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Interface dynamics and mixing rate for a shear stress driven, rotating, two-layer stratified fluid

W. F. Rizk (1), P. A. Davies (1), A. J. S. Cuthbertson (1), Y. Nino (2).
(1) Division of Civil Engineering, University of Dundee, Dundee, DD1 4HN, United Kingdom.
(2) Department of Civil Engineering, University of Chile, Casilla 228-3, Santiago, Chile.

Experimental and analytical work is performed to determine the rate of mixing, velocity field and interface dynamics of an enclosed two-layer stratified fluid as a consequence of an imposed shear stress in the presence of rotation. Prior research has shown that interface dynamics and rate of mixing differ depending on whether the system was non-rotating or if the dominant force was the geophysical aspect rather than the shear stress. The aim is to better understand the hydrodynamics of lakes and/or reservoirs within a geophysical context involving a prescribed local forcing, in this case a continuous wind shear.

The apparatus used consists of an enclosed case of fluid on top of a steadily moving belt (to simulate the imposed wind shear), mounted onto a rotating table. The parameters that were varied for the experiments are the belt velocity U, the density step of the two layers $\Delta\rho$ and the rotational velocity Ω. Entrainment velocities u_e are inferred from density profiles as are the interface dynamics in the longitudinal and cross-sectional directions and the time taken to reach the homogeneous state. There is evidence to suggest that as U increases or $\Delta\rho$ decreases or Ω increases, u_e increases and there is a deformation of the shape of the interface in the longitudinal direction. The cross-sectional profile of the interface is found to be U-shaped due to the dominant force being the imposed shear stress rather than the rotational dynamics, with the presence of a jet to one side of the tank partly caused by the presence of rotation. PIV analysis shows strong velocities for the layer in contact with the moving belt relative to the motion within the overlying layer. There is a circulating flux of fluid within the lower layer in a plane approximately parallel with the belt.