IMPLEMENTATION OF THE FA ALGORITHM FOR RADAR DA IN HARMONIE v38

(FIRST TESTS IN A QUASI-OPERATIONAL SETTING)

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HELSINGOR, DENMARK, april 2015

IMPLEMENTATION of RADAR FA in HARMONIE v38

- Development carried out @ ECMWF (like prototype on v37)

- Multiple modifications due to migration from IBM P7 to CRAY XC30 in September 14

- Also ODB changes between v37 and v38

- Full integration into the HARMONIE-AEMET daily runs schedule (x 8) @ECMWF @ECMWF with other upper-air observations and Surface Analysis

- Tests comprising several rainy episodes during January and February 2015 and verification with in-situ observations using the vfld package (*thanks to Javier Calvo*)

About the FA Algorithm:

Two "modes"

a) standar : FA (q_r ,q_g ,q_s ,q ,T , u, v) **+** Amplitude correction (only DOW)

b) upscaled FA corrections :

FA (q_r ,q_g ,q_s ,q ,T , u, v) **+** (q,T,u,v)* **+** Amplitude correction (only DOW)

Steps in red use the 3D-Var algorithm (B matrix)

About the FA Algorithm:

- It takes radar data without geometrical transformations (*i.e. set of PPI s or "volumes*"), without thinning and requires calibration for Z and DOW (*i.e from byte counts to physical units, dBZ and m/s*). Local AEMET ODIM-BUFR format used.

- "Superobing" (500m bin x 0.8 azimuth degrees is below current 2.5Km model resolution) . 240 x 450 polar images -> 96 x 96 cartesian images. Lowest 2 elevations (<=2.5 degrees).

- Assimilation of Z based on the same idea as MF algorithm; i.e. use of reflectivity as proxy for relative humidity

- Both, Z and DOW use the same obs operator as MF algorithm

- Z (mm6/m3) and not dBZ (log(Z)) used in the assimilation. Adaptive cross-calibration between obs and model

- Gross check for similarity between radar image and model FG pseudo image (15% overlap)

About the FA Algorithm

Alignment

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

B matrix does not enter in the equation

R matrix does appear in the forcing term. Taken diagonal and used as normalization factor for the forcing term.

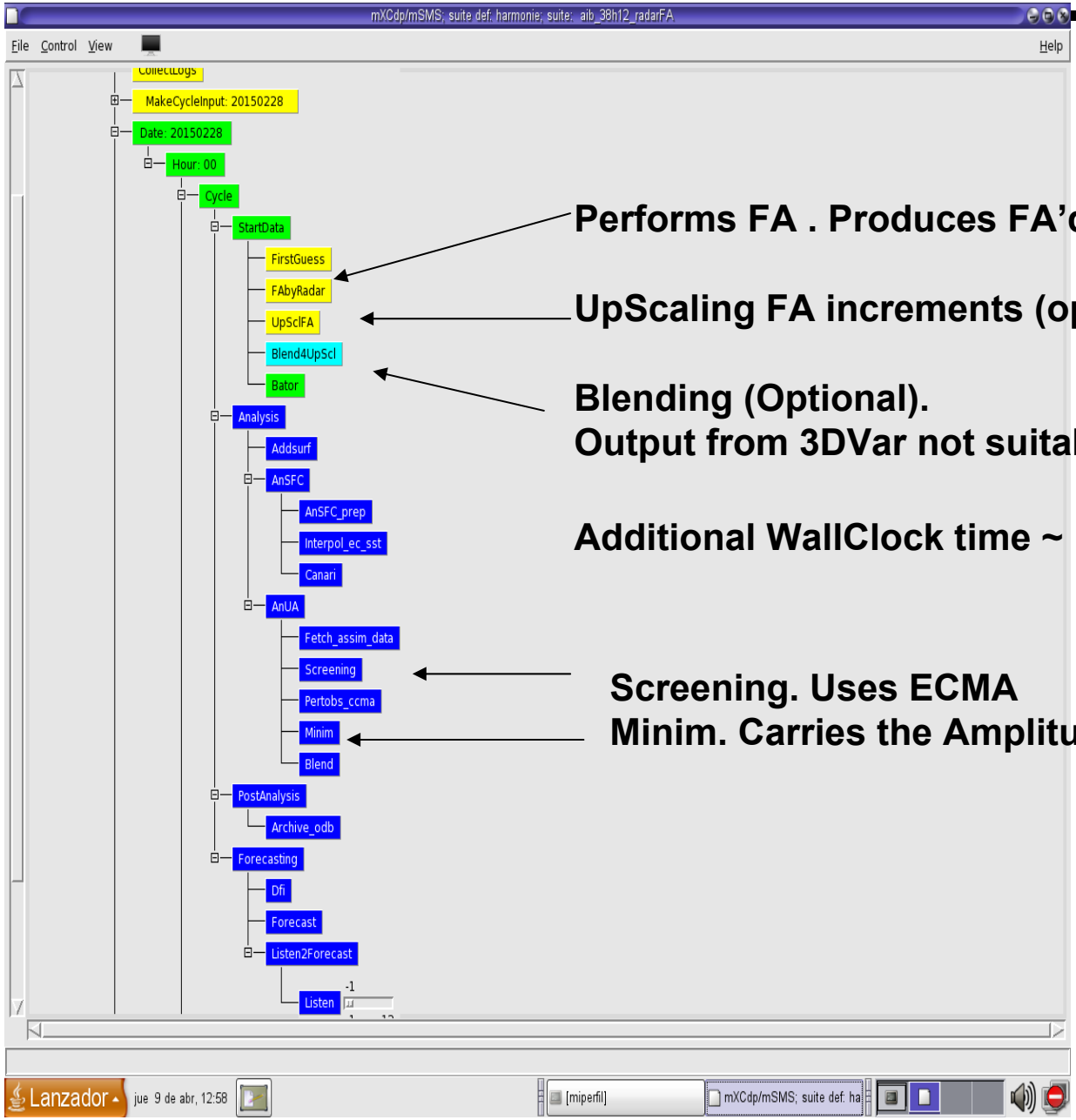
H operator carries geometry transformations and also transformations between analised variables and observed parameters

q fields computed on horizontal levels

Data void areas treated by means of 2D-masks

Orography: a) alignment on horizontal levels, **q** = **0** where $z < z_g$ also 2D masks are useful here
b) ad-hoc solutions, e.g : ps -> mslp

