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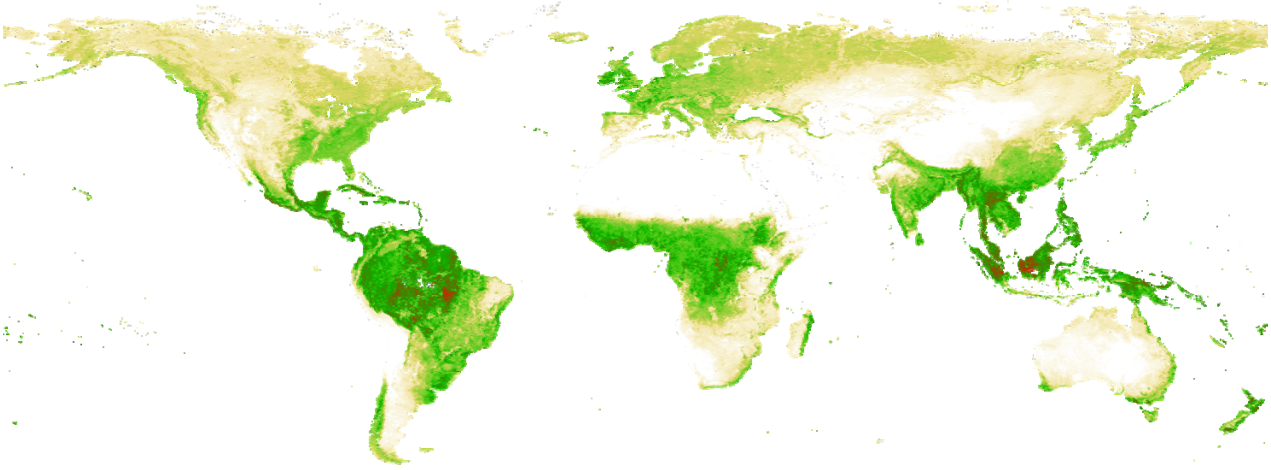
Institute for Environment and Sustainability

MERIS Level 3 Land Surface Aggregated Products Description



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Ophélie Aussedat, Malcolm Taberner, Nadine Gobron and Bernard Pinty

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This document describes the format of the products of the Medium Resolution Imaging Spectrometer (MERIS) Level 3 aggregated products. These data are operationally processed and produced at the Grid Processing-on Demand (G-POD) of European Space Research Institute (ESRIN) using the European Commission – DG Joint Research Centre (JRC) algorithm and software.

1 Outline and summary

The Medium Resolution Imaging Spectrometer (MERIS) has been launched on board the European platform Envisat and acquires operational data since mid 2002. MERIS scans the Earth's surface by the so called 'push-broom' method and the design is such that it acquires data over the Earth whenever illumination conditions are suitable. Envisat has a repeat cycle of the reference orbit of 3.5 days and a specific geographical location can be seen by MERIS from one to three days.

The MERIS land Level 2 product (named MERIS Global Vegetation Index, MGVI) corresponds to the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) and is operationally provided in the Space Oblique Mercator (SOM) projection at the reduced resolution, i.e. at 1.2 km spatial resolution. The FAPAR value is estimated from daily MERIS spectral measurements in the blue, red and near-infrared bands acquired at the top of the atmosphere using a physically based approach [1][2][3][4].

Establishing long term time series of remote sensing geophysical products, that are relevant for environmental applications at regional or global scale, calls for the production of high level products, i.e. at a lower spatial resolution relevant for modelling communities such as the carbon or climate domain. The spatially aggregated land products are therefore produced to be directly used for regional or global scale land analysis.

Section 2 summarizes the spatial aggregation algorithm associated with the MERIS land products, themselves generated by the MERIS time-composite processing chain [5] [6]. The following sections describe the format and content of the file corresponding to the aggregated product.

