BIOMASS Forest Disturbance Products Format Specification

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Change history

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		○ also replaced “uint8” with “ubyte” (all document)	
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30/04/2025	3.2.1	BPS-680: section 4.3.2, added units to LUT ACM phase variables and 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

Date	Issue	Change	Author
			Giorgi

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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 "Forest Disturbance Products Format Specification" for the BIOMASS Processing Suite (BPS) project.
This document is organized as follows:

- Section 2: Brief introduction about BPS and Forest Disturbance 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
ACM	Average Covariance Matrix
ADS	Annotation Data Set
AGB	Above Ground Biomass
ARESYS	Advanced Remote Sensing and Systems
ATBD	Algorithm Theoretical Basis Document
BPS	BIOMASS Processing Suite

Acronym	Description
CFM	Computed Forest Mask (by Forest Disturbance L2 processor)
COG	Cloud Optimized GeoTIFF
COM	Commissioning Phase
DEM	Digital Elevation Model
DGG	Discrete Global Grid
DSR	Data Set Record
FD	Forest Disturbance
FNF	Forest/Non-Forest Mask
GC	Global Cycle
INT	Interferometric Phase
L1c	Level-1c product
L2a	Level-2a product
L2b	Level-2b product
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
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] [L1PFD] 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 Disturbance 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 Disturbance product family is composed by:

- Level-2a (L2a): product composed by three stack-based images with different resolution and projection (latitude-longitude) with respect to the L1c source data:
  - one image representing the probability of change at a given Global cycle, obtained from L1c processing and auxiliary data;
  - one image representing the forest disturbance, a binary classification of intact/deforested areas, obtained from the probability of change;
  - the CFM (Computed Forest Mask) image which is an update, based on disturbance, of the FNF mask given as input, generated outside of BPS [AD6][AD7][AD8][AD9].

  The algorithms are envisaged to generate the product in INT phase with the optional possibility of having it also from TOM phase: in this case the FD product family will be empty but for the ADS ACM (see 4.3).
- Level-2b (L2b): product composed by the binary classification of intact/deforested areas (disturbance) and the probability of change images along with the CFM (see 6.2). All on map and tile based, derived from merging of L2a in a given Global cycle, on the tile.

The Forest Disturbance 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 FD processing is valid for INT phase only. *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 Disturbance 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 probability of change and forest disturbance images derived from processing of L1c data and CFM image derived from disturbance;
- 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 Disturbance 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);
- the MDS images, consisting of a raster with probability of change, one with the forest disturbance, and the CFM mask, stored in three Cloud Optimized GeoTIFF (COG) files;
- 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.9) and in all the LUT ADS images (noDataValue variable, see 4.3.2.1).

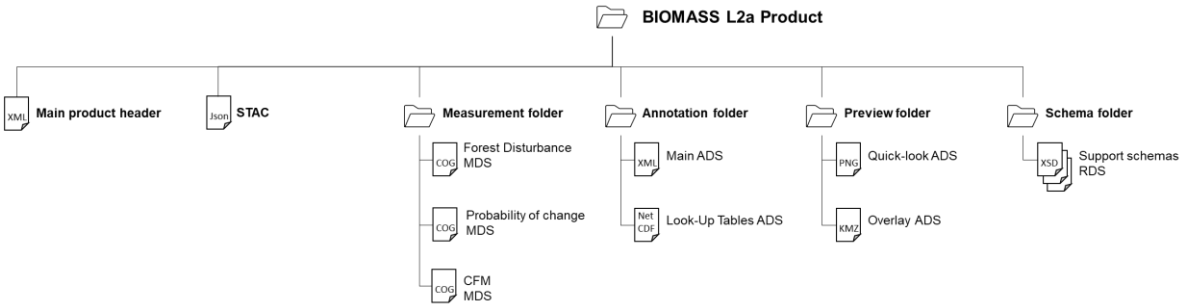

Fig.1 Forest Disturbance L2a products structure

File / Folder	Cardinality	Format	Description / Content
BIOMASS Forest Disturbance L2a Product		Folder	
∟ main product header	1	XML	Main product header
∟ STAC	1	JSON	STAC (https://stacspec.org) metadata.
∟ measurement		Folder	
∟ Forest Disturbance	1	COG	Forest Disturbance image MDS
∟ Probability of change	1	COG	Probability of forest change image MDS
∟ CFM	1	COG	Computed Forest Mask 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: – ACM matrix (all polarimetric layers) [AD8] – numberOfAverages matrix [AD8] – FNF, generated outside BPS
∟ preview		Folder	
∟ quicklook	3	PNG	Quick-look ADS, for each measurement
∟ overlay	3	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
∟ fd-proc-annotations.xsd	1	XSD	RDS

Tab.1 Forest Disturbance L2a products structure

3.1. Product format definition guidelines

The BIOMASS Forest Disturbance 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, LUTs have been introduced: stored in a single file, reducing annotation file dimensions and easing their 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_FD__L2A`: Forest Disturbance 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_[fd|probability|cfm].tiff` for image MDS;
  - `*_annot.xml` for main ADS;
  - `*_lut.nc` for Look-Up Tables ADS;
  - `*_[fd|probability|cfm]_ql.png` for quick-look ADS
  - `*_[fd|probability|cfm]_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*

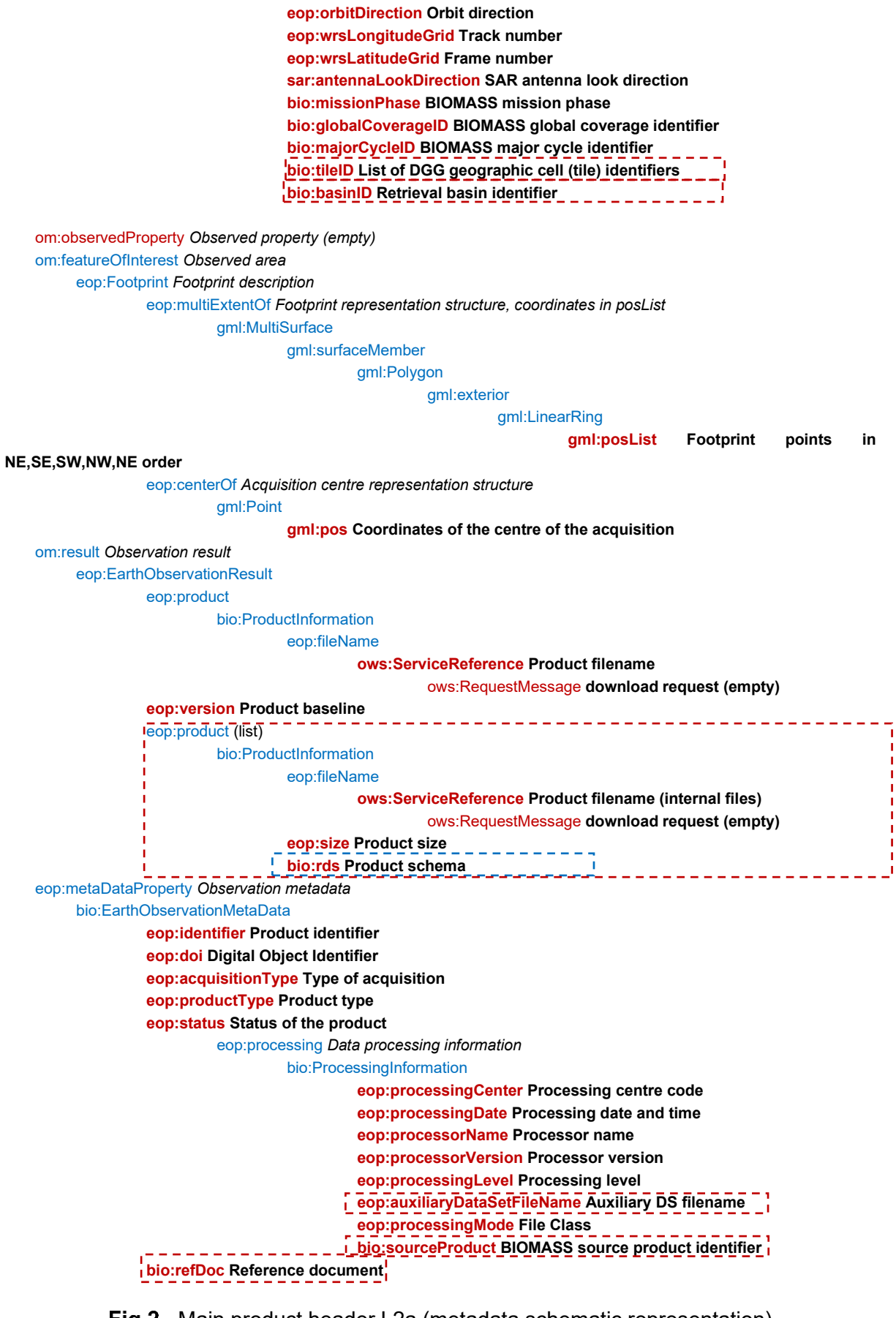

Fig.2 Main product header L2a (metadata schematic representation)

