

# Physical and chemical consequences of artificially deepened thermocline in a small humic lake – a paired whole-lake climate change experiment

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## Final author comments

Dear Editor A. Buttini,

Thank you for the constructive review of our manuscript. Consideration of the comments would definitely improve the quality of our manuscript. I was nice to note that both referees find the experiment interesting and properly executed. The main comments concern the discussion of the results, and we are therefore confident that we can improve the manuscript to make it suitable for publication. Please find below our own responses and suggestions on how to further improve the manuscript. Since Referee 2 had more critical comments, we deal with comments in the following order: Referee 2, Referee 1, comments by the Editor:

### Referee 2:

#### *Major comment 1: Discussion on results:*

The referee argues that the discussion on key results should be improved and that the discussion on results on changes in biota is rather speculative. As clearly stated in the Introduction (rows 19-21) the key aims of the manuscript were: a) describe the experimental design, b) describe the use of thermodynamic modelling for setting the manipulation targets (MyLake model), and c) present main results on observed changes in main physical and chemical variables. Since the experiment was very comprehensive and produced a very large amount of data, our intention was thus not to present detailed results on the effects on biology in the present manuscript, only to indicate that such results also are available. To make this even more clear, we therefore suggest to:

- delete the first paragraph discussing changes in biota on p. 2931 (lines 1-8)
- indicate on p. 2931, line 27 that the results on biology are presented in the papers by Rask et al. 2010 and Arvola et al. 2010.

The comment on the incomplete discussion regarding changes in main water chemistry variables is however valid. We therefore suggest to make the following changes to manuscript:

- Regarding changes in Hg: more clearly refer to papers by Verta et al. 2010 and Rask et al. 2010 where these results are described in detail.
- Discussion on CH<sub>4</sub> and CO<sub>2</sub>: Rewrite the section on p. 2930, lines 15-25 where this topic is discussed. It is a fact that these variables were not measured in the experiment, so this section is not very clear in this respect and should be rewritten.
- Results on DOC and N components: we agree that the discussion on these topics could be improved and suggest to a) include a new figure (Fig. 8) showing the time traces of these

compounds in both lakes, and b) discuss these results in more detail, also including some new references (section 3.3). Such a new figure was also suggested by Referee 1 (comment 3 below).

*Major comment 2: Representativeness of the experimental design regarding future climate change impacts:*

The referee argues that the experiment does not fully represent likely expected future changes in thermal properties, i.e. higher temperatures in the epilimnion without large changes in stratification. This is certainly true, and was recognized already when planning the experiment. As the reviewer also refers to, the topic is already extensively discussed. Our main points regarding this issue are:

- As discussed on p. 2928, line 19 to p. 2929, line 6, it is clearly recognized that the experiment is not giving a completely realistic picture of expected changes, but is the only realistic way how it is possible to manipulate the thermal properties in a whole lake.
- Even though the manipulation represents a rather extreme case, and the seasonal dynamics of this warming was different between the experimental situation and the modeled future, the uncertainty analysis indicated that the seasonal evolution was still within the range of year to year variability of climate warming (Fig. 6).
- The manipulation experiment indicates also a representative scenario for changes in single extreme years or changes in the lake wind exposure, due extensive forest management and forest fires. Several published papers referred to in the manuscript show that such catchment changes have indeed affected thermal regimes in lakes.
- The manipulation rather well represented the average simulated future increase in heat content in the summer/autumn season (section 3.2, p. 2924). Manipulation of the mean heat content and simulating changes in wind exposure were the main goal in the experimental design.

The comment made by referee is therefore valid, but we would argue that this has been both well recognized and extensively discussed in the manuscript already. The referee also finds the experiment to be both valuable and interesting in itself. We therefore suggest to only improve the discussion on the limnological implications of the observed changes, as suggested by the referee.

Responses to minor arguments:

- a description of chemical analyses will be included
- methods for totN and totP will be described
- year will be corrected (p. 2926)

**Referee 1:**

*Specific comment 1:* Section will be rewritten as suggested.

*Specific comment 2:* The pump used a submerged propeller and the equipment was installed at a depth of ca 1.5 m. This section will be extended to explain these facts as requested.

*Specific comment 3:* As indicated already above (comment 1 of Referee 2), a new figure (Fig 8) showing the time traces will be included as suggested.

*Specific comment 4:* This section will be rewritten as suggested.

*Specific comment 5:* The word strongly will be deleted as suggested.

*Specific comment 6:* Table 3 caption will be modified.

### **Comments by the Editor:**

*Improvement of section Discussion:* We agree that the discussion on results can be improved and have suggested necessary changes in the response to the comments by Referee 2 above. The consequences of the unusual hydrological situation will also be described in more detail in Section 4.

*Abstract:* Suggested changes will be made.

*Analytical methods:* A description of the main methods will be included in Section 2.4. TOC = Total organic carbon.

*Paper by Verta et al:* The paper is now in press and the citation will be changed accordingly.

*Comment regarding p. 2929, line 27:* Unit will be changed to mm.

*Comment regarding p. 2930 line 2:* Sentence will be changed to '.....over large areas in **northern** Europe and North America'.

*Figures 4 and 5:* We think that both Figure 4 and 5 are real key figures in the manuscript because they show/integrate a large amount of data on the seasonal development of two central variables affected by the experiment (pycnocline depth and water temperature). Labels in Fig. 4 will be inserted. Contour plots of Fig. 5 will be explained better in the results section as suggested.

We hope that we have been able to respond the main concerns of the referees and the Editor and that we could submit a revised manuscript implementing these suggested changes.

On behalf of the author team,

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