The 37th EWGLAM and the 22nd SRNWP Meeting

5-8 October 2015
Belgrade, Serbia

Data assimilation on convective scales in HIRLAM consortium : the status and the challenges

Jelena Bojarova & the HIRLAM team on DA&UO

+

= HARMONIE

Outlook

The goal

Code architecture + code maintenance

Integrated variational data assimilation system

future

Scale-dependent analysis/data assimilation

Flow-dependency: (L)ETKF, (3D/4D)EnVar

Initialisation/meso-scale balances

Large scale error constraint

Advanced surface data assimilation/
Use of low-peaking channels

research

A very short range forecasting applications :
1h 3DVAR RUC/RR, 1h 4DVAR

Field-alignment for radar data

Cloud mask initialisation

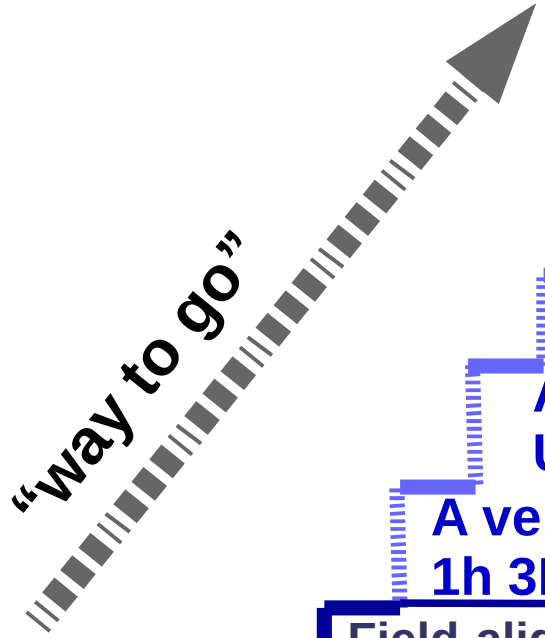
Impact studies/combined use of high-resolution observations

HARMONIE AROME 2h 4DVAR => more high-resolution observations

on-going

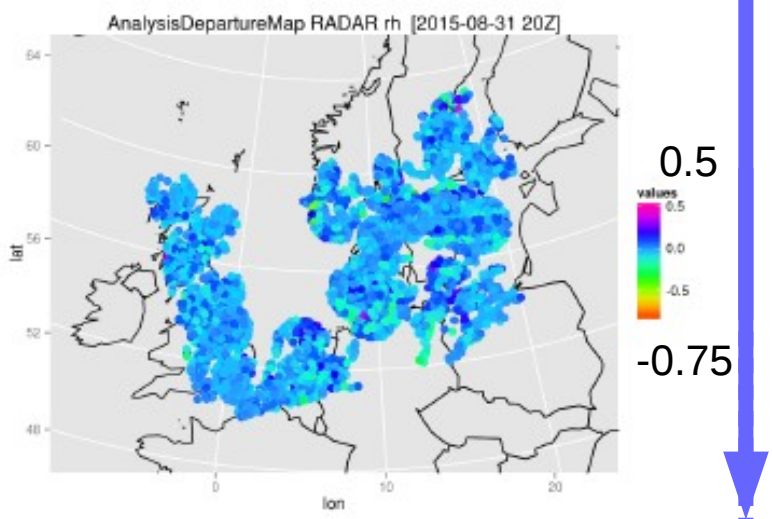
HARMONIE AROME 2.5km 3h 3DVAR + high-resolution observations in operational/pre-operations setup (IASI, ATOVS, ATMS, GPS-RO, ZTD GNSS, radar data (reflectivities, radar winds), Mode-S, scatterometer winds, conventional).

default



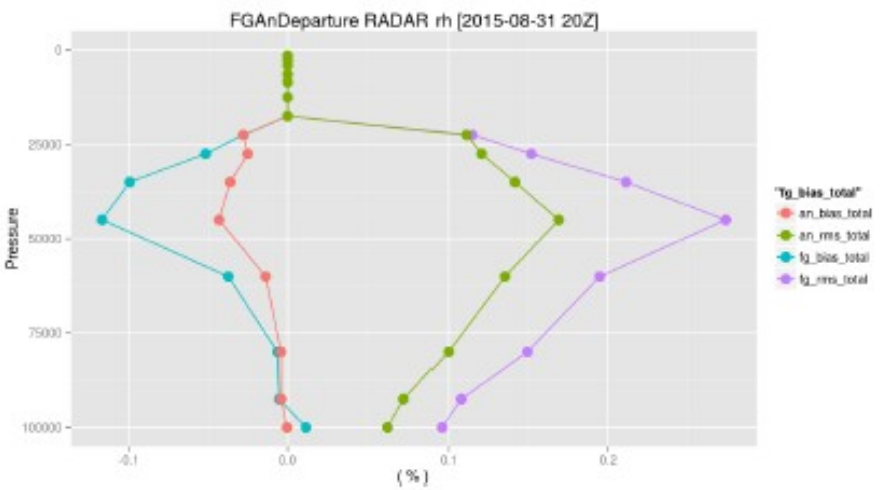
Use of high-resolution observations : radar data

Radar data transmitted via the BALTRAD “life feed” - the infrastructure demonstration project (SMHI) “awaiting OPERA functionalities ”



0.5

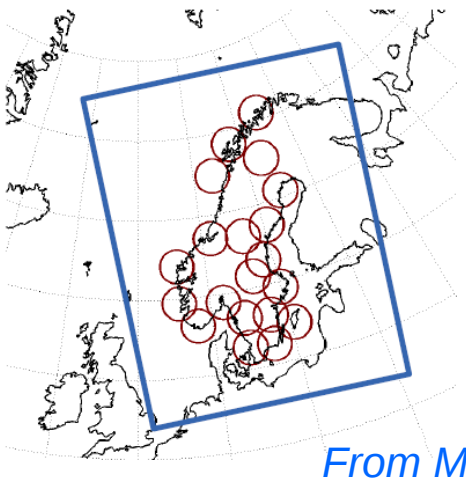
-0.75



an_bias
an_rms
fg_bias
fg_rms

From Mats Dahlbom (DMI)

Radar reflectivity from ~10 countries in b-suite at ***DMI***, radar winds in next parallel suite;



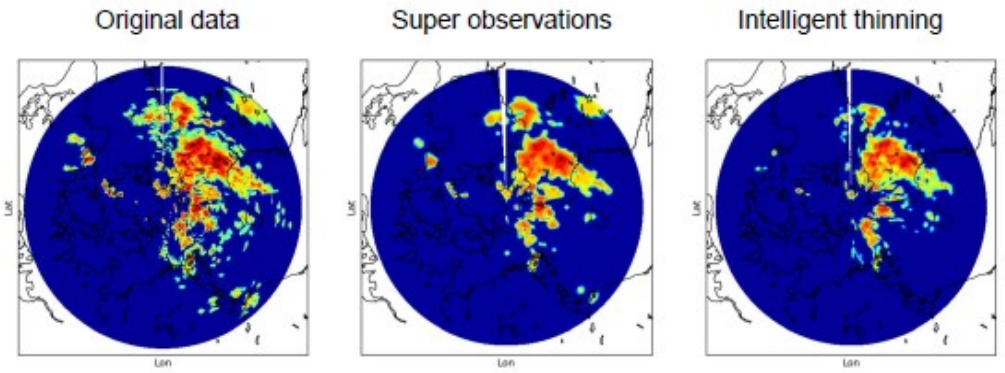
Operational assimilation of the radar data at MetCoOp since 16th of June 2015

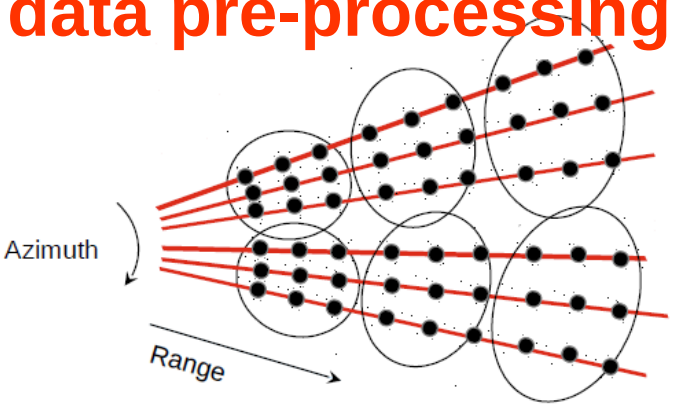
(different preprocessing at SMHI and MET Norway)

"inhomogeneities" in format for data coming from different countries *(... whole volume data/individual PPI/ radar winds with different elevations and scanning angles than reflectivities/...)* complicate assimilation of data

From Martin Ridal (MetCoOp/SMHI)

Use of high-resolution data : Radar data pre-processing



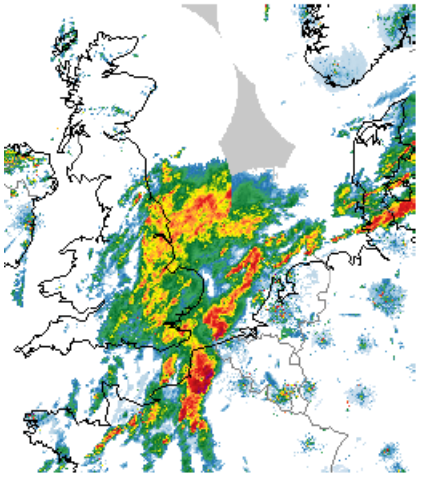


Use of super-obbing (polarmetric projection) instead of thinning reduces humidity bias

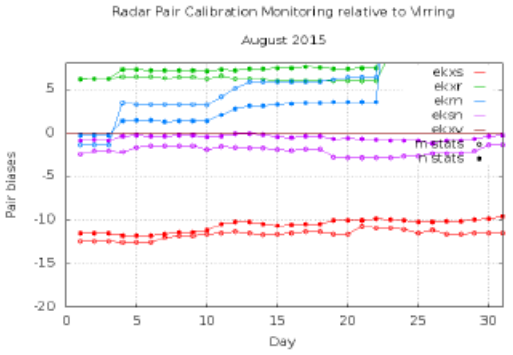
More advanced quality control (radial winds !) and motoring are needed.

