X-track, a new processing tool for altimetry in coastal areas

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ABSTRACT:
Oceanographic applications using altimeter data become very challenging when leaving the deep ocean for the coastal regions. Close to the coast, altimetric observations are often of lower quality for a number of reasons, including land contamination of the satellite footprint or inaccurate resolution of the high frequency barotropic ocean response. This paper presents a new processing toolbox to derive improved altimeter products (SSH, MSSH, SLA) dedicated for coastal applications.
Starting from classical GDR products, the system benefits from state-of-the-art corrective terms from the CTOH/LEGOS data bases (e.g. FES2004, Mog2D-G, MSSCLS01, non parametric SSB, ...). Particular attention is made to recover a maximum amount of exploitable data (dedicated editing criteria, interpolation of missing corrective terms). Where possible, local modelling of high frequency tidal and atmospheric loading corrections are used instead of standard, global ones. In addition, the orbit errors are reduced by a stability criterion and a high resolution mean sea surface consistent with the data is calculated. Finally, the system produces coastal altimeter SLA time series colocated onto mean tracks.

Quantitative and qualitative validations are made against regional hydrodynamic models simulations for the Bay of Biscay, the Northern Western Mediterranean Sea and the Kerguelen archipelago.

Methodology:

The new processing presented hereinafter was originally developed within the framework of the ALBICOCCA (Altimeter-Based Investigations in Corsica, Capraia and Contiguous Areas) Project in the Northern Western Mediterranean Sea. Additional developments lead to the **x-track** tool.

The objective is to improve both the quantity and quality of altimeter sea surface measurements in coastal regions, mainly by redefining the data editing strategy to minimize the loss of data during the correction phase and by using improved local modelling of tidal and short-period atmospheric forcing.

In the frame of coastal altimetry applications, an highly accurate mean sea surface is needed and there are no prior guaranty that the horizontal resolution of the global MSS sets are adequate, especially in the case of along-shore circulation studies. First, coastal circulation and bottom topography can be responsible for centimetric MSS variability on very short wavelength. Also, the mean sea surface depends on the data set used to derived it in terms of editing, applied geophysical corrections and time window. Thus **x-track** computes an along track MSS consistent with the altimeter data set on a regular grid following the satellite ground track.

Although the GRACE mission greatly improved the gravity field estimates and consequently the quality of the orbit ephemerises, it can remain geographically correlated errors in the orbit solutions. **X-track** reduces the effects of these orbit errors by monitoring the basin level variations cycle after cycle.

x-track main products are along track sea level anomalies and sea level anomalies on mean tracks. These products are available at both 1Hz and high rate (10/20 Hz) for the TOPEX/Poseidon, Jason-1, Geosat-Follow-On and Envisat altimetric missions.

