

The Cryosphere Discuss., referee comment RC1  
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## Comment on tc-2021-349

Anonymous Referee #1

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Referee comment on "Sunlight penetration dominates the thermal regime and energetics of a shallow ice-covered lake in arid climate" by Wenfeng Huang et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-349-RC1>, 2021

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The manuscript (TC-2021-349): "Radiative penetration dominates the thermal regime and energetics of a shallow ice-covered lake in an arid climate" by Huang et al., presented temperature and radiative flux observations in a shallow lake during the ice season. The lake was quite big and located in the Mongolian Plateau northwest China where the local weather was dominated by an arid climate. The observations have been made for 4 winter seasons. For each season, the observation covered between 1-2 months started from January to February or March. The heat fluxes across the ice-water interface and distributed within the lake water below the ice bottom were investigated. The paper concluded that the penetrated solar radiative flux contributed significantly to warming the lake water and creating large lake water heat flux below the ice bottom.

The shallow lake energy budget during winter is important. it plays an important role in lake water-bottom sediment interaction and eventually affects the lake or the surrounding watershed environment during the ice-free season. I found this research topic fits very well the scope of TC journal. The observations technique and data analyses presented in this manuscript are in general adequate. The method is sound, and the results are convincing. However, I found issues with respect to lack of clarity and weak causal presentations in various places in the manuscript. I think extra work is needed to improve the overall quality of this manuscript before it can be considered as TC publication. Please see my comments point by point below that I hope can be useful for authors to improve the manuscript.

1: The title of the manuscript makes me feel this study is rather qualitative. You might consider reformulating the text and making it look more quantitative, e.g. The impact of solar radiative flux on the thermal regimes and energetics of a shallow lake in an arid climate region during winter or something like that.

2: In the abstract, "The Central Asia" sounds like a very large area, I am sure there are papers focused on winter lake studies. It might be better to be more specific to point out your research domain, i.e., Mongolian Plateau

3: L20, "Results reveal that persistent bare ice permits 20%–35% of incident solar radiation..." is this range independent of bare ice thickness? please specify.

4: L22/23, "high water-to-ice heat flux (annually mean 20–45 W m<sup>-2</sup>) in mid-winter" What do you mean "annually mean" (annual mean)? How did you define the annual cycle? Your observations covered only partial winter, so "annual mean" is a bit misleading. Please revise accordingly.

5: After I read the entire manuscript, I felt you might consider adding more findings you have discovered in this study, for example, the heat flux within ice floe could be summarized in the abstract along with the water-to-ice heat flux.

6: Introduction: Please consider reformulating the last paragraph. I think the first half paragraph may suit better in the following Chapter. The second half of this paragraph looked like the objectives of this study. You may start with a discussion on what subjects or knowledge gaps were missing for the lake energy balance study. Then point out the objectives of this work.

7: Chapter 2 is named "Method". I would suggest you reconsider the title of this chapter, e.g. "Data and method" perhaps better.

8: Section 2.1 "study site" is kind of ok, but could you give a bit more information on the study site that is connected with the water-energy budget. I mean to provide some more information on the importance of lake water energy study for this particular region.

9: I see Figure 1 is fine in terms of illustration. However, the figure caption is not very informative and need to be reformulated. For example, there is no information in figure 1c.

10: Section 2.2 is ok. But it would be more interesting to describe field observations to some extent with text and even photos rather than list a bunch of numbers in a Table.

11: How do I understand the "total number of measuring depths showed in the bracket" in the third line of Table1 (Air-ice-water-sediment temperature)? What electric conductivity means here? How do you use it in this study?

12: Section 2.3 is better entitled as "method".

13: Figure 2 is nice, but I have seen it in a published paper by (Huang et al., 2019, <https://doi.org/10.1016/j.jhydrol.2019.124122>). Although Huang is also the first author of this manuscript, it might be better to cite the original source of this figure or make the necessary edition of Figure 2 accordingly.

14: L176, We classified errors into four ranges: please give a citation or add some arguments on such classifications. In addition, please check the notations of table 2.

15: Figure 3 is nice and informative. Please consider using international standard [dd/mm/yyyy] as the x-labels. Please check the figure legends: should it be the "transmitted" or "reflected" as in the figure caption.

16: In section 3.2, it would be better to discuss what do you know about the salinity stratification during your observational periods in order to support your statement on unconventional thermal stratification. How did you measure lake water salinity?

17: L236-246, Maybe you can argue that the water salinity seems to dominate the stratification of lake water below the ice and penetrating solar radiation below the ice layer as well as the heat flux from sediment determine the lake temperature profile? Why does winter 2017 differ from other seasons?

18: Figure 4 needs makeup. The current illustration is too messy and difficult to see clearly.

19: I think section 3.3 is a very important part of this study. I would like to see more discussions. For example, how did you get those numbers in the second paragraph? What are those numbers after the symbol " $\pm$ ", although I can make a pretty guess of them, you need to tell the readers?

20: L257-269, Figure 5 presents the temperature and salinity profiles in winter 2017. Please explain why under-ice mixing took place while the convection didn't. Please provide more details on how does the temperature-salinity interact with each other and whether the interaction could trigger convection or not?

21: L269, "Interestingly, the convective mixing process increased Fw by 33% in winter 2016 but decreased Fw by 26% in winter 2018, indicating a complicated effect of convection. Those increasing and decreasing are compared with what? Please write your results in a causal way.

22: L269-271, here authors stated that the convection increases the Fw in one winter but decreases it in another. Please elaborate on this finding and give some more discussions. Usually, the convection is believed to increase the Fw?

23: L272-280, This paragraph draws my attention a lot. It gives a very interesting result, again, I would like to see more discussion here. For example, a large Fw is often associated with a large  $Q_c$ , which means a strong heat transmission from lake water to lake ice at ice bottom rather than a net positive/negative deficit of heat flux at the ice-water interface to create freezing or melting. What would happen if there were a snow layer on top of lake ice?

24: L295, "small ( $-5-4 \text{ W m}^{-2}$ )" Not clear to me.

25: In section 4.1 you have defined 4 stages (I, II, III, IV). In section 2.3 You mentioned Winter phase I, Winter phase II. Are there any linkages between those groups of definition?

27: The conclusion section is too short. I would like to see a better synthesis of your results and a clear and concrete conclusion that can be regarded as take-home information to the lake ice modeller or lake environment researchers

28: The language can still be improved.