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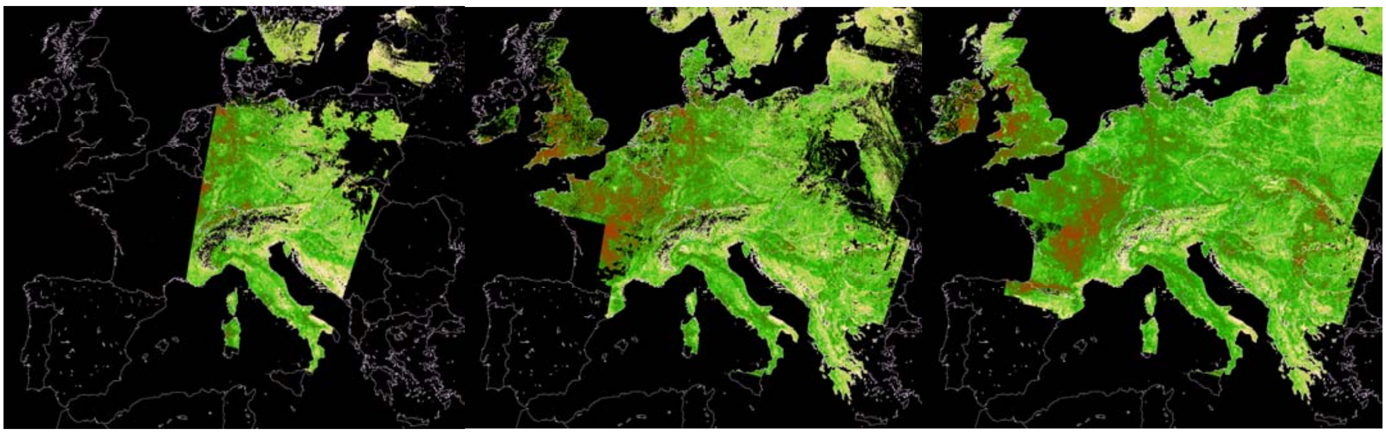

MERIS Level 3 Land Surface Time Composite

Product File Description

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1 Time Composite Product

The Medium Resolution Imaging Spectrometer (MERIS) Global Vegetation Index (MGVI) has been calibrated so as to generate numerical values (between 0 and 1) which correspond to the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) of vegetation over terrestrial surfaces [1][2][3][4]. FAPAR, a bio-geophysical variable, is intimately connected to the photosynthetic process and is regularly used in the estimation of plant primary productivity using diagnostic and predictive models.

This project aims at delivering high level FAPAR products with enhanced temporal information thanks to a dedicated composite procedure. Incidentally, this composite algorithm yields to enhanced spatial coverage as well.
The level 3 FAPAR product is a summary of the level 2 daily information[1] and is generated with an algorithm that reduces the high temporal frequency variability.

The time composite algorithm, itself, is described in [5]. It consists in selecting the day over the compositing period (for instance, 10 consecutive days or one month) that corresponds to the most representative value of the sequence. Briefly, these representative values are selected so that they correspond to the closest values to the corresponding arithmetic averages of the daily values calculated over the time composite period. It is a technique which can generally be applied in order to composite time sequence products such as FAPAR.

As a precursor to time compositing, the original level 2 input data are remapped over the user's geographical window at the same resolution. For instance, remapping is done at 1.2 km for the MERIS reduced resolution, or 300 meters for the full resolution. This remapping uses the nearest-neighbour resampling technique in order to preserve data integrity.

The proposed time composite product is composed of maps of FAPAR and associated quantities, covering 10-day or monthly periods. Each individual map value represents the actual measurement considered to be the most representative of the period. The actual geometry of illumination and observation, the date of acquisition and an evaluation of the quality of the composite value are retained and added to the final product.

