# Investigating the Bay of Biscay mesoscale dynamics from a combination of satellite observations.

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**SUMMARY :**
The Bay of Biscay is a complex environment with a chaotic topography and a wide range of ocean dynamics. Here we study the observability of the mesoscale activity from altimetry and other data sets.

## I. The data

For this study we used multi-mission gridded SLA over a period from October 1992 to December 2007. Merged SLA grids were produced by **SSALTO/DUACS** and distributed by **Aviso** with support from CNES. Along-track data have been processed using the X-track processor (Roblou et al., *in rev.* [1]), including up-to-date geophysical corrections (GOT 4.7 tide model & MOG2D barotropic model). These data have been generated, validated and distributed by the ***Centre de Topographie des Océans et de l'Hydrosphère*** (CTOH/LEGOS, France). Ocean Colour data products from MODIS sensor on Aqua are produced and distributed by the ***Ocean Biology Processing Group***.

## II. Observing the Bay of Biscay mesoscale dynamics from gridded Altimetry products.

A spectral analysis shows that dominant Sea Surface Height (SSH) variability occurs at annual frequencies, being 3-4 cm offshore / 5-6 cm over the shelf. Effects of aliased tidal harmonics is also apparent, especially on the shelf where non-linear harmonics appear (not shown).

In the center of the Bay of Biscay, significant SSH variability occurs from 100 to 300 days, especially around the 45°N parallel ***(fig.1)***. A Hovmöller diagram ***(fig.2)*** of this signal centred at 45°N indicates westward propagation of mesoscale features between 100 and 300 days, with an increase in energy in 1999-2003. A Radon Transform analysis (Hill et al., 2000[2]) indicates propagation speeds between 1 and 2 cm.s-1, consistent with previous studies (e.g. Pingree and Le Cann, 1992[3]).

Using standard eddy-tracking algorithms on the gridded altimetry data (e.g. Okubu-Weiss parameter, Isern-Fontenet et al., 2003[4]) we are able to track the most energetic eddies. Fig. 3 shows an example between October 2001 and September 2002, which corresponds to a strong westward propagating signal in ***Fig. 2***. The eddies which disappear from the Hovmöller diagram may indicate strong meridional drifts (as in ***Fig. 3***), or a sampling issue.

