

The EUMETSAT  
Network of  
Satellite Application  
Facilities



**NWC SAF**


Support to Nowcasting and  
Very Short Range Forecasting

# Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)

SAF/NWC/CDOP2/INM/PUM/14, Issue 1, Rev. 0.1


*4 December 2014*

*Applicable to SAFNWC/MSG version 2013*

 <p>NWC SAF Agencia Estatal de Meteorología</p>	<p>Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 &amp; CRPh v1.0)</p>	<p><b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14  <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014  <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1  <b>Page:</b> 2/29</p>
--	---	---


### REPORT SIGNATURE TABLE

Function	Name	Signature	Date
<b>Prepared by</b>	Cecilia Marcos (AEMET) Antonio Rodríguez (AEMET)		<i>4 December 2014</i>
<b>Reviewed by</b>	Marcelino Manso (AEMET)		<i>4 December 2014</i>
<b>Authorised by</b>	Pilar Fernández SAFNWC Project Manager		<i>4 December 2014</i>

 <p>NWC SAF Agencia Estatal de Meteorología</p>	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 3/29
--	--	--


### DOCUMENT CHANGE RECORD

Version	Date	Pages	CHANGE(S)
1.0	15 July 2013	29	Initial version Indications and recommendations given by the NWC SAF SW Package MSG 2013 DRR have been included.
1.0.1	4 December 2014	29	Update of the information about NWP data needed for the running of PCPh and CRPh algorithms.

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 4/29
---	--	--


## Table of contents

<b>1. INTRODUCTION .....</b>	<b>6</b>
1.1 SCOPE OF THE DOCUMENT .....	6
1.2 SCOPE OF OTHER DOCUMENTS .....	6
1.3 SOFTWARE VERSION IDENTIFICATION .....	6
1.4 DEFINITIONS, ACRONYMS AND ABBREVIATIONS .....	6
1.5 REFERENCES .....	7
1.5.1 Applicable Documents .....	7
1.5.2 Reference Documents .....	8
<b>2. PRECIPITATING CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) PRODUCT .....</b>	<b>9</b>
2.1 DESCRIPTION OF PRECIPITATION CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) .....	9
2.1.1 Goal of Precipitating Clouds from Cloud Physical Properties (PCPh) .....	9
2.1.2 Outline of Precipitating Clouds from Cloud Physical Properties (PCPh) .....	9
2.1.3 Description of Precipitating Clouds from Cloud Physical Properties (PCPh) outputs .....	10
2.2 IMPLEMENTATION OF PRECIPITATION CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) .....	11
2.2.1 Installation of Precipitating Clouds from Cloud Physical Properties (PCPh) .....	11
2.2.2 Preparation of Precipitating Clouds from Cloud Physical Properties (PCPh) .....	12
2.2.3 Execution of Precipitating Clouds from Cloud Physical Properties (PCPh) .....	12
2.3 INPUTS AND CONFIGURABLE PARAMETERS FOR PRECIPITATION CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) .....	12
2.3.1 List of inputs for Precipitating Clouds from Cloud Physical Properties (PCPh) .....	12
2.3.2 Configurable parameters for Precipitating Clouds from Cloud Physical Properties (PCPh) .....	13
2.4 SUMMARY OF PRECIPITATING CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) .....	14
2.5 TYPICAL KNOWN PROBLEMS AND RECOMMENDATION FOR USE .....	15
2.6 EXAMPLE OF PRECIPITATING CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) .....	16
2.7 VISUALIZATION .....	16
<b>3. CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) PRODUCT .....</b>	<b>17</b>
3.1 DESCRIPTION OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) .....	17
3.1.1 Goal of Convective Rainfall Rate from Cloud Physical Properties (CRPh) .....	17
3.1.2 Outline of Convective Rainfall Rate from Cloud Physical Properties (CRPh) .....	17
3.1.3 Description of Convective Rainfall Rate from Cloud Physical Properties (CRPh) outputs .....	19
3.2 IMPLEMENTATION OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) .....	21
3.2.1 Installation of Convective Rainfall Rate from Cloud Physical Properties (CRPh) .....	22
3.2.2 Preparation of Convective Rainfall Rate from Cloud Physical Properties (CRPh) .....	22
3.2.3 Execution of Convective Rainfall Rate from Cloud Physical Properties (CRPh) .....	22
3.3 INPUTS AND CONFIGURABLE PARAMETERS FOR CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) .....	23
3.3.1 List of inputs for Convective Rainfall Rate from Cloud Physical Properties (CRPh) .....	23
3.3.2 Configurable parameters for Convective Rainfall Rate from Cloud Physical Properties (CRPh) .....	24
3.4 SUMMARY OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) .....	26
3.5 TYPICAL KNOWN PROBLEMS AND RECOMMENDATION FOR USE .....	27
3.6 EXAMPLE OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) .....	28
3.7 VISUALIZATION .....	28

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 5/29
---	--	--

## List of Tables and Figures

Table 1: List of Applicable Documents.....	8
Table 2: List of Referenced Documents.....	8
Table 3: Model configuration file keywords table applicable to PCPh product .....	14
Table 4: False alarm ratio obtained for each PCPh probability of precipitation interval. ....	15
Table 5: Categorical scores for PCPh algorithm taking as rainy pixels those with probability of precipitation higher than a threshold .....	15
Table 6: Model configuration file keywords table applicable to CRPh product.....	25
Table 7: Accuracy measurements for instantaneous rates. Comparison among CRPh product using different CRPh_IQF thresholds.....	26
Table 8: Categorical scores for instantaneous rates. Comparison among CRPh product using different CRPh_IQF thresholds.....	27
Table 9: Accuracy measurements for hourly accumulations. Comparison among CRPh product using different CRPh_IQF thresholds. ....	27
Table 10: Categorical scores for hourly accumulations. Comparison among CRPh product using different CRPh_IQF thresholds.....	27
Figure 1: Function that connects Probability of Precipitation with CWP .....	9
Figure 2: PCPh_PC palette.....	10
Figure 3: PCPh probability of precipitation for 11 <sup>th</sup> February 2013 at 11:30 UTC over Europe....	16
Figure 4: Function that connects Rain Rates with CWP .....	18
Figure 5: CRPh_CRR palette .....	19
Figure 6: CRR_IQF palette .....	20
Figure 7: CRPh instantaneous rain rates for 25th May 2009 at 14:00 UTC over Europe.....	28
Figure 8: CRPh hourly accumulations for 25th May 2009 at 14:00 UTC over Europe.....	29

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 6/29
---	--	--

## 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, NWC SAF. The main objective of NWC SAF 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 NWC SAF webpage, <http://www.nwcsaf.org>. This document is applicable to the NWC SAF processing package for Meteosat satellites, SAFNWC/MSG.

