Comparison of improved altimeter coastal sea surface heights to tide gauge data in the Mediterranean Sea

A summary of the RECOSETO project results
L. Fenoglio-Marc¹, M. Fehlau¹, M. Becker¹, J. Bouffard³, S. Vignudelli³
1) Technische Universität Darmstadt, Institut für Physikalische Geodäsie – D-64287 Darmstadt;
2) Laboratoire d’Etudes en Géodésie et Océanographie Spatiales, LEGOS, France;
3) Consiglio Nazionale delle Ricerche, Istituto di Biologia, CNR, Pisa, Italy

Introduction
Satellite altimeter data in coastal region need a careful selection of data and corrections, as well as additional processing.
Purpose of the RECOSETO project is the improved estimation of sea level variability in coastal areas.
Here we analyze the Mediterranean Sea coastal regions using Topex and Envisat on-board and on-ground re-tracked data.

Data sets used
- **Altimetry (Level 2)**
- 1. T/P from Radarsat Altimeter Database System (RADS).
- 2. T/P re-tracked data (RGDR) from NASA/JPL PDAIA (Ref. 2.1) between July 2000 to August 2002 (cycles 290 to 364, without 362).
- Two types of 1Hz data from different re-tracking algorithms (RGDR1, RGDR2) are used.
- 3. Envisat GDR at 1 Hz and 10 Hz and waveform data from ESA SGDR products between March 2006 and December 2007 (cycles 46-68).
- **Tide gauges**
- Hourly sea level heights from tide gauge (TG) stations of Genova and Imperia from local authority APAT.
- **Bathymetry**
- GEBCO, Local

Validation by sea level comparison at tide gauges
In-situ tide gauge data are compared to time series of sea level anomaly at the five nearest normal points (NP) located offshore TG Genova and Imperia (Fig. 2). Ocean tide, inverse barometer and pole tide corrections are not applied. As data quality parameters, we compute correlation and Root Mean Square (RMS) between altimeter and tide gauge time series.
- **Envisat has higher correlation and lower RMS than T/P data (at Imperia and the last available NP for TG Genova).**
- **Higher correlation and lower RMS with decreasing distance from TG.**
- **Envisat RADS and SGDR data are very similar.**
A summary of the respective minimal distances in the vicinity of each station is presented in Tab. 1.

Distance analysis
Four types of distances related to the coast for each record are analyzed:
(1) distance to tide gauge, (2) distance to coast, (3) along-track sea-land (d) distance and (4) along-track land-sea (h) distance.
Most of the Envisat and T/P passes have a minimum distance to land smaller than 10 km. In sea-direction nearly 55% of Envisat and 45% of T/P passes have a minimum distance to coast smaller than 7 km. In land-sea direction only 15% of Envisat passes reach the coast within this distance, where no T/P record is available. Sea-land coastline crossing direction provides clearly more advantageous measurements conditions for both satellites.

Re-tracking
We retrack Envisat data from the SGDR waveforms using four methods as given in Tab. 2. The improvement percentage (IMP; [4]) is computed to check the quality of the retracted SSHs, using:

\[ \text{IMP} = \frac{\text{RMS} \text{ of raw} - \text{RMS} \text{ of retracted}}{\text{RMS} \text{ of raw}} \times 100\% \]

\( \text{RMS} \text{ of raw} \) and \( \text{RMS} \text{ of retracted} \) are the standard deviations of the differences between raw SSHs and retracted SSHs and geoid heights (EGM2008), respectively.

<table>
<thead>
<tr>
<th>Method</th>
<th>IMP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>-</td>
</tr>
<tr>
<td>Envisat RADS</td>
<td>2.2</td>
</tr>
<tr>
<td>Envisat SGDR</td>
<td>3.7</td>
</tr>
<tr>
<td>Envisat RADS</td>
<td>4.4</td>
</tr>
<tr>
<td>Envisat SGDR</td>
<td>5.0</td>
</tr>
</tbody>
</table>

The better performance of the altimeter for sea-land than for land-sea transitions appears from the above figure. The decrease power typical for ocean type waveforms occurs very near to land in the sea-land transition. The figure below shows an example of the retracker performance.

Summary: Major results
- **Data availability:**
  - 1. Envisat data perform better in coastal region with up to 35% more data available in the last 5 km.
  - 3. Envisat provides more usable data nearer to the coast, independently from the crossing direction.
  - 4. In land-sea direction, Envisat provides data for the last 7 km offshore, no T/P data available in this distance range.
  - 5. In sea-land direction, for 90% of all passes in Med both satellites provide usable data closer than 15 km to the coastlines.
- **Re-tracking:**
  - 1. Of the four retracking used for Envisat waveforms, the best is improved retracker, worst is OCOCG.
  - 2. The improved threshold algorithm shows a slight improvement of accuracy of SSH wet original on-board retracted data.
  - 3. Retracked data perform better near coast than the data not retracted.

References