



BIOMASS Forest Height Products Format Specification



biomass

Ref: BIO-BPS-FHPFD-ARE-010256

Issue: 3.4.0

Date: 13/03/2026

Document information

Title	BIOMASS Forest Height Products Format Specification
Internal Ref.	
External Ref.	BIO-BPS-FHPFD-ARE-010256
Date	13/03/2026
Issue	3.4.0
Pages	68

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

Prepared by	
Francesco Banda	Aresys
Emanuele Giorgi	Aresys
Riccardo Piantanida	Aresys
Davide D'Aria	Aresys
Paolo Mazzucchelli	Aresys

Checked by	
Davide D'Aria	Aresys

Approved by	
Davide D'Aria	Aresys

Change history

Date	Issue	Change	Author
23/03/2022	1.0	First issue of the document	Francesco Banda
09/06/2022	2.0	- Added L2a and L2b/L3 Products Format Specification (Sec. 4, 6) - Product schemas and descriptions updated (Sec. 3, 5) - CDR1-007: generic referencing to processing environment (Sec. 2) - CDR1-017: L2a product naming convention updated (Sec. 3.2) - CDR1-018: L2b/L3 product naming convention updated (Sec. 5.3) - CDR1-165: added STAC metadata placeholder (Sec. 3, 5) - CDR1-166: forest mask moved from measurement to annotation (Sec. 3, 5)	Emanuele Giorgi Francesco Banda
28/10/2022	2.1	- BPSPDR2-4: Removed optional and not needed elements from MPH (Sec. 4.1) - BPSPDR2-5: GeoCellID substituted with tileID (all the document) - BPSPDR2-7: verticalReflectivityDefaultProfile function clarified (Sec. 4.3.1) - BPSPDR2-9: reordered acronyms in alphabetical order (Sec. 1.3) - BPSPDR2-11: Added ZSTD compression EXIF code to GeoTIFF tag table (Sec. 4.2) - BPSPDR2-29: removed repetitions already described in Sec 1.2 (Sec. 2); added missing quotes (Sec. 3.1); added TCH acronym (Sec. 1.3) - BPSPDR2-32: solved TBD/TBC from document (all) - BPSPDR2-34: added to processing parameters of L2b the forest Masking Flag (Sec. 6.3.1.4) - BPSPDR2-54: specify that "no data values" are not used to apply modifications of the FNF (Sec. 3, 5) - BPSPDR2-63: compression strategy (description and processing parameters) updated for COG and NetCDF (Sec. 4.2, 4.3, 6.3) - BPSPDR2-64: specified TAG numbers for custom GeoTIFF private tags (Sec. 4.2)	Emanuele Giorgi Paolo Mazzucchelli Francesco Banda

Date	Issue	Change	Author
		- BPSPDR2-66 removed redundant NetCDF parameters (Sec. 4.3.2, 6.3.2) - Updated LUT ADS NetCDF format description for consistency with NetCDF4 (Sec. 4.3.2, 6.3.2) - BPSPDR2-79: updated L2b/L3 product structure, consequent removal of unneeded ADS LUT section (Sec. 5, 6.2, 6.3) - BPSPDR2-80: added to L2b/L3 input information, the tracking of L1c acquisitions used, in xml and with a heat map (Sec. 5, 6.2, 6.3.1.3) - BPSPDR2-81: removed start and stop times from L2b/L3 file name convention (Sec. 5.3) - BPSPDR2-82: added description in the text for the pixels marked as “no data value” and for its approach for each case (Sec. 3, 4.2, 4.3.1.2, 5) - BPSPDR2-83: improved consistency between documents (all the document) - Other processing parameters updates out of BPSPDR2 (Sec. 4.3, 6.3) - Updated LUT ADS NetCDF format description for consistency with NetCDF4 (Sec. 4.3.2, 6.3.2) - Introduced CFM (Computed Forest Mask), and updated initial FNF description (Sec. 2, 5, 6, 6.2) - Removed Quick look and overlay ADS sections, not foreseen for L2 (all the document). - Inserted RFI decorrelation factor in ADS (Sec. 4.3.1)	
13/3/2023	2.2	- BPS-219: updated naming convention, sections 3.2 and 5.3 - BPSCDR2-30: updated HeatMap definition - BPSCDR2-44: Quicklook reinserted	Paolo Mazzucchelli Emanuele Giorgi
31/07/2023	2.2.1	Post-FAT2 issue of the document	Paolo Mazzucchelli Emanuele Giorgi
17/11/23	3.0	CDR3 issue of the document - Added Overviews (sec. 4.2, 6.2) - Basin ID converted to list of strings (sec. 4.2, 4.3.1.1, 4.3.2.1, 6.3.1.1) - Units of measurement fixed where needed (sec. 4.3, 6.3) - Input Information DSR updated (sections 4.3.1, 6.3.1) - Removed L3 references across all the document	Paolo Mazzucchelli Emanuele Giorgi

Date	Issue	Change	Author
		BPS-491: Acquisition ID image COG layers order specified	
30/11/23	3.0.1	Release v.2.1.4 issue of the document - Updated productType in Sec 4.3.1, 6.3.1 and 7.1.1 - Updated pixelRepresentation, pixelType, noDataValue types in Sec 4.3.1, 6.3.1 and 7.1.1 - BPS-376: STAC position updated in doc - Updated compression options images and tables in Sec 4.3.1, 6.3.1 - Updated L2b Product Format overview (Sec 5) - Updated acquisitionFolderName definition (Tab 12, Tab 26) - BPSCDR2-79: MPH: reinserted bio:rds (Sec 4.1) - BPSCDR2-25: added new ref. - BPSCDR2-32: added ref to section 4.2 in section 3 - BPSCDR2-26: underline of common checked - BPS-484: Updated Primitive and common types (Tab 25) - also replaced "uint8" with "ubyte" (all document)	Paolo Mazzucchelli Emanuele Giorgi
12/12/23	3.0.2	Release v2.1.4 updated issue of the document - LUT attributes (list of strings), specified as json encoded - BPS-435: L2b product structure updated - Table with primitive types with attributes extended	Paolo Mazzucchelli Emanuele Giorgi
19/1/2024	3.0.3	DeltaFAT2 issue of the document: BPSCDR2-29: removed references from LUT content	Paolo Mazzucchelli
17/5/2024	3.0.4	Post DeltaFAT2 issue of the document - Added Acquisition Id Image to pixelRepresentationType - Added temporalDecorrelationGroundToVolumeRatio	Paolo Mazzucchelli
06/09/2024	3.0.5	FAT3 issue of the document Added correctTerrainSlopes flag to L2A FH processing parameters	Paolo Mazzucchelli Emanuele Giorgi
13/12/2024	3.1.0	Post-FAT3 issue of the document	Paolo Mazzucchelli Emanuele Giorgi
07/03/2025	3.2.0	Post-FAT3 issue of the document BPS-668: applyCalibrationScreen type updated	Paolo Mazzucchelli Emanuele Giorgi

Date	Issue	Change	Author
		BPS-FTO-BATCH4.2, L2 format changes - added <i>forestCoveragePercentage</i> in 4.3.1.1 product L2a DSR - added <i>verticalWavenumbers</i> and <i>heightOfAmbiguity</i> in 4.3.1.3 Input Information DSR - added <i>forest_coverage_percentage</i> in NetCDF, in 4.3.2.1 BPS-685: - updated naming convention	
30/04/2025	3.2.1	BPS-680: section 4.3.2, fixed units typo in LUT latitude longitude	Paolo Mazzucchelli Emanuele Giorgi
28/11/2025	3.3.0	Post-launch issue of the document (associated to BPS V4.2.0) Added Overlay ADS	Paolo Mazzucchelli Emanuele Giorgi
13/03/2026	3.4.0	Post-launch issue of the document (associated to BPS V4.4.0) - Updated <i>staQualityParametersType</i> - Added <i>polarisationCombinationMethod</i> to <i>generalConfigurationParametersType</i> - Removed old, solved comments	Paolo Mazzucchelli Emanuele Giorgi

Table of contents

1.	Introduction	7
1.1.	Context	7
1.2.	Scope of the document.....	7
1.3.	Acronyms	7
1.4.	Applicable documents.....	8
1.5.	Reference documents.....	9
2.	BPS and Forest Height Products Overview.....	10
3.	L2a Products Format Overview.....	11
3.1.	Product format definition guidelines	14
3.2.	Naming convention	15
4.	L2a Products Format Specification	16
4.1.	Main Product Header	16
4.2.	Measurement Data Sets (MDS).....	18
4.3.	Annotation data sets (ADS)	22
4.3.1.	Main ADS	22
4.3.2.	Look-Up Tables (LUT) ADS.....	43
4.3.3.	Quick-look ADS	47
4.3.4.	Overlay ADS	47
5.	L2b Products Format Overview.....	53
5.1.	Product format definition guidelines	55
5.2.	Naming convention	55
6.	L2b Products Format Specification	57
6.1.	Main Product header	57
6.2.	Measurement data sets (MDS)	58
6.3.	Annotation data sets (ADS)	59
6.3.1.	Main ADS	59
6.3.2.	Quick-look ADS	67
6.3.3.	Overlay ADS	67
7.	Appendix: Common Products Format Specification	68
7.1.	Annotation data sets (ADS)	68
7.1.1.	Primitive and common types.....	68

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 "Forest Height Products Format Specification" for the BIOMASS Processing Suite (BPS) project.

This document is organized as follows:

- Section 2: Brief introduction about BPS and Forest Height products;
- Section 3: Overview of L2a products format;
- Section 4: Detailed description of L2a products format specifications;
- Section 5: Overview of L2b products format;
- Section 6: Detailed description of L2b products format specifications.
- Section 7: Appendix containing xml primitive product types description.

1.3. Acronyms

Acronym	Description
ADS	Annotation Data Set
AGB	Above Ground Biomass
ARESIS	Advanced Remote Sensing and Systems
BPS	BIOMASS Processing Suite
CFM	Computed Forest Mask (by Forest Disturbance L2 processor)
COG	Cloud Optimized GeoTIFF

Acronym	Description
COM	Commissioning Phase
DEM	Digital Elevation Model
DGG	Discrete Global Grid
DSR	Data Set Record
FD	Forest Disturbance
FH	Forest height
FNF	Forest/Non-Forest Mask
GC	Global Cycle
INT	Interferometric Phase
L1c	Level-1c product
L2a	Level-2a product
L2b	Level-2b product
LCM	Land Cover Map (ESA CCI/C3S)
LERC	Limited Error Raster Compression
LUT	Look-Up Tables
MDS	Measurement Data Set
MPH	Main Product Header
NetCDF	Network Common Data Form
OGC	Open Geospatial Consortium
RDS	Representation Data Set
SAR	Synthetic Aperture Radar
STA	Stack interferometric product
STAC	Spatio Temporal Asset Catalogs
TCH	Top Canopy Height
TBD	To Be Defined
TOM	Tomographic Phase

1.4. 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 2/3
- [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
- [AD6] BIOMASS Production Model, BIO-ESA-EOPG-EEGS-TN-0046, issue 3.5
- [AD7] BIO-BPS-TN-PRODMOD, BIOMASS Production Model Technical Note, I/R 1/2/2
- [AD8] BIOMASS L2 FD ATBD, I/R, 2/1/4
- [AD9] BIOMASS L2 FH ATBD, I/R, 2/1/4

1.5. 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] Network Common Data Form (NetCDF), Python <https://unidata.github.io/netcdf4-python>
- [RD8] Well-Known Text representation of coordinate reference systems, <https://www.iso.org/standard/63094.html>
- [RD9] [PDD] BIO-BPS-PPD-ARE-010083, BIOMASS Product Performance Description, I/R 3/0/1
- [RD10] [L1PDF] BIO-BPS-L1PFD-ARE-010076, BIOMASS L1 Product Format Specification, I/R 1/2/8
- [RD11] https://docs.ogc.org/is/19-008r4/19-008r4.html#_geotiff_configuration_geokeys

2. BPS and Forest Height 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 Forest Height product family is composed by:

- Level-2a (L2a): product composed by two stack-based images representing top canopy height and its quality layer, obtained from L1c processing and auxiliary data and with a different resolution and projection (latitude-longitude) with respect to the L1c source data. Same algorithms are envisaged to generate the same product in INT and TOM phases;
- Level-2b (L2b): top canopy height and quality layer images, on map and tile based, derived from merging of L2a in a given Global cycle, on the tile;

The Forest Height product family is generated during routine phase by the BIOMASS Processors (i.e., L2a Processor for L2a products, L2b Processor for L2b products running in the operational processing environment. The L2b FH processing has optional internal dependency on FD L2b .L2 products are internal products generated only for the BIOMASS scientific team.