### 1.1 SCOPE OF THE DOCUMENT

This document is the Product User Manual (PUM) for the PPh-PGE14 (Precipitation products from Cloud Physical Properties) belonging to the SAFNWC/MSG software. PGE14 generates two different products: Precipitating Clouds from Cloud Physical Properties (PCPh) and Convective Rainfall rate from Cloud Physical Properties (CRPh).

PUM document contains practical information on the characteristics of the products, including the input data and the outputs of the products. 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 PGE14 document [AD 2], showing the validation results for PGE14 v1.0 that gives information about the extended validation performed over Spain for a complete year.

The Interface Control Documents ICD/3 [AD 3] defines the format of the output products generated by the SAFNWC/MSG software.


The Interface Control Documents ICD/1 [AD 4] describes the External and Internal Interfaces of the SAFNWC/MSG software.

### 1.3 SOFTWARE VERSION IDENTIFICATION

This document contains practical information on the characteristics of the PPh algorithm implemented in the delivery 2013 of the SAFNWC/MSG package. This delivery corresponds to PPh-PGE14: version 1.0 of PCPh and version 1.0 of CRPh.

### 1.4 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

AEMET	Agencia Estatal de Meteorología
ATBD	Algorithm Theoretical Basis Document
COT	Cloud Optical Thickness
CRPh	Convective Rainfall Rate from Cloud Physical Properties
CSI	Critical Success Index

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 7/29
---	--	--


CT	Cloud Type
CWP	Cloud Water Path
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAR	False Alarm Ratio
ICD	Interface Control Document
ICP	Illumination Conditions Parameter
IQF	Illumination Quality Flag
IR	Infrared
MAE	Mean Absolute Error
ME	Mean Error
MSG	Meteosat Second Generation
NWC SAF	Satellite Application Facility for Nowcasting
PC	Percentage of Corrects
PCPh	Precipitating Clouds from Cloud Physical Properties
PGE	Product Generation Element
POD	Probability of Detection
PoP	Probability of Precipitation
PPh	Precipitation from Cloud Physical Properties
$R_{eff}$	Effective Radius
RMSE	Root Mean Square Error
RR	Rain Rate
SAF	Satellite Application Facility
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SW	Software

## 1.5 REFERENCES

### 1.5.1 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 applies.

Reference	Title	Code	Vers	Date
[AD 1]	Algorithm Theoretical Basis Document for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	SAF/NWC/CDOP2/INM/SCI/ATB D/14	1.0	15/07/13
[AD 2]	Validation Report for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	SAF/NWC/CDOP2/INM/SCI/VR/1 5	1.0	15/07/13

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 8/29
---	--	--

Reference	Title	Code	Vers	Date
[AD 3]	SAFNWC/MSG Output Products Format Definition	SAF/NWC/CDOP2/INM/SW/ICD/3	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]	NWC SAF Product Requirements Document	NWC/CDOP2/SAF/AEMET//MGT/PRD	1.2	15/07/13

*Table 1: List of Applicable Documents*

### 1.5.2 Reference Documents

Reference	Title
[RD.1]	Daniel Rosenfeld, William L. Woodley, Amit Lerner, Guy Kelman, Daniel T. Lindsey, 2008. Satellite detection of severe convective storms by their retrieved vertical profiles of cloud particle effective radius and thermodynamic phase. J. Geophys. Res. D4, 113.
[RD.2]	

*Table 2: List of Referenced Documents*



## 2. PRECIPITATING CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) PRODUCT

### 2.1 DESCRIPTION OF PRECIPITATION CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH)

#### 2.1.1 Goal of Precipitating Clouds from Cloud Physical Properties (PCPh)

Precipitating Clouds from Cloud Physical Properties (PCPh) product, developed within the NWC SAF context, is a Nowcasting tool that provides estimation on the probability of precipitation (PoP) occurrence. In this context, PoP is defined as the instantaneous probability that a rain rate greater than or equal to 0.2 mm/h occurs at the pixel level.

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.

#### 2.1.2 Outline of Precipitating Clouds from Cloud Physical Properties (PCPh)

The PoP estimation is done using information on the cloud physical properties, Effective Radius ( $R_{eff}$ ) and Cloud Optical Thickness (COT). Using these two parameters the Cloud Water Path (CWP) is computed. The following step connects CWP with PoP for each pixel, through the following relationship:

$$PoP = 43.7 * Ln(CWP) - 198.1$$

Where PoP is the Probability of Precipitation occurrence (%) and CWP is the Cloud Water Path ( $gm^{-2}$ ).

The graph of this function can be observed in Figure 1.

