Validation results of the NWCSAF/MSG Clear Air Products

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GENERAL OBJECTIVES

➢ Extensive validation of the **precipitable water** in three layers (sfc-840hPa, 840hPa-437hPa and 437hPa-top) and in the total column together with the **lifted index.**

➢Estimation of the **quality** and **spatial behavior** of each clear air parameter.

➢ All parameters are validated using **a long period** (at least one year) **=> all seasons** are included.

➢ Comparison with the **previous version 1.3** output: improvements.

➢ The parameters are validated using the **MSG-N region =>** different geographical areas and various atmospheric conditions are considered.

➢ Analysis of the **areas** with **worst performances =>** future algorithm improvements.

METHODOLOGY OUTLINE

➢ **According to last NWCSAF Steering Group Meeting (CDOP-SG01)**
   => Delivery 2008:

   - **PGE06 version 3.0 (TPW):** the usual PGE06 product has been replaced by the former 4th
   PGE07 output (TPW control obtained with neural networks).
   - **PGE07 version 2.0 (LPW):** 3 outputs (boundary, middle and high layers).
   - **PGE08 version 2.0 (SAI-LI):** 1 output (lifted index)

➢ **Testing of the improvements in the delivery 2008 (including the radiance local bias correction and the parameter local adjustment). <u>Following criteria:</u>**

   - **PGE06 v3.0 versus the fourth output of PGE07 v1.3.**
   - **PGE07 v2.0 versus the three layers of PGE07 v1.3.**
   - **PGE08 v2.0 versus PGE08 v1.3.**

✓ An intermediary version product will be presented, hereafter the **"<u>improved v1.3</u>"** which includes only the radiance local bias correction (before the parameter local adjustment).

METHODOLOGY OUTLINE

- **Period**: July 2005-December 2006 (at 00 and 12 UTC) :

  - **Cloud mask (SAFNWC CMa)**: reprocessing of **version v1. 3** using ECMWF analyses as inputs (instead of NWP forecasts)

  - Reprocessing of **clear air SAFNWC** products (for the **3 versions**)

- Validation over <u>pixels</u> classified as <u>clear</u> (no additional constraints)

- Collocation of all validating data with the SAFNWC parameter data using **McIDAS**; reading of the SAFNWC HDF-5 files and calculation of statistical parameters with **IDL** routines.

- Exclusion of desert pixels (non-realistic results).

✓ **All the ECMWF datasets used on the tuning of the algorithms (neural networks, bias calculation, etc) cover <u>temporal periods totally different to the ECMWF validation period</u>.**

VALIDATION DATASET

1. ECMWF ANALYSIS FIELDS

- **Download of quantitative analyses from July 2005 to June 2006 (00 and 12 UTC) from MARS/ECMWF.**

- **The region is defined by the corners (70ºN, 40ºW) and (28ºN, 40ºE), with a grid step of 0.5º.**

- **The ECMWF parameters have been remapped to SEVIRI projection using McIDAS and IDL routines.**

- **One every ten has been extracted to build the validation dataset and only zenith angles lower than 70º are considered.**

- **<u>Desert pixels excluded in the validation</u> (non-realistic results) : differentiation of desert and non desert pixels done through the Global Land Cover-LANDSAF/MSG group of the Valencia University (25 classes of land cover, among which "bare areas" includes desert areas)**

VALIDATION DATASET

2. RADIOSONDE DATA

- Use of radiosonde profiles from 102 RAOB stations over MSG-N region for the period of 1st July 2005-31st December 2006 at 00 and 12 UTC (provided by the University of Wyoming).

- The stations over desert areas have been removed through the desert mask (Valencia University).
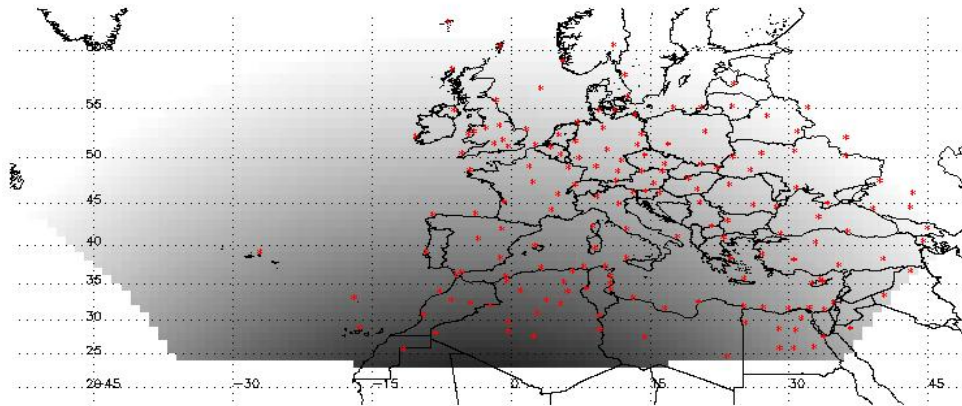
Stations covered by a significant zenith angle (<70º) over the MSG-N region

VALIDATION DATASET

3. INTEGRATED WATER VAPOR from GPS

- European Network of Global Positioning System (GPS) ground-based receivers are routinely used to provide near-real-time estimations of precipitable water vapor => another <u>independent water vapour measurement source.</u>

- Comparison with GPS data for <u>1-year period</u> (1st May 2005- 30th April 2006) from the 178 GPS sites of <u>two processing centres</u> (GFZ and METO).

- Most independent and reliable validation source in this study.

1.VALIDATION WITH ECMWF

VALIDATION OVER SEA PIXELS

The scatter plots displayed on the next slides show the BL, ML, HL, TPW and LI parameters from ECMWF analysis data versus the SEVIRI PW and SAI parameters (TPW, LPW_BL, LPW_ML, LPW_HL and SAI_LI) for the period **1st July 2005-31st June 2006** at 00 and 12 UTC over **sea pixels.**

0	128	256	385	513	642
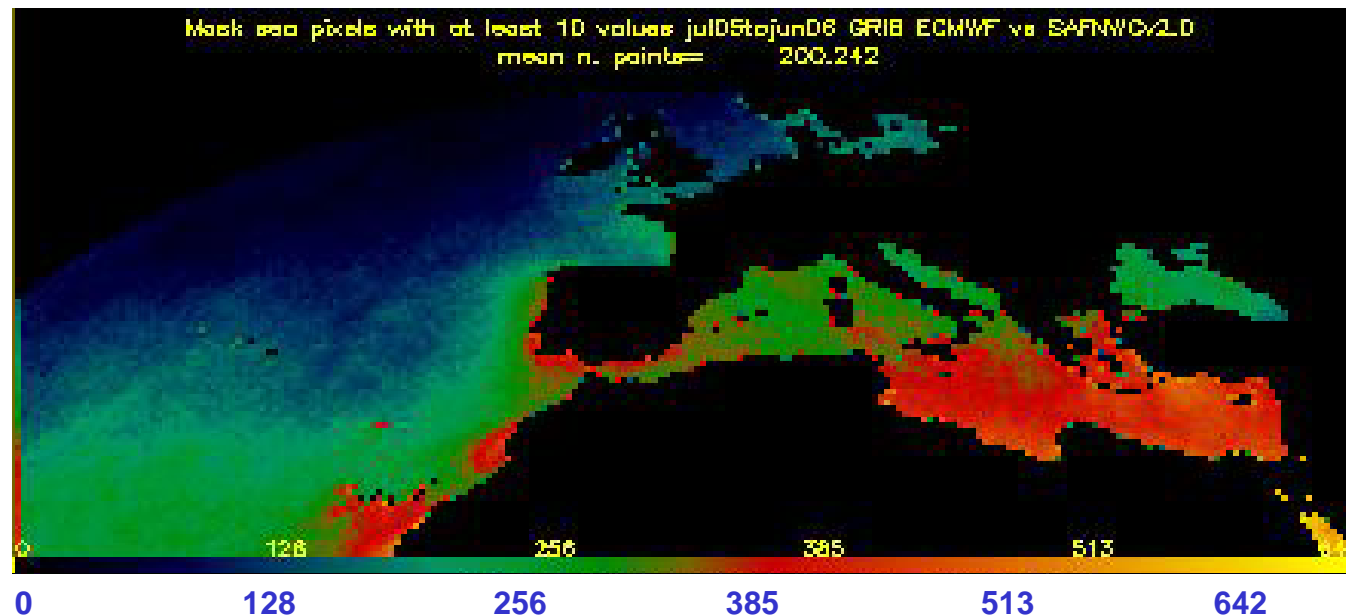
Number of pixels used in validation =>Few clear air days over the North Atlantic (bad representation reflected on the statistical parameters)

TPW over sea pixels

Increasing 0.06

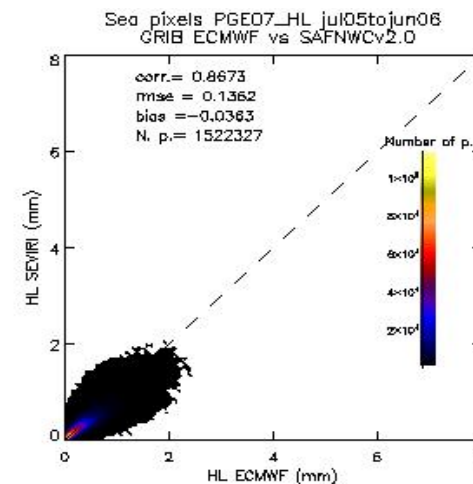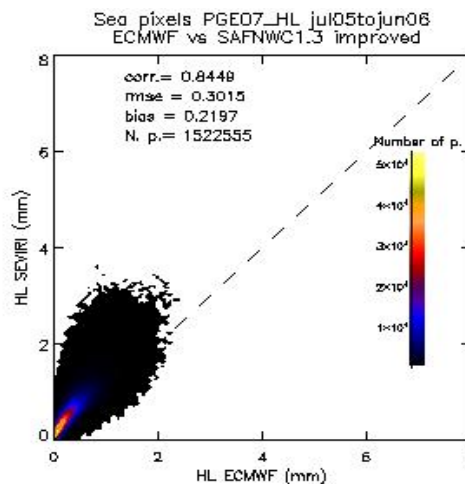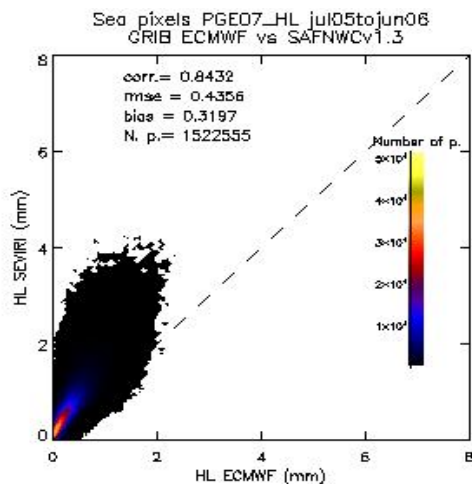| Statistical parameters	TPW		
	Current (v1.3)	Current + radiance local bias (Improved v1.3)	**Delivery 2008 v3.0**
Correlation	**0.7689**	0.8139	**0.8338**
bias (mm)	0.2311	-0.2209	0.4666
rms (mm)	**4.9090**	4.3353	**4.0558**

