Coastal multi-satellite altimetry data & tide gauge records
Techniques, Applications and Validation on two areas

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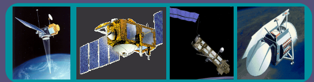
Abstract

The excellent spatial and temporal resolution of satellite altimetry means that the sea surface topography is well sampled for the deep oceans. However, the coastal ocean dynamics are much more complex, being characterized by a wide range of spatial and temporal scales, which are more difficult to observe with a classical altimetric product.

A coastal multi-atellite (Topex/Poseidon, Jason1, Envisat, GFO) altimetric data set has been derived from each mission's GDR products using a new processing strategy developed for coastal zone applications. Particular attention is given to the tide and inverse barometer corrections using a high-resolution 2D gravity wave model (MOG2D).

In order to validate this multi-satellite altimetric data set, sea surface height data have been compared with tide gauges records in two coastal regions : the Western Mediterranean Sea and the South Indian Ocean at Kerguelen, Crozet and Saint-Paul Islands. We also focus on techniques which combine altimetric and tide gauges data in order to better capture physical coastal processes such as wave propagation or coastal currents. The spatial and temporal scales accessible through these observing systems are then compared to numerical barotropic and 3D coastal models.

Coastal multi-satellite data processing



CTOH database
Topex Poseidon, Jason 1, Envisat, GFO

Classical editing
10 & 20 htz data
Noise filtering
(Loess filter along track)

Deasaliasing corrections :
Ocean Tide: Mog2D regional tidal solutions
Barotropic response: Mog2D regional model

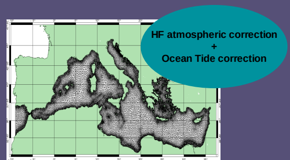
Orbit & large scale error reduction

Sea Surface Anomaly at t

MOG2D in the Medsea regional configuration

- Lynch and Gray (1979), adapted by Greenberg and Lyard
- Barotropic, free surface, non-linear and time-stepping model
- solves the continuity and momentum equations in a single wave equation
- implemented on a finite element grid (2D)

➔ Higher resolution on a steeper and shallower bathymetric zone.
➔ Adequate for studying the high frequency response to meteorological forcing (*Lyard & Roblou, 2003*) and oceanic tides (*Roblou, pers. Comm.*) in coastal areas.



Orbit & large scale error reduction

- First step : Large-scale time-dependent error filtering

Spatial Filtered SLA

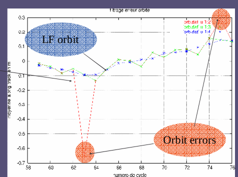
Along track mean of Sea leavel Anomaly (red curve) f(t)

Orbit error localization 2 rms filtering on f(t)-LF

Interpolation f_2(t)

Loess filtering (blue curve) f_3(t)

SLA_new = SLA-f(t)+f_3(t)

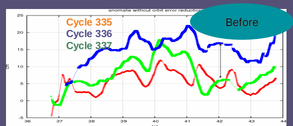


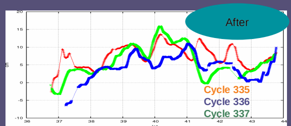
- Second step: mono satellite crossover minimization technique
  - Hypothesis: orbit error is a bias on a short arc orbit
  - Minimization of the cost function (inversion with a Cholesky decomposition)

$$f=\sum_{i=0}^{N}\left(\sum_{j=0}^{N_j}\left(\alpha_{i,j}+a_i-\beta_{j,i}-b_j\right)^2\right)^2$$

N(i) number of crossover points for the track i
Alpha(i,j) Sea surface height at the crossover point between track i & j
Beta(j,i) Sea surface height at the crossover point between track j & i
a(i) et b(j) constant values along each satellite track which minimize

- Third step : loop with the first step (iterative processing)

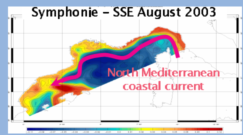




Main Results on the Mediterranean Sea

Symphonie : a coastal model

- Symphonie is basically a three dimensional primitive equation model of the coastal ocean.
- Geophysical coordinates : -1,74E - 10,95 E / 38,26 N - 45,61 N
- Horizontal resolution : 3 km * 3 km
- Lateral Boundary conditions : MFSTEP OGCM
- Surface Boundary conditions : Aladin Weather Forecast (Météo-France)



run 2001 - 2003

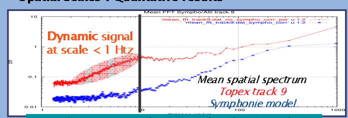
Symphonie model elevations

Interpolation along each Satellite track in space & time

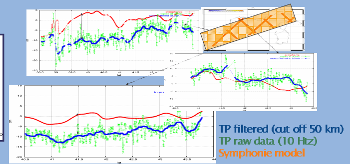
Sea Surface Anomaly at t

Altimetry vs Symphonie model

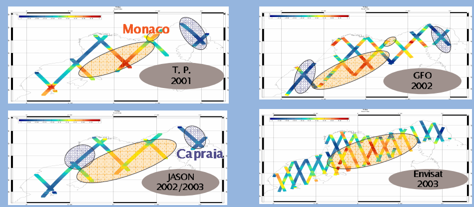
- Spatial Scales : Qualitative results



- Good agreement in lage spatial scales (>50 km)
- Problems of bias between model & altimetry
- Spectral spatial energy is less in the model