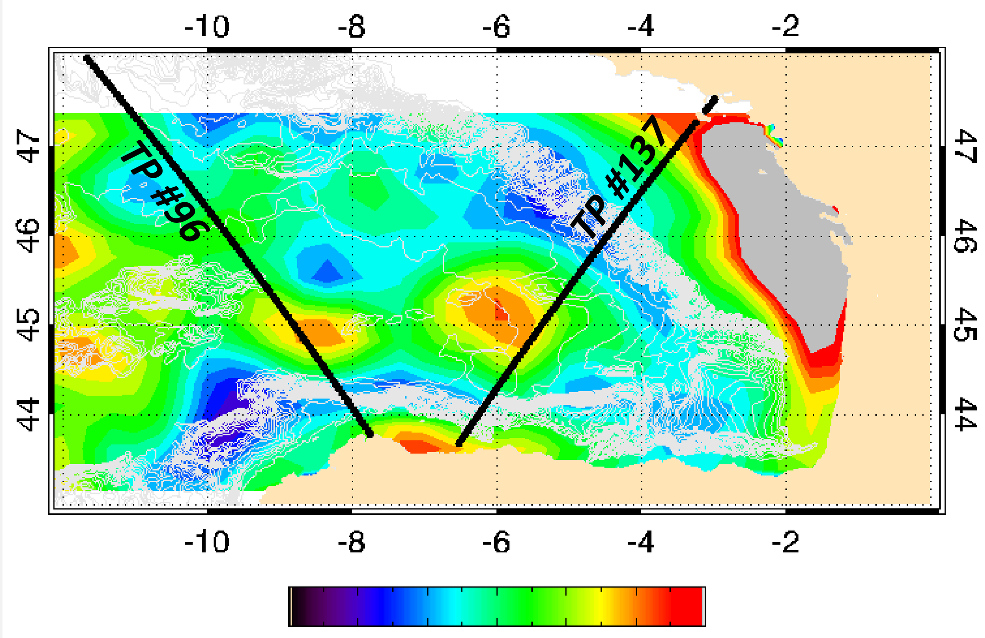


***Figure 1.*** RMS in cm of the residual signal of 100 to 300 days filtered signal, from October 1992 to December 2007

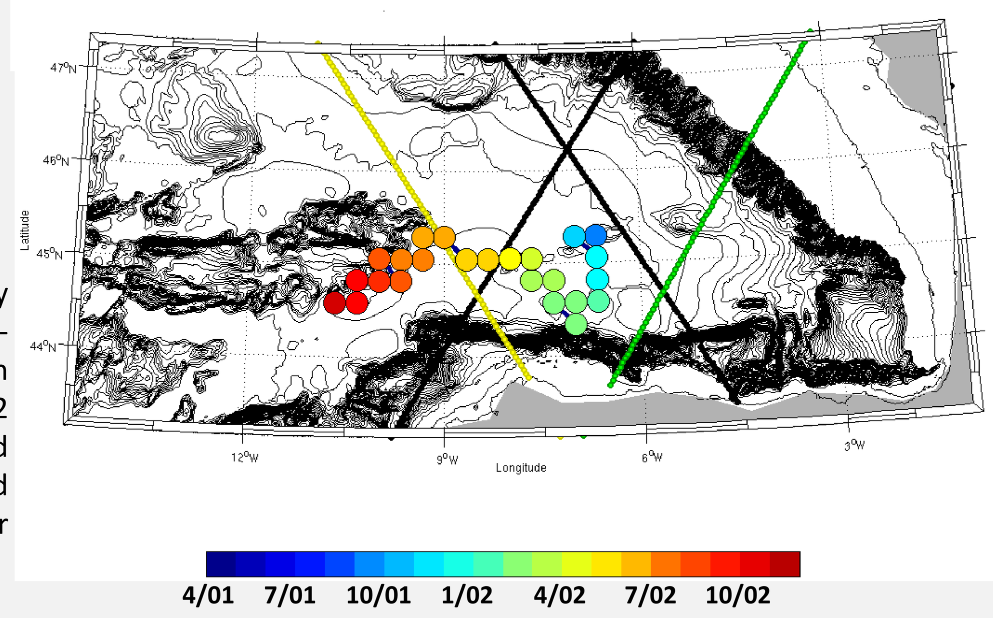


***Figure 3.*** Anticyclonic eddy tracked using an Okubo-Weiss algorithm between 5/8/2001 and 22/9/2002 with T/P tracks overlaid (yellow is track #96 and green #137 for comparison with ***fig.6***.

