SMALL-SCALE PROCESSES IN THE MEDITERRANEAN SEA DEEP CONVECTION AREAS : A NUMERICAL STUDY THROUGH NESTING APPROACH

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Abstract

Two-ways nesting approach using a regional Mediterranean configuration of the NEMO model is developed to study key areas of deep winter convection, including mechanisms such as pre-conditioning, mixing and spreading at mesoscale in other parts of the basin. Inter-annual variability of the convection is evaluated as well as the impact of explicitly resolved mesoscale structures on the general thermohaline circulation. Results show an increase of the convective volume and a large impact on the spreading dynamics of newly formed deep waters.

Keywords: Water convection, Circulation models, Mediterranean Sea

Oceanic circulation of the Mediterranean Sea is mainly driven by two important processes : the surface circulation of Atlantic buoyant water along the southern coasts [1] and the winter deep convection in several locations of the northern part of the basin : North-Western sub-basin, Adriatic Sea and Aegean Sea [2]. The latter is a key process impacting the long term general thermohaline circulation of the Mediterranean Sea by redistributing the water masses throughout the whole water column and playing a major role in the ventilation of surface waters. Convection also plays a major role in the ventilation of surface water and therefore is crucial for ocean heat and CO2 uptake in a context of climate warming.

Recent progress in observation networks have highlighted the formation of submesoscale coherent vortices at the end of the convection episode [3] implying the need to provide new insights regarding the mechanisms at small-scales involved in the turbulent mixing of surface waters and the subsequent export of newly formed water mass outside of the convection area. Those structures could last several months and therefore potentially impact the spreading of intermediate and deep water masses. More generally, (sub) mesoscale features are expected to account for a significant part of the deep convection inter-annual variability. Therefore, this study aims to explore the impact of such structure on the deep-convection and in fine on the general thermohaline circulation.

To tackle this problem, eddy resolving models are needed. However even for regional configuration such as the Mediterranean Sea, the cost of high resolution simulation over several decades to study long-term variability is still high. We therefore follow a two-ways nesting approach, ie inside a low resolution (eddy-permitting) simulation, key areas are modelled using a higher (eddy-resolving) resolution and both part of the domain are interacting with each other. This approach allows us to explicitly resolve mesoscale dynamics inside defined area (downscaling) and to diagnose the feedback of this dynamics outside of the high-resolution area (upscaling). We use a mediterranean regional configuration of NEMO general circulation model at 1/12^{o} resolution (NEMO-MED12 [4]). We take advantage of the Adaptative Mesh Refinement module AGRIF [5] included in NEMO to implement two-ways nested domain at 1/36^{o} resolution. Nested domain are defined in the largest convection area of the Mediterranean Sea *i.e.* Gulf of Lion, Adriatic Sea and Aegean Sea. Several simulations covering the 1979-2013 time frame are carried-out : a control case without nesting, a set of 3 simulations with a single nested domain in one of the convection area and a simulation with the 3 nested domain altogether. Challenging those simulations allows us to determine the contribution of each area in the formation of deep and intermediate water.

Numerical studies [6] using a nested domain in the Gulf of Lion to reproduce one particular convection event, have shown a large impact of mesoscale structures on the resolution of the pre-conditioning and mixing stages of the convection leading to a 36% average increase of the convective volume. It is expected that the explicit resolution of mesoscale dynamics in area of intense winter convection will strongly impact the export/spreading of deep and intermediate water. An example of such transport by mesoscale eddies is shown in Fig. 1 for the Gulf of Lion area for simulations at 1/12^{o} and 1/36^{o}.

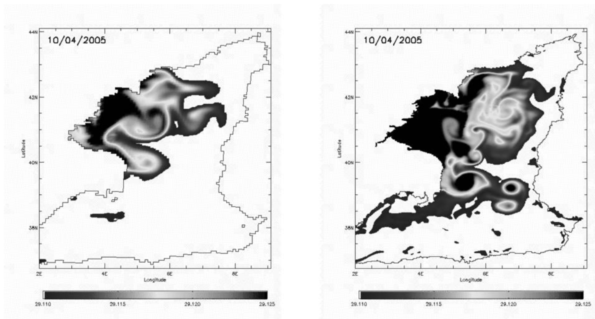

Fig. 1. Density at 2000 m depth at the end of a convection event in 2005 showing the spreading of deep water in the western mediterranean basin for (left) the control case at 1/12 resolution and (right) a simulation at 1/36 resolution (NEMO-MED36) of the Mediterranean Sea.

Future works will be devoted to achieve the resolution of ~1km and explicitly resolve the submesoscale coherent vortices (SCVs) and filaments by implementing several levels of nested domains.

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