Biogeosciences Discussions

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Comment on bg-2021-81

L. Kutzbach (Referee)

Referee comment on "Field-scale CH_4 emission at a subarctic mire with heterogeneous permafrost thaw status" by Patryk Łakomiec et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-81-RC3, 2021

General comments

The manuscript of Lakomiec et al. presents very valuable data and analyses of land-atmosphere fluxes of methane at a heterogeneous permafrost-affected mire. The study is particularly relevant because it allows conclusions about the effects of permafrost thaw-induced landscape transformation on methane emissions. The question of how methane fluxes of permafrost regions will change in the warming Arctic is of great importance for assessing the climate-carbon cycle feedbacks in our Earth system. It is very good that the study is able to present three complete annual methane balances including winter seasons; such data is still very scarce for the Arctic – but urgently needed. The topic fits well in the scope of Biogeosciences.

The study approach in general is sound, and the applied methods are state of the art. However, I have several questions and requests for clarifications, which I list in the list of specific comments.

I think that the introduction and discussion are a bit narrow when it comes to referencing related work. The manuscript mostly refers to studies previously performed at Stordalen mire, however, there is not much discussion about related work around the Arctic.

The manuscript is already well structured and mostly well written. However, I have some comments on some text parts that appear to have been missed by the internal review. These are given in the list of technical comments.

I recommend to accept the scientifically interesting and relevant manuscript of Lakomiec et al. for publication in Biogeociences after major revisions.

Specific comments

l. 62: Do you refer here to surface-near air temperature or soil temperature or permafrost temperature?

l. 104-109: Pleae refer here in the introduction to previous studies that have conducted similar comparisons, e.g., Hommeltenberg et al. (2014), Rößger et al. (2019), Kim et al. (2020). Rößger et al. (2020) investigated methane fluxes from a heterogenous tundra ecosystem; thus this article would be quite appropriate for comparison also in other regards.

l. 123: Specify if surface-near air temperature is meant.

l. 153: The tube length is very long. Can you assure that flow was turbulent throughout the tube? What ist he high-frequency attenuation oft the fluxes due to the tube transport effects?

l. 168-181: Please describe better the locations of the ancillary soil measurements. In a heterogenous mire landscape peat temperature can have large spatial variability. Particularly of interest is what site you choose as being representative for the heterogeneous eastern area composed of drier palsas and thawed wetter sites.

l. 202-203: I do not understand this approach of removing flux values when two consecutive data points originated from different wind direction sectors? Which flux values where then removed? Why was this done?

l. 213-215: Have you tried to model also 30 min fluxes? Why not modelling the 30 min flux data (as Rößger et al. (2019))?

l. 222-223: Please describe in more detail how the 30 min data were „aggregated" to annual footprint climatologies.

l. 235-237: How is the weighting calculation exactly done? Which quantity of the „climatology" was used for weighting the contribution of a mosaic pixel?

l. 245-246: The statement that "...methane emissions … do not show diel cycle" is too

bold. Figure S4 shows that there is systematic diurnal variability – even for whole-year data. Indeed, it would be good to analyse diurnal variability month by month.

l. 274: Rößger et al. (2019) applied ANN for a heterogenous tundra; the paper might be interesting for comparison.

l. 323-333: I think that the equations (1) and (2) are only valid under rather strong assumptions that should be clearly stated. In my view equation (1) and equation (2) can be considered valid for the 30-min periods for which the footprint contributions of the two contrasting landcover types f_p and f_t are estimated. However, using the same form of the equation for annual averages is only valid if the time series of the footprint contributions fp and ft, respectively, are uncorrelated with the temporal development of the emission factors E_p and E_t, respectively. If they would show some correlation, the average of the product f*E would equal the product of the averages of f and E, respectively, plus the covariance of f and E. Therefore, one maybe important assumption is that f and E of the respective landcover types are uncorrelated. Other important assumptions are that the average methane fluxes of the palsa sites in the eastern area and in the western area are equal and that the average methane fluxes of the thawed sites in the eastern area and in the western area are equal. It would be good if this assumption could be backed by more comprehensive description of microtopography, hydrology and vegetation of palsa and thawed sites of the western and eastern areas, respectively.

