SAF NWC / MSG Output Products Format Definition

SAF/NWC/CDOP2/INM/SW/ICD/3, Issue 7, Rev. 0

15 July 2013

Applicable to SAFNWC/MSG version 2013

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REPORT SIGNATURE TABLE

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Reviewed by	DRI Review Board		June 2013
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DOCUMENT CHANGE RECORD

Version	Date	Pages	CHANGE(S)
Document code SAF/NWC/INM/SW/ICD/3			
1.0	09 June 99	17	First published version (previously included in SAF/NWC/INM/SW/ICD/1)
2.0	03 December 1999	25	Updates of header fields (e.g. include offset and scaling factor). Update of parameters of all products. Updates according to comments of STG meeting.
2.1	20 December 1999	25	Update of offset an scaling factor fields (Type and position). Update of format of Cloud Type product
2.2	25 February 2000	26	Updates provided from partners included. Comments from STG OWP included. Change bars have been used.
2.3	28 June 2000	26	Parameters description tables completed for the SAFNWC products.
2.4	10 October 2000	30	Products for INM PGEs described, and RDT output format updated. Implemented RID from MTR: NWCMSG_Output_Format_Barlgag_90
2.5	16 May 2001	34	TPW, LPW, SAI and CRR output fomat updated
3.0	3 September 2001	35	Consolidation of the Document for the SIRR The Output Format for all the SAFNWC/MSG products has been updated
3.1	25 January 2002	40	Update from corrigendum SAF/NWC/INM/COR/1 Update of the RDT output format. Update section 3.11 (High Resolution Wind Vectors from HRVIS (HRW) Product) Change bars have been used.
Document code SAF/NWC/IOP/INM/SW/ICD/3			
0.1	30 May 2003	47	Contributions to ZAMG products have been included: *Updated sections: 3.12" Automatic Satellite Image Interpretation (ASII) Product" and 3.14 " Air Mass Analysis (AMA) Product"* Contributions to MF-DPr product have been included: *Updated section 3.13 "Rapid Developing Thunderstorms (RDT) Product"* Contributions to INM product have been included: *Updated section 3.7 "Convective Rainfall Rate (CRR) Product"* *Updated section 3.8 "Total Precipitable Water (TPW) Product"* *Updated section 3.9 "Layer Precipitable Water (LPW) Product"* *Updated section 3.10 "Stability Analysis Imagery (SAI) Product"* *Updated sectioin 3.11 "High Resolution Winds (HRW) Product"* Image-like products in HDF5 format. General revision. Document homogenised. Change bars have been used
1.0draft	26 March 2004	47	First checking and tunning tasks: - *Updated PGE01. Cma_Test product definition and CMA_QUALITY list of values* - *Updated PGE02. CT_QUALITY list of values* - *Updated PGE03. CTTH_QUALITY used method and CTTH_QUALITY list of values*

Version	Date	Pages	CHANGE(S)
			- *Updated PGE06. Output product in 8 bits* - *Updated PGE07. Removed LPW_HEIGHT keyword* - *Updated PGE08. Stored values are now in ºC* - *Updated PGE09: new descriptors added in the BUFR product, removed old ones and updated some definitions.* - *Minor corrections in PGE10 product description* - *Updated PGE11. CTTH_HEIGHT replaced by CTTH_PRES* *Air mass classes description table for PGE12 has been updated* Description of the Palette definition file has been moved to ICD/1
1.0	19 May 2004	47	Product structure figures have been homogenised *Note: Change bars apply to v0.1*
1.1draft	30 September 2004	47	Sec 3.7 : Output product format for PGE05 have been modified - CRR_CORRECTIONS changed to CRR_QUALITY - Two new bits included in CRR_QUALITY parameter - Colour palette included Sec 3.9: LPW: Bug. Parameter LPW_RADRANGE corrected by LPW_RAN_RAN Sec 3.10: SAI: Bug. Parameter SAI_RADRANGE corrected by SAI_RAN_RAN Sec. 3.11 : PGE09: Bug in descriptors definition 0 33 201 & 0 33 201
1.1	27 October 2004	47	DRI-2 review: - No changes
1.2d	28 March 2005	47	Section 3.12: Identification " Areas of rapid cyclogenesis" changed to "Areas of dry intrusions (possible rapid cyclogenesis)". Minor updates Section 3.14: Minor updates Section 3.6 : No likelihood for heavy precipitation assigned, light to moderate precipitation contains for the time being total precipitation likelihood. Section 3.13: Updated introduction of the RDT. New comments added.
1.2	12 April 2005	47	Updated document version and date to be in line with the provided SW (project management requirement). DRI-3 Review - Section 3.6: PC information has been corrected after discrepancies identified with the scientific SUM
2.0d	31 July 2006	60	Sec 3.7: Included relation between classes an rainfall rate for CRR product Sec 3.11: Updated BUFR description of the HRW product Sec 3.12: Minor updates in ASII product Sec 3.13: Description of the two versions for RDT BUFR files Sec 3.14: Updated the air mass classes of the AMA product
2.0rev	29 September 2006	63	INM revised version: Updated applicable document table Sec 3.11: Updated BUFR description of the HRW product Version submitted to ORR-2 RB for revision *Note: Change bars apply to v1.2*
2.0	19 January 2007	31	Document updated after ORR-2 / OR-2006. Minor updates after final revision

Version	Date	Pages	CHANGE(S)
			Note: Change bars apply to v1.2
Document code SAF/NWC/CDOP/INM/SW/ICD/3			
2.1draft	07 November 2007	68	Document title has been changed according EUMETSAT guidelines provided for CDOP. Section 3.1: Updated Table 4 SAFNWC/MSG Output Products Names Section 3.7: CRR Output product format has been changed Section 3.8: TPW Output product format has been changed Section 3.9: LPW Output product format has been changed Section 3.12: ASII Output product format has been changed Section 3.14: AMA Output product format has been changed Document submitted to the DRI-2008 Review Board
2.1rev	03 December 2007	61	Document updated after DRI-2008. Document title from v2.0 has been recovered to avoid user misunderstandings (see related action 7 of DRI-2008) Minor changes after final revision *Note: Change bars apply to v2.0*
2.1	09 January 2008	59	Final release for SAFNWC/MSG v2008 *Note: Change bars apply to v2.0*
3.0d	01 December 2008	60	Section 3.3 : Updated Cma_TEST description information. Section 3.7 : Updated CRR description information. Section 3.12: Updated ASII BUFR edition number. Section 3.13: Updated RDT descriptor information Section 3.14: Updated AMA description information Figure 7: Included new bands and new palette. Updated Table 7: CRR Parameters - Added CRR_ACCUM and CRR_INTENSITY parameters - Updated CRR_DATAFLAG parameter Updated Table 12: HRW BUFR product description Updated Table 13: Code table definition for HRW descriptors Document submitted to the DRI-2009 Review Board
3.0	16 February 2009	59	Document updated after DRI-2009. Minor changes after final revision
3.1	02 July 2009	68	Updated for PGE13 v0.1 patch delivery to beta testers - Table 3: Included PGE13 information - Figure 9: Updated image including all PGE07 palettes - Section 3.15: New section describing the SPhR product format

Version	Date	Pages	CHANGE(S)
			production number Sec 3.13.4 (former 3.13.3): Updated Sec 3.12: Updates in ASII product Sec 3.14: Updates in AMA product Table 12 and 13: Updated with new descriptors information
5.0	1 April 2011	74	Final release for SAFNWC/MSG v2011
6.0d	15 December 2011	90	Delivered to DRI-2012 RB for review: Updated to SAFNWC/MSG v2012 Removal of PGE06, PGE07 and PGE08 from SAFNWC/MSGv2012 Sec 3.8: Text of PGE09 descriptor 033207 has been modified Sec 3.12: Changes in SPhR diff bands calibrations Sec 3.11: Updates in AMA_QUALITY parameter Sec 3.10: Complete review in order to add information about BUFR version 3, used by PGE11.
6.0	15 February 2012	68	Final version after DRI-2012 Change bars refer to previous applicable version 5.0
Document code SAF/NWC/CDOP2/INM/SW/ICD/3			
7.0d	May 2013	77	Updated to SAFNWC/MSG v2013: Sec 3.7:PGE05/CRR product output updated in v2013: New PALETTE-3 for intensity that leads to a visualization identical to CRR classes' one. Changes in the conversion between intensity and classes. Modifications in CRR_ACCUM palette. Sec 3.8: PGE09/HRW product output updated in v2013, including: New HRW trajectories BUFR output . New EUMETSAT BUFR template AMV output format. Sec 3.10: PGE11/RDT product output updated in v2013 New section 3.12 has been added for new PGE14 (PPh) PGE12 (AMA) has been removed
7.0	15 July 2013	77	Final version after DRR-2013 Change bars refer to previous applicable version 6.0

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1. INTRODUCTION

1.1 PURPOSE

This document defines the format of the products generated by the SAFNWC MSG-based application, referred to as SAFNWF/MSG from now on. The major purpose of the SAFNWC is the timely generation of near real time products suitable for Nowcasting and Very Short Range Forecasting based on MSG SEVIRI data.

This document provides a full description of the header structures used to store the output products. In addition, all the specific parameters stored in each product are also described.

1.2 SCOPE

The purpose of this document is to define the format of the SAFNWC/MSG output products.

After having discussed the topic during several meetings, the decision of using the HDF5 format has been taken. This format has been identified as the most suitable one for the SAFNWC/MSG products.

HDF5 is a file format and library for storing scientific data. It was designed and implemented to meet growing and ever-changing scientific data-storage and data-handling needs, to take advantage of the power and features of today's computing systems.

The description of the following sections apply exclusively to the SAFNWC image-like products, i.e. do not apply to the products generated in BUFR format (see Table 3: SEVIRI based SAFNWC/MSG products). BUFR (*Binary Universal Form for the Representation of meteorological data*) is a World Meteorological Organization (WMO) standard binary code for the exchange and storage of data and it is used by a subset of the products. BUFR format description can be checked at the WMO official page http://www.wmo.int

1.3 DEFINITIONS AND ACRONYMS

See [RD.1.] for a complete list of acronyms for the SAFNWC project.

1.4 REFERENCES

See Help Desk web tool (http://www.nwcsaf.org) for last versions and dates of each document

1.4.1 Applicable Documents

For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the current edition of the document referred to applies.

Current documentation can be found at SAFNWC Help Desk web: http://www.nwcsaf.org

Reference	Title	Code	Vers	Date
[AD.1.]	NWCSAF Product Requirements Document	SAF/NWC/CDOP/INM/MGT/PRD	1.2	17/11/11
[AD.2.]	Software Requirements Document for the SAF NWC	SAF/NWC/CDOP/INM/SW/SRD/1	1.0	16/02/09
[AD.3.]	Architectural Design Document for the SAFNWC/MSG	SAF/NWC/CDOP2/INM/SW/AD/1	7.0	15/07/13
[AD.4.]	Interface Control Document for the External and Internal Interfaces of the SAFNWC/MSG	SAF/NWC/CDOP2/INM/SW/ICD/1	7.0	15/07/13
[AD.5.]	Interface Control Document for the NWCLIB of the SAFNWC/MSG	SAF/NWC/CDOP2/INM/SW/ICD/2	7.0	15/07/13

Table 1: List of Applicable Documents

1.4.2 Reference Documents

The reference documents contain useful information related to the subject of the project. These reference documents complement the applicable ones, and can be looked up to enhance the information included in this document if it is desired.

For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the current edition of the document referred to applies

Current documentation can be found at SAFNWC Help Desk web: http://www.nwcsaf.org

Reference	Title	Code	Vers	Date
[RD.1.]	The Nowcasting SAF Glossary	SAF/NWC/CDOP/INM/MGT/GLO		
[RD.2.]	Co-ordination group of Meteorological Satellites, LRIT/HRIT Global Specification	CGMS/03	2.6	12/08/99
[RD.3.]	Software User Manual for the SAFNWC/MSG Application: Software Part	SAF/NWC/CDOP2/INM/SW/SUM/2	7.0	15/07/13
[RD.4.]	Software User Manual for the PGE11 of the SAF NWC/MSG: Scientific Part	SAF/NWC/CDOP2/MFT/SCI/PUM/11	2.4	15/07/13

Table 2: List of Reference Documents

1.5 DOCUMENT OVERVIEW

This document contains the definition of the SAFNWC/MSG output products format.

2. GLOBAL SYSTEM OVERVIEW

The diagram in Figure 1 has been depicted using information available in the SAFNWC/MSG SRD [AD.2.] and ADD [AD.3.]. It shows all the interfaces of the SAFNWC/MSG application, where the external interfaces are identified with a label beginning with "e", and the internal interfaces with a label beginning with "i".

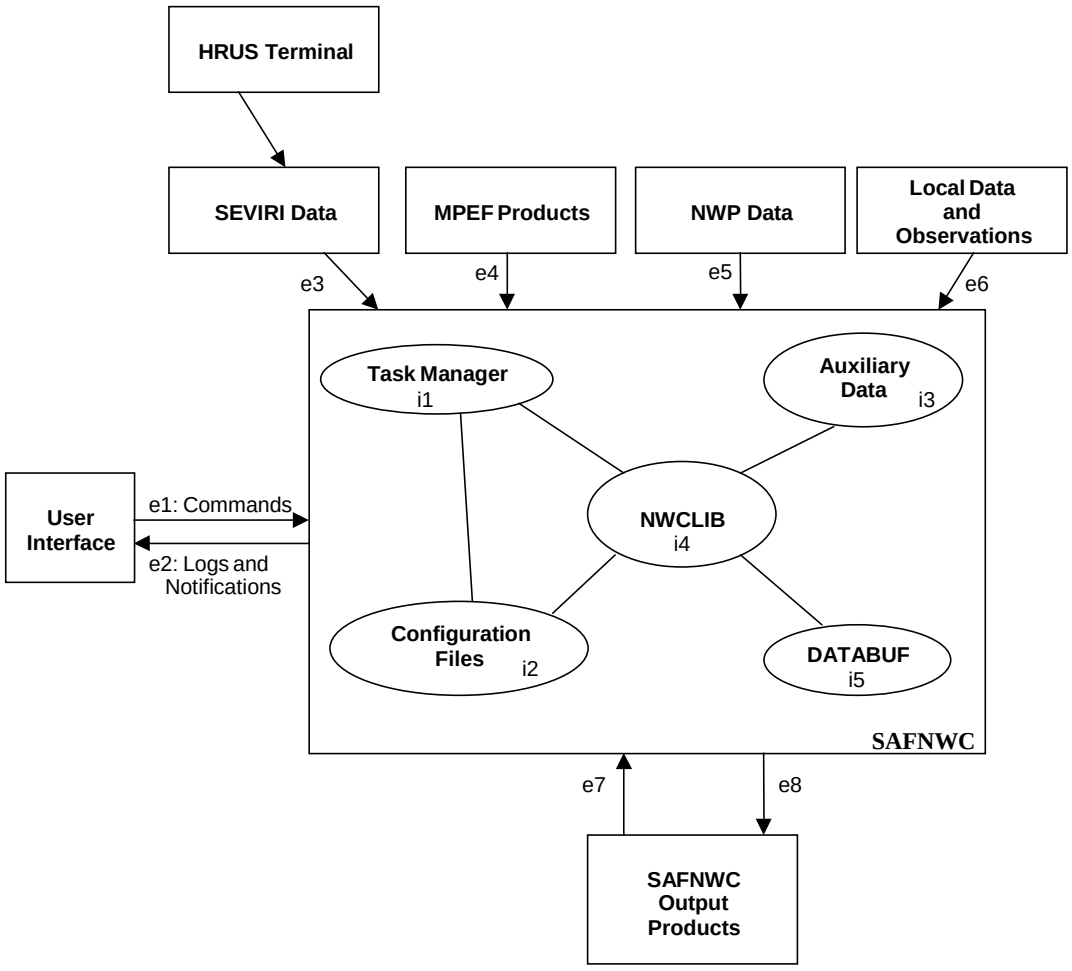


Figure 1: SAFNWC/MSG Interfaces

The SAFNWC/MSG output products format is defined in this document, whereas all other interfaces represented in Figure 1 are described in [AD.4.], except i4 (NWCLIB) which can be found in [AD.5.].

3. SAFNWC/MSG PRODUCTS FORMAT DEFINITION

The SAFNWC/MSG will generate any of the following products based on SEVIRI input data.

Component	Acronym	Product Name	Product Format
PGE01	CMa	Cloud Mask and Cloud Amount	HDF5
PGE02	CT	Cloud Type	HDF5
PGE03	CTTH	Cloud Top Temperature/Height	HDF5
PGE04	PC	Precipitating Clouds	HDF5
PGE05	CRR	Convective Rainfall Rate	HDF5
PGE09	HRW	High Resolution Wind Vectors	BUFR
PGE10	ASII	Automatic Satellite Image Interpretation	BUFR
PGE11	RDT	Rapid Developing Thunderstorms	BUFR
PGE13	SPhR	SEVIRI Physical Retrieval	HDF5
PGE14	PPh	Precipitation Products from Physical Properties	HDF5

Table 3: SEVIRI based SAFNWC/MSG products

3.1 SAFNWC/MSG PRODUCT NAMES

The product's names for the SAFNWC/MSG output products in HDF5 format, will follow a strict naming convention as described in Table 4

Field Name	Description	Data Type	Value
Product_id (1)	Identifier for SAFNWC	6 char.	"SAFNWC"
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (2)	Spacecraft identifier	4 char.	"MSG*i*" (where i is an integer)
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (3)	product name	4 char.	PGE specific, any of: "CMa_", "CT__", "CTTH", "PC__", "CRR_", "HRW_", "ASII", "RDT_", "SPhR". "PCPh", "CRPh"
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (4)	Acquisition date of the SEVIRI image (UTC)	12 char.	"YYYYMMDDhhmm" (YYYY : Year, MM : Month, DD : day, hh: hour, mm: minute)
Field Separator	separator	1 char.	"_" (underscore)
Product_id(5)	Processed region name	12 char.	Name of the region which has been processed (e.g. FRANCE1)
Field Separator	Separator for extension	1 char.	"."
Extension	Extension of the product name to indicate the type of data	3 char.	For HDF5 format: h5

Table 4: SAFNWC/MSG Output Products Names

For clarification purposes, and example of a possible SAFNWC/MSG product name is given here:

```
SAFNWC_MSG1_CT___200708141430_SPAIN3______.h5
```

3.2 STRUCTURE OF SAFNWC/MSG PRODUCTS FORMAT

As presented in the scope of the document (1.2) the following sections apply exclusively to the SAFNWC image products (BUFR product format is not described wthin this document). A SAFNWC image-like product is composed by a set of parameters stored in one file in HDF5 format. This file has the following structure:

- General attributes, containing general information of the product, information about the satellite status and/or image/product processing known at the start of a particular repeat cycle and information related to the SAFNWC product as scaling factors or quality indicators.
- A dataset for each colour palette applied to a parameter or parameters of the product

- A dataset for each parameter of the product

Figure 2: SAFNWC/MSG product format example

General attributes are the same in all SAFNWC product files. These attributes and their values are shown in the table below:

Attribute Name	Description	Value
SAF	SAF package	NWC
PACKAGE	SW Package	SAFNWC/MSG
PRODUCT_NAME	Defines the name of the product	One of: CMa_, CT__, CTTH, PC__, CRR_, SPhR_
NC	Number of columns	Depends on the processed region size
NL	Number of lines	Depends on the processed region size
XGEO_UP_LEFT	Up left X coordinate in georeferenced grid (in meters)	Depends on the used region
YGEO_UP_LEFT	Up left Y coordinate in georeferenced grid (in meters)	Depends on the used region
XGEO_LOW_RIGHT	Low right X coordinate in georeferenced grid (in meters)	Depends on the used region
YGEO_LOW_RIGHT	Low right Y coordinate in georeferenced grid (in meters)	Depends on the used region
TIME_STAMP_UP_LINE	Time stamps for the upper line of the processing region	YYYYMMDDhhmmss
TIME_STAMP_LOW_LINE	Time stamps for the lower line of the processing region	YYYYMMDDhhmmss
PROJECTION	String defining the relation between the projection coordinates (in meters) and the geographical coordinates. To be used as geostationary projection description for the PROJ.4 Cartographic Projections library (supported by OGC WKT).	+proj=geos +a=6378169.0 +b=6356583.8 +lon_0=0.0 +h=35785831.0
GEOTRANSFORM_GDAL_TABLE	GeoTransform table (GT) for affine transform: relationship between raster positions (in pixel/line coordinates) and georeferenced coordinates	-5570248.832537, 3000.403357, 0.000000, 5570248.832537, 0.000000, -3000.403357
PROJECTION_NAME	Projection name	"GEOS<sub_lon>" (as for the SEVIRI 1.5 image it is derived from)
REGION_NAME	Processed region name	Depends on the precessed region
CFAC	Column scaling factor This value can be used for image navigation applying the functions described in [RD.2.]	Derived from the MSG input images
LFAC	Line scaling factor This value can be used for image navigation applying the functions described in [RD.2.]	Derived from the MSG input images

