The EUMETSAT Network of Satellite Application Facilities

NWC SAF

Support to Nowcasting and Very Short Range Forecasting

Convective Rainfall Rate

Antonio Rodríguez
Cecilia Marcos

NWC SAF CDOP 2010 Users' Workshop

(Madrid, 26th – 28th April 2010)

OVERVIEW

INTRODUCTION

MAIN IMPROVEMENTS IMPLEMENTED DURING CDOP PHASE

- New Calibration
- Hourly Accumulations
- Incorporation of the Lightning activity information

EXTENDED VALIDATION OF VERSION 2010

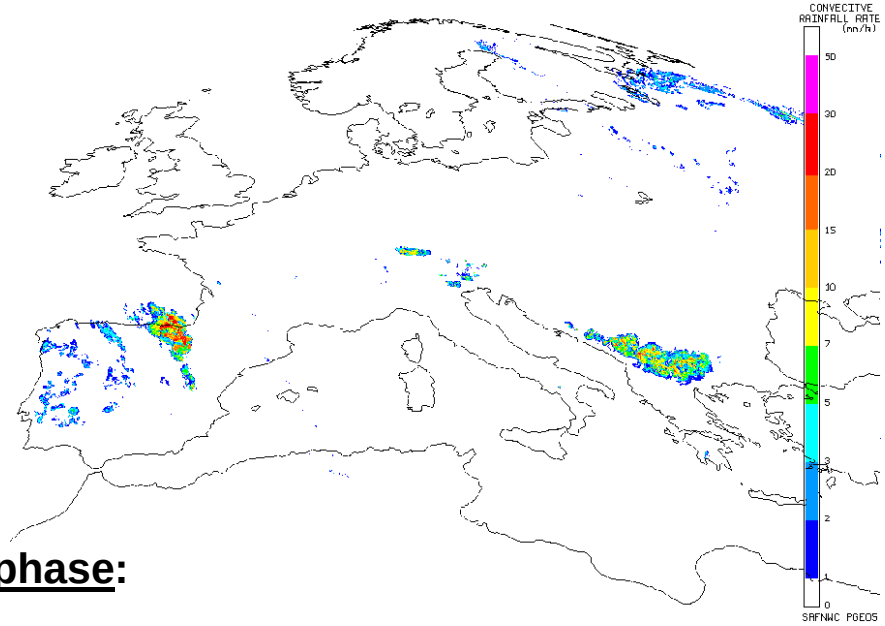
- Subjective validation over Spain
- Objective validation over Spain
  - ✓ Validation procedure
  - ✓ Validation results
- Objective validation over Hungary
  - ✓ Validation procedure
  - ✓ Validation results: Hungary vs Spain

EXAMPLES
FUTURE WORK
CONCLUSIONS

INTRODUCTION

CRR goal:

The CRR algorithm estimates rainfall rates from convective and stratiform associated systems, using MSG SEVIRI channels. (IR10.8µm, WV6.2 µm, VIS0.6 µm)



CRR product version during CDOP phase:

Version 2008 (v2.1): new radiances, rapid scan, hole parallax identification
Version 2009 (v3.0): new calibration, hourly accumulations *(and rain rates in mm/h),* parallax correction updated
Version 2010 (v3.1): lightning information

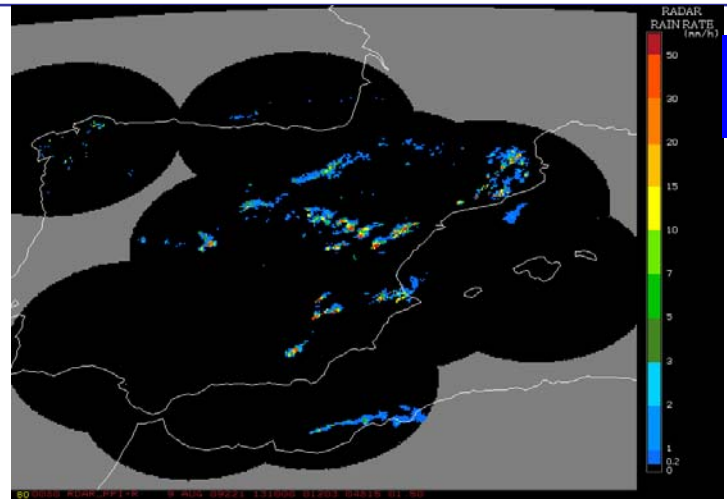
**The DATAFLAG and QUALITY outputs have been modified accordingly to every change.*

MAIN IMPROVEMENTS IMPLEMENTED DURING CDOP PHASE:

NEW CALIBRATION

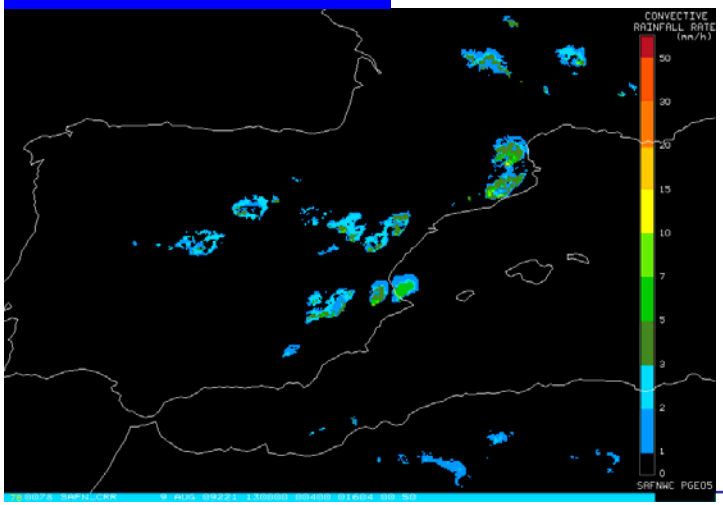
Calibration is a statistic method: CRR rates usually lower than radar ones:

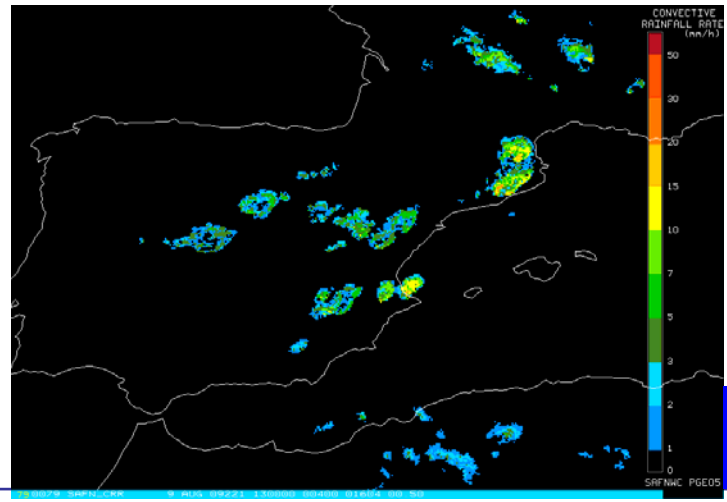
V2009: puts more weight to the higher rates in an empirical way providing a better adjusted precipitation pattern



PPI Radar product

CRR calibration 2008





CRR calibration 2009

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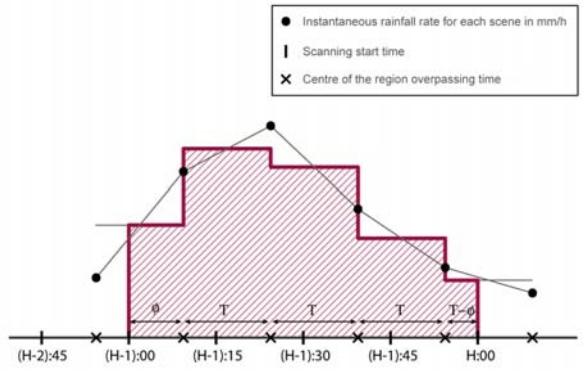
MAIN IMPROVEMENTS IMPLEMENTED DURING CDOP PHASE:

HOURLY ACCUMULATIONS

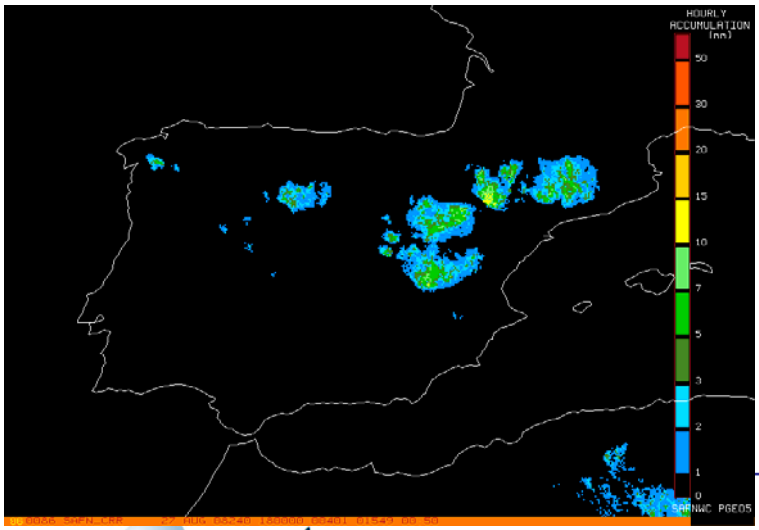
To compute the accumulations CRR products uses 6 slots of instanatateous rates in a trapezoidad integration:

$$A_6 = \frac{I_1 + I_2}{2}\phi + \frac{I_2}{2}T + I_3T + I_4T + \frac{I_5}{2}T + \frac{I_5 + I_6}{2}(T - \phi)$$



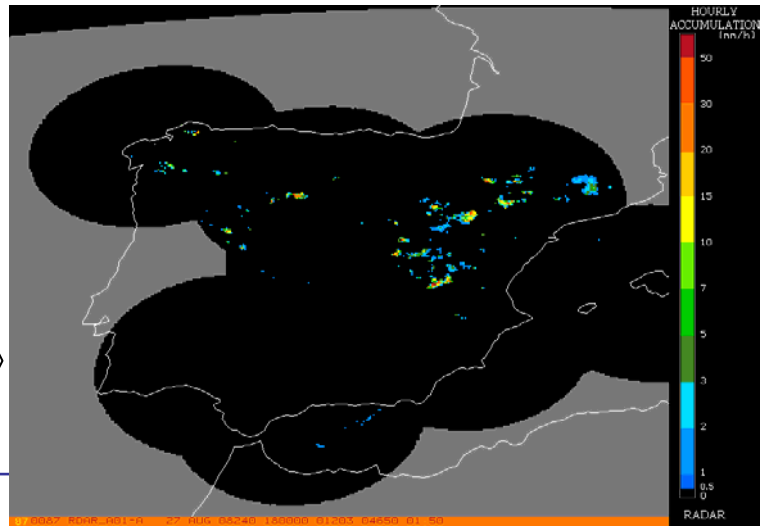
Where:

