High Level Description of the GIRO Application and Definition of the Input/Output Formats

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Version 1	08/04/2014		First draft of the document
Version 2a	08/07/2014		Modified according to the comments provided by: Tom Stone (USGS), Bertrand Fougnie (CNES), Sophie Lacherade (CNES), Jack Xiong (NASA), and Masaya Takahashi (JMA).
Version 2b	03/11/2014		Included the section 7.3.1 which describes the possibility to handle floating point observables from floating point digital count Moon imagettes.
Version 3	24/02/2015		Documentation consistent with the GIRO v1.0.0 release: included the new output variable lambda effective.

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1 INTRODUCTION

1.1 Purpose

In the framework of GSICS activities aimed at defining unified calibration references, EUMETSAT will implement a lunar calibration tool that will be made available within the GSICS community. The design of such a tool, called as GSICS Implementation of the ROLO model (GIRO), is a joint effort of different institutions, namely EUMETSAT, USGS, CNES, and NASA. This document has the aim of specifying the high level design requirements of GIRO.

1.2 Scope

This document is addressed to the people collaborating to the design of the tool (see the institutions listed in section 1.1), and will be used to create the final version of the high level design requirements.

1.3 Terms and abbreviations

- In the text the word *imagette* refers to the rectangular/squared portion of image-data that has been extracted for calibration purposed. An imagette contains exclusively the complete Moon disk and a portion of deep space. The calibration tool will be able to analyse sequences of imagettes extracted during the satellite operation.
- The index i is the index of the *i*th imagette of the Moon observation dataset.
- The index k is the index of the *k*th channel of the instrument.
- The index l is the index of the *l*th wavelength of the channel k.
- The term *Observables* refers to the set of quantities that are derived from processing of the Moon imagettes. For example, the total digital count signal derived from the digital count imagette of the Moon (i.e., $DC_{OBSi,k}$) is an observable as well as the total number of pixels from which this value has been derived (i.e., $N_{PIXi,k}$).

2 THE GIRO APPLICATION

Figure 1 gives an overview picture of the GIRO application.

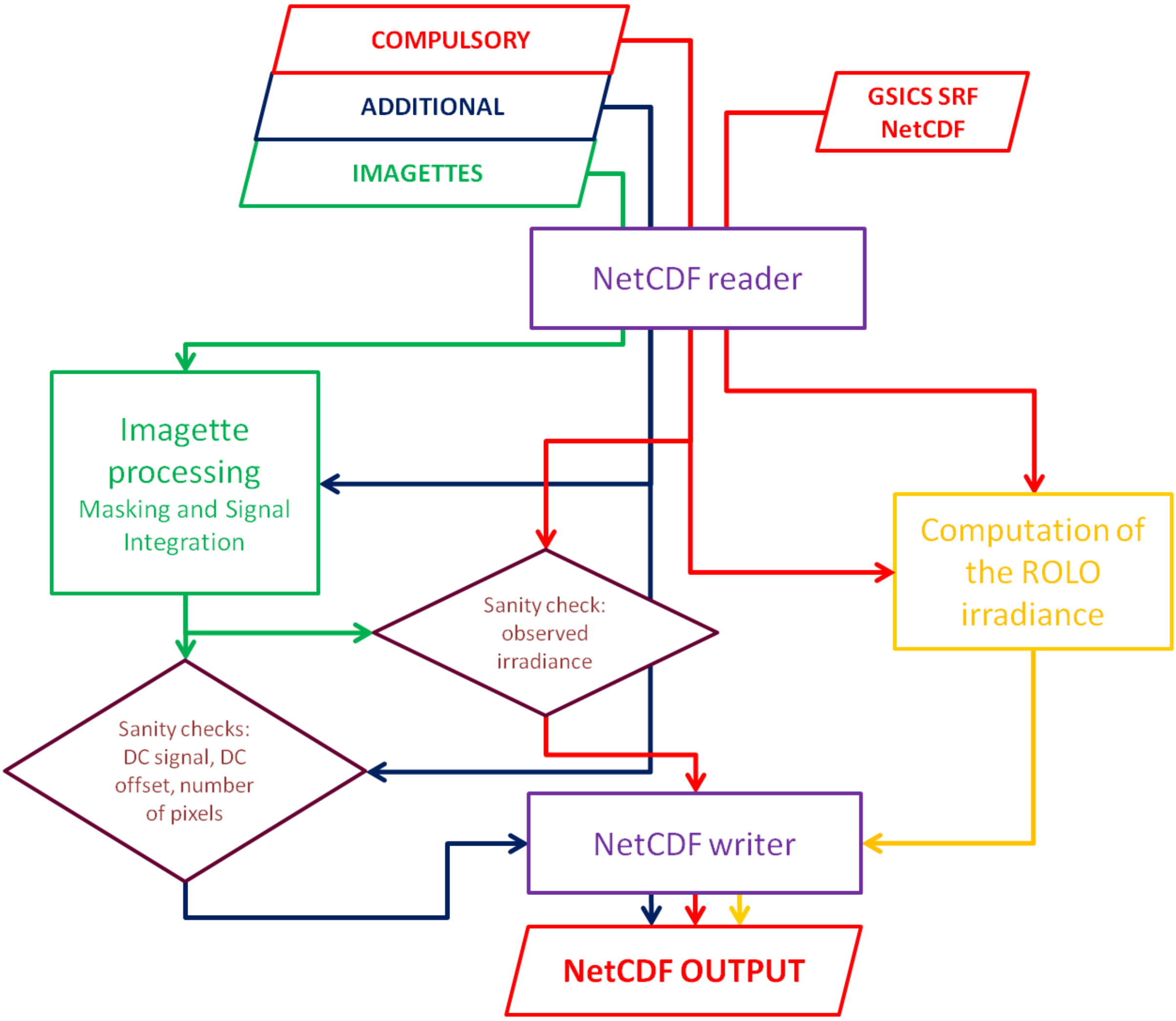

Figure 1: overview picture of the GIRO application in the case in which the NetCDF input file contains all the data (i.e., COMPULSORY, ADDITIONAL, and IMAGETTES).

Following the flow chart in Figure 1, the application reads both the lunar observation NetCDF file (here represented as the collection of *COMPULSORY*, *ADDITIONAL*, and *IMAGETTES* data) and the *GSICS* Spectral Response Function (SRF) *NetCDF* file (*NetCDF reader*). The format of the latter has been already defined within the GSICS community, while in this document we present a proposal for the format of the lunar observation files (see Section 7). The *NetCDF reader* also prepares the inputs for:

1. The two main computation blocks of the GIRO application represented as the green and the orange sub-blocks in the figure: the *Imagette processing* (the green block, see Section 5.2), and the *Computation of the ROLO irradiance* (the orange block, see Section 4.3).
2. The *Sanity check* blocks.

The quantities produced by the processing are collected to define the *NetCDF OUTPUT* which is prepared by the *NetCDF writer.* A proposal of the format of the NetCDF (output) lunar calibration file is also presented in Section 8.

In Section 3 the processing options offered by the GIRO application are described together with a description of the data required for the different options.

The input quantities employed in the processing of the ROLO (reference) irradiance and the imagette processing are presented respectively in Section 4 and 5. Section 6 describes the complete list of outputs.

