MTG Test Data Package Description - FCI Level 1C Enhanced User Familiarisation

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Change Record

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DCR = Document Change Request

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None

1 INTRODUCTION

1.1 Scope

This document is a test package description to be included with the delivery of the relevant test package. It details the contents of the test package and provides information about the limitations of the test package, the conformance to any relevant specifications and the intended use of the package.

1.2 Applicable Documents

	Document Title	Reference
[FCIL1PUG]	FCI L1 Product User Guide	EUM/MTG/USR/13/719113
[GFS]	MTG Generic Format Specification [GFS]	EUM/MTG/SPE/11/0252
[FCIL1FS]	MTG FCI Level 0 & 1 Format Specification [FCIL1FS]	EUM/MTG/SPE/10/0447

1.3 Reference Documents

	Document Title	Reference
RD-1	MSG Level 1.5 Image Data Format Description	EUM/MSG/ICD/105

1.4 Terminology

Acronyms and Abbreviations

Acronym/Abbr.	Explanation
CF	Climate and Forecast (metadata conventions)
FCI	Flexible Combiner Imager
FD	Full Disk
FDHSI	Full Disk High Spectral Imagery
HRFI	High Resolution Fast Imagery
LAC	Local Area Coverage
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
SEVIRI	Spinning Enhanced Visible and Infrared Imager

Definitions

Definition/Term	Explanation

2 TEST PACKAGE DESCRIPTION

2.1 Package Overview

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

MTGTD-272: FCI L1C Enhanced and Non-Nominal Products for User Familiarisation

The term test package is used throughout this document as a generic term referring to both test package and the actual test data.

This test data contains two FCI level 1C FDHSI datasets to be used for format familiarisation. The format for these test data is derived from:

- MTG Generic Format Specification, V4A
- MTG FCI Level 0 & 1 Format Specification, V4B

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 the following data:

FCI_1C_UNCOMPRESSED_NOMINAL.tar.gz - which contains a Full Disk High Spectral Imagery (FDHSI) dataset in nominal acquisition conditions.

FCI_1C_UNCOMPRESSED_NON-NOMINAL.tar.gz - which contains a Full Disk High Spectral Imagery (FDHSI) dataset with simulated missing data

FCI_1C_COMPRESSED_NOMINAL.tar.gz – which contains the same nominal dataset above but with CharLS compression applied to selected variables

FCI_1C_COMPRESSED_NON-NOMINAL.tar.gz – which contains same the non-nominal dataset above but with CharLS compression applied to selected variables

All above datasets contain:

- Full images of the Earth.
- 16 channels
- Size: 5568x5568 or 11136x11136 pixels, depending on the channel.

The datasets are divided into 40 body chunk files and 1 trailer chunk file (chunk “41”) each.

FCI_1C_REFGRIDS.tar.gz containing three NetCDFs, one for each FCI resolution, containing computed latitude and longitude variables for all Earth pixels inside an FCI full-disk:

- CM_OPE_GRIDDEF_MTI1+FCI_20190321090000_1km-V2.nc
- CM_OPE_GRIDDEF_MTI1+FCI_20190321090000_2km-V2.nc
- CM_OPE_GRIDDEF_MTI1+FCI_20190321090000_500m-V2.nc

sha256sum.txt file which contains the checksums for all files in the datasets

2.3 Package Usage

This packet of test data is for user familiarisation with the FCI-1C-RRAD dissemination format. It contains representative data contents only and is not generally suitable for scientific processing.

3 NEW FEATURES AND IMPROVEMENTS

This section presents the main new features implemented in this test data package, including quality improvements w.r.t. previously released FCI test datasets.

3.1 Radiance Data Simulation

The FCI radiance data for this package has been generated using SEVIRI Level 1.5 imagery as proxy data. The FCI infrared channels, i.e. at 3.8, 6.2, 7.3, 8.7, 9.6, 10.8, 12.0 and 13.4 µm, are sufficiently similar to the SEVIRI equivalents that no special simulation efforts are required, except for an update of the central wavelength. Among the shortwave or “reflectance” channels, the same applies for the 0.6, 0.8 and 1.6 µm channels.
However, the FCI channels at 0.4, 0.5, 0.9, 1.38 and 2.2 µm have no SEVIRI equivalents. Simulated values in these “new” channels were generated using auxiliary data (ECMWF forecast fields), physical models (cloud radiative properties) and SEVIRI derived (cloud) properties to make informed adjustments to the SEVIRI channel nearest in radiative characteristics.