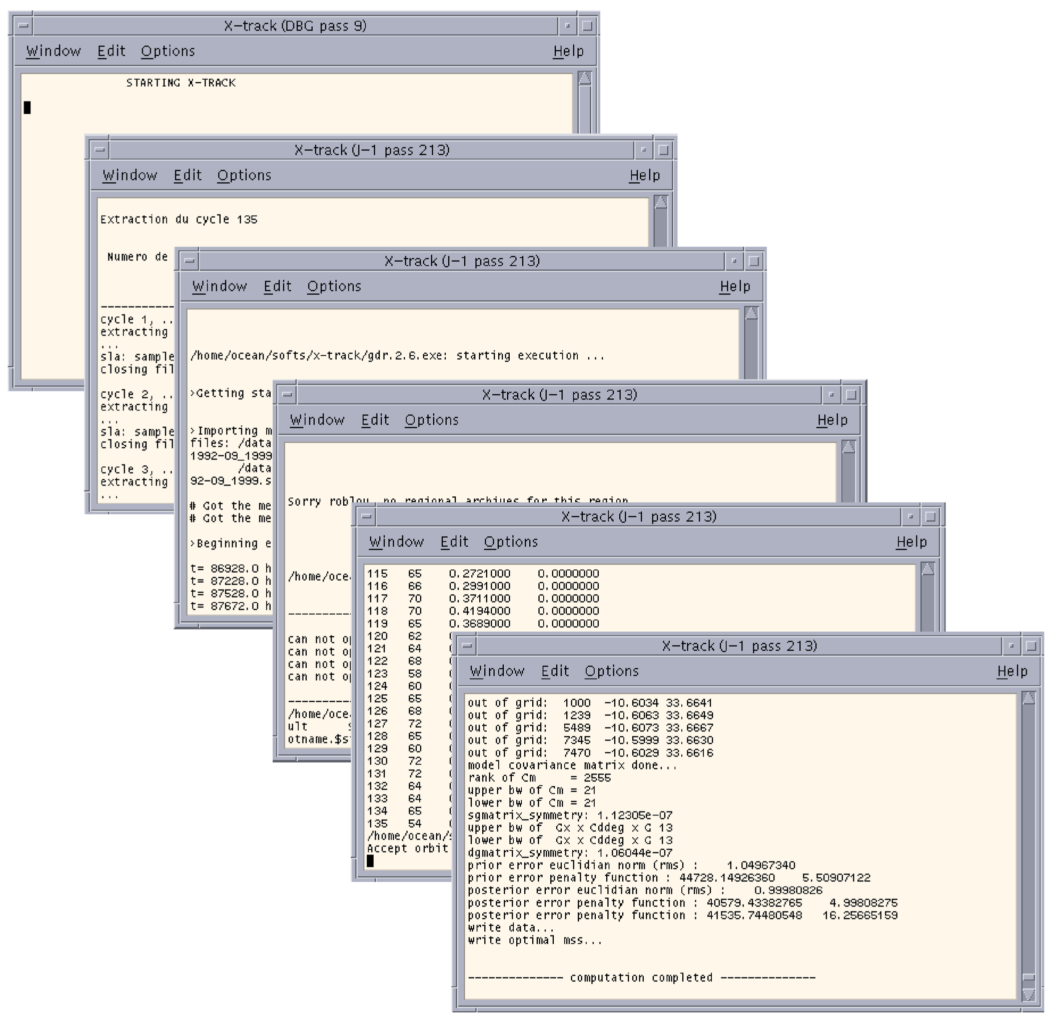

fig. 1: snapshot of the computation of an along track anomaly product with **x-track**

Tidal comparisons

Tidal constants computed from 10 years of T/P sea level measurements are compared to the solutions of two tidal models developed at LEGOS: FES2004 ([2]) is a global tidal model with data assimilation whereas Mog2D is a purely hydrodynamic model. Altimeter-derived tidal constituents are computed from a harmonic analysis of the **x-track** SLA on mean tracks products.

