IDEAS-QA4EO

MOS Product Format Specification

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AMENDMENT RECORD SHEET

The Amendment Record Sheet below records the history and issue status of this document.

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1.0	09/11/2020	First issue

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1. INTRODUCTION

Following the [COMM-PROP] a new version of the MOS processor has been delivered by Exprivia S.p.A., in order to introduce improvements in the quality of the MOS products, and a new format of the delivered products as well.

1.1 Purpose and Scope

The aim of this document is to describe a new format of the Level 2 (System corrected) and Level 3 (Orthorectified) products for both MESSR and VTIR MOS sensors.

1.2 Acronyms and Abbreviations

ACT	ACross Track
ALT	ALong Track
CSV	Comma Separated Value(s)
DN	Digital Number
KML	Keyhole Markup Language
NIR	Near InfraRed spectral bands
PNG	Portable Network Graphics
QL	Quick Look
RGB	Red-Green-Blue
TIF	Tagged Image File
TIR	Thermal Infrared spectral bands
VIS	VISible spectral bands
XML	eXtensible Markup Language

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

Document Title	Identifier	Internal Reference
MOS reprocessing commercial proposal	MOS_FIN-TN-0002 v2.2	[COMM-PROP]

2.2 Referenced Documents

Document Title	Identifier	Internal Reference
Products Naming Standard Convention	PGSI-GSEG-EOPG-TN-06-0001 v2.0	[ESA-PROD]
ESA Generic IPF Interface Specifications	MMFI-GSEG-EOPG-TN-07-0003 v1.6	[ESA-GEN-ICD]
TPML Interface Control Document	TPML-ID-ACS-GS-0157 v1.8	[ICD-TPML]
TPML Updated Mission Instrument Documentation MOS	TPML-TN-ACS-GS-0165 v1.1	[TN-UMID-TPML]
TIFF 6.0 Specification		[TIFF-SPEC]
GeoTIFF Revision 1.0 Specification	http://geotiff.maptools.org/spec/contents.html	[GTIFF-SPEC]
OGC GeoTIFF standard	19-008r4 v1.1 http://docs.opengeospatial.org/is/19-008r4/19-008r4.html	[GTIFF-OGC-SPEC]
Portable Network Graphics (PNG) Specification (Second Edition)	https://www.w3.org/TR/PNG/	[PNG-SPEC]
KML specification	https://developers.google.com/kml/documentation/kmlreference	[KML-SPEC]

3. MOS 1/1B MESSR PRODUCTS

The MOS MESSR processor can generate the following products:

- MES_ORT_1P: Orthorectified Map-oriented (Level3) products are the default products generated by the MOS MESSR processor in all cases where possible, with usage of LANDSAT improved GCP latest set.
- MES_SYC_1P: System corrected (Level 2) products are generated by the MOS MESSR processor when is not possible to generate MES_ORT_1P.
- AUX_TC_MM1: Time correlation file valid for MESSR sensor generated by the MOS MESSR processor, updating an input time correlation file AUX_TC_MM0. One file for each MESSR passage.
- AUX_TC_MV1: Time correlation file valid for VTIR sensor generated by the MOS MESSR processor, updating an input time correlation file AUX_TC_MV0. One file for each MESSR passage.

The products follow the ESA naming convention according to [ESA-PROD].

3.1 MOS 1/1B MESSR ORTHORECTIFIED LEVEL3 PRODUCTS (MES_ORT_1P)

The product is composed by several files grouped in a folder with extension “TIFF”. The folder is compressed in a zip file to facilitate the product circulation.

```
MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000.TIFF
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000_B1.TIF
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000_B2.TIF
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000_B3.TIF
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000_B4.TIF
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000.MD.XML
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000.QL.KML
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000.QL.PNG
|--> MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000.QR.CSV
```

The product is composed by:

- 4 images *_B[1-4].TIF in GeoTIFF format, one for each MESSR spectral band [TN-UMID-TPML]
- One *.MD.XML file in XML format, including metadata info
- One *.QL.PNG image in PNG format, containing the quick look image of the product. The image is an RGB plus Alpha channel in order to set as transparent all the unfilled pixels. The default configuration is band B3 for red, band B2 for green and B1 for blue, 512 pixels across-track.
- One *.QL.KML file in KML format, pointing to the previous QL image, and reporting the [longitude,latitude] coordinates of the four corners, in order to map the QL in Google-Earth.
- One *.QR.CSV quality report file in CSV format [COMM-PROP].

3.1.1 MES_ORT_1P: GeoTIFF images

The 4 spectral bands are saved in separate 8-bit GeoTIFF images.

The following TIF tags are filled [TIFF-SPEC].

Table 3-1. MES_ORT_1P TIFF tags

TIFF TAG name (number)	Value/Range
TIFFTAG_IMAGEWIDTH (256)	the image width (ACT direction)
TIFFTAG_IMAGELENGTH (257)	The image length (ALT direction)
TIFFTAG_SAMPLESPERPIXEL (277)	1
TIFFTAG_BITSPERSAMPLE (258)	8
TIFFTAG_PHOTOMETRIC (262)	1 (Black is zero)
TIFFTAG_PLANARCONFIG (284)	1 (simple image plane)
TIFFTAG_SAMPLEFORMAT (339)	1 (unsigned integer data)
TIFFTAG_ROWSPERSTRIP (278)	1
TIFFTAG_IMAGEDESCRIPTION (270)	B1: “MOS MESSR - Level 3 Product - VIS band B1” B2: “MOS MESSR - Level 3 Product - VIS band B2” B3: “MOS MESSR - Level 3 Product - NIR band B3” B4: “MOS MESSR - Level 3 Product - NIR band B4”

The following GeoTIF tags are filled [GTIFF-SPEC] [GTIFF-OGC-SPEC].

