MTG EUMETCast Africa Product User Guide [AfricaPUG]

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Document Change Record

Issue / Revision	*Date*	*DCN. No*	*Changed Pages / Paragraphs*
1	13/12/2019		Creation.
1A	16/12/2019		Merged all products for EUMETCast Africa. Source of information: • FCI 1C datasets based on [FCIL1PUG] v1H. • FCI level 2 based on [FCIL2FS] v2I and ATBD. • RGBs from: o Compilation of RGB Recipes, #1140581 o MSG Channels and RGB Colour Interpretation Guide, #919413 PDF guides: http://eumetrain.org/rgb_quick_guides/index.html
1B-1E	07/01/2020		Internal reviews for feasibility assessment.
2	09/03/2020		This preliminary version provides more details than those presented at the RAIDEG meetings and is submitted to RA-I-DEG for a last check that the proposed approach fulfils the needs of the users.
2A	14/07/2020		It reflects the status after the RAIDEG meeting in June 2020. §1.3.1 clarified Africa specific aspects in [GFS]. §1.4 open issues and assumptions §2.2 Slight modifications to align text with update in [FCIL1PUG], Version 1J §3.8 Remove bullet ‘Solar zenith angle calculation’. Alignment with [FCIL1PUG], Version 1J §4.1.3 Table 8 corrected the periodicity and SSD for Fire RGB in line with agreement at RAIDEG #10. Table 9 & 10: Clarified SCON and NMPHY dissemination. §4.3 The description of the RGB NMPHY, on the micro-physics of clouds particles, has been improved also adding a link to a guide. §4.7 added for characteristics of locally generated RGB §6 Added products sizes for LI-2-AFA. §7 SAF A.3 Slight modifications to align text with update in [FCIL1PUG], Version 1J Miscellaneous tracked with change bars.
2B	15/01/2021		§1.1 Scope and status updated

			§1.4 open issues updated, in particular the #6 & #7 on SAF. §5.4 Clarified that OCA is an option, should the available bandwidth would increase, as per open issue #4. It is not currently part of the baseline. §3.2 removed an ambiguity by clarifying that each FCI channel after application of the coverage mask is in a single file without chunk. §7 The list of disseminated SAF products is not yet agreed. This chapter provides only a list of candidate.

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1 INTRODUCTION

1.1 Scope

The proposed dissemination approach for MTG products via EUMETCast Africa has been discussed during successive WMO RA-I-DEG sessions over the last years. This preliminary Product User Guide provides more details on the disseminated product proposal and is submitted to RA-I-DEG for feedback / validation.

It reflects the status after the RAIDEG meeting in June 2020 and December 2021.

The dissemination proposal, as documented in [MTGDIS], has been approved by EUMETSAT Council in December 2020. Internal software development to implement the agreed baseline is on-going.

The residual open points will be addressed during future RAIDEG and evolution of the dissemination proposal will be submitted to the EUMETSAT Council for approval.

Relevant information will also be provided by EUMETSAT to reception station and display system manufacturers to support the adaptation of their systems to the EUMETCast Africa baseline.

This document is a User Guide for the Meteosat Third Generation (MTG) products disseminated by EUMETCast Africa. It describes the specifics of the dissemination via EUMETCast Africa by amending when relevant the Products User Guides.

The IODC services provided by MSG are not addressed in this document.

The bandwidth for the dissemination of products via EUMETCast Africa is very limited. Consequently, products for EUMETCast Europe (which are the inputs for EUMETCast Africa) have been tailored in order to provide the best fit for the needs of the End Users.

Although this document represents our current best knowledge of the instruments, and their customisations, it is likely that there will be evolutions in this knowledge in the years up to the launch of the first MTG satellite that will lead to updates in future releases of this document.

The following table presents the products presented in this document.

Description	Customised for EUMETCast Africa?	Section
16 products corresponding to the 16 FCI channels (Tuned MSG continuity with MTG innovation)	Customised	3.3
HRV continuity	Customised	3.3
FCI Severe Storm RGB	Customised	4.2
FCI Night Micro-physics RGB	Customised	4.3
FCI True Colour RGB	Customised	4.4
FCI Fire Temperature RGB	Customised	4.5
FCI Cloud Phase RGB	Customised	4.6

Description	Customised for EUMETCast Africa?	Section
FCI Fire product	Native	5.2
Subset of the FCI Global Instability Indices	Customised	5.3
Subset of the FCI Optical Cloud Analysis (option)	Customised	5.4
Lightning Imager, Accumulated Flash Area	Native	6
Subset of SAF Products	Customised	7

The column "Customised for EUMETCast Africa" means:

- Customised: This product is generated specifically for End Users in Africa.
- Native: This is one of the standard MTG products, and thus standard documentation is applicable. For example, [LIL2PUG] will be the Product User Guide for LI-2-AFA.

1.2 Acronyms and Definitions

Abbreviation/Term	Meaning
ABI	Advanced Baseline Imager
AHI	Advanced Himawari Imager
DT	Data Tailor (formerly EPCT)
EPCT	EUMETSAT Product Customisation Toolbox (currently Data Tailor)
FCI	Flexible Combined Imager
FD	Full Disc
FDHSI	Full Disc High Spectral Resolution Imagery
FDSS	Full Disc Scanning Service
IR	Infrared
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
ncML	netCDF Markup Language
netCDF	network Common Data Format
NIR	Near-Infrared
RC	Repeat Cycle
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SRF	Spectral Response Function
SSD	Spatial Sample Distance
TAS	Thales Alenia Space
UTC	Coordinated Universal Time
VIIRS	Visible Infrared Imaging Radiometer Suite (NOAA instrument)
VIS	Visible
VNIR	Visible and Near Infrared
VSM	Variable Source Matrix

Abbreviation/Term	Meaning
WMO	World Meteorological Organisation
XML	Extensible Markup Language

1.3 Applicable and Reference Documents

1.3.1 Applicable Documents

Acronym	Reference Number	Title
[FCIL1FS]	EUM/MTG/SPE/10/0447, v4A	MTG FCI Level 0 & 1 Format Specification
[FCIL1PUG]	EUM/MTG/USR/13/719113	MTG FCI L1 Product User Guide
[FCIL2PUG]	TBW (not yet available)	MTG FCI L2 Product User Guide
[GFS] (2)	EUM/MTG/SPE/11/0252, v4A	MTG Generic Format Specification
[LIL2PUG]	EUM/GEO/TEN/15/828715, Draft (not yet available)	MTG LI L2 Product User Guide
[MTGDIS] (1)	EUM/MTG/DOC/17/946090	MTG Products Distribution Baseline
[SAFPUG]	TBW	MTG SAF Product User Guide

(1) It will be replaced once available (after the launch) by the corporate EUMETCast dissemination baseline document.

(2) *[GFS] is expanded as follows:*

- *"type" can also take the value "RGB".*
- *"subtype" can also take the value "3KM", "1KM", "SCON", "NMPHY", "TCOL", "FIRET", "CPHAS", "AFRICA".*
- *"coverage" can also take the value "AF" (referring to a subset focused on Africa).*

1.3.2 Reference Documents

Acronym	Reference Number	Title
[CF]	http://cfconventions.org/	CF Conventions Document
[Meteosat-Grids]	https://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_CONF_2018_S1_MUELLER_P&RevisionSelectionMethod=LatestReleased&Rendition=Web	Geostationary Projection Grids for Three Generations of METEOSAT, Poster and Proceedings, EUMETSAT Meteorological Satellite Conference, 2018
[Miller]	https://doi.org/10.1175/BAMS-D-15-00154.1	A sight for sore eyes.
[NACDD]	https://geo-ide.noaa.gov/wiki/index.php?title=NetCDF_Attribute_Convention_for_Dataset_Discovery	NetCDF Attribute Convention for Dataset Discovery

Acronym	Reference Number	Title
[WMO-386]	http://www.wmo.int/pages/prog/www/ois/Operational_Information/Publications/WMO_386/WMO_386_Vol_I_2009_en.pdf	WMO Manual on the Global Telecommunication System - Volume I. 2009 Edition.

1.4 Open Issues & Assumptions

Open Issues from corresponding Product User Guides (for example: [FCIL1PUG]) are also relevant for products disseminated via EUMETCast Africa. Therefore, this section only presents additional Open Issues that are relevant for EUMETCast Africa only.

ID	Description
1	**Product sizes** All product sizes and data rates are estimated before launch and will be refined during in-orbit commissioning). They are typical values and are subject to change in particular due to actual meteorological conditions.
2	**In case of data rate larger than 3.5 Mbps** Should the product be larger than foreseen, exceeding the allocated bandwidth, the periodicity and coverage of channels and central RGB will be tuned to fit the allocation (no drop of channel or product). See also **Coverage mask for RGB night microphysics (FCI-RGB-NMPHY-AF).**
3	**Coverage mask for RGB night microphysics (FCI-RGB-NMPHY-AF)** As per extraordinary RAIDEG of June 2020, the coverage for FCI-RGB-NMPHY-AF has been extended to Africa + 1650km offshore with the assumption that more bandwidth should be available at night, due to a higher compression ratio of visible channels. Should the bandwidth at night be insufficient, the coverage of this product can be reduced to subsahara+ 20km.
4	**In case of required data rate smaller than estimated** Should the product be smaller than foreseen, below the allocated bandwidth, the RAIDEG will be able to select between: • some additional SAF, or • an improvement of channel/central RGB periodicity, or • changing product coverage, or • adding a subset of OCA (currently no OCA in the baseline)
5	**Coverage over islands** Current situation: It remains to be clarified for islands from the Atlantic and Pacific Oceans to the waters off Africa which ones are included in the coverage while ensuring a compromise between coverage, bandwidth and spatio-temporal continuity. Way forward: To be revisited when implementing the precise coverage per product, to be reviewed during a RAIDEG in 2021.

<table>
<tr><th>ID</th><th>Description</th></tr>
<tr><td>6</td><td>NWC-SAF in reception station
<u>Current situation:</u>
The inclusion of NWC SAF software in the reception stations (e.g. PUMA 20XX) would require complex SW adaptation to cope with specific aspects of EUMETCast Africa dissemination (e.g. file format, chunking, channel resolution of 3x3, coverage & periodicity configurable per channel). During execution an internet access is regularly required but cannot be assumed (and is thus a showstopper).
This has been analysed by the NWCSAF and discarded. The main difficulties are the reduced periodicity of some channels and the need of access to internet
<u>Way forward/Assumption:</u>
Thus this is no more considered and being replaced by the central generation/dissemination of NWCSAF products (see next item).
Alternatively:
- EUMETCast terrestrial would solve the problem for those able to connect in 2024 (connectivity tests on-going).
- External funding to cover dissemination cost would allow to disseminate more data and run NWCSAF software locally (after some tuning).</td></tr>
<tr><td>7</td><td>Centrally generated/disseminated NWC SAF
<u>Current situation:</u>
The list of disseminated SAF products is not yet agreed. The chapter 7 SAF Products provides only a list of candidate. Some MSG based SAF products are generated in EUMETSAT by executing the NWCSAF software (e.g. RDT) and then disseminated. There is a global provision of 0.4Mbps for the SAF in the bandwidth. However, this provision is not sufficient for transmitting all the MTG SAF products. Taking the example of RDT, a preliminary assessment indicates a significant impact on bandwidth e.g. around 0.2Mbps for a sub-sahara coverage every 10mn before compression.
<u>Way forward:</u>
RAIDEG to review the needs, potential solution and assess priorities among the SAF and NWCSAF products.
NWC SAF to support EUMETSAT for tailoring/configuring the NWCSAF to reduce the volume of data (e.g. no forecast only diagnosis, remove 2D image, remove lat/lon plan, subsahara + 1650km off-shore, lossless compression…) while satisfying the African User main needs. If deemed necessary, consider to make it part of SAF proposal for decision by EUM council by June 2021 for an implementation after March 2022 (as part of CDOP-4).
EUMETSAT to run centrally the tailored NWCSAF and disseminate the agreed tailored subset of the NWCSAF and SAF products.</td></tr>
</table>

ID	Description
8	**Non duplication on EUMETCast terrestrial** Assumption: The data disseminated via EUMETCast Africa are not duplicated via EUMETCast terrestrial. Rationale: No use case identified for reception of EUMETCast Africa data via EUMETCast TERrestrial. If a user in Africa has access to EUMETCast TERrestrial with enough bandwidth, it is able to retrieve from it a copy of the EUMETCast Europe data with higher quality (resolution, coverage, periodicity…) compared to EUMETCast Africa. Way Forward: It will be re-addressed in the future when we know how many users are able to connect to the Terrestrial service and the associated performance. Should this assumption be erroneous, it will be easy to reconfigure EUMETCast at any time, to add a copy of EUMETCast Africa on EUMETCast TERrestrial.

2 MISSION OVERVIEW AND GENERAL CONSIDERATIONS

This document has been written taking other Product User Guides as a reference. Therefore, in order to avoid duplicating information references to the original Product User Guide are provided throughout this document.

2.1 Mission overview

MTG is a highly innovative geostationary satellite system for Europe and Africa to support meteorological and related environmental services, especially for improving forecasts from several minutes up to a few hours ('nowcasts'). Forecasts such as these are the 'last line of defence' in weather forecasting, vital to protect the life and property of citizens in the case of severe storm events, and for complementing the skill of numerical weather prediction models.

As the successor of the current Meteosat Second Generation (MSG), MTG has the capability to fulfil the geostationary satellite data requirements of users in Europe and Africa, needed to continue supporting and improving applications and services at national meteorological centres. The first MTG data are planned to be available in 2022, when the commissioning will start..

The MTG programme includes the following observation missions on the MTG-I (Imager) satellite series, for the benefit of enhanced weather and related environmental services

- **Spectral imagery mission, achieved through the Flexible Combined Imager (FCI)**, providing 16 channels in the visible and infrared spectrum with a spatial sampling distance in the range of 1-2 km (also called normal resolution or Full Disc High Spectral resolution Imagery (FDHSI)); and/or four channels with a spatial sampling distance in the range 0.5-1 km (also called High spatial Resolution Fast Imagery (HRFI)). The FCI scans the Earth disc in 10 minutes in support of the Full Disc Scanning Service (FDSS), or the upper quarter of the disc (i.e., Europe) in 2.5 minutes in support of the Rapid Scanning Service (RSS).

