Using CTOH tidal constants for coastal studies

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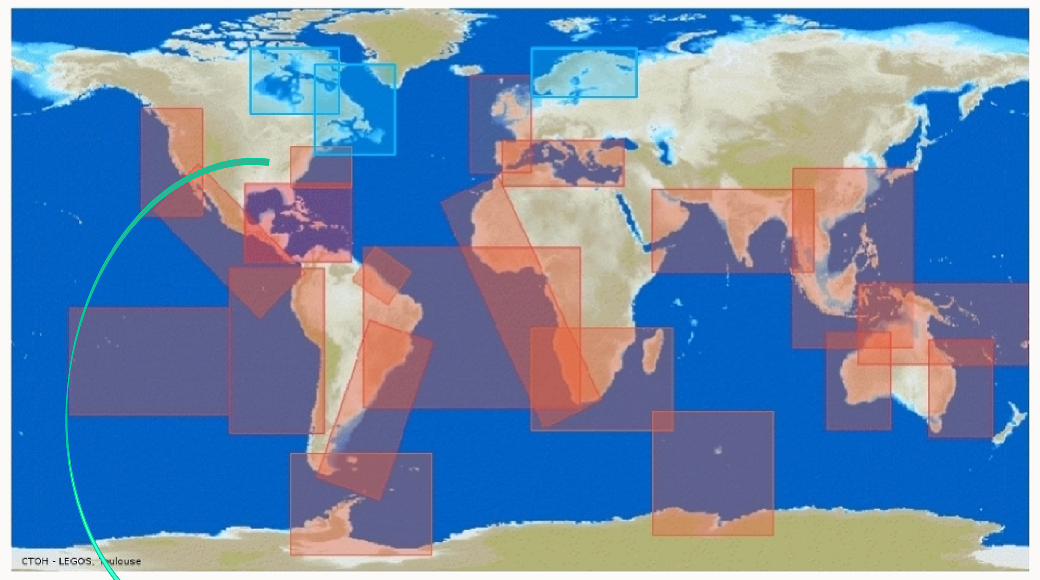
Since 2012, the Centre de Topographie des Océans et de l'Hydrosphère (CTOH) provides the community with large collection of tidal constants estimates over more than 20 coastal regions and continental shelves (http://ctoh.legos.obsmip. fr/products/coastal-products/coastal-products-1/tidal-constants). This tidal constants database is computed using the CTOH regional Sea Level Anomalies datasets, taking advantage of the TOPEX-Poseidon, Jason-1 and Jason-2 long time series and the X-TRACK coastal processing tool (Roblou et al., 2011)[1]. It provides tidal experts and coastal modelers with amplitude, phase lags and accuracy estimates for a wide spectrum of tidal constituents, every 6-7 km along the satellite ground tracks This presentation aims to highlight the performance of this regional tidal product through various case studies over coastal and shelf seas around the world. The performance of an empirical tidal correction derived from the CTOH along-track tidal constants database is compared to classical tidal corrections provided by models. In the Bay of Biscay, such strategy is expected to improve the observation of a seasonal slope current, the so-called Iberian Poleward Current. Case studies of tidal modeling applications are also presented here. The recently-issued FES2012 global tidal model as well as several regional models have been validated using this independent tidal constants database. It has been used for constraining a regional tidal model using data assimilation techniques. It has also provided a complete set of tidal estimates for prescribing open boundary conditions in local tidal models.

CTOH tidal constants product



➡ 20 areas available, **23 soon (Hudson Bay, Labrador Sea, Norway added)**

Harmonic analysis of long-term coastal SLA:

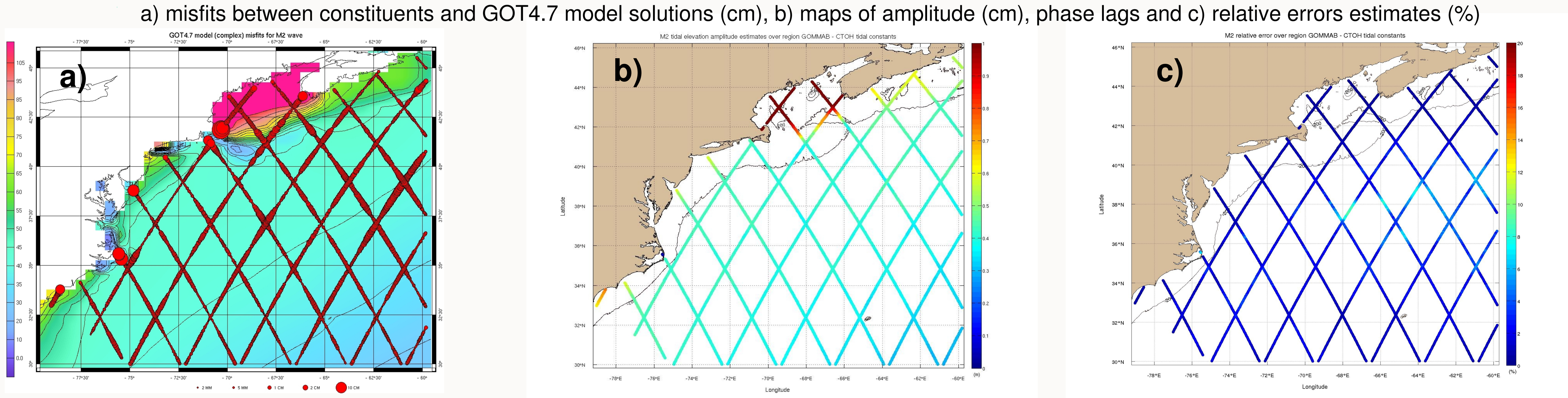
- Full corrected X-TRACK SLA, excepted for ocean tides
- Remove/restore a prior estimate (FES2004)
- TP+J1+J2 times series from 1992 and updated to March 2013
- TPN+J1N time series from 2002 to 2012, including Glorys-v2 20 years reanalyses (http://www.mercator-ocean.fr/science/GLORYS) as correction of the annual and semi-annual signal, because of too short time serie

Files contain tidal elevation amplitude, phase lag and error estimates (based on non tidal signal contamination) for a large spectrum:

- 73 constituents for TP+J1+J2, including non linear and secondary constituents
- 22 constituents for TPN+J1N

➡ Access to diagnostics online for principal constituents (M2, S2, N2, O1, K1, M4) as :

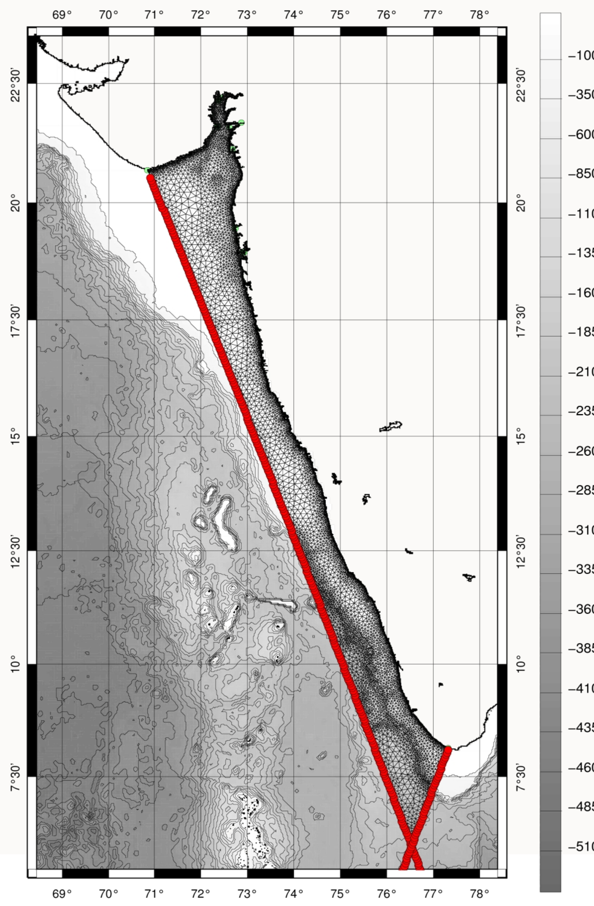
a) misfits between constituents and GOT4.7 model solutions (cm), b) maps of amplitude (cm), phase lags and c) relative errors estimates (%)



Exemple of dignostics in the Gulf of Main and Middle Atlantic Bight region

http://ctoh.legos.obs-mip.fr/products/coastal-products/coastal-products-1/tidal-constants

Model boundaries forcing



T-UGOm (*Toulouse Unstructured Grid Ocean model 2D, ex-Mog2D*)

