The EUMETSAT Network of Satellite Application Facilities

NWC SAF

Support to Nowcasting and Very Short Range Forecasting

Product User Manual for the "Convective Rainfall Rate" (CRR - PGE05 v3.1.1)

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3.0	2 March 2009	30	Initial version (content derived from Software User Manual for PGE05 (Convective Rainfall Rate) of the SAFNWC/MSG: scientific part) Indications and recommendations given by the DRI MSG 2009 have been included.
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1. INTRODUCTION

The EUMETSAT "Satellite Application Facilities" (SAF) are dedicated centres of excellence for processing satellite data, and form an integral part of the distributed EUMETSAT Application Ground Segment (http://www.eumetsat.int). This documentation is provided by the SAF on Support to Nowcasting and Very Short Range Forecasting, SAFNWC. The main objective of SAFNWC is to provide, further develop and maintain software packages to be used for Nowcasting applications of operational meteorological satellite data by National Meteorological Services. More information can be found at the SAFNWC webpage, http://www.nwcsaf.org. This document is applicable to the SAFNWC processing package for Meteosat satellites meteorological satellites, SAFNWC/MSG.

1.1 SCOPE OF THE DOCUMENT

This document is the Product User Manual (PUM) for the MSG product PGE05 (CRR) and contains practical information on the characteristics of the product, including the input data and the output product. It also gives information about the algorithm's implementation and configuration.

1.2 SCOPE OF OTHER DOCUMENTS

The Algorithm Theoretical Basis Document contains information about the product objectives, the algorithm scientific description, the needed input data and the output product [AD.1].

The Validation Report version v1.0 of the PGE05 document [AD.2], showing the validation results for PGE05 v3.1, that give information about the extended validation performed over Spain for a complete year period instead of the summer period and the validation over Hungary against radar data. Besides, a comparison with the validation performed by OMSZ against rain gauge data is also presented in this document.

The Interface Control Documents ICD/1 [AD.3] describes the External and Internal Interfaces of the SAFNWC/MSG software.

The Interface Control Documents ICD/3 [AD.4] describes the input and output data formats of the SAFNWC/MSG software.

The Architectural Design Document [AD.5] presents the general architecture of the SAFNWC software, and gives details on each PGE (interface with the SAFNWC software, architecture of each PGE).

1.3 SOFTWARE VERSION IDENTIFICATION

This document describes the algorithm implemented in the PGE05 version v3.1 of SAFNWC software package delivery.

Please note that the main content of this document is the same as in the document delivered with version 2011 and only minor adaptation in dates and references have been made as well as minor modifications according to SPR 485/SMR 457.

1.4 IMPROVEMENTS FROM PREVIOUS VERSION

As lightning activity is related to convection, this information has been added as a new input in order to improve the product results. This new input is optional and entails a number of configurable parameters that are described in the *Keywords description for Convective Rainfall Rate (CRR)* section.

The improvements are shown in the Validation Report [AD.2].

Due to the incorporation of the lightning information input, the currently CRR_QUALITY output contains more information. This information can also be found in the Interface Control Document [AD.3].

During the subjective validation it has been confirmed the negative effect of using the solar channel when the sun zenith angle is higher than 80º. So it is recommended setting the keyword "DAY_NIGHT_ZEN_THRESHOLD" to 80. This will be the default value used in the CRR v3.1 model configuration file.

1.5 ACRONYMS

ATBD	Algorithm Theoretical Basis Document
CRR	Convective Rainfall Rate
BALTRAD	Baltic Radar Network
CSI	Critical Success Index
2-D	Bi-dimensional
3-D	Tri-dimensional
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAR	False Alarm Ratio
HRIT	High Rate Information Transmission
ICD	Interface Control Document
INM	Instituto Nacional de Meteorología
IR	Infrared
MAE	Mean Absolute Error
ME	Mean Error
MSG	Meteosat Second Generation
NWCLIB	Nowcasting SAF Library
OMSZ	Hungarian Meteorological Service
PC	Percentage of Corrects
PGE	Product Generation Element
POD	Probability of Detection
PUM	Product User Manual
PWRH	Moisture Correction Factor
RAINSAT	Rainfall Satellite Technique

RMS	Root Mean Square error
SAF	Satellite Application Facility
SAF NWC	Satellite Application Facility for Nowcasting
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SUM	Software User Manual
SW	Software
VIS	Visible
WV	Water Vapour

1.6 REFERENCES

1.6.1 Applicable Documents

Reference	Title	Code	Vers	Date
[AD.1]	Algorithm Theoretical Basis Document for "Convective Rainfall Rate" (CRR - PGE05 v3.1.1)	SAF/NWC/CDOP/INM/SCI/ATBD/05	3.1.2	15/02/12
[AD.2]	Validation Report for "Convective Rainfall Rate" (CRR-PGE05 v3.1)	SAF/NWC/CDOP/INM/SCI/VR/06	1.0.1	01/04/11
[AD.3]	Interface Control Document for the External and Internal Interfaces of the SAFNWC/MSG	SAF/NWC/CDOP/INM/SW/ICD/1	6.0	15/02/12
[AD.4]	SAFNWC/MSG Output Products Format Definition	SAF/NWC/CDOP/INM/SW/ICD/3	6.0	15/02/12
[AD.5]	Architectural Design Document for the AEMET- related PGEs of the SAFNWC/MSG	SAF/NWC/CDOP/INM/SW/AD/4	6.0	15/02/12
[AD.6]	NWCSAF Product Requirements Document	SAF/NWC/CDOP/INM/MGT/PRD	1.2	17/11/11

Table 1: List of Applicable Documents

1.6.2 Reference Documents

Reference	Title
[RD.1]	Lábó, E., Putsay, M., Kocsis, Z. and Szenyán, I. 2009: Cross-verification of the Rapid Developing Thunderstorm and the precipitation products of the Nowcasting and Very Short-Range Forecasting SAF. Help Desk VS Reports.
[RD.2]	

Table 2. List of Reference Documents

2. DESCRIPTION OF THE CONVECTIVE RAINFALL RATE (CRR) PRODUCT

2.1 GOAL OF THE CONVECTIVE RAINFALL RATE (CRR) PRODUCT

The CRR algorithm developed within the SAF NWC context estimates rainfall rates from convective systems, using IR, WV and VIS MSG SEVIRI channels and calibration matrices generated from both SEVIRI and Radar data.

