Experimental investigation of the local entrainment velocity in a gravity current.

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The incorporation of ambient fluid into a flowing layer of turbulent fluid across a sharp interface that separates them, i.e., turbulent entrainment (TE), has long been a subject of investigations. The most common notion of TE is entrainment into a mean current of characteristic velocity U, e.g., a dense gravity current, via a flow with velocity u_e normal to the average turbulent/non-turbulent interface (TNTI). Dense gravity currents play an important role in the global ocean circulation and flux rates are found to be sensitive to the proper entrainment parametrization.

In the well-known Morton-Turner-Taylor entrainment hypothesis the entrainment velocity u_e was specified as $u_e = EU$, where E is the entrainment function. The parametrization of E has proved to be very difficult and until today remains poorly understood. The aim of this project is to study the entrainment process in terms of the instantaneous local entrainment velocity v_n and the surface area A_η of the contorted TNTI. These small scale quantities are related to their large scale counterparts by the fact that they drive the same flux across the interface: $u_e A = \int_{A_\eta} v_n dA$. The effect of the local density field on the behavior of v_n and A_η shall be studied for different Richardson numbers in the range of $0 < Ri < 1$ and $Re = O(4000)$.

The velocity field including its derivatives will be obtained by means of 3D Scanning Particle Velocimetry (SPTV). Simultaneously, the density field will be captured by Scanning Laser Induced Fluorescence (SLIF). Up to this point, the setup — comprising a tiltable flow tank with 2 m in length and 0.5 m in width and height as its centerpiece — has been realized. In order to verify the flow field 2D PIV measurements are performed in various planes. A result of these investigations with an initial density difference $\Delta\rho = 2.5 g/l$ is shown in Fig. 1.

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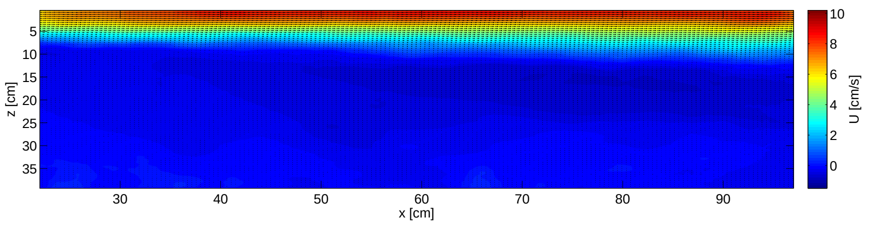

Figure 1: (a) Quiver plot of the mean flow field in the center plane oriented in the streamwise direction with inflow parameters $Ri = 0.2$ and $Re = 3700$. The underlying contour plot depicts the magnitude of the streamwise component.