Life cycle of small vortices generated by a vortex row in semi enclosed gulfs

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Résumé

The Gulf of Oman and the Gulf of Aden are intermediate basins which receive the outflows of salty water from the Persian Gulf and from the Red Sea, but also the waves and eddies from the Arabian Sea. These outflows settle at 250-300m and 600-1000m depths, respectively. The surface eddies in these two gulfs are dynamically deep reaching, and they strongly perturb these deep outflows. In the absence of these eddy fields, these two outflows should follow the coasts of Oman or of Somalia. But these eddies divert their paths away from the coast, advect them along curved trajectories around the eddy rims, elongate these outflows as salty filaments into these two gulfs and finally, can break these filaments into small eddies. Filaments and small eddies can also originate from the instability of upwelling fronts. Here we study the generation of small scale eddies and filaments by the larger eddies, to the mechanisms which underlie them and their lifecycle. To this end, we used in situ data and a primitive equation model (ROMS). Vic et al. (2015) studied the case of a mesoscale dipole, here we consider a vortex row with alternated polarities as revealed by satellite observations during the 2011 spring inter-monsoon. A continental slope exists north and south of the domain, parallel to these coasts. The eastern and western boundaries of the domain are open. It is shown that a) the large surface eddies rub on the slope and create a friction boundary layer b) this boundary layer detaches from the slope, advected by the vortex flow ; it then forms a filament c) this filament undergoes horizontal shear instability and forms a chain of small (submesoscale) eddies d) these small eddies are close and can merge ; thus they grow and become more resistent to the ambient shear created by the large vortices e) these small eddies are then advected around the large eddies towards the exit of the channel (of the gulf). This advection can be achieved by the larger eddy flow, or by dipolar coupling with opposite signed vortices. The small eddies often end up either sheared out by the ambient flow, dispersed by waves on the slope or merged into large eddies. As a result, these eddies have a maximal radius of 20 km and a maximal lifetime of 3 months. These characteristics are compatible with the available measurements at sea in this region.

Mots-Clés: mesoscale eddies, submesoscale vortices, topographic effect, frictional boundary layer, horizontal shear instability, vortex characteristics and lifetime, application to the Gulf of Oman and to the Arabian Sea.

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