

Geosci. Model Dev. Discuss., referee comment RC1  
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## **Comment on gmd-2021-432**

Anonymous Referee #1

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Referee comment on "Modeling subgrid lake energy balance in ORCHIDEE terrestrial scheme using the FLake lake model" by Anthony Bernus and Catherine Ottlé, Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-432-RC1>, 2022

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Modeling subgrid lake energy balance in ORCHIDEE terrestrial scheme using the FLake lake model by Bernus and Ottlé, 2022.

This article describes the implementation of the FLake lake model in ORCHIDEE. A subgrid approach has been adopted to represent lakes of different depths in the same model mesh. This ORCHIDEE-FLake coupling was evaluated with long offline simulations using reanalyses at resolutions of about 25 to 50 km. Thus, surface temperature and ice phenology have been evaluated on a thousand lakes. It is shown that the variability of atmospheric forcing has a strong impact on the dispersion of the results. Moreover, the tile approach for lakes of different depths has a significant effect on the ice formation date compared to a simulation where this subgrid approach is not activated. The impact of the lake tiling on the surface temperature is not significant.

This article describes a work to improve the representation of the surface and its processes by implementing a lake module. The work is based on work already done in other models and brings a novelty with the subgrid representation of lakes. This work can be tested in the LMDZ climate model and will undoubtedly help to explain or even reduce some of the temperature biases in high latitudes.

The article is well structured and clearly shows the contribution of the subgrid approach adopted to represent the lakes in this multi-tile system. However, some parts need to be clarified and my major comments concern the quality of the figures which is not sufficient for some of them and therefore deserves to be improved for a better reading of the manuscript. Data availability is not described.

Major comments:

The figures need to be improved. In particular, the units of the plotted fields are often missing (Fig. 2,3,4,5,7,8,10). For some of them the size is too small for a correct reading.

P11: Figure 2 is not satisfactory. Reading in landscape mode is not comfortable for the reader. A portrait orientation would be better. Also, the legend is wrong. Then add a, b, c, d to each of the panels and refer to them in the legend and in the discussion. The size of the thumbnails makes it almost impossible to read them: in my opinion we can remove the first map which lists all the lakes (depths from 1 to 500m) and be satisfied with the 3 classes, then choose the portrait mode and put 6 maps on the vertical: depth 1, fraction 1, depth 2, fraction 2...

P14: the figure 3 deserves to be improved. Units are missing on the longitudinal and latitudinal mean graphs. On the top right graph, 0, -10 and -20 appear: why this "-" sign? The legend is reversed (colors).

P19, L405-409: the errors cannot be read easily from figure 7, especially for small errors. A table containing the errors with in x the depths between 0 and 10m every 2m then between 10 and 20m every 5m and finally every 10m up to 50m, and in y the cumulative density function for 95, 90, 85, 80 and 50% the values of the errors as a function, would help in reading figure 7.

p25: figure 10 is difficult to read because it is too small, and the maps are presented in landscape mode, which does not facilitate reading. You have to enlarge each thumbnail (you have to zoom in +400% to see something, and some readers still use the paper format to read the articles). Also, the units are missing on the color bars.

The data availability is mandatory in many journals and GMD attaches great importance to this aspect. In this manuscript, this section is missing and should be added.

Minor comments:

P3, L60: MacKay's model did not participate in the LakeMIP intercomparison exercise.

P3, L74: MLake was not developed in SURFEX but in the SURFEX environment to allow for water exchange between lakes, rivers and land surfaces

P5, L127: the different forcing are presented and later it is said that their variability is large and that they have a strong impact in particular on the surface temperature. To

clarify this point it would be good to show how the forcing differ: for example, by showing average annual cycles of air temperature, radiation...

P5, L140: the methodology is not explicitly presented under this link. Please give more details on the methodology.

P6, L163: missing precipitation forcing that play a primary role when the snow module is activated.

P7, L178: the snow depth is calculated through an evolution equation that considers the snow precipitation rate in the time step.

P9, L236: "time split": how is this effect implemented in the coupled model? Is it in FLake, in the ORCHIDEE driver, or in a call interface to FLake? Please give details on this aspect, maybe proposing an appendix that describes it if it is justified.

P10, L255: the permanent water surfaces come from ESA-CCI? If so, please specify.

P12, L276: The Caspian Sea is treated as a lake: what motivated this choice?

P15, A329: the comparisons presented in this section refer to the year 2012 with no reason given. How does 2012 compare to other years? Do we see the same annual cycles? How do they differ? The results would have been more robust if Figure 4 had presented the results of the average annual cycle calculated over 2000-2016 as for 4.2.

P15, 341: there are no continuous observations on Lake VICTORIA: any explanation? Is this the case for other years between 2000 and 2016 and how does it affect the statistical results?

P16, L359: it would be interesting to add a comment on Baikal which is not frozen until mid-December while the model has a very cold temperature and therefore a strong negative bias.

P16, L364: the decomposition of the RMSE into SB, SDDS and LCS should be better highlighted in the appendix. What is the relationship between the 3 and how to interpret them should be added?

P16, L365: comparison to the ensemble mean is not clear: what I understand is that each point is the RMSE (e.g.) calculated for each forcing for the 1000 selected lakes. But the ensemble mean is the average of the RMSEs of the 5 simulations, right? It should be clarified in the text. The units on the y-axis should be added.

P16, A375-378: the explanation is not clear: what shows that LCS and SB explain 50% of the bias? The reader should be guided.

P16, L381: "the bias is mostly positive": this conclusion is not obvious when reading figure 5: the signed bias varies from -1 to +1 and on the right it is  $SB^2$  which is plotted, thus positive.

P19, L390: Why does the E2OFD forcing have better scores than the others? Which component of the forcing plays the most?

P19, L403: it is more a histogram than a PDF for which the sum of the values is 1.

P23, L432: CRJ and CRJ3med do not analyze water budgets, but rather surface energy balances (latent heat flux is an energy flux).

P27, L495: "used in this process": to be reworded to clarify the point

P27, L512: and so do LWST and ice phenology

P29: add the link between RMSE and the other components discussed in the manuscript; the superscript "F" appears in the LCS formulation and has not been defined

Technical comments:

P3, L62: models instead of Models

P5, L118: the ARC-Lake database

P5, L120: extra parenthesis after 0.7 K; bias instead of biase; "for day" and "for night" could be replaced by "during daytime" and "at night"

P5, L132: a space is missing before WFDEI

P7, L185: units should be homogenized throughout the manuscript (degrees Kelvin and not Celsius, superscript notation, italics...)

P10, L263: use etc. or ... but not etc...

P12, L279: FLake instead of Flake

P12, L298: CNC3med appears twice.

P14, A324: put a "-" sign in front of 11 days

P15, L331: eight instead of height

P15, L334: year instead of Year

P16, L362: corresponding instead of correct?

P16, A369: extra parenthesis before between; 3.16 and 2.82 shall be followed by K

P19, L384: missing units for RMSE

P19, L402: median depth

P23, L453: 30°N

P23, L459 Lake Superior

P27, L495: techniques instead of technics