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Submesoscale resolving simulations with second order turbulence closure

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Submesoscale processes play an important role in breaking down the balance transferring energy to smaller scales (Capet and McWilliams 2008 a,b,c). These flows are characterized by O(1) Rossby numbers and O(1) Richardson numbers indicating ageostrophic flow (Thomas et al., 2006). They can result in high vertical exchange between the mixed-layer and the interior, significantly higher than fluxes due to mesoscale eddies that were previously thought to be responsible for most of the biological production in the upper ocean. This study considers the influence of turbulent mixing on the evolution of submesoscale structures. A three-dimensional non-hydrostatic Process Studies Ocean Model (PSOM) (Mahadevan and Tandon 2006) is coupled to the one-dimensional General Ocean Turbulence Model (GOTM) (Burchard and Bolding 2003).

An appropriate second order closure scheme is chosen using idealized numerical experiments. Idealized wind entrainment experiments including the rotation of the Earth using GOTM, are compared against the Pollard, Rhines and Thompson (1972) (PRT) model results as well as with Price, Weller and Pinkel (1986) (PWP) results. For both of these sets, the k-epsilon turbulence closure scheme with Canuto A and B sets of coefficients is found to be most appropriate, in accordance with the non-rotating numerical results of Burchard and Bolding (2001). We also conduct experiments with diurnal cycle and compare these results against idealized experiments with the PWP model.

We next analyze sub-mesoscale resolving experiments with the k-epsilon closure that allow horizontal frontal gradients in the upper ocean, with initial conditions of Mahadevan and Tandon (2006) and Fox Kemper *et al.* (2007). The vertical fluxes at the edges of mesoscale eddies are found to be sensitive to the depth of baroclinicity of the fronts.

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