4.2. Measurement Data Sets (MDS)

The MDS of the L2a product is obtained by processing L1c images at the given Global cycle, along with the processing results from the previous Global cycle and it is composed by three images, each organised in separated Cloud Optimized GeoTIFF (COG) files [RD1]:

- the probability of change, being the quality layer, which identifies changes in areas at a given Global cycle; each pixel of the probability raster is a real value from 0 to 1, coded using a 4-byte float per pixel (float32);
- the forest disturbance is a binary classification of intact/deforested areas, coded using a 1-byte per pixel (ubyte);
- the CFM image is a mask computed from the CFM inside L2a product of previous Global Cycle and given as input, or from the FNF in input if it is first Global Cycle; basing on the forest disturbance MDS and coded using a 1-byte per pixel (ubyte).

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 input 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
MDS is composed by real and binary images: it is possible to introduce with benefit a strategy for data compression making use of native LibTIFF libraries capabilities [RD4]; depending on the data type, the strategy will be a GeoTIFF LERC+ZSTD compression for the real data and a ZSTD only (loss-less) for the binary one, in details:

- LERC compression algorithm, for the real data only, 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 compression algorithm, for both data types, with a configurable compression level from 0 to 9 (loss-less), where zero means no compression.

Both set by configuration: more details in sec. Tab.19.

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 or 8	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_FD__L2A: ” or “BIOMASS L2b FP_FD__L2B: ” and: “Probability of change” “Computed forest mask” “Forest Disturbance” “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) or 1 (unsigned integer 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	“-9999.0” 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 Not present in binary tiffs (FD and CFM)
Predictor	317	Variable	Integer of value “1” (PREDICTOR_NONE), meaning that no prediction scheme is used before coding. Present only in binary tiffs (FD and CFM)

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.

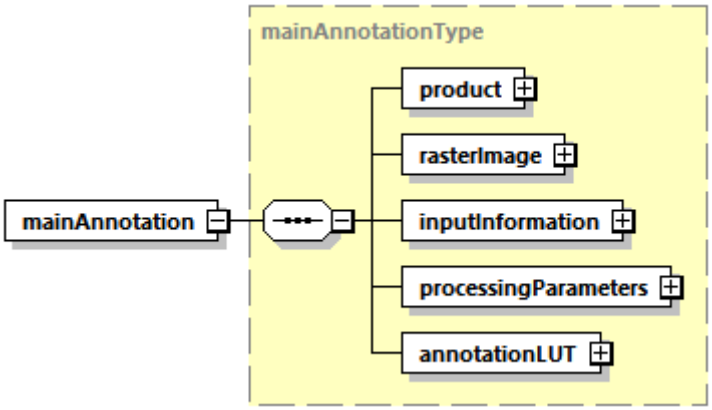

Fig.3 Main L2a ADS

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

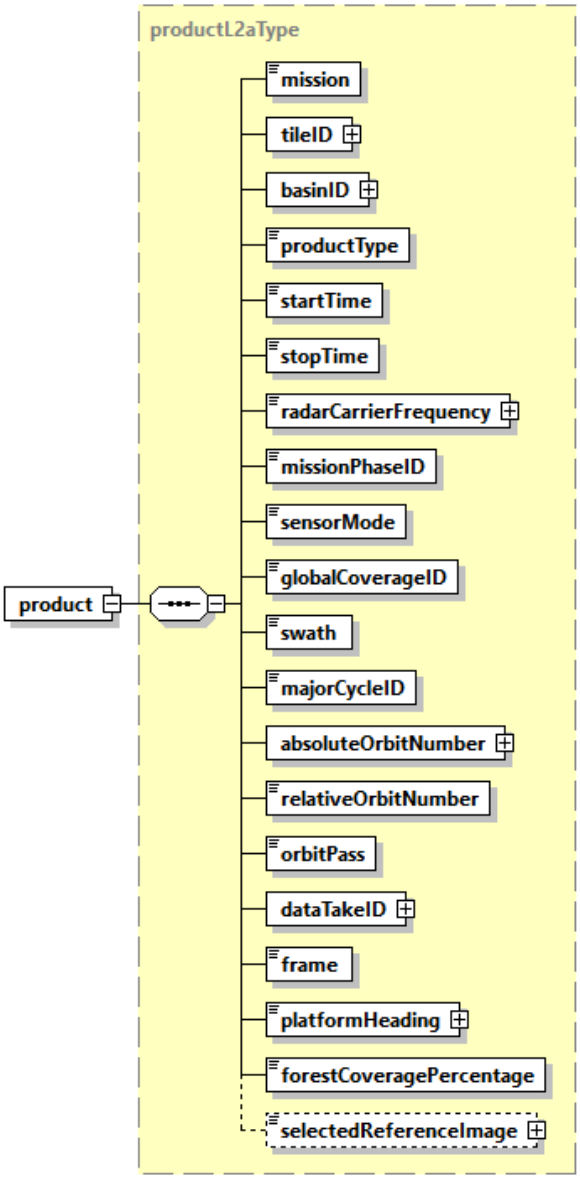

Fig.4 Product L2a DSR (productL2aType)

Name	Description	Data Type	Cardinality
mission	Mission (BIOMASS).	missionType	1
tileID	List of DGG geographic cell (tile)	stringListType	1

	identifiers.		
basinID	List of DGG Basin identifiers.	stringListType	1
productType	Product type (“FD_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).	integerListType	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).	integerListType	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
selectedReferenceImage	Index of the input STA acquisition selected as optimal reference image (guaranteeing the widest scene coverage),used during ground cancellation. Optional element, present only when ground cancellation is performed (FD, GN) and ***operationalMode*** configuration has been set to “***single reference***”.	selectedReferenceImageType	0,1

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

Name	Description	Data Type	Cardinality
acquisitionID	*Acquisition folder name, to better identify the input image referred by the integer value.*	*xsd:string*	*1*
selectedReferenceImage	Zero based Integer value of the selected reference image, based on the image reading order.	xsd:unsignedByte	1

Tab.8 selectedReferenceImageType

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.