IMPLEMENTATION of RADAR FA in HARMONIE v38



Performs FA . Produces FA'd FG, CCMA, and ECMA ODBs

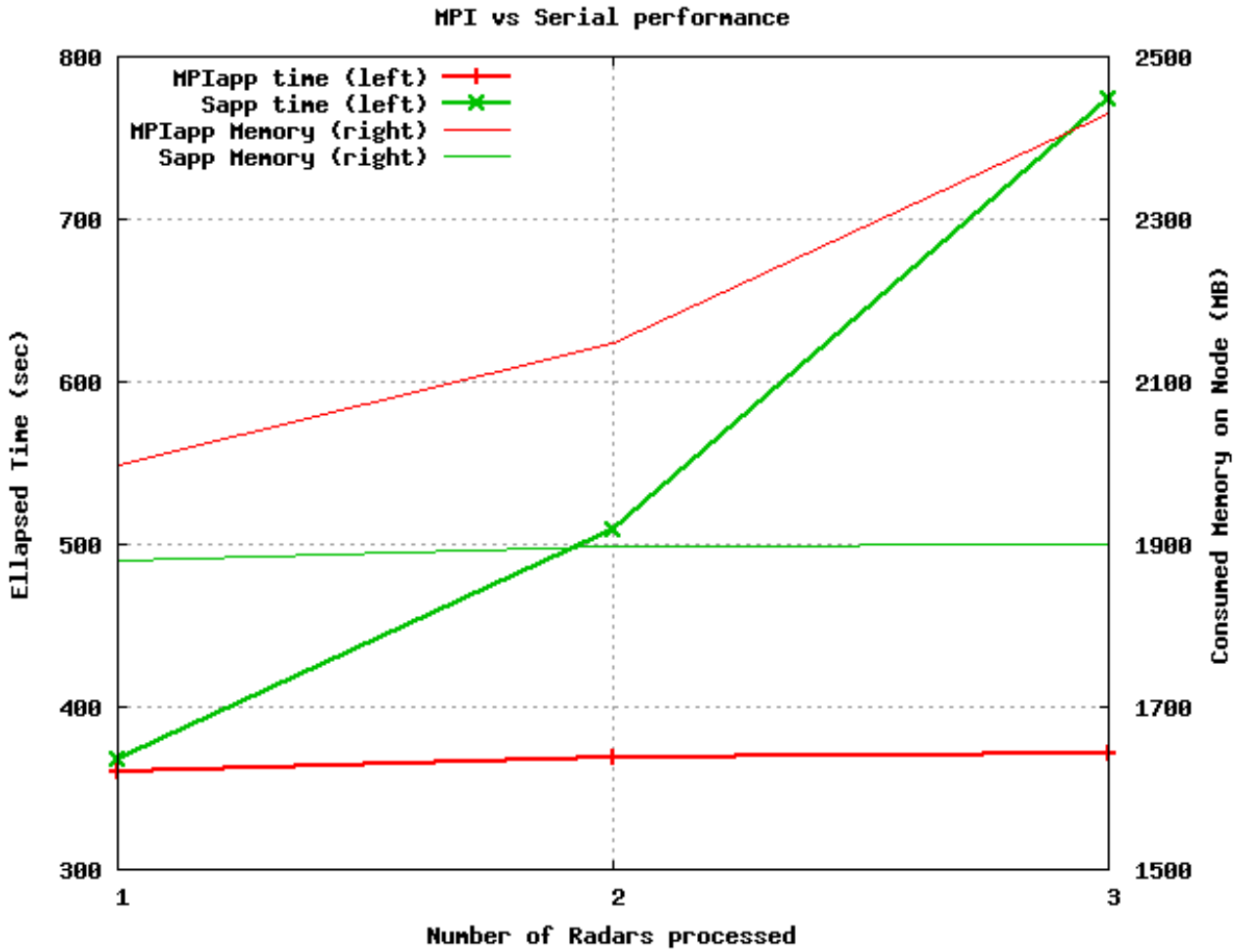
UpScaling FA increments (optional). Uses CCMA