Inhomogeneous radar data network (varying signal-to-noise ration) induce artificial signals

An example

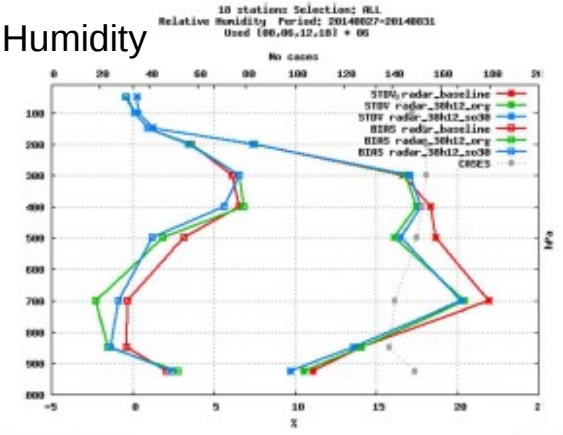


Quality Issues



From Mats Dahlbom (DMI) & Martin Ridal (SMHI)

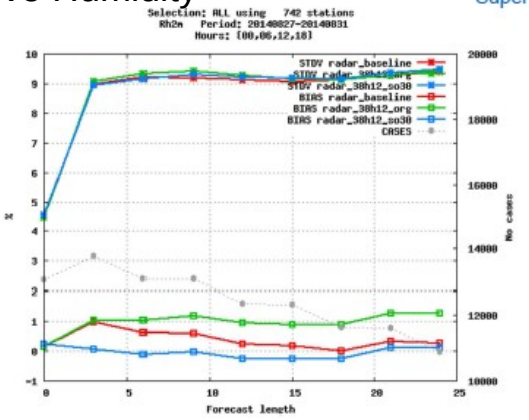
Relative Humidity



2 m relative humidity

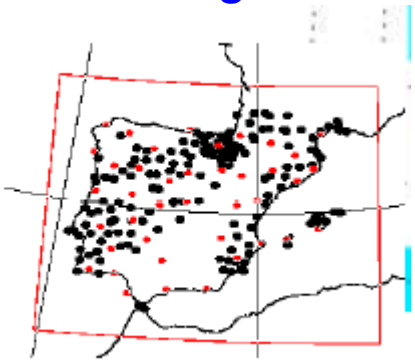
2m Relative Humidity

Baseline
Old thinning (blind)
Superobservations



Use of high-resolution data : ZTD GNSS

VarBC + thinning + tuning of DA system



Jana Sanchez Arriola et al

✓ **STATIC Bias Correction**

ob=ob-bias, *bias =cte, calculated from o-b from the passive run of the month before*

✓ **VARIATIONAL Bias Correction (VBC)**

-One single predictor: offset value

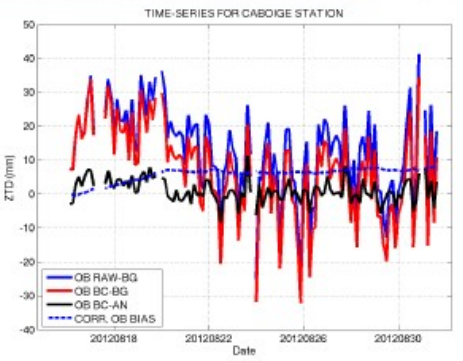
Time-serie from GNSS ZTD at CABOIGE_ :

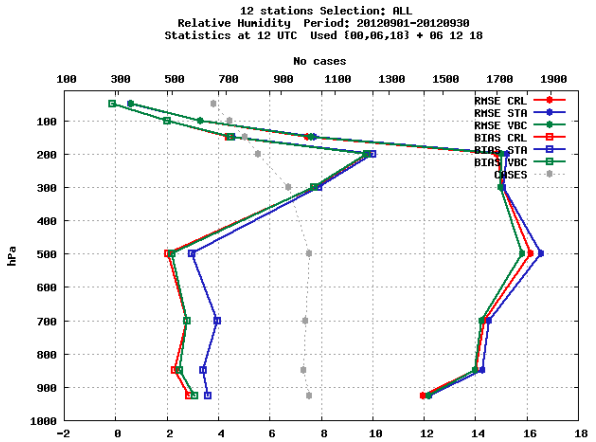
ob-bg departure before and after VBC

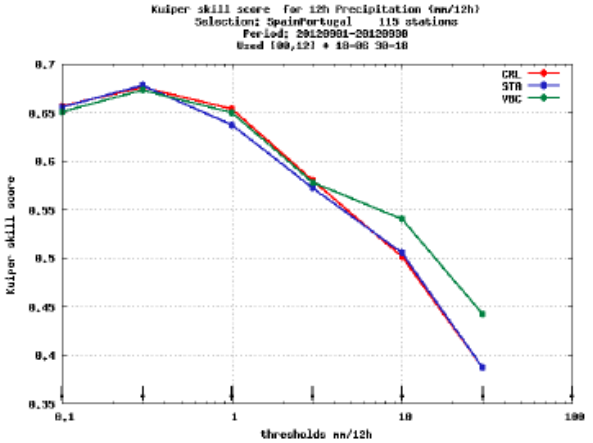
--- Estimated ob bias to be corrected

Bias corrected ob-an departure

ASM 2015, Copenhagen.

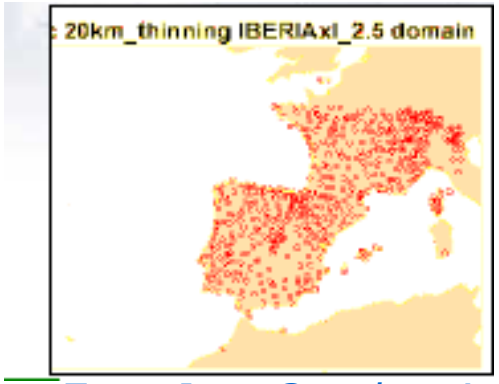






– assimilation of ZTD GNSS improves short range weather forecasts both in statistical sense and in the individual case studies

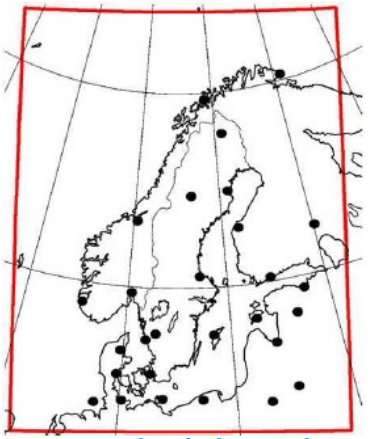
One month verification period: 1-30 September 2012



From Jana Sanchez Arriola (AEMET)

