MSI L1 PRODUCT DEFINITIONS

VOLUME A: NOMINAL PRODUCTS

ECGP

DRL REF: ECGP-TS-02

Prepared by: ECGP Team

Approved by:

Authorized by:

Code:	EC.ICD.GMV.MSI.00001
Version:	03.07
Date:	18/12/2024
Internal code:	GMV 21585/15 V12/24

DOCUMENT STATUS SHEET

Version	Date	Pages	Changes
01.00	15/05/2015	27	Version for the TRR2 First issue of the document In the first draft of this documnent, information related to product definition has been extracted from the original ICD and included in this document. Following changes have been implemented: • L0 Product definition moved back to ICD • Support Files definition moved back to ICD • Intermediate Data Files definition moved back to ICD • Land/Water Mask is needed as input. • Calibration product split in three differenent products and definitions moved to volume B • New fields in output products for the height and land water mask • Band dimension removed from L1C fields that are corregistered (the information was redundant). • StateVector Quality added for all MSI L1 Products No bar changes are included because more than 30% of the document has been changed.
01.01	22/07/2015	22	Version for the TRR2 Close-out Following RIDs have been implemented: • RID-TRR2-43: Clarified that the headers are also included in the netCDF4/HDF5 datablock (sections 5.6, 5.7 and 5.8) • RID-TRR2-42: Sections 4 a 6 of version 01.00 removed. Subsections 7.x of version 01.00 reviewed. • RID-TRR2-47: Packaging of L0 and L1 products in a ZIP file. Additional changes: • CCDB_Redundancy field added for each acquisition time.
01.02	12/10/2016	23	Version for the AR2 Close-out Following RIDs have been implemented: DL-MSI-11: PixelQuality values defined.
02.00	13/03/2017	22	Redline version generated by ESA + Additonal changes from GMV • Interface change for the MSI Nominal L1b and MSI Regridded L1c implementing EarthCARE metadata convention.
02.01	14/07/2021	21	Version for the ECGP V3.1: • No packaging as ZIP. • Product Format Version Specified in the scope section. • JIRA Issue ECGP-86;EC-GSCDR-198 sensing time in annotation header without GPS o time_synchronisation_status field added to MSI_NOM_1B data block and MSI_RGR_1C data block • JIRA Issue ECGP-84;EC-GSCDR-64 MSI instrument overview o Table of applicable documents updated: Code of [AD.11] corrected. o Table of reference documents updated: Code of [RD.2] corrected. o Section 4.1.13 updated: Reference to Figure 12 replaced by Figure 4.6 o New section "Across-track dependency central wavelength" added and table with MSI bands
03.00	06/04/2022	22	Version for the MSI V4: o Section 4 has been reviewed. o Section 5 has been updated with the new definition of MSI_NOM_1B and MSI_RGR_1C products.
03.01	29/06/2022	22	Version for the MSI V4-rc3 closeout: • [ECL1-506] Following has been changed: o Missing sunglint_flag field added to L1B and L1C tables o "drift" text was missing in following fields (it has been added): ▪ TIR_relay_temperature_drift_high_flag ▪ TIR_bench_temperature_drift_high_flag ▪ TIR_cover_temperature_drift_high_flag ▪ TIR_detector_bias_voltage_vfid_drift_high_flag ▪ TIR_detector_bias_voltage_vskim_drift_high_flag
03.02	09/12/2022	23	Version for the MSI V4-rc5 closeout: • [ECL1-528] Typo corrected in flag_field_data_memory_error_flag • [ECL1-527] CCDBVersion changed to string • [ECL1-542] MSI ECGP: Solar spectral irradiance implementation

Version	Date	Pages	Changes
			• Product format minor version bumped because of the new variables. • Version of Applicable and Reference documents updated

03.03	08/02/2023	23	Version for the MSI V4.01-rc1
			• [ECL1-577]
			  ○ Added sunglint_reflectance
			  ○ Minor product format version of the Nominal products (both 1B and 1C) is bumped because there is a new field in the product (backward compatibility is maintained)
			  ○ Estimated size of output products updated
			• Applicable documents updated
			• Section 5.7.3 and 5.8.3 (SPH descriptions) reshaped. No changes in the contents

03.04	20/09/2023	23	Following ticket implemented: • [ECL1-596] ○ Figure 4.2 in section 4.1.2 (VNS detector zone and area layout) and the text around updated
03.05	09/10/2023	23	Version for the MSI V4.02-rc1: • Format of the Specific Product Header in the HDR file has changed. Instead of writing the variables in the SPH as <variableName>value</variableName> they are written like: <variableName> <description>description text</description> <units>if applicable</units> <scalar>value</scalar> </variableName> • Description and Units are also written in the h5 (in previous version it was not). Product format version has been bumped to 5.0 because this change breaks backward compatibility if a processor is reading information from the SPH in the HDR file.
03.06	12/04/2024	24	Version for the MSI V4.3-rc1: • [ECSYSTEM-874] Added geoid_offset and geoid_offset_across_track_index to MSI_RGR and MSI_NOM products. • Product format version has been bumped to 5.1 because this change adds new field to the products. • [ECSYSTEM-907] pixel_values_uncertainty added to MSI_RGR product • [ECSYSTEM-908] add flag count to quality statistics MSI_NOM product • [ECL1-618] geoid_offset description updated
03.07	18/12/2024	24	Version for the MSI V4.6-rc2: • [ECL1-711] Some field descriptions updated (format not affected) • [ECL1-705] New attributes and variables added to the product.

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LIST OF TABLES AND FIGURES

1. INTRODUCTION

1.1. PURPOSE

This document has been produced in the frame of the "EarthCARE Ground Processor" project and its purpose is to describe the format and content of the L1 nominal and regridded products for the MSI processor.

1.2. SCOPE

This document has been derived from the original ICD where all interfaces (commanding, monitoring, input and output data) were described. In this document, the information related to MSI L1B Nominal and MSI L1C Regridded Products has been extracted from the original ICD and has been included in this dedicated document.

