**#Reviewer 2**

This manuscript investigates the spatial patterning and environmental controls (namely water table depth, dissolved oxygen, soil temperature, GPP and various vegetation parameters) of methane emissions from a small sedge valley fen over a three-year period. They found methane emissions were lowest in the driest part of the fen, increased as moved towards the stream in the middle where the water table was seemingly in the optimal position and then decreased again closest to the stream due to the high amount of dissolved oxygen in the peat. Given the complexity in understanding $CH_4$ emissions from northern peatlands, the authors have done a good job of identifying the properties that are likely to influence them.

The methane emissions recorded from this site are within the range of other similar peatland systems.

I thank the authors for putting together a neat study which is well written and reads well. It will be a useful addition to the literature. The results section could do with some clarity, as the wording used is a little confusing and I found myself having to go back and remind myself a few times. I shuffle of some figures to and from the supplementary information will provide the reader with better clarity. I think the discussion overall is well written and the authors clearly have a strong understanding on the controls on CH4 emissions in this site. However, I do think there needs to be some more information included for this system in the context of the wider landscape/hydrogeomorphic setting? The link to 'climate change' is a little tangible – with much of the work being focused on the environmental characteristics measured. I think giving the reader a greater understanding of the context of these ecosystems in wider landscape will help improve the 'impacts of climate change'.

-Thank you for suggesting modifying the paper from a larger view of the topic, this was a very good point. In general, the studied fen type is rather common in many regions and therefore our results have global significance. We added the below texts to Introduction.

"Valley fens are widespread in shallow water bodies in river or stream valleys with a slow flow of mineral-rich water (e.g., Everglades, USA; Biebrza, Poland), or in pools, lakes or other landscape depressions receiving a slow flow of discharging groundwater and/or surface water (e.g., rich fens in Norfolk Broads, UK; Weerribben-Wieden, The Netherlands) (Lamers et al., 2015). In addition, in boreal permafrost peatlands in Siberia and north America, the running water-controlled systems probably are common due to the difficulty of water penetration into the soil. However, it is difficult to provide a number for the percentage of peatlands globally that may be classified as valley fens, because of the complex spatial structure and gradients between different peatland types, and differences in terminology."

Also, we now describe the site better from the catchment point of view (texts below) in section 2.1.

"The catchment area of the stream has a size of 5.1 $km^2$ and is draining to Pallasjärvi lake a few hundred meters after leaving the fen. The lowest and highest points of the catchment area range

from 268 to 375 m a.s.l. The soils consist mainly of glacial till, while the land cover at the catchment consists of coniferous and mixed coniferous-deciduous forests (*c*. 80%) and forested and open peatlands (*c*. 20%). Dominating tree species include Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and Downy birch (*Betula pubescens*). The coniferous forests dominate at the catchment. Furthermore, some of the peatlands in the eastern part have been drained for forestry purposes during the same period. In such valley mires with streams, the watercourse is small compared to those with, e.g., large rivers and does not provide significant amounts of water through overbank flooding. However, they can form a complex mosaic of habitats around streams with small catchments, for example, at our site the central stream with a limited floodplain has developed a riparian strip characterised by e.g., *Equisetum fluviatile*, *Carex limosa* and *Salix lapponum*. The impact of flowing water on a particular site also depends on the shape of the site, compared to other sites that with streams presented, the long narrow shape of Lompolojänkkä therefore undergoes stronger effects by the stream than many other sites."

Specific comments:

Line 19: I find the phrase 'climate changed caused variations' rather awkward and would recommend tweaking it.

-We modified the expression by deleting "climate change caused" and adding "under climate changes" to the end of the following sentence.

Line 55: Given the novelty of this study is the focus on valley fens which according to the authors are understudied, it would be useful to note approximately how much land they cover in Finland? It's not clear to me if these are a common peatland type in this region or whether this study (although scientifically sound and interesting) may not be applicable across larger areas?

-Valley fens are commonly found in many regions; unfortunately, we are not able to estimate the coverage of them either in Finland or globally. Please see our response to the general comments.

Section 2.1 Give more context to the wider area here.

-We added the information on the size of the site, the surrounding vegetation and some text related to the water flowing feature. Please see our response to the general comments.

Line 116: What do you mean by different habitats? Distance from stream or different vegetation communities – this is not clear here.

-Here we meant generally different locations of the site. We rephrased the text.

Line 123: What do you mean by relatively dry areas? Are they just a 'bit drier' than the completely saturated area or is the water table consistently well below the surface?

