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The impact of the vertical discretization scheme on the accuracy of a model of the European north-west shelf

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The choice of the vertical coordinate system is the single most important factor affecting the quality of ocean model simulations (e.g. Griffies et al. 2000). This is especially true in regions such as the European North-West Shelf (NWS), where complex ocean dynamics result from the combination of a variety of multi-scale physical processes.

As part of the Copernicus Marine Environment Monitoring Service, the Met Office runs an operational coupled ocean-wave forecasting system of the NWS. The ocean model employed is a regional implementation of NEMO hydrodynamic code (Madec 2017), further developed by both the Met Office and the National Oceanography Centre under the umbrella of the Joint Marine Modelling Programme (JMMP). Here we describe the work of the JMMP group in assessing the impact of different vertical coordinate systems on the accuracy of the solution of the free-running NWS ocean model.

Five different vertical discretization schemes are compared: i) geopotential z-levels with partial steps, ii) s-levels following a smooth version of the bottom topography using either the Song & Haidvogel (1994) or iii) the Siddorn & Furner (2013) stretching functions, iv) the hybrid Harle et al. (2013) s-z with partial step scheme, and v) the multi-envelope s-coordinate system of Bruciaferri et al. (2018). Three different type of numerical experiments with increasing level of complexity are conducted: i) an idealised test for horizontal pressure gradient errors (HPGE), ii) a barotropic simulation forced only by the astronomical tides (TIDE) and iii) a fully baroclinic simulation using realistic initial condition and external forcing (REAL).

Numerical results of the HPGE test show that s-levels models develop the highest spurious currents (order of cm/s), the multi-enveloping method allows relatively reduction of the error of pure s-levels grids while z-levels with partial steps or the hybrid s-z scheme are affected by the smallest error (order of mm/s). The TIDE experiment reveals some differences between the models for amplitude and phase of the major tidal components. Preliminary results of the REAL experiment show that models differing only in the vertical discretization schemes broadly represent the same general ocean dynamics, although presenting non-trivial differences in the active tracers and flow fields especially in the proximity of the shelf-break.

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