Table 3-2. MES_ORT_1P GeoTIFF tags

GeoTIFF TAG name (number)	Value/Range
ModelPixelScaleTag (33550)	50.0,50.0,0.0 (spacing, spacing, 0)
ModelTiepointTag (33922)	0, 0, 0, MapX-spacing/2, MapY+spacing/2,0 With MapX = Top-left corner’s northing MapY = Top-left corner’s Easting spacing = see above
GTModelTypeGeoKey (1024)	1 (Projection Coordinate System)
GTRasterTypeGeoKey (1025)	1 (Standard pixel fills grid cell)
GTCitationGeoKey (1026)	“UTM Zone <zone>[N,S] WGS84” (e.g. “UTM Zone 34N WGS84”) "MOS Level 3 - Orthorectified"
GeogLinearUnitsGeoKey (2052)	9001 (Linear Meter]
GeogAngularUnitsGeoKey (2054)	9102 (Angular Degree)
ProjectedCSTypeGeoKey (3072)	[32601,32660] (WGS84 UTM zones 1N to 60N) [32701,32760] (WGS84 UTM zones 1S to 60S)
GeographicTypeGeoKey (2048)	4326 (WGS84)
ProjectionGeoKey (3074)	(16000,17999) With: UTM (North) Format: 160zz UTM (South) Format: 161zz

3.1.2 MES_ORT_1P: XML metadata

3.1.2.1 XML files representation convention

The content of XML files is represented by a table with the following representation and meaning.

XML tag name	XML attribute name	Description	Value/Range
<elem_tag> This the name of an XML tag.		***<elem_tag_description>*** This is a brief description of the *<elem_tag>*.	A single value, or a list of values or a range of values. Notes on default values or special values can be reported.
	<attr_name> This is the name of one attribute of the tag <elem_tag>	***<attr_tag_description>*** This is a brief description of the attribute *<attr_tag>*. The light blue colour of these cells aims to points out them more.	"
<section_tag> This is the name of an XML tag that represents a "section"/level including other XML tags or sections.	***<section_tag_description>*** This is a brief description of the section/level *<section_tag>*. The heavy blue colour of these cells emphasizes more the opening of a new XML section.		
…	…	…	…
XML tag ***<section_tag>*** is closed This row points out that a previously "opened" XML section is now closed. Also in this case, the different row colour (light green) serves to highlight it.			
…	…	…	…

Table 3-3. MES_ORT_1P MD file format

XML tag name	XML attribute name	Description	Value/Range
mission		Mission identifier	MOS-1 or MOS-1b
sensor		Sensor identifier	MESSR
creation_date		Creation date	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds

	unit		UTC
product_orientation		Product orientation	MAP ORIENTED
processing_level		Processing Level	Level 3 Orthorectified
geometric_resampling_algo		Geometric resampling algorithm	Cubic Convolution
QL_file_name		Name of the QL file	file name
product_file_name		Name of the product (the folder name)	file name
scene_info	Collect parameters valid for the whole frame or computed at centre scene		
track		Track number	[1,237]
frame		Frame number	[1,496]
orbit_number		Orbit's number	>=1
orientation		Orbit's direction	DESCENDING or ASCENDING
orientation_heading		Orientation to UTM grid	[-180,180]
	unit		deg
ellipsoid		Ellipsoid identifier	WGS84
map_projection		map projection identifier	UTM
lat		Latitude	[-90,90]
	unit		deg
lon		longitude	[-90,90]
	unit		deg
utm_zone		UTM zone	[-60,60] Note: Negative values are for Southern hemisphere zones.
utmY		UTM Y	
	unit		m
utmX		UTM X	
	unit		m
vaa		Viewing Azimuth Angle	[-180,180]
	unit		deg
vea		Viewing Elevation Angle	[-90,90]
	unit		deg
vza		Viewing Zenith Angle	[-90,90]
	unit		deg
saa		Sun Azimuth Angle	[-180,180]
	unit		deg
sea		Sun Elevation Angle	[-90,90]
	unit		deg

sza		Sun Zenith Angle	[-90,90]
	unit		deg
XML tag ***scene_info*** is closed			
gcp_info	***Ground Control Point info***		
number_of_potential_gcp		Number of potential GCPs	>= 0
number_of_used_gcp		Number of used GCPs	>= 0
rmse_gcp_displacement		RMSE GCPS displacement	>= 0.0
	unit		m
XML tag ***gcp_info*** is closed			
cloud_percentage		Cloudiness percentage	[0.0,100.0] or -1 if not computed.
	unit		%
list_of_cloud_votes	Cloud votes, one for each image's quarter q=[1,4]		
cloud_vote		Quarter cloud vote	[-1,10] The votes correspond to these cloudiness percentage intervals: 0 = 0.0 1 = (1.0,10.0] 2 = (10.0,20.0] 3 = (20.0,30.0] 4 = (30.0,40.0] 5 = (40.0,50.0] 6 = (50.0,60.0] 7 = (60.0,70.0] 8 = (70.0,80.0] 9 = (80.0,90.0] 10 = (90.0,10.0] Note: -1 = No cloudiness assessment.
	column	Quarter column index	[1,2]
	row	Quarter row index	[1,2]
q-th XML tag ***cloud_vote*** is closed			
XML tag ***list_of_cloud_votes*** is closed			
list_of_bands	It collects info specific for each processed spectral band		
	count	number of bands	4
band	It collects info for a given spectral band b=[1,4]		
	name	Band name	B1,B2,B3,B4
file_name		The name of the GeoTIFF file storing the current spectral band	file name
lines		The number of image's lines	>= 1

pixels		The number of image's pixels	>= 1
pixel_size		The pixel spacing	50.0
	unit		m
sensing_start		Sensing start time	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
sensing_stop		Sensing stop time	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
DNmin		Minimum DN value in the image	[0,255]
	unit		DN
DNmax		Maximum DN value in the image	[0,255]
	unit		DN
DNmean		Mean DN value of the image	[0.0,255.0]
	unit		DN
DNstd		Standard deviation DN value of the image	[0.0,255.0]
	unit		DN
rad_gain_scale		Scale factor to convert from DN to TOA radiances *TOA = rad_gain_scale*DN + rad_bias*	1.0
	unit		W/m2/sr/m-6
rad_bias		Bias to convert from DN to TOA radiances	0.0

