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CTOH studies for extending the range of altimetry applications over the ocean and continental surfaces

Fabien Blarel; Damien Allain; Florence Birol; Malik Boussaroque; Robin Chevrier; Lucrèce Djeumeni; Wassim Fkaier; Yvan Gouzènes; Fabien Léger; Rosemary Morrow; Fernando Niño; Oscar Vergara

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The Center for Topography of the Oceans and Hydrosphere (CTOH) is a French Observation Service created in 1989 and dedicated to satellite altimetry studies. It focuses on the development and promotion of new processing approaches of the altimetric data for emerging research domains (coastal ocean, oceanic sub-mesoscale phenomena, continental surface water, sea ice, polar caps). It works in close relationship with space agencies (mainly CNES and ESA) at different levels for satellite altimetry missions: preparation of new missions, definition of the user's needs, CAL/VAL studies, signal analysis & data reprocessing, development of thematic products, teaching and outreach.

In terms of data distribution, the CTOH maintains a global GDR data base for almost all altimetry missions since Topex/Poseidon. All the products are made homogeneous (addition of the most recent parameters / corrections for the old missions) and provided in netcdf format.

- A new version of **ERS-2 data, reprocessed by the CTOH for hydrological applications** is also available (it includes ICE-1 and ICE-2 retracers).
- The **CASH Topex product, made in 2006 for hydrological applications** by the CASH consortium (IRD, LEGOS, CLS and BRLi), has been reformatted from its original binary format into NetCDF4 file format by using the naming GDR-D parameter

Database: L1 & L2 products

Along-Track L1/L2 GDR Products

Mission	Prod. Name	Cycle		Date	
		start	end	start	end
Cryosat-2	cs2_b_gop_c_gdr	1	11	2010-07-16	2021-02-25
	cs2_b_ice_d_gdr	2	10	2010-07-16	2021-02-25
EnvSat	env_a_esa_v0300_sgdr	6	94	2002-05-14	2010-10-23
	env_b_esa_v0300_sgdr	95	113	2010-10-26	2012-04-08
ERS-2	ers2_a_ctoh_v0100_gdr	1	89	1995-05-17	2003-11-24
	ja1_a_cnes_e_sgdr	1	259	2002-01-15	2009-01-26
Jason-1	ja1_b_cnes_e_sgdr	262	374	2009-02-10	2012-03-03
	ja1_c_cnes_e_sgdr	500	537	2012-05-07	2013-06-21
	ja2_a_cnes_d_sgdr	0	303	2008-07-04	2016-10-02
Jason-2	ja2_b_cnes_d_sgdr	305	327	2016-10-13	2017-05-17
	ja2_c_cnes_d_sgdr	500	537	2017-07-11	2018-07-18
	ja2_d_cnes_d_sgdr	600	644	2018-07-25	2019-10-01
Jason-3	ja3_a_cnes_f_sgdr	0	227	2016-02-12	2022-04-07
	ja3_b_cnes_f_sgdr	300	312	2022-04-25	2022-07-27
Sentinel-3A	s3a_a_lan_%_sgdr	1	89	2016-03-01	2022-08-30
	s3a_a_wat_%_sgdr	1	89	2016-03-01	2022-08-30
	s3b_a_lan_%_sgdr	3	19	2018-05-11	2018-11-27
Sentinel-3B	s3b_a_wat_%_sgdr	2	19	2018-05-11	2018-11-27
	s3b_b_lan_%_sgdr	19	70	2018-11-28	2022-09-01
	s3b_b_wat_%_sgdr	19	70	2018-11-28	2022-09-01
Sentinel-6A	s6a_a_lrm_f06_gdr	4	65	2020-12-17	2022-08-15
	s6a_a_sar_f06_gdr	4	65	2020-12-17	2022-08-15
Saral	sr1_a_cnes_f_sgdr	1	35	2013-03-14	2016-07-04
	sr1_b_cnes_f_sgdr	100	162	2016-07-04	2022-07-18
Topex	tpx_a_cash_v0220_gdr	10	359	1992-12-21	2002-06-22

Corrections added to all GDR databases by CTOH :

- Ionospheric correction (NIC09, GIM, IIS)
- Wet Tropo (GPD+ [Fernandez])
- Tide models (GOT48, FES14)
- Inverse barometer (ECMWF, Aviso DAC)
- Mean Dynamic Topo (hybride)
- Mean Sea Surface: (DTU_2021, CNES_15)
- Geoids (EGM08, EIGEN_6C4d)
- Bathymetry (Gridone, gebco14)
- Dist. to nearest coast (Leuliette, Stumpf, GSHHS)
- Dry Troposphere
- Doppler Slope

Both 1Hz and 10/20/40Hz data are available globally. For some products, the CTOH database contains also L1 products (waveforms). All in netcdf format (except GFO).

