Signature of Coastal Dynamical Processes in Satellite Altimetry

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Objectives

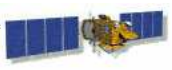
To evaluate the observability and signature of two slope currents, in present altimetric data.

Approach

Characterizing the signal in near-coastal altimetric measurements for high- frequency (typical of shelf and slope processes) to much slower motions (resulting from the open ocean circulation influence):

. In the Northwestern Mediterranean Sea → analysis of the spatial and temporal variability of the Liguro Provençal Current (LPC) system from interannual to intraseasonal time scales

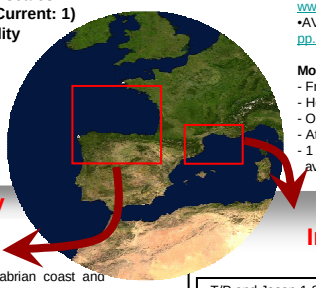
. In the Bay of Biscay → two complementary studies on progress on the Navidad Current: 1) seasonal to interannual signature from 15 years of data; 2) high frequency variability over the year 2004.



Tools

- **Along-track altimetric data and satellite SST observations**
- **Simulation from a numerical high resolution regional model (Symphonie)**

These studies are part of the 'Multisensor Impact assessment in Coastal and Shelf Seas' (MICSS) 2008 OST project (PI: P. De Mey; Co-Is: N. Ayoub, F. Birol, J. Lamouroux and F. Lyard).



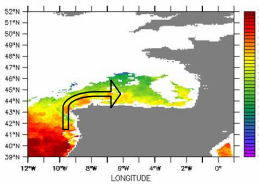
Data and model

Altimetric data
TOPEX/Poseidon and Jason-1 along track data, processed through the X-Track software (Roblou et al.,2007; Birol et al., 2008) developed at LEGOS and dedicated to coastal and marginal seas applications.

Satellite SST data
•AVHRR Pathfinder 5,Terra/Aqua MODIS daily night-time products provided by www.podaac.jpl.noaa.gov (Vasquez et al, 1998); spatial resolution: ~4km.
•AVHRR daily interpolated fields (R.W Reynolds et al., 2007): (http://ghrsst-pp.metoffice.com).

Model: primitive equations SYMPHONIE model (Marsaleix et al., 2006)
- Free surface, generalized sigma coordinates, include tides
- Horizontal resolution: 3km, 43 vertical levels
- Open boundary conditions: MERCATOR simulation
- Atmospheric forcing: 3 hourly ALADIN (METEO-France) fields
- 1 year of Symphonie simulation (Jan-Dec 2004); model outputs = daily averages.

Signature of the Navidad Current in the Bay of Biscay



The Navidad Current in the litterature :

- A **warm**, salty current flowing **eastward** along the Cantabrian coast and coming from the Portuguese coast
- Appears between **October and March.**
- Influence to **depth 1500m**.
- Velocity ~ **0.15 m/s**

(*Garcia-Soto et al. (2002); Friocourt et al ,(2007)*)

Fig. 1: SST observations for 14th January 2003 showing temperature along the Cantabrian coast warmer than in the rest of the basin (~+1°C) likely associated to the presence of the Navidad Current. Units are in °C.

Seasonal to interannual variability *(M. Le Henaff, J. Bouffard)*

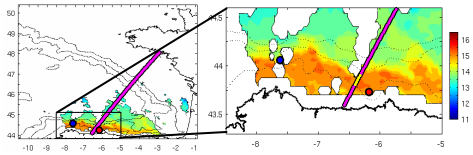


Fig. 2:
Left: SST measurements from AVHRR from Jan 8, 1996, over the Bay of Biscay, together with Topex/Poseidon track 137 (purple points), Estaca de Bares buoy (blue) and Cabo de Penas current meter (red). 200m, 2000m and 4000m level depths are in dotted lines. Right: zoom on the zone of interest: the yellow points along the T/P track are the points on which the slope current is evaluated from altimetric data.

