Product User Manual for SAFNWC/MSG "Precipitating Cloud" (PC-PGE04 v1.5)

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Applicable to SAFNWC/MSG version 2013

Applicable to the following PGE:s:

PGE	Acronym	Product ID	Product name	Version number
PGE04	PC	SAFNWC/MSG/PGE04	Precipitating Clouds	1.5

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REPORT SIGNATURE TABLE

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DOCUMENT CHANGE RECORD

Version	Date	Pages	CHANGE(S)
1.5d	23 January 2009	16	New Document for v2009
1.5	2 March 2009	17	Changes after DRI-2009: -Corrected erroneous references and add short reference names -Acronym list updated -Erroneous reference to PPS in chapter 1.3 deleted -Applicable documents: dates and codes updated -clarified reference to last scientific update in section 1.7
1.5.1d	19 April 2010	22	. – no scientific updates. Adapted date, issue and revision to v. 2010 - Included reference to VS report nov. 2009
1.5.1	25 May 2010	18	Added the full NWCSAF logotype on first page.
1.5.2d	11 February 2011	18	No scientific updates. Adapted date, issue and rev. to v2011.
1.5.3.d	11 October 2011	18	No scientific updates. Adapted date, issue and rev. to v2012.
1.5.3	15 February 2012	18	Updated references
1.5.4	15 July 2013	18	No scientific updates. Adapted date, issue and rev. to v2013

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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 for the SAFNWC MSG Precipitating Clouds product. The document describes how to use the product after installation. It is meant to support the interpretation as well as describe the possibilities and limitations.

1.2 SCOPE OF OTHER DOCUMENTS

The algorithm used in the Precipitating Clouds Product is described in more detail in the corresponding Algorithm Theoretical Basis document [AD. 6].

Validation of the algorithm is detailed in the Validation report for Precipitating Clouds [AD. 1].

Instructions how to install, configure and execute the software are given in the Software User Manual for NWCSAF MSG Package [AD. 2].

The Interface Control Documents [AD. 3] (for the External and Internal Interfaces of the SAFNWC/MSG) and [AD. 4](MSG Output Product Format Definition) detail the input and output data format for the SAFNWC/MSG software.

1.3 WHO SHOULD READ THIS MANUAL

This document is intended for the end-user, i.e. the forecaster.

For the person in charge of building and installing the MSG software package, thus the sys-admin we refer to the Software User Manual ([AD. 2]), which will of course also be relevant for the science-admin.

For the person interested in the algorithms in detail we refer to the Algorithm theoretical Basis Document[AD. 6].

1.4 SOFTWARE VERSION IDENTIFICATION

This document describes the algorithms implemented in the PGE04 version v1.5 of the 2012 SAFNWC/MSG software package delivery.

1.5 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

Acronym	Explanation	Acronym	Explanation
CDOP	Continuous Development and Operational Phase	**CM**	Cloud Mask (also PGE01)
		CT	Cloud Type (also PGE02)

Acronym	Explanation
CTTH	Cloud Top Temperature, Height and Pressure (also PGE03)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAR	False Alarm Rate
FOV	Field Of View
HDF5	Hierarchical Data format version 5
IR	Infrared
LUT	Look-Up-Table
MSG	Meteosat second generation
NIR	Near Infrared
NORDRAD	Nordic Weather Radar Network
NWP	Numerical Weather Prediction
PC	Precipitating Cloud (also PGE04)
PCPN	Precipitation
PGE	Process Generating Element
PI	Precipitation Index
POD	Probability Of Detection
POFD	Probability Of False Detection
RGB	Red Green Blue
SAF	Satellite Application Facility
SAFNWC	Satellite Application Facility for support to NoWcasting
SEVIRI	Imager onboard MSG satellites
SMHI	Swedish Meteorological and Hydrological Institute
SW	SoftWare
TOA	Top Of Atmosphere
USGS	U.S. Geological Survey
VIS	Visible

For a list of SAF-acronyms see also [RD.1].

