Authors' response to Editor's comments on "CH4 and N2O dynamics in the boreal forest–mire ecotone" by B. Ťupek et al., BGD, 11, 8049–8084, 2014, boris.tupek@helsinki.fi, 13 November 2014

Please, find Editors comment proceed by "!" and our response proceeded by "#". symbol. Suggested text for the manuscript uses same font as our BGD paper.

Revised Submission

Editor Initial Decision: Publish subject to minor revisions (Editor review) (22 Oct 2014) by Donatella Zona

Comments to the Author:

Dear Authors,

! After assessing the reviewers' comments and your answers to their suggestions I had the general impressions that you addressed they key points of the reviewers. ***# Thank you!***

! However, from my personal reading of the manuscript, I think some additional points need to be addressed as stated below. I found the introduction a bit too short, with not many references to previous relevant work, and for example no studies cited on the impact of pH on the fluxes (which seemed to be a key result). There should be a more comprehensive case for what was measured and why in the study in the introduction. Please expand this part. Same for the discussion, which could be expanded.

 # We expanded introduction by adding following text with references into the manuscript:

Methane production potential in peat soils generally increases positively with pH (Juottonen et al. 2005, Ye et al. 2012), whereas CH_4 oxidation of forested peatlands has narrow pH optimum around 5.5 (Saari et al. 2004). The forest-mire transitions could become CH_4 sources during the period of elevated water table depth and higher pH levels.

In nutrient rich mires, N_2O emissions increase during drier periods through increased ammonification and nitrification (Regina et al. 1996, Nykänen et al. 1995, von Arnold et al. 2005). Nitrification and supply of nitrate for denitrification increases with higher pH (Regina et al., 1996). However, if nitrate is available low pH increases N_2O emissions (Weslien et al., 2009). Thus, if nitrate would be present during water level drawdown conditions then the forest-mire transitions could become sources of N_2O.

In order to evaluate the underlying factors behind CH_4 and N_2O forest floor fluxes, we measured the fluxes and environmental variables such as soil temperature, soil moisture, water table depth, and soil water pH on 9 sites along the forest-mire ecotone during exceptionally different meteorological conditions. In order to detect statistical significant differences between CH_4 and N_2O fluxes of 9 sites we used two-way analysis of variance; and for better understanding of flux responses to environmental factors we used linear and non-linear regression models, and residual sensitivity analysis.

 # We expanded discussion as in our replies below.

!Page 14 lines 25-26, this is very interesting, but you should provide some references to studies showing a similar result.

 # We supported following statement by relevant studies.

The duration of exceptionally increased high water levels was probably too short for CH_4 producing bacteria to relocate and/or adapt to water saturated conditions. Methane production potential of mire varies in relation to methanogen communities, substrate availability, pH, and temperature (Jouttonen et al. 2005, Jouttonen et al. 2008). Unlike in open mires, in drier conditions (similar to our forest-mire margin) decrease in methanogen community is associated with low CH_4 production potential and with low emissions (Yrjälä et al. 2011). In forest-mire margin, also relatively small population of methanotrophic microbes, coupled with *Sphagnum* mosses, and low CH_4 oxidation potential, related to low CH_4 concentrations in moss layer, could indicate low production potential (Larmola et al. 2010). It's known that water level depth is major control of CH_4 oxidation, and that *Sphagnum* species originally not oxidising CH_4 need several days up to a month to activate methanotrophs through a water phase (Larmola et al. 2010, Putkinen et al. 2012).

! In the discussion it is stated that highly acidic pH limit methanogenesis, but Fig. 8 a shows a negative relationship. Please explain if the impact of pH is different on the methanotropic community, and/or if this results is due to reduced methanogenesis (and add references for dependence of both processes on pH).

 # We clarified pH limitation on methanogenesis and relation to methanotrophy

Temporally water saturated soil layers of pristine forest-mire transitions had low CH_4 production partly due to highly acidic pH levels imposing physiological restrictions on soil microbial communities. Methanogenic activity in water saturated organic soils can be reduced by high acidity (e.g. Ye et al. 2012). Activity of methanotrophic microbes of peatlands, forest peatlands, and upland forest soils is also pH dependent with optimum above 5(Danilova and Dedysh 2013, Saari et al. 2004). Our forest-mire transitions had mean pH below 5 and demonstrated lowest net CH_4 oxidation rates in comparison to upland forests on mineral soils (Fig.8) which is in line with Saari et al (2004). Although, methane oxidation by methanothrophs in mineral soil sites was positively pH dependent (all mineral soil sites were net sinks), in mineral soil sites CH_4 production is primarily limited by high oxygen content.

