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Influence of deep vortices on the ocean surface

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The oceanic motion at mesoscale (20-200 km) and submesoscale (0.5-20 km) is highly populated by vortices. These recirculating structures are more energetic than the mean flow, they trap water masses from their origination areas and advect them across the ocean, with consequent impact on the 3D distribution of heat and tracers. Mesoscale and submesoscale structures characterize the ocean dynamics both at the sea-surface and at intrathermocline depths (0-1500 m), and are presently investigated by means of model outputs and satellite (surface) data, the latest being the only way to get high resolution and synoptic observations at planetary scale (e.g., thermal-band observations, future altimetric observations given by the SWOT mission). The scientific question arising from this context is related to the role of the ocean surface for inferring informations on mesoscale and submesoscale vortices at depth. This study has also been motivated by the recent detection of subsurface eddies east of the Arabian Peninsula (PHYSINDIEN experiment - 2011).

Using analytical models in the frame of the quasi-geostrophic (QG) theory, we could describe the theoretical altimetric signature of non-drifting and of drifting subsurface eddies. Numerical experiments, using both QG and primitive equations models, allowed us to investigate the surface expression of intrathermocline eddies interacting with baroclinic currents or evolving under planetary beta-effect. The eddies' characteristics (radius, depth, thickness, velocity) were varied in order to represent various oceanic examples (Meddies, Swoddies, Reddies, Peddies, Leddies). Idealized simulations with the ROMS model, confirming theoretical estimates, showed that drifting subsurface-intensified vortices can induce dipolar sea level anomalies, up to 3 cm. This result, compatibly with future SWOT measurement accuracies (about 2 cm), represents a contribution for systematic and synoptic detection of subsurface vortices.