1.6 REFERENCES

1.6.1 Applicable Documents

Reference	Title	Code	Vers	Date
[AD. 1]	Validation Report for Precipitating Clouds (PC-PGE04v1.4)	SAF/NWC/CDOP/SMHI/SCI/VR/01	1.4	19/11/07
[AD. 2]	Software User Manual for the SAFNWC/MSG Application: Software Part	SAF/NWC/CDOP/INM/SW/SUM/2	6.0	15/02/2012
[AD. 3]	Interface Control Document for the External and Internal Interfaces of the SAFNWC/MSG	SAF/NWC/CDOP/INM/SW/ICD/1	6.0	15/02/2012
[AD. 4]	SAFNWC/MSG Output Product Format Definition	SAF/NWC/CDOP/INM/SW/ICD/3	6.0	15/02/2012
[AD. 5]	Architectural Design Document for the SAFNWC	SAF/NWC/CDOP/INM/SW/AD/1	6.0	15/02/2012
[AD. 6]	Algorithm Theoretical Basis Document for "Precipitating Clouds" (PC-PGE04 v1.5)	SAF/NWC/CDOP/SMHI/SCI/ATBD/04	1.5.3	15/02/2012
[AD. 7]	Cross-Verification of the Rapid Development Thunderstorm and the Precipitation Products of the Nowcastion and Vert Short Range Forecasting SAF	Visiting scientist report by Eszter Lábó, Mária Putsay, Zsófia Kocsis and Ildikó Szenyán		15/11/2009

Table 1: List of Applicable Documents

1.6.2 Reference Documents

Reference	Title	Code	Vers	Date
[RD.1]	The Nowcasting SAF Glossary	SAF/NWC/CDOP/INM/MGT/GLO	1.5	15/04/2011
[RD.2]	SAFNWC Product Requirements Document	SAF/NWC/INM/MGT/PRD	1.2	17/11/2011

Table 2: List of Referenced Documents

1.7 SCIENTIFIC UPDATES SINCE MSG VERSION 2011

No scientific updates have been implemented since NWCSAF/MSG version 2011.

2. DESCRIPTION OF THE PRODUCT

2.1 GOAL OF THE PC PRODUCT

Goal of the PC product is to give a first guideline to the forecaster where to expect precipitation, especially for areas where no radar data is available. The product provides the probability of precipitation for each Meteosat pixel.

Since the coupling of radiances from visible and infrared channels with precipitation is rather weak, large areas are marked as potentially precipitating (more than 10% precipitation likelihood). The skill the derive stratiform precipitation is limited and potential precipitation area is overestimated, but indicating low likelihood. Strong convective precipitation can be better estimated from METEOSAT data than rain from stratiform precipitation, and the NWCSAF convective rain rate product and the rapidly developing thunderstorm product can be consulted for more detailed analysis of severe convection.

2.2 OUTLINE OF THE PRECIPITATING CLOUD ALGORITHM

2.2.1 General algorithm design

The precipitating clouds product gives the total likelihood of precipitation without attempting to estimate intensity. To derive the likelihood of precipitation, a precipitation Index PI is constructed from those IR and visible spectral features which are most correlated with precipitation. The precipitation likelihood for each value of the PI is determined statistically by comparison with collocated precipitation measurements. For the tuning of the current algorithm version French gauge network measurements for one year of data were used.

In the calculation of the PI special attention has been given to spectral features in the visible, which implicitly contain information on cloud microphysical properties at the cloud top, such as effective radius and cloud phase. The algorithm employed is cloud type dependent in the sense that mapping from PI to precipitation likelihood makes use of cloud type dependent lookup tables. For the PI calculation a day and a night version exists, where the night version only makes use of IR channels not influenced by sunlight.