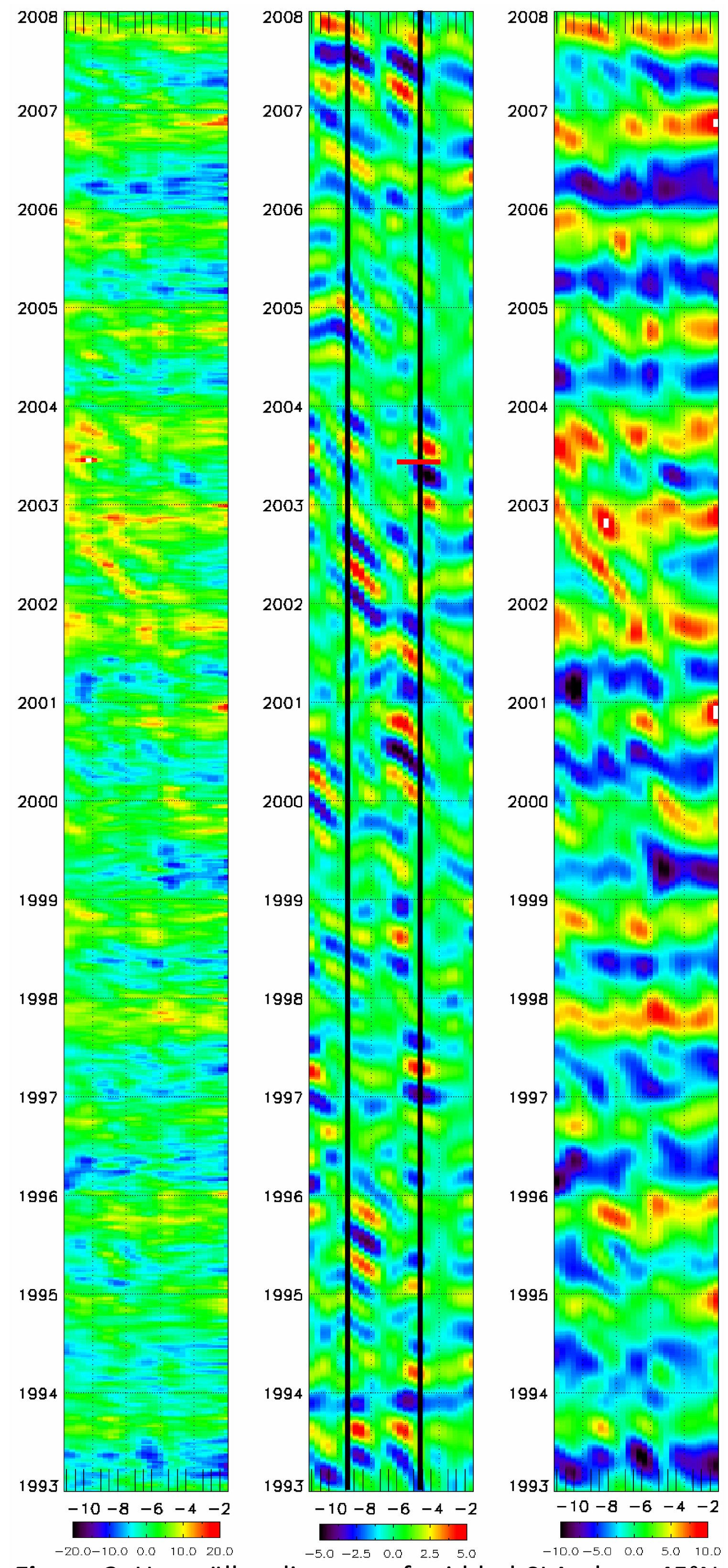

***Figure 2.*** Hovmöller diagram of gridded SLA along 45°N parallel against time : raw SLA (left panel), SLA filtered from 100 to 300 days (middle panel) and SLA filtered from signals longer than 300 days (right panel). Red line corresponds to the position of MODIS image on ***fig.7***.

***CONCLUSION*** : Certain larger-scale eddies can be tracked with the gridded altimetry data, but we cannot track smaller features continuously within the Bay of Biscay, since they tend to "hide" between tracks.

## III. Observing « eddy-like » features from along-track data

Alongtrack altimeter data gives us finer along-track spatial sampling (resolving scales at 10-20 km, Bouffard et al., 2008[5]) to better estimate the true eddy scales (although at limited locations). Wavelet analysis has been applied to the Xtrack processed regional along-track altimeter data to extract coherent « eddy-like » features along an altimeter pass, as described by Lilly et al. (2003)[6].

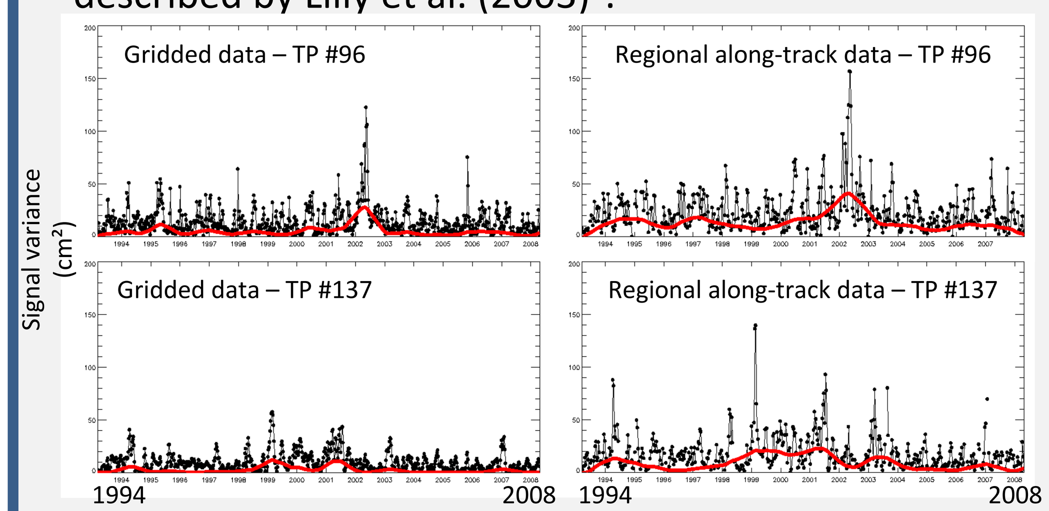


***Figure 5.*** Wavelet spectrum (variance of SLA in cm²) against time. Left panels have been computed from gridded data, and right panels from along-track data. Upper panels for J1 track 96 and lower panel for track 137. Red lines are smoothed SLA variances over a 1-year period.