Blending (Optional).
Output from 3DVar not suitable for Surface Analysis

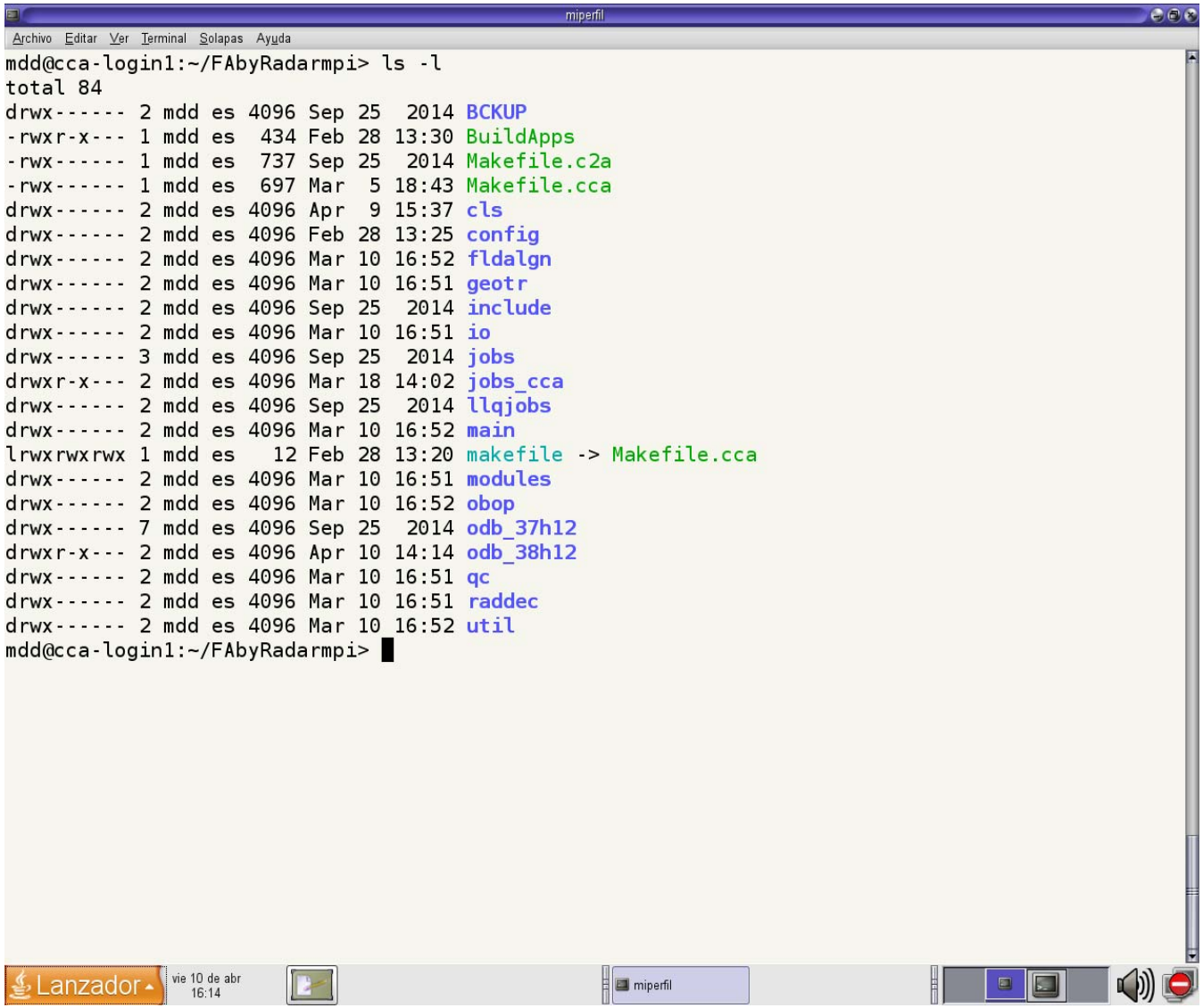
Additional WallClock time ~ 10 minutes

Screening. Uses ECMA
Minim. Carries the Amplitude correction

Parallel Processing



FA SW package

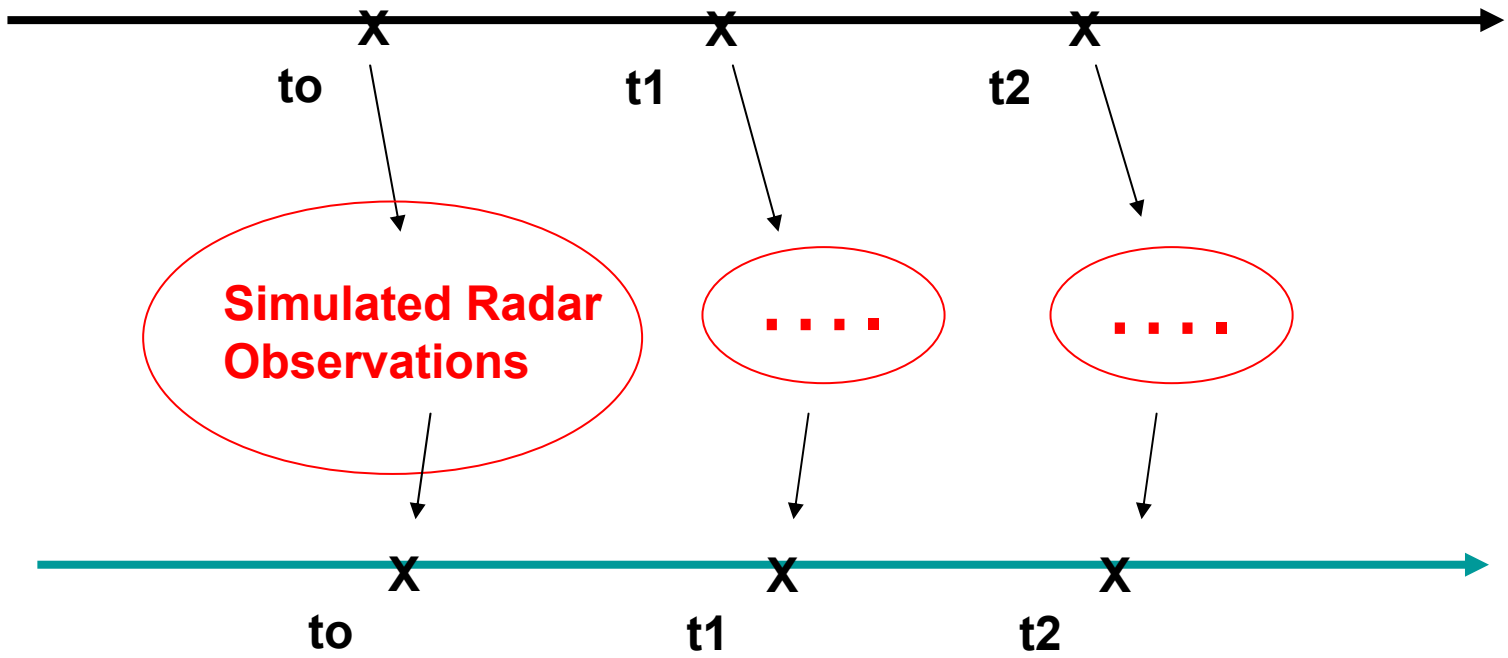


Validation

Validation done with experiments using simulated data. A number of advantages

- Permits to put aside (momentarily) questions like QC whose solution have their own time schedule
- Complete access to validation reference (“truth”)
- Allows tests on data acquisition schedules that are not implemented (e.g. number and frequency of PPIs)
- It describes an ideal situation (“upper bound” for expected impact)
- Can be made “more real” by adding arbitrary amounts of noise and with known characteristics (variances, correlation length scales, etc …)

Twin0 (“nature”) : Init + LBC from enda#1



TwinN (“expN”) ….

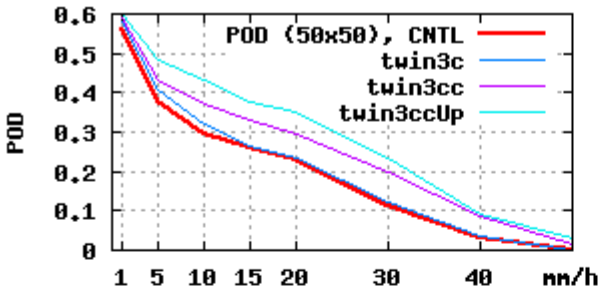
Twin1 (“model”) : Init + LBC from enda#4

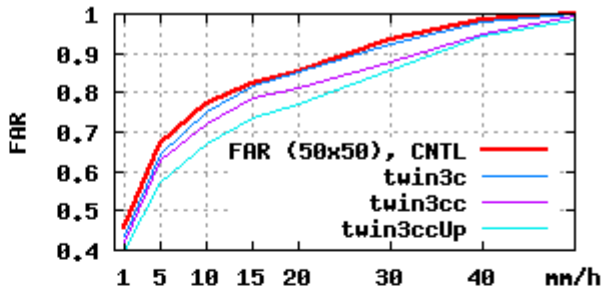
Precipitation (mm/h) (at grid point level)

Prob. of Detection

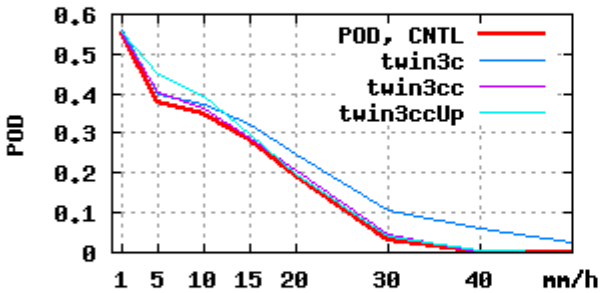
False Alarm Rate

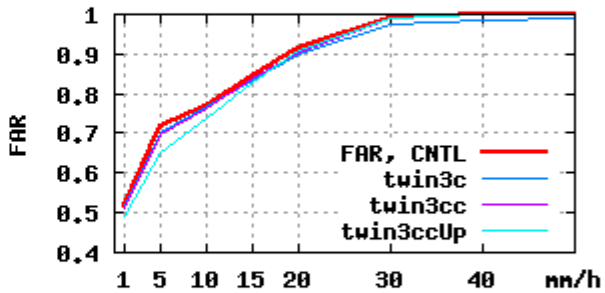
+1 , +3



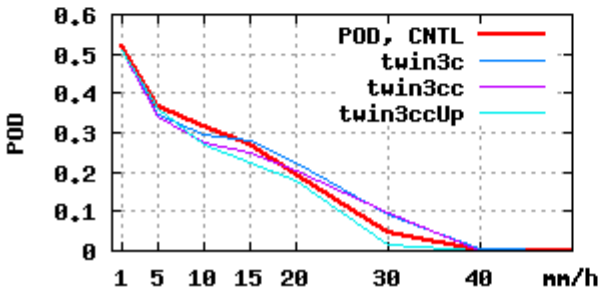


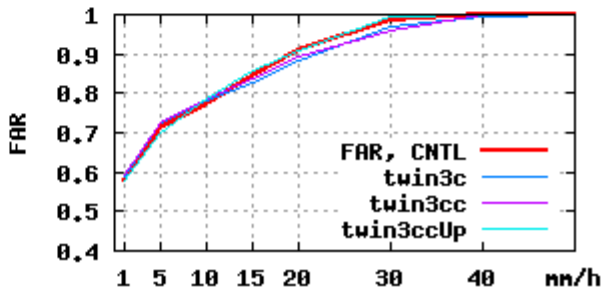
+4 , +6





+7 , +9



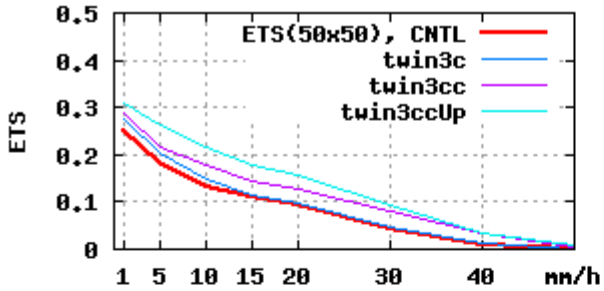


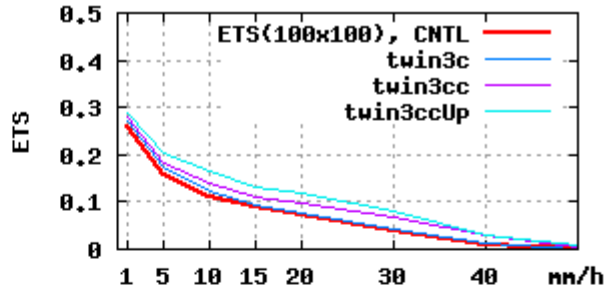
Precipitation (mm/h) **Equitable Threat Score** (at grid point level)

