DT CorSSH Product Handbook

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Nomenclature: -

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Chronology Issues:		
Issue:	Date:	Reason for change:
1.0	2014/04/18	1st issue for CorSSH products distributed in 2014
1.1	2014/09/15	Update for Altika and Hy-2A products

D : page deleted I : page inserted M : page modified

List of Acronyms:

ATP	Along Track Product
Aviso+	Archiving, Validation and Interpretation of Satellite Oceanographic data
Cersat	Centre ERS d'Archivage et de Traitement
CLS	Collecte, Localisation, Satellites
CMA	Centre Multimissions Altimetriques
Cnes	Centre National d'Etudes Spatiales
CorSSH	Corrected Sea Surface Height
Doris	Doppler Orbitography and Radiopositioning Integrated by Satellite
DT	Delayed Time (>30days)
ECMWF	European Centre for Medium-range Weather Forecasting
EN	Envisat
G2	GFO
GDR	Geophysical Data Record(s)
GFO	Geosat Follow-On
GOT	Global Ocean Tides
IB	Inverse Barometer
IGDR	Interim Geophysical Data Record(s)
J1	Jason-1
J2	Jason-2
JMR	Jason-1 Microwave Radiometer
LWE	Large Wavelength Error
MSS	Mean Sea Surface
MWR	Microwave Radiometer
Nasa	National Aeronautics and Space Administration
NRT	Near Real Time (48/72h)
OER	Orbit Error Reduction
OSDR	Operational Sensor Data Records
POE	Precise Orbit Ephemeris
RD	Reference Document
RT	Real Time (<10h)
Ssalto	Segment Sol multimissions d'ALTimétrie, d'Orbitographie et de localisation précise.
SLA	Sea Level Anomaly
SSB	Sea State Bias
SSH	Sea Surface Height
TAI	IAT – International Atomic Time
TMR	Topex Microwave Radiometer
T/P	Topex/Poseidon
UTC	Universal Time Coordinated

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Applicable documents / reference documents

RD 1: Jason-2 validation and cross calibration activities (Annual report 2013),
http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation_report/J2/SALP-RP-MA-EA-22270-CLS_1_0_RapportAnnuel_J2_2013.pdf
Ref: SALP-RP-MA-EA-22270-CLS

RD 2: Saral/AltiKa reprocessing GDR-T Patch2,
http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation_report/SaralPatch2ReprocessingReport.pdf
Ref: SALP-RP-MA-EA-22345-CLS

RD 3: Jason-1 validation and cross calibration activities (Annual report 2013),
http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation_report/annual_report_j1_2013.pdf
Ref: SALP-RP-MA-EA-22269-CLS

RD 4: Envisat RA2/MWR ocean data validation and cross calibration Activities (Annual Report 2013).
http://www.aviso.altimetry.fr/fileadmin/documents/calval/validation_report/EN/annual_report_en_2013.pdf
Ref: SALP-RP-MA-EA-22293-CLS

RD 5: AVISO and PO.DAAC User Handbook – IGDR and GDR Jason-1 Products
Ref: SMM-MU-M5-OP-13184-CN

Bibliography

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**.

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**.

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.

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**.

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

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., 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., 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**.

Contents

1. Introduction

The purpose of this document is to describe products generated by the 1Hz monomission along-track Delayed Time altimeter data processing segment, named **DT CorSSH** products. A large number of altimeter missions are proposed: HY-2A, SARAL/AltiKa, Jason-1&2, Envisat, ERS-1&2, TOPEX/Poseidon, GFO.

The generation of those products is part of the CNES SALP project (Altimetry and Precise Positioning Service). This project is responsible for the implementation and exploitation in operational conditions of altimetry missions as well as for preparation of future missions.

Ssalto is CNES component in charge of:

- Altimetry & DORIS processing,
- Instrument command and control,
- Products dissemination and archiving (Aviso+).

It generates:

