# Monitoring and diagnosis of analysis results

HARMONIE SYSTEM TRAINING WEEK
Norrköping, 19-23 September, 2011

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# Structure

- Introduction
- Automatically produced daily monitoring plots
- Some other daily diagnostics easily produced
- Diagnostic tools to apply once and to redo every now and then when modifying your forecasting system
- Potential improvements

# What to look at to monitor/diagnose the data assimilation system?

- Observations utilized for each data assimilation cycle
- Quality of different observation types and individual observations
- Impact of different observations on the analysis (and forecasts)
- Functionality and tuning of bias correction and quality control
- General functionality of data assimilation system
- Pre-scribed statistics for background and observation errors
- …?

# General

- Quite a lot of monitoring results are automatically produced for each data assimilation cycle and others can easily be derived.
- Most of the diagnostics tools have their origin in HIRLAM and are adopted to use in HARMONIE.
- There is still room for improvements and extensions, in particular monitoring of satellite data  and surface data assimilation.

# Illustration of monitoring results available each data assimilation cycle

Results from Ulfs experiment alaro_36h14_mixbc

Platform: ecgate/c1a
Domain: SCANDINAVIA_5.5
PHYSICS: ALARO
SURFACE: SURFEX
DA:Surface and upper-air data assimilation
Period: 1-31 January, 2010

SCANDINAVIA_5.5 domain

## Illustration of plots from each data assimilation cycle

Raw data on ecfs:

•ec:/snh/harmonie/alaro_36h14_mixbc/YYYY/MM/DD/HH//logfiles.tar
(HM_Date_YYYYMMDDHH.html)

•ec:/snh/harmonie/alaro_36h14_mixbc/YYYY/MM/HH/DD/odb_stuff.tar
(odb_can.tar,odbvar.tar, odb_ccma.tar, VARBC.cycle)

•ec:/snh/harmonie/alaro_36h14_mixbc/YYYY/MM/DD/HH/
UA (FA): ICMSHANAL+0000, MXMIN1999+0000 (ANAB1999+0000), ICMSHHARM+0006
SURFEX( lfi): AROMOUT_.0000.lfi, AROMOUT_.0006.lfi

On ecgate:

$HOME/hm_home/alaro_36h14_mixbc/sms/config_exp.h: OBSMONITOR=obstat:obtime

•hm_home/alaro_36h14_mixbc/archive/extract/WebgraF
placed on
$SCRATCH/hm_home/alaro_36h14_mixbc/archive/extract
tar –cvf WebgraF.tar WebgraF ( -> WebgraF.tar)
bring WebgraF.tar (gzipped) to a file-system of your institute

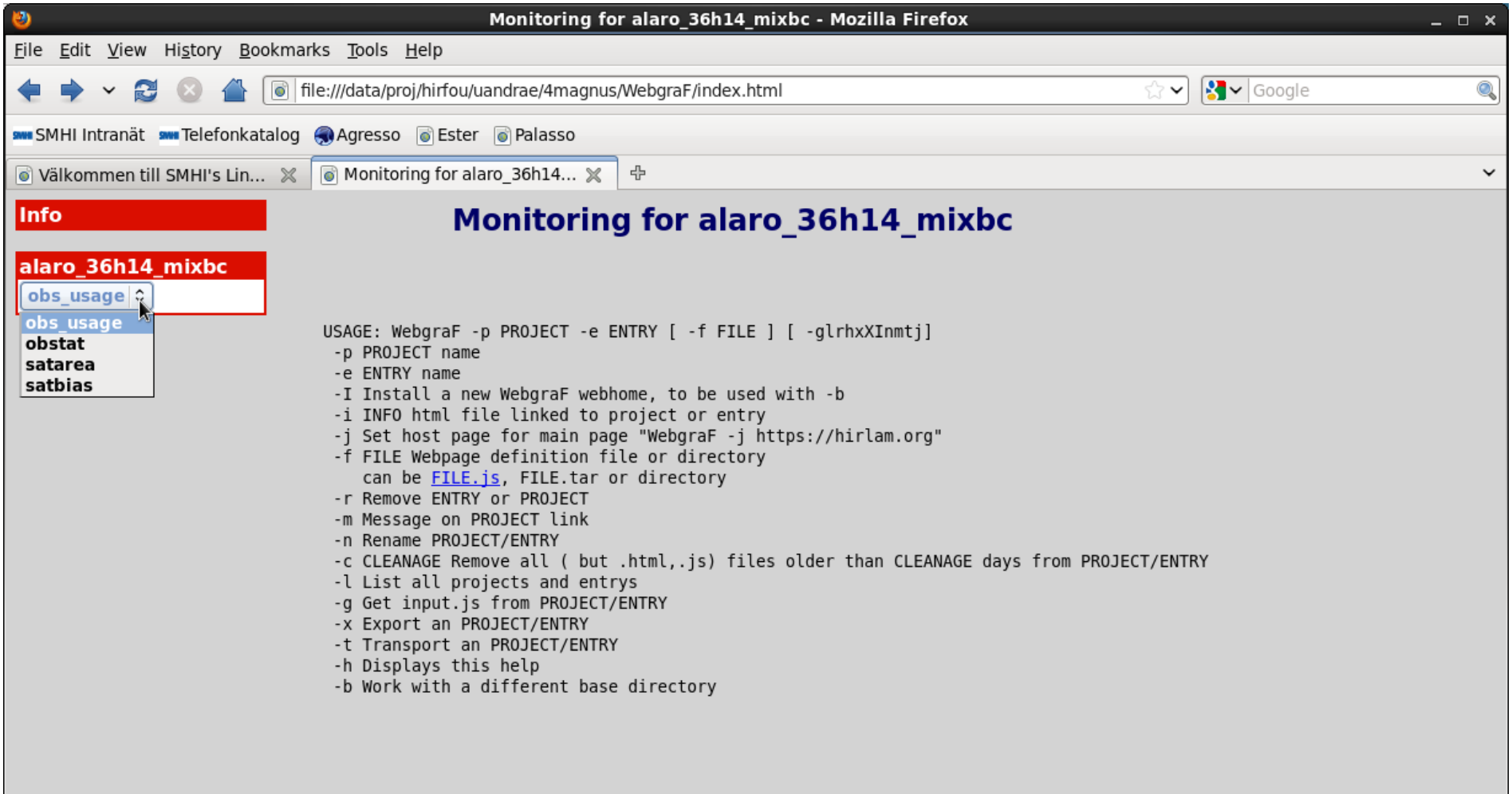
Intermediate useful files that are stored:
$SCRATCH/hm_home/alaro_36h14_mixbc/archive/extract
ecma_amsu_YYYYMMDDHH.gz, ecma_conv_YYYYMMDDHH.gz, ccma_YYYYMMDDHH.gz

# Displaying monitoring results using the WebgraF web-interface

on SMHI file system:

cd /data/proj/hirfou/uandrae/4magnus/

ftp ecaccess.ecmwf.int, followed by get WebgraF.tar, followed by tar –xvf WebgraF.tar



Observation usage timeseries Fig: AMDAR-Aircraft;00 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www-int/data/proj/hirfou/uandrae/4magnus/WebgraF/alaro_36h14_mixbc/index.html?choice_ind=obs

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Observation usage timeseries ...