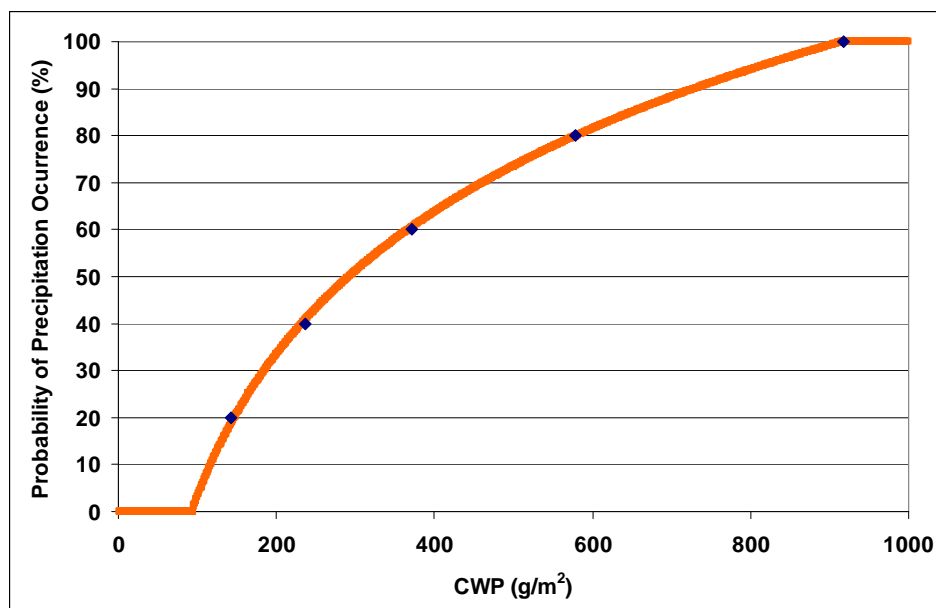



Figure 1: Function that connects Probability of Precipitation with CWP

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 10/29
---	--	---

### 2.1.3 Description of Precipitating Clouds from Cloud Physical Properties (PCPh) outputs

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

#### *PCPh PC:*

The PCPh\_PC output provides an estimation of the probability of precipitation from 0% to 100% of probability.

The probability of precipitation is given as an integer value that takes values from 0 to 100.

The colour scale delivered with the product is divided into five PoP intervals as can be observed in Figure 2.

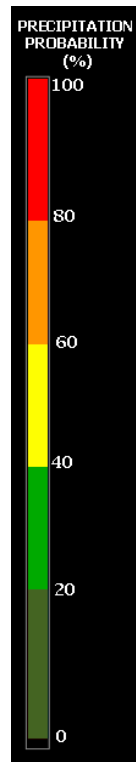


Figure 2: PCPh\_PC palette

#### *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

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 11/29
---	--	---

### ***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

The HDF-5 output files are stored in \$SAFNWC/export/PGE14. Detailed information on the HDF-5 format file can be found in [AD 3].

## **2.2 IMPLEMENTATION OF PRECIPITATION CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH)**

### 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.

### **2.2.1 Installation of Precipitating Clouds from Cloud Physical Properties (PCPh)**

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 PGE14 file to be stored into the \$SAFNWC/bin directory.

Once the PGE14 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.

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 12/29
---	--	---

## 2.2.2 Preparation of Precipitating Clouds from Cloud Physical Properties (PCPh)

The configuration file in charge of the region where the product is going to be run has an optional name and “.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 PGE14 model configuration file that has an optional name and “.cfm” extension. Through this file the user can configure the way the product is going to be run by choosing options such as the parallax correction to be used.

In order to apply parallax correction, NWP data (*List of inputs for Precipitating Clouds from Cloud Physical Properties (PCPh)*) have to be available in \$SAFNWC/import/NWP\_data directory.

## 2.2.3 Execution of Precipitating Clouds from Cloud Physical Properties (PCPh)

The execution step is the real-time process of the PPh images over the region. This process consists of the launch of the command PGE14 along with the required parameters: slot, region file name and model configuration file.

PCPh requires mainly five steps:

- First step consists of an initialisation, which performs the environment settings for a given region. Check the existence of the required PGE02 files.
- Second step is intended to read the external PGE02 files.
- Third step is the computation of CWP.
- Fourth step computes PoP from CWP as well as PCPh\_QUALITY and PCPh\_DATAFLAG.
- Fifth step applies Parallax correction if chosen. PCPh\_QUALITY is updated.
- Last step writes the product outputs in NWC SAF format.

## 2.3 INPUTS AND CONFIGURABLE PARAMETERS FOR PRECIPITATION CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH)

### 2.3.1 List of inputs for Precipitating Clouds from Cloud Physical Properties (PCPh)

PGE02 Cloud type (CT) physical properties:


CT-PGE02 Phase, COT and  $R_{\text{eff}}$  parameters are mandatory inputs to PCPh.

The Phase will be read from PGE02 CT HDF-5 which must be located in \$SAFNWC/export/PGE02 directory.

COT and  $R_{\text{eff}}$  parameters will be read from temporary files generated by PGE02 located in \$SAFNWC/tmp directory.

Satellite imagery:

IR10.8 SEVIRI brightness temperature at full IR spatial resolution is a mandatory input to compute Parallax Correction. It must be placed by the user in HRIT format in the \$SAFNWC/import/SEVIRI\_data directory. Then it will be extracted on the desired region by SAFNWC software package.

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 13/29
---	--	---

### Numerical model:

The NWP files must be located in \$SAFNWC/import/NWP\_data directory. In real time operational mode, the NWC SAF package has predefined tools (coordinated by the NWC SAF Task Manager daemon) which check every minute for new NWP data making automatically the spatial remapping to the predetermined regions to process on to \$SAFNWC/tmp directory. This avoids spending time in every call to PGE to make the remapping process. In off-line operational mode, the “AllMapping” script allows to do the spatial remapping.

This information is used by default for parallax correction. In case of lack of NWP parameters parallax correction will be run using a climatological profile.

There are no studies on the impact of NWP data horizontal and temporal resolutions on the corrected position of the rainy pixels throughout parallax correction at this time. Some studies are expected to be done in this line in the future. NWP vertical resolution required by parallax correction is the following:

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

### Ancillary data sets:

Climatological profile is necessary as a back up for Parallax correction in case NWP is not available. This information is included in the software package and is located in the \$SAFNWC/import/Aux\_data directory.

### Model configuration file for PGE14 (safnwc\_pge14.cfm):

PGE14 model configuration file contains configurable system parameters in the generation process of both PCPh and CRPh products. This file is placed in the \$SAFNWC/config directory. The PCPh product related parameters refers to ancillary datasets, numerical model data and parallax correction. The complete list of these parameters and the explanation of the most useful ones is available on List of configuration parameters of this manual.

### Region configuration file (region.cfg):

This file set the dimensions and positions where PGE14 products will be obtained and is located in \$SAFNWC/config directory.

## **2.3.2 Configurable parameters for Precipitating Clouds from Cloud Physical Properties (PCPh)**


Model configuration file contains configurable items in the product generation process such as corrections to be run, NWP parameters to be used by the PGE, etc.

The PPh model configuration file needed for the execution of PGE14 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).

