SSALTO/DUACS User Handbook:

Mozambique (M)SLA Near-Real Time Products

Reference : CLS-DOS-NT-06-034
Nomenclature : SALP-MU-P-EA-21065-CLS
Issue : 1rev 0
Date : 2016/08/20

CENTRE NATIONAL D'ÉTUDES SPATIALES

Chronology Issues :		
Issue :	Date :	Reason for change :
1.0	2016/08/20	

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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
BGLO	Biais Grande Longueur d'Onde
Cal/Val	Calibration - Validation
CERSAT	Centre ERS d'Archivage et de Traitement
CORSSH	CORrected Sea Surface Height
C2	Cryosat-2
DAC	Dynamic Atmospheric Correction
DT	Delayed Time
DTU	Mean Sea Surface computed by Technical University of Danemark
DUACS	Data Unification and Altimeter Combination System
E1	ERS-1
E2	ERS-2
EN	Envisat
ENN	Envisat on its non repetitive orbit (since cycle 94)
ECMWF	European Centre for Medium-range Weather Forecasting
ENACT	ENhanced ocean data Assimilation and Climate prediction
G2	Geosat Follow On
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 new orbit (since cycle 262)
J1G	Jason-1 on its geodetic orbit (since May 2012)
J2	OSTM/Jason-2
J2N	OSTM/Jason-2 on its new orbit
J3	Jason-3
JPL	Jet Propulsion Laboratory
LAS	Live Access Server
LWE	Long Wavelength Errors
MADT	Map of Absolute Dynamic Topgraphy
MDT	Mean Dynamic Topography
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

PO.DAAC	Physical Oceanography Distributed Active Archive Centre
POE	Precise Orbit Ephemeris
RD	Reference Document
SAD	Static Auxiliary Data
SARAL	Satellite with ARgos and ALtika
SLA	Sea Level Anomaly
SSALTO	Ssalto multimission ground segment
SSH	Sea Surface Height
T/P	Topex/Poseidon
TPN	Topex/Poseidon on its new orbit (since cycle 369)

Contents

1. Introduction

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 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 2014. All the information about this last reprocessing is detailed in Pujol et al., 2016 [56].
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) **gridded heights** products (level 4) are available free of charge for all projects.

- Duacs **gridded geostrophic current anomalies** 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:
http://www.aviso.altimetry.fr/en/data/data-access/registration-form.html.

2. Latest operational operations

2.1. Jason-3 mission for NRT products (September 2016)

Jason-3 has been implemented in the SL-TAC system on September 2016 as the new reference mission. By succeeding TOPEX/Poseidon, Jason-1, and Jason-2, Jason-3 extends the high precision altimetry data record to support climate monitoring, operational oceanography and seasonal forecasting. Launched on January 17th 2016, Jason-3 is the result of collaboration between CNES, NASA, EUMETSAT and NOAA. Jason-3 has the same orbit than the current Jason-2 mission, Jason-2 will be moved to a new orbit in order to improve the spatial resolution of gridded products. **Note that the integration of Jason-3 in the SSALTO/Duacs system leads to the deactivation of the current Jason-2 mission. Jason-2 will be reintroduced later in the system when available in a new dataset named "j2n".**