This product can be obtained for every SEVIRI slot that is every 15 minutes in the normal mode. It is also prepared to run in the Rapid Scan mode with a temporal resolution of 5 minutes.

2.2 ALGORITM OUTLINE OF CONVECTIVE RAINFALL RATE (CRR)

2.2.1 Processing of the Convective Rainfall Rate (CRR)

The basic CRR mm/h value for each pixel is obtained from the calibration matrices.

Composite radar data are compared pixel by pixel with geographically matched MSG data in the same resolution, and the rainfall rate R is obtained, as a function of two or three variables (IR brightness temperature, IR-WV brightness temperature differences and normalised VIS reflectances):

R = f (IR, IR-WV, VIS), for 3-D calibration

R = f (IR, IR-WV), for 2-D calibration

The retrieval of the basic CRR values can be latitude dependant or not. This option can be chosen by the user through the CRR model configuration file. See *List of configuration parameters for Convective Rainfall Rate (CRR)* of this document.

When the CRR retrieval is latitude dependant, it is needed to use Spanish and difference matrices. The difference matrices are built with the differences between the elements of the Nordic and Spanish matrices.

When the CRR retrieval is not latitude dependant, the basic rainfall rate retrieved over a particular region will be directly read from regional matrices. For the time being only Spanish and Nordic regional matrices have been computed, nevertheless users can include and name their own regional matrices.

A filtering process is performed in order to eliminate stratiform rain data which are not associated to convective clouds: the obtained basic CRR data are set to zero if all the pixels in a grid of a selected semisize (def. value: 3pix) centred on the pixel have a value lower than a selected threshold (def. value: 3mm/h). The threshold and the size of the grid can be modified by the user through the model configuration file.

To take into account the temporal and spatial variability of the cloud tops, the amount of moisture available to produce rain and the influence of orographic effects on the precipitation distribution, several correction factors can be applied to the basic CRR value by the users. So that, the possible correction factors are the moisture correction, the cloud top growth/decaying rates or evolution correction, the cloud top temperature gradient correction, the parallax correction and the orographic correction.

At this stage, the CRR precipitation pattern computed in the previous step is combined with a precipitation pattern derived through a lightning algorithm.

At the end of the process the final values of the CRR rainfall rates are used in order to obtain five different outputs as described in section *2.3.*

2.2.2 Convective Rainfall Rate (CRR) calibration matrices description

All the calibration matrices must be placed in $SAFNWC/import/Aux_data.

2.2.2.1 2-D Matrix

This matrix provides the basic CRR Rainfall rate value (mm/h) depending on the IR brightness temperature and the IR-WV brightness temperature differences.

The T10.8 range is divided into 51 classes from 203K to 303K, every 2K.

The IR-WV brightness temperature differences are divided into 41 classes from -21K to 59K, every 2K.

Axis	Parameter	Units	Origin of axis	Step	Number of elements
1	IR108-WV62	K	-21K	+2 K	41
2	IR108	K	203 K	+2 K	51

Table 3. 2D Calibration matrices structure

2.2.2.2 3-D Matrix

This matrix provides the basic CRR Rainfall rate value (mm/h) depending on the IR brightness temperature, the IR-WV brightness temperature differences and the VIS normalized reflectances.

The T10.8 range is divided into 19 classes from 203K to 275K, every 4K.

The IR-WV brightness temperature differences are divided into 40 classes from -19K to 59K, every 2K.

The VIS normalized reflectances range is divided into 50 classes from 1% to 99% every 2%.

Axis	Parameter	Units	Origin of axis	Step	Number of elements
1	IR108-WV62	K	-19 K	+2 K	40
2	VIS-N	%	1 %	+2 %	50
3	IR108	K	203 K	+4 K	19

Table 4. 3D Calibration matrices structure

2.2.2.3 Difference Matrices

The 2-D and 3-D difference matrices, which are necessary in order to apply the latitude correction to the basic CRR rainfall rate retrieved, have the same structure as the 2-D and 3-D ones described above. These matrices have been obtained with the differences between the elements of the Nordic and Spanish matrices.

2.2.2.4 Calibration matrices use

The latitude dependant option is used by default. In this case two different matrices are needed: the Spanish and the difference matrices. The names of these matrices for this option are CRR_EUR_2D.dat and CRR_EUR_3D.dat for the basic values, and CRR_DIFFS_2D.dat and CRR_DIFFS_3D.dat for the latitude correction. Only these matrices must be used with the latitude dependant option.

The CRR retrieval can be chosen not to be latitude dependant. This can be carried out through the configuration file setting the APPLY_DIFF_MATRIX keyword to zero. In this case the basic rainfall rate retrieved over a particular region will be directly read from regional matrices.

The names of the available regional matrices are CRR_SP_2D.dat, CRR_SP_3D.dat, CRR_NOR_2D.dat and CRR_NOR_3D.dat, which have been calibrated with data from the Spanish region and the Baltic region respectively.

2.2.3 Convective Rainfall Rate (CRR) correction factors

Moisture Correction Factor

When thunderstorms take place in quite moist environments the computed rainfall rate should be greater than when they occur in dry air masses. To consider this effect a moisture correction factor has been developed. It adjusts the estimates when the air is dry or quite moist. This factor has been defined as the product of the total precipitable water, PW, in the layer from surface to 500 hPa. by the relative humidity, RH, (mean value between surface and 500 hPa. level), obtained from a numerical model.

An environment is considered to be dry if PWRH is significantly below 1.0 and quite moist if PWRH is greater than 1.0.

The PWRH factor decreases rainfall rates in very dry environments and increases them in very moist ones.

Cloud Growth Rate Correction Factor

Convective rain is assumed to be associated with growing clouds exhibiting overshooting tops. Consecutive satellite IR images are used to indicate vertically growing and decaying cloud systems.

