BIOMASS L1a/b/c Products Format Specification

Ref: BIO-BPS-L1PFD-ARE-010076
Issue: 1.6.1
Date: 02/04/2026

Document information

Title	**BIOMASS L1a/b/c Products Format Specification**
Internal Ref.	
External Ref.	BIO-BPS-L1PFD-ARE-010076
Date	02/04/2026
Issue	1.6.1
Pages	142

Recipients	
Cristiano Lopes	ESA – ESRIN
Michele Caccia	ESA – ESRIN
Muriel Pinheiro	ESA – ESRIN

Prepared by	
Riccardo Piantanida	
Davide D'Aria	
Paolo Mazzucchelli	
Federico Boniardi	

Checked by	
Davide D'Aria	

Approved by	
Davide D'Aria	

Change history

Date	Issue	Change	Author
14/05/2021	1.0	First issue of the document	Riccardo Piantanida
28/06/2021	1.0.1	Post-SRR issue of the document: • SRR-034: Figure with product graphical representation added (Sec. 3) • SRR-035: Guideline section added (Sec. 3.1, 5.1) • SRR-036: Section renamed and expanded (Sec. 3.3, 5.2) • SRR-037: Product naming convention (high-level) added (Sec. 3.4, 5.3) • SRR-038: Fields added to SAR Image MDS (Sec. 4.2.1) • SRR-039: SCS-CAL products description added (Sec. 2, 3.2, 3.4) • SRR-040, SRR-158: References to GDAL libraries removed where not needed (all) • SRR-043: Tables formatting reviewed and improved (all) • SRR-044: List cardinalities justified (all) • SRR-045, SRR-162: References for datum description added (Sec. 4.3.1.16) • SRR-046: Polarimetric calibration section renamed (Sec. 4.3.1, 4.3.1.11.) • SRR-047: Polynomials update frequency clarified (all) • SRR-048: Height computation reference added (Sec. 4.3.2.3) • SRR-137: References to Google Earth removed (Sec. 3, 4.3.5) • SRR-150: References to launch date removed (Sec. 1.1) • SRR-151: Geolocation grids cardinality and accuracy described (Sec. 4.2.1) • SRR-152: SAR image MDS components ordering described (Sec. 4.2.1) • SRR-153: KML overlay replaced with KMZ one (Sec. 3, 4.3.5) • SRR-156: Typo in Dask library name corrected (Sec. 4.2.1) • SRR-157: SAR image MDS strip-related tags removed (Sec. 4.2.1) • SRR-159: Frame field description improved, productComposition moved to Acquisition information DSR (Sec. 4.3.1.1) • SRR-160: RangeTimeInterval field description improved (Sec. 4.3.1.2) • SRR-161: ValidityStartLine/ValidityStopLine fields removed, azimuthTime field description improved in polynomial annotations (all) • SRR-164: UTC time fields description improved (Sec. 4.3.1.16) • SRR-165: txPulseList field description improved (Sec. 4.3.1.3) • SRR-166: Range compression method field added (Sec. 4.3.1.5, 4.3.1.16) • SRR-167: Absolute calibration constant application clarified (Sec. 4.2.1, 4.3.1.10)	Riccardo Piantanida

<table>
<tr><th>Date</th><th>Issue</th><th>Change</th><th>Author</th></tr>
<tr><td></td><td></td><td>SRR-168: Incidence and elevation angles computation clarified (Sec. 4.3.2.3)
SRR-169: Formulas in LUTs description reviewed, cardinality better detailed (Sec. 4.3.2.3)</td><td></td></tr>
<tr><td>15/10/2021</td><td>1.1</td><td>PDR1 issue of the document
L1c Products Format Specification section completed (Sec. 5, 6)
Primitive and common types description section moved to Appendix (Sec. 7)
Solved several TBDs on L1a/b Products Format Specification:
Added SAR image MDS overviews details (Sec. 4.2.1)
Added LUT ADS compression details (Sec. 4.3.2)
Added LUT ADS sampling grid details (Sec. 4.3.2)
Added Quick-look ADS colour coding details (Sec. 4.3.4)
Added Overlay ADS KML description (Sec. 4.3.5)
Remaining SRR RIDs addressed:
SRR-038: noPixelValue field in Main and LUT ADS renamed noDataValue, to be better aligned with GDAL_NODATA tag in SAR image MDS (Sec. 4.3.1, 4.3.2)
SRR-044: Updated cardinality of internalCalibrationSequence (Sec. 4.3.1.6)
SRR-135: SAR image MDS compression strategy updated (Sec. 4.2.1)
SRR-155: MPH high-level summary added (Sec. 4.1)</td><td>Riccardo Piantanida</td></tr>
<tr><td>17/12/2021</td><td>1.1.1</td><td>Post-PDR1 issue of the document:
PDR1-106: SAR image MDS overviews levels updated (Sec.4.2.1)
PDR1-107: Colour coding scheme updated (Sec. 4.3.4)
PDR1-108: Various editorials fixed (ALL)
PDR1-109: Clarification about LUT down-sampling factors added (Sec. 4.3.2.3)
PDR1-110: Footprint coordinates convention clarified (Sec. 4.1, 4.3.1.2)
PDR1-112: dcValue type updated to double (Sec. 4.3.1.5)
PDR1-113: noDataValue type updated (Sec. 4.3.2.2)
PDR1-114: Master/slave images terminology replaced with primary/secondary one (Sec. 5, 6, 7)
PDR1-115: insarPreProcessingFlag meaning clarified (Sec. 6.3.3.1)
PDR1-116: Baseline errors annotations replaced with more generic ones (Sec. 6.3.3.3)
PDR1-118: meanBitRate meaning clarified (Sec. 4.3.1.3)
PDR1-120: missionPhaseID values updated, driftPhaseFlag added (Sec. 4.3.1.1)
PDR1-122: Figure and tables labels harmonized (ALL)</td><td>Riccardo Piantanida</td></tr>
<tr><td>23/03/2022</td><td>1.2</td><td>CDR1 issue of the document
DEM version specified as heightModelType attribute (Sec. 7.1.1)</td><td>Riccardo Piantanida</td></tr>
</table>

Date	Issue	Change	Author
		• PDR1-115: InSAR Pre-Processing step replaced by Range Spectral Filtering step (Sec. 6.3.3.1) • PDR1-116: Figure updated (Sec. 6.3.3.3) • PDR1-119: L1a/b Antenna pattern DSR section removed as currently empty; L1a/b and L1c Quality DSR sections filled (Sec. 4.3.1.13, 6.3.3.4)	
29/06/2022	1.2.1	Post-CDR1 issue of the document • Various (minor) updates to align document to latest issues of L1 and Stack ATBDs (ALL) • CDR1-191, CDR1-158: Parameters added to ionosphere correction DSR (Sec. 4.3.1.11) • CDR1-217, CDR1-175: Framing parameters definition updated to reflect latest ICD changes (Sec. 4.3.1.1, 7.1.1) • CDR1-176: RFI mitigation-related processing parameters aligned to AUX_PP1 ones (Sec. 4.3.1.5, 7.1.1) • CDR1-198, CDR1-159: Added the possibility to have 3 or 4 polarizations in the L1c product (Sec. 5, 4.2.1, 6.3.3.1, 7.1.1) • CDR1-161: Name and meaning of rangeSpectralFilteringFlag clarified (Sec. 6.3.3.1) • CDR1-162, CDR1-173: Quality thresholds taken from AUX_PP* files added to quality DSRs (Sec. 4.3.1.13, 6.3.3.4) • CDR1-177: L1c product RFI-related parameters reviewed and updated (Sec. 6.3.3, 6.3.4) • CDR1-178: Clarified meaning of shifts included in LUT ADS (Sec. 5) • CDR1-180: LUT ADS groundPhasesScreenQuality map kept as float to support potential future evolution (currently it can assume only 0 or 1 values) (Sec. 6.3.4) • CDR1-181: BIOMASS DTM added to height models list (Sec. 7.1.1) • CDR1-183: Added note on L1c LUT ADS sampling (Sec. 6.3.4) • CDR1-184: Added ionospheric corrections parameters useful for L1c processing (Sec. 4.3.1.11) • CDR1-185: Parameter slowIonosphereQuality added (Sec. 6.3.3.3) • CDR1-171: Broken links fixed (ALL) • CDR1-066: Quicklook generation procedure updated to have more homogeneous results (Sec. 4.3.4)	Riccardo Piantanida
13/03/2023	1.2.2	Post-FAT1 issue of the document • CDR1-249, BPSPDR2-83, BPSCDR2-27: Overall update of the document to ensure consistency with ATBDs and PFDs documents (ALL) • CDR1-158, CDR1-184: Added required quality flags (Sec. 4.3.1.11, 4.3.1.13, 4.3.2) • CDR1-172: Added up-to-date details on SAR image MDS and LUT ADS compression (Sec. 4.2.1, 4.3.2)	Riccardo Piantanida

Date	Issue	Change	Author
		• CDR1-174: Added details about SAR image MDS VRT file (Sec. 4.2.1) • CDR1-178: Added clarification on azimuthCoregistrationShifts (Sec. 6.3.4) • CDR1-228, BPSPDR2-31, BPSPDR2-84: List of geometric layers in LUT ADS reviewed and updated (Sec. 4.3.2, 6.3.4) • BPSPDR2-87: Polarizations enumerative extended (Sec. 7.1.1)	
31/07/2023	1.2.3	Post-FAT2 issue of the document • BPSCDR1-1: Added tag for MAX_Z_ERROR (Sec. 4.2.1) • BPSFAT2-19	Riccardo Piantanida
06/10/2023	1.2.4	Post-FAT2 issue of the document (associated to BPS V2.1.3) • Updated type of dataTakeID field (Sec. 4.3.1.1)	Riccardo Piantanida
17/11/2023	1.2.5	Post-FAT2 issue of the document (associated to BPS V2.1.4, 1st review) • Review of the document to specify units of measure where missing (ALL) • Reviewed description of LUT ADS (Sec. 4.3.2, 6.3.4)	Riccardo Piantanida Federico Boniardi
30/11/2023	1.2.6	Post-FAT2 issue of the document (associated to BPS V2.1.4, 2nd review) • Added clarifications to some coregistered image main ADS fields (Sec. 7.3.3) • Updated product types of some coregistered image main ADS fields (Sec. 7.3.3) • Update layerType and uomType enumerative (Sec. 7.1.1)	Riccardo Piantanida Federico Boniardi
10/12/2023	1.2.7	Post-FAT2 issue of the document (associated to BPS V2.1.4, 3rd review) • Corrected cardinality in Annotation LUT DSR (Sec. 4.3.1.14) • Removed noDataValueFloat and noDataValueBool in L1c LUTs (in favor of noDataValue) (Sec. 6.3.4.2)	Riccardo Piantanida Federico Boniardi
17/05/2024	1.2.8	Post-DeltaFAT2 issue of the document • BPS-221: PGA removed from autofocus methods (Sec. 4.3.1.5, 7.1.1) • BPS-437: VRT file removed for L1b products (Sec. 4, 4.2.1) • BPS-494: heightModel field description updated, heightModelUsedFlag field added (Sec. 4.3.1.12) • BPS-505: Updated L1 LUT description (Sec. 4.3.2) • BPS-541, BPSFAT2-144: extendedSwathProcessingFlag field added (Sec. 4.3.1.5) • New grids for of the stack LUTs (no longer configurable but instead defined by the subsampling step of the LUTs of the primary L1a frame) • Use 64-bit LUTs for Lat/Lon/Height and axes • Added missing “Temporal Baseline” to primaryImageSelectionInformationType and primaryImageSelectionMethodType • Added skpDecompositionIndex to staQualityParametersType	Riccardo Piantanida Federico Boniardi

Date	Issue	Change	Author
		• Added skpEstimationWindowSize to staProcessingParametersType • Added rangeSpectralFilteringFlag and polarizationUsed to staCoregistrationParametersType • Section 4.3.1.5 Tab.23 new annotation to flag extended swath processing (BPS-541)	
06/09/2024	1.2.9	FAT3 issue of the document • Updated L1a/b RFI mitigation section in main ADS, added new layers for RFI Frequency-Domain masks in LUT ADS (Sec. 4.3.1.7, 4.3.2) • Changed polarizationUsedForCalibration to polarisationUsedForCalibration (consistent use of US/UK English). • Added Sec. 4.3.1.13.1 and Sec. 6.3.3.4.1 (overallProductQualityIndex for L1 and Stack respectively)	Riccardo Piantanida Federico Boniardi
13/12/2024	1.3.0	Post-FAT3 issue of the document • Updated description and tables of the L1 and Stack *overallProductQualityIndex* (Sec. 4.3.1.13.1, 6.3.3.4.1) • Overall update of data types (ALL)	Riccardo Piantanida Federico Boniardi

07/03/2025	1.4.0	Post-FAT3 issue of the document
		• Overall review and update of L1a/b annotations, to remove unused fields (Sec. 4.3.1):
		  o aocsMode / aocsSubMode: removed
		  o rxGain: removed
		  o temperatureList: removed
		  o errorCounters: only two counters kept (numIspHeaderErrors, numIspMissing)
		  o rollAngleList: replaced by rollBias
		  o incidenceAngleList / elevationAngleList: removed
		  o qualityParameters: maxTimeGap / maxTimeGapThreshold removed
		• Fixed typo in L1a/b channel imbalance annotation (Sec. 4.3.1.10)
		• Added default L1a/b LUT compression level (Sec. 4.3.2)
		• Updated L1c annotations (DSRs and LUTs) to comply with new specs of SKP, IOB, and BAE
		• Phase-like parameters now expressed in radians instead of degrees (ALL)
			Riccardo Piantanida
			Federico Boniardi

30/04/2025	1.4.1	Post-FAT3 issue of the document • Fixing of residual issues on phase-like parameters conversion to radians instead of degrees (ALL) • rxGainList field added back to L1a/b annotations (Sec. 4.3.1.3) • Channel imbalance and transmit power tracking field updated (Sec. 4.3.1.6) • Updated computation of L1a/b overall product quality index (Sec. 4.3.1.13.1)	Riccardo Piantanida Federico Boniardi
13/05/2025	1.4.2	Launch issue of the document • KMZ overlay replaced with KML one (Sec. 3, 4.3.5, 5, 6.3.7)	Riccardo Piantanida

Date	Issue	Change	Author
			Federico Boniardi
30/05/2025	1.4.3	Post-launch issue of the document • Updated conventions used for L1a, L1b and L1c quick-looks generation (Sec. 4.3.4, 6.3.6)	Riccardo Piantanida Federico Boniardi
23/07/2025	1.4.4	Post-launch issue of the document (associated to BPS V4.0.0) • Overlay ADS integrated with additional metadata (Sec. 4.3.5) • Updated L1c product format (Sec. 6): ○ Updated LUT definition ○ Updated bitset of the overallProductQualityIndex ○ Updated staInSARParametersType ○ Fixed extra "s" in "PhasesScreen"	Riccardo Piantanida Federico Boniardi
28/11/2025	1.5.0	Post-launch issue of the document (associated to BPS V4.2.0) • Updated L1a/b main ADS RFI related annotations (Sec. 4.3.1.5, 4.3.1.7, 7) • Updated L1a/b overall product quality index to add DC fallback activation flag (Sec. 4.3.1.13.1) • Updated L1c product format (Sec. 6, 7): ○ Deprecate BIC annotations ○ Add annotations for InSAR calibration (PPR)	Riccardo Piantanida Federico Boniardi
23/01/2026	1.5.1	Post-launch issue of the document (associated to BPS V4.3.0) • Updated L1a/b overall product quality index to add geomagnetic equator crossing fallback activation flag (Sec. 4.3.1.13.1)	Riccardo Piantanida
13/03/2026	1.6.0	Post-launch issue of the document (associated to BPS V4.4.0) • Updated L1a/b product format (Sec. 4): ○ Foreseen the possibility to have 2 quick-looks for L1a product (Sec. 3) and updated naming convention (Sec. 3.4) and description (Sec. 4.3.4) ○ Added inOutBandPowerRatioList section (Sec. 4.3.1.4) ○ terrainSlope LUT replaced by rangeTerrainSlope and azimuthTerrainSlope ones (Sec. 4.3.2) • Updated L1c product format (Sec. 6): ○ Foreseen the possibility to have 2 quick-looks for L1c product (Sec. 5) and updated naming convention (Sec. 5.3) ○ Update L1c annotations with Multi-Squint Calibration annotations ○ Deprecate PPR-related annotations from L1c products ○ Deprecate *rangeSpectralFilteringFlag* from L1c product annotations ○ terrainSlope LUT replaced by rangeTerrainSlope and azimuthTerrainSlope ones (Sec. 4.3.2)	Riccardo Piantanida Federico Boniardi
02/04/2026	1.6.1	Post-launch issue of the document (associated to BPS V4.4.1) • Updated L1a/b product format (Sec. 4):	Riccardo Piantanida

Date	Issue	Change	Author
		◦ Fixed cardinality of dcEstimate and fmRateEstimate (Sec. 4.3.1.8) • Updated L1c product format (Sec. 5, 6): ◦ Fixed list of quick-look files in L1c products (Sec. 5, 6.3.6) ◦ Added coherence and interferogram LUTs (Sec. 5, 6.3.4) ◦ Fixed residual issue in Tab. 80 and 82 (Sec. 6.3.3.1, 6.3.3.4)	Federico Boniardi

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1. Introduction

1.1. Context

BIOMASS is ESA's 7th Earth Explorer mission. The purpose of the BIOMASS is to reduce the uncertainty in the worldwide spatial distribution and dynamics of forest biomass in order to improve current assessments and future projections of the global carbon cycle. This objective will be achieved by the implementation of a P-band SAR mission, providing global maps of forest biomass stocks, forest disturbance and growth.
The BIOMASS mission will also provide 3D views of forests through the "tomographic" phase and will also support additional science needs arising from the opportunity to explore the Earth for the first time with a P-band SAR system from space offering the possibility to "see" below the vegetated areas and in beneath bare soil or icy regions.

To achieve its challenging objectives, the BIOMASS mission requires a specific data processing strategy that combines different technologies at different processing level in order to generate the final Above Ground Biomass global map.

1.2. Scope of the document

The purpose of this document is to provide the "L1a/b/c Products Format Specification" for the BIOMASS Processing Suite (BPS) project.
This document is organized as follows:

- Section 2: Brief introduction about BPS and L1 products;
- Section 3: Overview of L1a/b products format;
- Section 4: Detailed description of L1a/b products format specifications;
- Section 5: Overview of L1c products format;
- Section 6: Detailed description of L1c products format specifications;
- Section 7 (Appendix): Detailed description of common products format specifications.

1.3. Acronyms

Acronym	Description
ADS	Annotation Data Set
ARESYS	Advanced Remote Sensing and Systems
BPS	BIOMASS Processing Suite
COG	Cloud Optimized GeoTIFF
DEM	Digital Elevation Model

Acronym	Description
DGM	Detected Ground-range Multi-looked
DSR	Data Set Record
L1a	Level-1a product
L1b	Level-1b product
L1c	Level-1c product
L1M	Level-1 Monitoring product
L1S	Level-1 Standard product
LUT	Look-Up Tables
MDS	Measurement Data Set
MPH	Main Product Header
NetCDF	Network Common Data Form
OGC	Open Geospatial Consortium
PARC	Polarimetric Active Radar Calibrator
RDS	Representation Data Set
SAR	Synthetic Aperture Radar
SCS	Single-look Complex Slant-range

1.4. Symbols and Variables

Acronym	Description
β^0	Beta-nought quantity
σ^0	Sigma-nought quantity
γ^0	Gamma-nought quantity

1.5. Applicable documents

[AD1] [L1_PFD] BIO-ESA-EOPG-EEGS-TN-0044, BIOMASS L1 Product Format Definition, I/R 2/0

[AD2] [PROD_NAMING] BIO-ESA-EOPG-EEGS-TN-0050, BIOMASS Products Naming Convention, I/R 2/4

[AD3] [MPH] BIO-ESA-EOPG-EEGS-TN-0051, BIOMASS Products - Main Product Header Definition, I/R 2/3

[AD4] [AUX_FMT] BIO-ESA-EOPG-EEGS-TN-0054, BIOMASS Auxiliary Product Format Definition, I/R 2/1/1

[AD5] PE-ID-ESA-GS-584, Earth Observation Mission Software File Format Specification, I/R 1/4

1.6. Reference documents

[RD1] Cloud Optimized GeoTIFF format, https://www.cogeo.org/

[RD2] GDAL library, https://gdal.org/

[RD3] GDAL library Wiki - Cloud Optimized GeoTIFF section, https://trac.osgeo.org/gdal/wiki/CloudOptimizedGeoTIFF#HowtoreaditwithGDAL

[RD4] LibTIFF - TIFF Library and Utilities, https://libtiff.gitlab.io/libtiff/

[RD5] TIFF format tags, https://www.loc.gov/preservation/digital/formats/content/tiff_tags.shtml

[RD6] Network Common Data Form (NetCDF) format, https://www.unidata.ucar.edu/software/netcdf/

[RD7] Well-Known Text representation of coordinate reference systems, https://www.iso.org/standard/63094.html

2. BPS and L1 Products Overview

BIOMASS is a fully polarimetric SAR mission with its radar instrument relying on a single imaging mode, being Stripmap (SM), declined into 3 different swaths (S1, S2, S3) to achieve the global coverage.

The Level-1 product family is composed by:

- Level-1a (L1a): Single-look Complex Slant (SCS) data, consisting of SAR focused complex data lying in the Zero-Doppler azimuth plane and in slant range geometric projection with all the necessary radiometric and geometric corrections;
- Level-1b (L1b): Detected Ground Multi-look (DGM) data, consisting of SAR focused detected data lying in the Zero-Doppler azimuth plane and in ground range geometric projection with all the necessary radiometric and geometric corrections;
- Level-1c (L1c): stack interferometric product (STA), consisting of co-registered and phase calibrated SCS products based for both TOM or INT sequences from the same swath and major cycle acquisitions.

The L1 product family is generated during routine phase by the BIOMASS Processors (i.e., L1 Processor for L1a and L1b products, STA Processor for L1c product) running in the operational processing environment which is part of the PDGS. For specific calibration purposes and for products acquired over transponder (PARC), it is possible to manually activate the generation of four additional L1a (SCS) products, indicated with the acronym SCS-CAL, each one keeping into account and compensating the delay introduced by the transponder for one of its four scattering responses (i.e., Gt1, Gt2, X and Y).

These products serve the BIOMASS primary and secondary objectives. The BIOMASS products and associated metadata definition is such that it allows the generation of higher-level products for known and unknown applications but also to support the verification and monitoring activities during the commissioning and routine phases.

All the L1 BIOMASS products are belonging to the following product category:

- Level-1 Standard products (L1S), that is the “complete” focused data. In other words, it contains all the data sets being measurement, annotation and representation.

while the L1a and L1c (i.e., all except L1b) belong also to another product category, being:

- Level-1 Monitoring product (L1M), that is the “light” product for monitoring purpose, that is derived from the L1S by removing the images component of the measurement data set.

BIOMASS acquires data-takes as long segment of several minutes. For practical reasons related to data volume all the L1 products are chopped to generate subsets of prefixed size, defined as frames, and lying on the L1 framing grid. Such chopping is the default production rule for the generated BIOMASS L1 products. However, there will be cases where the framing is not required and the L1 might be floating (i.e., not aligned to the L1 framing grid) and the framing is disabled, generating products long as the whole Data Take. The proposed L1 organisation is valid independent on whether or not the products' chopping into frames is applied or not.

In Sec. 3 an overview of L1a/b products format is provided, while its detailed description is included in Sec. 4. The same will be done for L1c products respectively in Sec. 5 and 0.

3. L1a/b Products Format Overview

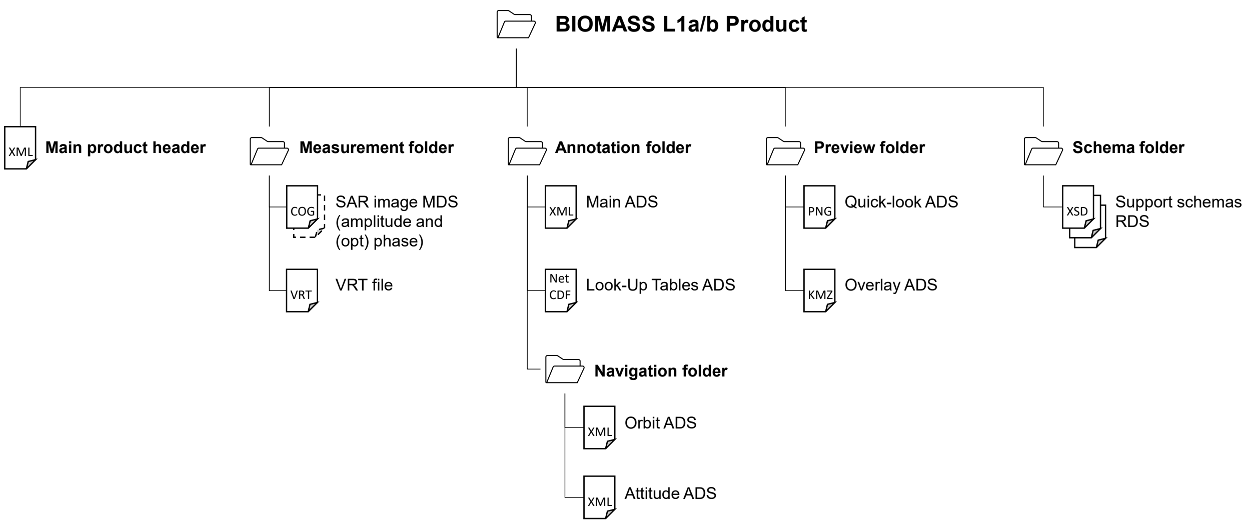
The BIOMASS L1a or L1b product is a folder containing a collection of information, grouped together into files referred to as data sets, and data sets are collected and grouped into several sub-folders in order to achieve a physical tree forming a complete product.

These products contain 3 kinds of datasets:

- the Measurement Data Sets (MDS), containing images derived from instrument data;
- the Annotation Data Sets (ADS), containing metadata that describes the properties and characteristics of the measurement data or how the measurement data was generated;
- the Representation Data Sets (RDS), containing information about the format or syntax of the measurement and annotation data sets and can be used to validate and exploit these data.

The declination and customisation of this format structure for BIOMASS L1a and L1b products is summarised in the following figure and table. In particular, a typical product contains:

- a main product header, an XML file including high-level information about the product origin, structure and main metadata (see Sec. 4.1);
- SAR image MDS, including the SAR image binary raster data for all the four BIOMASS polarisations, organised in two Cloud Optimized GeoTIFF (COG) files, one for amplitude and one for phase (only for L1a products) components (see Sec. 4.2);
- main annotation ADS, including the properties and characteristics of the measurement data or how the measurement data was generated, stored in a single XML file (see Sec. 4.3.1);
- Look-Up Table (LUT) ADS, including those metadata being too voluminous to be coded efficiently in an XML file (i.e., Look-Up Tables) and requiring a binary NetCDF file (see. Sec. 4.3.2);
- orbit and attitude ADS, including orbit and attitude information in dedicated XML files (see Sec. 4.3.3);
- quick-look and overlay ADS, including an averaged and decimated preview of the SAR image data set and information about its geographic coverage (see Sec. 4.3.4 and 4.3.5);
- XML schemas RDS, including the schemas needed for all the XML files included in the product.



L1a/b products structure

Fig 1

File / Folder	Cardinality	Format	Description / Content
BIOMASS L1a/b Product		Folder	
∟ main product header	1	XML	Main product header
∟ measurement		Folder	
∟ sar image	1 or 2	COG	SAR image MDS 2 files = 1 for amplitude + 1 for phase (only for L1a products) 4 components each (1 per polarization)
∟ sar image	0 or 1	VRT	SAR image MDS (support) Present only for L1a products
∟ annotation		Folder	
∟ main	1	XML	Main ADS, including: - Acquisition information DSR - SAR image DSR - Instrument parameters DSR - RAW data analysis DSR - Processing parameters DSR - Internal calibration DSR - RFI mitigation DSR - Doppler parameters DSR - Radiometric calibration DSR - Polarimetric distortion DSR - Ionosphere correction DSR - Geometry DSR - Quality DSR - Annotation LUT DSR
∟ lut	1	NetCDF	Look-Up Tables ADS, including: - RFI time-domain masks DSR (one per

			polarisation) - RFI frequency-domain masks DSR (one per polarisation) - Radiometric calibration DSR (sigma-nought and gamma-nought maps) - Ionosphere correction DSR (FR, phase screen, TEC, range and azimuth shifts and autofocus phase screen maps) - Denoising DSR (one per polarisation) - Geometry DSR (latitude/longitude/height maps, incidence and elevation angles maps)
∟ navigation		Folder	
∟ orbit	1	XML (EOF)	Orbit DSR
∟ attitude	1	XML (EOF)	Attitude DSR
∟ preview		Folder	
∟ quicklook	1 or 2	PNG	Quick-look ADS L1a can have 2 files (Pauli decomposition and HSV representation) or just 1 (selected between these two) L1b has 1 file (Lexicographic representation)
∟ overlay	1	KML	Overlay ADS
∟ schema		Folder	
∟ main annotation.xsd	1	XSD	RDS
∟ orbit.xsd	1	XSD	RDS
∟ attitude.xsd	1	XSD	RDS
∟ overlay.xsd	1	XSD	RDS
∟ common types.xsd	1	XSD	RDS

Tab.1 L1a/b products structure

3.1. Product format definition guidelines

The BIOMASS L1a/b products format here described has been defined following a set of guidelines and principles, being the main ones:

- follow a structure and an organization into datasets (MDS, ADS and RDS) already adopted with success in other SAR mission (Sentinel-1 above all) and already known to the users;
- rely on existing ESA conventions wherever possible (main product header OGC-compliant, orbit and attitude files in EOF format, …);

- rely on existing and known-to-the-users standards and formats (COG and NetCDF format for binary files, XML format and corresponding XSD schemas for annotation files, PNG and KML format for quick-looks and overlays, …).