2 Aggregated Products

MERIS Level-3 Aggregated Products (MLAP) are produced from MERIS Level-3 Time Composite Products (MTCP) at either reduced resolution (1.2 km) or full resolution (300 m). The time composite algorithm is described in [5]. It is based on the selection of the day over the time compositing period (10 consecutive days or 1 month) that corresponds to the most representative value of FAPAR.

The MLAP are produced by spatially aggregating MTCP over a low spatial resolution window (the same or a different geographical window). All information concerning the spatial resolution of the aggregated products as well as the type of projection are given in the header of the file.

The algorithm searches for all pixels (e.g. the inputs pixel at 1.2 km) that are located in each grid cell of the new geographical region (output window). These pixels are then combined together by applying an operator to their values. The algorithm of aggregation implements two operators 1) computation of the mean, the standard deviation, the number of samples and 2) computation the median. The averaged values refer mostly to the geophysical measurements, like the FAPAR and associated values (see [6] for the list) and the median values are used when the geometry of measurements (such as the sun and observation zenith and azimuth angles) are reported.

The MLAP including datasets and metadata are stored in Hierarchical Data Format (HDF4.2) files. The datasets are multidimensional arrays containing scientific data values. The metadata contain information about either the file in general or a specific dataset. In this document the metadata referring to the entire file are described first, followed by an explanation of the scientific datasets and their associated metadata for aggregated products.

3 Hierarchical Data Format (HDF)

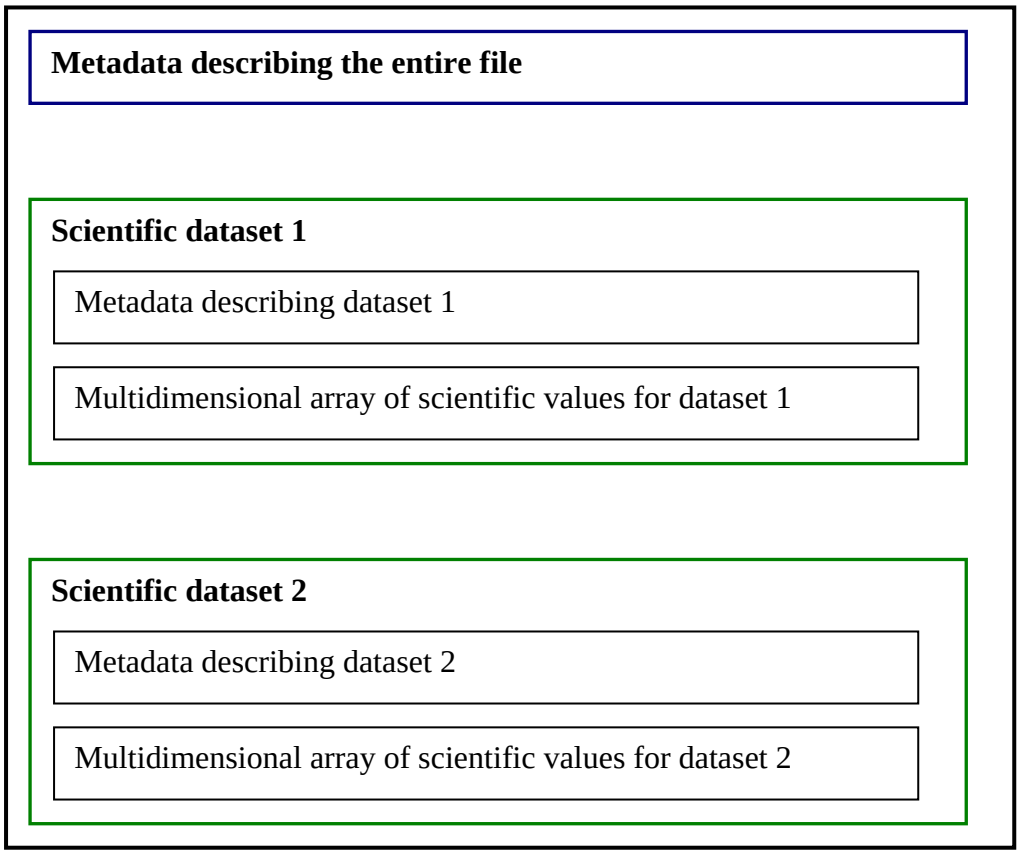
The Level 3 product is saved in a Hierarchical Data Format (HDF, version 4.2)[1] file. HDF is a physical file format for storing scientific data. HDF enables storing several datasets in a file by providing convenient data structures. HDF files are also self-describing: for each data structure there is comprehensive information about the data itself and its location in the file. This information is referred to as *metadata*.