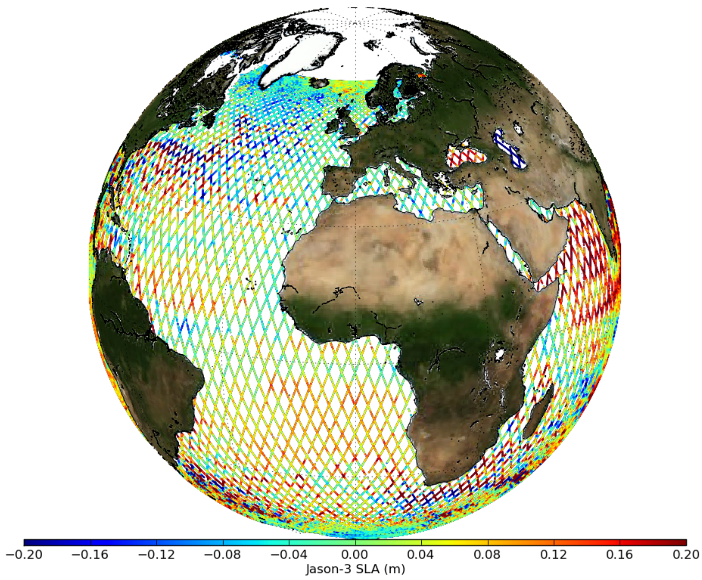

Figure 1: *Example of Jason-3 Sea Level Anomalies (SLA) map for one cycle*

2.2. July 4th 2016, new phase for AltiKa

On July 4th 2016, SARAL/AltiKa has begun its new phase named "Saral Drifting Phase". It now flies free of station keeping manoeuvers; the repetitive ground track is no more maintained and the ground track will drift. This decision - endorsed by Cnes and ISRO management - is due to the technical issues encountered since March 2015. As the SSALTO/Duacs processing was already configured as a geodetic mission, thus no change is foreseen on the chain. Note that the cycle number will jump to #100. And one cycle will always contain 1002 passes but the numbering and localisation are different: for example, pass 20 in cycles 1 to 35 is the same ground track with +/-1 1km deviation. Pass 20 in cycle 100 is different from pass 20 in cycles 1 to 35 and is also different from pass 20 in cycles 101, 102,... .

The following points summarizes the past events on the mission:
1/Due to reaction wheel issues, SARAL station keeping maneuvers couldn't be performed nominally since **March 31st, 2015**. As a result, SARAL/AltiKa's ground track has been drifting with deviations from the nominal track overtaking 10km depending on the latitude, instead of +/-1km usually.
2/Between **April 1st, and August 11th, 2015**, the SARAL/AltiKa's ground track has been drifting from its nominal track.
3/**Since August 11th, 2015** and thanks to many maneuvers, the platform was again under control and the nominal track has been reached.
Consequently, this drift had an impact on the SSALTO/Duacs AL products between **April 1st, 2015 and August 11th, 2015**. As the mission was processed as a repetitive mission (see below), the distance between the theoretical track and the true track position was large, this projection processing induced an additional error in the product. Since mid may 2015, we had indeed observed an increase of the variability of the SARAL/AltiKa SLA at short wavelengths (< about 200km).
4/**Since June 30th, 2015**, in order to limit the degradation of the quality of the product in NRT processing, the SARAL/AltiKa mission was processed as a geodetic mission as decribed below.

Processing for a repetitive mission:
In this case, the position of the points vary from one cycle to another one **within +/- 1 km**. The processing for a repetitive mission (like Jason-2 for example) includes the projection of the measurement onto a theoretical track position in order to benefit from the precise Mean Profile estimated from past missions (see 3.2.6.1.).
Processing for a geodetic mission:
In this case, the positions of the points can vary from one cycle to another one of **more than +/- 1km**.The processing for a non repetitive or a geodetic mission (like Crysoat-2 for example) avoids the projection of the measurement into a theoretical track position because it doesn't exists. In order to correct the measurement for computing Sea Level Anomalies, a gridded Mean Sea Surface (MSS) solution is used rather than a more precise Mean Profile for SLA computation (see 3.2.6.1.). However, SSALTO/Duacs processing includes an along-track filtering that strongly reduces this error signature on filtered products (see 3.2.6.1.).

3. SSALTO/Duacs system

3.1. 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.

