MTGTD-360 Spectrally Representative FCI L1C Test Products - Package Description

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Change Record

Version	***Date***	***DCR* No.*** *if applicable*	***Description of Changes***
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1 TEST DATA PACKAGE OVERVIEW

1.1 Document Purpose and Scope

This is the Package Description document for the package MTGTD-360 Spectrally Representative FCI L1C Test Products.

This dataset uses the FCI SRF delivered in the package MTGTD-392 [MTGTD-392] and also available via the EUMETSAT website.

It is recommended to use this dataset in conjunction with the MTG FCI L1 Product User Guide [FCIL1PUG].

1.2 Applicable Documents

ID	Document Title	Reference

1.3 Reference Documents

ID	Document Title	Reference
[FCIL1FS]	MTG FCI Level 0 & 1 Format Specification [FCIL1FS]	EUM/MTG/SPE/10/0447
[GFS]	MTG Generic Format Specification [GFS]	EUM/MTG/SPE/11/0252
[FCIL1PUG]	MTG FCI L1 Product User Guide [FCIL1PUG]	EUM/MTG/USR/13/719113 https://www.eumetsat.int/media/45923
[MTGTD-392]	MTGTD-392 FCI SRF for Users - Package Description	EUM/MTG/TEN/22/1291669
[MTGTD-298]	MTGTD-298 FCI 1C 26-Hour Test Data for Users - Package Description	EUM/MTG/DN/21/1240265

1.4 Baseline

The baseline documents for this delivery are:

Document Title	Version
[GFS]	4A
[FCIL1FS]	4C

1.5 Terms of Use

The user of the Test Data acknowledges that the following limitations apply:

1. Test Data is provided ‘as is’, with EUMETSAT being unable to make any warranty or guarantee as to its properties, quality, or fitness for any specific purpose beyond facilitating user familiarisation with FCI L1C products.

2. Test Data shall not be used for operational purposes, nor shall it be cited in scientific publications or disclosed through other publicly available channels and internet platforms without prior agreement with EUMETSAT.

3. Test Data shall not be transferred, passed on or made available to any third parties without adequately indicating the nature and source of the data.

4. EUMETSAT shall bear no liability for any consequences, whether direct or indirect, arising from any use of Test Data. This includes but is not limited to adaptations carried out to user equipment or software based on the qualities of Test Data. Equally, EUMETSAT cannot be held liable for the interface between such adaptations and the decryption equipment required to decrypt and use Test Data. Any and all adaptations, upgrades or configurations are done at the user’s own risk.

5. Test Data will be made available only up until the respective satellite is declared operational. EUMETSAT shall not be liable if the provision of Test Data should deteriorate, be reduced or discontinued for any given reason prior to the respective satellites being declared operational.

6. EUMETSAT reserves the right, without prejudice to any other rights and remedies, to prohibit the use of Test Data without notice in the event that the user fails to observe any of its obligations, specifically those listed under points 2 and 3.

Any dispute, controversy or claim arising out of or relating to the interpretation, application or performance of these Terms of Use shall be settled in accordance with the Rules of Arbitration of the ICC.

2 TEST DATA PACKAGE CONTENTS AND USAGE

2.1 Package Overview

This document is the test package description for the following test package:

MTGTD-360 Spectrally Representative FCI L1C Test Products

MTGTD-360 is an evolution to the previously delivered MTGTD-298 FCI 1C 26-Hour Test Data for Users package that was released to users in October 2021. While both datasets have the same format specification baseline, the content is radically different. The radiances contained in the previous package were a plain copy of the SEVIRI channels, while this dataset contains simulated channels that are spectrally representative of the actual FCI output (see section 3.1).

The package contains a compressed and uncompressed version of the data. The compressed data has been generated using external HDF filters based on the CharLS compression (please refer to [FCIL1PUG] for further information). Note that the products disseminated in NRT will be in the CharLS-compressed version, while archive products may make use of the standard netCDF Deflate compression.

This test data contains 24 hours of FCI Level 1C FDHSI datasets to be used for product familiarisation. The format for these test data is derived from:

- MTG Generic Format Specification, V4A
- MTG FCI Level 0 & 1 Format Specification, V4C

The term dataset refers to a number of associated files. In this case, the files of each dataset are all associated to an FCI repeat cycle.

2.2 Package Contents

This package contains a Full Disk High Spectral Imagery (FDHSI) dataset in nominal acquisition conditions. The dataset ranges from 20/09/2017 00:00 to 20/09/2017 23:59 with one repeat cycle (RC) every 10 minutes, totalling to 144 RCs (see 2.3.5 for more information).

All datasets above contain:

- Full images of the (rectified) Earth disk as seen from geostationary orbit over the (0,0) lat/lon point.
- 16 simulated channels
- 2-D array sizes: 5568x5568 pixels for IR channels and 11136x11136 pixels for VIS-NIR channels.

The single RC datasets are divided into 40 body chunks and 1 trailer chunk file (chunk “41”) each. The body chunks contain the 2-D arrays (including the image data) and auxiliary geometric information. The trailer chunk is a single file, coming at the end of the repeat cycle, containing summarised information for the complete repeat cycle.

The data compressed and uncompressed files are provided under COMPRESSED and UNCOMPRESSED subdirectories. Each repeat cycle of chunks is provided in a separate zip archive file. The zip archive also contains a sha256sum checksum file (see below)

In addition, the zip archive FCI-latitude-longitude-grids.zip contains the FCI 1C latitude/longitude grids at 500m,. 1km, 2km and 3km resolutions plus an sha256sum.txt checksum file.

2.3 Package Usage

The main aim for this packet of test data is user familiarisation with the FCI-1C-RRAD-FDHSI-FD format and radiometric content. The content of the channel radiances has been generated with a sophisticated simulation framework, and may be used for scientific purposes, taking into account the various limitations (see section 4.2).

2.3.1 How do I check the validity of my test package download?

A checksum file ("sha256sum.txt") has been generated for the dataset. “sha256sum” is very similar to the standard “md5sum” command, but it provides a better validation. It is available by default in multiple Unix/Linux operating systems.

