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Splitting turbulence algorithm for mixing parameterization embedded in the ocean climate model. Examples of data assimilation and Prandtl number variations.

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Series of experiments were performed with a three-dimensional, free surface, sigma coordinate eddy-permitting ocean circulation model for Atlantic (from 30°S) – Arctic and Bering sea domain (0.25 degrees resolution, Institute of Numerical Mathematics Ocean Model or INMOM) using vertical grid refinement in the zone of fully developed turbulence (40 sigma-levels). The model variables are horizontal velocity components, potential temperature, and salinity as well as free surface height. For parameterization of viscosity and diffusivity, the original splitting turbulence algorithm (STA) is used when total evolutionary equations for the turbulence kinetic energy (TKE) and turbulence dissipation frequency (TDF) split into the stages of transport-diffusion and generation-dissipation. For the generation-dissipation stage the analytical solution was obtained for TKE and TDF as functions of the buoyancy and velocity shift frequencies (BF and VSF). The proposed model with STA is similar to the contemporary differential turbulence models, concerning the physical formulations. At the same time, its algorithm has high enough computational efficiency.

For mixing simulation in the zone of turbulence decay, the two kind numerical experiments were carried out, as with assimilation of annual mean climatic buoyancy frequency, as with variation of Prandtl number function dependence upon the BF, VSF, TKE and TDF. The CORE-II data for 1948-2009 were used for experiments. Quality of temperature T and salinity S structure simulation is estimated by the comparison of model monthly profiles T and S averaged for 1980-2009, with T and S monthly data from the World Ocean Atlas 2013. Form of coefficients in equations for TKE and TDF on the generation-dissipation stage makes it possible to assimilate annual mean climatic buoyancy frequency in a varying degree that cardinally improves adequacy of model results to climatic data in all analyzed model domain. The numerical experiments with modified Prandtl number presents possibility for essential improvement of the TKE attenuation with depth and more realistic water entrainment from pycnocline into the mixed layer.

The high sensitivity is revealed of the eddy-permitting circulation stable model solution to the change of the used above mixing parameterizations. This sensitivity is connected with significant changes of density fields in the upper baroclinic ocean layer over the total considered area. For instance, assimilation of annual mean climatic buoyancy frequency in equations for TKE and TDF leads to more realistic circulation in the North Atlantic. Variations of Prandtl number made it possible to simulate intense circulation in Beaufort Gyre owing to steric effect during the whole period under consideration.

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