Norwegian Meteorological Institute

HIRLAM upper-air data assimilation status and short-term plan

Roger Randriamampianina
and many colleagues from HIRLAM

39th EWGLAM and 24th SRNWP Meeting, Reading, UK

outline

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

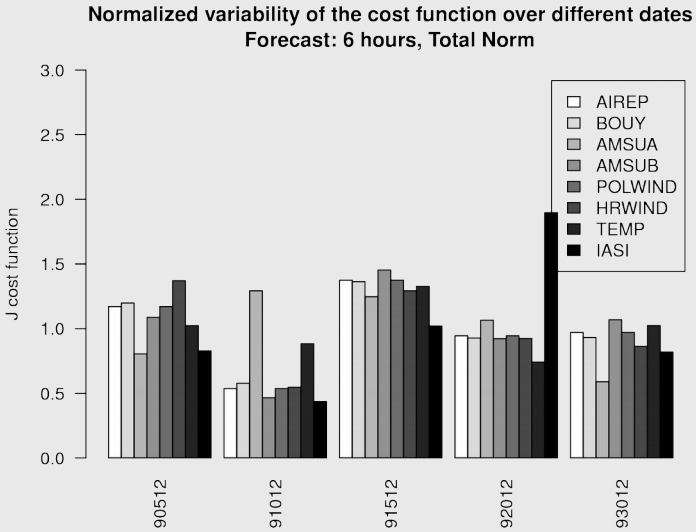
- Some development works related to UA-DA;

- Local implementation of observations;

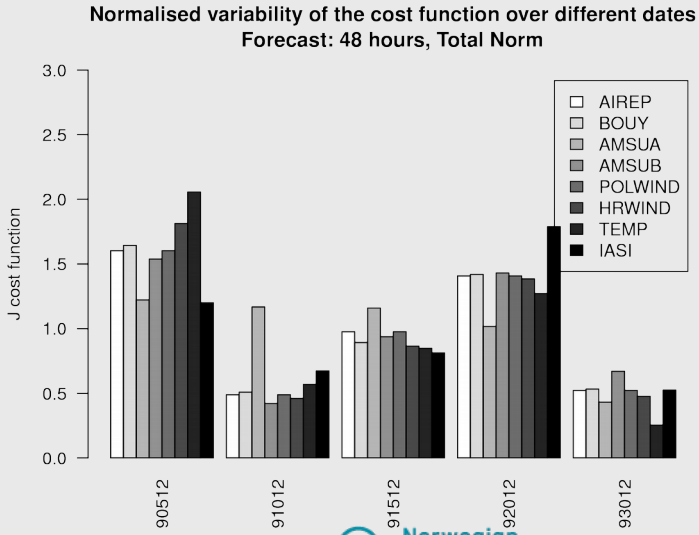
- Concluding remarks and outlook

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**, (geo)AMV;
- **Radar observations:** Reflectivity;
- **Bias correction scheme:** Variational (VarBC).



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



Highlight of the progress – initialisation

– Cloud initialisation: under implementation by **E. Gregow**, M. Lindskog, T. Landelius, S. Van de Veen & T Moene in CY38h1.2

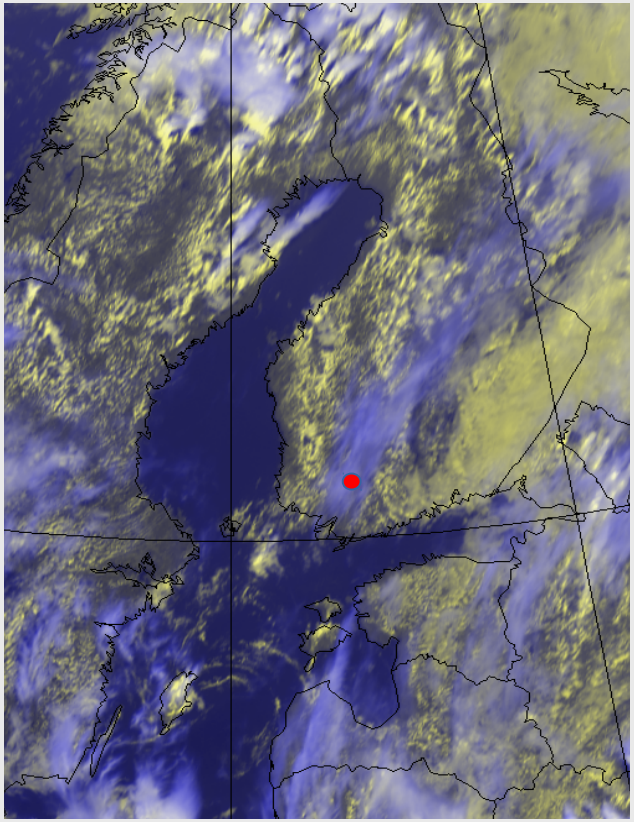
The different steps of the implementation of Van der Veen (2013) technique:

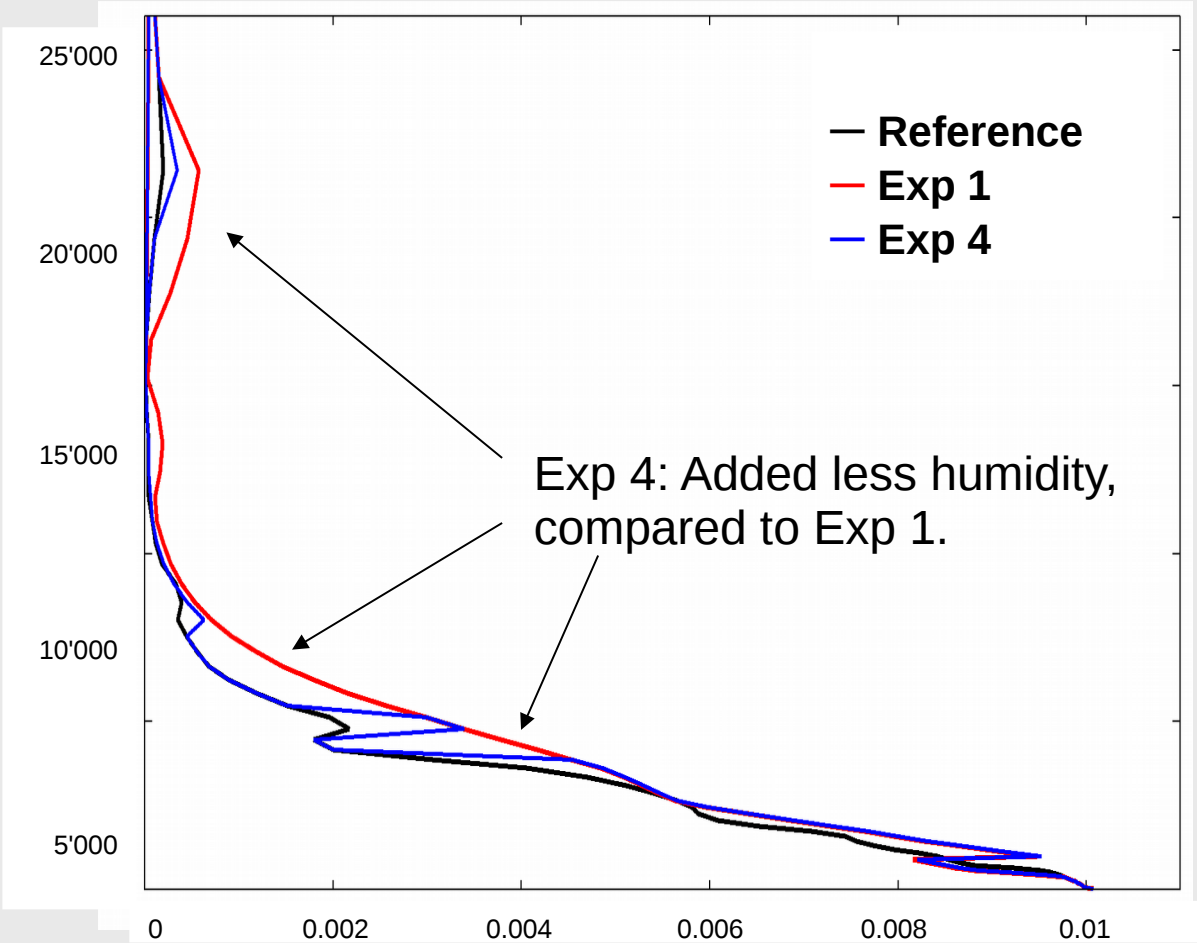
1 – Cloud-base from Synop data → Interpolated cloud-base field (“Van der Veen Method” method) (Exp 1);

