# Assimilation of Radar Reflectivities using the Field Alignment Technique

Carlos Geijo

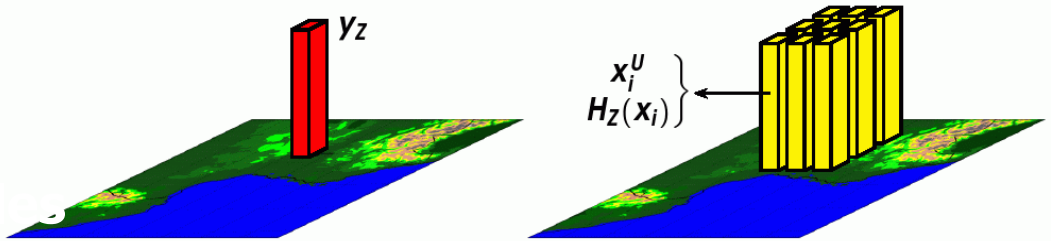
# Assimilation of Radar Reflectivities using the FA technique

- Presentation of the Method
- Presentation of the Verification Method using Radar Images
- Presentation of the Experiment and its results

# The Motivation

**The fundamental problem with the assimilation of radar reflectivities is the indirect relationship between rain echos and the analysis variables**

**The solution implemented in HARMONIE uses model profiles in the neighbourhood of the radar observation to retrieve a relative humidity pseudo-observation**




$$y_{po}^{U} = \sum_{\substack{i \in \\ \text{neighbours}}} x_i^U \frac{\exp\left(-\frac{1}{2}\|y_Z - H_Z(x_i)\|^2\right)}{\sum_{\substack{j \in \\ \text{neighbours}}} \exp\left(-\frac{1}{2}\|y_Z - H_Z(x_j)\|^2\right)}$$

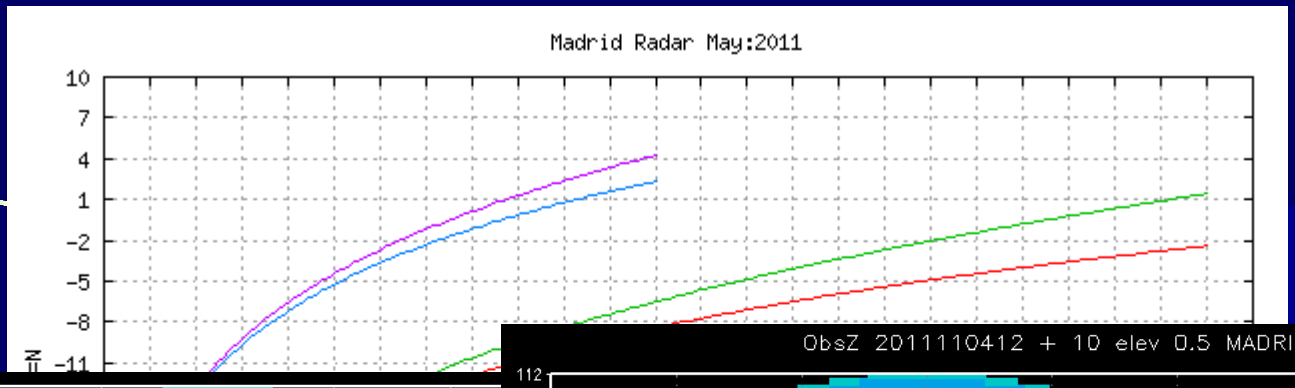
$y_{po}^{U}$: column of pseudo-observed relative humidity,
$y_Z$: column of observed reflectivities,
$x_i^U$: column of relative humidity,
$H_Z(x_i)$: column of simulated reflectivities.

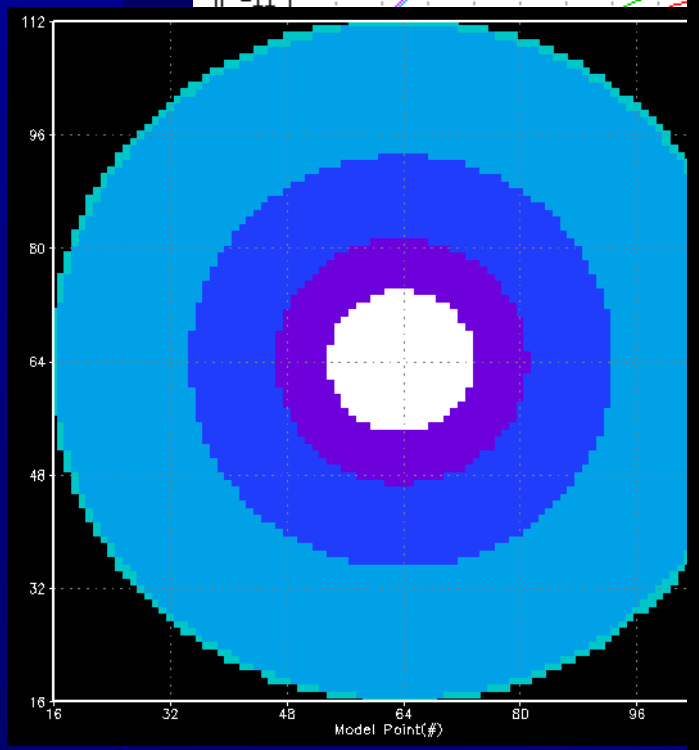
***The FA technique offers the possibility to re-arrange in a coherent way the humidity and reflectivity fields of the model forced by the spatial distribution of the radar echos***

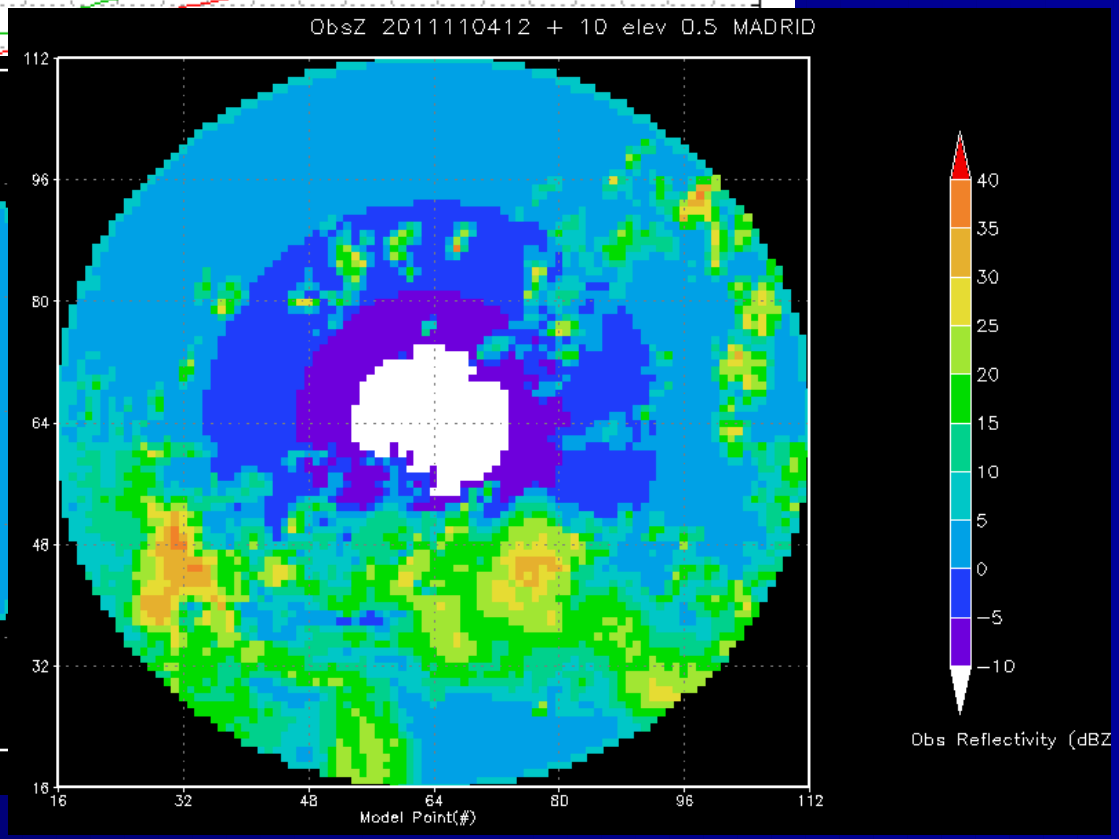
# Sketch of The Method

- Generate from the Model Guess: Z, Cloud, Hydro Species and Relative Humidity fields in Radar Geometry
- Splice Obs and Model fields using a ring-shaped Transition Zone
- Smooth the Z fields (only these !) and Align them
- With the deformation field, Drag the Cloud, Hydro and RH fields (the same deformation for all !)
- QC and Project the Increments back to Grid Points
- Use the Aligned fields as input for the 3D-Var Analysis

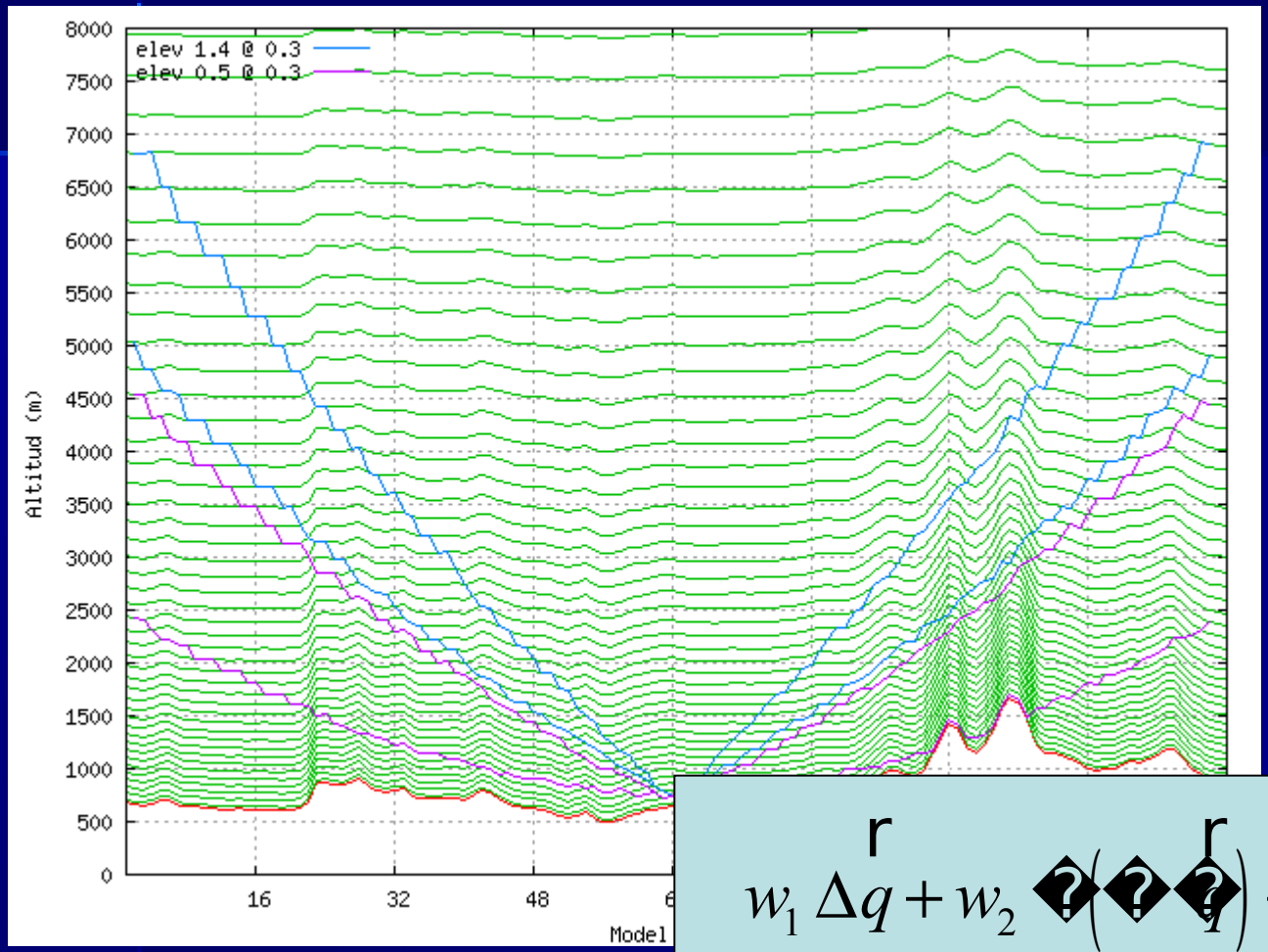
# Sketch of The Method : treatment of "no echo" data



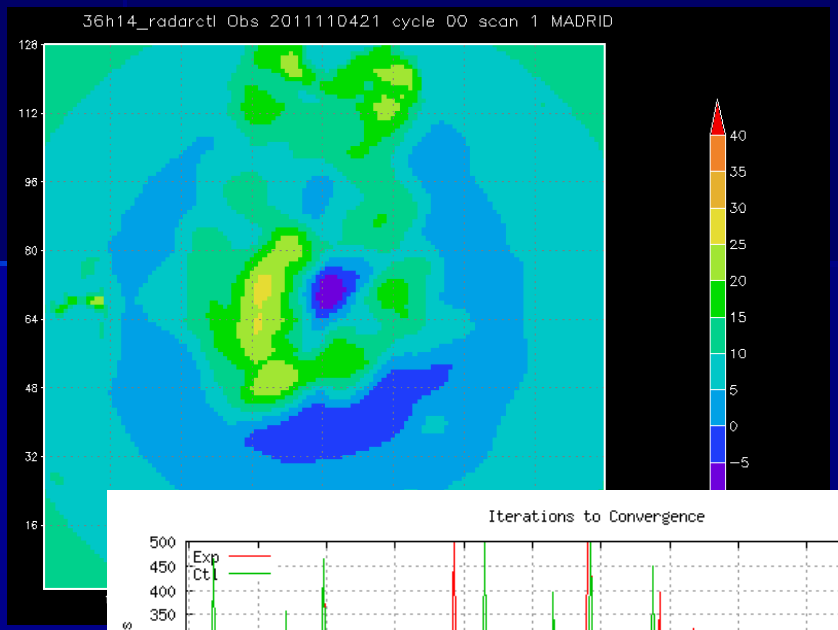
# Sketch of The Method :
# Radar Geometry used in this study: polar coordinates

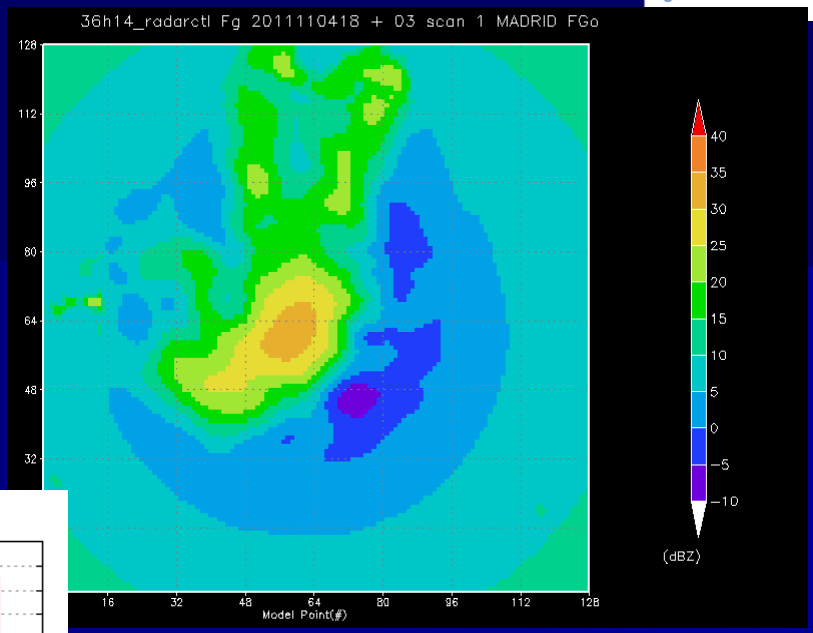


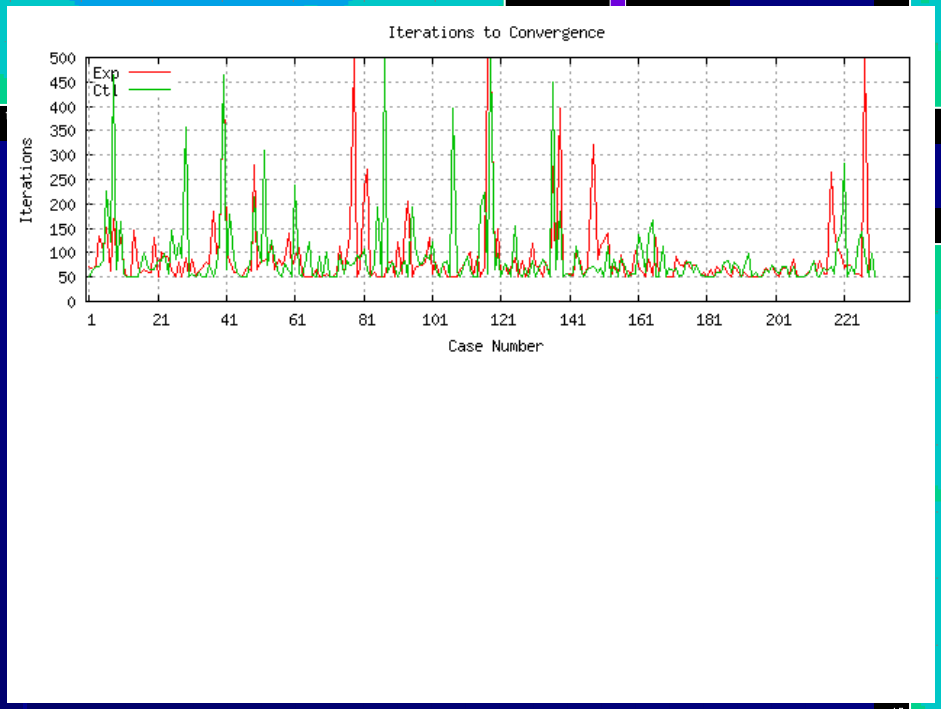

$$w_1 \Delta q + w_2 \left( \quad \right) +$$

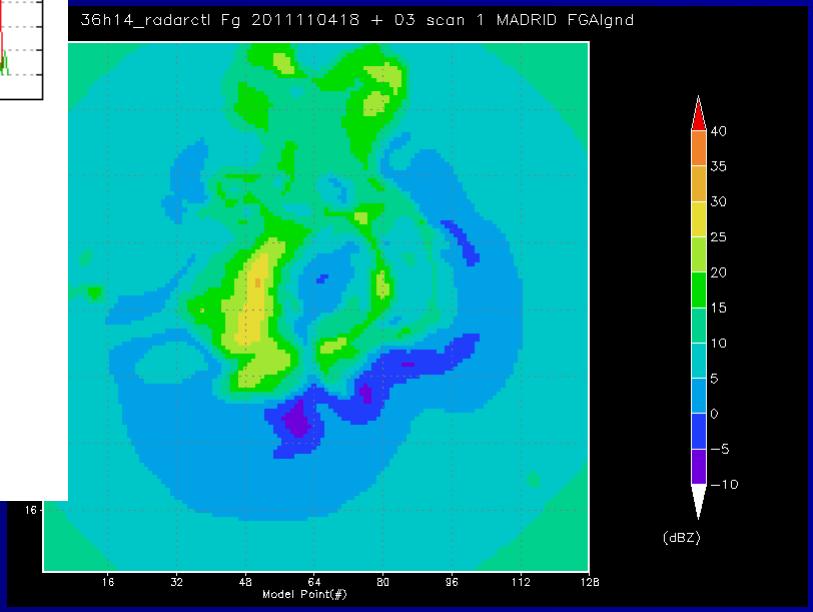
$$\left( \quad \right)^T H^T R^{-1} \left( H X^f(p) - Y \right) = 0$$