The versions of the product formats defined in this document are:

- MSI_NOM_1B: 5.1
- MSI_RGR_1C: 5.2

and must be reflected in the "formatMajorVersion" and "formatMinorVersion" of the MainProductHeader.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form part of this document to the extent specified herein. Applicable documents are those referenced in the Contract or approved by the Approval Authority. They are referenced in this document in the form [AD.X]:

Table 2-1: Applicable Documents

Ref.	Title	Code	Version	Date
[AD.1]	Earth Observation Mission CFI Software - General Software User Manual	EO-MA-DMS-GS-0002	4.20	30/10/2020
[AD.2]	ECSIM Interface Control Document	ECSIM-DMS-TEC-ICD01-R	1.7	18/11/2008
[AD.3]	Architecture of the ESSS and ECGP	EC.TN.ASD.SY.00017	7	19/12/2014
[AD.4]	Volume 0 Products Definitions - Introduction	EC.ICD.ASD.SY.00004	8	12/12/2014
[AD.5]	Volume 1 Products Definitions - Common Products Definitions	EC.ICD.ASD.SY.00005	12	25/07/2019
[AD.6]	ESSS and ECGP Common Interface Control Document	EC.ICD.ASD.SY.00009	8	09/12/2014
[AD.7]	Requirements for the ESSS & ECGP	EC.RS.ASD.SYS.00007	8	26/05/2010
[AD.8]	MSI ECGP Algorithm Theoretical Baseline Document	EC.TN.SSTL.MSI.00014	17	28/07/2021
[AD.9]	EarthCARE PDGS Generic IPF Interface Definition	EACA-GSEG-EOPG-TN-15-0001	01.04	01/09/2017
[AD.10]	Space Engineering - Software	ECSS-E-ST-40	C	06/03/2009
[AD.11]	Volume 4a Products Definitions – MSI L0 Products Definitions	EC.ICD.ASD.MSI.00020	6	11/12/2014
[AD.12]	Volume 6 Products Definitions – Auxiliary Data	EC.ICD.ASD.SY.00025	6	12/12/2014
[AD.13]	Earth Explorer Ground Segment File Format Standard	PE-TN-ESA-GS-0001	2.0	03/05/2012
[AD.14]	ECGP Interface Control Document (ICD)	EC.ICD.GMV.SY.00001	04.04	12/04/2024

2.2. REFERENCE DOCUMENTS

The following documents, although not part of this document, amplify or clarify its contents. Reference documents are those not applicable and referenced within this document. They are referenced in this document in the form [RD.X]:

Table 2-2: Reference Documents

Ref.	Title	Code	Version	Date
[RD.1]	List of Acronyms and Abbreviations	EC.LI.ASD.SY.00001	4	10/01/2013
[RD.2]	Volume 4b Products Definitions – MSI L1 Products Definitions	EC.ICD.ASD.ATL.00020	6	11/12/2014
[RD.3]	MSI L1 Product Definitions Volume B: Calibration Products	EC.ICD.GMV.MSI.00002	03.05	12/04/2024

3. TERMS, DEFINITIONS AND ABBREVIATED TERMS

3.1. DEFINITIONS

Concepts and terms used in this document and needing a definition are included in the following table:

Table 3-1: Definitions

Concept / Term	Definition

3.2. ACRONYMS

General EarthCARE abbreviations are in [RD.1]. Specific abbreviations used in this document are given below.

Acronyms used in this document and needing a definition are included in the following table:

Table 3-2: Acronyms

Acronym	Definition
ATLID	ATmospheric LIDar
BBR	EarthCARE Broadband Radiometer
CCDB	Characterisation/Calibration Database
ECGP	EarthCARE Level-1 Ground Processor
ESSS	EarthCARE Satellite System Simulator
FEE	Front-end electronics module
FHN	Friedrichshafen – Germany
GERB	Geostationary Earth Radiation Budget
GUI	Graphical User Interface
HMI	Human-Machine Interface
H/W	Hardware
ICD	Interface Control Document
ICU	Instrument Control Unit
IMDD	Instrument Measurement Data Definition
ISP	Instrument Source Packet
LW	Long-Wave
MDS	Measurement Data Stream
MSI	MultiSpectral Imager
PCD	Product Confidence Data
PDD	Product Definition Document
PDGS	Payload Data Ground Segment
SCOE	Spacecraft Check-Out Equipment
SRDB	Spacecraft Reference Data Base
SW	Short-Wave
S/W	Software
TDS	Test Data Set
TOA	Top Of Atmosphere
TW	Total Wave
UV	Ultra-Violet
WGS	World Geodetic System

4. MSI INSTRUMENT OVERVIEW

The Multi-Spectral Imager (MSI) comprises two separate co-mounted instruments:

- The Thermal Infrared (TIR)
- The Visual, Near-Infrared and SWIR (VNS).

Table 4-1: Spectral bands of MSI

Band #	Band Name	Spectral range (µm)
1	VIS	0.660-0.680
2	VNIR	0.855-0.875
3	SWIR1	1.625-1.675
4	SWIR2	2.160-2.260
5	TIR1	8.35-9.25
6	TIR2	10.35-11.25
7	TIR3	11.55-12.45

4.1. VNS INSTRUMENT

4.1.1. VNS OPTICS

The diagram below shows the layout of the VNS optics.