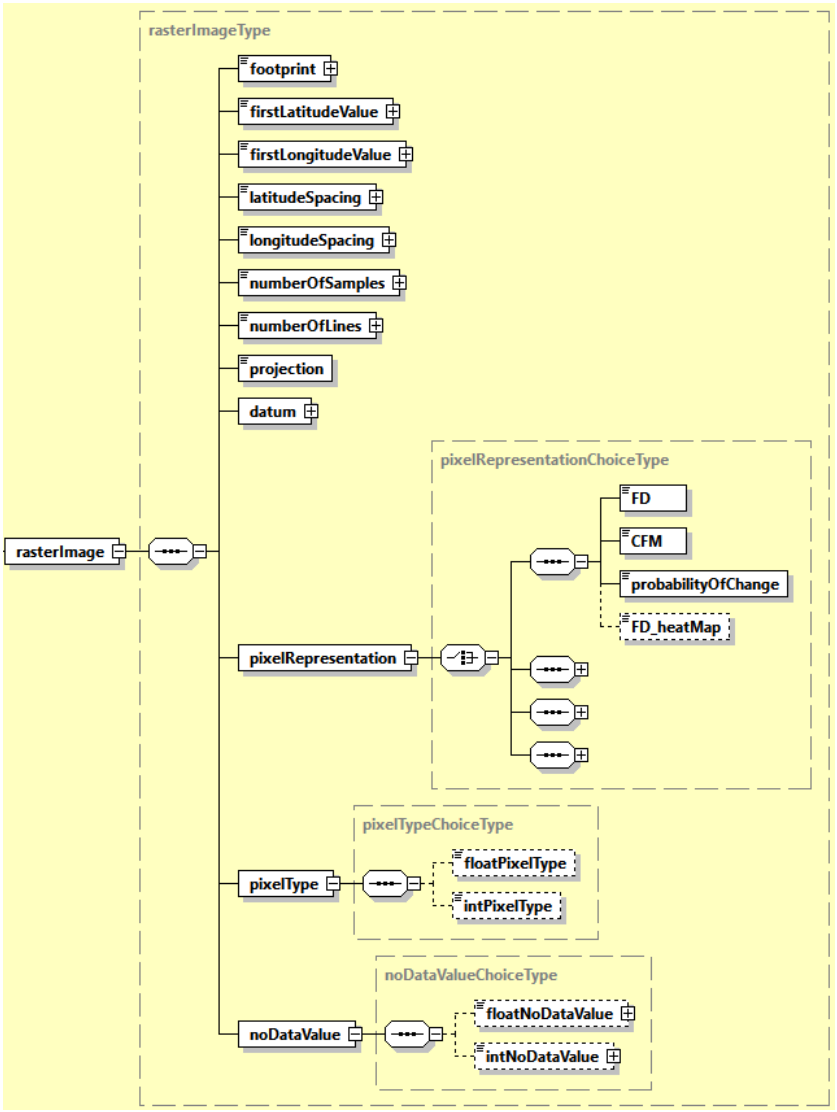

Fig.5 Raster image DSR (rasterImageType)

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.	pixelRepresentationChoiceType	1
pixelType	Data type of output pixels within the image MDS.	pixelTypeChoiceType	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.	noDataValueChoiceType	1

Tab.9 Raster image DSR (rasterImageType)

Name	Description	Data Type	Cardinality
FD	Representation of the image pixels within the image MDS: Forest Disturbance	pixelRepresentationType	1
CFM	Representation of the image pixels within the image MDS: Computed forest mask	pixelRepresentationType	1
probabilityOfChange	Representation of the image pixels within the image MDS: Probability of change	pixelRepresentationType	1
FD_heatMap	Representation of the image pixels within the image MDS: Heat Map (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.10 pixelRepresentationChoiceType (only L2a/L2b FD choice 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	pixelTypeType	1

Tab.11 pixelTypeChoiceType

Name	Description	Data Type	Cardinality
floatNoDataValue	Pixel value in case of invalid data. The value is always set to -9999.0	xsd:float	1
intNoDataValue	Pixel value in case of invalid data. The value is always set to 255	xsd:unsignedByte	1

Tab.12 noDataValueChoiceType

4.3.1.3. Input Information DSR

This DSR contains information about the L1c acquisitions in input to the L2a processor. An overview is provided by figures and tables below.

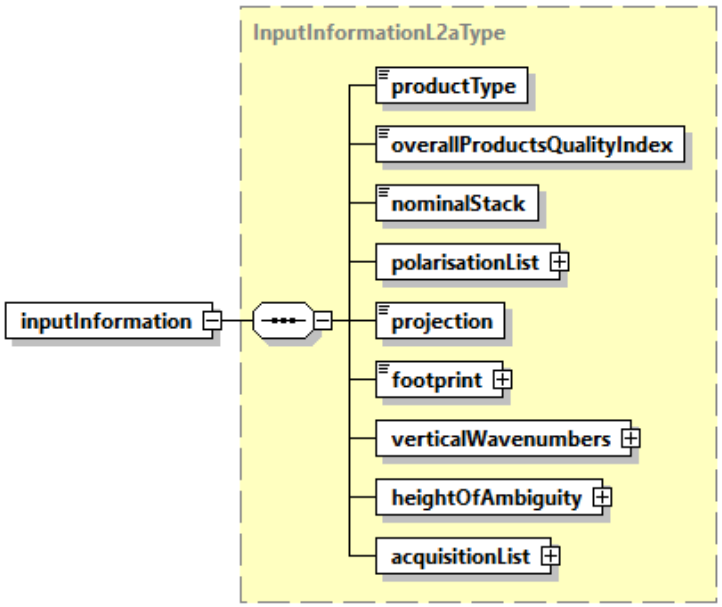

Fig.6 Input Information DSR (InputInformationL2aType)

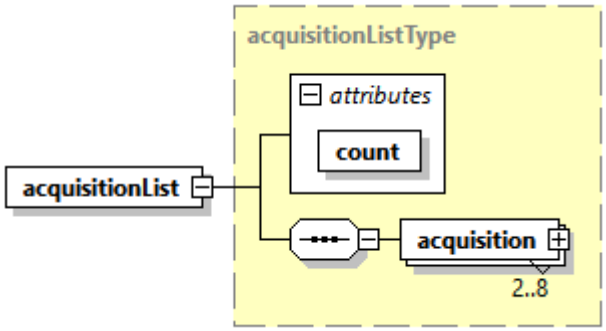

Fig.7 Input Information DSR, acquisition list detail (acquisitionListType)

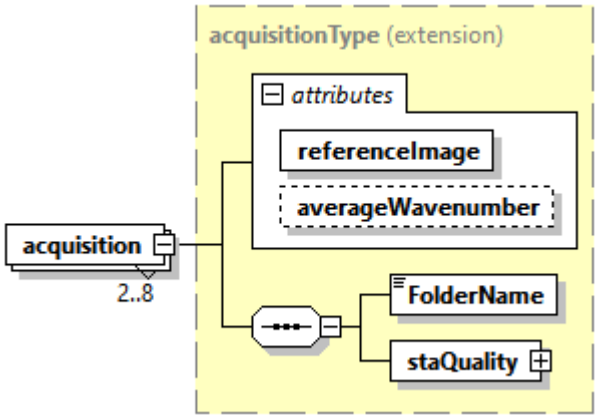

Fig.8 Input Information DSR, acquisition detail (acquisitionType)

