Modeling 50 years of historical temperature profiles in a large central European lake

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ABSTRACT: A unique data set of 50 years of monthly temperature profiles from Lake Zurich, a normally ice-free lake located on the Swiss Plateau, allowed the one-dimensional numerical k-ε lake model [SIMSTRAT] to be calibrated (1948- 1957) and validated (1958-1997). Hindcasts of temperature profiles agree excellently with the measured data. Both interannual and intraannual variations in thermal structure are reproduced well during the entire 50-yr simulation, thus demonstrating the stability and good prognostic qualities of the model. Simulations conducted with raised and lowered air temperatures (Tair) suggest that an increase in Tair will lead to an increase in lake water temperature at all depths. In comparison to the continuous modeling approach taken in this study, the commonly employed discontinuous modeling approach (with no heat carryover during winter) substantially underestimated the degree of long-term hypolimnetic warming that can be expected to result from an increase in Tair. Thus, whereas the discontinuous approach yields valid predictions for strictly dimictic lakes that are ice-covered each winter, heat carryover during winter makes a continuous approach necessary in lakes like Lake Zurich that are only facultatively dimictic. The significant degree of hypolimnetic warming found in this study suggests that the response of facultatively dimictic lakes to increases in Tair is likely to differ from that of the strictly dimictic lakes modeled in other investigations. In Lake Zurich, an increase in Tair is predicted to result in more frequent suppression of deeply penetrative winter mixing events, with a potentially negative impact on the lake ecosystem.