- Level 1 data (i.e timed and located, expressed in appropriate units and checked for quality data) of Jason-2, SARAL/AltiKa, Jason-1, Topex/Poseidon missions.
- Level 2 data (i.e data corrected from instrumental, atmospheric and geophysical corrections, and validated for quality assurance) of Jason-2, SARAL/AltiKa, Jason-1, Topex/Poseidon missions.
- Higher level of data is also delivered with specific processing: multimission (Duacs) (Cryosat-2, HY-2A, SARAL/AltiKa, Jason-1&2, Envisat, ERS-1&2, TOPEX/Poseidon , GFO) and monomission (HY-2A, SARAL/AltiKa, Jason-1&2, Envisat, ERS-1&2, TOPEX/Poseidon , GFO). Those two processes have common steps (acquisition, applying of consistent corrections, editing, applying of specific algorithms, validation of crossovers..).
    - The multimission process has specific steps of Long Wavelength Error correction (LWE) and of homogenization of the missions onto a reference mission and provides level 3 (along-track) and level 4 (gridded merged) products in Delayed Time and in Near-Real Time.
    - The monomission process doesn't take into account these steps and provides 1Hz Delayed-Time products equivalent to "reduced GDR" products containing Sea Surface Height (SSH), Significant wave height (SWH), backscatter coefficient (Sigma0) and a set of corrections. These corrections are provided enabling you to add/adapt new formulas to apply them yourself.

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. Data Processing

2.1. Overview of the monomission component

The monomission component of Ssalto ground segment is in charge of the Delayed Time (DT) production and processing of 1 Hz HY-2A, Saral/AltiKa, Topex/Poseidon, ERS-1, ERS-2, GFO, Jason-1, Jason-2, Envisat data in order to provide highly accurate long time series of altimeter data.

The monomission system delivers 1Hz DT CorSSH products for HY-2A, Jason-1, Jason-2, Envisat, T/P, GFO, Altika, ERS-1 and ERS-2 missions.

Note that monomission products by definition are not intercalibrated at crossover points. Thus Jason-1 and Envisat data for example may not be homogeneous at a given point, since their orbits are different. Please also note that these products are not corrected from Large Wavelength Error (LWE), unlike multimission Ssalto/Duacs products.

2.1.1. Data used

2.1.1.1. Altimeter data

Delayed Time products are generated from GDR products detailed in Table 1.

All GDR products are computed with a Precise Orbit Ephemeris (POE) and are delivered within 2 months depending on the mission. For several missions, an updated orbit is used, the other corrections are detailed in tables 2 and 3.

Altimetry product	Source	Availability	Type of orbit
Topex/Poseidon GDR-C	NASA/CNES	-	GSFC POE (std0809)
Jason-1 GDR-C	CNES/NASA	-	CNES POE (GDR-D standard)
Jason-2 GDR-D	CNES/NASA	~60 days	CNES POE
GFO GDR	NOAA	-	GSFC (std0809) /NASA POE
ERS-1 OPR	IFREMER/ESA	-	ESA/Reaper
ERS-2 OPR	IFREMER/ESA	-	ESA/Reaper
Envisat GDR-V2.1+	ESA	-	CNES POE
HY-2A	NSOAS	Best effort (~60 days)	CNES POE
Saral/Altika	CNES	~60 days	CNES POE

Table 1: Aviso+ Delayed Time Input data overview.

2.1.1.2. Dynamic Auxiliary Data

Various Dynamic Auxiliary Data are needed to process these altimeter data. The pressure and wet tropospheric correction grids (gaussian grids) are provided by ECMWF, and the pole tide is computed from IERS data in order to homogenize the corrections for ERS-1 and ERS-2 missions (see Tables 2 and 3) .

2.1.2. Selecting valid data

The processing starts with quality control and validation of altimetric data and geophysical corrections. This is part of the validation task of T/P, Jason-1, Jason-2, Envisat, Saral/AltiKa and HY-2A GDRs performed by the CLS Space Oceanography Division for Aviso/Altimetry (CNES) and F-PAC (ESA). Only valid ocean data are selected. Specific editing criteria are applied near the coasts (10-50 km).

2.1.3. 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).

2.2. Product Generation

2.2.1. Computing the corrected sea surface height

To compute the correct value of sea surface height, the following operation is done:

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

Moreover, another variable is added in the product:

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

'Sea Surface Height' is the height of the sea surface above the reference ellipsoid. **'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.

'Altimeter Range' is the distance from the center of mass of satellite to the surface of the Earth, as measured by altimeters (figure 1).

'Corrections': see table 2 and 3.

The 'Mean Sea Surface' is the mean of the sea surface height relative to ellipsoid over 15 years. It is computed on a regular grid and combines the data of all satellites.

