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NUMERICAL SIMULATION OF STABLY STRATIFIED FLOW AROUND AN OBSTACLE

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ABSTRACT

This paper describes a numerical study of the two dimensional flow of a linearly stably stratified fluid around a body (vertical or horizontal thin strip) towed horizontally at constant velocity U. The major dimensionless parameters governing this problem are the internal Froude number $Fr = U/NL$, the Reynolds number $\mathrm{Re} = UD/\nu$, the ratio of intrinsic length scales $C = \Lambda/L$ and the Peclet number $Pe = UL/\kappa_S$ (L is the dimension of the strip; N is buoyancy frequency, $\Lambda = \left(d\left(\ln\rho\right)/dz\right)$ is stratification length scale, ν is kinematic viscosity and κ_S is salt diffusivity). The set of the dimensionless parameters define conditions of numeric and small scale laboratory modeling of environmental flows. Fields of velocity, density and their gradients were computed and visualized.

In the flow pattern, transient and attached (Lee) internal waves, downstream wakes and vortices are distinguished. The density distribution and the vertical component of velocity are anti-symmetric with respect to the horizontal axis whereas the horizontal component is symmetric. Downstream of the body, the motion of fluids is on phase opposition.

A blocked region is formed in front of the strip that is moving with the same speed as the body in the near field upstream, the leading edge of the blocked liquid is defined by the condition of equality between the fluid local velocity and the body velocity, the length of blocked area increases when the body velocity decreases. These data explain the existence of void zones in the flow. A more uniform blocked liquid is collected from the central plane vicinity and particles from an outer source cannot penetrate inside this volume. The normalized length of the upstream blocked region is proportional to inverse Froude number.

The pattern of flow near moving horizontal strip fully agrees with analytical results [3;5], attached internal waves near the body and details of the fine structure of the boundary layer are distinguished, one peak band for the horizontal component and two bands for the vertical component of velocity are visualized in the flow around the horizontal strip.

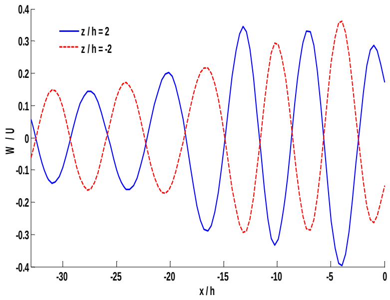

Fig 1. Vertical velocity profiles past the strip

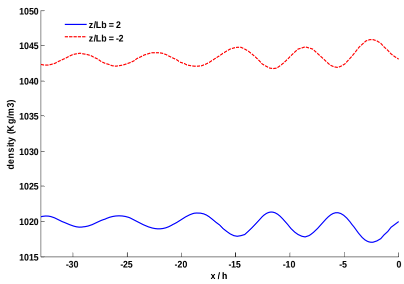

Fig 2. Density profiles past the strip

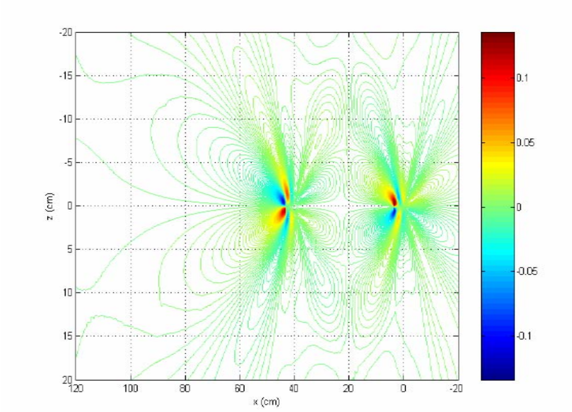

Fig 3. Iso-vertical velocity, Lx = 40 cm, Tb = 6.28 s U = 0.55 cm/s, t/Tb = 1.27

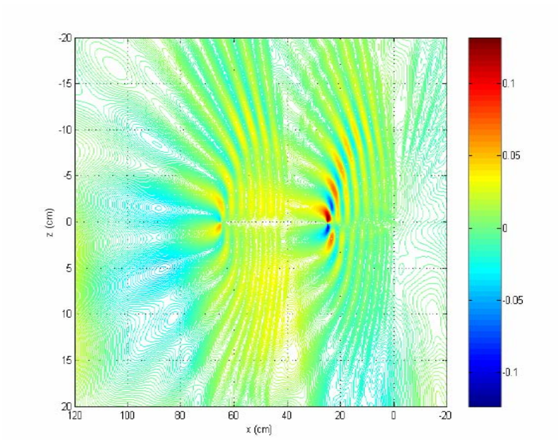

Fig 4. Iso-vertical velocity, Lx = 40 cm, Tb = 6.28 s U = 0.55 cm/s, (a) t/Tb = 10.16

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