ALTimetry Innovative Coastal Approach Product (ALTICAP) handbook

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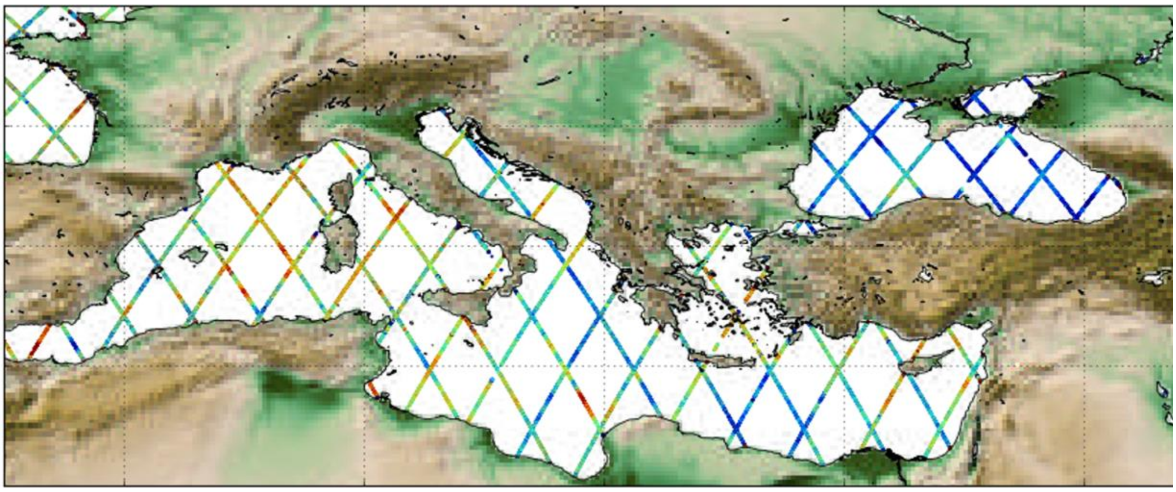

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Chronology Issues:		
Issue:	Date:	Reason for change:
1.0	17/01/2024	1st issue

List of Acronyms:

ADT	Absolute Dynamic Topography (=SLA+MDT)
AVISO+	Archivage, Validation et Interprétation des données des Satellites Océanographiques
ALTICAP	ALTimetry Innovative Coastal Approach Product
CLS	Collecte Localisation Satellites
CMEMS	Copernicus Marine Environment Monitoring Service
CNES	Centre National d'Etudes Spatiales
CTOH	Centre de Topographie des Océans et de l'Hydrosphère
DUACS	Data Unification and Altimeter Combination System
FTP	File Transfer Protocol
MDT	Mean Dynamic Topography (difference between Mean Sea Surface (MSS) and Geoid)
NetCDF	Network Common Data Format
SLA	Sea Level Anomaly (a.k.a. sea surface height with respect to a mean sea surface)

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1. Overview of this document

This document serves as the user manual for ALTICAP, the ALTimetry Innovative Coastal Approach Product. ALTICAP was developed by CTOH/LEGOS, CLS, and Noveltis as part of a CNES project.

The product includes experimental 20-Hz coastal Sea Level Anomaly (SLA° data (from 0 to 500 km from the coast at global scale) derived from delayed-time measurements from the Jason-3 altimeter along the satellite's track. Its purpose is to provide simple and easy-to-use files with a resolution consistent with the physical signal observable. The Sea Level Anomaly has been corrected for standard corrections, which are provided in the accompanying files. The product is distributed in two formats: one with one file per day, containing measurements for several tracks, and another with one file per track, containing the timeseries of data for the entire period.

The document is organized as follows:

- Chapter 2; presentation
- Chapter 3; processing: input data and method applied for the 2 products
- Chapter 4; the product description, with the different files provided, the nomenclature & the file format
- Chapter 5; how to download products.

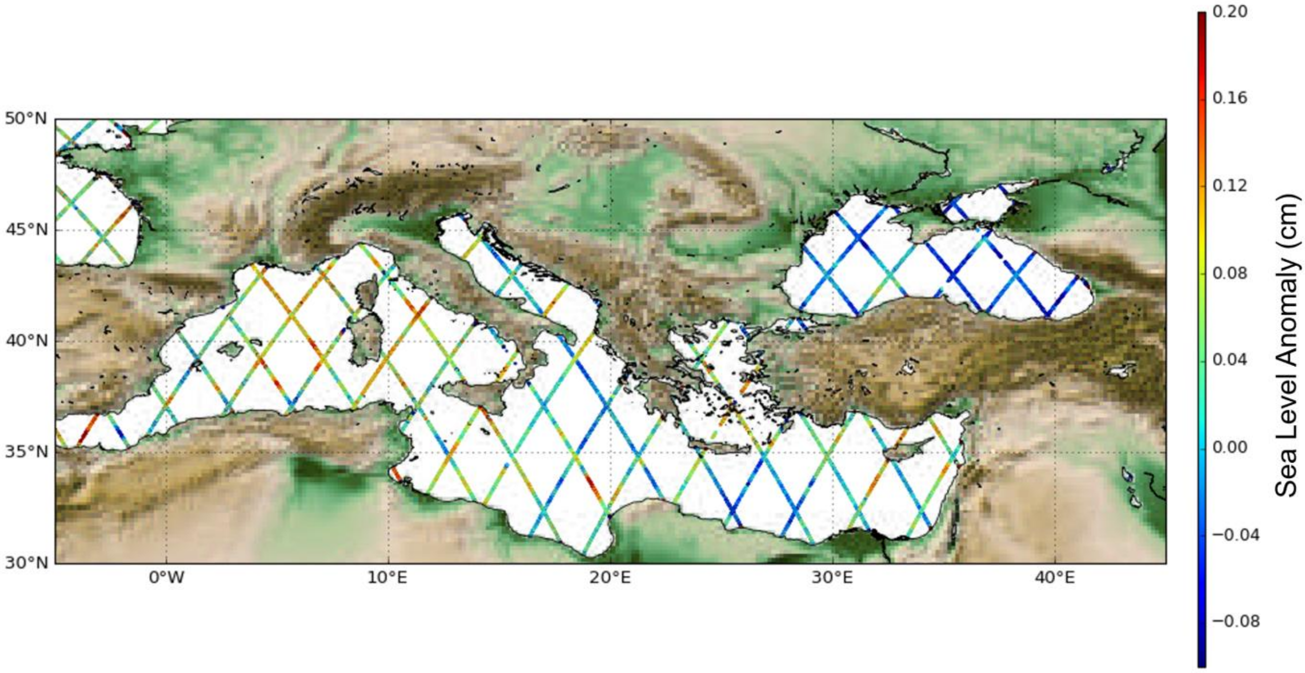

Figure 1: SLA (cm) for Jason-3 ALTimetry Innovative Coastal Approach Product over Mediterranean Sea between 20 and 29 April 2020

