CRYOSAT Ground Segment
Instrument Processing Facility

Baseline E Evolutions
[BAS-E-EVO]

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Document Change Record

Issue /Rev.	**Class (R=Review /A=Approval)**	**Date**	**Reason for Change**	**Changed Pages/Paragraphs**
1.0	R	29/01/2021	First Release	All
2.0	A	26/07/2021	Issue after final Baseline E Processors release	Section 5: table updated to introduce ARs implemented since QWG#8 meeting. ARs not relevant to users have been removed. Section 6: content aligned with ARs in Section 5. Old ARs descriptions clarified Section 7 renamed to "Evolutions Postponed to Baseline F" Section 8 removed

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 Level 1b Processor Interface Control Document	CS-ID-ACS-GS-0116	[L1b-ICD]
CRYOSAT Ground Segment Payload Data Segment Level 2 Processor Interface Control Document	CS-ID-ACS-GS-0117	[L2-ICD]
CRYOSAT Ground Segment Payload Data Segment Level-0 Products Specification Format	CS-ID-ACS-GS-0119	[L0-FMT]
Cryosat Instrument Processing Facility L1b Level 1b product Formats Specification	CS-RS-ACS-GS-5106	[PROD-FMT]
Cryosat Instrument Processing Facility Ocean CONFORM Product Formats Specification	C2-RS-ACS-ESL-5266	[PFS-OCE]
Cryosat Instrument Processing Facility L1b Ice L1b CONFORM Product Formats Specification	C2-RS-ACS-ESL-5264	[PFS-I-L1b]
Cryosat Instrument Processing Facility L1b Ice L2 CONFORM Product Formats Specification	C2-RS-ACS-ESL-5265	[PFS-I-L2]
[DPM] - IPF1 Detailed Processing Model v5.3	CS-TN-ACS-GS-5105	[DPM]
Cryosat IPF_STR_PROC: Detailed Processing Model	CS-DD-ARS-GS-5003	[STR-DPM]

1.2 REFERENCE DOCUMENTS

Document Title	Identifier	Reference

2 DEFINITIONS AND ABBREVIATIONS

ACS	Advanced Computer Systems S.p.A.
ARTS	Anomaly Report Tracking System
ATP	Acceptance Test Plan and Procedures document
CFI	Customer Furnished Item
COM	Centre Of Mass
CONFORM	CryOsat Netcdf FORMat
COTS	Commercial Off The Shelf
EE	Earth Explorer
EO	Earth Observation
ESA	European Space Agency
FOS	CryoSat Ground Segment Flight Operation System
G/S	Ground Segment
GDR	Global Data Record
HW	Hardware
ICD	Interface Control Document
ID	IDentifier
I/O	Input/Output
IPF	Instrument Processing Facility
ISP	Instrument Source Packet
LE	Leading Edge of the waveform
LIRT	Land Ice ReTracker
NRT	Near Real Time
OO	Object Oriented
PCD	Product Confidence Data
PCONF	Processor Configuration File
PDS	CryoSat Ground Segment Payload Data Segment
QWG	Quality Working Group
SPR	Software Problem Report
SVVP	System Verification and Validation Plan
TBC	To Be Clarified
TBD	To Be Defined
USO	Ultra-Stable Oscillator
UTC	Universal Time Co-ordinates

3 DOCUMENT STRUCTURE

The document includes the following sections:

Section 4 – Introduction	Introduction to the whole document
Section 5 – General Overview	This section gives an overview of the CryoSat IPF1 & IPF2 ICE processors as well as a short introduction to the netCDF format
Section 6 – Baseline E Evolutions Released	This section describes the improvements and new features included in the ICE Baseline E processors
Section 7 – Evolutions Postponed to Baseline F	This section includes features which are still under development and which implementation has been postponed to Baseline F

4 INTRODUCTION

This document describes the evolutions and improvements implemented in the ICE Instrument Processing Facilities (IPF) at Baseline E.

4.1 PURPOSE AND SCOPE

The purpose of the document is to provide users with a clear list of the Baseline E evolutions affecting the quality of the products, to support the investigation of improvements and differences compared with the previous Baseline D release. Implemented evolutions are listed in section 6, while section 7 describes a few pending items which have been postponed to Baseline F. The evolutions are reported using the official ID with which they have been registered in the Anomaly Report Tracking System (ARTS) used for the CryoSat project (https://arts.esrin.esa.int/).

5 GENERAL OVERVIEW

All CryoSat Science Level 1 (L1) and Level 2 (L2) products are generated in NetCDF format and follow the conventions specified in the relevant CryoSat NetCDF format (CONFORM) documents, [PFS-I-L1b] and [PFS-I-L2], respectively. The Calibration and Monitoring products are still generated in Earth Explorer product format, which is specified in [PROD-FMT].