The **Reference ellipsoid** used for Jason-1&2, Topex/Poseidon and GFO is the first-order definition of the non-spherical shape of Earth with:

- equatorial radius of 6378.1363 kilometers
- flattening coefficient of 1/298.257000000

Concerning DT-CorSSH products of other missions, the sea surface heights are adjusted above Jason-1 ellipsoid, **so all the DT CorSSH products are referenced to the same ellipsoid.**

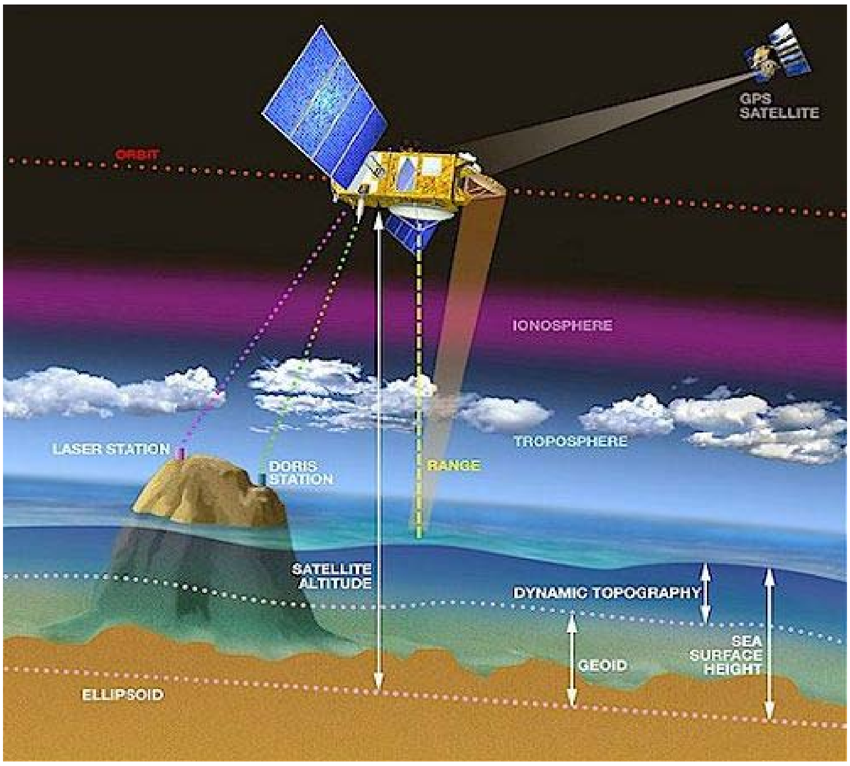

Figure 1 : Altimetry principle

2.2.2. 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.

For example:

For Jason-1, an ascending pass (odd numbers) begins at Latitude -66.15 deg and ends at +66.15 deg. A descending pass is the opposite (+66.15 deg to -66.15 deg).

The passes are numbered from 1 to 254 representing a full repeat cycle of the Jason-1 ground track for the repetitive orbit; for Jason-1, a repeat cycle is about 9.9156 days.

Since May 2012 (cycles≥500) Jason -1 is no longer on an exact repetitive orbit but on a geodetic orbit. Thus, cycles are numbered using the 10.9 day sub-cycle and the passes are numbered from 1 to 280.

For Envisat, it was on its repetitive orbit until cycle 95, with cycles of 35 days and with 1002 passes per cycles. Since cycle 95, it is on a drifting orbit of pseudo-cycles of 30 days and 862 passes per pseudo-cycle (a pseudo-cycle means that the orbit is not exactly the same from one cycle to another one because the orbit is drifting).

2.2.3. Available products

Monomission component delivers Delayed Time processed CorSSH products using fully processed data from various altimetric missions (Topex/Poseidon, Jason-1, Jason-2, GFO, ERS-1, ERS-2, ENVISAT, HY-2A and Altika)

Each product contains data series which correspond to a complete satellite's cycle; therefore, products availability will depends on the satellite's orbital period.

The main reference characteristics for computing DT CorSSH are summarized in following table. These information are provided by appropriated fields in the data file.

	Jason-1	Jason-2	Topex/Poseidon	HY-2A	Altika
Orbit	Cnes POE (GDR-D standards)		GSFC POE (std0809)	Cnes POE (GDR-D standards)	Cnes POE (GDR-D standards)
Dry troposphere	Model computed from ECMWF Rectangular grids (S1 and S2 atmospheric tides applied)	Model computed from ECMWF Gaussian grids (S1 and S2 atmospheric tides applied)	Model computed from ERA Interim Gaussian grids (new S1 and S2 atmospheric tides are applied)	Model computed from ECMWF Gaussian grids (S1 and S2 atmospheric tides applied)	Model computed from ECMWF Gaussian grids (S1 and S2 atmospheric tides applied)
Wet troposphere	From JMR/AMR radiometer		From TMR radiometer [Scharoo *et al. 2004*]	Model computed from ECMWF Gaussian grids	From Altika radiometer
Ionosphere	From dual-frequency altimeter range measurements		From dual-frequency altimeter range measurements (Topex), from Doris (Poseidon)	GIM model [Iijima et al,1998]	GIM model [Iijima et al,1998]
Sea State Bias	Non parametric SSB [Tran et al., 2012]	Non parametric SSB [Tran et al., 2012]	Non parametric SSB [Tran et al., 2010]	Linear model	Linear model
Ocean tide and loading tide	GOT4.8 (including ocean tides, loading effect, long period equilibrium tide, S1 tides…)				
Solid Earth tide	Elastic response to tidal potential [Cartwright and Tayler, 1971], [Cartwright and Edden, 1973]				
Pole tide	From GDR [Wahr, 1985]				
Dynamic atmospheric correction	MOG2D High Resolution forced with ECMWF pressure and wind field (S1 and S2 excluded) [Carrère and Lyard, 2003] + inverse barometer computed from rectangular grids.				
Mean Sea Surface used	CNES-CLS11 referenced [1993, 2012]				