2 – Cloud-base estimation: mean “climatological” cloud base (SMHI solution) (Exp 2);

3 – Exclude certain cloud classes from SAF product, and account for saturation of WV against ice (only to water) in the upper-troposphere (Exp 3);

4 – Detection of the cloud layers and control of the humidity tendency (Exp 4);





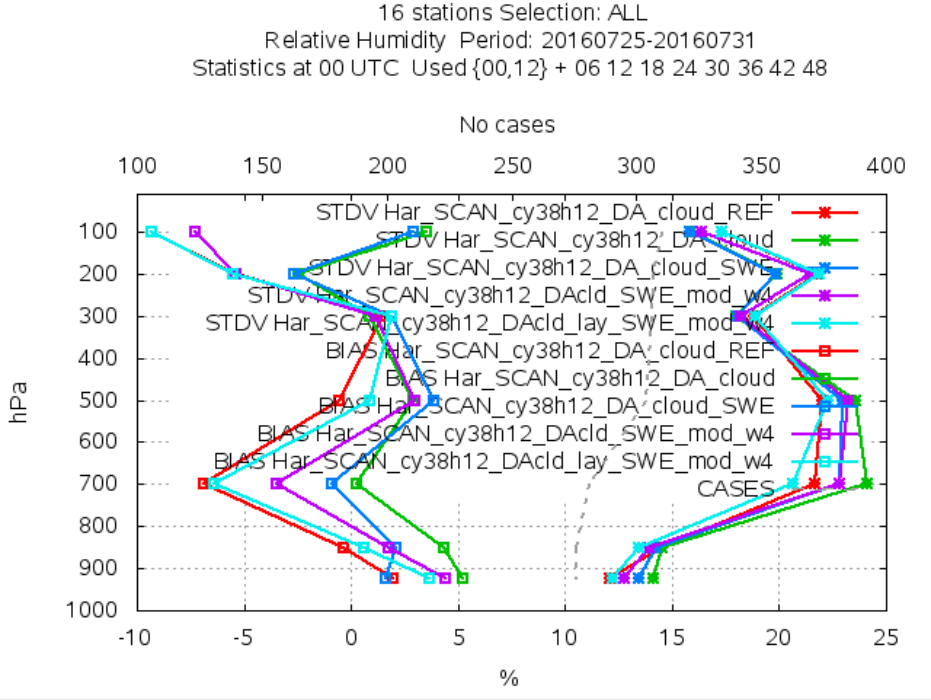
Highlight of the progress – cloud initialisation

