Norwegian Meteorological Institute

HIRLAM upper-air data assimilation

Roger Randriamampianina
with contribution of HIRLAM colleagues

LACE WD, 2017, Ljubljana

outline

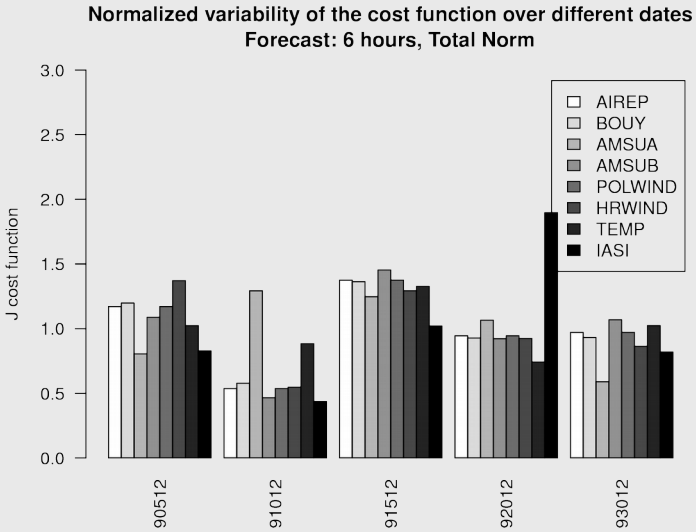
- Operational upper air data assimilation (UA-DA) systems in HIRLAM;

- Some reported issues with operational DA;

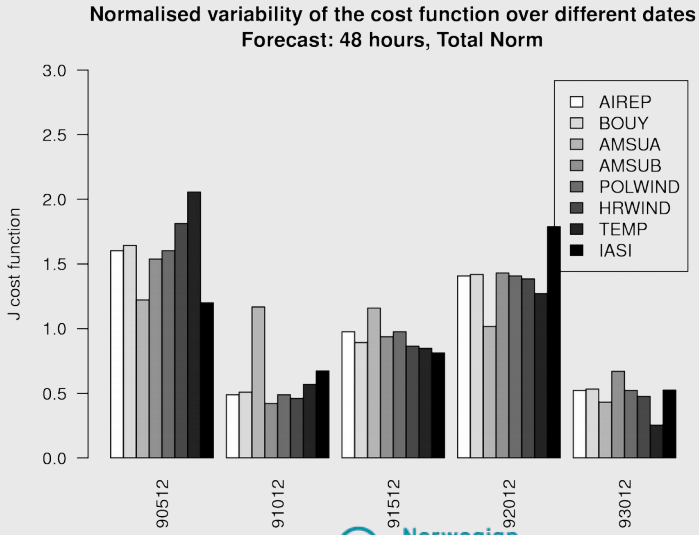
- Some development works related to UA-DA;

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



Upper air DA – observed issues

Radiance processing:

```
WARNING:  Problems in RTTOV call for NOAA    19   223 SENSOR=MHS
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 WARNING:  Problems in RTTOV call for NOAA    19   223 SENSOR=MHS

You always see it for noaa19 but sometimes for all
 WARNING:  Problems in RTTOV call for METOP    2     4 SENSOR=MHS
 WARNING:  Problems in RTTOV call for NOAA    18   209 SENSOR=AMSUB
 WARNING:  Problems in RTTOV call for METOP    1     3 SENSOR=MHS


WARNING:  Problems in RTTOV call for NOAA    19   223 SENSOR=MHS

  Setting FG to missing values
 2017/06/26  07:26:49  fatal   in module rttov_checkinput.F90:0194
    invalid zenith angle (profile number =        1)
 2017/06/26  07:26:49  fatal   in module rttov_direct.F90:0402

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 2017/06/26  07:26:49  fatal   in module rttov_direct.F90:0402
```

Magnus L. contacted Nadia Fourrie

MF (Nadia Fourrie) regularly have this kind of message.
The zenith angle from the BUFR does not have the right value.

```
2017/06/26  07:26:49  fatal   in
module rttov_checkinput.F90:0194
     invalid zenith angle (profile
number =        1)
```

This happens sometimes. You could have a look at the data to check the value of this parameter and verify that the read value is out of the range allowed by RTTOV.

This needs careful update of the radiance reading routine in Bator

Upper air DA – observed issues
Convergence of the variational scheme

Convergence issue:

GRTEST TENTATIVE CONCLUSIONS :
GRTEST function f looks continous.
GRTEST the best gradient test found has 4 satisfactory digits.
GRTEST SAYS: **THE GRADIENT IS ACCEPTABLE.**
GRTEST could not check grad convergence.
GRTEST large-scale Taylor estimate of d2f= 7670637.33695617
GRTEST large-scale d3f/d2f= 41741.8229401185
GRTEST the Taylor quadraticity test has -3 satisfactory digits.
GRTEST: **THE T-QUADRATICITY IS BAD.**
GRTEST finite diff. d2f estimate no1: 8204479.29880757
GRTEST finite diff. d2f estimate no2: 8204534.52534275
GRTEST the fin.dif. estimates of d2f have 5 satisfactory digits.
GRTEST: **THE FD-QUADRATICITY IS ACCEPTABLE.**
GRTEST Goodbye.

Highlight of the progress – Rapid Refresh: local implementation

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

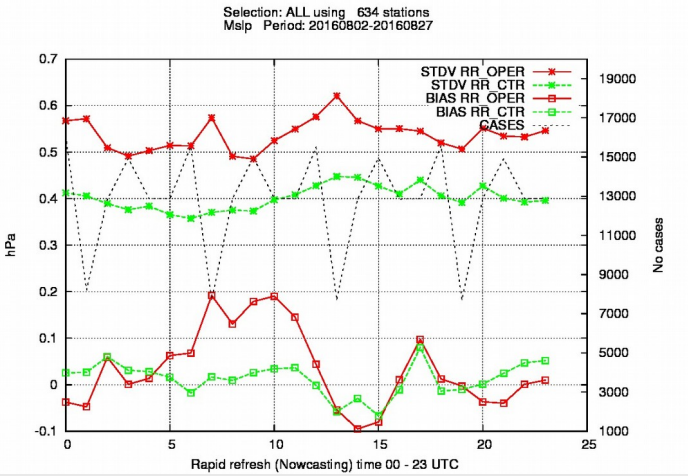
Roger Randriamampianina, SAWIRA2 project

Tested observations on top of conventional observations:

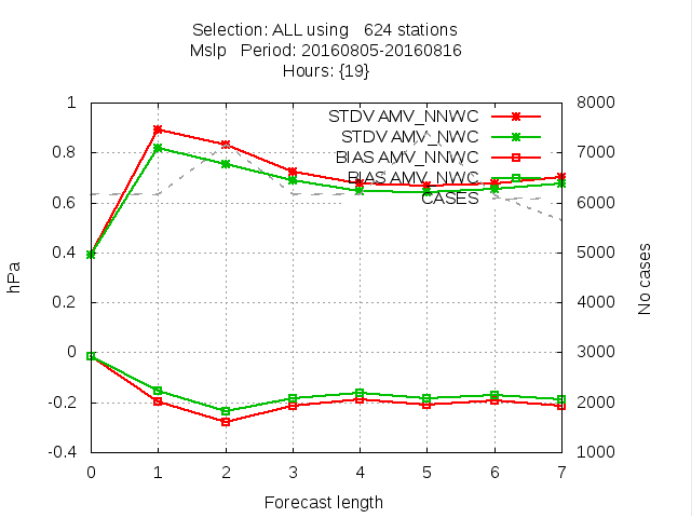
- Atmospheric Motion Vectors (AMV), ATOVS (AMSU-A, AMSU-B/MHS), IASI

Short-range(red) vs nowcast (green)

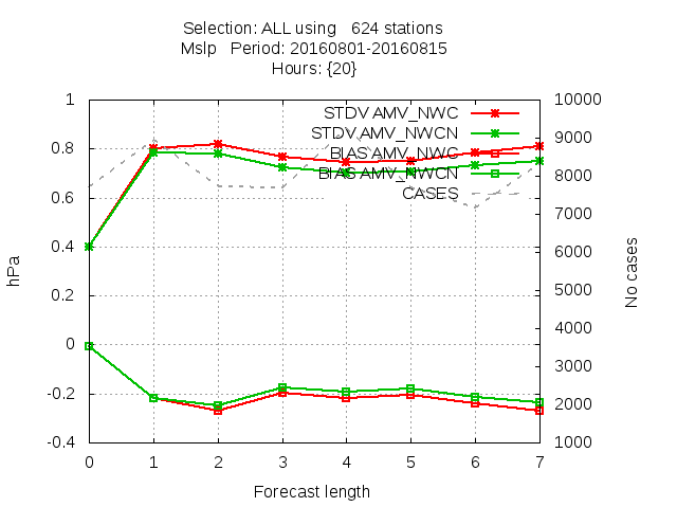
Similar impact for T2m and Hu2m except V10m is neutral



