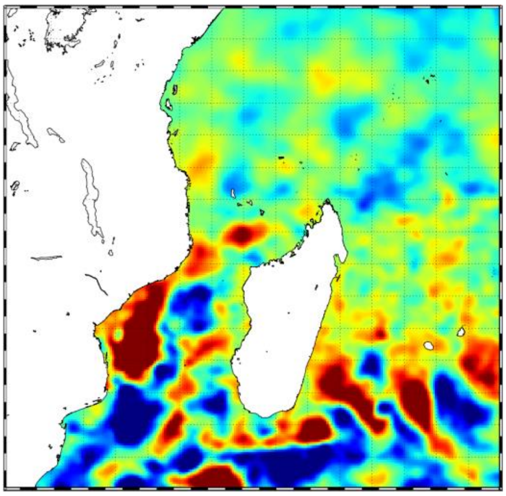
SSALTO/DUACS User Handbook:

Mozambique (M)SLA Near-Real-Time products



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List of Acronyms:

AL	AltiKa
ATP	Along-Track Product
ADT	Absolute Dynamic Topography
AVISO	Archiving, Validation and Interpretation of Satellite Oceanographic data
C2	Cryosat-2
DAC	Dynamic Atmospheric Correction
DT	Delayed Time
DUACS	Data Unification and Altimeter Combination System
EAN	Estimate Accuracy Number
ECMWF	European Centre for Medium-range Weather Forecasting
GIM	Global Ionospheric Maps
GDR	Geophysical Data Record(s)
HY-2A	Haiyang-2A
IERS	International Earth Rotation Service
IGDR	Interim Geophysical Data Record(s)
J1	Jason-1
J1N	Jason-1 on its interleaved orbit (since cycle 262)
J1G	Jason-1 on its geodetic orbit (since May 2012)
J2	OSTM/Jason-2
J2N	OSTM/Jason-2 on its interleaved orbit
J2G	OSTM/Jason-2 on Long Repeat orbit
J3	Jason-3
JPL	Jet Propulsion Laboratory
LWE	Long Wavelength Errors
MOE	Medium Orbit Ephemeris
MP	Mean Profile
MSLA	Map of Sea Level Anomaly
MSS	Mean Sea Surface
NRT	Near-Real Time
OE	Orbit Error
OER	Orbit Error Reduction
Opendap	Open-source Project for a Network Data Access Protocol

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1. Overview of this document

The purpose of this document is to describe the products distributed by Aviso+ for the Mozambique region:

- the along-track Sea Level Anomalies heights (SLA-H)
- the gridded Sea Level Anomalies heights (MSLA-H)
- the gridded geostrophic velocities anomalies (MSLA-UV)

The products are derived from the SSALTO/Duacs processing which integrates in near-real-time, data from Sentinel-3A, Sentinel-3B, Jason-3, Saral/AltiKa, Crysoat-2 and OSTM/Jason-2 missions.

DUACS provides a consistent and homogeneous catalogue of products for varied applications, both for near real time applications and offline studies.

The products presented have been reprocessed in 2018. All the information about this last reprocessing is detailed in Pujol et al., 2016

Some DUACS gridded products are available free of charge. Commercial use of some gridded products is subject to separate agreement and licence (Contact aviso@altimetry.fr).

Note that the Copernicus Marine Environment Monitoring Service (CMEMS http://http://marine.copernicus.eu/) is now in charge of the processing and distribution of the global, Mediterranean Sea,Black Sea, Arctic and Europe Sea level Anomalies Heights along-track and gridded products. Please, refer to CMEMS if you need one of those products.

1.1. Data policy and data access

All SSALTO/DUACS product users need an account on FTP, for Near-Real-Time data and for along-track and gridded products.

As described in the Licence agreement,

- Duacs along-track (level 3) are available free of charge for all projects.
- Duacs gridded products (level 4) are available free of charge for scientific studies or non-profit projects only. Commercial use of gridded products or applications not in line with the standard license agreement is subject to separate agreement and licence (Contact aviso@altimetry.fr).

Please, subscribe to get access to SSALTO/DUACS products by filling the registration form on:

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

2. SSALTO/Duacs system

2.1. Introduction

This chapter presents the input data used by the system and an overview of the different processing steps necessary to produce the output data.

Following figure gives an overview of the system, where processing sequences can be divided into 7 main steps:

- acquisition
- homogenization
- input data quality control
- multi-mission cross-calibration
- product generation
- merging
- final quality control

