Assimilation of DOW radar data using the FA method

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The objectives of this work are:

- Implement a prototype for the application of the FA method to radar DOW data.

Precedents: The application to reflectivity data was inconclusive and complicated by the fact that the assimilation of reflectivities bears only an indirect relation to HARMONIE analysis variables.

- Determine its impact on the quality of HARMONIE / AROME short range forecasts.

Questions: is it detrimental to the first hours of the forecasts?, how long does the impact last? Is it possibly useful in an operational environment?

- Extract conclusions that can be useful for future work in this direction

The **alignment** has been done **on model levels**, instead of on PPIs.

Careful determination of the **observation operator (smoothness, normalization) !**

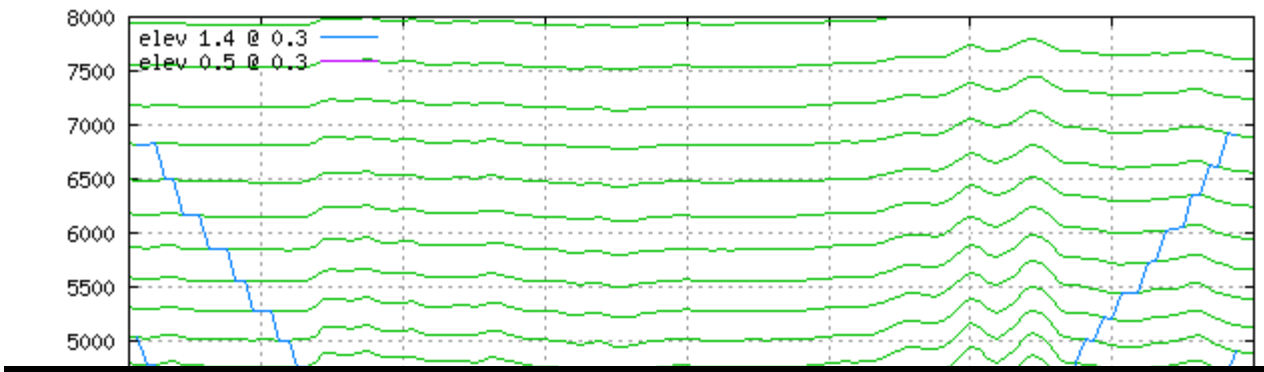
$$w_1 \Delta \vec{q} + w_2 \nabla\left(\nabla \times \vec{q}\right) + (\nabla X^f)^T H^T R^{-1}\left(H X^f - Y\right) = 0$$

