Using high rate altimeter measurements for coastal studies: example in the Northwestern Mediterranean Sea

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Appropriate data (re)processing and analysis allow the optimisation of the number of informations which can be derived from altimeter measurements. This is particularly true in the coastal zone where data are generally discarded due to problems with the altimeter radar echoes or to inaccurate corrections, but also because the standard processing is not tuned for ocean marginal regions. This results in a relatively large (10-40 km) data gap next to the coast in standard altimetric products. Even if this remains a very challenging exercise, several scientific groups work on extending satellite altimetric products into the shelf and coastal seas (COASTALT, PISTACH, CTOH, ...), by means of appropriate corrections and data (re)processing. This enhances data availability and accuracy close to land and then allows a better observation of the coastal oceans. Here, the potential of full rate measurements will be analysed in the context of coastal studies in the Northwestern Mediterranean Sea.

Context and data processing

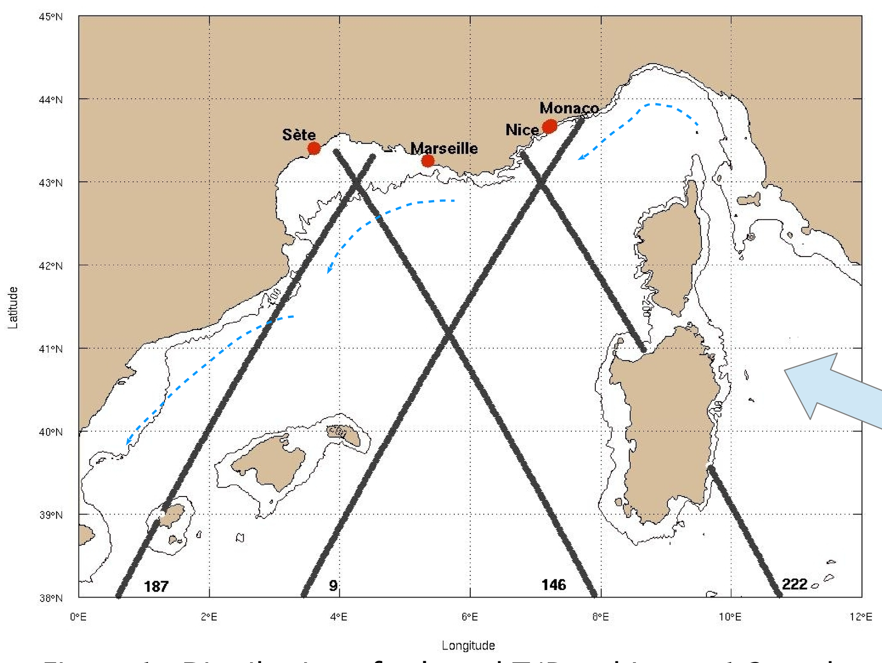


Figure 1 : Distribution of selected T/P and Jason-1,2 tracks. The 200-m and 1000-m isobaths are shown (from ETOPO2v2 Database). Red solid circles indicate the locations of tide gauge stations (from SONEL data base). Blue dashed arrows give a shematic view of the Liguro Provencal Current (LPC).

Here, we analyse the skill of the original high-rate altimetry data, relative to conventional 1-Hz data, to recover coastal sea level variations in the test case of the northwestern Mediterranean Sea. Performance will be quantified through a comparison with different tide gauge sea level time series (more details in Birol et al.2012)[2]. The Northwestern Mediterranean Sea is an interesting case study because of the complex nature of its flow (short spatial and temporal wavelengths)

Altimetric data:

➢ Starting from 10 Hz (T/P), 20 Hz (Jason-1& Jason-2) measurements provided in standard GDRs and interpolating 1Hz geophysical corrections at 10 Hz/20Hz frequency.

➢ Using X-TRACK data processing.

Tide gauges measurement :

➢ Provided by the SONEL service (Système d'Observation du Niveau des Eaux Littorales; http://www.sonel.org/).

➢ Four stations selected : Sète, Marseille, Nice, Monaco, because of their proximity to altimeter groundtracks and of their time series.

➢ Hourly averaged and and linear interpolated to the time of satellite observations

➢ Tide signal and Dynamic Atmospheric Correction removed

	Sète	Marseille	Nice	Monaco
Time period	01/10/1992 11/01/2011	27/10/1998 31/05/2011	18/03/1998 31/05/2011	16/04/1998 31/05/2011
Corresponding track	146	187	222	9
Distance from the closest altimeter data (km)	19.49	66.23	58.58	25.8

Table 1: Time period, closest satellite track and approximate distance from the closest alongtrack T/P-Jason1,2 altimeter location for each tide gauge station.

