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Biogeosciences Discussions

Interactive comment on "Spatial and temporal variation of methane emissions in drained eutrophicpeat agro-ecosystems: drainage ditches as emission hotspots" *by* A. P. Schrier-Uijl et al.

A. P. Schrier-Uijl et al.

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Reply to both reviewers:

We would like to thank the reviewers for their detailed comments on our paper. The reviewers raised a number of critical points that are well taken. Some of them have indeed also at one stage or another been considered during the writing process. We have sometimes perhaps tried to be concise at the expense of clarity. In a preliminary response during the open discussion phase we have responded to a number of main points. In this final response we will try to clarify and respond to al points made by both referees in detail.

Reply to reviewer 1

Overall:

Poor site descriptions

We propose to include the following tables as appendices

Table 1. Site descriptions (soil class, topography, landform, humand influence, parent material, drainage)

Table 2. Soil profile descriptions (depth, colour, material, pH-KCL, N-NH4, N-NO3, %C, %N)

Novelty of the present paper

The aim of this paper was to study spatial emission patterns in fen meadow ecosystems at landscape scale. Indeed to understand longer term temporal variation longer time series are needed. We have therefore deleted the word ‘temporal’ from the title and replaced it by ‘seasonal’ emissions.

Stratification of the fen meadow landscape into land form elements to study spatial variability seems very important to us and validates the writing of this manuscript. As pointed out before, methane emissions from drainage ditches and other small water bodies have not been reported often and are therefore often overlooked.

The site of Hendriks et al, 2007 is a very different site in terms of management and vegetation cover. Also the main part of the fen meadow area in Atlantic Europe, and especially in the Netherlands ($>$90%) is intensively or extensively managed, and therefore estimates of CH4 emission can not be based on data of the nature reserve of Hendriks et al. 2007 only

Uncertainty of balances

The reviewer is critical of the weak predictive power of the temperature regression lines and the lack of biological parameters that could help understand the spatial and temporal patterns of the CH4 fluxes. As the reviewer points out the methane emitted from

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the surface is the result of the complex, partially counteracting processes production, oxidation and consumption of CH_4. We agree when the reviewer suggests that more information is needed about the uncertainties of the year balances as calculated with linear regression and trapezoidal integration. In the revised paper we will expand table 1 with 3 extra columns which will show the uncertainties of both the trapezoidal integration and regression based year balances. We will delete figure 4. and insert instead table 3 to show statistics of the regression based fluxes:

Table 3. Linear regression equations of natural logarithm-transformed CH4 fluxes and air or water temperature, for each location and each landform element; number in bracket is 95% confidence limit of each parameter.

In the discussion we propose to explain in more detail why we think that for estimating year balances the regression based method is more reliable than the integration based method (including discussion of diurnal variation of methane emissions). Figures 5 and 6 will be removed as suggested by the reviewer.

Effectively, we know that temperature cannot be the only driver for methane emissions (as pointed out before). We for instance expected a strong influence from anaerobic versus aerobic conditions in the upper part of the soil caused by water table fluctuations reducing methane oxidations. And in ditches we expect that (except from temperature) turbulence caused by wind/pressure differences, causes variation in methane emissions.

The reviewer suggests that activity status of plants and substrate flows mainly control the diurnal emission cycle. In our case, in the ditch (where emissions and uncertainties are the highest) plants are less likely to contribute on a diurnal basis.

Daytime night time differences (due to stomatal opening and closure and root exudation (see e.g. Chanton et al 1993, Xianonan Duan et al., 2005) particularly in aquatic macrophytes, have been pointed out as possibly confounding our results. In the field, the activity status of the grass can play a role, although the dominant grasses in our

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study sites are not aerenchymatic plants. Micrometeorological studies (e.g. Hargreaves & Fowler, 1998, Kroon et al 2007) have found no systematic effect, other than explainable through temperature differences between day and night. The measurement of labile carbon flows would possibly have provided in sight but would also have been laborious and was for the purpose of this study not our first choice. We thus have no data on this.

Ongoing continuous micrometeorological measurements of methane at our site at the landscape scale (Kroon et al, 2007) show good agreement (R^2 ~0.7) with temperature regression estimates based on up scaling of the chamber measurements from different landscape scale elements (Schrier, Kroon et al. in prep for Biogeosciences discussions). For the period August – November 2007 we estimated the methane emission to be 46 kg/ha as measured by micro meteorological measurements and 56 kg/ha as estimated by upscaling of temperature based regressions of the different landforms measured by the chamber method.

