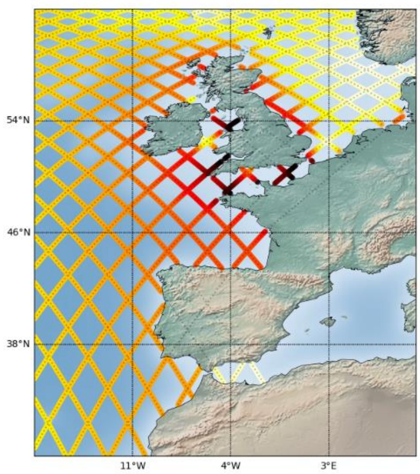
CTOH Along-Track Tidal Constants regional products (X-TRACK Tidal Constants) User Handbook



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List of Acronyms:

ADT	Absolute Dynamic Topography
Aviso+	Archiving, Validation and Interpretation of Satellite Oceanographic data
CLS	Collecte, Localisation, Satellites
CNES	Centre National d'Etudes Spatiales
CTOH	Centre de Topographie des Océans et de l'Hydrosphère
NRT	Near Real Time
SSALTO	Segment Sol multimissions d'ALTimétrie, d'Orbitographie et de localisation précise.
SLA	Sea Level Anomaly

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1. Introduction

The CTOH computes and distributes regional along-track tidal constants products for the following altimeter long time series missions:

- Topex/Poseidon+Jason-1+Jason-2
- Topex/Poseidon interleaved+Jason-1 interleaved

Publications should include the following statement in the Acknowledgments: "Altimetry data used in this study (doi 10.6096/CTOH_X-TRACK_Tidal_2018_01) were developed, validated by the CTOH/LEGOS, France and distributed by Aviso+".

1.1. Data Policy and conditions of use

The X-TRACK along-track Tidal Constants products are available free of charge for scientific studies or non-profit projects only as stated in the licence agreement

2. Processing

Using the X-TRACK T/P-Jason regional **Sea Level Anomalies** long time series **(also distributed, see** https://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/regional/x-track-sla.html), tidal constants are computed along-track, about 6-7 km between points, for 73 tidal constituents (see **Table 1**) by using harmonic analysis. In addition, two associated errors are estimated for each tidal constituent

2.1. Product content

The product is available in a number of different regions (see Figure 1) consists in 1-Hz along-track tidal constants (amplitude and phase lags) and two associated errors. They are provided in NetcdF format and include along the nominal ground track:

- Tidal elevation amplitude
- Tidal elevation phase lag
- Tidal analysis mean square error
- Tidal analysis error for background contamination
- Number of samples
- Constituent name

Sa	Ssa	MSm	Mm	Mqm
Mf	MStm	Mtm	MSqm	O1
2Q1	Sig1	Q1	Ro1	P1
MP1	M1	KI1	Pi1	J1
K1	Psi1	Phi1	Tta1	MNS2
SO&	OO1	KQ1	OQ2	N2
E2	2mk2	2N2	Mu2	M(KS)2
Nu2	MSK2	M(SK)2	M2	S2
MKS2	La2	L2	T2	2SM2
R2	K2	MSN2	KJ2	S3
2MK3	M3	SO3	MK3	M4
SK3	N4	3MS4	MN4	SK4
SN4	MS4	MK4	S4	2MK6
2MN6	M6	MSN6	2MS6	
2SM6	MSK6	3MS8	MSf	

Table 1: List of the 73 tidal constituents in the X-TRACK tidal constant product.

