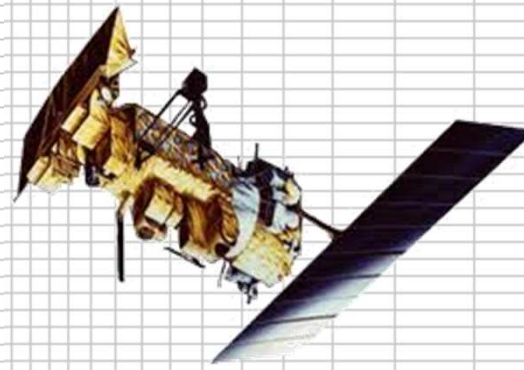


HARMONIE ATOVS data assimilation and coordinated impact study



**ALADIN / HIRLAM 23rd Workshop / All-Staff Meeting
Reykjavik, Iceland, 15-19 April, 2013**

**Magnus Lindskog, Mats Dahlbom, Sigurdur Thorsteinsson,
Per Dahlgren, Roger Randriamampianina, Jelena Bojarova**

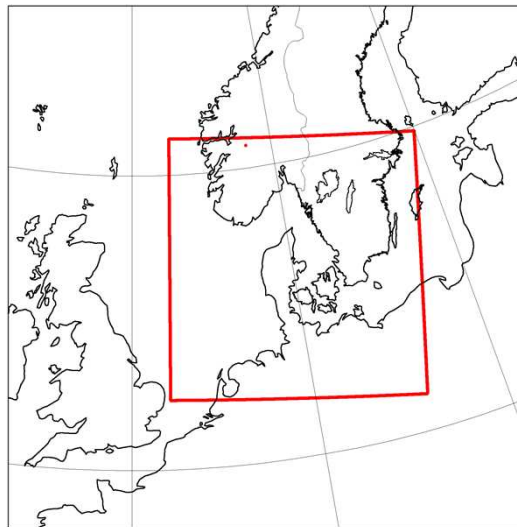
(with input from Dick Dee, Bjarne Amstrup and Vincent Guidard)



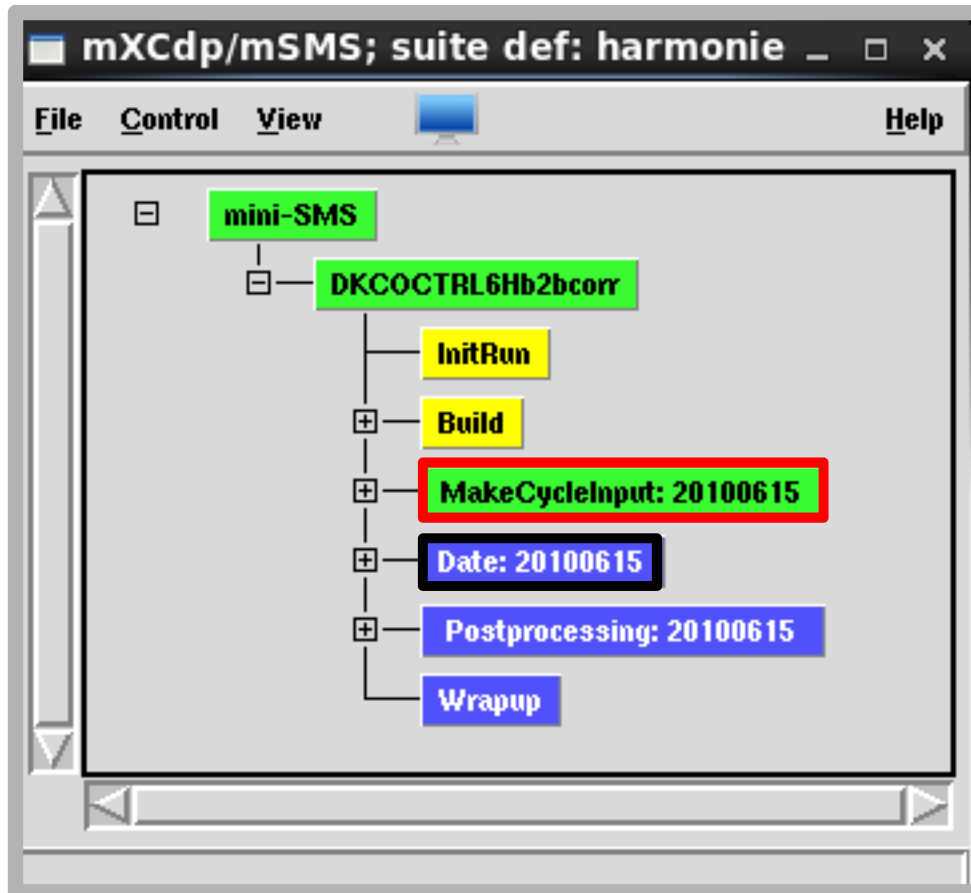
- Introduction
- ATOVS instruments and channels
- Data pre-processing and selection
- Evaluation and tuning of variational bias correction (VarBC)
- ATOVS in coordinated impact study
- Concluding remarks

HARMONIE reference system

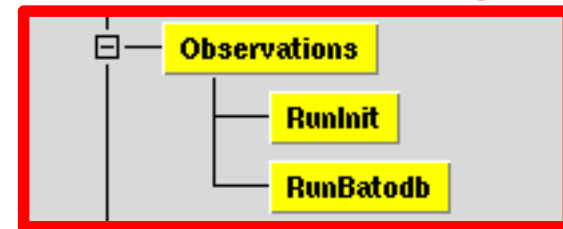
- HARMONIE CY37h1.2
- Old Denmark area
- 65 vertical levels with model top at 10 hPa
- Conventional types of observations
- 6 h data assimilation cycle