2.2.2 Data sources for Precipitationg Clouds

- Meteosat visible and IR channels:

  Daytime: vis0.6, NIR1.6, IR3.9, IR6.2, IR7.3, IR10.8, IR12.0

  Nighttime: IR6.2, IR7.3, IR10.8, IR12.0
- Cloud type product
- NWP surface temperature

2.2.3 Graphical overview of the Precipitating Clouds product (PGE04)

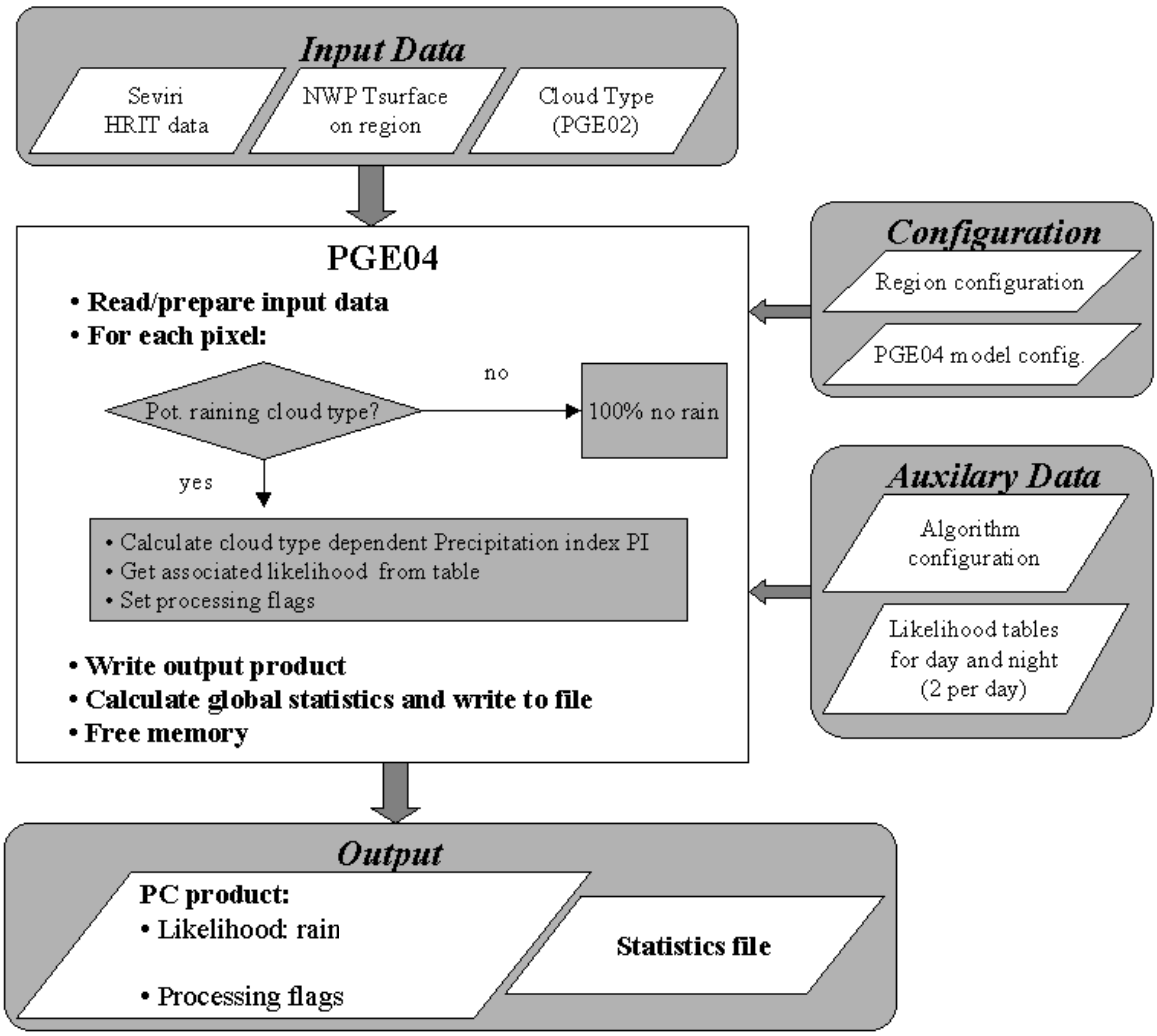

Figure 1: schematic overview over the Precipitating Clouds product

2.2.4 Description of the output

The precipitating clouds product gives the likelihood of precipitation:

- Class 1: total precipitation likelihood for rain > 0.1 mm/h
- Class2: obsolete, set to 0

The likelihood is given in intervals of 10%:

0% to 5% → 0%
> 5% to 15% → 10%
> 15% to 25% → 20%
> 25% to 35% → 30%
> 35% to 45% → 40%
> 45% to 55% → 50%
> 55% to 65% → 60%
> 65% to 75% → 70%
> 75% to 85% → 80%
> 85% to 95% → 90%
> 95% to 100% → 100%

Please pay attention to that the value in the HDF5 dataset has to be multiplied by the scaling factor 10, as specified in the HDF file to arrive at the correct likelihood. The product is supplied in HDF5 format and has the same resolution as in the original SEVIRI image.