Starting from this consolidated "background", several new features, aimed at improving in particular the products usability, have been introduced, in particular:

- the way SAR data are stored, with one COG file for amplitudes and one for phase values (with one component for each of the four data polarisation), differently from the standard approach based on real and imaginary parts. This choice presents a wide set of advantages for the users, as described in Sec. 4.2);
- only one file for all the annotations instead of one per polarization, reducing as much as possible information duplication and spreading into several positions;
- only one file for all the LUTs, reducing annotation file dimensions and easing their access, management and applicability to SAR data.

In the end, the L1a/b products format has been defined together with L1c one, following the same guidelines and trying to identify a structure that can be applied to both with the minimum changes, easing even more their access to the users.

3.2. Differences between L1a and L1b products

The structure described in the previous section is valid both for L1a and L1b products, with the following differences:

- SAR image MDS is composed by two files for L1a products (amplitude and phase components) and by just one file for L1b ones (amplitude component);
- Main ADS includes the same DSR for both L1a and L1b products, but some specific fields (e.g., rangeCoordinateConversion, …) will be filled only for L1a or L1b ones. Single cases are detailed in format specification, described in the next section.

Note that all L1a products share the same format, then both SCS and SCS-CAL ones. They can be distinguished through their product type, as defined in Sec. 3.4.

3.3. L1M products

As described above, L1M products are a "light" version of L1S ones, to be used for monitoring purposes.

It has to be noted that L1M products are generated by L1 processor in the same flow of L1S ones, without the need of specific processing. In addition, they are generated only alongside L1a and not L1b ones.

L1M products are identical to L1S ones except for SAR image MDS (and 'measurement' sub-folder), which is present only in L1S products.

3.4. Naming convention

The BIOMASS L1a/b product and all data sets files naming are addressed and described in details in [AD2].
Recalling the main points, the naming of the products directories is the following:

`<MMM>_<TTTTTTTTTT>_<yyyymmddThhmmss>_<YYYYMMDDTHHMMSS>_<P>_G<CC>_M<NN>_C<nn>_T<TTT>_F<FFF>_<BB>_<DDDDDD>`

where:

- `<MMM>`: Satellite ID;
- `<TTTTTTTTTT>`: Product Type/File Type, i.e.:
    - `S[1,2,3]_SCS__1S`: Stripmap L1 Single-look Complex Slant - Standard product;
    - `S[1,2,3]_SCS[1,2,X,Y]_1S`: Stripmap L1 Single-look Complex Slant Calibration (`1: Gt1, 2:Gt2, X, Y`) - Standard product;
    - `S[1,2,3]_DGM__1S`: Stripmap L1 Detected Ground Multi-look - Standard product;
    - `S[1,2,3]_SCS__1M`: Stripmap L1 Single-look Complex Slant - Monitoring Product;
- `<yyyymmddThhmmss>`: UTC start date and time (acquisition Zero Doppler Time);
- `<YYYYMMDDTHHMMSS>`: UTC stop date and time (acquisition Zero Doppler Time);
- `<P>`: Mission phase identifier;
- `<CC>`: Global Coverage identifier;
- `<NN>`: Major Cycle identifier;
- `<nn>`: Repeat Cycle identifier;
- `<TTT>`: Track number of the product;
- `<FFF>`: Frame/slice number of the product;
- `<BB>`: Baseline Identifier;
- `<DDDDDD>`: Compact creation date.

The internal files in the L1 product inherit the same naming convention, with the following changes:

- capital letters conversion to lowercase;
- “Baseline Identifier and “Compact Creation Date” naming parts removal, except for Main Product Header file;
- addition of a dataset type depending suffix and extension, i.e.:
    - `*.xml` for main product header;
    - `*_i_[abs,phase].tiff` for SAR image MDS;
    - `*_i.vrt` for VRT file;
    - `*_annot.xml` for main ADS;
    - `*_lut.nc` for Look-Up Tables ADS;
    - `*_orb.xml` for orbit ADS;
    - `*_att.xml` for attitude ADS;

- `*_ql_pauli.png` for quick-look ADS with Pauli decomposition;
- `*_ql_hsv.png` for quick-look ADS with HSV representation;
- `*_ql_lexicographic.png` for quick-look ADS with Lexicographic representation;
- `*_map.kml` for overlay ADS;
- `*.xsd` for support schemas RDS.

4. L1a/b Products Format Specification

4.1. Main product header

The Main Product Header (MPH) is an XML file present in all the BIOMASS L1 products. BIOMASS L1 products are folder based and the MPH is top level leaf of the product tree.

The MPH main scope is to provide all the information related to the:

- Genesis of the product;
- Identification of the product for example for cataloguing purposes;
- Product consistency (filesize).

For the detailed description of the MPH content and format refer to [AD3]. Here just a schematic representation is reported.

```
bio:EarthObservation Root element of metadata representation tailored for BIOMASS SAR products
    om:phenomenonTime Time coverage of the product
        gml:TimePeriod Time coverage of the product as a period
            gml:beginPosition Start date and time of the product
            gml:endPosition Stop date and time of the product
    om:resultTime Time when the sensing data has become available
        gml:TimeInstant Identifiable position in time
            gml:timePosition Date and time of data availability
    om:validTime Time validity of the product
        gml:TimePeriod Time validity of the product as a period
            gml:beginPosition Validity start date and time of the product
            gml:endPosition Validity stop date and time of the product
    om:procedure Procedure used to sense the data
        eop:EarthObservationEquipment Equipment used to sense the data
            eop:platform Platform description
                eop:Platform Nested element for platform description
                    eop:shortName Satellite name
            eop:instrument Instrument description
                eop:Instrument Nested element for instrument description
                    eop:shortName Sensor name
            eop:sensor Sensor description
                eop:Sensor Nested element for sensor description
                    eop:sensorType Sensor type
                    eop:operationalMode Sensor operational mode
                    eop:swathIdentifier Swath identifier
            eop:acquisitionParameters Acquisition parameters
                bio:Acquisition Acquisition description
                    eop:orbitNumber Acquisition orbit number (orbit start)
                    eop:lastOrbitNumber Last orbit number (orbit stop)
                    eop:orbitDirection Orbit direction
                    eop:wrsLongitudeGrid Track number
                    eop:wrsLatitudeGrid Frame number
                    eop:ascendingNodeDate Date and time of ANX
                    eop:startTimeFromAscendingNode Start time from ANX
                    eop:completionTimeFromAscendingNode Stop time from ANX
                    sar:polarisationMode SAR Polarisation mode
                    sar:polarisationChannels SAR Polarisation channels
```

sar:antennaLookDirection SAR antenna look direction
bio:missionPhase BIOMASS mission phase
bio:instrumentConfID BIOMASS instrument configuration identifier
bio:dataTakeID BIOMASS data take identifier
bio:orbitDriftFlag BIOMASS orbit drift flag
bio:globalCoverageID BIOMASS global coverage identifier
bio:majorCycleID BIOMASS major cycle identifier
bio:repeatCycleID BIOMASS repeat cycle identifier
om:observedProperty Observed property (empty)
om:featureOfInterest Observed area
eop:Footprint Footprint description
eop:multiExtentOf Footprint representation structure, coordinates in posList
gml:MultiSurface
gml:surfaceMember
gml:Polygon
gml:exterior
gml:LinearRing
gml:posList Footprint points, i.e. 4 corner coordinates of the scene starting with the first-right in flight direction and proceeding CCW (first point to be added as fifth point to close the polygon)
eop:centerOf Acquisition centre representation structure
gml:Point
gml:pos Coordinates of the centre of the acquisition
om:result Observation result
eop:EarthObservationResult
eop:browse
eop:BrowseInformation
eop:type Browse type
eop:referenceSystemIdentifier Coordinate reference system name
eop:fileName
ows:ServiceReference Browse Image filename
ows:RequestMessage download request (empty)
eop:product
bio:ProductInformation
eop:fileName
ows:ServiceReference Product filename
ows:RequestMessage download request (empty)
eop:version Product baseline
eop:product (list)
bio:ProductInformation
eop:fileName
ows:ServiceReference Product filename (internal files)
ows:RequestMessage download request (empty)
eop:size Product size
bio:rds Representation data file related to xml product
eop:metaDataProperty Observation metadata
bio:EarthObservationMetaData
eop:identifier Product identifier
eop:doi Digital Object Identifier
eop:acquisitionType Type of acquisition
eop:productType Product type
eop:status Status of the product
eop:downlinkedTo Downlink information
eop:DownlinkInformation
eop:acquisitionStation Acquisition station
eop:acquisitionDate Downlink date time
eop:processing Data processing information
bio:ProcessingInformation
eop:processingCenter Processing centre

eop:processingDate Processing date and time
eop:processorName Processor name
eop:processorVersion Processor version
eop:processingLevel Processing level
eop:auxiliaryDataSetFileName Auxiliary DS file name
eop:processingMode File Class
bio:sourceProduct BIOMASS source product identifier
bio:TAI-UTC Difference between TAI and UTC times of product
bio:numOfTFs Number of transfer frames
bio:numOfTFsWithErrors Number of transfer frames with errors
bio:numOfCorruptedTFs Number of corrupted transfer frames
bio:numOfISPs Number of instrument source packets
bio:numOfISPsWithErrors Number of instrument source packets with errors
bio:numOfCorruptedISPs Number of corrupted instrument source packets
bio:numOfLines Number of L0 lines
bio:numOfMissingLines Number of L0 missing lines
bio:numOfCorruptedLines Number of L0 corrupted lines
bio:incompleteSlice Incomplete L0 slice flag
bio:partialSlice Partial L0 slice flag
bio:framesList List of L1 frames contained in L0
bio:incompleteFrame Incomplete L1 frame flag
bio:partialFrame Partial L1 frame flag
bio:refDoc Reference document

Main product header (metadata schematic representation)

Fig.2

4.2. Measurement data sets (MDS)

4.2.1. SAR image MDS

The SAR image MDS is used to store the SAR image binary raster data as generated by the L1 processor for all the foreseen BIOMASS data polarisations (HH, HV, VH, VV).

The format used to store the SAR image MDS is the Cloud Optimized GeoTIFF [RD1].

A Cloud Optimized GeoTIFF (COG) is a regular GeoTIFF file, aimed at being hosted on a HTTP file server, with an internal organization that enables more efficient workflows on the cloud. It does this by leveraging the ability of clients issuing HTTP GET range requests to ask for just the parts of a file they need.

The COG format is natively supported by GDAL library [RD2][RD3] and by libraries and tools based on GDAL library (Dask and Rasterio packages for Python, …).

Differently from other SAR missions (and from the standard way of storing SAR data), for the BIOMASS mission SAR data are stored separating amplitude and phase values of each pixel instead of its real and imaginary parts. In particular, the SAR image MDS will be composed by two files:

- one COG file with the amplitude values (square root of beta-nought quantity, absolute calibration constant applied, linear scale) of each pixel;
- one COG file with the phase values (radians) of each pixel.

For both the files, four separated components will be used, one for each BIOMASS data polarisation in lexicographic order (i.e., HH, HV, VH, VV). It must be noted that all the four polarisations of BIOMASS L1 products will be sampled over the same sampling grid, allowing an easy access through the different components.

Obviously for L1b products (DGM) only the first file with the amplitude values will be included in the product, being the data already detected and not complex.

The main rationale behind this choice stands in the products usability. Amplitude and phase representation has in fact several advantages from the users' point of view:

- ease image visualization on a map, either using a data browser on a cloud computing platform or through a GIS software on a local PC, and the generation of overviews;
- run applications that exploit the amplitude only;
- run fast workflows on a cloud computing platform on a custom subset of data;
- speed-up applications working on all the polarisations together;

and more.

Compression strategy

The separation of amplitude and phase parts allows to introduce with benefit a set of different strategies for data compression. Making use of native LibTIFF libraries capabilities [RD4], it is possible to adopt:

- 32bits/pixel + GeoTIFF LERC_ZSTD compression (MAX_Z_ERROR=0.0001) for amplitude part;
- 32bits/pixel + GeoTIFF LERC_ZSTD compression (MAX_Z_ERROR=0.001) for phase part.

This approach will allow to achieve a considerable compression factor (~2x with an error of 0.06dB on amplitude @-37dB and of 0.001rad / 0.0572deg on phase).

VRT – GDAL Virtual Format

The VRT driver is a format driver for GDAL that allows a virtual GDAL dataset to be composed from other GDAL datasets with repositioning, and algorithms potentially applied as well as various kinds of metadata altered or added.

For the sake of "retro-compatibility" and to ease the management of BIOMASS data by those SAR processing applications designed to work on real and imaginary parts, it is foreseen to include in BIOMASS L1a products a VRT file (XML format). The scope is to describe how to pass from the amplitude and phase representation (stored on disk) to the real and imaginary parts one. VRT files are natively managed by GDAL library allowing to perform this transcoding on-the-fly directly during the access to the data stored on disk, so that the whole process is transparent for the user.

Here below a sample VRT file is reported:


```
<<?xml version="1.0" encoding="utf-8"?>
<VRTDataset rasterXSize="1380" rasterYSize="21265">
  <GCPList Projection="GEOGCRS[&quot;WGS 84&quot;,ENSEMBLE[&quot;World Geodetic System 1984
ensemble&quot;,MEMBER[&quot;World Geodetic System 1984 (Transit)&quot;],MEMBER[&quot;World Geodetic System
1984 (G730)&quot;],MEMBER[&quot;World Geodetic System 1984 (G873)&quot;],MEMBER[&quot;World Geodetic System
1984 (G1150)&quot;],MEMBER[&quot;World Geodetic System 1984 (G1674)&quot;],MEMBER[&quot;World Geodetic System
1984 (G1762)&quot;],MEMBER[&quot;World Geodetic System 1984 (G2139)&quot;],ELLIPSOID[&quot;WGS
84&quot;,6378137,298.257223563,LENGTHUNIT[&quot;metre&quot;,1]],ENSEMBLEACCURACY[2.0]],PRIMEM[&quot;Gree
nwich&quot;,0,ANGLEUNIT[&quot;degree&quot;,0.0174532925199433]],CS[ellipsoidal,3],AXIS[&quot;geodetic latitude
(Lat)&quot;,north,ORDER[1],ANGLEUNIT[&quot;degree&quot;,0.0174532925199433]],AXIS[&quot;geodetic longitude
(Lon)&quot;,east,ORDER[2],ANGLEUNIT[&quot;degree&quot;,0.0174532925199433]],AXIS[&quot;ellipsoidal height
(h)&quot;,up,ORDER[3],LENGTHUNIT[&quot;metre&quot;,1]],USAGE[SCOPE[&quot;Geodesy. Navigation and positioning
using GPS satellite system.&quot;],AREA[&quot;World.&quot;],BBOX[-90,-180,90,180]],ID[&quot;EPSG&quot;,4979]]">
    <GCP Id="1" Info="GCP1" Pixel="0" Line="0" X="2.766610117165289" Y="40.867629249542226"
Z="47.44995130971074"/>
    <GCP Id="2" Info="GCP2" Pixel="0" Line="2000" X="2.7229108886640847" Y="40.9850029875603"
Z="47.6954053286463"/>
    <!-- omissis -->
    <GCP Id="46" Info="GCP46" Pixel="1379" Line="18000" X="1.7056110678368939" Y="41.777702020736534"
Z="527.1823539100587"/>
    <GCP Id="47" Info="GCP47" Pixel="1379" Line="20000" X="1.657004737026843" Y="41.8941560464991"
Z="652.2788440166041"/>
    <GCP Id="48" Info="GCP48" Pixel="1379" Line="21264" X="1.6270188350235635" Y="41.96792825220514"
Z="688.6636372571811"/>
  </GCPList>
  <Metadata>
```

```
    <MDIType key="AREA_OR_POINT">Area</MDIType>
    <MDIType key="MATRIX_REPRESENTATION">SCATTERING</MDIType>
    <MDIType key="ABS_MAX_Z_ERROR">0.0001</MDIType>
    <MDIType key="PHASE_MAX_Z_ERROR">0.001</MDIType>
    <MDIType key="PolarisationsSequence">HH HV VH VV</MDIType>
    <MDIType key="Swath">S2</MDIType>
    <MDIType key="DATETIME">2024-05-31T13:19:44.034802</MDIType>
    <MDIType key="IMAGEDESCRIPTION">BIOMASS L1</MDIType>
    <MDIType key="SOFTWARE">BPS-Biomass L1 Processor-2.2.3</MDIType>
  </Metadata>
  <VRTRasterBand dataType="CFloat32" band="1" subClass="VRTDerivedRasterBand">
    <Description>HH</Description>
    <NoDataValue>-9999.0</NoDataValue>
    <Metadata>
      <MDIType key="POLARIMETRIC_INTERP">HH</MDIType>
    </Metadata>
    <ColorInterp>Gray</ColorInterp>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_abs.tiff</SourceFil
ename>
      <SourceBand>1</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_phase.tiff</Source
Filename>
      <SourceBand>1</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <PixelFunctionType>polar</PixelFunctionType>
    <SourceTransferType>Float32</SourceTransferType>
    <PixelFunctionArguments amplitude_type="AMPLITUDE"/>
  </VRTRasterBand>
  <VRTRasterBand dataType="CFloat32" band="2" subClass="VRTDerivedRasterBand">
    <Description>HV</Description>
    <NoDataValue>-9999.0</NoDataValue>
    <Metadata>
      <MDIType key="POLARIMETRIC_INTERP">HV</MDIType>
    </Metadata>
    <ColorInterp>Gray</ColorInterp>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_abs.tiff</SourceFil
ename>
      <SourceBand>2</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_phase.tiff</Source
Filename>
      <SourceBand>2</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <PixelFunctionType>polar</PixelFunctionType>
    <SourceTransferType>Float32</SourceTransferType>
    <PixelFunctionArguments amplitude_type="AMPLITUDE"/>
```

```
  </VRTRasterBand>
  <VRTRasterBand dataType="CFloat32" band="3" subClass="VRTDerivedRasterBand">
    <Description>VH</Description>
    <NoDataValue>-9999.0</NoDataValue>
    <Metadata>
      <MDIType key="POLARIMETRIC_INTERP">VH</MDIType>
    </Metadata>
    <ColorInterp>Gray</ColorInterp>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_abs.tiff</SourceFil
ename>
      <SourceBand>3</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_phase.tiff</Source
Filename>
      <SourceBand>3</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <PixelFunctionType>polar</PixelFunctionType>
    <SourceTransferType>Float32</SourceTransferType>
    <PixelFunctionArguments amplitude_type="AMPLITUDE"/>
  </VRTRasterBand>
  <VRTRasterBand dataType="CFloat32" band="4" subClass="VRTDerivedRasterBand">
    <Description>VV</Description>
    <NoDataValue>-9999.0</NoDataValue>
    <Metadata>
      <MDIType key="POLARIMETRIC_INTERP">VV</MDIType>
    </Metadata>
    <ColorInterp>Gray</ColorInterp>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_abs.tiff</SourceFil
ename>
      <SourceBand>4</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <SimpleSource>
      <SourceFilename
relativeToVRT="1">bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_i_phase.tiff</Source
Filename>
      <SourceBand>4</SourceBand>
      <SourceProperties RasterXSize="1380" RasterYSize="21265"/>
    </SimpleSource>
    <PixelFunctionType>polar</PixelFunctionType>
    <SourceTransferType>Float32</SourceTransferType>
    <PixelFunctionArguments amplitude_type="AMPLITUDE"/>
  </VRTRasterBand>
</VRTDataset>
```


Metadata

The TIFF and GeoTIFF tags used to annotate SAR image MDS are described in the following table. For the complete description of each tag refer to official TIFF format documentation [RD5].

Tag Name	Code	Value	Description
ImageWidth	256	Variable	Number of columns in the image, i.e. the number of pixels per row.
ImageLength	257	Variable	Number of rows of pixels in the image.
BitsPerSample	258	32 or 16	Number of bits per component.
Compression	259	32946 (DEFLATE), 34887 (LERC), 50000 (ZSTD)	Compression scheme used on the image data.
LercParameters	50674	Variable	LERC compression parameters: version, additional compression. e.g. 4,2 for LERC v4 with ZSTD
PhotometricInterpretation	262	1	Colour space of the image. Always set to 1 (minimum value is black).
ImageDescription	270	Variable	A string that describes the image. Examples: “BIOMASS L1a” and “BIOMASS L1b”.
SamplesPerPixel	277	3, 4	The number of components per pixel. Always set to 4 for L1a/b, i.e., one per polarisation in the order defined by PolarisationsSequence, can be 3 or 4 for L1c.
PlanarConfiguration	284	2	How the components of each pixel are stored. Always set to 2 (separate).
Software	305	Variable	Software name and version that created the image.
DateTime	306	Variable	Date and time of image creation in the format: YYYY:MM:DD HH:MM:SS
TileWidth	322	Variable	The tile width in pixels. This is the number of columns in each tile.
TileLength	323	Variable	The tile length (height) in pixels. This is the number of rows in each tile.
TileOffsets	324	Variable	For each tile, the byte offset of that tile, as compressed and stored on disk.

TileByteCounts	325	Variable	For each tile, the number of (compressed) bytes in that tile.
SampleFormat	339	3 or 1	Specifies how to interpret each data sample in a pixel. Set to 3 (IEEE floating point data) or 1 (unsigned integer data).
ModelTiePointTag	33922	N * (pixel, line, lat, long, h)	Maps image pixels to geographic coordinates, where N is the number of tie points in the scene, i.e.: - 5 tie points along range direction - 1 tie point each 10 seconds along azimuth direction Note: values have been computed in order to have an overall accuracy not worse than 100m (above ellipsoid).
GeoKeyDirectoryTag	34735	Variable	Contains the value of all GeoTIFF keys of type SHORT and the location of the values for GeoTIFF keys of other types.
GDAL_METADATA	42112	Variable	Contains GDAL metadata (see table below)
GDAL_NODATA	42113	Variable	ASCII encoded nodata or background pixel value.

Tab.2 SAR image MDS – TIFF and GeoTIFF tags

The GDAL_METADATA tag content is listed in the following table

Tag Name	Value	Description
Swath	S1,S2,S3	Image swath: S1,S2,S3
PolarisationsSequence	Variable	String: list of polarisations associated to the raster bands in the corresponding order. For esample: “HH HV VH VV” means that band 1 corresponds to the HH polarization, band 2 to the HV polarization band 3 to the VH polarization and band 4 to the VV polarization
MAX_Z_ERROR	Variable	Maximum compression error threshold. Used only in case compression scheme is LERC, LERC_DEFLATE or LERC_ZSTD.
MATRIX_REPRESENTATION	SCATTERING or SYMMETRIZED_SCATTERING	SCATTERING is used for l1a/l1b product. SYMMETRIZED SCATTERING is used for l1c products when the cross-polarisations are combined.

POLARIMETRIC_INTERP	Variable	This metadata is associated to the GDAL raster band. For each raster band it specifies which polarization the band is associated to. Possible values are “HH”, “HV”, “VH”, “VV”

Tab.3 SAR image MDS – GDAL_METADATA tiff tag content

Overviews

The usage of amplitude and phase representation together with the exploitation of GDAL library allows to easily add to amplitude COG file one or more overviews of the SAR image. Overviews are sub-sampled versions of a SAR image. Adding one or more overviews at different resolution levels allows to use pyramidal viewers directly on SAR image amplitude file, without the need of transcoding operations or of further processing.

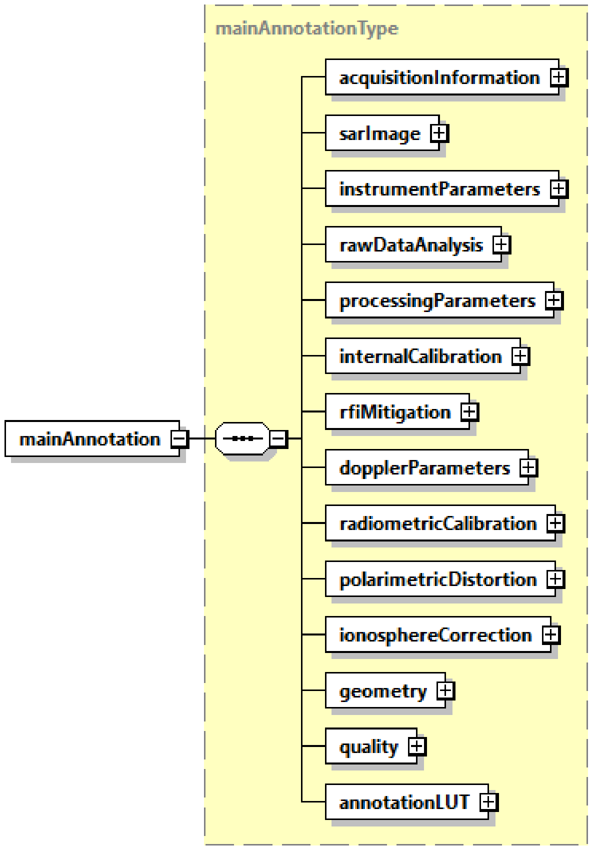
The following (minimum) number of overviews is foreseen:

- for L1a products:
  1. multi-look factors (range x azimuth): 2x2 (ground resolution ~ 100x17m)
  2. multi-look factors (range x azimuth): 5x5 (ground resolution ~ 250x42m)
  3. multi-look factors (range x azimuth): 10x10 (ground resolution ~ 500x83m)
  4. multi-look factors (range x azimuth): 20x20 (ground resolution ~ 1kmx167m)
- for L1b products:
  1. multi-look factors (range x azimuth): 2x2 (ground resolution ~ 100x100m)
  2. multi-look factors (range x azimuth): 5x5 (ground resolution ~ 250x250m)
  3. multi-look factors (range x azimuth): 10x10 (ground resolution ~ 500x500m)
  4. multi-look factors (range x azimuth): 20x20 (ground resolution ~ 1x1km)

4.3. Annotation data sets (ADS)

4.3.1. Main ADS

This section describes in details the content of main ADS and of all its DSR.
An overview is provided by figure and table below.



Main ADS

Name	Description	Data Type	Cardinality
acquisitionInformation	Acquisition information DSR. This DSR contains information that applies to the entire data set.	acquisitionInformationType	1
sarImage	SAR image DSR. This DSR contains all the necessary information to exploit the measurement data set (i.e. SAR images).	sarImageType	1
instrumentParameters	Instrument parameters DSR. This DSR contains the main instrument settings at the time of imaging.	instrumentParametersType	1

rawDataAnalysis	RAW data analysis DSR. This DSR contains the main elements related to the RAW data consolidation and analysis performed by the processor.	rawDataAnalysisType	1
processingParameters	Processing parameters DSR. This DSR contains the exhaustive list of static SAR processing parameters and of corrections applied.	processingParametersType	1
internalCalibration	Internal calibration DSR. This DSR contains the results of the internal calibration analysis performed by the processor.	internalCalibrationType	1
rfiMitigation	Radio Frequency Interference mitigation DSR. This DSR contains information on detected RFI and on their mitigation.	rfiMitigationType	1
dopplerParameters	Doppler parameters DSR. This DSR contains the Doppler Centroid (DC) and Frequency Modulation rate (FM) parameters estimated and used during processing.	dopplerParametersType	1
radiometricCalibration	Radiometric calibration DSR. This DSR contains all the necessary information to absolutely calibrate the data pixels.	radiometricCalibrationType	1
polarimetricDistortion	Polarimetric distortion DSR. This DSR contains the necessary information e.g. receive and transmit polarisation distortion matrix, allowing users to correct for them if not applied at processing level.	polarimetricDistortionType	1
ionosphereCorrection	Ionosphere correction DSR. This DSR contains the results of the ionosphere correction estimated and applied by the processor.	ionosphereCorrectionType	1
geometry	Geometry DSR. This DSR contains all the necessary information to understand the Earth model/geometry used in the image and its geolocation.	geometryType	1
quality	Quality DSR. This DSR contains in a single DSR quality flags and thresholds for basic quality assessment done at processing level.	qualityType	1
annotationLUT	Annotation LUT DSR. This DSR contains the list of Look-Up Tables (LUTs) complementing product main annotations.	layerListType	1

Tab.4 Main ADS

The content of each DSR is described making use of tables as the one here above. All the tables share the same structure and are filled following the same conventions, i.e.:

- Name: defines the name of the element or attribute;
- Description: describes the purpose of the element or attribute including the units (if applicable). The absence of a unit designation for string data types implies a string literal and for numerical data types (integers, floats, etc…) the absence of a unit designation implies an absolute number;
- Data Type: defines the data type of the element or attribute;
- Cardinality: for elements, this column defines the number of occurrences of the element in the form `minOccurs..maxOccurs`; for attributes, "optional" means the attribute may or may not be present and "required" means the presence of the attribute is mandatory.

In general, elements are displayed in normal font, attributes are displayed in *italics*.

Data types requiring a dedicated definition table are underlined, for all the others the common reference is Sec. 7.1.1.

4.3.1.1. Acquisition information DSR

This DSR contains information that applies to the entire data set.

