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Interactive comment on "Geographic and seasonal variation of dissolved methane and aerobic methane oxidation in Alaskan lakes" *by* K. Martinez-Cruz et al.

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Anonymous Referee #1

Thank you for providing constructive comments on our manuscript, "Geographic and seasonal variation of dissolved methane and aerobic methane oxidation in Alaskan lakes (bg-2015-49)". We have re-written the manuscript, taking into account your concerns and recommendations.

Comment: Martinez-Cruz and co-authors performed surveys along a transect through Alaska, incorporating 30 lakes during a summer and a winter season. By doing this, they accumulated a huge data-set on methane - and oxygen concentrations in these

lakes. Additionally they analysed aerobic methane oxidation (MO) rates. This became possible due to a laser spectroscopy method for the field, newly developed by this group. The authors are well known specialists for studies on greenhouse gases (GHG), mainly on methane in arctic environments. Global changes in climate lead to thawing of permafrost in the arctic regions, with related increase in organic carbon supply to aquatic systems. The study is highly important because of the amount of data from arctic lakes, as well as because of the differences in the lakes, chosen. Methane oxidation within the environment of production is one of the most important pathways to mitigate GHG emission to the atmosphere. It is a merit of this study to summarize such a data-set from the arctic. The ms is well written. The authors have chosen a fixed pattern of sampling depths (same depths in all lakes, except very shallow or very deep ones). To overcome the problem of sampling outside the oxycline, the place of maximum MO, they used a double monod model. A sensitivity analysis was conducted to calculate the MO rate when affinities (Ks-CH4 and Ks-O2) would change. It is an important paper addressing relevant scientific (and social) question on the basis of a well developed sampling design.

Our answer: We are grateful for this encouraging comment.

Specific comments:

1. A clear description of yedoma and non-yedoma types is needed on a prominent position.

Our answer: We have modified the section located on Page 4215 L.26, as follows; “Yedoma-type permafrost is an organic-rich (about 2% carbon by mass) Pleistocene-age permafrost with ice content of 50–90% by volume (Zimov et al., 2006), which occurs mainly in the previously unglaciated regions of Siberia, Alaska, and NW Canada (Czudek and Demek, 1970; Walter et al., 2007; Kanevskiy et al., 2011; Grosse et al., 2013). Non-yedoma permafrost is characterized by thinner ice-rich horizons and have

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a more widespread distribution (Ping et al., 2008; Tarnocai et al., 2009; Hugelius et al. 2014)".

1.a. In both tables I recommend to underlay the yedoma lakes rows by a light grey bar

Our answer: We agree and we have modified both Tables.

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2. page2/line 4: dependance of MO on CH4 and O2 concentrations is to general; I would prefer to read about 'relation at the interface'

2.a. page2/line 4: MO depends only indirectly on OC supply –via methanogenesis and see 2. on relation at interface

Our answer: We have modified that section of the Abstract, as follows;

"Aerobic CH4 oxidation depends mainly on lake CH4 and oxygen (O2) concentrations, in such manner that higher MO rates are usually found at the oxic/anoxic interface, where both molecules are present. MO also depends on temperature, and via methanogenesis, on organic carbon input to lakes, including from thawing permafrost in thermokarst (thaw)-affected lakes."

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3. page2/line 13: CH4 concentration may be lower at a given depth in summer due to the better oxygen supply compared to winter; it should not be called 'deficit'

Our answer: We agree and we removed the term "deficit", as follows;

"We found that in the winter, aerobic CH4 oxidation was mainly controlled by the dissolved O2 concentration, while in the summer it was controlled primarily by the CH4 concentration, which was scarce compared to dissolved O2".