Subsequently, the FCI simulated radiances, available at SEVIRI spatial resolution, were interpolated in the spatial domain (using the bilinear interpolation method) to the FCI grid sizes (2km and 1km nadir resolution) for both heritage and new channels.

3.2 Missing Data Simulation

In the non-nominal dataset, missing data has been artificially injected into the imagery to simulate the effects of data packets loss in the satellite downlink. Corrupted pixels are flagged with the `missing_warning` flag (see section **Error! Reference source not found.**) and are replaced with `_FillValue`. Figure 1 shows an example of an RGB created from the corrupted data.
Note that due to an in-field separation of the sensing units on the instrument, at a given time the different channels do not observe the exact same geographic area. This leads to a shift in the position of the missing data segments from one channel to another.

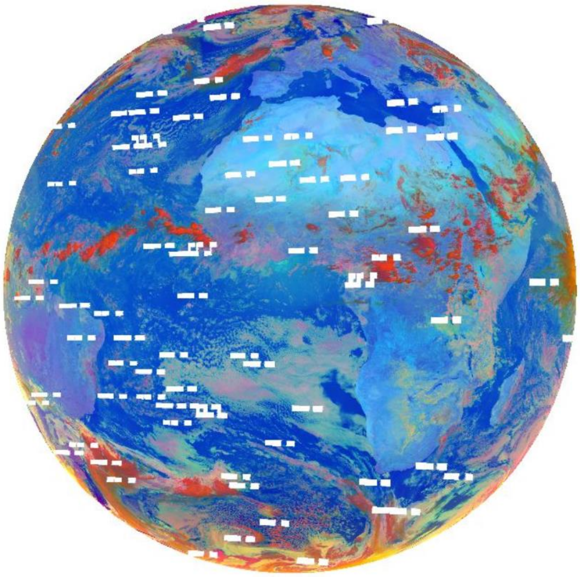

Figure 1: Day-microphysics RGB composite of the non-nominal data. Missing data segments are clearly visible in white color. RGB generated with Satpy.

3.3 Fire 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 wildfires 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. Figure 2 shows an example of simulated fires in the 3.8 µm channel.

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.

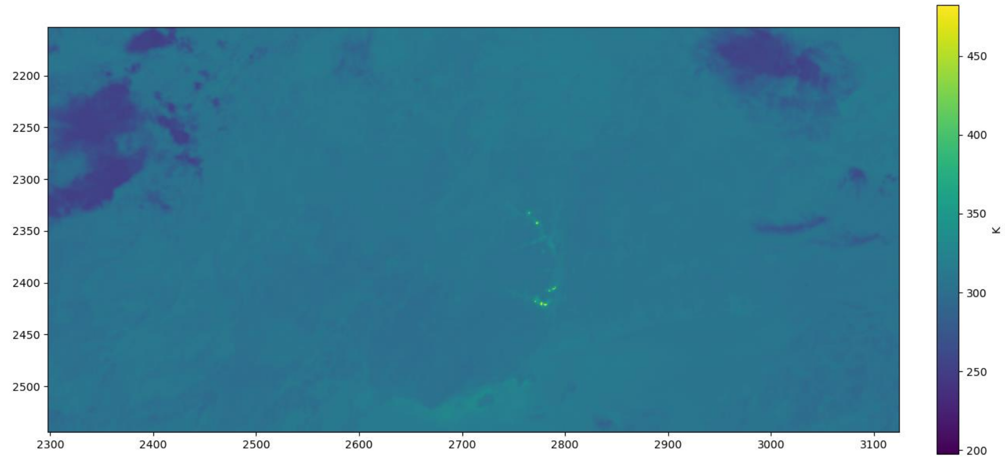

Figure 2: Area North of the Gulf of Guinea with simulated fires in the center of the image. Shown is the IR 3.8 µm channel with brightness temperature values in Kelvin units.

3.4 Pixel Geolocation Grids

Several corrections have been implemented in the datasets to improve the pixel geolocation accuracy. The pixel geolocation grid is stored in the L1c files using the variables `data/<channel_name>/measured/x` and `data/<channel_name>/measured/y` that contain scanning azimuth/elevation angles (see FCIL1PUG for further information).

