

## ***Interactive comment on “Organic sediment formed during inundation of a degraded fen grassland emits large fluxes of CH<sub>4</sub> and CO<sub>2</sub>” by M. Hahn-Schöfl et al.***

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letter The author comments are given in italics after the respective referee comments.

### **Anonymous Referee #1 (from 2 February 2011)**

References could be given to more accurate work on fresh OM. Suitable references can be found from e.g. Kiikkilä, O., Kitunen, V. & Smolander, A. 2011. Properties of dissolved organic matter derived from silver birch and Norway spruce stands: Degradability combined with chemical characteristics. *Soil Biology & Biochemistry* 43: 421-430.

*The following text will be added in the revised manuscript on page 9288, line 16: Ki-*

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*ikkilä et al. (2011) showed that dissolved organic carbon (DOC) derived from fresh plant material was clearly more degradable and contained a greater amount of labile compounds than DOC derived from the humus layer of a forest soil. Cumulative CO<sub>2</sub>-loss from forest humus DOC was up to 21% and was twofold from plant DOC in a 110 days incubation. Kiikkilä et al. (2011) will be added to the References.*

However, the authors go further and by citing other work state that introduction of aquatic species with aerenchyma and capability to oxygenate the sediment may potentially reduce the CH<sub>4</sub> emissions by means of more recalcitrant litter production and enhanced methanotrophy (page 9292, lines 9-15). I feel that such conclusions fall outside the scope of the present laboratory work and should be omitted from the final version of the manuscript.

*The respective text will be removed from the manuscript. The following text will be added: In the future, it should be investigated if the expected colonization of flooded areas by adapted plant species such as *Typha* sp., reeds or sedges might also reduce this potential risk as their litter is slowly decomposed (Brinson et al., 1981). Lai (2009) will be removed from the References.*

The Results section (pages 9285-9286) could be more fluent, if less numbers were inserted in the text. Instead, references to the figures showing the dynamics could be used for readability. It is hardly a simplification to express differences such as 8, 13, 43 or 675 times higher.

*The Results section on pages 9285-9286 will be revised by reducing numbers and by inserting references to figures and tables.*

The statement on lines 4-7 (page 9291) repeats what has been said earlier and is perhaps not needed.

*This sentence will be removed.*

### **Anonymous Referee #2 (from 20 February 2011)**

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## GENERAL COMMENTS

I recommend to revise the presentation of equation (1) which is used for the calculation of gas production fluxes (see specific comments). Also, a correct equation for the flux calculation by the flow-through chambers must be given.

*We followed the suggestion of the reviewer, revised equation (1) and added a second equation for the flow-through chambers.*

Furthermore, I find the differentiation of “peat profile incubation” and “top soil substrate incubation” suboptimal and potentially confusing. In my view, we can consider all materials incubated in this study as soil substrates. Most of them are organic soil or peat materials. Maybe it would be better to differentiate between soil substrates before rewetting and after rewetting? I think that the main difference between the two experiments and incubation materials is not the difference between “peat” and “soil”.

*Following this suggestion we changed the names of “peat profile incubation” to “peat layer incubation” and of “top soil substrate incubation” to “organic substrate incubation”.*

## SPECIFIC COMMENTS

Page 9275, lines 6-7: “. . . nearly zero”: Please indicate for which region this is a valid statement. Globally? Europe? Germany?

*The net climate impact of natural peatlands in Europe is nearly zero (Drösler et al., 2008).*

Page 9275, lines 15-17: Please write these two sentences clearer. What do you mean with “. . . nutrients remain in the peat”? In which form? Which process leads to eutrophication?