- **Lightning imagery mission, achieved through the Lightning Imager (LI) instrument**, detecting lightning discharges taking place in clouds or between cloud and ground continuously over almost the full Earth disc, with a location defined in a grid of 2km..

The EUMETCast Africa service will provide data products to End Users derived from the FCI Full Disc Scanning Service (FDSS) and the LI instrument.

Applications benefitting from the MTG spectral imager (FCI) include:

- ***detection of rapid atmospheric processes such as severe storms;***
- ***monitoring of clouds, dust outbreaks, aerosols, fires, land surface changes and a range of other phenomena.***

Applications benefitting from the MTG lightning imager (LI) include:

- ***improved monitoring and forecasting of severe storms;***
- ***enhanced lightning-related safety for air traffic routing and control.***

The following sections introduced general information necessary to understand the rest of the document.

2.2 Level 1c Reference Grid tailored for EUMETCast Africa

The reference grid defines the geo-referenced position of the *image pixel centroids* of FCI imagery at *level 1c* in a normalized geostationary projection. The normalized geostationary projection describes the view from a virtual satellite to an idealized Earth. The virtual satellite is in a geostationary orbit, perfectly located in the Equator plane at nominally 0 degrees longitude. This point on the equator is the origin of the projection.

The level 1c Reference Grid steps are equiangular in both the virtual satellite azimuth and elevation and equal to the *spatial sampling angle* of the considered channel. The corresponding projected distance at the *sub-satellite point* is the *spatial sampling distance (SSD)*.

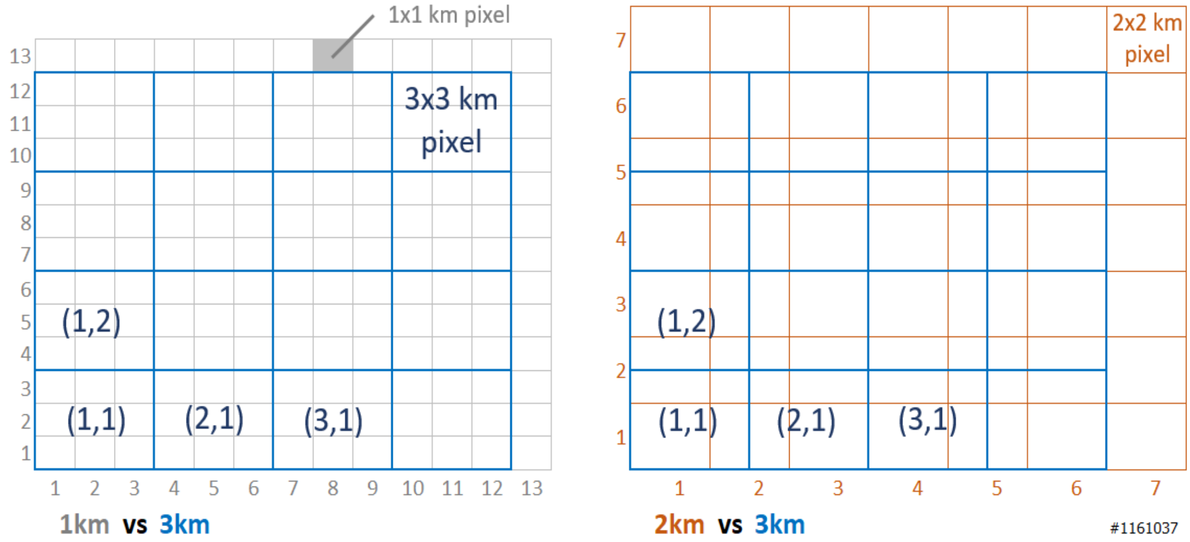

Figure 1: Diagrams illustrating the spatial alignment of the L1c reference grids.

The Figure 1 illustrates how the reference grids for the different SSD values are aligned, with the origin pixel at position (1,1) located in the SW corner. Information to generate the reference grid in the GEOS "Normalized Geostationary Projection" is provided in the dataset. Information on how to use the parameters given in the Level 1c product to reconstruct the reference grid are provided in [FCIL1PUG]. Additional information about the Meteosat grids is provided in [Meteosat-Grids]. Note that the 3x3km grid is unique for the products that are disseminated via EUMETCast Africa.

The normalized geostationary projection defines the line of sight of each pixel centre P as a vector representing the view from the virtual satellite. This vector is expressed as a function of the two angles elevation (ϕ_S) and azimuth (λ_S) and is defined as follows:

$$\lambda_s = \arctan\left(\frac{r_2}{r_1}\right)$$

$$\phi_s = \arcsin\left(\frac{r_3}{\sqrt{r_1^2 + r_2^2 + r_3^2}}\right)$$

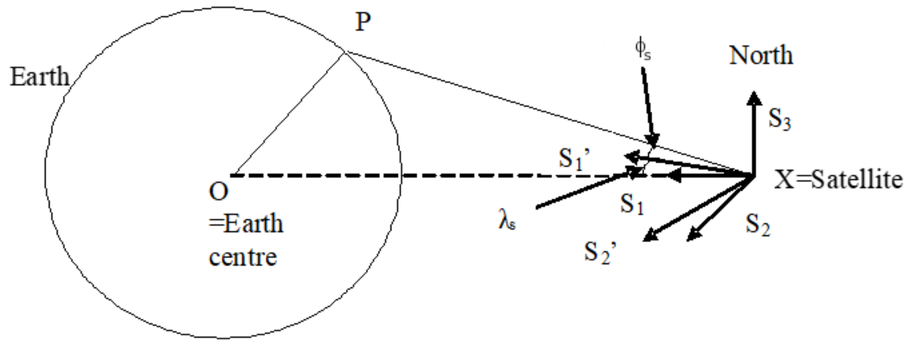

Figure 2: Angular Definition of the Reference Grid

The diagram above shows the angular definition of the reference grid where:

1. the frame (s1,s2,s3) has its origin at the satellite position, (s3) points northwards, and (s1) directs to the centre of the Earth
2. the vector r of coordinates (r_1, r_2, r_3) in the frame (s1,s2,s3) is a pixel line of sight vector with r = XP/norm(XP)

In order to geolocate the radiances, the user must first calculate the corresponding azimuth, elevation coordinate for each row and column pixel, and then calculate the corresponding latitude, longitude coordinate from the azimuth, elevation information. This is described in the following:

Let (r,c) be the coordinates (row and column) of any pixel of the L1c image. Row and columns are counted increasingly when going from bottom to up (south to north) and left to right (west to east) and beginning at 1. Therefore, the South-West corner of a L1c image has coordinates (1,1). For each channel, the correspondence between the row and column position (r, c) and the azimuth and elevation position (λ, ϕ) of the pixel centre is written:

$$\lambda_s = \lambda_0 - (c\text{-}1) \cdot Azimuth\_Grid\_Sampling$$
$$\phi_s = \phi_0 + (r\text{-}1) \cdot Elevation\_Grid\_Sampling$$

where:

1. *Azimuth_Grid_Sampling* and *Elevation_Grid_Sampling* are the reference grid spatial sampling angles, representing viewing angle increments between pixels in the W-E and S-N directions, respectively. The corresponding values are given in Table 1.
2. λ_0 and ϕ_0 are the angles from the centre of the projection to the centre of the pixel in the first row and first column of the reference grid, respectively. Note that the first row, column of the reference grid is indexed (1,1). The values correspond to *Azimuth_Grid_Sampling* * (columns –1)/2 or *Elevation_Grid_Sampling* * (rows –1)/2, respectively, and are given in Table 1 too.

Note that the E-W viewing angle (λ_0) does not correspond to the standard definition of azimuth, for an observation from the instrument perspective, which runs from negative to positive from West to East. Instead, it runs from negative to positive from East to West.

The N-S viewing angle corresponds to the standard definition of elevation, for an observation from the instrument perspective.

SSD (km)	λ_0		ϕ_0		Grid Sampling		Columns in Full Disc	Rows in Full Disc
	degrees	radians	degrees	radians	degrees	radians		
1	8.9138402398	0.1555758612	-8.9138402398	-0.1555758612	0.001601048988	2.7943576E-05	11136	11136
2	8.9130397083	0.1555618893	-8.9130397083	-0.1555618893	0.003202097973	5.5887153E-05	5568	5568
3	8.9122391722	0.1555479173	-8.9122391722	-0.1555479173	0.004803146953	8.3830729E-05	3712	3712

Table 1: Values per SSD for the reference grids used for FCI L1c

With these values, the coordinates of the Earth centre (origin of the projection) in the Full Disc image are (5568.5, 5568.5), (2784.5, 2784.5), and (1856.5, 1856.5) for the 1km, 2km, and 3km channels, respectively.

2.3 Coverage masking applicable to products disseminated via EUMETCast Africa

In order to reduce the product size, a masking algorithm per product is applied during the processing. The coverage masks (see Figure 5 to Figure 11) are set such that they give a radiance measurement within the same extent on Earth, (e.g. for all channels, on the level 1c grid). Operationally, this extent is always covered if the spacecraft orbit and pointing are within their tolerances. The user can therefore expect to have data (e.g. a radiance measurement) everywhere in the un-masked area all the time, i.e. from one repeat cycle to the next. An exception being that the orbit longitude or maximum inclination is changed but in that case, the masks will be regenerated.

The coverage masks are a compromise between the disseminated area of interest and the size of the product. The effect on the size of the products is estimated by the "area" which is available:

- 100% represents all the Earth pixels in a Full Disc (it excludes deep space pixels).
- 0% means that no pixel at all is disseminated.

The considerations made when selecting which parts of the Earth disc are selected or not on a product (channel) are:

- Global or large coverages are considered for channels relevant to airplane navigation.
- The region of Africa north of the Sahara region is discarded when the data are only relevant to the countries in this region as they can receive the data via EUMETCast Europe.
- Pixels over the oceans, for channels which are more related to applications over land. For this purpose the distance from the pixel to the coast can be tuned.
- The Gulf of Guinea is of interest for navigation routes, for ships sailing between the Cape of Good Hope in South Africa and the North Atlantic Ocean.

- America, because the weather over America is of limited interest for End Users in Africa.

These coverage masks are applied to FCI level 1, FCI level 2, and RGB datasets provided to EUMETCast Africa.

The coverage masks consist of a static array as big as the image to mask. For every pixel, there is a Boolean value:
- True: The corresponding pixel is disseminated.
- False: The output pixel value is set to NC_FILL_VALUE (the default netCDF value when the data is missing).

These tables present the candidate coverage masks:

Area [%]	**Coverage of Full Disc**
100.00%	GEO Full Disc
94.76%	Disc but no America
50.00%	Africa + 1650 km offshore
33.00%	Africa + 500km offshore
27.00%	Africa + 100 km offshore
25.75%	Africa + 20 km offshore
25.50%	Africa land only

Area [%]	**Coverage of Subsahara**
68.62%	Subsahara but no America
36.44%	Subsahara + 1650 km offshore
20.62%	Subsahara + 100 km offshore
19.72%	Subsahara + 20 km offshore
19.51%	Subsahara land only

The following figures display the coverage masks.

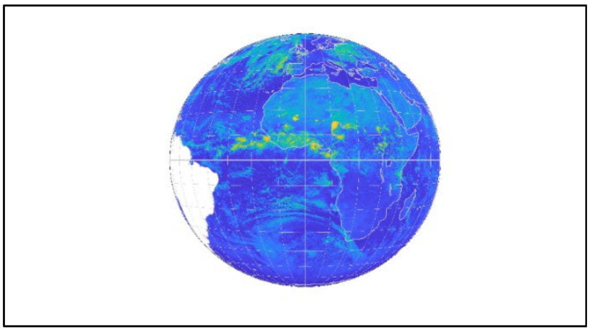

Figure 3: Coverage Full Disc, but no America.

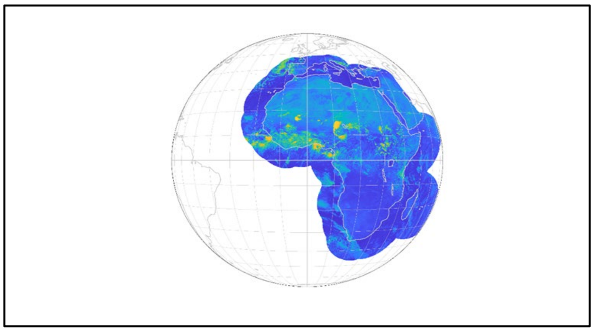

Figure 4: Coverage Africa + 1650km offshore.

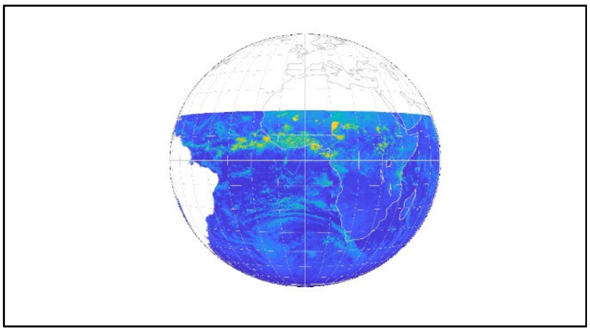

Figure 5: Coverage Subsahara but no America.

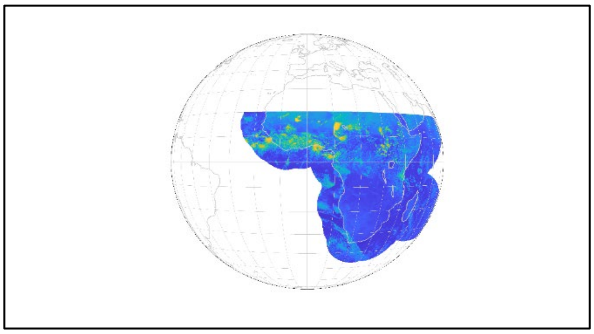

Figure 6: Coverage Subsahara + 1650km offshore.