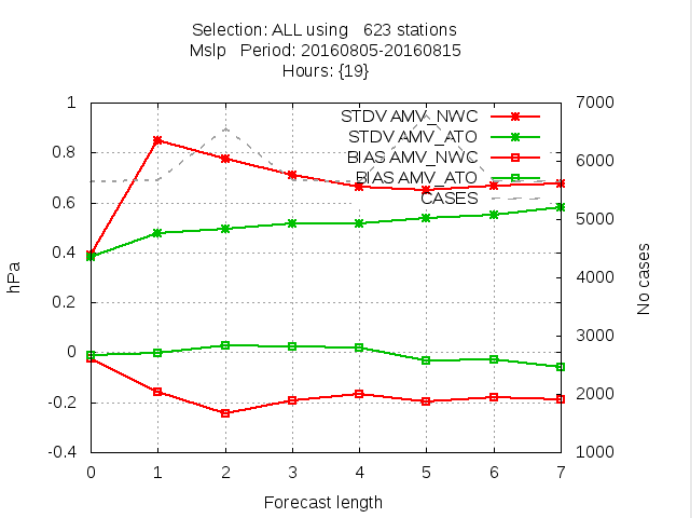
Positive impact of AMV



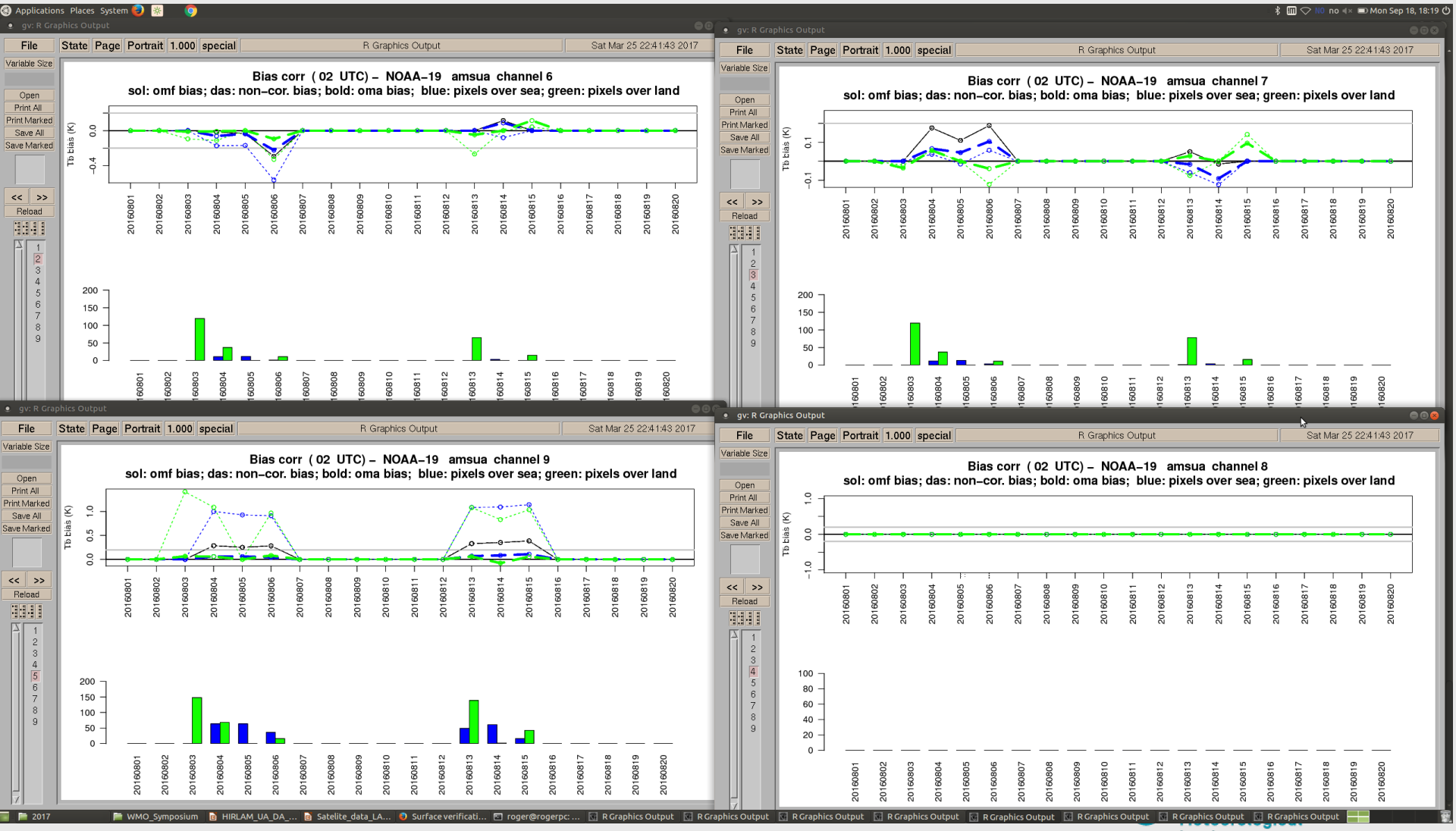
Positive impact of IASI



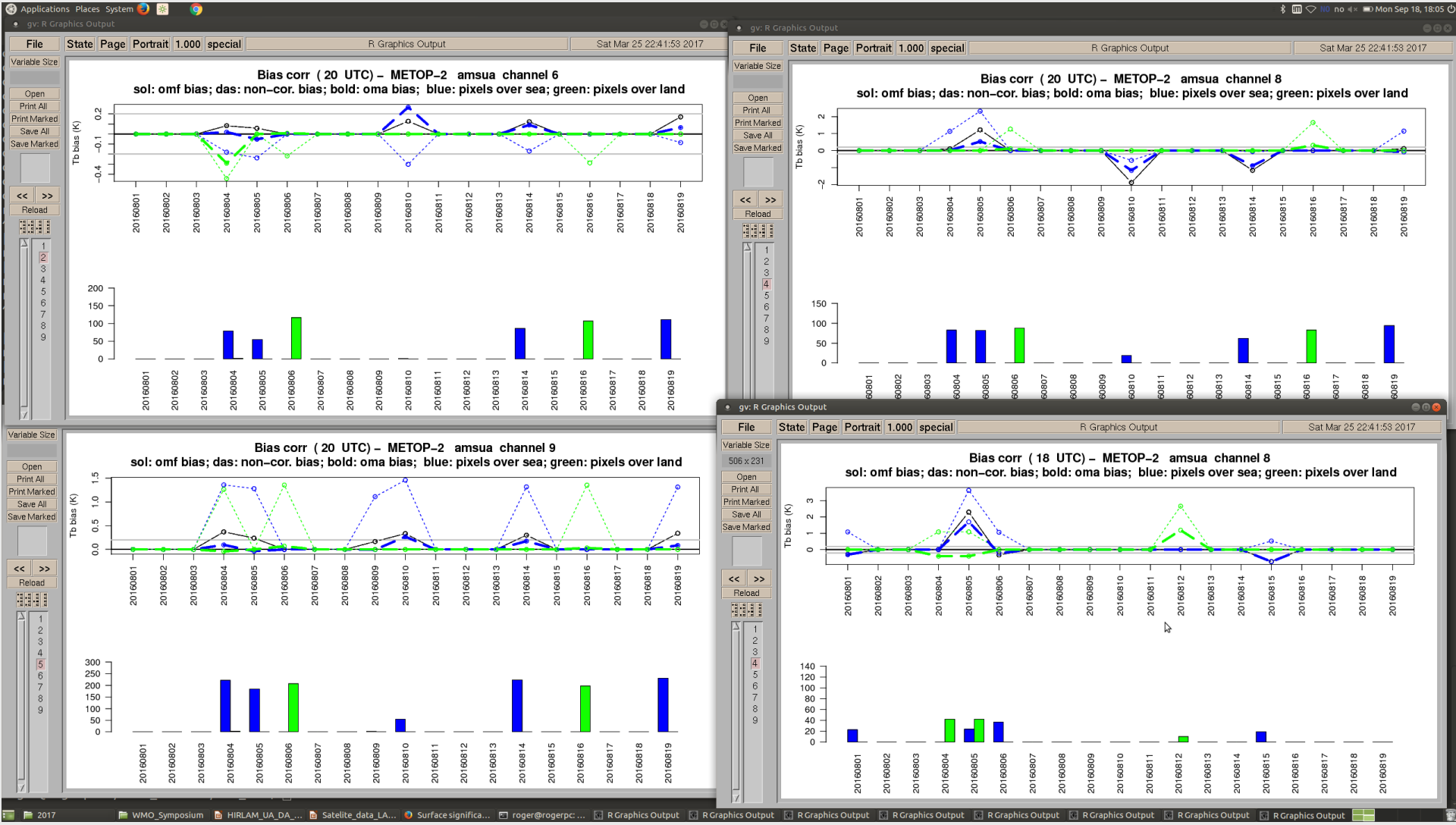
Negative impact of ATOVS



Upper air DA – observed issues



Upper air DA – observed issues



Bad channel 8 from Metop-A is one of the reasons