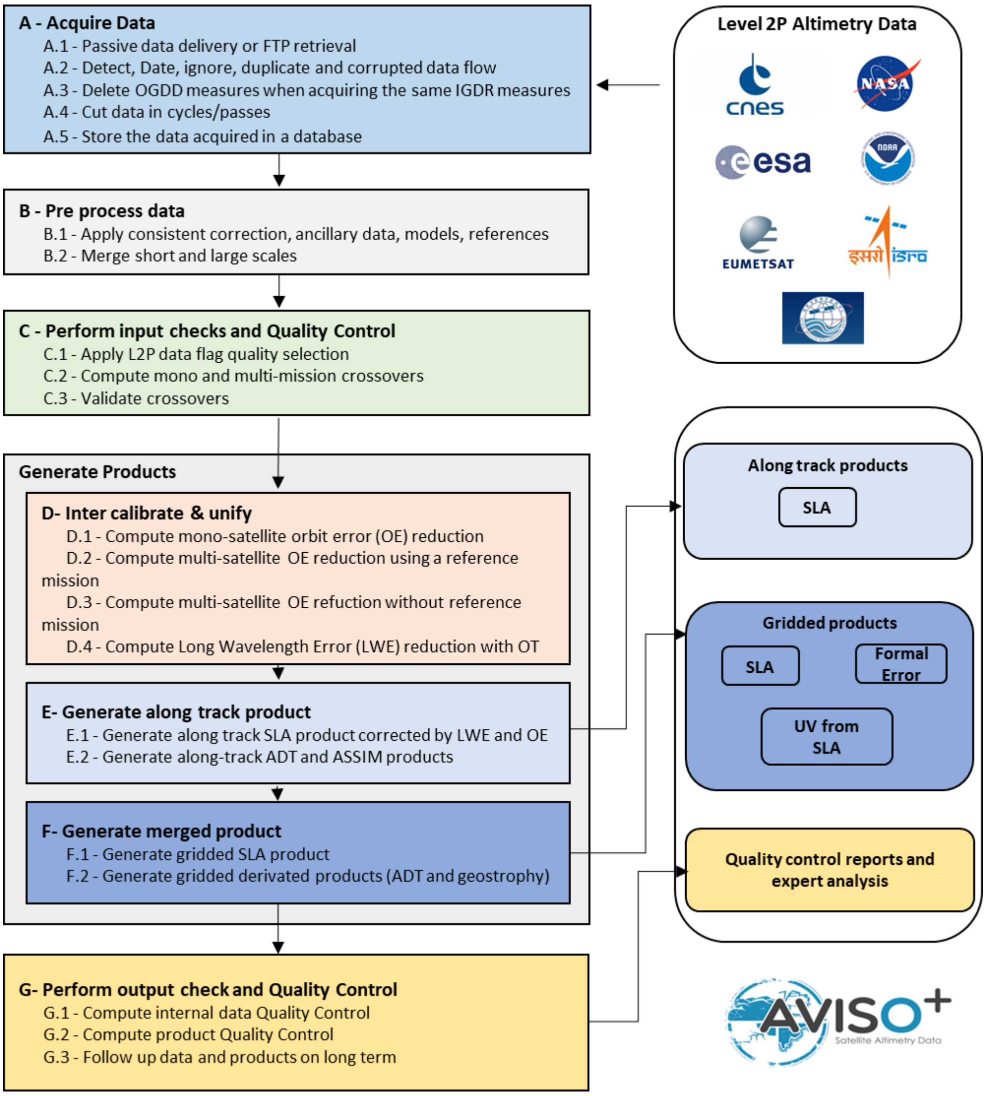

Figure 1 : DUACS processing sequences

2.2. Near Real Time processing steps

2.2.1. Input data, models and corrections applied

To produce along-track (L3) and maps (L4) products in near-real time, the system uses two flows, based on the same instrumental measurements but with a different quality:

- The 24hours or 48hours input data (depending on the mission) that are the latest high-quality altimeter data produced within this timeliness. There are the Interim Geophysical Data Records (IGDRs) or the Short Time Critical (STC) L2P products.
- The 3hours to 5hours input data (depending on the mission) to complete IGDRs or STC products. These fast delivery products (OGDRs or L2P NRT) do not always benefit from precise orbit determination, nor from some external model-based corrections (Dynamic Atmospheric Correction (DAC), Global Ionospheric Maps (GIM)).

Integration of fast delivery data increased the resilience and precision of the system. A better restitution of ocean variability is observed, especially in high energetic areas. See Figure 3: Overview of the near real time system data flow management.

Altimetric	product	Source	Availability	Type of orbit
Sentinel-3B	L2P STC	CLS/CNES/EUMETSAT	-48h	MOE
	L2P NRT	CLS/CNES/EUMETSAT	-3h	Navigator (GNSS for baseline and DORIS for backup)
Sentinel 3A	L2P STC	CLS/CNES/EUMETSAT	-48h	MOE
	L2P NRT	CLS/CNES/EUMETSAT	-3h	Navigator (GNSS for baseline and DORIS for backup)
Jason-3	IGDR	CNES/NASA/EUMETSAT/NOAA	-24h	CNES MOE GDR-E
	OGDR	CNES/NASA/EUMETSAT/NOAA	-3 to 5h	Navigator
OSTM/Jason-2	IGDR	CNES	-24h	CNES MOE GDR-E
	OGDR	NOAA/EUMETSAT	-3 to 5h	Navigator
Cryosat-2	IGDR-like	ESA/CNES	-48h	CNES MOE GDR-E
	OGDR-like	ESA/CNES	Best effort	Navigator
Saral/AltiKa	IGDR	CNES	-48h	CNES MOE GDR-E
	OGDR	ISRO/EUMETSAT	-3 to 5h	Navigator

Table 1: Near-Real Time Input data overview

	NRT products from IGDR or L2P STC (1)			
	j3;j2g	c2	al	s3a; s3b
Product	Version D	CPP	version T patch 2	L2P S3A/B product
Orbit	CNES MOE GDR-E	CNES MOE GDR-E	CNES MOE GDR-E	MOE
Ionospheric	bi-frequency altimeter range measurements	GIM model [Iijima et al,1998]		Filtered dual-frequency altimeter range measurements [Guibbaud et al., 2015]
Dry troposphere	Model computed from ECMWF Gaussian grids (S1 and S2 atm tides applied)			
Wet troposphere	AMR radiometer (enhancement in coastal regions)	Model computed from ECMWF Gaussian grids		From Sentinel-3A/B MicroWave Radiometer
DAC	MOG2D High Resolution forced with ECMWF pressure and wind fields (S1 and S2 were excluded) [Carrere and Lyard, 2003]+ inverse barometer. Filtering temporal window is recentered using forecasts			
Ocean tide	FES2014 [Carrère et al., 2015]			
Pole tide	[Wahr, 1985]			
Solid earth Tide	Elastic response to tidal potential [Cartwright and Tayler, 1971], [Cartwright and Edden, 1973]			
Loading tide	GOT4v8			
Sea state bias	Non Parametric SSB [N. Tran et al., 2012] (with cycles J2 1-36 using GDR-D	Non parametric SSB from J1 with unbiased sigma0	Hybrid SSB (method from Scharroo et al, 2004 applied to al)	Non parametric SSB [Tran et al., 2012]
Orbit error		Global multi-mission crossover minimization (Le Traon and Ogor, 1998)		
LW errors	Optimal Interpolation [Le Traon et al., 1998]			
Intercalibration	Reference from cycle 20			
Mean profile (see 2.2.6.1.)	J3: Computed with 20 years of TP/J1/J2 data; referenced [1993,2012] J2N: computed with 6 years of TPN/J1N; referenced [1993,2012]	The MSS_CNES_CLS15 referenced [1993,2012] is used since April 22th 2016.		

(1)A flag included in the along-track files indicates the source of the production (OGDR\NRT or IGDR\STC): flag=1 for the Interim GDR (IGDR) or Short Time Critical (STC) and flag=0 for Operational GDR (OGDR) or Near Real Time (NRT).

Table 2 : Corrections and models applied in NRT products produced from IGDRs or L2P STC.