CTOH develops new altimetry products and tools

Fine-resolution ocean products

The weekly mean and time varying position of the main Southern Ocean polar fronts has been calculated from 1993 to 2021, using the updated time variable sea level.

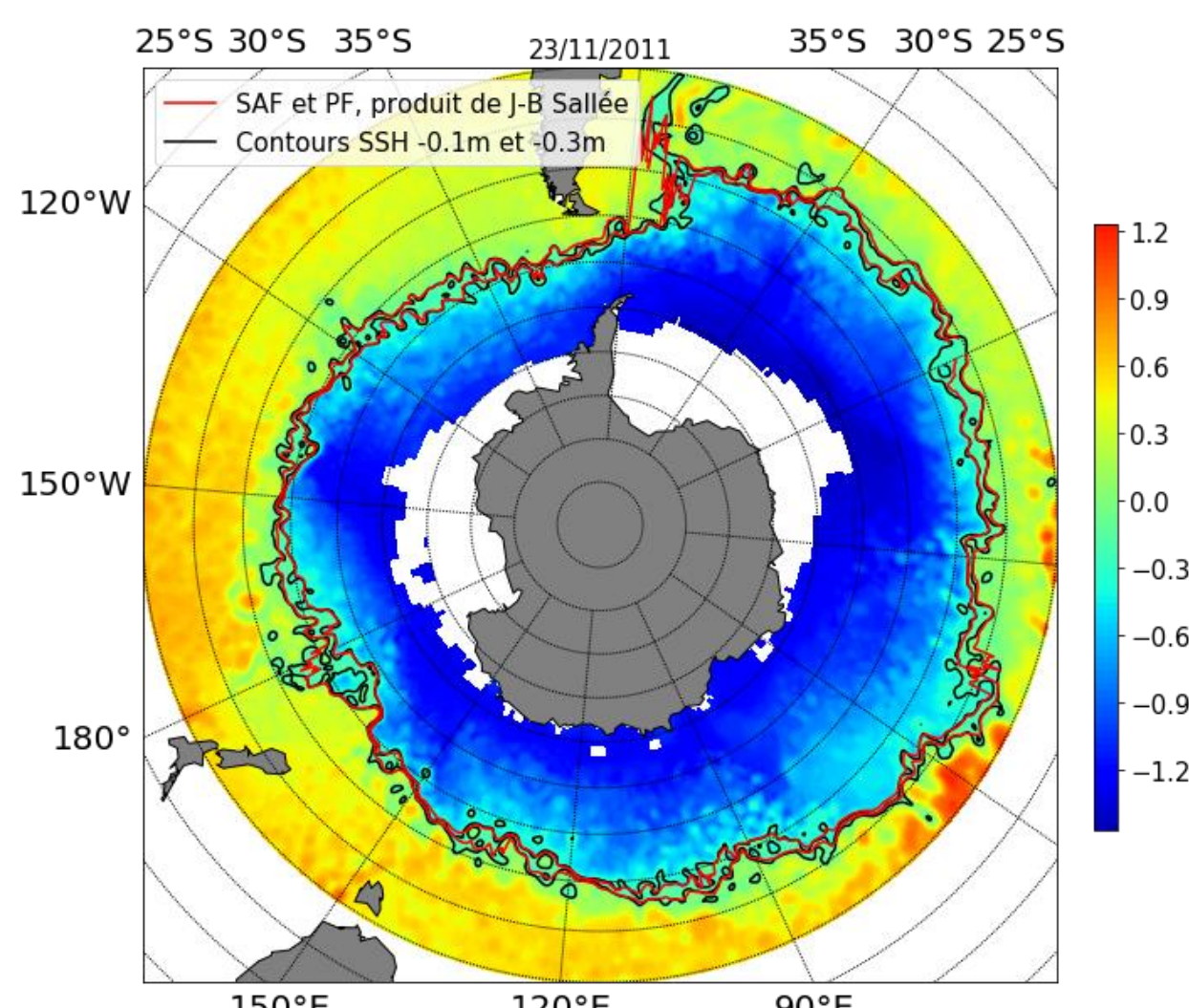
The position of the Polar Front, and the northern and southern branches of the SubAntarctic Front (SAF-N and SAF-S) are computed using contours of sea level of constant values, from CMEMS global ADT-H data, taking into account meanders following Auger et al., (2018).