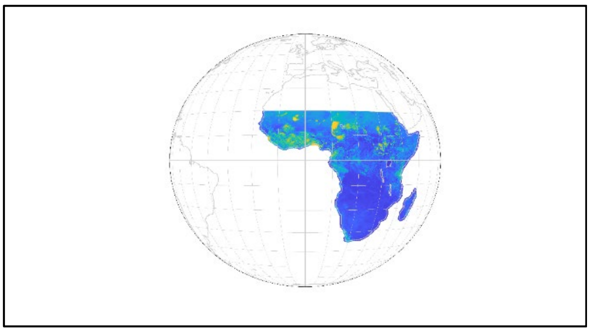

Figure 7: Coverage Subsahara + 100km offshore.

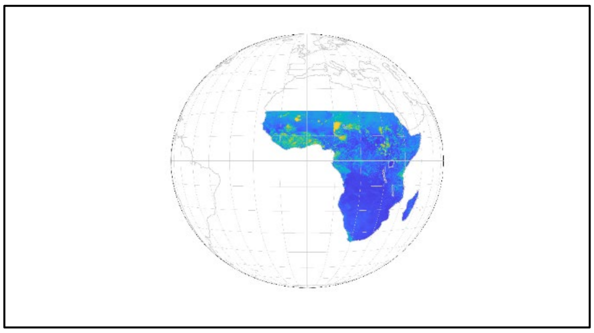

Figure 8: Coverage Subsahara + 20 km offshore.

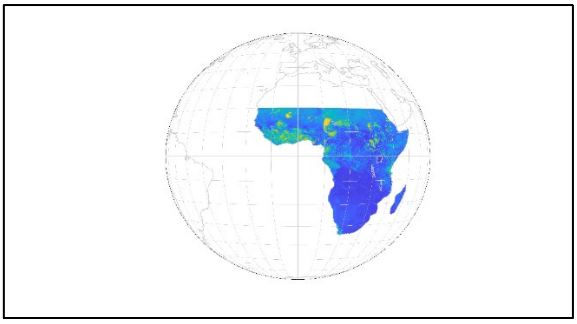

Figure 9: Coverage Subsahara land only.

3 FLEXIBLE COMBINED IMAGER (FCI) LEVEL 1

3.1 Introduction

The FCI will provide follow-on services currently provided by the Meteosat Second Generation (MSG) Spinning Enhanced Visible and Infrared Imager (SEVIRI).

The main aim of the FCI 1C datasets disseminated via EUMETCast Africa is to provide continuity of the MSG service in terms of channels and pixel resolution. In addition, this aim is improved with more channels, higher radiometric precision and better periodicity.

The Products disseminated to End Users via EUMETCast Africa are always derived from the Full Disc Scanning Service (FDSS). To reduce the size of Products, subsampling has been applied by reducing their coverage and spatial resolution (details are provided in Appendix A).

3.2 List of FCI L1c Products at 3km and 1 km

The baseline is to disseminate the 16 FCI L1c channels as 16 independent products, in 16 different files, not as a single product containing the data of the 16 channels in chunks (which is the approach for EUMETCast Europe). Each product corresponds to a channel at a given periodicity, covering a subset of the Earth disc (after application of its own coverage mask). In addition, the VIS06 channel is distributed at 1 km SSD, providing some continuity of the SEVIRI broadband high-resolution visible (HRV) channel. Therefore, there are up to 17 FCI L1c products per 10-minute Repeat Cycle.

Description	Product ID	Spectral Channel	Coverage	Periodicity
Tuned MSG continuity with MTG innovation, **3km** SSD	FCI-1C-RRAD-3KM-AF-VIS04	VIS 0.4	Subsahara land only	≤4 times/day
	FCI-1C-RRAD-3KM-AF-VIS05	VIS 0.5	Subsahara land only	≤4 times/day
	FCI-1C-RRAD-3KM-AF-VIS06	VIS 0.6	Full Disc but no America	10 minutes
	FCI-1C-RRAD-3KM-AF-VIS08	VIS 0.8	Full Disc but no America	10 minutes
	FCI-1C-RRAD-3KM-AF-VIS09	VIS 0.9	Africa + 1650 km offshore	30 minutes
	FCI-1C-RRAD-3KM-AF-NIR13	NIR 1.3	Full Disc but no America	30 minutes
	FCI-1C-RRAD-3KM-AF-NIR16	NIR 1.6	Full Disc but no America	10 minutes
	FCI-1C-RRAD-3KM-AF-NIR22	NIR 2.2	Full Disc but no America	30 minutes
	FCI-1C-RRAD-3KM-AF-IR38	IR 3.8	Full Disc but no America	10 minutes
	FCI-1C-RRAD-3KM-AF-IR63	WV 6.3	Full Disc but no America	20 minutes
	FCI-1C-RRAD-3KM-AF-IR73	WV 7.3	Full Disc but no America	20 minutes
	FCI-1C-RRAD-3KM-AF-IR87	IR 8.7	Africa + 1650 km offshore	10 minutes
	FCI-1C-RRAD-3KM-AF-IR97	IR 9.7	Full Disc but no America	10 minutes
	FCI-1C-RRAD-3KM-AF-IR105	IR 10.5	Full Disc but no America	10 minutes
	FCI-1C-RRAD-3KM-AF-IR123	IR 12.3	Full Disc but no America	10 minutes
	FCI-1C-RRAD-3KM-AF-IR133	IR 13.3	Subsahara land only	≤4 times/day
HRV continuity, same as 3KM VIS06 product, but with **1km** SSD	FCI-1C-RRAD-1KM-AF-VIS06	VIS 0.6	Africa + 500 km offshore	10 minutes

Table 2: List of FCI 1C products

The Table 2 presents the summary of FCI level 1C products disseminated via EUMETCast Africa. Both the coverage and periodicity are configurable parameters and therefore subject to changes. The interpretation of the coverage names is provided in Appendix A (Product Subsampling).

The periodicity of one repeat cycle of the native FCI L1c full-disc radiance dataset (FCI-1C-RRAD-FDHSI-FD) is 10 minutes. Therefore:

- Channels disseminated every 10 minutes have the same periodicity as the native dataset.
- Channels disseminated every 20 minutes or every 30 minutes, corresponding to every second or every third native dataset.
- Channels disseminated "up to 4 times a day" have low priority. They are disseminated at fixed time of the day, when there is enough bandwidth, avoiding the peak periods of the day (e.g. noon).

All the product are formatted in netCDF and have a SSD of 3x3km except for the HRV continuity product which has an SSD of 1x1km.

The Product ID is built as illustrated in Table 3.

	Elements to build the Product ID					
Product ID	**Data Source**	**Processing Level**	**Type**	**Subtype**	**Coverage**	**Sub-setting**
FCI-1C-RRAD-3KM-AF-VIS04	FCI	1C	RRAD	3KM or 1KM	AF	e.g. VIS04 as per Table 2

Table 3: Example of FCI L1C Product IDs for EUMETCast Africa.

3.3 FCI L1c Product details

3.3.1 Description

There are two groups of FCI Level 1C RRAD products:

- The 16 products at 3km SSD: subtype labelled "3KM"
- The single product at 1km SSD: subtype labelled "1KM"

Regarding the 16 products, each of them contains a single FCI 1C channel. This represents a significant change with respect to the native FCI-1C-RRAD product (which is disseminated via EUMETCast Europe), because the native product includes the 16 channels in the same product for a single Repeat Cycle.

These 16 products ensure the continuity of MSG in term of channels and pixel resolution, but with improved periodicity of 10 minutes for eight of the 16 channels (see Table 3), including the new FCI channels (VIS0.4, VIS0.5, VIS0.9, NIR1.3, NIR2.2).

The SSD of these 16 products is always the same: 3km. In addition, the coverage depends on the channel, see Table 2 for a summary.

The HRV product is also a single channel FCI 1C RRAD product. It only contains the VIS 0.6 channel, at 1km SSD. Note that the VIS 0.6 channel is also provided in one of the 3km SSD products.

Product ID	Size of Product After Compression [MBytes]	Daily Volume [GB/day]	Average Data Rate [Mbps]
FCI-1C-RRAD-3KM-AF-VIS04	1.9	0.01	0.001
FCI-1C-RRAD-3KM-AF-VIS05	1.9	0.01	0.001
FCI-1C-RRAD-3KM-AF-VIS06	10.4	1.49	0.138
FCI-1C-RRAD-3KM-AF-VIS08	10.0	1.44	0.134
FCI-1C-RRAD-3KM-AF-VIS09	3.8	0.18	0.017
FCI-1C-RRAD-3KM-AF-NIR13	9.7	0.47	0.043
FCI-1C-RRAD-3KM-AF-NIR16	9.5	1.37	0.127
FCI-1C-RRAD-3KM-AF-NIR22	9.5	0.45	0.042
FCI-1C-RRAD-3KM-AF-IR38	9.6	1.38	0.128
FCI-1C-RRAD-3KM-AF-IR63	4.8	0.35	0.032
FCI-1C-RRAD-3KM-AF-IR73	7.8	0.56	0.052
FCI-1C-RRAD-3KM-AF-IR87	4.0	0.58	0.054
FCI-1C-RRAD-3KM-AF-IR97	9.0	1.30	0.120
FCI-1C-RRAD-3KM-AF-IR105	10.5	1.51	0.139
FCI-1C-RRAD-3KM-AF-IR123	10.2	1.46	0.136
FCI-1C-RRAD-3KM-AF-IR133	1.8	0.01	0.001
FCI-1C-RRAD-HRV-AF	32.5	4.67	0.433
Total		**17.2**	**1.60**

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Table 4: Size, daily volume, and data rate per FCI Level 1C product

For information, the estimated product size before compression, or the space required in memory after decompression, is:

Each of the 3KM products: 72 MB/product
1KM (HRV) product: 651 MB/product

Note 1: The average product sizes after compression (Table 4) are maximum upper estimates (i.e. solar channels during daylight).

Note 2: All these product sizes include 5% system margin.

3.3.2 Short format description

The format of these products is as described in [FCIL1FS].

These products do not contain trailer chunks. Body chunks are aggregated in a single file product, and relevant information from trailer chunks is inserted into the final file.

The exact description for these products, provided as ncML files, can be found in Appendix B.

3.3.3 File name examples

See Appendix D for a full description of the file names and how to build them. These are 2 examples:

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-**3KM**-**AF**-**IR105**-CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_**JLS**_C_0034_0002.nc

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-**1KM**-**AF**-**VIS06**-CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_**JLS**_C_0034_0002.nc

3.4 Instrument Characteristics

This information can be found in [FCIL1PUG], in particular for what relates to:

- Spectral Channels
- Spectral Response Function (SRF)
- Image Acquisition Principle
- Focal Plane Arrangement
- On-board Calibration Principle
- Detection Chain

3.5 FCI Level 1 Processing Algorithms

This information can be found in [FCIL1PUG], in particular for what relates to:

- Stray-Light Correction
- INR
- GSICS

3.6 Characteristics of the level 1c Registered Radiance Dataset

3.6.1 Row and Column Numbering

The general concept can be found in [FCIL1PUG].

The numbering of the rows and columns in these products is presented in the Table 5.

	3KM Products (3km SSD)	1KM Product (1km SSD)
Rows, from South to North	From 1 until 3712	From 1 until 11136
Columns, from West to East	From 1 until 3712	From 1 until 11136

Table 5: Numbering of rows and columns

3.6.2 Level 1c Reference Grid

Regarding the topics indicated in the following table, please find more information in the corresponding document.

Topic	Where to find more information
Normalized Geostationary Projection	See [FCIL1PUG]
Spectral Channels	See [FCIL1PUG]
Availability within timeliness	See [EURD] & [MTGDIS]

3.7 Format

Regarding the topics indicated in the following table, please find more information in the corresponding document.

Topic	Where to find more information
Data Chunks	Not used over Africa, one file per product, see table below
Rectified Radiance	See [FCIL1PUG]
Swath Information	See [FCIL1PUG]
Radiance Encoding	See [FCIL1PUG]
Pixel Quality	See Appendix A
Index Mapping	See Appendix A
Special Compression	CharLS as per [FCIL1PUG].

The differences between the FCI L1c products disseminated via EUMETCast Africa (3KM and 1KM), and the products disseminated via EUMETCast Europe, are presented in the following table.

Characteristic	EUMETCast Africa		EUMETCast Europe
	FCI 1C 3KM	FCI 1C 1KM	FCI 1C FDHSI
Periodicity	Multiple of 10 minutes in the range 10 minutes to 4 times a day (it depends on the product)	Repeat cycle of 10 minutes	Repeat cycle of 10 minutes
Number of Products per Repeat Cycle	Up to 16 products (1 per FCI 1C channel)	1 product (only vis_06 channel)	1 product (containing all 16 channels)
Number of Body Chunks per Repeat Cycle	No chunk (a single file per product)	No chunk (a single file per product)	40 chunks
Body Chunks Content	Each file contains data of a single channel	Each file contains data of a single channel	Each chunk contains data of 16 channels
Number of Trailer Chunks	No trailer chunk	No trailer chunk	1 per Repeat Cycle
Total Number of Chunks per Repeat Cycle	Not applicable	Not applicable	41 (40 bodies + 1 trailer)

How the information of the input chunks is inserted in the final product	Each product contains the aggregation of all the body chunks in a single file (a body chunk). In addition, there is a netCDF group containing the information from the trailer chunk.	Each product contains the aggregation of all the body chunks in a single file (a body chunk). In addition, there is a netCDF group containing the information from the trailer chunk.	40 body chunks and 1 trailer chunk.

Table 6: Comparison between the FCI level 1C products disseminated via EUMETCast Africa and via EUMETCast Europe.

The decision of disseminating each channel as a product over the full coverage, instead of all channels in a single product (and in chunks) as done for EUMETCast Europe, has these consequences:

- The 16 products at 3x3 km SSD and the product at 1x1km are formatted the same way.
- The users can select which channels are received/archived/processed and drop the others.
- Each channel has its own transmission priority (particularly important in case of dissemination congestion).
- Each individual product/file has a stable and repetitive size.
- All the products/file correspond to the earth disc (after coverage mask application).
- Each product is provided in a single file (no chunk to be aggregated).
- It is easy to implement at EUMETSAT and easy to use by African users.
- It avoids tiny files.