Verification: 1 week,
25-31 July 2016

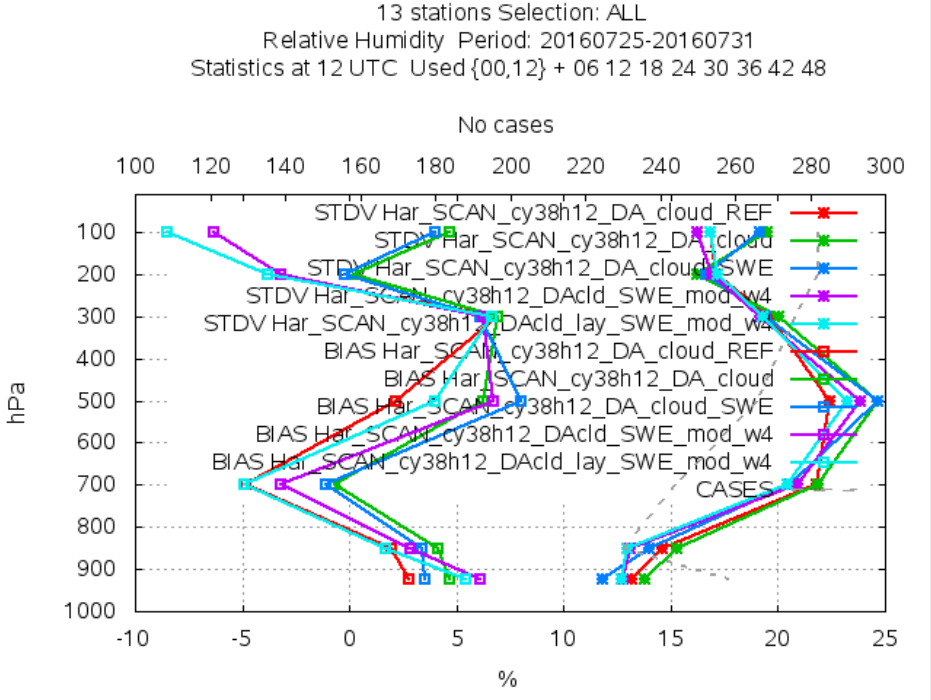
- Relative Humidity at
00 and 12 UTC

- Reference
- Exp 1
- Exp 2
- Exp 3
- Exp 4

Verification at 00 UTC



Verification at 12 UTC



Highlight of the progress – initialisation

– Back and forth nudging scheme implementation: Ole Vignes

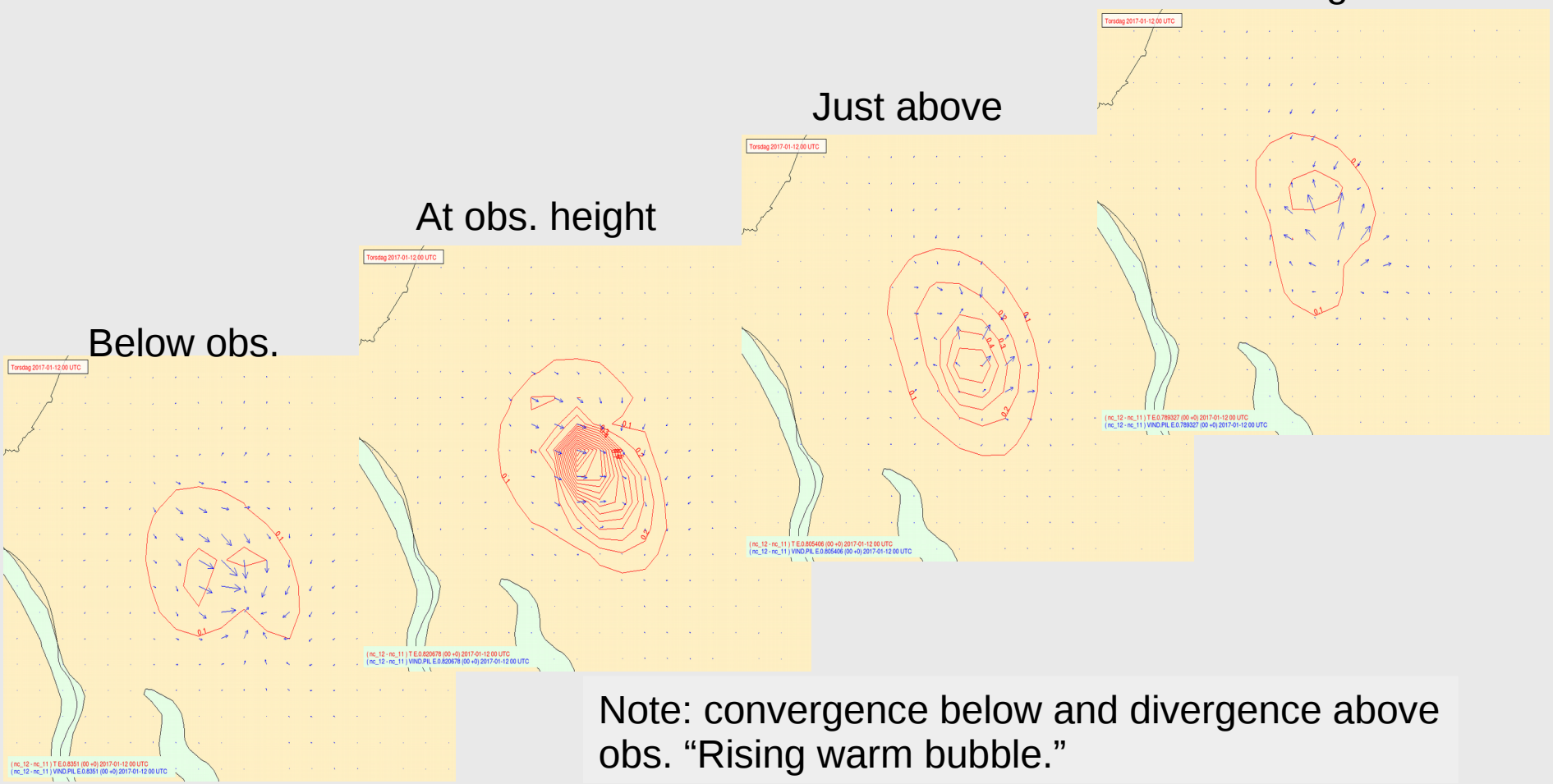
Implemented in context of digital filter initialization (but only single obs. so far).
Have been studying the effect of a single temperature observation, effect of multiple back and forth passes and length of time action (at a single point).
Examples of increments produced (certainly not geostrophic!):

Even higher

Just above

At obs. height

Below obs.



Note: convergence below and divergence above obs. “Rising warm bubble.”

Highlight of the progress – initialisation

– Considering the variational constraints encoded in an operator M

M: Non-hydrostatic semi-implicit system: **Carlos Geijog**

$$2J(x^k) = \int_o^{\tau_3} w_o^k \left\| x^k - x_o^k \right\|^2 + w_c^k \left\| Mx^k - x_\bullet^k \right\|^2$$

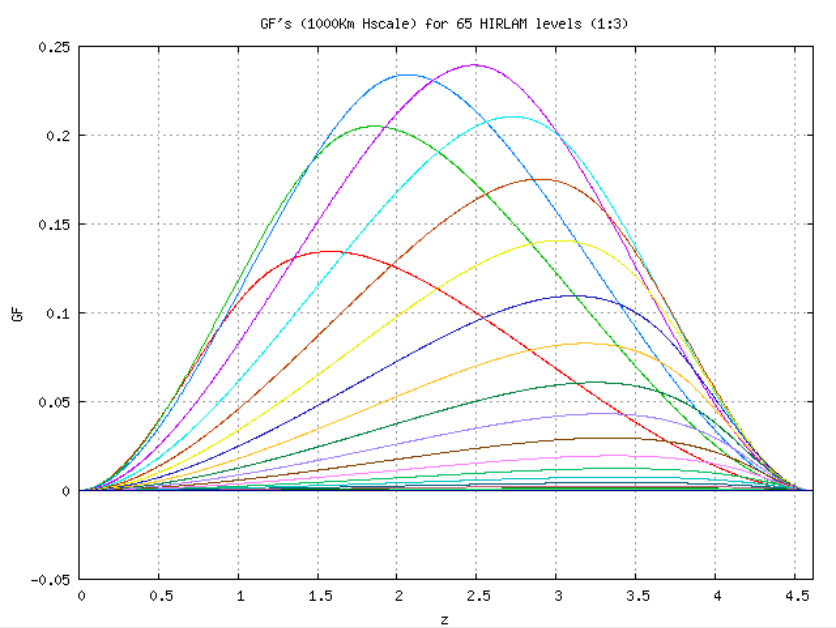
– Search for a solution in the vicinity of the background;

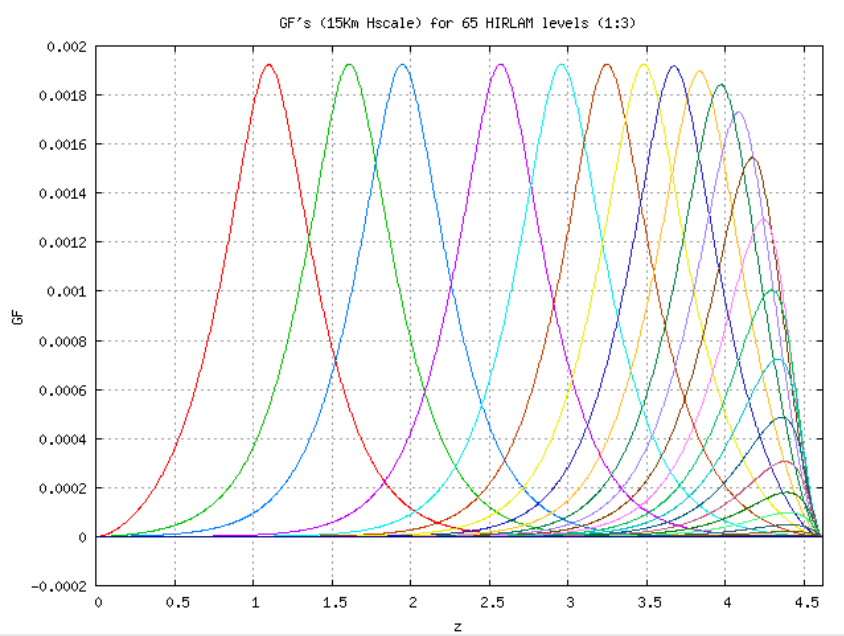
– using Green's Functions to find scale dependent balance operator;

– focusing mainly on wind analysis;

– to be coupled with field alignment scheme.

