



Meteorologisk
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*The status and the short term plans
on data assimilation activities in
HIRLAM*

EWGLAM/SRNWP Meeting
10-13 October, Tallinn, Estonia

Jelena Bojarova
(with the dedicative and enthusiastic help of all others)



Powerful and flexible research tool
designed for synoptic scale systems

HIRLAM (HIgh Resolution
Limited Area Model)

ECMWF IFS (Integrated
Forecasting System)

ALADIN (Aire Limitée Adaptation
Dynamique Développement InterNational)

The goal: move operational activities here
but is still under development

HARMONIE (*Hirlam Aladin* Regional/Meso-
scale Operational NWP In Europe)



HIRLAM research:

a number of scientific research topics has reached a mature stage !!! (are published, in review or will soon be published).

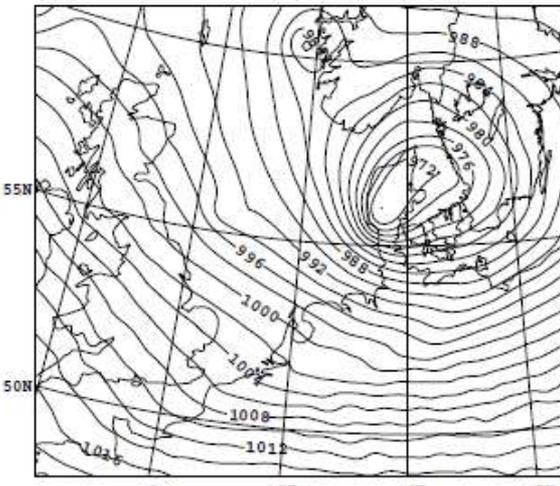
Emphasis:

- ✓ flow-dependent data assimilation methods for upper air;
- ✓ novel approaches toward initialisation of small-scale processes
(RUC;
improved precipitation forecast;
towards assimilation of cloud observations)
- ✓ surface modelling and data assimilation

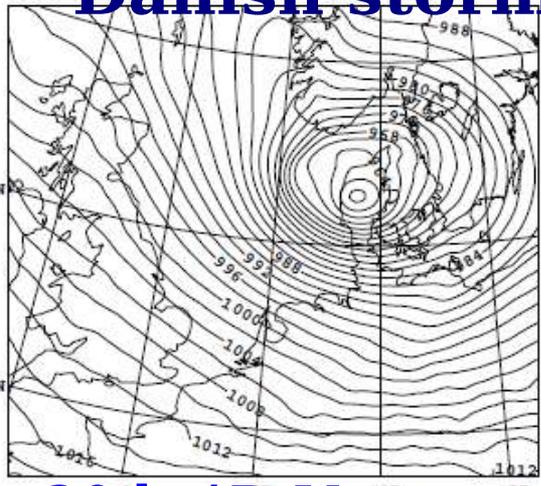
HIRLAM 4D-Var paper (Gustafsson et al., submitted)



