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Vertical transport and flow patterns in a small stratified lake

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In densely populated or agriculturally used regions, small lakes often tend to be eutrophic due to human activities. The hypolimnion may become anoxic degrading the water quality in the lake and possibly in the surrounding groundwaters. The redistribution and transport of matter within such lakes is therefore of interest. Study site is a quarry pond in the Rhinegraben near Ludwigshafen, Germany (800×200 m, mean depth 9 m, max. depth 20 m). The governing circulation and mixing processes show patterns particularly influenced by the density stratification.

From weekly measured temperature profiles we quantitatively estimated profiles of effective vertical transport coefficients K_z. In the stratified regions, K_z at the level of heat conduction ($\sim 10^{-7}$ m^2/s) is the upper limit for vertical transport. Towards the lake bottom, we found an increase of K_z to $\sim 10^{-5}$ m^2/s.

With a bottom mounted 1200 kHz-ADCP, we performed velocity flow measurements. In general, the lake responds weakly to the wind forcing with horizontal velocities of several cm/s, reaching a few dm/s at the surface. However, after stronger wind incidents, we observed clear multilayer flow structures persisting less than one day. Whereas velocity and temperature spectra seem to be quasi-continuously at a timescale of several days, short time Fourier analysis on this events revealed distinct maxima in the range of $0.3\,\mathrm{h}^{-1}$.