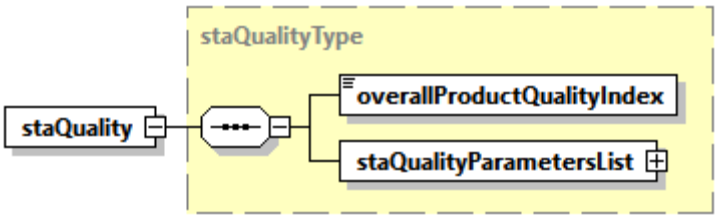

Fig.9 Input information DSR, staQualityType

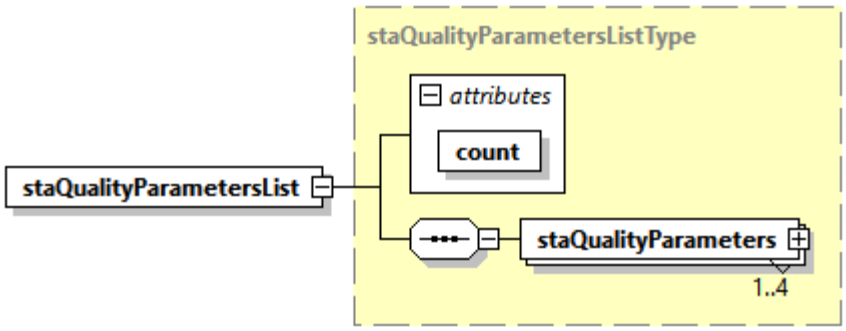

Fig.10 Input information DSR, staQualityParametersListType

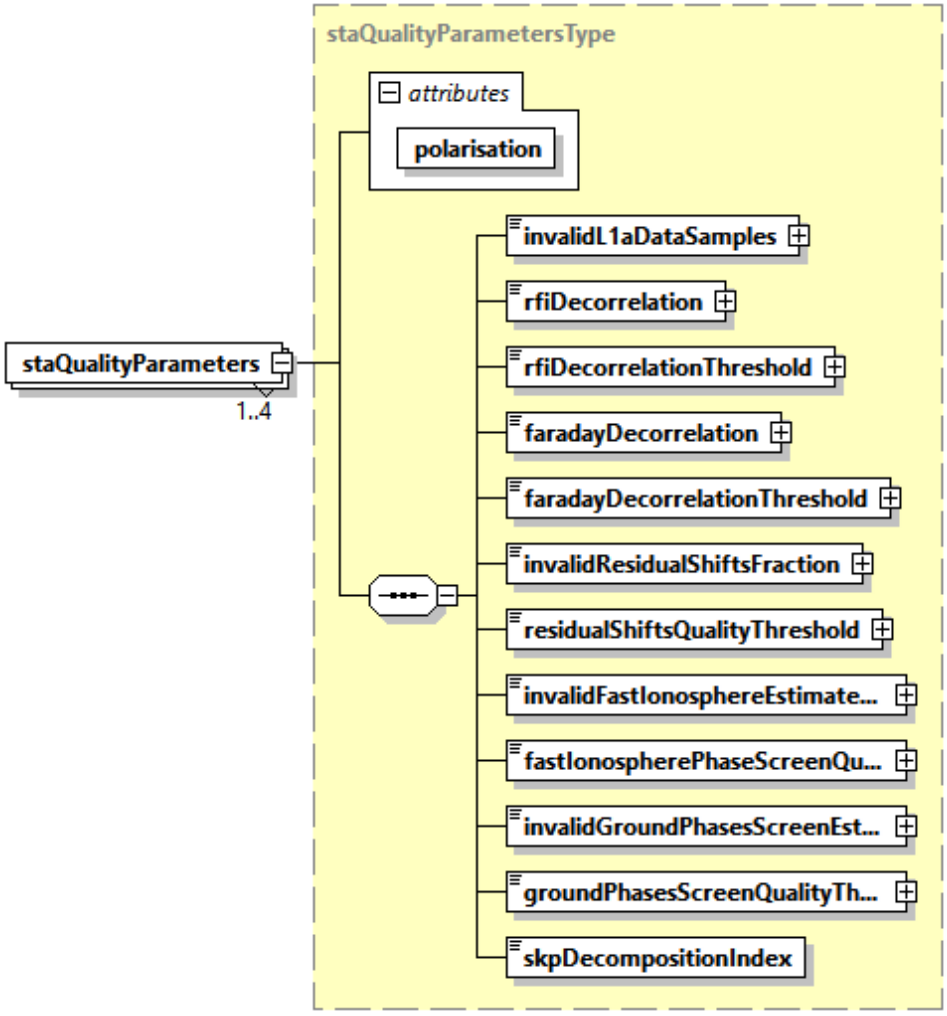

Fig.11 Input information DSR, staQualityParametersType

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.	polarisationListType	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
acquisitionList	Info about acquisition of the stack.	acquisitionType	1

Tab.13 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] (or a couple of images for the images pair selection for ground cancellation, 4.3.1.4)

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

Tab.14 Input information DSR (acquisitionListType)

Name	Description	Data Type	Cardinality
referenceImage	*Flag to indicate if this is the reference image or not.*	*bool*	*1*
averageWavenumber	*Average Wavenumber*	*float*	*1*
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]	staQualityType	1

Tab.15 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.	staQualityParametersListType	1

Tab.16 Input information DSR (staQualityType)

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

Tab.17 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
invalidFastIonosphereEstima	Number of invalid residual ionospheric scintillation phase screen estimates,	xsd:float	1

tesFraction	expressed as a normalized fraction of the total number of residual ionospheric scintillation phase screen estimates. The value is between 0 and 1.		
fastIonospherePhaseScreenQualityThreshold	Threshold on residual ionospheric scintillation 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 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 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 decomposition failure etc.) and the exported SKP-related LUTs contain values obtained from a contingency handling procedure. 0 otherwise.	xsd:unsignedInt	1

Tab.18 STA quality DSR (staQualityParametersType)

Name	Description	Data Type	Cardinality
count		*xsd:unsignedInt*	*required*
polarisation	Polarisation (HH, VH, VV).	polarisationType	3

Tab.19 Input information DSR (polarisationListType)

4.3.1.4. Processing parameters L2a DSR

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

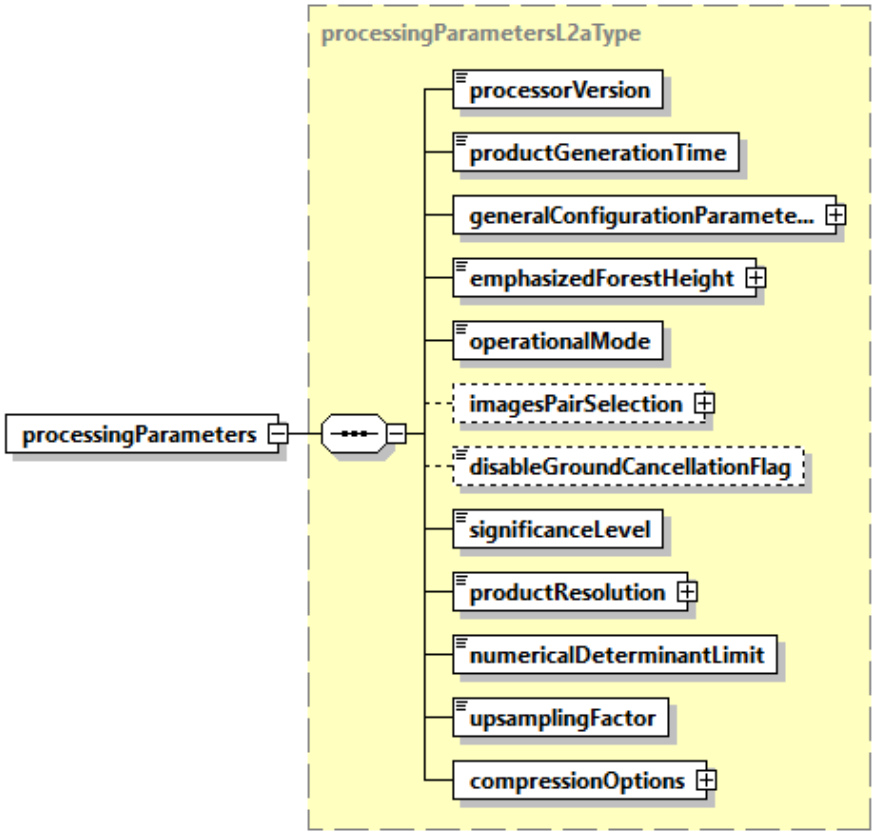

Fig.12 Processing parameters L2a DSR (processingparametersL2aType)

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	generalConfigurationParametersType	1

	Forest Disturbance processing).		
emphasizedForestHeight	Value of the height [m] which has been emphasized during ground cancellation [AD8].	floatWithUnit	1
operationalMode	Ground Cancellation method used between the followings. "single reference": direct computation with a preliminary automatic reference image selection. *or* "insar pair": debug operational mode, perform computation with only the two images specified in the optional element *imagesPairSelection.* Note: in case of only two images available, the operationalMode is automatically set to "insar pair" (without the need of *imagesPairSelection* element).	operationalModeType	1
imagesPairSelection	Optional: if	acquisitionListType	0..1

	operationalMode is “insar pair” and if this element is present, this means that ground cancellation has being performed using only the two images specified here.		
disableGroundCancellationFlag	False, if the ground cancellation has been performed. True, if ground cancellation has been disabled. Optional, default is False.	bool	0..1
significanceLevel	Significance level, expressed as a percentage, applied in the change detection algorithm [AD8].	xsd:float	1
productResolution	Value in [m] used as the resolution on ground grange map and also to perform the covariance averaging in radar coordinates.	floatWithUnit	1
numericalDeterminantLimit	Lower threshold to avoid numerical errors when computing pol covariance matrices determinants. Positive float	xsd:float	1

	number,		
compressionOptions	Configurable compression options for all the L2a MDS COG and ADS NetCDF LUT variables (see 4.3.2 for LUT "ZLIB" compression details).	compressionOptionsL2aType	1
upsamplingFactor	Upsampling factor used during covariance computation.	xsd:unsignedByte	1