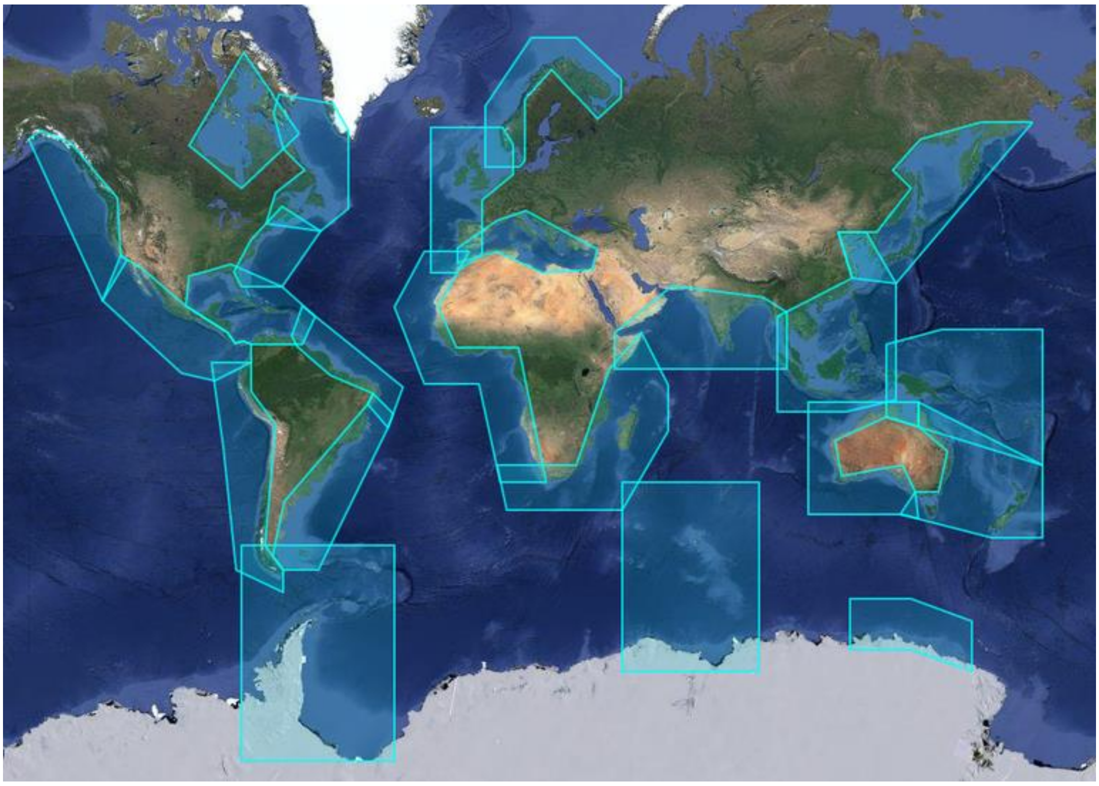

Figure 1: Map of the regions provided for X-TRACK Coastal products

2.2. Processing method

Processing is based on the X-TRACK SLA long time series. The T/P-Jason SLA time series are long enough to derive the empirical harmonic constants by using harmonic analysis. Details can be found in Birol et al. (2017). The harmonic analysis is applied on the X-TRACK SLA fully corrected (see Table 2) except for ocean tides, at each point along the ground-tracks (every 6–7 km). The set of constituents analyzed directly depends on the length and the temporal sampling of the SLA record. The main issue in altimeter data harmonic analysis is the aliased frequencies and subsequent separation periods. The extent of this issue depends on the considered mission time sampling. After more than 20 years of duration, most of the alias issue have vanished in T/P and Jason nominal missions. In case of limited time series, such as for the T/P-Jason interleaved, admittance methods are used. In addition to the harmonic constants, two associated errors are estimated for each tidal constituent. The first one is directly computed from the inverse method theory. The second one is calculated by taking into account the ocean background signal at aliased tidal frequencies. More details can be found in Carrere et al. (2004).

3. X-TRACK Coastal along-track tidal constants Products

Two X-TRACK along-track tidal constant products available are based on the X-TRACK SLA combined missions

- Topex/Poseidon interleaved + Jason-1 interleaved and
- Topex/Poseidon + Jason-1 + Jason-2.

3.1. Temporal availability

Mission	Start	End
T/P+Jason-1+Jason-2	1993/02/28 (cycle 17 of T/P)	2015/07/24 (cycle 259 of Jason-2)
T/P interleaved+Jason-1 interleaved	2002/09/21 (cycle 369 of T/P)	2012/02/02 (cycle 372 of Jason-1)

Table 2: temporal availability of each time series

3.2. Nomenclature of files

The nomenclature used for these products is:

ctoh.sla.ref.<MISSION>.<ZONE>.<TRACK_number>.mgr.nclzma

(note that lzma is a compression algorithm)

MISSION	TP+J1+J2 TPN+J1N	TOPEX/Poseidon+ Jason-1+ OSTM/Jason-2 TOPEX/Poseidon New (interleaved) Orbit+ Jason-1 New (interleaved) Orbit
ZONE(1)(2)	ADELIE AMAZON ASA CHINASEA DRAKE EAUSTRALIA GOM GULFSTREAM HUMBOLDT KERGUELEN LABRADOR MEDSEA NEA NINDIAN NORWAY NWA NWP SEA WAFRICA WAUSTRALIA WLA WTP	Adelie-Mertz Amazon Atlantic South America China Sea Drake passage East Australia Gulf of Mexico Caribbean Sea Gulf Stream Humboldt current Kerguelen Islands Labrador Sea Mediterranean Sea North East Atlantic North Indian Ocean Norway North West America North West Pacific South and East Africa West Africa West Australia West Latin America - California West Tropical Pacific
TRACK_NUMBER	XXXX	Number of pass (depending on the satellite)

Table 3: Nomenclature of files

(1)X-TRACK along-track tidal constant products are not available for the Hudson region.