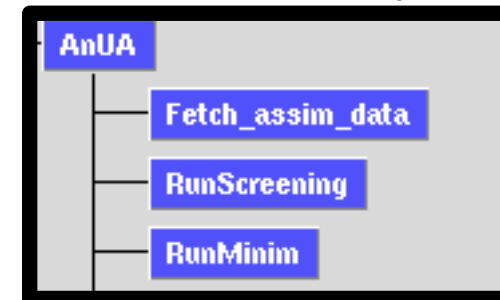
Mini-sms and handling of ATOVS data



Pre-processing



Upper-air analysis



ATOVS-Advanced Tiros Operational Vertical Sounder

AMSUA-A and AMSU- B/MHS ATOVS microwave-instruments

AMSU-A (15 channels)

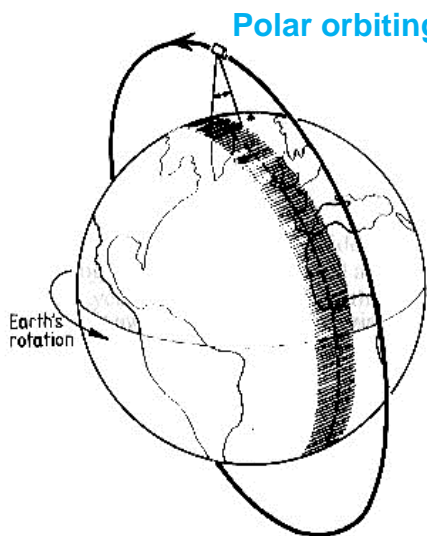
- NOAA-15, NOAA-16, NOAA-17, NOAA-18, NOAA-19, METOP

AMSU-B (5 channels)

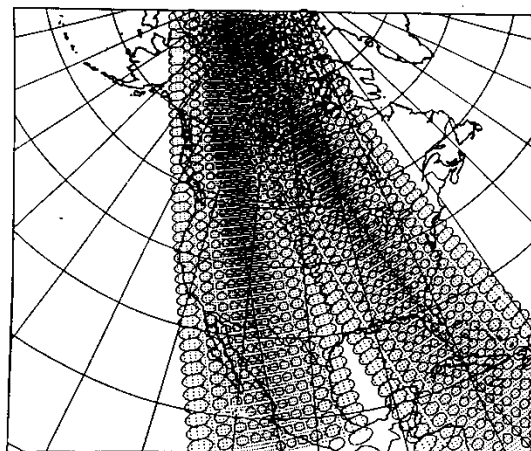
- NOAA-15, NOAA-16, NOAA-17

MHS (5 channels)

- NOAA-18, NOAA-19, METOP



Scanning transversal to satellite path

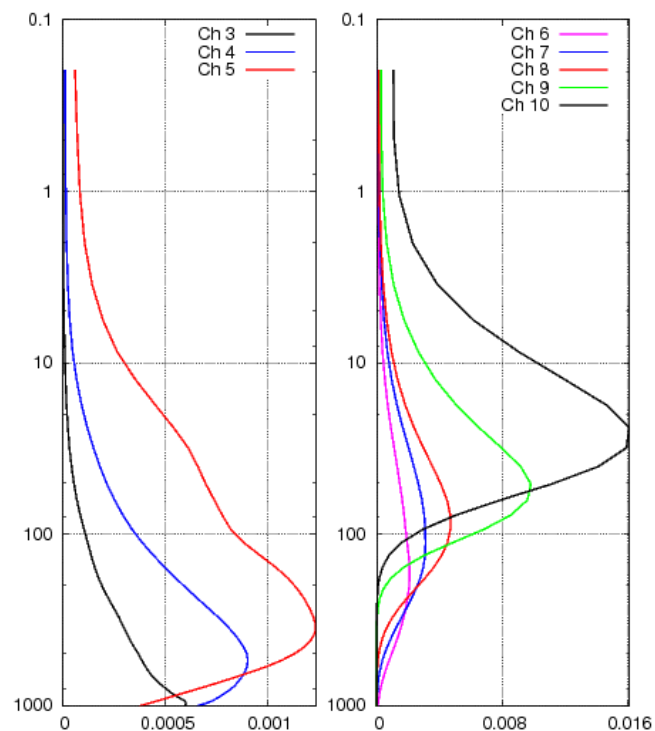


Scanning characteristics

	AMSU-A	AMSU-B/ MHS
Max scan angle	+/- 48°	+/- 49°
IFOV	3.3°	1.1°
Nadir res.	~45 km	~16 km

