Along-track Level-2+ (L2P) SLA

Product Handbook

for missions Jason-3, OSTM/Jason-2, Jason-1, SARAL/AltiKa, Crysoat-2, HaiYang-2A, ERS-1, ERS-2, ENVISAT, Geosat Follow On, TOPEX/Poseidon

Nomenclature: SALP-MU-P-EA-23150-CLS

Issue: 2 rev 0

Date: December 2020

Chronology Issues:			
Issue:	Date:	Validated by	Reason for change:
1.0	2017/09/20		Creation of the document
1.1	2020/01/20		Precision about editing threshold
2.0	2020/11/16		Reprocessing of all missions in version 03_00

List of Acronyms:

ATBD	Algorithm Theoretical Baseline Document
ATP	Along Track Product
Aviso+	Archiving, Validation and Interpretation of Satellite Oceanographic data
CLS	Collecte, Localisation, Satellites
CMA	Centre Multimissions Altimetriques
Cnes	Centre National d'Etudes Spatiales
ECMWF	European Centre for Medium-range Weather Forecasting
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GDR	Geophysical Data Record(s)
GOT	Global Ocean Tides
IB	Inverse Barometer
IGDR	Interim Geophysical Data Record(s)
LRM	Low Resolution Mode
LWE	Large Wavelength Error
L2P	Level-2+ product: global 1 Hz along-track data (sea level anomaly, its components and validity flag) over marine surfaces based on Level-2 products
MSS	Mean Sea Surface
MWR	Microwave Radiometer
Nasa	National Aeronautics and Space Administration
NRT	Near Real Time
NTC	Non Time Critical
OER	Orbit Error Reduction
OSDR	Operational Sensor Data Records
POE	Precise Orbit Ephemeris
RD	Reference Document
SAR	Synthetic Aperture Radar
Ssalto	Segment Sol multimissions d'ALTimétrie, d'Orbitographie et de localisation précise.
SLA	Sea Level Anomaly
SSB	Sea State Bias
SSH	Sea Surface Height
STC	Short Time Critical
TAI	IAT - International Atomic Time
T/P	Topex/Poseidon
UTC	Universal Time Coordinated

Contents

1. Introduction

The purpose of this document is to describe products generated by the 1Hz monomission along-track altimeter data processing segment for Cryosat-2, SARAL/AltiKa, HaiYang-2A, Jason-3, OSTM/Jason-2, Jason-1, Geosat Follow On, ERS-1, ERS-2, Envisat missions named along-track L2P SLA products.

Note that L2P products are also delivered for Sentinel-3A mission, the handbook is available here:

https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk_L2P_S3.pdf

The generation of those products is part of the Cnes SALP (Service d'Altimétrie et Localisation Précise). The dissemination of those products is part of the Cnes AVISO-SALP.

After a description of the input data, a short overview of the processing steps is presented. Then complete information about user products is provided, giving nomenclature, format description, and software routines.

2. Overview

2.1. Altimetry principle

The altimeter measures the **'Altimeter Range'** which is the distance between the center of mass of satellite to the surface of the Earth (figure 1). This allows computing the **'Sea Surface Height'** which is the height of the sea surface above the reference ellipsoid. The **'Satellite Altitude'** refers to the distance of the center of mass of the satellite above a reference point. The reference point will usually be either on the reference ellipsoid or the center of the Earth.

'Sea Surface Height' = 'Satellite Altitude' - 'Altimeter Range' - 'Corrections'

The **'Corrections'** due to environmental conditions need to be applied in order to retrieve the correct **'Sea Surface Height'**. They are listed in Table 2 and depend on the timeliness of the product.

Moreover another variable is often used in altimetry:

'Sea Level Anomaly'= 'Sea Surface Height' - 'Mean Sea Surface'

The '**Mean Sea Surface**' is the mean of the sea surface height relative to ellipsoid over 20 years. It is computed on a regular grid and combines the data of all satellites.

The **Reference ellipsoid** used for all missions in NTC is the World Geodetic System (WGS) 84 reference ellipsoid.

- Equatorial radius of 6 378 137 m
- Flattening coefficient of 1/298.257 223 563

Note that for Sentinel-3 L2P NRT/STC the first-order definition of the non-spherical shape of Earth is still used with:

- Equatorial radius of 6378.1363 kilometers
- Flattening coefficient of 1/298.257

It is planned to switch to the WGS84 reference ellipsoid also for the Sentinel-3 L2P NRT/STC products by end of 2021.

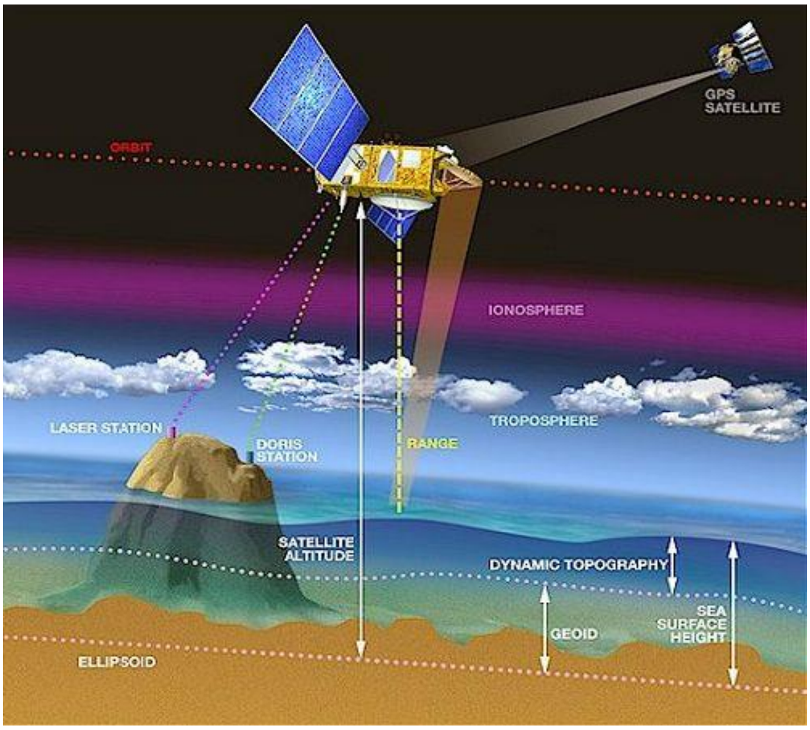

Figure 1. Altimetry principle

2.1.1. Orbits, Passes and Repeat cycle

'Orbit' is one revolution around the Earth by the satellite.