The L1 products are generated from the SIRAL instrument Level 0 data by the Instrument Processing Facility Level 1 (IPF1) processor. The algorithms are defined in [DPM]. The IPF1 processing chains generate five types of L1 products:

❐ **Level 1B (L1B)**

The L1B data is the main product output from the IPF1. In the case of SIRAL's SAR and SARIn acquisition modes, the L1B data are strongly compressed in size following the application of SAR/SARIn algorithms and multilook for speckle reduction.

❐ **Level 1B Calibration (CAL)**

CAL1 and CAL2 products also belong to the L1B class. CAL1 data are available for LRM, SAR and SARIn modes, while CAL2 data are available only for SAR and SARIn modes.

❐ **Full Bit Rate (FBR)**

The FBR product is an intermediate output before the L1B processing is completed. This is the highest processing stage reached before information compression occurs. In particular, the FBR data for SAR and SARIn modes still contain the echo data as complex numbers.

❐ **Monitoring (MON)**

Monitoring data is a systematic product aiming to provide timely information on the health of the instrument. It consists of a set of instrument parameters which may be produced rapidly and routinely starting from LRM/tracking (TRK) SIRAL data, SAR or SARIn data.

❐ **Level 1B Science Stack (L1B-S)**

L1B-S Stack products (in SAR/SARIn modes) provide detailed information about the waveform stack and might be useful to particular end users. This is considered an optional product.

The IPF1 generates the following products:

- **Level 1B Science Data (distributed to Users)**
  - LRM Level 1B generated and distributed in CONFORM
  - SAR Level 1B generated and distributed in CONFORM
  - SARIn Level 1B generated and distributed in CONFORM
  - SAR Level 1B Stack generated and distributed in CONFORM (optionally generated during reprocessing campaigns, not operationally)

- SARIn Level 1B Stack generated and distributed in CONFORM (optionally generated during reprocessing campaigns, not operationally)

- **FBR Science Data**
  - LRM FBR generated in Earth Explorer format, but no longer distributed to users
  - SAR FBR generated and distributed in CONFORM
  - SARIn FBR generated and distributed in CONFORM
- **Auxiliary Calibration Data**
  - CAL1 LRM generated and distributed in Earth Explorer format
  - CAL1 SAR generated and distributed in Earth Explorer format
  - CAL1 SARIn generated and distributed in Earth Explorer format
  - CAL2 SAR generated and distributed in Earth Explorer format
  - CAL2 SARIn generated and distributed in Earth Explorer format
  - Complex CAL1 SARIn generated and distributed in Earth Explorer format
- **Monitoring Products**
  - MON LRM/TRK generated and distributed in Earth Explorer format
  - MON SAR generated and distributed in Earth Explorer format
  - MON SARIn generated and distributed in Earth Explorer format

The IPF2 processor generates L2 products for each science mode (LRM, SAR and SARIn) from the corresponding L1B data. Additionally, a Global Data Record (GDR) product is generated by concatenating multi-mode L2 products between two consecutive ascending equator crossing nodes. The following products are distributed to users:

- **Level 2 Science Data (distributed to Users)**
  - LRM Level 2 generated and distributed in CONFORM
  - SAR Level 2 generated and distributed in CONFORM
  - SARIn Level 2 generated and distributed in CONFORM
  - GDR product generated and distributed in CONFORM
- **Level 2 In-Depth (L2I) Science Data (distributed to Users)**
  - LRM Level 2I generated and distributed in CONFORM
  - SAR Level 2I generated and distributed in CONFORM
  - SARIn Level 2I generated and distributed in CONFORM

A common format is defined for all the L2 products, independent of the SIRAL operational mode. A L2 product is generated soon after a L1B product is available, thus, resembling still a data driven approach. This implies that following this first generation step, there will be L2 products still separated by acquisition mode (LRM, SAR, SARIn) defined over the same time window of the L1B input.

The L2 product is the main output from the L2 processors and is distributed as a compact product, a format designed to minimise the data volume distributed to users. However, for all modes, another L2 product is available, called 'In-depth L2' (L2I) and identified with an 'I' in the filetype (e.g. SIR_xxxI2_). This product contains many more parameters and flags and is therefore much larger. This detailed product is required as the input to the second pass of the L2 SAR processing chain, where the sea surface height anomaly is interpolated to the location of all measurements identified as sea ice to allow the computation of freeboard.

The L2I products are sometimes referred to as the Intermediate products. This is an old terminology coming from the early phases of the CryoSat project and should not be used anymore.

The table below provides a summary of the evolutions included in the Baseline E release. Anomalies and evolutions are identified by an ARTS ID, the same identification code used in ESA's Anomaly Report Tracking System (ARTS) (https://arts.esrin.esa.int/).

