

INDES

Product User Manual - Altimeter satellite observations

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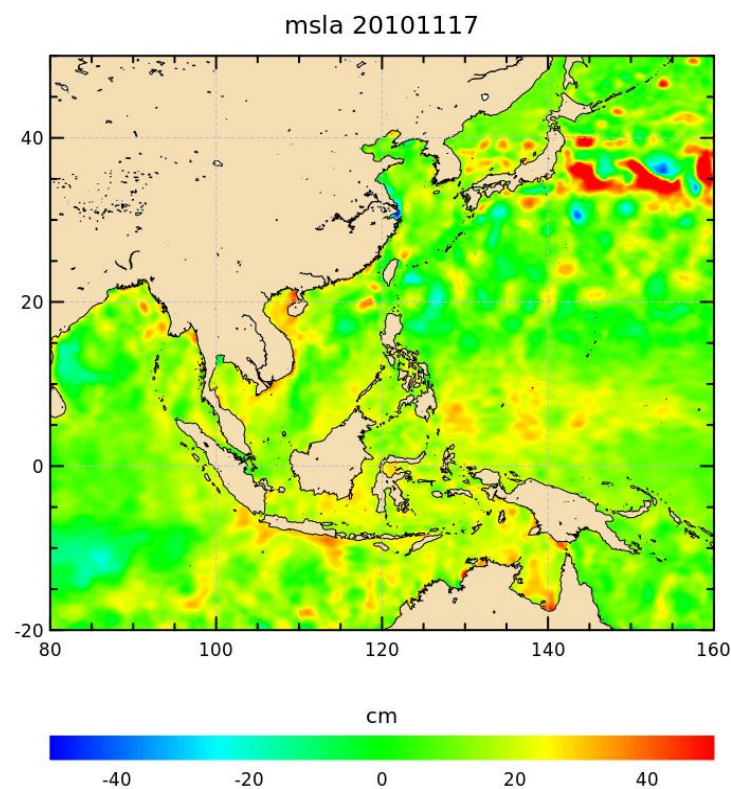
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1. PURPOSE

This document presents the information needed by users for the **Altimeter satellite observation** products provided in the frame of the Indeso project.

This document is organized as follows:

- Chapter 2; processing: input data and method applied.
- Chapter 3; the product description, with the different files provided, the nomenclature
- Chapter 4; the file format
- Chapter 5; how to download products.
- Chapter 6; bibliographical references



2. PROCESSING

This dataset is a regionally-tuned weekly altimeter product specially developed for the INDES0 area; it is based on the DUACS processing system (**Developing Use of Altimetry for Climate Studies; Dibarboure et al. 2011**). It includes data come from all available altimeter missions: (Jason-2, Cryosat-2 and AltiKa) and is subject to the evolution of altimeter missions. Sea Level Anomaly fields are provided with respect to a 20-year mean (1993-2012). Indeed, a mean profile, which is particular to each repeat-track mission, is subtracted to compute sea level anomaly. No mean profile is available for drifting-track missions (Cryosat-2), thus a Mean Sea Surface gridded field is used to compute the SLA (MSS-CNES-CLS-11 is used; Schaeffer et al. 2012).

- **Corrections:** All missions benefit from the latest altimeter standards to guaranty the best quality of the data: Orbit, Wet Troposphere Correction, Dry troposphere correction, Iono-



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sphere Correction, Dynamic Atmospheric Correction, Sea State Bias and Tides. GOT4.8 tidal model is used in the product (Ray 1999).

- Homogenization: All altimeter data are homogenized with respect to the Jason-2 mission, which is the flying reference altimeter mission at the present time.
- Filtering: Data are filtered from residual noise and small-scale signals. An along-track low-pass Lanczos filter is applied with a specific wavelength for the regional product. An optimal mapping technique, derived from Le Traon et al (1999), is used to construct the final maps of SLA combined product.
- Quality control: Data are cross-validated/cross-checked. The multi-mission cross-calibration process removes any residual orbit error, or long wavelength error (LWE), as well as large-scale biases and discrepancies between various data flows.
- Resolution: The horizontal resolution of the regional MSLA grid is $1/8^\circ$. Regional correlation scales are considered in order to optimize the merging.
- Time frequency: This product is available every Wednesday with a one week time resolution.