The complete set of files in the test package can be validated against their checksums using the command:

```
sha256sum --check sha256sum.txt
```

2.3.2 How can I display the information inside the files?

You can display the structure of the document using “ncdump” (in a Unix/Linux environment). It provides the CDL description of a netCDF file (you need to install the netCDF libraries).

```
ncdump -h FILE.nc
```

These netCDF files have been generated using the "netCDF-4 enhanced" format using HDF5 as the storage format.

```
file FILE.nc
FILE.nc: Hierarchical Data Format (version 5) data
```

You could use standard HDF5 tools, for example hdfview.

```
hdfview FILE.nc
```

A good tool to display netCDF files is Panoply. You can download it from NASA (http://www.giss.nasa.gov/tools/panoply/). In a Unix/Linux system, run it with the command:

```
panoply.sh
```

A further good tool for displaying FCI data using Python is *Satpy*. The *Satpy* free and open source Python library, as part of the *Pytroll* framework, offers a vast range of functionalities for reading, manipulating, and writing data from remote-sensing earth-observing meteorological satellite instruments. *Satpy* includes a reader for FCI L1c FDHSI imagery (called "fci_l1c_nc"), making the reading, geolocating and processing of FCI data very easy and fast. See [FCIL1PUG] for further information, or visit *Satpy*'s documentation at http://satpy.readthedocs.org/. An updated tutorial for reading a repeat cycle of data and generate a resampled RGB is available in the documentation's examples.

2.3.3 How can I build a full disk out of the body chunks?

Filenames containing the string CHK_BODY are body chunks. Each chunk contains a single strip of data for each of the 2-D arrays (`effective_radiance`, `pixel_quality`, `index_map`),wide in the East-West direction (5568 or 11136 columns), and narrow in the North-South direction (typically about 138 or 278 rows). By stacking the single strips from each chunk vertically, the complete (square) array for the full-disk can be composed.
There are 40 body chunks for each FDHSI product. **Error! Reference source not found.** shows an example of the first three chunks of a channel. White areas to the left and right of the colored Earth are masked deep-space values. They contain the FillValue NC_FILL_USHORT (65535).
Please note that the image data is stored "upside-down" in the files, i.e. the origin of the row/column counting corresponds to the South-West corner of the Earth's view.

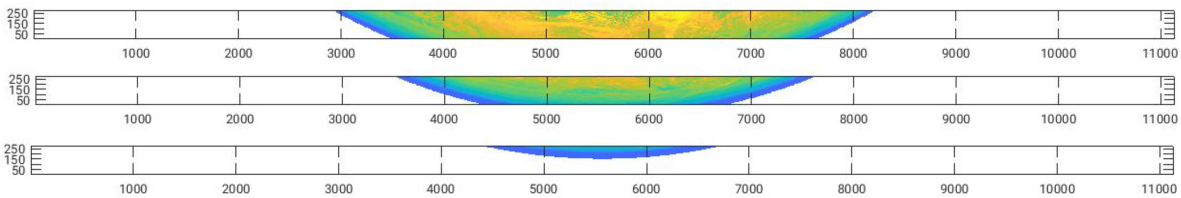


Figure 1: Example of the first three chunks of a channel in a nominal dataset, showing the Southern part of the Earth's disk. The axes denote the row/column numbering. Note that the rows have been inverted to visualise the Earth with a North-up orientation.

2.3.4 How can I geolocate the data?

The FCI L1c radiance data is registered to a reference grid with fixed latitude and longitude positions according to the spatial resolution of the data. In order to reduce the size of the dataset, the latitude/longitude arrays for the radiance, pixel quality and index map variables are not

included in the FCI L1c product. Instead, the pixels of these variables can be geolocated by the pixels' position within the grid/image array. The formulae for creating the reference grid and linking a pixel position to a latitude/longitude value are given in the FCI L1c Product User Guide [FCIL1PUG].
Note that this package includes auxiliary files containing computed lat/lon arrays for every pixel in the 500m, 1 km, 2 km and 3km full-disk grids. These products use the 1km and 2km grids. Users may use these files for validating their computation of the pixels geolocation. Note that the grids have been encoded to integers inside the NetCDF files using a scale_factor. For this reason, users can expect a minor deviation (in the order of 1e-8° in the lat/lon space, corresponding to less than 2mm distance at the Earth's surface) between the grids contained in the auxiliary files and the grids computed using the parameters inside the L1c files as described in [FCIL1PUG].

2.3.5 Which repeat cycles are included in the dataset? How do I match them with SEVIRI?

The start date of the produced FCI FDHSI Level-1c repeat cycles are as follows:

- 20.09.2017 00:00:00
- 20.09.2017 00:10:00
- 20.09.2017 00:20:00
- …
- 20.09.2017 23:40:00
- 20.09.2017 23:50:00

The data simulation framework is based on SEVIRI data inputs. Since the repeat cycle intervals are different for SEVIRI (15 min) and FCI (10 min), a specific correspondence strategy was applied, as shown in Table 1. The SEVIRI repeat cycle with the closest start date is associated to each FCI repeat cycle. This means that some SEVIRI repeat cycles are associated to two consecutive FCI repeat cycles, and that the real temporal resolution of the dataset is still the one from SEVIRI (15 min repeat cycles).

FCI Repeat Cycle Start Date	SEVIRI Repeat Cycle Start Date
…	…
05.04.2020 16:00:00	20.09.2017 16:00:00
20.09.2017 16:10:00	20.09.2017 16:15:00
20.09.2017 16:20:00	20.09.2017 16:15:00
20.09.2017 16:30:00	20.09.2017 16:30:00
20.09.2017 16:40:00	20.09.2017 16:45:00
20.09.2017 16:50:00	20.09.2017 16:45:00
20.09.2017 17:00:00	20.09.2017 17:00:00
…	…

Table 1: Temporal correspondence between FCI and SEVIRI input images

2.3.6 How do I decompress the compressed version of the data?

The `effective_radiance`, `pixel_quality` and `index_map` variables in the compressed version of the data have been compressed with the CharLS algorithm. If you try to extract the data from these variables, and the CharLS library is not properly installed, you will get an error.

This CharLS library is known to work properly in Linux/Unix environments and only works with the netCDF library of the C language.

There are two possible solutions for decompressing the data using the C netCDF library. Either write a C code to read the data, or use the “nccopy” command from the netCDF tools.