3.8 FCI L1 Dataset Usage

The following can be found in [FCIL1PUG].

- Reconstructing Reference Grids
- Unpacking Coded Radiances
- Effective Radiance Unit Conversion
- Effective Radiance to Brightness Temperature for IR Channels
- Converting Effective Radiance to Reflectance for VNIR Channels
- Radiometric Noise Assessment
- Radiometric Accuracy Assessment
- Special decompression of Radiances
- Radiometric Noise and Accuracy Look-Up Tables
- Timing Information

4 FLEXIBLE COMBINED IMAGER (FCI) RGB

4.1 Introduction

4.1.1 General information about RGBs

General information about RGBs can be found in the following guidance documents:

- WMO/EUMETSAT standard RGB schemes: http://www.wmo.int/pages/prog/sat/documents/RGB-WS-2012_FinalReport.pdf
- EUMETrain RGB quick guides: http://eumetrain.org/rgb_quick_guides/index.html
- EUMETrain Colour interpretation guides: http://eumetrain.org/RGBguide/rgbs.html
- EUMETrain MSG Interpretation Guide: http://www.eumetrain.org/IntGuide/

4.1.2 Generation of RGB Datasets

This document contains descriptions (the so-called 'recipes') about how to create the standard RGB types from FCI L1c data. For each RGB type, a table contains the needed parameters:

Colour beam	Channel (difference)	Range			Gamma Value
Red	Channel1a – Channel1b	MIN1	MAX1	K or %	Gamma1
Green	Channel2a – Channel2b	MIN2	MAX2	K or %	Gamma2
Blue	Channel3a – Channel3b	MIN3	MAX3	K or %	Gamma3

Table 7: Template of the parameters used on the RGB recipes.

The first column refers to the colour of the output RGB channel.

The second column shows which channels (or channel combinations) should be visualised in the red, green and blue colours beams. Before combining them, these images have been calibrated and enhanced.

- The measured values have been calibrated by calculating reflectivity (R) or brightness temperature (BT) values. In case of solar channels, the calibration includes solar zenith angle correction as well: the reflectivity has been divided by the cosine of the solar zenith angle. Note: the zenith angle has been capped (e.g. at 80 degree).
- Then the images are *enhanced*. The enhancement expands the range (MIN, MAX) of R or BT values to the full range of display values (0-255, BYTE) by a linear stretching and possibly a non-linear stretching.
    - The images are linearly stretched within the brightness temperature or reflectivity ranges. The 3rd and 4th columns of Table 7 contain the lower and upper limit of the corresponding ranges, while the 5th column contains the unit. In some cases, the range is "inverted", i.e. the MAX and the MIN values are reversed.
    - In some cases, a non-linear stretching is applied. It could be a piecewise linear expansion, or a so-called "gamma correction". If the gamma parameter (6th

column of Table 7) is greater than 1 then the image becomes brighter and the contrast of the darker tones increases. If gamma parameter is lower than 1 then the image becomes darker and the contrast of the brighter tones increases. If gamma is equal to 1 then no gamma correction is needed.

- The 6th column contains the Gamma parameter for stretching the interval.

The equation of the gamma correction is:

$$BYTE = 255 * \left(\frac{X - MIN}{MAX - MIN}\right)^{1/Gamma}$$

Where:

- X is the input value, the actual calibrated value: Reflectivity (R) or Brightness Temperature (BT).
- MIN and MAX are the lower and upper limit of the range of the stretching.
- Gamma is the parameter of the gamma correction.
- BYTE is the output value, the intensity of the enhanced image. The full range of displayed values is 0-255.

Before combining the channels, each of them is calibrated and enhanced in one or two steps:

- First a linear stretch is performed within the brightness temperature or reflectivity ranges.
- Afterwards a so-called gamma correction is performed for the green component.

The gamma correction enhances the contrast in the darker or in the brighter tones (depending on the Gamma parameter), and it makes the image darker or brighter. In the case of the green component of the Severe Convection RGB, Gamma equals 0.5, and therefore the contrast of the bright tones are increased.

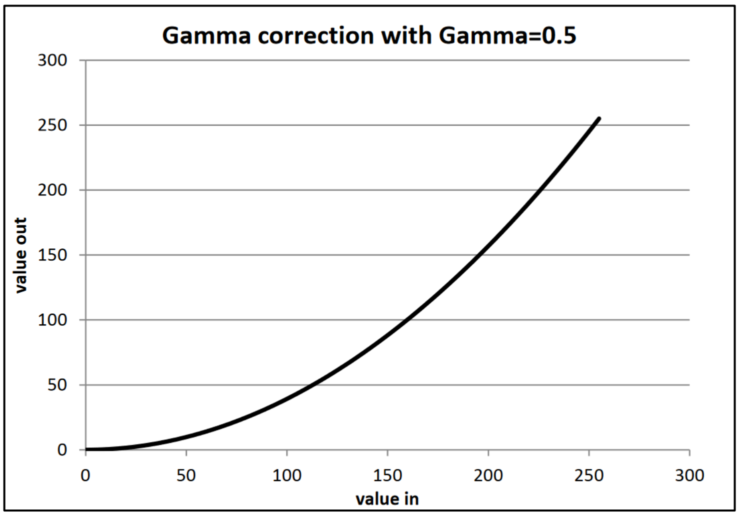

Figure 10: Gamma correction with Gamma=0.5.

4.1.3 Summary of Centrally generated RGB Products

The Table 8 provides a summary of the RGB products available via EUMETCast Africa, in particular their coverage mask, periodicity, and SSD. The coverage mask and periodicity are configurable parameters, therefore submit to changes. The list of available coverage masks is given in Section 2.3.

Product Name	Product ID	Coverage Mask	Periodicity	SSD
Severe Convection RGB	FCI-1C-RGB-SCON-AF	Subsahara + 20km offshore	10 minutes	1x1km
Night Microphysics RGB	FCI-1C-RGB-NMPHY-AF	Subsahara + 20km offshore	20 minutes	1x1km
True Colour RGB	FCI-1C-RGB-TCOL-AF	Full Disc	20 minutes	3x3km
Fire Temperature RGB	FCI-1C-RGB-FIRET-AF	Subsahara + 20km offshore	30 minutes	1x1km
Cloud Phase RGB	FCI-1C-RGB-CPHAS-AF	Subsahara + 20km offshore	10 minutes	1x1km

Table 8: List of FCI RGB products

Products disseminated continuosly				
Product ID	**Size of Product After Compression [MBytes]**	**Products Per Day**	**Daily Volume [GB/day]**	**Data Rate per Repeat Cycle[Mbps]**
FCI-1C-RGB-TCOL-AF	14.1	72	1.02	0.094
FCI-1C-RGB-FIRET-AF	25.1	48	1.20	0.111
FCI-1C-RGB-CPHAS-AF	25.1	144	3.61	0.334
Total			**5.8**	**0.54**

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Table 9: Size, daily volume, and data rate per FCI RGB product generated continuosly day and night

Products disseminated during 12/day				
Product ID	**Size of Product After Compression [MBytes]**	**Products Per Day**	**Daily Volume [GB/day]**	**Data Rate per Repeat Cycle[Mbps]**
FCI-1C-RGB-SCON-AF (only daylight)	25.1	72	1.80	0.334
FCI-1C-RGB-NMPHY-AF (only night)	25.1	36	0.90	0.167
Total			**0.9**	**0.17**

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Table 10: Size, daily volume, and data rate per FCI RGB product generated during 12h/day

Note that SCON (Severe Convection) and NMPHY (Night Microphysics) are never disseminated during the same time interval. It is one or the other, SCON during daylight and NMPHY during night.

4.1.4 Naming Convention

Following the naming convention indicated in Appendix D, these are some example file names.

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-**RGB**-**SCON**-**AF**--CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_x_C_0034_0002.tif

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-**RGB**-**NMPHY**-**AF**--CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_x_C_0034_0002.tif

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-**RGB**-**TCOL**-**AF**--CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_x_C_0034_0002.tif

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-**RGB**-**FIRET**-**AF**--CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_x_C_0034_0002.tif

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-**RGB**-**CPHAS**-**AF**--CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_x_C_0034_0002.tif

4.2 FCI-1C-RGB-SCON-AF, Severe Convection (Storms) RGB

4.2.1 Description

Primary aim: Monitoring of convection.

Secondary aims: Monitoring (the cloud top microphysics) of high clouds.

Time period and area of its main application: Daytime, in convection season at low- and mid-latitudes, although different tunings/version should be used for low- and mid-latitudes.

Guidelines: Ice clouds usually have large ice crystals at the top. For the mid-latitude continental storms the presence of small ice crystals on (or above) the cloud top and/or very cold cloud top temperatures are possible indicators of severity. This RGB was tuned to highlight such high clouds, and it does this with excellent colour contrast.

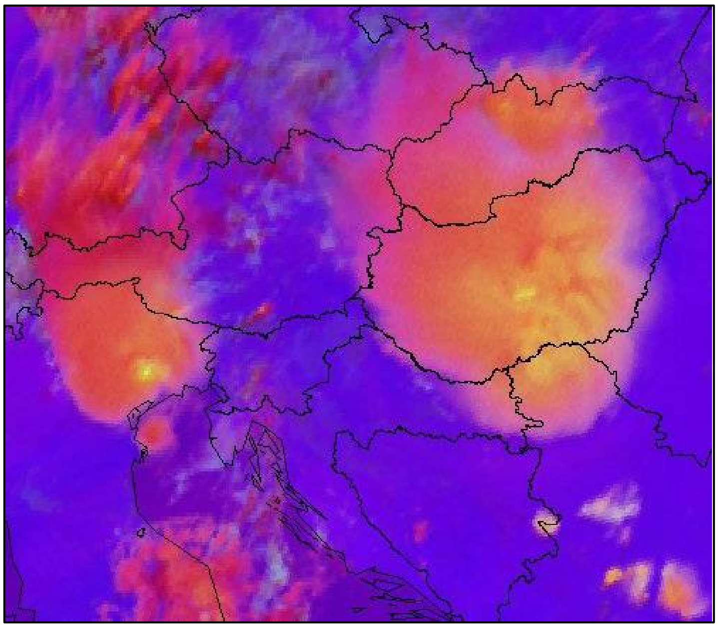

Table 11: Severe Convection (Storms) RGB from SEVIRI, 29 June 2006, 12:25 UTC.

4.2.2 Generation

These datasets are generated according to the recipe presented the following table.

Colour beam	Channel (difference)	Range			Gamma
Red	WV6.3 – WV7.3	-35	+5	K	1
Green	IR3.8 – IR10.5	-5	+60	K	0.5
Blue	NIR1.6 – VIS0.6	-75	+25	%	1

Table 12: Recipe for generating the Severe Convection RGB.

The table above shows which channel differences are visualised in the red, green, and blue colour beams.

The following table shows, which channel differences, are used in this RGB type, and lists some of the land and cloud features which typically make a low or high contribution to the colour beams in this RGB.

- WV6.3 – WV7.3 is used to highlight high-level clouds.
- IR3.8 – IR10.5 is used to highlight those cloud tops with are covered by small ice crystals and/or which are very cold.
- NIR1.6 – VIS0.6 is used to separate ice from water clouds.

Colour	Channels	Physically relates to	Smaller contribution to the signal of	Larger contribution to the signal of
Red	WV6.3 – WV7.3	Cloud top height	No mid or high cloud	High-level clouds
Green	IR3.8 – IR10.5	Cloud top particle size and temperature	Opaque ice cloud with large cloud top particles and/or not very cold cloud top temperature	Opaque ice cloud with small crystals and/or very cold cloud top temperature
Blue	NIR1.6 – VIS0.6	Cloud top phase	Thick ice clouds	Water clouds, land, sea surface

4.2.3 Benefits

- It highlights with excellent colour contrast those high clouds whose cloud tops are very cold and/or covered by small ice crystals.
- It helps to identify intense updrafts in mid-latitude, continental convective clouds.

4.2.4 Limitations

- It works only during the day.
- Pixel colour fades during dawn/dusk when the sun angle is low.
- The Yellow colour is a common effect of small ice crystals and cold cloud top temperature.
- It was not designed to provide full cloud analysis. This high clouds-oriented RGB contains very little information about lower level clouds and the surface.
- Snow-covered land might have a similar colour as high clouds with large crystals.
- One has to be careful when using this RGB, to interpret it well. Yellow colour does not necessarily mean strong updraft or severe storm. Small ice crystals can be present in a convective cloud top without a strong updraft.

4.2.5 Remarks

- Small particles at the top of a convective cloud do not necessarily indicate a strong updraft.
  - A continental convective cloud with a cold cloud base usually has small ice crystals at the top, without a strong updraft.

  - Highly polluted convective cloud (like pyro Cb) usually has small ice crystals at the top, without a strong updraft.
- There are some (non-convective) ice cloud types which consist of small ice crystals, like high-level Lee clouds or highly polluted cirrus clouds (e.g. dust carried aloft can lead to long-lived small ice particles).

4.2.6 More Information

See the Severe Storms RGB Quick Guide.
http://eumetrain.org/rgb_quick_guides/quick_guides/SevereStormsRGB.pdf

4.3 FCI-1C-RGB-NMPHY-AF, Night Microphysics (Fog/low Clouds)

4.3.1 Description

Primary aim: Detection of fog/low clouds at night.

Secondary aim: Full cloud analyses at night and fire monitoring.

Time period and area of its main application: Low- and mid- and high-latitudes, at night.

Guidelines: It provides the best colour contrast between flog/low cloud and cloud-free areas at night. However, in the case of solar radiation (during the day, twilight, solar equinox around midnight) this RGB is not usable.
Over cloud-free areas, moisture boundaries might be seen.

