CRYOSAT Ground Segment
Instrument Processing Facility

Baseline D COP Evolutions
[BAS-D-COP-EVO]

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Document Change Record

Issue /Rev.	**Class (R=Review /A=Approval)**	**Date**	**Reason for Change**	**Changed Pages/Paragraphs**
1.0	A	14/07/2023	First Release	All
1.1	R	14/07/2023	New Evolutions tracked	Sections 6.19 to 6.25 added
1.2	R	26/09/2024	Final BaselineD evolutions added	All

TABLE OF CONTENTS

1 APPLICABLE AND REFERENCE DOCUMENTS

1.1 APPLICABLE DOCUMENTS

Document Title	Identifier	Reference
PDS IPF Generic Interface Guidelines Issue 2.2	CS-ID-ACS-GS-0001	[PROC-ICD]
CRYOSAT Ground Segment Payload Data Segment COP - ICD	C2-ID-ACS-ESL-5217	[COP-ICD]
CRYOSAT Ground Segment Payload Data Segment Level-0 Products Specification Format	CS-ID-ACS-GS-0119	[L0-FMT]
Cryosat Instrument Processing Facility Ocean CONFROM Product Formats Specification	C2-RS-ACS-ESL-5266	[PFS-OCE]

1.2 REFERENCE DOCUMENTS

Document Title	Identifier	Reference
IOP & GOP Product Format Specification	C2-RS-ACS-ESL-5213	[COP-FMT]
COP Baseline-D-PHB V5.3	-	[OCE-PH]

2 DEFINITIONS AND ABBREVIATIONS

ACS	Advanced Computer Systems S.p.A.
ATP	Acceptance Test Plan and Procedures document
CIF	Customer Item Furnished
CONFORM	CryOsat Netcdf FORMat
COTS	Commercial Off The Shelf
EO	Earth Observation
ESA	European Space Agency
FOS	CryoSat Ground Segment Flight Operation System
G/S	Ground Segment
HW	Hardware
ID	IDentifier
I/O	Input/Output
IPF	Instrument Processing Facility
ISP	Instrument Source Packet
OO	Object Oriented
PCD	Product Confidence Data
PDS	CryoSat Ground Segment Payload Data Segment
SPR	Software Problem Report
SVVP	System Verification and Validation Plan
TBC	To Be Clarified
TBD	To Be Defined
UTC	Universal Time Co-ordinates

3 DOCUMENT STRUCTURE

The document includes the following sections:

Section 1 – Introduction	Introduction to the whole document
Section 2 - General Overview	This section gives an overview of the CryoSat IPF1 cop production as well as a short introduction to the netCDF.
Section 3 – Baseline D COP Evolutions Released	This section includes the new feature improved in the COP processors
Section 4 – Baseline D COP Pending Evolutions	This section includes the foreseen feature still under development but to be included in the final release of the COP Baseline D

4 INTRODUCTION

This document specifies the Baseline D COP Evolutions taken on board for the COP IPF1/IPF2 Processors.

The list of ARTS reported in the section 6 and 7 are the official ID with which the main evolution have been registered in https://arts.esrin.esa.int/, the Anomaly Report Tracking System used for the CryoSat2 project.

1.1 PURPOSE AND SCOPE

The purpose of the document is to support final user with a clear list of all the Baseline D COP evolutions, to detect the improvements and the differences since previous Baseline C COP release.

The data CryoSat after the Transfer To Operation (TTO) of the baseline D reflect he changes written in section 6.

In section 7 are listed few pending evolutions not yet officially delivered and expected to be evaluated AFTER the QWG 2023 meeting.

5 GENEREAL OVERVIEW

5.1 OVERVIEW OF THE CRYOSAT OCEAN PRODUCTION

The CryoSat ocean chains process SIRAL instrument Level 0 LRM, SAR and SARin products to generate L1b and L2 ocean products by applying the processing algorithms specified for the ocean.

The ocean processing chains provide three classes of products sorted according to their delivering latency:

- **Near-Real Time Ocean Products (NOP)** – delivered three hours after acquisition
- **Intermediate Ocean Products (IOP)** – delivered 48 hours after acquisition
- **Geophysical Ocean Products (GOP)** – delivered one month after acquisition

The processing applied to generate these products is the same and the only difference lies in the different types of auxiliary files (i.e. corrections and orbit) used for the generation: the shorter the latency, the poorer the accuracy of the orbit used for the generation.

All these products are further classified according to processing level (L1b and L2) and the acquisition mode (LRM, SAR and SARin) and therefore the total ocean production consists of the following products:

- **L1b Ocean Products – nine products:**
  - **L1b LRM (NOP, IOP and GOP)** containing LRM measurements and data
  - **L1b SAR (NOP, IOP and GOP)** containing PLRM (data acquired in SAR mode and reduced to a sequence of LRM-like echoes) and SAR measurements and data
  - **L1b SARin (NOP, IOP and GOP)** containing PLRM (data acquired in SARin mode and reduced to a sequence of LRM-like echoes) and SARin measurements and data

- **L2 Ocean Products – nine products:**
  - **L2 LRM (NOP, IOP and GOP)** containing LRM measurements and data
  - **L2 SAR (NOP, IOP and GOP)** containing PLRM and SAR measurements and data
  - **L2 SARin (NOP, IOP and GOP)** containing PLRM and PSAR (i.e. the two SARin channels data averaged in the L1b processing and retracked as SAR data in the L2 processing) measurements and data

Beside the products listed above, one more set of L2 products is generated by the CryoSat Ocean Chains and they are the pole to pole products, i.e. multi-mode L2 products with a half-orbit coverage (from one pole to the other): LRM, SAR and SARin L2 products are concatenated into a single P2P product.
Accordingly, the list of products has to be completed with:

- **Pole to Pole Ocean Products – two products:**
  - **IOP P2P** containing LRM, SAR and SARin L2 IOP data and covering half an orbit.
  - **GOP P2P** containing LRM, SAR and SARin L2 GOP data and covering half an orbit.

NOP P2P products do not exist because of the three hours latency constraint.