Operational in MetCoOp
since 17 Feb 2015

Pre-operational in large Iberian domain

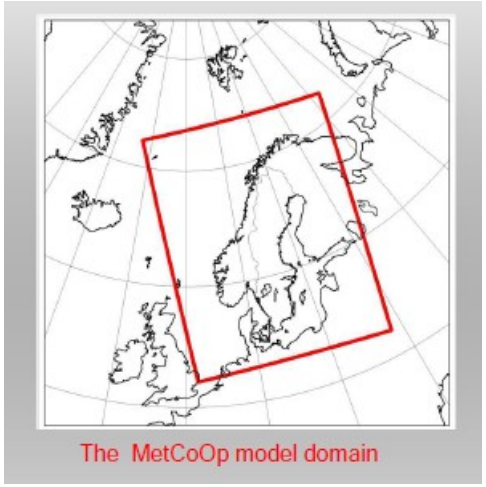


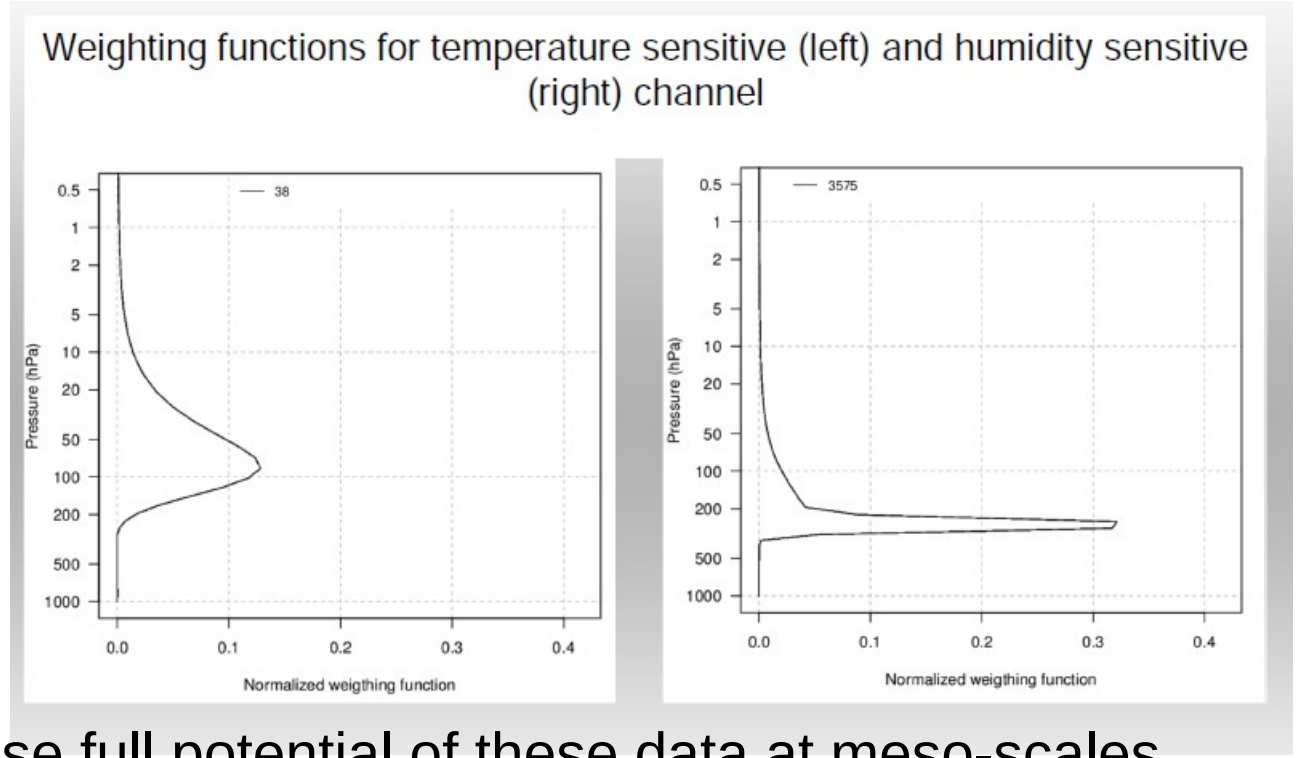
Magnus Lindskog (MetCoOp/SMHI)

ROBH, METO
+
More NGAA data (in progress)

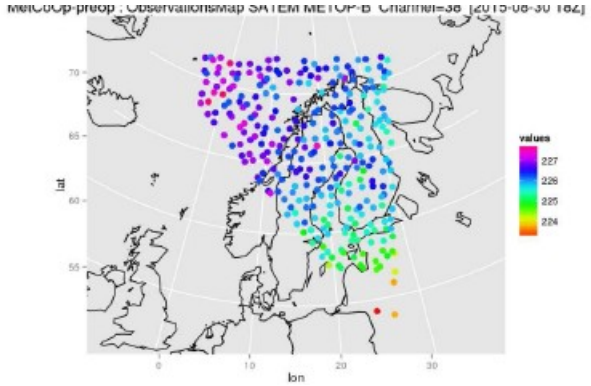
Use of high-resolution data : IASI data

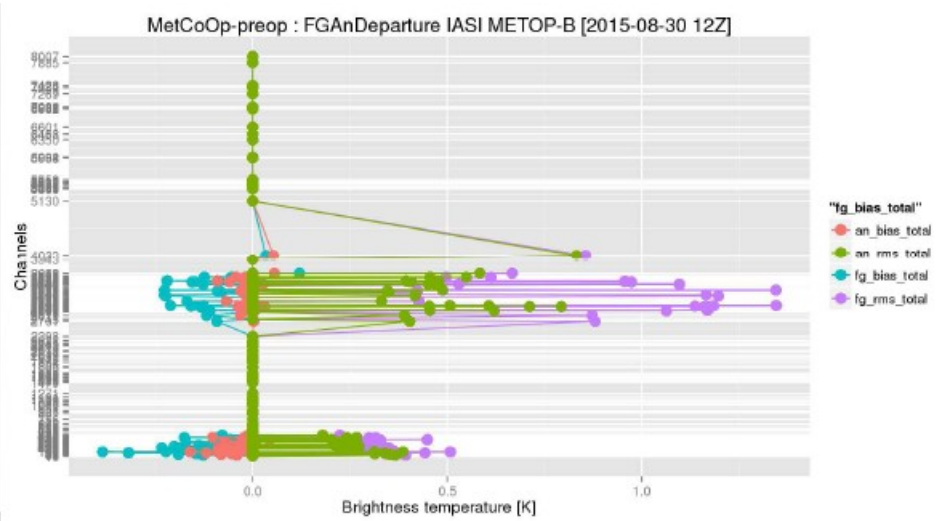
Active in pre-operational run since 15th of August 2015





Still a lot to be done to use full potential of these data at meso-scales
(low peaking channels !)



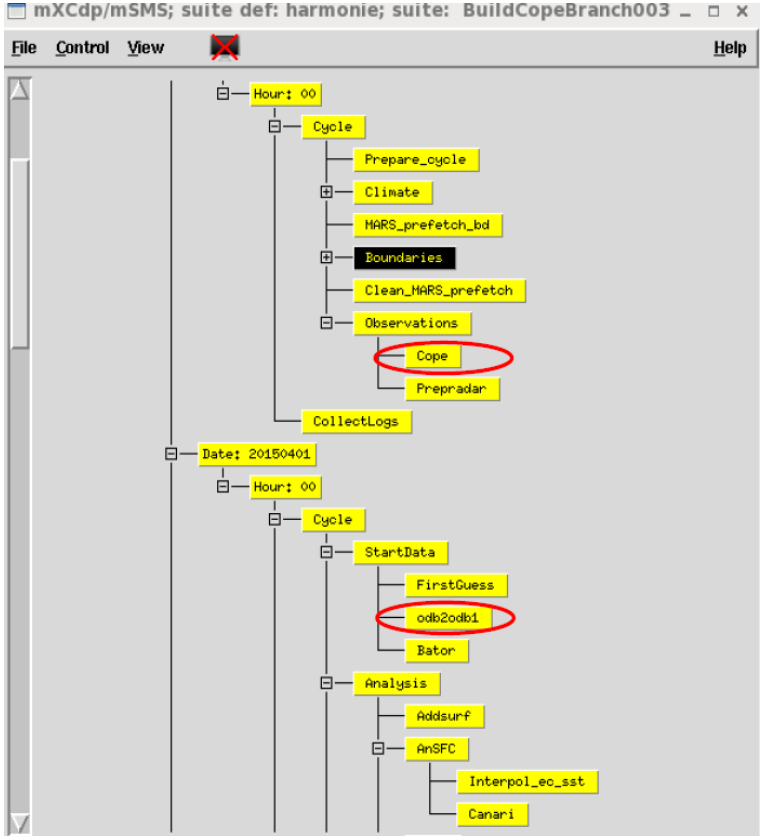


Extensive monitoring is essential!

From Magnus Lindskog and Roger Randriamampianina (MetCoOp)