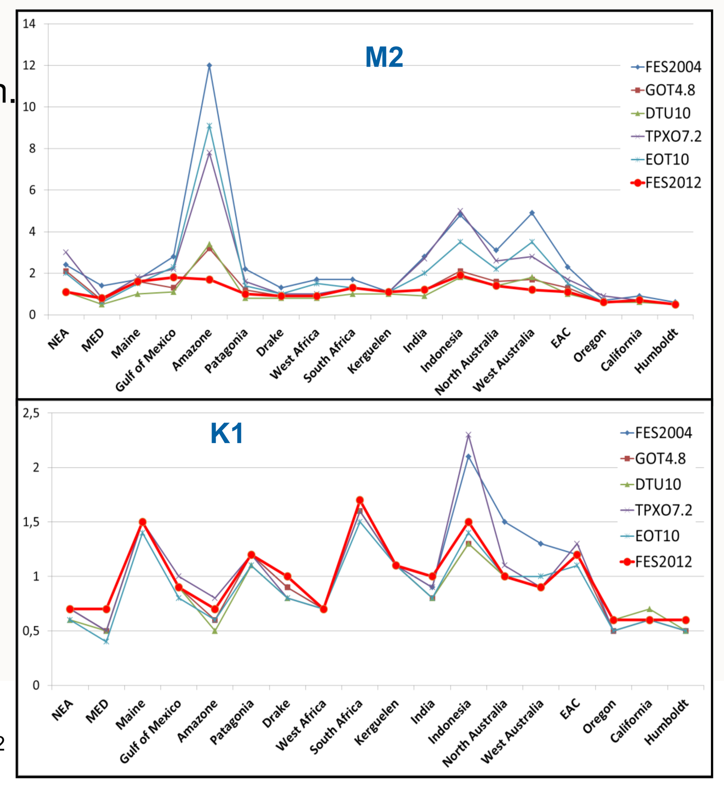
- 2D barotropic model
- Using finite element for the spatial discretization
- Based on the non-linear shallow water equations (Lynch and Gray, 1979)
- Without data assimilation
- model run for the major tidal waves (M2, K1, O1, P1, S2,….)
- ETOPO2 modified bathymetry (Sindhu et al., 2007)
- **Forced at the open ocean boundaries with altimetry (CTOH tidal constants products)**

See Testut and UnniKrishnan : Improving regional tidal modeling in regions of complex topography.Application to the continental shelf off the west coast of India, Marine Geodesy,submitted

FES2012 model validation

FES2012 is the latest version of the *FES* (Finite Element Solution) tide model and has been recently issued (*20 years of progress in radar altimetry*, 2012). FES2012 takes advantage of longer altimeter time series, improved modelling and data assimilation techniques, and more accurate ocean *bathymetry*. Special care have been made to addres the major non-linear tides issue and to the spatial resolution.

In this figure, various tidal model are compared to **CTOH tidal constants database** for the major constituents M2 and K1 in terms of averaged complex difference amplitude (cm). Overall misfit is less than 2cm for both M2 and K1. FES2012 model performances are very close to DTU10 model for M2, and highlight significant improvements with respect to FES2004.



Carrère et al., 2012[2]

http://www.legos.obs-mip.fr/recherches/equipes/ecola/projets/fes2012

Study impact in the Bay of Biscay

Tidal constants are used to compute an empirical tidal correction for the SLA. We compare two SLA datasets: the reference X-TRACK product and the so-called empirical dataset with this new tidal correction (the two datasets only differ in the tidal correction). The case of the Bay of Biscay is studied with the aim to identify the signature of the Iberian Poleward Current and to investigate the impact of the new correction on this signature.

First, we compare the SLA RMS for the two datasets. The RMS is lowered into the basin by about 1 cm to about 5 cm on the shelf with the new correction. Over a narrow coastal strip, it remains as high as for the X-TRACK data. The large variations between the shelf and the coast lead to errors in calculating geostrophic currents anomalies. So for this study, we have considered only the points where the RMS is lower than 8 cm and the percentage of valid data larger than 70%. See figure 1.

We use data from tide gauges and buoys to validate our empirical data set. Comparisons are made for the period 2005-2008 for gauges Crouesty, La Rochelle and Saint-Jean de Luz and 2005-2006 for Le Conquet and Santander (only data available at the time of the study).