		*TOA = rad_gain_scale*DN + rad_bias*	
	unit		W/m2/sr/m-6
l0_input_lines		The number of processed lines of the input Level 0	>= 1
l0_input_pixels		The number of processed pixels per line of the input Level 0	>= 1
l0_missing_lines		The number of missing lines among the processed lines of the input Level 0	>= 0
corners	Collect geo-location info of each of the 4 image's corners		
corner	Geo-location info for a given image's corner c=[1,4]		
	position		TL,TR,BL,BR With: TL = Top-left TR: Top-right BL: Bottom-left BR: Bottom-right
line		Corner's line number (0-relative)	>= 0
pixel		Corner's pixel number (0-relative)	>= 0
lat		Latitude	[-90,90]
	unit		deg
lon		longitude	[-90,90]
	unit		deg
utmY		UTM Y	
	unit		m
utmX		UTM X	
	unit		m
c-th XML tag ***corner*** is closed			
XML tag ***corners*** is closed			
b-th XML tag ***band*** is closed			
XML tag ***list_of_bands*** is closed			

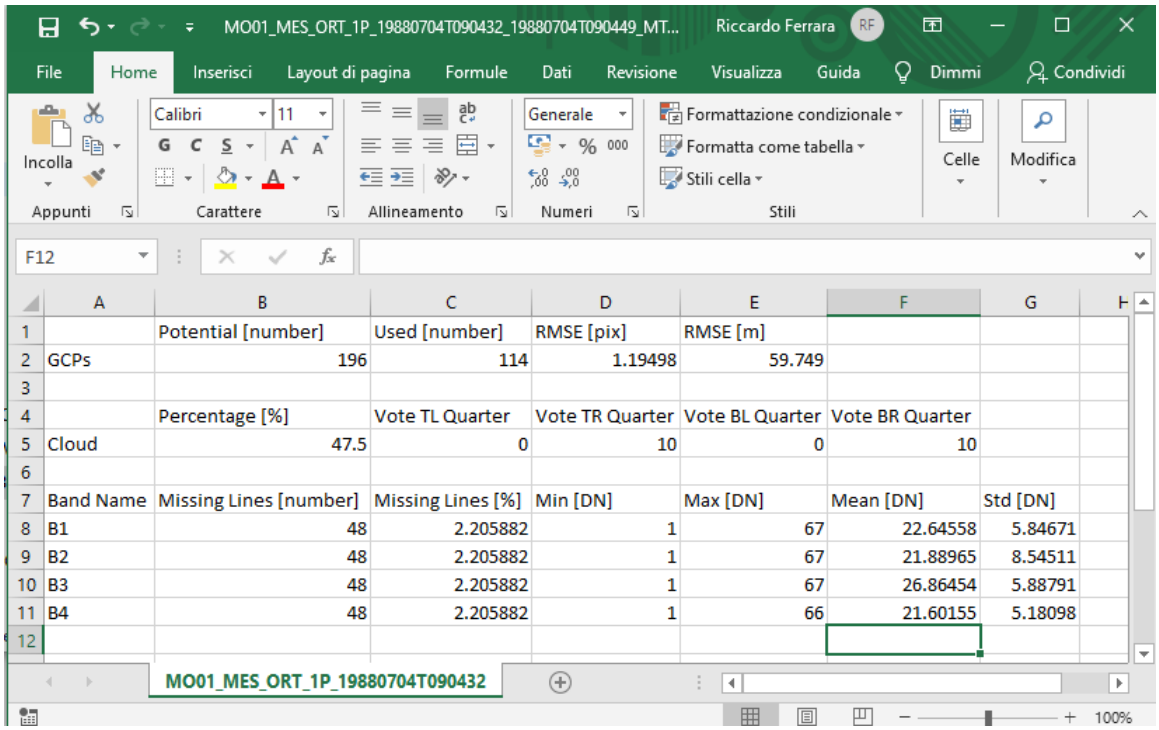
3.1.3 MES_ORT_1P: CSV quality report

The quality report in CSV format (comma separated values) contains the following info:

- Missing lines
- Number of potential GCPs

- Number of used GCPs
- RMSE GCP displacement
- Cloudiness percentage and vote (-1 values means “not computed”)
- Image statistics (min,max,average, std).

Figure 3-1. MES_ORT_1P CSV quality report file format



MO01_MES_ORT_1P_19880704T090432_19880704T090449_MT... — Riccardo Ferrara

File | Home | Inserisci | Layout di pagina | Formule | Dati | Revisione | Visualizza | Guida | Dimmi | Condividi

Incolla | Calibri | 11 | Generale | Formattazione condizionale | Formatta come tabella | Stili cella | Celle | Modifica

Appunti | Carattere | Allineamento | Numeri | Stili

F12

	A	B	C	D	E	F	G
1		Potential [number]	Used [number]	RMSE [pix]	RMSE [m]		
2	GCPs	196	114	1.19498	59.749		
3							
4		Percentage [%]	Vote TL Quarter	Vote TR Quarter	Vote BL Quarter	Vote BR Quarter	
5	Cloud	47.5	0	10	0	10	
6							
7	Band Name	Missing Lines [number]	Missing Lines [%]	Min [DN]	Max [DN]	Mean [DN]	Std [DN]
8	B1	48	2.205882	1	67	22.64558	5.84671
9	B2	48	2.205882	1	67	21.88965	8.54511
10	B3	48	2.205882	1	67	26.86454	5.88791
11	B4	48	2.205882	1	66	21.60155	5.18098
12							

MO01_MES_ORT_1P_19880704T090432

100%

3.1.4 MES_ORT_1P: Quick Look file

The Quick Look of the product is saved as a RGB + Alpha channel PNG file [PNG-SPEC]

The Quick Look size in ACT direction has a fixed dimension (the default is 512), while in ALT direction it is automatically computed in order to maintain the original aspect ratio.

The bands used to compose the RGB are the following:

- Red channel: NIR Band B3
- Green channel: VIS Band B2
- Blue channel: VIS Band B1

Track and frame numbers are annotated in the metadata of the PNG.