Use of high-resolution data : COPE pre-processing

COPE:
Continuous
Observation
Processing
Environment

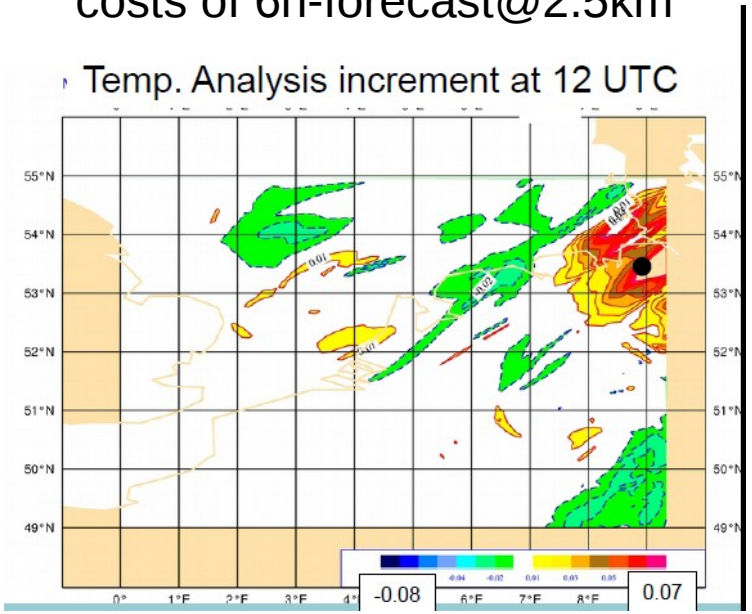


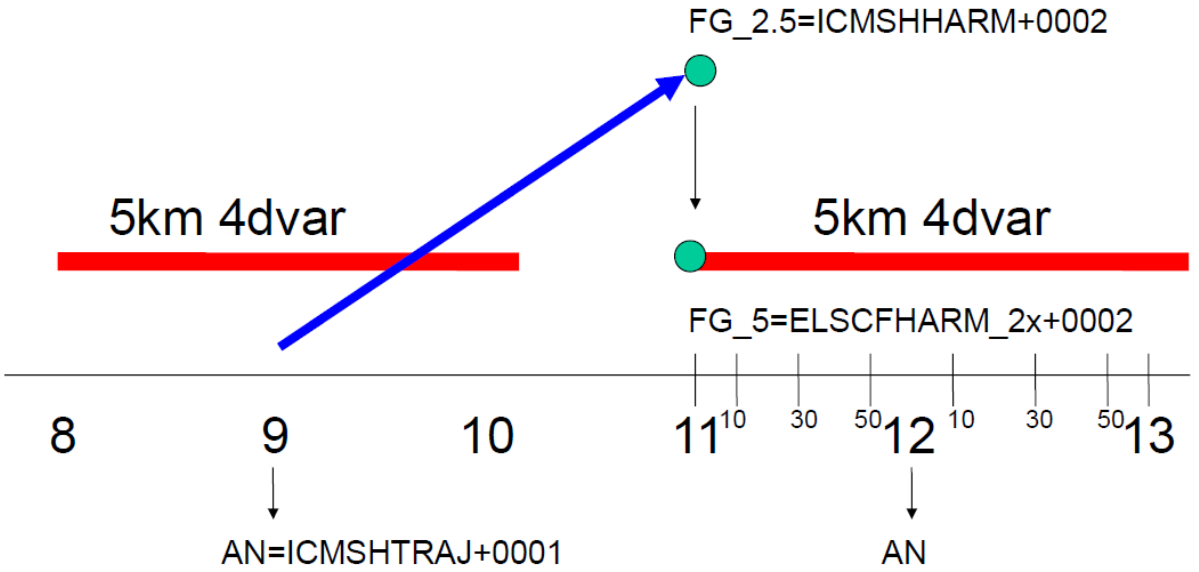
- Components for a quasi-continuous obs processing
- More scalable and timely observation processing
- COPE will facilitate a more transparent framework for observation processing
- Allow external partners to collaborate and share observation processing components.

COPE Team: Eoin Whelan (MetEireann), Mats Dahlbom & Bjarne Amstrup (SMHI)

Baseline algorithmic development : HARMONIE AROME 4DVAR

- Inner loop at 5km
- Assimilation window 2 hours
- Update frequency 3 hours
- Observation window 20 minutes
- Hydrostatic non-linear run and simplified linear physics
- Observation set : conventional + Mode-S EHS
- Costs of 4DVAR@5km order of costs of 6h-forecast@2.5km





Encouraging results!
– improved verification scores for wind speed and wind direction biases
– improved verification scores for 3h accumulated precipitation and specific humidity profiles.

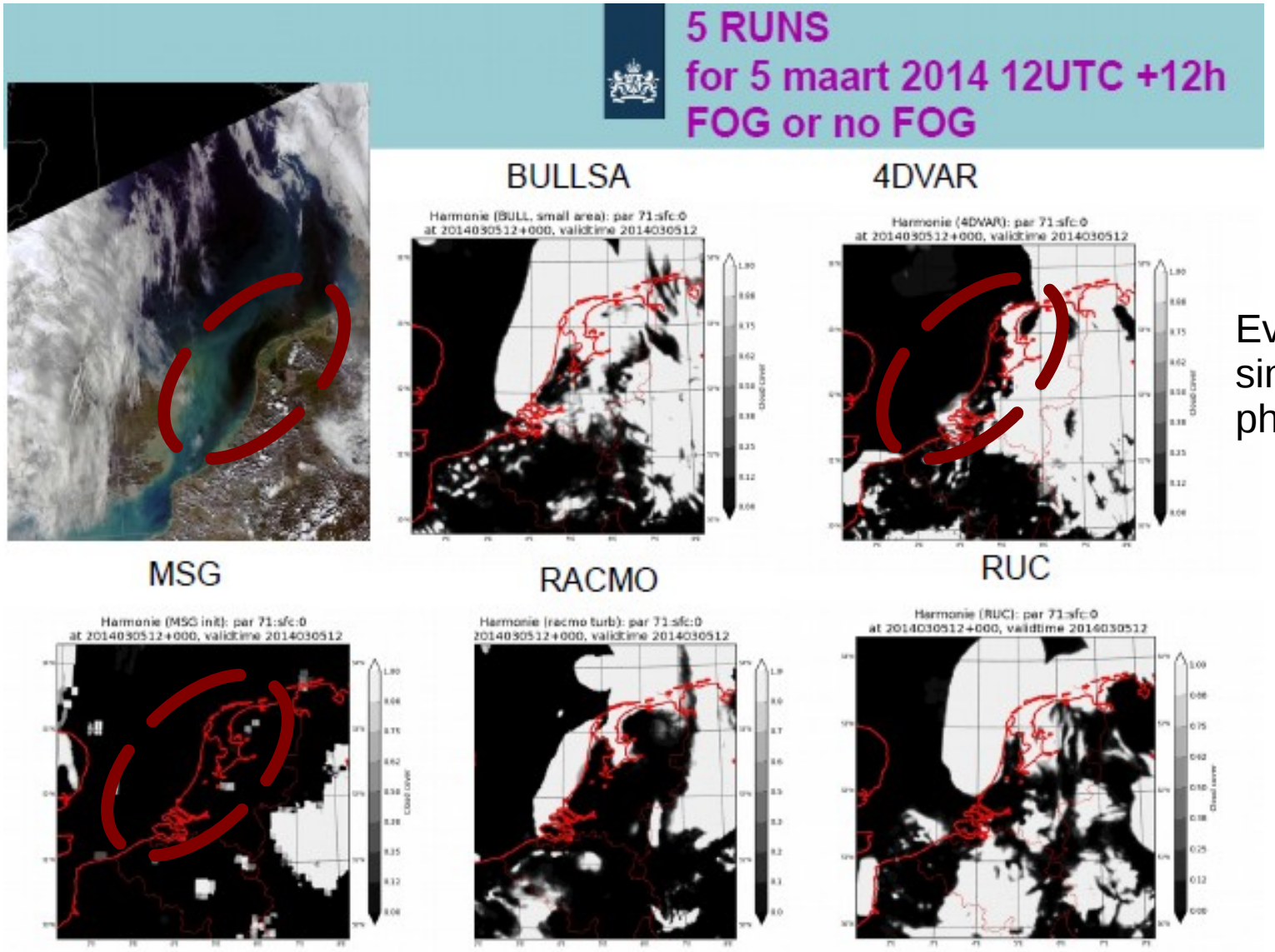
More high-resolution observations !

Jan Barkmeier et al

Baseline algorithmic development : “artificial fog problem”

MSG – cloud mask initialisation scheme which allows to induce “physically” consistent moist balances and removes the artificial fog

Encouraging results with HARMONIE AROME 4DVAR !

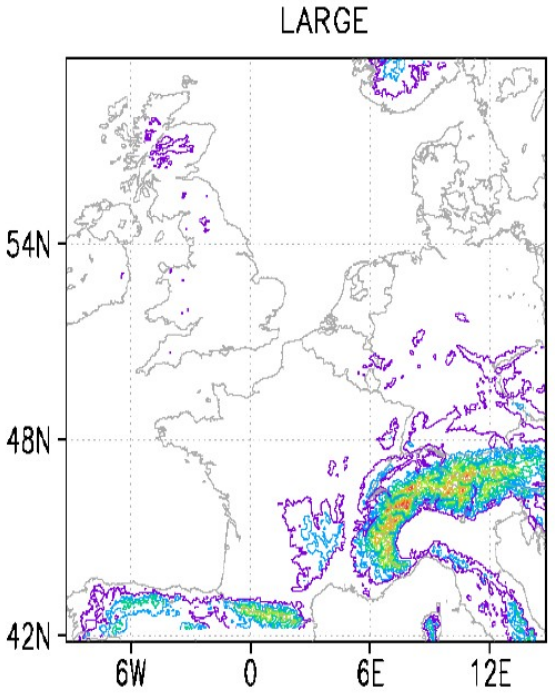


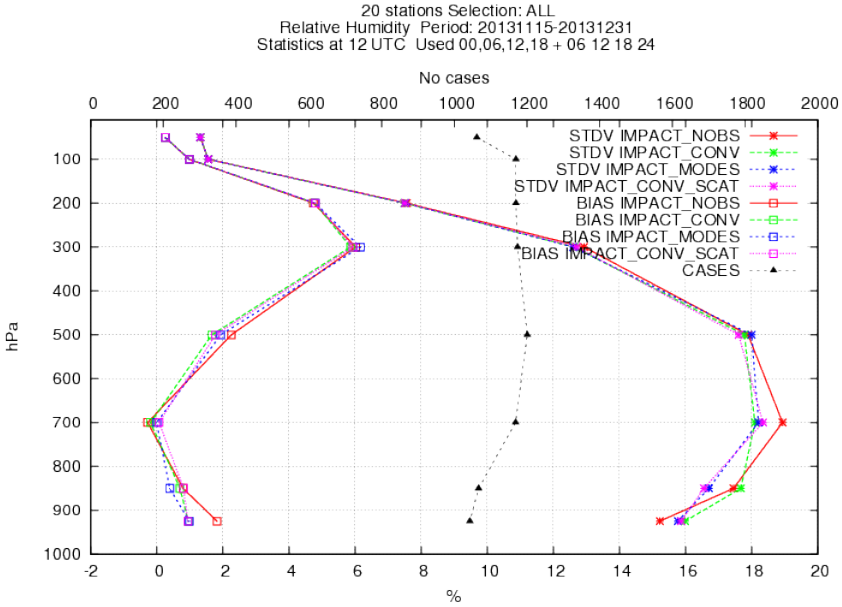
Even very simple linear physics helps!