[1] http://envisat.esa.int/dataproducts/meris/CNTR6-1 3.htm#eph.meris.merisdf.2p.MER_RR__2P

2 Hierarchical data format (HDF)

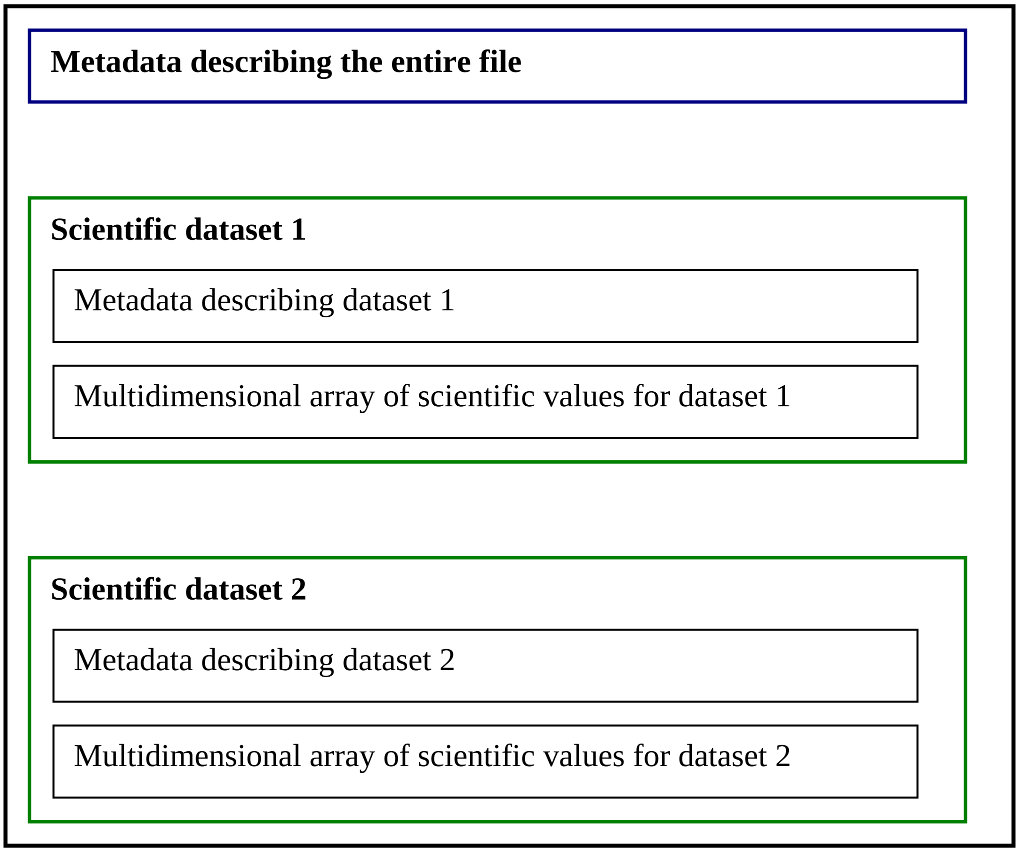
The level 3 product is written in a Hierarchical Data Format (HDF, version 4.2)[2] file. HDF is a physical file format for storing scientific data. HDF enables storing several datasets in a file by providing various convenient data structures. HDF files are also self-describing: for each data structure, 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 time composite product are multidimensional arrays stored in the file using the HDF structures called *Scientific Data Set* (SDS). It also uses the concept of metadata to add information to the entire file and to each dataset. They are HDF *Attributes.* Basically, the level 3 product is stored as a single HDF file, containing several datasets of scientific data as well as some 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.

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

Figure 1 Sample HDF file structure



The following sections describe 1) the metadata referring to the entire file, 2) the scientific datasets and associated metadata and, finally 3) the level 3 flags that users must consider when interpreting the product.

3 Metadata describing the entire file

Information common to all the datasets or about the entire file is stored as metadata. These include the geographical projection definition, the name and version of the software used for the processing, the time compositing period, etc. Some of the fields always appear in the level 3 products and are called mandatory, whilst others are optional.

