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

A summary of the RECOSETO project results

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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 analyse the Mediterranean Sea coastal regions using Topex and Envisat on-board and on-ground re-tracked data.

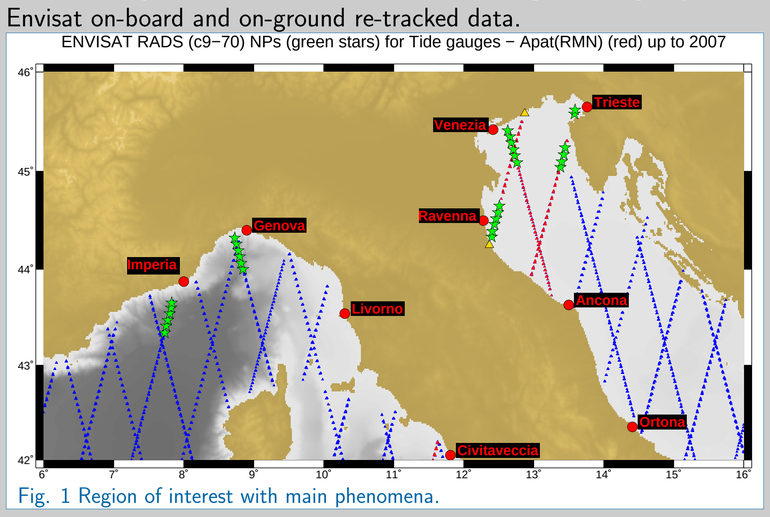

Fig. 1 Region of interest with main phenomena.

The main goals of this study are:

1. Investigation of the selection criteria which are more suitable to retain a great amount of data along the coasts.
2. attempt to determine to what extend the land and ocean characteristics might affect the altimeter data in coastal regions
3. validation of the altimeter sea surface heights by comparison with sea level heights observed at a set of tide gauge stations.
4. nvestigation of reduction of the residuals with and without application of ocean tide and MOG2D pressure

We consider the Envisat cycles 46 to 68.

Data sets used

- Altimetry (Level 2)

1. T/P from Radar Altimeter Database System (RADS).
2. T/P retracked data (RGDR) from NASA/JPL PODAAC (Rel. 2.1) between July 2000 to August 2002 (cycles 290 to 364, without 362). Two types of 1Hz data from different retracking algorithms (RGDR1, RGDR2) are used.
3. Envisat GDR at 1 Hz and 18 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
- Bathymetrie
  - GEBCO, Local

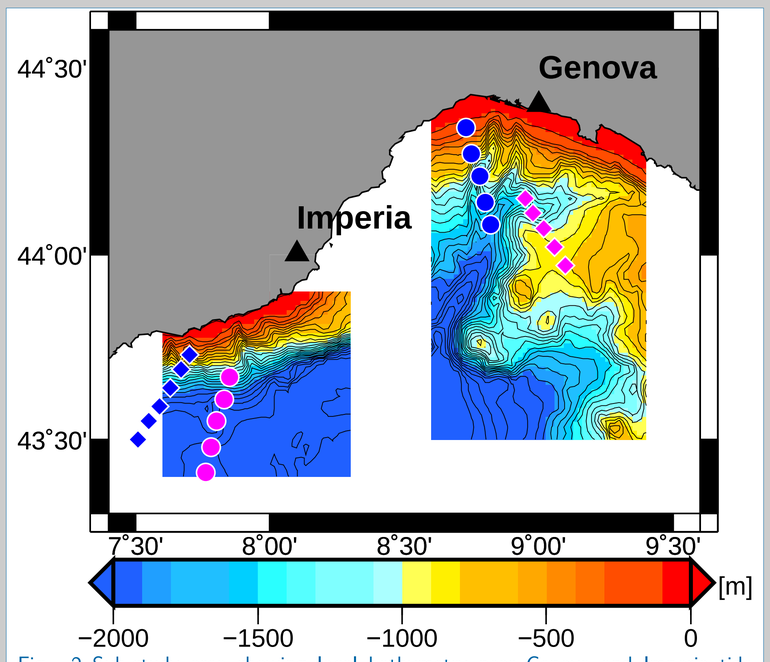

Fig. 2 Sub-study area showing local bathymetry near Genova and Imperia tide gauge stations and position of the Envisat 1 Hz normal points along Envisat passes 801 and 216 respectively

Distance analysis

Four types of distances related to the coast for each record are analysed: (1) distance to tide gauge, (2) distance to coast, (3) along-track sea-land (sl) distance and (4) along-track land-sea (ls) distance.