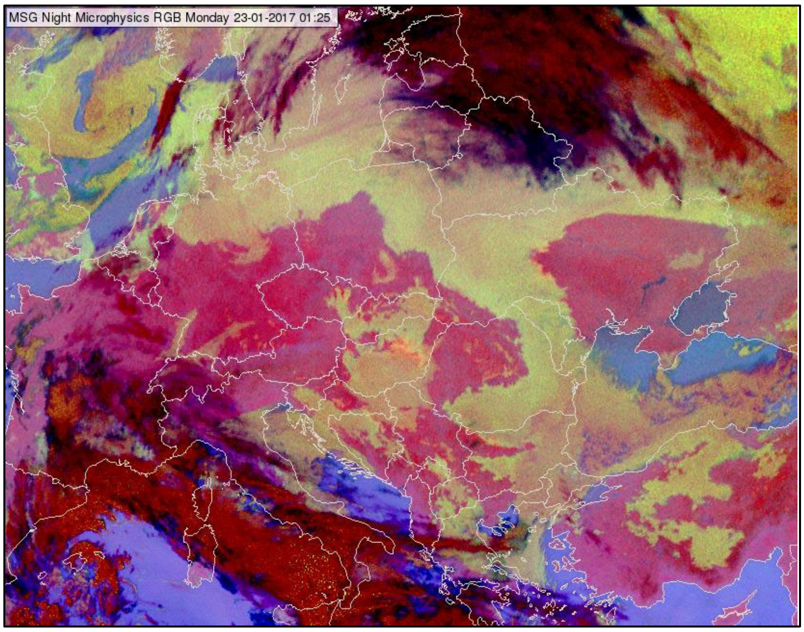

Figure 11: Night Microphysics RGB from SEVIRI, 23 January 2017, 01:25 UTC.

4.3.2 Generation

These datasets are generated according to the recipe presented in Table 13.

Colour beam	Channel (difference)	Range			Gamma
Red	IR12.3 – IR10.5	-4	+2	K	1
Green	IR10.5 – IR3.8	0	+10	K	1
Blue	IR10.5	243	293	K	1

Table 13: Recipe for generating the Night Microphysics RGB.

The Night Microphysics RGB is composed of the IR3.8, IR10.5 and the IR12.3 channels. The input values are calibrated Brightness Temperatures (measured in [K]).

The channels are enhanced (linearly stretched) within the brightness temperature ranges shown in the table. No gamma correction is applied.

4.3.3 Background

The table shows which channels (or channel differences) are used in this RGB type, and lists some of the land and cloud features which typically make a low or high contribution to the colour beams in this RGB.

- IR12.3 – IR10.5 channel difference helps to separate thin from thick clouds.
- The IR10.5 – IR3.8 is the key channel difference for fog/low cloud detection
- IR10.5 channel helps to separate thick clouds according to their cloud top temperature.

The colour of the cloud-free surface depends not only on the surface temperature, but also on the atmospheric low-level moisture content.

Colour	Channels	Physically relates to	Smaller contribution to the signal of	Larger contribution to the signal of
Red	IR12.3 – IR10.5	Cloud optical thickness	Thin clouds	Thick clouds
Green	IR10.8 – IR3.8	Cloud phase	Thin ice clouds	Thick fog/water clouds
Blue	IR10.5	Cloud top temperature Land sea temperature	Cold clouds	Warm surface Warm clouds

Interpreting low clouds and fog in satellite imagery is often a challenge if using individual IR channels, due to the small temperature difference between the cloud tops and adjacent cloud-free land. The Night Microphysics RGB solves this problem by using three different IR wavelengths. Low water clouds and fog emit less radiation at 3.8 µm compared to 10.5 µm. This brightness temperature difference (BTD) field is used in the Green Channel to highlight regions of low clouds. The channel difference in Red channel (12.3- 10.5 µm) is used as a proxy to cloud thickness and repeats the use of the 10.5 µm thermal channel to enhance areas of warm, low clouds where fog is more likely. The Night Microphysics RGB is also an efficient tool to identify other cloud types in the mid and upper atmosphere.

4.3.4 Benefits

- At low and mid-latitudes the Night Microphysics RGB provides the best colour contrast between water clouds and cloud-free surface at night.
- It provides full cloud analysis at night.

- In some special conditions it provides night-time snow detection, only if the temperature is very low and the snow is deep enough to completely cover the vegetation.
- It detects dust clouds.
- It detects fires, even if they are much smaller than the pixel size.

4.3.5 Limitations

- It is not designed to be used during the day. During the day, the Day Microphysics RGB, or the 24-hour Microphysics RGB are recommended for fog or low cloud detection.
- The colours change in cases where solar radiation is present: all clouds appear magenta, except the fog/low clouds which may even “disappear” during twilight. Around the solar equinox the IR3.8 channel may contain some solar radiation around midnight, spoiling this RGB in some areas.
- Fog and low clouds cannot be separated from each other based only on their colours.
- Fog/low cloud can be covered by higher level clouds. If there are thin cirrus clouds above fog/low clouds, the Night Microphysics RGB might not detect the fog/low clouds.
- The thinner the low clouds/fog, the more the colour looks like the colour of the ground (pinkish). The detection of very thin fog/low clouds is problematic.
- The IR3.8 brightness temperature values of the high, very cold clouds are often noisy resulting in green dots in the reddish-brownish ice clouds. Therefore, this RGB is not recommended for nigh-time convection analysis. The IR10.8 single channel is more appropriate for this purpose.
- There is no snow detection at night. Except some special cases (see benefits).

4.3.6 More Information

See the Night Microphysics RGB Quick Guides:
http://eumetrain.org/rgb_quick_guides/quick_guides/NightRGB.pdf

https://nasasporttraining.wordpress.com/2016/10/18/rgb-nighttime-microphysics-interactive-quick-guide/

4.4 FCI-1C-RGB-TCOL-AF, True Colour

4.4.1 Description

True colour imagery was designed to display the Earth in colours similar to what we might see with the human eyes. The product is a combination of the three channels that are sensitive to the red, green, and blue visible light. It is a new capability of MTG FCI, because not all necessary input channels are available with MSG SEVIRI.

True Colour images are easy to interpret and allow the fast identification of surface types (desert, vegetation, snow cover, algal blooms) and atmospheric features (e.g. clouds, smoke, dust, smog, haze, and volcanic ash.). Some examples are given in Figure 12.

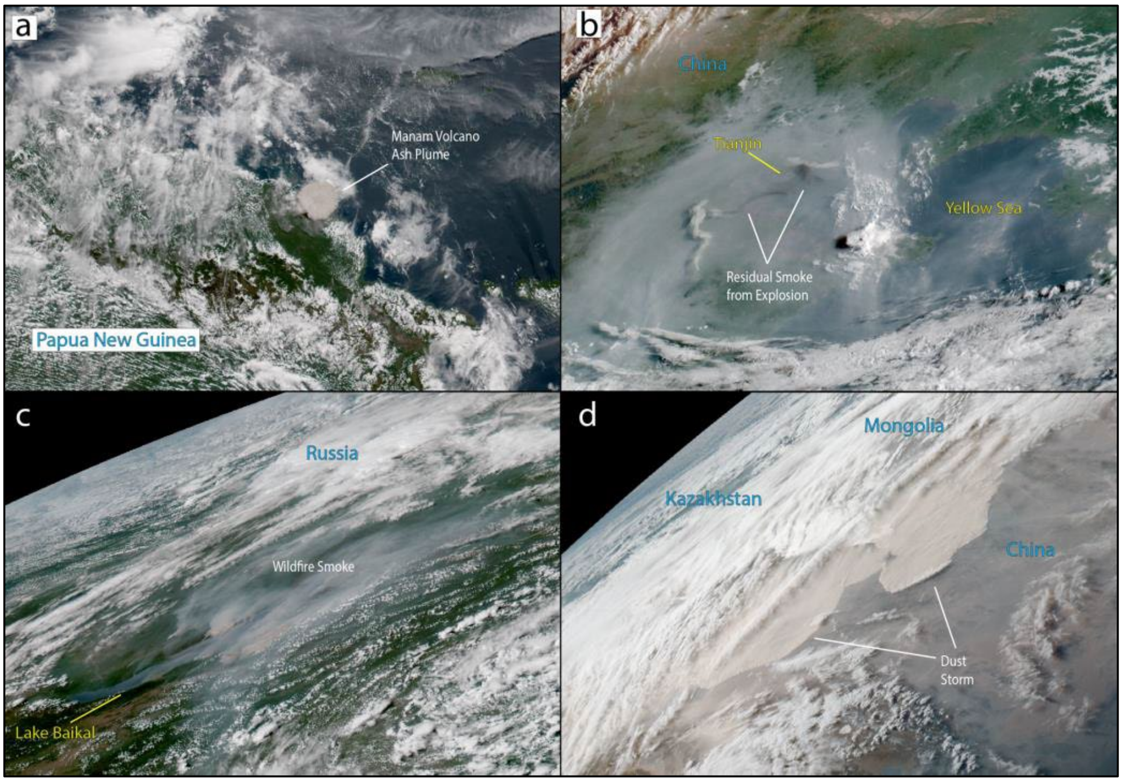

Figure 12: True colour RGB from the AHI, on-board Himawari-8 satellite.

4.4.2 Generation

These datasets are generated according to the recipe presented in Table 14.

Colour beam	Channel (difference)	Range			
Red	VIS0.6	0	110	%	piecewise linear stretching
Green	VIS0.5	0	110	%	
Blue	VIS0.4	0	110	%	

Table 14: Recipe for generating the True Colour RGB.

To improve the quality of the True Colour RGB images, the Rayleigh scattering effect is removed from the single channels before the combined RGB is produced. For further improvement to the visual representation of vegetation and bare soil, the correction from [Miller] is applied, taking into account the slight shift of the green channel VIS0.5 with respect to the average reflectance peak of vegetation.

4.4.3 Background

Colour	Channels	Physically relates to	Smaller contribution to the signal of	Larger contribution to the signal of
Red	VIS0.6	Red, green, and blue light as typically seen by the human eye	Low reflectance for the given band	High reflectance for the given band
Green	VIS0.5			
Blue	VIS0.4			

4.4.4 Benefits

Primary applications:

- Surface/atmospheric features: Identify vegetation, algal blooms, snow/ice, and aerosols (dust, smoke, haze, sand, ash).
- Surface types are true colour: Identify blue water bodies, green forests, yellow/tan deserts, etc.
- Aerosols appear darker/diffuse: Haze/smog is usually spread over a wide region and more transparent. Smoke is darker grey than haze/smog. Dust and volcanic ash may appear brownish.

Secondary applications:

- Clouds: High reflection of solar radiation off clouds is sensed in visible channels. Clouds are white because all 3 channels have a large contribution to the RGB.

4.4.5 Limitations

- Daytime only: True colour relies on solar reflectance from the visible channels, and thus is not available at night.
- Difficult to distinguish snow and clouds: Both snow and clouds appear bright white. Snow can sometimes be distinguished by its spatial relationship to rivers, mountains, and valleys. Animating the imagery will also help differentiate stationary snow cover from drifting clouds.
- Sunglint complicates water scenes: Where water surfaces reflect sunglint toward the satellite, complex patterns of brightness/darkness can appear based on surface roughness.

4.4.6 More Information

See the NOAA True Colour RGB:
https://weather.msfc.nasa.gov/sport/training/quickGuides/rgb/QuickGuide_TrueColorRGB_NASA_SPoRT.pdf

4.5 FCI-1C-RGB-FIRET-AF, Fire Temperature

4.5.1 Description

This RGB allows the user to identify where the most intense fires are occurring and differentiate these from “cooler” fires. The RGB takes advantage of the fact that from 3.8 micro-meters to shorter wavelengths, background solar radiation and surface reflectance increases. This means that fires need to be more intense in order to be detected by the 2.2 and 1.6 micro-meters bands, as more intense fires emit more radiation at these wavelengths. Therefore, small or “cooler” fires will only show up at 3.8 micro-meters and appear red while increases in fire intensity cause greater contributions of the other channels resulting in fires appearing as yellow-white.

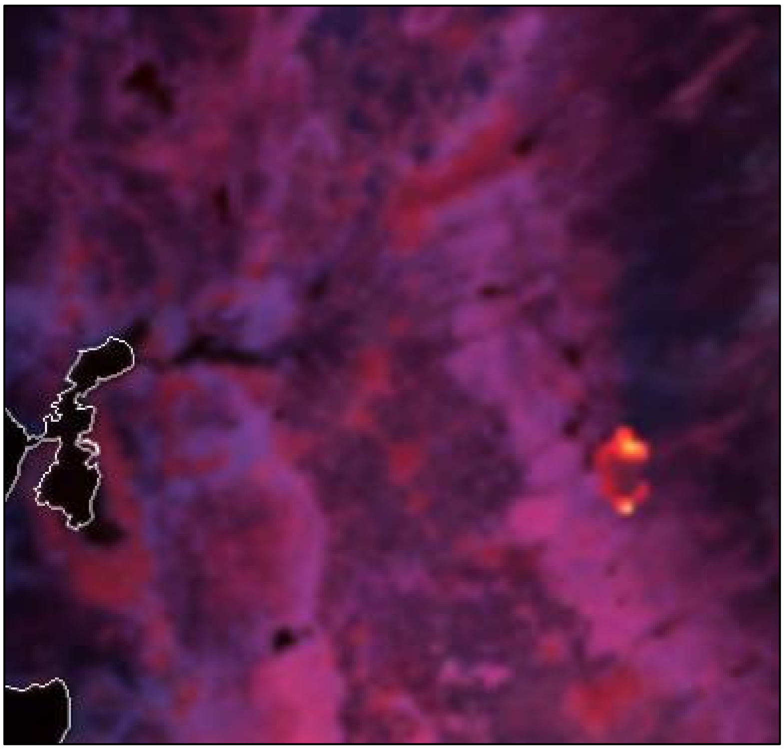

Figure 13: Fire temperature RGB from ABI, on-board GOES-16. See fire complex on the right side.

4.5.2 Generation

These datasets are generated according to the recipe presented in Table 14.

Colour beam	Channel (difference)	Range			Gamma
Red	IR3.8	273	333	K	0.4
Green	NIR2.2	0	100	%	1
Blue	NIR1.6	0	75	%	1

Table 15: Recipe for generating the Fire Temperature RGB.