- ***A_i*: hourly accumulation, in mm, corresponding to the time i.**
- ***T*: time interval between scenes in hours (T= 0.25)**
- ***Φ*: part of *T* that corresponds to the time that takes the satellite to reach the centre of the region.**
- ***I_i*: Instantaneous rainfall rate for each scene in mm/h**



One hour accumulated CRR

One hour accumulated Radar



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MAIN IMPROVEMENTS IMPLEMENTED DURING CDOP PHASE:

INCORPORATION OF THE LIGHTNING INFORMATION

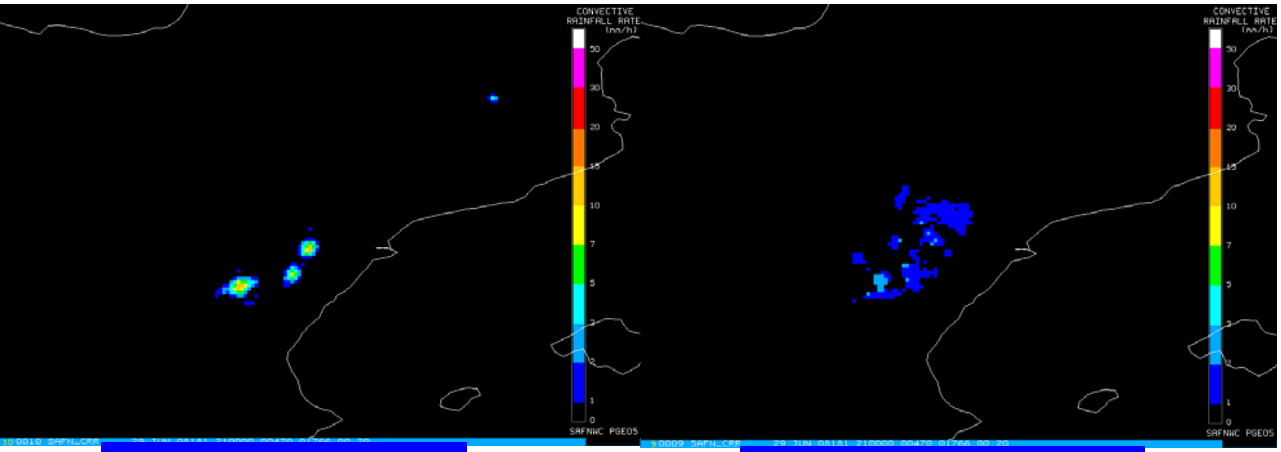
The **Lightning algorithm** developed assumes that **the higher are the spatial and temporal density of lightning, the higher are the probability and the intensity of convective precipitation**.

The **rain rates** assigned to every lightning takes into account:

- the **time distance 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.**

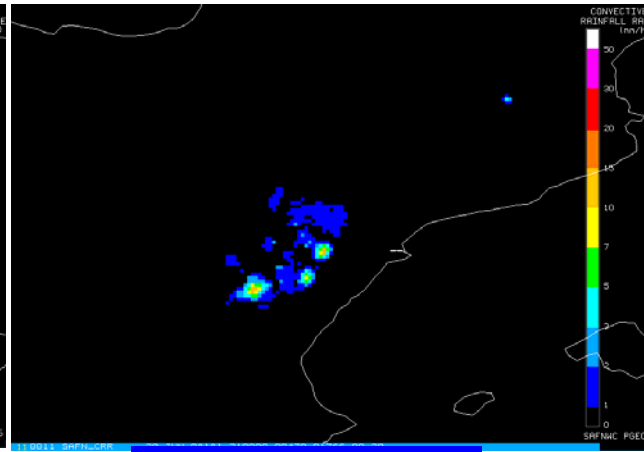
Only **Cloud-to-Ground lightning flashes** are used by this algorithm.

When the **lightning precipitation pattern** has been computed, it is compared to the **CRR precipitation one** in order to obtain the **final product**, that will contain the **highest rain rates** of the two.



Lightning algorithm

CRR without lightning



CRR with lightning

MAIN IMPROVEMENTS IMPLEMENTED DURING CDOP PHASE:
INCORPORATION OF THE LIGHTNING INFORMATION

- The **lightning algorithm calibration** has only been performed for the Spanish region with the **AEMET lightning network**, using **convective events occurred during 2007** as it is explained in the CRR ATDB for v2010.

- As **every ground based lightning detection network** has **different performance in detection efficiency and location accuracy**, the **product does not use by default the lightning information.**

So **it is highly recommended to the users to adapt the algorithm coefficients** (in model configuration file) to their **specific lightning detection network**.

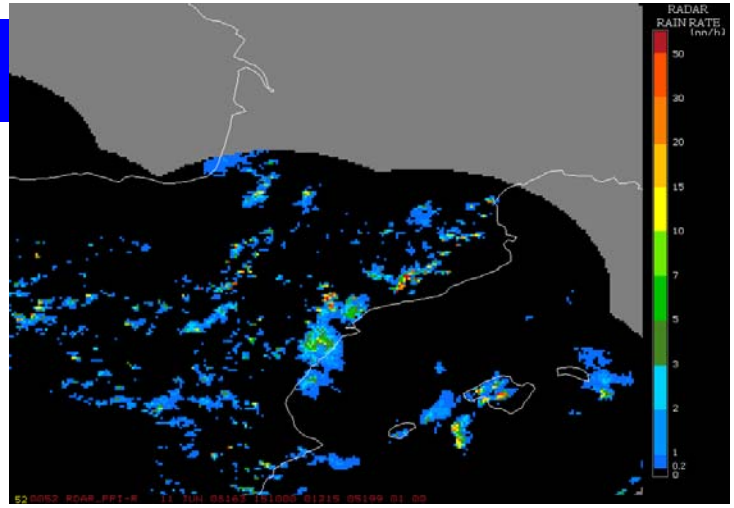
- This issue **could be solved in the future** with the use of the **uniform lightning information from MTG Lightning Imager for all the coverage area**.

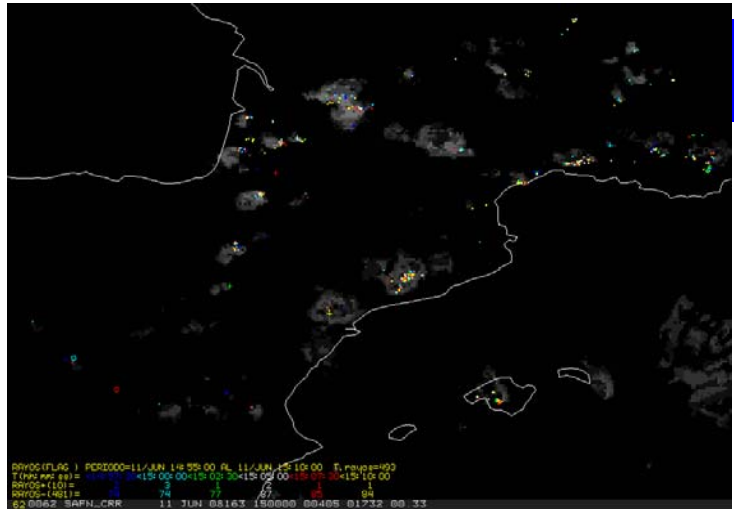
EXTENDED VALIDATION OF VERSION 2010:

SUBJECTIVE VALIDATION OVER SPAIN

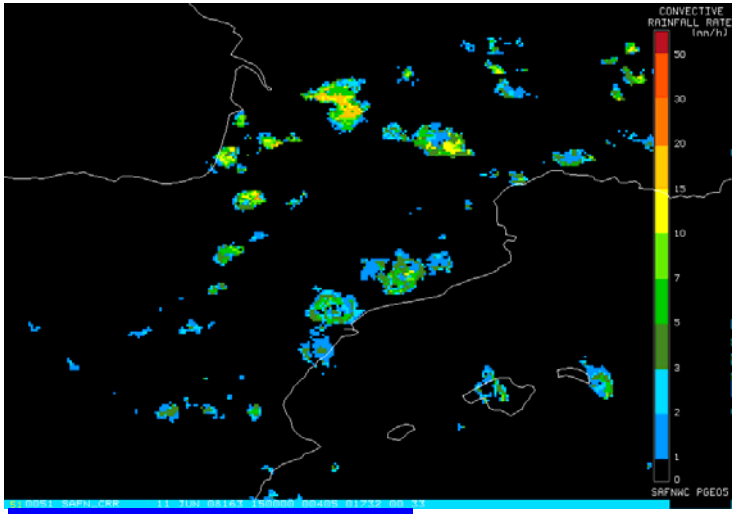
11th Jun 2008 at 15:00 UTC

PPI Radar product

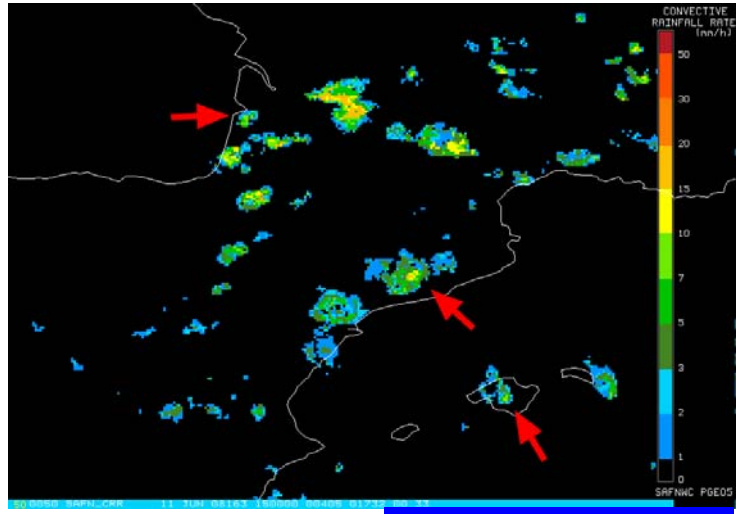




Lightning information



CRR without lightning



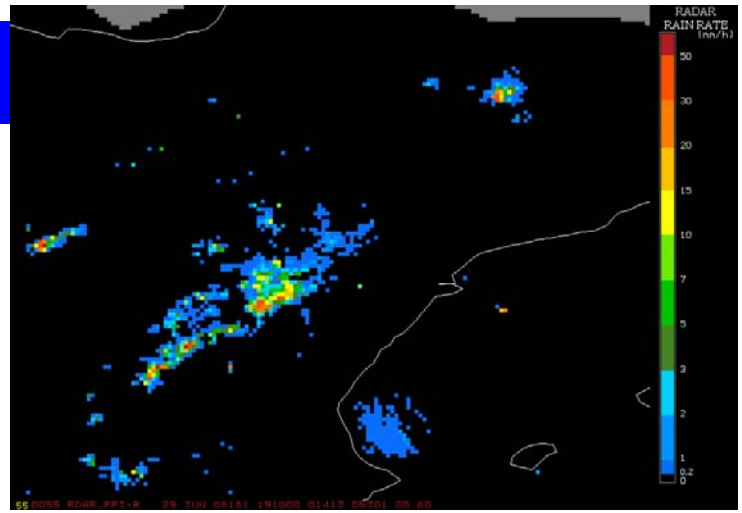
CRR with lightning

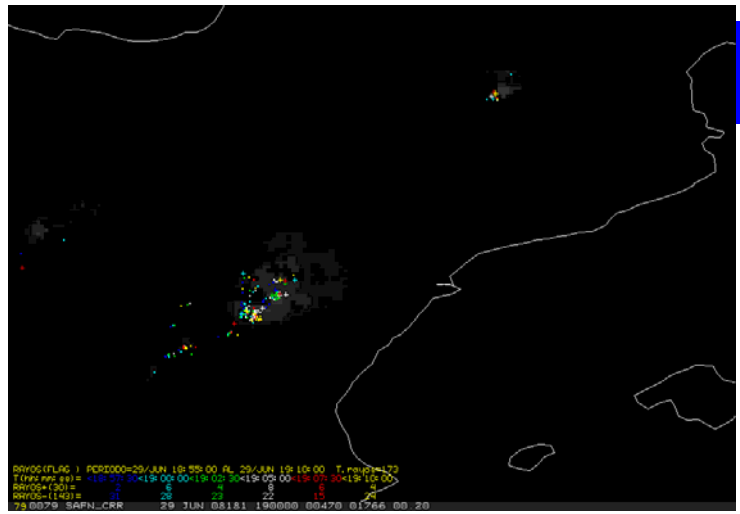
EXTENDED VALIDATION OF VERSION 2010:

SUBJECTIVE VALIDATION OVER SPAIN

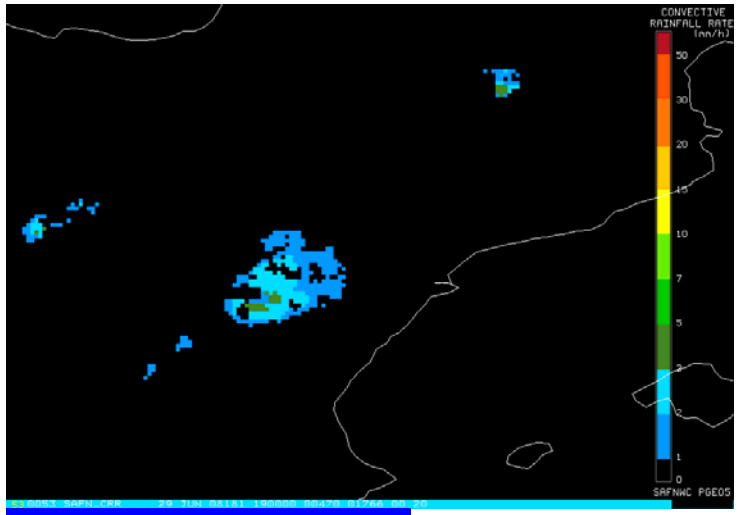
29th Jun 2008 at 19:00 UTC

PPI Radar product

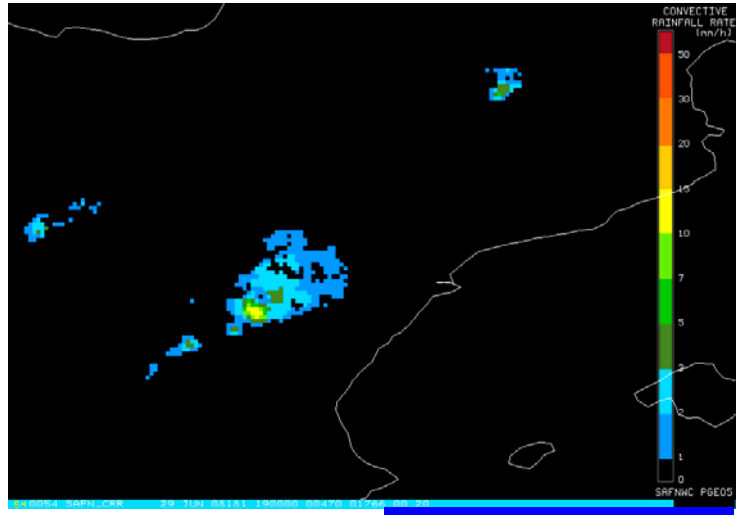




Lightning information



CRR without lightning



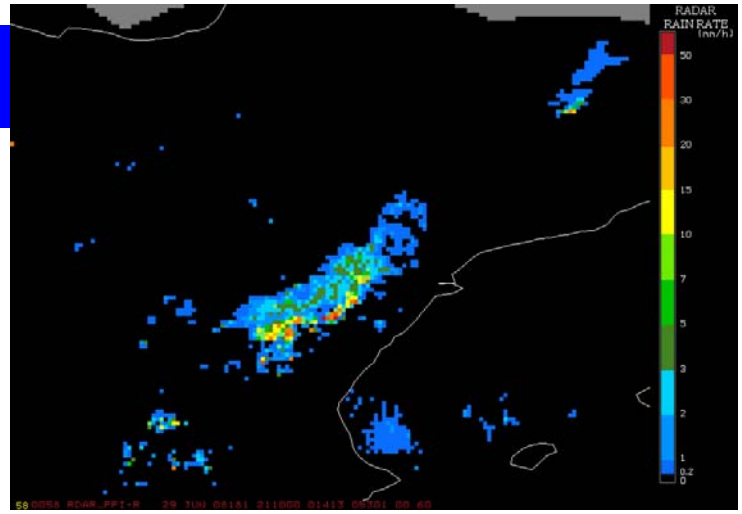
CRR with lightning

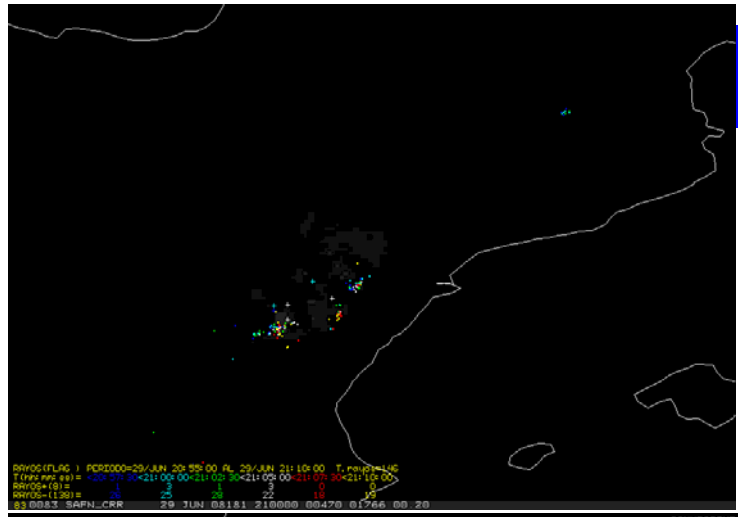
EXTENDED VALIDATION OF VERSION 2010:

SUBJECTIVE VALIDATION OVER SPAIN

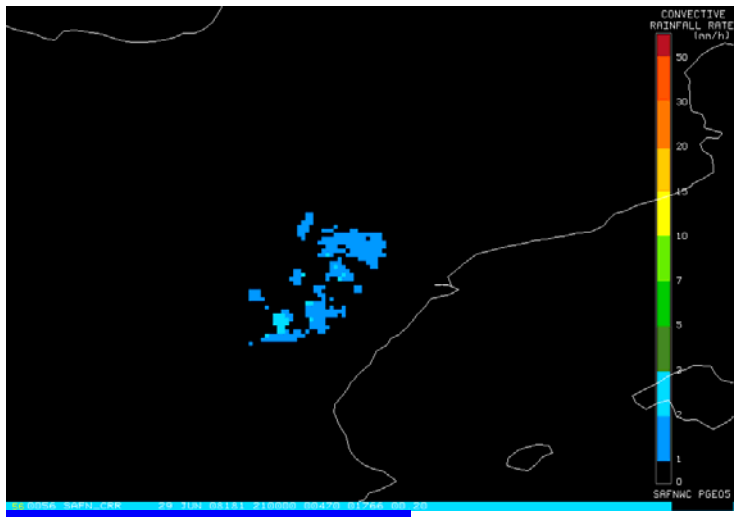
29th Jun 2008 at 21:00 UTC

PPI Radar product

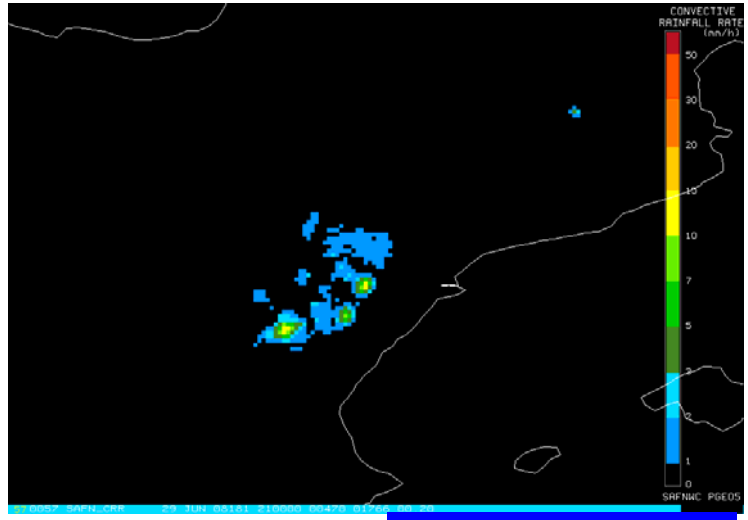




Lightning information



CRR without lightning



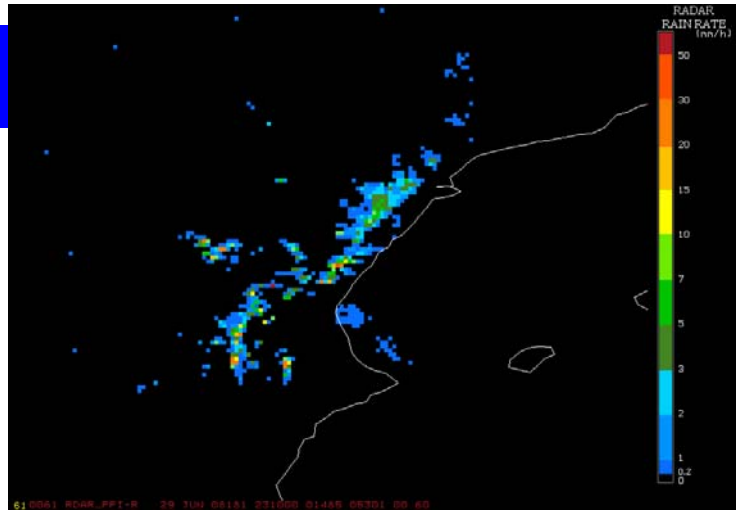
CRR with lightning

EXTENDED VALIDATION OF VERSION 2010:

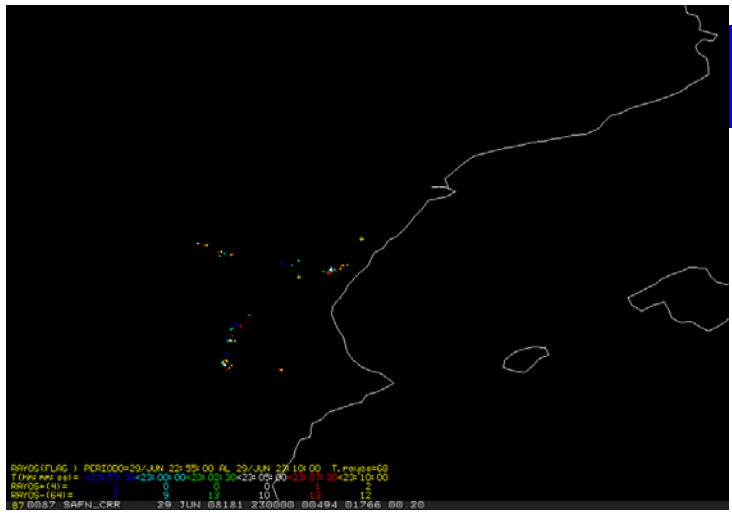
SUBJECTIVE VALIDATION OVER SPAIN

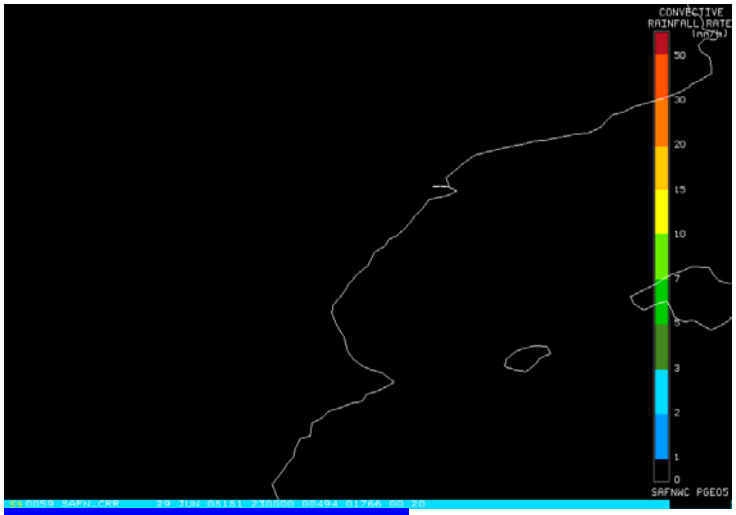
29th Jun 2008 at 23:00 UTC

PPI Radar product

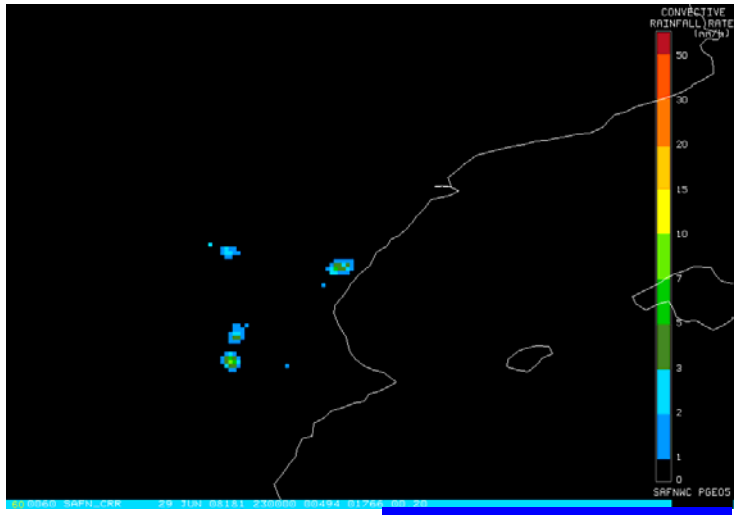


Lightning information





CRR without lightning



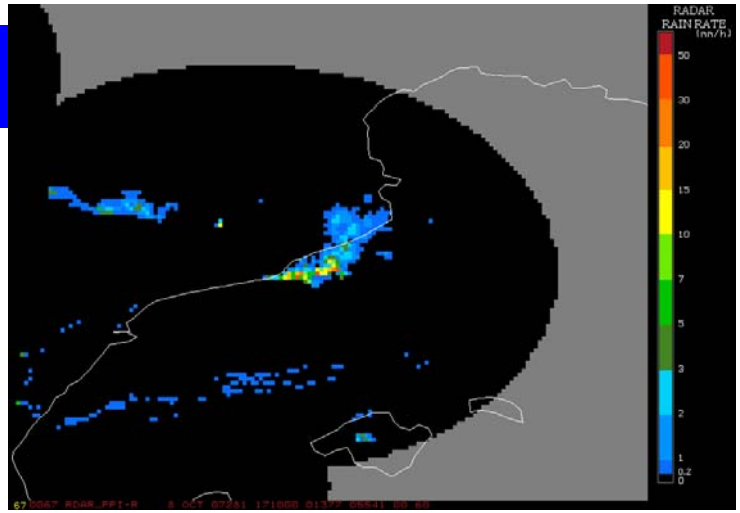
CRR with lightning

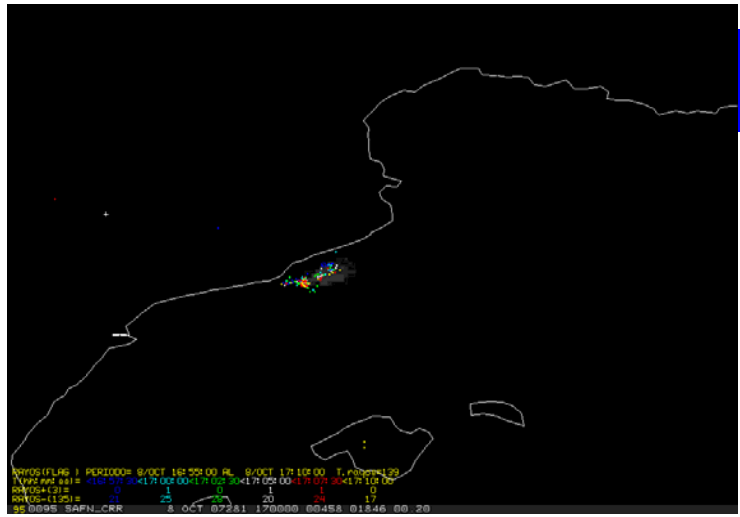
EXTENDED VALIDATION OF VERSION 2010:

SUBJECTIVE VALIDATION OVER SPAIN

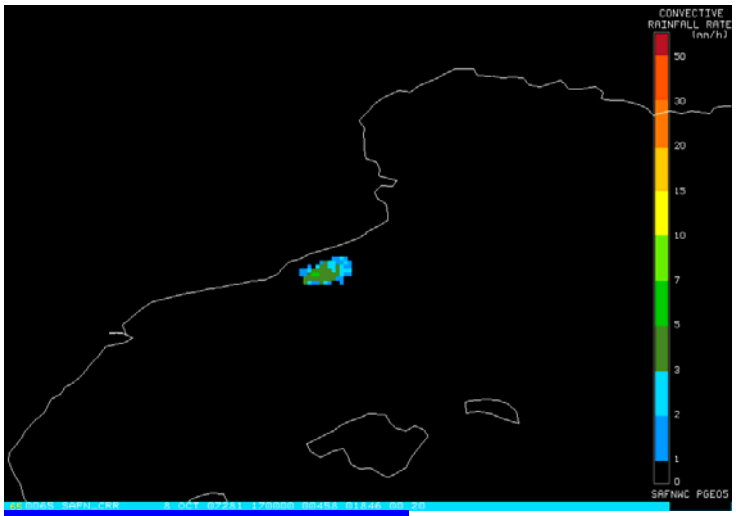
8th October 2007 at 17:00 UTC

PPI Radar product

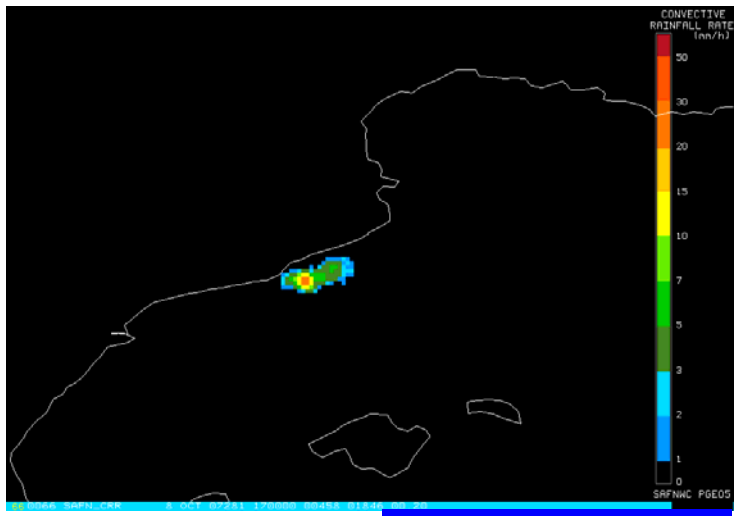




Lightning information



CRR without lightning



CRR with lightning

EXTENDED VALIDATION OF VERSION 2010:
OBJECTIVE VALIDATION PROCEDURE OVER SPAIN

The objective validation over the Spanish region has been made comparing the CRR instantaneous rates from classes and the hourly accumulations with the corresponding radar values considered as "truth data".