==> **See Carlos Geijog presentation for more details**

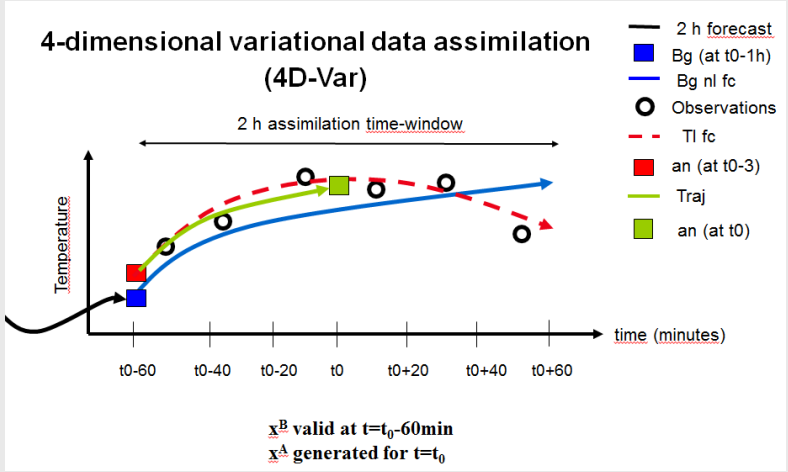


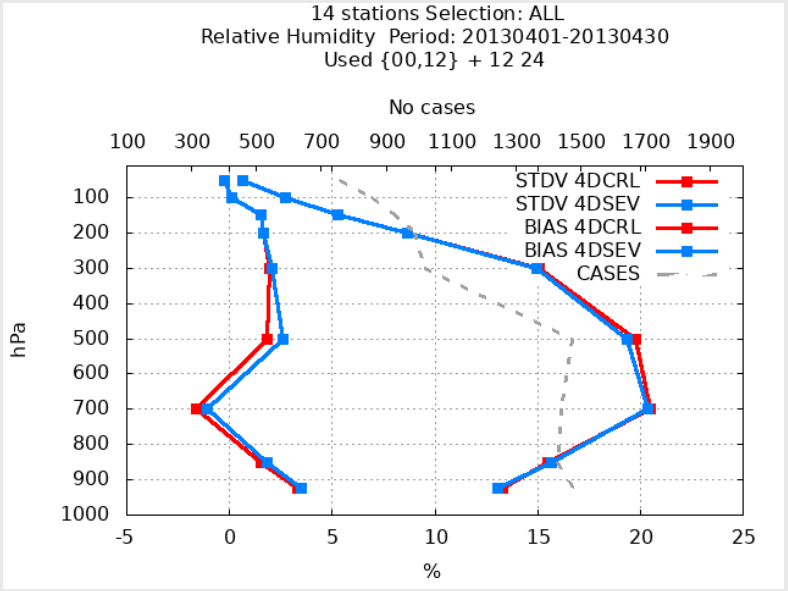


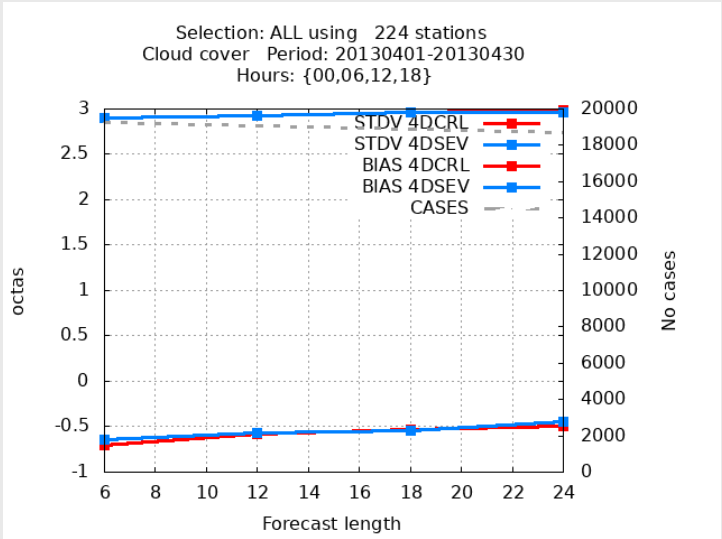
Development of 4DVar – assimilation of Seviri radiances

Scores for verification against observations (April, 2013)
SEVIRI radiances at t0-60min and t0+60min

4DVar study performed
in southern European domain
By
Magnus Lindskog, Tomas Landelius
Heiner Körnich and Sandra Andersson







(no improvements in winds or temperatures)

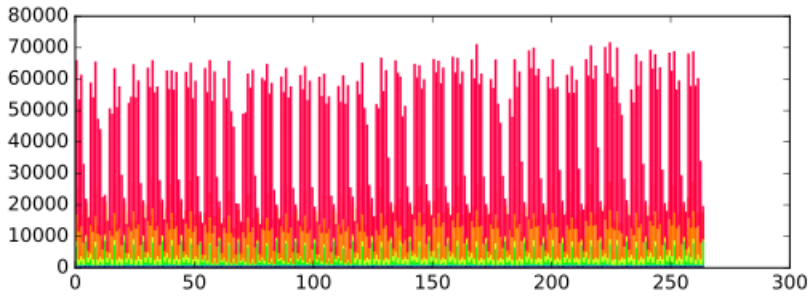
Please see Inger-Lise Frogner's presentation for LETKF development at AEMET by Pau Escriba

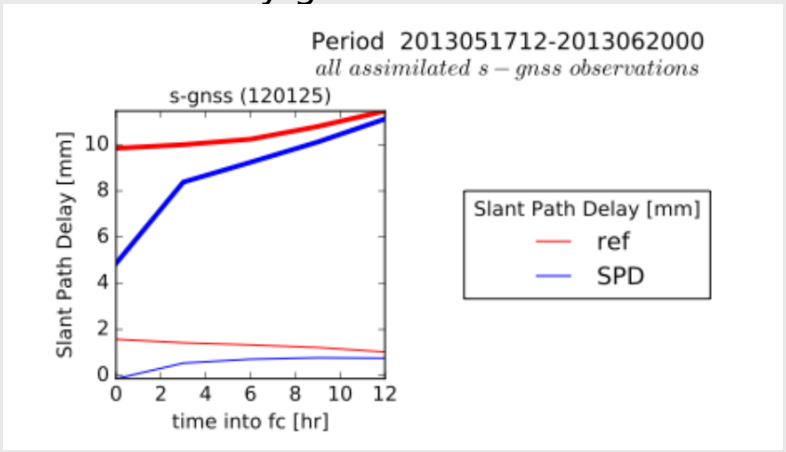
Highlight of the progress – Implementation of new obs type

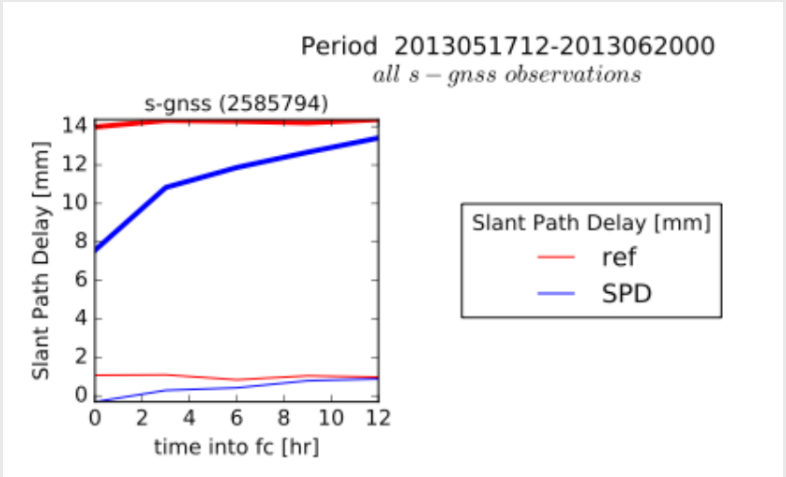
Implementation of GNSS slant delay observation in HARMONIE-AROME DA by Siebren de Haan
Comprehensive presentation can be found on Hirlam wiki page:
https://hirlam.org/trac/attachment/wiki/Meetings/Data_assimilation/Video_Meetings/2017/Retrieval_data_assimilation/FWS-WG2-SdH.pptx