3.1.5 MES_ORT_1P: KML Quick Look file

An additional file in KML format [KML-SPEC] is generated, in order to In order to locate and display the product by Google Earth. This KML file points to the Quick Look PNG image and reports the product’s geo-location (by the positions of its 4 corners).

Figure 3-2. MESSR QL KML file example

MO01_MES_ORT_1...990_0000.QL.KML

```
<?xml version ="1.0" encoding="UTF-8"?>
<kml xmlns:kml="http://www.opengis.net/kml/2.2" xmlns:gx="http://www.google.com/kml/ext/2.2" xmlns="http://www.opengis.net/kml/2.2">
   <Document>
      <name>MESSR L3 98/62 Map Overlay</name>
      <Folder>
         <name>MESSR L3 98/62 Scene Overlay</name>
         <GroundOverlay>
            <name>MESSR L3 98/62 Image Overlay</name>
            <Icon>
               <href>MO01_MES_ORT_1P_19880704T090432_19880704T090449_MTI_6990_0000.QL.PNG</href>
            </Icon>
            <gx:LatLonQuad>
               <coordinates>22.0737,40.7815 23.5843,40.7576 23.6291,41.881 22.0924,41.9059</coordinates>
            </gx:LatLonQuad>
         </GroundOverlay>
      </Folder>
   </Document>
</kml>
```

3.2 MOS 1/1B MESSR SYSTEM CORRECTED LEVEL2 PRODUCTS (MES_SYC_1P)

The product is composed by several files grouped in a folder with extension “TIFF”. The folder is compressed in a zip file to facilitate the product circulation.

```
MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.TIFF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B1.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B2.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B3.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B4.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.MD.XML
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.QL.KML
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.QL.PNG
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.QR.CSV
```

The product is composed by:

- 4 images *_B[1-4].TIF in GeoTIFF format, one for each MESSR spectral band [TN-UMID-TPML]
- One *.MD.XML file in XML format, including metadata info
- One *.QL.PNG image in PNG format, containing the quick look image of the product. The image is an RGB plus Alpha channel. The default configuration is band B3 for red, band B2 for green and B1 for blue, 512 pixels across-track.
- One *.QL.KML file in KML format, pointing to the previous QL image, and reporting the [longitude,latitude] coordinates of the four corners, in order to map the QL in Google-Earth.
- One *.QR.CSV quality report file in CSV format [COMM-PROP].

The products follow the ESA naming convention according to [ESA-PROD].

3.2.1 MES_SYC_1P: GeoTIFF images

The 4 spectral bands are saved in separate 8-bit GeoTIFF images.

The following TIF tags are filled [TIFF-SPEC].

Table 3-4. MES_SYC_1P TIFF tags

TIFF TAG name (number)	Value/Range
TIFFTAG_IMAGEWIDTH (256)	the image width (ACT direction)

TIFFTAG_IMAGELENGTH (257)	The image length (ALT direction)
TIFFTAG_SAMPLESPERPIXEL (277)	1
TIFFTAG_BITSPERSAMPLE (258)	8
TIFFTAG_PHOTOMETRIC (262)	1 (Black is zero)
TIFFTAG_PLANARCONFIG (284)	1 (simple image plane)
TIFFTAG_SAMPLEFORMAT (339)	1 (unsigned integer data)
TIFFTAG_ROWSPERSTRIP (278)	1
TIFFTAG_IMAGEDESCRIPTION (270)	B1: "MOS MESSR - Level 2 Product - VIS band B1" B2: "MOS MESSR - Level 2 Product - VIS band B2" B3: "MOS MESSR - Level 2 Product - NIR band B3" B4: "MOS MESSR - Level 2 Product - NIR band B4"

The following GeoTIF tags are filled [GTIFF-SPEC] [GTIFF-OGC-SPEC].

Table 3-5. VTI_SYC_1P GeoTIFF tags

GeoTIFF TAG name (number)	Value/Range
ModelTiepointTag (33922)	tp_num*(tp_pix,tp_lin,0,tp_lon,tp_lat,tp_h) With: tp_num: number of annotated tie points tp_pix: n-th tie point ACT pixel index tp_lin: n-th tie point ALT line index tp_lon: n-th tie_point longitude [deg] tp_lat: n-th tie_point latitude [deg]
GTModelTypeGeoKey (1024)	2 (Geographic latitude-longitude system)
GTRasterTypeGeoKey (1025)	1 (Standard pixel fills grid cell)
GTCitationGeoKey (1026)	"MOS Level 2 – System Corrected"
GeogLinearUnitsGeoKey (2052)	9001 (Linear Meter]
GeogAngularUnitsGeoKey (2054)	9102 (Angular Degree)
GeographicTypeGeoKey (2048)	4326 (WGS84)
GeogEllipsoidGeoKey (2056)	7030 (WGS84, the default) Other possible ellipsoids are (see [GTIFF-SPEC] for the codes): - AIRY1849 - AUS65 - BESSEL1841 - CLARKE1858 - CLARKE1866 - CLARKEIGN1880 - EVEREST1830 - GRS80 - HELMERT07 - ED50 - NEW_INTERNATIONAL67 - KRASSOWSKY40 - PLESSIS1817 - STRUVE1860 - CLARKE1880
GeogSemiMajorAxisGeoKey (2057)	6378137.000 (for WGS84, the default)
GeogSemiMinorAxisGeoKey (2058)	6356752.314 (for WGS84, the default)
GeogInvFlatteningGeoKey (2059)	SemiMajorAxis/(SemiMajorAxis - SemiMinorAxis)

