Comment on gmd-2021-440
Anonymous Referee #1

Referee comment on "Climate Projections over the Great Lakes Region: Using Two-way Coupling of a Regional Climate Model with a 3-D Lake Model" by Pengfei Xue et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-440-RC1, 2022

The paper presents climate projections of the Great Lakes region based on a regional climate model (GLARM) coupled with an ocean model (FVCOM) applied to the Great lakes. Climate projections derived from 3 ESMs and for two RCP scenarios have been used. The predictions for the mid and late 21st century are discussed. The results show the increased lake surface temperature and reduced ice cover at annual and seasonal scales with strongest changes over the Lake Superior.

Overall comments:

The paper is interesting and well written. The results are reasonable and well discussed. My main concern is the use of an ocean model to simulate the lake processes and the fact that the processes which are represented are not really described. It seems that only the energy transfers are represented and that there are no coupling with the surface model hydrology. I would like to know how the water volume of the lake is constrained, are they some glaciers melting water and lateral runoff inputs, water table exchanges? how these contributions are impacted by climate warming? And how can they modify lake temperatures in addition to the direct exchanges with the atmosphere?

Specific comments:

- Equation 1, P7: I am not familiar with these scores, is there a justification to have this form of combination of the metrics? I am wondering if the exponent should be 1/(m+n) instead of 1/(mxn)? Is there a reference to this equation that could be added?

- P12, Table 2, REA is not defined, how did you combined the 3 statistical metrics?

- P14, line 263, evaporation and latent heat flux are the same variable (in different units) please modify your sentence.

- Figure 4: it would be more clear to map the differences mod/obs in the right column

- Figure 5: the names of the lakes need to be added on the plots,

- Figure 6: the legend is not clear, is it annual mean of the differences that are plotted, what about seasonal variations?
- Figure 9: Total precipitation changes are plotted, how is it shared between rainfall and snowfall? How rainfall is treated when it falls over the lake? Can it freeze/melt when the lake is ice covered?

- Figure 13 and text related: do you have explanations concerning the lower warming of the Erie lake? The lake is the shallowest, it should be more impacted by the atmosphere warming, did I miss something?