COFF	Column offset This value can be used for image navigation applying the functions described in [RD.2.]	Depends on the processed region. Define the column offset to pixel λ=ϕ=0
LOFF	Line offset This value can be used for image navigation applying the functions described in [RD.2.]	Depends on the processed region. Define the line offset to pixel λ=ϕ=0
NB_PARAMETERS	Number of parameters	Depends on the SAFNWC product
GP_SC_ID	MSG spacecraft types	For MSG1=321, for MSG2=322, for MSG3=323
IMAGE_ACQUISITION_TIME	Image acquisition time	Start acquisition time for the SEVIRI15 processed image Format: YYYYMMDDhhmm
SPECTRAL_CHANNEL_ID	Identification of spectral channels used	Depends on SAFNWC/MSG product. 1 bit per channel, where LSB bit is HRV, MSB is IR13.4; values are 0 if not used, 1 if used
NOMINAL_PRODUCT_TIME	Nominal time of the SAFNWC product	YYYYMMDDhhmm
SGS_PRODUCT_QUALITY	Overall reliability of the product, if given by PGE	0 .. 100 as computed by corresponding PGE
SGS_PRODUCT_COMPLETENESS	Coverage area of the product relative to the nominal coverage, if given by PGE	0 .. 100 as computed by corresponding PGE
PRODUCT_ALGORITHM_VERSION	Version of the algorithm used to produce the present product	2013

Table 5:SAFNWC product file general attributes

Output products in HDF5 format, contains several datasets, each containing different parameters of the product. These datasets contains a set of attributes including relevant information. A common set of attributes is fixed for all datasets of all products. Names and values are shown in the next table

Attribute Name	Description	Value
CLASS	Dataset type	IMAGE
IMAGE_VERSION	Image version	1.0
IMAGE_SUBCLASS	Image subclass	IMAGE_INDEXED
IMAGE_COLORMODEL	Color model for the parameter image	RGB
N_LINES	Number of columns	Depends on the processed region size
N_COLS	Number of lines	Depends on the processed region size
PRODUCT	Defines the name of the product	One of: CMa_, CT__, CTTH, PC__, CRR_, SPhR, PCPh, CRPh
ID	Defines the name of the parameter	Depends on the parameter
SCALING_FACTOR	Scaling factor for the parameter	Depends on the parameter
OFFSET	Offset of the scaling factor	Depends on the parameter
PALETTE	Reference to palette applied to the parameter image (only if a palette is applied)	Depends on the palette dataset identification

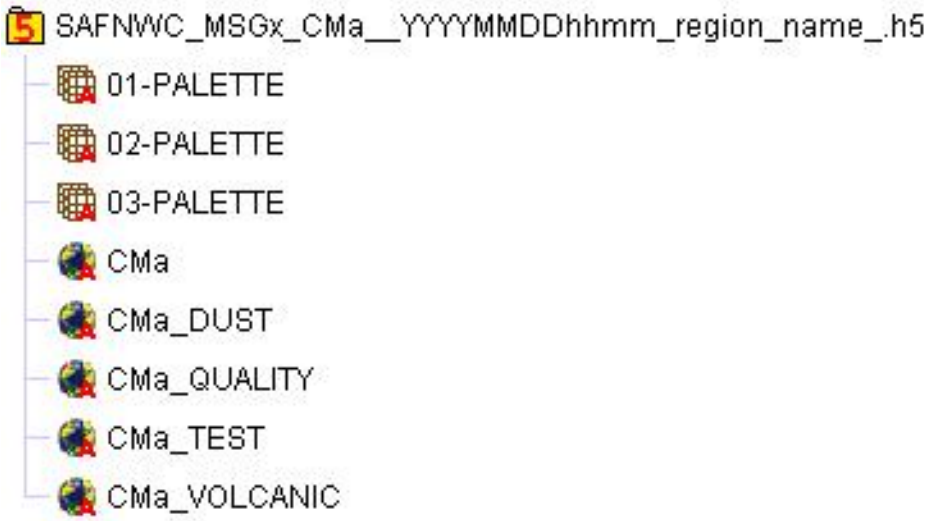
Table 6: Product parameters attributes

3.3 CLOUD MASK (CMA) PRODUCT

This product provides information on the possible occurrence of clouds within each pixel to delineate all absolutely cloud-free pixels in a satellite scene with a high degree of confidence. In addition, the product provides information on the presence of aerosols and snow/ice, and helps to distinguish between thick and semitransparent clouds.

The product resolution will be the one of the original SEVIRI image.

The CMa product files structure is shown below:



01-PALETTE is applied to CMa parameter (see [AD.4.])
02-PALETTE is applied to CMa_DUST parameter (see [AD.4.])
03-PALETTE is applied to CMa_VOLCANIC parameter (see [AD.4.])

Figure 3: CMa product file structure

Five different parameters had been identified:

- **Cloud mask (CMa)**. Possible values are:

  0 Non-processed containing no data or corrupted data

  1 Cloud-free no contamination by snow/ice covered surface, no contamination by clouds ; but contamination by thin aerosol (dust clouds or volcanic plume) remains possible

  2 Cloud contaminated partly cloudy or semi-transparent. May include also dust clouds or volcanic plumes.

  3 Cloud filled opaque clouds completely filling the FOV. May include also thick dust clouds or volcanic plumes.

  4 Snow/Ice contaminated

  5 Undefined has been processed but not classified due to known separability problems

- **Cloud mask tests (CMa_TEST)**. Bit mask, 16 bits. 1 bit per test, activated (i.e. set to 1) if the test was succesful.

  0 T10.8µm or SST

  1 R0.6µm (land) or R0.8µm (sea)

  2 sunglint test using 3.8µm

  3 Spatial coherence test

  4 T10.8µm - T12.0µm

  5 T10.8µm - T3.8µm or T12.0µm - T3.8µm

  6 T3.8µm - T10.8µm

7 spatial smoothing (reclassify isolated cloud-free pixels)

8 T8.7µm - T3.8

9 R1.6µm (sea)

10 T8.7µm - T10.8µm or T10.8µm - T8.7µm

11 snow using 1.6µm or 3.9µm

12 HRV based test

13 stationary cloud in twilight

14 spatial expansion of stationary cloud in twilight

15 temporal-differencing

- **Quality (CMa_QUALITY)**. Composed by 6 sub-parameters:

10	9	8	7	6	5	4	3	2	1	0
HRV_flag	Temporal_flag	Quality		SEVIRI_input_data		NWP_input_data		Illumination		

Ilumination: 3 bits to define illumination and viewing conditions. Possible values are:

0 Undefined (space)

1 Night

2 Twilight

3 Day

4 Sunglint

NWP_input_data: 2 bits to describe NWP input data. Possible values are:

0 Undefined (space)

1 All NWP parameters available (no low level inversion)

2 All NWP parameters available (low level inversion)

3 At least one NWP parameter missing

SEVIRI_input_data: 2 bits to describe SEVIRI input data. Possible values are:

0 Undefined (space)

1 All useful SEVIRI channels available

2 At least one useful SEVIRI channel missing

3 At least one mandatory SEVIRI channel missing

Quality: 2 bits to describe the quality of the processing itself. Possible values are:

0 Non processed (containing no data or corrupted data)

1 Good quality (high confidence)

2 Poor quality (low confidence)

3 Reclassified after spatial smoothing (very low confidence)

Temporal_flag: 1 bit for temporal processing indicator (significant for cloud-free pixels)
0 Not performed
1 Performed

HRV_flag: 1 bit for HRV processing indicator (significant for cloud-free pixels)
0 Not performed
1 Performed

CMa_QUALITY values are calculated as follows:

CMa_QUALITY=Illumination + NWP_input_data*8 + SEVIRI_input_data*32 + Quality*128 + TEMPORAL_flag*512 + HRV_flag*1024

- **Dust detection (CMa_DUST)**. Possible values are:
  - 0 Non processed (containing no data or corrupted data)
  - 1 dust
  - 2 non dust
  - 3 undefined (due to known separability problems)

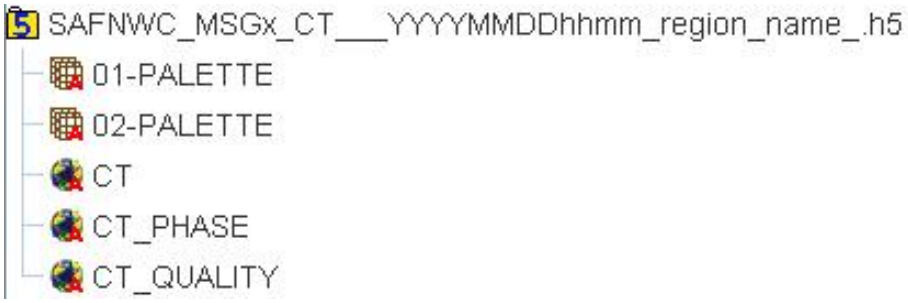
- **Volcanic plume detection (CMa_VOLCANIC)**. Possible values are:
  - 0 Non processed (containing no data or corrupted data)
  - 1 volcanic plume
  - 2 non volcanic plume
  - 3 undefined (due to known separability problems)

CMa product is coded in HDF5 format

3.4 CLOUD TYPE (CT) PRODUCT

This product contains information on the major cloud classes for all pixels identified as cloudy on a high spatial and temporal resolution (SEVIRI resolution).

The CT product files structure is shown below:



01-PALETTE is applied to CT parameter (see [AD.4.])
02-PALETTE is applied to CT_PHASE parameter (see [AD.4.])

Figure 4: CT product file structure

Three different parameters had been identified:

- **Cloud type (CT)**. Twenty-one different categories will be considered:

  0 non-processed containing no data or corrupted data

  1 cloud free land no contamination by snow/ice covered surface, no contamination by clouds ; contamination by thin aerosol (dust clouds or volcanic plume) possible

  2 cloud free sea no contamination by snow/ice covered surface, no contamination by clouds ; contamination by thin aerosol (dust clouds or volcanic plume) possible

  3 land contaminated by snow

  4 sea contaminated by snow/ice

  5 very low and cumuliform clouds

  6 very low and stratiform clouds

  7 low and cumuliform clouds

  8 low and stratiform clouds

  9 medium and cumuliform clouds

  10 medium and stratiform clouds

  11 high opaque and cumuliform clouds

  12 high opaque and stratiform clouds

  13 very high opaque and cumuliform clouds

  14 very high opaque and stratiform clouds

  15 high semi-transparent thin clouds

  16 high semi-transparent meanly thick clouds

  17 high semi-transparent thick clouds

  18 high semi-transparent above low or medium clouds

  19 fractional clouds

  20 undefined (undefined by CMa)

- **Quality (CT_QUALITY)**. Compound by 5 sub-parameters:

9	8	7	6	5	4	3	2	1	0
Separation	Quality		SEVIRI_input_data		NWP_input_data		Illumination		

Ilumination: 3 bits to define illumination and viewing conditions. Possible values are:

0 Undefined (space)

1 Night

2 Twilight

3 Day

4 Sunglint

NWP_input_data: 2 bits to describe NWP input data. Possible values are:

0 Undefined (space)

1 All NWP parameters available (no low level inversion)

2 All NWP parameters available (low level inversion)

3 At least one NWP parameter missing

SEVIRI_input_data: 2 bits to describe SEVIRI input data. Possible values are:

0 Undefined (space)

1 All useful SEVIRI channels available

2 At least one useful SEVIRI channel missing

3 At least one mandatory SEVIRI channel missing

Quality: 2 bits to describe the quality of the processing itself. Possible values are:

0 Non processed (containing no data or corrupted data)

1 Good quality (high confidence)

2 Poor quality (low confidence)

3 Reclassified after spatial smoothing (very low confidence)

Separation: 1 bit set to 1 to indicate that the separation between cumuliform and stratiform clouds has been performed.

CT_QUALITY values are calculated as follows:

CT_QUALITY = Illumination+NWP_input_data*8 + SEVIRI_input_data*32 + Quality*128 + Separation * 512

- **Cloud phase (CT_PHASE)**. Possible values are:

0 Non processed (containing no data or corrupted data)

1 water cloud

2 ice cloud

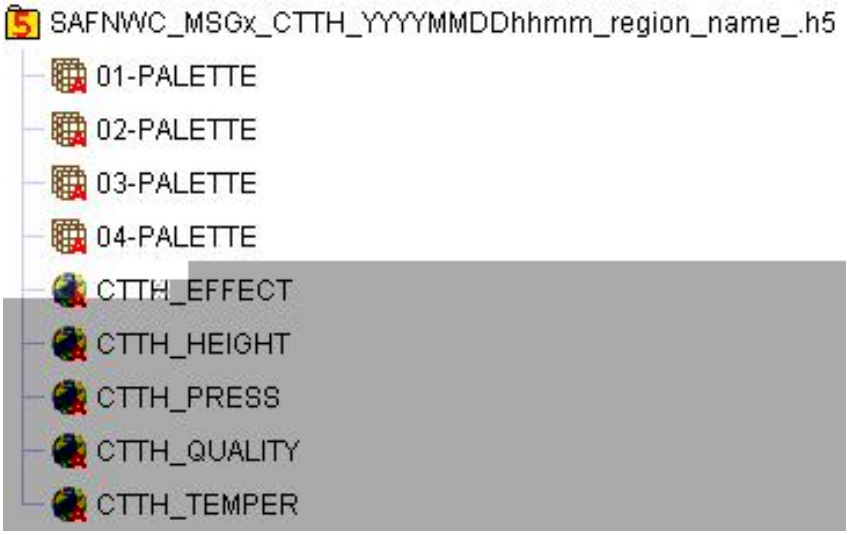
3 undefined (due to known separability problems)

The product is coded in HDF5 format.

3.5 CLOUD TOP TEMPERATURE/HEIGHT (CTTH) PRODUCT

This product contains information on the cloud top temperature and height for all pixels identified as cloudy in the scene on a high spatial and temporal resolution (SEVIRI resolution).

The CTTH product files structure is shown below:



01-PALETTE is applied to CTTH_PRESS parameter (see [AD.4.])
02-PALETTE is applied to CTTH_HEIGHT parameter (see [AD.4.])
03-PALETTE is applied to CTTH_TEMPER parameter (see [AD.4.]))
04-PALETTE is applied to CTTH_EFFEC parameter (see [AD.4.])

Figure 5: CTTH product file structure

Five different parameters had been identified:

- **Cloud top pressure (CTTH_PRESSURE)**.

  Cloud pressure : from 0 hPa up to 1050 hPa ; step : 25 hPa

  Linear conversion from count to pressure :

  Cloud Pressure = gain * $Count_{6bits}$ + intercept

  where: intercept = -250 hPa

  gain = 25 hPa/count

  Special count = 0 used when no cloud pressure is available

- **Cloud top height (CTTH_HEIGHT)**.

  Cloud height : from -400 m up to 20000 m ; step : 200 m

  Linear conversion from count to height :

  Cloud Height = gain * $Count_{7bits}$ + intercept

where: intercept = -2000 m

gain = 200 m/count

Special count = 0 used when no cloud height is available

- **Cloud top temperature (CTTH_TEMPERATURE)**.

  Cloud temperature : from 180K up to 320K ; step : 1K

  Linear conversion from count to temperature :

  Cloud Temperature = gain * $Count_{8bits}$ + intercept

  where: intercept = 150K

  gain= 1K/count

  Special count = 0 used when no cloud temperature is available

- **Effective cloudiness (CTTH_EFFECTIVE)**.

  Effective cloudiness : from 0% up to 100% ; step : 5%

  Linear conversion from count to cloudiness :

  Cloudiness= gain * $Count_{5bits}$ + intercept

  where: intercept = -50%

  gain = 5%/count

  Special count = 0 used when no cloudiness is available

- **Quality (CTTH_QUALITY)**. It is composed by 6 sub-parameters

13	12	11	10	9	8	7	6	5	4	3	2	1	0

2 All NWP parameters available, thermal inversion present

3 Some NWP pressure level missing, no thermal inversion

4 Some NWP pressure level missing, thermal inversion present

5 At least one mandatory NWP information is missing

SEVIRI_input_data: 2 bits to describe SEVIRI input data. Possible values are:

0 undefined (space)

1 All SEVIRI useful channels available

2 At least one SEVIRI useful channel missing

3 At least one SEVIRI mandatory channel is missing

Method_used: 4 bits to describe which method has been used. Possible values are:

0 Non-processed

1 Opaque cloud, using rttov

2 Opaque clouds, not using rttov

3 Intercept method 10.8µm/13.4µm :

4 Intercept method 10.8µm/6.2µm :

5 Intercept method 10.8µm/7.3µm :

6 Radiance Ratioing method 10.8µm/13.4µm

7 Radiance Ratioing method 10.8µm/6.2µm

8 Radiance Ratioing method 10.8µm/7.3µm

9 Spare

10 Spare

11 Spare

12 Spare

13 Opaque cloud, using RTTOV, in case thermal inversion

14 Spatial smoothing (gap filling in semi-transparent cloud field)

15 Spare for not yet defined methods

Quality: 2 bits to describe quality of the processing itself:

0 No result (Non-processed, cloud free, no reliable method)

1 Good quality (high confidence)

2 Poor quality (low confidence)

CTTH_QUALITY values are calculated as follows:

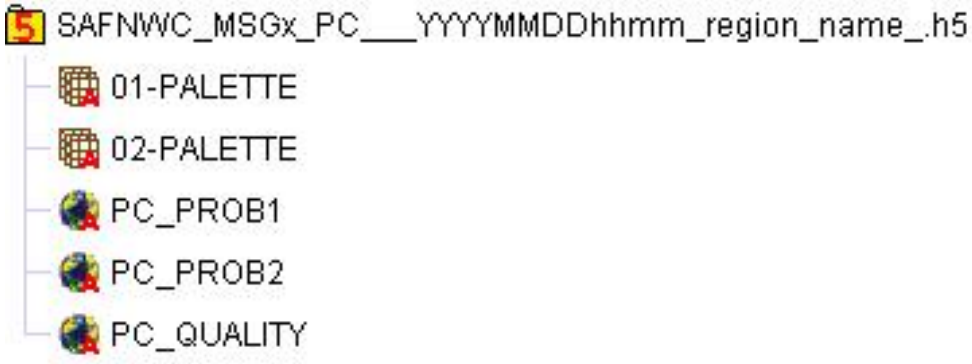
CTTH_QUALITY= Processing_status + Rttov_sim*4 + NWP_input_data*8 +
SEVIRI_input_data*64 + Method_used*256 + Quality*4096

The product is coded in HDF5 format.

3.6 PRECIPITATING CLOUDS (PC) PRODUCT

This product contains information on the presence of precipitation for each SEVIRI pixel. Up to version 1.1 the parameter coded in this product represented a numerical value for the precipitation probability for the pixels identified as cloudy (CT product) within three precipitation intensity classes: no precipitation (less than 0.1mm/h), light to moderate precipitation (0.1mm/h to 5.0mm/h, named PC_PROB1) and heavy precipitation (>5.0mm/h, named PC_PROB2). Tuning for version 1.2 showed that it was not possible to distinguish the heavy precipitation class from light to moderate precipitation. Thus in version 1.2 PC_PROB1 is used for total Precipitation likelihood

The PC product files structure is shown below:



01-PALETTE is applied to PC_PROB1 parameter (see [AD.4.])
02-PALETTE is applied to PC_PROB2 parameter (see [AD.4.])

Figure 6: PC product file structure

Three different parameters are given:

- **Total precipitation likelihood (PC_PROB1)**.

  Value range from 0% to 100%, step : 10%

  Linear conversion from count to probability:

  $P1 = gain * Count_{4bits} + intercept$,

  where intercept = 0%

  gain = 10%

  Special count = 15 used when no P1 available

- **PC_PROB2 : still available, but not used**

  Set to 0.

  Special count = 15 used when no P1 available

- **Quality (PC_QUALITY)**. Bit mask, 8bits.

Bit #	Meaning of the bit – 1/0
0	Processed/non-processed
1	MSG channels missing/not missing
2	CT used/not used
3	MSG solar channels used/not used
4	MSG land/no land
5	High terrain/no high terrain
6	NWP data missing/not missing
7	MSG cloud mask low quality/no low quality

The PC product is coded in HDF5 format

3.7 CONVECTIVE RAINFALL RATE (CRR) PRODUCT

This product provides information about instantaneous as well as hourly acummulated convective rain from the SEVIRI channels, being useful for locating heavy precipitation cores.

The product is computed for all pixels in the selected region and the resolution of the output product will be the one of the original SEVIRI image.

CRR values can be optionally adjusted using lightning data as additional input.

The CRR product files structure is shown below:

01-PALETTE is applied to CRR parameter (see [AD.4.])
02-PALETTE is applied to CRR_ACCUM parameter (see [AD.4.])