(2)X-TRACK TPN+J1N along-track tidal constant products are not available for the Labrador region.

4. Data format

This chapter presents the data storage format used for X-TRACK Coastal tide products.

4.1. NetCdf

The products are stored using the NetCDF format.

NetCDF (network Common Data Form) is an interface for array-oriented data access and a library that provides an implementation of the interface. The netCDF library also defines a machine-independent format for representing scientific data. Together, the interface, library, and format support the creation, access, and sharing of scientific data. The netCDF software was developed at the Unidata Program Center in Boulder, Colorado. The netCDF libraries define a machine-independent format for representing scientific data. Please see Unidata NetCDF pages for more information, and to retreive NetCDF software package on:

https://www.unidata.ucar.edu/software/netcdf/

NetCDF data is:

- Self-Describing. A netCDF file includes information about the data it contains.
- Architecture-independent. A netCDF file is represented in a form that can be accessed by computers with different ways of storing integers, characters, and floating-point numbers.
- Direct-access. A small subset of a large dataset may be accessed efficiently, without first reading through all the preceding data.
- Appendable. Data can be appended to a netCDF dataset along one dimension without copying the dataset or redefining its structure. The structure of a netCDF dataset can be changed, though this sometimes causes the dataset to be copied.
- Sharable. One writer and multiple readers may simultaneously access the same netCDF file.

The products are stored in **NetCDF** defined by the Cooperative Ocean/Atmosphere Research Data Service (COARDS) and Climate and Forecast (CF) metadata conventions.

The CF convention generalises and extends the COARDS convention but relaxes the COARDS constraints on dimension and order and specifies methods for reducing the size of datasets. A wide range of software is available to write or read NetCDF/CF files. API are made available by UNIDATA http://www.unidata.ucar.edu/software/netcdf :

