#Reviewer 1 Tim Moore

This manuscript examines the emission of methane from a small wetland during the summer over a three year period (though the upper parts of the wetland were sampled in only the third year) and provides environmental measurements to help explain the patterns that were observed. The methane emission rates are consistent with other peatland systems in this type of environment. The originality of the study is the focus on emissions in the central part of the wetland, a mesotrophic sedge fen, which show that methane emission rates are smallest at the upper, drier part of the wetland, increase in the middle section which is wetter and then decrease in the central part which is essentially a very wet riparian strip with slowly flowing water in a stream. Methane production, consumption and emission are complex processes in terms of a multitude of influencing factors and the authors attempted to identify properties which may be important in the creation of the emission patterns. These include dissolved oxygen, temperature, plant distribution and estimates of plant production (GPP), LAI and presence of arenchymous species. Through essentially correlative analysis, the authors demonstrate the importance of flowing water and dissolved oxygen is reducing methane emissions in the central part of the fen, the drier conditions producing small emissions at the margin, resulting in maximum emissions in the middle part of the upland-stream transect. The manuscript concludes with speculation on the effect of climate change in these types of wetlands, though no strong predictions were made, rather an identification of environmental changes' linkages to methane emission.

The authors have assembled a good data base on a complicated northern wetland (compared to bogs for example). It is unfortunate that the upper parts of the wetland were not sampled until the third year, which provides evidence of the peak methane emissions part way to the fluvial section, but it seems that the third year results could probably occur in the earlier two years. As with such a complex system, with counter- acting properties influencing methane emission rates, it is difficult to tell how generally applicable these results will be. I think the paper would be strengthened by a greater consideration of the setting of the wetland within the overall watershed about which there is little mention. Climate change effects will be moderated by the other parts of the watershed, which seems to be forested from photographs and thus it would be useful to know the size of the wetland (which is about 1 km2) and the size, topography and soils/vegetation of the overall watershed. It would also be useful to know how common such mesotrophic sedge wetlands are in these landscapes and whether they are 'unique' so that application of the broad principles from this study may be inapplicable. Fens are more difficult to understand and model, than 'boring bogs'.

-We thank the reviewer for suggesting modifying the paper from a larger view of the topic. 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."

I have made some specific comments and suggestions on the pdf, which I hope will improve the utility of the manuscript.

Specific comments:

Line 26: lower peat temperatures→ cooler peat temperatures

-Changed as suggested.

Lines 27-28: move this sentence to after the next one, makes it a bit more 'fluent'.

-Changed as suggested.

Line 50: litter degradation rates→faster litter degradation rates

-Changed as suggested.

Line 112: a scale added to 1c would be useful.

-A scale was added to Fig. 1c. However, some parts of the illustration might not be scaled into the actual size, such as the size of the chambers and the distance between each chamber. Therefore, we also added the text "Note some parts may not be scaled accurately" in the caption.

Line 114: 1f does not seem to have 50, 60 and 90 plots visible, thus taken in 2017 or 2018?

-The drone image was taken in year 2018, this information is now added to the figure caption.

Line 118: peat temperatures were greater→ peat temperatures were warmer

-Changed as suggested.

Line 119: there were also larger temperature variations between the different depths in the drier parts?

-Yes, we meant in the drier parts. We now added the information there.

Line 121: deepest→maximum. What is the thickness of the peat along the transect from the central area to the margin.

-We changed deepest to maximum. Mathijssen et al. (2014) has demonstrated the peatland development history of this site based on multiple basal cores collected from different locations of the site. According to their study, the peat thickness of our sampled area ranges from *c.* 1 to 2.5 m.

Line 123: dry is "relative" so "relatively" is redundant.

-Changed as suggested.

Line 124: seem 57% is pretty precise to quality for a "c", which means "about".

-We deleted "c".

Line 128: comment on overall catchment characteristics, relevant to the present study.

-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 comment.

Line 180: dissolved oxygen concentration, the unites appear to be %: % of what? Perhaps % of saturation? Please clarify.

-Yes, it is percent of air saturation. The information has been added.

Lines 252: S. warnsdorfii→S.warnstorfii

-Corrected.

Line 329: I assume the data for the three plot sets further from the stream are from only 2019. In (a) I cannot see the 60 m set, though it does appear in Fig. 4d, at the same median as at 50 m. What are the red circles?

-Yes, the three plot sets (50, 60 and 90) further from the stream are only from 2019. According to our definition, distances from the stream between 40 to 50 m are set as 50 m set, 50 to 60 are 60 m set, and 80 to 90 are 90 m set. In Figure 5, the actual distances of the plots to the stream in m were used in the analysis. The actual distance of 60 m set is 51 m, so the data points almost in the middle of x-axis 40 to 60 are from 60 m set. To avoid confusion, we now used “Distance to stream sampling set” when mention plot sets 10, 20, … 60 and used “Distance to stream (m)” for the actual distance. The red circles are model predicted CH_4 fluxes for different distances to stream.

Line 403: lower peat temperature→ cooler peat temperature

-Changed as suggested.

Line 498: lower panel→ lowest panel

-Changed as suggested.

Line 639: italicize journal title

-Changed as suggested.

Lines 775-777: misplaced reference

-Corrected.