The gauges SLA time series are 48-hour filtered, and we have considered the average of the SLA at the three altimetric points closest to the tide gauge.

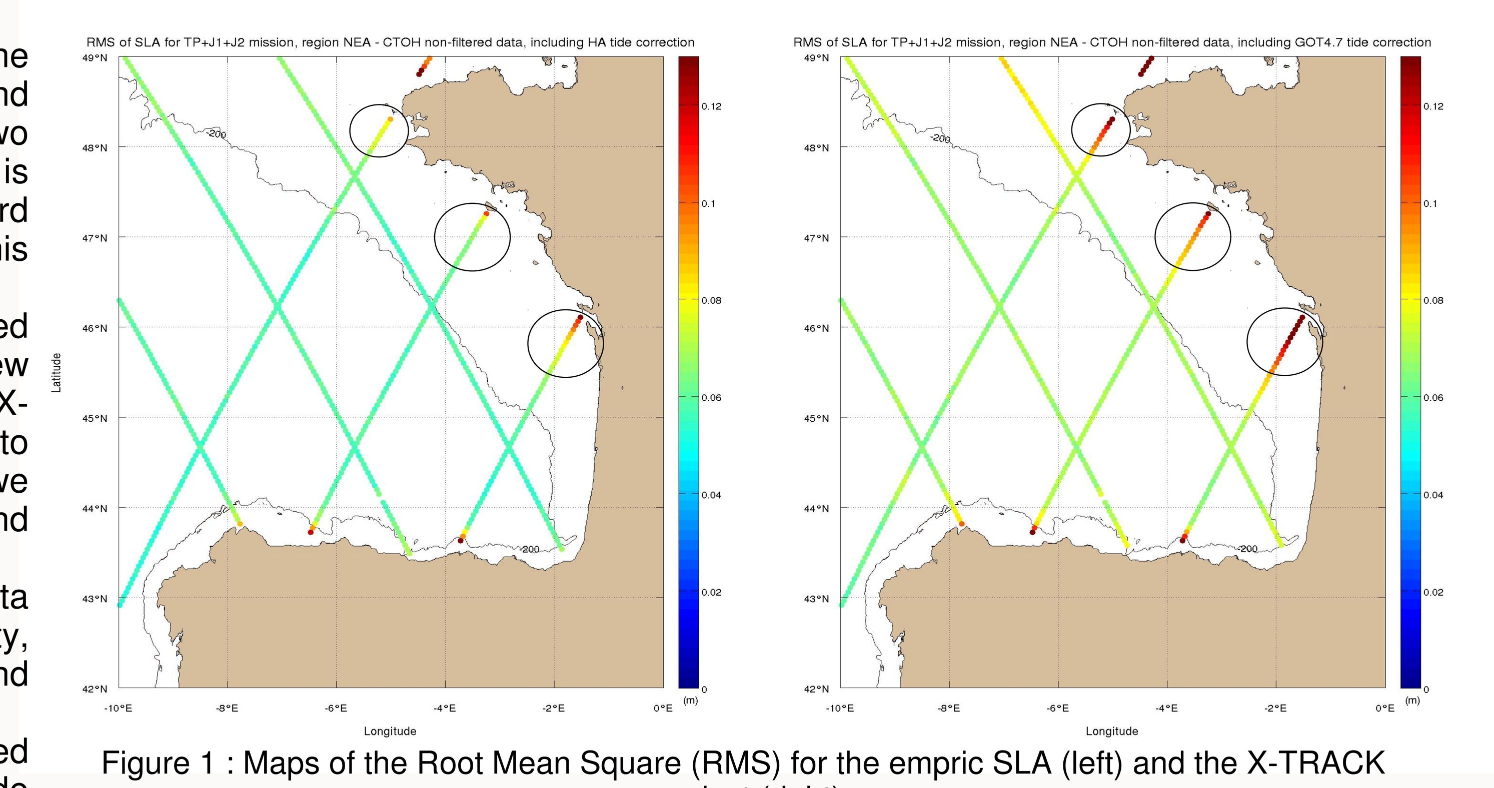


Figure 1 : Maps of the Root Mean Square (RMS) for the empric SLA (left) and the X-TRACK product (right)