### **2.3.2.1 Keywords table for Precipitating Clouds from Cloud Physical Properties (PCPh)**

The PGE14 model configuration file contains the following information applicable to PCPh product:

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 14/29
---	--	---

Keyword	Description	Type	Default Value(s)
<b>PGE_ID</b>	Identifier of the PGE	Chain of characters	PGE14
<b>SEV_BANDS</b>	SEVIRI channels to be used by PGE14	Chain of characters	IR108
<b>APPLY_PARALLAX_CORR</b>	Indicator whether the Parallax correction should be applied or not (1 yes: 0 no)	Integer	1
<b>OUTPUT_PRODUCT</b>	Products to be generated: ALL : Both CRPh and PCPh hdf5 products are generated CRPh : Only CRPh hdf5 product is generated PCPh : Only PCPh hdf5 product is generated	Chain of characters	ALL
<b>NWP_PARAM01</b>	Parameter : Temperature (K) sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT 1 BILIN
<b>NWP_PARAM02</b>	Parameter : Geopotential (m <sup>2</sup> s <sup>-2</sup> ) sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP 1 BILIN

*Table 3: Model configuration file keywords table applicable to PCPh product*

### **2.3.2.2 Keywords description for Precipitating Clouds from Cloud Physical Properties (PCPh)**

Below there is a description of the most useful keywords defined in PGE14 model configuration file and applicable to PCPh product in order to make easier the user exploitation:

- **APPLY\_PARALLAX\_CORR:** To decide whether the Parallax correction should be applied or not (1 yes: 0 no)
- **OUTPUT\_PRODUCT:** To decide which products are to be generated:
  - ALL : Both CRPh and PCPh hdf5 products are generated
  - CRPh : Only CRPh hdf5 product is generated
  - PCPh : Only PCPh hdf5 product is generated

## **2.4 SUMMARY OF PRECIPITATING CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) VALIDATION RESULTS**

The following tables summarize the validation results of PCPh product. More details can be obtained from the “Validation Report for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)” [AD 2].

### **Probability of precipitation intervals validation:**

It should bear in mind that a region with the probability of precipitation interval (A-B] should have  $100-B \leq FAR < 100-A$ .

Probability interval (%)	N	FAR (%)
0-20	900985	90,4
20-40	470407	76,6
40-60	352631	57,5
60-80	226405	34,9
80-100	117761	18,1

Table 4: False alarm ratio obtained for each PCPh probability of precipitation interval.

### Probability of precipitation thresholds validation:

Green colour values in the following table mean that FAR or POD values obtained in this validation fulfill the FAR and POD target values defined in the NWC SAF Product Requirements document [AD 5].

PoP threshold	N	FAR (%)	POD (%)	CSI (%)	PC (%)
20%	3072175	56,8	82,8	39,6	75,0
30%	3072175	50,5	74,6	42,3	79,7
40%	3072175	43,5	64,7	43,2	83,1
60%	3072175	29,2	40,1	34,4	84,9
80%	3072175	18,1	15,8	15,3	82,6

Table 5: Categorical scores for PCPh algorithm taking as rainy pixels those with probability of precipitation higher than a threshold

## 2.5 TYPICAL KNOWN PROBLEMS AND RECOMMENDATION FOR USE

This algorithm can be run only over daytime.

For undefined phase pixels, Reff and COT values are not computed by PGE02, so a 0% probability of precipitation is assigned in these cases by the algorithm.

As the main inputs of the product are computed by PGE02, there exists the need to run PGE02 previous to run PGE14.

It has been observed that pixels located in the surroundings of snow according to PGE02 take sometimes high values of CWP, so a probability of precipitation higher than 0% is assigned erroneously.

It is highly recommended to apply parallax correction for a better location of precipitation areas with respect to the ground below.

This product obtains the best results for convective events.



## 2.6 EXAMPLE OF PRECIPITATING CLOUDS FROM CLOUD PHYSICAL PROPERTIES (PCPH) VISUALIZATION

Below is shown an example of the PCPh product. It has been obtained at full resolution.

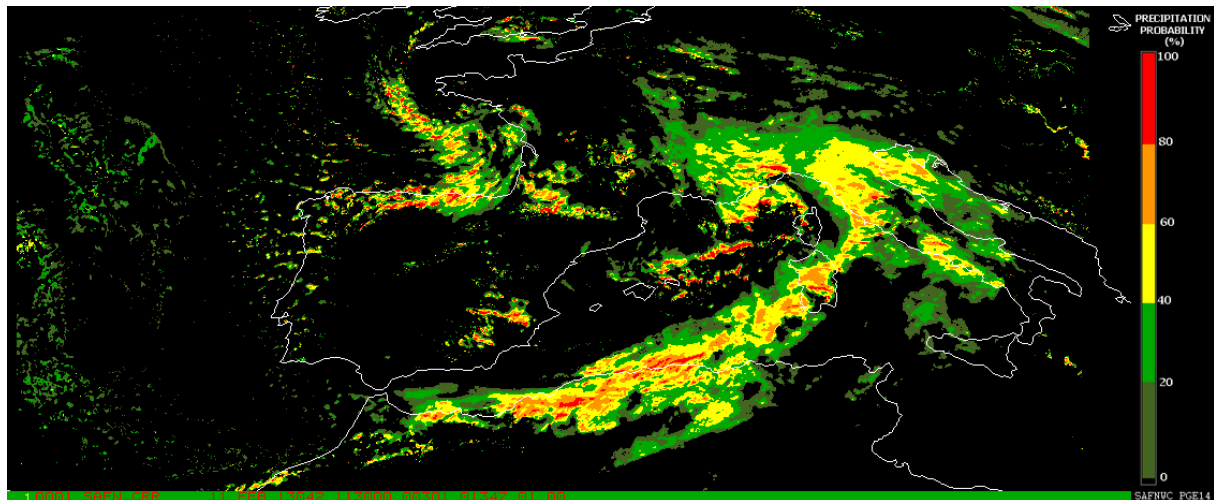



Figure 3: PCPh probability of precipitation for 11<sup>th</sup> February 2013 at 11:30 UTC over Europe



	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 17/29
---	--	---

### 3. CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) PRODUCT

#### 3.1 DESCRIPTION OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH)

##### 3.1.1 Goal of Convective Rainfall Rate from Cloud Physical Properties (CRPh)

Convective Rainfall Rate from Cloud Physical Properties (CRPh) product, developed within the NWC SAF context, is a Nowcasting tool that provides information on convective, and stratiform associated to convection, instantaneous rain rates and hourly accumulations.