3.1 Mandatory Metadata describing the entire file

These metadata are written by the time composite software to provide information about the entire file. They are mandatory and thus always contain a value. Some of them are common to all the level 3 files (platform/sensor name, product description, software name…) and only a small set of possible values exists. Other metadata are retrieved directly from the input MERIS level 2 files and vary from a level 3 file to another (for example the geographical projection, time composite period…).
Table 1 describes the various fields, their meaning and the format. The last column gives a list of existing possible values when the list is exhaustive.

Table 1 Mandatory metadata for describing the entire file

Metadata Name	Definition	Data Type (HDF4 standard)	Format	Possible values
Mission	Platform/Sensor name	CHAR8	*string*	**Envisat MERIS**
Latitude Units	Latitude units	CHAR8	*string*	**degrees** or **kilometers** or **meters**
Longitude Units	Longitude units	CHAR8	*string*	**degrees** or **kilometers** or **meters**
Processing Center	Institute where the data were processed	CHAR8	*string*	**Joint Research Centre - GVM / IES**
Software Name	Time Composition: software name	CHAR8	*string*	**TC; JRC - GVM / IES**
Software Version	Time Composition: software version	CHAR8	*string*	**TC - version *X.Y*** *X.Y being the version number*
Title	Product description	CHAR8	*string*	**MERIS Level-3 Data**
Start Year	Year of the first data used in Time Composition	INT16	*integer: YYYY* (Example:2003)	
End Year	Year of the last data used in Time Composition	INT16	*integer: YYYY* (Example:2003)	
Start Day	Day of the year of the beginning of the period.	INT16	*integer* from **1** to **366**	

End Day	Day of the year of the end of the period.	INT16	*integer* from **1** to **366**	
File Name	Name of the file	CHAR8	*string*	
Product Name	Product code	CHAR8	*string*	**MER_RR__3** or **MER_FR__3**
ProjectionMetaData	Information about the projection: the name, parameters, and coordinate boundaries.	CHAR8	*string*	

3.2 Optional Metadata describing the entire file

The optional metadata are written to the file if additional information from the JRC remapping program is available, as it is usually the case. If, under exceptional circumstances, this information is not available, then this metadata is not written.
Table 2 describes the various fields present in the file, their meaning and the format. The last column gives a list of existing possible values when the list is exhaustive.

Table 2 Optional metadata for describing the entire file

Metadata Name	Definition	Data Type (HDF4)	Units	Format	Possible values
Map projection	Projection name	CHAR8	N/A	*string*	**Rectangular** or **Sinusoidal** or **Lambert Azimuthal Equal Area**
Number of Lines	Number of lines in the datasets	INT32	N/A	*integer* 1 or higher	
Number of Columns	Number of columns in the datasets	INT32	N/A	*integer* 1 or higher	
Southernmost Latitude	Latitude of the southernmost pixel	FLOAT32	degrees	*float* from **-90.0** to **90.0**	

Northernmost Latitude	Latitude of the northernmost pixel	FLOAT32	degrees	*float* from **-90.0** to **90.0**	
Upper Left Latitude	Latitude of the upper left pixel	FLOAT32	degrees	*float* from **-90.0** to **90.0**	
Easternmost Longitude	Longitude of the easternmost pixel	FLOAT32	degrees	*float* from **-180.0** to **180.0**	
Westernmost Longitude	Longitude of the westernmost pixel	FLOAT32	degrees	*float* from **-180.0** to **180.0**	
Lower Left Longitude	Longitude of the lower left pixel	FLOAT32	degrees	*float* from **-180.0** to **180.0**	
Lower Right Longitude	Longitude of the lower right pixel	FLOAT32	degrees	*float* from **-180.0** to **180.0**	
Latitude Step	Y resolution	FLOAT32	Unit specified in *'Latitude units'*	*float*	*Example in degrees: 0.5 Example in meters: 3000*
Longitude Step	X resolution	FLOAT32	Unit specified in *'Longitude units'*	*float*	

4 Datasets contained in the file

The time composite algorithm selects the day over the compositing period that corresponds to the most representative value of the sequence. The time composite product thus contains several datasets available directly from the corresponding daily level 2 datasets. It also contains new datasets created by the time composite algorithm and providing quality information.