Regarding “nccopy”, if CharLS is properly installed, it will read the compressed file and will create an uncompressed output. Afterwards, you could use your favourite software to open the output file.

```
nccopy input_CharLS.nc output_uncompressed.nc
```

You may check the compression with the “h5ls” command (from HDF5 tools). This is an example having the “effective_radiance” compressed (note that compressed data is about 1771 times smaller than uncompressed):

```
!$ h5ls -v input_CharLS.nc/data/vis_06/measured/effective_radiance
[...]
Chunks:    {343, 22272} 15278592 bytes
Storage:   15278592 logical bytes, 8625 allocated bytes, 177143.10%
utilization
Filter-0:  HDF5 JPEG-LS filter-56782 OPT {2, 1, 343, 22272, 16, 1, 0, 0, 0, 0, 0, 0, 0}
Type:      native unsigned short
```

And this is an example after decompressing the data:

```
!$ h5ls -v output_uncompressed.nc/data/vis_06/measured/effective_radiance
[...]
Chunks:    {343, 22272} 15278592 bytes
Storage:   15278592 logical bytes, 15278592 allocated bytes, 100.00% utilization
Type:      native unsigned short
```

Java libraries (example: Panoply) do not currently work with CharLS.

Python libraries will also fail when trying to read the compressed variable if CharLS is not installed correctly. A simple way to import the FCIDECOMP (CharLS) filter into Python is to use the “hdf5plugin” library. After installation, add the “import hdf5plugin” line at the beginning of your Python script, and FCIDECOMP will automatically be imported into Python and will be used by common libraries to read the compressed data.

For further information, please refer to [FCIL1PUG].

2.3.7 Who do I contact with questions about this test data package?

Questions about this test package should be addressed to the EUMETSAT User Service Helpdesk at:

ops@eumetsat.int.

The inclusion of “MTGTD-360” in the title of the e-mail will uniquely identify the delivery and assist in routing the question to the relevant people.

3 GENERAL FEATURES OF THE DATASET

This section presents the main features implemented in this test data package, including improvements with respect to the previously released FCI test datasets [MTGTD-298].

3.1 Top of Atmosphere Radiance Simulation

The dataset represents a set of top-of-atmosphere (TOA) radiances for a set of full FCI disks covering 24 hours computed by radiative transfer simulations using realistic profiles of atmospheric constituents (gas, clouds and aerosols). The data were produced during the EUMETSAT contract EUM/CO/19/4600002367/MoL lead by Hygeos (https://www.eumetsat.int/HSR-Geo-simulations).
The simulations use the radiative transfer model ARTDECO (https://www.icare.univlille.fr/artdeco/) for the spectral range between 0.354 µm to 3.635 µm modelling the layers characterised by multiple-scattering using the adding and doubling techniques. RTTOV (https://nwpsaf.eu/site/software/rttov/) is used for the region between 3.635 µm and 15.503 µm. The two simulations are carefully joined in the 3.6 µm region ensuring seamless spectral characteristics.
The definition of the vertical profiles of clouds, aerosol and gaseous constituents is based on a combination of model data and remote-sensing products based on SEVIRI observations. In particular, hourly forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF) provide the vertical profiles of temperature, humidity, ozone and cloud liquid and ice water content together with surface winds, surface pressure and skin temperature. Values are linearly interpolated to the 15-minute SEVIRI repeat cycle and spatially interpolated on the SEVIRI spatial grid. The Copernicus Atmosphere Monitoring System (CAMS) global reanalysis (EAC4, https://www.ecmwf.int/en/forecasts/dataset/cams-global-reanalysis) provide the vertical profile of mass mixing ratio for the five aerosol species sea salt, desert dust, organic matter, black carbon and sulfates, interpolated to the spatial grid and the 15-minute repeat cycle of SEVIRI.
Extra auxiliary information on cloud phase, cloud top height, cloud particle effective dimension and cloud optical thickness come from the EUMETSAT Optimal Cloud Analysis (OCA) which retrieves cloud properties based on SEVIRI measurements. Cloud products are blended with the ECMWF cloud profiles to provide a full representation of the atmosphere state for each individual pixel.
Digital elevation model and surface type classification are static input based on the data used in the SEVIRI ground segment while the surface bi-directional reflection properties are adapted from MODIS-derived products.
The radiative transfer simulation are performed taking into account the spectral response functions of FCI channels provided by EUMETSAT (see [MTGTD-392]). Users will find a detailed description of the simulations and the data processing performed to produce the dataset in the technical report produced during the EUMETSAT study (https://www.eumetsat.int/media/49021).

3.2 Spatial Resampling

The TOA radiances described in the previous section were produced on the SEVIRI spatial grid by Hygeos. EUMETSAT have resampled them on the FCI spatial grids using nearest neighbour interpolation. The nearest neighbour method was selected in order to maintain a direct link with the simulated radiances on the SEVIRI grid.

3.3 Index Map and Swath Boundaries

The FCI L1c data uses the index map mechanism for an easy retrieval of acquisition and geometrical properties for each image pixel (see [FCIL1PUG] for further information). For this package, the index map and all principal related variables have been computed.
An FCI line-of-sight model and a pre-defined swath acquisition process simulated the Level 1b acquisition grids, which were then used by the rectification process to generate the index map and the geometric information.