# The Method at work

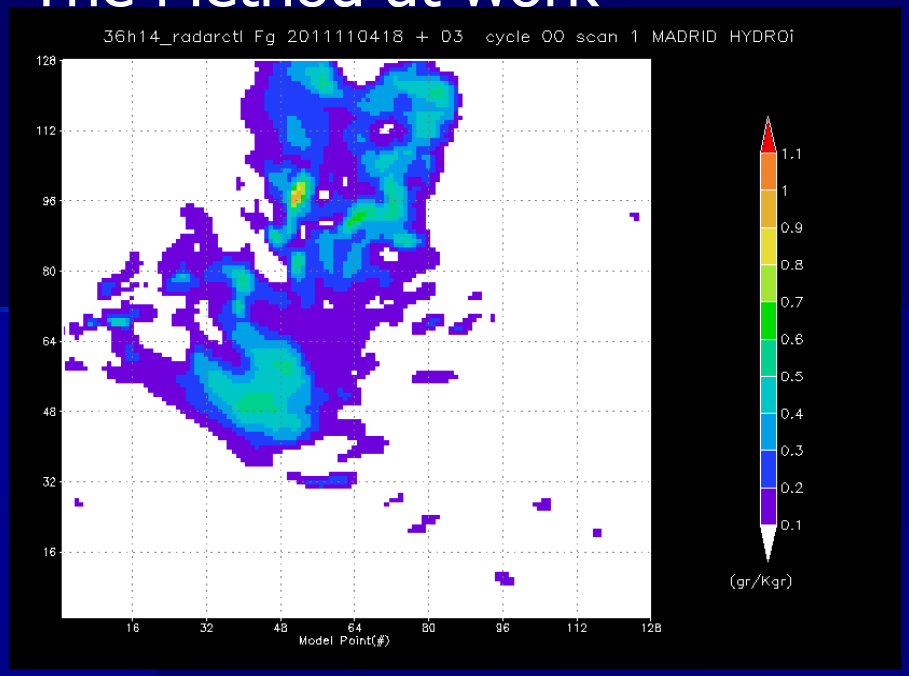


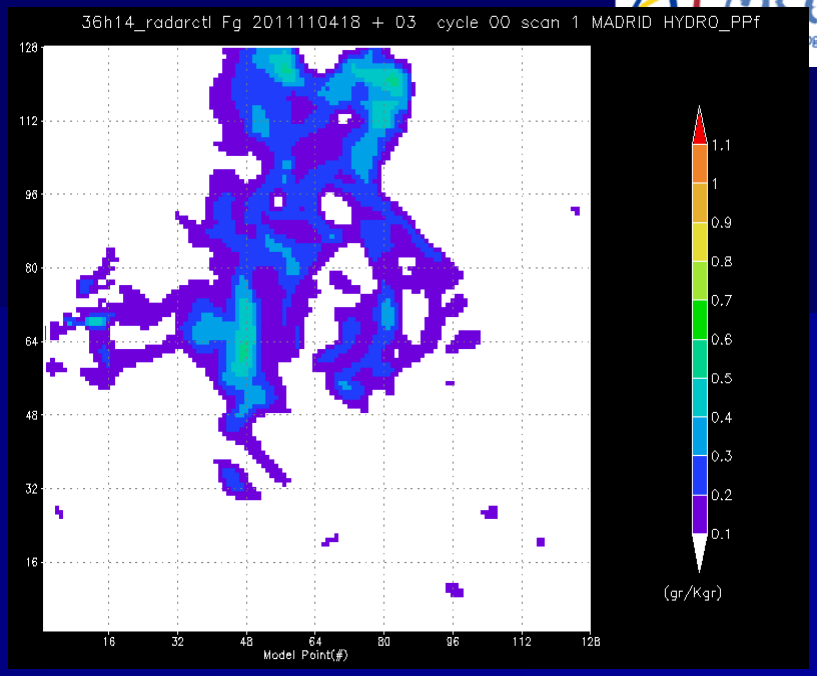



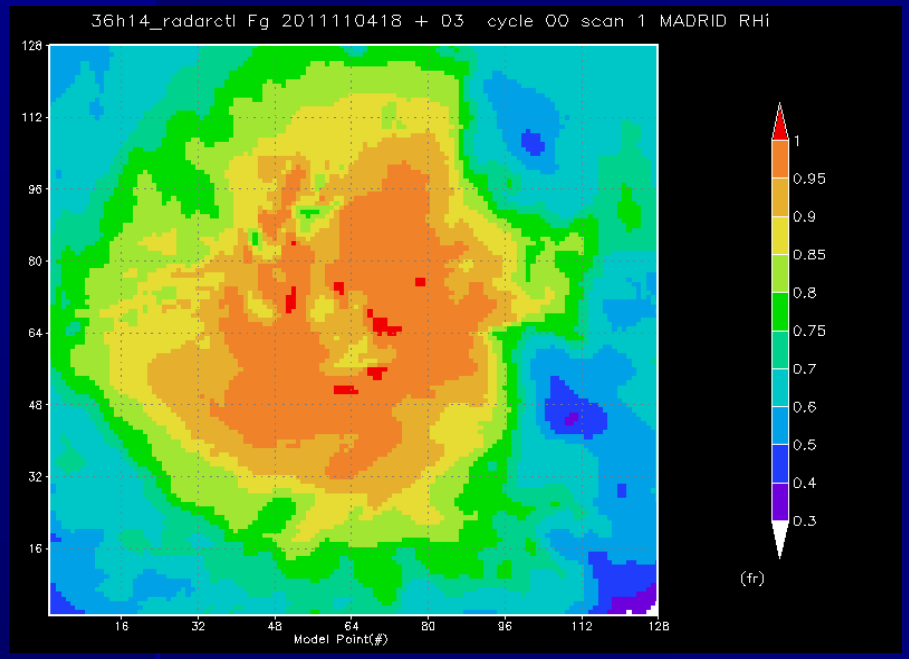



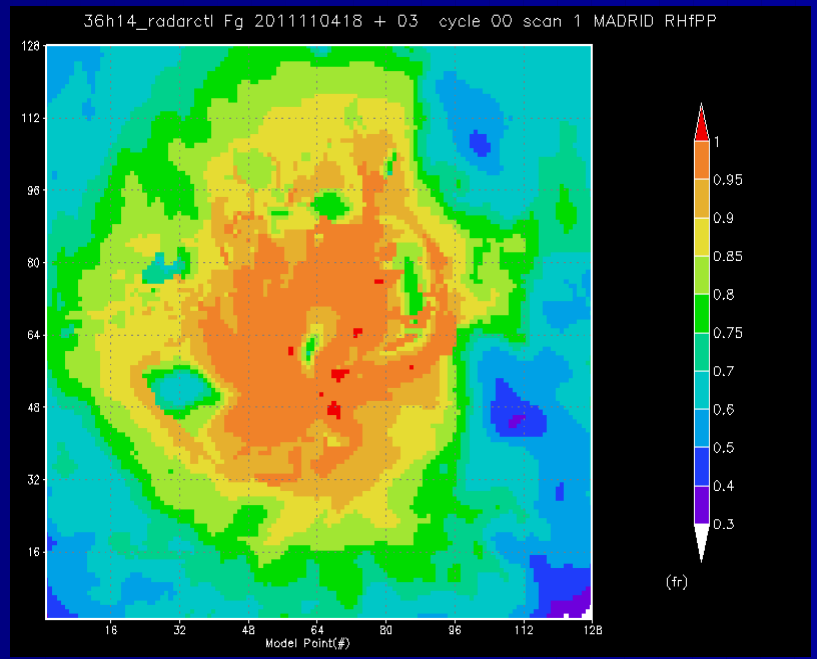



# The Method at work



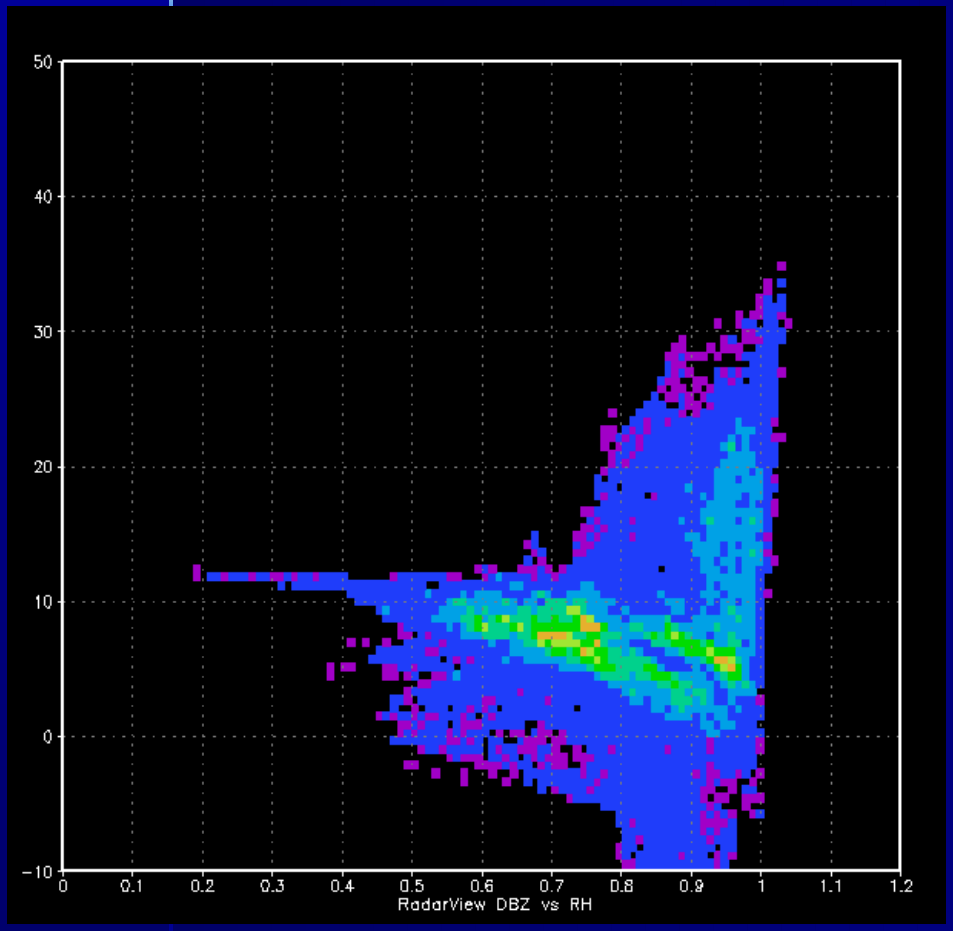



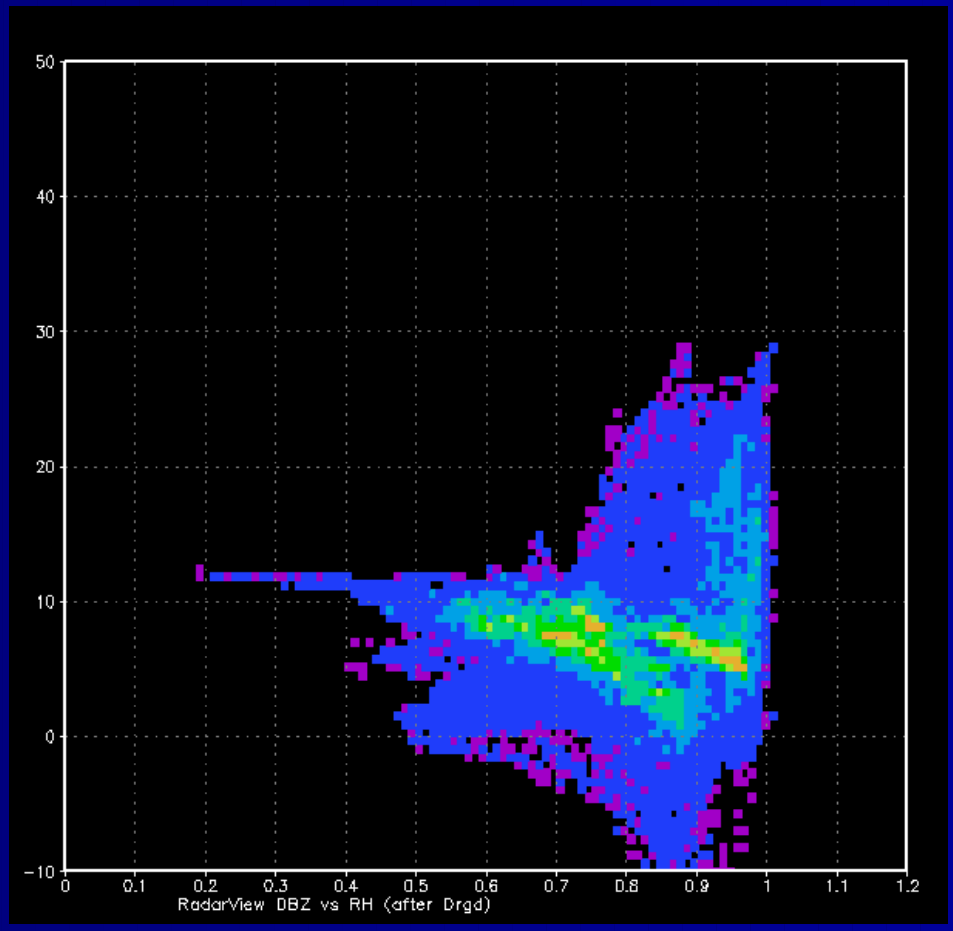



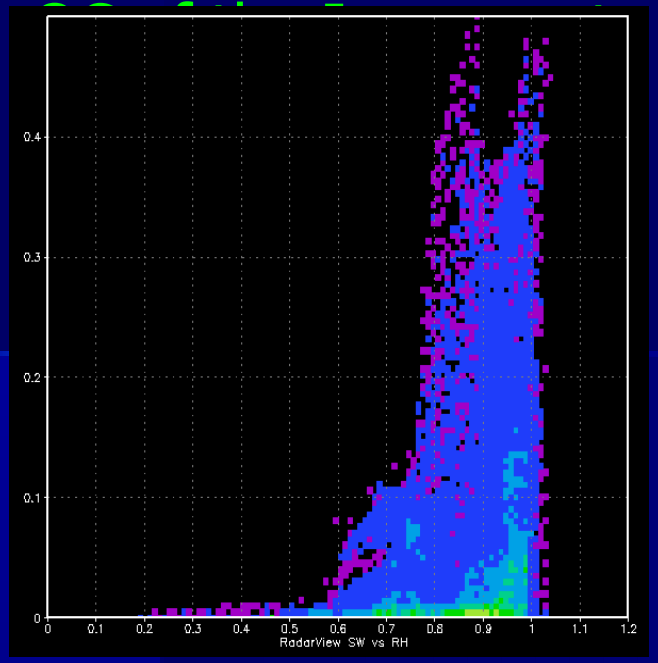



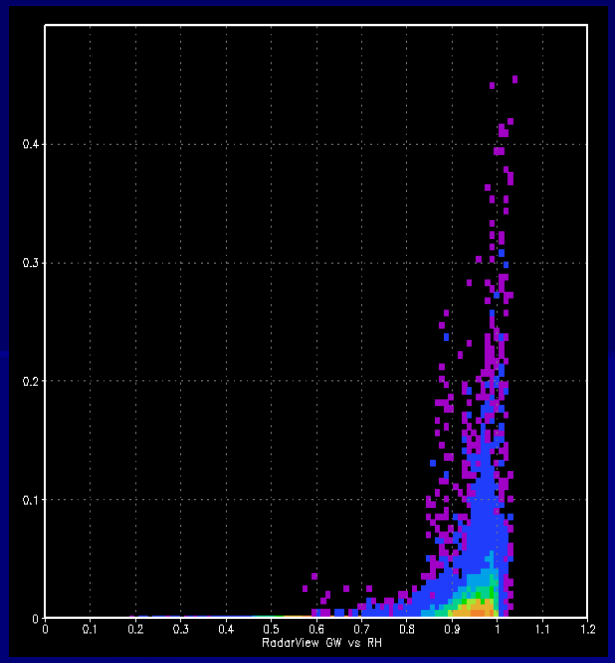
# QC of the Increments

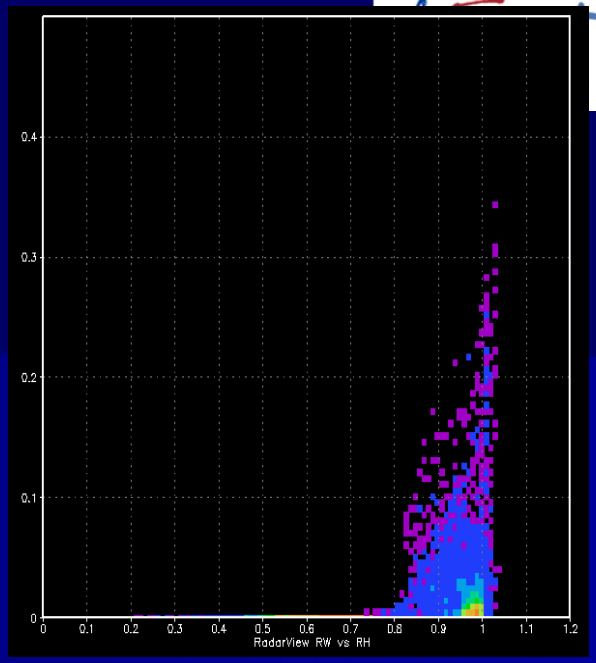
- The dragging of the fields is done using a simple SL scheme with bi-cubic Spline Interpolation. The question of how well this process conserves the relation between parameters naturally arises. The checks do not indicate obvious problems here.