Approach:
- **Coastal oriented processing** of the 10Hz SSH measurements (X-track, Roblou et al. 2007) :
  SLA = SSH – mean(SSH) – tides – IB – high freq. barotropic signal
- **Across track geostrophic current anomaly** : v= g/f * dSLA/dl (l=along track distance)

Results
- Good **agreement** with ***in situ* observations** (Fig 3)
- Monthly averages from mid-December to mid-February : **agreement** between **slope warm SST anomalies** and **accelerated current** (Fig 4, red circles: referenced intense Navidad occurrences)

Perspectives:
- Find sources for inconsistencies between *in situ* and remote sensing measurements to improve altimetric data treatment
- Use Jason 1 data after 2002
- Use other tracks, and study Armorican slope current (north of the BoB)

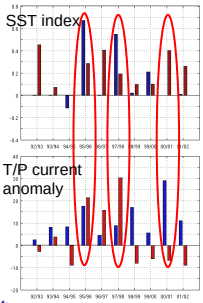


Fig. 3:
Across track geostrophic current (cm/s) on T/P track 137, on the top slope (black), compared to 2 day filtered surface zonal current at Estaca de Bares buoy (blue) and 2 day filtered 60m depth zonal current at Capo de Penas (red). In situ data kindly provided by Puertos del Estado (http://www.puertos.es/es/oceanografia_y_meteorologia/index.html).

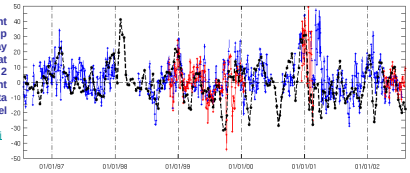


Fig. 4:
Top: SST anomaly (°C) along T/P track 137 between the top of the slope (200m to 1500m depth) and the neighboring area (up to 44.5°N), averaged from mid-December to mid-January (blue columns) and from mid-January to mid-February (red columns), from AVHRR available daily data.
Bottom: Same but for the across track geostrophic eastward current anomaly (cm/s) calculated along the T/P track 137 on the top of the slope (200m to 1500m depth).

High frequency variability in 2004 *(G. Herbert, N. Ayoub)*

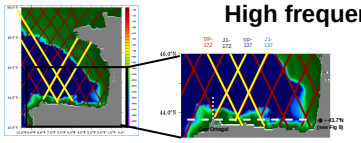


Fig.5: Domain bathymetry with T/P and Jason-1 tracks.

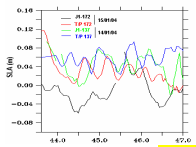


Fig. 6 : SLA (m) from 43.6 to 47°N along 4 tracks on Jan 14 and 15 2004.

→Evidence of an eastward acceleration along the coast
→ Large variability between consecutive tracks

Altimetric data **T/P 172 Track** **Model SLA**

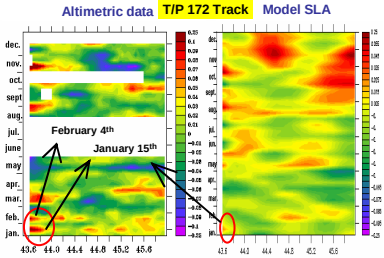


Fig. 7 : SLA (m) along the T/P 172 track from Jan to Dec 2004, between 43.6 and 46°N, from the altimetric data and from the model (same space and time sampling along the track than the altimetric data).

- **What is the signature of the Navidad Current in altimetric data in winter 2004?**
- **Is it consistent with SST signals ? With a high resolution simulation?**

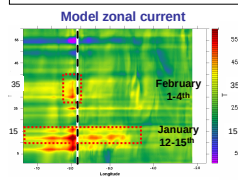


Fig. 8 : Zonal current anomaly (m/s, eastward when positive values) from the SYMPHONIE model and SST (°C) from daily AVHRR interpolated fi elds along 43.7°N between 10°W and 1°E from Jan 1 to Mar 31 2004. The black dotted lines correspond to Cap-Ortegal location (see also Fig 5).