Special count = 15= 150% used when no data value is available. The forecaster is likely to receive the product displayed as an image, similar to Figure 2.

Using the 20% class as a threshold for precipitation detection gives a fairly save estimate of possible precipitation, although some light to moderate precipitation migh be missed (deep green in Figure 2). Using 30% as theshold (light green in Figure 2) provides usually a subjectively better fit to radar data, but more real precipitation remains undetected while there is still a slight overestimation of precipitation area.

2.2.4.1 Flags

The product contains also quality information in a separate field. The quality information is indicating under which circumstances the PC product was derived. Except for the field indicating whether solar channels were used, it should not be of much interest to the forecaster, and most likely it will not be required to visualize this information.

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

Table 3: Quality flags of PGE04

The quality information is indicating under which circumstances the PC product was derived.

2.2.5 Statistics file

The statistics file is an ASCII file summarising the distribution of probabilities over the complete region. It can be easily used for verification whether 2 runs are identical. Files may also be used to easily accumulate statistics on general algorithm performance.

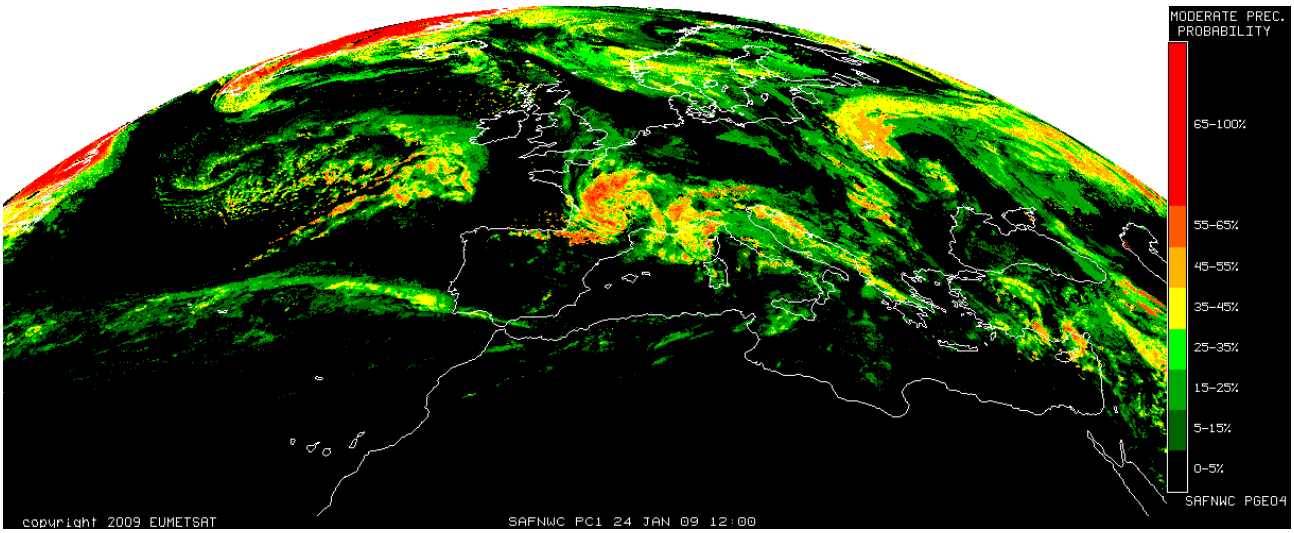

Figure 2: 200901241200 precipitating clouds product over MSG-N, configured for day algorithm. Dark green hues present precipitation likelihood classes 10%-20%,light green 30%, yellow40% and orange/red hues 50% and higher.