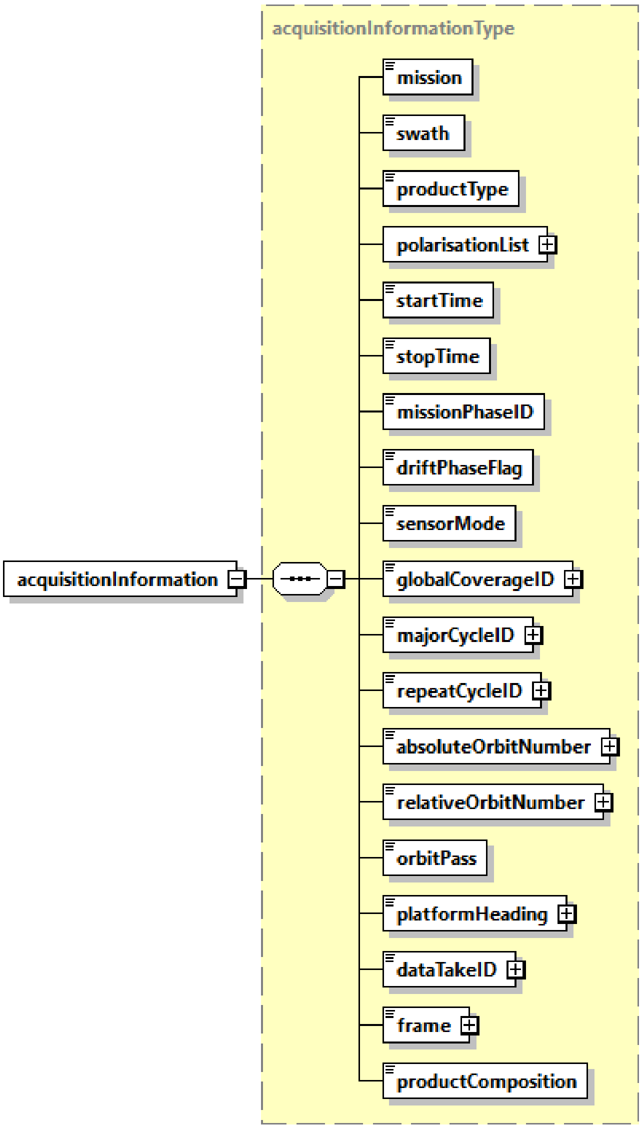


Fig.4

Acquisition information DSR (acquisitionInformationType)

Name	Description	Data Type	Cardinality
mission	Mission (BIOMASS).	missionType	1
swath	Swath (S1, S2, S3).	swathType	1
productType	Product type (SCS, DGM).	productType	1
polarisationList	List of polarisations.	polarisationListType	1

startTime	Zero Doppler start time of the image [UTC].	timeType	1
stopTime	Zero Doppler stop time of the image [UTC].	timeType	1
missionPhaseID	Mission phase identifier (COM, TOM, INT).	missionPhaseIDType	1
driftPhaseFlag	True if in drift phase, False otherwise.	bool	1
sensorMode	Sensor mode (Measurement, RX Only, External Calibration).	sensorModeType	1
globalCoverageID	Global coverage identifier.	xsd:unsignedShort	1
majorCycleID	Major cycle identifier.	xsd:unsignedShort	1
repeatCycleID	Repeat cycle identifier.	xsd:unsignedShort	1
absoluteOrbitNumber	Absolute orbit number at data set start time.	xsd:unsignedShort	1
relativeOrbitNumber	Relative orbit number (track) at data set start time.	xsd:unsignedShort	1
orbitPass	Orbit pass (Ascending, Descending).	orbitPassType	1
platformHeading	Platform heading relative to North [deg].	doubleWithUnit	1
dataTakeID	Data take identifier.	xsd:unsignedInt	1
frame	Frame identifier. This value is considered unique per beam. In case the product is non-framed, this field is empty. In case the product has been obtained from the merging of two frames, this number corresponds to the longer one.	xsd:unsignedShort	1
productComposition	Product composition indicator, where the valid values are: “Nominal”, to indicate a framed product of nominal length; “Merged”, if the product is resulting from the merging of a “short” frame with the contiguous one; “Partial”, if the product length is not nominal, but it is not merged to a contiguous one since it is “long enough”; “Incomplete”, if the product length is not nominal due to contingency (e.g., data loss); “Not Framed”, if the product is not framed, i.e., as long as input L0 one.	productCompositionType	1

Tab.5 Acquisition information DSR (acquisitionInformationType)

Name	**Description**	**Data Type**	**Cardinality**
count		xsd:unsignedInt	*required*

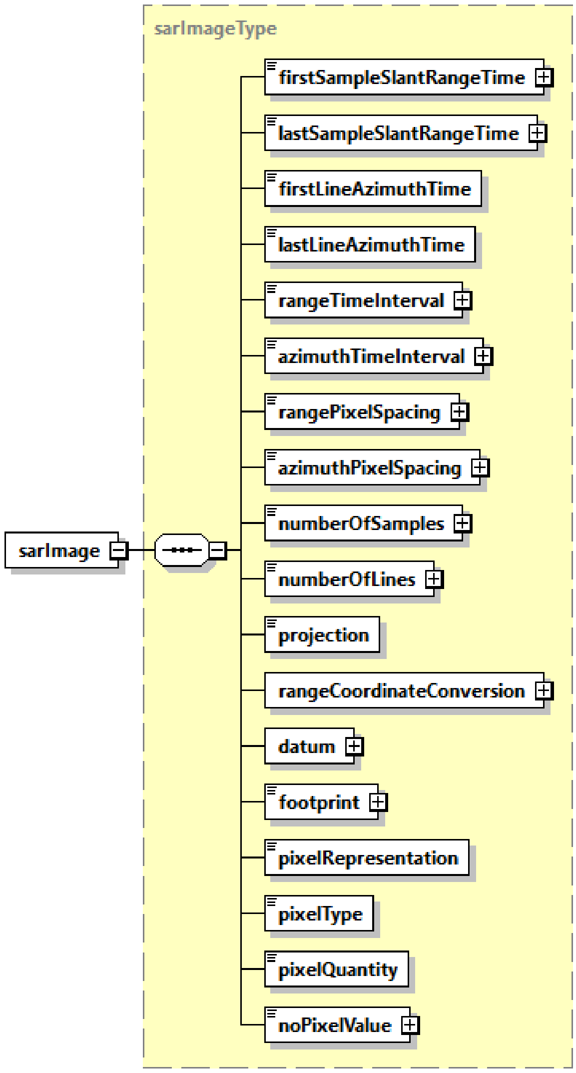
polarisation	Polarisation (HH, HV, VH, VV).	polarisationType	1 .. 4

Tab.6 Acquisition information DSR (polarisationListType)

4.3.1.2. SAR image DSR

This DSR contains all the necessary information to exploit the measurement data set (i.e. SAR images).

Fig.5



SAR image DSR (sarImageType)

Name	Description	Data Type	Cardinality
firstSampleSlantRangeTime	Two-way slant range time to first sample of the image [s].	doubleWithUnit	1
lastSampleSlantRangeTime	Two-way slant range time to last sample of the image [s].	doubleWithUnit	1
firstLineAzimuthTime	Zero Doppler azimuth time of the first line of the image [UTC].	timeType	1

lastLineAzimuthTime	Zero Doppler azimuth time of the last line of the image [UTC].	timeType	1
rangeTimeInterval	Time spacing between range samples of the image [s]. For L1a products, this value is the inverse of the range sampling frequency. For L1b products, this value is obtained dividing rangePixelSpacing for half the speed of light.	doubleWithUnit	1
azimuthTimeInterval	Time spacing between azimuth lines of the image [s].	doubleWithUnit	1
rangePixelSpacing	Pixel spacing between range samples [m].	floatWithUnit	1
azimuthPixelSpacing	Nominal pixel spacing between azimuth lines [m].	floatWithUnit	1
numberOfSamples	Total number of samples in the image (image width).	xsd:unsignedInt	1
numberOfLines	Total number of lines in the image (image length).	xsd:unsignedInt	1
projection	Projection of the image, either Slant Range or Ground Range.	projectionType	1
rangeCoordinateConversion	List of coordinateConversion records that describe conversion between the slant range and ground range coordinate systems. The list contains an entry for each 10 seconds. This list applies to and is filled in only for DGM products and therefore has a length of zero for SCS products.	coordinateConversionListType	1
datum	Datum used during processing.	datumType	1
footprint	Image footprint, expressed as a list of latitude and longitude values separated by spaces [deg]. Values are specified for each of the 4 corner coordinates of the scene quicklook, starting with the first-right in flight direction and proceeding CCW (same convention used in MPH and overlay ADS).	floatArrayWithUnits	1
pixelRepresentation	Representation of the image pixels within the image MDS (I Q, Abs Phase, Abs, Pow Phase, Pow).	pixelRepresentationType	1

pixelType	Data type of output pixels within the image MDS.	pixelTypeType	1
pixelQuantity	Physical quantity stored in output data (Beta-Nought, Sigma-Nought or Gamma-Nought).	pixelQuantityType	1
noDataValue	Pixel value in case of invalid data.	xsd:float	1

Tab.7 SAR image DSR (sarImageType)

Name	Description	Data Type	Cardinality
count	*Number of coordinate conversion records within the list.*	xsd:unsignedInt	*required*
coordinateConversion	Polynomial used to convert image pixels between slant range and ground range. The coefficients used on range lines between updates are found by linear interpolation between the updated and previous values. Considering the worst case (entire slice processed non-framed, one entry each 10 seconds), list maxOccurs is set to 15.	coordinateConversionType	0 .. 15

Tab.8 SAR image DSR (coordinateConversionListType)

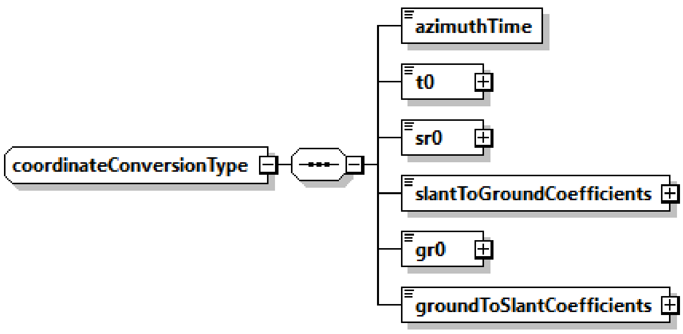


Fig.6 SAR image DSR (coordinateConversionType)

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time corresponding to the start of the current polynomial validity area [UTC].	timeType	1
t0	Two-way slant range time origin for coordinate conversion polynomial [s].	doubleWithUnit	1

sr0	Slant range origin used for ground range calculation [m].	doubleWithUnit	1
slantToGroundCoefficients	Coefficients to convert from slant range to ground range. `Ground range = g0 + g1(sr-sr0) + g2(sr-sr0)^2 + g3(sr-sr0)^3 + g4(sr-sr0)^4 + ... + gN(sr-sr0)^N` where `sr` is the slant range distance to the desired pixel and `N` is the number of coefficients in the array minus one.	doubleArray	1
gr0	Ground range origin used for slant range calculation [m].	doubleWithUnit	1
groundToSlantCoefficients	Coefficients to convert from ground range to slant range coefficients. `Slant range = s0 + s1(gr-gr0) + s2(gr-gr0)^2 + s3(gr-gr0)^3 + s4(gr-gr0)^4 + ... + sN(gr-gr0)^N` where `gr` is the ground range distance to the desired pixel and `N` is the number of coefficients in the array minus one.	doubleArray	1

Tab.9 SAR image DSR (coordinateConversionType)

4.3.1.3. Instrument parameters DSR

This DSR contains the main instrument settings at the time of imaging.

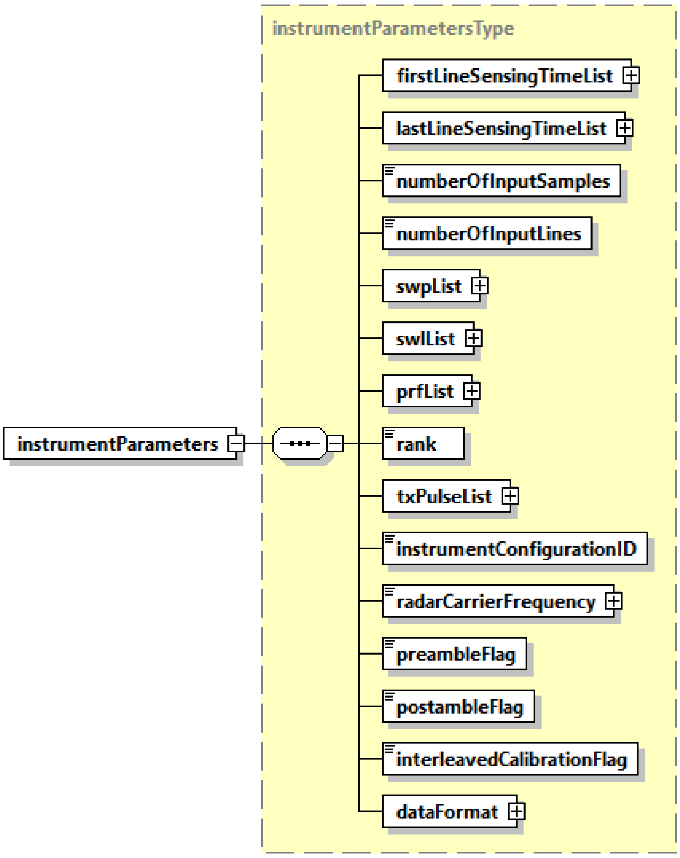


Fig.7

Instrument parameters DSR (instrumentParametersType)

Name	Description	Data Type	Cardinality
firstLineSensingTimeList	Sensing time of first line of the input RAW data for all the polarisations [UTC].	firstLineSensingTimeListType	1
lastLineSensingTimeList	Sensing time of last line of the input RAW data for all the polarisations [UTC].	lastLineSensingTimeListType	1
numberOfInputSamples	Number of samples of the input RAW data.	xsd:unsignedInt	1
numberOfInputLines	Number of lines of the input RAW data.	xsd:unsignedInt	1
swpList	List of Sampling Window Position changes (SWP) [s]. The list contains an entry for each on-board SWP update.	swpListType	1

swlList	List of Sampling Window Length changes (SWL) [s]. The list contains an entry for each on-board SWL update.	swlListType	1
prfList	List of Pulse Repetition Frequency changes (PRF) [Hz]. The list contains an entry for each on-board PRF update.	prfListType	1
rank	Number of PRIs between transmitted pulse and received echo.	xsd:unsignedShort	1
txPulseList	List of transmitted pulses. The list contains an entry for each on-board transmitted pulse update.	txPulseListType	1
instrumentConfigurationID	Instrument configuration identifier.	xsd:unsignedInt	1
radarCarrierFrequency	Radar carrier frequency [Hz].	doubleWithUnit	1
rxGainList	RX gain list.	rxGainListType	1
preambleFlag	True if input RAW data contain preamble sequence, False otherwise.	bool	1
postambleFlag	True if input RAW data contain postamble sequence, False otherwise.	bool	1
interleavedCalibrationFlag	True if input RAW data contain interleaved calibration sequences, False otherwise.	bool	1
dataFormat	Data format for instrument samples. There is one element corresponding to the data format for each packet type in the segment.	dataFormatType	1

Tab.10 Instrument parameters DSR (instrumentParametersType)

Name	**Description**	**Data Type**	**Cardinality**
count		xsd:unsignedInt	*required*
firstLineSensingTime	Sensing time of first line of the input RAW data for the current polarisation [UTC].	timeTypeWithPolarisation	1 .. 4

Tab.11 Instrument parameters DSR (firstLineSensingTimeListType)

Name	**Description**	**Data Type**	**Cardinality**

count		xsd:unsignedInt	*required*
lastLineSensingTime	Sensing time of last line of the input RAW data for the current polarisation [UTC].	timeTypeWithPolarisation	1 .. 4

Tab.12 Instrument parameters DSR (lastLineSensingTimeListType)

Name	Description	Data Type	Cardinality
count	*Number of SWP records within the list.*	xsd:unsignedInt	*required*
swp	SWP record [s]. This record holds the SWP for the given Zero Doppler azimuth time. Considering the worst case (entire slice processed non-framed, one change each 10 seconds), list maxOccurs is set to 15.	stateType	1.. 15

Tab.13 Instrument parameters DSR (swpListType)

Name	Description	Data Type	Cardinality
count	*Number of SWL records within the list.*	xsd:unsignedInt	*required*
swl	SWL record [s]. This record holds the SWL for the given Zero Doppler azimuth time. Considering the worst case (entire slice processed non-framed, one change each 10 seconds), list maxOccurs is set to 15.	stateType	1.. 15

Tab.14 Instrument parameters DSR (swlListType)

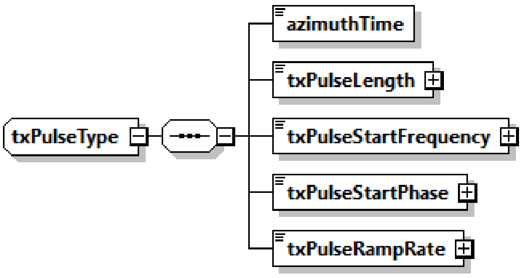
Name	Description	Data Type	Cardinality
count	*Number of PRF records within the list.*	xsd:unsignedInt	*required*
prf	PRF record [Hz]. This record holds the PRF for the given Zero Doppler azimuth time. List maxOccurs is set to 5, considered as worst case.	stateType	1.. 5

Tab.15 Instrument parameters DSR (prfListType)

Name	Description	Data Type	Cardinality
count	*Number of transmitted pulse records within the list.*	xsd:unsignedInt	*required*

txPulse	Transmitted pulse record. This record holds the nominal transmitted pulse information for the given Zero Doppler azimuth time. List maxOccurs is set to 5, considered as worst case.	txPulseType	1.. 5

Tab.16 Instrument parameters DSR (txPulseListType)



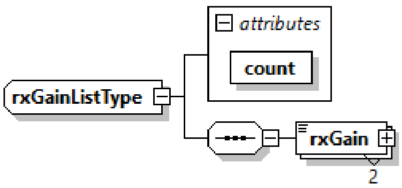
Instrument parameters DSR (txPulseType)

Fig.8

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time of transmitted pulse change [UTC].	timeType	1
txPulseLength	Transmit pulse length [s].	doubleWithUnit	1
txPulseStartFrequency	Starting frequency of the transmit pulse [Hz].	doubleWithUnit	1
txPulseStartPhase	Starting phase of the transmit pulse [rad].	doubleWithUnit	1
txPulseRampRate	The linear rate at which the frequency changes over the pulse duration [Hz/s].	doubleWithUnit	1

Tab.17 Instrument parameters DSR (txPulseType)

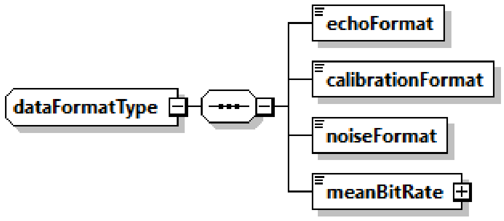
Fig.9



Instrument parameters DSR (rxGainListType)

Name	Description	Data Type	Cardinality
rxGain	RX gain, extracted from RAS control message.	floatWithPolarisation	2

Tab.18 Instrument parameters DSR (rxGainListType)



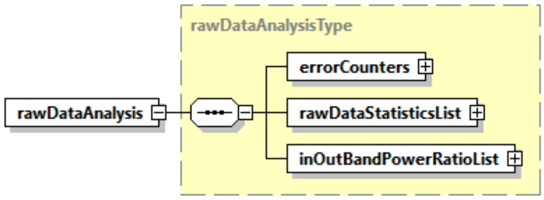
Instrument parameters DSR (dataFormatType)

Name	Description	Data Type	Cardinality
echoFormat	Data format of echo packets.	dataFormatModeType	1
calibrationFormat	Data format of calibration packets.	dataFormatModeType	1
noiseFormat	Data format of noise packets.	dataFormatModeType	1
meanBitRate	The calculated mean bit rate for the segment provide as input to the processor [Mbps].	doubleWithUnit	1

Tab.19 Instrument parameters DSR (dataFormatType)

4.3.1.4. RAW data analysis DSR

This DSR contains the main elements related to the RAW data consolidation and analysis performed by the processor.

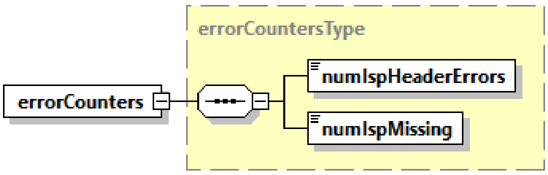


RAW data analysis DSR (rawDataAnalysisType)

Name	Description	Data Type	Cardinality
errorCounters	Error counters computed starting from input Instrument Source Packets stream.	errorCountersType	1
rawDataStatisticsList	Extracted RAW data I and Q channels statistics for all the polarisations.	rawDataStatisticsListType	1
inOutBandPowerRatioList	In/out-of-band power ratio list. This element contains lists of in/out-of-band power ratio measurements. The list contains an entry for each measurement made along azimuth and it is organised per polarisation.	inOutBandPowerRatioListType	1

Tab.20 RAW data analysis DSR (rawDataAnalysisType)

Fig.12



RAW data analysis DSR (errorCountersType)

Name	Description	Data Type	Cardinality
numIspHeaderErrors	Total number of errors detected in ISP headers.	xsd:unsignedInt	1
numIspMissing	Total number of missing ISP.	xsd:unsignedInt	1

Tab.21 RAW data analysis DSR (errorCountersType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
rawDataStatistics	Extracted RAW data I and Q channels statistics for the current polarisation.	rawDataStatisticsType	1 .. 4

Tab.22 RAW data analysis DSR (rawDataStatisticsListType)

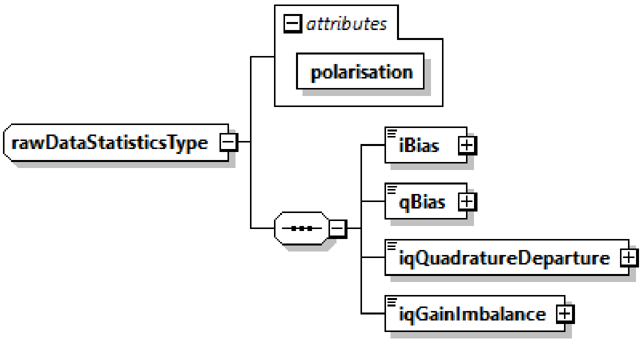


Fig.13 RAW data analysis DSR (rawDataStatisticsType)

Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
iBias	Calculated I bias.	xsd:double	1
qBias	Calculated Q bias.	xsd:double	1
iqQuadratureDeparture	Calculated I/Q quadrature departure.	xsd:double	1
iqGainImbalance	Calculated I/Q gain imbalance.	xsd:double	1

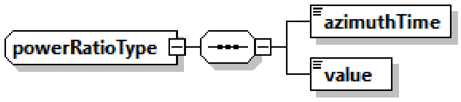
Tab.23 RAW data analysis DSR (rawDataStatisticsType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
powerRatioList	In/out-of-band power ratio measurements for the current polarisation.	powerRatioListType	1 .. 4

Tab.24 RAW data analysis DSR (inOutBandPowerRatioListType)

Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
count	*Number of in/out-of-band power ratio measurements for the current polarisation within the list.*	xsd:unsignedInt	*required*
powerRatio	In/out-of-band power ratio measurements. Considering the worst case (entire slice processed non-framed, one entry each 5 seconds), list maxOccurs is set to 30.	powerRatioType	1 .. 30

Tab.25 RAW data analysis DSR (powerRatioListType)



RAW data analysis DSR (powerRatioType)

Fig.14

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time of the in/out-of-band power ratio measurement [UTC].	timeType	1
value	In/out-of-band power ratio measurement.	xsd:float	1

Tab.26 RAW data analysis DSR (powerRatioType)

4.3.1.5. Processing parameters DSR

This DSR contains the exhaustive list of static SAR processing parameters and of corrections applied.

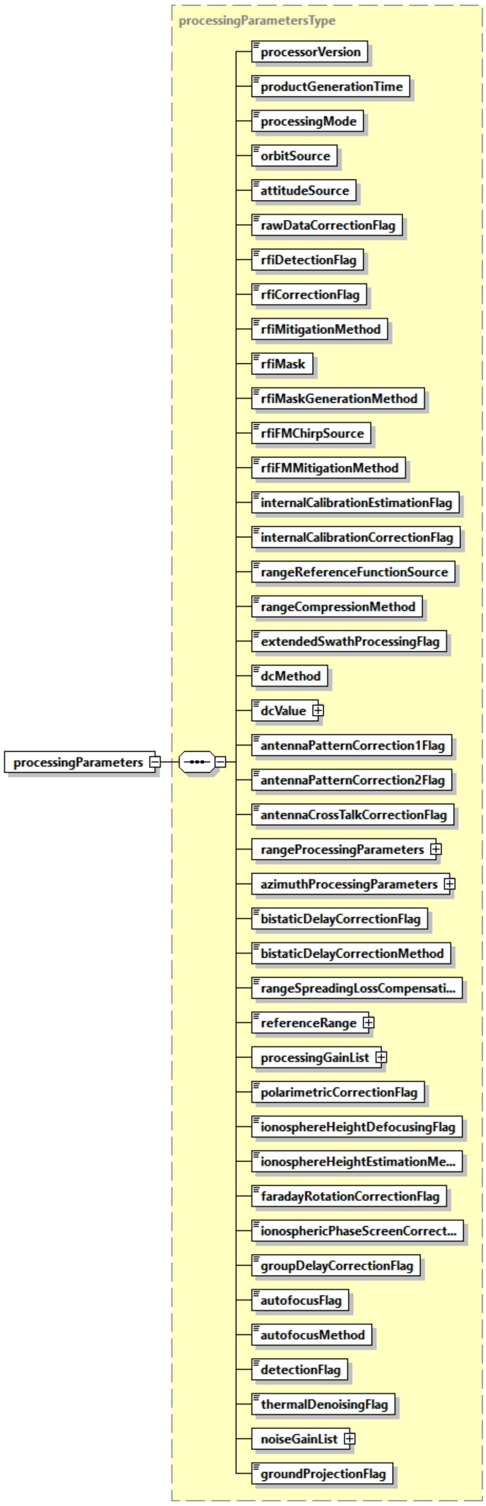


Fig.15 Processing parameters DSR (processingParametersType)

Name	Description	Data Type	Cardinality
processorVersion	Version of the processor used to generate the product.	xsd:string	1
productGenerationTime	Product generation time [UTC].	timeType	1
processingMode	Processing mode (Nominal, PARC).	processingModeType	1
orbitSource	Source of the orbit data used during processing. Set to “Extracted” if the orbit information extracted from source packets is used during processing. Set to “Auxiliary” if the orbit information from an input auxiliary file is used during processing.	orbitAttitudeSourceType	1
attitudeSource	Source of the attitude data used during processing. Set to “Extracted” if the attitude information extracted from source packets is used during processing. Set to “Auxiliary” if the attitude information from an input auxiliary file is used during processing.	orbitAttitudeSourceType	1
rawDataCorrectionFlag	True if raw data correction was performed, False otherwise.	bool	1
rfiDetectionFlag	True if RFI detection was performed, False otherwise.	bool	1
rfiCorrectionFlag	True if RFI correction was performed, False otherwise. Implies activation of rfiDetectionFlag.	bool	1
rfiMitigationMethod	Domain where the RFI mitigation step was performed (Time, Frequency, Time and Frequency, Frequency and Time).	rfiMitigationMethodType	1
rfiMask	RFI mask used for mitigation. Valid values are: "Single", to use the same mask for all the polarizations; "Multiple", to use a dedicated mask for each polarization.	rfiMaskType	1

rfiMaskGenerationMethod	Polarization-dependent RFI masks combination method (AND, OR). Used only in case rfiMask is set to Single.	rfiMaskGenerationMethodType	1
rfiFMChirpSource	Chirp source for Frequency Domain detection.	rangeReferenceFunctionType	1
rfiFMMitigationMethod	Frequency Domain mitigation method.	rfiFMMitigationMethodType	1
internalCalibrationEstimationFlag	True if internal calibration estimation was performed, False otherwise.	bool	1
internalCalibrationCorrectionFlag	True if internal calibration correction was performed, False otherwise.	bool	1
rangeReferenceFunctionSource	Chirp source to be used for range compression (Nominal, Replica or Internal).	rangeReferenceFunctionType	1
rangeCompressionMethod	Range compression method used during processing (Matched Filter or Inverse Filter).	rangeCompressionMethodType	1
extendedSwathProcessingFlag	True if processing was extended in the range direction including samples not having the full phase history, False otherwise.	bool	1
dcMethod	Doppler Centroid estimation method used during processing (Geometry, Combined, Fixed).	dcMethodType	1
dcValue	Doppler centroid value used during processing [Hz]. Used only in case dcMethod is set to Fixed.	doubleWithUnit	1
antennaPatternCorrection1Flag	True if antenna pattern correction (first step) was applied, False otherwise.	bool	1
antennaPatternCorrection2Flag	True if antenna pattern correction (second step) was applied, False otherwise.	bool	1
antennaCrossTalkCorrectionFlag	True if antenna cross-talk correction was applied, False otherwise.	bool	1

rangeProcessingParameters	Parameters used during range processing.	spectrumProcessingParametersType	1
azimuthProcessingParameters	Parameters used during azimuth processing.	spectrumProcessingParametersType	1
bistaticDelayCorrectionFlag	True if bistatic delay correction was applied, False otherwise.	bool	1
bistaticDelayCorrectionMethod	Method used for bistatic delay correction (Bulk or Full).	bistaticDelayCorrectionMethodType	1
rangeSpreadingLossCompensationFlag	True if range spreading loss compensation was performed, False otherwise.	bool	1
referenceRange	Range spreading loss reference slant range [m]. The range spreading loss is compensated by amplitude scaling each range sample by `1/Grsl(R)`, where: - `Grsl(R) = cuberoot(rRef/R)` - `R` = slant range of sample.	doubleWithUnit	1
processingGainList	Processing gain computed and applied multiplicatively to the image during processing for all the polarisations.	processingGainListType	1
polarimetricCorrectionFlag	True if polarimetric correction has been performed, False otherwise.	bool	1
ionosphereHeightDefocusingFlag	True if defocusing at ionosphere height has been performed, False otherwise.	bool	1
ionosphereHeightEstimationMethod	Ionosphere height estimation method (Automatic, Feature Tracking, Squint Sensitivity, Model, Fixed).	ionosphereHeightEstimationMethodType	1
faradayRotationCorrectionFlag	True if Faraday Rotation correction has been performed, False otherwise.	bool	1
ionosphericPhaseScreenCorrectionFlag	True if ionospheric phase screen correction has been performed, False otherwise.	bool	1

groupDelayCorrectionFlag	True if group delay correction has been performed, False otherwise.	bool	1
autofocusFlag	True if autofocus has been performed, False otherwise.	bool	1
autofocusMethod	Autofocus method used during processing (Map Drift).	autofocusMethodType	1
detectionFlag	True if detection has been performed, False otherwise.	bool	1
thermalDenoisingFlag	True if thermal denoising has been performed, False otherwise.	bool	1
noiseGainList	Processing gain computed and applied multiplicatively to the thermal noise level before using it during denoising step for all the polarisations.	noiseGainListType	1
groundProjectionFlag	True if slant range to ground range conversion has been performed, False otherwise.	bool	1

Tab.27 Processing parameters DSR (processingParametersType)

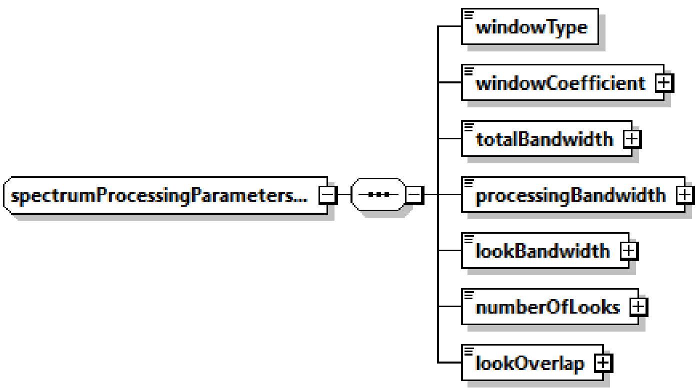


Fig.16 Processing parameters DSR (spectrumProcessingParametersType)

Name	Description	Data Type	Cardinality
windowType	Name of the weighting window type used during processing.	weightingWindowType	1

windowCoefficient	Value of the weighting window coefficient used during processing.	xsd:double	1
totalBandwidth	Total available bandwidth [Hz].	doubleWithUnit	1
processingBandwidth	Bandwidth used during processing [Hz].	doubleWithUnit	1
lookBandwidth	Bandwidth for each look used during processing [Hz].	doubleWithUnit	1
numberOfLooks	Number of looks.	xsd:unsignedInt	1
lookOverlap	Overlap between looks [Hz].	doubleWithUnit	1

Tab.28 Processing parameters DSR (spectrumProcessingParametersType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
processingGain	Processing gain computed and applied multiplicatively to the image during processing for the current polarisation.	floatWithPolarisation	1 .. 4

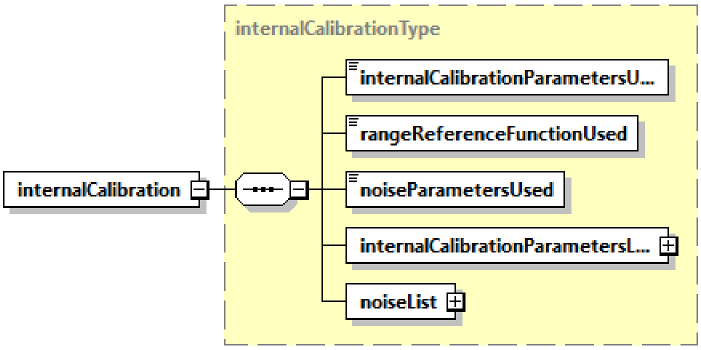
Tab.29 Processing parameters DSR (processingGainListType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
noiseGain	Processing gain computed and applied multiplicatively to the thermal noise level before using it during denoising step for the current polarisation.	floatWithPolarisation	1 .. 4

Tab.30 Processing parameters DSR (noiseGainListType)

4.3.1.6. Internal calibration DSR

This DSR contains the results of the internal calibration analysis performed by the processor.