2.1. INPUT DATA

To produce maps products in real time, the system uses two flows, based on the same instrumental measurements but with a different quality:

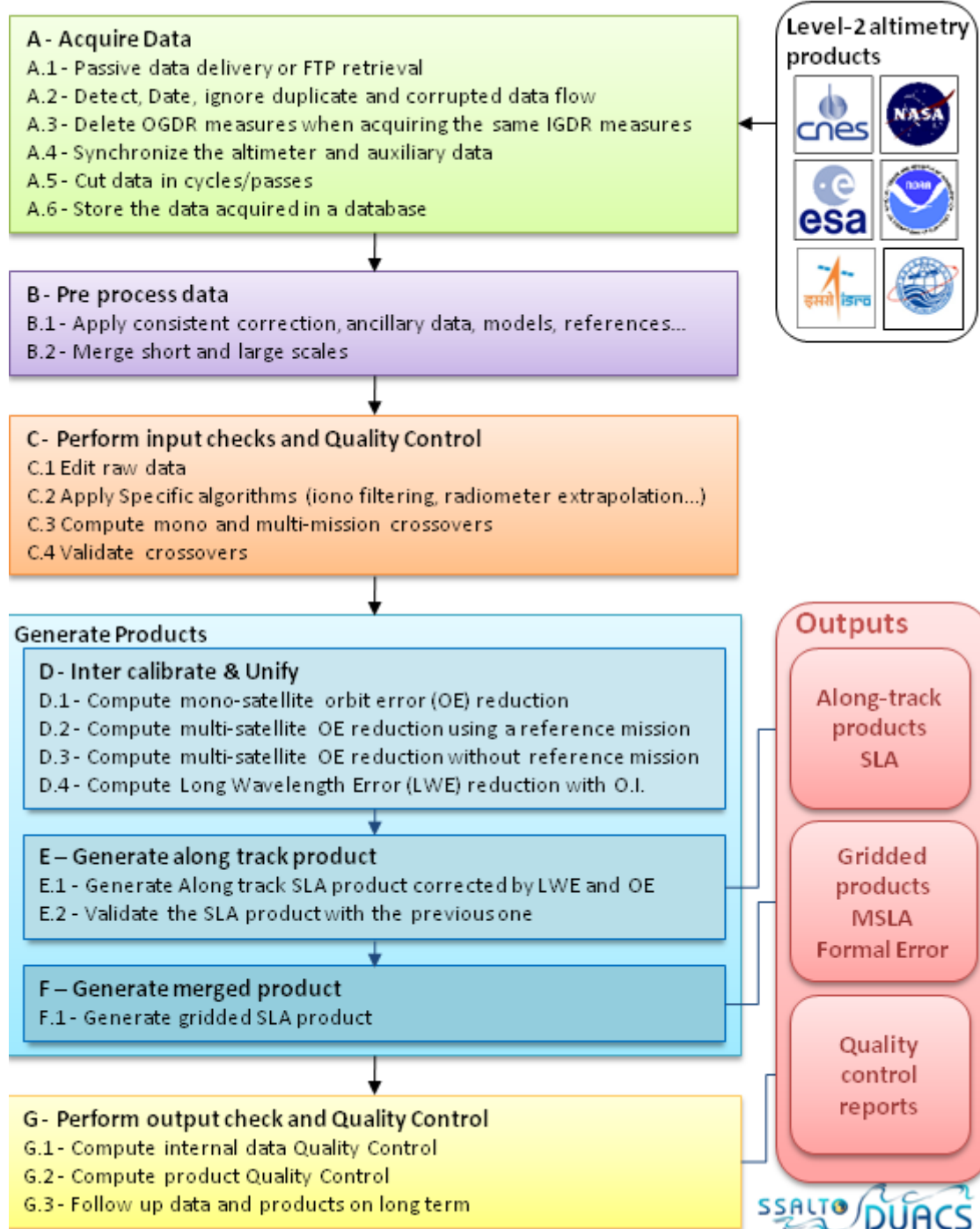
- The IGDRs that are the latest high-quality altimeter data produced in near-real-time.
- The OGDRs that include real time data (SARAL/AltiKa, OSTM/Jason-2 and Cryosat-2) to complete IGDRs. These fast delivery products do not always benefit from precise orbit determination, nor from some external model-based 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.