The L2b BIOMASS products are geocoded to a specific tile based geographic DGG [RD9], while the L2a products are geocoded in a latitude longitude projection with the same origin and sampling of the DGG, but with an extension of the current L2a product ground coverage.

NOTE: Provided that FD algorithm proper validation will only be possible with BIOMASS in orbit, the strategy proposed to deal with FH/AGB dependency on FD is to initially input to FH/AGB a Forest/Non-Forest mask generated outside of BPS [AD6][AD7][AD8][AD9]. After testing FD performance with BIOMASS in orbit, FD dependency can be switched on again, provided it has a satisfactory performance.

3. L2a Products Format Overview

The BIOMASS Forest Height L2a 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 forest height image and quality layer, derived from processing of L1c 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 Forest Height L2a products is summarised in the following figure and table. In particular, a typical product contains:

- a main product header (MPH), an XML file including high-level information about the product origin, structure and main metadata;
- STAC metadata: the SpatioTemporal Asset Catalog specification (<https://stacspec.org/en>) provides a common structure for describing and cataloging spatiotemporal assets (it is a file that represents information about the earth captured in a certain space and time);
- Forest Height image MDS, including the Forest Height image binary raster data and quality layer, organised in two Cloud Optimized GeoTIFF (COG) files (specific coding information in section 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;
- 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 file;
- quick-look ADS, including an averaged and decimated previews of measurement MDS;
- Overlay ADS, for viewing the Quick-look ADS in any application that supports KML format (like, e.g., Google Earth or GIS applications);
- XML schemas RDS, including the schemas needed for all the XML files included in the product.

No Data Value

L2a Data Sets pixels will have a no data value of -9999.0 (float32) or 255 (ubyte) depending on data type, where the input L1c pixels are invalid and for each pixel discarded by the algorithm. The value is reported in the MDS COG metadata (GDAL_NODATA tag, see Tab.2), in the Raster Image DSR (noDataValue element, see Tab.8) and in LUT ADS (noDataValue variable, see 4.3.2.1).

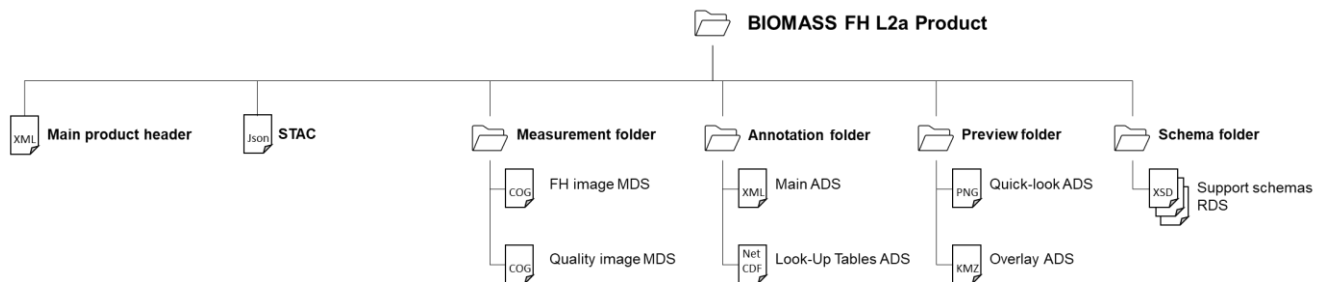


Fig.1 Forest Height L2a products structure

File / Folder	Cardinality	Format	Description / Content
BIOMASS Forest Height L2a Product		Folder	
└ main product header	1	XML	Main product header
└ STAC	1	JSON	STAC (https://stacspec.org) metadata.
└ measurement		Folder	
└ Forest Height	1	COG	Forest Height image MDS
└ Quality	1	COG	Quality image MDS
└ annotation		Folder	
└ main	1	XML	Main ADS, including: - Product DSR - Raster image DSR - Input information DSR - Processing parameters DSR - Annotation LUT DSR
└ lut	1	NetCDF	Look-Up Tables ADS, including: FNF, generated outside BPS [AD6][AD7][AD8][AD9]
└ preview		Folder	
└ quicklook	2	PNG	Quick-look ADS, for each measurement
└ overlay	1	KML	Overlay ADS, for each quicklook
└ schema		Folder	
└ main annotation.xsd	1	XSD	RDS
└ L2a, L2b common annotation.xsd	1	XSD	RDS
└ common types.xsd	1	XSD	RDS
└ fh-proc-annotations.xsd	1	XSD	RDS

Tab.1 Forest Height L2a products structure

3.1. Product format definition guidelines

The BIOMASS Forest Height L2a 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,...);
- 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 for quick-looks, KML for overlays).

Starting from this consolidated “background”, in order to improve the products usability, a LUT has been introduced to reduce annotation file dimensions and easing its access, management and applicability.

In the end, the L2a products format has been defined together with L2b 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. Naming convention

The BIOMASS L2a product and all data sets files naming are addressed and described in detail in [AD2].

The naming of the products directories is here proposed following the main points in [AD2]:

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

where:

- <MMM>: Satellite ID;
- <TTTTTTTTTT>: Product Type/File Type, i.e.:
 - FP_FH__L2A: Forest Height L2a product;
- <yyyymmddThhmmss>: UTC start date and time (min time validity of the stack);
- <YYYYMMDDTHHMMSS>: UTC stop date and time (max time validity of the stack);
- <P>: Mission phase identifier;
- <CC>: Global Coverage identifier;
- <NN>: Major Cycle identifier;
- <___> Repeat Cycle identifier, set to special value (not used in L2 products);
- <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 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_[fh|quality].tiff for image MDS;
 - *_annot.xml for main ADS;
 - *_lut.nc for Look-Up Tables ADS;
 - *_[fh|fhquality]_ql.png for quick-look ADS
 - *_[fh|fhquality]_map.kml for overlay ADS
 - *.xsd for support schemas RDS.
 - *.json for STAC

4. L2a Products Format Specification

4.1. Main Product Header

The Main Product Header (MPH) is an XML file present in all the BIOMASS L2 products. BIOMASS L2 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).

It must be noted that, while the footprint is inherited from lower level products (thus vertices represent the extent of the acquired data), DGG tiles (tileId list) are related to the full extent of L2a product (that is geocoded).

For the detailed description of the MPH content and format refer to [AD3]. Here just a schematic representation is reported, , where this notation is applicable:

This is a container of other elements

This element or block of elements can occur more than one time (i.e. it is a list)

This is a container of actual metadata

This is a mandatory element for the standard which is left empty by this specification

This element or block of elements is optional

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*



Fig.2 Main product header L2a (metadata schematic representation)

4.2. Measurement Data Sets (MDS)

The MDS of the L2a product is constituted by two images:

- the biophysical measurement consisting of the Forest Height binary raster, representing Top Canopy Height (TCH);
- a layer of quality, consisting of a percentage bias value for each of the Forest Height image pixel, indicating the inversion performance.

The two quantities are organised in separated Cloud Optimized GeoTIFF (COG) files [RD1] and coded using a 4-byte float per pixel (float32).

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, ...).

The MDS images ground coverage is corresponding to the geocoded spatial stack coverage of inputs L1c used to compute L2a product: the L2a MDS images are geocoded to the minimum required latitude-longitude coverage to accommodate for the product on ground, following the same sampling requirements specified in [RD9] ensuring a ground sampling always better than the resolution.

Compression strategy

The MDS images are composed by real values: it is possible to introduce with benefit a strategy for data compression, making use of native LibTIFF libraries capabilities [RD4] adopting a GeoTIFF LERC+ZSTD compression, where:

- LERC compression algorithm can be configured to decide how lossy the compression will be, through the “MAX_Z_ERROR” option (loss-less only if set to zero);
- ZSTD is a loss-less compression algorithm with a configurable compression level from 0 to 9, where zero means no compression.

Both set by configuration. More details in sec. 4.3.1.4.

Metadata

The TIFF and GeoTIFF tags used to annotate the MDS files are described in the following table. For the complete description of each tag refer to official TIFF format documentation [RD5] and official GeoTIFF documentation [RD11].

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	Number of bits per component.
Compression	259	34887, 34926	Compression scheme used on the image data (LERC and 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. Valid Strings are composed by prefix: "BIOMASS L2a FP_FH_L2A: " or "BIOMASS L2b FP_FH_L2B: " and: "Forest Height [m]" "Forest height quality" "Forest Mask" (L2b only) "Heat Map" (L2b only) "acquisition id image" (L2b only)
SamplesPerPixel	277	1	The number of components per pixel. Always set to 1, since each product is stored in a different file.
PlanarConfiguration	284	1	How the components of each pixel are stored. Always set to 1 (contiguous).
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)
ModelPixelScaleTag	33550	Variable	List of doubles, (ScaleX, ScaleY, ScaleZ) where ScaleX and ScaleY give the horizontal and vertical spacing of raster pixels. The ScaleZ is zero.
ModelTiePointTag	33922	N * (pixel, line, 0, lat, long, 0)	Maps image pixels to geographic coordinates, where N is the number of tie points in the scene.
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.
GeoDoubleParamsTag	34736	Variable	Contains the value of all GeoTIFF keys of type DOUBLE.
GeoAsciiParamsTag	34737	Variable	Contains the value of all GeoTIFF keys of type ASCII.
GDAL_METADATA	42112	Variable	Contains GDAL metadata (see table below)
GDAL_NODATA	42113	"-9999" or "255"	Pixel value used in case of invalid data. ASCII string encoded value. (See 3)
LercParameters	50674	Variable	LERC compression parameters: version, additional compression. e.g. 4,2 for LERC v4 with ZSTD

Tab.2 MDS – TIFF and GeoTIFF tags

The GDAL_METADATA tag content is listed in the following table

Tag Name	Value	Description
basinID	list of strings	List of DGG basin identifiers (for querying purposes). More than one ID in case of tile covering more than one geographic location. Private Tag code.

MAX_Z_ERROR	float	Absolute maximum error present in the image data, due to LERC compression. Private Tag code.
Swath	string	Image swath. Private Tag code (L2A only)
tileID	list of strings	List of DGG geographic cell (tile) identifiers (for querying purposes). Private Tag code.

Tab.3 MDS – GDAL_METADATA tiff tag content

Overviews

The exploitation of GDAL library allows to easily add to COG file one or more overviews of the L2 image.

Overviews are sub-sampled versions of an L2 image. Adding one or more overviews at different resolution levels allows to use pyramidal viewers directly on L2 image file, without the need of transcoding operations or of further processing.

The following (minimum) number of overviews is foreseen:

- multi-look factors (latitude x longitude) of 2x2.
- multi-look factors (latitude x longitude) of 4x4.

4.3. Annotation data sets (ADS)

4.3.1. Main ADS

This section describes in details the content of main ADS for L2a products. An overview is provided by figure and table below.