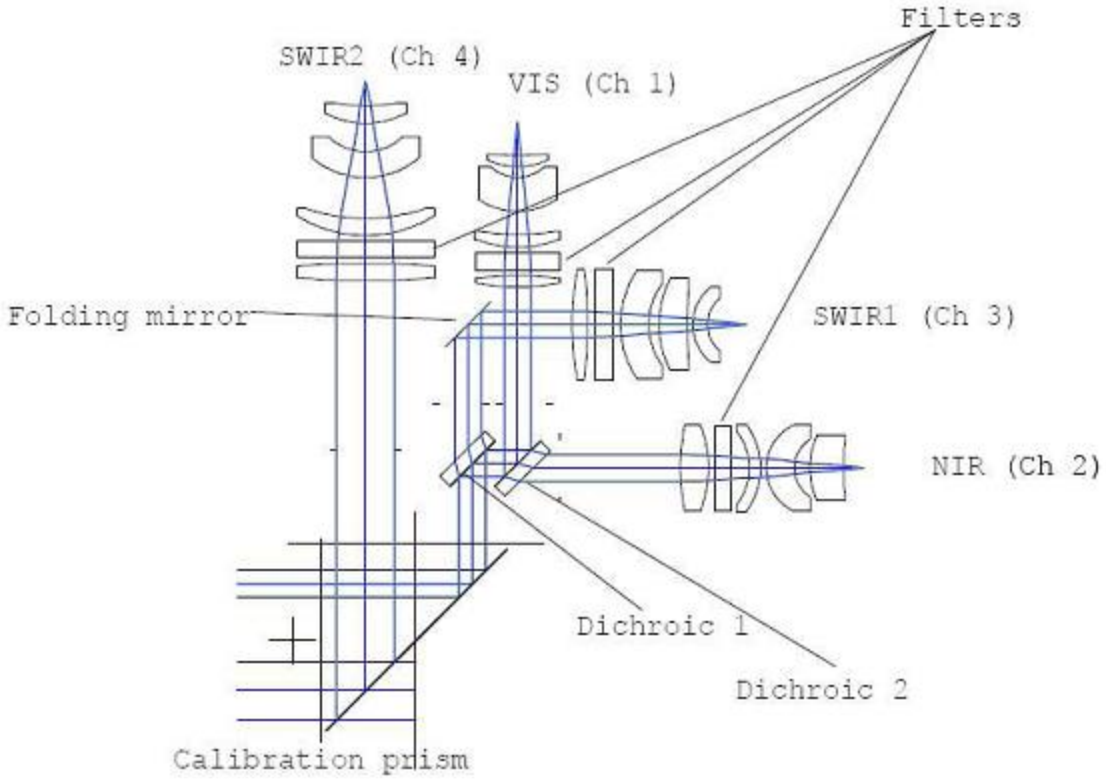

Figure 4.1: VNS Optical Design

The VNS optical section consists of four separate telescopes pointing through two apertures. One common aperture is provided for VIS, NIR and SWIR1 channels; plus a dedicated aperture for SWIR2. All channels share the same calibration source, using a shutter for dark calibration, and a diffuser prism for viewing sunlight for "sun" calibration.

4.1.2. VNS DETECTOR

The VNS camera is intended to detect sunlight reflected from the Earth (atmosphere or surface). It is not expected or required to produce useful data at night.

The VNS covers Visible, Near-IR and two Short-wave IR bands using a total of FOUR "lineshaped" 1-dimensional quantum detectors operating as push-broom scanners. Each spectral band is defined by means of narrow-band filters.

Each VNS detector contains 512 pixels. However, a maximum of 384 pixels can be accommodated in each ground-line ISP, so the outer 64 at each end are ignored. A physical mask is then applied to the next 12 pixels in from each end of the detector, providing zones of "blind" pixels that receive no incident flux, and are used to read out background offsets. The central 360 image pixels are iluminated.

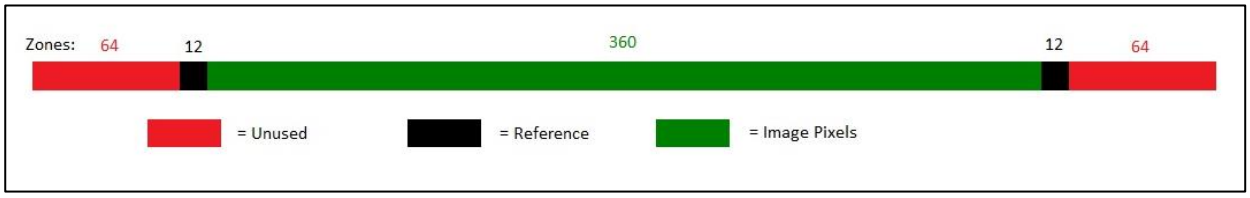

Figure 4.2: VNS Detector Zone & Area Layout

The Silicon detectors used for the VIS and NIR bands have fairly low dark-current noise but high read-out noise. This favours taking relatively long exposures to maximise SNR. By contrast to this, the InGaAs detectors used for the SWIR1 and SWIR2 bands are characterised by a high dark-current signal. This means that they tend to saturate quickly so can be used for only relatively short integration periods.

To overcome this problem, each detector is read out multiple times.

4.1.3. VNS CALIBRATION

The VNS camera will be "calibrated" periodically (daily) using an on-board control procedure (OBCP) which is executed by the ICU:

- The VNS mechanism is moved to bring one of two available diffusers into alignment with the telescope apertures, and the instrument collects signals as the diffusers are illuminated by the sun over a period of about 22 seconds. Data collected here can be used as a "bright" calibration reference against which to correct for degradation of camera performance.
- The calibration continues with a period where the shutter is closed; this period is used to collect "dark" signals from which information regarding detector offsets can be derived (by averaging). The default viewing period is 256 GL.
- The ICU averages the dark-view data from each detector to determine the fixed-pattern offsets:
    - The averaged dark signals from each active detector form a flat-field data-set which will not be applied until a specific command is issued following VNS CAL. The FF data will be stored in a designated buffer within the array of 32 available buffers.
    - The flat-field measurements will then be subtracted from all subsequent VNS science data before onward transmission to the ground.

The selection of diffusers to be used in the OBCP is constrained: Diffuser 2 is to be used for routine calibrations, but its optical properties may thereby degrade slightly over time.Diffuser 1 will be used infrequently in order to preserve its optical properties. Comparison between calibrations made with each diffuser will be used to assess diffuser degradation and thereby to correct for long-term drift in diffuser performance.

4.2. TIR INSTRUMENT

4.2.1. TIR OPTICS

The diagram below displays the TIR instrument optical design.