Data assimilated
- STD : 5%
- TEMP
- AMDAR
- Mode-S EHS

STD
- positive impact over whole forecast
- bias correction works sub-optimal
- too short time window?
- all observations show very good statistics



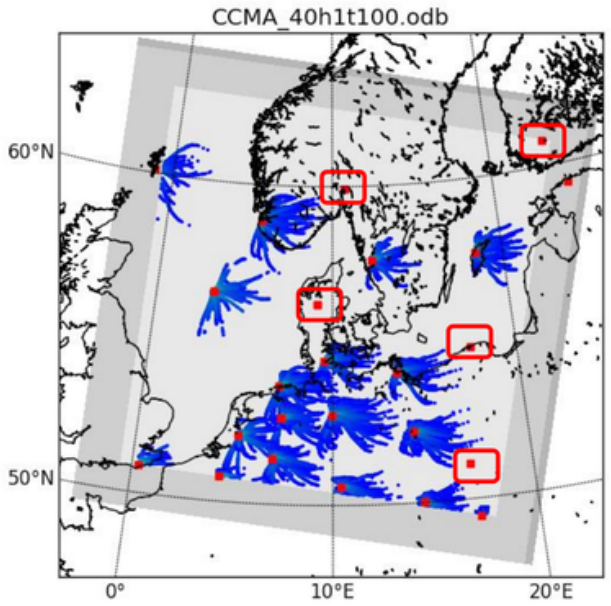




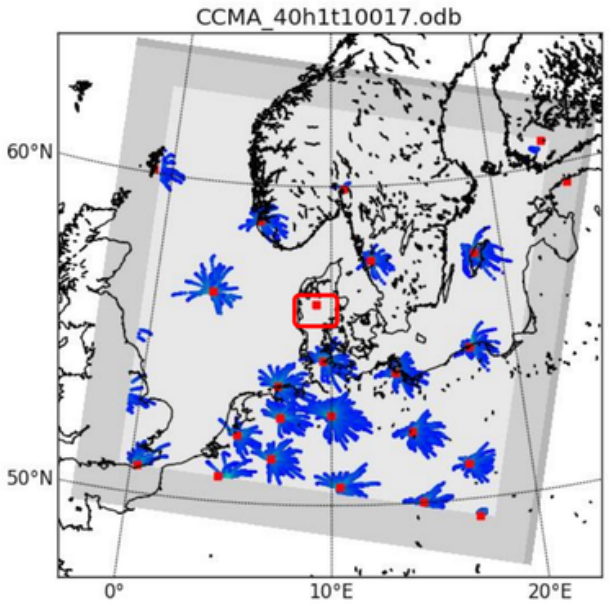
Highlight of the progress – Upgrade the DA system

Processing of radiosonde BUFR format – Eoin Whelan

Data coverage



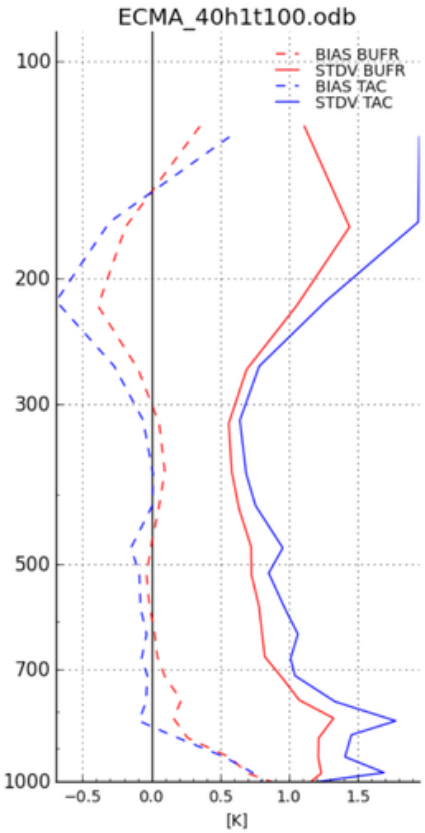
December 2015



February 2017

Highlight of the progress – Upgrade the DA system
Radiosonde BUFR format – Eoin Whelan

Impact study: Temperature O-B



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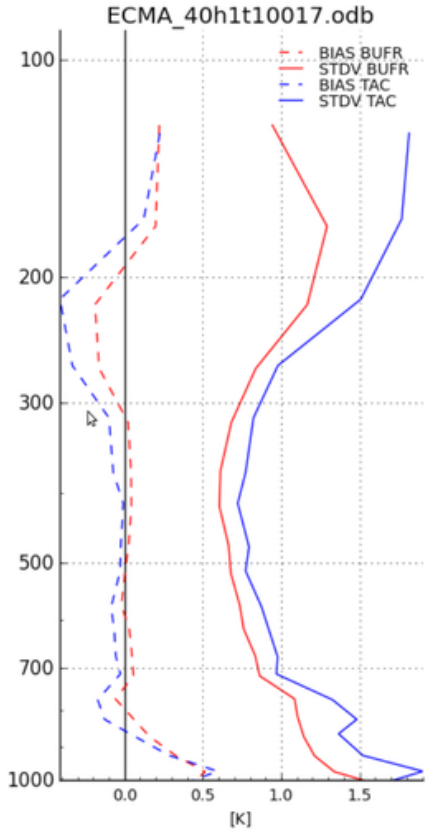
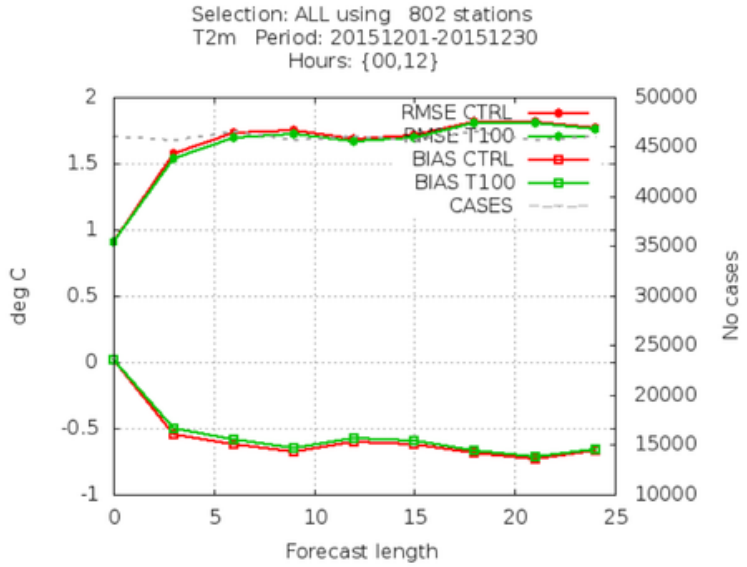