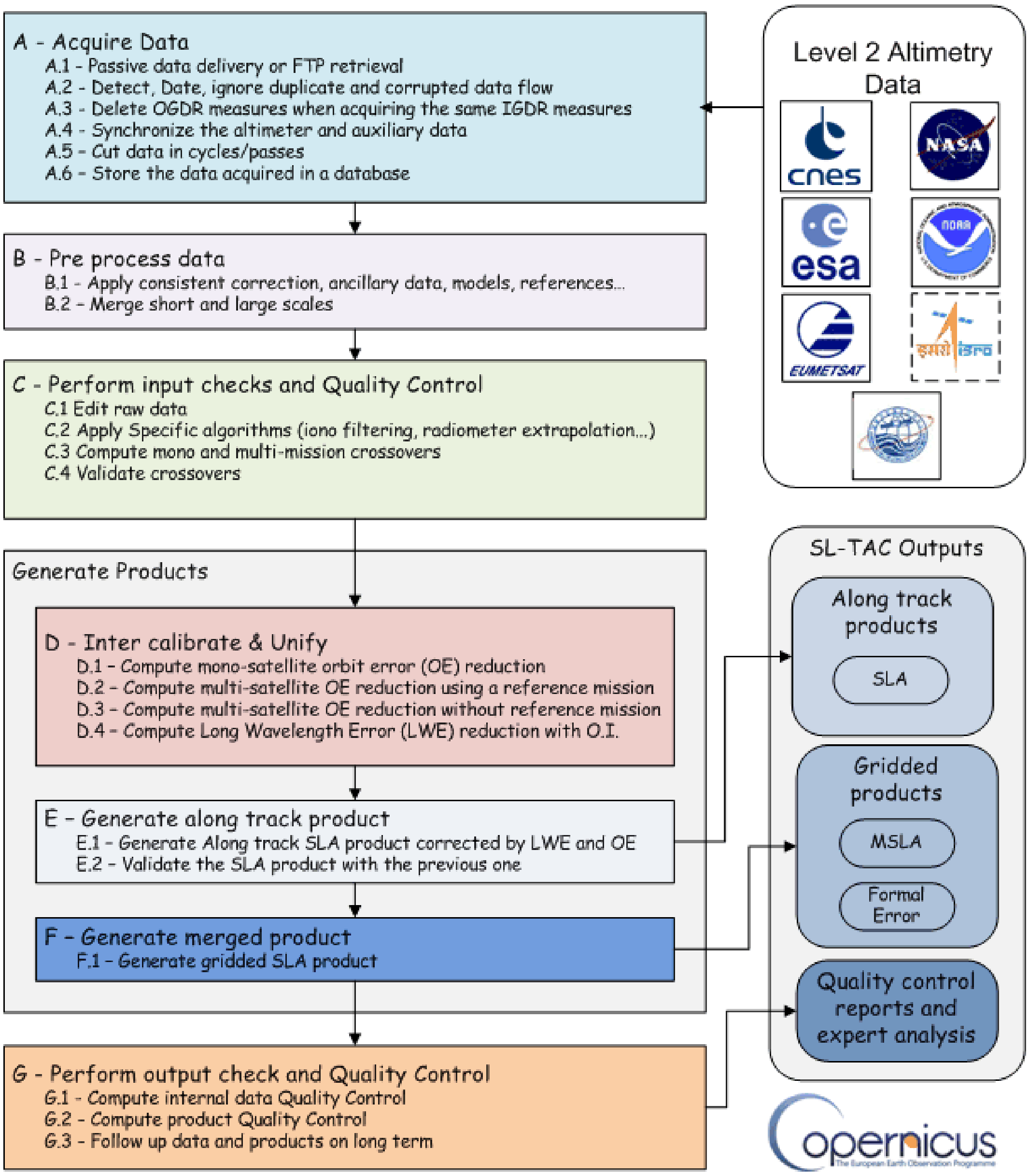

Figure 2: *SSALTO/Duacs processing sequences*

3.2. Near Real Time processing steps

3.2.1. Input data, models and corrections applied

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

- The IGDRs that are the latest high-quality altimeter data produced in near-real-time.
- The OGDRs that include real time data (Jason-3, SARAL/AltiKa, OSTM/Jason-2 and Cryosat-2) to complete IGDRs. These fast delivery products 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 OGDR data increased the resilience and precision of the system. A better restitution of ocean variability is observed, especially in high energetic areas.

Altimetric product		Source	Availability	Type of orbit
Jason-3	IGDR	CNES/NASA/EUMETSAT/NOAA	~24h	CNES MOE GDR-E
	OGDR	CNES/NASA/EUMETSAT/NOAA	~3 to 5 h	Navigator
OSTM/Jason-2	IGDR	CNES	~24h	CNES MOE GDR-E
	OGDR	NOAA/EUMETSAT	~3 to 5 h	Navigator
Cryosat-2	IGDR-like	ESA/CNES	~48 h	CNES MOE GDR-E
	OGDR-like	ESA/CNES	best effort	Navigator
Saral/AltiKa	IGDR	CNES	~48 h	CNES MOE GDR-E
	OGDR	ISRO/EUMETSAT	~3 to 5 h	Navigator

Table 1: SSALTO/Duacs Near-Real Time Input data overview

See Figure 3: Overview of the near real time system data flow management.

	NRT product from IGDR [1]			
	j3; j2	c2	al	h2
Product	version D	CPP [4]	version T patch 2	HPP [52]
Orbit	CNES MOE GDR-E	CNES MOE GDR-E	CNES MOE GDR-E	CNES MOE GDR-D
Ionopheric	bi-frequency altimeter range measurements	GIM model (Iijima et al,1998[32])		
Dry tropo	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		Model computed from ECMWF Gaussian grids
DAC	MOG2D High Resolution forced with ECMWF pressure and wind fields (S1 and S2 were excluded) (Carrere and Lyard, 2003[7])+ inverse barometer. Filtering temporal window is recentered using forecasts			
Ocean tide	FES2014 [5]			
Pole tide	[Wahr, 1985 [72]]			
Solid earth tide	Elastic response to tidal potential [Cartwright and Tayler, 1971[9]], [Cartwright and Edden, 1973[10]]			
Loading tide	GOT4v8 (S1 and S2 are included)			
Sea state bias	Non Parametric SSB [N. Tran et al., 2012[68]] (with cycles J2 1-36 using GDR-D	Non parametric SSB from J1 with unbiased sigma0	Hybrid SSB (method from Scharroo et al, 2004 [66] applied to al)	Calculated from HPP [52]: -3.45% of SWH
Orbit error		Global multi-mission crossover minimization (Le Traon and Ogor, 1998[41])		
LW errors	Optimal Interpolation [Le Traon et al., 1998[40]]			
Intercalibration	Reference from cycle 20			
Mean profile (see 3.2.6.1.)	Computed with 20 years of TP/J1/J2 data; referenced [1993,2012]	The MSS_CNES_CLS11 [49] referenced [1993,2012] is used		

(1) A flag included in the along-track files indicates the source of the production (OGDR or IGDR). If flag=0, the processed data comes from OGDRs; if flag=1, the processed data comes from IGDRs.

