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Changes of hydrology and carbon cycling in a mid-latitude lake from Late Glacial to Anthropocene: model-data comparison for Lake Gosciaz, Central Poland

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Lake sediments are considered among the most valuable archives of climatic and environmental changes on continents. Studies aimed at reconstruction of continental climates based on lake sediments are usually of interdisciplinary character, comprising physicochemical, biological and isotopic tools. To utilize fully the potential of lacustrine sediments as environmental archives, a deeper understanding of hydrology and carbon cycling in lakes under contrasting climatic conditions is required.

Lake Gosciaz is situated in central Poland (52˚35'N, 19˚21'E, 64.3 m a.s.l.) in the Vistula river valley. It is the largest in a group of four lakes which were formed during the final stages of the last glaciation, on the outskirts of retreating Fennoscandian ice sheet. Laminated sediments of Lake Gosciaz have been a subject of extensive interdisciplinary investigations aimed at reconstructing environmental and climatic changes in central Europe during late Glacial and Holocene. Also process studies aimed at better understanding of carbon cycling in the present-day lake have been carried out.

The presented study was focussed on long-term changes of δ^{18}O of lake water and δ^{13}C of authigenic calcite preserved in sediments of Lake Gosciaz. The available isotope records span entire history of the lake, from Younger Dryas till recent times. Changes of δ^{18}O of aquatic cellulose have been used to derive information on past evolution of ^{18}O isotope composition of lake water, while δ^{13}C of authigenic calcite gave insights into variations in carbon cycling in the system. Quantitative mass-balance models describing both hydrology and carbon cycling in the lake were constructed and used to evaluate past changes in the system.

The water balance of Lake Gosciaz varied dramatically in the past. It evolved from fast, through-flow lake during Younger Dryas, characterized by the total inflow to evaporation ratio (I/E) in the order of 30-35, through evaporation-dominated system during early Holocene (I/E $\approx$ 3-4), back to relatively fast, groundwater controlled lake at present (I/E = 10). In addition, in order to fit the reconstructed changes of δ^{18}O of lake water, some changes of the relative humidity need to be postulated (reduction in the order of 5 to 10% across the YD/PB boundary, and subsequent increase to the present-day value of ca. 85%).

The modeling of carbon cycling in the lake revealed that δ^{13}C of authigenic calcite is controlled mainly through flux of dissolved inorganic carbon entering the lake with inflowing waters. The remaining two processes which influence carbon isotope composition of total dissolved inorganic carbon pool and δ^{13}C of authigenic calcite are related to photosynthesis and respiration of organic matter, both produced in the lake and transported from the catchment. Satisfactory agreement between measured and simulated δ^{13}C values of authigenic calcite could be reached by appropriate adjustment of these three factors. The strong link between lakes' hydrology and carbon isotope signature of authigenic calcite observed in the studied system was not recognized earlier in the literature.