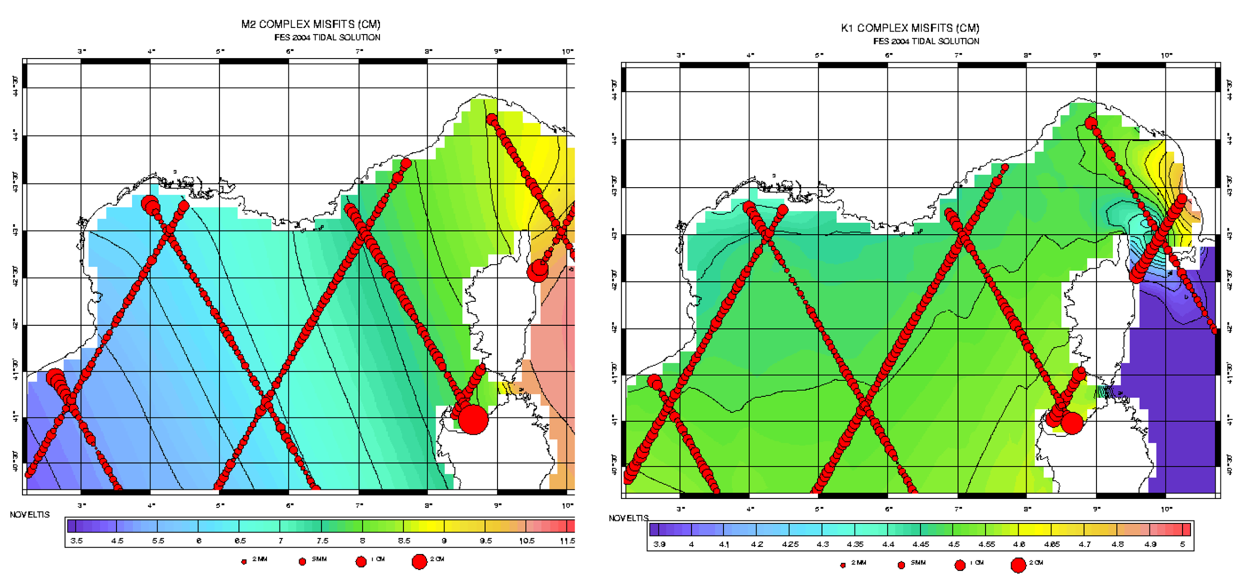

Fig 2: tidal misfits in the Northern western Mediterranean Sea for M2 and K1 constituents: background chart represents the tidal amplitude in cm from FES 2004 model ([2]). The size of the red circles is proportional to the modulus of the complex difference between model and observation.

In fig. 2, altimeter-derived tidal constants are compared to the reference global tidal model FES2004 ([2]). The mean rms error is 0.7cm on both M2 and K1 tidal constituents. This residual error is constant over the whole domain for both constituents and thus can be interpreted as the combination of both residual modelling errors and residual noise in the altimeter measurements. On the north of the Gulf of Lion and along the Spanish coast, the increase of the error is probably due to unresolved high frequency dynamics in the de-aliasing corrections whereas the hot red spot in the north of Sardinia is caused by erroneous altimeter data.

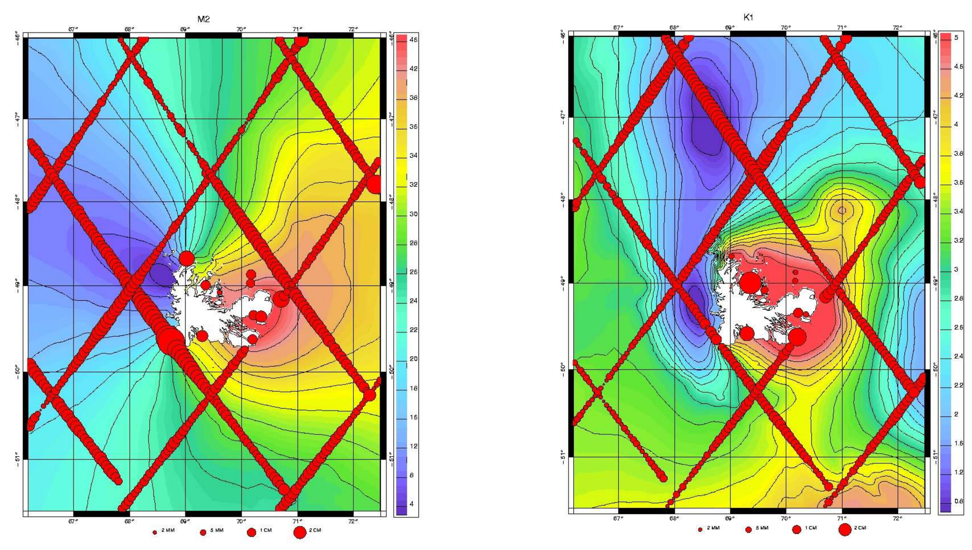

Fig 3: tidal misfits over the Kerguelen archipelago for M2 and K1 constituents: background chart represents the tidal amplitude in cm from Mog2D regional model. The size of the red circles is proportional to the modulus of the complex difference between model and observation.

Over the Kerguelen Archipelago, the altimeter-derived tidal constants are compared to the tidal solutions of a new regional Mog2D platform under development at LEGOS. The preliminary tidal solutions of this model (fig.3) shows a good agreement with the altimeter data: 1.3 cm rms for M2 and 1.0 cm RMS for K1.

These results are very encouraging because they are very close to those obtained by comparison to FES 2004 solution: 1.1 cm rms on M2 and 0.7 cm rms on K1.

