Norwegian Meteorological Institute

Hirlam High Resolution Limited Area Model

Highlight of recent progress in HIRLAM upper-air data assimilation

Roger Randriamampianina
with contribution from HIRLAM colleagues

EWGLAM, 2018, Salzburg, Austria

outline

- Operational upper air data assimilation (UA-DA) systems in HIRLAM

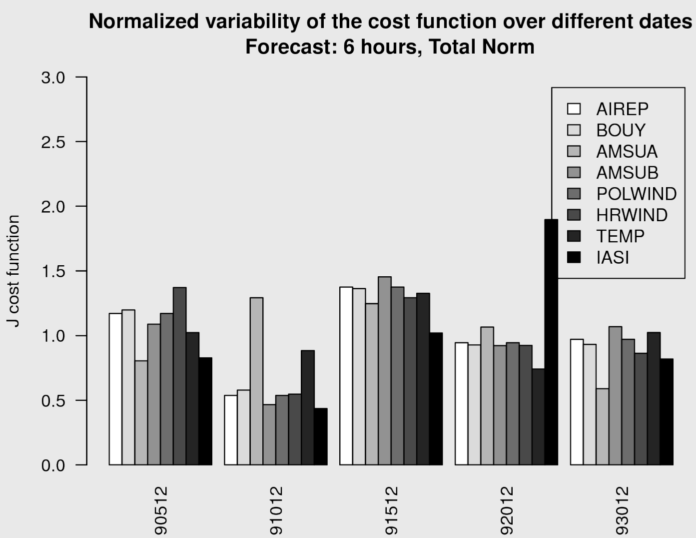
- Algorithmic development

- Improving the use of observations

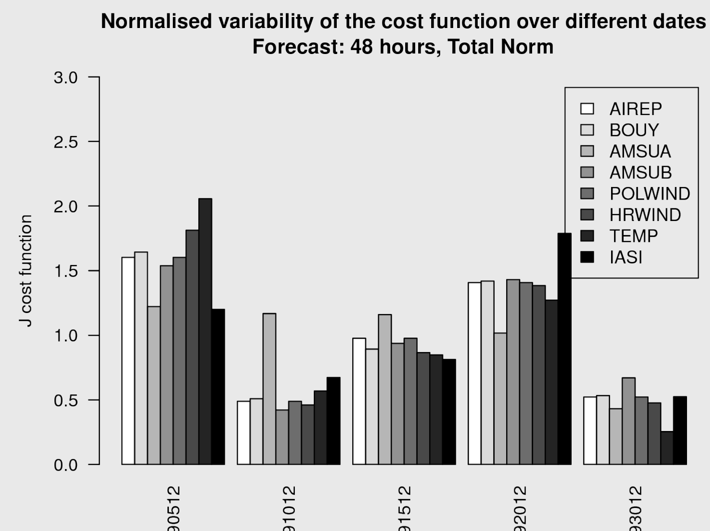
- Concluding remarks and further plan

Operational upper air data assimilation (UA-DA) systems

- **Assimilation scheme:** 3D-VAR;
- **Cycling Strategy:** 3 hourly;
- **Conventional observations:** SYNOP, SHIP, BUOY, AMDAR, AIREP, ACARS, ModeS EHS, Pilots, TEMP;
- **Satellite radiances:** AMSU-A, AMSU-B/MHS, ATMS, IASI;
- **Satellite retrievals:** Scatterometer, GNSS ZTD, GPS RO, ***AMV***;
- **Radar observations:** Reflectivity;
- **Bias correction scheme:** Variational (VarBC).



Experiment run with AROME-MetCoOp Sensitivity of the forecast model to different observations



Field Alignment (FA) & Variational Constraint (VC)