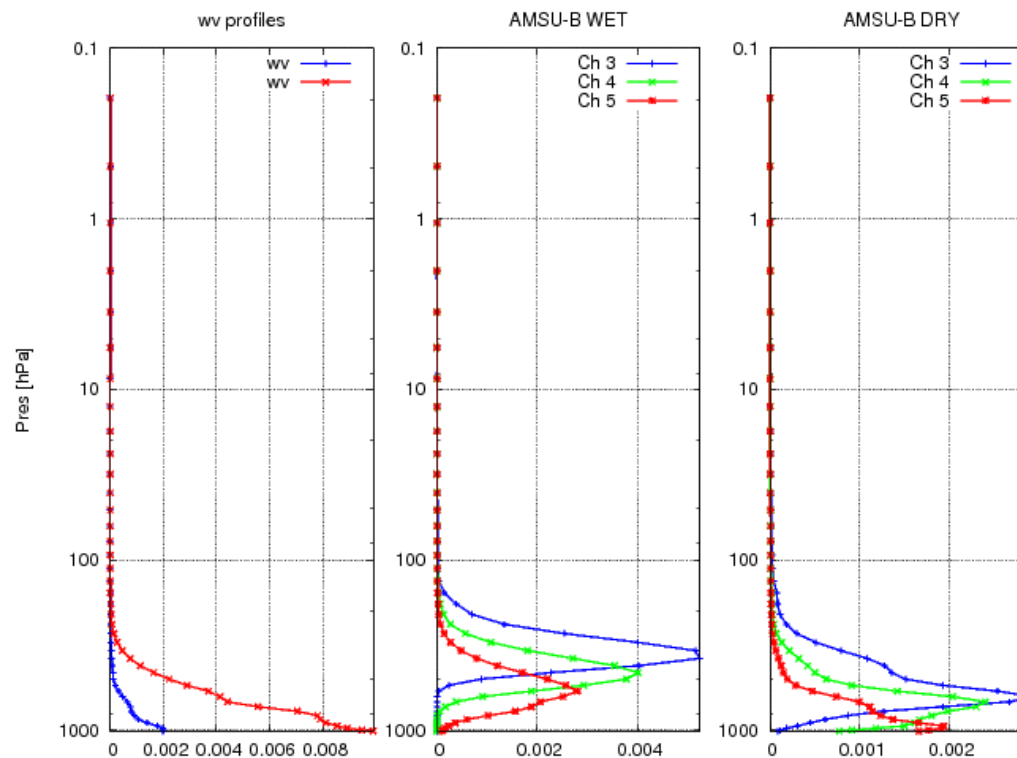
Weighting functions

AMSU-A



AMSU-A weighting functions

AMSU-B



WV profiles

AMSU-B weighting functions

ATOVS BUFR data from different streams

ECMWF MARS archive

Instrument codes for
AMSU-A, AMSU-B and MHS:
3, 4 and 15

Local processing software

Instrument codes for
AMSU-A, AMSU-B and MHS:
3, 4 and 11

Angles θ_1 to θ_N along a scanline:
always positive
(data from left to right)

Angles θ_1 to θ_N along a scanline:
negative and positive
(- to the left and + to the right)

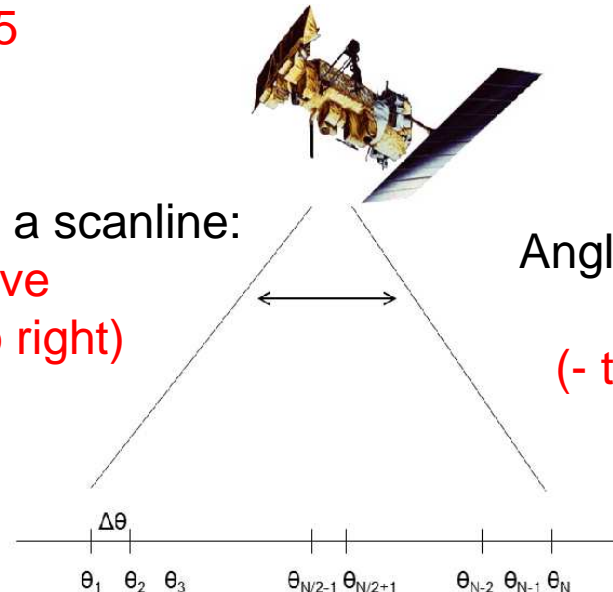


Illustration of scanning procedure for ATOVS instrument along a scanline. θ -scan angle and $\Delta\theta$ -IFOV.

Data usage

AMSU-A from: NOAA-15, NOAA-16, NOAA-18, NOAA-19, METOP

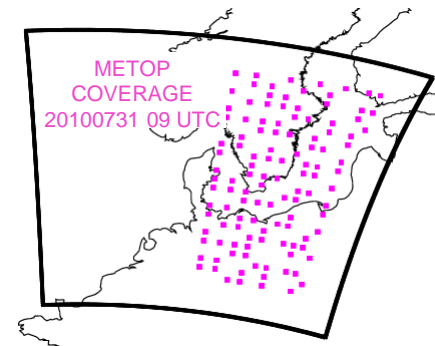
Used channels: ch 6-9 + ch 5 (over sea)

Except NOAA-19 ch 8, METOP-A ch 7

AMSU-B/MHS from: NOAA-18, METOP

Used channels: ch 5 + 3,4 (over sea)

In addition LISTE_LOC_\${HH} in BATOR to reject data from satellite passes that just touches the domain (manual procedure and domain specific)



Thinning

Minimum and average thinning distances for different ATOVS instruments

Instrument	RMIND_RAD1C (km)	RFIND_RAD1C (km)
AMSU-A	60	80
AMSU-B	40	80
MHS	40	80

Variational Bias Correction (VarBC)

Linear predictor model for bias in each channel:

$$\mathbf{b}(\mathbf{x}, \boldsymbol{\beta}) = \sum_{i=0}^{N_p} \beta_i \mathbf{p}_i(\mathbf{x})$$

Cost function:

\mathbf{J}_b : background constraint for \mathbf{x}
 \mathbf{J}_β : background constraint for $\boldsymbol{\beta}$

$$J(\mathbf{x}, \boldsymbol{\beta}) = (\mathbf{x}_b - \mathbf{x})^T \mathbf{B}_x^{-1} (\mathbf{x}_b - \mathbf{x}) + (\boldsymbol{\beta}_b - \boldsymbol{\beta})^T \mathbf{B}_\beta^{-1} (\boldsymbol{\beta}_b - \boldsymbol{\beta})$$

$$+ [\mathbf{y} - \mathbf{b}(\mathbf{x}, \boldsymbol{\beta}) - h(\mathbf{x})]^T \mathbf{R}^{-1} [\mathbf{y} - \mathbf{b}(\mathbf{x}, \boldsymbol{\beta}) - h(\mathbf{x})]$$

\mathbf{J}_o : bias-corrected observation constraint

$$\sigma_\beta^2 = \frac{\beta_b}{\sigma_o^2 / N}$$

Parameter background value – final estimate from previous analysis

N large means strong constraint- less adaptivity (5000 default)

Predictors

VarBC original default predictors for AMSU-A channels 6-9
and AMSU-B/MHS channels 3-5:

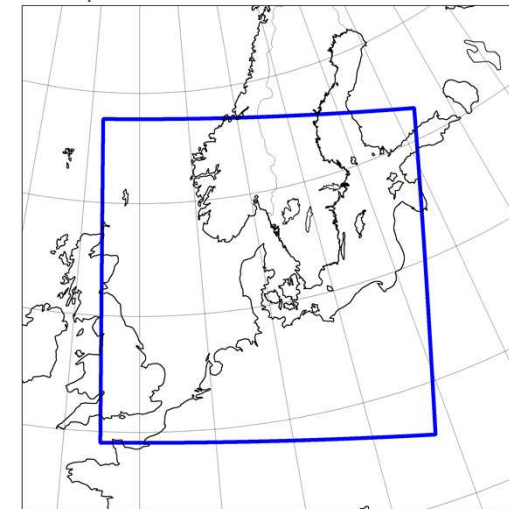
Predictor no.	Predictor
0	constant
1	1000-300hPa thickness
2	200-50hPa thickness
5	10-1hPa thickness
6	50-5hPa thickness
8	nadir view angle
9	nadir view angle **2
10	nadir view angle **3

Evaluation and tuning of VarBC

Experiments with ATOVS in passive mode for spinning up of predictor coefficients

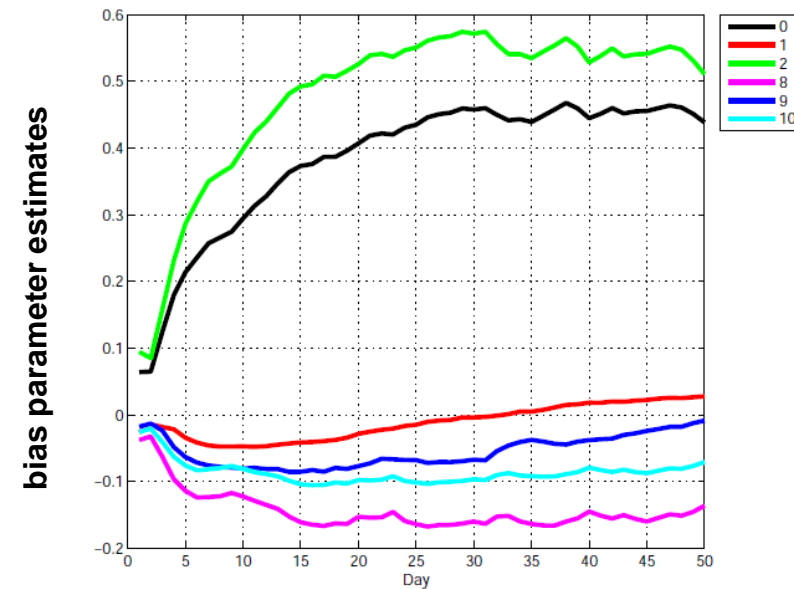
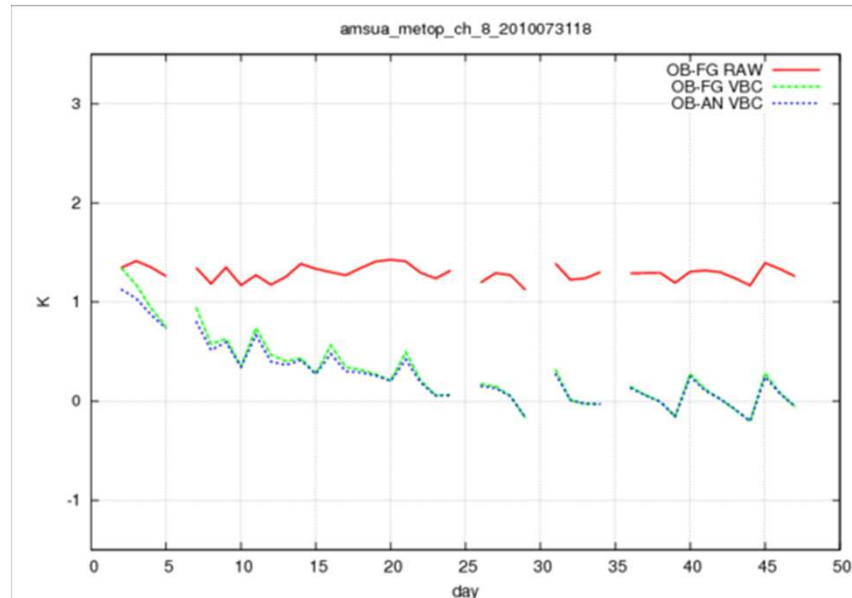
- Extended Danish domain
- 20100615 ->
- Starting from zero predictor parameters (cold start)

$$\mathbf{b}(\mathbf{x}, \boldsymbol{\beta}) = \sum_{i=0}^{N_p} \beta_i \mathbf{p}_i(\mathbf{x})$$