Section 7 and 8 provide respectively the details of the NetCDF file format for the lunar observation files (i.e., the inputs of the lunar calibration procedure) and the lunar calibration files (i.e., the output of the lunar calibration).

3 INPUT CLASSIFICATION AND PROCESSING OPTIONS

Three categories of input data are represented in Figure 1. These are organized according to their importance/role within the GIRO processing:

1. Compulsory: data that must be provided by the user in order to perform any processing.
2. Additional: data that should be provided in perspective of future processing.
3. Imagettes: data that must be provided in order to perform the optional check on the computation of the values provided in 1 and 2.

In the following we present the different processing associated to each case. Such description has the aim of providing to the reader a general view of the processing options without presenting any detail of the computation and output writing.

3.1 Compulsory (Basic processing)

Figure 2 provides the flow diagram representing the basic processing.

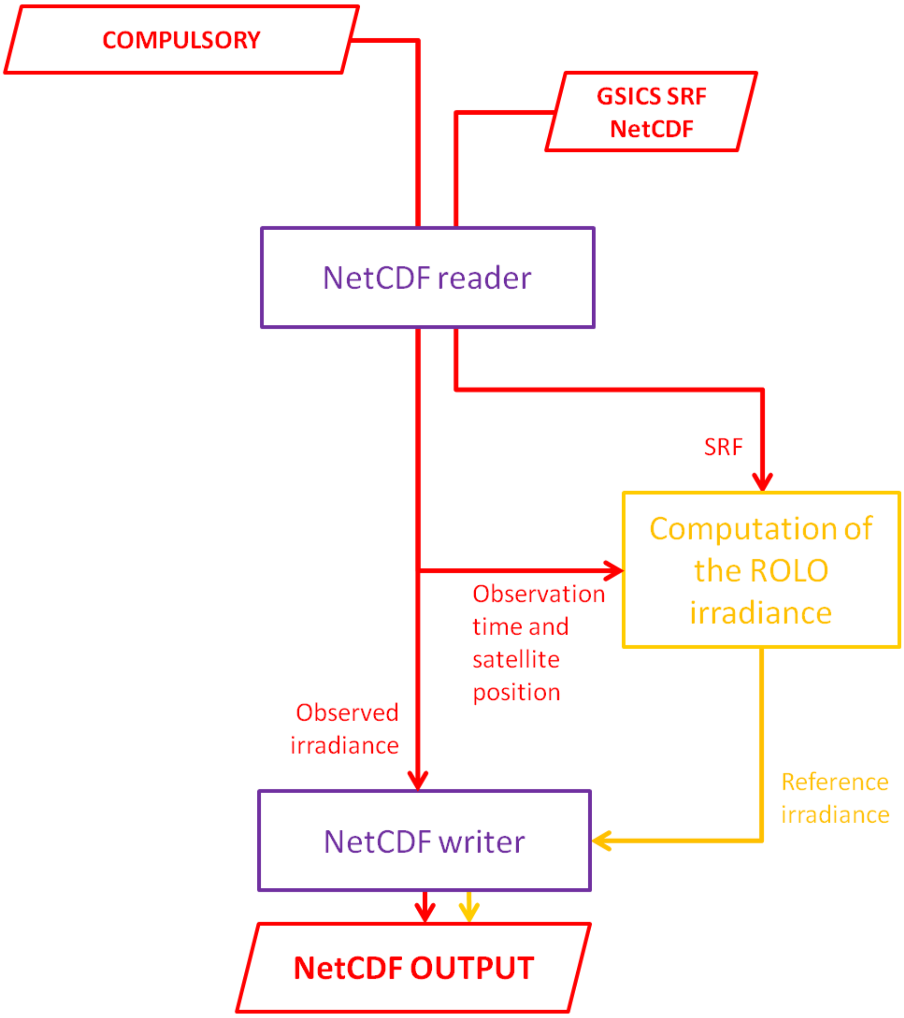

Figure 2: flow diagram of the basic processing performed when only the compulsory data are provided to the GIRO application.

In this case the application uses the observation time and the position of the satellite at the observation time to derive the reference irradiance. This irradiance is stored in the output file together with the observed irradiance provided by the user. The aim of the basic processing is to allow the user to perform the comparison between the observed irradiance and the reference irradiance (the irradiance bias).

3.2 Additional

Figure 3 illustrates how both compulsory and additional data are handled by the GIRO application.

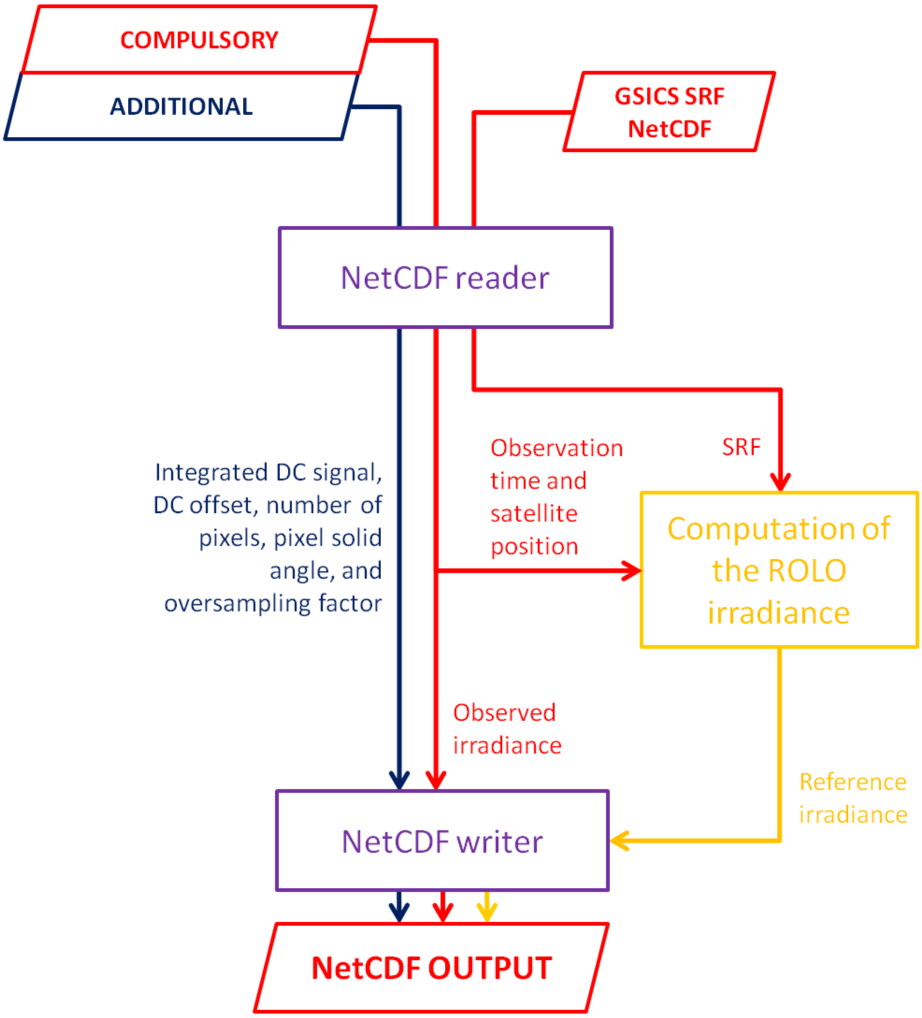

Figure 3: flow diagram of the processing performed when both compulsory and additional data are provided to the GIRO application.