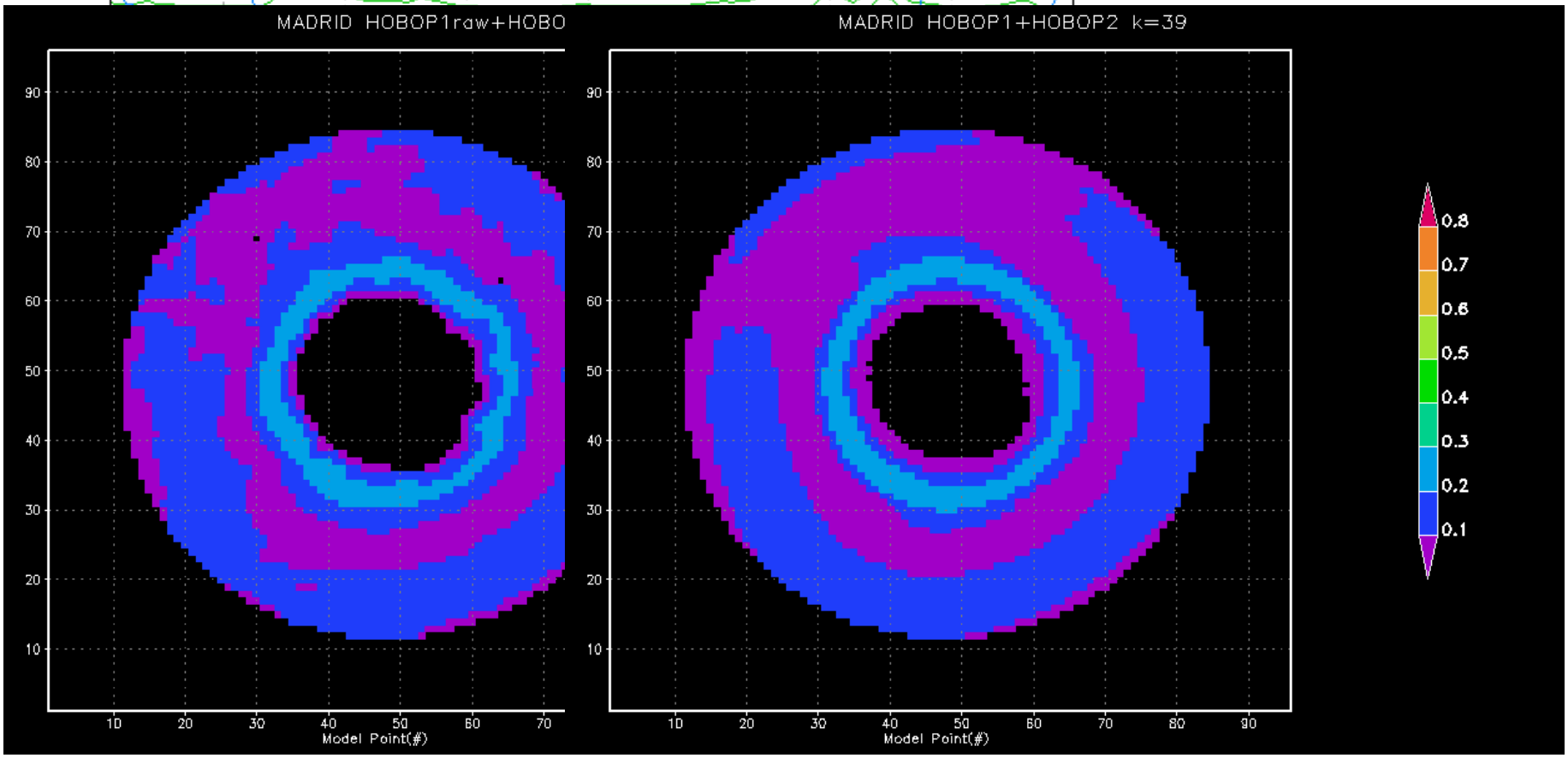
$$H = H(i, j, lev, PPI);$$

$$\sum_{lev} H(i, j, lev, PPI) = 1;$$

$$H X = \sum_{lev} H(i, j, lev, PPI)\, X(i, j, lev)$$

$$H^T X = \sum_{PPI} H(i, j, lev, PPI) X(i, j, PPI)$$

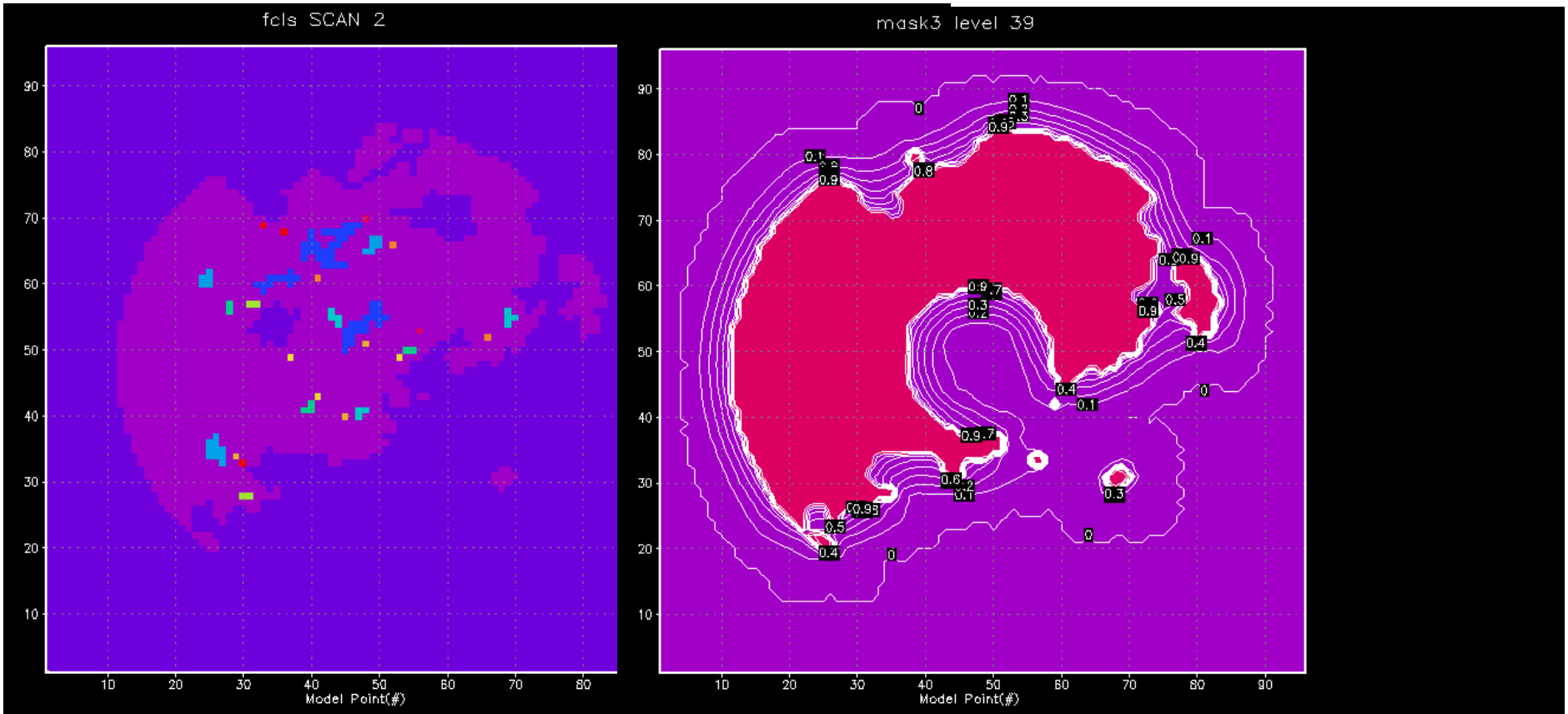

elev 1.4 @ 0.3
elev 0.5 @ 0.3
8000
7500
7000
6500
6000
5500
5000

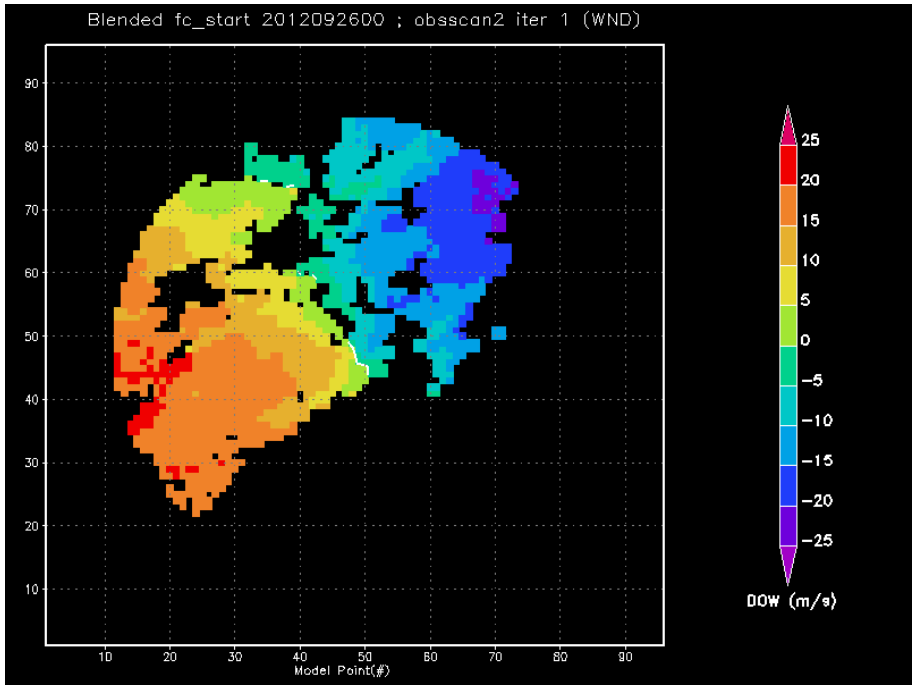

MADRID HOBOP1raw+HOBO
MADRID HOBOP1+HOBOP2 k=39
Model Point(#)
Model Point(#)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

