CONTRIBUTION OF IMPROVED ALTIMETRY TO A STUDY OF COASTAL OCEAN DYNAMICS IN THE NW MEDITERRANEAN SEA (MARINA PROJECT)

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ABSTRACT

Monitoring the dynamics of marginal oceanic systems raises complex and challenging issues, owing to the wide spectrum of spatial and temporal scales of the oceanic processes occurring there (Cipollini et al., 2008). Sustained in situ observation programs are not yet adequate to give the necessary information with the required accuracy. Similarly, remote sensing methods show limitations in the marginal sea surface (e.g., radar altimetry, SST, ocean color) encounter intrinsic limitations when moving near coasts. The current altimeter systems are designed with open ocean in mind and in most cases do not account for specificities of the coastal zone, such as bathymetry, coastline, island or land. Recovering the data in the coastal zone requires an integrated approach through the merging of in situ, remote sensing and model data, the setting and exploitation of an improved (reprocessed) coastal altimeter dataset with this approach is one of the central objectives of the MARINA (Merged Integrated Approach) project funded by CNES within the Ocean Surface Topography Science Team research framework.

A data integration pilot study in the area of Corsica and Sardinia islands in the NW Mediterranean Sea is reported here. Met-ocean parameters have been collected and processed to be compared and merged with high resolution, optimized coastal altimetry products from the X-TRACK processor. The results of this study are illustrated, highlighting the potential and limitations of such data sets.

MARINA OBJECTIVES

There is an increasing consensus that coastal management requires a holistic, view-based on better quality and more integrated information on which a scientifically sound policy can be built. 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 modeling and data assimilation.

In this framework, our research program is intended to pursue two main objectives:
1) to enhance the satellite altimetry coverage and quality in the marginal ocean by using a multi-satellite approach and coastal-oriented altimetry processors (Roblou et al., 2007);
2) to exploit satellite altimetry in the context of regional hydrodynamic modeling of shelves and coastal circulation, with focus in the NWMED.

DE-ALISING CORRECTION PRECISION

The goal of this validation phase is to check the relevance of the strategy defined for the whole Med Sea for de-aliasing the atmospheric influence in the X-TRACK processor and check whether it is applicable in the Bonifacio Strait. So, the different corrections available within X-TRACK product, namely FES2004, GOT4.7 and M2, will be compared. De-aliasing models available for atmospheric effects are considered in comparison to in situ measurements (Tables 1 and 2).

ATMOSPHERIC EFFECTS

Table 1: modulus of the complex difference between significant tidal constituent at both tide gauges and tides derived from model, in cm.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Model</th>
<th>Porto Torres</th>
<th>Sénétosa</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>0.6</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>FES2004</td>
<td>1.1</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>GOT4.7</td>
<td>1.1</td>
<td>1.0</td>
<td>1.2</td>
</tr>
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</table>

As previously suggested by Vignudelli et al., 2005 and Bouffard et al., 2008, no single model outperforms the others for all conditions. Hence, a combination of models should be implemented to optimize the tidal correction.

This validation highlights also very close performances for the global or regional configuration of M2/GOT4.7 model, used for the area as also observed in the Corsica Channel by Vignudelli et al., 2005.

The Bonifacio strait constitutes a very interesting case study, as both ends of the strait are equipped with permanent, quality-controlled tide gauges and where TOPEXPOSEIDON-Jason-1 (and now Jason-2) and ENVISAT altimetry missions overflights in a multi-crossover configuration. Land contamination issues and complex coastal dynamics make altimetry processing particularly challenging in the area.

To overcome these issues, the respective contribu- tion (Table 1) of tide effects to the tidal signals at Porto Torres and Sénétosa tide gauges is showing that tides derived from model, in the area, are not as accurate as tides derived from altimetry (Figure 2).

A tidal analysis exercise of the X-TRACK SLA products for T/P plus Jason-1 overall mission is performed in order to assess the potential of the data set for studies of tides in the Strait of Bonifacio. Altimeter data are sampled every 0.7km (i.e. what would be 10Hz over the whole mission) on a reference track. Several de-aliasing strategies have been tested, whether one use a M2 regional model or a FES2004 global atlas or no model for removing tides. Results are compared to available tidal models (Table 3) and in situ data (Figure 2).

NB: Due to the very few samples of ENVISAT data available (~40-45 cycles), a similar harmonic analysis is not possible as yet.

As noticed on the comparisons, tide gauges (and once K1 is upgraded in a composite tidal solution), tidal analysis of X-TRACK SLA product shows very close performances when compared to the tidal models available. Of course, FES2004 and GOT4.7 models are integrating altimetry. However, the results of the M2 model, which is purely hydrodynamic, shows results very close to the GOT4.7 solution. A tidal analysis is very close to the homogeneous tide K1. Another remarkable feature is that this high rate data set performs in a consistent way every 0.7km, with good agreement very close to the coast with a very low signalisation rate, making us confident on the quality of the SLA.

Differences in S2 amplitudes between analyses of ascending and descending passes illustrate a residual alias at this period from an improper correction of meteor effects in altitude. Actually, the 6-hour time-resolution of the meteorological forcing fields is highly suspected to be responsible of these differences and a higher time resolution would probably help a lot in reducing these discrepancies. This assumption would be also verified with respect to the various meteor stations available in the area.

DATA SET ANALYSIS

The along track altimeter-derived estimates of sea level every 0.7 km are compared with the Porto Torres and Sénétosa tide gauges over a common recording period. Tidal gauge sea level records are sub-sampled to the exact times of overpass of each altimetric pass. The Mog2D-Medsea composite combination is applied to de-kaleidoscope high frequency dynamics whereas only Mog2D-Medsea is applied to tidal gauge records as tides had already been removed by harmonic analysis. Figure 3 shows that along-track correlations with Porto Torres (left side) and Sénétosa (right side) range between 0.6 and 0.7. The lower number of data along the coast (which also impacts correlation) may be due to the landing of the data set. We also expect to get more usable data in this coastal strip with specialized re-tracking techniques and improved wet tropospheric path delay corrections.

CONCLUDING REMARKS

X-TRACK post-processing strategy has been assessed over the Strait of Bonifacio, for high data rates, from the combination of T/P plus Jason-1 missions. This 15-year enhanced SLA data set is validated and ready for investigations of coastal dynamics of the Strait.

Our investigations will include absolute current comparisons featuring regional geostrophic currents and inter-comparison with in situ data and other remote sensing data set (e.g. SST, ocean color) synergies with circulation models, will also be investigated.

In a next future, we will also set up and validate an 18Hz ENVISAT data set and make inter-comparison experiments with COASTALT data set (including retracked SSH, marine reprocessing).