	NRT products from OGDR or L2P NRT (2)			
	j3;j2g	c2	al	s3a;s3b
Product standard ref	Version D	CPP	version T patch 2	L2P S3A/B product
Orbit	Navigator	Navigator	Navigator	Navigator
Ionospheric	bi-frequency altimeter range measurements	GIM model (Iijima et al,1998)		Filtered dual-frequency altimeter range measurements [Guibbaud et al., 2015]
Dry troposphere	Model computed from ECMWF Gaussian grids (S1 and S2 atm tides applied)			
Wet troposphere	AMR radiometer (enhancement in coastal regions)	Model computed from ECMWF Gaussian grids		From Sentinel-3A/B MicroWave Radiometer
DAC	MOG2D High Resolution forced with ECMWF pressure and wind fields (S1 and S2 were excluded) (Carrere and Lyard, 2003)+ inverse barometer. Filtering temporal window is recentered using forecasts			
Ocean tide	FES2014 since April 22th 2016			
Pole tide	[Wahr, 1985]			
Solid earth tide	Elastic response to tidal potential [Cartwright and Tayler, 1971], [Cartwright and Edden, 1973]			
Loading tide	GOT4v8			
Sea state bias	Non Parametric SSB [N. Tran et al., 2012] (with cycles J2 1-36 using GDR-D)	Non parametric SSB from J1 with unbiased sigma0	Hybrid SSB (method from Scharroo et al, 2004 applied to al)	Non parametric SSB [Tran et al., 2012]
Orbit error		Specific filtering of long-wavelength signal (3)		
LW errors	Optimal Interpolation [Le Traon et al., 1998]			
Intercalibration	Reference from cycle 20			
Mean profile (see 2.2.6.1.)	J3: Computed with 20 years of TP/J1/J2 data; referenced [1993,2012] J2N: computed with 6 years of TPN/J1N; referenced [1993,2012]	The MSS_CNES_CLS15 referenced [1993,2012] is used since April 22th 2016.		

(2) A flag included in the along-track files indicates the source of the production (OGDR or NRT or IGDR or STC): flag=1 for the Interim GDR (IGDR) or Short Time Critical (STC) and flag=0 for Operational GDR (OGDR) or Near Real Time (NRT).
(3) Specific data processing was applied on long wave-length signal (§2.2.3. of the user manual)

Table 3 : Corrections and models applied in NRT products produced from OGDRs or L2P NRT.

2.2.2. Acquisition

The acquisition process is twofold:

- Straightforward retrieval and reformatting of altimeter data and dynamic auxiliary data (pressure and wet troposphere correction grids from ECMWF are provided by Meteo France, TEC grids from JPL, NRT MOG2D corrections,...) from external repositories.

- Synchronization process.

To be homogenized properly, altimeter data sets require various auxiliary data. The acquisition software detects, downloads and processes incoming data as soon as they are available on remote sites (external database, FTP site). Data are split into passes if necessary. If data flows are missing or late, the synchronization engine put unusable data in waiting queues and automatically unfreezes them upon reception of the missing auxiliary data. This processing step delivers "raw" data, that is to say data that have been divided into cycles and passes, and ordered chronologically. Note that for Sentinel-3a and Sentinel-3b input data this process is already done.

The acquisition step uses two different data flows in near-real time: the OGDR or L2P NRT flow (within a few hours), and the IGDR or L2P STC flow (within a few days).

For each OGDR or L2P NRT input, the system checks that no equivalent IGDR or L2P STC entry is available in the data base before acquisition; for each IGDR or L2P STC input, the system checks and delete the equivalent OGDR or L2P NRT entry in the data base. These operations aim to avoid duplicates in the system.

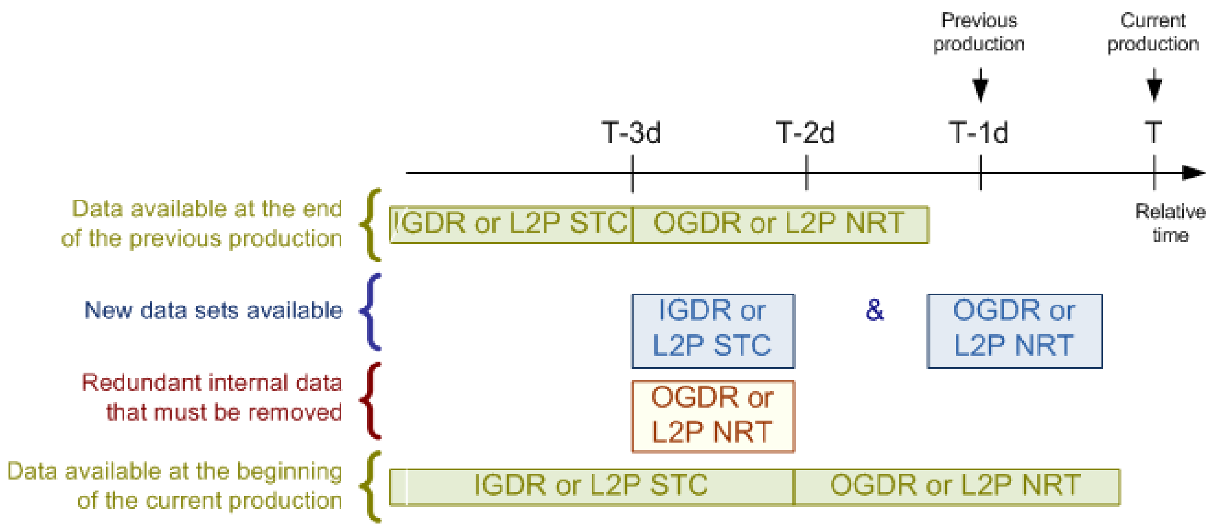

Figure 2 : Overview of the near real time system data flow management

2.2.3. Homogenization

The homogenization process consists of applying the most recent corrections, models and references homogeneously for all missions and recommended for altimeter products. Each mission is processed separately as its needs depend on the base input data. The list of corrections and models currently applied is provided in tables 2 and 3 for NRT data. The system includes SLA filtering to process OGDR or L2P NRT data. The processing extracts from these data sets the short scales (space and time) which are useful to better describe the ocean variability in real time, and merge this information with a fair description of large scale signals provided by the multi-satellite observation in near real time (read: IGDR-based or L2P STC data). Finally a "hybrid" SLA is computed.