Table 2 : Aviso+ Reference products corrections overview for Jason-1, Jason-2, HY-2A, Topex/Poseidon and Altika

	Envisat	ERS-1	ERS-2	GFO
Orbit	Cnes POE (GDR-D standards)	Reaper [Rudenko *et al.*, 2012]		GSFC POE (std0809)/NAVSOC POE (where no GSFC POE)
Dry troposphere	Model computed from ERA Interim Gaussian grids (new S1 and S2 atmospheric tides are applied)			Model computed from ERA Interim Rectangular grids (new S1 and S2 atm tides applied)
Wet troposphere	Cycles ≤94:From MWR radiometer (dist≥ 50km from the coasts) and from ECMWF model (50>dist≥10km). For cycles≥95: From MWR radiometer.	From MWR radiometer	From MWR with neural algorithm [Tran and Obligis, 2003], corrected for 23.6 GHz TB drift [Scharoo *et al.* 2004]	From GFO radiom.
Ionosphere	cycles ≤64: from dual-frequency altimeter range measurements cycles≥65 : GIM model [Ijima *et al.*, 1999] corrected for 8 mm bias	Reaper (NIC09 model, [Scharroo and Smith, 2010])	cycles ≤36: Bent model, cycles≥37 : GIM model [Iijima *et al.*, 1999]	GIM model [Iijima *et al.*, 1999]
Sea State Bias	Non parametric SSB [Tran et al., 2012]	BM3 [Gaspar and Ogor, 1994]	Non parametric SSB [Mertz *et al.*,2005]	Non parametric SSB [Tran et al., 2010]
Ocean tide and loading tide	GOT4.8 (including ocean tides, loading effect, long period equilibrium tide, S1 tides…)			
Solid Earth tide	Elastic response to tidal potential [Cartwright and Tayler, 1971], [Cartwright and Edden, 1973]			
Pole tide	computed from IERS data [Wahr, 1985]			
Dynamic atmospheric correction	MOG2D High Resolution forced with ECMWF pressure and wind field (S1 and S2 excluded) [Carrère and Lyard, 2003] + inverse barometer computed from rectangular grids.	MOG2D High Resolution forced with ERA-Interim pressure and wind field (S1 and S2 excluded) [Carrère and Lyard, 2003] + inverse barometer computed from rectangular grids.		MOG2D High Resolution forced with ECMWF pressure and wind field (S1 and S2 excluded) [Carrère and Lyard, 2003] + inverse barometer computed from rectangular grids.
Mean Sea Surface used	CNES-CLS11 referenced [1993, 2012]			

Table 3 : Aviso+ Reference products corrections overview for Envisat, ERS-1, ERS-2 and GFO.

3. Product Presentation

3.1. How to access products

Delayed Time (DT) CorSSH products are available via **authenticated** servers: **FTP** or **Online Data Extraction Service (ODES)**. Please subscribe to get access to the products: http://www.aviso.altimetry.fr/en/data/data-access/registration-form.html

To download the products, user must read carefully the products licence and accept it. The access will be given by e-mail.

The following acknowledgement must be cited:

"The Delayed Time (DT) CorSSH products are processed with support from CNES (by CLS Space Oceanography Division) and distributed by AVISO+".