../alaro_36h14_mixbc

obs_usage

# Observation usage timeseries

**Hour**

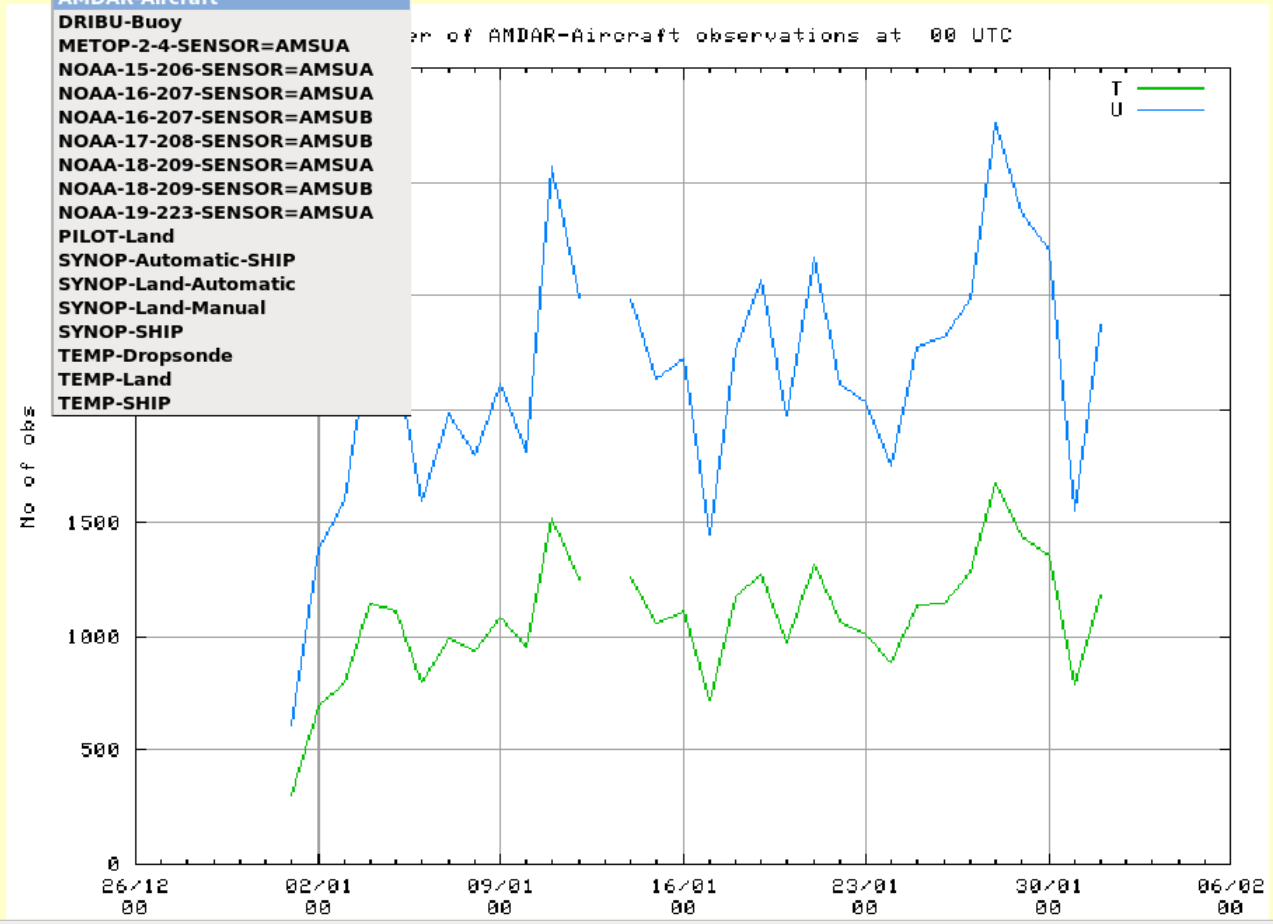
00
06
12
18

**Resize**

**Obstype**

AMDAR-Aircraft

AIREP-Aircraft
AMDAR-Aircraft
DRIBU-Buoy
METOP-2-4-SENSOR=AMSUA
NOAA-15-206-SENSOR=AMSUA
NOAA-16-207-SENSOR=AMSUA
NOAA-16-207-SENSOR=AMSUB
NOAA-17-208-SENSOR=AMSUB
NOAA-18-209-SENSOR=AMSUA
NOAA-18-209-SENSOR=AMSUB
NOAA-19-223-SENSOR=AMSUA
PILOT-Land
SYNOP-Automatic-SHIP
SYNOP-Land-Automatic
SYNOP-Land-Manual
SYNOP-SHIP
TEMP-Dropsonde
TEMP-Land
TEMP-SHIP




Done

HARMONIE usage maps and departues of conventional observations Fig: Map;airep_t;2010020100 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www-int/data/proj/hirfou/uandrae/4magnus/WebgraF/alaro_36h14_mixbc/index.html?choice_ind=obs

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HARMONIE usage maps and de...

../alaro_36h14_mixbc

obstat

Plottype

Map

Departure

Resize

# HARMONIE usage maps and departues of conventional observations

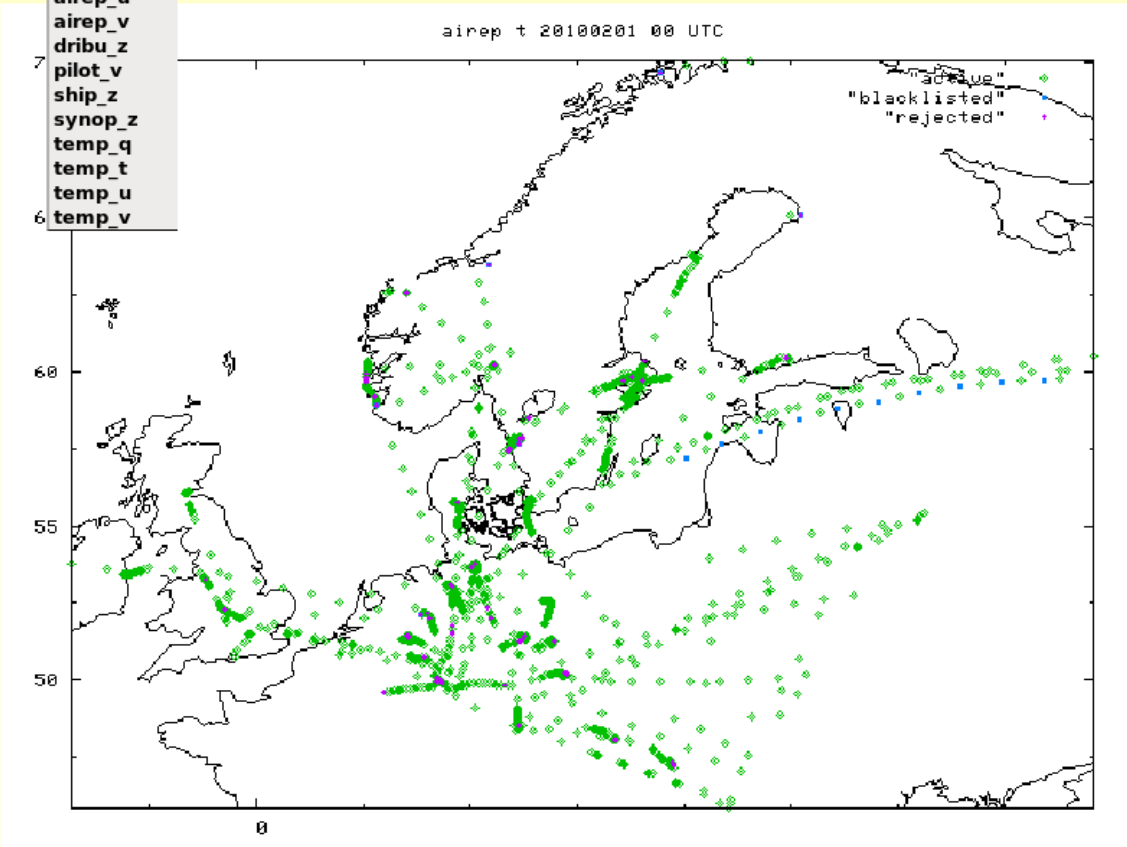
Obstype

airep_t

airep_t
airep_u
airep_v
dribu_z
pilot_v
ship_z
synop_z
temp_q
temp_t
temp_u
temp_v

Date

2010020100




Done

HARMONIE usage maps and departues of conventional observations Fig: Departure;airep_t;2010020100 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www-int/data/proj/hirfou/uandrae/4magnus/WebgraF/alaro_36h14_mixbc/index.html?choice_ind=obs

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HARMONIE usage maps and de...