	ARTS ID	Description
1.	**CRYO-IDE-344**	Baseline-E: Compensation of the range bias contribution due to datation bias correction
2.	**CRYO-IDE-339**	Update to EE-CFI V3.7.6 for IPF1/IPF2 (ICE and NRT chains)
3.	**CRYO-IDE-338**	Baseline-E: Filtering of outliers in SHA interpolation
4.	**CRYO-IDE-337**	Baseline-E: Interpolation of sea surface height anomaly across file boundaries and mode changes
5.	**CRYO-IDE-336**	Baseline-E: CryoSat Quaternion Product module for Star Tracker Processor
6.	**CRYO-IDE-358**	Baseline E quaternion product IRF. To be grouped with CRYO-IDE-336
7.	**CRYO-IDE-329**	Baseline-E: On ground mitigation of SIRAL datation
8.	**CRYO-IDE-328**	Baseline-E: Stack Zero Mask
9.	**CRYO-IDE-320**	Baseline-E: Instrument Range Correction Comments update
10.	**CRYO-IDE-311**	Baseline-E: Land Ice Retracker improvements
11.	**CRYO-IDE-310**	Baseline-E: Range field comments update
12.	**CRYO-IDE-309**	Baseline-E: 1 Hz WF Height field name update

13.	**CRYO-IDE-308**	Baseline-E: Window Delay Comment update
14.	**CRYO-IDE-306**	Baseline-E: SARIn Degraded processing
15.	**CRYO-IDE-305**	Baseline-E: SARIn ambiguity check flag bits
16.	**CRYO-IDE-303**	Baseline-E: adding PLRM @20Hz to ICE L1B products
17.	**CRYO-IDE-302**	Baseline-E: compression of netCDF
18.	**CRYO-IDE-301**	Baseline-E: adding variables lat_cor_01 lon_cor_01 to L1B products
19.	**CRYO-IDE-278**	New Snow Depth correction dedicated to sea-ice areas and land ice areas
20.	**CRYO-IDE-250**	Pseudo LRM Processing from SARIn Acquisition
21.	**CRYO-IDE-249**	New L1B-S Stack Product for CryoSat
22.	**CRYO-IDE-352**	Baseline-E: L1BS Attributes Correction. To be grouped with CRYO-IDE-249
23.	**CRYO-IDE-246**	Zero Mask for Surface Sample Stack characterisation
24.	**CRYO-IDE-226**	Missed quantized values in CAL1 SARIn Path Delay correction on Rx1
25.	**CRYO-IDE-224**	Outliers in CAL1 LRM Gain Variation Type2 corrections
26.	**CRYO-IDE-321**	Baseline-E: SAR mode peakiness scaling for non-sea-ice surfaces
27.	**CRYO-IDE-345**	Slope doppler correction for OCOG and LIRT
28.	**CRYO-IDE-346**	Backscatter power in Baseline D

6 BASELINE-E EVOLUTIONS RELEASED

This section includes a short desctiption of the evolutions implemented at Baseline E.

6.1 CRYO-IDE-344

6.1.1 Compensation of the range bias contribution due to datation bias correction

In the L1 Pre-Processors (LRM, SAR, SARIn) the following modifications are 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 Processor Configuration File (PCONF) with value +1 or 0 or -1. Configuration value currently set is 1.
- distance_s(k) is the projected distance between the antenna and the centre of mass (COM) from [Section 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

6.1.2 Evidence of the evolution:

The window_delay for LRM/SAR/SARIn FBR products now includes this correction.

6.2 CRYO-IDE-339

6.2.1 Update to CFI V3.7.6 for IPF1/IPF2 (ICE and NRT chains)

The updated Earth Explorer-CFI 3.7.6 software library has been integrated in both IPF1 and IPF2 and properly tested. This new version provides the ability for the processors to properly handle multiple DORIS Navigator Orbit files in NRT processing, which was limited in the previous library version.

6.2.2 Evidence of the evolution:

Successful handling of multiple DORIS Navigator Orbit files in NRT processing, thereby reducing the number of processing failures.

6.3 CRYO-IDE-338

6.3.1 Filtering of outliers in SHA interpolation

In Baseline D, the sea surface height anomaly was interpolated at all locations by performing a linear fit to all records discriminated as surface type 'lead' within a configurable radius of time from the central location. Outliers caused by retracking errors for complex waveforms, misdiscrimination of surface type, land contamination, and off-nadir leads would cause this fit to model the actual sea surface with less accuracy. For Baseline E, a pre-processing step of filtering outliers via sigma-clipping process with a configurable threshold was proposed and implemented. This will remove outliers before the fitting process is started. As there are more outliers with long range rather than short range, due to off-nadir leads, a small increase in the height of the interpolated sea surface height anomaly is expected.

6.3.2 Evidence of the evolution:

The interpolated surface height anomaly (SHA) in Baseline E passes more centrally through the cluster of lead SHA measurements at the start of the track. The overall track is generally smoother, as the sea surface would be expected to behave.

Preliminary tests using one month of data show an overall 13 millimeter reduction in freeboard height, due to an increase in height of the interpolated sea surface. When the change in freeboard height is median averaged onto a 25 km grid, the magnitude of the change appears to correlate with the thickness of the sea ice. In thicker regions, fewer lead records are detected and off-nadir leads have a greater impact upon the data, so filtering out these records will have a greater impact. Over thinner regions with plenty of lead detections, the interpolation was already of higher quality and so filtering has less of an effect.

