Bias correction of observations

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ALADIN/HIRLAM common data assimilation training week

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Outline

- Peculiarities of radiance observations;

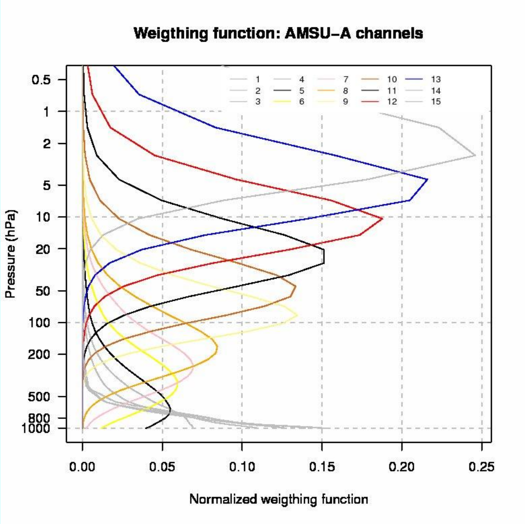
- Need for bias correction – VARBC and its set up;

- Processing of radiance data for ARP/ALD/ARM assimilation;

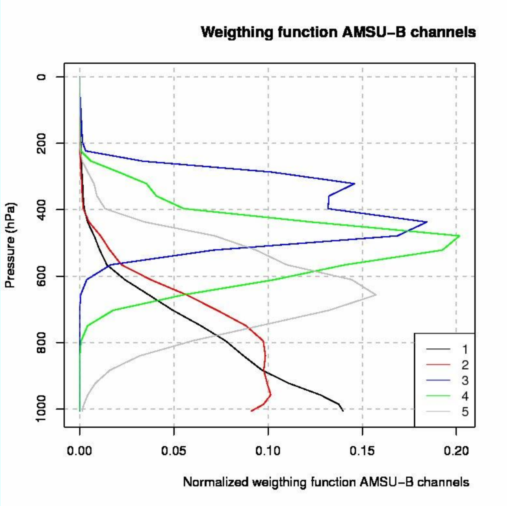
- Bias correction for aircraft data.

Peculiarity of satellite measurements

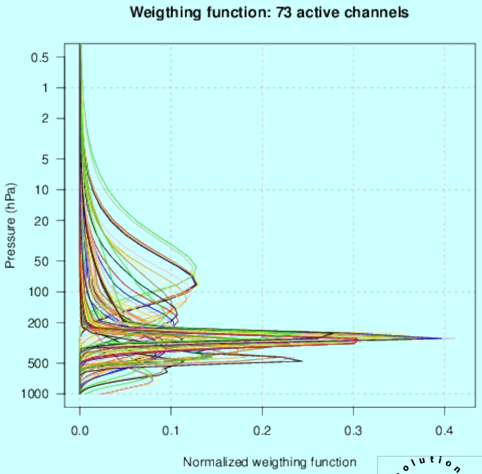
- ➔ Satellites do passive remote sensing;
- ➔ They do infrared or microwave sounding of temperature or humidity profiles;
- ➔ For satellite instruments the sensing is done with different frequency bands (channels), which are sensitive to specific atmospheric layers;
- ➔ No direct measure of temperature nor humidity profiles;
- ➔ Need for specific observation operator – the RTTOV radiative transfer model.



AMSU-A



AMSU-B



IASI

Need of bias correction for radiance assimilation

The following reasons can play as source of bias between radiance observations and the background information:

➔ Inefficiency in the characterisation of the instruments;
➔ Deficiencies in the forward models – the radiative transfer model;
➔ Errors can come from data processing;
➔ Bias in the background atmospheric state provided by the NWP
(no intention to correct this one – it can reinforce the model systematic error, *Auligné et al. 2007*).