3.2. Overview

Information regarding the latest improvements and changes are available on the Aviso+ web site.

http://www.aviso.altimetry.fr/en/data/product-information/updates-and-reprocessing/monomission-data-updates.html

3.3. Temporal availability

mission	Begin date	End date	Characteristics
ERS-1*	1992/10/23 (cycle 15)	1993/12/20 (cycle 27)	35-day phase C
	1994/04/10 (cycle 30)	1996/06/02 (cycle 53)	35-day phase G
ERS-2	1995/05/15 (cycle 1)	2003/07/02 (cycle 85)	35-day phase A
Topex/Poseidon	1992/09/25 (cycle 1)	2002/08/11 (cycle 364)	10-day initial phase
	2002/08/11 (cycle 365)	2005/10/08 (cycle 481)	10-day second phase (drifting orbit from pass 111 of cycle 365 to pass 172 of cycle 368)
Envisat	2002/05/14 (cycle 6)	2010/10/26 (cycle 95)	35-day phase
	2010/10/26 (cycle 96)	2012/04/07 (cycle 113)	Drifting phase
GFO	2000/01/07 (cycle 37)	2008/09/07 (cycle 222)	17-day phase
Jason-1	2002/01/15 (cycle 1)	2009/01/26 (cycle 259)	10-day initial phase
	2009/02/10 (cycle 262)	2012/03/03 (cycle 374)	10-day second phase
	2012/05/07 (cycle 500)	2013/06/21 (cycle 537)	Drifting phase
Jason-2	2008/07/12 (cycle 1)	ongoing	10-day initial phase
HY-2A	2017/04/12 (cycle 67)	ongoing	14-day phase
Altika	2013/03/14 (cycle 1)	ongoing	35-day phase

Table 3: temporal availability of missions.

* Note that for ERS-1 a specific cycle notation has been adopted: the whole period of ERS-1 has been divided into 35 days periods, thus the cycle 1 is considered to be the first cycle of phase A (begins on the 26th July 1991) and the cycle 53 is the last cycle of phase G (ends on 3rd June 1996).

3.4. Nomenclature

Generally speaking, the nomenclature used for all CORSSH products is designed to be self-explanatory and to ease data selection and data access. The standard filename nomenclature is:

CorSSH_<**MISSION**>_C<**CYCLE**>_P<**PASS**>_<**DATEBEGIN**>_<**DATEEND**>.nc

where

MISSION is the mission name:

- J2 for Jason-2
- J1 for Jason-1
- EN for Envisat
- TP for Topex/Poseidon
- E1 for ERS-1
- E2 for ERS-2
- G2 for GFO
- H2 for HY-2A
- AL for Altika

CYCLE is the number of the satellite's cycle on 4 digits.

PASS is the number of the satellite's pass in cycle on 4 digits

DATEBEGIN is the begin date of the pass with format YYYYMMDD_HH:MM:SS. Note that this date is computed with all the points of the pass (valid or not valid). A validation is made for the computation of the CorSSH values (see section 2.1.2), some points may thus be eliminated. As a consequence, the date of the first measurement in the file may be greater than DATEBEGIN. The real values of begin and end dates are displayed in the file itself: the global attributes first_meas_time and last_meas_time.

DATEEND is the end date of the pass with format YYYYMMDD_HH:MM:SS. Note that this date is computed with all the points of the pass (valid or not valid). A validation is made for the computation of the CorSSH values (see section 2.1.2), some points may thus be eliminated. As a consequence, the date of the last measurement in the file may be lower than DATEEND. The real values of begin and end dates are displayed in the file itself: the global attributes first_meas_time and last_meas_time.

nc stands for NetCDF.

4. Data Format

4.1. Introduction

This chapter presents the data storage format and convention used for CorSSH products. All products are distributed in NetCDF 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.

4.2. DT CorSSH Format

4.2.1. Dimensions

1 Dimension is defined:

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

4.2.2. Data Handling Variables

18 variables are defined in the products. You will find hereafter the definitions of the variables:

<table>
<tr><th>Name of variable</th><th>Type</th><th>Content</th><th>Unit</th><th>Missions</th></tr>
<tr><td>time</td><td>double</td><td>Time of measurements</td><td>seconds since 2000-01-01 00:00:00 UTC</td><td>all</td></tr>
<tr><td>lat</td><td>int</td><td>Latitude value of measurements</td><td>degrees_north</td><td>all</td></tr>
<tr><td>lon</td><td>int</td><td>Longitude value of measurements</td><td>degrees_east</td><td>all</td></tr>
<tr><td>swh</td><td>short</td><td>Significant wave height</td><td>meters</td><td>all</td></tr>
<tr><td>sig0</td><td>short</td><td>Backscatter coefficient</td><td>dB</td><td>all</td></tr>
<tr><td>corrected_sea_surface_height</td><td>int</td><td>Corrected sea surface height</td><td>meters</td><td>all</td></tr>
<tr><td>wet_tropo_corr_rad</td><td>short</td><td rowspan="2">Wet tropospheric correction</td><td rowspan="2">meters</td><td>J2 and AL.</td></tr>
<tr><td>wet_tropo_corr_composite</td><td>short</td><td>all except J2 and AL.</td></tr>
<tr><td>iono_corr_alti_filtr</td><td rowspan="4">int</td><td rowspan="4">Ionospheric correction</td><td rowspan="4">meters</td><td>J1,J2</td></tr>
<tr><td>iono_corr_model_gim</td><td>G2,AL,H2</td></tr>
<tr><td>iono_corr_model_nic</td><td>E1</td></tr>
<tr><td>iono_corr</td><td>EN,E2,TP</td></tr>
<tr><td>sea_state_bias</td><td rowspan="3">short</td><td rowspan="3">Sea state bias</td><td rowspan="3">meters</td><td>J2,EN,J1,TP,AL,H2</td></tr>
<tr><td>sea_state_bias_neural</td><td>E2,G2</td></tr>
<tr><td>sea_state_bias_param</td><td>E1</td></tr>
<tr><td>solid_earth_tide</td><td>short</td><td>Solid Earth tide height</td><td>meters</td><td>all</td></tr>
<tr><td>pole_tide</td><td>short</td><td>Pole tide height</td><td>meters</td><td>all</td></tr>
<tr><td>bathymetry</td><td>int</td><td>Bathymetry</td><td>meters</td><td>all</td></tr>
<tr><td>dry_tropo_corr_model_ecmwf_gauss</td><td rowspan="3">short</td><td rowspan="3">Dry tropospheric correction</td><td rowspan="3">meters</td><td>J2,EN,J1,H2,AL</td></tr>
<tr><td>dry_tropo_corr_model_ecmwf_cart</td><td>G2</td></tr>
<tr><td>dry_tropo_corr.model_era_interim</td><td>E2,E1,TP</td></tr>
<tr><td>dyn_atmosph_corr</td><td rowspan="2">short</td><td rowspan="2">Combined atmospheric correction</td><td rowspan="2">meters</td><td>J2,EN,J1,G2,H2,AL</td></tr>
<tr><td>dyn_atmosph_corr_model_era_interim</td><td>E2,E1,TP</td></tr>
<tr><td>ocean_tide_height_model_got</td><td>int</td><td>Ocean tide height</td><td>meters</td><td>all</td></tr>
<tr><td>mean_sea_surface_cnescls_ref20</td><td>int</td><td>Mean sea surface height</td><td>meters</td><td>all</td></tr>
<tr><td>inter_mission_bias</td><td>int</td><td>Bias to have consistent time series since TOPEX/Poseidon</td><td>meters</td><td>all</td></tr>
<tr><td>sea_level_anomaly</td><td>int</td><td>sea Level Anomaly relative to MSS</td><td>meters</td><td>all</td></tr>
</table>

Table 4: Overview of data handling variables in DT CorSSH NetCDF file.

4.2.2.1. Attributes

Additional attributes may be available in Along Track Product (ATP) files. They are providing information about the type of product or the processing and parameter used.