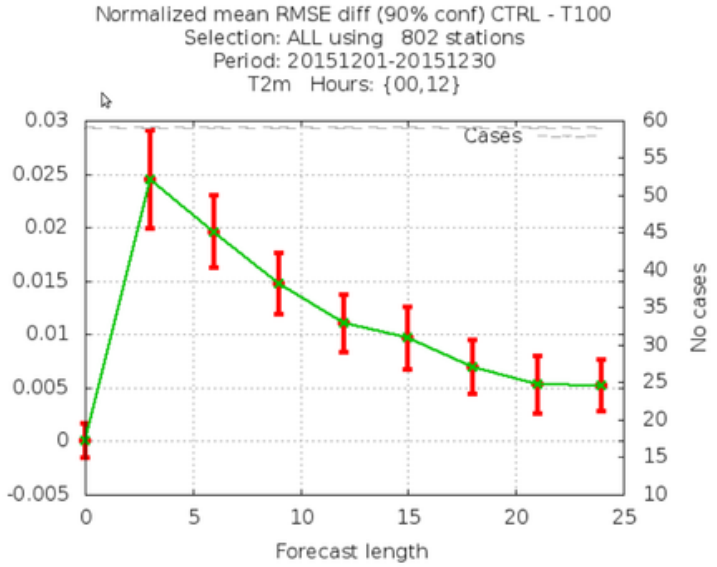
February 2017

Highlight of the progress – Upgrade the DA system
Radiosonde BUFR format – Eoin Whelan

Surface parameters



RMSE



RMSE DIFF

Highlight of the progress – Rapid Refresh: local implementation

Task: Development of 1-hour non-cycling DA – Rapid Refresh

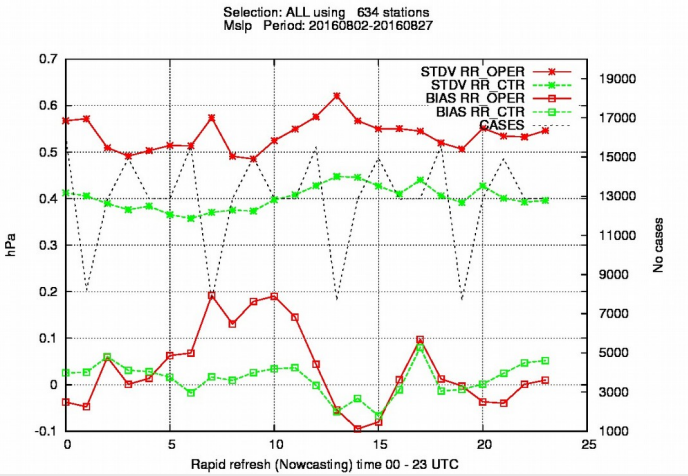
Roger Randriamampianina, SAWIRA2 project

Tested observations on top of conventional observations:

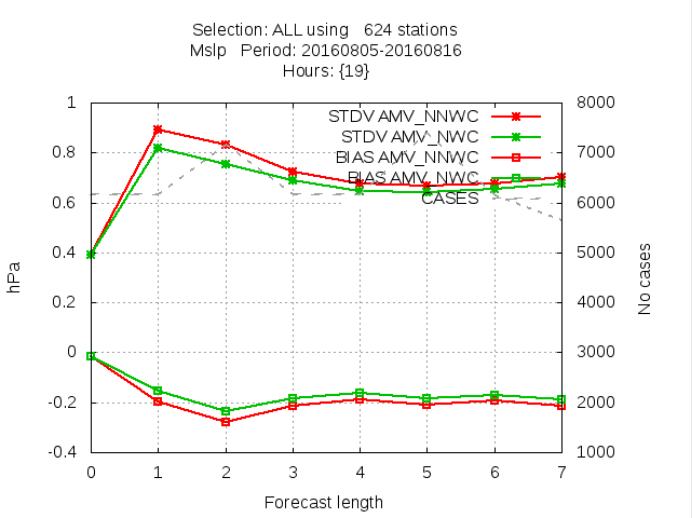
- Atmospheric Motion Vectors (AMV), ATOVS (AMSU-A, AMSU-B/MHS), IASI

Short-range(red) vs nowcast (green)

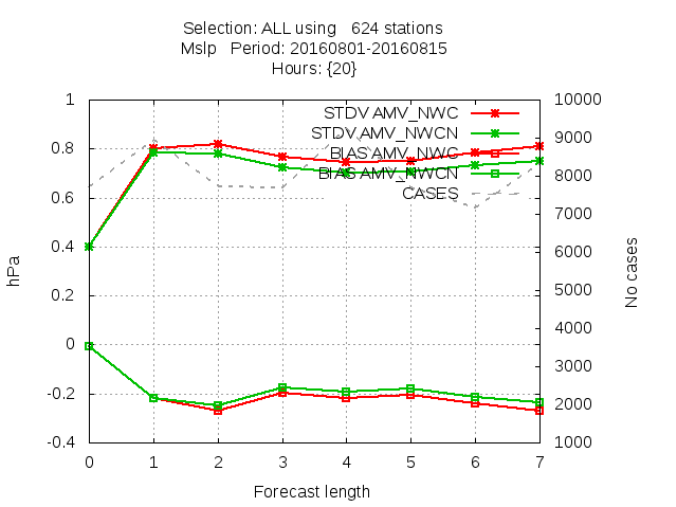
Similar impact for T2m and Hu2m except V10m is neutral



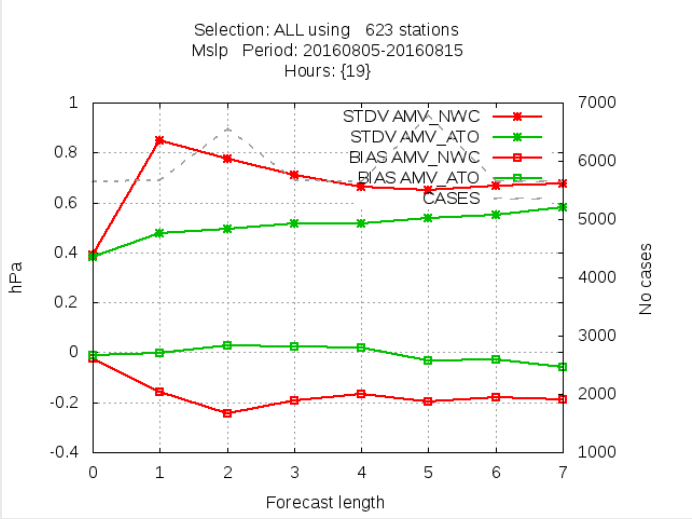
Positive impact of AMV



Positive impact of IASI



Negative impact of ATOVS

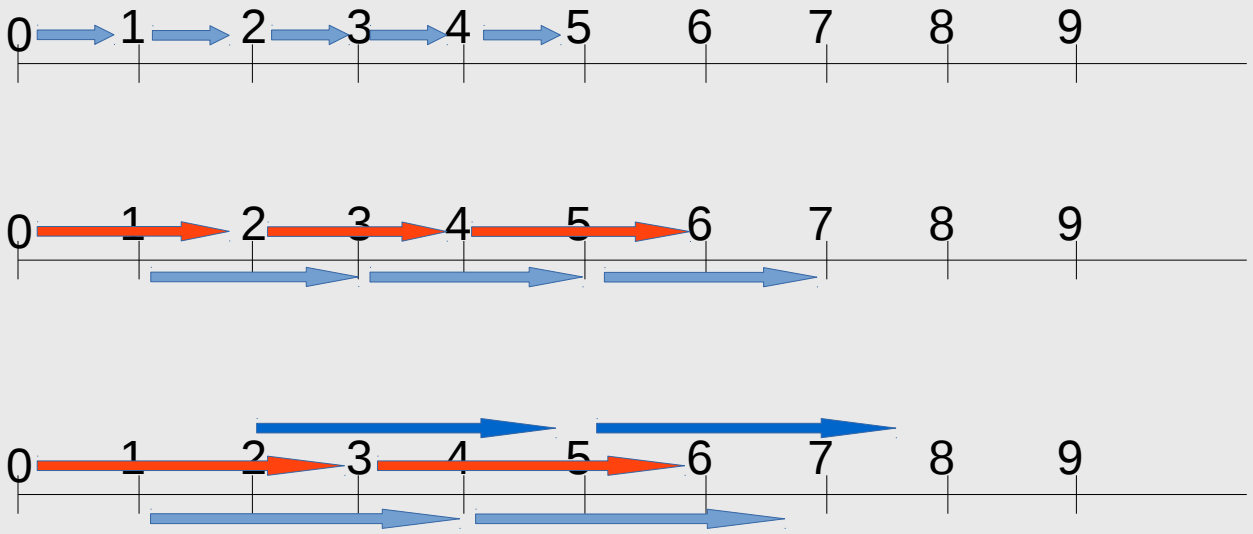


What can we do to better assimilate radiances in nowcasting?