These values are chosen for continuity with the former dataset distributed by the CTOH, based on Sallée et al. (2008).

Values used for the fronts computation are :

- SAF_N : 0m
- SAF_S : -0.10m
- PF : -0.30m. This new extension will be available on the AVISO+ website in early 2023.

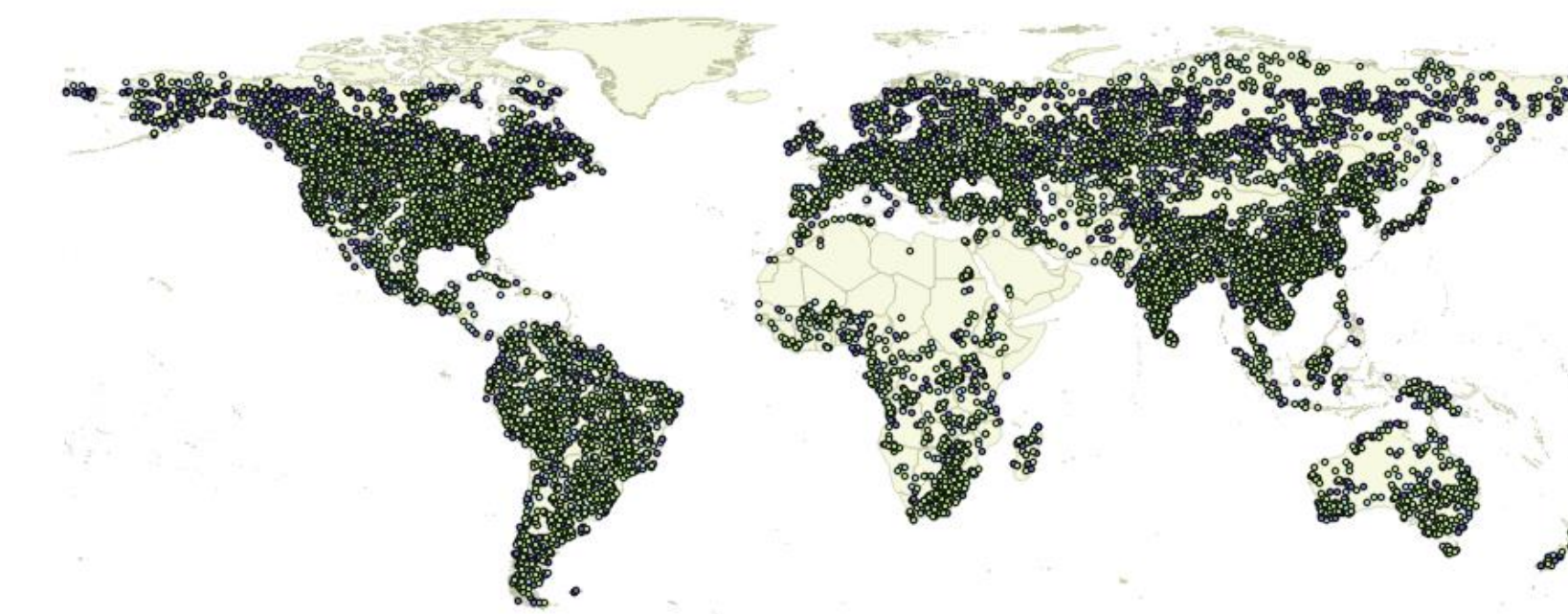
References :
- Sallée, J.B et al; Journ. of Climate, 2008, Vol. 21(12), pp. 3020-3039
- Auger, M. et al.; https://zenodo.org/record/4094960#.X5BPM9Azy2x (2018).