The cloud growth correction factor, also designated as evolution correction factor, only changes the magnitude of the rain rate through a coefficient if the analysed pixel becomes warmer in the second image. The coefficient value can be modified by the user through the keyword COEFF_EVOL_GRAD_CORR_00 in the model configuration file (Default value for Normal Mode (0.35) is set in the configuration file. Recommended value for Rapid Scan mode is 0.55).

The cloud growth rate correction factor can not be applied when consecutive images are not available. In this case the alternative method of Cloud-top Temperature Gradient Correction is applied.

Cloud-top Temperature Gradient Correction Factor

This alternative correction method is based on the fact that much information can be extracted from the cloud-top structure on a single IR image.

This correction factor, also designated as gradient correction factor, is based on a search of the highest (coldest) and lowest (less cold) cloud tops. The idea is to search for the pixels that are below the average cloud top surface temperature (local temperature minima) and assume these pixels indicate active convection associated with precipitation beneath.

The hessian of the temperature field is analysed for each pixel with a temperature lower than 250K, in order to search for those pixels with extreme values as is explained in the Algorithm Theoretical Basis Document [AD.1]. Rain rate corresponding to those pixels which have a maximum (meaning that are warmer than its surroundings) is modified by multiplying a coefficient. The value of that coefficient can be selected by the user through the keyword COEFF_EVOL_GRAD_CORR_01 in the model configuration file (Default value: 0.25). In those pixels which have neither a local IR temperature maximum nor minimum, the rain rate is modified through a coefficient controlled by the keyword COEFF_EVOL_GRAD_CORR_02 (Default value: 0.50). Otherwise rain rate is not modified.

Parallax correction

To apply the orographic correction factor is necessary to know the exact cloud position with respect to the ground below. This is not a problem when a cloud is located directly below the satellite; however, as one looks away from the sub-satellite point, the cloud top appears to be farther away from the satellite than the cloud base. This effect increases as you get closer to the limb and as clouds get higher.

The parallax correction depends on three factors: a) the cloud height, b) the apparent position on the earth of that cloud and c) the position of the satellite.

The last two factors are known, but the first one has to be estimated. Two height estimation methods have been studied: numerical model and climatological profile obtained from the 1962 standard atmosphere model. Both of them are based on the conversion of each IR10.8 brightness temperature to height. By default, height is estimated using NWP data.

When the Parallax Correction is working, a spatial shift is applied to every pixel with precipitation according to the basic CRR value. If in this re-mapping process two pixels of the original image are assigned to the same pixel of the final image, the algorithm takes the maximum value of the rainfall rate, and if a pixel of the final image is not associated to any pixel of the original image (a "hole" appears in the final image), the software identifies the pixels with "hole" and assigns to them a value of the rainfall rate that is the result of applying a 3x3 median filter centred on the hole pixel.

Orographic correction factor

Local topography has long been recognised to have an effect on the distribution and intensity of precipitation. However, the rain induced by orographic forcing is a complex process associated with complicated flows. Rainfall amounts are dependent on the atmospheric flow over the mountains and on the characteristics of the flow disturbances created by the mountains themselves.

This correction factor uses the interaction between the wind vector (corresponding to 850 hPa level from the NWP) and the local terrain height gradient in the wind direction to create a multiplier that enhances or diminishes the previous rainfall estimate, as appropriate.

2.2.4 Lightning algorithm

As lightning activity is related with convection, this information has been added to the product. Only Cloud-to-Ground lightning flashes are used by this algorithm.

To incorporate this information into the product a rain rate has been assigned to every lightning depending on:

- the time distance ($\Delta\tau$) between the lightning event and scanning time of the processing region centre.
- the location of the lightning
- the spatial density of lightning in a time interval

Once the precipitation pattern has been computed, it is compared to the CRR precipitation pattern in order to obtain the final product. This final product contains the highest rain rate of the two.

2.3 Description of the Convective Rainfall Rate (CRR) outputs

CRR product is coded in HDF5 format. The available outputs are the following:

CRR classes:

The rainfall rates obtained by the CRR algorithm expressed in mm/h are converted into eleven classes as it is shown bellow:

CLASSES	RAINFALL RATE (mm/h)
0	rate < 1
1	1 = rate < 2
2	2 = rate < 3
3	3 = rate < 5
4	5 = rate < 7
5	7 = rate < 10
6	10 = rate < 15
7	15 = rate < 20
8	20 = rate < 30
9	30 = rate < 50
10	rate ≥ 50

Table 5. CRR classes

This output includes the following palette:

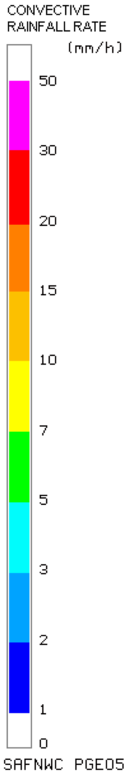

Figure 1. CRR palette

CRR hourly accumulations:

Rainfall rates from the images in the last hour are used in order to compute the hourly accumulation. This output is expressed in mm and includes a palette that uses the same colours as the classes output palette.

CRR intensity in mm/h:

Rainfall rates in mm/h are necessary to calculate the hourly accumulation. This is the reason for the existence of this output. It is not intended to be used as a Nowcasting tool, therefore it has no palette.

CRR_QUALITY:

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:

1 bit for moisture correction:

0: No correction

1: Corrected by PWHR factor

1 bit for cloud growth rate correction:

0: No correction

1: Corrected by IR data from previous slot

1 bit for cloud top temperature correction:

0: No correction

1: Corrected by IR temperature gradient

1 bit for parallax correction:

0: No correction

1: Corrected by parallax

1 bit for orographic effect correction:

0: No correction

1: Corrected by orographic effects

1 bit for latitude dependant:

0: No latitude dependant

1: Latitude dependant

1 bit for solar channel used:

0: No solar channel used

1: Solar channel used

1 bit for lightning information used:

0: No lightning information used

1: Lightning information used

CRR_DATAFLAG:

8 bits mask indicating the processing status of each pixel:

- 1 bit for IR10.8, WV6.2 or VIS0.6 data missing
  - 0: All the channel data required are available
  - 1: There is a missing data in some channel
- 1 bit to indicate if the set of SEVIRI data is out of the calibration matrices range
  - 0: The set of SEVIRI data is contained in the calibration matrices range
  - 1: The set of SEVIRI data is out of the calibration matrices range
- 1 bit to identify mathematical errors
  - 0: No mathematical error
  - 1: A mathematical error has occurred
- 1 bit for the convective filter
  - 0: The CRR value remains the same
  - 1: The CRR value has been set to zero because of the filtering process
- 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
- 2 bits the hourly accumulation CRR band 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)
- 1 bit for the status of the CRR pixels used to compute the hourly accumulation
  - 0: All the pixels used in the computing of the hourly accumulation have their CRR_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 CRR_DATAFLAG bits set to 1

3. IMPLEMENTATION OF THE CONVECTIVE RAINFALL RATE (CRR) PRODUCT

Previous condition and licences

The right to use, copy or modify this software is in accordance with EUMETSAT Policy for the SAFNWC/MSG software package.

