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Are perialpine lakes a net source or sink of carbon? A sediment trap study of Lake Geneva, Switzerland

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Sediments in freshwater systems store a similar amount of carbon as is sequestered in marine sediments, but different sources of carbon have different climatic and carbon cycle implications. For example, recently synthesized biospheric C presents a drawdown of CO_2, while the (re)-burial of rock-derived C does not affect atmospheric CO_2 levels. In this study, we investigate particulate organic and inorganic carbon (POC and PIC, respectively) sedimentation fluxes in Lake Geneva (Switzerland). We aim to disentangle different sources of carbon and quantifying their impact on the carbon cycle of the lake and its catchment.

Between the summer of 2022 and 2023, we deployed sediment traps at two locations – one proximal and the other distal to the delta of the upper Rhone River - the major source of water and sediment to the lake. These sites were selected to capture contrasts between material sourced from the river (allochthonous) and in-lake productivity (autochthonous). Natural abundance radiocarbon (^{14}C) measurements in combination with stable carbon isotopes ($\delta^{13}C$) are used to constrain the sources of POC and PIC, and to compare results with signatures of dissolved and particulate carbon exported by the Rhone River and within the lake water column and additional information stemming from ongoing time-series observation programs.

We find significant fluctuations in POC and PIC flux throughout the year, with corresponding fluxes to the deep sediment trap following a clear seasonal trend. The highest fluxes occur in the summer months when, based on similarity to dissolved inorganic carbon (DIC) $\Delta^{14}C$ values, export is dominated by autochthonous carbon inputs. In the deltaic site, high mass and POC flux was associated with increased river discharge during summer, while corresponding $\Delta^{14}C$ are lower, reflecting substantial pre-aged, allochthonous POC supply. While PIC fluxes show no clear seasonal trends in the delta-proximal trap, corresponding $\Delta^{14}C$ values suggest seasonal variations in autochthonous (aquatic production) and allochthonous (rock-derived) carbonate sedimentation. Through connecting our findings with the wealth of existing information about this exceptionally well-monitored source-to-sink system we are seeking to build a more comprehensive understanding and to use it as a model system for other perialpine and hardwater lakes globally.