Consistent signal corresponding to the signature of the Navidad current in the altimetric data, in the model and SST observations close to the Iberian coast around Jan 15 and Feb 4:

Fig. 8→ High frequency variability made of pulses of eastward current associated.with warm water spreading along the Iberian coast around the same dates.

Fig. 7→ - Eastward geostrophic current anomaly (red circles) around Jan 15 and FEb 4.
- Larger high frequency variability of SLA in the data than in the model.
- Higher values of SLA in the data.

- **Navidad 'events' have a signature in altimetric data.**
- **Analysis of altimetric+SST+model suggests a large variability on short time scales (O(1day)): is it specific to 2004?**
- **Future work: extend the study to 2003 and 2005.**

Signature of the LPC In the Northern Mediterranean sea

(F. Birol, M. Cancet)

- T/P and Jason-1 SLA data have been extracted from Jan. 1993 to Oct. 2007 (the distribution of selected tracks over the area is shown in Fig.9)
- Comparison between tide gauge and altimetric SLA → Good agreement near the coast for both the seasonal cycle and the high frequency signal (see poster n°56 by Birol et al.)
- Cross-track geostrophic velocity anomalies have been computed from along-track SLA gradients
- A monthly mean velocity climatology is constructed

Objective: analyze the potential value of *altimetric* data in the observation of the Liguro-Provençal-Catalan (LPC) coastal current variability

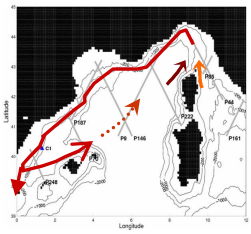


Fig 9: Liguro-Provençal-Catalan Current circulation and distribution of selected tracks. Descending tracks appear to be approximately perpendicular to the direction of the LPC. The 200-m, 1000-m and 2000-m isobaths are also highlighted.

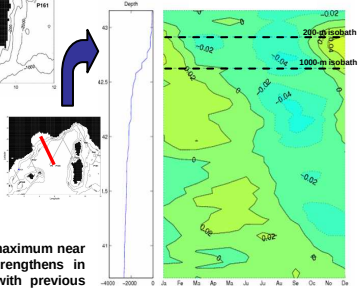


Fig.10: Seasonal evolution of the cross-track geostrophic velocity anomalies along pass 146 (in m/s). The 200-m and 1000-m isobaths are highlighted. Positive values mean an increase of the current speed in the southwestward direction.

→ The seasonal variability is maximum near the shelf break, the LPC strengthens in winter, which is consistent with previous knowledge

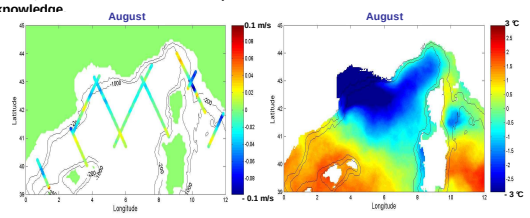


Fig. 11: Monthly climatological maps of cross-track geostrophic velocity anomalies (left) and of SST anomalies (right) for August and December. Monthly SST anomalies have been constructed by removing the average monthly mean over the domain. The SST data set covers the period Nov. 2004 – Oct. 2007. They were provided by the European Medspiration project.

→ The winter SST pattern shows a steep thermal front over the shelf break that separates the relatively warm waters of the LPC current from the colder upwelling waters spreading from the Gulf of Lion.

→ A consistent regional picture of the seasonal evolution of the boundary flow emerges : intensification (decrease) of the boundary flow in winter (summer).

→ Perspective: study of the interannual variability.

Acknowledgment: Many thanks to P. Marsaleix P (www.poc.obs-mip.fr) for the Symphonie simulation.

References:
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- **Roblou L.,** F. Lyard, M. Le Hénaff and C. Maraldi (2007): X-TRACK, A new processing tool for altimetry in coastal oceans, *Proc. ENVISAT Symposium*, Montreux, Switzerland.