A modern isotope record of changes in water and carbon budgets in a groundwater-fed lake: Blue Lake, South Australia

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ABSTRACT: Groundwater is often a major component of lake water and chemical balances. Alteration in catchment subsurface water balances through land-use change and pumping can affect lake biogeochemical cycles through changes in groundwater flow rates. We present a modern (~200 yr) sediment isotope record ($\delta^{18}O_{carb}$, $\delta^{13}C_{carb}$, and $\delta^{13}C_{org}$) of changes to the water and carbon budget of Blue Lake, which is situated in karstic limestone in South Australia and is mostly fed by groundwater. The 3.5‰ decrease in $\delta^{18}O_{carb}$ and $\delta^{13}C_{carb}$ deposited in lake sediments since ~1850 reflects higher rates of groundwater through-flow due to rainfall variability, land-use change, and increased rates of pumping over the past 40 yr. Calculated water residence times, based on the isotopic data, were 23 ± 2 yr before 1850 and decreased by the late twentieth century to 8 ± 2 yr. Concomitant dissolved inorganic carbon (DIC) residence times were 3.8 and 2.2 yr, respectively. Although burial rates of $CaCO_3$ have increased by about threefold over the past 40 yr, there is no evidence that substantial changes in organic carbon deposition has occurred. The shorter DIC residence time is largely due to increased input and higher CO_2 evasion rates. About 88% of C_{carb} and ~96% of C_{org} generated within the water column is remineralized, but the isotopic composition is essentially unaltered in the sediments. The measured variations in $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ of sediments are thought to reflect changes to DIC residence time and increased CO_2(aq) concentrations rather than changes in lake productivity.