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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Future projections of temperature and mixing regime of European temperate lakes" *by* Tom Shatwell et al.

Tom Shatwell et al.

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We thank referee #2 for her/his time and effort and for providing constructive comments.

General comments Comment: Paper addresses relevant scientific questions within the scope of HESS, namely internal physical mechanisms determining the response of lakes to a future warmer climate. It presents new analysis of northern temperate lakes variables in a projected moderate climate warming scenario (Radiative Concentration Pathway 4.5, RCP4.5). In addition, all lakes used in this study have different combination of morphology and mixing regime, yet they all are situated rather close to each other, what makes analysis even more interesting and relevant. Paper reaches sub-

stantial conclusions on lake vertical mixing, ice formation dates and water transparency behaviour according to the projected climate change. Methods and assumptions are valid and rather clearly outlined, the only clarification is needed for light extinction constant for Arendsee. Paper results are sufficient to support the interpretations and conclusions presented. Model experiment description and explanations of result calculation methodology are sufficiently complete and precise to allow their reproduction by fellow scientists (good traceability of results). Also, authors give possibility to download initial data or model output. They give proper credit to related work and clearly indicate their own new/original contribution to the analysis of lake main variables in future warming climate and indicate each authors input. Paper title clearly reflects the contents of the manuscript, abstract provides a concise and complete summary of the research done. Overall presentation of the paper is well structured and clear, language fluent and precise, all mathematical formulae, symbols, abbreviations, and units are correctly defined and used, number and quality of references are appropriate.

Answer: Thank you for the overview and highlighting the strengths of the manuscript. Our response to the extinction coefficient is given below.

Specific comments Comment: 1. p4, l13 - could you add some explanation how constant 2.17 was derived?

Answer: Light extinction (γ) in Müggelsee, Heiligensee, and Stechlinsee was calculated using the Lambert-Beer law from simultaneous light measurements at different depths (generally 0.5 m apart) recorded with spherical sensors (Licor, Nebraska). Using regression, we related light extinction to parallel measurements of Secchi depth using the relationship γ = c / hsecchi (Poole and Atkins, 1929). We determined the constant c to be 2.05$\pm$0.04 (mean $\pm$ s.e, n=300) for Müggelsee, 2.13$\pm$0.10 (n=52) for Heiligensee (Shatwell et al., 2016), and 2.33$\pm$0.08 (n=57) for Stechlinsee. In the absence of direct measurements in Arendsee, light extinction was estimated from Secchi depth measurements as γ = 2.17 / hsecchi, where the constant c = 2.17 was simply the mean of the estimates from the other three lakes.

Comment: 2. p6, l5 - could you specify on the technique used to detect lake variable changes for rather small lakes (lake water surface area vary between 0.3- 7.3 km2) if simulations were performed at a horizontal resolution 0.44_? Or this is only atmospheric forcing resolution?

Answer: This was the resolution of the atmospheric forcing. We will clarify this point in the revision.

Comment: 3. p6, l17 - what period of data was used to empirically determine the value?

Answer: We used the period 1.11.1991 to 24.8.2004. However we mistakenly stated the name of the weather station, which was Menz, not Potsdam.

Comment: 4. p27, Fig.5 - Stechlinsee and Arendsee patterns look very similar, horizontal and vertical grids would help to better see if any difference is present.

Answer: we added gridlines to the plots and slightly expanded the vertical scale (see Fig. 1).

Comment: 5. p28, Fig.6 - mixed layer depth values especially for Stechlinsee and Arendsee are not visible (as well as winter and autumn periods for all 4 lakes), as it was mentioned that there are 58% and 75% respectively that these lakes are ice-free is it possible to show values on the graph (extending y and x axis)? Or an explanation why it shouldn't be done?