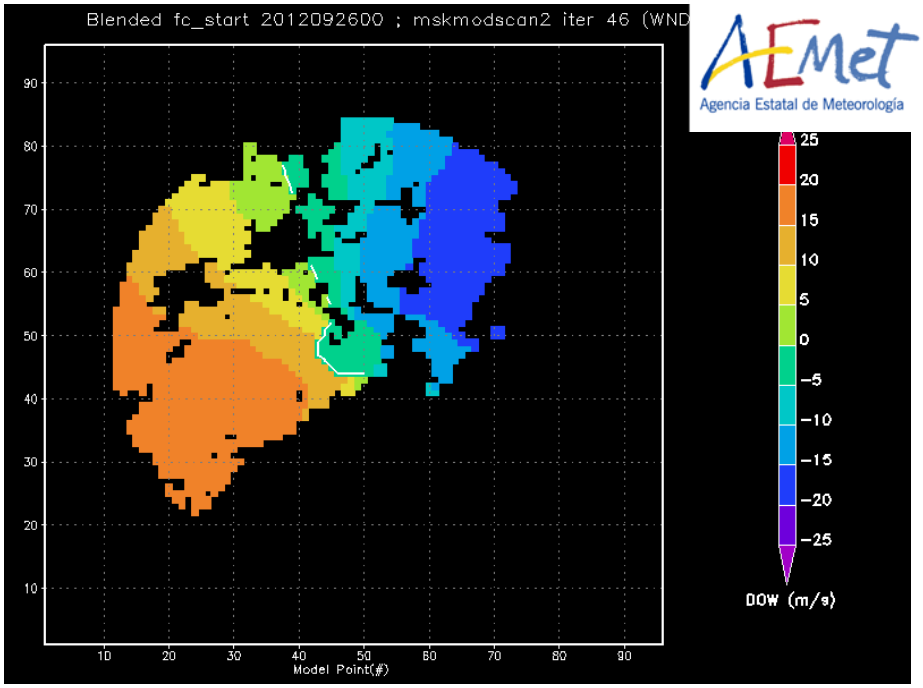
Implemetation of a prototype

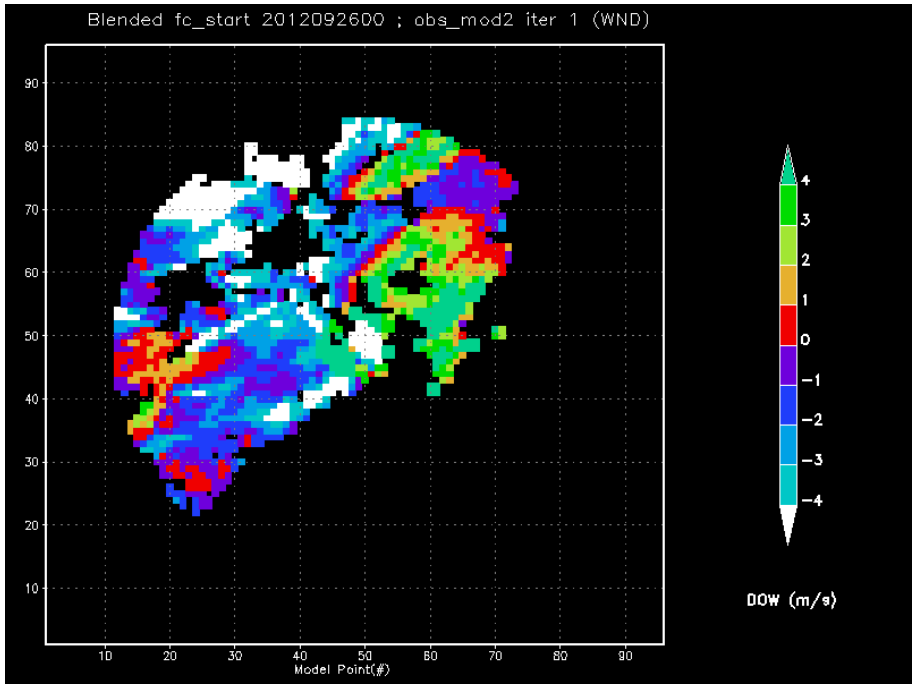
PPI DOW data has **data void areas**. This is a challenge because the FA algorithm likes smooth continuous deformations.

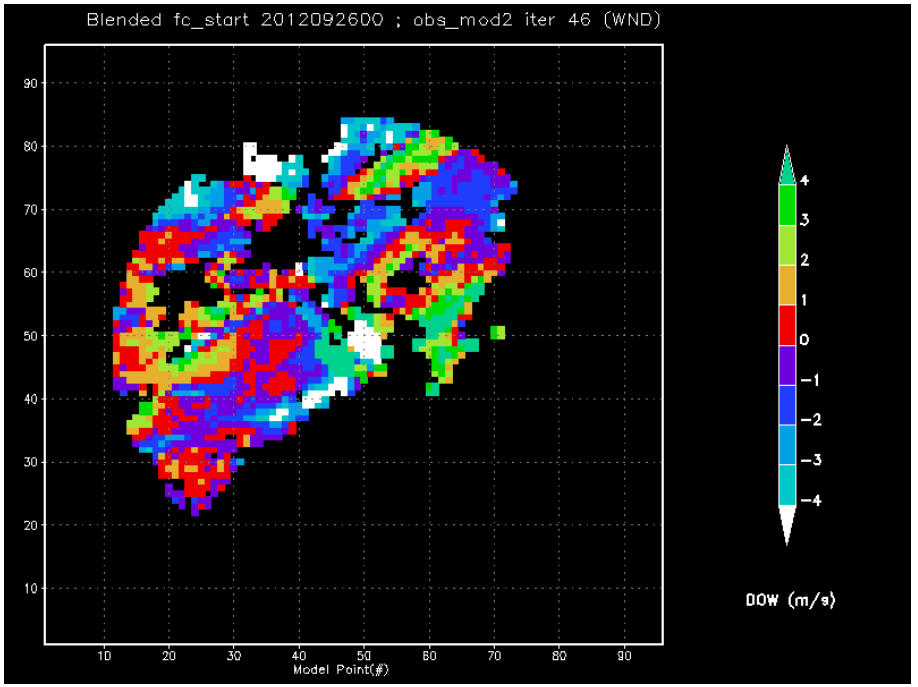
A satisfactory solution has been found by intensive use of **2D-clustering** and **masks** to modulate the forcing term of the FA equation and to filter the q field



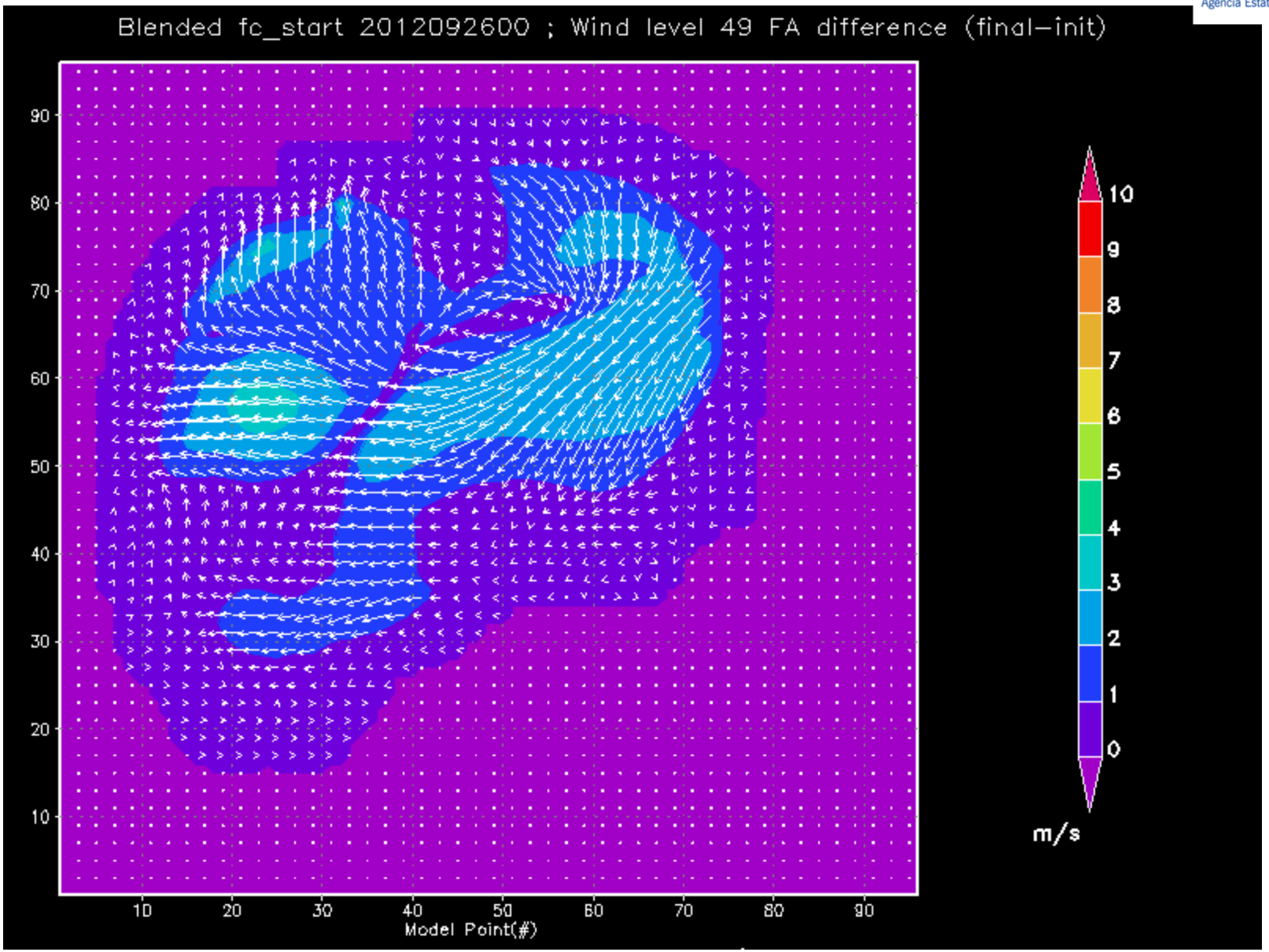

Blended fc_start 2012092600 ; obsscan2 iter 1 (WND)
25
20
15
10
5
0
−5
−10
−15
−20
−25
DOW (m/s)
Model Point(#)


Blended fc_start 2012092600 ; mskmodscan2 iter 46 (WND
25
20
15
10
5
0
−5
−10
−15
−20
−25
DOW (m/s)
Model Point(#)


Blended fc_start 2012092600 ; obs_mod2 iter 1 (WND)
4
3
2
1
0
−1
−2
−3
−4
DOW (m/s)
Model Point(#)


Blended fc_start 2012092600 ; obs_mod2 iter 46 (WND)
4
3
2
1
0
−1
−2
−3
−4
DOW (m/s)
Model Point(#)

Implemetation of a prototype



Implemetation of a prototype

The **criteria for convergence** is now more complicated because it takes place on several levels at the same time (typically between levels 30 and 50; 65 levels). A conservative approach has been adopted not to twist too much the fields

The prototype has been **tested on many different cases**. A limit of 50 iterations has been found to be a good limit. Also the algorithm on a given level stops if the accumulation of stress becomes too big (a discontinous jump of more than 10%).