2. The ALTimetry Innovative Coastal Approach product

2.1. Versioning of the AVISO+ ALTimetry Innovative Coastal Approach product

The product is distributed in version 1.0

2.2. Acknowledgments

When using the product, please cite in the text the following citation:

"ALTimetry Innovative Coastal Approach Product (ALTICAP) used in this study (DOI 10.24400/527896/a01-2023.020) was funded by CNES, developed and validated by the CTOH/LEGOS, CLS and Noveltis and CLS and distributed by AVISO+".

2.3. User's feedback

The product is an experimental product.

Each and every question, comment, example of use, and suggestion will help us improve the future version. You're welcome to ask or send them to aviso@altimetry.fr.

3. Processing

3.1. Processing

The main processing steps are described in this section.

The following figure gives an overview of the production system, where the main processing sequences can be divided into different steps:

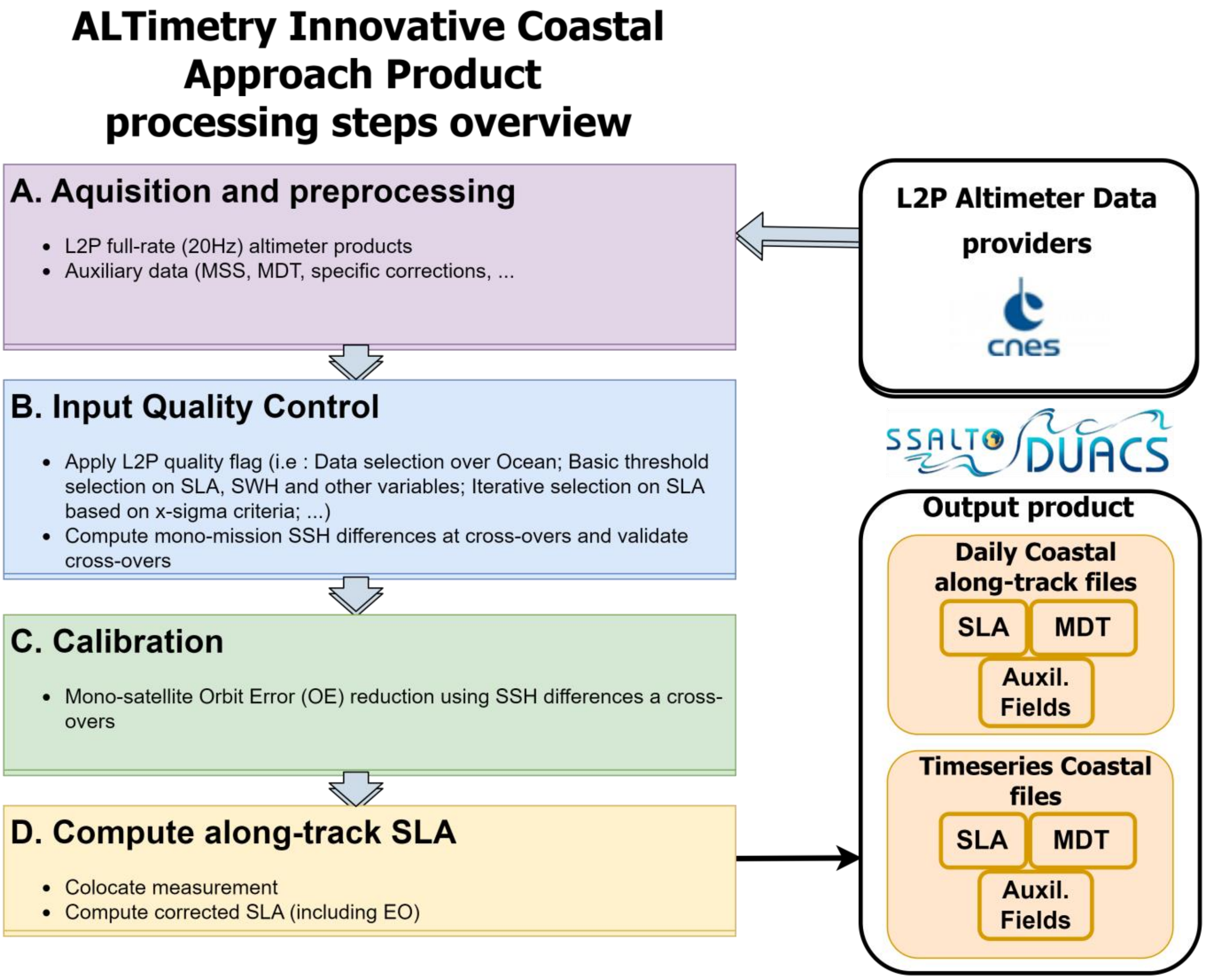

Figure 2: Experimental ALTimetry Innovative Coastal Approach Product (ALTICAP) system processing

3.1.1. Altimeter Input data description

The altimeter measurements used in input of the ALTimetry Innovative Coastal Approach experimental product system consist in Level2p (L2P) products. They are generated from Delayed Time product (GDR) from Jason-3 missions as described in Table 1. The standards are changed afterwards as described in section 3.1.3.

Altimeter mission	Type of product	Period of time	Source
Jason-3	GDR	12 Feb 2016 – 4 Jul 2021	CNES

Table 1: input data for the ALTimetry Innovative Coastal Approach product

3.1.2. Input data quality control

The L2 Input Data Quality Control is a critical process applied to guarantee that the ALTimetry Innovative Coastal Approach Experimental product uses only the most accurate altimeter data. The system is supplied with L2p altimeter products that include a quality flag for each measurement. The valid data selection is directly based on this quality flag. Thanks to the high quality of current missions, this process rejects a small percentage of altimeter measurements, but these erroneous data could be the cause of a significant quality loss.