Figure 7: CRR product file format

Each pixel in the SAF output file will contain five parameters with the following information:

<table>
<tr><th>Parameter</th><th>Comment</th></tr>
<tr><td>CRR</td><td>Convective Rainfall Rate class
<table>
<tr><th>Class</th><th>Rainfall rate (mm/h)</th></tr>
<tr><td>0</td><td>rate < 0.2</td></tr>
<tr><td>1</td><td>1.0 > rate >= 0.2</td></tr>
<tr><td>2</td><td>2.0 > rate >= 1.0</td></tr>
<tr><td>3</td><td>3.0 > rate >=2.0</td></tr>
<tr><td>4</td><td>5.0 > rate >= 3.0</td></tr>
<tr><td>5</td><td>7.0 > rate >= 5.0</td></tr>
<tr><td>6</td><td>10.0 > rate >= 7.0</td></tr>
<tr><td>7</td><td>15.0 > rate >= 10.0</td></tr>
<tr><td>8</td><td>20.0 > rate >= 15.0</td></tr>
<tr><td>9</td><td>30.0 > rate >= 20.0</td></tr>
<tr><td>10</td><td>50.0 > rate >= 30.0</td></tr>
<tr><td>11</td><td>rate >= 50.0</td></tr>
</table></td></tr>
<tr><td>CRR_ACCUM</td><td>Convective Rainfall Rate Accumulation in mm
CRR_ACCUM(mm) = Scale * Counts + Offset
Where:
Scale = 0.2 Offset = 0</td></tr>
<tr><td>CRR_INTENSITY</td><td>Convective Rainfall Rate Intensity in mm/h
CRR_INTENSITY(mm/h) = Scale * Counts + Offset
Where:
Scale = 0.2 Offset = 0</td></tr>
<tr><td>CRR_QUALITY</td><td>8 bits mask indicating which corrections have been applied for each pixel. Moreover, it indicates whether the product is latitude dependant or not, and if the SEVIRI solar channel and the lightning information have been used during the computation of the CRR:
<table>
<tr><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td>Lightning used</td><td>Solar channel used</td><td>Latitude dependant (always 1)</td><td>Orographic</td><td>Parallax</td><td>Gradient</td><td>Evolution</td><td>Humidity</td></tr>
</table></td></tr>
<tr><td>CRR_DATAFLAG</td><td>8 bits mask indicating the processing status:
<table>
<tr><th>Bit 7</th><th colspan="2">Bit 6 Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th></tr>
<tr><td>Accumulation Status</td><td colspan="2">Missing Accumulation Band</td><td>Parallax Flag</td><td>Filter Flag</td><td>Mathematical Error</td><td>Fixed to 0</td><td>Missing Band</td></tr>
</table>
Where each bit is set to ‘1’ if:
Bits 7: One of the CRR pixels used for accumulation have at least one CRR_DATAFLAG bit set to 1 (filter flag is not taken into account)
Bits 5-6: Accumulation previous CRR bands status
0: All required bands were available
1: One previous CRR band is missing
2: At least two previous CRR bands are missing (no consecutive)
3: At least two previous CRR bands are missing (some are consecutive)
Bit 4 : Pixel that was a hole because of the parallax correction, and then was filled by the median filter.
Bit 3 : Pixel has been set to zero because of the filtering process
Bit 2 : A mathematical error was generated
Bit 1 : Fixed to 0
Bit 0 : Pixel with missing data in some required band</td></tr>
</table>

Table 7: CRR parameters

Product Header parameters SGSProductQuality and SGSProductCompleteness (%) has been calculated as follows:

SGSProductQuality = 100

*SGSProductCompleteness = (Number of pixels with no error / Total number of pixels) * 100*

CRR product is coded in HDF5 format

3.8 HIGH RESOLUTION WIND VECTORS (HRW) PRODUCT

This product provides information on Atmospheric motion vectors (AMVs), satellite winds calculated from up to seven MSG/SEVIRI channels: HRVIS, VIS06, VIS08, WV062, WV073, IR108 and IR120, including Clear air AMVs from WV062 and WV073 channels (using five of them as default option: HRVIS, VIS08, WV062, WV073 and IR120). In addition, it provides trajectories through the successive tracking of the same tracer in consecutive slots.

Each vector of the HRW product is defined by speed (in m/s), vector direction (in degrees), together with the position (in degrees latitude/longitude), the height assignment (in pressure hPa), quality information and information about the method used to extract the product.

The products are coded in BUFR format compliant with the requirements of the BUFR coding/decoding software being part of the BUFRDC library and described in: BUFR User's Guide, *Version August 2008.*

Two kinds of output BUFR templates are possible, depending on the value of BUFR_OUTPUT_FORMAT in the model configuration file: "NWC", for NWCSAF BUFR template format, and "EUM" for EUMETSAT BUFR template format.

Next sections describe the format of the outputs produced in these two cases:

3.8.1 NWCSAF BUFR template

When BUFR_OUTPUT_FORMAT is set to "NWC", output will consist on up to four BUFR bulletins containing:

1. A set of "basic winds".
2. A set of "detailed winds".
3. A set of "basic trajectories".
4. A set of "detailed trajectories".

3.8.1.1 Winds

A dataset composed of wind data from a "basic scale" (with a tracer resolution of 24x24 pixels as default value) is always generated, while an additional output product storing the winds computed from a "detailed scale" (with a resolution of half the size of the "basic scale"; 12x12 pixels in the default configuration) is generated only if it is specified in the model configuration file (keyword CDET = ALL or RANGE). This output BUFR bulletins are placed at $SAFNWC/export/PGE09 directory and are distinguished as follows:

"Basic scale winds" output product:

`SAFNWC_MSGx_HRW__YYYYMMDDhhmm_Region_____B.buf`

"Detailed scale winds" output product:

`SAFNWC_MSGx_HRW__YYYYMMDDhhmm_Region_____D.buf`

As it can be noted, both files follow the nomenclature for the PGEs from the MSG/SAFNWC, but in order to distinguish between them, the product for "basic winds" is labelled with an ending _B (basic) and the product for "detailed winds" is labelled with _D (detailed).

A maximum of 1000 winds are stored in each BUFR message. When this limit is reached, a new BUFR message (fixed section + replicated section) is stored into the output product. In addition, winds form different channels are stored in different BUFR messages.

The HRW product output format is composed by a set of BUFR messages following the next pattern (this information is in file /import/Aux_data/PGE09/B0000000000214012094.TXT):

Descriptor	Name	Units	Scale	Reference	Number of bits
001007	SATELLITE IDENTIFIER	CODE TABLE 001007	0	0	10
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 001031	0	0	16
001032	GENERATING APPLICATION	CODE TABLE 001032	0	0	8
002023	SATELLITE DERIVED WIND COMPUTATION METHOD	CODE TABLE 002023	0	0	4
002057	ORIGIN OF FIRST GUESS INFORMATION	CODE TABLE 002057	0	0	4
002152	SATELLITE INSTRUMENT USED IN DATA PROCESSING	FLAG TABLE 002152	0	0	31
002153	SATELLITE CHANNEL CENTRE FREQUENCY	Hz	-8	0	26
002154	SATELLITE CHANNEL BAND WIDTH	Hz	-8	0	26
004001	YEAR	YEAR	0	0	12
004002	MONTH	MONTH	0	0	4
004003	DAY	DAY	0	0	6
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004025	TIME PERIOD OR DISPLACEMENT	MINUTE	0	-2048	12
005044	SATELLITE CYCLE NUMBER	NUMERIC	0	0	11
033035	MANUAL/AUTOMATIC QUALITY CONTROL	CODE TABLE 033035	0	0	4
060000	SEGMENT SIZE AT NADIR IN X DIRECTION (PIXELS)	PIX	0	0	7
060001	SEGMENT SIZE AT NADIR IN Y DIRECTION (PIXELS)	PIX	0	0	7
117000	REPLICATION OPERATOR[4]	-	0	0	0
031002	EXTENDED DELAYED DESCRIPTOR REPLICATION FACTOR (WINDS)	NUMERIC	0	0	16
060100	WIND SEQUENCE NUMBER	NUMERIC	0	0	24
060101	PRIOR WIND SEQUENCE NUMBER	NUMERIC	0	0	24
002028	SEGMENT SIZE AT NADIR IN X DIRECTION	M	-1	0	18
002029	SEGMENT SIZE AT NADIR IN Y DIRECTION	M	-1	0	18
002164	TRACER CORRELATION METHOD	CODE TABLE 002164	0	0	3
005001	LATITUDE (HIGH ACCURACY)	DEGREE	5	-9000000	25
006001	LONGITUDE (HIGH ACCURACY)	DEGREE	5	-18000000	26
005011	LATITUDE INCREMENT (HIGH ACCURACY)	DEGREE	5	-9000000	25
006011	LONGITUDE INCREMENT (HIGH ACCURACY)	DEGREE	5	-18000000	26
007004	PRESSURE	PA	-1	0	14
011001	WIND DIRECTION	DEGREE_TRUE	0	0	9
011002	WIND SPEED	M/S	1	0	12
012001	TEMPERATURE	K	1	0	12
033007	PER CENT CONFIDENCE (WITH FORECAST TEST)	%	0	0	7
033007	PER CENT CONFIDENCE (WITHOUT FORECAST TEST)	%	0	0	7
060102	TRACER TYPE (CODE TABLE 060102)	CODE TABLE 060102	0	0	2
060103	HEIGHT ASSIGNMENT METHOD (CODE TABLE 060103)	CODE TABLE 060103	0	0	4
060200	NUMBER OF WINDS COMPUTED FOR THE TRACER	NUMERIC	0	0	3
060201	CORRELATION TEST (CODE TABLE 060201)	CODE TABLE 060201	0	0	3
060202	APPLIED QUALITY TESTS (CODE TABLE 060202)	CODE TABLE 060202	0	0	11
060203	NUMBER OF AVAILABLE NWP WIND GUESS LEVELS	NUMERIC	0	0	7
060204	NUMBER OF PREDECESSOR WINDS	NUMERIC	0	0	7
060205	OROGRAPHIC INDEX (CODE TABLE 060205)	CODE TABLE 060205	0	0	3

[4] *Replication descriptor 117000 describes the number of replication factors: 17*

Descriptor	Name	Units	Scale	Reference	Number of bits
060206	CLOUD TYPE (SAFNWC/MSG)(CODE TABLE 060206)	CODE TABLE	0	0	5
060207	WIND CHANNEL (SEVIRI CHANNEL ID) (CODE TABLE 060207)		0	0	4
060208	CORRELATION	%	0	0	7
060209	PRESSURE ERROR	PA	-1	0	14

White entries: Fixed factors
Grey entries: Replicated factors

Table 8: HRW BUFR product description

HRW uses global and local descriptors (bold descriptors in Table 8)

Definitions of the CODE TABLE descriptors used, are listed hereunder

Descriptor	Description
001007	Satellite identifier Possible values : 055: MSG-1 056: MSG-2 057: MSG-3 1023: Missing value
001031	Identification of the generating centre This value is specified by BUFR_CENTER_OR parameter in the model configuration file.
001032	BUFR edition number Only possible value: 4
002023	

Descriptor	Description
002152	Satellite instrument data used in the processing Bit No – (1_based) 1: High-resolution infrared sounder(HIRS) 2.: Microwate sounding unit (MSU) 3: Stratospheric sounding unit (SSU) 4: AMI wind mode 5 : AMI wave mode 6 : AMI image mode 7: RADAR altimeter 8: ATSR 9: Geostacionary Imager 10: Geostacionary Sounder 11: Geostacionary Earth radiation (GERB) 12-30: Reserved All 31: Missing value The satellite instrument of MSG is a geostacionary imager
002164	Tracer correlation method Possible values: 0: LP - Norms least square minimum (Euclidean distance) 2: CC - Cross correlation
033035	Manual/automatic quality control Possible values: 0: Automatic quality control passed and not manually checked 1: Automatic quality control passed and manually checked and passed 2: Automatic quality control passed and manually checked and deleted 3: Automatic quality control failed and manually not checked 4: Automatic quality control failed and manually checked and failed 5: Automatic quality control failed and checked and re-inserted 6-14: Reserved 15: Missing value Value for this PGE is 0
060102	Type of tracer Possible values: 0: ‘Basic tracer’ 1: ‘Detailed tracer related to a Narrow basic tracer’ 2: ‘Detailed tracer related to a Wide basic tracer’ 3: ‘Detailed tracer unrelated to a Basic tracer’.
060103	Height assignment method Values 0 to 3 are related to ‘Brightness temperature interpolation height assignment method’. Values 8 to 15 are related to ‘CCC height assignment method’. Although defined in this table, due to the actual implementation of HRW algorithm, values 2, 9, 11 are never used in reality. Possible values: 0: ‘NWP interpolation using Top pressure in a Clear air AMV’ 1: ‘NWP interpolation using Top pressure in a Cloudy AMV’ 2: ‘NWP interpolation using Base pressure in a Clear air AMV’ 3: ‘NWP interpolation using Base pressure in a Cloudy AMV’ 8: ‘CCC method using lower threshold and the cold branch in a Clear air AMV’ 9: ‘CCC method using lower threshold and the warm branch in a Clear air AMV’ 10: ‘CCC method using higher threshold and the cold branch in a Clear air AMV’ 11: ‘CCC method using higher threshold and the warm branch in a Clear air AMV’ 12: ‘CCC method using lower threshold and the cold/dark branch in a Cloudy AMV’ 13: ‘CCC method using lower threshold and the warm/bright branch in a Cloudy AMV’ 14: ‘CCC method using higher threshold and the cold/dark branch in a Cloudy AMV’ 15: ‘CCC method using higher threshold and the warm/bright branch in a Cloudy AMV’.

Descriptor	Description
060201	Correlation test. Possible values: 0: 'Wind not selected as the Best wind for a tracer not having the Best correlation value' 1: 'Wind not selected as the Best wind for a tracer having the Best correlation value' 2: 'Wind selected as the Best wind for a tracer not having the Best correlation value' 3: 'Wind selected as the Best wind for a tracer having the Best correlation value'.
060202	Applied Quality tests: For each one the next Quality flags (Orographic flag, Forecast quality flag, Spatial quality flag, Temporal quality flag, Interscale quality flag), next possible values: 0: 'Wind for which the corresponding quality test could not be calculated' 1: 'Wind whose corresponding quality test is more than a 21% worse than for the wind calculated for the same tracer with the best quality test (in the orographic test, the orographic flag value is at least two units lower than for the wind calculated for the same tracer with the best orographic flag)' 2: 'Wind whose corresponding quality test is up to a 21% worse than for the wind calculated for the same tracer with the best quality test (in the orographic test, the orographic flag value is one unit lower than for the wind calculated for the same tracer with the best orographic flag)' 3: 'Wind with the best corresponding quality test among the winds calculated for a tracer'.
060205	Orographic index Possible values : 0: Orographic index not calculated 1: Important static orographic influence detected 2: Less important static orographic influence detected 3: Important dynamic orographic influence detected 4: Less important dynamic orographic influence detected 5: No orographic influence detected but stability present in all previous positions of the tracer 6: No orographic influence detected, with stabilty not present in a previous position of the tracer
060206	Cloud type associated to the tracer Possible values: Cloud type (CT) output values in section 3.4. If "Brightness temperature interpolation height assignment method" has been used, three additional values are possible: 21: Multiple cloud types. 22: Multiple clear air types. 23: Mixed cloudy/clear/air types.
060207	Flag indicating which SEVIRI channel was used for the wind calculation Possible values: 0: HRVIS 1: VIS06 2: VIS08 5: WV063 6: WV073 9: IR108 10: IR120

Table 9: Code table definition for HRW descriptors

3.8.1.2 Trajectories

As for the winds case, a dataset composed of trajectories related to a "basic scale" (with a tracer resolution of 24x24 pixels as default value) is always generated, while an additional output product storing the trajectories computed from the "detailed scale" (with a tracer resolution half the size of the "basic scale", and 12x12 pixels as default value) is generated only if it is specified in the model configuration file (keyword CDET = ALL or RANGE). This output BUFR bulletins are placed at $SAFNWC/export/PGE09 directory and are distinguished as follows:

"Basic trajectories" output product:

`SAFNWC_MSGx_HRW__YYYYMMDDhhmm_Region_____BTRAJ.buf`

"Detailed trajectories" output product:

`SAFNWC_MSGx_HRW__YYYYMMDDhhmm_Region_____DTRAJ.buf`

In this case, each trajectory is contained in one BUFR message. Therefore, HRW trajectories product output format is composed by a set of BUFR messages following the next pattern (this information is in file /import/Aux_data/PGE09/B0000000000214012097.TXT):

Descriptor	Name	Units	Scale	Reference	Number of bits
001007	SATELLITE IDENTIFIER	CODE TABLE 001007	0	0	10
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 001031	0	0	16
001032	GENERATING APPLICATION	CODE TABLE 001032	0	0	8
002023	SATELLITE DERIVED WIND COMPUTATION METHOD	CODE TABLE 002023	0	0	4
002057	ORIGIN OF FIRST GUESS INFORMATION	CODE TABLE 002057	0	0	4
002152	SATELLITE INSTRUMENT USED IN DATA PROCESSING	FLAG TABLE 002152	0	0	31
002153	SATELLITE CHANNEL CENTRE FREQUENCY	Hz	-8	0	26
002154	SATELLITE CHANNEL BAND WIDTH	Hz	-8	0	26
004001	YEAR	YEAR	0	0	12
004002	MONTH	MONTH	0	0	4
004003	DAY	DAY	0	0	6
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004025	TIME PERIOD OR DISPLACEMENT	MINUTE	0	-2048	12
005044	SATELLITE CYCLE NUMBER	NUMERIC	0	0	11
033035	MANUAL/AUTOMATIC QUALITY CONTROL	CODE TABLE 033035	0	0	4
060000	SEGMENT SIZE AT NADIR IN X DIRECTION (PIXELS)	PIX	0	0	7
060001	SEGMENT SIZE AT NADIR IN Y DIRECTION (PIXELS)	PIX	0	0	7
060102	TRAJECTORY SEQUENCE NUMBER	NUMERIC	0	0	24
117000	REPLICATION OPERATOR[6]	-	0	0	0
031002	EXTENDED DELAYED DESCRIPTOR REPLICATION FACTOR (TRAJ. SECTORS)	NUMERIC	0	0	16
002164	TRACER CORRELATION METHOD	CODE TABLE 002164	0	0	3
005001	LATITUDE (HIGH ACCURACY)	DEGREE	5	-9000000	25
006001	LONGITUDE (HIGH ACCURACY)	DEGREE	5	-18000000	26
005011	LATITUDE INCREMENT (HIGH ACCURACY)	DEGREE	5	-9000000	25
006011	LONGITUDE INCREMENT (HIGH ACCURACY)	DEGREE	5	-18000000	26
007004	PRESSURE	PA	-1	0	14
011001	WIND DIRECTION	DEGREE TRUE	0	0	9
011002	WIND SPEED	M/S	1	0	12
012001	TEMPERATURE	K	1	0	12
033007	PER CENT CONFIDENCE (WITH FORECAST TEST)	%	0	0	7
033007	PER CENT CONFIDENCE (WITHOUT FORECAST TEST)	%	0	0	7
060103	HEIGHT ASSIGNMENT METHOD (CODE TABLE 060103)	CODE TABLE 060103	0	0	4
060205	OROGRAPHIC INDEX (CODE TABLE 060205)	CODE TABLE 060205	0	0	3
060206	CLOUD TYPE (SAFNWC/MSG)	CODE TABLE 060206	0	0	5
060207	WIND CHANNEL (SEVIRI CHANNEL ID)	NUMERIC	0	0	4
060208	CORRELATION	%	0	0	7
060209	PRESSURE ERROR	PA	-1	0	14

White entries: Fixed factors
Grey entries: Replicated factors

Definitions of the CODE TABLE descriptors used are listed in Table 9.