3.1 INSTALLATION STEP FOR CONVECTIVE RAINFALL RATE (CRR)

The software installation procedure does not require special resources. It is restricted to decompress the distribution file (a gz-compressed tar file) and to successfully build the executable PGE05 file to be stored into the $SAFNWC/bin directory.

Once the PGE05 of the SAFNWC/MSG is installed and configured in the system, its operational use requires the definition of some Configuration files in order to select the regions to be processed and some needed configurable parameters.

The automatic set of pre-defined time scheduling (of the preparation step) is in Programmed Task Definition Files.

3.2 PREPARATION STEP FOR CONVECTIVE RAINFALL RATE (CRR)

The configuration file in charge of the region where the product is going to be run, has an optional name and the ".cfg" extension. This file contains the region centre location and the size image. When the application is installed, some region configuration files appear in $SAFNWC/config. Each of them corresponds to a different region; nevertheless users can create their own region configuration file.

The configuration file in charge of the product settings is the PGE05 model configuration file that has an optional name and the ".cfm" extension. Through this file the user can configure the way the product is going to be run choosing options such as the type of calibration or the corrections to be used.

In order to apply some corections, NWP data (*Convective Rainfall Rate (CRR) dynamic inputs*) have to be available in $SAFNWC/import/NWP_data directory.

In order to use the lightning information, the "Lightning information file for PGE05" (*4.1.1Convective Rainfall Rate (CRR) dynamic inputs*) have to be available in $SAFNWC/import/Obs_data directory.

3.3 EXECUTION STEP FOR CONVECTIVE RAINFALL RATE (CRR)

The execution step is the real-time process of the SEVIRI images over the region. This process consists of the launch of the command PGE05 along with the required parameters: slot, region configuration file name and model configuration file name.

PGE05 requires mainly six steps:

- First step consists of an initialisation, which performs the environment settings for a given region, and the Day/Night mask for all the pixels processed.

- Second step is intended to read the external data as SEVIRI bands.

- Third step is to normalise the VIS image, in case the solar channel is used.

- Fourth step holds the core process for the computation of the CRR product. For each pixel the next parameters are calculated: CRR mm/h basic values, Quality and Data flags.

- Fifth step develops those corrections that have been chosen to be applied using the output data from the previous step. CRR mm/h values, Quality and Data flags are updated.

- Sixth step computes rain rates from lightning information if this option has been chosen. This data are combined with the output data from the previous step. CRR mm/h values, Quality and Data flags are updated.

- Last step converts the mm/h CRR values into classes, computes the hourly accumulations and writes the product outputs in SAFNWC format.

4. INPUTS AND CONFIGURABLE PARAMETERS FOR CONVECTIVE RAINFALL RATE (CRR) PRODUCT

4.1 LIST OF INPUTS FOR CONVECTIVE RAINFALL RATE (CRR)

4.1.1 Convective Rainfall Rate (CRR) dynamic inputs

Satellite imagery:

The following SEVIRI brightness temperatures and visible reflectances are needed at full IR spatial resolution:

T10.8µm	TPrev10.8µm	T6.2µm	VIS0.6µm
Mandatory	Optional*	Mandatory	Optional

Table 6. CRR SEVIRI inputs

The SEVIRI channels are input by the user in HRIT format and extracted on the desired region by SAFNWC software package.

* If TPrev10.8µm is not available, the Cloud Growth Rate Correction Factor can not be computed but the Cloud-top Temperature Gradient Correction Factor is computed instead as an alternative.

Numerical model:

This information is mandatory for moisture and orographic corrections. When this information is not available, CRR is computed without applying these two corrections.

Parallax correction can run without the NWP parameters using the climatological profile.

For moisture correction:

Relative Humidity at 1000, 925, 850, 700 and 500 hPa

Dew Point temperature at 2 m

Temperature at 2 m

Temperature at 1000, 925, 850, 700, 500 hPa

Surface Pressure

For parallax correction:

Temperature at 1000, 925, 850, 700, 500, 400, 300, 250 and 200 hPa

Geopotential at 1000, 925, 850, 700, 500, 400, 300, 250 and 200 hPa

For orographic correction:

U and V wind components in 850 hPa

Lightning information file for PGE05:

A file with information on every lightning occurred in a time interval is mandatory to choose the option of adjusting the CRR precipitation pattern with the lightning information. Information about the "Lightning information file for PGE05" structure can be found in the Interface Control Document [AD.3].

4.1.2 Convective Rainfall Rate (CRR) static inputs

Sun angles associated to SEVIRI imagery

This information is mandatory for normalising the VIS image when the solar channel is used. It is computed by the CRR software itself using the definition of the region and the satellite characteristics.

Ancillary data sets:

Basic calibration matrices (3-D, 2-D) are available in the SAFNWC software package and are needed by the CRR software.

Difference matrices (3-D, 2-D) are available in the SAFNWC software package and they are mandatory if latitude correction is required.

Users can choose which matrices will the SW use trough the model configuration file.

Saturation Vapour table is mandatory for Humidity correction.

Saturation Vapour Polynomial Coefficients table is mandatory for Humidity correction.

Climatological profile is mandatory for Parallax correction.