In this case the application performs the basic processing presented in section 3.1 and handles the additional information so to store these in the output file. The list of additional data will be used to derive additional calibration outputs. This aspect is still under discussion among the GIRO development group members.

3.3 Processing of the imagettes for checking purposes

Figure 4 provides the flow diagram representing the processing of the complete set of data.

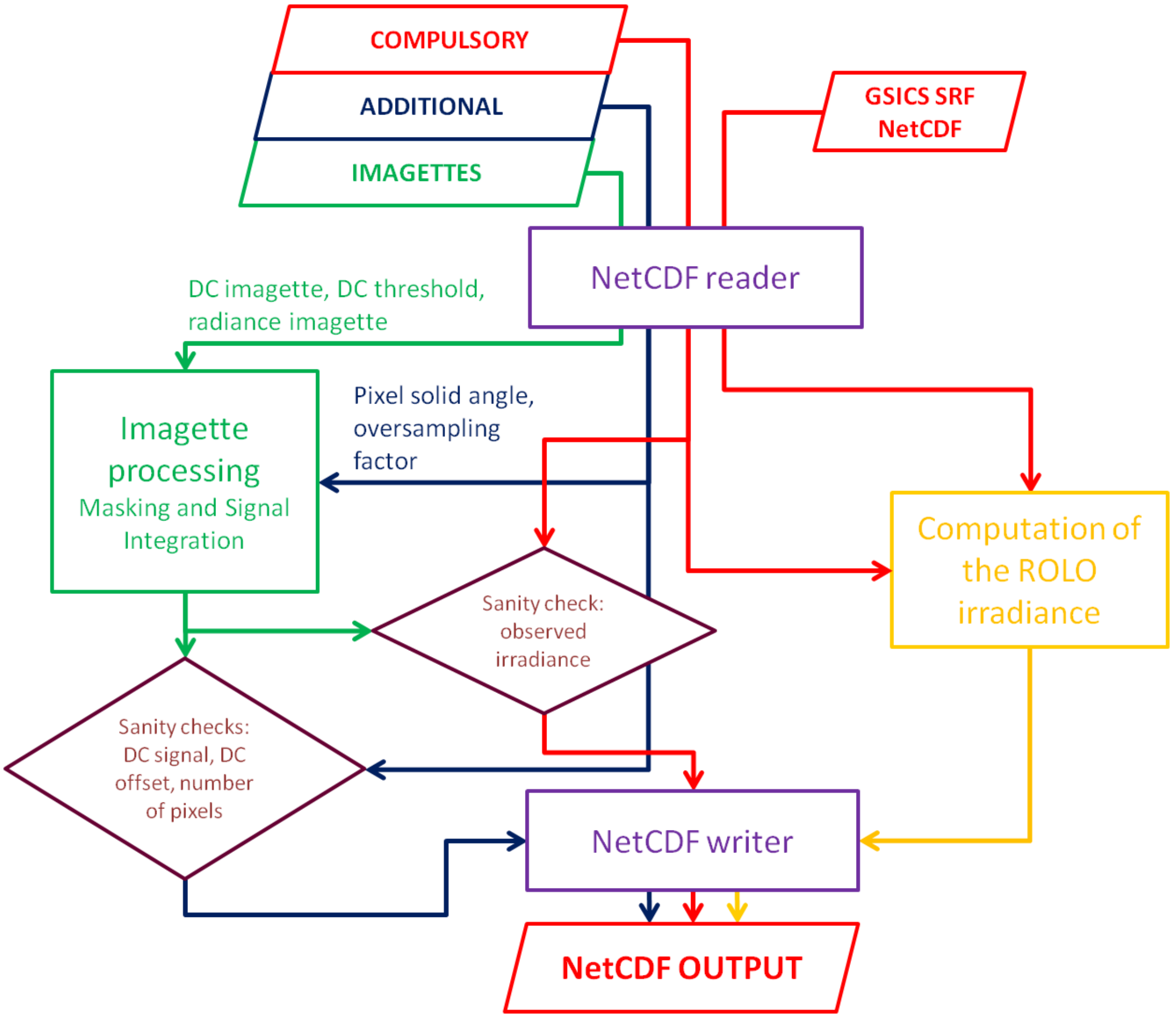

Figure 4: flow diagram of the processing performed when all the data are provided to the GIRO application.

When the user provides the DC imagette, the DC threshold for masking purposes, and the radiance imagette, the GIRO application derives:

1. The observed irradiance.
2. The integrated DC signal.
3. The DC offset.
4. The number of pixels from which both the observed irradiance and the integrated DC signal are derived.

The computation of these quantities is performed by the *Imagette processing* block which employs also the pixel solid angle and the oversampling factor (categorized as additional information). The aim of deriving alterative values for 1, 2, 3, and 4 (part of the compulsory and additional groups of data passed by the user) is to provide a measure of the difference between the values the user has computed and the ones derived by applying standard imagette processing available in the GIRO application. Such a check is performed in the sanity check blocks. Discrepancies are recorded in a text file and the data provided by the user are not modified or replaced. After the checks have been performed both the compulsory and the additional information provided by the user reach the *NetCDF write* block and are stored as outputs, independently of the results of the sanity checks.

Finally it is important to stress here that the three level of processing cannot be performed if the required information are not provided correctly to the GIRO application. For example, the processing in section 3.3 cannot be performed by providing only the compulsory and imagettes data.

4 COMPUTATION OF THE ROLO IRRADIANCE

In this section we report few details of the computation of the ROLO irradiance to show how the inputs provided by the user are employed.

4.1 Inputs extracted from the lunar observation NetCDF file

INPUT	DESCRIPTION
t_i	**UTC time of the *i*th Moon observation. More in detail, this is the time at which the Moon has been detected by the instrument. For instruments that acquire the Moon image with multiple scans the time should be representative of the instant in which the central part of the Moon has been acquired.**
x_{Si}, y_{Si}, z_{Si}	**The official satellite Cartesian coordinates at the time of the *i*th Moon observation as released by the institution operating the satellite.**
Ref_i	**Name of the reference frame in which the coordinates are expressed. The coordinates must be expressed either in the J2000 pseudo-inertial frame or in an ITRF93 frame.**

*Table 1: **compulsory** inputs extracted from the lunar observation NetCDF file.*

4.2 Inputs extracted from the GSICS Spectral Response Function NetCDF file

INPUT	DESCRIPTION
$Chan_k$	**Name of the channel *k* as available in the SRF file.**
λ_c^k	**The value of the central wavelength of the channel *k*.**
λ_l^k	**The *l*th wavelength of the SRF of channel *k*.**
$SRF_k(\lambda_l^k)$	**The SRF of the channel *k*.**

Table 2:* compulsory *inputs extracted from the GSICS Spectral Response Function NetCDF file.

4.3 The computation of the ROLO irradiance

The diagram in Figure 5 outlines the details of the *Computation of the ROLO irradiance*.