Small area

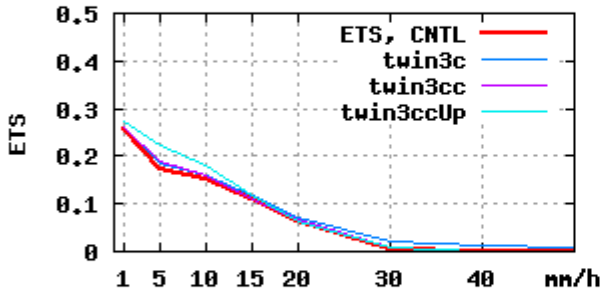
Big area

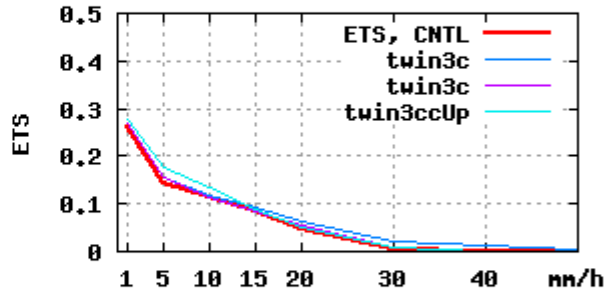
+1 , +3



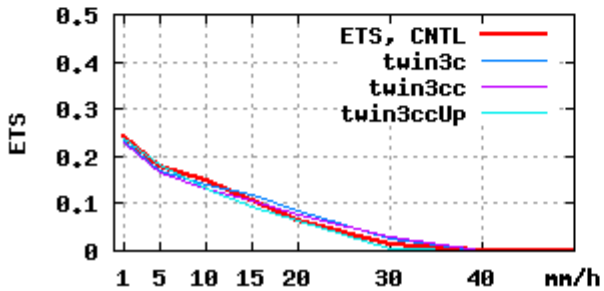


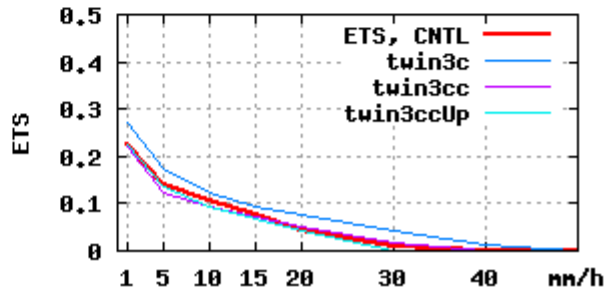
+4 , +6



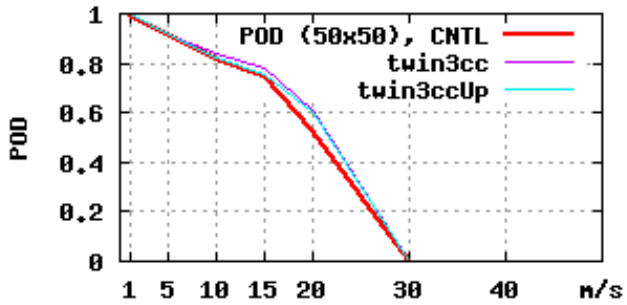
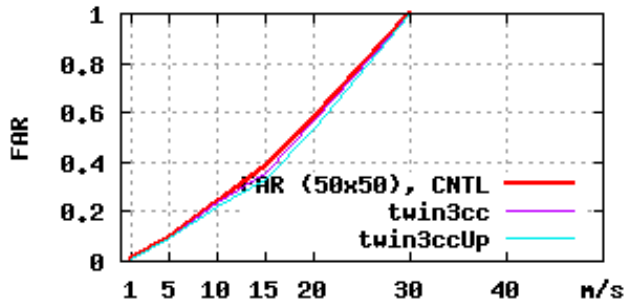
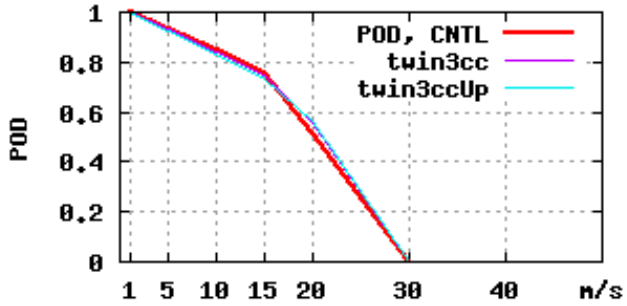
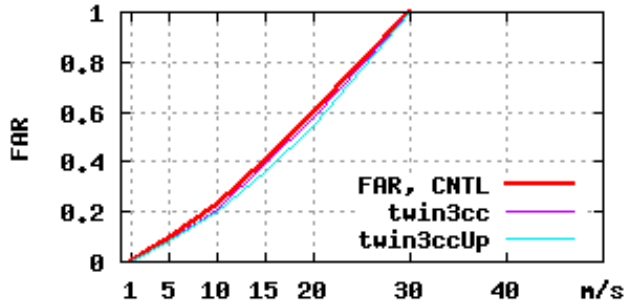
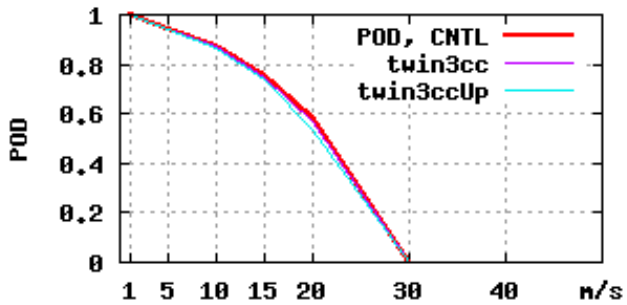
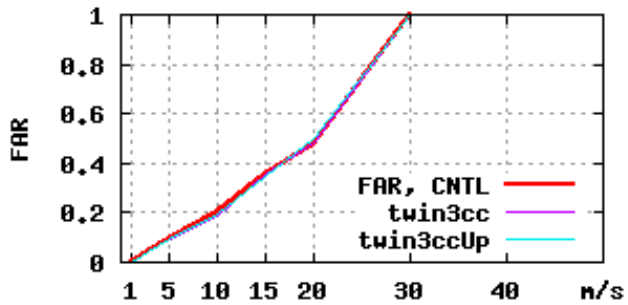


+7 , +9





Wind Gust (m/s) (at grid point level)