Tab.20 Processing parameters L2a DSR (processingparametersL2aType

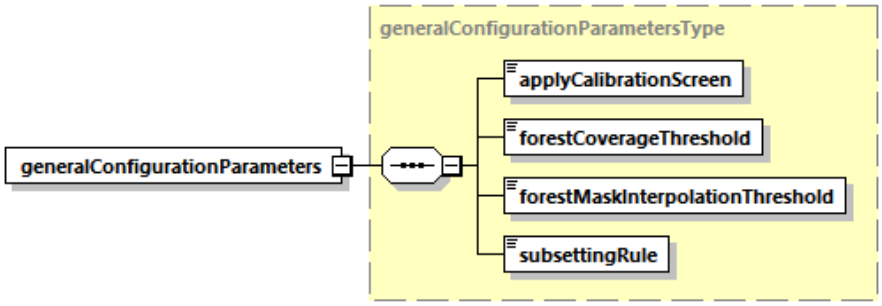

Fig.13 Processing parameters L2a DSR (generalConfigurationParametersType)

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 FD L2a processor).	subsettingRuleType	1

Tab.21 Processing parameters L2a DSR (generalConfigurationParametersType)

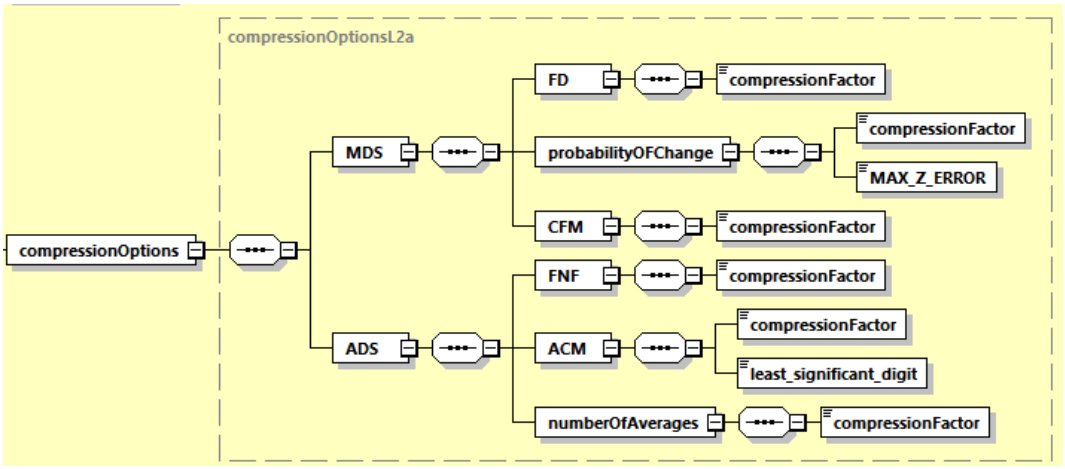

Fig.14 Processing parameters L2a DSR (compressionOptionsL2aType)

Name	Description	Data Type	Cardinality
MDS → probabilityOfChange → compressionFactor	LERC_ZSTD algorithm compression factor for the probability of change image MDS. From 0 to 9, where zero means no compression.	xsd:unsignedByte	1
MDS → probabilityOfChange → MAX_Z_ERROR	For the probability of change image MDS, define exactly how lossy the LERC compression algorithm is allowed to be, specifying the absolute maximum error admitted. Zero means loss-less	xsd:float	1

	compression.		
MDS → FD → compressionFactor and MDS → CFM → compressionFactor	ZSTD algorithm compression factor for the FD and CFM binary images MDS. From 0 to 9, where zero means no compression.	xsd:unsignedByte	1
ADS →FNF → compressionFactor and ADS →numberOfAverages → compressionFactor	ZLIB algorithm compression factor for the FNF and numberOfAverages ADS. From 0 to 9, where zero means no compression.	xsd:unsignedByte	1
ADS → ACM → compressionFactor	ZLIB algorithm compression factor valid for all the ACM ADS LUT layers. From 0 to 9, where zero means no compression.	xsd:unsignedByte	1
ADS → ACM → least_significant_digit	For all the layers of ACM LUT ADS, define exactly how lossy the ZLIB compression algorithm is allowed to be, specifying the power of ten of the smallest decimal place in the data that is a reliable value. See 4.3.2.	xsd:unsignedByte	1

Tab.22 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.

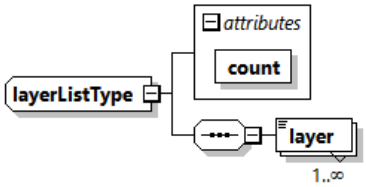

Fig.15 Annotation LUT DSR (layerListType)

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

Tab.23 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.

Complex images disk storage details
Differently from other SAR missions (and from the standard way of storing SAR data), for the BIOMASS mission, complex data are stored separating amplitude and phase values of each pixel instead of its real and imaginary parts. In particular for FD, the ACM ADS is a matrix of 6 images of which three real and three complex, so in total there will be 9 layers, because the three complex images will be separated each in two different NetCDF layers:

- one layer with the amplitude values of each pixel;
- one layer with the phase values (radians) of each pixel.

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.

The LUT ADS provides:

- external Forest/Non-Forest mask (generated outside of BPS [AD6][AD7][AD8][AD9]).
- ACM, averaging of the computed covariance from input L1c data stack at the given Global cycle with the previous cycle ACM from L2a given in input, with a total of 9 layers needed to store the three real images and the three complex images which are separated in amplitude and phase layers.
- Number of averages, the number of ACM covariances averaged so far at given Global cycle, pixel wise.

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.

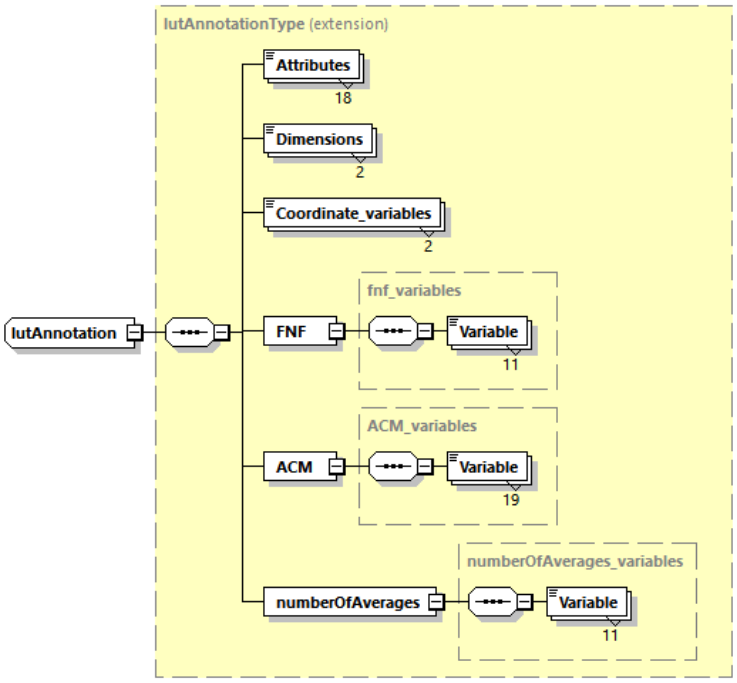

Fig.16 Look-Up Tables (LUT) ADS

Compression strategy

ACM LUT ADS data variable is composed by real float values, FNF is binary integer and numberOfAverages is integer. Depending on data type it is possible to introduce with benefit the following strategy for data compression making use of native Python NetCDF4 capabilities [RD7], using the ZLIB compression algorithm and featuring:

- for binary data (FNF) and integer data (numberOfAverages) a compression level from 0 to 9 (loss-less), where zero means no compression;
- for real float data variable (ACM) a compression level from 0 to 9 and an additional option "*least_significant_digit*" to decide how lossy the compression will be.

