New advances in altimetry towards the coast : example of the CTOH sea level products

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Historical 1 Hz X-TRACK Sea Level product

The X-TRACK processing chain has been developed in the 2000s in order to recover as much altimetry sea level data as possible in the coastal zones. X-TRACK is now a multi-mission L3 (i.e. alongtrack) regional product covering all the coastal ocean, produced by the CTOH observational service and freely distributed by the AVISO+ service. In Improving the number and quality of near-shore sea level data, X-TRACK allows to better understand the coastal ocean, its variability (past, present, future) and how sea level evolves from the open ocean to the coastal zone.

From the initial X-TRACK sea level product, the CTOH derives different products for coastal applications such as **tidal** or **coastal dynamics** studies, **long-term sea level change**. **All are freely available through different web portals.**

Data doi: 10.6096/CTOH_X-TRACK_2017_02

Where : https://www.aviso.altimetry.fr/

Birol et al., 2017. "Coastal Applications from Nadir Altimetry: Example of the X-TRACK Regional Products." *Advances in Space Research*, 59 (4), 936-953.

X-TRACK Product	Altimetry mission													
	Topex	Jason-1	Jason-2	Jason-3	Topex interleaved	Jason-1 interleaved	Jason-2 interleaved	ERS-1	ERS-2	Envisat	SARAL	Geosat Follow-On	Sentinel-3A	HaiYang-2A
1 Hz	■	■	■	■	■	■				■	■	■		
Tidal 1 Hz	■	■	■		■	■								
ALES 20 Hz		■	■	■						■	■			
Trends 20 Hz		■	■	■										
L2P 1 Hz	■	■	■	■	■	■	■	■	■	■	■	■	■	■

X-TRACK/L2P: 1 Hz Sea Level product

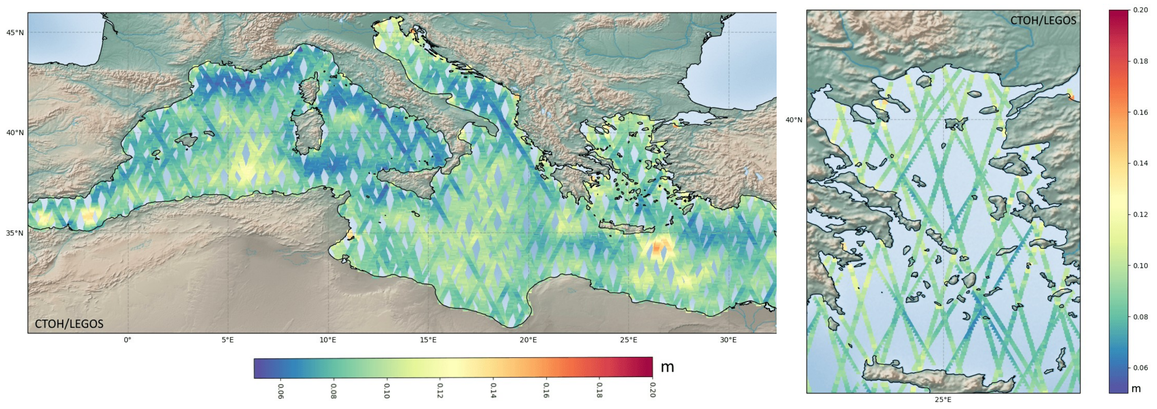


Figure 1 : Standard deviation of the sea level anomaly (in m) from the X-TRACK L2P dataset, computed over the period 2003-2008, in the Mediterranean Sea (left) and the Aegean Sea (right). 3 different orbits are represented: TP+J1+J2+J3 (circle), ERS1+ERS2+ENV+SRL (square) and GFO (triangle).

