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

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1. The Latex10 campaign

➔ Region of study
The Gulf of Lion (GoL)
- Large continental shelf
- Mistral/Tramontane main wind forcings:
- Northern Current dynamical barrier to cross-shelf exchanges

Latex10 campaign (1)
- September 1-24, 2010, western part of the GoL
- Adaptive sampling strategy to focus on (sub)mesoscale dynamics

➔ Remote sensing, Lagrangian and ship-based observations
• AVHRR pseudo-SST
• 14 SVP Lagrangian drifters (15-m drogue)
• Underway surface temperature and salinity
• Hull-mounted ADCP

➔ 3. Horizontal diffusivity

➔ Main hypothesis: front width from balance between two competing processes
1. Convergence by mesoscale straining \( (\gamma) \)
2. Mixing by small-scale turbulence (parametrized by eddy diffusivity \( K_v \))

\[ W(x) = \frac{T_r + T_i}{2} = \frac{T_r - T_i}{2} + \left( \frac{1}{\gamma^2} \frac{C_3}{2K_v} \right)(x - \mu) \]

Width parameter C3

➔ From front width \( (C_3) \) and strain rate \( (\gamma) \) is possible to quantify eddy diffusivity \( (K_v) \)

➔ Estimate front width and strain rate
- Front widths estimated by fitting analytical solution to 19 observed cross-front profiles of SST and SSS (left)
- Strain rate computed from exponential separation rate of Lyap01 and Lyap02 Lagrangian drifters (bottom right)
- The two are combined to obtain 76 estimates of horizontal eddy diffusivity

➔ Quantify horizontal eddy diffusivity
- Log-normal distribution
- 70% of values between 0.4 – 5 m² s⁻¹
- Front widths range from 1 to 4 km
- \( K_v \) values similar for SST and SSS fronts

2. In-situ Lagrangian coherent structures

➔ Recursive drifter array deployments
- LCS computed in near-real time from AVISO velocities (daily, 1/8 degree)
- Deployment of 3 drifter arrays (Lyap01, Lyap02, Lyap03) to investigate LCS along continental slope
- In-situ LCS from dispersion patterns

➔ Migration of in-situ LCSs and hyperbolic point tracked for two weeks
- LCS reliable diagnostic also in coastal regions
- Altimetry-based LCS show same limitations in coastal regions
- In-situ LCS associated with a strong thermal front

➔ Characteristics of the Latex10 front
- Convergence of warmer (open NW Mediterranean) and colder (western GoL) shelf water masses
- Mostly compensated
- Coastal corridor through which shelf waters left the GoL
- Multiple sections collected across the front
- Used for direct quantification of:
  ➔ Cross-front eddy-diffusivity
  ➔ Along-front cross-shelf fluxes

3. In-situ Lagrangian coherent structures

➔ 2. In-situ Lagrangian coherent structures

➔ Estimate near-inertial oscillations (NIO)

Above: NIO from Lagrangian drifter velocities (gray); residual component (red) from moving average (blue)
Right: Strong NIO after Mistral/Tramontane events (wind speed > 15 knots; wind direction from -90 to 0)

➔ Identify outflow from continental shelf and inflow from open sea
- NIO velocities removed from ADCP observations (green)
- Outflowing shelf waters (U+C) and inflowing open waters (C) from SST and SSS observations along 4 sections of the LCS

➔ Quantify cross-shelf exchanges along the front
- Total volumes exchanged within the upper mixed layer (0 to 22.8 m) during front lifetime (2 weeks):
  ➔ Outflow of shelf waters 90 km³
  ➔ Inflow of open waters 25 km³
- 3 to 4 of such events are sufficient to completely renew the upper mixed layer of the whole GoL

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References

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