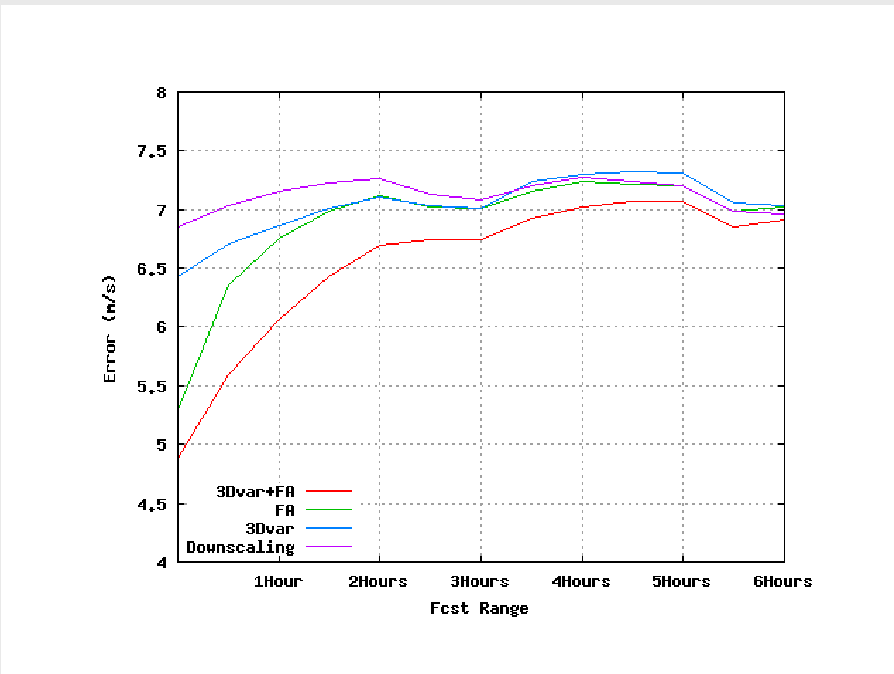
Carlos Geijo

Assimilation of Doppler Wind Radar Data in HARMONIE

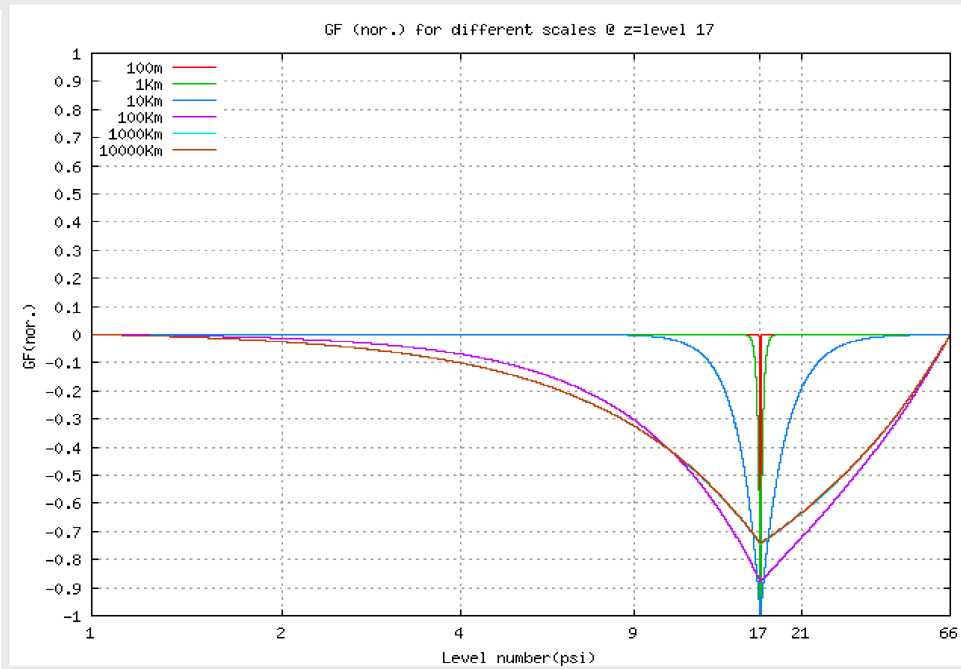
– Verification of forecasted radial wind using the own radar data:

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

– Results averaged over more than 150 cases:



Testing the FA in HARMONIE system

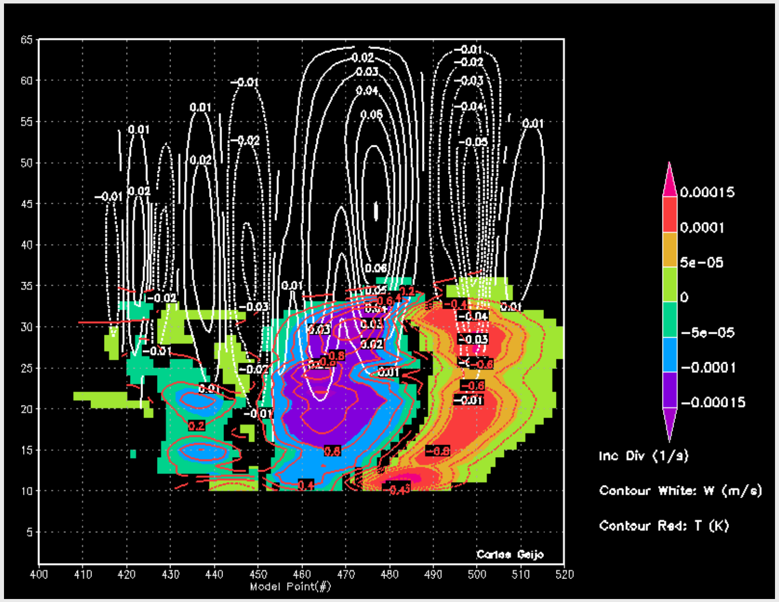


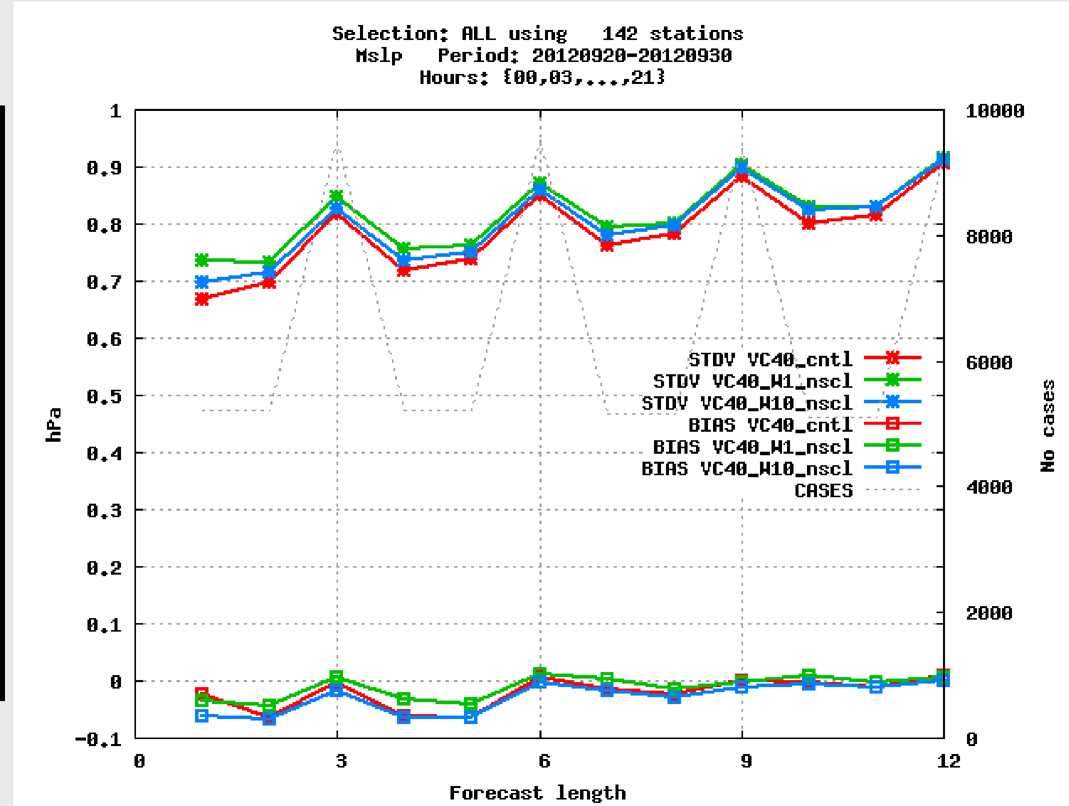
Property of the Green Function

FA and VC

Carlos Geijo

Balanced Vertical Motions





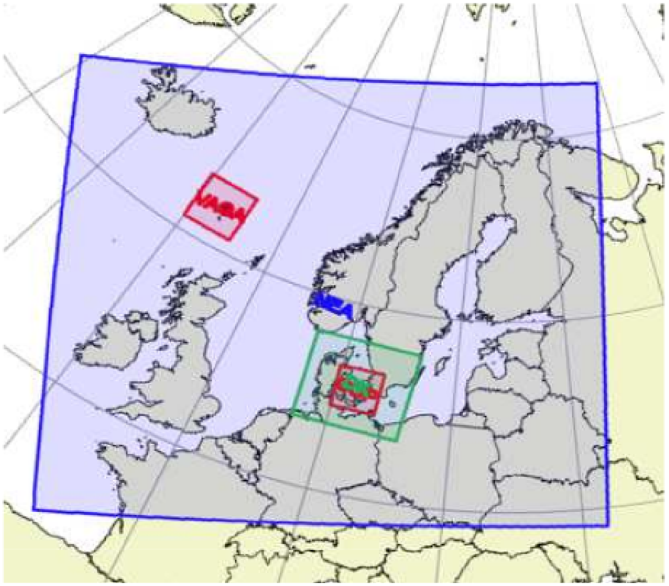
Still issue with horizontal spreading/ balance

3h-DA cycles with conventional obs (~3*10[3] obs/cycle) . No surface analysis.
Control: 3D-VAR (Red line)
Experiments: (Green (w=1) and blue (w=10) lines)3D-VAR with no statbal (LUNIVARIATE=.T.) and VC for balancing. Verification using the standard HIRLAM tool.

Ensemble nowcasting

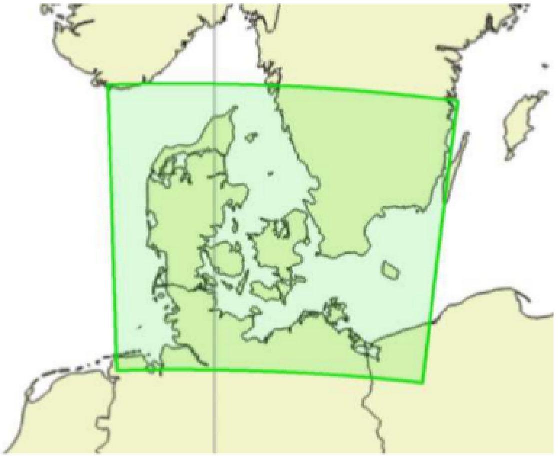
Xiaohua Yang

Operational COMEPS@DMI



24 +1 members, Harmonie-arome@2.5 km
1200x1080x65 gridmesh
Time-lagged EDA/EPS with

- hourly 3DVAR (control)
- 4 perturbed members each hour, 57h forecast
- Perturbation (EDA)
  - observation, multi-physics, surface, SLAF



COMEPS-nowcasting (prototype)

Basics: Ensemble Harmonie-arome @750m + radar extrapolation, 7 to 13 NWP members,, 800x720x65
10 min update with time-lagged EDA/EPS

- 3DVAR every 10 min, 9 h forecast
- COMEPS@2.5 km as LBC

Upper air DA – Ensemble nowcasting – Xiaohua Yang

Danmarks Meteorologiske Institut

Toward a nowcasting RUC at sub-km

Motivation: DMI wishes to develop a forecast capability to warn rapidly developing convection which often is characterised by a
very short life cycle (1-3 h), very small scales (few km).

Approach: an ensemble RUC with NWP-based sub-km resolution nowcasting + radar extrapolation (in first hour)

- **Model**: sub-km Harmonie-arome with capability for small scale convection; possibly + nudging
- **Assimilation:** variational approach with 3DVAR/4DVAR
- **Ensemble**: a time lagged EDA with RUC on overlapping windows

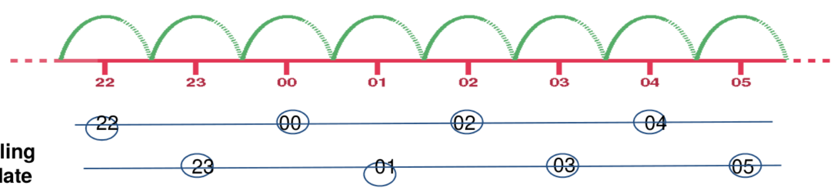
Extension of DMI-COMEPS from hourly, 2.5 km system toward sub-hourly and sub-km

Also use of more observations from crowd can be considered

Danmarks Meteorologiske Institut

How to achieve frequent analysis update

Cycling strategy with intermittent DA



2h cycling
1h update

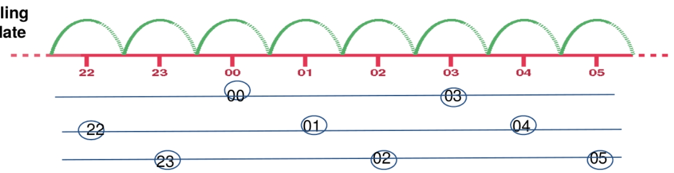
Assimilation window **2h,** data between **-1** and **1 h**
Background from **2h** forecast of previous cycle