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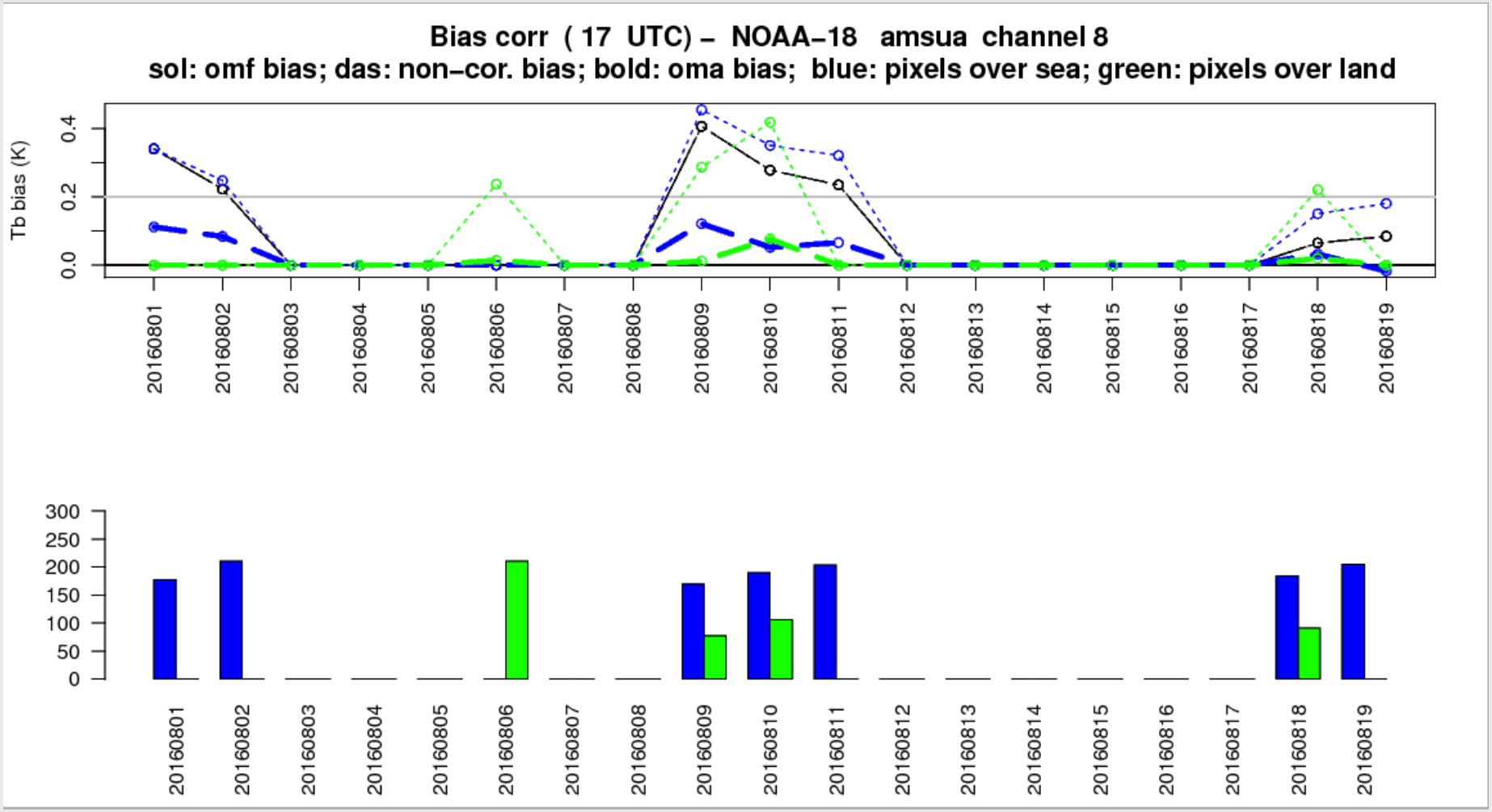
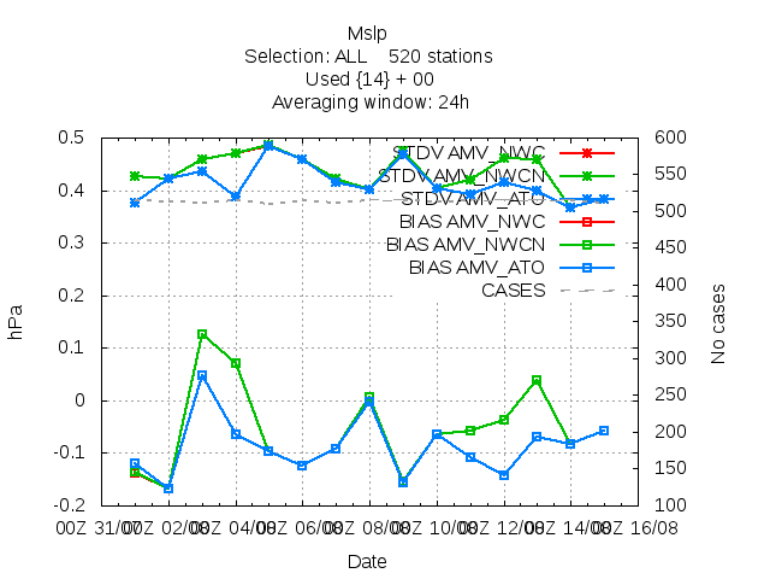
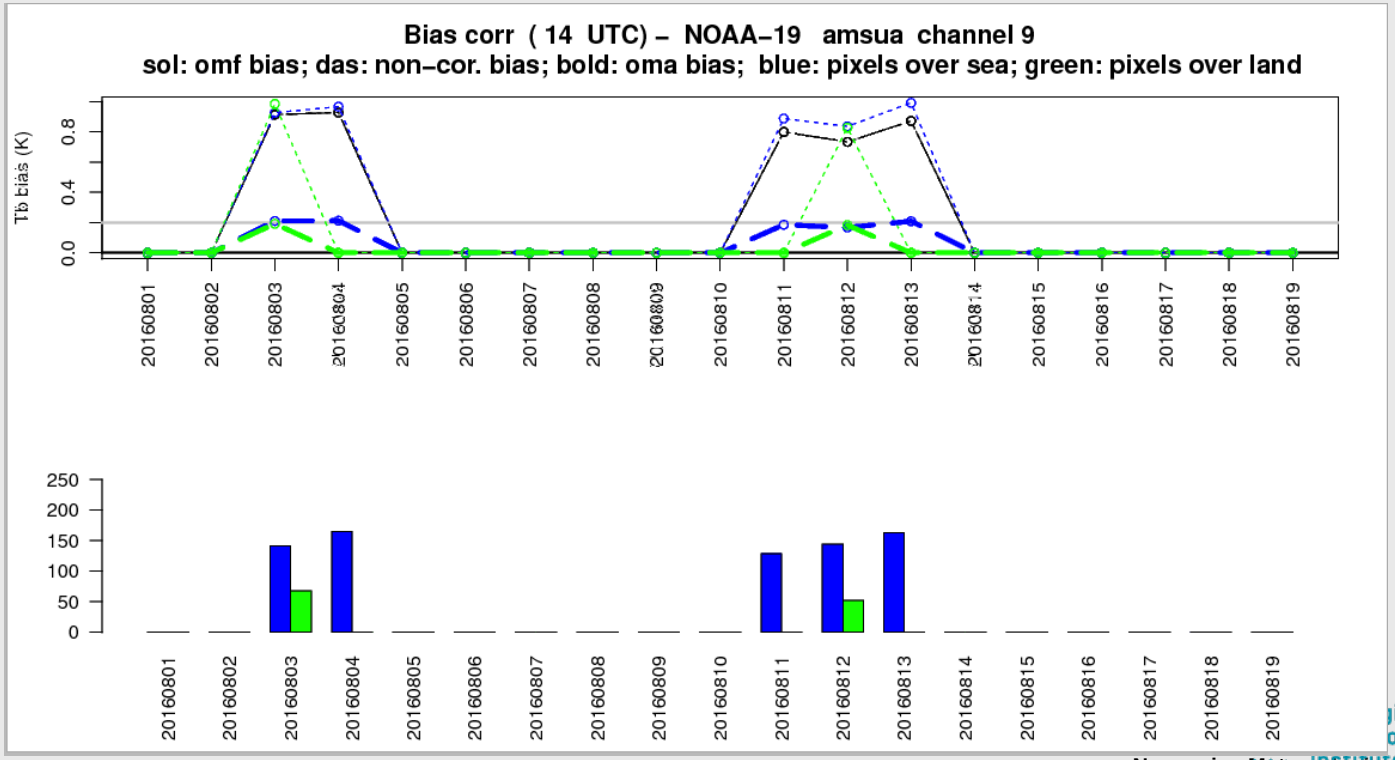


One of the reasons of failure of ATOVS assimilation is that the VarBC coefficients are not computed for rapid-refresh. They were taken from the oper MetCoOP.