The aligment process is very **cheap in terms of CPU** (one radar is done in a few seconds on a single task on c1a/c2a).

The algorithm **works well** !

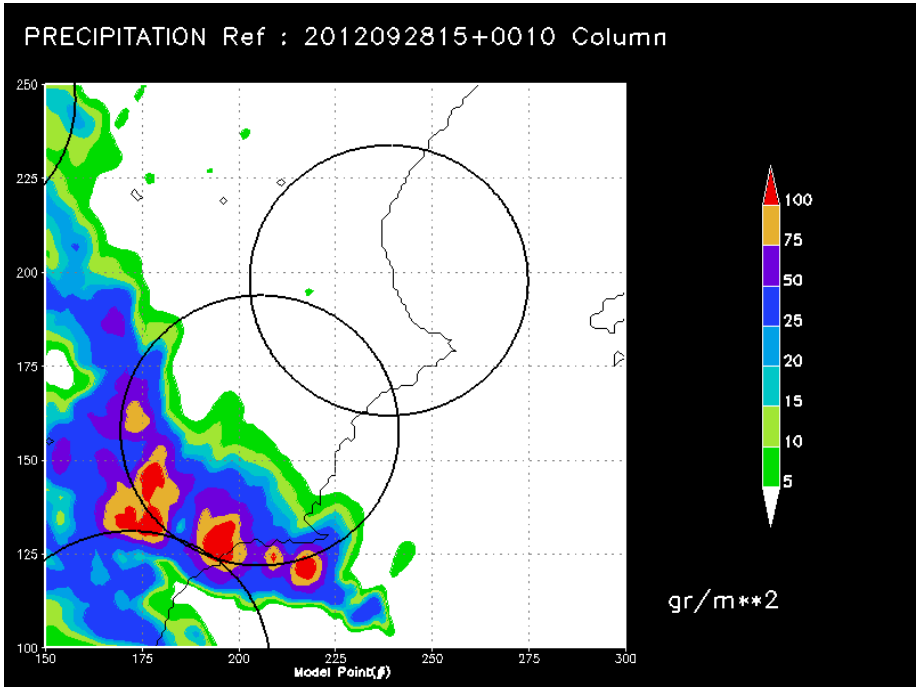
Impact on short-range forecasts

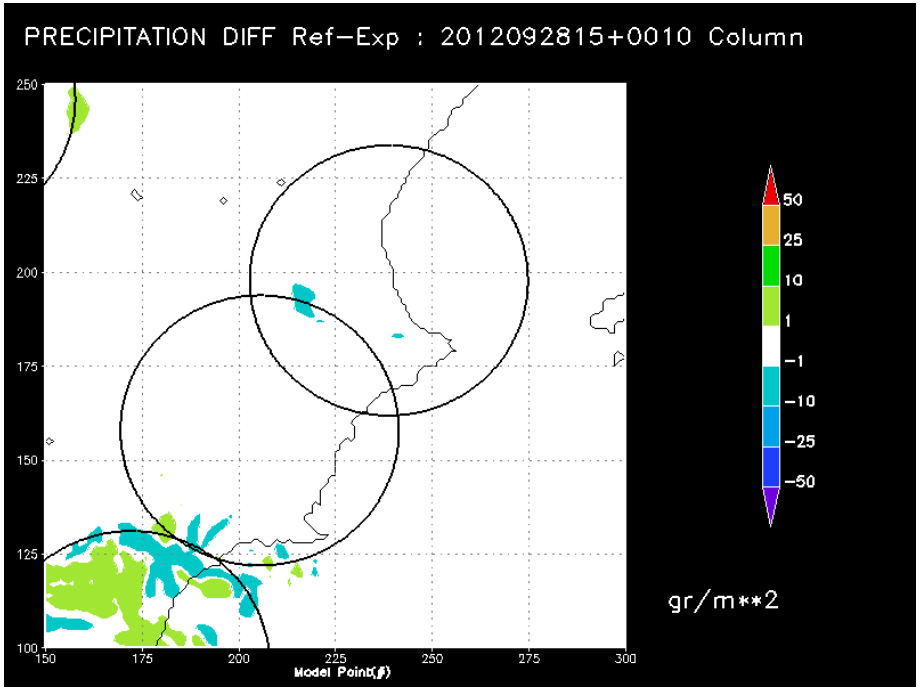
The fields resulting from the FA process are used as initial conditions for a set of short-range forecasts (up to 3 hours)

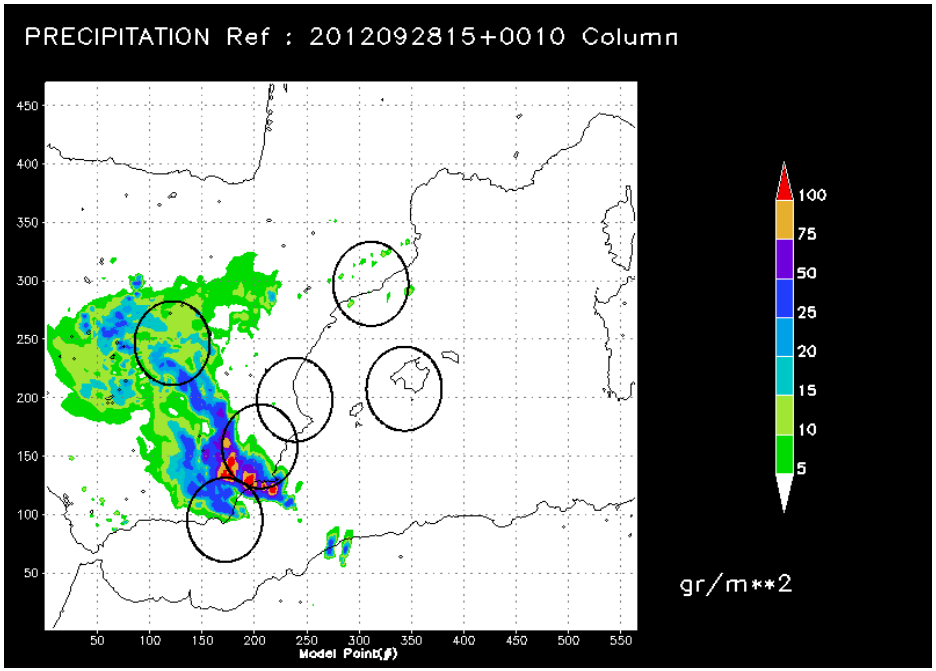
The experiment includes 6 radars over a 4 days period during HYMEX SOP-1 phase (26/Sept/12 – 29/Sept/12)