All set by configuration, more details in sec. Tab.19.

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 variables are defined in the Latitude Longitude based on DGG projection;
- there are three components, FNF, ACM and numberOfAverages matrices
- 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 geographic tile identifiers (NxxEyyy))*

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

productType: "FP_FD__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*

selected_reference_image *Optional [uint16] Index of the input STA acquisition selected as optimal reference image (guaranteeing the widest scene coverage), used during ground cancellation. Optional element, present only when ground cancellation is performed (FD, GN) and operationalMode configuration has been set to "single reference"*

acquisition_id_reference_image *Optional [str] Acquisition folder name, to better identify the input image referred by the selectedReferenceImage*

LUT ADS Dimensions / Coordinate variables:

Name: **Latitude**

size: *[int] size*

type: dtype(float32)

units: deg

description: LUTs latitude axis

Name: **Longitude**

size*: [int] size*

type: dtype(float32)

units: deg

description: LUTs 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, is the latitude-longitude based on DGG

Name: **coordinateReferenceSystem**

shape: (1, 1)

type: <class str>

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

Name: **geodeticReferenceFrame**

shape: (1, 1)

type: <class str>

description: Geodetic reference frame

Group Name: **ACM**

group description: ACM represents the covariance history of all previous cycles (see also *numberOfAverages* variable): it is obtained by averaging the covariance computed with FD algorithm at the given Global cycle with the previous ACM in input to the processor [AD8]. At first Global cycle it is the current covariance. It consists of six images of which three real and three complex, stored in nine NetCDF layers as three layers for the three real images and three complex images, each split in the amplitude value layer and the phase value (radians) layer.

ACM group contents:

Name: **layer1**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 1: ACM image 1 of 6, real, HH-HH

Name: **layer2**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 2: ACM image 2 of 6, amplitude value of complex image, HH-XP

Name: **layer3**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 3: ACM image 2 of 6, phase value of complex image [rad], HH-XP

units: rad

Name: **layer4**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 4: ACM image 3 of 6, amplitude value of complex image, HH-VV

Name: **layer5**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 5: ACM image 3 of 6, phase value of complex image [rad], HH-VV

units: rad

Name: **layer6**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 6: ACM image 4 of 6, real, XP-XP

Name: **layer7**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 7: ACM image 5 of 6, amplitude value of complex image, XP-VV

Name: **layer8**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 8: ACM image 5 of 6, phase value of complex image [rad], XP-VV

units: rad

Name: **layer9**

dimensions: (Longitude, Latitude)

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

type: dtype(float32)

description: layer 9: ACM image 6 of 6, real, VV-VV

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(float32)

description: Pixel value in case of invalid data. The value is always set to -9999.0. (See 3)

Name: **projection**

shape: (1, 1)

type: <class str>

description: LUT projection, is the latitude-longitude based on DGG

Name: **coordinateReferenceSystem**

shape: (1, 1)

type: <class str>

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

Name: **geodeticReferenceFrame**

shape: (1, 1)

type: <class str>

description: Geodetic reference frame

Name: **least_significant_digit**

shape: (1, 1)

type: unsignedByte

description: Power of ten of the smallest decimal place in the data that is a reliable value, adopted to the data during ZLIB compression.

Group Name: **numberOfAverages**

numberOfAverages group contents:

Name: **numberOfAverages**

dimensions: (Longitude, Latitude)

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

type: dtype(ubyte)

description: It represents, for the ACM, the number of covariances averaged so far at given Global cycle, pixel wise (see also *ACM* variable and [AD8]). At first Global cycle it is zero for each pixel.

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 float 255. (See 3)

Name: **projection**

shape: (1, 1)

type: <class str>

description: LUT projection, is the latitude-longitude based on DGG

Name: **coordinateReferenceSystem**

shape: (1, 1)

type: <class str>

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

Name: **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 all the MDS 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.

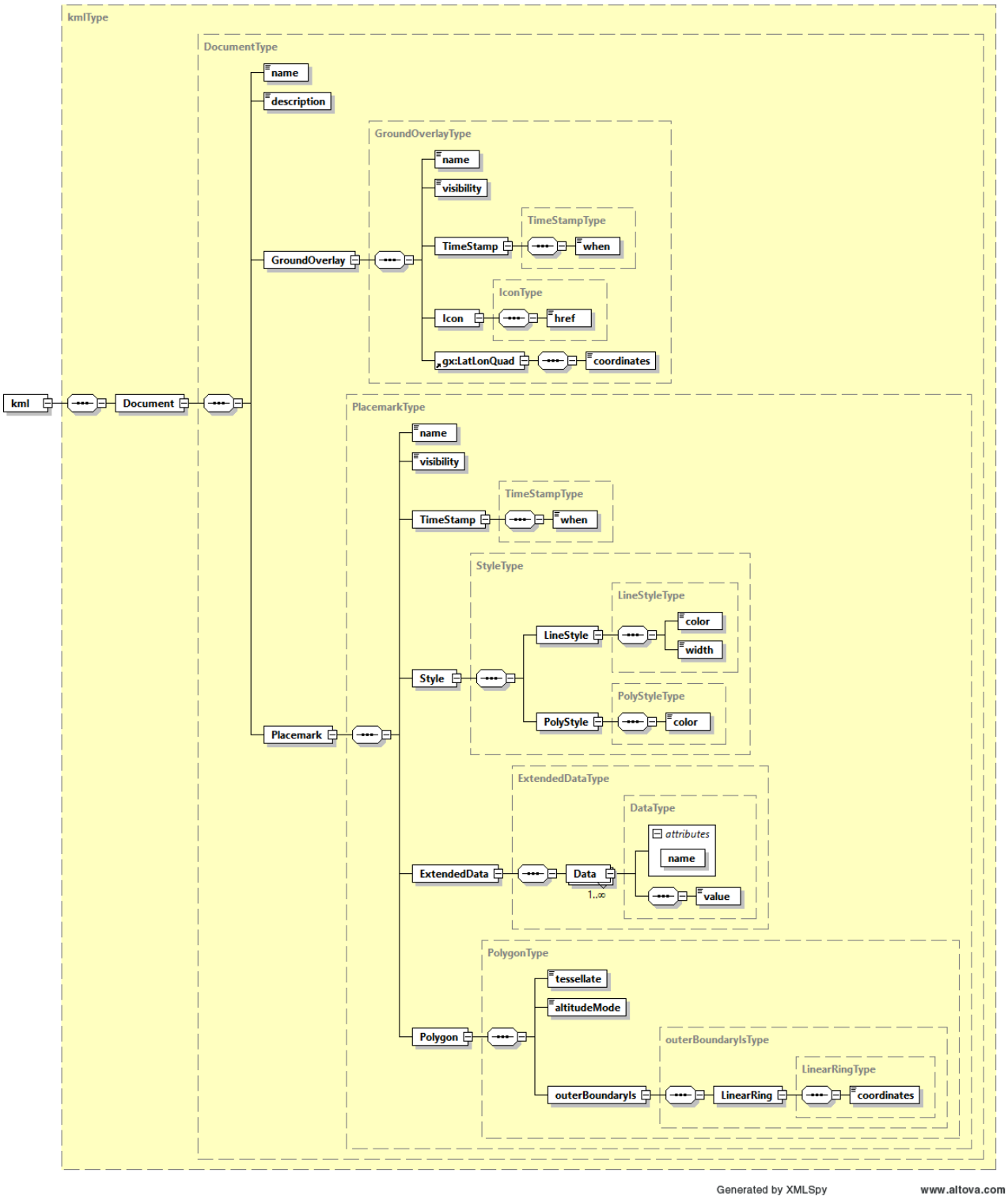

Fig.17 Overlay ADS

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

Tab.24 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.25 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.26 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.27 Overlay ADS (TimeStampType)

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

	on the map.		