➔ To correct the radiance bias we use an adaptive variational technique: VarBC

Need of bias correction for radiance assimilation

Variational Bias Correction (VarBC)

Linear predictor model for bias in each channel:

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

Cost function:

J_b: background constraint for x

J_β: background constraint for β

$$J(\mathbf{x}, \boldsymbol{\beta}) = (\mathbf{x}_b - \mathbf{x})^T \mathbf{B}_x^{-1} (\mathbf{x}_b - \mathbf{x}) + (\boldsymbol{\beta}_b - \boldsymbol{\beta})^T \mathbf{B}_\beta^{-1} (\boldsymbol{\beta}_b - \boldsymbol{\beta})$$
$$+ [\mathbf{y} - \mathbf{b}(\mathbf{x}, \beta) - h(\mathbf{x})]^T \mathbf{R}^{-1} [\mathbf{y} - \mathbf{b}(\mathbf{x}, \beta) - h(\mathbf{x})]$$

J_o: bias-corrected observation constraint

β_b Parameter background value – final estimate from previous analysis

$\sigma_\beta^2 = \sigma_o^2 / N$ N large means strong constraint- less adaptivity (5000 default)

See (Auligné et al. 2007), about the comparison with off-line techniques

Courtesy of Lindskog

VARBC predictors and setup (radiance)

The predictors are defined in
src/arpifs/module/varbc_pred.F90

The most used for radiance assimilation

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

VARBC is switched on automatically in scr/include.ass when we do radiance assimilation
LVARBC="T"

The setting of predictors for each instrument / channel is in
/src/arpifs/module/varbc_rad.F90
we overwrite them through namelists of Screening and Minim, based on our experiences (see later)

```
%varbc=(
 NAMVARBC=>{
 },
 NAMVARBC_RAD=>{
 'LBC_RAD' => '.TRUE.,',
 'yconfig(3,5)%nparam' => '10',
 'yconfig(3,5)%npredcs(1:10)' => '0,1,2,8,9,10,15,16,17,18',
 'yconfig(3,6)%nparam' => '5',
 'yconfig(3,6)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(3,7)%nparam' => '5',
 'yconfig(3,7)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(3,8)%nparam' => '5',
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 'yconfig(3,10)%nparam' => '5',
 'yconfig(3,10)%npredcs(1:5)' => '0,1,8,9,10',
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 'yconfig(4,2)%npredcs(1:4)' => '0,8,9,10',
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 'yconfig(15,4)%nparam' => '5',
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 'yconfig(15,5)%nparam' => '5',
 'yconfig(15,5)%npredcs(1:5)' => '0,1,8,9,10',
 'nbg_AMSUA' => '2000',
 'nbg_AMSUB' => '2000',
 'nbg_MHS' => '2000',
 'nbg_IASI' => '2000',
 },
```
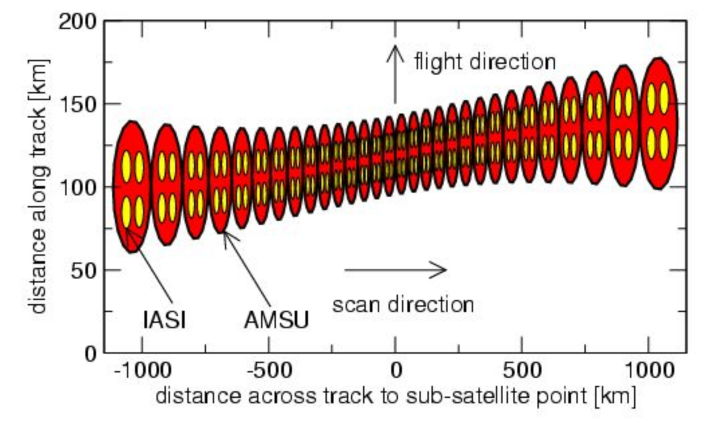
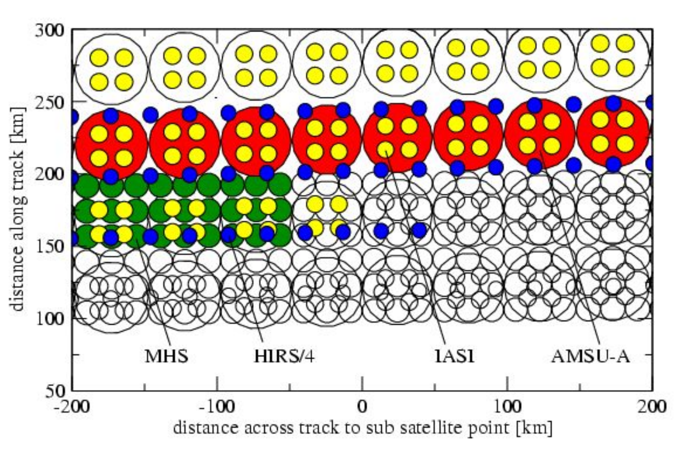