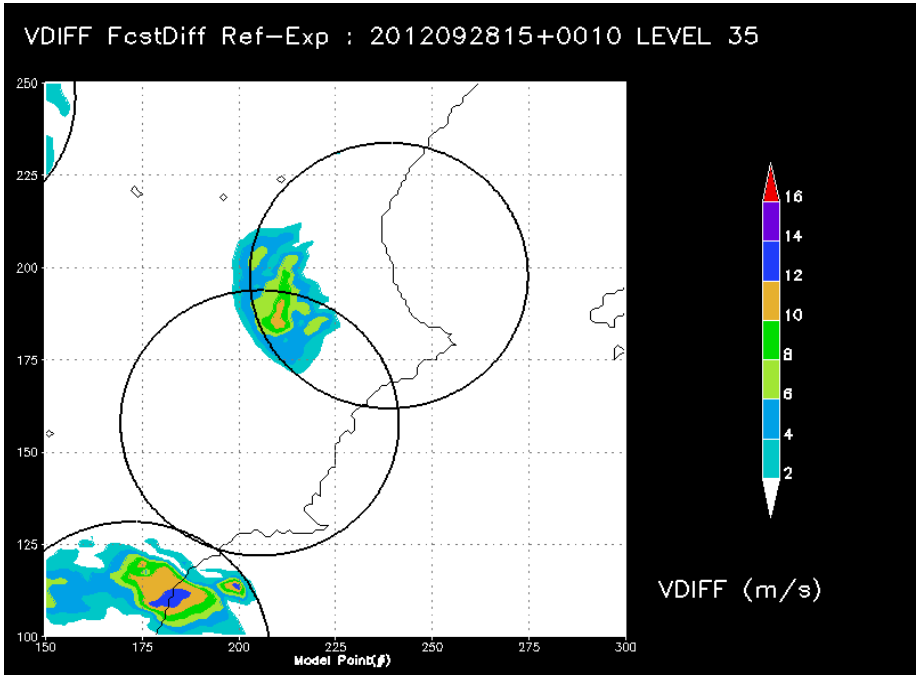
Only DOW data. Qc'd and upscaled to model resolution in an area 120 Km around the radar sites

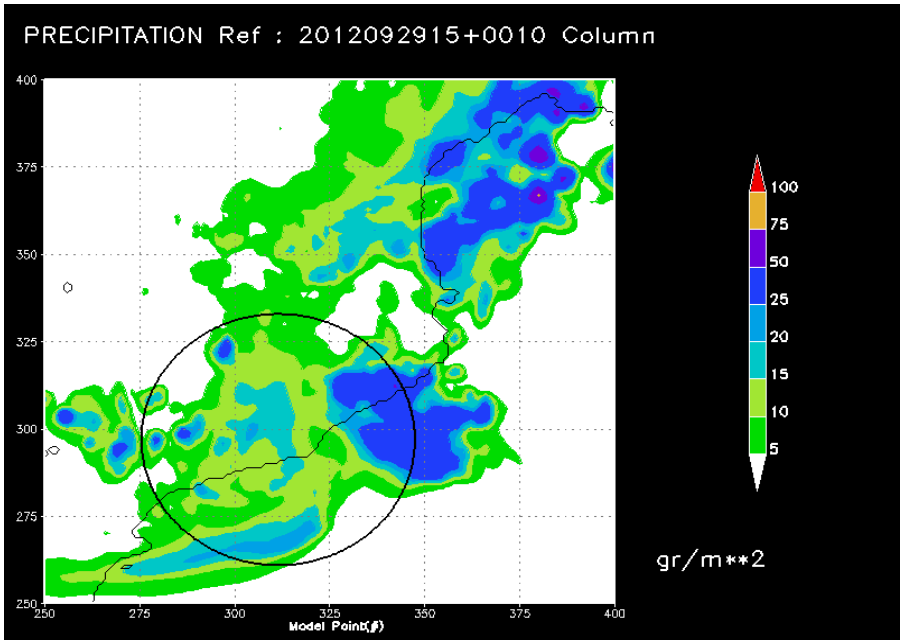
No 3DVar. No surface analysis. No Initialization. ("Blending mode")

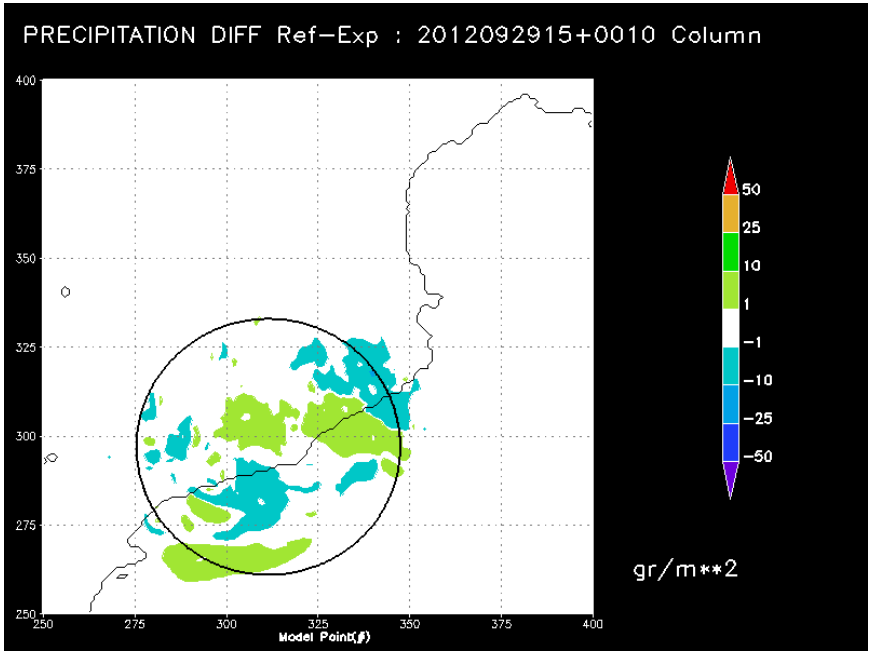

PRECIPITATION Ref : 2012092815+0010 Column
100
75
50
25
20
15
10
5
gr/m**2
Model Point(#)

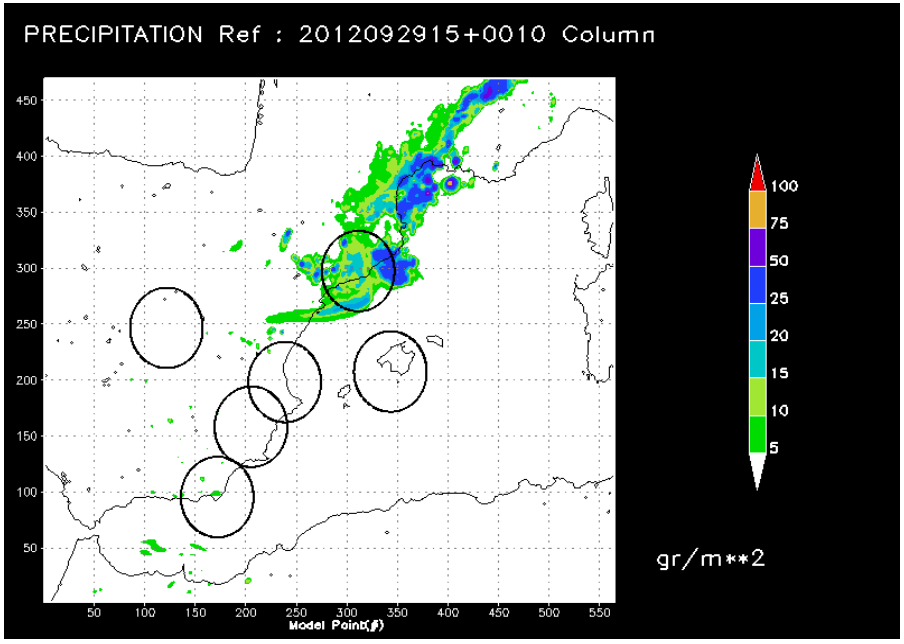

PRECIPITATION DIFF Ref-Exp : 2012092815+0010 Column
50
25
10
1
-1
-10
-25
-50
gr/m**2
Model Point(#)