Answer: We intentionally chose the scales to focus on the stable summer stratification period. Since weak stratification forms and breaks down regularly in spring, and the mixed layer depth jumps from shallow to deep before the more stable seasonal stratification begins, showing the ensemble mean mixed depth is not meaningful in early spring. Important information here was presented in the form of stratification start and end dates and trends in Fig 7 and Table 3. Thus we decided in this case not to alter the figure as suggested but retain the focus on the stable summer period.

Comment: 6. p30, Fig.8 - could you explain an interesting behaviour pattern of Heiligensee in annual mean temperature graph?

Answer: Our hypothesis for this behavior is: When extinction is very low, not all of the incident radiation is absorbed in the water column in Müggelsee because it is relatively shallow. Here an increase in extinction causes the mean temperature to increase because more radiation is absorbed in the water column. Stechlinsee and Arendsee on the other hand are deep enough that all radiation is absorbed, even at extremely low extinction. Here an increase in extinction causes the mean temperature to decrease because less radiation penetrates to deeper waters. Heiligensee is at the transition, also shifting from polymictic to dimictic with increasing extinction. This is apparently the cause of the interesting behavior, possibly with an interaction with warmer air temperature projected at the end of the century. This explanation will be added to the revised manuscript.

Comment: 7. p32, Table1 - could extra line with ice duration in days be added?

Answer: We added ice duration statistics for the two lakes for which we had ice data (Müggelsee and Stechlinsee - see table in the attached supplement).

Comment: 8. p33, Table2 - some correction with table rows is needed.

Answer: Thanks for the info, this seems to be a formatting issue. The section titles are too long to fit on one line in the narrow column, so the first row of each subsection has 2 lines. If the manuscript is accepted, this problem should disappear during typesetting.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-588/hess-2018-588-AC2-supplement.pdf

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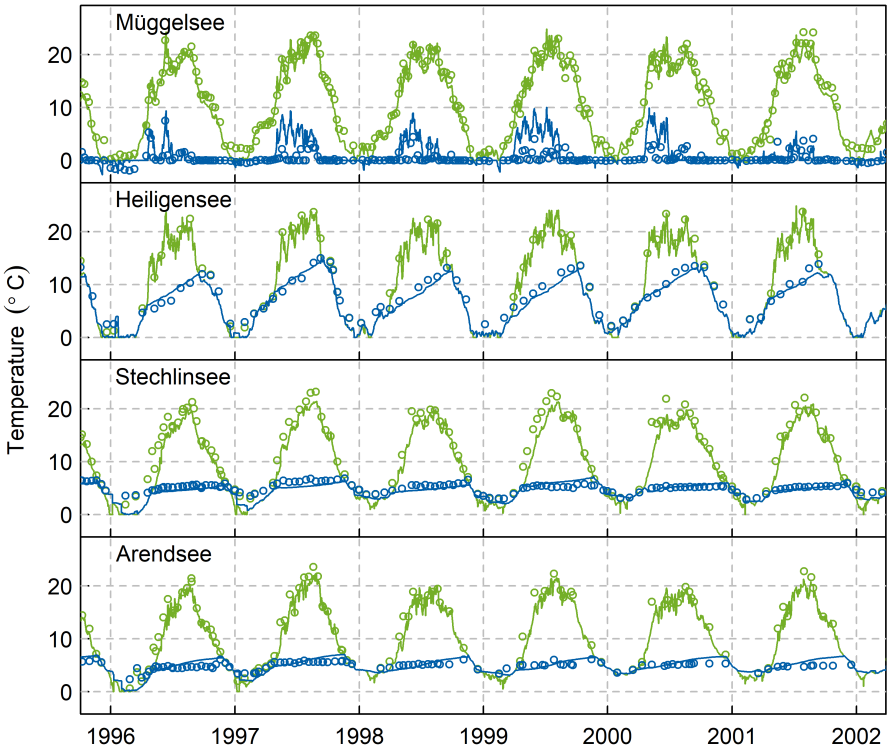

Fig. 1. Revised version of manuscript Fig 5 - validation of the model against measured data in the 4 lakes.