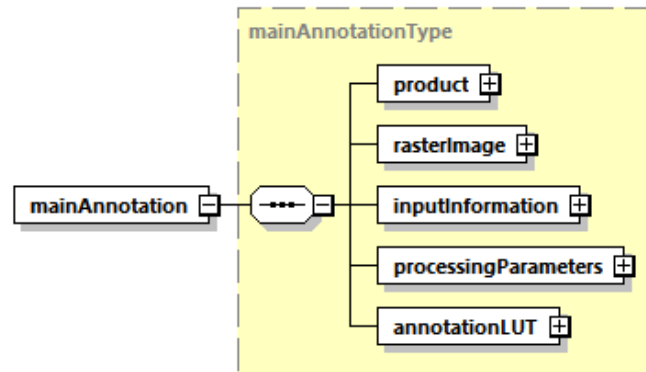


Fig.3 Main L2a ADS

Name	Description	Data Type	Cardinality
product	Product L2a DSR. This DSR contains the L2a product information.	<u>productL2aType</u>	1
rasterImage	Raster image DSR. This DSR contains all the necessary information to exploit the L2a product raster images.	<u>rasterImageType</u>	1
InputInformation	Input Information DSR. This DSR contains the necessary information to identify the input data set to the L2a processing.	<u>InputInformationL2aType</u>	1
processingParameters	Processing parameters DSR. This DSR contains the description of L2a processing parameters.	<u>processingParametersL2aType</u>	1
annotationLUT	Annotation LUT DSR. This DSR contains the list of Look-Up Tables (LUTs) complementing product main annotations.	<u>layerListType</u>	1

Tab.4 Main L2a 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. Product L2a DSR

This DSR contains the parameters to describe the L2a products.
An overview is provided by figure and table below.

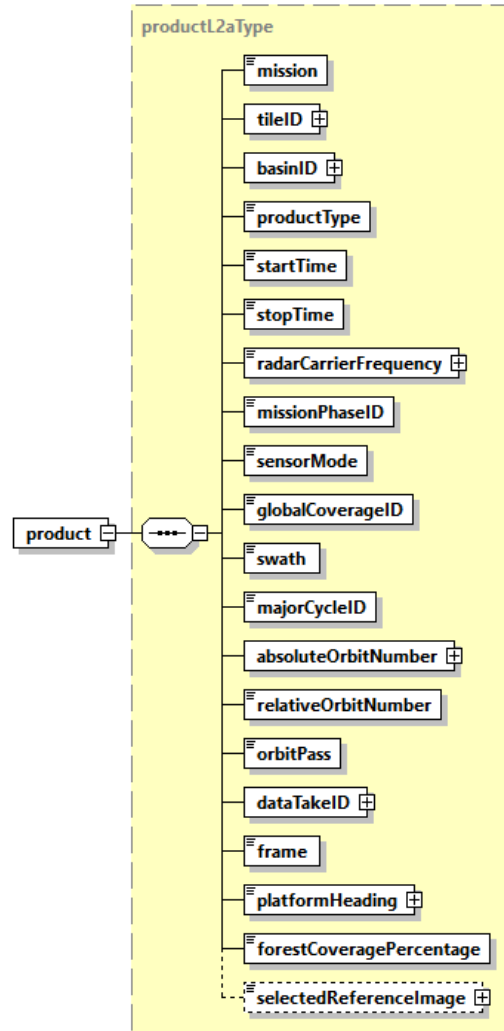


Fig.4 Product L2a DSR (productL2aType)

Name	Description	Data Type	Cardinality
mission	Mission (BIOMASS).	missionType	1
tileID	List of DGG geographic cell (tile) identifiers.	<u>stringListType</u>	1
basinID	List of DGG Basin identifiers.	<u>stringListType</u>	1
productType	Product type ("FH_L2A").	productType	1
startTime	Start time of the product image [UTC].	timeType	1
stopTime	Stop time of the product image [UTC].	timeType	1
radarCarrierFrequency	Radar carrier frequency [Hz].	doubleWithUnit	1
missionPhaseID	Mission phase identifier.	missionPhaseIDType	1
sensorMode	Sensor mode (always Measurement).	sensorModeType	1
globalCoverageID	Global coverage identifier.	xsd:unsignedShort	1
swath	Swath (S1, S2, S3).	swathType	1
majorCycleID	Major cycle identifier.	xsd:unsignedShort	1
absoluteOrbitNumber	List of absolute orbit numbers at start time (one for each input L1c).	<u>integerListType</u>	1
relativeOrbitNumber	Relative orbit number (track) at start time	xsd:unsignedShort	1
orbitPass	Orbit pass (Ascending, Descending).	orbitPassType	1
dataTakeID	List of data take identifiers (one for each input L1c).	<u>integerListType</u>	1
frame	Frame identifier.	xsd:unsignedShort	1
platformHeading	Platform heading relative to North [deg].	doubleWithUnit	1
forestCoveragePercentage	Forest coverage of the input STA products, compute as a percentage of all the pixels in the STA footprint.	double	1

Tab.5 Product L2a DSR (productL2aType)

Name	Description	Data Type	Cardinality
ID	Tile identifier string	string	1 .. unbounded

Tab.6 stringListType

Name	Description	Data Type	Cardinality
val	Integer value	uint32	1 .. unbounded

Tab.7 integerListType

4.3.1.2. Raster Image DSR

This DSR contains all the necessary information to exploit the raster images of the product. An overview is provided by figure and table below.

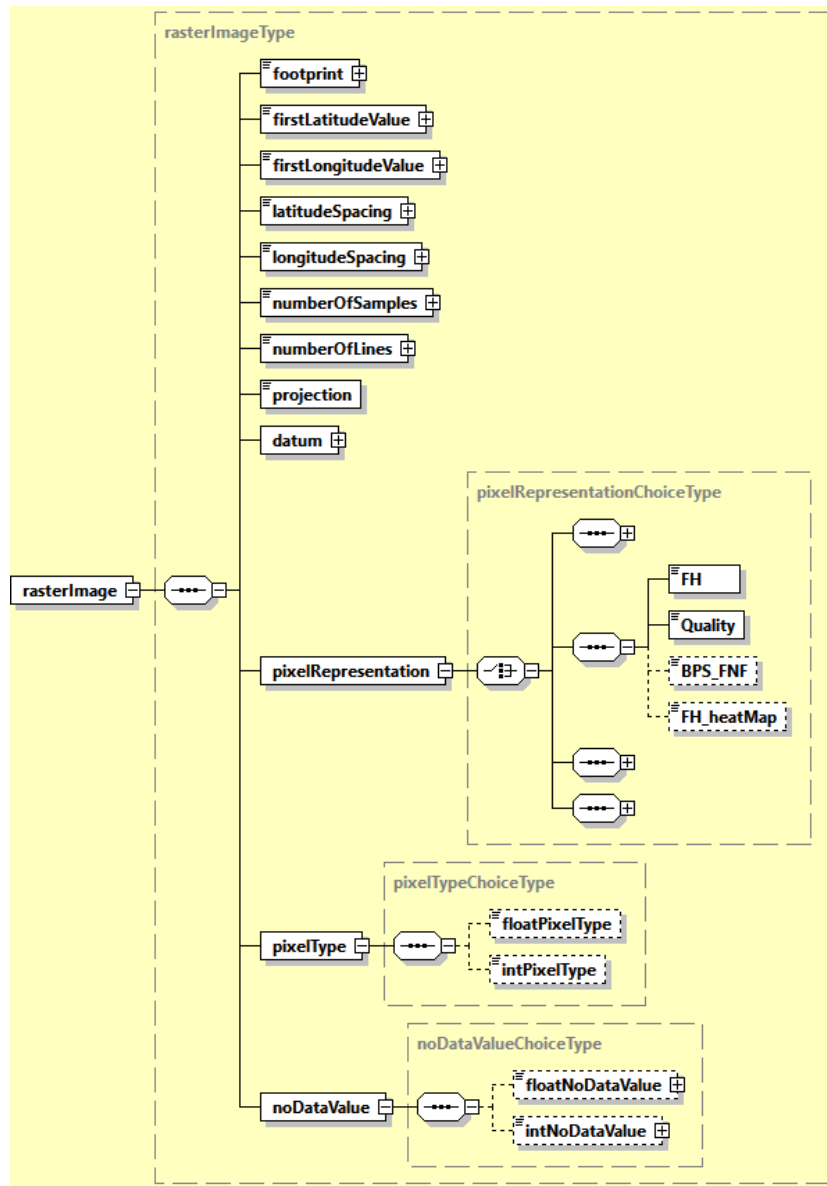


Fig.5 Raster image DSR (rasterImageType)

Name	Description	Data Type	Cardinality
footprint	Image footprint, expressed as a list of latitude, longitude tuples in NE, SE, SW, NW order [deg].	floatArrayWithUnits	1
firstLatitudeValue	First latitude value of the image [deg].	floatWithUnit	1
firstLongitudeValue	First longitude value of the image [deg].	floatWithUnit	1

latitudeSpacing	Latitude spacing between samples [deg].	floatWithUnit	1
longitudeSpacing	Longitude spacing between samples [deg].	floatWithUnit	1
numberOfSamples	Total number of samples in the image.	xsd:unsignedInt	1
numberOfLines	Total number of lines in the image.	xsd:unsignedInt	1
projection	Projection of the image: "Latitude longitude based on DGG".	projectionType	1
datum	Datum used during processing.	datumType	1
pixelRepresentation	Representation of the image pixels within the image MDS.	<u>pixelRepresentationChoiceType</u>	1
pixelType	Data type of output pixels within the image MDS.	<u>pixelTypeChoiceType</u>	1
noDataValue	Pixel value in case of invalid data. The value is always set to -9999.0 float32 or 255 ubyte, depending on data type, see section 3, 5.	<u>noDataValueChoiceType</u>	1

Tab.8 Raster image DSR (rasterImageType

Name	Description	Data Type	Cardinality
FH	Representation of the image pixels within the image MDS: Forest Height [m]	pixelRepresentationType	1
Quality	Representation of the image pixels within the image MDS: Forest height quality	pixelRepresentationType	1
FH_heatMap	Representation of the image pixels within the image MDS: Heat Map (Only L2b)	pixelRepresentationType	0,1
BPS_FNF	Representation of the image pixels within the image MDS: Forest Mask (Only L2b)	pixelRepresentationType	0,1
Acquisition_Id_Image	Representation of the image pixels within the image MDS: acquisition_id_image (Only L2b)	pixelRepresentationType	0,1

Tab.9 pixelRepresentationChoiceType(L2a/L2b FH described here)

Name	Description	Data Type	Cardinality
floatPixelType	Data type of output pixels within the image MDS: 32 bit Float	pixelTypeType	1
intPixelType	Integer data type of output pixels within the image MDS: 8 bit Unsigned Integer (L2b only)	pixelTypeType	0,1

Fig.7 Input Information DSR, acquisition list detail (acquisitionListType)

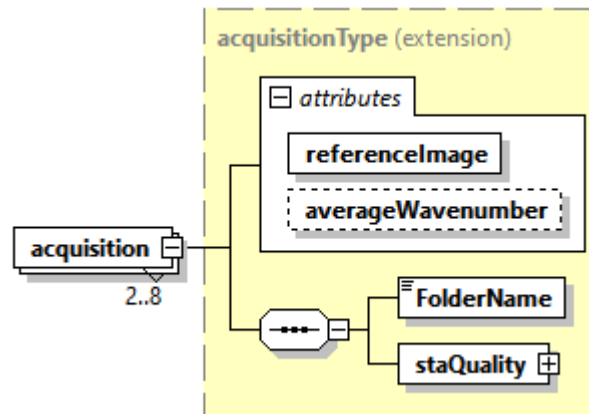


Fig.8 Input Information DSR, acquisition detail (acquisitionType)

