Contribution of entrainment and vertical plumes to the winter cascading of cold shelf waters in a deep lake

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ABSTRACT: Observations made from vertical moorings of thermistors and current meters are used to analyze the relative contribution of the entrainment of overlying water and the cold plumes convecting from the surface to the cascade of dense shelf waters down the sides of Lake Geneva. Assuming a steady state and ignoring the effects of the Earth's rotation, a simple model was introduced and 25 individual slugs of gravity currents were analyzed. The average drag coefficient, which includes the effects of friction on the slope and the interface between the gravity current and the ambient water, is found to be equal to $C_n = (4.6 \pm 1.5) \times 10^{-3}$. The volume flux in the gravity current increases with downslope distance—a consequence of both the entrainment of water into the gravity current and the supply of cold water from the plumes. Entrainment was found to be, on average, 1.9 ± 0.9 times the contribution of vertical plumes, suggesting that the latter may be important in the dynamics of the cascade.