Abstract Submitted
for the DFD07 Meeting of
The American Physical Society

Rapid Gravitational Adjustment of a Horizontal Shear Layer

KARL HELFRICH, BRIAN WHITE, Woods Hole Oceanographic Institution —

Shallow coastal ocean flows frequently involve strong horizontal shear layers in combination with a horizontal density gradient. Examples include estuarine outflows and separating flows around headlands and islands. The stability and evolution of the shear layer formed from the initial state of two co-flowing streams with laterally-varying, but depth independent, velocity and density is explored through three-dimensional nonhydrostatic numerical calculations. In the absence of the density contrast, the shear layer undergoes the classic instability including roll-up of the vertical vorticity into well-defined vortices. The addition of the density gradient results in a lateral gravity-driven flow resembling a lock-exchange. The lateral adjustment leads to tilting (from vertical) and stretching of the emerging shear layer vortices, greatly amplifying vorticity in the vortex cores. This converts horizontal shear into vertical shear and ultimately the rapid break-down of the vortices, large density overturns, and vertical mixing. The work is guided by a simple scaling argument that compares the timescale for growth of the linearly most unstable wave on a pure shear layer to the timescale for the transverse gravitational adjustment. For large values of this ratio the gravitational adjustment dominates and inhibits the shear instability. As this ratio decreases, the shear and gravity-driven flows become increasingly coupled, producing strong mixing.

Karl Helfrich
Woods Hole Oceanographic Institution

Date submitted: 03 Aug 2007 Electronic form version 1.4