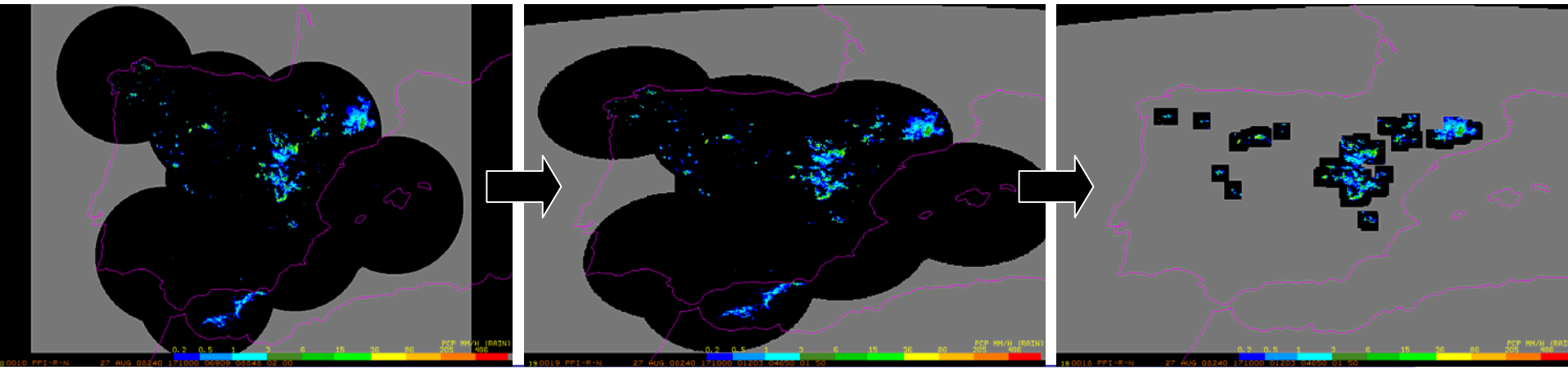
Validation period: the whole year 2008. (Up to 85 days)

The CRR values have been obtained by using all the corrections with the default values and with the fields from the European centre model at 0.5 x 0.5 degrees every 6h.

The validation process has been the same as the one used in previous works which is based on grid boxes averaged values comparisons.

EXTENDED VALIDATION OF VERSION 2010:
OBJECTIVE VALIDATION PROCEDURE OVER SPAIN

- **Radar images re-projected to the satellite projection.**
- **Ground echoes elimination: Through a rain image obtained from the IR10.8 data using the basic AUTOESTIMATOR algorithm (Vicente, G.A. et al, 1998).**
- **Selection of convective situations to validate: 15% of the echoes must be greater than 6 km in Echotop image.**
- **Selection of the validation area: boxes of 15x15 pixels centred on that ones that reaches a top of 6 km and a rainfall rate of 3 mm/h simultaneously and the CRR rainy pixels outside (to compute all the possible false alarms)**
- **3 by 3 pixels boxes averaged values are computed for both radar and CRR products. These pairs are used to compute accuracy and categorical (rain/no rain) statistics.**

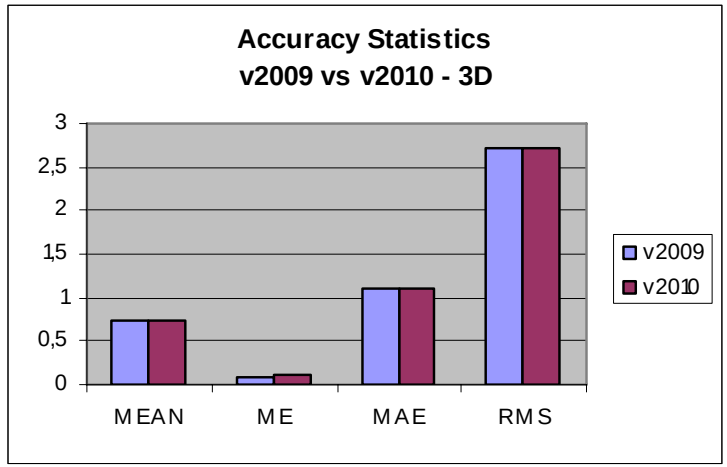


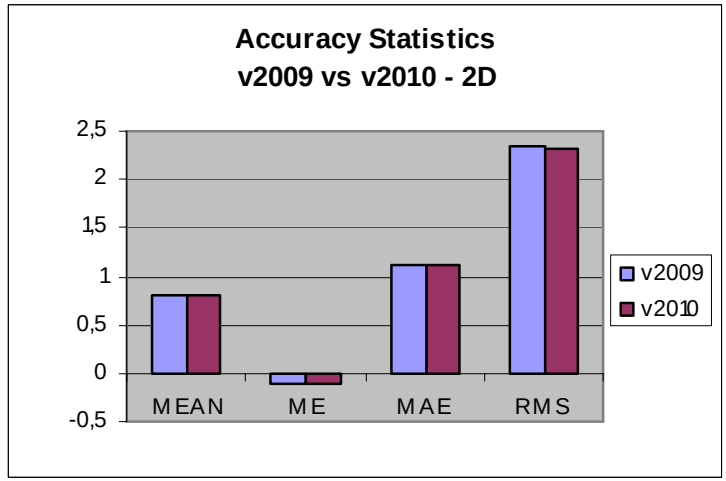
EXTENDED VALIDATION OF VERSION 2010:

RESULTS OF THE OBJECTIVE VALIDATION OVER SPAIN

Instantaneous precipitation: Accuracy Statistics

Calibration	N	MEAN (mm/h)	ME (mm/h)	MAE (mm/h)	RMS (mm/h)
3D v2009	850692	0.73	0.09	1.11	2.73
3D v2010	850761	0.73	0.10	1.10	2.71
2D v2009	681469	0.81	- 0.11	1.11	2.35
2D v2010	681556	0.81	- 0.10	1.11	2.33





V2010 uses lightning data

Very slight differences between both versions (better results within v2010)

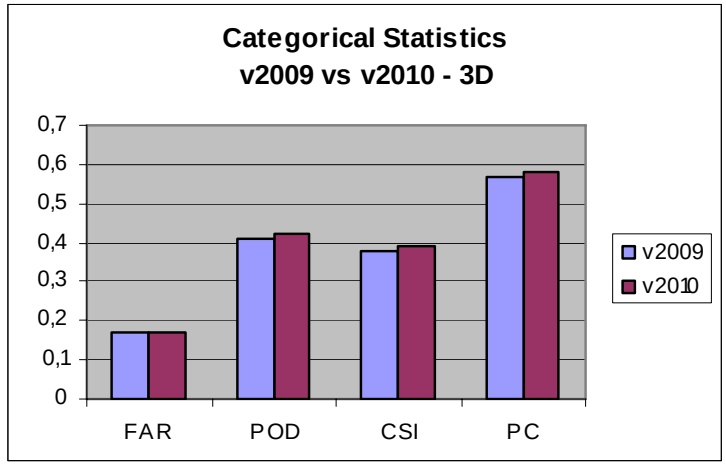
Little underestimation with by 2D Calibration (ME always close to zero)

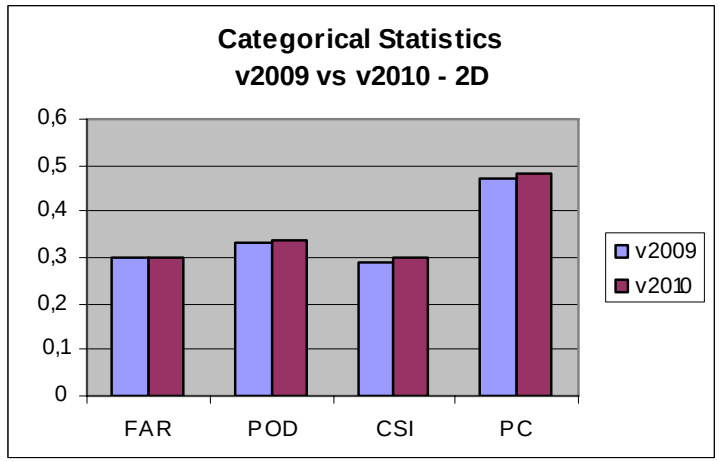
EXTENDED VALIDATION OF VERSION 2010:

RESULTS OF THE OBJECTIVE VALIDATION OVER SPAIN

Instantaneous precipitation: Categorical Statistics

Calibration	FAR (%)	POD (%)	CSI (%)	PC (%)
3D v2009	17.4	41.4	38.1	57.4
3D v2010	17.4	42.2	38.7	57.8
2D v2009	30.2	33.0	28.9	47.4
2D v2010	29.7	34.0	29.8	48.0





Similar results (better in v2010)

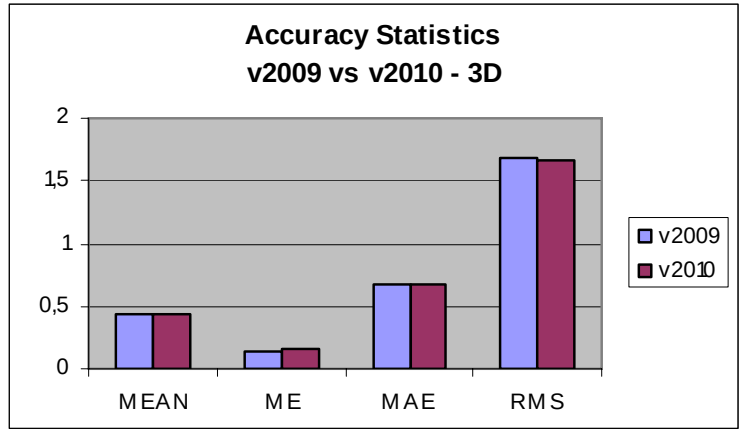
Light increase in the POD for v2010 (better values in 3D calibration)

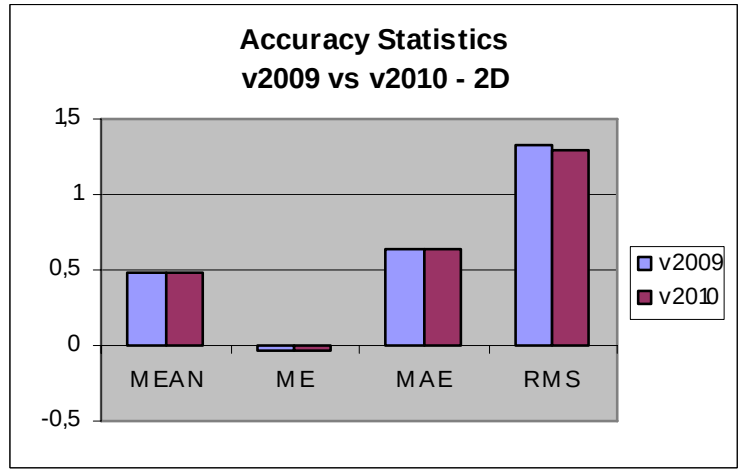
EXTENDED VALIDATION OF VERSION 2010:

RESULTS OF THE OBJECTIVE VALIDATION OVER SPAIN

Hourly accumulations: Accuracy Statistics

Calibration	N	MEAN (mm/h)	ME (mm/h)	MAE (mm/h)	RMS (mm/h)
3D v2009	610444	0.44	0.14	0.68	1.68
3D v2010	610479	0.44	0.15	0.67	1.67
2D v2009	497530	0.48	- 0.03	0.64	1.32
2D v2010	497600	0.48	- 0.03	0.64	1.30





Very similar results for both versions

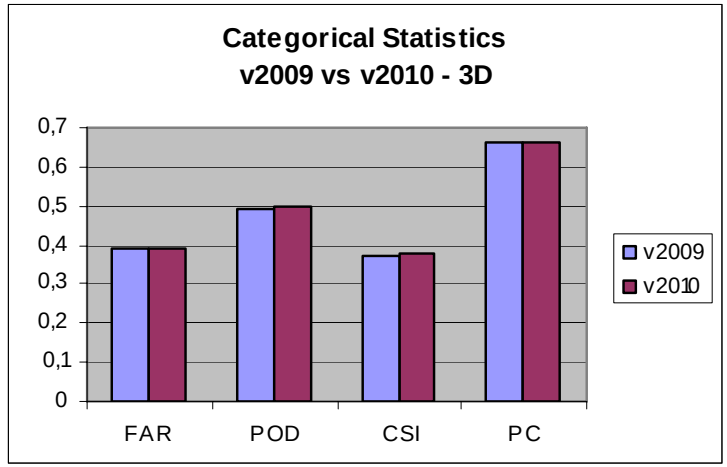
RMS slightly smaller for v2010
RMS smaller for 2D calibration

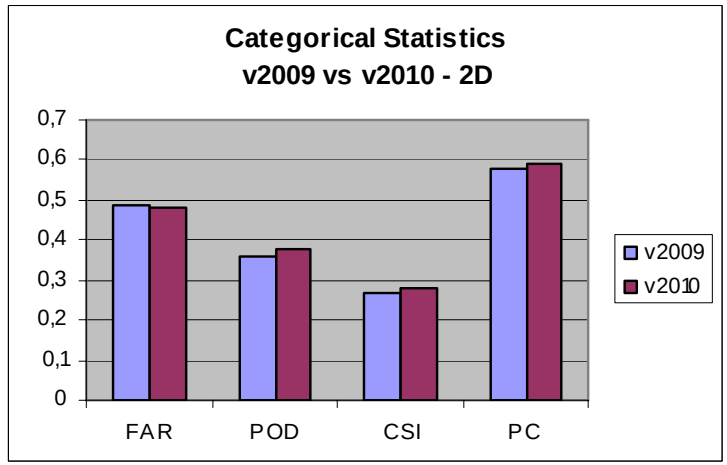
EXTENDED VALIDATION OF VERSION 2010:

RESULTS OF THE OBJECTIVE VALIDATION OVER SPAIN

Hourly accumulations : Categorical Statistics

Calibration	FAR (%)	POD (%)	CSI (%)	PC (%)
3D v2009	39.2	48.8	37.1	65.8
3D v2010	38.9	49.7	37.8	66.1
2D v2009	49.0	36.4	27.0	58.4
2D v2010	48.1	38.0	28.1	59.5





Small improvements in v2010 better noticed for 2D Calibration:

- **False alarm ratio decreases**
- **Probability of detection increases**

EXTENDED VALIDATION OF VERSION 2010:
OBJECTIVE VALIDATION PROCEDURE OVER HUNGARY

- **The validation procedure followed over Hungary has been the same as the one used over Spain. But the Radar product used to obtain the instantaneous rain rates has been the Maximum reflectivity in the vertical.**

- **OMSZ has provided the radar data (Maximum reflectivity in the vertical, ECHOTOP and Accumulations) for a set of convective events occurred over Hungary in the period from 15th May to 15th September of 2009.**

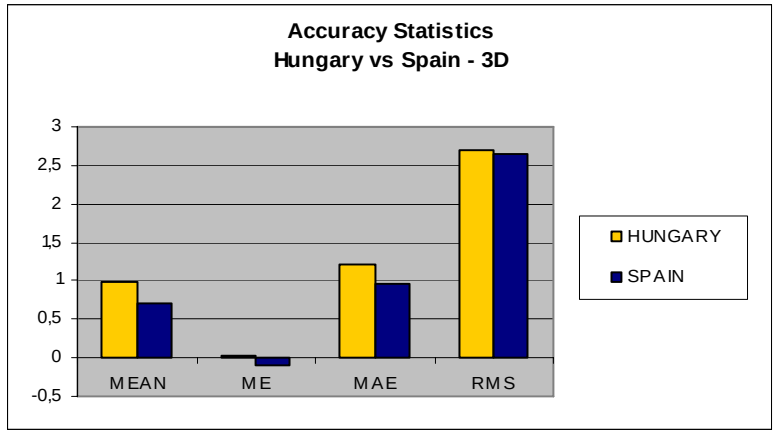
- **To compare results obtained over Hungary and over Spain, they have been computed statistics results from the Spanish validation for the same period (15th May to 15th September 2008). No lightning data have been used for this comparison.**

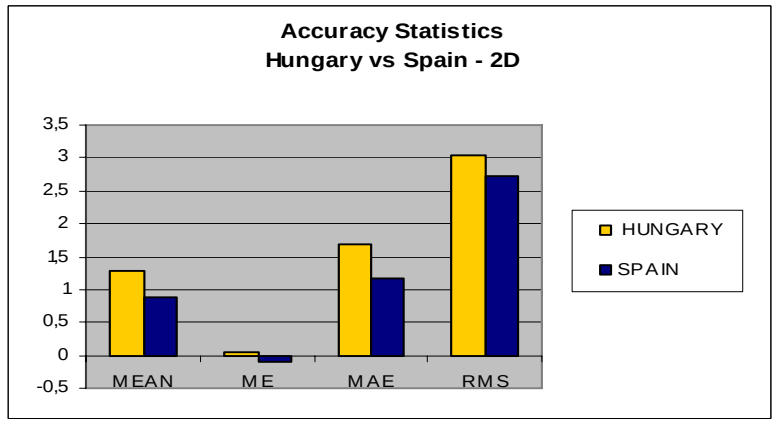
- **A validation over the same period against Rain Gauges has been carried out by OMSZ.**

EXTENDED VALIDATION OF VERSION 2010: RESULTS OF THE OBJECTIVE VALIDATION OVER HUNGARY

Instantaneous precipitation: Accuracy Statistics

Calibration	N	MEAN (mm/h)	ME (mm/h)	MAE (mm/h)	RMS (mm/h)
3D HUNGARY	266758	0,98	0,02	1,21	2,70
3D SPAIN	413771	0,72	- 0,09	0,96	2,64
2D HUNGARY	166810	1,27	0,04	1,7	3,03
2D SPAIN	264669	0,89	-0,11	1,18	2,71





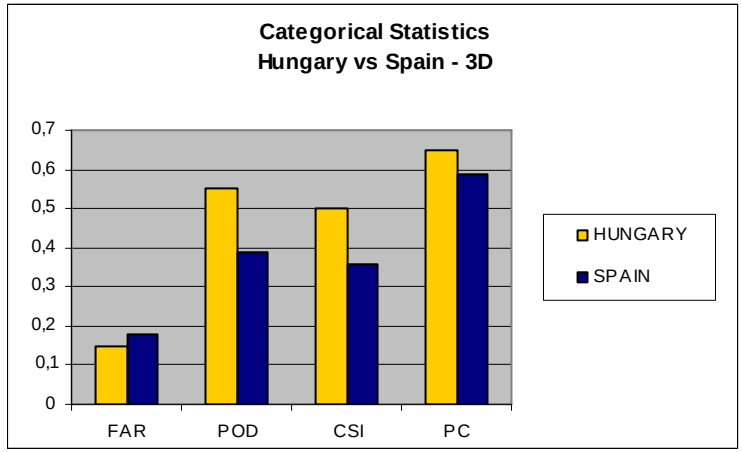
Similar results for both regions

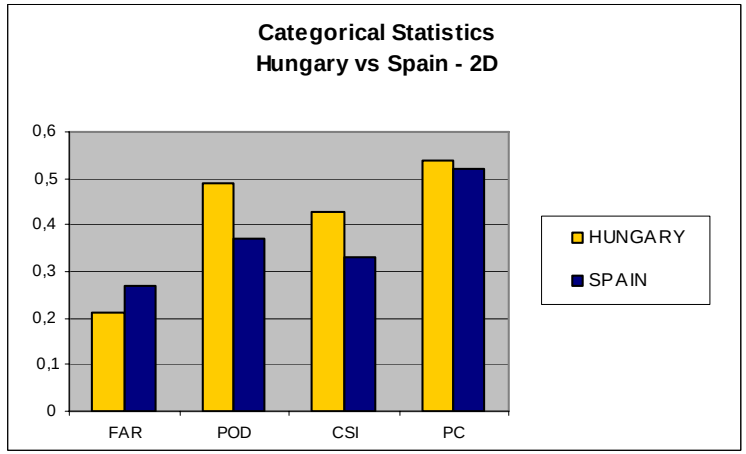
Higher values of MAE and RMS over Hungary: the precipitation measured was also greater

EXTENDED VALIDATION OF VERSION 2010: RESULTS OF THE OBJECTIVE VALIDATION OVER HUNGARY

Instantaneous precipitation: Categorical Statistics

Calibration	FAR (%)	POD (%)	CSI (%)	PC (%)
3D HUNGARY	0,15	0,55	0,5	0,65
3D SPAIN	0,18	0,39	0,36	0,59
2D HUNGARY	0,21	0,49	0,43	0,54
2D SPAIN	0,27	0,37	0,33	0,52



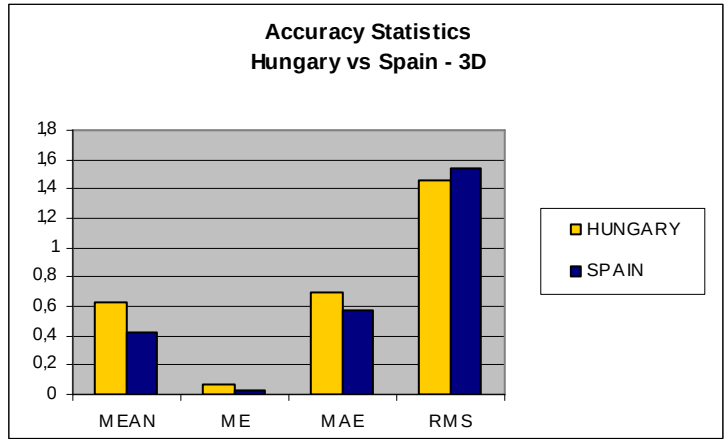


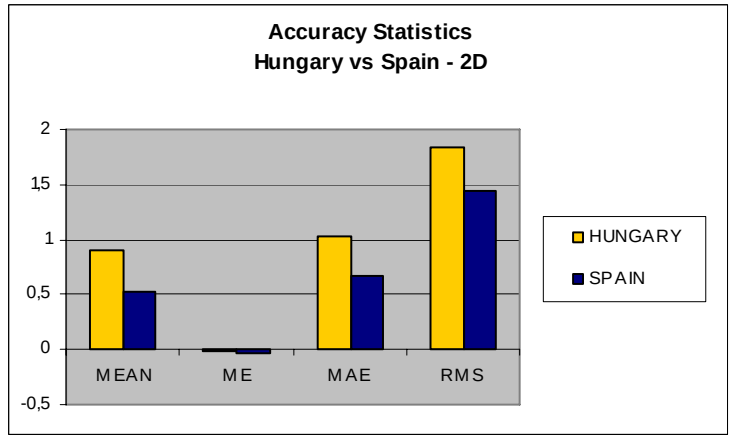
Better results obtained over Hungary:
Validation against Maximum reflectivity in the vertical Radar product.