A satellite **'Pass' or 'Track'** is half a revolution of the Earth by the satellite from one extreme latitude to the opposite extreme latitude. Passes with odd numbers correspond to ascending orbits, from minimum to maximum latitude; passes with even numbers correspond to descending orbits, from maximum to minimum latitude.

'Repeat Cycle' is the time period that elapses until the satellite flies over the same location again. Every "pass file" of a given cycle (identified by its track number) flies over the same path as the pass file of every other cycle in the same repeat-cycle phase, and covers oceans basins continuously.

The table below lists the characteristics of all the missions:

Altimeter mission	Cycle duration (days)	Latitude range (°N)	Number of tracks in the cycle	Inter-track distance at equator (km)	Sun-synchronous	Dual-frequency Altimeter	Radiometer on board
Jason-3	10	±66	254	~315	No	Yes	Yes
OSTM/Jason-2	10	±66	254	~315	No	Yes	Yes
OSTM/Jason-2 Interleaved	10	±66	254	~315			
Cryosat-2	29 (sub cycle)	±88	840	~98	No	No	No
SARAL/AltiKa	35	±81.5	1002	~80	Yes	No	Yes

SARAL-DP/AltiKa	-	±81.5	-	-			
HaiYang-2A	14	±81	386	~210	Yes	Yes	Yes
HaiYang-2A geodetic	168	±81	-	-			
Topex/Poseidon	10	±66	254	~315	No	Yes	Yes
Topex/Poseidon Interleaved	10	±66	254	~315			
Jason-1	10	±66	254	~315	No	Yes	Yes
Jason-1 Interleaved	10	±66	254	~315			
Jason-1 Geodetic	10.91	±66	280	-			
Envisat	35	±81.5	1002	~80	Yes	Yes (S-band lost after cycle 65)	Yes
Envisat-New	30	±81.5	862	-			
ERS-1	35	±81.5	1002	~80	Yes	Yes	Yes
ERS-1 geodetic	168	±81.5	-	-			
ERS-2	35	±81.5	1002	~80	Yes	Yes	Yes
Geosat Follow On	17	±72	488	~165	No	No	Yes

Table 1: characteristics of the different missions

2.2. Operating modes

The Cryosat-2 mission is mainly in LRM (Low Resolution Mode) and it is SAR Mode when it is activated (activated in some patches over the globe for each cycle).

The other missions (SARAL/AltiKa, Envisat, Jason-1/2/3, ERS-1/2, Topex/Poseidon, Geosat Follow On, Haiyang-2A) are on LRM mode.

3. Data Processing

3.1. Overview

The processing steps of the system are overviewed on Figure 2. The L2P products are also delivered in Near-Real-Time (NRT) and Short Time Critical (STC) for Sentinel-3 only (see dedicated handbook (https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/hdbk_L2P_S3.pdf)), and in Non Time Critical (NTC) for all the missions. The objective is:

- To provide operational applications with directly useable continuous and high quality altimeter data.
- To provide user friendly altimeter database where users can directly access to valid sea level height content without additional processing.

In Non Time Critical, it is to maintain a consistent and user friendly altimeter database using the state-of-the-art recommendations from altimetry community before the complete reprocessing of L2 products.

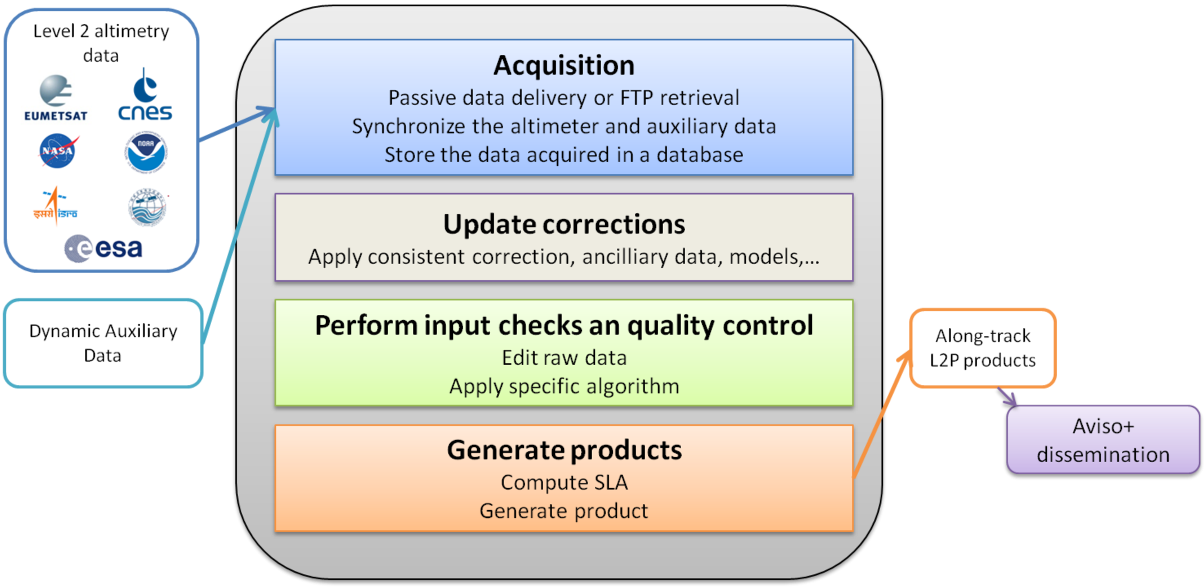

Figure 2. Processing steps of the system

The L2P products are along-track products that contain time, sea level anomaly, information of validity of the data and all corrections which were necessary to compute the sea level anomaly (range, orbital altitude, environmental and geophysical corrections). These products contain only marine surfaces. They have a homogenized format and content for all altimeter missions. Note that the variable inter_mission_bias can be different between L2P NRT/STC and L2P NTC data. L2P products are the input data for the L3 production.