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4. page2/line 17: the meaning of ‘landscape processes’ could be more clearly described as ‘coupling of terrestrial and aquatic habitats’

4.a. page2/line 17/Fig 1 etc: the thawing permafrost needs to be more clearly described: when thawing impacts terrestrial plants in the catchment of the lakes (p12/l13), a direct surface input/inflow of thawed material into the lake seems to be likely; perhaps this can be shown in Fig 1 also

Our answer: Thank you for this comment. We agree and we modified the abstract section, by adding a new sentence on coupling of terrestrial and aquatic habitats, as follows; “Thermokarst (thaw) lakes formed in yedoma-type permafrost had significantly higher CH4 oxidation rates compared to other thermokarst and non-thermokarst lakes formed in non-yedoma permafrost environments. As thermokarst lakes formed in yedoma-type permafrost have been identified to receive large quantities of terrestrial organic carbon from thaw and subsidence of the surrounding landscape into the lake (Walter Anthony et al. 2014), these results confirm that coupling of terrestrial and aquatic habitats play an important role in lake CH4 cycling”. We also modified Figure 1, as suggested.

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5. page2/line 22: references should be clear (in text, in list) if Walter, Walter Anthony or Anthony, KMW (p21/l30) are different persons

Our answer: All of these are the same person. Walter is a maiden name, and Walter Anthony is a married name. We revised the manuscript to more consistently refer to this person and clearly follow the reference database.

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6. page5/line 13: please delete ‘offshore and’

Our answer: Thank you for this observation. Changed accordingly.

7. page6/line 13: please, give full name of HE-TDLAS –I guess it is an abbreviation

Our answer: This is correct, we included now a full reference;

“To avoid long delays in sample transfer from remote locations to the laboratory, we determined dissolved CH4 concentrations with a previously described method based on Headspace Equilibration using Infrared Tunable Diode Laser Absorption Spectroscopy (HE-TDLAS; Sepulveda-Jauregui et al., 2012)”.

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8. page10/line 25: see 7., here TK

Our answer: The first reference on TK was presented on Page 9, L10 (P4221, L10 of the PDF file). Please note that according to the first general comment from reviewer 2 (Dr. Stepanenko), we modified the statistical test from Tukey-Kramer to Kruskal-Wallis multiple comparison test. However, based on this comment, we decided to write out Kruskal-Wallis every time it appears in the text.

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9. page12/line 13: nutrient supply (P, N) can force bacterial and algal growth also, with similar effect on sedimentation etc.

Our answer: Thank you for this important clarification. We modified this sentence, as follows;

“Walter Anthony et al. (2014) and Sepulveda-Jauregui et al. (2014) showed that thawing yedoma permafrost not only provides ancient (Pleistocene-aged) organic carbon stimulating CH4 production but also phosphate and nitrogen (ammonium), which promotes bacterial, algal and contemporary plant growth in and around lakes”.

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10. page12/line 20: see 4a: please, describe clearly, where thawed C reaches the lake; deep under beneath the sediment or from the catchment or in medium depth directly from thawed surface sediments (as in Fig. 1)

Our answer: This is an important comment that we took into account, trying to describe concisely the carbon release, as follows;

“Contemporary organic matter decomposes in part to form CH4 in surface lake sediments, whereas ancient yedoma carbon is progressively released from thaw bulb beneath lakes to surface sediments (Heslop et al., 2015). Hence, organic carbon is made available to microbial decomposition in both shallow and deep sedimentary environments (Fig. 1)”.

Please note that we modified Fig. 1 accordingly.

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11. page13/line 13: “CH4 production was higher due to warmer sediments” as there is no measurement for this statement, it should be rewritten

Our answer: We agree, we modified that sentence accordingly;

“In summer, although CH4 production was probably higher due to warmer sediments, ice was not a physical barrier to CH4 exchange between the lake water and the atmosphere (Fig. 1).

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12. page13/line 15ff: The title of ms “Geographic and seasonal variation. . .” has to be followed by a clear statement about geographical variation;

a. please replace ‘concentration..of lakes’ by ‘number of lakes’ or ‘portion of ..’

Our answer: We are not sure we understand clearly the first part of this comment. Reviewer 1 will probably agree that “geographic” refers to “all of the natural features

of a region or regions" and as such, our manuscript discuss in detail the effect of the landscape, permafrost type and latitude. If Reviewer 1 could be more specific we would be happy to further attend to this comment in our manuscript. We agree with the second part of the comment and we changed "concentration of yedoma lakes" to "proportion of yedoma lakes"

Comment: The references are on the state of the art. All figures are necessary and well prepared.

Our answer: Thanks for your supporting review.

Interactive comment on Biogeosciences Discuss., 12, 4213, 2015.