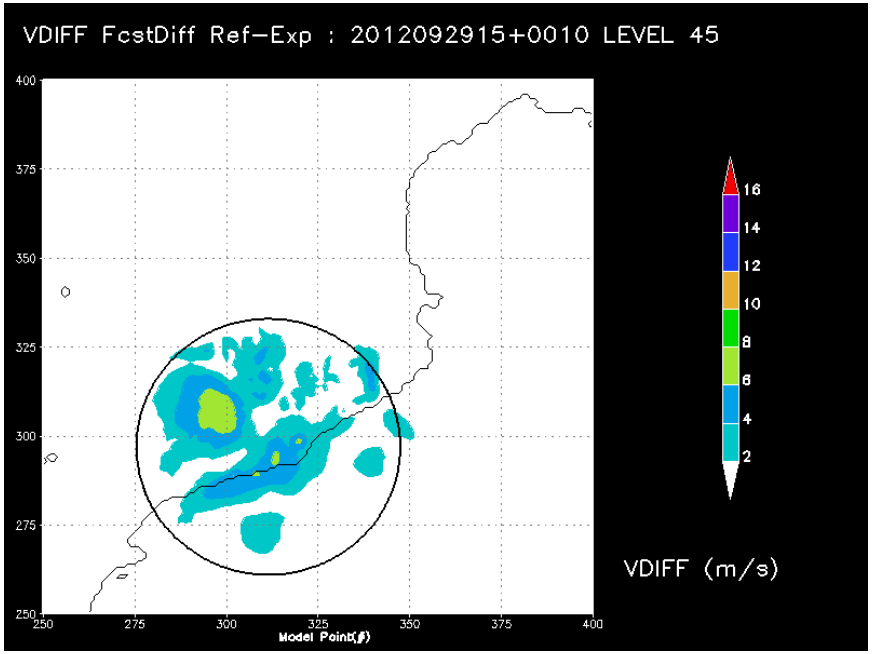

PRECIPITATION Ref : 2012092815+0010 Column
100
75
50
25
20
15
10
5
gr/m**2
Model Point(#)


VDIFF FcstDiff Ref-Exp : 2012092815+0010 LEVEL 35
16
14
12
10
8
6
4
2
VDIFF (m/s)
Model Point(#)

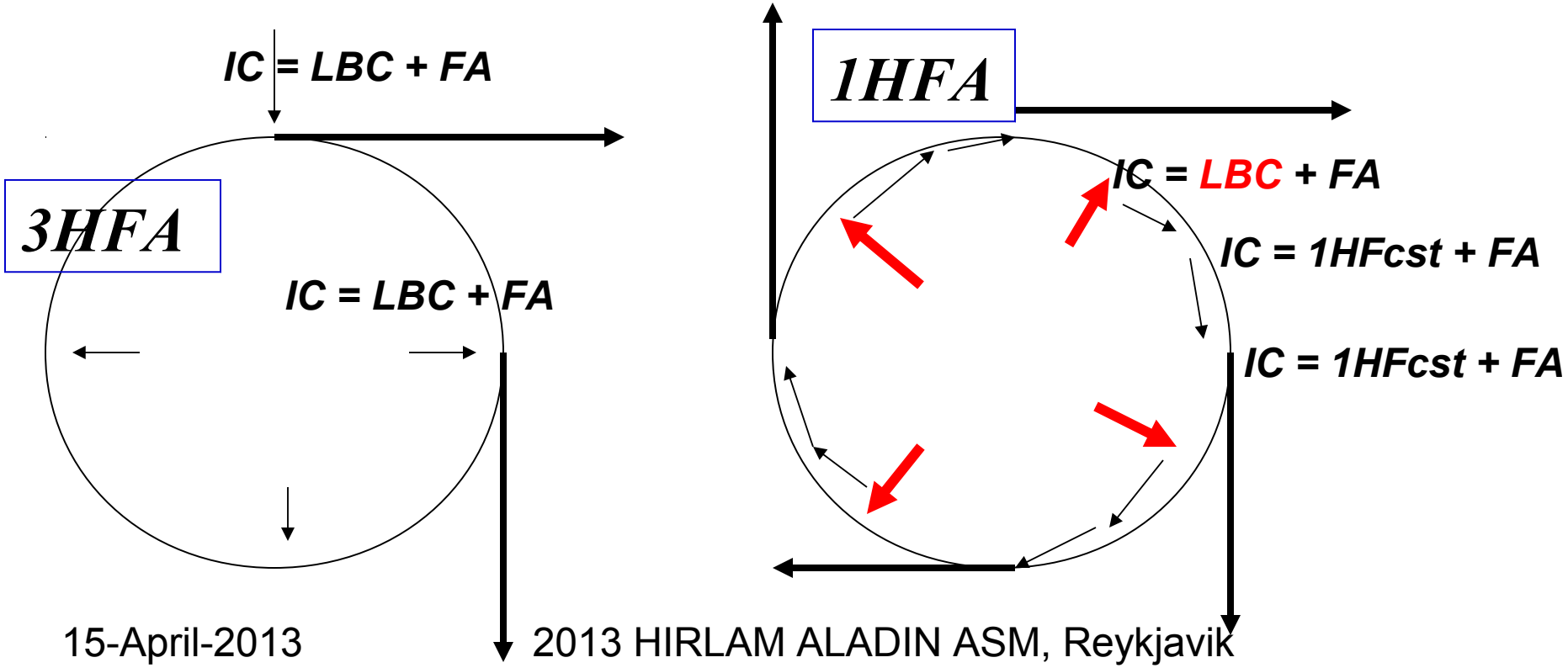

PRECIPITATION Ref : 2012092915+0010 Column
100
75
50
25
20
15
10
5
gr/m**2
Model Point(#)


PRECIPITATION DIFF Ref-Exp : 2012092915+0010 Column
50
25
10
1
-1
-10
-25
-50
gr/m**2
Model Point(#)


PRECIPITATION Ref : 2012092915+0010 Column
100
75
50
25
20
15
10
5
gr/m**2
Model Point(#)

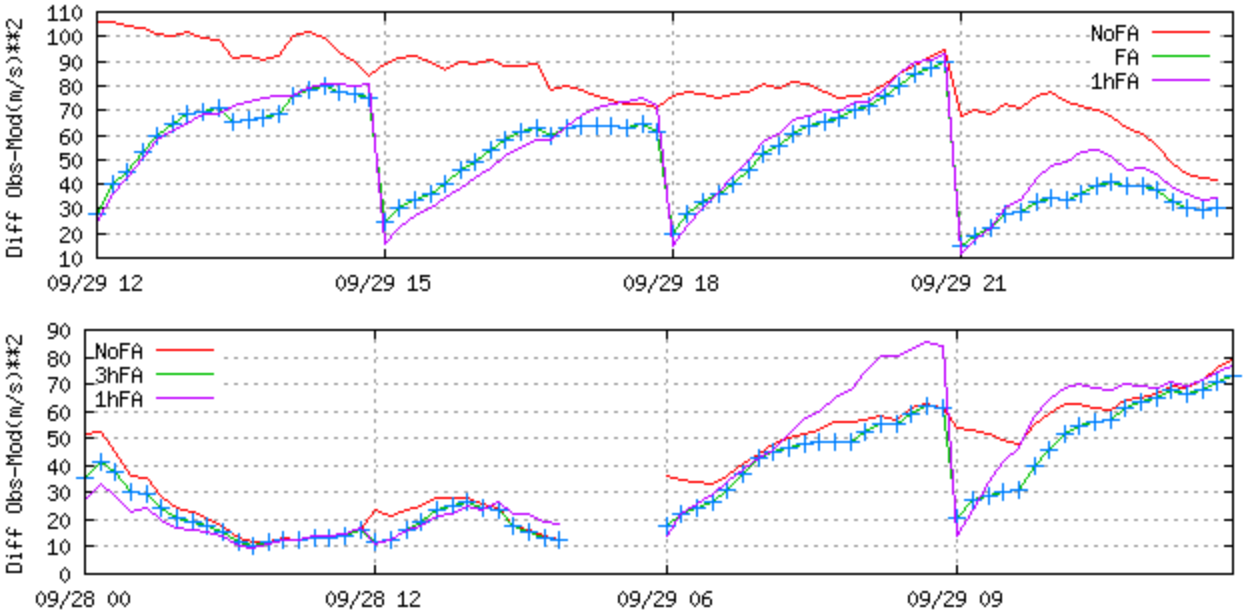

VDIFF FcstDiff Ref-Exp : 2012092915+0010 LEVEL 45
16
14
12
10
8
6
4
2
VDIFF (m/s)
Model Point(#)