3.2. Input Data

3.2.1. Level-2 altimeter data

In order to produce Along-track L2P products, the system **uses Level-2 Water** instrumental measurements (containing Ocean data). Indeed there are different data products associated with the three levels of processing of altimeter data:

- Level-0 (L0) is the raw telemetered data
- Level-1 (L1) is the Level-0 data corrected for instrumental effects
- Level-2 (L2) is the Level-1 data corrected for geophysical effects

There are different levels of data latency related to the Level-2 availability of the auxiliary or ancillary data as detailed in Table 2:

Altimetry product	Source	Availability
Jason-3 GDR-D/F	CNES	100 days
OSTM/Jason-2 GDR-D	CNES	100 days
Jason1 GDR-E	CNES/NASA	-
SARAL/AltiKa GDR-F	CNES	70 days
Cryosat-2 baseline C	ESA	best effort
ERS-1/2 OPR	IFREMER/ESA	-
ENVISAT GDR-V3	ESA	-
Geosat Follow On GDR	NOAA	-
HaiYang-2A GDR	NSOAS	best effort
Topex/POSEIDON GDR-C	CNES/NASA	-

Table 2: timeliness Input data overview.

3.2.1.1. Dynamic and static auxiliary data

In order to compute the Sea Level Anomaly, various corrections are needed, some of them replace the ones from the L2 input product such as the Mean Sea Surface, the tidal model, ... The complete description of all the corrections used in the L2P products is given in table 3.

3.2.2. Applying altimetric corrections

Altimetric measurements need to be corrected for instrumental errors, environmental perturbations (wet tropospheric, dry tropospheric and ionospheric effects), the ocean sea state influence (sea state bias), the tide influence (ocean tide, earth tide and pole tide) and atmospheric pressure (combined atmospheric correction : high frequency fluctuations of the sea surface topography and inverted barometer height correction). The detail of these corrections applied is given in table 2. This table corresponds to the current available L2P standard 03_00 (global attribute “product_version” in the L2P files) for NTC products. Note that the product_version may in the future develop differently between L2P NRT/STC and L2P NTC products.

Note that in Non-Time Critical (NTC) delivery, the products will be delivered in the reference version containing the corrections consistent with the products delivered in the frame of the Copernicus Marine Service project. This version will be reprocessed roughly every 3 years.

NTC L2P	Poseidon Topex	Jason 1	Jason 2	Jason 3	ERS-1	ERS-2	ENVISAT	SARAL	Geosat FO	Cryosat 2	HY 2A
ORBIT	GSFC STD18	POE-E	POE-F		Reaper		POE-E	POE-F	GSFC	POE-F	POE-D
IONOSPHERIC	Filtered dual-frequency altimeter range measurements [Guibbaud et al. 2015] ; DORIS on Poseidon		Filtered dual-frequency altimeter range [Guibbaud et al. 2015] (from SSB C-band)	Filtered dual-frequency altimeter range measurements [Guibbaud et al. 2015]	Reaper NIC09 model [Scharroo and Smith, 2010]	GIM [Ijima et al., 1999]	Filtered from L2 ; c>65 : GIM [Ijima et al., 1999] corrected for 8mm bias	GIM [Ijima et al., 1999]	GIM [Ijima et al., 1999]		
SEA STATE BIAS	Non parametric [N. Tran et al. 2010] ; BM4 on Poseidon	Non parametric [N. Tran 2015]	Non parametric [N. Tran 2012]		BM3 [Gaspar and Ogor, 1994]	Non parametric [Mertz et al., 2005]	Non parametric [N. Tran 2017]	Non parametric [N. Tran 2018]	Non parametric [Tran and Labroue, 2010]	Non parametric [N. Tran 2018] Baseline C	Non Parametric [N. Tran 2012 Vent S. Labroue]
WET TROPOSPHERE	GPD+ [Fernandes and Lazaro, 2016]	JMR (GDRE) radiometer	AMR radiometer		GPD+ [Fernandes and Lazaro, 2016]		MWR radiometer reprocessed	Neuronal Network (5 entries) V4	GFO Radiometer and ECMWF model	GPD+ [Fernandes and Lazaro, 2016]	ECMWF model
DRY TROPOSPHERE	ERA5 (1-hour) model based										
DYNAMICAL ATMOSPHERIC CORRECTION	TUGO High frequencies forced with analysed ERA 5 pressure and wind field + inverse barometer Low frequences		TUGO HF forced with analysed ERA 5 pressure and wind field; and after 02/2016 MOG2D HF forced with analysed ECMWF pressure and wind field + inverse barometer LF	MOG2D HF forced with analysed ECMWF pressure and wind [Carrere and Lyard, 2003; operational version 3.2.0] + inverse barometer LF	TUGO High frequencies forced with analysed ERA 5 pressure and wind field + inverse barometer Low frequences			TUGO HF forced with analysed ERA 5 pressure and wind field; and after 02/2016 MOG2D HF forced with analysed ECMWF pressure and wind field + inverse barometer LF	TUGO High frequencies forced with analysed ERA 5 pressure and wind field + inverse barometer Low frequences	TUGO High frequencies forced with analysed ERA 5 pressure and wind field ; and after 02/2016 MOG2D High frequencies forced with analysed ECMWF pressure and wind field + inverse barometer Low frequences	
OCEAN TIDE	FES 2014 B [Carrère et al. 2016]										
INTERNAL TIDE	ZARON 2019 (HRETv8.1 tidal frequencies: M2, K1, S2, O1)										
POLE TIDE	DESAI et al.2015 ; Mean Pole Location 2017										
SOLID TIDE	Elastic response to tidal potential [Cartwright and Tayler, 1971 ; Cartwright and Edden, 1973]										
MEAN SEA SURFACE	Composite (SCRIPPS,CNES/CLS15,DTU15)										

Table 3. Reference corrections overview (in grey same standards as L2P not reprocessed products, in green standards updated in L2P products reprocessed, in yellow L2 reprocessed missions)

3.2.3. Selecting valid data

The processing starts with quality control and validation of altimetric data and geophysical corrections in order to select valid ocean data.

Editing criteria are used to select valid measurements over ocean. The editing process is divided into 3 parts as described below:

3.2.3.1. Editing by flags:

A first step is to select the points where the editing thresholds will be applied. The points where:

- the ice flag is 0 (Ocean).

  Note that for ERS-1/2, the ice flag is set to 'ice' if:

  For points with | LATITUDE | >50, if the number of elementary measurements <17 and

  |calculated wet tropo – ECMWF model wet tropo | > 0.1 meters

- and the surface_type flag is 0 (Open Sea or Semi-enclosed sea) or 1 (enclosed sea or lake)

are taken into account.

3.2.3.2. Editing with parameters thresholds:

The editing criteria are defined as minimum and maximum thresholds for altimeter, radiometer and geophysical parameters (Table 4). They are expected to remain constant throughout the mission, so that monitoring the number of edited measurements allows an observation of data quality. Measurements are edited if at least one of the parameters does not lie within those thresholds. The values indicated here are general but in detail, we adapted them according to specific criteria for each mission (mission frequency, distance to coast, ...).