Availability and consistency of high rate (10/20 Hz) altimeter data

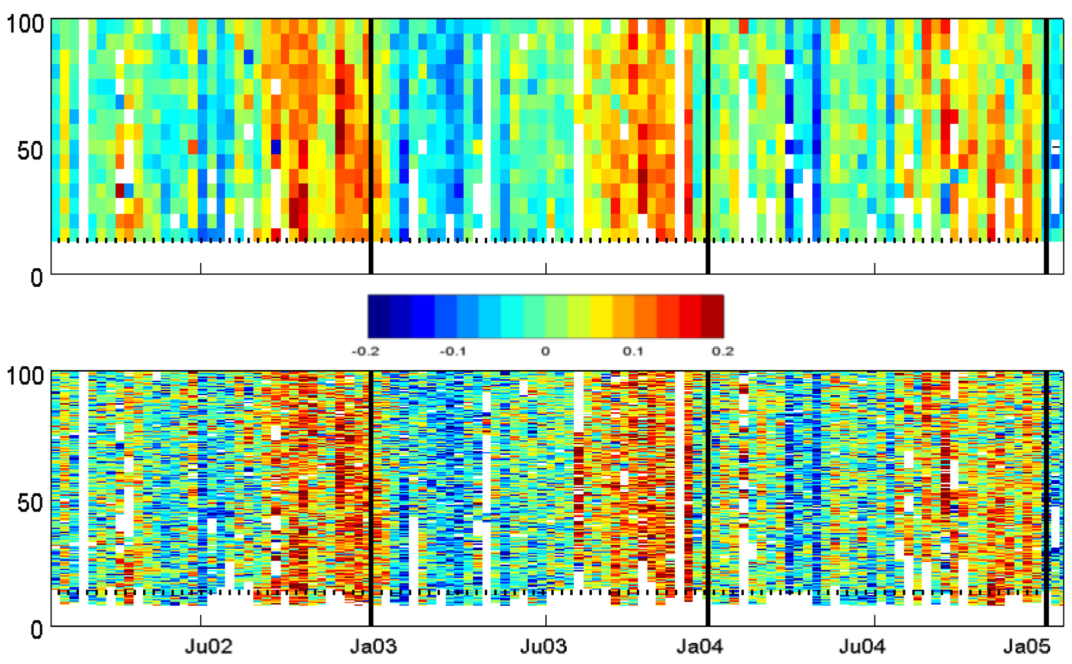


Figure 2: Time-space diagrams of 1-Hz (top), 20-Hz SLA (bottom), along track 146 for Jason-1 (first three years of data). The nearshore limit of the 1-Hz data at 13 km is marked by the dotted black line on all plots.

