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Dispersion of homogenized water plumes in coastal areas : The Ushant Front

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Coastal areas boarding the Bay of Biscay and the Channel are marked by tourism, economical, scientific, and military activities, and count remarkable environmental marine reserves. The Ushant front evolution is one of the coastal processes of interest in the area. Understanding the dispersion processes of the mixed water plumes in coastal, stratified fluid areas, and their sensitivity to seasonal and local parameters is a preliminary and compulsory analysis before real modeling. Realistic simulations of the Ushant Front aim to understand the evolution of the front, and to assess weaknesses of the model to represent this particular aspect of the process.

Several academical experiments are carried out, consisting in continuously homogenizing a water column (the ZMP) situated in the middle of a centered domain or near the eastern boundary of a rectangular domain of stratified fluid. The sensitivity of processes of dispersion to configuration parameters such as topography, vertical diffusion, bottom friction, and stratification are assessed.
Realistic experiments and comparison of the Ushant Front egdes with in situ and satellite data are presented.

The shallow water model MICOM (Miami Isopycnal Coordinate Ocean Model) is used for academical studies, with a four layer stratification. Potential vorticity anomaly is used as a tracer of the mixed waters, and calculated dispersion rates and scale analysis indicate the evolution of dispersion and baroclinic instability production as a function of the varying parameters. The realistic model HYCOM (Hybrid Coordinate Ocean Model) is used to represent the Ushant Front between 2008 and 2010.

Mixing produces baroclinically unstable structures rapidly forming vortices, often constituting baroclinic dipoles or hetons. On the f-plane, with a slope gradient directed positively eastwards, topographic effects guide vortices northwards and then zonally, creating a tree shape plume of mixed water. When mixing is produced against an eastern wall, mirror effects and a thin Kelvin current contribute to propagate cyclonic vortices northwards along the boundary. Under topographic and coastal effects, the dynamics adopts a regime where undulatory and auto-propagative mechanisms conjugate to trap all the mixed water in a plume northwards. Diapycnal mixing entrainment dictates the production rate. The ratio between the homogenization rate of the ZMP and the dispersion mechanisms intensity delimits two dynamical regimes for respectively low to high vertical diffusion coefficients : a sub-productive regime where vertical diffusion limits the dispersion rate, and a self-restrictive regime where dispersion mechanisms dictate the propagation of homogenized waters. A decrease of stratification has two counteracting effects on the propagation of the dipolar structures emerging from the ZMP: their size is reduced but the coupling between layers is reinforced. The latter effect is not strong enough so that baroclinic instability and homogenized water dispersion is inhibited when the stratification is reduced. Bottom friction significantly impacts the dynamics in our configuration. It annihilates the bottom layer circulation and the dynamics is close to a reduced gravity situation where the barotropic mode is inhibited. This drastically modifies the transport properties of the vortical structures and reduces dispersion.

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