- SEVIRI data acquired before Dec. 2017 is known to be affected by a geolocation shift of half low-resolution pixel in North and West direction (see RD-1 for further information). Since FCI test datasets are created using SEVIRI data as proxy, previously distributed test datasets contained this geolocation offset. The shift has now been corrected for this package, such that the provided geolocation grid matches the underlying radiances.
- Previously released test datasets contained an additional small mismatch between the provided grid and the rectified radiances, due to slightly different Earth models used by the data generation processes. This issue has now been fixed.
- The `scale_factor` and `add_offset` parameters used to convert the `x` and `y` variables from integers to floats are now stored in the files with double precision to minimize the geolocation error originating from the encoding/decoding process.
- The variable attribute `data/mtg_geos_projection.sweep_angle_axis` has been changed from “x” to “y” to be in line with the convention used for the geostationary projection computation (see FCIL1PUG for further information).

3.5 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`

Each L1c body chunk contains the full information for the entire repeat cycle; the pixel values in the `index_map` variable can thus be directly used as indices for the vector variables listed above.

To provide additional information on the acquisition process, the variable `data/<channel_name>/swath/swath_boundary` is present in the L1c files (see FCIL1PUG for more information). This variable has now been computed and included in the files.

3.6 Radiometric coefficients

In this dataset, the radiometric coefficients have been computed using the radiative properties (i.e. spectral response functions) of the FCI instrument. This includes the variables

- `radiance_unit_conversion_coefficient`
- `radiance_to_bt_conversion_coefficient_a`
- `radiance_to_bt_conversion_coefficient_b`
- `radiance_to_bt_conversion_coefficient_wavenumber`
- `channel_effective_solar_irradiance`

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

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.

Note: the variables `radiance_to_bt_conversion_coefficient_c1` and `radiance_to_bt_conversion_coefficient_c2`, which were affected by unit issues in previous test dataset releases, are now corrected.

3.7 Radiometric Noise Look-Up Tables

The FCI radiometric noise, as characterised on-ground, 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.