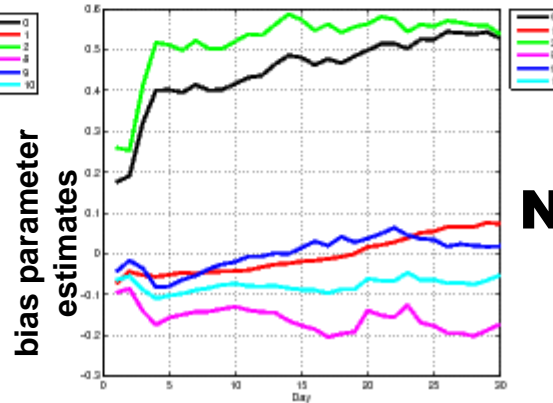
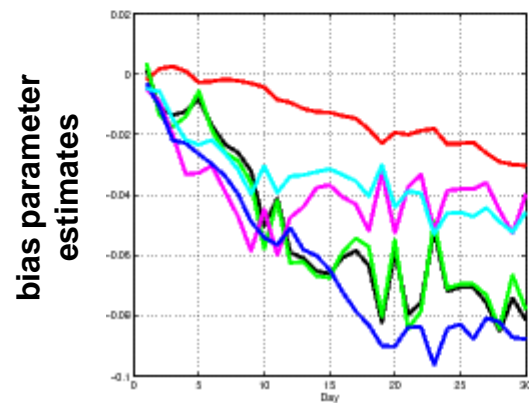
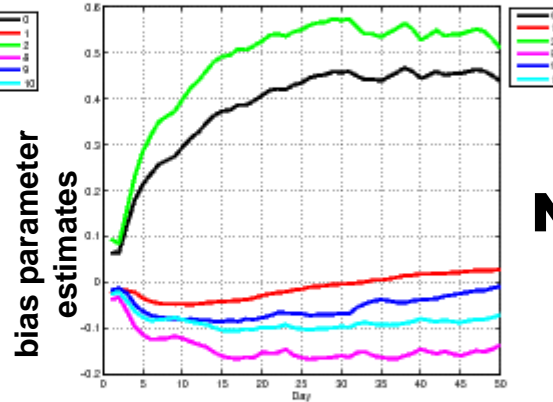
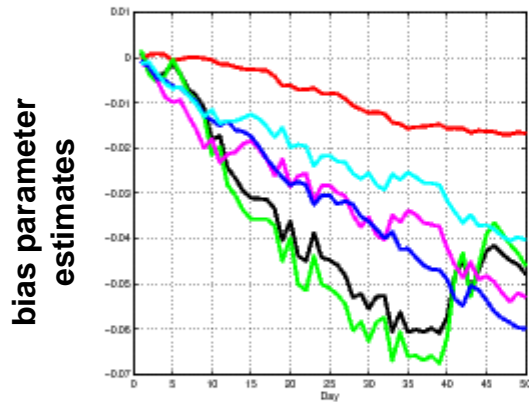
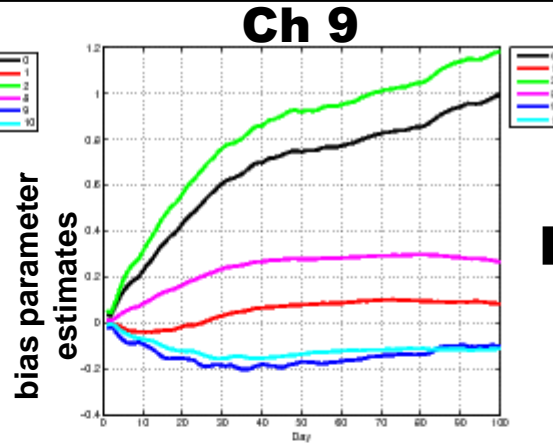
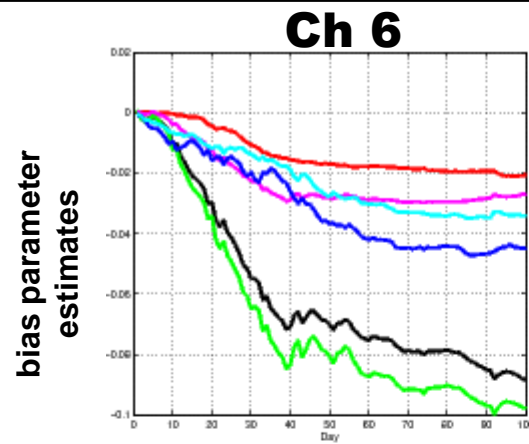


640x640x65 gp

β_i



Evaluation and tuning of VarBC



**NOAA-19
VARBC
Bias
parameter
evolution**

N-5000



N-2500

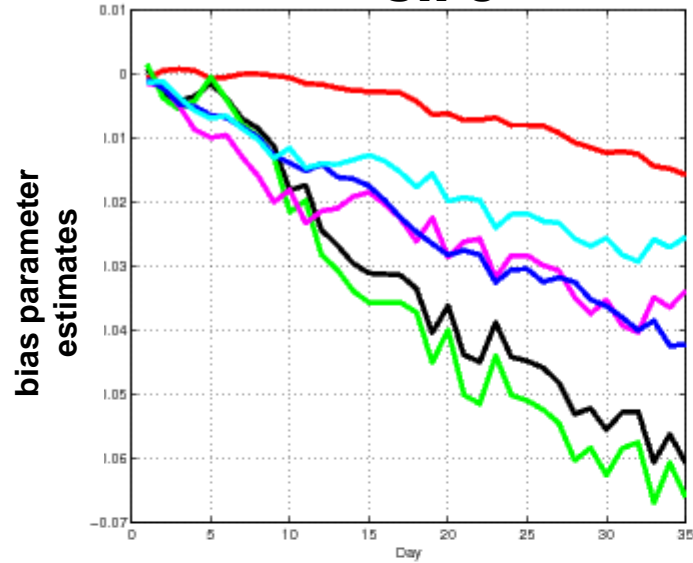
N-500

Predictor no.	Predictor
0	constant
1	1000-300hPa thickness
2	200-50hPa thickness
5	10-1hPa thickness
6	50-5hPa thickness
8	nadir view angle
9	nadir view angle **2
10	nadir view angle **3