The historical maps are produced with GDRs which are the highest quality of data (improved orbit).

Altimeter	Product	Source	Availability	Type of orbit
Jason-2	IGDR	CNES	~24h	CNES MOE GDR-D
	OGDR	CNES	~3 to 5h	
	GDR	CNES	~60 days	
Cryosat-2	IGDR-like	ESA/CNES	~48 h	CNES MOE GDR-D
	OGDR-like	ESA/CNES	best effort	
	GDR-like	ESA/CNES	~60 days	
Saral/AltiKa	IGDR	CNES	~48 h	CNES MOE GDR-D
	OGDR	ISRO/EUMETSAT	~3 to 5 h	
	GDR	CNES	~40 days	

Table 1: list of Altimetry input Data

2.2. METHOD



2.2.1. CORRECTIONS

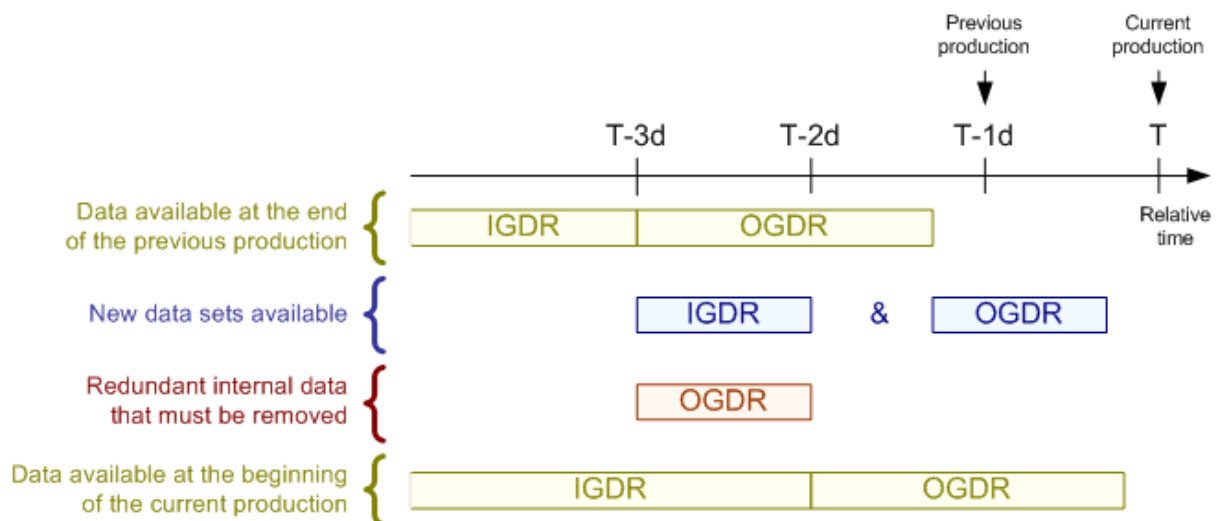
All missions benefit from the latest altimeter standards to guaranty the best quality of the data: Orbit, Wet Troposphere Correction, Dry troposphere correction, Ionosphere Correction, Dynamic Atmospheric Correction, Sea State Bias and Tides. GOT4.8 tidal model is used in the product (Ray 1999).