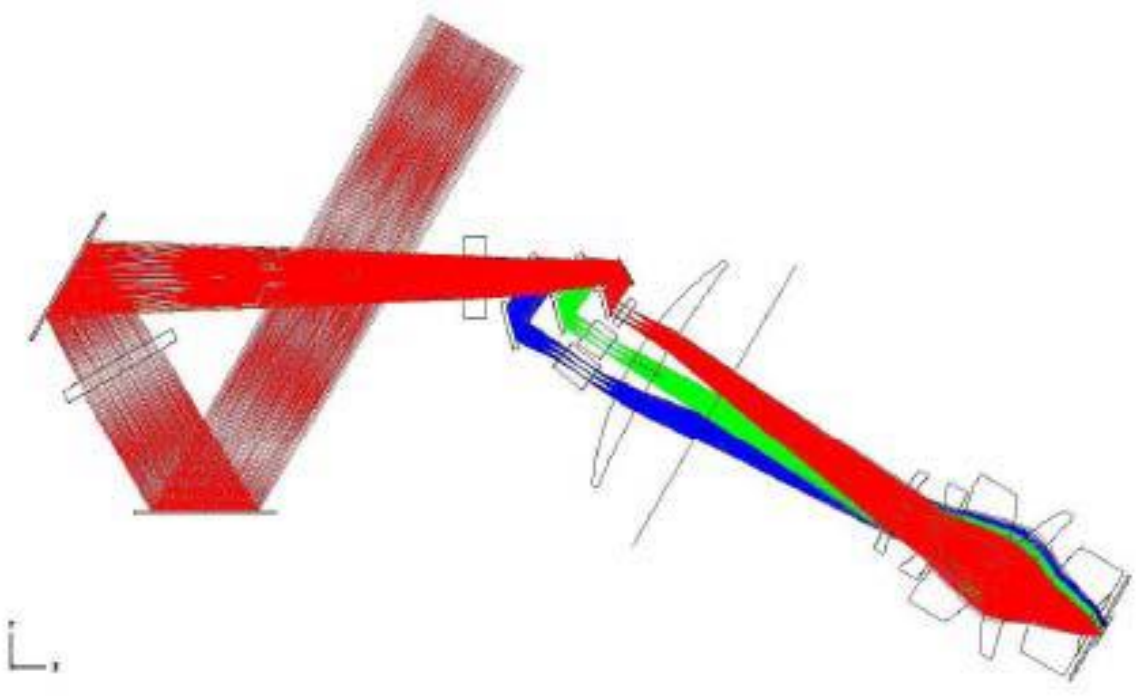

Figure 4.3: TIR Optical Design

All three TIR bands share signals from the same aperture, but they follow different optical pathways within the instrument (despite there being a single lens system). Also, they inhabit different spectral domains.

This also illustrates how the TIR optics also forms images on the detector array of various reference zones of the Filter Mask (in addition to the three filtered signal bands). The two sets of reference rows (Reference A and Reference B) will be imaged and combined by the FEE to create the Background Reference Band that forms an additional output channel. Because they are imaging a uniform flux field, any optical distortions in these reference areas are largely self-cancelling.

4.2.2. TIR DETECTOR

The TIR camera operates in the Thermal-IR, acquiring data in three spectral bands (labelled 7, 8 and 9) whose characteristics are defined by filters.

The TIR uses a single two-dimensional detector 384 elements wide (acrosstrack) whose surface area is shared between three differently-spectrally-filtered copies of the same scene. All the active regions of the detector are read out completely at every ground line period and stored in RAM within the FEE. Each active detector row (384 elements) contains approximately 360 elements which are exposed to the image.

The TIR camera sensitivity is relatively low, especially after spectral filtering has been applied. or this reason the detector signals are processed within the FEE according to a TDI (TimeDelay-Integrate) scheme which consists in using regions comprising 19 detector rows per band, maintaining a rolling buffer within the FEE which contains the detector signals collected within the past 19 ground line periods. This permits a signal-to-noise improvement by a factor close to 4.5 (square-root of 19). When a summation containing 19 valid rows has been calculated, it is output to the ICU; this happens once per ground line. Each image packet therefore results from a time-domain summation over the past 19 GL. Each output value therefore contains a summation made along one detector column.

The TIR camera is especially sensitive to small temperature deviations and to noise (especially fixed-pattern noise); for this reason two more zones of the detector are set aside to view a "constant temperature" target, the reference black body (BB). These zones comprise in total 38 detector rows (i.e. exactly twice the TDI region widths), and signals from these zones are simply summed together and output at each ground line to form the "REFerence" signal. The REF signal is combined with the raw spectral band signals at the start of signal processing to compensate for thermal drifts and detector noise issues.

The TIR raw science data stream therefore comprises four channels: band 7, band 8, band 9 and REF (channel IDs 5, 6, 7 and 8 respectively).

4.2.3. TIR CALIBRATION

The TIR is sensitive to environmental influences, including internal temperatures and detector bias voltages. Processing includes various "compensation mechanisms" which address small deviations in these parameters compared to expected values.

The TIR camera is equipped with an internal "calibration black body" (CBB). This unit is not thermally controlled, but very precise temperature measurements are made available via the HKTM data stream.

The TIR will be subjected to periodic (daily) calibration using an on-board control procedure (OBCP):

- The TIR mechanism (the "calibration mirror assembly" or CMA) will be moved to direct the TIR view towards the "cold-space" port. The CMA will dwell in this position for a while and then signals from all four channels will be acquired and averaged for a defined period (256 GL) by the ICU. The data thus collected characterise the fixed-pattern offset of the TIR detector, and they are made available for use as a flat field data-set which can be used to monitor and correct signal offsets.
- The CMA will then be moved in order to direct the camera's view towards the internal calibration BB; following a settling period, signals in each band will be acquired and averaged. The data thus collected can be used to check the calibration of the instrument.
- The CMA is finally moved back to the nadir view position to view the ground. A settling time is required before the image data can be trusted.

5. MSI L1 NOMINAL PRODUCTS

MSI L1 Nominal Products are generated by the MSI L1 Processor.

5.1. TRANSFER MECHANISM

All EarthCARE Products are composed by two physical files:

- One XML for the headers (*filemane*.HDR)
- One binary file for the records containing the data (*filename*.h5)

Both files are located into a folder with the same name (i.e. *filename)*.

5.2. FILE NAMING CONVENTION

The file naming convention for the EarthCARE Products is described in [AD.5].

5.3. DIMENSIONS

Following table contains all dimensions used in the definition of the MSI L1 Nominal products.

"Name" is used in the description of the product datablock below (for brevity).

"Dimension label" is the actual name of the dimension in the NetCDF product.

Table 5-1: MSI NetCDF Dimensions

Name	Description	N Elements	Dimension label
t	Dimension used to define variables depending on the number of samples recorded during the measurement time	Variable	along_track
b	Dimension used to define variables that are Band dependant	7	band
pix	Dimension used to define variables that contain arrays of pixels	384	across_track
vns_b	Dimension used to define variables that are only VNS Band dependent	4	VNS_band

5.4. SIZE AND FREQUENCY OF TRANSFERS

Being 1/8 of orbit the nominal time frame for the EarthCARE L1 products, the size of the MSI L1 products is given for such time frame i.e. 1/8 of orbit. Following table summarises the sizes and frequency of generation of MSI L1 Nominal and Regridded products.

Sizes below are provided without margin and assume no compression.