Tab.28 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.29 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.30 Overlay ADS (PlacemarkType)

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

Tab.31 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.32 Overlay ADS (LyneStyleType)

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

Tab.33 Overlay ADS (PolyStyleType)

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

Tab.34 Overlay ADS (ExtendedDataType)

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

Tab.35 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.36 Overlay ADS ()

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

Tab.37 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.38 Overlay ADS (LinearRingType)

5. L2b Products Format Overview

The BIOMASS Forest Disturbance 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 Disturbance L2b product is summarised in the following table. A typical product contains:

- a main product header (MPH), an XML file including high-level information about the product origin, structure and main metadata;
- the main images MDS, including the Forest Disturbance binary raster data, the computed CFM mask and the probability of change, all aggregated in L2b tiles and organised in three Cloud Optimized GeoTIFF (COG) files;
- the aggregated Heat Map annotation, two maps of integers which store, pixel wise, how many L1c images contribute to the L2b pixel (first layer) and how many L1c images contribute to the decision, 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).

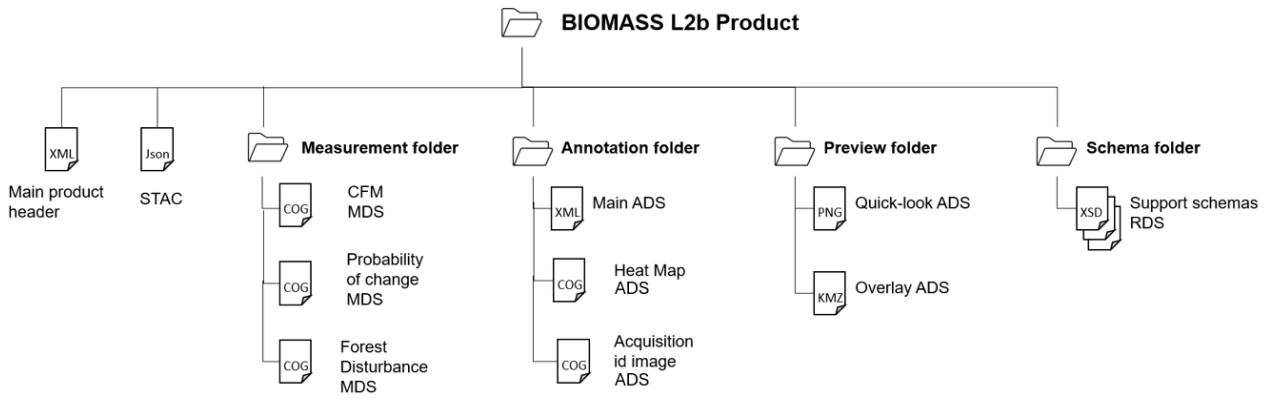

Fig.18 Forest Disturbance L2b products structure

File / Folder	Cardinality	Format	Description / Content
BIOMASS Forest Disturbance L2b Product		Folder	
∟ main product header	1	XML	Main product header
∟ STAC	1	JSON	STAC (https://stacspec.org) metadata.
∟ measurement		Folder	
∟ Forest Disturbance	1	COG	Forest Disturbance image MDS
∟ Probability of change	1	COG	Probability of forest change MDS
∟ CFM	1	COG	Computed Forest Mask MDS
∟ annotation		Folder	
∟ main	1	|	Main ADS, including: – Product DSR – Raster Image DSR – Input information DSR – Processing parameters DSR
∟ Heat Map	2	COG	Pixel wise agreeing and contributing L1c counters
∟ acquisition id image	1	COG	Pixel wise binary indicator of contributing images
∟ preview		Folder	
∟ quicklook	3	PNG	Quick-look ADS for: • Forest Disturbance (from measurement)

			• Probability Of Change (from measurement) • CFM (from measurement) • Heat Map agreeing (from annotations) • Heat Map contributing (from annotations)
∟ overlay	3	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
∟ fd-proc-annotations.xsd	1	XSD	RDS

Tab.39 Forest Disturbance 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< TTTTTTT>_B<BBB>_<BB>_<DDDDDD>`

where:

- `<MMM>`: Satellite ID;
- `<TTTTTTTTTT>`: Product Type/File Type, i.e.:
  - `FP_FD__L2B`: Forest Disturbance 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 0º N or S are both valid);
  - `E|W`: stands for East or West;
  - `bbb`: longitude over 3 digits padded with zeros (at 0º 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_[fd|probability|cfm].tiff` for image MDS;
  - `*_annot.xml` for main ADS;
  - `*_i_[acquisition_id_image|heatmap].tiff` for images in annotations;
  - `*_[fd|probability|cfm|hmagreeing|hmcontrib]_ql.png` for quick-look ADS;

- `*_[fd|probability|cfm|hmagreeing|hmcontrib]_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 Heat Map annotation:

- Forest Disturbance is the main MDS consisting on the binary classification image, showing where forest changes occurred at the given Global cycle;
- probability of change, which is the quality layer MDS;
- CFM image, the mask accounting for the cumulative disturbance updates;
- Heat Map of integer numbers (ubyte) which stores, pixel wise, two maps, with the number of L1c images contributing to the L2b pixel (first layer) and the number of L1c images contributing to the final decision. (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.43).

For all the 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 product 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.

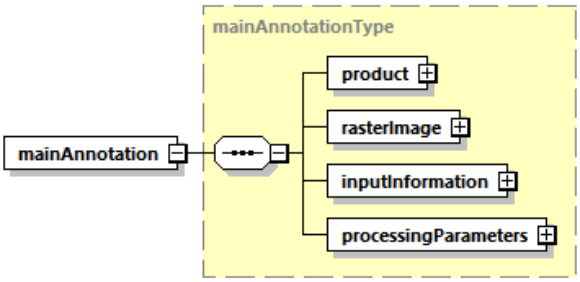

Fig.19 main L2b ADS

Name	Description	Data Type	Cardinality
product	Product L2b DSR. This DSR contains the L2b product information.	productL2bType	1
rasterImage	Raster image DSR. This DSR contains all the necessary information to exploit the L2b raster images.	rasterImageType	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.	InputInformationL2bL3ListType	1
processingParameters	Processing parameters DSR. This DSR contains the description of L2b processing parameters.	processingParametersL2bType	1

Tab.40 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.

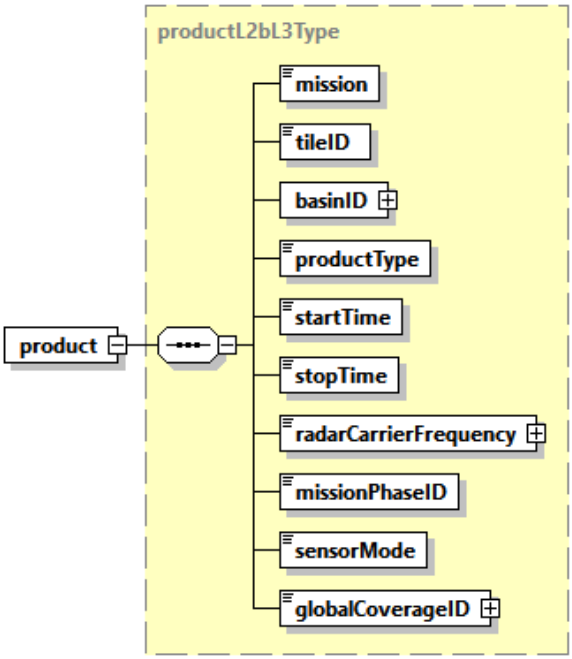

Fig.20 product L2b DSR

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 (“FD_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.41 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 forest disturbance, probability of change, CFM and Heat Map it is already described in Fig.5, Tab.9, Tab.10, Tab.11, Tab.12 with the differences are:

- the projection which here is the specific “DGG” described in [RD9].
- The FD_heatMap is present, as described in in Tab.10

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 *InputInformationL2aListType*, see description in 4.3.1.3 and Tab.13, Tab.14, Tab.19.