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.
- synchronisation process.

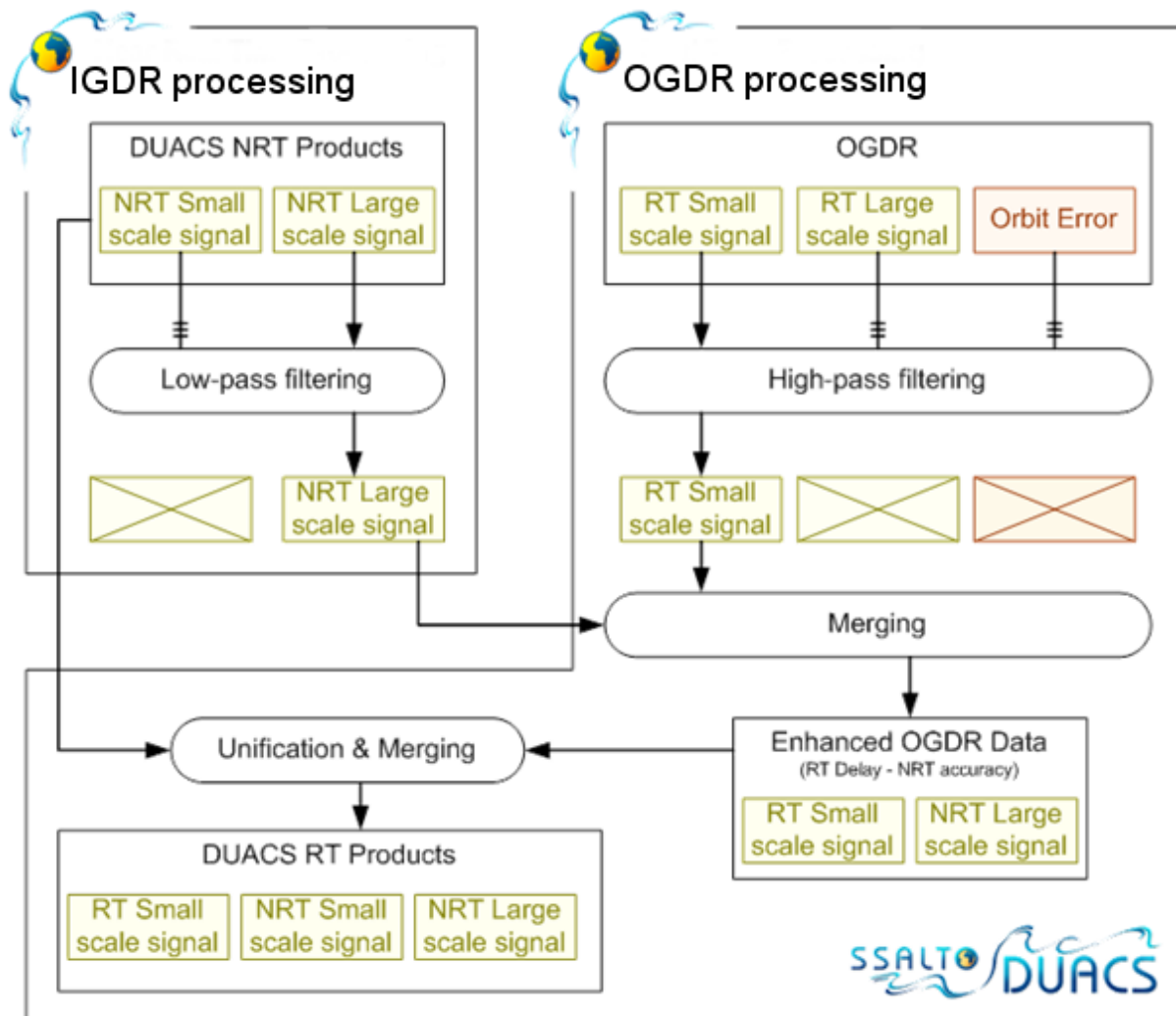
To be homogenized properly, altimeter data sets require various auxiliary data. The acquisition software detects, downloads and processes incoming data as soon as they are available on remote sites (external database, FTP site). Data are split into passes if necessary. If data flows are missing or late, 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.