Mslp
Selection: ALL 520 stations
Used {14} + 00
Averaging window: 24h
STDV AMV_NWC
STDV AMV_NWCN
STDV AMV_ATO
BIAS AMV_NWC
BIAS AMV_NWCN
BIAS AMV_ATO
CASES
hPa
No cases
Date


Bias corr (14 UTC) – NOAA–19 amsua channel 9
sol: omf bias; das: non–cor. bias; bold: oma bias; blue: pixels over sea; green: pixels over land
Tb bias (K)

Highlight of the progress – initialisation

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

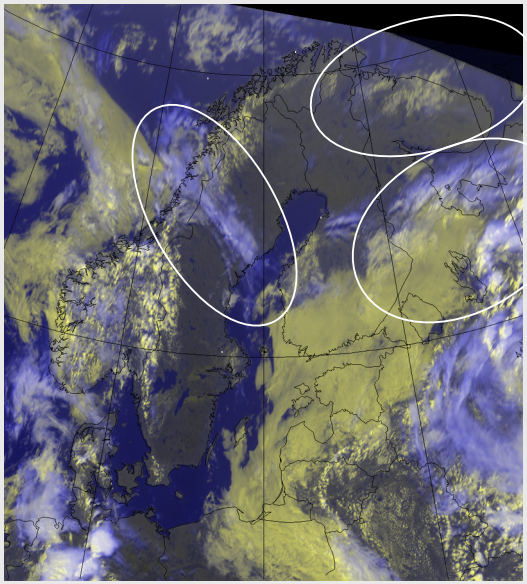
- Input from NWCSAF Cloud-Type classes: Gives too much clouds (especially high-clouds)

- Saturation water vapor only to water: Related to too much high-clouds
  New code to calculate saturation water vapor for ice (upper levels)

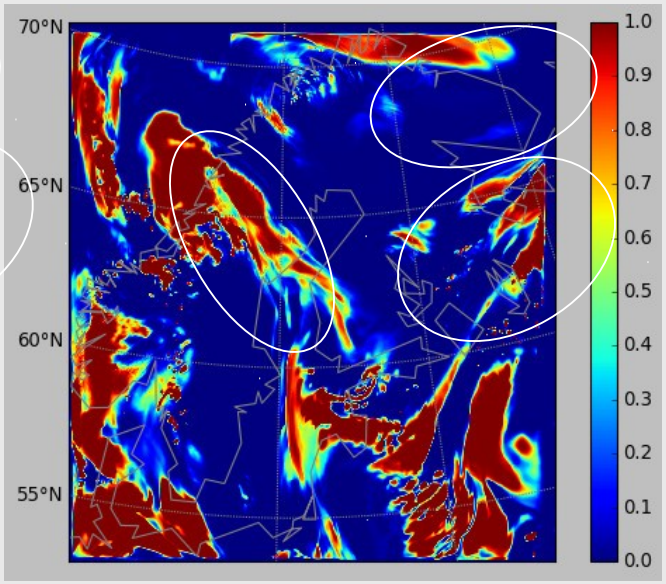
- Cloud-base estimation: Related to low-clouds
  MSG – Synop based
  MSG_SWE – Climatological estimates, “first-guess”

- Thresholds effecting the humidity profiles: Related to whole vertical profile of cloud

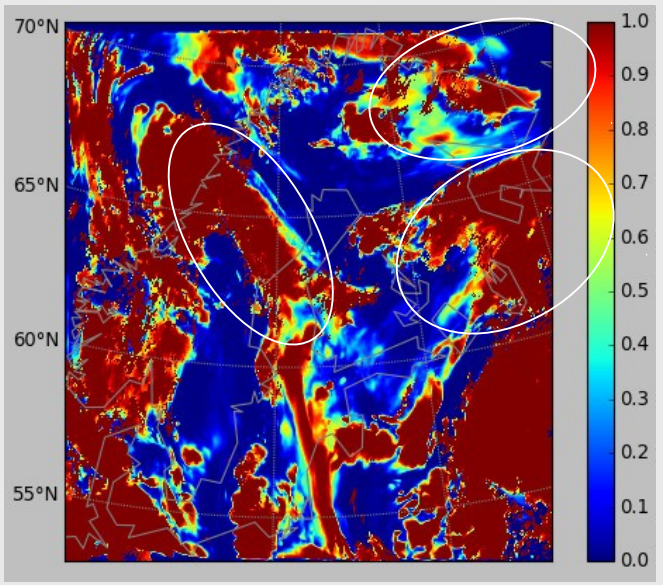
Satellite



Har. Reference



Har. MSG-NWCSAF



Highlight of the progress – initialisation

– Back and forth nudging scheme implementation: Ole Vignes

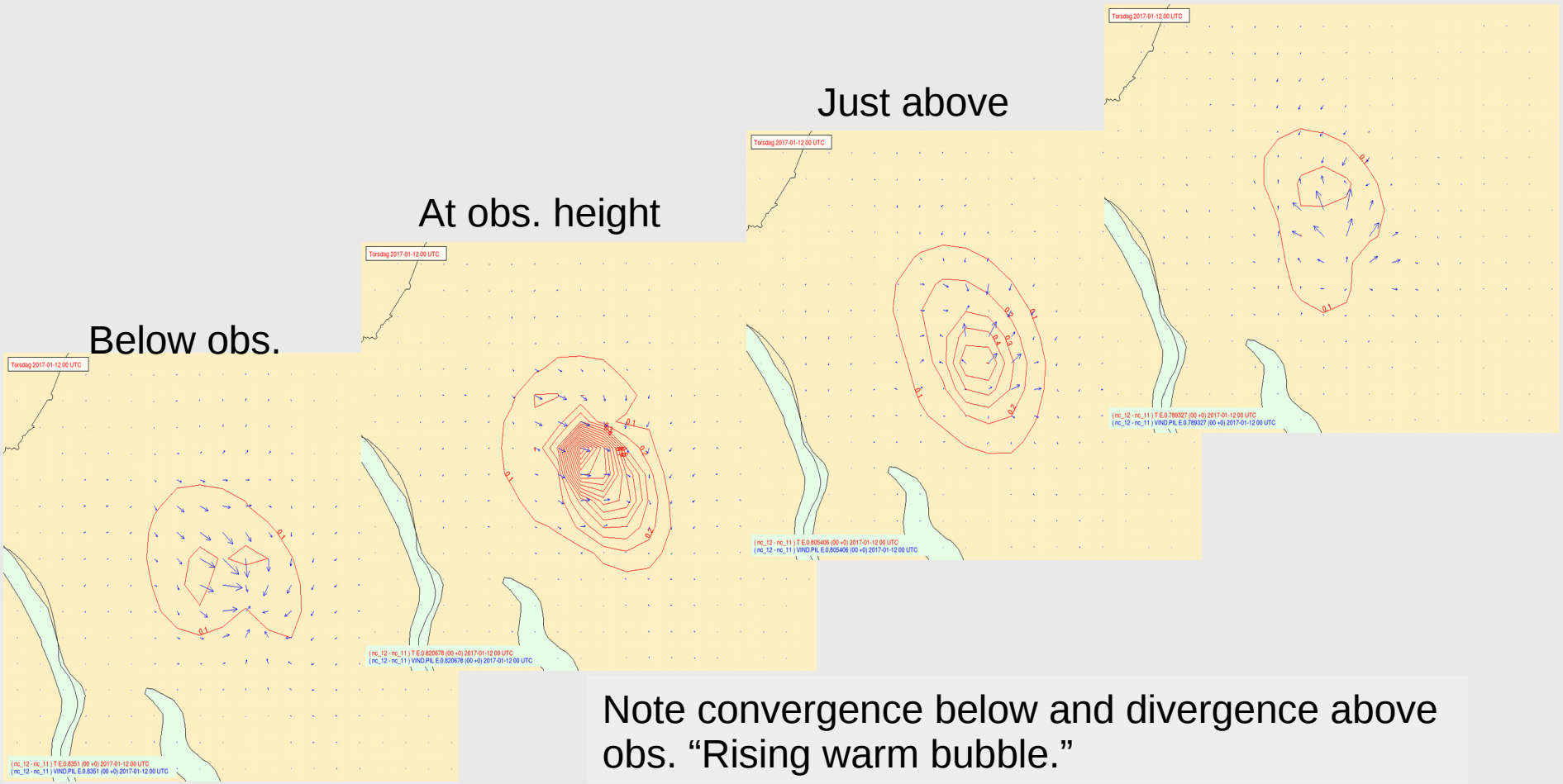
Implemented in context of digital filter initialization (but only single obs. so far).
Have been studying the effect of a single temperature observation, effect of multiple back and forth passes and length of time action (at a single point).
Examples of increments produced (certainly not geostrophic!):