How to achieve frequent analysis update

Danmarks Meteorologiske Institut

Cycling strategy with intermittent DA

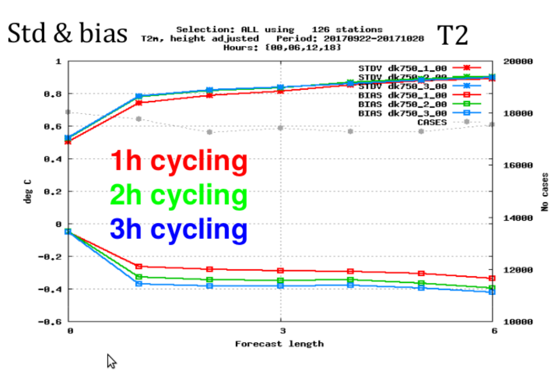
3h cycling
1h update

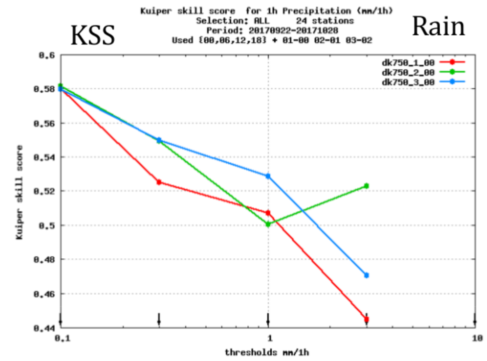


Assimilation window **3h,** (**-1.5** and **1.5 h)**
Background from **3h** forecast of previous cycle

- + **extended use of obs (longer window, less thinning)**
- + **reduced spin-up**
- + **feasible for larger, time lagged ensemble**
- + **better load balance for ensemble model**

Upper air DA – Ensemble nowcasting – Xiaohua Yang





Dilemma about assimilation window length & cycling frequency

1h cycling clearly advantageous for dry surface parameters like MSLP/T2m
But for cloud and precipitation, 1h cycling is less optimal compared to 2h/3h

The situation may depend on obs data, analysis schemes, ...

Danish Meteorological Institute — Xiaohua Yang, EUMETNET Workshop on Ensemble-Nowcasting, 16-18 May 2018

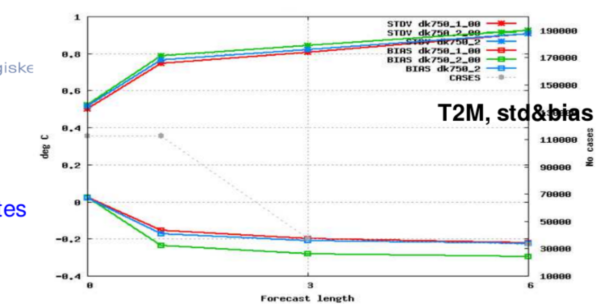
Independent,parallel cycling system

Results
according to today's model accuracy!

partially connected system

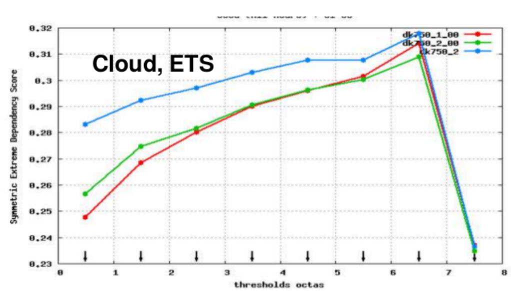
Danmarks Meteorologiske Institut

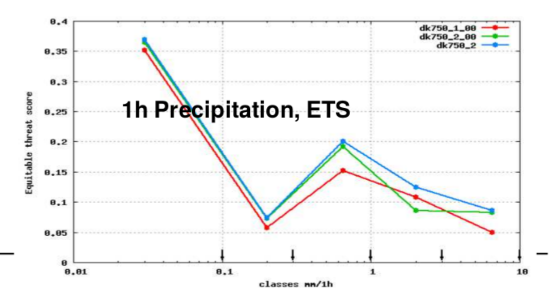
Partial coupling
between adjacent suites



1 hour cycling
2 hour cycling, parallel
2 hour cycling, partially connected

Reducing the moisture spinup!





4D-Var development

Nils Gustafsson, Jan Barkmeijer, Magnus Lindskog, Jelena Bojarova

HARMONIE Multi-incremental 4D-Var – some technical improvements

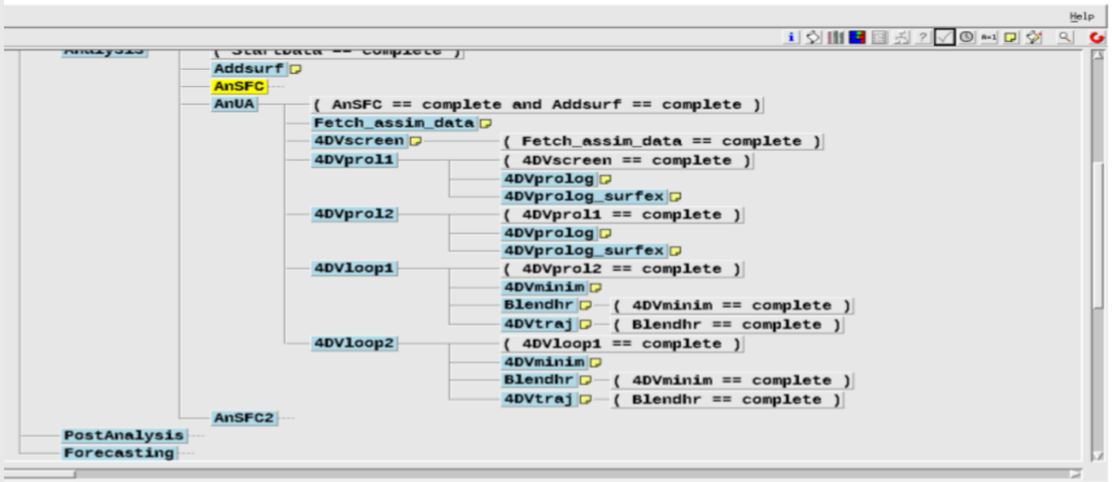
- Multi-incremental 4DVAR with multiple resolutions
  (different resolutions in different outer loops)
- 2D parallelization
- Treat the humidity in spectral space
- Increment for TL model = 0 at first iteration
- Handling of VARBC coefficients in control vector file
- Problem with skin temperature for AMSU assimilation in second outer loop – "fixed" by using model skin temperature. Using skin temperature and emissivity as "slack variables" during minimization could be considered.
- "EZONE" has to be increased in case of very coarse resolution outer loops