Overview of the near real time system data flow management

2.2.3. HOMOGENIZATION

The Homogenization process consists in applying the most recent corrections, models and references recommended for altimeter products. Each mission is processed separately as its needs depend on the base input data. The system includes SLA filtering to process OGDR data. DUACS extract 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 DUACS data). Finally an "hybrid" SLA is computed.



Merging pertinent information from IGDR and OGDR processing

2.2.4. 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 (J2), 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).

2.2.5. COMPUTATION OF RAW SLA (SEA LEVEL ANOMALIES)

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.

2.2.5.1. 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 is computed with 15 years of ERS-1, ERS-2 and Envi-sat, referenced to the period [1993, 2012].
- The Mean Profile used for Jason-2 is computed with 20 years of T/P, Jason-1 and Jason-2, referenced to years [1999, 2012].
- No Mean Profile can be used for Cryosat-2 mission (c2) because there is no repetitive track. The MSS must be used instead (see below).

2.2.5.2. 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.

2.2.5.3. USE OF A MSS

The repeat track analysis is impossible for Cryosat-2 mission (c2) because the satellite is not in a repetitive orbit phase. 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, referenced [1993,2012]

2.2.5.4. FILTERING AND SUB-SAMPLING

Residual noise and small scale signals are then removed by filtering the data using a Lanczos filter at 100km. A sub-sampling of 14km is finally applied. Along-track SLA are then produced. The filtering and sub-sampling is adapted to the region as a function of the characteristics of the area.

2.2.6. 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 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 artefacts. 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.

In historical processing the products are computed with a centred computation time window for OER, LWE and mapping processes: indeed, for each day of production, the map of date D uses the data in the time interval of [D-42, D+42].

In the near-real-time processing, contrary to delayed-time 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 interval of [D-42, D], [D-3-42, D+3] and [D-6-42, D+6]).

3. DESCRIPTION OF THE PRODUCT SPECIFICATION

3.1. PRODUCT GENERAL CONTENT AND SPECIFICATIONS

Each Indeso product includes a series of related datasets. Those datasets are delivered with different names (see nomenclature), contents (see NetCDF contents) and format (below).

Note that the datasets available for a given user depend on the user profile.

Dataset Name	Dataset	Production	Geographical	Spatial Re-	File for-
					

	time coverage	frequency	coverage	solution	mat
Map of SLA historical	from start to (T0 - 30 days)	weekly	20S-25N/90E-144E	1/8°	netCDF CF
Map of SLA historical & real-time	from start to T0	weekly	20S-25N/90E-144E	1/8°	netCDF CF

Table 2: list of Altimetry datasets

3.2. NOMENCLATURE OF FILES

Files downloaded using Indeso downloading services are named using a unique identifier (13 digits, corresponding to the current time (downloading time) in milliseconds since January 1, 1970 midnight UTC.) at the end of the file name. The metrics pdf are compressed within a zip file (nomenclature of both the zip file and the pdf within are listed here).

Map of SLA historical
MAP_SLA_%Y%m%d.nc

Map of SLA historical&real-time
MAP_SLA-RT_%Y%m%d.nc

Where

Date	Macro used	# digits	Ex: Date 2001/03/20
Year	%Y	4	2001
Month	%m	2	03
Day in month	%d	2	20

3.3. ACKNOWLEDGMENTS

(a) Original INDES0 Products - or Value Added Products or Derivative Works developed from INDES0 Products including pictures - shall include the following credit conspicuously displayed and written in full:

"© INDES0, 2013, a system implemented by CLS for Balitbang KP, all rights reserved".