Even higher

Just above

At obs. height

Below obs.



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

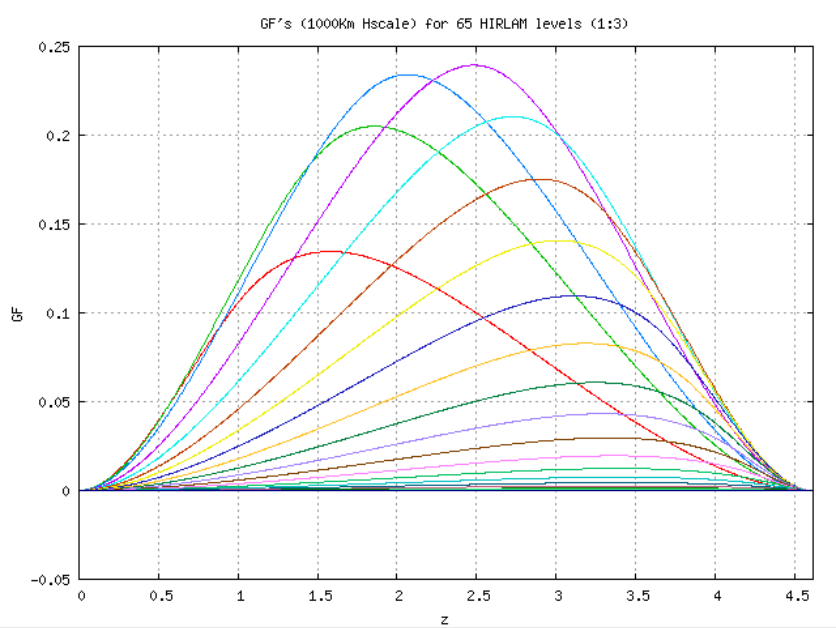
Highlight of the progress – initialisation

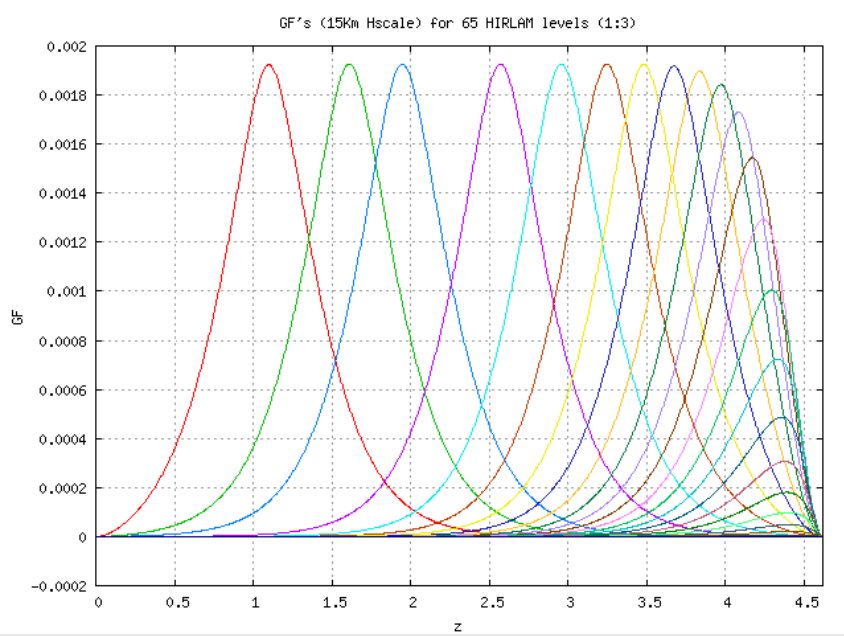
– Considering the variational constraints encoded in an operator M
M: Non-hydrostatic semi-implicit system: **Carlos Geijog**

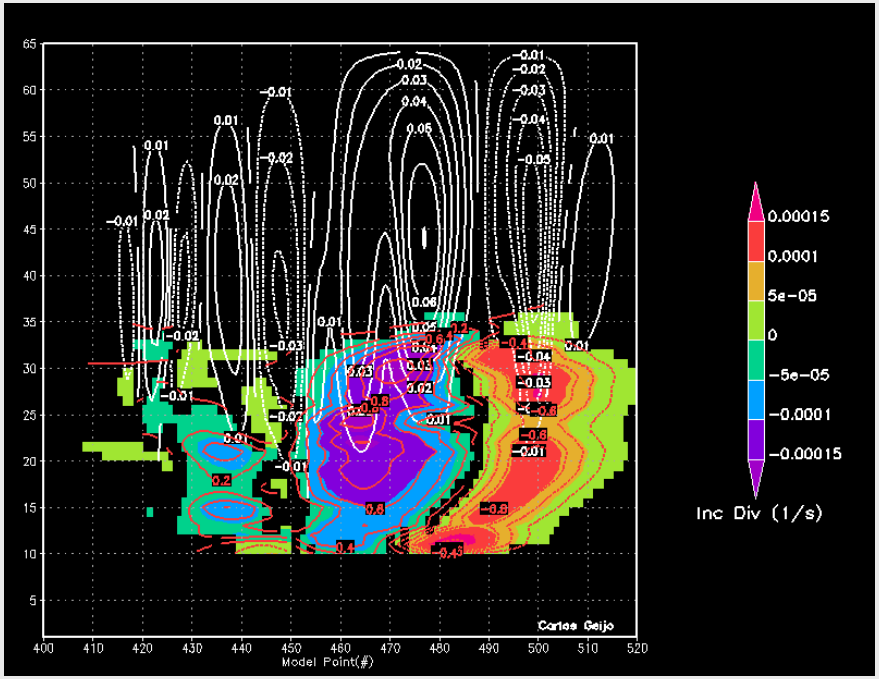
$$2J(x^k) = \int_o^{\tau_n} w_o^k \left\| x^k - x_o^k \right\|^2 + w_c^k \left\| Mx^k - x_\bullet^k \right\|^2$$

