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Detection of subsurface-intensified eddies from observations of the sea-surface: a case study for Mediterranean Water Eddies in a long-term high-resolution simulation

Daniele Ciani (1,2), Xavier Carton (2), Ana Claudia Barbosa Aguiar (3), Alvaro Peliz (4), Igor Bashmachnikov (5,6), Federico Ienna (4), and Bertrand Chapron (2)

(1) Consiglio Nazionale Delle Ricerche, Istituto di Scienze dell'Atmosfera e del Clima, Rome, Italy (daniele.ciani@artov.isac.cnr.it), (2) Laboratoire d'Océanographie Physique et Spatiale, Univ. Brest, CNRS, Ifremer, IRD, Brest, France, (3) Met Office, Fitzroy Road, Exeter, United Kingdom, (4) Instituto Dom Luiz, Faculdade de Ciencias da Universidade de Lisboa, Lisbon, Portugal, (5) St. Petersburg State University, St. Petersburg, Russia, (6) Nansen International Environmental and Remote Sensing Centre, St. Petersburg, Russia

Subsurface-intensified eddies are ubiquitous in the world ocean. They can be generated by exchanges of water masses between semi-enclosed evaporation basins and the open ocean or by deep convection. Past and recent studies have shown that these eddies are carriers of large amounts of heat and salt, that they are coherent over inter-annual timescales and that they can migrate for several thousands of miles from their origination areas towards the open ocean. Hence, subsurface-intensified eddies can influence the three-dimensional distribution of oceanic tracers at global scale. The synoptic knowledge of the eddies positions and mean pathways is then crucial for evaluating temperature and salinity budgets in the world ocean. At present day, satellite sensors constitute the ideal tool for the synoptic and global scale observations of the ocean. Since they only provide informations on the oceanic surface, we characterized the signatures that subsurface eddies generate at the sea-surface, to determine the extent to which they can be isolated from the surrounding surface turbulence and be considered as a trace of an underlying eddy.

We studied the surface signature of subsurface-intensified anticyclones (Mediterranean Water Eddies - Meddies) in a realistic, long-term (20 years) and high resolution simulation (dx = 3 km) based on the ROMS model. The novelty and advantage of this approach is given by the simultaneous availability of the full 3D eddies characteristics, the ones of the background ocean and of the sea-surface (in terms of sea-surface height, temperature and salinity). This also allowed us to speculate on a synergy between different satellite observations for the automatic detection of subsurface eddies from space. The along trajectory properties and surface signatures of more than 90 long-lived Meddies were analyzed. We showed that the Meddies constantly generate positive anomalies in sea-surface height and that these anomalies are principally related to the Meddy potential vorticity structure at depth (around 1000 m below the sea-surface). Such anomalies were long-lived, mostly migrated exhibiting southwestward trajectories, their intensities were O(10 cm) and extended horizontally up to more than 300 km (around 1.5 times the Meddy diameter). On the other hand, the Meddies thermohaline surface signatures proved to be mostly dominated by the local surface conditions and their structure poorly correlated to the Meddy structure at depth (e.g. the Meddy volume-integrated salt and temperature content). These results point out that satellite altimetry is the most suitable approach to track subsurface-intensified eddies from observations of the sea-surface, also encouraging the use of future high-resolution altimetric observations (e.g. SWOT) to detect subsurface oceanic motions from satellite sensors.