The complete set of the L1b and L2 CryoSat Ocean Product and their dependencies is depicted in figure 2.1-1 where each product is identified by the following file types:.
The following table provides the Product Identification for each CONFORM product generated by the IPF1.

Product Identification	Description
SIR_NOPM1B	NRT L1B LRM Ocean Product
SIR_NOPR1B	NRT L1B SAR Ocean Product
SIR_NOPN1B	NRT L1B SARin Ocean Product
SIR_IOPM1B	Intermediate L1B LRM Ocean Product
SIR_IOPR1B	Intermediate L1B SAR Ocean Product
SIR_IOPN1B	Intermediate L1B SARin Ocean Product
SIR_GOPM1B	Geophysical L1B LRM Ocean Product
SIR_GOPR1B	Geophysical L1B SAR Ocean Product
SIR_GOPN1B	Geophysical L1B SARin Ocean Product
SIR_NOPM_2	NRT L2 LRM Ocean Product
SIR_NOPR_2	NRT L2 SAR Ocean Product
SIR_NOPN_2	NRT L2 SARin Ocean Product
SIR_IOPM_2	Intermediate L2 LRM Ocean Product
SIR_IOPR_2	Intermediate L2 SAR Ocean Product
SIR_IOPN_2	Intermediate L2 SARin Ocean Product
SIR_GOPM_2	Geophysical L2 LRM Ocean Product
SIR_GOPR_2	Geophysical L2 SAR Ocean Product
SIR_GOPN_2	Geophysical L2 SARin Ocean Product
SIR_IOP_2_	Intermediate L2 Pole-to-Pole Ocean Product
SIR_GOP_2_	Geophysical L2 Pole-to-Pole Ocean Product

The Earth Explorer format of the products is specified in [PROD-FMT].
The CONFORM format of the products are specified in [PFS-I-L1b] and [PFS-I-L2].

In the next table, the summary of the evolutions included in the Baseline E are indicated: in red, those not in place in the dataset used for the QWG analysis.

	ARTS ID	Description
1.	**CRYO-IDE-344**	Baseline-E: Compensation of the range bias contribution due to datation bias correction
2.	**CRYO-COP-3**	Meteo fields set to default over land & continental ice
3.	**CRYO-COP-16**	H2Corr-related SSHA Crossover bias
4.	**CRYO-COP-28**	Incorrect Product_Location in L2 GOP product

5.	**CRYO-COP-30**	L1_Processing_Quality mismatch between values in DBL global attributes and HDR
6.	**CRYO-COP-34**	Digital Object Identifier field implementation in L1b and L2 COP
7.	**CRYO-COP-36**	Tai_utc_difference attribute to be updated
8.	**CRYO-COP-37**	Processing quality HR flag currently not set
9.	**CRYO-COP-44** **CRYO-COP-72** **CRYO-COP-73**	Baseline-C: PLRM/LRM biases (CMEMS) Baseline D: Biases on the SWH, sigma-0, SSHA and wind-speed
10.	**CRYO-COP-52**	Update to CFI V3.7.6 for IPF1/IPF2 (COP chain)
11.	**CRYO-COP-55**	COP IPF2: Mispointing angles for SAMOSA retracker
12.	**CRYO-COP-59**	Discrepancies between Ocean Baseline-C PHB and products
13.	**CRYO-COP-60**	COP STR PROC update to use new EE CFI
14.	**CRYO-COP-62**	COP failures due to a segmentation fault
15.	**CRYO-COP-68**	pole_tide_01 set to 0 in COP BLD
16.	**CRYO-COP-71**	P2P Ascending "wrong" flag
17.		
18.	**CRYO-COP-74**	SSB Computation
19.		
20.	**CRYO-COP-74**	SSB Computation
21.	**CRYO-COP-77**	Update in the SSHA computation to include non-equilibrium long period ocean tide and internal tide corrections
22.	**CRYO-COP-78** **CRYO-COP-81** **CRYO-COP-88**	Sarin range ocean
23.	**CRYO-COP-79**	Update of the geophysical model MSS from DTU15 to DTU21

		Update of the geophysical model MDT from CNES/CLS15 to CNES/CLS18
		Update of the geophysical model for the polar tide from Wahr85 to Desai 2015 with coefficient 2017
		Addition of the model for internal tide correction (Zaron 2019)
		Update of the surface type mask from 4-states to 7-states classification
		Update in the SSHA computation to include non-equilibrium long period ocean tide and internal tide corrections
		Update of the SAMOSA retracker from version 2.3 to version 2.5
24.	**CRYO-COP-86**	Missing reference attribute for new slope model added

6 BASELINE-D COP EVOLUTIONS RELEASED

This section includes a short desctiption of the implemented evolutions.

6.1 CRYO-IDE-344 COMPENSATION OF THE RANGE BIAS CONTRIBUTION DUE TO DATATION BIAS CORRECTION

In all the PreProcessors (LRM, SAR SARin) the following modifications are proposed to be implemented 1. Refinement of the datation bias computation 2. Compensation of the range bias contribution due to datation bias correction

Further compensation to be added for the k-th burst

window_delay(k) = window_delay(k)+flag*distance_s(k)*altitude_rate(k)*2/speed_of_light

where

→ window_delay(k) is the window delay for the k-th burst

→ flag is the flag read from the PCONF with value +1 or 0 or -1. Configuration value currently set is 1.

→ distance_s(k) is the projected distance antenna-COM from [4.2.3.3.4-3] in CS-TN-ACS-GS-5105

→ altitude_rate(k) is the altitude rate for the k-th burst → speed_of_light is the speed of light

6.1.1 Evidence of the evolution:

Window_delay for LRM/SAR/SARin L1B products includes correction.

6.2 CRYO-COP-3 METEO FIELDS SET TO DEFAULT OVER LAND & CONTINENTAL ICE

It has been observed that the Dry Tropospheric Correction (DTC), Wet Tropospheric Correction (WTC), Inverse Barometric (IB) correction and the U- and V-components of the model wind vector from the ECMWF models show nominal values over ocean and closed sea surface types, but no valid values are provided over land and continental ice.

This is due to Fes side effect. A correction has been implemented to skip fes activation on land and ice surface.