Parameters	Minimum value	Maximum value
Sea Surface Height	-130m	100m
Sea Level Anomaly	-7m	7m
Standard deviation on the range	0	depends on SWH value (min 0.2m)
Nb measurements of range	from 6 to 20 (mission dependent)	DV
Dry troposphere correction	-2.5m	-1.9m
Dynamical Atmospheric correction	-2m	2m
Wet troposphere correction	-0.5m	-0.001m
Sea State Bias	-0.5m	0.00m
Standard deviation of backscatter coefficient	0	1dB
Oceanic tide	-5m	5m
Earth tide	-1m	1m
Pole tide	-15m	15m
Altimeter wind speed	0m/s	30m/s
Backscattering coefficient (after applying bias versus Topex)	7dB	30dB
Significant wave height	0m	15m
Filtered ionosphere	-0.4m	0.04m

correction		
Square off-nadir angle	from -0.36 to 0 (mission dependent)	from 0.09 to 0.64 (mission dependent)
Nb measurements of backscatter coefficient	10	DV

Table 4. Editing thresholds for each parameter for NTC timeliness

3.2.3.3. Editing by statistical validation on the track :

A final editing is used in order eliminate the tracks where orbit error can be very high:

For a track with a minimum of 200 points where:

- the bathymetry <-1000m,
- the oceanic variability <0.1m,
- the distance to the coast >10km,
- the latitude is <66°.

An entire pass is eliminated if one of these criteria is true for the pass statistics computed with the selected open ocean situations:

- the mean of Sea Level Anomaly >0.15m,
- the standard deviation of the Sea Level Anomaly > 0.2m.

3.2.3.4. Iterative editing of sea level anomaly for NTC data:

Data are edited with a median filter, taking into account the ocean variability.

$|R| > 3\ [\sigma(R) + \sigma\ (MSLA)\ ]$

Where :

R= SLA – SLA low pass filtered at 500 km

σ (MSLA) is the standard deviation of a mean ocean variability.

3.3. Product Generation

The **'Sea Level Anomalies'** as described in section 2.1 are computed with the corrections given in Table3.

In order to allow the user to compute himself its own **'Sea Surface Height'** depending on his needs, the corrections used to compute the **'Sea Level Anomalies'** are present in the output product (see Table for details about the names of variables). This allows computing the raw **'Sea Surface Height'**

Each product will contain one file per pass. The files are zipped (*.gz). The files will be delivered in cycles folders for L2P NTC products.

4. Product Presentation

4.1. Temporal availability

Altimeter mission	input data availability Start-End dates
Jason-3	2016/02/16 (cycle 1) Ongoing
OSTM/Jason-2	2008/07/12 (cycle 1) 2016/10/02 (cycle 303)
OSTM/Jason-2 Interleaved	2016/10/13 (cycle 305) 2017/09/14 (cycle 506)
Cryosat-2	2011/01/28 (cycle 7) Ongoing
SARAL/AltiKa	2013/03/14 (cycle 1) 2016/07/04 (cycle 35)
SARAL-DP/AltiKa	2016/07/04 (cycle 100) Ongoing
HaiYang-2A	2014/04/12 (cycle 67) 2016/05/03 (cycle 120)
HaiYang-2A geodetic	2016/03/24 (cycle 121) 2020/06/09 (cycle 288)
Topex/Poseidon	1992/09/25 (cycle 1) 2002/08/21 (cycle 365)
Topex/Poseidon Interleaved	23/08/2002 (cycle 366) 2005/09/29 (cycle 481)
Jason-1	2002/01/15 (cycle 1) 2009/01/26 (cycle 259)
Jason-1 Interleaved	2009/02/10 (cycle 262) 2012/03/03 (cycle 374)
Jason-1 Geodetic	2012/05/07 (cycle 500) 2013/06/21 (cycle 537)
Envisat	2002/05/14 (cycle 6) 2010/10/18 (cycle 93)
Envisat-New	2010/11/27 (cycle 96) 2012/04/08 (cycle 113)
ERS-1	1992/10/23 (cycle 15) 1993/12/20 (cycle 27) And 1995/03/240 (cycle 41) 1996/06/02 (cycle 53)
ERS-1 geodetic	04/10/1994 (cycle 30) 03/21/1995 (cycle 40)
ERS-2	1995/05/15 (cycle 1) 2003/09/15 (cycle 86)
Geosat Follow On	2000/01/07 (cycle 37) 2008/09/07 (cycle 222)

Table 5. Temporal availability of LP2 products.

4.2. Nomenclature

The generic model of L2P filename is:

global_sla_l2p_<data_type>_<mission>_<cycle>_<pass>_<begin_date>_ <end_date>_<production_date>.nc

The L2P products name components are:

- The type of data timeliness (ntc): <data_type>
- The mission (tp,j1,j2,j3,al,c2,h2,g2,e1,e2,en): <mission>
- The cycle/pass considered: <cycle>_<pass>
- The begin and end dates of the data: <begin_date>_<end_date>
- The production date: <production_date>

This is a filename example:

global_sla_l2p_ntc_al_C0142_P1002_20200817T180131_20200817T185149_20201204T091549.nc.gz

In case of L2P reprocessing activities, the GLOBAL_SLA_L2P_NTC product will be available in two versions :

- The reference product
- The reprocessed product

The nomenclature of these two products is the same, but a global attribute containing the version number within the L2P product allows distinguishing them. Furthermore the files will be available in distinct directories.

5. Data Format

This chapter presents the data storage format and convention used for L2P products. All products are distributed in NetCDF-4 with norm CF.

NetCDF (Network Common Data Form) is an open source, generic and multi-platform format developed by Unidata. An exhaustive presentation of NetCDF and additional conventions is available on the following web site:

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

All basic NetCDF conventions are applied to files.

Additionally the files are based on the attribute data tags defined by the Cooperative Ocean/Atmopshere Reasearch Data Service (COARDS) and Climate 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 made available by UNIDATA (http://www.unidata.ucar.edu/software/netcdf):

- C/C++/Fortran
- Java
- MATLAB, Objective-C, Perl, Python, R, Ruby, Tcl/Tk.

5.1. L2P Format

5.1.1. Dimensions

1 Dimension is defined:

- **time:** number of data in current file, sampled at 1Hz.