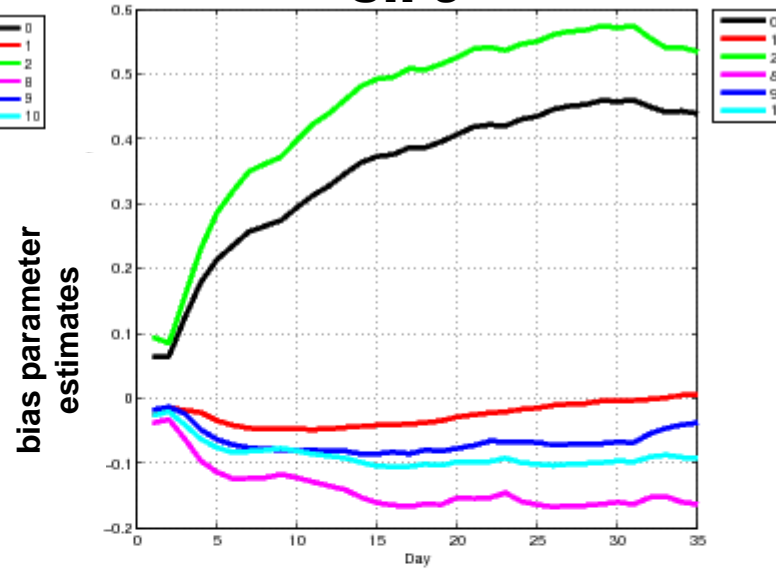
Evaluation and tuning of VarBC



Ch 6

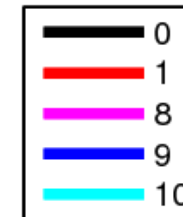
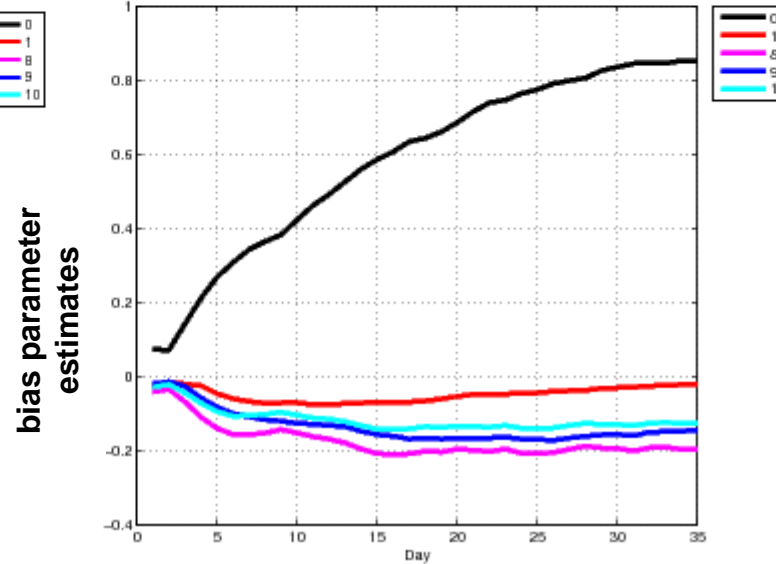
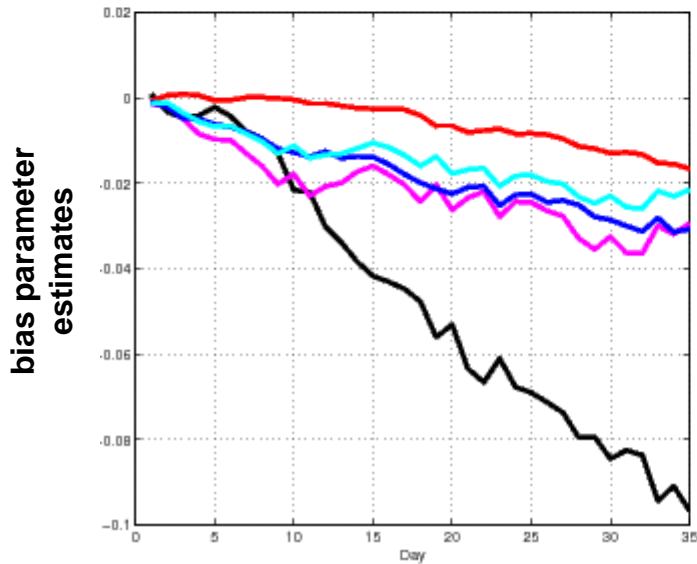


Ch 9



Changing predictors

N-2500



Predictor no.	Predictor
0	constant
1	1000-300hPa thickness
2	200-50hPa thickness
5	10-1hPa thickness
6	50-5hPa thickness
8	nadir view angle
9	nadir view angle **2
10	nadir view angle **3

Coordinated impact study



640x640x65 gp

(7-31 August, 2010)

Spin-up 20100615-20100730 (+ 20100801-20100806)

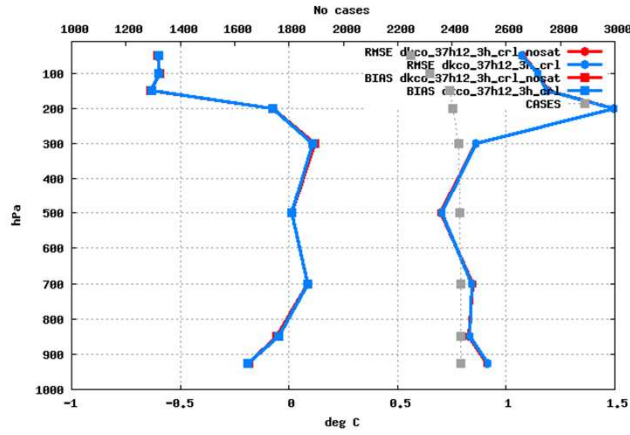
- Baseline runs with conventional and ATOVS data 3h cycle and 6h DA cycle
- Thereafter runs with additional data (GNSS, RADAR, IASI)
 - Additional run without ATOVS data with 3h da cycle

ATOVS in coordinated impact study



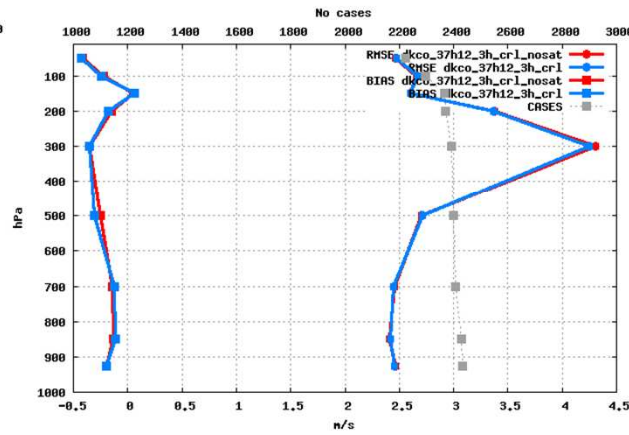
Temperature

25 stations Selection: ALL
 Temperature Period: 20100807-20100831
 Statistics at 00 UTC Used {00,06,12,18} + 06 12 18 24