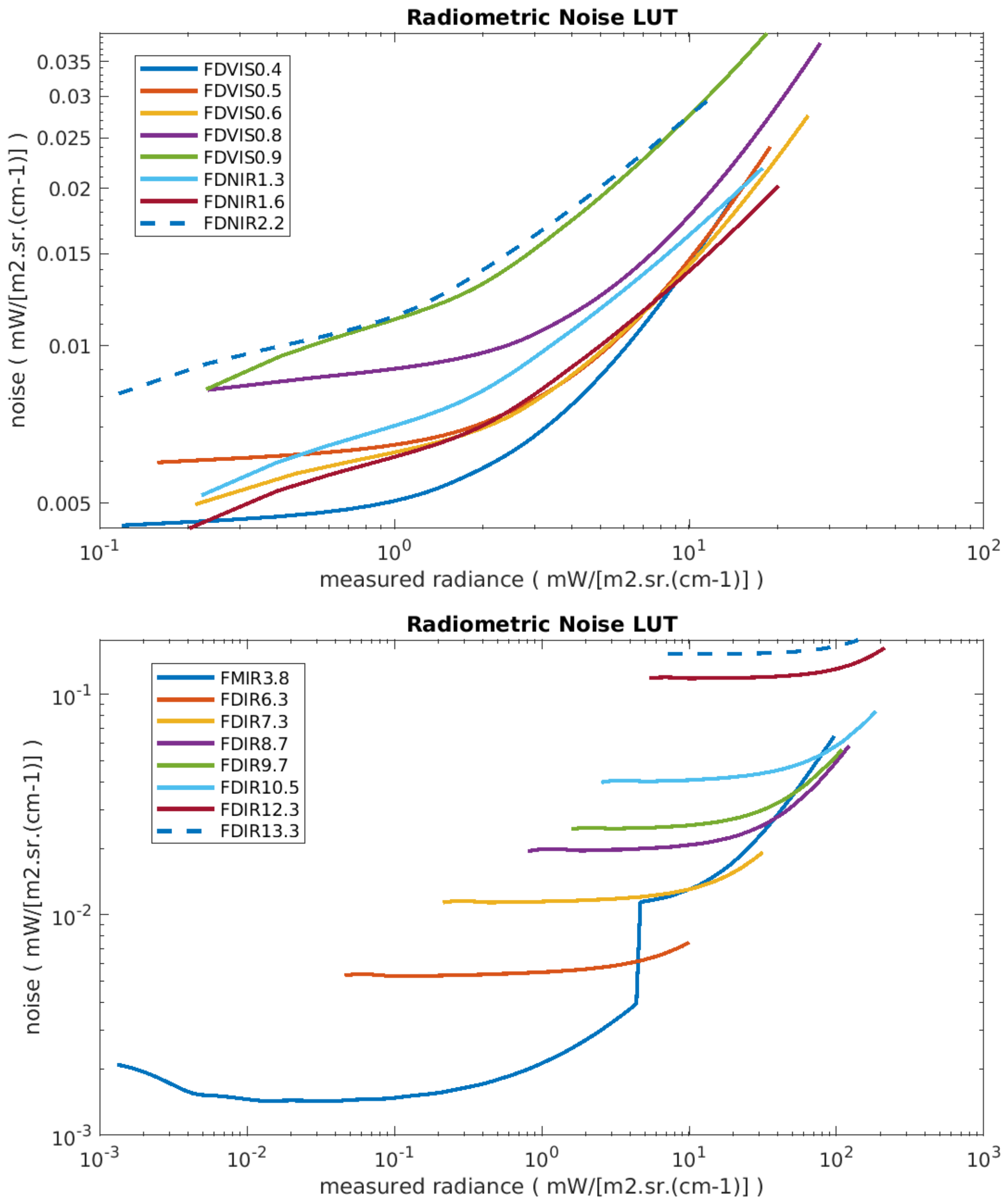

Figure 3: Radiometric noise for the FDHSI channels (VIS/NIR on top and IR on the bottom), in [mW/(m^2.sr.cm^{-1})].