(It was expected a better behavior of a later FES version, but the upgrade of FES lib have not been implemented due to a non compatibility with used OS.

A FES upgraded would need an update of the VM, and maybe of the PDS platform.)

6.2.1 Evidence of the evolution

FES not applied over land and ice surface.

6.3 CRYO-COP-16 H2CORR-RELATED SSHA CROSSOVER BIAS

Analyses performed raised an interesting result regarding the LRM datasets. Indeed, the COR2 truncate evolution implemented in baseline-C processing made appear differences of -1 or +1 cm depending on the radial velocity sign. In average this correction has no impact on the LRM range since ascending and descending passes have an opposite sign for a given location. However, through the analysis of crossovers, it makes appear a pseudo time tag bias of 400us contained in the baseline-C dataset (that includes the COR2 correction).

A pattern on SWH and sigma0 at low radial velocity is introduced in baseline D with respect to baseline C. Since baseline D has a lower dependency between Delta (SWH) (SARM-PLRM) and PLRM SWH than baseline C, this confirms that the lower pseudo time tag bias on PLRM was already present in baseline C. This issue details a more generic issue already tracked in CRYO-COP-16.

6.3.1 Evidence of the evolution

Accounting for a correction of a pseudo time tag bias of 394us in the calculation of the baseline-C SSH, the error estimated at crossovers is strongly reduced and the map of differences at crossovers is more homogeneous.

6.4 CRYO-COP-28 INCORRECT PRODUCT_LOCATION IN L2 GOP PRODUCT

When plotting the latitude and longitude from the data file (fields: lat_01, lat_20_plrm_ku and lat_20_ku), we can see that continuous valid '1 Hz' values and '20 Hz plrm' values are provided, however the 20 Hz values do not continue to the end of the product (and are set to NaN). Perhaps where NaN values are encountered at the end of the product, the error value is set in the HDR files. Therefore, the problem may need to be addressed at a variable level as well as HDR level.

The equivalent L1B products have valid values in the HDR files.

This problem is an anomaly of the L2 COP SP, that seems to be due to a bad management of the case where the 20Hz HR measurements have no corresponding 1Hz measurement.

6.4.1 Evidence of the evolution

Product Location correct for the cases in which there is no corresponding 1 Hz measurement to 20 Hz measurement.

6.5 CRYO-COP-30 L1_PROCESSING_QUALITY MISMATCH BETWEEN VALUES IN DBL GLOBAL ATTRIBUTES AND HDR

This issue impacts P2P products

The l1b_processing_quality field reported in the global attributes section of the DBL product is not correct since it refers to the last L2 product processed (and included in the P2P). The value of this field in the HDR file is also incorrect as it is set to zero in all P2P products.

Furthermore the l1b_processing_quality should match between the HDR and the DBL.

6.5.1 Evidence of the evolution

L1_Processing_Quality is in agreement between netcdf product and corresponding HDR metadata file and is computed on the basis of all the

6.6 CRYO-COP-34 DIGITAL OBJECT IDENTIFIER FIELD IMPLEMENTATION IN L1B AND L2 COP

The COP L1b and L2 should foreseen a new field to store the DOI (Digital Object Identifier). This field should be implemented at global attributes level.

The description of the field could be “DOI (Digital Object Identifier)”

6.6.1 Evidence of the evolution

DOI information available in the netcdf product for all COP processors level.

6.7 CRYO-COP-36 TAI_UTC_DIFFERENCE ATTRIBUTE TO BE UPDATED

CRYO-COP-8 reports a number of discrepancies that were observed in the naming of fields and attributes in the Baseline-C COP products (.nc file) compared to the latest Product Format Specification documents.

Whilst the majority of these inconsistencies were amended and updated in the COP IPF1v3.6 & IPF2v3.8, a few outstanding inconsistencies remain.

In particular, the time variables in the Ocean products have an attribute for the tai_utc_difference.
It was confirmed that this value should be set to 37 and should be consistent between all time variables and all L1B and L2 products. The Product Format Specification (v3.3) has been correctly updated to 3.7.

6.7.1 Evidence of the evolution

Tai_utc_difference attribute correctly set in the COP L1B/L2 netcdf product

6.8 CRYO-COP-37 PROCESSING QUALITY HR FLAG CURRENTLY NOT SET

The l1b_processing_quality_hr field in the global attributes section of the netcdf file is currently set to zero in all L1B SAR and SARIn mode ocean products. As a result the l1b_proc_flag_hr is set to 1(=percentage of errors greater than threshold).

This is because the l1b_processing_quality_hr field is currently not set/used in the current release.

A modification is required to make available the l1b_processing_quality_hr in the OSAR and OSARIn chains. With this field implemented, the l1b_proc_flag_hr will be automatically in agreement.

6.8.1 Evidence of the evolution

l1b_processing_quality_hr field correctly filled in all COP products.

6.9 BASELINE-C/D: PLRM/LRM BIASES (CMEMS) (CRYO-COP-44/CRYO-COP-72/CRYO-COP-73)

This issue involves the analysis of:

•The stability of PLRM/LRM biases
•The impact to use the SAR processing instead of PLRM on these biases
•The amplitude of these biases on GOP product

Some analysis performed by CLS and presented at QWG 2021 was forwarded, but the user come back with some questions:

1. Concerning the SLA bias between LRM and PLRM currently used in CMEMS products: the temporal stability of this bias is not discussed however. It is possible to have more information about this point?
2. Concerning the SARM-PLRM SLA differences: the conclusions shows that these biases are SWH dependent, so surely varying with space and time. It seems that the amplitude of these biases can reach more than 4 cm in case of high SWH (> 4m) (slide #8). This is a limitation for SARM implementation in CMEMS. Is it possible to accurately correct these biases at ground segment level? Without knowing those bias we would have to cancel the switch on SAR mode.

NOC has been involved in the discussion.