(b) In case of any publication, the Licensees will ensure credit INDES0 in the following manner:

"© INDES0, 2013, a system implemented by CLS for Balitbang KP, all rights reserved".

4. DATA FORMAT

4.1. 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, and to retrieve NetCDF software package on: <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 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.

4.2. STRUCTURE AND SEMANTIC OF NETCDF FILES

Variable name	Description (long_name)	Standard_name	Dimensions	Units
MAP_SLA-RT_%Y%m%d.nc or MAP_SLA_%Y%m%d.nc				
Netcdf-CF Grid Dimensions: lon=432, lat=360, time=1				
lat	latitude	latitude	(lat)	degrees_north
lon	longitude	longitude	(lon)	degrees_east
time	hours since YYYY-MM-DD 00:00:00 00:00:00.0	time	(time)	days since 1950-01-01 00:00:00
sla	Sea level anomalies	sea_surface_height_above_sea_level	(time,lat,lon)	m

5. HOW TO DOWNLOAD A PRODUCT

5.1. REGISTRATION

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

License shall include:

- Data use conditions,
- Legal and contractual clauses

5.2. ACCESS SERVICES

Different services enable registered users to access the data. Depending on the dataset, not all of them are relevant.

Dataset Name	File format	Discover	View	Get
Map of SLA historical & real-time	netCDF CF	Yes	Yes	Yes
Map of SLA historical	netCDF CF	Yes	Yes	Yes

6. REFERENCES

Carrère, L. and F. Lyard (2003). "Modelling the barotropic response of the global ocean to atmospheric wind and pressure forcing - comparisons with observations." *GRL* **30**(6).

Dibarboure G., M-I. Pujol, F. Briol, P.Y. Le Traon, G. Larnicol, N. Picot, F. Mertz and M. Ablain (2011). "Jason-2 in DUACS: Updated System Description, First Tandem Results and Impact on Processing and Products", *Marine Geodesy*, 34, 214-241.

Ducet, N., P.-Y. Le Traon, and G. Reverdin, 2000: Global high resolution mapping of ocean circulation from TOPEX/Poseidon and ERS-1 and -2. *J. Geophys. Res.*, 105, 19477-19498

Le Traon, P.-Y., F. Nadal, and N. Ducet, 1998: "An improved mapping method of multisatellite altimeter data", *J. Atmos. Oceanic Technol.*, 15, 522-534.

Ray, R. (1999). "A global ocean tide model from Topex/Poseidon altimetry: GOT99.2." *NASA Tech Memo 209478*: 58 pages.

Le Traon, P.-Y. and G. Dibarboure, 1999: Mesoscale mapping capabilities of multi-satellite altimeter missions. *J. Atmos. Oceanic Technol.*, 16, 1208-1223

Le Traon, P.-Y., F. Nadal, and N. Ducet, 1998: An improved mapping method of multisatellite altimeter data. *J. Atmos. Oceanic Technol.*, 15, 522-534.

Le Traon, P.-Y. and F. Ogor, 1998: ERS-1/2 orbit improvement using TOPEX/POSEIDON: the 2 cm challenge. *J. Geophys. Res.*, 103, 8045-8057.

Le Traon, P.-Y., G. Dibarboure, and N. Ducet, 2001: Use of a High-Resolution Model to Analyze the Mapping Capabilities of Multiple-Altitude Missions. *J. Atmos. Oceanic Technol.*, 18, 1277-1288

Pascual, A., Y. Faugère, G. Larnicol, P-Y Le Traon, 2006: Improved description of the ocean mesoscale variability by combining four satellite altimeters. *Geophys. Res. Lett.*, 33

Schaeffer P., Y. Faugere, J. F. Legeais, A. Ollivier, T. Guinle, N. Picot (2012), The CNES CLS11 Global Mean Sea Surface Computed from 16 Years of Satellite Altimeter Data. *Marine Geodesy*, 2012, Special Issue, *Jason-2*, Vol.35.