Geophysical Research Abstracts
Vol. 20, EGU2018-16336, 2018
EGU General Assembly 2018

Disentangling drivers of Holocene lake level fluctuations in Northeastern Germany

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Past lake level fluctuations are commonly considered to primarily represent climate variations. Lake level studies are therefore the most common tool to study changes in hydroclimate. However, it is also well known that a lakes water budget is influenced by further factors. Most importantly, evapotranspiration in the catchment of a lake is influenced by the landcover. We here explore the importance of climate versus landcover on Holocene lake level fluctuations in NE Germany. To that end we study lake level fluctuations at Lake Tiefer See (N 53.59, E 12.53) and compare with the landcover reconstructions.

Lake Tiefer See is one of the rare lakes with long sequences of annually laminated Holocene sediments in northern Germany. Our lake level reconstruction is based on long cores from the lake centre as well as 20 cores from the lake margin and surrounding peatlands. Analysis included geochemical parameters as well as macrofossil and pollen. Dating is based on varve counts, radiocarbon dates, microtephras and on pollen stratigraphies. Results from all cores were combined to determine the most probably range of the lake level during the Holocene. The results show very high lake level fluctuations during the early Holocene, more stable, intermediate water levels in the mid-Holocene and mostly high water levels in the Late Holocene after 4000 cal. BP. Overall, the lake level fluctuated by more than 6 m during the Holocene, with maxima in the early and late Holocene and the minimum around 9000 cal. BP.

To explore the causes of lake level fluctuations we first compare the results with REVEALS based landcover reconstructions, calculated with the REVEALSinR function from the R package DISQOVER. At least partly, the lake level changes synchronous with landcover. The lake level increases after 4000 cal. BP with the widespread expansion of agriculture in the Bronze Age, and decreases during subsequent periods of reforestation. However, other changes in the lake level do not appear to be related to changes in landcover, for example mid Holocene lake level fluctuations.

To evaluate effects of landcover change on the lake level we applied hydrological modelling. To that end past vegetation composition in the catchment area of the lake was reconstructed with the extended downscaling approach (EDA) from the DISQOVER package. From that we estimated cumulative transpiration and finally groundwater recharge. Differences in groundwater recharge are likely to cause fluctuations in groundwater levels and consequently also in lake levels, as Lake Tiefer See is largely groundwater fed. The modelled lake level fluctuations have a similar magnitude as the reconstructed lake level fluctuations. Therefore, both landcover reconstructions and hydrological modelling support our hypotheses that landcover changes, besides climate variations, are an important control on ground- and lake water level fluctuations.

This study is a contribution to the Virtual Institute of Integrated Climate and Landscape Evolution (ICLEA; www.iclea.de) of the Helmholtz Association (Grant Number VH-VI-415) and is supported by Helmholtz infrastructure of the Terrestrial Environmental Observatory (TERENO) North-eastern Germany.