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Comment on bg-2021-216

Anonymous Referee #1

Referee comment on "Excess soil moisture and fresh carbon input are prerequisites for methane production in podzolic soil" by Mika Korkiakoski et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-216-RC1, 2021

Recent reports on greenhouse gases budget reveal that CH4 emissions have been increasing over the past decade, raising concerns for the role of CH4 on global warming. Warming may also contribute to the increase in CH4 emissions. As the authors mention, high latitude regions contribute substantially to CH4 emissions due to the large areal extent of wetlands. Although forest soils partially offset such emissions by oxidizing some of the atmospheric CH4, it is very important to understand how such a balance will be altered by warming. In this regard, this manuscript is timely and addresses an important question, which --in my opinion-- is relevant to the readership of this journal and beyond.

The paper is well written and clear. I only have a couple of concerns that I believe the authors should address for the sake of clarity.

It is not clear the amount of water that is being delivered through irrigation and how this amount was decided. Because the research question has to do with soil water content, it seems logical to me that the irrigation water should be decided based on the soil water content. Furthermore, to really trigger methane production (as well as other anaerobic processes), it is well known that the soil water content should rise above the soil water at field capacity. For methanogenesis, we also know that with soils at (or almost) saturation, it still takes 1 to 2 weeks (sometimes more) before methane starts being produced. There is a lot of literature from rice cultivation on this, for example. Thus, with irrigation active only once a week it is not surprising that methane production was low, or perhaps even absent, from the plots.

Also, rainfall (which this irrigation aimed to mimic) is intermittent but not at regular intervals. This is very important for biogeochemical processes. The fact that sometimes two rain events happen very close with each other may cause soil water content to reach very high values, necessary for anaerobic processes. An equal amount of rainfall delivered over regular interval may not lead to very high water contents. This may also explain why in a wet year you can observe CH4 production, whereas an equal amount of water delivered more regularly through irrigation may not lead to CH4 production.

Lastly, if the authors wanted to find the threshold in soil water content (or rainfall) leading to soils becoming a CH4 source, why not increasing irrigation (in frequency and amount)? This is also connected to my first point. It should be the soil water content to dictate the amount of water needed for soils to become anaerobic. I find this an interesting question and it is very unfortunate that the authors were not "successful" in finding this rainfall threshold. It would have been a very useful result, but I do not follow entirely why the authors did not explore higher water contents and irrigation water amounts.

I believe the authors should discuss these points in depth for a stronger and more sound paper. Hope my comments are useful.

Minor points:

The need of labile C (e.g., sugars) is also needed from an energetic perspective, as anaerobic processes in general are not very favorable thermodynamically.

There are also recent methane budgets to consider. See for example:
https://essd.copernicus.org/articles/12/1561/2020/