An editing dedicated to high rate altimeter measurements (20 Hz) based on the SLA coherence between consecutive measurements was used to select valid measurements. It includes different steps :

First, aberrant values are detected using thresholds on SLA and SWH and removed.

The ice contaminated measurements are detected using a combination of the ice concentration provided by OSISAF and the product ice_flag.

Then, the rain/bloom selection is made

Robust statistics along each track are used to reject aberrant values on SLA based on a n*sigma criteria. A modulation with the ocean variability is used in order to limit the rejection of measurements in high variability areas (e.g. Gulf Stream).

Then, the standard deviation of the SLA around its mean on a defined windows (SLARunSTD) is calculated. As this quantity is linearly dependent on waves at first order, it is possible to estimate an expected SLARunSTD in relation with observed waves. By the comparison between observed and expected SLARunSTD it is possible to detect the incoherent values of SLA.

3.1.3. Corrections and Calibration

This product has been developed following a Round Robin study aimed at comparing 21 algorithms used to calculate 20Hz SLA data from altimetry in low resolution mode (LRM) and targeting the ocean region between 0 and 200 km from the coast. In the following document you will find the complete protocol followed during this Round Robin study, as well as access to all the results obtained: RoundRobinSpecificationPlan_v5.pdf. A summary is also provided in [Birol et al, 2022].

Please note that the processing solution adopted to compute the ALTimetry Innovative Coastal Approach experimental product is a compromise between:

1. The capability of each algorithm (correction or parameter) to provide the best SLA dataset over the entire strip between 0 and 200 km from the coast (and not necessarily in the most coastal zone) in order to guarantee continuity with the open ocean.
2. The availability of the correction or parameter on several altimetry missions.
3. A guarantee of product continuity in the future.

The different standards selected used for deriving AltiCAP SLA from Jason-3 measurements are summarized in Table 2.

We also apply global bias to reduce the impact of different standards between the ALTICAP and the DUACS 1Hz altimetry product (operational products delivered by CMEMS: https://doi.org/10.48670/moi-00148)

Finally, the mono-mission Orbit Error Reduction (OER) algorithm aims to reduce large errors in order to generate a global, consistent and accurate dataset.

	Jason-3
Orbit	GDR-F
Retracking	Adaptive [Thibault et al., 2021] and [Poisson et al., 2018]
Sea State Bias	Non parametric SSB 3D, using same methodology as in [Tran et al., 2021]
Ionosphere	GIM model computed from vertical Total Electron Content maps [Chou et al., 2023] rescaled on the orbit altitude using Dettmering method [Dettmering et al., 2022]
Wet troposphere	GPD+ [Fernandes et al., 2015]
Dry troposphere	Model based on ECMWF Gaussian grids (S1 and S2 atmospheric tides are applied)
Combined atmospheric correction	MOG2D High frequencies forced with analysed ECMWF pressure and wind fields (S1 and S2 were excluded) + inverse barometer computed from rectangular grids [Carrere and Lyard, 2003]
Ocean tide	FES 2022c (non structured grid) [Carrere et al, 2022]
Load tide	FES 2022c (structured grid) [Carrere et al, 2022]
Solid Earth tide	Elastic response to tidal potential [Cartwright and Tayler, 1971], [Cartwright and Edden, 1973]
Pole tide	[Wahr, 1985] until Jul 20, [Desai et al., 2015] & Mean Pole location 2017 after
Internal tide	[Zaron, 2019] (HRETv8.1 tidal frequencies: M2, K1, S2, O1)
MSS	CNES-CLS2022 [Schaeffer et al., 2023]
MDT	CNES-CLS2022 [Jousset et al., 2023]

Table 2: Standards used for computing Sea Level Anomaly from Jason-3 altimeter measurements

3.1.4. Along-track products generation

3.1.4.1. SLA computation

The Sea Level Anomalies (SLA) are used in oceanographic studies. They are computed from the difference of the instantaneous SSH minus a precise estimate of the Mean Sea Surface (MSS) for a reference period. The MSS CNES_CLS22 was used in the experimental ALTimetry Innovative Coastal Approach over the 20-year (1993-2012) altimetry reference period (see **Erreur ! Source du renvoi introuvable.**)

Each point of the tracks is colocalized with the theoretical track. The theoretical position corresponds to the exact repetitive position that the ground track may have if the satellite was perfectly maintained on its orbit. It was estimated using the first cycles of the Topex/Poseidon mission, which also defined the ground track position for the Jason series. The files provide information about the latitude, longitude and distance to the nearest theroretical point is given (see Table 2)

4. Description of the ALTimetry Innovative Coastal Approach product

4.1. General product content and specifications

Two types of files are provided to accommodate different uses of the data:

Covered period	Spatial/Temporal coverage	Delivery format
27 Feb 2016 - 3 Jul 2021	Global between 0 and 500 km from coast / 20Hz ~ 350m	1 file per day containing the measurements of one day over the globe
		1 file per track containing the timeseries at each point

Table 1: Characteristics of the ALTimetry Innovative Coastal Approach product

4.2. Nomenclature of files

4.2.1. Daily files

The daily files have the following nomenclature:

dt_coastal_j3_phy_20hz_{DateMeas}_{DateProd}.nc

where:

{DateMeas} is the date of the measurement in YYYYMMDD

{DateProd} is the date of the production of the file in YYYYMMDD

4.2.2. Timeseries files

The timeseries files have the following nomenclature

dt_coastal_j3_phy_20hz_t{PassNumber}.nc

{PassNumber} is the Jason-3 pass number from 001 to 254.

4.3. NetCDF

The products are stored using the NetCDF CF 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 on the NetCDF software package: http://www.unidata.ucar.edu/packages/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 of 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 NetCDF version provided here is version 4 “classic”.