6.4 CRYO-IDE-337

6.4.1 Interpolation of sea surface height anomaly across file boundaries and mode changes

In Baseline D, the interpolation of the sea surface height anomaly is performed on a per-file basis. This can introduce discontinuities in the interpolation at mode change boundaries. As an evolution for Baseline E an analysis was conducted to determine the best way forward to implement freeboard retrieval using continuous interpolation of the sea surface height anomaly across mode changes.

The final implementation chosen modified the SAR Pass B processor to add the capability to use adjacent files in different modes to extend the interpolation window. The implemented change impacts SAR Pass B and SARIn L2 processing chains in which, respectively, SARIn and SAR Pass A products adjacent to the processing window are needed in order to improve the interpolation of the sea surface height anomaly.

6.4.2 Evidence of the evolution:

The effect of the improvement is seen at the edges of individual files where the interpolation is now using data from adjacent files, reducing or removing discontinuites. It was also demonstrated that the change to the processing method has no impact in the middle of a file where the interpolation window is completely contained within data from that file.

6.5 CRYO-IDE-336

6.5.1 CryoSat Quaternion Product module for Star Tracker Processor

The Star Tracker processor has been updated to compute the attitude quaternions in the Geocentric Mean of 2000 Inertial Coordinate Frame for CryoSat starting from the mispointing angles in the Explorer Orbit-CFI Satellite Nominal Attitude Frame.

These attitude quaternions are written in a XML file to be distributed to users on request, since the quality of the product is currently being assessed by expert users. If a positive feedback is received, the products will be made available to the entire scientific community through the Science server.

The main features are:

- Quaternion products are optional, can be enabled using an input flag
- Quaternion products will contain the attitude angles as unit quaternions
- Only meaningful values are stored in the output product (zero values are filtered out)

6.5.2 Evidence of the evolution:

Generation of a new star tracker product named AUX_PROQUA, which includes quaternions.

6.6 CRYO-IDE-328

6.6.1 Stack Zero Mask

This variable is meant to be used by users developing physical retrackers: it contains the information of the zeroes in the stack to properly apply a mask during the retracking. Each element of the mask refers to a look in the stack and indicates the index of the first of the last sample set to zero. The elements of the mask can assume four different values:

a) FillValue: all the samples in the look are equal to zero;
b) 0: all the samples in the look are different from zero;
c) positive value: index of the first sample equal to zero;
d) negative value: opposite of index of the first sample different from zero.

The Specialised SAR/SARIn IPF1 was modified to

- Add new variable ***stack_mask_start_stop_20_ku***
- Compute the information to be written

- Add a PCONF flag to activate the module

6.6.2 Evidence of the evolution:

A new stack mask variable is now available in the SAR/SARIn L1B products.

6.7 CRYO-IDE-320

6.7.1 Instrument Range Correction Comments update

In Baseline D L1B/FBR products, the comment of all the variables related to "Instrument Range Corrections" says that the correction is 2-way while it is actually a 1-way correction.

This has been updated in all the related variables comments at Baseline E.

6.7.2 Evidence of the evolution:

The instrument range correction comments have been updated for L1B/FBR LRM/SAR/SARIn products.

6.8 CRYO-IDE-311

6.8.1 Land Ice Retracker improvements

At Baseline E a number of updates have been implemented to the LRM land ice retracking (LIRT):

- The LIRT code has been updated to use system-provided versions of library packages (which should be more robust in OS upgrades)
- The initialisation of LIRT retracker and filtering of results has been tuned
- The slope correction and slope doppler computation has been changed to use LIRT results (rather than the CFI results). As the LIRT generates more valid retracks than the CFI, this will increase the number of records that are slope corrected.

At Baseline E a number of updates have been implemented for SARIn land ice retracking:

- The unwrapping of phase values when initializing the phase fit.
- Change to the phase fit initialization removes a small number of spikes in height measurements. This may improve overall results, but tends to happen most in steep areas where results may then be flagged as ambiguous.

6.8.2 Evidence of the evolution:

Testing with a small dataset over Greenland shows small improvements in the mean and standard deviation of crossovers in LRM mode. For SARIn mode, a smaller improvement was observed, however the change is expected to impact only a small number of records with wrapping occurring in the windowed part of the phase waveform that is used for the fit.

6.9 CRYO-IDE-310

6.9.1 Range field comments update

In the Baseline D products, the comments of the range fields (range_1_20_ku, range_2_20_ku, range_3_20_ku) are inconsistent. Only the range_1_20_ku field contains the information that it "does not include geophysical corrections", whilst this information needs to be added to the comments for the range_2_20_ku and range_3_20_ku fields as well. This update has been implemented in the Baseline E products.