Decreasing 0.85
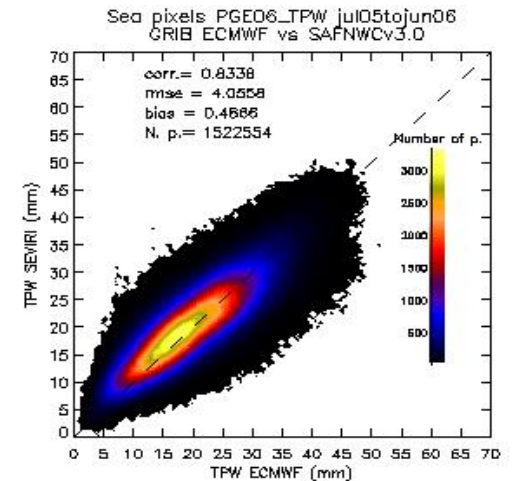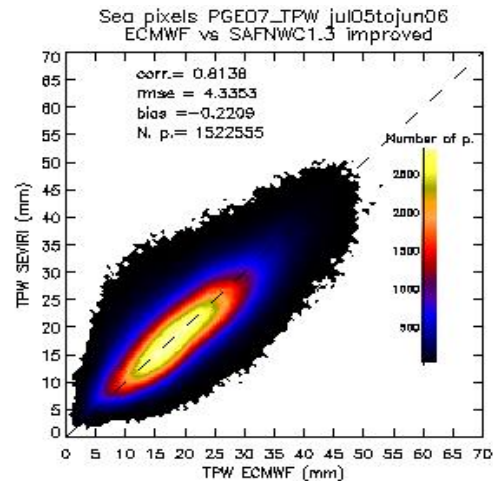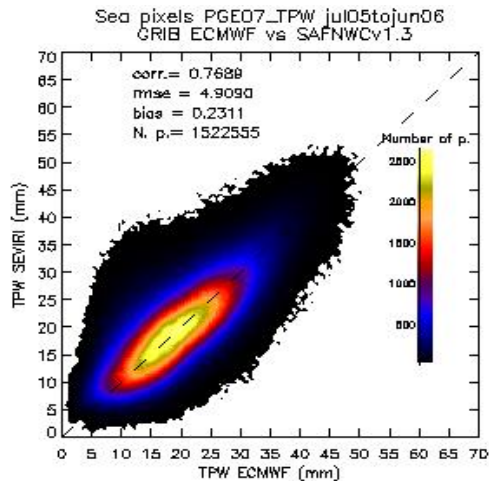
LPW_BL over sea pixels

Increasing 0.06

Statistical parameters	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v3.0
	LPW_BL		
Correlation	**0.7295**	0.7741	**0.7881**
bias (mm)	-0.2209	-0.2852	0.2116
rms (mm)	**2.8308**	2.6184	**2.5636**

Decreasing 0.27
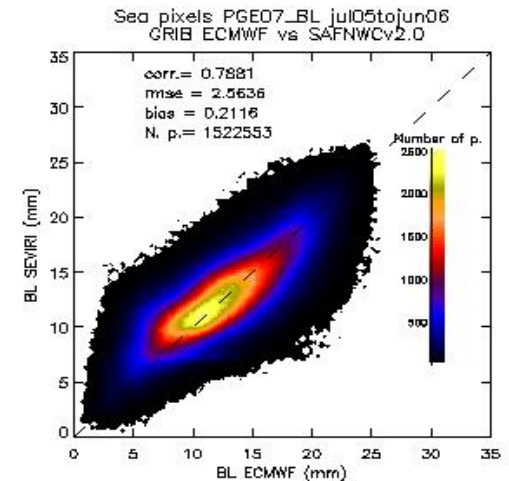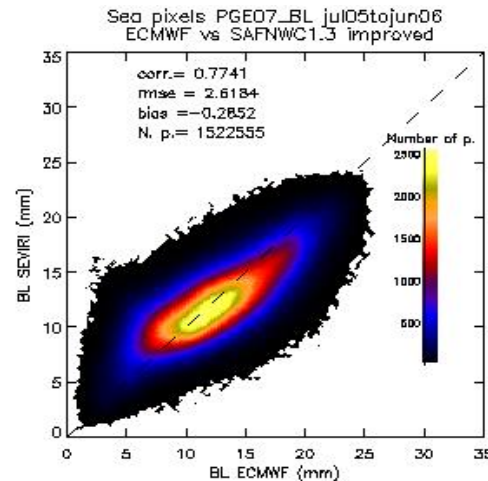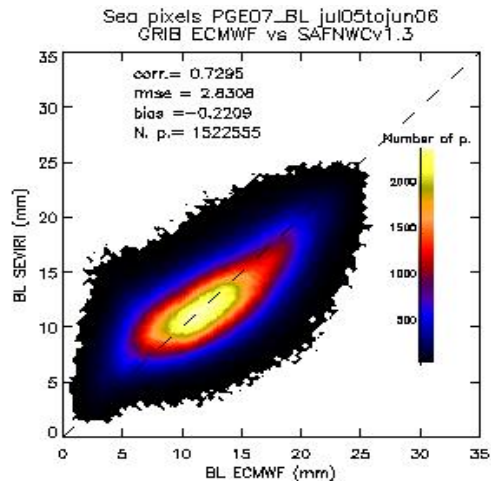
LPW_ML over sea pixels

Increasing 0.06

| Statistical parameters	LPW_ML		
	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v3.0
Correlation	0.7448	0.7838	0.8207
bias (mm)	0.0794	-0.0922	0.2486
rms (mm)	2.9198	2.5762	2.3141

Decreasing 0.61
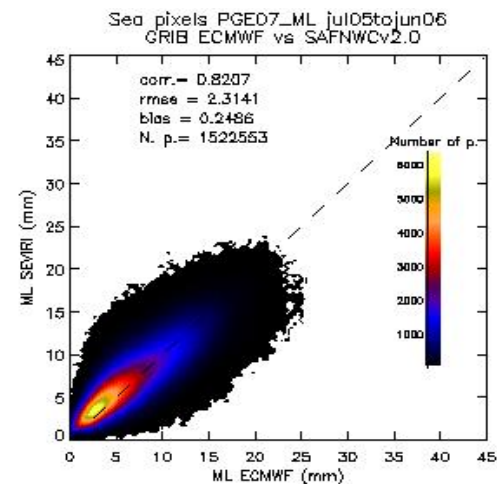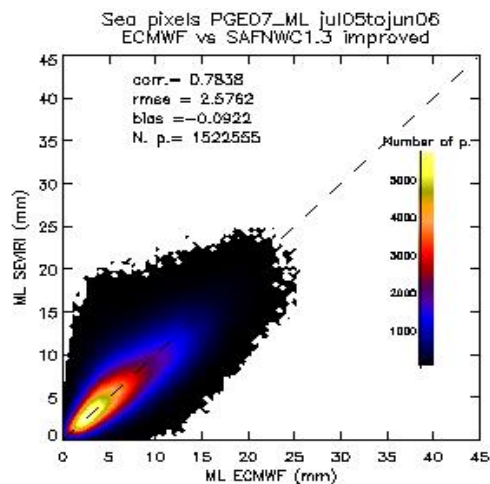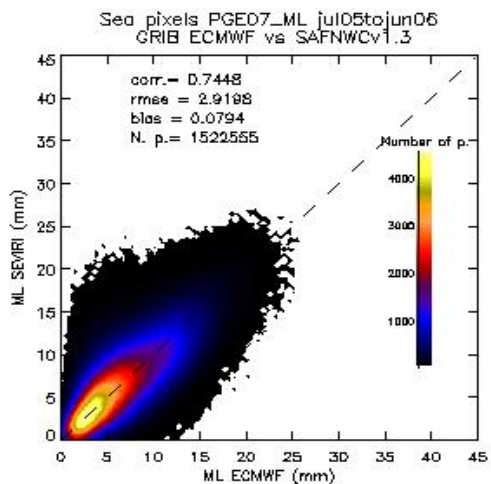
LPW_HL over sea pixels

Increasing 0.03

Statistical parameters	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v3.0
LPW_HL			
Correlation	**0.8432**	0.8449	**0.8673**
bias (mm)	0.3197	0.2197	-0.0363
rms (mm)	**0.4356**	0.3015	**0.1362**

Decreasing 0.30

Sea pixels PGE07_HL jul05tojun06
GRIB ECMWF vs SAFNWCv1.3

corr.= 0.8432
rmse = 0.4356
bias = 0.3197
N. p.= 1522555

Sea pixels PGE07_HL jul05tojun06
ECMWF vs SAFNWC1.3 improved

corr.= 0.8449
rmse = 0.3015
bias = 0.2197
N. p.= 1522555

Sea pixels PGE07_HL jul05tojun06
GRIB ECMWF vs SAFNWCv2.0

corr.= 0.8673
rmse = 0.1362
bias =-0.0363
N. p.= 1522327

SAI_LI over sea pixels

Increasing 0.08ºC

Statistical parameters	SAI_LI		
	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v3.0
Correlation	0.5043	0.5367	0.5784
bias (mm)	-3.9442	-3.6561	-0.5476
rms (mm)	5.3290	5.0473	3.4303

Decreasing 1.9ºC
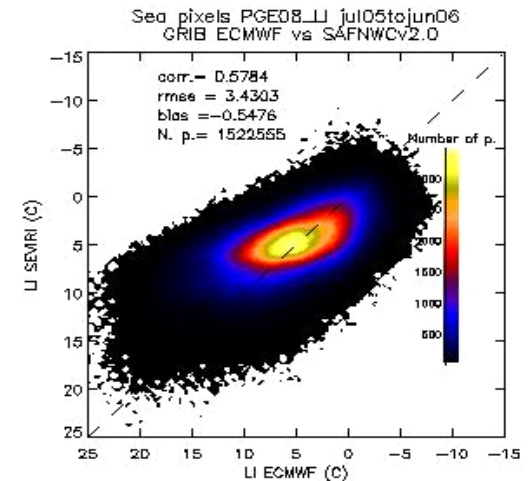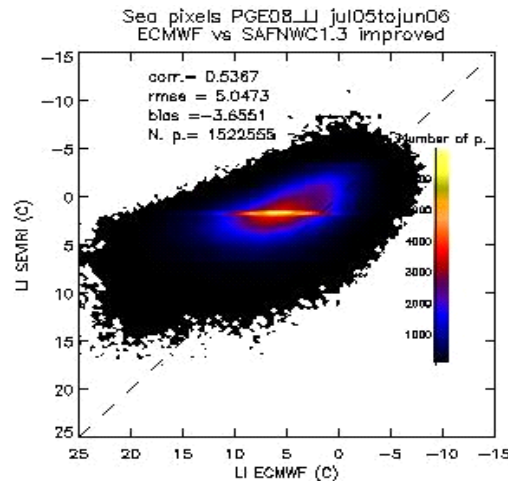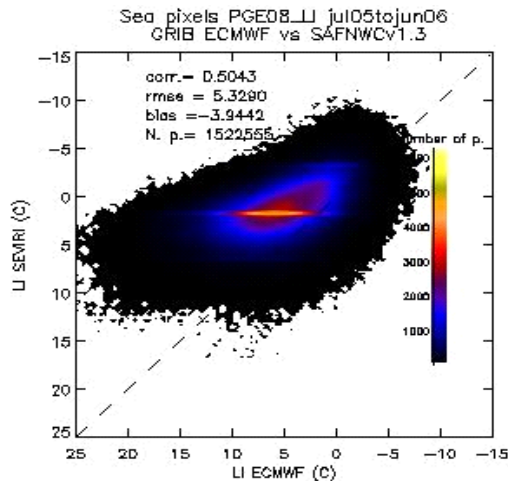
SPATIAL DISTRIBUTION (over sea)