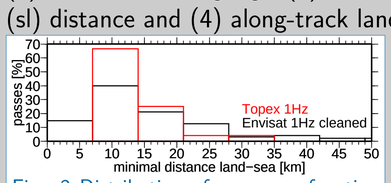

Fig. 3 Distribution of passes as function of minimum along-track distance land-sea

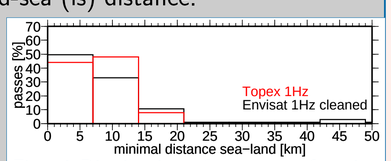

Fig. 4 Distribution of passes as function of minimum distance sea-land

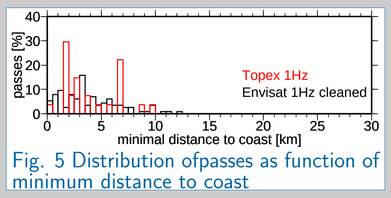

Fig. 5 Distribution ofpasses as function of minimum distance to coast

Most of the Envisat and T/P passes have a minimum distance to land smaller than 10 km. In sea-land 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 retracked SSHs, using

$$\mathrm{IMP} = \frac{\delta_{raw} - \delta_{retracked}}{\delta_{raw}} * 100\%$$

where $\delta\ raw$ and $\delta\ retracked$ are the standard deviations of the differences between raw SSHs and retracked SSHs and geoid heights (EGM2008), respectively. The success rate of the 5- β method is 87% and 100% for the other methods. The Improved Threshold and the 5- β method turn out to be the most suitable method producing the biggest IMP value.

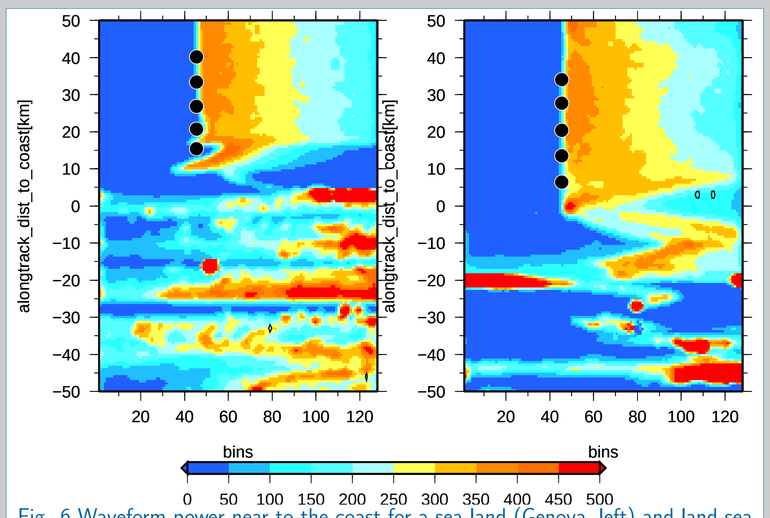

Fig. 6 Waveform power near to the coast for a sea-land (Genova, left) and land-sea (Imperia, right) transition

The better performance of the altimeter for sea-land than for land-sea transtions appears from the above figure. The power decrease 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.

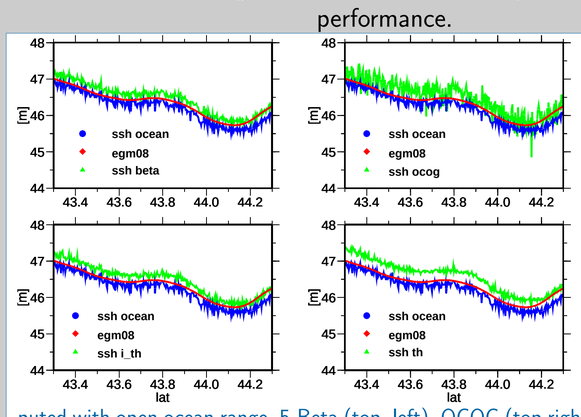

Fig. 7 SSH computed with open ocean range, 5-Beta (top, left), OCOG (top right), threshold (below right) and Improved Threshold (below, left). Reference is geoid EGM2008

Field	Retracker	δ_{raw} (m)	δ_{retr} (m)	IMP
5 beta (86.97%)		0.209	0.084	59.8
OCOG (100%)		0.214	0.220	-2.8
Threshold (100%)		0.214	0.090	57.9
Imp. Threshold (100%)		0.214	0.086	59.8
On board ocean-1 (100%)		0.214	0.088	58.9

Table 1: Statistics of Evisat 18 Hz waveform retracking (cycle 59, Pass 801 near Genova) : succesfull processed waveforms in %, standard deviation of the difference between SSH (raw) and SSH(retracked) and EGM2008, improved percentage

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 first 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 at 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.

