On the effect of different grid resolutions and mixing schemes on vertical dynamics in coastal ocean models: a case-study in a shallow, semi-enclosed basin (northern Adriatic Sea)

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The northern Adriatic Sea (located in the northernmost part of the Mediterranean Sea) is a Region Of Freshwater Influence (ROFI), since the discharge from the Po River and other minor contributions play a significant role in determining its dynamics. Other peculiar features are a shallow bathymetry, strong atmospheric forcing, mainly related to the Bora and Sirocco wind regimes, and tidal motions in peripheral environments, such as the Venice Lagoon. These drivers make the northern Adriatic Sea one of the dense water formation sites of the Mediterranean.
Vertical dynamics influences mesoscale variability and contributes in shaping horizontal properties: for example, thermohaline stratification determines the Rossby radius of deformation, which amounts to a few kilometers in the northern Adriatic and require eddy permitting models featuring a resolution high enough to fully capture the mesoscale.
In this work, we investigate the role of different vertical mixing parameterizations and grid discretizations in hydrodynamic modelling. In particular, we explored the capability of different implementations of the MITgcm model to represent and reproduce the vertical structure of the water column. We ran a series of numerical experiments: firstly, we analyzed a batch of tests on periodic boundary idealized “boxes”, to evaluate the effect of different mixing schemes and vertical grids. Four of the setups have been selected and adopted for a series of 5-year long simulations of northern Adriatic hydrodynamics, forced by the atmospheric fields from the COSMO model, with initial and open boundary conditions provided by the Copernicus Marine Service Mediterranean Physics Reanalysis products. River discharge rates come either from climatologies or available flow rate data.
As expected, the increased vertical resolution shows a better agreement both with SST from satellite and in situ profiles of temperature. After the preliminary tests on different vertical parameterizations, we identified two mixing schemes with the best performances. The turbulent kinetic energy mixing scheme (GGL90) reduced the skill score values (bias, RMSD) along the entire water column; it is noteworthy that this scheme shows good results even at the coarser resolution, at times outperforming the other selected scheme (KPP), even when using the high resolution grid.
The improved representation of the vertical structure entails an increased accuracy in reproducing mesoscale dynamics, through a novel assessment of spatial and temporal variability of the Rossby radius of deformation.
Such a detailed representation of the scales of motion is essential to properly describe coastal processes in marginal seas, such as the northern Adriatic, for both physics and biogeochemistry.