

We thank the two anonymous Reviewers and the Editor for their reviews of our manuscript and their useful comments. Below are point-by-point responses to all of the comments and questions. The original reviewer' comments are shown in *grey (italics, smaller font)*, and our responses are presented in black (normal font).

Reviewer #1 (Anonymous)

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General comments

The authors present a case study in which they reconstruct the development of a thermokarst lake in Holocene-age sediments in the Canadian Arctic, primarily by interpreting lake geomorphology and a pair of sediment cores extracted from the bed. Overall the study is interesting, the topic is clearly appropriate for the journal, the data seem sufficient to support most of the conclusions, and the narrative is fairly clear. I also appreciated the video supplement, showing ice wedge furrows in the shallow platform of the lake.

Thank you for these positive comments. The video supplement clearly shows that the lake is currently developing by lateral expansion related to thermokarst processes.

Two of the most interesting and novel aspects of the study are that the lake formed in recent sediments (instead of Pleistocene-aged Yedoma deposits) and its initiation was during a time that was cooler than the present – the authors address both these points, but I think they could do a better job of emphasizing them early on in the paper, and even in the abstract.

We modified several sentences, and added new ones, to put more emphasis on these two aspects. The fact that lake initiation started in Holocene sediment during a colder climate has important implications for thermokarst modeling. The abstract, the Introduction, as well as the Conclusions, were modified accordingly. We also changed the title, which now reads as follows: « Thermokarst lake initiation and development in syngenetic ice-wedge polygon terrain during a cooling climatic trend, Bylot Island (Nunavut), Eastern Canadian Arctic ».

I am also a bit confused about part of the conceptual model [...] specifically, what happens to the sediments beneath the deepest part of the lake [...], as described in my last comment in the list below.

See our reply to the last comment below. The confusion came from our inaccurate wording. We have changed the text.

My detailed comments, presented below, are listed by line number in the manuscript.

Thank you. We replied to all comments and changed the text accordingly.

Specific comments

16: I think this is a good place to emphasize that the lake you studied is from the Holocene, as opposed to the Pleistocene. You could write “Here we present the gradual transition from syngenetic ice wedge polygon terrain to a thermokarst lake in Holocene sediments in the Eastern Canadian Arctic.” Also, remove the s from “terrains.”

We made the suggested changes.

26: I recommend emphasizing that the Neoglacial cooling period was cooler than today. For example, you could write “this happened in the middle of the Neoglacial cooling period, likely under colder-than-present and wetter-than-average conditions.”

We changed the sentence as suggested. As mentioned above, we also modified the title to take that comment into account.

37: Remove the word “a” in “a significant variability.”

Removed.

42: The sentence that begins with “Lakes located in [...]” is unclear. I think you are distinguishing between lakes that form in Yedoma and lakes that don’t, but I’m not sure what you mean by the phrase “form a separate lake category.” I recommend rewriting this sentence, emphasizing that 1) some thermokarst lakes that form in Yedoma can be up to several meters deep, and 2) the focus of this paper is on younger lakes that don’t form in Yedoma.

We modified the beginning of the sentence as follows: «Some of the lakes located in [...]». Also, we added a sentence afterwards to mention that most thermokarst lakes are located in formerly glaciated terrains (i.e. Yedoma lakes are an exception).

54: Check to make sure the Cryosphere allows citations of papers in preparation. I’m not sure this is the case. This also applies to your citation of Tank et al. in line 415.

We included the Preskienis et al. paper because we knew that it would be submitted quickly after our own submission. It has been submitted since then (November 2019) and is now ‘in review’. We modified the citations in the text and the reference list accordingly. Regarding the Tank et al. paper, it was already ‘in review’ in late 2019, and it still is.

Message to the Editors: We hope that these papers will be accepted for publication by the time our manuscript is published. Meanwhile, we can provide a copy of these manuscripts (read-only) for reference to the reviewers. If this is not OK with the Editors, we can find another solution.

56-62: Are all thermokarst lakes inevitably destroyed by one of these mechanisms? You make it sound like this is the case.

The outcomes presented are the ones we know about (they have been studied, and we refer to these studies). To be more cautious, we added ‘generally’: « [...] thermokarst lake development generally ends with one or more of the following [...] ».

86: Change “These glacial valleys [...]” to “The valleys of these glaciers[...]”

Change made.

109-118: It would be nice to state the maximum depth of the lake somewhere in this paragraph.

Detailed lake morphology (including maximum depth) is provided in the Results section. However, we added the maximum depth in this paragraph, as suggested: « The sampled lake, informally named Gull Lake (maximum depth ~ 4.2 m), is located [...] ».

147: Please define gyttja the first time you use this word.