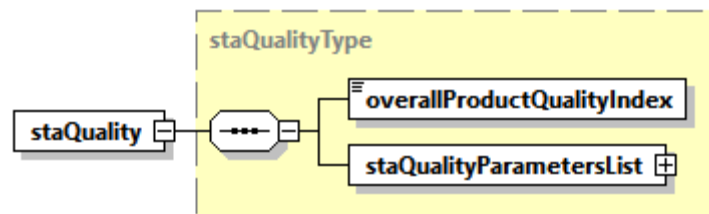


Fig.9 Input information DSR, staQualityType

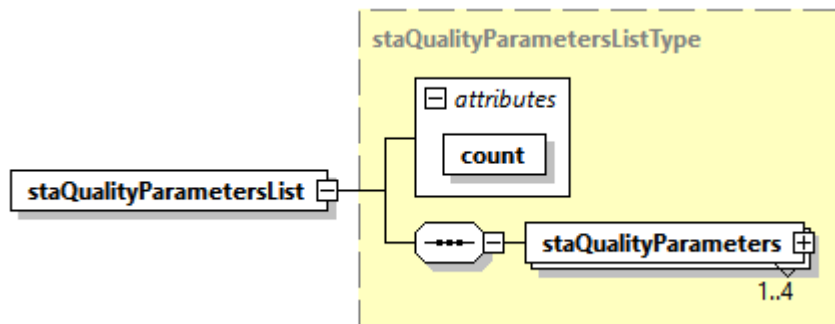


Fig.10 Input information DSR, staQualityParametersListType

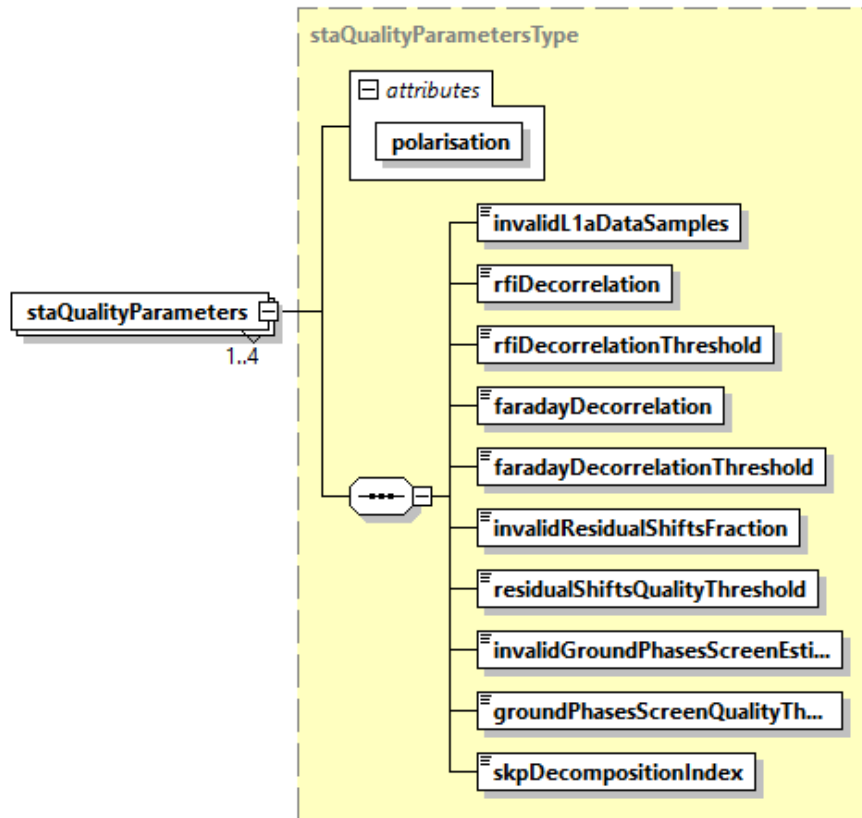


Fig.11 Input information DSR, staQualityParametersType

Name	Description	Data Type	Cardinality
productType	Input product type: always “STA” (L1c STA)	productType	1
overallProductsQualityIndex	Quality index based on the "overallProductQualityIndex" of the single STA input data, giving a qualitative overall idea of the input stack. Equal to "0" if all STA feature "overallProductQualityIndex"=False and to "1" if at least one is degraded.	xsd:unsignedByte	1
nominalStack	True if it is a nominal stack (3 STA products for INT phase or 7 STA products for TOM phase), False otherwise	bool	1
polarisationList	List of polarisations composing input L1c data: for each polarisation it is also specified, with an attribute, the decorrelation factors due to RFI strength.	<u>polarisationListType</u>	1
projection	Projection of the input acquisitions, always “Slant Range”.	projectionType	1

footprint	Image footprint of all the acquisitions composing the stack, expressed as a list of latitude, longitude tuples in NE, SE, SW, NW order [deg].	floatArrayWithUnits	1
verticalWavenumbers	Minimum and maximum values of the vertical wavenumbers [rad/m] in the read and used Input STA products.	minMaxTypeWithUnit	1
heightOfAmbiguity	Minimum and maximum values of the height of ambiguity (HoA) [m], computed from the vertical wavenumbers in the read and used Input STA products.	minMaxTypeWithUnit	1
acquisitionsList	Info of each acquisition composing the stack, in input to L2a.	<u>acquisitionListType</u>	1

Tab.12 Input Information DSR (InputInformationL2aType)

The acquisitionListType is composed by 2 to 8 entries, where each entry is an L1c acquisition folder name string, as defined in [RD10]

Name	Description	Data Type	Cardinality
count	Number of acquisitions.	unsignedInt	required
acquisition	Info about acquisition of the stack.	acquisitionType	2..8

Tab.13 Input information DSR (acquisitionListType)

Name	Description	Data Type	Cardinality
referenceImage	Flag to indicate if this is the reference image or not.	bool	1
averageWavenumber	Optional Average Wavenumber, it is not used in FH (only in L2A FD)	float	0
FolderName	Folder name which univocally identifies an acquisition of the stack.	xsd:string	1
staQuality	Folder name which univocally identifies an acquisition of the stack, as defined in [RD10].	<u>staQualityType</u>	1

Tab.14 Input information DSR (acquisitionType)

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. Equal to 0 for valid products and to 1 for invalid ones.	xsd:unsignedInt	1
staQualityParametersList	Quality parameters list. The list contains an entry for each output product's polarisation.	<u>staQualityParametersListType</u>	1

Tab.15 Input information DSR (staQualityType)

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

Tab.16 STA quality DSR (staQualityParametersListType)

Name	Description	Data Type	Cardinality
polarisation		polarisationType	required
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
invalidResidualShiftsFraction	Number of invalid residual coregistration shifts, expressed as a normalized fraction of the total number of residual coregistration shifts. 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
invalidGroundPhasesScreenEstimatesFraction	Number of invalid ground phase screen estimates, expressed as a normalized fraction of the total number of ground phase screen estimates. The value is between 0 and 1.	xsd:float	1
groundPhasesScreenQualityThreshold	Threshold on ground 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 skipPhaseCorrectionFlag is set to True.	xsd:float	1
skipDecompositionIndex	Error code for the SKP decomposition. Positive if the SKP decomposition hit a nonblocking contingency case (e.g. SVD decomposition failure etc.) and the exported SKP-related LUTs contain values obtained from a contingency handling procedure. 0 otherwise.	xsd:unsignedInt	1

Tab.17 STA quality DSR (staQualityParametersType)

Name	Description	Data Type	Cardinality
count	Number of polarization images.	xsd:unsignedInt	required

polarisation	Polarisation (HH, VH, VV).	polarisationType	3
--------------	----------------------------	------------------	---

Tab.18 Input information DSR (polarisationListType)

4.3.1.4. Processing parameters L2a DSR

This DSR contains the exhaustive list of L2a Forest Height inversion processing parameters applied. An overview is provided by figure and table below.

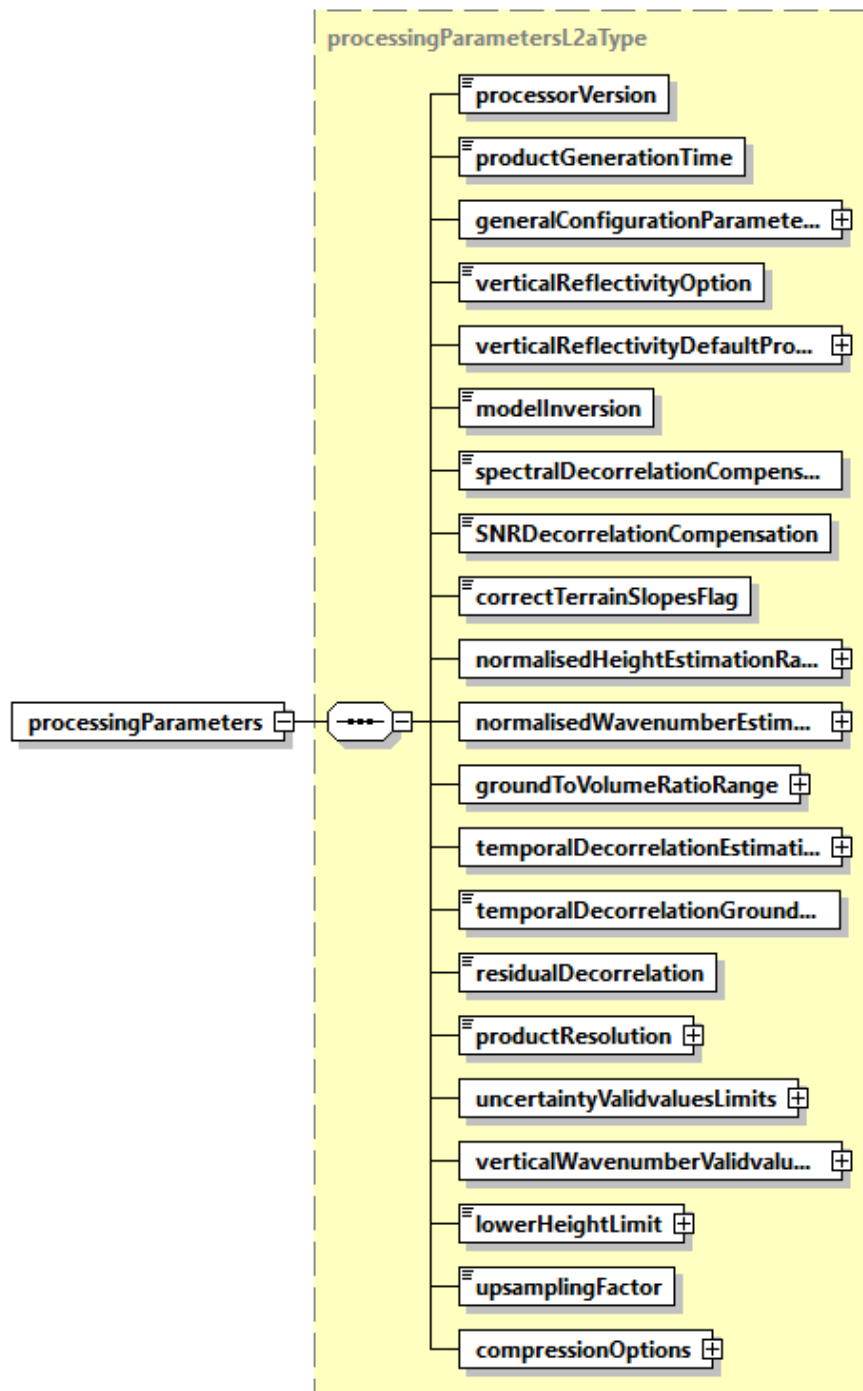


Fig.12 Processing parameters L2a DSR (processingparametersL2aType)

