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Assessment of vertical and horizontal mixing schemes in eddy-permitting and eddy-resolving simulations with the NEMO model in shelf-sea applications

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We evaluate the capability of the NEMO model to represent vertical and horizontal mixing in eddy permitting and eddy resolving simulations, a with a focus on shelf sea environments. For this purpose two NEMO configurations are used: NEMO-shelf Atlantic Marginal Model with 7 km resolution (AMM7v3.2; O'Dea el al 2010) provides a realistic application to a broad tidally active continental shelf and GYRE v3.4 with 0.1o and 1/40o resolution provides a more idealised case. To avoid artificial mixing due to advection, the Piecewise Parabolic Method has been employed both for vertical and horizontal advection.
Five different parameterizations of vertical mixing have been tested. Three of them are already available in NEMO: (a)TKE (turbulent kinetic energy scheme),(b)-(c) GLS (generic length scale scheme) with k-ε closure and Canuto A and Kantha-Clayson ,1994 (KC) structural functions. Two newer vertical mixing schemes have also been implemented and tested: Canuto et al, 2012 and KC closure with constants proposed in Kantha ,2004.
For horizontal mixing, we used Smagorinsky type Laplacian diffusivity and Laplacian/bilaplacian Smagorinsky type viscosity (Griffies and Hallberg, 2000). In this case we tested the capability of model to resolve eddies and represent sharp fronts depending on the coefficient in the Smagorinsky diffusivity. In the case of AMM7 configuration the results have been compared with SCANFISH observations for 2001 in the North Sea. For Gyre simulations, representing processes in the open ocean, we compare the results of eddy permitting (1/10o) and eddy resolving (1/40o) simulations.
It has been found that TKE vertical mixing scheme is much more diffusive in comparison with all GLS simulations. For GLS case, Canuto schemes gives more realistic mixed layer depth in comparison with SCANFISH data with while KC closures represents better the width of pycnocline.