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.

##### 3.1.2 Outline of Convective Rainfall Rate from Cloud Physical Properties (CRPh)

The convective rainfall rate estimation is done using information on the cloud physical properties, Effective Radius ( $R_{eff}$ ) and Cloud Optical Thickness (COT). Using these two parameters the Cloud Water Path (CWP) is computed. Depending on some  $R_{eff}$  and CWP thresholds, the precipitation area is enclosed. Only in those pixels belonging to the precipitation area, the rain rate is computed.

To assign an instantaneous rain rate to each pixel, the following relationship between CWP and precipitation intensity is applied:

$$RR = 50 * \left\{ 1 - \exp \left[ -0.5 * \left( \frac{CWP - 155}{1700} \right)^2 \right] \right\}$$

Where RR is the Rainfall Rate ( $\text{mmh}^{-1}$ ) and CWP is the Cloud Water Path ( $\text{gm}^{-2}$ ).

The graph of this function can be observed in Figure 4.

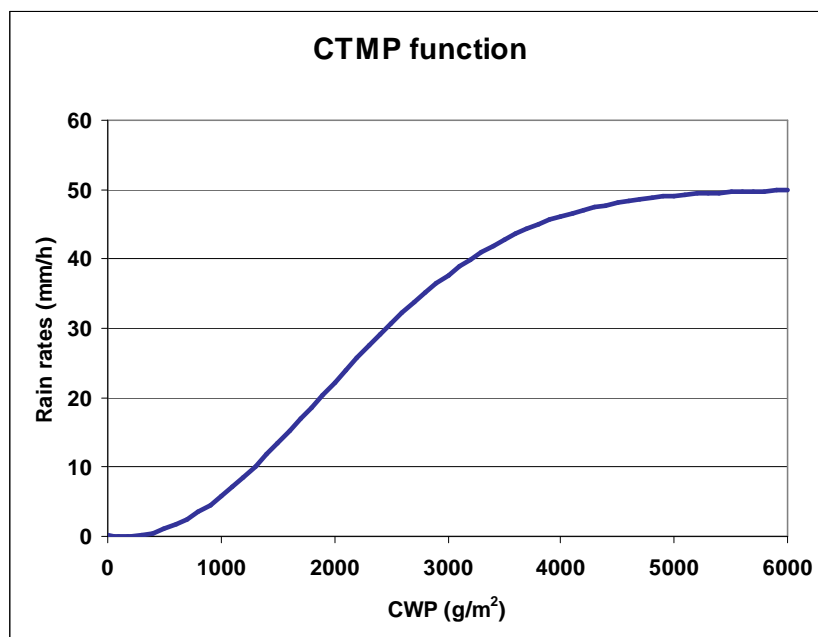


Figure 4: Function that connects Rain Rates with CWP

Rain rates estimation from geostationary satellite data can not be very accurate so trying to estimate rain rates higher than 50 mm/h using this type of data is not realistic. For this reason a maximum limit of 50 mm/h has been established.

It has been seen that, under some conditions, rain rates assigned by this product are erroneously high. In order to provide the user with information about the reliability of the estimated rain rates an illumination quality flag (CRPh\_IQF) has been developed.

CRR\_IQF (%) is included as an output of the product and it must be understood as an indicator of the confidence that a forecaster can have on the rain rates estimated by the product.

For a better convective precipitation area location the parallax correction can be applied to this product. This option is chosen by the user through the product model configuration file and it is applied by default.

As lightning activity can provide valuable information about convection, a lightning algorithm can be applied to derive a precipitation pattern that will be combined with the CRR one computed in the previous step in order to complement it.

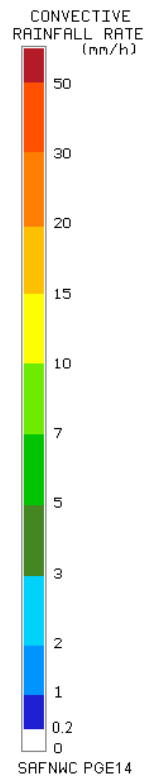
At the end of the process the final values of the CRR rainfall rates in mm/h are used in order to obtain hourly accumulations and five different outputs as described in section 3.1.3 are completed.

### 3.1.3 Description of Convective Rainfall Rate from Cloud Physical Properties (CRPh) outputs

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

#### ***CRPh\_CRR:***

This output provides rainfall rates from 0.0 to 51.0 mm/h with a step of 0.2 mm/h and includes the following palette:



*Figure 5: CRPh\_CRR palette*


#### ***CRPh\_ACCUM:***

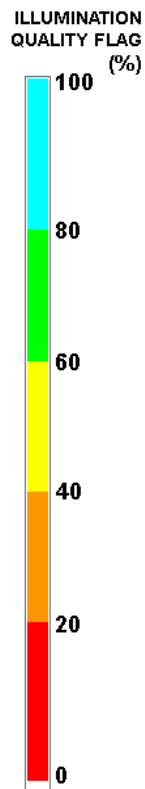
The hourly accumulations have been computed using the rainfall rates from the images in the last hour. This output provides precipitation accumulations from 0.0 to 51.0 mm with a step of 0.2 mm and includes a palette that uses the same thresholds and colours as the intensities output palette.

#### ***CRPh\_IQF:***

CRR\_IQF is a flag that provides information on the confidence that a user can have on the estimated rain rates according to the illumination conditions and viewing angles.

The colour scale provided with the product is divided into five intervals as can be observed in Figure 6.

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 20/29
---	--	---



*Figure 6: CRR\_IQF palette*

***CRPh\_QUALITY:***

3 bits mask indicating if parallax correction and lighting information 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

1 bit for lightning information used

0: No lightning information used

1: Lightning information used

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 21/29
---	--	---

### ***CRPh\_DATAFLAG:***

8 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

2 bits for the hourly accumulation CRR output status

0: All required scenes were available

1: One previous CRR scene is missing

2: At least two previous CRR scenes are missing (no consecutive)

3: At least two previous CRR scenes 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

The HDF-5 output files are stored in \$SAFNWC/export/PGE14. Detailed information on the HDF-5 format file can be found in [AD 3].

