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Transport across and along the shelf induced by coastal eddies

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Coastal areas are of great importance for human activities and marine ecosystems. Coastal flows play a predominant role in the spreading of pollutants and in the distribution of nutrients. For instance, the Algerian Current and the Libyo-Egyptian Current in the southern Mediterranean are well-known examples of coastal currents. They are characterized by mesoscale and submesoscale structures (meanders, eddies, filaments) flowing above complex bathymetry (slopes up to 10%, rapid changes in slopes). These mesoscale features are mainly the result of coastal currents instabilities and their dynamics are important components for vertical mixing between the deep ocean and the surface euphotic layer, and for the horizontal cross-shelf transport of geochemical species from the coast to the open ocean. However, a steep shelf topography may strongly modify the stability, the wavelength selection of unstable perturbations and therefore the size and the trajectories of surface eddies. This work is therefore dedicated to the study of the impact of the bathymetry on the dynamic leading to the eddy formation and the mesoscale shelf-sea transport.

First, in the NEMO ocean general circulation model (OGCM), we implemented an idealized two-layer configuration in a circular basin, similar to rotating tank experiments, in order to mimic a surface current above a quiescent deep ocean. Linear slopes are added in the bottom layer to represent the oceanic bathymetry. The high resolution of the horizontal grid (10 grid points by baroclinic deformation radius) allows the model to resolve mesoscale features. Secondly, we performed some laboratory experiments and we used standard particle image velocimetry (PIV) technique to make quantitative comparisons with the numerical runs.

We show that the topographic parameter To (ratio between the shelf slope and the isopycnal slope) is the relevant parameter to quantify the shelf slope impact on the linear stability and the non-linear dynamics of the surface current. For finite or large value of To the surface current tends to be stabilized above the steep shelf and smaller scale eddies are formed in good agreement with the linear stability analysis. At the non-linear stage, the bathymetry induces a secondary splitting of vortices and smaller submesoscale vortices are generated over the shelf slope. The bathymetry also modifies the eddy trajectories and tends to inhibit the cross-shelf transport. We investigate though the impact of the shelf slope on the shelf-sea transport by means of lagrangian particles launched in the core of the current and tracked along their trajectory.