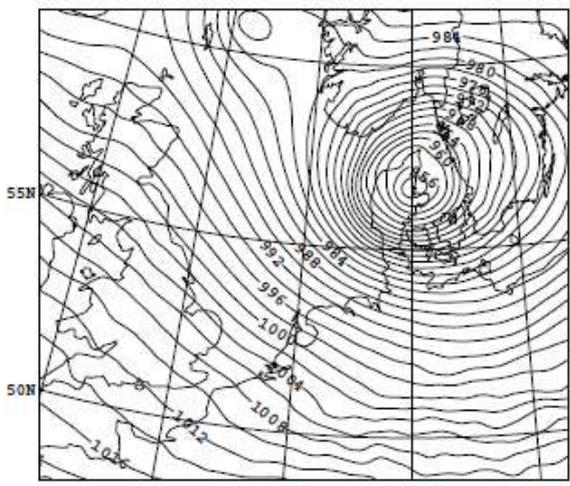
Danish storm



+30 h 3D-Var

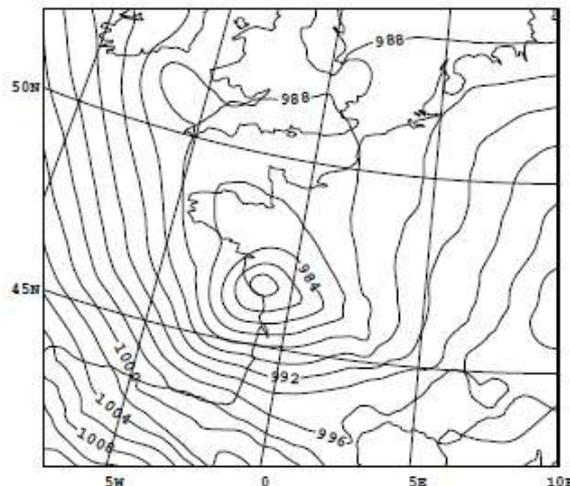


+30 h 4D-Var

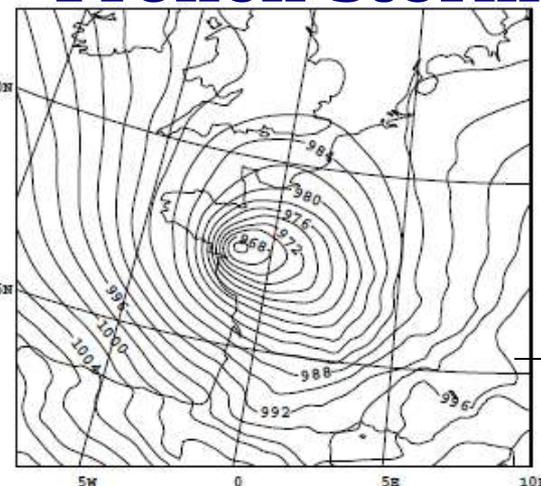


4D-Var analysis

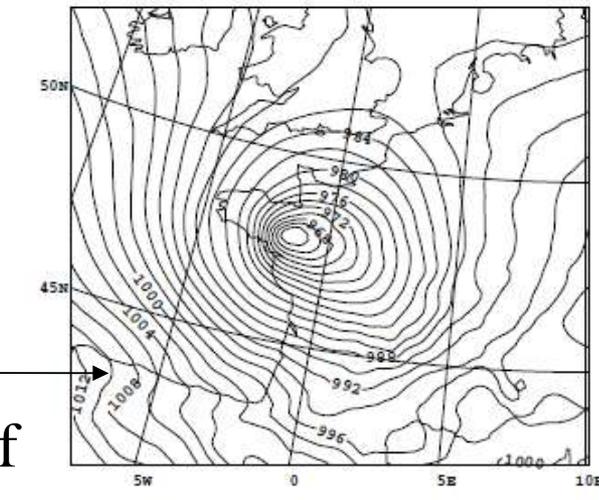
French storm



+6h 3D-Var



+6h 4D-Var



f
g

4D-Var analysis

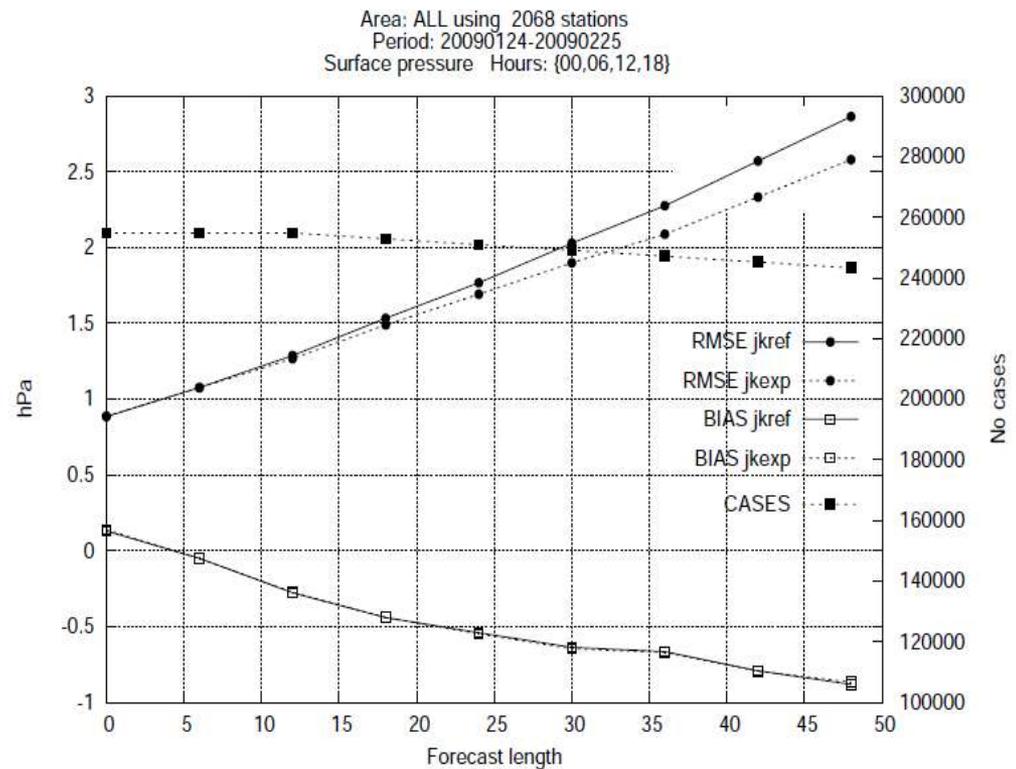


Large scale error constraint in HIRLAM 4D-Var (Dahlgren et al., in review)

$$J = J_b + J_o + J_k$$

$$J_k(\hat{\zeta}) = \frac{1}{2}(\hat{\zeta} - \hat{\zeta}_{ls})^T B_{ls}^{-1}(\hat{\zeta} - \hat{\zeta}_{ls})$$

ζ_{ls} (large scale vorticity)
is constrained by a short
ECMWF forecast at the
start of the assimilation
window



Control of lateral boundary conditions (Gustafsson, manuscript)



Two formulations were compared:

$$J_{lbc} = (\delta \mathbf{x}^{lbc}(t_K))^T \mathbf{B}_{lbc}^{-1} \delta \mathbf{x}^{lbc}(t_K)$$

(1) Control LBC at the end of the assimilation window

(2) Control tendency of the LBCs over the assimilation window (pre-conditioning)

Similar results were obtained!

Single simulated observation experiment

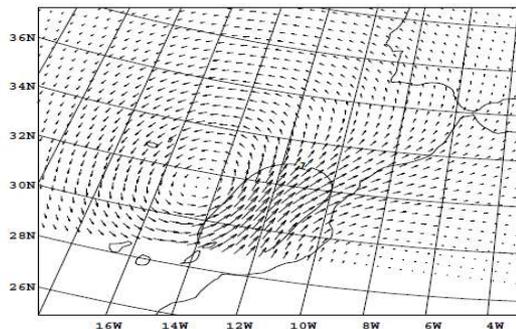
Simulated observation SW 9 m/s at 32N 12W 3Dec 1999 11 UTC

3 December 1999
Assimilation window
06UTC – 11UTC

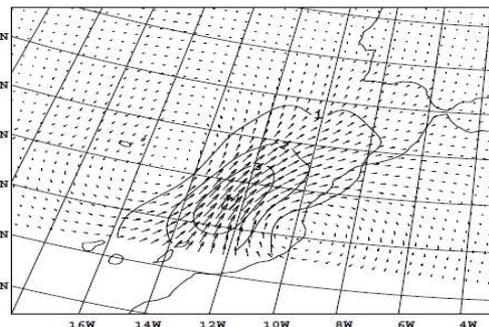
Strong SW inflow in the background field