UPDATE 10/06/2019 – Feedback to NOC from Matthias

For this diagnosis we used Operational COP baseline-C products from 8th of October 2017 to 13th of May 2018. This diagnosis is performed over the SARM Pacific box (you should shorten the box to its minimum size as the SARM mask changed). Then we compute SLA average as function of latitude steps (the larger the latitude bins are, the stronger is the noise reduction). On the North and South part of the patch your SLA is computed in LRM, inside the patch you compute SARM & P-LRM SLA. It allows having a precise estimation of the bias (noise is removed) between the different SIRAL mode.
An important thing is the choice of passes used to compute the SLA. You should select only the passes that entirely cross the SARM box. The following scheme explain the optimal and the wrong passes configurations: The blue box is the SARM pacific patch. Green passes are passes you should select, red passes should be removed because once averaged as function of latitude they will mix SARM and LRM measurements for latitudes ranged between lat_min_box and lat_max_box.

6.9.1 Evidence of the evolution

Correction on H2Cor, and for SAR SAMOSA v2.5, and SAMOSA mispointing anomaly in the **baseline D**.

Bias recomputed and took into account after the 1-Year generation and correction of the SSHA for SAR and SARin modes.

The biases were calculated taking as reference the mission Jason-2, in the Pacific SAR box.

The bias on the SWH and on the sig-0 are different from the one applied in the SSB calculation. All the biases are not visible/applied in the L2 products.

	LRM/SAR	PLRM/SAR	LRM/PLRM
SWH bias	-0.052	-0.087	0.034
Sigma-0 bias [dB]	0.159 dB	0.131 dB	0.028
SSHA bias [m]	-0.011	+0.001	-0.012
Wind speed [m/s]	-0.366	-0.358	-0.009

In addition, Figure 1 shows the Baseline-D ascending/descending SSH differences for PLRM data averaged in 2° by 2° grid. A clear North/South hemispheric pattern is visible with negative differences in the North and positive differences in the South. This kind of pattern is usually linked to a pseudo time tag bias in the dataset.

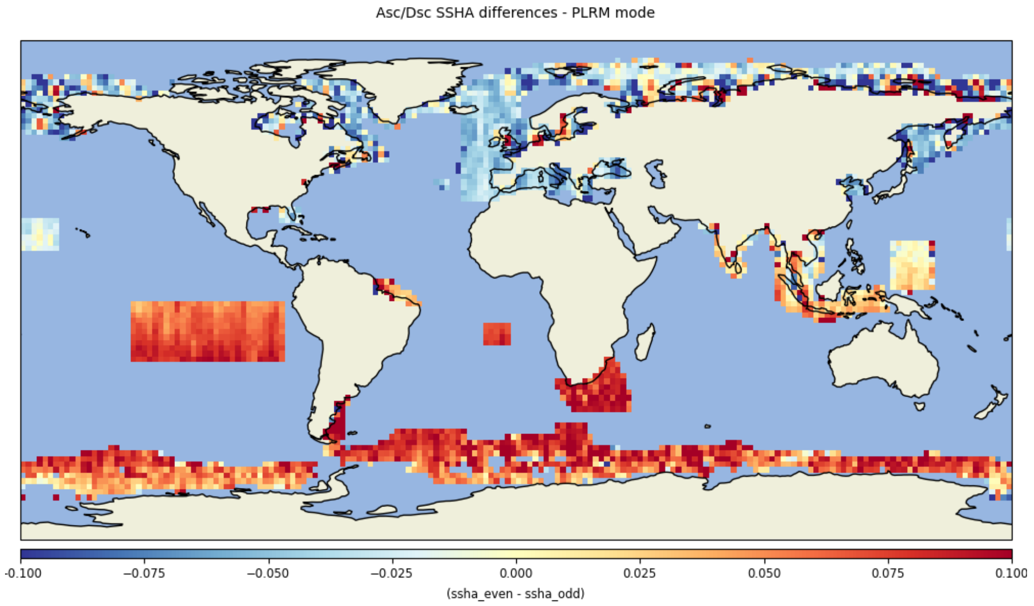


Figure 1: SSHA differences at the crossovers in the PLRM mode before compensation

Performing a linear regression between the radial velocity and SSH differences at crossovers we obtained a coefficient of 1800 μs. Correcting the SSH for this effect, the inconsistency between ascending and descending tracks is reduced, and the map of differences is more homogeneous, as shown in Figure 2.

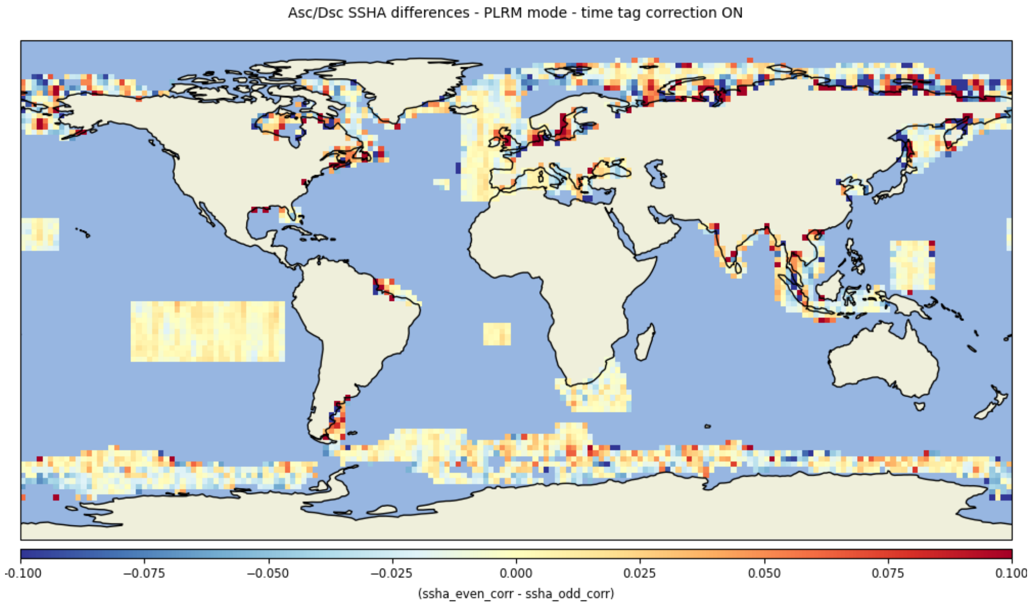


Figure 2: SSHA differences at the crossovers in the PLRM mode after compensation

The applied correction is computed using the following formula:

ssha_01_corrected = ssha_01 - 1800.E-6 * orb_alt_rate_01

The formula can be linked to the ticket CRYO-COP-73 “PLRM shows a large pseudo time tag bias”. but the investigation is still missing regarding this ticket.