The selected time step for the index map generation is 0.1 s, which results in 6000 distinct values for each parameter over the course of one repeat cycle.
The vector variables in the files, containing computed values that can be accessed using the index in the `data/<channel_name>/measured/index_map` variable, are:

- `time`
- `state/platform/subsatellite_longitude`
- `state/platform/subsatellite_latitude`
- `state/platform/platform_altitude`
- `state/celestial/earth_sun_distance`
- `state/celestial/sun_satellite_distance`
- `state/celestial/subsolar_latitude`
- `state/celestial/subsolar_longitude`
- `data/swath_direction`
- `data/swath_number`

Note: compared to the last test data releases, the mechanism for handling the indices of the index map has been changed, to account for constraints in the operational ground processor.
In previous test data releases (e.g. [MTGTD-298]) each L1c body chunk contained the full information for the entire repeat cycle in each vector variable (i.e., in each chunk, every vector variable had 6000 entries). In this setup, the pixel values in the `index_map variable` could thus directly be used as indices to access the values in the vector variables.
In the new setup, as implemented in this test data package, this is not possible anymore. The vector variables in each chunk now contain only the data entries relevant for all pixels making up that chunk. Due to the different time span covered by the different chunks, the vector variables now have changing dimensions across the chunks. For this reason, the variables `index` (and optionally `index_offset`) shall be now used in combination with the `index_map` variable to map the values of the vector variables to the pixels. The variable `data/index` for a chunk gives the list of `index_map` values relevant for this particular chunk, while `index_offset` contains the lowest value in the index variable.
For a better understanding of the usage of the data, a simple example is provided in the following (Figure 2). For the sake of simplicity, the full-disk is assumed to be composed by two chunks in this example. Bold indicates the actual variables in the product, italic the array positions on the vector. Index variables start with 1. Zero-based numbering of vectors is assumed. Yellow cells indicated the selected example values. Vector is an example for a vector variable as listed above. The first table shows the parameter for the full disk without any

chunking. The second and third tables illustrate how the information is stored in two chunks called “chunk 1” and “chunk 2”.
The setup described above allows the users two possible ways of getting the vector variable parameters. They are called method 1 and method 2 in the example below.

Full Disk	**index_offset**	1									
	index	1	2	3	4	5	6	7	8	9	10
	actual array position	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
	vector1	20.1	22.5	24.3	26.6	27.9	32.5	34.2	36.7	38.8	41.1

chunk 1	**index_offset**	**1**														
	index	**1**	**2**	**3**	**4**	**5**	**6**	**7**								
	actual array position	*0*	*1*	*2*	*3*	*4*	*5*	*6*								
	vector1	**20.1**	**22.5**	**24.3**	**26.6**	**27.9**	**32.5**	**34.2**								
	index map	1	1	2	3	3	3	4	4	4	5	5	6	6	7	7

method 1 vector_value = vector(index_map-index_offset)
For index_map = 3
vector_value = vector(3-1) = vector(2) = 24.3

method 2 vector_value = vector(index array position where index = index_map)
For index_map = 3
vector_value = vector(index array posiiton where index = index_map)) = vector(2) = 24.3

chunk 2	**index_offset**	**5**														
	index	**5**	**6**	**7**	**8**	**9**	**10**									
	actual array position	*0*	*1*	*2*	*3*	*4*	*5*									
	vector1	**27.9**	**32.5**	**34.2**	**36.7**	**38.8**	**41.1**									
	index map	5	5	5	6	6	6	7	7	8	8	9	9	9	9	10

method 1 vector_value = vector(index_map-index_offset)
For index_map = 8
vector_value = vector(8-5) = vector(3) = 36.7

method 2 vector_value = vector(index array position where index = index_map)
For index_map = 8
vector_value = vector(index array posiiton where index = index_map)) = vector(3) = 36.7

Figure 2: Example for the usage of the variable index_map, index and index_offset in the new setup.

To provide additional information on the acquisition process, the variable `data/<channel_name>/swath/swath_boundary` is present and populated in the L1c files.

3.4 Radiometric coefficients

In this dataset, the radiometric coefficients have been computed using the radiative properties (i.e. spectral response function (SRF)) of the FCI instrument. The SRF, as obtained by Thales Alenia Space (France) and ESA, has been established by a combination of theoretical modelling and measurements (NIR and IR filters and windows, as well as VIS retinas). The SRFs used by this dataset have been released to users, see [MTGTD-392].

The computed radiometric coefficients include the variables
- `radiance_unit_conversion_coefficient`
- `radiance_to_bt_conversion_coefficient_a`
- `radiance_to_bt_conversion_coefficient_b`
- `radiance_to_bt_conversion_coefficient_wavenumber`

each present in the group `data/<channel_name>/measured`.

Also the parameters `spectral_width_actual` and `central_wavelength_actual` in `data/<channel_name>` have been computed and populated.

Additionally, the encoding (“packing”) of the radiances (`effective_radiance` variable) from floats to integer counts has been performed using `scale_factor` and `add_offset` parameters in line with the FCI properties. For this reason, the counts can cover the full counts dynamic range of FCI, namely 0 to 4095 (and 0 to 8191 for the fire 3.8µm channel).

Channel Effective Solar Irradiance

Due to a difference in the employed solar spectra, the solar irradiance values assumed by the radiance simulation framework are different to the ones as computed for the FCI model. To allow a correct and consistent radiance-to-reflectance conversion using the parameters contained in the L1c files, the values for `data/<channel_name>/measured/channel_effective_solar_irradiance` have been populated using the simulation framework values. Users interested in the values computed using the FCI convention can refer to Table 2. Note that the operational products will be populated using the FCI convention.

Table 2: Channel effective solar irradiance values as calculated for the simulation framework (populated in the files) and for the FCI model. Units of mW/(m^2.(cm^-1)).

	vis_04	vis_05	vis_06	vis_08	vis_09	nir_13	nir_16	nir_22	ir_38
FCI	37.42935	48.81421	66.15742	72.87559	72.08456	69.73279	63.35496	36.42759	10.68266
Sim	37.28372	49.18896	65.72137	71.64363	72.59216	68.16991	62.72358	38.32212	18.28421

3.5 Hotspots simulation

The FCI IR 3.8 µm channel features an extended dynamic range ("warm range"), designed to provide improved radiance measurements of very hot surfaces, such as wildfires. The extended dynamic range, with pixel count values between 4096 and 8191, needs to be decoded using the `effective_radiance` attributes `warm_scale_factor` and `warm_add_offset` (see FCIL1PUG for more information).

To allow users to get acquainted with this format, this dataset contains simulated hotspots that span over the full dynamic range.
For this, the 3.8 µm channel pixels that reached saturation in the proxy SEVIRI 3.9 µm channel (at around 335 K brightness temperature), were manually replaced to have a brightness temperature in the range 335 K - 500 K. Additionally, the same pixels in the 10.5 µm channel were assigned the same brightness temperature.