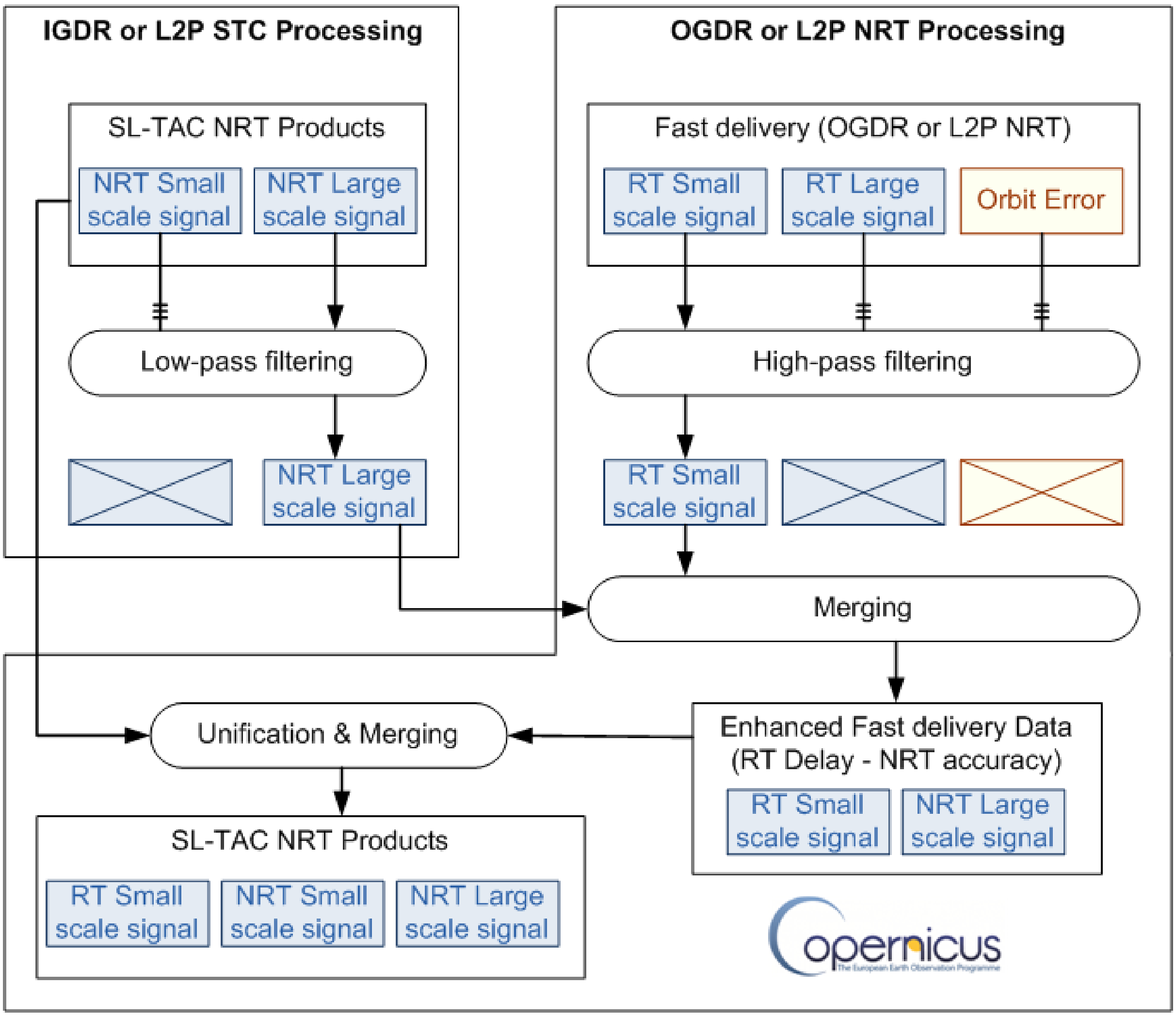

Figure 3 : Merging pertinent information from IGDR or L2P STC and OGDR or L2P NRT processing}

2.2.4. Input data quality control

The Input Data Quality Control is a critical process applied to guarantee that DUACS uses only the most accurate altimeter data. 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. The quality control relies on standard raw data editing with quality flags or parameter thresholds, but also on complex data editing algorithms based on the detection of erroneous artifacts, mono and multi-mission crossover validation, and macroscopic statistics to edit out large data flows that do not meet the system's requirements.

2.2.5. Multi-mission cross-calibration

The Multi-mission Cross-calibration process ensures that all flows from all satellites provide a consistent and accurate information. It removes any residual orbit error (OE, Le Traon and Ogor, 1998) or long wavelength error (LWE, Le Traon et al., 1998), as well as large scale biases and discrepancies between various data flows.

This process is based on two very different algorithms: a global multi-mission crossover minimization for orbit error reduction (OER), and Optimal Interpolation (OI) for LWE.

Multi-satellite crossover determination is performed on a daily basis. All altimeter fields (measurement, corrections and other fields such as bathymetry, MSS,...) are interpolated at crossover locations and dates. Crossovers are then appended to the existing crossover database as more altimeter data become available. This crossover data set is the input of the Orbit Error Reduction (OER) method. Using the precision of the reference mission orbit (TP/J1/J2/J3), a very accurate orbit error can be estimated. This processing step does not concern OGDR nor L2P NRT data.

LWE is mostly due to residual tidal, high frequency ocean signals remaining errors and residual orbit error. The OI used for LWE reduction uses precise parameters derived from:

- accurate statistical description of sea level variability
- regional correlation scales item
- mission-specific noise and precise assumptions on the long wavelength errors to be removed (from a recent analysis of one year of data from each mission).

2.2.6. Product generation

The product generation process is composed of four steps: computation of raw SLA, cross-validation, filtering sub-sampling, and generation of by-products.

2.2.6.1. Variables description

sla_filtered

The dynamical part of the signal: Sea Level Anomaly (SLA) is deduced from the SSH using a Mean Sea Surface (MSS) over a period N:

$SLA_N = SSH - MSS_N$

Where the Sea Surface Height (SSH) above the reference ellipsoïd is:

SSH = Orbit - Altimetric Range

The sla is filtered and subsampled.

ugosa and vgosa

The geostrophic current products disseminated to users are computed using a 9-point stencil width methodology (Arbic et al, 2012) for latitudes outside the ±5°N band. In the equatorial band, the Lagerloef methodology (Lagerloef et al, 1999) introducing the ß plane approximation is used. The reader can refer to Pujol et al (2016) for additional details.

EAN (Estimate Accuracy Number) on geostrophic current are deduced from comparison between altimeter L4 products and drifter measurements (see Pujol et al 2016 for methodology). Synthesis is presented below.

Selection criteria	zonal	meridional
Global excluding equatorial band (±5°N)	10.4 (10.8)	10.5 (11)
High variability areas (>200 cm²)	14.8 (15.1)	16 (16.3)
Low variability areas (<200 cm²)	10.1 (10.6)	10.2 (10.8)

Table 4 : RMS of the differences between DUACS DT2018 geostrophic current (L4) products and independent drifter measurements (unit = cm/s). In parenthesis: same kind of statistics but with DUACS DT-2014. Statistics are presented after latitude selection (5° <|LAT| < 60°).

Geostrophic currents derived from altimeter gridded products are usually underestimated when compared to the in-situ observations. Errors on geostrophic currents have been estimated to range between 5 and 15 cm/s depending on the ocean surface variability. As for SLA field, NRT products quality is reduced and more sensitive to the constellation changes.

