Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2020-263-AC2, 2020

Interactive comment on "Topography-based modelling reveals high spatial variability and seasonal emission patches in forest floor methane flux" *by* Elisa Vainio et al.

Elisa Vainio et al.

elisa.vainio@helsinki.fi

Received and published: 22 October 2020

We answer here shortly the main comments pointed out by the Referee #2. We will answer all the rest of the comments in detail later, as well as get back to the suggested modifications.

Referee #2: There are two larger general comments: 1) Concerning the upscaling method:

AC: Initially, we tested how the different spatial explanatory variables are affecting on how well the model can predict the CH4 fluxes. Soil moisture was the most important

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explanatory variable, while the other variables had only a marginal impact on the model performance. Thus, we opted the selected approach of modelling soil moisture first, and using that for the CH4 flux. Other variables, such as slope or the wetness-indices, could not predict the CH4 flux as well directly. However, due to the Referee #1 comment, we will re-evaluate our modelling approach and consider modelling CH4 fluxes directly with RF technique with soil moisture included as a driver.

"On top of this, there is never a discussion of why the approach of modeling soil moisture and then CH4 flux is advantageous. Furthermore, the authors dedicate a large portion of this manuscript to the upscaling exercise, but barely, if at all, discuss whole plot scale fluxes. It would be interesting to hear how much the estimated net CH4 sources offset the plot level sink between the two time periods, and how uncertain their plot level fluxes are. After all, the primary purpose of upscaling is not to accurately predict CH4 flux at every individual point, it is to enhance our predictive capability of large-scale CH4 exchange in a way that reflects soil heterogeneity."

AC: Please see our main responses to Referee #1 for the reasoning for using this two-step modelling approach. We agree with the referee that the primary purpose of upscaling is to get an accurate estimate of landscape fluxes and not at individual points. We will revise the text so that this message gets across to the reader clearly, and add discussion on the whole area flux and the modelling, decreasing the proportion of some smaller details in the discussion. This was actually one of the main reasons why the analysis on chamber location bias was done (Fig. 10). Typically, mean of CH4 fluxes observed at a handful of chamber locations is reported and considered as representative of ecosystem CH4 exchange, however, this neglects any bias stemming from non-representative sampling locations. By using mean upscaled CH4 flux as a reference, we were able to show that 15-20 randomly selected chamber measurement locations (out of 60 locations available) were able to produce as accurate estimate of the landscape CH4 flux as averaging over all the chamber data. This information should prove useful when designing future chamber measurement campaigns in similar locations aiming to achieve accurate landscape-level flux estimates without upscaling with e.g. machine learning techniques.

2) "It would be more useful to randomly subsample the flux observations and build soil moisture-CH4 relationships from the random subsets. Then see how upscaled fluxes based on these relationships compare to the predictions made using the whole dataset."

AC: We acknowledge that the wording on lines 422-425 in the manuscript needs clarification, and this has maybe caused misunderstanding. The idea of the analysis shown in Fig. 10 in the manuscript was to evaluate how many chamber measurement locations were needed to get an accurate estimate of landscape-level flux by only averaging over the measured chamber data without any upscaling with RF. Here the mean upscaled CH4 flux was used as a reference since it accounts for the soil heterogeneity (see above). It was shown that average over 15-20 locations resulted in a similar bias as average over all the chamber measurement locations. This should be useful information for future chamber measurements in similar locations. We will revise the text so that this analysis is clearer and describe the methodology briefly also in Materials and Methods (Sect. 2).

"The authors should also report their modeled CH4 predicted fluxes for pixels corresponding to the sample sites, which would help explain whether differences in upscaled fluxes are caused by a model bias or because of the heterogeneity of the predictor variable domain."

AC: Thank you for this comment, we will evaluate this.

Specific comments:

AC: Overall, here are good suggestions on how to improve the paper. We will try out most of the suggested improvements, as well as add the SD values in text with the reported mean values. The CH4 highest emission (1080 μmol m$-$2 h$-$1) was detected on 5 June 2013 from chamber SW–W-3. This measurement was reported in the results, but omitted from further data analysis, even though there was no indication of any error in the measurement. The sample point was located on small water pond, where the water table level was most of the time above the peat surface. The CH4 emissions from this sample point were at the same level with typical peatland emissions. One possible explanation for the highest emission would be ebullition. Fig. 3 is indeed the correlation between the mean of all CH4 fluxes at each point and the mean of soil moisture at each point.

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