../alaro_36h14_mixbc

obstat

Plottype

Map

Departure

Resize

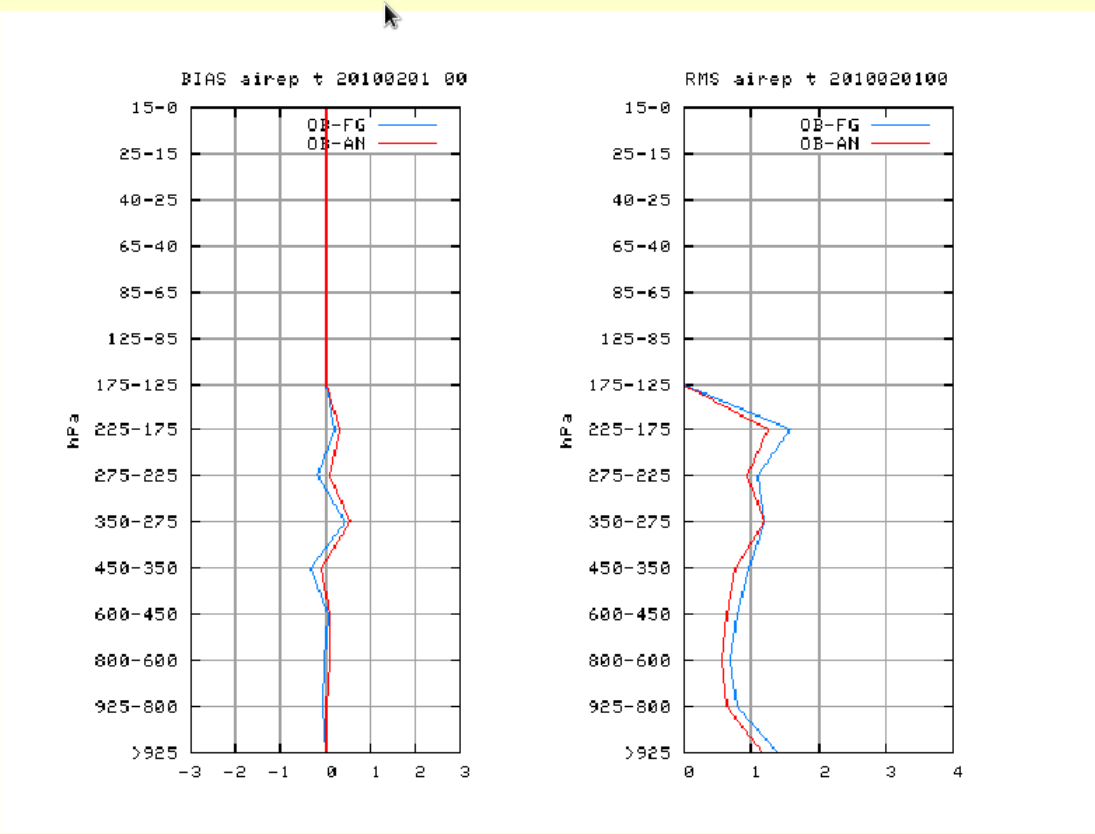
# HARMONIE usage maps and departues of conventional observations

Obstype

airep_t

Date

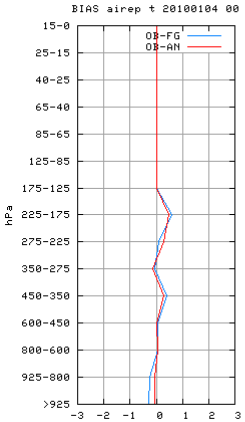
2010020100



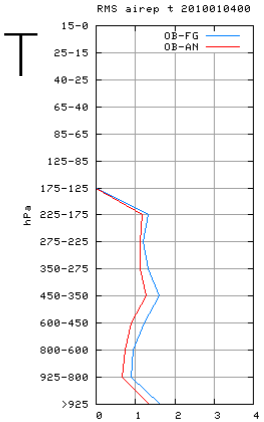

Done

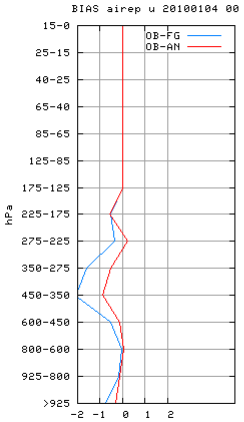
# Observation fit statistics for 2010010400

## AIREP

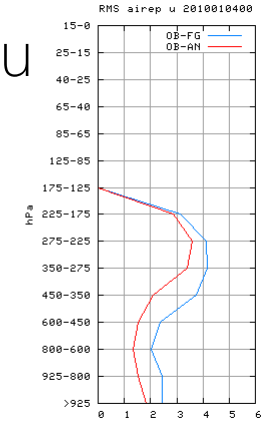



T

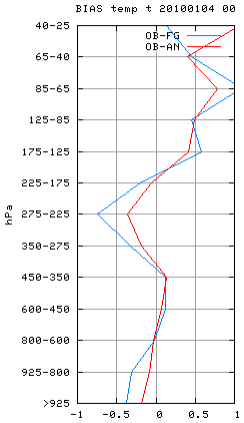


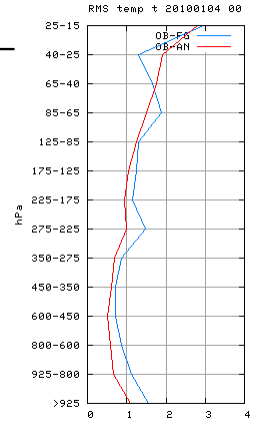

u

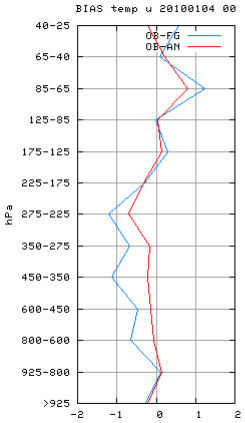



## Radiosonde

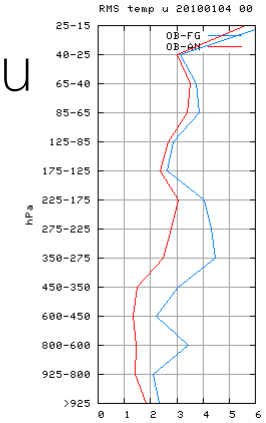


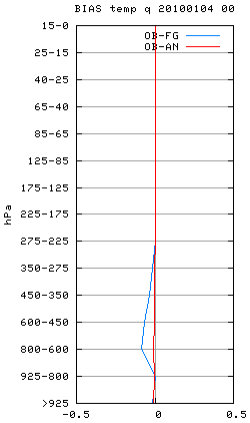

T



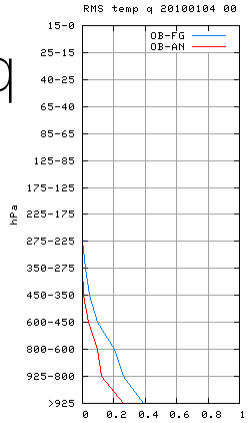




u




q



HARMONIE daily time-series of satelite bias correction Fig: NOAA19;ch_9;2010012600 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www-int/data/proj/hirfou/uandrae/4magnus/WebgraF/alaro_36h14_mixbc/index.html?choice_ind=satbias

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HARMONIE daily time-series of...

