Observational challenges for studying coastal eddies: an application case in the Bay of Biscay

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OUTLINE

1- OBSERVATION OF COASTAL SURFACE CURRENTS BY LAND-BASED HF RADARS

2- OBSERVATION OF COASTAL EDDIES IN THE SE BAY OF BISCAY

3- NEW APPROACHES FOR THE STUDY OF COASTAL EDDIES:
   • HIGH-RESOLUTION SURFACE CURRENTS USING SURFACE QUASI-GEOSTROPHIC (SQG) APPROXIMATION

4- CONCLUSIONS AND FUTURE WORK
- Measure total surface currents
- The temporal and time scales resolved depend mainly on the operation frequency and available bandwidth

**LAND-BASED HF RADARS**

### Typical scales

<table>
<thead>
<tr>
<th></th>
<th>SE Bay of Biscay</th>
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<tbody>
<tr>
<td>Temp. resol.</td>
<td>1 hour</td>
</tr>
<tr>
<td>10min - 3 hours</td>
<td></td>
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<tr>
<td>Range resol.</td>
<td>5 km</td>
</tr>
<tr>
<td>100 m - 12 km</td>
<td></td>
</tr>
<tr>
<td>Max. range</td>
<td>150 km (Good data)</td>
</tr>
<tr>
<td>200-300 km</td>
<td></td>
</tr>
<tr>
<td>Integration depth</td>
<td>1-3 m</td>
</tr>
<tr>
<td>10 cm - 3 m</td>
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COASTAL EDDIES IN THE SE BAY OF BISCAY

EDDIES OBSERVED BY HF RADAR AND SATELLITE IR & VISIBLE

• Case study of an eddy monitored by remote sensing and HFR during 20 days

• Similar anticyclonic eddies were observed between November and March in other years (recurrent feature in SE BoB)

• Rubio et al. discussed on the effects of the eddies in the cross-shelf export of coastal waters.

Rubio et al., 2018 RSE doi:10.1016/j.rse.2017.10.037
Surface Quasi Geostrophy (SQG)

• For a non-divergent flow it is possible to define a stream-function such that

\[ \vec{v}(\vec{x}) = \vec{e}_z \times \nabla \psi(\vec{x}) \]

• The reconstruction of surface currents from SST is possible through the SQG approximation, if the environmental conditions are appropriate

\[ \hat{\psi}(\vec{k}) \propto k^{-1} \hat{T}_b(\vec{k}) \]

Limitations of SST + SQG

- SST patterns have to be correlated to subsurface potential vorticity patterns

- Phase shifts are typically introduced by:
  - Mixed Layer dynamics (e.g. Isern-Fontanet et al. JGR 2008, JPO 2014)
  - Salinty contribution (e.g. Isern-Fontanet et al. GRL 2017)

- Geostrophic currents: no-wind, no-tides, ...
Limitations of HF radars

EXAMPLE OF HF RADAR CURRENTS IN THE SE BAY OF BISCAY

- Radiales correspondientes
- Totals km 24/05/2013 01:00
- Totals OMA km 24/05/2013 01:00

10 cm/s
Limitations of altimetry

Tracks of Jason 3 (dotted) and Sentinel 3/4 (for 2018)

Spatial distribution of the number of anticyclone cores (2011-2014)

HF radar + along-track SLA (Jason3)


Revisit period: Sentinel 3A: 23 days
Jason 3: 10 days

Kubio et al. (presented by Cristina González-Haro) | Atlantic from Space Workshop | 23-25/01/2019 | Slide 9
R = 0.97

SQG

HF Radar
R = 0.67
FUTURE WORK

• Merge SST-based information with HF radar
  • e.g. SST-phase + HFR spectra (Isern-Fontanet et al. JPO 2014, González-Haro et al. JGR 2014)
  • Others: low resolution SST (AMSR2) or L-band SSS

• Extend the reconstruction of coastal currents along the whole Atlantic coast
  • Improve gaps in HF radars
  • Retrieve currents in areas not covered by HF Radar

CONCLUSIONS

• Observed recurrent coastal eddies by a land-based HF radar in the SE Bay of Biscay play a significant role in the export of coastal waters towards the open ocean (Rubio et al. 2018).

• Their observation using satellite measurements and radar HF is possible but limited by the discontinuous coverage and/or resolution of the data.

• The SQG approximation on visible and satellite IR data allows to retrieve the 3D dynamics of eddies (under appropriate environmental and dynamical conditions).
CONCLUSIONS

• These eddies could play a very significant role in the transport of water masses in the Atlantic. In the absence of an extensive HF radar network along the basin coast, the combined use of HF radars and remote sensing maps to extract dynamic information on these coastal processes emerges as a promising approach.
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