6.9.2 Evidence of the evolution:

The range field comments have been updated in the L2 products.

6.10 CRYO-IDE-309

6.10.1 1 Hz WF Height field name update

It is correct to provide the average waveform variables in the LRM products (variables have the suffix 'avg') because they contain real average information. However, in the case of the SAR/SARIn products, these variables contain pseudo LRM information, so it is more appropriate to rename them with the suffix 'PLRM'.

In Baseline D there is a single and shared format for the LRM/SAR/SARIn L1B product. However, the need to introduce PLRM variables for SAR and SARIn means that a shared format would leave many variables set to fillValue in LRM (all PLRM variables) and some variables set to fillValue in SAR/SARIn (avg variables).

Therefore, at Baseline E a new product format is introduced for LRM (with 'avg' varibales, but without 'PLRM' variables) and a separate product format is introduced for SAR/SARIn (with 'PLRM' variables, but without 'avg' variables).

6.10.2 Evidence of the evolution:

L1B LRM format:

- 1Hz average variables remain in the L1B LRM products only (identified by 'avg' in the variable name as they are in Baseline D)
- No 'PLRM' variables are included in the LRM L1B products

L1B SAR/SARIn format:

- 1Hz and 20Hz PLRM variables are introduced for SAR/SARIn only (identified by 'plrm' in the variable name)

- No 'avg' variables are included in the SAR/SARIn products

6.11 CRYO-IDE-308

6.11.1 Window Delay Comment update

The L1B Product Format Specification (PFS) states, for the Ultra-Stable Oscillator (USO) correction, that it is applied to the window delay (2-way) for L1B products. However, at Baseline D the L1B window delay field (window_del_20_ku) comment hasn't been updated to say that this includes the USO correction.

In the L1B product, the calibrated 2-way window delay (window_del_20_ku) field comment needs to be updated (in the products and PFS) to say that it now includes the correction for the USO (i.e. it should be updated to "it includes the USO correction and all range corrections given in the variable instr_cor_range_tx_rx for all the modes and in the variable instr_cor_range_rx for SARIn only"). This change has been implemented at Baseline E.

6.11.2 Evidence of the evolution:

In L1B products, the comment for the window delay has been updated to include the specific reference to the USO correction.

6.12 CRYO-IDE-306

6.12.1 SARIn Degraded processing

The SIRAL instrument has the ability to operate in SARIn Degraded (SID) mode when one of the two receiving antennas fails. Under these conditions, it is not possible to retrieve the phase information in the SARIn acquisition mode and instead the across-track angle computation is performed using a slope model.

In Baseline D, the PCONF section relevant to SID processing was not updated. At Baseline E the L2 PCONF should be updated with the following changes:

- An update of the window centre parameter for SARIn degraded mode (to 512)
- Addition of a new field for the peakiness factor (SARIn_peak_fact)

6.12.2 Evidence of the evolution:

The L2 PCONF SID parameters have been updated to allow SARIn degraded processing to operate in future if needed.

6.13 CRYO-IDE-305

6.13.1 SARIn ambiguity check flag bits

In Baseline D, the flag bits in the L2 field flag_prod_status_20_ku relating to the SARIn ambiguity check (surface_model_unavailable and sarin_height_ambiguous) were always set to zero. These bits are both expected to vary in SARIn data over Antarctica and Greenland. This affects only the L2 SARIn products and has been fixed at Baseline E.

6.13.2 Evidence of the evolution:

The L2 flag_prod_status_20_ku has been corrected. In the Baseline-E L2 SARIn products the flag bits relating to the SARIn ambiguity check (surface_model_unavailable and sarin_height_ambiguous) are now correctly set.

6.14 CRYO-IDE-303

6.14.1 Adding PLRM @20Hz to ICE L1B products

As an evolution at Baseline E, the Pseudo-LRM (PLRM) 20 Hz variables have been added to the L1B SAR/SARIn products.

6.14.2 Evidence of the evolution:

20 Hz PLRM variables are now available in the SAR/SARIn L1B products (variables labelled 'plrm').

6.15 CRYO-IDE-302

6.15.1 Compression of netCDF

As an evolution at Baseline E, a compression in the L1B and L2 NetCDF products has been added. A parameter to set the compression level has been added to the PCONF.

6.15.2 Evidence of the evolution:

At Baseline E, the L1B and L2 product size has been reduced.

6.16 CRYO-IDE-301

6.16.1 Adding variables lat_cor_01 and lon_cor_01 to L1B products

As an evolution at Baseline E, the lat_cor_01 and lon_cor_01 have been added to the L1B LRM, SAR and SARIn products. These variables provide the latitude and longitude measurements that correspond to the 1 Hz correction timestamp (time_cor_01).

6.16.2 Evidence of the evolution:

The lat_cor_01 and lon_cor_01 variables are now available in L1B products.