6.10 CRYO-COP-52 UPDATE TO CFI V3.7.6 FOR IPF1/IPF2 (COP CHAIN)

The version of EECFI 3.7.6 has been integrated in both IPF1 and IPF2 and properly tested.

6.10.1 Evidence of the evolution

No specific evidence

6.11 CRYO-COP-55 COP IPF2: MISPOINTING ANGLES FOR SAMOSA RETRACKER

During the activities related to the calibration of the CryoSat interferometer, it has been verified that the accuracy of the mispointing angles (yaw, pitch and roll) provided in Baseline-C Level1b products, could be improved. As a consequence it has been decided to update the bias for roll and pitch that are compensated when the mispointing angles are computed. The Baseline-D incorporates these corrections by default.

6.11.1 Evidence of the evolution

No specific evidence

6.12 CRYO-COP-60 COP STR PROC UPDATE TO USE NEW EE CFI

The version of EECFI 3.7.6 has been integrated in COP_STR and properly tested.

6.12.1 Evidence of the evolution

No specific evidence.

6.13 CRYO-COP-62 COP FAILURES DUE TO A SEGMENTATION FAULT

From the analysis of COP failed jobs, it has been verified that Cryosat Satellite, sometimes, sends incorrect science datation, shifted ahead by 1 radar cycle. Thales confirmed this finding.

It has been decided to proceed fixing all the wrong datation in the L0 product, restoring the correct radar cycle, before the L1B product processing.

The correction involves:

- LRM L1 pre-processor: from L0 to L1B
- SAR/SARIN pre-processors: from L0 to FBR/L1B

6.13.1 Evidence of the evolution

FBR/L1B wrong datation corrected for the radar cycle. Before this fix, no products were available since the processing fails.

6.14 CRYO-COP-59 DISCREPANCIES BETWEEN OCEAN BASELINE-C PHB AND PRODUCTS

The discrepancies between the baseline C/D products and the Product Handbook have been checked and corrected.

6.14.1 Evidence of the evolution

PHB aligned to implementation. Applicable reference is version [OCE-PH]

6.15 CRYO-COP-71 P2P ASCENDING "WRONG" FLAG

For P2P products, it has been observed that the Ascending flag indicated in the product is sometimes in disagreement with effective ascending satellite direction.

This is because the reference value used to compute the ascending flag is the start time of the P2P product, which is, in some cases, slightly before the Pole transition.

The best way to compute it is to use the midle point of the product Pole to Pole.

6.15.1 Evidence of the evolution

Correct ascending flag value for the P2P products.

6.16 SAMOSA RETRACKER: UPDATE FROM V2.3 TO V2.5

The SAMOSA retracker has been updated from version 2.3 to version 2.5 to address range dependency issues with Significant Wave Height (SWH) (Dinardo et al., 2015).

6.16.1 Evidence of the evolution

Using validation TDS, Samosa implementation has been validated using comparison with v2.3 of Samosa. A final performance assessment has be performed on the 1-years of data generated by ESA.

During the validation phase, a memory leak was discovered in the SAMOSA retracker, which causes an unclear crash in the processing chain. This was fixed with CRYO-COP-70.

6.17 CRYO-COP-79 GEOPHYSICAL MODEL UPDATES FOR LEVEL 1 AND LEVEL 2:

6.17.1 MSS SOL1 FROM CNES/CLS15 to CNES/CLS22

The MSS sol1 has been updated to CNES/CLS22.

For instance, CryoSat-2 and SARAL/AltiKa data sampled at high frequencies were enhanced using a dedicated filtering process and corrected from oceanic variability using the results of the objective analysis of sea-level anomalies provided by DUACS multi-missions gridded sea-level anomalies fields (MSLA).

6.17.1.1 Evidence of the evolution

Update of the static auxiliary data corresponding to the MSS sol1.

6.17.2 MDT SOL1 FROM CNES/CLS15 to CNES/CLS22

The MDT CNES/CLS22 is now used as MDT sol 1 for the baseline D. This replaces CNES/CLS15. CNES/CLS22 includes major advance from the CNES/CLS15:

- An improved resolution from 1/4° to 1/8°
- New input model as MSS CNES-CLS22, GOCO05S geoid, optimal filter

6.17.2.1 Evidence of the evolution

Update of the static auxiliary data corresponding to the MDT sol1.

6.17.3 Update MSS SOL2 from DTU15 to DTU21

The MSS DTU21 is now used as MSS sol 2 for the baseline D. This replaces DTU15. DTU18 includes major advance from the DTU15:

- Use of Sentinel-3 data
- Use of an improved 7 years of CryoSat-2 data
- New processing chain and updated editing
- New data correction model as FES2014 as ocean tide model

6.17.3.1 Evidence of the evolution

Update of the static auxiliary data corresponding to the MSS sol2.

6.17.4 Update MDT SOL2 from DTU13 to DTU22

Initially, a new geodetic mean dynamic topography model DTU22MDT is derived using the new DTU21MSS mean sea surface. The DTU21MSS model has been derived by including re-tracked CRYOSAT-2 altimetry also, hence, increasing its resolution. Some issues in the Polar regions have been solved too. The geoid model was XGM2019e complete to d/o 2160. For more information, please refers to the ftp space of DTU.

6.17.4.1 Evidence of the evolution

Update of the static auxiliary data corresponding to the MDT sol2.