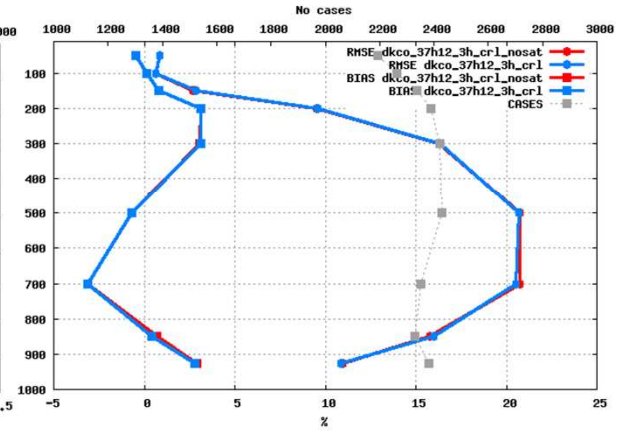
Wind Speed

25 stations Selection: ALL
 Wind speed Period: 20100807-20100831
 Statistics at 00 UTC Used {00,06,12,18} + 06 12 18 24

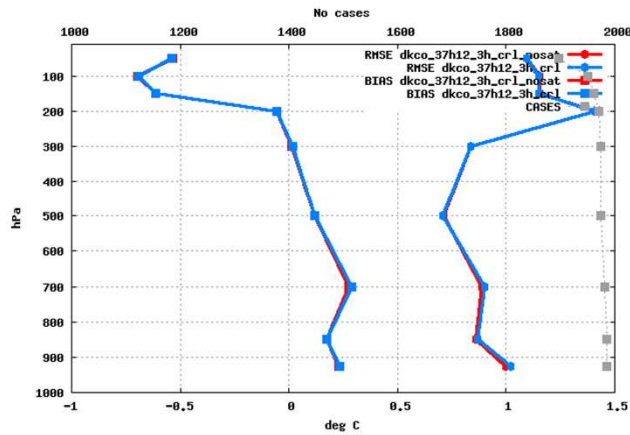


RH

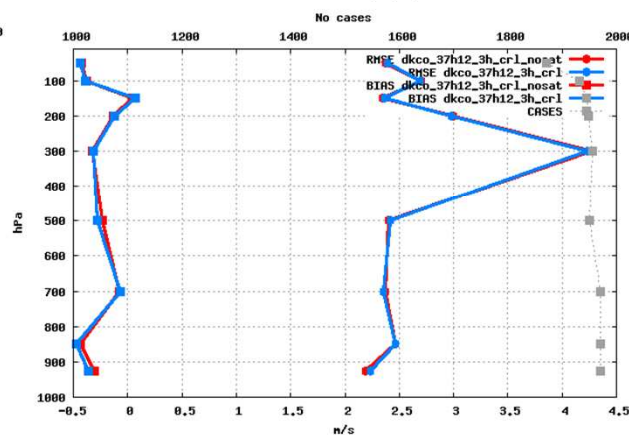
25 stations Selection: ALL
 Relative Humidity Period: 20100807-20100831
 Statistics at 00 UTC Used {00,06,12,18} + 06 12 18 24



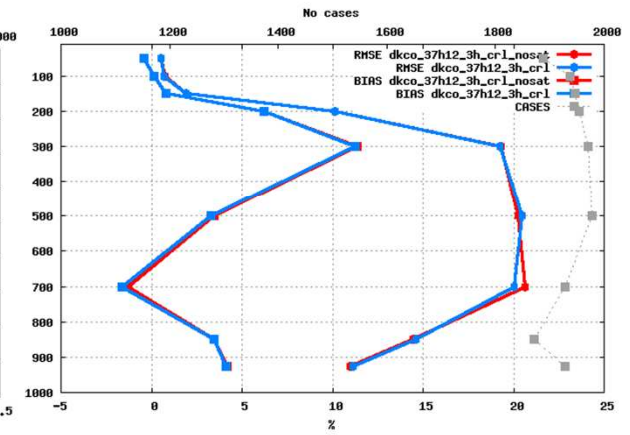
26 stations Selection: ALL
 Temperature Period: 20100807-20100831
 Statistics at 12 UTC Used {00,06,12,18} + 06 12 18 24



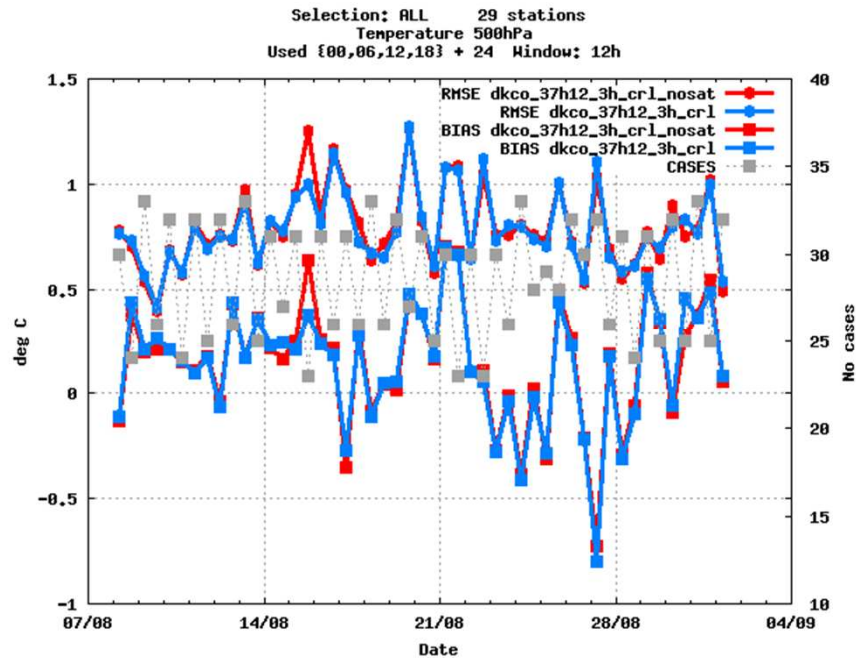
26 stations Selection: ALL
 Wind speed Period: 20100807-20100831
 Statistics at 12 UTC Used {00,06,12,18} + 06 12 18 24



