Dear editor,

Thank you very much for your letter regarding our manuscript entitled "A field study on ice melting and breakup in a boreal lake, Pääjärvi, in Finland". We are truly grateful to the comments and suggestions from you and the reviewers. The manuscript has been carefully revised. The point-by-point answers to the comments and suggestions were listed as below.

Response to Reviewer 1# Comments

The revised text underwent essential restructuring and shortening and presents the results in a much more concise and coherent way than the previous version. The value of the new findings is now clear: the detailed quantification of the late phase of lake ice melt in terms of relationship between the surface, bottom, and internal ice melting rates contributes towards better understanding of the global balance of seasonal freshwater ice. The new observations on the biogeochemical parameters within and underneath the ice cover add a valuable facet on the effect of the ice melt on physical-biological coupling in lakes.

Some minor remarks:

The new section explaining the heat balance calculations provides the necessary background to the field estimates and puts them into the general context. If set earlier in the textflow, before the geochemistry results, closer connected to the field data on ice melt rates…

Response: Thanks for your advice. We interchanged the order of 3.3 and 3.4. And we changed all the numbers of the figures in 3.3 and 3.4.

The value of Qw0 of 1 W/m^2 is rather arbitrary. While the conductive flux from water to ice is indeed small, it can still vary within an order of magnitude. A range of possible values should be mentioned here.

Response: Thanks for your suggestion. We adjusted this part and gave the range of possible values of Q_{w0}.

The background term Q_{w0} is not known but for molecular conduction the scale is $Q_{w0} = k_w \, \partial T/\partial z \sim 1$ W m^{-2}, where $k_w = 0.56$ W m^{-1} °C^{-1} is thermal conductivity of water, and in general mid-winter data suggest that $Q_{w0} < 5$ W m^{-2}. With $Q_{w0} = 1$ W m^{-2}, we have $Q_w = 11.5$ W m^{-2} and the corresponding melt rate at the ice bottom would be 0.33 cm d^{-1}.

Some details on estimates of k0 in Eq. 4 would be useful to follow the derivations without searching through the cited literature.

Response: Thanks for your suggestion. We added some details on estimates of k_0 in Eq. 4.

where k_0 is independent of the surface temperature but depends on time, and k_1~15 W m^{-2} °C^{-1}. In exact terms, k_0 includes the radiation balance and latent heat flux at

$T_a = T_0$, and their correction for $T_a \neq T_0$ plus the sensible heat flux is included in k_1. In Lake Pääjärvi, k_0 varies between -50 W m^{-2} and 115 W m^{-2} in summer (Leppäranta and Wen, 2022).

L64 "but, however": remove either "but" or "hovewer"
Response: Changed as suggested.

L92 "final results": remove "final"
Response: We have removed "final".

Fig. 4 "Sluash": correct spelling
Response: You are right. We have corrected the spelling of "sluash" as "slush".

L297 remove "Now"
Response: We have removed "Now".

L432 remove "very"
Response: We have removed "very".

L434-435: The entire sentence can be removed as repetition.
Response: We have removed the entire sentence.

Response to Reviewer 2# Comments

The manuscript has been improved significantly in terms of its language, structure, and presentation, but some minor technical modifications should be taken care before possible acceptance.
[1] L20: delete "during"
Response: We have deleted "during".

[2] L41: in and below
Response: Changed as suggested.

[3] L310: but depends mainly on…
Response: Changed as suggested.

[4] Section 4.1: this section seems quite isolated from the main contents of the ms and maybe can be skipped over, and none of your results was used to analyze or understand the ice phenology and its variability. You mentioned "Field data of lake ice are very important to examine and predict ice phenology", but how you examined or predicted?
Response: Thanks for your suggestion. We have adjusted this section but not remove. In this manuscript, ice decay was monitored from the start to the final breakup resulting with a full time-series of the evolution of ice thickness, structure, and

geochemical properties. However, the ice break up date is also an significant ice phenological parameter during ice melting period. Based on the ice break data from the Lammi Biological Station, we can see the interannual variations of ice breakup date in a boreal lake, Pääjärvi. We mentioned "Field data of lake ice are very important to examine and predict ice phenology", we examined it from the following references and we put the references in the manuscript. Which can be seen in Line 356-359.

George, G. D.: The impact of the North Atlantic Oscillation on the development of ice on Lake. Windermere, Climatic Change 81, 455–468, 2007.

Williams, G., Layman, K. L. and Stefan, H. G.: Dependence of lake ice covers on climatic, geographic and bathymetric variables, Cold Reg. Sci. Tech., 40, 145–164, 2004.

Stefan, H. G., and Fang, X.: Simulated climate change effects on ice and snow covers on lakes in a temperate region, Cold Reg. Sci. Tech., 25, 137–152, 1997.

[5] Sections 4.2 and 4.3: Since the authors compared their results from the studied lake with those from others and other lakes, e.g. in terms of melting rate, heat flux from water, and geochemistry, it would be better if you can tell why they are different or even similar. And most important, can we get some common points or understanding when intercomparing, like in a broader scope?

Response: Thanks for your advice. We adjusted this part and added some explanation about why the melting rate, heat flux from water, and geochemistry are different or even similar. And we got some common points or understanding when comparing with other research. Which can be seen in Line 385-387, Line 393-394, Line 406, and Line 436-437.

[6] L428-432: This part can be removed or significantly shortened.

Response: Thanks for your suggestion. We have significantly shorted this part based on your comments.

Ice season has a specific role in the local environment and human life, and it has an impact on the lake ecology far beyond the ice period. Research of lake ice has largely increased to evaluate the impact of the predicted climate change on the ice phenology and properties. During the melting period, it is difficult to do fieldwork due to the deterioration of the ice cover, and therefore only few data have been collected.