Table 5-2: MSI L1 products size and frequency of transfers

MDS type	Size	Frequency of transfer	Comments
MSI_NOM_1B	1300 MB	8 per orbit.	Assuming 10.000 acquisition times at 14.49 Hz, there are 11.5 minutes of acquisition, i.e. 1/8 of 92 minutes (approximately one orbit).
MSI_RGR_1C	285 MB	8 per orbit.	Assuming 10.000 acquisition times at 14.49 Hz, there are 11.5 minutes of acquisition, i.e. 1/8 of 92 minutes (approximately one orbit).

5.5. DATA DEFINITION

MSI L1 Products have different components, but there is a common structure for all of them. In this structure is included the Fixed Product Header and the main Product Header which are identical for all products and so it is described below.

5.6. DATA STRUCTURE

MSI L1 Products have different components, but there is a common structure for all of them. This structure is presented in the table below.

Table 5-3: L1 Product logical structure

HeaderData
FixedProductHeader
VariableProductHeader
MainProductHeader
SpecificProductHeader
ScienceData

According to the above structure, the products are physically composed by:

- Headers (FixedProductHeader and VariableProductHeader) included in the XML file
- ScienceData included in the netCDF4/HDF5 binary file (which also contains the headers)

There are two different MSI L1 Products, sharing this structure. In this structure it is included the FixedProductHeader and the MainProductHeader which are identical for all products and so it is described only once below.

5.7. MSI_NOM_1B

This is the Nominal MSI L1B product. It is separated in the four components described below.

5.7.1. MSI_NOM_1B FIXED PRODUCT HEADER

The FixedProductHeader is common for all ECGP products and is defined in Products Definitions Volume 1 [AD.5].

5.7.2. MSI_NOM_1B MAIN PRODUCT HEADER

The MainProductHeader for the MSI L1B Products is identical to the MainProductHeader defined in Products Definitions Volume 1 [AD.5] but with following predefined values specific to MSI L1B Nominal product:

- fileCategory = "MSI_"
- productType = "NOM_"
- productLevel = "1B"

5.7.3. MSI_NOM_1B SPECIFIC PRODUCT HEADER

The Specific Product Header for the EarthCARE L1 Products follows the specification defined in section 6.1 of [AD.5], which defines following elements:

In case of MSI_NOM_1B, the SpecificProductHeader sub-group contains:

Table 5.4: MSI NOM L1 SPH structure

Group/Field Name	# Dims	Dimensions	Type	Units	Description
InputFileList	0	-	NC_STRING	N/A	String containing the logical file names (without extension) of all input files used by the processor to generate the product.
ConfigurationParameters	0	-	NC_STRING	N/A	String that contains is a copy of the processor configuration file

Group/Field Name	# Dims	Dimensions	Type	Units	Description
geoid_offset_across_track_index	0	-	NC_SHORT	N/A	Index of the pixel closest to nadir for reference band. This pixel's latitude and longitude are used to compute geoid_offset
QualityStatistics	0	-	NetCDF Group	N/A	This group contains an arbitrary number of quality statistics parameters. See following table

Table 5.5: MSI NOM L1 QualityStatistics group

Field Name	# Dims	Dimensions	Type	Units	Description
GroundLineCount	0	-	NC_INT	N/A	Total number of ground lines in this data set
InvalidGroundLineCount	0	-	NC_INT	N/A	Number of invalid ground lines in this data set
InvalidPixelCount	0	-	NC_INT	N/A	Total number of invalid or out of range pixels in the remaining valid ground lines
TIR_detector_temperature_drift_high_flag_count	0	-	NC_INT	N/A	Total number of set TIR_detector_temperature_drift_high_flag
TIR_detector_temperature_sensitivity_correction_flag_count	0	-	NC_INT	N/A	Total number of set TIR_detector_temperature_sensitivity_correction_flag
TIR_relay_lens_temperature_drift_high_flag_count	0	-	NC_INT	N/A	Total number of set TIR_relay_lens_temperature_drift_high_flag
TIR_relay_lens_temperature_sensitivity_correction_flag_count	0	-	NC_INT	N/A	Total number of set TIR_relay_lens_temperature_sensitivity_correction_flag
TIR_bench_temperature_drift_high_flag_count	0	-	NC_INT	N/A	Total number of set TIR_bench_temperature_drift_high_flag
TIR_bench_temperature_sensitivity_correction_flag_count	0	-	NC_INT	N/A	Total number of set TIR_bench_temperature_sensitivity_correction_flag
TIR_cover_temperature_drift_high_flag_count	0	-	NC_INT	N/A	Total number of set TIR_cover_temperature_drift_high_flag
TIR_cover_temperature_sensitivity_correction_flag_count	0	-	NC_INT	N/A	Total number of set TIR_cover_temperature_sensitivity_correction_flag
TIR_detector_bias_voltage_VFID_drift_high_flag_count	0	-	NC_INT	N/A	Total number of set TIR_detector_bias_voltage_VFID_drift_high_flag
TIR_detector_bias_voltage_VFID_sensitivity_correction_flag_count	0	-	NC_INT	N/A	Total number of set TIR_detector_bias_voltage_VFID_sensitivity_correction_flag
TIR_detector_bias_voltage_VSKIM_drift_high_flag_count	0	-	NC_INT	N/A	Total number of set TIR_detector_bias_voltage_VSKIM_drift_high_flag
TIR_detector_bias_voltage_VSKIM_sensitivity_correction_flag_count	0	-	NC_INT	N/A	Total number of set TIR_detector_bias_voltage_VSKIM_sensitivity_correction_flag
detector_latchup_flag_count	0	-	NC_INT	N/A	Total number of set detector_latchup_flag for all bands
science_data_memory_error_flag_count	0	-	NC_INT	N/A	Total number of set science_data_memory_error_flag
flat_field_data_memory_error_flag_count	0	-	NC_INT	N/A	Total number of set flat_field_data_memory_error_flag
ancillary_data_memory_error_flag_count	0	-	NC_INT	N/A	Total number of set ancillary_data_memory_error_flag

Field Name	# Dims	Dimensions	Type	Units	Description
instrument_control_unit_analog_to_digital_converter_latchup_flag_count	0	-	NC_INT	N/A	Total number of set instrument_control_unit_analog_to_digital_converter_latchup_flag
VNS_data_memory_error_flag_count	0	-	NC_INT	N/A	Total number of set VNS_data_memory_error_flag

5.7.4. MSI_NOM_1B SCIENCE DATA

The Science Data of this product is formatted as NetCDF/HDF5 file and have following fields:

Table 5-6: MSI NOM L1B Datablock structure

Field Name	#Dims	Dimensions	Type	Units	Description
pixel_values	3	b, t, pix	NC_FLOAT	$Wm^{-2}sr^{-1}um^{-1}$ Or Kelvin	Corrected pixel values. Radiance in $Wm^{-2}sr^{-1}um^{-1}$ for bands VIS/NIR/SWIR1/SWIR2 and Temperature in Kelvin for TIR channels
latitude	3	b, t, pix	NC_DOUBLE	deg	Latitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.
longitude	3	b, t, pix	NC_DOUBLE	deg	Longitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.
solar_azimuth_angle	3	b, t, pix	NC_FLOAT	deg	Solar azimuth angle per pixel
solar_elevation_angle	3	b, t, pix	NC_FLOAT	deg	Solar elevation angle per pixel
sensor_azimuth_angle	3	b, t, pix	NC_FLOAT	deg	Sensor azimuth angle per pixel
sensor_elevation_angle	3	b, t, pix	NC_FLOAT	deg	Sensor elevation angle per pixel
surface_elevation	3	b, t, pix	NC_FLOAT	m	The surface height of this point referenced to the ellipsoid WGS84.
land_flag	3	b, t, pix	NC_BYTE	unitless	Flag which indicates if 1 = land 0 = water
sunglint_flag	3	b, t, pix	NC_BYTE	unitless	Flag which indicates if 1 = sunglint 0 = no glint
sunglint_reflectance	3	b, t, pix	NC_FLOAT	unitless	Calculated sunglint reflectance value
pixel_quality_status	3	b, t, pix	NC_BYTE	unitless	MSI Pixel Quality Status Enumeration 0: PIXEL_OK 1: PIXEL_UNRESPONSIVE 2: PIXEL_SATURATED 3: PIXEL_SUNGLINT
line_quality_status	2	b,t	NC_SHORT	unitless	Bits 0-2: pixel quality 3 bytes summarising pixel quality. Bit 3: Lost TIR REF packet Loss of a TIR REF packet would set "bad line" flag in all TIR bands for a period of 19 GL following the restoration of TIR REF signals. Bit 4: TIR sensitivity deviation flag

Field Name	#Dims	Dimensions	Type	Units	Description
					The setting of any TIR sensitivity deviation flag shall cause a line to be marked. Bit 5: FDIR checks Deviation in any of the low-severity FDIR monitors shall cause the appropriate image lines to be marked, differentiated by camera (VNS or TIR). The one exception concerns FEE temperature: an FDIR violation in this quantity shall cause ALL image lines to be marked. Bit 6:VNS EDAC flag For VNS data only, the raising of the EDAC flag shall cause ALL VNS lines to be marked. The duration of the marking shall follow that of the flag. Bit 7: FF buffer If any ISP is detected which has a flat-field buffer ID of zero, then the data derived form that ISP shall be marked as untrustworthy. Bit 8: Science Data Error Status. Flags is raised if an error affects the flat fields being used to process science data in the ICU, or that a detector suffers a problem which shifts its signal significantly.
time	1	t	NC_DOUBLE	seconds since 1 Jan 2000 00:00:00	Sensing time
state_vector_quality_status	1	t	NC_INT	unitless	S/C State Vector Quality field copied from the ISP Private Science Data Header
time_synchronisation_status	1	t	NC_BYTE	unitless	Long name: Instrument time synchronisation status Status of the time synchronisation between the instrument and the satellite Bit 3: Time Type 0 = Elapsed Time (ET); 1 = OBT Bit 4: Sync. Source 0 = internal; 1 = external Bit 5: Ext. Sync. Source Detail 0 = MIL-Bus Major Frame; 1 = 1Hz Pulse Bit 6: Sync. Status 0 = NoSync; 1 = InSync Bit 7: …Synchronization Enabled/Disabled 0 = Disabled; 1 = Enabled
ccdb_redundancy_flag	1	t	NC_BYTE	unitless	Flag to identify the redundancy configuration. 0=nominal chain 1=redundant chain
calibration_maintenance_gain	2	b,pix	NC_FLOAT	unitless	Vectors showing gains applied at this point in the mission.
detector_temperature	2	b, t	NC_FLOAT	Kelvin	From ICU ISP ANC data, five values (TIR bands all take the same single TIR detector temperature.)

Field Name	#Dims	Dimensions	Type	Units	Description
housekeeping_data_within_limits_status	1	t	NC_INT	unitless	Flags that indicate if any of the FDIR checks parameters outside the limits. Each bit correspond to one parameter flags. See table Table 5-7 below for a detailed specification of each bit.
quality_vector_status	2	b, t	NC_SHORT	unitless	MSI Quality vector
wing_sum	2	b, t	NC_INT	ADU	Wing elements sum in each band. VNS bands only.
VNS_solar_azimuth_angle	1	t	NC_FLOAT	deg	Solar azimuth angles in VNS frame
VNS_solar_elevation_angle	1	t	NC_FLOAT	deg	Solar elevation angles in VNS frame
TIR_detector_temperature_drift	1	t	NC_FLOAT	Kelvin	DIFFERENCE: (current value – average at last TIR CAL) : detector temperature
TIR_detector_temperature_drift_high_flag	1	t	NC_BYTE	unitless	Excessive drift warning flag: TIR detector temperature sensitivity.
TIR_detector_temperature_sensitivity_correction_flag	1	t	NC_BYTE	unitless	Flag for whether sensitivity correction was applied
TIR_relay_lens_temperature_drift	1	t	NC_FLOAT	Kelvin	DIFFERENCE: (current value – average at last TIR CAL) : relay temperature (averaged)
TIR_relay_lens_temperature_drift_high_flag	1	t	NC_BYTE	unitless	Excessive drift warning flag: relay temperature sensitivity
TIR_relay_lens_temperature_sensitivity_correction_flag	1	t	NC_BYTE	unitless	Flag for whether sensitivity correction was applied
TIR_bench_temperature_drift	1	t	NC_FLOAT	Kelvin	DIFFERENCE: (current value – average at last TIR CAL) : bench temperature sensitivity
TIR_bench_temperature_drift_high_flag	1	t	NC_BYTE	unitless	Excessive drift warning flag: bench temperature
TIR_bench_temperature_sensitivity_correction_flag	1	t	NC_BYTE	unitless	Flag for whether sensitivity correction was applied
TIR_cover_temperature_drift	1	t	NC_FLOAT	Kelvin	DIFFERENCE: (current value – average at last TIR CAL) : case temperature sensitivity
TIR_cover_temperature_drift_high_flag	1	t	NC_BYTE	unitless	Excessive drift warning flag: cover temperature.
TIR_cover_temperature_sensitivity_correction_flag	1	t	NC_BYTE	unitless	Flag for whether sensitivity correction was applied
TIR_detector_bias_voltage_VFID_drift	1	t	NC_FLOAT	Volt	DIFFERENCE: (current value – average at last TIR CAL) : VFID bias drift
TIR_detector_bias_voltage_VFID_drift_high_flag	1	t	NC_BYTE	unitless	Excessive drift warning flag: VFID bias sensitivity
TIR_detector_bias_voltage_VFID_sensitivity_correction_flag	1	t	NC_BYTE	unitless	Flag for whether sensitivity correction was applied
TIR_detector_bias_voltage_VSKIM_drift	1	t	NC_FLOAT	Volt	DIFFERENCE: (current value – average at last TIR CAL) : VSKIM bias drift