Possible solutions:

– Make the VarBC more flexible in handling of different sets of observations, including missing data in some update time (assimilation time);

– Use cycling data assimilation with (partially) overlapping windows (Yang et al. 2017);



One 1-hour cycling DA system

Two 2-hour cycling DA systems

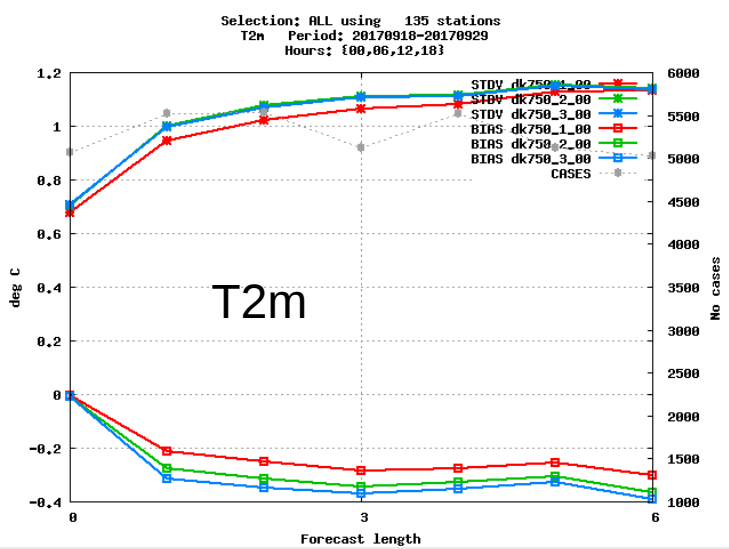
Three 3-hour cycling DA systems

==> These systems have the same cost, but gain in observation usage, especially if 4DVar is used as DA

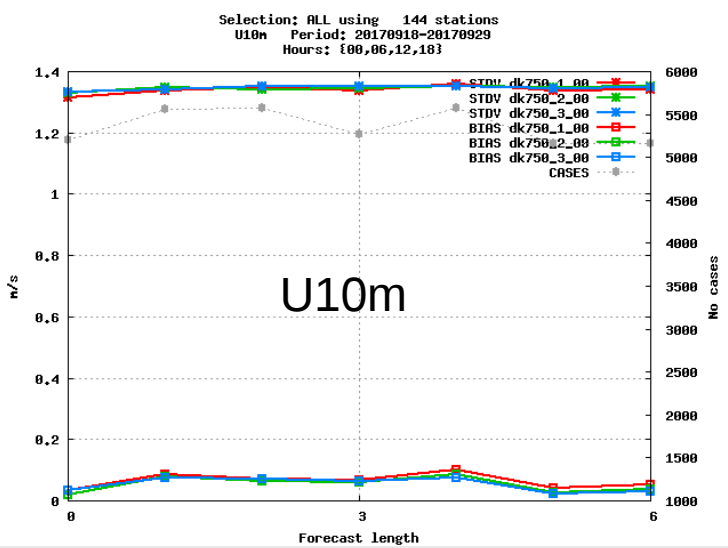
Overlapping windows with 3DVar

1h, 2h and 3h cycling assimilation with HARMONIE 40h1 on DK750 domain (750 m horizontal resolution, 2017 September 18-29.

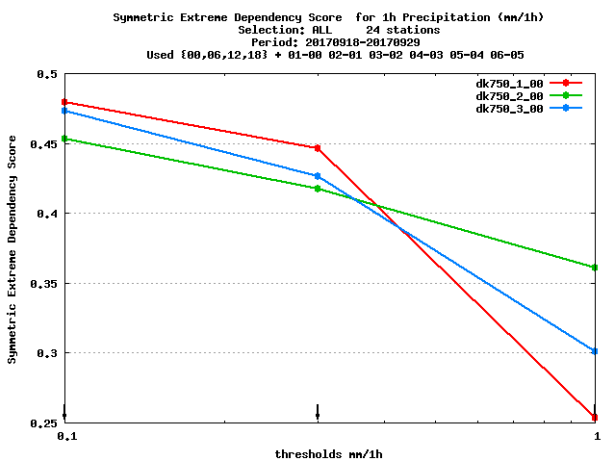
(Xiaohua Yang (DMI) and Roger Randriamampianina)