The day chosen by the time composite algorithm is that of the selected FAPAR value. If a valid FAPAR value does not exist in the considered period, then the day is selected based on an analysis of the flag values. Where appropriate, other datasets will be derived from this selected day. Because of this procedure, some datasets contain valid values even when there were no valid FAPAR values during the entire period.

To perform the selection from the flags values, priority orders are assigned to each of them as described in Table 3.

Table 3 Level 2 flags priority order

<table>
<tr><td rowspan="5">Higher towards lower priority order</td><td>Water and deep shadow</td></tr>
<tr><td>Cloud</td></tr>
<tr><td>Invalid rectified values</td></tr>
<tr><td>Bad value</td></tr>
<tr><td>No data</td></tr>
</table>

4.1 Dataset Dimensions

Dataset dimensions are stored in HDF files so that several datasets can share them.
In this *Time Compositing* case, all the datasets have the same *first* and *second* dimensions. The first dimension is "**`Number of lines`**" and the second is "**`Number of Columns`**". Each dimension is given a short name used for the purpose of this document and described in Table 4.

Table 4 Datasets dimensions

Dimension Name	Definition	Short name
Number of Lines	Number of lines in the map	D1
Number of Columns	Number of columns in the map	D2
Number of Bytes	Number of bytes needed to code each data value.	D3

4.2 Datasets available from level 2

The time composite algorithm selects the most representative day for a period. The level 3 datasets contain the values copied from the corresponding level 2 datasets for the selected day. Table 5 describes these datasets.

Table 5 Datasets available from level 2

Field Name	Definition	Dimension List	Data Type	Units
MGVI	FAPAR	D1 D2	UINT8	N/A
BRF_Rec_Red	Rectified Red reflectance	D1 D2	UINT8	N/A
BRF_Rec_Nir	Rectified Near Infrared reflectance	D1 D2	UINT8	N/A
norm_surf_reflec_X (X=2,5,8,13)	Normalized surface reflectance. X represents the MERIS band number	D1 D2	UINT16	N/A
solar_zenith	Sun zenith angle	D1 D2	UINT32	degrees
view_zenith	Sensor zenith angle	D1 D2	UINT32	degrees
solar_azimuth	Solar azimuth angle	D1 D2	UINT32	degrees
view_azimuth	Sensor azimuth angle	D1 D2	UINT32	degrees
Flag_ass_pixel.pix	Level 2 flags	D1 D2 D3	UINT8 (* 3)	N/A

4.3 Datasets generated for level 3

New datasets are generated by the time composite algorithm to provide further information about the selected values and quality assessment. The various fields are described in Table 6.

Table 6 Datasets generated for level 3

Field Name	Definition	Dimension List	Data Type	Valid range	Units
dMGVI	Day of the Month for the particular data value selected during Time Composition.[3]	D1 D2	UINT8	From 1 to 31	Day of the Month
sd_MGVI	FAPAR Standard deviation over the time period.	D1 D2	UINT8	From 0 to 254	N/A
nb_MGVI	Number of valid FAPAR values within the time period.	D1 D2	UINT8	From 1 to 31	N/A
flag	Level 3 flags.	D1 D2	UINT8	From 0 to 255	N/A

4.4 Metadata describing the datasets

4.4.1 Metadata definition

Metadata exist in the HDF file to provide comprehensive information about the data and are associated to each dataset. They are HDF *Attributes*.