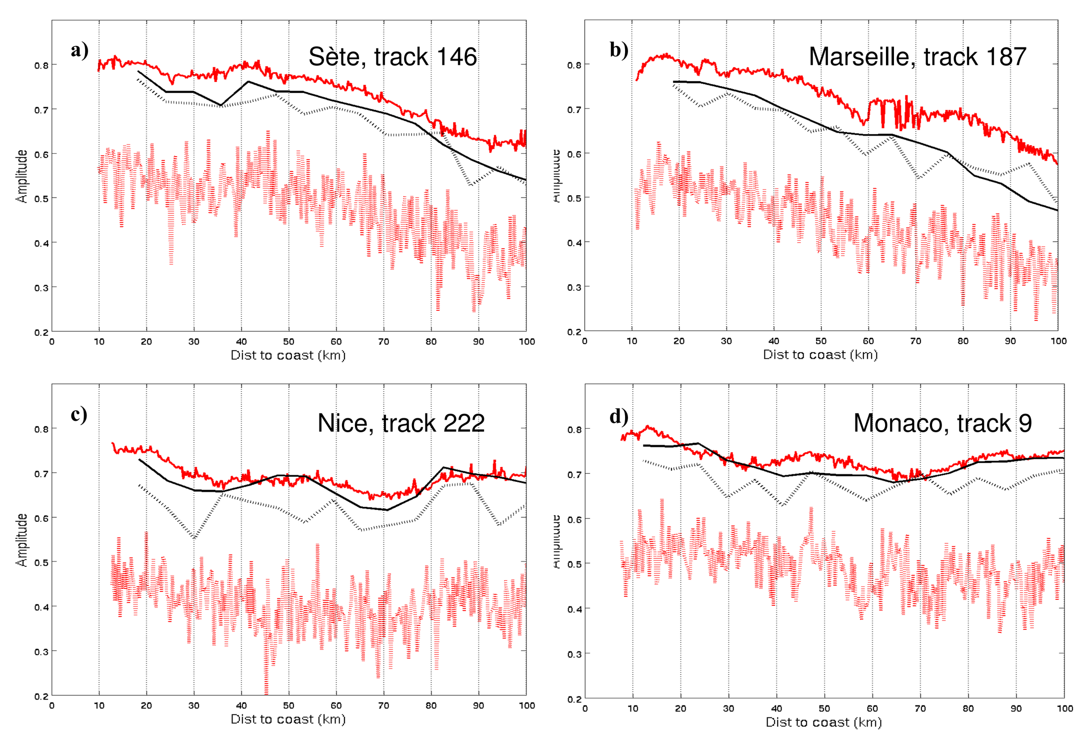


Figure 4 : Correlation coefficients between Jason-1 and tide gauge SLA as a function of distance to the French coast, using both the 20-Hz (in red) and the 1-Hz (in black) SLA, and for tracks 146 (a), 187 (b), 222 (c) and 9 (d). The thin dashed curves correspond to raw SLA and the thick curves correspond to low-pass filtered SLA, using a 30-km cut-off frequency.

➢ Comparison between 1Hz and 20 Hz SLA (figure 2):

➢ **20 Hz SLA with 1Hz SLA**: large scale structure are coherent

➢ Higher noise level in raw HF SLA

➢ BUT Higher data availability close to the coast (~some kilometers) in 20Hz data

➔ Need to be filtered

➢ Availability of the high rate SLA wrt 1Hz SLA (table 2):

• for distance <30km from land: significant improvement for Jason-1&2 (>10%); slightly less for T/P

• for distance between 30 and 50 km: small increase for all missions

• for distance > 50km from land: no significant difference between 1Hz and HF datasets (except for Jason-2, -5%, still under study)

➢ Choice of the filter (figure 3):

• A low pass **Lanczos filter** has been applied to the 10/20 Hz SLA in the alongtrack direction aside from the classical 18-20 points boxcar average. The cut-off frequency has been chosen from the analysis of the mean correlation values obtained by comparing the tide gauge data with all 10/20 Hz low-pass filtered altimeter located closer than 50 km to land.

• correlation increase by about 0.2 between raw and 3km filtered SLA for Jason-1&2

• T/P correlations values increase more regularly with the cut-off frequency

• stability of the correlation coefficients after cut-off frequencies larger than 30 km for the three missions

➢ Comparison of 30km low-pass filtered altimeter and tide gauge data (figure 4):

• correlation coefficients between altimetry and nearest tide gauge anomaly time series calculated at each reference point along the different tracks

• after filtering 10/20Hz measurements, the same level of sea level accuracy obtained as using the classical 1-Hz altimeter data, while retaining more data closer to the coast.

➔ The use of Lanczos-filtered 10/20-Hz SLA allows a significant gain in the number of useful altimeter SLA data near the coast.

Satellite mission	d <= 30km	30km < d < 50 km	d > 50 km
Topex/Poseidon	57.99% / **60.59%** **(+4.5%)**	81.18% / **82.83%** **(+2%)**	86.38% / **86.3%** **(+0.1%)**
Jason-1	68.46% / **75.5%** **(+10.3%)**	87.94% / **89.27%** **(+1.5%)**	91.87% / **91.28%** **(-0.6%)**
Jason-2	63 .76% / **72.07%** **(+13%)**	92% / **93.85%** **(+2%)**	96.28% / **91.49%** **(-5%)**

Table 2: Average value of the percentage of valid 1Hz and 10/20Hz (in bold) SLA as a function of the distance to the French coast and of the satellite mission. The numbers in brackets indicate the mean gain/lost in number of valid data when using 10/20Hz data

