Multi-platform synergies for the direct investigation of ocean fronts: a case study in the North-western Mediterranean

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In the last decade, high-resolution numerical models have highlighted the key contribution of (sub)mesoscale dynamics to the ocean energy budget, tracer transport and biogeochemical cycles. At the same time, direct and quantitative observations of submesoscale processes are still particularly challenging, and many of the theoretical hypotheses and model results remain virtually untested in the field. Due to the ephemeral and localized nature of eddies, fronts and filaments, key aspects in the design of field experiments for their direct investigation include *a*) the implementation of sampling strategies optimized in near-real time to target a specific structure; *b*) the integration of multi-platform observations to contextualize the localized high-resolution observations into a larger dynamical context.

The Latex10 campaign (September 1-24, 2010) adopted an adaptive sampling strategy that included satellite, ship-based and Lagrangian observations to collect a series of sections across a thermal front in the western Gulf of Lion (NW Mediterranean). AVHRR imagery of pseudo-SST showed that the front originated from the mesoscale-induced stirring of coastal (colder) and open (warmer) waters. Their movement was tracked in-situ through the optimized deployment of a series of Lagrangian drifter arrays. The trajectories were used to localize the front axis and to define the ship route for the cross-sections. Ship-based observations identified the TS signature of the water masses across the front and provided a direct estimate of the associated currents.

Our analysis integrated the datasets from the various platforms to investigate different aspects associated with the front dynamics: i) Dispersion patterns of the drifter arrays identified and tracked in-situ Lagrangian coherent structures associated with the front. These were compared to the ones from remote sensing, evidencing limitations of satellite altimetry in the coastal region [*Nencioli et al.*, 2011]. ii) Cross-front profiles from the ship-mounted thermosalinograph were combined with strain rates from the drifter arrays to compute in-situ estimates of submesoscale horizontal diffusivity across the front, providing an important term of comparison for numerical model parametrizations [*Nencioli et al.*, 2013]. iii) Near-inertial currents retrieved from the drifter trajectories were used to correct the instantaneous currents measured by the ship-mounted ADCP. These were used to estimate the cross-shelf fluxes associated with the front, suggesting that 3 to 4 of such events are sufficient to completely renew the surface waters of the Gulf of Lion [*Nencioli et al., Submitted*].

Future (sub)mesoscale-focused field experiments can further improve the approach developed for Latex10 by extending the high-resolution observations to the first few hundred meters of the water column (e.g. through ship-towed profilers), and by including biological and biogeochemical parameters (e.g. through optical and acoustic sensors). This type of strategy and design will be crucial to provide the in-situ observations required to better understand the physical and ecological impact of (sub)mesoscale processes in the oceans, and to contribute and support the further development of numerical models and future high-resolution satellite missions.

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