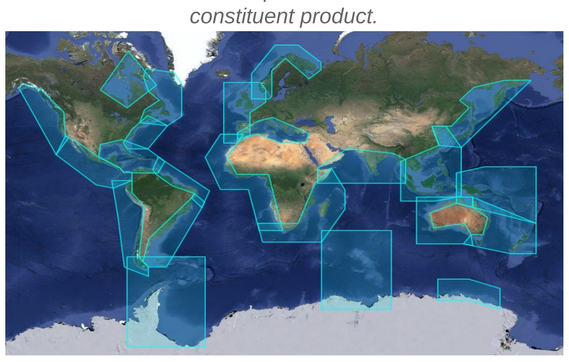
A new L3 product is available, combining X-TRACK processing and the L2P altimetry product delivered by AVISO+, including the most recent parameters and corrections for all altimetry missions dedicated to the ocean.

Note that an intermission bias is applied for all missions, adjusted on the GMSL to compare all missions together. The missions that are on the same orbit are systematically combined in a single time series.

This new product provides then an homogeneous and easy-to-use sea level solution for 14 missions, with an unprecedented spatial and temporal coverage for a coastal sea level product.

X-TRACK-L2P

Figure 2 : Map of the zones covered by X-TRACK, X-TRACK/L2P sea level product and X-TRACK tidal constituent product.



Data doi: 10.24400/527896/a01-2022.020

Where : https://www.aviso.altimetry.fr/

X-TRACK/ALES 20Hz Sea Level product

In the context of the ESA Climate Change Initiative project, two coastal altimeter processing approaches have been combined (ALES & X-TRACK) to reprocess data from the Jason-1,2,3 missions. It allows extending the spatial coverage of altimetry sea level time series up to 1.2-4 km to the coast (depending on the area).

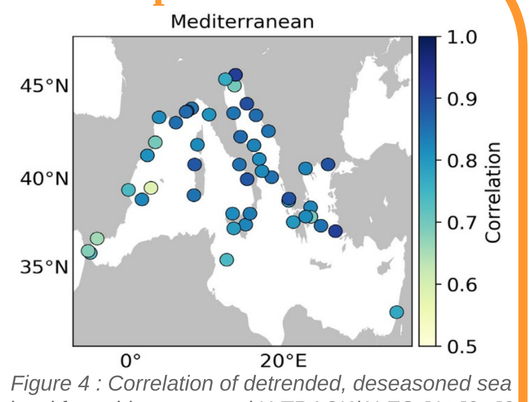


Figure 4 : Correlation of detrended, deseasoned sea level from tide gauge and X-TRACK/ALES J1+J2+J3 altimetry time-series in the Mediterranean Sea

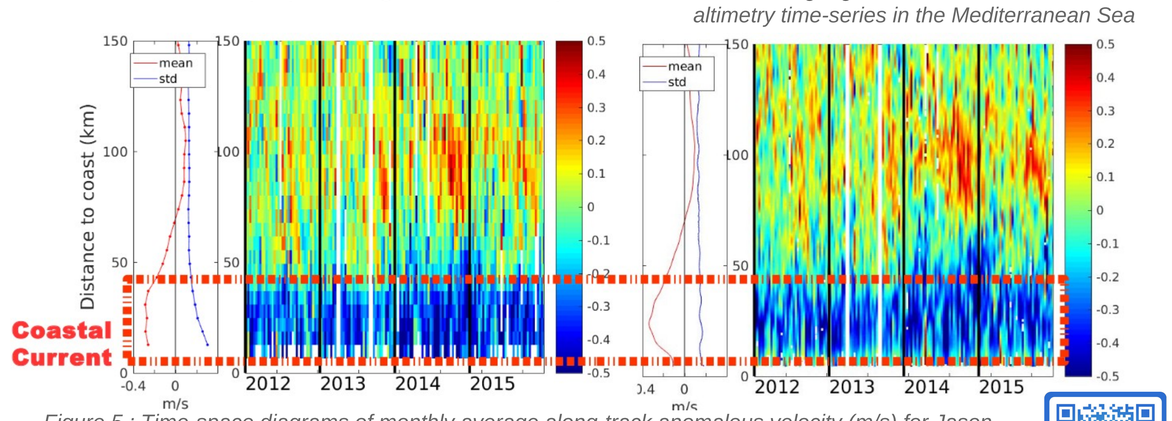


Figure 5 : Time-space diagrams of monthly average along-track anomalous velocity (m/s) for Jason track 222 in Mediterranean Sea using both X-TRACK 1Hz (left) and X-TRACK/ALES 20 Hz (right) data