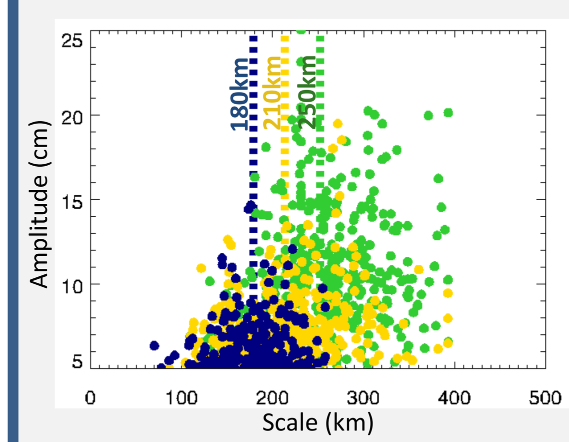


***Figure 6.*** Scale/Amplitude diagram from wavelet analysis for tracks #137 (blue), #96 (yellow) and #87 (green). Dotted lines are the corresponding mean scales. Track #87 is located further out (~16°W).

This technique is very efficient in terms of computational time, and rapidly provides details on observed features, such as their amplitude, scales and space/time location. We focus here on two tracks crossing the high mesoscale variability region in the Bay of Biscay (see position on ***fig.1*** and ***fig.2***).

Typical eddy widths from the wavelet analysis are ~150 km, corresponding to an equivalent Rossby radius of 20-30 km (see detected feature with corresponding wavelet on ***fig.4***.). This is smaller than the spatial decorrelation scales used in the gridded altimetry maps.

Wavelet analysis along tracks 96 and 137 shows that the mapped data captures larger features but misses the smaller structure (see ***Fig. 5***), and underestimates the amplitudes by 53% within the Bay of Biscay.

***CONCLUSION*** : Wavelet analysis of alongtrack data can improve tracking of these finer scale eddies. We can better locate and track the smaller eddies using multi-altimeter alongtrack analysis (e.g. T/P, J1, GFO, ENV from 2002-2005)

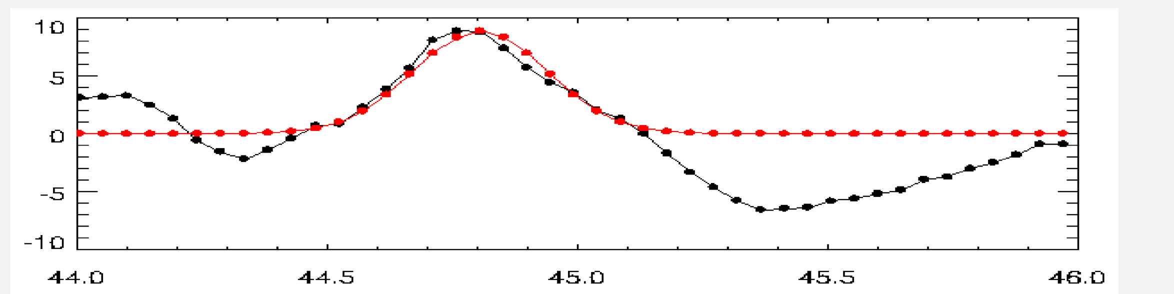


***Figure 4*** Jason-1 track 137 on 23/02/2003 (black dotted line) with corresponding wavelet (having a width of about 150 km)