4.4. Structure and semantic of NetCDF files

Below are the definitions of the variables defined in the Coastal Altimetry product. The variables are the same for the two file types provided

Name of variable	Type	Content	Unit
time	double	Time of measurements	seconds since 1950-01-01 00:00:00 UTC
latitude	int	Latitude value of measurements	degrees_north
longitude	int	Longitude value of measurements	degrees_east
latitude_theoretical	int	The theoretical position corresponds to the exact repetitive position that the ground track may have if the satellite was perfectly maintained on its orbit. It was estimated using the first cycles of the Topex/Poseidon mission, also defining the ground track position for the Jason series	degrees_north
longitude_theoretical	int		degrees_east
cycle	short	Cycle the measurement belongs to	-
track	short	Track the measurement belongs to	-
distance_from_theoretical	short	Distance between the real position and the theoretical position of measurement	meter
distance_from_coast	short	Distance between the real measurement position and the nearest coast [GSHHG, Wessel P. and Swith W., doi:10.1029/96JB00104]	meter
sea_level_anomaly	short	Sea level anomaly with dac, ocean_tide, load_tide, internal_tide correction applied	meter
validation_flag	short	Validation flag (0 = valid measurement; 1 = invalid measurement)	0, 1
dac	short	Dynamic atmospheric correction	meter
ib_lf	short	Low Frequency component of the inverse barometer	meter
internal_tide	short	Internal Tide signal: coherent mode M2/K1/O1/S2	meter
mdt	short	Mean dynamic topography	meter
ocean_tide	short	Ocean tide height	meter
load_tide	short	Loading tide model	meter
swh	short	Significant Wave Height on main altimeter frequency band	meter
wind_speed	short	Wind speed on main altimeter frequency band	meter/second
inter_mission_bias	float	bias to have consistent time series with DUACS operational products	meter

Table 2: Overview of data handling variables in ALTimetry Innovative Coastal Approach product files.

5. How to download a product

5.1. Registration

To access data, registration is required. During the registration process, the user shall accept using license for the use of AVISO+ products and services.

- if not registered on AVISO+, please, fill the form and select the product ‘ALTimetry Innovative Coastal Approach product’ on http://www.aviso.altimetry.fr/en/data/data-access/registration-form.html
- if already registered on AVISO+, please request the addition of this ‘ALTimetry Innovative Coastal Approach product’ on your personal account on https://www.aviso.altimetry.fr/en/my-aviso-plus.html

5.2. Access Services

Note that once your registration is processed (see above), AVISO+ will validate your registration by e-mail as soon as possible (within 5 working days during working hours, Central European Time). The access information will be available in your personal account on https://www.aviso.altimetry.fr/en/my-aviso-plus.html.

6. Bibliography

Birol et al., Round Robin Assessment of altimetry algorithms for coastal Sea Surface Height data, OSTST 2022, https://doi.org/10.24400/527896/a03-2022.3363 ,

Carrere L., F . Lyard, M . Cancet, D . Allain, E . Fouchet, M . Dabat, M . Tchilibou, R . Ferrari, Y . Faugère, 2022, FES22 Tidal Atlas, https://doi.org/10.24400/527896/a03-2022.3287

Cartwright, D. E., R. J. Tayler, 1971, "New computations of the tide-generating potential," Geophys. J. R. Astr. Soc., 23, 45-74.

Cartwright, D. E., A. C. Edden, 1973, "Corrected tables of tidal harmonics," Geophys. J. R. Astr. Soc., 33, 253-264.

Chou, M.-Y., Yue, J., Wang, J., Huba, J. D., El Alaoui, M., Kuznetsova, M. M., Rastätter, L., Shim, J. S., Fang, T.-W., Meng, X., Fuller-Rowell, D., and Retterer, J. M.: Validation of Ionospheric Modeled TEC in the Equatorial Ionosphere During the 2013 March and 2021 November Geomagnetic Storms, Space Weather, 21, e2023SW003480, https://doi.org/10.1029/2023SW003480, 2023.

Desai, S., Wahr, J. & Beckley, B. Revisiting the pole tide for and from satellite altimetry. J Geod 89, 1233–1243 (2015). https://doi.org/10.1007/s00190-015-0848-7

Dettmering, D., & Schwatke, C. (2022). Ionospheric corrections for satellite altimetry - impact on global mean sea level trends. Earth and Space Science, 9, e2021EA002098. https://doi.org/10.1029/2021EA002098

Fernandes M. J., Clara Lázaro, Michaël Ablain, Nelson Pires, 2015, Improved wet path delays for all ESA and reference altimetric missions, *Remote Sensing of Environment*, Volume 169,Pages 50-74, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2015.07.023

Jousset S., Mulet S., Wilkin J., Greiner E., Dibarboure G. and Picot N.: "New global Mean Dynamic Topography CNES-CLS-22 combining drifters, hydrological profiles and High Frequency radar data", OSTST 2022, https://doi.org/10.24400/527896/a03-2022.3292

Poisson, J.-C.; Quartly, G.D.; Kurekin, A.A.; Thibaut, P.; Hoang, D.; Nencioli, F. Development of an ENVISAT Altimetry Processor Providing Sea Level Continuity Between Open Ocean and Arctic Leads. IEEE Trans. Geosci. Remote Sens. 2018, 56, 5299–5319. https://doi.org/10.1109/TGRS.2018.2813061.

Schaeffer, P.; Pujol, M.-I.; Veillard, P.; Faugere, Y.; Dagneaux, Q.; Dibarboure, G.; Picot, N. The CNES CLS 2022 Mean Sea Surface: Short Wavelength Improvements from CryoSat-2 and SARAL/AltiKa High-Sampled Altimeter Data. Remote Sens. 2023, 15, 2910. https://doi.org/10.3390/rs15112910

Tran N., D. Vandemark, E.D. Zaron, P. Thibaut, G. Dibarboure, N. Picot, Assessing the effects of sea-state related errors on the precision of high-rate Jason-3 altimeter sea level data, Advances in Space Research, Volume 68, Issue 2, 2021, Pages 963-977, ISSN 0273-1177, https://doi.org/10.1016/j.asr.2019.11.034 .

Thibaut, P. and Piras, F. and Roinard, H. and Guerou, A. and Boy, F. and Maraldi, C. and Bignalet-Cazalet, F. and Dibarboure, G. and Picot, N. "Benefits of the "Adaptive Retracking Solution" for the JASON-3 GDR-F Reprocessing Campaign," 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, Brussels, Belgium, 2021, pp. 7422-7425, doi: 10.1109/IGARSS47720.2021.9553647.

Wahr, J. M.: Deformation induced by polar motion, Journal of Geophysical Research: Solid Earth, 90, 9363–9368, https://doi.org/10.1029/JB090iB11p09363, 1985.