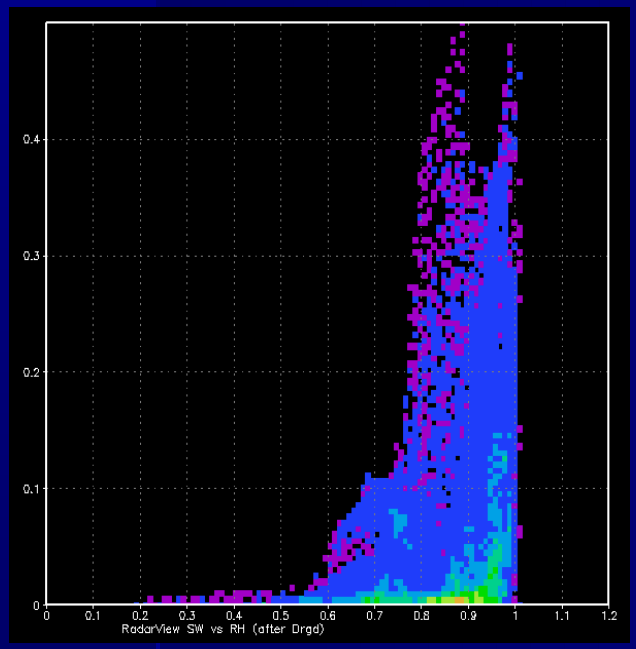


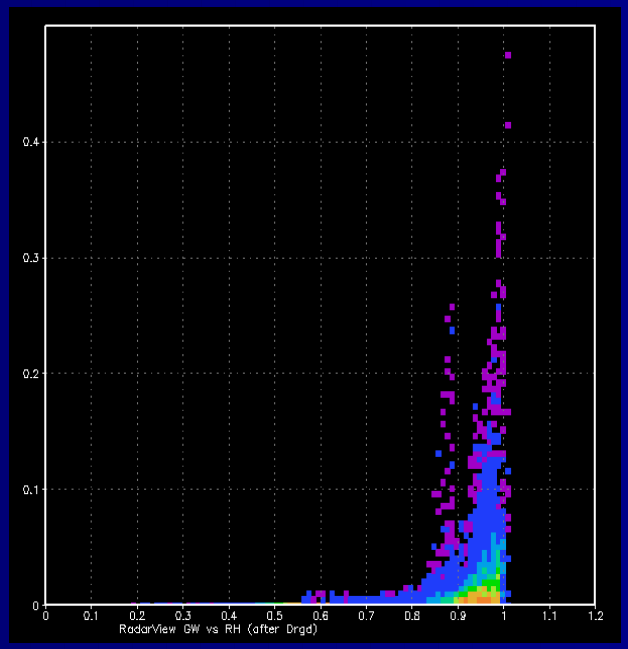



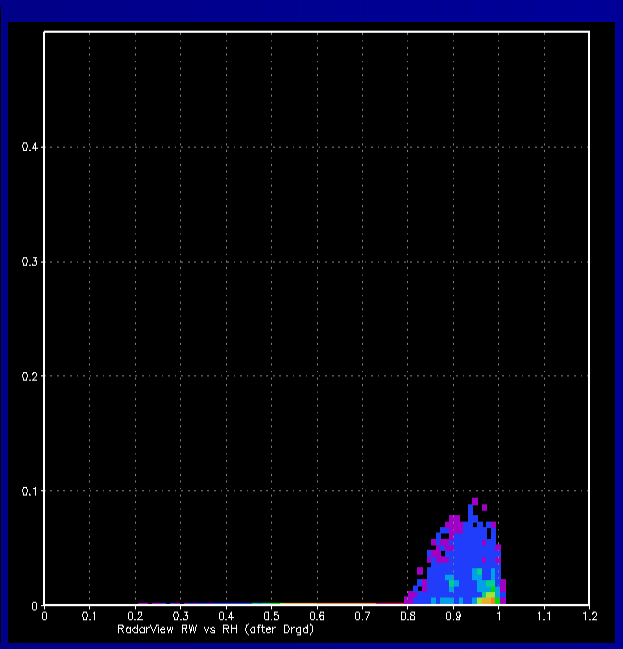

RadarView SW vs RH

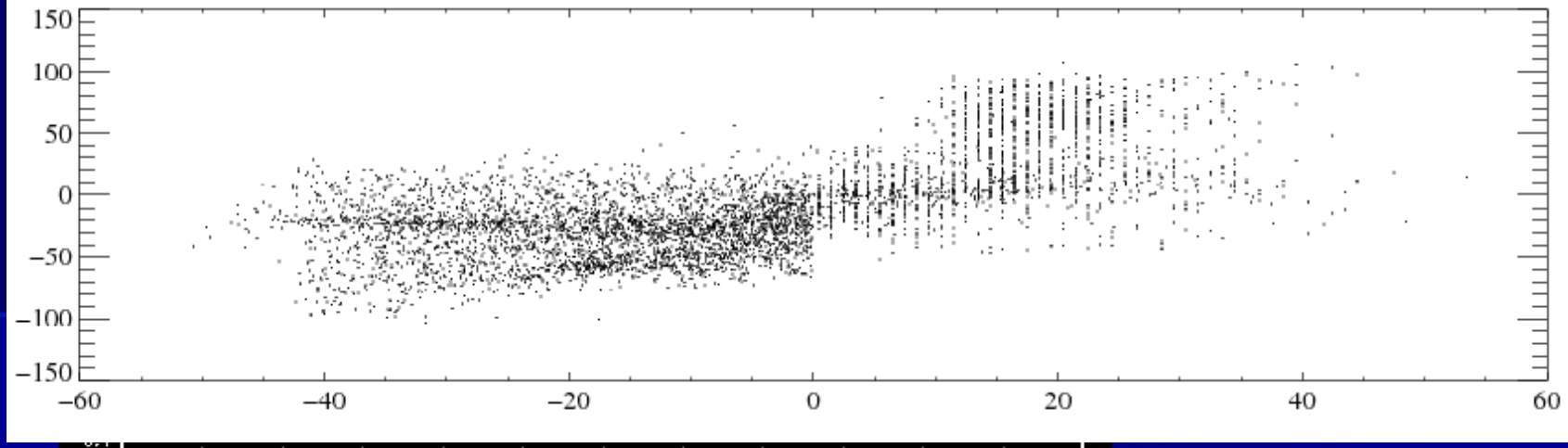

RadarView GW vs RH

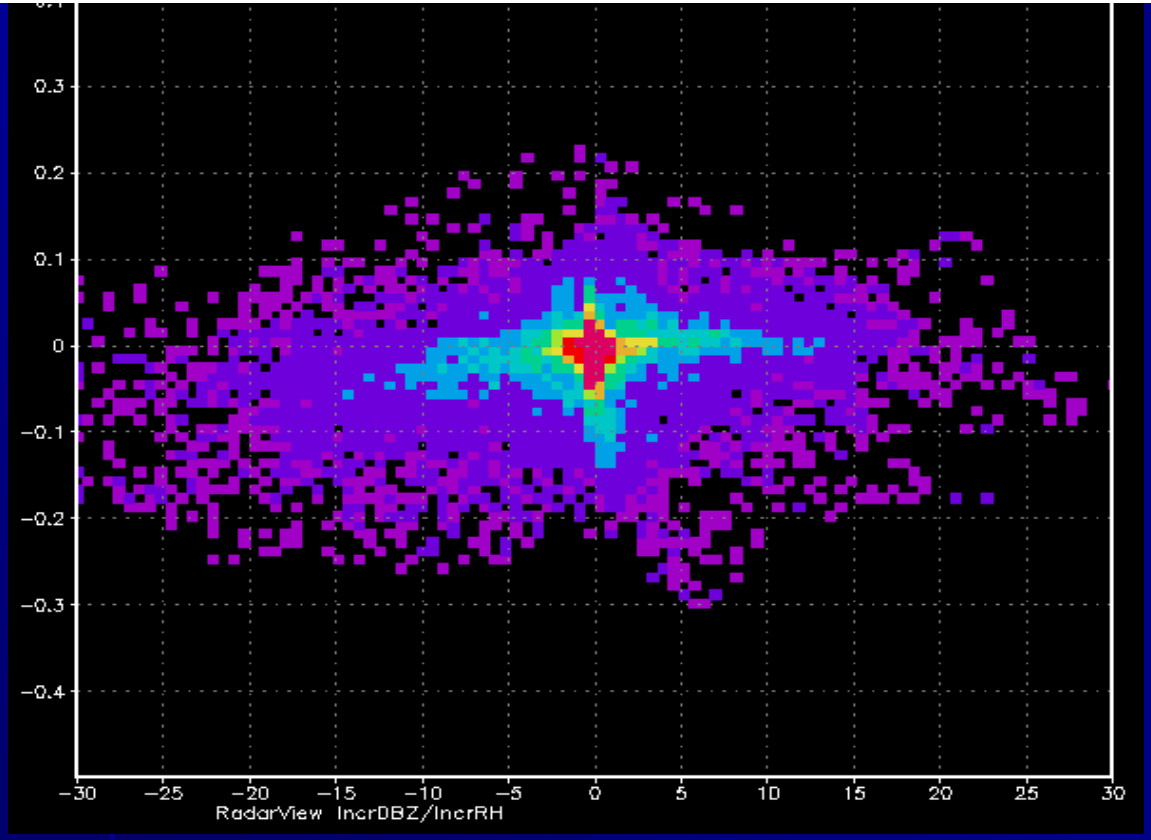

RadarView RW vs RH


RadarView SW vs RH (after Drgd)


RadarView GW vs RH (after Drgd)

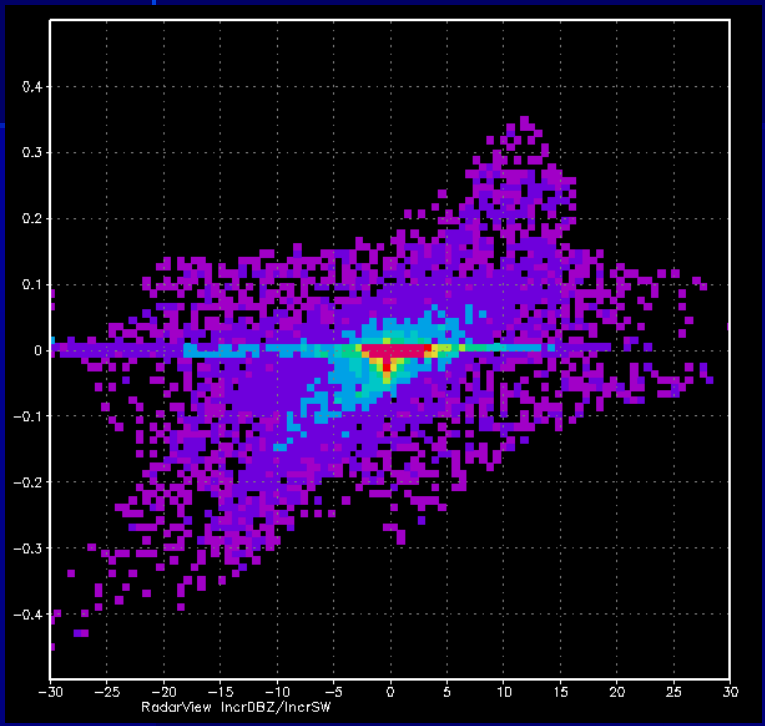

RadarView RW vs RH (after Drgd)

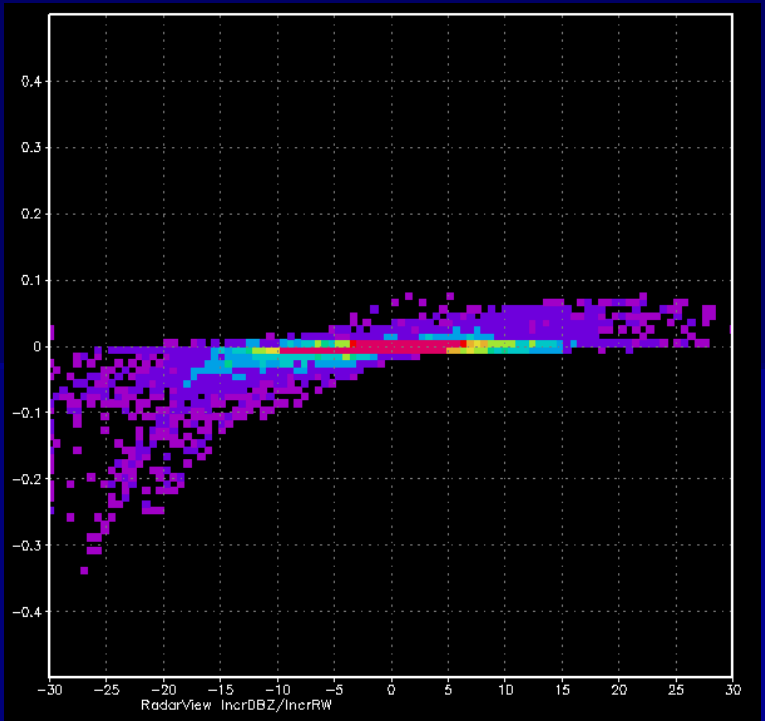

150
100
50
0
−50
−100
−150
−60
−40
−20
0
20
40
60

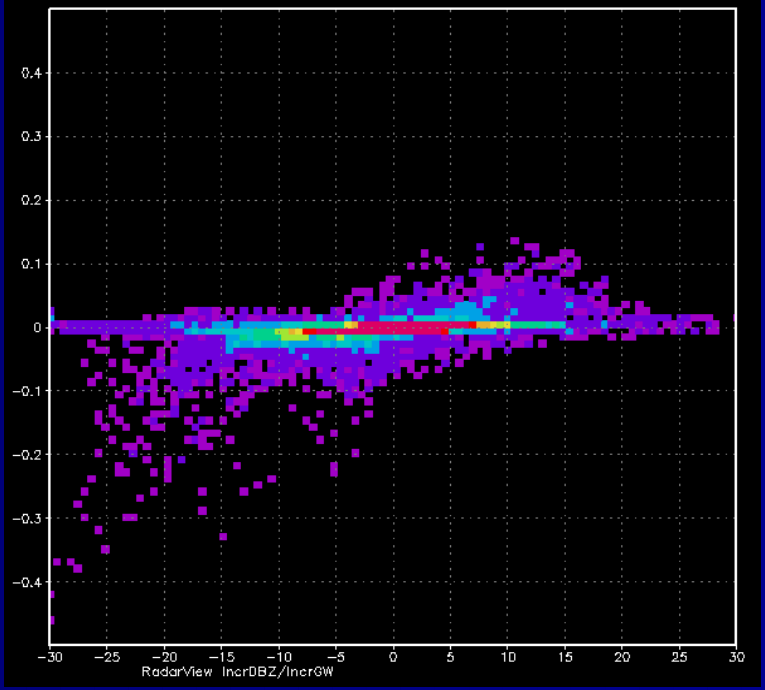

0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−30
−25
−20
−15
−10
−5
0
5
10
15
20
25
30
RadarView IncrDBZ/IncrRH