3. IMPLEMENTATION OF THE PRODUCT

The implementation is described in Software User Manual ([AD. 2]). Interesting for the forecaster is that the region is configurable. However auxiliary data for a new region has to be compiled beforehand. The product generation is usually scheduled automatically by the task manager.

4. INPUTS AND CONFIGURABLE PARAMETERS

4.1 LIST OF INPUTS

Please note that the precipitating cloud product (PGE04) requires the cloudtype product as input (PGE02), and for that even the Cloudmask product has to be run (PGE01).

- NWP surface temperature
- Sun zenith, satellite view zenith, and sun-satellite view relative azimuth difference angle
- Output from Cloud Type
- Seviri data

4.2 CONFIGURABLE PARAMETERS

The Precipitating Cloud product has been designed to allow a full configuration and flexibility to update/tune the algorithm without having to modify the code. However most of these configurable parameters are only of interest to the developer. The only configurable parameters potentially of interest to the users are the configuration of when to switch from day- to nighttime scheme, and that it is in principle possible to define which cloud types are treated as potentially raining.

- The default configuration is that the night time algorithm is activated when the sun zenith angle is greater than 80 degrees. It is possible to configure the product to only use the night algorithm by setting the sun zenith angle threshold to 0 in the algorithm configuration file. This would avoid discontinuities in the product at the day/night deliminator on the cost of degrading performance during day time.
- In principle it is possible to configure which cloud classes are treated as potentially raining. Please consult the NWCSAF helpdesk before changing the validated default configuration.

The possible configurable parameters are described in the Software User Manual [AD. 2].

5. VALIDATION

5.1 SUMMARY OF VALIDATION RESULTS

The PC product can be validated against co-located radar data, synop current weather observations or rain gauge data. For more information on product validation see validation reports [AD. 1] and [AD. 6]. When verifying likelihood results of the PC product, it is important to somehow quantify the algorithm performance and give guidance to answer the question whether it is raining or not. It is important to understand that a simplified "categorical estimate", which has been derived from the likelihood distribution, degrades the product on the one hand (no "fair" comparison) but, on the other hand, makes it more practical to use for the forecaster.

A simple way to convert likelihood estimates into easily verifiable estimates of precipitation is to set a threshold for rain according to algorithm performance. Which threshold of total precipitation likelihood does best divide the precipitating from the non-precipitating events? (Usually 20% or 30% of total precipitation likelihood!)

The performance of this "hard-clustering" is verified using contingency tables. Evaluating the performance at different threshold levels gives also an overview of how closely assigned probability values match real occurrence of rain, as illustrated in Figure 3 and Figure 4.