TPW BIAS
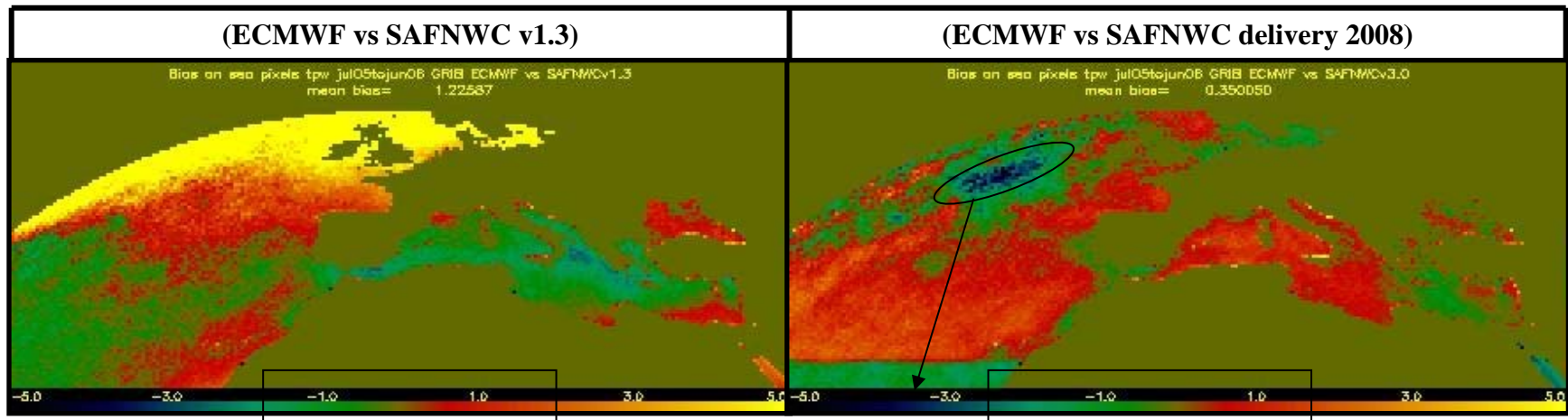
- **Bias reduction** for the latest version over the whole region, especially in the Baltic area.
- **Bad performances over the North Atlantic**, probably associated to the lack of clear air pixels over this area => detailed analysis in perspective.
- **Similar results** are obtained for the rest of the LPW (BL, ML, HL) and SAI parameters.
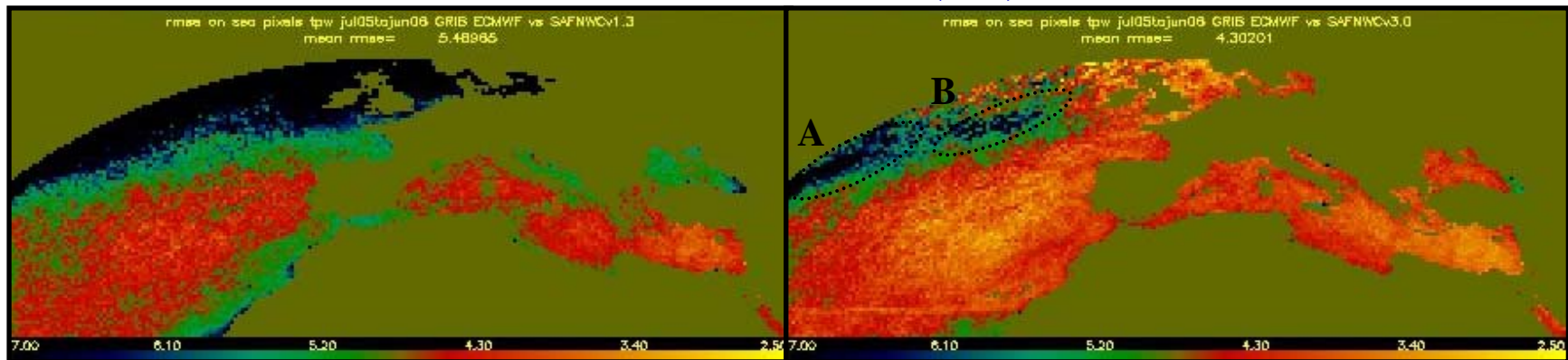
SPATIAL DISTRIBUTION (over sea)

(ECMWF vs SAFNWC v1.3) **TPW CORRELATION COEFFICIENT** **(ECMWF vs SAFNWC v3.0)**
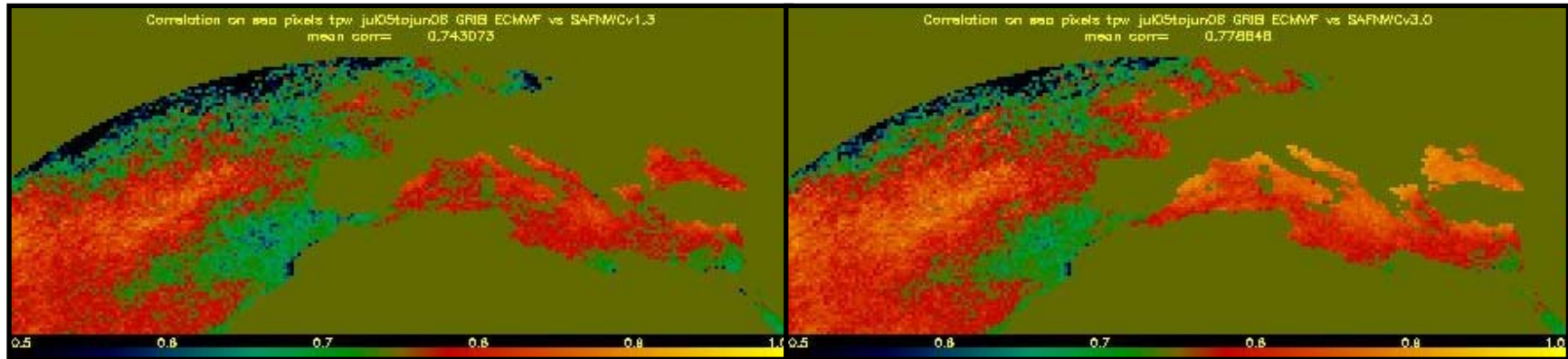
SAFNWC TPW versus ECMWF analysis TPW correlation coefficient <u>increases</u>: more red and yellow pixels are found in the latest version v3.0 (yellow ⇔ maximum correlation).
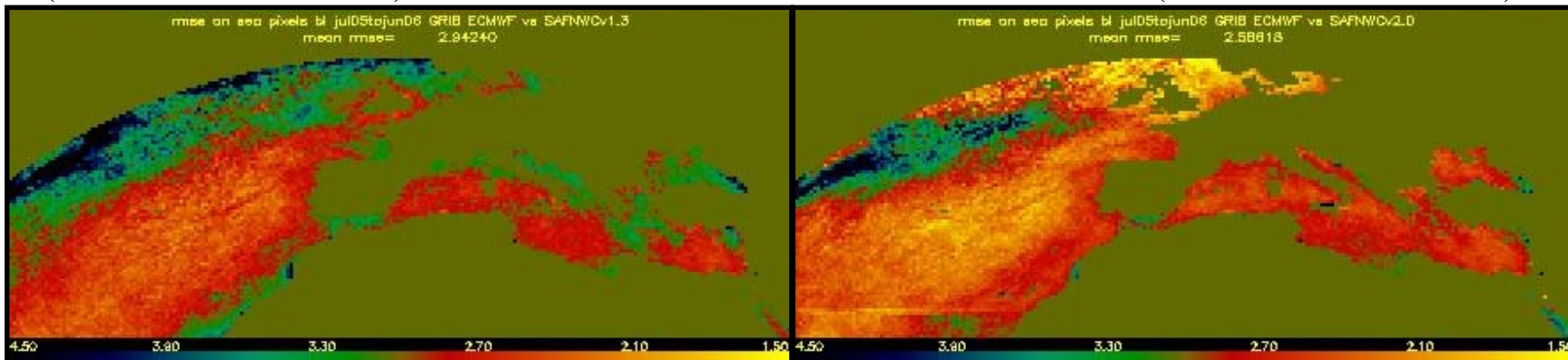
TPW RMS ERROR (mm)

The rms error coefficient decreases: more red and yellow pixels are found in the latest version 3.0 (yellow ⇔ minimum rms error). Areas "A" and "B" represent the highest rmse values: area "A" also has low correlation and area "B" is associated with the highest bias.
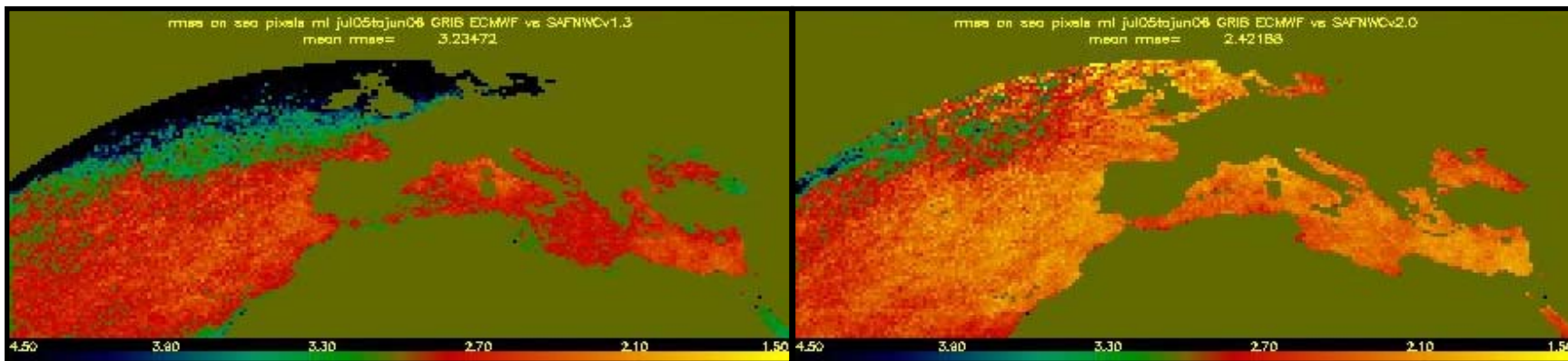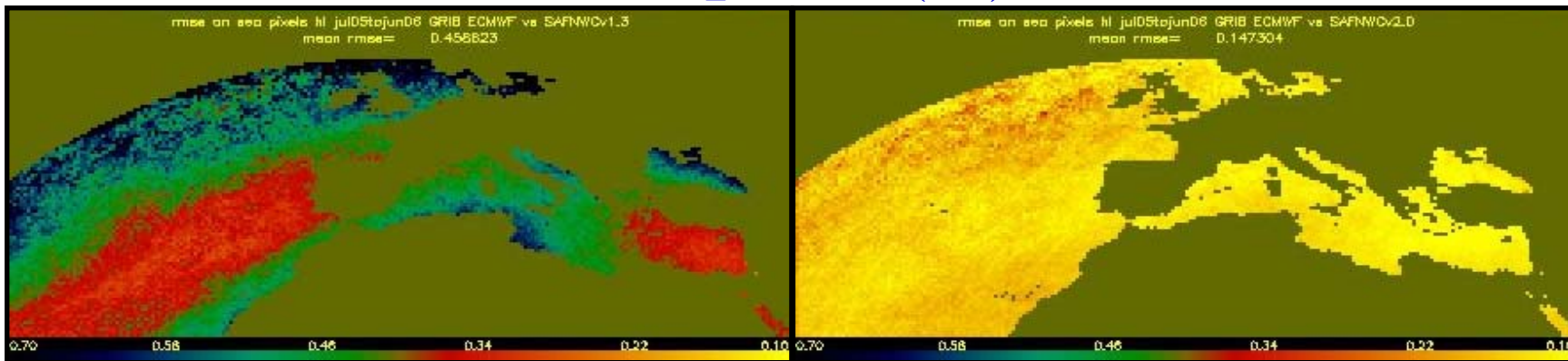
LPW_BL RMSE (mm)

(ECMWF vs SAFNWC v1.3)   **(ECMWF vs SAFNWC v2.0)**
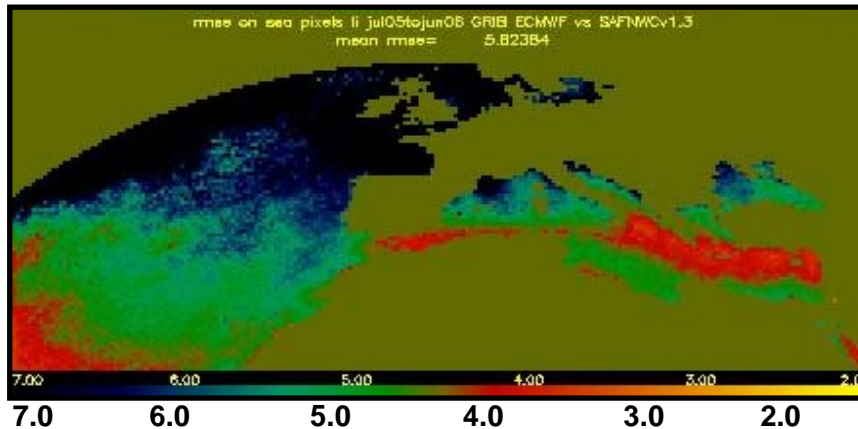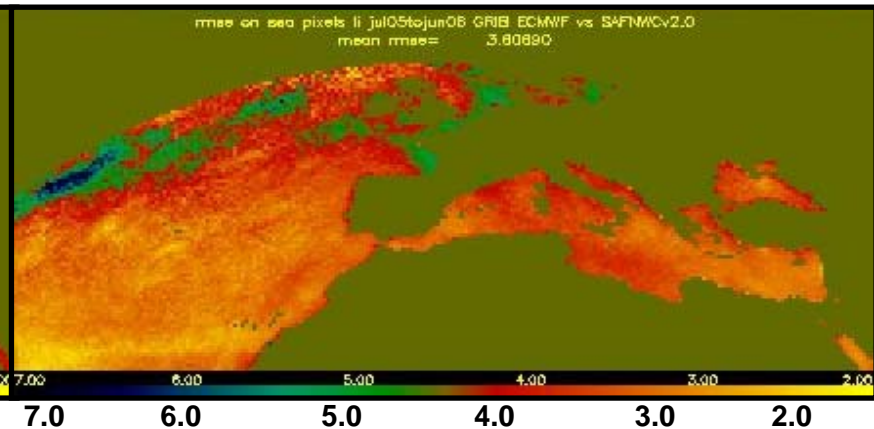

LPW_ML RMSE (mm)

LPW_HL RMSE (mm)

SPATIAL DISTRIBUTION (over sea)

### SAI_LI RMS ERROR (ºC)

(ECMWF vs SAFNWC v1.3) **(ECMWF vs SAFNWC v2.0)**

- The **<u>rms error coefficient significantly decreases</u>** in version 2.0 =>
  Careful analysis required on the coastal areas colored in green.
- The <u>correlation coefficient</u> increases but <u>not enough</u> => necessary improvement of
this parameter.