../alaro_36h14_mixbc

satbias

# HARMONIE daily time-series of satelite bias correction

**Satellite**

NOAA15
NOAA16
NOAA18
NOAA19
METOP

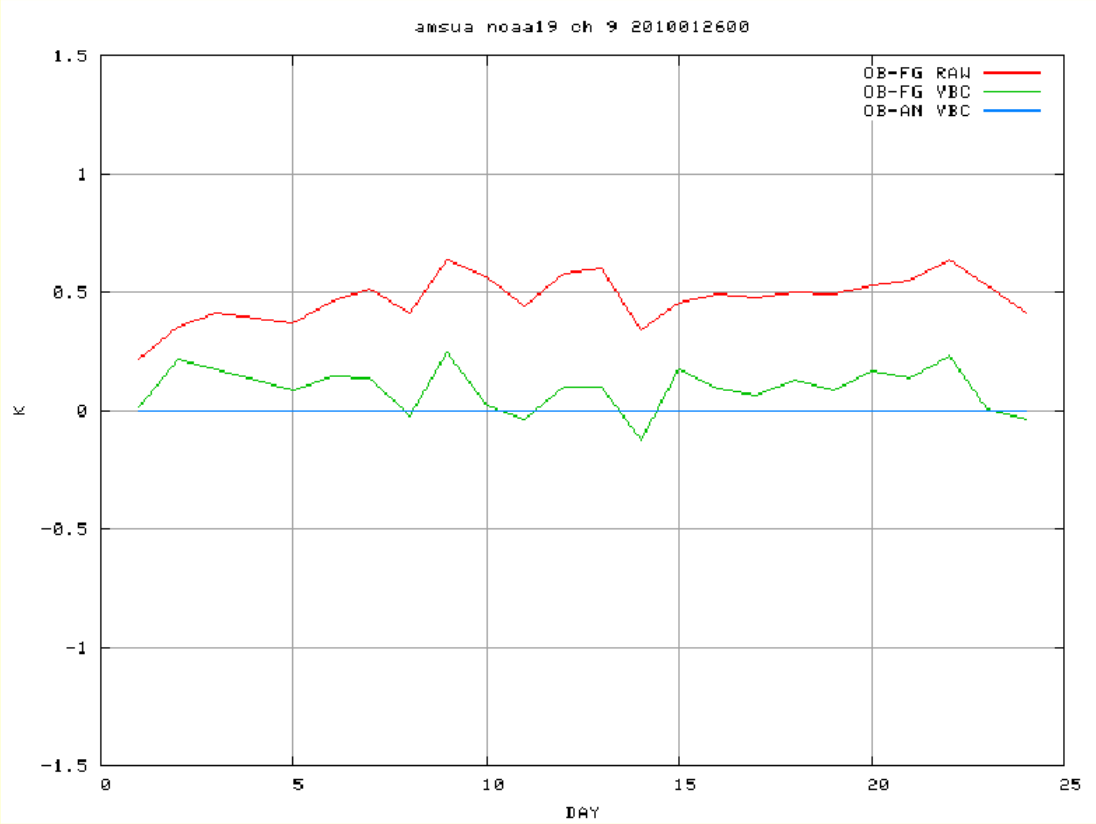
**Channel**

ch_6
ch_7
ch_8
ch_9
ch_10

**Resize**

**Date**

2010012600




Done

HARMONIE maps of amsua departures and bias-correction Fig: NOAA19;9;ob(raw)-fg;2010013100 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www-int/data/proj/hirfou/uandrae/4magnus/WebgraF/alaro_36h14_mixbc/index.html?choice_ind=satarea

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HARMONIE maps of amsua dep...

