Guideline for high-resolution models, using an ocean model with probability distribution functions of the Arctic Ocean

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Huge computational resources and technical development are required to prepare a high resolution basin-scale circulation model, in which thermohaline circulation interacts with mesoscale features (~10 km) and small-scale plumes (~1 km). A new modeling approach for evaluation of this high resolution model is proposed on the basis of a probability distribution function (PDF) on the temperature–salinity (*T–S*) plane, which can represent horizontal heterogeneity within each grid of low resolution models. The *T–S* distribution retains only the probabilities of different water types, while their locations are discarded in the grid. Time progressions of the PDF are calculated as the basic equations. Following the last year report, a new component has been implemented and examined to reproduce more realistic distributions of water masses.

For an initial trial, a simple box model is chosen as the basic model, with one active box for the surface layer of the Arctic Ocean (200m thick), which is fresher and receives saltier water from the Greenland Sea and could mix with the Arctic subsurface layer. The active box has sea ice and receives atmospheric forcing and freshwater flux. This box model possesses a salinity-driven state, at which the saltier water enters the active box and becomes fresher, along with a convected state with the subsurface layer as another solution.

As global warming proceeds, ice formation is decreasing in the Arctic Ocean. The Atlantic Water, which flows into the Arctic Ocean partly modified under ice formation in the Barents Sea, will reduce the density of the Arctic Ocean subsurface layer under global warming. The surface layer may become sensitive to vertical convection with the subsurface layer, developing plumes.

The mechanisms to increase and reduce heterogeneity are represented by divergence and convergence of the PDF, respectively. The heterogeneity is intensified by external forcing, and reduced by horizontal diffusion. Convection with the subsurface layer tends to concentrate the PDF to its (*T, S*). As either the heterogeneity is doubled, or the subsurface layer is freshened by 0.1, the solution near the salinity-driven state has a convected portion increased, shifting toward the convected state.

As the additional PDF box model, the inflow from the Atlantic is distributed over the higher salinity area, and then, the low-salinity water including the Pacific Water is supplied to a certain *T–S* point, mixing within the lower salinity area. In this more realistic PDF model, the convergence to the convected state shows sensitivity to the reduction in the subsurface layer density, a little more weakly than the basic PDF model. The low salinity core is retained near the Pacific Water (*T, S*), even though the higher salinity portion contains convection. The sensitivity to the horizontal heterogeneity is significantly weakened.

The PDF model tested in this study has shown that the Atlantic Water portion can be convected with plumes. Thus, the requirement of a plume-resolving model is suggested. As the next step, the PDF will be implemented in a low-resolution model without resolving mesescale eddies, and then, could be implemented in an eddy-resolving model, which does not resolve a plume in a convective region.

The reference is given as Ikeda (1997), *J. Phys. Oceanogr.*, **27**, 2576-2589.

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