## **3.2 IMPLEMENTATION OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH)**

### 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.

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 22/29
---	--	---

### 3.2.1 Installation of Convective Rainfall Rate from Cloud Physical Properties (CRPh)

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 PGE14 file to be stored into the \$SAFNWC/bin directory.

Once the PGE14 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.

### 3.2.2 Preparation of Convective Rainfall Rate from Cloud Physical Properties (CRPh)

The configuration file in charge of the region where the product is going to be run has an optional name and “.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 PGE14 model configuration file that has an optional name and “.cfm” extension. Through this file the user can configure the way the product is going to be run choosing options such as parallax correction to be applied or lightning information to be used.

In order to apply parallax correction, NWP data (*List of inputs for Convective Rainfall Rate from Cloud Physical Properties (CRPh)*) have to be available in \$SAFNWC/import/NWP\_data directory.


In order to use the lightning information, the “Lightning information file for PGE14” (*List of inputs for Convective Rainfall Rate from Cloud Physical Properties (CRPh)*) have to be available in \$SAFNWC/import/Obs data directory.

### 3.2.3 Execution of Convective Rainfall Rate from Cloud Physical Properties (CRPh)

The execution step is the real-time process of the PPh images over the region. This process consists of the launch of the command PGE14 along with the required parameters: slot, region file name and model configuration file.

CRPh requires mainly five steps:

- First step consists of an initialisation, which performs the environment settings for a given region. Check the existence of the required PGE02 files.
- Second step is intended to read the external PGE02 files.
- Third step is the computation of CWP.
- Fourth step computes the precipitation area and the rain rates within the computed precipitation area as well as CRPh\_QUALITY , CRPh\_DATAFLAG, and CRPh\_IQF.
- Fifth step applies Parallax correction if chosen. CRPh\_QUALITY is 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. CRPh mm/h values, CRPh\_QUALITY and CRPh\_DATAFLAG are updated.

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 23/29
---	--	---

- Last step computes the hourly accumulation, updates CRR\_DATAFLAG and writes the product outputs in NWC SAF format.

### 3.3 INPUTS AND CONFIGURABLE PARAMETERS FOR CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH)

#### 3.3.1 List of inputs for Convective Rainfall Rate from Cloud Physical Properties (CRPh)

##### PGE02 Cloud type (CT) physical properties:

CT-PGE02 Phase, COT and  $R_{\text{eff}}$  parameters are mandatory inputs to CRPh.

The Phase will be read from PGE02 CT HDF-5 which must be located in \$SAFNWC/export/PGE02 directory.

COT and  $R_{\text{eff}}$  parameters will be read from temporary files generated by PGE02 located in \$SAFNWC/tmp directory.

##### Satellite imagery:

IR10.8 SEVIRI brightness temperature at full IR spatial resolution is a mandatory input to compute Parallax Correction. It must be placed by the user in HRIT format in the \$SAFNWC/import/SEVIRI\_data directory. Then it will be extracted on the desired region by SAFNWC software package.

##### Numerical model:

The NWP files must be located in \$SAFNWC/import/NWP\_data directory. In real time operational mode, the NWC SAF package has predefined tools (coordinated by the NWC SAF Task Manager daemon) which check every minute for new NWP data making automatically the spatial remapping to the predetermined regions to process on to \$SAFNWC/tmp directory. This avoids spending time in every call to PGE to make the remapping process. In off-line operational mode, the “AllMapping” script allows to do the spatial remapping.

This information is used by default for parallax correction. In case of lack of NWP parameters parallax correction will be run using a climatological profile.

There are no studies on the impact of NWP data horizontal and temporal resolutions on the corrected position of the rainy pixels throughout parallax correction at this time. Some studies are expected to be done in this line in the future. NWP vertical resolution required by parallax correction is the following:

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

##### Ancillary data sets:

Climatological profile is necessary as a back up for Parallax correction in case NWP is not available. This information is included in the software package and is located in the \$SAFNWC/import/Aux\_data/PGE14 directory.

##### Lightning information file for CRPh product:

A file with information on every lightning stroke occurred in a time interval is mandatory to choose the option of adjusting the CRPh precipitation pattern with the lightning information provided by ground based lightning detection networks. Information about the “Lightning information file for CRPh product” structure can be found in the Interface Control Document [AD 4]. This file must be located in \$SAFNWC/import/Obs\_data.

The CRR lightning algorithm and the coefficients applied have been derived for Spain using the lightning information from the AEMET lightning detection network.

Ground based lightning detection networks provide information with different performances in detection efficiency and location accuracy. For this reason, the keyword APPLY\_LIGHTNING in the model configuration file 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 lightning coefficients to the specific performances of the used lightning detection network through the appropriate keywords in the model configuration file.

Model configuration file for PGE14 (safnwc\_pge14.cfm):

PGE14 model configuration file contains configurable system parameters in the generation process of both PCPh and CRPh products. This file is placed in the \$SAFNWC/config directory. The CRPh product related parameters refers to ancillary datasets, numerical model data, lightning algorithm and parallax correction. The complete list of these parameters and the explanation of the most useful ones is available on List of configuration parameters of this manual.

Region configuration file (region.cfg):

This file set the dimensions and positions where PGE14 products will be obtained and is located in \$SAFNWC/config directory.

### 3.3.2 Configurable parameters for Convective Rainfall Rate from Cloud Physical Properties (CRPh)

Model configuration file contains configurable items in the product generation process such as corrections to be run, NWP parameters to be used by the PGE, coefficients, etc.

The PPh model configuration file needed for the execution of PGE14 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).