Elevation mask is mandatory for orographic correction

Model configuration file for PGE05:

The CRR model configuration file contains configurable system parameters in the product generation process related with algorithm thresholds, ancillary datasets, numerical model data, corrections to be applied, etc. The complete list of these parameters and the explanation of the most useful ones is available on *List of configuration parameters* of this manual and in the Interface Control Document [AD.3]

4.2 LIST OF CONFIGURATION PARAMETERS FOR CONVECTIVE RAINFALL RATE (CRR)

Model configuration file describes configurable items in the product generation process such as algorithm thresholds, SEVIRI channels to be used by the PGE, coefficients, etc.

The CRR model configuration file needed for the execution of PGE05 must be placed at the $SAFNWC/config directory.

The only constraint in the use of any name is the key used to specify the parameters to be used from NWP models: NWP_PARAM. The use of this keyname is mandatory, and will be used by a pre-processing task in charge of remapping NWP incoming files (in GRIB format).

4.2.1 Keywords table for Convective Rainfall Rate (CRR)

The CRR model configuration file contains the following information:

Keyword	Decription	Type	Default Value(s)
PGE_ID	Identifier of the PGE	Chain of characters	PGE05
SEV_BANDS	SEVIRI channels to be used by PGE05	Chain of characters	VIS06 WV62 IR108
DAY_NIGHT_ZEN_THRESHOLD	Solar zenith angle to select between day and night cases (in degrees)	Double	80
WIN_FILTER_SEMISIZE	Semi-size of the window used to filter the Basic CRR image (in pixels). Window_Size=(2*WIN_FILTER_SEMISIZE +1) * (2*WIN_FILTER_SEMISIZE +1)	Integer	3
FILTER_THRESHOLD	Threshold for filtering process	Integer	3
APPLY_HUMIDITY_CORR	Indicator whether the Humidity correction should be applied or not (1 yes: 0 no)	Integer	1
APPLY_EVOL_GRAD_CORR	Indicator whether the Evolution/Gradient correction should be applied or not (1 yes: 0 no)	Integer	1
APPLY_PARALLAX_CORR	Indicator whether the Parallax correction should be applied or not (1 yes: 0 no)	Integer	1
APPLY_OROGRAPHIC_CORR	Indicator whether the Orographic correction should be applied or not (1 yes: 0 no)	Integer	1
COEFF_EVOL_GRAD_CORR_00	Coefficient used when the Evolution/Gradient correction is applied. When two consecutives IR images are available and the Evolution correction is applied, if in a pixel the IR brightness temperature increases, the CRR value computed in that pixel is multiplied by this coefficient.	Real	0.35
COEFF_EVOL_GRAD_CORR_01	Coefficient used when the Evolution/Gradient correction is applied. When the previous IR image is not available and the Gradient correction is applied, this coefficient multiplies the previous computed CRR value if the analysed pixel has a local IR temperature maximum.	Real	0.25
COEFF_EVOL_GRAD_CORR_02	Coefficient used when the Evolution/Gradient correction is applied. When the previous IR image is not available and Gradient correction is applied, this coefficient multiplies the previous computed CRR value if the analysed pixel has not a local IR temperature maximum or minimum.	Real	0.50
MATRIX_CRR_3D	Calibration matrix for day time using solar channel	Chain of characters	CRR_EUR_3D.dat
MATRIX_CRR_2D	Calibration matrix for night time or day time but not using solar channel	Chain of characters	CRR_EUR_2D.dat
MATRIX_DIFF_3D	Difference matrix to be used with 3D calibration matrix	Chain of characters	CRR_DIFFS_3D.dat
MATRIX_DIFF_2D	Difference matrix to be used with 2D calibration matrix	Chain of characters	CRR_DIFFS_2D.dat

Keyword	Decription	Type	Default Value(s)
USE_SOLAR_CHANNEL	Indicates if the SEVIRI solar channel has to be used in the computation of the CRR (1 yes: 0 no)	Integer	1
APPLY_DIFF_MATRIX	Indicates if the matrix to be used for the retrieval of the CRR is latitude dependent (1 yes: 0 no)	Integer	1
APPLY_LIGHTNING	Indicator whether the Lightning information should be used or not (1 yes: 0 no)	Integer	0
LIGHTNING_DELTA_TIME	Time interval to consider lightning data files	Integer	15
RAIN_LIGHTNING_RATE_1	Rain rate parameter 1 linked to observed lightning	Real	2.3
RAIN_LIGHTNING_RATE_2	Rain rate parameter 2 linked to observed lightning	Real	0.75
RAIN_LIGHTNING_RATE_3	Rain rate parameter 3 linked to observed lightning	Real	0.25
RAIN_LIGHTNING_RATE_4	Rain rate parameter 4 linked to observed lightning	Real	0.1
COEFF_N_LIGHTNING_A	Coefficient "a" to be applied during the lightning adjustment function	Real	0.45
COEFF_N_LIGHTNING_B	Coefficient "b" to be applied during the lightning adjustment function	Real	0.7
NWP_PARAM01	Parameter :Wind Velocity (u-component) type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_UW NWP_UW_TYPE 850 1 BILIN
NWP_PARAM02	Parameter :Wind Velocity (v-component) type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_VW NWP_VW_TYPE 850 1 BILIN
NWP_PARAM03	Parameter : Humidity type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PR NWP_PR_TYPE 1000 1 BILIN
NWP_PARAM04	Parameter : Humidity type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PR NWP_PR_TYPE 925 1 BILIN
NWP_PARAM05	Parameter : Humidity type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PR NWP_PR_TYPE 850 1 BILIN

Keyword	Decription	Type	Default Value(s)
NWP_PARAM06	Parameter : Humidity type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PR NWP_PR_TYPE 700 1 BILIN
NWP_PARAM07	Parameter : Humidity type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PR NWP_PR_TYPE 500 1 BILIN
NWP_PARAM08	Parameter : 2m dewpoint temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_2D NWP_2D_TYPE NWP_2D_TYPE 1 BILIN
NWP_PARAM09	Parameter : 2m air temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_2T NWP_2T_TYPE NWP_2T_TYPE 1 BILIN
NWP_PARAM10	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 1000 1 BILIN
NWP_PARAM11	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 925 1 BILIN
NWP_PARAM12	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 850 1 BILIN
NWP_PARAM13	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 700 1 BILIN