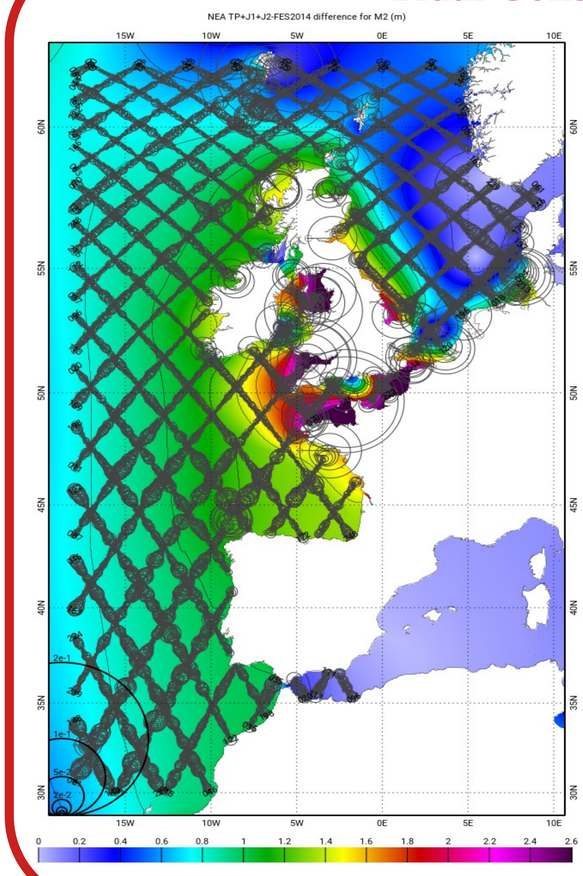
Data doi: 10.5270/esa-sl_cci-xtrack_ales_sla-200206_201805-v1.1-202005

Where : https://climate.esa.int

Birol et al., 2021. The X-TRACK/ALES multi-mission processing system: New advances in altimetry towards the coast. *Advances in Space Research*, 67(8), 2398-2415.

X-TRACK/ALES

Tidal Constituent product



From the X-TRACK 1 Hz Sea Level product (see above), the CTOH service has developed a regional tidal constant product also covering the world coastal ocean. Empirical harmonic constants (amplitude, phase and error estimates) are derived from X-TRACK sea level time series for a total of 73 tidal constituents by harmonic analysis.

This altimetry-derived tidal product complements tide gauge observations and is an independent source of information for tidal model validation and/or tidal studies.

Figure 3 : Vector differences between FES2014 global tidal model and the X-TRACK TP+J1+J2 tidal constants for M2. The background color map shows the M2 amplitude from model (m)

X-TRACK Tidal

Data doi: 10.6096/CTOH_X-TRACK_Tidal_2018_01

Where : https://www.aviso.altimetry.fr/

Birol et al., 2017. "Coastal Applications from Nadir Altimetry: Example of the X-TRACK Regional Products." *Advances in Space Research*, 59 (4), 936-953.

Long-term coastal sea level trends

From the X-TRACK/ALES Sea Level product (see above), a strict editing is applied in the 20 km coastal area. 756 altimetry virtual coastal stations located around the world are then selected. The corresponding monthly sea level time series for the period from January 2002 to December 2019 and associated trends are computed and made available in a dedicated product. It offers in particular new information on the sea level evolution and trends in regions without tide gauges.

Figure 6 : Coastal sea level trends (mm:yr) at the first valid point from the coast at the selected virtual stations

Data doi: 10.17882/74354

Where : https://www.seanoe.org

Cazenave et al., 2022. New network of virtual altimetry stations for measuring sea level along the world coastlines. *Communications Earth & Environment,* 3, 117.

Benveniste et al., 2020. Coastal sea level anomalies and associated trends from Jason satellite altimetry over 2002–2018. *Scientific Data* 7, 357.

Virtual Coastal Station