Observations of mixing near the sides of a deep lake in winter

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ABSTRACT: The dissipation rate of turbulent kinetic energy per unit mass, ε, vertical eddy diffusivity, K_z, and the rate of dissipation of temperature variance, x, are estimated over the sloping sides of Lake Geneva both far from and near the bed, using temperature data from horizontal tracks of a submarine during periods of winter cooling. The estimated values are about one order of magnitude greater near the slope than those distant from it. The mean dissipation rate per unit mass averaged over the epilimnion varies between $O(10^{-10})$ $m^2 s^{-3}$ in calm weather to $O(10^{-8})$ $m^2 s^{-3}$ in winds of 8 m s^{-1}, for surface buoyancy fluxes of 6×10^{-9} $m^2 s^{-3}$ and 1.1×10^{-8} $m^2 s^{-3}$, whereas near the slope ε has an average value of 3×10^{-8} $m^2 s^{-3}$. The relation between K_z and εN^{-2} (where N is the buoyancy frequency) is examined. Values of the mixing efficiency, $\Gamma = \varepsilon N^{-2} K_z^{-1}$, of 0.15 ± 0.1 and 0.16 ± 0.1 21 z are obtained in the upper 10-m layer for calm and windy conditions, respectively. Near the slope, Γ is found to be 0.22 ± 0.2, slightly larger than in surface layers under windy conditions. Different mixing mechanisms in different regions, near the slope and in the surface waters of the epilimnion and relatively calm deeper layers, can be identified in the diagram of overturn Froude number versus overturn Reynolds number. Mixing near the slope in the epilimnion appears to be related to the gravitational winter cascading of cold water down the sloping sides of the lake.