ON MONITORING THE COASTAL DYNAMICS THROUGH AN INTEGRATED APPROACH (MARINA PROJECT)

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ABSTRACT:
Altimetric missions in the last 15 years (TOPEX/Poseidon, ERS-1/2, GFO, Jason-1, and ENVISAT) have resulted in great advance in deep ocean research and operational oceanography. However, oceanographic applications using satellite altimeter data become very challenging over regions extending from nearshore to continental shelf and slope (Cipollini et al., 2007). Unlike what happens over the deep ocean, intrinsic difficulties in the corrections (e.g., the high frequency ocean response to tidal and atmospheric loading, the mean sea level, etc.) and issues of land contamination in the radar footprint have so far resulted in systematic flagging and rejection of these data. In the prospect of forthcoming altimeter missions (SARAL/AltiKa, SWOT, Sentinel-3, etc.) which in virtue of their design might be better suited for use in the coastal ocean, a number of studies have dealt with the problem of re-analyzing, improving and possibly exploiting the existing archive to monitor coastal dynamics. The early encouraging results (Vignudelli *et al.*, 2005; Bouffard *et al.*, 2008) support the need of continued research in coastal altimetry, with the opportunity of providing inputs and recommendations to future missions.

The MARINA (MARgin INtegrated Approach) projects aims at mitigating or removing, where possible, the obstacles to promote coastal altimetry to operational status. Here we propose an integrated approach which consists in (i) building a multi-satellite data set optimised for shelves and coastal studies using regional de-aliasing corrections and regional mean sea surface and/or regional geoid models, (ii) exploiting this data set in the context of regional hydrodynamic modelling of shelves and coastal circulation. We will investigate this integrated approach in two coastal systems with remarkable ocean dynamics, namely (i) the Northwesten Mediterranean Sea (hereafter NWMED) with a particular emphasis on the spatial and temporal variability of the coastal circulation using tridimensional hydrodynamical modelling and data assimilation (in collaboration with two other OSTST projects led by P. De Mey and F. Birol) and (ii) the Gulf of Maine and the Middle Atlantic Bight with particular emphasis on monitoring coastal currents using coastal radars (in collaboration with a US team led by J. Wilkin).

MARINA PROJECT TEAM

Since many years, the core team of the MARINA project has gained strong experience on the topic of coastal altimetry within several national and international collaborations (e.g. the French-Italian ALBICOCCA project, the Eu/INTAS-funded ALTICORE project, the ESA-funded COASTALT initiative, ...) and is actively involved in monitoring of the NWMED.

This international team has been brought together for its deep acquaintance with the field of hydrodynamic modelling, remote sensing, *in situ* data processing and coastal oceanography.

X-TRACK PROCESSOR

Former studies have taught the scientific community several lessons about the use of altimetry for coastal applications. First, current products reject a significant amount of data in the coastal strip not only because of radar echoes interferences with the surrounding land but also due to suboptimal editing criteria. Moreover, standard products remain noisy in these areas for two principal reasons: on one hand, data editing is not designed for coastal zones and on the other hand, high frequency corrections (tides and ocean response to atmospheric loading) are inaccurate enough.

The objective of the **X-TRACK** processor 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 where possible, or the most up-to-date global models.

In the frame of coastal altimetry applications, an highly accurate mean sea surface is needed as well and there are no prior guarantees that the horizontal resolution of the global mean sea surface (MSS) products are adequate, especially in the case of along-shore circulation studies. Thus the **X-TRACK** processor permits the computation of an optimal, along track MSS consistent with the optimized altimeter data set and on a high resolution, regular grid following the satellite ground track (Roblou *et al.*, 2007).

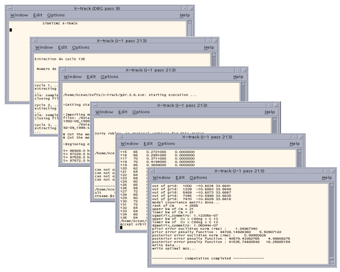


Fig. 1: snapshot of the **x-track processor** software

INTERNATIONAL FRAMEWORK

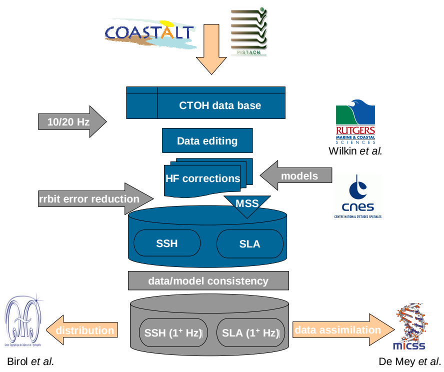


Fig. 2: diagram view of planned improvments on the X-TRACK processor and coordination within the international context