Internal calibration DSR (internalCalibrationType)

Name	Description	Data Type	Cardinality
internalCalibrationParametersUsed	Internal calibration parameters effectively used during processing (Model or Extracted).	internalCalibrationSourceType	1
rangeReferenceFunctionUsed	Chirp source effectively used for range compression (Nominal, Replica or Internal). Can be different from rangeReferenceFunctionSource.	rangeReferenceFunctionType	1
noiseParametersUsed	Noise parameters used during processing (Model or Extracted).	internalCalibrationSourceType	1
internalCalibrationParametersList	Internal calibration parameters list. This element contains lists of internal calibration parameters calculated from the calibration pulses extracted from the downlink. The list contains an entry for each calibration sequence contained in the input data and it is organised per polarisation. If the list is empty, the nominal parameters values in the	internalCalibrationParametersListType	1

	instrument auxiliary data file will be used instead.		
noiseList	Noise list. This element contains lists of noise parameters derived from the noise ISPs. The list contains an entry for each noise sequence contained in the input data and it is organised per polarisation. If the list is empty, the nominal noise value in the instrument auxiliary data file will be used instead.	noiseListType	1

Tab.31 Internal calibration DSR (internalCalibrationType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
internalCalibrationSequenceList	Internal calibration parameters derived from the calibration pulses for the current polarisation.	internalCalibrationSequenceListType	1 .. 4

Tab.32 Internal calibration DSR (internalCalibrationParametersListType)

Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
count	*Number of internal calibration sequences for the current polarisation within the list.*	xsd:unsignedInt	*required*
internalCalibrationSequence	Internal calibration parameters derived from the calibration pulses. Considering the worst case (10 minutes datatake, one entry each 10 seconds), list maxOccurs is set to 60.	internalCalibrationSequenceType	0 .. 60

Tab.33 Internal calibration DSR (internalCalibrationSequenceListType)

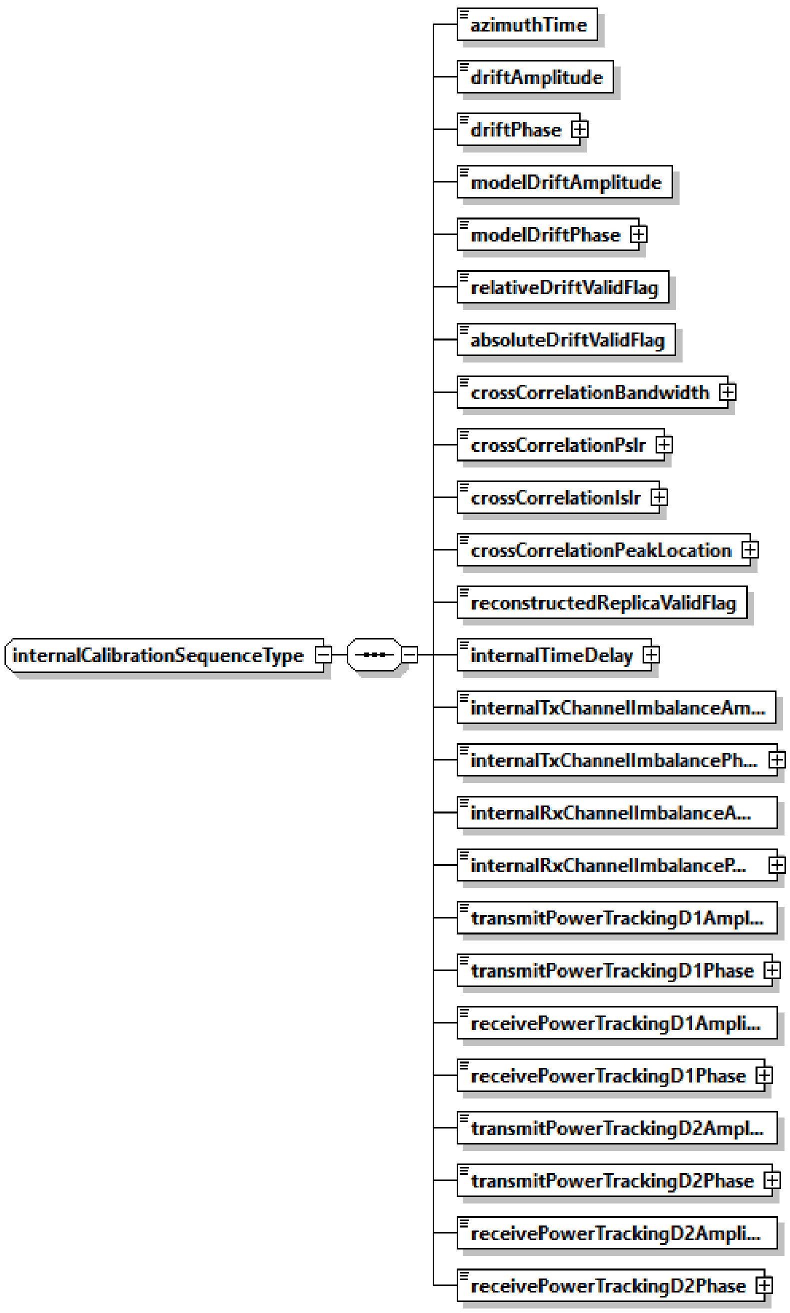


Fig.18 Internal calibration DSR (internalCalibrationSequenceType)

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time in azimuth at which internal calibration parameters applies [UTC].	timeType	1
driftAmplitude	Amplitude drift for the current power gain product (PGP).	xsd:float	1

driftPhase	Phase drift for the current power gain product (PGP) [rad].	floatWithUnit	1
modelDriftAmplitude	Amplitude drift derived from model.	xsd:float	1
modelDriftPhase	Phase drift derived from model [rad].	floatWithUnit	1
relativeDriftValidFlag	Indicates if the current amplitude and phase drifts are valid (within the configured threshold) when compared to the mean and standard deviation of all the amplitude and phase drifts.	bool	1
absoluteDriftValidFlag	Indicates if the current amplitude and phase drifts are valid (within the configured threshold) when compared to the value of the model.	bool	1
crossCorrelationBandwidth	3-dB pulse width of chirp replica cross-correlation function between the reconstructed replica and the nominal replica [Hz].	floatWithUnit	1
crossCorrelationPslr	Peak Side Lobe Ratio (PSLR) of replica cross-correlation function between the reconstructed replica and the nominal replica [dB].	floatWithUnit	1
crossCorrelationIslr	Integrated Side Lobe Ratio (ISLR) of cross-correlation function between the reconstructed replica and the nominal replica [dB].	floatWithUnit	1
crossCorrelationPeakLocation	Peak location of cross-correlation function between the reconstructed replica and the nominal replica [samples].	floatWithUnit	1
reconstructedReplicaValidFlag	Indicates if the cross-correlation between the nominal replica and this extracted replica resulted in a valid peak location.	bool	1
internalTimeDelay	Internal time delay [s] representing the calculated deviation of the location of this replica from the location of the transmitted pulse, i.e. the nominal replica.	floatWithUnit	1
internalTxChannelImbalanceAmplitude	Amplitude of instrument internal transmit channel imbalance.	xsd:float	1
internalTxChannelImbalancePhase	Phase of instrument internal transmit channel imbalance [rad].	floatWithUnit	1
internalRxChannelImbalanceAmplitude	Amplitude of instrument internal receive channel imbalance.	xsd:float	1

internalRxChannelImbalancePhase	Phase of instrument internal receive channel imbalance [rad].	floatWithUnit	1
transmitPowerTrackingD1Amplitude	Amplitude of transmit power tracking for doublet D1.	xsd:float	1
transmitPowerTrackingD1Phase	Phase of transmit power tracking for doublet D1 [rad].	floatWithUnit	1
receivePowerTrackingD1Amplitude	Amplitude of receive power tracking for doublet D1.	xsd:float	1
receivePowerTrackingD1Phase	Phase of receive power tracking for doublet D1 [rad].	floatWithUnit	1
transmitPowerTrackingD2Amplitude	Amplitude of transmit power tracking for doublet D2.	xsd:float	1
transmitPowerTrackingD2Phase	Phase of transmit power tracking for doublet D2 [rad].	floatWithUnit	1
receivePowerTrackingD2Amplitude	Amplitude of receive power tracking for doublet D2.	xsd:float	1
receivePowerTrackingD2Phase	Phase of receive power tracking for doublet D2 [rad].	floatWithUnit	1

Tab.34 Internal calibration DSR (internalCalibrationSequenceType)

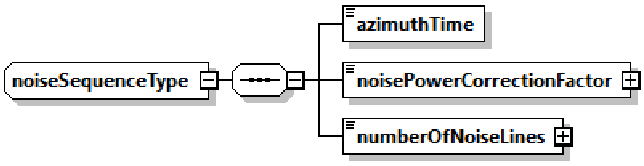
Name	**Description**	**Data Type**	**Cardinality**
count		xsd:unsignedInt	*required*
noiseSequenceList	Noise parameters derived from the noise packets for the current polarisation.	noiseSequenceListType	1 .. 4

Tab.35 Internal calibration DSR (noiseListType)

Name	**Description**	**Data Type**	**Cardinality**
polarisation		*polarisationType*	*required*
count	*Number of noise sequences for the current polarisation within the list.*	xsd:unsignedInt	*required*
noiseSequence	Noise parameters derived from noise packets.	noiseSequenceType	0 .. 2

	List maxOccurs is set to 2 considering one entry for preamble and one for postamble noise sequences.		

Tab.36 Internal calibration DSR (noiseSequenceListType)



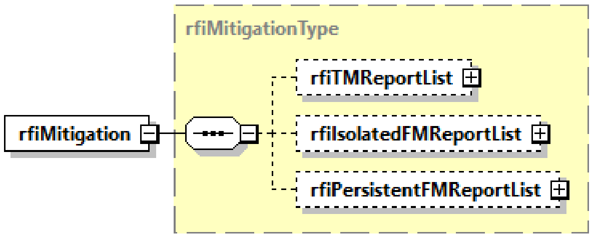
Internal calibration DSR (noiseSequenceType)

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time of the noise measurement [UTC].	timeType	1
noisePowerCorrectionFactor	Noise power correction factor.	xsd:float	1
numberOfNoiseLines	Number of noise lines used to calculate noise correction factor.	xsd:unsignedInt	1

Tab.37 Internal calibration DSR (noiseSequenceType)

4.3.1.7. Radio Frequency Interference mitigation DSR

This DSR contains information on detected RFI and on their mitigation.



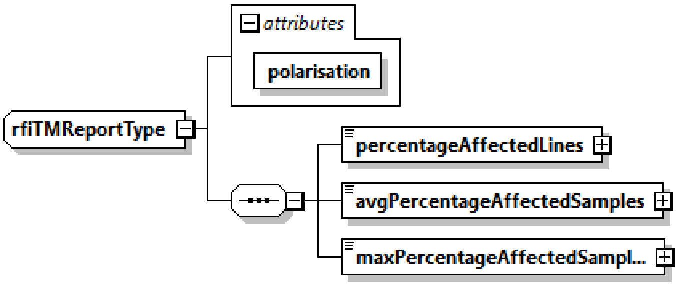
Radio Frequency Interference mitigation DSR (rfiMitigationType)

Name	Description	Data Type	Cardinality
rfiTMReportList	Time-domain RFI mitigation report list. This element is present only if time-domain RFI mitigation is performed.	rfiTMReportListType	0 .. 1
rfiIsolatedFMReportList	Frequency-domain isolated RFI mitigation report list. This element is present only if frequency-domain RFI mitigation is performed.	rfiIsolatedFMReportListType	0 .. 1
rfiPersistentFMReportList	Frequency-domain persistent RFI mitigation report list. This element is present only if frequency-domain RFI mitigation is performed.	rfiPersistentFMReportListType	0 .. 1

Tab.38 Radio Frequency Interference mitigation DSR (rfiMitigationType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
rfiTMReport	Time-domain RFI mitigation report.	rfiTMReportType	1 .. 4

Tab.39 Radio Frequency Interference mitigation DSR (rfiTMReportListType)



Radio Frequency Interference mitigation DSR (rfiTMReportType)

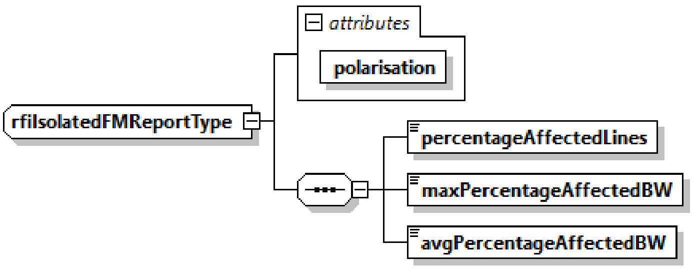
Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
percentageAffectedLines	Percentage of input RAW data lines affected by RFI.	xsd:float	1
avgPercentageAffectedSamples	Average percentage of affected input RAW data samples in the lines containing RFI.	xsd:float	1
maxPercentageAffectedSamples	Maximum percentage of input RAW data samples affected by RFI in the same line.	xsd:float	1

Tab.40 Radio Frequency Interference mitigation DSR (rfiTMReportType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
rfiIsolatedFMReport	Frequency-domain isolated RFI mitigation report.	rfiIsolatedFMReportType	1 .. 4

Tab.41 Radio Frequency Interference mitigation DSR (rfiIsolatedFMReportListType)

Fig.22



Radio Frequency Interference mitigation DSR (rfiIsolatedFMReportType)

Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
percentageAffectedLines	Percentage of input RAW data lines affected by isolated RFI.	xsd:float	1
maxPercentageAffectedBW	Max percentage of bandwidth affected by isolated RFI in a single line.	xsd:float	1
avgPercentageAffectedBW	Average percentage of bandwidth affected by isolated RFI	xsd:float	1

Tab.42 Radio Frequency Interference mitigation DSR (rfiIsolatedFMReportType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
rfiPersistentFMReport	Frequency-domain persistent RFI mitigation report.	rfiPersistentFMReportType	1 .. 4

Tab.43 Radio Frequency Interference mitigation DSR (rfiPersistentFMReportListType)

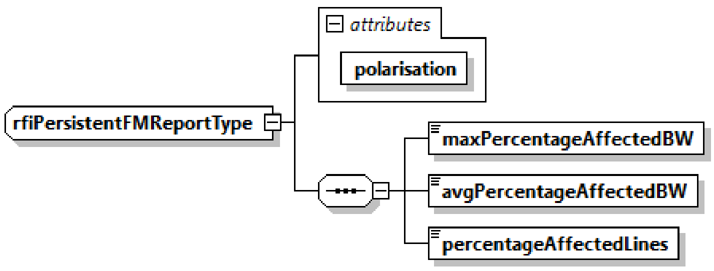


Fig.23 Radio Frequency Interference mitigation DSR (rfiPersistentFMReportType)

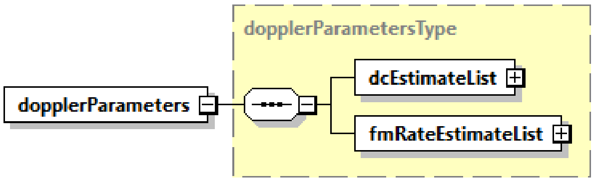
Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
maxPercentageAffectedBW	Max percentage of bandwidth affected by persistent RFI.	xsd:float	1
avgPercentageAffectedBW	Average percentage of bandwidth affected by persistent RFI.	xsd:float	1

percentageAffectedLines	Percentage of lines affected by persistent RFI.	xsd:float	1

Tab.44 Radio Frequency Interference mitigation DSR (rfiPersistentFMReportType)

4.3.1.8. Doppler parameters DSR

This DSR contains the Doppler Centroid (DC) and Frequency Modulation rate (FM) parameters estimated and used during processing.



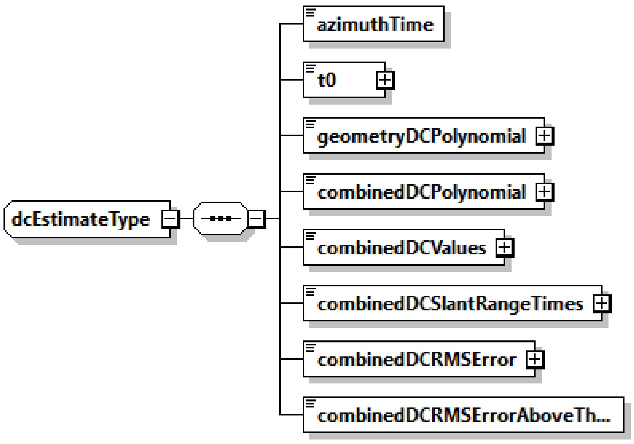
Doppler parameters DSR (dopplerParametersType)

Name	Description	Data Type	Cardinality
dcEstimateList	List of Doppler Centroid estimates that have been calculated during image processing. The list contains an entry for each Doppler Centroid estimate made along azimuth, i.e., each N seconds, where N is configurable.	dcEstimateListType	1
fmRateEstimateList	List of Frequency Modulation rate estimates that have been calculated during image processing. The list contains an entry for each Frequency Modulation rate estimate made along azimuth, i.e., each N seconds, where N is configurable.	fmRateEstimatesListType	1

Tab.45 Doppler parameters DSR (dopplerParametersType)

Name	Description	Data Type	Cardinality
count	*Number of dcEstimate records within the list.*	xsd:unsignedInt	*required*
dcEstimate	Doppler Centroid estimate record which contains the Doppler Centroid calculated from geometry and estimated from the data, associated signal-to-noise ratio values and indicates which DCE method was used by the IPF during image processing. Considering the worst case (entire slice processed non-framed, one entry each 1 second), list maxOccurs is set to 150.	dcEstimateType	1.. 150

Tab.46 Doppler parameters DSR (dcEstimateListType)



Doppler parameters DSR (dcEstimateType)

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time corresponding to the start of the current polynomial validity area [UTC].	timeType	1
t0	Two-way slant range time origin for polynomial [s].	doubleWithUnit	1
geometryDCPolynomial	Doppler Centroid estimated from orbit and attitude, expressed as the following polynomial (assuming 5 coefficients): `DC = d0 + d1(tSR-t0) + d2(tSR-t0)^2 + d3(tSR-t0)^3 + d4(tSR-t0)^4` where `tSR` is the two-way slant range time.	floatArray	1
combinedDCPolynomial	Doppler Centroid estimated from both orbit and attitude and data, expressed as the following polynomial (assuming 5 coefficients): `DC = d0 + d1(tSR-t0) + d2(tSR-t0)^2 + d3(tSR-t0)^3 + d4(tSR-t0)^4` where `tSR` is the two-way slant range time.	floatArray	1
combinedDCValues	Combined Doppler Centroid estimates [Hz]. Each estimate represents the Doppler Centroid frequency at the slant range time	doubleArrayWithUnits	1

	specified by combinedDCSlantRangeTimes, estimated within the current block. The values are averaged on all the polarisations used for estimation.		
combinedDCSlantRangeTimes	Two-way slant range times combinedDCValues are referred to [s].	doubleArrayWithUnits	1
combinedDCRMSError	The RMS error of the Doppler Centroid estimate [Hz]. It is calculated as the average of the individual RMS residual errors between input fine Doppler Centroid estimates and the fitted polynomial. If the Doppler Centroid was not estimated with combined approach, this is set to 0.	doubleWithUnit	1
combinedDCRMSErrorAboveThreshold	False if the RMS error is below the acceptable threshold for the Doppler Centroid estimated with combined approach. True if the RMS error is greater than or equal to the acceptable threshold.	bool	1

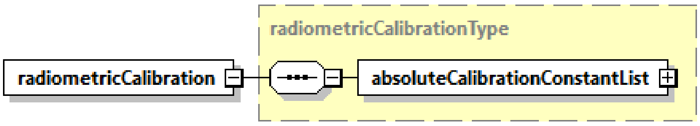
Tab.47 Doppler parameters DSR (dcEstimateType)

Name	**Description**	**Data Type**	**Cardinality**
count	*Number of fmRateEstimate records within the list.*	xsd:unsignedInt	*required*
fmRateEstimate	Frequency Modulation rate estimate record. Considering the worst case (entire slice processed non-framed, one entry each 1 second), list maxOccurs is set to 150.	slantRangePolynomialType	1.. 150

Tab.48 Doppler parameters DSR (fmRateEstimatesListType)

4.3.1.9. Radiometric calibration DSR

This DSR contains all the necessary information to absolutely calibrate the data pixels.



Radiometric calibration DSR (radiometricCalibrationType)

Name	Description	Data Type	Cardinality
absoluteCalibrationConstantList	Absolute calibration constant. Already applied to the image during processing for all the polarisations.	calibrationConstantListType	1

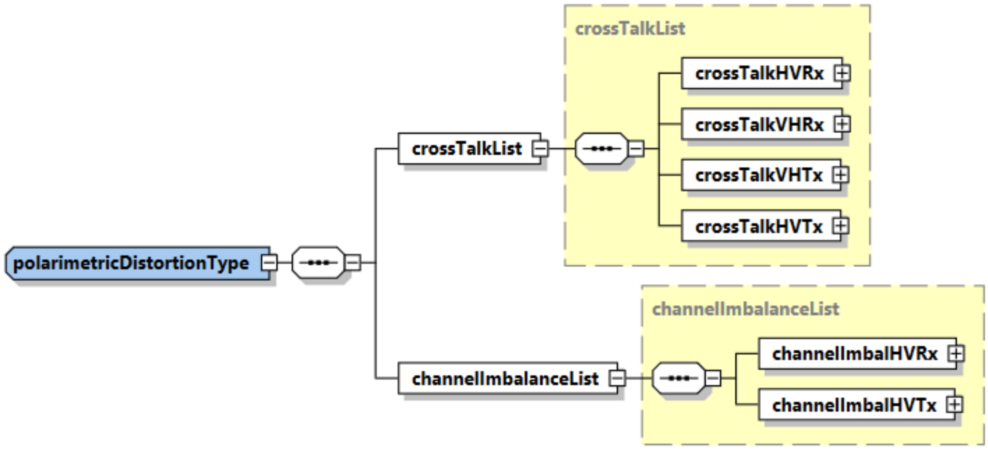
Tab.49 Radiometric calibration DSR (radiometricCalibrationType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
absoluteCalibrationConstant	Absolute calibration constant applied multiplicatively to the image during processing for the current polarisation.	floatWithPolarisation	1 .. 4

Tab.50 Radiometric calibration DSR (calibrationConstantListType)

4.3.1.10. Polarimetric distortion DSR

This DSR contains the necessary information e.g. receive and transmit polarisation distortion matrix, allowing users to correct for them if not applied at processing level.



Polarimetric distortion DSR (polarimetricDistortionType)

Fig.27

Name	Description	Data Type	Cardinality
crossTalkList	System cross-talk values.	crossTalkList	1
channelImbalanceList	System channel imbalance values.	channelImbalanceList	1

Tab.51 Polarimetric distortion DSR (polarimetricDistortionType)

Name	Description	Data Type	Cardinality
crossTalkHVTx	H to V system cross-talk on transmit values, δ_4.	complex	1
crossTalkVHTx	V to H system cross-talk on transmit values, δ_3.	complex	1
crossTalkHVRx	H to V system cross-talk on receive values, δ_1.	complex	1
crossTalkVHRx	V to H system cross-talk on receive values, δ_2.	complex	1

Tab.52 Polarimetric distortion DSR (crossTalkList)

Name	Description	Data Type	Cardinality
channelImbalHVTx	H to V system channel imbalance on transmit values, f_2.	complex	1

channelImbalHVRx	H to V system channel imbalance on receive values, f_1.	complex	1

Tab.53 Polarimetric distortion DSR (channelImbalanceList)

4.3.1.11. Ionosphere correction DSR

This DSR contains the results of the ionosphere correction estimated and applied by the processor.

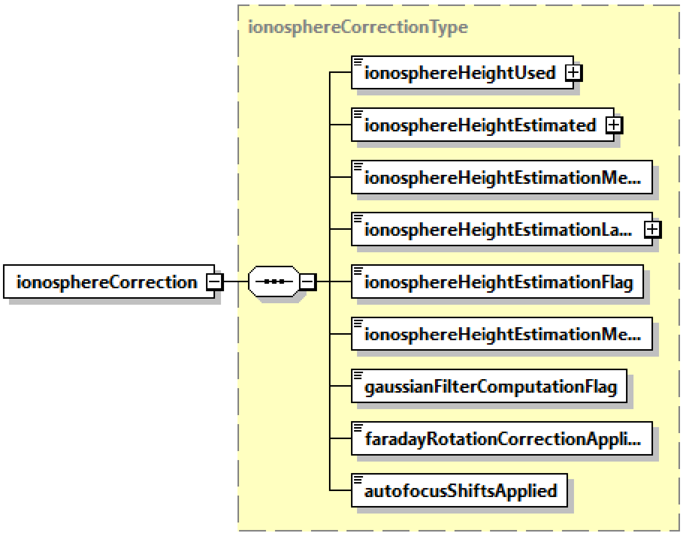


Fig.28 Ionosphere correction DSR (ionosphereCorrectionType)

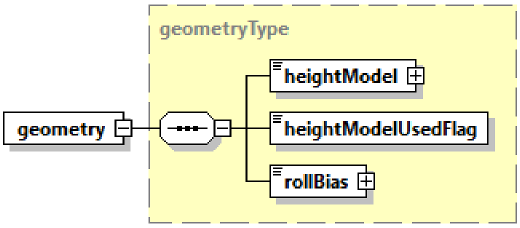
Name	**Description**	**Data Type**	**Cardinality**
ionosphereHeightUsed	Ionosphere height used for processing [m] (-1 if not available).	floatWithUnit	1
ionosphereHeightEstimated	Ionosphere height estimated using Feature Tracking or Squint Sensitivity method, if selected via configuration [m] (-1 if not available).	floatWithUnit	1
ionosphereHeightEstimationMethodSelected	Ionosphere height estimation method selected for ionospheric processing, between Feature Tracking and Squint Sensitivity, when ionosphereHeightEstimationMethod is set to Automatic (NA if not available).	ionosphereHeightEstimationMethodType	1
ionosphereHeightEstimationLatitudeValue	Latitude value used to select ionosphere height estimation method between Feature Tracking and Squint Sensitivity, when ionosphereHeightEstimationMethod is set to Automatic [deg].	floatWithUnit	1
ionosphereHeightEstimationFlag	True if ionosphere height estimation is completed successfully, False otherwise.	bool	1

ionosphereHeightEstimationMethodUsed	Ionosphere height estimation method effectively used for ionospheric processing. Can be different from ionosphereHeightEstimationMethod and ionosphereHeightEstimationMethodSelected. (NA if not available)	ionosphereHeightEstimationMethodType	1
gaussianFilterComputationFlag	True if computed filter dimensions are below maximum allowed values, False otherwise.	bool	1
faradayRotationCorrectionApplied	Flag indicating if Faraday Rotation correction has been effectively applied or not. Can be different from faradayRotationCorrectionFlag.	bool	1
autofocusShiftsApplied	Flag indicating if correction of azimuth shift estimated through autofocus has been effectively applied or not. Can be different from autofocusFlag.	bool	1

Tab.54 Ionosphere correction DSR (ionosphereCorrectionType)

4.3.1.12. Geometry DSR

This DSR contains all the necessary information to understand the Earth model/geometry used in the image and its geolocation.