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
generalConfigurationParameters	General processing flags (not specific to the Forest Height processing).	<u>generalConfigurationParametersType</u>	1
verticalReflectivityOption	Specify which vertical reflectivity profile has been used: default modelled profile or tomographic profile (out of BPS scope). See also verticalReflectivityDefaultProfile.	<u>verticalProfileOptionType</u>	1
verticalReflectivityDefaultProfile	Used if verticalReflectivityOption is set to "default profile", in this case the profile stored to xml is used: a modeled tomographic volume-only reflectivity profile normalized to unit height; deterministic and fixed for all the globe [AD9].	<u>verticalReflectivityProfileType</u>	1
modelInversion	Model inversion algorithm used between single or dual (baseline).	<u>modelInversionType</u>	1
spectralDecorrelationCompensationFlag	True if range spectral decorrelation compensation has been applied, False otherwise.	bool	1
SNRDecorrelationCompensation	True if SNR decorrelation compensation has been applied, False otherwise.	bool	<u>1</u>
correctTerrainSlopesFlag	True if terrain slope correction has been applied, False otherwise.	bool	<u>1</u>
normalisedHeightEstimationRange	Validity range of heights used for the canopy height	minMaxType	1

	estimation process, normalized.		
normalisedWavenumberEstimationRange	Validity range of wavenumbers used for the canopy height estimation process, normalized.	minMaxNumType	1
groundToVolumeRatioRange	Validity ground to volume ratio range used for the canopy height estimation process.	minMaxNumType	1
temporalDecorrelationEstimationRange	Validity temporal decorrelation range used for the canopy height estimation process.	minMaxNumType	1
temporalDecorrelationGroundToVolumeRatio	Ratio of temporal decorrelation between ground and volume (0.0 means no temporal decorrelation for ground, while 1.0 means ground and volume are equally impacted by temporal decorrelation)	xsd:float	1
residualDecorrelation	Residual non-volumetric decorrelation used in error model computation.	xsd:float	1
productResolution	Value in [m] used as the resolution on ground range map and also to perform the coherence averaging in radar coordinates.	floatWithUnit	1
uncertaintyValidvaluesLimits	Uncertainty valid values limits applied, as a percentage: estimates out of this limits have been discarded and set to no data value.	minMaxType	1
verticalWavenumberValidvaluesLimits	Vertical wavenumber valid values limits in [rad/m] applied: estimates out of this limits have been discarded and set to no data value.	minMaxType	1
lowerHeightLimit	FH estimates lower this limit [m] were discarded and set to no data value	floatWithUnit	1

upsamplingFactor	Upsampling factor used for coherence.	xsd:unsignedByte	1
compressionOptions	Configurable compression options for all the L2 MDS COG and ADS NetCDF LUT variables (see 4.3.2 for LUT “ZLIB” compression details).	compressionOptionsL2Type	1

Tab.19 Processing parameters L2a DSR (processingparametersL2aType)

Name	Description	Data Type	Cardinality
count	Number of values composing the function.	xsd:unsignedInt	required
val	N floating point values which compose the default modelled tomographic volume-only reflectivity profile function.	xsd:float	1..N

Tab.20 Processing parameters L2a DSR (verticalReflectivityProfileType)

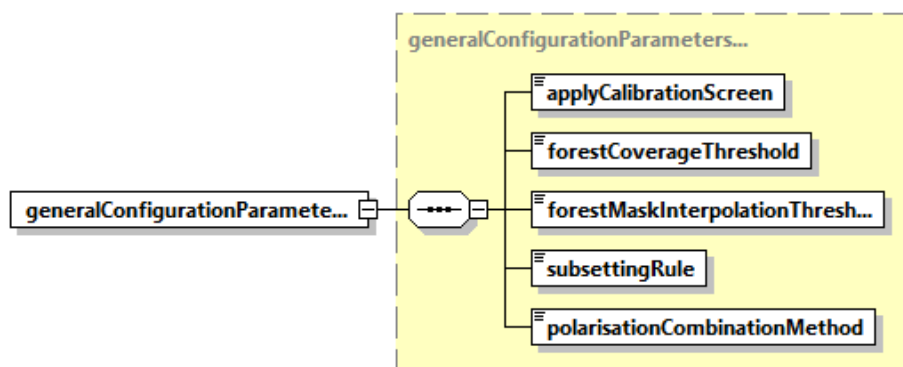
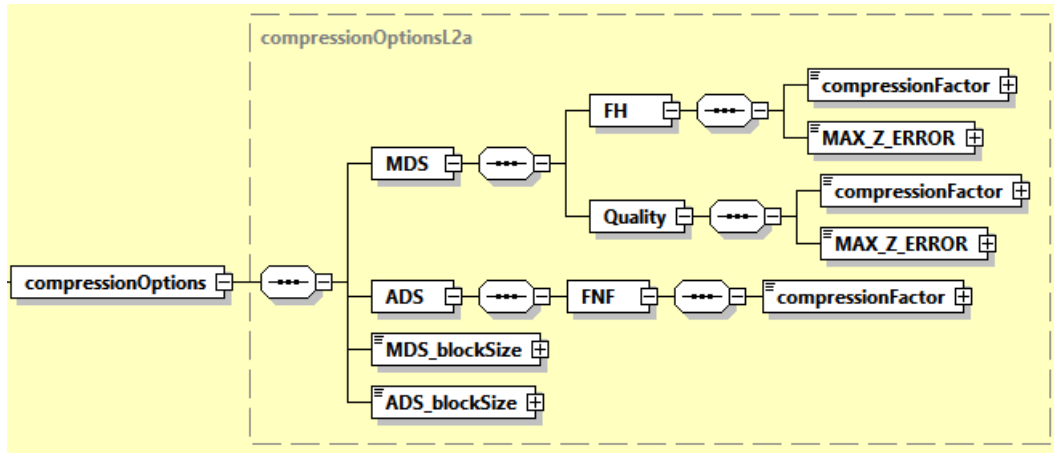


Fig.13 Processing parameters L2a DSR (generalConfigurationParametersType)

Name	Description	Data Type	Cardinality
applyCalibrationScreen	Phase calibration performed: “none”: no phase screen has been applied “geometry”: only flattening phase screen has been applied (i.e., as computed from acquisition geometry) “skp”: complete phase screen has been applied (default)	calibrationScreenType	1
forestCoverageThreshold	Minimum percentage forest coverage in L2a product footprint, used to trigger L2a processing.	xsd:float	1
forestMaskInterpolationThreshold	This parameter is a threshold which has been used to fix rounding of pixels with decimal values originated from binary FNF interpolation onto L2a grid. This created a safety buffer around forest border.	xsd:float	1
subsettingRule	In case of more than three acquisitions the user selected subsetting rule is here annotated (always “geometry” for FH L2a processor).	subsettingRuleType	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

Tab.21 Processing parameters L2a DSR (generalConfigurationParametersType)

Fig.14 Processing parameters L2a DSR (compressionOptionsL2Type)

Name	Description	Data Type	Cardinality
MDS → FH → compressionFactor MDS → Quality → compressionFactor	ZSTD algorithm compression factor for both FH and quality images MDS. From 0 to 9, where zero means no compression.	xsd:unsignedByte	1
MDS → FH → MAX_Z_ERROR MDS → Quality → MAX_Z_ERROR	For both FH and quality images MDS, define exactly how lossy the LERC compression algorithm is allowed to be, specifying the absolute maximum error admitted. Zero means loss-less compression.	xsd:float	1
ADS → FNF → compressionFactor	ZLIB algorithm compression factor for the FNF ADS. From 0 to 9, where zero means no compression.	xsd:unsignedByte	1
MDS_blockSize	MDS COG blocking algorithm size. Same value is used for both data array dimensions.	xsd:unsignedByte	1
ADS_blockSize	ADS NetCDF chunking algorithm size. Same value is used for both data array dimensions.	xsd:unsignedByte	1

Processing parameters L2a DSR (compressionOptionsL2aType)

4.3.1.5. Annotation LUT DSR

This DSR contains the list of Look-Up Tables (LUTs) complementing product main annotations. An overview is provided by figure and table below.

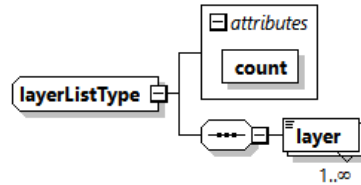


Fig.15 Annotation LUT DSR (layerListType)

Name	Description	Data Type	Cardinality
<i>count</i>	<i>Number of layers.</i>	<i>xsd:unsignedInt</i>	<i>required</i>
layer	LUT layer content.	layerType	1 .. unbounded

Tab.22 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 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 format adopted for LUT ADS is NetCDF one [RD6] and in particular the used implementation is the Python NetCDF4 [RD7]. Thanks to the flexibility provided by this format, all the components of this ADS are stored in the same file.

The LUT ADS provides the Forest/Non-Forest mask (generated outside of BPS [AD6][AD7][AD8][AD9]).

Fig.16 provides a schematic representation of the LUT ADS structure. Note that an XSD diagram has been used for this purpose, even if there is no link between the two formats. The ADS is organised as follows:

- a series of root level *Attributes*, containing all those global parameters referring to the product as a whole;
- a *Dimensions* group, where *names* and *lengths* of the dimensions used when creating data arrays are here defined;
- a series of *Coordinate variables*, special variables to store the axis data values, for each dimension in the *Dimensions* group;
- a series of components (groups of variables), one for each LUT stored in the ADS. Each component is 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 LUT definition.

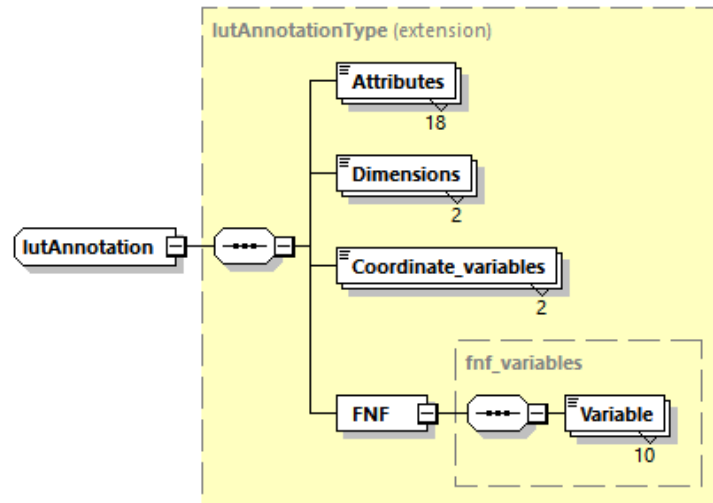


Fig.16 Look-Up Tables (LUT) ADS

Compression strategy

The NetCDF data arrays variable is composed by binary values, it is possible to introduce with benefit a strategy for data compression making use of native Python NetCDF4 capabilities [RD7], using the ZLIB (loss-less) compression algorithm, with a compression level from 0 to 9, where zero means no compression, set by configuration, more details in sec. 4.3.1.4.