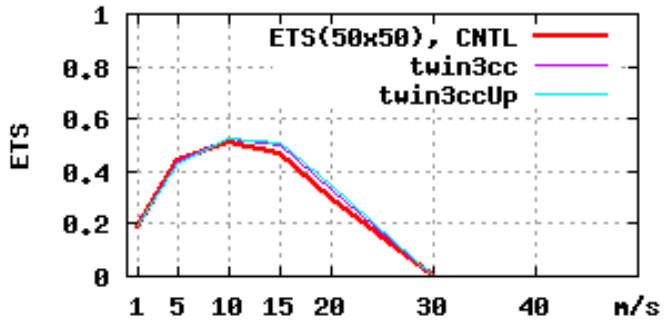
	Prob. of Detection	False Alarm Rate
+1 , +3		
+4 , +6		
+7 , +9		

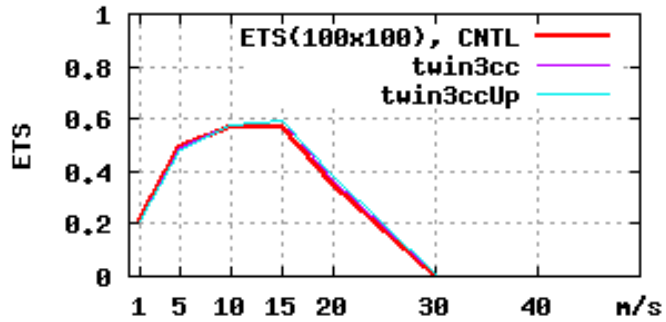
Wind Gust (m/s) **Equitable Threat Score** (at grid point level)