-With *relatively dry areas* we meant basically having a water table below the surface unlike the surrounding inundated areas. Considering together with the comment from referee one, we deleted "relatively".

Figure 1: Would be useful to include a scale bar to 1c and change the colour of the floating chambers so the difference between the static collars is clearer to the reader. Or use the drone image as the base image for the experimental design.

-As suggested, a scale bar was added to Figure 1c, and we changed the symbol of floating chambers.

Line 199: I find it confusing that use the word 'clusters' for location of sampling plots but also for the different plant communities. I think you should change one for clarity. When it comes to the results, it becomes difficult to follow.

-As suggested, we now use "clusters" only for plant communities. For flux sampling plots, we used "sets".

Figure 3: I would recommend moving this to the supplementary information. I would actually replace it with Figure A2 as I think it is interesting for the reader to see the spatial variation in the landscape of the different vegetation communities rather than an ordination plot.

-We carefully considered the reviewer's suggestion, but we prefer to keep them as they are – Figures 3 demonstrates the vegetation of the flux sampled plots, and the vegetation clustering information that we used in the data analyses. It also underpins the information that Figure 2A indicates, i.e. the vegetation structure is dominantly controlled by the stream.

Line 252: Typo: should be *S. warnstorfii*

-Corrected.

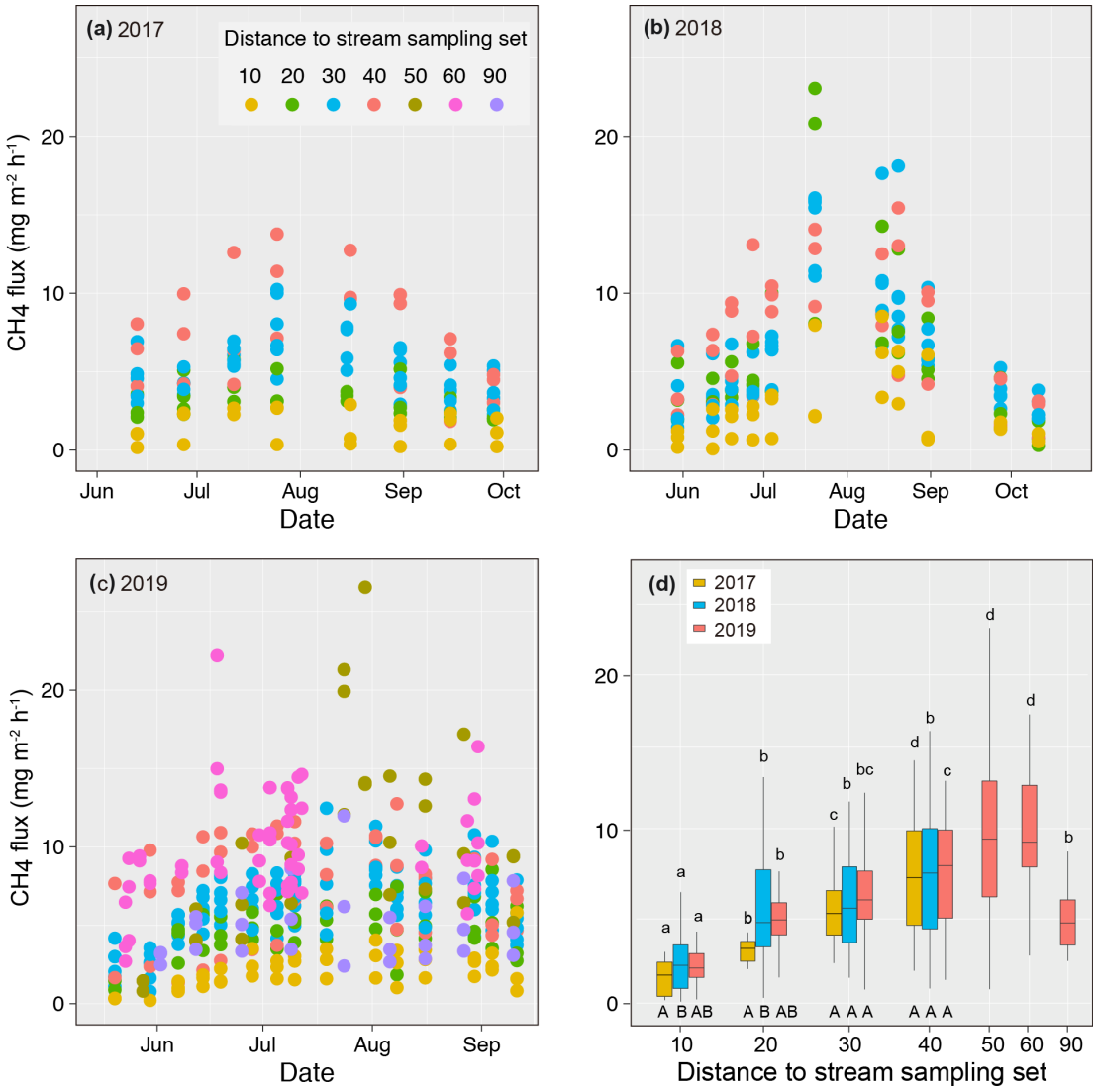
Line 262: This is where the use of cluster becomes confusing. Could you change it to Plots?