*To keep the introduction short, the referred text will be revised as follows (starting on page 9275, line 14): Furthermore, long-term drainage and agricultural use of peatlands cause irreversible chemical and physical changes in peat characteristics, a loss of*

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*organic carbon and concurrently internal eutrophication of the peat soils (Zak et al. 2008).*

*In addition, a detailed description of the eutrophication process of the Zarnekov site will be added in the site description (starting on page 9277, line 22): Long-term drainage and previous agricultural use led to a loss of organic carbon (due to peat oxidation) and, therefore, to an enrichment of P and N with decreasing molar ratios of C:P and C:N in upper soil layers (Zak & Gelbrecht 2007). Concurrently, organic bound P and N was transformed into labile inorganic forms (peat mineralization) supporting the internal eutrophication of the peat soils (Zak et al. 2008).*

Page 9276, lines 17-18: Where did the sand originate?

*On page 9284, line 28 we will add: The sand intrusion is due to erosion from an adjacent bank built for agricultural machinery.*

Page 9277, lines 11-12: Where there more intensive drainage activities in the 20th century additional to the drainage activities in the 18th century? I would expect that the land management in the 20th century had a much stronger impact on the peatland hydrology than the prior drainage activities.

*The text will be revised as follows: Drainage of these areas began in the early 18th century and was strongly intensified at the end of the 1960s for agricultural use as intensive grassland (Lenschow et al., 2003).*

Page 9277, line 20: “muck-soils”. Is this term referring to the soil material or the soil type?

*This term is referring to the soil material. The text will be changed to: . . . according to the von Post scale (Puustjärvi, 1970), however, since the soil material is strongly mineralized they are also called “muck-soils” (Okruszko, 1995).*

Page 9279, lines 13-15: How was this linearity checked? By which statistical measure? I doubt that a reasonable checking of linearity is possible with 3 data points. (The

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degrees of freedom of a linear regression would be  $3 - 2 = 1$  !) Maybe it would be better to state that you just assumed linearity.

*We assumed linearity.*

Page 9279, lines 16-17: Why did you omit the sampling point at 0.5 h for the regression? The three sampling points were used for the regression.

*As the text in the manuscript is unclear we will omit "... with two sampling points (after 0 and 1 h) ...".*

Page 9279, lines 19-27: I urgently recommend to use consistent quantity equations which are independent of the units used. Equation (1) is actually a mixture of a quantity equation and a numerical-value equation. The quantity equation would be:  $FC-CO_2 = (M \times p \times V)/(R \times T \times A) \times \Delta c/\Delta t \times 1/Ct \times f$ . It is unusual to use rho as symbol for pressure which is normally symbolized by p. Rho is normally used for density. You could also omit f in the equation and define M as the atomic mass of carbon.

*As suggested, equations will be given as a quantity equations for both gases and for the two different measurement types (steady-state and flow-through chambers). The text on page 9279, lines 16-27 will be revised as follows: Emission rates of CO<sub>2</sub> and CH<sub>4</sub> related to carbon content of the peat substrate and time [mg C d<sup>-1</sup> kg<sup>-1</sup> C] were calculated according to Eq. (1): emission rate =  $(M \times p \times V)/(R \times T \times A) \times dc/dt \times 1/Ct$  in which M is the atomic mass of carbon, p is the air pressure, V the volume of the headspace, R the gas constant, T the temperature, A the area of the incubation vessel, dc the difference of gas concentrations, dt the time interval between gas sampling, and Ct is the carbon content of the peat substrate.*

*Starting on page 9281, line 28 the text will be revised as follows: Gas fluxes related to carbon content of the sediment or peat substrate and time [mg C d<sup>-1</sup> kg<sup>-1</sup> C] were calculated according to Eq. (2): emission rate =  $(M \times p \times v)/(R \times T \times A) \times dc/Ct$  in which M is the atomic mass of carbon, p is the air pressure, v the air flow, R the gas*

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*constant, T the temperature, A the area of the incubation vessel, dc the difference of gas concentrations, and Ct is the carbon content of the peat substrate.*

Page 9281, lines 14-16: Why did you choose for the "top soil substrate" incubation a different temperature than for the "peat profile" incubation? Can you preclude biases in the comparison due to the application of different incubation temperatures?