The correlation coefficient and the associated p-value are given for each tide gauge on figure 2 as follows: value for the empirical data / value for the X-TRACK data. Correlations at Santander reach 0.8 but are not significant (p> 0.05). This seems due to the too short time series used. For Le Conquet, correlations are poor, also because of the short time series, but also because of the specificity of the site where the tidal signal is large and difficult to correct. At La Rochelle, the use of the empirical dataset leads to a marked improvement of the correlation. In contrast, we do not observe such an improvement at the tide gauge Le Crouesty This is probably due to the use of altimetric data points that are located far from the tide gauge – because of the data selection criteria described above

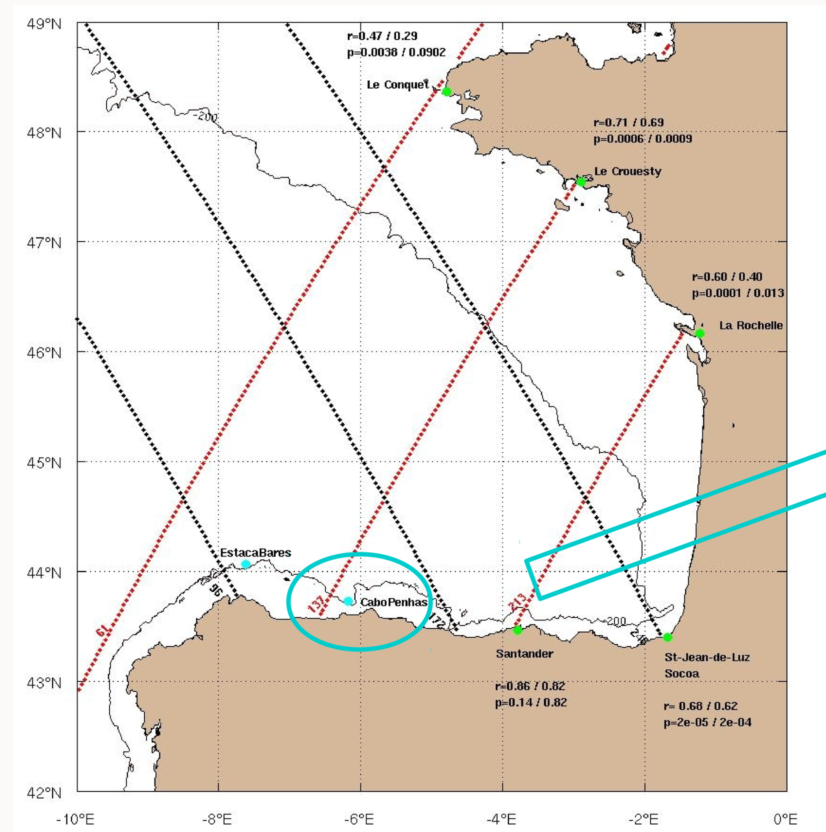


Figure 2 : shows the altimetric ascending (red) and descending (black) tracks in the Bay of Biscay, the tide gauges used (green) from REFMAR (Réseau de REFérence des obsevartions MARégraphiques : http://refmar.shom.fr/fr, and from Puerto del Estado : http://www.puertos.es/