Keyword	Decription	Type	Default Value(s)
NWP_PARAM14	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 500 1 BILIN
NWP_PARAM15	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 400 1 BILIN
NWP_PARAM16	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 300 1 BILIN
NWP_PARAM17	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 250 1 BILIN
NWP_PARAM18	Parameter : Temperature type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT NWP_PT_TYPE 200 1 BILIN
NWP_PARAM19	Parameter : Surface pressure type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_SP NWP_SP_TYPE NWP_SP_LEVEL 1 BILIN
NWP_PARAM20	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 1000 1 BILIN
NWP_PARAM21	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 925 1 BILIN

Keyword	Decription	Type	Default Value(s)
NWP_PARAM22	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 850 1 BILIN
NWP_PARAM23	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 700 1 BILIN
NWP_PARAM24	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 500 1 BILIN
NWP_PARAM25	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 400 1 BILIN
NWP_PARAM26	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 300 1 BILIN
NWP_PARAM27	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 250 1 BILIN
NWP_PARAM28	Parameter : Geopotential type of level : level : sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP NWP_GEOP_TYPE 200 1 BILIN

Table 7. Keywords table

4.2.2 Keywords description for Convective Rainfall Rate (CRR)

Below there is a description of the most useful keywords defined in PGE05 model configuration file in order to make easier the user exploitation:

- DAY_NIGHT_ZEN_THRESHOLD: to choose the solar zenith angle that selects between 2D and 3D Calibrations. By default this keyword is set to 80º.
- USE_SOLAR_CHANNEL: to choose whether the Software will use the solar channel (only for day time) or not. By default this keyword is set to 1 (the solar channel is going to be used).
- APPLY_DIFF_MATRIX: to decide whether the retrieval of the CRR value will be latitude dependant (keyword set to 1) or not (keyword set to 0). By default this keyword is set to 1.
- MATRIX_CRR_2D: to indicate the name of calibration matrix for night time or day time but not using solar channel. The name of this matrix for latitude dependant option has to be the default value (CRR_EUR_2D.dat). The name of this matrix for not latitude dependant option will be the name chosen for the 2-D regional matrix. For the time being only CRR_SP_2D.dat and CRR_NOR_2D.dat are available.
- MATRIX_CRR_3D: to indicate the name of calibration matrix for day time using solar channel. The name of this matrix for latitude dependant option has to be the default value (CRR_EUR_3D.dat). The name of this matrix for not latitude dependant option will be the name chosen for the 3-D regional matrix. For the time being only CRR_SP_3D.dat and CRR_NOR_3D.dat are available.
- MATRIX_DIFF_2D: to indicate the name of difference matrix to be used with 2-D calibration matrix for latitude dependant option. The name of this matrix has to be the default value (CRR_DIFFS_2D.dat).
- MATRIX_DIFF_3D: to indicate the name of difference matrix to be used with 3-D calibration matrix for latitude dependant option. The name of this matrix has to be the default value (CRR_DIFFS_3D.dat).
- COEFF_EVOL_GRAD_CORR_00: When two consecutives IR images are available and the Evolution correction is applied, if in a pixel the IR brightness temperature increases, the CRR value computed in that pixel is multiplied by this coefficient. (Default value for Normal Mode (0.35) is set in the configuration file. Recommended value for Rapid Scan mode is 0.55).
- COEFF_EVOL_GRAD_CORR_01: When the previous IR image is not available and the Gradient correction is working, this coefficient multiplies the initial CRR value if the analysed pixel has a local IR temperature maximum. (Default value: 0.25).
- COEFF_EVOL_GRAD_CORR_02: When the previous IR image is not available and the Gradient correction is working, this coefficient multiplies the initial CRR value if the analysed pixel has neither a local IR temperature maximum nor minimum. (Default value: 0.50).
- WIN_FILTER_SEMISIZE: The obtained basic CRR data are set to zero if all the pixels in a grid with a WIN_FILTER_SEMISIZE pixels semisize (default value: 3pix) centred on the pixel have a value lower than a selected threshold. The size of this window will be:

  (WIN_FILTER_SEMISIZE*2+1) x (WIN_FILTER_SEMISIZE*2+1)

- FILTER_THRESHOLD: The basic CRR data obtained from the matrices are set to zero if all the pixels in the selected window filter centred on the pixel have a value lower than FILTER_THRESHOLD. (Default value: 3 mm/h).
- APPLY_LIGHTNING: To decide whether the lightning information will be used (keyword set to 1) or not (keyword set to 0) to combine the CRR precipitation pattern. By default this keyword is set to 0.
- LIGHTNING_DELTA_TIME: Time interval before the scanning time of the processing region centre, where the lightning occurrences will be taken into account by the lightning algorithm. (Default value: 15 min).
- RAIN_LIGHTNING_RATE_1: Rain amount assigned to the pixels corresponding to the Z1 area according to the lightning algorithm. A detailed description of the lightning algorithm can be found in the Algorithm Theoretical Basis Document for PGE05 [AD.1]. (Default value: 2,30 mm).
- RAIN_LIGHTNING_RATE_2: Rain amount assigned to the pixels corresponding to the Z2 area according to the lightning algorithm. A detailed description of the lightning algorithm can be found in the Algorithm Theoretical Basis Document for PGE05 [AD.1]. (Default value: 0,75 mm).
- RAIN_LIGHTNING_RATE_3: Rain amount assigned to the pixels corresponding to the Z3 area according to the lightning algorithm. A detailed description of the lightning algorithm can be found in the Algorithm Theoretical Basis Document for PGE05 [AD.1]. (Default value: 0,25 mm).
- RAIN_LIGHTNING_RATE_4: Rain amount assigned to the pixels corresponding to the Z4 area according to the lightning algorithm. A detailed description of the lightning algorithm can be found in the Algorithm Theoretical Basis Document for PGE05 [AD.1]. (Default value: 0,10 mm).
- COEFF_N_LIGHTNING_A: Coefficient "a" of the equation that modifies the rain rate according to the density of lightning around each pixel in the lightning algorithm. (Default value: 0,45).
- COEFF_N_LIGHTNING_B: Coefficient "b" of the equation that modifies the rain rate according to the density of lightning around each pixel in the lightning algorithm. (Default value: 0,7).