VALIDATION OVER NON-DESERT LAND PIXELS

The scatter plots displayed on the next slides show the BL, ML, HL, TPW and LI parameters from ECMWF analysis data versus the SEVIRI TPW, LPW and SAI parameters for the period **1st July 2005-31st June 2006** (at 00 and 12 UTC) over **non-desert land pixels**.
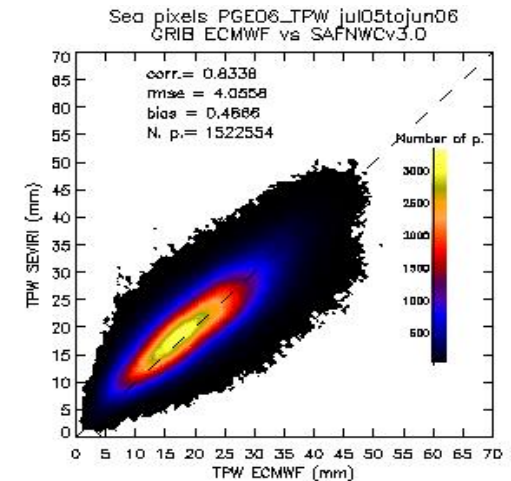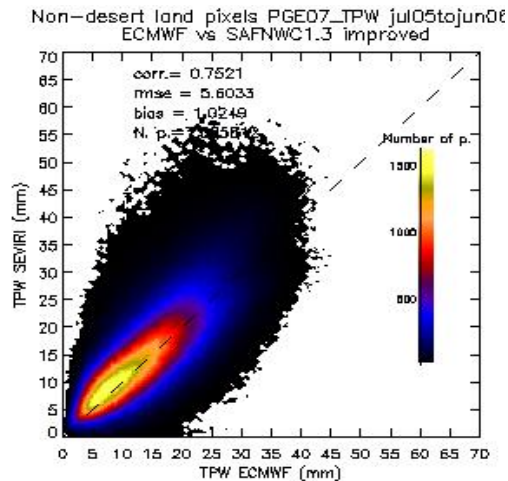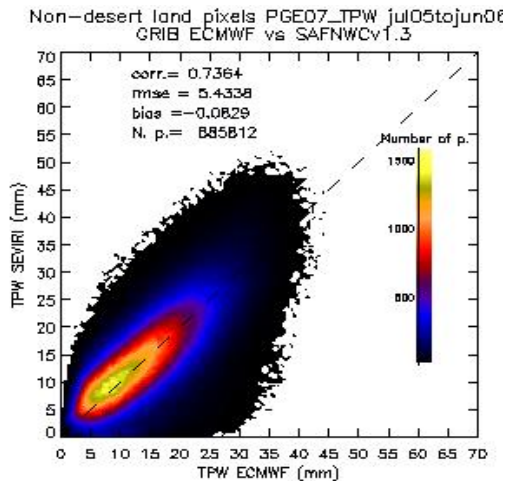

| 0 | 128 | 256 | 385 | 513 | 642 |
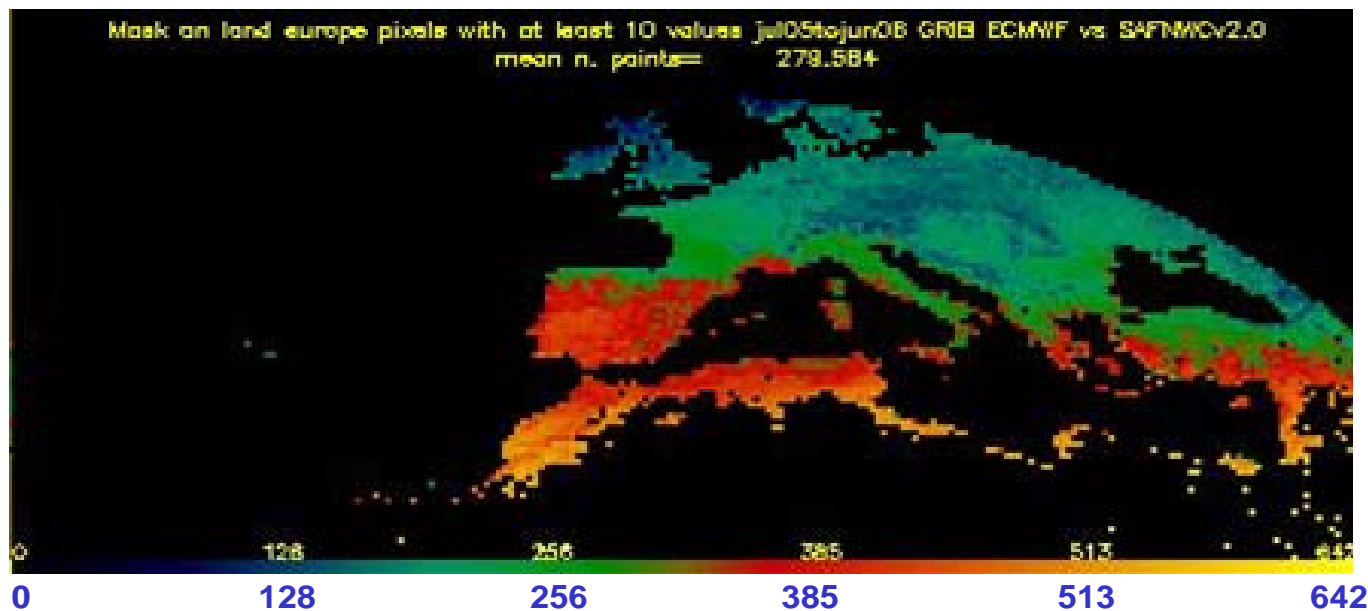
Number of pixels used in validation => few clear air days found over North Europe

TPW over non-desert land pixels

Increasing 0.05

Statistical parameters	TPW		
	Current (v1.3)	**Current + radiance local bias (Improved v1.3)**	**Delivery 2008 v3.0**
Correlation	**0.7364**	0.7521	**0.7944**
bias (mm)	-0.0829	1.0249	0.4181
rms (mm)	**5.4338**	5.6033	**4.4181**

Decreasing 1.02

Non−desert land pixels PGE07_TPW jul05tojun06
GRIB ECMWF vs SAFNWCv1.3
corr.= 0.7364
rmse = 5.4338
bias =−0.0829
N. p.= 885812

Non−desert land pixels PGE07_TPW jul05tojun06
ECMWF vs SAFNWC1.3 improved
corr.= 0.7521
rmse = 5.6033
bias = 1.0249
N. p.= ...

Sea pixels PGE06_TPW jul05tojun06
GRIB ECMWF vs SAFNWCv3.0
corr.= 0.8338
rmse = 4.0558
bias = 0.4686
N. p.= 1522554

LPW_BL over non-desert land pixels

Statistical parameters	LPW_BL		
	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v2.0
Correlation	0.7458	0.7683	0.7924
bias (mm)	-0.5232	-0.2078	0.0689
rms (mm)	3.0373	3.0026	2.5610

Increasing 0.04
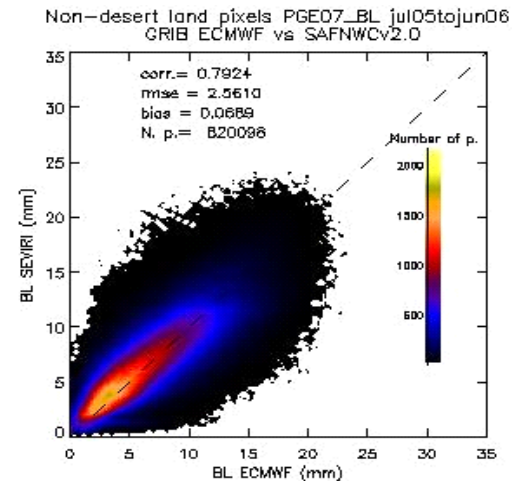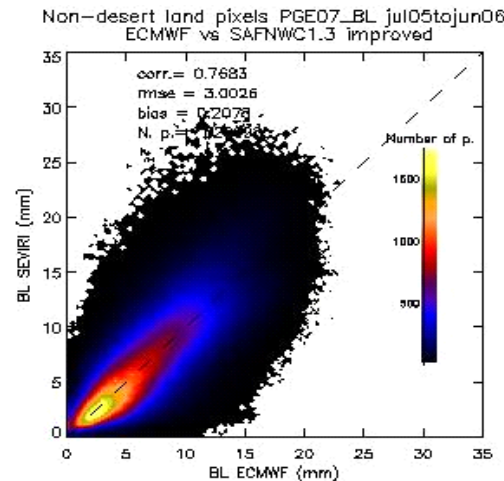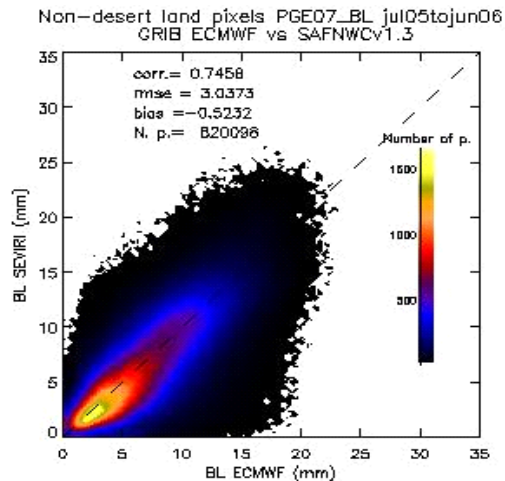
Decreasing 0.48

LPW_ML over non-desert land pixels

Increasing 0.11

Statistical parameters	LPW_ML		
	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v2.0
Correlation	0.6823	0.7112	0.7870
bias (mm)	0.3112	0.8080	-0.2579
rms (mm)	3.5941	3.6251	2.7253

Decreasing 0.88

Non-desert land pixels PGE07_ML jul05tojun06 GRIB ECMWF vs SAFNWCv1.3
corr.= 0.6823
rmse = 3.5941
bias = 0.3112
N. p.= 885812

Non-desert land pixels PGE07_ML jul05tojun06 ECMWF vs SAFNWC1.3 improved
corr.= 0.7113
rmse = 3.6251
bias = 0.8080
N. p.= 885812

Non-desert land pixels PGE07_ML jul05tojun06 GRIB ECMWF vs SAFNWCv2.0
corr.= 0.7870
rmse = 2.7253
bias =-0.2579
N. p.= 885812
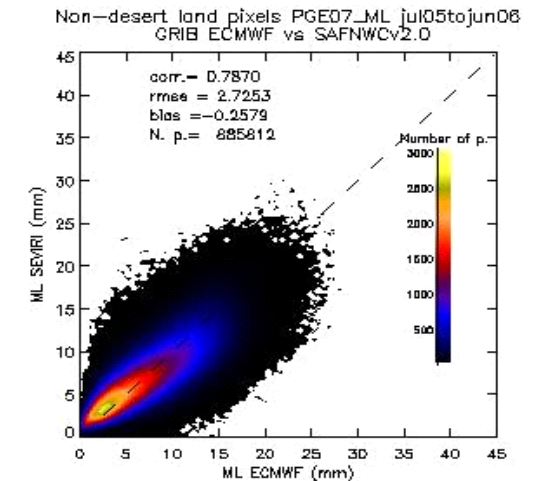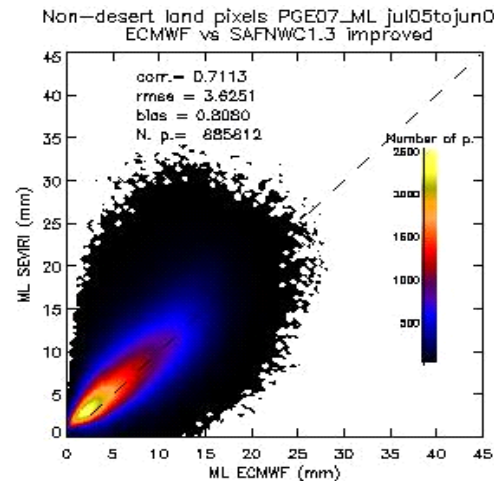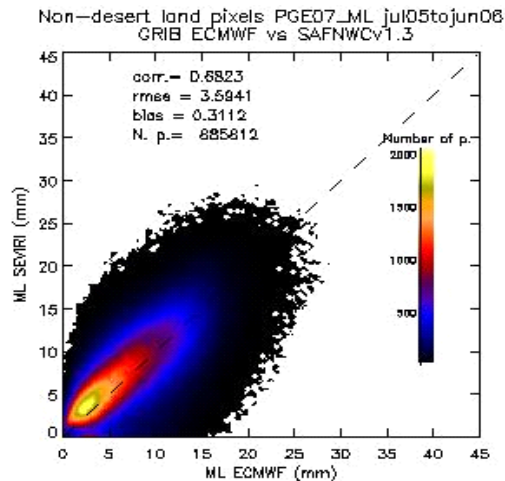
LPW_HL over non-desert land pixels