2.2.6.2. Computation of raw SLA

The SSH anomalies are used in oceanographic studies. They are computed from the difference of the instantaneous SSH minus a temporal reference. This temporal reference can be a Mean Profile (MP) in the case of repeat track or a gridded MSS when the repeat track cannot be used. The errors affecting the SLAs, MPs and MSS have different magnitudes and wavelengths. The computation of the SLAs and their errors associated are detailed in Dibarboure et al, 2010.

Use of a Mean Profile

In the repeat track analysis at 1 Hz (when the satellites flies over a repetitive orbit), measurements are re-sampled along a theoretical ground track (or mean track) associated to each mission. Then a Mean Profile (MP) is subtracted from the re-sampled data to obtain SLA. The MP is a time average of similarly re-sampled data over a long period.

Altimeter mission,	MP description
Jason-3	MP computed with Topex/Poseidon [January 1993, April 2002; cycles 11 to 353], Jason-1 [April 2002, October 2008; cycles 10 to 249] and Jason-2 [October 2008, December 2015; cycles 10 to 273] measurements. Referenced to the [1993, 2012] period (Taburet et al, in prep).
Sentinel-3A	Hybrid MP computed with Sentinel-3A [June 2016, August 2018; cycles 5 to 35] (Dibarboure et Pujol, 2018)
Sentinel-3B	No MP available for theses missions. A gridded MSS is used as described below
Jason-2 Long Repeat Orbit Phase	
Cryosat-2	
SARAL-DP/AltiKa	

Table 5: Mean Profiles (MPs) and Mean Sea Surfaces (MSS) used for the SLA computation along the different altimeters tracks.

Computation of a Mean Profile

The computation of a Mean Profile is not a simple average of similarly co-located SSH data from the same ground track on the maximum period of time as possible.

- Indeed, as the satellite ground track is not perfectly controlled and is often kept in a band of about 1km wide, precise cross-track projection and/or interpolation schemes are required to avoid errors.
- The ocean variability is removed to minimize the seasonal/interannual aliasing effects. The mesoscale variability error is eliminated with an iterative process using a priori knowledge from Sea Level maps derived from previous iterations or from other missions. This process enables us to reference the mean profiles for all missions to a common period (reference period) for the sake of consistency with other missions. The reference period is [1993, 2012] and is thus independent from the number of years used to compute mean profiles.
- Moreover, the inter-annual variability error is accounted for by using the MSS.
- Finally, for these Mean Profiles, the latest standards and a maximum of data were used in order to increase as much as possible the quality of their estimation. Note that a particular care was brought to the processing near coasts.

Specificity of Sentinel-3A: The Hybrid Mean Profile (HMP) used for Sentinel-3A uses a dedicated filtering and is fully described in Dibarboure and Pujol (2018).

Use of a MSS

The repeat track analysis is impossible for Cryosat-2 mission (c2), AltiKa mission (al) after July 1st, 2015 because the satellite is not in a repetitive orbit phase. Moreover, it is not possible for the moment to compute a mean profile for Sentinel-3B (s3b) because there is not enough data to compute it. The alternative is to use the MSS instead. The gridded MSS is derived from along track MPs and data from geodetic phases. Thus any error on the MP is also contained in the MSS. There are essentially 4 types of additional errors on gridded MSS which are hard to quantify separately:

- To ensure a global MSS coherency between all data sets, the gridding process averages all sensor-specific errors and especially geographically correlated ones.
- The gridding process has to perform some smoothing to make up for signals which cannot be resolved away from known track, degrading along-track content.
- There are also errors related to the lack of spatial and temporal data (omission errors).
- The error stemming from the geodetic data: the variability not properly removed before the absorption in the MSS.

The MSS used in the products is MSS_CNES_CLS15, referenced [1993, 2012]

2.2.6.3. Cross validation

After the repeat track analysis, the cross-validation technique is used as the ultimate screening process to detect isolated and slightly erroneous measurements. Small SLA flows are compared to previous and independent SLA data sets using a 12 year climatology and a 3 sigma criteria for outlier removal.

2.2.6.4. Filtering and sub-sampling

Residual noise and small scale signals are then removed by filtering the data using a Lanczos filter.

The filtering and subsampling is **adapted to each region and product** as a function of the characteristics of the area and of the assimilation needs.

2.2.7. Generation of gridded Sea Level Anomalies (MSLA) products

2.2.7.1. Merging process

The Merging process is twofold: mapping and generation of by-products.

A mapping procedure using optimal interpolation with realistic correlation functions is applied to produce SLA maps (MSLA or L4 products) at a given date. The procedure generates a combined map merging measurements from all available altimeter missions (Ducet et al., 2000). The mapping process takes into account an updated suboptimal Optimal Interpolation parameterization to minimize transition artifacts. More accurate correlation scales are used compared to Ducet et al., taking into account optimally the spatial variability of the signal.

Combining data from different missions significantly improves the estimation of mesoscale signals (Le Traon and Dibarboure, 1999), (Le Traon et al., 2001), (Pascual et al., 2006). Several improvements were made compared to the version used by (Le Traon et al., 1998). An improved statistical description of sea level variability, noise and long wavelength errors is used. Covariance functions including propagation velocities that depend on geographical position were thus used. For each grid point, the zonal and meridional spatial scales, the time scale and the zonal and meridional propagation velocities were adjusted from five years of TP+ERS combined maps. In addition to instrumental noise, a noise of 10\% of the signal variance was used to take into account the small scale variability which cannot be mapped and should be filtered in the analysis.

Time window

In the NRT DUACS processing, contrary to DT case, the products cannot be computed with a centered computation time window for OER, LWE and mapping processes: indeed, as the future data are not available yet, the computation time window is not centered (for each day of production, 2 maps are computed: for the maps of date D and D-6 are using respectively the data in the time interval of [D-42, D] and [D-6-42, D+6]).

OGDR or L2P NRT specificity

SLA computation from OGDR or L2P NRT is based on the same algorithms, only parameters are different in order to take into account fast delivery files specificity. LWE and mapping process are based on IGDR or STC and GDR or NTC (Non Time Critical) available residuals, also with specific parameters.

Formal mapping error

The formal mapping error represents a purely theoretical mapping error. It mainly represents errors induced by the constellation sampling capability and consistency with the spatial/temporal scales considered, as described in Le Traon et al (1998) or Ducet et al (2000). The formal mapping error is expressed in meters and is delivered in the same NetCDF file as the SLA.

The combined map is used to generate by-products such as geostrophic currents.

Geostrophic currents

The geostrophic current computation is described in section 2.2.6.1

2.2.8. Quality control

The production of homogeneous products with a high quality data and within a short delay is the key feature of the processing system. But some events (failure on payload or on instruments, delay, maintenance on servers), can impact the quality of measurements or the data flows. A strict quality control on each processing step is indispensable to appreciate the overall quality of the system and to provide the best user services.