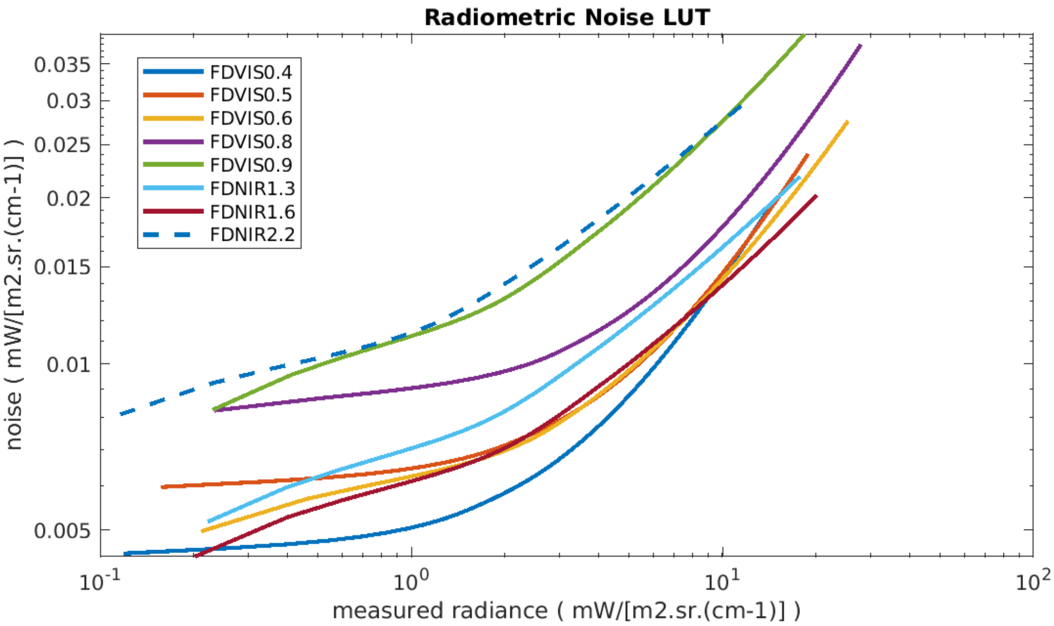
Pixels in the 3.8 µm channel with count values inside the extended dynamic range are marked in the `data/ir_38/measured/pixel_quality` variable with the `extended_dynamic_range_warning` flag.

Please note that this fire simulation process is solely designed for the test usage of the extended dynamic range, and is therefore not suitable for training fire detection algorithms.
Please note also that due to saturation effects in the original SEVIRI 3.9 µm channel in sunglint/sun-straylight areas, a high number of spurious hot pixels may appear in affected areas of the imagery.

3.6 Radiometric Noise Look-Up Tables

The FCI radiometric noise, as characterised on-ground (knowledge at the instrument's CDR), are provided in the trailer in the following variables:
data/<channel_name>/measured/radiometric_noise_lut_radiance (x-axis)
data/<channel_name>/measured/radiometric_noise_lut_noise (y-axis).

Figure 3 shows the characterised LUTs for all channels, with radiance and noise expressed in [mW/(m^2.sr.cm^{-1})]. Figure 4 shows the same LUTs expressed in SNR (for VIS/NIR) and Noise Equivalent Delta Temperature (NEdT) in [K]. The measured radiances are expressed in measured apparent reflectance (n.u., see [FCIL1PUG] section 8.5) for VIS/NIR and in temperature in [K] for the IR channels.



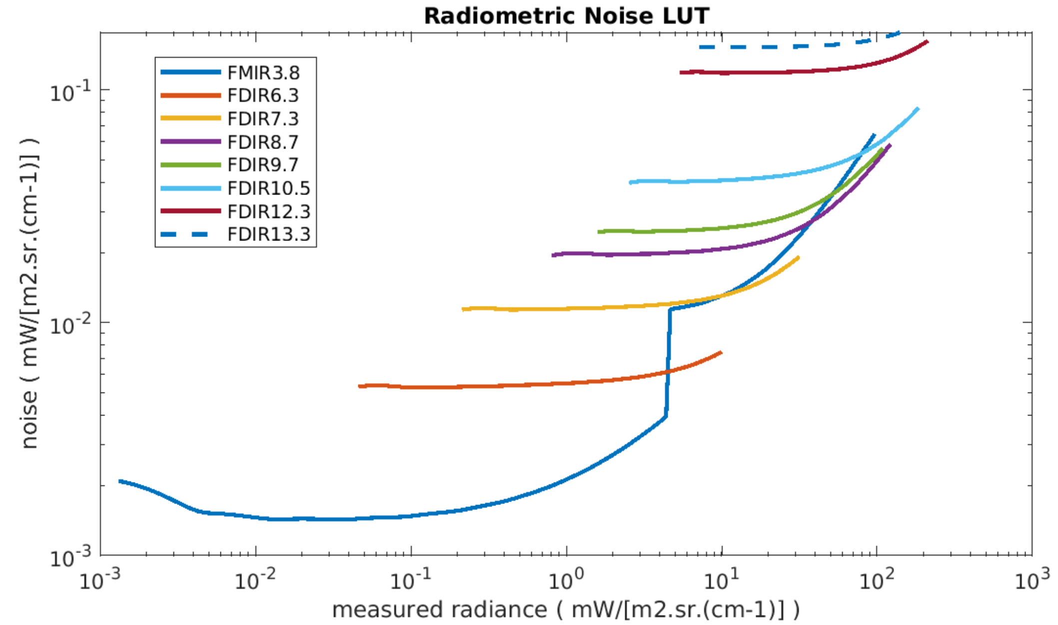
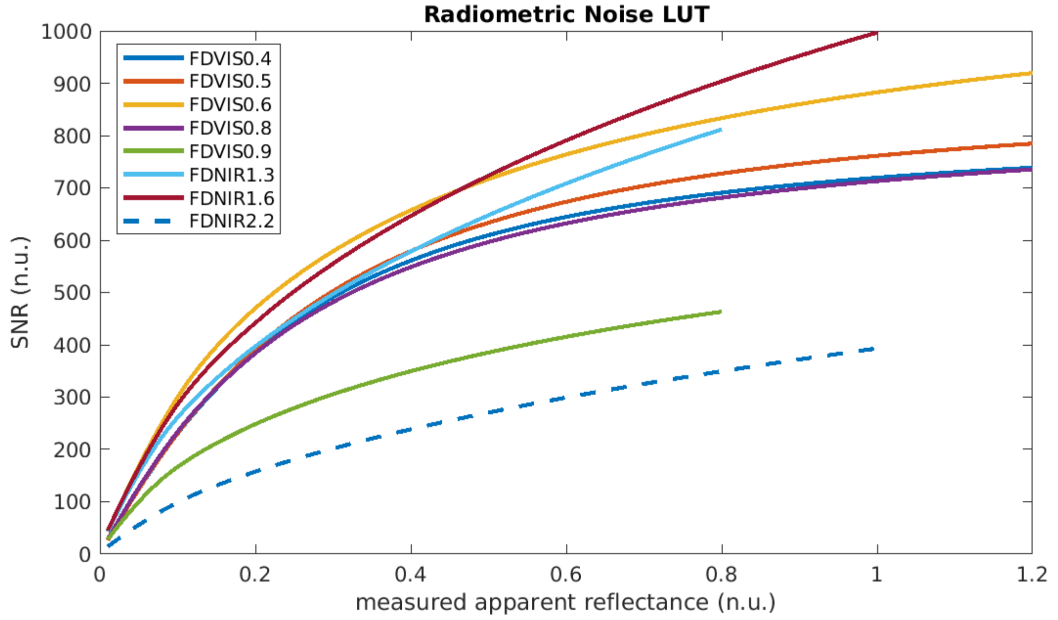