meter
eters

# QC of the Increments

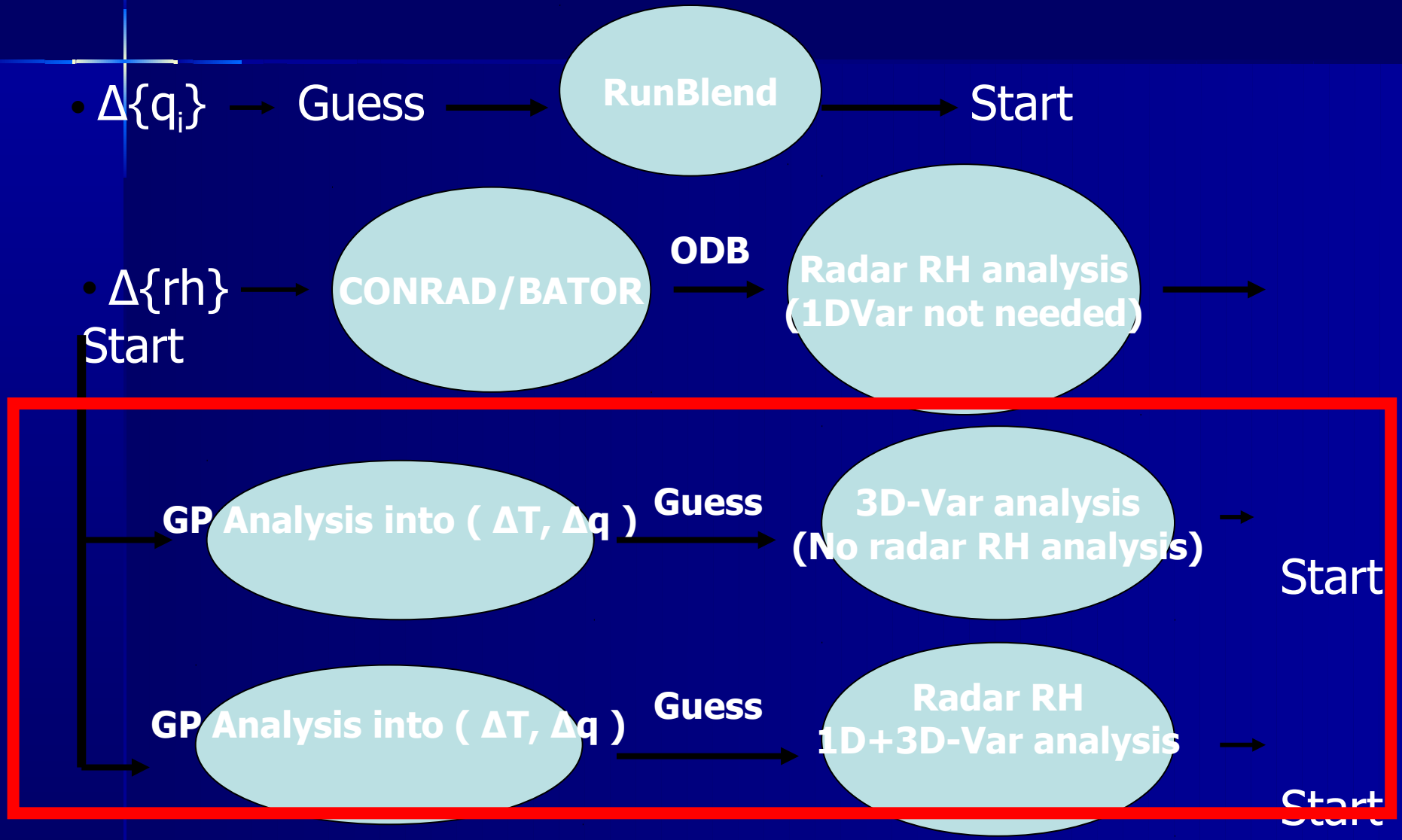


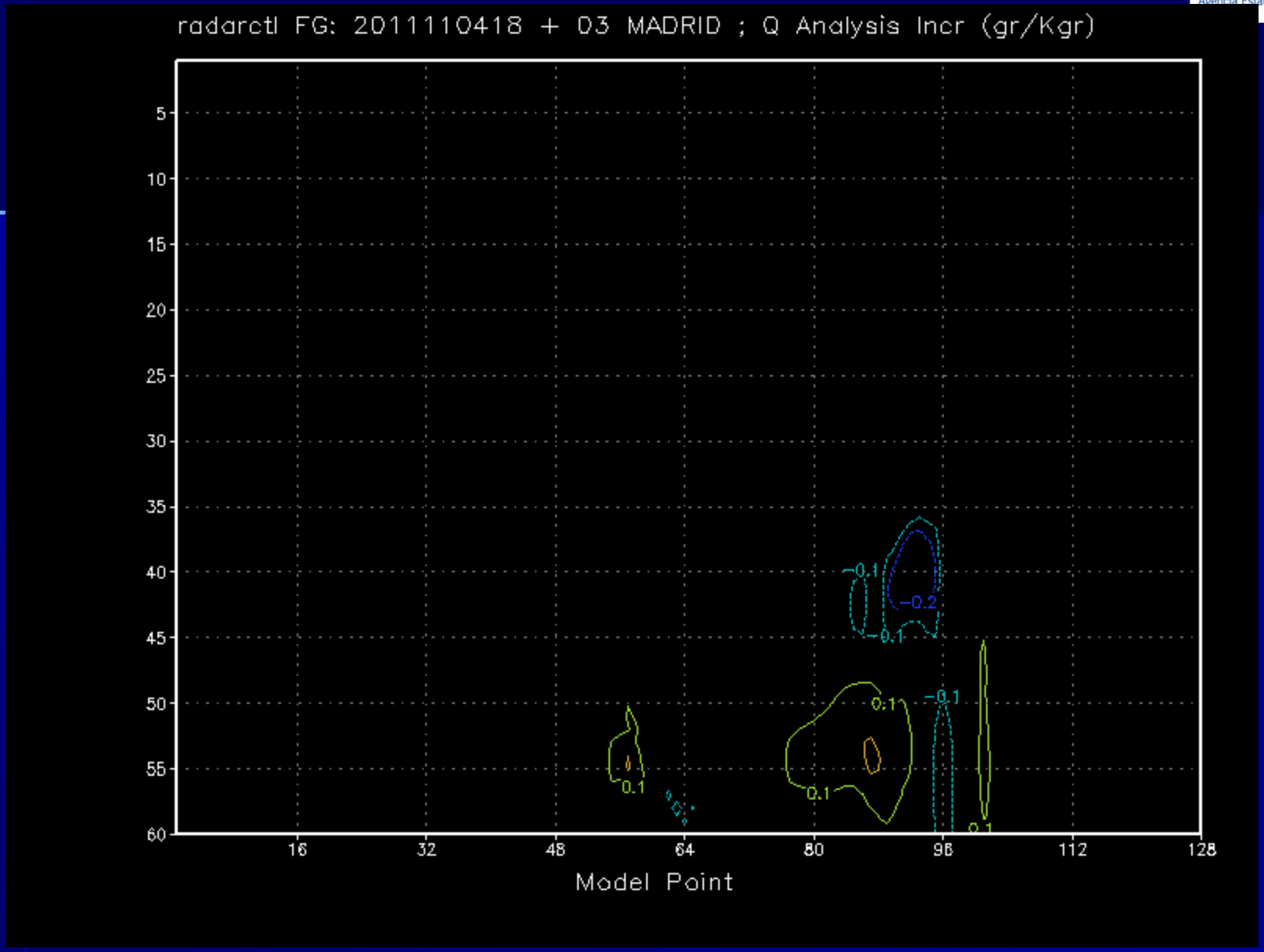



# Injection of the results into the Initial Conditions

We have several options (in all cases DOW analysis incl.):



# Analysis of the Increments



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# The Verification

- We focus on the location errors of precipitation structures. The SAL method gives only a general magnitude of this error, an improved method is required

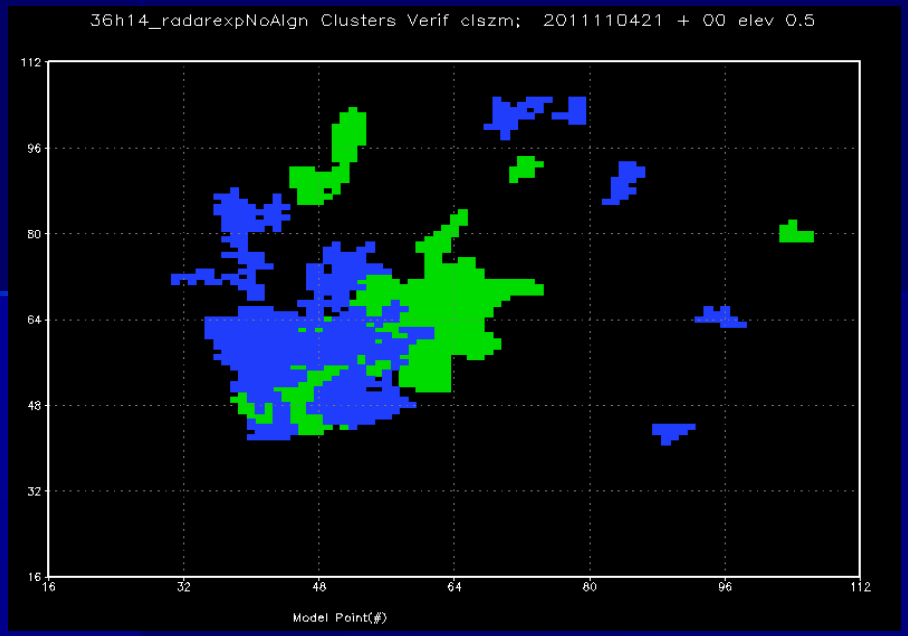
- As SAL, the method is based on clustering the reflectivity fields of radar images and model forecasts. A 4-connectivity algorithm is used

- We joint the centers of clusters from both sets in such a way that all are connected *and the total longitude is minimum.* This last requirement is important to get a meaningful measure and is achived by removing "redundant arrows", the longer ones first.

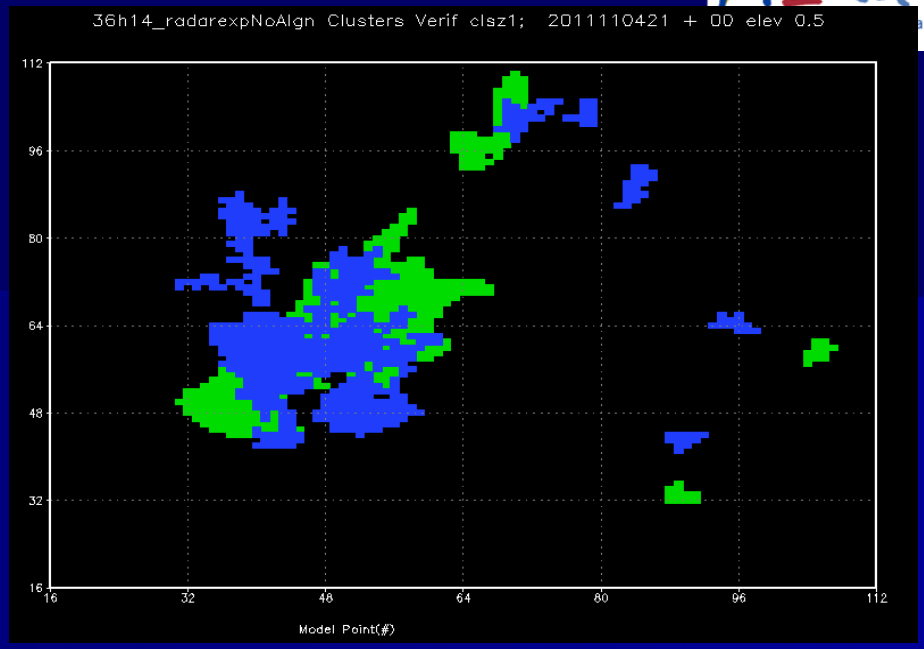
- In reality, to find this minimum is a complex problem that may need a lot of computations. However, a simple method has been implemented that allows to reach a good approximate solution quickly

- A further enhancement of this method is to apply it together with a "death leaves" technique. We generate by bootstrapping many cluster arrangements and see how likely is to achieve better results than the model

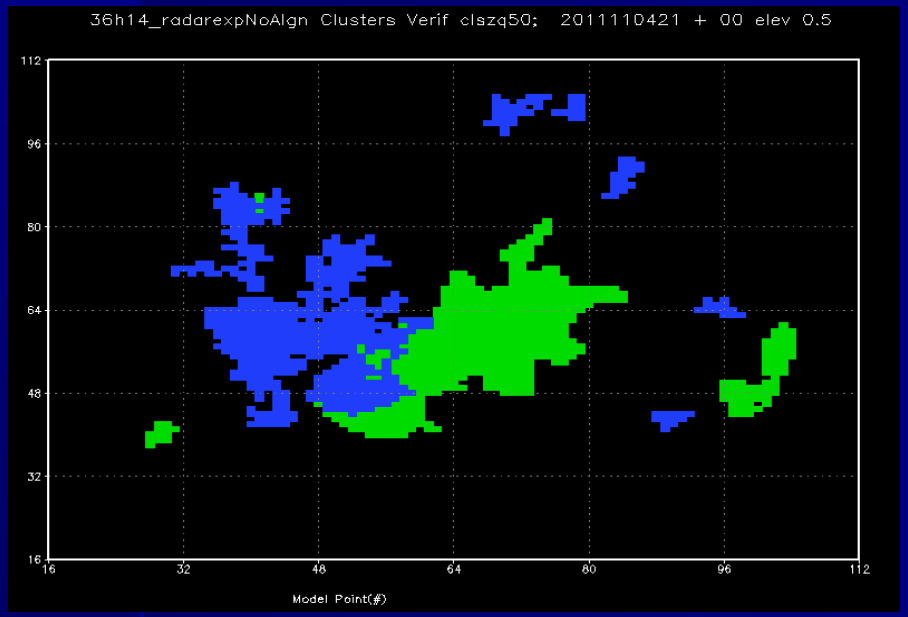
# The model D=240, Pvalue=12.4



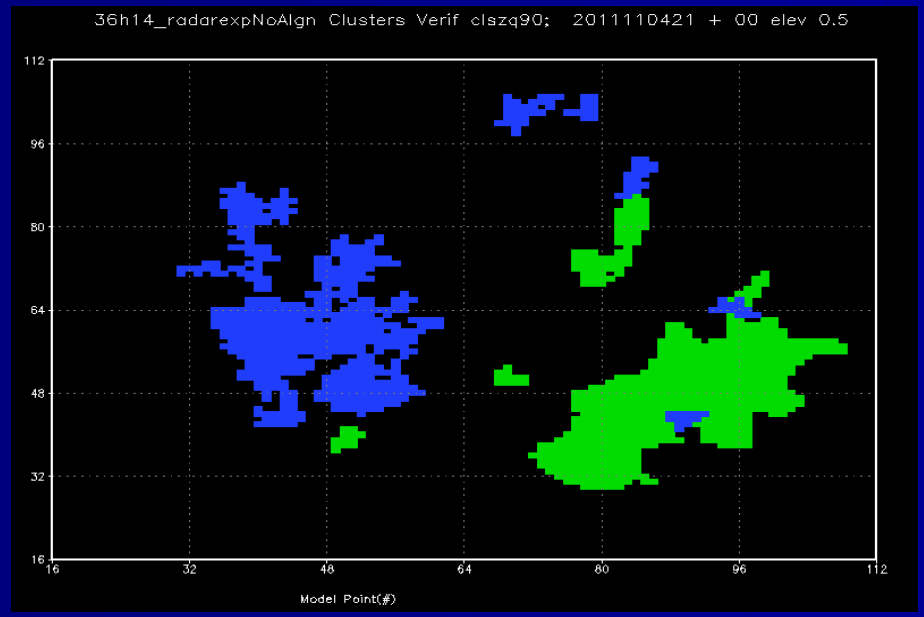

# The best D=166, Pvalue=0.1




# The median D=364, Pvalue=50.0




# One very bad case D=532, Pvalue=90

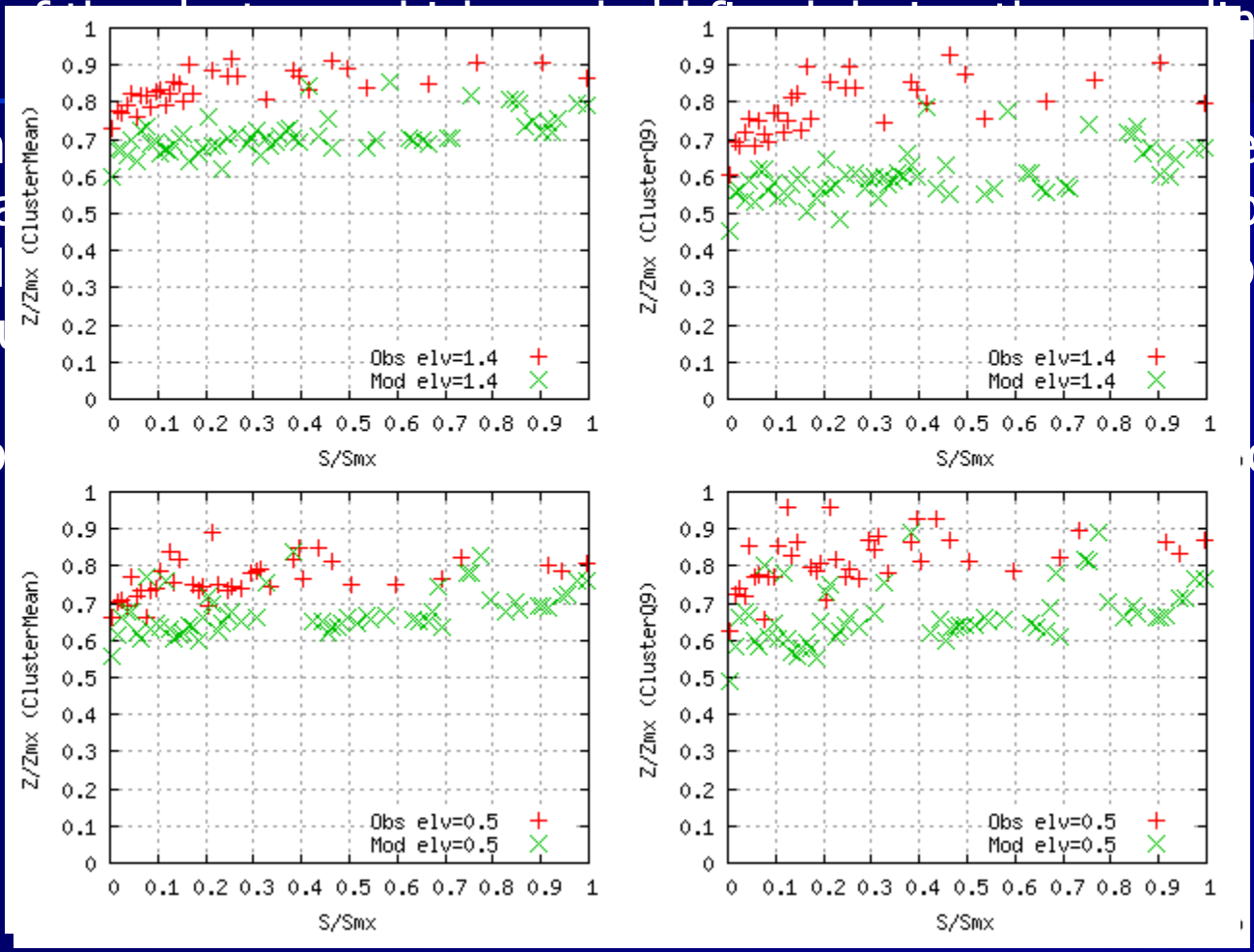


# The Verification

- To interpret correctly the results, it is important to bare in mind that the probability so obtained is a probability conditioned to the orientation, and shape [illegible] ag

- During th [illegible] ell when there was a [illegible] roblem can be handled [illegible] y considering different cl[illegible]

- As a by-p [illegible] oriented" statistics



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# Experiment & Results

- **Period of precipitation bands sweeping the area of Madrid beginning of November 2011 (11/04 09 UTC until 11/05 18 UTC)**
- **8 runs (3H interval) up to +18H with HARMONIE 36h1.4; 2.5Km; 60L**
- **Only Radar Data (DOW and Z) assimilated in this study**
- **The 2 last scans of each volume assimilated (elev 1.4 and 0.5). Short pulse. maximum range: 120 Km**
- **4 experiments:**

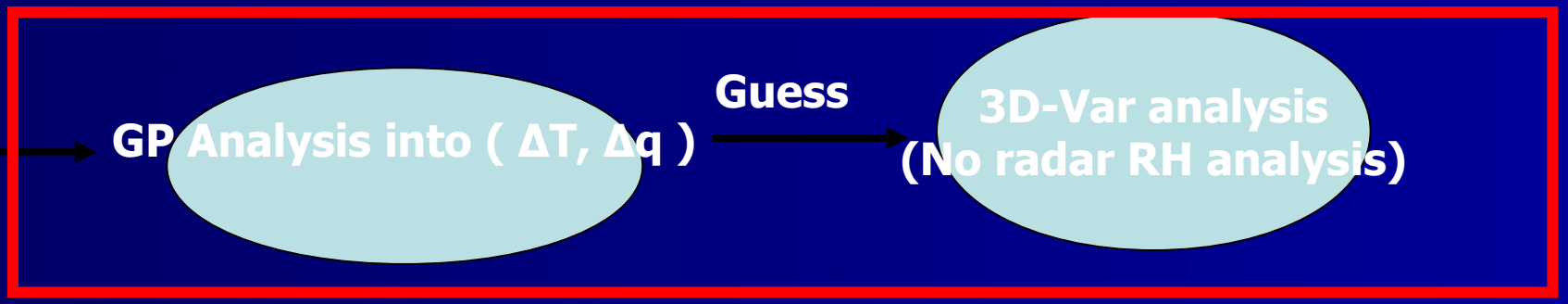
**a) Baseline: "blending mode"**

**b) Control: (1D-3DV) Radar Ass. with Guess from the baseline (+3H FCST)**

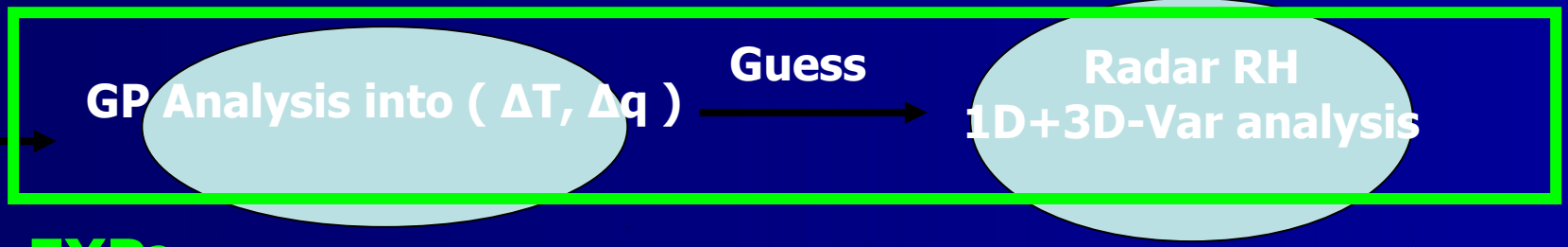
**c) Exp1: as control, RH assimilated by FA *only* (no 1D-3DV)**