With control of LBC

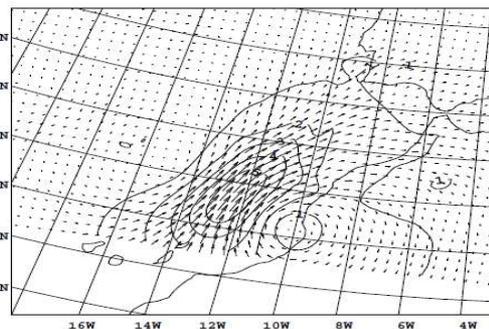
06 UTC



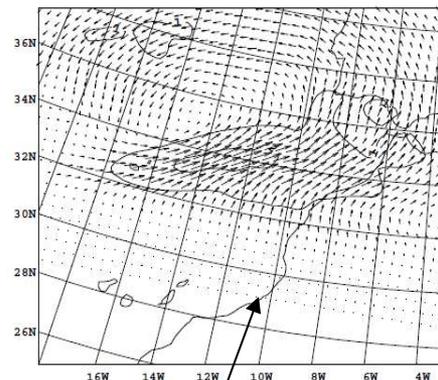
09 UTC



11 UTC



Without control of LBC

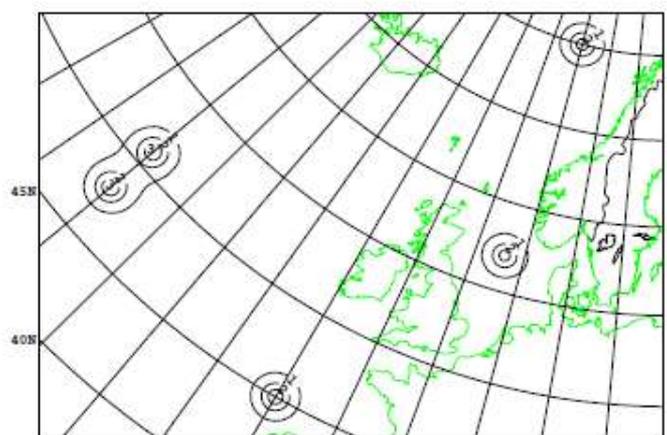


Relaxation towards 0 in LBC zone

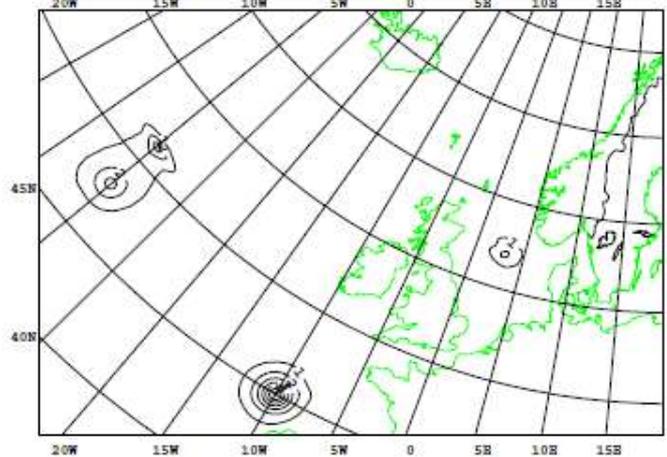


New moisture control variable (QJRMS)

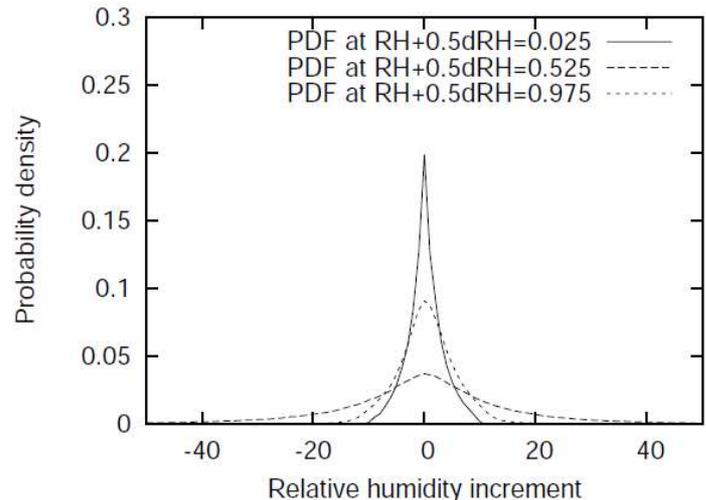
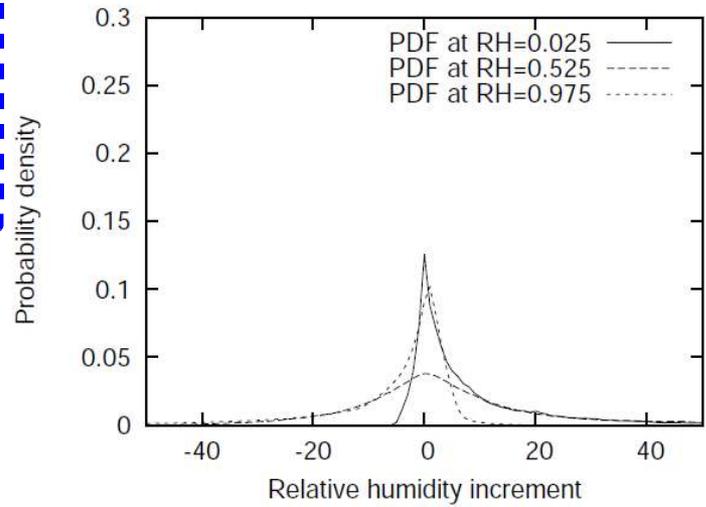
$$\delta RH^* = \frac{\delta q}{q_s(T_b)} \frac{(\delta RH^*)^{ub}}{\sigma (RH_b + 0.5\delta RH)}$$



q control



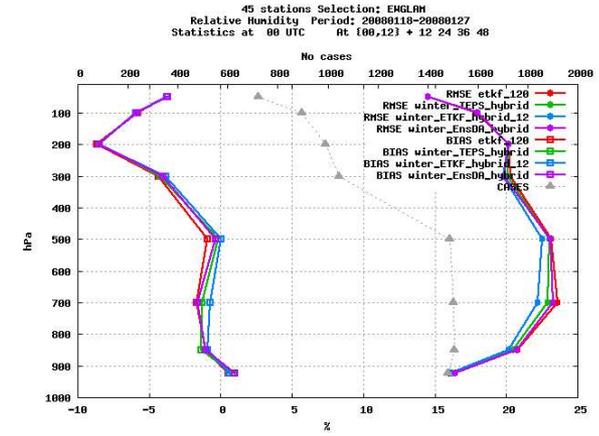
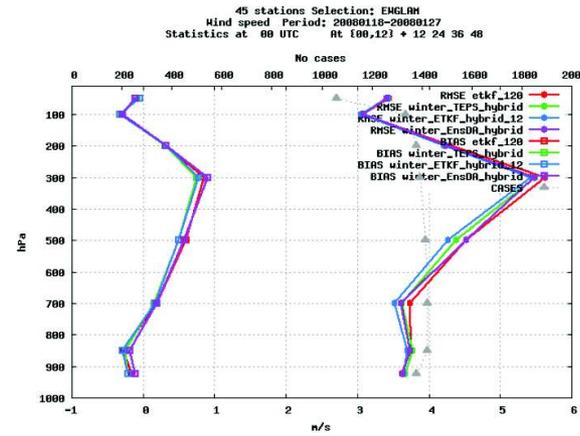
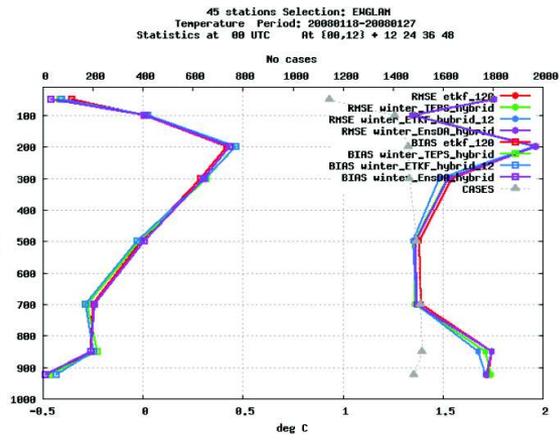
Rh*/sigma control