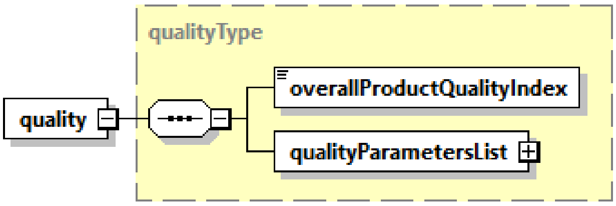
Geometry DSR (geometryType)

Name	Description	Data Type	Cardinality
heightModel	Digital Elevation Model (DEM) commanded for usage during processing (with version as attribute).	heightModelType	1
heightModelUsedFlag	True if the DEM effectively used during processing is the commanded one reported in heightModel, False otherwise (i.e. ellipsoid has been used for contingency handling).	bool	1
rollBias	Bias added to roll estimated from attitude to offset it [deg].	floatWithUnit	1

Tab.55 Geometry DSR (geometryType)

4.3.1.13. Quality DSR

This DSR contains in a single DSR quality flags and thresholds for basic quality assessment done at processing level.



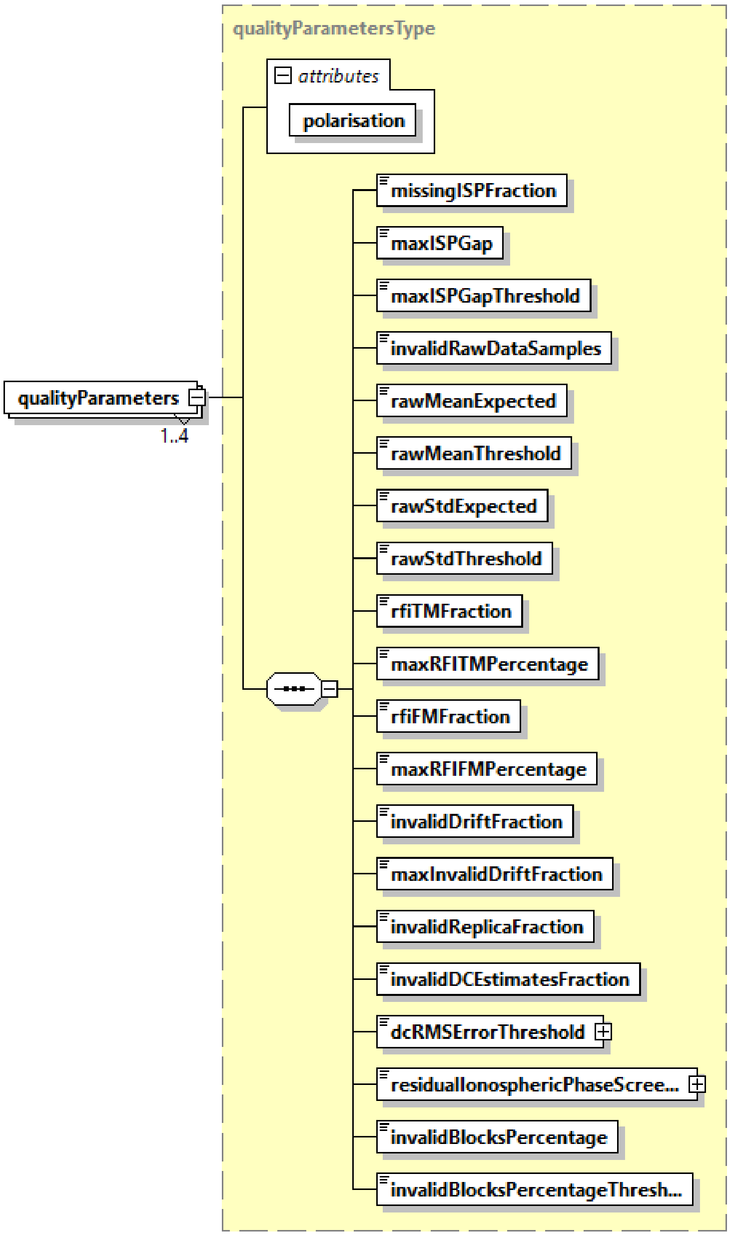
Quality DSR (qualityType)

Name	Description	Data Type	Cardinality
overallProductQualityIndex	Overall product quality index. This annotation is calculated based on specific quality parameters and gives an overall quality value to the product.	xsd:unsignedInt	1
qualityParametersList	Quality parameters list. The list contains an entry for each polarisation.	qualityParametersListType	1

Tab.56 Quality DSR (qualityType)

Name	Description	Data Type	Cardinality
count		xsd:unsignedInt	*required*
qualityParameters	Quality parameters for the current polarisation.	qualityParametersType	1 .. 4

Tab.57 Quality DSR (qualityParametersListType)



Fig

Quality DSR (qualityParametersType)

Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
missingISPFraction	Number of missing ISP, expressed as a normalized fraction of the total number of ISP.	xsd:float	1
maxISPGap	Maximum number of gaps between science data ISPs.	xsd:unsignedInt	1

maxISPGapThreshold	Threshold on maxISPGap. If maxISPGap exceeds this parameter, the processing will not continue.	xsd:unsignedInt	1
invalidRawDataSamples	Number of invalid raw data samples (according to their mean and standard deviation), expressed as a normalized fraction of the total number of samples.	xsd:float	1
rawMeanExpected	This parameter specifies the expected mean of the samples in the extracted raw data.	xsd:float	1
rawMeanThreshold	This is the value X such that the measured mean must fall between the rawMeanExpected-X and rawMeanExpected+X.	xsd:float	1
rawStdExpected	This parameter specifies the expected standard deviation of the samples in the extracted raw data.	xsd:float	1
rawStdThreshold	This is the value X such that the measured standard deviation must fall between the rawStdExpected-X and rawStdExpected+X.	xsd:float	1
rfiTMFraction	Normalized fraction of image pixels impacted by time-domain RFI.	xsd:float	1
maxRFITMPercentage	Maximum normalized percentage of image pixels impacted by time-domain RFI. If the percentage exceeds this parameter, the processing will not continue.	xsd:float	1
rfiFMFraction	Normalized fraction of image spectrum impacted by frequency-domain RFI.	xsd:float	1
maxRFIFMPercentage	Maximum normalized percentage of image spectrum impacted by frequency-domain RFI. If the percentage exceeds this parameter, the processing will not continue.	xsd:float	1
invalidDriftFraction	Number of invalid drift values, expressed as a normalized fraction of the total number of drifts.	xsd:float	1
maxInvalidDriftFraction	Maximum number of invalid drift values allowed, expressed as a normalized fraction of the total number of drifts. If the percentage of the invalid drifts does not exceed this value, then the invalid drifts will be discarded and only the valid ones will be further used in the processing. Otherwise, all the calculated drift values will be discarded and replaced with the corresponding model values.	xsd:float	1

invalidReplicaFraction	Number of invalid replicas, expressed as a normalized fraction of the total number of replicas extracted.	xsd:float	1
invalidDCEstimatesFraction	Number of invalid DC estimated, expressed as a normalized fraction of the total number of DC estimates.	xsd:float	1
dcRMSErrorThreshold	Doppler Centroid estimation root mean squared (RMS) error threshold [Hz]. If the RMS error of the Doppler Centroid combined estimates is above this threshold they are not used during processing; instead, the Doppler Centroid calculated from geometry is used.	floatWithUnit	1
residualIonosphericPhaseScreenStd	Quality measure of the ionospheric phase estimated by Faraday Rotation, expressed as standard deviation of the residual ionospheric phase screen [rad].	xsd:float	1
invalidBlocksPercentage	Normalized fraction of image blocks that need to have estimated an azimuth shift higher than the maximum allowed one, used to consider an autofocus estimation valid or not.	xsd:float	1
invalidBlocksPercentageThreshold	Minimum normalized percentage of blocks within the image that need to have estimated an azimuth shift smaller than the maxValidShift threshold. If the minimum percentage is not met, no correction based on the azimuth shift estimates will be applied.	xsd:float	1

Tab.58 Quality DSR (qualityParametersType)

4.3.1.13.1. Overall Product Quality Index

As mentioned in Tab. 54, the *overallProductQualityIndex* is an unsigned integer value (*i.e.* a 32-bit integer ranging from 0 to 2^{32} – 1) that summarizes the execution history of the L1 Processor. The L1's *overallProductQualityIndex* is the decimal representation of a 32-bit array that is defined as follows:

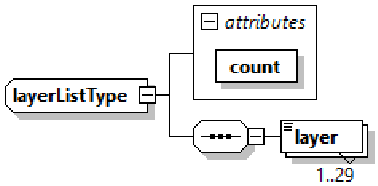
Bit #	Module/Sub-step	Bit-Flipping Condition
0	Input products and auxiliary files ingestion	*- Intentionally left blank, i.e. 0 -*
1		*- Intentionally left blank, i.e. 0 -*
2		*- Intentionally left blank, i.e. 0 -*
3		*- Intentionally left blank, i.e. 0 -*
4	RAW data analysis	RAW data statistics out of boundaries (set to 1 if *invalidRawDataSamples*>0, otherwise set to 0)
5		*- Intentionally left blank, i.e. 0 -*

Bit #	Module/Sub-step	Bit-Flipping Condition
6		*- Intentionally left blank, i.e. 0 -*
7		*- Intentionally left blank, i.e. 0 -*
8	Internal calibration	Invalid calibration sequences above threshold (set to 1 if *invalidDriftFraction*>0 or if *invalidReplicaFraction*>0, otherwise set to 0)
9		*- Intentionally left blank, i.e. 0 -*
10		*- Intentionally left blank, i.e. 0 -*
11		*- Intentionally left blank, i.e. 0 -*
12	RFI mitigation	*- Intentionally left blank, i.e. 0 -*
13		*- Intentionally left blank, i.e. 0 -*
14		*- Intentionally left blank, i.e. 0 -*
15		*- Intentionally left blank, i.e. 0 -*
16	Doppler Centroid estimation	Doppler Centroid estimation fallback from Combined method to Geometry method activated (set to 1 if activated, otherwise set to 0)
17		Doppler Centroid estimation root mean squared (RMS) error above threshold (set to 1 if *invalidDCEstimatesFraction*>0, otherwise set to 0)
18		*- Intentionally left blank, i.e. 0 -*
19		*- Intentionally left blank, i.e. 0 -*
20	Range and azimuth compression	*- Intentionally left blank, i.e. 0 -*
21		*- Intentionally left blank, i.e. 0 -*
22		*- Intentionally left blank, i.e. 0 -*
23		*- Intentionally left blank, i.e. 0 -*
24	Polarimetric and ionospheric corrections	Ionosphere height estimation failing (set to 1 if *ionosphereHeightEstimationFlag*==False, otherwise set to 0)
25		IRI model used (set to 1 if IRI model is used as fallback solution, due to failure of ionosphere height estimation, or set to 0 if it is used on purpose or not used)
26		Gaussian filter size out of boundaries (set to 1 if *gaussianFilterComputationFlag*==False, otherwise set to 0)
27		Inconsistent phaseScreen and rangeShifts LUTs (see Sec. 4.3.2 and L1 ATBD Sec. 4.10.3.5) (set to 1 in case of inconsistency, otherwise set to 0)
28		Geomagnetic equator crossing fallback activated, i.e., phase screen and group delay corrections not applied (set to 1 if activated, otherwise set to 0)
29		*- Intentionally left blank, i.e. 0 -*
30	Autofocus	Number of failing estimations above threshold (set to 1 if *autofocusShiftsApplied*==False, otherwise set to 0)
31		*- Intentionally left blank, i.e. 0 -*

Note that some bits are intentionally left blank to support user-defined custom information. The quality index bits aim at providing the user with hints for tracing possible problems in case of failures in the processing.

4.3.1.14. Annotation LUT DSR

This DSR contains the list of Look-Up Tables (LUTs) complementing product main annotations.



Annotation LUT DSR (layerListType)

Name	Description	Data Type	Cardinality
count	*Number of layers.*	*unsignedInt*	*required*
layer	LUT layer content.	layerType	1 .. 30

Tab.59 Annotation LUT DSR (layerListType)

4.3.2. Look-Up Tables (LUT) ADS

This section describes in details the content of Look-Up Tables (LUT) ADS.

This ADS complements the Main ADS one, including all those annotations that can be represented as 2D maps of values. This approach has been chosen in order to avoid worsening the Main ADS readability and handling, and also to provide an easier access to such information.

The name (LUT ADS) comes from the fact that this ADS contains a set of components, each of which:

- is defined over a sampling grid which is a sub-sampled version of the grid over which the SAR image MDS is defined;
- provides additional details about the domain over which the SAR image MDS is defined (latitude/longitude/height maps, …), or
- provides layers of correction that have been already applied to the SAR image MDS during L1 processing (RFI mitigation masks, …) or that can be applied directly by the user on L1 data (denoising maps, …).

The format adopted for LUT ADS is NetCDF one [RD6]. Thanks to the flexibility provided by this format, all the components of this ADS are stored in the same file. In this way, considering that some layers are dedicated to geocoding information (latitude/longitude/height maps), it will be possible to directly place all the other maps on a geographical grid.

The LUT ADS file is organised as follows:

- a series of root level *attributes*, containing all those global attributes referring to the file as a whole;
- a *dimensions* group, where names and lengths of the dimensions used when creating data arrays (variables) are defined;
- a series of *coordinate variables*, containing special variables to store the axes data values for each dimension in the *dimensions* group;
- a series of *components*, each one composed by a group of variables which can be divided in:
  - the data arrays, storing the annotation Look-Up Tables themselves. A variable represents an array of values of the same data type and it is defined over two or more dimensions from the *dimensions* group;
  - ancillary scalar variables containing other useful metadata to complete the data definition.

Note that the LUT are defined over different sampling grids, depending on their specific definition, on the point in the processing chain where they have been computed (e.g., RFI masks are defined over a sub-sampled version of the RAW data sampling grid) and on the configured decimation factors.

Compression strategy

The NetCDF file used for LUT ADS will be in general a compressed one.

It must be noticed that considering that (see also Sec. 4.3.2.3):

- a L1a frame is a raster of 1500x30000 pixels (range x azimuth, worst-case in terms of data size);
- the decimation ratio for a LUT is of a factor 20x120, except for geometry-based LUT for which a factor 2x12 is used;
  NOTE: factor 2x12 allows to get a sampling close to DEM posting, i.e., ~90m for Copernicus DEM;
- LUT are typically (except rfiTimeMask*, rfiFreqMask*, latitude, longitude and height ones) stored using float precision;
- the LUT ADS contains a maximum of 30 components;

the LUT ADS will have a size <80MB.

In order to reduce this size, a compression is applied. In particular, a zlib (LSD=None) compression is used with compression level equals 2. This level combines good compression (~2x) with a small increase in compression/decompression time.

4.3.2.1. Attributes

The attributes contain the same list of parameters described in Sec. 4.3.1.1 for the Acquisition information DSR. For all the details about these parameters refer to this section.
In addition, those included in the following table are added.

Name	Description	Data Type	Cardinality
noDataValueBool	Pixel value in case of LUT invalid data. Used for Boolean LUT (RFI masks).	bool	1
noDataValueFloat	Pixel value in case of LUT invalid data. Used for float and double LUT.	float	1
referenceAzimuthTime	Reference azimuth time to be used together with LUT relative azimuth time axes [UTC].	timeType	1

Tab.60 LUT ADS additional attributes

4.3.2.2. Dimensions / Coordinate variables

The table below describes the dimensions and coordinate variables.

Name	Description	Data Type	Cardinality
slantRangeTimeRAW	Slant range time axis for LUT defined on RAW data sampling grid [s].	float	1
rangeFreqRAW	Range frequency axis for LUT defined on RAW data sampling grid [Hz].	float	1
relativeAzimuthTimeRAW	Azimuth relative time axis for LUT defined on RAW data sampling grid [s]. Reference is referenceAzimuthTime value in attributes.	float	1
slantRangeTimeRGC	Slant range time axis for LUT defined on range compressed data sampling grid [s].	double	1
relativeAzimuthTimeRGC	Azimuth relative time axis for LUT defined on range compressed data sampling grid [s]. Reference is referenceAzimuthTime value in attributes.	double	1
slantRangeTimeSLC	Slant range time axis for LUT defined on azimuth compressed data sampling grid [s].	float	1
relativeAzimuthTimeSLC	Azimuth relative time axis for LUT defined on azimuth compressed data sampling grid [s]. Reference is referenceAzimuthTime value in attributes.	float	1

Tab.61 LUT ADS dimensions and coordinate variables

4.3.2.3. Groups of variables

The table below describes the groups of variables. It shall be kept into account that the list of variables present in a given product can be just a subset of this one, depending on the configuration of L1 processing chain generating it (e.g., if the RFI mitigation step is deactivated, the rfiTimeMask* and the rfiFreqMask* variables won't be present in the LUT ADS).

Name	Description	Data Type	Cardinality
group: rfiMitigation variables: rfiTimeMaskHH, rfiTimeMaskHV, rfiTimeMaskVH, rfiTimeMaskVV	Two-dimensional masks covering the whole SAR image and describing the areas where RFI time-domain mitigation has been applied (ones) or not (zeros) during L1 processing. One mask per polarisation is foreseen (by default, 4 in total). AUX_FMT LUT group: RFI based LUT	matrix (bool)	4 (only if RFI mitigation step is activated)
group: rfiMitigation variables: rfiFreqMaskHH, rfiFreqMaskHV,	Two-dimensional masks covering the whole SAR image and describing the areas where RFI frequency-domain mitigation has been applied (ones) or not (zeros) during L1 processing. One mask per polarisation is foreseen (by default, 4 in total).	matrix (bool)	4 (only if RFI mitigation

rfiFreqMaskVH, rfiFreqMaskVV	AUX_FMT LUT group: RFI based LUT		step is activated)
group: radiometry variable: sigmaNought	Two-dimensional map covering the whole SAR image and describing the conversion factor to translate the beta-nought values into sigma-nought ones. The conversion shall be performed in the following way: $$\sigma^0 = \beta^0 \cdot \sigma^0_{LUT}$$ where: • β^0 are the values stored in the SAR image MDS (amplitudes) squared; • σ^0_{LUT} is this LUT (amplitudes) squared; • σ^0 are the sigma-nought values after the conversion. Being this LUT defined over a sub-sampled grid with respect to the SAR image, a bilinear interpolation of the LUT is required before its application on the data. AUX_FMT LUT group: DEM based LUT	matrix (float)	1
group: radiometry variable: gammaNought	As the sigma-nought map, but to translate the beta-nought values into gamma-nought ones. AUX_FMT LUT group: DEM based LUT	matrix (float)	1
group: ionosphereCorrection variable: faradayRotationPlane	Two-dimensional map covering the whole SAR image and describing the Faraday Rotation plane computed during L1 ionospheric processing. Values are expressed in [rad]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if ionospheric correction step is activated)
group: ionosphereCorrection variable: faradayRotation	Two-dimensional map covering the whole SAR image and describing the Faraday Rotation (final one, including plane) computed during L1 ionospheric processing. Values are expressed in [rad]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if ionospheric correction step is activated)
group: ionosphereCorrection variable: faradayRotationStd	Two-dimensional map covering the whole SAR image and describing the Faraday Rotation expected standard deviation. Values are expressed in [rad]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if ionospheric correction step is activated)
group: ionosphereCorrection variable: phaseScreen	Two-dimensional map covering the whole SAR image and describing the phase screen computed during L1 ionospheric processing. Values are expressed in [rad].	matrix (float)	1 (only if ionospheric correction

	AUX_FMT LUT group: Image based LUT		step is activated)
group: ionosphereCorrection variable: tec	Two-dimensional map covering the whole SAR image and describing the TEC map computed during L1 ionospheric processing. Values are expressed in [TECU]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if ionospheric correction step is activated)
group: ionosphereCorrection variable: rangeShifts	Two-dimensional map covering the whole SAR image and describing the range shifts computed during L1 ionospheric processing. Values are expressed in [m]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if ionospheric correction step is activated)
group: ionosphereCorrection variable: azimuthShifts	Two-dimensional map covering the whole SAR image and describing the azimuth shifts computed during L1 ionospheric processing. Values are expressed in [m]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if ionospheric correction step is activated)
group: ionosphereCorrection variable: autofocusPhaseScreen	Two-dimensional map covering the whole SAR image and describing the autofocus phase screen computed during L1 ionospheric processing. Values are expressed in [rad]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if autofocus step is activated)
group: ionosphereCorrection variable: autofocusPhaseScreenStd	Two-dimensional map covering the whole SAR image and describing the autofocus phase screen standard deviation based on the WLS double integration. Values are expressed in [rad]. AUX_FMT LUT group: Image based LUT	matrix (float)	1 (only if autofocus step is activated)
group: denoising variables: denoisingHH, denoisingHV, denoisingVH, denoisingVV	Two-dimensional maps covering the whole SAR image and describing the conversion factor to translate the SAR image values into denoised values. Note that, depending on the quantity the denoising shall be applied to (beta/sigma/gamma-nought), the denoising map shall be previously converted to the same quantity. This can be done applying the conversion above described for the sigma-nought map, considering that denoising map values are to be interpreted as powers instead of amplitudes. The denoising operation shall be performed in the following way (assuming sigma-nought quantity is used): $\widetilde{\sigma^0} = \sigma^0 - \sigma_{LUT}^{noise}$	matrix (float)	4

	where: • σ^0 are the values stored in the SAR image MDS squared and converted into sigma-nought through the dedicated LUT; • σ_{LUT}^{noise} is this LUT; • $\widetilde{\sigma^0}$ are the sigma-nought powers after the conversion. Being this LUT defined over a sub-sampled grid with respect to the SAR image, a bilinear interpolation of the LUT is required before its application on the data. One mask per polarisation is foreseen (by default, 4 in total). AUX_FMT LUT group: Image based LUT		
group: geometry variable: latitude	Two-dimensional map covering the whole SAR image and describing the latitude coordinates of each (sub-sampled) pixel. Values are expressed in [deg]. AUX_FMT LUT group: DEM based LUT	matrix (double)	1
group: geometry variable: longitude	Two-dimensional map covering the whole SAR image and describing the longitude coordinates of each (sub-sampled) pixel. Values are expressed in [deg]. AUX_FMT LUT group: DEM based LUT	matrix (double)	1
group: geometry variable: height	Two-dimensional map covering the whole SAR image and describing the height coordinates of each (sub-sampled) pixel, derived from the Digital Elevation Model (DEM) used during processing. Values are expressed in [m], with the same reference of the used DEM. AUX_FMT LUT group: DEM based LUT	matrix (double)	1
group: geometry variable: incidenceAngle	Two-dimensional map covering the whole SAR image and describing the incidence angle of each (sub-sampled) pixel. Values are computed during L1 processing considering an average height. Values are expressed in [deg]. AUX_FMT LUT group: DEM based LUT	matrix (float)	1
group: geometry variable: elevationAngle	Two-dimensional map covering the whole SAR image and describing the elevation angle of each (sub-sampled) pixel. Values are computed during L1 processing considering an average height. Values are expressed in [deg]. AUX_FMT LUT group: DEM based LUT	matrix (float)	1
group: geometry variable: rangeTerrainSlope	Two-dimensional map covering the whole SAR image and describing the local terrain slopes along range direction computed using the Digital Elevation Model (DEM).	matrix (float)	1

	Values are expressed in [deg]. AUX_FMT LUT group: DEM based LUT		
group: geometry variable: azimuthTerrainSlope	Two-dimensional map covering the whole SAR image and describing the local terrain slopes along azimuth direction computed using the Digital Elevation Model (DEM). Values are expressed in [deg]. AUX_FMT LUT group: DEM based LUT	matrix (float)	1

Tab.62 LUT ADS groups of variables

As mentioned above, LUT are defined over different sampling grids.
By default, these sampling grids are set to have a ground resolution of 1x1km (range x azimuth), except for geometry-based LUTs for which a resolution close to DEM one is kept, i.e., 90x90m. This means that the default down-sampling factors with respect to SAR image MDS sampling grid are:

- 20x120 for L1a products (2x12 for geometry-based LUTs);
- 20x20 for L1b products (2x2 for geometry-based LUTs).

These parameters are configurable.