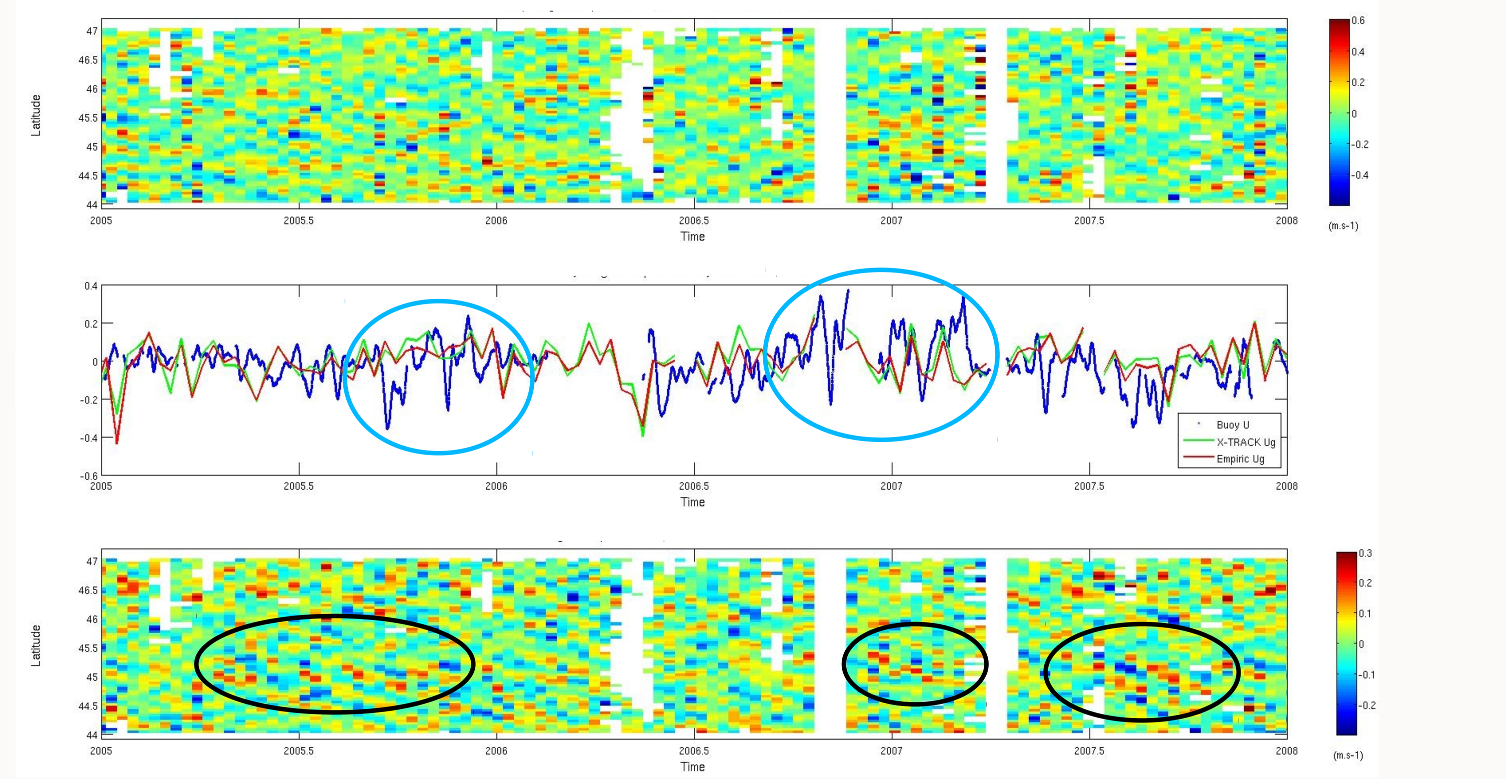


Figure 3 :hovmüller diagrams of the geostrophic current anomalies derived from the empirical dataset along track #137 (top); hovmüller diagram of the differences between empirical and X-TRACK derived geostrophic current anomalies (bottom); time series of the zonal surface current anomalies at the Cabo de Penhas buoy (blue) and of the geostrophic current anomalies averaged over the three closest points to the buoy and derived from the empirical (red) and X-TRACK (green) dataset. The buoy data has been filtered over 20-days. Units are m/s.

Conclusion & perspectives:

- This regional product can be used for a wide range of applications.
- The computation of tidal constants from ERS-Envisat data is under analysis.
- **The use of an empirical tidal correction derived from altimetry data may be considered in specific cases, i.e when tidal models fail to provide good corrections since tidal signals appear to be aliased at frequencies corresponding to mesoscale.**

We have compared geostrophic current anomalies derived from the empiric SLA datasets and the X-TRACK SLA product to the zonal surface current anomalies at the Cabo de Penhas buoy. The winter intensification of the Iberian Poleward Current seems to be well observed by the buoy but not systematically in altimetric data (blue circles).

The empirical tidal correction improves coastal currents but seems to remove the mesoscale signal, highlighted by the the difference diagram between empirical and X-TRACK derived geostrophic current anomalies (black circles) in figure 3.

➡ We need to more investigate the impact of this empric tidal correction in this region and others, and update in-situ time series for a quantitative assessment of this dataset for dynamics studies

References

(1)Roblou et al., 2011: Coastal Altimetry, Springer Berlin Heidelberg

(2) Carrère et al., 2012:: FES 2012 : a new tidal model taking advantage of nearly 20 years of altimetry measurements, presented OSTST meeting, Venise

Acknowledgment

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