../alaro_36h14_mixbc

satarea

# HARMONIE maps of amsua departures and bias-correction

**Satellite**

NOAA15
NOAA16
NOAA18
NOAA19
METOP

**Date**

2010013100

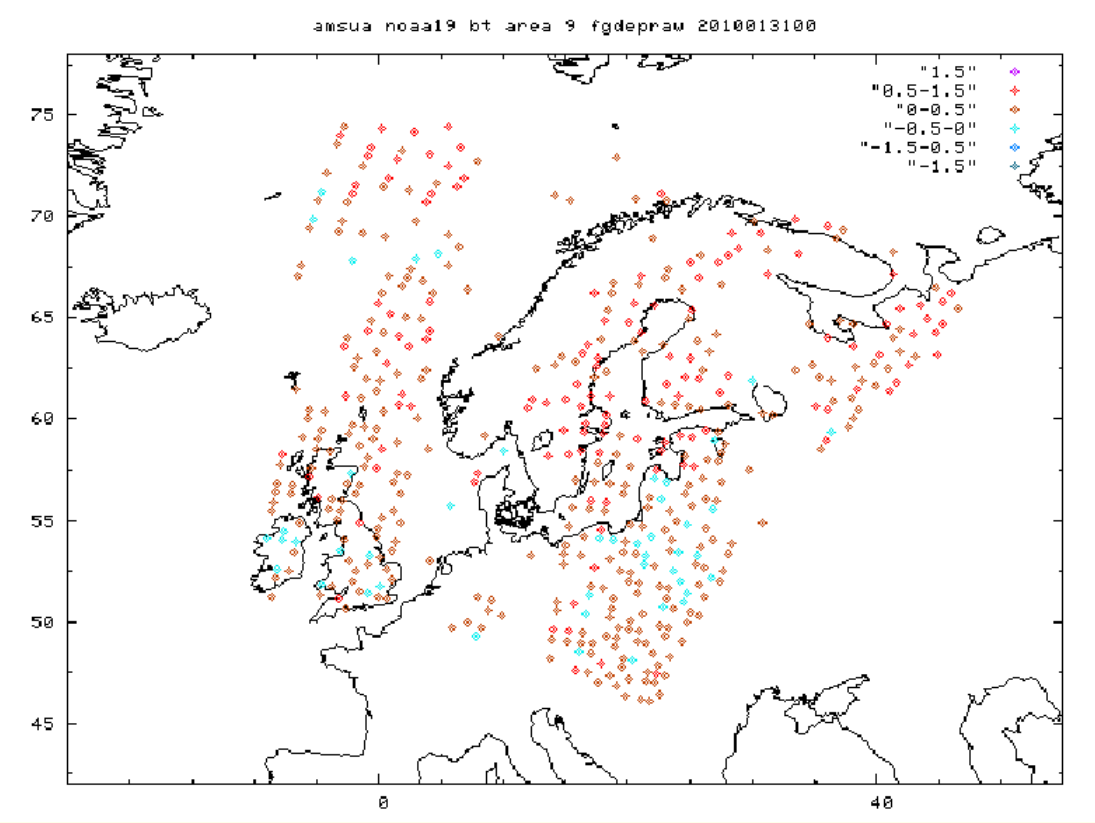
**Channel**

6
7
8
9
10

**Type**

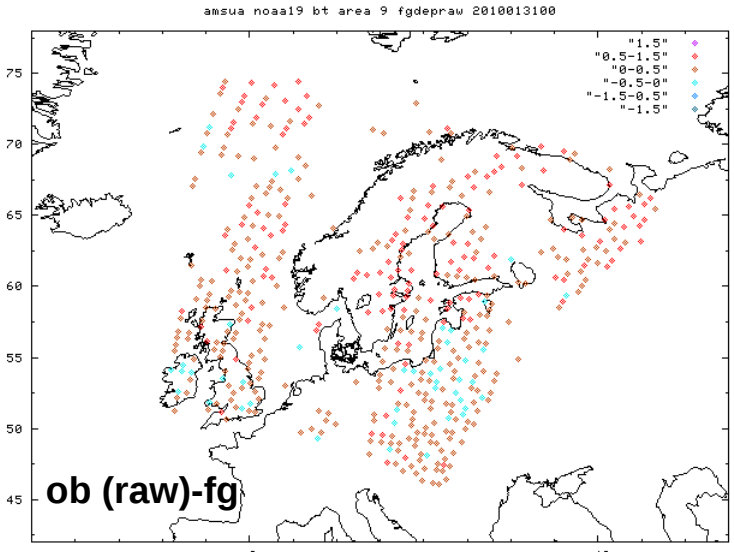
ob(raw)-fg
ob-fg
ob-an
bcorr

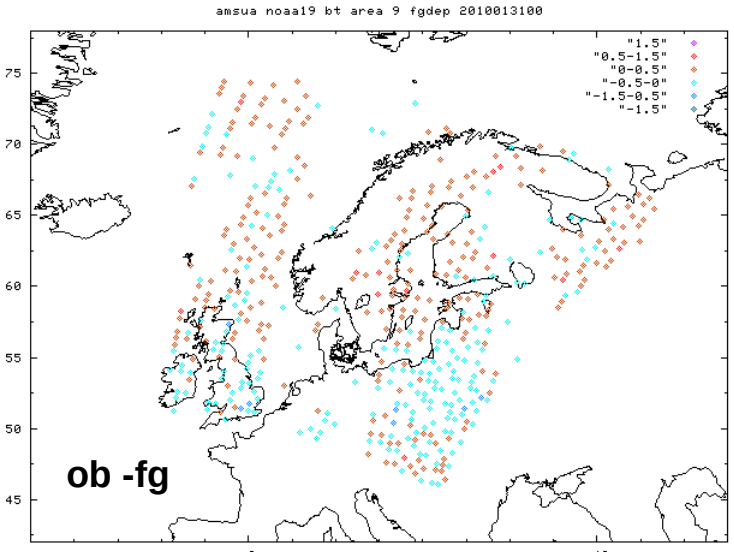
**Resize**

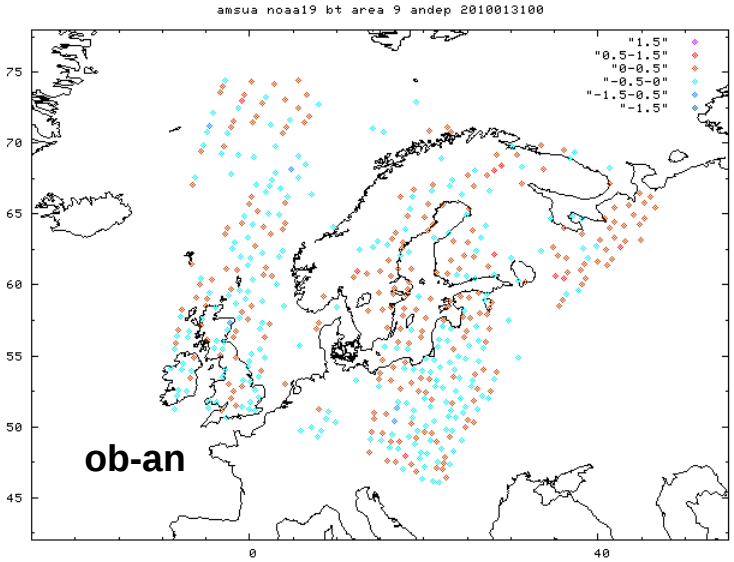


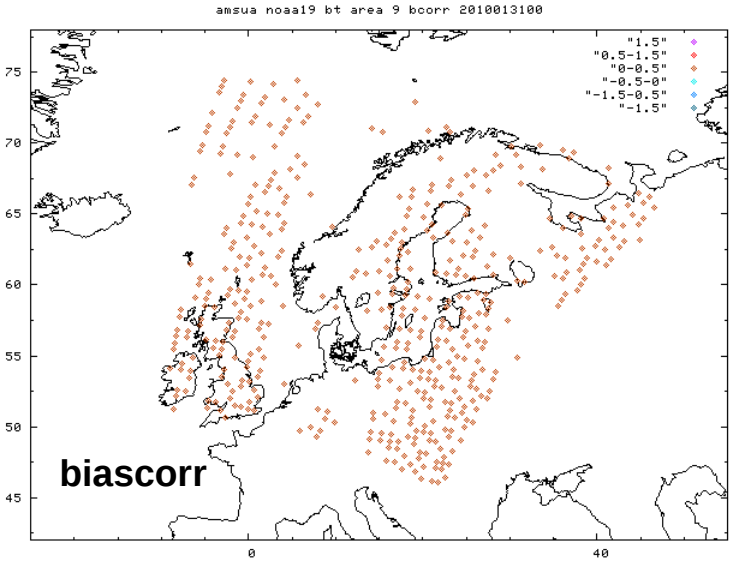

Done

# NOAA-19 ASMSU-A bias and biascorrection 2010013100



# How to derive and plot information of Cost function minimization

On ecgate go to $SCRATCH, then

```
ecp ec:/snh/harmonie/alaro_36h14_mixbc/YYYY/MM/DD/HH//logfiles.tar .
tar –xvf  logfiles.tar Date_harmonie.log
grep -i ‘grepcost – iter’ HM_Date_2010010312.html  | awk '{print $4,$6,$7}‘ > out.dat
```

