Comment on tc-2022-31

Anonymous Referee #2

Referee comment on "Global evaluation of process-based models with in situ observations to detect long-term change in lake ice" by Mohammad Arshad Imrit et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-31-RC2, 2022

Global evaluation of process-based models with in situ observations to detect long-term change in lake ice

Overall, I have serious concerns about this paper and note what I consider to be fatal flaws. While the paper does present an interesting premise, I do not recommend publication at this time. I outline my major concerns here for the Authors to take into consideration for a possible publication at a later time.

In situ data:

The first thing that strikes me is the lack of information on the validation data. Where are the 2658 lakes? Are they evenly distributed through the northern hemisphere? Do they represent lakes across the entire northern hemisphere? How far north does the dataset extend? While seemingly minor to not include a map, this is actually quite a major problem. Especially with the comments about longitude being an important explanation for the RMSE, and a lack of validation data from 0 to -50 longitude. Does that not negate the results of longitude being the most important with not much validation data in the region where Figure 3 shows the highest PDP? (Also, why does the scale for ice off end in a different geographic region than ice on? Is this a difference in the geographic region of the in situ data for ice on and off?)

Figure 5 raises some serious concerns for me regarding your in situ data. Ice off in early January for the extreme years? When ice on is around the same time? does that mean those years were essentially ice free? Looking at ~1977 for Monona, it appears that ice on is about -30 (early Dec?) while ice off is -20, assuming the plots are aligned, which perhaps they are not. Why is Monona essentially ice free when Mendota is not? Isn't

Monona shallower than Mendota? How can it be essentially ice free that year when Mendota is ice covered? Even Lake Michigan was mostly frozen in the late 1970s. It also doesn't match the records online: https://www.aos.wisc.edu/~sco/lakes/monona-dur.gif

the shortest ice season was 49 days in 97/98. Are you using different data? Something is not quite right here. Perhaps I am not interpreting Figure 5 correctly, but if that's the case than the explanation needs to be improved.

Lake depths:

Lake depth is an extremely important variable to represent in ice modelling. The manuscript notes the use of the Global Lake Data Base for some models and 50 m depth for the CLM4.5.

The GLDB used to have some assumed data based on geology or other factors where lake depths are unknown, though perhaps this has been improved in recent years. This is a very useful dataset for sure considering the lack of gridded bathymetry data available, but it is an assumption that the depths are representative in your grid cells since they are not all observation based. An acknowledgment of the uncertainty this introduces is important, perhaps a figure showing the range of depths per grid cell? Something to give the reader a sense of how representative the data set is?

Are the other models using values around 50 m for depth as well in every grid cell? Does this mean that the CLM4.5 is using 50 m for northern grid cells as well? This is unclear, and if 50 m is assumed everywhere it is most certainly not a valid assumption to make - especially for most northern latitudes in the Northern Hemisphere. This ties back into the lack of map for your study area/data. If you are only doing regions with the very large lakes in them, perhaps the 50 m is acceptable, but that is very deep for a 'typical' lake and would not be representative of the Northern Hemisphere in general.

Extreme events:

Oddities in your in situ data aside - 1 grid cell is not a sufficient example to make comments on extreme events. Your discussion says ENSO was responsible for some early break-ups in literature (line 265: ENSO events 265 have been attributed to several noticeably early break-ups for lakes in recent decades, such as 1972, 1982, and 1997). Those don't appear to be the years with extreme early ice off in figure 5; what about the other extremely early dates? If you want to include an examination of extreme events I would suggest you pick several geographically different grid cells to compare and do a more thorough examination.

Minor wording issue here that jumped out and reads as if you are saying intermittent ice cover extends into the arctic and explains the low RMSE in that latitude range. Line 249-250 – explanation of lowest RMSE.

"…between 50 and 65° latitude which reflects the higher density of lakes in northern latitudes and highest abundance of lakes currently experiencing intermittent ice cover (Sharma et al., 2019)." Is this mis-cited? Or referring to a specific geographic region perhaps? 50-65 latitude in North America covers Lake Winnipeg, Lake Athabasca, Great Slave Lake. That latitude range covers the low Arctic as well where there is most definitely not intermittent ice cover. And how does intermittent ice cover tend towards the low RMSE you are explaining here? The high abundance of lakes in that region does make sense though. Perhaps revise that sentence to remove the inference of intermittent ice cover resulting in low RMSE values, or revise to better explain why it does affect them. It's unclear as written.