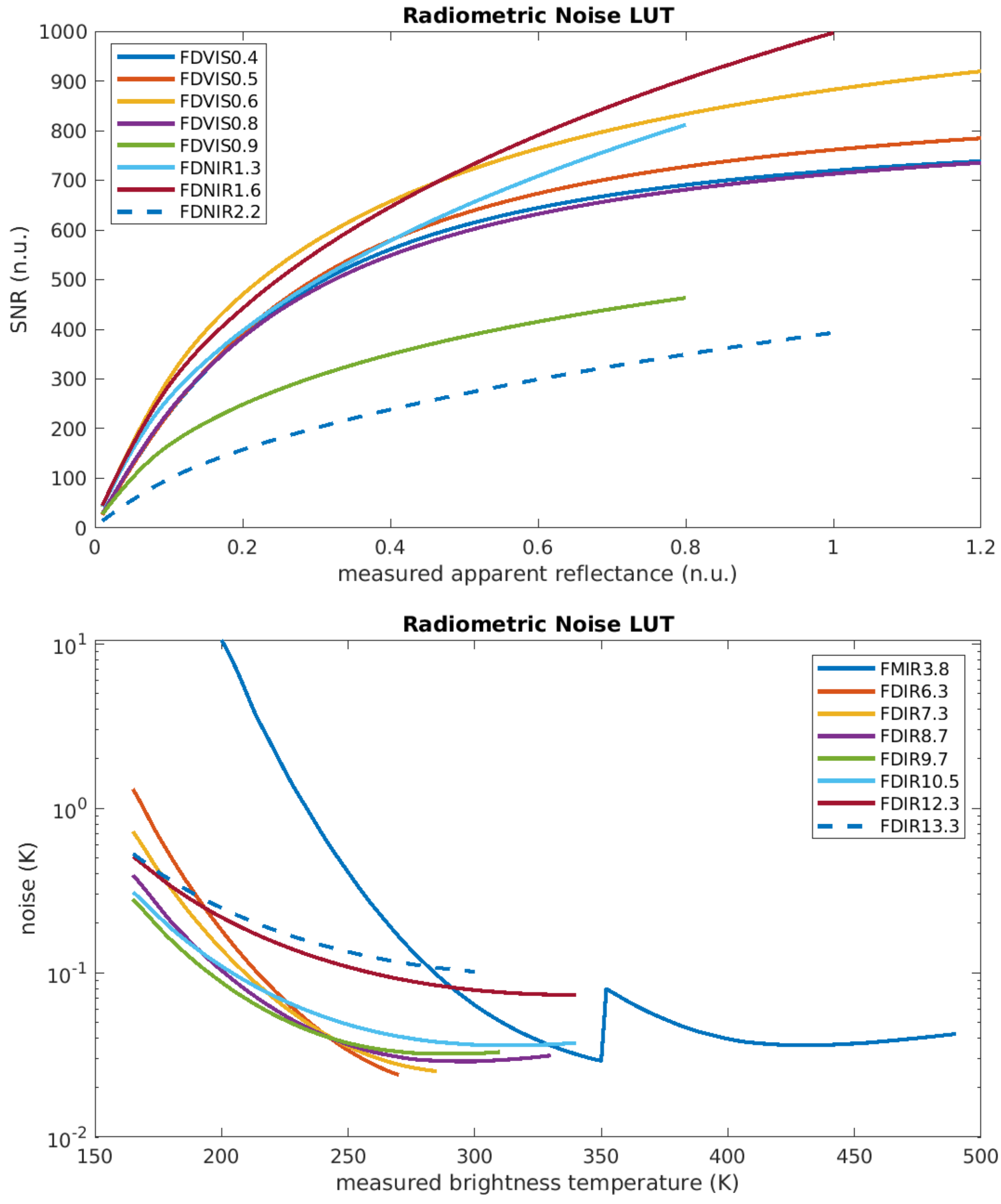

Figure 4: Radiometric noise for the FDHSI channels (VIS/NIR on top and IR on the bottom), in SNR [unitless] and NEdT [K].

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.

4 KNOWN LIMITATIONS

We include here some known limitations in the provided dataset. There are two groups of limitations: about 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 major variables and attributes have been filled with representative values for this package.

4.1.1 Expected Format Evolution

The format and contents of the FCI L1C dataset is not finalised and 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. As netCDF files are self-descriptive, the impact of these changes will be minor.

4.1.2 Body Chunk Sizes

The datasets have been chunked from a complete repeat cycle dataset using a simplification that simulates the changing duration of the chunks whilst retaining a fixed, roughly swath-sized section of the reference grid. The number of reference grid rows in the body chunk and the duration of the body chunks should only be considered as a rough sizing estimate for the operational values.

4.1.3 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 CF compatible.

4.1.4 No Internal Chunking

Currently, no optimised chunking of large arrays has been performed.

4.1.5 Disseminated datasets

These datasets are compressed using the CharLS algorithm, and therefore they represent the datasets that will be disseminated during the MTG operations.

In parallel, uncompressed datasets will be archived at EUMETSAT. Upon request, these uncompressed datasets will be delivered to users. This release provides both the compressed and uncompressed datasets.

4.2 Data Content Issues

This test package is intended for format familiarisation. As such, the data contents, whilst having the broad characteristics of an operational dataset, are not meant to be used for scientific processing or validation and many of the more detailed physical characteristics of an actual FCI L1C dataset may be absent or inaccurate.

Some of the known limitations are described below.

4.2.1 Compression Rate

Compressed datasets are about 696 Mbytes, and uncompressed datasets are about 7.1 GBytes.

These differences between compressed and uncompressed sizes could indicate that the compression (CharLS algorithm) is very efficient. This is mostly correct, but there an important comment to be done. SEVIRI was the input to generate this dataset, and it was interpolated to get 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.

4.2.2 OCA Limitations

Cloud products from SEVIRI used to simulate the new solar reflectance channels (0.4-2.2 µm) were not available outside a view angle of greater than approximately 73°. For this reason, the 1.3 µm channel does not have valid radiances near the disk edge, while the other simulated solar channels contain only minor discontinuities.

4.2.3 Space Mask Issues

A preliminary Earth mask has been applied to the datasets to mask out space pixels. Due a difference in the Earth's geometric models used by the SEVIRI and FCI imagery processing, the channels contain a thin rim of deep-space pixels, with radiance values close to zero, that have not been masked out (set to _FillValue).

4.2.4 Missing Values

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 .

4.2.5 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.

5 USING THE TEST PACKAGE

5.1 What does this dataset contain?

This dataset contains the "FCI Level 1C Format Familiarisation" test data in the FDHSI full-disk, low-resolution, 16-channel format.

These datasets are presented as a series of body chunks, followed by a trailer chunk containing information derived for the full repeat cycle.

5.2 What does each product folder contain?

Each dataset consists of multiple netCDF files with the suffix ".nc". These are listed in Appendix A.2.

Filenames containing the string CHK_BODY are body chunks. Stacked vertically, these files contain the complete repeat cycle information. I.e., each chunk contains a single strip of data, very wide in the East-West direction (11136 or 22272 columns), and very narrow in the North-South direction (typically about 138 or 278 rows). There are 40 body chunks for each FDHSI product. Figure 5 shows the first three chunks of the vis_04 nominal dataset. White areas to the left and right of the colored Earth are masked values. They contain the FillValue NC_FILL_USHORT.

