The unexpected nature of the tidal currents observed off the Landes coast (44°N)

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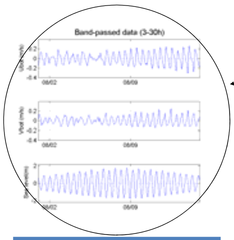
The bottom tidal currents at 55m depth vanish in Autumn !



Highlight of velocities and sea level during the first two weeks of August

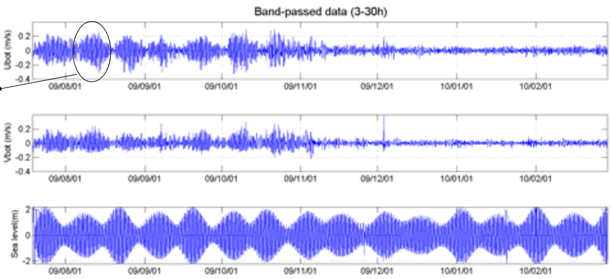
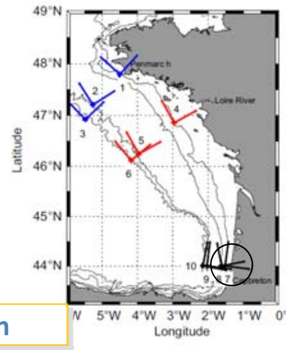


Figure 1: Cross-shore (top), long-shore (middle) bottom currents, and sea level (bottom)

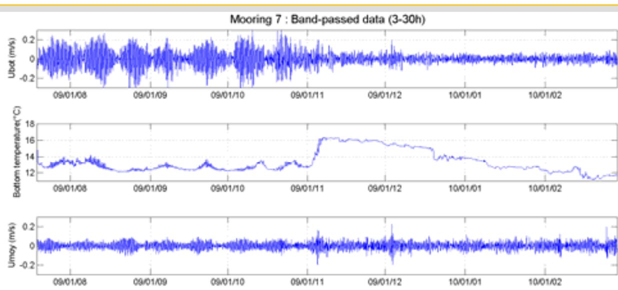
At Aspex7 mooring (depth of 60m), the high frequency bottom currents (fig 1) are semi diurnal (M2 period of 12.42h).
At the beginning of November, the two velocity components decrease dramatically.
Sea level shows a classical spring–neap cycle all year long.

The Aspex experiment



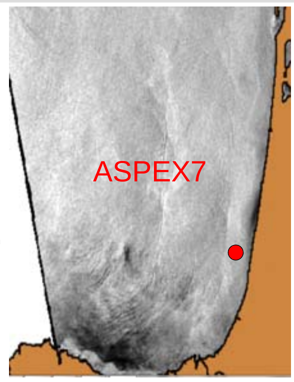
From summer 2009 to fall 2011, 10 ADCP moorings have been deployed along 3 transects. Bottom temperature has been recorded. The seasonal circulation revealed by these observations have been recently described by Le Boyer et al (2013)

The decrease of bottom current is linked to the break down of the stratification



A very fast increase of the bottom temperature is observed on 2009/01/11. This corresponds to a downwelling situation (induced by westerlies) and a rise of a strong poleward current (not shown) as described by Batifoulier et al (2011).
The high bottom temperatures reveal the downwelling process and the beginning of the break down of the stratification.
In 2010 (not shown), the same situation occurred at nearly the same date (November the 6th) .
The depth averaged currents (bottom pannel) do not evidence such decrease of high frequency currents

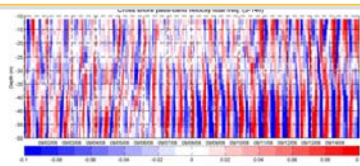
Other evidence of internal wave propagation



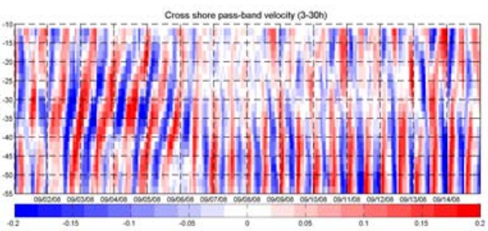
Extract of an ERS1 SAR image the 2009/08/12

Main finding : At first order, coastal tidal currents in summer result of internal tide propagation. When the stratification breaks down in autumn, baroclinic (internal) tidal currents disappear and tidal currents are purely barotropic (and weak).