->

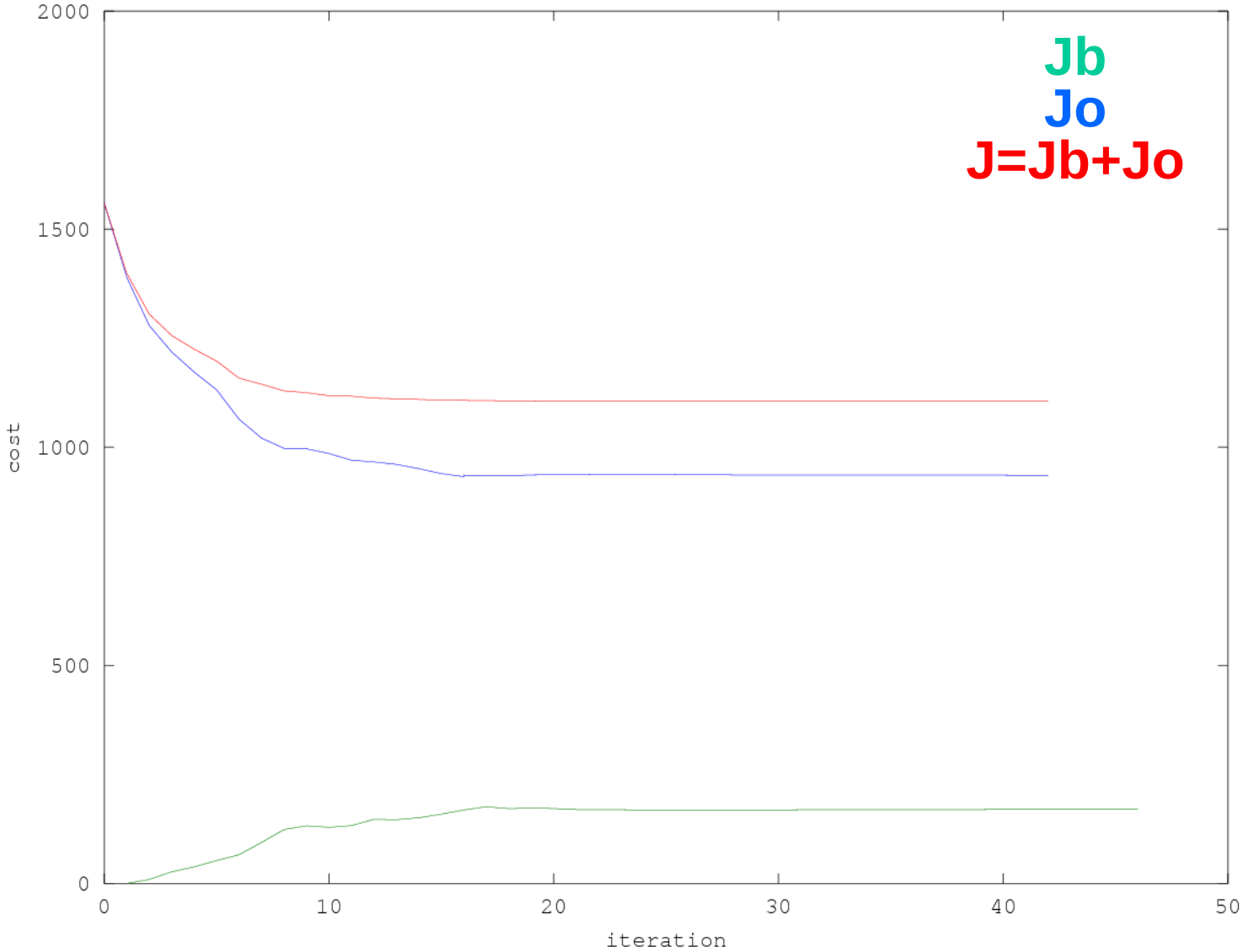
```
more out.dat
```

->

```
0 288235.563138
0.000000000000 1560.13110649 0.00000000000
1 1389.98178552 9.10205729598
2 1279.04101911 26.4942541088
3 1218.49069048 37.8142691175
…
999 935.646296242 169.685692755
```

Remove first and last line and plot column 1 against, 2 (jb), 3(Jo) and (2+3) J

# Cost as function of number of iterationsin the minimization



**How to generate plot sof analysis increments from each data assimilation cycle**

Raw data on ecfs:

•ec:/snh/harmonie/alaro_36h14_mixbc/YYYY/MM/DD/HH/

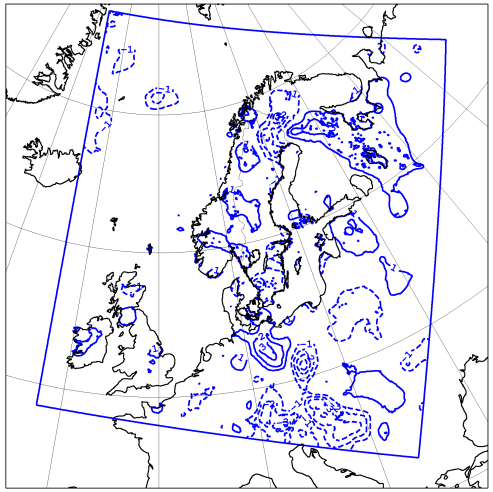
UA (FA): ICMSHANAL+0000, MXMIN1999+0000 (ANAB1999+0000), ICMSHHARM+0006

SURFEX( lfi): AROMOUT_.0000.lfi, AROMOUT_.0006.lfi

Convert to grib and plot (analysis increments) difference files:

Temp anincr 200 hPa (tenth of K)

T2m anincr 200 hPa (K)



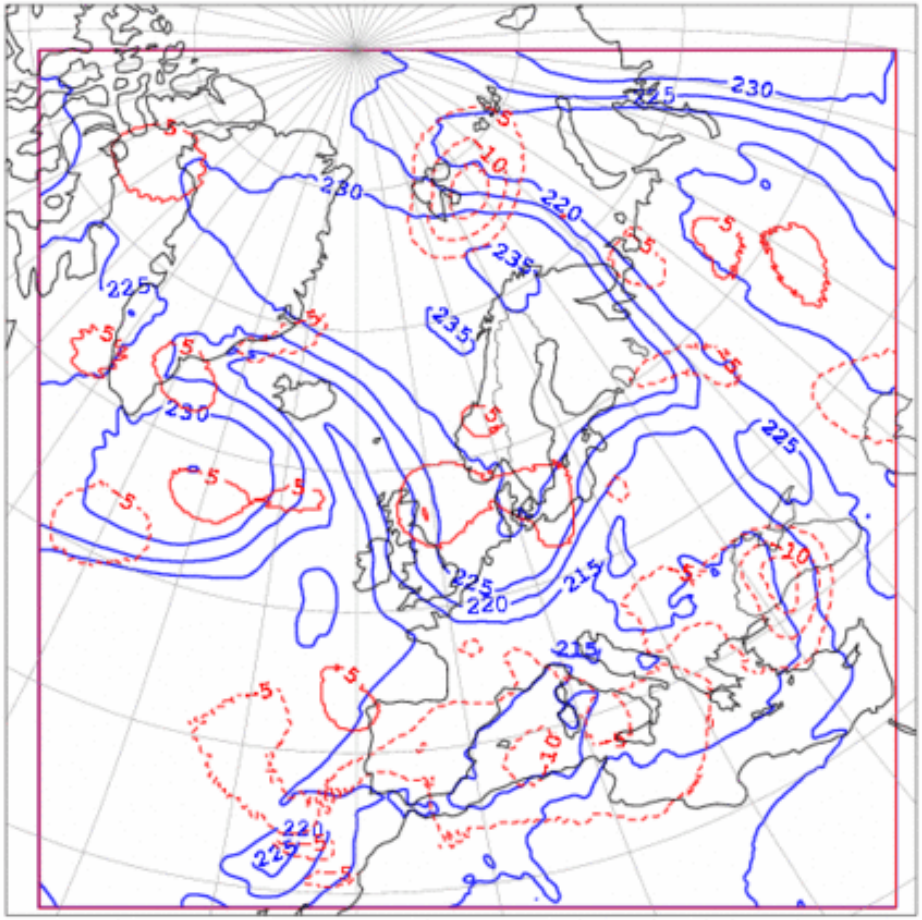
MXMIN1999+0000(T)- ICMSHANAL+0000(T)

ICMSHANAL+0000 (T)-ICMSHHARM+0006(T-6)

Also take a look at plot tg1,tg2, wg1,w2 analysis increments from surfex files

Also plot the background fields and analysis increments themselves.
Example of analysis increment och background field.

Temperature at i 200 hPa




**Unith: tenths of Kelvin**

**Unit: Kelvin**

# Some diagnosis that to do once and repeat when changing characteristics of data assimilation and modelling system

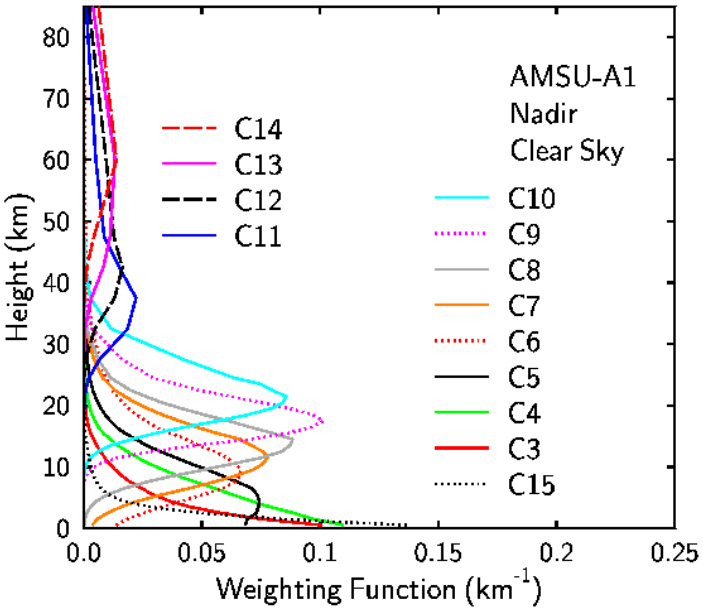
- Diagnosis of background error statistics using jbdiagnose and single observation impact studies.
- Tuning of background error standard deviations (REDNMC)
- Tuning of first guess check rejection limits

