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Interactive comment on "Upscaling methane emission hotspots in boreal peatlands" *by* F. Cresto Aleina et al.

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We thank the Anonymous Referee 1 for his relevant comments which will help in raising the quality of the manuscript and in clarifying its message. Our answers are below Referee's comments (in italics).

1) *The new Hotspot model configuration somewhere is referred as parameterization, somewhere as new numerical approach. This is a bit confusing maybe the author could choose the best definition of what they did.*

We thank the reviewer for the suggestion, and we chose the definition "parameterization" consistently throughout the text.

2) *Equations (1) and (2): how is the lateral flux estimated in the two cases? Does*

the spatial distribution of the Hotspots have an influence on the soil moisture flux and thus, indirectly on soil saturation and methane emission? Equation (2): if there is only one bucket, what is lateral flux R? Eventually, they could provide a schematic representation of the three configurations within Figure 1. Are there hummocks and hollows in the Single Bucket configuration? How is the spatial distribution of Hotspots in the Hotspot configuration?

The lateral flux is implemented in the same way in the two versions, but in the explicit micro-topography representation the water can flow from cell to cell, while in the Single Bucket version the water simply flows out of the system. We included this information in the revised version of the text. Hummocks and hollows are not represented in the Single Bucket version, which works at the resolution of the whole domain. Hummocks and hollows are not explicitly represented in the Hotspot parameterization either, since its configuration is identical to the Single Bucket version. Nevertheless, the effect of the micro-topography on water table level is included in the Hotspot parameterization according to Equations 4 to 7.

It is difficult to represent these differences graphically, and Figure 1 is a schematic of the HH model in the Microtopography configuration (we modified this information in the revised version of the paper). We think that the differences among the three versions can be better highlighted in a table, and therefore we listed them in Table 1.

3) *Equations (4) and (7): q is used for fraction of saturated surface and for methane emission. Change symbols to avoid confusion.*

We used the same symbol because it is the same parameter. We assumed a linear relationship between methane emitting area and the emitted fluxes, and therefore we simply substitute the term FCH4(Wt) to the term A in Equation 4. We inserted this information explicitly in the revised text to clarify this passage.

4) *Figure 3: The Hotspot configuration mimic the Microtopography when methane emission is very high, and the Single Bucket when the Hotspot are not active (if I*

understood correctly, at low methane emission), underestimating the methane flux, apparently. Could you comment on that?

The beginning and the end of the simulation is where the fraction of saturated area q (Equation 7) has its minima, and therefore the Hostpot parameterization is less effective. We included this information in the text. As we discussed in paragraph 3.2, also other variables could play a role in these time slices. For example, peat depth is still averaged over the whole domain.

5) *Equation (6): is the methane flux from the HH model in the Single Bucket version estimated by averaging over the whole model domain or over the unsaturated part of the domain only? Please specify and comment on that.*

The Single Bucket model provides only an average flux from the whole domain, i. e., it is not possible to distinguish between saturated or unsaturated part. We assumed the fluxes from the Single Bucket model to be correspondant to the ones of an unsaturated area because of the too deep water table simulated in this configuration.

6) *Section 3.1, second line: specify what are the three surface classes.*

Thank you for the comment, we inserted this information.

7) *Finally, a few comments on the ecological relevance of the results presented in the manuscript under discussion as well as a discussion on the reason why we need such accurate estimation of methane emission could be added. Would similar literature models predict the same results?*

We thank the reviewer for this suggestion. The results are relevant for the magnitude of the differences in fluxes. The Hotspot parameterization doubles the cumulative fluxes over the season in respect to the Single Bucket version, despite its low computational costs. From an ecological perspective, modelling CH4 fluxes more accurately will help our estimates of carbon stocks, which may help constrain dynamic vegetation models, bacterial C consumption models, and potential feedbacks with the atmosphere.

Also, modelling hydroecology effects of "slower" runoff from a peatland can potentially influence vegetation dynamics of mosses in models including moss dynamics, e. g., Porada et al. (2013). The HH model is novel in the physical representation of lateral fluxes of water among hummocks and hollows, but other models representing surface heterogeneity controls on methane fluxes (e. g., Bohn et al., 2013), display similar effects. Therefore, and because of the process-based nature of the HH model, we are confident in hypothesizing similar results if a Hotspot-like parameterization was to be applied to other models. We included this extended discussion in the revised version of the text.

References:

Bohn, T. J., Podest, E., Schroeder, R., Pinto, N., McDonald, K. C., Glagolev, M., Filippov, I., Maksyutov, S., Heimann, M., Chen, X., and Lettenmaier, D. P.: Modeling the large-scale effects of surface moisture heterogeneity on wetland carbon fluxes in the West Siberian Lowland, Biogeosciences, 10, 6559–6576, doi:10.5194/bg-10-6559-2013, 2013.

Porada, P., Weber, B., Elbert, W., Pöschl, U., and Kleidon, A.: Estimating global carbon uptake by lichens and bryophytes with a process-based model, Biogeosciences, 10, 6989–7033, doi:10.5194/bg-10-6989-2013, 2013.

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