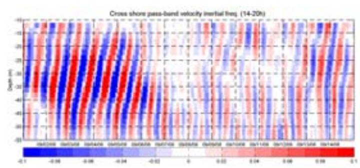
The cross-shore velocity component show very strong vertical shear revealing the nature of an internal wave. A spectral analysis (not shown) highlights two main frequencies : tidal (around 12h) and near inertial frequency (17h at 44°N). The cross shore velocities at tidal frequency (upper right) and around inertial frequency (lower right) are shown.



Band–passed (3-14h) cross-shore velocity near tidal frequency



Band–passed (3-30h) cross-shore velocity



Band–passed (14-20h) cross-shore velocity near inertial frequency

Internal tide generation : Why the baroclinic currents are so strong (vs. barotropic currents) ? A new hypothesis

The internal tide is generated by the interaction of the barotropic tidal current with the bathymetry. The body force expressed by the formulation of Baines (1982) shows that the double shelf breaks system ("Plateau des Landes" and Aquitanian shelf) defines region of potential generation of internal tides.

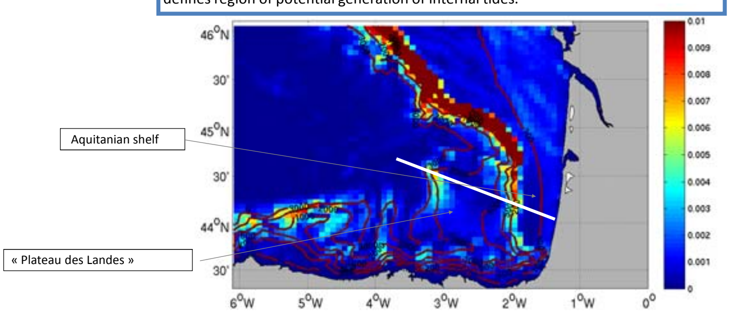
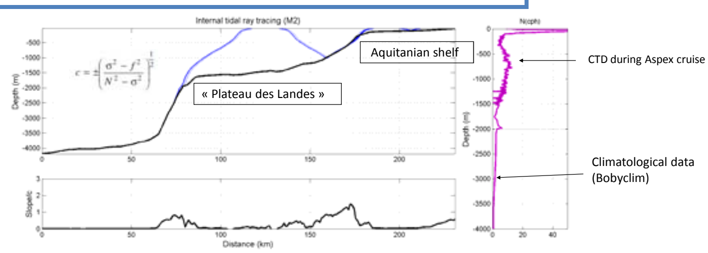


Figure : Maximum absolute values (m^2/s^2) of the depth integrated body force (Baines 1982). Barotropic currents are issued from a Mars2D model (700m resolution)
White thick line : transect shown on the figure at the right

Internal tides (IT) in a continuously stratified ocean can be described by beams emanating from critical slope bathymetry. The IT energy follows characteristic pathways with a slope to the horizontal given by C (see formula on the figure). When the sea floor slope equals C, the internal tides generation becomes more efficient. In the region of the Landes, both slopes are critical and the width of the "Plateau des Landes" allows near resonant situation which could enhance baroclinic currents



$$c = \pm\left(\frac{\sigma^2 - f^2}{N^2 - \sigma^2}\right)^{\frac{1}{2}}$$

Ray- tracing diagram (up) along the transect shown on the left figure. Lower pannel : Ratio bottom slope/c showing critical slope when ratio =1

Perspective and future observations to be done…

These observations suffer the lack of hydrological (at least temperature) data in the water column. A more complete experiment dedicated to this region remain to be set up in the near future to validate (or not) this not usual internal tide generation process.

References:
Baines P. G. , 1982. On internal tide generation models. Deep Sea Res, 29, 307-338.
Batifoulier F., Lazure P., Bonneton P. 2011. A coastal poleward jet induced by crosshore winds in the Bay of Biscay. Journal of Geosphysical Research 117 Article Number: C03023 DOI: 10.1029/2011JC007658
Le Boyer, A., Charria, G., Le Cann, B., Lazure, P., Marie, L., 2013. Circulation on the shelf and the upper slope of the Bay of Biscay. CONTINENTAL SHELF RESEARCH 55, 97–107.