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

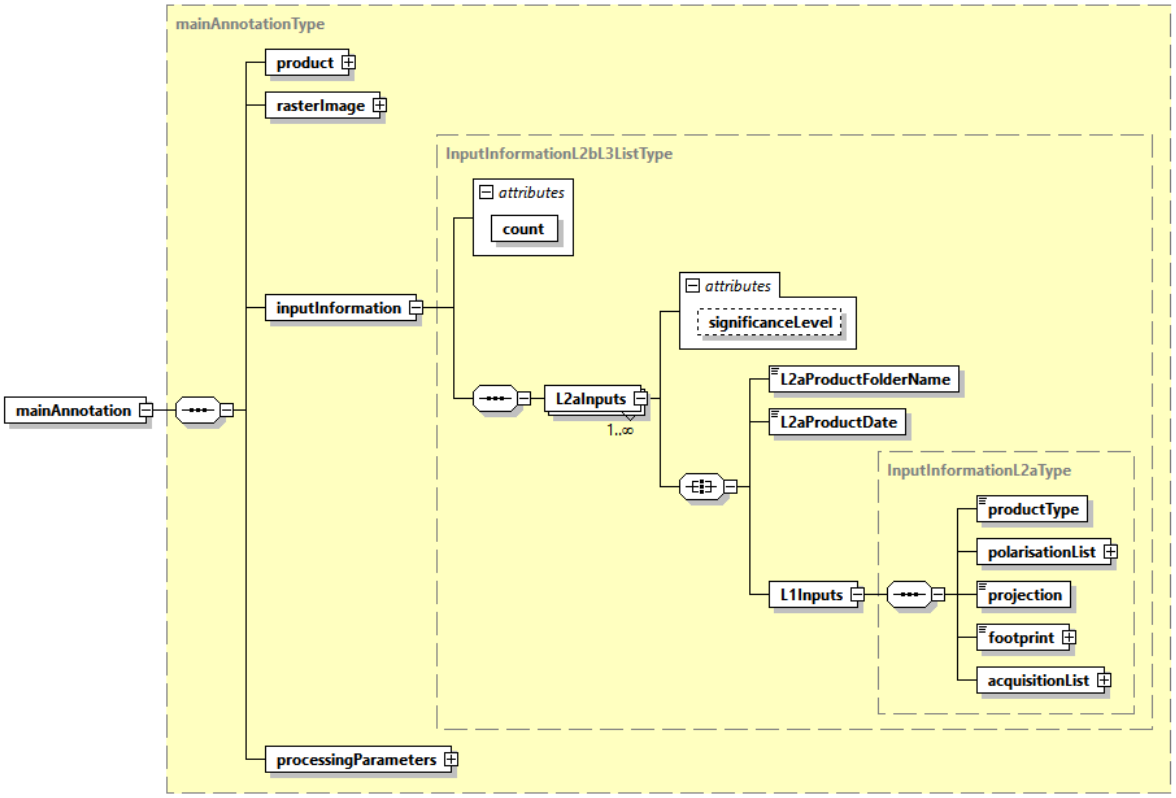

Fig.21 Input information L2b DSR (InputInformationL2bL3ListType)

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

Tab.42 Input information L2b DSR (InputInformationL2bL3ListType)

Name	Description	Data Type	Cardinality
significanceLevel	*XML attribute: level of significance used for the disturbance computation (single value from configuration). (One value for each "L2aInputs" entry).*	*xsd:float*	*1*
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.13, Tab.14, Tab.19. (One element for each "L2aInputs" entry).	InputInformationL2axsdType	1

Tab.43 Input information L2b DSR (L2aInputsType)

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.

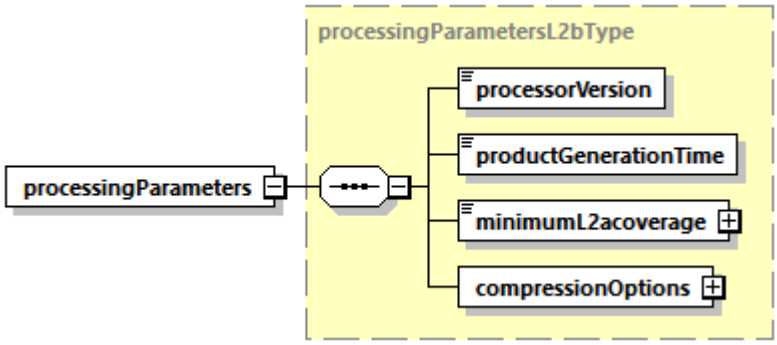

Fig.22 processing parameters L2b DSR

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
minimumL2aCoverage	The minimum percentage of tile coverage used to trigger the computation.	xsd:float	1
compressionOptions	Configurable compression options for all the L2b MDS.	compressionOptionsL2bType	1

Tab.44 Processing parameters L2b DSR

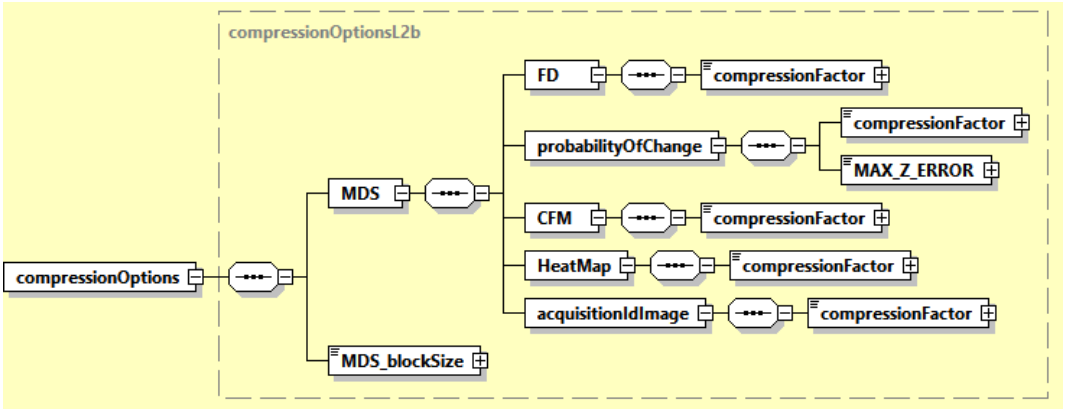

Fig.23 Processing parameters L2b DSR (compressionOptionsL2bType)

Name	Description	Data Type	Cardinality
MDS → FD → compressionFactor MDS → probabilityOfChange → compressionFactor MDS →CFM → compressionFactor MDS → HeatMap → compressionFactor MDS → acquisitionIdImage → compressionFactor	ZSTD algorithm compression factor for all the MDS. From 0 to 9, where zero means no compression.	xsd:unsignedByte	1
MDS → probabilityOfChange → MAX_Z_ERROR	For the probability of change image 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
MDS_blockSize	MDS COG blocking algorithm size. Same value is used for both data array dimensions.	xsd:unsignedByte	1

Tab.45 Processing parameters L2b DSR (compressionOptionsL2bType)

6.3.2. Quick-look ADS

The Quick-look ADS is composed by lower resolution versions of all the MDS images.
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
operationalModeType	Enumeration of Ground Cancellation algorithm to be used.	xsd:string	single reference multi reference insar pair
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.	xsd:string	I Q Abs Phase Abs Probability of change Computed forest mask Forest Disturbance Heat Map Acquisition Id Image Forest Height [m] Forest height quality Forest mask Ground Cancelled Backscatter Above Ground Biomass [t/ha] Above Ground Biomass

			quality [t/ha]
pixelTypeType	Enumeration of image pixel data types.	xsd:string	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.46 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 *referenceImage* attribute is a *bool* to indicate if the acquisition is the reference one. The optional *averageWavenumber* attribute is a float with the average value of the vertical wavenumber of the acquisition. Not used in image pair acquisitions (imagesPairSelection in 4.3.1.4)	xsd:string	referenceImage (mandatory, bool) averageWavenumber (optional, float)

Tab.47 Primitive product types with custom attributes

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

Tab.48 Common product types (datumType)

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

Tab.49 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	xsd:string	1

	of elements in the array.		

Tab.50 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.51 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.52 Common product types (doubleWithUnit)