2.2.8.1. Final quality Control

The Quality Control is the final process used before product delivery. In addition to daily automated controls and warnings to the operators, each production delivers a large QC Report composed of detailed logs, figures and statistics of each processing step. Altimetry experts analyze these reports twice a week (only for internal validation, those reports are not disseminated).

3. Description of the product

3.1. Near Real Time Products

The products contain the following variables:

product	variables
Along-track NRT-PHY (for physical) product containing for each mission	sla_filtered
	flag
Gridded NRT-PHY product containing High resolution Maps (Cartesian grids 1/8°x1/8°) containing	err
	sla
	ugosa,vgosa

Table 6: list of variables contained in the delivered files

3.2. Delay of the products

The products availability in near-real time is

- for along-track products: 3 to 12 hours after the measurement
- for gridded products: day-0 and day-6 days

Those products are delivered every day.

Two merged maps are produced daily, each with a different delay and quality:

- A 6-day delay, which represents a final NRT map production,
- and a 0-day delay, which represents a preliminary map production, based on IGDR/STC and OGDR/NRT production.

Then, these maps are replaced when a better quality data is available:

At d_{0+6}, the final NRT map replaces the preliminary map which was produced at d_0.

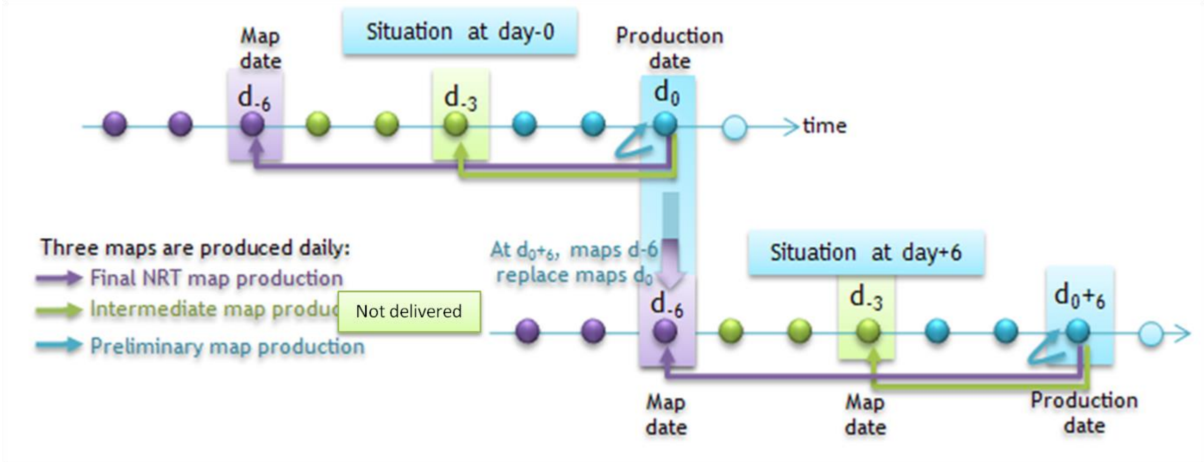

Figure 4 : Two merged maps are produced daily: final map (d-6) and preliminary map (d0)

3.2.1. Temporal availability

The following table presents the available products by mission and by data period:

Near real time products:

mission	Temporal Time availability
Sentinel-3B	2018/11/23 - ongoing
Sentinel-3A	ongoing
Jason-3	ongoing
OSTM/Jason-2 Long Repeat Orbit	ongoing
Cryosat2	ongoing
Saral/Altika	ongoing
Merged	ongoing

3.3. Nomenclature of file

3.3.1. Along-track Near Real Time SLA files

The nomenclature used for the along-track NRT-SLA products is:

DELAY_ZONE_MISSION_PRODUCT_l3_DATEDATA_DATEPROD.FORMAT

DELAY	nrt	near-real time products
ZONE	mozambique	region
MISSION	j2g	OSTM/Jason-2 Long Repeat orbit
	j3	Jason-3
	c2	Cryosat-2
	al	Saral/AltiKa
	s3a	Sentinel-3A
	s3b	Sentinel-3B
PRODUCT	phy_vfec	contains physical fields as described in 3.1
DATADATA	YYYYMMDD	date of the dataset
DATEPROD	YYYYMMDD	production date of the dataset
FORMAT	nc	NetCDF4 CF1.6

Table 7 : Nomenclature of along-track products

3.3.2. Gridded Near Real Time products

The nomenclature used for these products is:

DELAY_ZONE_MISSION_PRODUCT_l4_DATEDATA_DATEPROD.FORMAT

DELAY	nrt	near-real time products
ZONE	mozambique	region
MISSION	allsat	Combined data
PRODUCT	phy	maps of sea level anomaly, error and geostrophic currents
DATADATA	YYYYMMDD	date of the dataset
DATEPROD	YYYYMMDD	production date of the dataset
FORMAT	nc	NetCDF4 CF1.6

Table 8 : Nomenclature of gridded products

4. Data format

This chapter presents the data storage format used for SSALTO/DUACS products.

4.1. NetCdf

The products are stored using the NetCDF4 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:

http://www.unidata.ucar.edu/packages/netcdf/index.html.

NetCDF data is:

- Self-Describing. A netCDF file includes information about the data it contains.
- \item 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 NetCDF files are based on the attribute data tags defined by the Cooperative Ocean/Atmosphere Research Data Service (COARDS) and Climate and Forecast (CF) metadata conventions. The CF convention generalizes 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

4.2. Structure and semantic of NetCDF along-track (L3) files

In addition to these conventions, the files are using a common structure and semantic:

- 1 dimension is defined:
  - **time** : it is used to check NetCDF variables depending on time.
- The following variables are defined:
  - **short sla_filtered** : contains the Sea Level Anomaly filtered values for each time given,
  - **int longitude** : contains the longitude for each measurement,
  - **int latitude** : contains the latitude for each measurement,
  - **short track** : contains the track number for each measurement,
  - **double time** : contains the time in days since 1950-01-01 00:00:00 UTC for each measurement,
  - **short flag** : The origin of the data is determined by the types of geophysical data records (GDR) used in computation of the SLA: 1 for the Interim GDR (IGDR) or Short Time Critical (STC) and 0 for Operational GDR (OGDR) or Near Real Time (NRT).
  - **short cycle** : contains the cycle number for each measurement.
- global attributes:
  - the global attributes gives information about the creation of the file.