Increasing 0.13

| Statistical parameters	LPW_HL		
	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v2.0
Correlation	**0.7431**	0.7676	**0.8673**
bias (mm)	0.3776	0.3145	-0.0363
rms (mm)	**0.2559**	0.2145	**0.1362**

Decreasing 0.12
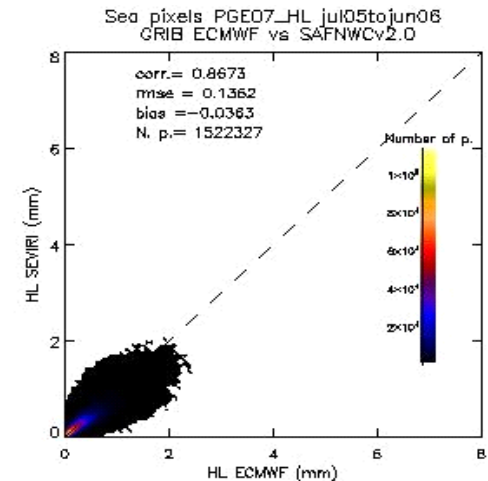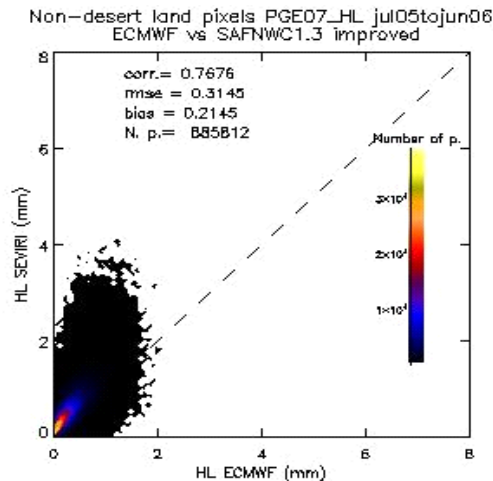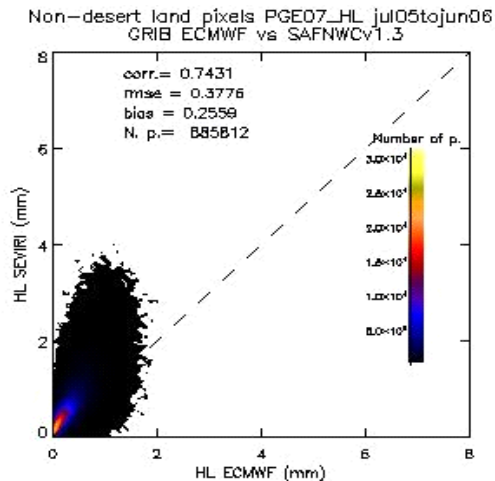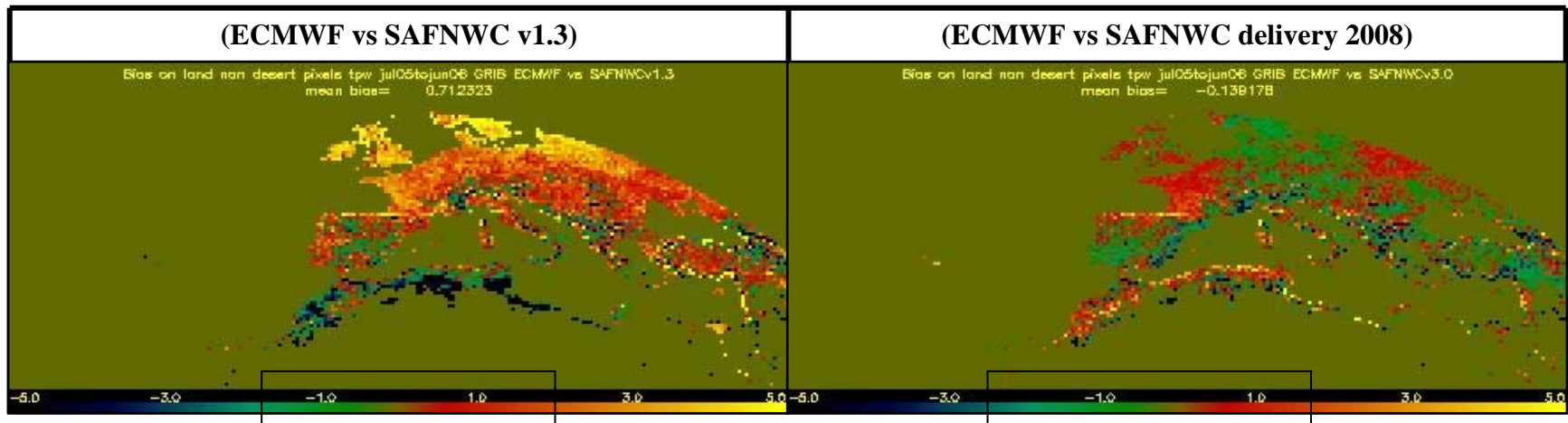
SAI_LI over non-desert land pixels

Increasing 0.15°

Statistical parameters	SAI_LI		
	Current (v1.3)	Current + radiance local bias (Improved v1.3)	Delivery 2008 v2.0
Correlation	**0.4648**	0.5337	**0.6118**
bias (mm)	-0.3772	-0.1872	-0.2420
rms (mm)	**4.6683**	4.3253	**4.0590**

Decreasing 0.63°
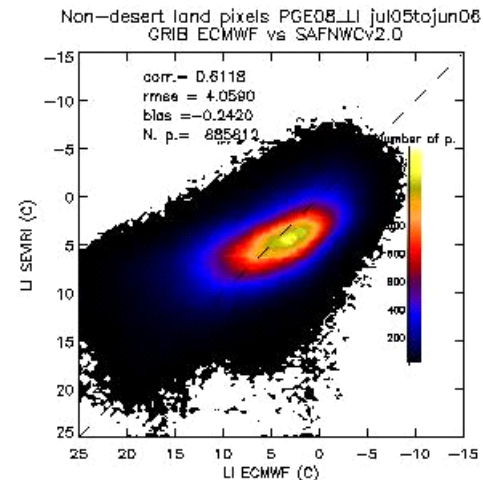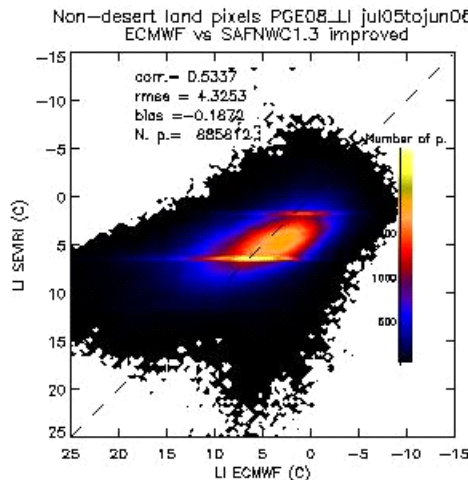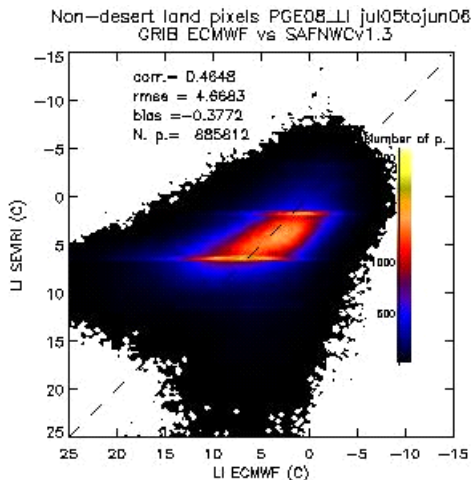
SPATIAL DISTRIBUTION (over non-desert land)

TPW BIAS

- **Bias reduction** for the latest version v3.0 over the whole region, especially in North Europe.
- Poor behaviour observed over few pixels (blue and yellow): they are being carefully checked in order to know the reasons of this.
- Similar results are obtained for the rest of the LPW (BL, ML, HL) and SAI parameters.

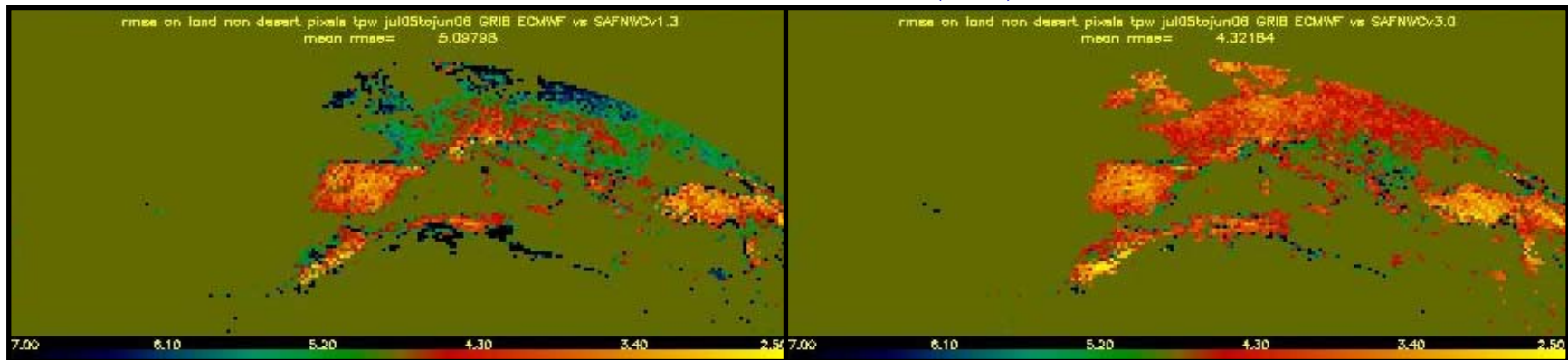# SPATIAL DISTRIBUTION (over non desert land)

(ECMWF vs SAFNWC v1.3) **TPW CORRELATION COEFFICIENT** **(ECMWF vs SAFNWC v3.0)**
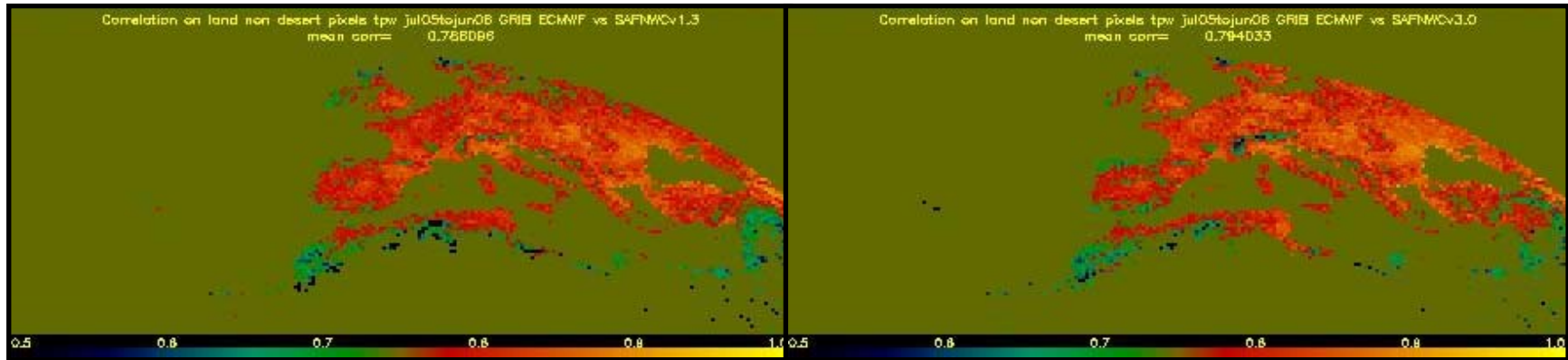
Correlation coefficient <u>increases:</u> pixels tend to be a bit more yellow over Central Europe.