Field Name	#Dims	Dimensions	Type	Units	Description
TIR_detector_bias_voltage_VSKIM_drift_high_flag	1	t	NC_BYTE	unitless	Excessive drift warning flag: VFID bias sensitivity
TIR_detector_bias_voltage_VSKIM_sensitivity_correction_flag	1	t	NC_BYTE	unitless	Flag for whether sensitivity correction was applied
detector_latchup_flag	2	b, t	NC_BYTE	unitless	Flags indicating detector latchup status
detector_power_status	2	b, t	NC_BYTE	unitless	Flags indicating detector power supply status
science_packet_transmission_status	1	t	NC_SHORT	unitless	Integer in which the lowest 9 bits contain the transmission status for each ISP channel: - Bit 0 = VIS - Bit 1 = NIR - Bit 2 = SWIR-1 - Bit 3 = SWIR-2 - Bit 4 = TIR Band 7 - Bit 5 = TIR Band 8 - Bit 6 = TIR Band 9 - Bit 7 = TIR REF - Bit 8 = TIR AUX (diagnostic ISP containing raw TIR data). The expected values for this ISP channel status word (in the absence of faults) are as follows: - “Day-time” operation (total 9 packets / GL, of which 8 are generated by the FEE) : 0x00FF - “Night Time” operation (between VNS CAL end and start of VNS DAY, total 6 packets per GL of which 5 are generated by the FEE) : 0x01F0 The expected values given above may need modification through the life of the mission if the MSI operators react to a fault condition.
science_data_memory_error_flag	1	t	NC_BYTE	unitless	If this flag is raised, then one of the science packets received by the ICU from the FEE has suffered a corruption. There is no way to determine which packet may have been affected, or where in any packet the error occurred. There may be an effect on the science data or on the header information.
flat_field_data_memory_error_flag	1	t	NC_BYTE	unitless	If this flag is raised, there is an error in the application of flat fields to the science packets. There is no way to determine which channel(s) might be affected, nor the severity of the effect
ancillary_data_memory_error_flag	1	t	NC_BYTE	unitless	If this flag is raised, there is an error in the ADC Buffers E and F that may perhaps affect some of the ancillary data withing the ICU AUX packet.
instaument_control_unit_analog_to_digital_converter_latchup_flag	1	t	NC_BYTE	unitless	The effect of this error is that all ADC-mediated readings may be affected for a period until the automatic recovery process finishes
VNS_data_memory_error_flag	2	t	NC_BYTE	unitless	Flags is raised when there is a VNS RAM double-bit error.
solar_spectral_irradiance	2	vns_b, pix	NC_FLOAT	$Wm^{-2}um^{-1}$	Solar irradiance for this band

Field Name	#Dims	Dimensions	Type	Units	Description
geoid_offset	1	t	NC_FLOAT	m	Height of geoid EGM96 over the ellipsoid WGS84 (in m). Altitudes are referenced over WGS84. To obtain the altitude over geoid EGM96, user need to subtract geoid offset from the altitude referenced over WGS84

Next table details the contents of the fdir_flags variable:

Table 5-7: fdir_flags contents

Bit	TM Designator	Name	Low Limit	High Limit	Units
0	LHT08828	FEE Temperature	287,00	302,00	K
1	LHT08832	TIROU Temp 10 (Cover)	286,90	288,40	K
2	LHT08833	TIROU Temp 11 (Cover)	286,90	288,40	K
3	LHT08834	VNS Temp 3 (OU)	295,15	297,15	K
4	LHT08836	VNS Temp 4 (OU)	295,15	297,15	K
5	LHT08837	VNS Temp 1 (OU)	295,15	297,15	K
6	LHT08838	VNS Temp 2 (OU)	295,15	297,15	K
7	LHT08839	TIROU Temp 2 (Bench)	287,40	288,90	K
8	LHT08840	TIROU Temp 3 (Bench)	287,40	288,90	K
9	LHT08841	TIROU Temp 4 (Relay)	292,40	293,90	K
10	LHT08844	TIROU Temp 5 (Relay)	292,40	293,90	K
11	LHT08847	TIROU Temp 7 (RBB)	292,50	294,00	K
12	LHT08860	VNS Temp 5 (CF)	222,45	224,45	K
13	LHT08861	VNS Temp 6 (CF)	222,45	2224,45	K
14	LHT08863	TIROU CBB A	285,40	288,65	K
15	LHT08864	TIROU CBB B	285,40	289,00	K
16	LHT08871	VNS SWIR-2 DETECTOR Temp	232,30	236,30	K
17	LHT08872	TIR DETECTOR Temp	294,75	296,25	K
18	LHT08583	FEE 7V Filter P	7,00	8,10	V
19	LHT08580	TIR VFID	3,64	3,68	V
20	LHT08581	TIR VSKIM	5,24	5,27	V

5.8. MSI_RGR_1C

This is the Regridded MSI L1C product. It is separated in the four components described below.

5.8.1. MSI_RGR_1C FIXED PRODUCT HEADER

The Fixed Product Header is common for all ECGP products and is defined in Products Definitions Volume 1 [AD.5].