6.17.5 Update polar tide from Wahr85 to Desai 2015 with coefficient 2017 (CRYO-COP-68)

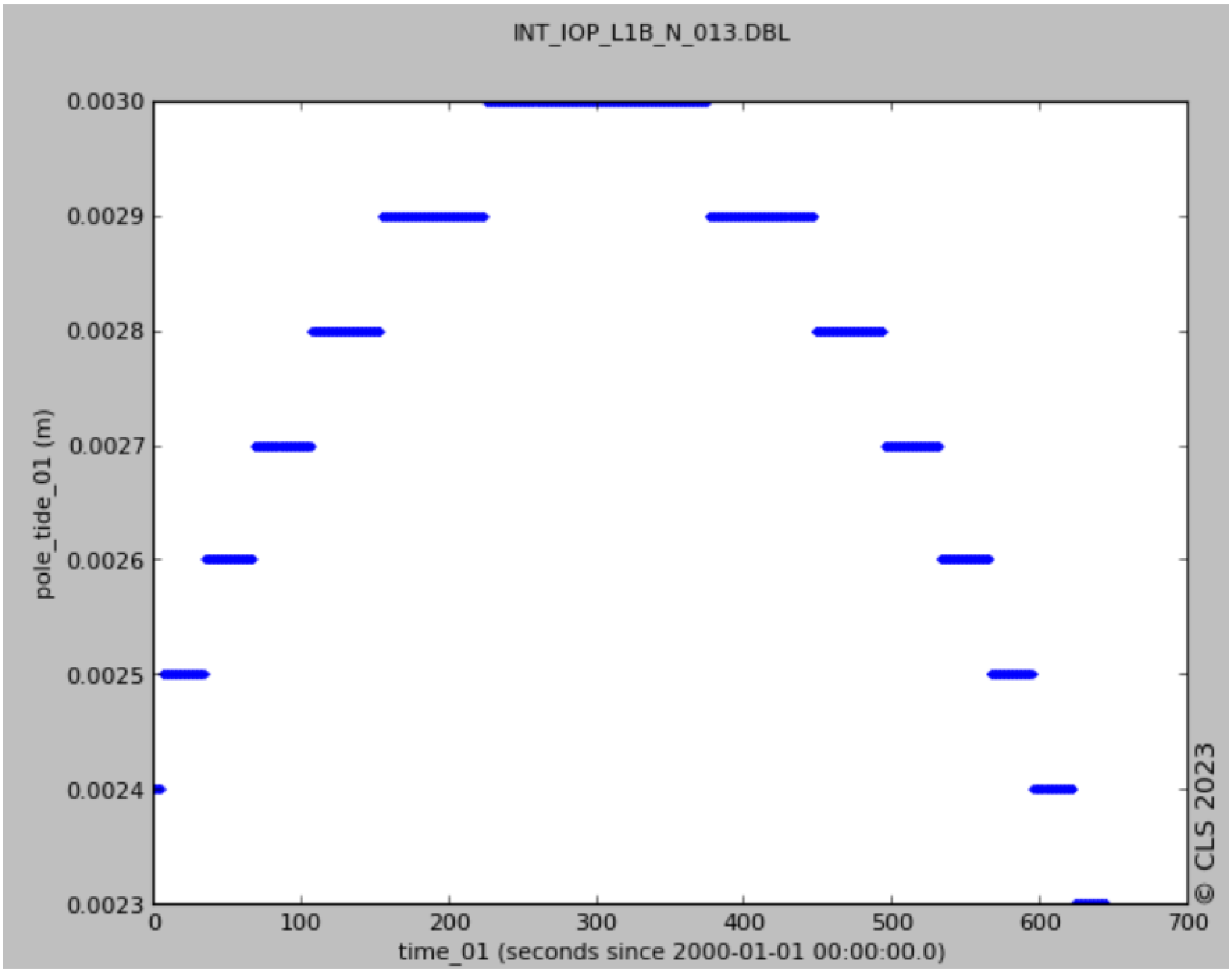
The pole tide model has been updated with DESAI 2015 model and 2017 coefficient. In a first moment, there was also the issue that the pole_tide_01 variable had values to 0. This was fixed before the Transfer to operation of baseline D.

Indeed, in the Test data set (TDS) of COP Baseline D it was noticed that for the pole tide correction has value of 0, whereas in the same TDS with Baseline C it was approximately equal to 0.003.

Furthermore, there are some inconsistencies in the Baseline-D PFS. From the L1B PFS of Baseline D, it was found that the scale factor was changed from 0.001 to 0.0001 (PFS). The L2 scale factor remains 0.001. In the L1B Product Format Specification (PFS), the source is "Wahr 1985 Deformation of the Earth induced by polar motion – J. Geophys. Res. (Solid Earth), 90, 9363-9368.", whereas in the L2 PFS the source has been updated and is "DESAI 2015 Coefficient 2017".

6.17.5.1 Evidence of the evolution

The pole tide correction assumes the expected values:



6.17.6 Addition of the model for internal tide correction (Zaron 2019)

The internal tide model has been implemented to be aligned with GDR-F standard. The variable on the internal tide model was added to the output products.

The Zaron (2019) model has be implemented.

6.17.6.1 Evidence of the evolution

New ADF for the internal tide correction and addition of a new variable in the output products.

6.17.7 Update of the surface type mask

The surface type mask has been upgraded with one issued from 7-states classification that has been implemented in the geo-CFI for the Ice chain

6.17.7.1 Evidence of the evolution

Update of the output variables.

6.17.8 Update of the SSB solutions (CRYO-COP-74)

Updated for both LRM/PLRM and SAR modes, specifically optimized for CryoSat-2. For SARin modes, no updates have been performed.

6.17.8.1.1 SSB COMPUTATION

Following the updated SAMOSA version (v2.5), a CalVal activity followed by a recomputation of SSB solutions have been performed by CLS, to update the SSB auxiliary data file for LRM/PLRM and SAR cases.

Two biases have been added in the processing chain.

- **A bias on the sigma-0** applied within the wind speed retrieval algorithm. The bias has been added in the processing chain since it was not foreseen until now. The bias application impacts the wind values and is visible in the L2 products. It has been determined for each mode (LRM, PLRM and SAR) to align the Cryosat's wind values to ERA5 estimations and helps also to provide more homogeneous wind speed estimations between these three datasets. For delivery 4.10 and 4.11, the bias value is not null for the LRM/PLRM cases. It was not found necessary in the SAR case; therefore, the value was set to 0 here.
- **A bias on SWH** has been included within the SSB computation step but its impact is not visible in the SWH L2 outputs. This bias has been added in the processing chain since it was not foreseen until now. Their values were estimated based on comparison between LRM, PLRM, SAR SWH and ERA5 SWH data to homogenize the different Cryosat's datasets between themselves for the SSB calculation purpose. This was done because the LRM SSB table mainly drives the two other SSB tables (for PLRM and SAR) and therefore the different SWH estimations need to be consistent between themselves as they are used as inputs for the different SSB computations. The SWH bias has an impact only on the SSB estimations and is not null only for SAR cases.