Small area

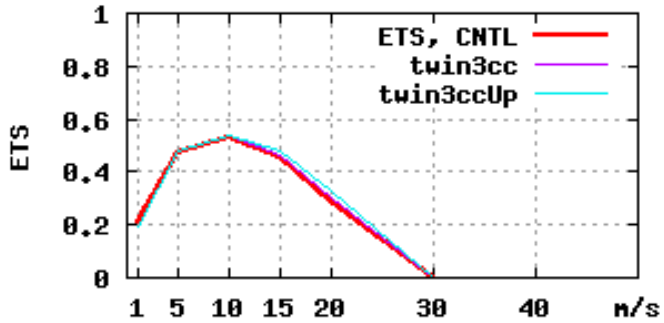
Big area

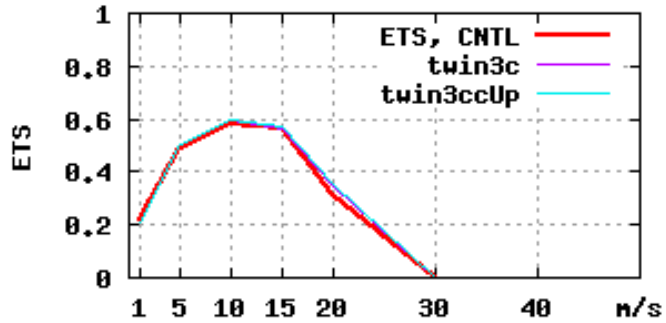
+1 , +3



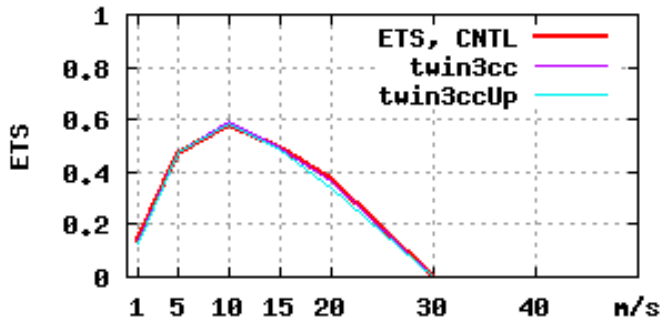


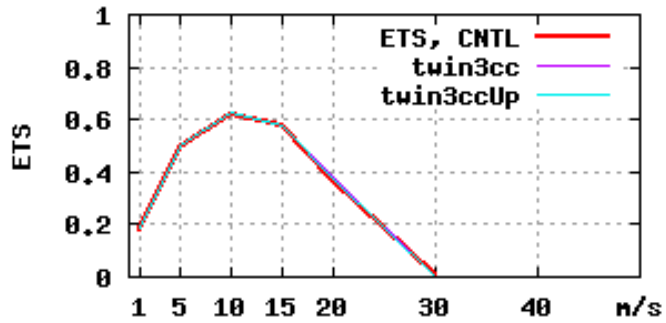
+4 , +6

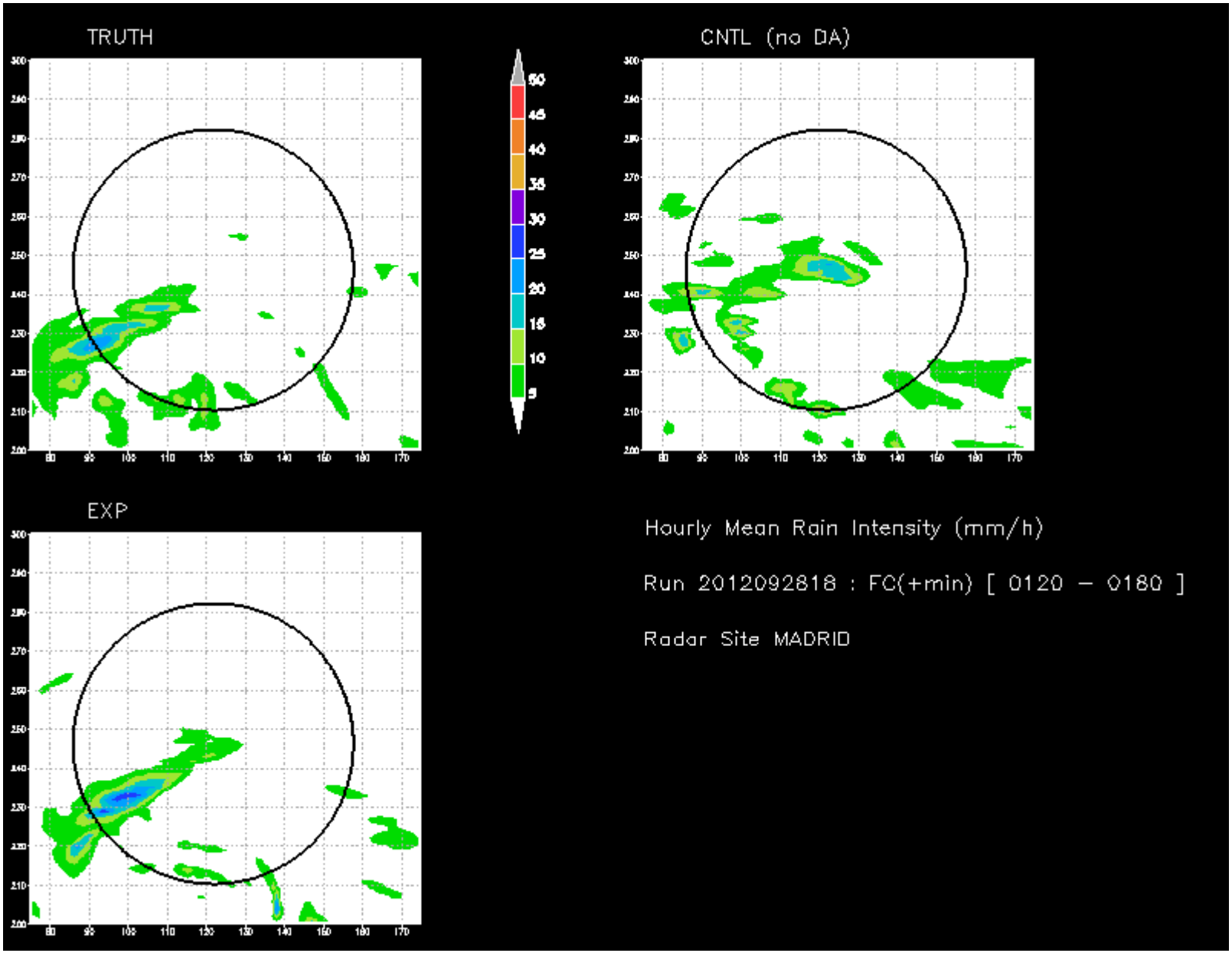


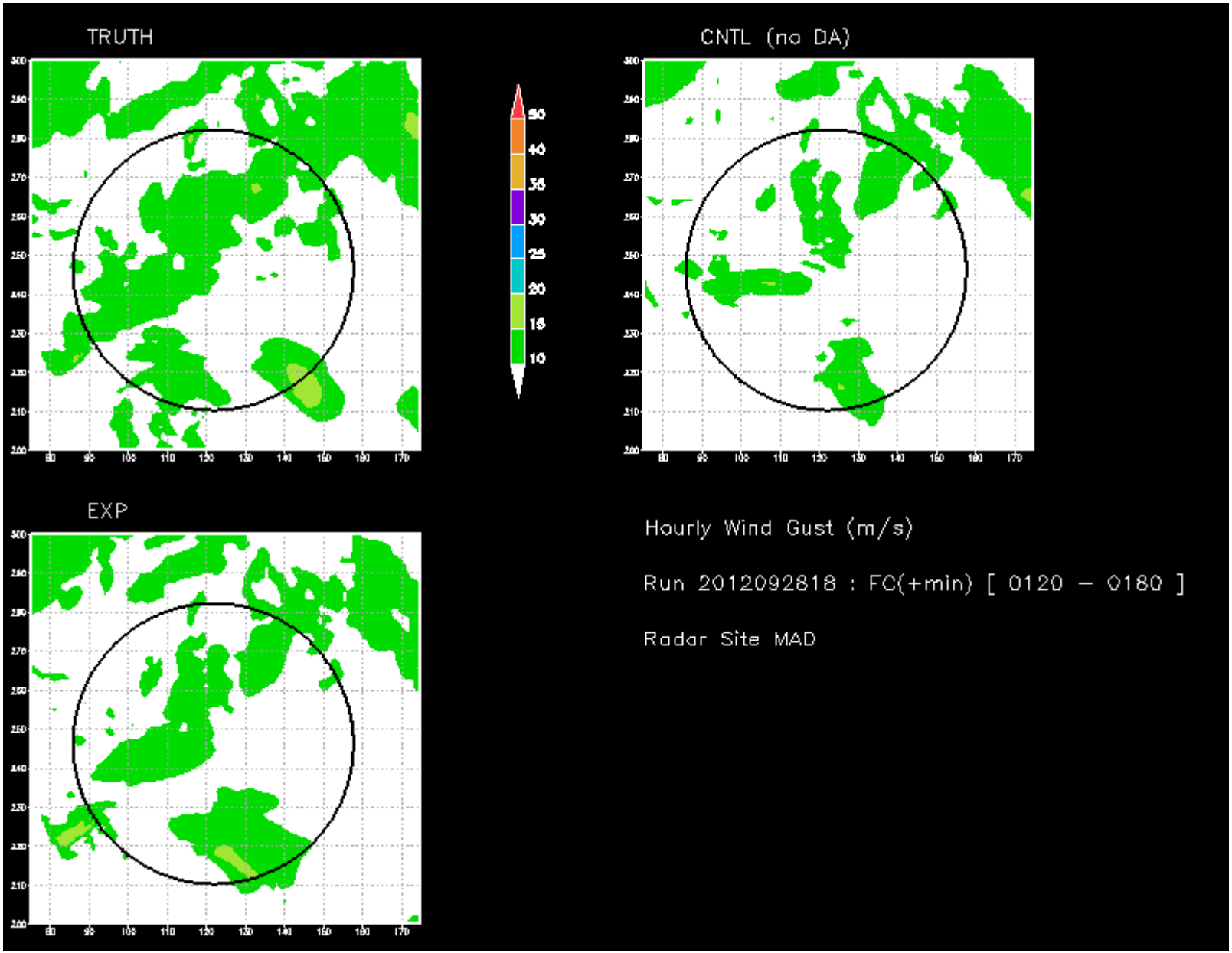


+7 , +9






TRUTH
CNTL (no DA)
EXP
50
45
40
35
30
25
20
15
10
5
Hourly Mean Rain Intensity (mm/h)
Run 2012092818 : FC(+min) [0120 – 0180]
Radar Site MADRID


TRUTH
CNTL (no DA)
EXP
50
40
35
30
25
20
15
10
Hourly Wind Gust (m/s)
Run 2012092818 : FC(+min) [0120 – 0180]
Radar Site MAD

Verification

Verification done with experiments using real data. So far already several experiments carried out

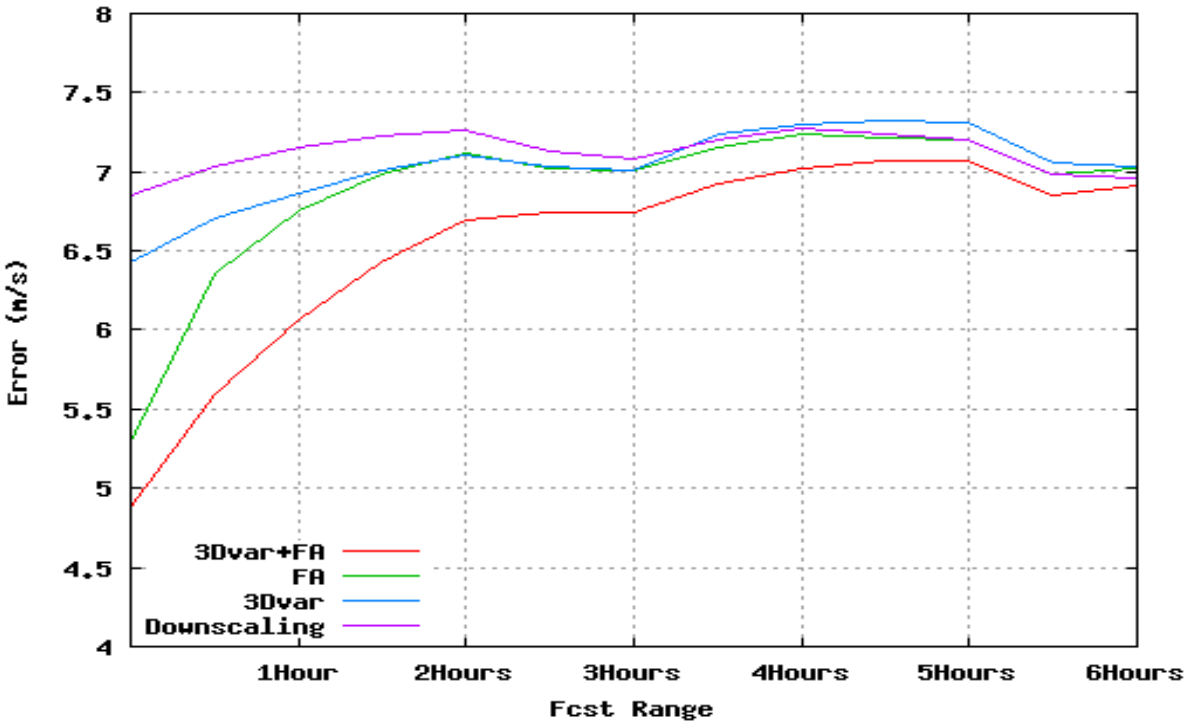
- SOP-1 HYMEX data (September 2012)
- January-February 2015 NRT data (quasi-operational setting)
- Problems related to lack of appropriate QC on the data
- Issues related to verification methodology and verification data