**d) Exp2: as Exp1, RH assimilated by FA + (1D-3DV)**

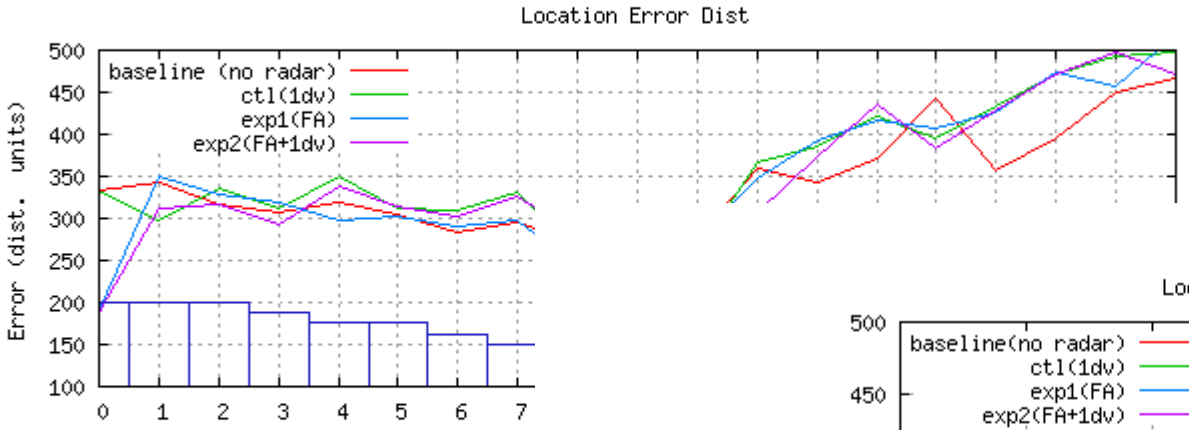

- Δ{rh} generated by FA

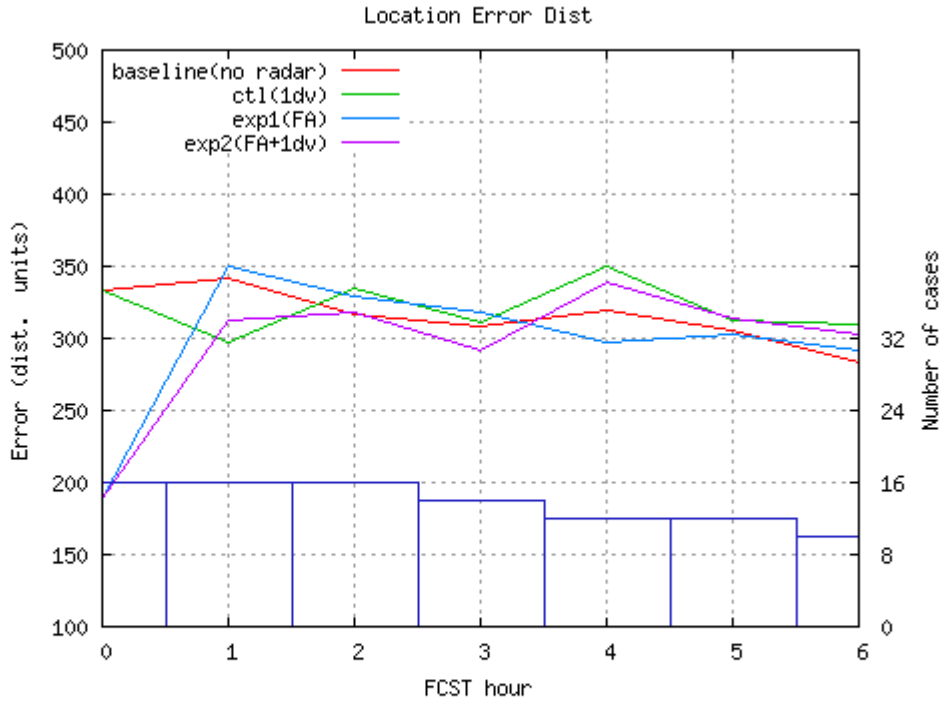


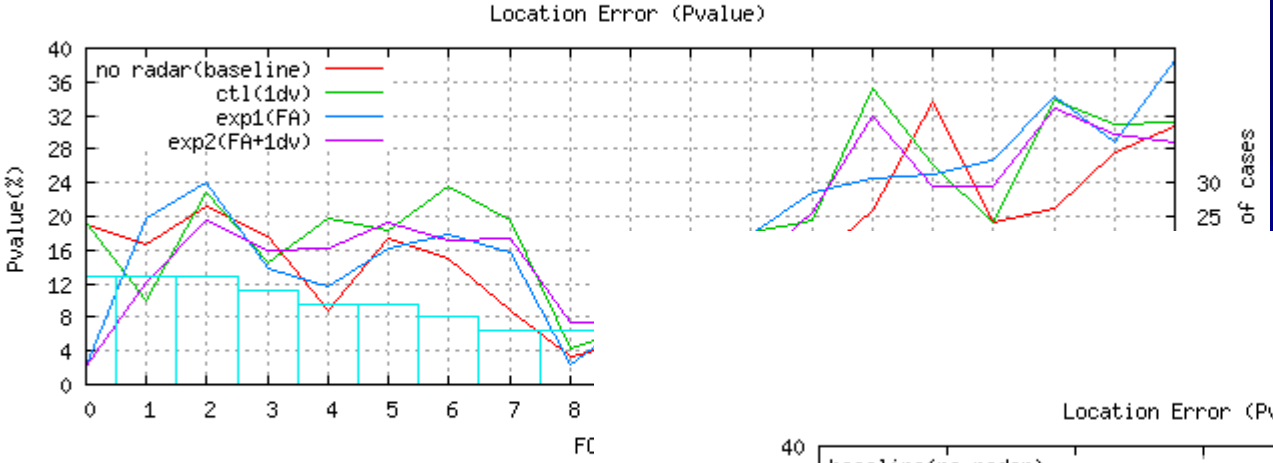

EXP1

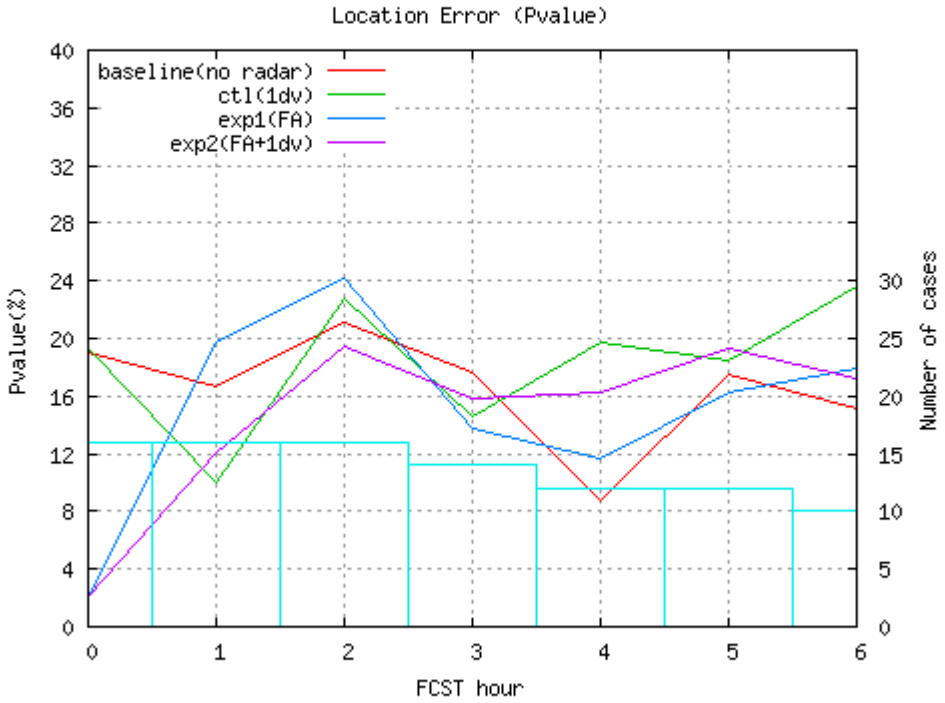


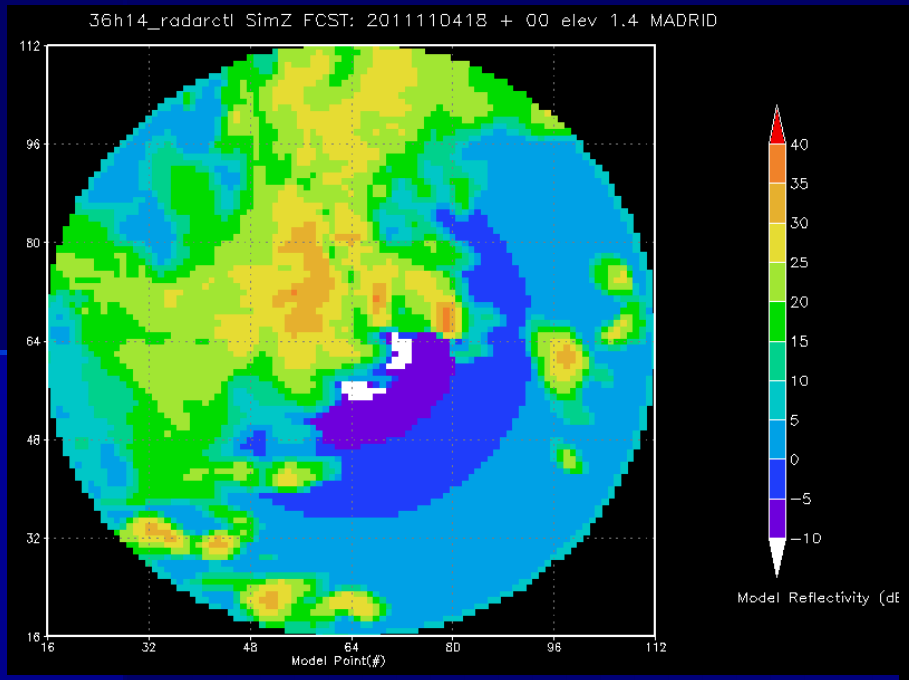

**EXP2**

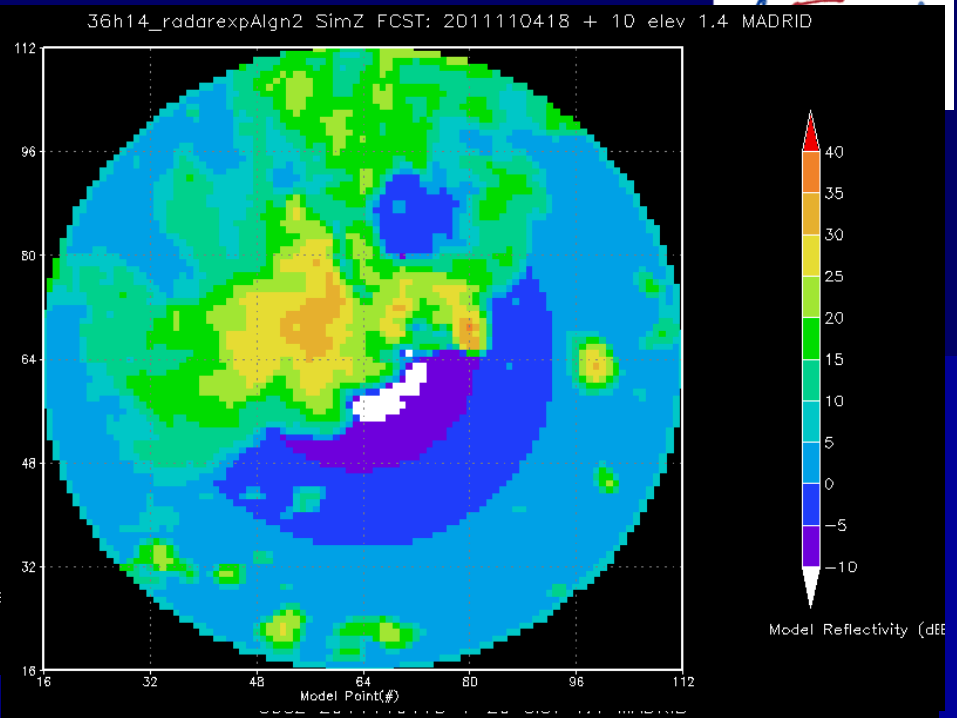

Location Error Dist
baseline (no radar)
ctl(1dv)
exp1(FA)
exp2(FA+1dv)
Error (dist. units)
cases

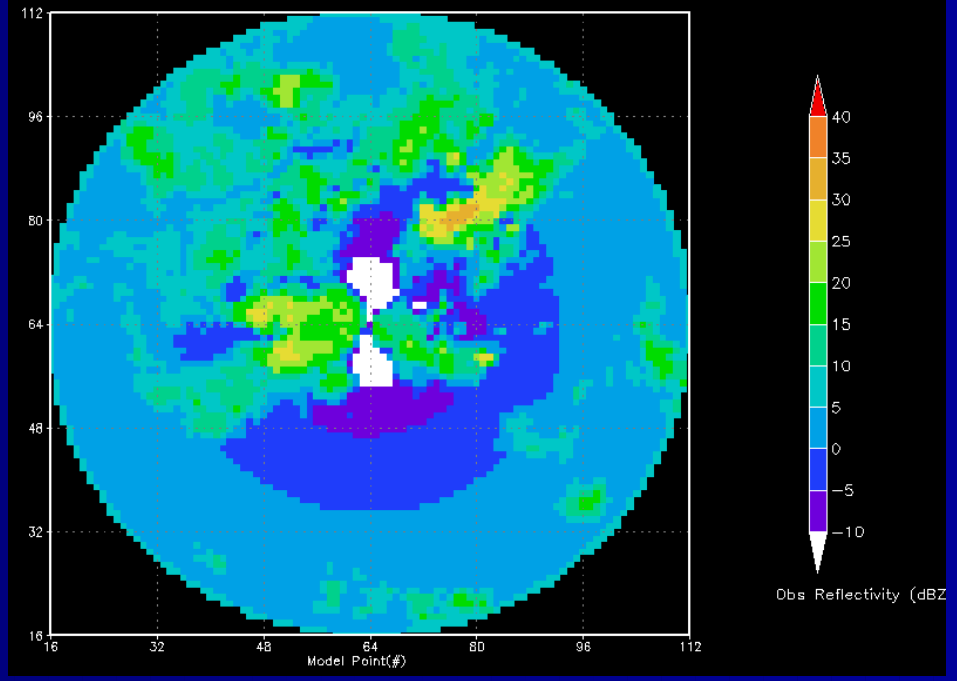

Location Error Dist
baseline(no radar)
ctl(1dv)
exp1(FA)
exp2(FA+1dv)
Error (dist. units)
Number of cases
FCST hour


Location Error (Pvalue)
no radar(baseline)
ctl(1dv)
exp1(FA)
exp2(FA+1dv)
Pvalue(%)
of cases
FC


Location Error (Pvalue)
baseline(no radar)
ctl(1dv)
exp1(FA)
exp2(FA+1dv)
Pvalue(%)
Number of cases
FCST hour


36h14_radarctl SimZ FCST: 2011110418 + 00 elev 1.4 MADRID
112
96
80
64
48
32
16
16
32
48
64
80
96
112
Model Point(#)
40
35
30
25
20
15
10
5
0
−5
−10
Model Reflectivity (dE


36h14_radarexpAlgn2 SimZ FCST: 2011110418 + 10 elev 1.4 MADRID
112
96
80
64
48
32
16
16
32
48
64
80
96
112
Model Point(#)
40
35
30
25
20
15
10
5
0
−5
−10
Model Reflectivity (dE


112
96
80
64
48
32
16
16
32
48
64
80
96
112
Model Point(#)
40
35
30
25
20
15
10
5
0
−5
−10
Obs Reflectivity (dBZ

# Evaluation of the Results

- The FA technique works satisfactorily with radar reflectivity images

- In the experiments carried out in this study, the FA method does not improve the RH analysis with respect to the 1D+3D technique, in terms of forecast rain location

- The correction of the error location of the precipitation structures does not feedback into the convention dynamics of the HARMONIE model, and therefore its impact is null

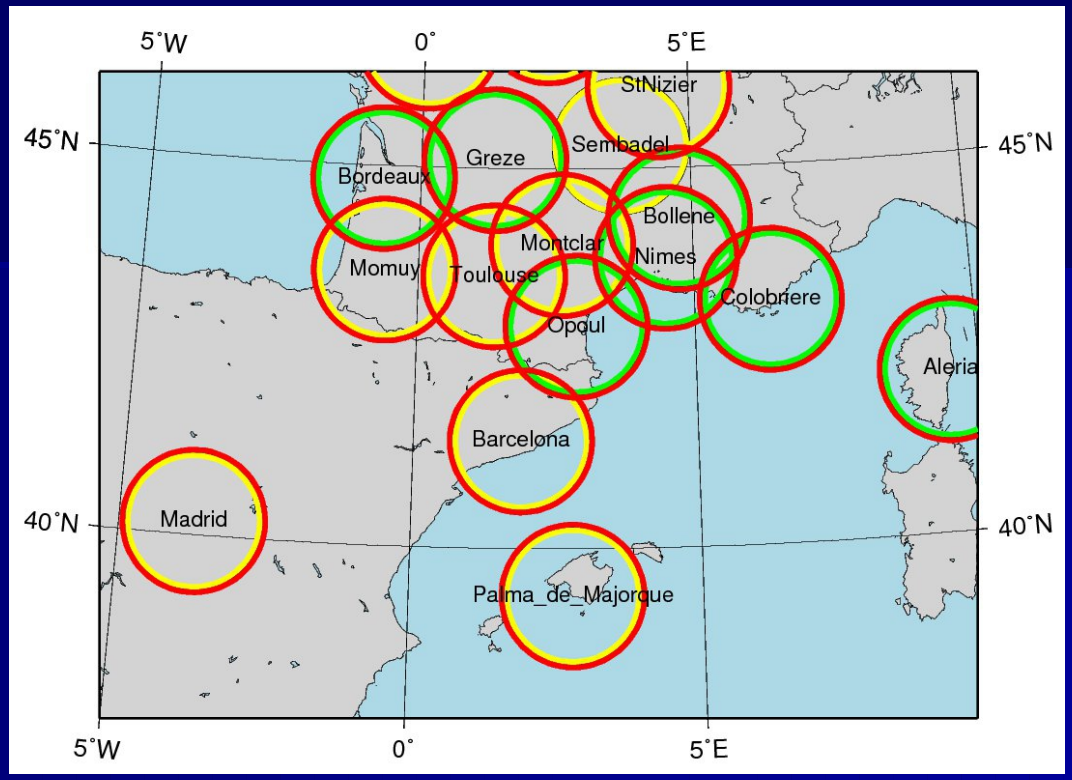
- It remains to be studied the impact using other parameters that are more important in driving the dynamics of the HARMONIE model (e.g. DOW)

