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Discussions

Interactive comment on "Multimodel simulation of vertical gas transfer in a temperate lake" *by* Sofya Guseva et al.

Anonymous Referee #1

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The study continues a series of previously published lake model intercomparison efforts by extending those on modeling of dissolved oxygen and carbon dioxide in lakes. Five models are used in the comparison, whereas only two of them simulate the oxygen and CO_2 regimes directly. Three others are confined to modeling of the thermal stratification and ice regime, considered here apparently as "potential candidates" for their extension on biogeochemical processes. As such, the approach is legitime, since the correct simulation of the seasonal thermal stratification and ice duration is the key prerequisite for adequate modeling of the dissolved gases transport between their major sources and sinks at the surface and the bottom of a lake.

Concerns arise however about the way one of the models—FLake—was treated in the study. The authors correctly state in the description of the model experiments that

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Discussion paper

FLake “stands aside from the other 1-D models due to the . . . bulk-structure which employs the concept of <temperature profile> self-similarity. . . ”. This high level of parameterization ensures computational efficiency of the model, which was primarily designed for prediction of surface temperatures in global/regional climate models and numerical weather prediction (NWP). On the other hand, the model parameterizations put some constraints on the model application to real lakes. One crucially important feature of FLake is that the model equations are derived in the assumption of preserving the heat capacity or *volume of the lake*. In this regard, the “baseline” configuration applied in this study with the maximum lake depth as model input is inappropriate for FLake and would produce a priori incorrect results. Another issue of the parameterized model refers to correct choice of the few “shape factor” parameters determining the stratification pattern. The latter is not resolved in FLake numerically, but parameterized via few “shape factor”-constants related to the spatial integrals over the stratified layer. Several recent publications, including co-authorship of one of the authors of the present study, (Shatwell et al., 2016; Kirillin et al., 2017; Shatwell et al., 2019; Su et al., 2019) discussed the appropriate choice of the shape factor constants in FLake and have demonstrated that the set of constants used in the NWP-version of the model should be amended if the vertical thermal structure is in question apart from the lake surface temperatures. In particular, the unrealistically weak deep stratification and the corresponding high depth of the surface mixed layer, as reported in the present study, are the results of applying the NWP-constants together with the maximum lake depth as the model lake depth.

Hence, the FLake-outcomes discussed here are useless or even misleading for the potential FLake-users.

I see two ways of possible modification of the study: (i) excluding FLake from the study completely, confining the set of tested models to four models; (ii) re-designing the FLake-experiments in the corrected way with corresponding changes in the results/discussion.

Regarding the biogeochemical part, the study would benefit from an extension of the discussion on possible ways of improving the representation of biogeochemistry, in particular, the deep oxygen (chlorophyll) maximum in oligotrophic lakes, and the vertical distribution of carbon dioxide across the water column.

Note also that the temperature profile within the ice cover in FLake is not assumed to be linear, but parameterized via a time-varying shape-function with a linear asymptotic.

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