5.1.2. Data Handling Variables

You will find hereafter the definitions of the variables defined in the product:

Name of variable	Type	Content	Unit
time	double	Time of measurements	seconds since 2000-01-01 00:00:00 UTC
latitude	int	Latitude value of measurements	degrees_north
longitude	int	Longitude value of measurements	degrees_east
range	int	Range	meters
altitude	int	Altitude of the satellite	meters
wet_tropospheric_correction	short	Wet tropospheric correction	meters
wet_tropospheric_correction_model	short		
ionospheric_correction	int	Ionospheric correction	meters
sea_state_bias	short	Sea state bias	meters
solid_earth_tide	short	Solid Earth tide height	meters
pole_tide	short	Pole tide height	meters
Internal tide	int	Internal tide height	meters
dry_tropospheric_correction_model	short	Dry tropospheric correction	meters
dynamic_atmospheric_correction	short	Combined atmospheric correction	meters
ocean_tide_height	int	Ocean tide height	meters
mean_sea_surface	int	Mean sea surface height	meters
inter_mission_bias	int	Bias to have consistent time series since TOPEX/Poseidon	meters
sea_level_anomaly	int	Sea Level Anomaly relative to MSS	meters
validation_flag	byte	Flag indicating if Sea Level Anomaly is valid (validation_flag=0) or not (validation_flag=1)	none

Table 6. Overview of data handling variables in L2P NetCDF file.

5.1.2.1. Attributes

Additional attributes may be available in L2P files. They are providing information about the type of product or the processing and parameter used.

5.1.2.2. Example of L2P file

```
netcdf global_sla_l2p_ntc_al_C0142_P1002_20200817T180131_20200817T185149_20201204T091549 {
dimensions:
  time = 2854 ;
variables:
  double time(time) ;
    time:units = "seconds since 2000-01-01 00:00:00.0" ;
    time:long_name = "time (sec. since 2000-01-01)" ;
    time:standard_name = "time" ;
    time:calendar = "gregorian" ;
  int latitude(time) ;
    latitude:scale_factor = 1.e-06 ;
    latitude:comments = "Positive latitude is North latitude, negative latitude is South latitude." ;
    latitude:long_name = "latitude" ;
    latitude:standard_name = "latitude" ;
    latitude:units = "degrees_north" ;
  int longitude(time) ;
    longitude:scale_factor = 1.e-06 ;
    longitude:comments = "East longitude relative to Greenwich meridian" ;
    longitude:long_name = "longitude" ;
    longitude:standard_name = "longitude" ;
    longitude:units = "degrees_east" ;
  int altitude(time) ;
    altitude:_FillValue = 2147483647 ;
    altitude:comment = "Altitude of satellite above the reference ellipsoid (WGS84)." ;
    altitude:scale_factor = 0.0001 ;
    altitude:coordinates = "longitude latitude" ;
    altitude:add_offset = 700000. ;
    altitude:long_name = "1Hz altitude of satellite" ;
    altitude:standard_name = "height_above_reference_ellipsoid" ;
    altitude:units = "m" ;
  int range(time) ;
    range:_FillValue = 2147483647 ;
    range:comment = "All instrumental corrections included, i.e. distance antenna-COG, USO drift correction, internal path
correction, Doppler correction, modeled instrumental errors corrections and system bias." ;
    range:scale_factor = 0.0001 ;
    range:coordinates = "longitude latitude" ;
    range:add_offset = 700000. ;
    range:long_name = "corrected 1 Hz altimeter range in main altimeter frequency band" ;
    range:standard_name = "altimeter_range" ;
    range:units = "m" ;
  short wet_tropospheric_correction(time) ;
    wet_tropospheric_correction:_FillValue = 32767s ;
    wet_tropospheric_correction:comment = "Computed at the altimeter time-tag from the radiometer brightness
temperatures, the Ka-band backscatter coefficient, the sea surface temperature and the lapse rate (decreasing rate of the
atmosphere temperature with altitude). A wet tropospheric correction must be added (negative value) to the instrument
range to correct this range measurement for wet tropospheric range delays of the radar pulse." ;
    wet_tropospheric_correction:scale_factor = 0.0001 ;
    wet_tropospheric_correction:source = "Altika radiometer" ;
    wet_tropospheric_correction:coordinates = "longitude latitude" ;
    wet_tropospheric_correction:long_name = "radiometer or model wet tropospheric correction correction" ;
    wet_tropospheric_correction:standard_name = "altimeter_range_correction_due_to_wet_troposphere" ;
    wet_tropospheric_correction:units = "m" ;
```