3.2.2 MES_SYC_1P: XML metadata

Table 3-6. MES_SYC_1P MD file format

XML tag name	XML attribute name	Description	Value/Range
mission		Mission identifier	MOS-1 or MOS-1b
sensor		Sensor identifier	MESSR
creation_date		Creation date	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
product_orientation		Product orientation	PATH ORIENTED
processing_level		Processing Level	Level 2
geometric_resampling_algo		Geometric resampling algorithm	Nearest Neighbour
QL_file_name		Name of the QL file	file name
product_file_name		Name of the product (the folder name)	file name
scene_info	Collect parameters valid for the whole frame or computed at centre scene		
orbit_number		Orbit's number	>=1
orientation		Orbit's direction	DESCENDING or ASCENDING
orientation_heading		Heading angle	[-180,180]
	unit		deg
ellipsoid		Ellipsoid identifier	WGS84
lat		Latitude	[-90,90]
	unit		deg
lon		longitude	[-90,90]
	unit		deg
vaa		Viewing Azimuth Angle	[-180,180]
	unit		deg
vea		Viewing Elevation Angle	[-90,90]
	unit		deg

vza		Viewing Zenith Angle	[-90,90]
	unit		deg
saa		Sun Azimuth Angle	[-180,180]
	unit		deg
sea		Sun Elevation Angle	[-90,90]
	unit		deg
sza		Sun Zenith Angle	[-90,90]
	unit		deg
cloud_percentage		Cloudiness percentage	[0.0,100] or -1 (not computed)
	unit		%
XML tag ***scene_info*** is closed			
list_of_cloud_votes	Cloud votes, one for each image's quarter q=[1,4]		
cloud_vote		Quarter cloud vote	[-1,10] The votes correspond to these cloudiness percentage intervals: 0 = 0.0 1 = (1.0,10.0] 2 = (10.0,20.0] 3 = (20.0,30.0] 4 = (30.0,40.0] 5 = (40.0,50.0] 6 = (50.0,60.0] 7 = (60.0,70.0] 8 = (70.0,80.0] 9 = (80.0,90.0] 10 = (90.0,10.0] Note: -1 = No cloudiness assessment.
	column	Quarter column index	[1,2]
	row	Quarter row index	[1,2]
q-th XML tag ***cloud_vote*** is closed			
XML tag ***list_of_cloud_votes*** is closed			
list_of_bands	It collects info specific for each processed spectral band		
	count	number of bands	4
band	It collects info for a given spectral band b=[1,4]		
	name	Band name	B1,B2,B3,B4
file_name		The name of the GeoTIFF file storing the current spectral band	file name
lines		The number of image's lines	>= 1

pixels		The number of image's pixels	>= 1
pixel_size		The pixel spacing	50.0
	unit		m
sensing_start		Sensing start time	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
sensing_stop		Sensing stop time	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
DNmin		Minimum DN value in the image	[0,255]
	unit		DN
DNmax		Maximum DN value in the image	[0,255]
	unit		DN
DNmean		Mean DN value of the image	[0.0,255.0]
	unit		DN
DNstd		Standard deviation DN value of the image	[0.0,255.0]
	unit		DN
rad_gain_scale		Scale factor to convert from DN to TOA radiances *TOA = rad_gain_scale*DN + rad_bias*	1.0
	unit		W/m2/sr/m-6
rad_bias		Bias to convert from DN to TOA radiances	0.0

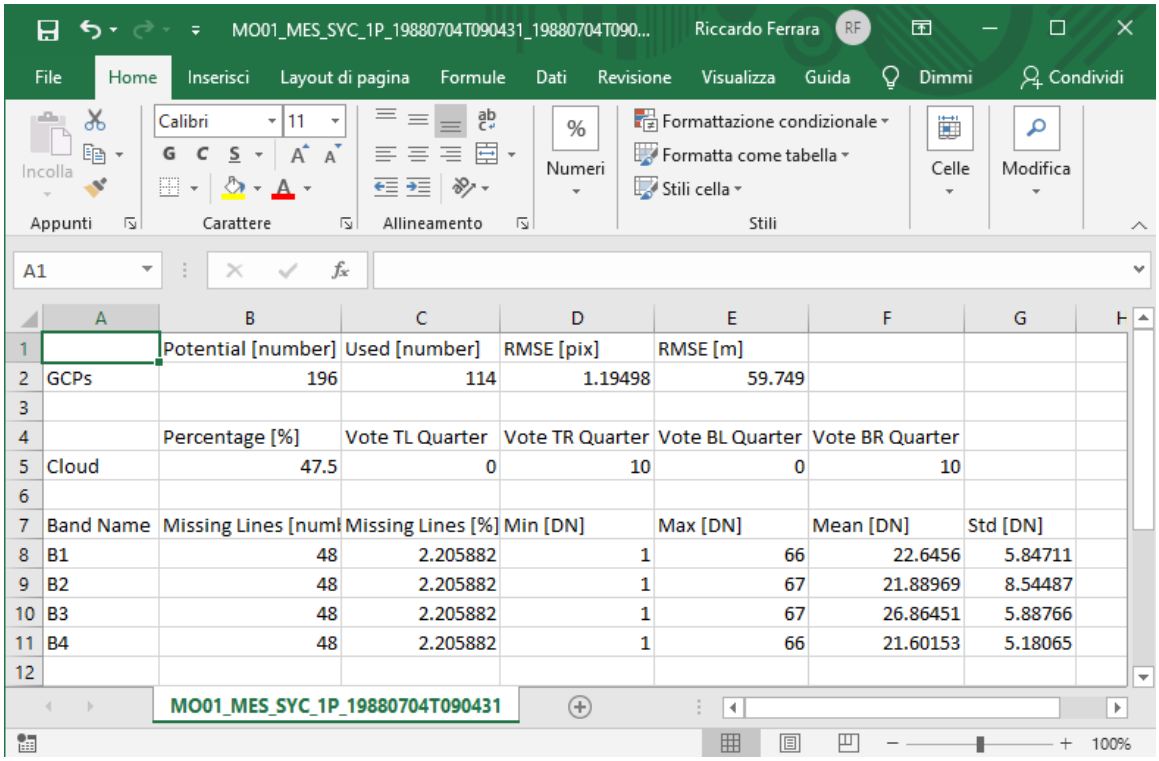
		*TOA = rad_gain_scale*DN + rad_bias*	
	unit		W/m2/sr/m-6
l0_input_lines		The number of processed lines of the input Level 0	>= 1
l0_input_pixels		The number of processed pixels per line of the input Level 0	>= 1
l0_missing_lines		The number of missing lines among the processed lines of the input Level 0	>= 0
corners	Collect geo-location info of each of the 4 image's corners		
corner	Geo-location info for a given image's corner c=[1,4]		
	position		TL,TR,BL,BR With: TL = Top-left TR: Top-right BL: Bottom-left BR: Bottom-right
line		Corner's line number (0-relative)	>= 0
pixel		Corner's pixel number (0-relative)	>= 0
lat		Latitude	[-90,90]
	unit		deg
lon		longitude	[-90,90]
	unit		deg
c-th XML tag ***corner*** is closed			
XML tag ***corners*** is closed			
b-th XML tag ***band*** is closed			
XML tag ***list_of_bands*** is closed			