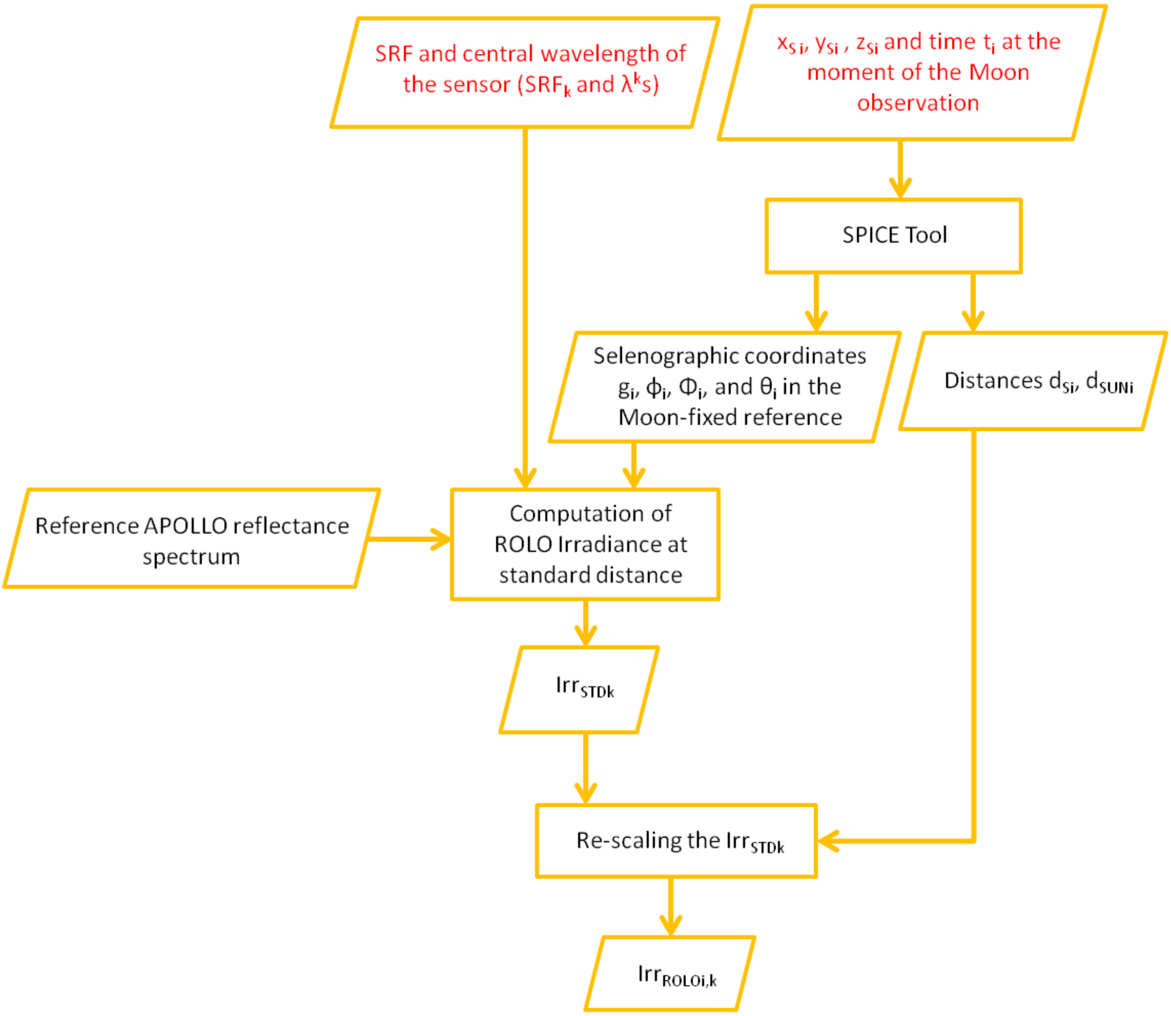

Figure 5: flow diagram of the Computation of the ROLO irradiance. In the diagram Irr_{STD} stands for ROLO irradiance at d_{SUNi} = 1AU and d_{Si} = 384400 km.

5 OBERVABLES, IMAGETTE PROCESSING AND SANITY CHECKS

5.1 Inputs

Table 3 provides the list of input (**compulsory** and **additional**) that allow for a) a direct comparison with the lunar irradiance as derived by the ROLO model and b) further sanity check and/or analysis after the computation of the ROLO lunar irradiance. Table 4 shows which **input** is needed to perform the optional processing on a lunar imagette in order to make further sanity checks on the observables: $DC_{OBSi,k}$, $Off_{DCi,k}$, $N_{PIXi,k}$, $Irr_{OBSi,k}$.

INPUT	DESCRIPTION
$Irr_{OBSi,k}$	**The observed irradiance from the *i*th Moon observation of the instrument *k*.**
$DC_{OBSi,k}$	**The integrated digital count signal from the *i*th Moon observation of the channel *k* as derived from the same pixels from which $Irr_{OBSi,k}$ has been derived.**
$Off_{DCi,k}$	**The digital count offset from the *i*th Moon observation of the channel *k* derived as the average value over the deep space portion of the imagette.**
$N_{PIXi,k}$	**Number of pixels from which both Irr_{OBSi} and DC_{OBSi} have been derived.[1]**
$\Omega_{PIXi,k}$	**Pixel solid angle for the i*th* observation of the channel *k*.**
$F_{PIXi,k}$	**Oversampling factor for the i*th* observation of the channel *k*.**

Table 3: compulsory and additional inputs extracted from the lunar observation NetCDF file.

QUANTITY	DESCRIPTION
$Imgt_{Radi,k}$	**Radiance imagette for the *i*th Moon observation of the channel *k*.**
$Imgt_{DCi,k}$	**Digital count imagette for the *i*th Moon observation of the channel *k*.**

[1] Different methods can be employed to derive $Irr_{OBSi,k}$ and $DC_{OBSi,k}$; for example, one can rely on a masking method which changes for the different observations. For this reason the user must provide $N_{PIXi,k}$.

$Thld_{DCi,k}$	**Threshold in digital count that will be used to derive a mask with which $Irr_{OBSi,k}$ and $DC_{OBSi,k}$ will be derived. When set to zero these two quantities will be derived from the complete imagette.**

Table 4: imagettes inputs extracted from the lunar observation NetCDF file.

5.2 Imagette processing to derive and check the observables

The diagram in Figure 6 outlines the details of the *Imagette processing* starting from the imagettes data and part of the additional data.