3.8.2 EUMETSAT BUFR template

On the other hand, when BUFR_OUTPUT_FORMAT is set to "EUM", basic and detailed scale winds are produced (the later only if it is specified in the model configuration file (keyword CDET = ALL or RANGE). But in this case, output BUFR bulletins are compliant with the EUMETSAT BUFR template instead of using the NWCSAF local tables, producing AMV bulletins similar to those produced by the EUMETSAT/MPEF AMVs. These outputs are placed at $SAFNWC/export/PGE09 directory with the following names:

"Basic scale winds" output product in EUMETSAT BUFR template format:

`SAFNWC_MSGx_HRW__YYYYMMDDhhmm_Region_____BEUM.buf`

"Detailed scale winds" output product in EUMETSAT BUFR template format:

`SAFNWC_MSGx_HRW__YYYYMMDDhhmm_Region_____DEUM.buf`

These files contain different BUFR messages per channel, and within each message there is one subset per wind. A maximum of 100 subsets are stored in a BUFR message, and if this maximum is exceeded a new message will be created. Therefore EUMETSAT template format is composed by a set of BUFR messages following the next pattern (this information is contained in file /import/Aux_data/PGE09/B0000000000000012000.TXT):

Descriptor	Name	Units	Scale	Reference	Number of bits
001007	SATELLITE IDENTIFIER	CODE TABLE 1007	0	0	10
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 1031	0	0	16
002020	SATELLITE CLASSIFICATION	CODE TABLE 2020	0	0	9
002028	SEGMENT SIZE AT NADIR IN X DIRECTION	M	0	0	18
002029	SEGMENT SIZE AT NADIR IN Y DIRECTION	M	0	0	18
004001	YEAR	YEAR	0	0	12
004002	MONTH	MONTH	0	0	4
004003	DAY	DAY	0	0	6
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
005001	LATITUDE (HIGH ACCURACY)	DEGREE	5	-9000000	25
006001	LONGITUDE (HIGH ACCURACY)	DEGREE	5	-18000000	26
002152	SATELLITE INSTRUMENT DATA USED IN PROCESSING	FLAG TABLE 2152	0	0	31
002023	SATELLITE DERIVED WIND COMPUTATION METHOD	CODE TABLE 2023	0	0	4
007004	PRESSURE	PA	-1	0	14
011001	WIND DIRECTION	DEGREE TRUE	0	0	9
011002	WIND SPEED	M/S	1	0	12
002153	SATELLITE CHANNEL CENTRE FREQUENCY	Hz	-8	0	26
002154	SATELLITE CHANNEL BAND WIDTH	Hz	-8	0	26
012071	COLDEST CLUSTER TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
002164	TRACER CORRELATION METHOD	CODE TABLE 2164	0	0	3
008012	LAND/SEA QUALIFIER	CODE TABLE 8012	0	0	2
007024	SATELLITE ZENITH ANGLE	DEGREE	2	-9000	15
002057	ORIGIN OF FIRST GUESS INFORMATION	CODE TABLE 2057	0	0	4
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004001	YEAR	YEAR	0	0	12
004002	MONTH	MONTH	0	0	4
004003	DAY	DAY	0	0	6
004004	HOUR	HOUR	0	0	5
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004024	TIME PERIOD OR DISPLACEMENT	HOUR	0	-2048	12
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
011001	WIND DIRECTION	DEGREE TRUE	0	0	9
011002	WIND SPEED	M/S	1	0	12

008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
011001	WIND DIRECTION	DEGREE TRUE	0	0	9
011002	WIND SPEED	M/S	1	0	12
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
011001	WIND DIRECTION	DEGREE TRUE	0	0	9
011002	WIND SPEED	M/S	1	0	12
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
008021	TIME SIGNIFICANCE	CODE TABLE 8021	0	0	5
004004	HOUR	HOUR	0	0	5
004005	MINUTE	MINUTE	0	0	6
004006	SECOND	SECOND	0	0	6
011001	WIND DIRECTION	DEGREE TRUE	0	0	9
011002	WIND SPEED	M/S	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
002163	HEIGHT ASSIGNMENT METHOD	CODE TABLE 2163	0	0	4
007004	PRESSURE	PA	-1	0	14
012001	TEMPERATURE/DRY BULB TEMPERATURE	K	1	0	12
222000	QUALITY INFORMATION FOLLOWS				
236000	DEFINE BIT-MAP				
031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
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031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
031031	DATA PRESENT INDICATOR	FLAG TABLE 31031	0	0	1
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 1031	0	0	16
001032	GENERATING APPLICATION (QUALITY CONTROL USING FORECAST)	CODE TABLE 1032	0	0	8
033007	% CONFIDENCE	%	0	0	7
033007	% CONFIDENCE	%	0	0	7
033007	% CONFIDENCE	%	0	0	7
033007	% CONFIDENCE	%	0	0	7
222000	QUALITY INFORMATION FOLLOWS				
237000	REUSE PREVIOUSLY DEFINED BIT-MAP				
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 1031	0	0	16
001032	GENERATING APPLICATION (QUALITY CONTROL USING FORECAST)	CODE TABLE 1032	0	0	8
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
222000	QUALITY INFORMATION FOLLOWS				
237000	REUSE PREVIOUSLY DEFINED BIT-MAP				
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 1031	0	0	16
001032	GENERATING APPLICATION (QUALITY CONTROL USING FORECAST)	CODE TABLE 1032	0	0	8
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7
222000	QUALITY INFORMATION FOLLOWS				
237000	REUSE PREVIOUSLY DEFINED BIT-MAP				
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 1031	0	0	16
001032	GENERATING APPLICATION (QUALITY CONTROL WITHOUT FORECAST)	CODE TABLE 1032	0	0	8
033036	% CONFIDENCE THRESHOLD	%	0	0	7
033036	% CONFIDENCE THRESHOLD	%	0	0	7
033036	% CONFIDENCE THRESHOLD	%	0	0	7
033036	% CONFIDENCE THRESHOLD	%	0	0	7
222000	QUALITY INFORMATION FOLLOWS				
237000	REUSE PREVIOUSLY DEFINED BIT-MAP				
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 1031	0	0	16
001032	GENERATING APPLICATION (QUALITY CONTROL WITHOUT FORECAST)	CODE TABLE 1032	0	0	8
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
033035	MANUAL-AUTOMATIC QUALITY CONTROL	CODE TABLE 33035	0	0	4
222000	QUALITY INFORMATION FOLLOWS				
237000	REUSE PREVIOUSLY DEFINED BIT-MAP				
001031	IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	CODE TABLE 1031	0	0	16
001032	GENERATING APPLICATION (QUALITY CONTROL WITHOUT FORECAST)	CODE TABLE 1032	0	0	8
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7
033036	NOMINAL CONFIDENCE THRESHOLD	%	0	0	7

3.9 AUTOMATIC SATELLITE IMAGE INTERPRETATION (ASII) PRODUCT

This product provides automatic interpretation of features seen on satellite images in the form of designations of conceptual models and geographical locations where these models are identified.

The main use of this product is the identification of:

- Cold fronts
- Warm fronts
- Occlusions
- Wave structures at cold fronts
- Areas of intensification at fronts by jet streak crossing
- Areas of dry intrusions (possible rapid cyclogenesis)
- Areas of enhanced convection
- Comma clouds
- Areas with cold air cloudiness
- Cb complexes.

The format of this product is BUFR. Note that from v2009 on, the used BUFR edition is No. 4. The BUFR result files contain a certain number (in release v2013 of the SAFNWC/MSG package: 20) of telegrams which describe the longitudes and latitudes of the grid points where conceptual models are diagnosed. The employed naming convention mimics the SAFNWC system for BUFR format files to the extent possible (it actually adds only the designation of the sub-product, which are: a) based on satellite data only b) based on satellite + NWP data). The following table lists the components used to build the file names.

Field Name	Description	Data Type	Value
Product_id (1)	Identifier for SAFNWC	6 char.	"SAFNWC"
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (2)	Spacecraft identifier	4 char.	"MSG*i*" (where *i* is an integer)
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (3)	product name	4 char.	The PGE-specific code "ASII".
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (4)	Date of acquisition of SEVIRI image (year on 2 characters and julian day within year)	5 char.	"yyddd"
Field Separator	separator	1 char.	"_" (underscore)
Product_id (5)	slot of the day	3 char.	"0ss" ranging in 001 to 096 for nominal satellite scanning cycle
Field Separator	separator	1 char.	"_" (underscore)
Product_id(6)	Name of processed region	12 char.	Taken from the region configuration file and padded by underscores where necessary.
Field Separator	Separator for extension	1 char.	"."
Product_id(7)	Name of sub-product	7 char.	Name of the sub-product coded in the BUFR file. One of the following: "SATonly" or "SAT+NWP"
Field Separator	Separator for extension	1 char.	"."
Extension	Extension of the product name to indicate the type of data	3 char.	buf

Table 10: File name components of PGE10 ASII output

The template of the BUFR files is as follows:

101000 SPECIFICATION OF THE REPLICATION

031002 EXTENDED DELAYED DESCRIPTOR REPLICATION FACTOR

301023 expands to:

005002 LATITUDE (COARSE ACCURACY)

006002 LONGITUDE (COARSE ACCURACY)

000013 ELEMENT NAME, LINE 1

000014 ELEMENT NAME, LINE 2

The following conceptual models appear in the given order in the BUFR output files of PGE10, SAFNWC/MSG release v2013. If the strings from ELEMENT NAME, LINE 1 and ELEMENT NAME, LINE 2 are concatenated, these element designations can be reproduced during decoding.

```
warm front
cold front
cold front under warm air advection
front intensification by jet streak crossing
enhanced cumuli
dry intrusion
cold air cloudiness
mature cumulonimbus
growing cumulonimbus
decaying cumulonimbus
occlusion
comma
non-developing wave
developing wave
upper wave
upper level low
mesoscale convective system
lee cloudiness
jet cloud (fibres)
embedded convective cell
```

Explicit output of Atmospheric Motion Vectors (AMV) can be requested in the model configuration file (see the ICD document of SAFNWC/MSG). The format of these optional products is BUFR. Note that from v2009 on, the used BUFR edition is No. 4. The employed naming convention mimics the SAFNWC system for BUFR format files to the extent possible (it actually adds only the designation of the sub-product, which are: a) AMV based on IR 10.8 satellite data b) AMV based on WV 6.2 satellite data). The following table lists the components used to build the file names.

Field Name	Description	Data Type	Value
Product_id (1)	Identifier for SAFNWC	6 char.	"SAFNWC"
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (2)	Spacecraft identifier	4 char.	"MSG*i*" (where *i* is an integer)
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (3)	product name	4 char.	The PGE-specific code "ASII".
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (4)	Acquisition date of the SEVIRI image (UTC)	12 char.	"YYYYMMDDhhmm" (YYYY : Year, MM : Month, DD : day, hh: hour, mm: minute)
Field Separator	separator	1 char.	"_" (underscore)
Product_id(5)	Name of processed region	12 char.	Taken from the region configuration file and padded by underscores where necessary.
Field Separator	Separator for extension	1 char.	"."
Product_id(6)	Name of sub-product	5 char.	Name of the sub-product coded in the BUFR file. One of the following: "IRAMV" or "WVAMV"
Field Separator	Separator for extension	1 char.	"."
Extension	Extension of the product name to indicate the type of data	3 char.	buf

Table 11: File name components of PGE10 AMV output

Each AMV BUFR file contains a telegram which sequentially holds quadruplets (longitude, latitude, u-component [in ms^{-1}], v-component [in ms^{-1}]) of all derived atmospheric motion vectors. The template of each of the BUFR telegram looks as follows:

```
103000  SPECIFICATION OF THE REPLICATION
031002  EXTENDED DELAYED DESCRIPTOR REPLICATION FACTOR
301023  expands to:
      005002  LATITUDE (COARSE ACCURACY)
      006002  LONGITUDE (COARSE ACCURACY)
011003  U-COMPONENT
011004  V-COMPONENT
```

3.10 RAPID DEVELOPING THUNDERSTORMS (RDT) PRODUCT

The RDT product provides information about significant convective systems from MCC (meso-alpha scale) down to smaller scales ones, and possibly isolated storms (meso-gamma scale). The basic objectives are twofold: identification, monitoring and tracking of intense convective systems as well as detection of rapid developing convective cells. In the RDT product, the convective systems will be presented like "objects" with their most relevant properties like size, movement, minimum of temperature, area and temperature trends, etc.

The RDT processes an output in ASCII format in order to depict achieved cloud trajectories. This format is described at the end of this chapter.

The RDT output is coded in BUFR format, describing current cloud cells. The following description of convective systems object is built on European working Group on Operational meteorological WorkstationS EGOWS proposals.

Concerning RDT BUFR output, the successive PGE11 releases have lead to propose the following possibilities:

- an initial version of BUFR encoding (version 1) listing all current detected and tracked cloud cells on the domain, convective or not
- a second possibility of BUFR encoding (version 2), in order to include some historical information of cloud cells, and on request to limit the encoding to only current convective cells. The choice of version by user is driven by a dedicated parameter in configuration model file (*.cfm) for PGE11 (see [AD.11])
- on request, for versions 1 or 2, the encoding of a production number. This possibility allows to distinguish products when RDT is processed on various regions or satellites. For convenient purposes, two additionnal files have been provided, taking into account the corresponding descriptor in each case (version 1 or 2 of RDT BUFR).

  This possibility is compliant with the original mode of processing (ascending compatibility): for example, no optional parameter is requested if the user does not need production number
- In order to enrich cloud cells with additional information a third approach of RDT BUFR encoding (version 3) is available. The principle is to provide a more complete spatial description of cells: second level (which corresponds to top-tower description), new attributes (PGE02, PGE05). It is still possible to limit the size of the product by encoding only significant cells. In that case, the previous non significant periods of those cells are also encoded, to enable trajectory reconstitution during post processing.. This version 3 of BUFR is available for v2012 delivery.
- In order to describe new attributes of v2013 (overshooting tops), a version 4 has been developped. The replication of descriptors in BUFR code is limitated (descriptor 1XXYYY, with XX 2 bits encoded i.e. maximum 63). Before introducing new attributes it has been necessary to suppress those unused up to now. Well, this version 4 is very similar to the version 3, as detailled below.

As mentionned in [AD.4], the coding of RDT product is driven by a local BUFR descriptors file. Six such files are now provided, one for each possibility of BUFR coding, (version 1 and 2 with or without product number, and versions 3 and 4).. Some values of given KEYWORDS have to be updated whenever necessary. In particular, some local descriptors could have to be adapted, depending on local usage of local BUFR tables.

The following detailed descriptions of local descriptors are compliant with local BUFR tables used in Météo-France.

In the following paragraphs, tables describe the structure of each RDT BUFR version, with the list of used BUFR descriptors. Some characteristics are highlighted:

- section 4 of BUFR lists some global characteristics, and then a descriptor's replication for the structure of a cloud cell: the list of descriptors for a cloud cell is surrounded by a green edge
- other minor replication sequences are light-blue-shaded.
- data type descriptors are yellow-shaded
- local descriptor are highlighted in red
- when descriptors sequences are used (version 2 and 3), *their content is reminded and highlighted in grey*

Description of local descriptors used, and comments about descriptors will be detailed in paragraph 3.13.5 below.

3.13.1 - BUFR Version 1

In this version of RDT BUFR files, all cloud systems detected and tracked by the RDT algorithm are described. This means that both convective and other cloud systems are stored in RDT BUFR files, even if only convective cloud systems (cloud system objects with a code value of 0 for the descriptor 008200) have to be visualized.

The temporal links between successive BUFR RDT products can be rebuilt using the identification marks of cloud systems in the current and previous images (descriptors 001220). Each cloud system holds the identification of its "father" in the previous product.

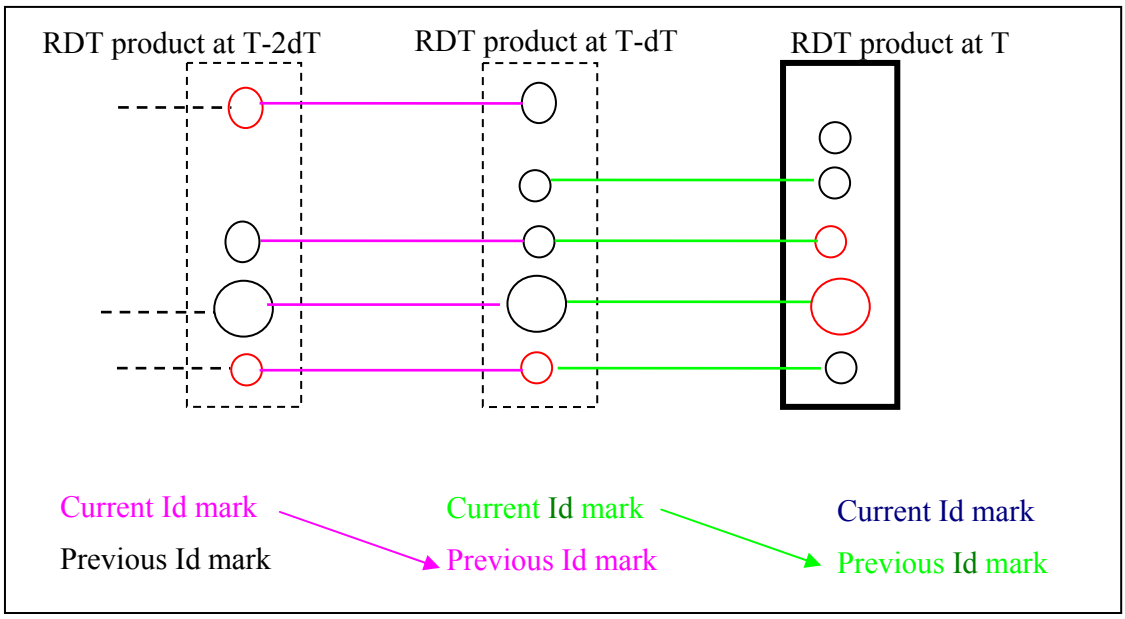


Figure : Illustration and key of temporal links between cells with successive version 1 of BUFR RDT products. Products contain all detected and tracked cells (convectives symbolized in red)

The version 1 of BUFR format of the RDT product, driven by the local BUFR descriptor file PGE11_BUFR_table, is as follows:

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
1	001033	0	0	8	Code table	Identification of originating/generating centre
2	001007	0	0	10	Code table	Satellite identifier
3	008021	0	0	5	Code table	Time significance code for analysis (= 16)
4	004001	0	0	12	Year	Year of the satellite image used as input to derive this message
5	004002	0	0	4	Month	Month of the satellite image used as input to derive this message
6	004003	0	0	6	Day	Day of the satellite image used as input to derive this message
7	004004	0	0	5	Hour	Hour of the satellite image used as input to derive this message
8	004005	0	0	6	Minute	Minute of the satellite image used as input to derive this message
9	008021	0	0	5	Code table	Time significance code for analysis (= 16) or forecast (= 4)
10	004001	0	0	12	Year	Year of validity of cloud systems
11	004002	0	0	4	Month	Month of validity of cloud systems
12	004003	0	0	6	Day	Day of validity of cloud systems
13	004004	0	0	5	Hour	Hour of validity of cloud systems
14	004005	0	0	6	Minute	Minute of validity of cloud systems
15	007002	-1	-40	16	M	Altitude: base of chart layer
16	007002	-1	-40	16	M	Altitude: top of chart layer
17	102000	0	0	0		Replication operator
18	031002	0	0	16	Numeric	Number of points on the edge of the domain
19	005002	2	-9000	15	Degree	Latitude (coarse accuracy) of one point on the edge of the domain
20	006002	2	-18000	16	Degree	Longitude (coarse accuracy) of one point on the edge of the domain
21	008011	0	0	6	Code table	Meteorological feature code for cloud (=12)
22	008007	0	0	4	Code table	Dimensional significance code for area (=2)
23	160000	0	0	0		Replication operator
24	031002	0	0	16	Numeric	Number of cloud systems
25	102000	0	0	0		Replication operator
26	031002	0	0	16	Numeric	Number of points of contour of the cloud system
27	005002	2	-9000	15	Degree	Latitude (coarse accuracy) of one point of contour
28	006002	2	-18000	16	Degree	Longitude (coarse accuracy) of one point of contour
29	008200 *	0	0	2	Code table	Nature (convective or not) of the cloud system
30	025229 *	0	0	24	CCITTIA5	Method used to diagnose the nature of the cloud system
31	033007	0	0	7	Numeric	Percentage of confidence on the diagnostic of the nature of the cloud system
32	001220 *	0	0	248	CCITTIA5	Identification mark of the cloud system (format YYYYMMDDhhmm_Tb_lat_lon)
33	001220 *	0	0	248	CCITTIA5	Identification mark of the cloud system in previous image (format YYYYMMDDhhmm_Tb_lat_lon or “FIRST” for cloud system first detected in the current image)
34	033230 *	0	0	3	Code table	Spatial quality indicator of the cloud system
35	033231 *	0	0	4	Code table	Temporal quality indicator of the tracking of the cloud system
36	025228 *	0	0	5	Code table	Data type for satellite (= 0)
37	007193 *	1	0	12	K	Brightness temperature threshold used to define the cloud system
38	005002	2	-9000	15	Degree	Latitude (coarse accuracy) of the centre of gravity of the cloud system.
39	006002	2	-18000	16	Degree	Longitude (coarse accuracy) of the centre of gravity of the cloud system.
40	004001	0	0	12	Year	Year of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
41	004002	0	0	4	Month	Month of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
42	004003	0	0	6	Day	Day of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
43	004004	0	0	5	Hour	Hour of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
44	004005	0	0	6	Minute	Minute of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
45	004006	0	0	6	Second	Second of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
46	019191 *	-3	0	25	m	Length of the great axis of the fitting ellipse of the cloud system
47	019192 *	-3	0	25	m	Length of the small axis of the fitting ellipse of the cloud system
48	019193 *	0	0	9	Degree true	Angle of the fitting ellipse of the cloud system
49	008021	0	0	5	Code table	Time significance code for first detection of the system (= 17)
50	004001	0	0	12	Year	Year of the first detection of the cloud system

3.13.2 - BUFR Version 2

RDT is coded in version 2 of RDT BUFR when argument **–bufr** is set to the value **2** (default 1).

In this version of RDT BUFR files, convective systems which have been filtered because of their level of activity (if filter is activated, see [RD.4]) will be distinguished from non convective ones (using a code value of 3 for a necessary new descriptor 008205).

The user has been given the choice to include in the BUFR files all cloud systems detected and tracked by the RDT algorithm, or to limit the BUFR description to cells discriminated as convective only (i.e. cloud system objects with a code value of 0 and with a lower priority 3, for the descriptor 008200), strongly reducing the size of BUFR files. This is allowed through a negative value of the -bufr argument (**–bufr** is set to the value **–2**).

Other major modification consists in including historical information of cells at given time steps, the length of this historical information being tunable by the user. The default value is set to 180 minutes (3 hours), and can be decreased through **–bufr_histo** argument. This applies to gravity center position, minimum temperature, and lightning activity.

Moreover, a numerical index is now used for the identification of a cloud cell, reducing the size of the file. The cell's number and the cell's date are sufficient to identify an unique cloud system in a BUFR files. The cell's number at birth date is also given for postprocessing purposes (for example, in order to reconstitut a complete trajectory).

The temporal links between successive BUFR RDT products can be rebuilt using identification numbers (descriptors 001222). Each cloud system holds the index of its ancestor, which becomes unique regarding the birth date. This reference becomes the trajectory identification and can be found in any of the corresponding previous cells of previous products.