Table 2: Corrections and models applied in SSALTO/Duacs NRT products produced from IGDRs.

	NRT product from OGDR [2]		
	j3; j2	c2	al
Product standard ref	version D	CPP [4]	version T patch 2
Orbit	Navigator		
Ionopheric	bi-frequency altimeter range measurements	GIM model (Iijima et al,1998[32])	
Dry tropo-sphere	Model computed from ECMWF Gaussian grids (S1 and S2 atm tides applied)		
Wet tropo-sphere	AMR radiometer (enhancement in coastal regions)	Model computed from ECMWF Gaussian grids	
DAC	MOG2D High Resolution forced with ECMWF pressure and wind fields (S1 and S2 were excluded) (Carrere and Lyard, 2003[7])+ inverse barometer. Filtering temporal window is decentered using forecasts		
Ocean tide	FES2014 [5]		
Pole tide	[Wahr, 1985 [72]]		
Solid earth tide	Elastic response to tidal potential [Cartwright and Tayler, 1971[9]], [Cartwright and Edden, 1973[10]]		
Loading tide	GOT4v8 (S1 and S2 are included)		
Sea state bias	Non Parametric SSB [N. Tran et al., 2012[68]] (with cycles J2 1-36 using GDR-D	Non parametric SSB from J1 with unbiased sigma0	Hybrid SSB (method from Scharroo et al, 2004 [66] applied to al)
Orbit error		Specific filtering of long-wavelength signal[3]	
LW errors	Optimal Interpolation [Le Traon et al., 1998[40]]		
Intercalibration	Reference from cycle 20		
Mean profile (see 3.2.6.1.)	Computed with 20 years of TP/J1/J2 data; referenced [1993,2012]	The MSS_CNES_CLS11 [49] referenced [1993,2012] is used	

(2) A flag included in the along-track files indicates the source of the production (OGDR or IGDR). If flag=0, the processed data comes from OGDRs; if flag=1, the processed data comes from IGDRs.
(3) Specific data processing was applied on long wave-length signal (§3.2.3. of the user manual).

Table 3: Corrections and models applied in SSALTO/Duacs NRT products produced from OGDRs.

3.2.2. 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.
- synchronisation 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 synchronisation 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.
The acquisition step uses two different data flows in near-real time: the OGDR flow (within a few hours), and the IGDR flow (within a few days).
For each OGDR input, the system checks that no equivalent IGDR entry is available in the data base before acquisition; for each IGDR input, the system checks and delete the equivalent OGDR entry in the data base. These operations aim to avoid duplicates in SSALTO/Duacs system.

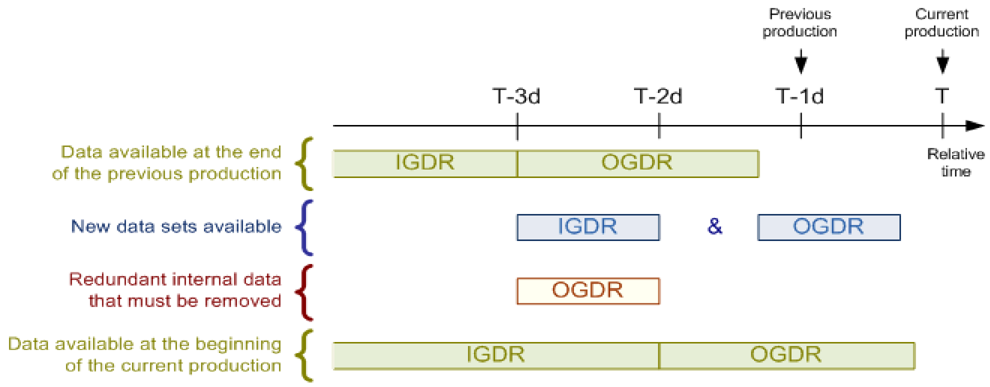

Figure 3: *Overview of the near real time system data flow management*

3.2.3. 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 data. The SSALTO/Duacs 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 data). Finally an "hybrid" SLA is computed.