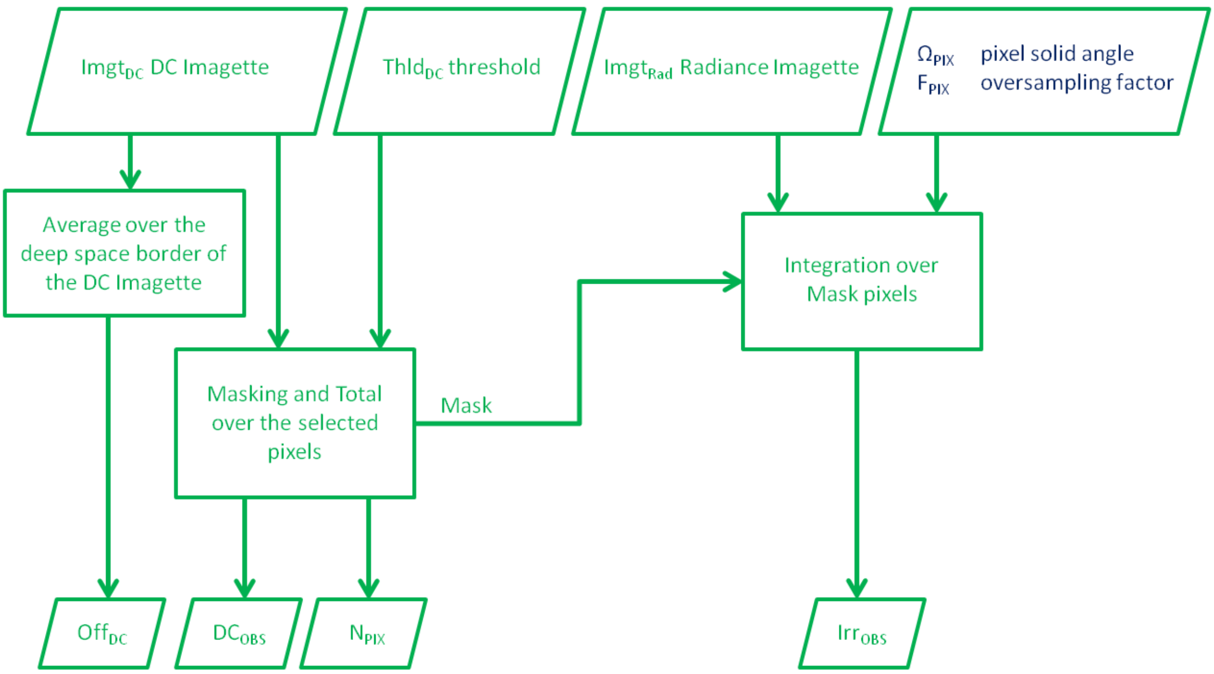

Figure 6: flow diagram of the Imagette processing. In the diagram the mask derived by applying a threshold to the DC imagette is used for the processing of the radiance imagette when calculating the observed irradiance.

The *Average over the deep space border of the DC imagette* is calculated by averaging the values of the DC imagette of a border of 5 pixels along the imagette edge[2]. The masking applied to the DC imagette is based on the rule: $Imgt_{DC} \geq Thld_{DC}$ is good ($< Thld_{DC}$ is rejected). The good pixels are summed-up to derive DC_{OBS} (i.e., the integrated DC signal from the DC imagette), and the total number of good pixels sets N_{PIX}. In the next step the good pixels of the mask are used to select the radiance pixel and, by means of the pixel solid angle and oversampling factor, to derive the observed irradiance Irr_{OBS}:

$$Irr_{OBS} = \sum_{pixel \in Mask} \frac{\Omega_{PIX}}{F_{PIX}} \cdot Imgt_{Rad}.$$

[2] Please note that in the definition of the imagette given in § 1.3 the deep space is part of the content of the imagette.

For the way the imagette processing is implemented the DC imagette and the radiance imagette must have the same spatial resolution or, in other words, one must be able to derive the radiance imagette from the DC imagette by applying the official calibration formula.

6 OUTPUTS

In the following the list of outputs produced by the lunar calibration tool for each Moon imagette are listed. Such outputs can be formatted in three different levels of completeness: *Basic*, *Partial,* and *Complete* (see Table 5).

MODE	OUTPUT	DESCRIPTION
Basic	$Irr_{ROLOi,k}$	ROLO irradiance for the geometry of the *i*th observation for the channel *k*.
	t_i	UTC time of the *i*th Moon observation. More in detail, this is the time at which the Moon has been detected by the instrument. For instruments that acquire the Moon image with multiple scans the time should be representative of the instant in which the central part of the Moon has been acquired.
	$Chan_k$	Name of the channel *k* as available in the SRF file.
	λ_c^k	The value of the central wavelength of the channel *k*.
	$Irr_{OBSi,k}$	The observed irradiance from the *i*th Moon observation of the instrument *k*.
	$DC_{OBSi,k}$	The integrated digital count signal from the *i*th Moon observation of the channel *k* as derived from the same pixels from which $Irr_{OBSi,k}$ has been derived.
	$Off_{DCi,k}$	The digital count offset from the *i*th Moon observation of the channel *k* derived as the average value over the deep space portion of the imagette.
	$N_{PIXi,k}$	Number of pixels from which both Irr_{OBSi} and DC_{OBSi} have been derived.
	$\Omega_{PIXi,k}$	Pixel solid angle for the i*th* observation of the channel *k*.
	$F_{PIXi,k}$	Oversampling factor for the i*th* observation of the channel *k*.

Partial	**Basic +**	
	θ_i, ϕ_i, d_{Si}	Selenographic coordinates of the Satellite at the time of the *i*th Moon observation.
	$\Theta_i, \Phi_i, d_{SUNi}$	Selenographic coordinates of the Sun at the time of the *i*th Moon observation.
	x_{Si}, y_{Si}, z_{Si}	The official satellite Cartesian coordinates at the time of the *i*th Moon observation as released by the institution operating the satellite.
	$x_{SUNi}, y_{SUNi}, z_{SUNi}$	The Cartesian coordinates of the Sun at the time of the *i*th Moon observation. This set of coordinates must be expressed in the same reference in which the satellite coordinates are expressed.
	$x_{MOONi}, y_{MOONi}, z_{MOONi}$	The Cartesian coordinates of the Moon at the time of the *i*th Moon observation. This set of coordinates must be expressed in the same reference in which the satellite coordinates are expressed.
	Ref_i[3]	Name of the reference frame in which the coordinates are expressed. The coordinates must be expressed either in the J2000 pseudo-inertial frame or in an Earth-fixed frame.
	g_i	Phase-angle of the *i*th Moon observation.
Complete	**Partial +**	
	$A_{ROLOi}(\lambda_{ROLO})$	ROLO reflectance spectrum expressed at the ROLO wavelengths for the *i*th Moon observation.
	λ_{ROLO}	ROLO wavelengths.
	$A_{ROLOi}(\lambda_{APO})$	ROLO reflectance spectrum expressed at the APOLLO sample's wavelengths for the *i*th Moon observation.

[3] In general the output should contain a single string with the name of the reference in which all the output coordinates at all times are expressed.

	λ_{APO}	APOLLO sample's wavelengths.

Table 5: outputs of the lunar calibration tool for the ith imagette and channel k.

7 NETCDF CONVENTION FOR LUNAR OBSERVATION FILES

In this section the convention adopted to define the lunar observation files is described. In the current concept, a single file contains information/data from different channels of an instrument. In detail, here we list the global attributes, variables, and dimensions. However, each user will be free of adding extra information to the input files when these are considered to be important.

The _FillValue (i.e., the value that must be used for missing data) is set to -999 in both integer and floating point variables.