*The two incubations were performed at different temperatures due to technical reasons. CO<sub>2</sub> and CH<sub>4</sub> production rates of similar substrates were in the same range in both incubations. In addition to temperature, anaerobic conditions have to be considered. The substrates used for the "top soil substrate incubation" were under anaerobic conditions for 2.5 years prior to incubation and consequently CH<sub>4</sub> formation increased rapidly, comparable with the start of CH<sub>4</sub> formation in the "peat profile incubation" (upper peat layer).*

Page 9282, line 1: The calculation of the gas fluxes using a flow-through chamber must be different than for the closed-chamber approach! It is a quite different measurement principle, and the air flow velocity has to be taken into account.

*See comment above.*

Page 9282, lines 12-14: Why the air had to be moved? Did the air in the tube installed at some soil depth not mix enough by diffusion within the whole tube volume without inserting water?

*The air inside the silicone tube was moved by inserting water into the tube in order to guarantee that the appropriate quantity of gas was sampled. The silicone tube was closed at both ends. For sampling, a gas-tight syringe was attached to one end of the tube. Leaving the other end closed would have resulted in an underpressure in the tube when using the syringe. In the case the other end was opened, ambient air would have been sucked into the silicone tube. After taking the gas sample, the air in the silicone tube was removed in order to avoid oxygen to diffuse into the anaerobic*

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*substrate incubated.*

Page 9283, line 11: "substrate availability": Maybe better "substrate decomposability" or "substrate degradability"? Availability is probably not only determined by C:N or C:P ratios but also by adsorption/desorption in soils, soil water dynamics and other soil processes.

*We agree. The term "substrate degradability" will be used in the revised manuscript. On page 9292, line 7 "... presence of readily available and energy-rich substrates ..." will be changed to "... presence of readily degradable and energy-rich substrates ...".*

Page 9290, lines 25-26: I would be good to write this somewhat more specific. Are you referring to the bulk of organic material of the peat? Or to a specific size/quality fraction?

*We will make it clear that we are referring to the bulk peat by changing the text to: Our findings show that it is not the quality of the bulk peat substrate itself but the presence of fresh organic matter that determines anaerobic GHG production.*

#### TECHNICAL COMMENTS

Page 9274, lines 2-3: I suggest rephrasing: "... alter local emissions of greenhouses gases as CO<sub>2</sub> and CH<sub>4</sub>."

*Will be revised accordingly.*

Page 9274, line 16: I suggest inserting "the" before "2.5".

*Will be revised accordingly.*

Page 9274, line 22: I suggest adding: "than for the new sediment layer" after "lower". Remove comma before "and". Insert "a" before "newly flooded".

*Will be revised accordingly.*

Page 9274, line 28: I suggest inserting "Significant" before "anaerobic".

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*Will be revised accordingly.*

Page 9275, line 4: I suggest inserting "the" before "total".

*Will be revised accordingly.*

Page 9275, line 6: "more efficient" ? Than what? Maybe better: "which has a higher global warming potential than CO<sub>2</sub>"

*Will be revised accordingly.*

Page 9275, line 10: I suggest inserting "the" before "net".

*Will be revised accordingly.*

Page 9275, line 25: I suggest "yr" instead of "y" as unit symbol.

*Will be revised accordingly.*

Page 9276, lines 19-20: Remove hyphen: "newly formed".

*Will be revised accordingly in the entire document.*

Page 9277, line 5: I suggest rewording: "moderately continental temperate".

*Will be revised accordingly.*

Page 9277, line 11: I suggest "low-intensity agriculture".

*The text will be revised as follows: Drainage of these areas began in the early 18<sup>th</sup> century and was strongly intensified at the end of the 1960s for agricultural use as intensive grassland (Lenschow et al., 2003).*

Page 9277, line 15: I suggest inserting "the" before "Zarnekow".