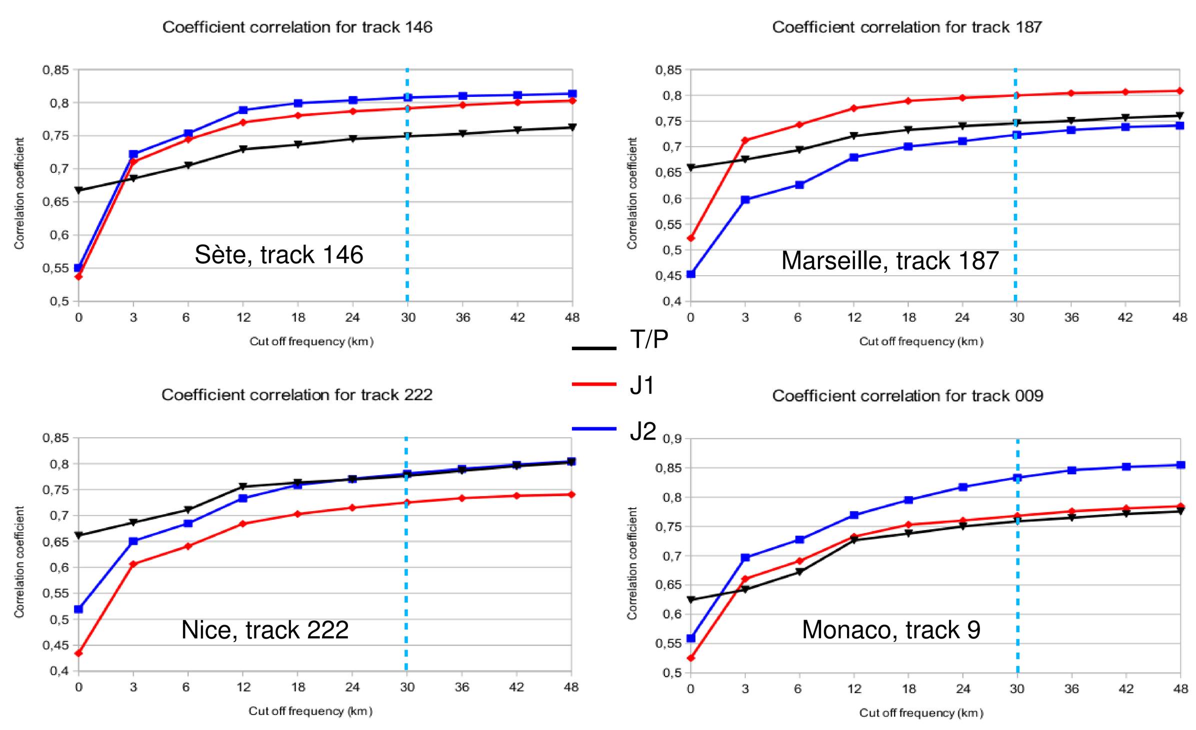


Figure 3: Average correlation deduced from the comparison between all 10/20-Hz low-pass filtered altimeter data located closer than 50-km from land and the nearest tide gauge observations. The x-axis represents the cut-off frequency used in the low-pass filter. Dashed blue lines mark the 30km cut off frequency

Application to the regional coastal circulation

In order to verify the good representation of the LPC in the altimeter data, we have compared Sea Surface Temperature (SST) fields with geostrphic velocity anomaly derived from altimetry.