Example of a NetCDF sla file:

```
netcdf nrt_mozambique_j3_phy_vfec_l3_20190201_20190205 {
dimensions:
        time = 484 ;
variables:
        double time(time) ;
                time:axis = "T" ;
                time:calendar = "gregorian" ;
                time:long_name = "Time of measurement" ;
                time:standard_name = "time" ;
                time:units = "days since 1950-01-01 00:00:00" ;
        int longitude(time) ;
                longitude:add_offset = 0. ;
                longitude:long_name = "Longitude of measurement" ;
                longitude:scale_factor = 1.e-06 ;
                longitude:standard_name = "longitude" ;
                longitude:units = "degrees_east" ;
        int latitude(time) ;
                latitude:add_offset = 0. ;
                latitude:long_name = "Latitude of measurement" ;
                latitude:scale_factor = 1.e-06 ;
                latitude:standard_name = "latitude" ;
                latitude:units = "degrees_north" ;
        short cycle(time) ;
                cycle:coordinates = "longitude latitude" ;
                cycle:long_name = "Cycle the measurement belongs to" ;
                cycle:units = "1" ;
        short track(time) ;
                track:coordinates = "longitude latitude" ;
                track:long_name = "Track in cycle the measurement belongs to" ;
                track:units = "1" ;
        short flag(time) ;
                flag:_FillValue = 32767s ;
                flag:comment = "The origin of the data is determined by the types of geophysical data records (GDR) used in
computation of the SLA: 1 for the Interim GDR (IGDR) or Short Time Critical (STC) and 0 for Operational GDR (OGDR) or
Near Real Time (NRT)." ;
                flag:coordinates = "longitude latitude" ;
                flag:long_name = "Data origin" ;
                flag:meaning = "OGDR_or_NRT, IGDR_or_STC" ;
                flag:units = "1" ;
                flag:values = 0s, 1s ;
        short sla_filtered(time) ;
                sla_filtered:_FillValue = 32767s ;
                sla_filtered:add_offset = 0. ;
                sla_filtered:comment = "The sea level anomaly is the sea surface height above mean sea surface and it is
referenced to the [1993, 2012] period; see the product user manual for details" ;
```

```
        sla_filtered:coordinates = "longitude latitude" ;
        sla_filtered:long_name = "Sea level anomaly filtered and subsampled" ;
        sla_filtered:scale_factor = 0.001 ;
        sla_filtered:standard_name = "sea_surface_height_above_sea_level" ;
        sla_filtered:units = "m" ;

// global attributes:
        :Conventions = "CF-1.6" ;
        :Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
        :cdm_data_type = "Swath" ;
        :comment = "Sea Level Anomalies referenced to the [1993, 2012] period" ;
        :contact = "aviso@altimetry.fr" ;
        :creator_email = "aviso@altimetry.fr" ;
        :creator_name = "SSALTO/DUACS" ;
        :creator_url = "www.aviso.altimetry.fr" ;
        :date_created = "2019-02-05T02:53:03Z" ;
        :date_issued = "2019-02-05T02:53:03Z" ;
        :date_modified = "2019-02-05T02:53:03Z" ;
        :geospatial_lat_max = -0.165578 ;
        :geospatial_lat_min = -29.990617 ;
        :geospatial_lat_resolution = 0.102515 ;
        :geospatial_lat_units = "degrees_north" ;
        :geospatial_lon_max = 59.661929 ;
        :geospatial_lon_min = 31.217821 ;
        :geospatial_lon_resolution = 0.0408139999999975 ;
        :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" ;
        :history = "2019-02-05T02:53:03Z: Creation" ;
        :institution = "CLS, CNES" ;
        :keywords = "Oceans > Ocean Topography > Sea Surface Height" ;
        :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 = "L3" ;
        :product_version = "2019" ;
        :project = "SSALTO/DUACS" ;
        :references = "www.aviso.altimetry.fr" ;
        :software_version = "18.2.0_DUACS_DT2018_baseline" ;
        :source = "Jason-3 measurements" ;
        :ssalto_duacs_comment = "Jason-3 is the reference mission used for the altimeter inter-calibration processing" ;
        :standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table
v37" ;
        :summary = "SSALTO/DUACS Near-Real-Time Level-3 sea surface height measured by Jason-3 altimetry
observations over Mozambique Sea." ;
        :time_coverage_duration = "P14H23M48.879700S" ;
        :time_coverage_end = "2019-02-01T23:53:07Z" ;
        :time_coverage_resolution = "P1S" ;
        :time_coverage_start = "2019-02-01T09:29:18Z" ;
        :title = "NRT Jason-3 Mozambique Sea Along track SSALTO/DUACS Sea Level Anomalies L3 product" ;
```

4.3. Structure and semantic of NetCDF maps (L4) files

In addition to the conventions described above, the files are using a common structure and semantic:

- 4 Dimensions are defined:
  - **Time** : date of the map,
  - **Latitude** : contains the latitude of grid points ,
  - **Longitude**: contains the longitude of grid points,
  - **nv**: used for mapping conventions

- the variables used for all grids are defined below:
  - **Float time** : contains the time in days since 1950-01-01 00:00:00 UTC,

- **Float latitude** : contains the latitude for each measurement,
- **Float longitude** : contains the longitude for each measurement,
- **Float lat_bnds** : contains the min and max in latitude of each box,
- **Float lon_bnds** : contains the min and max in longitude of each box,
- **Int crs** : used for mapping conventions,
- **Int sla** : contains the sea level anomaly wich is the sea surface height above mean sea surface; it is referenced to the [1993, 2012] period **I**
- **Int err** : contains the formal mapping error in meters,
- **Int ugosa** : contains the zonal component of the geostrophic velocity of the measurements
- **Int vgosa** : contains the meridian component of the geostrophic velocity of the measurements
- **Int nv** : Vertex

- global attributes:
  - the global attributes gives information about the creation of the file. Not that there is a new global attribute called "platform" indicating the list of satellites taken into account to compute the maps.

