EGU23-9662, updated on 15 May 2023
https://doi.org/10.5194/egusphere-egu23-9662
EGU General Assembly 2023

A moored profiling platform to study turbulent mixing in density currents in a large lake

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During calm cooling periods, differential cooling can induce winter cascading which is an important process for littoral-pelagic exchange and deep water renewal in large, deep lakes (Fer et al., 2001; Peeters et al., 2003). Generated in the shallow near-shore regions, such cold-water density currents travel down the sloping lakebed until they reach their depth of neutral buoyancy. The latter is strongly dependent on the entrainment of warmer ambient water, often expressed by the entrainment coefficient (i.e., the ratio of the entrainment velocity to the bulk velocity of the density current, e.g., Legg, 2012). Fer et al. (2001, 2002) studied density currents in Lake Geneva and showed that they occur in the form of cold-water pulses that last 1-2 hours, with a typical thickness of 10 m, a mean velocity of ~5 cm s^{-1} and an entrainment coefficient of ~0.03.

With recent advances in instrument capabilities, our recent investigations in Lake Geneva reveal also the presence of shorter, but still strong, temperature fluctuations of O(10) min in those density currents. To investigate further the mechanisms of entrainment in cascading flows, we designed a turbulence platform that was deployed on the sloping bed of Lake Geneva at 25-m depth. The platform is equipped with (high frequency) temperature and current velocity sensors which collect data over 3 meters vertically. A connection to the shore via a cable laid on the lakebed enables to control the platform's vertical position and ensures continuous long-term measurements at high frequency. The background variables, such as velocity and temperature profiles, characterizing the nearshore zone in the surrounding of the platform are measured continuously using lower resolution sensors.

Here, we briefly expose the design of the platform, present a case of cascading flow and give small-scale hydrodynamic details of eddies that are observed intermittently within the density currents. Indeed, instantaneous unstable profiles (warm water intruding below cold water) within the dense cold flow show the presence of large eddies with spatial scales similar to the thickness of the mean current. The preliminary results shed light on the mechanism of warm ambient water entrainment into the cold-water density current. The high intermittency of occurrence of large eddies, i.e., those that contribute the most to entrainment, contrasts with the classic concept of a bulk entrainment coefficient.

Fer, I., Lemmin, U., & Thorpe, S. A. (2001). Cascading of water down the sloping sides of a deep lake in winter. *Geophysical Research Letters*, *28*(10), 2093–2096. https://doi.org/10.1029/2000GL012599

Fer, I., Lemmin, U., & Thorpe, S. A. (2002). Winter cascading of cold water in Lake Geneva. *Journal of Geophysical Research: Oceans*, *107*(C6), 13-1-13–16. https://doi.org/10.1029/2001JC000828

Legg, S. (2012). Overflows and convectively driven flows. In E. Chassignet, C. Cenedese, & J. Verron (Eds.), *Buoyancy-Driven Flows* (pp. 203-239). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511920196.006

Peeters, F., Finger, D., Hofer, M., Brennwald, M., Livingstone, D. M., & Kipfer, R. (2003). Deep-water renewal in Lake Issyk-Kul driven by differential cooling. *Limnology and Oceanography*, *48*(4), 1419–1431. https://doi.org/10.4319/lo.2003.48.4.1419