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Stratified flows past a thin plate

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We consider flow produced by uniform motion of a thin strip with finite length along sloping trajectory in an incompressible continuously stratified fluid. The set of fundamental equations including the Navier-Stokes accounting for the gravity in the Boussinesq approximation, the continuity and diffusion equations and the closing linearized state equation is analysed. The boundary conditions are no-slip for velocity components and no-flux for substance on the strip surface and attenuation of all perturbations at infinity. We use the finite-difference method with splitting for physical parameters on spaced "chessboard" grid for spatial derivatives.

It is known that even in a motionless continuously stratified fluid fine diffusion induced flow is formed on an obstacle due to breaking of natural diffusion flux of substance on topography. On a motionless sloping plate both ascending and descending flows are formed along its upper and lower surfaces. Nearby the plate upper and lower edges the flows are transformed into the jets generating dissipative-gravity waves or so-called horizontal streaky structures. Uniform motion of the plate initiates shifts of fluid particles from neutral buoyancy horizons and leads to internal wave generation. The change of total forces and moments which act upon both sides of the moving plate as well as the transformation of stratified flow wave structure are traced for different parameters of the plate and medium (length, velocity and slope angle of trajectory of the moving plate, value of buoyancy period of stratified fluid). The comparisons of the results with the Prandtl-Blazius theory demonstrate substantial differences near the plate edges where the conditions for boundary layer approximation are broken.

The comparisons of the calculated flow patterns with exact solution of the linearized version of the problem with underlying plane are implemented. The best agreement of both approaches is observed for the case of horizontal movement of the plate. With an increase of trajectory slope to horizon the noticeable differences appear in the flow patterns due to influence of nonlinear effects. The calculations are compared with the schlieren images of stratified flows around both motionless and moving plates, measurements of marker displacements and conductivity variations.