short wet_tropospheric_correction_model(time) ;
wet_tropospheric_correction_model:_FillValue = 32767s ;
wet_tropospheric_correction_model:comment = "Computed at the altimeter time-tag from the interpolation of 2 meteorological fields that surround the altimeter time-tag. A wet tropospheric correction must be added (negative value) to the instrument range to correct this range measurement for wet tropospheric range delays of the radar pulse." ;
wet_tropospheric_correction_model:scale_factor = 0.0001 ;
wet_tropospheric_correction_model:source = "European Center for Medium Range Weather Forecasting" ;
wet_tropospheric_correction_model:coordinates = "longitude latitude" ;
wet_tropospheric_correction_model:long_name = "operational ECMWF model wet tropospheric correction" ;
wet_tropospheric_correction_model:standard_name = "altimeter_range_correction_due_to_wet_troposphere" ;
wet_tropospheric_correction_model:units = "m" ;
wet_tropospheric_correction_model:institution = "ECMWF" ;
short dry_tropospheric_correction_model(time) ;
dry_tropospheric_correction_model:_FillValue = 32767s ;
dry_tropospheric_correction_model:comment = "Computed at the altimeter time-tag from the interpolation of 2 meteorological fields (use of mean sea level pressure) that surround the altimeter time-tag. A dry tropospheric correction must be added (negative value) to the instrumentv range to correct this range measurement for dry tropospheric range delays of the radar pulse." ;
dry_tropospheric_correction_model:scale_factor = 0.0001 ;
dry_tropospheric_correction_model:coordinates = "longitude latitude" ;
dry_tropospheric_correction_model:long_name = "Dry tropospheric correction computed from ECMWF ERA5 reanalysis" ;
dry_tropospheric_correction_model:standard_name = "altimeter_range_correction_due_to_dry_troposphere" ;
dry_tropospheric_correction_model:units = "m" ;
short dynamic_atmospheric_correction(time) ;
dynamic_atmospheric_correction:_FillValue = 32767s ;
dynamic_atmospheric_correction:comment = "- Before 02/2016, the TUGO high resolution model is used, forced with ECMWF reanalysis ERA5 pressure and wind speed fields. This correction is computed by adding the high frequency fluctuations of the sea surface topography computed by TUGO model and the low-frequencies of the inverted barometer effect computed from ERA5 MSL pressure. The cut-period between high/low frequencies is 20 days. - After 02/2016, the MOG2D high resolution model is used, forced with operational ECMWF pressure and wind speed fields. This correction is computed by adding the high frequency fluctuations of the sea surface topography computed by MOG2D and the low-frequency of the inverted barometer effect computed from MSL ECMWF pressure. The cut-period between high/low frequencies is 20 days." ;
dynamic_atmospheric_correction:scale_factor = 0.0001 ;
dynamic_atmospheric_correction:coordinates = "longitude latitude" ;
dynamic_atmospheric_correction:long_name = "dynamic atmospheric correction" ;
dynamic_atmospheric_correction:units = "m" ;
dynamic_atmospheric_correction:institution = "LEGOS/CNES/CLS" ;
int ocean_tide_height(time) ;
ocean_tide_height:_FillValue = 2147483647 ;
ocean_tide_height:comment = "Includes high frequency and long period ocean tide height and the corresponding loading tide height." ;
ocean_tide_height:scale_factor = 0.0001 ;
ocean_tide_height:source = "FES2014b" ;
ocean_tide_height:coordinates = "longitude latitude" ;
ocean_tide_height:long_name = "FES model geocentric ocean tide height" ;
ocean_tide_height:standard_name = "sea_surface_height_amplitude_due_to_geocentric_ocean_tide" ;
ocean_tide_height:units = "m" ;
ocean_tide_height:institution = "LEGOS/NOVELTIS/CNES/CLS" ;
short solid_earth_tide(time) ;
solid_earth_tide:_FillValue = 32767s ;
solid_earth_tide:comment = "Calculated using Cartwright and Tayler tables and consisting of the second and third degree constituents. The permanent tide (zero frequency) is not included." ;
solid_earth_tide:scale_factor = 0.0001 ;
solid_earth_tide:source = "Cartwright and Edden [1973] Corrected tables of tidal harmonics - J. Geophys. J. R. Astr. Soc., 33, 253-264." ;
solid_earth_tide:coordinates = "longitude latitude" ;
solid_earth_tide:long_name = "solid earth tide height" ;
solid_earth_tide:standard_name = "sea_surface_height_amplitude_due_to_earth_tide" ;

```
      solid_earth_tide:units = "m" ;
      solid_earth_tide:institution = "National Institute of Oceanography (UK)" ;
   short pole_tide(time) ;
      pole_tide:_FillValue = 32767s ;
      pole_tide:comment = "Update of the model for rotational deformation and update of the linear mean pole model based on the 2017 reference." ;
      pole_tide:scale_factor = 0.0001 ;
      pole_tide:source = "Desai, Shailen & Wahr, John & Beckley, B.. (2015). Revisiting the pole tide for and from satellite altimetry. Journal of Geodesy. 89. DOI:10.1007/s00190-015-0848-7. And J. C. Ries and S. Desai: Conventional model update for rotational deformation. In Fall AGU Meeting, New Orleans, LA, 2017" ;
      pole_tide:coordinates = "longitude latitude" ;
      pole_tide:long_name = "geocentric pole tide height" ;
      pole_tide:standard_name = "sea_surface_height_amplitude_due_to_pole_tide" ;
      pole_tide:units = "m" ;
      pole_tide:institution = "IERS" ;
   short sea_state_bias(time) ;
      sea_state_bias:_FillValue = 32767s ;
      sea_state_bias:comment = "Tran2019 empirical solution fitted on one year of SARAL GDR-F data. A sea state bias correction must be added (negative value) to the instrument range to correct this range measurement for sea state delays of the radar pulse." ;
      sea_state_bias:scale_factor = 0.0001 ;
      sea_state_bias:source = "N. Tran 2019" ;
      sea_state_bias:coordinates = "longitude latitude" ;
      sea_state_bias:long_name = "sea surface height bias due to sea surface roughness on main altimeter frequency band" ;
      sea_state_bias:standard_name = "sea_surface_height_bias_due_to_sea_surface_roughness" ;
      sea_state_bias:units = "m" ;
   short ionospheric_correction(time) ;
      ionospheric_correction:_FillValue = 32767s ;
      ionospheric_correction:comment = "Global ionospheric maps (GIM) model. An ionospheric correction must be added (negative value) to the instrument range to correct this range measurement for ionospheric range delays of the radar pulse." ;
      ionospheric_correction:scale_factor = 0.0001 ;
      ionospheric_correction:long_name = "GIM ionospheric correction on main altimeter frequency band" ;
      ionospheric_correction:standard_name = "altimeter_range_correction_due_to_ionosphere" ;
      ionospheric_correction:units = "m" ;
      ionospheric_correction:institution = "NASA/JPL" ;
   short internal_tide(time) ;
      internal_tide:_FillValue = 32767s ;
      internal_tide:comment = "Version of the model is HRET_v8.1. The following tidal frequencies are included: M2, K1, O1, S2" ;
      internal_tide:scale_factor = 0.0001 ;
      internal_tide:source = "E. D. Zaron. Baroclinic tidal sea level from exact-repeat mission altimetry. Journal of Physical Oceanography, 49(1):193-210, 2019." ;
      internal_tide:coordinates = "longitude latitude" ;
      internal_tide:long_name = "internal tide height" ;
      internal_tide:units = "m" ;
   int mean_sea_surface(time) ;
      mean_sea_surface:_FillValue = 2147483647 ;
      mean_sea_surface:comment = "Combined SIO/CNES-CLS-15/DTU15 mean sea surface (referenced to 20 year period)." ;
      mean_sea_surface:scale_factor = 0.0001 ;
      mean_sea_surface:source = "SIO_CNESCLS15_DTU15" ;
      mean_sea_surface:coordinates = "longitude latitude" ;
      mean_sea_surface:long_name = "mean sea surface height above reference ellipsoid" ;
      mean_sea_surface:units = "m" ;
      mean_sea_surface:institution = "SIO/CNES/CLS/DTU" ;
   short sea_level_anomaly(time) ;
      sea_level_anomaly:_FillValue = 32767s ;
      sea_level_anomaly:quality_flag = "validation_flag" ;
```

```
      sea_level_anomaly:comment = "altitude of satellite (altitude) - ocean altimeter range (range) - ionospheric correction (ionospheric_correction) - dry tropospheric correction (dry_tropospheric_correction_model) - wet tropospheric correction (wet_tropospheric_correction) - sea state bias correction (sea_state_bias) - solid earth tide height (solid_earth_tide) - geocentric ocean tide height  (ocean_tide_height) - geocentric pole tide height (pole_tide) - dynamic atmospheric correction (dynamic_atmospheric_correction) - internal tide height (internal_tide) - mean sea surface (mean_sea_surface) - inter mission bias  (inter_mission_bias)" ;
      sea_level_anomaly:scale_factor = 0.0001 ;
      sea_level_anomaly:coordinates = "longitude latitude" ;
      sea_level_anomaly:long_name = "sea level anomaly" ;
      sea_level_anomaly:standard_name = "sea_surface_height_above_sea_level" ;
      sea_level_anomaly:units = "m" ;
   int inter_mission_bias(time) ;
      inter_mission_bias:_FillValue = 2147483647 ;
      inter_mission_bias:units = "m" ;
      inter_mission_bias:long_name = "bias to have consistent time series since TOPEX/Poseidon" ;
      inter_mission_bias:scale_factor = 0.0001 ;
      inter_mission_bias:coordinates = "longitude latitude" ;
   byte validation_flag(time) ;
      validation_flag:_FillValue = 127b ;
      validation_flag:flag_meanings = "valid_data_over_ocean rejected_data" ;
      validation_flag:long_name = "validation flag" ;
      validation_flag:coordinates = "longitude latitude" ;
      validation_flag:flag_values = 0b, 1b ;

// global attributes:
      :Conventions = "CF-1.6" ;
      :cycle_number = 142LL ;
      :pass_number = 1002LL ;
      :absolute_pass_number = 142284LL ;
      :equator_time = "2020-08-17 18:26:38.607000" ;
      :equator_longitude = 352.14 ;
      :first_meas_time = "2020-08-17 18:01:31.754466" ;
      :last_meas_time = "2020-08-17 18:51:49.884586" ;
      :creator_email = "aviso@altimetry.fr" ;
      :cdm_data_type = "swath" ;
      :references = "http://aviso.altimetry.fr" ;
      :Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
      :institution = "CLS,CNES,EUMETSAT" ;
      :creator_name = "AVISO" ;
      :title = "NTC Altika Global Ocean Along track Sea Level Anomalies L2P products" ;
      :standard_name_vocabulary = "http://cf-pcmdi.llnl.gov/documents/cf-standard-names/standard-name-table/25/cf-standard-name-table.html" ;
      :summary = "The Non Time Critical Level-2P sea surface height above mean sea surface products for Altika mission." ;
      :project = "Salp marine altimetry service" ;
      :platform = "Altika" ;
      :contact = "aviso@altimetry.fr" ;
      :source = "Altika measurements" ;
      :based_on = "Altika NTC" ;
      :creator_url = "http://aviso.altimetry.fr" ;
      :processing_level = "L2P" ;
      :software_version = "L2PDT: 4.02.4; OCTANT: 13.3.0-20200605" ;
      :product_version = "L2PNTC : 03_00" ;
      :creation_date = "2020-12-04T09:15:49" ;
}
```