l. 360-361: Sentence too vague: Where and when the western sector is colder? Which depth? Time scale?

l. 369, Figure 2: The lowest panel does not show water depth but water table height. However, it would be more suitable to show water table depth or height referenced to a reference point at the ground surface in the investigated mire. The jump in water table height between the summer of 2014 and the summer of 2015 appears unrealistic. Please check the water level times series for biases and inhomogeneities in the time series.

l. 387-390: Please write more specific, e.g. "…on average over all three years more than 90% to the fluxes measured at the eddy covariance tower."

l.392, Caption figure 3: Please describe more precise what is shown in the bottom panel. How are these average contributions of contrasting landcover types calculated. Generally, I would prefer another diagram type that allows evaluation of the variability of footprint contributions of the two landcover types.

l. 419-420: How did you deal with the autocorrelation in the time series? Serial dependence of data points could lead to biased results of the Wilcoxon test.

l. 433-434: How were differences tested? See comment above.

l. 455: Unclear what "breakout week" means.

l. 565-572: I find the discussion of the explanatory strength of incoming shortwave radiation confusing. The GLM parameters in Table S2 for the explanatory variable incoming shortwave radiation are all negative, indicating that methane emissions were lowered under high incoming shortwave radiation. Thus, the GLM results do not suggest strong relations between shortwave radiation, photosynthesis, substrate supply and CH4 production. Or was the sign convention for incoming radiation different than I assumed?

l. 724-725: The hysteresis-like behaviour can be also explained by the phase lags between different temperatures in air, ground surface and different soil depths.

Figure S1: Specify in the caption if soil or air temperature is shown. At which height in the atmosphere?

Technical comments

l. 62: I recommend to always place a space between numerical value and unit, also for the unit „°C". Please see „The International System of Units" (BIPM, 2019, section 5.4.3).
l. 99: Please correct awkward sentence: „…while the second one is thawing, wetter areas." (singular-plural)
l. 102: Insert „the" to „the palsa plateau".
l. 123: Comma before „and" (independent clause)
l. 131: I suggest to insert a comma and use „which" instead of „that" here (unrestrictive clause).
l. 150: Correct „closed-path"
l. 160: Insert „a" before „LI-7200.."
l. 164: I do not think that „a.g.l." is a standard abbreviation directly clear for everybody.
l. 215: Remove „be".
l. 219: Remove „a".
l. 229-230: I suggest wrinting „50 cm x 50 cm" (equal 2500 cm^2)
l. 236: Correct „climatology".
l. 295: Insert comma before „and".
l. 302: Hyphenate "gap-filled".
l. 314: Hyphenate „gap-filling".
l. 360: Remove comma before "was".
l. 361: Remove commas before "between" and "at".
l. 413: Correct: "after averaging"
l. 637: Remove comma before "because"
l. 637: Correct "have".
l. 637-638: Improve awkward sentence.
l. 639: Remove "the".

L. 675: Insert comma before “which”.
l. 696: Insert comma before “but”
L. 714: Correct “the gap distribution”.
l. 719: Insert comma before “further”
l. 720: Hyphenate “low-emissions wetlands”

References:

Rößger, N., Wille, C., Veh, G., Boike, J., & Kutzbach, L. (2019). Scaling and balancing methane fluxes in a heterogeneous tundra ecosystem of the Lena River Delta. Agricultural and Forest Meteorology, 266, 243-255.
Kim, Yeonuk, Mark S. Johnson, Sara H. Knox, T. Andrew Black, Higo J. Dalmagro, Minseok Kang, Joon Kim, and Dennis Baldocchi. "Gapâ□□filling approaches for eddy covariance methane fluxes: A comparison of three machine learning algorithms and a traditional method with principal component analysis." Global change biology 26, no. 3 (2020): 1499-1518.
Hommeltenberg, J., Mauder, M., Drösler, M., Heidbach, K., Werle, P., & Schmid, H. P. (2014). Ecosystem scale methane fluxes in a natural temperate bog-pine forest in southern Germany. Agricultural and Forest Meteorology, 198, 273-284.