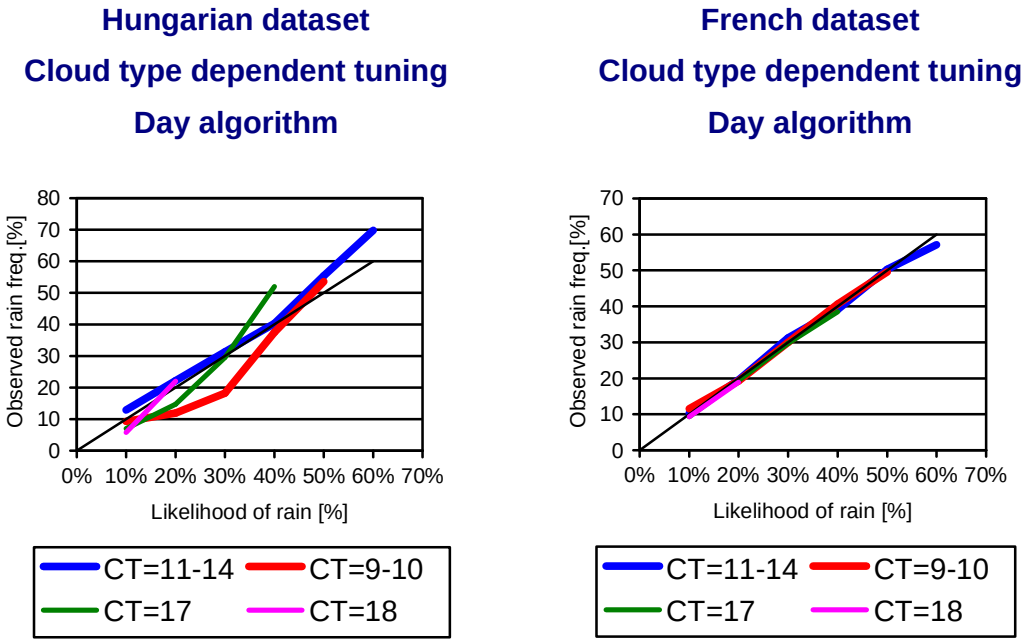

Figure 3: Likelihood of rain from PC product versus observed rain frequency. Cloud type dependent tuning on French gauge data.Left: independent validation against Hungarian gauge data 2004, right: performance on dependent French gauge data set 2004. verified against 30 min averages in gauge data. Blue:high and very high clouds, red: medium level clouds,green: thick cirrus,cyan: cirrus over lower clouds.

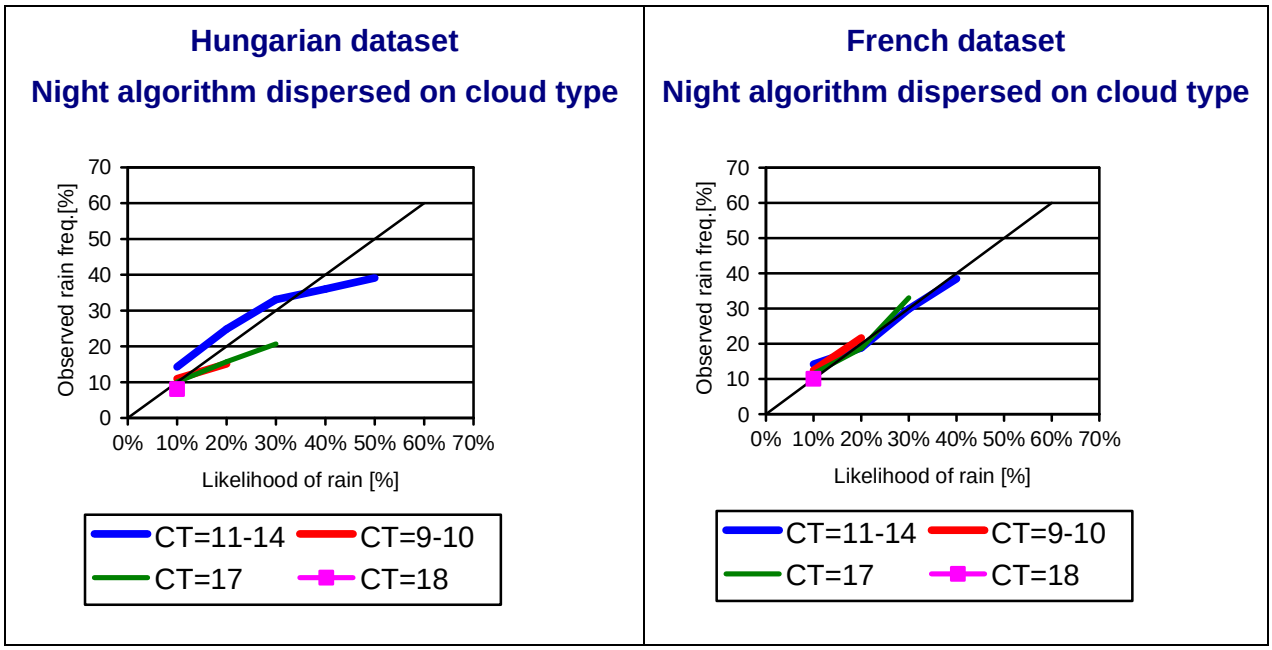

Figure 4: Likelihood of rain versus observed rain frequency. Same as Figure 3 but for night time.