SAF_N and PF position, based on former CTOH product (red), and on the new product with updated Sea Level data (black)

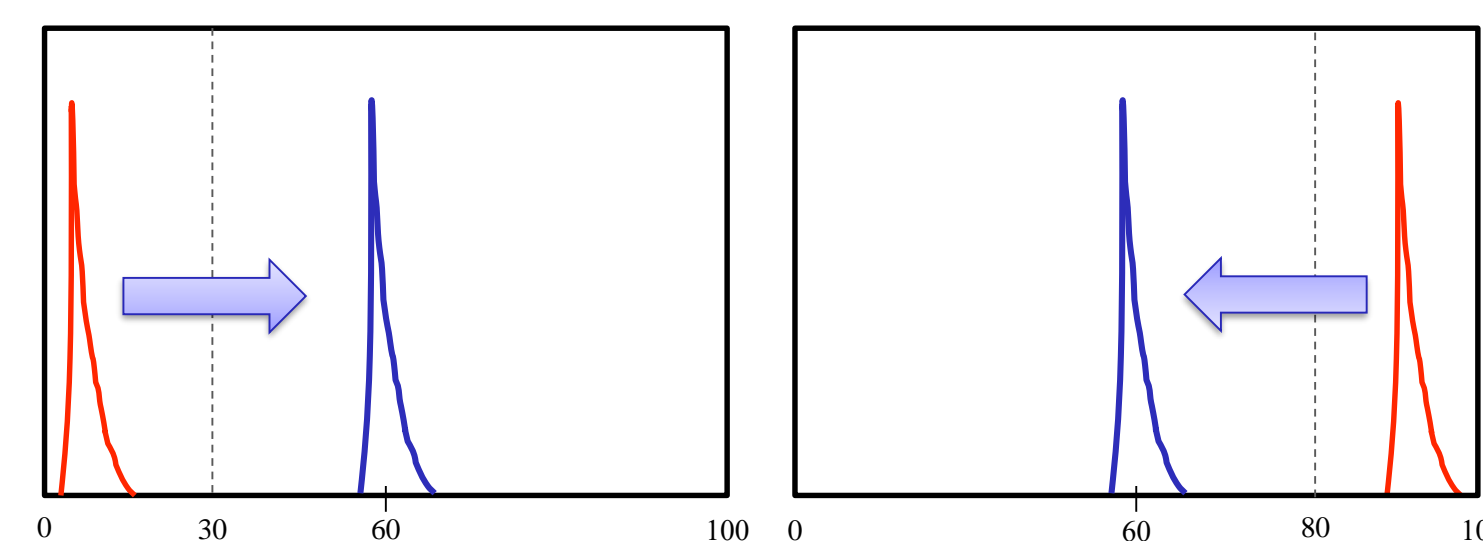
Hydrologic Target Database Updates

Since 2018, the Open Loop Tracking Command (OLTC) represents a major evolution in the acquisition of quality measurement over inland waters. Thanks to the last four years of available data, we can now start to improve the OLTC database of all the mission by correcting erroneous targets, densifying some interesting areas or creating new targets for specific applications.



- Sentinel-6 : 3037 targets updated
- Sentinel-3A : 4262 targets updated
- Sentinel-3B : 4051 targets updated
- Jason-3 Interleaved : New Generation of 31216 targets
- SWOT 1-Day Orbit : New Generation of 5813 targets

Main objective of the update : Center the signal on the middle of the acquisition window