From Sibbo van der Veen & Jan Barkmeier (KNMI)

High-resolution observations impact studies

- Systematic evaluation of the added value from different observation types and development of validation/verification tools
- Tuning of the data assimilation system for combined use of observations

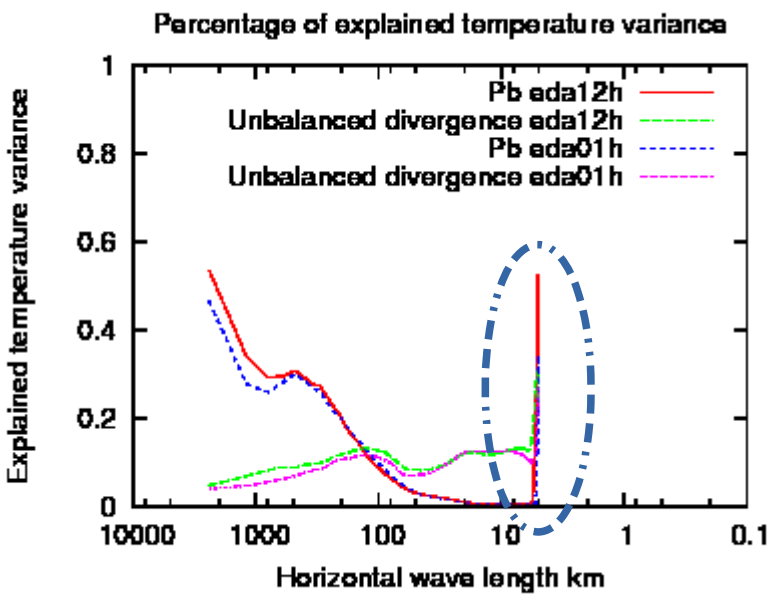


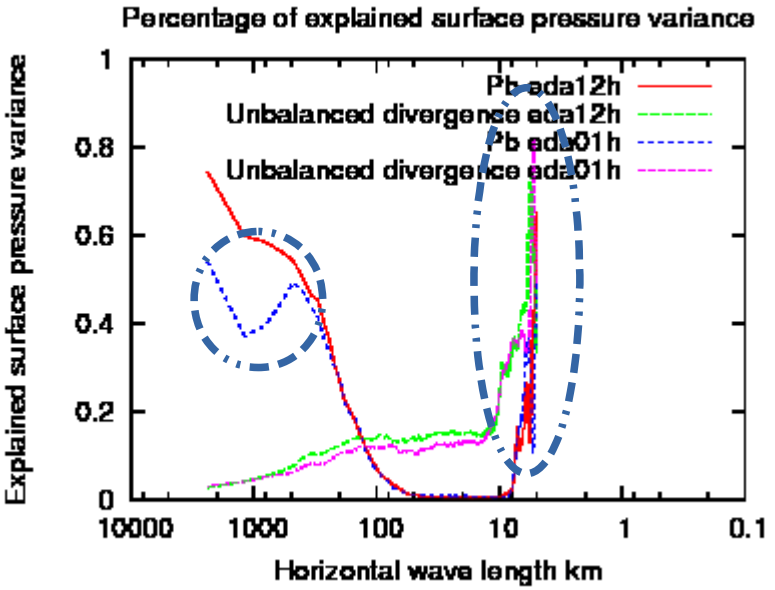


No observations	(3D-Var) - finished
Conventional obs.	(3D-Var) - finished
Conventional obs. and MODE S	(3D-Var) - finished
Conventional obs. and SCAT	(3D-Var) - finished
Conventional obs. and MODE S	(4D-Var) - running
Conventional obs. and Radar data	(3D-Var) - running
Conventional obs. and MSG cloud masking	(3D-Var) - planned

Gert-Jan Marseille et al (KNMI)

Systematic deficiencies: analysis of structure functions





1) Obvious 2Δx problem

2) Destructed statistical balances at large scales due to data assimilation

3) Aliasing of high-order terms on 2Δx, 3Δx, 4Δx, 5Δx waves

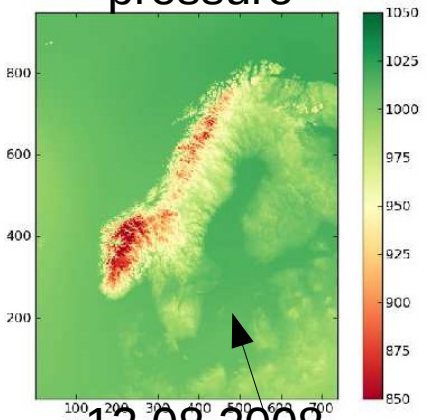
- Numerical noise due to “linear grid” and non-linear model interactions => aliasing of higher-order terms on the shortest waves. **Modelling of processes on the scales below 12.5 km for 2.5 km AROME should be interpreted with care** (=> experimentation with a cubic grid)
- Destroyed geostrophic balance at large scale by data assimilation (WHY?! => model climate and observations climate do not match) => **Constrain Large Scale Error!**
- Inserted surface pressure signal leaves domain on a speed of gravity way => **revisit Initialisation at meso-scales**

Nils Gustafsson et al

Climatological structure functions

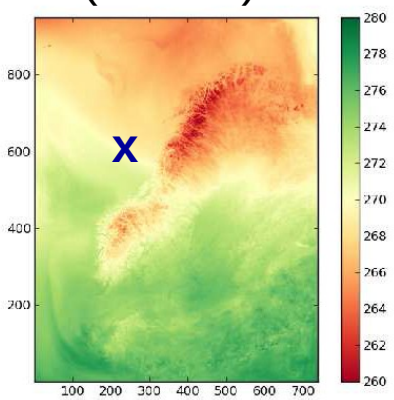
6 EDA-based HarmEPS AROME 2.5 perturbations 06UTC + 12h

Surface pressure



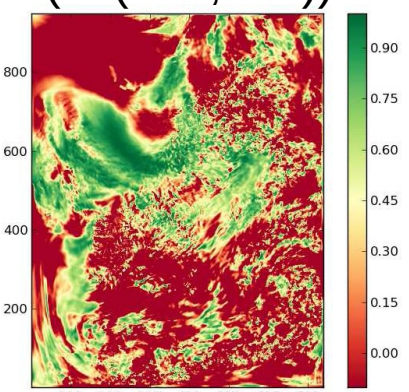
12 08 2008

Temperature (control)

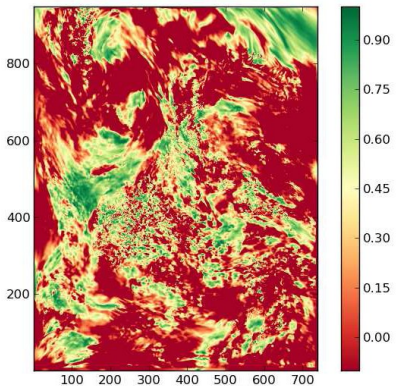


12 08 2008

Correlation to a single point (x=(235,595))

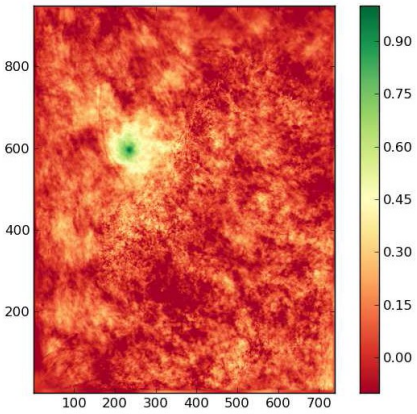


12 08 2008

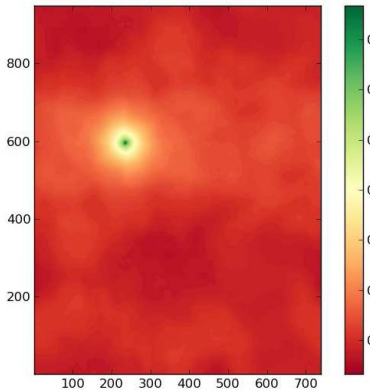


18 08 2008

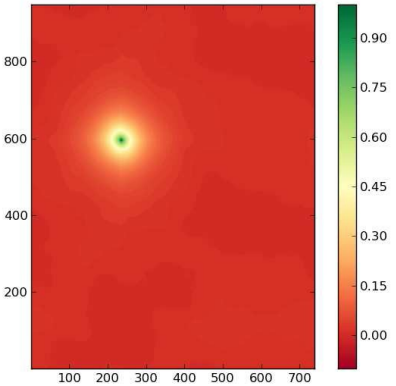
Correlation to a single point (x=(235,595))