Here below a sample LUT ADS is reported (obtained with ncdump command).

```
netcdf bio_s2_scs__1s_20170111t050609_20170111t050630_i_g03_m03_c03_t010_f001_lut {
dimensions:
	slantRangeTimeRAW = 87 ;
	relativeAzimuthTimeRAW = 322 ;
	rangeFreqRAW = 87 ;
	slantRangeTimeRGC = 72 ;
	relativeAzimuthTimeRGC = 214 ;
	slantRangeTimeSLC = 69 ;
	relativeAzimuthTimeSLC = 180 ;
variables:
	float slantRangeTimeRAW(slantRangeTimeRAW) ;
		slantRangeTimeRAW:units = "s" ;
	float relativeAzimuthTimeRAW(relativeAzimuthTimeRAW) ;
		relativeAzimuthTimeRAW:units = "s" ;
	float rangeFreqRAW(rangeFreqRAW) ;
		rangeFreqRAW:units = "Hz" ;
	double slantRangeTimeRGC(slantRangeTimeRGC) ;
		slantRangeTimeRGC:units = "s" ;
	double relativeAzimuthTimeRGC(relativeAzimuthTimeRGC) ;
		relativeAzimuthTimeRGC:units = "s" ;
	float slantRangeTimeSLC(slantRangeTimeSLC) ;
		slantRangeTimeSLC:units = "s" ;
	float relativeAzimuthTimeSLC(relativeAzimuthTimeSLC) ;
		relativeAzimuthTimeSLC:units = "s" ;

// global attributes:
		:mission = "BIOMASS" ;
		:swath = "S2" ;
		:productType = "SCS" ;
```

```
		string :polarisationList = "H/H", "H/V", "V/H", "V/V" ;
		:startTime = "2017-01-11T05:06:09.332291" ;
		:stopTime = "2017-01-11T05:06:30.423772" ;
		:missionPhaseID = "INT" ;
		:driftPhaseFlag = "False" ;
		:sensorMode = "Measurement" ;
		:globalCoverageID = 3US ;
		:majorCycleID = 3US ;
		:repeatCycleID = 3US ;
		:absoluteOrbitNumber = 10US ;
		:relativeOrbitNumber = 10US ;
		:orbitPass = "Ascending" ;
		:platformHeading = 0. ;
		:dataTakeID = 1234US ;
		:frame = 1US ;
		:productComposition = "Nominal" ;
		:noDataValueBool = "False" ;
		:noDataValueFloat = -9999. ;
		:referenceAzimuthTime = "2017-01-11T05:06:09.332291" ;
		:_NCProperties = "version=2,netcdf=4.9.0,hdf5=1.12.2" ;

group: rfiMitigation {
  variables:
	ubyte rfiTimeMaskHH(relativeAzimuthTimeRAW, slantRangeTimeRAW) ;
		rfiTimeMaskHH:_FillValue = 0UB ;
		rfiTimeMaskHH:description = "RFI Time Domain Mask H/H" ;
	ubyte rfiTimeMaskHV(relativeAzimuthTimeRAW, slantRangeTimeRAW) ;
		rfiTimeMaskHV:_FillValue = 0UB ;
		rfiTimeMaskHV:description = "RFI Time Domain Mask H/V" ;
	ubyte rfiTimeMaskVH(relativeAzimuthTimeRAW, slantRangeTimeRAW) ;
		rfiTimeMaskVH:_FillValue = 0UB ;
		rfiTimeMaskVH:description = "RFI Time Domain Mask V/H" ;
	ubyte rfiTimeMaskVV(relativeAzimuthTimeRAW, slantRangeTimeRAW) ;
		rfiTimeMaskVV:_FillValue = 0UB ;
		rfiTimeMaskVV:description = "RFI Time Domain Mask V/V" ;
	ubyte rfiFreqMaskHH(relativeAzimuthTimeRAW, rangeFreqRAW) ;
		rfiFreqMaskHH:_FillValue = 0UB ;
		rfiFreqMaskHH:description = "RFI Frequency Domain Mask H/H" ;
	ubyte rfiFreqMaskHV(relativeAzimuthTimeRAW, rangeFreqRAW) ;
		rfiFreqMaskHV:_FillValue = 0UB ;
		rfiFreqMaskHV:description = "RFI Frequency Domain Mask H/V" ;
	ubyte rfiFreqMaskVH(relativeAzimuthTimeRAW, rangeFreqRAW) ;
		rfiFreqMaskVH:_FillValue = 0UB ;
		rfiFreqMaskVH:description = "RFI Frequency Domain Mask V/H" ;
	ubyte rfiFreqMaskVV(relativeAzimuthTimeRAW, rangeFreqRAW) ;
		rfiFreqMaskVV:_FillValue = 0UB ;
		rfiFreqMaskVV:description = "RFI Frequency Domain Mask V/V" ;
  } // group rfiMitigation

group: ionosphereCorrection {
  variables:
	float phaseScreen(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
		phaseScreen:_FillValue = -9999.f ;
		phaseScreen:description = "Phase Screen (Bickel & Bates)" ;
		phaseScreen:units = "rad" ;
	float faradayRotationPlane(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
		faradayRotationPlane:_FillValue = -9999.f ;
		faradayRotationPlane:description = "Faraday Rotation Plane" ;
		faradayRotationPlane:units = "rad" ;
```

```
        float faradayRotation(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            faradayRotation:_FillValue = -9999.f ;
            faradayRotation:description = "Faraday Rotation" ;
            faradayRotation:units = "rad" ;
        float faradayRotationStd(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            faradayRotationStd:_FillValue = -9999.f ;
            faradayRotationStd:description = "Faraday Rotation Std" ;
            faradayRotationStd:units = "rad" ;
        float tec(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            tec:_FillValue = -9999.f ;
            tec:description = "TEC" ;
            tec:units = "TECU" ;
        float rangeShifts(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            rangeShifts:_FillValue = -9999.f ;
            rangeShifts:description = "Range Shifts" ;
            rangeShifts:units = "m" ;
        float azimuthShifts(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            azimuthShifts:_FillValue = -9999.f ;
            azimuthShifts:description = "Azimuth Shifts" ;
            azimuthShifts:units = "m" ;
        float autofocusPhaseScreen(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            autofocusPhaseScreen:_FillValue = -9999.f ;
            autofocusPhaseScreen:description = "Phase Screen (Autofocus)" ;
            autofocusPhaseScreen:units = "rad" ;
        float autofocusPhaseScreenStd(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            autofocusPhaseScreenStd:_FillValue = -9999.f ;
            autofocusPhaseScreenStd:description = "Phase Screen Std (Autofocus)" ;
            autofocusPhaseScreenStd:units = "rad" ;
  } // group ionosphereCorrection

group: denoising {
  variables:
        float denoisingHH(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            denoisingHH:_FillValue = -9999.f ;
            denoisingHH:description = "Denoising H/H" ;
        float denoisingHV(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            denoisingHV:_FillValue = -9999.f ;
            denoisingHV:description = "Denoising H/V" ;
        float denoisingVH(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            denoisingVH:_FillValue = -9999.f ;
            denoisingVH:description = "Denoising V/H" ;
        float denoisingVV(relativeAzimuthTimeSLC, slantRangeTimeSLC) ;
            denoisingVV:_FillValue = -9999.f ;
            denoisingVV:description = "Denoising V/V" ;
  } // group denoising

group: geometry {
  variables:
        double latitude(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            latitude:_FillValue = -9999. ;
            latitude:description = "Latitude" ;
            latitude:units = "deg" ;
        double longitude(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            longitude:_FillValue = -9999. ;
            longitude:description = "Longitude" ;
            longitude:units = "deg" ;
        double height(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            height:_FillValue = -9999. ;
            height:description = "Height" ;
```

```
            height:units = "m" ;
        float incidenceAngle(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            incidenceAngle:_FillValue = -9999.f ;
            incidenceAngle:description = "Incidence Angle" ;
            incidenceAngle:units = "deg" ;
        float elevationAngle(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            elevationAngle:_FillValue = -9999.f ;
            elevationAngle:description = "Elevation Angle" ;
            elevationAngle:units = "deg" ;
        float rangeTerrainSlope(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            rangeTerrainSlope:_FillValue = -9999.f ;
            rangeTerrainSlope:description = "Range Terrain Slope" ;
        float azimuthTerrainSlope(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            azimuthTerrainSlope:_FillValue = -9999.f ;
            azimuthTerrainSlope:description = "Azimuth Terrain Slope" ;
  } // group geometry

group: radiometry {
  variables:
        float sigmaNought(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            sigmaNought:_FillValue = -9999.f ;
            sigmaNought:description = "Sigma Nought" ;
        float gammaNought(relativeAzimuthTimeRGC, slantRangeTimeRGC) ;
            gammaNought:_FillValue = -9999.f ;
            gammaNought:description = "Gamma Nought" ;
  } // group radiometry
}
```

4.3.3. Orbit and attitude ADS

The Orbit and Attitude ADS will be included as dedicated files in L1a/b products.
Their format is the EO Mission CFI SW Format Specification, as mentioned in [AD4] and described in [AD5]. This is the same format of the auxiliary orbit and attitude files taken input by the L1 processor. For what concern their content, in principle it will be the same too, unless the L1 processor performs any interpolation, extrapolation, … operation. In this case the modified orbit and attitude information are annotated in these two ADS.

4.3.4. Quick-look ADS

The Quick-look ADS is a lower resolution version of the SAR image MDS. It is stored in PNG file format and it is always included with any BIOMASS L1 product.
The following rules and properties apply to Quick-look ADS:

- for L1a products, quick-looks are a power detected, averaged and decimated version of the full SAR image;
- for L1b products, quick-looks are a squared averaged and decimated version of the full SAR image.

BIOMASS products can contain one or two quick-look images, depending on the product type and on the selected colour coding method, which are a combination of the imagery from all the four polarisation channels. This is done exploiting the three Red-Green-Blue (RGB) channels of the PNG image and the Pauli decomposition colour coding scheme, i.e.:

- Red channel: $|\mathrm{HH} - \mathrm{VV}|$ (double bounce);
- Green channel: $|\mathrm{HV} + \mathrm{VH}|$ (volume scattering);
- Blue channel: $|\mathrm{HH} + \mathrm{VV}|$ (surface scattering).

or the HSV one, i.e. (see also https://en.wikipedia.org/wiki/HSL_and_HSV):

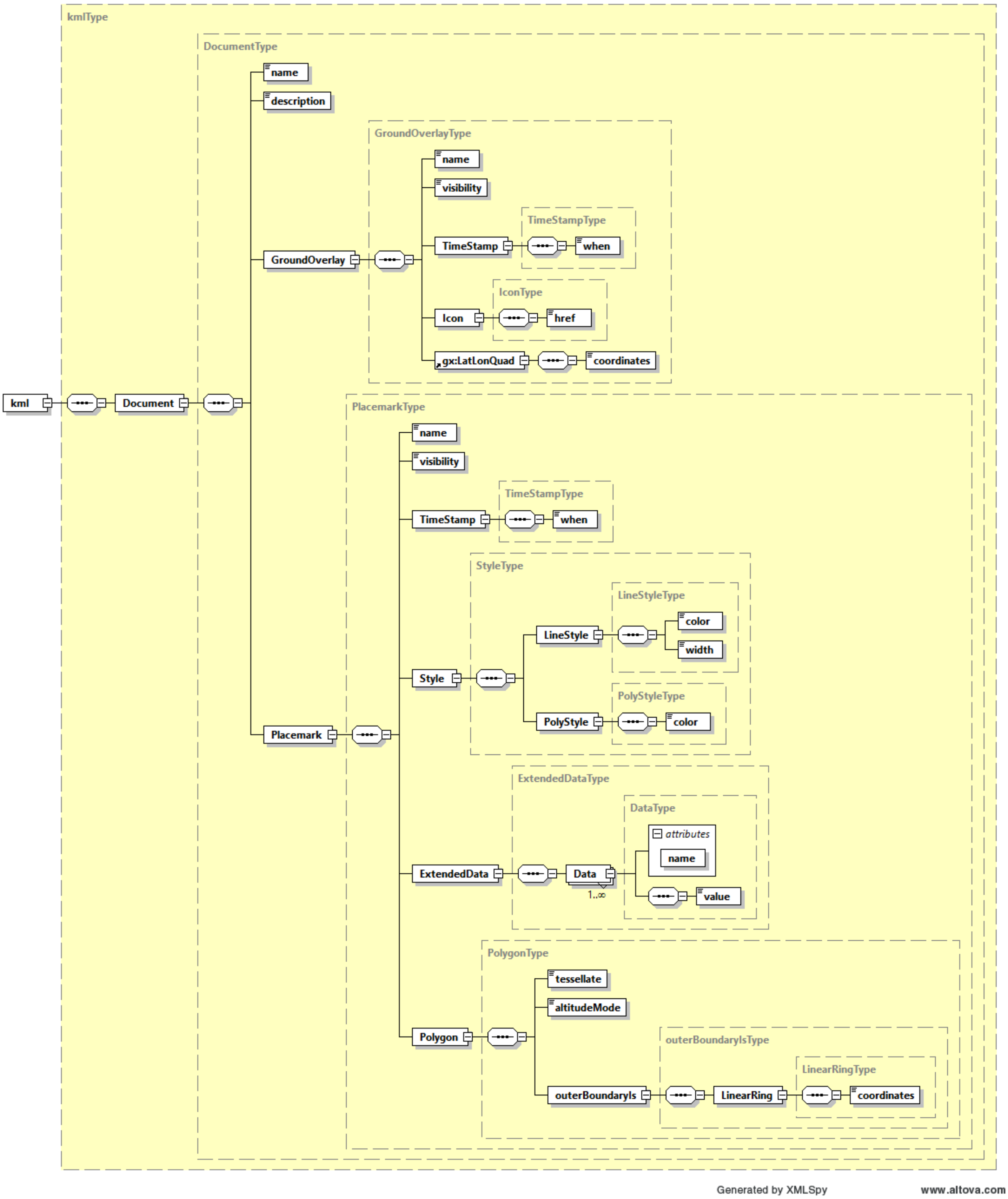
- H: hue values;
- S: saturation values;
- V: brightness values.

for L1a products and the Lexicographic one for L1b products, i.e.:

- Red channel: $|\mathrm{HH}|$;
- Green channel: $\frac{1}{2}\sqrt{\mathrm{HV}^2 + \mathrm{VH}^2}$;
- Blue channel: $|\mathrm{VV}|$.

4.3.5. Overlay ADS

The Overlay ADS is a Keyhole Markup Language (KML) file that describes the product coverage area and is suitable for viewing the Quick-look ADS in any application that supports KML format (like, e.g., Google Earth or GIS applications). Its structure is described in the following figure and tables.



Overlay ADS

Name	Description	Data Type	Cardinality
Document	Document container for KML components.	DocumentType	1

Tab.63 Overlay ADS

Name	Description	Data Type	Cardinality
name	Name of the document.	xsd:string	1
description	Description of the document.	xsd:string	1
GroundOverlay	Contains the parameters required to specify the footprint of the image and overlay the quicklook image on a map.	GroundOverlayType	1
Placemark	Contains the metadata associated to the overlay.	PlacemarkType	1

Tab.64 Overlay ADS (DocumentType)

Name	Description	Data Type	Cardinality
name	Name of the ground overlay.	xsd:string	1
visibility	Specifies whether the feature is drawn in the 3D viewer when it is initially loaded (0: not visible, 1: visible).	xsd:unsignedInt	1
TimeStamp	Structure containing the time stamp of the overlay that can be used for dynamic visualizations over time.	TimeStampType	1
Icon	Structure describing the image file used on the map overlay.	IconType	1
LatLonQuad	Structure containing the latitude and longitude coordinates used to position the image overlay on the map.	LatLonQuadType	1

Tab.65 Overlay ADS (GroundOverlayType)

Name	Description	Data Type	Cardinality
when	Overlay time stamp in ISO 8601 format (YYYY-MM-DDThh:mm:ss).	xsd:string	1

Tab.66 Overlay ADS (TimeStampType)

Name	Description	Data Type	Cardinality
href	A local file specification or URL used to load the desired image and overlay it on the map.	xsd:string	1

Tab.67 Overlay ADS (IconType)

Name	**Description**	**Data Type**	**Cardinality**
coordinates	A string of 5 lon,lat coordinate pairs which describe the corners of the image. The string is of the form: *lon,lat lon,lat lon,lat lon,lat lon,lat* The coordinates must appear in the following order: *last line first pixel, last line last pixel, first line last pixel, first line first pixel, last line first pixel*	xsd:string	1

Tab.68 Overlay ADS (LatLonQuadType)

Name	**Description**	**Data Type**	**Cardinality**
Name	Name of the placemark.	xsd:string	1
visibility	Specifies whether the feature is drawn in the 3D viewer when it is initially loaded (0: not visible, 1: visible).	xsd:unsignedInt	1
TimeStamp	Structure containing the time stamp of the placemark that can be used for dynamic visualizations over time	TimeStampType	1
Style	Structure describing the stype used to display the placemark.	StyleType	1
ExtendedData	Structure containing the metadata associated to the overlay.	ExtendedDataType	1
Polygon	Structure containing the latitude and longitude coordinates used to position the image overlay on the map.	PolygonType	1

Tab.69 Overlay ADS (PlacemarkType)

Name	**Description**	**Data Type**	**Cardinality**
LyneStyle	Line style.	LyneStyleType	1
PolyStyle	Polygon style.	PolyStyleType	1

Tab.70 Overlay ADS (StyleType)

Name	**Description**	**Data Type**	**Cardinality**

color	Line color in 32 bit hex format (AABBGGRR order).	xsd:string	1
width	Line width.	xsd:unsignedInt	1

Tab.71 Overlay ADS (LyneStyleType)

Name	Description	Data Type	Cardinality
color	Polygon color in 32 bit hex format (AABBGGRR order).	xsd:string	1

Tab.72 Overlay ADS (PolyStyleType)

Name	Description	Data Type	Cardinality
Data	Metadata.	DataType	1..inf

Tab.73 Overlay ADS (ExtendedDataType)

Name	Description	Data Type	Cardinality
value	Metadata value.	xsd:string	1

Tab.74 Overlay ADS (DataType)

Name	Description	Data Type	Cardinality
tessellate	Tessellate option.	xsd:unsignedInt	1
altitudeMode	Altitude mode option.	xsd:string	1
outerBoundaryIs	Polygon outer boundary description.	outerBoundaryIsType	1

Tab.75 Overlay ADS ()

Name	Description	Data Type	Cardinality
LinearRing	Linear ring description.	LinearRingType	1

Tab.76 Overlay ADS (outerBoundaryIsType)

Name	Description	Data Type	Cardinality
coordinates	A string of 5 lon,lat,height coordinate tuples which describe the corners of the image. The string is of the form: *lon,lat,height lon,lat,height lon,lat,height lon,lat,height lon,lat,height* The coordinates must appear in the following order: *last line first pixel, last line last pixel, first line last pixel, first line first pixel, last line first pixel*	xsd:string	1

Tab.77 Overlay ADS (LinearRingType)

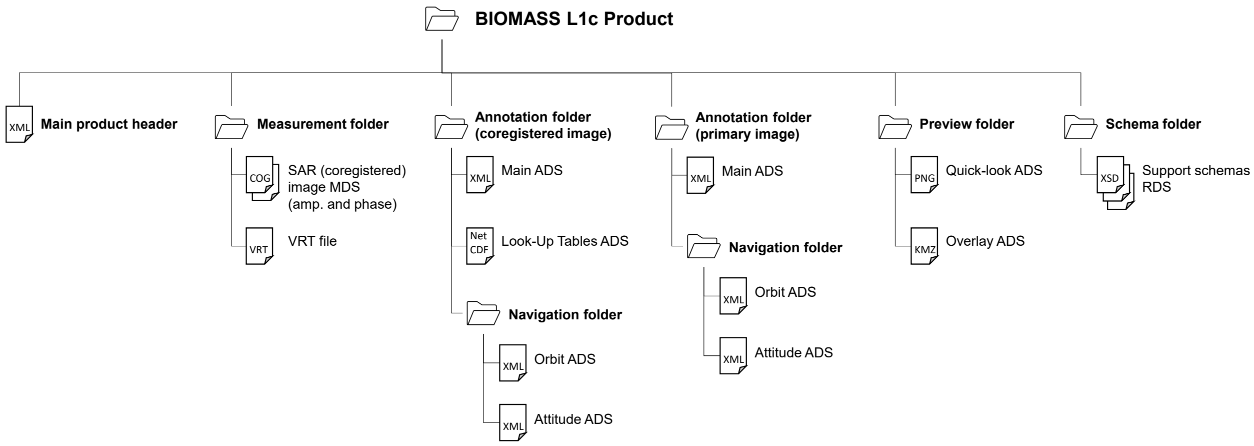
5. L1c Products Format Overview

The BIOMASS L1c product, as well as L1a and L1b ones, is a folder containing a collection of information, grouped together into files referred to as data sets, and data sets are collected and grouped into several sub-folders in order to achieve a physical tree forming a complete product. Differently from L1a and L1b products, L1c ones contain both information related to primary and to the coregistered SAR images.

The kinds of datasets are the same of L1a and L1b products, i.e., the Measurement Data Sets (MDS), the Annotation Data Sets (ADS) and the Representation Data Sets (RDS).

The declination and customisation of this format structure for BIOMASS L1c product is summarised in the following table. In particular, a typical product contains:

- a main product header, an XML file including high-level information about the product origin, structure and main metadata (see Sec. 6.1);
- SAR (coregistered) image MDS, including the coregistered image binary raster data for the three or four BIOMASS polarisations (depending on configuration), organised in two Cloud Optimized GeoTIFF (COG) files, one for amplitude and one for phase components (see Sec. 6.2);
- primary image main annotation ADS, a copy of the primary image L1a product main ADS XML file, including only relevant DSR (see Sec. 6.3.1);
- coregistered image main annotation ADS, a copy of the secondary image L1a product main ADS XML file, with DSR content updated where needed and new DSR, specific for the coregistration process, added (see Sec. 6.3.3);
- coregistered image Look-Up Table (LUT) ADS, including those metadata being too voluminous to be coded efficiently in an XML file (i.e., Look-Up Tables) and requiring a binary NetCDF file (see. Sec. 6.3.4), i.e.:
  - copy of secondary image L1a product LUT radiometric calibration and denoising DSR, resampled over coregistration grid;
  - new coregistration (range and azimuth coregistration shifts and quality index maps) and InSAR DSR (RFI impact, residual fast-varying ionospheric phase and ground calibration phase maps, plus related quality indexes maps)
  - copy of primary image L1a product LUT geometry DSR;
- orbit and attitude ADS, including orbit and attitude information, both for primary and coregistered images, in dedicated XML files (see Sec. 6.3.2 and 6.3.5 respectively);
- quick-look and overlay ADS, including an averaged and decimated preview of the coregistered SAR image data set and information about its geographic coverage (see Sec. 6.3.6 and 6.3.7);
- XML schemas RDS, including the schemas needed for all the XML files included in the product.



L1c products structure

File / Folder	Cardinality	Format	Description / Content
BIOMASS L1c Product		Folder	
∟ main product header	1	XML	Main product header
∟ measurement		Folder	
∟ sar image	2	COG	SAR (coregistered) image MDS 2 files = 1 for amplitude + 1 for phase 3 or 4 components each (1 per polarization)
∟ sar image	1	VRT	SAR (coregistered) image MDS (support)
∟ annotation_primary		Folder	
∟ main	1	XML	Primary image main ADS Copy of primary image L1a product main ADS, including only relevant DSR
∟ navigation		Folder	
∟ orbit	1	XML (EOF)	Orbit DSR
∟ attitude	1	XML (EOF)	Attitude DSR
∟ annotation_coregistered		Folder	
∟ main	1	XML	Coregistered image main ADS Copy of secondary image L1a product main ADS, with DSR content updated where needed + - STA processing parameters DSR - STA coregistration parameters DSR - STA InSAR parameters DSR - STA quality DSR

∟ lut	1	NetCDF	Coregistered image Look-Up Tables ADS: - Copy of secondary image L1a product LUT DSR, resampled over coregistration grid: - Radiometric calibration DSR (sigma-nought and gamma-nought maps) - Denoising DSR (one per polarisation) - Copy of primary image L1a product LUT DSR: - Geometry DSR (latitude/longitude/height maps, incidence and elevation angles maps) Additionally: - Coregistration DSR (range and azimuth coregistration shifts and quality index maps, wavenumbers, flattening phase screens) - For secondary images only, Interferometric quantities (coherence and interferogram with respect to the coregistration primary). - Optionally, SKP DSR (SKP calibration phase screen and quality indicators) - Optionally, Multi-Squint Calibration DSR (ionospheric phase screens)
∟ navigation		Folder	
∟ orbit	1	XML (EOF)	Orbit DSR
∟ attitude	1	XML (EOF)	Attitude DSR
∟ preview		Folder	
∟ quicklook	1 to 4	PNG	Quick-look ADS L1c can have up to 4 quick-look files: - At least 1 of Pauli and HSV decomposition - Optionally, and for secondary images only, the coherence vs primary - Optionally, and for secondary images only, the flattened interferogram vs primary
∟ overlay	1 to 4	KML	Overlay ADS. 1 overlay per quick-look file.
∟ schema		Folder	
∟ main annotation.xsd	1	XSD	RDS
∟ orbit.xsd	1	XSD	RDS
∟ attitude.xsd	1	XSD	RDS
∟ overlay.xsd	1	XSD	RDS
∟ common types.xsd	1	XSD	RDS

Tab.78 L1c product structure

5.1. Product format definition guidelines

Refer to Sec. 3.1.

5.2. L1M products

As described above, L1M products are a “light” version of L1S ones, to be used for monitoring purposes.
It has to be noted that L1M products are generated by STA processor in the same flow of L1S ones, without the need of specific processing.
L1M products are identical to L1S ones except for SAR image MDS (and ‘measurement’ sub-folder), which is present only in L1S products.

5.3. Naming convention

The naming convention for the BIOMASS L1c products and their related data are described in details in [AD2] and briefly recalled in Section 3.4. In summary, L1c product names differs from L1a/b products names in what follows:

- `<TTTTTTTTTT>`: Product Type/File Type:
    - `S[1,2,3]_STA__1S`: Stripmap L1 Coregistered stack - Standard product;
    - `S[1,2,3]_STA__1M`: Stripmap L1 Coregistered stack - Monitoring Product;
- `<yyyymmddThhmmss>`: UTC start date and time after coregistration;
- `<YYYYMMDDTHHMMSS>`: UTC stop date and time after coregistation.

Note that start and end times of L1c products do not necessarily coincide with those of the source L1a products since L1c products are coregistered on the primary image grid (see Stack ATBD, Section 4). Consequently, start and end times are updated according to the azimuth coregistration shifts estimated by the stack.

6. L1c Products Format Specification

6.1. Main product header

The Main Product Header (MPH) is an XML file present in all the BIOMASS L1 products. BIOMASS L1 products are folder based and the MPH is top level leaf of the product tree.

The MPH main scope is to provide all the information related to the:

- Genesis of the product;
- Identification of the product for example for cataloguing purposes;
- Product consistency (file size).

For the detailed description of the MPH content and format refer to [AD3]. For a schematic representation see Sec. 4.1.

6.2. Measurement data sets (MDS)

6.2.1. SAR (coregistered) image MDS

The SAR image MDS is used to store the SAR image binary raster data as generated by the Stack processor for all the foreseen BIOMASS data polarisations (HH, HV, VH, VV). This image is the coregistered version of the secondary image received in input by the Stack processor from the L1 processor (L1a product). It is resampled over the same sampling grid of the primary image, with the following conventions:

- the coregistered image pixels exceeding the primary one extent are thrown away;
- the primary image pixels not overlapping the coregistered one will be represented as invalid data.

The format used to store the SAR (coregistered) image MDS is again the Cloud Optimized GeoTIFF (COG) [RD1].

All the details about COG format and about its usage to store SAR image MDS already explained in Sec. 4.2.1 for L1a products (compression strategy, usage of VRT files, metadata, overviews, …) apply as well to L1c products.

6.3. Annotation data sets (ADS)

6.3.1. Primary image main ADS

This ADS is an exact copy of the main ADS included in the L1a product (primary one) received in input by the Stack processor..

6.3.2. Primary image orbit and attitude ADS

The primary image Orbit and Attitude ADS will be included as dedicated files in L1c products. These files are also a exact copies of the homonymous files included in the L1a product (primary one) received in input by the Stack processor and described in Sec. 4.3.3.

6.3.3. Coregistered image main ADS

This ADS is a copy of the main ADS included in the L1a product (secondary one) received in input by the Stack processor with some modifications. Details are reported in the following table, taking as reference the similar list described in Sec. 4.3.1.

Name	**Description**	**Differences between L1a and L1c**
acquisitionInformation	Acquisition information DSR. This DSR contains information that applies to the entire data set.	Updated fields: • productType becomes STA • startTime and stopTime updated after coregistration • polarisationList will cointain the output polarization
sarImage	SAR image DSR. This DSR contains all the necessary information to exploit the measurement data set (i.e. SAR images).	Copied from primary image main ADS (considering that the coregistered image is resampled over the same sampling grid of the primary image and a different noDataValue can be selected)
instrumentParameters	Instrument parameters DSR. This DSR contains the main instrument settings at the time of imaging.	No differences
rawDataAnalysis	RAW data analysis DSR. This DSR contains the main elements related to the RAW data consolidation and analysis performed by the processor.	No differences
processingParameters	Processing parameters DSR. This DSR contains the exhaustive list of static SAR processing parameters and of corrections applied.	No differences

internalCalibration	Internal calibration DSR. This DSR contains the results of the internal calibration analysis performed by the processor.	No differences
rfiMitigation	Radio Frequency Interference mitigation DSR. This DSR contains information on detected RFI and on their mitigation.	No differences
dopplerParameters	Doppler parameters DSR. This DSR contains the Doppler Centroid (DC) and Frequency Modulation rate (FM) parameters estimated and used during processing.	No differences
radiometricCalibration	Radiometric calibration DSR. This DSR contains all the necessary information to absolutely calibrate the data pixels.	No differences
polarimetricDistortion	Polarimetric distortion DSR. This DSR contains the necessary information e.g. receive and transmit polarisation distortion matrix, allowing users to correct for them if not applied at processing level.	No differences
ionosphereCorrection	Ionosphere correction DSR. This DSR contains the results of the ionosphere correction estimated and applied by the processor.	No differences
geometry	Geometry DSR. This DSR contains all the necessary information to understand the Earth model/geometry used in the image and its geolocation.	No differences
quality	Quality DSR. This DSR contains in a single DSR quality flags and thresholds for basic quality assessment done at processing level.	No differences
annotationLUT	Annotation LUT DSR. This DSR contains the list of Look-Up Tables (LUTs) complementing product main annotations.	Content updated with the list of layers included in the coregistered image LUT ADS
staProcessingParameters	Stack processing parameters DSR. This DSR contains the exhaustive list of static stack processing parameters and of corrections applied.	New
staCoregistrationParameters	Stack coregistration parameters DSR. This DSR contains high-level information about data coregistration step.	New
staInSARParameters	Stack InSAR parameters DSR. This DSR contains high-level information about calibration steps.	New
staQuality	Stack quality DSR. This DSR contains in a single DSR quality flags and thresholds for	New

	basic quality assessment done at processing level.	

Tab.79 Coregistered image main ADS

The content of the new DSR is described in the following sections.

6.3.3.1. STA processing parameters DSR

This DSR contains the exhaustive list of static stack processing parameters and of corrections applied.