The various maps contained in the aggregated product are multidimensional arrays stored in the file using the HDF structures called *Scientific Data Set* (SDS). The concept of metadata is used to add information to the entire file and to each dataset. Metadata are stored as HDF *Attributes*. The Level 3 products are consisting of several datasets of scientific data as well as metadata.

Figure 1 illustrates the structure of an HDF file containing two SDS and their associated metadata plus global metadata about the entire file. A typical MERIS Level 3 HDF file follows the same architecture but contains more datasets.

[1] http://hdf.ncsa.uiuc.edu/hdf4.html

Figure 1 Sample HDF file structure



The next sections describe 1) the metadata referring to the entire file and, 2) the scientific datasets and associated metadata.

3.1 Metadata describing the entire file

Information common to all the datasets or about the entire file (platform/sensor name, product description, software name, etc …) are stored as metadata. These also include the geographical projection definition and the time compositing period.

Table 1 summarized the various fields, their meaning, and their format. The last column gives a list of possible values when this list is exhaustive.

Table 1 Mandatory metadata for describing the entire file

Metadata Name	Definition	Data Type (HDF4 standard)	Format
Mission	Platform/Sensor name	CHAR8	**Envisat MERIS**
Processing Center	Institute where the data were processed	CHAR8	**ESA ESRIN**
Software Name	Time Composite software name	CHAR8	**ReMap - JRC - GEM / IES**
Software Version	Time Composite Software version	CHAR8	**ReMap Aggregate - Version 3.2**

Start Year	Year of the first file used in Time Composite	INT16	*Format=YYYY*
End Year	Year of the last file used in Time Composite	INT16	*Format=YYYY*
Title	Description of the product	CHAR8	**MERIS Level-3 Data**
Start Day	Day of the year; first day of the time composite period	INT16	From **1** to **366**
End Day	Day of the year; last day of the time composite period	INT16	From **1** to **366**
File Name	Name of the file	CHAR8	*Format=string*
Product Name	Short name	CHAR8	**MER**_*XX*__**3 aggregated Products** *XX=RR or FR*
ProjectionMetaData	Information about the projection: the projection parameter and the coordinate boundaries of the map.	CHAR8	*Format=string*

3.2 Dimensions

Dimensions are stored in HDF files so that several datasets can share common ones. All the datasets have the same *first* and *second* dimensions. Dimension one is **Number of Lines** and Dimension two is **Number of Columns**.

4 Data products contained in the file

The aggregated products contain information about the MGVI/FAPAR values ***inside each grid cell*** and correspond to the ***spatial average values***, the ***standard deviation*** and the ***number of samples*** used to make the statistic. Additional products concern several statistics on the number of pixels detected by several flags, the spatial averaged value of the normalized reflectance in the blue, green, red and near-infrared domain and the two rectified bands, and four median values with standard deviation of both illumination and viewing angles.

Table 2 provides the list of the generated datasets, their type and their meaning.