4.5.3 Background

Colour	Channels	Physically relates to	Smaller contribution to the signal of	Larger contribution to the signal of
Red	IR3.8	Cloud top phase and temperature	Cold land surfaces, water, snow clouds	Hot land surface (low fire temperature)
Green	NIR2.2	Particle size / land type	Large ice/water particles, snow, oceans	Small ice/water particles (medium fire temperature)
Blue	NIR1.6	Particle size / land type	Ice clouds with large particles, snow, oceans	Water clouds (high fire temperature)

4.5.4 Benefits

- Fire hotspot locations are detected: The saturation brightness temperature of the shortwave IR 3.8 micro-meters channels is low, around 500 K (i.e. relatively low intensity fire). Therefore, "hotspots" of wild fires look red in RGB.
- Fire intensity can be analysed: High intensity fires are near a maximum of 1400 K and this is near the peak emission detection (i.e. saturation) of the 1.6 micro-meters channel. Therefore, active fires in the RGB transition from red to yellow to white as intensity increases and near-IR channels become saturated.

4.5.5 Limitations

- Cloud cover blocks view of fire: The fires will only be visible in the RGB in clear sky areas.
- Cloud features/type have fewer details: While water vs ice clouds can be identified, other RGB products are better at displaying cloud features.
- Daytime only application for clouds: The reflectance from clouds are not available at night in the near-IR bands used in the RGB.
- False "red" fires due to land type: Some surfaces in arid, dry regions are highly emissive at 3.8 micro-meters and will appear red but they are not on fire.

4.5.6 More Information

Source of information:
http://rammb.cira.colostate.edu/training/visit/quick_guides/Fire_Temperature_RGB.pdf

4.6 FCI-1C-RGB-CPHAS-AF, Cloud Phase

4.6.1 Description

Aim: Separation of water from ice clouds and information on cloud top particle size.

Area and time period of its main application: Low-, mid-, and high-latitude regions, daytimes.

Application and guidelines: It provides good quality microphysical information on cloud tops. This FCI RGB more reliably separates water from ice clouds than using SEVIRI. However, phase detection of very thin clouds is still problematic in some cases. Dust RGB, 24-hour Microphysics RGB, or the Cloud Type RGB may help to distinguish thin ice clouds from thin water clouds.
In the case of thick ice and water clouds, it provides good colour contrast between cloud top regions covered by small and large particles.
It does not contain temperature information. Using it together with either the Day Microphysics RGB or an IR10.5 image can be useful.

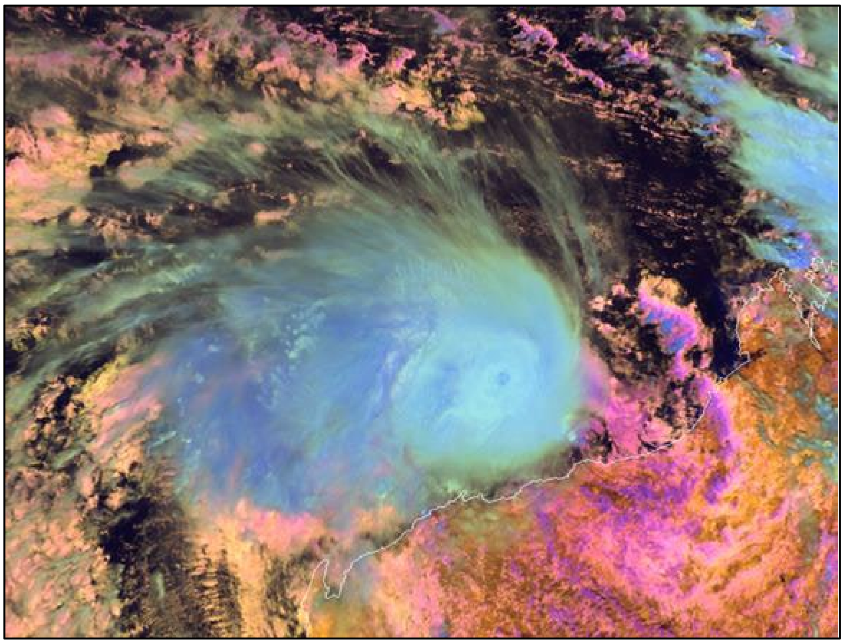

Figure 14: Himawari AHI Cloud Phase RGB, NW coast of Australia.

4.6.2 Generation

These datasets are generated according to the recipe presented in Table 16.

Colour beam	Channel (difference)	Range			Gamma
Red	NIR1.6	0	50	%	1
Green	NIR2.2	0	50	%	1
Blue	VIS0.6	0	100	%	1

Table 16: Recipe for generating the Cloud Phase RGB.

The Cloud Phase RGB is composed of the NIR1.6, NIR2.2 and VIS0.6 bands. The calibrated data is linearly enhanced within the reflectivity ranges shown in the Table 16.

The aim of this RGB is to monitor cloud top microphysics. If provides good cloud top phase identification for thick clouds.

This RGB was originally designed for the VIIRS instrument (on-board NOAA satellites).

4.6.3 Background

This table shows which channels are used in the Cloud Phase RGB. Both NIR2.2 and NIR1.6 are microphysical channels providing information on cloud top phase and particle size in a different way. Using them together enables a reliable separation between thick ice and water clouds. Note that the same channels are used for the red and blue colour beams in a Natural colour RGB. While the latter has a separate focus on vegetation, the Cloud Phase RGB focuses mostly on cloud top microphysics.

Colour	Channels	Physically relates to	Smaller contribution to the signal of	Larger contribution to the signal of
Red	NIR1.6	Cloud phase (and cloud top particle size)	Thin ice clouds	Thick water clouds
Green	NIR2.2	Cloud top particle size (and phase)	Thick clouds with large particles	Thick clouds with small particles
Blue	VIS0.6	Cloud optical thickness	Thin clouds	Thick clouds

4.6.4 Benefits

- It provides more reliable separation between ice and water clouds than the SEVIRI RGBs, unless the cloud is too thin.
- In the case of thick ice and thick water clouds, it provides better separation between smaller and larger particles on top of the clouds. Thus, the colour contrast of thick ice clouds is higher than in the Day Microphysics RGB.
- The Cloud Phase RGB is useful for convection monitoring:
  - Cloud top glaciation is well seen in the developing phase.
  - The presence of small particles on (or above) mature mid-latitude, continental thunderstorm tops is an indicator of updraft intensity, thus possible severity.
- Less thin clouds have a good colour contrast versus the (snow free) surface features. Although the snow-covered surface and the ice clouds covered by large particles have similar colours (dark and medium blue), the snow is usually darker.

4.6.5 Limitations

- Limited to daytime applications.
- Separation of very thin water and ice clouds is problematic in some cases.
- It does not contain temperature information.

- The snow-covered surface and ice clouds covered by large particles have similar colours (dark and medium blue).

4.6.6 Remarks

- Thin cirrus clouds not seen well because it does not use infrared channels.
- Small ice particles on the top of thick cloud do not always indicate a severe storm, nor a convective cloud.
- It is less sensitive to very thin above-anvil cirrus clouds than the Severe Storms RGB.
- The shades of colour partially depend on solar and satellite viewing angles.

4.6.7 More Information

See Cloud Phase RGB Quick Guide:
http://eumetrain.org/rgb_quick_guides/quick_guides/CloudPhaseRGB.pdf

4.7 Characteristics of locally generated RGB

The RGB can also be generated locally (i.e. by the End Users). The following table provides the main characteristics in term of periodicity and coverage for the most common RGB when taking into account the characteristics of the contributing channels (see §3.2) effectively disseminated.

Local RGB	Periodicity	Area	Coverage	Comment
Airmas	20 min	95%	Disc but no America	
24h micro	10 min	50%	Africa + 1650 km offshore	
Day micro	30 min	50%	Africa + 1650 km offshore	
Night micro	10 min	95%	Disc but no America	See §4.3 for a central RGB disseminated at 1x1km over a reduced area
Severe Conv	20 min	95%	Disc but no America	See §4.2 for a central RGB disseminated at 1x1km over a reduced area
Natural Color	10 min	95%	Disc but no America	
Snow	10 min	95%	Disc but no America	
Fire temp	30 min	95%	Disc but no America	See §5.2 for the FIRE product and §4.5 for a central RGB disseminated at 1x1km over a reduced area
True Color	A few times per day	20%	Subsahara land only	See §4.4 for a central RGB disseminated at 1x1km over a the full disc
Cloud phase	30 min	95%	Disc but no America	See §4.6 for a central RGB disseminated at 1x1km over a reduced area
Dust	10 min	50%	Africa + 1650 km offshore	
Cloud type	30 min	95%	Disc but no America	

Figure 15: Examples of RGB that can be generated locally with an SSD of 3x3km

5 FLEXIBLE COMBINED IMAGER (FCI) LEVEL 2

5.1 Introduction

FCI level 2 products are generated at EUMETSAT HQ using the native FCI full-disc level 1 products (FCI-1C-RRAD-FDHSI-FD) as input.

5.1.1 Summary of FCI Level 2 Products

The Table 17 provides a summary of the FCI Level 2 products disseminated via EUMETCast Africa, in particular their coverage mask, periodicity, and resolution. The coverage mask and periodicity are configurable parameters, therefore they could change. See Section 2.3 for the list of available coverage masks. Native resolution refers to the resolution of the product generated at EUMETSAT HQ and disseminated via EUMETCast Europe. The sizes, data volumes and rates for these FCI L2 products are provided in Table 18.

Product ID	Coverage Mask	Periodicity	Resolution
FCI-2-FIR-x-FD (native)	Full Disc	10 minutes	2 km (native)
FCI-2-GII-AFRICA-AF	Africa +1650km offshore	10 minutes	6 km (native)
FCI-2-OCA-AFRICA-AF[1]	Africa land only	10 minutes	2 km (native)

Table 17: List of FCI Level 2 products

Product ID	Size of Product after Compression [MBytes]	Daily Volume [GB/day]	Average Data Rate [Mbps]
FCI-2-FIR-x-FD (native)	7	1.01	0.093
FCI-2-GII-AFRICA-AF	2.2	0.32	0.029
FCI-2-OCA-AFRICA-AF[2]	24	3.46	0.320
Total		**4.8**	**0.44**

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Table 18: Size, daily volume, and data rate per FCI Level 2 product

5.2 FCI-2-FIR, Fire Product

This product provides a fire probability parameter (*quality_fire*), which can be used in addition to the fire flag (*fire_result*) to identify potential fires with low confidence. This fire probability parameter will allow the users to decide on their own balance between Detection Efficiency and False Alarm Rate.

[1] This product is optional, see open issue #4.
[2] This product is optional, see open issue #4.

Name	shape	Type	Enumerated Values
fire_result	number_of_rows x number_of_columns	enumerated NC_BYTE	No fire detected=0, Possible fire detected=1, Fire detected=2, Missing/undefined=3
quality_fire	number_of_rows x number_of_columns	enumerated NC_BYTE	Not processed (no/corrupt data) or missing=0, Good quality (high confidence)=1, Poor quality (low confidence)=2.

Table 19: Main parameters in FCI L2 FIR product.

The algorithm considers the emission from a black body at different temperatures, according to Planck's law. Total radiance and peak wavelength provide an estimation of the probability of finding a fire in the pixel.

The measurements in channel IR 3.8 are influenced by water vapour absorption, CO2 absorption, solar reflectance during day, and sub-pixel size clouds over hot surfaces.

The FIR algorithm shall only be applied to land surfaces, which means that off-shore oil burning fires or fires on small islands (e.g. active volcanoes which also fall under the hot spot category) are not monitored by the algorithm. Bare soil land surfaces are also excluded from the processing. Pixels are considered as bare soil, if the surface types are desert or open shrub land, where this classification is taken from climatological background information.

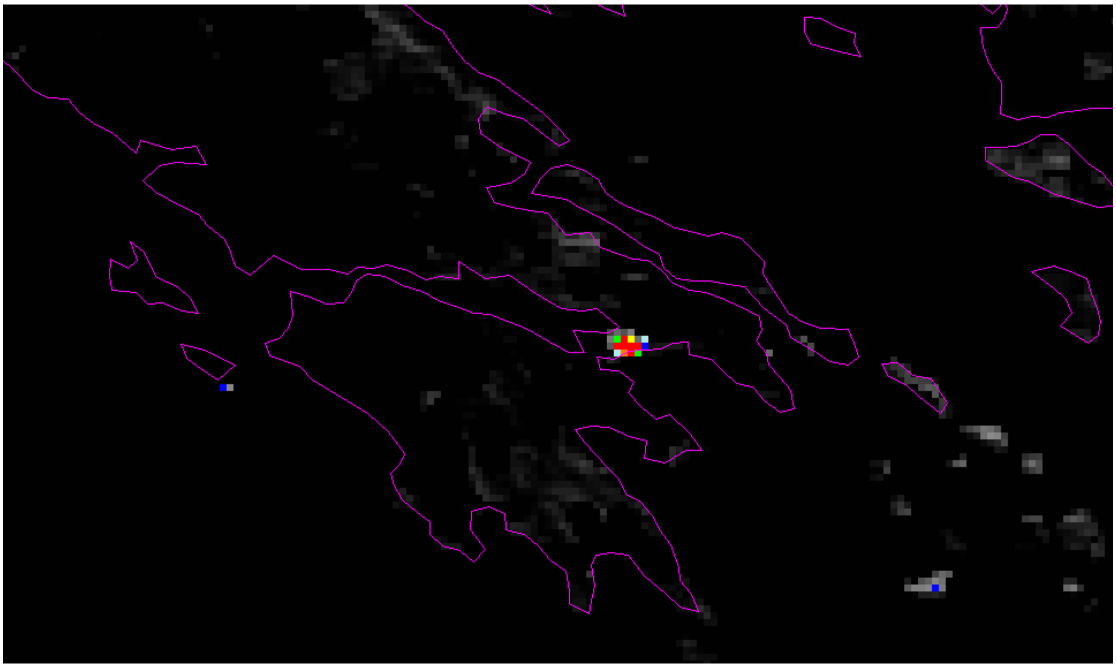


Figure 16: Fire detection over Greece

The Figure 16 shows the fire probability in the following colour coding:

Colour	Fire Probability [0.0–1.0]
Red	>0.9
Orange	>0.8
Yellow	>0.7
Green	>0.6
Turquoise	>0.5
Blue	>0.4
Grey	<0.4

This product is disseminated via EUMETCast Africa in its native format. For more details see [FCIL2PUG] for more details.

