Bias correction of radiance observations:

Roger Randriamampianina

ALADIN/HIRLAM common data assimilation training week

Budapest, 10-15 February 2019

Outline

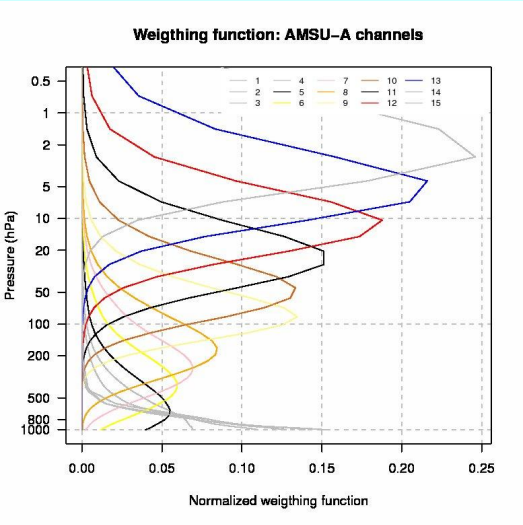
- Peculiarities of radiance observations;

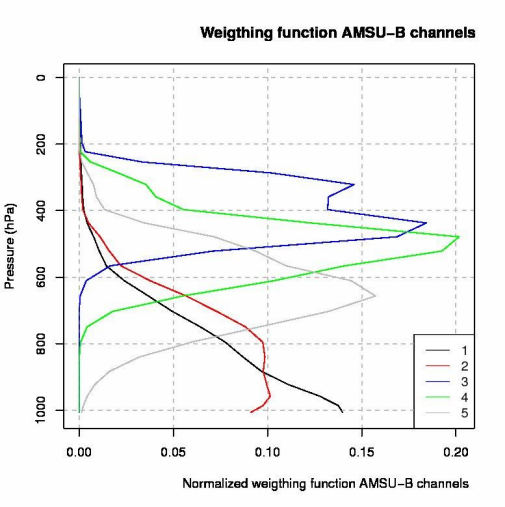
- Need for bias correction – VARBC and its set up;

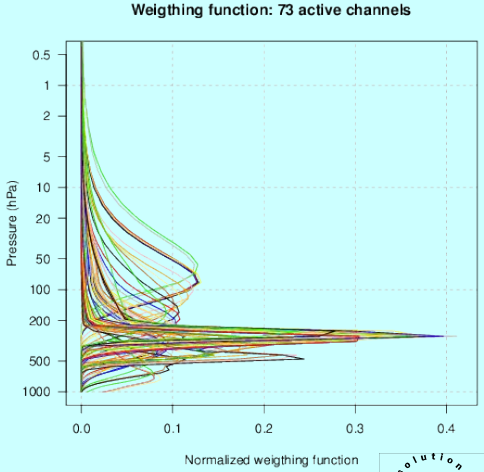
- Processing of radiance data for ARP/ALD/ARM assimilation;

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

VARBC predictors and setup

The predictors are defined in *src/arp/module/varbc_pred.F90*

The most used for radiance assimilation

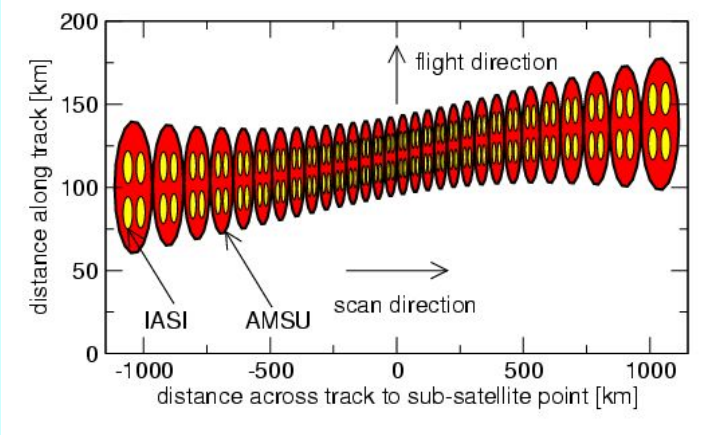
Predictor no.	Predictor
0	constant
1	1000-300hPa thickness
2	200-50hPa thickness
5	10-1hPa thickness
6	50-5hPa thickness
8	nadir view angle
9	nadir view angle **2
10	nadir view angle **3

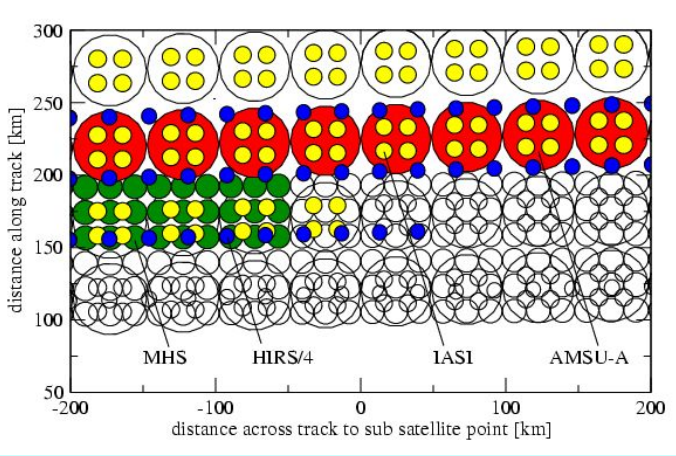
VARBC is witched on automatically in scr/include.ass when we chose a radiance assimilation
LVARBC="T"

The setting of predictors for each instrument / channel is in */src/arp/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',
 'yconfig(3,8)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(3,9)%nparam' => '5',
 'yconfig(3,9)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(3,10)%nparam' => '5',
 'yconfig(3,10)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(4,2)%nparam' => '4',
 'yconfig(4,2)%npredcs(1:4)' => '0,8,9,10',
 'yconfig(4,3)%nparam' => '5',
 'yconfig(4,3)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(4,4)%nparam' => '5',
 'yconfig(4,4)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(4,5)%nparam' => '5',
 'yconfig(4,5)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(15,2)%nparam' => '4',
 'yconfig(15,2)%npredcs(1:4)' => '0,8,9,10',
 'yconfig(15,3)%nparam' => '5',
 'yconfig(15,3)%npredcs(1:5)' => '0,1,8,9,10',
 'yconfig(15,4)%nparam' => '5',
 'yconfig(15,4)%npredcs(1:5)' => '0,1,8,9,10',
 '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)



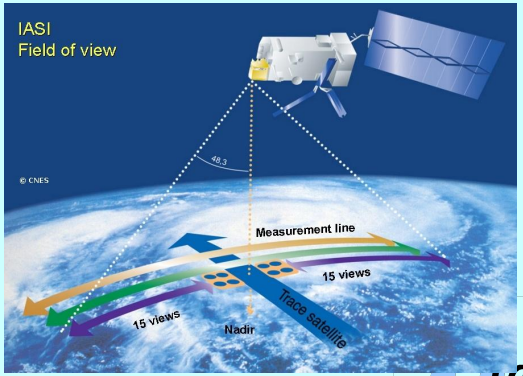


" ...It (VARBC) updates the bias inside the assimilation system by finding corrections that minimize the systematic radiance departures while simultaneously preserving (or improving) the fit to other observed data inside the analysis. .. (Auligné et al. 2007)

The pre-thinning technique:

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

Jargon: field of view (FOV), field of regard (FOR)



Thank you

Thank you for your attention!

Köszönöm a figyelmet!

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