7.1 Global Attributes

Global Attributes		
NAME	**CONTENT**	**DESCRIPTION**
Conventions	**CF-1.6**	
Metadata_Conventions	**Unidata Dataset Discovery v1.0**	Conventions to "*identify and define a list of NetCDF global attributes recommended for describing a NetCDF dataset to discovery systems such as Digital Libraries*". Details can be found on: http://www.unidata.ucar.edu/software/thredds/current/netcdf-java/formats/DataDiscoveryAttConvention.html
standard_name_vocabulary	**CF Standard Name Table (Version 21, 12 January 2013)**	Mandatory for CF-1.5 and later
project	**"project name" (e.g., Global Space-based Inter-Calibration System http://gsics.wmo.int)**	Name of the project
title	**GSICS "Platform name"+ "Instrument Name" lunar observation file (e.g. GSICS MSG-2+SEVIRI+VIS06 lunar observation file)**	Title of the file in which the platform name and the instrument name must be specified together with the content of the file

summary	**Lunar observation file**	Summary of the content of the file
keywords	**“free content”**	Useful keywords for browsing purposes
references	**TBD**	TBD
institution	**“institution name” (e.g. EUMETSAT)**	Name of the institution that created the file
licence	**“terms of use”**	Text describing the institution policy for the use/sharing of the data. This field could in principle contain also the GSICS policy (for the shared test-dataset)
creator_name	**e.g., EUMETSAT - European Organisation for the Exploitation of Meteorological Satellites**	Detailed info on the creator of the file (these can be detailed info about the institution)
creator_email	**ops@eumetsat.int**	
creator_url	**http://www.eumetsat.int**	
instrument	**e.g., MSG2 SEVIRI**	Name of the instrument
instrument_wmo_code	**(56, 207)**	Come from the WMO’s Common Code Tables C-5 and C-8. This was proposed in 2010: https://groups.google.com/forum/#!topic/gsics-dev/FVV68cGgVWU
data_source	**“free content” e.g., Level 1.0**	The data in which the Moon measure is available. In order to understand how the Moon imagette has been processed to account for detector equalization, conversion to radiance, etc. the user should refer to the history in the global attributes
date_created	**YYYY-MM-DDTHH:MM:SSZ**	UTC time of the creation of the file
date_modified	**YYYY-MM-DDTHH:MM:SSZ**	UTC time of the latest update to the file

history	**"free content"**	Useful information. For example, this field can contain info about the extraction method used to obtain the Moon imagette
id	**e.g., W_XX-EUMETSAT-Darmstadt,VISNIR+SUBSET+MOON,MSG2+SEVIRI _C_EUMG_"Moon observation time YYYYMMDDHHMMSS" _"version number".nc**	Name of the file defined following the GSICS convention https://gsics.nesdis.noaa.gov/wiki/Development/FilenameConvention "VISNIR+SUBSET+MOON" is fixed. "version_number" is a major version of global attribute: "processing_level" in the two-digit format.
wmo_data_category	**101 for Imager data(satellite)**	The definition can be found on the Table C-13 http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/WMO306_vI2_CommonTable_en.pdf
wmo_international_data_subcategory	**0 for Multi-purpose VIS/IR imagery**	
processing_level	**e.g. "v1.0.0"**	Follows "Data Versioning" on the GSICS netCDF convention: https://gsics.nesdis.noaa.gov/wiki/Development/NetcdfConvention
doc_url		Document URL describes methods to generate lunar observation file (if exists). This is proposed to easily get the documents for user convenience.
doc_doi		Document doi if exists.

Table 6: proposal for Global Attributes of the GSICS lunar observation files.

7.2 Dimensions

DIMENSIONS		
NAME	**VALUE**	**DESCRIPTION**
chan	**e.g. 4 for SEVIRI**	Number of channels

chan_strlen	**e.g. 6 for SEVIRI**	Maximum length of variable: **channel_name** (see Table 8)
date	**1**	Number of date
sat_ref_strlen	**6**	Maximum length of variable: sat_pos_ref (i.e. "ITRF93")
col	**e.g. 499 for SEVIRI**	Largest number of columns for the imagettes. For example, for SEVIRI's low-res channels the nominal imagette dimension is 147 while for the high-res channel the dimension is 499. For this reason col is set to 499.
row	**e.g. 499 for SEVIRI**	Same description of **col**
sat_xyz	**3**	X, Y, and Z axis of satellite position

Table 7: proposal for Dimensions of the GSICS lunar observation files.

7.3 Variables

Table 8 gives the list of variables as they should appear in the input GSICS lunar observation NetCDF files. The colour code reflects the three categories of input as presented in Section 3:

1. **Compulsory**
2. **Additional**
3. **Imagettes**

If not provided, additional and imagettes variables should be filled with _FillValue

VARIABLES					
NAME [dimension]	**LONG NAME**	**ATBD NAME**	**UNITS**	**VALUE**	**TYPE**
date[date]	**time of lunar observation**	t_i	seconds since 1970-01-01T00:00:00Z	e.g. 127796549 1.0	double precision floating point
channel_name[chan,	**channel**	$Chan_k$	1	As expressed	character

chan_strlen]	**identifier**			in the GSICS SRF file	
sat_pos[sat_xyz]	**satellite position x y z in sat_pos_ref**	x_{Si}, y_{Si}, z_{Si}	km		double precision floating point
sat_pos_ref[sat_ref_strlen]	**reference frame of satellite position**	Ref_i		either “J2000” or “ITRF93”	character
irr_obs[chan]	**observed lunar irradiance**	$Irr_{OBSi,k}$	W m^{-2} µm^{-1}		double precision floating point
dc_obs[chan]	**integrated digital counts of lunar observation**	$DC_{OBSi,k}$	1		32-bit integer
dc_obs_offset[chan]	**averaged digital counts offset of deep space**	$Off_{DCi,k}$	1		double precision floating point
moon_pix_num[chan]	**number of moon pixels**	$N_{PIXi,k}$	1		32-bit integer
pix_solid_ang[chan]	**pixel solid angle**	$\Omega_{PIXi,k}$	sr		double precision floating point
ovrsamp_fa[chan]	**oversampling factor**	$F_{PIXi,k}$	1		double precision floating point
rad_obs_imgt[row,col,chan]	**observed moon radiance imagette**	$Imgt_{RADi,k}$	W sr^{-1} m^{-2} µm^{-1}		double precision floating point
dc_obs_imgt[row,col	**observed moon digital counts**	$Imgt_{DCi,k}$	1		32-bit integer

,chan]	imagette				
moon_pix_thld[chan]	digital counts threshold for moon masking	$Thld_{DCi,k}$	1		32-bit integer

Table 8: proposal for Variables of the GSICS lunar observation files.

The storing of both the DC and radiance imagettes in their respective multi-dimensional arrays must be done according to the following rule: the common origin of the arrays is the pixel [0, 0]. Refer to Figure 7 **for a graphical explanation.**