Two experiment configurations have been tested: "**3HFA**" and "**1HFA**". The aim is to study the effect on the initial conditions of increasing the frequency of the FA correction

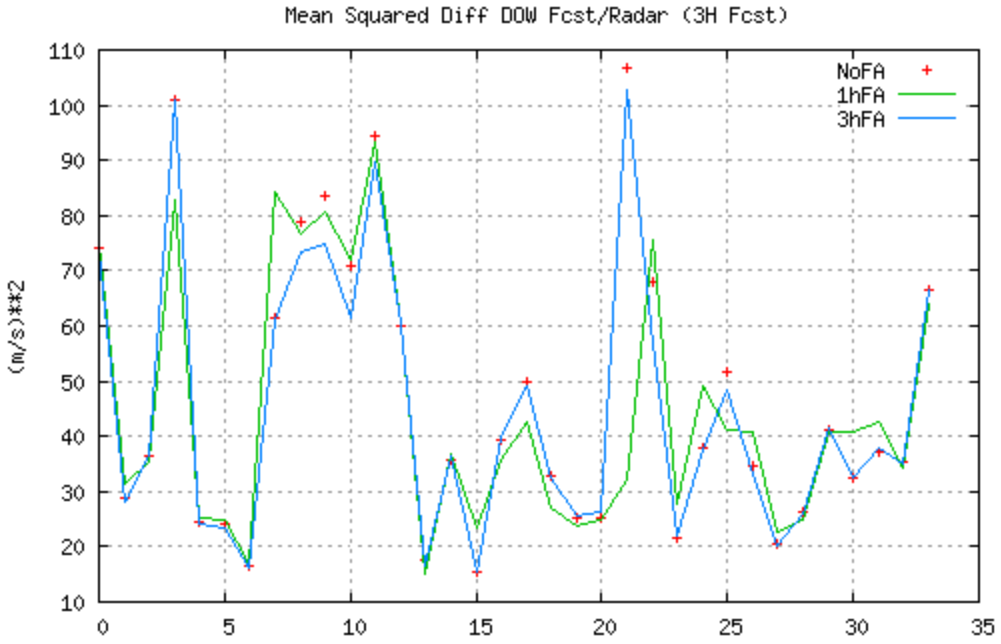


Impact on short-range forecasts

*Verification using **DOW radar data**. Mean Squared difference in radial wind between model and observations (.e.g., (mod-ob)**2) averaged over two PPIs for each case*



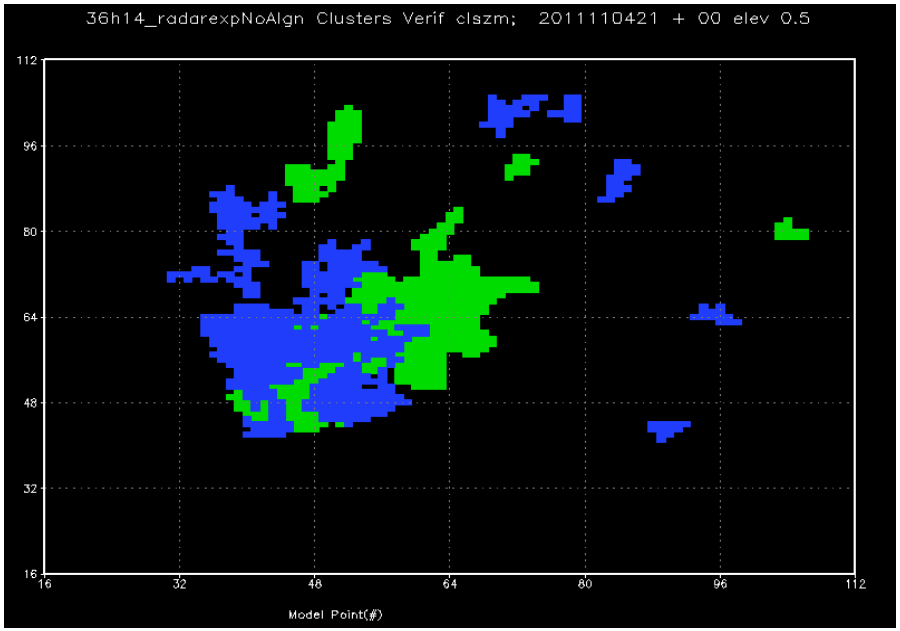
Impact on short-range forecasts



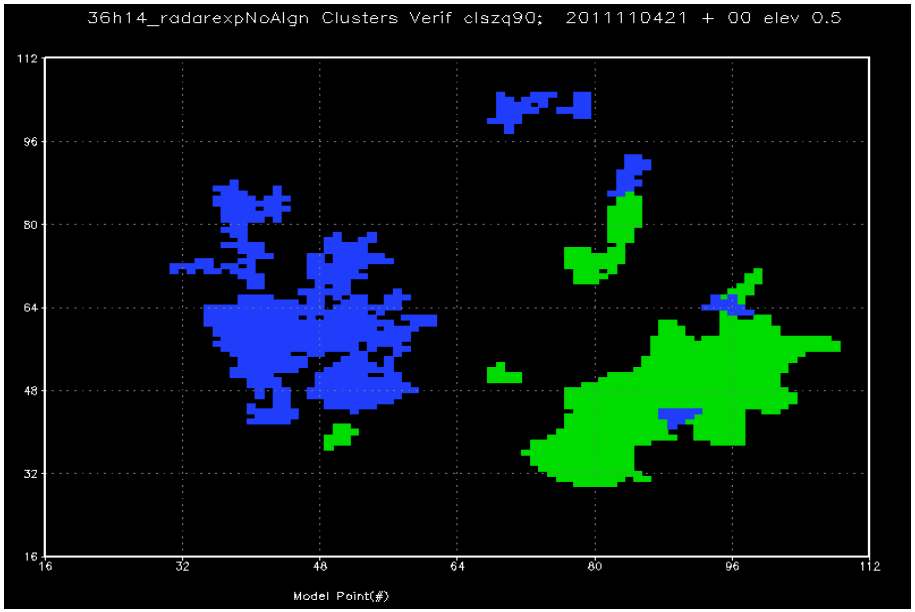
Verification using ***Reflectivity radar data***

We use the method based on measuring the distance between clusters in a given scene….