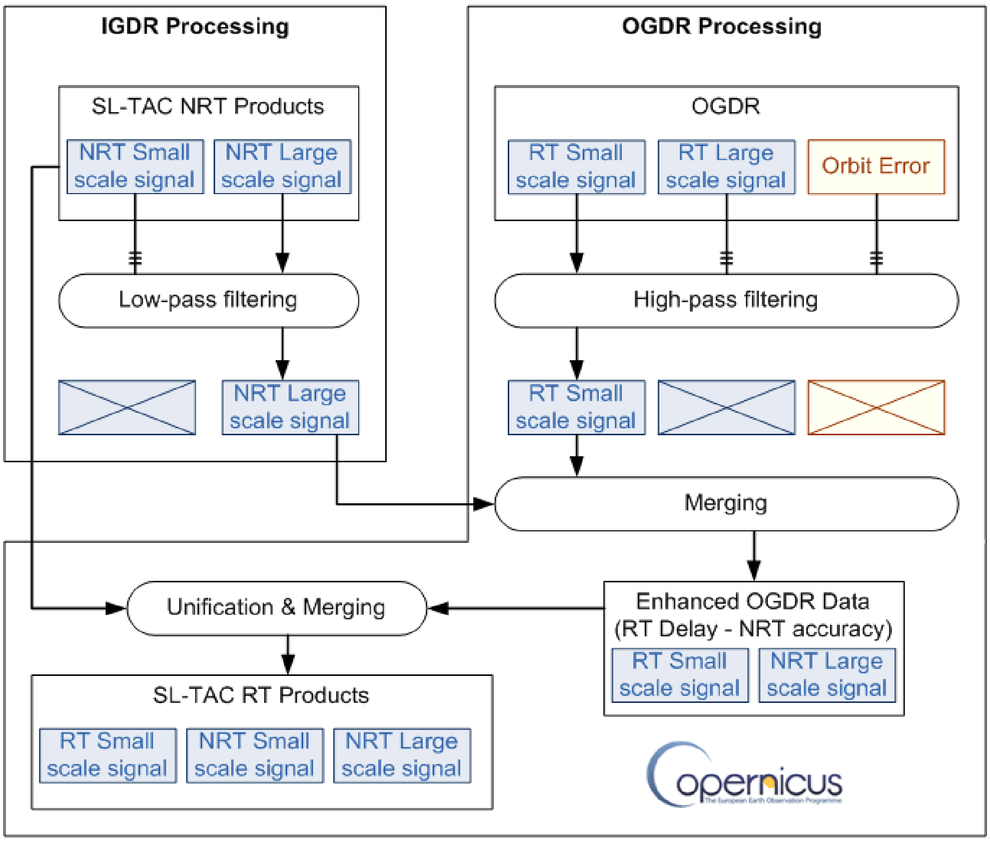

Figure 4: *Merging pertinent information from IGDR and OGDR processing*

3.2.4. Input data quality control

The Input Data Quality Control is a critical process applied to guarantee that SSALTO/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 artefacts, mono and multi-mission crossover validation, and macroscopic statistics to edit out large data flows that do not meet the system's requirements.

3.2.5. 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[41]), or long wavelength error (LWE, Le Traon et al., 1998[40]), 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 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
- 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).

3.2.6. 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.

3.2.6.1. 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 [15].

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.

- The Mean Profile used for Saral/Altika until June 30th, 2015 is computed with 15 years of ERS-1, ERS-2 and Envisat, referenced to the period [1993, 2012]. Since July 1st, 2015, no Mean Profile can be used for AltiKa because the orbit is drifting. The MSS is used instead of the MP (see below).
- The Mean Profile used for Jason-3 and Jason-2 is computed with 20 years of T/P, Jason-1 and Jason-2, referenced to years [1993, 2012].
- No Mean Profile can be used for Cryosat-2 mission (c2). The MSS must be used instead (see below).

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 variabilty 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.

Use of a MSS

The repeat track analysis is impossible for Cryosat-2 mission (c2) and AltiKa mission 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 HY-2A 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_CLS11 [49], referenced [1993,2012]

3.2.6.2. 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.

3.2.6.3. Filtering and sub-sampling

Residual noise and small scale signals are then removed by filtering the data using a Lanczos filter. The filtering and sub-sampling is **adapted to each region and product** as a function of the characteristics of the area and of the assimilation needs.

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

3.2.7.1. 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[21]). The mapping process takes into account an updated suboptimal Optimal Interpolation parameterization to minimize transition artefacts. 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[42]), (Le Traon et al., 2001[43]), (Pascual et al., 2006[50]). Several improvements were made compared to the version used by (Le Traon et al., 1998[40]). 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 centred 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, 3 maps are computed: for the maps of date D, D-3 and D-6 are using respectively the data in the time intervall of [D-42, D], [D-3-42, D+3] and [D-6-42, D+6]).