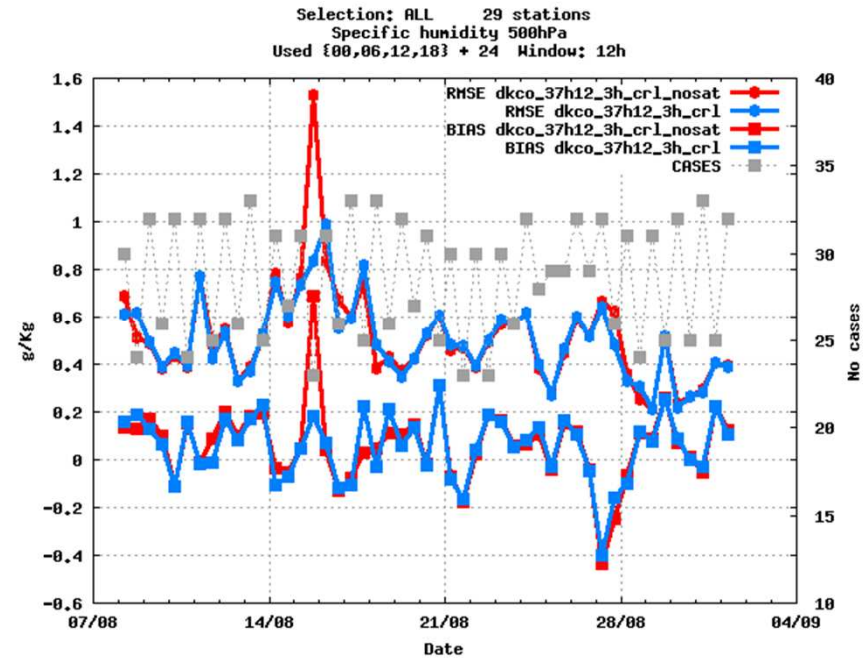
26 stations Selection: ALL
 Relative Humidity Period: 20100807-20100831
 Statistics at 12 UTC Used {00,06,12,18} + 06 12 18 24



Time series bias/RMS Temperature 500 hPa

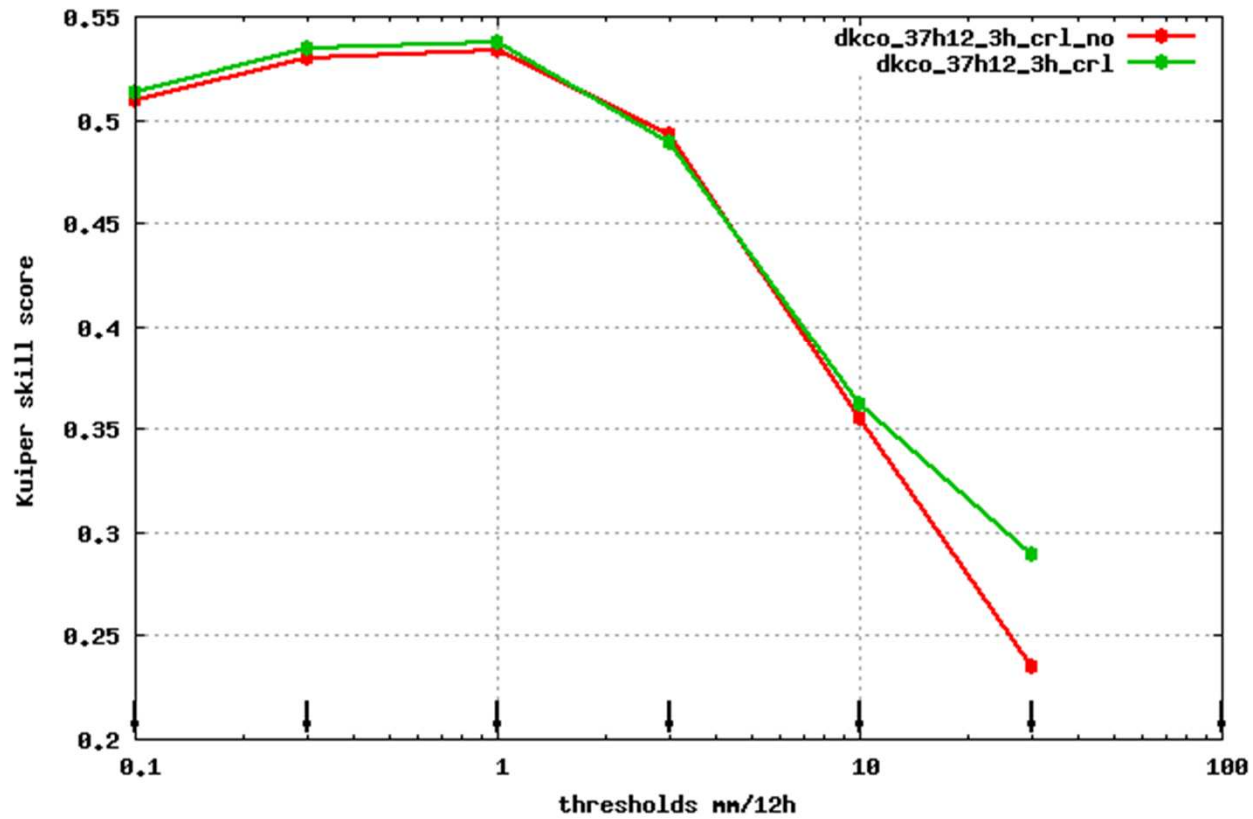


Time series bias/RMS Specific humidity 500 hPa



Precipitation

Kuiper skill score for Precipitation (mm/12h)
Selection: ALL 524 stations
Period: 20100807-20100831
Used {00,12} + 18-06 30-18



- Data assimilation of ATOVS data properly working in cy 37h.1.2.
- Cy 37h.12 data assimilation tested with BUFR data from ECMWF MARS archive and some locally processed data.
- VarBC predictors adjusted to HARMONIE configuration.
- Tools for diagnostics important and updated.
- First results with ATOVS data assimilation over extended Danish domain and more experiments ongoing.