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Biogeosciences Discussions

Interactive comment on "Seasonal dynamics of methane emissions from a subarctic fen in the Hudson Bay Lowlands" *by* K. L. Hanis et al.

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Dear Referee #1, We'd like to thank you for your positive and helpful review of the manuscript "Seasonal dynamics of methane emissions from a subarctic fen in the Hudson Bay Lowlands" BG 2013 85. Our response to your constructive comments and recommended changes follows:

We have made the following suggested changes to the manuscript:

Page 4541, line 2: inserted "and" before 25

Page 4541, line 3: replaced "in northern" with "from northern"

Page 4546, line 23: merged the two sentences as following:". . . growing season, the

data. . .”

Page 4553, line 1: deleted “also”

Page 4553, line 2: deleted “, and” and replace with “; in contrast”

Page 4556, line 5: combined the two sentences as suggested: “. . . Greenland where measurements. . .”

We’d also like to address your comments and recommendations:

Page 4543, lines 15-25: I would suggest including these dates into Table 1; would be much easier to follow the trend of snow melt. You could also add there the length of growing season for each year. Page 4546, lines 24-26: perhaps added to table 1?

We have added four columns to Table; onset of snow melt, onset of ice and snow cover, non-frozen period, and measurement period.

Page 4548: within section 3 (3.1, 3.2. . .) please deïňĄne “normal” when you talk about precipitation, temperature. . . I guess you refer here to the 1971–2000 Climate Normals for Churchill, Manitoba but make sure it is clear within the text.

Thank you for catching this omission within the text body. The 1971 – 2000 Climate Normals for Churchill, Manitoba are only referred to directly within Table 1. The first sentence of Section 3.1 (Page 4548, line 2) will now read “. . . warmer than the 1971 – 2000 Climate Normals for Churchill, Manitoba (normal; Environment Canada, 2012) for all study months . . .”.

Page 4548, 3.2, line 23: will you be able to insert an explanation on why did you focus only on 2009, what happened with capturing the other years’ spring melt?

We focused on the spring melt of 2009 because it had the best data coverage compared to spring melts of other years. The data coverage for the other years was less than 2009 because of delay in site setup in 2008 and site down time (various instrument and power issues) in other years.

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The text has been changed in 3.2 (Page 4548, lines 22 and 33, sentence 2) to: “In other years instrument and flux station repairs delayed measurements until after the spring melt period.”

Page 4550, 3.3: please start with a paragraph in which you explain what happened with the other years’ coverage. . . why 2011 was mostly covered and other years not?

Fall 2011 was focused on because it provided the best data coverage than other years; the reason being instrument and equipment repairs in other years and improvement in power management of the monitoring system in 2011 allowed for better data coverage in fall 2011.

The text has been revised (first paragraph of Section 3.3 (Page 4550, line 1)): “The fall of 2011 provided the most extensive coverage of FCH4 due to the power relay automation of the flux station implemented in 2011 field season that conserved power (Fig. 3).”

Page 4551, line 26: will you be able to show inter-growing seasonal variations in Fig 2?

We mistakenly included reference to Fig. 2 on line 26. The statement now correctly refers to data shown only in Fig. 4.

Page 4552, 3.5: You reference very well your annual emissions how about looking into literature for interannual variability? Do you observe similar trends, is everywhere 2008 a high emitting year and 2010 a low one?

We acknowledge that annual emissions referenced from other studies should include the measurement years to show interannual variability most clearly for comparative purposes. This has been added to the text. No other work has been published within the HBL related to methane fluxes near Churchill, Manitoba during the study period for us to compare interannual variability at the regional scale.

Page 4555, lines 1-13: regarding winter ïňĆuxes, some say that it may contribute to

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up to 40% (Saarnio, 1999) and others to 10% of annual CH4 budget (Rinne 2007)... probably truth is somewhere in the middle. Can you up-scale your emissions and present annual budgets for HBL and see if they fall within literature range (see Pickett-Heaps 2011, Worthy, 2000 and Roulet, 1990)?

Rinne et al (2007) and Alm et al (1999) monitored CH4 fluxes from northern fens not underlain by permafrost. Alm et al (1999) found soil temperatures at 10 – 120 cm depths to be 0 - 6°C for the winter period (October through April). Soil temperatures > 0°C would be conducive to methane production and consumption by the microbial community. In contrast, our fen is within the zone of continuous permfrost, being frozen throughout the winter period (mean soil temperature 5 – 60 cm depth was -2°C and ranged from -7 to 0°C). Therefore we believe over-winter fluxes should be negligible at our fen site at the northern tip of the Hudson Bay Lowlands. However, we acknowledge further monitoring is required to have confidence in low winter fluxes.

The second half of the paragraph on Page 4555 line 6, starting at "We did not measure FCH4 over the winter period..." will be deleted and re-written as follows: "Further, the gases released from these bubbles during melt contributed to the overall spatial average flux measured with the flux tower, and they were not special events when we consider the seasonal pattern over a large spatial area. We did not measure FCH4 over the winter period. While previous studies have found winter methane fluxes to contribute up to 40% (Alm et al 1999) and 10% (Rinne et al 2007) of the annual CH4 budget, the measured fluxes came from fens not underlain by permafrost where over-winter soil temperatures remain $\geq$ 0°C for October through April. Soil temperatures > 0°C would be conducive to methane production and consumption by the microbial community. In contrast, our fen is within the zone of continuous permafrost, being frozen throughout the winter period (mean soil temperature 5 – 60 cm depth was -2°C and ranged from -7 to 0°C). Therefore we believe over-winter fluxes should be negligible at our fen however we acknowledge further monitoring is required to have confidence in low winter fluxes."

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With respect to scaling up methane emissions to present an annual budget for the HBL, Pickett-Heaps et al (2011), Worthy et al (2000) and Roulet et al (1994) were able to obtain spatial averaged fluxes of methane based on modelling of aircraft and surface observations. Our near-surface measurements are from a fen environment at the northern tip of the HBL, however methane flux measurements at the same scale as our measurements have not been done within the HBL during the same time frame over other surface types such as raised peat plateau bogs, water bodies i.e. ponds or lakes, or boreal regions of these surface types which have greater tree cover, nor have aircraft based methane measurements been collected. Therefore, at present we cannot scale our measurements to represent the entire HBL.

Interactive comment on Biogeosciences Discuss., 10, 4539, 2013.