Wessel, P., and Smith, W. H. F. (1996), A global, self-consistent, hierarchical, high-resolution shoreline database, J. Geophys. Res., 101(B4), 8741–8743, https://doi.org/10.1029/96JB00104

Zaron, E. D., 2019: Baroclinic Tidal Sea Level from Exact-Repeat Mission Altimetry. J. Phys. Oceanogr., 49, 193–210, https://doi.org/10.1175/JPO-D-18-0127.1

7. Appendix A. Product header

7.1. ALTimetry Innovative Coastal Approach product file: One file per day

The daily files are using a common structure and semantic as shown in the example below for the Jason-3 on day 2020/12/22.

```
netcdf dt_coastal_j3_phy_20hz_20210703_20231201 {
dimensions:
	time = UNLIMITED ; // (611514 currently)
variables:
	double time(time) ;
		time:_FillValue = 9.96920996838687e+36 ;
		time:standard_name = "time" ;
		time:long_name = "Time of measurement in UTC" ;
		time:units = "days since 1950-01-01T00:00:00+00:00" ;
		time:calendar = "gregorian" ;
		time:axis = "T" ;
	short cycle(time) ;
		cycle:_FillValue = -32767s ;
		cycle:long_name = "Cycle the measurement belongs to" ;
		cycle:units = 1 ;
		cycle:coordinates = "longitude latitude" ;
	short track(time) ;
		track:_FillValue = -32767s ;
		track:long_name = "Track in cycle the measurement belongs to" ;
		track:units = 1 ;
		track:coordinates = "longitude latitude" ;
	int longitude(time) ;
		longitude:_FillValue = -2147483647 ;
		longitude:scale_factor = 1.e-06 ;
		longitude:long_name = "Longitude of measurement" ;
		longitude:standard_name = "longitude" ;
		longitude:units = "degrees_east" ;
		longitude:add_offset = 0. ;
	int latitude(time) ;
		latitude:_FillValue = -2147483647 ;
		latitude:scale_factor = 1.e-06 ;
		latitude:long_name = "Latitude of measurement" ;
		latitude:standard_name = "latitude" ;
		latitude:units = "degrees_north" ;
		latitude:add_offset = 0. ;
	int longitude_theoretical(time) ;
		longitude_theoretical:_FillValue = -2147483647 ;
		longitude_theoretical:scale_factor = 1.e-06 ;
```

```
		longitude_theoretical:long_name = "Theoretical longitude of measurement" ;
		longitude_theoretical:standard_name = "longitude" ;
		longitude_theoretical:units = "degrees_east" ;
		longitude_theoretical:add_offset = 0. ;
		longitude_theoretical:comment = "The theoretical position corresponds to the exact repetitive position that the ground track may have if the satellite was perfectly maintained on its orbit. It was estimated using the first cycles of the Topex/Poseidon mission, also defining the ground track position for the Jason series" ;
	int latitude_theoretical(time) ;
		latitude_theoretical:_FillValue = -2147483647 ;
		latitude_theoretical:scale_factor = 1.e-06 ;
		latitude_theoretical:long_name = "Theoretical latitude of measurement" ;
		latitude_theoretical:standard_name = "latitude" ;
		latitude_theoretical:units = "degrees_north" ;
		latitude_theoretical:add_offset = 0. ;
	short distance_from_theoretical(time) ;
		distance_from_theoretical:_FillValue = -32767s ;
		distance_from_theoretical:scale_factor = 1. ;
		distance_from_theoretical:long_name = "Distance between the real position and the theoretical position of measurement" ;
		distance_from_theoretical:units = "m" ;
		distance_from_theoretical:add_offset = 0. ;
	short distance_from_coast(time) ;
		distance_from_coast:_FillValue = -32767s ;
		distance_from_coast:scale_factor = 1000. ;
		distance_from_coast:long_name = "Distance between the real measurement position and the nearest coast" ;
		distance_from_coast:units = "m" ;
		distance_from_coast:add_offset = 0. ;
		distance_from_coast:references = "GSHHG (Wessel P. and Swith W., doi:10.1029/96JB00104)" ;
	short sea_level_anomaly(time) ;
		sea_level_anomaly:_FillValue = -32767s ;
		sea_level_anomaly:scale_factor = 0.001 ;
		sea_level_anomaly:long_name = "Sea level anomaly with dac, ocean_tide, load_tide, internal_tide correction applied" ;
		sea_level_anomaly:standard_name = "sea_surface_height_above_sea_level" ;
		sea_level_anomaly:units = "m" ;
		sea_level_anomaly:add_offset = 0. ;
		sea_level_anomaly:comment = "The sea level anomaly is the sea surface height above mean sea surface height (MSS); It is computed with the following formula: sea_level_anomaly = Orbit -Range - int inter_mission_bias - dac - ocean_tide - load_tide - internal_tide - Solid_earth_tide - Pole_tide - Ionosphere - Dry_troposphre - Wet_troposphere - SSB - MSS. Part of the corrections applied are given in the following variables : inter_mission_biais, ocean_tide, load_tide, internal_tide, dac. See the product user manual for details" ;
		sea_level_anomaly:coordinates = "longitude latitude" ;
		sea_level_anomaly:quality_flag = "validation_flag" ;
```

```
	short validation_flag(time) ;
		validation_flag:_FillValue = -32767s ;
		validation_flag:long_name = "Validation flag" ;
		validation_flag:units = 1 ;
		validation_flag:meaning = "0 = valid measurement; 1 = invalid measurement" ;
		validation_flag:coordinates = "longitude latitude" ;
		validation_flag:values = "0 , 1" ;
	short dac(time) ;
		dac:_FillValue = -32767s ;
		dac:scale_factor = 0.001 ;
		dac:long_name = "Dynamic Atmospheric Correction" ;
		dac:units = "m" ;
		dac:add_offset = 0. ;
		dac:references = "MOG2D High Resolution forced with ECMWF pressure and wind
fields (S1 and S2 were excluded) + inverse barometer computed from rectangular grids.
(Carrere and Lyard, 2003, https://doi.org/10.1029/2002GL016473)" ;
		dac:comment = "The DAC correction is the sum of two components: the high
frequency signal induced by wind and pressure forcing and estimated with the MOG2D
model; and the low frequency signal deduced for the inverse barometer static response of
the ocean to atmospheric pressure forcing. The last component is given in the ib_lf variable.
The sla in this product is already corrected for the dac; the uncorrected sla can be computed
as follows: [uncorrected sla]=[sla from product]+[dac]; see the product user manual for
details" ;
		dac:coordinates = "longitude latitude" ;
	short ib_lf(time) ;
		ib_lf:_FillValue = -32767s ;
		ib_lf:scale_factor = 0.001 ;