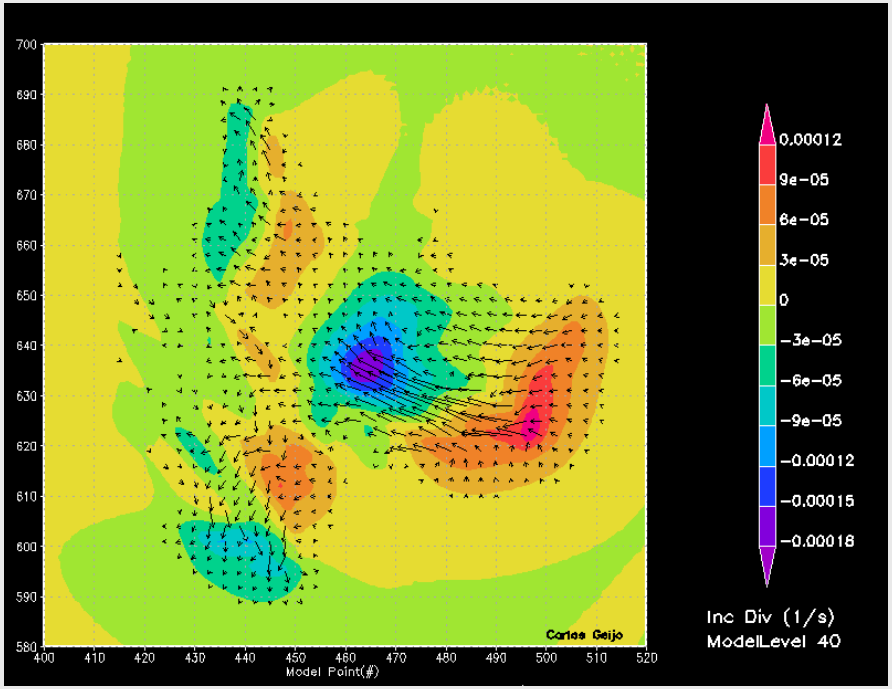
– Search for a solution in the vicinity of the background;
– using Green's Functions to find scale dependent balance operator;
– focusing mainly on wind analysis;
– to be coupled with field alignment scheme.

==> **It's a work in progress!**



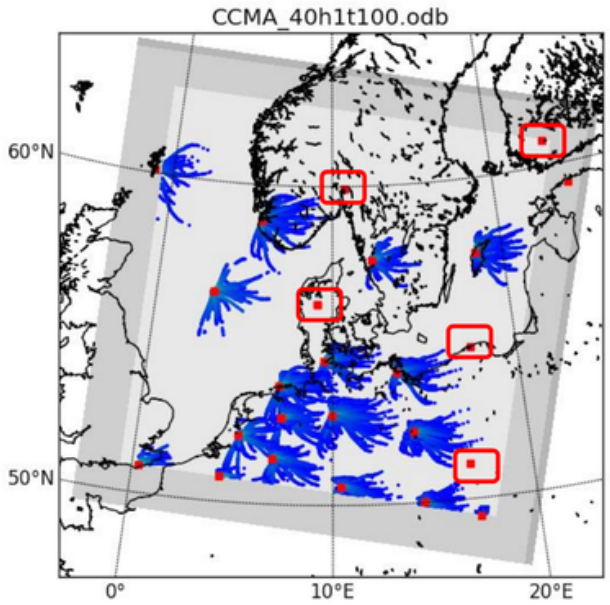



0.00015
0.0001
5e-05
0
-5e-05
-0.0001
-0.00015
Inc Div (1/s)
Carlos Geijo
Model Point(#)

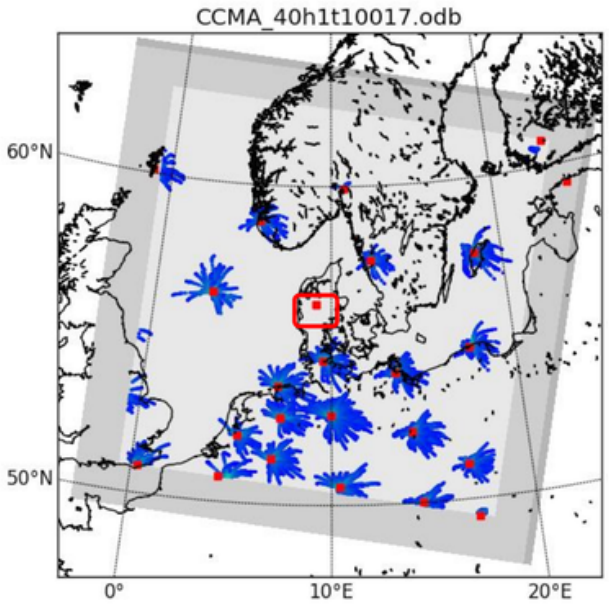

0.00012
9e-05
6e-05
3e-05
0
-3e-05
-6e-05
-9e-05
-0.00012
-0.00015
-0.00018
Inc Div (1/s)
ModelLevel 40
Carlos Geijo
Model Point(#)