6.17 CRYO-IDE-278

6.17.1 New Snow Depth correction dedicated to sea-ice areas

The snow climatology model used in Baseline D (Warren) is seen by some as out of date. Additionally, in the Baseline-D processing, the snow depth is not used to apply a delay correction to the freeboard computation as there was no agreement on the relationship of the magnitude of the delay correction to snow depth at the time of previous baselines.

In Baseline E, a modification of the Warren snow depth according to the sea ice type has been implemented. The modified snow depth is masked by a geographic validity polygon and used to compute a delay correction to the height of the sea ice floe records (where the sea ice type is known only). The correction is provided in the L2 product so that users may apply it if desired. It is **not** applied in the L2 processing, and the parameter 'freeboard_20_ku' has been renamed as 'radar_freeboard_20_ku' to make it clearer to users which freeboard this parameter represents.

6.17.2 Evidence of the evolution:

Baseline-E L2 products now include the variable 'snow_depth_cor_20_ku', which contains snow depth corrections in L2 SAR and SARIn products over sea ice regions, where snow depth climatology is available. No snow depth climatology is currently available for the Antarctic.

Baseline-E L2I products now include flags indicating the sea ice type (flag_sea_ice_type_20_ku). Flags are determined by the input Dynamic Sea Ice Types files.

As requested by users, the snow depth correction is not applied to the 'freeboard_20_ku'. To make this clearer, the 'freeboard_20_ku' variable has been renamed to 'radar_freeboard_20_ku'.

Compensating for delay due to snow will increase height and therefore freeboard, more over multi-year ice than first-year ice types. This is observed in the test data, when 'snow_depth_cor_20_ku' is applied to 'radar_freeboard_20_ku'. The magnitude of the correction has been verified from the input parameters to the correction (modified snow depth) along a track of data.

6.18 CRYO-IDE-250

6.18.1 Pseudo LRM Processing from SARIn Acquisition

Covered by CRYO-IDE-303.

6.19 CRYO-IDE-249

6.19.1 New L1B-S Stack Product for CryoSat

At Baseline E, a new L1B-S Stack product has been defined. This will be generated only during reprocessing campaigns, not operationally.

6.19.2 Evidence of the evolution:

The Baseline E IPF1 processors are capable to generate, optionally, a new L1B-S Stack product. This product type is distributed to users only on demand.

6.20 CRYO-IDE-246

6.20.1 Zero Mask for Surface Sample Stack characterisation

Covered by CRYO-IDE-328

6.21 CRYO-IDE-226

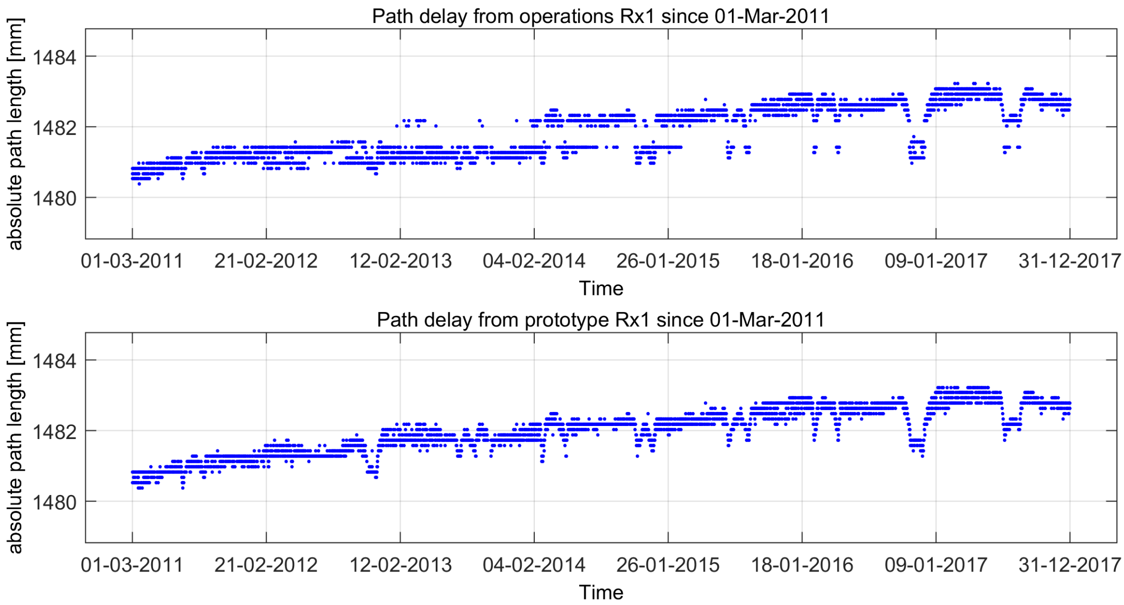
6.21.1 Missed quantized values in CAL1 SARIn Path Delay correction on Rx1

By analysis of internal path delay corrections for CAL1 SARin Rx1 in Baseline D it was noticed that some values were never assumed (top panel of figure below). This was verified to be due to implementation of the CAL1 processor.