DATA DISTRIBUTION

The Center for Topographic studies of the Oceans and Hydrosphere (**CTOH**) is a French national observational and expertise service dedicated to satellite altimetry studies. The CTOH produces and distributes regional SLA products computed using the **X-TRACK** processor (Fig.4). Once validated, these coastal-oriented SLA data sets are made freely available through the CTOH website:

www.legos.obs-mip.fr/observations/ctoh/COTIER

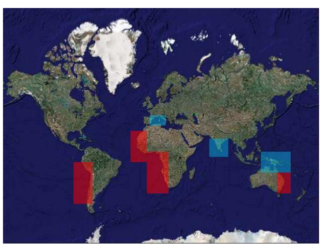


Fig. 4: available and under validation data sets (more details: see also poster n°56, Birol et al., TOWARD COASTAL ALTIMETRY APPLICATIONS)

OBJECTIVES AND WORK PLAN

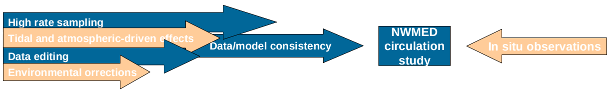
There is an increasing consensus that coastal management requires a holistic view, based on better quality and more integrated geospatial and environmental information on which a scientifically sound policy can be built (as suggested by the IOOS initiative), instead of a sector by sector approach. In the future, an important, international research effort will be made on coastal zones (GMES and IMBER initiatives) and will aim at developing operational oceanography at regional and coastal scales. As for deep ocean, coastal operational oceanography will be made possible only in an integrated approach, merging process-oriented studies, remote-sensed and *in situ* observing systems, ocean modelling and data assimilation.

In this framework, our research program is intended to pursue two central objectives:

1) to enhance the satellite altimetry coverage and quality in the marginal ocean by using a multi-satellite approach;

2) to exploit satellite altimetry in the context of regional hydrodynamic modelling of shelves and coastal circulation, with focus in the NWMED.

PRELIMINARY RESULTS



First steps have been already achieved in order to perform consistent comparisons between altimetry observations and numerical model elevations. For that purpose, a tricky point lies in the fact that both signals differ through their vertical reference (geoid is unknown in models). To overcome that difficulty, one can preferentially form and compare observed and modelled SLA, by referencing observations and model with respect to estimates of the mean dynamic topography (measured from a known ellipsoid for observations, and from an unknown geoid for models).

Processing the model SLA consists here in forming the deviation of the SSH with respect to the modelling period, to which one should add signals that are not necessarily included in the model, such as tides and atmospheric forcing response, or mean steric changes such as in Boussinesq models (i.e. volume conserving models). Concerning observations, the SLA should be computed as the deviation of the SSH measurements within the modelling period.

Following that methodology, a comparison has been achieved between 1Hz **X-TRACK** observations and **SYMPHONIE** (Marsaleix *et al.*, 2008) modelling of the NWMED area. Results in Fig. 5 show a good agreement between model and altimetry SLA in the typical synoptic scale and meso-scale. Moreover, altimeter data seems to provide additional information at shorter scales that are not represented in the model simulation.

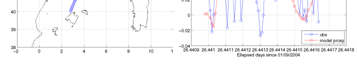


Fig.5: comparison between SYMPHONIE model and JASON-1 altimetry SLA, with respect to the described methodology. NWMED area, year 2004.

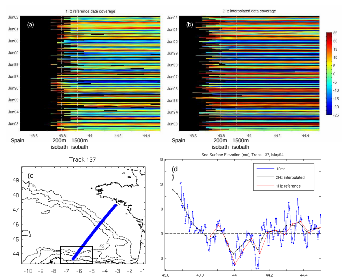


Fig. 3: SLA (cm) data coverage close to the Cantabrian coast (Spain), along T/P track 137, from 1992 to 2002. Top panel: (a) 1Hz X-TRACK SLA; (b) 2Hz SLA infered from 10Hz X- TRACK SLA. Vertical dot dashed white lines indicate the 200m depth and the 1500m depth latitudes. Bottom panel: (c) geographical location; (d) SLA (cm) along T/P track 137 from 1Hz/2Hz/10Hz measurements at cycle 62 (May 94).

10/20Hz data streams have been added to the **X-TRACK** processor in the prospect of monitoring Kelvin waves and/or western currents, which is not possible with 1Hz data sets at high latitudes where internal Rossby radius is o(10km).

For instance, in the framework of the MICSS (Multi sensor Impact assessment in Coastal and Shelf Seas) project (De Mey *et al.*), retrieving the 10Hz SLA data set from TOPEX/Poséidon processed with the **X-TRACK** processor permits to reconstruct along track SLA with a significant improvement of the data coverage (Fig.3b) with respect to 1Hz SLA data coverage (Fig.3a). This improved data set should permit to study the dynamics along the Cantabrian slope (Spain), which was not feasible with former classical data sets. In addition, Fig.3d raises interesting perspectives regarding the quality of the high rate 2Hz SLA along the Cantabrian slope.

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