-As suggested, we now use "clusters" only for plant communities, and "sets" for sampling plots.

Figure 4: Given you have 7 symbols; I think these figures would benefit from colour rather than being black. It's hard to tell the difference between some of them. Again, the use of cluster here is confusing – I think plots would make much more sense. I would maybe use capitalised letters for the significant difference between studied year for each plot or cluster. I'm not sure I understand this as it seems you are looking at (for example) CH4 in 2017 at 10, 20, 30, 40 m from stream and see there is no significant difference? How does that differ from the letters above the plot? Are the letters below just looking at differences WITHIN plot/cluster? And not across years?

-We tried new plots with sampling sets indicated using colors (see below). However, we feel the quality is quite the same as that using symbols, especially for data in 2019 that have many overlapping data points. We therefore prefer to keep the use of symbols to make the figures readable in both online and printed versions. However, to improve the quality of the symbol figures, we now enlarged the symbols. We changed "cluster" to "set".

We now used capitalized letters for the differences between studied years for each sampling set. The letters below the plots are used to indicate the difference between studied years for each sampling set, for example, if we look at set 10, the letters (A, B, AB) below the plots indicate the difference of $CH_4$ flux at set 10 between years 2017, 2018, and 2019.




Line 306: Do you mean there was variation within each of the three plots at each distance from the stream but also there is overall difference in CH4 with distance from stream. This is a little confusing.

-Yes, this is what we meant. We now rephrased the text as shown below.

"Even though there were variations in $CH_4$ fluxes within each of the replicated sample plots for each sample set, clear spatial patterns related to their distance to the stream were also evident."

I have to admit, I find it rather confusing you create vegetation community classes but then don't use them once you start focusing on distance from stream?

-When we built mixed models, we tested if the plant community structure was important in driving $CH_4$ by adding the vegetation community clusters as potential predictors in the model, but they were not significant. Instead, the distance to stream is a significant predictor. In our case, it seems the stream has an override direct control on $CH_4$ which leaves the importance of plant species composition negligible. The relevant information was presented in section 3.3 and also in the first paragraph of section 4.2.

Figure 5: Can you use a different colour for the circles, the red and pink colour used are quite similar. Also do the pink circles in 5a represent 26m? Why 26 m? It's unclear to me here why you have 1m and 26 m?

-In Fig.5a, the color circles are predicted $CH_4$ flux for different distances to stream under a constant temperature. We used the color to separate them from the observed data circles. The idea in the figure was to create a transect of distance to stream to demonstrate how the distance modified the responses to temperature. The use of 1, 26, and 60 was rather random, but we always used numbers within the range of the collected dataset, i.e., from 0 to 89 m.

This applied also to the original Figure 6 when setting different levels of the interactive variables. However, during the revision process, we realized that we hadn't considered the distribution of residuals of the final three-year data model in the original submission, and learned that a variance function is needed for our dataset as the residuals clearly show a cone shape indicating violation of the homogeneity assumption. In the revised version, we corrected this. While doing so, the interaction between distance to stream and temperature became nonsignificant ($p = 0.113$), and therefore we ended excluding the interaction and correcting the related text, figures and tables. We sincerely appologise for this.

Figure 6: I find these figures quite hard to interpret given you have a combination of each interaction between variables. Again, the colours are very similar and should be changed to more contrasting colours.

-In Figure 6, the relationship between $CH_4$ and each significant predictor is presented in one plot. If the predictor has interactions with another predictor, the interactions are presented by setting a transect of values for that interactive predictor and are presented using different colors. To simplify the figures a bit and also being inspired by the reviewer's comments on Figure 5, we made some modifications to Figure 6. Instead of setting four different levels, we now use only three levels for the interactive variables, i.e. min., average and max. values of the variables in the collected dataset. We also tried to clarify the figure text to help the readers.