TPW RMS ERROR (mm)

The rms error coefficient decreases: more red and yellow pixels are found in the latest version 3.0 (yellow ⇔ minimum rms error). Rms error and correlation values in North Europe are comparable to the ones over the Spanish region for v3.0 (requirement of the past **' Product Assessment Review Workshop' in Madrid, October 2005).**
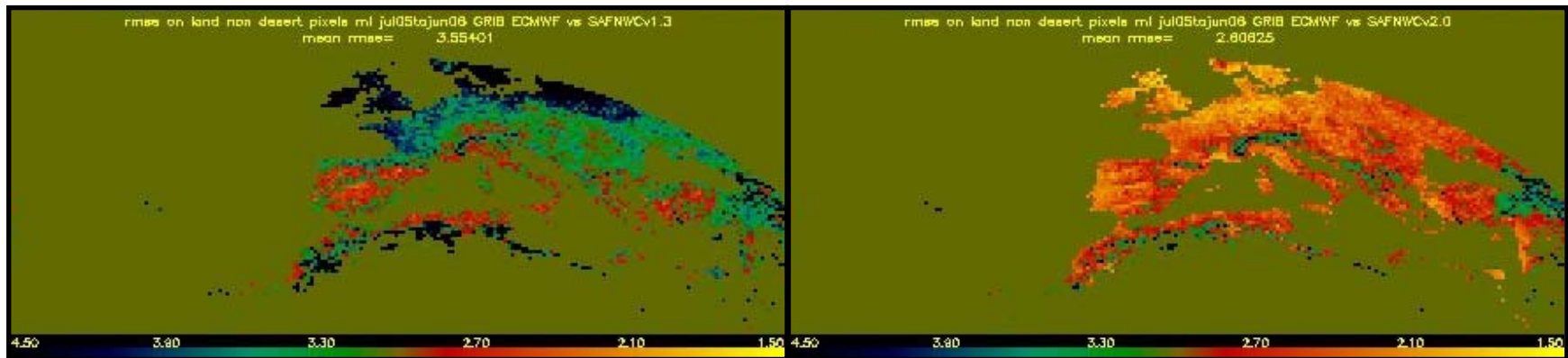
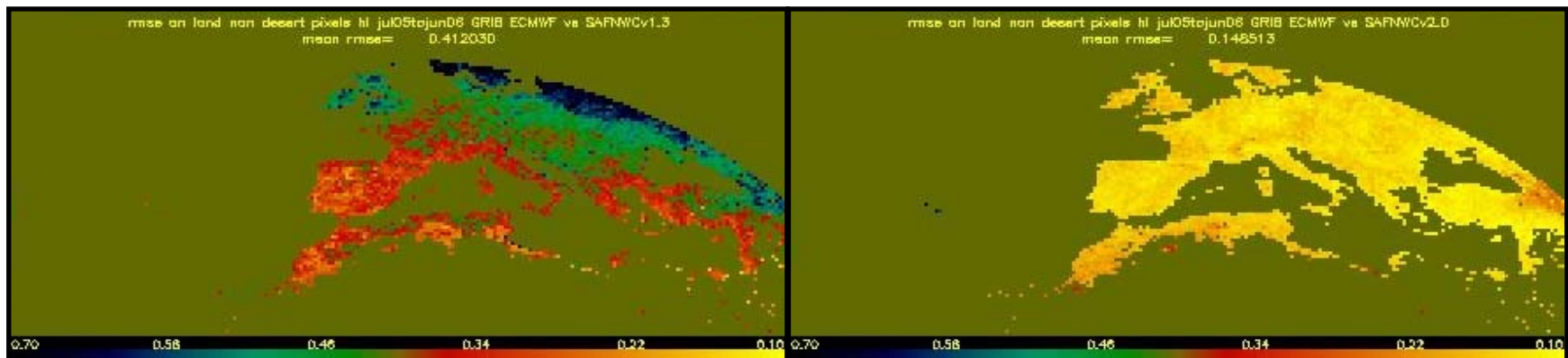LPW_BL RMSE (mm)

(ECMWF vs SAFNWC v1.3) (ECMWF vs SAFNWC v2.0)
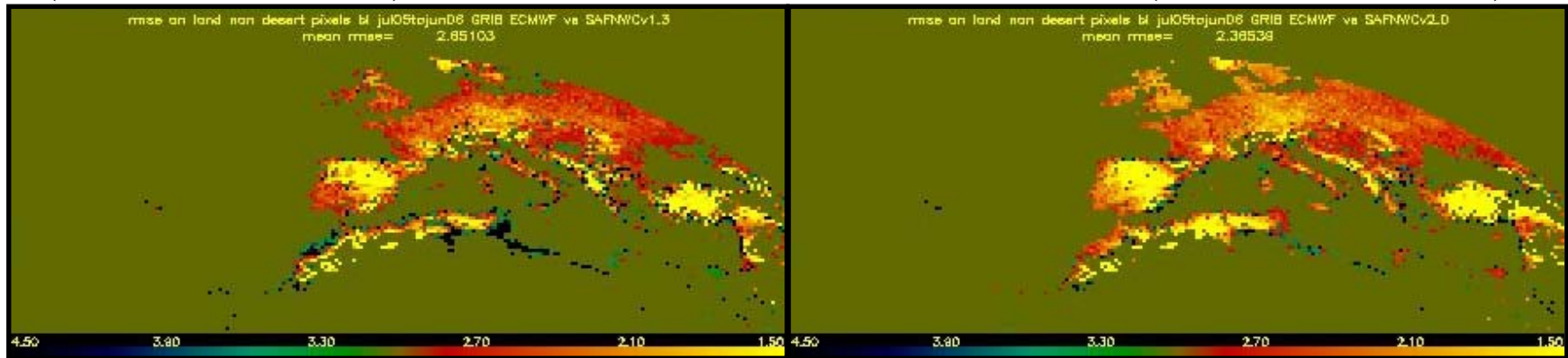
LPW_ML RMSE (mm)
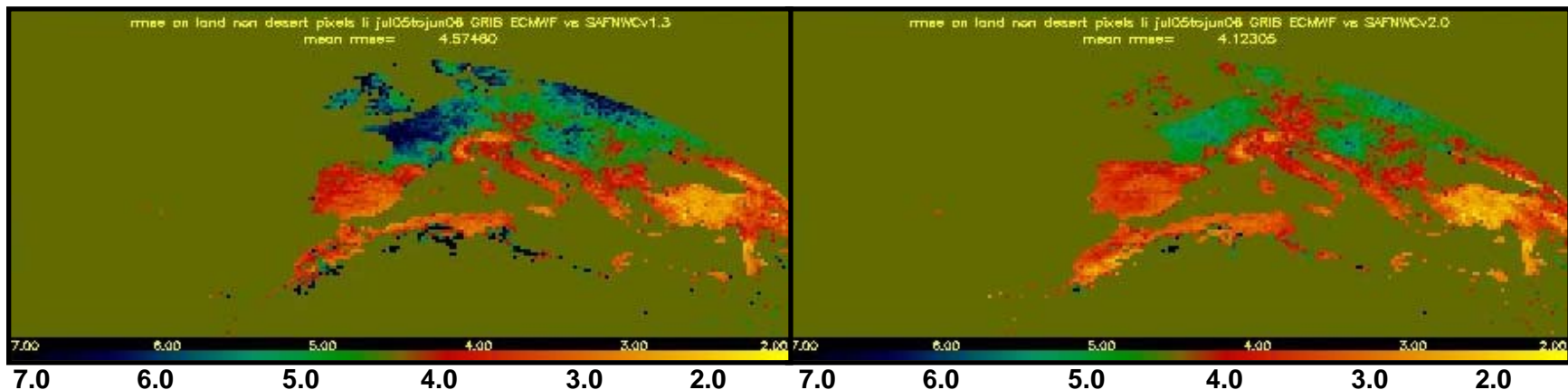
LPW_HL RMSE (mm)

SPATIAL DISTRIBUTION (over non desert land)

SAI_LI RMS ERROR (ºC)

**(ECMWF vs SAFNWC v1.3)**   **(ECMWF vs SAFNWC v2.0)**

- The **rms error coefficient significantly decreases** in version 2.0 =>
  More detailed analysis is required for the regions still colored in green.
- Future improvements are still necessary on this parameter.

2. RADIOSOUNDING COMPARISON

VALIDATION with RADIOSONDES: non-desert.

The scatter plots displayed next show the comparison of the SEVIRI TPW, LPW(LPW_BL, LPW_ML, LPW_HL) and SAI_LI parameters versus the equivalent parameters from **radiosounding profiles** for the period of 1st July 2005-31st December 2006 at 00 and 12 UTC. The **improvements** in TPW,LPW and SAI parameters on the latest version (delivery 2008) are significant for all parameters: **correlation coefficients increases and the rms error decreases in all parameters.**
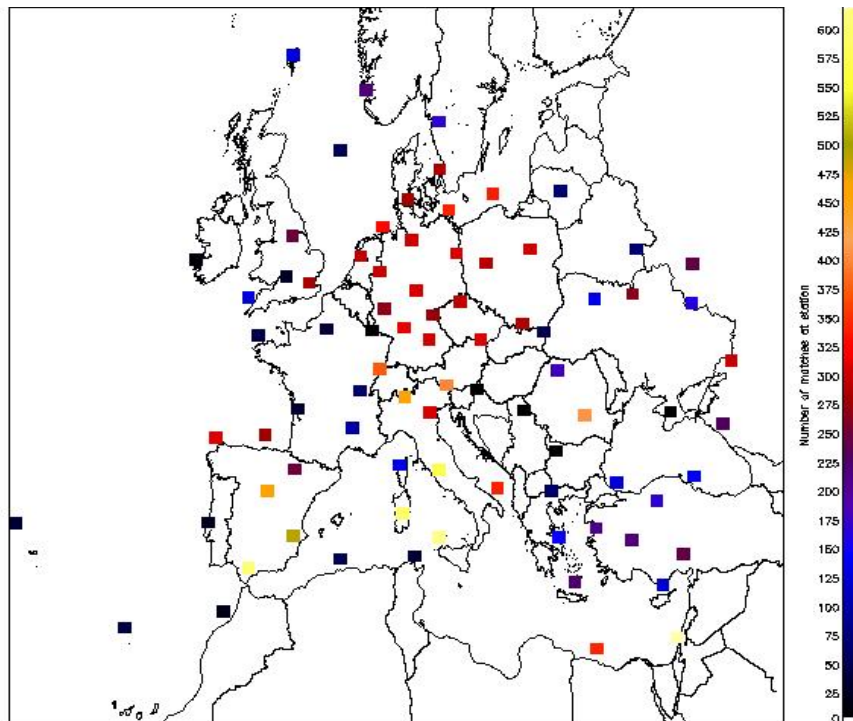
⇨ **Number of pixels used in the validation:**

- Collocation of both databases (only stations with more than 12 matches have been included)
- Stations from North Europe present less clear air days than the southern ones.
- Stations over desert areas have been removed (use of desert mask).