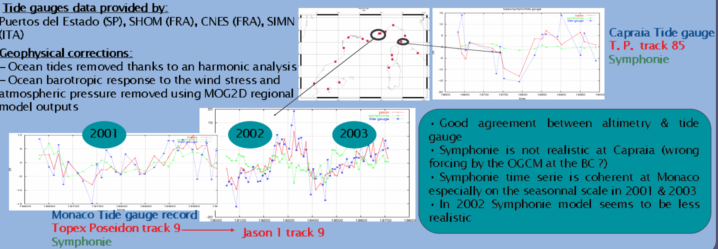
- Correlation between altimetry and Symphonie model



Altimetry vs model : Who is right ? ➔ Tide gauge records

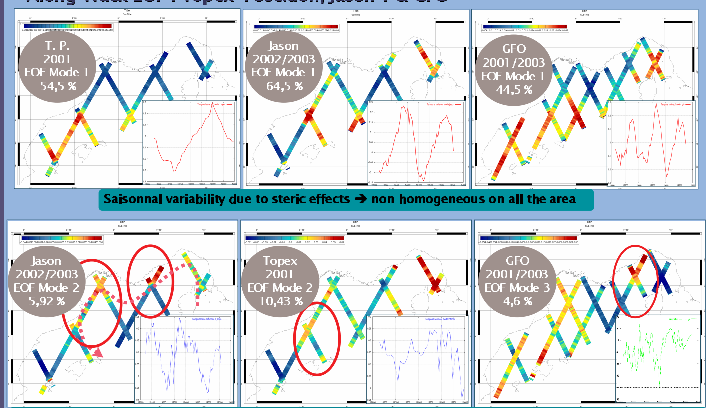
Tide gauges data provided by:
Puertos del Estado (SP), SHOM (FRA), CNES (FRA), SIMN (ITA)

Geophysical corrections:
- Ocean tides removed thanks to an harmonic analysis
- Ocean barotropic response to the wind stress and atmospheric pressure removed using MOG2D regional model outputs



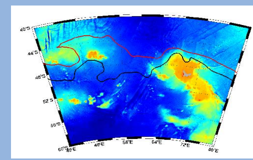
- Good agreement between altimetry & tide gauge
- Symphonie is not realistic at Capraia (wrong forcing by the OGCM at the BC ?)
- Symphonie time serie is coherent at Monaco especially on the seasonnal scale in 2001 & 2003
- In 2002 Symphonie model seems to be less realistic

Along Track EOF : Topex-Poseidon, Jason 1 & GFO

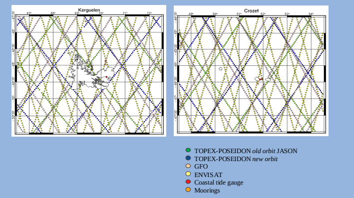


Slope inversions on multi temporal scales ➔ increase & decrease of the North Current intensity *(cf Millot et al.)*

South Indian Ocean : Crozet & Kerguelen islands



The Crozet and the Kerguelen shelves, and the fronts of the Antarctic Circumpolar Current.



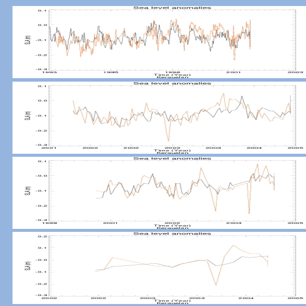
New data processing vs classical data processing

Standard deviation between the coastal tide gaudes times series and the altimetric time series

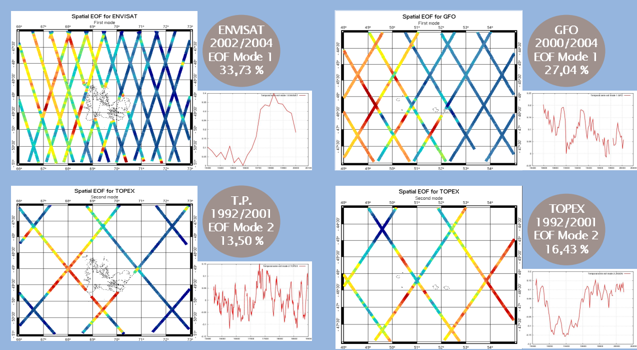
RMS (cm)		Classical data processing	Data processing improved
Kerguelen	TOPEX	7,12	4,94
	JASON	5,07	4,78
	GFO	6,16	5,14
	ENVISAT	5,14	6,54
Crozet	TOPEX	5,67	4,10

➔ Improvement of the new altimetric data processing .

Comparison of the Kerguelen tide gauge time serie with the multi-satellite altimetric data



Along Track EOF : Topex-Poseidon, Jason 1, GFO and ENVISAT



Conclusions and perspectives

- **Coastal altimetry is possible !!**
  - The improved altimetric data processing exhibits a good agreement with tide gauges observations for all satellite missions and on two areas.
  - It also shows a good agreement with the Symphonie model (far from the model boundaries) at scales > 1month and for spatial scale greater than 50 km.
  - EOF of coastal altimetric product exhibit regionnal circulation on different temporal scales.
- **Perspectives**
  - This study exhibits the need of improving the 3 D models in terms of boundary conditions and of small spatial scales resolving.
  - The altimetric data processing should also take into account the specific coastal requirements suggested by the Albicocca project (particular data editing and environmental altimetric corrections recovering)
    ➔ *Vignudelli et al., 2005*
  - The next step will be to assimilate these coastal altimetric data in a 3 D model to improve its performances in small time and spatial scales.