Table 2 Datasets contained in MERIS aggregated products

Original name & method		Field Name	Definition	Data Type
MGVI	mean	fapar	Fraction of Absorbed Photosynthetically Active Radiation (MGVI) (grid cell average)	UINT8
	standard deviation	sd_spatial_fapar	Standard deviation of FAPAR inside the grid cell	UINT8
	number of samples	nb_spatial_fapar	Number of pixels used to generate FAPAR statistics inside the grid cell	UINT8
sd_MGVI	mean	dev_temporal_fapar	Standard deviation for the FAPAR during the Time Composite (grid cell average).	UINT8
	standard deviation	sd_dev_temporal_fapar	Standard deviation of temporal deviation of FAPAR during the time composite period	UINT8
nb_MGVI	mean	nb_temporal_fapar	Number of valid FAPAR values used during time composite(grid cell average).	UINT8
	standard deviation	sd_nb_temporal_fapar	Standard deviation of number of daily FAPAR estimates used in time composite	UINT8
flag	number of samples	nb_flag_bright	Number of bright soil surface pixels inside the grid cell	UINT16
	number of samples	nb_flag_clouds_ice	Number of cloud or ice pixels inside the grid cell	UINT16
	number of samples	nb_flag_vegetation	Number of land surface pixels inside the grid cell	UINT16
	number of samples	nb_flag_water	Number of water bodies or cloud shadow pixels inside the grid cell	UINT16

norm_surf_reflec_X (X=2,5,8,13)	mean	norm_surf_reflec_X (X=2,5,8,13)	Normalized surface reflectance (grid cell average). X represents the MERIS band number	UINT16
BRF_Rec_Red	mean	REC_RED	Red Rectified Reflectance (grid cell average)	UINT8
BRF_Rec_Nir	mean	REC_NIR	Near Infrared Rectified Reflectance (grid cell average)	UINT8
solar_zenith	median	sun_zenith	Solar zenith angle (grid cell median)	UINT32
	standard deviation	sd_sun_zenith	Standard deviation of solar zenith angle inside the grid cell	UINT32
view_zenith	median	sat_zenith	Observation zenith angle (grid cell median)	UINT32
	standard deviation	sd_sat_zenith	Standard deviation of sensor zenith angle inside the grid cell	UINT32
solar_azimuth	median	sun_azimuth	Sun azimuth angle (grid cell median)	UINT32
	standard deviation	sd_sun_azimuth	Standard deviation of solar azimuth angle inside the grid cell	UINT32
view_azimuth	median	sat_azimuth	Observation azimuth angle (grid cell median)	UINT32
	standard deviation	sd_sat_azimuth	Standard deviation of sensor azimuth angle inside the grid cell	UINT32

4.1 Metadata describing the datasets

4.1.1 Metadata definition

Metadata exist in the HDF file to provide comprehensive information about the data and can be associated with each field. They are stored as HDF *Attributes.*

All the fields are stored as HDF *Scientific Data Set* (SDS) and all have the same metadata (**`slope`**, **`intercept`**, **`_FillValue`**, and **`long_name)`**. The metadata are described in Table 3 and the valid values are given in Table 4 for each data field.

Table 3 Metadata describing the dataset: definition

Metadata Name	Definition	Data Type
slope	Scaling factor	FLOAT64
intercept	Offset value	FLOAT64
_FillValue	Bad value for the variable	"Variable type"
Long_name	Label describing the variable	CHAR8

In order to reduce the HDF file size, a scientific dataset can be scaled to fit a small data type. Data scaled into *"byte"* format can be converted to its *"real"* value by the relation:

real_value=file_data_value*slope+intercept

With *file_data_value* being the *'byte'* value written in the file.

4.1.2 Metadata valid values

Table 4 gives the actual metadata values for each dataset.