OGDR specificity
SLA computation from OGDR is based on the same algorithms, only parameters are different to take into account OGDR specificity. LWE and mapping process are based on IGDR and GDR available residuals, also with specific parameters.

Change of resolution
In DUACS 2014 version, after the feedback from users, the Mercator grid projection with 1/3° x1/3° spatial resolution (Global product) is abandoned. The DUACS 2014 Global products are directly computed on a Cartesian 1/4°x1/4° spatial resolution. Please, refer to the technical note `http://www.aviso.altimetry.fr/fileadmin/documents/data/duacs/Duacs2014.pdf` and to Pujol et al., 2016

[56] for comparison between DUACS 2014 and former version.

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) [40] or Ducet et al (2000) [21]. 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 or absolute dynamic topography.

Geostrophic currents

Since DUACS 2014 version, the geostrophic current computation is improved with:

- The use of the 9-point stencil width method (Arbic et al, 2012, [3]) at latitudes appart from ±5°. It contributes to reduce the impact of the anisotropy introduced by the Cartesian 1/4° grid resolution.

- The SLA computation is Largerloef et al, 1999 [37] in the equatorial band is improved in order to smooth the transition at ±5° and improve the consistency between altimeter products and drifter observations.

More information can be found in http://www.aviso.altimetry.fr/fileadmin/documents/data/duacs/Duacs2014.pdf and Pujol et al., 2016 [56].

3.2.8. Quality control

The production of homogeneous products with a high quality data and within a short delay is the key feature of the SSALTO/Duacs 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.

3.2.8.1. Final quality Control

The Quality Control is the final process used by SSALTO/Duacs 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 analyse these reports twice a week (only for internal validation, those reports are not disseminated). A shorter report is delivered to DUACS users upon each product delivery.
This QC activity is used as a modest Cal/Val activity on NRT products. It provides level2 product centres with a detailed feedback on potential anomalies for a fast reprocessing of erroneous IGDR flows.

The Quality Reports are now on the authenticated server. To access them via a browse, please type your login and password in the following address:
ftp://LOGIN:PASSWORD@ftp.aviso.altimetry.fr/quality_report/

3.2.8.2. Performance indicators

To appreciate the quality situation of the DUACS system, performance indicators are computed daily. They aim at evaluate the status of the main processing steps of the system: the input data availability, the input data coverage, the input data quality and the output product quality. These indicators are computed for each and every currently working satellite, and combined to obtain the overall status.

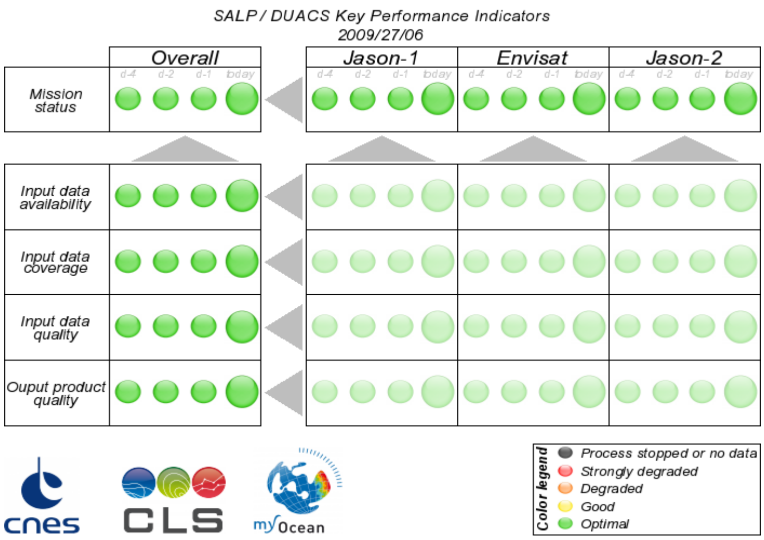

Figure 5: *Example with the key performance indicator on 2009/06/27*

See the description, the latest and previous indicators on Aviso website:
http://www.aviso.altimetry.fr/en/data/product-information/information-about-mono
ssaltoduacs-multimission-altimeter-products/key-performance-indicators.html

4. SSALTO/DUACS Products

4.1. Near Real Time Products

The purpose of the NRT component is the acquisition of altimeter data from various altimeter missions in near-real time (i.e. within a few days at most) and in real-time for global area on all satellites (i.e. within a few hours), the validation and correction of these altimeter data sets (i.e edition and selection, update of corrections and homogenization, orbit error reduction) in order to produce each day along-track and gridded products.
Exploitation of real time OGDR data allows the DUACS system to produce multi-mission maps with 0-day and 3-day delay whereas historical NRT (IGDR-based) production have a 6-day delay (induced by historical trade-off in terms of timeliness vs quality).
The quality measurements in the NRT processing is more sensitive to the number of altimeter missions involved in the system. This is mainly due to the orbit error and the non-centered processing time-window (in NRT case, "future" data are not available; the computation time window takes into account only the 6 weeks before the date).
If two altimeters are acknowledged as the bare minimum needed to observe mesoscale signals in DT maps, three or even four missions are needed to obtain equivalent accuracy in NRT (Pascual et al., 2006[50]).