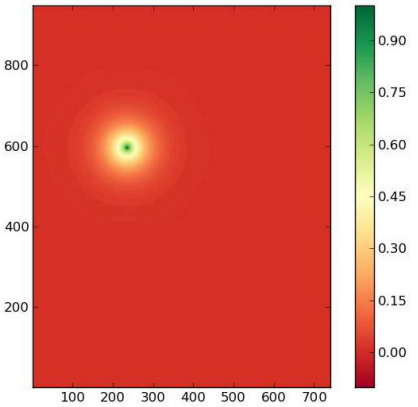
Average over 25 cases



Single case + homogeneity



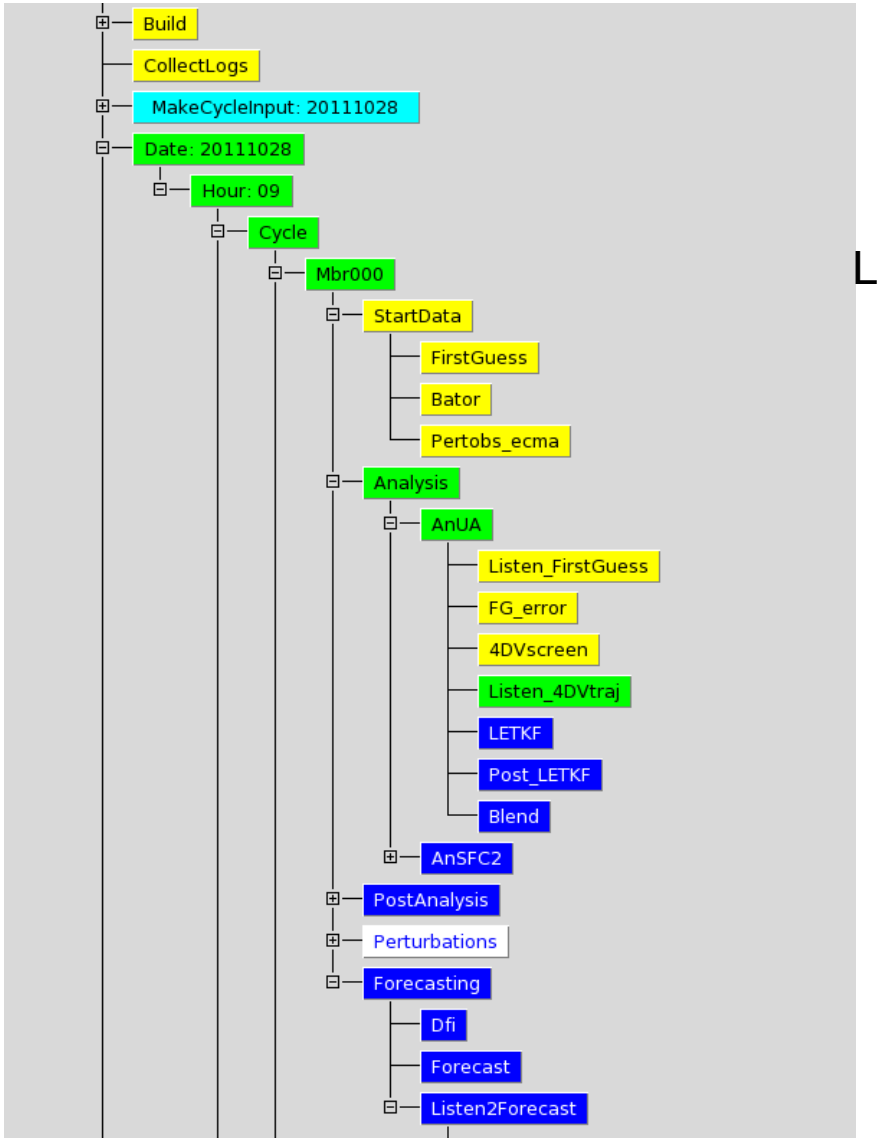
Average over 25 cases + homogeneity



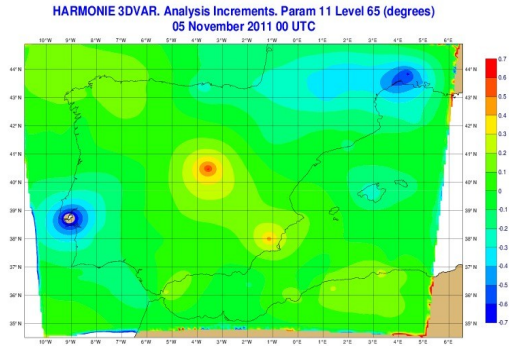
Single case + Homogeneity + Isotropy

Family Corporation (Nils & Jelena)

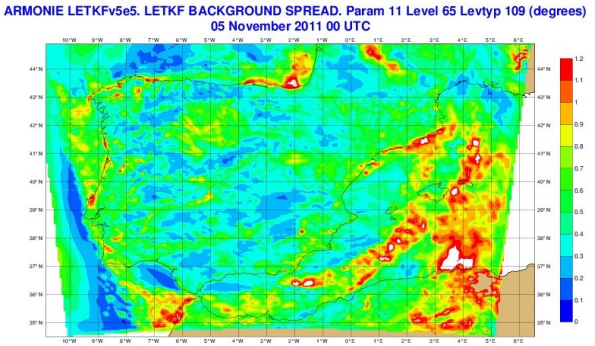
Flow-dependent data assimilation : HARMONIE LETKF

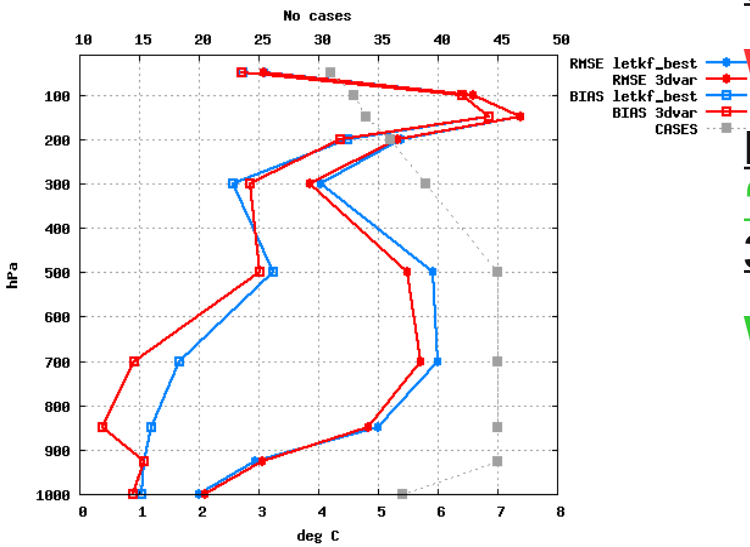


3DVAR



LETKF





Scheme is under development :
Problems with small ensemble spread at certain areas and imbalances

LETKF "better" than 3DVAR:

WD00, Q, RH, TD00

LETKF "worse" than 3DVAR:

WD12, TD12

LETKF "equals" 3DVAR:

WS, Z, T

From Pau Escribá (AEMET):
THANKS To Mats Hamrud (ECMWF) !

Stand alone development : Field alignment for radar data

Full integration into HARMONIE-AEMET dally run schedule (x8) @ ECMWF with other UA observations and surface analysis

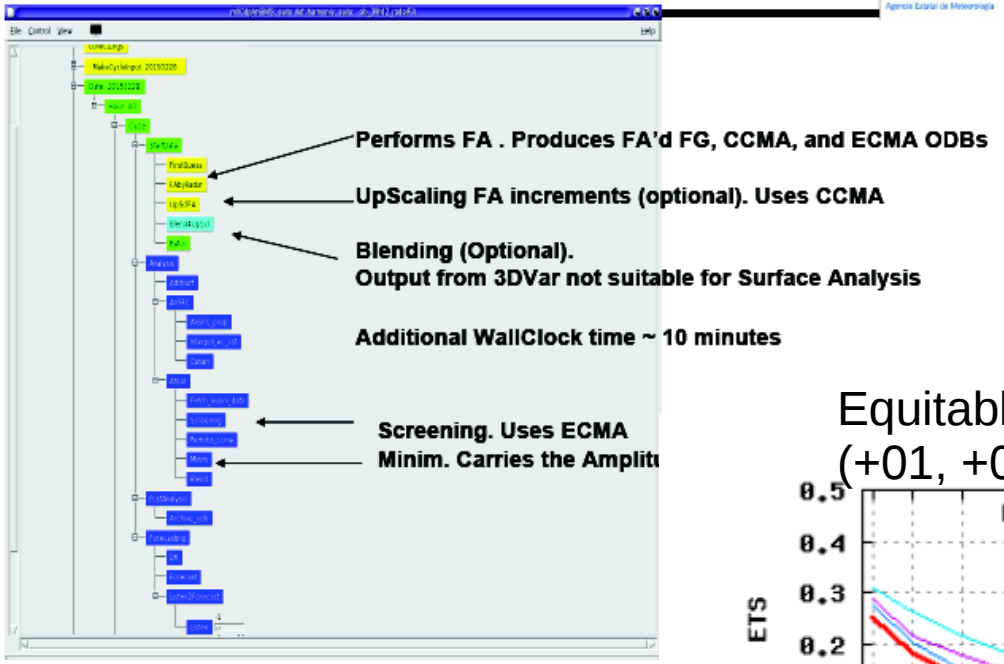
Two "modes"