Table 4 Metadata describing the dataset: values

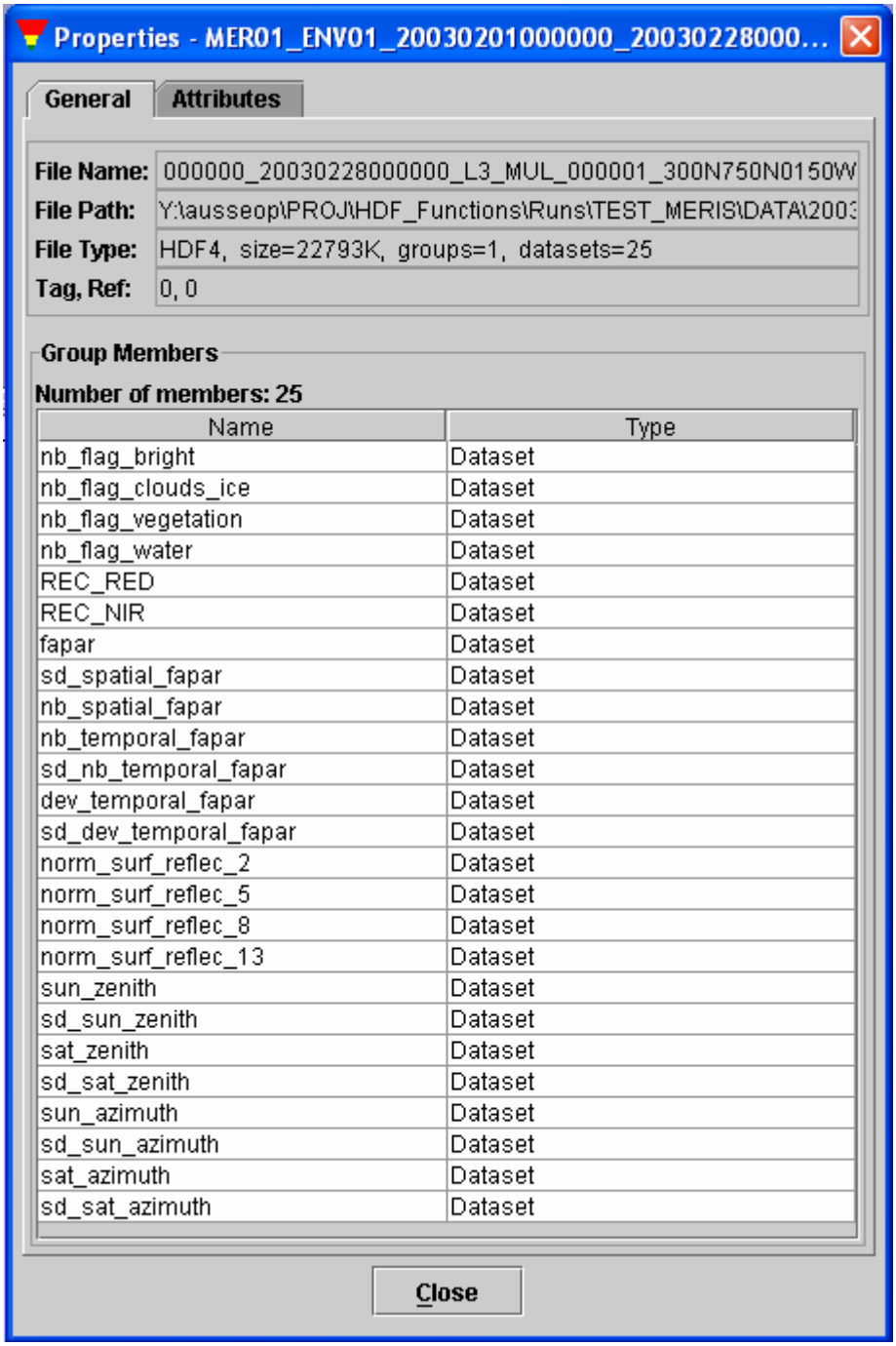
Field Name & HDF type	_Fillvalue	slope	intercept	long_name
fapar (UINT8)	0	0.003937	-0.003937	Fraction of Absorbed Photosynthetically Active Radiation (MGVI) (grid cell average)
sd_spatial_fapar (UINT8)	255	0.003937	0.0	Standard deviation of FAPAR inside the grid cell
nb_spatial_fapar (UINT16)	0	1.0	0.0	Number of pixels used to generate FAPAR statistics inside the grid cell
dev_temporal_fapar (UINT8)	255	0.003937	0.0	Standard deviation for the FAPAR during the Time Composite (grid cell average).
sd_dev_temporal_fapar (UINT8)	255	0.003937	0.0	Standard deviation of temporal deviation of FAPAR during the time composite period
nb_temporal_fapar (UINT8)	0	1.0	0.0	Number of valid FAPAR values used during time composite (grid cell average).