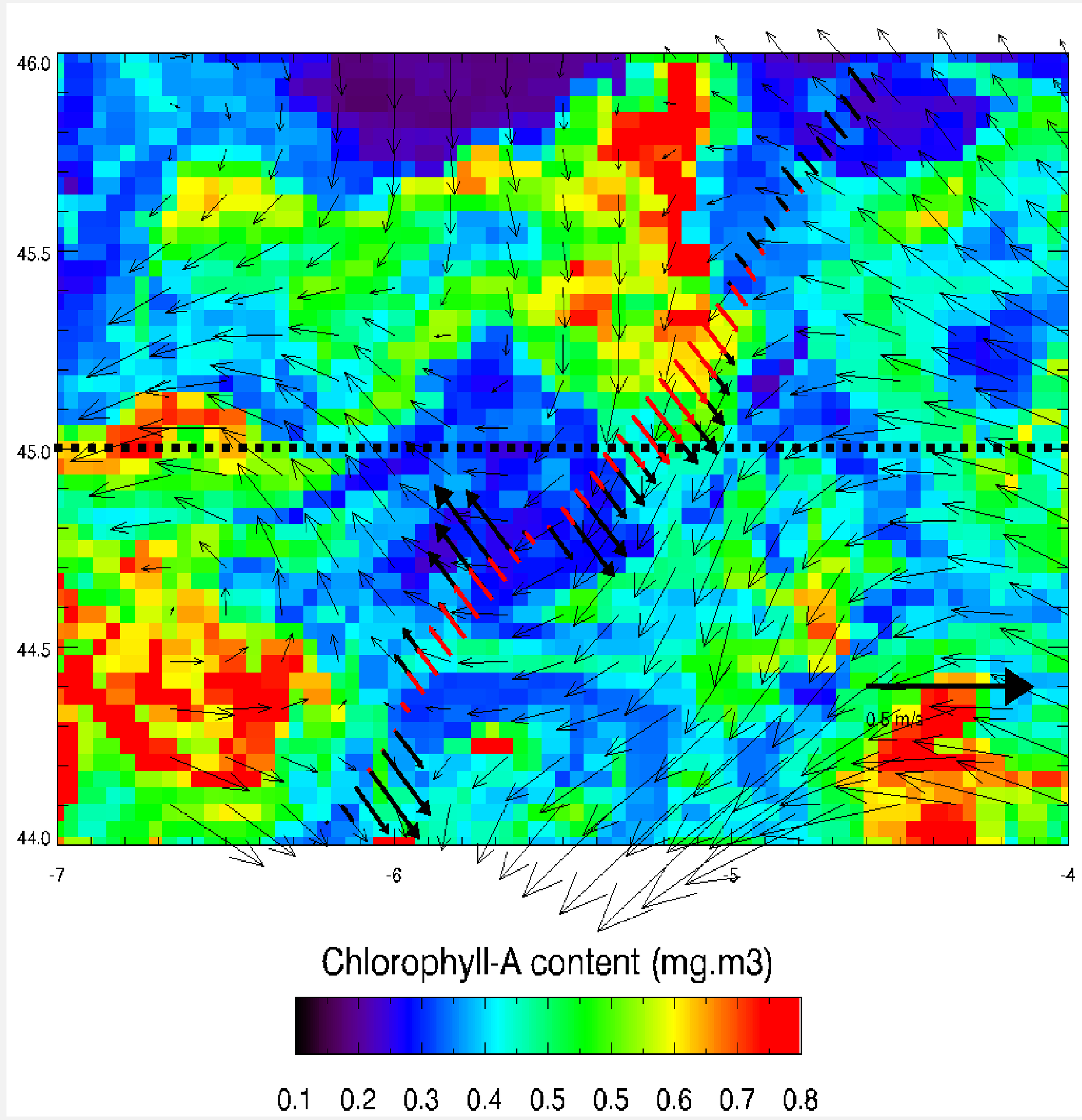


***Figure 7.*** MODIS Chlorophyll content image from 19/03/2003 with overlayed altimetric data. Thin arrows are gridded geostrophic velocity field; black arrows are across-track geostrophic component and red arrows are across-track geostrophic component from gridded SLA reprojected over the track. Dotted line is the 45°N parallel as seen in ***fig.2***.

***A case study : Eddy structure off Cabo de Peñas on 19th March 2003***

The differences between the along-track data and the gridded data in **Fig.5** may be due to errors or small-scale signals. **Fig.7** shows an example of an "eddy-like" feature detected in the wavelet analysis but not in the gridded fields. At this date (19/03/2003), wavelet power exhibited a local peak, with a scale-averaged variance of about 80 cm² with a maximum for a spatial width around 150km. When comparing across-track geostrophic velocities with the gridded geostrophic field, the latter does not display a vortex pattern. However, with an available MODIS chlorophyll content image ***(fig.7)***, the "eddy-like" feature is confirmed by the swirling structure present on chlorophyll data. Altimetry and chlorophyll data are matching closely ***(fig.7),*** with maximum velocities (~$0.3 m.s^{-1}$) at about 30km from the eddy centre, in agreement with an eddy surveyed with hydrographical data in the zone (Pingree and Le Cann, 1992[3]). Also interesting are the filament recirculations north and south of the core: this eddy contributes to the intense stirring of chlorophyll-rich waters in the area.

## Conclusion and perspectives

We have shown that specially processed along-track data can reveal fine-scale eddy features in the Bay of Biscay.
Smaller-scale eddies show non-zonal propagation and appear to interact strongly with the bathymetry.
Forcing of these eddies is under investigation.
A more extensive study using multi-mission altimetry data with other satellite data and model simulations is underway.

***References***
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