5. SUMMARY OF CONVECTIVE RAINFALL RATE (CRR) PRODUCT VALIDATION RESULTS

An extended validation of the CRR product has been carried out using data corresponding to convective events occurred along the whole year 2008 over Spain. A subjective validation comparing CRR v3.0 and v3.1 using lightning information over Spain has also been carried out. Other validations using data of convective events occurred in the 2009 summer period over Hungary have also been performed using both radar and rain gauges data. The validation against Hungarian rain gauges has been done by OMSZ; more information on this validation can be found in the corresponding validation report [RD.1]. A detailed description of the validations against radar data and their results can be found in the document Validation Report [AD.2].

Results of the validation against Hungarian radars are very similar to the ones obtained for the Spanish radars. Due to the differences in the validation method and the kind of data to be validated, less similarity has been obtained in the validation against Hungarian rain gauges.

The RMS error values obtained in the last version, for instantaneous rates, are lower than the target RMS error defined in the NWCSAF Product Requirement document [AD.6], which is 3.3 mm/h, in all the validations performed except for the one against rain gauges over Hungary. For hourly accumulations, RMS error values obtained in all validations are lower than the target RMS error, that is 2.5 mm.

This document shows the results corresponding to the validation performed over Spain.

Two different outputs of the product have been validated: Classes and hourly accumulations. Both accuracy and categorical statistics have been computed.

The validation process is based on the comparison of Radar rates, taken as "truth data", with the CRR values, in 3 x 3 pixels boxes.

The RMS values obtained in the last version (that are 2.7 mm/h for instantaneous rates and 1.7 mm for hourly accumulations) are lower than the target RMS defined in the NWCSAF Product Requirement Document [AD.6], that are 3.3 mm/h and 2.5 mm respectively. Green colour values in tables means that RMS error values obtained in that validation are lower than the target RMS error defined in the NWCSAF Product Requirement document [AD.6]. Red colour means RMS error higher than the target RMS error.

5.1 INSTANTANEOUS RATES

Accuracy statistics

Calibration	N	MEAN (mm/h)	ME (mm/h)	MAE (mm/h)	RMS (mm/h)
3D v2010	850761	0.73	0.10	1.10	2.71
2D v2010	681556	0.81	- 0.10	1.11	2.33

Table 8. Accuracy statistics for instantaneous rates

Categorical statistics

Calibration	FAR (%)	POD (%)	CSI (%)	PC (%)
3D v2010	17.4	42.2	38.7	57.8
2D v2010	29.7	34.0	29.8	48.0

Table 9. Categorical statistics for instantaneous rates

5.2 HOURLY ACCUMULATIONS

Accuracy statistics

Calibration	N	MEAN (mm/h)	ME (mm/h)	MAE (mm/h)	RMS (mm/h)
3D v2010	610479	0.44	0.15	0.67	1.67
2D v2010	497600	0.48	- 0.03	0.64	1.30

Table 10. Accuracy statistics for hourly accumulations

Categorical statistics

Calibration	FAR (%)	POD (%)	CSI (%)	PC (%)
3D 2010	38.9	49.7	37.8	66.1
2D 2010	48.1	38.0	28.1	59.5

Table 11. Categorical statistics for hourly accumulations

6. CONVECTIVE RAINFALL RATE (CRR) PRODUCT ASSUMPTIONS AND LIMITATIONS

The CRR product is based on a calibration method which requires the availability of a training set of precipitation data derived from radar information, to be used as ground truth to derive the relationship between satellite information and rainfall rate.

Regarding the radar data:

- The drop size distribution, used to obtain the radar rainfall rates (mm/h) from the radar reflectivity (Dbz), has been assumed to be the Marshall Palmer type throughout the calibration and validation procedures.

- No online operational method has been applied in order to adjust the radar rainfall intensities using rain gauge measurements.

Regarding the regional dependant calibration:

- Calibration matrices have only been computed with Spanish and BALTRAD data. For the time being no calibration for inner continental European region has been done.

Regarding seasonal calibration:

- Calibration matrices have been built only with summer cases

Regarding the lightning algorithm:

- The CRR lightning algorithm in CRR v3.1, and the coefficients applied, have been derived for Spain using the lightning information from the AEMET lightning detection network. Concerning this particular, it is important to highlight that ground based lightning detection networks provide information with different performances in detection efficiency and location accuracy. For this reason, in the model configuration file the keyword APPLY_LIGHTNING is set to 0 and by default the lightning information is not used.

- Before to use the lightning algorithm it is highly recommended to the user to adapt the coefficients to the specific performances of the lightning detection network serving that information.

- This issue could be solved in a satisfactory manner in the future with the use of lightning information provided by MTG Lightning Imager which will be able to provide lightning information with uniform and controlled performances all around the coverage area.

However, the CRR product provides useful information as a complement to Radar products allowing the forecasters to identify convective areas.

7. EXAMPLE OF CONVECTIVE RAINFALL RATE (CRR) PRODUCT VISUALISATION

7.1.1 Instantaneous Rates

Below is shown an image corresponding to CRR classes output. It has been obtained at full resolution and all corrections have been applied.