#### 3.3.2.1 Keywords table for Convective Rainfall Rate from Cloud Physical Properties (CRPh)

The PGE14 model configuration file contains the following information applicable to CRPh product:

Keyword	Description	Type	Default Value(s)
<b>PGE_ID</b>	Identifier of the PGE	Chain of characters	PGE14
<b>SEV_BANDS</b>	SEVIRI channels to be used by PGE14	Chain of characters	IR108
<b>APPLY_PARALLAX_CORR</b>	Indicator whether the Parallax correction should be applied or not (1 yes: 0 no)	Integer	1
<b>OUTPUT_PRODUCT</b>	Products to be generated: ALL : Both CRPh and PCPh hdf5 products are generated CRPh : Only CRPh hdf5 product is generated PCPh : Only PCPh hdf5 product is generated	Chain of characters	ALL



<b>APPLY_LIGHTNING</b>	Indicator whether the Lightning information should be used or not (1 yes: 0 no)	Integer	0
<b>LIGHTNING_DELTA_TIME</b>	Time interval to consider lightning data files	Integer	15
<b>RAIN_LIGHTNING_RATE_1</b>	Rain rate parameter 1 linked to observed lightning	Real	2.3
<b>RAIN_LIGHTNING_RATE_2</b>	Rain rate parameter 2 linked to observed lightning	Real	0.75
<b>RAIN_LIGHTNING_RATE_3</b>	Rain rate parameter 3 linked to observed lightning	Real	0.25
<b>RAIN_LIGHTNING_RATE_4</b>	Rain rate parameter 4 linked to observed lightning	Real	0.1
<b>COEFF_N_LIGHTNING_A</b>	Coefficient “a” to be applied during the lightning adjustment function	Real	0.45
<b>COEFF_N_LIGHTNING_B</b>	Coefficient “b” to be applied during the lightning adjustment function	Real	0.7
<b>NWP_PARAM01</b>	Parameter : Temperature (K) sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_PT 1 BILIN
<b>NWP_PARAM02</b>	Parameter : Geopotential (m <sup>2</sup> s <sup>-2</sup> ) sampling rate : (=segment size) interpolation method.	Chain of characters	NWP_GEOP 1 BILIN

Table 6: Model configuration file keywords table applicable to CRPh product

### 3.3.2.2 Keywords description for Convective Rainfall Rate from Cloud Physical Properties (CRPh)

Below there is a description of the most useful keywords defined in PGE14 model configuration file applicable to CRPh product in order to make easier the user exploitation:

- **APPLY\_PARALLAX\_CORR:** To decide whether the Parallax correction should be applied or not (1 yes: 0 no)
- **OUTPUT\_PRODUCT:** To decide which products are to be generated:
  - ALL : Both CRPh and PCPh hdf5 products are generated
  - CRPh : Only CRPh hdf5 product is generated
  - PCPh : Only PCPh hdf5 product is generated
- **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 PGE14 [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 PGE14 [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 PGE14 [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 PGE14 [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).

### 3.4 SUMMARY OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPH) VALIDATION RESULTS

The following tables summarize the validation results of CRPh algorithm. More details can be obtained from the Validation Report for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0) [AD 2].

Green colour values in tables mean that FAR or POD values obtained in this validation fulfill the FAR and POD target values defined in the NWCSAF Product Requirement document [AD 5].

#### 3.4.1 Instantaneous rates

##### Accuracy statistics:

Algorithm	N	Mean (mm/h)	ME (mm/h)	MAE (mm/h)	RMSE (mm/h)
CRPh_IQF $\geq$ 0 %	579705	0,62	0,85	1,38	4,10
CRPh_IQF $\geq$ 20 %	579670	0,62	0,85	1,38	4,10
CRPh_IQF $\geq$ 40 %	563371	0,62	0,81	1,33	3,97
CRPh_IQF $\geq$ 60 %	367610	0,61	0,40	0,94	2,76
CRPh_IQF $\geq$ 80 %	170182	0,58	0,16	0,70	1,89

Table 7: Accuracy measurements for instantaneous rates. Comparison among CRPh product using different CRPh\_IQF thresholds.

### Categorical scores:

Algorithm	FAR (%)	POD (%)	CSI (%)	PC (%)
CRPh_IQF $\geq$ 0 %	27,4	84,2	63,9	73,9
CRPh_IQF $\geq$ 20 %	27,4	84,2	63,9	73,9
CRPh_IQF $\geq$ 40 %	27,2	84,2	64,1	74,1
CRPh_IQF $\geq$ 60 %	26,4	84,5	64,8	74,9
CRPh_IQF $\geq$ 80 %	25,4	84,9	65,9	76,0

Table 8: Categorical scores for instantaneous rates. Comparison among CRPh product using different CRPh\_IQF thresholds.

### 3.4.2 Hourly accumulations

#### Accuracy statistics:

Algorithm	N	Mean (mm/h)	ME (mm/h)	MAE (mm/h)	RMSE (mm/h)
CRPh_IQF $\geq$ 0 %	297809	0,43	0,68	0,94	2,55
CRPh_IQF $\geq$ 20 %	297794	0,43	0,68	0,94	2,55
CRPh_IQF $\geq$ 40 %	270484	0,42	0,59	0,85	2,35
CRPh_IQF $\geq$ 60 %	180351	0,40	0,40	0,67	1,84
CRPh_IQF $\geq$ 80 %	83630	0,39	0,24	0,51	1,35

Table 9: Accuracy measurements for hourly accumulations. Comparison among CRPh product using different CRPh\_IQF thresholds.


#### Categorical scores:

Algorithm	FAR (%)	POD (%)	CSI (%)	PC (%)
CRPh_IQF $\geq$ 0 %	47,2	91,0	50,2	65,6
CRPh_IQF $\geq$ 20 %	47,2	91,0	50,2	65,6
CRPh_IQF $\geq$ 40 %	47,4	90,8	50,0	65,6
CRPh_IQF $\geq$ 60 %	47,3	90,9	50,1	66,3
CRPh_IQF $\geq$ 80 %	47,0	91,8	50,6	66,8

Table 10: Categorical scores for hourly accumulations. Comparison among CRPh product using different CRPh\_IQF thresholds.

### 3.5 TYPICAL KNOWN PROBLEMS AND RECOMMENDATION FOR USE

This algorithm can be run only over daytime.

	Product User Manual for “Precipitation products from Cloud Physical Properties” (PPh-PGE14: PCPh v1.0 & CRPh v1.0)	<b>Code:</b> SAF/NWC/CDOP2/INM/PUM/14 <b>Issue:</b> 1.0.1 <b>Date:</b> 4 December 2014 <b>File:</b> SAF-NWC-CDOP2-INM-SCI-PUM-14_v1.0.1 <b>Page:</b> 28/29
---	--	---

For undefined phase pixels,  $R_{\text{eff}}$  and COT values are not computed by PGE02, so a 0 mm/h rain rate is assigned in these cases by the algorithm.