All the datasets are HDF *Scientific Data Set* (SDS) and, except for the **`flag_ass_pixel.pix`** dataset, have the same metadata (**`slope`**, **`intercept`**, **`_FillValue`**, and **`long_name`**). The metadata are described in Table 7 and the valid values are given later in Table 8 for each dataset.

Table 7 Metadata describing the dataset: definition

Metadata Name	Definition	Data Type
slope	Scaling factor	FLOAT64

[3] The day chosen is that of the selected FAPAR value. If a valid FAPAR value does not exist, then the day is selected based on an analysis of the flag values.

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.

4.4.2 Metadata valid values

Table 8 gives the actual metadata values for each dataset.

Table 8 Metadata describing the dataset: values

Field Name	_Fillvalue	slope	intercept	long_name
MGVI	0	0.003937	-0.003937	FAPAR (Fraction of Photosynthetically Active Radiation) Values
BRF_Rec_Red	0	0.003937	-0.003937	Rectified reflectance - Red
BRF_Rec_Nir	0	0.003937	-0.003937	Rectified reflectance - NIR
norm_surf_reflec_X	0	Depends on the level 2 processing version		Normalized surface reflectance X
solar_zenith	4294967295	1*10e-6	0	Solar Zenith Angle
view_zenith	4294967295	1*10e-6	0	Sensor Zenith Angle
solar_azimuth	4294967295	1*10e-6	0	Solar Azimuth Angle
view_azimuth	4294967295	1*10e-6	0	Sensor Azimuth Angle
Flag_ass_pixel.pix	0 0 0	1.0	0.0	-
dMGVI	0	1.0	0.0	Day selected (FAPAR or Flag)
sd_MGVI	255	0.003937	0.0	Mean deviation for FAPAR
nb_MGVI	0	1.0	0.0	Number of FAPAR observations
flag	None	1.0	0.0	Level-3 Processing Flags

5 Level 3 Flags

Level 3 flags (Table 9) give information about the pixel state and the FAPAR validity. If the FAPAR is not valid, the flags describe the reason.
The "**MGVI value**" column shows the relationship between the flag values and the MGVI dataset. The interpretation of the flag themselves is also shown in this table.

Table 9 Flags values

Value	Description	MGVI value
0	Water detected by MERIS mask.	0 (bad value)
16	Water detected by MGVI algorithm	0 (bad value)
101	Land and valid FAPAR value	From 1 to 255
102	Bright surface	1
104	Invalid rectified BRF	0 (bad value)
210	Cloud detected by MERIS mask.	0 (bad value)
211	Cloud detected by MGVI algorithm	0 (bad value)
254	No valid FAPAR value delivered by the MGVI algorithm	0 (bad value)
255	Missing data	0 (bad value)

6 Example of HDF File content

The MERIS level 3 file contains 16 datasets. The following figures are examples of MERIS level 3 HDF datasets (Figure 2) and metadata (Figure 3 and Figure 4), when opened with the *HDFView* Software[4].