Processing of the radiance data, pre-thinning of data (in Bator)

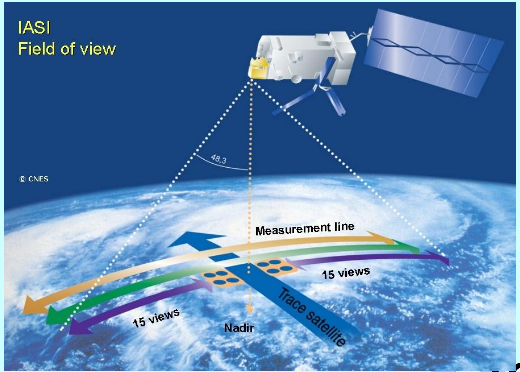




" ...It (VARBC) updates the bias inside the assimilation system by finding corrections that minimize the systematic radiance departures while simultaneously preserving (or improving) the fit to other observed data inside the analysis. .. (Auligné et al. 2007)

The pre-thinning technique:

– one can think about collocation of pixels from different instruments;



GNSS ZTD

In similar way we apply also the VarBC to assimilate GNSS ZTD

How to proceed with ATOVS radiances? Check the wiki page below:
https://hirlam.org/trac/wiki/HarmonieSystemDocumentation/ObservationHowto/Atovs

Feedbacks about how to improve it are welcome

VARBC predictors and setup (aircraft)

The predictors are defined in
src/arpifs/module/varbc_pred.F90

Predictor 0
Predictor 25 -- ascent rate (hPa/s)
Predictor 26 -- descent rate (hPa/s)

The setting of predictors for each aircraft is in
/src/arpifs/module/varbc_airep.F90

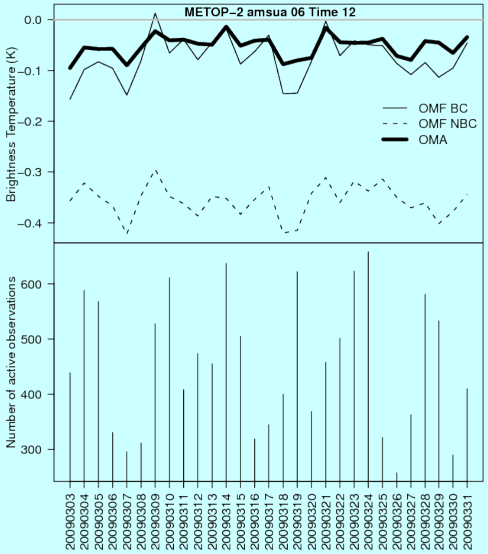
```
&NAMVARBC_AIREP
LBC_ACARS=.FALSE.,
LBC_AIRCT=.FALSE.,
LBC_AMDAR=.FALSE.,
LBC_CODAR=.FALSE.,
LBC_COLBA=.FALSE.,
NBG_ACARS=
NBG_AIRCT=
NBG_AMDAR=
NBG_CODAR=
NBG_ACARS=
/
```