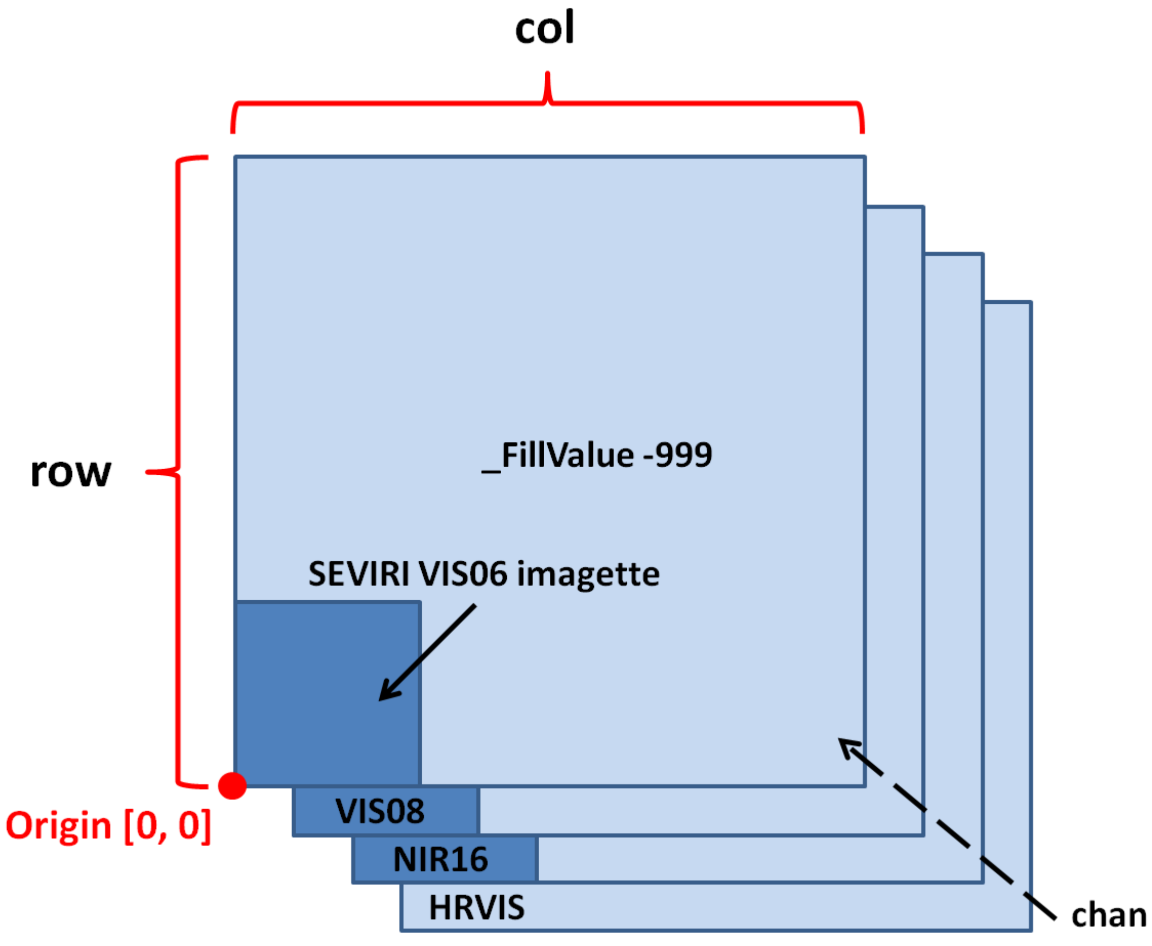

Figure 7: arrangement of an imagette within the multi-dimensional array whose dimensions are set by [col, row, chan]. In this specific example the HRVIS imagette is not available and the 4th array is filled with -999. However col and row are set by the dimensions of the HRVIS imagette.

7.3.1 Further option for storing the observables from the digital count imagette

The three variables dc_obs (int), dc_obs_offset (double), and dc_obs_imgt (three-dimensional array of int) can have two attributes that allow one to store as integers floating point values through a rescaling formula. Let's consider as an example: the user must store dc_obs = 3457.27 since the digital count imagette is a floating point variable. dc_obs must be an integer in the lunar observation file (see Table 8); in order to store it the user can use the variable attribute scale_factor = 0.01 (for example) and store dc_obs = 345727. The GIRO application will check the availability of the attribute "scale_factor" and in the case in which this has been stored by the user will compute: dc_obs (double) = dc_obs (int) * scale_factor. The user can also employ an offset named "add_offset" for the same purpose. The complete re-scaling that can be performed within the GIRO application is in fact: dc_obs * scale_factor + add_offset. In the case in which the user decides to re-scale one of the three quantities dc_obs, dc_obs_offset, and dc_obs_imgt <u>the re-scaling must be applied to the three quantities with the same rule and with the same "scale_factor" and "add_offset" values</u>.

7.4 Name format for the lunar observation files

In Table 6 the global attribute id contains the name of the lunar observation file. For sake of clarity we describe here again the lunar observation file name format:

W_'WMO_location_indicator',VISNIR+SUBSET+MOON,'Satellite_Name'+'Instrument_Name'_C_'WMO_CCCC_Code'_'Moon_observation_time_YYYYMMDDHHMMSS'_'version_number'.nc

where the characters in red are fixed. In case the user's institution does not have any WMO location indicator and CCCC Code we propose to define these two fields/codes by adopting the following rules:

CODE	RULE
WMO_location_indicator	Country Code (ISO)-Institution Acronym-Additional Code; please note that the separator " - " is needed in this code. The ISO 3166 country code can be found at: https://www.iso.org/obp/ui/#search The Additional Code should be either the acronym of an institution bureau (e.g., in the case of JMA the additional code is MSC which means Meteorological Satellite Center), or the city of the institution (e.g., in the EUMETSAT case the additional code is Darmstadt).
WMO_CCCC_Code	A list of WMO CCCC codes can be found at this link to the document "WMO No. 9 - Weather Reporting CCCCs by Location Indicator Volume C1 - Catalogue of Meteorological Bulletins Location Indicators used in the Abbreviated Headings (TTAAii CCCC)": https://www.wmo.int/pages/prog/www/ois/Operational_Information/VolumeC1/CCCC_en.pdf . In case the user will encounter problems in finding the appropriate code we propose the use the Institution Acronym used in the WMO_location_indicator.

8 NETCDF CONVENTION FOR LUNAR CALIBRATION FILES

In this section the convention adopted to define the lunar calibration files is described. In the current concept, we have different files for the different channels of an instrument (following the concept of section 7). In detail, here we list the global attributes, variables, and dimensions as produced by the lunar calibration tool. The output of the calibration is comprehensive of the calibration results plus the input quantities.

8.1 Global Attributes

Global Attributes		
NAME	**CONTENT**	**DESCRIPTION**
Conventions	**CF-1.6**	
Metadata_Conventions	**Unidata Dataset Discovery v1.0**	Conventions to "*identify and define a list of NetCDF global attributes recommended for describing a NetCDF dataset to discovery systems such as Digital Libraries*". Details can be found on: http://www.unidata.ucar.edu/software/thredds/current/netcdf-java/formats/DataDiscoveryAttConvention.html
standard_name_vocabulary	**CF Standard Name Table (Version 19, 22 March 2012)**	Mandatory for CF-1.5 and later
project	**"project name" (e.g., Global Space-based Inter-Calibration System http://gsics.wmo.int)**	Name of the project
title	**GSICS "Platform name" + "Instrument Name" vs ROLO + "ROLO version" lunar calibration file (e.g. GSICS MSG-2+SEVIRI+VIS06 vs ROLO1.0 lunar calibration file)**	Title of the file in which the platform name, the instrument name, and the reference model name must be specified together with the content of the file
summary	**Lunar calibration file**	Summary of the content of the file
keywords	**"free content"**	Useful keywords for browsing purposes