- Tested with shorter period runs with "operational observations"

4D-Var development

Nils Gustafsson, Jan Barkmeijer, Magnus Lindskog, Jelena Bojarova

HARMONIE Multi-incremental 4D-Var – affordable operationally

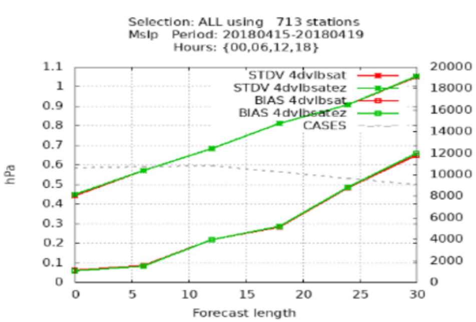


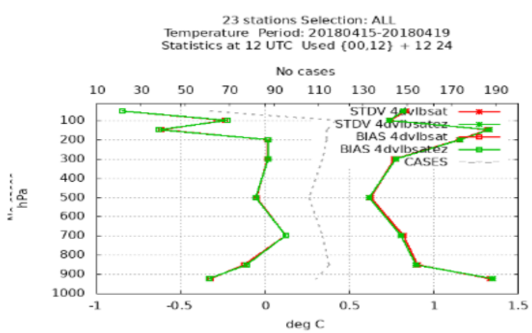
bg

fg

Outer 4dVar loops with different horizontal resolution in different outer loops

Control vector in spectral space – padded with zeroes when resolution is increased





4dvlbsat : 30 iter 3 dx + 30 iter 3 dx

4dvlbsatez : 20 iter 6 dx (needed to extend EZONE to 25) + 10 iter 3 dx

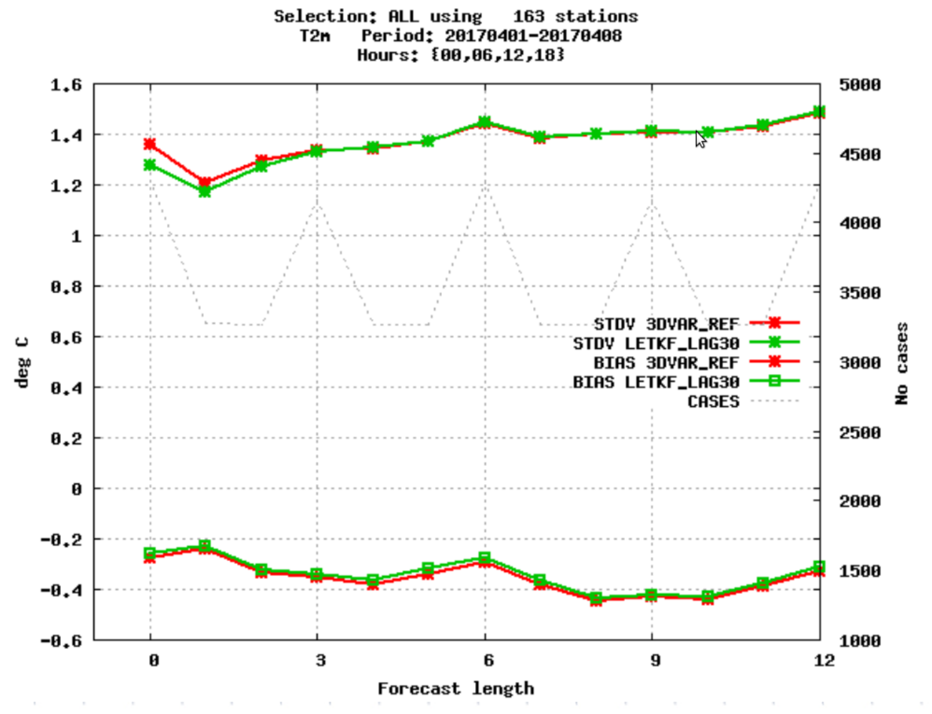
Both with satellite and conv. data.

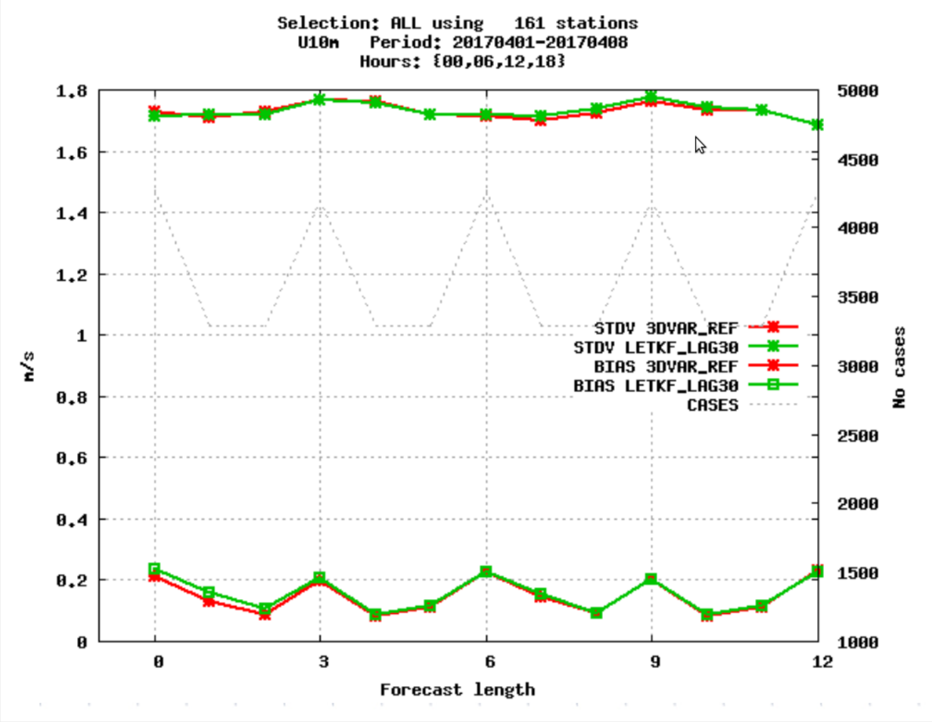
LETKF

Pau Escriba & Jelena Bojarova

– LETKF is quite mature after several tunings but still not finished
– In a 8 day (short) verification period **the LETKF performance is comparable to 3DVAR, even better in some parameters when assimilating only conventional observations**
– Many short-period testing have been done
– More verification with longer periods is needed