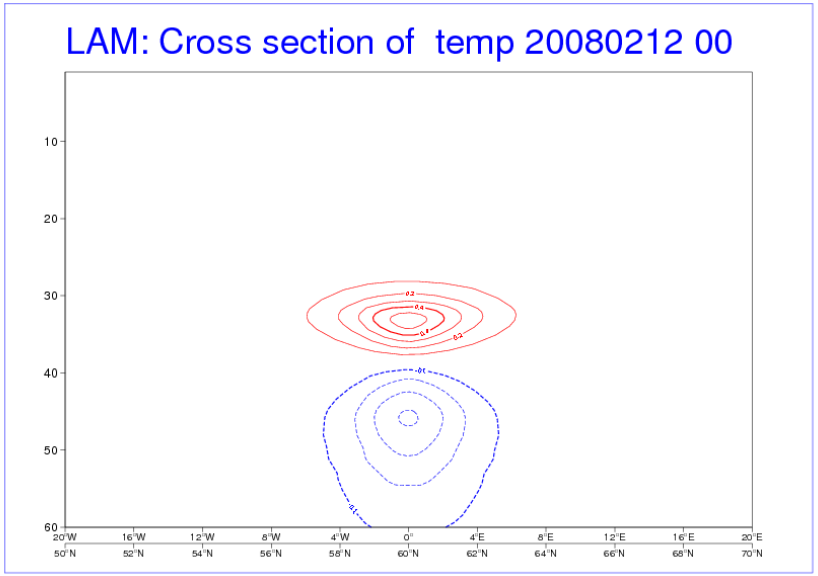
# Single Observation Impact Experiments

https://hirlam.org/trac/wiki/HarmonieSystemDocumentation/SingleObs
http://cimss.ssec.wisc.edu/itwg/itsc/itsc17/posters/7.22_randriamampianina.pdf

Impact of one single AMSU-A channel 7 observation in HARMONIE 3D-Var. Observation time at 20080212 12 UTC, 0 degree longitude, 60 degree latitude. Observed value 1 K warmer than corresponding background value.

Vertical cross section of temperature increments (K) at the beginning of the assimilation time window.




- Positive - Negative

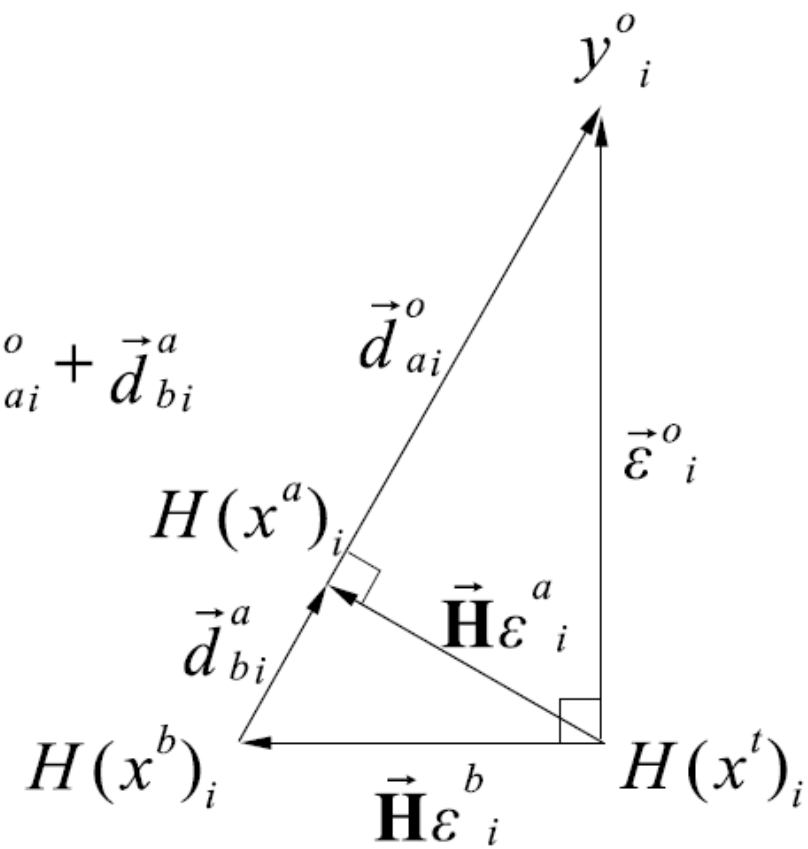
# Tuning of background error standard deviations

- Desroziers et. al (2005) presented methodology for diagnosing background and observation error variances from statistics of observation minus analysis and observation minus background equivalent. This statistics is contained in stored ccma_YYYYMMDDHH.gz files. Utilize a couple of months of these files.
- There is ongoing work to introduce this methodology into HARMONIE reference system

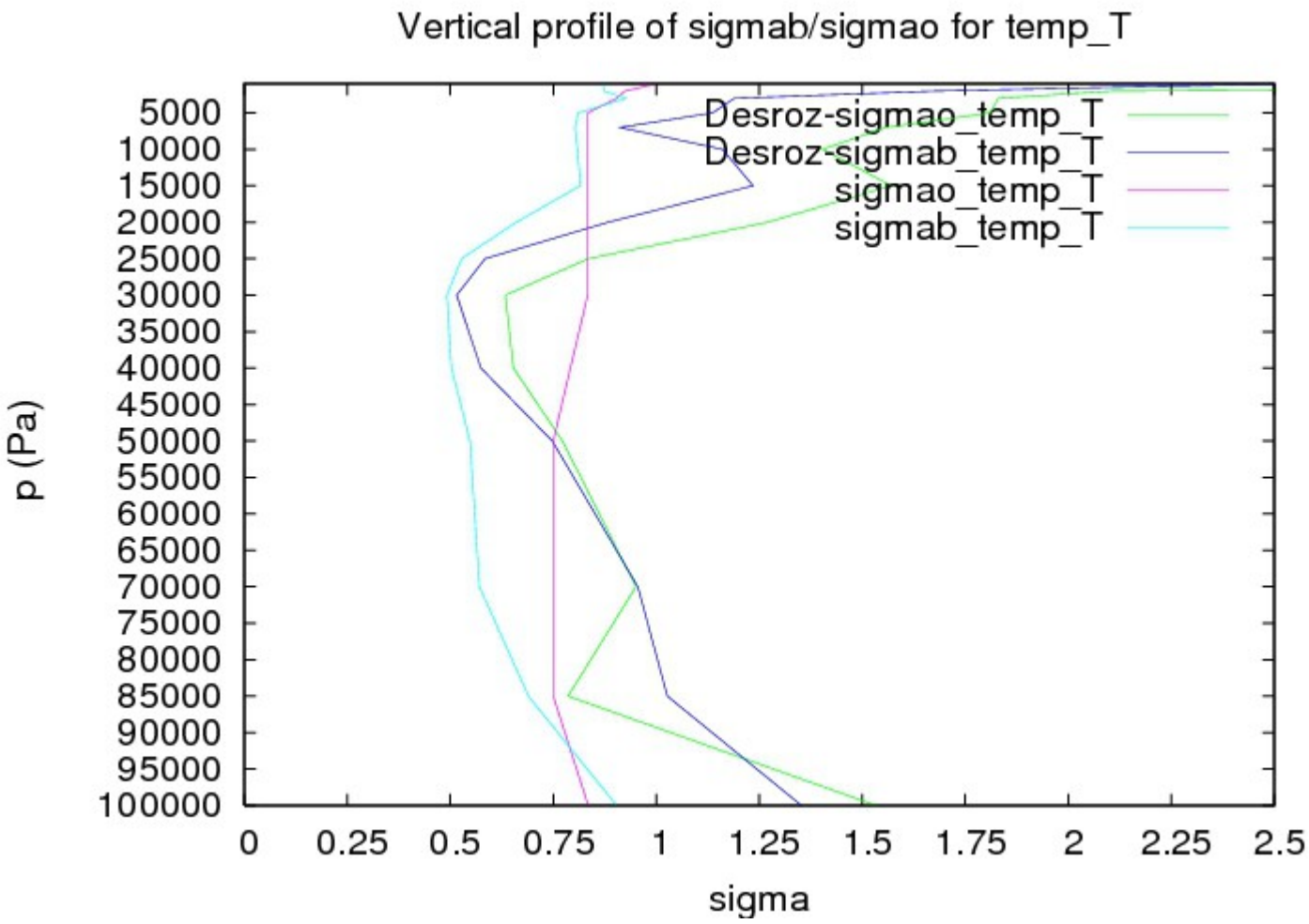
$$E[\boldsymbol{d}_b^a(\boldsymbol{d}_b^o)^T] = \boldsymbol{H}\boldsymbol{B}\boldsymbol{H}^T,$$