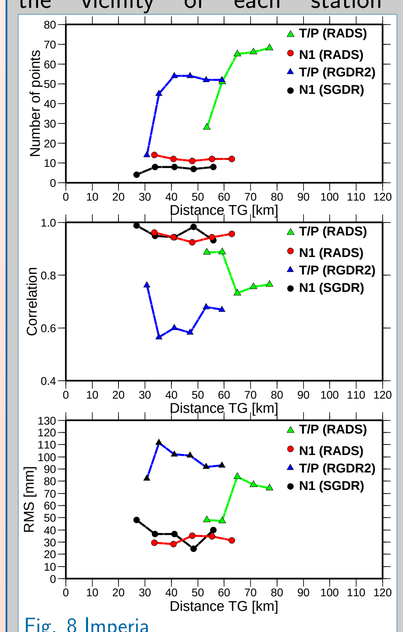

Fig. 8 Imperia

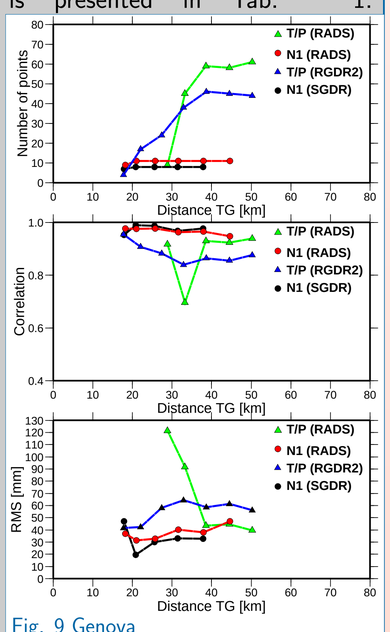

Fig. 9 Genova

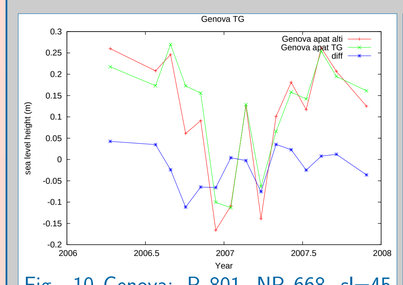

Fig. 10 Genova: P 801, NP 668, sl=45 km

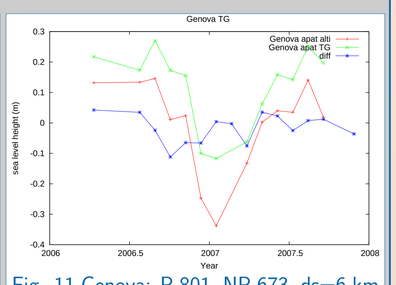

Fig. 11 Genova: P 801, NP 673, ds=6 km

- Reduction of residuals by additional corrections

Two solutions are considered:

- Regional: tide (MOG2D purely hydrodynamic) + dynamin response to wind and pressure (MOG2D) + inverse barometer (MOG2D)
- Global: tide (GOT4.7, R.Ray) + dynamic response to wind and pressure (MOG2D global) + inverse barometer (MOG2D global)

Small reduction of rms depending from location, maximum in Trieste

- Land-sea and sea-land transitions

Field	Station	Distance to coast (km)	Distance TG (km)	Distance alongtrack (km)
Genova n1 SGDR sl 801		6.4	17.9	6.1
Genova n1 RADS sl 801		6.2	18.2	5.9
Genova tx RGDR2 ls 044		15.5	17.7	18.2
Genova tx RADS ls 044		24.2	28.8	32.2
Imperia n1 SGDR ls 216		8.9	28.7	10.1
Imperia n1 RADS ls 216		20.3	33.6	24.2
Imperia tx RGDR2 sl 009		6.0	30.8	6.9
Imperia tx RADS sl 009		24.4	53.4	30.7

Table 2: Minimum distance to coast

Summary: Major results

- Data availability :
  1. Envisat data perform better in coastal region with up to 15% more 1 Hz data available in the last 5 km.
  2. Sea-land perform better than land-sea transitions.
  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 coastline.
- Re-tracking :
  1. Of the four retracking used for Envisat waveforms, the best ist improved retracker, worst is OCOG.
  2. The improved threshold algorithm shows a slight improvement of accuracy of SSH wrt original on-board retracked data.
  3. Retracked data perform better near coast then the data not retracked.

References

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Acknowledgements
We acknowledge ESA, CNES, JPL for the GDR and RGDR data and DEOS/NOAA for the RADS database. The RECOSETO Project is founded by DFG.

Ocean Surface Topography Science Team (OSTST) Meeting, Nice 10-12 November 2008