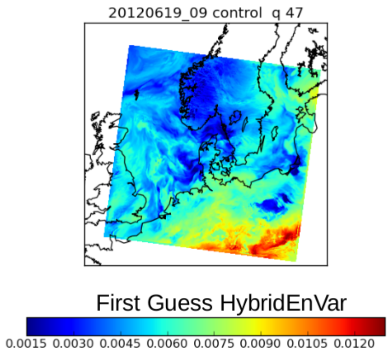
More about the tests and the results can be found on our last working week page



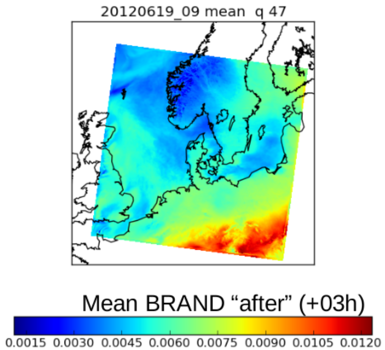


Hybrid EnVar implementation and Brand
Brand: A perturbation technique through B

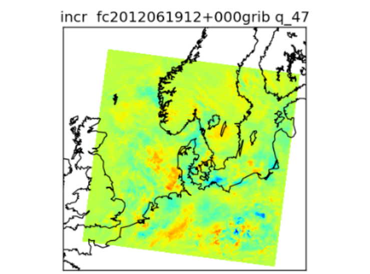
Jelena Bojarova



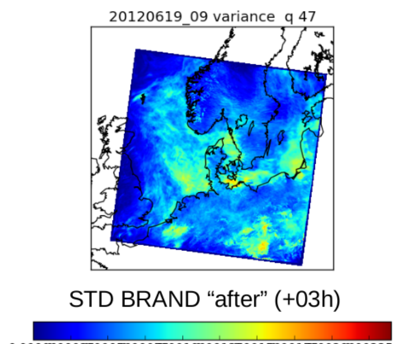
First Guess HybridEnVar



Mean BRAND “after” (+03h)



Analysis Increment



STD BRAND “after” (+03h)

20120613 00 UTC

				Hybrid EnVar (BRAND “after” Small spread)		Hybrid EnVar (BRAND “after” Large spread)	
			#obs	“o-b”	“o-a”	“o-b”	“o-a”
SYNOP	LAND	Z	87	18.03	4.61	15.53	2.23
		Z	297	47.98	12.44	53.56	6.39
	SHIP	Z	16	2.49	1.22	7.06	0.82
		U	10	8.84	6.16	8.25	3.82
		Z	28	10.37	6.31	11.27	2.95
		U	16	13.08	9.11	13.79	4.59
AIREP	AMDAR	U	124	37.86	11.99	44.28	4.28
		T	62	10.36	6.07	13.08	2.32
DRIBU		Z	1	0.01	0.02	0.07	0.01
TEMP		U	2362	960.48	669.28	1098.07	629.02
		T	613	618.36	485.95	648.85	463.03
		Q	345	366.04	126.73	478.10	114.29
J		Jo	3961	2093.96	1339.93	2391.96	1233.79
		Jb			120.42		82.31
		Je			60.85		84.85

EnVar: implementation following *Gustafsson and Bojarova (2014)* is done and testing and further development of the scheme is ongoing.

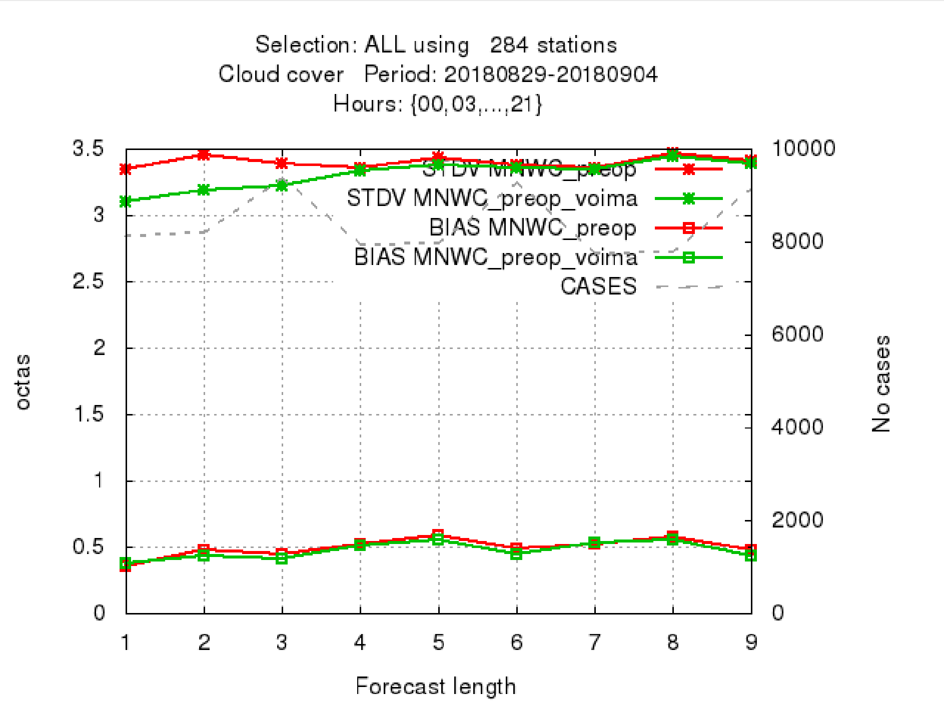
Brand: Implementation is finished. Tuning of the technique is needed.