		ib_lf:long_name = "Low frequency part of inverse barometer" ;
		ib_lf:standard_name =
"sea_surface_height_correction_due_to_air_pressure_at_low_frequency" ;
		ib_lf:units = "m" ;
		ib_lf:add_offset = 0. ;
		ib_lf:comment = "The ib_lf is one of the components of the dac correction" ;
		ib_lf:coordinates = "longitude latitude" ;
	short internal_tide(time) ;
		internal_tide:_FillValue = -32767s ;
		internal_tide:scale_factor = 1.e-06 ;
		internal_tide:long_name = "Internal Tide signal: coherent mode M2/K1/O1/S2" ;
		internal_tide:units = "m" ;
		internal_tide:add_offset = 0. ;
		internal_tide:references = "(Zaron, 2019; https://doi.org/10.1175/JPO-D-18-
0127.1) (HRETv8.1 tidal frequencies: M2, K1, S2, O1)" ;
		internal_tide:comment = "The sla in this file is already corrected for the
internal_tide; the uncorrected sla can be computed as follows: [uncorrected sla]=[sla from
product]+[internal_tide]; see the product user manual for details" ;
		internal_tide:coordinates = "longitude latitude" ;
	short mdt(time) ;
		mdt:_FillValue = -32767s ;
```

```
            mdt:scale_factor = 0.001 ;
            mdt:long_name = "Mean dynamic topography" ;
            mdt:standard_name = "sea_surface_height_above_geoid" ;
            mdt:units = "m" ;
            mdt:add_offset = 0. ;
            mdt:comment = "The mean dynamic topography is the sea surface height above
geoid; it is used to compute the absolute dynamic topography adt=sla+mdt" ;
            mdt:coordinates = "longitude latitude" ;
        short ocean_tide(time) ;
            ocean_tide:_FillValue = -32767s ;
            ocean_tide:scale_factor = 0.001 ;
            ocean_tide:long_name = "Ocean tide model" ;
            ocean_tide:units = "m" ;
            ocean_tide:add_offset = 0. ;
            ocean_tide:references = "FES2022c (unstructured grid) (Carrere et al, 2022,
https://doi.org/10.24400/527896/a03-2022.3287)" ;
            ocean_tide:comment = "The sla in this file is already corrected for the ocean_tide;
the uncorrected sla can be computed as follows: [uncorrected sla]=[sla from
product]+[ocean_tide]; see the product user manual for details" ;
            ocean_tide:coordinates = "longitude latitude" ;
        short load_tide(time) ;
            load_tide:_FillValue = -32767s ;
            load_tide:scale_factor = 0.001 ;
            load_tide:long_name = "Loading tide model" ;
            load_tide:units = "m" ;
            load_tide:add_offset = 0. ;
            load_tide:references = "FES2022c (structured grid) (Carrere et al, 2022,
https://doi.org/10.24400/527896/a03-2022.3287)" ;
            load_tide:comment = "The sla in this file is already corrected for the loading tide;
the uncorrected sla can be computed as follows: [uncorrected sla]=[sla from
product]+[load_tide]; see the product user manual for details" ;
            load_tide:coordinates = "longitude latitude" ;
        short swh(time) ;
            swh:_FillValue = -32767s ;
            swh:scale_factor = 0.001 ;
            swh:long_name = "Significant Wave Height on main altimeter frequency band" ;
            swh:standard_name = "sea_surface_wave_significant_height" ;
            swh:units = "m" ;
            swh:add_offset = 0. ;
            swh:coordinates = "longitude latitude" ;
        short wind_speed(time) ;
            wind_speed:_FillValue = -32767s ;
            wind_speed:scale_factor = 0.001 ;
            wind_speed:long_name = "Wind speed on main altimeter frequency band" ;
            wind_speed:standard_name = "wind_speed" ;
            wind_speed:units = "m s-1" ;
            wind_speed:add_offset = 0. ;
            wind_speed:coordinates = "longitude latitude" ;
```

```
	float inter_mission_bias ;
		inter_mission_bias:long_name = "bias to have consistent time series since
TOPEX/Poseidon" ;
		inter_mission_bias:units = "m" ;
		inter_mission_bias:comment = "This bias was used for the sea_level_anomaly field
computation" ;

// global attributes:
		:Conventions = "CF-1.6" ;
		:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
		:comment = "Sea Surface Height measured by altimeters referenced to the
[1993,2012] period" ;
		:contact = "aviso@altimetry.fr" ;
		:creator_url = "www.aviso.altimetry.fr" ;
		:geospatial_lat_resolution = 5.19999999966103e-05 ;
		:geospatial_lat_units = "degrees_north" ;
		:geospatial_lon_resolution = 0.00177899999999909 ;
		:geospatial_lon_units = "degrees_east" ;
		:geospatial_vertical_max = 0. ;
		:geospatial_vertical_min = 0. ;
		:geospatial_vertical_positive = "down" ;
		:geospatial_vertical_resolution = "point" ;
		:geospatial_vertical_units = "m" ;
		:institution = "CNES, CTOH, CLS, NOVELTIS" ;
		:keywords = "Oceans > Ocean Topography > Sea Surface Height Anomaly" ;
		:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
		:license =
"http://www.aviso.altimetry.fr/fileadmin/documents/data/License_Aviso.pdf" ;
		:doi = "10.24400/527896/a01-2023.020" ;
		:platform = "Jason-3" ;
		:processing_level = "L2P" ;
		:product_version = "V1.1" ;
		:project = "GT-COTIER (CNES)" ;
		:reference_document = "Handbook" ;
		:references = "www.aviso.altimetry.fr" ;
		:software_version = "0.0_DUACSNG_baseline" ;
		:source = "Jason-3 GDR measurements" ;
		:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata
Convention Standard Name Table v37" ;
		:summary = "GT-COTIER Delayed-Time Level-2P sea surface height anomaly
measured by Jason-3 altimetry observations in coastal areas over the global ocean." ;
		:time_coverage_resolution = "PT0.005S" ;
		:title = "DT Jason-3 Coastal Along track Sea Surface Height Anomaly product" ;
		:geospatial_lat_min = -66.148744 ;
		:geospatial_lat_max = 66.148924 ;
		:geospatial_lon_min = 0.000565 ;
		:geospatial_lon_max = 359.999829 ;
		:time_coverage_start = "2021-07-03T00:06:34Z" ;
```

```
:time_coverage_end = "2021-07-03T23:58:56Z" ;
:time_coverage_duration = "P23H52M22S" ;
:date_created = "2023-12-01T15:04:29Z" ;
:date_issued = "2023-12-01T15:04:29Z" ;
:date_modified = "2023-12-01T15:04:29Z" ;
:history = "2023-12-01T15:04:29Z: Creation" ;
```