Assimilation of Doppler Wind Radar Data in HARMONIE

- **Verification of forecasted radial wind using the own radar data:**

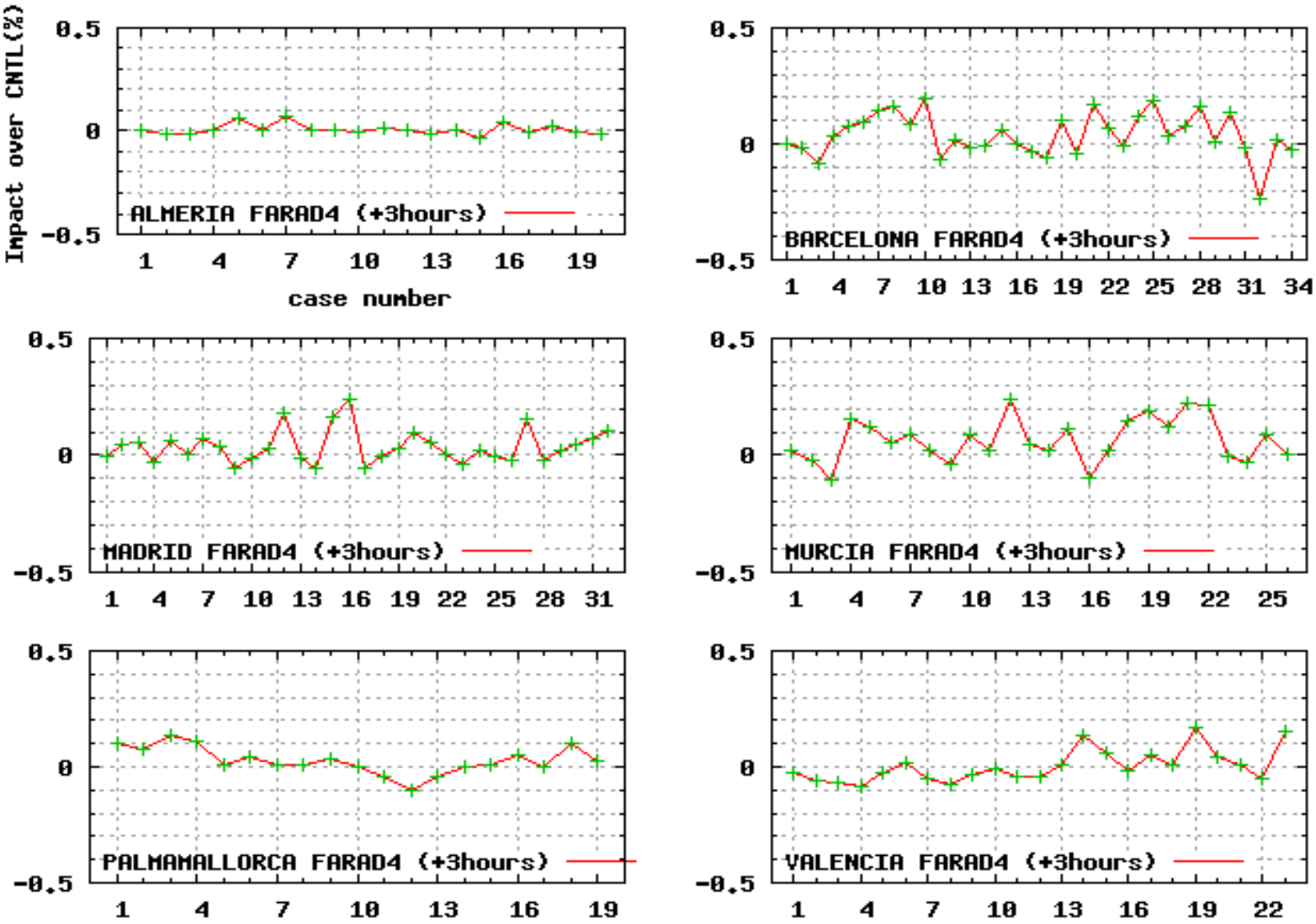
$$\text{Error} \equiv \langle (\text{Fcst} - \text{Radar})^2 \rangle^{1/2}_{\text{PPI=0.5}} + \langle (\text{Fcst} - \text{Radar})^2 \rangle^{1/2}_{\text{PPI=1.4}}$$

- **Results averaged over more than 150 cases (SOP-1 HYMEX):**



Assimilation of Doppler Wind Radar Data in HARMONIE

- **Case-by-case analysis of the Impact (+3Hours) :**



IMPLEMENTATION of RADAR FA in HARMONIE v38

Operational Verification

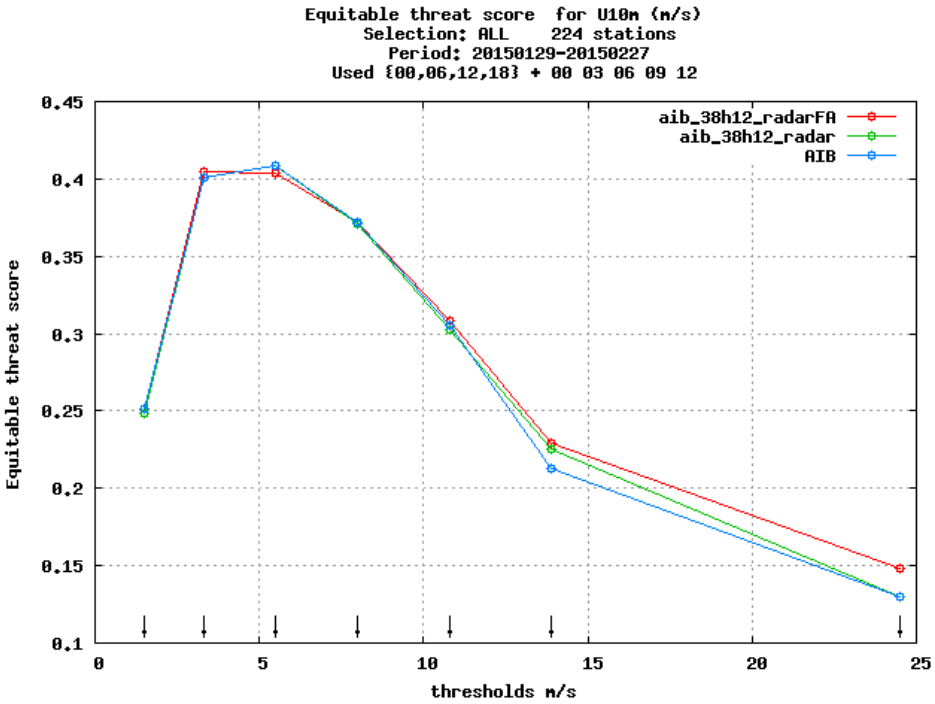
Thanks to Javier Calvo

Sample Size: 222 stations, 1 month (Feb 2015)