sd_nb_temporal_fapar (UINT8)	255	1.0	0.0	Standard deviation of number of daily FAPAR estimates used in time composite
nb_flag_bright (UINT16)	65535	1.0	0.0	Number of bright soil surface pixels inside the grid cell
nb_flag_clouds_ice (UINT16)	65535	1.0	0.0	Number of cloud or ice pixels inside the grid cell
nb_flag_vegetation (UINT16)	65535	1.0	0.0	Number of land surface(vegetation) pixels inside the grid cell
nb_flag_water (UINT16)	65535	1.0	0.0	Number of water bodies or cloud shadow pixels inside the grid cell
norm_surf_reflec_X (X=2,5,8,13) (UINT16)	0	Depends on the level 2 processing version		Normalized surface reflectance (grid cell average). X represents the MERIS band number
REC_RED (UINT8)	0	0.003937	-0.003937	Red Rectified Reflectance (grid cell average)
REC_NIR (UINT8)	0	0.003937	-0.003937	Near Infrared Rectified Reflectance (grid cell average)
sun_zenith (UINT32)	4294967295	1*10e-6	0.0	Solar zenith angle (grid cell median)
sd_sun_zenith (UINT32)	4294967295	1*10e-6	0.0	Standard deviation of solar zenith angle inside the grid cell
sat_zenith (UINT32)	4294967295	1*10e-6	0.0	Observation zenith angle (grid cell median)
sd_sat_zenith (UINT32)	4294967295	1*10e-6	0.0	Standard deviation of sensor zenith angle inside the grid cell
sun_azimuth (UINT32)	4294967295	1*10e-6	0.0	Sun azimuth angle (grid cell median)
sd_sun_azimuth (UINT32)	4294967295	1*10e-6	0.0	Standard deviation of solar azimuth angle inside the grid cell
sat_azimuth (UINT32)	4294967295	1*10e-6	0.0	Observation azimuth angle (grid cell median)
sd_sat_azimuth (UINT32)	4294967295	1*10e-6	0.0	Standard deviation of sensor azimuth angle inside the grid cell

5 Example of MLAP file content

The MLAP file contains 25 datasets. The following figures display examples of MERIS level 3 Aggregated HDF datasets (Figure 2) and metadata (Figure 3 and Figure 4), when opened with the *HDFView* Software[2].