7.2. ALTimetry Innovative Coastal Approach product file: timeseries file

The timeseries files are using a common structure and semantic as shown in the example below for the Jason-3 track 222.

```
netcdf dt_coastal_j3_phy_20hz_t222 {
dimensions:
        nbpoints = 23611 ;
        nbcycles = 199 ;
variables:
        int latitude_theoretical(nbpoints) ;
                latitude_theoretical:_FillValue = -2147483647 ;
                latitude_theoretical:long_name = "Theoretical latitude of measurement" ;
                latitude_theoretical:standard_name = "latitude" ;
                latitude_theoretical:units = "degrees_north" ;
                latitude_theoretical:comment = "The theoretical position corresponds to the exact repetitive position that the ground track may have if the satellite was perfectly maintained on its orbit. It was estimated using the first cycles of the Topex/Poseidon mission, also defining the ground track position for the Jason series" ;
                latitude_theoretical:add_offset = 0. ;
                latitude_theoretical:scale_factor = 1.e-06 ;
        int longitude_theoretical(nbpoints) ;
                longitude_theoretical:_FillValue = -2147483647 ;
                longitude_theoretical:long_name = "Theoretical longitude of measurement" ;
                longitude_theoretical:standard_name = "longitude" ;
                longitude_theoretical:units = "degrees_east" ;
                longitude_theoretical:comment = "The theoretical position corresponds to the exact repetitive position that the ground track may have if the satellite was perfectly maintained on its orbit. It was estimated using the first cycles of the Topex/Poseidon mission, also defining the ground track position for the Jason series" ;
                longitude_theoretical:add_offset = 0. ;
                longitude_theoretical:scale_factor = 1.e-06 ;
        int latitude(nbpoints, nbcycles) ;
                latitude:_FillValue = -2147483647 ;
                latitude:long_name = "Latitude of measurement" ;
                latitude:units = "degrees_north" ;
                latitude:add_offset = 0. ;
                latitude:scale_factor = 1.e-06 ;
                latitude:standard_name = "latitude" ;
        int longitude(nbpoints, nbcycles) ;
                longitude:_FillValue = -2147483647 ;
                longitude:long_name = "Longitude of measurement" ;
                longitude:units = "degrees_north" ;
                longitude:add_offset = 0. ;
```

