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Geoscientific Model Development Discussions

Interactive comment on "Numerical study of the seasonal thermal and gas regimes of the large artificial reservoir in Western Europe using LAKE2.0 model" *by* Maksim Iakunin et al.

Anonymous Referee #2

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General comments

It is useful that this paper presents a model comparison that focuses on the factors that would be most important in influencing the heat and gas fluxes from a lake. It was good to see model comparisons focusing on the mixed layer. However, there is a need to clearly state the criteria used to define the mixed layer. I was pleased to see the specific comparison of measured heat fluxes and gas fluxes collected at high resolution with simulated data from two models. This not commonly done and is a unique and valuable aspect of this paper. And for these reasons I think this paper does document important progress in lake model development and does deserve to be accepted for publication

following revision.

I think for a modeling study such as this there is a need for more information on calibration. How the model was calibrated and what the final error levels were. It doesn't need to be extensive but as a minimum I would like to see a listing of the final calibrated parameter values, as well as a brief description of what each parameter does. A scatter plot of the simulated vs measured temperature. And some statistics on model fit (ie RMSE , MAE etc) Furthermore, I'm assuming that the model was calibrated against measurements of water temperature, but this may not entirely be the case since there were measurements of gas concentrations and heat fluxes that could in theory also be used for calibration. What was used for calibration should be clearly stated.

One of the most important aspects of this paper is the comparison between the simulated gas fluxes with measured data. Therefore, I do think there is a need to better describe the equations governing CO2 and O2 concentrations. I was not that familiar with Lake 2.0 but after searching a bit I found that this is not the first time CO2 and O2 have been simulated with Lake 2.0, even though this paper may be one of the best verification studies. I would like to see some overview description of the main processes affecting the CO2 and O2 concentrations and also more clear references to the original publications where the equations describing these processes are completely defined

There were two things that were changed in the version of the model used in this study (the fixed pH value and the equations affecting diffusion in the hypolimnion) and also one assumption (fixed chlorophyll concentration) which I suspect and which later in the paper the authors also suspect leads to errors in the simulated oxygen concentration. I think all three of these should be evaluated in a sensitivity analysis as part of the paper in section 2.4 as was done with the light extinction coefficient.

There are quite a few small language errors in the paper. I have tried to suggest solutions to many in the technical comments. These should not be allowed to take away from the good scientific and technical aspects of this study, so I think it would be

good to have paper carefully proofread for language before the final submission

Specific comments

Abstract - Since you mention the Flake model in the abstract I think you should have a brief statement about how well it worked compared to Lake2.0

Line 40 - what do you mean by “to complete the results”. Does Flake do something that Lake2.0 does not? Or are you comparing the results of the two models

Lines 98-99 I think you could give a bit more information. What type of errors? How much missing information was there? Linear interpolation?

Line 104 Are not these fluxes also occurring through the surface?

Line 105 and unlike Hostetler model I don’t know what you mean by unlike Hostetler model. Are you using this model as well? Or our components of this model embedded in Lake2.0?

Line 141 the description of photosynthesis is rather unusual. Is it really reasonable to assume that chlorophyll remains constant while photosynthesis is changing? Perhaps this simplification can be justified by the fact that the modeling is mainly looking at gas exchange and not the biology of the lake. However, photosynthesis will affect both O2 and CO2. Assuming a constant chlorophyll concentration could greatly under or over estimate the total photosynthesis in the epilimnion. I think there should be more justification for the constant chlorophyll assumption. Perhaps a sensitivity analysis on how changes in chlorophyll affect the gas flux estimates.

Later in lines 150-160 you document a large seasonal variation in the attenuation coefficient. How much of this is due to changes in chlorophyll? Could this variability invalidate the assumption of a constant chlorophyll concentration? Also in this section the model was modified to allow the input of a varying extinction coefficient which is a good idea. However, this could be described more clearly. It is stated that “introduce a new variable,the water extinction coefïňĄcient for photosynthetically active radiation

(PAR), to the model setup” How does this coefficient differ from the coefficients described in line 120. Perhaps you mean that the existing coefficient described in line 120 was changed from a fixed model coefficient to a time varying one? However Im still a little confused since PAR is usually considered to be between 400-700 nm and measured as a photon flux density, whereas I would think that the coefficient described on line 120 would have a wider bandwidth and would be measured in terms of watts

Lines 165-166 need to be made clearer.

Starting at line 177 there are two changes to the model described one concerning pH and the other concerning hypolimnetic diffusivity. Sensitivity analysis should be done for both of these and these results would be better presented in the section starting on line 150

Line 191 this information is better place in the section on observational data (see comment above).

Line 207 Model simulations of the mixed layer depth (MLD) are discussed. The method for defining the MLD should be described in the methods section. Also in figure 4 it would be good to show a plot of the variations in the MLD over time. In the caption of fig 4 describe what the dashed horizontal lines represent.

Line 232 states “water temperature of thermocline beneath the ML at any depth” Don’t you mean water temperature of the hypolimnion?

Line 252 states “Present results show comparable differences between the FLake and the LAKE2.0 models and EC measurements over lakes (Stepanenko et al., 2014; Heiskanen et al., 2015)” To me present studies means the study being described in this paper. Do you mean something like other recent studies?

Lines 255-259 Is it possible to estimate the depth of the horizontal flows from the surface temperature of the inflowing river? It seems like this would be most significant if the inflows are moving through the surface layer.

Line 270 In the second week of May, CO2 probe accidentally dismounted from the platform and remained. - I think you should just remove these data from the plot You clearly do not believe they are meaningful and have a good explanation for this.