As the main inputs of the product are computed by PGE02, there exists the need to run PGE02 previous to run PGE14.

It has been observed that pixels located in the surroundings of snow according to PGE02 take high values of CWP, so a rain rate higher than 0 mm/h is assigned erroneously.

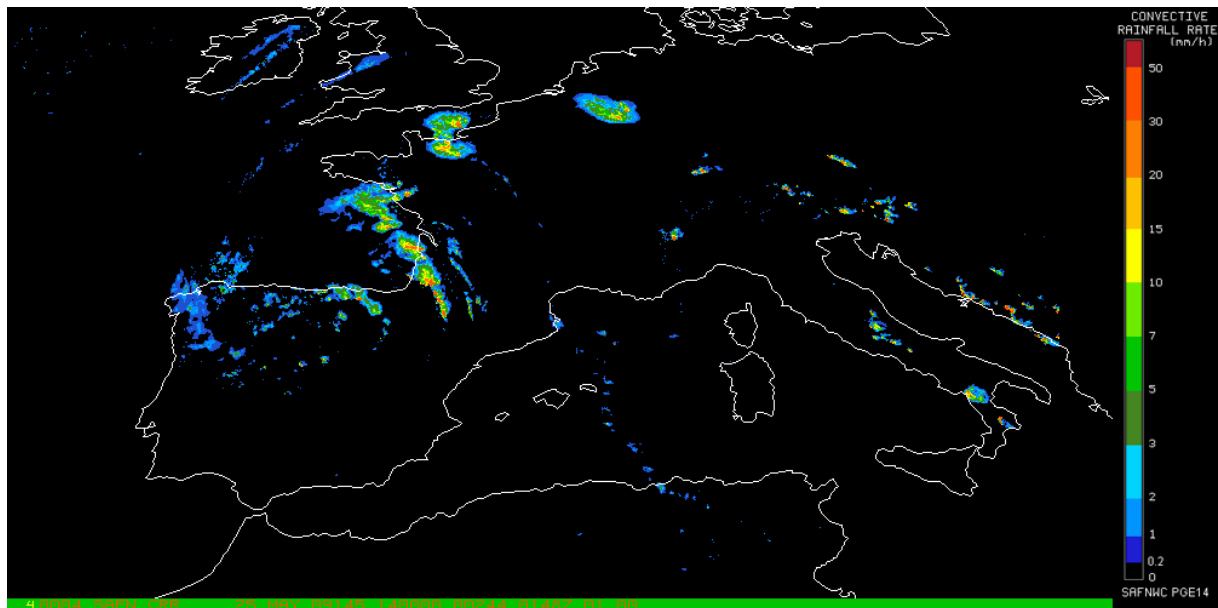
It is highly recommended to apply parallax correction for a better location of precipitation areas with respect to the ground below.

There exists a high dependence on illumination conditions for this product.

It must be borne in mind that these kind of cloud top based precipitation indirect methods necessarily have uncertainties. Although not found during the calibration and validation processes, according to the literature it is possible to find small ice particles in high-level strong updrafts of deep convective clouds [RD.1]. This could cause erroneous rain rate estimations.

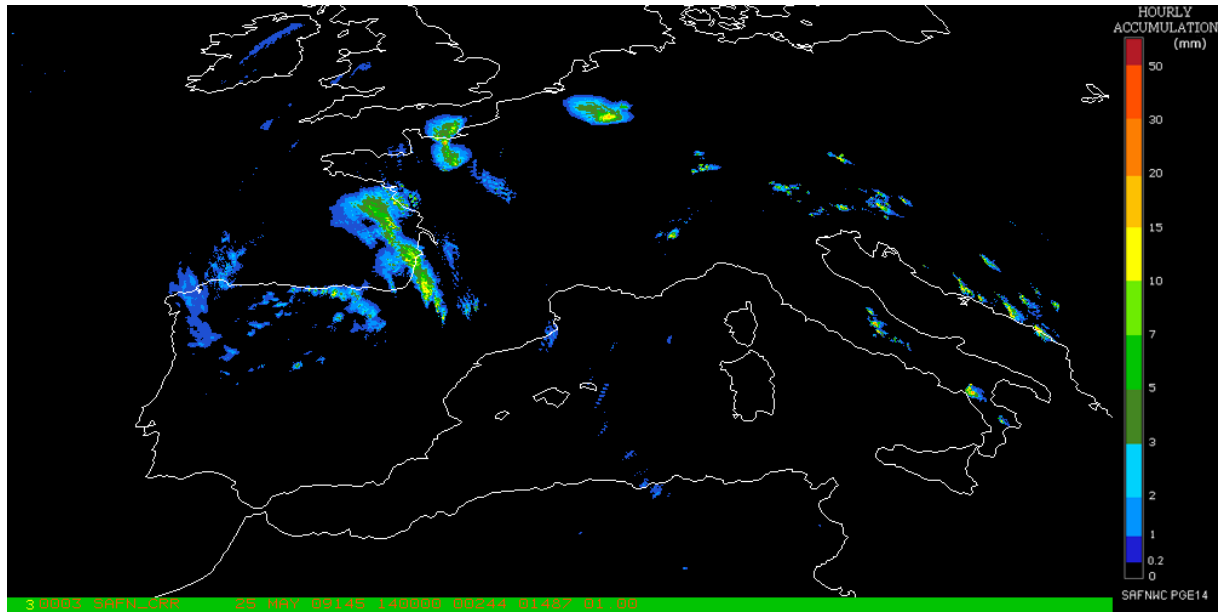
### 3.6 EXAMPLE OF CONVECTIVE RAINFALL RATE FROM CLOUD PHYSICAL PROPERTIES (CRPh) VISUALIZATION

Below is shown an image of the instantaneous rain rates CRPh product. It has been obtained at full resolution



*Figure 7: CRPh instantaneous rain rates for 25th May 2009 at 14:00 UTC over Europe*

Below is shown an image of the hourly accumulation CRPh product. It has been obtained at full resolution.



*Figure 8: CRPh hourly accumulations for 25th May 2009 at 14:00 UTC over Europe*