5.3 FCI-2-GII, Global Instability Indices

5.3.1 Description

The GII (Global Instability Indices) product contains a series of air mass parameters which are derived from retrieved temperature, humidity and ozone profiles. The physical retrieval is an optimal estimation using observed radiances and forecast atmospheric profiles. The derivation and retrieval is only performed in clear-sky areas.

This product is generated over defined Field of Regards (FoR). The size is dependent on the coverage selected and the Field of Regard size. The nominal FoR size is 3x3 (for the FCI IR channel 2 km rectified grid). For a full-disc coverage there are 5568x5568 pixels for an FCI 2km rectified grid, hence nominally 1856x1856 FoRs.

The GII product is derived per Repeat Cycle, in principle every 10 minutes.

More information can be found in [FCIL2PUG].

5.3.2 Format Description tailored for EUMETCast Africa

The main differences of EUMETCast Africa with respect to the product disseminated via EUMETCast Europe or EUMETCast terrestrial are the followings:

- Removal of the following variables:
  - /prec_water_low
  - /prec_water_mid
  - /prec_water_high
  - /prec_water_total
  - /percent_cloud_free
  - /number_of_iterations

- Include only these variables in the output:
  - /lifted_index
  - /k_index

- These auxiliary variables have to be included in the output as well:
  - /longitude (see [OI#3])
  - /latitude (see [OI#3])
  - /product_quality
  - /product_completeness
  - /product_timeliness

The "/" sign indicates that the variables are located in the root groups of the netCDF structure.

The reference for this data format (FCI-2-GII-AFRICA.ncml) is provided in Appendix B.

5.3.3 Naming Convention

Following the naming convention indicated Appendix D, these are some example file names:

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-2-**GII**-**AFRICA**-**AF**--CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_x_C_0034_0002.nc

5.4 FCI-2-OCA, Optimal Cloud Analysis (option)

This product is optional, see open issue #4. It is currently not in the baseline.

5.4.1 Description

The OCA (Optimal Cloud Analysis) product contains information on cloud properties estimated using the formal technique of optimal estimation. Information is provided for up to a maximum of two cloud layers. This can also include dust or ash clouds.

This is a pixel based product. The size is dependent on the coverage selected and on meteorological conditions. For a full Earth coverage there are 5568 x 5568 pixels (for an FCI 2km rectified grid).

The OCA product is derived per Repeat Cycle, in principle every 10 minutes (but this is a configuration parameter for EUMETCast Africa).

5.4.2 Format Description tailored for EUMETCast Africa

The differences of EUMETCast Africa with respect to the product disseminated via EUMETCast Europe or EUMETCast terrestrial are the followings:

- Removal of the following variables:
    - /retrieved_cloud_top_temperature
    - /retrieved_cloud_top_height
    - /retrieved_fractional_cloud_cover
    - /retrieval_error_cloud_optical_thickness
    - /retrieval_error_cloud_particle_effective_radius
    - /retrieval_error_cloud_top_pressure
    - /quality_jmeas
- These are the most important variables to include in the output:
    - /retrieved_cloud_phase (PHASE)
    - /retrieved_cloud_optical_thickness (COT)
    - /retrieved_cloud_particle_effective_radius (CRE)
    - /retrieved_cloud_top_pressure (CTP)
- These auxiliary variables have to be included in the output as well:
    - /mtg_geos_projection
    - /x
    - /y
    - /product_quality
    - /product_completeness
    - /product_timeliness

The "/" sign indicates that the variables are located in the root groups of the netCDF structure.

The reference for this data format (FCI-2-OCA-AFRICA.ncml) is provided in Appendix B.

5.4.3 Naming Convention

Following the naming convention indicated in Appendix D, these are some example file names.

W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-2-**OCA**-**AFRICA**-**AF**--CHK-BODY---NC4E_C_EUMT_20180101121212_**DT**_OPE_20180101103000_20180101103020_N_x_C_0034_0002.nc

6 LI-2-AFA, ACCUMULATED FLASH AREA

This product is disseminated via EUMETCast Africa in its native format, and therefore there is a minimum description here. See [LIL2PUG] for more details.

This is the Lightning Imager Accumulated Flash Area dataset. The most important parameters in this product are *x* and *y* (which provide the location of the pixel in the FCI IR 2km grid), and the *accumulated_flash_area* value at the location [x,y]. These are 1-dimensional arrays, having a *pixels* number of elements (*pixels* is the corresponding netCDF dimension). See these netCDF variables in the table below.

Name	Shape	Data Type	Description
x	pixels	Short integer	X coordinate in reference grid of each contributing lightning data point.
y	pixels	Short integer	Y coordinate in reference grid of each contributing lightning data point.
accumulated_flash_area	pixels	Unsigned integer	Flash Area accumulation values per contributing pixel on the reference grid.

This is based on the Accumulated Products Repeat Cycle. The baseline for the time duration of the Accumulated Products Repeat Cycle is 30 seconds, but this is a configurable parameter.

The coverage provided by the Lightning service is provided hereafter. It is made by the combination of the four optical heads, each corresponding to a square in Figure 17.

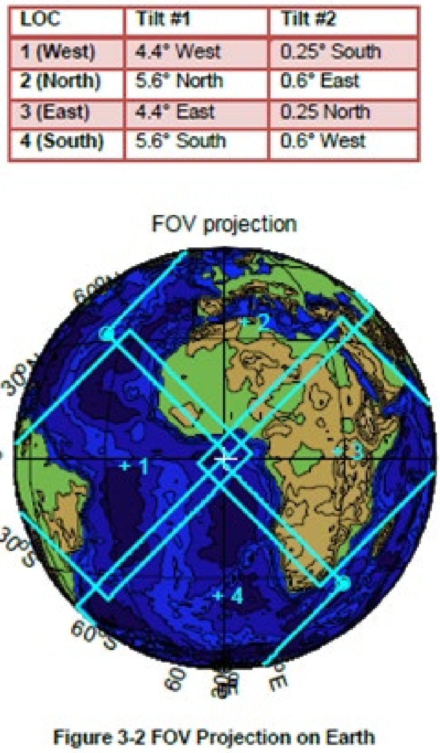

LOC	Tilt #1	Tilt #2
1 (West)	4.4° West	0.25° South
2 (North)	5.6° North	0.6° East
3 (East)	4.4° East	0.25 North
4 (South)	5.6° South	0.6° West

Figure 17 Lightning service coverage area

The LI instrument will experience periods of reduced performance when the sun is close to the instrument field of view, i.e. around midnight. This translates to a degraded detection capability in some areas whose location varies over the year. The intention is to provide a map indicating the expected performances as a function of geolocation, time of day, and day of year. The map will be available after the instrument commissioning activities following the MTG-I1 launch and will be provided to users through a mechanism to be defined.

The size of the LI-2-AFA products depend on the number of detected flashes. An average size is estimated as 1.9 MBytes every 30 seconds, which corresponds to 5.6 GBytes/day, and a continuous data rate about 0.52 Mbps.

7 SAF PRODUCTS

The whole chapter is work in progress covered by open issues described in §1.4.

There is a provision for a continuous data rate of 0.45 Mbps which is insufficient for all the products listed here. The following Table 20 presents the list of SAF products that are candidate for dissemination via EUMETCast Africa: The final list will be a subset that has not been agreed yet.

The involved SAFs are:

- H SAF– Support to Operational Hydrology and Water Management
- LSA SAF – Land Surface Analysis
- OSI SAF – Ocean and Sea Ice
- NWC SAF – Now Casting SAF

The H, LSA and OSI SAF would be disseminated in their native format, and therefore they are not further described here. See [SAFPUG] & [MTGDIS] for more details.
A tailored version of the NWC SAF software would run centrally (at EUM headquarters) and the resulting agreed tailored subset of the NWCSAF (and SAF products) would be disseminated.

SAF	Product	Description
H	H-2-H40-x-ZC	Hydrology SAF - Precipitation rate at ground by GEO/IR supported by LEO/MW and MTG FCI - Coverage Centre
H	H-2-H42-DAY-ZC	Hydrology SAF - Accumulated precipitation at ground by blended MW+IR and MTG FCI - Daily
H	H-2-H42-HOUR-ZC	Hydrology SAF - Accumulated precipitation at ground by blended MW+IR and MTG FCI - Hourly
H	H-2-H43-x-FD	Hydrology SAF - Snow detection and coverage
H	H-2-H50-x-FD	Hydrology SAF - Rainfall intensity
LSA	LSA-2-ALBEDO-x-ZC	Land SAF - Surface Albedo
LSA	LSA-2-LST-x-ZC	Land SAF - Land Surface Temperature
OSI	OSI-3-DLISSID-x-ZC	Ocean Sea Ice (OSI) SAF - Downward Long wave Irradiance (DLI) combined with the Solar Surface Irradiance (SSI) - Daily [2 products]
OSI	OSI-3-DLISSIH-x-ZC	Ocean Sea Ice (OSI) SAF - Downward Long wave Irradiance (DLI) combined with the Solar Surface Irradiance (SSI) - Hourly [2 products]
OSI	OSI-3-SST-x-ZC	Ocean Sea Ice (OSI) SAF - Sea Surface Temperature
NWC	NWC-[TBD]	Geostationary Nowcasting Cloud Mask – MSG continuity
NWC	NWC-[TBD]	Geostationary Nowcasting Cloud Top Temperature and Height – MSG continuity
NWC	NWC-[TBD]	Geostationary Nowcasting Cloud Type – MSG continuity
NWC	NWC-[TBD]	Convective Rain Rate (CRR) – MSG continuity

SAF	Product	Description
NWC	NWC-[TBD]	Convective Rainfall Rate from Microphysical properties (CRRPh). It is a different approach (different algorithm) to provide the same kind of output as Convective Rainfall Rate. It is expected that CRRPh will become better than CRR and at some time CRR will be superseded by CRRPh.
NWC	NWC-[TBD]	Rapidly Developing Thunderstorms (RDT) – MSG continuity

Table 20: List of SAF products candidate for dissemination

APPENDIX A SUBSAMPLING OF FCI IMAGERY

The subsampling is applied to three netCDF variables: ***effective_radiance***, ***pixel_quality***, and ***index_map***. The algorithm is different for each of these variables.

A.1 Effective_radiance

On top of the processing from FCI level 0 to level 1c (described in [FCIL1PUG]) a spatial subsampling is applied to the level 1c to generate a new dataset, also at level 1c, with a 3x3km spatial sampling distance like on MSG. The algorithm for subsampling is a convolution followed by a bilinear interpolation. The latter is a weighted average, first done per column (or per row) and afterwards per row (or per column; the order does not change the outcome). During commissioning alternate algorithm(s) may be studied if the selected algorithm is not satisfactory.

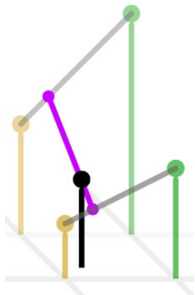


Table 21: Selected algorithm for subsampling: bilinear interpolation.

A.2 Pixel_quality

According to the [FCIL1PUG], each pixel has an 8-bit sample quality flag. When all bits are unset (FALSE) then the pixel quality should be "nominal". The setting of the bits is described in Table 22.

Bit	Name	Interpretation
0	missing_warning	Pixel has a contribution from missing samples following rectification.
1	radiometric_warning	Pixel may have radiometric errors due to a contribution from samples with radiometric errors following rectification. Radiometric errors in this sense arise from calibration activities occurring during the repeat cycle that do not impact the calibration of the complete repeat cycle, e.g. offset computation: deep space skipped due to Sun light pollution or Moon intrusion, insufficient number of valid deep space samples.
2	noise_warning	Pixel may be noisy (have a non-nominal noise level) due to a contribution from noisy samples following rectification.
3	geolocation_warning	Pixel may not have a very accurate geolocation since it has been computed using interpolated data.
4	saturation_warning	Pixel has a contribution from saturated samples following rectification.
5	straylight_correction_warning	Pixel has a contribution from samples that have been corrected for solar stray light contamination (above a set threshold).
6	extended_dynamic_range_warning	For the IR3.8 channel only: Pixel has a contribution from samples selected from the FAIR3.8 detector measurements
7	encoding_saturation_warning	Pixel is saturated from the process of encoding into 12-bits (13-bits for FAIR3.8).

Table 22: Description of flags in pixel_quality parameter.

The value of the aggregated *pixel_quality* variable is computed as the worst pixel quality among the contributing pixels. In other words, it is computed applying the logical operator OR.

These are the steps illustrated in the Figure 18 (less significant bit on the left):

A) The nine 1x1km pixels that are part of the corresponding 3x3km pixel are extracted (in the example 4 out 9 have quality issue).

B) Values per pixel are transformed from decimal to binary (in the example 3 in decimal gives 11000000 in binary).

C) A logical OR operation is performed per column of bits.

D) All bits are combined together and transformed from binary to decimal (in the example 11100000 in binary gives 7 in decimal).

E) The final value for the pixel quality is determined (in the example "7").