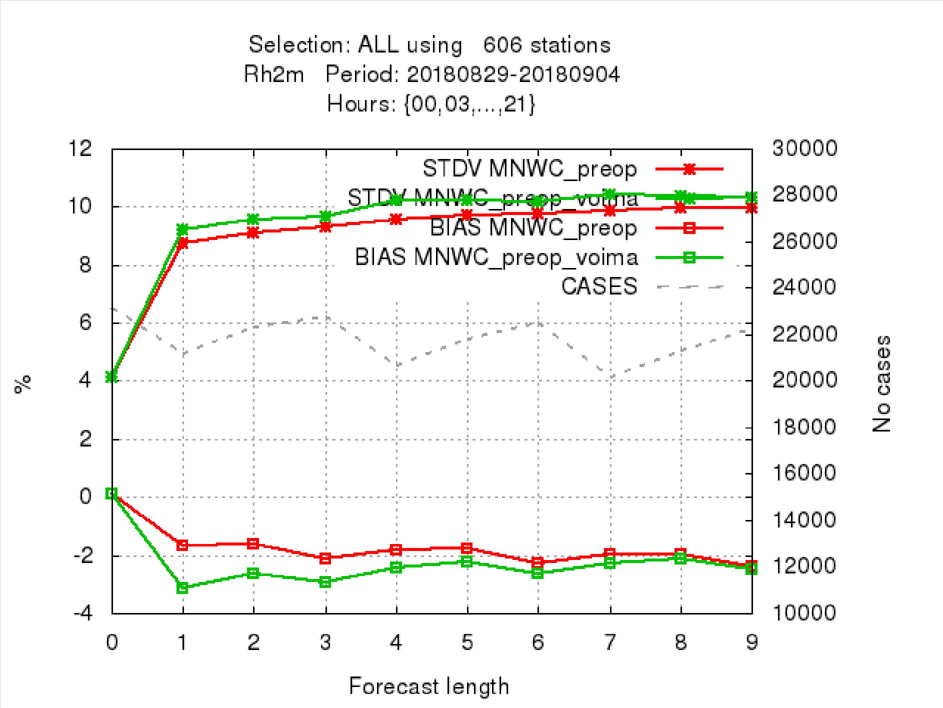
Using cloud data in nowcasting initialisation

Erik Gregow

– 7-days: 29 Aug- 4 Sep 2018
– MNCW_preop – rapid refresh without MSG cloud initialisation
– MNCW_preop_voima – rapid refresh with MSG cloud initialisation

–> Good impact on cloudiness, but further tuning is needed for the other verified parameters.