- A new cluster-based method for the verification of location errors has been introduced and tested with success

# Prise en compte des radars AEMET dans AROME

Thibaut Montmerle, Carlos Geijo (AEMET)

**Radars de Palma de Majorque, Madrid et Barcelone:**



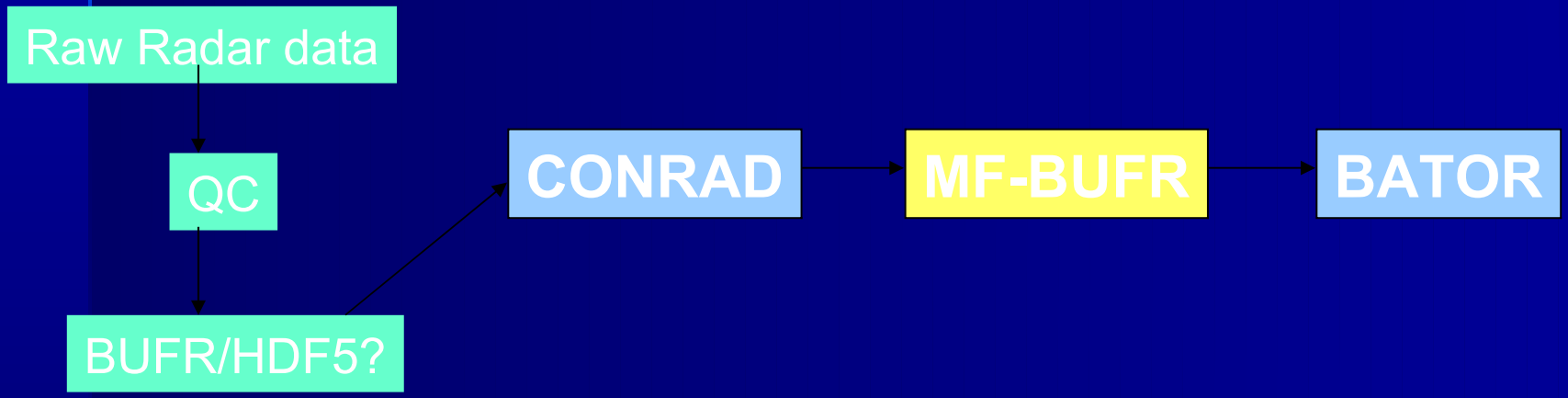

- 3 élévations 0.5°, 1.4° et 2.3°, PRF=250 Hz, portée 240 km: Z seulement
- **2 élévations 0,5° et 1,4°**, PRF=1200Hz/900Hz, portée de 120km : Z, DOW, QF

- données en coordonnées polaires: $\delta r$ = 500m, $\delta az$ = 0.8°
- échos de sol supprimés via l'analyse du spectre Doppler
- si Z=0: pixels valides non pluvieux

# 1ere étape: conversion de format: CONRAD

(M. Groensleth, Met No)

CONversion de données RADar au format MF-BUFR (C. Geijo)




⇒ Création de fichiers MF-BUFR **en polaire**

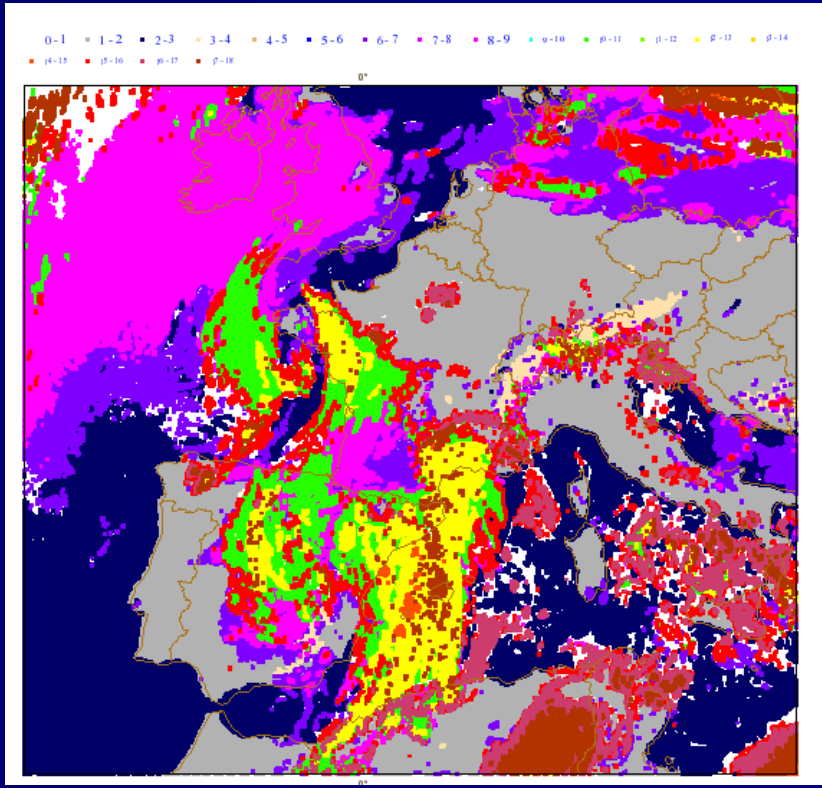
⇒ **écriture d'une version bator polaire/cartésien** en cy36t1 et cy38t1 (avec filtrage médian et sous-échantillonnage des données sur une maille régulière)

**Expériences de test en cy36t1:**

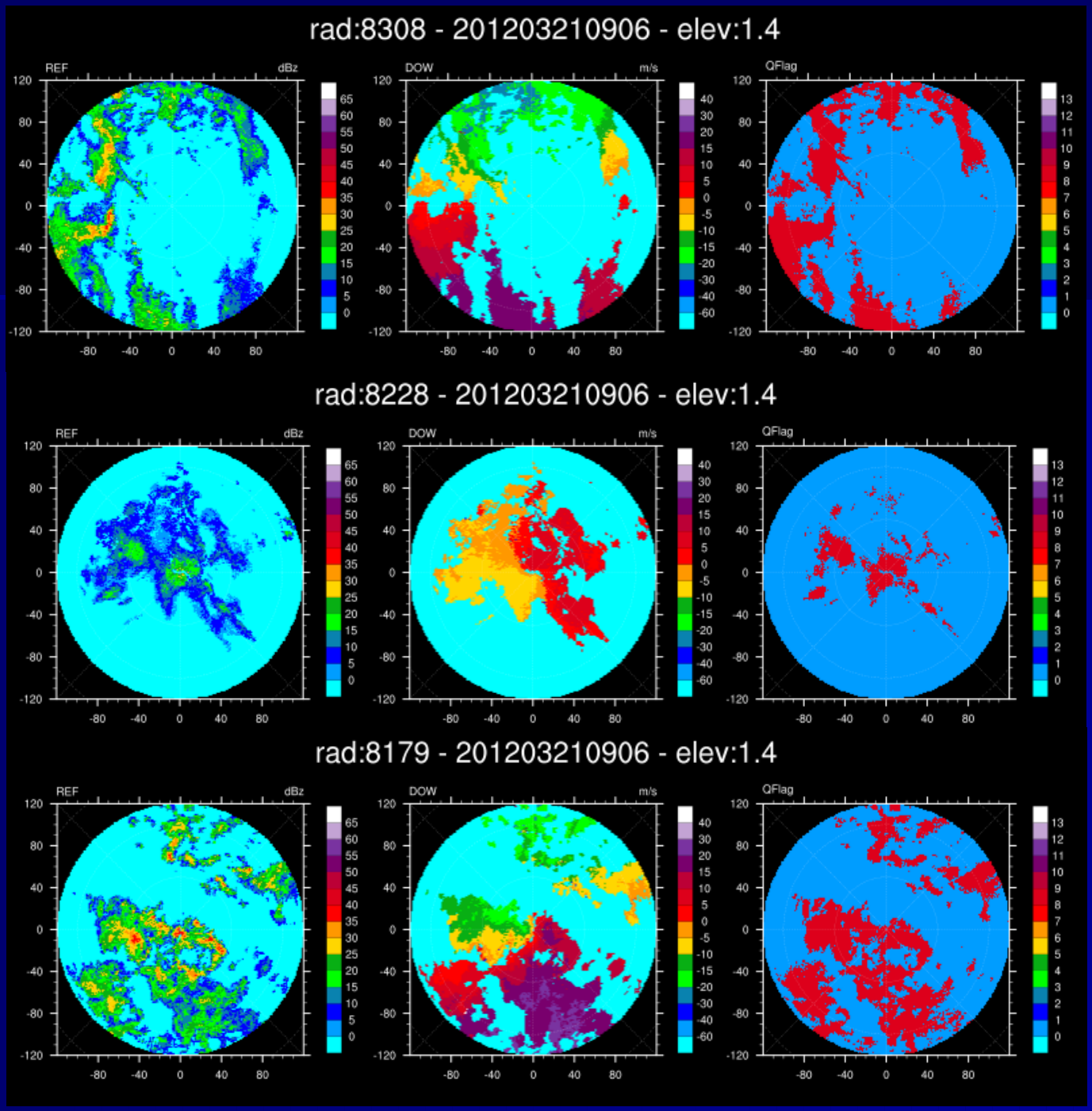
**79J0** : CNTRL: Arome oper

**79J1** : 79J0 avec PMA, MAD et BAR en plus

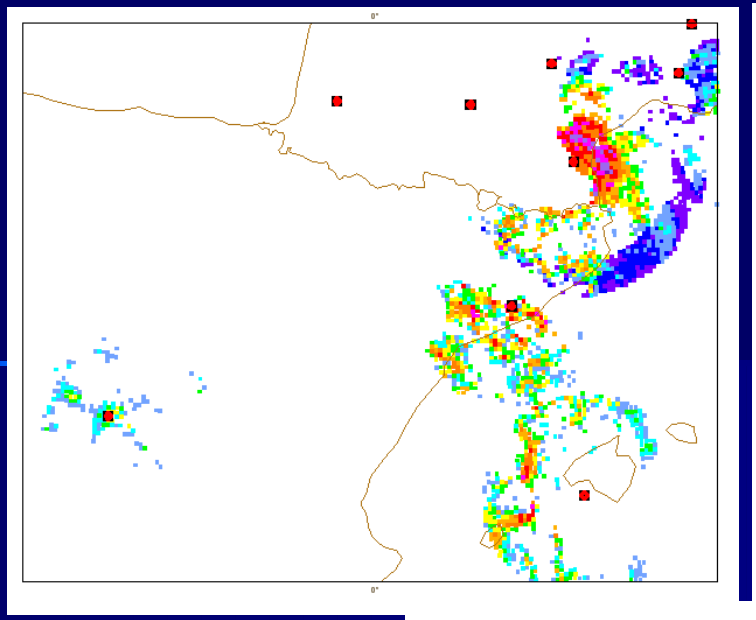
Cas du 21 mars 2012, 6 réseaux successifs, 1er réseau à 9h