4.2.2.2. Example of file

```
netcdf CorSSH_AL_C0001_P0001_20130314_053927_20130314_062945 {
dimensions:
        time = 1758 ;
variables:
        double time(time) ;
                time:long_name = "time (sec. since 1950-01-01)" ;
                time:standard_name = "time" ;
                time:units = "seconds since 2000-01-01 00:00:00.0" ;
                time:calendar = "gregorian" ;
        int lat(time) ;
                lat:long_name = "latitude" ;
                lat:standard_name = "latitude" ;
                lat:units = "degrees_north" ;
                lat:scale_factor = 1.e-06 ;
                lat:comment = "Positive latitude is North latitude, negative
                           latitude is South latitude." ;
        int lon(time) ;
                lon:long_name = "longitude" ;
                lon:standard_name = "longitude" ;
                lon:units = "degrees_east" ;
                lon:scale_factor = 1.e-06 ;
                lon:comment = "East longitude relative to Greenwich meridian" ;
        int corrected_sea_surface_height(time) ;
                corrected_sea_surface_height:_FillValue = -2147483647 ;
                corrected_sea_surface_height:long_name = "Corrected sea surface
                           height above the reference" ;
                corrected_sea_surface_height:standard_name =
                           "sea_surface_height_above_reference_ellipsoid" ;
                corrected_sea_surface_height:institution = "CNES/CLS" ;
                corrected_sea_surface_height:units = "m" ;
                corrected_sea_surface_height:scale_factor = 0.0001 ;
                corrected_sea_surface_height:comment = "Sea surface height
                           corrected form geophysical impacts." ;
        short dry_tropo_corr_model_ecmwf_gauss(time) ;
                dry_tropo_corr_model_ecmwf_gauss:_FillValue = -32767s ;
                dry_tropo_corr_model_ecmwf_gauss:long_name = "ECMWF model dry
                           tropospheric correction" ;
                dry_tropo_corr_model_ecmwf_gauss:standard_name =
                           "altimeter_range_correction_due_to_dry_troposphere" ;
                dry_tropo_corr_model_ecmwf_gauss:institution = "ECMWF" ;
                dry_tropo_corr_model_ecmwf_gauss:units = "m" ;
                dry_tropo_corr_model_ecmwf_gauss:scale_factor = 0.0001 ;
                dry_tropo_corr_model_ecmwf_gauss:comment = "Computed at the
                    altimeter time-tag from the interpolation of 2 meteorological
                    fields that surround the altimeter time-tag. A dry tropospheric
                    correction must be added (negative value) to the instrument
                    range to correct this range measurement for dry tropospheric
                    range delays of the radar pulse. This atmospheric correction is
                    provided courtesy of ECMWF." ;
        short dyn_atmosph_corr(time) ;
                dyn_atmosph_corr:_FillValue = -32767s ;
                dyn_atmosph_corr:long_name = "dynamical atmospheric correction" ;
                dyn_atmosph_corr:institution = "LEGOS/CNES" ;
```

```
                dyn_atmosph_corr:units = "m" ;
                dyn_atmosph_corr:scale_factor = 0.0001 ;
                dyn_atmosph_corr:comment = "MOG2D high resolution forced with ECMWF
                           pressure and wind fields plus inverse barometer. This
                    correction is computed by adding the high frequency
                    fluctuations of the sea surface topography and the inverted
                    barometer height correction computed from rectangular grids." ;
        int ocean_tide_height_model_got(time) ;
                ocean_tide_height_model_got:_FillValue = -2147483647 ;
                ocean_tide_height_model_got:long_name = "GOT model geocentric ocean
                           tide height" ;
                ocean_tide_height_model_got:standard_name =
                    "sea_surface_height_amplitude_due_to_geocentric_ocean_tide" ;
                ocean_tide_height_model_got:source = "GOT4.8" ;
                ocean_tide_height_model_got:institution = "NASA/GSFC" ;
                ocean_tide_height_model_got:units = "m" ;
                ocean_tide_height_model_got:scale_factor = 0.0001 ;
                ocean_tide_height_model_got:comment = "Goddard Ocean Tide -
                    Includes the corresponding loading tide (load_tide_sol1) and
                    equilibrium long-period ocean tide height (ocean_tide_equil).
                    The permanent tide (zero frequency) is not included in this
                    parameter because it is included in the geoid and mean sea
                    surface (geoid, mean_sea_surface)." ;
        short solid_earth_tide(time) ;
                solid_earth_tide:_FillValue = -32767s ;
                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:source = "Cartwright and Tayler tidal potential
                           [1971]" ;
                solid_earth_tide:institution = "National Institute of Oceanography
                           (UK)" ;
                solid_earth_tide:units = "m" ;
                solid_earth_tide:scale_factor = 0.0001 ;
                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." ;
        short sea_state_bias_neural(time) ;
                sea_state_bias_neural:_FillValue = -32767s ;
                sea_state_bias_neural:long_name = "Non parametric sea surface
                           height bias due to sea surface roughness on main
                    altimeter frequency band" ;
                sea_state_bias_neural:standard_name =
                           "sea_surface_height_bias_due_to_sea_surface_roughness" ;
                sea_state_bias_neural:units = "m" ;
                sea_state_bias_neural:scale_factor = 0.0001 ;
                sea_state_bias_neural:comment = "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." ;