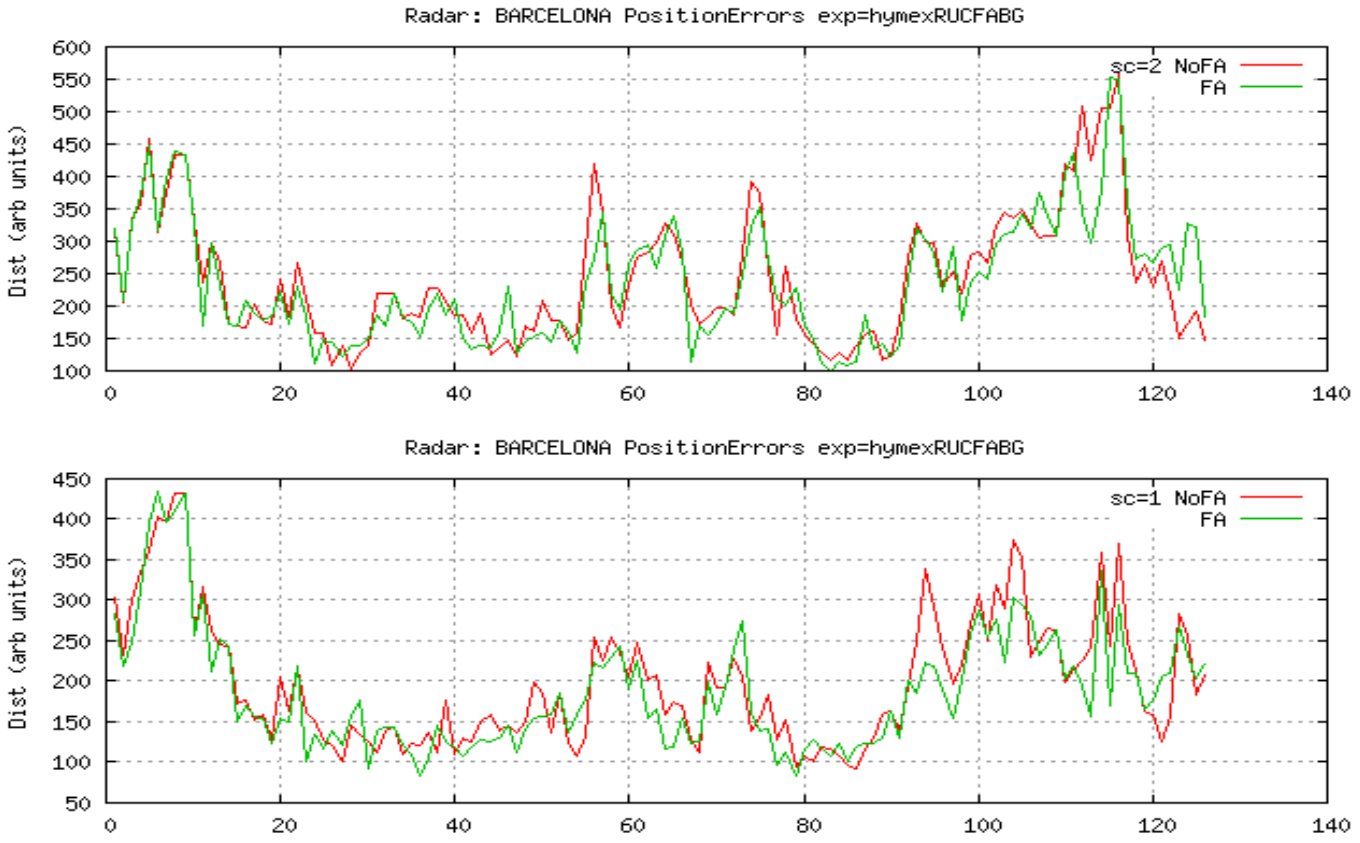
D=240



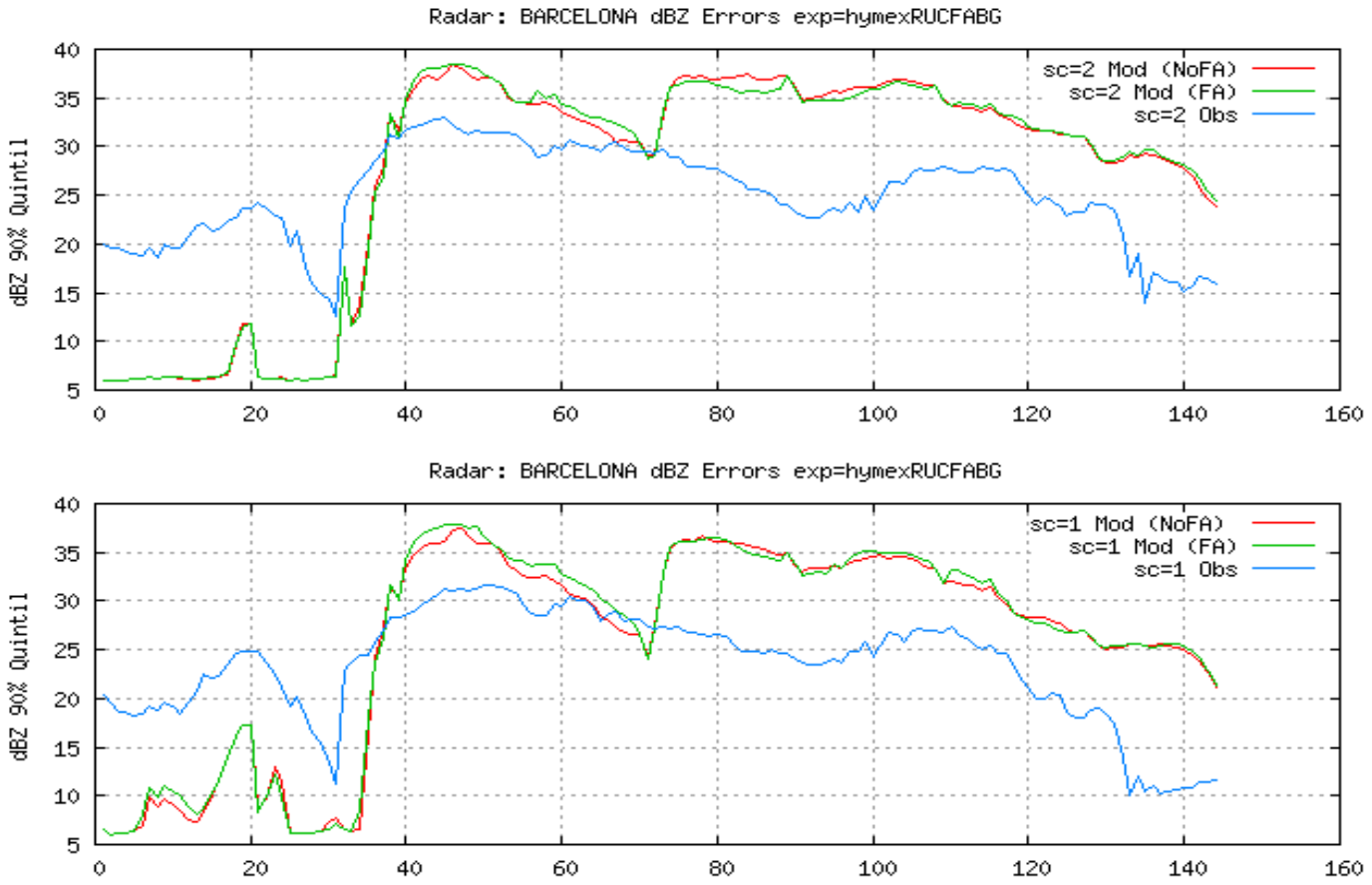
D=532



The first results do not indicate any clear impact on this parameter, either in position …



… or amplitude



Conclusions

- FA can produce smooth increments at model resolution. These increments can be easily filtered and extrapolated using satistical interpolation methods
- It is flow-dependent
- It is non-linear
- It is efficient
- In the cases considered up to now, the increments over the first hours evolve in a realistic way (no obvious spin-up problems)
- The impact on the wind field (analysed) is neutral or positive and significant in some cases. The impact on precipitation (not analysed) appears neutral in these tests

Conclusions

- Important issue: the tests with 1 hour cycling do not give good results. Where the problem *exactly* comes from ?

- A question that is connected to the previous one: the assimilation of reflectivity radar data, does it make sense if running HARMONIE in “blending mode” ?

- More tests and more development work is necessary

- HARMONIE as NWP-NWC (NWP nowcasting) system : not only scientific issues involved