4.3.2.1. Look-Up tables detailed content

The content of L2a LUT ADS is reported hereafter, where:

- the series of *Attributes* contain the same list of parameters described in Sec. 4.3.1.1 for the Product L2a DSR (for all the details about these parameters refer to this section);
- the *Dimensions* group is composed by Latitude and Longitude, as the data array variable is defined in the Latitude Longitude based on DGG projection;
- there is only one data array variable, which is the Forest/Non-Forest mask;
- this notation is applicable:
 - **this is the attribute or variable name**
 - this is the actual content of constant values over the mission
 - *this is a description of values content which depends on the processing*

LUT ADS Attributes:

mission: "BIOMASS"

tileID: [string] json encoded list of DGG geographical tile identifiers (NxxEyyy)

basinID: [string] json encoded list of DGG Basin identifiers

productType: FP_FH_L2A

startTime: [str: YYYY-MM-DD hh:mm:ss.ppp] Start time of the product image, UTC

stopTime: [str: YYYY-MM-DD hh:mm:ss.ppp] Stop time of the product image, UTC

radarCarrierFrequency: [float32] Radar carrier frequency [Hz]

missionPhaseID: [str: COM, TOM or INT] Mission phase identifier

sensorMode: "Measurement"

globalCoverageID: [uint16] Global coverage identifier

swath: [str: S1, S2 or S3] BIOMASS swath identifier

majorCycleID: [uint16] Major cycle identifier

absoluteOrbitNumber: [list of uint32] List of absolute orbit numbers at start time (one for each input L1c)

relativeOrbitNumber: [uint16] Relative orbit number (track) at start time

orbitPass: [str: Ascending or Descending] Orbit pass

dataTakeID: [string] json encoded list of data take identifiers (one for each input L1c)

frame: [uint16] Frame identifier

platform_heading: [float32] Platform heading relative to North, deg

forest_coverage_percentage: [float32] Forest coverage of the input STA products, compute as a percentage of all the pixels in the STA footprint

LUT ADS Dimensions / Coordinate variables:

Name: **Latitude**

size: [int] size

type: dtype(float32)

units: deg

description: FNF LUT latitude axis

Name: **Longitude**

size: *[int] size*

type: dtype(float32)

units: deg

description: FNF LUT longitude axis

LUT ADS group of variables:

Group Name: **FNF**

FNF group contents:

Name: **FNF**

dimensions: (Longitude, Latitude)

shape: *([int] x shape, [int] y shape)*

type: dtype(ubyte)

description: Forest/Non-Forest mask : this is an external image, defined outside of BPS from aggregated C3S LCM, representing the initial two-dimensional mask, here defined in the same latitude-longitude based on DGG projection used for L2a images and cropped to have a coverage containing the L2a product image boundaries. It defines, for each geographical pixel, the initial presence or absence of forest.

Name: **firstSample**

shape: (1, 1)

type: dtype(uint32)

description: Product image MDS sample the first LUT sample corresponds to

Name: **firstLine**

shape: (1, 1)

type: dtype(uint32)

description: Product image MDS line the first LUT line corresponds to

Name: **samplesInterval**

shape: (1, 1)

type: dtype(uint32)

description: Number of product image MDS samples one LUT sample corresponds to

Name: **linesInterval**

shape: (1, 1)

type: dtype(uint32)

description: Number of product image MDS lines one LUT line corresponds to

Name: **pixelType**

shape: (1, 1)

type: <class str>

description: Data type of output LUT pixels

Name: **noDataValue**

shape: (1, 1)

type: dtype(ubyte)

description: Pixel value in case of invalid data. The value is always set to 255. (See 3)

Name: **projection**

shape: (1, 1)

type: <class str>

description: LUT projection, DGG, as described in [RD8]

Name: **coordinateReferenceSystem**

shape: (1, 1)

type: <class str>

description: Coordinate reference systems, as per WKT representation [RD7]

Name: datum, **geodeticReferenceFrame**

shape: (1, 1)

type: <class str>

description: Geodetic reference frame

4.3.3.Quick-look ADS

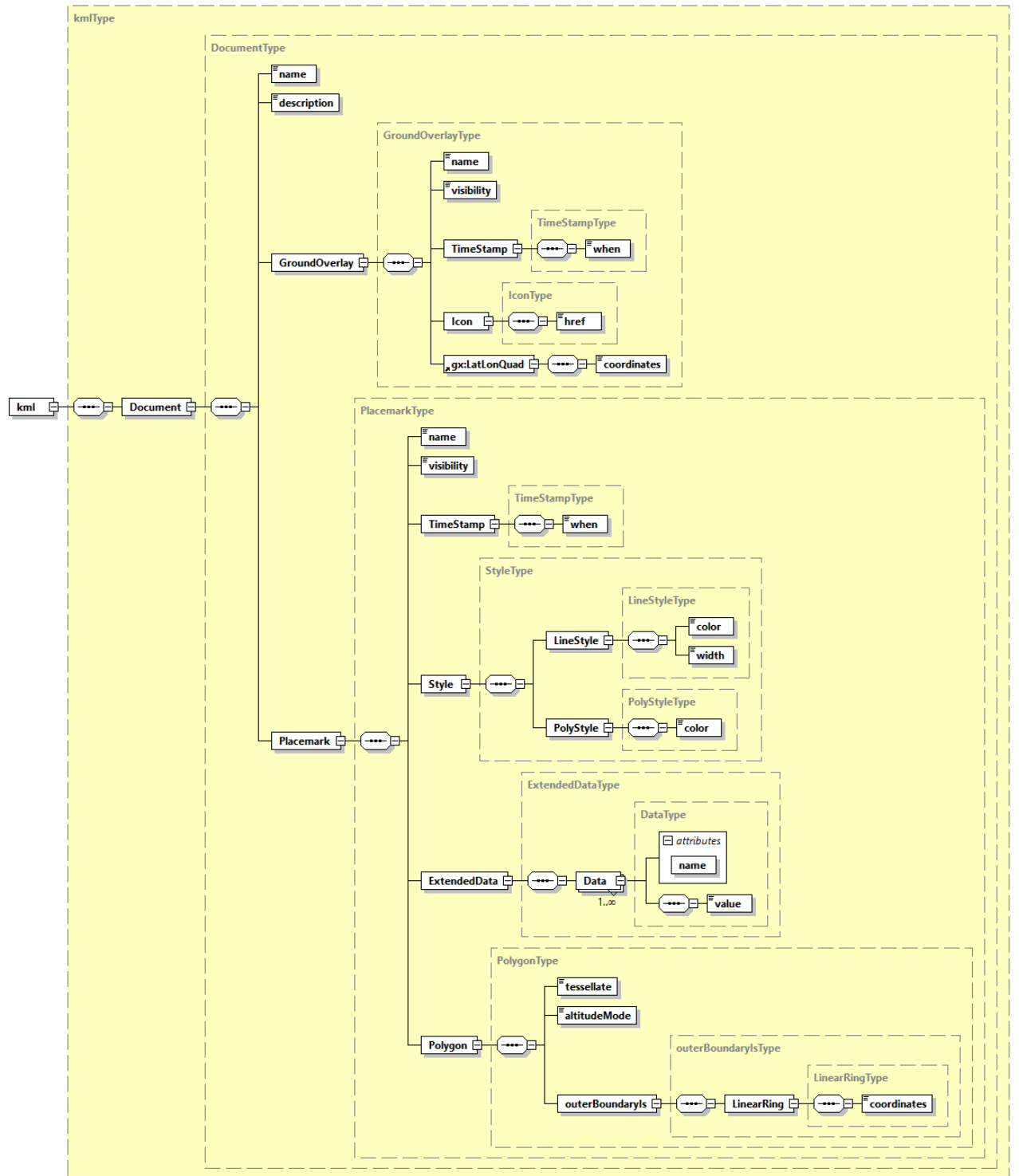
The Quick-look ADS is composed by lower resolution versions of the MDS Forest Height and quality layer images; they are stored in PNG file format and they are always included with any BIOMASS L2 product.

The quantities are composed by real values, so the images are generated without any other processing than averaging and decimation.

4.3.4.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.



Generated by XMLSpy

www.altova.com

Fig.17 Overlay ADS

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

Tab.23 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.24 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.25 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.26 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.27 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: <i>lon,lat lon,lat lon,lat lon,lat lon,lat</i> The coordinates must appear in the following order: <i>last line first pixel, last line last pixel, first line last pixel, first line first pixel, last line first pixel</i>	xsd:string	1

Tab.28 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.29 Overlay ADS (PlacemarkType)

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

Tab.30 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.31 Overlay ADS (LyneStyleType)

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

Tab.32 Overlay ADS (PolyStyleType)

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

Tab.33 Overlay ADS (ExtendedDataType)

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

Tab.34 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.35 Overlay ADS ()

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

Tab.36 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: <i>lon,lat,height lon,lat,height lon,lat,height lon,lat,height lon,lat,height</i> The coordinates must appear in the following order: <i>last line first pixel, last line last pixel, first line last pixel, first line first pixel, last line first pixel</i>	xsd:string	1

Tab.37 Overlay ADS (LinearRingType)

5. L2b Products Format Overview

The BIOMASS Forest Height L2b 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.

The kinds of datasets are the same of L2a products, i.e., the Measurement Data Sets (MDS), the Annotation Data Sets (ADS) and the Representation Data Sets (RDS); the only difference from L2a is the absence of a “Measurement folder” in order to keep the output structure simpler and the consequent presence of MDS images and additional annotations at root level, together with the main product header.

The declination and customisation of this format structure for BIOMASS Forest Height L2b product is summarised in the following table. A typical product contains:

- a main product header, an XML file including high-level information about the product origin, structure and main metadata;
- Forest Height image MDS, including the Forest Height binary raster and the quality layer, organised in separated Cloud Optimized GeoTIFF (COG) files;
- BPS_FNF image annotation: this is the mask applied; if the L2b FD product is provided as input, BPS_FNF is the CFM pre-computed contained in L2b FD product [AD8], otherwise it is the FNF from L2a annotation LUT. In a Cloud Optimized GeoTIFF (COG) file;
- Heat Map annotation, a map of floating point values which stores, pixel wise, the sum of weights used to compute each L2b pixel, in a Cloud Optimized GeoTIFF (COG) file;
- 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;
- STAC metadata ADS (see description in section 3)
- quick-look ADS, including an averaged and decimated previews of measurement MDS;
- Overlay ADS, for viewing the Quick-look ADS in any application that supports KML format (like, e.g., Google Earth or GIS applications);
- XML schemas RDS, including the schemas needed for all the XML files included in the product.

No need for Look-Up Tables (LUT) ADS in L2b products.

No Data Value

L2b Data Sets pixels will have a no data value of -9999.0 (float32) or 255 (ubyte) depending on data type, where the input L2a pixels are invalid and for each pixel discarded by the algorithm. The value is reported in all the MDS COG metadata (GDAL_NODATA tag, see Tab.2) and in the Raster Image DSR (noDataValue element, see 6.3.1.2).