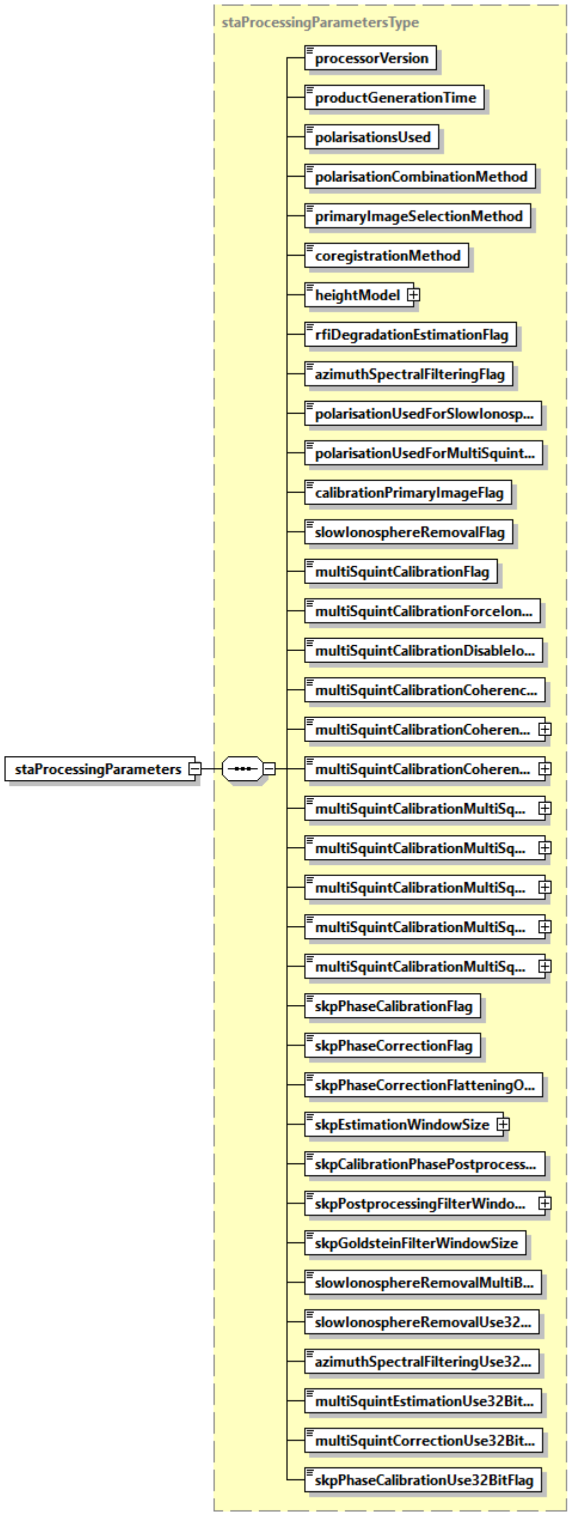


Fig.35 STA processing parameters DSR (staProcessingParametersType)

Name	Description	Data Type	Cardinality

processorVersion	Version of the processor used to generate the product.	xsd:string	1
productGenerationTime	Product generation time [UTC].	timeType	1
polarisationsUsed	Number of polarisations used for processing (3 or 4).	xsd:unsignedInt	1
polarisationCombinationMethod	Polarisations combination method: “HV” or “VH”, if just one of the two is selected (in addition to HH and VV ones); “Average”, if the average of HV and VH is computed and used; “None” if no combination is performed (all the four polarizations are used).	polarisationCombinationMethodType	1
primaryImageSelectionMethod	Coregistration primary image selection method (Geometry, Geometry and Quality, Temporal Baseline).	primaryImageSelectionMethodType	1
coregistrationMethod	Coregistration method (Geometry, Geometry and Data).	coregistrationMethodType	1
heightModel	Digital Elevation Model (DEM) used during coregistration (with version as attribute). This field is taken from the L1a input product.	heightModelType	1
rfiDegradationEstimationFlag	True if estimation of degradation due to RFI filtering was performed, False otherwise.	bool	1
azimuthSpectralFilteringFlag	True if azimuth spectral filtering was performed, False otherwise.	bool	1
polarisationUsedForSlowIonosphereRemoval	Polarisation used for the Slow-Ionosphere Removal (IOB) step.	polarisationType	1
polarisationUsedForMultiSquintCalibration	Polarisation used for estimation in the Multi-Squint Calibration (MSC) step.	polarisationType	1

calibrationPrimaryImageFlag	True if image used as primary for multi-baseline calibration steps is the same as the one used for coregistration, False otherwise.	bool	1
slowIonosphereRemovalFlag	True if slow-varying ionospheric phase screen estimation and removal was performed, False otherwise.	bool	1
multiSquintCalibrationFlag	True if Multi-Squint calibration module was enabled, False otherwise.	bool	1
multiSquintCalibrationForceIonosphereCorrectionFlag	True if Multi-Squint ionosphere calibration step was forcefully executed by user, False otherwise.	bool	1
multiSquintCalibrationDisableIonosphereCorrectionFlag	True if Multi-Squint ionosphere calibration step was forcefully executed by user, False otherwise.	bool	1
multiSquintCalibrationCoherenceImprovementThreshold	Threshold on the coherence gian that was used to trigger the Multi-Squint ionosphere calibration step.	xsd:float	1
multiSquintCalibrationCoherenceAzimuthWindowSize	The multi-looking window in along-track direction used for estimating the standard coherence (coherence test) [m].	floatWithUnit	1
multiSquintCalibrationCoherenceRangeWindowSize	The multi-looking window in slant-range direction used for estimating the standard coherence (coherence test) [m].	floatWithUnit	1
multiSquintCalibrationMultiSquintCoherenceSubBandResolution	The squint axis resolution of the Multi-Squint coherence matrix [m].	floatWithUnit	1
multiSquintCalibrationMultiSquintHighResCoherenceRangeWindowSize	The high resolution multi-look window in slant-range direction for the Multi-Squint cohrence matrix [m].	floatWithUnit	1
multiSquintCalibrationMultiSquintHighResCoherenceAzimuthWindowSize	The high resolution multi-look window in along-track direction for the Multi-Squint cohrence matrix [m].	floatWithUnit	1

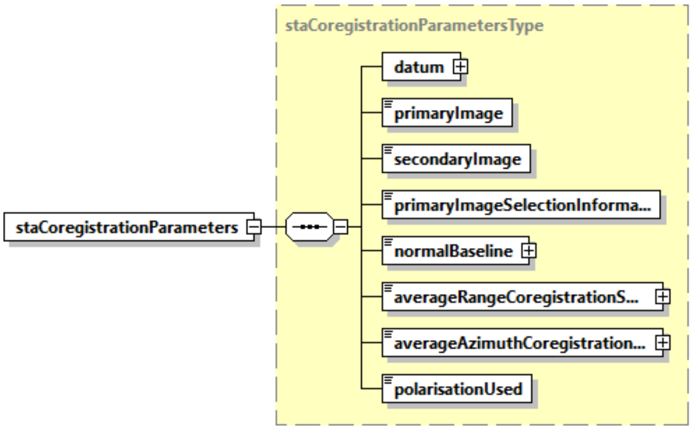
multiSquintCalibrationMultiSquintLowResCoherenceAzimuthWindowSize	The low resolution multi-look window in along-track direction for the Multi-Squint cohrence matrix [m].	floatWithUnit	1
multiSquintCalibrationMultiSquintLowResCoherenceRangeWindowSize	The low resolution multi-look window in slant-range direction for the Multi-Squint cohrence matrix [m].	floatWithUnit	1
skpPhaseCalibrationFlag	True if ground steering phases estimation was performed, False otherwise.	bool	1
skpPhaseCorrectionFlag	True if either the ground steering phases or the flattening phases were corrected, False otherwise.	bool	1
skpPhaseCorrectionFlatteningOnlyFlag	True if only the flattening phases was corrected (and hence no SKP calibration phase). False otherwise.	bool	1
skpEstimationWindowSize	Estimation window size [m]. Note that this window size must be larger than the LUT resolution grid in both range and azimuth.	floatWithUnit	1
skpCalibrationPhasePostprocessing	Postprocessing applied to the SKP calibration phase screens.	skpPhaseCalibrationPostprocessingType	1
skpPostprocessingFilterWindowSize	Filter window size used in SKP postprocessing in case of "Boxcar" or "Median" filter [m].	floatWithUnit	1
skpGoldsteinFilterWindowSize	Filter window size applied to the spectrum (in frequency bins), used in SKP postprocessing in case of "Goldstein" filter [px].	xsd:unsignedInt	1
slowIonosphereRemovalMultiBaselineThreshold	Threshold used for selecting the interferometric pair for baseline error correction (IOB) as fraction of of the critical baseline.	xsd:float	1
azimuthSpectralFilteringUse32BitFlag	True if AZF was run with 32-bit precision.	bool	1

slowIonosphereRemovalUse32BitFlag	True if IOB was run with 32-bit precision.	bool	1
multiSquintEstimationUse32BitFlag	True if the estimation step of the MSC was run with 32-bit precision.	bool	1
multiSquintCorrectionUse32BitFlag	True if the ionosphere correction step of the MSC was run with 32-bit precision.	bool	1
skpPhaseCalibrationUse32BitFlag	True if SKP was run with 32-bit precision.	bool	1

Tab.80 STA processing parameters DSR (staProcessingParametersType)

6.3.3.2. STA coregistration parameters DSR

This DSR contains high-level information about data coregistration step.



STA processing parameters DSR (staCoregistrationParametersType)

Fig.36

Name	Description	Data Type	Cardinality
datum	Datum used during coregistration.	datumType	1
primaryImage	Product name of coregistration primary image.	xsd:string	1
secondaryImage	Product name of coregistration secondary image.	xsd:string	1
primaryImageSelectionInformation	Information used to select coregistration primary image (Geometry, Geometry and RFI Correction, Geometry and FR Correction, Geometry and RFI+FR Corrections, Temporal Baseline).	primaryImageSelectionInformationType	1
normalBaseline	Normal baseline between primary and secondary images [m].	floatWithUnit	1
averageRangeCoregistrationShift	Average coregistration shift	floatWithUnit	1

	along range direction [m].		
averageAzimuthCoregistrationShift	Average coregistration shift along azimuth direction [m].	floatWithUnit	1
polarisationUsed	Polarization used for shift estimation.	polarisationType	1

Tab.81 STA processing parameters DSR (staCoregistrationParametersType)

6.3.3.3. STA InSAR parameters DSR

This DSR contains high-level information about calibration steps.

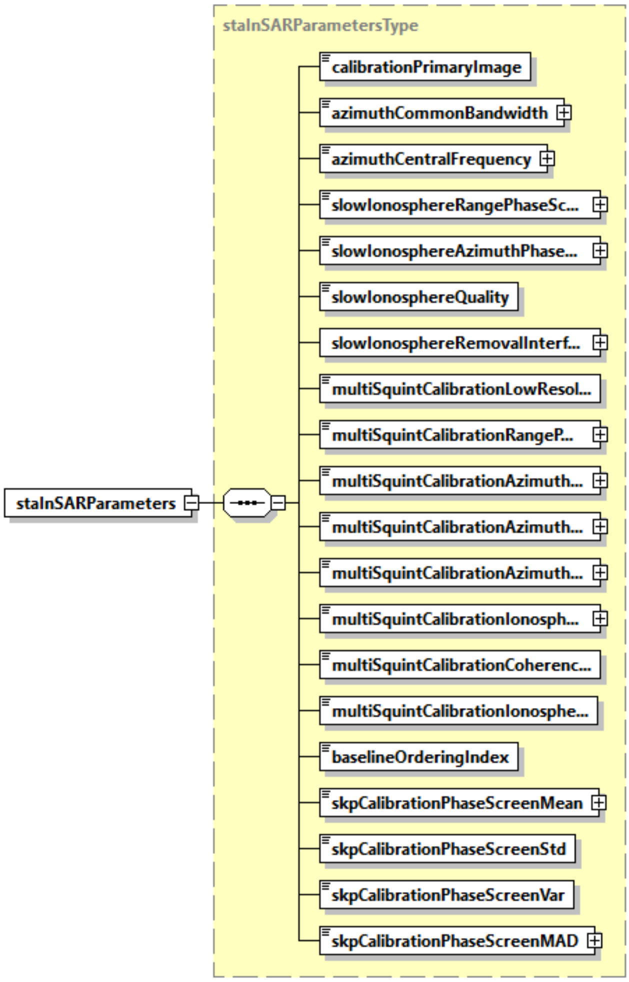


Fig.37

STA processing parameters DSR (staInSARParametersType)

Name	Description	Data Type	Cardinality
calibrationPrimaryImage	Product name of multi-baseline calibration steps primary image (or, simply, calibration primary image).	xsd:string	1
azimuthCommonBandwidth	Azimuth bandwidth in common with primary image after azimuth spectral filtering step [Hz].	floatWithUnit	1
azimuthCentralFrequency	Azimuth central frequency after azimuth spectral filtering step [Hz].	floatWithUnit	1

slowIonosphereRangePhaseScreen	Estimated slope of background ionosphere in range direction [rad/s].	floatWithUnit	1
slowIonosphereAzimuthPhaseScreen	Estimated slope of background ionosphere in azimuth direction [rad/s].	floatWithUnit	1
slowIonosphereQuality	Quality of the background ionosphere estimation. The value is between 0 (bad quality) and 1 (good quality).	xsd:float	1
slowIonosphereRemovalInterferometricPairs	Interferometric pairs used to estimate the slow-varying ionosphere calibration.	interferometricPairListType	1
multiSquintCalibrationLowResolutionFlag	True if Multi-Squint calibration was executed in low resolution modality, False otherwise.	bool	1
multiSquintCalibrationRangePhaseSlope	Phase plane slope estimated by the Multi-Squint Calibration module, in slant-range direction [rad/s].	floatWithUnit	1
multiSquintCalibrationAzimuthPhaseSlope	Phase plane slope estimated by Multi-Squint Calibration module, in along-track direction [rad/s].	floatWithUnit	1
multiSquintCalibrationAzimuthShift	Constant shift in along-track direction estimated from spectral analysis on the Multi-Squint coherence [m].	floatWithUnit	1
multiSquintCalibrationAzimuthFrequencyCentroid	Spatial (along-track) frequency centroid from spectral analysis on the Multi-Squint coherence [1/m].	floatWithUnit	1
multiSquintCalibrationIonosphericLayerAltitudes	Altitude of the ionospheric layers estimated by the Multi-Squint Calibration module [m].	floatArrayWithUnits	1
multiSquintCalibrationCoherenceCheckValue	Coherence improvement used during the coherence check of the Multi-Squint Calibration module.	xsd:float	1
multiSquintCalibrationIonosphereCorrectionFlag	True if the Multi-Squint Calibration module executed the ionosphere correction. False otherwise.	xsd:bool	1

baselineOrderingIndex	Index in of the product with respect to the baseline-based ordering.	xsd:unsignedInt	1
skpCalibrationPhaseScreenMean	Circular mean of SKP calibration phase screen [rad].	floatWithUnit	1
skpCalibrationPhaseScreenStd	Circular standard deviation of SKP calibration phase screen.	xsd:float	1
skpCalibrationPhaseScreenVar	Circular dispersion of SKP calibration phase screen.	xsd:float	1
skpCalibrationPhaseScreenMAD	Mean absolute deviation of SKP calibration phase screen [rad].	floatWithUnit	1

Tab.82 STA processing parameters DSR (staInSARParametersType)

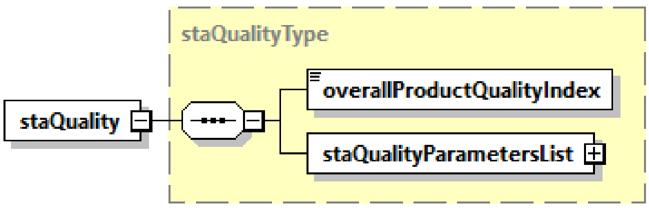
Name	**Description**	**Data Type**	**Cardinality**
count		*xsd:unsignedInt*	*required*
interferometricPairListType	List of interferometric pairs expressed as indices.	interferometricPairType	≥ 0

Tab.83 STA processing parameters DSR (interferometricPairListType)

6.3.3.4. STA quality DSR

This DSR contains in a single DSR quality flags and thresholds for basic quality assessment done at processing level.

Fig.38



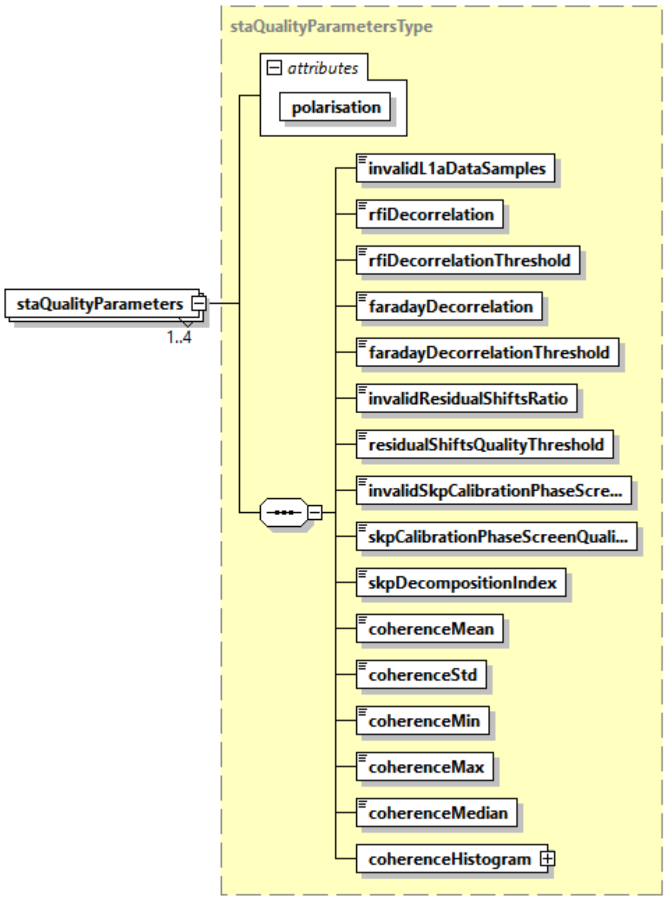
STA quality DSR (staQualityType)

Name	Description	Data Type	Cardinality
overallProductQualityIndex	Overall product quality index. This annotation is calculated based on specific quality parameters and gives an overall quality value for the product.	xsd:unsignedInt	1
staQualityParametersList	Quality parameters list. The list contains an entry for each output product's polarisation.	staQualityParametersListType	1

Tab.84 STA quality DSR (staQualityType)

Name	Description	Data Type	Cardinality
count		xsd:*unsignedInt*	*required*
staQualityParameters	Quality parameters for the current polarisation.	staQualityParametersType	1 .. 4

Tab.85 STA quality DSR (staQualityParametersListType)



STA quality DSR (staQualityParametersType)

Name	Description	Data Type	Cardinality
polarisation		*polarisationType*	*required*
Fig.39 invalidL1aDataSamples	Number of invalid L1a data samples (according to their mean and standard deviation), expressed as a normalized fraction of the total number of samples. The value is between 0 and 1.	xsd:float	1
rfiDecorrelation	Decorrelation factor due to RFI strength. The value is between 0 and 1.	xsd:float	1
rfiDecorrelationThreshold	Maximum decorrelation factor due to RFI strength admissible to use the image as the primary image. The value is between 0 and 1 and copied from the AUX-PPS.	xsd:float	1
faradayDecorrelation	Decorrelation factor due to Faraday residual. The value is between 0 and 1.	xsd:float	1
faradayDecorrelationThreshold	Maximum decorrelation factor due to Faraday residual admissible to use the image as the primary image. The value is between 0 and 1 and copied from AUX-PPS.	xsd:float	1
invalidResidualShiftsRatio	Ratio of invalid residual coregistration shifts with respect to the number of pixels of the coregistration reference image. The value is between 0 and 1.	xsd:float	1
residualShiftsQualityThreshold	Threshold on residual coregistration shifts quality. The value is between 0 and 1 and copied from AUX-PPS. Residual shifts with a quality lower than this threshold are not used for processing.	xsd:float	1
iinvalidSkpCalibrationPhaseScreenRatio	Ratio between invalid SKP calibration phase estimations and the size of the SKP phase screen. The value is between 0 and 1.	xsd:float	1
skpCalibrationPhasesScreenQualityThreshold	Threshold on the SKP calibration phase screen estimation quality. The value is between 0 and 1 and copied from the AUX-PPS. Estimates with a quality lower than this threshold are not corrected. Used only in case skpPhaseCorrectionFlag is set to True.	xsd:float	1
skpDecompositionIndex	Error code for the SKP decomposition. Positive if the SKP decomposition hit a nonblocking contingency case (e.g. SVD	xsd:unsignedInt	1

	decomposition failure etc.) and the exported SKP-related LUTs contain values obtained from a contingency handling procedure. 0 otherwise.		
coherenceMean	Mean coherence (amplitude) of the calibrated L1c frame with respect to the coregistration primary.	xsd:float	1
coherenceStd	Standard deviation of the coherence (amplitude) of the calibrated L1c frame with respect to the coregistration primary.	xsd:float	1
coherenceMin	Minimum coherence (amplitude) of the calibrated L1c frame with respect to the coregistration primary.	xsd:float	1
coherenceMax	Maximum coherence (amplitude) of the calibrated L1c frame with respect to the coregistration primary.	xsd:float	1
coherenceMedian	Median coherence (amplitude) of the calibrated L1c frame with respect to the coregistration primary.	xsd:float	1
coherenceHistogram	Coherence distribution of the calibrated L1c frame with respect to the coregistration primary.	histogramType	1

Tab.86 STA quality DSR (staQualityParametersType)

Name	**Description**	**Data Type**	**Cardinality**
bins	The bins of the histogram	floatArray	1
pdfValues	The PDF values of the histograms	floatArray	1

Tab.87 The histogramType.

6.3.3.4.1. Overall Product Quality Index

As mentioned in Tab. 72, the *overallProductQualityIndex* is an unsigned integer value (*i.e.* a 32-bit integer ranging from 0 to $2^{32} - 1$) that summarizes the execution history of the Stack Processor as well as a high-level information on the quality of the input stack. Similarly to that of the L1_P processor, the Stack's *overallProductQualityIndex* is the decimal representation of a 32-bit array that is defined as follows:

Bit #	Module/Sub-step	Bit-Flipping Condition
0	**L1a input**	Nonzero if the *overallQualityIndex* is nonzero for the source L1a input[1] product (see Section 4.3.1.13.1)
1	**Pre-processor**	At least 1 expected LUT is missing from the source L1a input product (*e.g.* FR LUT is missing, and primary selection uses FR index)
2		Source L1a input product has a non-nominal set of polarizations (*i.e.* it's not a quad-pol HH,HV,VH,VV)
3		Source L1a input product has non-nominal swath duration, *i.e.* not between 20.5s and 21.5s
4		Source L1a input product has inconsistent *phaseScreen* and *rangeShifts* LUTs (see Section 4.3.2, and L1 ATBD Section 4.10.3.5)
5	**Coregistrator**	Coregistration from data failed due to fitting quality index below *fittingQualityThreshold* (Automatic mode only, see Stack ATBD Section 4.2.4.3 and AUX_FMT Table 84)
6		Shift accuracy below *residualShiftsQualityThreshold* for at least 1 pixel (Geometry and Data mode only, see Stack ATBD Section 4.5.1 and AUX_FMT Table 84)
7		*- Intentionally left blank, i.e. 0 -*
8		*- Intentionally left blank, i.e. 0 -*
9	**AZF**	*- Intentionally left blank, i.e. 0 -*
10		*- Intentionally left blank, i.e. 0 -*
11	**IOB**	*phaseScreen* and/or *rangeShifts* LUTs (see Section 4.3.2.3) are missing from the source L1a input product and *compensateIonoPhaseScreenFlag* is set to true in AUX_PPS (see AUX_FMT Table 88)
12		Estimation quality below *slowIonosphereQualityThreshold* (see AUX_FMT Table 88)
13		Failed Single-baseline estimation for at least 1 interferometric pair containing the current frame (Multi-baseline mode only, see Stack ATBD Section 5.2.5)[2]
14		Current frame outside of region affected by slow-varying ionosphere, that is, above *latitudeThreshold* (see Stack ATBD Section 5.2 and AUX_FMT Table 88)
15	**MSC**	*- Intentionally left blank, i.e. 0 -*
16		*- Intentionally left blank, i.e. 0 -*
17		*- Intentionally left blank, i.e. 0 -*
18		*- Intentionally left blank, i.e. 0 -*
19		*- Intentionally left blank, i.e. 0 -*
20		*- Intentionally left blank, i.e. 0 -*
21		*- Intentionally left blank, i.e. 0 -*
22		*- Intentionally left blank, i.e. 0 -*
23	**SKP**	DEM resolution too coarse with respect to the selected *estimationWindowSize* (see AUX_FMT, Table 90)
24		SKP estimation failure, *i.e.* it failed to compute the SKP decomposition or failed to compute the scattering mechanisms (*e.g.* due to invalid SVD decomposition or inadmissible ranges, see Stack ATBD Section 5.5.2.3 and Section 5.4.2.4).
25		SKP correction failure, *i.e.* the same failures reported in Bit #24 occurred and *phaseCorrection* is not "None" (see AUX_FMT Table 90).

[1] By *source L1a* input product, we refer to the L1a product from which the L1c product is generated, and similarly for *coregistration primary* and *calibration reference* L1a products.
[2] The calibration reference image is not updated; thus, this bit will be always populated with a 0 even if a SB estimation failed for a pair containing the calibration reference index. This is to prevent the user or L2 processor to consider this a potentially faulty product.

Bit #	Module/Sub-step	Bit-Flipping Condition
26		Fraction of SKP valid phase screen estimations, *i.e.* above *groundPhasesScreenQualityThreshold,* is below *overallProductQualityThreshold* (see Stack ATBD Section 5.4.2.8 and AUX_FMT Table 90)
27		Invalid number of polarizations (*i.e.* neither 3 nor 4)
28		*- Intentionally left blank, i.e. 0 -*
29	**Stack**	Coregistration primary L1a product had nonzero *overallQualityIndex* (see Section 4.3.1.13.1)
30		Calibration reference L1a product had nonzero *overallQualityIndex* (see Section 4.3.1.13.1)
31		At least 1 L1a input product other than the source L1a input product had nonzero *overallQualityIndex* (see Section 4.3.1.13.1)

Note that some bits are intentionally left blank to support user-defined custom information. The stack's bits aim at providing the user with hints for tracing possible problems in case of failures in the processing. Bit #29 stores high-level information on the quality of the coregistration primary (if the coregistration primary has low quality, the entire stack may have been affected). Bit #30 can be useful since most estimated phase screens are defined with respect to the calibration reference. Finally, Bit #31 provides control on the other L1a input frames, which may be valuable information in the case of modules that use Multi-Baseline estimations.

6.3.4. Coregistered image Look-Up Tables (LUT) ADS

This section describes in details the content of Coregistered image Look-Up Tables (LUT) ADS.

Adopting the same strategy described in Sec. 4.3.2 for L1a/b products, this ADS complements the Main ADS one, including all those annotations that can be represented as 2D maps of values. We chose this approach in order to avoid worsening the Main ADS readability and handling, and to provide an easier access to such information.

This ADS is a copy of the LUT ADS included in the L1a product (secondary one) received in input by the Stack processor with some modifications that mostly affect variable groups and grids (see Section 6.3.4.1). A detailed description of the content of the LUTs are reported in the following table.

Name	Description	Differences between L1a and L1c
rfiTimeMaskHH rfiTimeMaskHV rfiTimeMaskVH rfiTimeMaskVV	Binary masks (one per polarisation) describing where RFI time-domain mitigation has been / has not been applied.	Not copied
rfiFreqMaskHH rfiFreqMaskHV rfiFreqMaskVH rfiFreqMaskVV	Binary masks (one per polarisation) describing where RFI frequency-domain mitigation has been / has not been applied.	Not copied
sigmaNought	Two-dimensional map describing the conversion factor to translate the beta-nought values into sigma-nought ones.	Copied from secondary image LUT ADS and resampled over the primary image sampling grid but downsampled to the resolution of the grid of the geometric LUTs of the coregistration primary L1a product. Consequently, this LUT may have a different decimation factor than that of the source L1a product (see Section 6.3.4.1).
gammaNought	Two-dimensional map describing the conversion factor to translate the beta-nought values into gamma-nought ones.	Copied from secondary image LUT ADS and resampled over the primary image sampling grid but downsampled to the resolution of the grid of the geometric LUTs of the coregistration primary

		L1a product. Consequently, this LUT may have a different decimation factor than that of the source L1a product (see Section 6.3.4.1)
faradayRotationPlane	Two-dimensional map describing the Faraday Rotation plane computed during L1 ionospheric processing.	Not copied
faradayRotation	Two-dimensional map describing the Faraday Rotation (final one, including plane) computed during L1 ionospheric processing.	Not copied
faradayRotationStd	Two-dimensional map describing the Faraday Rotation expected standard deviation computed during L1 ionospheric processing.	Not copied
phaseScreen	Two-dimensional map describing the phase screen computed during L1 ionospheric processing.	Not copied
tec	Two-dimensional map describing the TEC map computed during L1 ionospheric processing.	Not copied
rangeShifts	Two-dimensional map describing the range shifts computed during L1 ionospheric processing.	Not copied
azimuthShifts	Two-dimensional map describing the azimuth shifts computed during L1 ionospheric processing.	Not copied
autofocusPhaseScreen	Two-dimensional map describing the autofocus phase screen computed during L1 ionospheric processing.	Not copied
autofocusPhaseScreenStd	Two-dimensional map describing the autofocus phase screen standard deviation computed during L1 ionospheric processing.	Not copied
denoisingHH denoisingXX denoisingHV denoisingVH denoisingVV	Two-dimensional maps (one per polarisation) describing the conversion factor to translate the SAR image values into denoised values.	Copied from secondary image LUT ADS and resampled over the primary image sampling grid but downsampled to the resolution of the grid of the geometric LUTs of the coregistration primary L1a product. Consequently, this LUT may have a different decimation factor than that of the source L1a product (see Section 6.3.4.1). The denoising maps reflect the output polarization of the stack (*e.g.* if cross-pol merging is active, the LUT will

		contain a denoising term for X/X but not for H/V and V/H).
latitude	Two-dimensional map describing the latitude coordinates of each (sub-sampled) pixel.	Copied from secondary image LUT ADS and resampled over the primary image sampling grid but down-sampled to the resolution of the grid of the geometric LUTs of the coregistration primary L1a product. These LUTs have the same decimation factors as those of the source L1a product (see Section 6.3.4.1)
longitude	Two-dimensional map describing the longitude coordinates of each (sub-sampled) pixel.	
height	Two-dimensional map describing the height coordinates of each (sub-sampled) pixel, derived from the Digital Elevation Model (DEM) used during processing.	
incidenceAngle	Two-dimensional map describing the incidence angle of each (sub-sampled) pixel.	
elevationAngle	Two-dimensional map describing the elevation angle of each (sub-sampled) pixel.	
rangeTerrainSlope	Two-dimensional map describing the local terrain slopes in slant-range direction.	
azimuthTerrainSlope	Two-dimensional map describing the local terrain slopes in along-track direction.	
waveNumbers	Two-dimensional map describing the wavenumbers computed w.r.t. the incidence angles map.	New
flatteningPhaseScreen	Two-dimensional map containing the estimated phase contributions due to the topography.	New
rangeCoregistrationShifts	Two-dimensional map describing the coregistration shifts in slant-range direction. This LUT contains the shifts applied to the image.	New
rangeOrbitCoregistrationShifts	Two-dimensional map describing the coregistration shfits in slant-range direction obtained only from orbit and scene geometry (see Section 4.1 of the Stack ATBD)	New
azimuthCoregistrationShifts	Two-dimensional map describing the coregistration shifts in azimuth direction. This LUT contains the shifts applied to the image.	New
azimuthOrbitCoregistrationShifts	Two-dimensional map descrbing the coregistration shifts in azimuth direction obtained only from orbit and scene geometry (see Section 4.1 of the Stack ATBD)	New
coregistrationShiftsQuality	Two-dimensional map describing the quality of residual coregistration shifts estimated from data.	New
coherence	Two-dimensional map storing the coherence of secondary images with respect to the coregistration primary.	New

Interferogram	Two-dimensional map storing the interferometric phases with respect to the coregistration primary.	New
ionospherePhaseScreens	Stack of one (single-layer) or more (multi-layer) two-dimensional map that stores the estimated ionospheric phase screens.	New
skpCalibrationPhaseScreen	Two-dimensional map containing the estimated phase contributions due to the (forest) disturbance.	New
skpCalibrationPhaseScreenQuality	Two-dimensional map describing the quality of estimated phase screen (i.e., the FNF mask).	New

Tab.88 Coregistered image LUT ADS variables

In the following table the new variables are described in detail. Note that the components in a L1c product can also be a subset of this one, depending on the selected processing configuration. Nonetheless, for completeness and to aid operators interested in evaluating the quality/performance of the stack, each product contains all the LUTs possibly generated by the stack with the provided configuration, even when their content is expected to be trivial or redundant (e.g. under nominal circumstances, *flatteningPhaseScreen* must be all 0's when the L1c product is a coregistration primary).