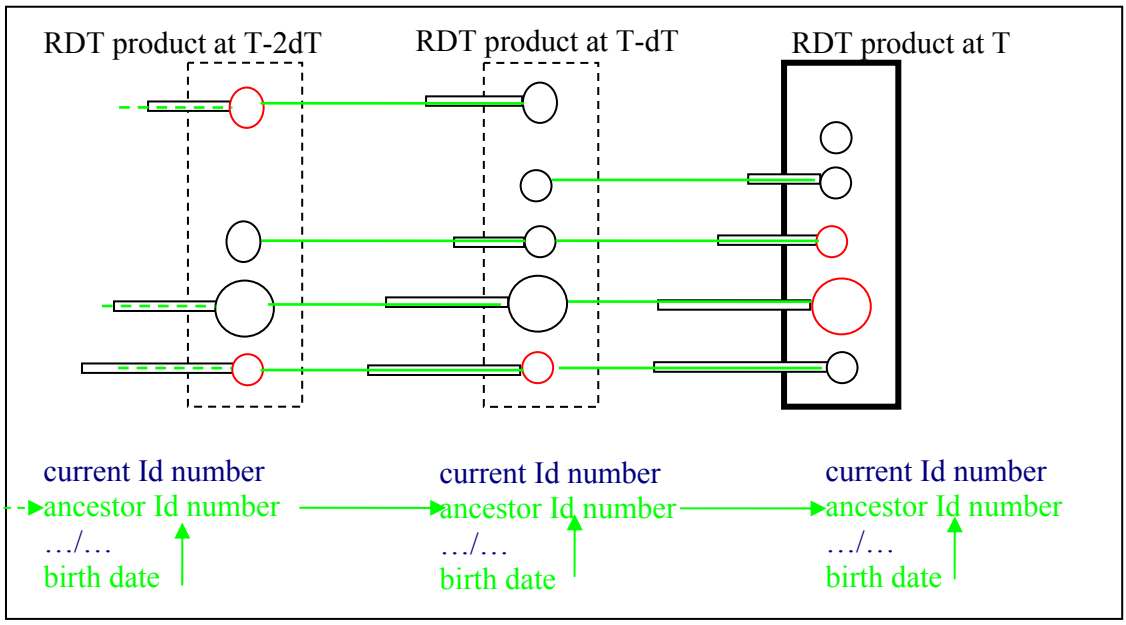


Figure : Illustration and key of temporal links between cells with successive version 2 of BUFR RDT products. Included temporal series of parameters illustrated by thin rectangle, length depending on cell's history and software limit (default 180 min, tunable through –bufr_histo argument)

Finally, the coding relies on the existing sequences of descriptors, particularly in section 3 of BUFR file.

The version 2 of BUFR format of the RDT product, driven by the local BUFR descriptor file PGE11_BUFR_table2 , is described below:

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
1	001033	0	0	8	Code table	Identification of originating/generating centre
2	001007	0	0	10	Code table	Satellite identifier
3	008021	0	0	5	Code table	Time significance code for analysis (= 16)
4	**301011**					Date(Y/M/D) of the satellite image used as input to derive this message
	004001	*0*	*0*	*12*	*Year*	*Year*
	004002	*0*	*0*	*4*	*Month*	*Month*
	004003	*0*	*0*	*6*	*Day*	*Day*
5	**301012**					Date(H/mn) of the satellite image used as input to derive this message
	004004	*0*	*0*	*5*	*Hour*	*Hour*
	004005	*0*	*0*	*6*	*Minute*	*Minute*
6	008021	0	0	5	Code table	Time significance code for analysis (= 16) or forecast (= 4)
7	**301011**					Date(Y/M/D) of validity of cloud systems
	004001	*0*	*0*	*12*	*Year*	*Year*
	004002	*0*	*0*	*4*	*Month*	*Month*
	004003	*0*	*0*	*6*	*Day*	*Day*
8	**301012**					Date(H/mn) of validity of cloud systems
	004004	*0*	*0*	*5*	*Hour*	*Hour*
	004005	*0*	*0*	*6*	*Minute*	*Minute*
9	007002	-1	-40	16	M	Altitude: base of chart layer
10	007002	-1	-40	16	M	Altitude: top of chart layer
11	101000	0	0	0		Replication operator
12	031002	0	0	16	Numeric	Number of points on the edge of the domain
13	**301023**					Position (coarse accuracy) of one point on the edge of the domain
	005002	*2*	*-9000*	*15*	*Degree*	*Latitude*
	006002	*2*	*-18000*	*16*	*Degree*	*Longitude*
14	163000	0	0	0		Replication operator (63 next descriptors)
15	031002	0	0	16	Numeric	Number of cloud systems
16	008011	0	0	6	Code table	Meteorological feature code for cloud (=12)
17	008007	0	0	4	Code table	Dimensional significance code for area (=2)
18	101000	0	0	0		Replication operator
19	031002	0	0	16	Numeric	Number of points of contour of the cloud system
20	**301023**					Position (coarse accuracy) of one point of contour
	005002	*2*	*-9000*	*15*	*Degree*	*Latitude*
	006002	*2*	*-18000*	*16*	*Degree*	*Longitude*
21	008205 *	0	0	**3**	Code table	Nature (convective or not) of the cloud system
22	025229 *	0	0	24	CCITTIA5	Method used to diagnose the nature of the cloud system
23	**033007**	0	0	7	Numeric	Percentage of confidence on the diagnostic of the nature of the cloud system
24	001222 *	0	0	**16**	Numeric	Identification **number** of the cloud system
25	001222 *	0	0	**16**	Numeric	Identification **number** of the cloud system **at birth**
26	033230 *	0	0	3	Code table	Spatial quality indicator of the cloud system
27	033231 *	0	0	4	Code table	Temporal quality indicator of the tracking of the cloud system
28	025228 *	0	0	5	Code table	Data type for satellite (= 0)
29	007193 *	1	0	12	K	Brightness temperature threshold used to define the cloud system
30	**301011**					Date(Y/M/D) of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
	004001	*0*	*0*	*12*	*Year*	*Year*
	004002	*0*	*0*	*4*	*Month*	*Month*
	004003	*0*	*0*	*6*	*Day*	*Day*
31	**301013**					Date(H/mn/sec) of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
	004004	*0*	*0*	*5*	*Hour*	*Hour*
	004005	*0*	*0*	*6*	*Minute*	*Minute*
	004006	*0*	*0*	*6*	*Second*	*Second*
32	019191 *	-3	0	25	m	Length of the great axis of the fitting ellipse of the cloud system
33	019192 *	-3	0	25	m	Length of the small axis of the fitting ellipse of the cloud system
34	019193 *	0	0	9	Degree true	Angle of the fitting ellipse of the cloud system

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
35	008021	0	0	5	Code table	Time significance code for first detection of the system (= 17)
36	**301011**					Date(Y/M/D) of the first detection of the cloud system
	004001	*0*	*0*	*12*	*Year*	*Year*
	004002	*0*	*0*	*4*	*Month*	*Month*
	004003	*0*	*0*	*6*	*Day*	*Day*
37	**301012**					Date(H/mn) of the first detection of the cloud system
	004004	*0*	*0*	*5*	*Hour*	*Hour*
	004005	*0*	*0*	*6*	*Minute*	*Minute*
38	019006	2	0	14	$m.s^{-1}$	Speed of motion of the cloud system
39	019005	0	0	9	Degree true	Direction of motion of the cloud system
40	033003	0	0	3	Code table	Quality information of motion of the cloud system
41	020016	-1	0	14	Pa	Pressure of top of the cloud system
42	033232 *	0	0	3	Code table	Quality indicator of the height of top of the cloud system
43	020013	-1	-40	11	m	Height of base of the cloud system
44	008003	0	0	6	Code table	Vertical significance code for cloud top (=2)
45	008023	0	0	6	Code table	First order statistics code for average (=4)
46	012063	1	0	12	K	Average value of brightness temperature at the top of the cloud system.
47	008003	0	0	6	Code table	Cancellation of cloud top description (= 63)
48	102000	0	0	0		Replication operator
49	031001	0	0	8	Numeric	Number of areas to follow
50	007193 *	1	0	12	K	Brightness temperature threshold used to define the following area of the cloud system
51	019194 *	-6	0	28	m^2	Area of the cloud system at this brightness temperature threshold
52	004025	0	-2048	12	Minute	Time interval used to compute the following area expansion rate
53	019200 *	5	-2^{20}	21	/s	Area expansion rate of the cloud system
54	008201 *	0	0	3	Code table	Qualitative value of this area expansion rate
55	004025	0	-2048	12	Minute	Time interval used to compute the following cooling rate
56	012250 *	4	-1024	11	K/s	Cooling rate of the cloud system
57	008201 *	0	0	3	Code table	Qualitative value of this cooling rate
58	008193 *	0	0	5	Code table	Phase of the life cycle of the cloud system
59	**106000**	**0**	**0**	**0**		**Replication operator**
60	**031001**	**0**	**0**	**8**	**Numeric**	**Number of historical cells to follow**
61	**004025**	**0**	**-2048**	**12**	**Minute**	**Time interval of the following with the current cell**
62	**301023**					Position (coarse accuracy) of the centre of gravity of the cloud system.
	005002	*2*	*-9000*	*15*	*Degree*	*Latitude*
	006002	*2*	*-18000*	*16*	*Degree*	*Longitude*
63	008003	0	0	6	Code table	Vertical significance code for cloud top (=2)
64	008023	0	0	6	Code table	First order statistics code for minimum (=3)
65	012063	1	0	12	K	Minimum value of brightness temperature at the top of the cloud system.
66	008003	0	0	6	Code table	Cancellation of cloud top description (= 63)
67	025228 *	0	0	5	Code table	Cancellation of the data type (= 31)
68	025228 *	0	0	5	Code table	Data type for lightning (= 2)
69	004026	0	-4096	13	Second	Maximum time difference between the date of a given pixel of the cloud system and the date of lightning flashes which occur before the date of validity to be considered into the counting.
70	004026	0	-4096	13	Second	Maximum time difference between the date of a given pixel of the cloud system and the date of lightning flashes which occur after the date of validity to be considered into the counting.
71	**104000**	**0**	**0**	**0**		**Replication operator**
72	**031001**	**0**	**0**	**8**	**Numeric**	**Number of historical steps to follow**
73	**004025**	**0**	**-2048**	**12**	**Minute**	**Time interval of the following with the current cell**
74	016193 *	0	0	16	Numeric	Number of negative cloud-to-ground lightning flashes
75	016194 *	0	0	16	Numeric	Number of positive cloud-to-ground lightning flashes
76	016195 *	0	0	16	Numeric	Number of intracloud lightning flashes
77	025228 *	0	0	5	Code table	Cancellation of the data type (= 31)
78	008007	0	0	4	Code table	Cancellation of dimensional significance (= 15)

Local descriptors are indicated with a *
Green frame: *Cells description lines*
Blue line: *Repetition cycle*
Yellow line: *Data type*
Violet line: *Dimensional indicator of the described object (Cell)*

Table 13: RDT BUFR product description - version 2

3.13.3 - BUFR Version 1 or 2 with production number

When a production number becomes necessary for the post processing of RDT products, there is the possibility to encode a dedicated number in the BUFR Version 1 or Version 2, through a modified file listing encoded descriptors PGE11_BUFR_table_Nprod or PGE11_BUFR_table2_Nprod.

The only difference with the "no production number case" concerns the insertion of a dedicated general descriptor 008022 in the third place, and the shift of following descriptor indexes.

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
1	001033	0	0	8	Code table	Identification of originating/generating centre
2	001007	0	0	10	Code table	Satellite identifier
3	**008022**	**0**	**0**	**16**	**Numeric**	**Total number (with respect to accumulation or average)**
4	008021	0	0	5	Code table	Time significance code for analysis (= 16)
5	…/…	…/…	…/…	…/…	…/…	…/…

3.13.4 – BUFR Version 3

RDT will be coded in version 3 of RDT BUFR when argument **–bufr** is set to the value **3** or **-3** (default is 1).

This version gives up parameters time series encoding, but allows a more complete spatio-temporal description of cloud systems, through additional attributes, and eventually contours or historical data.

- In this version of RDT BUFR files, the software's release is identified by the descriptor 025061, in the header of section 4
- When PGE11 is run with PGE02 (CT data) and/or PGE05 (CRR data), version 3 of BUFR contains additional attributes for cloud cells: main Cloud Type (local descriptor 020091), main Cloud Phase (descriptor 020056), and maximum Convective Rain Rate (descriptor 013014), with corresponding quality codes.
- When "–crrdiscri" argument of model configuration file is set to 1, CRR attribute is used for forcing convective diagnostic when above a given threshold (default 50mm/h, tunable with the value of "–crrdiscri" argument). This option is similar with lightning data, but has not been evaluated neither validated.
- Depending on cloud morphology, a "second information level" may be encoded for some significant cells. For this release these are additional cells whose contour corresponds to "top of tower" (delta_Ttour under minimum temperature). They are linked to the main significant "tower-base" level through ancestor's Identification number (descriptor 001222).
- When specifying negative "–bufr -3" argument in model configuration file, version 3 of BUFR output will be limited to "significant" cloud systems only. Cloud cells will be considered as significant when they are diagnosed as convective, or when they are associated with electric activity (if RDT is operated with lightning data), or when they are associated with high rain rates (≥10mm/h, if RDT is operated with SAF/NWC CRR product). As the output is limited to those cells, the size of output file is hightly decreased.

In that case, historical information is added for new significant cells only, through the encoding of cells at previous slots. Those previous cells are generally not significant, and not synchroneous with the product date. But they may allow to access previous attributes of current significant cell without accessing previous output files. Thus, RDT output is more documented, and the product becomes self-informative for full postprocessing

In any case, the temporal links between successive BUFR RDT products can be completly rebuilt using identification numbers (descriptors 001222), like version 2 of BUFR RDT. Each cloud system holds the index of its ancestor, which becomes unique regarding the birth date. This reference becomes the trajectory identification and can be found in any of the corresponding previous cells encoded in the previous products or in the most recent one for newly significant cells.

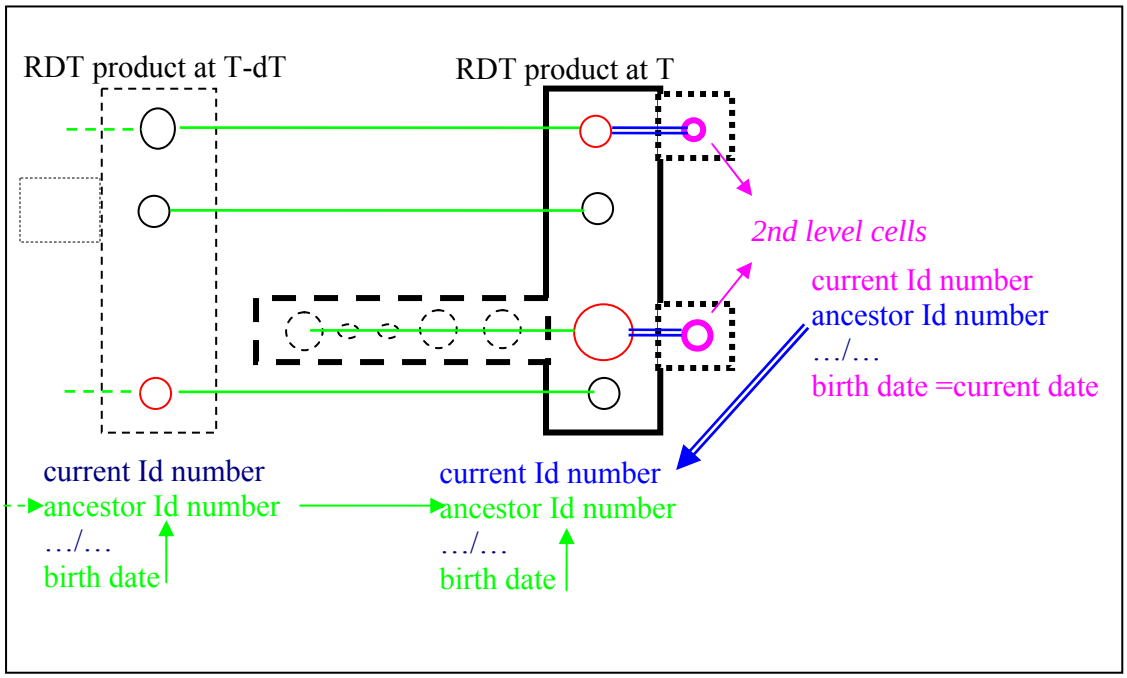


Figure : version 3 of BUFR RDT : Illustration and key of temporal links between successive cells of successive products, (or between included previous cells of newly significant if option "–bufr - 3"). Illustration and key of link between main cell and second level cell (magenta)

The version 3 of BUFR format of the RDT product, driven by the local BUFR descriptor file PGE11_BUFR_table3 , is described below:

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
1	001033	0	0	8	Code table	Identification of originating/generating centre
2	001007	0	0	10	Code table	Satellite identifier
3	008022	0	0	16	Numeric	Total number (with respect to accumulation or average) = production number
4	025061	0	0	96	CCITTIA5	Software identification and version number
5	008021	0	0	5	Code table	Time significance code for analysis (= 16)
6	301011	0	0	0		Date(YY/MM/DD) of the satellite image used as input to derive this message
0	*004001*	*0*	*0*	*12*	*Year*	*Year*
0	*004002*	*0*	*0*	*4*	*Month*	*Month*
0	*004003*	*0*	*0*	*6*	*Day*	*Day*
7	301012	0	0	0		Date(HH/mm) of the satellite image used as input to derive this message

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
0	*004004*	*0*	*0*	*5*	*Hour*	*Hour*
0	*004005*	*0*	*0*	*6*	*Minute*	*Minute*
8	008021	0	0	5	Code table	Time significance code for analysis (= 16) or forecast (= 4)
9	301011	0	0	0		Date(YY/MM/DD) of validity of cloud systems
0	*004001*	*0*	*0*	*12*	*Year*	*Year*
0	*004002*	*0*	*0*	*4*	*Month*	*Month*
0	*004003*	*0*	*0*	*6*	*Day*	*Day*
10	301012	0	0	0		Date(HH/mm) of validity of cloud systems
0	*004004*	*0*	*0*	*5*	*Hour*	*Hour*
0	*004005*	*0*	*0*	*6*	*Minute*	*Minute*
11	007002	-1	-40	16	M	Altitude: base of chart layer
12	007002	-1	-40	16	M	Altitude: top of chart layer
13	101004	0	0	0		Replication operator **(4)**
14	301023	0	0	0		Position (coarse accuracy) of the 4 corner points of the domain
0	*005002*	*2*	*-9000*	*15*	*Degree*	*Latitude*
0	*006002*	*2*	*-18000*	*16*	*Degree*	*Longitude*
15	159000	0	0	0		Replication operator (descriptors for each cell)
16	031002	0	0	16	Numeric	Number of cloud systems
17	008011	0	0	6	Code table	Meteorological feature code for cloud (=12)
18	008007	0	0	4	Code table	Dimensional significance code for area (=2)
19	101000	0	0	0		Replication operator
20	031002	0	0	16	Numeric	Number of points of contour of the cloud system
21	301023	0	0	0		Position (coarse accuracy) of one point of contour
0	*005002*	*2*	*-9000*	*15*	*Degree*	*Latitude*
0	*006002*	*2*	*-18000*	*16*	*Degree*	*Longitude*
22	008205*	0	0	3	Code table	Nature (convective or not) of the cloud system
23	025229*	0	0	24	CCITTIA5	Method used to diagnose the nature of the cloud system
24	033007	0	0	7	Numeric	Percentage of confidence on the diagnostic of the nature of the cloud system
25	001222*	0	0	16	Numeric	Identification number of the cloud system
26	001222*	0	0	16	Numeric	Identification number of the cloud system at birth
27	033230*	0	0	3	Code table	Spatial quality indicator of the cloud system
28	033231*	0	0	4	Code table	Temporal quality indicator of the tracking of the cloud system
29	025228*	0	0	5	Code table	Data type for satellite (= 0)
30	007193*	1	0	12	K	Brightness temperature threshold used to define the cloud system
31	301023	0	0	0		Position (coarse accuracy) of the centre of gravity of the cloud system.
0	*005002*	*2*	*-9000*	*15*	*Degree*	*Latitude*
0	*006002*	*2*	*-18000*	*16*	*Degree*	*Longitude*
32	301011	0	0	0		Date(YY/MM/DD) of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
0	*004001*	*0*	*0*	*12*	*Year*	*Year*
0	*004002*	*0*	*0*	*4*	*Month*	*Month*
0	*004003*	*0*	*0*	*6*	*Day*	*Day*
33	301013	0	0	0		Date(HH/mm/ss) of scanning of the centre of gravity of the cloud system by the SEVIRI radiometer
0	*004004*	*0*	*0*	*5*	*Hour*	*Hour*
0	*004005*	*0*	*0*	*6*	*Minute*	*Minute*
0	*004006*	*0*	*0*	*6*	*Second*	*Second*
34	019191*	-3	0	25	m	Length of the great axis of the fitting ellipse of the cloud system
35	019192*	-3	0	25	m	Length of the small axis of the fitting ellipse of the cloud system
36	019193*	0	0	9	Degree true	Angle of the fitting ellipse of the cloud system
37	008021	0	0	5	Code table	Time significance code for first detection of the system (= 17)
38	301011	0	0	0		Date(YY/MM/DD) of the first detection of the cloud system
0	*004001*	*0*	*0*	*12*	*Year*	*Year*
0	*004002*	*0*	*0*	*4*	*Month*	*Month*

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
0	*004003*	*0*	*0*	*6*	*Day*	*Day*
39	301012	0	0	0		Date(HH/mm) of the first detection of the cloud system
0	*004004*	*0*	*0*	*5*	*Hour*	*Hour*
0	*004005*	*0*	*0*	*6*	*Minute*	*Minute*
40	019006	2	0	14	$m.s^{-1}$	Speed of motion of the cloud system
41	019005	0	0	9	Degree true	Direction of motion of the cloud system
42	033003	0	0	3	Code table	Quality information of motion of the cloud system
43	008023	0	0	6	Code table	First order statistics code for minimum (=3)
44	012063	1	0	12	K	Minimum value of brightness temperature at the top of the cloud system.
45	008023	0	0	6	Code table	First order statistics code for average (=4)
46	012063	1	0	12	K	Average value of brightness temperature –of the cloud system.
47	102000	0	0	0		Replication operator
48	031001	0	0	8	Numeric	Number of areas to follow
49	007193*	1	0	12	K	Brightness temperature threshold used to define the following area of the cloud system
50	019194*	-6	0	28	m^2	Area of the cloud system at this brightness temperature threshold
51	004025	0	-2048	12	Minute	Time interval used to compute the following area expansion rate
52	019200*	5	-2^{20}	21	s^{-1}	Area expansion rate of the cloud system
53	008201*	0	0	3	Code table	Qualitative value of this area expansion rate
54	004025	0	-2048	12	Minute	Time interval used to compute the following cooling rate
55	012250*	4	-1024	11	K/s	Cooling rate of the cloud system
56	008201*	0	0	3	Code table	Qualitative value of this cooling rate
57	008193*	0	0	5	Code table	Phase of the life cycle of the cloud system
58	020016	-1	0	14	Pa	Pressure of top of the cloud system
59	033232*	0	0	3	Code table	Quality indicator of the height of top of the cloud system
60	020224*	0	0	5	Code Table	Type of the cloud system
61	020056	0	0	3	Code Table	Phase of cloud
62	033003	0	0	3	Code table	Quality information
63	008003	0	0	6	Code table	vertical significance code for precipitable water (= 2)
64	013014	4	0	12	kgm-2s-1	Rainfall rate
65	033003	0	0	3	Code table	Quality information
66	008003	0	0	6	Code table	Cancellation of vertical significance (= 63)
67	025228*	0	0	5	Code table	Cancellation of the data type (= 31)
68	025228*	0	0	5	Code table	Data type for lightning (= 2)
69	004026	0	-4096	13	Second	Maximum time difference between the date of a given pixel of the cloud system and the date of lightning flashes which occur before the date of validity to be considered into the counting.
70	004026	0	-4096	13	Second	Maximum time difference between the date of a given pixel of the cloud system and the date of lightning flashes which occur after the date of validity to be considered into the counting.
71	016193*	0	0	16	Numeric	Number of negative cloud-to-ground lightning flashes
72	016194*	0	0	16	Numeric	Number of positive cloud-to-ground lightning flashes
73	016195*	0	0	16	Numeric	Number of intracloud lightning flashes
74	025228*	0	0	5	Code table	Cancellation of the data type (= 31)
75	008007	0	0	4	Code table	Cancellation of dimensional significance (= 15)

Local descriptors are indicated with a *
Green frame: *Cells description lines*
Blue line: *Repetition cycle*
Yellow line: *Data type*
Violet line: *Dimensional indicator of the described object (Cell)*

Table 18: RDT BUFR product description - version 3

3.13.4 – BUFR Version 4

RDT will be coded in version 4 of RDT BUFR when argument **–bufr** is set to the value **4** or **-4** (default is 1).