- C/C++/Fortran
- Java
- MATLAB, Objective-C, Perl, Python, R, Ruby, Tcl/Tk

In addition to these conventions, the files are using a common structure and semantic as shown in the example below:

```
netcdf ctoh.sla.ref.TPN+J1N.waustralia.201.mgr {
dimensions:
	constituent = 75 ;
	namelength = 10 ;
	records = 330 ;
variables:
	char constituentname(constituent, namelength) ;
		constituentname:long_name = "tidal_spectrum" ;
		constituentname:standard_name = "tidal_spectrum" ;
		constituentname:short_name = "spectrum" ;
```

```
double lat(records) ;
        lat:long_name = "latitude" ;
        lat:standard_name = "latitude" ;
        lat:short_name = "lat" ;
        lat:units = "degrees_north" ;
        lat:valid_min = -90. ;
        lat:valid_max = 90. ;
        lat:scale_factor = 1. ;
        lat:add_offset = 0. ;
        lat:_FillValue = 1.e+35 ;
double lon(records) ;
        lon:long_name = "longitude" ;
        lon:standard_name = "longitude" ;
        lon:short_name = "lon" ;
        lon:units = "degrees_east" ;
        lon:valid_min = -180. ;
        lon:valid_max = 180. ;
        lon:scale_factor = 1. ;
        lon:add_offset = 0. ;
        lon:_FillValue = 1.e+35 ;
double amplitude(records, constituent) ;
        amplitude:long_name = "tidal_elevation_amplitude" ;
        amplitude:standard_name = "amplitude" ;
        amplitude:short_name = "Ha" ;
        amplitude:units = "m" ;
        amplitude:valid_min = 0. ;
        amplitude:scale_factor = 1. ;
        amplitude:add_offset = 0. ;
        amplitude:_FillValue = 1.e+35 ;
double phase_lag(records, constituent) ;
        phase_lag:long_name = "tidal_elevation_phase_lag" ;
        phase_lag:standard_name = "phase_lag" ;
        phase_lag:short_name = "Hg" ;
        phase_lag:units = "degrees" ;
        phase_lag:valid_min = 0. ;
        phase_lag:valid_max = 360. ;
        phase_lag:scale_factor = 1. ;
        phase_lag:add_offset = 0. ;
        phase_lag:_FillValue = 1.e+35 ;
double mean_square_error(records, constituent) ;
        mean_square_error:long_name = "tidal_analysis_mean_square_error" ;
        mean_square_error:standard_name = "error" ;
        mean_square_error:short_name = "mse" ;
        mean_square_error:units = "m" ;
        mean_square_error:valid_min = 0. ;
        mean_square_error:scale_factor = 1. ;
        mean_square_error:add_offset = 0. ;
        mean_square_error:_FillValue = 1.e+35 ;
double bg_contamination_error(records, constituent) ;
        bg_contamination_error:long_name = "tidal analysis error from background contamination" ;
        bg_contamination_error:standard_name = "background_noise_error" ;
        bg_contamination_error:short_name = "background error" ;
        bg_contamination_error:units = "m" ;
        bg_contamination_error:valid_min = 0. ;
        bg_contamination_error:scale_factor = 1. ;
        bg_contamination_error:add_offset = 0. ;
        bg_contamination_error:_FillValue = 1.e+35 ;
```

```
	short sample(records) ;
		sample:long_name = "number_of_samples" ;
		sample:standard_name = "samples" ;
		sample:short_name = "samples" ;
		sample:valid_min = 0s ;
		sample:valid_max = 1000s ;
		sample:scale_factor = 1s ;
		sample:add_offset = 0s ;
		sample:_FillValue = 32767s ;
		sample:units = "count" ;

// global attributes:
		:Conventions = "CF-1.6" ;
		:file_name =
"prod_201611/prod/WAUSTRALIA/TPN+J1N/FES12/DAC_G/SLA/ctoh.sla.ref.TPN+J1N.waustralia.201.mgr.
nc" ;
		:date = "Mon Jun 26 19:28:46 2017" ;
		:software = "altimetry-detidor" ;
		:version = "2.0" ;
		:production = "CTOH/LEGOS, http://ctoh.legos.obs-mip.fr" ;
		:institution = "CTOH/LEGOS, http://ctoh.legos.obs-mip.fr" ;
		:history = "product creation Mon Jun 26 19:28:46 2017" ;
		:title = "Tidal harmonic constants along the long-term TOPEX/Poseidon, Jason-1/2 ground track" ;
		:contact = "ctoh_products@legos.obs-mip.fr" ;
		:time_series_first_date_used = "27-09-2002" ;
		:time_series_last_date_used = "24-01-2012" ;
		:time_series_file_name =
"prod_201611/prod/WAUSTRALIA/TPN+J1N/FES12/DAC_G/SLA/ctoh.sla.ref.TPN+J1N.waustralia.201.nc" ;
		:time_series_origin = "X-TRACK SLA" ;
		:time_series_validation = "Statistical QC@CTOH" ;
		:doi = "10.6096/CTOH_X-TRACK_Tidal_2018_01" ;
		:license = "https://www.aviso.altimetry.fr/fileadmin/documents/data/License_Aviso.pdf" ;
		:references =
"https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk_XTRACKtidal_CTOH.pdf" ;
```

5. Accessibility of the products

5.1. Aviso+ registration

Please fill the online form on

https://www.aviso.altimetry.fr/en/data/data-access/endatadata-accessregistration-form.html

and select the product “Regional X-TRACK Tidal Constants Along-track“ in the category “Auxiliary products”

Aviso+ will send you your own access (login/password) by e-mail as soon as possible.

The access will be available on your dedicated products page on

https://www.aviso.altimetry.fr/no_cache/en/my-aviso-plus.html

5.2. Folders on the ftp server

Access restrictions are applied on folders. Your account gives you an access to a given list of altimetry data. Thus, the folders you're not subscribed to are empty.

6. Contacts

For more information, please contact:

Aviso+ User Services
CLS
11 rue Hermès
Parc Technologique du canal
F-31520 Ramonville Cedex
France
E-mail: aviso@altimetry.fr
On Internet: https://www.aviso.altimetry.fr/

The user service is also interested in user feedbacks; questions, comments, proposals, requests are much welcome.

Bibliography

Birol F., N. Fuller, F. Lyard, M. Cancet, F. Niño, C. Delebecque, S. Fleury, F. Toublanc, A. Melet and M. Saraceno, F. Léger, (2017). Coastal applications from nadir altimetry: example of the X-TRACK regional products. Advances in Space Research, 10.1016/j.asr.2016.11.005 .

Carrere, L., Le Provost, C., Lyard, F., 2004. On the statistical stability of the M2 barotropic and baroclinic tidal characteristics from along-track TOPEX/Poseidon satellite altimetry analysis. J. Geophys. Res., Am. Geophys. Union 109 (C03033), 13. http://dx.doi.org/10.1029/2003JC001873