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Convectively driven transport in temperate lakes

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ABSTRACT: Penetrative convection in the surface layer of a midsize temperate lake (5 km^2) was investigated in both summer and winter using a conductivity-temperature-depth (CTD) logger mounted on an autonomous underwater vehicle (AUV) flown repeatedly along horizontal transects at selected depths. In summer, the epilimnion cooled differentially during a calm evening (240 and 297 W m^{-2} on the east and west sides of the lake, respectively). These cooling rates agree well with the average net heat flux of 270 W ths. In summer, the epilimnion cooled differentially during a calm evening (240 and 297 W estimated from meteorological data. Density currents were driven by this differential cooling. In winter, CTD profiles during a sunny day showed four distinct thermal layers beneath the ice (~50 cm thick), consistent with radiative penetrative convection: a stratified diffusive layer just beneath the ice (top 1.6 m); a well-mixed convective layer (that deepens at 1.14 m d^{-1} and warms at 0.015°C d^{-1} during the observation period); an entrainment layer (1.5 m thick); and a weakly stratified quiescent layer (to bottom). AUV transects, flown at constant depths in each layer, revealed a 150-m wide region displaying evidence of penetrative convection, surrounded by regions with negligible heat changes. These high-resolution, horizontal CTD measurements provided insight into previously unresolved physical dynamics of the well-mixed layer of a temperate lake in quasi-shear-free conditions that would have been difficult to quantify during summer months and impossible under winter ice cover without the use of an AUV platform.

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