This version is very similar to version 3, the structure in particular is almost identical

- Overshooting tops can be analyzed in v2013 (provided that corresponding argument is not set to zero in model configuration file), and may be encoded for the corresponding significant cells.
- When specifying negative "–bufr -4" argument in model configuration file, BUFR output will be limited to "significant" cloud systems only (convective, electric, high rain rates). Cells associated with overshooting top are considered as significant. As the output is limited to those significant cells, the size of output file is hightly decreased.

  In that case, like in version 3, historical information is added for newly significant cells only, through the encoding of cells at previous slots.

When looking at descriptor list in the "PGE11_BUFR_table4" file, on can note that the difference with version 3 concerns

=> the suppression of 3 attributes/descriptors : 008201 qualitative values of expansion and cooling rates have never been determined (missing values), and 004025 time interval for cooling rate is redundant with the one of expansion rate

=> the insertion of 7 descriptors for encoding overshoot description of a cloud cell.

008003-Descriptor of vertical characteristic (top of cloud)

105000-Replication descriptor for 5 next descriptors

031001 Descriptor of number of overshoot described in the cell

301023- Position descriptor

012063-brightness temperature descriptor

012065-standard deviation of brightness temperature, used to code BTD

012065-standard deviation of brightness temperature, used to code gap to surrounding tropopause

Consequently, there is a shift of following descriptor indexes in the auxiliary file. The total number of replicated descriptor of a cloud cell is 63 (replication descriptor n°15 163000), which is the maximum allowed in this case with this structure.

Of course when no overshoot is associated with a cloud cell (number=0) -which is the most frequent case- position, temperature, BTD and gap to tropopause attributes are not encoded.

Below are detailed the changes in the descriptor list, which is up-to-date in the auxiliary file PGE11_BUFR_table4

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
15	163000	0	0	0		Replication operator (63 descriptors for each cell)
51	004025	0	-2048	12	Minute	Time interval used to compute the following ~~area expansion~~ rates

N°	Descriptor	Scale	Ref. value	Data bit width	Unit	Significance
52	019200*	5	-1048576	21	s^{-1}	Area expansion rate of the cloud system
~~53~~	~~008201*~~	~~0~~	~~0~~	~~3~~	~~Code table~~	~~Qualitative value of this area expansion rate~~
~~54~~	~~004025~~	~~0~~	~~-2048~~	~~12~~	~~Minute~~	~~Time interval used to compute the following cooling rate~~
53	012250*	4	-1024	11	K/s	Cooling rate of the cloud system
~~55~~	~~008201*~~	~~0~~	~~0~~	~~3~~	~~Code table~~	~~Qualitative value of this cooling rate~~
54	008193*	0	0	5	Code table	Phase of the life cycle of the cloud system
55	008003	0	0	6	Code table	vertical significance code for cloud top (= 2)
56	105000	0	0	0		Replication operator for next 5 descriptors
57	031001	0	0	8	Numeric	Number of overshoots of the cloud system
58	301023	0	0	0		Position (coarse accuracy) of the overshoot
	005002	*2*	*-9000*	*15*	*Degree*	*Latitude*
	006002	*2*	*-18000*	*16*	*Degree*	*Longitude*
59	012063	1	0	12	K	Brightness temperature at the overshoot
60	012065	1	0	12	K	Standard deviation brightness temperature = brightness temperature difference WV-IR
61	012065	1	0	12	K	Standard deviation brightness temperature = temperature difference over tropopause
62	020016	-1	0	14	Pa	Pressure of top of the cloud system
63	033232*	0	0	3	Code table	Quality indicator of the height of top of the cloud system

Table 19: RDT BUFR product description – difference of version 4 with version 3

3.13.5 – Description of local descriptors and Comments

Local descriptors used: descriptor: name, *unit* (scale / ref. Value / Data bit width)**:**

- **001220**: (version 1) Identification mark of a cloud system, *CCITTIA5* (0, 0, 248).
- **001222**: (version 2 and 3) Identification number of a cloud system, *numeric* (0, 0, 16).
- **007193**: Brightness temperature, *K* (1, 0, 12).
- **008193**: Phase of phenomenon life cycle, *code table* (0, 0, 5).

Code figure	Meaning
0	Triggering
1	Growing
2	Mature
3	Decaying
4	**Not used**
31	Missing

- **008200**: (version 1) Nature of the cloud system, *code table* (0, 0, 2).

Code figure	Meaning
0	Convective cloud system
1	Cloud system originating from the split of a previous convective cloud system
2	Other cloud system
3	Missing

- **008201**: Qualitative value, *code table* (0, 0, 3).

Code figure	Meaning
0	Very high
1	High
2	Moderate
3	Low
7	Missing

- **008205**: (version 2 and 3) Nature of the cloud system, *code table* (0, 0, 3).

Code figure	Meaning
0	Convective cloud system
1	Cloud system originating from the split of a previous convective cloud system
2	Other cloud system
3	Filtered Convective cloud system (convective non active)
7	Missing

- **012250**: Cooling rate, *K/s* (4, -1024, 11).
- **016193**: Number of negative cloud-to-ground lightning flashes, *numeric* (0, 0, 16).
- **016194**: Number of positive cloud-to-ground lightning flashes, *numeric* (0, 0, 16).
- **016195**: Number of intracloud lightning flashes, *numeric* (0, 0, 16).
- **019191:** Length of the great axis of the fitting ellipse of the cloud system, *m* (-3, 0, 25).
- **019192:** Length of the small axis of the fitting ellipse of the cloud system, *m* (-3, 0, 25).
- **019193:** Angle of the fitting ellipse of the cloud system, *Degree true* (0, 0, 9).
- **019194**: Area, m^2 (-6, 0, 28).
- **019200**: Area expansion rate, */s* (5, -2^{20}, 21).
- **020224**: Type of the cloud system, *code table* (0, 0, 5).

Code figure	Meaning
0	non-processed
1	cloud free land
2	cloud free sea
3	land contaminated by snow
4	sea contaminated by snow/ice
5	very low and cumuliform clouds
6	very low and stratiform clouds
7	low and cumuliform clouds
8	low and stratiform clouds
9	medium and cumuliform clouds
10	medium and stratiform clouds
11	high opaque and cumuliform clouds
12	high opaque and stratiform clouds
13	very high opaque and cumuliform clouds
14	very high opaque and stratiform clouds
15	high semi transparent thin clouds
16	high semitransparent meanly thick clouds
17	high semitransparent thick clouds
18	high semitransparent above low or medium clouds
19	fractional clouds (sub-pixel water clouds)
20	undefined (undefined by CMa)
31	Missing

- **025228**: Data used for diagnostic, *code table* (0, 0, 5).

Code figure	Meaning
0	Satellite data
1	Radar data
2	Lightning data
30	Other data
31	Missing

- **025229**: Method used to diagnose the nature (convective or not) of a cloud system, *CCITTIA5* (0, 0, 24).
- **033230**: Spatial quality indicator of the cloud system, *code table* (0, 0, 3).

Code figure

Code figure	Meaning
0	Nominal
1	The cloud system was first detected in a satellite image, received just after a missing image
2	A sequence of consecutive missing images, longer than 1h30 and shorter than 2h30, took place during the tracking of the cloud system, the tracking "over crossed" this sequence of non-available images because the size of the cloud system just before it was larger than 7000 km^2
3	The spatial quality indicator of the cloud system was not nominal in at least one image
4	Both 1 & 2
5	Both 1 & 3
6	Both 2 & 3
7	1, 2 & 3
15	Missing

- **033232**: Quality indicator of the height of top of the cloud system, *code table* (0, 0, 3).

Code figure	Meaning
0	Very good
1	Good
2	Medium
3	Low
4	Very low
7	Missing

Comments:

1. Descriptors of the header follow the Météo-France proposal of general header for meteorological objects.
2. The first date coded in this header is the date of the satellite image used to compute the cloud systems objects described in the BUFR file. The time significance code (descriptor 008021) for this date is always 16 (Analysis).
3. The second date coded in this header is the date of validity of the cloud systems objects described in the BUFR file. The time significance code for this date (descriptor 008021) can be:

Code figure	Meaning
4	Forecast
16	Analysis

   For a given RDT product, its value is always 16 and the date of validity of the cloud systems objects is the date of the scan of the pixel located at the center of the region used to compute this RDT product.

4. The descriptors (007002) are filled with 2^{15} (missing code value).
5. The first position descriptors replication identifies the region of RDT processing.:

   With version 1 both latitude/longitude descriptors (005002/006002) are replicated, with other versions only the position descriptor sequence (301023) is replicated

   In version 1 and 2, it may describe, upon user's request, either the 4 corner points of the region (default), either the contour of the processed region (-contour_region set to the value 1 in cfm file). In this case the points describe the edges of the geographical domain of the satellite images used to derive the RDT product. The number of points depends on the chosen domain, and is equal or below the number of pixels of the region perimeter

With version 3, only the 4 corner points are encoded, and the replication descriptor includes the fixed number of replication (101004, i.e. four replications of 1 position descriptor)

6. The number of cloud systems, from which depends the length of BUFR file, appear in the next replication sequence (descriptor 031002) following replication operator 160000 (version 1) or 163000 (version 2) or 159000 (version 3)
7. In order to comply with discussions of the WMO Commission of Codes, the descriptors 008011 and 008007 have been moved between version 1 and version 2, beyond replication descriptors mentioned above,. Cancellation field 008007 applies in that case to each cloud system and number of fields reported in replication operator is changed accordingly.
8. The descriptors in following positions (005002/006002 in version 1, 301023 in version 2 and 3) give access to the list of contour points for each cloud system. There is an upper limit of 200 for the number of such contour points.
9. Concerning the local descriptor 008200 used in version 1 or 008205 used in version 2 and 3:

   In the RDT product, only convective cloud systems (cloud system with code 0) are intended to be visualized. Nevertheless, the user could have some interest to visualize also other systems on the basis of other criteria. BUFR version 1 RDT product contents all convective and non convective systems. BUFR version 2 also identifies those which have been declassified (code value 3) on the basis of their level of activity.
   Note: With BUFR version ≥2, it is possible to limit the content of product to "significant" systems, i.e. convectives, but also eventually electric ones (if lightning data are used only as "passive" input) or those associated with high rain rates (≥10mm/h when PGE11 run with PGE05) or overshoots.

10. The descriptor 025229 contains a string that identifies the method used to diagnose the convective nature of the cloud system currently described. Four possibilities are used currently:
    - **SAT**: the convective nature of the cloud system has been diagnosed using the discrimination method only based on satellite data system (see section 11.3.2.3 of the Scientific Report of the RDT).
    - **LGH**: the convective nature of the cloud system has been diagnosed with the occurrence of lightning flashes in the vicinity of cloud system (see section 11.3.3 of the Scientific Report of the RDT). This is the case when argument "–lightning" is set to a value >0 by the user
    - **CRR** (version 3 only): the convective nature of the cloud system has been diagnosed with the occurrence of very high rain rates, estimated from PGE05 data. This is the case when both arguments "-crr" and "-crrdiscri" are set to the value 1 by the user. 50mm/h is the default rain rate threshold for forcing convective diagnostic, and may be adapted by user with argument "-crrdiscri" > 1.
    - **OTD** (versions ≥3): when an overshoot is detected, the cloud cell can be considered as convective. This can help to force the convective diagnostic in case of cold start of PGE11, when historical depth is not sufficient.
11. The descriptor 033007 gives the percentage of confidence on the diagnostic of the nature of the cloud system currently described. This allows to the user to eliminate convective systems which are diagnosed as convective at a low level of confidence.

    Note: when the method used to diagnose the convective nature of the cloud system is set to "**LGH"**, the percentage of confidence on this diagnostic is 100 %.

12. The first descriptor 001220 (version 1) contains the identification mark of the cloud system currently described. The format is "YYYYMMDDhhmm_Tb_lat_lon" where:

    - "YYYYMMDDhhmm" is the date of the satellite image (also given in descriptors n°4 to 8) used to derive this RDT product,
    - "Tb" is the brightness temperature threshold used to define this cloud system (integer value).
    - "lat" and "lon" are the positions of the gravity center of this cloud system (with the precision of 0.01°).

    The identification mark is always composed of a string of 31 characters. An example of such a string is "200007080430_-10__+42.91__+4.32".

    The second descriptor 001220 contains the identification mark of the object corresponding to the cloud system currently described in the previous satellite image. If this cloud system is detected for the first time by the software in the current satellite image, then this descriptor is filled with the string "FIRST_____" (the symbol "_" is repeated 26 times).

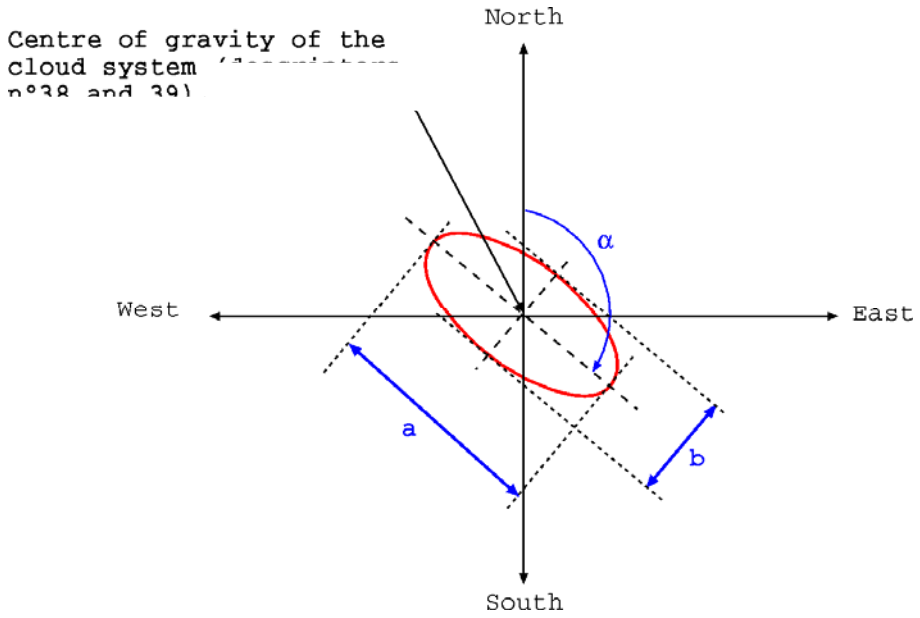
13. The first descriptor 001222 (version 2 or 3) contains the identification number of the cloud system currently described. Used with the date of the image, this number is sufficient to identify the system.

    The second descriptor 001222 contains the identification number of the object corresponding to the cloud system currently described at birth in first image. If this cloud system is detected for the first time by the software in the current satellite image, then this descriptor is filled with the value 0., this number is sufficient to identify the system at birth when it is used with the date of first detection

14. The descriptor 007193 contains the brightness temperature threshold used to define the cloud system currently described.

15. The descriptors 019191 o 019193 give the characteristics of a fitting ellipse of the cloud system (see following figure):

    - Descriptor 019191 gives the value of the length of the major axis of this ellipse (length "**a**" in the following figure).
    - Descriptor 019192 gives the value of the length of the minor axis of this ellipse (length "**b**" in the following figure).
    - Descriptor 019193 gives the value of the orientation of this ellipse (angle "**α**" in the following figure).



16. The global BUFR descriptor 033003 contains quality information. It is used here for the following parameters: quality of the diagnostic of motion of the cloud system (version 2 and 3), quality of the Cloud Type and Phase and of the rain rate estimate (version 3). Following values are encoded:

    0: data not suspect

    1: data slightly suspect

    2: data highly suspect

    3: data considered unfit for use

    7: quality information not given

17. The descriptor 020016 contains the pressure of top of the cloud system. This pressure of top comes from the parameter "cloud top pressure" (CTTH_PRES) of the CTTH product of the SAFNWC. It is defined as the tenth percentile of the distribution of this pressure below the cloud system.

    The quality of this estimated pressure (descriptor 033232) is related to the pixels of the cloud system which are used to compute the percentile of the CTTH_PRES parameter. More precisely, the quality is defined as follows:

    - If some pixels of the cloud system are "opaque" (i.e. the effective cloudiness, coming from the CTTH_EFFECTIVE parameter of the CTTH product, is equal to 100%), then the percentile was evaluated only taking into account these pixels and the quality is set to "very good".
    - Else, if some pixels of the cloud system have an effective cloudiness greater or equal to 90% and the quality of the processing of these pixels is "good" (see the CTTH_QUALITY parameter of the CTTH product), then the percentile was evaluated only taking into account these pixels and the quality is set to "good".
    - Else, if some pixels of the cloud system have an effective cloudiness greater or equal to 90%, then the percentile was evaluated only taking into account these pixels and the quality is set to "medium".

- Else, if the quality of the processing of some pixels is "good" (CTTH_QUALITY parameter of the CTTH product), then the percentile was evaluated only taking into account these pixels and the quality is set to "low".
- Else, the percentile was evaluated only taking into account pixels for which the CTTH_PRES parameter was not "UNKNOWN" and the quality is set to "very low".

18. The descriptor 020013 (version 1 and 2) contains an estimation of the height of the base of the cloud system. In the current RDT product it is always set to "Missing". Because no plan is foreseen to manage this value, version 3 of BUFR RDT does not take this descriptor into account
19. The replication loop of descriptors 007193 and 019194 gives the areas of the cloud system at different brightness temperature thresholds (the exact number of these thresholds is given in descriptor 031001: its length is variable, depending on cloud systems, but is less than abs (Twarm - Tcold)/delta_tempe (see SAF-NWC-IOP-MFT-SCI-SUM-1). This should be less than 100, in any meaningful case). For a given temperature threshold:
    - Descriptor 007193 gives the value of the brightness temperature threshold used to define the following area of the cloud system.
    - Descriptor 019194 gives the value of the area of the cloud system at this brightness temperature threshold.

20. The 3 descriptors 004025, 019200, 008201 describe the area expansion rate of the cloud system:

    If we call:

    - $D_{validity}$ the date of validity of the cloud system
    - D_{before} the date of validity of the same cloud system detected in the previous image.

    ⇒ If the brightness temperature threshold $T_{validity}$ of the cloud system is warmer than the brightness temperature threshold T_{before} used to defined the same cloud in the previous image, then:

    ⇨ If the minimum brightness temperature $T^{\mathbf{min}}_{validity}$ of the cloud system is warmer than T_{before} then:

    - $A_{validity}$ is the area of the cloud system at the temperature threshold $T_{validity}$.
    - A_{before} is the area of the cloud system in the previous image at the same temperature threshold.