longitude:scale_factor = 1.e-06 ;
longitude:standard_name = "longitude" ;
int cycle(nbcycles) ;
cycle:_FillValue = -2147483647 ;
cycle:units = "count" ;
cycle:long_name = "Cycle the measurement belongs to" ;
double time(nbpoints, nbcycles) ;
time:_FillValue = 9.96920996838687e+36 ;
time:standard_name = "time" ;
time:long_name = "Time of measurement in UTC" ;
time:units = "days since 1950-01-01T00:00:00+00:00" ;
time:calendar = "gregorian" ;
short sea_level_anomaly(nbpoints, nbcycles) ;
sea_level_anomaly:_FillValue = -32767s ;
sea_level_anomaly:long_name = "Sea level anomaly with dac, ocean_tide, load_tide, internal_tide correction applied" ;
sea_level_anomaly:standard_name = "sea_surface_height_above_sea_level" ;
sea_level_anomaly:units = "m" ;
sea_level_anomaly:comment = "The sea level anomaly is the sea surface height above mean sea surface height (MSS); It is computed with the following formula: sea_level_anomaly = Orbit -Range - int inter_mission_bias - dac - ocean_tide - load_tide - internal_tide - Solid_earth_tide - Pole_tide - Ionosphere - Dry_troposphre - Wet_troposphere - SSB - MSS. Part of the corrections applied are given in the following variables : inter_mission_biais, ocean_tide, load_tide, internal_tide, dac. See the product user manual for details" ;
sea_level_anomaly:quality_flag = "validation_flag" ;
sea_level_anomaly:scale_factor = 0.001 ;
short distance_from_theoretical(nbpoints, nbcycles) ;
distance_from_theoretical:_FillValue = -32767s ;
distance_from_theoretical:long_name = "Distance between the real position and the theoretical position of measurement" ;
distance_from_theoretical:units = "m" ;
distance_from_theoretical:add_offset = 0. ;
distance_from_theoretical:scale_factor = 1. ;
short dac(nbpoints, nbcycles) ;
dac:_FillValue = -32767s ;
dac:long_name = "Dynamic Atmospheric Correction" ;
dac:units = "m" ;
dac:references = "MOG2D High Resolution forced with ECMWF pressure and wind fields (S1 and S2 were excluded) + inverse barometer computed from rectangular grids. (Carrere and Lyard, 2003, https://doi.org/10.1029/2002GL016473)" ;
dac:comment = "The DAC correction is the sum of two components: the high frequency signal induced by wind and pressure forcing and estimated with the MOG2D model; and the low frequency signal deduced for the inverse barometer static response of the ocean to atmospheric pressure forcing. The last component is given in the ib_lf variable. The sla in this product is already corrected for the dac; the uncorrected sla can be computed

```
as follows: [uncorrected sla]=[sla from product]+[dac]; see the product user manual for details" ;
		dac:add_offset = 0. ;
		dac:scale_factor = 0.001 ;
	short ib_lf(nbpoints, nbcycles) ;
		ib_lf:_FillValue = -32767s ;
		ib_lf:long_name = "Low frequency part of inverse barometer" ;
		ib_lf:standar_name = "sea_surface_height_correction_due_to_air_pressure_at_low_frequency" ;
		ib_lf:units = "m" ;
		ib_lf:comment = "The ib_lf is one of the components of the dac correction" ;
		ib_lf:add_offset = 0. ;
		ib_lf:scale_factor = 0.001 ;
	short internal_tide(nbpoints, nbcycles) ;
		internal_tide:_FillValue = -32767s ;
		internal_tide:long_name = "Internal Tide signal: coherent mode M2/K1/O1/S2" ;
		internal_tide:units = "m" ;
		internal_tide:references = "(Zaron, 2019; https://doi.org/10.1175/JPO-D-18-0127.1) (HRETv8.1 tidal frequencies: M2, K1, S2, O1)" ;
		internal_tide:comment = "The sla in this file is already corrected for the internal_tide; the uncorrected sla can be computed as follows: [uncorrected sla]=[sla from product]+[internal_tide]; see the product user manual for details" ;
		internal_tide:add_offset = 0. ;
		internal_tide:scale_factor = 1.e-06 ;
	short ocean_tide(nbpoints, nbcycles) ;
		ocean_tide:_FillValue = -32767s ;
		ocean_tide:long_name = "Ocean tide model" ;
		ocean_tide:units = "m" ;
		ocean_tide:references = "FES2022c (unstructured grid) (Carrere et al, 2022, https://doi.org/10.24400/527896/a03-2022.3287)" ;
		ocean_tide:comment = "The sla in this file is already corrected for the ocean_tide; the uncorrected sla can be computed as follows: [uncorrected sla]=[sla from product]+[ocean_tide]; see the product user manual for details" ;
		ocean_tide:add_offset = 0. ;
		ocean_tide:scale_factor = 0.001 ;
	short load_tide(nbpoints, nbcycles) ;
		load_tide:_FillValue = -32767s ;
		load_tide:long_name = "Loading tide model" ;
		load_tide:units = "m" ;
		load_tide:references = "FES2022c (structured grid) (Carrere et al, 2022, https://doi.org/10.24400/527896/a03-2022.3287)" ;
		load_tide:comment = "The sla in this file is already corrected for the loading tide; the uncorrected sla can   be computed as follows: [uncorrected sla]=[sla from product]+[load_tide]; see the product user manual for details" ;
		load_tide:add_offset = 0. ;
		load_tide:scale_factor = 0.001 ;
	short validation_flag(nbpoints, nbcycles) ;
```

```
		validation_flag:_FillValue = -32767s ;
		validation_flag:long_name = "Validation flag" ;
		validation_flag:meaning = "0 = valid measurement; 1 = invalid measurement"
;
		validation_flag:values = "0, 1" ;
		validation_flag:units = "1" ;
	short mdt(nbpoints, nbcycles) ;
		mdt:_FillValue = -32767s ;
		mdt:long_name = "Mean dynamic topography" ;
		mdt:standard_name = "sea_surface_height_above_geoid" ;
		mdt:add_offset = 0. ;
		mdt:comment = "The mean dynamic topography is the sea surface height
above geoid; it is used to compute the absolute dynamic topography adt=sla+mdt" ;
		mdt:scale_factor = 0.001 ;
		mdt:units = "m" ;
	short swh(nbpoints, nbcycles) ;
		swh:_FillValue = -32767s ;
		swh:long_name = "Significant Wave Height on main altimeter frequency
band" ;
		swh:standard_name = "sea_surface_wave_significant_height" ;
		swh:add_offset = 0. ;
		swh:scale_factor = 0.001 ;
		swh:units = "m" ;
	short wind_speed(nbpoints, nbcycles) ;
		wind_speed:_FillValue = -32767s ;
		wind_speed:long_name = "Wind speed on main altimeter frequency band" ;
		wind_speed:unit = "m s-1" ;
		wind_speed:add_offset = 0. ;
		wind_speed:scale_factor = 0.001 ;
		wind_speed:units = "m s-1" ;
	float inter_mission_bias(nbcycles) ;
		inter_mission_bias:long_name = "bias to have consistent time series since
TOPEX/Poseidon" ;
		inter_mission_bias:units = "m" ;
		inter_mission_bias:comment = "This bias was used for the sea_level_anomaly
field computation" ;
	short distance_from_coast(nbpoints) ;
		distance_from_coast:_FillValue = -32767s ;
		distance_from_coast:long_name = "Distance to the nearest coast" ;
		distance_from_coast:units = "m" ;
		distance_from_coast:references = "GSHHG (Wessel P. and Swith W.,
doi:10.1029/96JB00104)" ;
		distance_from_coast:add_offset = 0. ;
		distance_from_coast:scale_factor = 1000. ;

// global attributes:
		:pass_number = "222" ;
		:Conventions = "CF-1.6" ;
```

```
		:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
		:comment = "Sea Surface Height measured by altimeters referenced to the [1993,2012] period" ;
		:contact = "aviso@altimetry.fr" ;
		:creator_url = "www.aviso.altimetry.fr" ;
		:spatial_resolution = "350m" ;
		:geospatial_lat_units = "degrees_north" ;
		:geospatial_lon_units = "degrees_east" ;
		:geospatial_vertical_max = 0. ;
		:geospatial_vertical_min = 0. ;
		:geospatial_vertical_resolution = "point" ;
		:institution = "CNES, CTOH, CLS, NOVELTIS" ;
		:keywords = "Oceans > Ocean Topography > Sea Surface Height Anomaly" ;
		:keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
		:license = "http://www.aviso.altimetry.fr/fileadmin/documents/data/License_Aviso.pdf" ;
		:platform = "Jason-3" ;
		:processing_level = "L2P" ;
		:product_version = "V1.0" ;
		:project = "GT-COTIER (CNES)" ;
		:reference_document = "Handbook" ;
		:references = "www.aviso.altimetry.fr" ;
		:source = "Jason-3 GDR measurements" ;
		:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table v37" ;
		:summary = "GT-COTIER Delayed-Time Level-2P sea surface height anomaly measured by Jason-3 altimetry observations in coastal areas over the global ocean." ;
		:time_coverage_resolution = "P9DT21H58M27.84S" ;
		:title = "DT Jason-3 Coastal Along track Sea Surface Height Anomaly product" ;
		:geospatial_lat_min = -66.145581 ;
		:geospatial_lat_max = 66.145016 ;
		:geospatial_lon_min = -55.351123 ;
		:geospatial_lon_max = 110.510981 ;
		:time_coverage_start = "2016/02/16" ;
		:time_coverage_end = "2021/07/02" ;
		:time_coverage_duration = "P5Y142D" ;
		:date_created = "2023/11/02" ;
}
```

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