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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Response of water temperatures and stratification to changing climate in three lakes with different morphometry" *by* M. R. Magee and C. H. Wu

Anonymous Referee #2

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The authors use an extensive dataset on water temperatures from three neighboring lakes to test and validate a one-dimensional lake temperature model. The model is subsequently used for reconstruction of the thermal and stratification regime of the lakes during the last century and for sensitivity studies exploring the lake response to changes in mean annuals of air temperature and wind speed. The idea behind the sensitivity experiments is to elucidate the dissimilarity in the response of lakes with different depths and surface areas subject to identical external atmospheric forcing. The problem statement is clear. The methods are generaly relevant to the questions stated in the study (except the application of a 1d time-depth model to investigation of the effects of horizontal extensions on lake thermics, which requires additional justification,

see below). My major concern is the analysis of the results, which looks superficial, and representation of the outcomes, which is lengthy and poorly structured. The analysis is confined to descriptive presentation of model outcomes without an insight into the physical mechanisms producing the observed effects. Verbal presentation of trends in lake thermal characteristics covering several paragraphs is exhausting and not really informative. The manuscript presents a nice set of data and numerical results, which can serve as a basis for a well-thought study, but has liitle value for the reader in its present form. The manuscript requires a more detailed description of the model and discussion on its uncertainties and relevance to the real lake processes; the discussion should be rethought, moving the accent from the descriptive listing of the model responses to varying inputs to the discussion on the physical mechanisms producing thes responses.

Here are some major critical points:

- Effects of lake surface area on the response to the atmospheric forcing are continiously mentioned throughout the manuscript and are among the main subjects of the model sensitivy runs. However, the entire discussion is based on the ouptuts of a one-dimensional model, i.e. none of the physical processes depending on the horizontal dimensions are modeled directly, but *parameterized* in the model. Hence, the response of the model outcomes to varying surface area does not necessarily coincide with the response of real lakes to the same perturbations. To analyze properly the modeling results the authors need to (i) present the deteils on the model parameterizations related to the effects of horizontal advection, wind fetch, horizontally varying depth, and other horizontal processes, such as mixing by internal waves and upwelling of hypolimnetic waters in near-shore areas of the lake; (ii) when discussing the modeling results state clearly which of them can be extrapolated on the real lakes, which horizontal processes are missed by the model, and how it can affect the real situations; (iii) differentiate between the effects produced by incerase of the wind energy input due to larger aurface area from those produced by increase of the thermal inertia due to larger lake volume,

like, in particular, timing of the stratification onset (Section 4.3.1).

- Do the lakes have ice cover in winter? The ice model is repeatedly mentioned in the ms, but no results on the ice regime are presented/discussed. Duration of the ice-ciovered period directly affects timing of the summer stratification onset and summer hypolimnetic temperatures. Any discussion on these variables is incomplete without considering the ice regime.

- Section 4.3 Sensitivity runs can be shortened, at least, to a half and moved from 'Discussion' to 'Results'. The actual discussion should be added, considering the reasons for the observed dependencies, their relevance to the processes in real lakes and novelty of the results compared to the state-of-the-art in this area of research.

Minor comments:

P3L16 What is 'thermocline shifts'? Please, explain

P6L29 Provide model parameters and simulation specifications here.

P9L7 Add 'summer epilimnetic' to 'temperatures'

P10L13 and other appearances: replace '0.067 days earlier decade^{-1}' to '$+0.067$ days decade^{-1}'

P10L28 onwards: 'J m^{-2}' are not correct units for heat flux. Provide flux values in understandable units.

P11L17 How lake morphometry can affect the shortwave flux of solar radiation??

P14L12 and at other places: Schmidt stability is irrelevant to non-stratified lakes and cannot be used for comparison.

P17L9 See above

P17L18 Evaporation depends on surface temperatures, not the deep water temperatures. Explain what do you mean in this sentence, or remove it and find another

explanation for the phenomenon.

P17L2529 Actually, the main driver for epilimnetic temperatures is solar radiation not air temperature. If air temperature is the 'main driver', what do you mean under 'wind. . . a more dominant mechanism'?

P18L14-15 Explain, why stronger winds should produce higher spatial variability in wind stress. How did you estimate changes in turbulence and why do you think they are nonlinear? Table 2, Fig. 3: The model seems to produce consistently a positive bias in lake temperatures. Any explanation for this?

Typos:

P4L12 Capitalize 'Secchi'

P5L29 remove second appearance of 'Lake Mendota'

P8L15 replace 'decreased' with 'decrease'

P12L13 replace 'difficulty' with 'difficult'

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