Figure 3: Radiometric noise for the FDHSI channels (VIS/NIR on top and IR on the bottom), in [mW/(m^2.sr.cm^{-1})].



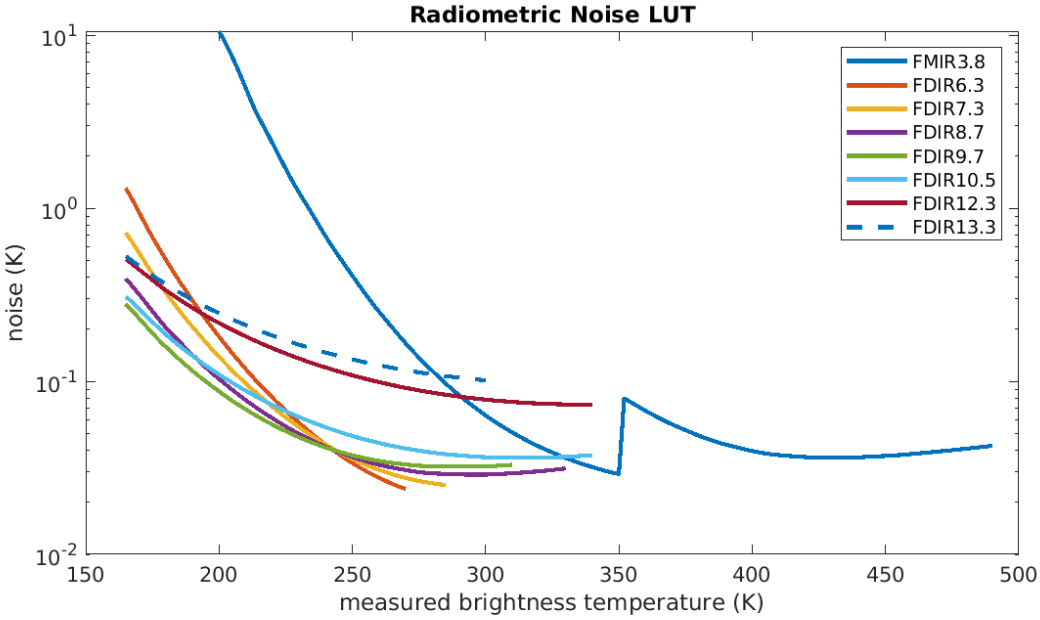


Figure 4: Radiometric noise for the FDHSI channels (VIS/NIR on top and IR on the bottom), in SNR [unitless] and NEdT [K].

Note that the images above display the originally characterised LUTs. In the L1c NetCDF files, the values are not stored in the original floats, but as encoded ("packed") integers using `scale_factor` and `add_offset` (similarly to the effective radiance variable, see FCIL1PUG). Note that the `radiometric_noise_lut_radiance` variable for channel `ir_38` has been encoded using `warm_scale_factor` and `warm_add_offset` for the extended dynamic range (pixel count values between 4096 and 8191).
In this dataset, optimal `scale_factor` and `add_offset` have been computed individually for each channel and variable in order to minimise the loss of precision due to the integer quantisation effect. With the computed parameters, no significant quantisation effects can be observed in the decoded floats, apart from minor steps in the very low-radiance part of the ir_38 channel.

3.7 Filename Start and End Times

In previously released test datasets, the start and end times indicated in the filename of each chunk were populated by simply using 15 s steps between each (body) chunk. In this dataset, the start and end times have been populated using the actual sensing start and end times of the data included in each chunk, as in the convention for the operational products (see [FCIL1PUG]).

4 KNOWN LIMITATIONS

We include here some known limitations in the provided dataset. There are two groups of limitations: about the format, and about the data itself.

4.1 Format Issues

This test data release aims at providing a data format as close as possible to the data format of the future FCI data. The majority of the main variables and attributes have been filled with representative values for this package. The format and contents of the FCI L1C dataset may require modifications and additions as the MTG system evolves during development. However, it is expected that the overall format and philosophy of the format will not change and that future updates will be minor.

4.1.1 CF Convention Conformance

The CF 1.6 and forthcoming CF 1.7 conventions do not cover the enhanced netCDF-4 constructs that are used in the MTG products such as groups, enumerated data types and unsigned data types. This means that the MTG products cannot currently conform to existing CF conventions. It is hoped that the creation of a CF 2.0 that is compatible with netCDF-4 will allow the products to be made fully CF compatible.

4.1.2 Body Chunk Sizes

The number of reference grid rows in each body chunk and the duration of the body chunks should only be considered as a sizing estimate for the operational values. Operational processing needs may require an adaptive chunking during the nominal dataset production.