        short pole_tide(time) ;
                pole_tide:_FillValue = -32767s ;
                pole_tide:long_name = "geocentric pole tide height" ;
                pole_tide:standard_name =
                           "sea_surface_height_amplitude_due_to_pole_tide" ;
                pole_tide:source = "Wahr [1985]" ;
                pole_tide:institution = "IERS" ;
                pole_tide:units = "m" ;
                pole_tide:scale_factor = 0.0001 ;
        short swh(time) ;
                swh:_FillValue = -32767s ;
                swh:long_name = "significant wave height on main altimeter
                           frequency band" ;
                swh:standard_name = "sea_surface_swell_wave_significant_height" ;
                swh:units = "m" ;
```

```
                swh:scale_factor = 0.001 ;
                swh:comment = "All instrumental corrections included, i.e. modeled
                          instrumental errors correction (modeled_instr_corr_swh)
                    and system bias" ;
        short sigma0(time) ;
                sigma0:_FillValue = -32767s ;
                sigma0:long_name = "backscatter coefficient" ;
                sigma0:standard_name =
                          "surface_backwards_scattering_coefficient_of_radar_wave"
                    ;
                sigma0:units = "dB" ;
                sigma0:scale_factor = 0.01 ;
                sigma0:comment = "All instrumental corrections included, excepted
                          the system bias, i.e. AGC instrumental errors correction,
                    internal calibration correction, modeled instrumental errors
                    correction and atmospheric attenuation." ;
        int bathymetry(time) ;
                bathymetry:_FillValue = -2147483647 ;
                bathymetry:long_name = "bathymetry" ;
                bathymetry:standard_name = "height_above_sea_floor" ;
                bathymetry:source = "ETOPO1" ;
                bathymetry:institution = "NASA/GSFC" ;
                bathymetry:units = "m" ;
                bathymetry:scale_factor = 0.0001 ;
        short wet_tropo_corr_rad(time) ;
                wet_tropo_corr_rad:_FillValue = -32767s ;
                wet_tropo_corr_rad:long_name = "radiometer wet tropospheric
                          correction" ;
                wet_tropo_corr_rad:standard_name =
                          "altimeter_range_correction_due_to_wet_troposphere" ;
                wet_tropo_corr_rad:units = "m" ;
                wet_tropo_corr_rad:scale_factor = 0.0001 ;
                wet_tropo_corr_rad:comment = "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 . This correction is computed from the data of the
                    onboard radiometer." ;
        int iono_corr_model_gim(time) ;
                iono_corr_model_gim:_FillValue = -2147483647 ;
                iono_corr_model_gim:long_name = "GIM model ionospheric correction
                          on main altimeter frequency band" ;
                iono_corr_model_gim:standard_name =
                          "altimeter_range_correction_due_to_ionosphere" ;
                iono_corr_model_gim:source = "GIM Iijima et al [1998]" ;
                iono_corr_model_gim:institution = "NASA/JPL" ;
                iono_corr_model_gim:units = "m" ;
                iono_corr_model_gim:scale_factor = 0.0001 ;
                iono_corr_model_gim: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." ;
        int mean_sea_surface_cnescls_ref20(time) ;
                mean_sea_surface_cnescls_ref20:_FillValue = -2147483647 ;
                mean_sea_surface_cnescls_ref20:long_name = "CNES-CLS mean sea
                          surface height computed on a 20 years reference period" ;
                mean_sea_surface_cnescls_ref20:source = "CNES-CLS11 Schaeffer et al
                          [2012]" ;
                mean_sea_surface_cnescls_ref20:institution = "CNES/CLS" ;
                mean_sea_surface_cnescls_ref20:units = "m" ;
                mean_sea_surface_cnescls_ref20:scale_factor = 0.0001 ;
                mean_sea_surface_cnescls_ref20:comment = "CNES-CLS11 mean sea
                          surface computed on a 20 years reference period." ;
        int sea_level_anomaly(time) ;
                sea_level_anomaly:_FillValue = -2147483647 ;
                sea_level_anomaly:long_name = "sea level anomaly" ;
                sea_level_anomaly:standard_name =
```

```
                            "sea_surface_height_above_sea_level" ;
                sea_level_anomaly:units = "m" ;
                sea_level_anomaly:scale_factor = 1.e-06 ;
        int inter_mission_bias(time) ;
                inter_mission_bias:_FillValue = -2147483647 ;
                inter_mission_bias:long_name = "Bias to have consistent time series
                            since TOPEX/Poseidon" ;
                inter_mission_bias:standard_name = "inter_mission_bias" ;
                inter_mission_bias:units = "m" ;
                inter_mission_bias:scale_factor = 0.0001 ;

// global attributes:
                :Conventions = "CF-1.6" ;
                :cycle_number = 1 ;
                :pass_number = 1 ;
                :absolute_pass_number = 1 ;
                :first_meas_time = "2013-03-14 05:44:49.840163" ;
                :last_meas_time = "2013-03-14 06:23:52.890566" ;
                :mission_name = "Altika" ;
}
```

5. Updates

For all information relative to corrections updates, please check the Aviso+ website at:
http://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products/global/corssh.html
Check out the Aviso+ website for more information and more useful netCDF tools.

6. Contacts

For more information, please contact:

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E-mail: aviso@altimetry.fr
On Internet: http://www.aviso.altimetry.fr/

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