.TRUE.
The one you want to correct and setup the NBG_*

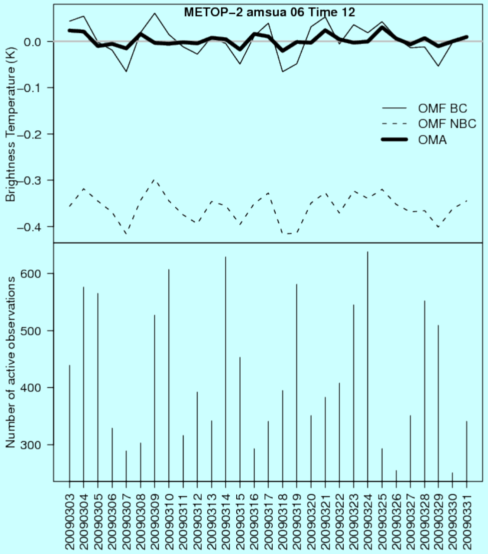
Testing this solution in the Copernicus Arctic reanalysis showed promising results, but also some issues related to the growing size of the VarBC files in CY40. Hopefully, this solved in CY43...

VarBC: Update strategy

Default: update using previous cycle



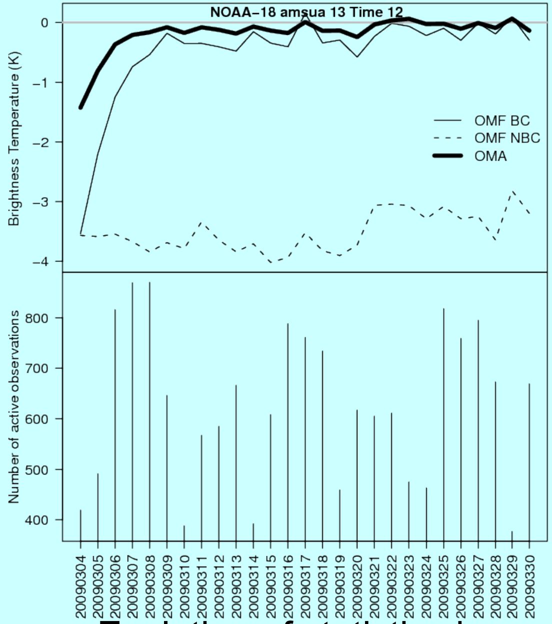
Update daily per assimilation



Time series of corrected (thin lines) and non-corrected (dashed line) OMF and OMA (bold line) biases (upper graphs) for channel 6 of METOP AMSU-A, associated with the number of active observations (lower graphs) for the 1200 UTC assimilation time. These graphs show the temporal evolution of the bias by applying the “default” (left) and the daily (right) update techniques.

Randriamampianina et al. 2011

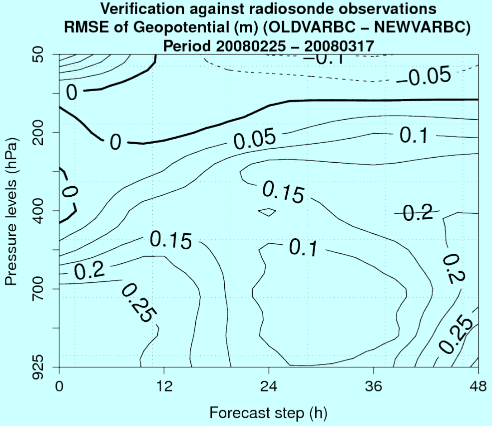
Impact of daily update

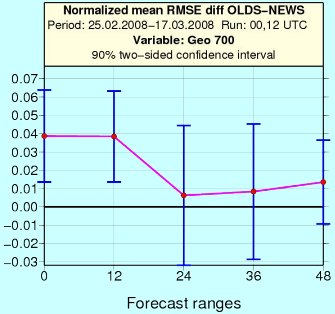


Evolution of statistics in cold-start regime

(Randriamampianina et al. 2011)

Impact of the decision on Harmonie/Norway analyses and forecasts





Thank you

Thank you for your attention!

Köszönöm a figyelmet!

References

Aulingé T, McNally AP, Dee DP. 2007. Adaptive bias correction for satellite data in a numerical weather prediction system. *Q. J. R. Meteorol. Soc*. **133**: 631–642.

Randriamampianina, R.,T. Iversen and A. Storto, 2011: Exploring the assimilation of IASI radiances in forecasting polar lows. *Q. J. R. Meteor. Soc.*, **137**. 1700–1715.