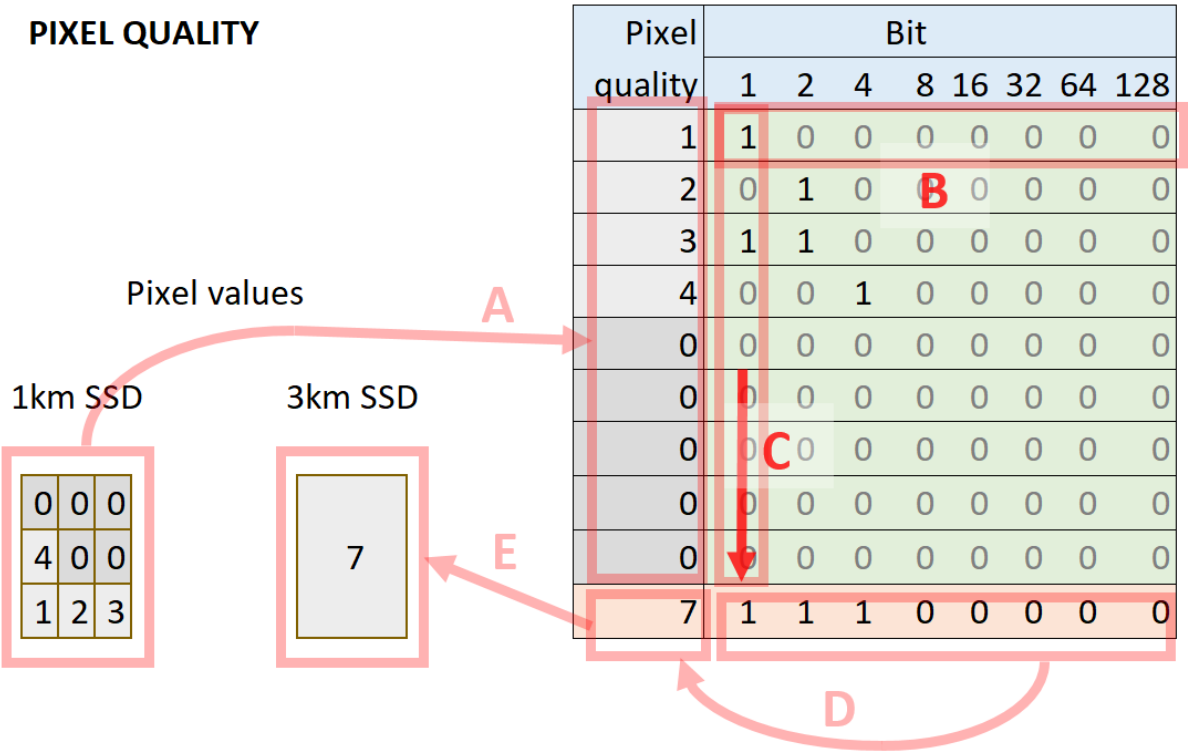


Figure 18: pixel_quality, subsampling calculation example.

A.3 Index_map

Within the *measurement* group for each channel, there is a bi-dimensional array, the *index_map*. It contains an integer number, an index, per pixel (2-byte unsigned short integer per pixel). The index represents a number of time intervals from the start of the repeat cycle. The default time interval is 0.1 seconds, but can be modified within the range 0.01 to 1s by ground processing, if needed.

A collection of geometric parameters is included within the *data* group and is applicable to all channel data groups. The geometric parameters are: *swath_direction*, *swath_number*, *time* (of acquisition), *subsatellite_latitude*, *subsatellite_longitude*, *altitude* (of the satellite), *subsolar_latitude, subsolar_longitude,* and *state.celestial.sun_satellite_distance*. The geometric parameters are calculated for each of the time intervals covered during the repeat cycle. An additional geometric parameter, *earth_sun_distance*, is given for a single time at the mid-point of the repeat cycle. Using the index value from the *index_map* for a particular pixel, the geometrical parameters applicable at the time of acquisition of that pixel can be established. The value of *data.swath_direction* is set to 0 for East-to-West scans, to 1 for West-to-East scans, and 2 during u-turns and retrace.

Regarding the subsampling from 1km SSD to 3km SSD, the value of the *index_map* variable at 3km is calculated as the median value of the corresponding pixels at 1km SSD. In other words, the 3km value is the integer that separates the 1km lower half samples from the higher half samples.

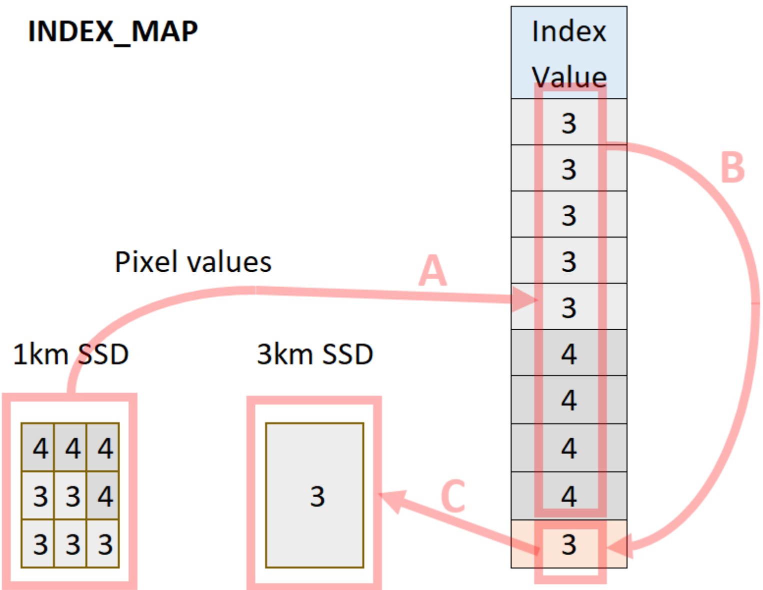
These are the steps:

A) The nine 1x1km pixels that are part of the corresponding 3x3km pixel are extracted.

B) The median (the value that keeps half the input values below and half the input values above) is calculated.

C) The final value (“3”) is the corresponding value for the 3x3 SSD.

See an example in Figure 19.



a

Figure 19: index_map, subsampling calculation example.

APPENDIX B FORMAT DESCRIPTIONS

The following embedded files provide the format of the customised products.

These are ncML files describing the content of the product files in the NetCDF Markup Language (NcML) format using XML syntax. They were extracted from the VSM files.

For native products (products that are not customised for EUMETCast Africa), no ncML description is provided here. Please refer to their corresponding Product User Guide.

FCI-1C-RRAD-3KM-BODY.ncml

FCI-1C-RRAD-HRV-BODY.ncml

FCI-2-GII-AFRICA.ncml

FCI-2-OCA-AFRICA.ncml

APPENDIX C FCI LEVEL 1C CHANNEL WAVELENGTHS

The following table presents the characteristics of the FCI channels wavelengths. There are 16 channels, covering from visible to infrared wavelengths. For more details, see [FCIL1PUG].

Channel Number	Spectral Channel	Central Wavelength, λ0	Spectral Width, Δλ0
1	VIS 0.4	0.444 µm	0.060 µm
2	VIS 0.5	0.510 µm	0.040 µm
3	VIS 0.6	0.640 µm	0.050 µm
4	VIS 0.8	0.865 µm	0.050 µm
5	VIS 0.9	0.914 µm	0.020 µm
6	NIR 1.3	1.380 µm	0.030 µm
7	NIR 1.6	1.610 µm	0.050 µm
8	NIR 2.2	2.250 µm	0.050 µm
9	IR 3.8	3.800 µm	0.400 µm
10	WV 6.3	6.300 µm	1.000 µm
11	WV 7.3	7.350 µm	0.500 µm
12	IR 8.7	8.700 µm	0.400 µm
13	IR 9.7	9.660 µm	0.300 µm
14	IR 10.5	10.500 µm	0.700 µm
15	IR 12.3	12.300 µm	0.500 µm
16	IR 13.3	13.300 µm	0.600 µm

APPENDIX D NAMING CONVENTION

All MTG products have a WMO-compatible name, following the WMO file naming convention [WMO-386] (cf Attachment II-15 p25 2009 edition).

The filename will consist of the dataset (or product) name with a file_type and a compression field:

(dataset_name) . (file_type) (compression)

Where:

dataset_name is composed of the following fields, separated by underscore symbols, "_":

(pflag)_(productidentifier)_(oflag)_(originator)_(yyyyMMddhhmmss)_(freeformat)

productidentifier is composed of the following fields, separated by commas:

(locationindicator),(datadesignator),(freedescription)

freedescription is composed of the following fields with plus symbol or dash symbol separators:

(spacecraftid)-(data_source)−(processing_level)−(type)−(subtype)−(coverage)−(subsetting)−(component1)−(component2)−(component3)−(purpose)−(format)

freeformat is composed of the following fields, separated by underscore symbols, "_":

(facility_or_tool) _(environment)_(start_time)_(end_time)_
(processing_mode)_(special_compression)_(disposition_mode)_
(repeat_cycle_in_day)_ (count_in_repeat_cycle)

The order of the fields is mandatory.

NOTE: If there is no relevant value within the freeformat section, the field is left out. This can lead to the allowable repetition of underscores.

The following table shows the fully expanded set of name fields in the correct order, with values described for FCI L1c datasets. Following the main table, subsequent subsections describes the allowed values for the selected fields in greater detail. Where a field has "no value" as a setting this implies no character is present in the file name.

Name Field	Description	FCI-1C 3KM and 1KM	FCI-1C RGB	FCI-2
pflag	WMO mandated	“W”	“W”	“W”
locationindicator	WMO mandated	“XX-EUMETSAT-Darmstadt”	“XX-EUMETSAT-Darmstadt”	“XX-EUMETSAT-Darmstadt”
datadesignator	The type of data with respect to the categories and subcategories defined in [|WMO-386],	“IMG+SAT”	“IMG+SAT”	“IMG+SAT”
spacecraftid	Spacecraft indicator	“MTIn” for MTG Imager n where n = 1, 2, 3 or 4	“MTIn” for MTG Imager n where n = 1, 2, 3 or 4	“MTIn” for MTG Imager n where n = 1, 2, 3 or 4
data_source	Instrument, platform or SAF	“FCI”	“FCI”	“FCI”
processing_level	Processing Level	“1C”	“1C” because they have been generated from 1C datasets	“2”
type	Identifies the type of data	“RRAD” for rectified radiances	“**RGB**”	“**GII**” for Global Instability Indices, “**OCA**” for Optimal Cloud Analysys
subtype	Identifies a sub-type for the type.	“**3KM**” for MSG continuity with MTG innovation “**1KM**” for HRV continuity	“**SCON**” for Severe Storm (convection), “**NMPHY**” for Night Microphysics (fog and low clouds), “**TCOL**” for True Colour, “**FIRET**” for Fire Temperature, “**CPHAS**” for Cloud Phase	“**AFRICA**”, indicating subsetting
coverage	Coverage of the full accumulation interval	“**AF**” for Africa coverage	“**AF**”	“**AF**”
subsetting	Identification of the type of subsetting performed	**[channel]** Example: “VIS06”	No value	No value
component1	Identifies a first level component of the product	“x”	“x”	“x”
component2	Identifies a second level component of the product	“x”	“x”	“x”
component3	Identifies a third level component of the product	No Value	No Value	No Value

Name Field	Description	FCI-1C 3KM and 1KM	FCI-1C RGB	FCI-2
purpose	The intended purpose of the dataset. This normally refers to the intended final recipient.	No Value “DIS” for a dissemination dataset (has CharLS compression)	“DIS” for a dissemination dataset	“DIS” for a dissemination dataset
format	The intended encoding format of the dataset.	“NC4E” for netCDF-4 enhanced model	“**GTF**” for GeoTIFF	“NC4E” for netCDF-4 enhanced model
oflag	WMO mandated	“C”	“C”	“C”
originator	WMO mandated	“EUMT”	“EUMT”	“EUMT”
yyyyMMddhhmm ss	Is the UTC time of the processing, defined as the time of the formatting of the dataset/product by the processor [TBC-EUMETSAT], formatted in Abbreviated Generalised Time format e.g. yyyy = year MM = month dd = day of month hh = hour of day mm = minute of hour ss = second of minute			
facility_or_tool	Facility or tool producing the dataset	“**DT**” = Data Tailor “GTT” = Generic Test Tool	“**DT**” = Data Tailor “GTT” = Generic Test Tool	“**DT**” = Data Tailor “GTT” = Generic Test Tool
environment	Ground Segment Environment producing the dataset	“OPE” - Operational	“OPE” - Operational	“OPE” - Operational
start_time	UTC Time of start of Sensing Data formatted in Abbreviated Generalised Time format (see above).	This is the time of the first measurement in the product	The time of the first measurement in the product.	The time of the first measurement in the product.
end_time	UTC Time of end of Sensing Data formatted in Abbreviated Generalised Time format (see above).	The time of the last measurement in the product	The time of the last measurement in the product	The time of the last measurement in the product
processing_mode	Identification of the mode of processing	“N” = nominal	“N” = nominal	“N” = nominal

Name Field	Description	FCI-1C 3KM and 1KM	FCI-1C RGB	FCI-2
special_compression	This field provides identification of a special compression technique that has been applied to one or more variables in the dataset. Special compression does not include the standard netCDF data compression or "deflation" using in-built zlib support which is transparent to the user.	"**JLS**" = JPEG-LS. Lossless JPEG compression has been applied internally. No Value – no special compression	No Value – no special compression	No Value – no special compression
disposition_mode	Shows disposition of the dataset from the perspective of an end-user"s needs.	"O" = operational "T" = testing	"O" = operational "T" = testing	"O" = operational "T" = testing
repeat_cycle_in_day	4-digit number (right-justified, zero-filled) indicating the expected current repeat cycle or group accumulation interval in the day for this particular dataset. The counter starts at 0001 for the first repeat cycle at or after midnight and resets for the next repeat cycle at or after the following midnight.	Variable	Variable	Variable
count_in_repeat_cycle	4-digit number (right-justified, zero-filled) indicating the expected count value of the dataset chunk in the repeat cycle. The counter will have discontinuities when chunks are not produced. The counter starts from 1 and resets when the repeat_cycle_in_day value changes. The counter increments for each chunk in a repeat cycle or accumulation interval (whether header, body or trailer). A value of 0 is used for datasets for which the counter is not applicable (e.g. datasets which are not chunk-able).	Variable	Variable	Variable
file_type	Indicator of the encoding format of the data, according to WMO conventions.	".nc" – netCDF	"**.tif**" - GeoTIFF	".nc" – netCDF

Name Field	Description	FCI-1C 3KM and 1KM	FCI-1C RGB	FCI-2
compression	Indicator of compression applied to the dataset as a whole according to WMO conventions (as opposed to the internal compression of variable indicated by the "special_compression" name field).	No value	No value	No value

Table 23: Breakdown of the fields in the file naming convention