At Baseline E, the CAL1 Processor has been modified and validated for the new polynomial fitting algorithm to locate the peak of the range impulse response. This evolution is expected to allow for a finer estimate of the internal path delay correction for all the SIRAL instrumental modes and in particular for SARin Receiving Chain 1, i.e. the transmit and receive channel.

6.21.2 Evidence of the evolution:

Missing quatization values are now produced with the new algorithm developed for Baseline E, as shown in the bottom panel of the following figure.



6.22 CRYO-IDE-224

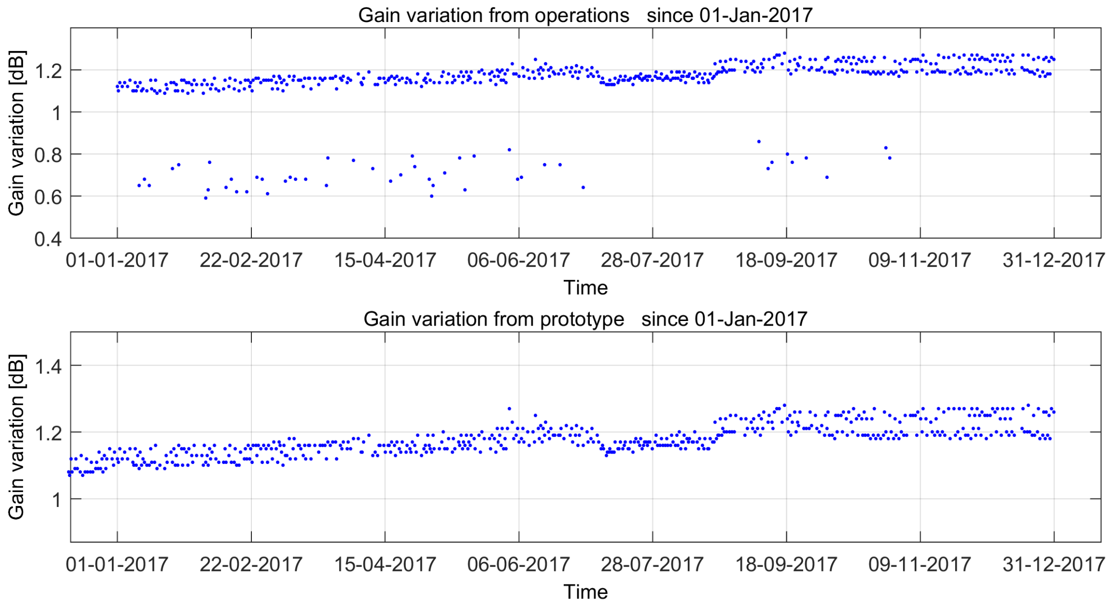
6.22.1 Outliers in CAL1 LRM Gain Variation Type2 corrections

At Baseline D, the gain variation correction in some of the CAL1 LRM products was out of scale. For this reason, those CAL1 products were invalidated not to be used in the operational processing.

At Baseline E, the CAL1 Processor has been modified and validated for the new polynomial fitting algorithm to locate the peak of the range impulse response. This evolution is expected to increase the frequency of valid CAL1 LRM products so that the L1 LRM products will be generated using up to date instrument calibration corrections.

6.22.2 Evidence of the evolution:

The following figure shows that with the implementation of this new algorithm at Baseline E the outliers in the gain varation correction from CAL1 LRM are no longer present.



6.23 CRYO-IDE-329

6.23.1 On ground mitigation of SIRAL datation

It is known that the burst datation in FBR is unstable, as the burst rate is not steady. This has no impact on the quality of the L1B products in the case of Delay/Doppler processing, but it does have an impact on Fully-Focussed SAR (FFSAR) processing. It was suggested that the on ground mitigation of SIRAL datation errors can be added to FBR data in order to support FFSAR processing.

At Baseline E, an algorithm has been designed by Aresys to mitigate the unsteady burst datation in FBR. This improvement is new in the Baseline E VO2.0 package release. Validation has been conducted with Aresys' support, using acquisitions over the Crete transponder.

A few considerations:

- Jitter in the SIRAL datation is observed since 2010 with negligible impact on the quality of the SAR/SARIn L1B products
- A new processing technique, FFSAR, improves along track resolution up to 0.5m, but this requires very accurate echoes datations
- FBR products to be used by scientific community by applying FFSAR processing
- L1B products not impacted by this improvement, FBR improved for datation mitigation (configurable)

Background:

- Each Radar Cycle (RC) is identified by a datation assigned by the SIRAL to the Instrument Source Packet
- Until the next measure, a Radar Cycle Interval (RCI) is added to the last known timestamp

- Both Burst Repetition Interval (BRI) and Radar Cycle Interval (RCI) are not an integer number of Fine Datation unit (FDU) -> observed on FBR data
- The rounding errors are summed up so that when the next PPS starts, the FDU counter is reset and a difference much larger than RCI is observed by analysis of the FBR products

The mitigation algorithm:

- reconstructs the correct datation of RCs (taking into account that also the RCI is not multiple of FDU)
- reconstructs the correct datation of Bursts (for SAR only, taking into account that also the BRI is not multiple of FDU and that in SAR mode there are 4 bursts for each RC)
- applies the USO correction to clock time (even if this correction has been verified to be negligible)
- Jitter detection is based on configurable threshold: in all the datation sequences, jitter are detected and corrected

In Baseline E, datation jumps compatible to the time jitter (due to the on-board rounding error) are detected and the new datation is re-computed on ground.

