NUMERICAL MODELLING OF DENSITY FLOWS IN COASTAL WATERS

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The origin and dynamics of density flows in the Baltic Sea are wide and varied (1, 2, 5). River run-off, water exchange with lagoons and fjords, wind effects, storm mixing, salt-water inflows into the Baltic Sea, winter cooling and others are sources of density flows. Small spatial and temporal scales of this type of flows require consideration of horizontal inhomogeneity of the density field, non-stationary character of processes, rotation of the Earth, etc. This leads to significant difficulties for analytical and three-dimensional modelling.

As it turned out, it is possible to divide three-dimensional problem for two two-dimensional problems in horizontal and vertical planes. The analysis of features of density flow propagation was done using two numerical two-dimensional models (3, 4) – model of propagation of density flow in vertical plane over horizontal or inclined bottom (XZ-model) and model of propagation in horizontal plane taking into account the rotation of the Earth (XY-model).

Figures 1-3 represents results of numerical modelling of density flow with sediments in XZ-plane (fig. 1), the movement of the finite volume of dense water in the surrounding less dense water in XZ-plane (fig. 2) and propagation of salt seawater over the bottom in freshwater lagoon in XY plane (fig. 3).

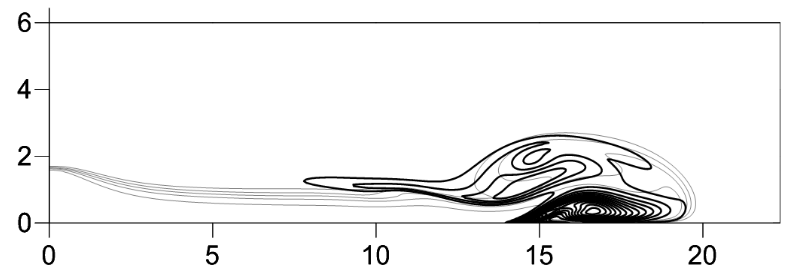

Figure 1: The distribution of isolines of excess density values (gray lines) and tracer values (solid black lines), which identifies the suspended material. The isolines of excess density values pass consequently the values from 0.1 to 0.85 step 0.15; The isolines of tracer – from 0.12 to 0.36 step 0.02. Parameters of the current: grid 2001x501, $\Delta\rho_0$=0.001 g/cm^3, u_0=3 cm/s, $_{h0}$=6 cm, v_{ef}=10^{-1}cm^2/s, angle of the slope 7^O.

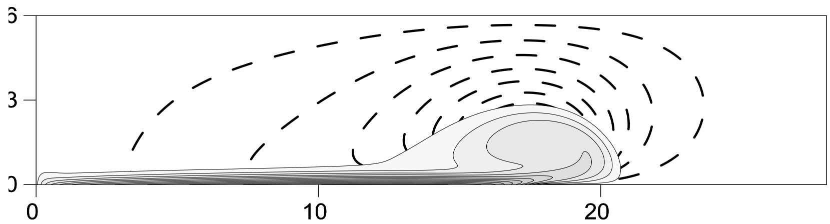

Figure 2: The distribution of isolines of excessdensity values (solid line) and flow function values (dotted line). The isolines of excessdensity values pass consequently the values from 0.01 to 0.23 step 0.02; The isolines of flow function – from 0.15 to 2.15 step 0.25. Parameters of the current: grid 700x120, $\Delta\rho_0$=0.001 g/cm^3, u_0=1cm/s, h_0=2cm, v_{ef}=10^{-1}cm^2/s, angle of the slope 10^O.

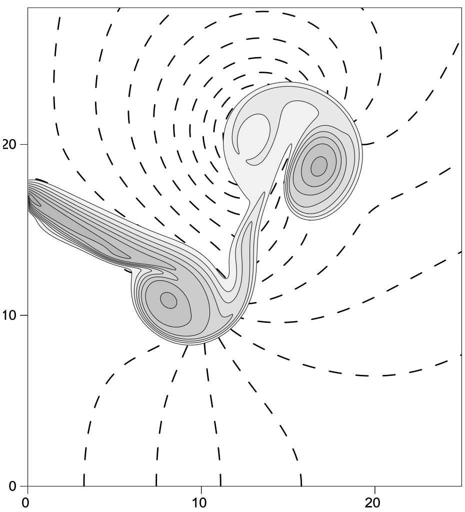

Figure. 3: The distribution of isolines of excessdensity values (solid line) and flow function values (dotted line). The isolines of excessdensity values pass consequently the values from 0.05 to 0.75 step 0.12; The isolines of flow function – from 0.1 to 2.5 step 0.15. Parameters of the current: grid 700x120, $\Delta\rho_0$=0.00005 g/cm^3, u_0=2cm/s, h_0=2cm, ν_{ef}=10^{-1} cm^2/s, f=0.1 s^{-1}.

The use of two-dimensional models allowed to obtaina number of interesting physical results. In particular, to clarify the role of density gradients in the “head” of density flow on their propagation in coastal regions as well as the mixing processes and sediment transport.

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