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# *Interactive comment on* "Simulating Lake Tanganyika's hydrodynamics under a changing climate" *by* Kevin Sterckx et al.

**Anonymous Referee #1**

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GENERAL COMMENTS: This manuscript discusses the warming of Lake Tanganyika with future climate change as per the RCP8.5 scenario, as assessed through 3D numerical simulations. Though both the topic and the study case are of high relevance, this manuscript provides a too small contribution to be published on its own. As a matter of fact, despite the use of a 3D model, the study of "lake hydrodynamics", as introduced in the title, is reduced to only epilimnetic temperature variations, mostly addressing the surface only, without any detail on water circulations. Temperature variations in the hypolimnion are neglected: while they are increasingly slow with increasing depth, they nevertheless do occur. The study should have dealt with the growing inertia of deep waters through proper long-term simulations of thermal structure evolution, especially given the exceptional depth of Lake Tanganyika. Furthermore, while SLIM 3D works



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great for assessing present day hydrodynamics as regards both the stratification dynamics and circulations, I have several concerns as regards its application to climate change studies, due to its incomplete modelling of lake surface heat budget. The comparison of SLIM 3D with the 1D model FLake is not correctly developed, as explained in the specific comments below. The manuscript also implicitly relies too much on the Delandmeter et al. (2017) paper: no details about the model are given herein, which puzzles the general reader. The most relevant ones, e.g. mesh resolution, should at least be provided. Methods are not clearly explained and I have some concerns over the results, some model blemishes being overly evident. The Introduction and the very small Discussion sections lack an actual insight and a comparison against the wide literature available on lake warming with climate change and the related modelling efforts. The organisation of the paper is poor and makes me think that it is an incomplete rearrangement of a M.Sc. thesis. Several language errors are also present. Because of these general reasons, in addition to the specific comments below, I must suggest the rejection of the manuscript by the journal. I hope my comments would stimulate the Authors to expand and review their work and try to publish it again soon.

SPECIFIC COMMENTS: L. 54: What is the meaning of the expression “more anoxic”? It does not make sense. L59. The expression “rotate upwards” should be replaced with something more technical. L60-65. This whole passage is unclear. L73-76. If a paper follows a standard structure, there is no need to present a recap of its content. L101-106. This whole passage is contradictory. Which is the trophic state of the lake? What is the anthropogenic influence on it? It is not clear. L130-131. Wind accelerates also because the drag coefficient of water is much lower than that of land cover. L131-135. This discussion on the Froude number of wind is unclear. L146-148. This sentence is in contradiction with those above, in which it is stated that the Lake Tanganyika area experiences a single rainfall season. L154. What is the meaning of “poor vegetation conditions”? L169-174. This whole passage is unclear. L193-195. This passage is unclear. Which part of the heat budget at the surface simulated by the model? Which part is neglected? What is the relaxation term? What is the “certain period” for which heat

is retained into the lake and then released? L232-240. Given what is stated in the paper, SLIM 3D and FLake are not proper models to hold a comparison between 1D and 3D lake models, as they neglect different relevant phenomena: SLIM 3D does not consider the full heat budget at the water surface interface, while FLake does not consider temperature variations within the epilimnion. L241-245. I do not understand this whole section. ARC Lake is never mentioned before in the paper and its use is not clearly explained here. L246-254. Given that climate change is an ongoing process and that the thermal structure of deep meromictic lakes presents a thermal inertia in the scale of years up to centuries, why didn't you perform a single simulation of the 1980-2099 time span? That way, you would have been able to properly simulate the response of Lake Tanganyika to climate evolution, including temperature dynamics within the hypolimnion. Simulating separate time spans may be acceptable for lakes which display annual mixing, but it is strongly elusive for a meromictic basin. L260-261. A 1D model is supposed to give a horizontally averaged estimation of water temperature. How does the FLake simulation compare against the horizontally averaged observed surface water temperature from ARC Lake? L268-271. This comparison does not make sense, as the two models produce different outputs and the 1D one cannot reproduce horizontal surface temperature variations by definition. The two models should be compared over a common basis, i.e. over horizontally averaged temperature. L272-276. This whole passage is unclear. L279-281. This does not make sense. See the comments above. L281-282. I would say that for a lake of the size of Lake Tanganyika, the possibility of introducing spatially heterogeneous boundary conditions in the 3D model plays a larger part than 3D circulations on reproducing spatial heterogeneity, especially if only surface temperature is accounted. Moreover, which boundary conditions were used to drive the 1D model? Were atmospheric boundary conditions averaged over the lake surface or were data at the lake deepest point considered? L288-290. What kind of instabilities are the authors referring to? It is not clear in the sentence. Figs. 4 and 5. Such large numerical instabilities (as in Fig. 4a) cannot be presented in a journal paper. The Authors should identify the causes and address them. I see that the bathy-





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metrical profile of the shores is roughly sketched through large steps. Does this affect calculations? By the way, what is the resolution of the numerical mesh of the SLIM 3D model? It is not specified in the paper. Wasn't a better bathymetry available? Most importantly, where are the cross sections placed? L301-302. Why should the centre of the lake be the location of maximum turbulence? It is not clear. L310-313. Such information should be conveyed within the Methods, not in the Results. L313-314. A basic investigation should be performed to understand such issue. L314-316. This sentence is puzzling. Do the Authors imply that climate change has negligible effect on lake surface temperatures? Fig. 6. What is the reason behind the sparse blue points? I suspect there is an error of some sort in data processing or in model results. L320-321. How is the spatial IQR calculated? Which data are used to determine the distribution of results? At which time? Fig. 11. What is the reason behind the sparse green points? See the comment above. L352-353. This sentence is not clear. Figs. 14 and 16 Why do numerical instabilities always arise in January? See the comment above. L382. Which kind of additional validation was performed in this work which confirms that the model can be used for climate change projections? L399-400. How is this possible? ARC Lake provided observations of surface temperature only. L402-404. This sentence misses a verb.

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