6. Products accessibility

6.1. access

The L2P products are available via the authenticated **Aviso+ FTP (online products)**:

- You first need to register via the Aviso+ web portal and sign the License Agreement: https://www.aviso.altimetry.fr/en/data/data-access/registration-form.html
- you need to choose the product **"Sea Level Anomalies Along-Track Level 2+ (L2P) for other missions"** in the list of products
- note that a specific demand needs to be addressed for **L2P Sentinel-3 products** by clicking on **"Sea Level Anomalies Along-track Level-2+ (L2P) Sentinel-3"**

A login /Password will be provided via email with all the necessary information to access the products.

- Once you are registered, the access to the products is given in your personal MY AVISO+ account in the 'product page' available on:

  https://www.aviso.altimetry.fr/no_cache/en/my-aviso-plus.html

6.2. citation

The following acknowledgement must be cited when using the products:

"The L2P products for missions Jason-3, OSTM/Jason-2, Jason-1, SARAL/AltiKa, Crysoat-2, HaiYang-2A, ERS-1, ERS-2, ENVISAT, Geosat Follow On, TOPEX/Poseidon are processed on behalf of CNES SALP project and distributed by AVISO+".

7. News, updates and reprocessing

7.1. Operational news

To be kept informed about events occurring on the satellites and on the potential services interruption, see the [Duacs] operational news on the Aviso+ website:

https://www.aviso.altimetry.fr/no_cache/en/news/operational-news-and-status.html

7.2. Updates and reprocessing

An Aviso+ web page is dedicated to updates and reprocessing of monomission products such as L2P products:
https://www.aviso.altimetry.fr/en/data/product-information/updates-and-reprocessing/monomission-data-updates.html

8. Contacts

For more information, please contact:

Aviso+ User Services
CLS
8-10 rue Hermès
Parc Technologique du canal
F-31520 Ramonville Cedex
France
Tél: (+33) (0) 561 394 780
Fax: (+33) (0) 561 393 782
E-mail: aviso@altimetry.fr
On Internet: https://www.aviso.altimetry.fr/

The user service is also interested in user feedbacks; questions, comments, proposals, requests are much welcome.

Bibliography

Boy, F., Desjonquères J.-D., Picot N., 2011 : "Cryosat LRM, TRK and SAR processing", http://www.aviso.altimetry.fr/fileadmin/documents/OSTST/2011/oral/01_Wednesday/Splinter%201%20IP/06%20%20Boy%20CPP%20Presentation.pdf, OSTST 2011

Carrère, L, F. Lyard, M. Cancet, A. Guillot, N. Picot, 2015: FES2014: a new tidal model on the global ocean with enhanced accuracy in shallow seas and in the Arctic region, OSTST2015: http://meetings.aviso.altimetry.fr/fileadmin/user_upload/tx_ausyclsseminar/files/29Red1100-2_ppt_OSTST2014_FES2014_LC.pdf

Carrère, L., F. Lyard, D. Allain, M. Cancet, N. Picot, A. Guillot, Y. Faugère, S.Dupuy, R. Baghi, 2016: Final version ofthe FES2014 global ocean tidal model, which includes a new loading tide solution.OSTST 2016

Carrère, L. and F. Lyard, 2003: Modeling the barotropic response of the global ocean to atmospheric wind and pressure forcing – comparison with observations, *Geophys. Res. Lett.*, **30(6)**, 1275.