*Will be revised accordingly.*

Page 9277, line 25: Insert comma after "inundation".

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*Will be revised accordingly.*

Page 9277, line 28: Reword: "... dying-off of plants."

*Will be revised accordingly.*

Page 9278, lines 11-12: I suggest removing the commas before "as well as" and after "chemistry".

*Will be revised accordingly.*

Page 9278, line 25: I suggest inserting the units to all quantities: "0.6 m x 0.4 m x 0.4 m" (following the recommendations of the International System of Units (SI)).

*Will be revised accordingly.*

Page 9279, line 12: I suggest inserting "were" after "and".

*Will be revised accordingly.*

Page 9279, line 21: "headspace" instead of "head space".

*Will be revised accordingly.*

Page 9280, line 27: I would remove: "... , so as..."

*Will be revised accordingly.*

Page 9281, line 5: This statement does not become clear enough: "assumed" or "applied"?

*The text will be revised as follows: All three substrates were taken from locations under water-saturated soil conditions and therefore we assume that conditions were anaerobic at the start of the subsequent incubation.*

Page 9281, line 20: I suggest "measurements" (plural).

*Will be revised accordingly.*

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Page 9281, line 24: Change word order: "... does not fully compensate..."

*Will be revised accordingly.*

Page 9282, lines 21-22: Insert comma before "and" and "was" after "chambers".

*Will be revised accordingly.*

Page 9282, line 24: Insert comma after "analysis".

*Will be revised accordingly.*

Page 9282, lines 28-29: Please write more precisely: Which values were corrected for water content?

*The text will be revised as follows: Measured solid C and N values for the sediment/peat substrates were corrected for water content when dried at 105 °C.*

Page 9283, line 21: Insert "the" before "upper".

*Will be revised accordingly.*

Page 9283, lines 24-26: I suggest rewording: "The cumulative CO<sub>2</sub> fluxes over 363 days for the incubation of the material from the upper peat layer were... than for the incubation of the material from the middle peat layer and ... than for the incubation of the material from the lower peat layer." Or something like that...

*Will be revised accordingly.*

Page 9284, line 7: I suggest inserting "in the soil organic matter" after "initial C".

*Will be revised accordingly.*

Page 9287, line 15: Insert comma before "and".

*Will be revised accordingly.*

Page 9288, lines 3-5: I suggest rewording, the sentence now uses a rather casual

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style. The peat did not have “time to” do something.

*The text will be revised as follows: Anaerobic decomposition depleting “labile” substrates could have occurred 2.5 years longer in the peat in the top soil substrate incubation.*

Page 9288, line 9-10: Reword: “. . . study which reported rates of CO<sub>2</sub> and CH<sub>4</sub> production that were . . .”

*Will be revised accordingly.*

Page 9288, line 10: I suggest removing the comma before “where”.

*Will be revised accordingly.*

Page 9288, line 26: Insert comma before “and”.

*Will be revised accordingly.*

Page 9289, line 3: I suggest removing the comma before “as”.

*Will be revised accordingly.*

Page 9289, line 24: I suggest removing the commas around “therefore”.

*Will be revised accordingly.*

Page 9291, line 1: I suggest rewording: “. . .and the decomposition of sedge residues. . .”

*Will be revised accordingly.*

Page 9291, line 8: Insert hyphen: “dying-off”

*Will be revised accordingly.*

Page 9291, line 19: I suggest “can be” instead of “are”.

*Will be revised accordingly.*

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Page 9291, line 23: I suggest inserting “high” after “extreme”.

*Will be revised accordingly.*

Page 9292, line 4: Insert comma before “and”

*Will be revised accordingly.*

Page 9292, line 5: Remove hyphen: “newly formed”.

*Will be revised accordingly.*

Page 9292, line 8: “substrates” instead of “substrate”.

*Will be revised accordingly.*

Page 9292, line 9: “sediments” instead of “sediment””, “newly formed”

*Will be revised accordingly.*

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