Figure 2 Example of MERIS Level 3 Aggregated HDF datasets



[2] http://hdf.ncsa.uiuc.edu/hdf-java-html/hdfview/

Figure 3 Example of MERIS Level 3 Aggregated HDF metadata for the whole file

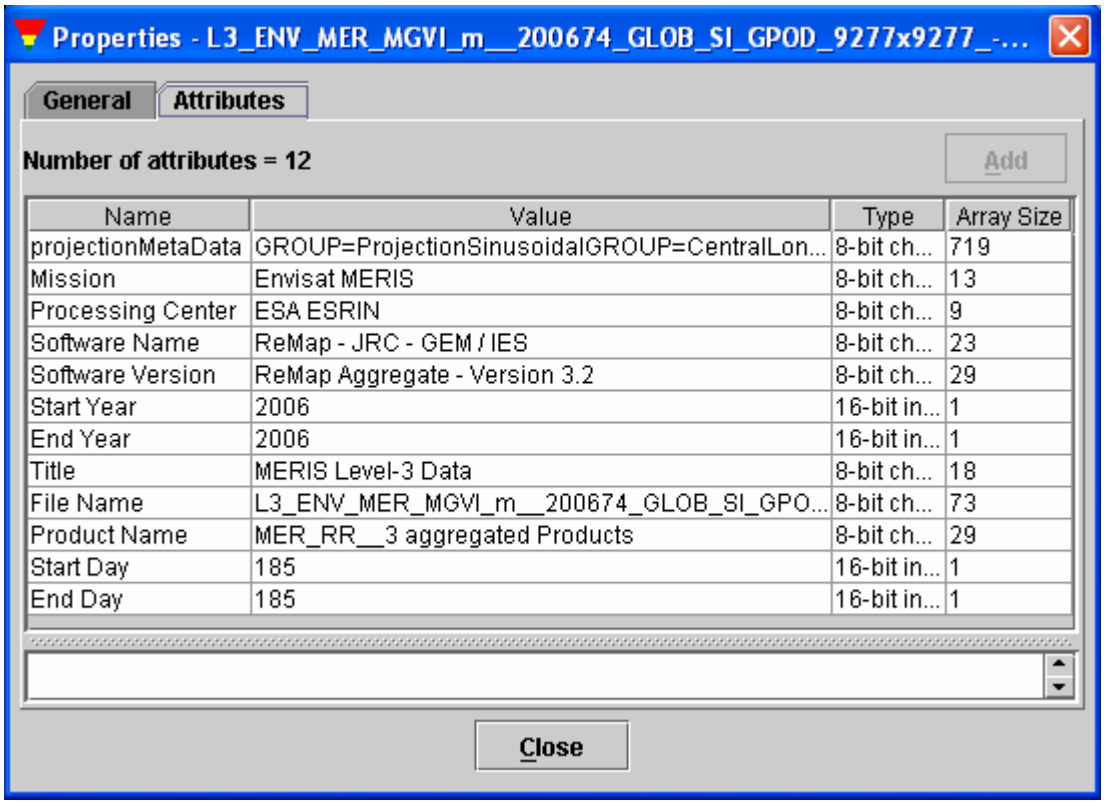
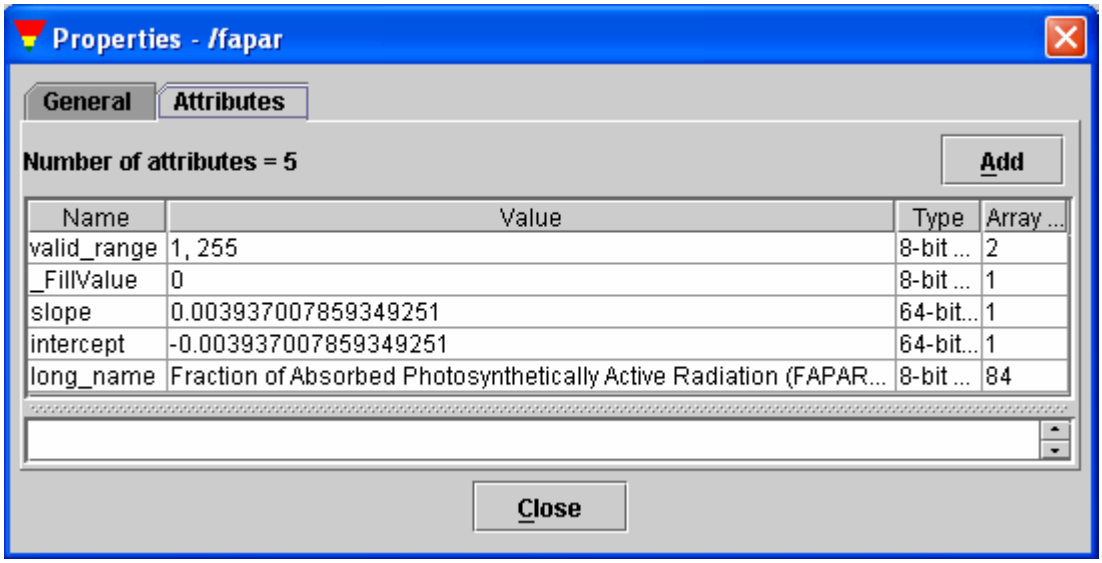


Figure 4 Example of MERIS level 3 HDF metadata describing the dataset fapar



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Abstract

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