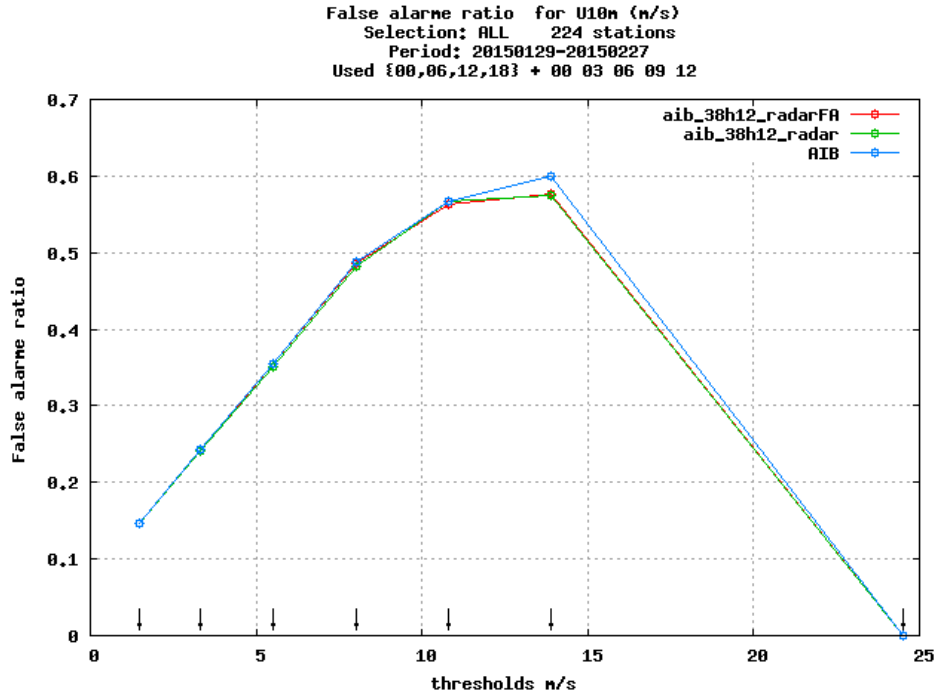
Parameter : 10m wind speed

Settings : FCST up to +12H, 3H cycle DA

EquitableThreat Score



False Alarm Ratio

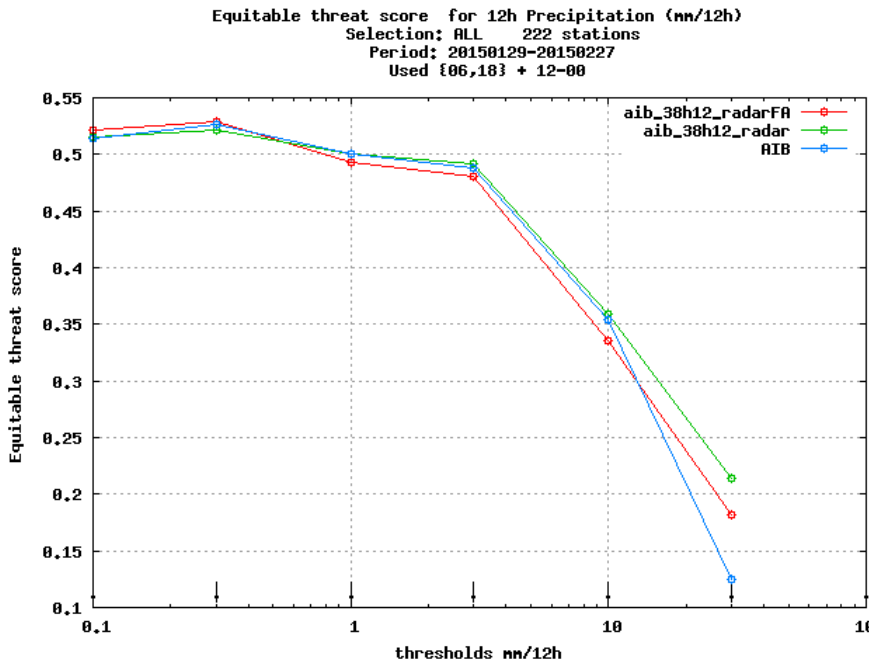


Operational Verification

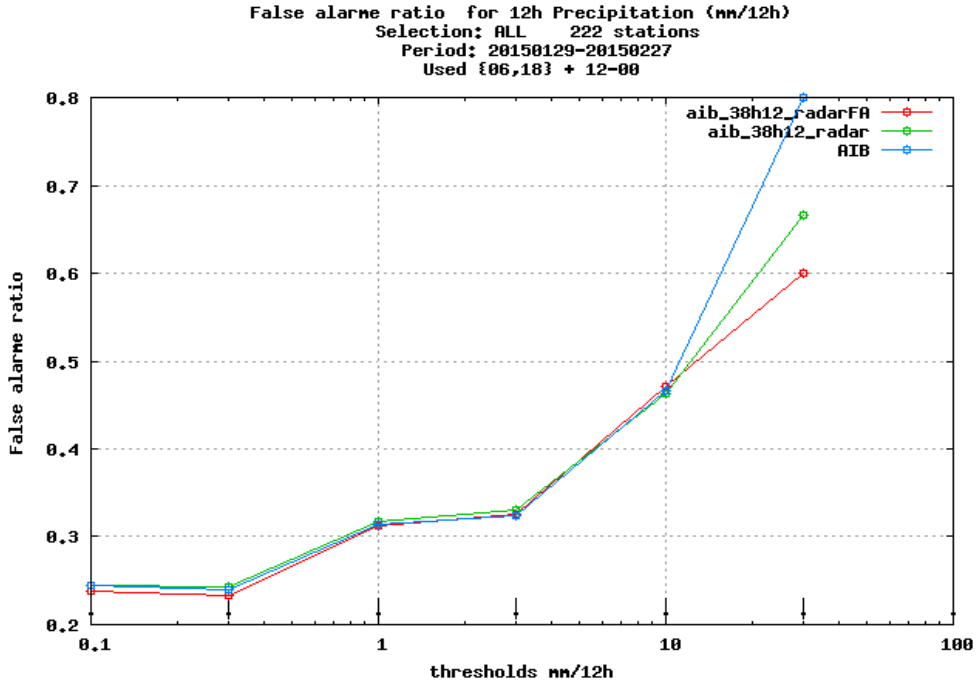
Thanks to Javier Calvo

Sample Size: 222 stations, 1 month (Feb 2015)
Parameter : Precipitation (mm/12H)
Settings : FCST up to +12H, 3H cycle DA

EquitableThreat Score



False Alarm Ratio



Today's conclusions

- The FA algorithm for radar DA has now reached a mature status and is ready to ready to enter in operations

- In the context of operational exploitation of radar data, the issue of radar data data QC is probably the most relevant issue still pending

- The method, as it is now implemented, has clear interest for NWP-NWC applications

- From the developer's point of view, it may be worth studying the way to take take advantage of this methodology in more sophisticated DA algorithms: 4DVar, 4DVar, 4DEnsVar, …

- Also the extension to other data sources (satellite) looks interesting

Mange Tak !