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

Figure 2 Example of MERIS level 3 HDF datasets

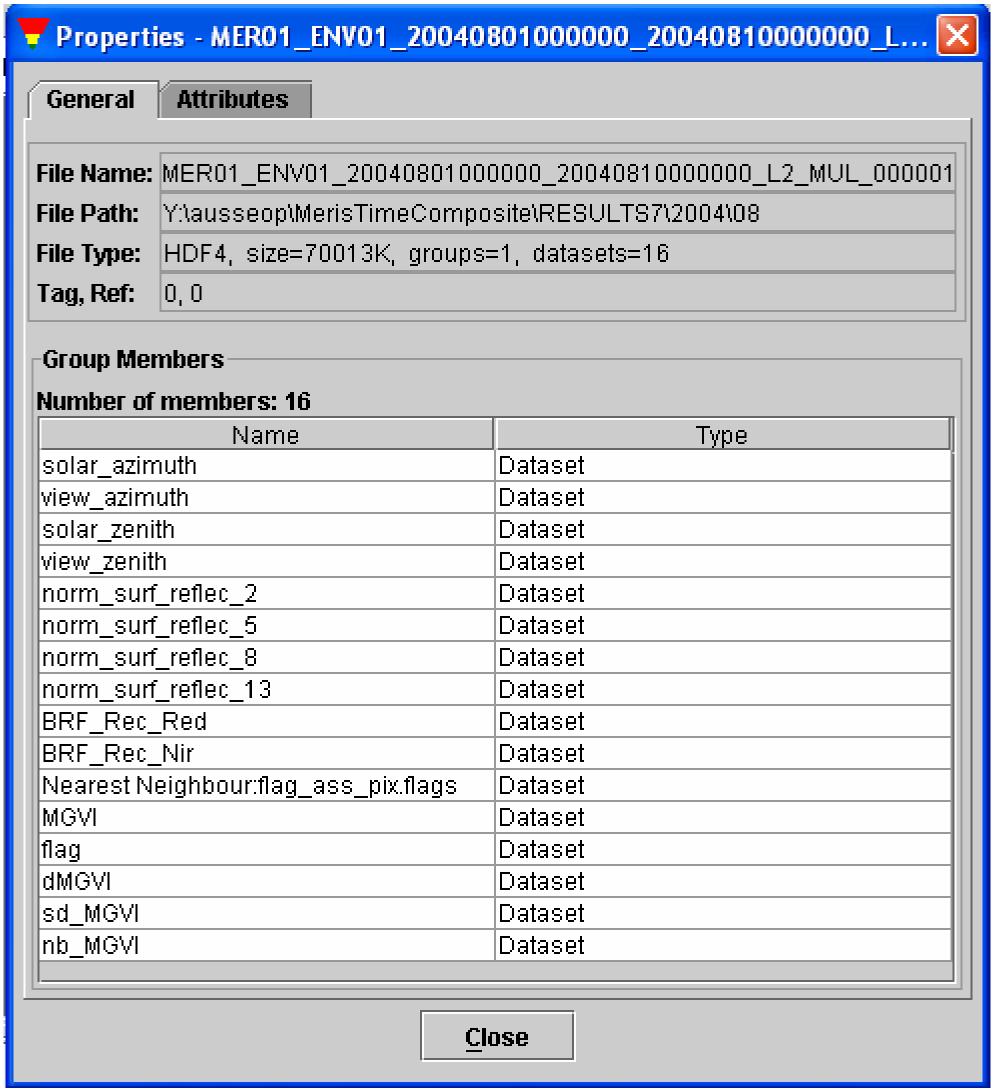
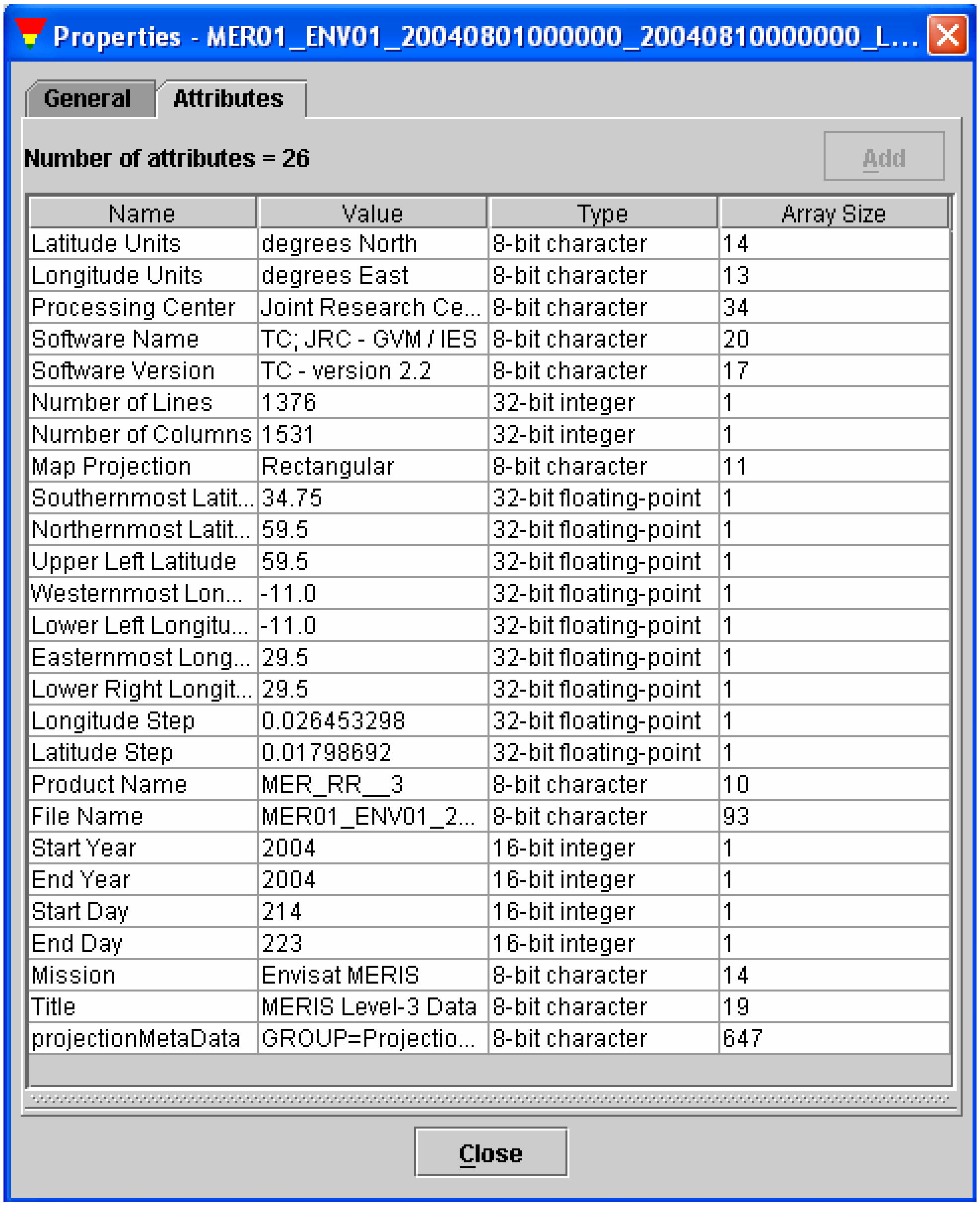