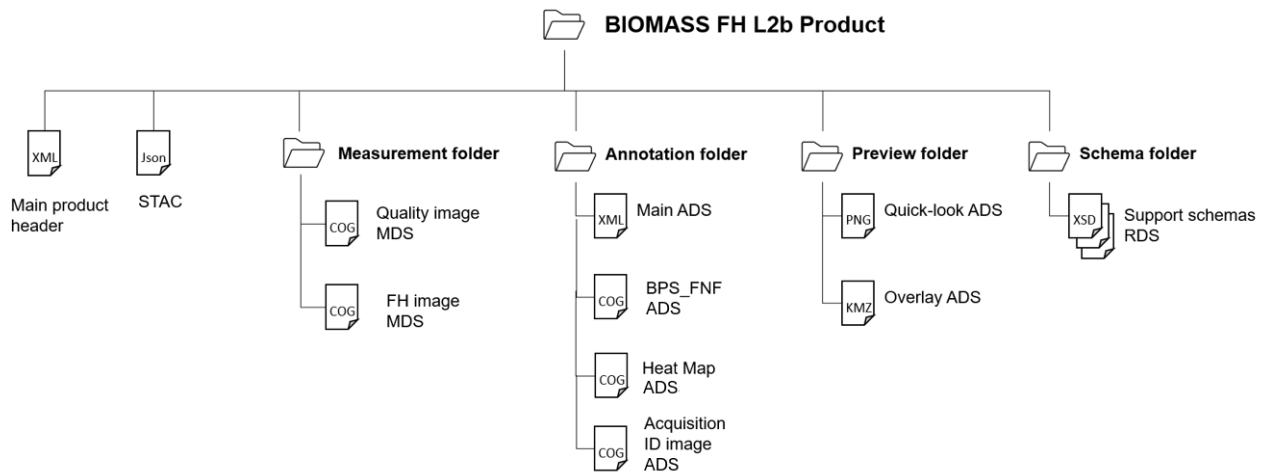


Fig.18 Forest Height L2b products structure

File / Folder	Cardinality	Format	Description / Content
BIOMASS Forest Height L2b Product		Folder	
└ main product header	1	XML	Main product header
└ STAC	1	JSON	STAC (https://stacspec.org) metadata.
└ measurement		Folder	
└ FH	1	COG	Forest Height image MDS
└ Quality	1	COG	Forest Height Quality image MDS
└ annotation		Folder	
└ main	1		Main ADS, including: – Product DSR – Raster Image DSR – Input information DSR – Processing parameters DSR

L BPS_FNF	1	COG	FNF or CFM mask
L Heat Map	1	COG	Pixel wise: sum of weights
L Acquisition ID Image	1	COG	Pixel wise binary indicator of contributing images
L preview		Folder	
L quicklook	4	PNG	Quick-look ADS, for: - FH (from measurement) - FH Quality (from measurement) - BPS_FNF (from annotations) - Heat Map (from annotations)
L overlay	4	KML	Overlay ADS, for each quicklook
L schema		Folder	
L main annotation.xsd	1	XSD	RDS
L L2a, L2b common annotation.xsd	1	XSD	RDS
L common types.xsd	1	XSD	RDS
L fh-proc-annotations.xsd	1	XSD	RDS

Tab.38 Forest Height L2b products structure

5.1. Product format definition guidelines

Refer to Sec. 3.1.

5.2. Naming convention

The BIOMASS L2b product and all data sets files naming are addressed and described in details in [AD2].

The naming of the products directories is here proposed following the main points in [AD2]:

<MMM>_<TTTTTTTTTT>_<P>_G<CC>_T<TTTTTTTT>_B<BBB>_<BB>_<DDDDDD>

where:

- <MMM>: Satellite ID;
- <TTTTTTTTTT>: Product Type/File Type, i.e.:
 - FP_FH__L2B: Forest Height L2b product;

- <P>: Mission phase identifier;
- <CC>: Global Coverage identifier;
- <TTTTTTT>: Tile number of the product, the seven digits are [N|S] aa [E|W] bbb, where:
 - N|S: stands for North or South;
 - aa: latitude in two digits padded with zeros (at 0° N or S are both valid);
 - E|W: stands for East or West;
 - bbb: longitude over 3 digits padded with zeros (at 0° E or W are both valid);
- <BBB>: Basin literal identifier of the product (string);
- <BB>: Baseline Identifier;
- <DDDDDD>: Compact creation date.

The internal files in the 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_[fh|fhquality].tiff for image MDS;
 - *_annot.xml for main ADS;
 - *_i_[acquisition_id_image|heatmap|bps_fnf].tiff for images in annotations;
 - *_[bps_fnf|fh|heatmap]_ql.png for quick-look ADS;
 - *_[bps_fnf|fh|heatmap]_map.kml for overlay ADS;
 - *.xsd for support schemas RDS.
 - *.json for STAC

For basins, the following notation is used:

- • *South America tropical: 100*
- • *South America temperate: 200*
- • *Africa tropical/temperate: 300*
- • *Asia temperate: 400*
- • *Asia tropical: 500*
- • *Oceania tropical/temperate: 600*
- • *Exclusion zone: 700*

6. L2b Products Format Specification

6.1. Main Product header

The Main Product Header (MPH) is an XML file present in all the BIOMASS L2 products. BIOMASS L2 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]. It is very similar to the one described in 4.1, without following fields, which are not present in L2b:

- eop:swathIdentifier Swath identifier
- eop:orbitDirection Orbit direction
- eop:wrsLongitudeGrid Track number
- eop:wrsLatitudeGrid Frame number
- sar:antennaLookDirection SAR antenna look direction

6.2. Measurement data sets (MDS)

The MDS of the L2b products is constituted by the same quantities of L2a, together with the BPS_FNF and Heat Map annotations:

- the biophysical measurement consisting of the Forest Height image binary raster layer, representing Top Canopy Height (TCH);
- a layer of quality indication, consisting of a percentage value for each of the Forest Height image pixel;
- BPS_FNF: this is the Forest mask which defines, for each geographical pixel, the presence or absence of forest and which is used to discard invalid forest regions during aggregation of L2a in L2b products.

If the L2b FD product is provided as input, this MDS is the CFM pre-computed contained in L2b FD product, otherwise it is the FNF from L2a annotation LUT.

- a Heat Map of floating point values (float32) which stores, pixel wise, the weight sum that has been used to compute each L2b pixel (this information is completed with the list of all L1c images used by the processor, see input information DSR 6.3.1.3).
- Acquisition ID Image: a multilayer image (COG format) where each contributing L2a input incidence map is stored (as a binary map); the number of layers is equal to the number of L2a inputs and their order is the same with respect to the L2a inputs (Tab.42).

For all L2b images, following considerations are the same.

All the L2b images are geocoded to specific BIOMASS tiling latitude-longitude geographic DGG, described in [RD9], ensuring a ground sampling always better than the resolution.

In particular we have that L2b images are aggregations of the L2a products insisting on the same location on ground (a single *tile* of the above DGG); a different number of L2a products may be available for the MDS geographic grid tile, based on tile dimensions and swath coverage.

The format used to store the L2b images is again the Cloud Optimized GeoTIFF (COG) [RD1].

Details about COG format and its usage to store images are already explained in Sec. 4.2 for L2a products and apply as well to L2b products;

Metadata

Metadata is the same of the L2a one, already described in Sec. 4.2 and Tab.2, the only difference is the absence of “Swath” metadata in L2b.

Overviews

Same considerations already explained in 4.2

6.3. Annotation data sets (ADS)

6.3.1. Main ADS

This section describes in details the content of main ADS for L2b products. Differences from L2b are in the description, where needed.

An overview is provided by the two figures below and by the table which describes all the elements, both for L2b.

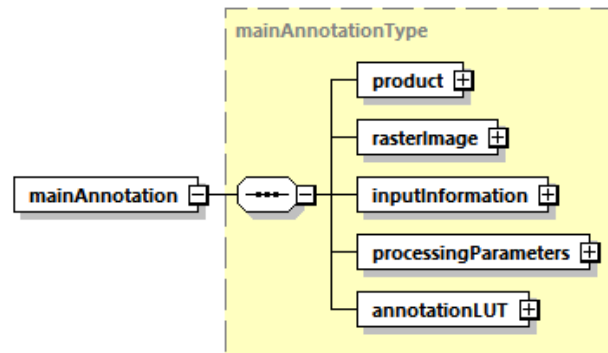


Fig.19 main L2b ADS

Name	Description	Data Type	Cardinality
product	Product L2b DSR. This DSR contains the L2b product information.	<u>productL2bType</u>	1
rasterImage	Raster image DSR. This DSR contains all the necessary information to exploit the L2b raster images.	<u>rasterImageType</u>	1
InputInformation	Input Information L2b DSR. This DSR contains the necessary information to identify the L2a products in input to L2b processor and also a list of all the L1c acquisitions used to generate those L2a products.	<u>InputInformationL2bL3ListType</u>	1
processingParameters	Processing parameters DSR. This DSR contains the description of L2b processing parameters.	<u>processingParametersL2bType</u>	1
annotationLUT	Annotation LUT DSR. This DSR contains the list of Look-Up Tables (LUTs) complementing product main annotations.	<u>layerListType</u>	1

Tab.39 Main L2b ADS

6.3.1.1. Product L2b DSR

This DSR contains the parameters to describe the L2b product.
An overview is provided by figures and table below.

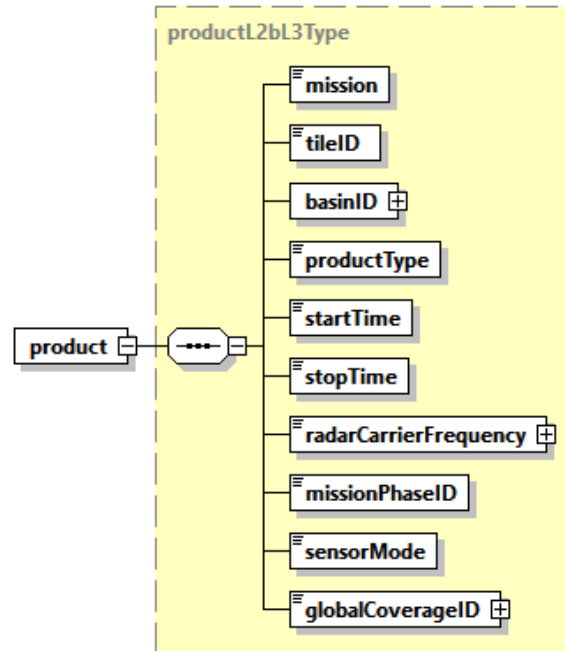


Fig.20 product L2b DSR

Name	Description	Data Type	Cardinality
mission	Mission (BIOMASS).	missionType	1
tileID	DGG geographic cell (tile) identifier (one element list).	xsd:string	1
basinID	List of DGG basin identifiers.	stringListType	1
productType	Product type (FH_L2B).	productType	1
startTime	Start time of the image [UTC].	timeType	1
stopTime	Stop time of the image [UTC].	timeType	1
radarCarrierFrequency	Radar carrier frequency [Hz].	doubleWithUnit	1
missionPhaseID	Mission phase identifier.	missionPhaseIDType	1
sensorMode	Sensor mode (always Measurement).	sensorModeType	1
globalCoverageID	Global coverage identifier.	xsd:unsignedShort	1

Tab.40 Product L2b DSR (productL2bType and productType)

6.3.1.2. Raster Image L2b DSR

This DSR contains all the necessary information to exploit the raster images of all the L2b MDS, it is already described in Fig.4, Tab.8, Tab.9, Tab.10, Tab.11 with the differences are:

- the projection which here is the specific “DGG” described in [RD9].
- The BPS_FNF and FH_heatMap are present, as described in in Tab.9

6.3.1.3. Input Information L2b DSR

This DSR contains, for each of the L2a Product in input to L2b processor:

- the folder name of L2a product;
- the L1c acquisitions used to generate that L2a product; it is an *InputInformationL2aType*, see description in 4.3.1.3 and Tab.12, Tab.13, Tab.18.

An overview is provided by figure below and in the table below for the *L2inputs*.