Done: « [...] general stratigraphic units, such as gyttja (organic-rich lacustrine mud), peat, silt and sand [...] ».

175-176: Please specify what you mean by “plotted on diagrams.” Is this describing Figure 5?

Yes, it is referring to Figure 5. We changed the sentence into: « [...] were displayed on abundance diagrams using the C2 software [...] ».

193: There is a Fortier et al. 2019 in your references, as well as a Fortier et al. 2019a and Fortier et al. 2019b. Please change this to a, b, and c and update your citations.

These references are all recent datasets involving either only two authors (Fortier and Bouchard, 2019a and 2019b), or more than two authors (Fortier et al., 2019). These references are as follows (we also specified this in the ‘Data availability’ section):

- Fortier, D., and Bouchard, F.: Computed tomography (CT) scanning of a lake sediment core, Bylot Island, Nunavut, Canada, v. 1.0 (2015-2015), Nordicana D54, doi: 10.5885/45612CE-AB27C20EB10D4509, [2019a](#).
- Fortier, D., and Bouchard, F.: Loss-on-ignition and grain size analysis of a lake sediment core, Bylot Island, Nunavut, Canada, v. 1.0 (2015-2015), Nordicana D52, doi: 10.5885/45603CE-21852993EE434926, [2019b](#).
- Fortier, D., Paquette, M., and Bouchard, F.: Ground-penetrating radar (GPR) surveys over a thermokarst lake, Bylot Island, Nunavut, Canada, v. 1.0 (2015-2015), Nordicana D53, doi: 10.5885/45609CE-E3573955017A4904, [2019](#).

200: Change “hyperboles” to “hyperbolas.”

Done.

280: Please provide more context for the sentence that begins “The fossiliferous marine sediments [...]” Right now it’s difficult to figure out how it fits into the paragraph.

We are referring to the silts and clays deposited by the marine transgression phase in the sentence just before. We slightly modified the text, so now it is more explicit: « Such fossiliferous marine sediments [...]».

287: I think you mean 4.8 kyr and 5.5 kyr instead of 4.8 yr and 5.5 yr.

The reviewer is right, good catch on this mistake. We changed the text accordingly.

321-324: Please explain your reasoning more thoroughly in the sentence that begins “Based on present-day lake morphology [...]” It’s difficult to figure out how you reached the conclusion that the initial depression in the surface must have been 1-2 m deep.

The reasoning is as follows:

In the sediment core from 2015, collected at ~ 4 m depth, we sampled about 0.7 m of silty peat. This unit is currently unfrozen. We know that the surrounding frozen ground of that unit contains over 50 % of ice by volume (Fortier and Allard, 2004). Hence, considering thaw settlement and consolidation, the silty peat layers found in the core must have made at least twice their current thickness when they were still frozen. That makes about 1.5-2 m thick of frozen silty peat before the lake started to form. Even if we assume that the thawing of the underlying glaciofluvial material may have caused some minor subsidence (because of a negligible excess ice content), there is still nearly 2 m of material missing (i.e. 4 m minus 1.5/2 m). Hence, we assumed there was a 1-2 m pre-existing depression.

We modified the text to make it clearer. For example, we added lake maximum depth (~ 4 m) in the sentence, and we added the following sentence: « Since this silty peat unit is about 1.5-2 m in thickness when still frozen (Fortier and Allard 2004), and since the underlying glaciofluvial unit is ice-poor (thus negligible subsidence upon thaw), there is 1-2 m elevation gap which can be explained by the presence of a preexisting depression. The latter is interpreted as a channel in the glacio-fluvial outwash underlying the silty peat. »

372-373: I'm confused by this part of the conceptual model. Please explain how "the deepest parts of the lake have now almost reached the underlying glacio-fluvial sand." (You also make this statement in lines 427-428.) As ground ice melts and subsidence occurs, the upper sediment layers reduce in thickness, but they typically are not removed. Are you indicating that the upper sediment layers beneath the lake bed are being removed as the lake expands, exposing the glacio-fluvial sands? If so, how is it that you can still see evidence of ice wedge polygon ridges and troughs in the deepest part of the lake bed (lines 363-367)?

We apologize for the confusion. We were inaccurate in our choice of words. The lake bottom is indeed still covered by silty peat sediments overlying glaciofluvial sands, as seen in the collected cores (Fig. 4). We meant that the 'thawing front' (or the base of the talik) is moving downwards (as thermokarst occurs) and has « now reached the underlying glacio-fluvial sand ». The same reasoning is valid for the statement at the end of section 5.3 (Implications for Arctic carbon dynamics).

We modified these two sentences:

« [...] the 'thawing front' (i.e. the base of the talik) has now reached the underlying glacio-fluvial sand [...] »

« [...] since the the base of the talik has reached the much less organic-rich layer [...] ».