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Numerical study of shear layers and von Karman streets in rotating shallow water

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To investigate shear layer and vortex street instability of flows beyond the deformation radius, we performed numerical simulations for quasigeostrophic and frontal geostrophic regimes.

We use a pseudo-spectral code to integrate the rotating shallow water equations. To take into account the obstacle, we implemented a volume penalization method in the shallow water code. This method consists in considering the whole domain as one porous media with permeability variying in space, zero in solid body and one in the fluid. This enables to consider complex geometry with a cartesian mesh grid.

To validate the implementation of such a method in a shallow water code, we compare the numerical simulations with laboratory experiments. The same features are found in both cases. As the deformation radius becomes smaller than the size of the obstacle, a double shear layer develops in the wake and remains stable several diameters behind the cylinder. The double shear layer is found to be asymmetrical and its destabilization leads to the formation of a highly non symmetric vortex street. Cyclones are elongated and distorted whereas anticyclones remain circular.

The same cyclone-anticyclone asymmetry is observed in destabilization of large scale double shear layers. To determine the source of this asymmetry, we analyse the linear stability of a double shear in both quasigeostrophic and frontal geostrophic regimes. Nonlinear saturation is determined thanks to numerical simulations. Numerical study enable to investigate a wide range of parameters, specially asymptotical regimes, and to identify the relevant controlling parameters.