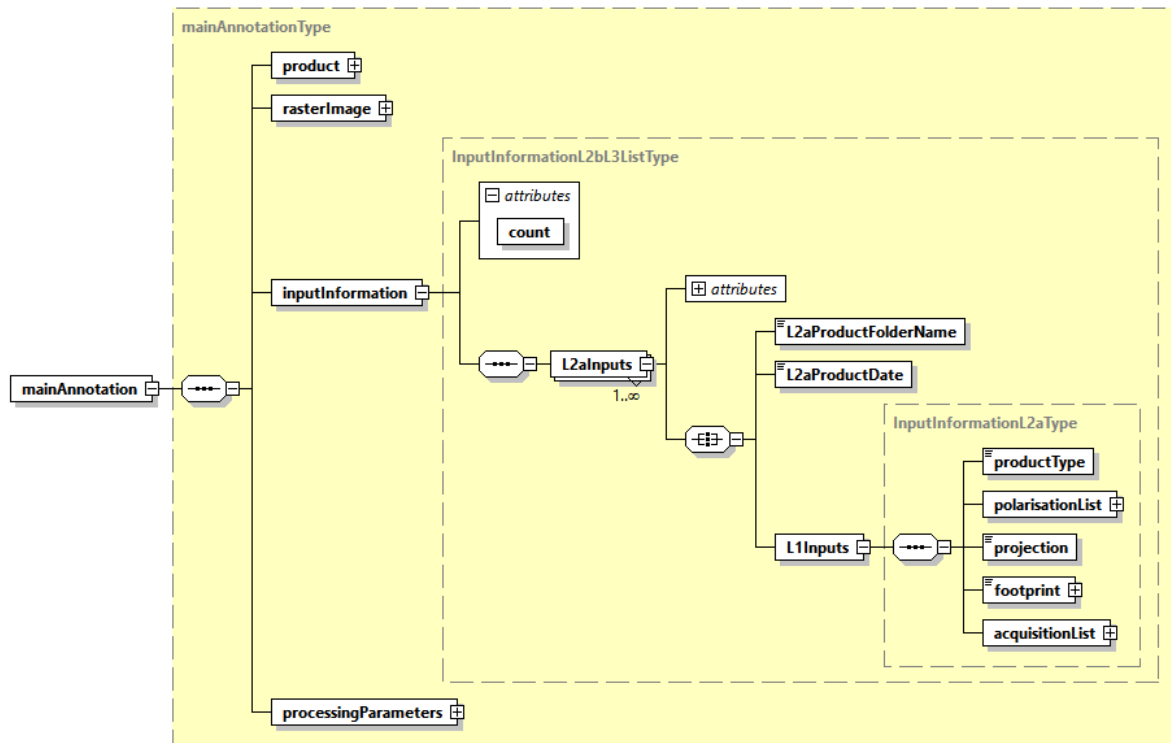


Fig.21 Input information L2b DSR (InputInformationL2bL3ListType)

Name	Description	Data Type	Cardinality
<i>count</i>	XML attribute.	<i>xsd:unsignedInt</i>	<i>required</i>
L2aInputs	One entry for each L2a product in input to L2b. Each entry contains two elements: L2aProductFolderName and L1inputs.	<u>L2aInputsType</u>	1..N

Tab.41 Input information L2b DSR (InputInformationL2bL3ListType)

Name	Description	Data Type	Cardinality
L2aProductFolderName	Folder name of each L2a product, as defined in sec. 3.2 (One string for each "L2aInputs" entry).	xsd:string	1
L2aProductDate	Product date for each L2a product	xsd:string	1
L1inputs	L1c acquisitions used to generate the L2a product. See 4.3.1.3 and Tab.12, Tab.13, Tab.18. (One element for each "L2aInputs" entry).	<u>InputInformationL2aType</u>	1

Tab.42 Input information L2b DSR (L2InputsType)

6.3.1.4. Processing parameters L2b DSR

This DSR contains the list of L2b processing parameters applied. An overview is provided by figures and table below.

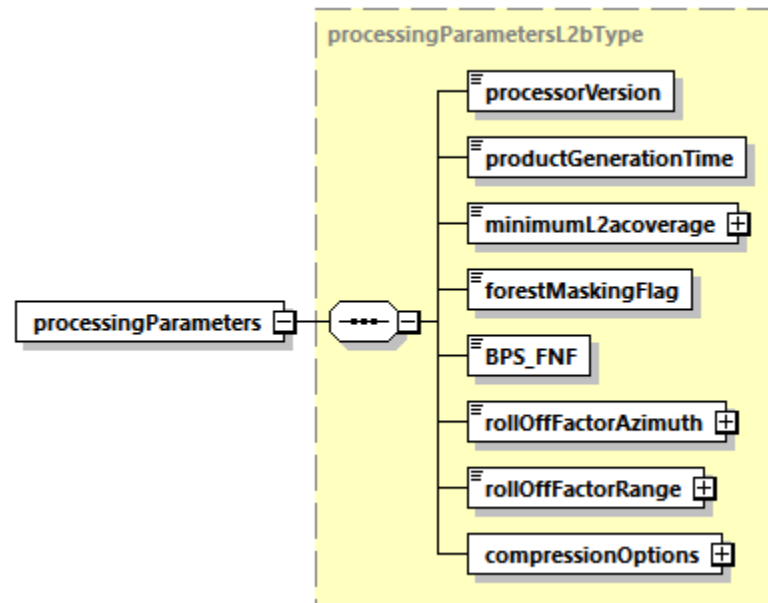


Fig.22 processing parameters L2b DSR (processingParametersL2bType)

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
BPS_FNF	Type of Forest Mask in the Biomass L2b product, it can be the CFM or FNF: CFM if L2b FD product is provided in input, FNF from L2a annotation LUT otherwise.	bps_fnfType	1
minimumL2aCoverage	The minimum percentage of tile coverage used to trigger the computation.	xsd:float	1
forestMaskingFlag	The minimum percentage of tile coverage used to trigger the computation.	bool	1
rollOffFactorAzimuth	True if forest/non-forest map masking has been performed during L2a products merging, false otherwise.	xsd:float	1

rollOffFactorRange	Feathering roll-off factor used.	xsd:float	1
compressionOptions	Configurable compression options for all the L2b MDS COG.	<u>compressionOptionsL2b Type</u>	1

Tab.43 Processing parameters L2b DSR (processingParametersL2bType)

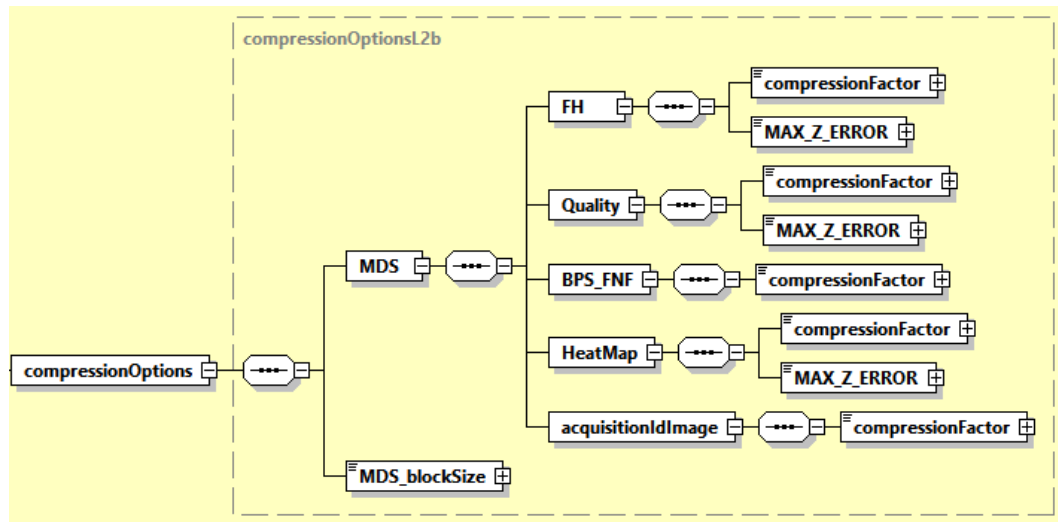


Fig.23 Processing parameters L2b DSR (compressionOptionsL2bType)

Name	Description	Data Type	Cardinality
MDS → FH → compressionFactor MDS → Quality → compressionFactor MDS → BPS_FNF → compressionFactor MDS → HeatMap → compressionFactor MDS → acquisitionIdImage → compressionFactor	ZSTD algorithm compression factor for the images MDS. From 0 to 9, where 0 means no compression.	xsd:unsignedByte	1
MDS → FH → MAX_Z_ERROR MDS → Quality → MAX_Z_ERROR MDS → Heat Map → MAX_Z_ERROR	For the FH, Quality and Heat Map images MDS, define exactly how lossy the LERC compression algorithm is allowed to be, specifying the absolute maximum error admitted.	xsd:float	1

	Zero means loss-less compression.		
MDS_blockSize	MDS COG blocking algorithm size. Same value is used for both data array dimensions.	xsd:unsignedByte	1

Tab.44 Processing parameters L2b DSR (compressionOptionsL2bType)

6.3.1.5. Annotation LUT DSR

This has no difference respect to the one already described in 4.3.1.5.

6.3.2. Quick-look ADS

The Quick-look ADS is composed by lower resolution versions of all the MDS images (Forest Height, quality layer, forest / non-forest mask, Heat Map).

The details about Quick-look ADS already explained in Sec. 4.3.3 for L2a products apply as well to L2b products.

6.3.3. 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).

The details about Quick-look ADS already explained in Sec.4.3.4 for L2a products apply as well to L2b products.

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
subsettingRuleType	Enumeration of available rules for INT subsetting: select three acquisitions from all the ones in input (when input is TOM phase).	xsd:string	geometry maintain all
calibrationScreenType	Type of calibration screen applied (none, if not applied)	xsd:string	none geometry skp
polarisationCombinationMethodType	Enumeration of polarisations combination methods.	xsd:string	HV VH Average None
bps_fnfType	Enumeration of Forest Mask: CFM from FD processor or FNF.	xsd:string	FNF CFM
verticalProfileOptionType	Vertical profile choice.	xsd:string	default profile
modelInversionType	Forest height inversion option	xsd:string	single dual
layerType	Enumeration of LUT layer contents.	xsd:string	FNF ACM Incidence angle [deg] numberOfAverages
missionType	Enumeration of valid BIOMASS mission names.	xsd:string	BIOMASS

swathType	Enumeration of all valid swath identifiers.	xsd:string	S1 S2 S3
productType	Enumeration of valid product types.	xsd:string	SCS DGM STA FH_L2A FH_L2B FD_L2A FD_L2B GN_L2A AGB_L2B
polarisationType	Enumeration of valid polarisations.	xsd:string	HH HV VH VV XX
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 INT TOM
sensorModeType	Enumeration of valid sensor mode abbreviations.	xsd:string	Measurement RX Only External Calibration
orbitPassType	Enumeration of the orbit pass direction values.	xsd:string	Ascending Descending
projectionType	Enumeration of the image projection.	xsd:string	Slant Range Ground Range Latitude longitude based on DGG DGG
pixelRepresentationType	Representation of the image pixels within the image MDS.	orbitPassType	I Q Abs Phase Abs Probability of change Computed forest mask Forest Disturbance Heat Map Forest Height [m] Forest height quality

			Forest mask Ground Cancelled Backscatter Above Ground Biomass [t/ha] Above Ground Biomass quality [t/ha] Acquisition Id Image
pixelTypeType	Enumeration of image pixel data types.	orbitPassType	32 bit Float 16 bit Signed Integer 16 bit Unsigned Integer 8 bit Unsigned Integer
coordinateReferenceSystemType	Coordinate reference systems, as per WKT representation [RD8].	xsd:string	
geodeticReferenceFrameType	Enumeration of geodetic reference frames.	xsd:string	WGS84 ITRF2000
uomType	Enumeration of unit of measures.	xsd:string	s UTC m samples lines deg rad Hz Hz/s dB Mbps C K rad/s mm/Km rad/m 1/m t/ha (rad/nT)^2
float	32 bit single precision floating point number.	xsd:float	units
double	64 bit double precision floating point number.	xsd:double	units
bool	Boolean (true or false).	xsd:boolean	(false) (true)

Tab.45 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
acquisitionType	String containing an acquisition folder name; The mandatory <i>referenceImage</i> attribute is a <i>bool</i> to indicate if the acquisition is the reference one. The optional <i>averageWavenumber</i> attribute is a float with the average value of the vertical wavenumber of the acquisition. Not used in FH.	xsd:string	referenceImage (mandatory, bool) averageWavenumber (optional, float)

Tab.46 Primitive product types with custom attributes

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

Tab.47 Common product types (datumType)

Name	Description	Data Type	Cardinality
min	Minimum value.	xsd:float	1
max	Maximum value.	xsd:float	1
num	Number of values.	xsd:unsignedShort	1

Tab.48 Common product types (minMaxNumType)

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.49 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.50 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.51 Common product types (doubleWithUnit)