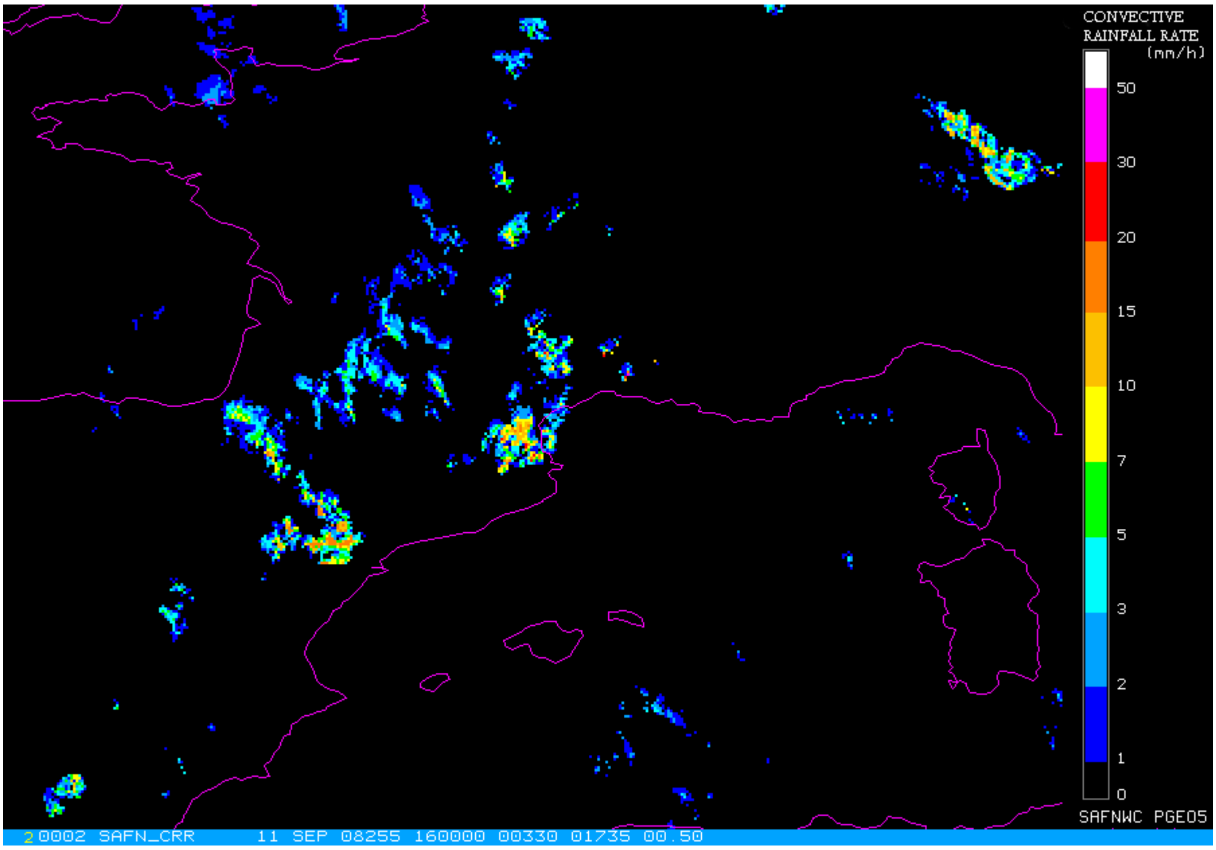

Figure 2. CRR classes output corresponding to 11th September 2008 at 16:00Z.

7.1.2 Hourly Accumulations

Below is shown an image corresponding to CRR hourly accumulations output. It has been obtained at full resolution and all corrections have been applied

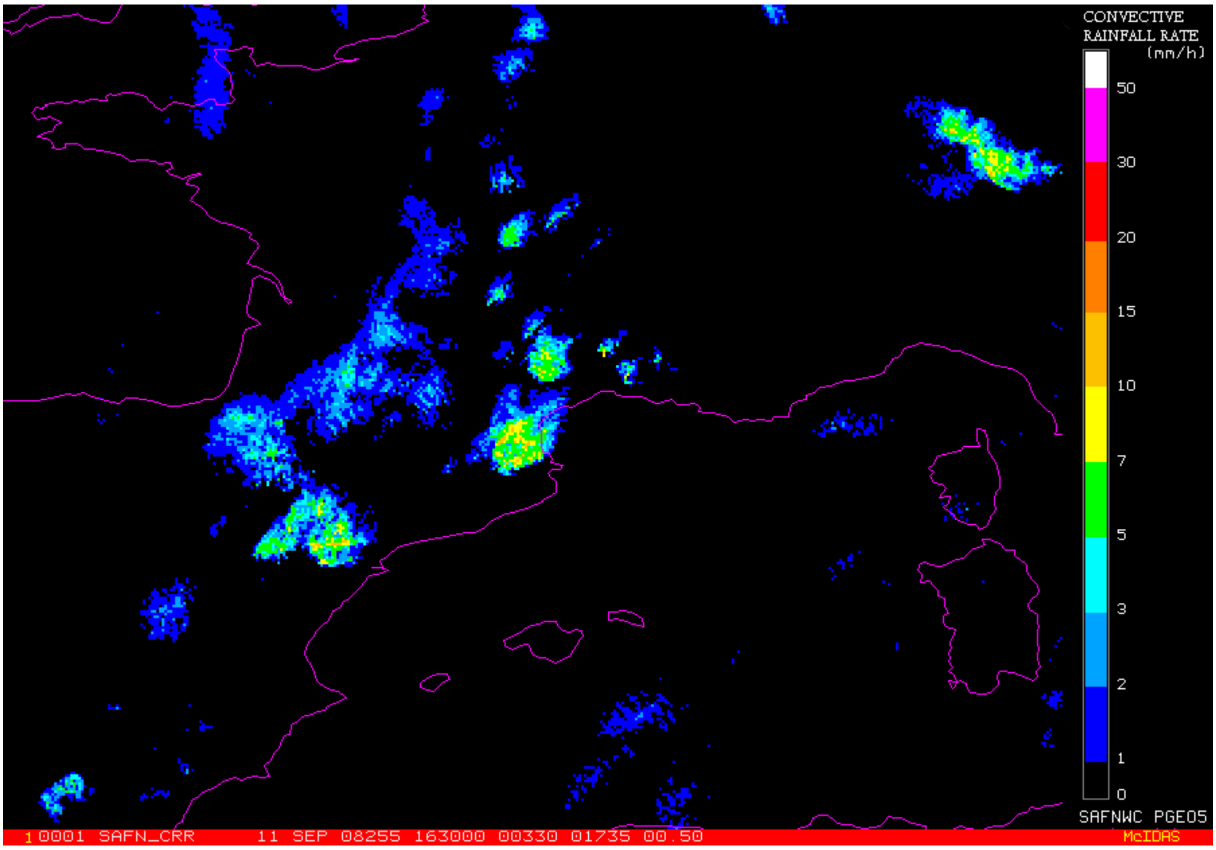

Figure 3. CRR hourly accumulations output corresponding to 11th September 2008 at 16:30Z