3.2.3 MES_SYC_1P: CSV quality report

The quality report in CSV format (comma separated values) contains the following info:

- Missing lines
- Cloudiness percentage and vote (-1 values means "not computed")
- Image statistics (min,max,average, std).

Figure 3-3. MES_SYC_1P CSV quality report file format



	A	B	C	D	E	F	G
1		Potential [number]	Used [number]	RMSE [pix]	RMSE [m]		
2	GCPs	196	114	1.19498	59.749		
3							
4		Percentage [%]	Vote TL Quarter	Vote TR Quarter	Vote BL Quarter	Vote BR Quarter	
5	Cloud	47.5	0	10	0	10	
6							
7	Band Name	Missing Lines [numl	Missing Lines [%]	Min [DN]	Max [DN]	Mean [DN]	Std [DN]
8	B1	48	2.205882	1	66	22.6456	5.84711
9	B2	48	2.205882	1	67	21.88969	8.54487
10	B3	48	2.205882	1	67	26.86451	5.88766
11	B4	48	2.205882	1	66	21.60153	5.18065
12							

3.2.4 MES_SYC_1P: Quick Look file

The description done in 3.1.4 is still valid.

3.2.5 MES_SYC_1P: KML Quick Look file

See 3.1.5.

Figure 3-4. MES_SYC_1P QL KML file example

MO01_MES_SYC_1...990_0000.QL.KML

```
<?xml version ="1.0" encoding="UTF-8"?>
<kml xmlns:kml="http://www.opengis.net/kml/2.2" xmlns:gx="http://www.google.com/kml/ext/2.2" xmlns="http://www.opengis.net/kml/2.2">
   <Document>
      <name>MESSR L2 98/62 Map Overlay</name>
      <Folder>
         <name>MESSR L2 98/62 Scene Overlay</name>
         <GroundOverlay>
            <name>MESSR L2 98/62 Image Overlay</name>
            <Icon>
               <href>MO01_MES_SYC_1P_19880704T090431_19880704T090449_MTI_6990_0000.QL.PNG</href>
            </Icon>
            <gx:LatLonQuad>
               <coordinates>22.1956,40.7695 23.7087,40.7439 23.7557,41.8677 22.2163,41.8943</coordinates>
            </gx:LatLonQuad>
         </GroundOverlay>
      </Folder>
   </Document>
</kml>
```

3.3 Time correlation files (AUX_TC_MM1 and AUX_TC_MV1)

The product is composed by several files grouped in a folder with extension “TIFF”. The folder is compressed in a zip file to facilitate the product circulation

Table 3-7. Time correlation files AUC_TC_MM1 and AUX_TC_MV1

XML tag name	XML attribute name	Description	Value/Range
TimeCorrelation			
UtcTime		UTC time	UTC=YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Year MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
TimeCode		Time code	[1,1000000000]
ClockStep		Clock step	[1,1000000000]
AlongTrackBias		It is an approximate correction of across track absolute localization valid for a whole pass. It is an angle in radians from the center of the earth, locally perpendicular to satellite velocity. It is calculated from MESSR data using GCPs. It is aimed to correct VTIR data from the same pass or as a first correction for MESSR for closeby passes to aid finding GCPs.	Any angle in radians (it should be small).
XML tag ***TimeCorrelation*** is closed			
L0TimeInfo			
LineNumber		L0 line number	>= 1
TimeCode		Time code	[1,1000000000]
UtcTime		UTC time	UTC=YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Year MM: Month DD: Day of month

			HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
XML tag ***L0TimeInfo*** is closed			

4. MOS 1/1B VTIR SYSTEM CORRECTED LEVEL2 PRODUCTS (VTI_SYC_1P)

The product is composed by several files grouped in a folder with extension “TIFF”. The folder is compressed in a zip file to facilitate the product circulation.

```
MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.TIFF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B1.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B2.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B3.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000_B4.TIF
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.MD.XML
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.QL.KML
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.QL.PNG
|--> MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.QR.CSV
```

The product is composed by:

- 4 images *_B[1-4].TIF in GeoTIFF format, one for each VTIR spectral band [TN-UMID-TPML]
- One *.MD.XML file in XML format, including metadata info
- One *.QL.PNG image in PNG format, containing the quick look image of the product. The image is an RGB plus Alpha channel. VTIR has only one VIS band, the B1, so all the three RGB channels are put equal to B1.
- One *.QL.KML file in KML format, pointing to the previous QL image, and reporting the [longitude,latitude] coordinates of the four corners, in order to map the QL in Google-Earth.
- One *.QR.CSV quality report file in CSV format [COMM-PROP].

The products follow the ESA naming convention according to [ESA-PROD].

4.1 VTI_SYC_1P: GeoTIFF images

The 4 spectral bands are saved in separate 8-bit GeoTIFF images.

The following TIF tags are filled [TIFF-SPEC].