Lines 298-299 Chlorophyll concentrations are given in mg/l should these be ug/l (10-6g/l)? The mg/l concentrations that are given are very high and would be considered typical of a highly eutrophic lake. They would also certainly greatly affect the O2 concentration I have the same concern for the values in table 4.

Line 322 You state “Such errors could be due to the sporadic input of measured wind speed, which values change rapidly” First I would suggest sporadic nature rather than input. But I also think this needs more of an explanation Are we talking about errors in both latent and sensible heat? And what is the mechanism by which sporadic winds are increasing model error?

Line 325 You state “On the second year of the experiment (October 2018, when the probe was returned to the platform), simulated CO2 values did not show big errors despite the fact that pH value remained constant during the whole simulation period.” But was not the pH also constant during the first year? Were there larger errors in the first year due to the fixed pH?

Line 334 This final paragraph needs to be reworked First I think you should be stressing that the Lake 2.0 model was shown to accurately simulate the heat fluxs and gas fluxes from the ML. I think this is one of the major model developments being described here. Secondly, I don’t think you should start out by say that Flake is good model – Im sure this is true but it is not the purpose of this paper. You should be stating that Lake 2.0 is as good or better than Flake as you have shown in some of the comparisons in the paper. Finally in terms of using these two models to improve weather predictions you state that Flake has lower computational demands. By why not give some numbers on this? How much slower is Lake 2.0? Is it realistic to think it could be used to support weather prediction in the future?

Technical corrections

Line 1 (Suggested change) The Alqueva reservoir (southeast of Portugal) being the largest artiïňĄcial lake in Western Europe and a strategic freshwater supply in the region. The reservoir is of scientiïňĄc interest and monitored in order to maintaining the quality and quantity of water and evaluate its impact on the regional climate. To support these tasks we conducted numerical studies of the thermal and gas regimes in the lake

(Suggested change)supplemented by the data observed at the weather stations and the ïňĆoating platforms deployed during the ïňĄeld campaign of the ALOP (ALentejo Observation and Prediction System) project. One-dimensional model LAKE2.0 was used for the numerical studies

line 8 this parameterization » this model?

Line 14 particpants » regulators

Line 20 allow to use them » allows them to be used

Line 25 models are important models is important

Line 30 for the lake ecosystem vital activity » regulating lake ecosystem processes

Line 39 allowing to reproduce the concentrations » that simulates the concentrations

Line 43 spelling (hypolimnion) forced with the observed data » forced with the observed meteorological data

Line 49 spreading along 83 km over » spreading over 83 km of of Guadiana » of the Guadiana

Line 51 the capacity of water » the storage capacity of water

Line 59 in favourable position. » into a favourable position. Rainfall seasons normally last from » Seasonal rainfall normally occurs between

Lines 64-65 Geographical and climatological factors make the Alqueva reservoir a vital source of fresh water needed to support the population and economy in the region, while on the other hand, an increasing anthropogenic

Line 71 air columns, over the water-atmosphere interface, and in the shores » air columns, at the water-atmosphere interface, and on the shores

Line 73 4 ïňĆoating platforms » four ïňĆoating platforms

Line 76 was settled on the platform » was deployed on the platform

Line 77 an eddy-covariance system, Campbell ScientiïňĄc Irgason, provides data for atmospheric » an eddy-covariance system, Campbell ScientiïňĄc, provides data of atmospheric

Line 89 and for punctually vertical proïňĄles » and was occasionally used to collect vertical profiles

Line 94 were obtained in automatic regime and transferred » were automatically downloaded and transferred

Line 96 weather stations and conduct measurements, to collect » weather stations, to conduct more detailed measurements, and to collect

Line 125 condition »conditions

Line 126 condition is»conditions are

Line 161 (Suggested change) In addition to LAKE2.0, The FLake model was used to simulate water temperature for the chosen period. FLake model (Mironov,

Line 162 a two-layer representation of the temperature proïňĄle » a two-layer representation of the lake's thermal structure

Line 196 (Suggested change) Water temperature is a crucial factor for Numerical Weather Prediction (NWP) applications, and as a regulator of lake ecosystem activ-

ity, and their ecosystems.

Line 237 its integral energy » the simulated heat content of the entire water column.

Line 245 is capable to calculate » are capable of calculating

Line 246 and the ïňĄgure 7 represents » and ïňĄgure 7 shows.

Line 270 are represented quite good » are represented quite well

Line 292 In November the turnover happens » In November, following turnover

Line 312 Alqueva reservoir with using the LAKE2.0 » Alqueva reservoir using the LAKE2.0

Line 316 correlation coefïňĄcients are 0.99 for both » correlation coefïňĄcients for the relationship between simulated and measured temperature are 0.99 for both

Line 317 FLake shows overestimation about 1.5 » FLake shows an overestimation of about 1.5

Line 318 show the same rate of overestimation » show the same level of overestimation

Line 324 good accordance » good corrospondance.

Line 328 of modernisation of LAKE2.0 » inclusion of a more complete description of the process regulating photosynthesis and respirations in the LAKE2.0 model

Line 329 (Suggested change) Although measured oxygen concentrations are well simulated values of O2 over short time intervals, the annual Alqueva oxygen cycle cannot be reproduced because the model does not respond to changes in algal concentration (underestimation of O2 values) and winter minimum (high overestimation). Winter overestimation is supposedly due to the relatively low water temperatures.

Why above is it supposedly? Are you not sure?

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