Geosci. Model Dev. Discuss., referee comment RC2
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Comment on gmd-2022-9

Anonymous Referee #2

Referee comment on "Thermal modeling of three lakes within the continuous permafrost zone in Alaska using the LAKE 2.0 model" by Jason A. Clark et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-9-RC2, 2022

Modeling of lake thermodynamics in polar regions is a highly relevant topic with regard to the response of the Arctic permafrost to the global change. The model LAKE has been intensively applied in recent studies on lake dynamics and air-lake interaction. Therefore, a study on the LAKE model abilities to simulate thermal properties of lakes in the permafrost zone falls into the scope of the GMD and is of interest for its readership. Comparison of the model performance for three Arctic lakes of different morphometry provides a necessary background for future analysis of the atmosphere-lake-permafrost interaction. Herewith, the study is a valuable contribution to modeling of lakes as components of the climate system. The methods, presentation of results, and discussion are generally adequate to the problem statement, however contain some gaps, related, in particular, to the effects of the spatial and temporal resolution on the modeling results and to the simulation of the water-sediment interaction as a crucial aspect of lake modeling in the permafrost zone. I recommend extending the study with relevant details providing the reader with a necessary overview of the model performance beyond the sensitivity to variations in the input forcing, which is currently the major focus of the manuscript.

As it was pointed out by the previous reviewer, the model validation is presented in a rather qualitative way, and some numerical scores of the model performance, like bias, absolute error, RMSE etc., will be useful here.

The temporal resolution of the model input was different for three different lakes: 1 day for one of them and 1 hour for the two others. It is unclear how the diurnal cycle of the atmospheric forcing and radiation was treated in the model. Were the daily data interpolated on sub-diurnal scales? If yes, how the interpolation was performed? How does the neglect of the sub-daily variations in the input data affect the model output? The question could be answered by comparison of model runs with daily and hourly inputs for the lakes where sub-diurnal data on forcing are available.

The vertical resolution for both water column and sediment was set to 1 meter and did not vary between lakes. What were the criteria for the choice of the resolution? One can assume that for the vertical diffusion rates within the sediment of 10^{-6} m^2 s^{-1}, the vertical resolution of 1 m will capture the processes with typical time scales of >10 days. Is it sufficient? How many vertical grid points did Fox Den have, whose depth is 1.5 m? Can you perform sensitivity runs demonstrating the effect of the vertical resolution on the model output?

L316, Section 5.4 The details on the sediment layer modeling results are crucial for discussion on the model applicability to permafrost lakes. The information is missing in the ms. How did the soil temperatures under the lake bottom vary during the modeling period? What are the values of the bottom heat flux and how do they depend on the model configuration, initial and boundary conditions?

Some minor remarks:

“It is a large lake (2,732,050 m2)...” why 2 km^2 area is large for a lake?

“ 30 cm and 250 cm” better use meters here for consistency.

In Fox Den the model calculated up to 1.0 m thick ice cover in a 1.5 m deep lake. Was the water volume/depth adjusted during the ice-covered period? Was 1 m vertical resolution sufficient for simulation?

L286: “The “dips” of water temperature in the LAKE model results for Toolik lake…” How did the vertical model resolution affect the representation of free convection? The 1 m resolution seems to be crude for the typical values of the convective layer entrainment rates of < 1 m/day (e.g. Kirillin et al. 2012).