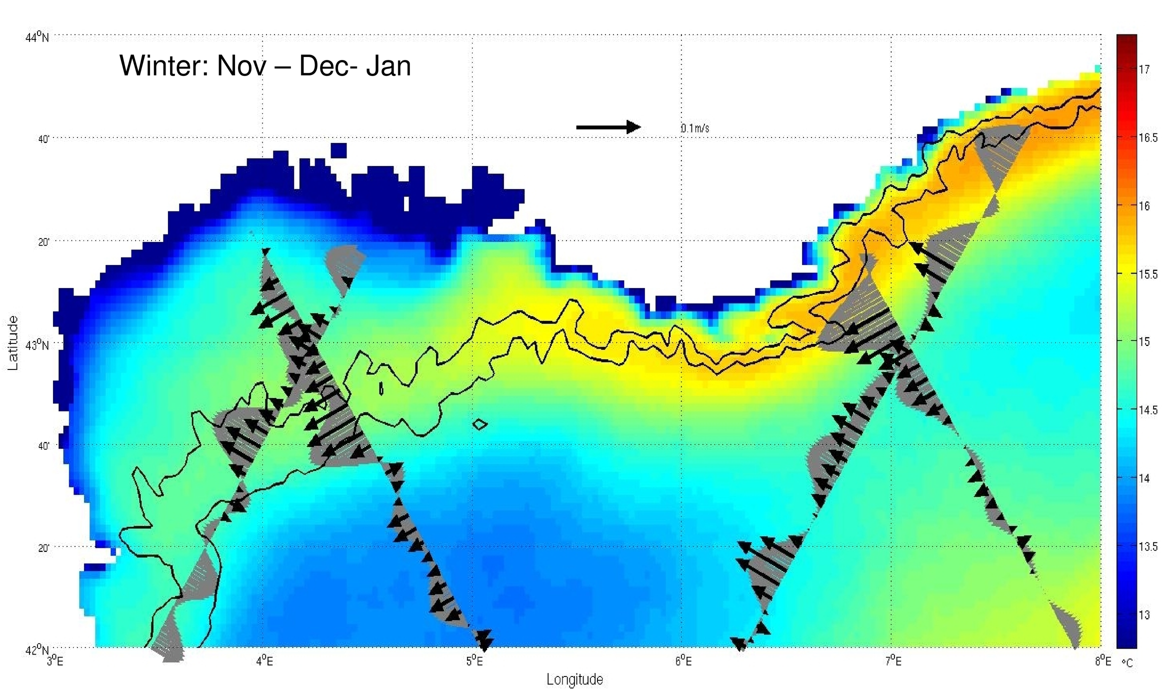


Figure 5 : Climatology of cross-track geostrophic current anomalies derived from 1-Hz (black arrows) and from 20-Hz (grey arrows) Jason-1 SLA for the winter season (November-December-January). The currents are superimposed on a map of the corresponding winter SST climatology (derived from AVHRR observations). The 200-m and 1000-m isobaths are also shown (black lines).

➢ SST climatology based on weekly SST composites (obtained from the DLR Earth Observation Information Service, http://eoweb.dlr.de) covering the period 2002-2007

➢ Velocity anomalies derived from 1Hz and 20Hz 30 km filtered SLA for Jason-1 (corresponding period of SST data)

➢ Good representation the warmer waters carried by the LPC Current along the continental shelf (figure5)

➢ Intensification of the derived velocity anomalies near the coasts

➢ **Consistency between observations and derived velocity anomalies**

➢ Consistency between 1Hz and 20Hz data

➢ High rate data are closest to the coast and allow a better representation of the LPC

➔ Very encouraging results but more investigations needed using in situ observations in order to optimize the processing

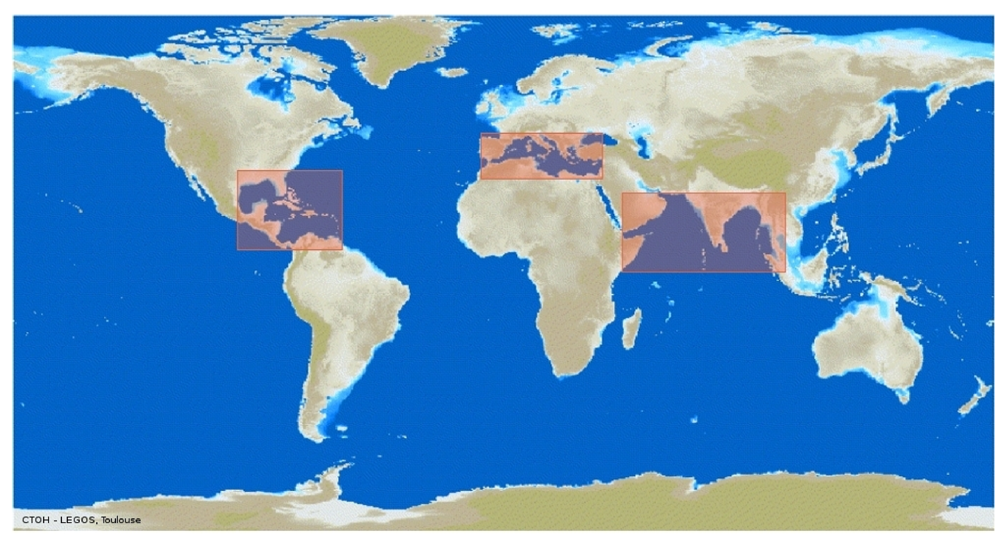
➔ Expertise support for CNES PISTACH project

References

(1) Roblou et al., 2011. Coastal Altimetry, Springer Berlin Heidelberg

(2) Birol et al., 2012. Evaluation of high rate (10/20Hz) altimeter data: a case study of the northwestern Mediterranean Sea (submitted)

Distributed products



➔ raw 10Hz (T/P) and 20 Hz (Jason 1-2) available in 3 regions

➔ Web site:

http://ctoh.legos.obs-mip.fr/products/coastal-products/

➢ Details on corrections applied, data processing ...

➢ Access to some regional diagnostics: maps of rms, percentage of data available, minimum and maximum values.

➔ Data request: mailto: ctoh_products@legos.obs-mip.fr http://ctoh.legos.obs-mip.fr/products/coastal-products/coastal-registration-form