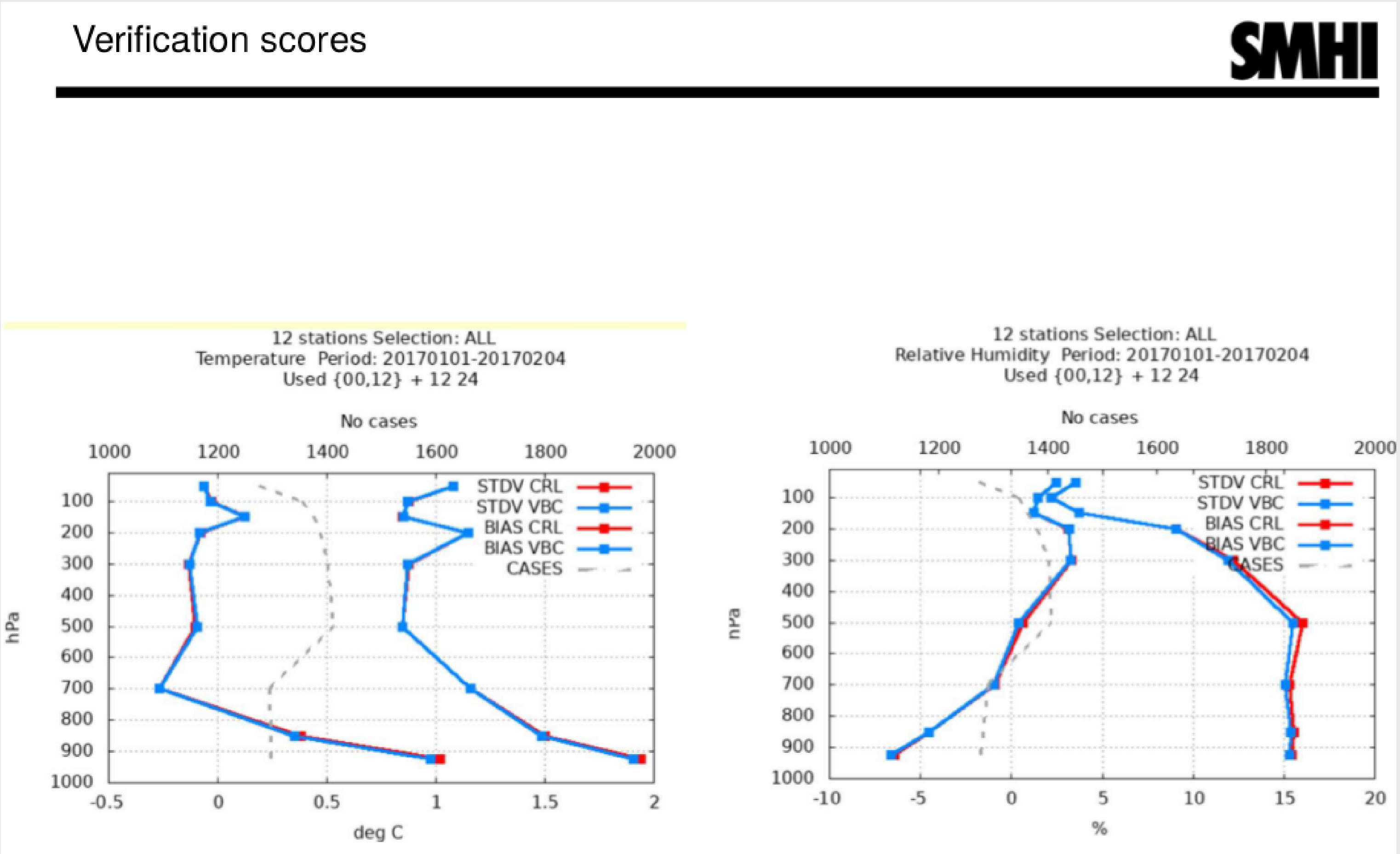


Variational bias correction for aircraft data

Magnus Lindskog

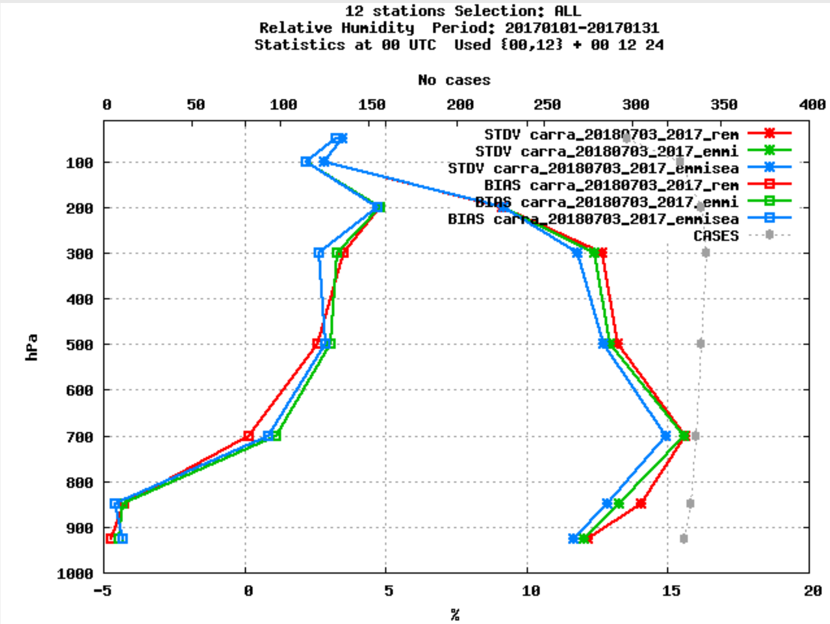
– Test with the off-set only;
– Seems to work well and do the bias corr.;
– Promising positive impact;
– Issue with growing file size;

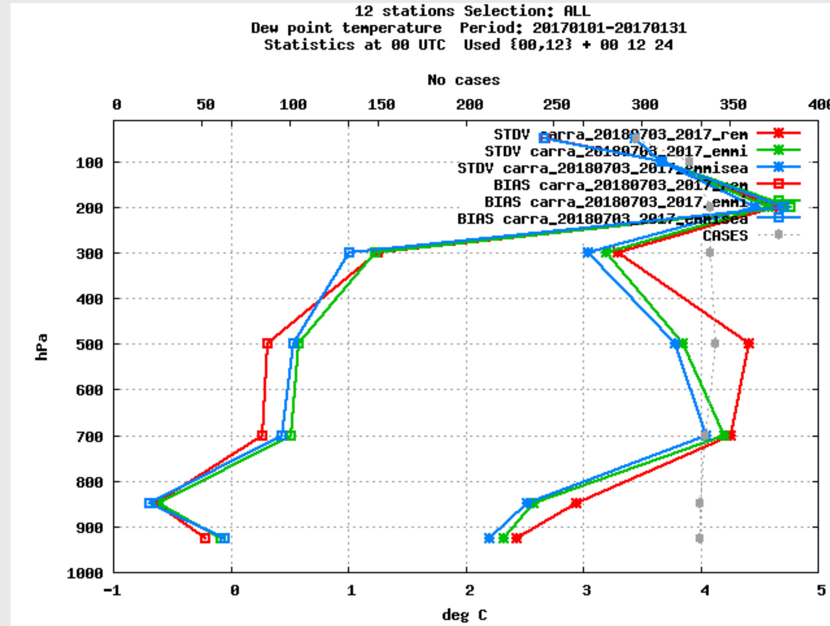
Neutral to slightly positive impact



Use of emissivity Atlas in microwave radiance assimilation

Sigurdur Thorsteinsson & Roger Randriamampianina





Very promising results!

Blue – use of emissivity over sea only;
Green – use of emissivity over sea and land;
Red – Not using the emissivity atlas.

Norwegian Meteorological Institute

Norwegian Meteorological Institute

Many thanks to Philippe Chambon & Florian Suzat (Météo France)

More on the use of observations

- Implementation of GNSS slant delay assimilation with very promising impact.
- MET Norway is involved in the CAL/VAL project with the Aeolus HLOS wind data. Our newest system 43h2 is ready for this challenge.
- Máté Mile is starting PhD with, among other tasks, special focus to effective resolution of observations (accounting for the real footprint of observations) in DA.
- We think it is very important to make all verified (“assimilable”) observations available in the operational systems. Specific resource is dedicated to this task at different centres.
- We are involved in Copernicus reanalysis for both European and Arctic regions.
  - allow short development works like improving the observation pre-processing, optimisation of the DA system, improvement of blacklisting procedure.

Concluding remarks and outlook

- **Continue the local implementation of more observations** …;
- **Continue exploring 1-h DA update (overlapping windows) and Rapid refresh**;
- **Working with initialisation schemes**: LHN, use of variational constraint, IAU;
- **Continue developing the 4D-VAR, LETKF and hybrid EnVar schemes**;
- **Further improve the treatment of radar data**;
- **Improve the observations pre-processing:** Bator for all observations and at the same time develop COPE to handle all observations;
- **Diagnose B computation** by checking Hirlam and MF/Aladin ways of computation;
- **Better accounting of large scale information** in initialisation and data assimilation;
- ….

Thank you