Sea level anomalies comparisons

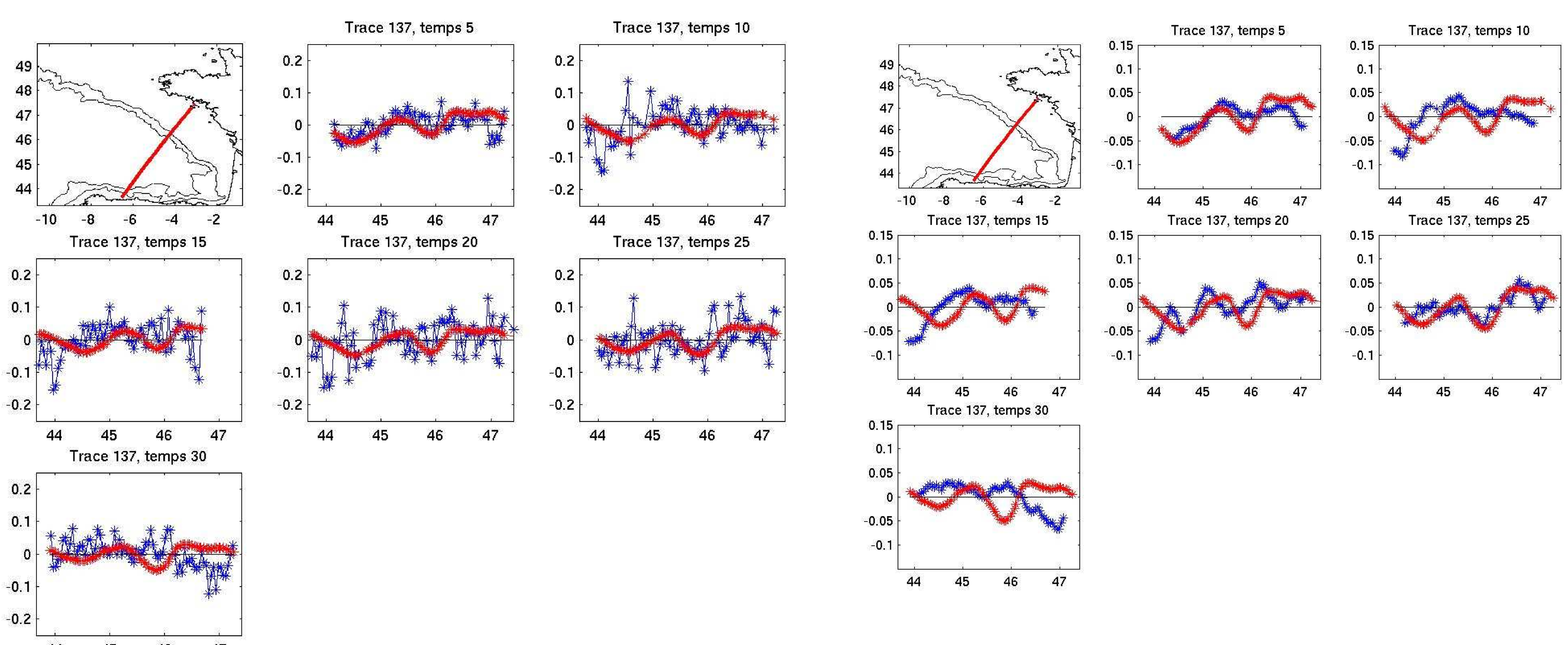

Fig 4:sea level anomalies comparisons in the Bay of Biscay along Jason-1 ground track 137. Blue: altimeter data. Red: Symphonie model. The left panel illustrates comparisons between Jason-1 along track sea level anomalies and Symphonie model outputs every 10 days (July-August 2004).The right panel illustrates similar comparisons where altimeter data have been low-pass filtered (50km).

X-track along track altimeter-derived SLA are compared to Symphonie model simulations ([3]).

In this simulation, the Symphonie model is forced by the wind fields from ALADIN gridded products (courtesy of Météo-France), air-sea fluxes are derived from bulk formulas and a general circulation term (from MERCATOR products) is prescribed at open boundaries using the VIFOP platform ([4]). The model is run on a Cartesian C grid, with 30 vertical levels (generalized sigma coordinates) and a 3 km-horizontal grid resolution.

For both altimeter data set (filtered or not), the comparisons between observations and model outputs show good agreements for all along track snapshots presented on fig. 4. There is a satisfying correlation regarding the synoptic scales processes as well as the meso-scales ones (fig. 4, right panel). Moreover, altimeter data provide additional information at shorter scales that are not represented in the Symphonie model simulation (fig. 4, left panel). The assimilation of such information on the short scales in the hydrodynamic models will be of great interest in the framework of the operational monitoring of the coastal dynamics.

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