Algorithm performance can be summarized as follows:

- **At the 20% detection threshold day and night algorithms perform almost equally well, whereas the day algorithm clearly exhibits more skill at the 30% threshold than the night algorithm. 20%can be used as a kind of hardclustering threshold for precipitation, but thresholding at 30% generally gives a better subjective fit to radar precipitation areas.**
- Day and nighttime algorithms exhibit different characteristics, and discontinuities at the day/night deliminator are apparent (see Figure 5). With just using IR channels at night, there are less areas assigned high precipitation likelihood and the precipitation areas are less defined at night time. For the night time algorithm precipitation occurrence is more strongly overestimated in winter, in summer more actual precipitation is missed. Both at 20% and 30 % threshold precipitation occurrence is overestimated.
- The work with separating cloud types has shown that:
  - Cloud type class 9-10 (medium level cloud) precipitation is overestimated at 20 percent detection level.
  - Cloud type class 17 and 18 (thick cirrus and cirrus over lower cloud) give bad results overall.
  - Cloud type class 11-14 (high and very high cloud) seems to be the easiest to handle
  - Considering cloud low clouds (CT 8) as possibly precipitating might be considered in the following versions

6. KNOWN PROBLEM AREAS AND LIMITATIONS

- The current version of the product contains a certain dependence on sun zenith angle.
- There is also a clear jump in algorithm performance between day and night algorithm, which cannot be totally avoided.
- The product degrades considerably at high viewing angles and use for viewing angles greater than 60 degrees is not recommended.
- The algorithm does currently not detect any precipitation from low clouds

7. EXAMPLE OF PRODUCT VISUALISATION

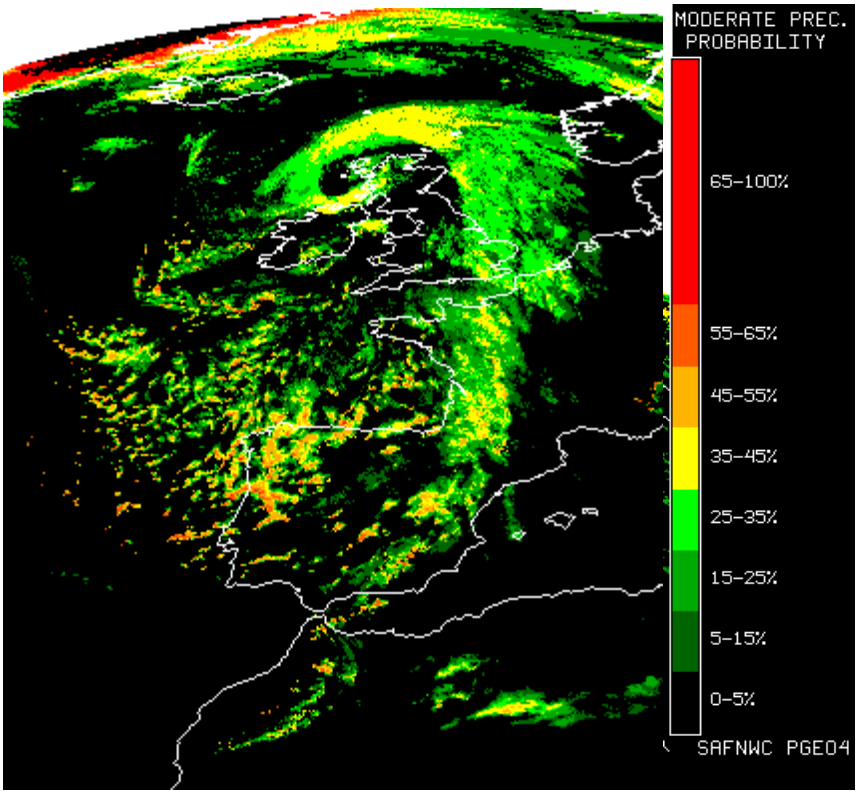

Figure 5: Example of the precipitating clouds product with a change from day to night algorithm diagonally over the British isles (northward night algorithm, south day algorithm).Please note typical features: precipitation area more spread out for night time algorithm, less detailed features and no high precipitation likelihood. At high satellite viewing angles the product becomes unreliable as seen by high precipitation likelihood at the rim of the Meteosat disk.(do not use for satellite viewing angles exceeding 60 degrees).