VALIDATION with RADIOSONDES : TPW

Increasing 0.01

Statistical parameters	Current LPW_TPW (v1.3)	Delivery 2008 v3.0
TPW		
Correlation	**0.7803**	**0.7907**
bias (mm)	1.6970	-0.7185
rms (mm)	**5.8739**	**5.2795**

Decreasing 0.59
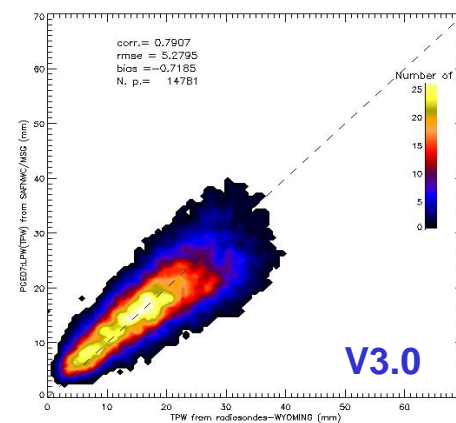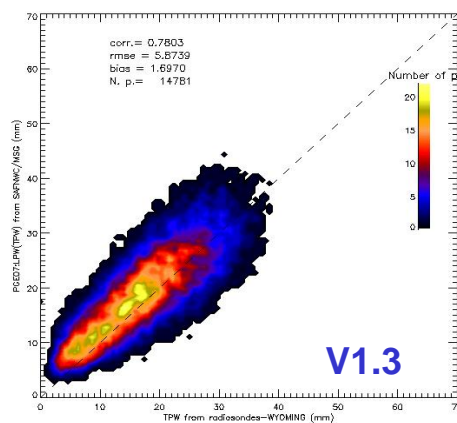
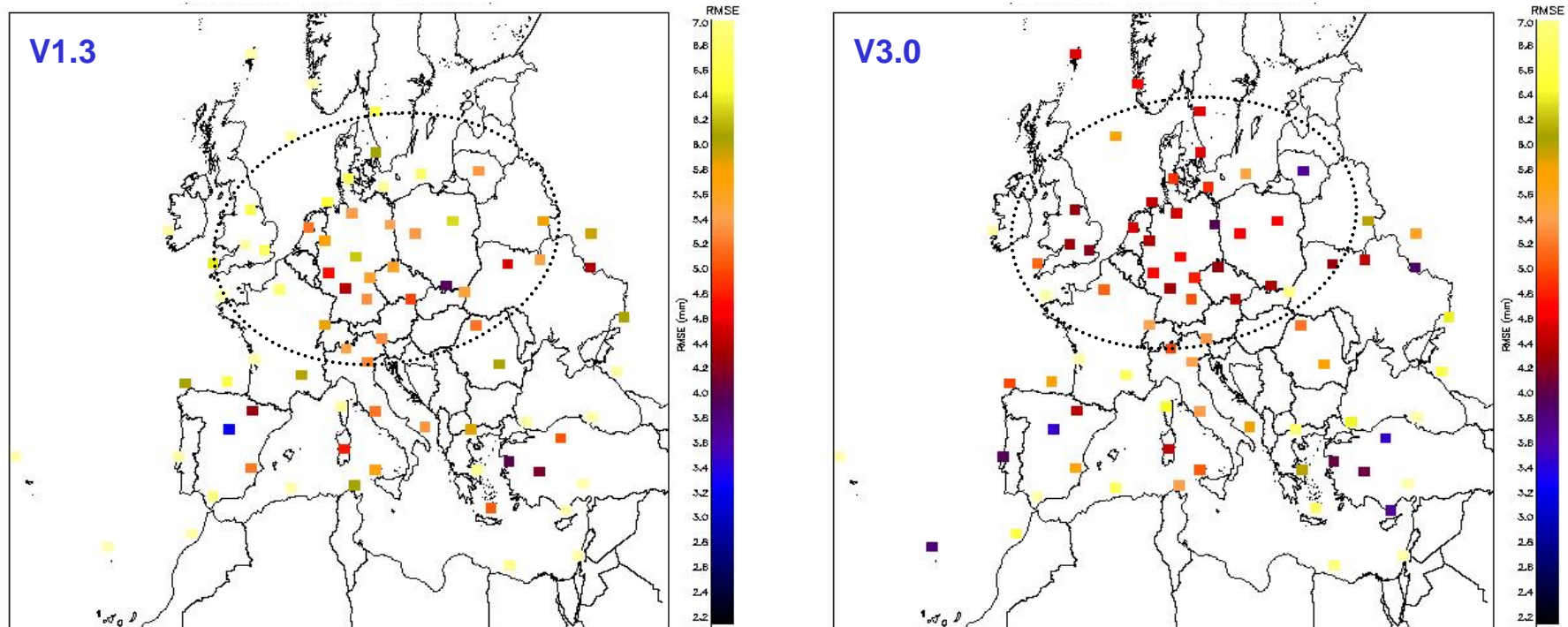# VALIDATION with RADIOSONDES : TPW

Spatial behaviour of rms errors between SAF_TPW and radiosonde TPW:

• Most significant improvements located over **North** and **Central Europe**, as it was already observed in the comparison between SAFNWC TPW and ECMWF TPW.

• Results corroborated by the spatial distribution of correlation coefficient.

VALIDATION with RADIOSONDES : LPW_BL

LPW_BL		
Statistical parameters	Current (v1.3)	Delivery 2008 v2.0
Correlation	0.7804	0.7582
rms (mm)	2.993	3.0404
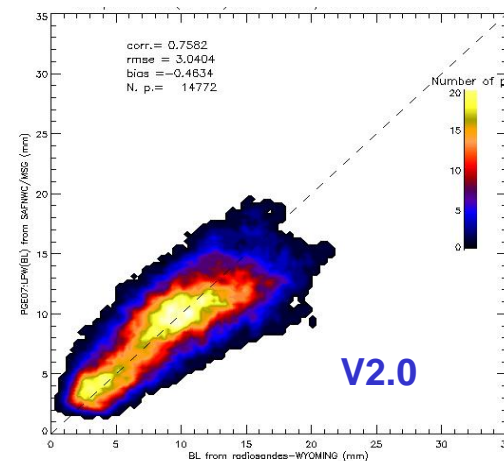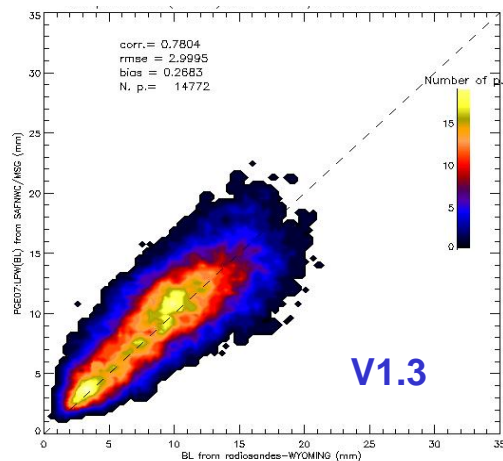
VALIDATION with RADIOSONDES : LPW_ML

Increasing 0.06

Statistical parameters	LPW_ML	
	Current (v1.3)	**Delivery 2008 v2.0**
Correlation	0.7197	0.7776
rms (mm)	3.7381	3.0661

Decreasing 0.67
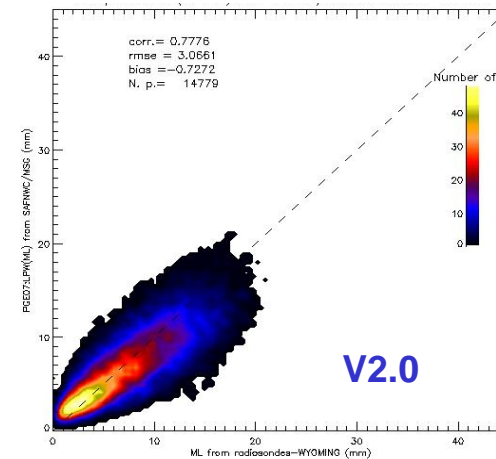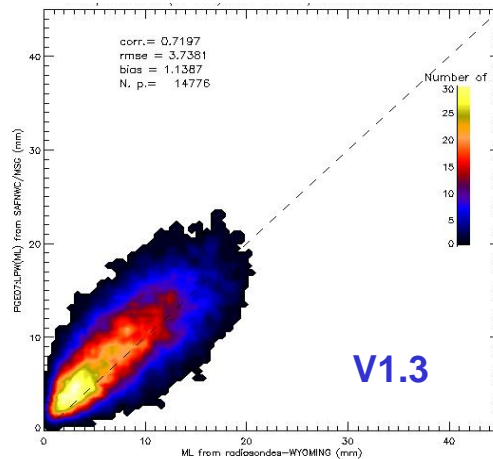
VALIDATION with RADIOSONDES : LPW_HL

LPW_HL		
Statistical parameters	**Current (v1.3)**	**Delivery 2008 v2.0**
Correlation	0.5896	0.5482
rms (mm)	0.4654	0.2146

Decreasing 0.25
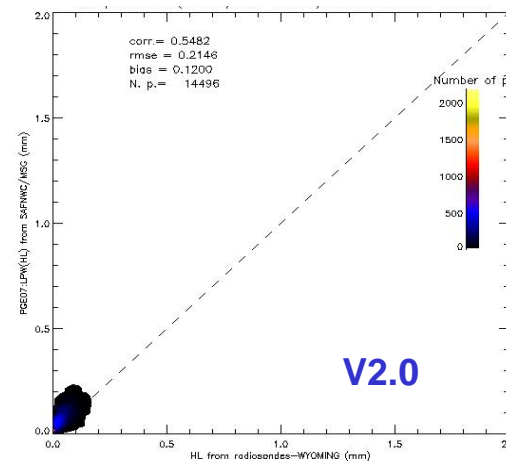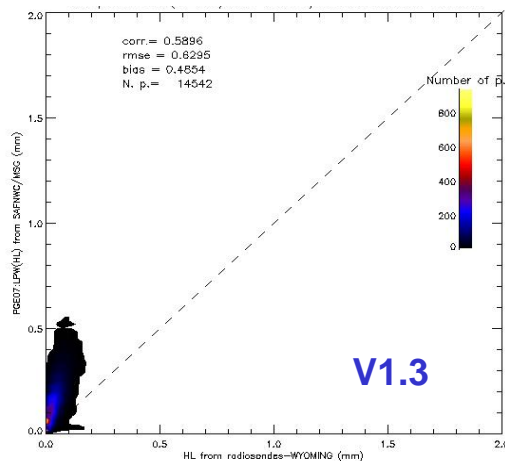
RADIOSONDE VALIDATION : spatial distribution
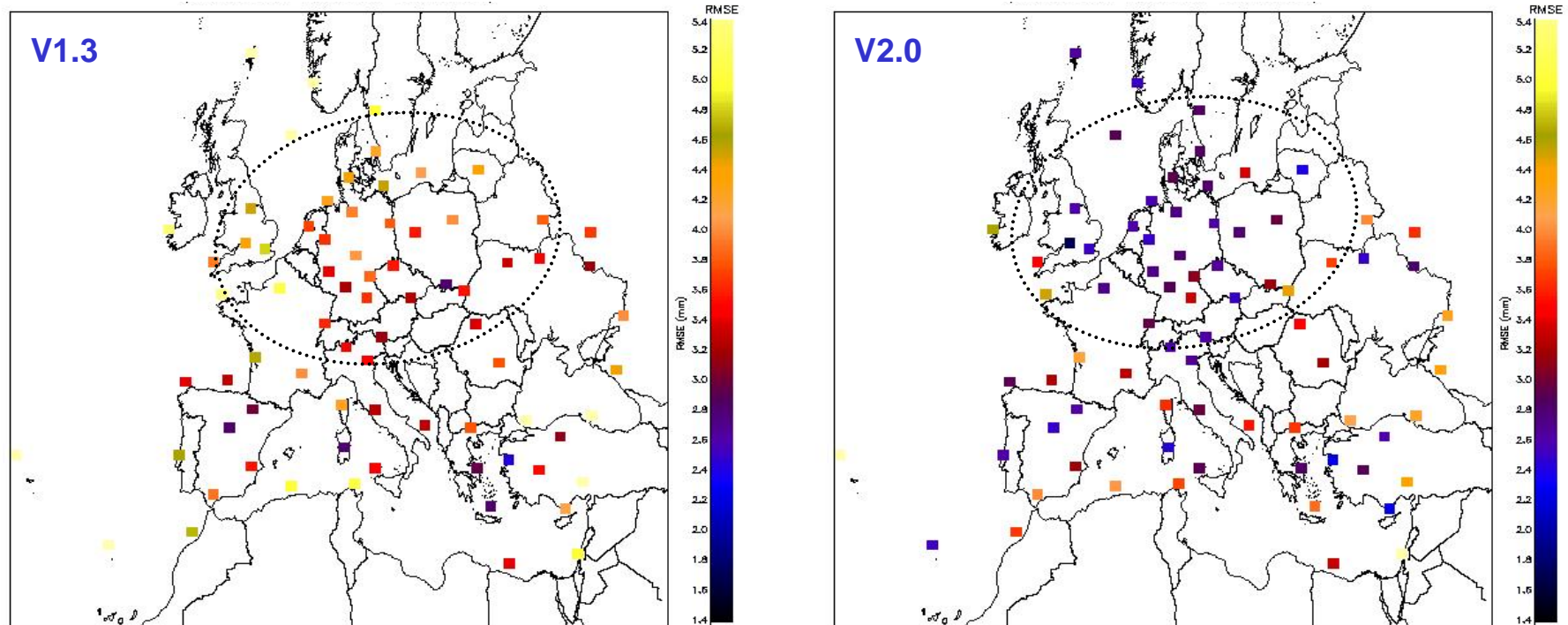
Spatial behaviour of <u>rms errors</u> between SAF LPW_ML and radiosonde ML:

- Best improvements over Central and North Europe (reduction of rmse): more significant for the middle layer ML.