Example of NetCDF gridded file:

```
netcdf nrt_mozambique_allsat_phy_l4_20190130_20190205 {
dimensions:
	time = 1 ;
	latitude = 240 ;
	longitude = 240 ;
	nv = 2 ;
variables:
	int crs ;
		crs:comment = "This is a container variable that describes the grid_mapping used by the data in this file. This variable does not contain any data; only information about the geographic coordinate system." ;
		crs:grid_mapping_name = "latitude_longitude" ;
		crs:inverse_flattening = 298.257 ;
		crs:semi_major_axis = 6378136.3 ;
	float time(time) ;
		time:axis = "T" ;
		time:calendar = "gregorian" ;
		time:long_name = "Time" ;
		time:standard_name = "time" ;
		time:units = "days since 1950-01-01 00:00:00" ;
	float latitude(latitude) ;
		latitude:axis = "Y" ;
		latitude:bounds = "lat_bnds" ;
		latitude:long_name = "Latitude" ;
		latitude:standard_name = "latitude" ;
		latitude:units = "degrees_north" ;
		latitude:valid_max = -0.125 ;
		latitude:valid_min = -30. ;
	float lat_bnds(latitude, nv) ;
		lat_bnds:comment = "latitude values at the north and south bounds of each pixel." ;
		lat_bnds:units = "degrees_north" ;
	float longitude(longitude) ;
		longitude:axis = "X" ;
		longitude:bounds = "lon_bnds" ;
		longitude:long_name = "Longitude" ;
		longitude:standard_name = "longitude" ;
		longitude:units = "degrees_east" ;
		longitude:valid_max = 59.875 ;
		longitude:valid_min = 30. ;
	float lon_bnds(longitude, nv) ;
		lon_bnds:comment = "longitude values at the west and east bounds of each pixel." ;
		lon_bnds:units = "degrees_east" ;
	int nv(nv) ;
		nv:comment = "Vertex" ;
		nv:units = "1" ;
```

```
        int err(time, latitude, longitude) ;
                err:_FillValue = -2147483647 ;
                err:comment = "The formal mapping error represents a purely theoretical mapping error. It mainly traduces errors induced by the constellation sampling capability and consistency with the spatial/temporal scales considered, as described in Le Traon et al (1998) or Ducet et al (2000)" ;
                err:coordinates = "longitude latitude" ;
                err:grid_mapping = "crs" ;
                err:long_name = "Formal mapping error" ;
                err:scale_factor = 0.0001 ;
                err:units = "m" ;
        int sla(time, latitude, longitude) ;
                sla:_FillValue = -2147483647 ;
                sla:comment = "The sea level anomaly is the sea surface height above mean sea surface; it is referenced to the [1993, 2012] period; see the product user manual for details" ;
                sla:coordinates = "longitude latitude" ;
                sla:grid_mapping = "crs" ;
                sla:long_name = "Sea level anomaly" ;
                sla:scale_factor = 0.0001 ;
                sla:standard_name = "sea_surface_height_above_sea_level" ;
                sla:units = "m" ;
        int ugosa(time, latitude, longitude) ;
                ugosa:_FillValue = -2147483647 ;
                ugosa:comment = "The geostrophic velocity anomalies are referenced to the [1993, 2012] period" ;
                ugosa:coordinates = "longitude latitude" ;
                ugosa:grid_mapping = "crs" ;
                ugosa:long_name = "Geostrophic velocity anomalies: zonal component" ;
                ugosa:scale_factor = 0.0001 ;
                ugosa:standard_name = "surface_geostrophic_eastward_sea_water_velocity_assuming_sea_level_for_geoid" ;
                ugosa:units = "m/s" ;
        int vgosa(time, latitude, longitude) ;
                vgosa:_FillValue = -2147483647 ;
                vgosa:comment = "The geostrophic velocity anomalies are referenced to the [1993, 2012] period" ;
                vgosa:coordinates = "longitude latitude" ;
                vgosa:grid_mapping = "crs" ;
                vgosa:long_name = "Geostrophic velocity anomalies: meridian component" ;
                vgosa:scale_factor = 0.0001 ;
                vgosa:standard_name = "surface_geostrophic_northward_sea_water_velocity_assuming_sea_level_for_geoid" ;
                vgosa:units = "m/s" ;

// global attributes:
                :Conventions = "CF-1.6" ;
                :Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
                :cdm_data_type = "Grid" ;
                :comment = "Sea Surface Height measured by Altimetry and derived variables" ;
                :contact = "aviso@altimetry.fr" ;
                :creator_email = "aviso@altimetry.fr" ;
                :creator_name = "SSALTO/DUACS" ;
                :creator_url = "www.aviso.altimetry.fr" ;
                :date_created = "2019-02-05T02:52:55Z" ;
                :date_issued = "2019-02-05T02:52:55Z" ;
                :date_modified = "2019-02-05T02:52:55Z" ;
                :geospatial_lat_max = -0.125 ;
                :geospatial_lat_min = -30. ;
                :geospatial_lat_resolution = 0.125 ;
                :geospatial_lat_units = "degrees_north" ;
                :geospatial_lon_max = 59.875 ;
                :geospatial_lon_min = 30. ;
                :geospatial_lon_resolution = 0.125 ;
                :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" ;
                :history = "2019-02-05 02:52:55Z: Creation" ;
                :institution = "CLS, CNES" ;
                :keywords = "Oceans > Ocean Topography > Sea Surface Height" ;
                :keywords_vocabulary = "NetCDF COARDS Climate and Forecast Standard Names" ;
                :license = "http://www.aviso.altimetry.fr/fileadmin/documents/data/License_Aviso.pdf" ;
                :platform = "Altika, Cryosat-2, Jason-3, OSTM/Jason-2 Long Repeat Orbit, Sentinel-3A, Sentinel-3B" ;
                :processing_level = "L4" ;
                :product_version = "2019" ;
                :project = "SSALTO/DUACS" ;
                :references = "www.aviso.altimetry.fr" ;
```

:software_version = "18.2.0_DUACS_DT2018_baseline" ;
:source = "Altimetry measurements" ;
:ssalto_duacs_comment = "Jason-3 is the reference mission used for the altimeter inter-calibration processing" ;
:standard_name_vocabulary = "NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table v37" ;
:summary = "SSALTO/DUACS Near-Real-Time Level-4 sea surface height and derived variables measured by multi-satellite altimetry observations over Mozambique Sea." ;
:time_coverage_duration = "P1D" ;
:time_coverage_end = "2019-01-30T00:00:00Z" ;
:time_coverage_resolution = "P1D" ;
:time_coverage_start = "2019-01-30T00:00:00Z" ;
:title = "NRT merged all satellites Mozambique Sea Gridded SSALTO/DUACS Sea Surface Height L4 product and derived variables" ;

5. How to download a product

5.1. Registration

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

Register at:

http://www.aviso.altimetry.fr/en/data/data-access/registration-form.html

or, if already registered on AVISO+, request the addition of this product by contacting aviso@altimetry.fr

5.2. Access Services

The data access on the FTP server is authenticated on ftp://ftp-access.aviso.altimetry.fr/

Note that once your registration is processed (see above), AVISO+ will send you your own access (login/password) by e-mail as soon as possible (within 5 working days during working hours, Central European Time). If you don't enter your login/password, you will only be able to access to the anonymous FTP, where you will not find the data you're interested in.

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