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

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

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

Dorandeu, J., M. Ablain, Y. Faugère, B. Soussi, and P. Vincent, 2004 : Jason-1 global statistical evaluation and performance assessment. Calibration and cross-calibration results. *Marine Geodesy*, **27**, **345-372**.M. Joana Fernandes, Clara Lázaro, Michaël Ablain, Nelson Pires, Improved wet path delays for all ESA and reference altimetric missions, Remote Sensing of Environment, Volume 169, November 2015, Pages 50-74, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2015.07.023.

Gaspar, P., S. Labroue and F. Ogor. Improving nonparametric estimates of the sea state bias in radar altimeter measurements of seal level, *J. Atmos. Oceanic Technology*, **19**, **1690-1707**, October 2002.

Gaspar, P., F. Ogor and C. Escoubes, Nouvelles calibration et analyse du biais d'etat de mer des altimetres TOPEX et POSEIDON. *Technical note 96/018 of CNES Contract 95/1523*, 1996.

Gaspar, P., and F. Ogor, Estimation and analysis of the Sea State Bias of the new ERS-1 and ERS-2 altimetric data (OPR version 6). Report of task 2 of IFREMER Contract n° 96/2.246 002/C, 1996.

Guibbaud, M., A. Ollivier and M. Ablain, A new approach for dual-frequency ionospheric correction filtering, ENVISAT Altimetry Quality Working Group (QWG), 2015 available in the Section 8.5 of the 2012 Envisat annual activity report:

http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation_report/EN/annual_report_en_2012.pdf

Hernandez, F., M.-H. Calvez, J. Dorandeu, Y. Faugère, F. Mertz, and P. Schaeffer., 2000 : Surface Moyenne Océanique : Support scientifique à la mission altimétrique Jason-1, et à une mission micro-satellite altimétrique. *Contrat SSALTO 2945 – Lot 2 – A.1. Rapport d'avancement. CLS/DOS/NT/00.313*, 40 pp. CLS Ramonville St Agne.

Iijima, B.A., I.L. Harris, C.M. Ho, U.J. Lindqwiste, A.J. Mannucci, X. Pi, M.J. Reyes, L.C. Sparks, B.D. Wilson, 1999: Automated daily process for global ionospheric total electron content maps and satellite ocean altimeter ionospheric calibration based on Global Positioning System data, *J. Atmos. Solar-Terrestrial Physics*, 61, 16, 1205-1218

Labroue, S., P. Gaspar, J. Dorandeu, O.Z. Zanifé, F. Mertz, P. Vincent, and D. Choquet, 2004 : Non parametric estimates of the sea state bias for Jason-1 radar altimeter. *Marine Geodesy* **27**, **453-481**.

Labroue, S., 2007: RA2 ocean and MWR measurement long term monitoring, 2007 report for WP3, Task 2 - SSB estimation for RA2 altimeter. Contract 17293/03/I-OL. CLS-DOS-NT-07-198, 53pp. CLS Ramonville St. Agne

Le Traon, P.-Y., F. Nadal, et N. Ducet, 1998b : An improved mapping method of multisatellite Altimeter data. *J. Atm. Oc. Tech.*, ***15***, **522-534**.

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

Lievin, M., C. Kocha, B. Courcol, S. Philipps, I. Denis, T. Guinle, C. Nogueira Loddo, G. Dibarboure, N. Picot, F. Bignalet Cazalet, 2020: REPROCESSING of SEA LEVEL L2P products for 28 years of altimetry missions. OSTST 2020 virtual meeting.

Martini A. and P. Féménias, 2000, "The ERS SPTR2000 Altimetric Range Correction: Results and validation", ERE-TN-ADQ-GSO-6001.

Mertz F., F. Mercier, S. Labroue, N. Tran, J. Dorandeu, 2005: ERS-2 OPR data quality assessment ; Long-term monitoring – particular investigation. CLS.DOS.NT-06.001 http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation_report/E2/annual_report_e2_2005.pdf

Obligis, E., Rahmani, A., Eymard, L., Labroue, S., & Bronner, E. (2009). An improved retrieval algorithm for water vapor retrieval: Application to the envisat microwave radiometer. IEEE Transactions on Geoscience and Remote Sensing, 47(9), 3057–3064. https://doi.org/10.1109/TGRS.2009.2020433

Ruf, C., S. Brown, S. Keihmand A. Kitiyakara, 2002a. JASON Microwave radiometer: On Orbit Calibration, Validation and Performance, Paper presented at Jason-1 and TOPEX/Poseidon Science Working Team Meeting, New Orleans (USA), **21-23 October.**

Scharroo, R., and W. H. F. Smith (2010), A global positioning system-based climatology for the total electron content in the ionosphere, J. Geophys. Res., 115, A10318, doi:10.1029/2009JA014719.

Scharroo, R., J. Lillibridge, and W.H.F. Smith, 2004: Cross-calibration and long-term monitoring of the Microwave Radiometers of ERS, Topex, GFO, Jason-1 and Envisat. *Marine Geodesy*, **97**.

Scharroo, R. and P. Visser, 1998: Precise orbit determination and gravity field improvement for the ERS satellites. *J Geophys. Res.*, **103,** 8113-8127.

Tran N., 2015: "Envisat Phase F - SSB", Technical Report CLS-DOS-NT-15-031, ESA ESL Contract.

Tran N., JC Poison, P. Thibaut, D. Vandemark, H. Feng, 2014: "PEACHI V1 - Rapport tâche 1.4: SSB", Technical Report CLS-DOS-NT-13-239, version 2.0, CNES Contract

Tran, N., S. Labroue, S. Philipps, E. Bronner, and N. Picot, 2010 : Overview and Update of the Sea State Bias Corrections for the Jason-2, Jason-1 and TOPEX Missions. *Marine Geodesy, accepted*.

Vincent, P., Desai S.D., Dorandeu J., Ablain M., Soussi B., Callahan P.S. and B.J. Haines, 2003: Jason-1 Geophysical Performance Evaluation. *Marine Geodesy*, **26,** 167-186.

Wahr, J. W., 1985, "Deformation of the Earth induced by polar motion," *J. of Geophys. Res. (Solid Earth)*, **90**, **9363-9368**.

Wunsch, C. 1972. Bermuda sea level in relation to tides, weather and baroclinic fluctuations. *Rev. Geophys. Phys.*, **10,1-49**.

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