    ⇨ Else:

    - $A_{validity}$ is the area of the cloud system at the temperature threshold T_{before}.
    - A_{before} is the area of the cloud system in the previous image at the same temperature threshold.

    ⇒ Else:

    ⇨ If the minimum brightness temperature $T^{\mathbf{min}}_{before}$ of the cloud system in the previous image is warmer than $T_{validity}$ then:

- $A_{validity}$ is the area of the cloud system at the temperature threshold T_{before}.
- A_{before} is the area of the cloud system in the previous image at the same temperature threshold.

⇨ Else:

- $A_{validity}$ is the area of the cloud system at the temperature threshold $T_{validity}$.
- A_{before} is the area of the cloud system in the previous image at the same temperature threshold.

Then, the area expansion rate (descriptor 019200) of the cloud system is defined as:

$$\frac{A_{validity} - A_{before}}{A_{before}} \times \frac{1}{D_{validity} - D_{before}}$$

- Descriptor 004025 gives the time interval used to compute this area expansion rate ($D_{validity}$-D_{before}).
- Descriptor 008201 gives a qualitative value of this area expansion rate. For the current RDT product, this value is set to "Missing".

21. The descriptors 004025, 012250, 008201 describe the cooling rate of the cloud system:
    - Descriptor 004025 gives the time interval used to compute this cooling rate. It is defined as the difference between the date of validity $D_{validity}$ of the cloud system and the date D_{before} when the cloud system had a minimum brightness temperature of T_{before}^{min}.
    - Descriptor 012250 gives the value of this cooling rate. It is defined by the following formulae:

      $$\frac{T_{validity}^{min} - T_{before}^{min}}{D_{validity} - D_{before}}$$

      where $T_{validity}^{min}$ is the minimum brightness temperature of the cloud system at date $D_{validity}$
    - Descriptor 008201 gives a qualitative value of this cooling rate. For the current RDT product, this value is set to "Missing".

22. The descriptor 008193 gives the phase of the cloud system: triggering, development, mature or decaying stages
23. With version 2 of BUFR RDT, an historical sequence of some parameters is included through the replication of descriptors 004025, 301023, 008003, 008023, 012063 and 008003

    Characteristics of the cloud system at different time steps before the current time are included. The exact number of steps is given in descriptor 031001: its length is variable, depending on the trajectories of the cloud systems, from 1 for current time, to a maximum of 13, i.e. an maximum historical "memory" of 180 minutes with a 15' scan (see [RD.4]). The user has the possibility to limit the length of this historical description, through an argument to the program (see [RD.3). For a given time step:

- Descriptor 004025 gives the time interval (positive value in minutes) of the following characteristics with the current cell. This value is equal to 0 for the current cell.
- Descriptor 301023 (sequence of descriptors 005002 and 006002) gives the position (latitude and longitude) of weighted gravity center of the cloud system (i.e. taking into account the brightness temperature value of each pixel of the cloud system).
- Descriptor 012063 gives the minimum brightness temperature of the cloud system (identified by descriptor for vertical significance 008003 and operator descriptor008023)

24. With version 3 of BUFR RDT, information derived from PGE02 and PGE05 can be included
    - Local descriptor 020224 indicates the larger proportion of Cloud Type issued from PGE02 over the horizontal extension of the cloud cell
    - Global descriptor 020056 is used to qualify the larger proportion of phase (water, ice or mixed) over the extension of the cloud cell , issued from PGE02
    - Descriptor 033003 indicates the quality extracted from PGE02 product for the concerned pixels
    - Descriptor 013014 (marked with vertical significance descriptor 008003) gives a mm/h rain rate estimate, derived from the maximum of Convective Rain Rate Intensity (issued from PGE05) over the horizontal extension of the cloud cell.
    - Descriptor 033003 concern PGE05 product quality of the concerned pixels
25. The descriptors 004026 to 016195 describe the counting of lightning flashes occurring below the cloud system:
    - Descriptor 004026 is equal to the value Δt_{before} of the parameter "-dt_light_before" of the PGE11 software (see the Software User Manual).
    - Descriptor 004026 is equal to the value Δt_{after} of the parameter "-dt_light_after" of the PGE11 software (see the Software User Manual).
    - With version 2 of BUFR RDT, historical lightning activity of the cloud system is listed at different previous time steps from current time, including current time. Local descriptor 004025 gives in that case the previous time interval (positive value in minutes) of the following with the current cell. When corresponding to current cell, this value is equal to 0. Other descriptors 016193, 016194, 016195 give the activity at these different time steps.
    - With version 1 or 3 of BUFR RDT, next descriptors describe lightning activity of the current cell
    - Local descriptor 016193 gives the number of negative cloud-to-ground lightning flashes occurring inthe vicinity of the cloud system. For a given pixel of the cloud system, the lightning flashes must occur inside the interval $[D_{pixel}-\Delta t_{before};D_{pixel}+\Delta t_{after}[$ where D_{pixel} is the date corresponding to the scanning of this pixel by the SEVIRI radiometer.
    - Local descriptor 016194 gives the number of positive cloud-to-ground lightning flashes occurring below the cloud system. For a given pixel of the cloud system, the lightning flashes must occur inside the interval $[D_{pixel}-\Delta t_{before};D_{pixel}+\Delta t_{after}[$ where D_{pixel} is the date corresponding to the scanning of this pixel by the SEVIRI radiometer.
    - Local descriptor 016195 gives the number of intracloud lightning flashes occurring in the vicinity of the cloud system. For a given pixel of the cloud system, the lightning

flashes must occur inside the interval $[D_{pixel}-\Delta t_{before};D_{pixel}+\Delta t_{after}[$ where D_{pixel} is the date corresponding to the scanning of this pixel by the SEVIRI radiometer.

3.13.6 - Cloud Trajectory format

At the end of the processing, PGE11 provides a consolidated record of all achieved trajectories during the time slot. The trajectory file is coded in ascii format. The name of the file depends on the frequency of production:

- Monthly (-freq_traj 0)
  *YYYYMM*_traject_*region_name_Tcold_Twarm_delta_tempe_SURFMIN*
- Daily (-freq_traj 1 default)
  *YYYYMMDD*_traject_*region_name_Tcold_Twarm_delta_tempe_SURFMIN*
- Each slot (-freq_traj 2)
  *YYYYMMDDHHmm*_traject_*region_name_Tcold_Twarm_delta_tempe_SURFMIN*

The missing value is –99999

This file is organized in rows. The first character differentiates different kinds of lines:

- a line beginning with 'T' indicates the beginning of the description of a whole trajectory. The description begins from the first detected cell to the last one, sequentially.
- Each cell is described by a group of different lines (I, S, S2, X, H, L) each documenting a particular aspect of the concerned cell
  - Lines beginning with 'I' = full identification of the cell
  - Lines beginning with 'S' = satellite morphology and radiative characteristics of tracked cell ('S2' = characteristics of corresponding tower top cell)
  - Lines beginning with 'X' = radiative and temporal characteristics of additional satellite channels, information from other PGEs or from NWP data
  - Lines beginning with 'H' = Vertical description of cell
  - Lines beginning with 'L' = association with lightning activity

1. Line “T”

The T line ("Path") describes a trajectory. The cells that compose it are outlined in the following lines.

Format:

T ch2 ch3 ch4 … ch14 ch15 ch16

ch2: The type of trajectory:
- 0: Path not convective
- 1: Trajectory convective
- 2: *internal use*

ch3: Flag test cutoff temporal trajectory
- 0: No break
- 1: The system has been detected just after a missing image
- 2:Trajectory with missing time step
- 3: The cutoff spatial index is not zero for at least one cell of the trajectory

- 4: 1 & 2
- 5: 1 & 3
- 6: 2 & 3
- 7: 1, 2 & 3
- 14: End of episode (edge of domain)

ch4: Flag test cutoff spatial trajectory

- 0: No break
- 1: Cell touching the edge of the domain
- 2: Pixel (s) of incalculable value to the cell
- 3: 1 & 2

ch5: The duration in minutes
ch6: The number of the first cell of the trajectory
ch7: The start date (Format YYYYMMDDhhmm)
ch8: The end date (Format YYYYMMDDhhmm)
ch9: Characteristic of trajectory start

- Normal: 'No'
- After a split 's'
- After a merge: 'g'
- After a complex case (undefined: merge + split) 'c'
- Error code: '.'

ch10: Number of cells integrated over the trajectory
ch11: Number of cells expelled during the course (cell split)
ch12: Characteristic of closure

- Normal: 'No'
- Termination in split case: 's'
- Termination in merge case: 'g'
- Termination in complex case: 'c'
- Error code: '.'

ch13: *internal use*
ch14: *internal use*
ch15: *internal use*
ch16: The probability of error of the method of discrimination (in%)

2. Line "I"

The "I" line identifies a cell.

Format:

I ch2 ch3 ch4 ch5 ch6 ch7 ch8 ch9 ch10 ch11 ch12 ch13 ch14

ch2: The date of the cell (Format YYYYMMDDhhmm)
ch3: His number (internal functioning of PGE11)
ch4: The cell identifier (Format YYYYMMDDhhmm_ <temperature of threshold> _ <latitude gravity center> _ <longitude gravity center >)
ch5: Its type (0 to 10)

- 0: diagnosis not convective (static model results)
- 1: diagnosis convective (static model results)
- 2: *internal use*
- 3: cell previously convective and declassified
- 4 & 5: convective nature of inherited primary link (5 if under development stage)
- 6 & 7: convective nature inherited a secondary link (7 if under development stage)

- 8 & 9 & 10: undefined

ch6: the likelihood of error diagnostics above (%) (-99999 if not diagnostic)
ch7: class of cell

- 0: mature Tmin <= -40 °C
- 1: mature transition Tmin <= -40 °C or Threshold temperature <=- 35 °C
- 2: Cold transition Tmin <= -35 °C or Threshold temperature <=- 25 °C
- 3: Warm transition Tmin <= -25 °C or Threshold temperature <=- 15 °C
- 4: Warm transition Tmin <= -15 °C or Threshold temperature <=- 5 °C
- 5: Hot cell (no active discrimination): Threshold temperature > -5 °C

ch8: the cell class at diagnosis convective (-99999 otherwise)

- 0: mature Tmin <= -40 °C
- 1: mature transition Tmin <= -40 °C or Threshold temperature <=- 35 °C
- 2: Cold transition Tmin <= -35 °C or Threshold temperature <=- 25 °C
- 3: Warm transition Tmin <= -25 °C or Threshold temperature <=- 15 °C
- 4: Warm transition Tmin <= -15 °C or Threshold temperature <=- 5 °C

ch9: age (minutes) in the class
ch10: age (minutes) convective (-99999 otherwise)
ch11: history (minutes) than available with 3 channels IR10.8, WV6.2, WV7.3
ch12: history (minutes) than available with 2 channels IR10.8, WV6.2
ch13: history (minutes) than available with channel IR10.8
ch14: history (minutes) with the maximum available channel IR10.8 without time interruption

3. Line “S” (or “S2”)

The S line ("satellite") gives the satellite characteristics of the cell (identified at the line 'I' preceding the line).

Format:

S ch2 ch3 ch4 ch5 ch6 ch7 … ch27 ch28 ch29 ch30 ch31

ch2: Date of the cell (Format YYYYMMDDhhmm)
ch3: His number (internal functioning of PGE11)
ch4: Threshold temperature at which the cell is defined
ch5: Number of the cell into the threshold process
ch6: Position of gravity center: Latitude
ch7: Position of gravity center: Longitude
ch8: Position of weighted gravity center: Latitude
ch9: Position of weighted gravity center: Longitude
ch10: Average temperature of the cell
ch11: Standard deviation of cell temperature
ch12: Minimum temperature of the cell
ch13: Area (km2)
ch14: Minor axis of the ellipse approaching the cell (in km)
ch15: Major axis of the ellipse approaching the cell (in km)
ch16: Orientation of the ellipse approaching the cell (angle in degrees from north)
ch17: *Internal use*
ch18: *Internal use*
ch19: *Internal use*
ch20: Average temperature gradient on the cell
ch21: Average of periphal gradient of temperature on the cell
ch22: Quantile 95% of previous attribute

ch23: Number of pixels on the periphery of the cell
ch24: Speed of movement in the X axis (horizontal) (pixels / hour)
ch25: Speed of movement in the Y axis (vertical) (pixels / hour)
ch26: cooling rate of the cell based on the minimum temperature (° C / h and positive when Tmin decreases)
ch27: Maximum height of the cloud (in meters)
ch28: height of cloud base (otherwise -99999)
ch29: Pixel location of the minimum temperature: Latitude
ch30: Pixel location of the minimum temperature: Longitude
ch31: Closest lightning = distance (in pixels) of the nearest impact

4. Line "X"

The X line describes the characteristics of additional channels, additional PGEs or NWP data of the cell (identified at the line 'I' preceding the line).

Format:

X ch2 ch3 ch4 ch5 ch6 ch7 … ch45 ch46 ch47 ch48 ch49

ch2: Date of the cell (Format YYYYMMDDhhmm)
ch3: His number (internal functioning of PGE11)
ch4: Attribute external Classification Cloud = cloud type predominant (PGE02)
ch5: Cloud Field Classification = surface corresponding proportion
ch6: Cloud Field Classification = external quality
ch7: Attribute WV = Minimum temperature channel WV6.2
ch8: Attribute WV = rate of cooling channel WV6.2
ch9: Attribute WV = Minimum temperature channel WV7.3
ch10: Attribute WV = rate of cooling channel WV7.3
ch11: Attribute WV = Brightness Temperature Difference WV-IR max value on cell
ch12: Attribute WV = Brightness Temperature Difference WV-IR 75% quantile
ch13: Attribute WV = Brightness Temperature Difference WV-IR 90% quantile
ch14: Attribute WV = Brightness Temperature Difference WV-IR report (nb relevant pixels surrounded by relevant pixels SIG) / (nb relevant pixels)
ch15: Attribute WV = Brightness Temperature Difference WV62-WV73 max value
ch16: Attribute WV = Brightness Temperature Difference WV62-WV73 quantile 75%
ch17: Attribute WV = Brightness Temperature Difference WV62-WV73 quantile 90%
ch18: Attribute WV = Brightness Temperature Difference WV62-WV73 report (nb relevant pixels surrounded by relevant pixels SIG) / (nb relevant pixels)
ch19: Attribute = Max VIS reflectance channel VIS0.6
ch20: Attribute VIS = rate of change of channel VIS0.6
ch21: Attribute IR16 = Maximum reflectance channel IR1.6
ch22: Attribute IR16 = rate of change of channel IR1.6
ch23: Attribute = VIS Reflectance Difference IR1.6-VIS0.6 max value
ch24: Attribute = VIS Reflectance Difference IR1.6-VIS0.6 quantile 75%
ch25: Attribute = VIS Reflectance Difference IR1.6-VIS0.6 quantile 90%
ch26: Attribute = VIS Reflectance Difference IR1.6-VIS0.6 report (nb relevant pixels surrounded by relevant pixels SIG) / (nb relevant pixels)
ch27: Attribute IR = Minimum temperature channel IR3.9
ch28: Attribute = IR cooling rate channel IR3.9
ch29: Attribute IR = Minimum temperature channel IR8.7
ch30: Attribute = IR cooling rate channel IR8.7

ch31: Attribute IR = Minimum temperature channel IR12.0
ch32: Attribute = IR cooling rate channel IR12.0
ch33: Attribute = IR Brightness Temperature Difference IR3.9-IR10.8 max value
ch34: Attribute = IR Brightness Temperature Difference IR3.9-IR10.8 quantile 75%
ch35: Attribute = IR Brightness Temperature Difference IR3.9-IR10.8 quantile 90%
ch36: Attribute = IR Brightness Temperature Difference IR3.9-IR10.8 report (nb relevant pixels surrounded by relevant pixels SIG) / (nb relevant pixels)
ch37: Attribute = IR Brightness Temperature Difference IR8.7-IR10.8 max value
ch38: Attribute = IR Brightness Temperature Difference IR8.7-IR10.8 quantile 75%
ch39: Attribute = IR Brightness Temperature Difference IR8.7-IR10.8 quantile 90%
ch40: Attribute = IR Brightness Temperature Difference IR8.7-IR10.8 report (nb relevant pixels surrounded by relevant pixels SIG) / (nb relevant pixels)
ch41: Attribute = IR Brightness Temperature Difference IR12.0-IR10.8 max value
ch42: Attribute = IR Brightness Temperature Difference IR12.0-IR10.8 quantile 75%
ch43: Attribute = IR Brightness Temperature Difference IR12.0-IR10.8 quantile 90%
ch44: Attribute = IR Brightness Temperature Difference IR12.0-IR10.8 report (nb relevant pixels surrounded by relevant pixels SIG) / (nb relevant pixels)
ch45 : Attribute NWP= predominant value over cell of convective mask: 0=NOCONV, 1=NEUTRAL, 1=CONV
ch46 : Attribute NWP= kind of convective index: 0=K index, 1=Lifted index, 2=Showalter index
ch47 : Attribute NWP= value of convective index (10% or 90%percentile depending on index)
ch48 : Attribute NWP= median value over cell of Tropopause Temperature
ch49 : Attribute NWP= median value over cell of Tropopause Pressure
ch50 : Attribute Cloud Phase=water (1) or ice (2) or mixed (3) (PGE02)
ch51 : Attribute maximum convective rain rate (mm/h) from CRR (PGE05)
ch52 : Attribute quality of convective rain rate from CRR (PGE05)

5. Line "O"

The "O" line documents overshoot characteristics associated with the cell defined in line "I". There are as many "O" lines as overshoots in the cell. In practice cells with more than one overshoot are not frequent.

Each overshoot is described by at least one point, corresponding to the main characteristic (minimum temperature and/or maximum BTD, etc …). The other points describe same overshoot.

O ch2 ch3 ... ch 22 ch23 ....

ch2: Date of the cell (Format YYYYMMDDhhmm)
ch3: its number (internal functioning of PGE11)
ch4 : main characteristics of overshoot : "IRMin", "BTDMax", "ReflMax"
ch5 : temperature (°C) of overshoot (IR10.8)
ch6 : horizontal gradient (°C/km)
ch7 : maximum temperature difference (°C) betwwen overshoot and surrounding pixels (always >= 0)
ch8 : number of warmer surrounding pixels
ch9 : BTD=WV6.2-IR10.8 (always >= 0)
ch10 : nb of pixels with BTD >=0
ch11 : WBTD=WV6.2-WV7.3 (when available)
ch12 : BTD4=IR10.8-IR8.7 (when available)
ch13 : BTD5=IR12.0-IR10.8 (when available)
ch14 : reflectance (VIS06) (when available)
ch15 : horizontal gradient of reflectance (VIS06) (when available)
ch16 : Reflectance Difference IR1.6-VIS0.6 (when available)

ch17 : reflectance (HRV) (missing)
ch18 : horizontal gradient of reflectance (HRV) (missing)
ch19 : pressure gap to tropopause (hPa)
ch20 : temperature gap to tropopause (°C)
ch21 : nb of points belonging to overshoot (always >=1)
ch22 : latitude of main point of overshoot
ch23 : longitude of main point of overshoot
ch24 : (latitude of next point)
ch25 : (longitude of next point)

.../...