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)

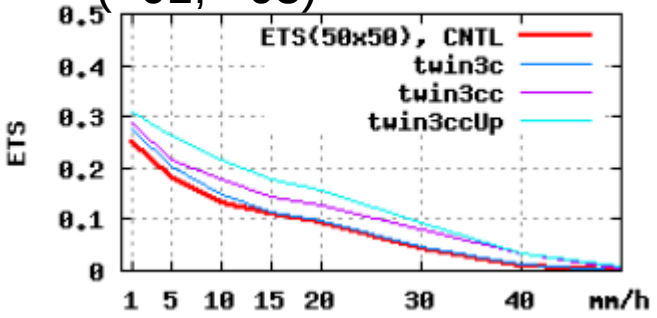
Steps in red use the 3D-Var algorithm (B matrix)



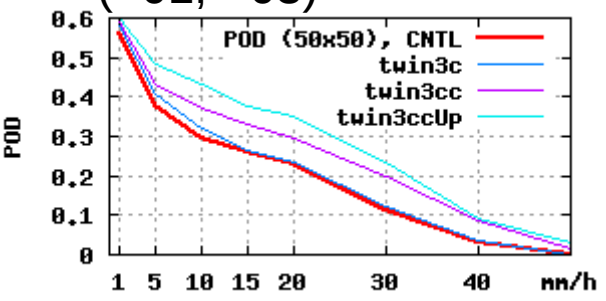
From Carlos Geijo (AEMET)

– currently implemented in CY38;
– has clear potential in NWP-NWC applications
– the extension to other data sources looks interesting

Equitable Thread Score (+01, +03)

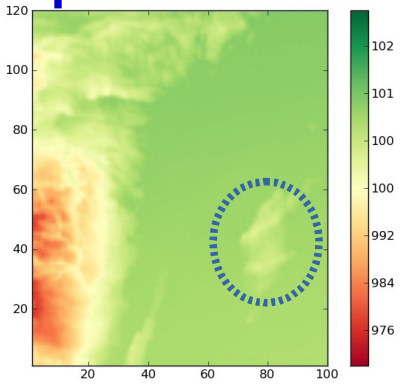


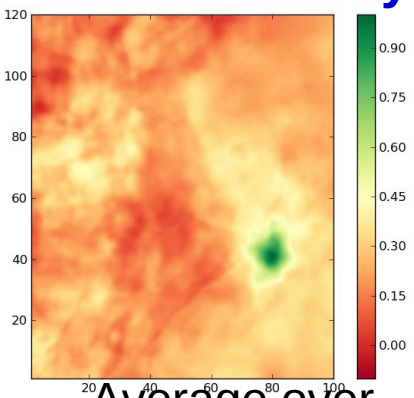
Probability of Detection (+01, +03)



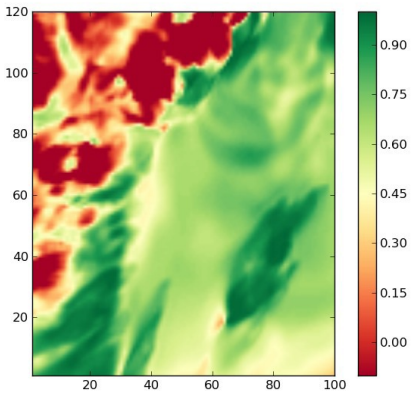
Future : Gotland revisited! (6 HarmonEPS perturbations 06UTC + 12h)

Strong response on the orography forcing (orography is not a stochastic process in itself!) => **high potential of HarmonEPS representing convective scale phenomena in particular driven by surface and PBL**

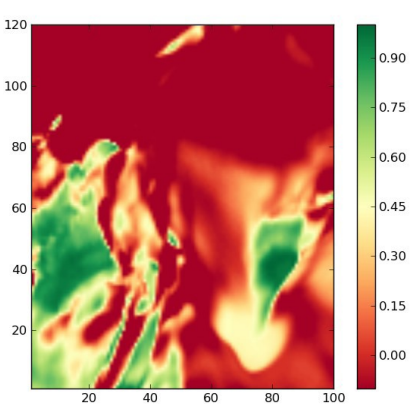




Average over 25 cases

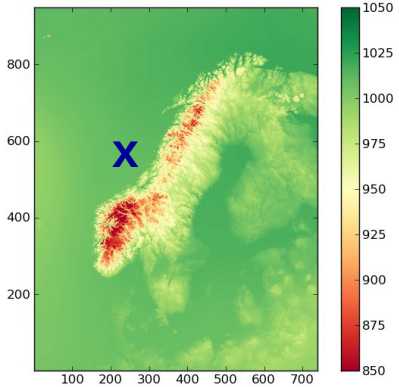


12 08 2008

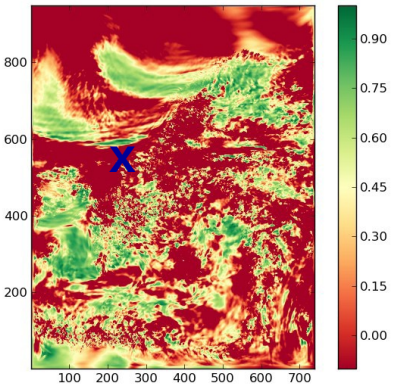


21 08 2008

Avoid averaging and homogeneity assumptions => Sample uncertainty and filter out noise! Localisation on prescribed scales are damaging for data assimilation (try scale-dependent localisation)



Surface pressure



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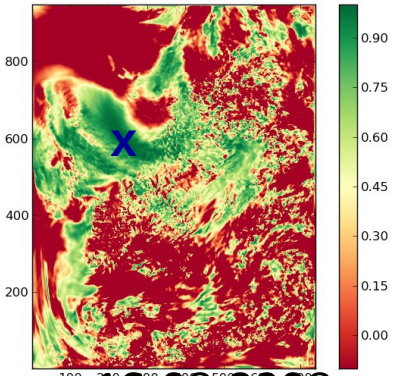
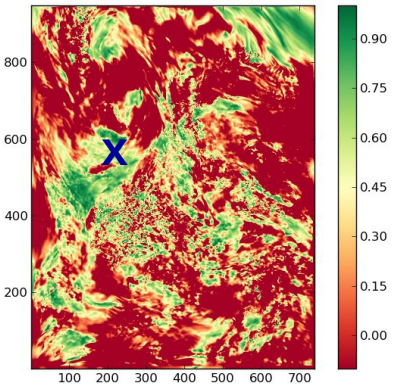


12 08 2008

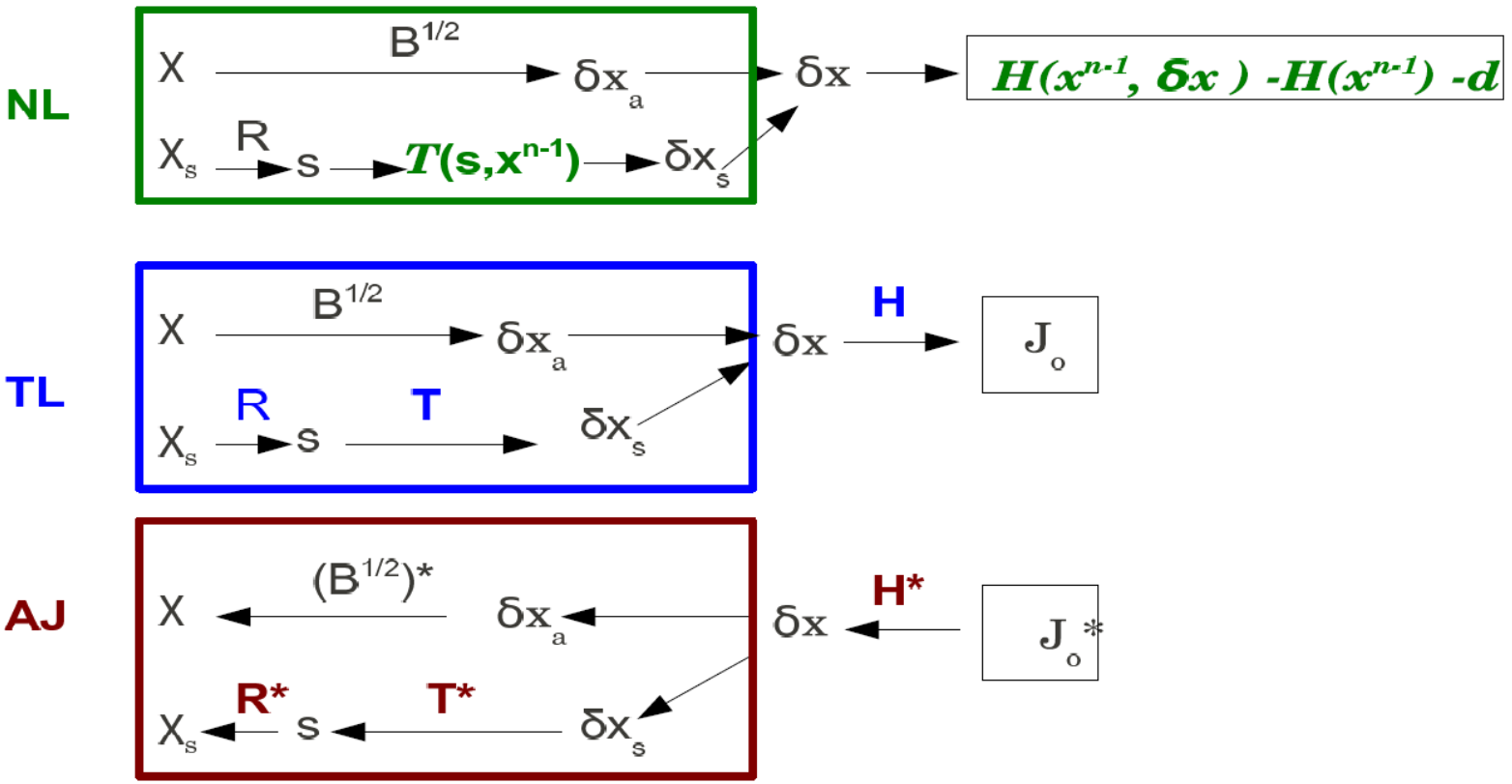


18 08 2008

Family corporation (Nils & Jelena)