Figure 3 Example of MERIS level 3 HDF metadata referring to the entire file



Properties - MER01_ENV01_20040801000000_20040810000000_L...

General | Attributes

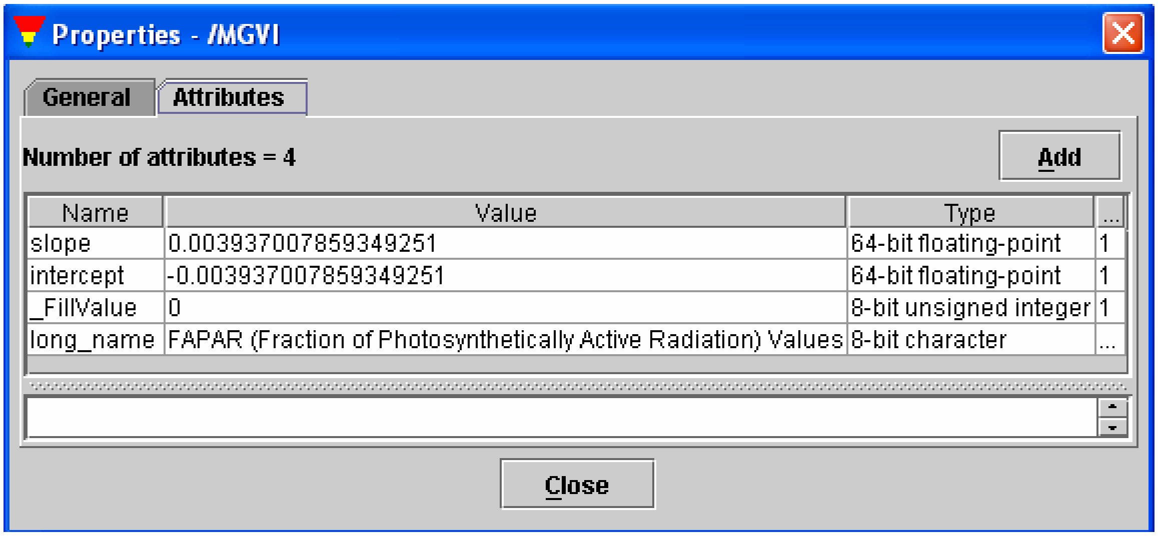
Number of attributes = 26

Add

Name	Value	Type	Array Size
Latitude Units	degrees North	8-bit character	14
Longitude Units	degrees East	8-bit character	13
Processing Center	Joint Research Ce...	8-bit character	34
Software Name	TC; JRC - GVM / IES	8-bit character	20
Software Version	TC - version 2.2	8-bit character	17
Number of Lines	1376	32-bit integer	1
Number of Columns	1531	32-bit integer	1
Map Projection	Rectangular	8-bit character	11
Southernmost Latit...	34.75	32-bit floating-point	1
Northernmost Latit...	59.5	32-bit floating-point	1
Upper Left Latitude	59.5	32-bit floating-point	1
Westernmost Lon...	-11.0	32-bit floating-point	1
Lower Left Longitu...	-11.0	32-bit floating-point	1
Easternmost Long...	29.5	32-bit floating-point	1
Lower Right Longit...	29.5	32-bit floating-point	1
Longitude Step	0.026453298	32-bit floating-point	1
Latitude Step	0.01798692	32-bit floating-point	1
Product Name	MER_RR__3	8-bit character	10
File Name	MER01_ENV01_2...	8-bit character	93
Start Year	2004	16-bit integer	1
End Year	2004	16-bit integer	1
Start Day	214	16-bit integer	1
End Day	223	16-bit integer	1
Mission	Envisat MERIS	8-bit character	14
Title	MERIS Level-3 Data	8-bit character	19
projectionMetaData	GROUP=Projectio...	8-bit character	647

Close

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



7 References

[1] Govaerts, Y., Verstraete, M. M., Pinty, B. and Gobron, N., 1999: Designing Optimal Spectral Indices: A Feasibility and Proof of Concept Study, *International Journal of Remote Sensing*, **20**, pp. 1853-1873.

[2] Gobron, N., Pinty, B., Verstraete, M. M. and Govaerts Y., 1999: The MERIS Global Vegetation Index (MGVI): Description and Preliminary Application, *International Journal of Remote Sensing*, **20**, pp. 1917-1927.

[3] Gobron, N., O. Aussedat, B. Pinty, M. Taberner & M. M. Verstraete (2004) 'Medium Resolution Imaging Spectrometer (MERIS) - Level 2 Land Surface Products - Algorithm Theoretical Basis Document', Revision 3.0, Institute for Environment and Sustainability, **EUR Report No. 21387 EN**, 20 pp.

[4] Gobron, N., O. Aussedat, B. Pinty, M. Taberner & M. M. Verstraete (2004) 'Medium Resolution Imaging Spectrometer (MERIS) - An optimized FAPAR Algorithm - Theoretical Basis Document', Revision 3.0, Institute for Environment and Sustainability, **EUR Report No. 21386 EN**, 20 pp.

[5] Pinty, B., N. Gobron, F. Mélin and M. M. Verstraete (2002) 'A Time Composite Algorithm Theoretical Basis Document', Institute for Environment and Sustainability, **EUR Report No. 20150 EN**, 8 pp.

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