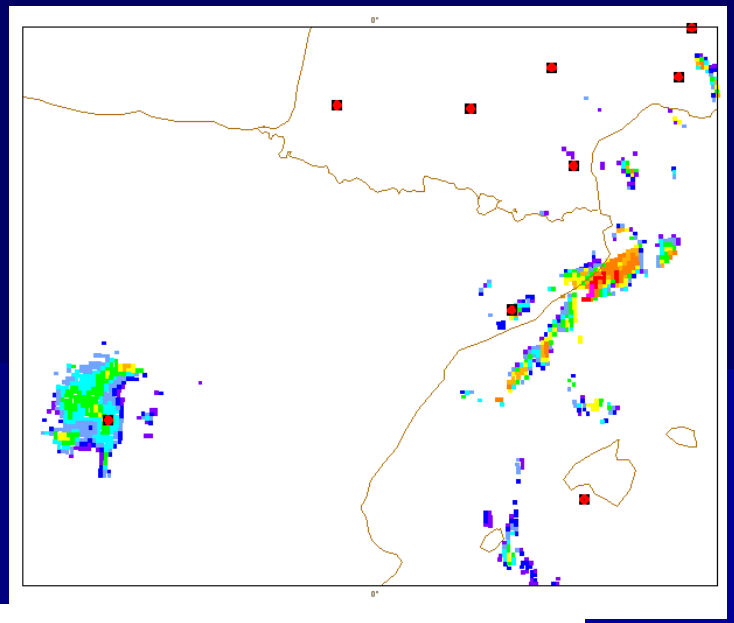


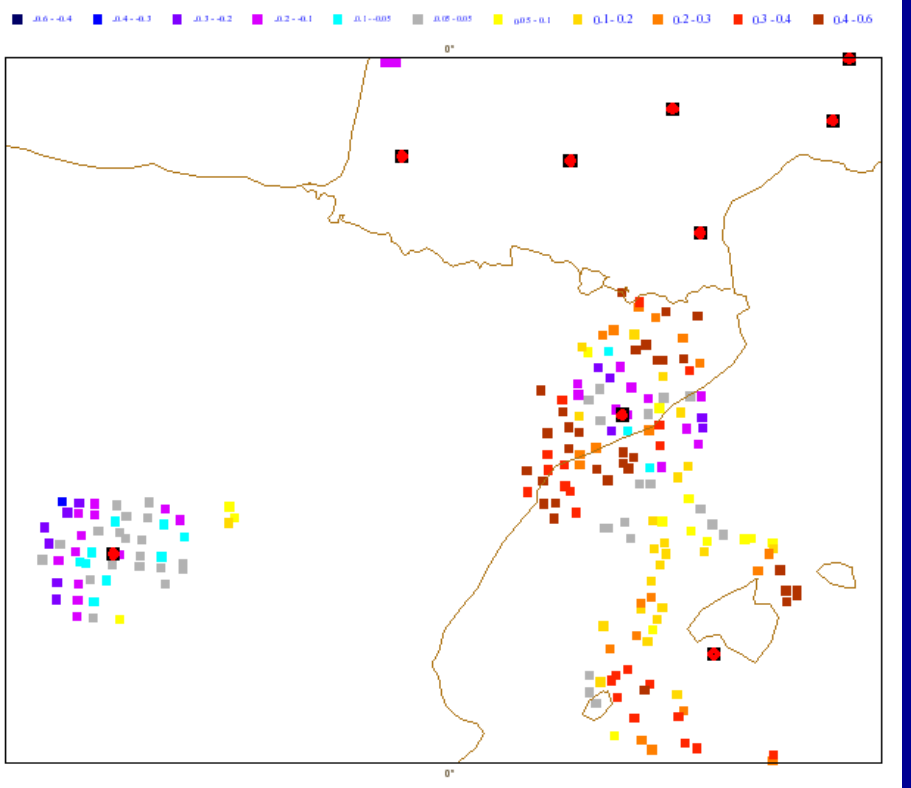
# MF-BUFR
# Elevation 1,4°



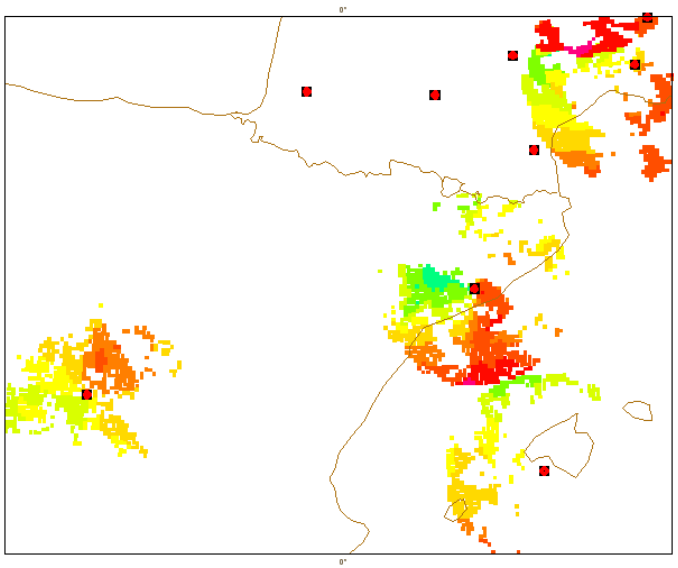
1.4° elev

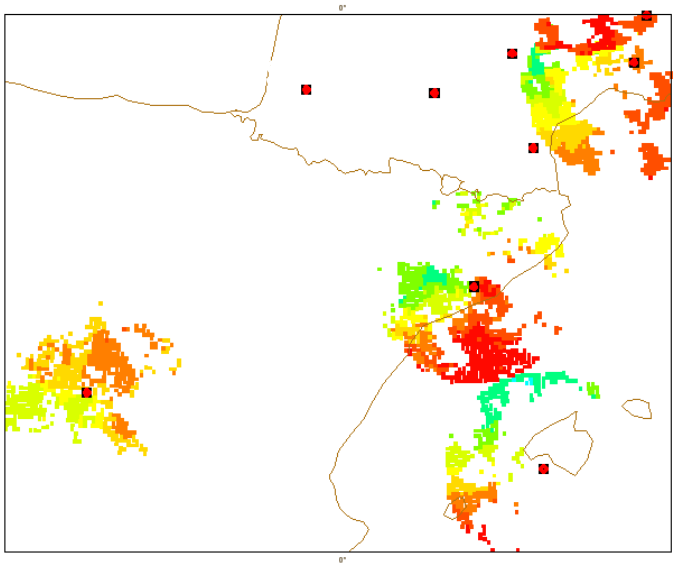




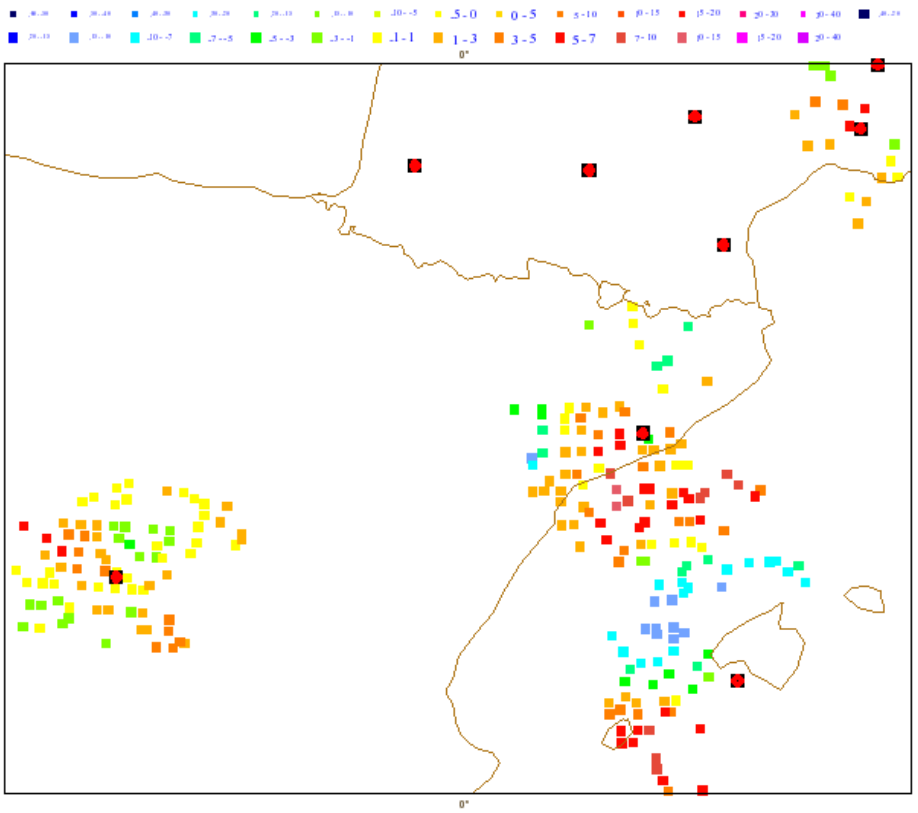


0.5° elev

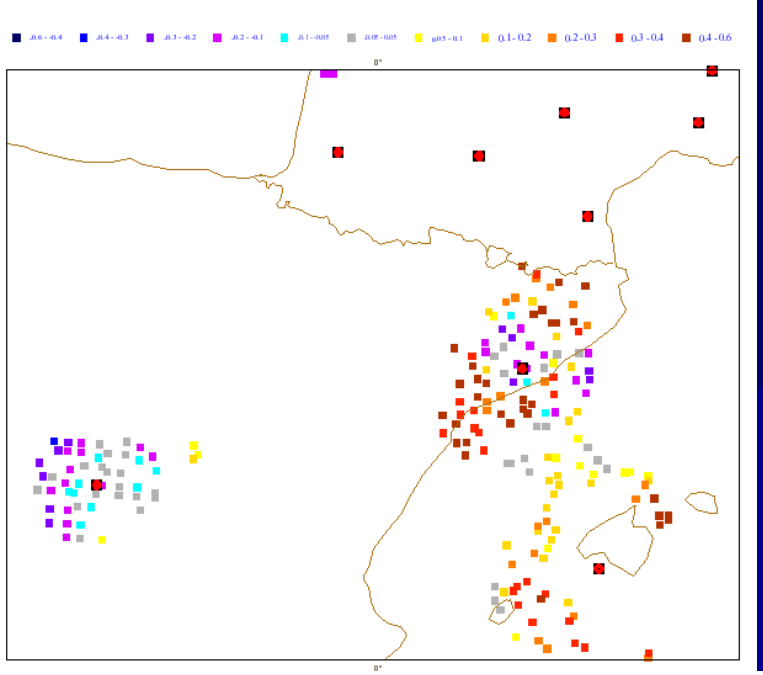


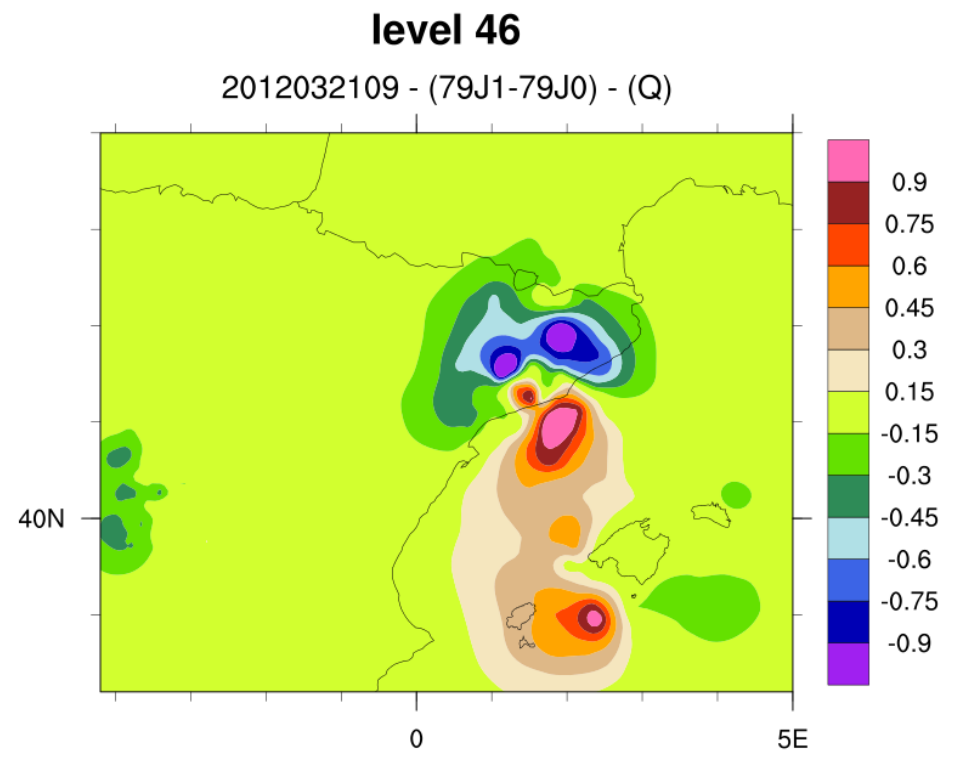


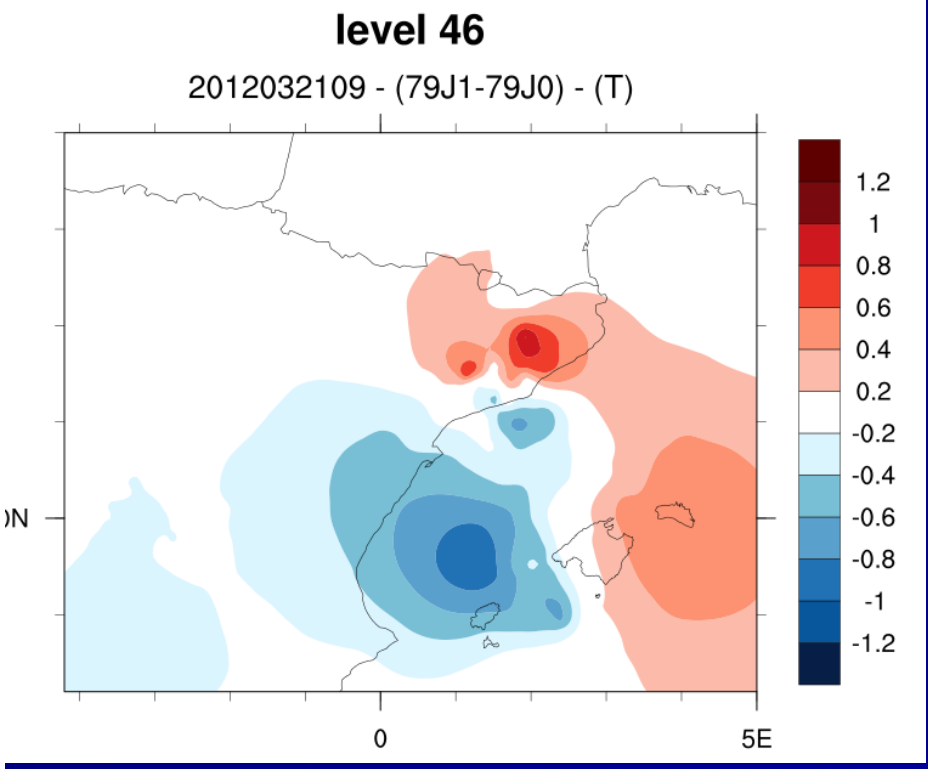
Inc DOW



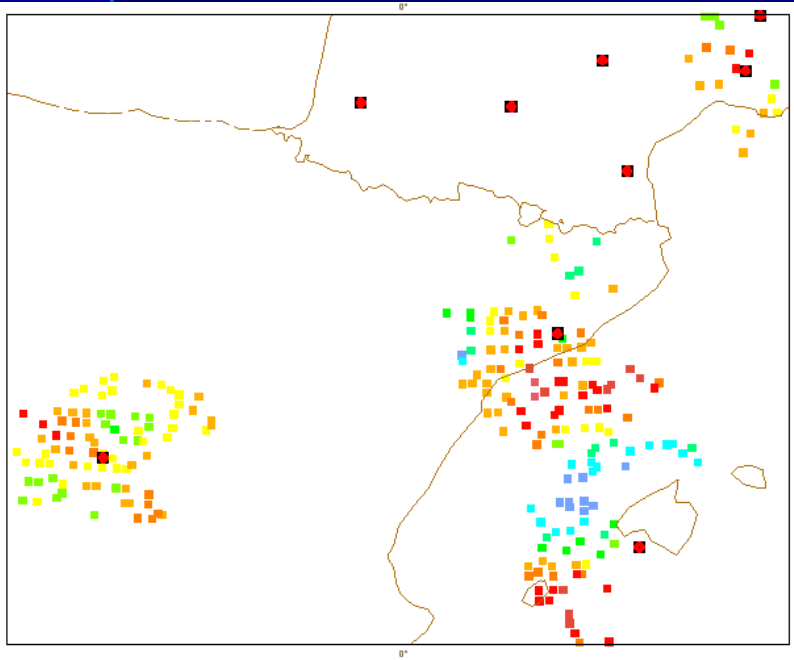
Différences des analyses, r9:

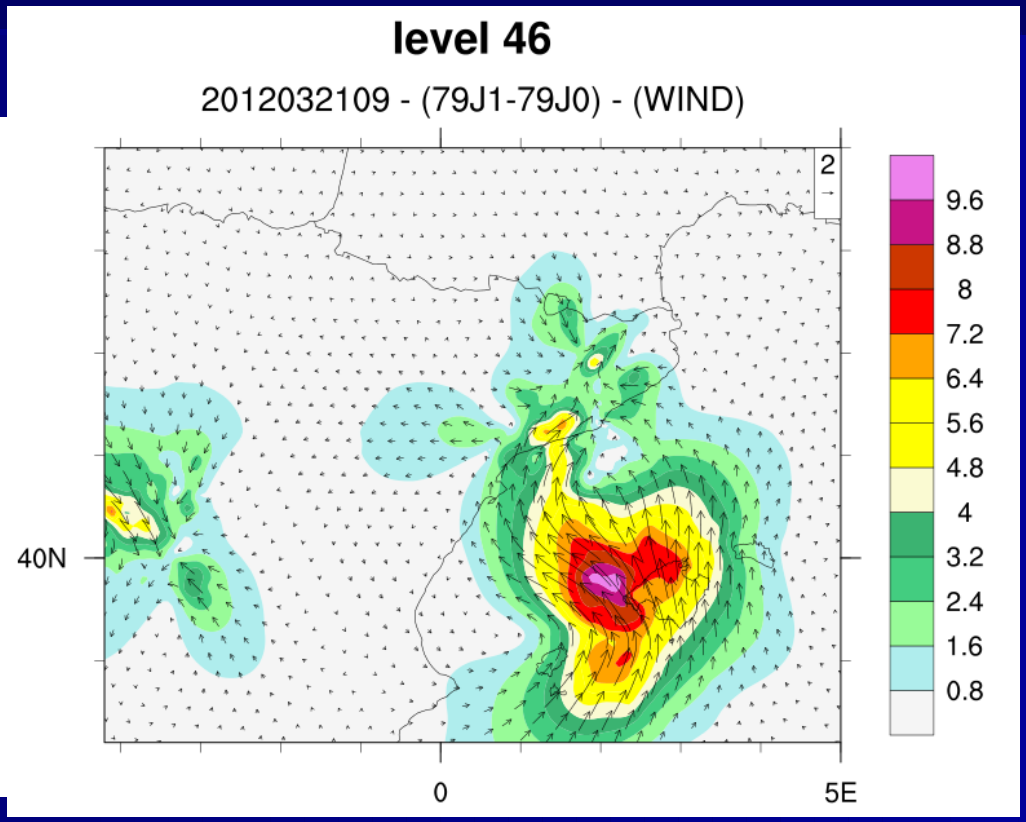




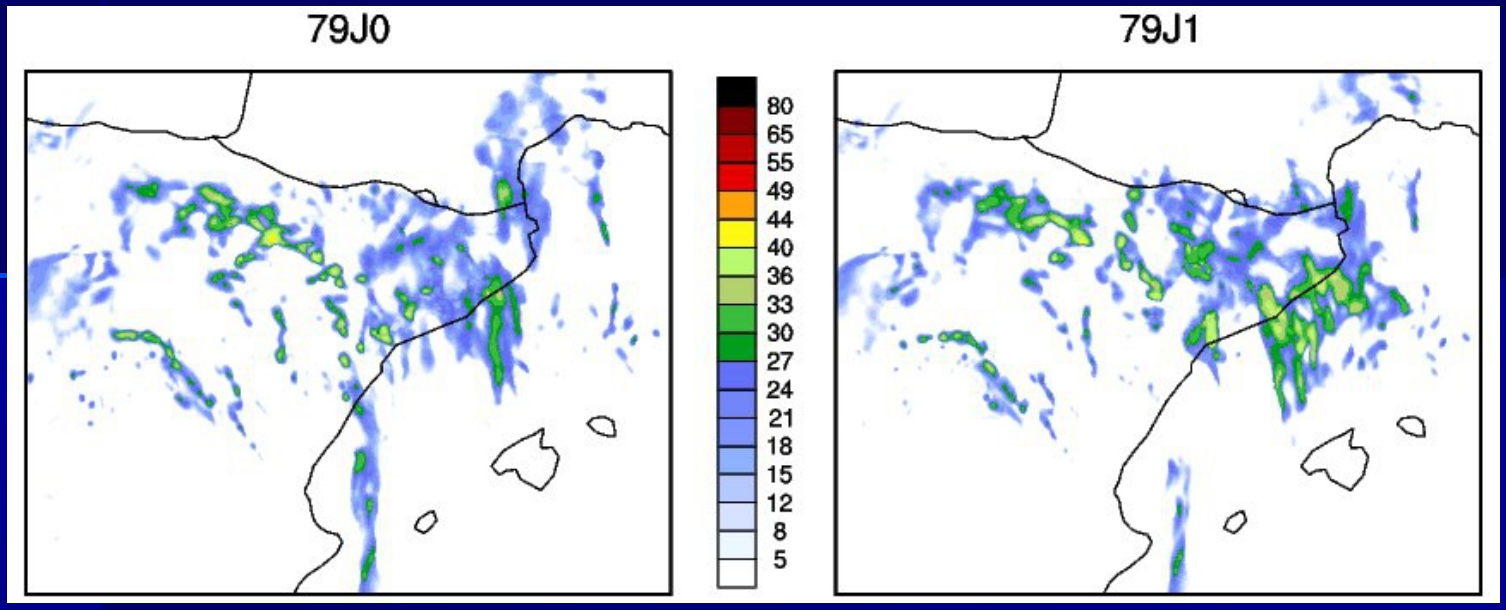



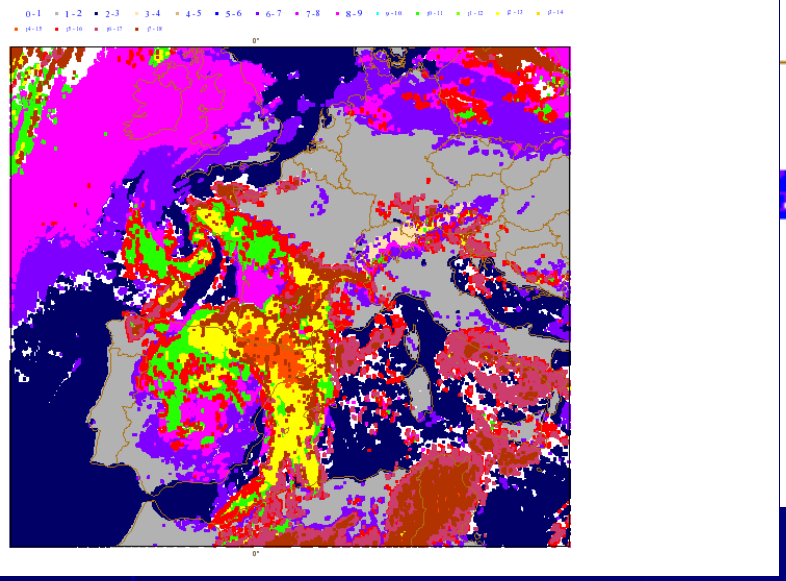
# Différences des analyses, r9

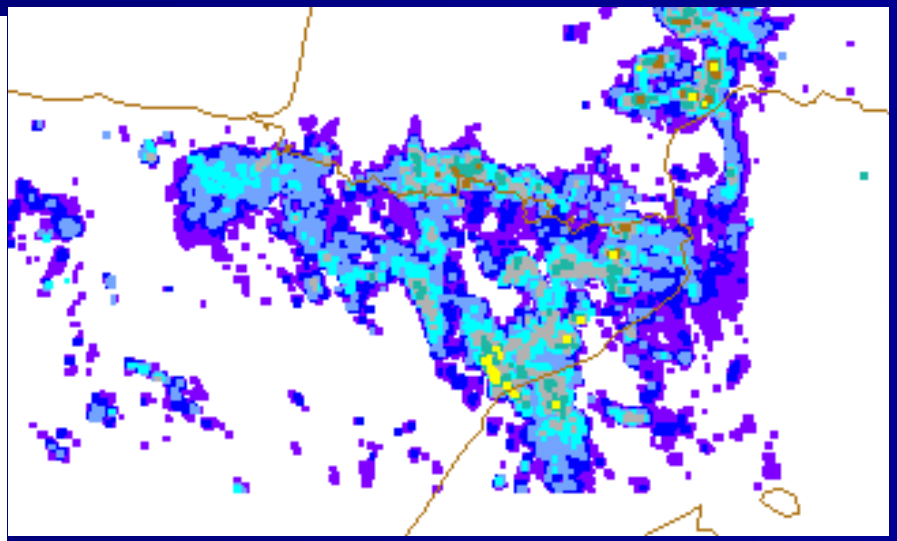




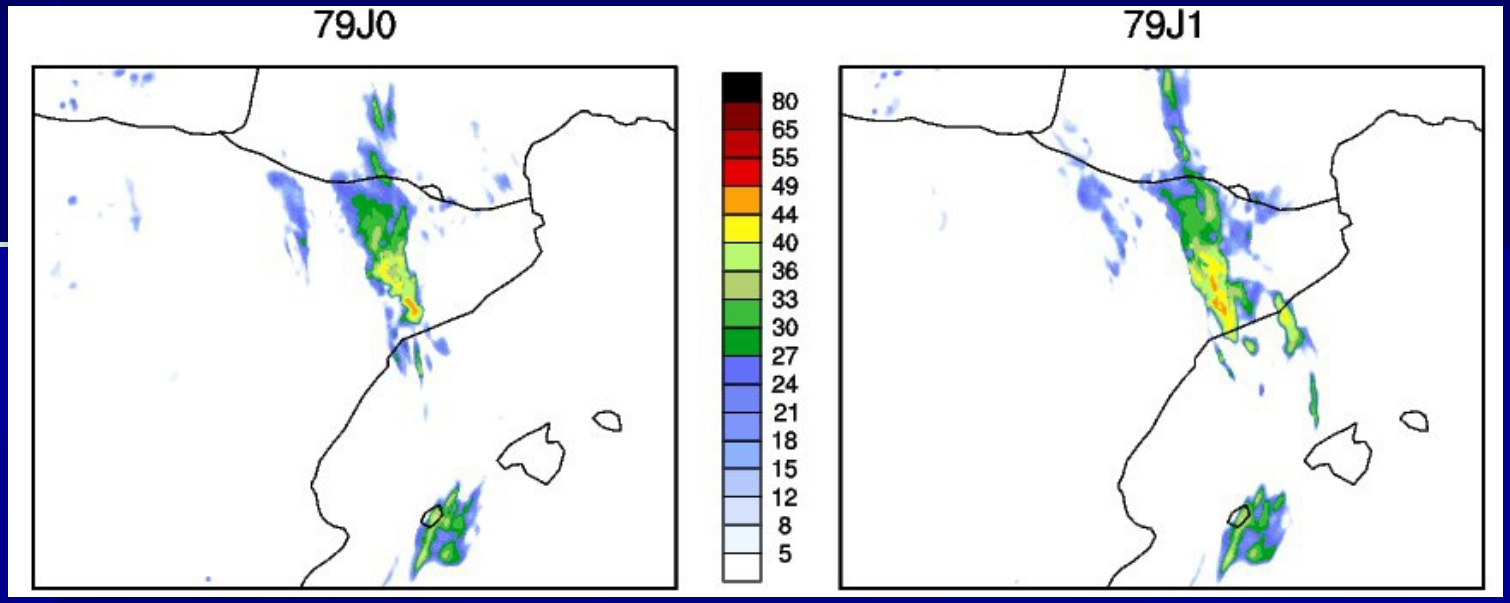

# Pluies cumulées sur 3h, 21 mars 2012 12h

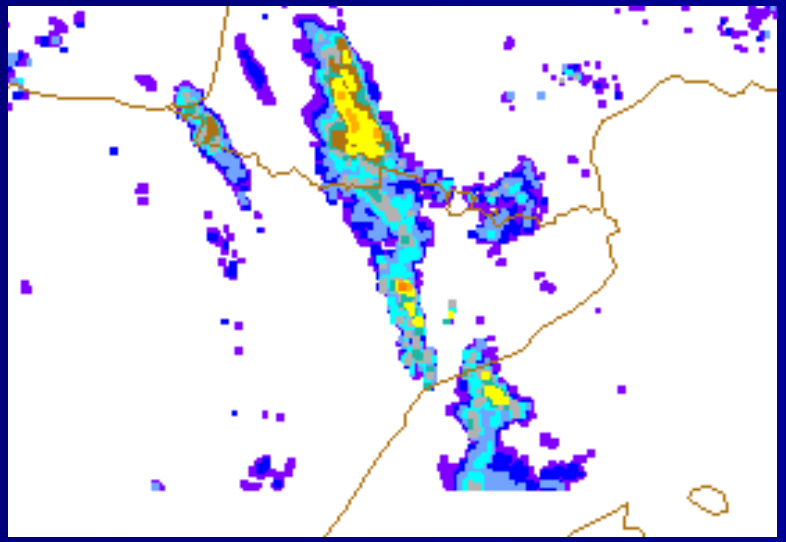


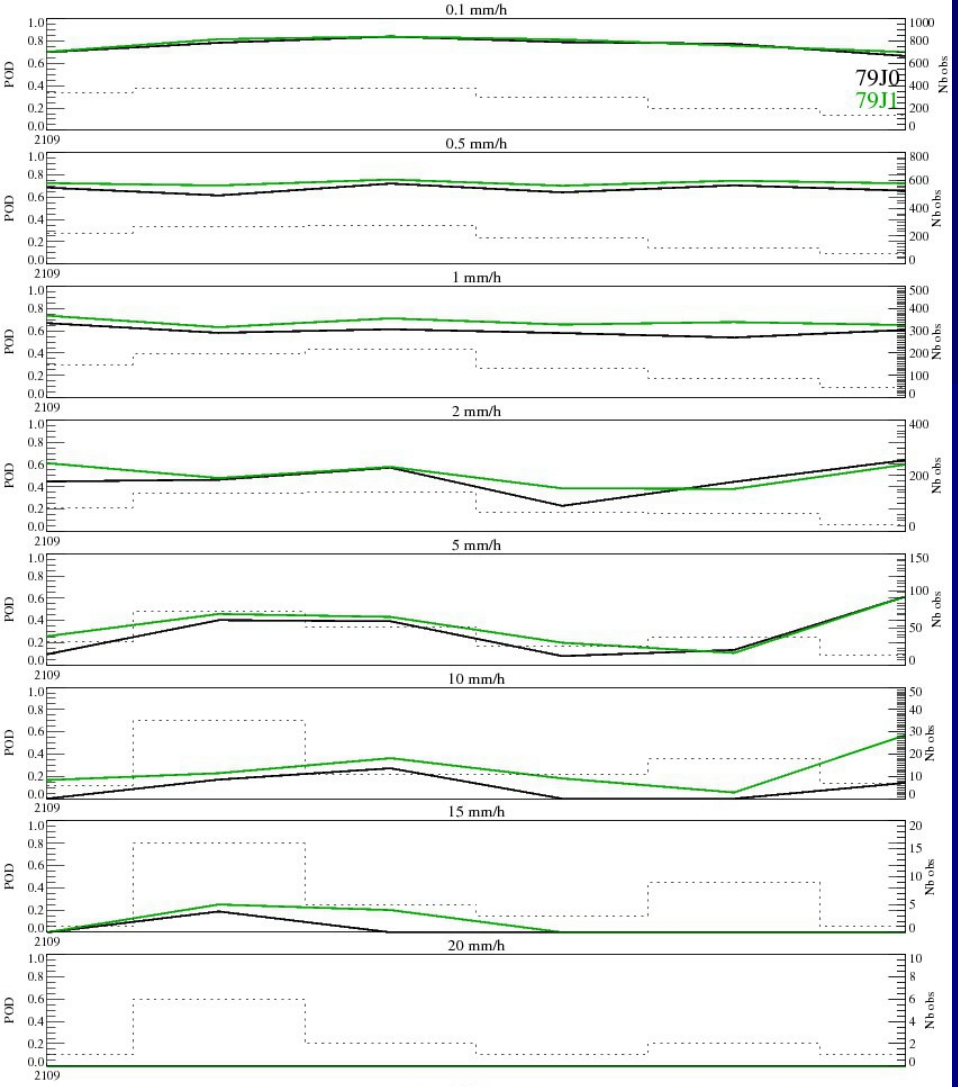



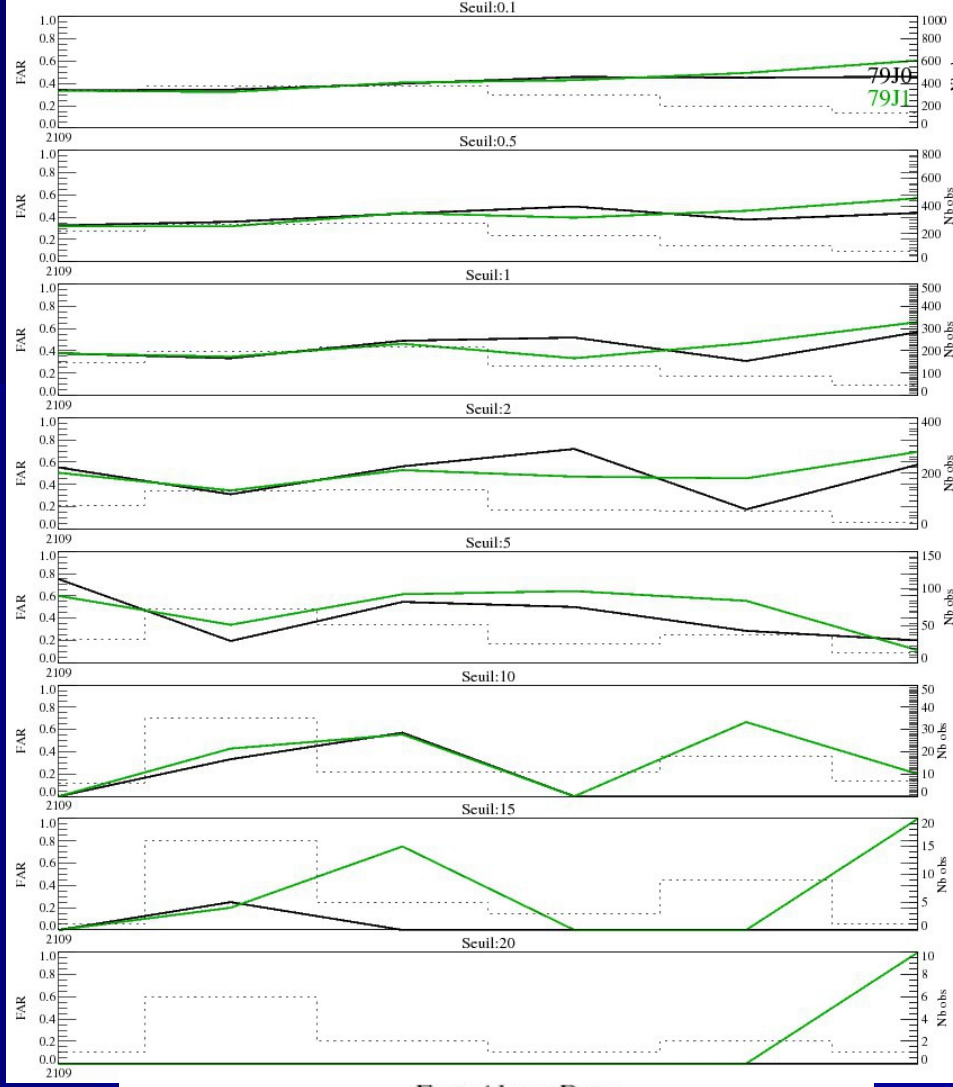


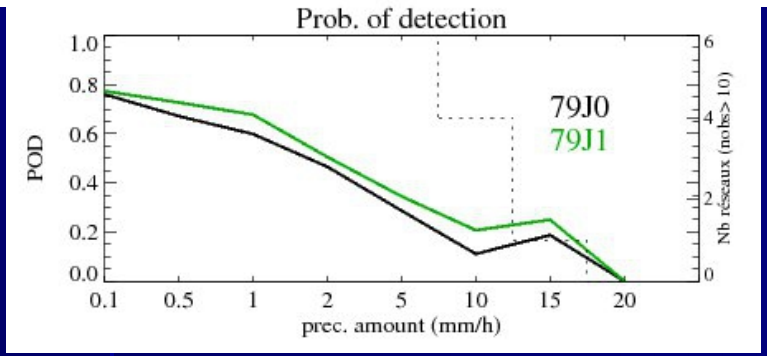
# Pluies cumulées sur 3h, prévi r18, 21 mars 2012 21h

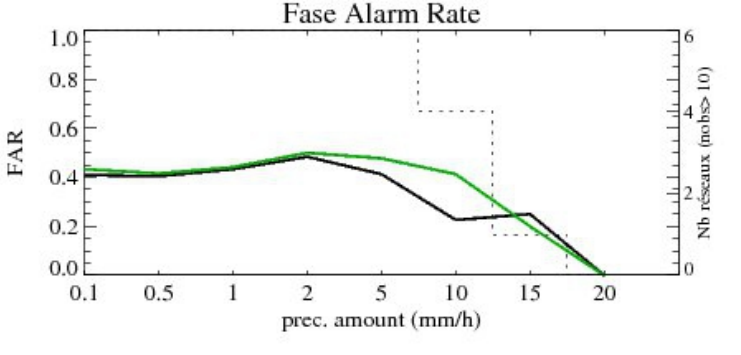



0.1 mm/h
0.5 mm/h
1 mm/h
2 mm/h
5 mm/h
10 mm/h
15 mm/h
20 mm/h
POD
Nb obs
79J0
79J1
2109

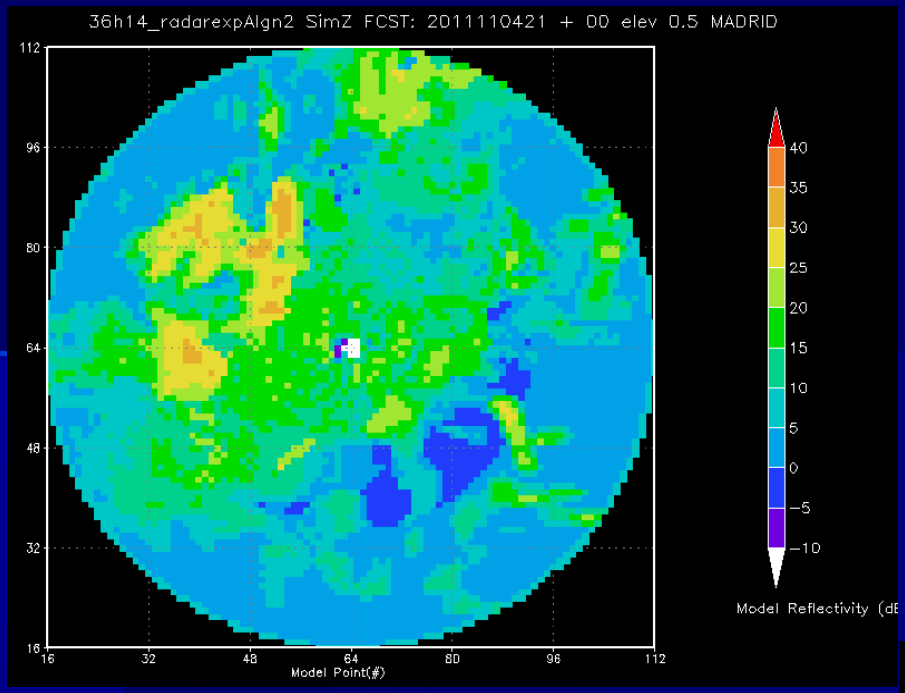

Seuil:0.1
Seuil:0.5
Seuil:1
Seuil:2
Seuil:5
Seuil:10
Seuil:15
Seuil:20
FAR
Nb obs
79J0
79J1
2109

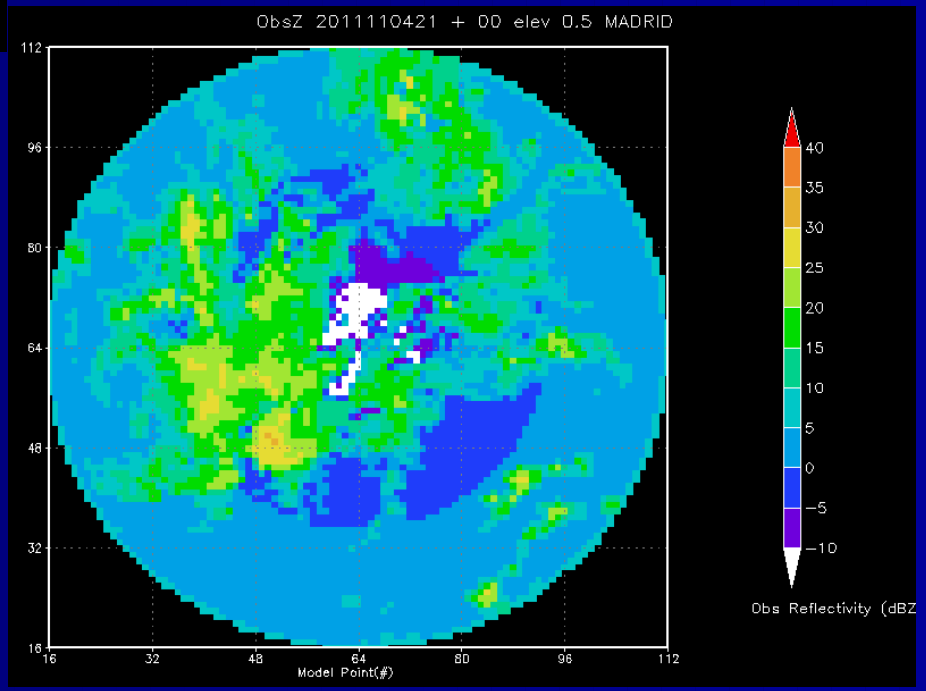

Prob. of detection
POD
Nb réseaux (nobs> 10)
prec. amount (mm/h)
79J0
79J1


Fase Alarm Rate
FAR
Nb réseaux (nobs> 10)
prec. amount (mm/h)

**Perspectives:**

- Très peu de mesures sols sur l'Espagne: Scores difficiles à valider. Merci Matthieu pour tes SYNOP?
- Décodage mosaïque Opera européenne en cours pour valider les structures précipitantes
- quid des 3 élévations supplémentaires pour Z?
- bator modifié en cours de phasage en cy38t1. Quel cycle pour Hymex? Pas de pb particulier pour un phasage en cy37
- Besoin de mettre en place une procédure plus officielle de fourniture des données avec AEMET, au moins pendant la période test et les SOPs


36h14_radarexpAlgn2 SimZ FCST: 2011110421 + 00 elev 0.5 MADRID
112
96
80
64
48
32
16
16
32
48
64
80
96
112
Model Point(#)
40
35
30
25
20
15
10
5
0
−5
−10
Model Reflectivity (dB


ObsZ 2011110421 + 00 elev 0.5 MADRID
112
96
80
64
48
32
16
16
32
48
64
80
96
112
Model Point(#)
40
35
30
25
20
15
10
5
0
−5
−10
Obs Reflectivity (dBZ