Table 4-1. VTI_SYC_1P TIFF tags

TIFF TAG name (number)	Value/Range
TIFFTAG_IMAGEWIDTH (256)	the image width (ACT direction)
TIFFTAG_IMAGELENGTH (257)	The image length (ALT direction)
TIFFTAG_SAMPLESPERPIXEL (277)	1
TIFFTAG_BITSPERSAMPLE (258)	8
TIFFTAG_PHOTOMETRIC (262)	1 (Black is zero)
TIFFTAG_PLANARCONFIG (284)	1 (simple image plane)
TIFFTAG_SAMPLEFORMAT (339)	1 (unsigned integer data)
TIFFTAG_ROWSPERSTRIP (278)	1
TIFFTAG_IMAGEDESCRIPTION (270)	B1: “MOS VTIR - Level 2 Product - VIS band B1” B2: “MOS VTIR - Level 2 Product - TIR band B2” B3: MOS VTIR - Level 2 Product - TIR band B3” B4: “MOS VTIR - Level 2 Product - TIR band B4”

The following GeoTIF tags are filled [GTIFF-SPEC] [GTIFF-OGC-SPEC].

Table 4-2. VTI_SYC_1P GeoTIFF tags

GeoTIFF TAG name (number)	Value/Range
ModelTiepointTag (33922)	tp_num*(tp_pix,tp_lin,0,tp_lon,tp_lat,tp_h) With: tp_num: number of annotated tie points tp_pix: n-th tie point ACT pixel index tp_lin: n-th tie point ALT line index tp_lon: n-th tie_point longitude [deg] tp_lat: n-th tie_point latitude [deg]
GTModelTypeGeoKey (1024)	2 (Geographic latitude-longitude system)
GTRasterTypeGeoKey (1025)	1 (Standard pixel fills grid cell)
GTCitationGeoKey (1026)	"MOS Level 2 – System Corrected"
GeogLinearUnitsGeoKey (2052)	9001 (Linear Meter]
GeogAngularUnitsGeoKey (2054)	9102 (Angular Degree)
GeographicTypeGeoKey (2048)	4326 (WGS84)
GeogEllipsoidGeoKey (2056)	7030 (WGS84, the default) Other possible ellipsoids are (see [GTIFF-SPEC] for the codes): - AIRY1849 - AUS65 - BESSEL1841 - CLARKE1858 - CLARKE1866 - CLARKEIGN1880 - EVEREST1830 - GRS80 - HELMERT07 - ED50 - NEW_INTERNATIONAL67 - KRASSOWSKY40 - PLESSIS1817 - STRUVE1860 - CLARKE1880
GeogSemiMajorAxisGeoKey (2057)	6378137.000 (for WGS84, the default)
GeogSemiMinorAxisGeoKey (2058)	6356752.314 (for WGS84, the default)
GeogInvFlatteningGeoKey (2059)	SemiMajorAxis/(SemiMajorAxis - SemiMinorAxis)

4.2 VTI_SYC_1P: XML metadata

Table 4-3. VTI_SYC_1P MD file format

XML tag name	XML attribute name	Description	Value/Range
mission		Mission identifier	MOS-1 or MOS-1b
sensor		Sensor identifier	VTIR
creation_date		Creation date	YYYY-MM-DDTHH:mm:ss.xxxxxx

			With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
product_orientation		Product orientation	PATH ORIENTED
processing_level		Processing Level	Level 2
geometric_resampling_algo		Geometric resampling algorithm	Nearest Neighbour
QL_file_name		Name of the QL file	file name
product_file_name		Name of the product (the folder name)	file name
scene_info	Collect parameters valid for the whole frame or computed at centre scene		
orbit_number		Orbit's number	>=1
orientation		Orbit's direction	DESCENDING or ASCENDING
orientation_heading		Heading angle	[-180,180]
	unit		deg
ellipsoid		Ellipsoid identifier	WGS84
lat		Latitude	[-90,90]
	unit		deg
lon		longitude	[-90,90]
	unit		deg
vaa		Viewing Azimuth Angle	[-180,180]
	unit		deg
vea		Viewing Elevation Angle	[-90,90]
	unit		deg
vza		Viewing Zenith Angle	[-90,90]
	unit		deg
saa		Sun Azimuth Angle	[-180,180]
	unit		deg
sea		Sun Elevation Angle	[-90,90]
	unit		deg
sza		Sun Zenith Angle	[-90,90]
	unit		deg
cloud_percentage		Cloudiness percentage	[0.0,100] or -1 (not computed)
	unit		%

XML tag ***scene_info*** is closed			
list_of_cloud_votes	Cloud votes, one for each image's quarter q=[1,4] Note: For VTIR it is always empty, due to lack of cloudiness info in input Level 0.		
cloud_vote		Quarter cloud vote	[-1,10] The votes correspond to these cloudiness percentage intervals: 0 = 0.0 1 = (1.0,10.0] 2 = (10.0,20.0] 3 = (20.0,30.0] 4 = (30.0,40.0] 5 = (40.0,50.0] 6 = (50.0,60.0] 7 = (60.0,70.0] 8 = (70.0,80.0] 9 = (80.0,90.0] 10 = (90.0,10.0] Note: -1 = No cloudiness assessment.
	column	Quarter column index	[1,2]
	row	Quarter row index	[1,2]
q-th XML tag ***cloud_vote*** is closed			
XML tag ***list_of_cloud_votes*** is closed			
list_of_bands	It collects info specific for each processed spectral band		
	count	number of bands	4
band	It collects info for a given spectral band b=[1,4]		
	name	Band name	B1,B2,B3,B4
file_name		The name of the GeoTIFF file storing the current spectral band	file name
lines		The number of image's lines	>= 1
pixels		The number of image's pixels	>= 1
pixel_size		The pixel spacing	880.0
	unit		m
sensing_start		Sensing start time	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour

			mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
sensing_stop		Sensing stop time	YYYY-MM-DDTHH:mm:ss.xxxxxx With: YYYY: Yesr MM: Month DD: Day of month HH: hour mm: minutes ss: seconds xxxxxx: milliseconds
	unit		UTC
DNmin		Minimum DN value in the image	[0,255]
	unit		DN
DNmax		Maximum DN value in the image	[0,255]
	unit		DN
DNmean		Mean DN value of the image	[0.0,255.0]
	unit		DN
DNstd		Standard deviation DN value of the image	[0.0,255.0]
	unit		DN
rad_gain_scale		Scale factor to convert from DN to TOA radiances *TOA = rad_gain_scale*DN + rad_bias*	1.0
	unit		W/m2/sr/m-6
rad_bias		Bias to convert from DN to TOA radiances *TOA = rad_gain_scale*DN + rad_bias*	0.0
	unit		W/m2/sr/m-6
l0_input_lines		The number of processed lines of the input Level 0	>= 1
l0_input_pixels		The number of processed pixels per line of the input Level 0	>= 1
l0_missing_lines		The number of missing lines among the	>= 0

