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A Numerical Investigation of the Tidal Internal Wave Dyanamics

A. Safray and I. Tkachenko

St. Petersburg Branch, P.P. Shirshov Institute of Oceanology, RAS, Laboratory of Dynamic Meteorology, St. Petersburg, Russian Federation (safr@ioras.nw.ru, 7-812-328-57-59)

For ocean motions with comparable horizontal and vertical scales hydrostatic balance is break down and using of non-hydrostatic system of equations (NHE) of motion is inevitable.

Here we present some results of numerical experiments with a fully 3D non-hydrostatic finite element (FE) ocean model. The model includes non-hydrostatic system of primitive equations of motion, equations of continuity, temperature, salinity, and constructed from them equation for pressure with co-called "artificial compressibility" and is completed with equation of state and k-? closure. The last one is a modification of Kantha-Clayson turbulent model with equation for fluctuations of temperature. But description of turbulent mixing and breaking in internal waves is still crucial. An example of applicability of Large Eddy Simulation to investigation of micro-scale dynamics shows an advantage of this method, but its using for processes of larger scales is not clear.

Numerical approximation of the equations of the model is based on a tetrahedron finite element mesh and has the second order of accuracy in time and space both. FE approximation with variable space resolutions allows one to describe a bottom topography and ocean boundaries in more details. In presented model, though using explicit scheme and due to that having a limited time step an economic computational algorithm had been elaborated. Due to that integration of NHE equations of the model needs computational time comparable with that for HE model. From the other hand, due to temporal scales of the problems of investigations, time step cannot be increased essentially from the physical point of view.

Another advantage of FE approximation consists of conservation of energy and natural treatment of boundary conditions. The problem of boundary conditions at the open boundaries (OBC) of domain of investigations, though often discussed and investigated by numbers of researches still remains a crucial problem of the ocean modelling. Discrepancies between borders of natural and model domains may produce large errors in computed bottom and boundary stresses and fluxes as well as in magnitudes of buoyancies forces, which may neglect all advantages of the NHE model. From the mathematical point of view, non-hydrostatic formulation unlike hydrostatic is well posed (Oliver and Sandstrem, 1978), but due to usual lack of hydrological information at open boundaries, OBC treatment still stays a weak point of ocean modelling. Some results of using different type of OBC are presented and compared.

Some results of investigation of the tidal internal wave transformation during M2 tidal cycle are discussed. Namely, an interaction of tidal flow with bottom obstacle produces a small-scale waves. Their dispositions coincide well with zones of extrema in the fields of vorticity. The last ones change their polarity with a depth in regions of small-scale activity.