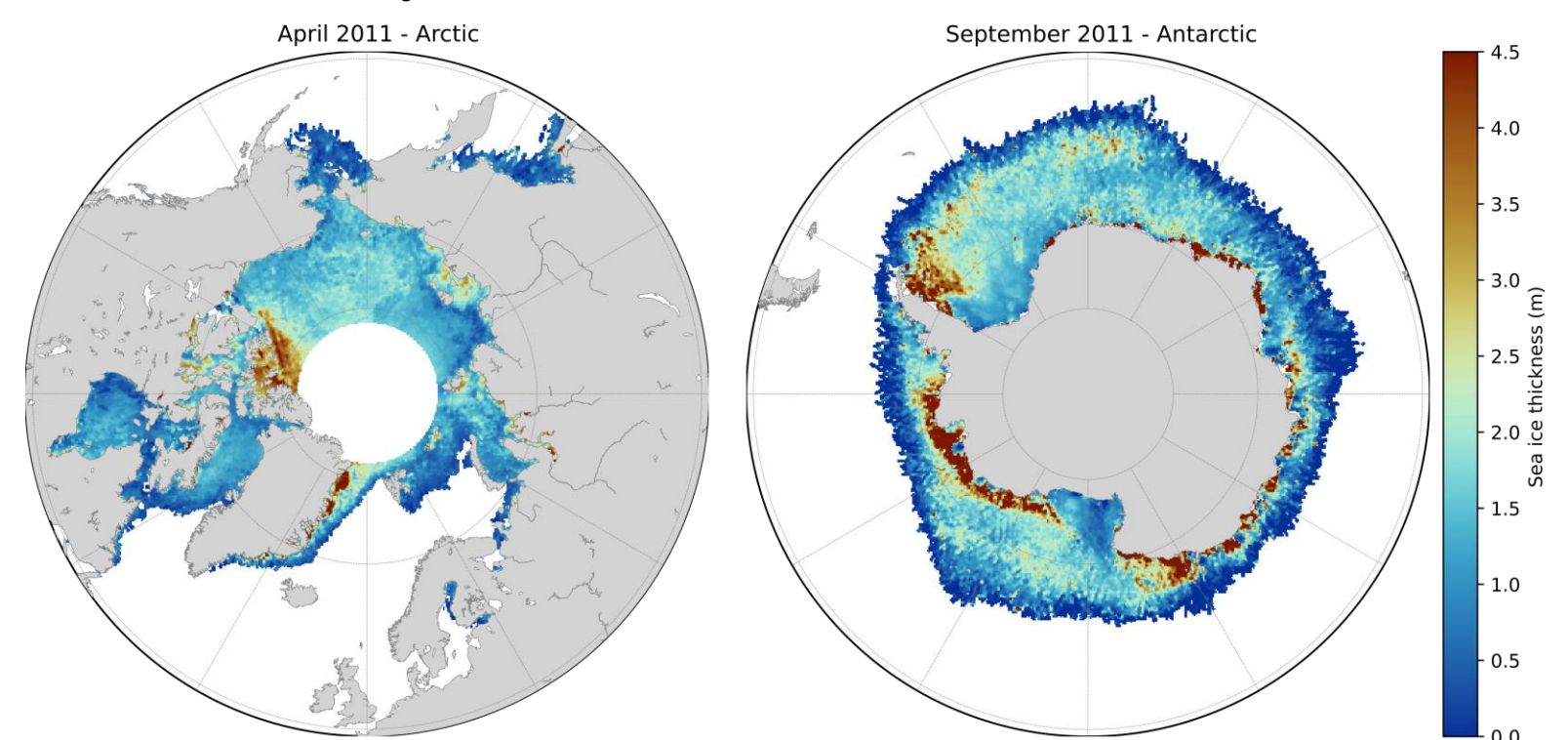
Using,

- Retracking analysis
- Feedback from the scientific community
- Cross mission validation
- The knowledge of Off-Nadir position

Nearly 30 years of Sea Ice Thickness (1994-2022)

28 years of monthly ice thickness are now available for both Arctic and Antarctic ocean with the related uncertainties. This time series has been retrieved by calibrating former altimeters estimates, from ERS-1, ERS-2, Envisat over CryoSat-2 using a neural network and taking advantage of the mission-overlap periods. For more information : see Bocquet et al 2022 (TC discussion) and poster APO2022_014 - Towards 30 years of Arctic sea ice freeboard retrieval using Altimetry.

Sea ice thickness for April and September 2011 respectively for Arctic and Antarctic ocean

