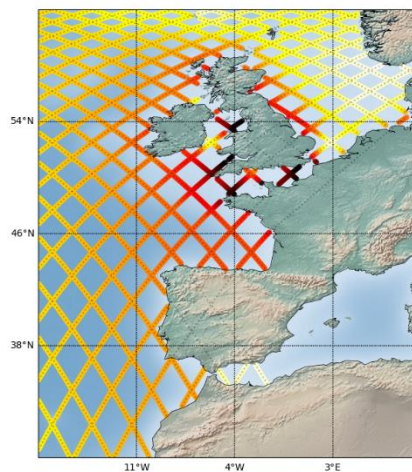




## CTOH Along-Track Tidal Constants regional products (X-TRACK Tidal Constants) User Handbook



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Nomenclature: SALP-MU-P-EA-23884-CLS

Issue: 1 rev 0

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Date: January 2020

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## 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 multitemps 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

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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](#)

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## 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.

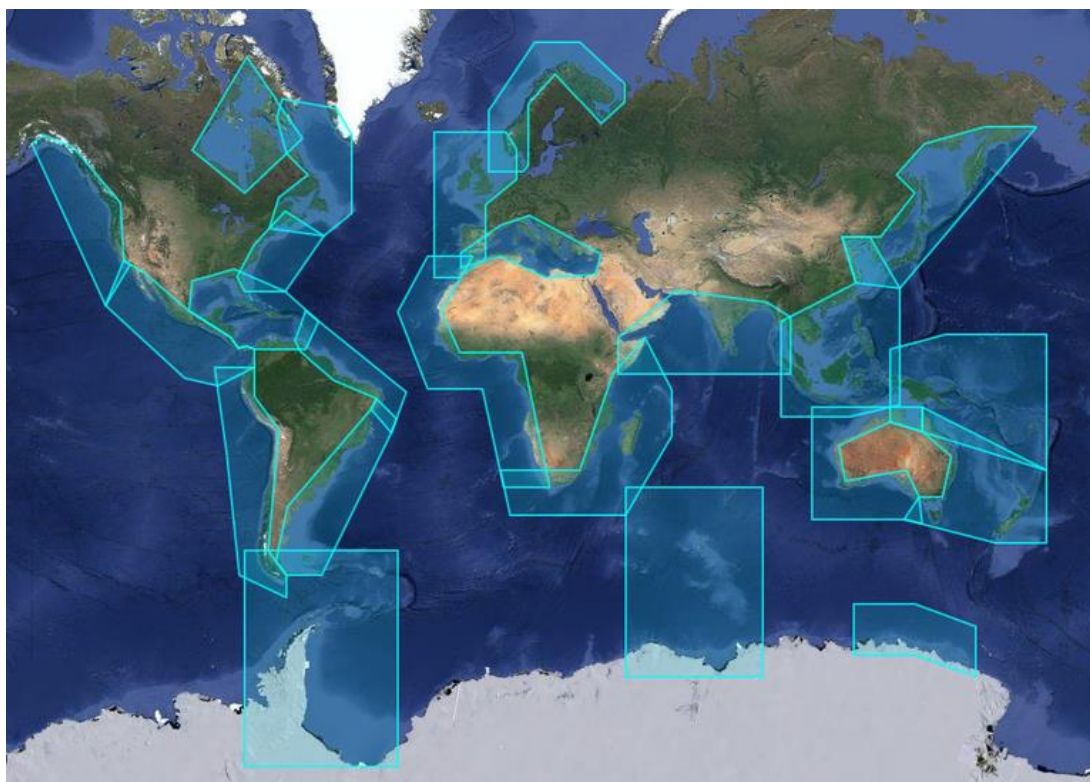


Figure 1: Map of the regions provided for X-TRACK Coastal products

## 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).

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## 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

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

**Table 3: Nomenclature of files**

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

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

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## 4. Data format

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

### 4.1. NetCdf

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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 retrieve 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+JIN.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 ;

```

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```
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.waustalia.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.waustalia.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" ;
```

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## 5. Accessibility of the products

### 5.1. Aviso+ registration

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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](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.

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## 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](mailto: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.

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Birol F., N. Fuller, F. Lyard, M. Cancet, F. Niño, C. Delebecque, S. Fleury, F. Toubanc, 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>