references	**TBD**	
institution	**“institution name” (e.g. EUMETSAT)**	Name of the institution that created the file
licence	**“terms of use”**	Text describing the institution policy for the use/sharing of the data. This field could in principle contain also the GSICS policy (for the shared test-dataset)
creator_name	**e.g., EUMETSAT - European Organisation for the Exploitation of Meteorological Satellites**	Detailed info on the creator of the file (these can be detailed info about the institution)
creator_email	**ops@eumetsat.int**	
creator_url	**http://www.eumetsat.int**	
instrument	**e.g., MSG2 SEVIRI**	Name of the instrument
instrument_wmo_code	**(56, 207)**	Come from the WMO’s Common Code Tables C-5 and C-8. This was proposed in 2010: https://groups.google.com/forum/#!topic/gsics-dev/FVV68cGgVWU
date_created	**YYYY-MM-DDTHH:MM:SSZ**	UTC time of the creation of the file
date_modified	**YYYY-MM-DDTHH:MM:SSZ**	UTC time of the latest update to the file
history	**“free content”**	Useful information. For example, this field can contain info about the calibration method, or model version, etc.
id	**e.g., W_XX-EUMETSAT-Darmstadt,SATCAL+RAC+GEOROLOVISNIR,MSG2+SEVIRI_C_EUMG_”Observation time of the first imagette of the sequence YYYYMMDDHHMMSS”_”version number”.nc**	Name of the file defined following the GSICS convention https://gsics.nesdis.noaa.gov/wiki/Development/FilenameConvention

wmo_data_category	**30 for Calibration dataset (satellite)**	The definition can be found on the Table C-13 http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/WMO306_vI2_CommonTable_en.pdf
wmo_international_data_subcategory	**5 for Re-Analysis Correction**	
processing_level	**e.g. "v1.0.0"**	Product version which follows "Data Versioning" on the GSICS netCDF convention: https://gsics.nesdis.noaa.gov/wiki/Development/NetcdfConvention
atbd_url		ATBD URL. This is proposed to easily get the documents for user convenience.
atbd_doi		doi for ATBD (if exists).
time_coverage_start	**YYYY-MM-DDTHH:MM:SSZ**	Observation time of the first imagette analysed in the time sequence (UTC)
time_coverage_end	**YYYY-MM-DDTHH:MM:SSZ**	Observation time of the last imagette analysed in the time sequence (UTC)
phase_angle_min	**2 [degree]**	Lowest value of the validity range of the lunar calibration (absolute value)
phase_angle_max	**92 [degree]**	Largest value of the validity range of the lunar calibration (absolute value)
reference_model	**ROLO version 3.11g**	Name of the reference model and its version (possibility to include here a hyperlink to an ATBD document)

Table 9: proposal for Global Attributes of the GSICS lunar calibration files.

8.2 Dimensions

DIMENSIONS

NAME	VALUE	DESCRIPTION
chan	**e.g. 4 for SEVIRI**	Number of channles
chan_strlen	**e.g. 6 for SEVIRI**	Maximum length of variable: chan. Conventional netCDF version (netCDF3) does not support type: strings, so we have to use type: character and specify the length. We can also generate imagette as netCDF4, but some GPRCs have difficulty to do that.
date		Number of dates/files
sat_ref_strlen	**6**	Maximum length of variable: sat_pos_ref (i.e. “ITRF93”)
sat_xyz	**3**	X,Y, and Z axis of satellite position
lambda_rolo	**32**	Number of ROLO spectrum
lambda_apollo	**221**	Number of APOLLO spectrum
lunar_obs_strlen	**e.g. 82 for SEVIRI data**	Length of lunar observation netCDF file name

Table 10: proposal for Dimensions of the GSICS lunar calibration files.

8.3 Variables

VARIABLES					
NAME	**LONG NAME**	**ATBD NAME**	**UNITS**	**VALUE**	**TYPE**
date[date]	**time of lunar observation**	t_i	seconds since 1970-01-01T00:00:00Z	e.g. 1277965491.0	double precision floating point
channel_name[chan,chan_strlen]	**channel identifier**		1	e.g. “VIS06”	character
central_wavelength[chan]	**nominal channel central wevelength**	λ_c^k	µm		double precision floating point
effective_wavelength[date,chan]	**effective wavelength of the observation**	λ_{Effi}^k	µm		double precision floating point
sat_selen_lat[date]	**satellite selenographic**	$\theta_i,$	degrees		double precision

	latitude				floating point
sat_selen_lon[date]	**satellite selenographic longitude**	ϕ_i	degrees		double precision floating point
dist_sat_moon[date]	**satellite moon distance**	d_{Si}	km		double precision floating point
sun_selen_lat[date]	**sun selenographic latitude**	Θ_i	degrees		double precision floating point
sun_selen_lon[date]	**sun selenographic longitude**	Φ_i	Degrees		double precision floating point
dist_sun_moon[date]	**sun moon distance**	d_{SUNi}	AU		double precision floating point
phase_ang[date]	**moon phase angle**	g_i	degrees		double precision floating point
sat_pos_ref[sat_ref_strlen]	**reference frame of satellite position**			either "J2000" or "ITRF93"	character
sat_pos[date, sat_xyz]	**satellite position x y z in sat_pos_ref**	x_{Si}, y_{Si}, z_{Si}	km		double precision floating point
sun_pos[date, sat_xyz]	**sun position in sat_pos_ref**	$x_{SUNi}, y_{SUNi}, z_{SUNi}$	km		double precision floating point
moon_pos[date, sat_xyz]	**moon position in sat_pos_ref**	$x_{MOONi}, y_{MOONi}, z_{MOONi}$	km		double precision floating point
irr_obs[date,chan]	**observed moon irradiance**	$Irr_{OBSi,k}$	W m^{-2} μm^{-1}		double precision floating point
irr_rolo[date,chan]	**rolo irradiance**	$Irr_{ROLOi,k}$	W m^{-2} μm^{-1}		double precision floating point
dc_obs[date,chan]	**integrated digital counts of lunar observation**	$DC_{OBSi,k}$	1		double precision floating point
dc_obs_offset[date, chan]	**averaged digital counts offset of deep space**	$Off_{DCi,k}$	1		double precision floating point
moon_pix_num[date,chan]	**number of moon pixels**	$N_{PIXi,k}$	1		32-bit integer
pix_solid_ang[date,chan]	**pixel solid angle**	$\Omega_{PIXi,k}$	sr		double precision floating point
ovrsamp_fa[date,chan]	**oversampling factor**	$F_{PIXi,k}$	1		double precision

					floating point
moon_pix_thld[date,chan]	**digital counts threshold for moon masking**	$Thld_{DCi,k}$	1		32-bit integer
rolo_spectr[date,chan,lambda_rolo]	**rolo reflectance spectrum at rolo wavelengths**	$A_{ROLOi}(\lambda_{ROLO})$	1		double precision floating point
rolo_lambdas[lambda_rolo]	**rolo wavelengths**	λ_{ROLO}	µm		double precision floating point
rolo_smooth_spectr[date,chan,lambda_apollo]	**rolo reflectance spectrum at apollo wavelengths**	$A_{ROLOi}(\lambda_{APO})$	1		double precision floating point
apollo_lambdas[lambda_apollo]	**apollo wavelengths**	λ_{APO}	µm		double precision floating point
moon_obs_file[date, lunar_obs_strlen][5]	**lunar observation file name**				character

Table 11: proposal for Variables of the GSICS lunar calibration files.

8.4 Name format for the lunar calibration file.

The file name format for the NetCDF lunar calibration file is defined automatically by the GIRO application by using part of the lunar observation filename. For this reason we the user must respect the format describe in section 7.4.

[5] The name of each file whose format has been described in section 7 and that has been used for the calibration.