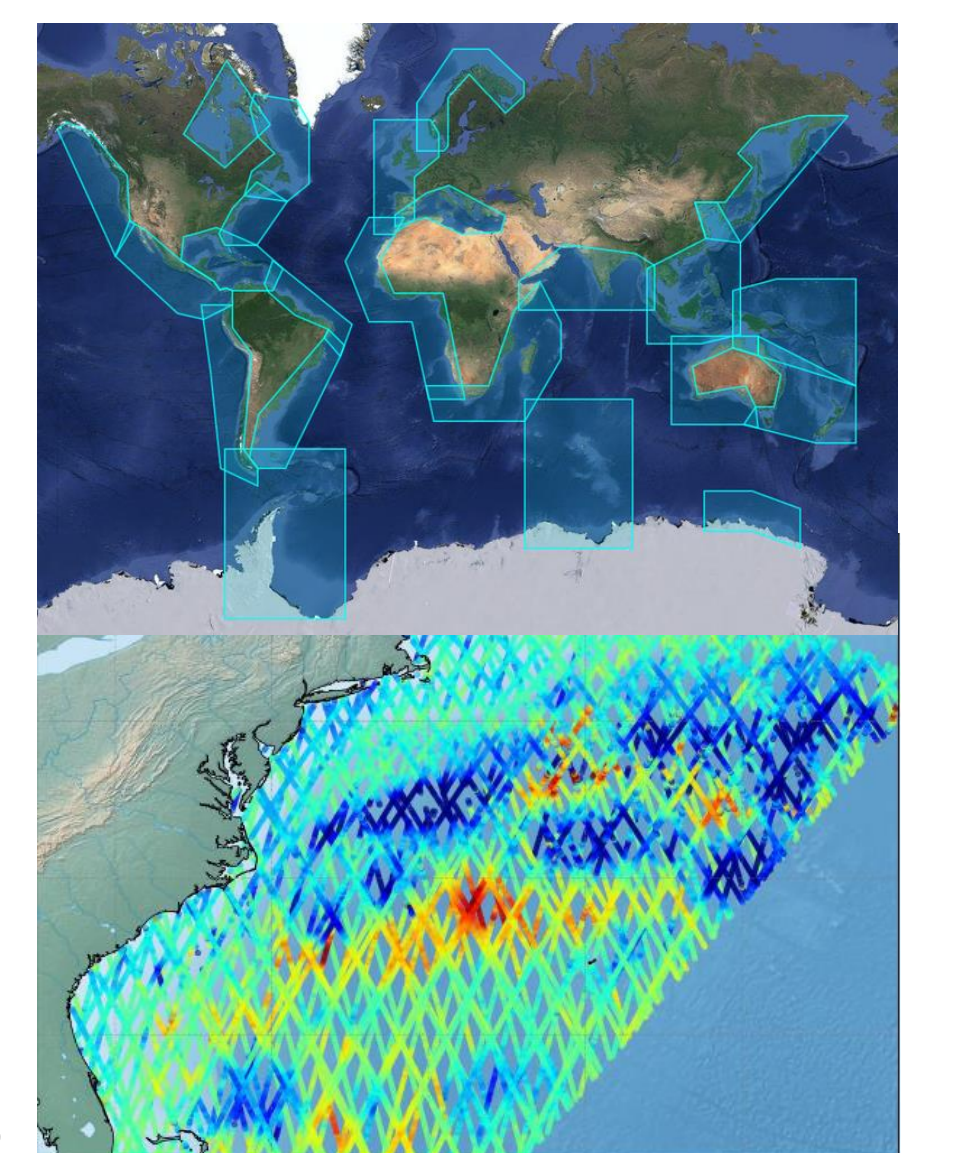


X-TRACK: Coastal products

We are pleased to announce a release of a new coastal along track product : XTRACK-L2P Sea Level Anomalies products for coastal applications in version 2022.

Along-track Sea Level Anomalies are projected onto the reference tracks with a spatial interval of about 6-7 km between points. The Sea Level Anomaly time series have been computed with the X-TRACK processing system (developed at LEGOS) starting from the Level 2 Plus (L2P) products distributed by Aviso+.

More information about this product and other CTOH coastal products can be found at the following poster COA2022_005: "New advances in altimetry towards the coast : example of the CTOH sea level products"



Map of the 23 zones covered by X-TRACK/L2P product (top), Mean Sea Level Anomaly over the period January to March 2004 using ERS1+ERS2+ENV+SRL, GFO and TP+J1+J2+J3 missions in the Gulfstream region (bottom)

Altimetry training courses

The CTOH holds teaching courses on altimetry (university training, workshop, individual request), with a focus on emerging applications. These training courses are created for showing users how to handle altimetry data in real cases using Jupyter notebooks in Python. The course topics cover a wide spectrum: principles of ocean and coastal altimetry, reading and using products, computation of derived parameters (series of sea or water levels, currents), comparison with in-situ data, among others. We contribute to virtual schools (ODYSSEA Oceanography From Space in Nov. 2020). The next training is scheduled in Feb. 2023 for the 13th Coastal altimetry Workshop).



Continental hydrology tool

Altimetry Time Series (AITiS) Software.



See the related poster SC42022_019

AITiS Software for generating Time-Series of Water Levels from Radar Altimetry Data



https://ctoh.legos.obs-mip.fr

OSTS Meeting, Venice, Italy, 2022