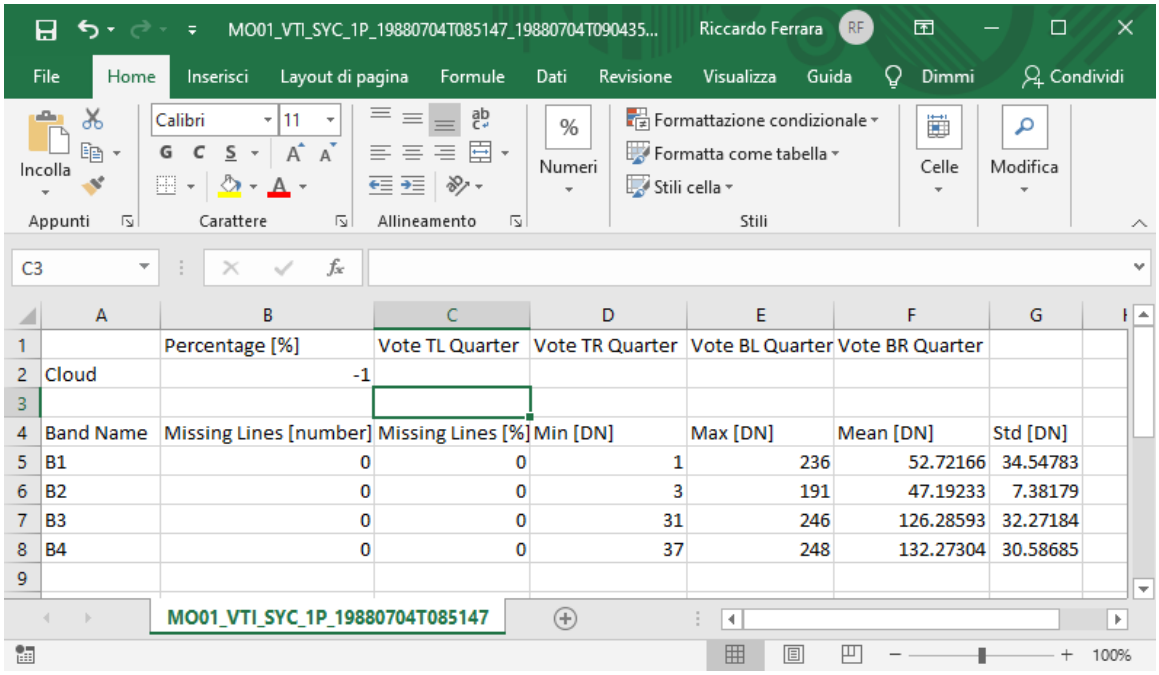
		processed lines of the input Level 0	
corners	Collect geo-location info of each of the 4 image's corners		
corner	Geo-location info for a given image's corner c=[1,4]		
	position		TL,TR,BL,BR With: TL = Top-left TR: Top-right BL: Bottom-left BR: Bottom-right
line		Corner's line number (0-relative)	>= 0
pixel		Corner's pixel number (0-relative)	>= 0
lat		Latitude	[-90,90]
	unit		deg
lon		longitude	[-90,90]
	unit		deg
c-th XML tag ***corner*** is closed			
XML tag ***corners*** is closed			
b-th XML tag ***band*** is closed			
XML tag ***list_of_bands*** is closed			

4.3 VTI_SYC_1P: CSV quality report

The quality report in CSV format (comma separated values) contains the following info:

- Missing lines
- Cloudiness percentage and vote (-1 values means "not computed")
- Image statistics (min,max,average, std).

Figure 4-1. VTI_SYC_1P CSV quality report file format



	A	B	C	D	E	F	G
1		Percentage [%]	Vote TL Quarter	Vote TR Quarter	Vote BL Quarter	Vote BR Quarter	
2	Cloud	-1					
3							
4	Band Name	Missing Lines [number]	Missing Lines [%]	Min [DN]	Max [DN]	Mean [DN]	Std [DN]
5	B1	0	0	1	236	52.72166	34.54783
6	B2	0	0	3	191	47.19233	7.38179
7	B3	0	0	31	246	126.28593	32.27184
8	B4	0	0	37	248	132.27304	30.58685
9							

4.4 VTI_SYC_1P: Quick Look file

The Quick Look of the product is saved as a RGB + Alpha channel PNG file [PNG-SPEC].

The Quick Look size in ACT direction has a fixed dimension (the default is 512), while in ALT direction it is automatically computed in order to maintain the original aspect ratio.

All the RGB channels are put equal to the VIS band B1, resulting in an image in grey-scale.

4.5 VTY_SYC_1P: KML Quick Look file

See 3.1.5.

Figure 4-2. VTI_SYC_1P QL KML file example

MO01_VTI_SYC_1...990_0000.QL.KML

```
<?xml version ="1.0" encoding="UTF-8"?>
<kml xmlns:kml="http://www.opengis.net/kml/2.2" xmlns:gx="http://www.google.com/kml/ext/2.2" xmlns="http://www.opengis.net/kml/2.2">
   <Document>
      <name>VTIR L2 Map Overlay</name>
      <Folder>
         <name>VTIR L2 Scene Overlay</name>
         <GroundOverlay>
            <name>VTIR L2 Image Overlay</name>
            <Icon>
               <href>MO01_VTI_SYC_1P_19880704T085147_19880704T090435_KSE_6990_0000.QL.PNG</href>
            </Icon>
            <gx:LatLonQuad>
               <coordinates>6.60308,43.0664 32.0616,39.9467 96.7965,73.821 -30.4216,85.3089</coordinates>
            </gx:LatLonQuad>
         </GroundOverlay>
      </Folder>
   </Document>
</kml>
```

End of Document