4.1.1. Delay of the products

The availability of the products in near real time is

- for along-track products: three to twelve hours after the measurement
- for gridded products: day-0 , day-3 and day-6 days.

Those products are delivered every day.

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

- A 6-day delay, which represents a final NRT map production,
- A 3-day delay, which represents an intermediate map production,;
- and a 0-day delay, which represents a preliminary map production, based on IGDR+OGDR 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.

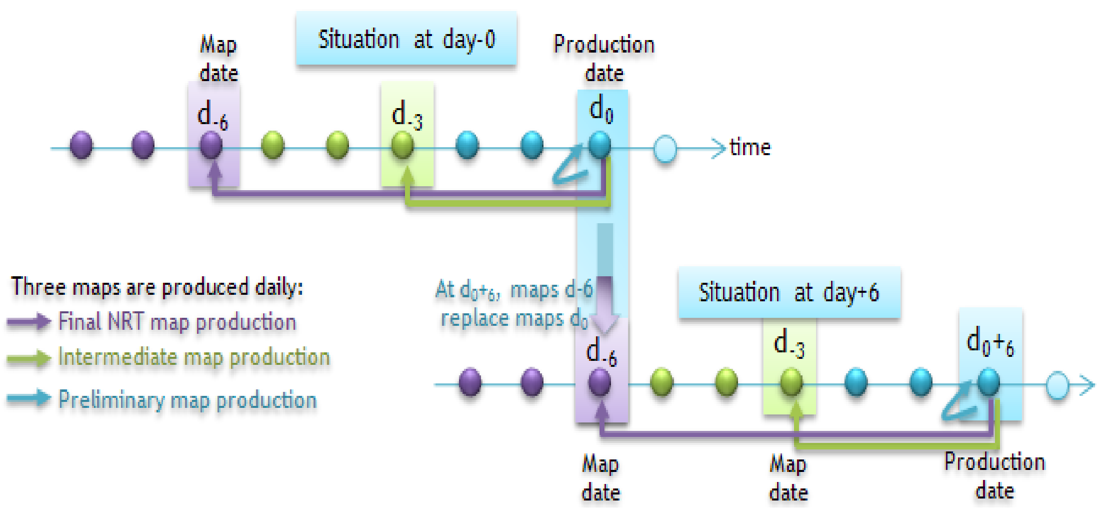

Figure 6: *Three merged maps are produced daily: final map (d-6), intermediate map (d-3) and preliminary map (d0)*

4.1.2. Temporal availibility

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

NRT	Jason-3	Jason-2	Cryosat-2	Saral/AltiKa	HY-2A	Merged
Temporal Time availability	2016/09/05 ongoing	2014/01/07 2016/09/05	2014/01/07 ongoing	2014/01/07 ongoing	2014/01/07 2016/01/05	2014/01/07 ongoing
SLA-H	X	X	X	X	X	
MSLA-H						X
MSLA-UV						X

5. Data format

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

5.1. NetCdf

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

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.

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

The NetCDF SSALTO/DUACS 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 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:

- 1 dimension is defined:
  - **time**: it is used to check NetCDF variables depending on time.
- 6 variables are defined:
  - short **SLA** or **ADT**: contains the Sea Level Anomaly or Absolute Dynamic Topography 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** : only for NRT products. flag=0, the processed data comes from OGDR; if flag=1, the processed data comes from the IGDR
  - short **cycle** : contains the cycle number for each measurement.
- global attributes:
  - the global attributes gives information about the creation of the file.

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

The NetCDF SSALTO/DUACS 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 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:

- 4 Dimensions are defined:
  - **time**: date of the map,
  - **lat**: contains the latitude of grid points ,
  - **lon**: contains the longitude of grid points,
  - **nv**: used for mapping conventions
- 8 or 9 Variables are used for all grids defined below:
  - float **time** : contains the time in days since 1950-01-01 00:00:00 UTC,
  - float **lat** : contains the latitude for each measurement,
  - float **lon** : 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
  - the fields used for msla_h files are:
    - int **sla**: contains the eea level anomalies of the measurements and
    - int **err**: contains the formal mapping error in meters
  - the fields used for msla_uv
    - int **u**: contains the zonal component of the geostrophic velocity of the measurements and
    - int **v**: contains the meridian component of the geostrophic velocity of the measurements
- 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.