EXTENDED VALIDATION OF VERSION 2010:
RESULTS OF THE OBJECTIVE VALIDATION OVER HUNGARY

Hourly accumulations: Accuracy Statistics

Calibration	N	MEAN (mm/h)	ME (mm/h)	MAE (mm/h)	RMS (mm/h)
3D HUNGARY	82908	0,63	0,07	0,69	1,46
3D SPAIN	298877	0,42	0,03	0,57	1,54
2D HUNGARY	53561	0,91	- 0,01	1,03	1,83
2D SPAIN	193267	0,53	- 0,03	0,67	1,44





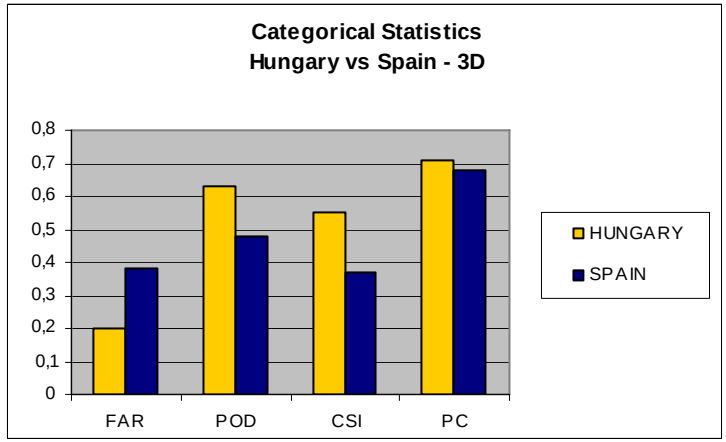
Similar accuracy statistics for both regions.

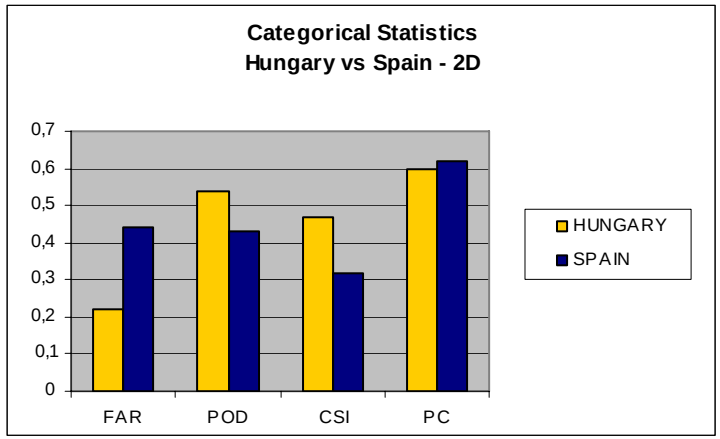
Worse over Hungary for the 2D calibration (significant higher precipitation measured in this case).

EXTENDED VALIDATION OF VERSION 2010:
RESULTS OF THE OBJECTIVE VALIDATION OVER HUNGARY

Hourly accumulations : Categorical Statistics

Calibration	FAR (%)	POD (%)	CSI (%)	PC (%)
3D HUNGARY	0,2	0,63	0,55	0,71
3D SPAIN	0,38	0,48	0,37	0,68
2D HUNGARY	0,22	0,54	0,47	0,6
2D SPAIN	0,44	0,43	0,32	0,62

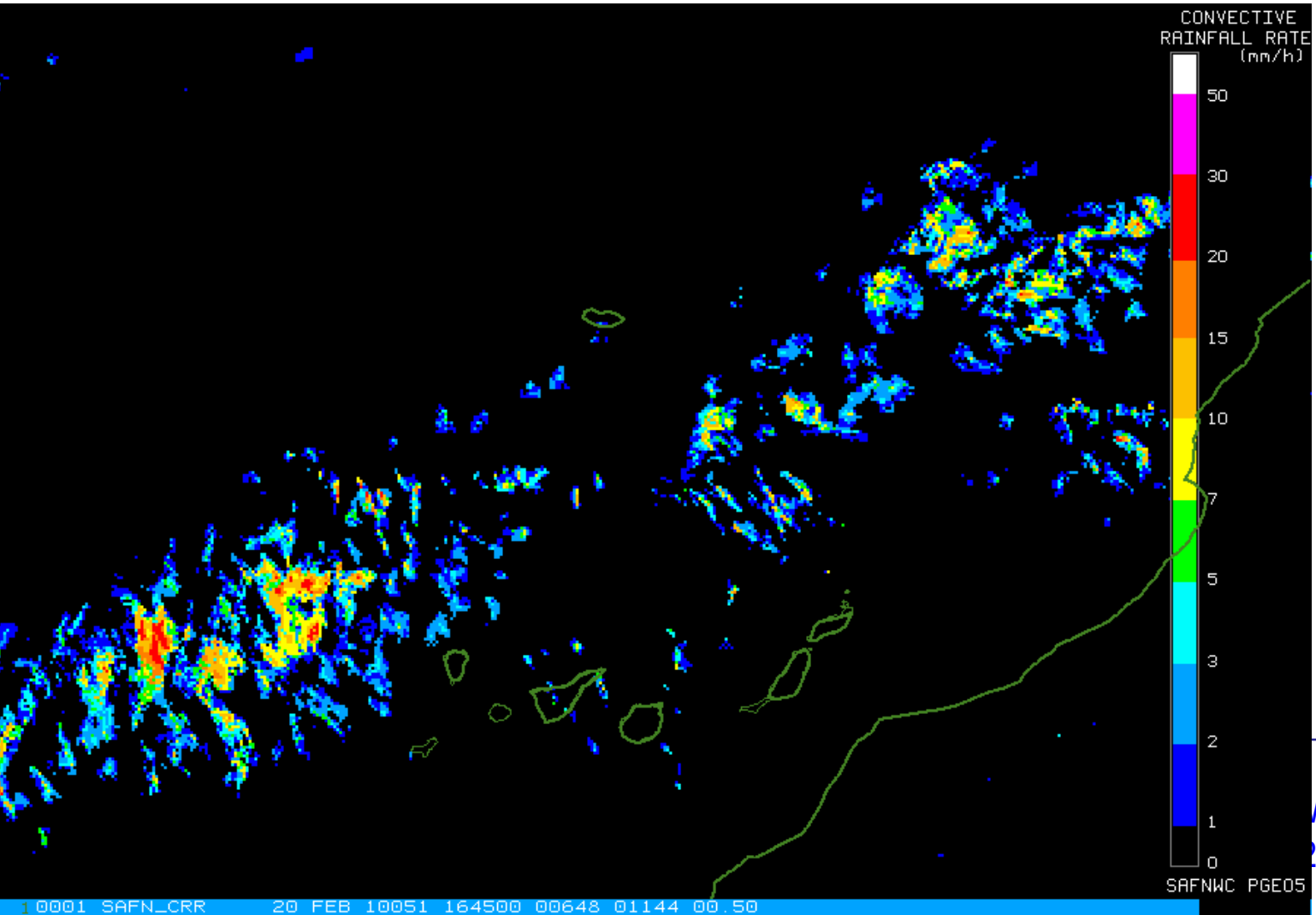




Better results for the validation over Hungary related to the type of radar product used as truth data.

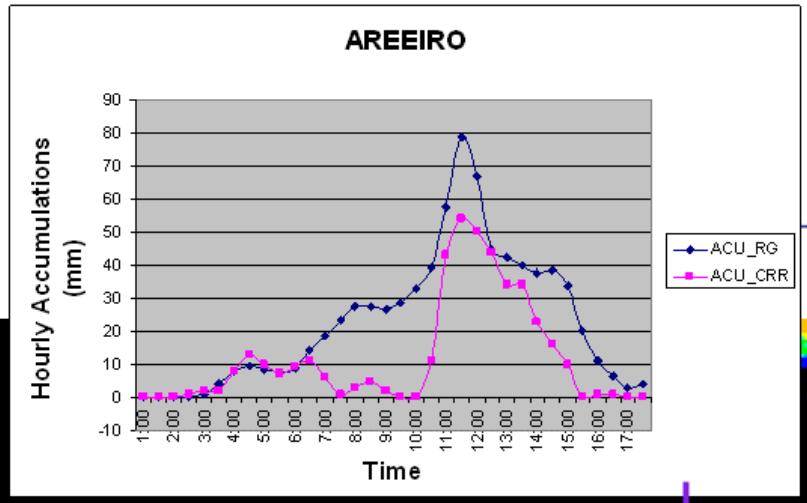
EXAMPLES

A convective system passed over the Portuguese island of **Madeira** on 20th February 2010. The heavy rain caused flash floods and landslides.