4.1.3 Compression Rate

These differences between the compressed and uncompressed data sizes indicate that the compression (CharLS algorithm) is very efficient. While this is mostly correct, but there is an important remark to be done: SEVIRI was the input to generate this dataset, and it was interpolated to get to the FCI resolution. Since this higher resolution is not real, the output is relatively smooth, and its compression is exceptionally efficient. Therefore the compression rate of the actual data will be slightly worse (less compressed) than this dataset.

4.2 Data Content Issues

This test package represents a scientifically consistent representation of top of Atmosphere radiance as it will be observed by the FCI instrument. These TOA radiances are computed at each pixel location using a detailed characterisation of the vertical profile of atmospheric constituents and accurate radiative transfer computations. In order to reduce the significant

computational resources necessary to produce such a comprehensive dataset, a number of assumptions and compromises were done to reduce the complexity of the simulations.
Therefore, the dataset presents a series of limitations the user needs to be aware of in order to correctly be able to use it for scientific applications.

4.2.1 Spatial and Temporal Resolution

The output of the TOA radiances simulation framework is in the native SEVIRI spatial resolution (3km grid) and temporal resolution (15 minutes repeat cycle). To generate this FCI dataset, a nearest-neighbour approach was applied to upsample the simulated data to the FCI spatial sampling (1km and 2 km grids, see also section 3.2) and temporal sampling (10 minutes repeat cycle, see also section 2.3.5). For this reason, while the files number, data sizes and shapes of this dataset are realistic for FCI, the actual spatial and temporal resolution of the data is still the one of SEVIRI.

4.2.2 Plane Parallel and Independent Pixel Approximation

The radiative transfer simulations are performed for each pixel independently and with a plane-parallel assumption. Three dimensional effects within a cloud layer or between adjacent pixels are not modelled as this would have been extremely expensive.

4.2.3 Artefacts Due to the Blending of SEVIRI L2 Product with Model Data

The representation of cloud properties coming from SEVIRI L2 cloud products and cloud profiles produced by the ECMWF model is not always consistent given the different spatial resolution of the two datasets and the difficulty of scaling the vertical distribution of the clouds in the model to the retrieved cloud top height. These problems affect the spatial consistency of the TOA radiation fields resulting in artefacts affecting some of the cloudy areas (Figure 5).

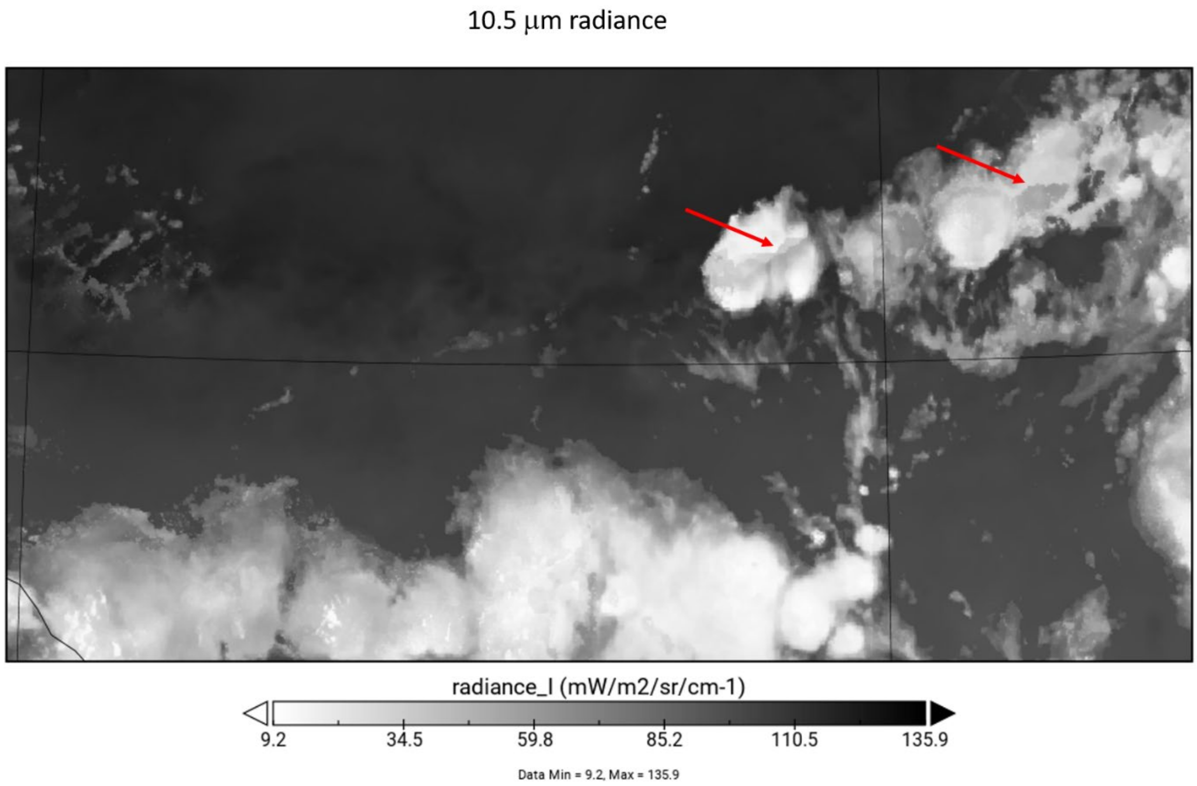


Figure 5 Top of atmosphere radiance in the 10.5 µm FCI channel. The red arrows indicate artefacts due to non-optimal blending of ECMWF cloud profiles and SEVIRI L2 cloud products.

4.2.4 Differences in Night Time and Day Time OCA Products

The OCA algorithm uses all available SEVIRI channels to retrieve cloud properties and during day time the availability of SEVIRI solar channels provide extra constraints to the retrieval. The retrieved cloud microphysical products such as cloud particle effective dimension and cloud optical thickness are particularly sensitive to the presence of the extra information coming from the solar channels and their retrieval therefore differs between night time and day time. This in turn affects the radiative transfer computations which use these microphysical products to define the optical properties of the cloud fields. In particular, the simulations of thermal infrared channels show a discontinuity across a longitudinal line dividing night-time and day-time pixels (Figure 6) linked to a slight change in the retrieved cloud optical thickness when no solar channels are available.