Future : Unified variational data assimilation framework

Extend variational data assimilation with additional optimization constraints and a non-linear change of variable and use an "outer-loop" device to integrate stand-alone algorithmic developments into the unified assimilation framework



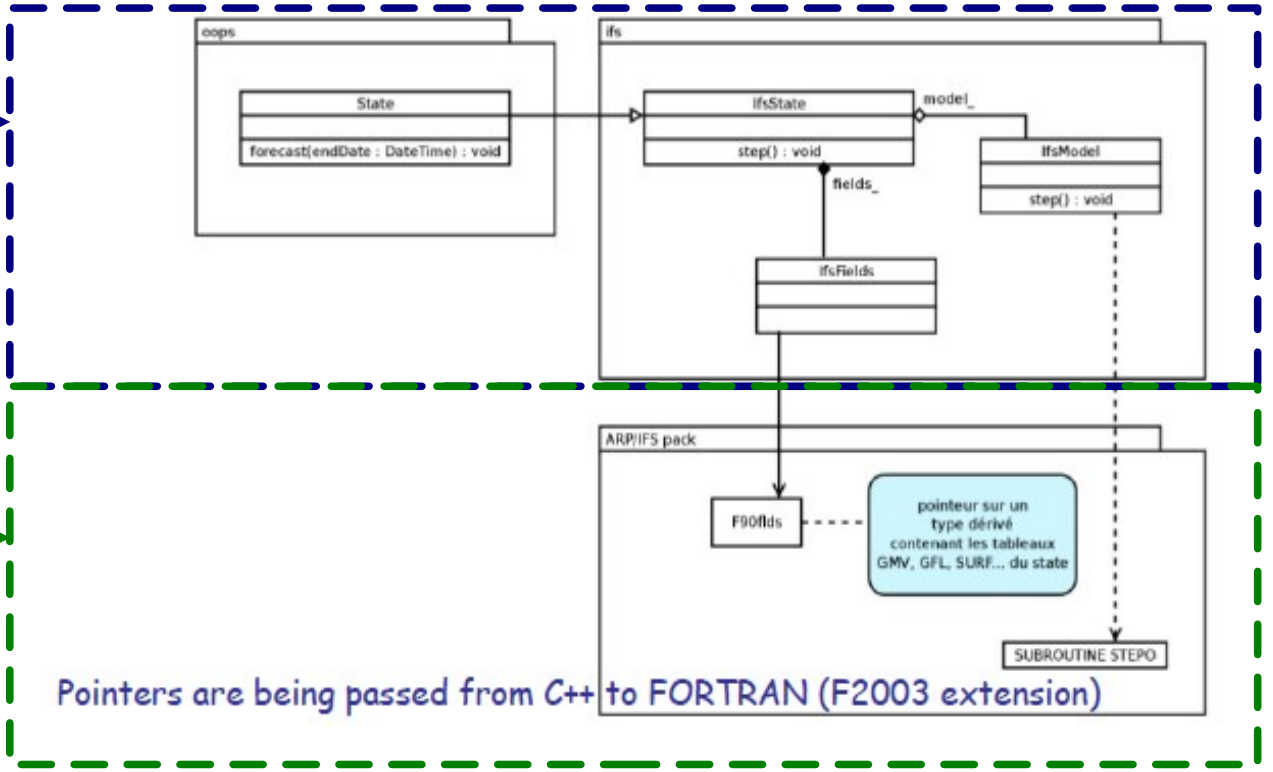
Proof-of-concept : Nehrkorn et al, 2015, "Correcting for Position Errors in Variational Data assimilation, Monthly Weather Review, 143, 1368-1381"

Future : OOPS

HARMONIE system is based on code system jointly developed by ALADIN and HIRLAM consortia and which shares common environment with IFS

Administrative C++ level

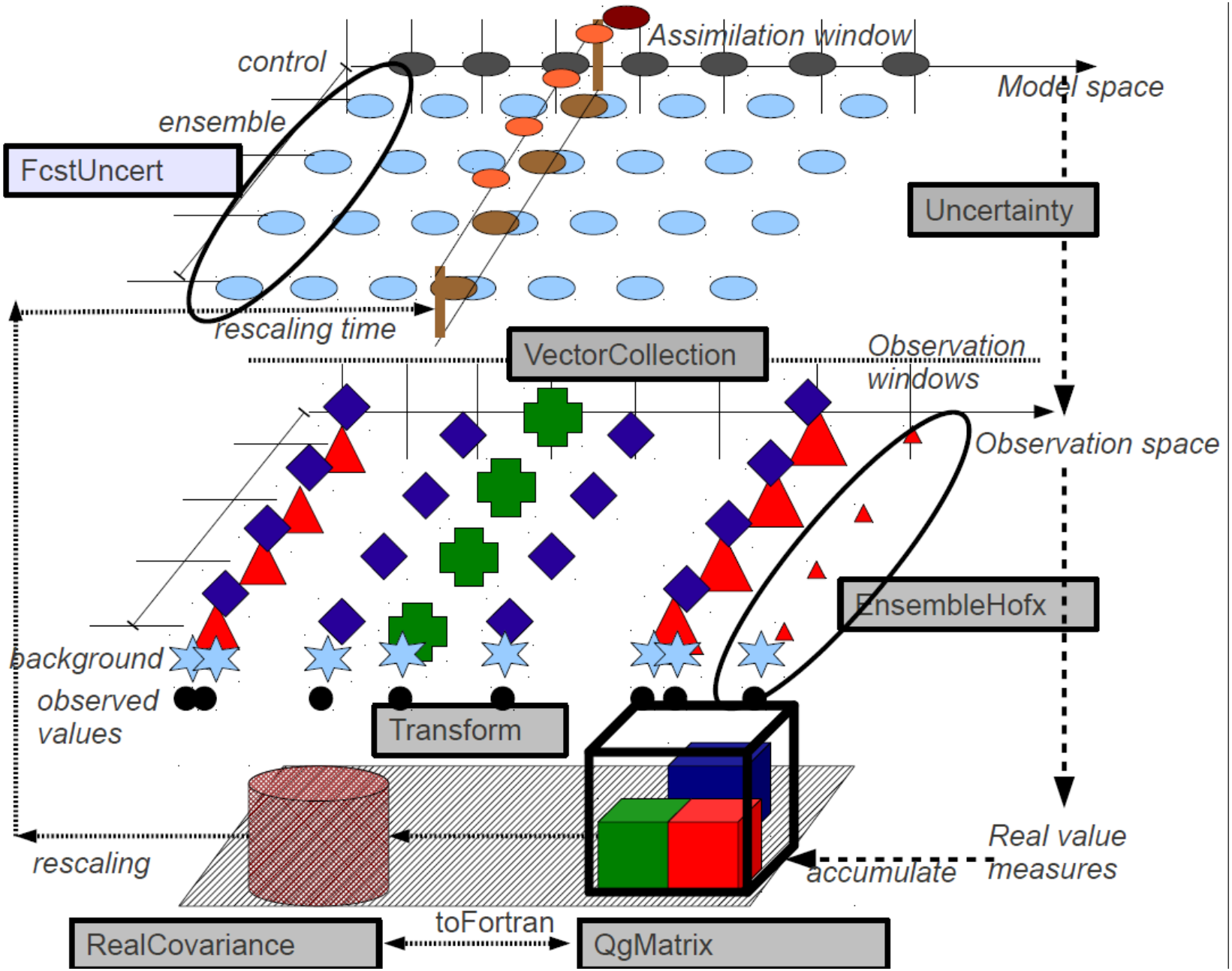
Low level scientific Fortran code



- OOPS (Object Oriented Programming System) environment provides the framework not only for code development but also for code design and code maintenance.
- Discussions between ECMWF and the ALADIN-HIRLAM partners about C++/OOPS code design, architecture and maintenance are on-going

From Claude Fischer (MF)

Future :
OOPS design of the ETKF-based rescaling scheme



From Jelena Bojarova (MET Norway/SMHI)

There is no elevator to the success....

YOU WILL HAVE TO TAKE THE STAIRS !