Name	Description	Data Type	Cardinality
group: coregistration rangeCoregistrationShifts	Two-dimensional map covering the whole SAR image and describing the coregistration shifts along range direction. These shifts are the sum of those estimated from geometry and, if available, of the residual ones estimated from data. Values are expressed in [m].	matrix (float)	1
group: coregistration rangeOrbitCoregistrationShfits	Two-dimensional map covering the whole SAR image and describing the coregistration shifts in slan-range direction obtained only from orbit and scene geometry (see Section 4.1 of the Stack ATBD). Values are expressed in [m].	matrix (float)	1
group: coregistration azimuthCoregistrationShifts	Two-dimensional map covering the whole SAR image and describing the coregistration shifts along azimuth direction. These shifts are the sum of those estimated from geometry and, if available, of the residual ones estimated from data. Values are expressed in [m].	matrix (float)	1
group: coregistration azimuthOrbitCoregistrationShifts	Two-dimensional map covering the whole SAR image and describing the coregistration shifts in azimuth direction obtained only from orbit and	matrix(float)	1

	scene geometry (see Section 4.1 of the Stack ATBD). Values are expressed in [m].		
group: coregistration flatteningPhaseScreen	Two-dimensional map covering the whole SAR image and representing the sole phase contribution due to the DEM. As per STA_P convention, the DEM phase compensation shall be executed using the '+' convention, that is, as $CoSCS \cdot e^{+j\Delta\phi_{flat}}$, where $\Delta\phi_{flat}$ is the content of this LUT (converted into radians). Values are expressed in [rad].	matrix (float)	1
group: coregistration waveNumbers	Two-dimensional map covering the whole SAR image and representing the vertical wavenumbers. Values are expressed in [rad/m].	matrix (float)	1
group: interferometry coherence	Two-dimensional map covering the whole SAR image and storing the coherence with respect to the coregistration primary.	matrix(float)	1 (only for secondary images)
group: interferometry interferogram	Two-dimensional map covering the whole SAR image and storing the interferometric phases with respect to the coregistration primary. Values are expressed in [rad].	matrix(float)	1 (only for secondary images)
group: multiSquintCalibration ionospherePhaseScreens	Stack of one (single-layer) or more (multi-layer) two-dimensional map that stores the onospheric phase screens estimated by the Multi-Squint Calibration module (MSC). Values are expressed in [rad].	3d array (float)	1 (only if the MSC's ionosphere correction is activated)
group: skpPhaseCalibration skpCalibrationPhaseScreen	Two-dimensional map covering the whole SAR image and describing the estimated phase contributions due to both the foreste disturbance. As per STA_P convention, the removal of the SKP phase screen shall be executed using the '+' convention, that is, as $CoSCS \cdot e^{+j(\Delta\phi_{flat}+\phi_{skp})}$, where ϕ_{skp} is the content of this LUT (converted into radians) and $\Delta\phi_{flat}$ are the geometric phases from DEM in radians (see *e.g.* the *flatteningPhaseScreen* LUT). Values are expressed in [rad].	matrix (float)	1 (only if the SKP module is successfully executed)
group: skpPhaseCalibration skpCalibrationPhaseScreenQuality	Two-dimensional map covering the whole SAR image and describing the quality of the estimated phase screen. Values are normalized between 0 (worst quality) and 1 (best quality). Invalid data (from FNF) are set to *noDataValue* (see AUX_FMT).	matrix (float)	1 (only if the SKP module is successfully executed)

Tab.89 Coregistered image LUT ADS new components variables with their groups. Variables inherited from L1a LUTs will preserve their original group.

6.3.4.1. Grids and Axes

Except for the *ionospherePhaseScreens* LUT, the sampling grid for all LUTs is that of the geometric LUTs of the L1a product used as coregistration primary. Under default configuration of the L1_P processor, that sampling grid has a ground resolution of approximately 90m x 90m (range x azimuth), which is the resolution of the DEM used (Copernicus DEM). More in details, it's the grid obtained by subsampling the primary data grid using range and azimuth subsampling steps that best approximate the target resolution for each axis. The *ionospherePhaseScreens* LUT is defined on the ionosphere estimation grid, which is the along-track azimuth axis of the Multi-Squint coherence matrix at a ionosphere reference altitude, inflated by the squint aperture of the RADAR, and the slant-range axis of the Multi-Squint coherence matrix, which is a subsampling of the SAR slant-range axis. Size and resolution of the *ionospherePhaseScreen* LUTs ultimately depends on the estimation parameters selected by the user in the AUX_PPS___.

Note that since the L1a product provides different subsampling factors for geometric LUTs and for all other LUTs, L1c *denoising*, gammaNought,* and *sigmaNought* LUTs may have different subsampling factors than those of the source L1a products, even for the coregistration primary image. Conversely, geometric LUTs are expected to have the same subsampling step as the L1a coregistration primary image.

6.3.4.2. Dimension / Coordinate Variables

The following table reports the dimensions and coordinate variables, which are similar (but not identical) to those in the L1a/b LUT.

Name	**Description**	**Data Type**	**Cardinality**
slantRangeTime	LUT slant range time axis associated to the stack sampling step (i.e. approximately 90m under default configuration). Values are expressed in [s].	double	1
relativeAzimuthTime	LUT azimuth relative time axis associated to the stack sampling step (i.e. approximately 90m under default configuration). As for L1a/b, the reference UTC time is *firstLineAzimuthTime* value in SAR image DSR. Values are expressed in [s].	double	1
ionosphereSlantRangeTime	Slant-range axis associate to the *ionospherePhaseScrens* LUT. This corresponds to the slant-range axis of the Multi-Squint coherence matrix.	float	1

	Values are expressed in [s].		
ionosphereRelativeAzimuthTime	Along-track axis associated to the *ionospherePhaseScreens* LUT. This corresponds to the inflated along-track axis of the Multi-Squint coherence at the reference ionospheric altitude. As for the *relativeAzimuthTimeAxis*, the reference UTC time is *firstLineAzimuthTime* in the SAR image DSR. Values are expressed in [s].	float	1
ionosphereLayers	A dimension that refers to the ionosphere layers, used to define the three-dimensional array of the *ionospherePhaseScreens* LUT.	N/A	1

6.3.4.3. Attributes

The L1c LUT annotation will contain the same attributes as in the L1a LUT with the sole exception of containing a common float noDataValue instead of noDataValueFloat and noDataValueBool, which are no longer present in the L1c LUT annotation file.

6.3.4.4. Example

Below a sample LUT ADS is reported (obtained with ncdump command).

```
netcdf bio_s3_sta__1s_20170225t094535_20170225t094556_i_g01_m02_c01_t017_f001_lut {
dimensions:
	relativeAzimuthTime = 1785 ;
	slantRangeTime = 818 ;
	ionosphereRelativeAzimuthTime = 1320 ;
	ionosphereSlantRangeTime = 261 ;
	ionosphereLayers = 4 ;
variables:
	double relativeAzimuthTime(relativeAzimuthTime) ;
		relativeAzimuthTime:units = "s" ;
	double slantRangeTime(slantRangeTime) ;
		slantRangeTime:units = "s" ;
	float ionosphereRelativeAzimuthTime(ionosphereRelativeAzimuthTime) ;
		ionosphereRelativeAzimuthTime:units = "s" ;
	float ionosphereSlantRangeTime(ionosphereSlantRangeTime) ;
		ionosphereSlantRangeTime:units = "s" ;

// global attributes:
		:mission = "BIOMASS" ;
		:swath = "S3" ;
		:productType = "STA" ;
		string :polarisationList = "H/H", "X/X", "V/V" ;
		:startTime = "2017-02-25T09:45:35.071893" ;
		:stopTime = "2017-02-25T09:45:56.095647" ;
		:referenceAzimuthTime = "2017-02-25T09:45:35.071893" ;
		:missionPhaseID = "INT" ;
```

```
                :driftPhaseFlag = "False" ;
                :sensorMode = "Measurement" ;
                :globalCoverageID = 1US ;
                :majorCycleID = 2US ;
                :repeatCycleID = 1US ;
                :absoluteOrbitNumber = 809US ;
                :relativeOrbitNumber = 17US ;
                :orbitPass = "Ascending" ;
                :platformHeading = 0. ;
                :dataTakeID = 13518US ;
                :frame = 1US ;
                :productComposition = "Nominal" ;
                :noDataValue = -9999. ;

group: radiometry {
  variables:
        float sigmaNought(relativeAzimuthTime, slantRangeTime) ;
                sigmaNought:_FillValue = -9999.f ;
                sigmaNought:description = "Sigma Nought" ;
        float gammaNought(relativeAzimuthTime, slantRangeTime) ;
                gammaNought:_FillValue = -9999.f ;
                gammaNought:description = "Gamma Nought" ;
  } // group radiometry

group: denoising {
  variables:
        float denoisingHH(relativeAzimuthTime, slantRangeTime) ;
                denoisingHH:_FillValue = -9999.f ;
                denoisingHH:description = "Denoising H/H" ;
        float denoisingXX(relativeAzimuthTime, slantRangeTime) ;
                denoisingXX:_FillValue = -9999.f ;
                denoisingXX:description = "Denoising X/X" ;
        float denoisingVV(relativeAzimuthTime, slantRangeTime) ;
                denoisingVV:_FillValue = -9999.f ;
                denoisingVV:description = "Denoising V/V" ;
  } // group denoising

group: geometry {
  variables:
        double latitude(relativeAzimuthTime, slantRangeTime) ;
                latitude:_FillValue = -9999. ;
                latitude:description = "Latitude" ;
                latitude:units = "deg" ;
        double longitude(relativeAzimuthTime, slantRangeTime) ;
                longitude:_FillValue = -9999. ;
                longitude:description = "Longitude" ;
                longitude:units = "deg" ;
        double height(relativeAzimuthTime, slantRangeTime) ;
                height:_FillValue = -9999. ;
                height:description = "Height" ;
                height:units = "m" ;
        float incidenceAngle(relativeAzimuthTime, slantRangeTime) ;
                incidenceAngle:_FillValue = -9999.f ;
                incidenceAngle:description = "Incidence Angle" ;
                incidenceAngle:units = "deg" ;
        float elevationAngle(relativeAzimuthTime, slantRangeTime) ;
                elevationAngle:_FillValue = -9999.f ;
                elevationAngle:description = "Elevation Angle" ;
                elevationAngle:units = "deg" ;
```

```
        float rangeTerrainSlope(relativeAzimuthTime, slantRangeTime) ;
            rangeTerrainSlope:_FillValue = -9999.f ;
            rangeTerrainSlope:description = "Range Terrain Slope" ;
            rangeTerrainSlope:units = "deg" ;
        float azimuthTerrainSlope(relativeAzimuthTime, slantRangeTime) ;
            azimuthTerrainSlope:_FillValue = -9999.f ;
            azimuthTerrainSlope:description = "Azimuth Terrain Slope" ;
            azimuthTerrainSlope:units = "deg" ;
    } // group geometry

group: coregistration {
    variables:
        float azimuthCoregistrationShifts(relativeAzimuthTime, slantRangeTime) ;
            azimuthCoregistrationShifts:_FillValue = -9999.f ;
            azimuthCoregistrationShifts:description = "Azimuth Coregistration Shifts" ;
            azimuthCoregistrationShifts:units = "m" ;
        float azimuthOrbitCoregistrationShifts(relativeAzimuthTime, slantRangeTime) ;
            azimuthOrbitCoregistrationShifts:_FillValue = -9999.f ;
            azimuthOribtCoregistrationShifts:description = "Azimuth Coregistration Shifts from Orbit" ;
            azimuthOrbitCoregistrationShifts:units = "m" ;
        float rangeCoregistrationShifts(relativeAzimuthTime, slantRangeTime) ;
            rangeCoregistrationShifts:_FillValue = -9999.f ;
            rangeCoregistrationShifts:description = "Range Coregistration Shifts" ;
            rangeCoregistrationShifts:units = "m" ;
        float rangeOrbitCoregistrationShifts(relativeAzimuthTime, slantRangeTime) ;
            rangeOrbitCoregistrationShifts:_FillValue = -9999.f ;
            rangeOribtCoregistrationShifts:description = "Range Coregistration Shifts from Orbit" ;
            rangeOrbitCoregistrationShifts:units = "m" ;
        float coregistrationShiftsQuality(relativeAzimuthTime, slantRangeTime) ;
            coregistrationShiftsQuality:_FillValue = -9999.f ;
            coregistrationShiftsQuality:description = "Coregistration Shifts Quality" ;
        float waveNumbers(relativeAzimuthTime, slantRangeTime) ;
            waveNumbers:_FillValue = -9999.f ;
            waveNumbers:description = "Vertical Wave Numbers (Kz)" ;
            waveNumbers:units = "rad/m" ;
        float flatteningPhaseScreen(relativeAzimuthTime, slantRangeTime) ;
            flatteningPhaseScreen:_FillValue = -9999.f ;
            flatteningPhaseScreen:description = "Flattening Phases Screen (DSI)" ;
            flatteningPhaseScreen:units = "rad" ;
    } // group coregistration

group: interferometry{
    variables:
        float coherence(relativeAzimuthTime, slantRangeTime) ;
            coherence:_FillValue = -9999.f ;
            coherence:description = "Interferometric coherence" ;
        float interferogram(relativeAzimuthTime, slantRangeTime) ;
            interferogram:_FillValue = -9999.f ;
            interferogram:description = "Interferometric phases" ;
            interferogram:units = "rad" ;
    } // group interferometry


group: multiSquintCalibration {
    variables:
        float ionospherePhaseScreens(ionosphereRelativeAzimuthTime, ionosphereSlantRangeTime, ionosphereLayers) ;
            ionospherePhaseScreens:_FillValue = -9999.f ;
            ionospherePhaseScreens:units = "rad" ;
            ionospherePhaseScreens:description = "Ionosphere Phase Screens [rad]" ;
```

```
} // group multiSquintCalibration

group: skpPhaseCalibration {
  variables:
       float skpCalibrationPhaseScreen(relativeAzimuthTime, slantRangeTime) ;
               skpCalibrationPhaseScreen:_FillValue = -9999.f ;
               skpCalibrationPhaseScreen:description = "SKP Calibration Phases" ;
               skpCalibrationPhaseScreen:units = "rad" ;
       float skpCalibrationPhaseScreenQuality(relativeAzimuthTime, slantRangeTime) ;
               skpCalibrationPhaseScreenQuality:_FillValue = -9999.f ;
               skpCalibrationPhaseScreenQuality:description = "SKP Estimation Quality" ;
  } // group skpPhaseCalibration
}
```

6.3.5. Coregistered image orbit and attitude ADS

The coregistered image Orbit and Attitude ADS will be included as dedicated files in L1c products.
These files are an exact copy of the homonymous files included in the L1a product (secondary one) received in input by the Stack processor and described in Sec. 4.3.3.

6.3.6. Quick-look ADS

The Quick-look ADS is a lower resolution version of the SAR (coregistered) image MDS and, optionally, the coherence and the interferogram with respect to the coregistration primary. Coherence and interferogram are exported only for secondary images, since for coregistration primary they are trivial.

As for the coregistered SAR image, Quick-look ADS are identical to those of L1a products; therefore we refer to Section 4.3.4 for more details on the color coding. Note that, in cases where cross-polarizations are combined, the conversion to RGB is identical to that described in Section 4.3.4, setting $\mathrm{HV} \coloneqq 2 \cdot \mathrm{XX}$ and $\mathrm{VH} \coloneqq 0$ in case of the Pauli and $\mathrm{HV} \coloneqq \mathrm{XX}$ in case of HSV. Pixels with missing data are shown in black.

As for the interferometric Quick-Looks, the coherence image is a grayscale image with the same size of the SAR image Quick-Look ADS. The color scheme maps linearly the 0-1 (min/max coherence) interval onto black/white. The interferogram uses OpenCV's JET color scheme[3] with boundaries $(-\pi, \pi)$, $-\pi$ being blue and π being red. Similarly to the coregistered Quick-Look ADS, missing data is shown in black.

6.3.7. Overlay ADS

[3] See https://docs.opencv.org/4.x/d3/d50/group__imgproc__colormap.html

All the details about Overlay ADS already explained in Sec. 4.3.5 for L1a products apply as well to L1c products for all Quick-Look ADS.

7. Appendix: Common Products Format Specification

7.1. Annotation data sets (ADS)

7.1.1. Primitive and common types

The following table summarizes and describes primitive product types used throughout the document.

Name	Description	Base Type	Values
missionType	Enumeration of valid BIOMASS mission names.	xsd:string	BIOMASS
swathType	Enumeration of all valid swath identifiers.	xsd:string	S1 S2 S3
acquisitionModeIDType	Enumeration of all valid acquisition modes.	xsd:string	S1 INT S2 INT S3 INT S1 TOM S2 TOM S3 TOM Rx Only
productType	Enumeration of valid product types.	xsd:string	SCS DGM STA FH_L2A FH_L2B FD_L2A FD_L2B GN_L2A AGB_L2B TFH_L2A
polarisationType	Enumeration of valid polarisations.	xsd:string	H V HH HV VH VV XX

groupType	Enumeration of valid LUT groups of variables.	xsd:string	DEM based LUT RFI based LUT Image based LUT
channelType	Enumeration of valid RGB channels.	xsd:string	RED GREEN BLUE
timeType	UTC time expressed according to ISO 8601 standard (1 microsecond resolution).	xsd:dateTime	
missionPhaseIDType	Enumeration of all valid BIOMASS mission phases.	xsd:string	COM TOM INT
sensorModeType	Enumeration of valid sensor mode abbreviations.	xsd:string	Measurement RX Only External Calibration
l1acQlColourCodingMethodType	Enumeration of L1a and L1c products quick-looks colour coding methods.	xsd:string	Pauli HSV Pauli and HSV
l1bQlColourCodingMethodType	Enumeration of L1b products quick-looks colour coding methods.	xsd:string	Lexicographic
orbitPassType	Enumeration of the orbit pass direction values.	xsd:string	Ascending Descending
projectionType	Enumeration of the image projection.	xsd:string	Slant Range Ground Range
pixelRepresentationType	Enumeration of image pixel representation types.	xsd:string	I Q Abs Phase Abs
pixelTypeType	Enumeration of image pixel data types.	xsd:string	32 bit Float 16 bit Signed Integer 16 bit Unsigned Integer
pixelQuantityType	Enumeration of pixel quantity types.	xsd:string	Beta-Nought Sigma-Nought Gamma-Nought
compressionMethodType	Enumeration of TIFF compression methods.	xsd:string	NONE DEFLATE ZSTD LERC LERC_DEFLATE LERC_ZSTD
productCompositionType	Enumeration of product composition indicators.	xsd:string	Nominal Merged

	The valid values are: "Nominal", to indicate a framed product of nominal length; "Merged", if the product is resulting from the merging of a "short" frame with the contiguous one; "Partial", if the product length is not nominal, but it is not merged to a contiguous one since it is "long enough"; "Incomplete", if the product length is not nominal due to contingency (e.g., data loss); "Not Framed", if the product is not framed, i.e., as long as input L0 one.		Partial Incomplete Not Framed
dataFormatModeType	Enumeration of compression method names.	xsd:string	BAQ 4 Bit BAQ 5 Bit BAQ 6 Bit Bypass
processingModeType	Enumeration of processing modes.	xsd:string	Nominal PARC
orbitAttitudeSourceType	Enumeration of value sources of orbit and attitude data. "Downlink" or "Auxiliary".	xsd:string	Downlink Auxiliary
rfiMitigationMethodType	Enumeration of RFI mitigation methods.	xsd:string	Time Frequency Time and Frequency Frequency and Time
rfiMaskType	Enumeration of RFI masks.	xsd:string	Single Multiple
rfiMaskGenerationMethodType	Enumeration of RFI mask generation methods.	xsd:string	AND OR
rangeReferenceFunctionType	Enumeration of the available range reference functions.	xsd:string	Nominal Replica Internal
rangeCompressionMethodType	Enumeration of the available range compression methods.	xsd:string	Matched Filter Inverse Filter
rfiFMMitigationMethodType	Enumeration of the available RFI Frequency	xsd:string	NOTCH_FILTER

	Domain mitigation methods.		NEAREST_NEIGHBOUR_INTERPOLATION
dcMethodType	Enumeration of Doppler Centroid calculation/estimation methods.	xsd:string	Geometry Combined Fixed
weightingWindowType	Enumeration of weighting window names.	xsd:string	Kaiser Hamming None
bistaticDelayCorrectionMethodType	Enumeration of bistatic delay correction methods.	xsd:string	Bulk Full
ionosphereHeightEstimationMethodType	Enumeration of ionosphere height estimation methods.	xsd:string	Automatic Feature Tracking Squint Sensitivity Model Fixed NA
ionosphereHeightSourceType	Enumeration of stack ionosphere height sources.	xsd:string	None Reference Image Manual
autofocusMethodType	Enumeration of autofocus methods.	xsd:string	Map Drift
internalCalibrationSourceType	Enumeration of the available internal calibration sources.	xsd:string	Extracted Model
heightModelType *Attribute: version*	Enumeration of Digital Elevation Models (DEM). *Attribute: DEM version. Default values:* • *COP-DEM_GLO-90-DGED-2021_1 EGM2008-2.5 for Copernicus DEM (convention: <format>-<delivery name> <geoid>-<resolution>)* • *SRTM_v1 EGM96 for SRTM (convention: SRTM_<version> <geoid>)* • *Empty value for Ellipsoid* *Version value has a one-to-one mapping with the*	xsd:string *Attribute: xsd:string*	Ellipsoid SRTM Copernicus DEM BIOMASS DTM

	physical folder where DEM to be used has been installed.		
coordinateReferenceSystemType	Coordinate reference systems, as per WKT representation [RD7].	xsd:string	
geodeticReferenceFrameType	Enumeration of geodetic reference frames.	xsd:string	WGS84 ITRF2000
polarisationCombinationMethodType	Enumeration of polarisations combination methods.	xsd:string	HV VH Average None
primaryImageSelectionMethodType	Enumeration of coregistration primary image selection methods.	xsd:string	Geometry Geometry and Quality Temporal Baseline
coregistrationMethodType	Enumeration of coregistration methods.	xsd:string	Geometry Geometry and Data Automatic
baselineMethodType	Enumeration of baseline method types (e.g. SingleBaseline or MultiBaseline).	xsd:string	Single-Baseline Multi-Baseline
ionosphereTypeType	Enumeration of the ionosphere types estimated by the BIC.	xsd:string	Linear Fast-varying None
coregistrationExecutionPolicyType	Enumeration of coregistration execution policies	xsd:string	Nominal Shift Estimation Only Warping Only
skpPhaseCorrectionType	Enumeration of supported corrections executed by SKP.	xsd:string	None Flattening Phase Screen Ground Phase Screen
skpPhaseCalibrationPostprocessingType	Postprocessing methods for the SKP calibration phase screen.	xsd:string	None Goldstein Boxcar Median
primaryImageSelectionInformationType	Enumeration of information used to select coregistration primary image.	xsd:string	Geometry Geometry and RFI Correction Geometry and FR Correction Geometry and RFI+FR Correction Temporal Baseline

layerType	Enumeration of LUT layer contents.	xsd:string	Faraday Rotation plane [rad] Faraday Rotation [rad] Faraday Rotation std [rad] Phase screen [rad] TEC [TECU] Range shifts [m] Azimuth shifts [m] Autofocus phase screen [rad] Autofocus phase screen std [rad] RFI time domain mask HH RFI time domain mask HV RFI time domain mask VH RFI time domain mask VV RFI frequency domain mask HH RFI frequency domain mask HV RFI frequency domain mask VH RFI frequency domain mask VV Sigma-nought LUT Gamma-nought LUT Denoising map HH Denoising map HV Denoising map VH Denoising map VV Denoising map XX Latitude [deg] Longitude [deg] Height [m] Incidence angle [deg] Elevation angle [deg] Range terrain slope [deg] Azimuth terrain slope [deg] FNF ACM numberOfAverages Azimuth coregistration shifts [m] Azimuth orbit coregistration shifts [m] Range coregistration shifts [m] Range orbit coregistration shifts [m] Coregistration shifts quality

			Wavenumbers [rad/m] Flattening phase screen [rad] Ionosphere Phase Screens [rad] SKP calibration phase screen [rad] SKP calibration phase screen quality Coherence Interferogram [rad]
uomType	Enumeration of unit of measures.	xsd:string	s UTC m samples lines deg rad Hz Hz/s MHz dB Mbps C K deg/s rad/s mm/Km deg/m rad/m 1/m t/ha (rad/nT)^2
bool	Boolean (true or false).	xsd:boolean	(false)|(true)

Tab.90 Primitive product types

The following table summarizes and describes those primitive product types for which attributes have been added with respect to base types.

Name	Description	Base Type	Attributes
timeTypeWithPolarisation	Extension of timeType with the indication of the corresponding polarisation.	timeType	polarisation
unsignedIntWithGroup	Extension of unsignedInt with the indication of the corresponding LUT group of variables. Attribute type is groupType	xsd:unsignedInt	group

unitInteger	Extension of the integer data type to include an optional "units" attribute.	xsd:integer	units
unitNonNegativeInteger	Extension of the nonNegativeInteger data type to include an optional "units" attribute.	xsd:nonNegativeInteger	units
float	32 bit single precision floating point number.	xsd:float	units
floatWithPolarisation	Extension of float with the indication of the corresponding polarisation.	xsd:float	polarisation
floatWithChannel	Extension of float with the indication of the corresponding RGB channel.	xsd:float	channel
double	64 bit double precision floating point number.	xsd:double	units
intArray	String containing an array of int values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	count
floatArray	String containing an array of float values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	count
doubleArray	String containing an array of double precision floating point values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	count
floatArray	String containing an array of float coefficient values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	count
floatArrayWithUnits	String containing an array of float values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	count units
doubleArrayWithUnits	String containing an array of double precision floating point coefficient values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	count units
complexArray	String containing an array of complex value pairs separated by spaces in the form of I Q I Q I Q ... The mandatory count attribute defines the number of complex elements in the array.	xsd:string	count

Tab.91 Primitive product types with custom attributes

The following tables describe common product types used throughout the document.

Name	Description	Data Type	Cardinality
re	32 bit single precision floating point real number.	xsd:float	1
im	32 bit single precision floating point imaginary number.	xsd:float	1

Tab.92 Common product types (complex)

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time of current value [UTC].	timeType	1
value	Current value.	floatWithUnit	1

Tab.93 Common product types (stateType)

Name	Description	Data Type	Cardinality
azimuthTime	Zero Doppler azimuth time corresponding to the start of the current polynomial validity area [UTC].	timeType	1
t0	Two-way slant range time origin for polynomial [s].	doubleWithUnit	1
polynomial	Local estimate expressed as the following polynomial: `X = c0+c1(tSR-t0)+c2(tSR-t0)^2+...` where `tSR` is the two-way slant range time.	doubleArray	1

Tab.94 Common product types (slantRangePolynomialType)

Name	Description	Data Type	Cardinality
slantRangeTime	Two-way slant range time corresponding to the start of the current polynomial validity area [s].	doubleWithUnit	1
t0	Zero Doppler azimuth time origin for polynomial [UTC].	timeType	1
polynomial	Local estimate expressed as the following polynomial: `X = c0+c1(tSR-t0)+c2(tSR-t0)^2+...` where tAZ is the Zero Doppler azimuth time.	doubleArray	1

Tab.95 Common product types (azimuthPolynomialType)

Name	Description	Data Type	Cardinality
coordinateReferenceSystem	Coordinate reference system.	coordinateReferenceSystemType	1
geodeticReferenceFrame	Geodetic reference frame.	geodeticReferenceFrameType	1

Tab.96 Common product types (datumType)

Name	Description	Data Type	Cardinality
min	Minimum value.	floatWithUnit	1
max	Maximum value.	floatWithUnit	1

Tab.97 Common product types (minMaxTypeWithUnit)

Name	Description	Data Type	Cardinality
count	counter	xsd:unsignedInt	1
units	units	uomType	1
floatArrayWithUnits	String containing an array of float values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	1

Tab.98 Common product types (floatArrayWithUnits)

Name	Description	Data Type	Cardinality
units	*units*	*uomType*	*1*
floatWithUnit	32 bit single precision floating point number.	xsd:float	1

Tab.99 Common product types (floatWithUnit)

Name	**Description**	**Data Type**	**Cardinality**
units	*units*	*uomType*	*1*
doubleWithUnit	64 bit double precision floating point number.	xsd: double	1

Tab.100 Common product types (doubleWithUnit)

Name	**Description**	**Data Type**	**Cardinality**
count	*counter*	*xsd:unsignedInt*	*1*
units	*units*	*uomType*	*1*
doubleArrayWithUnits	String containing an array of double precision floating point values separated by spaces. The mandatory count attribute defines the number of elements in the array.	xsd:string	1

Tab.101 Common product types (doubleArrayWithUnits)

Name	**Description**	**Data Type**	**Cardinality**
primary	Index of the primary inteferometric image with respect to a stack of images.	xsd:unisignedInt	1
secondary	Index of the secondary interferometric image with respect to a stack of images.	xsd:unsignedInt	1

Tab.102 Common product types (interferometricPairType)