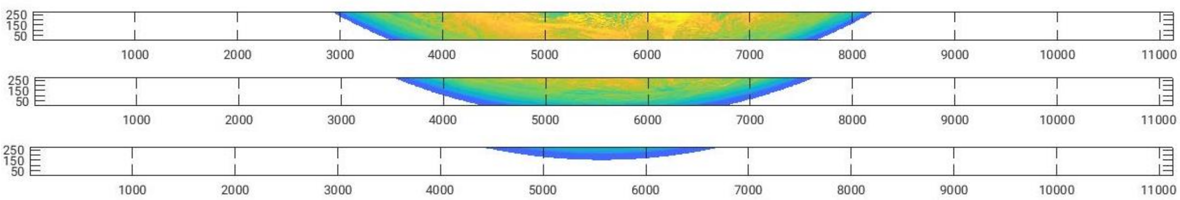

Figure 5: First three chunks of the VIS 0.4 channel of the nominal dataset.

The filename containing the string CHK_TRAIL is the trailer chunk. It is a single file, coming at the end of the repeat cycle, containing summarized information for the complete repeat cycle.

5.3 Checking the validity of the test package

A checksum file ("sha256sum.txt") has been generated with the command:

```
sha256sum `find ./` > sha256sum.txt
```

It is located at the top level of the delivery, see Appendix A.1.

"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
```

5.4 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. Therefore they follow as well the HDF5 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, making the processing of FCI data easy and fast. See FCIL1PUG for further information and a simple tutorial, or visit http://satpy.readthedocs.org/.

5.5 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 radiance, pixel quality and index map variables are not geolocated but instead have pixel positions within the grid. The formulae for creating the reference grid and linking pixel position to latitude/longitude position are given in the FCI L1C Product User Guide [FCIL1PUG].

Alternatively, the external grid files contained in this package provide computed latitude and longitudes for all Earth pixels in the L1c geostationary projection rectification grids.

5.6 Compression

The `effective_radiance`, `pixel_quality` and `index_map` variables 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.

The CharLS library only works with the netCDF library of the C language. Java libraries (example: Panoply) do not work. Python also crashes when reading these variables.

There are two possible solutions, in both cases related to use 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 are 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
```

5.7 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 "MTG FCI L1c Format Enhanced User Familiarisation" in the title of the e-mail will assist in routing the question to the FCI format team.

APPENDIX A TEST PACKAGE CONTENTS

This appendix provides the list of files included in the delivered package.

A.1 Checksum File

This is the file that contains the validity checksums for all other files in the package. It is located at the top level of the package and is called **sha256sum.txt.**

A.2 FDHSI Files

These are the files that comprise the FDHSI dataset.
There are example datasets for nominal and non-nominal cases in both compressed and uncompressed form.

Note that:

- There are 41 files per repeat cycle: 40 **body** chunks and 1 **trailer** chunk.
- The repeat cycle is the number **0073**.
- The chunk number increases from **0001** to **0041**.

```
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804120515_GTT_DEV_20130804120000_20130804120015_N__T_0073_0001.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804120530_GTT_DEV_20130804120015_20130804120030_N__T_0073_0002.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804120545_GTT_DEV_20130804120030_20130804120045_N__T_0073_0003.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804120600_GTT_DEV_20130804120045_20130804120100_N__T_0073_0004.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804120615_GTT_DEV_20130804120100_20130804120115_N__T_0073_0005.nc
[…]
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804121400_GTT_DEV_20130804120845_20130804120900_N__T_0073_0036.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804121415_GTT_DEV_20130804120900_20130804120915_N__T_0073_0037.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804121430_GTT_DEV_20130804120915_20130804120930_N__T_0073_0038.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804121445_GTT_DEV_20130804120930_20130804120945_N__T_0073_0039.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-BODY---NC4E_C_EUMT_20130804121500_GTT_DEV_20130804120945_20130804121000_N__T_0073_0040.nc
W_XX-EUMETSAT-Darmstadt,IMG+SAT,MTI1+FCI-1C-RRAD-FDHSI-FD--CHK-TRAIL---NC4E_C_EUMT_20130804121600_GTT_DEV_20130804120000_20130804121000_N__T_0073_0041.nc
```

A.3 Reference Grid Files

Reference grid files are provided for all three FCI resolutions. These contain the latitude/longitude coordinates for each reference grid pixel centered on (0,0) latitude/longitude. These data can be used to check the result of geolocation calculations based on the parameters within the products or geolocation values can be extracted directly from the file for processing.

NOTE: for FCI grids, rows and columns start counting from 1 and not 0.