TEMP BUFR format – Eoin Whelan

Data coverage



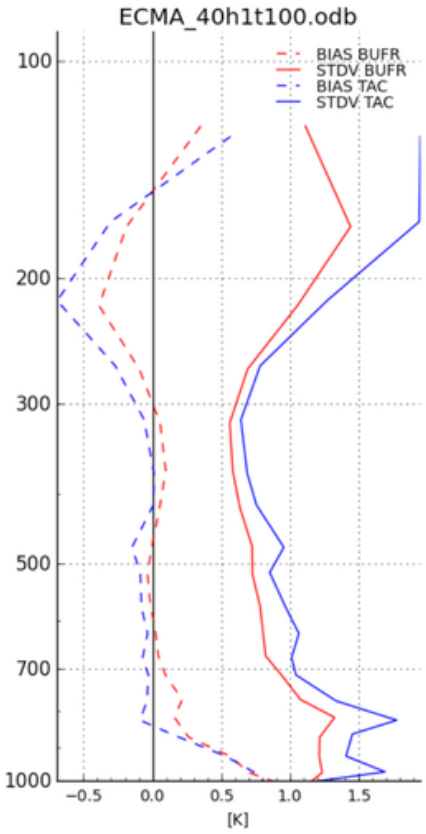
December 2015



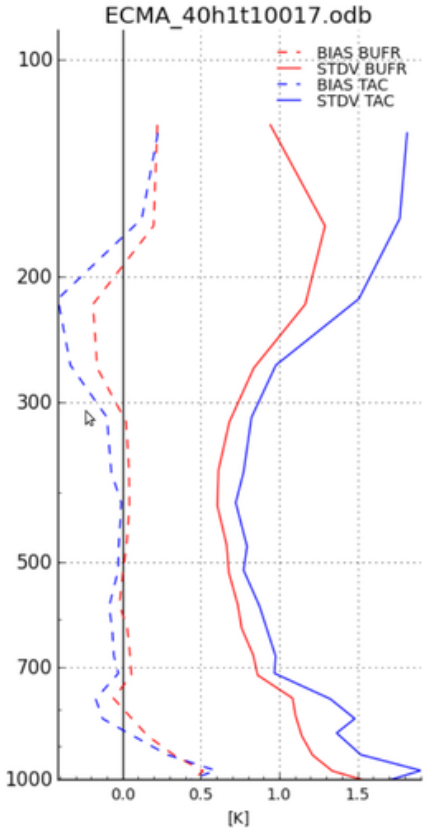
February 2017

TEMP BUFR format – Eoin Whelan

Impact study: Temperature O-B



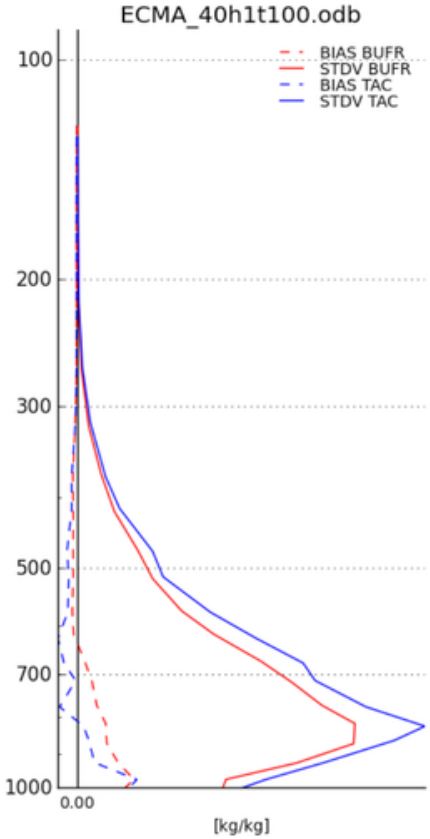
December 2015



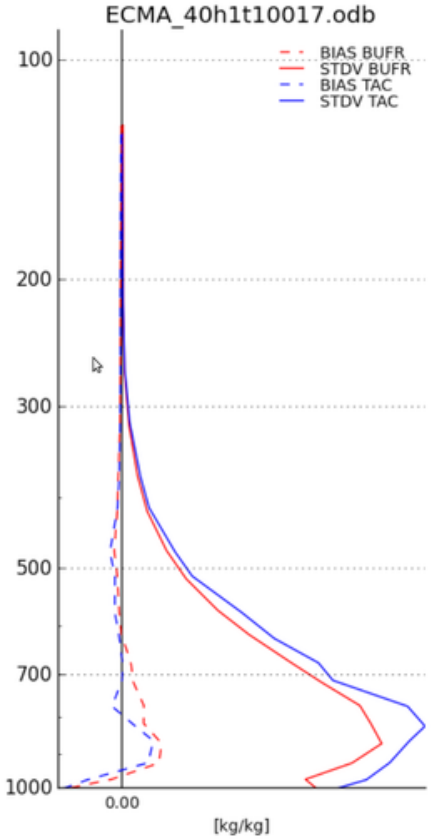
February 2017

TEMP BUFR format – Eoin Whelan

Impact study: Humidity O-B



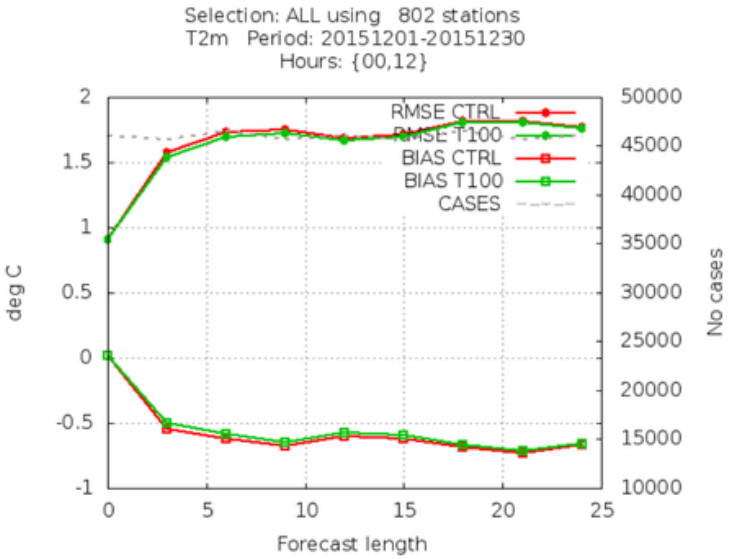
December 2015



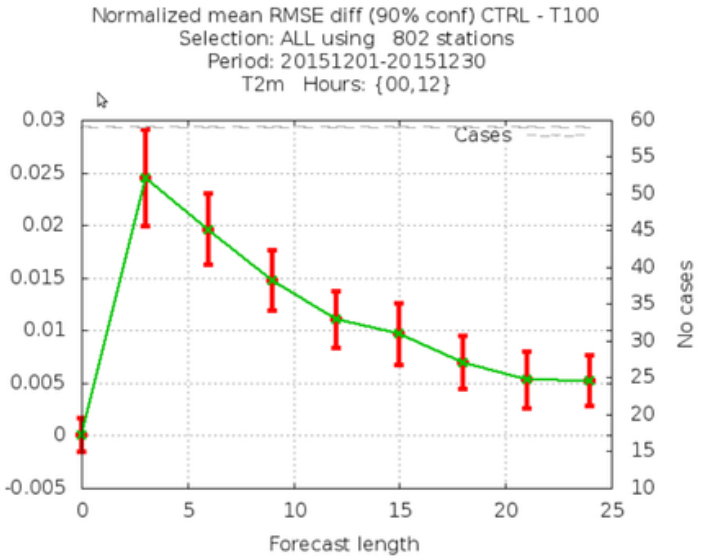
February 2017

TEMP BUFR format – Eoin Whelan

Surface parameters



RMSE



RMSE DIFF

Outlook – Just few of them ...

– Continue the local implementation of more observations …;

– Testing with 1-h cycling and Rapid refresh, overlapping windows;

– Working with initialisation schemes: LHN, back & forth nudging, use of variational constraint, IAU;

– Find solution for the convergence problem in our variational scheme;

– Continue developing the 4D-VAR and EnVar schemes;

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

– 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