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## Reply on RC3

Anthony Bernus and Catherine Ottlé

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Author 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-AC3>, 2022

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Modeling subgrid lake energy balance in ORCHIDEE terrestrial scheme using the FLake lake model by Bernus Anthony and Ottlé Catherine. This study presents new prognostic lake parametrizations in the ORCHIDEE surface modelling system within the global IPSL earth system model. Parametrizations of in-lake variables are based on Freshwater Lake (FLake model). Simulated lake water temperatures and ice phenology are compared against global observational data sets. The resolution of the atmospheric forcing, that is derived from various reanalyses, is shown to play important role for the simulated lake surface energy balance. It was found that lakes generally freeze earlier and melt later in the model than according to the observations. Uncertainties in modelling of freezing and melting of lake ice are discussed. Seasonal LWST distribution was found to be realistic in the majority of lakes studied. The manuscript reports results of extensive modelling and intercomparison work in a systematic way. The results mostly confirm earlier findings reported in literature during the last more than ten years. The authors are well aware of the previous studies related to the implementation of FLake parametrizations into different NWP and climate models and build their system taking this experience into account. An idea of treating lakes of different depth using prescribed separate subgrid tiles is suggested. The essential things are presented and discussed, valid methods used and the results seem reliable. Use of external data sets is well documented and references given.

A problem of the study may be that it covers too much areas, topics, data, models in the global scale and tries to reach conclusions on everything.

Would it be possible to discuss shortly the specifics of lakes in a global land-surface models v.s. high-resolution regional weather models?

Response: We would like first to thank the reviewer for his/her constructive comments. We have revised our manuscript following your suggestions.

Concerning your comment on the need to focus on specific lakes, we would like to note that our purpose is the development of a lake modeling at global scale in a land surface module included in a global earth system model. Therefore, we focused the evaluation at a global scale. At the scale of the model grid (typically  $0.5^\circ$ ) few lakes can be explicitly represented and most of them are aggregated in a generic lake tile with effective

parameters resulting from the aggregation. In the evaluation also, we focused on the variables that matter for the ESM energy budget, therefore lake surface temperature and energy fluxes as well as freezing states. Compared to high resolution models that require a better spatial discretization to model precisely the lake-atmosphere interactions on the atmosphere dynamics, for example the regional lake impacts on the energy and humidity horizontal and vertical advection, that are crucial to model and predict the regional weather and climate. Here at such large scale, the vertical processes are more important and it is crucial to correctly represent the temperature and humidity vertical gradients.

We highlighted this point in the introduction section, see lines 52-56.

FLake has been applied in both, quite a lot of reports exist in the literature about the NWP-model side results. Unfortunately the manuscript leaves a somewhat raw impression. It is not always easy to follow the reasoning of the authors, clarifications would be needed in several places. It would be good for the authors to go carefully through the whole text in order to improve the presentation, correct typos and English language mistakes. Some comments are given below in the specific remarks.

Response: the manuscript has been thoroughly revised following all the comments and suggestions of reviewers, all the figures were redone, and we have tried to clarify all the unclear sentences/sections highlighted by the reviewers.

Specific remarks

Abstract

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- 13-14 Which one of CRUJRA or ERA5 has smaller RMSE error ("best and worst")? c.f. l. 369-370.

Response: ERA5 presents the smallest errors. We have revised the sentence to make it more clear.

- Data and modelling framework
- 92 Please define PFTs here when using the acronym the first time

Response: "PFTs" stands for "Plant Functional Types (PFTs)", we have defined it here.

- 97- Could you please comment the use and differences between HydroLakes and Global Lake Data Base (GLDB), which is the native lake depth data base for FLake.

Response: Kourzeneva et al., 2010 developed GLDB for ECOCLIMAP context. Since we don't use the ECOCLIMAP land cover maps, and more over use the Hydrosheds data for river network definition, it was more convenient for us to use Hydrolakes.

- 142-243. The last sentence is unclear, please clarify.

"In brief, the interpolation of the meteorological variables is done linearly except for the solar radiation where the interpolation between two times, follows the typical daily evolution according to the solar zenithal angle. It should be noted that no extra atmospheric fields are needed to solve the energy balance at the lake – atmosphere

interface, same as what is done for the vegetation part.” □ ?????????

Response: we wanted to say that the same atmospheric variables are driving the energy balance on the vegetation and on the lake areas within the grid cell. The sentence was clarified in the revised version, a reference was added also. see lines 147 - 150.

- 180 Please tell how the surface extent is used in FLake within the ORCHIDEE grid.

Response: The lake surface extent is used in to estimate the lake fraction within the ORCHIDEE grid cell and also to estimate the fetch parameter, but this is done in a preprocessing phase. It is no more needed to run the model, therefore, we have modified this sentence, the average depth and radiative parameters of the lake tile are the only input parameters of FLake in our configuration.

- ORCHIDEE-FLake coupling developments
- 204 typo: parametrized

Response: It has been corrected

- 276 Lake Baikal (i, not the French double i)

Response: It has been corrected at each occurrence

- 282-283 Please clarify the circular shape

Response: The fetch parameter has been calculated for each lake of the tile according to its surface extent, assuming that all lakes have a circular pattern. The fetch tile value was assessed by averaging all the individual values weighted by their surface extent.

Therefore, we changed the sentence : “Considering a circular pattern for the lake shape” into: “Assuming a circular pattern, the fetch was set to the diameter of a circle of equivalent surface, and the effective fetch of the tile was derived from the aggregation of the fetch values of all the lakes falling in the lake tile considered (mean average).”

- 288 What exactly means configuration without lakes - what kind of surface was assumed instead of lakes?

Response: In the ORCHIDEE standard version, water surfaces are treated as bare soils (this was explained in section 2.1.1). Wwe added to specify “(i.e. considered as bare soil)”

- 291-92 What means 20 years of spin-up? Since 1980?

Response: To equilibrate the model prognostic variables, we run ORCHIDEE for a number of successive years before being able to get reliable simulations. In our case, we started the simulations on year 1979 which is the first year available in some of the forcings, and analyze the simulations from the year 2000. We have modified the sentence to be more clear and precise.

- 294 How many characters? Four or perhaps 3-5?

Response: Sorry, we meant 3-5 letters for the way of depth aggregation. It has been changed in the text.

- Results

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- 321 How did you derive SOF and EOF from the model simulation results? Based on simulated ice thickness, LWST? Please specify.

Response: Ice on/off dates were derived from the surface temperature simulated time series. We have specified it in the revision and discussed it more deeply in the manuscript, since this choice may explain part of the errors.

- 331 typo eight (not height)

Response: "h" has been removed

- 339 mistake: variations ... are

Response: corrected

- 361-362. Please clarify the first sentence. What means correct depth class tile here?

Response: we meant the tile in which the lake falls in. We have corrected the sentence to be more clear.

- Discussion and conclusions
- 493-496 Is this an attempt to evaluate the reanalysis results?

Response: No, comparison and evaluation of reanalysis datasets have been the subject of numerous studies and papers and in our case, we can not say that better agreement of our lake temperatures with observations is explained by the better quality of some of the forcings. By comparing various atmospheric datasets, we expected to separate model errors from forcing errors and identify systematic biases. This is what is discussed in the next paragraph, and this sentence was slightly modified in the revised version.

Perhaps it would be better to refer to their own considerations instead of suggesting simplified interpretations.

Response: We are not sure to understand if this comment is the rest of the previous sentence or another comment referring to another part of the discussion? Anyway, the discussion and conclusion parts have been thoroughly revised and we don't think that we are suggesting simplified interpretations. Sorry if we missed something.