6. Accessibility of the products

Aviso proposes several ways of accessing data. Some of them need an authentication. If you are not registered and want to access to an authenticated service, we request you to fill in the online form.
According to the type of SSALTO/DUACS data, products are available:

- Via **authenticated FTP** on
  ftp://ftp.aviso.altimetry.fr/
  Note that once your request is processed (after filling the online form), Aviso will send you your own access (login/password) by e-mail as soon as possible. If you don't enter your login/password, you will only access to the anonymous FTP, where you won't find the data you're interested in.
- Via the **Live Access Server** (LAS) on the AVISO web site (http://www.aviso.altimetry.fr/en/data/data-access/las-live-access-server.html). The LAS is a tool to draw your own map.
  Only gridded products are accessible via the LAS.
- Via **authenticated OpenDap**, a framework that simplifies all aspects of scientific data networking (http://www.aviso.altimetry.fr/en/data/data-access/aviso-opendap.html).
  Only gridded products are accessible via OpenDap.
- Via the **authenticated** Aviso data extraction (http://www.aviso.altimetry.fr/en/data/data-access/gridded-data-extraction-tool.html) tool enables you to extract a data sub-set from the Aviso gridded datasets. You can choose either an area (by its geographical coordinates or among pre-defined regions), or a period for variable(s) within a given dataset

	FTP	Opendap[1]	Aviso extraction Service[1]	LAS[1]
Near Real-Time	x			
« Historical » NRT (for data >1 month)	x	x	x	x

(1) Only gridded products

6.1. Folders on the ftp server

We keep your attention to well enter your login/password to get access to FTP server, if not, you will access only the anonymous FTP (/donnees/ftpsedr/ftpanonymous/pub/oceano/AVISO/SSH/duacs), where you only find sample data sets. Access restrictions are applied on folders. Your account gives you an access to a given list of altimetry data. Thus, the folders you're not subscribed to are empty.

6.1.1. Along-track Near Real Time SLA files

The nomenclature used for the along-track folders is:

regional-mozambique_<DELAY>_along-track_<FILTERING>_<PRODUCT>_<MISSION>

DELAY	near-real-time	near-real time products
FILTERING	filtered	filtered and sub-sampled products (*vfec*)
PRODUCT	sla	Sea Level Anomalies
MISSION	j2	Jason-2
	c2	Cryosat-2
	al	Saral/AltiKa
	h2	HY-2A

6.1.2. Gridded Near-Real-Time products (SLA, Geostrophic currents)

The nomenclature used for the folders is:

regional-mozambique_<DELAY>_grids_<NBSAT>_<PRODUCT>_<VARIABLE>

DELAY	near-real-time	near-real time products
NBSAT	all-sat-merged	maximum 4 satellites to compute the map
PRODUCT	msla	maps of sea level anomaly (only for uv)
VARIABLE	h	sea surface heights and error
	uv	sea surface geostrophic currents

6.2. Nomenclature of files

6.2.1. Along-track Near Real Time SLA files

The nomenclature used for the along-track products is:

nrt_mozambique_<MISSION>_<PRODUCT>_<VARIABLE>_<DATEDATA>_<DATEPROD>.nc

MISSION	j2	Jason-2
	c2	Cryosat-2
	al	Saral/AltiKa
	h2	HY-2A
	j3	Jason-3
PRODUCT	sla	Sea Level Anomaly
VARIABLE	$X_1X_2X_3X_4$	X_1 is "v" for validated data and "x" for non validated data X_2 is "f" for filtered data and "x" for non filtered data X_3 is "e" for sub-sampled and "x" for non sub-sampled data X_4 is "c" for LWE-corrected data and "x" for non-LWE-corrected data or raw data
DATEDATA	YYYYMMDD	date of the dataset
DATEPROD	YYYYMMDD	production date of the dataset

6.2.2. Gridded Near-Real-Time products (heights and Geostrophic currents)

The nomenclature used for these products is:

nrt_mozambique_<NBSAT>_<PRODUCT>_<VARIABLE>_<DATEMAP>_<DATEPROD>.nc

NBSAT	allsat	maximum 4 satellites to compute the map
PRODUCT	msla	maps of sea level anomaly
VARIABLE	h	sea surface heights
	uv	sea surface geostrophic currents
DATEMAP	YYYYMMDD	date of the dataset
DATEPROD	YYYYMMDD	production date of the dataset

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