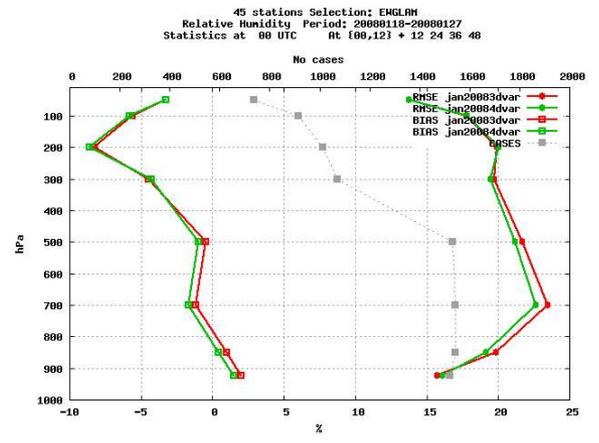
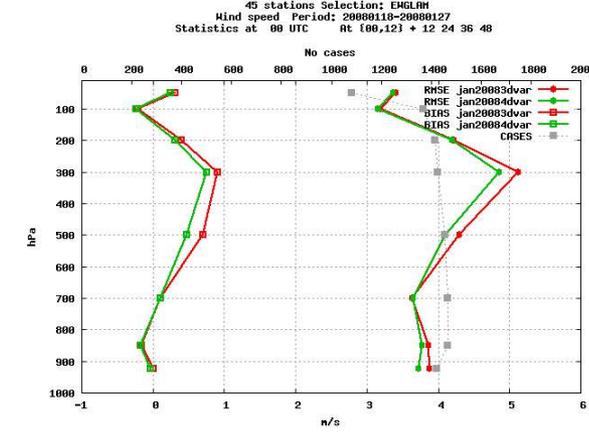
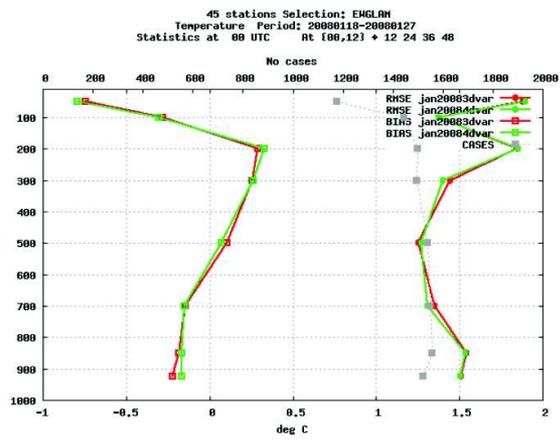


Verification scores : "winter case" 17Jan2008-27Jan2008 (too optimistic)

3D-Var versus hybrid approach (ETKF, EnsDA, TEPS)



3D-Var versus 4DVAR approach



Temp.

Wind speed

Rel. humid.



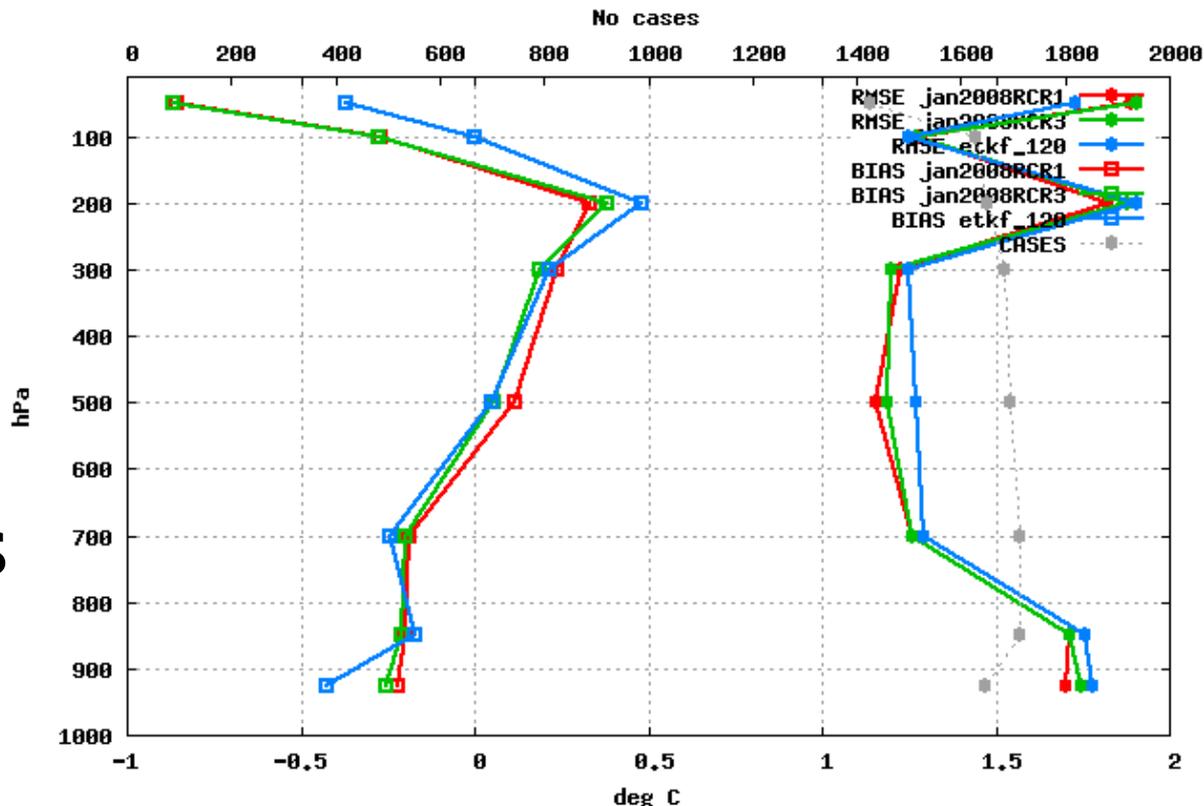
Problem (Jan 2011): HIRLAM EPS control worse than HIRLAM ref.