6. Line "H"

The "H" line documents the vertical structure associated to the cell defined in line "I"

Format:

H ch2 ch3 ch4 ch5 ch6 ch7 …

ch2: Date of the cell (Format YYYYMMDDhhmm)
ch3: His number (internal functioning of PGE11)
ch4: The threshold temperature of the hottest temperature for which the surface of the system is processed
ch5: The temperature increment between two consecutive surfaces
ch6: The number N of surfaces evaluated
ch7 to ch X (X = 6 + N): The ordered surfaces as follows: S (ch4), S (ch4 + ch5), S (ch4 +2*ch5), ..., S (ch4 + (N-1)*ch5)

7. Line "L"

The L line ("Lightning") documents the electrical activity of the cell (identified with the line 'I' preceding the line)

Format:

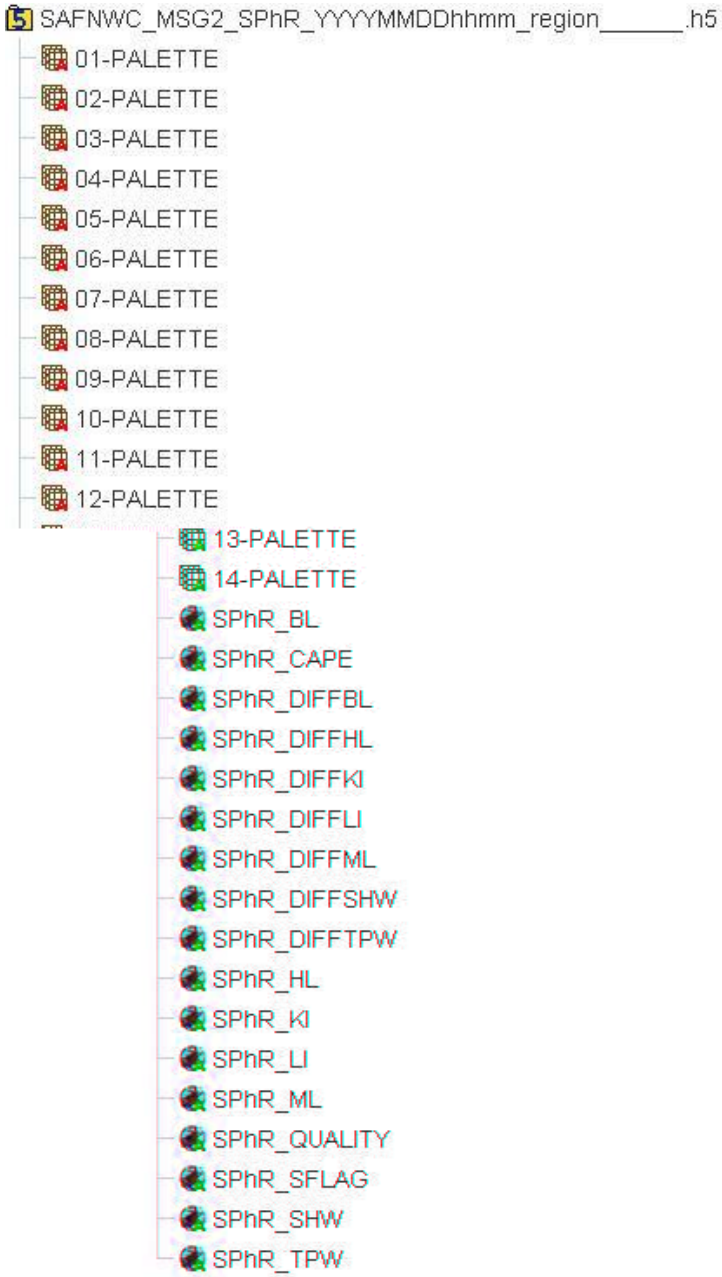
L ch2 ch3 ch4 ch5 ch6 ch7 … ch43 ch44 ch45 ch46 ch47

ch2: Date of the cell (Format YYYYMMDDhhmm)
ch3: His number (internal functioning of PGE11)
ch4: Number impact intra-cloud lightning in the cell in the]date-date_before; date+date_after]
ch5: Number of negative impacts lightning in the cell in the]date-date_before; date+date_after]
ch6: Number of positive impacts lightning in the cell the]date-date_before; date+date_after]
ch7: Average intensity of negative impacts in the the]date-date_before; date+date_after]
ch8: Standard deviation of intensity of negative impacts in the the]date-date_before; date+date_after]
ch9: Average intensity of positive impacts in the the]date-date_before; date+date_after]
ch10: Standard deviation of intensity of positive impacts in the the]date-date_before; date+date_after]
ch11 to ch16: for interval]first cell of trajectory, date-20 ']
ch11: Number of lightning negative impacts in the cell
ch12: Number of positive impacts lightning in the cell

ch13: Average intensity of negative impacts in the cell
ch14: Standard deviation of intensity of negative impacts in the cell
ch15: Average intensity of positive impacts in the cell
ch16: Standard deviation of intensity of positive impacts in the cell
ch17 to ch22: for interval]date –20', date-15']
ch17: Number of lightning negative impacts in the cell
ch18: Number of positive impacts lightning in the cell
ch19: Average intensity of negative impacts in the cell
ch20: Standard deviation of intensity of negative impacts in the cell
ch21: Average intensity of positive impacts in the cell
ch22: Standard deviation of intensity of positive impacts in the cell
ch23 to ch28: for interval]date-15', date-10']
ch23: Number of lightning negative impacts in the cell
ch24: Number of positive impacts lightning in the cell
ch25: Average intensity of negative impacts in the cell
ch26: Standard deviation of intensity of negative impacts in the cell
ch27: Average intensity of positive impacts in the cell
ch28: Standard deviation of intensity of positive impacts in the cell
ch29 to ch34: for interval]date-10', date-5']
ch29: Number of lightning negative impacts in the cell
ch30: Number of positive impacts lightning in the cell
ch31: Average intensity of negative impacts in the cell
ch32: Standard deviation of intensity of negative impacts in the cell
ch33: Average intensity of positive impacts in the cell
ch34: Standard deviation of intensity of positive impacts in the cell
ch35 to ch40: for interval]date-5', date]
ch35: Number of lightning negative impacts in the cell
ch36: Number of positive impacts lightning in the cell
ch37: Average intensity of negative impacts in the cell
ch38: Standard deviation of intensity of negative impacts in the cell
ch39: Average intensity of positive impacts in the cell
ch40: Standard deviation of intensity of positive impacts in the cell
ch41 to ch46: for interval]date, date+inf]
ch41: Number of lightning negative impacts in the cell
ch42: Number of positive impacts lightning in the cell
ch43: Average intensity of negative impacts in the cell
ch44: Standard deviation of intensity of negative impacts in the cell
ch45: Average intensity of positive impacts in the cell
ch46: Standard deviation of intensity of positive impacts in the cell
ch47: Date of first impact of lightning associated with that cell (YYYYMMDDHHMMSS)

3.11 SEVIRI PHYSICAL RETRIEVAL (SPHR) PRODUCT

This product gives information on total precipitable water (TPW), layer precipitable water (Boundary Layer (BL), Medium Layer (ML), High Layer (HL)) as well as Lifted Index (LI), K-Index (KI) and Showalter Index (SHW) derived from the temperature and moisture profiles retrieved from the SEVIRI infrared channels. Also the differences between the main parameters and the calculated from the background NWP profiles, are stored (SPhR_DIFFxx).



01-PALETTE is applied to the BL (see [AD.4.])
02-PALETTE is applied to the ML (see [AD.4.])
03-PALETTE is applied to the HL (see [AD.4.])
04-PALETTE is applied to the LI (see [AD.4.])
05-PALETTE is applied to the TPW (see [AD.4.])
06-PALETTE is applied to the SPhR_DIFFBL (see [AD.4.])
07-PALETTE is applied to the SPhR_DIFFML (see [AD.4.])
08-PALETTE is applied to the SPhR_DIFFHL (see [AD.4.])
09-PALETTE is applied to the SPhR_DIFFLI (see [AD.4.])
10-PALETTE is applied to the SPhR_DIFFKI (see [AD.4.])
11-PALETTE is applied to the SPhR_DIFFTPW (see [AD.4.])
12-PALETTE is applied to the SPhR_DIFFSHW (see [AD.4.])
13-PALETTE is applied to the SPhR_KI (see [AD.4.])
14-PALETTE is applied to the SPhR_SHW (see [AD.4.])

Figure 8: SPhR product file structure

Each pixel in the SAF output file will contains next parameters with the following information:

Parameter	Comment
SPhR_BL	Precipitable water in boundary layer (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 2 : pixel surface pressure less than 850 hPa 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: SPhR_BL (mm) = Scale * Counts + Offset Where: *Scale = 35/119* *Offset = -8 * 35/119* Range [128-255] for Cloudy pixels IR value (configurable in the model configuration file) degraded to 7 bits
SPhR_ML	Precipitable water in medium layer (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: SPhR_ML (mm) = Scale * Counts + Offset Where: *Scale = 45/119* *Offset = -8 * 45/119* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits
SPhR_HL	Precipitable water in high layer (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: SPhR_HL (mm) = Scale * Counts + Offset Where: *Scale = 8/119* *Offset = -8 * 8/119* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits
SPhR_TPW	Total Precipitable Water (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: TPW(mm) = Scale * Counts + Offset Where: *Scale = 70/119* *Offset = -8 * 70/119* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits

<table>
<tr><th>Parameter</th><th>Comment</th></tr>
<tr><td>SPhR_LI</td><td>Lifted index (º C)

Range [0-7] Reserved
0 : specific value for zenith angles > zenith angle threshold
4 : undefined input SEVIRI value (missing data)

Range [8-127] for Cloud-Free pixels:
SPhR_LI ()= Scale * Counts + Offset
Where:
Scale = -40/119Offset = 25-(8*-40/119)

<table><tr><th>LI value</th><th></th></tr><tr><td>0 <= v</td><td>Stable</td></tr><tr><td>-3 <= v < 0</td><td>Slightly Unstable</td></tr><tr><td>-6 <= v < -3</td><td>Unstable</td></tr><tr><td>-9 <= v < -6</td><td>Very Unstable</td></tr><tr><td>v < -9</td><td>Extremely Unestable</td></tr></table>
Range [128-255] for Cloudy pixels:
IR value (configurable in the model configuration file) degraded to 7 bits</td></tr>
<tr><td>SPhR_KI</td><td>K-index (ºC)

Range [0-7] Reserved
0 : specific value for zenith angles > zenith angle threshold
2 : pixel surface pressure less than 850 hPa
4 : undefined input SEVIRI value (missing data)

Range [8-127] for Cloud-Free pixels:
SPhR_KI ()= Scale * Counts + Offset
Where:
Scale = 60/119 Offset = -8*60/119

<table><tr><th>K-Index value</th><th>Storm probability</th></tr><tr><td>v < 15</td><td>≈0%</td></tr><tr><td>15 <= v < 20</td><td>< 20%</td></tr><tr><td>20 <= v < 25</td><td>20 – 40 %</td></tr><tr><td>25 <= v < 30</td><td>40 – 60 %</td></tr><tr><td>30 <= v < 35</td><td>60 – 80 %</td></tr><tr><td>35 <= v < 40</td><td>80 – 90 %</td></tr><tr><td>40 <= v</td><td>> 90 %</td></tr></table>
Range [128-255] for Cloudy pixels:
IR value (configurable in the model configuration file) degraded to 7 bits</td></tr>
<tr><td>SPhR_SHW</td><td>Showalter Index (ºC)

Range [0-7] Reserved
0 : specific value for zenith angles > zenith angle threshold
2 : pixel surface pressure less than 850 hPa
4 : undefined input SEVIRI value (missing data)

Range [8-127] for Cloud-Free pixels:
SPhR_SHWALTER()= Scale * Counts + Offset
Where:
Scale = -40/119Offset = 25-(8*-40/119)

<table><tr><th>Showalter value</th><th></th></tr><tr><td>0 <= v</td><td>Stable</td></tr><tr><td>-3 <= v < 0</td><td>Marginal instability</td></tr><tr><td>-6 <= v < -4</td><td>Large instability</td></tr><tr><td>v < -6</td><td>Extreme instability</td></tr></table>
Range [128-255] for Cloudy pixels:
IR value (configurable in the model configuration file) degraded to 7 bits</td></tr>
</table>

Parameter	Comment
SPhR_DIFFBL	Boundary layer differences between final profile and background (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: SPhR_DIFFBL(mm) = Scale * Counts + Offset Where: *Scale = 3/119* *Offset = -1.5 – (8*3/119)* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits
SPhR_DIFFML	Medium layer differences between final profile and background (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: SPhR_DIFFML(mm) = Scale * Counts + Offset Where: *Scale = 5/119* *Offset = -2.5 – (8*5/119)* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits
SPhR_DIFFHL	High layer differences between final profile and background (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: SPhR_DIFFHL(mm) = Scale * Counts + Offset Where: *Scale = 1.5/119* *Offset = -0.75 – (8*1.5/119)* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits
SPhR_DIFFTPW	Total Precipitable Water differences between final profile and background (mm) Range [0-7] Reserved 0 : specific value for zenith angles > zenith angle threshold 4 : undefined input SEVIRI value (missing data) Range [8-127] for Cloud-Free pixels: SPhR_DIFFTPW(mm) = Scale * Counts + Offset Where: *Scale = 4/119* *Offset = -1 –(8*5/119)* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits
SPhR_DIFFLI	Lifted index differences between final profile and background. SPhR_DIFFLI() = Scale * Counts + Offset Where: *Scale = 5/119* *Offset = -2.5 – (8*5/119)* Range [128-255] for Cloudy pixels: IR value (configurable in the model configuration file) degraded to 7 bits

<table>
<tr><th>Parameter</th><th>Comment</th></tr>
<tr><td>SPhR_DIFFKI</td><td>K-index differences between final profile and background.

Range [0-7] Reserved
0 : specific value for zenith angles > zenith angle threshold
4 : undefined input SEVIRI value (missing data)

Range [8-127] for Cloud-Free pixels:
SPhR_DIFFKI() = Scale * Counts + Offset
Where:
Scale = 14/119 Offset = -7 – (8*14/119)

Range [128-255] for Cloudy pixels:
IR value (configurable in the model configuration file) degraded to 7 bits</td></tr>
<tr><td>SPhR_DIFFSHW</td><td>Showalter differences between final profile and background.

Range [0-7] Reserved
0 : specific value for zenith angles > zenith angle threshold
4 : undefined input SEVIRI value (missing data)

Range [8-127] for Cloud-Free pixels:
SPhR_DIFFSHW() = Scale * Counts + Offset
Where:
Scale = 5/119 Offset = -2.5 – (8*5/119)

Range [128-255] for Cloudy pixels:
IR value (configurable in the model configuration file) degraded to 7 bits</td></tr>
<tr><td>SPhR_QUALITY</td><td>16 bit-mask indicating the quality status:

<table>
<tr><td>Bit #</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Data</td><td colspan="8">Delta BT RMS</td><td colspan="6">gamf</td><td colspan="2">Convergency error</td></tr>
</table>

Where
Delta BT RMS: Root mean square of differences between the SEVIRI and calculated brightness temperature.

gamf: Gamma parameter

Convergency error: Number of iterations where the convergency has failed.</td></tr>
<tr><td>SPhR_SFLAG</td><td>8 bit-mask indicating the processing status:

<table>
<tr><td>Bit #</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>Data</td><td colspan="3">[TBD]</td><td colspan="3">Retrieval iterations</td><td>Status Retrieval flag</td><td>Cloudy flag</td></tr>
</table>

Where
Cloudy flag:
(0) Cloudy pixel
(1) Cloud free pixel

Status Retrieval flag:
(0) Only first guess retrieval was performed for the pixel
(1) Physical retrieval was performed for the pixel

Retrieval iterations:
(0) Pixel not processed
(1) Pixel processed with first guess
(2) Pixel processed with 1st retrieval iteration
(3) Pixel processed with 2nd retrieval iteration
(4) Pixel processed with 3rd retrieval iteration</td></tr>
<tr><td>SPhR_CAPE</td><td>[TBD] Not used</td></tr>
</table>

Table 14: SPhR parameters

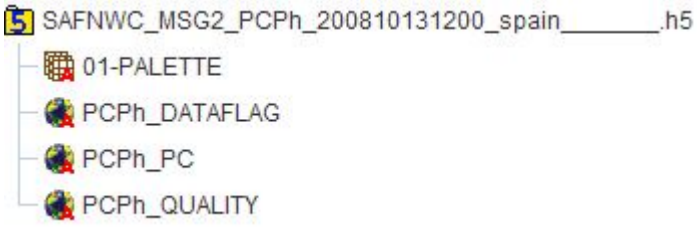
SPhR product is coded in HDF5 format.

3.12 PRECIPITATION PRODUCTS FROM PHYSICAL PROPERTIES (PPH)

This product gives information on Precipitating Clouds from Physical Properties and Convective Rainfall Rate from Physical Properties, which are provided in two separate HDF5 files: PCPh and CRPh.

3.12.1 Precipitating Clouds from Physical Properties (PCPh)

The PCPh product file structure is shown below:



01-PALETTE is applied to the PC(see [AD.4.])

Figure 9: PCPh product file structure

Three different parameters are given:

- **PCPh_PC: Total precipitation likelihood**

  Value range from 0% to 100%, step : 1%

- **PCPh_DATAFLAG**:

5 bits mask indicating the processing status of each pixel:

1 bit for cloud optical thickness, effective radius or phase data missing

0: Cloud optical thickness, effective radius and phase data are available

1: Cloud optical thickness, effective radius or phase data are missing

1 bit for cloud optical thickness or effective radius no computed (Out of the cloud, night time or undefined phase)

0: cloud optical thickness and effective radius computed

1: cloud optical thickness or effective radius no computed

1 bit to indicate if phase data have been computed

0: Phase is water or ice

1: Phase not computed or undefined

1 bit for IR10.8 data missing:

0: IR10.8 data available

1: IR10.8 data missing

1 bit to identify mathematical errors

0: No mathematical error

1: A mathematical error has occurred

0	1	2	3	4	5	6	7
For Reff, COT or Phase data missing	For Reff or COT no computed (Out of the cloud, night time or undefined phase)	To indicate if phase has been computed (*)	For 10.8IR data missing (mandatory for parallax correction)	To identify mathematical errors			

- **PCPh_QUALITY:**

2 bits mask indicating if parallax correction has been applied for each pixel:

1 bit for parallax correction:

0: No correction

1: Corrected by parallax

1 bit for the filled holes after parallax correction

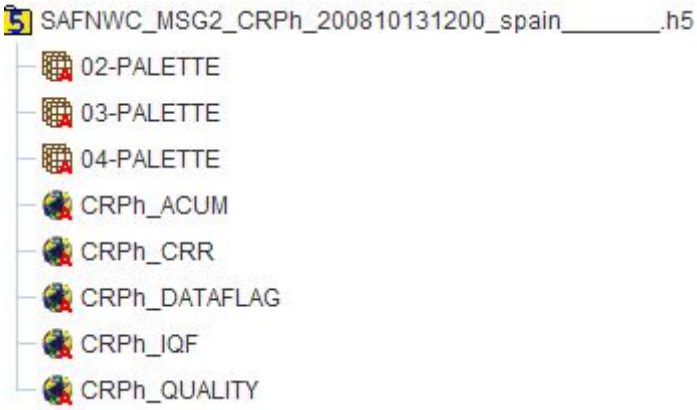
0: No hole due to the parallax correction

1: Hole due to the parallax correction filled by a median filter

0	1	3	2	4	5	6	7
Parallax Correction	Filled holes alter parallax correction						

3.12.2 Convective Rainfall Rate from Physical Properties (CRPh)

The CRPh product files structure is shown below:



02-PALETTE is applied to the CRR(see [AD.4.])
03-PALETTE is applied to the ACUM(see [AD.4.])
04-PALETTE is applied to the IQF(see [AD.4.])

Figure 10: CRPh product file structure

Five different parameters are given:

Parameter	Comment
CRPh_CRR	Convective Rainfall Rate intensity CRPh_CRR(mm/h) = Scale * Counts + Offset Where: *Scale = 0.2* *Offset = 0*

<table>
<tr><td>CRPh_ACUM</td><td>Convective Rainfall Rate Accumulation in mm
CRPh_ACUM(mm) = Scale * Counts + Offset
Where:
Scale = 0.2 Offset = 0</td></tr>
<tr><td>CRPh_IQF</td><td>Illumination condition indicator:
CRPh_IQF = 160.0 * ICP – 8.32
if CRPh_IQF < 0 then CRPh_IQF = 0;
if CRPh_IQF > 100 then CRPh_IQF = 100;
where:
ICP=cos(ZenSAT)*cos(ZenSUN)</td></tr>
<tr><td>CRPh_QUALITY</td><td>3 bits mask indicating if parallax correction has been applied for each pixel:
<table><tr><th>Bit 0</th><th>Bit 1</th><th>Bit 3</th><th>Bit 2</th><th>Bit 4</th><th>Bit 5</th><th>Bit 6</th><th>Bit 7</th></tr><tr><td>Parallax Correction</td><td>Filled holes alter parallax correction</td><td>Lightning information used</td><td></td><td></td><td></td><td></td><td></td></tr></table>1 bit for parallax correction
0: No correction
1: Corrected by parallax
1 bit for the filled holes after parallax correction
0: No hole due to the parallax correction
1: Hole due to the parallax correction filled by a median filter
1 bit for lightning information used
0: No lightning information used
1: Lightning information used</td></tr>
</table>

<table>
<tr><td>CRPh_DATAFLAG</td><td>8 bits mask indicating the processing status of each pixel:

<table>
<tr><th>Bit 0</th><th>Bit 1</th><th>Bit 3</th><th>Bit 2</th><th>Bit 4</th><th>Bit 5</th><th>Bit 6</th><th>Bit 7</th></tr>
<tr><td>For Reff, COT or Phase data missing</td><td>For Reff or COT no computed (Out of the cloud, night time or undefined phase)</td><td>To indicate if phase has been computed (*)</td><td>For 10.8IR data missing (mandatory for parallax correction)</td><td>To identify mathematical errors</td><td colspan="2">(2 bits) hourly accumulation CRPh_CRR band status</td><td>status of the CRPh_CRR pixels used to compute the hourly accumulation</td></tr>
</table>

1 bit for cloud optical thickness, effective radius or phase data missing
0: Cloud optical thickness, effective radius and phase data are available
1: Cloud optical thickness, effective radius or phase data are missing
1 bit for cloud optical thickness or effective radius no computed (Out of the cloud, night time or undefined phase)
0: cloud optical thickness and effective radius computed
1: cloud optical thickness or effective radius no computed
1 bit to indicate if phase data have been computed
0: Phase is water or ice
1: Phase not computed or undefined
1 bit for IR10.8 data missing
0: IR10.8 data available
1: IR10.8 data missing
1 bit to identify mathematical errors
0: No mathematical error
1: A mathematical error has occurred
2 bits for the hourly accumulation CRPh_CRR band status
0: All required bands were available
1: One previous CRPh_CRR band is missing
2: At least two previous CRPh_CRR bands are missing (no consecutive)
3: At least two previous CRPh_CRR bands are missing (some are consecutive)
1 bit for the status of the CRPh_CRR pixels used to compute the hourly accumulation
0: All the pixels used in the computing of the hourly accumulation have their CRPh_DATAFLAG bits set to 0
1: At least one of the pixels used in the computing of the hourly accumulation has at least one of its CRPh_DATAFLAG bits set to 1</td></tr>
</table>

Table 15: CRPh parameters