current manuscript gives no information about in situ fluxes. I suggest removing it.