41 stations Selection: ENGLAM
Temperature Period: 20080117-20080128
Statistics at 12 UTC At {00,12} + 12 24 36 48

RCR1 : HIRLAM ref.
Over EPS domain

RCR3 : As RCR1 but
setup reduced to
GLAMEPS setup

etkf_120 : HIRLAM EPS
control



**For the validation of HYBRID one cannot start from such a degraded system !
(Chances to improve are too good)!**



Validation of problem solution

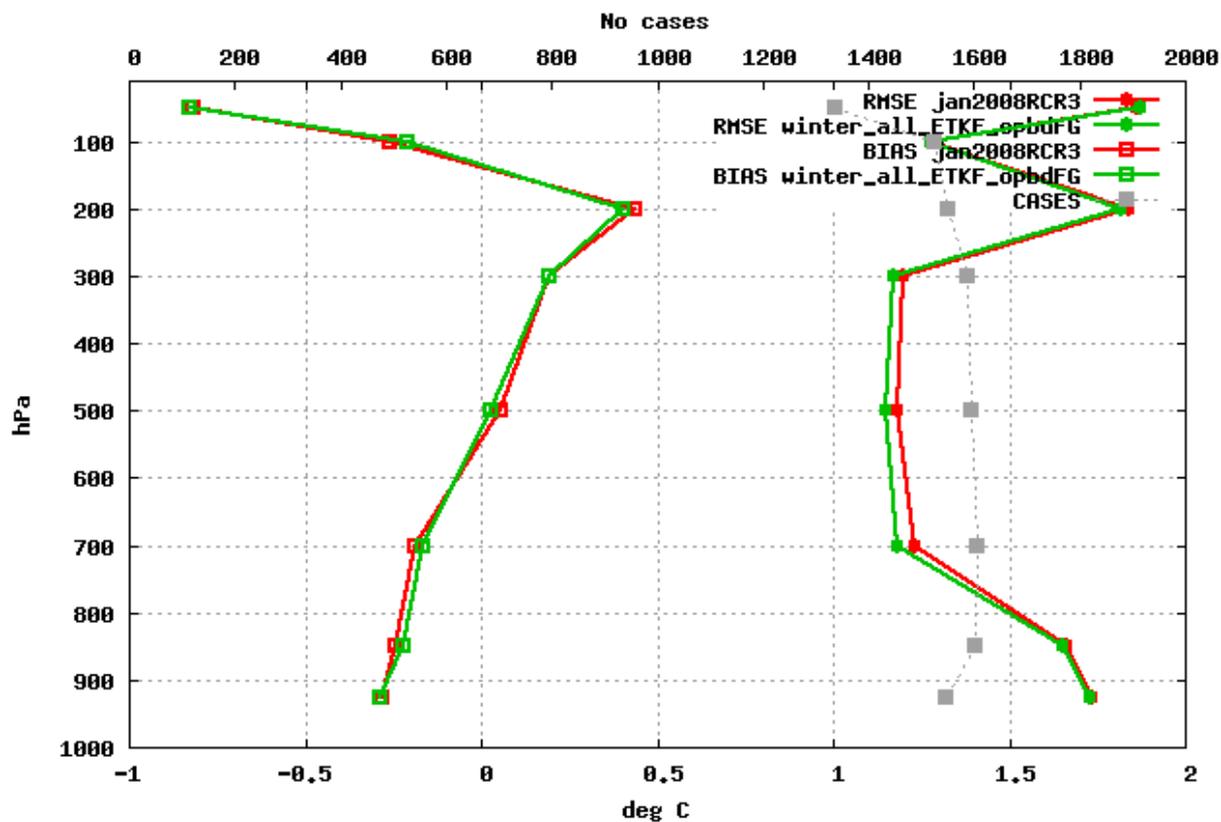
RCR3: HIRLAM

7.3 reference

OPBDFG : "Cured"

EPS control

41 stations Selection: EMGLAM
Temperature Period: 20080117-20080128
Statistics at 12 UTC At {00,12} + 12 24 36 48



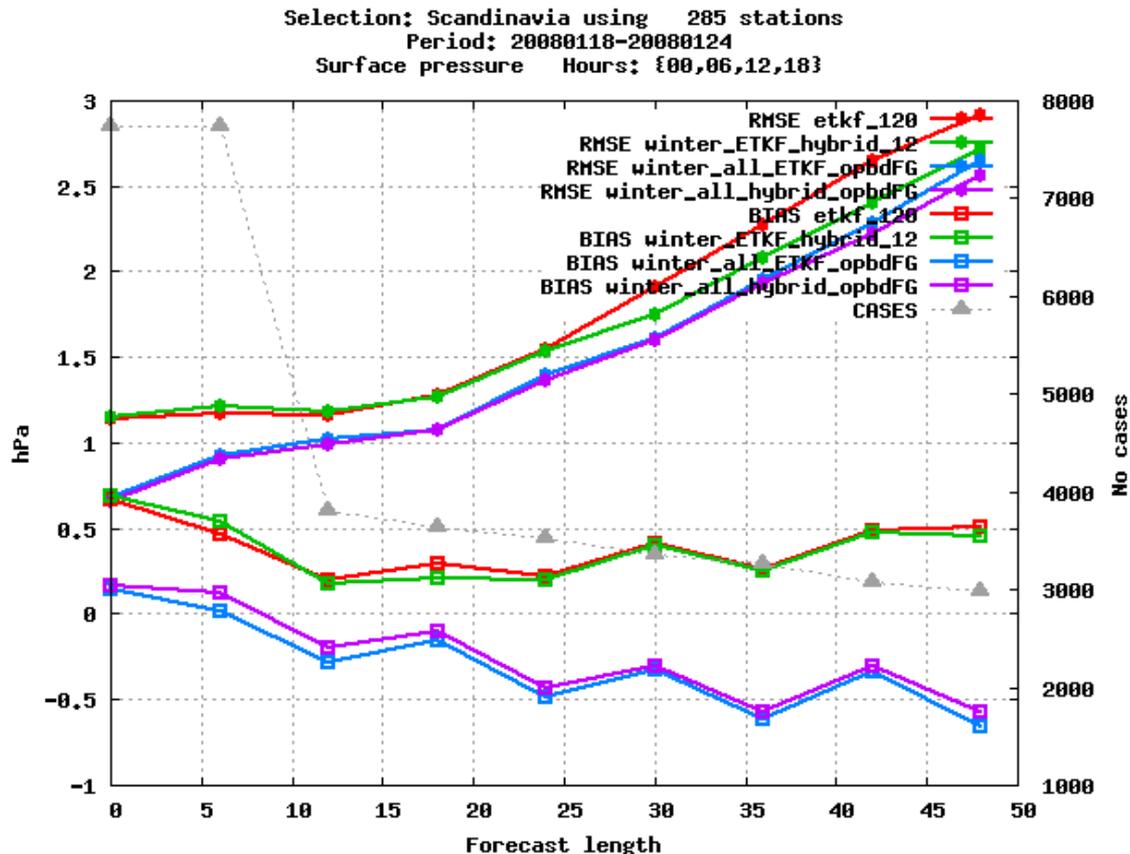
Are Results too good ?