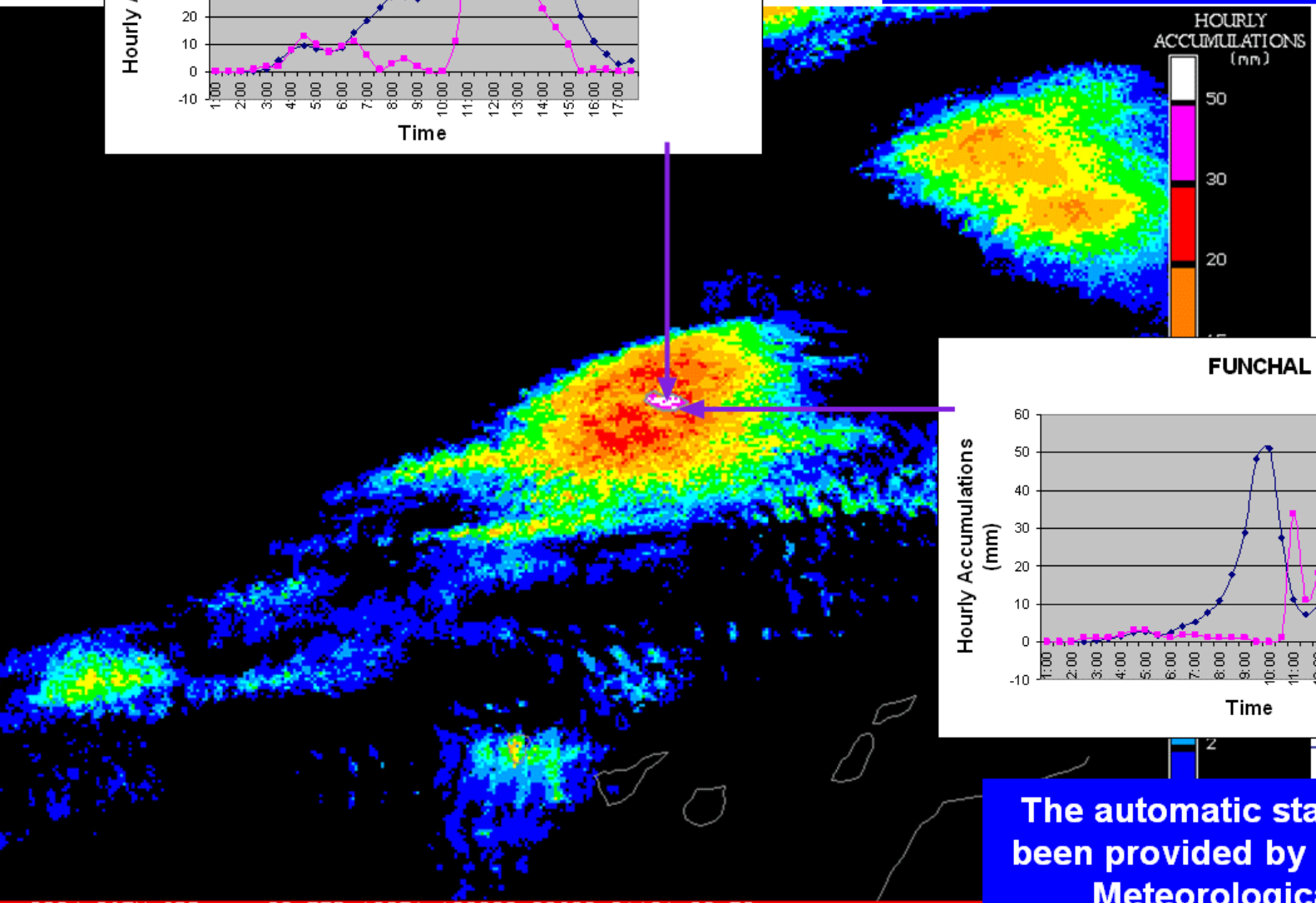
CRR instantaneous rain rates loop from 00:00 to 17:30 UTC

Workshop
2010)

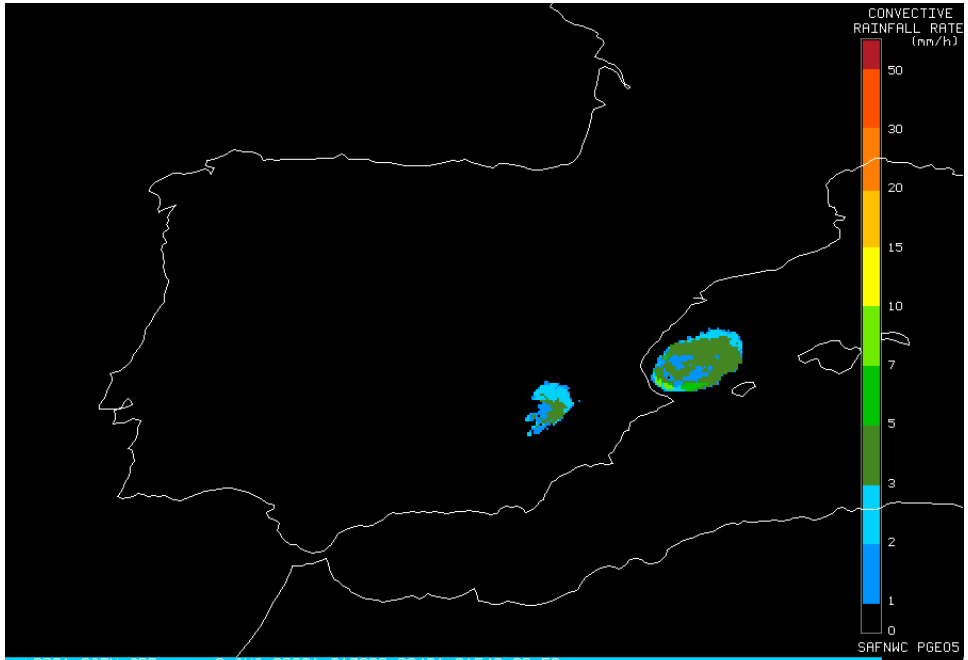


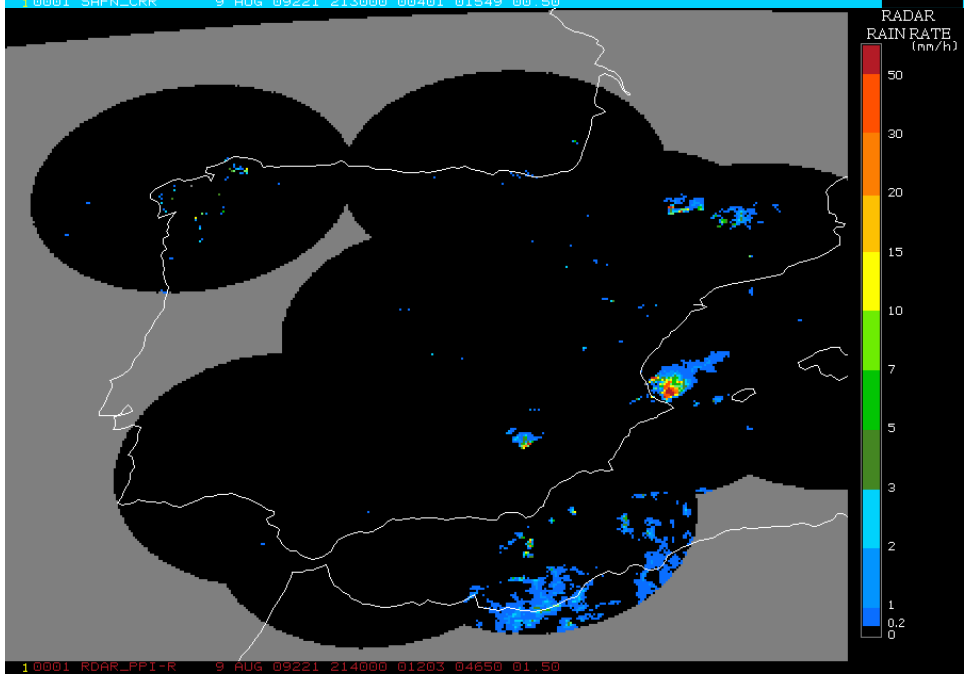
The hardest period took place around the 12:00 UTC.

CRR Hourly accumulations on 20th January at 12:00 UTC



The automatic station data have been provided by IM (Portuguese Meteorological Service)





EXAMPLES

Convective events during 4 days over Spain:

A set of convective storms took place over the centre and the east of the Iberian peninsula from **8th August to 11th August 2009**. The **heavy rain caused flash foods and power cuts** in several villages and cities of Salamanca. Intense hail storms occurred over Teruel causing **material damages**.

CRR instantaneous rain rates

Radar instantaneous rain rates

Loop: 9th August 2009 from 00:00 to 23:30 UTC

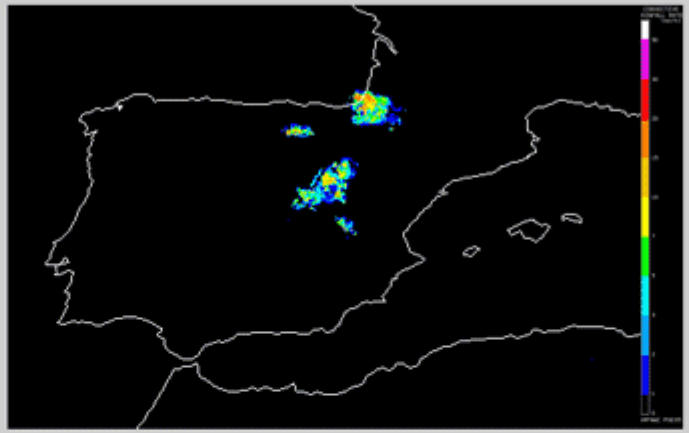
EXAMPLES

CRR characteristics

Table of contents

- Welcome
- Corrections
  - Moisture correction
  - Cloud top growth rate correction
  - Cloud top temperature gradient correction
  - Parallax correction
  - Orographic correction
- Limitations
  - Calibration method
  - Quantitative validation difficulties
  - 3D calibration against 2D calibration
- Usefulness and applications
  - Example 1
  - Example 2
  - Example 3
  - Example 4
- References

Convective Rainfall Rate product provides information on instantaneous rain rates and hourly accumulations from convective phenomena and stratiform phenomena associated to convection.



This web page illustrates some characteristic of the performance of this product, like the impact of the different corrections, the possible limitations and the usefulness of the product.

CRR Characteristics web:

*Information on the **impact of the different corrections, the possible limitations and usefulness**.*

http://www.nwcsaf.org/TopicalImages/TOPICAL_IMAGES/CRR_20090812/index.html

FUTURE WORK

- **CRR adaptation from SEVIRI channels to MTG-FCI ones.**
- **CRR adaptation to the lightning information from MTG-LI.**
- **Study the feasibility of improving the product results by including more satellite information (a higher number of channels, microwaves…)**
- **Ideas coming from this workshop will be considered**

CONCLUSIONS

Improvements included in the PGE05 product during the CDOP phase:

-**New calibration: Higher rates and some new convective cells are caught with the improved calibration.**

-**Hourly accumulations: Easy comparison with rain gauges and radar accumuations data. Especially useful to monitor extreme events when radar is not available.**

-**Lightning information: Better detection of convective areas especcially during night-time.**

Validation results:

-**The use of lightning data has very low impact in statistics scores (although always are better).**

-In general, similar results obtained for both validations over Spain and over Hungary against radar data.

-In all validation work against radar products the RMS error values obtained are lower than the target RMS error defined in the NWCSAF Product Requirement Document (3.3 mm/h for instantaneous rates, 2,5 mm for accumulations)

Thanks for your attention!