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Interactive comment on "Substrate potential of Eemian to Holocene permafrost organic matter for future microbial greenhouse gas production" *by* Janina G. Stapel et al.

Anonymous Referee #1

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Stapel et al have studied OM properties and microbial biomarkers throughout a permafrost section from Siberia going back to MIS5, to identify the lability of OM, and thus the availability of potential substrate for greenhouse gas generation due to microbial decomposition upon permafrost thaw. The authors find that OM deposited during glacials and interstadial periods likely contain most substrate, and thus contribute most to greenhouse gas emission upon thaw. The manuscript is generally well written, although the English and the use of punctuation marks is getting a bit sloppy towards the end. I have a few concerns about the manuscript, which I would like to see addressed before I can recommend this work for publication in Biogeosciences:

Introduction: The link between the general introduction on permafrost thaw, its con-

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sequences, and the scope of this study can use some improvement. For example, Bol'shoy Lyakhovsky Island is suddenly mentioned on P2, L15. Later it appears to be the study site, but it needs some more context in the introduction. Similar for the 'Eemian deposits in this study. . .' (P2, L30). Also include acetate, and the difference between free and bound acetate.

Stratigraphy: The composite core consists of different lithologies, i.e. lacustrine (MIS1 and MIS5), floodplain deposits (MIS4), and also contains cryostructures. I miss a discussion on how different sources may influence OM paramters, lipid abundance and distribution, or acetate availability? For example, GDGTs in lacustrine (MIS1 and MIS5) and floodplain deposits (MIS4) may have a mixed soil and aquatic origin. This may influence your results, especially when considering that an earlier study has shown that Siberian thermokarst lakes (probably comparable to the MIS5 deposits in this study?) can contain >200 times the concentration of branched GDGTs compared to Yedoma (Peterse et al., 2014, JGR-B). Similarly, isoGDGTs, archaeol, and PLFA concentrations may be influenced too. Another way to check sources could be to calculate BIT index values (Hopmans et al., 2004, EPSL). Peterse et al., 2014 (JGR-B) found that Yedoma has a significantly lower BIT index than in soils. Similar changes should be visible throughout the composite core studied here.

Methods: P4, L30: were samples decalcified prior to determining TOC? Otherwise total carbon is reported instead of TOC. P5, L5: was there any pre-treatment of the sample material prior to pyrolysis?

Discussion: P9, L3: How/in what figure/parameter is the contribution of aquatic OM reflected? Similar for the input of aquatic OM during MIS3 (P9, L32). Please clarify. Again P12, L10-11: what indicates the link to moist depositional conditions?

P.9, L27: I can't follow this sentence. Check grammar/order of words. Also: if glacial conditions would slow down degradation, how does it influence its production?

P.10, L15 and following: How can you be certain that GDGTs reflect past microbial

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biomass? In this study, only the core lipids are analyzed, whereas part of the GDGT pool may present as IPL, and thus derive from living biomass. Other studies have reported an IPL contribution of >30% to the GDGT pool in OC-rich soils (e.g. Peterse et al., 2011 Org Geochem). Furthermore, the manuscript refers to both microbial biomass and methanogens, of which the latter is of course more specific. Please go through the manuscript and check which level of specificity is relevant.

Fig. 2: Is there a reason why archaeol is plotted together with isoGDGTs? They do not necessarily share the same source. Instead, it would be more logical to plot archaeol next to e.g. GDGT-0/cren, which are both indicators of methanogenesis. These data can then also be used to compare with the acetate data.

L 20: Can you explain how exactly GDGT concentration data provides information on the activity of microbial biomass in the past? L23: Given that GDGT concentrations and TOC seem to covary (i.e. both higher in Yedoma?), it makes sense to normalize GDGT concentrations on TOC to distinguish between high GDGT concentrations due to high TOC content and actual elevated microbial biomass. Do the trends and conclusions still hold?

The choice of 'excellent' as description for substrate (in abstract and P10, L31) seems odd. In my opinion something can turn out to be, or has proven to be an excellent substrate, but you can not select something as an excellent substrate if it isn't compared to anything else.

The discussion on microbial activity in the active layer leads to the conclusion that MIS1, 3, 4 provide most substrate upon thaw. However, it is important to mention that there are only few active layer sediments included in this study, and that there are no active layer samples from MIS2 and MIS5 permafrost are included. There should be a few words on how representative this sample selection is. I furthermore miss the link between substrate availability and OM quality or composition and microbial biomarker abundance. I also miss a comparison with data from the literature. I have already men-

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tioned Peterse et al 2014, JGR-B (Branched glycerol dialkyl glycerol tetraether in Arctic lake sediments: sources and implications for paleothermometry at high latitudes), but there are more biomarker papers on Siberian (or Arctic in general) permafrost soils, and there must be on microbial community composition and OM properties, too. To name a few: Bischoff et al 2013, GBC. Response of methanogenic archaea to Late Pleistocene and Holocene climate changes in the Siberian Arctic. Knoblauch et al., 2013, GCB, Predicting long-term carbon mineralization and trace gas production from thawing permafrost of Northeast Siberia. Blaud et al., 2015, Res in Microb. Arctic soil microbial diversity in a changing world. And papers citing those.

P11, L31: Can you support the drawn similarities between TOC and free acetate with statistics? Is their relation stronger during MIS3 and 4 compared to during MIS1 and 5?

P12, L2-5: check the grammar of this sentence, I can't follow the reasoning. I think 'favoured' needs to be replaced with 'a result of' ....caused by the onset of the Holocene, when a warming climate caused unstable environmental conditions.... P12, L5-9: This sentence also seems to lack punctuation marks, verbs, logical order of words. Please check.

Specific comments: P1, Line 15: delete excellent P3, L5: abbreviation (PLFA) seems out of place here. P4, L30: replace grounding by grinding. P5, L2: past tense of grind is ground, not grounded P5, L9, replace were by was P5, L15: replace grounded by ground P.5, L17: polarity fractions, or fractions of increasing polarity P5, L20: what does PL stand for? P10, L23: increased P11, L31: similarities....are... P11, L34: ...the OM composition... P12, L5: reason P12, L10: replace 'implied' by 'caused' P12, L16: 'moist' or 'more moist'. 'Moister' does not exist. P12, L20: ...gas generation is accessible within permafrost. P12, L20: delete 'an'.

Terminology: P.11, L20: what is old freeze-look permafrost? P. 11, L 27: what is a thermos terrace?

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