New problem: After the correction HYBRID gives less positive impact



OLD 3D-Var
OLD HYBRID
NEW 3D-Var
New HYBRID

The ensemble spread became smaller after the corrections!
Interpretation: the bugs introduced “artificial” perturbations that were good for the HYBRID.
TO DO: re-tune inflation scheme! (ongoing)



The performance of the hybrid ensemble variational data assimilation is very sensitive to the overall parameter tuning !!!



For more information on flow dependent data assimilation please visit the posters :

→ [“Flow-dependency in data assimilation in HIRLAM community”](#)

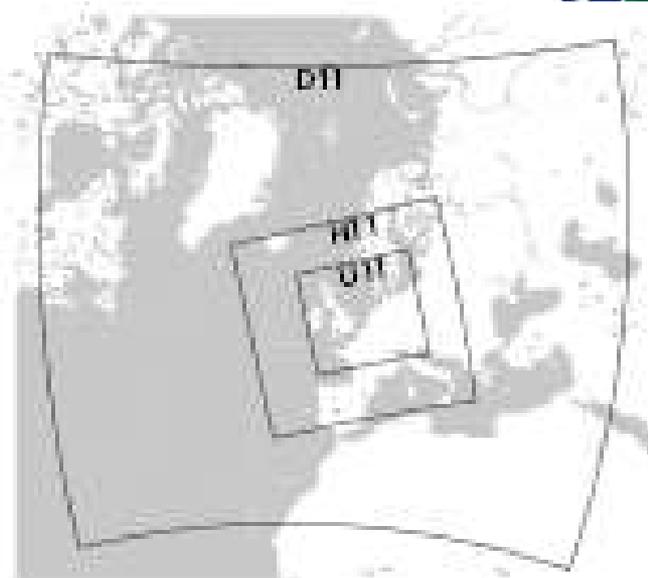
→ [“AEMET National poster”](#) (field alignment technique)

RUC and nowcasting



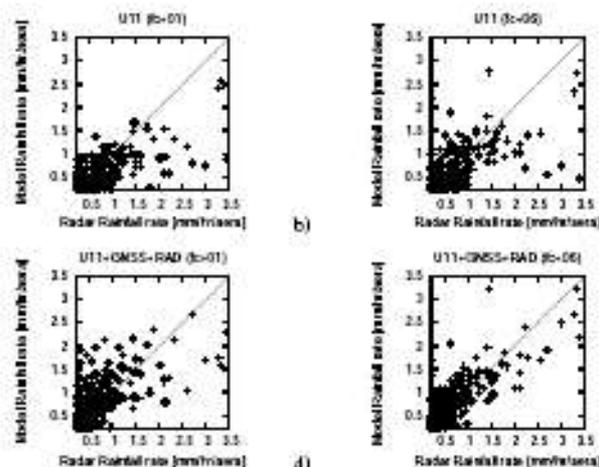
- ✓ Encouraging results in the direction of the very short range weather forecasting (nowcasting application);
- ✓ Study of the spin-up properties in relation to the different types of assimilated observations (ZTD GNSS, radar data, AMDAR, Mode-S)

Siebren de Haan (KNMI)



More results on the experiences with the RUC with HIRLAM/HARMONIE forecasting systems are presented in the poster:

→ [“Experimentation with RUC”](#)



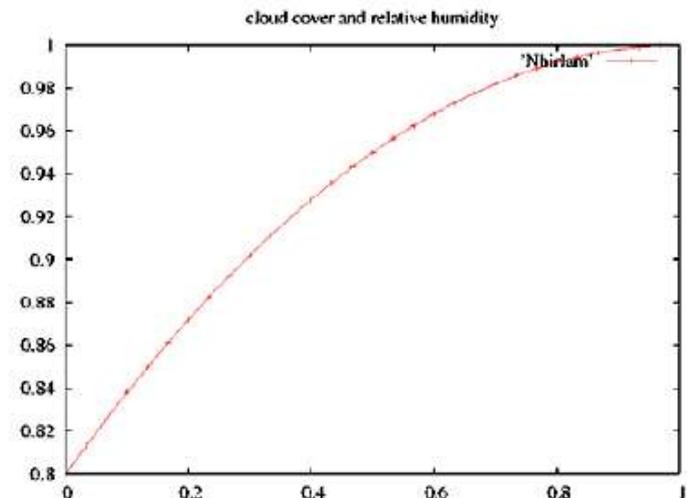
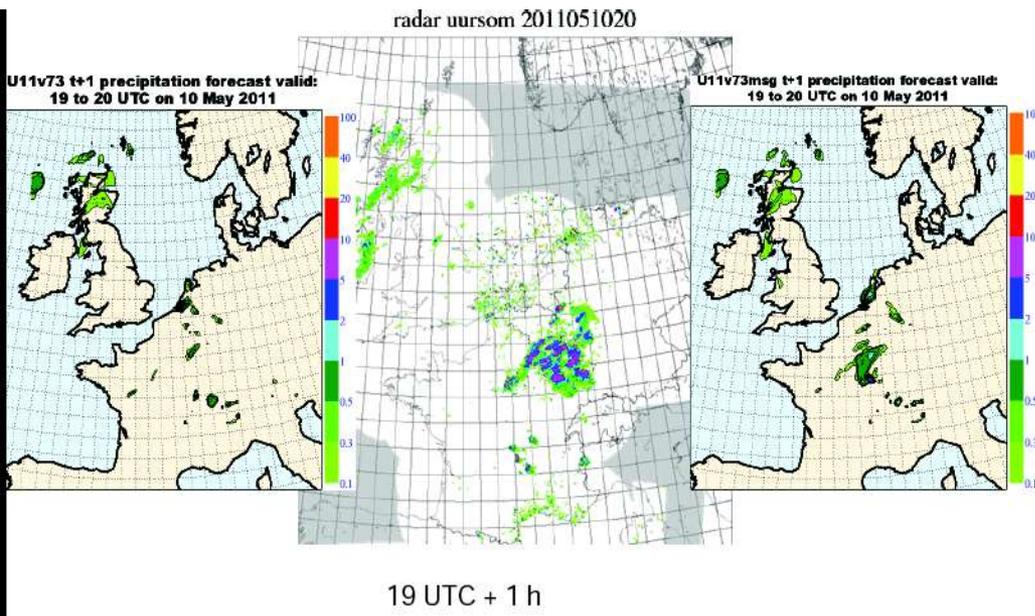


Transfer MSG clouds to HIRLAM clouds

Initialisation of the humidity field from the MSC cloud mask product (Sibbo van der Veen and Siebren de Haan, KNMI)