- Results corroborated by the spatial distribution of correlation coefficient.

- **Bad behaviour for the HL** probably associated to the bad representation of the humidity at the high troposphere on the radiosonde profiles => **<u>inclusion of a flag in the calculus of HL for the radiosonde in perspective.</u>**

3. COMPARISON with GPS

COMPARISON with GPS

Precipitable Water (SAF TPW vs GPS IWV)				
Parameters	**TPW vs IWV GFZ**		**TPW vs IWV METO**	
Algorithm version	**Current LPW_TPW (v1.3)**	**TPW (v3.0)**	**Current LPW_TPW (v1.3)**	**TPW (v3.0)**
Correlation	0.8360	0.8517	0.8088	0.8155
Bias	1.3665	-0.7529	2.8542	-1.1120
rms (mm)	4.3384	3.9837	6.2391	5.4382

Decreasing 0.35mm   **Decreasing 0.8mm**

- **Considerable improvements achieved** with the new correction (v3.0) for both processing centers.

- **Best agreement at GFZ center**:
- Possible impact of the lack of clear-air pixels, suspect decontaminations for UK area.
- Different IWV extraction algorithms for each center.

- 2D-histograms shown next: the LPW_TPW v1.3 was **systematically wetter** => this problem is corrected in the new version.

COMPARISON with GPS

SAFNWC versus GFZ centre
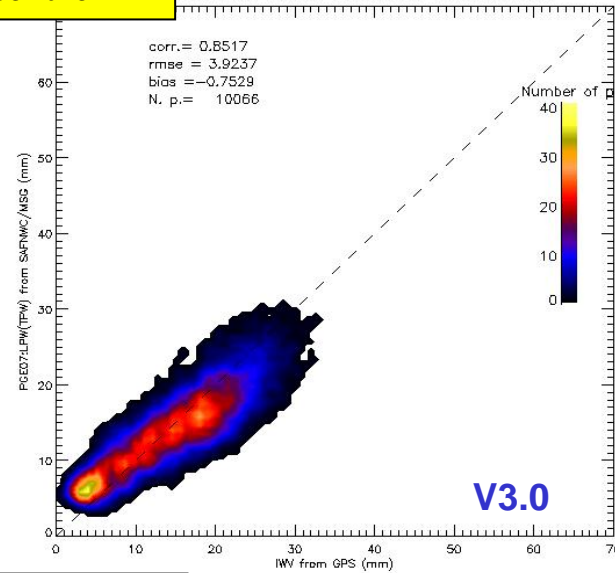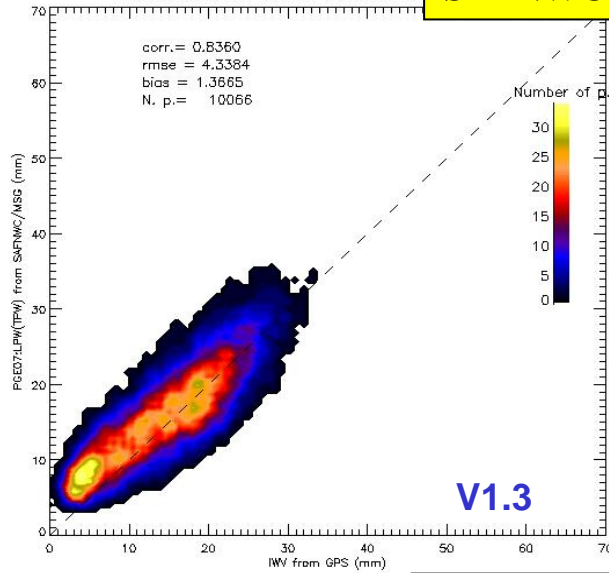
SAFNWC versus METO centre

COMPARISON with GPS

Spatial Behaviour RMSE of LPW(TPW) vs IWV
V1.3 period 20050501 to 20060430
(Stations with more than 200 matches)

Spatial Behaviour RMSE of LPW(TPW) vs IWV
V2.0 period 20050501 to 20060430
(Stations with more than 200 matches)

V1.3

V3.0
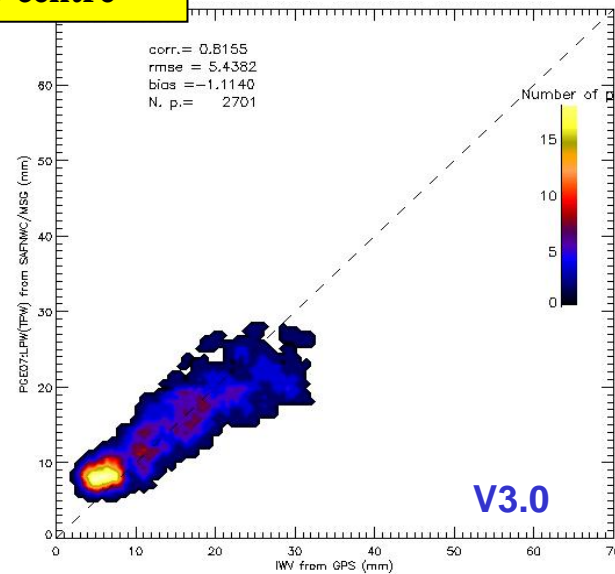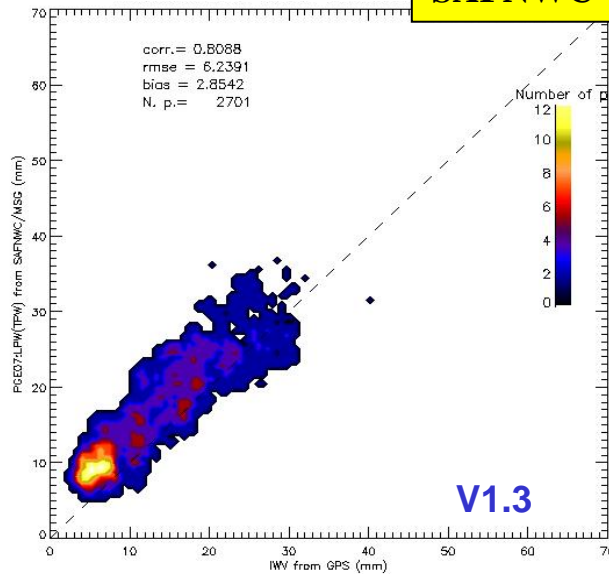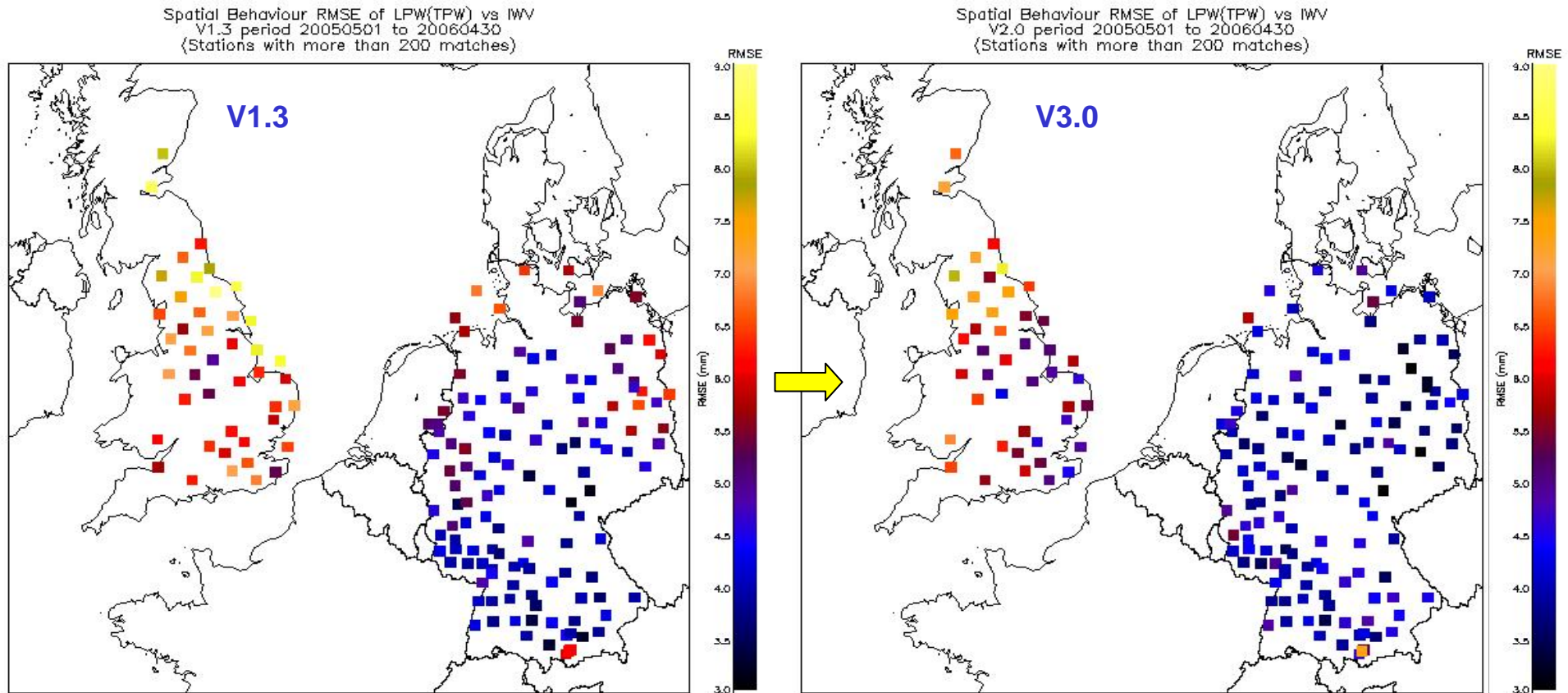
• **Very good results over GFZ stations (rmse below 4.0).**
• **GFZ database very reliable (optimal algorithm results) => sign of SAFNWC TPW accuracy over German region.**

CONCLUSIONS

• **The 2D-histograms and statistical parameters show that the parameter <u>accuracy increases</u> when the local bias correction is applied (delivery 2008):**
    - **ECMWF**: a general increase of correlation is observed as well as a reduction of rms error over both (sea and non-desert land pixels) when the are analysed, especially over North-Europe and over North and Baltic seas.
    - **Radiosonde**: similar results are found, being the rms errors over North and Central Europe comparable to those over the Peninsula (requirement of the Product Assessment Review Workshop in 2005).
    - **GPS IWV**: it also supports the previous results. Improvements for the latest version in both processing centres (GFZ and METO).

• A slight tendency to negative biases is highlighted: overcorrection of radiances at some points.

• Poor performance at some pixels (low correlation, high rmse) => further check.

• The bias radiance correction has a positive impact in the **LI** parameter.

• The quality of lifted index (SAI parameter) is not as good as for the precipitable water parameters, especially for very stable cases (LI >8°C). Still, trends of the LI are useful for forecasters (case studies, image loops)

• **It is not adequate to use this algorithm over desert pixels yet.**

IN PERSPECTIVE

- Other **sources** will be introduced in the **comparison process** in order to achieve a better assessment the quality.
- **Desert areas** and their **associated emissivity problems** need to be **carefully analysed** in future works. This may be done with the help of other data sources as IASI, atlas emissivities, etc.
- **To improve the validation databases:**
    - Including **flags** with **different altitudes** (SEVIRI pixel, ECMWF grib-cell and radiosonde in the corresponding database)
    - Introducing other **techniques** to **collocate databases** with different spatial resolution.
    - A more **detailed analysis** is being kept for radiosonde database (station by station)

- **High influence** of the **boundary layer** on the coded **lifted index** => other instability indices without this influence will be coded to use together with LI (Showalter stability index, K-index)

✓ The radiance definition change planned by EUMETSAT in 2008 should not modify significantly the results presented here, because this change has been taken into account as a correction in the algorithm.

THANKS FOR YOUR ATTENTION