6.23.2 Evidence of the evolution:

At Baseline E, the FBR datation is now adjusted for jitter. Analysis of the along-track phase computed from the FBR product, shows that there are no longer jumps due to the unsteady burst datation.

6.24 CRYO-IDE-321

6.24.1 Baseline-E: SAR mode peakiness scaling for non-sea-ice surfaces

In Baseline D SAR mode over a non-ocean surfaces, the pulse peakiness is 10 times larger than its real value when packed into the netCDF file. For sea-ice surfaces (flagged as ocean) the value is correctly scaled. The issue is due to the peakiness being computed in two different places in the code. For ocean data, the discrimination algorithm runs and computes the peakiness as part of discrimination. For non-ocean data, there is a separate call to compute peakiness where the scale factor was not updated to match the units used in the CONFORM format. In Baseline E the issue has been corrected.

6.24.2 Evidence of the evolution:

In Baseline E, the pulse peakiness is correctly computed for both ocean and non-ocean surfaces.

6.25 CRYO-IDE-345

6.25.1 Slope doppler correction for OCOG and LIRT

MSSL conducted a code review of all of the land ice retrackers in Baseline D to determine areas to look at for improvements. During the review, they observed that the CFI retracker applies a correction to the height measurements for slope doppler, but that this correction is not currently applied to the OCOG and LIRT elevations. The correction uses the altitude rate at L1 to account for the difference between the vector to nadir and the vector to the POCA. This issue concerns L2 LRM products over surface type 'continental ice' only. This correction should be enabled for the LIRT and OCOG retrackers at Baseline E.

6.25.2 Evidence of the evolution:

At Baseline E, the slope Doppler correction is applied to the OCOG and LIRT retrackers in LRM mode. The correction magnitude is small, in the order of centimetres, but it brings a small improvement to the performance in LRM mode over Greenland and Antarctica (surface type 'continental ice') in the along-track direction or where the surface is steeply sloping.

6.26 CRYO-IDE-346

6.26.1 Backscatter power in Baseline-D

Several users have independently reported a variation over time in the difference in backscatter power of LRM waveforms between Baselines C and D (between 0.4 and 0.9 dB). The variations were observed both over the Antarctic ice sheet and over the ocean and neither of them appeared to be associated to a physical change in the surface.

The issue was identified to originate from an error in the power scaling factors in the L1B LRM data only. This caused the backscatter computed at L2 to differ between Baseline C and Baseline D. The issue has been solved in Baseline E.

6.26.2 Evidence of the evolution:

A 1-day TDS was generated using the Baseline E IPF1 and the LRM waveform power compared with that of Baseline C and D. The waveform power computed in Baseline E now agrees with the one from Baseline C, while both are different from the waveform power from Baseline D. This shows that the issue has been solved in Baseline E.

7 EVOLUTIONS POSTPONED TO BASELINE F

7.1 CRYO-IDE-257

7.1.1 New High Resolution tidal model over the Polar Oceans

The Arctic Ocean is a challenging region for tidal modelling, because of its complex and not well-documented bathymetry, combined with the intermittent presence of sea ice and the fact that the in situ tidal observations are rather scarce at such high latitudes. As a consequence, the accuracy of the global tidal models decreases by several centimetres in the Polar Regions.

Better knowledge of the tides would improve the quality of the sea surface heights derived from altimetry at high latitudes as well as the quality of all derived products, such as the a CryoSat-derived freeboard.

NOVELTIS and DTU Space have recently developed a regional, high-resolution tidal atlas in the Arctic Ocean, in the framework of an extension of the CryoSat Plus for Oceans (CP4O) project funded by ESA (STSE program).

This Tidal atlas might be used to improve the Freeboard retrieval, especially over polar shallow-water areas of the Arctic and Antarctic Oceans (where CryoSat is generally operating in SARIn mode).

NOVELTIS have stated that they would be willing to provide tidal corrections from their ArcTide model as an operational service, which would require these corrections to be ingested from a dynamic auxiliary file as part of the L1 processing. As an alternative, FES2014b would also improve the quality of the L2 results and could be implemented in the L1 processing without the requirement of adding a new dynamic auxiliary file.

This evolution was deferred from Baseline E to a future baseline due to the length of time required to determine how the ArcTide model (not publicly available) could be integrated into the processing.