Change specific humidity, but keep buoyancy unchanged

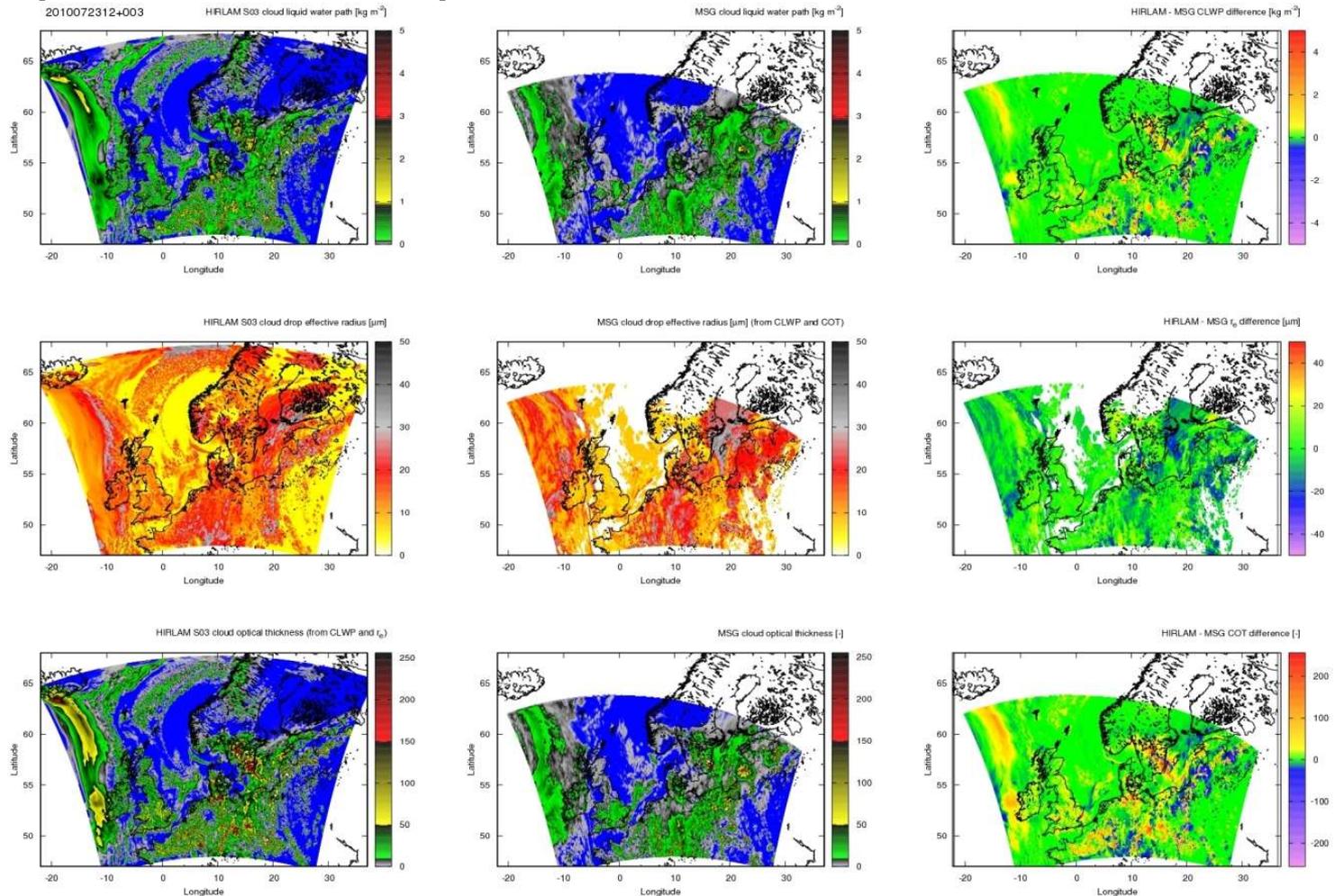
$$T_{new} = \frac{T_{virt,old}}{1 + 0.61 * q_{v,new} - q_{l+i,new}}$$



Physical cloud properties in the radiative transfer equation formulation (Kristian Pagn Nielsen, DMI)



(possible synergy with the ensemble prediction systems to relate dynamical uncertainty with the uncertainty of the cloud model variables)





Surface modelling and data assimilation

Posters, again:

- “FMI National poster”
- “Met.no National poster”

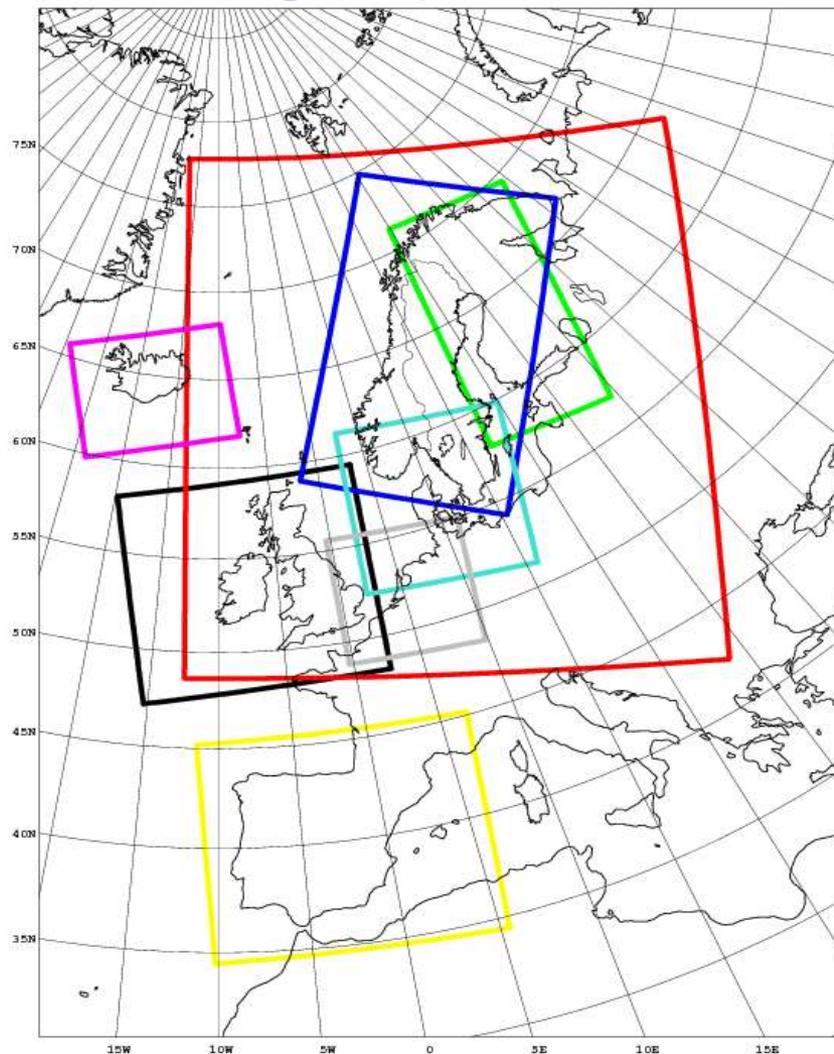
and talks:

- Laura Rontu talk
- Jean-Francya Mahfouf

HARMONIE Forecasting system DOMAINS



AEMET
DMI
FMI
KNMI
Met Eirann
met.no
SMHI
Veðurstofa



Domain	Cycle	Size	DX	MODEL	DA	COMMENTS
AEMET	36h1.3	384 x 400 x 60	2.5km	AROME	Downscaling or 3DVAR (two suites	3h HIRLAM 16km
DMI	36h1.3	384 x 400 x 65	2.5km	AROME	3DVAR CANARI OI_MAIN	3h ECMWF LBC
FMI	35h1	300 x 600 x 60	2.5km	AROME	Downscaling	1h HIRLAM 7.5k
KNMI	36h1.2	300 x 300 x 60	2.5km	AROME	3DVAR CANARI OI_MAIN	12h cycling Runs at ECMWF
Met Eirann	36h1.3	540 x 500 x 60	2.5km	AROME	BLENDING CANARI OI_MAIN	HIRLAM 10km L
Met.no	36h1.1	300 x 500 x 40	4km	ALARO NH SURFEX	BLENDING CANARI OI_MAIN	HIRLAM 8km LB
SMHI	36h1.3	506 x 574 x 60	5.5km	ALARO SURFEX	3DVAR CANARI OI_MAIN	3h ECMWF LBC



Research activities on data assimilation within the HARMONIE forecasting system:

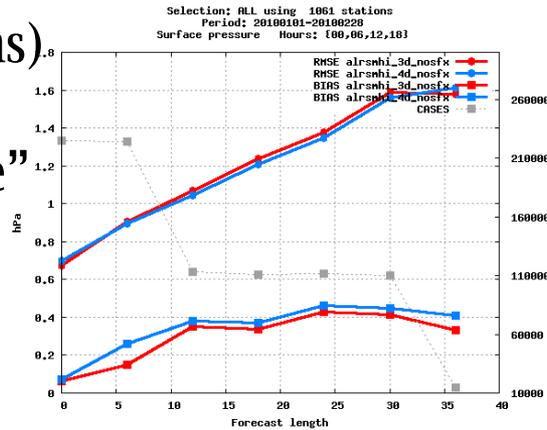
- 1) **Build up the necessary expertise** (Learn the source code and gain the necessary knowledge in OOPS to be able to use this tool efficiently)
- 2) Invest in the design of **the common preprocessing tools and local data exchange** (radar data assimilation efforts are presented in the poster)
- 3) Implementation of **high-frequency high-resolution observations** and the impact assessment through the **coordinated extended impact studies**
- 4) **Further development of data assimilation algorithms** (4D-VAR, ETKF/EDA, Hybrid ensemble variational data assimilation scheme, modelling of background error covariance)

The latest progress with of the HARMONIE 4D-VAR

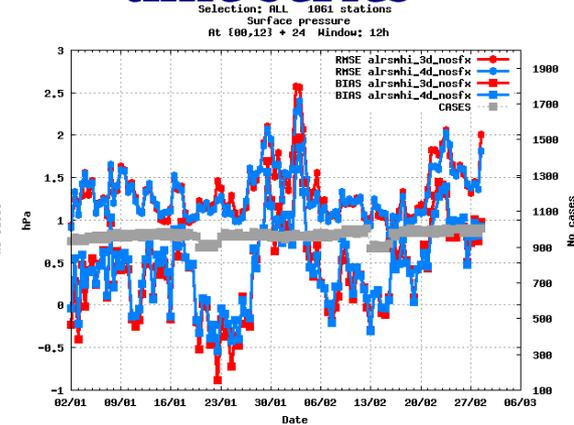


- **3D-Var** vs **4D-Var** (2 months)
- 1 Jan 2010-28 Feb 2010
- Swedish ALARO + “old surface”
- Conventional + AMSU-A
- model res. 5.5
- 4D-Var minimization 11 km

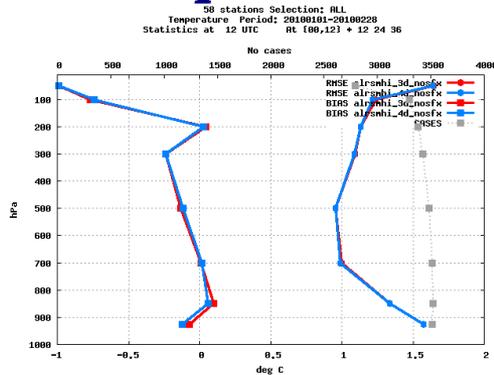
Ps bias + rms



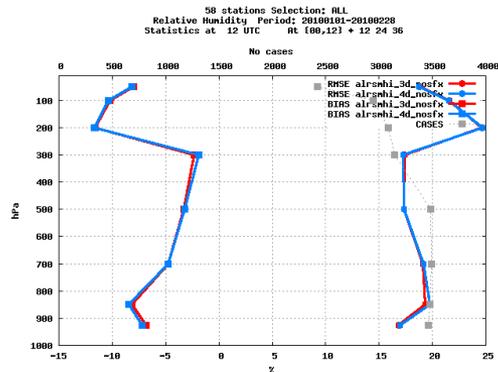
Ps time series



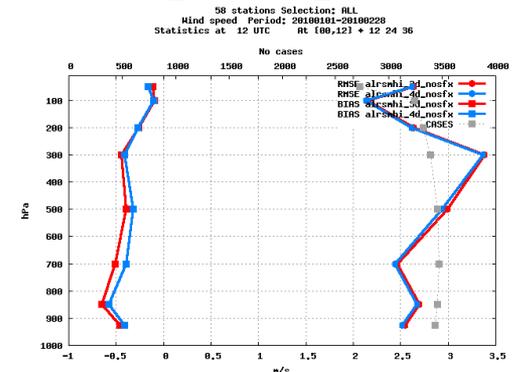
T profile



q profile



wind speed profile



HARMONIE 4D- Var under mini- sms

Status and short term developments

- Multiple outer loop iterations
- Surface analysis
- Properly working Jc DFI
- Utilization of satellite observations will be improved
- More advanced simplified physics will be added
- Application of wide extension zone (almost final stage)
- HARMONIE 4DVAR + AROME