	LRM	PLRM	SAR
SWH bias	/	/	SWH – 0.0236 m
Sigma0-bias for wind speed [dB]	(s0+att) – 0.11 dB	(s0+att) – 0.14 dB	/
SSB model	LRM_2023	LRM_2023	SAR_2023

6.17.8.1.2 EVIDENCE OF THE EVOLUTION

To verify the consistency between the SSB computation done by the CLS SSB expert and the correct implementation of the biases in the source code and the correct update of the auxiliary files, two products were necessary.

The product CS_OPER_INT_GOP_2__20141230T112618_20141230T113720_0001_CLS_400.DBL has been used for the LRM verification, whereas for the PLRM/SAR cases, the product CS_OPER_INT_GOP_2__20141230T115037_20141230T115203_0001.DBL has been used.

From this short SAR TDS (CS_OPER_INT_GOP_2__20141230T115037_20141230T115203_0001.DBL), we can see very good agreement on Figure 3 and Figure 4 for the 2 SSB variables (sea_state_bias_01 and sea_state_bias_01_plrm_ku) between the SSB values (in meters) obtained by the source code of the delivery 4.1.1 (or 4.1.0) and the SSB values computed by the CLS expert. These differences are shown by the blue curve. The red one displays the differences between the updated SSB values and those computed with the model used in the reference delivery (4.0.0).