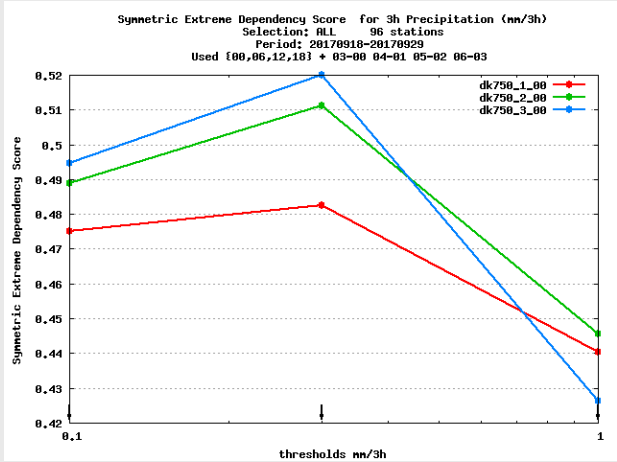
– 1h cycling
– 2h cycling
– 3h cycling



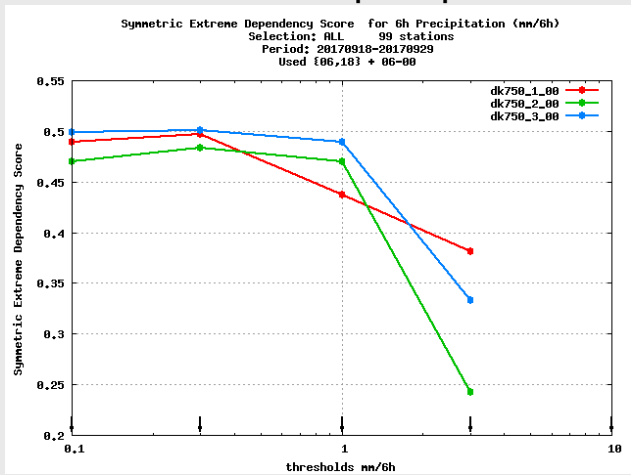
1h accumulated precipitation



3h accumulated precipitation

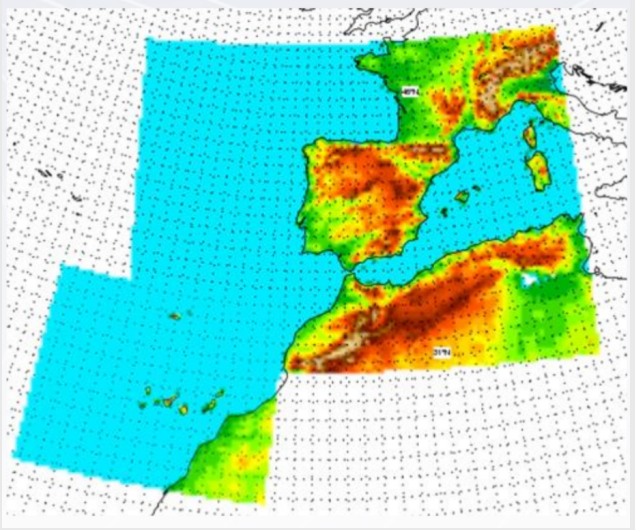


6h accumulated precipitation



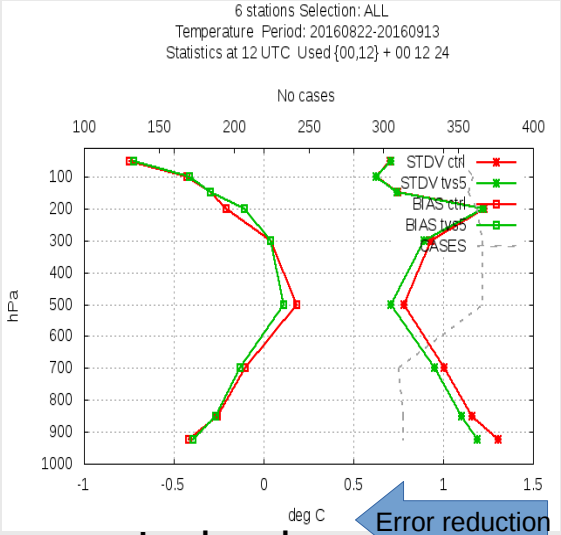
Highlight of the progress – 3D-VAR: local implementation

Task: Implement 3D-VAR DA with 3-hourly cycling

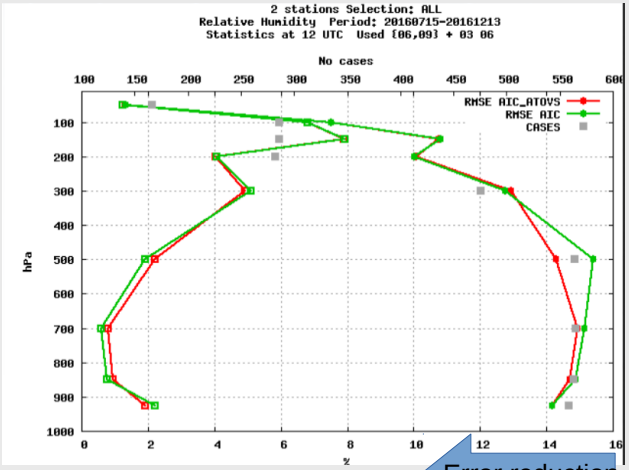


Iceland: Use conventional and ATOVS observations
Sigurdur Thorsteinsson and Roger Randriamampianina

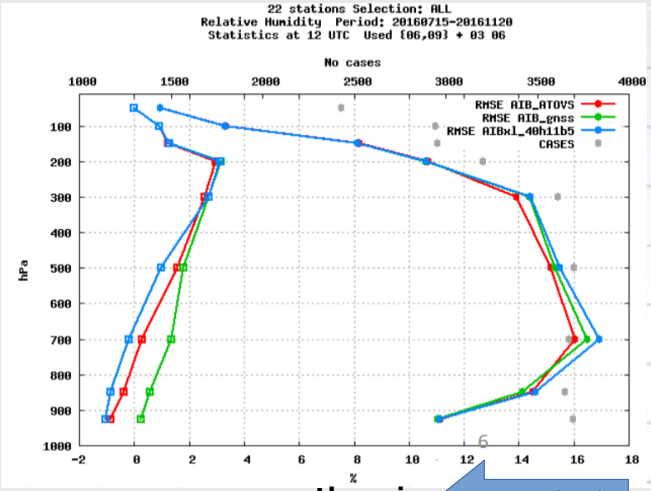
Spain: Use conventional, ATOVS and GNSS ZTD observations by
Maria Diez, Jana Arriola and Joan Campins



Iceland



Canary



Iberia

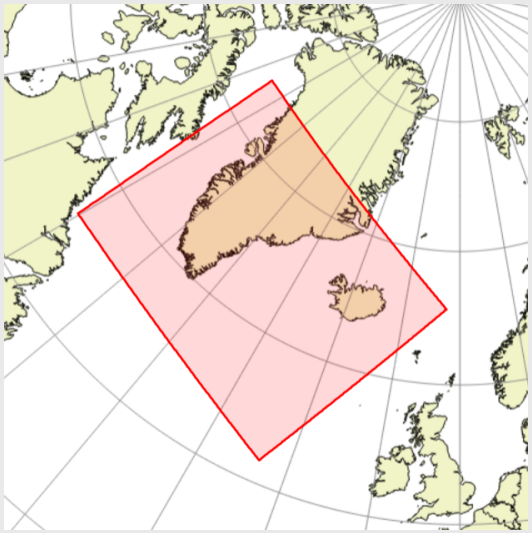
Error reduction

Error reduction

Error reduction

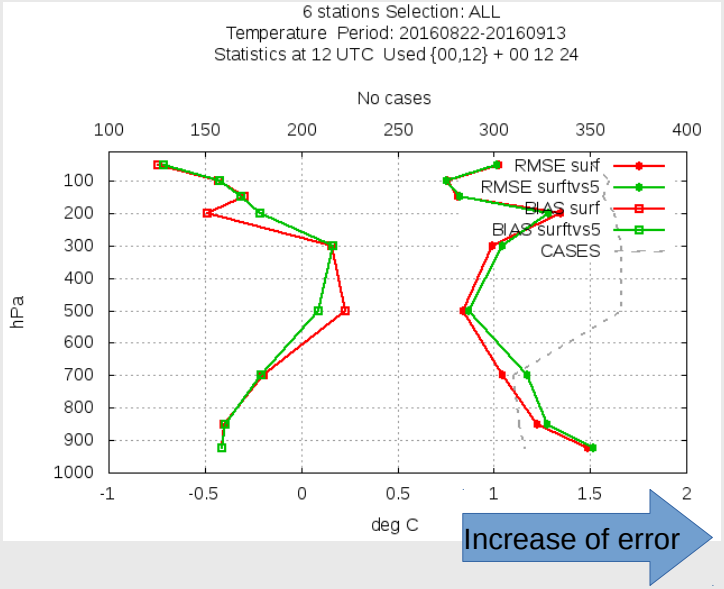
Highlight of the progress – 3D-VAR: local implementation

Need of “anchoring observations” in upper-air when using VarBC



Iceland implementation work

Assimilation of ATOVS with surface observations only



Concluding remarks and outlook

– Continue the local implementation of more observations …;

– Continue developing the 4DVAR, LETKF and EnVar schemes;

– Understand the quality control of radar data – ex. Baltrad vs Prorad tools;

– As soon as possible implement the All-Sky IFS solution in Harmonie-Arome DA;

– Continue testing different cycling strategies and Rapid refresh;

– Working with initialisation schemes: back & forth nudging, use of variational constraint, Incremental Analysis Update;

– Improving our pre-processing tool and at the same time develop COPE to handle all observations;

– Better accounting of large scale information in initialisation and data assimilation;

– Adding more observations from, for ex. Netatmo or smartphones;

– Contribute to OOPS development work.

Thank you