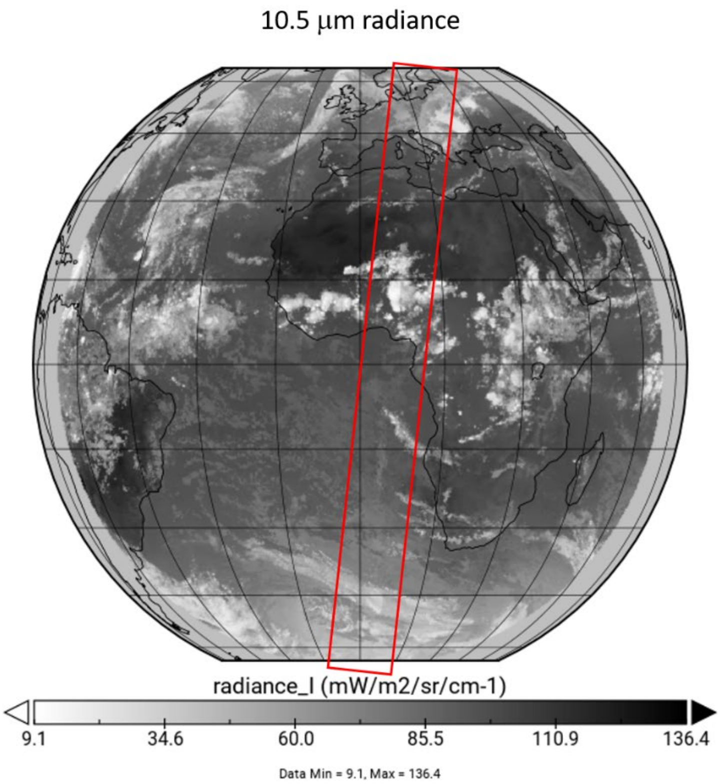


Figure 6 Top of atmosphere radiance in the 10.5 µm FCI channel. The red box highlights the transition area between day time and night time. A discontinuity in the simulated radiance can be observed across the area.

4.2.5 Surface Properties

Surface properties such as emissivity and bi-directional reflectance properties are kept constant during the 24-hour simulation. Therefore, this dataset is not suited for in depth analysis of surface characteristics.
Moreover, a uniform sediment concentration was used for all water bodies therefore no detailed analysis of water-leaving radiance will be possible with this dataset.

4.2.6 Stray-light and Sun-glint

The SEVIRI data that has been used as input for the generation of the simulated radiances is affected by stray-light and sun-glint effects, particularly in the first and last hours of the day. These artefacts are still present in the simulated dataset, as the simulation framework is not able to correctly cope with these particular illumination and geometric conditions. Radiance data in the affected regions may therefore not be realistic and should not be used for scientific analyses.

4.2.7 Missing Pixels at High Satellite Zenith Angles

The radiance simulation framework generated pixel values only up to satellite zenith angles of 75°. For this reason, a band of pixels around the Earth’s edge is not present in the data (see

Figure 7). These pixels contain FillValue in the radiance and index map arrays, and are flagged with “missing_warning” in the pixel quality variable.
Note that for this particular reason, the first and last chunk of each repeat cycle does not contain any image data. Index-related variables still contain valid data for consistency in this dataset. Also the start and end times of the chunks filenames have bene populated as if there was valid data inside the chunk.

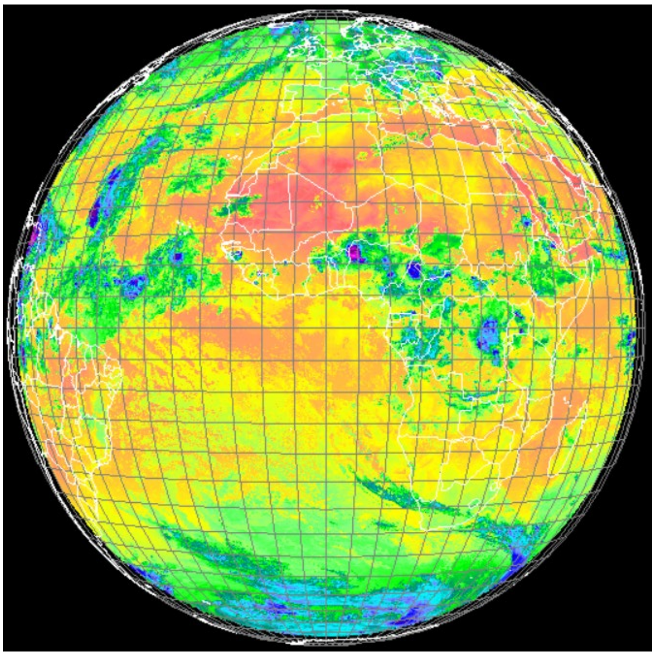


Figure 7: Example of an IR-10.5 µm full-disk image from the dataset, with the FCI lat/lon grid superimposed: the rim of missing pixels around the edge of the Earth is clearly visible.

4.2.8 Pixel Quality Flags

The pixel quality for each channel is stored in the variable `data/<channel_name>/measured/pixel_quality`.

The quality flags activated in the datasets are:
- `missing_warning` (bitmask bit position 0, value 1)
- `extended_dynamic_range_warning` (bitmask bit position 6, value 64)
- `encoding_saturation_warning` (bitmask bit position 7, value 128)

All other flags are not active and default to 0.

Note: in this test data package, the FillValue for the pixel quality variable has been changed from 255 to 0, in line with the [FCIL1FS].

4.2.9 Variables not Populated

A number of variables and attributes could not be populated with significant values, due to their simulation complexity or not yet available information. A string attribute or variable with no relevant content is set to a “null” string. A numerical variable with no relevant content is set to the default NetCDF _FillValue for the variable’s type, or the value specified in the variable’s _FillValue attribute.

In particular, the following variables under the /state/celestial group are not currently computed by the simulation code:

- solar_elevation
- solar_azimuth
- orbit_phase
- sun_eclipse_by_earth
- sun_eclipse_by_moon

Note that the solar_elevation and solar_azimuth variables are intended to describe the solar angles in the instrument frame (as seen by the satellite), rather than for each pixel on the ground.