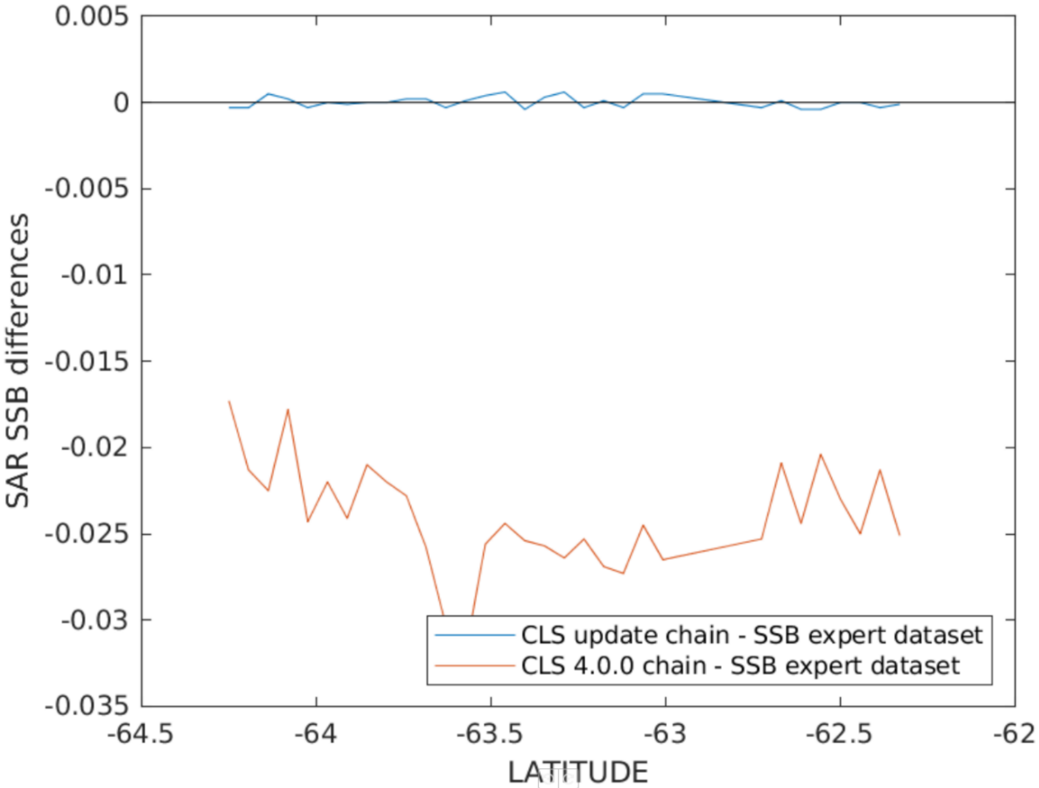


Figure 3: SAR SSB differences

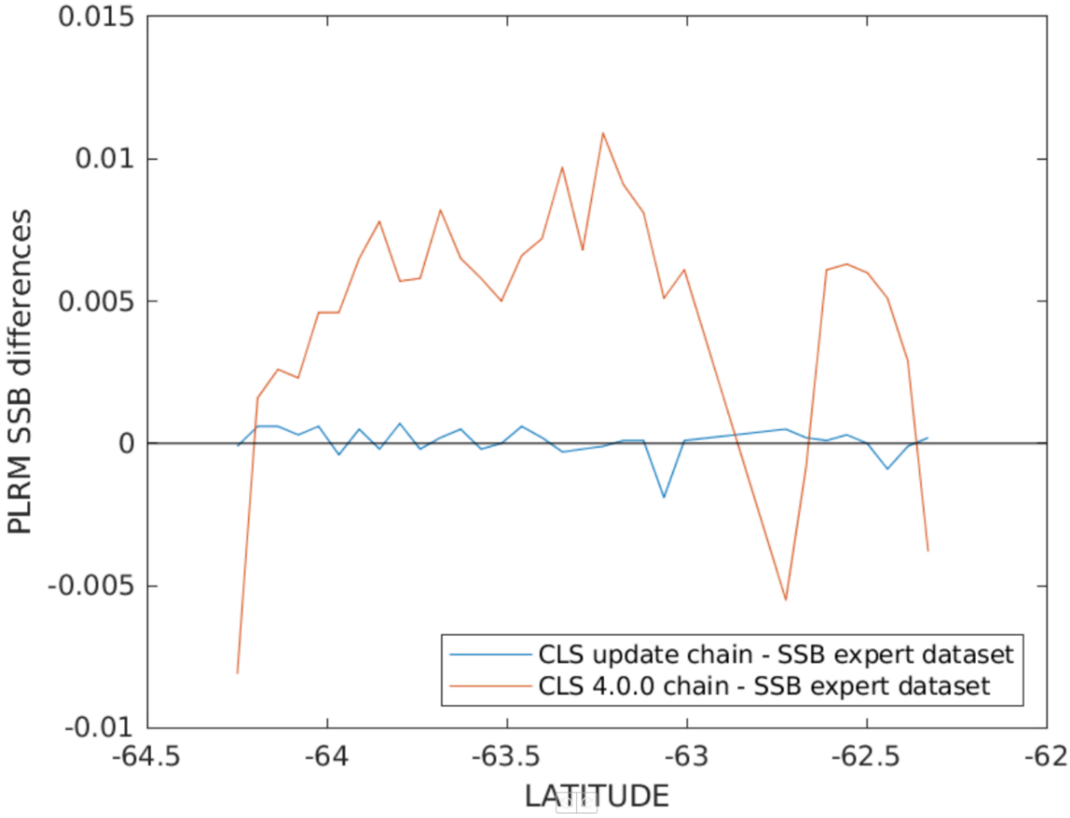


Figure 4: PRLM SSB differences

The same kind of plots is done for the LRM case (see Figure 5) on the LRM product CS_OPER_INT_GOP_2__20141230T112618_20141230T113720_0001_CLS_400.DBL

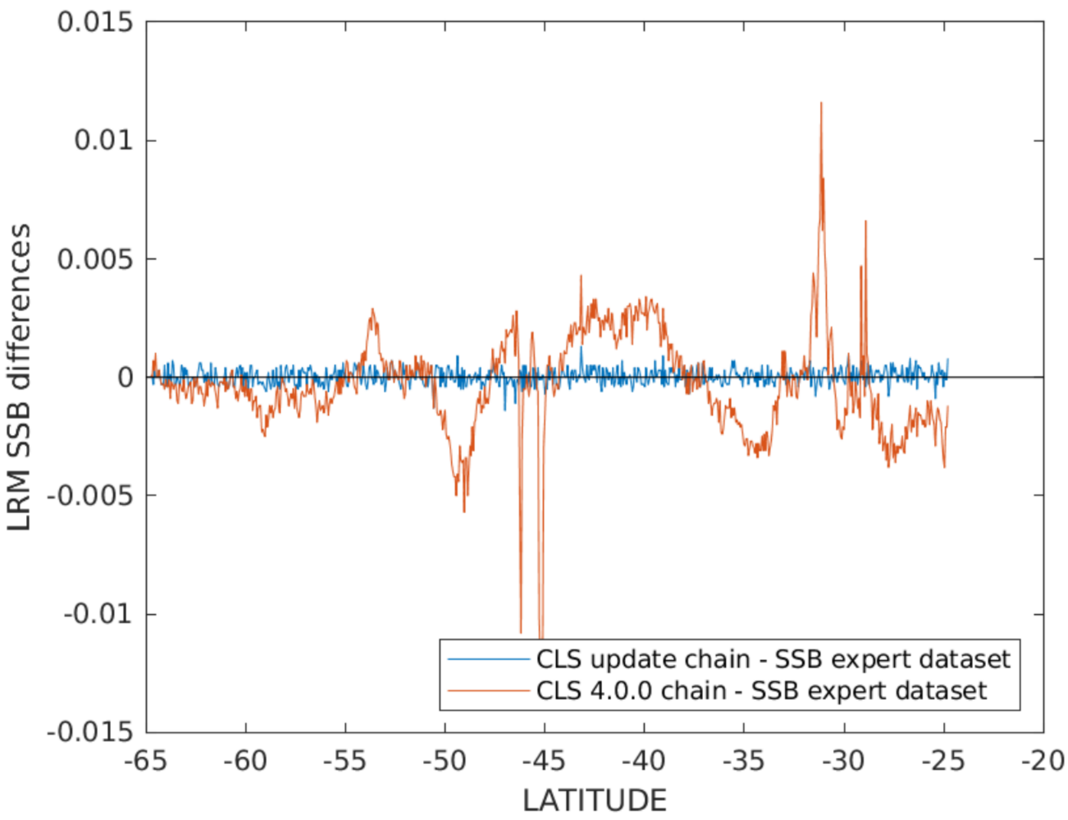


Figure 5: LRM SSB differences

For all cases, the SSB differences in blue show the very good agreement between the updated source code (4.1.0/4.1.1) with the computation performed by the CLS expert and validate the good implementation of the different changes in the processing.

Part of the ticket is also the update of the source field for the sea_state_bias_01* variables.

6.17.8.2 Evidence of the evolution

Update of the auxiliary data files in input of the processing, and impact on the ssb correction.

6.18 CRYO-COP-77 UPDATE IN THE SSHA COMPUTATION

Sea Surface Height Anomaly (SSHA) computation, by including non-equilibrium long period ocean tide (Carrere et al, 2016), internal tide (Zaron et al., 2016), and the Point of Closest Approach (POCA) slope correction (Sandwell et al, 2014) when available. The latter correction is applied only for LRM and PLRM modes.

The tickets included in the update are: CRYO-COP-68, CRYO-CROP-85, CRYO-COP-86, CRYO-CROP-90,

Furthermore, an anomaly has been detected in the calculation of the SSHA for SAR and SARin cases.

6.18.1 Evidence of the evolution

Update of the output variables.

6.19 SARIN RANGE OCEAN (CRYO-COP-78 AND CRYO-COP-81 AND CRYO-COP-88)

An important bias on the range_ocean variable for SARin scenarious has been detected during the QWG evaluation data baseline D (version 4.1.0). The bias has been resolved, and the range SARIn data are now aligned with adjacent range SAR, to have continuity between adjacent areas.

6.19.1 Evidence of the evolution

Plotting on a map Level 2 Pole to Pole products, no discontinuity can be observed between SARin and SAR data that are adjacent to them.