We demonstrate in this paper that handling emissions with the exponential regression results in large differences with simple trapezoidal integration, but we think we are justified to follow the former method because:

- Logarithmic regression gives a better fit than a linear relationship.
- The temperature regression based upscaling from the landscape scale already shows a good agreement with the area integrated based EC measurements.

Other points

We will add the time series of the water table in the field.

We will add the site names in the figures.

We think that the first reviewer with this additional information will have more confidence in the reliability and robustness of the reported results. Again we thank him for

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generating this discussion and forcing us to become more clear.

Reply to reviewer 2

Overall

The reviewer suggests that after some corrections and consideration of comments presented below the article is acceptable.

- The paper will be expanded by two tables that present site descriptions and soil descriptions of both sites (see table 1 and table 2 in the reply on reviewer 1). Soil water characteristics (pressure head (cm) and hydraulic conductivity (cm/d)) of eutric histosols as studied by Beuving (1984) will be inserted in the text:

- Information about the height of air temperature measurements and the location of the temperature sensor will be inserted in the text.
- We will provide additional information on the measurement frequency was and we will insert an extra table (table 3) with regressions statistics where we will show the number of observations used for regression after data quality checks.
- We will add the time series of the water table in the field.
- We will explain in more detail why we made the stepwise regression in this direction and not reversed.
- We will insert uncertainties for the farm based emissions as well as for the regression based and integration based emissions

Technical corrections

We propose to take into account all technical corrections as mentioned by reviewer 2. They are very useful and enhance the clarity of the manuscript.

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We again thank the second reviewer for his/her useful suggestions for improvement of the manuscript.

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Interactive comment on Biogeosciences Discuss., 5, 1237, 2008.

Site name	Soil class., topography and landform	Human influence	Parent material	Drainage
Oukoop	Fibric rheic eutric Histosol flat, (alluvial) plain	Intensive dairy farming	0-23 cm: anthropogenic	Poorly drained
		0-23 cm anthropogenic top soil	23-50 cm: clayey peat	Saturated for long periods as a result of compaction
		Manure, peat from ditches, few sand fragments	$>$ 50 cm: peat, 70% recognizable remnants of wood and reed	
				No run of
		Fertiliser: 300 kg/ha/yr		Mean highest GWT: ca. 25 cm
		Manure: 50 m3/ha/yr		Mean lowest GWT: ca. 50 cm
Stein	Fibric rheic eutric Histosol flat, (alluvial) plain	Extensive grazing/nature conservation since 20 years	0-29 cm: anthropogenic	Poorly drained
			29-55 cm: clayey peat	Saturated for long periods
		0-29 cm anthropogenic top soil	$>$ 55 cm: peat, 70% recognizable plant remnants	Mean highest GWT: ca. 20 cm
		Manure from the past, peat from ditches, few sand fragments		Since 2005, the GWT has been raised due to nature conservation activities
				Mean lowest GWT: ca. 45 cm

Site name	Depth	Colour	Material	pH-KCL	N-NH4	N-NO3	P-PO4	%C	%N
					mg/kg	mg/kg	mg/kg		
Oukoop	0-10 cm	10YR3/1	clayey peat	5.4	20.3	34.7	5.7	24.4	2.5
	10-20 cm	10YR3/2	clayey peat	5.4	14.8	29.1	3	22.9	2.4
Stein	0-10 cm	10YR2/1	clayey peat	4.6	8.4	13.1	0	14.6	1.3
	10-20 cm	10YR2/1	clayey peat	4.8	7	10.6	0	14.8	1.3

Management	Landform	LnCH4=	R2	F-test	p-value	n
Intensive	Ditch	-0.752 (±1.14) + 0.194 (±0.077)* Twater	0.26	25.1	0.000	74
		-0.606 (±0.69) + 0.176 (±0.041)*Tair	0.22	16.1	0.000	67
	Field	-0.884 (±0.45) + 0.087 (±0.03)* Tair	0.23	21.2	0.000	169
	Edge	0.504 (±0.905) + 0.093 (±1.24)* Tair	0.12	10.0	0.002	79
Extensive	Ditch	-1.979 (±1.25) + 0.218 (±0.077)* Twater	0.30	31.3	0.000	77
		-2.019 (±0.76) + 0.172 (±0.044)* Tair	0.22	17.9	0.000	57
	Field	-1.630 (±0.52) + 0.121 (±0.03) * Tair	0.37	43.4	0.000	117
	Edge	-0.816 (±0.06) + 0.126 (±0.08) * Tair	0.21	12.0	0.001	48

pF	h	k
	(cm)	(cm/d)
0	0	25.53
2	100	0.0349
4.2	15849	0.000002

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