Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2022-9

Anonymous Referee #1

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-RC1, 2022

This manuscript investigates the LAKE 2.0 model performance regarding the simulation of the seasonal cycle temperature in three Arctic lakes (Northern Alaska). Its relevance and main motivation is to improve the ability to model changes in Arctic lakes heat balance and the thermal effect over the permafrost, due to climate change. I think the topic is important for lake model´s development, numerical climate modeling and for limnology, as the number of modeling studies and available meteorological datasets for this region is quite scarce. The study showed that the LAKE model can be successfully considered for modeling the thermal regime of Arctic lakes. Additionally, a sensitivity analysis revealed that the model was not very sensible to the climate scenarios considered in this study. Results also show that snow depth and lake ice can have an important role in the heat storage by lakes. The manuscript is well written and easy to follow. I recommend the publication of this manuscript after the following comments are addressed.

Major comments:

I have some issues with the study. Firstly, I think that the model baseline simulations were not correctly validated. I can´t fully evaluate the model performance, and/or compare the model results with other model simulations (e.g. Guo et al., 2021, modeled Toolik lake) without a model evaluation metric such as: mean absolute error (MAE) or root mean square error (RMSE). Furthermore, I don´t understand how the model was calibrated. What function were you trying to minimize in order to optimize the model performance?

Secondly, why didn´t you show the lakes sediment temperature obtained with the model as a function of water temperature? This kind of data is quite relevant for other researchers.

Specific comments:

L25: I think that the word ”completes” is very strong.

L26-L29: This sentence is unclear to me. You say that the model “is not highly sensitive to the weather data perturbations”, and you conclude that “snow depth and lake ice strongly affect water temperatures during the frozen season”?

L31: I suggest the following change to this sentence: “Approximately forty percent…”

L70: **Description of the model:** I think that you need to improve the model description, namely, the multilayer snow and ice modules (Stepanenko and Lykossov, 2005; Stepanenko et al., 2011).

L85: **LAKE model setup:** Please describe the calibration procedure. Which parameters were calibrated in which ranges? Was calibration automatic? Please describe the parameters of the baseline simulation. The table 1 included in Stepanenko et al. (2016) is a very good example.

L94: **Input data**: Please describe all meteorological variables. How did you characterize the inflow water temperature to lake Toolik? Please describe the initial water temperature and sediments values, before and after the 10 years simulation.

L140: Please replace Wm^{-1} with Wm^{-2}.

L150: Do you have lake water level values? Do you think that neglecting the lake water level may lead to errors in surface heat flux predictions?

L156: I suggest adding a new section, “Evaluation metrics” for the “new” evaluation metrics (e.g. RMSE). The Z-score equation can also be included here. You don’t need to apply the “new” metrics to the sensitivity analysis.

L169: “During the frozen season, the modeled temperatures underestimate cooling in the lake.” By how much?

L189-190: “For 2013 and 2014 the modeled shallow (0, 3 m) water temperature was overestimated while for 2015 and 2016 shallow water temperature was underestimated, though it tracked observed temperature.” By how much?

L192: I can´t see the step-like dip in figures B1 and B2 can this fact be related with inflow water temperature?

L200: The datasets length (x values) shown in figures 3 and 4 is smaller than the datasets length shown in figures B1 and B2.

L210: “shallow depth water temperatures (1, 3, and 5 m 210 depth, -0.13 to 0.34)”. I can´t find the value -0.13 in Figure 5.

L246: “Modeled shallow water (1 m) temperature exceeded the observed temperatures” After the incorporation of inflows/outflows, the water temperature (1 m) in 2013 and 2014, still exceeds observed water temperatures. This kind of analysis would be easier with a model evaluation metric.

L270: I think that this entire section “Modeling Lake thermal effects in permafrost” must be in the introduction.

L286: “The “dips” of water temperature in LAKE model results for Toolik lake down to depths of 10 m prior to ice-off can be explained”. I can see the dip at 19 m (Figure 4, 2014-07).

L287: “can be explained by convective instability under the ice, where this instability can be caused by the under-ice penetration of solar radiation” As I said previously, I can´t see the “dips” in figures B1 and B2. Can this be related with the effect of lake inflow?

References:

Guo, M., Zhuang, Q., Yao, H., Golub, M., Leung, L. R., Pierson, D., and Tan, Z.: Validation and Sensitivity Analysis of a 1-D Lake Model Across Global Lakes, Journal of Geophysical Research: Atmospheres, 126, https://doi.org/10.1029/2020JD033417, 2021.

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Stepanenko, V. M., Machul'skaya, E. E., Glagolev, M. V., and Lykossov, V. N.: Numerical modeling of methane emissions from lakes in the permafrost zone, Izvestiya, Atmos. Ocean. Phys., 47, 252–264, doi:10.1134/S0001433811020113, 2011.

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