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Interactive comment on "Modern to millennium-old greenhouse gases emitted from freshwater ecosystems of the eastern Canadian Arctic" *by* F. Bouchard et al.

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Summary:

The study "Modern to millennium-old greenhouse gases emitted from freshwater ecosystems of the eastern Canadian Arctic" by Bouchard et al. presents summertime measurements of CO2 and CH4 emissions from different water bodies in a polygonal tundra landscape. In addition, the age and origins of the emitted gases are investigated by 14C and other comprehensive isotopic analysis. The study is outlined very well and addresses a highly relevant topic in permafrost ecosystem and climate research. A major finding of the study is that different water body types show very different turnover

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rates of different carbon stocks with different age. This finding indicates a very complex interplay between the water body type and carbon cycle. This demonstrates that reliable predictions on responses of permafrost ecosystems to climate warming require a much better understanding of the biogeochemical processes in Arctic freshwater systems. Therefore, I recommend publication of this study in BG after addressing some minor issues and including some uncertainty analysis. In addition, some other recommendations might be considered in a revised version of the manuscript.

General Comments:

The study is written very well and understandable. However, a few points concerning the discussion around climate feedback mechanisms require clarification (see specific comments).

Furthermore, the method section should include a description of the used temperature loggers and sensors (accuracy, location, and so on).

In addition, the calculated CH4 and CO2 fluxes are based on coarse assumptions (average atmospheric concentrations) and a very basic diffusion model. Therefore, it would be recommend to provide realistic uncertainty estimates. Straight forward error propagation methods (e.g. Monte-Carlo simulations) should be applicable. In particular, the available statistics from multiple concentration measurements should be used and could be further investigated. It should be clarified whether the calculated flux magnitudes and directions are significant.

It might be also interesting to calculate the vertical C-balance of the different water body types in order to clearly label them as sink or source for atmospheric carbon. For numerous polygon ponds the CO2 gradient seems to be on the order of about -5 μ mol to -10 μ mol which for some ponds is partly balanced by the CH4 gradient (Fig. 5). Taking into account some uncertainties in the atmospheric CO2 and CH4 concentrations and additional CH4 fluxes from ebullition, the C-balance of some ponds might shift from negative to neutral. A short uncertainty analysis is highly recommended as

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outlined above.

Table 3 could be partly translated into a simple (arrow) diagram in order to illustrate the flux differences

The result section appears short in comparison to the discussion. I recommend to embed descriptions of Fig.6 - 8 into the result section.

Specific Comments:

Title: Maybe "the eastern Canadian Arctic" is a bit too general since all investigations were carried out on Bylot Island which might be not representative for the entire eastern Canadian Arctic.

p.11664; l.6: The statement that the strength of climate feedback is determined by the age of the released carbon requires clarification. Why would carbon that is 5000 years old cause a stronger climate feedback than carbon that is only 500 years old? I completely understand that it makes a difference whether old carbon can be processed or not. However, this would not affect the carbon-climate feedback mechanism, but change the size of the carbon pool that can be activated. I agree that this is an important question which is also reflected in number publications which discuss the permafrost carbon pool every year in very important journals.

p.11664; l.9-12: I recommend to use the terms "glaciated" or "covered by ice sheets" instead of "ice covered". This might be picky, but it reminds the reader on the extend of the ice cover.

p.11664; l.15: I would say "contribute to positive climate feedback if released as GHGs".

p.11664; l.15-17: Is it possible that water bodies act as carbon sinks under current climate conditions and change to carbon sources or become neutral under warming? Anyways, the atmospheric GHG budget would be affected and, thus, a climate feedback would exist even though relatively modern carbon is processed. However, I agree

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that the size of the carbon pool that could become available due to the thaw of permafrost is important. In general, I suggest to reduce the argumentation on feedback mechanisms which are not explicitly in the focus of this study. The identification of carbon pools and their pathways and magnitudes of release already make up very good justifications.

p.11666; l.22-23: The information about birds might be not necessary. In general, this section could be condensed a bit. The study site description appears long compared to the result section.

p.11672; l 22-23: It should be clearly indicated that the measured temperature and oxygen profiles are not representative for entire July. The measured profiles depict a specific situation. Shallow water bodies such as polygon ponds can change their stratification within a few hours according to wind speed. Furthermore, it is very interesting that the temperature profiles c and d in Fig. 3 show bottom temperatures well below 4°C. Is there any explanation for this?

p.11674; l.18: I suggest to be more precise with the term feedback mechanism. Landscape features or elements such as a pond or a lake are not mechanisms per se. These landscape features can introduce processes which are relevant for climate feedback mechanisms. I think, a climate feedback mechanism is e.g. increased CH4 emission of an ecosystem due to warming. This could be caused by the formation or extension of lakes due to permafrost degradation and/or by general changes in the biogeochemical processes due to warmer conditions.

p.11678, l.22-26: This statement is only true under the assumption that only the number of lakes increases with climate warming while all ecosystem processes remain the same. The presented data give no evidence that CO2 emission or uptake of Arctic water bodies will not change with climate warming. This study investigates the current state of an ecosystem from which the response to climate warming is difficult to derive. Nevertheless, it is an important finding that under current conditions the investigated

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ponds are sources of CH4 but sinks of CO2. However, this state might or might not change under climate warming.

p.11681; l.19: Does thaw bulb mean talik?

Fig. 4: What indicates the separation line? CH4 and CO2 are already distinguished by filled and unfilled circles.

Fig. 5: I suggest to be consistent with units. Does [M] indicate mole? The text uses [m mol] frequently.

Interactive comment on Biogeosciences Discuss., 12, 11661, 2015.