!Page 15 line 1, it is not clear how the figure can help explaining the linkages between vegetation communities and fluxes.

 # We explain the link between vegetation in the figure and fluxes.

Beside differences in microsite soil water saturation, pH, and microbial communities, also plant communities (e.g. Saarnio et al., 1997, Strom et al. 2003, Riutta et al., 2007, Dorodnikov et al. 2011) play important role in explaining net CH_4 emissions. In our forest-mire margin e.g. in Pine Spruce swamp (KR) and in Paludified Spruce forest (KgK) vascular plants (Fig. 1c) could contributed to an increase in net forest floor CH_4 emissions (Supplement Fig. 3), if methane production occasionally increased.

!Also, on page 15 line 3-5: the aerenchima does not transport photosynthate, please correct, and explain better the link with vegetaiotn, and expand your references on this topic.

 # We reformulated the statement and expanded the references.

It's known that transport of recently photosynthesized carbon downwards to plant roots partly feeds microbial methane production (Alm et al., 1997, Dorodnikov et al. 2011). After methanogenesis, aerenchyma of vascular plants mediates transport of CH_4 to atmosphere and increases net emissions (Hornibrook et al. 2009, Dorodnikov et al. 2011). Small amount of methane that is transported by pore water diffusion is efficiently oxidized by methanotrophs in the aerobic layer of peat and Sphagnum mosses (Hornibrook et al. 2009, Larmola et al. 2010).

!Figure 4 shows a decrease in CH4 emissions with water table shallower than -20 cm in VSR1 and 2. I cannot find an explanation of this in the discussion.

 # We reformulated discussion on decrease of CH_4 emissions due to deeper water levels

Alternatively CH_4 emission in mires showed a Gaussian form response to water level depth with a reduction of the optimum under saturated or dry peat conditions (Fig. 4).

In mires, the form of CH_4 sensitivity to temperature and water table depth may be also determined by differences in pH, the composition of microbial and plant functional communities (Bubier et al. 1995, Jaatinen et al. 2004, Jouttonen et al. 2005, Jouttonen et al. 200, Larmola et al. 2010, Riutta et al. 2007, Saarnio et al. 1997, Saari et al. 2004, Yrjälä et al. 2011). The CH_4 emissions in VSR1 - Tall Sedge Pine Fen were larger than in VSR2 - Tall Sedge Pine Fen (Figure 4). Differences in pH could favor methanogen activity in less acid fen (Jouttonen et al. 2005, Yrjälä et al. 2011, Ye et al. 2012). Slightly different coverage of vascular aerynchymous plants and *Sphagnum* mosses between VSR1 and VSR2 (Fig. 1c) could strongly affect site specific CH_4 production and oxidation potentials. In VSR1 the water level was closer to the surface, and the lawn microsites had a greater abundance of *Menyanthes* species, which are known to mediate higher CH_4 transport (Bubier et al. 1995, Macdonald et al. 1998). Shallower form of CH_4 sensitivity to water table in a hummock type fen VSR2 than in lawn type of fen VSR1 could resulted from differences in plant mediated CH_4 emissions (e.g. Riutta et al. 2007, Hornibrook et al. 2009, Dorodnikov et al. 2011) or CH_4 oxidation potential between *Sphagnum* species (Larmola et al. 2010). For example in the study by Saarnio et al. (1997) the CH_4 flux response to water level would be exponential if it accounted only for emissions from hummock and *Carex* lawn microsites, but the response was Gaussian for flark, hummock, *Eriophorum* lawn and *Carex* lawn microsites taken together.

!The figures use fonts that are too small, please increase font size. Also, negative values for the water table are used in Fig. 4, while in Fig. 2 positive values are used. Please be consistent, and explain which sign convention you use.

 # We increased the fonts for Fig. 4, and used the positive values for the water table depth (to be consistent with Fig.2). We also changed the parameter values in Table 2.

!Please be consistent with the tenses used, sometimes the present is been used and sometimes the past to refer to results of this research.

 # We checked the use of tenses for the consistent use of past tense for all our results.

!Please address these comments and submit a revised version.
Best Regards, Donatella Zona

 # We thank Dr. Zona Donatella for the valuable comments on the manuscript. The comments were addressed and the revised version was submitted.

 # References

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