$$E[\boldsymbol{d}_a^o(\boldsymbol{d}_b^o)^T] = \boldsymbol{R},$$

$$\vec{d}^{\,o}_{bi} = \vec{d}^{\,o}_{ai} + \vec{d}^{\,a}_{bi}$$

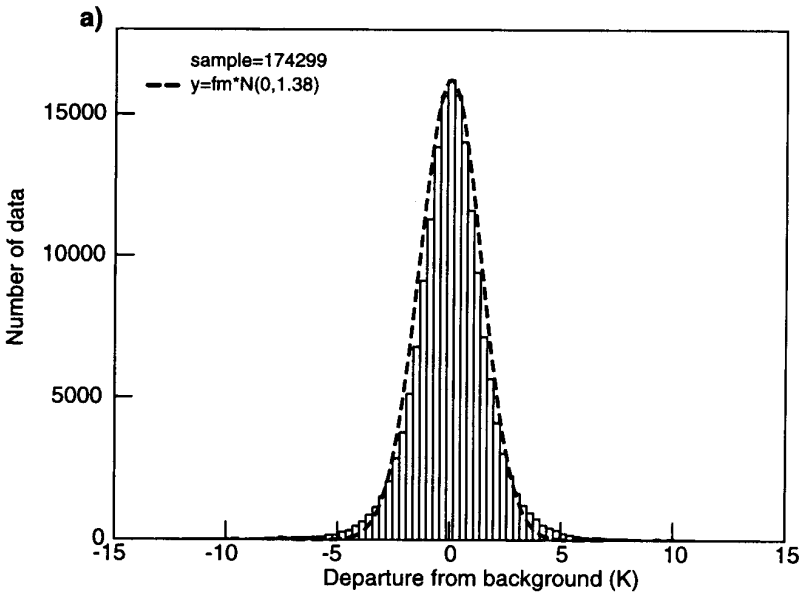


# Illustration of results from Desroziers method utilized to estimate sigmab/sigmao from statistics of (y-Hxb), (y-Hxa) (from Jana Sanchez Arriola)

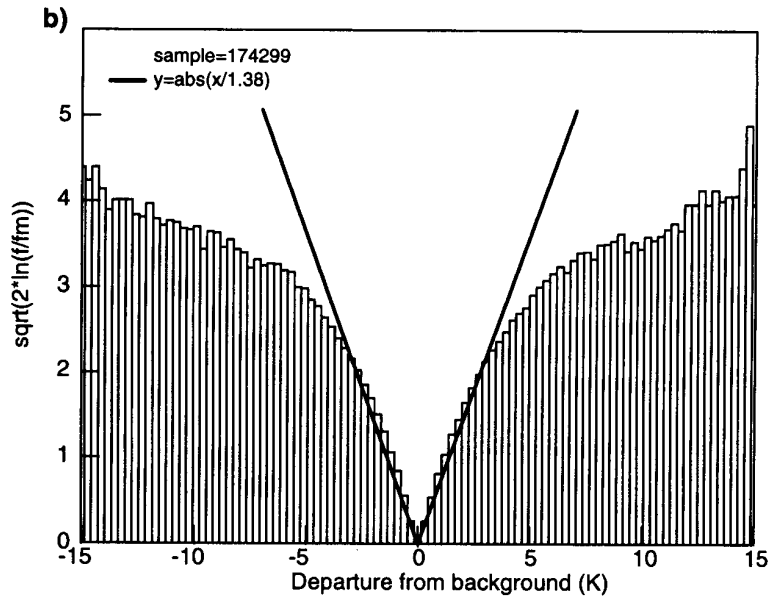


## “Objective” Tuning of BgQC and VarQC

(following Andersson and Järvinen, *QJR*, 1999)




Derive histograms (*f*) of ob-bg and ob-an




Transform histograms according to:

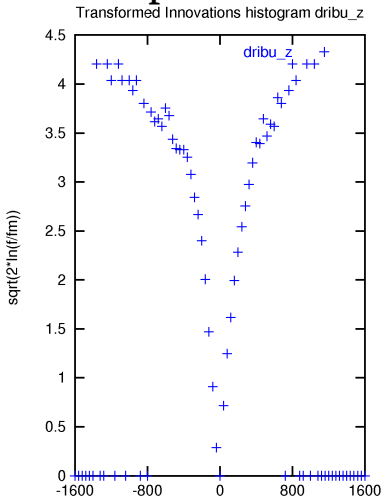
$$\hat{f} = \sqrt{-2\ln[f / \max(f)]}$$

Data from 14 days experiment

**HIRLAM EXAMPLE**

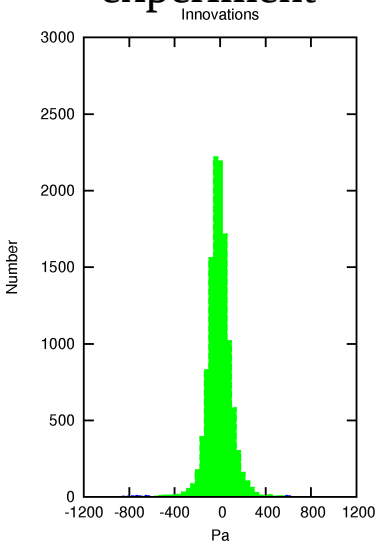
Data from 1 day experiment

**Transformed Histogram**

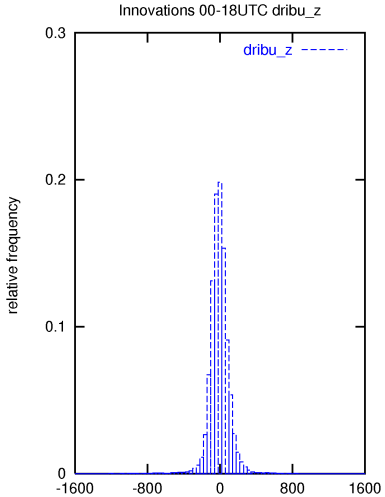



**Surface pressure innovation histograms (Pa)**

**DRIBU**




**Histogram**

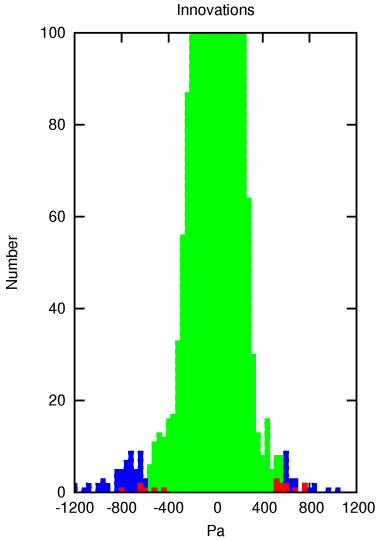



(Pa)

Accepted

VarQC rej

BgQC rej



# Potential improvements

- Extend the monitoring tool to cover more types of satellite observations as well as new types high resolution observations.
- Introduced various automatically produced monitoring plots for surface data assimilation.
- Automatic generation of plots for cost function minimization and analysis increments.
- Make sure on-going developments will be introduced into the reference system.
- Monthly averages of various statistics?
- New types of monitoring and diagnostics?