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The Vertical Transport in the Ocean: a Pump Driven by Meso and Submesoscale Structures

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The upper ocean can be considered as a vehicle for the exchange of gases between air and the deep ocean. Furthermore, the transport of nutrients through the mixed layer occurs via a combination of biogeochemical and physical pumps; both of these mechanisms play a fundamental role in the carbon cycle.

In the surface layer phytoplankton convert carbon dioxide into organic compounds using nutrients and light. Nutrients, which are depleted at the surface, can be transported into the mixed layer by vertical motion; recently, it has been discovered that this vertical transport is more often associated with submesoscale fronts of O(10) km (rather than inside mesoscale structures, of O(100) km, like eddies). At the submesoscale fronts, rates of O(100) m day^{-1} can emerge, particularly high compared to values of 10 m/day found at the mesoscales [M. Lèvy, et al. *J. Mar. Res.*, 2001]. At this fine scale, the vertical transport of nutrients is highly effective, upwelling waters from the depth rich of nutrients and downwelling depleted waters from the surface.

The fine-scale vertical transport mechanism has recently become of great interest, though is not completely understood. We investigate the dynamics and the transport of tracers at the meso and sub-mesoscales by running numerical simulations with a domain of 1024 km x 512 km x 1600 m, at 3 different resolutions: 8 km, 4km and 1km. We use the MIT general circulation model with free surface, linear bottom drag and free slip condition at the north and south walls. Non-linear 3^{rd} order advection scheme and biharmonic viscosity are applied. Furthermore, the fluid is forced by a constant zonal wind stress. The flow is zonally periodic and presents an idealized topography. We started from an initial vertical stratification and run the model to reach an equilibrium flow state. A passive tracer is released after the equilibrium is reached. We investigate how the fine scales are affecting the rate of vertical transport and the distribution of the tracer. We show that also the presence of the topography has an impact in driving this transport. Furthermore, the model can run in a non-hydrostatic configuration, allowing us to investigate the effect of this parameterization on the transport.