The Denmark Strait Overflow seen from different vertical grids in a high resolution context

Colombo P.[1], Barnier B.[1], Penduff T.[1], Molines J.-M. [1]
Chanut J. [2]
Deshayes J. [3]

[1] Institut des Géosciences de l'Environnement (IGE), Saint-Martin-D'Hères, France
[2] Mercator Ocean, Ramonville Saint Agne, France
[3] Laboratoire d'Océanographie et du Climat (LOCEAN), Paris, France.

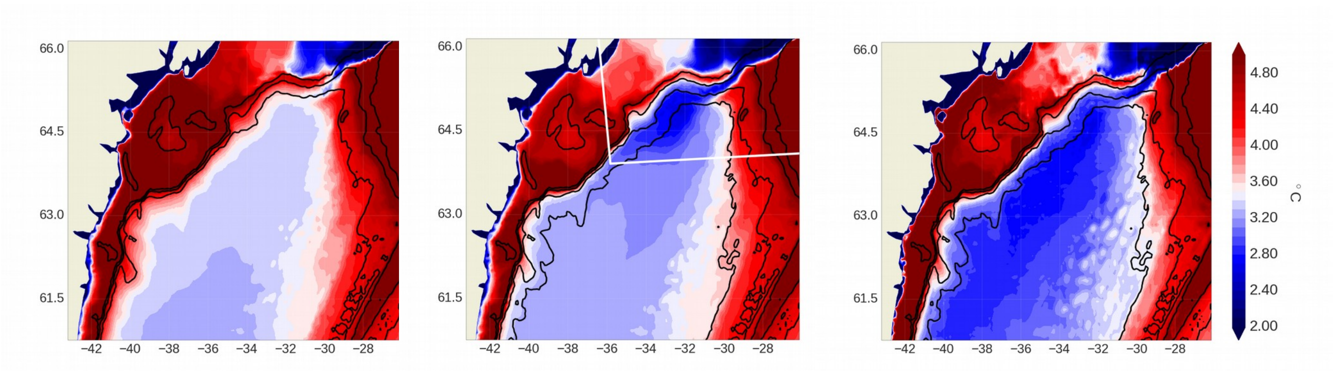
Overflows play an important role distributing the heat and salt fluxes in the ocean, feeding deep boundary currents and most of the world ocean deep waters. Therefore, an unrealistic representation of overflows in global models may have impacts over many aspects of the simulated state of the ocean.

To achieve a realistic representation of overflows is still a challenge for ocean modelling. This work addresses this problem using the community ocean general circulation model NEMO with a regional configuration of the Denmark Strait Overflow (DSO) at eddying resolutions. This work first proposes a definition of the DSO in order to characterize its associated water masses and to find the main caveats in a control simulation that uses the most standard parameters of the commonly used global configurations of NEMO (e.g. Drakkar configurations).

Thanks to this definition we then study the impacts on the DSO of a large number of model parameters through a range of eddy-permitting to eddy-resolving resolutions (e.g. 1/12° and 1/60°) in the classic z-coordinate system used in NEMO. Main findings were found increasing the horizontal and vertical resolution, but most model parameters have no significant impacts. In particular it was found that increasing vertical resolution without using a coherent horizontal resolution degrades the solution. The main reason is the EVD parameterisation that propagates the dense vein of fluid along a grid-slope, instead the topographic slope. Coherent and very high resolution both in the horizontal and in the vertical is needed in order to resolve Ekman bottom boundary layer dynamics and keep the EVD localized to the very bottom.

We also study the representation of the DSO with a hybrid terrain-following (s) and geopotential (z) coordinate system and obtained considerable improvements for a relatively small increase in computational cost. Finally, we propose a mixed s-z vertical coordinate that relies on a local implementation of s-coordinates within the z-coordinate model, limited to the area where DSO waters are produced. This local implementation is such that it minimizes the effects of pressure gradient errors linked to this type of coordinate, smoothly connects to the global z-coordinate, and does not add any significant computational cost. The improvement of the DSO is found to be drastic.

This work emphasizes the utility of adapting the vertical coordinate system to the main physical problem. A modeling challenge would be to have a vertical coordinate system that is locally adapted to the most critical ocean processes.



Annual mean bottom temperature of the last year of a 5 years simulation. From left to right: z-coordinate partial cell 1/12° 46 vertical levels, z-coordinate partial cell 1/12° plus local refinement (1/60°) 300 vertical levels, regional terrain following coordinate 1/12° 75.