5.8.2. MSI_RGR_1C MAIN PRODUCT HEADER

The Main Product Header for the MSI L1C Products is identical to the Main Product Header defined in Products Definitions Volume 1 [AD.5] but with following predefined values specific to MSI L1C Regridded product:

- fileCategory = "MSI_"
- productType = "RGR_"
- productLevel = "1C"

5.8.3. MSI_RGR_1C SPECIFIC PRODUCT HEADER

The Specific Product Header for the EarthCARE L1 Products follows the specification defined in section 6.1 of [AD.5], which defines following elements:

In case of MSI_RGR_1C, the SpecificProductHeader sub-group contains:

Table 5-8: MSI RGR L1 SPH structure

Group/Field Name	# Dims	Dimensions	Type	Units	Description
InputFileList	0	-	NC_STRING	N/A	String containing the logical file names (without extension) of all input files used by the processor to generate the product.
ConfigurationParameters	0	-	NC_STRING	N/A	String that contains is a copy of the processor configuration file
geoid_offset_across_track_index	0	-	NC_SHORT	N/A	Index of the pixel closest to nadir for reference band. This pixel's latitude and longitude are used to compute geoid_offset
QualityStatistics	0	-	NetCDF Group	N/A	This group contains an arbitrary number of quality statistics parameters. See following table

Table 5-9: MSI RGR L1 QualityStatistics group

Field Name	# Dims	Dimensions	Type	Units	Description
GroundLineCount	0	-	NC_INT	N/A	Total number of ground lines in this data set
InvalidGroundLineCount	0	-	NC_INT	N/A	Number of invalid ground lines in this data set
InvalidPixelCount	0	-	NC_INT	N/A	Total number of invalid or out of range pixels in the remaining valid ground lines

5.8.4. MSI_RGR_1C SCIENCE DATA

The Science Data of this product is formatted as NetCDF/HDF5 file and have following fields:

Table 5.7: MSI RGR L1C Science Data structure

Field Name	#Dims	Dimensions	Type	Units	Description
pixel_values	3	b, t, pix	NC_FLOAT	$Wm^{-2}sr^{-1}um^{-1}$ Or Kelvin	Corrected pixel values. Radiance in $Wm^{-2}sr^{-1}um^{-1}$ for bands VIS/NIR/SWIR1/SWIR2 and Temperature in Kelvin for TIR channels
latitude	2	t, pix	NC_DOUBLE	deg	Latitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.
longitude	2	t, pix	NC_DOUBLE	deg	Longitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.

Field Name	#Dims	Dimensions	Type	Units	Description
solar_azimuth_angle	2	t, pix	NC_FLOAT	deg	Solar azimuth angle
solar_elevation_angle	2	t, pix	NC_FLOAT	deg	Solar elevation angle
sensor_azimuth_angle	2	t, pix	NC_FLOAT	deg	Sensor azimuth angle
sensor_elevation_angle	2	t, pix	NC_FLOAT	deg	Sensor elevation angle
surface_elevation	2	t, pix	NC_FLOAT	m	The surface height of this point referenced to the ellipsoid WGS84.
land_flag	2	t, pix	NC_BYTE	unitless	Flag which indicates if 1 = land, 0 = water
sunglint_flag	2	t, pix	NC_BYTE	unitless	Flag which indicates if 1 = sunglint 0 = no glint
sunglint_reflectance	2	t, pix	NC_FLOAT	unitless	Calculated sunglint reflectance value
pixel_quality_status	3	b, t, pix	NC_BYTE	unitless	MSI Pixel Quality Status Enumeration 0: PIXEL_OK 1: PIXEL_UNRESPONSIVE 2: PIXEL_SATURATED 3: PIXEL_SUNGLINT
line_quality_status	2	b,t	NC_SHORT	unitless	Bits 0-2: pixel quality 3 bytes summarising pixel quality. Bit 3: Lost TIR REF packet Loss of a TIR REF packet would set "bad line" flag in all TIR bands for a period of 19 GL following the restoration of TIR REF signals. Bit 4: TIR sensitivity deviation flag The setting of any TIR sensitivity deviation flag shall cause a line to be marked. Bit 5: FDIR checks Deviation in any of the low-severity FDIR monitors shall cause the appropriate image lines to be marked, differentiated by camera (VNS or TIR). The one exception concerns FEE temperature: an FDIR violation in this quantity shall cause ALL image lines to be marked. Bit 6:VNS EDAC flag For VNS data only, the raising of the EDAC flag shall cause ALL VNS lines to be marked. The duration of the marking shall follow that of the flag. Bit 7: FF buffer If any ISP is detected which has a flat-field buffer ID of zero, then the data derived form that ISP shall be marked as untrustworthy. Bit 8: Science Data Error Status. Flags is raised if an error affects the flat fields being used to process science data in the ICU, or that a detector suffers a problem which shifts its signal significantly.

Field Name	#Dims	Dimensions	Type	Units	Description
time	1	t	NC_DOUBLE	seconds since 1 Jan 2000 00:00:00	Sensing time
state_vector_quality_status	1	t	NC_INT	unitless	S/C State Vector Quality field copied from the ISP Private Science Data Header
time_synchronisation_status	1	t	NC_BYTE	unitless	Long name: Instrument time synchronisation status Status of the time synchronisation between the instrument and the satellite Bit 3: Time Type 0 = Elapsed Time (ET); 1 = OBT Bit 4: Sync. Source 0 = internal; 1 = external Bit 5: Ext. Sync. Source Detail 0 = MIL-Bus Major Frame; 1 = 1Hz Pulse Bit 6: Sync. Status 0 = NoSync; 1 = InSync Bit 7: …Synchronization Enabled/Disabled 0 = Disabled; 1 = Enabled
ccdb_redundancy_flag	1	t	NC_BYTE	unitless	Flag to identify the redundancy configuration. 0=nominal chain 1=redundant chain
solar_spectral_irradiance	2	vns_b, pix	NC_FLOAT	$Wm^{-2}um^{-1}$	Solar irradiance for this band
geoid_offset	1	t	NC_FLOAT	m	Height of the geoid over the ellipsoid
pixel_values_uncertainty	3	b, t, pix	NC_FLOAT	$Wm^{-2}sr^{-1}um^{-1}$ Or Kelvin	Radiance (VNS bands) and brightness temperature (TIR bands) uncertainty
band	1	b	NC_STRING	unitless	Band (VIS, VNIR, SWIR1, SWIR2, TIR1, TIR2, TIR3)

END OF DOCUMENT